Holtek 32-Bit Microcontroller with Arm® Cortex®-M0+

HT32F50231/HT32F50241

User Manual

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Table of Contents

1 Introduction 22
Overview 22
Features 23
Device Information 26
Block Diagram 27

2 Document Conventions 28

3 System Architecture 29
Arm® Cortex®-M0+ Processor 29
Bus Architecture 30
Memory Organization 31
Memory Map 32
Embedded Flash Memory 34
Embedded SRAM Memory 34
AHB Peripherals 34
APB Peripherals 34

4 Flash Memory Controller (FMC) 35
Introduction 35
Features 35
Functional Descriptions 36
Flash Memory Map 36
Flash Memory Architecture 37
Booting Configuration 38
Page Erase 39
Mass Erase 40
Word Programming 41
Option Byte Description 42
Page Erase / Program Protection 43
Security Protection 44
Register Map 45
Register Descriptions 46
Flash Target Address Register – TADR 46
Flash Write Data Register – WRDR 47
Flash Operation Command Register – OCMR 48
Flash Operation Control Register – OPCR 49
Flash Operation Interrupt Enable Register – OIER 50
Flash Operation Interrupt and Status Register – OISR 51
Flash Page Erase / Program Protection Status Register – PPSR 53
Flash Security Protection Status Register – CPSR 54
Flash Vector Mapping Control Register – VMCR 55

Flash Manufacturer and Device ID Register – MDID 56
Flash Page Number Status Register – PNSR 57
Flash Page Size Status Register – PSSR 58
Device ID Register – DIDR 59
Custom ID Register n – CIDRn, n = 0 ~ 3 60

5 Power Control Unit (PWRCU) 61
Introduction 61
Features 62
Functional Descriptions 62
V_{DD} Power Domain 62
1.5 V Power Domain 64
Operation Modes 64
Register Map 66
Register Descriptions 66
Power Control Status Register – PWRSR 66
Power Control Register – PWRCR 67
Low Voltage / Brown Out Detect Control and Status Register – LVDCSR 69

6 Clock Control Unit (CKCU) 71
Introduction 71
Features 73
Function Descriptions 73
High Speed External Crystal Oscillator – HSE 73
High Speed Internal RC Oscillator – HSI 74
Auto Trimming of High Speed Internal RC Oscillator – HSI 74
Low Speed External Crystal Oscillator – LSE 76
Low Speed Internal RC Oscillator – LSI 76
Clock Ready Flag 76
System Clock (CK_SYS) Selection 76
HSE Clock Monitor 77
Clock Output Capability 77
Register Map 78
Register Descriptions 79
Global Clock Configuration Register – GCFGR 79
Global Clock Control Register – GCCR 80
Global Clock Status Register – GCSR 82
Global Clock Interrupt Register – GCIR 83
AHB Configuration Register – AHBCFGR 84
AHB Clock Control Register – AHBCCR 85
APB Configuration Register – APBCFGR 86
APB Clock Control Register 0 – APBCCR0 87
APB Clock Control Register 1 – APBCCR1 88
Clock Source Status Register – CKST 90

APB Peripheral Clock Selection Register 0 – APBPCSR0 91
APB Peripheral Clock Selection Register 1 – APBPCSR1 93
HSI Control Register – HSICR 94
HSI Auto Trimming Counter Register – HSIATCR 95
APB Peripheral Clock Selection Register 2 – APBPCSR2 96
MCU Debug Control Register – MCUDBGCR 97

7 Reset Control Unit (RSTCU) 99
Introduction 99
Functional Descriptions 100
Power On Reset 100
System Reset 100
AHB and APB Unit Reset 100
Register Map 101
Register Descriptions 101
Global Reset Status Register – GRSR 101
AHB Peripheral Reset Register – AHBPRSTR 102
APB Peripheral Reset Register 0 – APBPRSTR0 103
APB Peripheral Reset Register 1 – APBPRSTR1 104

8 General Purpose I/O (GPIO) 106
Introduction 106
Features 107
Functional Descriptions 107
Default GPIO Pin Configuration 107
General Purpose I/O – GPIO 107
GPIO Locking Mechanism 109
Register Map 109
Register Descriptions 110
Port A Data Direction Control Register – PADIRCR 110
Port A Input Function Enable Control Register – PAINER 111
Port A Pull-Up Selection Register – PAPUR 112
Port A Pull-Down Selection Register – PAPDR 113
Port A Open-Drain Selection Register – PAODR 114
Port A Output Drive Current Selection Register – PADRVR 115
Port A Lock Register – PALOCKR 116
Port A Data Input Register – PADINR 117
Port A Output Data Register – PADOUTR 117
Port A Output Set / Reset Control Register – PASRR 118
Port A Output Reset Register – PARR 119
Port A Sink Current Enhanced Selection Register – PASCER 119
Port B Data Direction Control Register – PBDIRCR 120
Port B Input Function Enable Control Register – PBINER 121
Port B Pull-Up Selection Register – PBPUR 122

Port B Pull-Down Selection Register – PBPDR 123
Port B Open-Drain Selection Register – PBODR 124
Port B Output Drive Current Selection Register – PBDRVR 125
Port B Lock Register – PBLOCKR 126
Port B Data Input Register – PBDINR 127
Port B Output Data Register – PBDOUTR 127
Port B Output Set / Reset Control Register – PBSRR 128
Port B Output Reset Register – PBRR 129
Port B Sink Current Enhanced Selection Register – PBSCER 129
Port C Data Direction Control Register – PCDIRCR 130
Port C Input Function Enable Control Register – PCINER 131
Port C Pull-Up Selection Register – PCPUR 132
Port C Pull-Down Selection Register – PCPDR 133
Port C Open Drain Selection Register – PCODR 134
Port C Output Current Drive Selection Register – PCDRVR 135
Port C Lock Register – PCLOCKR 136
Port C Data Input Register – PCDINR 137
Port C Output Data Register – PCDOUTR 137
Port C Output Set / Reset Control Register – PCSRR 138
Port C Output Reset Register – PCRR 139
Port C Sink Current Enhanced Selection Register – PCSCER 139

9 Alternate Function Input / Output Control Unit (AFIO) 140

Introduction 140
Features 141
Functional Descriptions 141
External Interrupt Pin Selection 141
Alternate Function 142
Lock Mechanism 142
Register Map 142
Register Descriptions 143
EXTI Source Selection Register 0 – ESSR0 143
EXTI Source Selection Register 1 – ESSR1 144
GPIO Port x Configuration Low Register – GPxCFGLR, x = A, B, C 145
GPIO Port x Configuration High Register – GPxCFGHR, x = A, B, C 146

10 Nested Vectored Interrupt Controller (NVIC) 147

Introduction 147
Features 148
Function Descriptions 149
SysTick Calibration 149
Register Map 149

11 External Interrupt / Event Controller (EXTI) 150
Introduction 150
Features 150
Function Descriptions 151
Wakeup Event Management 151
External Interrupt / Event Line Mapping 151
Interrupt and Debounce 151
Register Map 152
Register Descriptions 153
EXTI Interrupt n Configuration Register – EXTICFGRn, n = 0 ~ 15 153
EXTI Interrupt Control Register – EXTICR 154
EXTI Interrupt Edge Flag Register – EXTIEDGEFLGR 155
EXTI Interrupt Edge Status Register – EXTIEDGESR 156
EXTI Interrupt Software Set Command Register – EXTISSCR 157
EXTI Interrupt Wakeup Control Register – EXTIWAKUPCR 158
EXTI Interrupt Wakeup Polarity Register – EXTIWAKUPPOLR 159
EXTI Interrupt Wakeup Flag Register – EXTIWAKUPFLG 160

12 Analog to Digital Converter (ADC) 161
Introduction 161
Features 162
Function Descriptions 163
ADC Clock Setup 163
Channel Selection 163
Conversion Mode 163
Start Conversion on External Event 166
Sampling Time Setting 167
Data Format 167
Analog Watchdog 167
Interrupts 168
Register Map 169
Register Descriptions 170
ADC Conversion Control Register – ADCCR 170
ADC Conversion List Register 0 – ADCLST0 172
ADC Conversion List Register 1 – ADCLST1 173
ADC Input Sampling Time Register – ADCSTR 174
ADC Conversion Data Register y – ADCDRy, y = 0 ~ 7 175
ADC Trigger Control Register – ADCTCR 176
ADC Trigger Source Register – ADCTSR 177
ADC Watchdog Control Register – ADCWCR 178
ADC Watchdog Threshold Register – ADCTR 180
ADC Interrupt Enable Register – ADCIER 181
ADC Interrupt Raw Status Register – ADCIRAW 182

ADC Interrupt Status Register – ADCISR 183
ADC Interrupt Clear Register – ADCICLR 184

13 General-Purpose Timer (GPTM) 185

Introduction 185
Features 186
Functional Descriptions 186
Counter Mode 186
Clock Controller 188
Trigger Controller 190
Slave Controller 191
Master Controller 193
Channel Controller 194
Input Stage 196
Quadrature Decoder 198
Output Stage 199
Update Management 203
Single Pulse Mode 204
Asymmetric PWM Mode 206
Timer Interconnection 206
Trigger Peripherals Start 208
PDMA Request 209
Register Map 210
Register Descriptions 211
Timer Counter Configuration Register – CNTCFR 211
Timer Mode Configuration Register – MDCFR 212
Timer Trigger Configuration Register – TRCFR 215
Timer Control Register – CTR 216
Channel 0 Input Configuration Register – CH0ICFR 217
Channel 1 Input Configuration Register – CH1ICFR 218
Channel 2 Input Configuration Register – CH2ICFR 220
Channel 3 Input Configuration Register – CH3ICFR 221
Channel 0 Output Configuration Register – CH0OCFR 223
Channel 1 Output Configuration Register – CH1OCFR 225
Channel 2 Output Configuration Register – CH2OCFR 227
Channel 3 Output Configuration Register – CH3OCFR 229
Channel Control Register – CHCTR 231
Channel Polarity Configuration Register – CHPOLR 232
Timer PDMA/Interrupt Control Register – DICTR 233
Timer Event Generator Register – EVGR 235
Timer Interrupt Status Register – INTSR 236
Timer Counter Register – CNTR 239
Timer Prescaler Register – PSCR 240
Timer Counter-Reload Register – CRR 241

Channel 0 Capture/Compare Register – CH0CCR 242
Channel 1 Capture/Compare Register – CH1CCR 243
Channel 2 Capture/Compare Register – CH2CCR 244
Channel 3 Capture/Compare Register – CH3CCR 245
Channel 0 Asymmetric Compare Register – CH0ACR 246
Channel 1 Asymmetric Compare Register – CH1ACR 246
Channel 2 Asymmetric Compare Register – CH2ACR 247
Channel 3 Asymmetric Compare Register – CH3ACR 247

14 Pulse-Width-Modulation Timer (PWM) 248

Introduction 248
Features 249
Functional Descriptions 249
Counter Mode 249
Clock Controller 252
Trigger Controller 253
Slave Controller 254
Master Controller 256
Channel Controller 257
Output Stage 257
Update Management 261
Single Pulse Mode 261
Asymmetric PWM Mode 264
Timer Interconnection 264
Trigger Peripherals Start 267
PDMA Request 267
Register Map 268
Register Descriptions 269
Timer Counter Configuration Register – CNTCFR 269
Timer Mode Configuration Register – MDCFR 270
Timer Trigger Configuration Register – TRCFR 273
Timer Control Register – CTR 274
Channel 0 Output Configuration Register – CH0OCFR 275
Channel 1 Output Configuration Register – CH1OCFR 277
Channel 2 Output Configuration Register – CH2OCFR 279
Channel 3 Output Configuration Register – CH3OCFR 281
Channel Control Register – CHCTR 283
Channel Polarity Configuration Register – CHPOLR 284
Timer PDMA/Interrupt Control Register – DICTR 285
Timer Event Generator Register – EVGR 286
Timer Interrupt Status Register – INTSR 287
Timer Counter Register – CNTR 289
Timer Prescaler Register – PSCR 289
Timer Counter-Reload Register – CRR 290
Channel 0 Compare Register – CH0CR 290

Channel 1 Compare Register – CH1CR 291
Channel 2 Compare Register – CH2CR 291
Channel 3 Compare Register – CH3CR 292
Channel 0 Asymmetric Compare Register – CH0ACR 292
Channel 1 Asymmetric Compare Register – CH1ACR 293
Channel 2 Asymmetric Compare Register – CH2ACR 293
Channel 3 Asymmetric Compare Register – CH3ACR 294

15 Basic Function Timer (BFTM) 295
Introduction 295
Features 295
Functional Description 296
Repetitive Mode 296
One Shot Mode 297
Trigger ADC Start 297
Register Map 298
Register Descriptions 298
BFTM Control Register – BFTMCR 298
BFTM Status Register – BFTMSR 299
BFTM Counter Value Register – BFTMCNTR 300
BFTM Compare Value Register – BFTMCMPR 300

16 Motor Control Timer (MCTM) 301
Introduction 301
Features 302
Functional Descriptions 302
Counter Mode 302
Clock Controller 306
Trigger Controller 307
Slave Controller 308
Master Controller 310
Channel Controller 311
Input Stage 312
Output Stage 314
Update Management 325
Single Pulse Mode 327
Timer Interconnection 330
Trigger Peripherals Start 334
Lock Level Table 334
Register Map 334
Register Descriptions 335
Timer Counter Configuration Register – CNTCFR 335
Timer Mode Configuration Register – MDCFR 337
Timer Trigger Configuration Register – TRCFR 340

Timer Control Register – CTR 341
Channel 0 Input Configuration Register – CH0ICFR 342
Channel 1 Input Configuration Register – CH1ICFR 343
Channel 2 Input Configuration Register – CH2ICFR 345
Channel 3 Input Configuration Register – CH3ICFR 346
Channel 0 Output Configuration Register – CH0OCFR 348
Channel 1 Output Configuration Register – CH1OCFR 350
Channel 2 Output Configuration Register – CH2OCFR 352
Channel 3 Output Configuration Register – CH3OCFR 354
Channel Control Register – CHCTR 356
Channel Polarity Configuration Register – CHPOLR 358
Channel Break Configuration Register – CHBRKCFR 359
Channel Break Control Register – CHBRKCTR 360
Timer Interrupt Control Register – DICTR 362
Timer Event Generator Register – EVGR 363
Timer Interrupt Status Register – INTSR 365
Timer Counter Register – CNTR 367
Timer Prescaler Register – PSCR 368
Timer Counter Reload Register – CRR 369
Timer Repetition Register – REPR 369
Channel 0 Capture/Compare Register – CH0CCR 370
Channel 1 Capture/Compare Register – CH1CCR 371
Channel 2 Capture/Compare Register – CH2CCR 372
Channel 3 Capture/Compare Register – CH3CCR 373
Channel 0 Asymmetric Compare Register – CH0ACR 374
Channel 1 Asymmetric Compare Register – CH1ACR 374
Channel 2 Asymmetric Compare Register – CH2ACR 375
Channel 3 Asymmetric Compare Register – CH3ACR 375

17 Real Time Clock (RTC) 376

Introduction 376
Features 376
Functional Descriptions 377
RTC Related Register Reset 377
Low Speed Clock Configuration 377
RTC Counter Operation 377
Interrupt and Wakeup Control 377
RTCOUT Output Pin Configuration 378
Register Map 379
Register Descriptions 379
RTC Counter Register – RTCCNT 379
RTC Compare Register – RTCCMP 380
RTC Control Register – RTCCR 381

RTC Status Register – RTCSR 383
RTC Interrupt and Wakeup Enable Register – RTCIWEN 384

18 Watchdog Timer (WDT) 385
Introduction 385
Features 386
Functional Description 386
Register Map 388
Register Descriptions 388
Watchdog Timer Control Register – WDTCR 388
Watchdog Timer Mode Register 0 – WDTMR0 389
Watchdog Timer Mode Register 1 – WDTMR1 390
Watchdog Timer Status Register – WDTSR 391
Watchdog Timer Protection Register – WDTPR 392
Watchdog Timer Clock Selection Register – WDTCSR 393

19 Inter-Integrated Circuit (I²C) 394
Introduction 394
Features 395
Functional Descriptions 395
Two-Wire Serial Interface 395
START and STOP Conditions 395
Data Validity 396
Addressing Format 397
Data Transfer and Acknowledge 399
Clock Synchronization 400
Arbitration 400
General Call Addressing 401
Bus Error 401
Address Mask Enable 401
Address Snoop 401
Operation Mode 401
Conditions of Holding SCL Line 407
I²C Timeout Function 408
Register Map 408
Register Descriptions 409
I²C Control Register – I2CCR 409
I²C Interrupt Enable Register – I2CIER 410
I²C Address Register – I2CADDR 411
I²C Status Register – I2CSR 412
I²C SCL High Period Generation Register – I2CSHPGR 415
I²C SCL Low Period Generation Register – I2CSLPGR 416
I²C Data Register – I2CDR 417
I²C Target Register – I2CTAR 418

I²C Address Mask Register – I2CADDMR 419
I²C Address Snoop Register – I2CADDSR 420
I²C Timeout Register – I2CTOUT 421

20 Serial Peripheral Interface (SPI) 422
Introduction 422
Features 423
Functional Descriptions 423
Master Mode 423
Slave Mode 423
SPI Serial Frame Format 423
SPI Dual Mode 428
Status Flags 430
PDMA Interface 433
Register Map 433
Register Descriptions 434
SPI Control Register 0 – SPICR0 434
SPI Control Register 1 – SPICR1 436
SPI Interrupt Enable Register – SPIIER 438
SPI Clock Prescaler Register – SPICPR 439
SPI Data Register – SPIDR 440
SPI Status Register – SPISR 440
SPI FIFO Control Register – SPIFCR 442
SPI FIFO Status Register – SPIFSR 443
SPI FIFO Time Out Counter Register – SPIFTOCR 444

21 Universal Synchronous Asynchronous Receiver Transmitter (USART) 445
Introduction 445
Features 446
Functional Descriptions 446
Serial Data Format 446
Baud Rate Generation 447
Hardware Flow Control 448
IrDA 449
RS485 Mode 451
Synchronous Master Mode 453
Interrupts and Status 455
Register Map 455
Register Descriptions 456
USART Data Register – USRDR 456
USART Control Register – USRCR 457
USART FIFO Control Register – USRFCR 459
USART Interrupt Enable Register – USRIER 460
USART Status & Interrupt Flag Register – USRSIFR 462

USART Timing Parameter Register – USRTPR 464
USART IrDA Control Register – IrDACR 465
USART RS485 Control Register – RS485CR 466
USART Synchronous Control Register – SYNCR 467
USART Divider Latch Register – USRDLR 468
USART Test Register – USRTSTR 469

22 Universal Asynchronous Receiver Transmitter (UART) 470
Introduction 470
Features 471
Function Descriptions 471
Serial Data Format 471
Baud Rate Generation 472
Interrupts and Status 473
Register Map 473
Register Descriptions 474
UART Data Register – URDR 474
UART Control Register – URCR 475
UART Interrupt Enable Register – URIER 476
UART Status & Interrupt Flag Register – URSIFR 477
UART Divider Latch Register – URDLR 479
UART Test Register – URTSTR 480

23 Divider (DIV) 481
Introduction 481
Features 481
Functional Descriptions 481
Register Map 482
Register Descriptions 482
Divider Control Register – CR 482
Dividend Data Register – DDR 483
Divisor Data Register – DSR 483
Quotient Data Register – QTR 484
Remainder Data Register – RMR 484

24 Cyclic Redundancy Check (CRC) 485
Introduction 485
Features 485
Functional Descriptions 486
CRC Computation 486
Byte and Bit Reversal for CRC Computation 486
Register Map 487
Register Descriptions 487

CRC Control Register – CRCCR 487
CRC Seed Register – CRCSDR 488
CRC Checksum Register – CRCCSR 489
CRC Data Register – CRCDR 490

List of Tables

Table 1. Features and Peripheral List 26
Table 2. Document Conventions 28
Table 3. Register Map 33
Table 4. Flash Memory and Option Byte 37
Table 5. Booting Modes 38
Table 6. Option Byte Memory Map 42
Table 7. Access Permission of Protected Main Flash Page 43
Table 8. Access Permission When Security Protection is Enabled 44
Table 9. FMC Register Map 45
Table 10. Operation Mode Definitions 64
Table 11. Enter / Exit Power Saving Modes 65
Table 12. Power Status After System Reset 65
Table 13. PWRCU Register Map 66
Table 14. CKOUT Clock Source 77
Table 15. CKCU Register Map 78
Table 16. RSTCU Register Map 101
Table 17. AFIO, GPIO and I/O Pad Control Signal True Table 108
Table 18. GPIO Register Map 109
Table 19. AFIO Selection for Peripheral Map Example 142
Table 20. AFIO Register Map 142
Table 21. Exception Types 147
Table 22. NVIC Register Map 149
Table 23. EXTI Register Map 152
Table 24. Data Format in ADCDR [15:0] 167
Table 25. A/D Converter Register Map 169
Table 26. Counting Direction and Encoding Signals 199
Table 27. Compare Match Output Setup 200
Table 28. GPTM Register Map 210
Table 29. GPTM Internal Trigger Connection 215
Table 30. Compare Match Output Setup 258
Table 31. PWM Register Map 268
Table 32. PWM Internal Trigger Connection 273
Table 33. BFTM Register Map 298
Table 34. Compare Match Output Setup 315
Table 35. Output Control Bits for Complementary Output with a Break Event Occurrence 324
Table 36. Lock Level Table 334
Table 37. MCTM Register Map 334
Table 38. MCTM Internal Trigger Connection 340
Table 39. LSE Startup Mode Operating Current and Startup Time 377

Table 40. RTCOUT Output Mode and Active Level Setting 378
Table 41. RTC Register Map 379
Table 42. Watchdog Timer Register Map 388
Table 43. Conditions of Holding SCL line 407
Table 44. I²C Register Map 408
Table 45. I²C Clock Setting Example 416
Table 46. SPI Interface Format Setup 424
Table 47. SPI Mode Fault Trigger Conditions 432
Table 48. SPI Master Mode SPI_SEL Pin Status 432
Table 49. SPI Register Map 433
Table 50. Baud Rate Deviation Error Calculation – CK_USART = 20 MHz 448
Table 51. Baud Rate Deviation Error Calculation – CK_USART = 10 MHz 448
Table 52. USART Register Map 455
Table 53. Baud Rate Deviation Error Calculation – CK_UART = 20 MHz 472
Table 54. Baud Rate Deviation Error Calculation – CK_UART = 10 MHz 473
Table 55. UART Register Map 473
Table 56. DIV Register Map 482
Table 57. CRC Register Map 487

List of Figures

Figure 1. Block Diagram 27
Figure 2. Cortex®-M0+ Block Diagram 30
Figure 3. Bus Architecture 31
Figure 4. Memory Map 32
Figure 5. Flash Memory Controller Block Diagram 35
Figure 6. Flash Memory Map 36
Figure 7. Vector Remapping 38
Figure 8. Page Erase Operation Flowchart 39
Figure 9. Mass Erase Operation Flowchart 40
Figure 10. Word Programming Operation Flowchart 41
Figure 11. PWRCU Block Diagram 61
Figure 12. Power On Reset / Power Down Reset Waveform 63
Figure 13. CKCU Block Diagram 72
Figure 14. External Crystal, Ceramic and Resonators for HSE 73
Figure 15. HSI Auto Trimming Block Diagram 75
Figure 16. External Crystal, Ceramic and Resonators for LSE 76
Figure 17. RSTCU Block Diagram 99
Figure 18. Power On Reset Sequence 100
Figure 19. GPIO Block Diagram 106
Figure 20. AFIO / GPIO Control Signal 108
Figure 21. AFIO Block Diagram 140
Figure 22. EXTI Channel Input Selection 141
Figure 23. EXTI Block Diagram 150
Figure 24. EXTI Wakeup Event Management 151
Figure 25. EXTI Interrupt Debounce Function 152
Figure 26. ADC Block Diagram 161
Figure 27. One Shot Conversion Mode 164
Figure 28. Continuous Conversion Mode 164
Figure 29. Discontinuous Conversion Mode 166
Figure 30. GPTM Block Diagram 185
Figure 31. Up-counting Example 187
Figure 32. Down-counting Example 187
Figure 33. Center-aligned Counting Example 188
Figure 34. GPTM Clock Source Selection 189
Figure 35. Trigger Control Block 190
Figure 36. Slave Controller Diagram 191
Figure 37. GPTM in Restart Mode 191
Figure 38. GPTM in Pause Mode 192
Figure 39. GPTM in Trigger Mode 192

Figure 40. Master GPTMn and Slave GPTMm/TMm Connection 193
Figure 41. MTO Selection 193
Figure 42. Capture/Compare Block Diagram 194
Figure 43. Input Capture Mode 195
Figure 44. PWM Pulse Width Measurement Example 196
Figure 45. Channel 0 and Channel 1 Input Stages 196
Figure 46. Channel 2 and Channel 3 Input Stages 197
Figure 47. TI0 Digital Filter Diagram with N = 2 197
Figure 48. Input Stage and Quadrature Decoder Block Diagram 198
Figure 49. Both TI0 and TI1 Quadrature Decoder Counting 199
Figure 50. Output Stage Block Diagram 199
Figure 51. Toggle Mode Channel Output Reference Signal (CHxPRE = 0) 200
Figure 52. Toggle Mode Channel Output Reference Signal (CHxPRE = 1) 201
Figure 53. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode 201
Figure 54. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode 202
Figure 55. PWM Mode Channel Output Reference Signal and Counter in Centre-aligned Mode 202
Figure 56. Update Event Setting Diagram 203
Figure 57. Single Pulse Mode 204
Figure 58. Immediate Active Mode Minimum Delay 205
Figure 59. Asymmetric PWM Mode versus Center-Aligned Counting Mode 206
Figure 60. Pausing PWM0 using the GPTM CH0OREF Signal 207
Figure 61. Triggering PWM0 with GPTM Update Event 207
Figure 62. Trigger GPTM and PWM0 with the GPTM CH0 Input 208
Figure 63. GPTM PDMA Mapping Diagram 209
Figure 64. PWM Block Diagram 248
Figure 65. Up-counting Example 249
Figure 66. Down-counting Example 250
Figure 67. Center-aligned Counting Example 251
Figure 68. PWM Clock Selection Source 252
Figure 69. Trigger Control Block 253
Figure 70. Slave Controller Diagram 254
Figure 71. PWM in Restart Mode 254
Figure 72. PWM in Pause Mode 255
Figure 73. PWM in Trigger Mode 255
Figure 74. Master PWMn and Slave PWMm/TMm Connection 256
Figure 75. MTO Selection 256
Figure 76. Compare Block Diagram 257
Figure 77. Output Stage Block Diagram 257
Figure 78. Toggle Mode Channel Output Reference Signal (CHxPRE = 0) 258
Figure 79. Toggle Mode Channel Output Reference Signal (CHxPRE = 1) 259
Figure 80. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode 259

Figure 81. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode 260
Figure 82. PWM Mode Channel Output Reference Signal and Counter in Center-aligned Mode 260
Figure 83. Update Event Setting Diagram 261
Figure 84. Single Pulse Mode 262
Figure 85. Immediate Active Mode Minimum Delay 263
Figure 86. Asymmetric PWM Mode versus Center-aligned Counting Mode 264
Figure 87. Pausing PWM1 using the PWM0 CH0OREF Signal 265
Figure 88. Triggering PWM1 with PWM0 Update Event 265
Figure 89. Trigger PWM0 and PWM1 with the PWM0 Timer Enable Signal 266
Figure 90. PWM PDMA Mapping Diagram 267
Figure 91. BFTM Block Diagram 295
Figure 92. BFTM – Repetitive Mode 296
Figure 93. BFTM – One Shot Mode 297
Figure 94. BFTM – One Shot Mode Counter Updating 297
Figure 95. MCTM Block Diagram 301
Figure 96. Up-counting Example 303
Figure 97. Down-counting Example 303
Figure 98. Center-aligned Counting Example 304
Figure 99. Update Event 1 Dependent Repetition Mechanism Example 305
Figure 100. MCTM Clock Source Selection 306
Figure 101. Trigger Controller Block 307
Figure 102. Slave Controller Diagram 308
Figure 103. MCTM in Restart Mode 308
Figure 104. MCTM in Pause Mode 309
Figure 105. MCTM in Trigger Mode 309
Figure 106. Master MCTMn and Slave GPTMm Connection 310
Figure 107. MTO Selection 310
Figure 108. Capture/Compare Block Diagram 311
Figure 109. Input Capture Mode 311
Figure 110. PWM Pulse Width Measurement Example 312
Figure 111. Channel 0 and Channel 1 Input Stages 313
Figure 112. Channel 2 and Channel 3 Input Stages 313
Figure 113. TI0 Digital Filter Diagram with N = 2 314
Figure 114. Output Stage Block Diagram 314
Figure 115. Toggle Mode Channel Output Reference Signal – CHxPRE = 0 315
Figure 116. Toggle Mode Channel Output Reference Signal – CHxPRE = 1 316
Figure 117. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode 316
Figure 118. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode 317
Figure 119. PWM Mode 1 Channel Output Reference Signal and Counter in Centre-aligned Counting Mode 317
Figure 120. Dead-time Insertion Performed for Complementary Outputs 318

Figure 121. MCTM Break Signal Bolck Diagram 319
Figure 122. MT_BRK Pin Digital Filter Diagram with N = 2 319
Figure 123. Channel 3 Output with a Break Event Occurrence 320
Figure 124. Channel 0 ~ 2 Complementary Outputs with a Break Event Occurrence 321
Figure 125. Channel 0 ~ 2 Only One Output Enabled when Break Event Occurs 322
Figure 126. Hardware Protection When Both CHxO and CHxNO are in Active Condition 323
Figure 127. Update Event 1 Setup Diagram 325
Figure 128. CHxE, CHxNE and CHxOM Updated by Update Event 2 326
Figure 129. Update Event 2 Setup Diagram 326
Figure 130. Single Pulse Mode 327
Figure 131. Immediate Active Mode Minimum Delay 328
Figure 132. Asymmetric PWM Mode versus Center-aligned Counting Mode 329
Figure 133. Pausing GPTM using the MCTM CH0OREF Signal 330
Figure 134. Triggering GPTM with MCTM Update Event 1 331
Figure 135. Trigger MCTM and GPTM with the MCTM CH0 Input 332
Figure 136. CH1XOR Input as Hall Sensor Interface 333
Figure 137. RTC Block Diagram 376
Figure 138. Watchdog Timer Block Diagram 385
Figure 139. Watchdog Timer Behavior 387
Figure 140. I²C Module Block Diagram 394
Figure 141. START and STOP Condition 396
Figure 142. Data Validity 396
Figure 143. 7-bit Addressing Mode 397
Figure 144. 10-bit Addressing Write Transmit Mode 398
Figure 145. 10-bit Addressing Read Receive Mode 398
Figure 146. I²C Bus Acknowledge 399
Figure 147. Clock Synchronization during Arbitration 400
Figure 148. Two Master Arbitration Procedure 400
Figure 149. Master Transmitter Timing Diagram 402
Figure 150. Master Receiver Timing Diagram 404
Figure 151. Slave Transmitter Timing Diagram 405
Figure 152. Slave Receiver Timing Diagram 406
Figure 153. SCL Timing Diagram 416
Figure 154. SPI Block Diagram 422
Figure 155. SPI Single Byte Transfer Timing Diagram – CPOL = 0, CPHA = 0 424
Figure 156. SPI Continuous Data Transfer Timing Diagram – CPOL = 0, CPHA = 0 424
Figure 157. SPI Single Byte Transfer Timing Diagram – CPOL = 0, CPHA = 1 425
Figure 158. SPI Continuous Transfer Timing Diagram – CPOL = 0, CPHA = 1 425
Figure 159. SPI Single Byte Transfer Timing Diagram – CPOL = 1, CPHA = 0 426

Figure 160. SPI Continuous Transfer Timing Diagram – CPOL = 1, CPHA = 0 426
Figure 161. SPI Single Byte Transfer Timing Diagram – CPOL = 1, CPHA = 1 427
Figure 162. SPI Continuous Transfer Timing Diagram – CPOL = 1, CPHA = 1 427
Figure 163. SPI Dual Mode Bit Sequence – CPOL = 0, CPHA = 0, DFL = 0x8 (16-bit), MSB Transmitted First 428
Figure 164. SPI Dual Mode Bit Sequence – CPOL = 0, CPHA = 1, DFL = 0x8 (16-bit), MSB Transmitted First 428
Figure 165. SPI Dual Mode Bit Sequence – CPOL = 1, CPHA = 0, DFL = 0x8 (16-bit) , MSB Transmitted First 429
Figure 166. SPI Dual Mode Bit Sequence – CPOL = 1, CPHA = 1, DFL = 0x8 (16-bit) , MSB Transmitted First 429
Figure 167. SPI Dual Mode Data Read Example - CPOL = 1, CPHA = 1 430
Figure 168. SPI Multi-Master Slave Environment 431
Figure 169. USART Block Diagram 444
Figure 170. USART Serial Data Format 446
Figure 171. USART Clock CK_USART and Data Frame Timing 446
Figure 172. Hardware Flow Control between 2 USARTs 447
Figure 173. USART RTS Flow Control 448
Figure 174. USART CTS Flow Control 448
Figure 175. IrDA Modulation and Demodulation 449
Figure 176. USART I/O and IrDA Block Diagram 450
Figure 177. RS485 Interface and Waveform 451
Figure 178. USART Synchronous Transmission Example 452
Figure 179. 8-bit Format USART Synchronous Waveform 453
Figure 180. UART Block Diagram 469
Figure 181. UART Serial Data Format 470
Figure 182. UART Clock CK_UART and Data Frame Timing 471
Figure 183. Divider Functional Diagram 480
Figure 184. CRC Block Diagram 484
Figure 185. CRC Data Bit and Byte Reversal Example 485

1 Introduction

Overview

This user manual provides detailed information including how to use the devices, system and bus architecture, memory organization and peripheral instructions. The target audiences for this document are software developers, application developers and hardware developers. For more information regarding pin assignment, package and electrical characteristics, please refer to the datasheet.

The devices are high performance and low power consumption 32-bit microcontrollers based around an Arm® Cortex®-M0+ processor core. The Cortex®-M0+ is a next-generation processor core which is tightly coupled with Nested Vectored Interrupt Controller (NVIC), SysTick timer and advanced debug support.

The devices operate at a frequency of up to 20 MHz for HT32F50231/50241 to obtain maximum efficiency. It provides up to 64 KB of embedded Flash memory for code / data storage and 8 KB of embedded SRAM memory for system operation and application program usage. A variety of peripherals, such as Hardware Divider DIV, ADC, I^2C, USART, UART, SPI, BFTM, MCTM, GPTM, PWM, CRC-16/32, RTC, WDT and SW-DP (Serial Wire Debug Port), etc., are also implemented in the device series. Several power saving modes provide the flexibility for maximum optimization between wakeup latency and power consumption, which is an especially important consideration in low power applications.

The above features ensure that the devices are suitable for use in a wide range of applications, especially in areas such as white goods application control, power monitors, alarm systems, consumer products, handheld equipment, data logging applications, motor control and so on.

Features

- Core
  - 32-bit Arm® Cortex®-M0+ processor core
  - Up to 20 MHz operating frequency
  - Single-cycle multiplication
  - Integrated Nested Vectored Interrupt Controller (NVIC)
  - 24-bit SysTick timer
- On-chip Memory
  - Up to 64 KB on-chip Flash memory for instruction / data and option byte storage
  - 8 KB on-chip SRAM
  - Supports multiple booting modes
- Flash Memory Controller – FMC
  - 32-bit word programming with In System Programming Interface (ISP) and In Application Programming (IAP)
  - Flash protection capability to prevent illegal access
- Reset Control Unit – RSTCU
  - Supply supervisor: Power On Reset / Power Down Reset (POR / PDR), Brown-out Detector (BOD) and Programmable Low Voltage Detector (LVD)
- Clock Control Unit – CKCU
  - External 4 to 20 MHz crystal oscillator
  - Internal 20 MHz RC oscillator trimmed to ±2 % accuracy at 25 °C operating temperature
  - Internal 32 kHz RC oscillator
  - Independent clock divider and gating bits for peripheral clock sources
- Power Management – PWRCU
  - Flexible power supply:
    – V_{DD} power supply: 2.5 V to 5.5 V
    – V_{DDIO} power supply for I/O pins: 1.8 V to 5.5 V
  - Integrated 1.5 V LDO regulator for CPU core, peripheral and memory power supply
  - Three power domains: V_{DD}, V_{DDIO} and 1.5 V
  - Three power saving modes: Sleep, Deep-Sleep1, Deep-Sleep2
- External Interrupt / Event Controller – EXTI
  - Up to 16 EXTI lines with configurable trigger source and type
  - All GPIO pins can be selected as EXTI trigger source
  - Source trigger type includes high level, low level, negative edge, positive edge or both edge
  - Individual interrupt enable, wakeup enable and status bits for each EXTI line
  - Software interrupt trigger mode for each EXTI line
  - Integrated deglitch filter for short pulse blocking
- Analog to Digital Converter – ADC
  - 12-bit SAR ADC engine
  - Up to 1 Msps conversion rate
  - Up to 12 external analog input channels
- I/O ports – GPIO
  - Up to 40 GPIOs
  - Port A, B, C are mapped as 16 external interrupts – EXTI
  - Almost I/O pins are configurable output driving current

- Motor Control Timer – MCTM
  - 16-bit up / down auto-reload counter
  - 16-bit programmable prescaler allowing counter clock frequency division by any factor between 1 and 65536
  - Input Capture function
  - Compare Match Output
  - PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
  - Single Pulse Mode Output
  - Complementary Outputs with programmable dead-time insertion
  - Break input to force the timer's output signals into a reset or fixed condition
- General-Purpose Timer – GPTM
  - 16-bit up / down auto-reload counter
  - Up to 4 independent channels
  - 16-bit programmable prescaler allowing the counter clock frequency division by any factor between 1 and 65536
  - Input Capture function
  - Compare Match Output
  - PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
  - Single Pulse Mode Output
  - Encoder interface controller with two inputs using quadrature decoder
- Pulse-Width-Modulation Timer – PWM
  - 16-bit up / down auto-reload counter
  - Up to 4 independent channels
  - 16-bit programmable prescaler allowing counter clock frequency division by any factor between 1 and 65536
  - Compare Match Output
  - PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
  - Single Pulse Mode Output
- Basic Function Timer – BFTM
  - 32-bit compare / match count-up counter – No I/O control features
  - One shot mode – Counting stops after a match condition
  - Repetitive mode – Restart counter after a match condition
- Watchdog Timer – WDT
  - 12-bit down-counter with a 3-bit pre-scaler
  - Reset event for the system
  - Programmable watchdog timer window function
  - Register write protection function
- Real Time Clock – RTC
  - 24-bit up-counter with a programmable prescaler
  - Alarm function
  - Interrupt and Wake-up event
- Inter-integrated Circuit – I^2C
  - Supports both master and slave modes with a frequency of up to 1 MHz
  - Provides an arbitration function and clock synchronization
  - Supports 7-bit and 10-bit addressing modes and general call addressing
  - Supports slave multi-addressing mode with maskable address

- Serial Peripheral Interface – SPI
  - Supports both master and slave modes
  - Frequency of up to (f_{PCLK}/2) MHz for master mode and (f_{PCLK}/3) MHz for slave mode
  - FIFO Depth: 8 levels
  - Multi-master and multi-slave operation
- Universal Synchronous Asynchronous Receiver Transmitter – USART
  - Supports both asynchronous and clocked synchronous serial communication modes
  - Asynchronous operating baud-rate clock frequency up to (f_{PCLK}/16) MHz and synchronous operating baud-rate clock frequency up to (f_{PCLK}/8) MHz
  - Full duplex communication
  - Fully programmable characteristics of serial communication including: word length, parity bit, stop bit and bit order
  - Error detection: Parity, overrun and frame error
  - Auto hardware flow control mode – RTS, CTS
  - IrDA SIR encoder and decoder
  - RS485 mode with output enable control
  - FIFO Depth: 8-level for both receiver and transmitter
- Universal Asynchronous Receiver Transmitter – UART
  - Asynchronous serial communication operating baud rate clock frequency of up to (f_{PCLK}/16) MHz
  - Capability of full duplex communication
  - Fully programmable characteristics of serial communication including: word length, parity bit, stop bit and bit order
  - Error detection: Parity, overrun and frame error
- Hardware Divider – DIV
  - Signed / unsigned 32-bit divider
  - Operation in 8 clock cycles, load in 1 clock cycle
  - Division by zero error flag
- Cyclic Redundancy Check – CRC
  - Support CRC16 polynomial: 0x8005, $X^{16} + X^{15} + X^2 + 1$
  - Support CCITT CRC16 polynomial: 0x1021, $X^{16} + X^{12} + X^5 + 1$
  - Support IEEE-802.3 CRC32 polynomial: 0x04C11DB7, $X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$
  - Supports 1's complement, byte reverse & bit reverse operation on data and checksum
  - Supports byte, half-word & word data size
  - Programmable CRC initial seed value
  - CRC computation executed in 1 AHB clock cycle for 8-bit data and 4 AHB clock cycles for 32-bit data
- Debug Support
  - Serial Wire Debug Port – SW-DP
  - 4 comparators for hardware breakpoint or code / literal patch
  - 2 comparators for hardware watchpoints
- Package and Operation Temperature
  - 24/28-pin SSOP, 28-pin SOP, 24/33-pin QFN and 44/48-pin LQFP package types
  - Operation temperature range: -40 °C to 85 °C

Device Information

Table 1. Features and Peripheral List

Peripherals		HT32F50231	HT32F50241
Main Flash (KB)		32	63
Option Bytes Flash (KB)		1	1
SRAM (KB)		4	8
Timers	MCTM	1	
	GPTM	1	
	PWM	2	
	BFTM	2	
	WDT	1	
	RTC	1	
Communication	SPI	2	
	USART	1	
	UART	2	
	I^2C	2	
Hardware Divider		1	
CRC-16/32		1	
EXTI		16	
12-bit ADC		1	
Number of Channels		12 Channels	
GPIO		Up to 40	
CPU Frequency		Up to 20 MHz	
Operating Voltage		2.5 V ~ 5.5 V	
Operating Temperature		-40 °C ~ 85 °C	
Package		24/28-pin SSOP, 28-pin SOP, 24/33-pin QFN and 44/48-pin LQFP	

Block Diagram

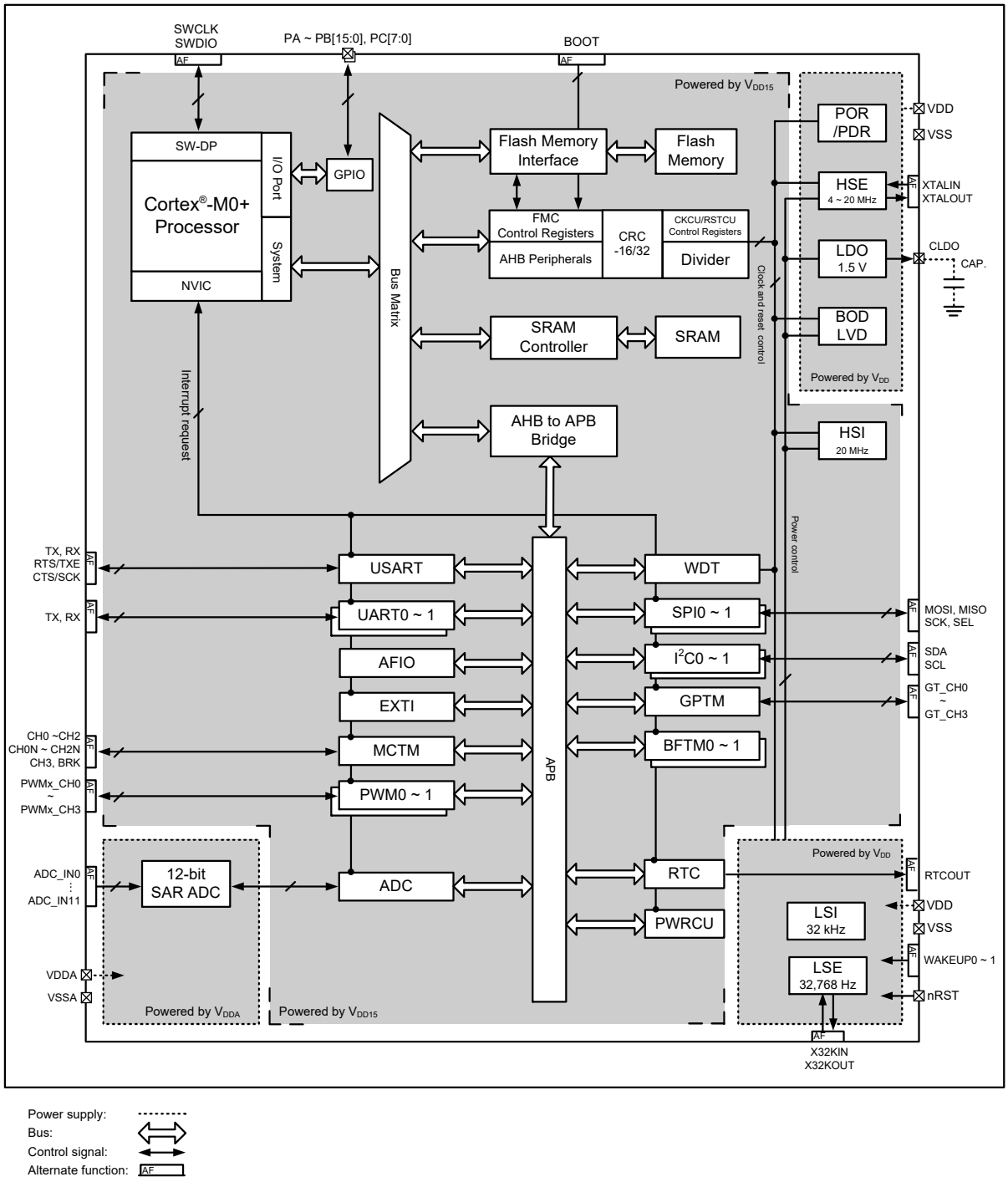


Figure 1. Block Diagram

2 Document Conventions

Unless otherwise specified, this document uses the conventions which showed as follows.

Table 2. Document Conventions

Notation	Example	Description
0x	0x5a05	The number string with a 0x prefix indicates a hexadecimal number.
0xnnnn_nnnn	0x2000_0100	32-bit Hexadecimal address or data.
b	b0101	The number string with a lowercase b prefix indicates a binary number.
NAME [n]	ADDR [5]	Specific bit of NAME. NAME can be a register or field of register. For example, ADDR [5] means bit 5 of ADDR register (field).
NAME [m:n]	ADDR [11:5]	Specific bits of NAME. NAME can be a register or field of register. For example, ADDR [11:5] means bit 11 to 5 of ADDR register (field).
X	b10X1	Don't care notation which means any value is allowed.
RW	19 18 SERDYIE | PLLRDYIE RW 0 RW 0	Software can read and write to this bit.
RO	3 2 HSIRDY | HSERDY RO 1 RO 0	Software can only read this bit. A write operation will have no effect.
RC	1 0 PDF | BAK_PORF RC 0 RC 1	Software can only read this bit. Read operation will clear it to 0 automatically.
WC	3 2 SERDYF | PLLRDYF WC 0 WC 0	Software can read this bit or clear it by writing 1. Writing a 0 will have no effect.
W0C	1 0 Reserved | MIF W0C 0	Software can read this bit or clear it by writing 0. Writing a 1 will have no effect.
WO	31 30 DB_CKSRC WO 0 WO 0	Software can only write to this bit. A read operation always returns 0.
Reserved	1 0 LLRDY | Reserved RO 0	Reserved bit(s) for future use. Data read from these bits is not well defined and should be treated as random data. Normally these reserved bits should be set to a 0 value. Note that reserved bit must be kept at reset value.
Word		Data length of a word is 32-bit.
Half-word		Data length of a half-word is 16-bit.
Byte		Data length of a byte is 8-bit.

3 System Architecture

The system architecture of devices that includes the Arm® Cortex®-M0+ processor, bus architecture and memory organization will be described in the following sections. The Cortex®-M0+ is a next generation processor core which offers many new features. Integrated and advanced features make the Cortex®-M0+ processor suitable for market products that require microcontrollers with high performance and low power consumption. In brief, The Cortex®-M0+ processor includes AHB-Lite bus interface. All memory accesses of the Cortex®-M0+ processor are executed on the AHB-Lite bus according to the different purposes and the target memory spaces. The memory organization uses a Harvard architecture, pre-defined memory map and up to 4 GB of memory space, making the system flexible and extendable.

Arm® Cortex®-M0+ Processor

The Cortex®-M0+ processor is a very low gate count, highly energy efficient processor that is intended for microcontroller and deeply embedded applications that require an area optimized, low-power processor. The processor is based on the ARMv6-M architecture and supports Thumb® instruction sets; single-cycle I/O port; hardware multiplier and low latency interrupt respond time. Some system peripherals listed below are also provided by Cortex®-M0+:

- Internal Bus Matrix connected with AHB-Lite Interface, Single-cycle I/O port and Debug Access Port (DAP)
- Nested Vectored Interrupt Controller (NVIC)
- Optional Wakeup Interrupt Controller (WIC)
- Breakpoint and Watchpoint Unit
- Optional Memory Protection Unit (MPU)
- Serial Wire debug Port (SW-DP)
- Optional Micro Trace Buffer Interface (MTB)

The following figure shows the Cortex®-M0+ processor block diagram. For more information, refer to the Arm® Cortex®-M0+ Technical Reference Manual.

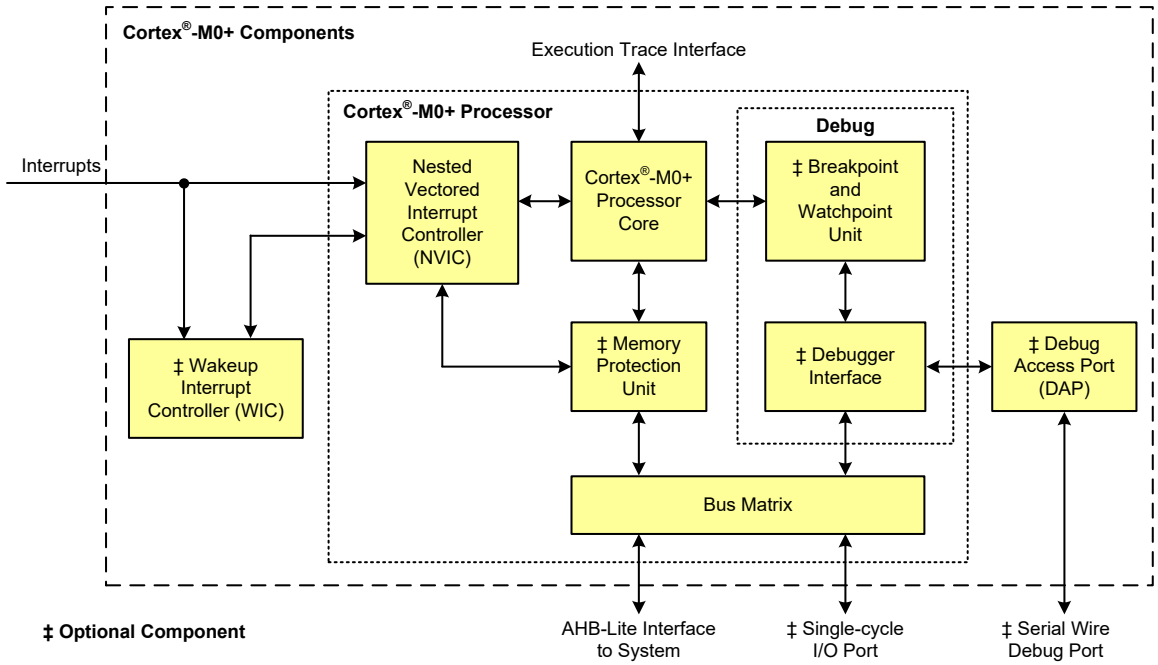


Figure 2. Cortex®-M0+ Block Diagram

Bus Architecture

The HT32F50231/50241 series devices consist of one master and four slaves in the bus architecture. The Cortex®-M0+ AHB-Lite bus is the master while the internal SRAM access bus, the internal Flash memory access bus, the AHB peripherals access bus and the AHB to APB bridges are the slaves. The single 32-bit AHB-Lite system interface provides simple integration to all system regions include the internal SRAM region and the peripheral region. All of the master buses are based on 32-bit Advanced High-performance Bus-Lite (AHB-Lite) protocol. The following figure shows the bus architecture of the HT32F50231/50241 series.

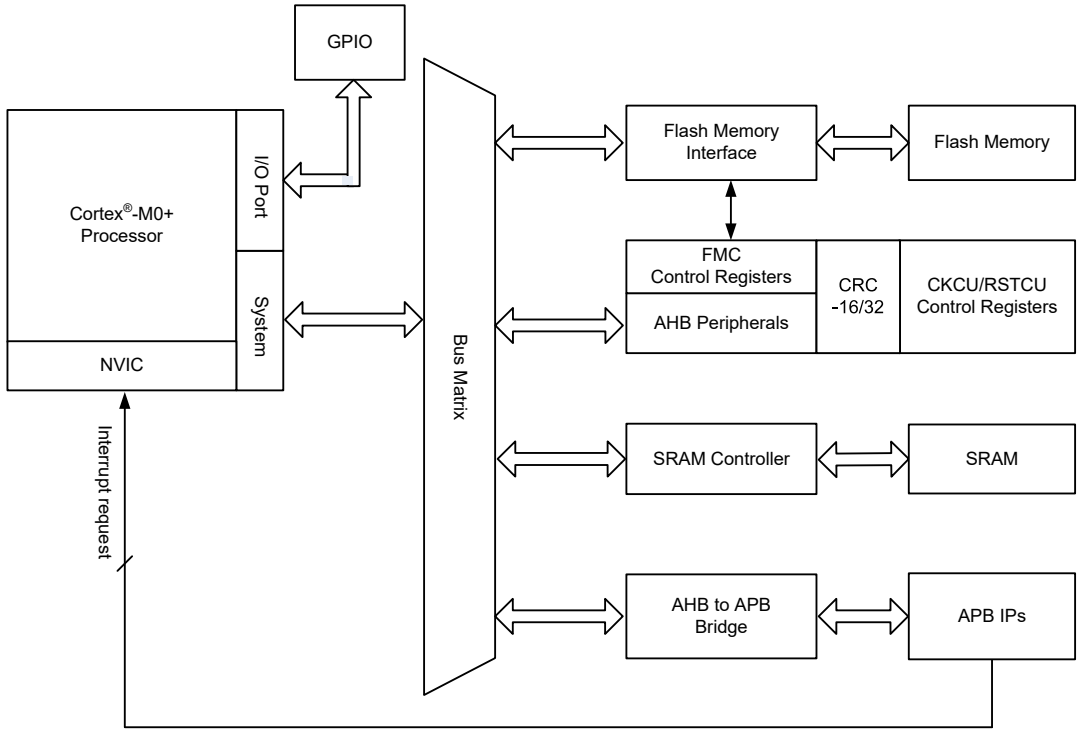


Figure 3. Bus Architecture

Memory Organization

The Arm® Cortex®-M0+ processor access and debug access share the single external interface to external AHB peripheral. The processor access takes priority over debug access. The maximum address range of the Cortex®-M0+ is 4 GB since it has 32-bit bus address width. Additionally, a pre-defined memory map is provided by the Cortex®-M0+ processor to reduce the software complexity of repeated implementation of different device vendors. However, some regions are used by the Arm® Cortex®-M0+ system peripherals. Refer to the Arm® Cortex®-M0+ Technical Reference Manual for more information. The following figure shows the memory map of HT32F50231/50241 series of devices, including Code, SRAM, peripheral and other pre-defined regions.

Memory Map

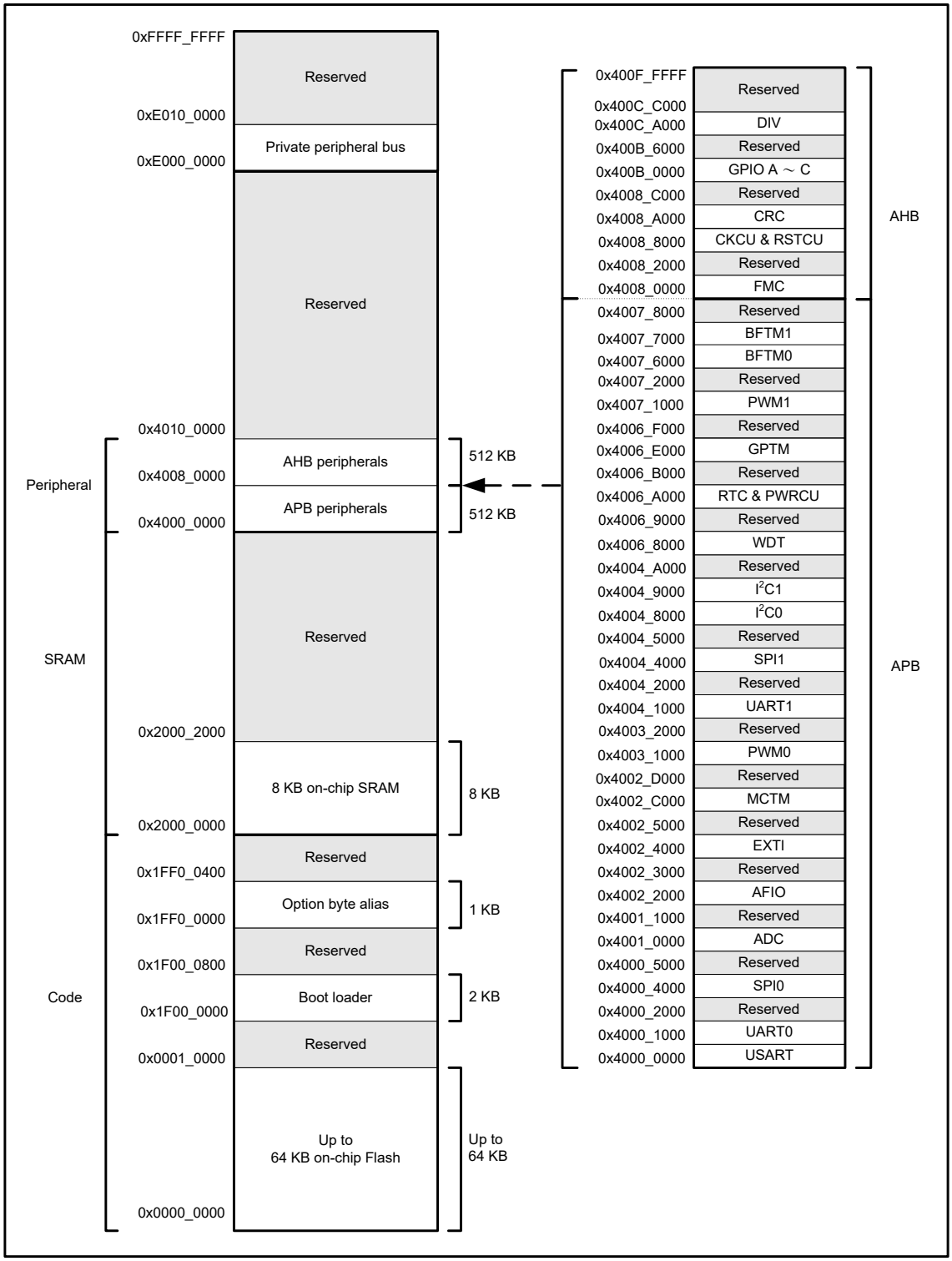


Figure 4. Memory Map

Table 3. Register Map

Start Address	End Address	Peripheral	Bus
0x4000_0000	0x4000_0FFF	USART	
0x4000_1000	0x4000_1FFF	UART0	
0x4000_2000	0x4000_3FFF	Reserved	
0x4000_4000	0x4000_4FFF	SPI0	
0x4000_5000	0x4000_FFFF	Reserved	
0x4001_0000	0x4001_0FFF	ADC	
0x4001_1000	0x4002_1FFF	Reserved	
0x4002_2000	0x4002_2FFF	AFIO	
0x4002_3000	0x4002_3FFF	Reserved	
0x4002_4000	0x4002_4FFF	EXTI	
0x4002_5000	0x4002_BFFF	Reserved	
0x4002_C000	0x4002_CFFF	MCTM	
0x4002_D000	0x4003_0FFF	Reserved	
0x4003_1000	0x4003_1FFF	PWM0	
0x4003_2000	0x4004_0FFF	Reserved	
0x4004_1000	0x4004_1FFF	UART1	
0x4004_2000	0x4004_3FFF	Reserved	APB
0x4004_4000	0x4004_4FFF	SPI1	
0x4004_5000	0x4004_7FFF	Reserved	
0x4004_8000	0x4004_8FFF	I^2C0	
0x4004_9000	0x4004_9FFF	I^2C1	
0x4004_A000	0x4006_7FFF	Reserved	
0x4006_8000	0x4006_8FFF	WDT	
0x4006_9000	0x4006_9FFF	Reserved	
0x4006_A000	0x4006_AFFF	RTC & PWRCU	
0x4006_B000	0x4006_DFFF	Reserved	
0x4006_E000	0x4006_EFFF	GPTM	
0x4006_F000	0x4007_0FFF	Reserved	
0x4007_1000	0x4007_1FFF	PWM1	
0x4007_2000	0x4007_5FFF	Reserved	
0x4007_6000	0x4007_6FFF	BFTM0	
0x4007_7000	0x4007_7FFF	BFTM1	
0x4007_8000	0x4007_FFFF	Reserved	
0x4008_0000	0x4008_1FFF	FMC	
0x4008_2000	0x4008_7FFF	Reserved	
0x4008_8000	0x4008_9FFF	CKCU & RSTCU	
0x4008_A000	0x4008_BFFF	CRC	
0x4008_C000	0x400A_FFFF	Reserved	
0x400B_0000	0x400B_1FFF	GPIOA	AHB
0x400B_2000	0x400B_3FFF	GPIOB	
0x400B_4000	0x400B_5FFF	GPIOC	
0x400B_6000	0x400C_9FFF	Reserved	
0x400C_A000	0x400C_BFFF	DIV	
0x400C_C000	0x400F_FFFF	Reserved	

Embedded Flash Memory

The HT32F50231/50241 series provide up to 64 KB on-chip Flash memory which is located at address 0x0000_0000. It supports byte, half-word and word access operations. Note that the Flash memory only supports read operations for the bus access. Any write operations to the Flash memory will cause a bus fault exception. The Flash memory has up to capacity of 64 pages. Each page has a memory capacity of 1 KB and can be erased independently. A 32-bit programming interface provides the capability of changing bits from 1 to 0. A data storage or firmware upgrade can be implemented using several methods such as In System Programming (ISP), In Application Programming (IAP) or In Circuit Programming (ICP). For more information, refer to the Flash Memory Controller section.

Embedded SRAM Memory

The HT32F50231/50241 series contain up to 8 KB on-chip SRAM which is located at address 0x2000_0000. It support byte, half-word and word access operations.

AHB Peripherals

The address of the AHB peripherals ranges from 0x4008_0000 to 0x400F_FFFF. Some peripherals such as Clock Control Unit, Reset Control Unit and Flash Memory Controller are connected to the AHB bus directly. The AHB peripherals clocks are always enabled after a system reset. Access to registers for these peripherals can be achieved directly via the AHB bus. Note that all peripheral registers in the AHB bus support only word access.

APB Peripherals

The address of APB peripherals ranges from 0x4000_0000 to 0x4007_FFFF. An APB to AHB Bridge provides access capability between the CPU and the APB peripherals. Additionally, the APB peripheral clocks are disabled after a system reset. Software must enable the peripheral clock by setting up the APBCCRn register in the Clock Control Unit before accessing the corresponding peripheral register. Note that the APB to AHB Bridge will duplicate the half-word or byte data to word width when a half-word or byte access is performed on the APB peripheral registers. In other words, the access result of a half-word or byte access on the APB peripheral register will vary depending on the data bit width of the access operation on the peripheral registers.

4 Flash Memory Controller (FMC)

Introduction

The Flash Memory Controller, FMC, provides functions of flash operation and pre-fetch buffer for the embedded on-chip Flash memory. Figure below shows the block diagram of FMC which includes programming interface, control register, pre-fetch buffer and access interface. Since the access speed of Flash memory is slower than the CPU, a wide access interface with pre-fetch buffer is provided to the Flash memory in order to reduce the CPU wait state, which will cause instruction gaps. The functions of word programming / page erase are also provided for instruction / data storage of Flash memory.

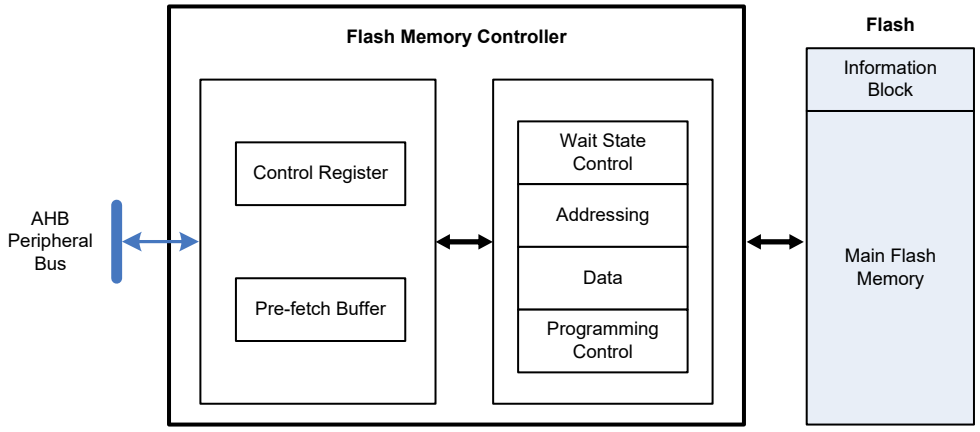


Figure 5. Flash Memory Controller Block Diagram

Features

- Up to 64 KB of on-chip Flash memory for storing instruction / data and option bytes
  - 64 KB (instruction / data + Option Byte)
  - 32 KB (instruction / data + Option Byte)
- Page size of 1 KB, totally up to 64 pages depending on the main Flash size
- Wide access interface with pre-fetch buffer to reduce instruction gaps
- Page erase and mass erase capability
- 32-bit word programming
- Interrupt capability when ready or error occurs
- Flash read protection to prevent illegal code / data access
- Page erase / program protection to prevent unexpected operation

Functional Descriptions

Flash Memory Map

The following figure is the Flash memory map of the system. The address ranges from 0x0000_0000 to 0x1FFF_FFFF (0.5 GB). The address from 0x1F00_0000 to 0x1F00_07FF is mapped to Boot Loader Block (2 KB). Besides, address 0x1FF0_0000 to 0x1FF0_03FF is the alias of Option Byte block (1 KB) which locates at the last page of main Flash physically. The memory mapping on system view is shown as below.

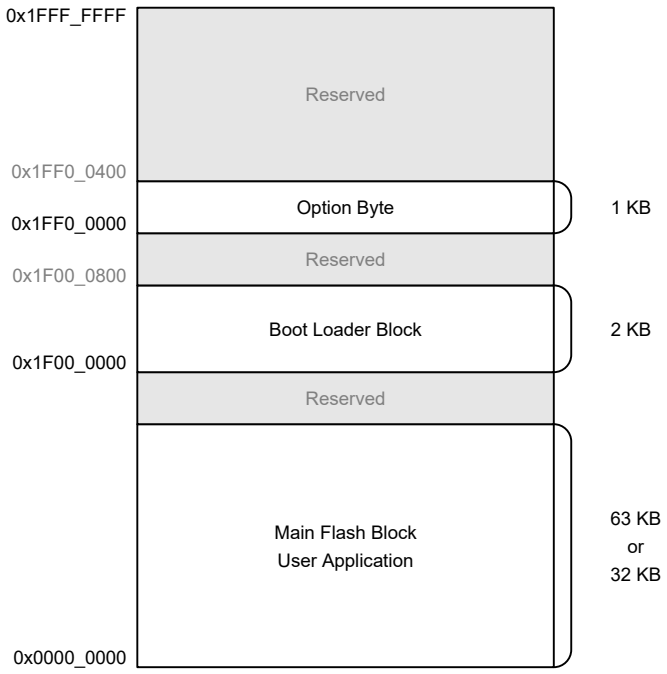


Figure 6. Flash Memory Map

Flash Memory Architecture

The Flash memory consists of up to 64 KB main Flash with 1 KB per page and 2 KB Information Block for Boot Loader. The main Flash memory contains totally 64 pages (or 32 pages for 32 KB device) which can be erased individually. The following table shows the base address, size and protection setting bit of each page.

Table 4. Flash Memory and Option Byte

Block	Name	Address	Page Protection Bit	Size
Main Flash Block	Page 0	0x0000_0000 ~ 0x0000_03FF	OB_PP [0]	1 KB
	Page 1	0x0000_0400 ~ 0x0000_07FF	OB_PP [1]	1 KB
	Page 2	0x0000_0800 ~ 0x0000_0BFF	OB_PP [2]	1 KB
	Page 3	0x0000_0C00 ~ 0x0000_0FFF	OB_PP [3]	1 KB
	⋮	⋮	⋮	⋮
	Page 60	0x0000_F000 ~ 0x0000_F3FF	OB_PP [60]	1 KB
	Page 61	0x0000_F400 ~ 0x0000_F7FF	OB_PP [61]	1 KB
	Page 62	0x0000_F800 ~ 0x0000_FBFF	OB_PP [62]	1 KB
	Page 63 (Option Byte)	Physical: 0x0000_FC00 ~ 0x0000_FFFF Alias: 0x1FF0_0000 ~ 0x1FF0_03FF	OB_CP [1]	1 KB
Information Block	Boot Loader	0x1F00_0000 ~ 0x1F00_07FF	NA	2 KB

Notes: 1. Information Block stores boot loader – This block can not be programmed or erased by user.
2. Option Byte is always located at last page of main Flash block.

Booting Configuration

The system provides two kinds of booting mode which can be selected through the BOOT pin. The value of BOOT pin is sampled during the power-on reset or system reset. Once the logic value is decided, the first 4 words of vector will be remapped to the corresponding source according to the booting mode. The booting mode is shown in the following table.

Table 5. Booting Modes

Booting Mode Selection Pin	Mode	Descriptions
BOOT		
0	Boot Loader	The source of Vector is Boot Loader
1	Main Flash	The source of Vector is main Flash

The Flash Vector Mapping Control Register, VMCR, is provided to change the setting of the vector remapping temporarily after the chip reset. The reset value of VMCR is determined by the BOOT pin status which will be sampled during the reset duration.

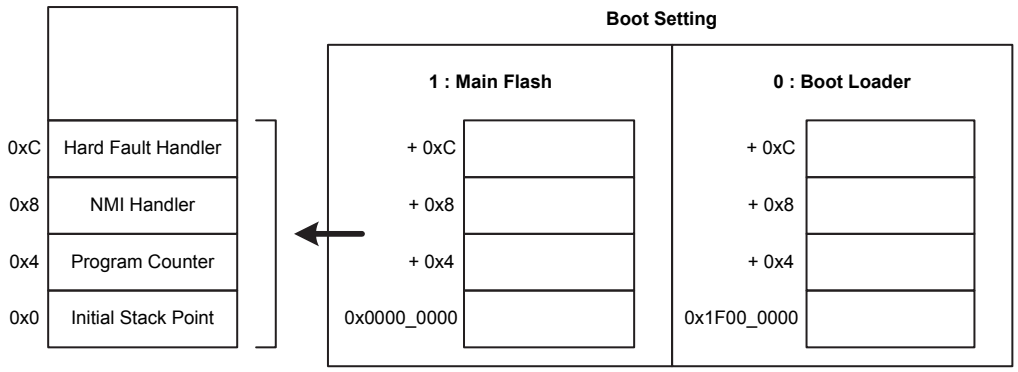


Figure 7. Vector Remapping

Page Erase

The FMC provides a page erase function which is used to reset partial content of Flash memory. Any page can be erased independently without affecting others. The following steps show the access sequence of the register for page erase.

- Check the OPCR register to confirm that no Flash memory operation is in progress (OPM [3:0] equals to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write the page address to TADR register.
- Write the page erase command to OCMR register (Set CMD [3:0] = 0x8).
- Commit page erase command to FMC by setting OPCR register (Set OPM [3:0] = 0xA).
- Wait until all the operations have been completed by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the page if required.

Note that a correct target page address must be confirmed. The software may run out of control if the target erase page is being used to fetch code or access data. The FMC will not provide any notification when this happens. Additionally, the page erase operation will be ignored on the protected pages. When this occurs, the OREF bit will be set by the FMC and then a Flash Operation Error interrupt will be generated if the OREIEN bit in the OIER register is set. The software can check the PPEF bit in the OISR register to detect this condition in the interrupt handler. The following figure shows the page erase operation flow.

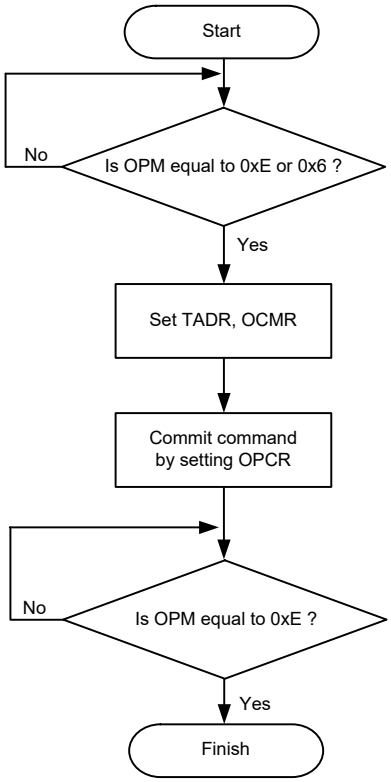


Figure 8. Page Erase Operation Flowchart

Mass Erase

The FMC provides a mass erase function which is used for resetting all the main Flash memory content. The following steps show the register access sequence for mass erase operation.

- Check OPCR register to confirm that no Flash memory operation is in progress (OPM [3:0] equals to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write mass erase command to OCMR register (Set CMD [3:0] = 0xA).
- Commit mass erase command to FMC by setting OPCR register (Set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Flash memory if required.

Since all Flash data will be reset as 0xFFFF_FFFF, the mass erase operation can be implemented by the program that runs in the SRAM or by the debugging tool that accesses FMC registers directly. The following figure displays the mass erase operation flow.

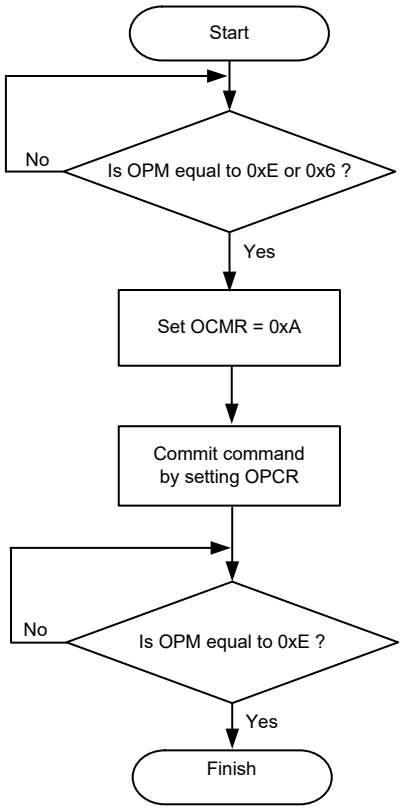


Figure 9. Mass Erase Operation Flowchart

Word Programming

The FMC provides a 32 bits word programming function which is used for modifying the Flash memory content. The following steps show the sequence of register access for word programming.

- Check OPCR register to confirm that no Flash memory operation is in progress (OPM [3:0] equals to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write word address to TADR register. Write data to WRDR register.
- Write word programming command to OCMR register (Set CMD [3:0] = 0x4).
- Commit word programming command to FMC by setting OPCR register (Set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Flash memory if required.

Note that the word programming operation can not be successively applied to the same address twice. Successive word programming operation to the same address must be separated by a page erase operation. Besides, the word program will be ignored on protected pages. When this occurs, the OREF bit will be set by the FMC and then a Flash Operation Error interrupt will be generated if the OREIEN bit in the OIER register is set. Software can check the PPEF bit in the OISR register to detect this condition in the interrupt handler. The following figure displays the word programming operation flow.

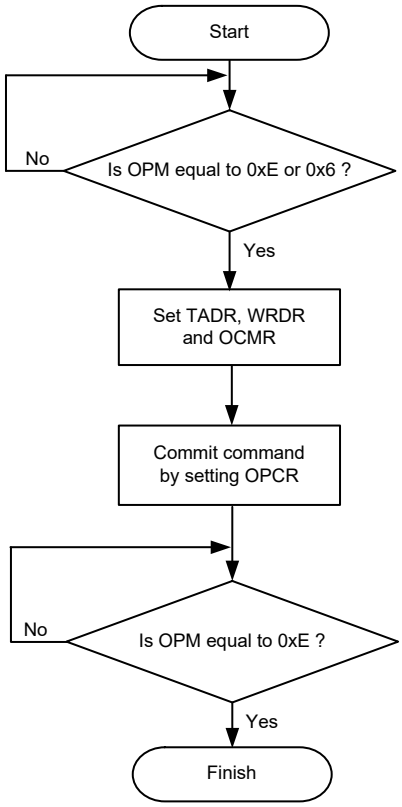


Figure 10. Word Programming Operation Flowchart

Option Byte Description

The Option Byte can be treated as an independent Flash memory of which base address is 0x1FF0_0000. The following table shows the function description and Option Byte memory map.

Table 6. Option Byte Memory Map

Option Byte	Offset	Description	Reset Value
Option Byte Base Address = 0x1FF0_0000			
OB_PP	0x000 0x004 0x008 0x00C	Flash Page Erase / Program Protection (n = 0 ~ 127) OB_PP [n] (n = 0 ~ 62) 0: Flash Page n Erase / Program Protection is enabled 1: Flash Page n Erase / Program Protection is disabled OB_PP [n] (n = 63 ~ 127) Reserved	0xFFFF_FFFF 0xFFFF_FFFF 0xFFFF_FFFF 0xFFFF_FFFF
OB_CP	0x010	Flash Security Protection OB_CP [0] 0: Flash Security protection is enabled 1: Flash Security protection is disabled Option Byte Protection OB_CP [1] 0: Option Byte protection is enabled 1: Option Byte protection is disabled OB_CP [31:2] Reserved	0xFFFF_FFFF
OB_CK	0x020	Flash Option Byte Checksum OB_CK [31:0] OB_CK should be set as the content value sum of 5 registers which offset address is from 0x000 to 0x010 in Option Byte (0x000 + 0x004 + 0x008 + 0x00C + 0x010) when the OB_PP or OB_CP register's content is not equal to 0xFFFF_FFFF. Otherwise, both page erase / program protection and security protection will be enabled.	0xFFFF_FFFF
OB_TOOL	0x030 ~ 0x04C	Reserved for Flash writer tool and boot loader.	0xFFFF_FFFF
OB_WDT	0x3F0	Flash Option Watchdog Timer Enable OB_WDT [15:0]: 0x7A92 If the OB_WDT [15:0] is set to 0x7A92, the WDT will be enabled immediately when the MCU power on reset or system reset occurs. The WDT can be disabled by software. OB_WDT [31:16]: Reserved	0xFFFF_FFFF

Page Erase / Program Protection

FMC provides functions of page erase / program protection to prevent unexpected operation of Flash memory. The page erase (CMD [3:0] = 0x8 in the OCMR register) or word programming (CMD [3:0] = 0x4) command will not be accepted by FMC on the protected pages. When the page erase or word programming command aimed at the protected pages is sent to the FMC, the PPEF bit in the OISR register will then be set by the FMC and the Flash operation error interrupt will be triggered to inform the CPU if the OREIEN bit in the OIER register is set. The page protection function can be enabled for each page independently by setting the OB_PP registers of the Option Byte. The following table shows the access permission of the main Flash page when the page protection is enabled.

Table 7. Access Permission of Protected Main Flash Page

Mode / Operation	ISP / IAP	ICP / Debug Mode
Read	O	O
Program	X	X
Page Erase	X	X
Mass Erase	O	O

Notes: 1. Note that the setting of write protection is based on page. The above access permission only affects the pages that enable protection function. Other pages are not affected.
2. Main Flash page protection is configured by OB_PP [127:0]. Option Byte is physically located at the last page of main Flash Option Byte page protection is configured by the OB_CP [1] bit.
3. The page erase on Option Byte area can disable the page protection of main Flash.
4. The page protection of Option Byte can only be disabled by a mass erase operation.

The following steps show the register access sequence for page erase / program protection procedure.

- Check OPCR register to confirm that no Flash memory operation is in progress (OPM [3:0] equals to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write OB_PP address to TADR register (TADR = 0x1FF0_0000).
- Write the data, which indicates the protection function of corresponding page is enabled or disabled, to the WRDR register (0: Enabled, 1: Disabled).
- Write word programming command to the OCMR register (Set CMD [3:0] = 0x4).
- Commit word programming command to FMC by setting the OPCR register (Set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of the OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Option Byte if required.
- The OB_CK field in the Option Byte must be updated according to the Option Byte checksum rule.
- Apply a system reset to active the new OB_PP setting.

Security Protection

FMC provides a Security protection function to prevent illegal code / data access of the Flash memory. This function is useful for protecting the software / firmware from illegal users. The function is activated by setting the Option Byte OB_CP [0] bit. Once the function has been enabled, all the main Flash data access through ICP / Debug mode, programming and page erase will not be allowed except the user's application. But the mass erase operation will still be accepted by FMC in order to disable this function. The following table shows the access permission of Flash memory when the security protection is enabled.

Table 8. Access Permission When Security Protection is Enabled

Mode / Operation	User Application(Note 1)	ICP / Debug Mode
Read	O	X (read as 0)
Program	O (Note 1)	X
Page Erase	O (Note 1)	X
Mass Erase	O	O

Notes: 1. User application means the software that is executed or booted from main Flash memory with the JTAG / SW debugger being disconnected. However, the Option Byte area and page 0 are still under protection where the Program / Page Erase operations are not accepted.
2. The Mass erase operation can erase the Option Byte area and disable the security protection.

The following steps show the register access sequence for Security protection procedure.

- Check the OPCR register to confirm that no Flash memory operation is in progress (OPM [3:0] equals to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write OB_CP address to the TADR register (TADR = 0x1FF0_0010).
- Write the WRDR register to set the OB_CP [0] as 0.
- Write word programming command to the OCMR register (Set CMD [3:0] = 0x4).
- Commit word programming command to FMC by setting the OPCR register (Set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of the OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Option Byte if required.
- The OB_CK field in the Option Byte must be updated according to the Option Byte checksum rule.
- Apply a system reset to active the new OB_CP setting.

Register Map

The following table shows the FMC registers and reset values.

Table 9. FMC Register Map

Register	Offset	Description	Reset Value
TADR	0x000	Flash Target Address Register	0x0000_0000
WRDR	0x004	Flash Write Data Register	0x0000_0000
OCMR	0x00C	Flash Operation Command Register	0x0000_0000
OPCR	0x010	Flash Operation Control Register	0x0000_000C
OIER	0x014	Flash Operation Interrupt Enable Register	0x0000_0000
OISR	0x018	Flash Operation Interrupt and Status Register	0x0001_0000
PPSR	0x020 0x024 0x028 0x02C	Flash Page Erase / Program Protection Status Register	0xXXXX_XXXX 0xXXXX_XXXX 0xXXXX_XXXX 0xXXXX_XXXX
CPSR	0x030	Flash Security Protection Status Register	0x0000_000X
VMCR	0x100	Flash Vector Mapping Control Register	0x0000_000X
MDID	0x180	Flash Manufacturer and Device ID Register	0x0376_XXXX
PNSR	0x184	Flash Page Number Status Register	0x0000_00XX
PSSR	0x188	Flash Page Size Status Register	0x0000_0400
DIDR	0x18C	Device ID Register	0x000X_XXXX
CIDR0	0x310	Custom ID Register 0	0xXXXX_XXXX
CIDR1	0x314	Custom ID Register 1	0xXXXX_XXXX
CIDR2	0x318	Custom ID Register 2	0xXXXX_XXXX
CIDR3	0x31C	Custom ID Register 3	0xXXXX_XXXX

Note: “X” means various reset values which depend on the Device, Flash value, option byte value or power on reset setting.

Register Descriptions

Flash Target Address Register – TADR

This register specifies the target address of the page erase and word programming operation.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	TADB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	TADB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	TADB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	TADB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	TADB	Flash Target Address Bits For programming operations, the TADR register specifies the address where the data is written. Since the programming length is 32 bits, the TADR shall be set as word-aligned (4 bytes). The TADB [1:0] will be ignored during programming operations. For page erase operations, the TADR register contains the page address which is going to be erased. Since the page size is 1 KB, the TADB [9:0] will be ignored in order to limit the target address as 1 Kbyte-aligned. For 64 KB main Flash addressing, TADB [31:16] should be zero and TADB [31:15] should be zero for 32 KB. Address from 0x1FF0_0000 to 0x1FF0_03FF is the 1 KB Option Byte. This field for available Flash address, it must be under 0x1FFF_FFFF. Otherwise, the Invalid Target Address interrupt will be occurred if the corresponding interrupt enable bit is set.

Flash Write Data Register – WRDR

This register specifies the data to be written for programming operation.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	WRDB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	WRDB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	WRDB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	WRDB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	WRDB	Flash Write Data Bits The data value for programming operation.

Flash Operation Command Register – OCMR

This register is used to specify the Flash operation commands that include word programming, page erase and mass erase.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				CMD			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[3:0]	CMD	Flash Operation Command The following table shows definitions of CMD [3:0] bits which specify the Flash operation. If an invalid command is set and the IOCMIEN bit is set to 1, an Invalid Operation Command interrupt will occur.

CMD [3:0]	Description
0x0	Idle (default)
0x4	Word programming
0x8	Page erase
0xA	Mass erase
Others	Reserved

Flash Operation Control Register – OPCR

This register is used for controlling the command commitment and checking the status of the FMC operations.

Offset: 0x010

Reset value: 0x0000_000C

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved			OPM				Reserved
Type/Reset				RW 0	RW 1	RW 1	RW 0	

Bits	Field	Descriptions
[4:1]	OPM	Operation Mode The following table shows the operation modes of the FMC. Users can commit command which is set by the OCMR register to the FMC according to the address alias setting in the TADR register. The contents of TADR, WRDR and OCMR registers shall be prepared before setting this register. After all the operation has been finished, the OPM field will be set as 0xE or 0xF by the FMC hardware. The Idle mode can be set when all the operations have been finished for power saving. Note that the operation status should be checked before the next action is applied to the FMC. The contents of TADR, WRDR, OCMR and OPCR registers should not be changed until the previous operation has been finished.

OPM [3:0]	Description
0x6	Idle (default)
0xA	Commit command to main Flash
0xE	All operation finished on main Flash
Others	Reserved

Flash Operation Interrupt Enable Register – OIER

This register is used to enable or disable interrupt function of FMC. The FMC will generate interrupts when the corresponding interrupt enable bit is set and the interrupt condition occurs.

Offset: 0x014

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved			OREIEN	IOCMIEN	OBEIEN	ITADIEN	ORFIEN
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[4]	OREIEN	Operation Error Interrupt Enable 0: Operation error interrupt is disabled 1: Operation error interrupt is enabled
[3]	IOCMIEN	Invalid Operation Command Interrupt Enable 0: Invalid Operation Command interrupt is disabled 1: Invalid Operation Command interrupt is enabled
[2]	OBEIEN	Option Byte Check Sum Error Interrupt Enable 0: Option Byte Check Sum Error interrupt is disabled 1: Option Byte Check Sum Error interrupt is enabled
[1]	ITADIEN	Invalid Target Address Interrupt Enable 0: Invalid Target Address interrupt is disabled 1: Invalid Target Address interrupt is enabled
[0]	ORFIEN	Operation Finished Interrupt Enable 0: Operation Finish interrupt is disabled 1: Operation Finish interrupt is enabled

Flash Operation Interrupt and Status Register – OISR

This register indicates the status of the FMC interrupt to check if an operation has been finished or an error occurs. The status bits, bit [4:0], if set high, are available to trigger the interrupt when the corresponding enable bits in the OIER register are set high.

Offset: 0x018

Reset value: 0x0001_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved						PPEF	RORFF
Type/Reset							RO 0	RO 1
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved			OREF	IOCMF	OBEF	ITADF	ORFF
Type/Reset				WC 0	WC 0	WC 0	WC 0	WC 0

Bits	Field	Descriptions
[17]	PPEF	Page Erase / Program Protected Error Flag 0: Page Erase / Program Protected Error does not occur 1: Operation error due to an invalid erase / program operation being applied to a protected page This bit is reset by hardware once a new flash operation command is committed.
[16]	RORFF	Raw Operation Finished Flag 0: The last flash operation command is not finished 1: The last flash operation command is finished The RORFF bit is directly connected to the Flash memory for debugging purpose.
[4]	OREF	Operation Error Flag 0: No flash operation error occurred 1: The last flash operation is failed This bit will be set when any Flash operation error, such as invalid command, program error and erase error, etc., occurs. The ORE interrupt occurs if the OREIEN bit in the OIER register is set. Reset this bit by writing 1.
[3]	IOCMF	Invalid Operation Command Flag 0: No invalid flash operation command was set 1: An invalid flash operation command has been written into the OCMR register This bit will be set high when an invalid flash operation command has been written into the OCMR register. The IOCM interrupt will occur if the IOCMIEN bit in the OIER register is set. Reset this bit by writing 1.

Bits	Field	Descriptions
[2]	OBEF	Option Byte Check Sum Error Flag 0: Check sum of Option Byte is correct 1: Check sum of Option Byte is incorrect This bit will be set high when the Option Byte checksum is incorrect. The OBE interrupt will occur if the OBEIEN bit in the OIER register is set. This bit is cleared to 0 by software writing 1 into it. However, the Option Byte Checksum Error Flag can not be cleared by software until the interrupt condition is cleared, which means that the Option Byte check sum value has to be correctly modified or the corresponding interrupt control is disabled. Otherwise, the interrupt will be continually generated.
[1]	ITADF	Invalid Target Address Flag 0: The target address is valid 1: The target address is invalid The data in the TADR field must be in the range from 0x0000_0000 to 0x1FFF_FFFF. Otherwise, this bit will be set high and an ITAD interrupt will be generated if the ITADIEN bit in the OIER register is set. Reset this bit by writing 1.
[0]	ORFF	Operation Finished Flag 0: Operation is not finished 1: Last flash operation command is finished This bit will be set high when the last flash operation is finished. The ORF interrupt will be generated if the ORFIEN bit in the OIER register is set. Reset this bit by writing 1.

Flash Page Erase / Program Protection Status Register – PPSR

This register indicates the status of Flash page erase / program protection.

Offset: 0x020 (0) ~ 0x02C (3)

Reset value: 0xXXXX_XXXX

	31	30	29	28	27	26	25	24
	PPSBn							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	23	22	21	20	19	18	17	16
	PPSBn							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	15	14	13	12	11	10	9	8
	PPSBn							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	7	6	5	4	3	2	1	0
	PPSBn							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X

Bits	Field	Descriptions
[127:0]	PPSBn	Page Erase / Program Protection Status Bits (n = 0 ~ 127) PPSB[n] = OB_PP[n] 0: The corresponding page is protected 1: The corresponding page is not protected The content of this register is not dynamically updated and will only be reloaded from the Option Byte when any kind of reset occurs. The erase or program function of specific pages is not allowed when the corresponding bits of the PPSR registers are reset. The reset value of PPSR [127:0] is determined by the Option Byte OB_PP [127:0]. Since the maximum page number of the main flash is various and dependent on the chip specification. Therefore, the every page erase / program protection status bit may protect one or two pages and dependent on the chip specification. The other remained bits of OB_PP and PPSR registers are reserved.

Flash Security Protection Status Register – CPSR

This register indicates the status of the Flash Memory Security protection. The content of this register is not dynamically updated and will only be reloaded by the Option Byte loader, which is active when any kind of reset occurs.

Offset: 0x030

Reset value: 0x0000_000X

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						OBPSB	CPSB
Type/Reset							RO X	RO X

Bits	Field	Descriptions
[1]	OBPSB	Option Byte Page Erase / Program Protection Status Bit 0: The Option Byte page is protected 1: The Option Byte page is not protected The reset value of OBPSB is determined by the Option Byte, OB_CP [1].
[0]	CPSB	Flash Security Protection Status Bit 0: Flash Security protection is enabled 1: Flash Security protection is not enabled The reset value of CPSB is determined by the Option Byte, OB_CP [0].

Flash Vector Mapping Control Register – VMCR

This register is used to control the vector mapping. The reset value of the VMCR register is determined by the external booting pin, BOOT, during the power-on reset period.

Offset: 0x100

Reset value: 0x0000_000X

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						VMCB	Reserved
Type/Reset							RW	X

Bits	Field	Descriptions
[1]	VMCB	Vector Mapping Control Bit The VMCB bits is used to control the mapping source of first 4-word vector (address 0x0 ~ 0xC). The following table shows the vector mapping setting.

BOOT	VMCB	Descriptions
Low	0	Boot Loader mode The vector mapping source is the boot loader area.
High	1	Main Flash mode The vector mapping source is the main Flash area.

The reset value of VMCR is determined by the pins status of BOOT during power-on reset and system reset. The vector mapping setting can be changed temporarily by setting the VMCB bit when the application is running.

Flash Manufacturer and Device ID Register – MDID

This register specifies the manufacture ID and device part number information which can be used as the product identity.

Offset: 0x180

Reset value: 0x0376_XXXX

	31	30	29	28	27	26	25	24
	MFID							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 1	RO 1
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	MFID							
Type/Reset	RO 0	RO 1	RO 1	RO 1	RO 0	RO 1	RO 1	RO 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	ChipID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	ChipID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X

Bits	Field	Descriptions
[31:16]	MFID	Manufacturer ID Read as 0x0376
[15:0]	ChipID	Chip ID Read the last 4 digital codes of the MCU device part number.

Flash Page Number Status Register – PNSR

This register specifies the page number of Flash memory.

Offset: 0x184

Reset value: 0x0000_00XX

	31		30		29		28		27		26		25		24	
	PNSB															
Type/Reset	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0
	23		**22**		**21**		**20**		**19**		**18**		**17**		**16**	
	PNSB															
Type/Reset	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0
	15		**14**		**13**		**12**		**11**		**10**		**9**		**8**	
	PNSB															
Type/Reset	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0
	7		**6**		**5**		**4**		**3**		**2**		**1**		**0**	
	PNSB															
Type/Reset	RO	X	RO	X	RO	X	RO	X	RO	X	RO	X	RO	X	RO	X

Bits	Field	Descriptions
[31:0]	PNSB	Flash Page Number Status Bits 0x0000_0010: Totally 16 pages for the on-chip Flash memory device 0x0000_0020: Totally 32 pages for the on-chip Flash memory device 0x0000_0040: Totally 64 pages for the on-chip Flash memory device 0x0000_0080: Totally 128 pages for the on-chip Flash memory device 0x0000_00FF: Totally 255 pages for the on-chip Flash memory device

Flash Page Size Status Register – PSSR

This register specifies the page size in bytes.

Offset: 0x188

Reset value: 0x0000_0400

	31	30	29	28	27	26	25	24
	PSSB							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	PSSB							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	PSSB							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 1	RO 0	RO 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	PSSB							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[31:0]	PSSB	Status Bits of Flash Page Size 0x200: That means the page size is 512 Byte per page 0x400: That means the page size is 1 KB per page 0x800: That means the page size is 2 KB per page

Device ID Register – DIDR

This register specifies the device part number information which can be used as the product identity.

Offset: 0x18C

Reset value: 0x000X_XXXX

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				ChipID			
Type/Reset					RO X	RO X	RO X	RO X
	15	14	13	12	11	10	9	8
	ChipID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	7	6	5	4	3	2	1	0
	ChipID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X

Bits	Field	Descriptions
[19:0]	ChipID	Chip ID Read the complete 5 digital codes of the MCU device part number.

Custom ID Register n – CIDRn, n = 0 ~ 3

This register specifies the custom ID information which can be used as the custom identity.

Offset: 0x310 (0) ~ 0x31C (3)

Reset value: Various depending on Flash Manufacture Privilege Information Block.

	31	30	29	28	27	26	25	24
	CID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	23	22	21	20	19	18	17	16
	CID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	15	14	13	12	11	10	9	8
	CID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X
	7	6	5	4	3	2	1	0
	CID							
Type/Reset	RO X	RO X	RO X	RO X	RO X	RO X	RO X	RO X

Bits	Field	Descriptions
[31:0]	CIDn	Custom ID Read as the CIDn[31:0] (n = 0 ~ 3) field in the Custom ID registers in Flash Manufacture Privilege Block.

5 Power Control Unit (PWRCU)

Introduction

The power consumption can be regarded as one of the most important issues for many embedded system applications. Accordingly the Power Control Unit, PWRCU, provides many types of power saving modes such as Sleep, Deep-Sleep1 and Deep-Sleep2 modes. These modes reduce the power consumption and allow the application to achieve the best trade-off between the conflicting demands of CPU operating time, speed and power consumption. The dash line in the Figure 11 indicates the power supply source of two digital power domains.

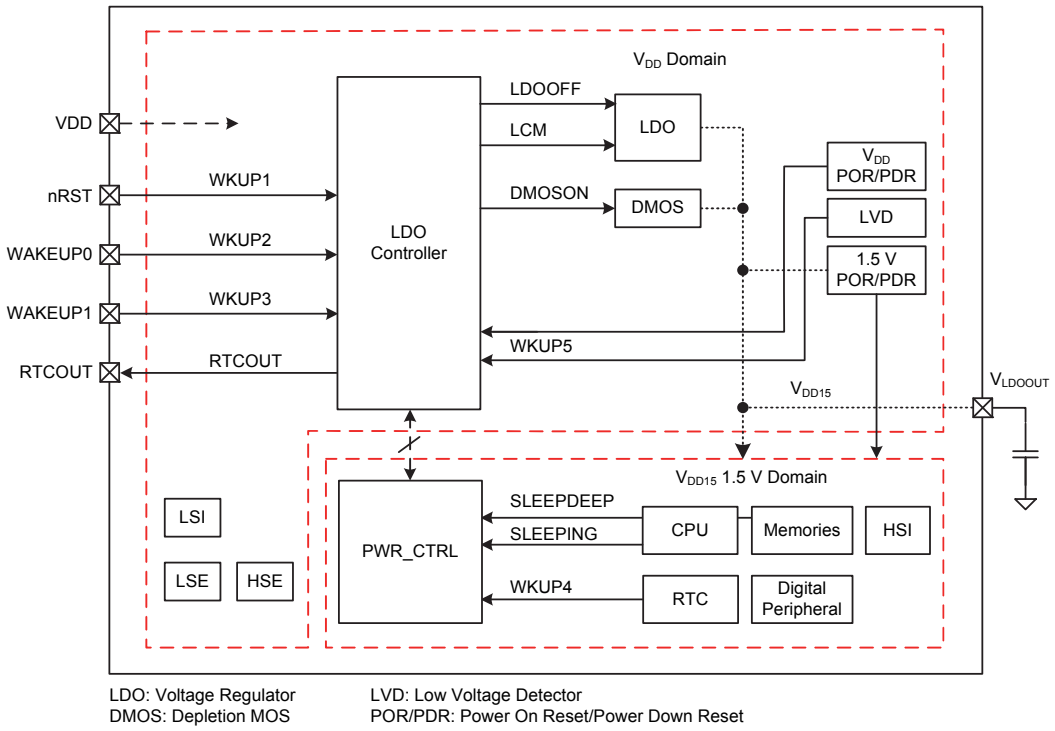


Figure 11. PWRCU Block Diagram

Features

- Three power domains: V_{DD}, V_{DDIO} and V_{DD15} 1.5 V power domains.
- Three power saving modes: Sleep, Deep-Sleep1 and Deep-Sleep2 modes.
- Internal Voltage regulator supplies 1.5 V voltage source.
- Additional Depletion MOS supplies 1.5 V voltage source with low leakage and low operating current.
- A power reset is generated when one of the following events occurs:
  - Power-on / Power-down reset (POR / PDR reset).
  - The control bits BODEN = 1, BODRIS = 0 and the supply power $V_{DD} \leq V_{BOD}$.
- BOD Brown-out Detector can issue a system reset or an interrupt when V_{DD} power source is lower than the Brown Out Detector voltage V_{BOD}.
- LVD Low Voltage Detector can issue an interrupt or wakeup event when V_{DD} is lower than a programmable threshold voltage V_{LVD}.

Functional Descriptions

V_{DD} Power Domain

LDO Power Control

The LDO will be automatically switched off when the following condition occurs:

- The Deep-Sleep2 mode is entered.

The LDO will be automatically switched on by hardware when the supply power $V_{DD} > V_{POR}$ if any of the following conditions occurs:

- Resume operation from the power saving mode – RTC wakeup, LVD wakeup, EXTI wakeup and WAKEUP pins.
- Detect a falling edge on the external reset pin (nRST).
- The control bit BODEN = 1 and the supply power $V_{DD} > V_{BOD}$.

To enter the Deep-Sleep1 mode, the PWRCU will request the LDO to operate in a low current mode, LCM. To enter the Deep-Sleep2 mode, the PWRCU will turn off the LDO and turn on the DMOS to supply an alternative 1.5 V power.

Voltage Regulator

The voltage regulator, LDO, Depletion MOS, DMOS, Low voltage Detector, LVD, Low Speed Internal RC oscillator, LSI, Low Speed External Crystal oscillator, LSE, and the High Speed External Crystal oscillator, HSE, are operated under the V_{DD} power domain. The LDO can be configured to operate in either normal mode (LDOOFF = 0, LDOLCM = 0, I_{OUT} = High current mode) or low current mode (LDOOFF = 0, LDOLCM = 1, I_{OUT} = Low current mode) to supply the 1.5 V power. An alternative 1.5 V power source is the output of the DMOS which has low static and driving current characteristics. It is controlled using the DMOSON bit in the PWRCR register. The DMOS output has weak output current and regulation capability and only operates in the Deep-Sleep2 mode for data retention purposes in the V_{DD15} power domain.

Power On Reset (POR) / Power Down Reset (PDR)

The device has an integrated POR / PDR circuitry that allows proper operation starting from V_{POR}. For more details concerning the power on / power down reset threshold voltage, refer to the electrical characteristics of the corresponding datasheet.

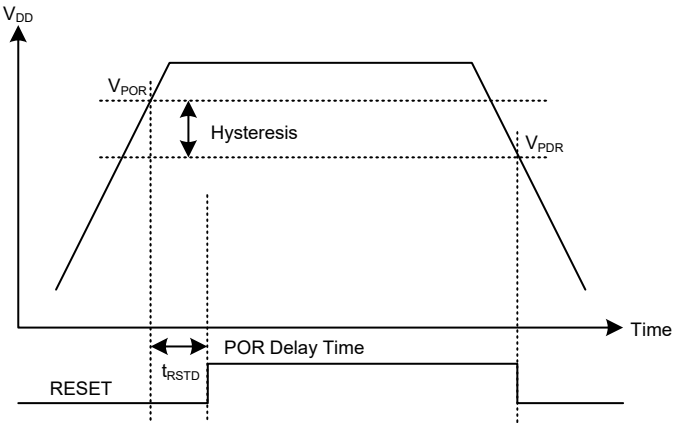


Figure 12. Power On Reset / Power Down Reset Waveform

Low Voltage Detector / Brown Out Detector

The Low Voltage Detector, LVD, can detect whether the supply voltage V_{DD} is lower than a programmable threshold voltage V_{LVD}. It is selected by the LVDS bits in the LVDCSR register. When a low voltage on the VDD power pin is detected, the LVDF flag will be active and an interrupt will be generated and sent to the MCU core if the LVDEN and LVDIWEN bits in the LVDCSR register are set. For more details concerning the LVD programmable threshold voltage V_{LVD}, refer to the electrical characteristics of the corresponding datasheet.

The Brown Out Detector, BOD, is used to detect if the V_{DD} supply voltage is equal to or lower than V_{BOD}. When the BODEN bit in the LVDCSR register is set to 1 and the V_{DD} supply voltage is lower than V_{BOD} then the BODF flag is active. The PWRCU will regard this as a power down reset situation and then immediately issue a system reset when the BODRIS bit is cleared to 0 or issue an interrupt to notify the CPU to execute a power down procedure when the BODRIS bit is set to 1. For more details concerning the Brown Out Detector voltage V_{BOD}, refer to the electrical characteristics of the corresponding datasheet.

High Speed External Oscillator

The High Speed External Oscillator, HSE, is located in the V_{DD} power domain. The HSE crystal oscillator can be switched on or off using the HSEEN bit in the Global Clock Control Register (GCCR). The HSE clock can be used directly as the system clock source.

LSE, LSI and RTC

The Real Time Clock Timer clock source can be derived from either the Low Speed Internal RC oscillator, LSI, or the Low Speed External Crystal oscillator, LSE. Before entering the power saving mode by executing WFI / WFE instruction, the MCU needs to setup the compare register with an expected wakeup time and enable the wakeup function to achieve the RTC timer wakeup event. After entering the power saving mode for a certain amount of time, the Compare Match flag, CMFLAG, will be asserted to wake up the device when the compare match event occurs. The details of the RTC configuration for wakeup timer will be described in the RTC chapter.

1.5 V Power Domain

The main functions that include high speed internal oscillator, HSI, MCU core logic, AHB / APB peripherals and memories and so on are located in this power domain. Once the 1.5 V is powered up, the POR will generate a reset sequence on 1.5 V power domain. Subsequently, to enter the expected power saving mode, the associated control bits including the LDOOFF, DMOSON and LDOLCM bits must be configured. Then, once a WFI or WFE instruction is executed, the device will enter an expected power saving mode which will be discussed in the following section.

High Speed Internal Oscillator

The High Speed Internal Oscillator, HSI, is located in the V_{DD15} power domain. When exiting from the Deep-Sleep mode, the HSI clock will be configured as the system clock for a certain period by setting the PSRCEN bit to 1. This bit is located in the Global Clock Control Register, GCCR, in the Clock Control Unit, CKCU. The system clock will not be switched back to the original clock source used before entering the Deep-Sleep mode until the original clock source stabilizes.

Operation Modes

Run Mode

In the Run mode, the system operates with full functions and all power domains are active. There are two ways to reduce the power consumption in this mode. The first is to slow down the system clock by setting the AHBPRE field in the CKCU AHBCFGR register, and the second is to turn off the unused peripherals clock by setting the APBCCR0 and APBCCR1 registers or slow down peripherals clock by setting the APBPCSR0 and APBPCSR1 registers to meet the application requirement. Reducing the system clock speed before entering the sleep mode will also help to minimize power consumption.

Additionally, there are several power saving modes to provide maximum optimization between device performance and power consumption.

Table 10. Operation Mode Definitions

Mode Name	Hardware Action
Run	After system reset, CPU fetches instructions to execute.
Sleep	1. CPU clock will be stopped. 2. Peripherals, Flash and SRAM clocks can be stopped by setting.
Deep-Sleep1 ~ 2	1. Stop all clocks in the 1.5 V power domain. 2. Disable HSI, HSE. 3. Turning on the LDO low current mode or DMOS to reduce the 1.5 V power domain current.

Sleep Mode

By default, only the CPU clock will be stopped in the Sleep mode. Clearing the FMCEN or SRAMEN bit in the CKCU AHBCCR register to 0 will have the effect of stopping the Flash clock or SRAM clock after the system enters the Sleep mode. If it is not necessary for the CPU to access the Flash memory and SRAM in the Sleep mode, it is recommended to clear the FMCEN and SRAMEN bits in the AHBCCR register to minimize power consumption. To enter the Sleep mode, it is only CPU executes a WFI or WFE instruction and lets the SLEEPDEEP signal to 0. The system will exit from the Sleep mode via any interrupt or event trigger. The accompanying table provides more information about the power saving modes.

Table 11. Enter / Exit Power Saving Modes

Mode	Mode Entry				Mode Exit
	CPU Instruction	CPU SLEEPDEEP	LDOOFF	DMOSON	
Sleep	WFI or WFE (Takes effect)	0	X	X	WFI: Any interrupt WFE: Any wakeup event (1) or Any interrupt (NVIC on) or Any interrupt with SEVONPEND = 1 (NVIC off)
Deep-Sleep1		1	0	0	Any EXTI in event mode or RTC wakeup or LVD wakeup (2) or WAKEUP pins
Deep-Sleep2		1	X	1	Any EXTI in event mode or RTC wakeup or LVD wakeup (2) or WAKEUP pins

Notes: 1. Wakeup event means EXTI line in event mode, RTC, LVD and WAKEUP pins

2. If the system allows the LVD activity to wake it up after the system has entered the power saving mode, the LVDEWEN and LVDEN bits in the LVDCSR register must be set to 1 to make sure that the system can be woken up by an LVD event and then the LDO regulator can be turned on when system is woken up from the Deep-Sleep2 mode.

Deep-Sleep Mode

To enter Deep-Sleep mode, configure the registers as shown in the preceding table and execute the WFI or WFE instruction. In the Deep-Sleep mode, all clocks including high speed oscillator, known as HSI and HSE, will be stopped. In addition, Deep-Sleep1 turns the LDO into low current mode while Deep-Sleep2 turns off the LDO and uses a DMOS to keep 1.5 V power. Once the PWRCU receives a wakeup event or an interrupt as shown in the preceding Mode-Exiting table, the LDO will then operate in normal mode and the high speed oscillator will be enabled. Finally, the CPU will return to Run mode to handle the wakeup interrupt if required. A Low Voltage Detection also can be regarded as a wakeup event if the corresponding wakeup control bit LVDEWEN in the LVDCSR register is enabled. The last wakeup event is a transition on the external WAKEUP pin sent to the PWRCU to resume from Deep-Sleep mode. During the Deep-Sleep mode, retaining the register and memory contents will shorten the wakeup latency.

Table 12. Power Status After System Reset

PORF	PORSTF	Description
1	1	Power-up for the first time after the V_{DD} power domain is reset: Power on reset when V_{DD} is applied for the first time or executing software reset command on the V_{DD} domain.
0	1	Restart from unexpected loss of the 1.5 V power or other reset (nRST, WDT, …)

WAKEUPn Pin Wakeup

The software can set the WUPnEN bit in register PWRCR to 1 to enable the WAKEUPn pin function before entering the power saving mode, waiting for a wakeup trigger signal occurrence on the WAKEUPn pin to wake up the system from the power saving mode. The external WAKEUPn pin interrupt shares the same exception number with the EXTI event wakeup interrupt. The software can set the EXTI Event Wakeup Interrupt Enable bit (EVWUPIEN) to 1 to assert the WKUP interrupt in the NVIC unit when both the WUPnEN and WUPFn bits are set to 1.

Although the WUPnEN bit is located in the V_{DD} domain, it also can be reset by the nRST reset pin. After the reset there will be a delay before the WUPnEN bit is active. This bit will not be active until the system reset is finished and the V_{DD} domain ISO signal is disabled. This means that the bit cannot be immediately set by software after a system reset is finished and the V_{DD} domain ISO signal is disabled. The delay time requires at least three 32 kHz clock periods after the WUPnEN bit reset has been finished.

Register Map

The following table shows the PWRCU registers and reset values. Note all the registers in this unit are located in the V_{DD15} power domain.

Table 13. PWRCU Register Map

Register	Offset	Description	Reset Value
PWRSR	0x100	Power Control Status Register	0x0000_0010
PWRCR	0x104	Power Control Register	0x0000_0000
LVDCSR	0x110	Low Voltage / Brown Out Detect Control and Status Register	0x0000_0000

Register Descriptions

Power Control Status Register – PWRSR

This register indicates power control status.

Offset: 0x100
Reset value: 0x0000_0010

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved						WUPF1	WUPF0
Type/Reset							RC 0	RC 0
	7	6	5	4	3	2	1	0
	Reserved			PORF	Reserved			
Type/Reset				RC 1				

Bits	Field	Descriptions
[9]	WUPF1	External WAKEUP1 Pin Flag 0: The WAKEUP1 pin is not asserted 1: The WAKEUP1 pin is asserted This bit is set by hardware when the WAKEUP1 pin asserts and is cleared by software read. Software should read this bit to clear it after a system wake up from the power saving mode.

Bits	Field	Descriptions
[8]	WUPF0	External WAKEUP0 Pin Flag 0: The WAKEUP0 pin is not asserted 1: The WAKEUP0 pin is asserted This bit is set by hardware when the WAKEUP0 pin asserts and is cleared by software read. Software should read this bit to clear it after a system wake up from the power saving mode.
[4]	PORF	Power On Reset Flag 0: V_{DD15} Power Domain reset does not occur 1: V_{DD15} Power Domain reset occurs This bit is set by hardware when V_{DD15} power on reset occurs, either a hardware power on reset or software reset. The bit is cleared by software read. This bit must be cleared after the system is first powered on, otherwise it will be impossible to detect when a V_{DD15} Power Domain reset has been triggered. When this bit is read as 1, a read software loop must be implemented until the bit returns again to 0.

Power Control Register – PWRCR

This register provides power control bits for the different kinds of power saving modes.

Offset: 0x104

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved					WUP1TYPE		WUP0TYPE
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	DMOSSTS	Reserved				WUP1EN	Reserved	WUP0EN
Type/Reset	RO 0					RW 0		RW 0
	7	6	5	4	3	2	1	0
	DMOSON	Reserved			LDOOFF	LDOLCM	Reserved	PWCURST
Type/Reset	RW 0				RW 0	RW 0		WO 0

Bits	Field	Descriptions
[19:18]	WUP1TYPE	WAKEUP1 Signal Trigger Type

WUP1TYPE [1:0]		WAKEUP1 Signal Trigger Type
0	0	Positive-edge Triggered
0	1	Negative-edge Triggered
1	0	High-level Sensitive
1	1	Low-level Sensitive

[17:16] WUP0TYPE WAKEUP0 Signal Trigger Type

WUP0TYPE [1:0]		WAKEUP0 Signal Trigger Type
0	0	Positive-edge Triggered
0	1	Negative-edge Triggered
1	0	High-level Sensitive
1	1	Low-level Sensitive

[15] DMOSSTS Depletion MOS Status
This bit is set to 1 if the DMOSON bit in this register has been set to 1.
This bit is cleared to 0 if the DMOSON bit has been set to 0 or if a POR / PDR reset occurred.

[10] WUP1EN External WAKEUP1 Pin Enable
0: Disable WAKEUP1 pin function
1: Enable WAKEUP1 pin function
The Software can set the WUP1EN bit as 1 to enable the WAKEUP1 pin function before entering the power saving mode. When WUP1EN = 1, a change on the WAKEUP1 pin wakes up the system from the power saving mode. As the WAKEUP1 pin is active high, this pin should be configured to an input and pull-down state.

[8] WUP0EN External WAKEUP0 Pin Enable
0: Disable WAKEUP0 pin function
1: Enable WAKEUP0 pin function
The Software can set the WUP0EN bit as 1 to enable the WAKEUP0 pin function before entering the power saving mode. When WUP0EN = 1, a change on the WAKEUP0 pin wakes up the system from the power saving mode. As the WAKEUP0 pin is active high, this pin should be configured to an input and pull-down state.

[7] DMOSON DMOS Control
0: DMOS is OFF
1: DMOS is ON
A DMOS is implemented to provide an alternative voltage source for the 1.5 V power domain when the CPU enters the Deep-Sleep mode (SLEEPDEEP = 1). The control bit DMOSON is set by software and cleared by software or V_{DD} power domain reset. If the DMOSON bit is set to 1, the LDO will automatically be turned off when the CPU enters the Deep-Sleep mode.

[3] LDOOFF LDO Operating Mode Control
0: The LDO operates in a low current mode when CPU enters the Deep-Sleep mode (SLEEPDEEP = 1). The V_{DD15} power is available
1: The LDO is turned off when the CPU enters the Deep-Sleep mode (SLEEPDEEP = 1). The V_{DD15} power is not available
Note: This bit is only available when the DMOSON bit is cleared to 0.

Bits	Field	Descriptions
[2]	LDOLCM	LDO Low Current Mode 0: The LDO is operated in normal current mode 1: The LDO is operated in low current mode Note: This bit is only available when CPU is in the run mode. The LDO output current capability will be limited at 10 mA below and lower static current when the LDOLCM bit is set. It is suitable for CPU, which is operated at lower speed system clock, to get a lower current consumption. This bit will be cleared to 0 when the LDO is powered down or V_{DD} power domain is reset.
[0]	PWCURST	Power Control Unit Software Reset 0: No action 1: Power Control Unit Software Reset is activated When this bit is set, it will reset all the related RTC and PWRCU registers.

Low Voltage / Brown Out Detect Control and Status Register – LVDCSR

This register specifies flags, enable bits and option bits for low voltage detector.

Offset: 0x110

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved	LVDS [2]	LVDEWEN	LVDIWEN	LVDF		LVDS [1:0]	LVDEN
Type/Reset		RW 0	RW 0	RW 0	RO 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				BODF	Reserved	BODRIS	BODEN
Type/Reset					RO 0		RW 0	RW 0

Bits	Field	Descriptions
[21]	LVDEWEN	LVD Event Wakeup Enable 0: LVD event wakeup is disabled 1: LVD event wakeup is enabled Setting this bit to 1 will enable the LVD event wakeup function to wake up the system when an LVD condition occurs which result in the LVDF bit being asserted. If the system requires to be woken up from the Deep-Sleep mode by an LVD condition, this bit must be set to 1.
[20]	LVDIWEN	LVD Interrupt Wakeup Enable 0: LVD interrupt wakeup is disabled 1: LVD interrupt wakeup is enabled Setting this bit to 1 will enable the LVD interrupt function. When an LVD condition occurs and the LVDIWEN bit is set to 1, an LVD interrupt will be generated and sent to the CPU NVIC unit.

Bits	Field	Descriptions
[19]	LVDF	Low Voltage Detect Status Flag 0: V_{DD} is higher than the specific voltage level 1: V_{DD} is equal to or lower than the specific voltage level When the LVD condition occurs, the LVDF flag will be asserted. When the LVDF flag is asserted, an LVD interrupt will be generated for CPU if the LVDIWEN bit is set to 1. However, if the LVDEWEN bit is set to 1 and the LVDIWEN bit is cleared to 0, only an LVD event will be generated rather than an LVD interrupt when the LVDF flag is asserted.
[22], [18:17]	LVDS [2:0]	Low Voltage Detect Level Selection For more details concerning the LVD programmable threshold voltage, refer to the electrical characteristics of the corresponding datasheet.
[16]	LVDEN	Low Voltage Detect Enable 0: Disable Low Voltage Detect 1: Enable Low Voltage Detect Setting this bit to 1 will generate an LVD event when the V_{DD} power is equal to or lower than the voltage set by LVDS bits. Therefore when the LVD function is enabled before the system is into the Deep-Sleep2 (DMOS is turn on and LDO is power down), the LVDEWEN bit has to be enabled to avoid the LDO does not activate in the meantime when the CPU is woken up by the low voltage detection activity.
[3]	BODF	Brown Out Detect Flag 0: $V_{DD} > V_{BOD}$ 1: $V_{DD} \leq V_{BOD}$
[1]	BODRIS	BOD Reset or Interrupt Selection 0: Reset the whole chip 1: Generate Interrupt
[0]	BODEN	Brown Out Detector Enable 0: Disable Brown Out Detector 1: Enable Brown Out Detector

6 Clock Control Unit (CKCU)

Introduction

The Clock Control unit, CKCU, provides functions of high speed internal RC oscillator, HSI, High speed external crystal oscillator, HSE, Low speed internal RC oscillator, LSI, Low speed external crystal oscillator, LSE, HSE clock monitor, clock prescaler, clock multiplexer and clock gating. The clock of AHB, APB and CPU are derived from system clock, CK_SYS, which can come from HSI, HSE, LSI and LSE. Watchdog Timer and Real Time Clock, RTC, use either LSI or LSE as their clock source.

A variety of internal clocks can also be wired out through CKOUT for debugging purpose. The clock monitor can be used to get clock failure detection of HSE. Once the clock of HSE does not function (could be broken down or removed or etc.), CKCU will force to switch the system clock source to HSI clock to prevent system halt.

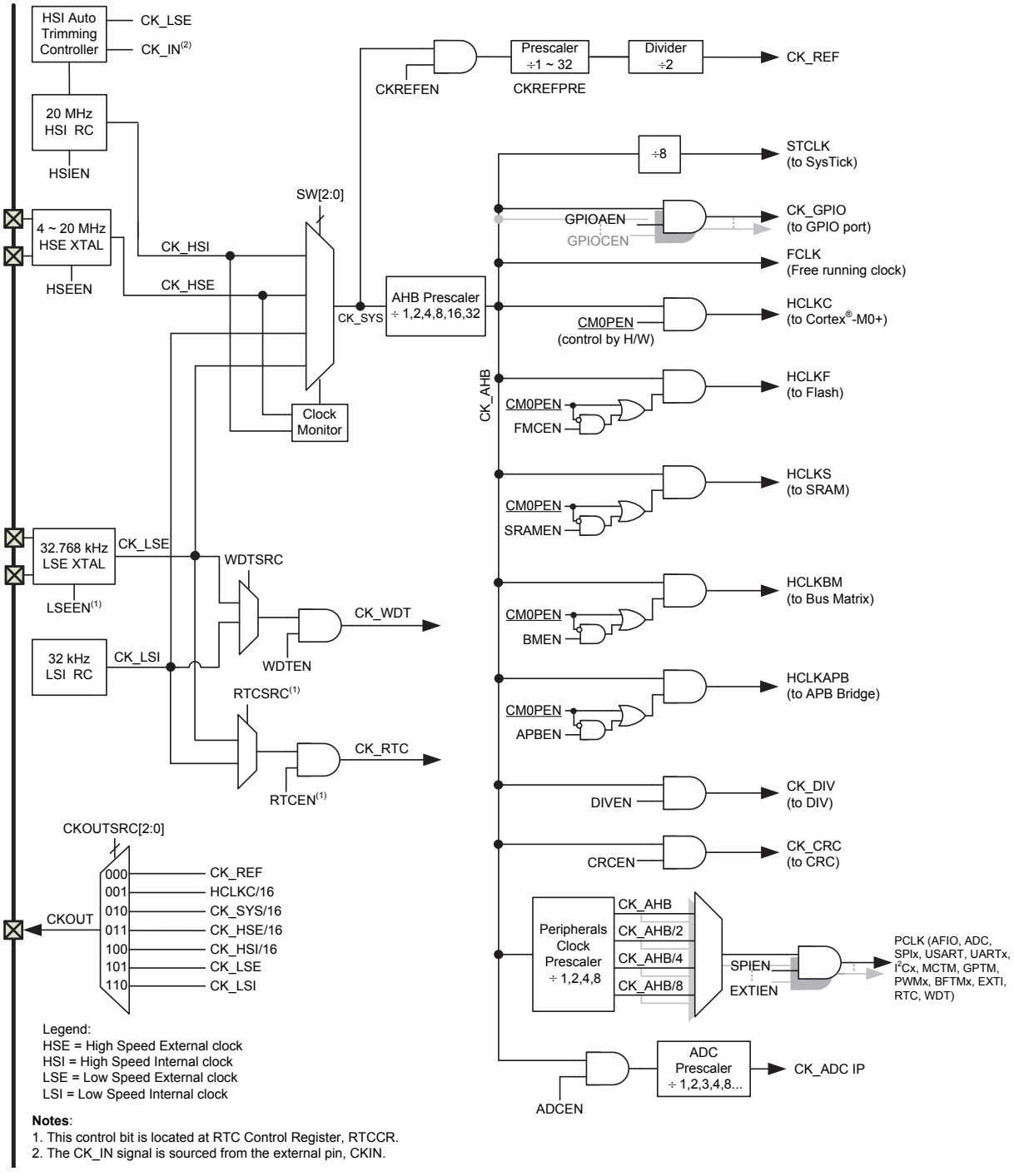


Figure 13. CKCU Block Diagram

Features

- 4 ~ 20 MHz external crystal oscillator (HSE)
- Internal 20 MHz RC oscillator (HSI) with configuration option calibration and custom trimming capability.
- 32,768 Hz external crystal oscillator (LSE) for Watchdog Timer, RTC or system clock.
- Internal 32 kHz RC oscillator (LSI) for Watchdog Timer, RTC or system clock.
- HSE clock monitor

Function Descriptions

High Speed External Crystal Oscillator – HSE

The high speed external 4 to 20 MHz crystal oscillator (HSE) produces a highly accurate clock source to the system clock. The related hardware configuration is shown in the following figure. The crystal with specific frequency must be placed across the two HSE pins (XTALIN / XTALOUT) and the external components such as resistors and capacitors are necessary to make it oscillate properly.

The following guidelines are provided to improve the stability of the crystal circuit PCB layout.

- The crystal oscillator should be located as close as possible to the MCU so that the trace lengths are kept as short as possible to reduce any parasitic capacitances.
- Shield any lines in the vicinity of the crystal by using a ground plane to isolate signals and reduce noise.
- Keep frequently switching signal lines away from the crystal area to prevent crosstalk.

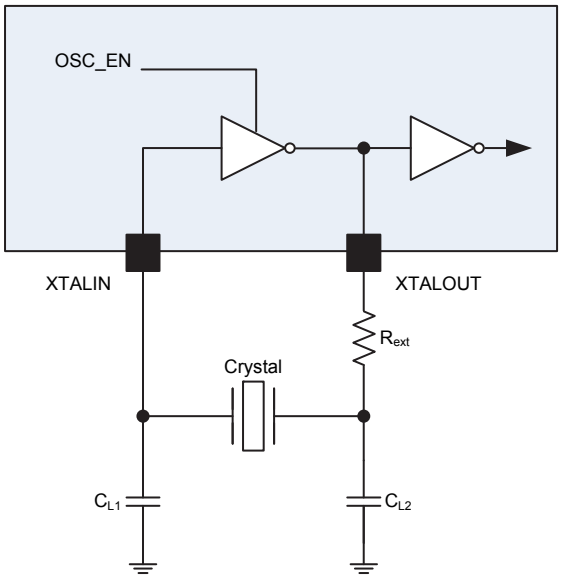


Figure 14. External Crystal, Ceramic and Resonators for HSE

The HSE crystal oscillator can be switched on or off using the HSEEN bit in the Global Clock Control Register (GCCR). The HSERDY flag in the Global Clock Status Register (GCSR) will indicate if the high-speed external crystal oscillator is stable. While switching on the HSE, the HSE clock will still not be released until this HSERDY bit is set by the hardware. The specific delay period is well-known as "Start-up time". The HSE clock can then be used directly as the system clock source.

High Speed Internal RC Oscillator – HSI

The high speed internal RC oscillator (HSI) is the default selection of clock source for the CPU when the device is powered up. The HSI RC oscillator provides a clock source in a lower cost because no external components are required. The HSI RC oscillator can be switched on or off using the HSIEN bit in the Global Clock Control Register (GCCR). The HSIRDY flag in the Global Clock Status Register (GCSR) will indicate if the internal RC oscillator is stable. The start-up time of HSI is shorter than the HSE crystal oscillator.

The accuracy of the frequency of the high speed internal RC oscillator HSI can be calibrated via the configuration options, but it is still less accurate than the HSE crystal oscillator. The applications, the environments and the cost will determine the use of the oscillators.

Software could configure the PSRCEN bit (Power Saving Wakeup RC Clock Enable) to 1 to force HSI clock to be system clock when wake-up from Deep-Sleep1/2 mode. Subsequently, the system clock is back to the original clock source if the original clock source ready flag is asserted. This function can reduce the wakeup time when using HSE as system clock.

Auto Trimming of High Speed Internal RC Oscillator – HSI

The frequency accuracy of the high speed internal RC oscillator HSI can vary from one chip to another due to manufacturing process variations, this is why each device is factory calibrated by Holtek for ±2 % accuracy at V_{DD} = 5 V and T_A = 25°C. But the accuracy is not enough for some applications and environments requirement. Therefore, this device provides the trimming mechanism for HSI frequency calibration using more accurate external reference clock. The detailed block diagram is shown as Figure 15.

After reset, the factory trimming value is loaded in the HSICOARSE[4:0] and HSIFINE[7:0] bits in the HSI Control Register (HSICR). The HSI frequency accuracy may be affected by voltage or temperature variations. If the application has to be driven by a more accurate HSI frequency, users can trim manually the HSI frequency using the HSIFINE[7:0] bits in the HSI Control Register (HSICR) or automatically adjust the HSI frequency using the Auto Trimming Controller (ATC) together with an external reference clock in the application. The reference clock can be provided form the following clock sources:

- 32,768 Hz low speed external crystal or ceramic resonator oscillator LSE output clock
- External pin (CKIN) with 1 kHz pulse

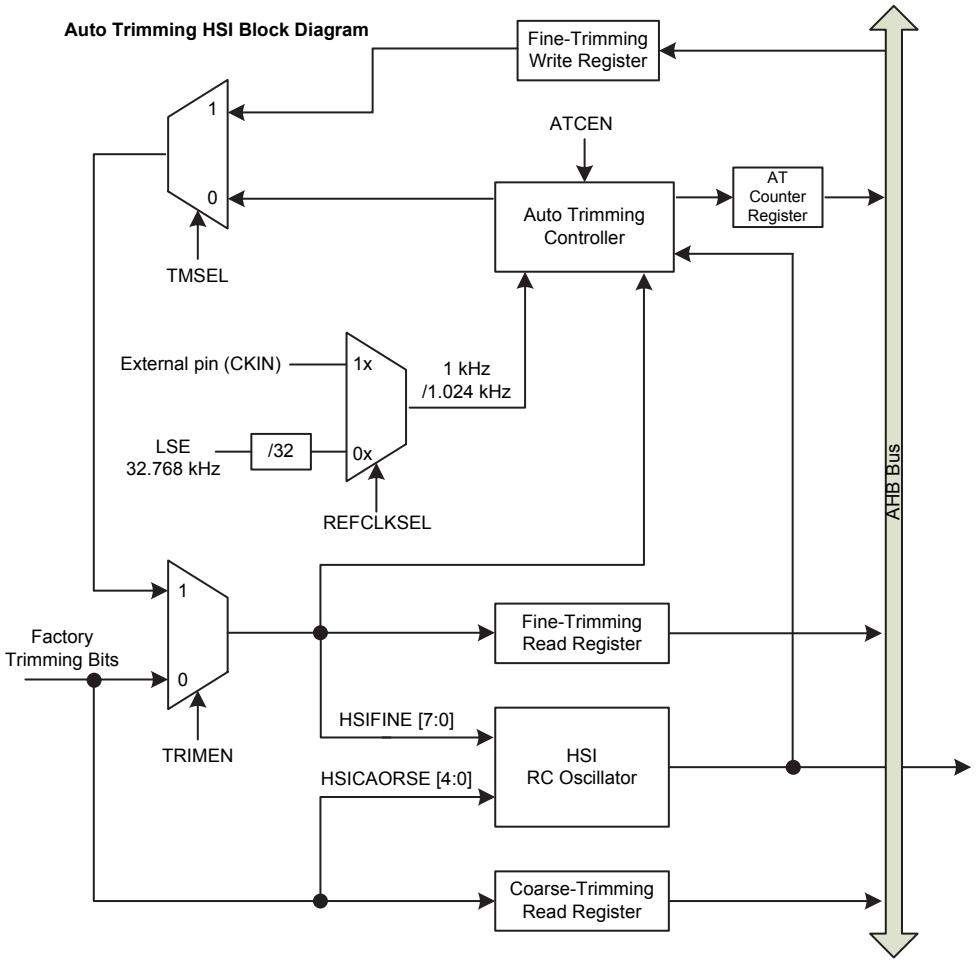


Figure 15. HSI Auto Trimming Block Diagram

Low Speed External Crystal Oscillator – LSE

The low speed external crystal or ceramic resonator oscillator with 32.768 kHz frequency produces a low power but highly accurate clock source for the circuits of Real-Time-Clock peripheral, Watchdog Timer or system clock. The associated hardware configuration is shown in the following figure. The crystal or ceramic resonator must be placed across the two LSE pins (X32KIN / X32KOUT) and the external capacitors are necessary to make it oscillate properly. The LSE oscillator can be switched on or off by using the LSEEN bit in the RTC Control Register (RTCCR). The LSERDY flag in the Global Clock Status Register (GCSR) will indicate if the LSE clock is stable.

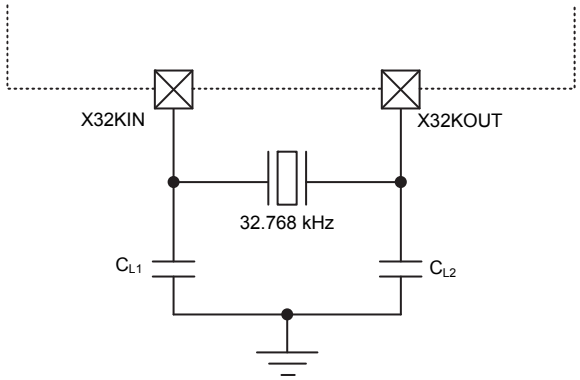


Figure 16. External Crystal, Ceramic and Resonators for LSE

Low Speed Internal RC Oscillator – LSI

The low speed internal RC oscillator with frequency of about 32 kHz produces a low power clock source for the circuits of Real-Time-Clock peripheral, Watchdog Timer or system clock. The LSI is also a clock source of low cost because no external component is needed to make it oscillates. The accuracy of the frequency of the low speed internal RC oscillator LSI is shown as the corresponding data sheet. The LSIRDY flag in the Global Clock Status Register (GCSR) will indicate if the LSI clock is stable.

Clock Ready Flag

CKCU provides clock ready flags for HSI, HSE, LSI and LSE to confirm those clocks are stable before using them as system clock source or other purpose. Software can check specific clock is ready or not by polling separate clock ready status bits in GCSR register.

System Clock (CK_SYS) Selection

After the system reset occurs, the default system clock source CK_SYS will be the high speed internal RC oscillator HSI. The CK_SYS may come from the HSI, HSE, LSI and LSE output clock and it can be switched from one clock source to another via the System Clock Switch bits, SW, in the Global Clock Control Register GCCR. The system will still run under the original clock until the destination clock gets ready. The corresponding clock ready status bits in the Global Clock Status Register GCSR will indicate whether the selected clock is ready to use or not. The CKCU also contains the clock source status bits in the Clock Source Status Register CKST to indicate which clock is currently used as the system clock. More details about function of clock enable are described in below.

If any following action takes effect, the HSI is always under enable state.

- Enable Clock monitor. (CKMEN)
- Configure clock switch register bits to select the HSI. (SW)
- Configure HSI enable register bit to 1. (HSIEN)

If any following action takes effect, the HSE is always under enable state.

- Configure clock switch register bits to select the HSE. (SW)
- Configure HSE enable register bit to 1. (HSEEN)

Programming guide of System clock selection is listed in following.

1. Enable any source clock which will become system clock.
2. Configuring the SW register bits to change system clock source will take effect after ready flag of source clock is asserted. Note that system clock will force to HSI if clock monitor is enabled and HSE clock configured as system clock is stuck at 0 or 1.

HSE Clock Monitor

The main function of the oscillator check is enabled by the HSE Clock Monitor Enable bit CKMEN in the Global Clock Control Register, GCCR. The HSE clock monitor should be enabled after the HSE oscillator start-up delay and be disabled when the HSE oscillator is stopped. Once the HSE oscillator failure is detected, the HSE oscillator will automatically be disabled. The HSE clock stuck flag CKSF in the Global Clock Interrupt Register GCIR will be set and an event of main oscillator failure will be generated if the clock fail interrupt enable bit CKSIE in the GCIR is set. This failure interrupt is connected to the exception vector of CPU Non-Maskable Interrupt, NMI. If the HSE is directly used as the system clock, when the HSE oscillator failure occurs, the HSE will be turned off and the system clock will be switched to the HSI automatically by the hardware.

Clock Output Capability

The device has the clock output capability to allow the clocks to be output on the specific external output pin CKOUT. The configuration registers of the corresponding GPIO port must be well configured in the Alternate Function I/O section, AFIO, to output the selected clock signal. There are seven output clock signals to be selected via the device clock output source selection bits CKOUTSRC in the Global Clock Configuration Register, GCFGR.

Table 14. CKOUT Clock Source

CKOUTSRC[2:0]	Clock Source
000	CK_REF = CK_SYS / (CKREFPRE + 1) / 2
001	HCLKC / 16
010	CK_SYS / 16
011	CK_HSE / 16
100	CK_HSI / 16
101	CK_LSE
110	CK_LSI

Register Map

The following table shows the CKCU register and reset value.

Table 15. CKCU Register Map

Register	Offset	Description	Reset Value
GCFGR	0x000	Global Clock Configuration Register	0x0000_0002
GCCR	0x004	Global Clock Control Register	0x0000_0803
GCSR	0x008	Global Clock Status Register	0x0000_0028
GCIR	0x00C	Global Clock Interrupt Register	0x0000_0000
AHBCFGR	0x020	AHB Configuration Register	0x0000_0001
AHBCCR	0x024	AHB Clock Control Register	0x0000_0065
APBCFGR	0x028	APB Configuration Register	0x0001_0000
APBCCR0	0x02C	APB Clock Control Register 0	0x0000_0000
APBCCR1	0x030	APB Clock Control Register 1	0x0000_0000
CKST	0x034	Clock Source Status Register	0x0100_0003
APBPCSR0	0x038	APB Peripheral Clock Selection Register 0	0x0000_0000
APBPCSR1	0x03C	APB Peripheral Clock Selection Register 1	0x0000_0000
HSICR	0x040	HSI Control Register	0xXXXX_0000 where X is undefined
HSIATCR	0x044	HSI Auto Trimming Counter Register	0x0000_0000
APBPCSR2	0x048	APB Peripheral Clock Selection Register 2	0x0000_0000
MCUDBGCR	0x304	MCU Debug Control Register	0x0000_0000

Register Descriptions

Global Clock Configuration Register – GCFGR

This register specifies the low power mode status and clock source for CKOUT.

Offset: 0x000

Reset value: 0x0000_0002

	31	30	29	28	27	26	25	24
	LPMOD			Reserved				
Type/Reset	RO	0 RO	0 RO	0				
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CKREFPRE					Reserved		
Type/Reset	RW	0 RW	0 RW	0 RW	0 RW	0		
	7	6	5	4	3	2	1	0
	Reserved					CKOUTSRC		
Type/Reset						RW	0 RW	1 RW 0

Bits	Field	Descriptions
[31:29]	LPMOD	Lower Power Mode Status 000: When Chip is in running mode 001: When Chip wants to enter Sleep mode 010: When Chip wants to enter Deep-Sleep1 mode 011: When Chip wants to enter Deep-Sleep2 mode Others: Reserved Set and reset by hardware.
[15:11]	CKREFPRE	CK_REF Clock Prescaler Selection CK_REF = CK_SYS / (CKREFPRE + 1) / 2 00000: CK_REF = CK_SYS / 2 00001: CK_REF = CK_SYS / 4 ... 11111: CK_REF = CK_SYS / 64 Set and reset by software to control CK_REF clock prescaler setting.
[2:0]	CKOUTSRC	CKOUT Clock Source Selection 000: (CK_SYS / (CKREFPRE + 1) / 2) is selected 001: (HCLKC / 16) is selected 010: (CK_SYS / 16) is selected 011: (CK_HSE / 16) is selected 100: (CK_HSI / 16) is selected 101: CK_LSE is selected 110: CK_LSI is selected 111: Reserved Set and reset by software.

Global Clock Control Register – GCCR

This register specifies the clock enable bits.

Offset: 0x004

Reset value: 0x0000_0803

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved						PSRCEN	CKMEN
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved				HSIEN	HSEEN	Reserved	HSEGAIN
Type/Reset					RW 1	RW 0		RW 0
	7	6	5	4	3	2	1	0
	Reserved					SW		
Type/Reset						RW 0	RW 1	RW 1

Bits	Field	Descriptions
[17]	PSRCEN	Power Saving Wakeup RC Clock Enable 0: No action 1: Use Internal RC clock (HSI) as system clock after a Deep-Sleep1/2 mode wakeup Software can set PSRCEN to high before entering Deep-Sleep1/2 mode in order to reduce the waiting time after wakeup. When PSRCEN = 1, hardware will select HSI as clock source after the system wakeup from Deep-Sleep1/2 mode. Meanwhile, instruction can start execution since the HSI clock is provided to MCU. After the original clock source, which is selected as CK_SYS before entering Deep-Sleep1/2 mode, is ready, hardware will switch back the clock source as originally.
[16]	CKMEN	HSE Clock Monitor Enable 0: Disable External crystal oscillator clock monitor 1: Enable External crystal oscillator clock monitor When hardware detects HSE clock stuck at low / high state, internal hardware will switch the system clock to internal high speed RC clock (HSI).
[11]	HSIEN	Internal High Speed Clock Enable 0: Internal RC oscillator clock is set to off 1: Internal RC oscillator clock is set to on Set and reset by software. This bit can not be reset if HSI clock is used as system clock.
[10]	HSEEN	External High Speed Clock Enable 0: External crystal oscillator clock is set to off 1: External crystal oscillator clock is set to on Set and reset by software. This bit can not be reset if the HSE clock is used as system clock.

Bits	Field	Descriptions
[8]	HSEGAIN	External High Speed Clock Gain Selection 0: HSE low gain mode 1: HSE high gain mode
[2:0]	SW	System Clock Switch 010: CK_HSE as system clock 011: CK_HSI as system clock 110: CK_LSE as system clock 111: CK_LSI as system clock Others: CK_HSI as system clock These bits are set and reset by software to select CK_SYS source. If the HSE oscillator is used directly or indirectly as the system clock and the HSE clock monitor function is enabled, once the HSE failure is detected, these bits will be set by hardware to force HSI (b011) as the system clock. Note: When switch the system clock using the SW bits, the system clock is not immediately switched and a certain delay is necessary. The software can monitor the CKSWST bit in the clock source status register CKST to make sure which clock is currently used as system clock.

Global Clock Status Register – GCSR

This register indicates the clock ready status.

Offset: 0x008

Reset value: 0x0000_0028

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
		Reserved	LSIRDY	LSERDY	HSIRDY	HSERDY		Reserved
Type/Reset			RO 1	RO 0	RO 1	RO 0		

Bits	Field	Descriptions
[5]	LSIRDY	Internal Low Speed Clock Ready Flag 0: Internal 32 kHz RC oscillator clock is not ready 1: Internal 32 kHz RC oscillator clock is ready Set by hardware to indicate that the LSI is stable to be used.
[4]	LSERDY	External Low Speed Clock Ready Flag 0: External 32.768 kHz RC oscillator clock is not ready 1: External 32.768 kHz RC oscillator clock is ready Set by hardware to indicate that the LSE is stable to be used.
[3]	HSIRDY	Internal High Speed Clock Ready Flag 0: Internal RC oscillator clock is not ready 1: Internal RC oscillator clock is ready Set by hardware to indicate that the HSI is stable to be used.
[2]	HSERDY	External High Speed Clock Ready Flag 0: External crystal oscillator clock is not ready 1: External crystal oscillator clock is ready Set by hardware to indicate that the HSE is stable to be used.

Global Clock Interrupt Register – GCIR

This register specifies interrupt enable and flag bits.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							CKSIE
Type/Reset								RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved							CKSF
Type/Reset								WC 0

Bits	Field	Descriptions
[16]	CKSIE	Clock Stuck Interrupt Enable 0: Disable clock fail interrupt 1: Enable clock fail interrupt Set and reset by software to enable / disable interrupt caused by clock monitor.
[0]	CKSF	Clock Stuck Interrupt Flag 0: Clock works normally 1: HSE clock is stuck Reset by software (Write 1 clear). Set by hardware when HSE clock stuck and CKMEN is set.

AHB Configuration Register – AHBCFGR

This register specifies frequency of system clock.

Offset: 0x020

Reset value: 0x0000_0001

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					AHBPRE		
Type/Reset						RW 0	RW 0	RW 1

Bits	Field	Descriptions
[2:0]	AHBPRE	AHB Pre-scaler 000: CK_AHB = CK_SYS 001: CK_AHB = CK_SYS / 2 010: CK_AHB = CK_SYS / 4 011: CK_AHB = CK_SYS / 8 100: CK_AHB = CK_SYS / 16 101: CK_AHB = CK_SYS / 32 110: CK_AHB = CK_SYS / 32 111: CK_AHB = CK_SYS / 32 Set and reset by software to control the division factor of the AHB clock.

AHB Clock Control Register – AHBCCR

This register specifies clock enable bits of AHB.

Offset: 0x024

Reset value: 0x0000_0065

	31	30	29	28	27	26	25	24
	Reserved							DIVEN
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved					PCEN	PBEN	PAEN
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
		Reserved	CRCEN	Reserved	CKREFEN	Reserved		
Type/Reset			RW 0		RW 0			
	7	6	5	4	3	2	1	0
	Reserved	APBEN	BMEN		Reserved	SRAMEN	Reserved	FMCEN
Type/Reset		RW 1	RW 1			RW 1		RW 1

Bits	Field	Descriptions
[24]	DIVEN	Divider Clock Enable 0: Divider clock is disabled 1: Divider clock is enabled Set and reset by software.
[18]	PCEN	GPIO Port C Clock Enable 0: Port C clock is disabled 1: Port C clock is enabled Set and reset by software.
[17]	PBEN	GPIO Port B Clock Enable 0: Port B clock is disabled 1: Port B clock is enabled Set and reset by software.
[16]	PAEN	GPIO Port A Clock Enable 0: Port A clock is disabled 1: Port A clock is enabled Set and reset by software.
[13]	CRCEN	CRC Module Clock Enable 0: CRC clock is disabled 1: CRC clock is enabled Set and reset by software.
[11]	CKREFEN	CK_REF Clock Enable 0: CK_REF clock is disabled 1: CK_REF clock is enabled Set and reset by software.
[6]	APBEN	APB bridge Clock Enable 0: APB bridge clock is automatically disabled by hardware during Sleep mode 1: APB bridge clock is always enabled during Sleep mode Set and reset by software. Users can clear the APBEN bit to 0 to reduce power consumption if the APB bridge is unused during Sleep mode.

Bits	Field	Descriptions
[5]	BMEN	Bus Matrix Clock Enable 0: Bus Matrix clock is automatically disabled by hardware during Sleep mode 1: Bus Matrix clock is always enabled during Sleep mode Set and reset by software. Users can clear the BMEN to 0 to reduce power consumption if the bus matrix is unused during Sleep mode.
[2]	SRAMEN	SRAM Clock Enable 0: SRAM clock is automatically disabled by hardware during Sleep mode 1: SRAM clock is always enabled during Sleep mode Set and reset by software. Users can clear the SRAMEN to 0 to reduce power consumption if the SRAM is unused during Sleep mode.
[0]	FMCEN	Flash Memory Controller Clock Enable 0: FMC clock is automatically disabled by hardware during Sleep mode 1: FMC clock is always enabled during Sleep mode Set and reset by software. Users can clear the FMCEN to 0 to reduce power consumption if the Flash Memory is unused during Sleep mode.

APB Configuration Register – APBCFGR

This register specifies the frequency of ADC conversion clock.

Offset: 0x028

Reset value: 0x0001_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved					ADCDIV		
Type/Reset						RW 0	RW 0	RW 1
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved							
Type/Reset								

Bits	Field	Descriptions
[18:16]	ADCDIV	ADC Clock Frequency Divide Selection 000: CK_ADC = (CK_AHB / 1) 001: CK_ADC = (CK_AHB / 2) 010: CK_ADC = (CK_AHB / 4) 011: CK_ADC = (CK_AHB / 8) 100: CK_ADC = (CK_AHB / 16) 101: CK_ADC = (CK_AHB / 32) 110: CK_ADC = (CK_AHB / 64) 111: CK_ADC = (CK_AHB / 3) Set and reset by software to control ADC conversion clock division factor.

APB Clock Control Register 0 – APBCCR0

This register specifies clock enable bits of APB peripherals.

Offset: 0x02C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	EXTIEN	AFIOEN		Reserved	UR1EN	UR0EN	Reserved	USREN
Type/Reset	RW 0	RW 0			RW 0	RW 0		RW 0
	7	6	5	4	3	2	1	0
		Reserved	SPI1EN	SPI0EN		Reserved	I2C1EN	I2C0EN
Type/Reset			RW 0	RW 0			RW 0	RW 0

Bits	Field	Descriptions
[15]	EXTIEN	External Interrupt Clock Enable 0: EXTI clock is disabled 1: EXTI clock is enabled Set and reset by software.
[14]	AFIOEN	Alternate Function I/O Clock Enable 0: AFIO clock is disabled 1: AFIO clock is enabled Set and reset by software.
[11]	UR1EN	UART1 Clock Enable 0: UART1 clock is disabled 1: UART1 clock is enabled Set and reset by software.
[10]	UR0EN	UART0 Clock Enable 0: UART0 clock is disabled 1: UART0 clock is enabled Set and reset by software.
[8]	USREN	USART Clock Enable 0: USART clock is disabled 1: USART clock is enabled Set and reset by software.
[5]	SPI1EN	SPI1 Clock Enable 0: SPI1 clock is disabled 1: SPI1 clock is enabled Set and reset by software.
[4]	SPI0EN	SPI0 Clock Enable 0: SPI0 clock is disabled 1: SPI0 clock is enabled Set and reset by software.

Bits	Field	Descriptions
[1]	I2C1EN	I²C1 Clock Enable 0: I²C1 clock is disabled 1: I²C1 clock is enabled Set and reset by software.
[0]	I2C0EN	I²C0 Clock Enable 0: I²C0 clock is disabled 1: I²C0 clock is enabled Set and reset by software.

APB Clock Control Register 1 – APBCCR1

This register specifies clock enable bits APB peripherals.

Offset: 0x030

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							ADCCEN
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved						BFTM1EN	BFTM0EN
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
		Reserved	PWM1EN	PWM0EN	Reserved			GPTMEN
Type/Reset			RW 0	RW 0				RW 0
	7	6	5	4	3	2	1	0
	Reserved	VDDREN	Reserved	WDTREN			Reserved	MCTMEN
Type/Reset		RW 0		RW 0				RW 0

Bits	Field	Descriptions
[24]	ADCCEN	ADC Controller Clock Enable 0: ADC clock is disabled 1: ADC clock is enabled Set and reset by software.
[17]	BFTM1EN	BFTM1 Clock Enable 0: BFTM1 clock is disabled 1: BFTM1 clock is enabled Set and reset by software.
[16]	BFTM0EN	BFTM0 Clock Enable 0: BFTM0 clock is disabled 1: BFTM0 clock is enabled Set and reset by software.
[13]	PWM1EN	PWM1 Clock Enable 0: PWM1 clock is disabled 1: PWM1 clock is enabled Set and reset by software.

Bits	Field	Descriptions
[12]	PWM0EN	PWM0 Clock Enable 0: PWM0 clock is disabled 1: PWM0 clock is enabled Set and reset by software.
[8]	GPTMEN	GPTM Clock Enable 0: GPTM clock is disabled 1: GPTM clock is enabled Set and reset by software.
[6]	VDDREN	V_{DD} Domain Clock Enable for Registers Access 0: Register access clock is disabled 1: Register access clock is enabled Set and reset by software.
[4]	WDTREN	Watchdog Timer Clock Enable for Registers Access 0: Register access clock is disabled 1: Register access clock is enabled Set and reset by software.
[0]	MCTMEN	MCTM Clock Enable 0: MCTM clock is disabled 1: MCTM clock is enabled Set and reset by software.

Clock Source Status Register – CKST

This register specifies status of clock source.

Offset: 0x034

Reset value: 0x0100_0003

	31	30	29	28	27	26	25	24
	Reserved					HSIST		
Type/Reset						RO 0	RO 0	RO 1
	23	22	21	20	19	18	17	16
	Reserved						HSEST	
Type/Reset							RO 0	RO 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					CKSWST		
Type/Reset						RO 0	RO 1	RO 1

Bits	Field	Descriptions
[26:24]	HSIST	Internal High Speed Clock Occupation Status (CK_HSI) xx1: HSI is used by System Clock (CK_SYS) (SW = 0x3) x1x: Reserved 1xx: HSI is used by Clock Monitor
[17:16]	HSEST	External High Speed Clock Occupation Status (CK_HSE) x1: HSE is used by System Clock (CK_SYS) (SW = 0x2) 1x: Reserved
[2:0]	CKSWST	Clock Switch Status 00x: Reserved 010: CK_HSE as system clock 011: CK_HSI as system clock 110: CK_LSE as system clock 111: CK_LSI as system clock The fields are status to indicate which clock source is using as system clock currently.

APB Peripheral Clock Selection Register 0 – APBPCSR0

This register specifies APB peripheral clock prescaler selection.

Offset: 0x038

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	UR1PCLK		UR0PCLK		Reserved		USRPCLK	
Type/Reset	RW 0	RW 0	RW 0	RW 0			RW 0	RW 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	Reserved		GPTMPCLK		Reserved		MCTMPCLK	
Type/Reset			RW 0	RW 0			RW 0	RW 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	BFTM1PCLK		BFTM0PCLK		Reserved			
Type/Reset	RW 0	RW 0	RW 0	RW 0				
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	SPI1PCLK		SPI0PCLK		I2C1PCLK		I2C0PCLK	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:30]	UR1PCLK	UART1 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[29:28]	UR0PCLK	UART0 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[25:24]	USRPCLK	USART Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[21:20]	GPTMPCLK	GPTM Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock

Bits	Field	Descriptions
[17:16]	MCTMPCLK	MCTM Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[15:14]	BFTM1PCLK	BFTM1 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[13:12]	BFTM0PCLK	BFTM0 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[7:6]	SPI1PCLK	SPI1 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[5:4]	SPI0PCLK	SPI0 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[3:2]	I2C1PCLK	I^2C1 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[1:0]	I2C0PCLK	I^2C0 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock

APB Peripheral Clock Selection Register 1 – APBPCSR1

This register specifies APB peripheral clock prescaler selection.

Offset: 0x03C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	VDDRPCLK		WDTRPCLK		Reserved			
Type/Reset	RW 0	RW 0	RW 0	RW 0				
	7	6	5	4	3	2	1	0
	Reserved		ADCCPCLK		EXTIPCLK		AFIOPCLK	
Type/Reset			RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:14]	VDDRPCLK	V_{DD} Domain Register Access Clock Selection 00: PCLK = CK_AHB / 4 01: PCLK = CK_AHB / 8 10: PCLK = CK_AHB / 16 11: PCLK = CK_AHB / 32 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[13:12]	WDTRPCLK	WDT Register Access Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[5:4]	ADCCPCLK	ADC Controller Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[3:2]	EXTIPCLK	EXTI Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock

Bits	Field	Descriptions
[1:0]	AFIOPCLK	AFIO Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock

HSI Control Register – HSICR

This register is to control the frequency trimming of HSI RC oscillation.

Offset: 0x040

Reset value: 0xXXXX_0000 where X is undefined

	31	30	29	28	27	26	25	24
	Reserved			HSICOARSE				
Type/Reset				RO X	RO X	RO X	RO X	RO X
	23	22	21	20	19	18	17	16
	HSIFINE							
Type/Reset	RW X	RW X	RW X	RW X	RW X	RW X	RW X	RW X
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	FLOCK		REFCLKSEL	TMSEL	ATMSEL	LTRSEL	ATCEN	TRIMEN
Type/Reset	RO 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[28:24]	HSICOARSE	HSI Clock Coarse Trimming Value These bits are initialized automatically at startup. They are adjusted by factory trimming and cannot trim by program.
[23:16]	HSIFINE	HSI Clock Fine Trimming Value These bits are initialized automatically at startup. They are also adjusted by factory trimming. But these bits provide an additional user-programmable trimming value that is added to the HSICOARSE[4:0] bits to get more accurate or compensate the variations in voltage and temperature that influence the frequency of the HSI. It can be programmed by software or automatically adjusted by the Auto Trimming Controller (ATC) with an external reference clock.
[7]	FLOCK	Frequency Lock 0: HSI frequency is not trimmed into target range 1: HSI frequency is trimmed into target range
[6:5]	REFCLKSEL	Reference Clock Selection 0x: Select 32.768 kHz external low speed clock source (LSE) 1x: Select external pin (CKIN) 1 kHz pulse These bits are used to select the reference clock for the HSI Auto Trimming Controller.

Bits	Field	Descriptions
[4]	TMSEL	Trimming Mode Selection 0: Automatic by Auto Trimming Controller 1: Manual by user program This bit is used to select the HSI RC oscillator trimming function by ATC hardware or user programming via the HSIFINE[7:0] bits in the HSI Control Register.
[3]	ATMSEL	Automatic Trimming Mode Selection 0: Auto Trimming Controller uses binary search to approach the target range 1: Auto Trimming Controller uses linear search to approach the target range This bit is selected the automatic trimming method by ATC hardware for HSI RC oscillator.
[2]	LTRSEL	Lock Target Range Selection 0: 0.1 % variation 1: 0.2 % variation This bit is selected the lock target range of the internal HSI RC oscillator trimming function for 0.1 % or 0.2 % variation.
[1]	ATCEN	ATC Enable 0: Disable Auto Trimming Controller 1: Enable Auto Trimming Controller
[0]	TRIMEN	Trimming Enable 0: HSI Trimming is disable 1: HSI Trimming is enable The bit enables the HSI RC oscillator trimming function by ATC hardware or user programming.

HSI Auto Trimming Counter Register – HSIATCR

This register contains the counter value of the HSI auto trimming controller.

Offset: 0x044

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved		ATCNT					
Type/Reset			RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	7	6	5	4	3	2	1	0
	ATCNT							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[13:0]	ATCNT	Auto Trimming Counter These bits contain the counter value of the HSI auto trimming controller.

APB Peripheral Clock Selection Register 2 – APBPCSR2

This register specifies APB peripheral clock prescaler selection.

Offset: 0x048

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				PWM1PCLK		PWM0PCLK	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved							
Type/Reset								

Bits	Field	Descriptions
[19:18]	PWM1PCLK	PWM1 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock
[17:16]	PWM0PCLK	PWM0 Peripheral Clock Selection 00: PCLK = CK_AHB 01: PCLK = CK_AHB / 2 10: PCLK = CK_AHB / 4 11: PCLK = CK_AHB / 8 PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock

MCU Debug Control Register – MCUDBGCR

This register specifies debug control of MCU.

Offset: 0x304

Reset value: 0x0000_0000 (Reset by VDD domain reset only)

	31	30	29	28	27	26	25	24
	DBPWM1	DBPWM0	Reserved					
Type/Reset	RW 0	RW 0						
	23	22	21	20	19	18	17	16
	Reserved				DBUR1	DBUR0	DBBFTM1	DBBFTM0
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved	DBDSLP2	DBI2C1	DBI2C0	DBSPI1	DBSPI0	Reserved	DBUSR
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0		RW 0
	7	6	5	4	3	2	1	0
	Reserved	DBGPTM	Reserved	DBMCTM	DBWDT	Reserved	DBDSLP1	DBSLP
Type/Reset		RW 0		RW 0	RW 0		RW 0	RW 0

Bits	Field	Descriptions
[31]	DBPWM1	PWM1 Debug Mode Enable 0: PWM1 counter continues to count even if the core is halted 1: PWM1 counter is stopped when the core is halted Set and reset by software.
[30]	DBPWM0	PWM0 Debug Mode Enable 0: PWM0 counter continues to count even if the core is halted 1: PWM0 counter is stopped when the core is halted Set and reset by software.
[19]	DBUR1	UART1 Debug Mode Enable 0: Same behavior as in normal mode 1: UART1 timeout is frozen when the core is halted Set and reset by software.
[18]	DBUR0	UART0 Debug Mode Enable 0: Same behavior as in normal mode 1: UART0 timeout is frozen when the core is halted Set and reset by software.
[17]	DBBFTM1	BFTM1 Debug Mode Enable 0: BFTM1 counter continues even if the core is halted 1: BFTM1 counter is stopped when the core is halted Set and reset by software.
[16]	DBBFTM0	BFTM0 Debug Mode Enable 0: BFTM0 counter continues to count even if the core is halted 1: BFTM0 counter is stopped when the core is halted Set and reset by software.
[14]	DBDSLP2	Debug Deep-Sleep2 0: LDO = Off (but turn on DMOS), FCLK = Off and CM0PEN = 0 in Deep-Sleep2 mode 1: LDO = On, FCLK = On and CM0PEN = 1 in Deep-Sleep2 mode Set and reset by software.

Bits	Field	Descriptions
[13]	DBI2C1	I²C1 Debug Mode Enable 0: Same behavior as in normal mode 1: I²C1 timeout is frozen when the core is halted Set and reset by software.
[12]	DBI2C0	I²C0 Debug Mode Enable 0: Same behavior as in normal mode 1: I²C0 timeout is frozen when the core is halted Set and reset by software.
[11]	DBSPI1	SPI1 Debug Mode Enable 0: Same behavior as in normal mode 1: SPI1 FIFO timeout is frozen when the core is halted Set and reset by software.
[10]	DBSPI0	SPI0 Debug Mode Enable 0: Same behavior as in normal mode 1: SPI0 FIFO timeout is frozen when the core is halted Set and reset by software.
[8]	DBUSR	USART Debug Mode Enable 0: Same behavior as in normal mode 1: USART timeout is frozen when the core is halted Set and reset by software.
[6]	DBGPTM	GPTM Debug Mode Enable 0: GPTM counter continues to count even if the core is halted 1: GPTM counter is stopped when the core is halted Set and reset by software.
[4]	DBMCTM	MCTM Debug Mode Enable 0: MCTM counter continues even if the core is halted 1: MCTM counter is stopped when the core is halted Set and reset by software.
[3]	DBWDT	Watchdog Timer Debug Mode Enable 0: Watchdog Timer counter continues to count even if the core is halted 1: Watchdog Timer counter is stopped when the core is halted Set and reset by software.
[1]	DBDSLP1	Debug Deep-Sleep1 0: LDO = Low power mode, FCLK = Off and CM0PEN = 0 in Deep-Sleep1 mode 1: LDO = On, FCLK = On and CM0PEN = 1 in Deep-Sleep1 mode Set and reset by software.
[0]	DBSLP	Debug Sleep Mode 0: LDO = On, FCLK = On and CM0PEN = 0 in Sleep mode 1: LDO = On, FCLK = On and CM0PEN = 1 in Sleep mode Set and reset by software.

7 Reset Control Unit (RSTCU)

Introduction

The Reset Control Unit, RSTCU, has three kinds of reset, the power on reset, system reset and APB unit reset. The power on reset, known as a cold reset, resets the full system during a power up. A system reset resets the processor core and peripheral IP components with the exception of the debug port controller. The resets can be triggered by an external signal, internal events and the reset generators. More information about these resets will be described in the following section.

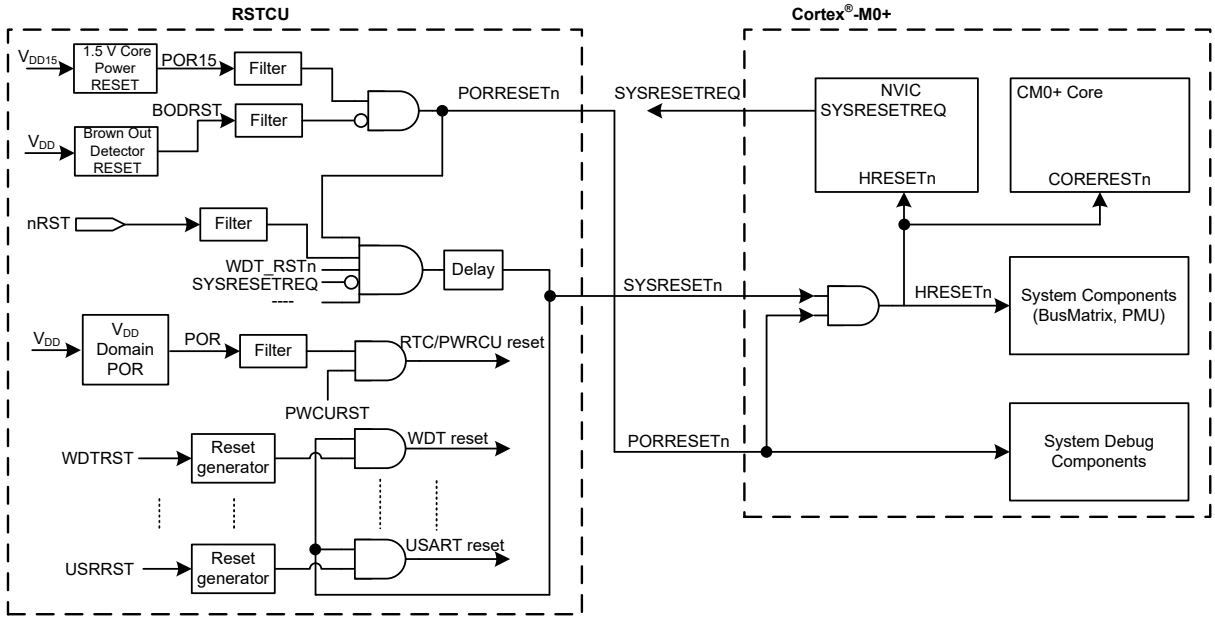


Figure 17. RSTCU Block Diagram

Functional Descriptions

Power On Reset

The Power on reset, POR, is generated by either an external reset or the internal reset generator. Both types have an internal filter to prevent glitches from causing erroneous reset operations. By referring to Figure 18, the POR15 active low signal will be de-asserted when the internal LDO voltage regulator is ready to provide a 1.5 V power. In addition to the POR15 signal, the Power Control Unit, PWRCU, will assert the BODF signal as a Power Down Reset, PDR, when the BODEN bit in the LVDCSR register is set and the brown-out event occurs. For more details about the PWRCU function, refer to the PWRCU chapter.

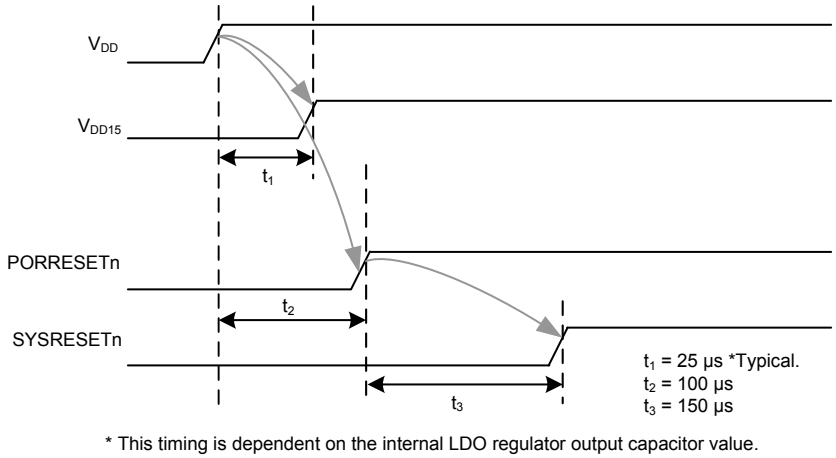


Figure 18. Power On Reset Sequence

System Reset

A system reset is generated by a power on reset (PORRESETn), a Watchdog Timer reset (WDT_RSTn), nRST pin or a software reset (SYSRESETREQ) event. For more information about SYSRESETREQ event, refer to the related chapter in the Cortex®-M0+ reference manual.

AHB and APB Unit Reset

The AHB and APB unit reset can be divided into hardware and software resets. A hardware reset can be generated by either power on reset or system reset for all AHB and APB units. Each functional IP connected to the AHB and APB buses can be reset individually through the associated software reset bits in the RSTCU. For example, the application software can generate a USART reset via the USRRST bit in the APBPRSTR0 register.

Register Map

The following table shows the RSTCU registers and reset values.

Table 16. RSTCU Register Map

Register	Offset	Description	Reset Value
GRSR	0x100	Global Reset Status Register	0x0000_0008
AHBPRSTR	0x104	AHB Peripheral Reset Register	0x0000_0000
APBPRSTR0	0x108	APB Peripheral Reset Register 0	0x0000_0000
APBPRSTR1	0x10C	APB Peripheral Reset Register 1	0x0000_0000

Register Descriptions

Global Reset Status Register – GRSR

This register specifies a variety of reset status conditions.

Offset: 0x100

Reset value: 0x0000_0008

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				PORSTF	WDTRSTF	EXTRSTF	NVICRSTF
Type/Reset					WC 1	WC 0	WC 0	WC 0

Bits	Field	Descriptions
[3]	PORSTF	Core 1.5 V Power On Reset Flag 0: No POR occurred 1: POR occurred This bit is set by hardware when a power on reset occurs and reset by writing 1 into it.
[2]	WDTRSTF	Watchdog Timer Reset Flag 0: No Watchdog Timer reset occurred 1: Watchdog Timer occurred This bit is set by hardware when a watchdog timer reset occurs and reset by writing 1 into it or by hardware when a power on reset occurs.
[1]	EXTRSTF	External Pin Reset Flag 0: No pin reset occurred 1: Pin reset occurred This bit is set by hardware when an external pin reset occurs and reset by writing 1 into it or by hardware when a power on reset occurs.

Bits	Field	Descriptions
[0]	NVICRSTF	NVIC Reset Flag 0: No NVIC asserting system reset occurred 1: NVIC asserting system reset occurred This bit is set by hardware when a system reset occurs and reset by writing 1 into it or by hardware when a power on reset occurs.

AHB Peripheral Reset Register – AHBPRSTR

This register specifies several AHB peripherals software reset control bits.

Offset: 0x104
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							DIVRST
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					PCRST	PBRST	PARST
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CRCRST	Reserved						
Type/Reset	RW 0							

Bits	Field	Descriptions
[24]	DIVRST	Divider Reset Control 0: No reset 1: Reset Divider This bit is set by software and cleared to 0 by hardware automatically.
[10]	PCRST	GPIO Port C Reset Control 0: No reset 1: Reset Port C This bit is set by software and cleared to 0 by hardware automatically.
[9]	PBRST	GPIO Port B Reset Control 0: No reset 1: Reset Port B This bit is set by software and cleared to 0 by hardware automatically.
[8]	PARST	GPIO Port A Reset Control 0: No reset 1: Reset Port A This bit is set by software and cleared to 0 by hardware automatically.
[7]	CRCRST	CRC Reset Control 0: No reset 1: Reset CRC This bit is set by software and cleared to 0 by hardware automatically.

APB Peripheral Reset Register 0 – APBPRSTR0

This register specifies several APB peripherals software reset control bits.

Offset: 0x108

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	EXTIRST	AFIORST		Reserved	UR1RST	UR0RST	Reserved	USRRST
Type/Reset	RW 0	RW 0			RW 0	RW 0		RW 0
	7	6	5	4	3	2	1	0
		Reserved	SPI1RST	SPI0RST		Reserved	I2C1RST	I2C0RST
Type/Reset			RW 0	RW 0			RW 0	RW 0

Bits	Field	Descriptions
[15]	EXTIRST	External Interrupt Controller Reset Control 0: No reset 1: Reset EXTI This bit is set by software and cleared to 0 by hardware automatically.
[14]	AFIORST	Alternate Function I/O Reset Control 0: No reset 1: Reset Alternate Function I/O This bit is set by software and cleared to 0 by hardware automatically.
[11]	UR1RST	UART1 Reset Control 0: No reset 1: Reset UART1 This bit is set by software and cleared to 0 by hardware automatically.
[10]	UR0RST	UART0 Reset Control 0: No reset 1: Reset UART0 This bit is set by software and cleared to 0 by hardware automatically.
[8]	USRRST	USART Reset Control 0: No reset 1: Reset USART This bit is set by software and cleared to 0 by hardware automatically.
[5]	SPI1RST	SPI1 Reset Control 0: No reset 1: Reset SPI1 This bit is set by software and cleared to 0 by hardware automatically.
[4]	SPI0RST	SPI0 Reset Control 0: No reset 1: Reset SPI0 This bit is set by software and cleared to 0 by hardware automatically.

Bits	Field	Descriptions
[1]	I2C1RST	I^2C1 Reset Control 0: No reset 1: Reset I^2C1 This bit is set by software and cleared to 0 by hardware automatically.
[0]	I2C0RST	I^2C0 Reset Control 0: No reset 1: Reset I^2C0 This bit is set by software and cleared to 0 by hardware automatically.

APB Peripheral Reset Register 1 – APBPRSTR1

This register specifies several APB peripherals software reset control bits.

Offset: 0x10C
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							ADCRST
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved						BFTM1RST	BFTM0RST
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
		Reserved	PWM1RST	PWM0RST	Reserved			GPTMRST
Type/Reset			RW 0	RW 0				RW 0
	7	6	5	4	3	2	1	0
	Reserved			WDTRST	Reserved			MCTMRST
Type/Reset				RW 0				RW 0

Bits	Field	Descriptions
[24]	ADCRST	A/D Converter Reset Control 0: No reset 1: Reset A/D Converter This bit is set by software and cleared to 0 by hardware automatically.
[17]	BFTM1RST	BFTM1 Reset Control 0: No reset 1: Reset BFTM1 This bit is set by software and cleared to 0 by hardware automatically.
[16]	BFTM0RST	BFTM0 Reset Control 0: No reset 1: Reset BFTM0 This bit is set by software and cleared to 0 by hardware automatically.
[13]	PWM1RST	PWM1 Reset Control 0: No reset 1: Reset PWM1 This bit is set by software and cleared to 0 by hardware automatically.

Bits	Field	Descriptions
[12]	PWM0RST	PWM0 Reset Control 0: No reset 1: Reset PWM0 This bit is set by software and cleared to 0 by hardware automatically.
[8]	GPTMRST	GPTM Reset Control 0: No reset 1: Reset GPTM This bit is set by software and cleared to 0 by hardware automatically.
[4]	WDTRST	Watchdog Timer Reset Control 0: No reset 1: Reset Watchdog Timer This bit is set by software and cleared to 0 by hardware automatically.
[0]	MCTMRST	MCTM Reset Control 0: No reset 1: Reset MCTM This bit is set by software and cleared to 0 by hardware automatically.

8 General Purpose I/O (GPIO)

Introduction

There are up to 40 General Purpose I/O port, GPIO, named PA0 ~ PA15, PB0 ~ PB15 and PC0 ~ PC7 for the device to implement the logic input/output functions. Each of the GPIO ports has related control and configuration registers to satisfy the requirement of specific applications. The really available General Purpose I/O port numbers are dependent on the device specification and package type. Plase refer the device data sheet for detail information.

The GPIO ports are pin-shared with other alternative functions (AFs) to obtain maximum flexibility on the package pins. The GPIO pins can be used as alternative functional pins by configuring the corresponding registers regardless of the AF input or output pins.

The external interrupts on the GPIO pins of the device have related control and configuration registers in the External Interrupt Control Unit (EXTI).

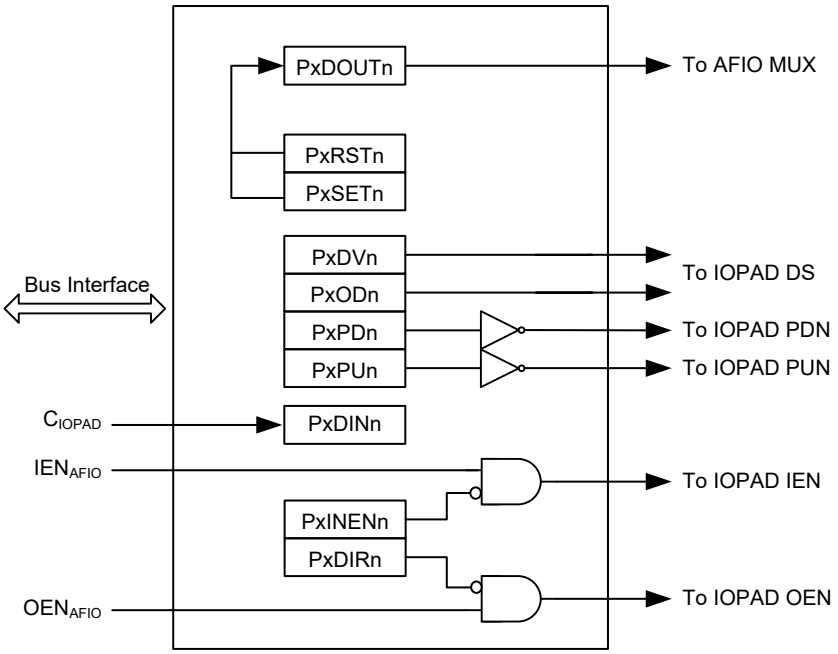


Figure 19. GPIO Block Diagram

Features

- Input / output direction control
- Input weak pull-up / pull-down control
- Output push-pull / open-drain enable control
- Output set / reset control
- Output drive current selection
- External interrupt with programmable trigger edge – Using EXTI configuration registers
- Analog input / output configurations – Using AFIO configuration registers
- Alternate function input / output configurations – Using AFIO configuration registers
- Port configuration lock

Functional Descriptions

Default GPIO Pin Configuration

During or just after the reset period, the alternative functions are all inactive and the GPIO ports are configured into the input disable floating mode, i.e. input disabled without pull-up / pull-down resistors. Only the boot and Serial-Wired Debug pins which are pin-shared with the I/O pins are active after a device reset.

- BOOT: Input enable with internal pull-up
- SWCLK: Input enable with internal pull-up
- SWDIO: Input enable with internal pull-up

General Purpose I/O – GPIO

The GPIO pins can be configured as inputs or outputs via the data direction control registers PxDIRCR (where x = A ~ C). When the GPIO pins are configured as input pins, the data on the external pads can be read if the enable bits in the input enable function register PxINER are set. The GPIO pull-up / pull-down registers PxPUR / PxPDR can be configured to fit specific applications. When the pull-up and pull-down functions are both enabled, the pull-up function has the higher priority while the pull-down function will be blocked until the pull-up function is released.

The GPIO pins can be configured as output pins where the output data is latched into the data register PxDOUTR. The output type can be setup to be either push-pull or open-drain by the open drain selection register PxODR. Only one or several specific bits of the output data will be set or reset by configuring the port output set and reset control register PxSRR or the port output reset control register PxRR without affecting the unselected bits. As the port output set and reset functions are both enabled, the port output set function has the higher priority and the port output reset function will be blocked. The output driving current of the GPIO pins can be selected by configuring the drive current selection register PxDRVR.

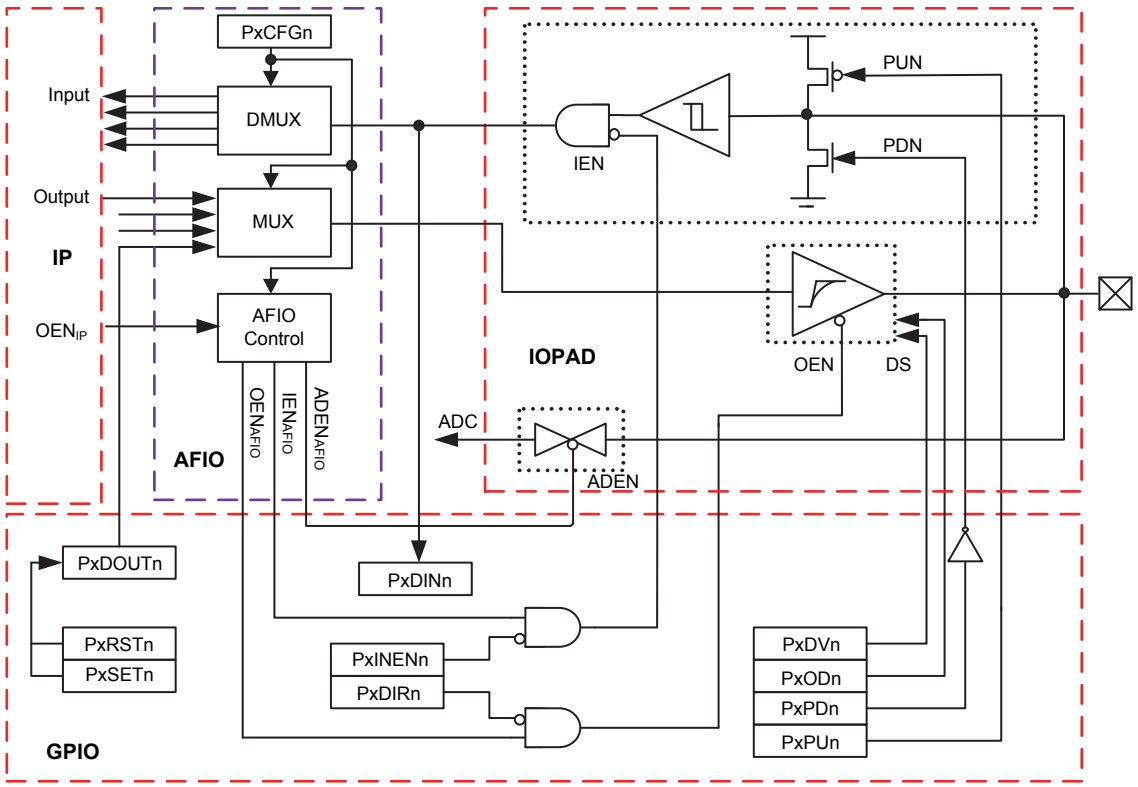


Figure 20. AFIO / GPIO Control Signal

PxDINn / PxDOUTn (x = A ~ C): Data Input / Data Output

PxRSTn / PxSETn (x = A ~ C): Reset / Set

PxDIRn (x = A ~ C): Direction

PxINENn (x = A ~ C): Input Enable

PxDVn (x = A ~ C): Output Drive

PxODn (x = A ~ C): Open Drain

PxPDn / PxPUn (x = A ~ C): Pull Down / Up

PxCFGn (x = A ~ C): AFIO Configuration

Table 17. AFIO, GPIO and I/O Pad Control Signal True Table

Type	AFIO			GPIO		PAD		
	$ADEN_{AFIO}$	OEN_{AFIO}	IEN_{AFIO}	PxDIRn	PxINENn	ADEN	OEN	IEN
GPIO Input (Note)	1	1	1	0	1	1	1	0
GPIO Output (Note)	1	1	1	1	0 (1 if need)	1	0	1 (0)
AFIO Input	1	1	0	0	X	1	1	0
AFIO Output	1	0	1	X	0 (1 if need)	1	0	1 (0)
ADC Input	0	1	1	0	0 (1 if need)	0	1	1 (0)
OSC Output	0	1	1	0	0 (1 if need)	0	1	1 (0)

Note: The signals, IEN and OEN, for I/O pads are derived from the GPIO register bits PxINENn and PxDIRn respectively when the associated pin is configured in the GPIO input / output mode.

GPIO Locking Mechanism

The GPIO also offers a lock function to lock the port until a reset event occurs. The PxLOCKR (x = A ~ C) registers are used to lock the port x and lock control options. The value 0x5FA0 is written into the PxLKEY field in the PxLOCKR registers to freeze the PxDIRCR, PxINER, PxPUR, PxPDR, PxODR, PxDRVR control and AFIO mode configuration (GPxCFGHR or GPxCFGLR, where x = A ~ C). If the value in the PxLOCKR register is 0x5FA0_0001, it means that the Port x Lock function is enabled and the Port x pin 0 is frozen.

Register Map

The following table shows the GPIO registers and reset values of the Port A ~ C.

Table 18. GPIO Register Map

Register	Offset	Description	Reset Value
GPIO A Base Address = 0x400B_0000			
PADIRCR	0x000	Port A Data Direction Control Register	0x0000_0000
PAINER	0x004	Port A Input Function Enable Control Register	0x0000_0200
PAPUR	0x008	Port A Pull-Up Selection Register	0x0000_3200
PAPDR	0x00C	Port A Pull-Down Selection Register	0x0000_0000
PAODR	0x010	Port A Open-Drain Selection Register	0x0000_0000
PADRVR	0x014	Port A Drive Current Selection Register	0x0000_0000
PALOCKR	0x018	Port A Lock Register	0x0000_0000
PADINR	0x01C	Port A Data Input Register	0x0000_3200
PADOUTR	0x020	Port A Data Output Register	0x0000_0000
PASRR	0x024	Port A Output Set / Reset Control Register	0x0000_0000
PARR	0x028	Port A Output Reset Control Register	0x0000_0000
PASCER	0x02C	Port A Sink Current Enhanced Selection Register	0x0000_0000
GPIO B Base Address = 0x400B_2000			
PBDIRCR	0x000	Port B Data Direction Control Register	0x0000_0000
PBINER	0x004	Port B Input Function Enable Control Register	0x0000_0000
PBPUR	0x008	Port B Pull-Up Selection Register	0x0000_0000
PBPDR	0x00C	Port B Pull-Down Selection Register	0x0000_0000
PBODR	0x010	Port B Open-Drain Selection Register	0x0000_0000
PBDRVR	0x014	Port B Drive Current Selection Register	0x0000_0000
PBLOCKR	0x018	Port B Lock Register	0x0000_0000
PBDINR	0x01C	Port B Data Input Register	0x0000_0000
PBDOUTR	0x020	Port B Data Output Register	0x0000_0000
PBSRR	0x024	Port B Output Set / Reset Control Register	0x0000_0000
PBRR	0x028	Port B Output Reset Control Register	0x0000_0000
PBSCER	0x02C	Port B Sink Current Enhanced Selection Register	0x0000_0000
GPIO C Base Address = 0x400B_4000			
PCDIRCR	0x000	Port C Data Direction Control Register	0x0000_0000
PCINER	0x004	Port C Input Function Enable Control Register	0x0000_0000
PCPUR	0x008	Port C Pull-Up Selection Register	0x0000_0000
PCPDR	0x00C	Port C Pull-Down Selection Register	0x0000_0000
PCODR	0x010	Port C Open-Drain Selection Register	0x0000_0000
PCDRVR	0x014	Port C Drive Current Selection Register	0x0000_0000

Register	Offset	Description	Reset Value
PCLOCKR	0x018	Port C Lock Register	0x0000_0000
PCDINR	0x01C	Port C Data Input Register	0x0000_0000
PCDOUTR	0x020	Port C Data Output Register	0x0000_0000
PCSRR	0x024	Port C Output Set / Reset Control Register	0x0000_0000
PCRR	0x028	Port C Output Reset Control Register	0x0000_0000
PCSCER	0x02C	Port C Sink Current Enhanced Selection Register	0x0000_0000

Register Descriptions

Port A Data Direction Control Register – PADIRCR

This register is used to control the direction of the GPIO Port A pin as input or output.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PADIR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PADIR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PADIRn	GPIO Port A pin n Direction Control Bits (n = 0 ~ 15) 0: Pin n is in input mode 1: Pin n is in output mode

Port A Input Function Enable Control Register – PAINER

This register is used to enable or disable the GPIO Port A input function.

Offset: 0x004

Reset value: 0x0000_0200

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PAINEN							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 1	RW 0
	7	6	5	4	3	2	1	0
	PAINEN							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PAINENn	GPIO Port A pin n Input Enable Control Bits (n = 0 ~ 15) 0: Pin n input function is disabled 1: Pin n input function is enabled When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state.

Port A Pull-Up Selection Register – PAPUR

This register is used to enable or disable the GPIO Port A pull-up function.

Offset: 0x008

Reset value: 0x0000_3200

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PAPU							
Type/Reset	RW 0	RW 0	RW 1	RW 1	RW 0	RW 0	RW 1	RW 0
	7	6	5	4	3	2	1	0
	PAPU							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PAPUn	GPIO Port A pin n Pull-Up Selection Control Bits (n = 0 ~ 15) 0: Pin n pull-up function is disabled 1: Pin n pull-up function is enabled Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.

Port A Pull-Down Selection Register – PAPDR

This register is used to enable or disable the GPIO Port A pull-down function.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PAPD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PAPD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PAPDn	GPIO Port A pin n Pull-Down Selection Control Bits (n = 0 ~ 15) 0: Pin n pull-down function is disabled 1: Pin n pull-down function is enabled Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.

Port A Open-Drain Selection Register – PAODR

This register is used to enable or disable the GPIO Port A open drain function.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	Reserved							
Type/Reset								
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	PAOD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	PAOD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PAODn	GPIO Port A pin n Open-Drain Selection Control Bits (n = 0 ~ 15) 0: Pin n Open-Drain output is disabled (The output type is CMOS output) 1: Pin n Open-Drain output is enabled (The output type is open-drain output) Note: When the open-drain function is enabled, the pin n internal pull-up or pull-down configuration will be invalid.

Port A Output Drive Current Selection Register – PADRVR

This register specifies the GPIO Port A output driving current.

Offset: 0x014

Reset value: 0x0000_0000

	31		30		29		28		27		26		25		24	
	PADV15				PADV14				PADV13				PADV12			
Type/Reset	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0
	23		22		21		20		19		18		17		16	
	PADV11				PADV10				PADV9				PADV8			
Type/Reset	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0
	15		14		13		12		11		10		9		8	
	PADV7				PADV6				PADV5				PADV4			
Type/Reset	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0
	7		6		5		4		3		2		1		0	
	PADV3				PADV2				PADV1				PADV0			
Type/Reset	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0	RW	0

Bits	Field	Descriptions
[31:0]	PADVn[1:0]	GPIO Port A pin n Output Drive Current Selection Control Bits (n = 0 ~ 15) 00: 4 mA source / sink current 01: 8 mA source / sink current 10: 12 mA source / sink current 11: 16 mA source / sink current

Port A Lock Register – PALOCKR

This register specifies the GPIO Port A lock configuration.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PALKEY							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	PALKEY							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	PALOCK							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PALOCK							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:16]	PALKEY	GPIO Port A Lock Key 0x5FA0: Port A Lock function is enabled Others: Port A Lock function is disabled To lock the Port A function, a value of 0x5FA0 should be written into the PALKEY field in this register. To execute a successful write operation on this lock register, the value written into the PALKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PALOCKR register will be aborted. The result of a read operation on the PALKEY field returns the GPIO Port A Lock Status which indicates whether the GPIO Port A is locked or not. If the read value of the PALKEY field is 0, this indicates that the GPIO Port A Lock function is disabled. Otherwise, it indicates that the GPIO Port A Lock function is enabled as the read value is equal to 1.
[15:0]	PALOCKn	GPIO Port A Pin n Lock Control Bits (n = 0 ~ 15) 0: Port A Pin n is not locked 1: Port A Pin n is locked The PALOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PALKEY field. The locked configurations including PADIRn, PAINENn, PAPUn, PAPDn, PAODn and PADVn setting in the related GPIO registers. Additionally, the GPACFGHR or GPACFGLR field register which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PALOCKR register can only be written once which means that PALKEY and PALOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port A reset occurs.

Port A Data Input Register – PADINR

This register specifies the GPIO Port A input data.

Offset: 0x01C

Reset value: 0x0000_3200

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PADIN							
Type/Reset	RO 0	RO 0	RO 1	RO 1	RO 0	RO 0	RO 1	RO 0
	7	6	5	4	3	2	1	0
	PADIN							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[15:0]	PADINn	GPIO Port A pin n Data Input Bits (n = 0 ~ 15) 0: The input data of pin n is 0 1: The input data of pin n is 1

Port A Output Data Register – PADOUTR

This register specifies the GPIO Port A output data.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PADOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PADOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PADOUTn	GPIO Port A pin n Data Output Bits (n = 0 ~ 15) 0: Data to be output on pin n is 0 1: Data to be output on pin n is 1

Port A Output Set / Reset Control Register – PASRR

This register is used to set or reset the corresponding bit of the GPIO Port A output data.

Offset: 0x024

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PARST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	PARST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	PASET							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	PASET							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[31:16]	PARSTn	GPIO Port A pin n Output Reset Control Bits (n = 0 ~ 15) 0: No effect on the PADOUTn bit 1: Reset the PADOUTn bit Note that when the PARSTn bit in this register or (and) the PARSTn bit in the PARR register is enabled, the reset function on the PADOUTn bit will take effect.
[15:0]	PASETn	GPIO Port A pin n Output Set Control Bits (n = 0 ~ 15) 0: No effect on the PADOUTn bit 1: Set the PADOUTn bit Note that the function enabled by the PASETn bit has the higher priority if both the PASETn and PARSTn bits are set at the same time.

Port A Output Reset Register – PARR

This register is used to reset the corresponding bit of the GPIO Port A output data.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PARST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	7	6	5	4	3	2	1	0
	PARST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[15:0]	PARSTn	GPIO Port A pin n Output Reset Control Bits (n = 0 ~ 15) 0: No effect on the PADOUTn bit 1: Reset the PADOUTn bit

Port A Sink Current Enhanced Selection Register – PASCER

This register specifies the GPIO Port A enhanced sink driving current.

Offset: 0x02C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PASCE15	PASCE14	PASCE13	PASCE12	PASCE11	PASCE10	PASCE9	PASCE8
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PASCE7	PASCE6	PASCE5	PASCE4	PASCE3	PASCE2	PASCE1	PASCE0
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PASCEn	GPIO Port A pin n Sink Current Enhanced Selection Control Bits (n = 0 ~ 15) 0: No enhanced sink current 1: Enhanced sink current

Port B Data Direction Control Register – PBDIRCR

This register is used to control the direction of GPIO Port B pin as input or output.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBDIR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBDIR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBDIRn	GPIO Port B pin n Direction Control Bits (n = 0 ~ 15) 0: Pin n is in input mode 1: Pin n is in output mode

Port B Input Function Enable Control Register – PBINER

This register is used to enable or disable the GPIO Port B input function.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBINEN							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBINEN							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBINENn	GPIO Port B pin n Input Enable Control Bits (n = 0 ~ 15) 0: Pin n input function is disabled 1: Pin n input function is enabled When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state.

Port B Pull-Up Selection Register – PBPUR

This register is used to enable or disable the GPIO Port B pull-up function.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBPU							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBPU							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBPUn	GPIO Port B pin n Pull-Up Selection Control Bits (n = 0 ~ 15) 0: Pin n pull-up function is disabled 1: Pin n pull-up function is enabled Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.

Port B Pull-Down Selection Register – PBPDR

This register is used to enable or disable the GPIO Port B pull-down function.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBPD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBPD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBPDn	GPIO Port B pin n Pull-Down Selection Control Bits (n = 0 ~ 15) 0: Pin n pull-down function is disabled 1: Pin n pull-down function is enabled Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.

Port B Open-Drain Selection Register – PBODR

This register is used to enable or disable the GPIO Port B open-drain function.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBOD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBOD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBODn	GPIO Port B pin n Open-Drain Selection Control Bits (n = 0 ~ 15) 0: Pin n Open Drain output is disabled (The output type is CMOS output) 1: Pin n Open Drain output is enabled (The output type is open-drain output) Note: When the open-drain function is enabled, the pin n internal pull-up or pull-down configuration will be invalid.

Port B Output Drive Current Selection Register – PBDRVR

This register specifies the GPIO Port B output driving current.

Offset: 0x014

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PBDV15		PBDV14		PBDV13		PBDV12	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	PBDV11		PBDV10		PBDV9		PBDV8	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	PBDV7		PBDV6		PBDV5		PBDV4	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBDV3		PBDV2		PBDV1		PBDV0	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	PBDVn[1:0]	GPIO Port B pin n Output Drive Current Selection Control Bits (n = 0 ~ 15) 00: 4 mA source / sink current 01: 8 mA source / sink current 10: 12 mA source / sink current 11: 16 mA source / sink current

Port B Lock Register – PBLOCKR

This register specifies the GPIO Port B lock configuration.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PBLKEY							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	PBLKEY							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	PBLOCK							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBLOCK							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:16]	PBLKEY	GPIO Port Block Key 0x5FA0: Port Block function is enabled Others: Port B Lock function is disabled To lock the Port B function, a value of 0x5FA0 should be written into the PBLKEY field in this register. To execute a successful write operation on this lock register, the value written into the PBLKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PBLOCKR register will be aborted. The result of a read operation on the PBLKEY field returns the GPIO Port B Lock Status which indicates whether the GPIO Port B is locked or not. If the read value of the PBLKEY field is 0, this indicates that the GPIO Port B Lock function is disabled. Otherwise, it indicates that the GPIO Port B Lock function is enabled as the read value is equal to 1.
[15:0]	PBLOCKn	GPIO Port B pin n Lock Control Bits (n = 0 ~ 15) 0: Port B pin n is not locked 1: Port B pin n is locked The PBLOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PBLKEY field. The locked configurations including PBDIRn, PBINENn, PBPUn, PBPDn, PBODn and PBDVn setting in the related GPIO registers. Additionally, the GPBCFGHR or GPBCFGLR register which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PBLOCKR register can only be written once which means that PBLKEY and PBLOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port B reset occurs.

Port B Data Input Register – PBDINR

This register specifies the GPIO Port B input data.

Offset: 0x01C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBDIN							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	7	6	5	4	3	2	1	0
	PBDIN							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[15:0]	PBDINn	GPIO Port B pin n Data Input Bits (n = 0 ~ 15) 0: The input data of corresponding pin is 0 1: The input data of corresponding pin is 1

Port B Output Data Register – PBDOUTR

This register specifies the GPIO Port B output data.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBDOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBDOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBDOUTn	GPIO Port B pin n Data Output Bits (n = 0 ~ 15) 0: Data to be output on pin n is 0 1: Data to be output on pin n is 1

Port B Output Set / Reset Control Register – PBSRR

This register is used to set or reset the corresponding bit of the GPIO Port B output data.

Offset: 0x024

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PBRST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	23	22	21	20	19	18	17	16
	PBRST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	15	14	13	12	11	10	9	8
	PBSET							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	7	6	5	4	3	2	1	0
	PBSET							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[31:16]	PBRSTn	GPIO Port B pin n Output Reset Control Bits (n = 0 ~ 15) 0: No effect on the PBDOUTn bit 1: Reset the PBDOUTn bit Note that when the PBRSTn bit in this register or (and) the PBRSTn bit in the PBRR register is enabled, the reset function on the PBDOUTn bit will take effect.
[15:0]	PBSETn	GPIO Port B pin n Output Set Control Bits (n = 0 ~ 15) 0: No effect on the PBDOUTn bit 1: Set the PBDOUTn bit Note that the function enabled by the PBSETn bit has the higher priority if both the PBSETn and PBRSTn bits are set at the same time.

Port B Output Reset Register – PBRR

This register is used to reset the corresponding bit of the GPIO Port B output data.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBRST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	7	6	5	4	3	2	1	0
	PBRST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[15:0]	PBRSTn	GPIO Port B pin n Output Reset Control Bits (n = 0 ~ 15) 0: No effect on the PBDOUTn bit 1: Reset the PBDOUTn bit

Port B Sink Current Enhanced Selection Register – PBSCER

This register specifies the GPIO Port B enhanced sink driving current.

Offset: 0x02C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PBSCE15	PBSCE14	PBSCE13	PBSCE12	PBSCE11	PBSCE10	PBSCE9	PBSCE8
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PBSCE7	PBSCE6	PBSCE5	PBSCE4	PBSCE3	PBSCE2	PBSCE1	PBSCE0
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PBSCEn	GPIO Port B pin n Sink Current Enhanced Selection Control Bits (n = 0 ~ 15) 0: No enhanced sink current 1: Enhanced sink current

Port C Data Direction Control Register – PCDIRCR

This register is used to control the direction of GPIO Port C pin as input or output.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCDIR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCDIRn	GPIO Port C pin n Direction Control Bits (n = 0 ~ 7) 0: Pin n is in input mode 1: Pin n is in output mode

Port C Input Function Enable Control Register – PCINER

This register is used to enable or disable the GPIO Port C input function.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCINEN							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCINENn	GPIO Port C pin n Input Enable Control Bits (n = 0 ~ 7) 0: Pin n input function is disabled 1: Pin n input function is enabled When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state.

Port C Pull-Up Selection Register – PCPUR

This register is used to enable or disable the GPIO Port C pull-up function.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCPU							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCPUn	GPIO Port C pin n Pull-Up Selection Control Bits (n = 0 ~ 7) 0: Pin n pull-up function is disabled 1: Pin n pull-up function is enabled Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.

Port C Pull-Down Selection Register – PCPDR

This register is used to enable or disable the GPIO Port C pull-down function.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCPD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCPDn	GPIO Port C pin n Pull-Down Selection Control Bits (n = 0 ~ 7) 0: Pin n pull-down function is disabled 1: Pin n pull-down function is enabled Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.

Port C Open Drain Selection Register – PCODR

This register is used to enable or disable the GPIO Port C open drain function.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCOD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCODn	GPIO Port C pin n Open Drain Selection Control Bits (n = 0 ~ 7) 0: Pin n Open Drain output is disabled (The output type is CMOS output) 1: Pin n Open Drain output is enabled (The output type is open-drain output) Note: When the open-drain function is enabled, the pin n internal pull-up or pull-down configuration will be invalid.

Port C Output Current Drive Selection Register – PCDRVR

This register specifies the GPIO Port C output driving current.

Offset: 0x014

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PCDV7		PCDV6		PCDV5		PCDV4	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PCDV3		PCDV2		PCDV1		PCDV0	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PCDVn[1:0]	GPIO Port C pin n Output Drive Current Selection Control Bits (n = 0 ~ 7) 00: 4 mA source / sink current 01: 8 mA source / sink current 10: 12 mA source / sink current 11: 16 mA source / sink current

Port C Lock Register – PCLOCKR

This register specifies the GPIO Port C lock configuration.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PCLKEY							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	PCLKEY							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	Reserved							
Type/Reset								
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	PCLOCK							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:16]	PCLKEY	GPIO Port C lock Key 0x5FA0: Port C Lock function is enabled Others: Port C Lock function is disabled To lock the Port C function, a value of 0x5FA0 should be written into the PCLKEY field in this register. To execute a successful write operation on this lock register, the value written into the PCLKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PCLOCKR register will be aborted. The result of a read operation on the PCLKEY field returns the GPIO Port C Lock Status which indicates whether the GPIO Port C is locked or not. If the read value of the PCLKEY field is 0, this indicates that the GPIO Port C Lock function is disabled. Otherwise, it indicates that the GPIO Port C Lock function is enabled as the read value is equal to 1.
[7:0]	PCLOCKn	GPIO Port C pin n Lock Control Bits (n = 0 ~ 7) 0: Port C pin n is not locked 1: Port C pin n is locked The PCLOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PCLKEY field. The locked configurations including PCDIRn, PCINENn, PCPUn, PCPDn, PCODn and PCDVn setting in the related GPIO registers. Additionally, the GPCCFGHR or GPCCFGLR register which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PCLOCKR register can only be written once which means that PCLKEY and PCLOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port C reset occurs.

Port C Data Input Register – PCDINR

This register specifies the GPIO Port C input data.

Offset: 0x01C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCDIN							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[7:0]	PCDINn	GPIO Port C pin n Data Input Bits (n = 0 ~ 7) 0: The input data of corresponding pin is 0 1: The input data of corresponding pin is 1

Port C Output Data Register – PCDOUTR

This register specifies the GPIO Port C output data.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCDOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCDOUTn	GPIO Port C pin n Data Output Bits (n = 0 ~ 7) 0: Data to be output on pin n is 0 1: Data to be output on pin n is 1

Port C Output Set / Reset Control Register – PCSRR

This register is used to set or reset the corresponding bit of the GPIO Port C output data.

Offset: 0x024

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	PCRST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCSET							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[23:16]	PCRSTn	GPIO Port C pin n Output Reset Control Bits (n = 0 ~ 7) 0: No effect on the PCDOUTn bit 1: Reset the PCDOUTn bit Note that when the PCRSTn bit in this register or (and) the PCRSTn bit in the PCRR register is enabled, the reset function on the PCDOUTn bit will take effect.
[7:0]	PCSETn	GPIO Port C pin n Output Set Control Bits (n = 0 ~ 7) 0: No effect on the PCDOUTn bit 1: Set the PCDOUTn bit Note that the function enabled by the PCSETn bit has the higher priority if both the PCSETn and PCRSTn bits are set at the same time.

Port C Output Reset Register – PCRR

This register is used to reset the corresponding bit of the GPIO Port C output data.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCRST							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[7:0]	PCRSTn	GPIO Port C pin n Output Reset Control Bits (n = 0 ~ 7) 0: No effect on the PCDOUTn bit 1: Reset the PCDOUTn bit

Port C Sink Current Enhanced Selection Register – PCSCER

This register specifies the GPIO Port C enhanced sink driving current.

Offset: 0x02C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	PCSCE7	PCSCE6	PCSCE5	PCSCE4	PCSCE3	PCSCE2	PCSCE1	PCSCE0
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	PCSCEn	GPIO Port C pin n Sink Current Enhanced Selection Control Bits (n = 0 ~ 7) 0: No enhanced sink current 1: Enhanced sink current

9 Alternate Function Input / Output Control Unit (AFIO)

Introduction

In order to expand the flexibility of the GPIO or the usage of peripheral functions, each I/O pin can be configured to have up to sixteen different functions such as GPIO or IP functions by setting the GPxCFGLR or GPxCFGHR register where x is the different port name. According to the usage of the IP resource and application requirements, suitable pin-out locations can be selected by using the peripheral I/O remapping mechanism. Additionally, various GPIO pins can be selected to be the EXTI interrupt line by setting the EXTInPIN [3:0] field in the ESSRn register to trigger an interrupt or event. Please refer to the EXTI section for more details.

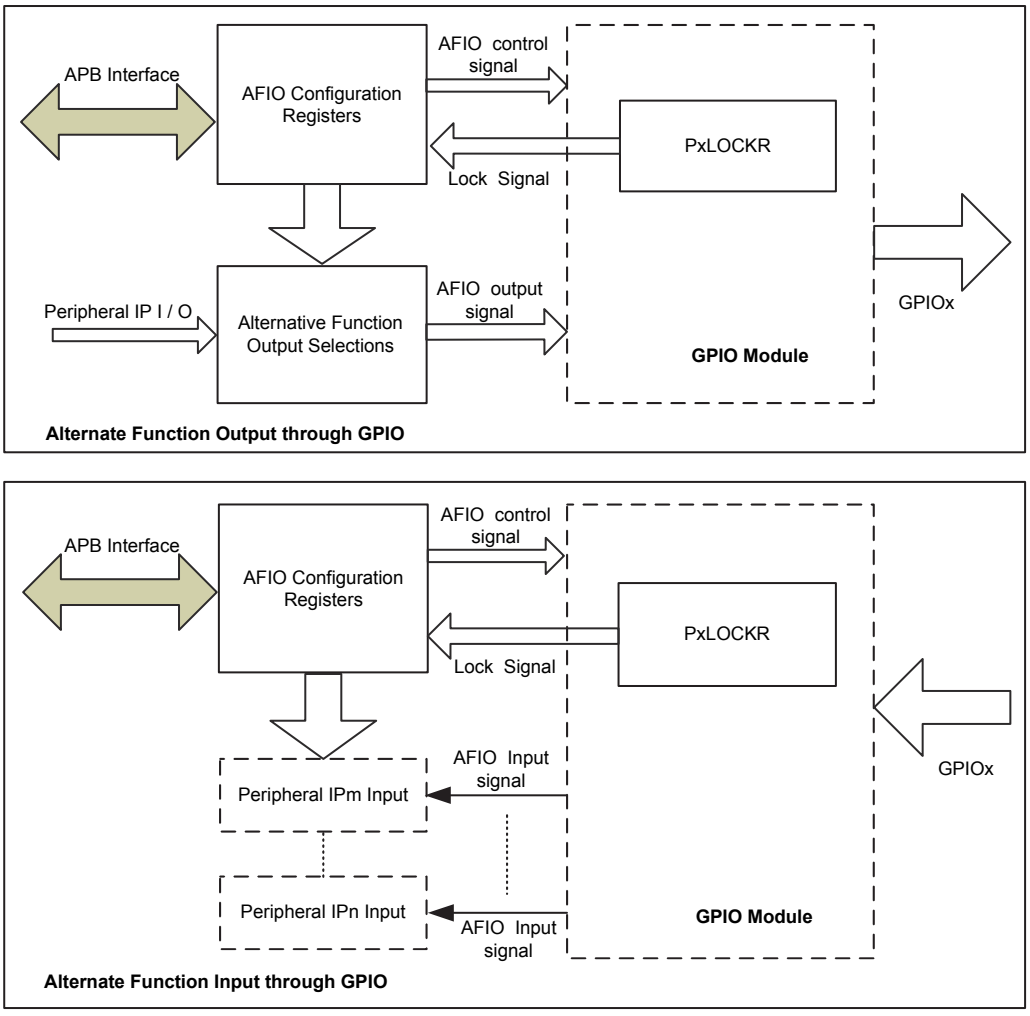


Figure 21. AFIO Block Diagram

Features

- APB slave interface for register access
- EXTI source selection
- Configurable pin function for each GPIO, up to sixteen alternative functions on each pin
- AFIO lock mechanism

Functional Descriptions

External Interrupt Pin Selection

The GPIO pins are connected to the 16 EXTI lines as shown in the accompanying figure. For example, users can set the EXTI0PIN [3:0] field in the ESSR0 register to b0000 to select the GPIO PA0 pin as EXTI line 0 input. Since not all the pins of the Port A ~ C are available in all package types, please refer to the pin assignment section for detailed pin information. The setting of the EXTInPIN [3:0] field is invalid when the corresponding pin is not available.

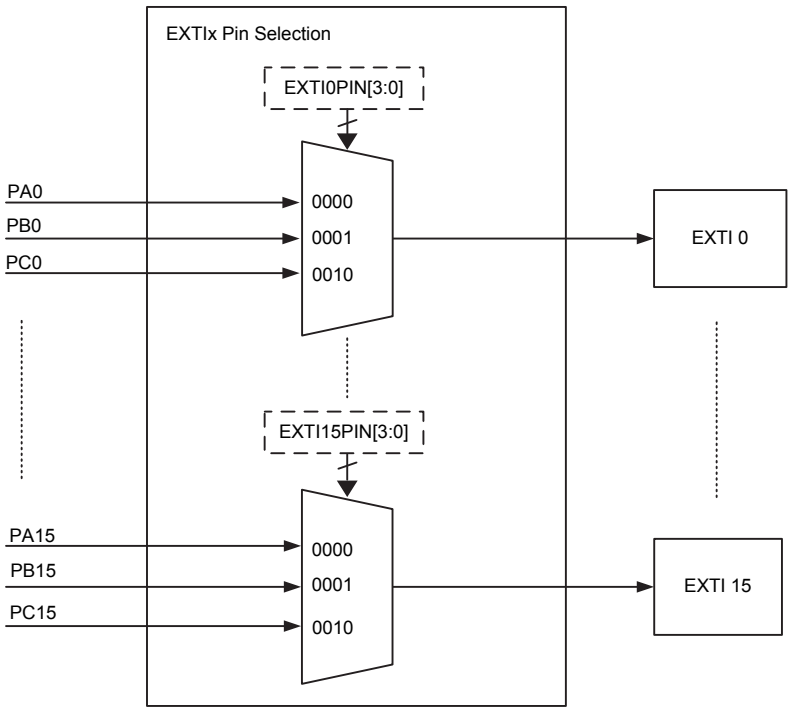


Figure 22. EXTI Channel Input Selection

Alternate Function

Up to sixteen alternative functions can be chosen for each I/O pad by setting the PxCFGn [3:0] field in the GPxCFGLR or GPxCFGHR (n = 0 ~ 15, x = A ~ C) registers. If the pin is selected as unavailable item which is noted as "N/A" item in the "Alternate Function Mapping" table of the device datasheet, this pin will be defined as default alternate function. Refer to the "Alternate Function Mapping" table in the device datasheet for the detailed mapping of the alternate function I/O pins. In addition to this flexible I/O multiplexing architecture, each peripheral has alternate functions mapped onto different I/O pins to optimize the number of peripherals available in smaller packages. The following description shows the setting of the PxCFGn [3:0] field.

- PxCFGn [3:0] = 0000: The default alternated function (after reset, AF0)
- PxCFGn [3:0] = 0001: Alternate Function 1 (AF1)
- PxCFGn [3:0] = 0010: Alternate Function 2 (AF2)
- …….
- PxCFGn [3:0] = 1110: Alternate Function 14 (AF14)
- PxCFGn [3:0] = 1111: Alternate Function 15 (AF15)

Table 19. AFIO Selection for Peripheral Map Example

AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
System Default	GPIO	ADC	N/A	GPTM /MCTM	SPI	USART /UART	I^2C	N/A	N/A	N/A	N/A	N/A	PWM	N/A	System Other

Lock Mechanism

The device also offers a lock function to lock the AFIO configuration using the GPIO lock register, PxLOCKR, until a reset event occurs. Refer to the GPIO Locking Mechanism section in the GPIO chapter for more details.

Register Map

The following table shows the AFIO registers and reset value.

Table 20. AFIO Register Map

Register	Offset	Description	Reset Value
ESSR0	0x000	EXTI Source Selection Register 0	0x0000_0000
ESSR1	0x004	EXTI Source Selection Register 1	0x0000_0000
GPACFGLR	0x020	GPIO Port A Configuration Low Register	0x0000_0000
GPACFGHR	0x024	GPIO Port A Configuration High Register	0x0000_0000
GPBCFGLR	0x028	GPIO Port B Configuration Low Register	0x0000_0000
GPBCFGHR	0x02C	GPIO Port B Configuration High Register	0x0000_0000
GPCCFGLR	0x030	GPIO Port C Configuration Low Register	0x0000_0000
GPCCFGHR	0x034	GPIO Port C Configuration High Register	0x0000_0000

Register Descriptions

EXTI Source Selection Register 0 – ESSR0

This register specifies the I/O selection of EXTI0 ~ EXTI7.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	EXTI7PIN				EXTI6PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	EXTI5PIN				EXTI4PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	EXTI3PIN				EXTI2PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	EXTI1PIN				EXTI0PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	EXTInPIN[3:0]	EXTIn Pin Selection (n = 0 ~ 7) 0000: PA Bit n is selected as EXTIn source signal 0001: PB Bit n is selected as EXTIn source signal 0010: PC Bit n is selected as EXTIn source signal Others: Reserved Note: Since not all GPIO pins are available in all products and package types, refer to the pin assignment section for detailed pin information. The EXTInPIN [3:0] field setting is invalid when the corresponding pin is not available.

EXTI Source Selection Register 1 – ESSR1

This register specifies the I/O selection of EXTI8 ~ EXTI15.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	EXTI15PIN				EXTI14PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	EXTI13PIN				EXTI12PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	EXTI11PIN				EXTI10PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	EXTI9PIN				EXTI8PIN			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	EXTInPIN[3:0]	EXTIn Pin Selection (n = 8 ~ 15) 0000: PA Bit n is selected as EXTIn source signal 0001: PB Bit n is selected as EXTIn source signal 0010: PC Bit n is selected as EXTIn source signal Others: Reserved Note: Since not all GPIO pins are available in all products and package types, refer to the pin assignment section for detailed pin information. The EXTInPIN [3:0] field setting is invalid when the corresponding pin is not available.

GPIO Port x Configuration Low Register – GPxCFGLR, x = A, B, C

This low register specifies the alternate function of GPIO Port x, x = A, B, C.

Offset: 0x020, 0x028, 0x030

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PxCFG7				PxCFG6			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	PxCFG5				PxCFG4			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	PxCFG3				PxCFG2			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PxCFG1				PxCFG0			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	PxCFGn[3:0]	Alternate function selection for port x pin n (n = 0 ~ 7) 0000: Port x pin n is selected as AF0 0001: Port x pin n is selected as AF1 : : 1110: Port x pin n is selected as AF14 1111: Port x pin n is selected as AF15 If the pin is selected as unavailable item which is noted as “N/A” item in the “Alternate Function Mapping” table of the device datasheet. This pin will be defined as default alternate function. Please refer to the “Alternate Function Mapping” table in the device datasheet for the detailed mapping of the alternate function I/O pins.

GPIO Port x Configuration High Register – GPxCFGHR, x = A, B, C

This high register specifies the alternate function of GPIO Port x. x = A, B, C.

Offset: 0x024, 0x02C, 0x034

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	PxCFG15				PxCFG14			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	PxCFG13				PxCFG12			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	PxCFG11				PxCFG10			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PxCFG9				PxCFG8			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	PxCFGn[3:0]	Alternate function selection for port x pin n (n = 8 ~ 15) 0000: Port x pin n is selected as AF0 0001: Port x pin n is selected as AF1 : : 1110: Port x pin n is selected as AF14 1111: Port x pin n is selected as AF15 If the pin is selected as unavailable item which is noted as “N/A” item in the “Alternate Function Mapping” table of the device datasheet. This pin will be defined as default alternate function. Please refer to the “Alternate Function Mapping” table in the device datasheet for the detailed mapping of the alternate function I/O pins.

10 Nested Vectored Interrupt Controller (NVIC)

Introduction

In order to reduce the latency and increase the interrupt processing efficiency, a tightly coupled integrated section, which is named as Nested Vectored Interrupt Controller (NVIC) is provided by the Cortex®-M0+. The NVIC controls the system exceptions and the peripheral interrupts which include functions such as the enable / disable control, priority, clear-pending, active status report, software trigger and vector table remapping. Refer to the Technical Reference Manual of Cortex®-M0+ for more details.

Additionally, an integrated simple, 24-bit down count timer (SysTick) is provided by the Cortex®-M0+ to be used as a tick timer for the Real Timer Operation System (RTOS) or as a simple counter. The SysTick counts down from the reloaded value and generates a system interrupt when it reaches zero. The accompanying table lists the system exceptions types and a variety of peripheral interrupts.

Table 21. Exception Types

Interrupt Number	Exception Number	Exception Type	Priority	Vector Address	Description
—	0	—	—	0x000	Initial Stack Point value
—	1	Reset	-3 (Highest)	0x004	Reset
-14	2	NMI	-2	0x008	Non-Maskable Interrupt. The clock stuck interrupt signal (clock monitor function provided by Clock Control Unit) is connected to the NMI input
-13	3	Hard Fault	-1	0x00C	All fault classes
—	4-10	Reserved	—	—	—
-5	11	SVCall	Configurable(1)	0x02C	SVC instruction System service call
—	12-13	Reserved	—	—	—
-2	14	PendSV	Configurable(1)	0x038	System Service Pendable request
-1	15	SysTick	Configurable(1)	0x03C	SysTick timer decremented to zero
0	16	LVD	Configurable(2)	0x040	Low voltage detection interrupt
1	17	RTC	Configurable(2)	0x044	RTC global interrupt
2	18	FMC	Configurable(2)	0x048	FMC global interrupt
3	19	WKUP	Configurable(2)	0x04C	EXTI event wakeup or external WAKEUP pin interrupt (3)
4	20	EXTI0 ~ 1	Configurable(2)	0x050	EXTI Line 0 & 1 interrupt
5	21	EXTI2 ~ 3	Configurable(2)	0x054	EXTI Line 2 & 3 interrupt
6	22	EXTI4 ~ 15	Configurable(2)	0x058	EXTI Line 4 ~ 15 interrupt
7	23	Reserved	—	0x05C	—
8	24	ADC	Configurable(2)	0x060	ADC global interrupt
9	25	Reserved	—	0x064	—
10	26	MCTM	Configurable(2)	0x068	MCTM global interrupt
11	27	Reserved	—	0x06C	—
12	28	GPTM	Configurable(2)	0x070	GPTM global interrupt
13	29	Reserved	—	0x074	—

Interrupt Number	Exception Number	Exception Type	Priority	Vector Address	Description
14	30	Reserved	—	0x078	—
15	31	PWM0	Configurable(2)	0x07C	PWM0 global interrupt
16	32	PWM1	Configurable(2)	0x080	PWM1 global interrupt
17	33	BFTM0	Configurable(2)	0x084	BFTM0 global interrupt
18	34	BFTM1	Configurable(2)	0x088	BFTM1 global interrupt
19	35	I^2C0	Configurable(2)	0x08C	I^2C0 global interrupt
20	36	I^2C1	Configurable(2)	0x090	I^2C1 global interrupt
21	37	SPI0	Configurable(2)	0x094	SPI0 global interrupt
22	38	SPI1	Configurable(2)	0x098	SPI1 global interrupt
23	39	USART	Configurable(2)	0x09C	USART global interrupt
24	40	Reserved	—	0x0A0	—
25	41	UART0	Configurable(2)	0x0A4	UART0 global interrupt
26	42	UART1	Configurable(2)	0x0A8	UART1 global interrupt
27	43	Reserved	—	0x0AC	—
28	44	Reserved	—	0x0B0	—
29	45	Reserved	—	0x0B4	—
30	46	Reserved	—	0x0B8	—
31	47	Reserved	—	0x0BC	—

Notes: 1. The exception priority can be changed using the NVIC System Handler Priority Registers. For more information, refer to the Arm® "Cortex®-M0+ Devices Generic User Guide" document.
2. The interrupt priority can be changed using the NVIC Interrupt Priority Registers. For more information, refer to the Arm® "Cortex®-M0+ Devices Generic User Guide" document.
3. Refer to the PWRCU chapter for the relevant configuration descriptions about the WAKEUP-pin wakeup interrupt.

Features

- 7 system Cortex®-M0+ exceptions
- Up to 32 Maskable peripheral interrupts
- 4 programmable priority levels (2 bits for interrupt priority setting)
- Non-Maskable interrupt
- Low-latency exception and interrupt handling
- Vector table remapping capability
  - Integrated simple, 24-bit system timer, SysTick
  - 24-bit down-counter
  - Auto-reloading capability
  - Maskable system interrupt generation when counter decreases to 0
  - SysTick clock source derived from the HCLK clock divided by 8

Function Descriptions

SysTick Calibration

The SysTick Calibration Value Register (SYST_CALIB) is provided by the NVIC to give a reference time base of 1 ms for the RTOS tick timer or other purposes. The TENMS field in the SYST_CALIB register has a fixed value of 2500 which is the counter reload value to indicate 1 ms when the clock source comes from the SysTick reference input clock STCLK with a frequency of 2.5 MHz (20 MHz divide by 8).

Register Map

The following table shows the NVIC registers and reset values.

Table 22. NVIC Register Map

Register	Offset	Description	Reset Value
NVIC Base Address = 0xE000_E000			
SYST_CSR	0x010	SysTick Control and Status Register	0x0000_0000
SYST_RVR	0x014	SysTick Reload Value Register	Unpredictable
SYST_CVR	0x018	SysTick Current Value Register	Unpredictable
SYST_CALIB	0x01C	SysTick Calibration Value Register	0x4000_09C4
NVIC_ISER	0x100	Interrupt Set Enable Register	0x0000_0000
NVIC_ICER	0x180	Interrupt Clear Enable Register	0x0000_0000
NVIC_ISPR	0x200	Interrupt Set Pending Register	0x0000_0000
NVIC_ICPR	0x280	Interrupt Clear Pending Register	0x0000_0000
NVIC_IPR0	0x400	Interrupt 0 ~ 3 Priority Register	0x0000_0000
NVIC_IPR1	0x404	Interrupt 4 ~ 7 Priority Register	0x0000_0000
NVIC_IPR2	0x408	Interrupt 8 ~ 11 Priority Register	0x0000_0000
NVIC_IPR3	0x40C	Interrupt 12 ~ 15 Priority Register	0x0000_0000
NVIC_IPR4	0x410	Interrupt 16 ~ 19 Priority Register	0x0000_0000
NVIC_IPR5	0x414	Interrupt 20 ~ 23 Priority Register	0x0000_0000
NVIC_IPR6	0x418	Interrupt 24 ~ 27 Priority Register	0x0000_0000
NVIC_IPR7	0x41C	Interrupt 28 ~ 31 Priority Register	0x0000_0000
CPUID	0xD00	CPUID register	0x410C_C601
ICSR	0xD04	Interrupt Control and State Register	0x0000_0000
VTOR	0xD08	Vector Table Offset Register	0x0000_0000
AIRCR	0xD0C	Application Interrupt and Reset Control Register	0xFA05_0000
SCR	0xD10	System Control Register	0x0000_0000
CCR	0xD14	Configuration and Control Register	0x0000_0208
SHPR2	0xD1C	System Handlers Priority Register 2	0x0000_0000
SHPR3	0xD20	System Handlers Priority Register 3	0x0000_0000

Note: For more detailed information of the above register, please refer to the "Cortex®-M0+ Devices Generic User Guide" document from Arm.

11 External Interrupt / Event Controller (EXTI)

Introduction

The External Interrupt / Event Controller, EXTI, comprises 16 edge detectors which can generate a wakeup event or interrupt requests independently. In the interrupt mode there are five trigger types which can be selected as the external interrupt trigger type, low level, high level, negative edge, positive edge and both edges, selectable using the SRCnTYPE field in the EXTICFGRn (n = 0 ~ 15) register. In the wakeup event mode, the wakeup event polarity can be configured by setting the EXTInWPOL (n = 0 ~ 15) field in the EXTIWAKUPPOLR register. If the EVWUPIEN bit in the EXTIWAKUPCR Register is set, the EVWUP interrupt can be generated when the associated wakeup event occurs and the corresponding EXTI wakeup enable bit is set. Each EXTI line can also be masked independently.

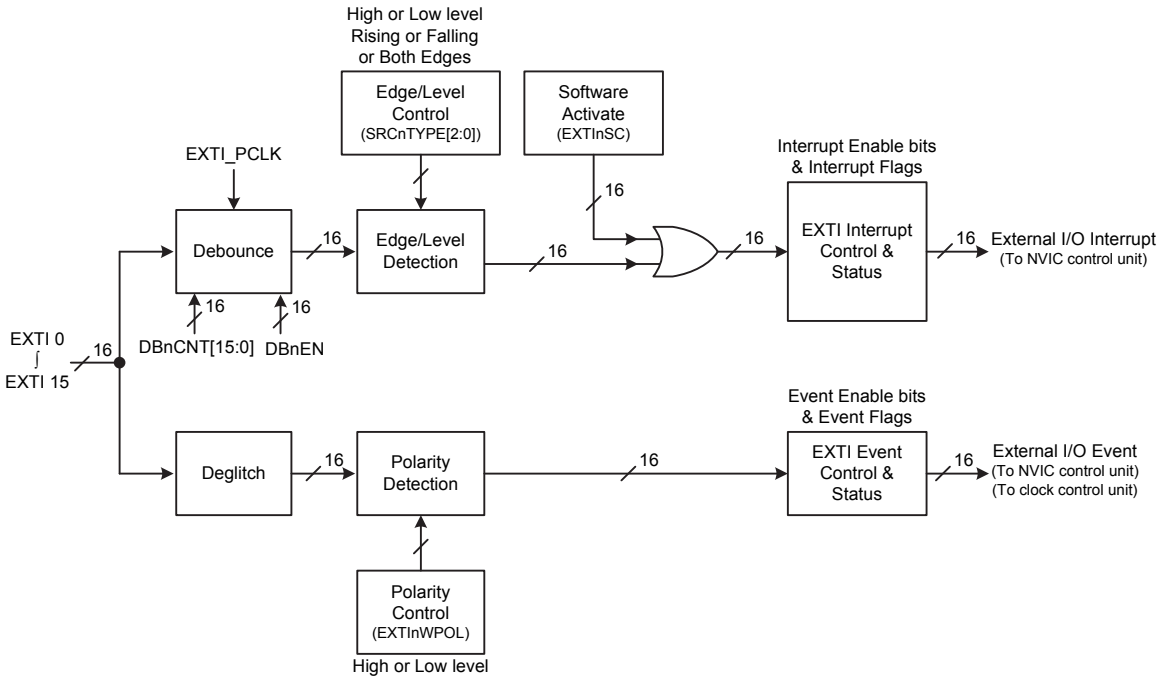


Figure 23. EXTI Block Diagram

Features

- Up to 16 EXTI lines with configurable trigger source and type
  - All GPIO pins can be selected as EXTI trigger source
  - Source trigger type includes high level, low level, negative edge, positive edge or both edge
- Individual interrupt enable, wakeup enable and status bits for each EXTI line
- Software interrupt trigger mode for each EXTI line
- Integrated deglitch filter for short pulse blocking

Function Descriptions

Wakeup Event Management

In order to wakeup the system from the power saving mode, the EXTI controller provides a function which can monitor external events and send them to the CPU core and the Clock Control Unit, CKCU. These external events include EXTI events, Low Voltage Detection, WAKEUP input pins and RTC wakeup function. By configuring the wakeup event enable bit in the corresponding peripheral, the wakeup signal will be sent to the CPU and the CKCU via the EXTI controller when the corresponding wakeup event occurs. Additionally, the software can enable the event wakeup interrupt function by setting the EVWUPIEN bit in the EXTIWAKUPCR register and the EXTI controller will then assert an interrupt when the wakeup event occurs.

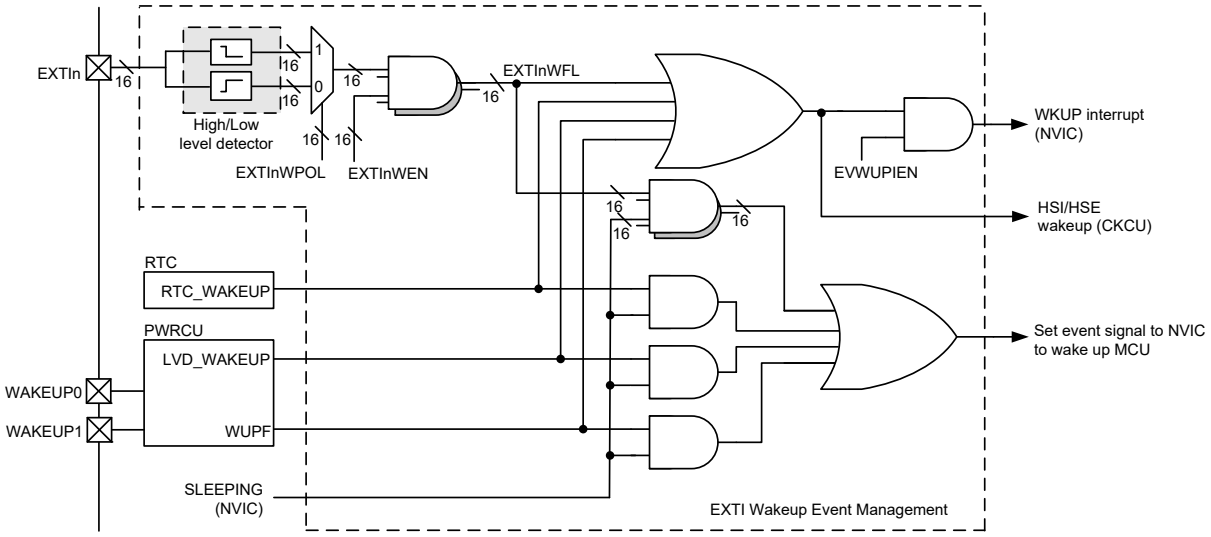


Figure 24. EXTI Wakeup Event Management

External Interrupt / Event Line Mapping

All GPIO pins can be selected as EXTI trigger sources by configuring the EXTInPIN [3:0] field in the AFIO ESSRn (n = 0 ~ 1) register to trigger an interrupt or event. Refer to the AFIO section for more details.

Interrupt and Debounce

The application software can set the DBnEN bit in the EXTIn Interrupt Configuration Register EXTICFGRn (n = 0 ~ 15) to enable the corresponding pin de-bounce function and configure the DBnCNT field in the EXTICFGRn so as to select an appropriate debounce time for specific applications. The interrupt signal will however be delayed due to the de-bounce function. When the device is woken up from the power saving mode by an external interrupt, an interrupt request will be generated by the EXTI wakeup flag. After the device has been woken up and the clock has recovered, the EXTI wakeup flag that was triggered by the EXTI line must be read and then cleared by application software. The accompanying diagram shows the relationship between the EXTI input signal and the EXTI interrupt / event request signal.

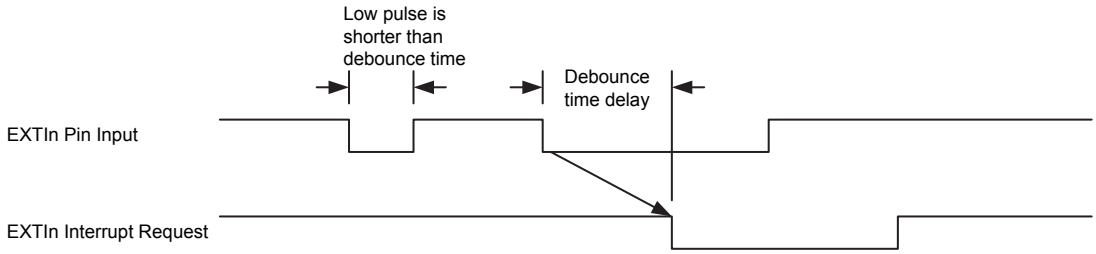


Figure 25. EXTI Interrupt Debounce Function

Register Map

The following table shows the EXTI registers and reset values.

Table 23. EXTI Register Map

Register	Offset	Description	Reset Value
EXTICFGR0	0x000	EXTI Interrupt 0 Configuration Register	0x0000_0000
EXTICFGR1	0x004	EXTI Interrupt 1 Configuration Register	0x0000_0000
EXTICFGR2	0x008	EXTI Interrupt 2 Configuration Register	0x0000_0000
EXTICFGR3	0x00C	EXTI Interrupt 3 Configuration Register	0x0000_0000
EXTICFGR4	0x010	EXTI Interrupt 4 Configuration Register	0x0000_0000
EXTICFGR5	0x014	EXTI Interrupt 5 Configuration Register	0x0000_0000
EXTICFGR6	0x018	EXTI Interrupt 6 Configuration Register	0x0000_0000
EXTICFGR7	0x01C	EXTI Interrupt 7 Configuration Register	0x0000_0000
EXTICFGR8	0x020	EXTI Interrupt 8 Configuration Register	0x0000_0000
EXTICFGR9	0x024	EXTI Interrupt 9 Configuration Register	0x0000_0000
EXTICFGR10	0x028	EXTI Interrupt 10 Configuration Register	0x0000_0000
EXTICFGR11	0x02C	EXTI Interrupt 11 Configuration Register	0x0000_0000
EXTICFGR12	0x030	EXTI Interrupt 12 Configuration Register	0x0000_0000
EXTICFGR13	0x034	EXTI Interrupt 13 Configuration Register	0x0000_0000
EXTICFGR14	0x038	EXTI Interrupt 14 Configuration Register	0x0000_0000
EXTICFGR15	0x03C	EXTI Interrupt 15 Configuration Register	0x0000_0000
EXTICR	0x040	EXTI Interrupt Control Register	0x0000_0000
EXTIEDGEFLGR	0x044	EXTI Interrupt Edge Flag Register	0x0000_0000
EXTIEDGESR	0x048	EXTI Interrupt Edge Status Register	0x0000_0000
EXTISSCR	0x04C	EXTI Interrupt Software Set Command Register	0x0000_0000
EXTIWAKUPCR	0x050	EXTI Interrupt Wakeup Control Register	0x0000_0000
EXTIWAKUPPOLR	0x054	EXTI Interrupt Wakeup Polarity Register	0x0000_0000
EXTIWAKUPFLG	0x058	EXTI Interrupt Wakeup Flag Register	0x0000_0000

Register Descriptions

EXTI Interrupt n Configuration Register – EXTICFGRn, n = 0 ~ 15

This register is used to specify the debounce function and select the trigger type.

Offset: 0x000 (0) ~ 0x03C (15)

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	DBnEN	SRCnTYPE			Reserved			
Type/Reset	RW 0	RW 0	RW 0	RW 0				
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	DBnCNT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	DBnCNT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31]	DBnEN	EXTIn De-bounce Circuit Enable Bit (n = 0 ~ 15) 0: De-bounce circuit is disabled 1: De-bounce circuit is enabled
[30:28]	SRCnTYPE	EXTIn Interrupt Source Trigger Type (n = 0 ~ 15)
[15:0]	DBnCNT	EXTIn De-bounce Counter (n = 0 ~ 15) The de-bounce time is calculated with DBnCNT × APB clock (EXTI_PCLK) period and should be long enough to take effect on the input signal.

SRCnTYPE [2:0]			Interrupt Source Type
0	0	0	Low-level Sensitive
0	0	1	High-level Sensitive
0	1	0	Negative-edge Triggered
0	1	1	Positive-edge Triggered
1	X	X	Both-edge Triggered

EXTI Interrupt Control Register – EXTICR

This register is used to control the EXTI interrupt.

Offset: 0x040

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	EXTI15EN	EXTI14EN	EXTI13EN	EXTI12EN	EXTI11EN	EXTI10EN	EXTI9EN	EXTI8EN
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	EXTI7EN	EXTI6EN	EXTI5EN	EXTI4EN	EXTI3EN	EXTI2EN	EXTI1EN	EXTI0EN
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	EXTInEN	EXTIn Interrupt Enable Bit (n = 0 ~ 15) 0: EXTI line n interrupt is disabled 1: EXTI line n interrupt is enabled

EXTI Interrupt Edge Flag Register – EXTIEDGEFLGR

This register is used to indicate if an EXTI edge has been detected.

Offset: 0x044

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	Reserved							
Type/Reset								
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	EXTI15EDF	EXTI14EDF	EXTI13EDF	EXTI12EDF	EXTI11EDF	EXTI10EDF	EXTI9EDF	EXTI8EDF
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	EXTI7EDF	EXTI6EDF	EXTI5EDF	EXTI4EDF	EXTI3EDF	EXTI2EDF	EXTI1EDF	EXTI0EDF
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0

Bits	Field	Descriptions
[15:0]	EXTInEDF	EXTIn Edge Detection Flag (n = 0 ~ 15) 0: No edge is detected 1: Positive or negative edge is detected This bit is set by the hardware circuitry when a positive or negative edge is detected on the corresponding EXTI line. Software should write 1 to clear it.

EXTI Interrupt Edge Status Register – EXTIEDGESR

This register indicates the polarity of a detected EXTI edge.

Offset: 0x048

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	Reserved							
Type/Reset								
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	EXTI15EDS	EXTI14EDS	EXTI13EDS	EXTI12EDS	EXTI11EDS	EXTI10EDS	EXTI9EDS	EXTI8EDS
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	EXTI7EDS	EXTI6EDS	EXTI5EDS	EXTI4EDS	EXTI3EDS	EXTI2EDS	EXTI1EDS	EXTI0EDS
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0

Bits	Field	Descriptions
[15:0]	EXTInEDS	EXTIn Edge Detection Status (n = 0 ~ 15) 0: Negative edge is detected 1: Positive edge is detected Software should write 1 to clear it.

EXTI Interrupt Software Set Command Register – EXTISSCR

This register is used to activate the EXTI interrupt.

Offset: 0x04C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	EXTI15SC	EXTI14SC	EXTI13SC	EXTI12SC	EXTI11SC	EXTI10SC	EXTI9SC	EXTI8SC
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	EXTI7SC	EXTI6SC	EXTI5SC	EXTI4SC	EXTI3SC	EXTI2SC	EXTI1SC	EXTI0SC
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	EXTInSC	EXTIn Software Set Command (n = 0 ~ 15) 0: Deactivates the corresponding EXTI interrupt 1: Activates the corresponding EXTI interrupt

EXTI Interrupt Wakeup Control Register – EXTIWAKUPCR

This register is used to control the EXTI interrupt and wakeup function.

Offset: 0x050

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	EVWUPIEN	Reserved						
Type/Reset	RW 0							
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	Reserved							
Type/Reset								
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	EXTI15WEN	EXTI14WEN	EXTI13WEN	EXTI12WEN	EXTI11WEN	EXTI10WEN	EXTI9WEN	EXTI8WEN
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	EXTI7WEN	EXTI6WEN	EXTI5WEN	EXTI4WEN	EXTI3WEN	EXTI2WEN	EXTI1WEN	EXTI0WEN
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31]	EVWUPIEN	EXTI Event Wakeup Interrupt Enable Bit 0: Disable EVWUP interrupt 1: Enable EVWUP interrupt
[15:0]	EXTInWEN	EXTIn Wakeup Enable Bit (n = 0 ~ 15) 0: Power saving mode wakeup is disabled 1: Power saving mode wakeup is enabled

EXTI Interrupt Wakeup Polarity Register – EXTIWAKUPPOLR

This register is used to select the EXTI line interrupt wakeup polarity.

Offset: 0x054

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	EXTI15WPOL	EXTI14WPOL	EXTI13WPOL	EXTI12WPOL	EXTI11WPOL	EXTI10WPOL	EXTI9WPOL	EXTI8WPOL
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	EXTI7WPOL	EXTI6WPOL	EXTI5WPOL	EXTI4WPOL	EXTI3WPOL	EXTI2WPOL	EXTI1WPOL	EXTI0WPOL
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	EXTInWPOL	EXTIn Wakeup Polarity (n = 0 ~ 15) 0: EXTIn wakeup is high level active 1: EXTIn wakeup is low level active

EXTI Interrupt Wakeup Flag Register – EXTIWAKUPFLG

This register is the EXTI interrupt wakeup flag register.

Offset: 0x058

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								

	15	14	13	12	11	10	9	8
	EXTI15WFL	EXTI14WFL	EXTI13WFL	EXTI12WFL	EXTI11WFL	EXTI10WFL	EXTI9WFL	EXIT8WFL
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0

	7	6	5	4	3	2	1	0
	EXTI7WFL	EXTI6WFL	EXTI5WFL	EXTI4WFL	EXTI3WFL	EXTI2WFL	EXTI1WFL	EXTI0WFL
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0	WC 0

Bits	Field	Descriptions
[15:0]	EXTInWFL	EXTIn Wakeup Flag (n = 0 ~ 15) 0: No wakeup occurs 1: System is woken up by EXTIn Software should write 1 to clear it.

12 Analog to Digital Converter (ADC)

Introduction

A 12-bit multi-channel Analog to Digital Converter is integrated in the device. There are a total of 14 multiplexed channels including 12 external channels on which the external analog signal can be supplied and 2 internal channels. If the input voltage is required to remain within a specific threshold window, the Analog Watchdog function will monitor and detect the signal. An interrupt will then be generated to inform that the input voltage is higher or lower than the set thresholds. There are three conversion modes to convert an analog signal to digital data. The A/D conversion can be operated in one shot, continuous and discontinuous conversion mode. A 16-bit data register is provided to store the data after conversion.

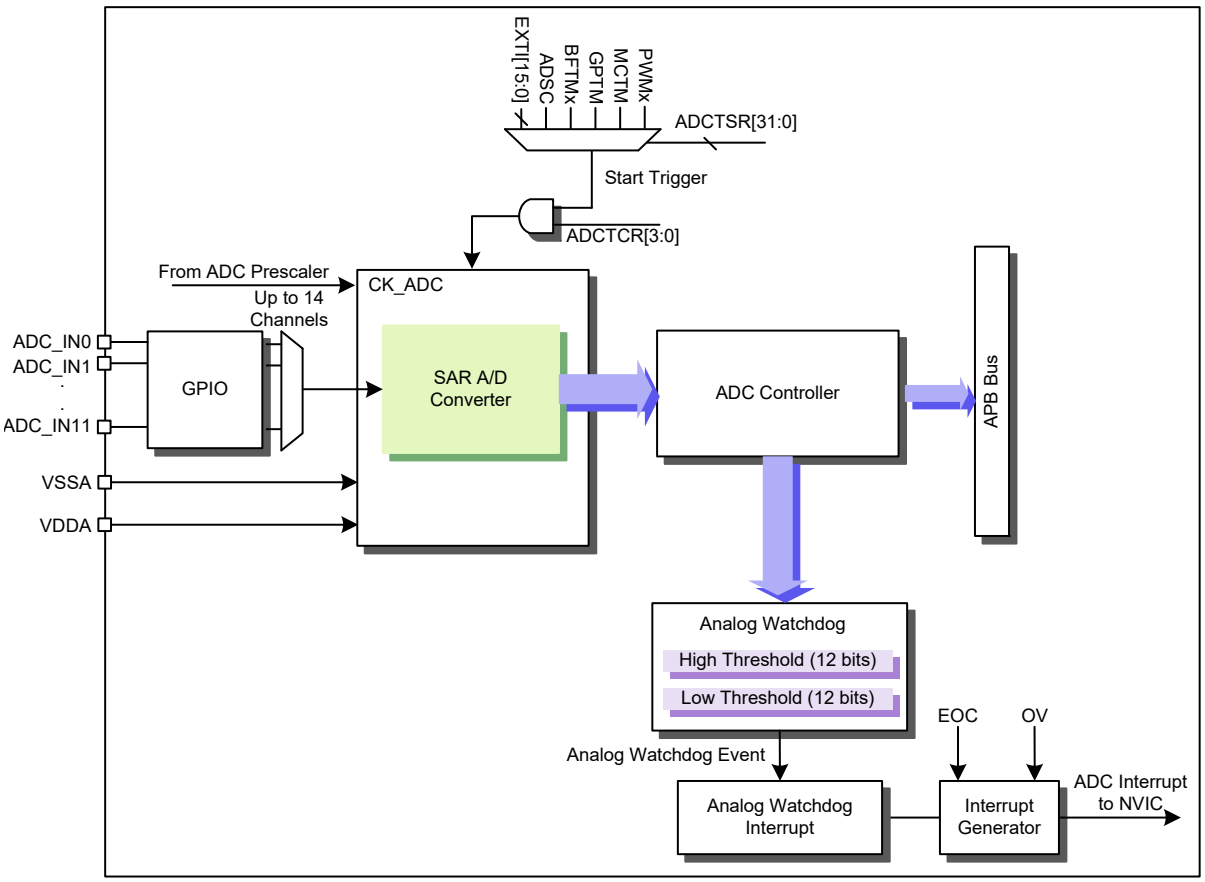


Figure 26. ADC Block Diagram

Features

- 12-bit SAR ADC engine
- Up to 1 Msps conversion rate
- 12 external analog input channels
- 2 internal analog input channels for reference voltage detection
- Programmable sampling time for conversion channel
- Up to 8 programmable conversion channel sequence and dedicated data registers for conversion result
- Three conversion modes
  - One shot conversion mode
  - Continuous conversion mode
  - Discontinuous conversion mode
- Analog watchdog for predefined voltage range monitor
  - Lower / upper threshold register
  - Interrupt generation
- Various trigger start sources for conversion modes
  - Software trigger
  - EXTI – External interrupt input pin
  - MCTM trigger
  - GPTM trigger
  - PWM0 / PWM1 trigger
  - BFTM0 / BFTM1 trigger
- Multiple generated interrupts
  - End of single conversion
  - End of subgroup conversion
  - End of cycle conversion
  - Analog Watchdog
  - Data register overwriting

Function Descriptions

ADC Clock Setup

The ADC clock, CK_ADC is provided by the Clock Controller which is synchronous and divided by with the AHB clock known as HCLK. Refer to the Clock Control Unit chapter for more details. Notes that ADC peripheral needs keeping at least two ADC clock cycles to switch between power-on and power off stage (ADCEN bit = '0').

Channel Selection

The A/D converter supports 14 multiplexed channels and converts the conversion results into ADC conversion data register. A conversion group can organize a sequence which can be implemented arranged in a specific conversion sequence length from 1 to 8. For example, conversion can be carried out with the following channel sequence: CH2, CH4, CH7, CH5, CH6, CH3, CH0 and CH1 one after another.

A group is composed of up to 8 conversions. The selected channels of the group conversion can be specified in the ADCLST0 ~ ADCLST1 registers. The total conversion sequence length is setup using the ADSEQL[2:0] bits in the ADCCR register.

Modifying the ADCCR register during a conversion process will reset the current conversion, after which a new start pulse is required to restart a new conversion.

Conversion Mode

The A/D has three operating conversion modes. The conversion modes are One Shot Conversion Mode, Continuous Conversion Mode and Discontinuous Conversion mode. Details are provided later.

One Shot Conversion Mode

In one shot conversion mode, the ADC will perform conversion cycles on the channels specified in the A/D conversion list registers ADCLSTn with a specific sequence when an A/D converter event trigger occurs. When the A/D conversion mode field ADMODE [1:0] in the ADCCR register is set to 0x0, the A/D converter will operate in the One Shot Conversion Mode. This mode can be started by a software trigger, an external EXTI event or a Timer event determined by the Trigger Control Register ADCTCR and the Trigger Source Register ADCTSR.

After Conversion

- The converted data will be stored in the 16-bit ADCDRy (y = 0 ~ 7) registers.
- The ADC regular single sample end of conversion event raw status flag, ADIRAWS, in the ADCIRAW register will be set when the single sample conversion is finished.
- An interrupt will be generated after a single sample end of conversion if the ADIES bit in the ADCIER register is enabled.
- An interrupt will be generated after a regular group cycle end of conversion if the ADIEC bit in the ADCIER register is enabled.

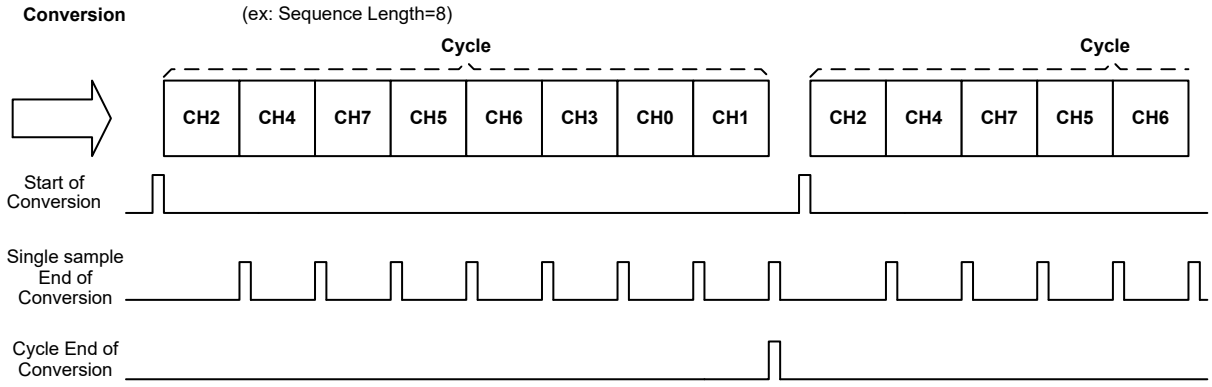


Figure 27. One Shot Conversion Mode

Continuous Conversion Mode

In Continuous Conversion Mode, repeated conversion cycle will start automatically without requiring additional A/D start trigger signals after a channels group conversion has completed. When the A/D conversion mode field ADMODE[1:0] is set to 0x2, the A/D converter will operate in the Continuous Conversion Mode which can be started by a software trigger, an external EXTI event or a Timer event determined by the Trigger Control Register ADCTCR and the Trigger Source Register ADCTSR.

After conversion:

- The converted data will be stored in the 16-bit ADCDRy (y = 0 ~ 7) registers.
- The ADC regular group and high priority group cycle end of conversion event raw status flag, ADIRAWC, in the ADCIRAW register will be set when the conversion cycle is finished.
- An interrupt will be generated after a regular or high priority group cycle end of conversion if the ADIEC bit in the ADCIER register is enabled.

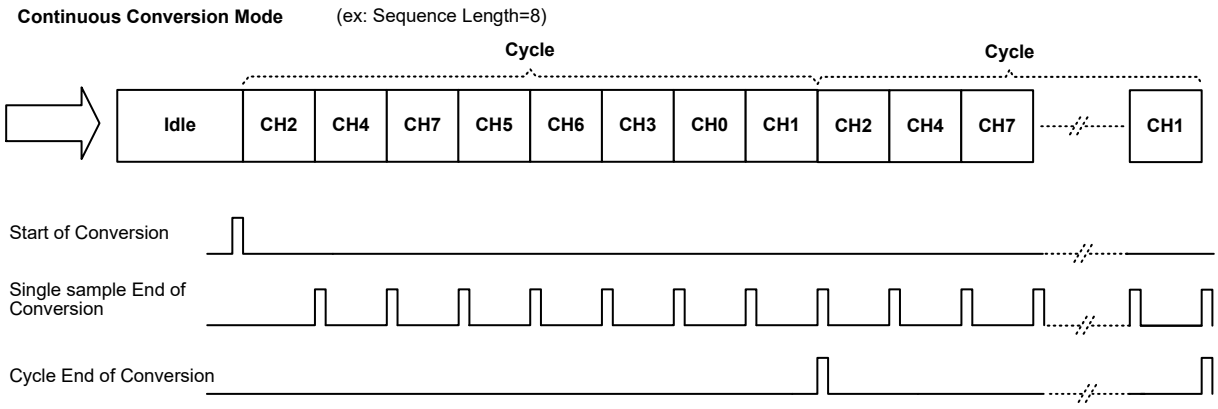


Figure 28. Continuous Conversion Mode

Discontinuous Conversion Mode

The A/D converter will operate in the Discontinuous Conversion Mode for channels group when the A/D conversion mode bit field ADMODE [1:0] in the ADCCR register is set to 0x3. The group to be converted can have up to 8 channels and can be arranged in a specific sequence by configuring the ADCLSTn registers where n ranges from 0 to 1. This mode is provided to convert data for the group with a short sequence, named as the A/D conversion subgroup, each time a trigger event occurs. The subgroup length is defined by the ADSUBL [2:0] field in the ADCCR register to specify the subgroup length. In the Discontinuous Conversion Mode the A/D converter can be started by a software trigger, an external EXTI event or a TM event for regular groups determined by the Trigger Control Register ADCTCR and the Trigger Source Register ADCTSR.

In the Discontinuous Conversion Mode, the A/D Converter will start to convert the next n conversions where the number n is the subgroup length defined by the ADSUBL field. When a trigger event occurs, the channels to be converted with a specific sequence are specified in the ADCLSTn registers. After n conversions have completed, the regular subgroup EOC interrupt raw flag ADIRAWG in the ADCIRAW register will be asserted. The A/D converter will now not continue to perform the next n conversions until the next trigger event occurs. The conversion cycle will end after all the group channels, of which the total number is defined by the ADSEQL[2:0] bits in the ADCCR register, have finished their conversion, at which point the cycle EOC interrupt raw flag ADIRAWC in the ADCIRAW register will be asserted. If a new trigger event occurs after all the subgroup channels have all been converted, i.e., a complete conversion cycle has been finished, the conversion will restart from the first subgroup.

Example:

A/D subgroup length = 3 (ADSUBL = 2) and sequence length = 8 (ADSEQL = 7), channels to be converted = 2, 4, 7, 5, 6, 3, 0 and 1 – specific converting sequence as defined in the ADCLSTn registers.

- Trigger 1: subgroup channels to be converted are CH2, CH4 and CH7 with the ADIRAWG flag being asserted after subgroup EOC.
- Trigger 2: subgroup channels to be converted are CH5, CH6 and CH3 with the ADIRAWG flag being asserted after subgroup EOC.
- Trigger 3: subgroup channels to be converted are CH0 and CH1 with the ADIRAWG flag being asserted after subgroup EOC. Also a Cycle end of conversion (EOC) interrupt raw flag ADIRAWC will be asserted.
- Trigger 4: subgroup channels to be converted are CH2, CH4 and CH7 with the ADIRAWG flag being asserted – conversion sequence restarts from the beginning.

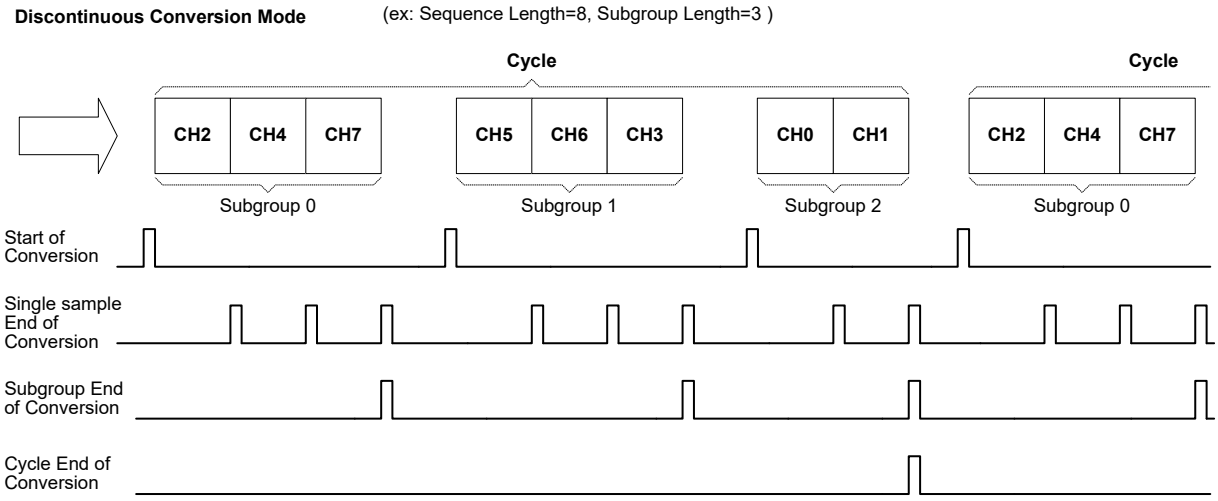


Figure 29. Discontinuous Conversion Mode

Start Conversion on External Event

An A/D converter conversion can be initiated by a software trigger, a General-Purpose Timer Module (GPTM) event, a Motor Control Timer Module (MCTM) event, a PWM Trigger Event, a Basic Function Timer Module (BFTM) event or an external trigger. Each trigger source can be enabled by setting the corresponding enable control bit in the ADCTCR register and then selected by configuring the associated selection bits in the ADCTSR register to start a group channel conversion.

An A/D converter conversion can be started by setting the software trigger bit, ADSC, in the ADCTSR register for the group channel when the software trigger enable bit, ADSW, in the ADCTCR register is set to 1. After the A/D converter starts converting the analog data, the corresponding enable bit ADSC will be cleared to 0 automatically.

The A/D converter can also be triggered to start a group conversion by a Timer event. The Timer events include a PWM master trigger output MTO, four PWM channel outputs CH0 ~ CH3, a GPTM or MCTM master trigger output MTO, four GPTM or MCTM channel outputs CH0 ~ CH3 and a BFTM trigger output. If the corresponding Timer trigger enable bit is set to 1 and the trigger output or the Timer channel event is selected via the relevant Timer event selection bits, the A/D converter will start a conversion when a rising edge of the selected trigger event occurs.

In addition to the internal trigger sources, the A/D converter can be triggered to start a conversion by an external trigger event. The external trigger event is derived from the external lines of the EXTI unit. If the external trigger enable bit ADEXTI is set to 1 and the corresponding EXTI line is selected by configuring the ADEXTIS field in the ADCTSR register, the A/D converter will start a conversion when an EXTI line activity occurs.

Sampling Time Setting

The conversion channel can be programmed the sampling time according to the input resistance of the input voltage source. This sampling time must be enough for the input voltage source to charge the internal sample and hold capacitor of the A/D converter to the input voltage level. By modifying the ADST [7:0] bits in the ADCSTR register, the sampling time of the analog input signal can be determined.

The total conversion time (T_{conv}) is calculated using the following formula:

$$T_{conv} = T_{Sampling} + T_{Latency}$$

Where the minimum sampling time $T_{Sampling}$ = 1.5 cycles (when ADST[7:0] = 0) and the minimum channel conversion latency $T_{Latency}$ = 12.5 cycles.

Example:

With the A/D Converter clock CK_ADC = 14 MHz and a sampling time = 1.5 cycles:

$$T_{conv} = 1.5 + 12.5 = 14 \text{ cycles} = 1\ \mu s$$

Data Format

The ADC conversed result can be read in the ADCDR register and output data format which is shown as following Table 24.

Table 24. Data Format in ADCDR [15:0]

Description	ADCDR Register Data Format
Right aligned	"0_0_0_0_d11_d10_d9_d8_d7_d6_d5_d4_d3_d2_d1_d0"

Analog Watchdog

The A/D converter includes a watchdog function to monitor the converted data. There are two kinds of thresholds for the watchdog monitor function, known as the watchdog lower threshold and watchdog upper threshold, which are specified by the ADLT bit field and ADUT bit field in the ADCTR register respectively. The watchdog monitor function is enabled by setting the watchdog upper and lower threshold monitor function enable bits, ADWUE and ADWLE, in the watchdog control register ADCWCR. The channel to be monitored can be specified by configuring the ADWCH and ADWALL bits. When the converted data is less or higher than the lower or upper threshold, as defined by the ADLT bit field and ADUT bit field in the ADCTR register respectively, the watchdog lower or upper threshold interrupt raw flags, ADIRAWL or ADIRAWU in the ADCIRAW register, will be asserted if the watchdog lower or upper threshold monitor function is enabled. If the lower or upper threshold interrupt raw flag is asserted and the corresponding interrupt is enabled by setting the ADIEL or ADIEU bit in the ADCIER register, the A/D watchdog lower or upper threshold interrupt will be generated.

Interrupts

When an A/D conversion is completed, an End of Conversion EOC event will occur. There are three kinds of EOC events which are known as single sample EOC, subgroup EOC and cycle EOC for A/D conversion. A single sample EOC event will occur and the single sample EOC interrupt raw flag, ADIRAWS bits in the ADCIRAW register, will be asserted when a single channel conversion has completed. A subgroup EOC event will occur and the subgroup EOC interrupt raw flag, ADIRAWG in the ADCIRAW register, will be asserted when a subgroup conversion has completed. A cycle EOC event will occur and the cycle EOC interrupt raw flag, ADIRAWC bits in the ADCIRAW register, will be asserted when a cycle conversion is finished. When a single sample EOC, a subgroup EOC or a cycle EOC raw flag is asserted and the corresponding interrupt enable bit, ADIES, ADIEG or ADIEC bit in the ADCIER register, is set to 1, the associated interrupt will be generated.

After a conversion has completed, the 12-bit digital data will be stored in the associated ADCDRy registers and the value of the data valid flag named as ADVLDy will be changed from low to high. The converted data should be read by the application program, after which the data valid flag ADVLDy will be automatically changed from high to low. Otherwise, a data overwrite event will occur and the data overwrite interrupt raw flag ADIRAWO bit in the ADCIRAW register will be asserted. When the related data overwrite raw flag is asserted, the data overwrite interrupt will be generated if the interrupt enable bit ADIEO in the ADCIER register is set to 1.

If the A/D watchdog monitor function is enabled and the data after a channel conversion is less than the lower threshold or higher than the upper threshold, the watchdog lower or upper threshold interrupt raw flag ADIRAWL or ADIRAWU in the ADCIRAW register will be asserted. When the ADIRAWL or ADIRAWU flag is asserted and the corresponding interrupt enable bit, ADIEL or ADIEU in the ADCIER register, is set a watchdog lower or upper threshold interrupt will be generated.

The A/D Converter interrupt clear bits are used to clear the associated A/D converter interrupt raw and interrupt status bits. Writing a 1 into the specific A/D converter interrupt clear bit in the A/D converter interrupt clear register ADCICLR will clear the corresponding A/D converter interrupt raw status and interrupt status bits. These bits are automatically cleared to 0 by hardware after being set to 1.

Register Map

The following table shows the A/D Converter registers and reset values.

Table 25. A/D Converter Register Map

Register	Offset	Description	Reset Value
ADCCR	0x000	ADC Conversion Control Register	0x0000_0000
ADCLST0	0x004	ADC Conversion List Register 0	0x0000_0000
ADCLST1	0x008	ADC Conversion List Register 1	0x0000_0000
ADCSTR	0x020	ADC Input Sampling Time Register	0x0000_0000
ADCDR0	0x030	ADC Conversion Data Register 0	0x0000_0000
ADCDR1	0x034	ADC Conversion Data Register 1	0x0000_0000
ADCDR2	0x038	ADC Conversion Data Register 2	0x0000_0000
ADCDR3	0x03C	ADC Conversion Data Register 3	0x0000_0000
ADCDR4	0x040	ADC Conversion Data Register 4	0x0000_0000
ADCDR5	0x044	ADC Conversion Data Register 5	0x0000_0000
ADCDR6	0x048	ADC Conversion Data Register 6	0x0000_0000
ADCDR7	0x04C	ADC Conversion Data Register 7	0x0000_0000
ADCTCR	0x070	ADC Trigger Control Register	0x0000_0000
ADCTSR	0x074	ADC Trigger Source Register	0x0000_0000
ADCWCR	0x078	ADC Watchdog Control Register	0x0000_0000
ADCTR	0x07C	ADC Watchdog Threshold Register	0x0000_0000
ADCIER	0x080	ADC Interrupt Enable register	0x0000_0000
ADCIRAW	0x084	ADC Interrupt Raw Status Register	0x0000_0000
ADCISR	0x088	ADC Interrupt Status Register	0x0000_0000
ADCICLR	0x08C	ADC Interrupt Clear Register	0x0000_0000

Register Descriptions

ADC Conversion Control Register – ADCCR

This register specifies the mode setting, sequence length and subgroup length of ADC conversion mode. Note that once the content of ADCCR is changed, the conversion in progress will be aborted and the A/D converter will return to an idle state. The application program has to wait for at least one CK_ADC clock before issuing the next command.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved					ADSUBL		
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved					ADSEQL		
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	ADCEN	ADCRST	Reserved					ADMODE
Type/Reset	RW 0	RW 0					RW 0	RW 0

Bits	Field	Descriptions
[18:16]	ADSUBL	ADC Conversion Subgroup Length The ADSUBL field specifies the conversion channel length of each subgroup for regular discontinuous mode. Subgroup length = ADSUBL [2:0] + 1. If the sequence length (ADSEQL [2:0] + 1) is not a multiple of the subgroup length (ADSUBL [2:0] + 1), the last subgroup will be the rest of the group channels that have not been converted.
[10:8]	ADSEQL	ADC Conversion Length 0x0: The channel specified by the ADSEQ0 field in the ADCLST0 register will be converted Others: Length of list queue = ADSEQL [2:0] + 1 The ADSEQL field specifies the whole conversion sequence length for the conversion group.
[7]	ADCEN	ADC Enable 0: Disable 1: Enable
[6]	ADCRST	ADC Reset 0: No effect 1: Reset A/D converter except for the A/D Converter controller

Bits	Field	Descriptions
[1:0]	ADMODE	ADC Conversion Mode

ADMODE [1:0]	Mode	Descriptions
00	One shot mode	After a start trigger, the conversion will be executed on the specific channels for the whole conversion sequence once.
01	Reserved	
10	Continuous mode	After a start trigger, the conversion will be executed on the specific channels for the whole sequence continuously until conversion mode is changed.
11	Discontinuous mode	After a start trigger, the conversion will be executed on the current subgroup. When the last subgroup is finished, the conversion will restart from the first subgroup if another start trigger occurs.

ADC Conversion List Register 0 – ADCLST0

This register specifies the conversion sequence order No.0 ~ No.3 of the ADC.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved			ADSEQ3				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	Reserved			ADSEQ2				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved			ADSEQ1				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved			ADSEQ0				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[28:24]	ADSEQ3	ADC Conversion Sequence Select 3 Select ADC input channel for the 3rd ADC conversion sequence. 0x00: ADC_IN0 0x01: ADC_IN1 0x02: ADC_IN2 0x03: ADC_IN3 0x04: ADC_IN4 0x05: ADC_IN5 0x06: ADC_IN6 0x07: ADC_IN7 0x08: ADC_IN8 0x09: ADC_IN9 0x0A: ADC_IN10 0x0B: ADC_IN11 0x0C: Analog ground, VSSA (V_{REF-}) 0x0D: Analog power, VDDA (V_{REF+}) 0x0E ~ 0x1F: Invalid setting and reserved. Don't set these values; it may cause the ADC operation become abnormally.
[20:16]	ADSEQ2	ADC Regular Conversion Sequence Select 2
[12:8]	ADSEQ1	ADC Regular Conversion Sequence Select 1
[4:0]	ADSEQ0	ADC Regular Conversion Sequence Select 0

ADC Conversion List Register 1 – ADCLST1

This register specifies the conversion sequence order No.4 ~ No.7 of the ADC.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved			ADSEQ7				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	Reserved			ADSEQ6				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved			ADSEQ5				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved			ADSEQ4				
Type/Reset				RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[28:24]	ADSEQ7	ADC Regular Conversion Sequence Select 7 Select ADC input channel for the 7th ADC conversion sequence. 0x00: ADC_IN0 0x01: ADC_IN1 0x02: ADC_IN2 0x03: ADC_IN3 0x04: ADC_IN4 0x05: ADC_IN5 0x06: ADC_IN6 0x07: ADC_IN7 0x08: ADC_IN8 0x09: ADC_IN9 0x0A: ADC_IN10 0x0B: ADC_IN11 0x0C: Analog ground, VSSA (V_{REF-}) 0x0D: Analog power, VDDA (V_{REF+}) 0x0E ~ 0x1F: Invalid setting and reserved. Don't set these values; it may cause the ADC operation become abnormally.
[20:16]	ADSEQ6	ADC Regular Conversion Sequence Select 6
[12:8]	ADSEQ5	ADC Regular Conversion Sequence Select 5
[4:0]	ADSEQ4	ADC Regular Conversion Sequence Select 4

ADC Input Sampling Time Register – ADCSTR

This register specifies the A/D converter input channel sampling time.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	ADST							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	ADST	ADC Input Channel Sampling Time Sampling time = (ADST [7:0] + 1.5) CK_ADC clocks.

ADC Conversion Data Register y – ADCDRy, y = 0 ~ 7

This register is used to store the conversion data of the conversion sequence order No.y which is specified by the ADSEQy field in the ADCLSTn (n = 0 ~ 1) registers.

Offset: 0x030 ~ 0x04C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	ADVLDy	Reserved						
Type/Reset	RC	0						
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	ADDy							
Type/Reset	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0
	7	6	5	4	3	2	1	0
	ADDy							
Type/Reset	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0	RO	0

Bits	Field	Descriptions
[31]	ADVLDy	ADC Conversion Data of Sequence Order No.y Valid Bit (y = 0 ~ 7) 0: Data are invalid or have been read 1: New data are valid
[15:0]	ADDy	ADC Conversion Data of Sequence Order No.y (y = 0 ~ 7) The conversion result of Sequence Order ADSEQy in the ADCLSTn (n = 0 ~ 1) registers

ADC Trigger Control Register – ADCTCR

This register contains the ADC start conversion trigger enable bits.

Offset: 0x070

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TM1	TM0	ADEXTI	ADSW
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[3]	TM1	ADC Conversion BFTM or PWM Event Trigger enable control 0: Disable conversion trigger by BFTM or PWM events 1: Enable conversion trigger by BFTM or PWM events
[2]	TM0	ADC Conversion GPTM or MCTM Event Trigger enable control 0: Disable conversion trigger by GPTM or MCTM events 1: Enable conversion trigger by GPTM or MCTM events
[1]	ADEXTI	ADC Conversion EXTI Event Trigger enable control 0: Disable conversion trigger by EXTI lines 1: Enable conversion trigger by EXTI lines
[0]	ADSW	ADC Conversion Software Trigger enable control 0: Disable conversion trigger by software trigger bit 1: Enable conversion trigger by software trigger bit

ADC Trigger Source Register – ADCTSR

This register contains the trigger source selection and the software trigger bit of the conversion.

Offset: 0x074

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved		TM1E			TM0E		
Type/Reset			RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	TM1S [2:1]		Reserved		TM1S [0]	TM0S		
Type/Reset	RW 0	RW 0			RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved				ADEXTIS			
Type/Reset					RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved							ADSC
Type/Reset								RW 0

Bits	Field	Descriptions
[29:27]	TM1E	PWM Trigger Event Selection of ADC Conversion 000: PWM MTO event 001: PWM CH0O event 010: PWM CH1O event 011: PWM CH2O event 100: PWM CH3O event Others: Reserved – Should not be used to avoid unpredictable results
[26:24]	TM0E	GPTM or MCTM Trigger Event Selection of ADC Conversion 000: GPTM or MCTM MTO event 001: GPTM or MCTM CH0O event 010: GPTM or MCTM CH1O event 011: GPTM or MCTM CH2O event 100: GPTM or MCTM CH3O event Others: Reserved – Should not be used to avoid unpredictable results
[23:22], [19]	TM1S	BFTM or PWM Trigger Timer Selection of ADC Conversion 000: BFTM0 001: BFTM1 010: PWM0 011: PWM1 Others: Reserved – Should not be used to avoid unpredictable results
[18:16]	TM0S	GPTM Trigger Timer Selection of ADC Conversion 000: MCTM 001: Reserved 010: GPTM Others: Reserved – Should not be used to avoid unpredictable results

Bits	Field	Descriptions
[11:8]	ADEXTIS	EXTI Trigger Source Selection of ADC Conversion 0x0: EXTI line 0 0x1: EXTI line 1 … 0xF: EXTI line 15 Note that the EXTI line active edge to start an A/D conversion is determined in the External Interrupt / Event Control Unit, EXTI.
[0]	ADSC	ADC Conversion Software Trigger Bit 0: No operation 1: Start conversion immediately This bit is set by software to start a conversion manually and then cleared by hardware automatically after conversion is started.

ADC Watchdog Control Register – ADCWCR

This register provides the control bits and status of the ADC watchdog function.

Offset: 0x078

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved				ADUCH			
Type/Reset					RO 0	RO 0	RO 0	RO 0
	23	22	21	20	19	18	17	16
	Reserved				ADLCH			
Type/Reset					RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	Reserved				ADWCH			
Type/Reset					RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved					ADWALL	ADWUE	ADWLE
Type/Reset						RW 0	RW 0	RW 0

Bits	Field	Descriptions
[27:24]	ADUCH	Upper Threshold Channel Status 0000: ADC_IN0 is higher than the upper threshold 0001: ADC_IN1 is higher than the upper threshold ... 1011: ADC_IN11 is higher than the upper threshold Others: Reserved If one of these status bits are set to 1 by the watchdog monitor function, this status field value should first be stored in the user-defined memory location in the corresponding ISR. Otherwise, the ADUCH field will be changed if another input channel converted data is higher than the upper threshold.

Bits	Field	Descriptions
[19:16]	ADLCH	Lower Threshold Channel Status 0000: ADC_IN0 is lower than the lower threshold 0001: ADC_IN1 is lower than the lower threshold ... 1011: ADC_IN11 is lower than the lower threshold Others: Reserved If one of these status bits are set to 1 by the watchdog monitor function, this status field value should first be stored in the user-defined memory location in the corresponding ISR. Otherwise, the ADLCH field will be changed if another input channel converted data is lower than the lower threshold.
[11:8]	ADWCH	ADC Watchdog Specific Channel Selection 0000: ADC_IN0 is monitored 0001: ADC_IN1 is monitored ... 1011: ADC_IN11 is monitored Others: Reserved
[2]	ADWALL	ADC Watchdog Specific / All Channel Setting 0: Only the channel which specified by the ADWCH field is monitored 1: All channels are monitored
[1]	ADWUE	ADC Watchdog Upper Threshold Enable Bit 0: Disable upper threshold function 1: Enable upper threshold function
[0]	ADWLE	ADC Watchdog Lower Threshold Enable Bit 0: Disable lower threshold function 1: Enable lower threshold function

ADC Watchdog Threshold Register – ADCTR

This register specifies the upper and lower threshold of the ADC watchdog function.

Offset: 0x07C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved				ADUT			
Type/Reset					RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	ADUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved				ADLT			
Type/Reset					RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	ADLT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[27:16]	ADUT	ADC Watchdog Upper Threshold Value Specify the upper threshold for the ADC watchdog monitor function.
[11:0]	ADLT	ADC Watchdog Lower Threshold Value Specify the lower threshold for the ADC watchdog monitor function.

ADC Interrupt Enable Register – ADCIER

This register contains the ADC interrupt enable bits.

Offset: 0x080

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							ADIEO
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved						ADIEU	ADIEL
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					ADIEC	ADIEG	ADIES
Type/Reset						RW 0	RW 0	RW 0

Bits	Field	Descriptions
[24]	ADIEO	ADC Data Register Overwrite Interrupt enable 0: ADC data register overwrite interrupt is disabled 1: ADC data register overwrite interrupt is enabled
[17]	ADIEU	ADC Watchdog Upper Threshold Interrupt enable 0: ADC watchdog upper threshold interrupt is disabled 1: ADC watchdog upper threshold interrupt is enabled
[16]	ADIEL	ADC Watchdog Lower Threshold Interrupt enable 0: ADC watchdog lower threshold interrupt is disabled 1: ADC watchdog lower threshold interrupt is enabled
[2]	ADIEC	ADC Cycle EOC Interrupt enable 0: ADC cycle end of conversion interrupt is disabled 1: ADC cycle end of conversion interrupt is enabled
[1]	ADIEG	ADC Subgroup EOC Interrupt enable 0: ADC subgroup end of conversion interrupt is disabled 1: ADC subgroup end of conversion interrupt is enabled
[0]	ADIES	ADC Single EOC Interrupt enable 0: ADC single end of conversion interrupt is disabled 1: ADC single end of conversion interrupt is enabled

ADC Interrupt Raw Status Register – ADCIRAW

This register contains the ADC interrupt raw status bits.

Offset: 0x084

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							ADIRAWO
Type/Reset								RO 0
	23	22	21	20	19	18	17	16
	Reserved						ADIRAWU	ADIRAWL
Type/Reset							RO 0	RO 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					ADIRAWC	ADIRAWG	ADIRAWS
Type/Reset						RO 0	RO 0	RO 0

Bits	Field	Descriptions
[24]	ADIRAWO	ADC Data Register Overwrite Interrupt Raw Status 0: ADC data register overwrite interrupt does not occur 1: ADC data register overwrite interrupt occurs
[17]	ADIRAWU	ADC Watchdog Upper Threshold Interrupt Raw Status 0: ADC watchdog upper threshold interrupt does not occur 1: ADC watchdog upper threshold interrupt occurs
[16]	ADIRAWL	ADC Watchdog Lower Threshold Interrupt Raw Status 0: ADC watchdog lower threshold interrupt does not occur 1: ADC watchdog lower threshold interrupt occurs
[2]	ADIRAWC	ADC Cycle EOC Interrupt Raw Status 0: ADC regular cycle end of conversion interrupt does not occur 1: ADC regular cycle end of conversion interrupt occurs
[1]	ADIRAWG	ADC Subgroup EOC Interrupt Raw Status 0: ADC regular subgroup end of conversion interrupt does not occur 1: ADC regular subgroup end of conversion interrupt occurs
[0]	ADIRAWS	ADC Single EOC Interrupt Raw Status 0: ADC regular single end of conversion interrupt does not occur 1: ADC regular single end of conversion interrupt occurs

ADC Interrupt Status Register – ADCISR

This register contains the ADC interrupt status bits. The corresponding interrupt status will be set to 1 if the associated interrupt event occurs and the related enable bit is set to 1.

Offset: 0x088
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							ADISRO
Type/Reset								RO 0
	23	22	21	20	19	18	17	16
	Reserved						ADISRU	ADISRL
Type/Reset							RO 0	RO 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					ADISRC	ADISRG	ADISRS
Type/Reset						RO 0	RO 0	RO 0

Bits	Field	Descriptions
[24]	ADISRO	ADC Data Register Overwrite Interrupt Status 0: ADC data register overwrite interrupt does not occur or data register overwrite interrupt is disabled 1: ADC data register overwrite interrupt occurs and data register overwrite interrupt is enabled
[17]	ADISRU	ADC Watchdog Upper Threshold Interrupt Status 0: ADC watchdog upper threshold interrupt does not occur or watchdog upper threshold interrupt is disabled 1: ADC watchdog upper threshold interrupt occurs and watchdog upper threshold interrupt is enabled
[16]	ADISRL	ADC Watchdog Lower Threshold Interrupt Status 0: ADC watchdog lower threshold interrupt does not occur or watchdog lower threshold interrupt is disabled 1: ADC watchdog lower threshold interrupt occurs and watchdog lower threshold interrupt is enabled
[2]	ADISRC	ADC Cycle EOC Interrupt Status 0: ADC cycle end of conversion interrupt does not occur or cycle end of conversion interrupt is disabled 1: ADC cycle end of conversion interrupt occurs and cycle end of conversion interrupt is enabled
[1]	ADISRG	ADC Subgroup EOC Interrupt Status 0: ADC subgroup end of conversion interrupt does not occur or subgroup end of conversion interrupt is disabled 1: ADC subgroup end of conversion interrupt occurs and subgroup end of conversion interrupt is enabled
[0]	ADISRS	ADC Single EOC Interrupt Status 0: ADC single end of conversion interrupt does not occur or single end of conversion interrupt is disabled 1: ADC single end of conversion interrupt occurs and single end of conversion interrupt is enabled

ADC Interrupt Clear Register – ADCICLR

This register provides the clear bits used to clear the interrupt raw and interrupt status of the ADC. These bits are set to 1 by software to clear the interrupt status and automatically cleared to 0 by hardware after being set to 1.

Offset: 0x08C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							ADICLRO
Type/Reset								WO 0
	23	22	21	20	19	18	17	16
	Reserved						ADICLRU	ADICLRL
Type/Reset							WO 0	WO 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					ADICLRC	ADICLRG	ADICLRS
Type/Reset						WO 0	WO 0	WO 0

Bits	Field	Descriptions
[24]	ADICLRO	ADC Data Register Overwrite Interrupt Status Clear Bit 0: No effect 1: Clear ADISRO and ADIRAWO bits
[17]	ADICLRU	ADC Watchdog Upper Threshold Interrupt Status Clear Bit 0: No effect 1: Clear ADISRU and ADIRAWU bits
[16]	ADICLRL	ADC Watchdog Lower Threshold Interrupt Status Clear Bit 0: No effect 1: Clear ADISRL and ADIRAWL bits
[2]	ADICLRC	ADC Cycle EOC Interrupt Status Clear Bit 0: No effect 1: Clear ADISRC and ADIRAWC bits
[1]	ADICLRG	ADC Subgroup EOC Interrupt Status Clear Bit 0: No effect 1: Clear ADISRG and ADIRAWG bits
[0]	ADICLRS	ADC Single EOC Interrupt Status Clear Bit 0: No effect 1: Clear ADISRS and ADIRAWS bits

13 General-Purpose Timer (GPTM)

Introduction

The General-Purpose Timer consists of one 16-bit up/down-counter, four 16-bit Capture/Compare Registers (CCRs), one 16-bit Counter-Reload Register (CRR) and several control/status registers. It can be used for a variety of purposes including general timer, input signal pulse width measurement or output waveform generation such as single pulse generation or PWM output. The GPTM supports an encoder interface using a quadrature decoder with two inputs.

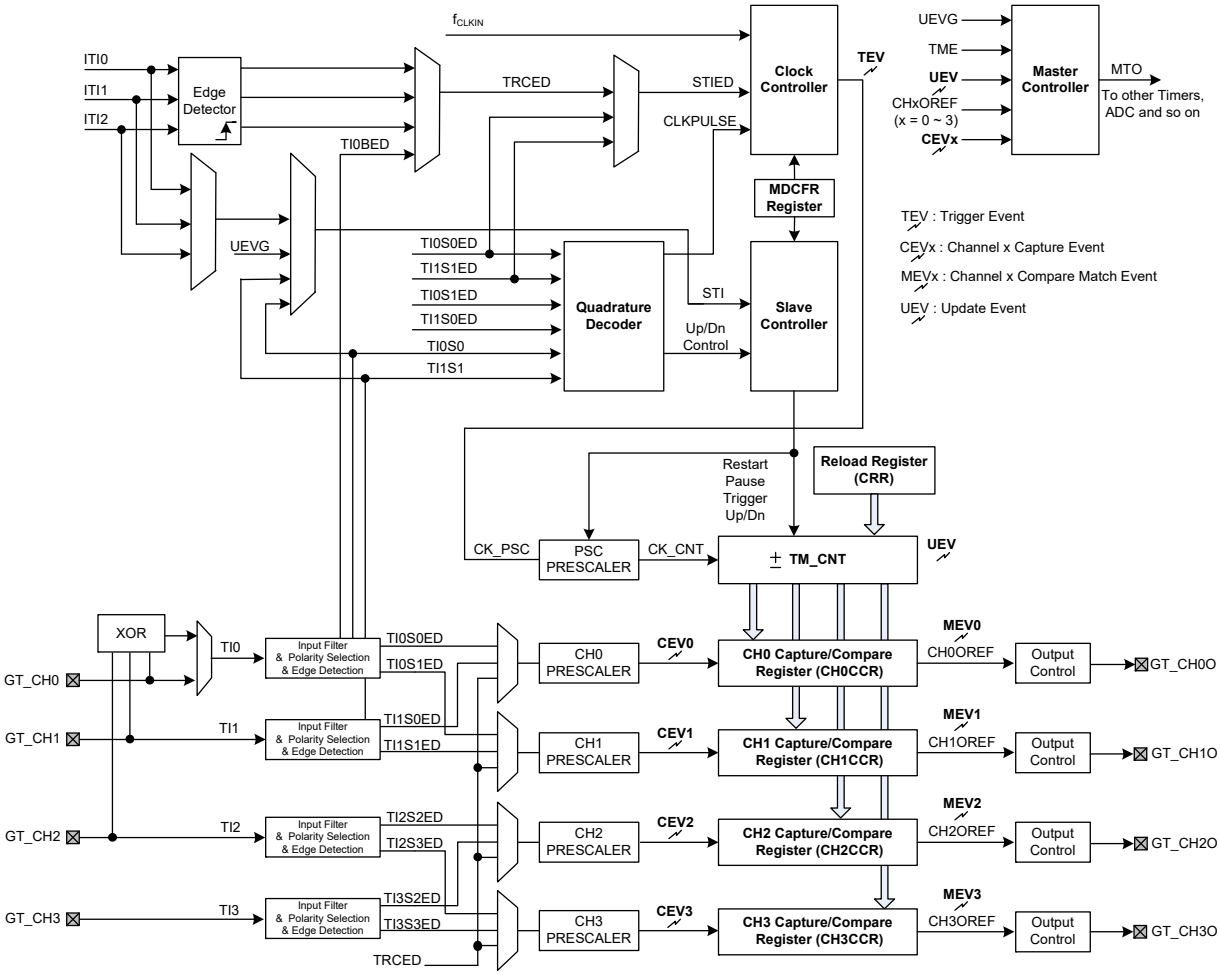


Figure 30. GPTM Block Diagram

Features

- 16-bit up/down auto-reload counter
- 16-bit programmable prescaler that allows division of the prescaler clock source by any factor between 1 and 65536 to generate the counter clock frequency
- Up to 4 independent channels for:
  - Input Capture function
  - Compare Match Output
  - Generation of PWM waveform – Edge and Center-aligned Mode
  - Single Pulse Mode Output
- Encoder interface controller with two inputs using quadrature decoder
- Synchronization circuit to control the timer with external signals and to interconnect several timers together
- Interrupt generation with the following events:
  - Update event
  - Trigger event
  - Input capture event
  - Output compare match event
- GPTM Master/Slave mode controller

Functional Descriptions

Counter Mode

Up-Counting

In this mode the counter counts continuously from 0 to the counter-reload value, which is defined in the CRR register, in a count-up direction. Once the counter reaches the counter-reload value; then restarts from 0 and generates a counter overflow event. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 0 for the up-counting mode.

When the update event is generated by setting the UEVG bit in the EVGR register to 1, the counter value will also be initialized to 0.

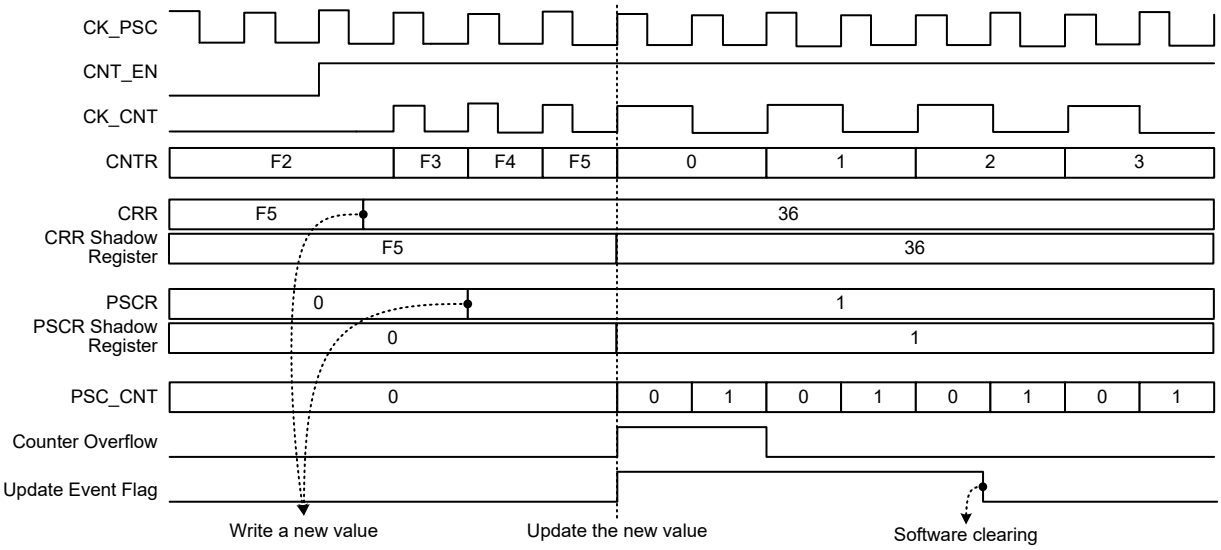


Figure 31. Up-counting Example

Down-Counting

In this mode the counter counts continuously from the counter-reload value, which is defined in the CRR register, to 0 in a count-down direction. Once the counter reaches 0; then restarts from the counter-reload value and generates a counter underflow event. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 1 for the down-counting mode.

When the update event is set by the UEVG bit in the EVGR register, the counter value will also be initialized to the counter-reload value.

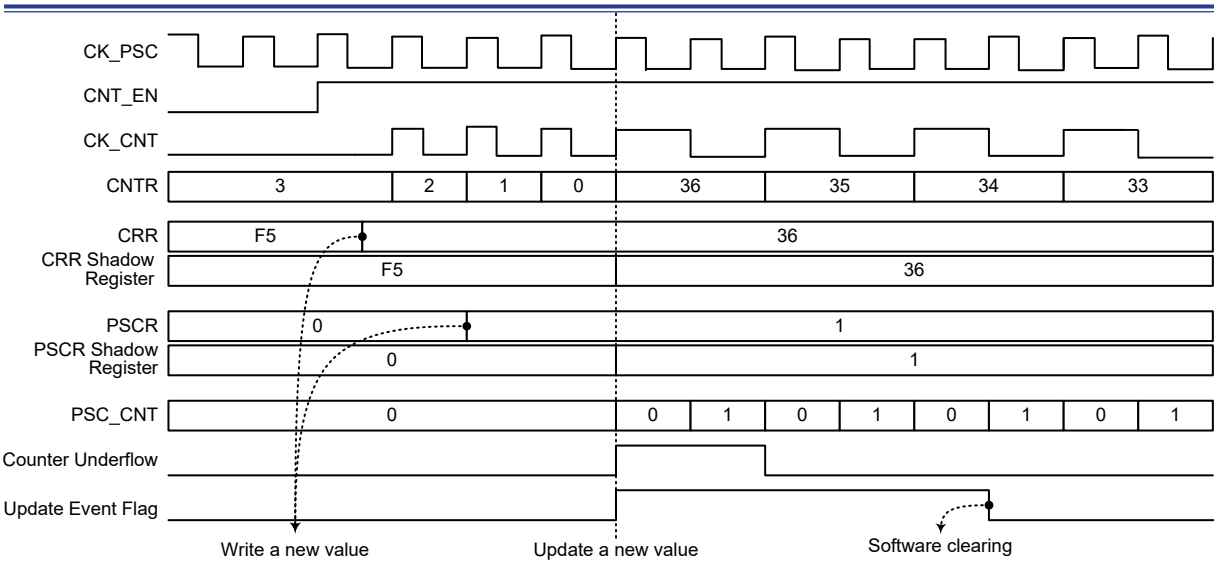


Figure 32. Down-counting Example

Center-Aligned Counting

In the center-aligned counting mode, the counter counts up from 0 to the counter-reload value and then counts down to 0 alternatively. The Timer module generates an overflow event when the counter counts to the counter-reload value in the up-counting mode and generates an underflow event when the counter counts to 0 in the down-counting mode. The counting direction bit DIR in the CNTCFR register is read-only and indicates the counting direction when in the center-aligned mode. The counting direction is updated by hardware automatically.

Setting the UEVG bit in the EVGR register will initialize the counter value to 0 irrespective of whether the counter is counting up or down in the center-aligned counting mode.

The update event interrupt flag bit in the INTSR register will be set to 1, when an overflow or underflow event occurs.

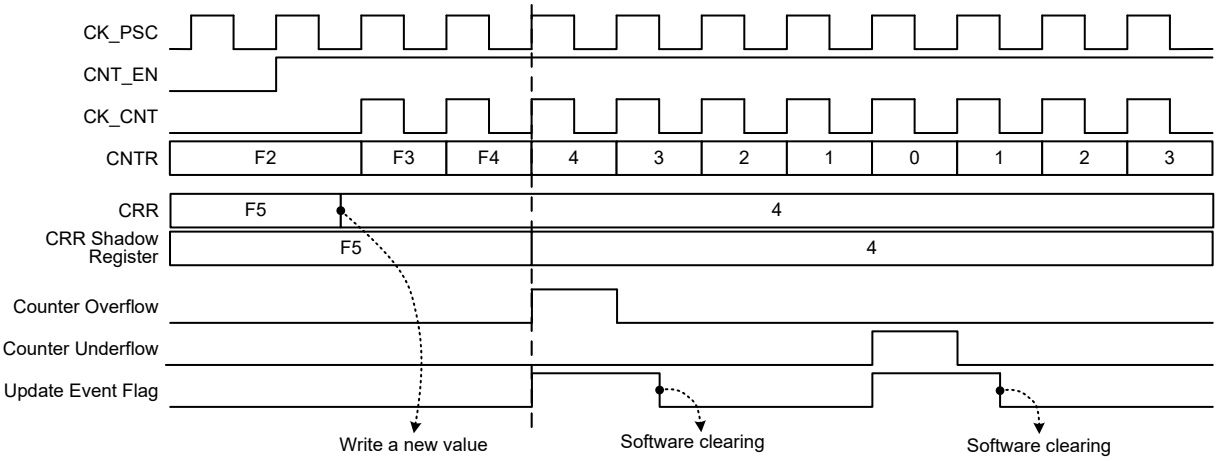


Figure 33. Center-aligned Counting Example

Clock Controller

The following describes the Timer Module clock controller which determines the clock source of the internal prescaler counter.

- Internal APB clock f_{CLKIN}:
  The default internal clock source is the APB clock f_{CLKIN} used to drive the counter prescaler when the slave mode is disabled. When the slave mode selection bits SMSEL in the MDCFR register are set to 0x4, 0x5 or 0x6, the internal APB clock f_{CLKIN} is the counter prescaler driving clock source. If the slave mode controller is enabled by setting SMSEL field in the MDCFR register to an available value including 0x1, 0x2, 0x3 and 0x7, the prescaler is clocked by other clock sources selected by the TRSEL field in the TRCFR register and described as follows.
- Quadrature Decoder:
  To select Quadrature Decoder mode the SMSEL field should be set to 0x1, 0x2 or 0x3 in the MDCFR register. The Quadrature Decoder function uses two input states of the GT_CH0 and GT_CH1 pins to generate the clock pulse to drive the counter prescaler. The counting direction bit DIR is modified by hardware automatically at each transition on the input source signal. The input source signal can be derived from the GT_CH0 pin only, the GT_CH1 pin only or both GT_CH0 and GT_CH1 pins.

■ STIED

The counter prescaler can count during each rising edge of the STI signal. This mode can be selected by setting the SMSEL field to 0x7 in the MDCFR register. Here the counter will act as an event counter. The input event, known as STI here, can be selected by setting the TRSEL field to an available value except the value of 0x0. When the STI signal is selected as the clock source, the internal edge detection circuitry will generate a clock pulse during each STI signal rising edge to drive the counter prescaler. It is important to note that if the TRSEL field is set to 0x0 to select the software UEVG bit as the trigger source, then when the SMSEL field is set to 0x7, the counter will be updated instead of counting.

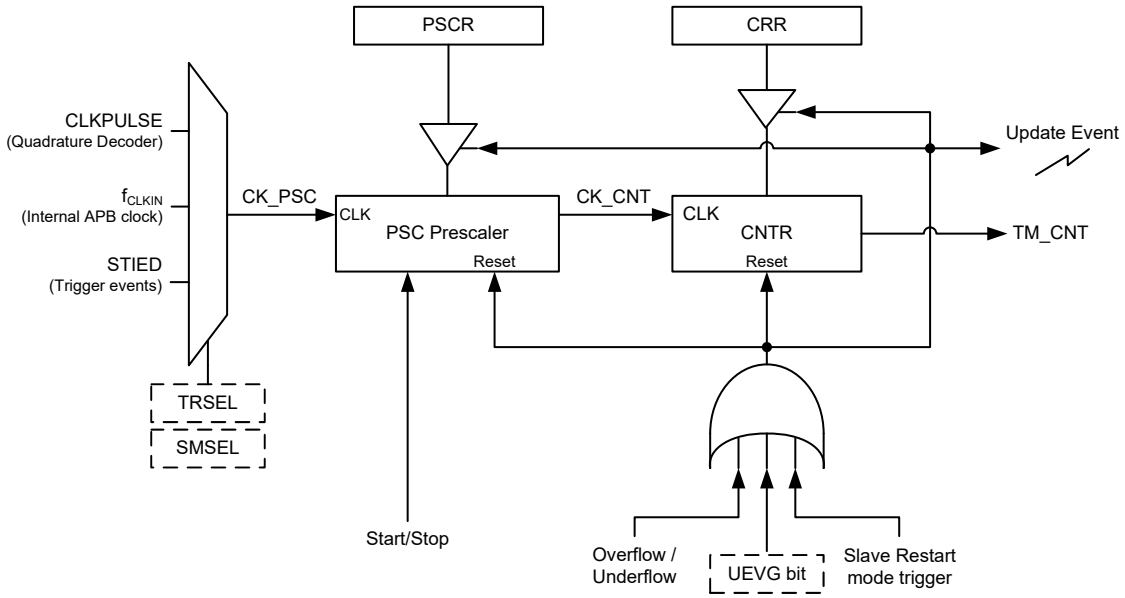


Figure 34. GPTM Clock Source Selection

Trigger Controller

The trigger controller is used to select the trigger source and setup the trigger level or trigger edge condition. For the internal trigger input, it can be selected by the Trigger Selection bits TRSEL in the TRCFR register. For all the trigger sources except the UEVG bit software trigger, the internal edge detection circuitry will generate a clock pulse at each trigger signal rising edge to stimulate some GPTM functions which are triggered by a trigger signal rising edge.

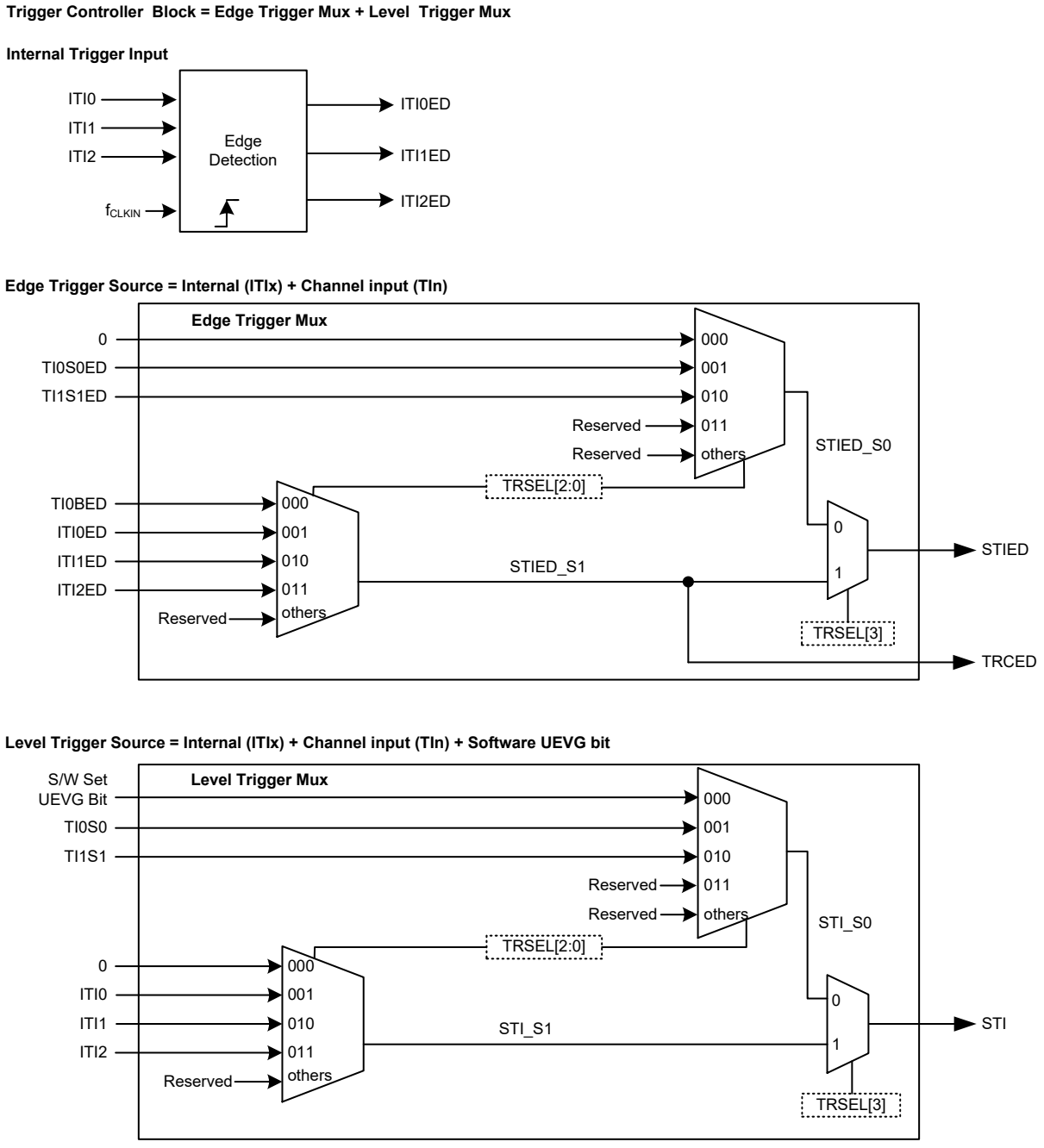


Figure 35. Trigger Control Block

Slave Controller

The GPTM can be synchronized with an external trigger in several modes including the Restart mode, the Pause mode and the Trigger mode which can be selected by the SMSEL field in the MDCFR register. The trigger input of these modes comes from the STI signal which is selected by the TRSEL field in the TRCFR register. The operation modes in the Slave Controller are described in the accompanying sections.

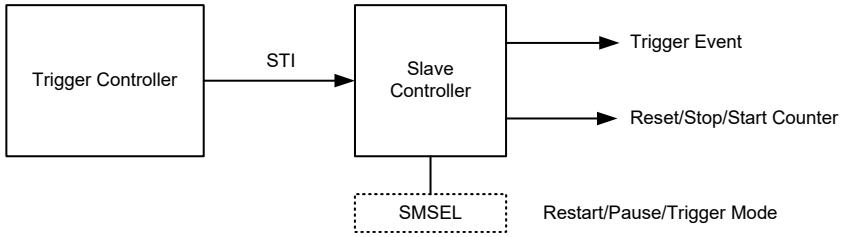


Figure 36. Slave Controller Diagram

Restart Mode

The counter and its prescaler can be reinitialized in response to a rising edge of the STI signal. When an STI rising edge occurs, the update event software generation bit named UEVG will automatically be asserted by hardware and the trigger event flag will also be set. Then the counter and prescaler will be reinitialized. Although the UEVG bit is set to 1 by hardware, the update event does not really occur. It depends upon whether the update event disable control bit UEVDIS is set to 1 or not. If the UEVDIS is set to 1 to disable the update event to occur, there will no update event be generated, however the counter and prescaler are still reinitialized when the STI rising edge occurs. If the UEVDIS bit in the CNTCFR register is cleared to enable the update event to occur, an update event will be generated together with the STI rising edge, then all the preloaded registers will be updated.

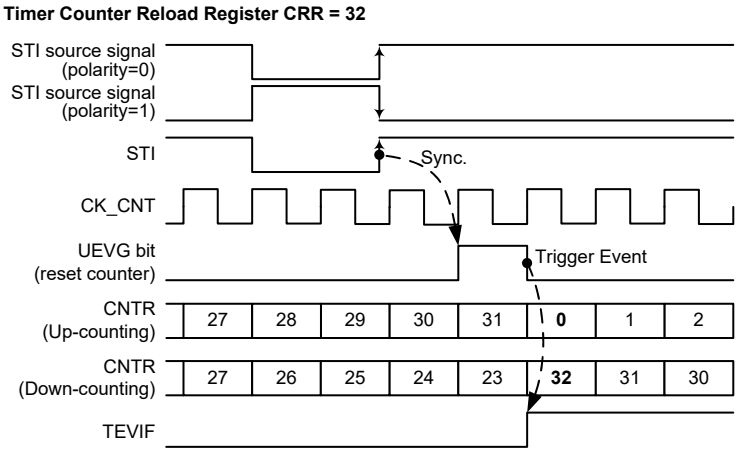


Figure 37. GPTM in Restart Mode

Pause Mode

In the Pause Mode, the selected STI input signal level is used to control the counter start/stop operation. The counter starts to count when the selected STI signal is at a high level and stops counting when the STI signal is changed to a low level, here the counter will maintain its present value and will not be reset. Since the Pause function depends upon the STI level to control the counter stop/start operation, the selected STI trigger signal can not be derived from the TI0BED signal.

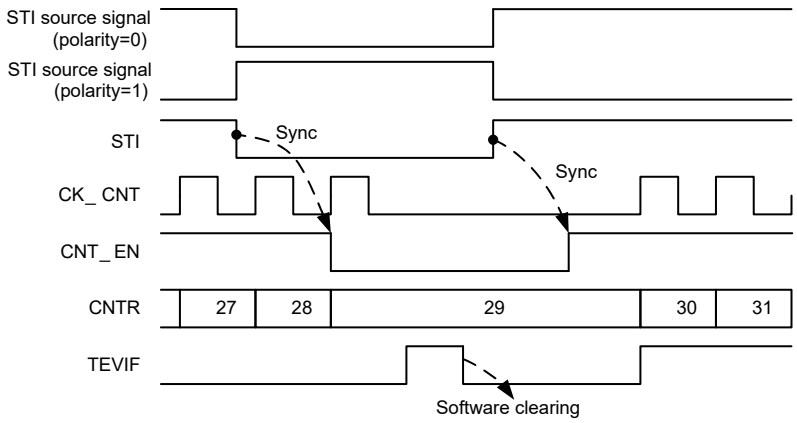


Figure 38. GPTM in Pause Mode

Trigger Mode

After the counter is disabled to count, the counter can resume counting when an STI rising edge signal occurs. When an STI rising edge occurs, the counter will start to count from the current value in the counter. Note that if the STI signal is selected to be derived from the UEVG bit software trigger, the counter will not resume counting. When software triggering using the UEVG bit is selected as the STI source signal, there will be no clock pulse generated which can be used to make the counter resume counting. Note that the STI signal is only used to enable the counter to resume counting and has no effect on controlling the counter to stop counting.

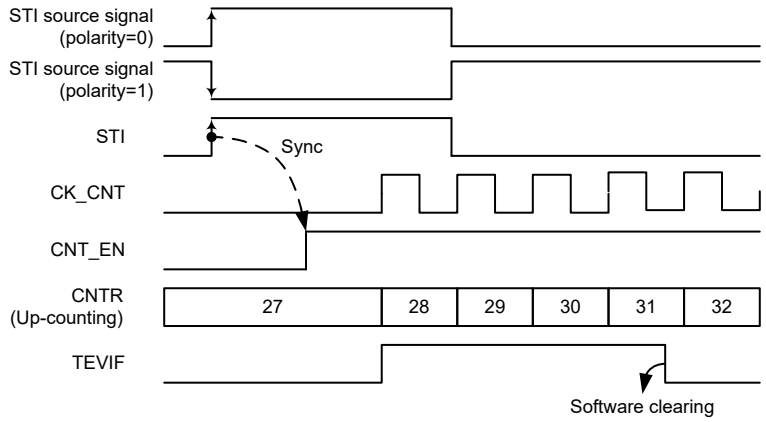


Figure 39. GPTM in Trigger Mode

Master Controller

The GPTMs and TMs can be linked together internally for timer synchronization or chaining. When one GPTM is configured to be in the Master Mode, the GPTM Master Controller will generate a Master Trigger Output (MTO) signal which includes a reset, a start, a stop signal or a clock source which is selected by the MMSEL field in the MDCFR register to trigger or drive another GPTM or TM, if exists, which is configured in the Slave Mode.

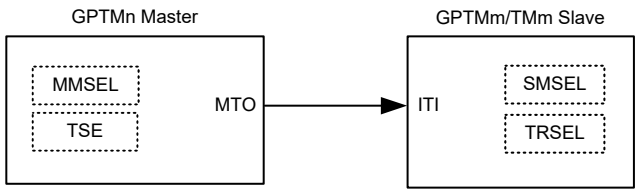


Figure 40. Master GPTMn and Slave GPTMm/TMm Connection

The Master Mode Selection field, MMSEL, in the MDCFR register is used to select the MTO source for synchronizing another slave GPTM or TM if exists.

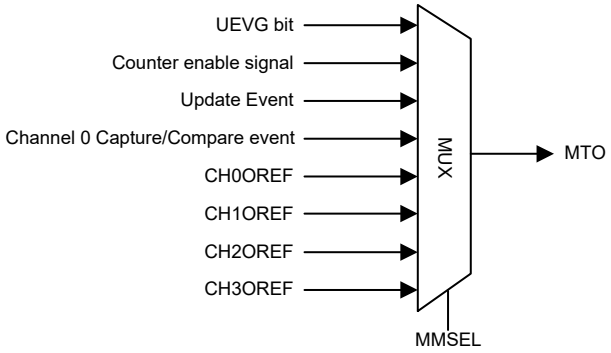


Figure 41. MTO Selection

For example, setting the MMSEL field to 0x5 is to select the CH1OREF signal as the MTO signal to synchronize another slave GPTM or TM. For a more detailed description, refer to the related MMSEL field definitions in the MDCFR register.

Channel Controller

The GPTM has four independent channels which can be used as capture inputs or compare match outputs. Each capture input or compare match output channel is composed of a preload register and a shadow register. Data access of the APB bus is always implemented by reading/writing the preload register.

When used in the input capture mode, the counter value is captured into the CHxCCR shadow register first and then transferred into the CHxCCR preload register when the capture event occurs.

When used in the compare match output mode, the contents of the CHxCCR preload register is copied into the associated shadow register, the counter value is then compared with the register value.

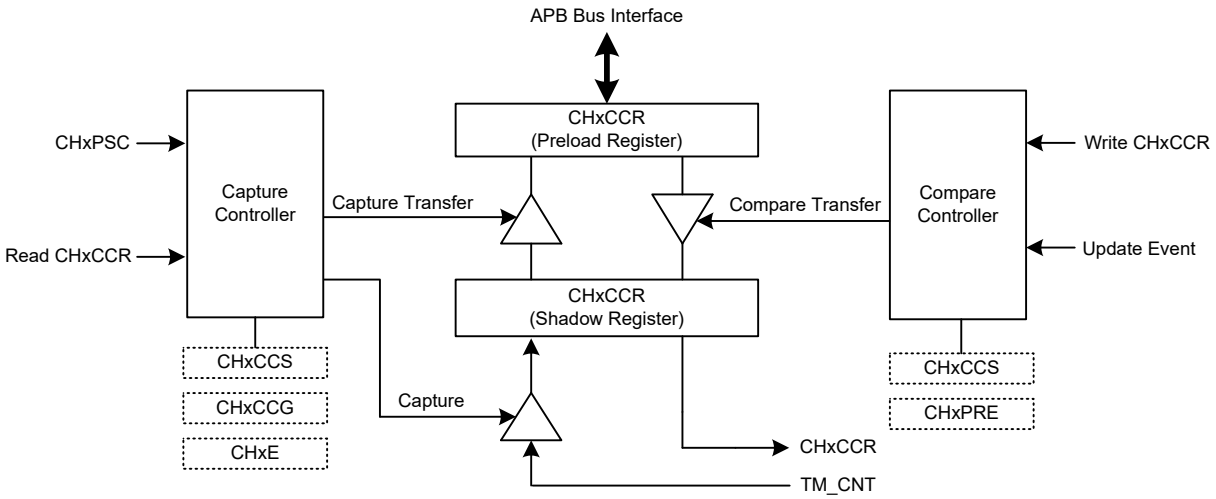


Figure 42. Capture/Compare Block Diagram

Capture Counter Value Transferred to CHxCCR

When the channel is used as a capture input, the counter value is captured into the Channel Capture/Compare Register (CHxCCR) when an effective input signal transition occurs. Once the capture event occurs, the CHxCCIF flag in the INTSR register is set accordingly. If the CHxCCIF bit is already set, i.e., the flag has not yet been cleared by software, and another capture event on this channel occurs, the corresponding channel Over-Capture flag, named CHxOCF, will be set.

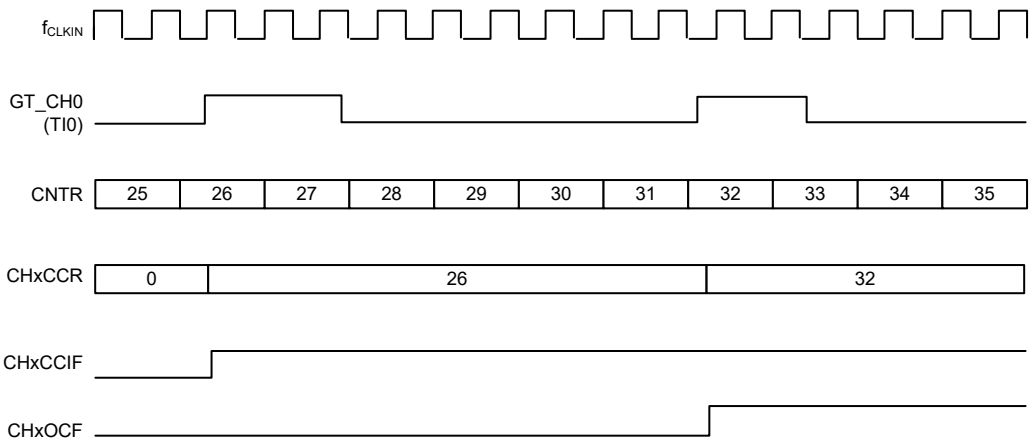


Figure 43. Input Capture Mode

Pulse Width Measurement

The input capture mode can be also used for pulse width measurement from signals on the GT_CHx pins, TIx. The following example shows how to configure the GPTM operated in the input capture mode to measure the high pulse width and the input period on the GT_CH0 pin using channel 0 and channel 1. The basic steps are shown as follows.

- Configure the capture channel 0 (CH0CCS = 0x1) to select the TI0 signal as the capture input.
- Configure the CH0P bit to 0 to choose the rising edge of the TI0 input as the active polarity.
- Configure the capture channel 1 (CH1CCS = 0x2) to select the TI0 signal as the capture input.
- Configure the CH1P bit to 1 to choose the falling edge of the TI0 input as the active polarity.
- Configure the TRSEL bits to 0x1 to select TI0S0 as the trigger input.
- Configure the Slave controller to operate in the Restart mode by setting the SMSEL field in the MDCFR register to 0x4.
- Enable the input capture mode by setting the CH0E and CH1E bits in the CHCTR register to 1.

As the following diagram shows, the high pulse width on the GT_CH0 pin will be captured into the CH1CCR register while the input period will be captured into the CH0CCR register after input capture operation.

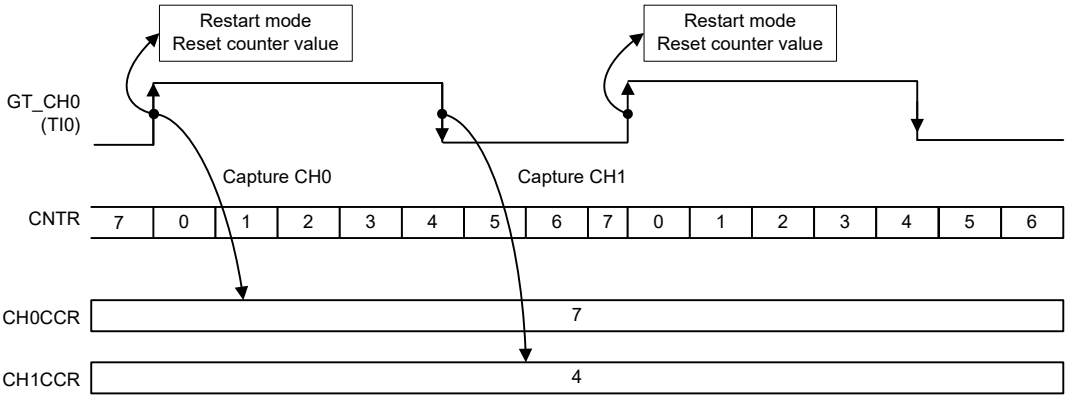


Figure 44. PWM Pulse Width Measurement Example

Input Stage

The input stage consists of a digital filter, a channel polarity selection, edge detection and a channel prescaler. The channel 0 input signal (TI0) can be chosen to come from the GT_CH0 signal or the Excusive-OR function of the GT_CH0, GT_CH1 and GT_CH2 signals. The channel input signal (TIx) is sampled by a digital filter to generate a filtered input signal TIxFP. Then the channel polarity and the edge detection block can generate a TIxS0ED or TIxS1ED signal for the input capture function. The effective input event number can be set by the channel capture input source prescaler setting field, CHxPSC.

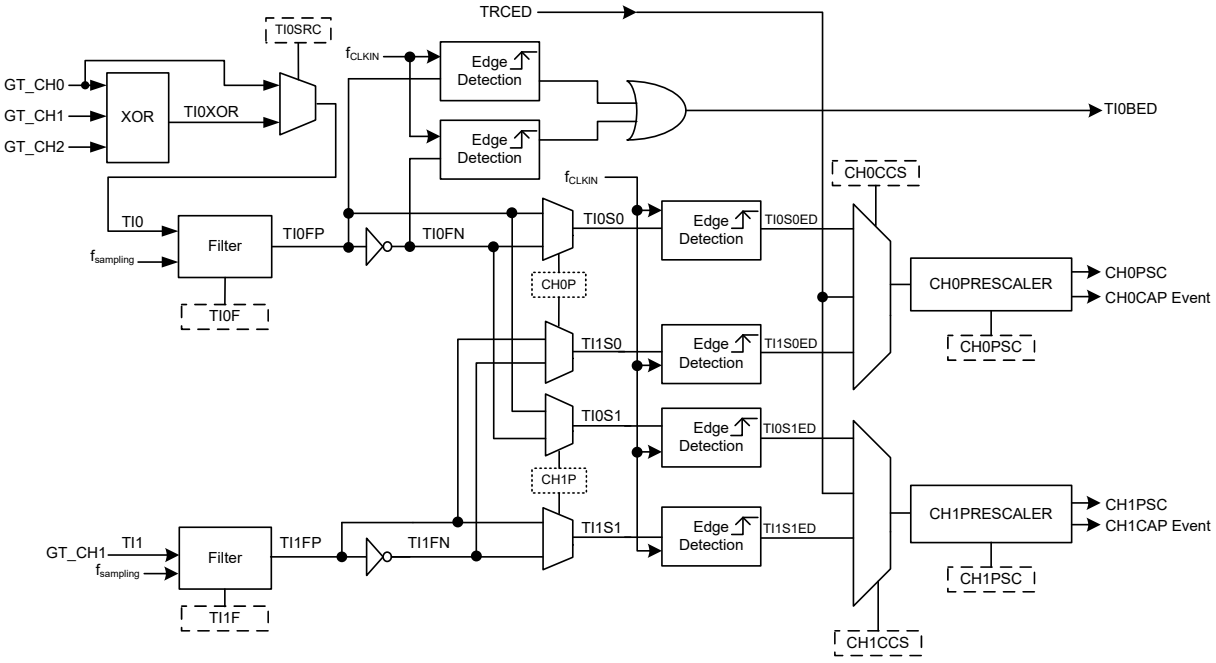


Figure 45. Channel 0 and Channel 1 Input Stages

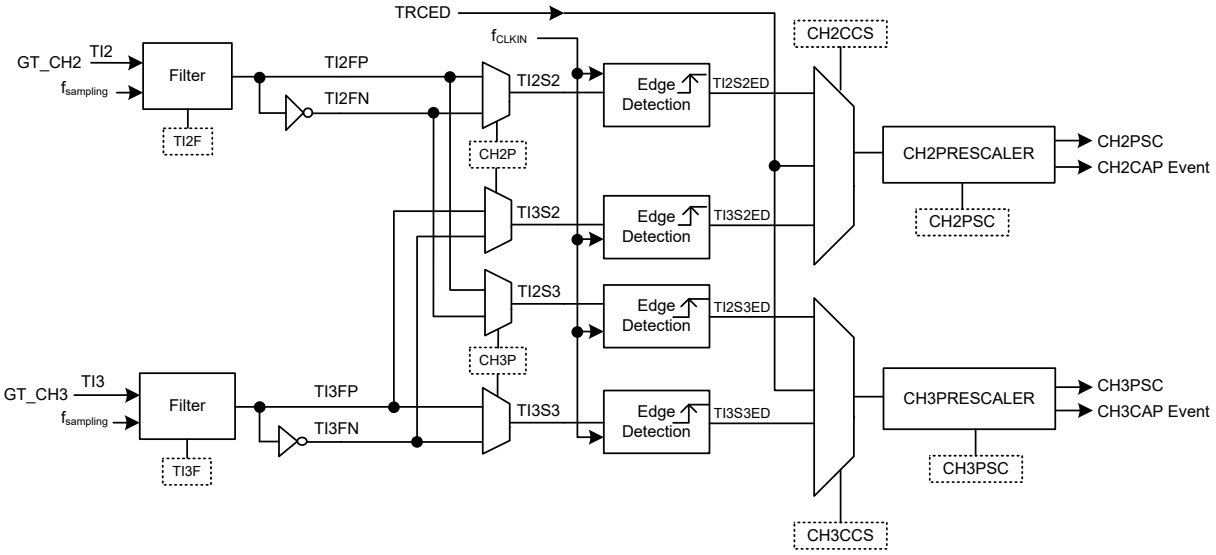


Figure 46. Channel 2 and Channel 3 Input Stages

Digital Filter

The digital filters are embedded in the input stage for the GT_CH0 ~ GT_CH3 pins respectively. The digital filter in the GPTM is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal. The N value can be 0, 2, 4, 5, 6 or 8 according to the user selection for each filter by setting the TIxF field in the CHxICFR register.

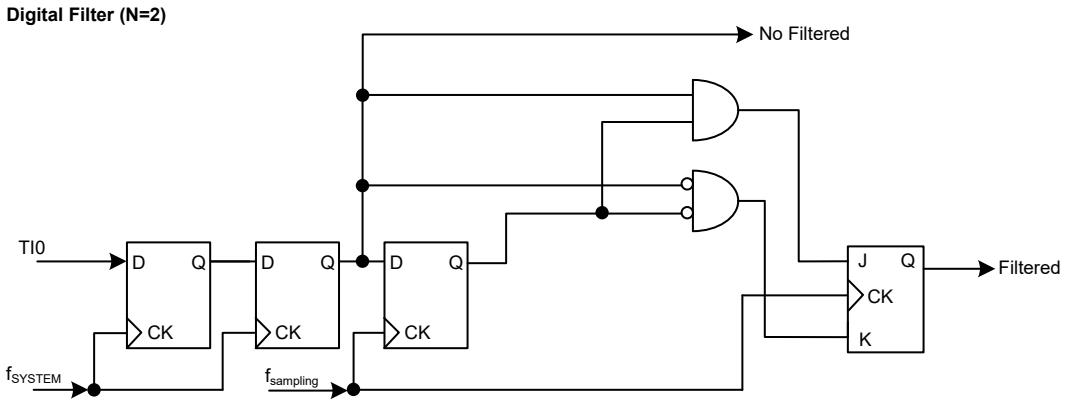


Figure 47. TI0 Digital Filter Diagram with N = 2

Quadrature Decoder

The Quadrature Decoder function uses two quadrantal inputs TI0 and TI1 derived from the GT_CH0 and GT_CH1 pins respectively to interact to generate the counter value. The DIR bit is modified by hardware automatically during each input source transition. The input source can be either TI0 only, TI1 only or both TI0 and TI1, the selection made by setting the SMSEL field to 0x1, 0x2 or 0x3. The mechanism for changing the counter direction is shown in the following table. The Quadrature decoder can be regarded as an external clock with a directional selection. This means that the counter counts continuously in the interval between 0 and the counter-reload value. Therefore, users must configure the CRR register before the counter starts to count.

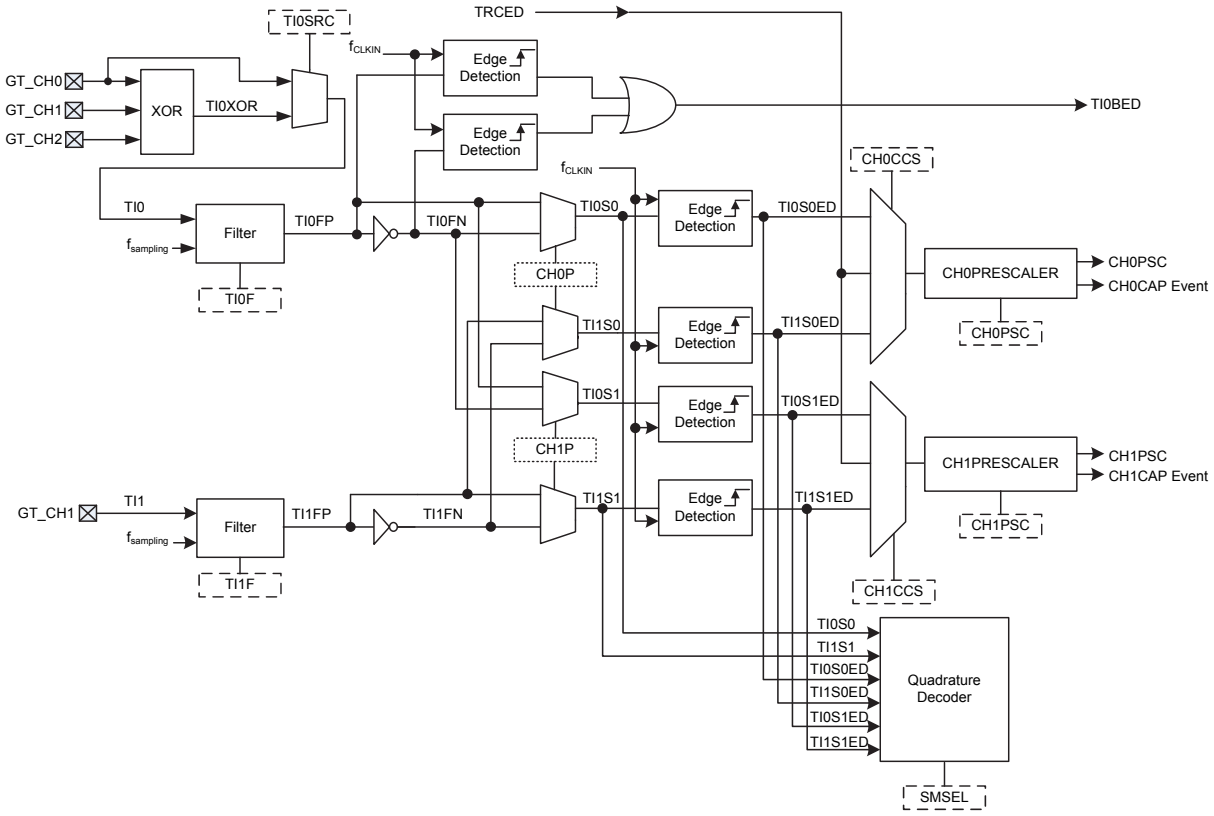


Figure 48. Input Stage and Quadrature Decoder Block Diagram

Table 26. Counting Direction and Encoding Signals

Counting Mode	Level	TI0S0		TI1S1	
		Rising	Falling	Rising	Falling
Counting on TI0 only (SMSEL = 0x1)	TI1S1 = High	Down	Up	—	—
	TI1S1 = Low	Up	Down	—	—
Counting on TI1 only (SMSEL = 0x2)	TI0S0 = High	—	—	Up	Down
	TI0S0 = Low	—	—	Down	Up
Counting on TI0 and TI1 (SMSEL = 0x3)	TI1S1 = High	Down	Up	X	X
	TI1S1 = Low	Up	Down	X	X
	TI0S0 = High	X	X	Up	Down
	TI0S0 = Low	X	X	Down	Up

Note: "—" → means "no counting"; "X" → impossible

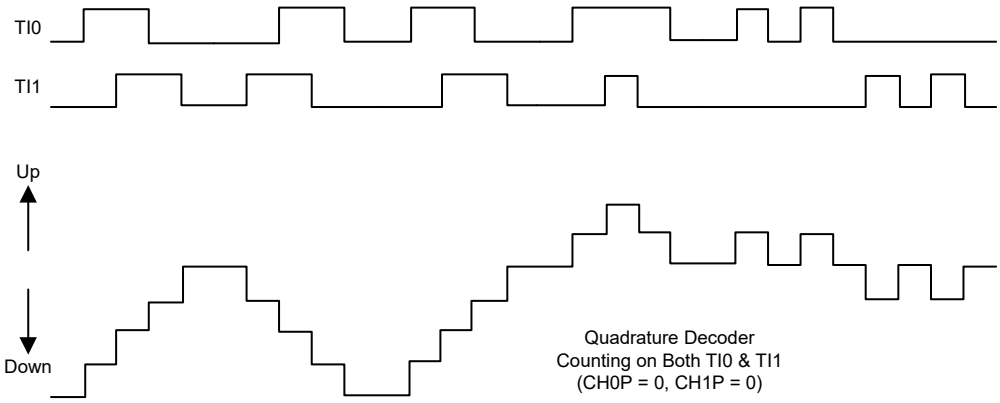


Figure 49. Both TI0 and TI1 Quadrature Decoder Counting

Output Stage

The GPTM has four channels for compare match, single pulse or PWM output function. The channel output GT_CHxO is controlled by the CHxOM, CHxP and CHxE bits in the corresponding CHxOCFR, CHPOLR and CHCTR registers.

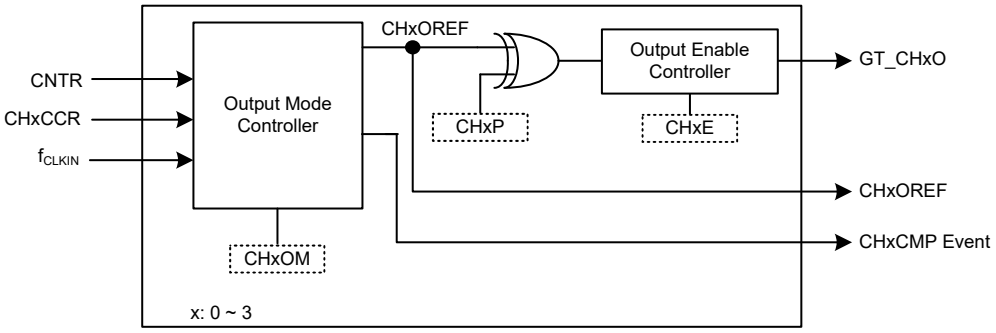


Figure 50. Output Stage Block Diagram

Channel Output Reference Signal

When the GPTM is used in the compare match output mode, the Channel x Output Reference signal, CHxOREF, is defined by the CHxOM field setup. The CHxOREF signal has several types of output function which defines what happens to the output when the counter value matches the contents of the CHxCCR register. In addition to the low, high and toggle CHxOREF output types, there are also PWM mode 1 and PWM mode 2 outputs. In these modes, the CHxOREF signal level is changed according to the count direction and the relationship between the counter value and the CHxCCR content. There are also two modes which will force the output into an inactive or active state irrespective of the CHxCCR content or counter values. With regard to a more detailed description refer to the relative bit definition. The accompanying Table 33 shows a summary of the output type setup.

Table 27. Compare Match Output Setup

CHxOM Value	Compare Match Level
0x0	No change
0x1	Clear Output to 0
0x2	Set Output to 1
0x3	Toggle Output
0x4	Force Inactive Level
0x5	Force Active Level
0x6	PWM Mode 1
0x7	PWM Mode 2

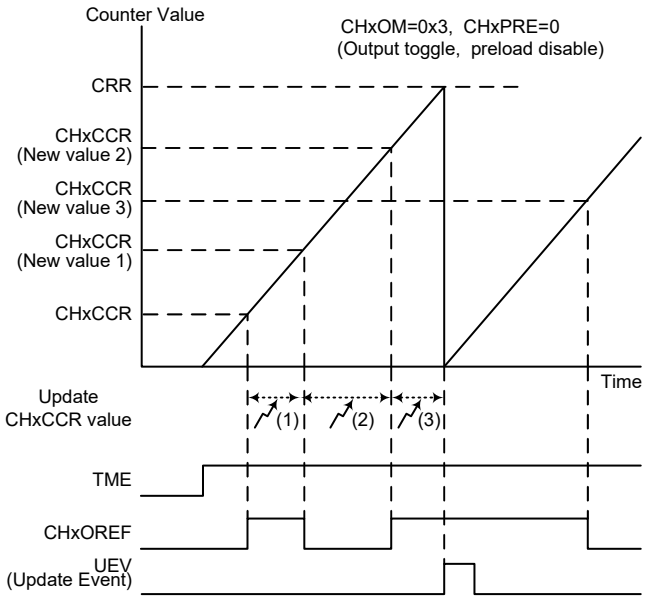


Figure 51. Toggle Mode Channel Output Reference Signal (CHxPRE = 0)

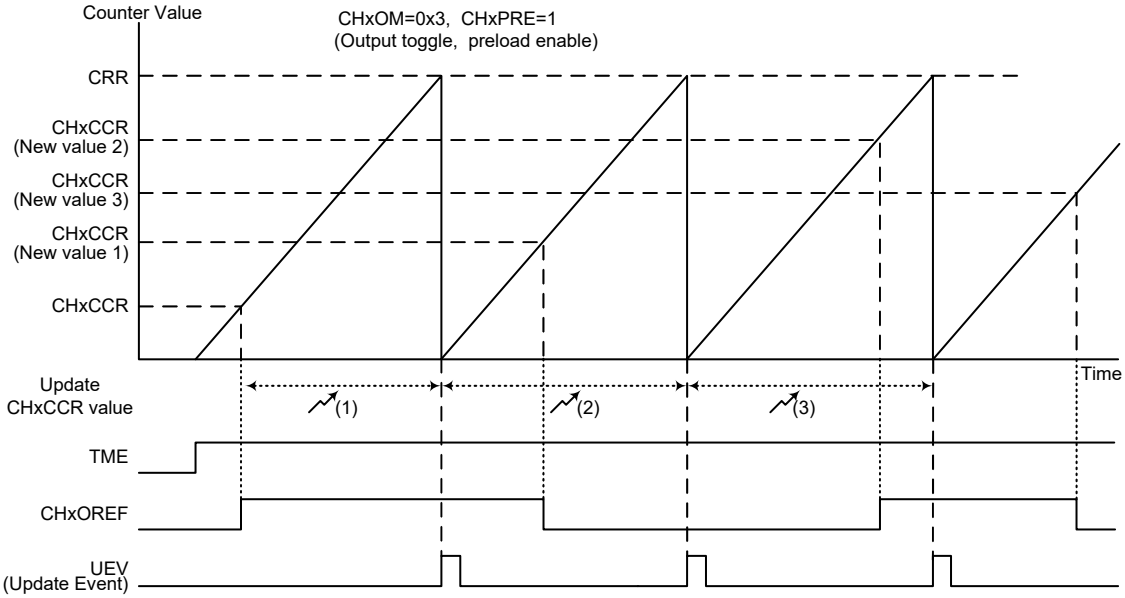


Figure 52. Toggle Mode Channel Output Reference Signal (CHxPRE = 1)

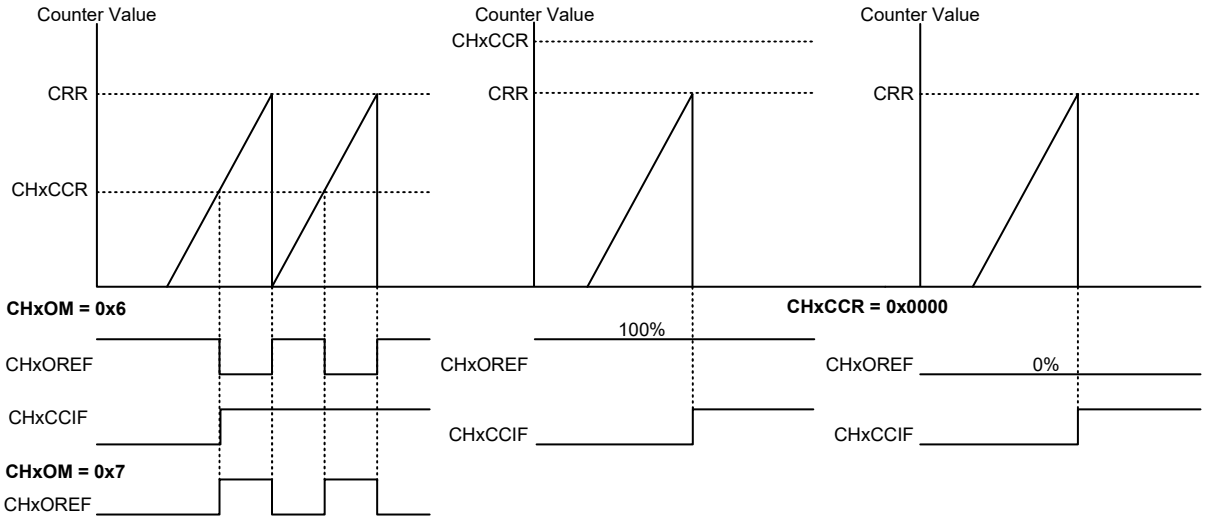


Figure 53. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode

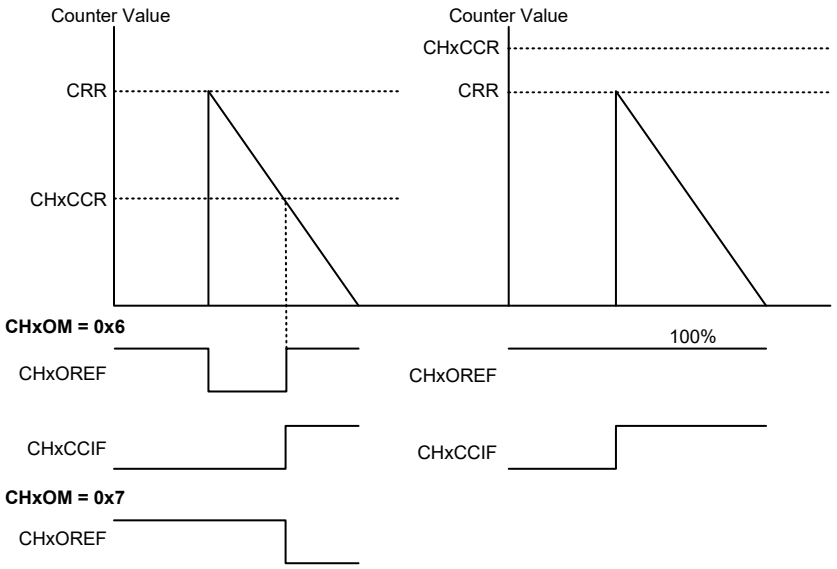


Figure 54. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode

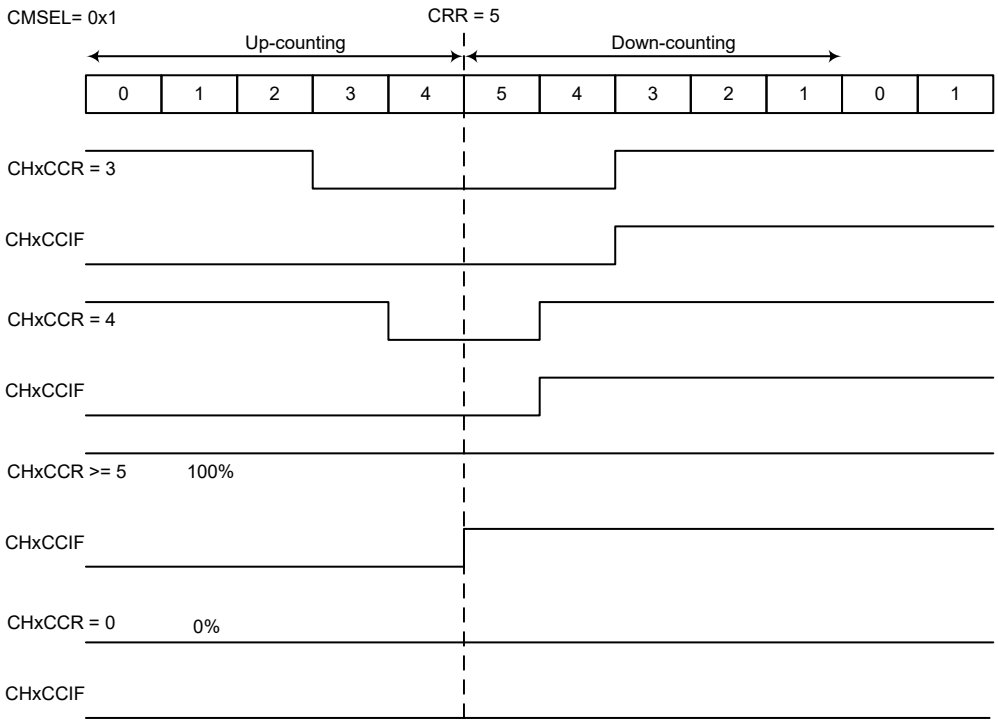


Figure 55. PWM Mode Channel Output Reference Signal and Counter in Centre-aligned Mode

Update Management

The Update event is used to update the CRR, the PSCR, the CHxACR and the CHxCCR values from the actual registers to the corresponding shadow registers. An update event occurs when the counter overflows or underflows, the software update control bit is triggered or an update event from the slave controller is generated.

The UEVDIS bit in the CNTCFR register can determine whether the update event occurs or not. When the update event occurs, the corresponding update event interrupt will be generated depending upon whether the update event interrupt generation function is enabled or not by configuring the UGDIS bit in the CNTCFR register. For more detailed description, refer to the UEVDIS and UGDIS bit definition in the CNTCFR register

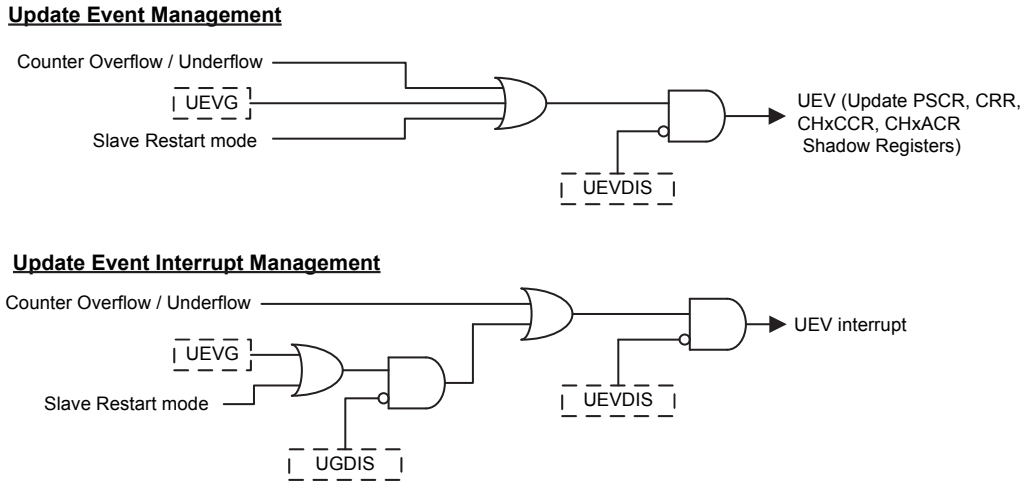


Figure 56. Update Event Setting Diagram

Single Pulse Mode

Once the timer is set to operate in the single pulse mode, it is not necessary to set the timer enable bit TME in the CTR register to 1 to enable the counter. The trigger to generate a pulse can be sourced from the STI signal rising edge or by setting the TME bit to 1 using software. Setting the TME bit to 1 or a trigger from the STI signal rising edge can generate a pulse and then keep the TME bit at a high state until the update event occurs or the TME bit is written to 0 by software. If the TME bit is cleared to 0 using software, the counter will be stopped and its value held. If the TME bit is automatically cleared to 0 by a hardware update event, the counter will be reinitialized.

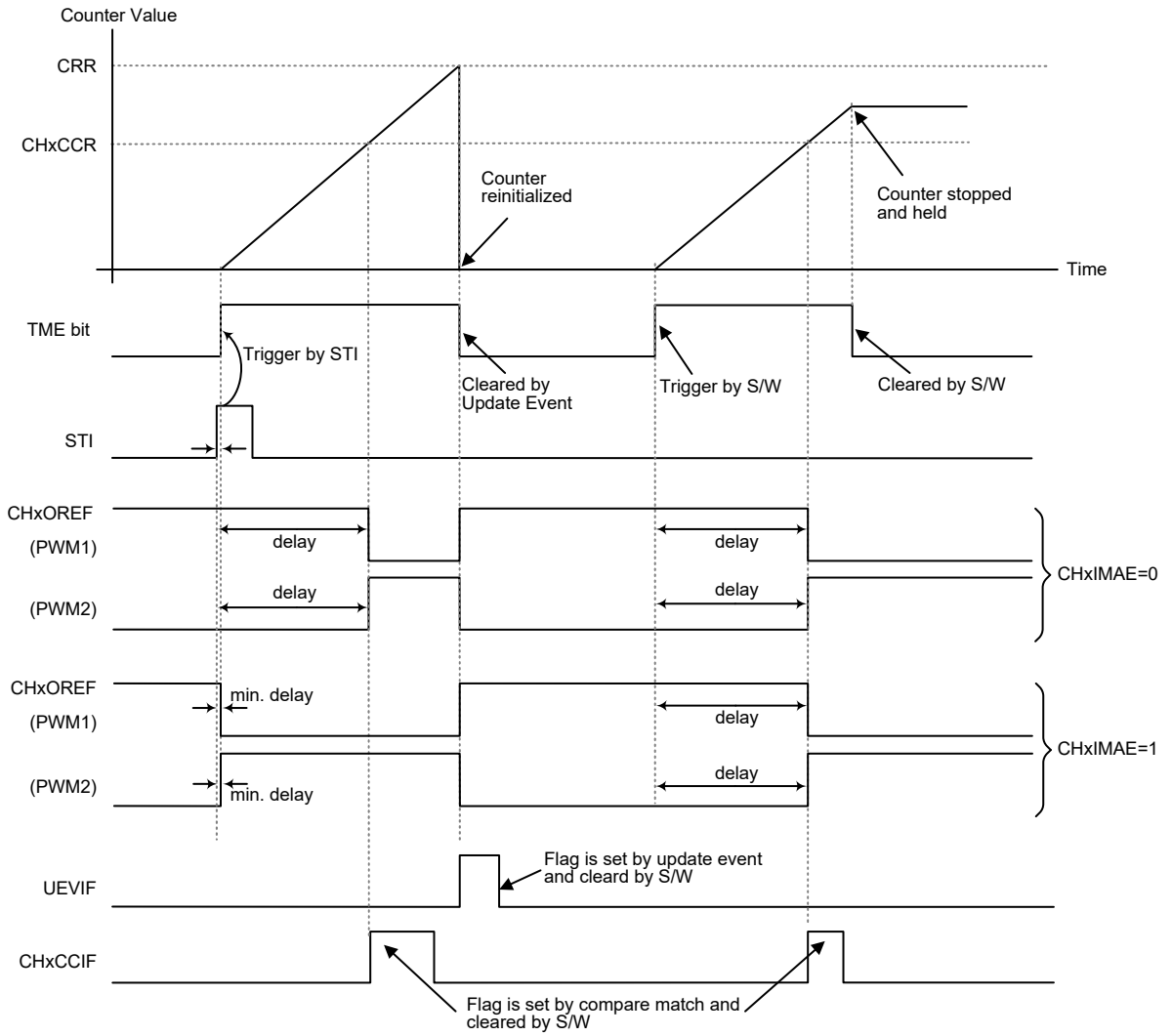


Figure 57. Single Pulse Mode

In the Single Pulse mode, the STI active edge which sets the TME bit to 1 will enable the counter. However, there exist several clock delays to perform the comparison result between the counter value and the CHxCCR value. In order to reduce the delay to a minimum value, the user can set the CHxIMAE bit in each CHxOCFR register. After an STI rising edge trigger occurs in the single pulse mode, the CHxOREF signal will immediately be forced to the state which the CHxOREF signal will change to as the compare match event occurs without taking the comparison result into account. The CHxIMAE bit is available only when the output channel is configured to operate in the PWM mode 1 or PWM mode 2 and the trigger source is derived from the STI signal.

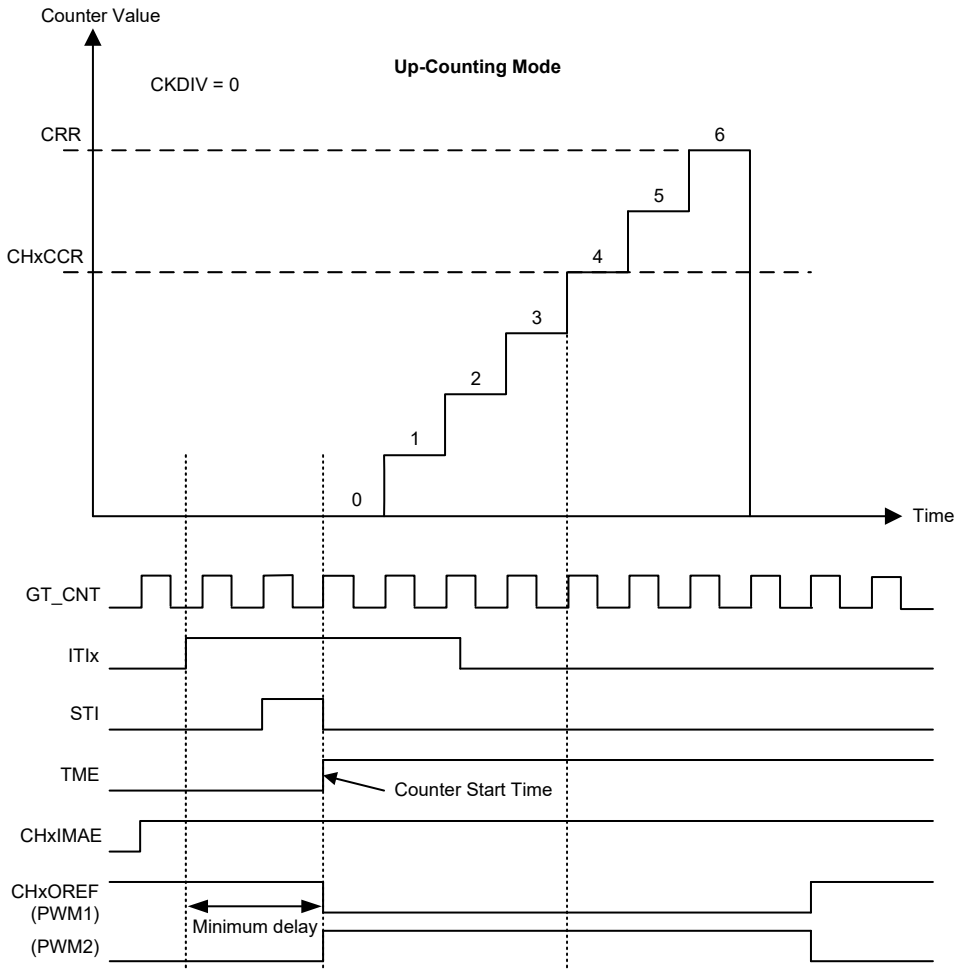


Figure 58. Immediate Active Mode Minimum Delay

Asymmetric PWM Mode

Asymmetric PWM mode allows two center-aligned PWM signals to be generated with a programmable phase shift. While the PWM frequency is determined by the value of the CRR register, the duty cycle and the phase-shift are determined by the CHxCCR and CHxACR register. When the counter is counting up, the PWM uses the value in CHxCCR as up-count compare value. When the counter is into counting down stage, the PWM uses the value in CHxACR as down-count compare value. The Figure 59 is shown as an example for asymmetric PWM mode in center-aligned counting mode.

Note: Asymmetric PWM mode can only be operated in center-aligned counting mode.

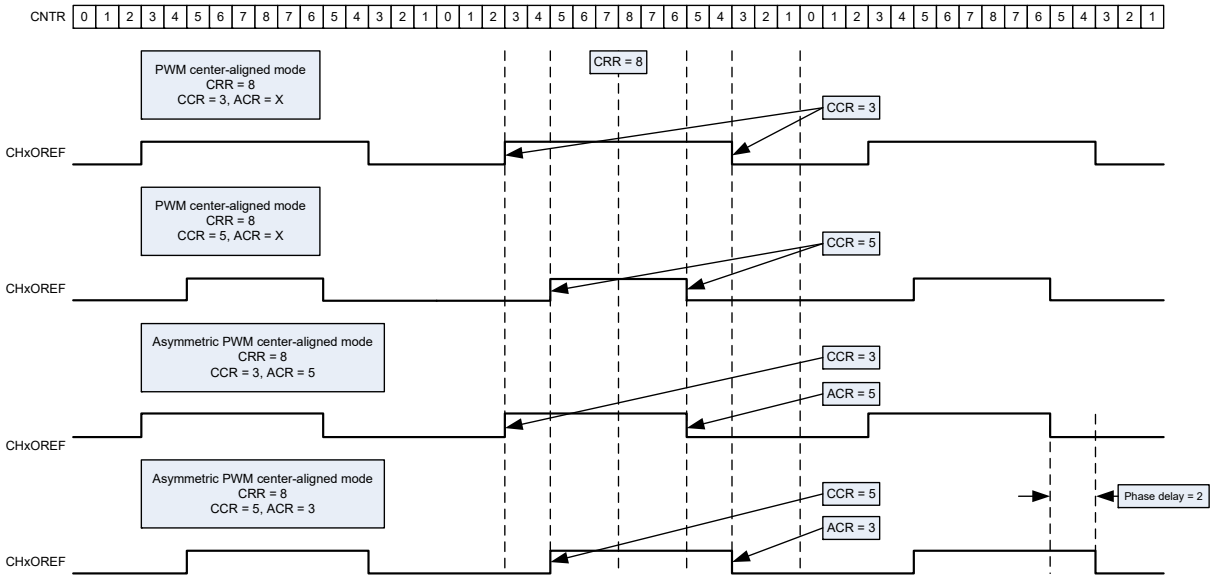


Figure 59. Asymmetric PWM Mode versus Center-Aligned Counting Mode

Timer Interconnection

The timers can be internally connected together for timer chaining or synchronization. This can be implemented by configuring one timer to operate in the Master mode while configuring another timer to be in the Slave mode. The following figures present several examples of trigger selection for the master and slave modes.

Using One Timer to Enable/Disable another Timer Start or Stop Counting

- Configure GPTM as the master mode to send its channel 0 Output Reference signal CH0OREF as a trigger output (MMSEL = 0x4).
- Configure GPTM CH0OREF waveform.
- Configure PWM0 to receive its input trigger source from the GPTM trigger output (TRSEL = 0xA).
- Configure PWM0 to operate in the pause mode (SMSEL = 0x5).
- Enable PWM0 by writing '1' to the TME bit.
- Enable GPTM by writing '1' to the TME bit.

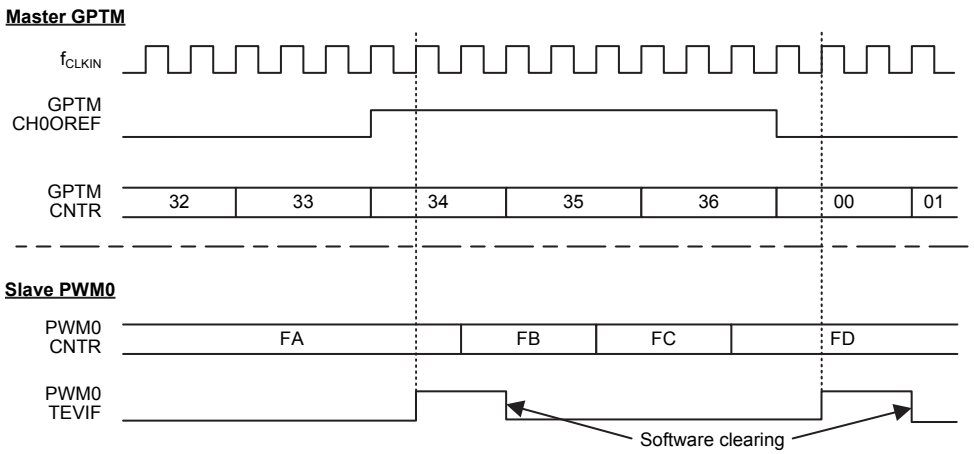


Figure 60. Pausing PWM0 using the GPTM CH0OREF Signal

Using one Timer to Trigger another Timer Start Counting

- Configure GPTM to operate in the master mode to send its Update Event UEV as the trigger output (MMSEL = 0x2).
- Configure the GPTM period by setting the CRR register.
- Configure PWM0 to get the input trigger source from the GPTM trigger output (TRSEL = 0xA).
- Configure PWM0 to be in the slave trigger mode (SMSEL = 0x6).
- Start GPTM by writing '1' to the TME bit.

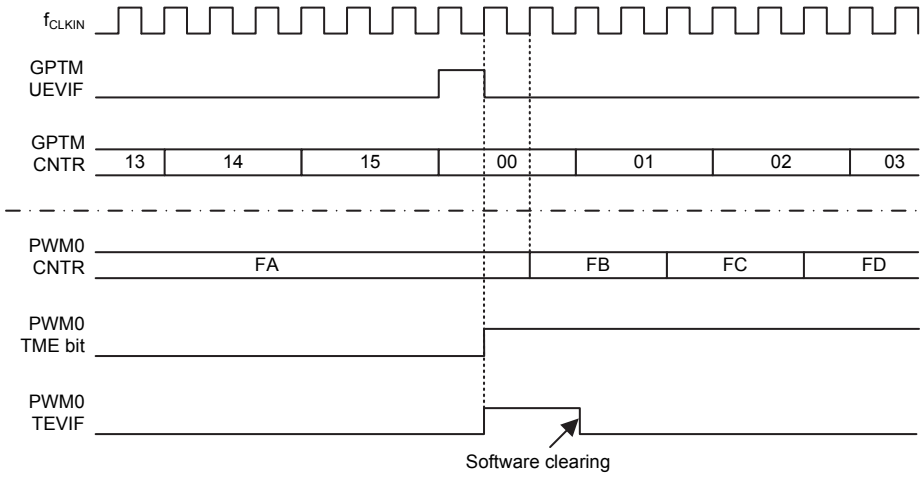


Figure 61. Triggering PWM0 with GPTM Update Event

Starting Two Timers Synchronously in Response to an External Trigger

- Configure GPTM to operate in the master mode to send its enable signal as a trigger output (MMSEL = 0x1).
- Configure GPTM slave mode to receive its input trigger source from GT_CH0 pin (TRSEL = 0x1).
- Configure GPTM to be in the slave trigger mode (SMSEL = 0x6).
- Enable the GPTM master timer synchronization function by setting the TSE bit in the MDCFR register to 1 to synchronize the slave timer.
- Configure PWM0 to receive its input trigger source from the GPTM trigger output (TRSEL = 0xA).
- Configure PWM0 to be in the slave trigger mode (SMSEL = 0x6).

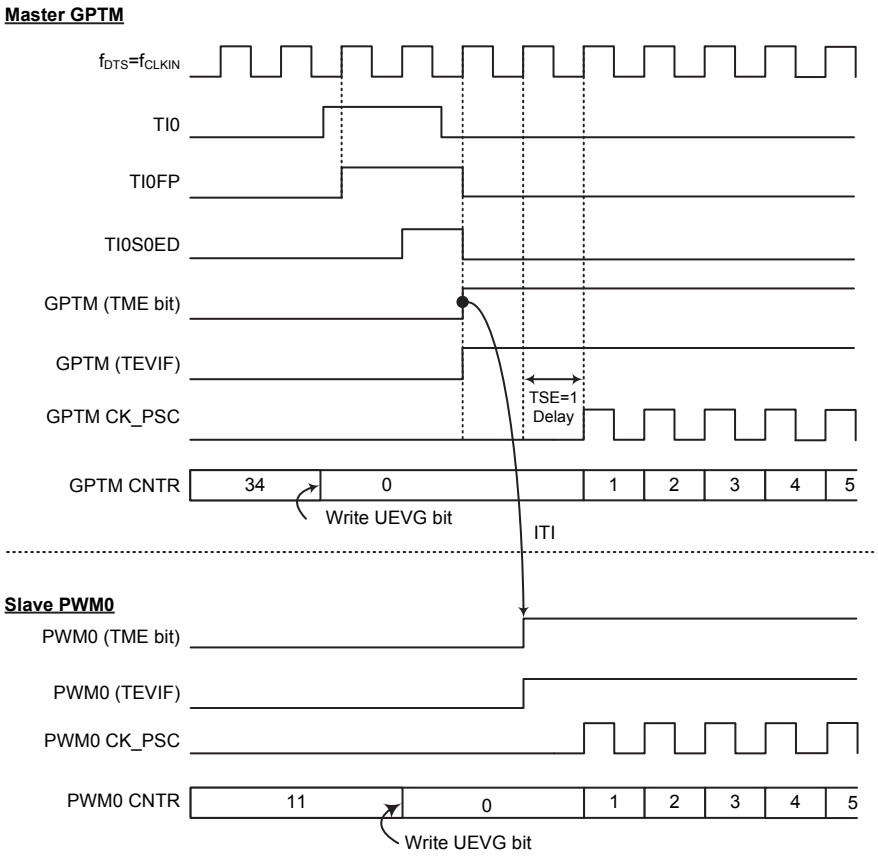


Figure 62. Trigger GPTM and PWM0 with the GPTM CH0 Input

Trigger Peripherals Start

To interconnect to the peripherals, such as ADC, Timer and so on, the GPTM could output the MTO signal or the channel compare match output signal CHxOREF (x = 0~3) to be used as peripherals input trigger signal and depending on the MCU specification.

PDMA Request

The GPTM supports the interface for PDMA data transfer. There are certain events which can generate the PDMA requests if the corresponding enable control bits are set to 1 to enable the PDMA access. These events are the GPTM update events, trigger events and channel capture/compare events. When the PDMA request is generated from the GPTM channel, it can be derived from the channel capture/compare event or the GPTM update event selected by the channel PDMA selection bit, CHCCDS, for all channels. For more detailed PDMA configuring information, refer to the corresponding section in the PDMA chapter.

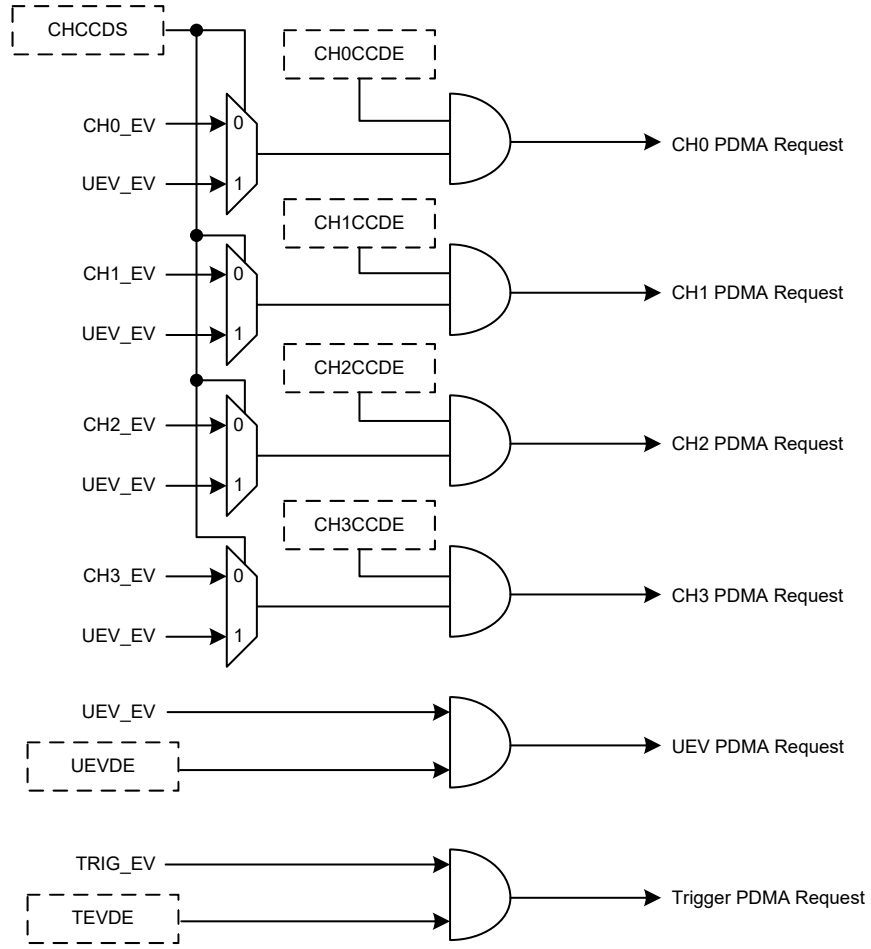


Figure 63. GPTM PDMA Mapping Diagram

Register Map

The following table shows the GPTM registers and reset values.

Table 28. GPTM Register Map

Register	Offset	Description	Reset Value
CNTCFR	0x000	Timer Counter Configuration Register	0x0000_0000
MDCFR	0x004	Timer Mode Configuration Register	0x0000_0000
TRCFR	0x008	Timer Trigger Configuration Register	0x0000_0000
CTR	0x010	Timer Control Register	0x0000_0000
CH0ICFR	0x020	Channel 0 Input Configuration Register	0x0000_0000
CH1ICFR	0x024	Channel 1 Input Configuration Register	0x0000_0000
CH2ICFR	0x028	Channel 2 Input Configuration Register	0x0000_0000
CH3ICFR	0x02C	Channel 3 Input Configuration Register	0x0000_0000
CH0OCFR	0x040	Channel 0 Output Configuration Register	0x0000_0000
CH1OCFR	0x044	Channel 1 Output Configuration Register	0x0000_0000
CH2OCFR	0x048	Channel 2 Output Configuration Register	0x0000_0000
CH3OCFR	0x04C	Channel 3 Output Configuration Register	0x0000_0000
CHCTR	0x050	Channel Control Register	0x0000_0000
CHPOLR	0x054	Channel Polarity Configuration Register	0x0000_0000
DICTR	0x074	Timer PDMA/Interrupt Control Register	0x0000_0000
EVGR	0x078	Timer Event Generator Register	0x0000_0000
INTSR	0x07C	Timer Interrupt Status Register	0x0000_0000
CNTR	0x080	Timer Counter Register	0x0000_0000
PSCR	0x084	Timer Prescaler Register	0x0000_0000
CRR	0x088	Timer Counter-Reload Register	0x0000_FFFF
CH0CCR	0x090	Channel 0 Capture/Compare Register	0x0000_0000
CH1CCR	0x094	Channel 1 Capture/Compare Register	0x0000_0000
CH2CCR	0x098	Channel 2 Capture/Compare Register	0x0000_0000
CH3CCR	0x09C	Channel 3 Capture/Compare Register	0x0000_0000
CH0ACR	0x0A0	Channel 0 Asymmetric Compare Register	0x0000_0000
CH1ACR	0x0A4	Channel 1 Asymmetric Compare Register	0x0000_0000
CH2ACR	0x0A8	Channel 2 Asymmetric Compare Register	0x0000_0000
CH3ACR	0x0AC	Channel 3 Asymmetric Compare Register	0x0000_0000

Register Descriptions

Timer Counter Configuration Register – CNTCFR

This register specifies the GPTM counter configuration.

Offset: 0x000
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							DIR
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved							CMSEL
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							CKDIV
Type/Reset							RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved						UGDIS	UEVDIS
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[24]	DIR	Counting Direction 0: Count-up 1: Count-down Note: This bit is read only when the Timer is configured to be in the Center-aligned mode or when used as a Quadrature decoder.
[17:16]	CMSEL	Counter Mode Selection 00: Edge-aligned mode. Normal up-counting and down-counting available for this mode. Counting direction is defined by the DIR bit. 01: Center-aligned mode 1. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-down period. 10: Center-aligned mode 2. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up period. 11: Center-aligned mode 3. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up and count-down periods.
[9:8]	CKDIV	Clock Division These two bits define the frequency ratio between the timer clock (f_{CLKIN}) and the dead-time clock (f_{DTS}). The dead-time clock is also used for digital filter sampling clock. 00: $f_{DTS} = f_{CLKIN}$ 01: $f_{DTS} = f_{CLKIN} / 2$ 10: $f_{DTS} = f_{CLKIN} / 4$ 11: Reserved

Bits	Field	Descriptions
[1]	UGDIS	Update event interrupt generation disable control 0: Any of the following events will generate an update PDMA request or interrupt - Counter overflow/underflow - Setting the UEVG bit - Update generation through the slave mode 1: Only counter overflow/underflow generates an update PDMA request or interrupt
[0]	UEVDIS	Update Event Disable control 0: Enable the update event request by one of following events: - Counter overflow/underflow - Setting the UEVG bit - Update generation through the slave mode 1: Disable the update event (However the counter and the prescaler are reinitialized if the UEVG bit is set or if a hardware restart is received from the slave mode)

Timer Mode Configuration Register – MDCFR

This register specifies the GPTM master and slave mode selection and single pulse mode.

Offset: 0x004
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							SPMSET
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved					MMSEL		
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved					SMSEL		
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved							TSE
Type/Reset								RW 0

Bits	Field	Descriptions
[24]	SPMSET	Single Pulse Mode Setting 0: Counter counts normally irrespective of whether the update event occurred or not 1: Counter stops counting at the next update event and then the TME bit is cleared by hardware

Bits	Field	Descriptions
[18:16]	MMSEL	Master Mode Selection Master mode selection is used to select the MTO signal source which is used to synchronize the other slave timer.

MMSEL [2:0]	Mode	Descriptions
000	Reset Mode	The MTO signal in the Reset mode is an output derived from one of the following cases: 1. Software setting UEVG bit 2. The STI trigger input signal which will be output on the MTO signal line when the Timer is used in the slave Restart mode
001	Enable Mode	The Counter Enable signal is used as the trigger output.
010	Update Mode	The update event is used as the trigger output according to one of the following cases when the UEVDIS bit is cleared to 0: 1. Counter overflow / underflow 2. Software setting UEVG 3. Slave trigger input when used in slave restart mode
011	Capture/Compare Mode	When a Channel 0 capture or compare match event occurs, it will generate a positive pulse used as the master trigger output.
100	Compare Mode 0	The Channel 0 Output reference signal named CH0OREF is used as the trigger output.
101	Compare Mode 1	The Channel 1 Output reference signal named CH1OREF is used as the trigger output.
110	Compare Mode 2	The Channel 2 Output reference signal named CH2OREF is used as the trigger output.
111	Compare Mode 3	The Channel 3 Output reference signal named CH3OREF is used as the trigger output.

Bits	Field	Descriptions
[10:8]	SMSEL	Slave Mode Selection

SMSEL [2:0]	Mode	Descriptions
000	Disable Mode	The prescaler is clocked directly by the internal clock.
001	Quadrature Decoder Mode 1	The counter uses the clock pulse generated from the interaction between the TI0 and TI1 signals to drive the counter prescaler. A transition of the TI0 edge is used in this mode depending upon the TI1 level.
010	Quadrature Decoder Mode 2	The counter uses the clock pulse generated from the interaction between the TI0 and TI1 signals to drive the counter prescaler. A transition of the TI1 edge is used in this mode depending upon the TI0 level.
011	Quadrature Decoder Mode 3	The counter uses the clock pulse generated from the interaction between the TI0 and TI1 signals to drive the counter prescaler. A transition of one channel edge is used in the quadrature decoder mode 3 depending upon the other channel level.
100	Restart Mode	The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.
101	Pause Mode	The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal.
110	Trigger Mode	The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the counter start control is determined by the STI signal.
111	STIED	The rising edge of the selected trigger signal STI will clock the counter.

[0]	TSE	Timer Synchronization Enable 0: No action 1: Master timer (current timer) will generate a delay to synchronize its slave timer through the MTO signal.

Timer Trigger Configuration Register – TRCFR

This register specifies the trigger source selection of GPTM.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TRSEL			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[3:0]	TRSEL	Trigger Source Selection These bits are used to select the trigger input (STI) for counter synchronization. 0000: Software Trigger by setting the UEVG bit 0001: Filtered input of channel 0 (TI0S0) 0010: Filtered input of channel 1 (TI1S1) 0011: Reserved 1000: Channel 0 Edge Detector (TI0BED) 1001: Internal Timing Module Trigger 0 (ITI0) 1010: Internal Timing Module Trigger 1 (ITI1) 1011: Internal Timing Module Trigger 2 (ITI2) Others: Reserved Note: These bits must be updated only when they are not in use, i.e. the slave mode is disabled by setting the SMSEL field to 0x0.

Table 29. GPTM Internal Trigger Connection

Slave Timing Module	ITI0	ITI1	ITI2
GPTM	PWM0	—	PWM1

Timer Control Register – CTR

This register specifies the timer enable bit (TME), CRR buffer enable bit (CRBE) and Channel PDMA selection bit (CHCCDS).

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							CHCCDS
Type/Reset								RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						CRBE	TME
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[16]	CHCCDS	Channel PDMA event selection 0: Channel PDMA request derived from the channel capture/compare event. 1: Channel PDMA request derived from the Update event.
[1]	CRBE	Counter-Reload register Buffer Enable 0: Counter-reload register can be updated immediately 1: Counter-reload register can not be updated until the update event occurs
[0]	TME	Timer Enable bit 0: GPTM off 1: GPTM on – GPTM functions normally When the TME bit is cleared to 0, the counter is stopped and the GPTM consumes no power in any operation mode except for the single pulse mode and the slave trigger mode. In these two modes the TME bit can automatically be set to 1 by hardware which permits all the GPTM registers to function normally.

Channel 0 Input Configuration Register – CH0ICFR

This register specifies the channel 0 input mode configuration.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	TI0SRC	Reserved						
Type/Reset	RW 0							
	23	22	21	20	19	18	17	16
	Reserved				CH0PSC		CH0CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI0F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31]	TI0SRC	Channel 0 Input Source TI0 Selection 0: The GT_CH0 pin is connected to channel 0 input TI0 1: The XOR operation output of the GT_CH0, GT_CH1, and GT_CH2 pins are connected to the channel 0 input TI0
[19:18]	CH0PSC	Channel 0 Capture Input Source Prescaler Setting These bits define the effective events of the channel 0 capture input. Note that the prescaler is reset once the Channel 0 Capture/Compare Enable bit, CH0E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 0 capture input signal is chosen for each active event 01: Channel 0 Capture input signal is chosen for every 2 events 10: Channel 0 Capture input signal is chosen for every 4 events 11: Channel 0 Capture input signal is chosen for every 8 events
[17:16]	CH0CCS	Channel 0 Capture/Compare Selection 00: Channel 0 is configured as an output 01: Channel 0 is configured as an input derived from the TI0 signal 10: Channel 0 is configured as an input derived from the TI1 signal 11: Channel 0 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH0CCS field can be accessed only when the CH0E bit is cleared to 0.

Bits	Field	Descriptions
[3:0]	TI0F	Channel 0 Input Source TI0 Filter Setting These bits define the frequency divided ratio used to sample the TI0 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS} / 2$, N = 6 0101: $f_{sampling} = f_{DTS} / 2$, N = 8 0110: $f_{sampling} = f_{DTS} / 4$, N = 6 0111: $f_{sampling} = f_{DTS} / 4$, N = 8 1000: $f_{sampling} = f_{DTS} / 8$, N = 6 1001: $f_{sampling} = f_{DTS} / 8$, N = 8 1010: $f_{sampling} = f_{DTS} / 16$, N = 5 1011: $f_{sampling} = f_{DTS} / 16$, N = 6 1100: $f_{sampling} = f_{DTS} / 16$, N = 8 1101: $f_{sampling} = f_{DTS} / 32$, N = 5 1110: $f_{sampling} = f_{DTS} / 32$, N = 6 1111: $f_{sampling} = f_{DTS} / 32$, N = 8

Channel 1 Input Configuration Register – CH1ICFR

This register specifies the channel 1 input mode configuration.

Offset: 0x024
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				CH1PSC		CH1CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI1F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[19:18]	CH1PSC	Channel 1 Capture Input Source Prescaler Setting These bits define the effective events of the channel 1 capture input. Note that the prescaler is reset once the Channel 1 Capture/Compare Enable bit, CH1E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 1 capture input signal is chosen for each active event 01: Channel 1 Capture input signal is chosen for every 2 events 10: Channel 1 Capture input signal is chosen for every 4 events 11: Channel 1 Capture input signal is chosen for every 8 events
[17:16]	CH1CCS	Channel 1 Capture/Compare Selection 00: Channel 1 is configured as an output 01: Channel 1 is configured as an input derived from the TI1 signal 10: Channel 1 is configured as an input derived from the TI0 signal 11: Channel 1 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH1CCS field can be accessed only when the CH1E bit is cleared to 0.
[3:0]	TI1F	Channel 1 Input Source TI1 Filter Setting These bits define the frequency divided ratio used to sample the TI1 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS}$ / 2, N = 6 0101: $f_{sampling} = f_{DTS}$ / 2, N = 8 0110: $f_{sampling} = f_{DTS}$ / 4, N = 6 0111: $f_{sampling} = f_{DTS}$ / 4, N = 8 1000: $f_{sampling} = f_{DTS}$ / 8, N = 6 1001: $f_{sampling} = f_{DTS}$ / 8, N = 8 1010: $f_{sampling} = f_{DTS}$ / 16, N = 5 1011: $f_{sampling} = f_{DTS}$ / 16, N = 6 1100: $f_{sampling} = f_{DTS}$ / 16, N = 8 1101: $f_{sampling} = f_{DTS}$ / 32, N = 5 1110: $f_{sampling} = f_{DTS}$ / 32, N = 6 1111: $f_{sampling} = f_{DTS}$ / 32, N = 8

Channel 2 Input Configuration Register – CH2ICFR

This register specifies the channel 2 input mode configuration.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				CH2PSC		CH2CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI2F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[19:18]	CH2PSC	Channel 2 Capture Input Source Prescaler Setting These bits define the effective events of the channel 2 capture input. Note that the prescaler is reset once the Channel 2 Capture/Compare Enable bit, CH2E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 2 capture input signal is chosen for each active event 01: Channel 2 Capture input signal is chosen for every 2 events 10: Channel 2 Capture input signal is chosen for every 4 events 11: Channel 2 Capture input signal is chosen for every 8 events
[17:16]	CH2CCS	Channel 2 Capture/Compare Selection 00: Channel 2 is configured as an output 01: Channel 2 is configured as an input derived from the TI2 signal 10: Channel 2 is configured as an input derived from the TI3 signal 11: Channel 2 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH2CCS field can be accessed only when the CH2E bit is cleared to 0.

Bits	Field	Descriptions
[3:0]	TI2F	Channel 2 Input Source TI2 Filter Setting These bits define the frequency divided ratio used to sample the TI2 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS} / 2$, N = 6 0101: $f_{sampling} = f_{DTS} / 2$, N = 8 0110: $f_{sampling} = f_{DTS} / 4$, N = 6 0111: $f_{sampling} = f_{DTS} / 4$, N = 8 1000: $f_{sampling} = f_{DTS} / 8$, N = 6 1001: $f_{sampling} = f_{DTS} / 8$, N = 8 1010: $f_{sampling} = f_{DTS} / 16$, N = 5 1011: $f_{sampling} = f_{DTS} / 16$, N = 6 1100: $f_{sampling} = f_{DTS} / 16$, N = 8 1101: $f_{sampling} = f_{DTS} / 32$, N = 5 1110: $f_{sampling} = f_{DTS} / 32$, N = 6 1111: $f_{sampling} = f_{DTS} / 32$, N = 8

Channel 3 Input Configuration Register – CH3ICFR

This register specifies the channel 3 input mode configuration.

Offset: 0x02C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				CH3PSC		CH3CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI3F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[19:18]	CH3PSC	Channel 3 Capture Input Source Prescaler Setting These bits define the effective events of the channel 3 capture input. Note that the prescaler is reset once the Channel 3 Capture/Compare Enable bit, CH3E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 3 capture input signal is chosen for each active event 01: Channel 3 Capture input signal is chosen for every 2 events 10: Channel 3 Capture input signal is chosen for every 4 events 11: Channel 3 Capture input signal is chosen for every 8 events
[17:16]	CH3CCS	Channel 3 Capture/Compare Selection 00: Channel 3 is configured as an output 01: Channel 3 is configured as an input derived from the TI3 signal 10: Channel 3 is configured as an input derived from the TI2 signal 11: Channel 3 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH3CCS field can be accessed only when the CH3E bit is cleared to 0.
[3:0]	TI3F	Channel 3 Input Source TI3 Filter Setting These bits define the frequency divided ratio used to sample the TI3 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS}$ / 2, N = 6 0101: $f_{sampling} = f_{DTS}$ / 2, N = 8 0110: $f_{sampling} = f_{DTS}$ / 4, N = 6 0111: $f_{sampling} = f_{DTS}$ / 4, N = 8 1000: $f_{sampling} = f_{DTS}$ / 8, N = 6 1001: $f_{sampling} = f_{DTS}$ / 8, N = 8 1010: $f_{sampling} = f_{DTS}$ / 16, N = 5 1011: $f_{sampling} = f_{DTS}$ / 16, N = 6 1100: $f_{sampling} = f_{DTS}$ / 16, N = 8 1101: $f_{sampling} = f_{DTS}$ / 32, N = 5 1110: $f_{sampling} = f_{DTS}$ / 32, N = 6 1111: $f_{sampling} = f_{DTS}$ / 32, N = 8

Channel 0 Output Configuration Register – CH0OCFR

This register specifies the channel 0 output mode configuration.

Offset: 0x040

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH0OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH0IMAE	CH0PRE	Reserved	CH0OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH0IMAE	Channel 0 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH0OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH0CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH0IMAE bit is available only if the channel 0 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH0PRE	Channel 0 Capture/Compare Register (CH0CCR) Preload Enable 0: CH0CCR preload function is disabled The CH0CCR register can be immediately assigned a new value when the CH0PRE bit is cleared to 0 and the updated CH0CCR value is used immediately. 1: CH0CCR preload function is enabled The new CH0CCR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH0OM[3:0]	Channel 0 Output Mode Setting These bits define the functional types of the output reference signal CH0OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH0OREF is forced to 0 0101: Force active – CH0OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 0 has an active level when CNTR < CH0CCR or otherwise has an inactive level. - During down-counting, channel 0 has an inactive level when CNTR > CH0CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 0 is has an inactive level when CNTR < CH0CCR or otherwise has an active level. - During down-counting, channel 0 has an active level when CNTR > CH0CCR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 0 has an active level when CNTR < CH0CCR or otherwise has an inactive level. - During down-counting, channel 0 has an inactive level when CNTR > CH0ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 0 has an inactive level when CNTR < CH0CCR or otherwise has an active level. - During down-counting, channel 0 has an active level when CNTR > CH0ACR or otherwise has an inactive level Note: When channel 0 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3).

Channel 1 Output Configuration Register – CH1OCFR

This register specifies the channel 1 output mode configuration.

Offset: 0x044

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH1OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH1IMAE	CH1PRE	Reserved	CH1OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH1IMAE	Channel 1 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH1OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH1CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH1IMAE bit is available only if the channel 1 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH1PRE	Channel 1 Capture/Compare Register (CH1CCR) Preload Enable 0: CH1CCR preload function is disabled. The CH1CCR register can be immediately assigned a new value when the CH1PRE bit is cleared to 0 and the updated CH1CCR value is used immediately. 1: CH1CCR preload function is enabled The new CH1CCR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH1OM[3:0]	Channel 1 Output Mode Setting These bits define the functional types of the output reference signal CH1OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH1OREF is forced to 0 0101: Force active – CH1OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 1 has an active level when CNTR < CH1CCR or otherwise has an inactive level. - During down-counting, channel 1 has an inactive level when CNTR > CH1CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 1 has an inactive level when CNTR < CH1CCR or otherwise has an active level. - During down-counting, channel 1 has an active level when CNTR > CH1CCR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 1 has an active level when CNTR < CH1CCR or otherwise has an inactive level. - During down-counting, channel 1 has an inactive level when CNTR > CH1ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 1 has an inactive level when CNTR < CH1CCR or otherwise has an active level. - During down-counting, channel 1 has an active level when CNTR > CH1ACR or otherwise has an inactive level Note: When channel 1 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3).

Channel 2 Output Configuration Register – CH2OCFR

This register specifies the channel 2 output mode configuration.

Offset: 0x048

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH2OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH2IMAE	CH2PRE	Reserved	CH2OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH2IMAE	Channel 2 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH2OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH2CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH2IMAE bit is available only if the channel 2 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH2PRE	Channel 2 Capture/Compare Register (CH2CCR) Preload Enable 0: CH2CCR preload function is disabled. The CH2CCR register can be immediately assigned a new value when the CH2PRE bit is cleared to 0 and the updated CH2CCR value is used immediately. 1: CH2CCR preload function is enabled The new CH2CCR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH2OM[3:0]	Channel 2 Output Mode Setting These bits define the functional types of the output reference signal CH2OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH2OREF is forced to 0 0101: Force active – CH2OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 2 has an active level when CNTR < CH2CCR or otherwise has an inactive level. - During down-counting, channel 2 has an inactive level when CNTR > CH2CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 2 has an inactive level when CNTR < CH2CCR or otherwise has an active level. - During down-counting, channel 2 has an active level when CNTR > CH2CCR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 2 has an active level when CNTR < CH2CCR or otherwise has an inactive level. - During down-counting, channel 2 has an inactive level when CNTR > CH2ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 2 has an inactive level when CNTR < CH2CCR or otherwise has an active level. - During down-counting, channel 2 has an active level when CNTR > CH2ACR or otherwise has an inactive level Note: When channel 2 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3).

Channel 3 Output Configuration Register – CH3OCFR

This register specifies the channel 3 output mode configuration.

Offset: 0x04C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH3OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH3IMAE	CH3PRE	Reserved	CH3OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH3IMAE	Channel 3 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH3OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH3CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH3IMAE bit is available only if the channel 3 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH3PRE	Channel 3 Capture/Compare Register (CH3CCR) Preload Enable 0: CH3CCR preload function is disabled. The CH3CCR register can be immediately assigned a new value when the CH3PRE bit is cleared to 0 and the updated CH3CCR value is used immediately. 1: CH3CCR preload function is enabled The new CH3CCR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH3OM[3:0]	Channel 3 Output Mode Setting These bits define the functional types of the output reference signal CH3OREF 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH3OREF is forced to 0 0101: Force active – CH3OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 3 has an active level when CNTR < CH3CCR or otherwise has an inactive level. - During down-counting, channel 3 has an inactive level when CNTR > CH3CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 3 has an inactive level when CNTR < CH3CCR or otherwise has an active level. - During down-counting, channel 3 has an active level when CNTR > CH3CCR or otherwise has an inactive level 1110: Asymmetric PWM mode 1 - During up-counting, channel 3 has an active level when CNTR < CH3CCR or otherwise has an inactive level. - During down-counting, channel 3 has an inactive level when CNTR > CH3ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 3 has an inactive level when CNTR < CH3CCR or otherwise has an active level. - During down-counting, channel 3 has an active level when CNTR > CH3ACR or otherwise has an inactive level Note: When channel 3 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3).

Channel Control Register – CHCTR

This register contains the channel capture input or compare output function enable control bits.

Offset: 0x050

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	CH3E	Reserved	CH2E	Reserved	CH1E	Reserved	CH0E
Type/Reset		RW 0		RW 0		RW 0		RW 0

Bits	Field	Descriptions
[6]	CH3E	Channel 3 Capture/Compare Enable - Channel 3 is configured as an input (CH3CCS = 0x1/0x2/0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 3 is configured as an output (CH3CCS = 0x0) 0: Off – Channel 3 output signal CH3O is not active 1: On – Channel 3 output signal CH3O is generated on the corresponding output pin
[4]	CH2E	Channel 2 Capture/Compare Enable - Channel 2 is configured as an input (CH2CCS = 0x1/0x2/0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 2 is configured as an output (CH2CCS = 0x0) 0: Off – Channel 2 output signal CH2O is not active 1: On – Channel 2 output signal CH2O is generated on the corresponding output pin
[2]	CH1E	Channel 1 Capture/Compare Enable - Channel 1 is configured as an input (CH1CCS = 0x1/0x2/0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 1 is configured as an output (CH1CCS = 0x0) 0: Off – Channel 1 output signal CH1O is not active 1: On – Channel 1 output signal CH1O is generated on the corresponding output pin
[0]	CH0E	Channel 0 Capture/Compare Enable - Channel 0 is configured as an input (CH0CCS = 0x1/0x2/0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 0 is configured as an output (CH0CCS = 0x0) 0: Off – Channel 0 output signal CH0O is not active 1: On – Channel 0 output signal CH0O is generated on the corresponding output pin

Channel Polarity Configuration Register – CHPOLR

This register contains the channel capture input or compare output polarity control.

Offset: 0x054

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	CH3P	Reserved	CH2P	Reserved	CH1P	Reserved	CH0P
Type/Reset		RW 0		RW 0		RW 0		RW 0

Bits	Field	Descriptions
[6]	CH3P	Channel 3 Capture/Compare Polarity - When Channel 3 is configured as an input (CH3CCS = 0x1/0x2/0x3) 0: capture event occurs on a Channel 3 rising edge 1: capture event occurs on a Channel 3 falling edge - When Channel 3 is configured as an output (CH3CCS = 0x0) 0: Channel 3 Output is active high 1: Channel 3 Output is active low
[4]	CH2P	Channel 2 Capture/Compare Polarity - When Channel 2 is configured as an input (CH2CCS = 0x1/0x2/0x3) 0: capture event occurs on a Channel 2 rising edge 1: capture event occurs on a Channel 2 falling edge - When Channel 2 is configured as an output (CH2CCS = 0x0) 0: Channel 2 Output is active high 1: Channel 2 Output is active low
[2]	CH1P	Channel 1 Capture/Compare Polarity - When Channel 1 is configured as an input (CH1CCS = 0x1/0x2/0x3) 0: capture event occurs on a Channel 1 rising edge 1: capture event occurs on a Channel 1 falling edge - Channel 1 is configured as an output (CH1CCS = 0x0) 0: Channel 1 Output is active high 1: Channel 1 Output is active low
[0]	CH0P	Channel 0 Capture/Compare Polarity - When Channel 0 is configured as an input (CH0CCS = 0x1/0x2/0x3) 0: capture event occurs on a Channel 0 rising edge 1: capture event occurs on a Channel 0 falling edge - When Channel 0 is configured as an output (CH0CCS = 0x0) 0: Channel 0 Output is active high 1: Channel 0 Output is active low

Timer PDMA/Interrupt Control Register – DICTR

This register contains the timer PDMA and interrupt enable control bits.

Offset: 0x074

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved					TEVDE	Reserved	UEVDE
Type/Reset						RW 0		RW 0
	23	22	21	20	19	18	17	16
	Reserved				CH3CCDE	CH2CCDE	CH1CCDE	CH0CCDE
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved					TEVIE	Reserved	UEVIE
Type/Reset						RW 0		RW 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CCIE	CH2CCIE	CH1CCIE	CH0CCIE
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[26]	TEVDE	Trigger event PDMA Request Enable 0: Trigger PDMA request is disabled 1: Trigger PDMA request is enabled
[24]	UEVDE	Update event PDMA Request Enable 0: Update event PDMA request is disabled 1: Update event PDMA request is enabled
[19]	CH3CCDE	Channel 3 Capture/Compare PDMA Request Enable 0: Channel 3 PDMA request is disabled 1: Channel 3 PDMA request is enabled
[18]	CH2CCDE	Channel 2 Capture/Compare PDMA Request Enable 0: Channel 2 PDMA request is disabled 1: Channel 2 PDMA request is enabled
[17]	CH1CCDE	Channel 1 Capture/Compare PDMA Request Enable 0: Channel 1 PDMA request is disabled 1: Channel 1 PDMA request is enabled
[16]	CH0CCDE	Channel 0 Capture/Compare PDMA Request Enable 0: Channel 0 PDMA request is disabled 1: Channel 0 PDMA request is enabled
[10]	TEVIE	Trigger event Interrupt Enable 0: Trigger event interrupt is disabled 1: Trigger event interrupt is enabled
[8]	UEVIE	Update event Interrupt Enable 0: Update event interrupt is disabled 1: Update event interrupt is enabled
[3]	CH3CCIE	Channel 3 Capture/Compare Interrupt Enable 0: Channel 3 interrupt is disabled 1: Channel 3 interrupt is enabled

Bits	Field	Descriptions
[2]	CH2CCIE	Channel 2 Capture/Compare Interrupt Enable 0: Channel 2 interrupt is disabled 1: Channel 2 interrupt is enabled
[1]	CH1CCIE	Channel 1 Capture/Compare Interrupt Enable 0: Channel 1 interrupt is disabled 1: Channel 1 interrupt is enabled
[0]	CH0CCIE	Channel 0 Capture/Compare Interrupt Enable 0: Channel 0 interrupt is disabled 1: Channel 0 interrupt is enabled

Timer Event Generator Register – EVGR

This register contains the software event generation bits.

Offset: 0x078

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					TEVG	Reserved	UEVG
Type/Reset						WO 0		WO 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CCG	CH2CCG	CH1CCG	CH0CCG
Type/Reset					WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[10]	TEVG	Trigger Event Generation The trigger event TEV can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: TEVIF flag is set
[8]	UEVG	Update Event Generation The update event UEV can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Reinitialize the counter The counter value returns to 0 or the CRR preload value, depending on the counter mode in which the current timer is being used. An update operation of any related registers will also be performed. For more detailed descriptions, refer to the corresponding section.
[3]	CH3CCG	Channel 3 Capture/Compare Generation A Channel 3 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 3 If Channel 3 is configured as an input, the counter value is captured into the CH3CCR register and then the CH3CCIF bit is set. If Channel 3 is configured as an output, the CH3CCIF bit is set.

Bits	Field	Descriptions
[2]	CH2CCG	Channel 2 Capture/Compare Generation A Channel 2 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 2 If Channel 2 is configured as an input, the counter value is captured into the CH2CCR register and then the CH2CCIF bit is set. If Channel 2 is configured as an output, the CH2CCIF bit is set.
[1]	CH1CCG	Channel 1 Capture/Compare Generation A Channel 1 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 1 If Channel 1 is configured as an input, the counter value is captured into the CH1CCR register and then the CH1CCIF bit is set. If Channel 1 is configured as an output, the CH1CCIF bit is set.
[0]	CH0CCG	Channel 0 Capture/Compare Generation A Channel 0 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 0 If Channel 0 is configured as an input, the counter value is captured into the CH0CCR register and then the CH0CCIF bit is set. If Channel 0 is configured as an output, the CH0CCIF bit is set.

Timer Interrupt Status Register – INTSR

This register stores the timer interrupt status.

Offset: 0x07C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					TEVIF	Reserved	UEVIF
Type/Reset						W0C 0		W0C 0
	7	6	5	4	3	2	1	0
	CH3OCF	CH2OCF	CH1OCF	CH0OCF	CH3CCIF	CH2CCIF	CH1CCIF	CH0CCIF
Type/Reset	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0

Bits	Field	Descriptions
[10]	TEVIF	Trigger Event Interrupt Flag This flag is set by hardware on a trigger event and is cleared by software. 0: No trigger event occurs 1: Trigger event occurs
[8]	UEVIF	Update Event Interrupt Flag This bit is set by hardware on an update event and is cleared by software. 0: No update event occurs 1: Update event occurs Note: The update event is derived from the following conditions: - The counter overflows or underflows - The UEVG bit is asserted - A restart trigger event occurs from the slave trigger input
[7]	CH3OCF	Channel 3 Over-Capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH3CCIF bit is already set and it is not yet cleared by software
[6]	CH2OCF	Channel 2 Over-Capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH2CCIF bit is already set and it is not cleared yet by software
[5]	CH1OCF	Channel 1 Over-Capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH1CCIF bit is already set and it is not cleared yet by software.
[4]	CH0OCF	Channel 0 Over-Capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH0CCIFbit is already set and it is not yet cleared by software.
[3]	CH3CCIF	Channel 3 Capture/Compare Interrupt Flag - Channel 3 is configured as an output: 0: No match event occurs 1: The content of the counter CNTR has matched the content of the CH3CCR register This flag is set by hardware when the counter value matches the CH3CCR value except in the center-aligned mode. It is cleared by software. - Channel 3 is configured as an input: 0: No input capture occurs 1: Input capture occurs This bit is set by hardware on a capture event. It is cleared by software or by reading the CH3CCR register.

Bits	Field	Descriptions
[2]	CH2CCIF	Channel 2 Capture/Compare Interrupt Flag - Channel 2 is configured as an output: 0: No match event occurs 1: The content of the counter CNTR has matched the content of the CH2CCR register This flag is set by hardware when the counter value matches the CH2CCR value except in the center-aligned mode. It is cleared by software. - Channel 2 is configured as an input: 0: No input capture occurs 1: Input capture occurs. This bit is set by hardware on a capture event. It is cleared by software or by reading the CH2CCR register.
[1]	CH1CCIF	Channel 1 Capture/Compare Interrupt Flag - Channel 1 is configured as an output: 0: No match event occurs 1: The content of the counter CNTR has matched the content of the CH1CCR register This flag is set by hardware when the counter value matches the CH1CCR value except in the center-aligned mode. It is cleared by software. - Channel 1 is configured as an input: 0: No input capture occurs 1: Input capture occurs This bit is set by hardware on a capture event. It is cleared by software or by reading the CH1CCR register.
[0]	CH0CCIF	Channel 0 Capture/Compare Interrupt Flag - Channel 0 is configured as an output: 0: No match event occurs 1: The content of the counter CNTR has matched the content of the CH0CCR register This flag is set by hardware when the counter value matches the CH0CCR value except in the center-aligned mode. It is cleared by software. - Channel 0 is configured as an input: 0: No input capture occurs 1: Input capture occurs This bit is set by hardware on a capture event. It is cleared by software or by reading the CH0CCR register.

Timer Counter Register – CNTR

This register stores the timer counter value.

Offset: 0x080

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CNTV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CNTV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CNTV	Counter Value

Timer Prescaler Register – PSCR

This register specifies the timer prescaler value to generate the counter clock.

Offset: 0x084

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PSCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PSCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PSCV	Prescaler Value These bits are used to specify the prescaler value to generate the counter clock frequency f_{CK_CNT}. $f_{CK\_CNT} = \frac{f_{CK\_PSC}}{PSCV[15:0]+1}$, where the f_{CK_PSC} is the prescaler clock source.

Timer Counter-Reload Register – CRR

This register specifies the timer counter-reload value.

Offset: 0x088

Reset value: 0x0000_FFFF

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CRV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
	CRV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1

Bits	Field	Descriptions
[15:0]	CRV	Counter-Reload Value The CRV is the reload value which is loaded into the actual counter register.

Channel 0 Capture/Compare Register – CH0CCR

This register specifies the timer channel 0 capture/compare value.

Offset: 0x090

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH0CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH0CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH0CCV	Channel 0 Capture/Compare Value - When Channel 0 is configured as an output: The CH0CCR value is compared with the counter value and the comparison result is used to trigger the CH0OREF output signal. - When Channel 0 is configured as an input: The CH0CCR register stores the counter value captured by the last channel 0 capture event.

Channel 1 Capture/Compare Register – CH1CCR

This register specifies the timer channel 1 capture/compare value.

Offset: 0x094

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH1CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH1CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH1CCV	Channel 1 Capture/Compare Value - When Channel 1 is configured as an output: The CH1CCR value is compared with the counter value and the comparison result is used to trigger the CH1OREF output signal. - When Channel 1 is configured as an input: The CH1CCR register stores the counter value captured by the last channel 1 capture event.

Channel 2 Capture/Compare Register – CH2CCR

This register specifies the timer channel 2 capture/compare value.

Offset: 0x098

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH2CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH2CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH2CCV	Channel 2 Capture/Compare Value - When Channel 2 is configured as an output: The CH2CCR value is compared with the counter value and the comparison result is used to trigger the CH2OREF output signal. - When Channel 2 is configured as an input: The CH2CCR register stores the counter value captured by the last channel 2 capture event.

Channel 3 Capture/Compare Register – CH3CCR

This register specifies the timer channel 3 capture/compare value.

Offset: 0x09C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH3CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH3CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH3CCV	Channel 3 Capture/Compare Value - When Channel 3 is configured as an output: The CH3CCR value is compared with the counter value and the comparison result is used to trigger the CH3OREF output signal. - When Channel 3 is configured as an input: The CH3CCR register stores the counter value captured by the last channel 3 capture event.

Channel 0 Asymmetric Compare Register – CH0ACR

This register specifies the timer channel 0 asymmetric compare value.

Offset: 0x0A0

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH0ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH0ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH0ACV	Channel 0 Asymmetric Compare Value When channel 0 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

Channel 1 Asymmetric Compare Register – CH1ACR

This register specifies the timer channel 1 asymmetric compare value.

Offset: 0x0A4

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH1ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH1ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH1ACV	Channel 1 Asymmetric Compare Value When channel 1 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

Channel 2 Asymmetric Compare Register – CH2ACR

This register specifies the timer channel 2 asymmetric compare value.

Offset: 0x0A8

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH2ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH2ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH2ACV	Channel 2 Asymmetric Compare Value When channel 2 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

Channel 3 Asymmetric Compare Register – CH3ACR

This register specifies the timer channel 3 asymmetric compare value.

Offset: 0x0AC

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH3ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH3ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH3ACV	Channel 3 Asymmetric Compare Value When channel 3 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

14 Pulse-Width-Modulation Timer (PWM)

Introduction

The Pulse-Width-Modulation Timer consists of one 16-bit up/down-counter, four 16-bit Compare Registers (CRs), one 16-bit Counter-Reload Register (CRR) and several control/status registers. It can be used for a variety of purposes including general timer and output waveform generation such as single pulse generation or PWM output.

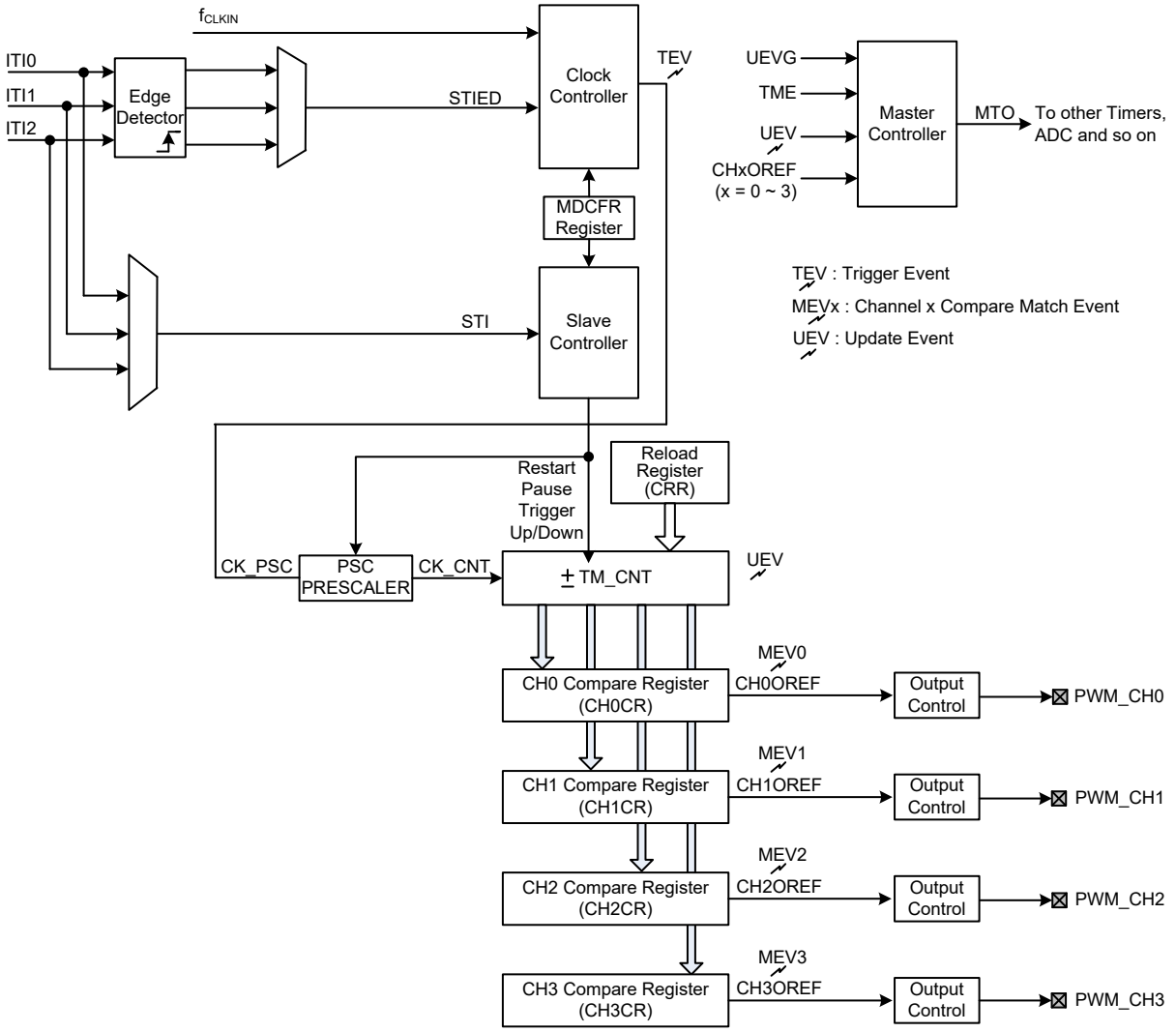


Figure 64. PWM Block Diagram

Features

- 16-bit up/down auto-reload counter
- 16-bit programmable prescaler that allows division of the prescaler clock source by any factor between 1 and 65536 to generate the counter clock frequency
- Up to 4 independent channels for:
  - Compare Match Output
  - Generation of PWM waveform - Edge and Center-aligned Mode
  - Single Pulse Mode Output
- Synchronization circuit to control the timer with external signals and to interconnect several timers together
- Interrupt generation with the following events:
  - Update event
  - Trigger event
  - Output compare match event
- PWM Master/Slave mode controller

Functional Descriptions

Counter Mode

Up-Counting

In this mode the counter counts continuously from 0 to the counter-reload value, which is defined in the CRR register, in a count-up direction. Once the counter reaches the counter-reload value; then restarts from 0 and generates a counter overflow event. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 0 for the up-counting mode.

When the update event is generated by setting the UEVG bit in the EVGR register to 1, the counter value will also be initialized to 0.

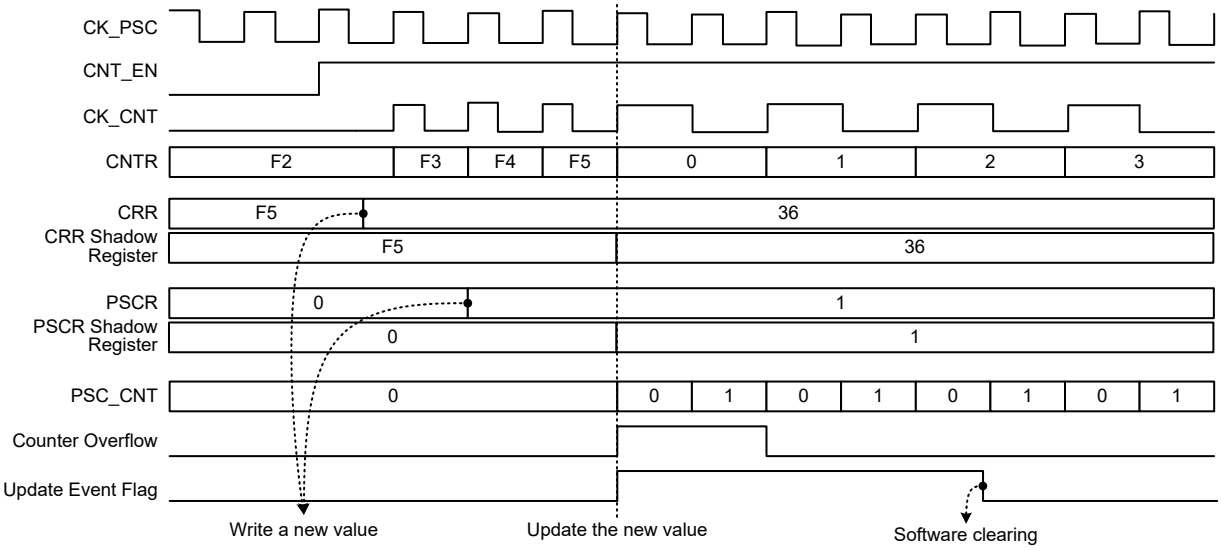


Figure 65. Up-counting Example

Down-Counting

In this mode the counter counts continuously from the counter-reload value, which is defined in the CRR register, to 0 in a count-down direction. Once the counter reaches 0; then restarts from the counter-reload value and generates a counter underflow event. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 1 for the down-counting mode.

When the update event is set by the UEVG bit in the EVGR register, the counter value will also be initialized to the counter-reload value.

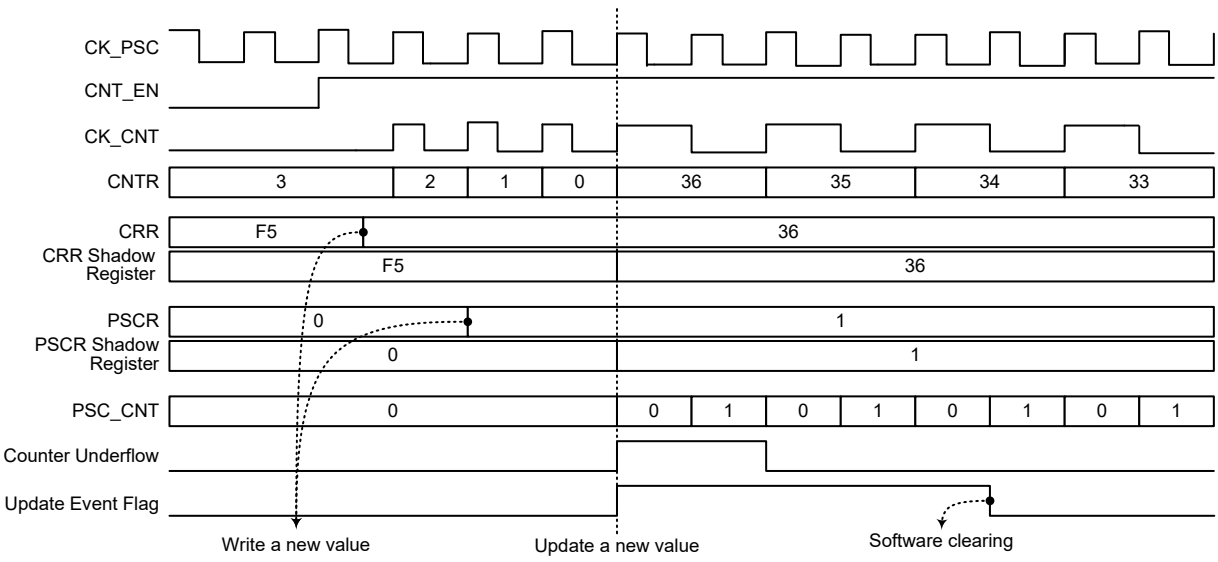


Figure 66. Down-counting Example

Center-Aligned Counting

In the center-aligned counting mode, the counter counts up from 0 to the counter-reload value and then counts down to 0 alternatively. The Timer module generates an overflow event when the counter counts to the counter-reload value in the up-counting mode and generates an underflow event when the counter counts to 0 in the down-counting mode. The counting direction bit DIR in the CNTCFR register is read-only and indicates the counting direction when in the center-aligned mode. The counting direction is updated by hardware automatically.

Setting the UEVG bit in the EVGR register will initialize the counter value to 0 irrespective of whether the counter is counting up or down in the center-aligned counting mode.

The update event interrupt flag bit in the INTSR register will be set to 1, when an overflow or underflow event occurs.

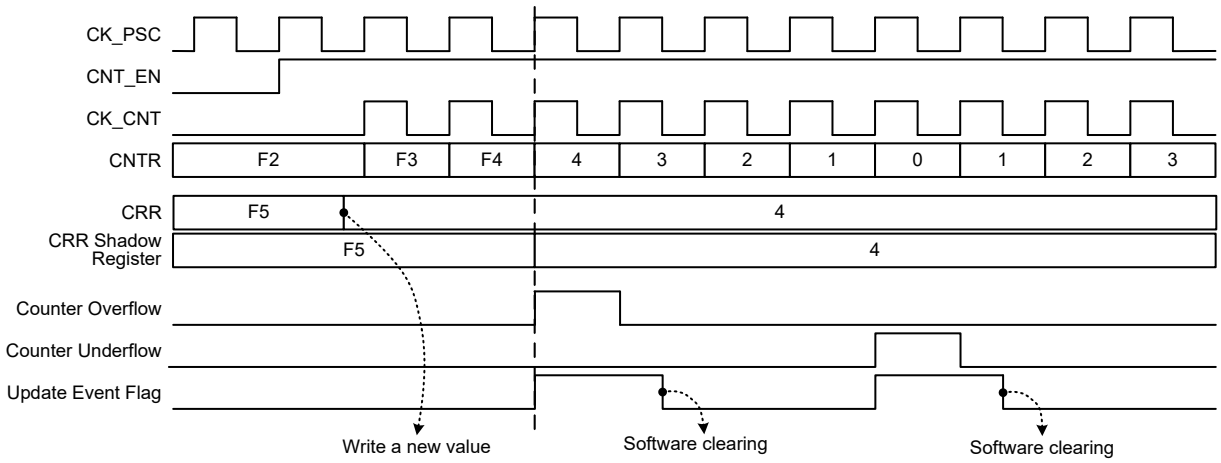


Figure 67. Center-aligned Counting Example

Clock Controller

The following describes the Timer Module clock controller which determines the clock source of the internal prescaler counter.

- Internal APB clock f_{CLKIN}:
  The default internal clock source is the APB clock f_{CLKIN} used to drive the counter prescaler.
- STIED:
  The counter prescaler can count during each rising edge of the STI signal. This mode can be selected by setting the SMSEL field to 0x7 in the MDCFR register. Here the counter will act as an event counter. The input event, known as STI here, can be selected by setting the TRSEL field to an available value except the value of 0x0. When the STI signal is selected as the clock source, the internal edge detection circuitry will generate a clock pulse during each STI signal rising edge to drive the counter prescaler. It is important to note that if the TRSEL field is set to 0x0 to select the software UEVG bit as the trigger source, then when the SMSEL field is set to 0x7, the counter will be updated instead of counting.

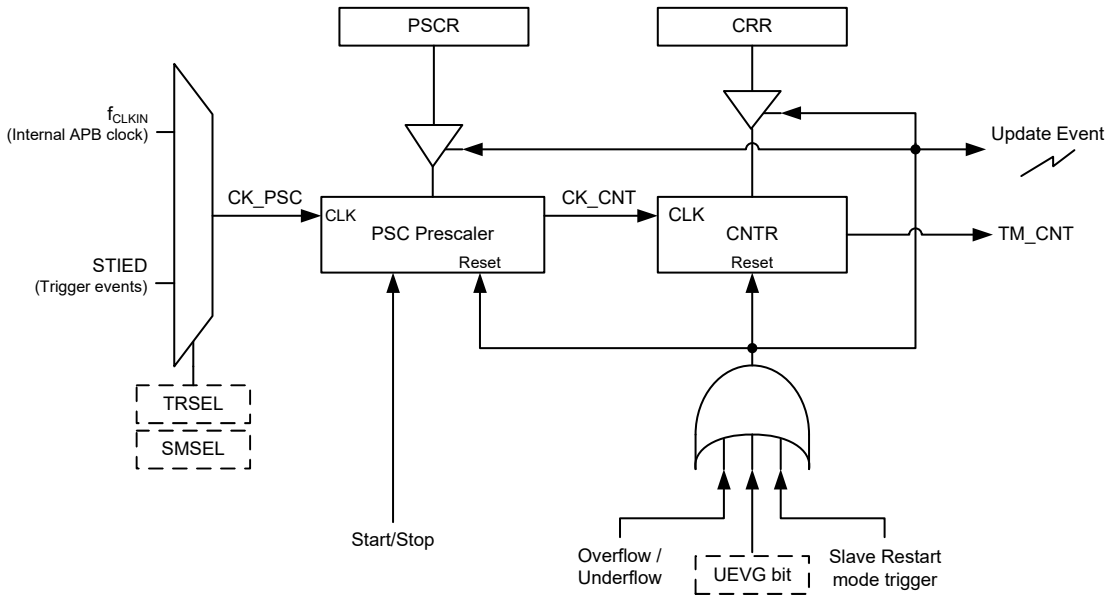


Figure 68. PWM Clock Selection Source

Trigger Controller

The trigger controller is used to select the trigger source and setup the trigger level or edge trigger condition. For the internal trigger input, it can be selected by the Trigger Selection bits TRSEL in the TRCFR register. For all the trigger sources except the UEVG bit software trigger, the internal edge detection circuitry will generate a clock pulse at each trigger signal rising edge to stimulate some PWM functions which are triggered by a trigger signal rising edge.

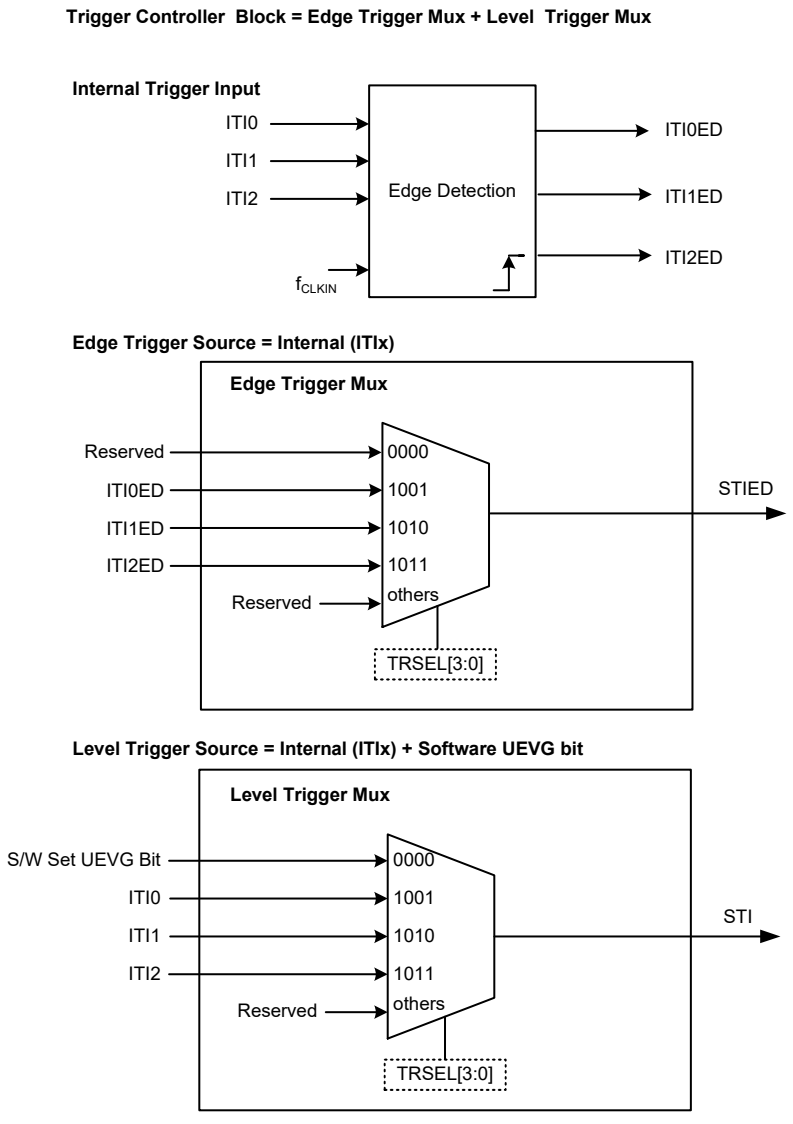


Figure 69. Trigger Control Block

Slave Controller

The PWM can be synchronized with an external trigger in several modes including the Restart mode, the Pause mode and the Trigger mode which is selected by the SMSEL field in the MDCFR register. The trigger input of these modes comes from the STI signal which is selected by the TRSEL field in the TRCFR register. The operation modes in the Slave Controller are described in the accompanying sections.

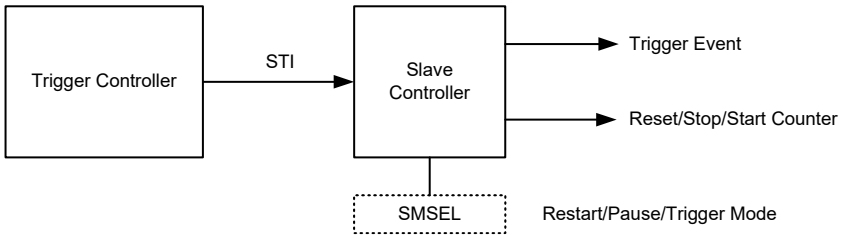


Figure 70. Slave Controller Diagram

Restart Mode

The counter and its prescaler can be reinitialized in response to a rising edge of the STI signal. When an STI rising edge occurs, the update event software generation bit named UEVG will automatically be asserted by hardware and the trigger event flag will also be set. Then the counter and prescaler will be reinitialized. Although the UEVG bit is set to 1 by hardware, the update event does not really occur. It depends upon whether the update event disable control bit UEVDIS is set to 1 or not. If the UEVDIS is set to 1 to disable the update event to occur, there will no update event be generated, however the counter and prescaler are still reinitialized when the STI rising edge occurs. If the UEVDIS bit in the CNTCFR register is cleared to enable the update event to occur, an update event will be generated together with the STI rising edge, then all the preloaded registers will be updated.

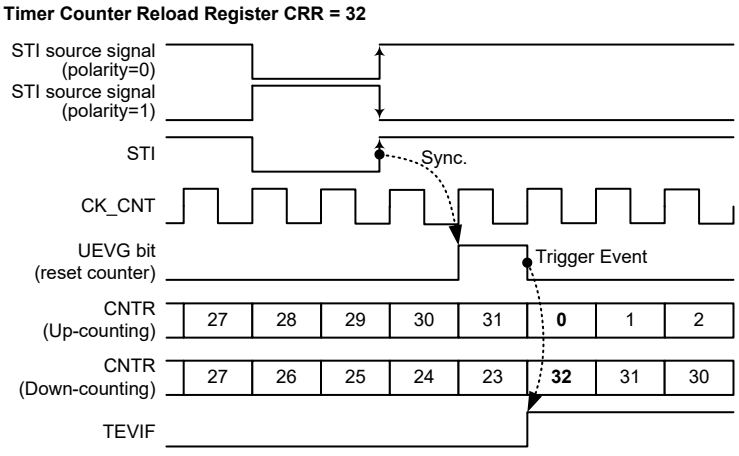


Figure 71. PWM in Restart Mode

Pause Mode

In the Pause Mode, the selected STI input signal level is used to control the counter start/stop operation. The counter starts to count when the selected STI signal is at a high level and stops counting when the STI signal is changed to a low level, here the counter will maintain its present value and will not be reset. Since the Pause function depends upon the STI level to control the counter stop/start operation.

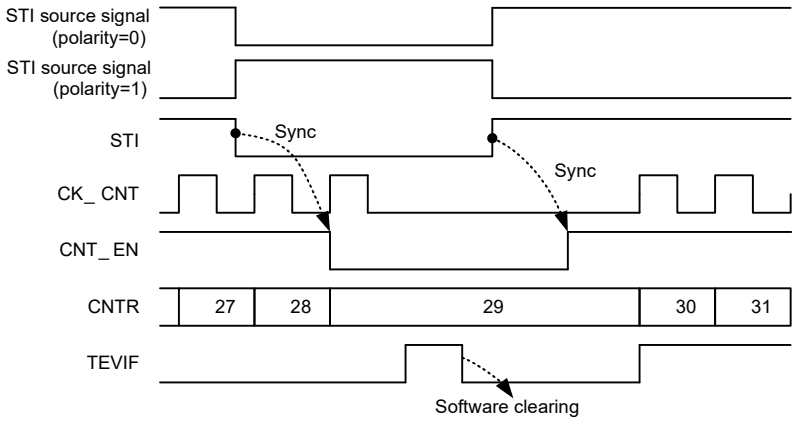


Figure 72. PWM in Pause Mode

Trigger Mode

After the counter is disabled to count, the counter can resume counting when an STI rising edge signal occurs. When an STI rising edge occurs, the counter will start to count from the current value in the counter. Note that if the STI signal is selected to be derived from the UEVG bit software trigger, the counter will not resume counting. When software triggering using the UEVG bit is selected as the STI source signal, there will be no clock pulse generated which can be used to make the counter resume counting. Note that the STI signal is only used to enable the counter to resume counting and has no effect on controlling the counter to stop counting.

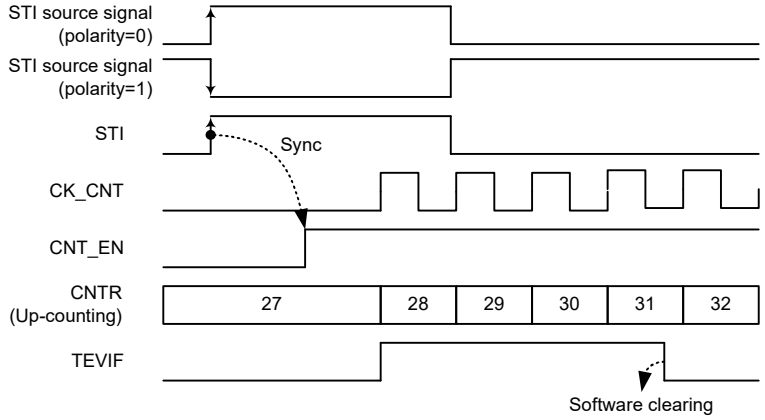


Figure 73. PWM in Trigger Mode

Master Controller

The PWMs and TMs can be linked together internally for timer synchronization or chaining. When one PWM is configured to be in the Master Mode, the PWM Master Controller will generate a Master Trigger Output (MTO) signal which includes a reset, a start, a stop signal or a clock source which is selected by the MMSEL field in the MDCFR register to trigger or drive another PWM or TM, if exists, which is configured in the Slave Mode.

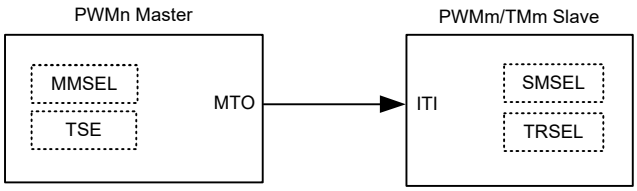


Figure 74. Master PWMn and Slave PWMm/TMm Connection

The Master Mode Selection bits, MMSEL, in the MDCFR register are used to select the MTO source for synchronizing another slave PWM or TM if exists.

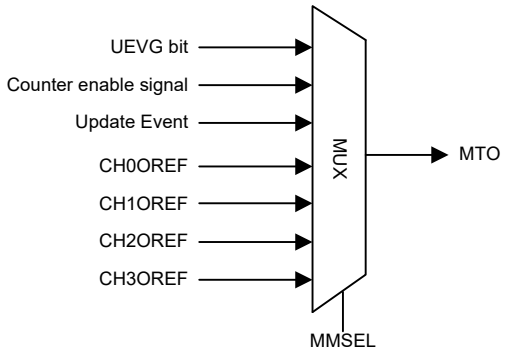


Figure 75. MTO Selection

For example, setting the MMSEL field to 0x5 is to select the CH1OREF signal as the MTO signal to synchronize another slave PWM or TM. For a more detailed description, refer to the related MMSEL field definitions in the MDCFR register.

Channel Controller

The PWM has four independent channels which can be used as compare match outputs. Each compare match output channel is composed of a preload register and a shadow register. Data access of the APB bus is always implemented by reading/writing preload register.

When used in the compare match output mode, the contents of the CHxCR preload register is copied into the associated shadow register; the counter value is then compared with the register value.

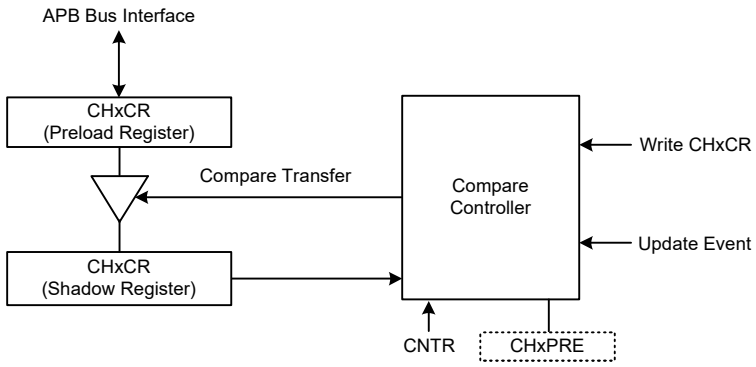


Figure 76. Compare Block Diagram

Output Stage

The PWM has four channels for compare match, single pulse or PWM output function. The channel output PWM_CHx is controlled by the CHxOM, CHxP and CHxE bits in the corresponding CHxOCFR, CHPOLR and CHCTR registers.

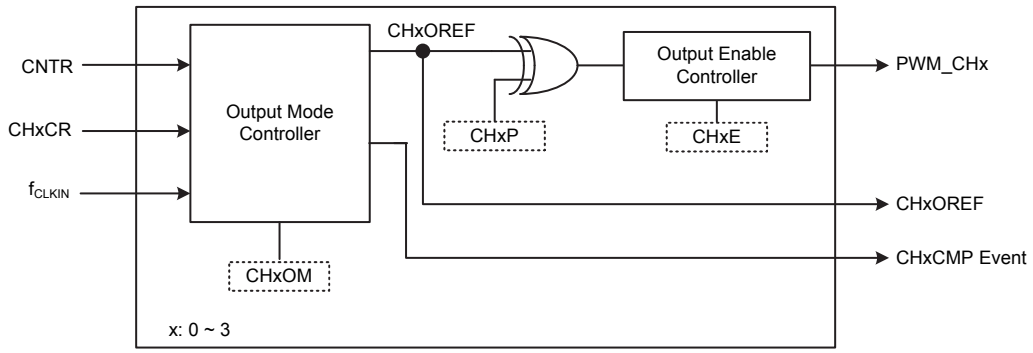


Figure 77. Output Stage Block Diagram

Channel Output Reference Signal

When the PWM is used in the compare match output mode, the Channel x Output Reference signal, CHxOREF, is defined by the CHxOM field setup. The CHxOREF signal has several types of output function which defines what happens to the output when the counter value matches the contents of the CHxCR register. In addition to the low, high and toggle CHxOREF output types; there are also PWM mode 1 and PWM mode 2 outputs. In these modes, the CHxOREF signal level is changed according to the count direction and the relationship between the counter value and the CHxCR content. There are also two modes which will force the output into an inactive or active state irrespective of the CHxCR content or counter values. With regard to a more detailed description refer to the relative bit definition. The accompanying Table 36 shows a summary of the output type setup.

Table 30. Compare Match Output Setup

CHxOM Value	Compare Match Level
0x0	No change
0x1	Clear Output to 0
0x2	Set Output to 1
0x3	Toggle Output
0x4	Force Inactive Level
0x5	Force Active Level
0x6	PWM Mode 1
0x7	PWM Mode 2
0xE	Asymmetric PWM mode 1
0xF	Asymmetric PWM mode 2

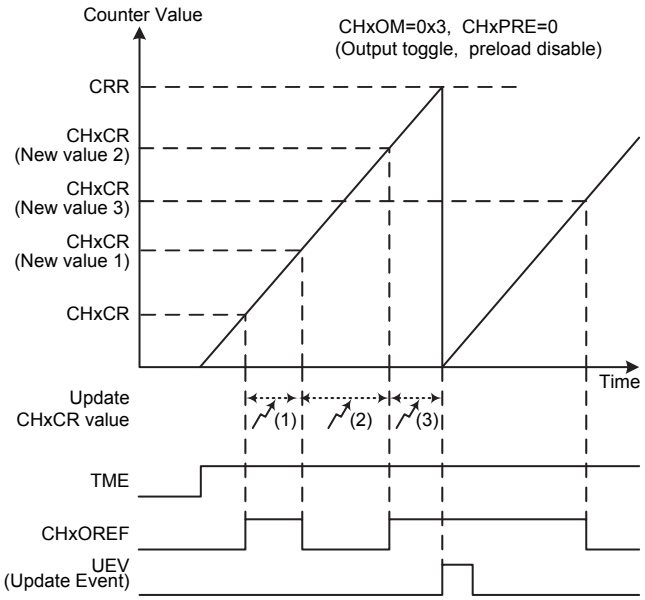


Figure 78. Toggle Mode Channel Output Reference Signal (CHxPRE = 0)

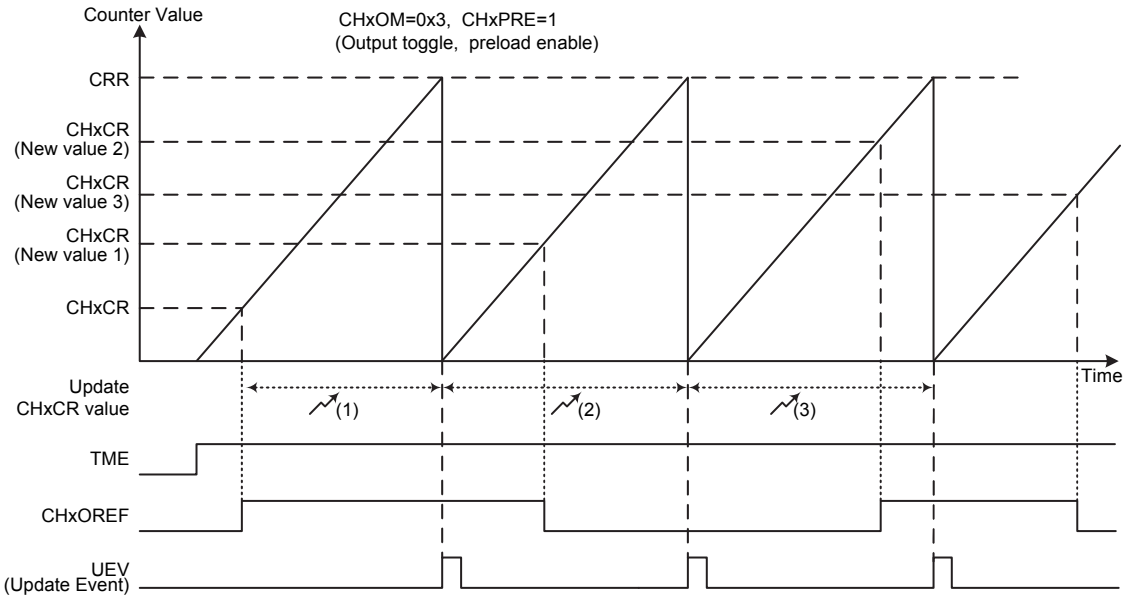


Figure 79. Toggle Mode Channel Output Reference Signal (CHxPRE = 1)

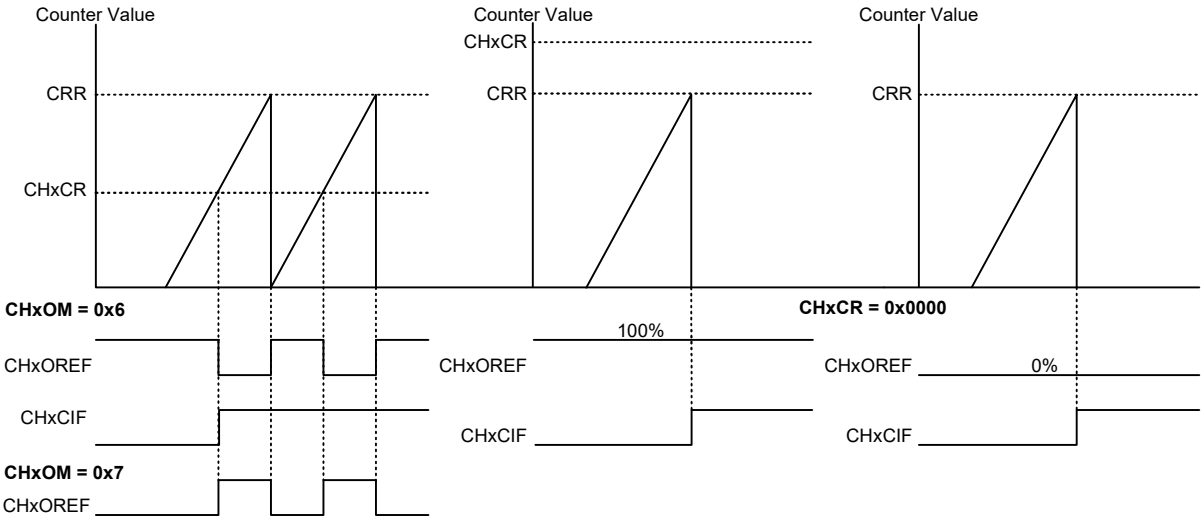


Figure 80. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode

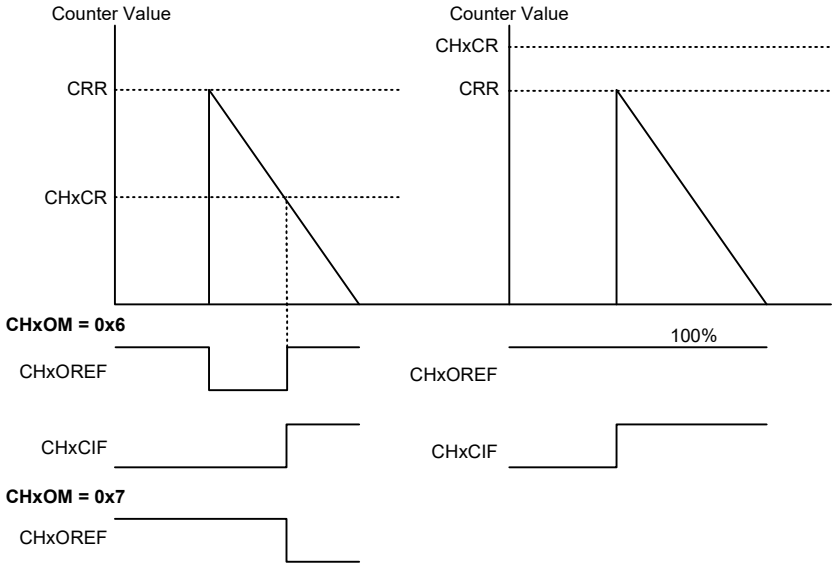


Figure 81. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode

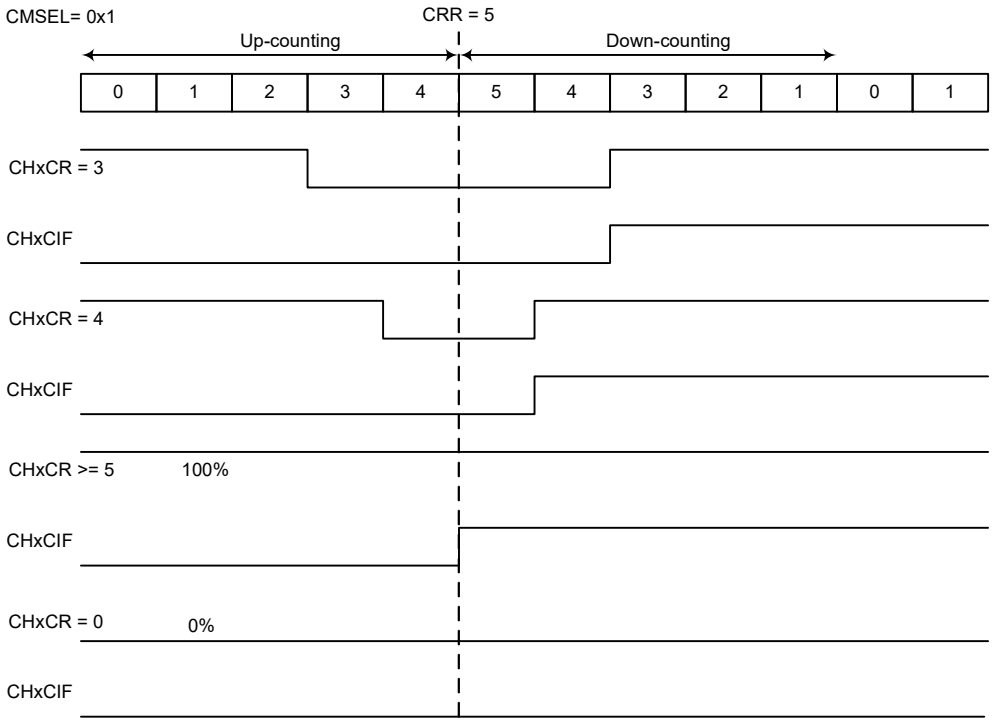


Figure 82. PWM Mode Channel Output Reference Signal and Counter in Center-aligned Mode

Update Management

The Update event is used to update the CRR, the PSCR, the CHxACR and the CHxCR values from the actual registers to the corresponding shadow registers. An update event occurs when the counter overflows or underflows, the software update control bit is triggered or an update event from the slave controller is generated.

The UEVDIS bit in the CNTCFR register can determine whether the update event occurs or not. When the update event occurs, the corresponding update event interrupt will be generated depending upon whether the update event interrupt generation function is enabled or not by configuring the UGDIS bit in the CNTCFR register. For more detailed description, refer to the UEVDIS and UGDIS bit definition in the CNTCFR register.

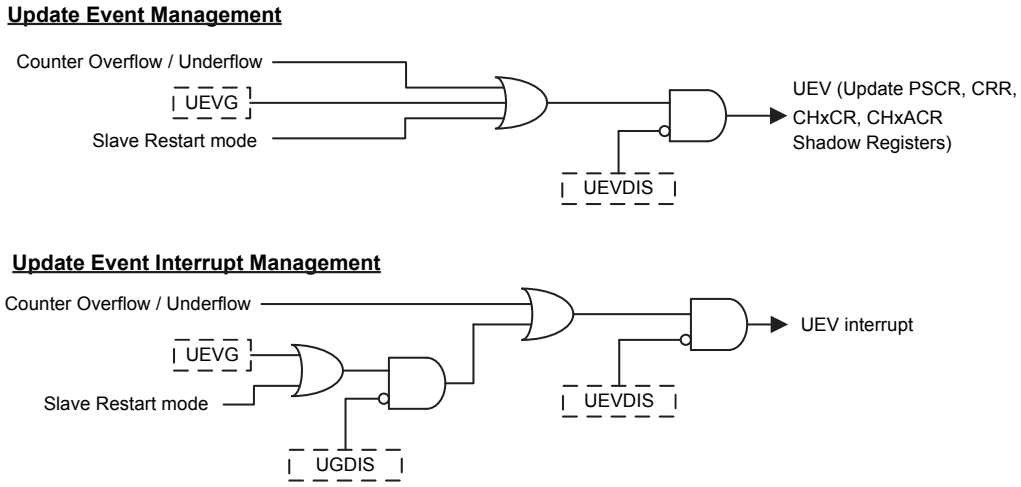


Figure 83. Update Event Setting Diagram

Single Pulse Mode

Once the timer is set to operate in the single pulse mode, it is not necessary to set the timer enable bit TME in the CTR register to 1 to enable the counter. The trigger to generate a pulse can be sourced from the STI signal rising edge or by setting the TME bit to 1 using software. Setting the TME bit to 1 or a trigger from the STI signal rising edge can generate a pulse and then keep the TME bit at a high state until the update event occurs or the TME bit is written to 0 by software. If the TME bit is cleared to 0 using software, the counter will be stopped and its value held. If the TME bit is automatically cleared to 0 by a hardware update event, the counter will be reinitialized.

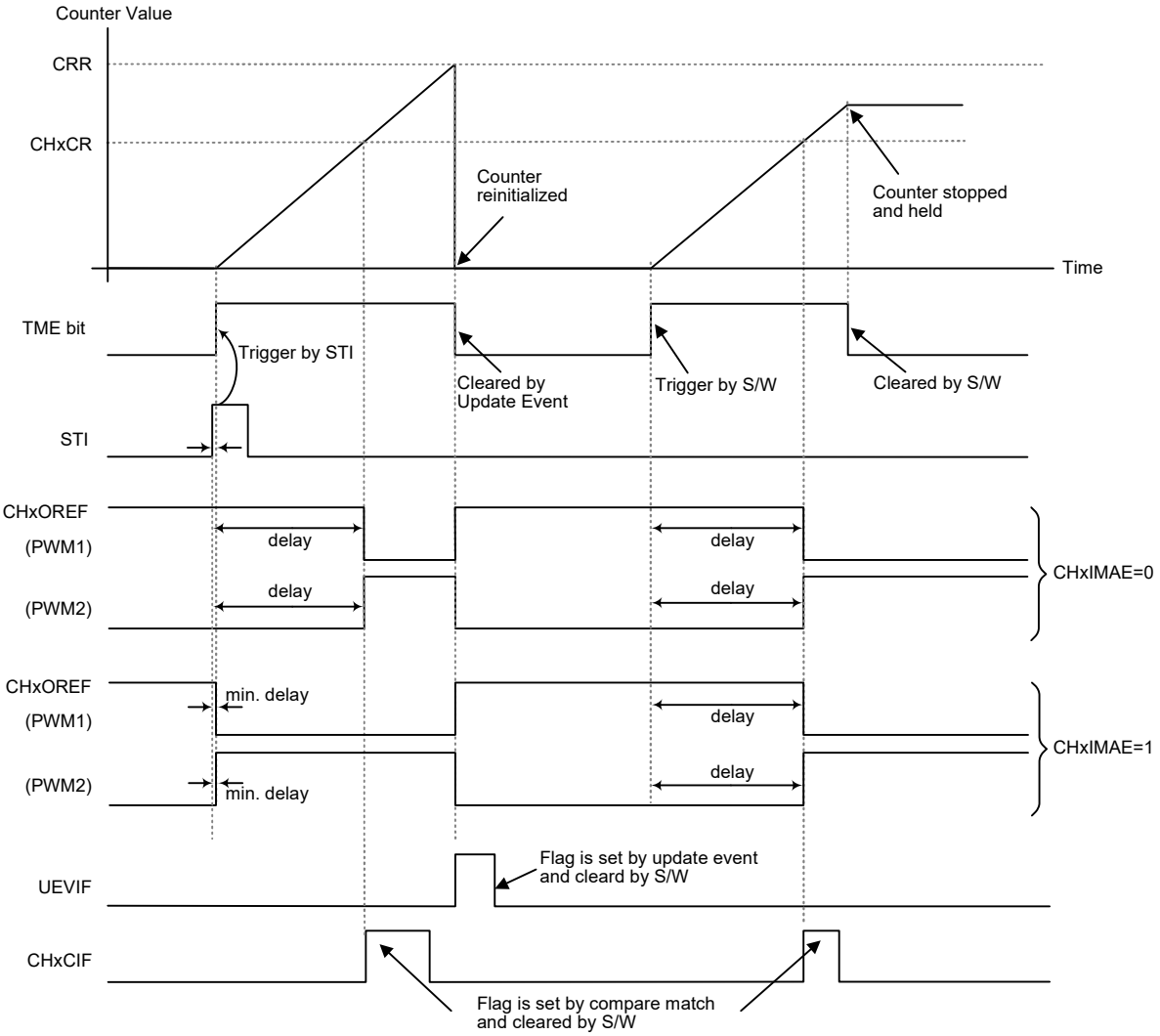


Figure 84. Single Pulse Mode

In the Single Pulse mode, the STI active edge which sets the TME bit to 1 will enable the counter. However, there exist several clock delays to perform the comparison result between the counter value and the CHxCR value. In order to reduce the delay to a minimum value, the user can set the CHxIMAE bit in each CHxOCFR register. After a STI rising edge trigger occurs in the single pulse mode, the CHxOREF signal will immediately be forced to the state which the CHxOREF signal will change to as the compare match event occurs without taking the comparison result into account. The CHxIMAE bit is available only when the output channel is configured to operate in the PWM mode 1 or PWM mode 2 and the trigger source is derived from the STI signal.

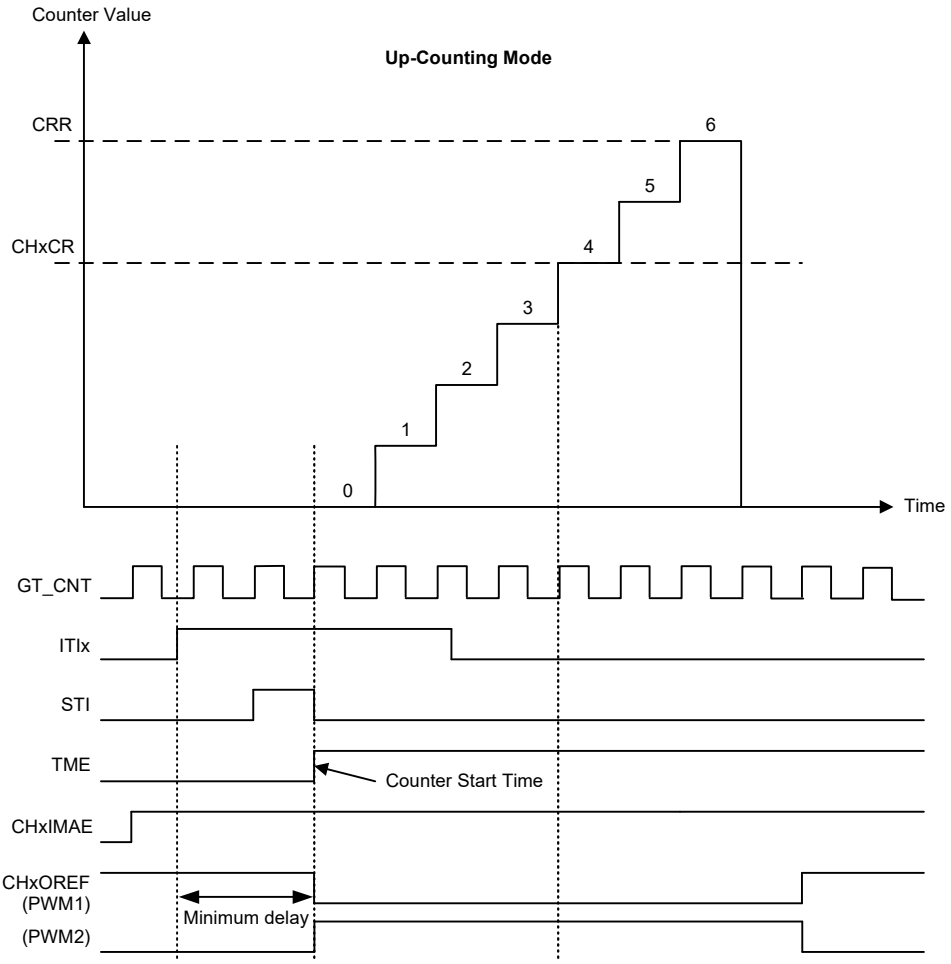


Figure 85. Immediate Active Mode Minimum Delay

Asymmetric PWM Mode

Asymmetric PWM mode allows two center-aligned PWM signals to be generated with a programmable phase shift. While the PWM frequency is determined by the value of the CRR register, the duty cycle and the phase-shift are determined by the CHxCR and CHxACR register. When the counter is counting up, the PWM uses the value in CHxCR as up-count compare value. When the counter is into counting down stage, the PWM uses the value in CHxACR as down-count compare value. The Figure 86 is shown an example for asymmetric PWM mode in center-aligned counting mode.

Note: Asymmetric PWM mode can only be operated in center-aligned counting mode.

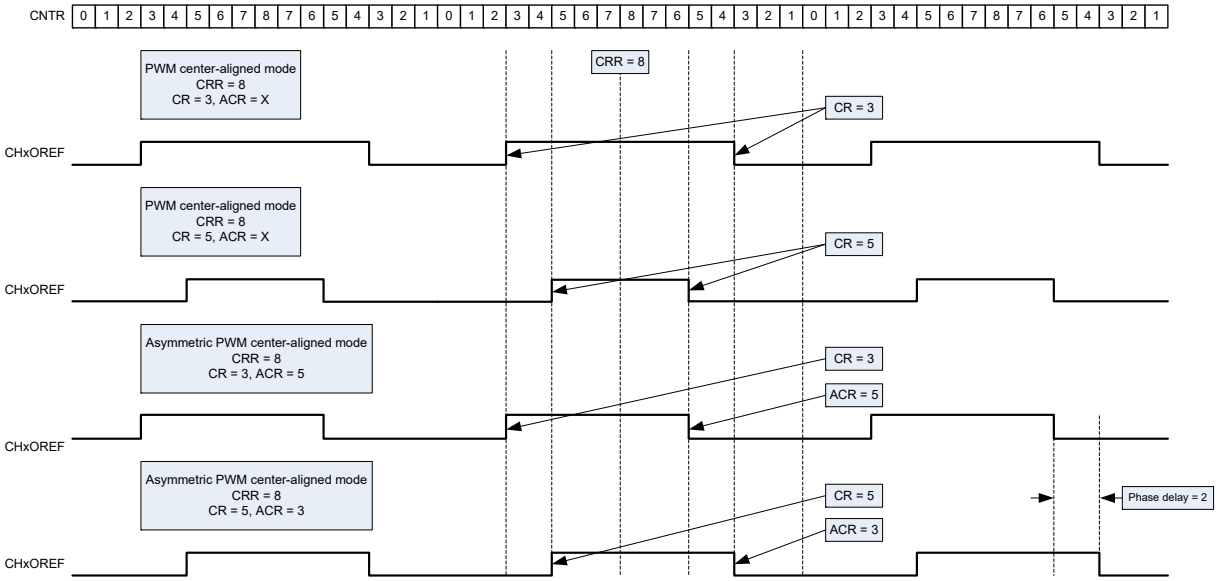


Figure 86. Asymmetric PWM Mode versus Center-aligned Counting Mode

Timer Interconnection

The timers can be internally connected together for timer chaining or synchronization. This can be implemented by configuring one timer to operate in the Master mode while configuring another timer to be in the Slave mode. The following figures present several examples of trigger selection for the master and slave modes.

Using one timer to enable/disable another timer start or stop counting

- Configure PWM0 as the master mode to send its channel 0 Output Reference signal CH0OREF as a trigger output (MMSEL = 0x4).
- Configure PWM0 CH0OREF waveform.
- Configure PWM1 to receive its input trigger source from the PWM0 trigger output (TRSEL = 0x9).
- Configure PWM1 to operate in the pause mode (SMSEL = 0x5).
- Enable PWM1 by writing '1' to the TME bit.
- Enable PWM0 by writing '1' to the TME bit.

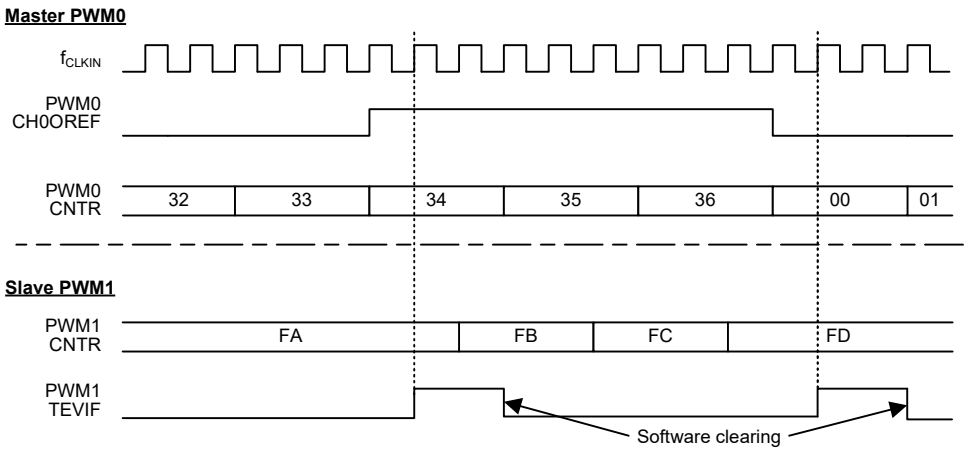


Figure 87. Pausing PWM1 using the PWM0 CH0OREF Signal

Using one timer to trigger another timer start counting

- Configure PWM0 to operate in the master mode to send its Update Event UEV as the trigger output (MMSEL = 0x2).
- Configure the PWM0 period by setting the CRR register.
- Configure PWM1 to get the input trigger source from the PWM0 trigger output (TRSEL = 0x9).
- Configure PWM1 to be in the slave trigger mode (SMSEL = 0x6).
- Start PWM0 by writing '1' to the TME bit.

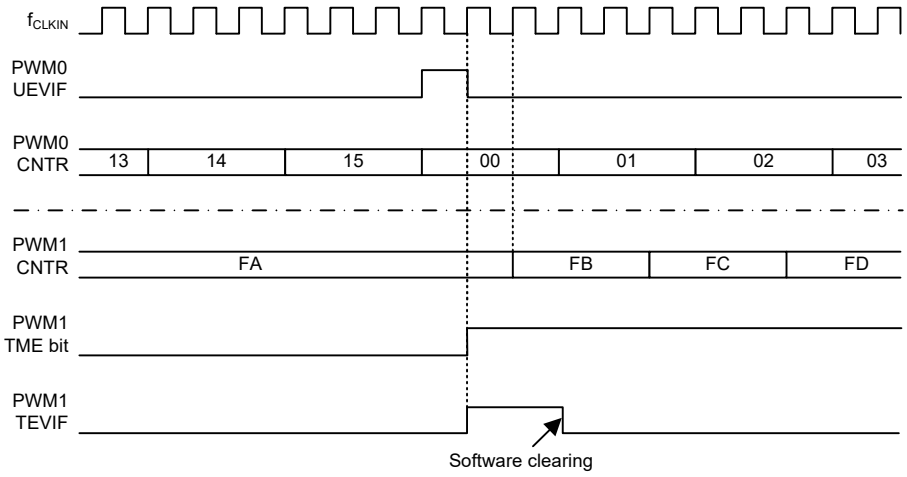


Figure 88. Triggering PWM1 with PWM0 Update Event

Starting two timers synchronously with the master enable MTO signal trigger

- Configure PWM0 to operate in the master mode to send its enable signal as a trigger output (MMSEL = 0x1).
- Enable the PWM0 master timer synchronization function by setting the TSE bit in the MDCFR register to 1 to synchronize the slave timer.
- Configure PWM1 to receive its input trigger source from the PWM0 trigger output (TRSEL = 0x9).
- Configure PWM1 to be in the slave trigger mode (SMSEL = 0x6).
- Start PWM0 by writing '1' to the TME bit.

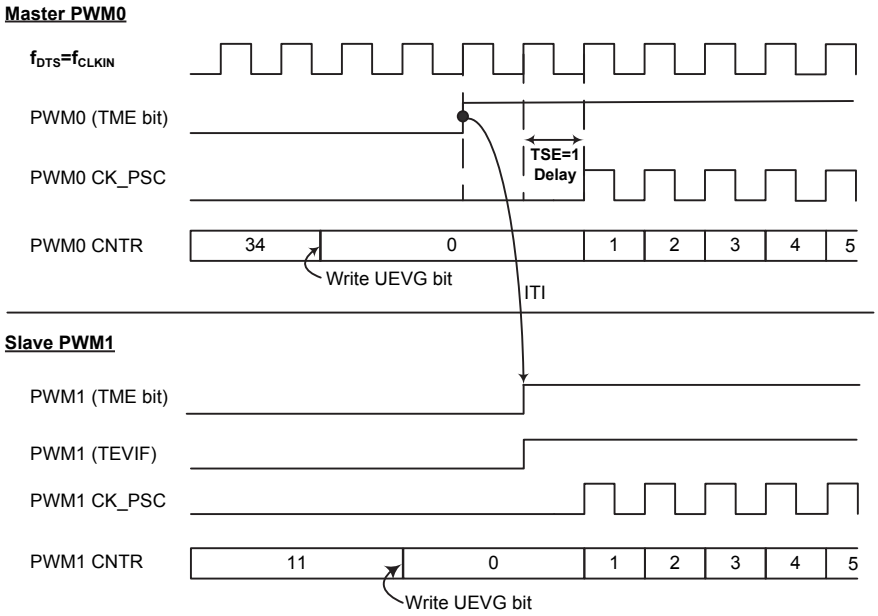


Figure 89. Trigger PWM0 and PWM1 with the PWM0 Timer Enable Signal

Trigger Peripherals Start

To interconnect to the peripherals, such as ADC, Timer and so on, the PWM could output the MTO signal or the channel compare match output signal CHxOREF (x = 0 ~ 3) to be used as peripherals input trigger signal and depending on the MCU specification.

PDMA Request

The PWM supports the interface for PDMA data transfer. There are certain events which can generate the PDMA requests if the corresponding enable control bits are set to 1 to enable the PDMA access. These events are the PWM update events, trigger events and channel compare events. When the PDMA request is generated from the PWM channel, it can be derived from the channel compare event or the PWM update event selected by the channel PDMA selection bit, CHCDS, for all channels. For more detailed PDMA configuring information, refer to the corresponding section in the PDMA chapter.

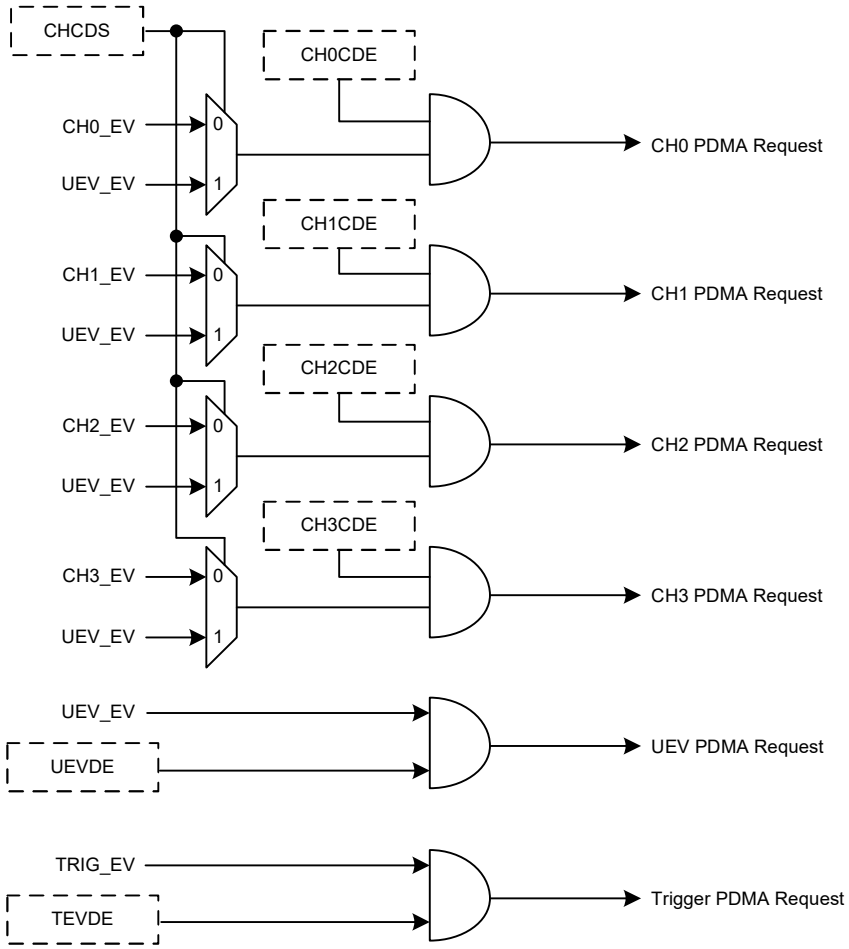


Figure 90. PWM PDMA Mapping Diagram

Register Map

The following table shows the PWM registers and reset values.

Table 31. PWM Register Map

Register	Offset	Description	Reset Value
CNTCFR	0x000	Timer Counter Configuration Register	0x0000_0000
MDCFR	0x004	Timer Mode Configuration Register	0x0000_0000
TRCFR	0x008	Timer Trigger Configuration Register	0x0000_0000
CTR	0x010	Timer Control Register	0x0000_0000
CH0OCFR	0x040	Channel 0 Output Configuration Register	0x0000_0000
CH1OCFR	0x044	Channel 1 Output Configuration Register	0x0000_0000
CH2OCFR	0x048	Channel 2 Output Configuration Register	0x0000_0000
CH3OCFR	0x04C	Channel 3 Output Configuration Register	0x0000_0000
CHCTR	0x050	Channel Control Register	0x0000_0000
CHPOLR	0x054	Channel Polarity Configuration Register	0x0000_0000
DICTR	0x074	Timer PDMA / Interrupt Control Register	0x0000_0000
EVGR	0x078	Timer Event Generator Register	0x0000_0000
INTSR	0x07C	Timer Interrupt Status Register	0x0000_0000
CNTR	0x080	Timer Counter Register	0x0000_0000
PSCR	0x084	Timer Prescaler Register	0x0000_0000
CRR	0x088	Timer Counter-Reload Register	0x0000_FFFF
CH0CR	0x090	Channel 0 Compare Register	0x0000_0000
CH1CR	0x094	Channel 1 Compare Register	0x0000_0000
CH2CR	0x098	Channel 2 Compare Register	0x0000_0000
CH3CR	0x09C	Channel 3 Compare Register	0x0000_0000
CH0ACR	0x0A0	Channel 0 Asymmetric Compare Register	0x0000_0000
CH1ACR	0x0A4	Channel 1 Asymmetric Compare Register	0x0000_0000
CH2ACR	0x0A8	Channel 2 Asymmetric Compare Register	0x0000_0000
CH3ACR	0x0AC	Channel 3 Asymmetric Compare Register	0x0000_0000

Register Descriptions

Timer Counter Configuration Register – CNTCFR

This register specifies the PWM counter configuration.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							DIR
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved							CMSEL
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						UGDIS	UEVDIS
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[24]	DIR	Counting Direction 0: Count-up 1: Count-down Note: This bit is read only when the Timer is configured to be in the Center-aligned mode.
[17:16]	CMSEL	Counter Mode Selection 00: Edge-aligned mode. Normal up-counting and down-counting available for this mode. Counting direction is defined by the DIR bit. 01: Center-aligned mode 1. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-down period. 10: Center-aligned mode 2. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up period. 11: Center-aligned mode 3. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up and count-down periods.
[1]	UGDIS	Update event interrupt generation disable control 0: Any of the following events will generate an update PDMA request or interrupt - Counter overflow/underflow - Setting the UEVG bit - Update generation through the slave mode 1: Only counter overflow/underflow generates an update PDMA request or interrupt
[0]	UEVDIS	Update event Disable control 0: Enable the update event request by one of following events: - Counter overflow/underflow - Setting the UEVG bit - Update generation through the slave mode 1: Disable the update event (However the counter and the prescaler are reinitialized if the UEVG bit is set or if a hardware restart is received from the slave mode)

Timer Mode Configuration Register – MDCFR

This register specifies the PWM master and slave mode selection and single pulse mode.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							SPMSET
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved					MMSEL		
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved					SMSEL		
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved							TSE
Type/Reset								RW 0

Bits	Field	Descriptions
[24]	SPMSET	Single Pulse Mode Setting 0: Counter counts normally irrespective of whether the update event occurred or not. 1: Counter stops counting at the next update event and then the TME bit is cleared by hardware.

Bits	Field	Descriptions
[18:16]	MMSEL	Master Mode Selection Master mode selection is used to select the MTO signal source which is used to synchronize the other slave timer.

MMSEL [2:0]	Mode	Descriptions
000	Reset Mode	The MTO signal in the Reset mode is an output derived from one of the following cases: 1. Software setting UEVG bit 2. The STI trigger input signal which will be output on the MTO signal line when the Timer is used in the slave Restart mode
001	Enable Mode	The Counter Enable signal is used as the trigger output.
010	Update Mode	The update event is used as the trigger output according to one of the following cases when the UEVDIS bit is cleared to 0: 1. Counter overflow / underflow 2. Software setting UEVG 3. Slave trigger input when used in slave restart mode
011	—	Reserved
100	Compare Mode 0	The Channel 0 Output reference signal named CH0OREF is used as the trigger output.
101	Compare Mode 1	The Channel 1 Output reference signal named CH1OREF is used as the trigger output.
110	Compare Mode 2	The Channel 2 Output reference signal named CH2OREF is used as the trigger output.
111	Compare Mode 3	The Channel 3 Output reference signal named CH3OREF is used as the trigger output.

Bits	Field	Descriptions
[11:8]	SMSEL	Slave Mode Selection

SMSEL [2:0]	Mode	Descriptions
000	Disable mode	The prescaler is clocked directly by the internal clock.
001	—	Reserved
010	—	Reserved
011	—	Reserved
100	Restart Mode	The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.
101	Pause Mode	The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal.
110	Trigger Mode	The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the counter start control is determined by the STI signal.
111	STIED	The rising edge of the selected trigger signal STI will clock the counter.

[0]	TSE	Timer Synchronization Enable 0: No action 1: Master timer (current timer) will generate a delay to synchronize its slave timer through the MTO signal.

Timer Trigger Configuration Register – TRCFR

This register specifies the trigger source selection of PWM.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TRSEL			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[3:0]	TRSEL	Trigger Source Selection These bits are used to select the trigger input (STI) for counter synchronization. 0000: Software Trigger by setting the UEVG bit 1001: Internal Timing Module Trigger 0 (ITI0) 1010: Internal Timing Module Trigger 1 (ITI1) 1011: Internal Timing Module Trigger 2 (ITI2) Others: Reserved Note: These bits must be updated only when they are not in use, i.e. the slave mode is disabled by setting the SMSEL field to 0x0.

Table 32. PWM Internal Trigger Connection

Slave Timing Module	ITI0	ITI1	ITI2
PWM0	PWM1	GPTM	—
PWM1	PWM0	GPTM	—

Timer Control Register – CTR

This register specifies the timer enable bit (TME), CRR buffer enable bit (CRBE) and Channel PDMA selection bit (CHCDS).

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							CHCDS
Type/Reset								RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						CRBE	TME
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[16]	CHCDS	Channel PDMA event selection 0: Channel PDMA request derived from the channel compare event. 1: Channel PDMA request derived from the Update event.
[1]	CRBE	Counter-Reload register Buffer Enable 0: Counter-reload register can be updated immediately 1: Counter-reload register can not be updated until the update event occurs
[0]	TME	Timer Enable bit 0: PWM off 1: PWM on When the TME bit is cleared to 0, the counter is stopped and the PWM consumes no power in any operation mode except for the single pulse mode and the slave trigger mode. In these two modes the TME bit can automatically be set to 1 by hardware which permits all the PWM registers to function normally.

Channel 0 Output Configuration Register – CH0OCFR

This register specifies the channel 0 output mode configuration.

Offset: 0x040

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH0OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH0IMAE	CH0PRE	Reserved	CH0OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH0IMAE	Channel 0 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH0OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH0CR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH0IMAE bit is available only if the channel 0 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH0PRE	Channel 0 Compare Register (CH0CR) Preload Enable 0: CH0CR preload function is disabled The CH0CR register can be immediately assigned a new value when the CH0PRE bit is cleared to 0 and the updated CH0CR value is used immediately. 1: CH0CR preload function is enabled The new CH0CR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH0OM[3:0]	Channel 0 Output Mode Setting These bits define the functional types of the output reference signal CH0OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH0OREF is forced to 0 0101: Force active – CH0OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 0 has an active level when CNTR < CH0CR or otherwise has an inactive level. - During down-counting, channel 0 has an inactive level when CNTR > CH0CR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 0 is has an inactive level when CNTR < CH0CR or otherwise has an active level. - During down-counting, channel 0 has an active level when CNTR > CH0CR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 0 has an active level when CNTR < CH0CR or otherwise has an inactive level. - During down-counting, channel 0 has an inactive level when CNTR > CH0ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 0 has an inactive level when CNTR < CH0CR or otherwise has an active level. - During down-counting, channel 0 has an active level when CNTR > CH0ACR or otherwise has an inactive level. Note: When channel 0 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3)

Channel 1 Output Configuration Register – CH1OCFR

This register specifies the channel 1 output mode configuration.

Offset: 0x044

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH1OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH1IMAE	CH1PRE	Reserved	CH1OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH1IMAE	Channel 1 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH1OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH1CR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH1IMAE bit is available only if the channel 1 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH1PRE	Channel 1 Compare Register (CH1CR) Preload Enable 0: CH1CR preload function is disabled. The CH1CR register can be immediately assigned a new value when the CH1PRE bit is cleared to 0 and the updated CH1CR value is used immediately. 1: CH1CR preload function is enabled The new CH1CR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH1OM[3:0]	Channel 1 Output Mode Setting These bits define the functional types of the output reference signal CH1OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH1OREF is forced to 0 0101: Force active – CH1OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 1 has an active level when CNTR < CH1CR or otherwise has an inactive level. - During down-counting, channel 1 has an inactive level when CNTR > CH1CR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 1 has an inactive level when CNTR < CH1CR or otherwise has an active level. - During down-counting, channel 1 has an active level when CNTR > CH1CR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 1 has an active level when CNTR < CH1CR or otherwise has an inactive level. - During down-counting, channel 1 has an inactive level when CNTR > CH1ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 1 has an inactive level when CNTR < CH1CR or otherwise has an active level. - During down-counting, channel 1 has an active level when CNTR > CH1ACR or otherwise has an inactive level. Note: When channel 1 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3)

Channel 2 Output Configuration Register – CH2OCFR

This register specifies the channel 2 output mode configuration.

Offset: 0x048

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH2OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH2IMAE	CH2PRE	Reserved	CH2OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH2IMAE	Channel 2 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH2OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH2CR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH2IMAE bit is available only if the channel 2 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH2PRE	Channel 2 Compare Register (CH2CR) Preload Enable 0: CH2CR preload function is disabled. The CH2CR register can be immediately assigned a new value when the CH2PRE bit is cleared to 0 and the updated CH2CR value is used immediately. 1: CH2CR preload function is enabled The new CH2CR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH2OM[3:0]	Channel 2 Output Mode Setting These bits define the functional types of the output reference signal CH2OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH2OREF is forced to 0 0101: Force active – CH2OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 2 has an active level when CNTR < CH2CR or otherwise has an inactive level. - During down-counting, channel 2 has an inactive level when CNTR > CH2CR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 2 has an inactive level when CNTR < CH2CR or otherwise has an active level. - During down-counting, channel 2 has an active level when CNTR > CH2CR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 2 has an active level when CNTR < CH2CR or otherwise has an inactive level. - During down-counting, channel 2 has an inactive level when CNTR > CH2ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 2 has an inactive level when CNTR < CH2CR or otherwise has an active level. - During down-counting, channel 2 has an active level when CNTR > CH2ACR or otherwise has an inactive level. Note: When channel 2 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3)

Channel 3 Output Configuration Register – CH3OCFR

This register specifies the channel 3 output mode configuration.

Offset: 0x04C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH3OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH3IMAE	CH3PRE	Reserved	CH3OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH3IMAE	Channel 3 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH3OREF signal will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH3CR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH3IMAE bit is available only if the channel 3 is configured to be operated in the PWM mode 1 or PWM mode 2.
[4]	CH3PRE	Channel 3 Compare Register (CH3CR) Preload Enable 0: CH3CR preload function is disabled. The CH3CR register can be immediately assigned a new value when the CH3PRE bit is cleared to 0 and the updated CH3CR value is used immediately. 1: CH3CR preload function is enabled The new CH3CR value will not be transferred to its shadow register until the update event occurs.

Bits	Field	Descriptions
[8][2:0]	CH3OM[3:0]	Channel 3 Output Mode Setting These bits define the functional types of the output reference signal CH3OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH3OREF is forced to 0 0101: Force active – CH3OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 3 has an active level when CNTR < CH3CR or otherwise has an inactive level. - During down-counting, channel 3 has an inactive level when CNTR > CH3CR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 3 has an inactive level when CNTR < CH3CR or otherwise has an active level. - During down-counting, channel 3 has an active level when CNTR > CH3CR or otherwise has an inactive level 1110: Asymmetric PWM mode 1 - During up-counting, channel 3 has an active level when CNTR < CH3CR or otherwise has an inactive level. - During down-counting, channel 3 has an inactive level when CNTR > CH3ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 3 has an inactive level when CNTR < CH3CR or otherwise has an active level. - During down-counting, channel 3 has an active level when CNTR > CH3ACR or otherwise has an inactive level Note: When channel 3 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1/0x2/0x3)

Channel Control Register – CHCTR

This register contains the channel compare output function enable control bits.

Offset: 0x050

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	CH3E	Reserved	CH2E	Reserved	CH1E	Reserved	CH0E
Type/Reset		RW 0		RW 0		RW 0		RW 0

Bits	Field	Descriptions
[6]	CH3E	Channel 3 Compare Enable 0: Off – Channel 3 output signal CH3O is not active 1: On – Channel 3 output signal CH3O is generated on the corresponding output pin
[4]	CH2E	Channel 2 Capture/Compare Enable 0: Off – Channel 2 output signal CH2O is not active 1: On – Channel 2 output signal CH2O is generated on the corresponding output pin
[2]	CH1E	Channel 1 Capture/Compare Enable 0: Off – Channel 1 output signal CH1O is not active 1: On – Channel 1 output signal CH1O is generated on the corresponding output pin
[0]	CH0E	Channel 0 Capture/Compare Enable 0: Off – Channel 0 output signal CH0O is not active 1: On – Channel 0 output signal CH0O is generated on the corresponding output pin

Channel Polarity Configuration Register – CHPOLR

This register contains the channel compare output polarity control.

Offset: 0x054

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	CH3P	Reserved	CH2P	Reserved	CH1P	Reserved	CH0P
Type/Reset		RW 0		RW 0		RW 0		RW 0

Bits	Field	Descriptions
[6]	CH3P	Channel 3 Compare Polarity 0: Channel 3 Output is active high 1: Channel 3 Output is active low
[4]	CH2P	Channel 2 Compare Polarity 0: Channel 2 Output is active high 1: Channel 2 Output is active low
[2]	CH1P	Channel 1 Compare Polarity 0: Channel 1 Output is active high 1: Channel 1 Output is active low
[0]	CH0P	Channel 0 Compare Polarity 0: Channel 0 Output is active high 1: Channel 0 Output is active low

Timer PDMA/Interrupt Control Register – DICTR

This register contains the timer PDMA and interrupt enable control bits.

Offset: 0x074

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved					TEVDE	Reserved	UEVDE
Type/Reset						RW 0		RW 0
	23	22	21	20	19	18	17	16
	Reserved				CH3CDE	CH2CDE	CH1CDE	CH0CDE
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved					TEVIE	Reserved	UEVIE
Type/Reset						RW 0		RW 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CIE	CH2CIE	CH1CIE	CH0CIE
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[26]	TEVDE	Trigger event PDMA Request Enable 0: Trigger PDMA request is disabled 1: Trigger PDMA request is enabled
[24]	UEVDE	Update event PDMA Request Enable 0: Update event PDMA request is disabled 1: Update event PDMA request is enabled
[19]	CH3CDE	Channel 3 Compare PDMA Request Enable 0: Channel 3 PDMA request is disabled 1: Channel 3 PDMA request is enabled
[18]	CH2CDE	Channel 2 Compare PDMA Request Enable 0: Channel 2 PDMA request is disabled 1: Channel 2 PDMA request is enabled
[17]	CH1CDE	Channel 1 Compare PDMA Request Enable 0: Channel 1 PDMA request is disabled 1: Channel 1 PDMA request is enabled
[16]	CH0CDE	Channel 0 Compare PDMA Request Enable 0: Channel 0 PDMA request is disabled 1: Channel 0 PDMA request is enabled
[10]	TEVIE	Trigger event Interrupt Enable 0: Trigger event interrupt is disabled 1: Trigger event interrupt is enabled
[8]	UEVIE	Update event Interrupt Enable 0: Update event interrupt is disabled 1: Update event interrupt is enabled
[3]	CH3CIE	Channel 3 Compare Interrupt Enable 0: Channel 3 interrupt is disabled 1: Channel 3 interrupt is enabled

Bits	Field	Descriptions
[2]	CH2CIE	Channel 2 Compare Interrupt Enable 0: Channel 2 interrupt is disabled 1: Channel 2 interrupt is enabled
[1]	CH1CIE	Channel 1 Compare Interrupt Enable 0: Channel 1 interrupt is disabled 1: Channel 1 interrupt is enabled
[0]	CH0CIE	Channel 0 Compare Interrupt Enable 0: Channel 0 interrupt is disabled 1: Channel 0 interrupt is enabled

Timer Event Generator Register – EVGR

This register contains the software event generation bits.

Offset: 0x078

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					TEVG	Reserved	UEVG
Type/Reset						WO 0		WO 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CG	CH2CG	CH1CG	CH0CG
Type/Reset					WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[10]	TEVG	Trigger Event Generation The trigger event TEV can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: TEVIF flag is set
[8]	UEVG	Update Event Generation The update event UEV can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Reinitialize the counter The counter value returns to 0 or the CRR preload value, depending on the counter mode in which the current timer is being used. An update operation of any related registers will also be performed. For more detailed descriptions, refer to the corresponding section.

Bits	Field	Descriptions
[3]	CH3CG	Channel 3 Compare Generation A Channel 3 compare event can be generated by software setting this bit. It is cleared by hardware automatically. 0: No action 1: Compare event is generated on channel 3
[2]	CH2CG	Channel 2 Compare Generation A Channel 2 compare event can be generated by software setting this bit. It is cleared by hardware automatically. 0: No action 1: Compare event is generated on channel 2
[1]	CH1CG	Channel 1 Compare Generation A Channel 1 compare event can be generated by software setting this bit. It is cleared by hardware automatically. 0: No action 1: Compare event is generated on channel 1
[0]	CH0CG	Channel 0 Compare Generation A Channel 0 compare event can be generated by software setting this bit. It is cleared by hardware automatically. 0: No action 1: Compare event is generated on channel 0

Timer Interrupt Status Register – INTSR

This register stores the timer interrupt status.

Offset: 0x07C
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					TEVIF	Reserved	UEVIF
Type/Reset						W0C 0		W0C 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CIF	CH2CIF	CH1CIF	CH0CIF
Type/Reset					W0C 0	W0C 0	W0C 0	W0C 0

Bits	Field	Descriptions
[10]	TEVIF	Trigger Event Interrupt Flag This flag is set by hardware on a trigger event and is cleared by software. 0: No trigger event occurs 1: Trigger event occurs

Bits	Field	Descriptions
[8]	UEVIF	Update Event Interrupt Flag This bit is set by hardware on an update event and is cleared by software. 0: No update event occurs 1: Update event occurs Note: The update event is derived from the following conditions: - The counter overflows or underflows - The UEVG bit is asserted - A restart trigger event occurs from the slave trigger input
[3]	CH3CIF	Channel 3 Compare Interrupt Flag 0: No match event occurs 1: The content of the counter CNTR has matched the contents of the CH3CR register. This flag is set by hardware when the counter value matches the CH3CR value except in the center-aligned mode. It is cleared by software.
[2]	CH2CIF	Channel 2 Compare Interrupt Flag 0: No match event occurs 1: The content of the counter CNTR has matched the contents of the CH2CR register This flag is set by hardware when the counter value matches the CH2CR value except in the center-aligned mode. It is cleared by software.
[1]	CH1CIF	Channel 1 Compare Interrupt Flag 0: No match event occurs 1: The content of the counter CNTR has matched the contents of the CH1CR register This flag is set by hardware when the counter value matches the CH1CR value except in the center-aligned mode. It is cleared by software.
[0]	CH0CIF	Channel 0 Compare Interrupt Flag 0: No match event occurs 1: The content of the counter CNTR has matched the content of the CH0CR register This flag is set by hardware when the counter value matches the CH0CR value except in the center-aligned mode. It is cleared by software.

Timer Counter Register – CNTR

This register stores the timer counter value.

Offset: 0x080

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CNTV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CNTV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CNTV	Counter Value

Timer Prescaler Register – PSCR

This register specifies the timer prescaler value to generate the counter clock.

Offset: 0x084

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PSCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PSCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PSCV	Prescaler Value These bits are used to specify the prescaler value to generate the counter clock frequency f_{CK_CNT}. $f_{CK\_CNT} = \frac{f_{CK\_PSC}}{PSCV[15:0]+1}$, where the f_{CK_PSC} is the prescaler clock source.

Timer Counter-Reload Register – CRR

This register specifies the timer counter-reload value.

Offset: 0x088

Reset value: 0x0000_FFFF

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CRV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
	CRV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1

Bits	Field	Descriptions
[15:0]	CRV	Counter-Reload Value The CRV is the reload value which is loaded into the actual counter register.

Channel 0 Compare Register – CH0CR

This register specifies the timer channel 0 compare value.

Offset: 0x090

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH0CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH0CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH0CV	Channel 0 Compare Value The CH0CR value is compared with the counter value and the comparison result is used to trigger the CH0OREF output signal.

Channel 1 Compare Register – CH1CR

This register specifies the timer channel 1 compare value.

Offset: 0x094

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH1CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH1CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH1CV	Channel 1 Compare Value The CH1CR value is compared with the counter value and the comparison result is used to trigger the CH1OREF output signal.

Channel 2 Compare Register – CH2CR

This register specifies the timer channel 2 capture/compare value.

Offset: 0x098

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH2CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH2CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH2CV	Channel 2 Compare Value The CH2CR value is compared with the counter value and the comparison result is used to trigger the CH2OREF output signal.

Channel 3 Compare Register – CH3CR

This register specifies the timer channel 3 compare value.

Offset: 0x09C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH3CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH3CV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH3CV	Channel 3 Compare Value The CH3CR value is compared with the counter value and the comparison result is used to trigger the CH3OREF output signal.

Channel 0 Asymmetric Compare Register – CH0ACR

This register specifies the timer channel 0 asymmetric compare value.

Offset: 0x0A0

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH0ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH0ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH0ACV	Channel 0 Asymmetric Compare Value When channel 0 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

Channel 1 Asymmetric Compare Register – CH1ACR

This register specifies the timer channel 1 asymmetric compare value.

Offset: 0x0A4

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH1ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH1ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH1ACV	Channel 1 Asymmetric Compare Value When channel 1 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

Channel 2 Asymmetric Compare Register – CH2ACR

This register specifies the timer channel 2 asymmetric compare value.

Offset: 0x0A8

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH2ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH2ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH2ACV	Channel 2 Asymmetric Compare Value When channel 2 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

Channel 3 Asymmetric Compare Register – CH3ACR

This register specifies the timer channel 3 asymmetric compare value.

Offset: 0x0AC

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH3ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH3ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH3ACV	Channel 3 Asymmetric Compare Value When channel 3 is configured as asymmetric PWM mode and the counter is counting down, the value written is this register will be compared to the counter.

15 Basic Function Timer (BFTM)

Introduction

The Basic Function Timer Module, BFTM, is a 32-bit up-counting counter designed to measure time intervals, generate one shot pulses or generate repetitive interrupts. The BFTM can operate in two modes which are repetitive and one shot modes. The repetitive mode restarts the counter at each compare match event which is generated by the internal comparator. The BFTM also supports a one shot mode which will force the counter to stop counting when a compare match event occurs.

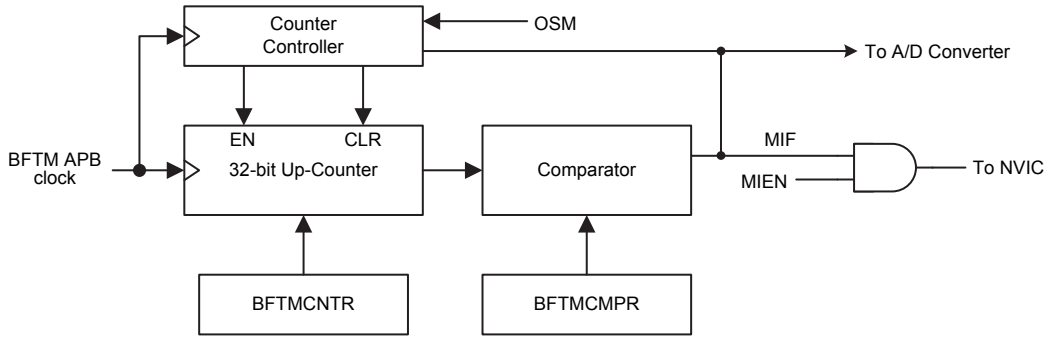


Figure 91. BFTM Block Diagram

Features

- 32-bit up-counting counter
- Compare Match function
- Includes debug mode
- Clock source: BFTM APB clock
- Counter value can be R/W on the fly
- One shot mode: counter stops counting when compare match occurs
- Repetitive mode: counter restarts when compare match occurs
- Compare Match interrupt enable / disable control

Functional Description

The BFTM is a 32-bit up-counting counter which is driven by the BFTM APB clock, PCLK. The counter value can be changed or read at any time even when the timer is counting. The BFTM supports two operating modes known as the repetitive mode and one shot mode allowing the measurement of time intervals or the generation of periodic time durations.

Repetitive Mode

The BFTM counts up from zero to a specific compare value which is pre-defined by the BFTMCMPR register. When the BFTM operates in the repetitive mode and the counter reaches a value equal to the specific compare value in the BFTMCMPR register, the timer will generate a compare match event signal, MIF. When this occurs, the counter will be reset to 0 and resume its counting operation. When the MIF signal is generated, a BFTM compare match interrupt will also be generated periodically if the compare match interrupt is enabled by setting the corresponding interrupt control bit, MIEN, to 1. The counter value will remain unchanged and the counter will stop counting if it is disabled by clearing the CEN bit to 0.

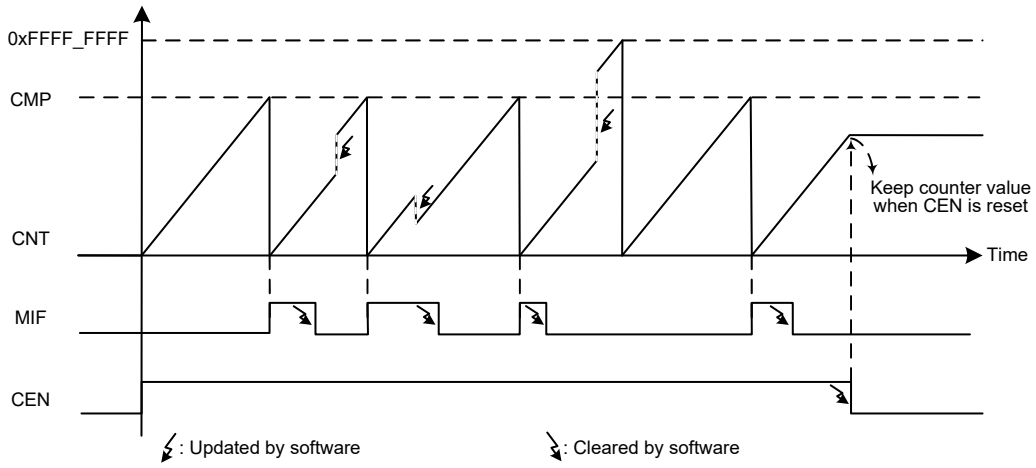


Figure 92. BFTM – Repetitive Mode

One Shot Mode

By setting the OSM bit in BFTMCR register to 1, the BFTM will operate in the one shot mode. The BFTM starts to count when the CEN bit is set to 1 by the application program. The counter value will remain unchanged if the CEN bit is cleared to 0 by the application program. However, the counter value will be reset to 0 and stop counting when the CEN bit is cleared automatically to 0 by the internal hardware when a counter compare match event occurs.

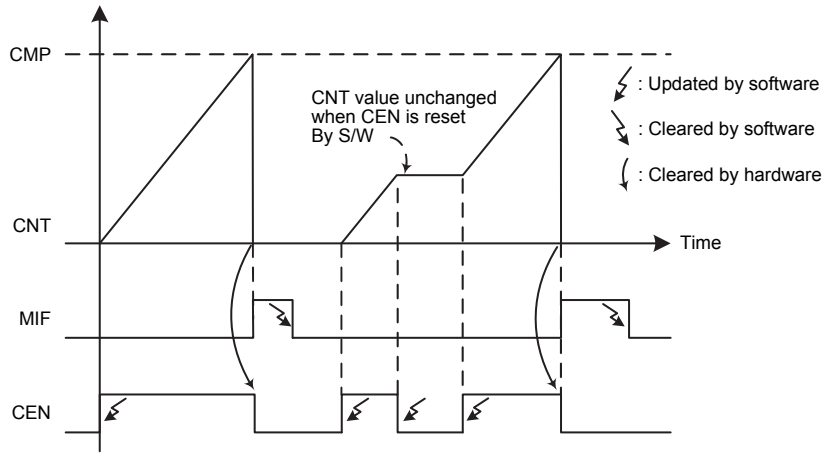


Figure 93. BFTM – One Shot Mode

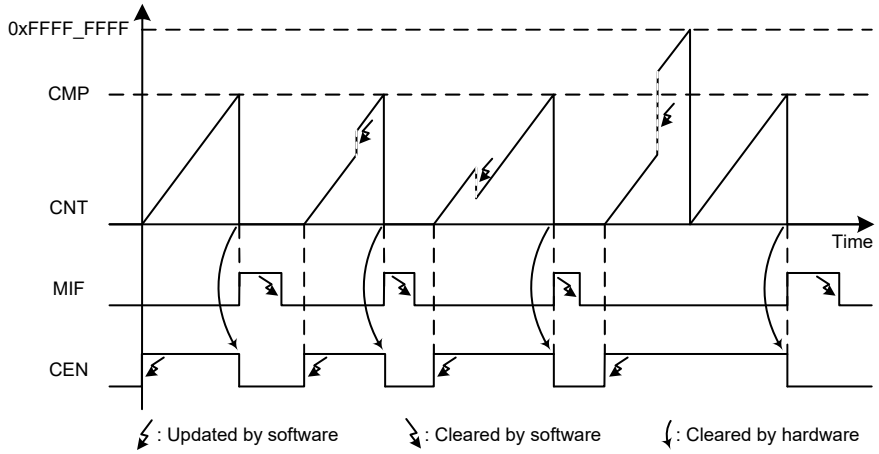


Figure 94. BFTM – One Shot Mode Counter Updating

Trigger ADC Start

When a BFTM compare match event occurs, a compare match interrupt flag, MIF, will be generated which can be used as an A/D Converter input trigger source.

Register Map

The following table shows the BFTM registers and their reset values.

Table 33. BFTM Register Map

Register	Offset	Description	Reset Value
BFTMCR	0x000	BFTM Control Register	0x0000_0000
BFTMSR	0x004	BFTM Status Register	0x0000_0000
BFTMCNTR	0x008	BFTM Counter Value Register	0x0000_0000
BFTMCMPR	0x00C	BFTM Compare Value Register	0xFFFF_FFFF

Register Descriptions

BFTM Control Register – BFTMCR

This register specifies the overall BFTM control bits.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					CEN	OSM	MIEN
Type/Reset						RW 0	RW 0	RW 0

Bits	Field	Descriptions
[2]	CEN	BFTM Counter Enable Control 0: BFTM is disabled 1: BFTM is enabled When this bit is set to 1, the BFTM counter will start to count. The counter will stop counting and the counter value will remain unchanged when the CEN bit is cleared to 0 by the application program regardless of whether it is in the repetitive or one shot mode. However, in the one shot mode, the counter will stop counting and be reset to 0 when the CEN bit is cleared to 0 by the timer hardware circuitry which results from a compare match event.
[1]	OSM	BFTM One Shot Mode Selection 0: Counter operates in repetitive mode 1: Counter operates in one shot mode
[0]	MIEN	BFTM Compare Match Interrupt Enable Control 0: Compare Match Interrupt is disabled 1: Compare Match Interrupt is enabled

BFTM Status Register – BFTMSR

This register specifies the BFTM status.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved							MIF
Type/Reset								W0C 0

Bits	Field	Descriptions
[0]	MIF	BFTM Compare Match Interrupt Flag 0: No compare match event occurs 1: Compare match event occurs When the counter value, CNT, is equal to the compare register value, CMP, a compare match event will occur and the corresponding interrupt flag, MIF will be set. The MIF bit is cleared to 0 by writing a data “0”.

BFTM Counter Value Register – BFTMCNTR

This register specifies the BFTM counter value.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	CNT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	CNT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	CNT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CNT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	CNT	BFTM Counter Value A 32-bit BFTM counter value is stored in this field which can be read or written on the fly.

BFTM Compare Value Register – BFTMCMPR

The register specifies the BFTM compare value.

Offset: 0x00C

Reset value: 0xFFFF_FFFF

	31	30	29	28	27	26	25	24
	CMP							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	23	22	21	20	19	18	17	16
	CMP							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	15	14	13	12	11	10	9	8
	CMP							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
	CMP							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1

Bits	Field	Descriptions
[31:0]	CMP	BFTM Compare Value This register specifies a 32-bit BFTM compare value which is used for comparison with the BFTM counter value.

16 Motor Control Timer (MCTM)

Introduction

The Motor Control Timer consists of one 16-bit up/down-counter, four 16-bit Capture/Compare Registers (CCRs), one 16-bit Counter-Reload Register (CRR), one 8-bit Repetition Counter (REPR) and several control/status registers. It can be used for a variety of purposes which include general time measurement, input signal pulse width measurement, output waveform generation for signals such as single pulse generation or PWM generation, including dead time insertion.

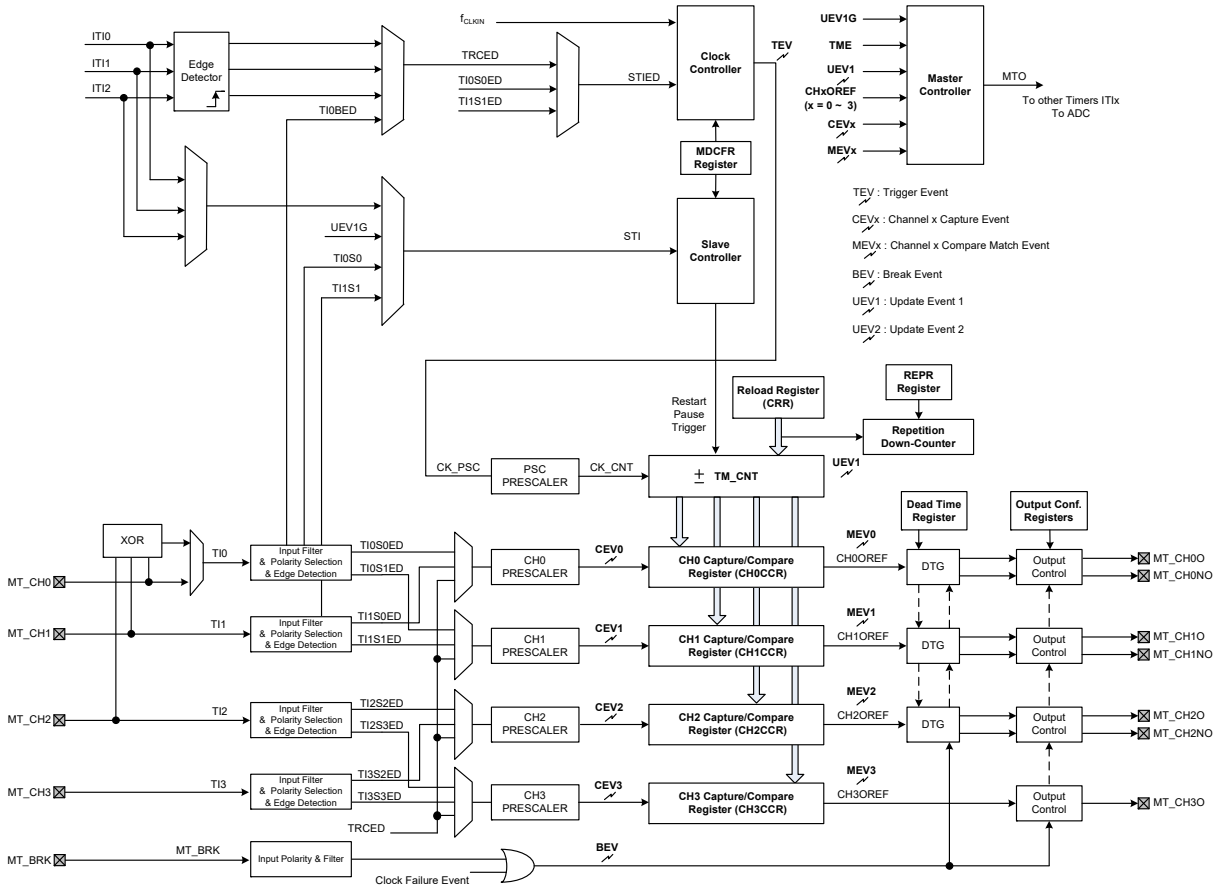


Figure 95. MCTM Block Diagram

Features

- 16-bit up/down auto-reload counter
- 16-bit programmable prescaler that allows division the counter clock frequency by any factor between 1 and 65536
- Up to 4 independent channels for:
  - Input Capture function
  - Compare Match Output
  - PWM waveform Generation – Edge and Center-aligned Counting Mode
  - Single Pulse Mode Output
- Complementary Outputs with programmable dead-time insertion
- Repetition counter updates timer registers only after a given number of counter cycles
- Synchronization circuit controls the timer with external signals and can interconnect several timers together
- Interrupt generation on the following events
  - Update event 1
  - Update event 2
  - Trigger event
  - Input capture event
  - Output compare match
  - Break event – only interrupt
- MCTM Master/Slave mode controller
- Supports 3-phase motor control and hall sensor interface
- Break input signals to assert the timer output signals in reset state or in a known state

Functional Descriptions

Counter Mode

Up-Counting

In this mode the counter counts continuously from 0 to the counter-reload value, which is defined in the CRR register, in a count-up direction. Once the counter reaches the counter-reload value; then restarts from 0 and generates a counter overflow event. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 0 for the up-counting mode.

When an update event 1 is generated by setting the UEV1G bit in the EVGR register to 1, the counter value will also be initialised to 0.

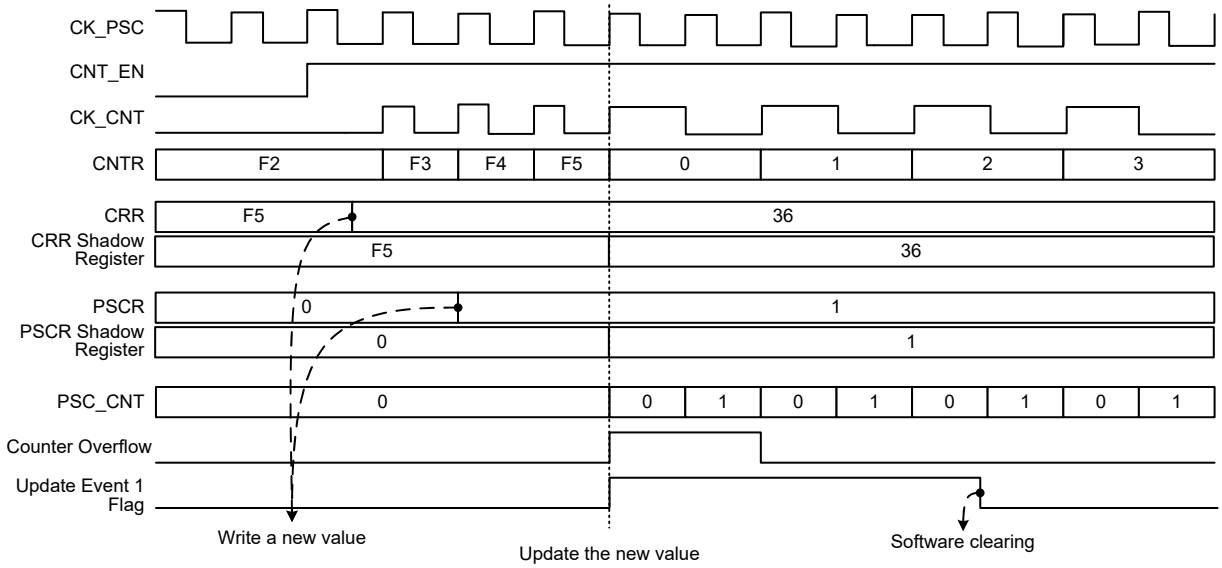


Figure 96. Up-counting Example

Down-Counting

In this mode the counter counts continuously from the counter-reload value, which is defined in the CRR register, to 0 in a count-down direction. Once the counter reaches 0; then restarts from the counter-reload value and generates a counter underflow event. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 1 for the down-counting mode.

When an update event 1 is generated by setting the UEV1G bit in the EVGR register to 1, the counter value will also be initialised to the counter-reload value.

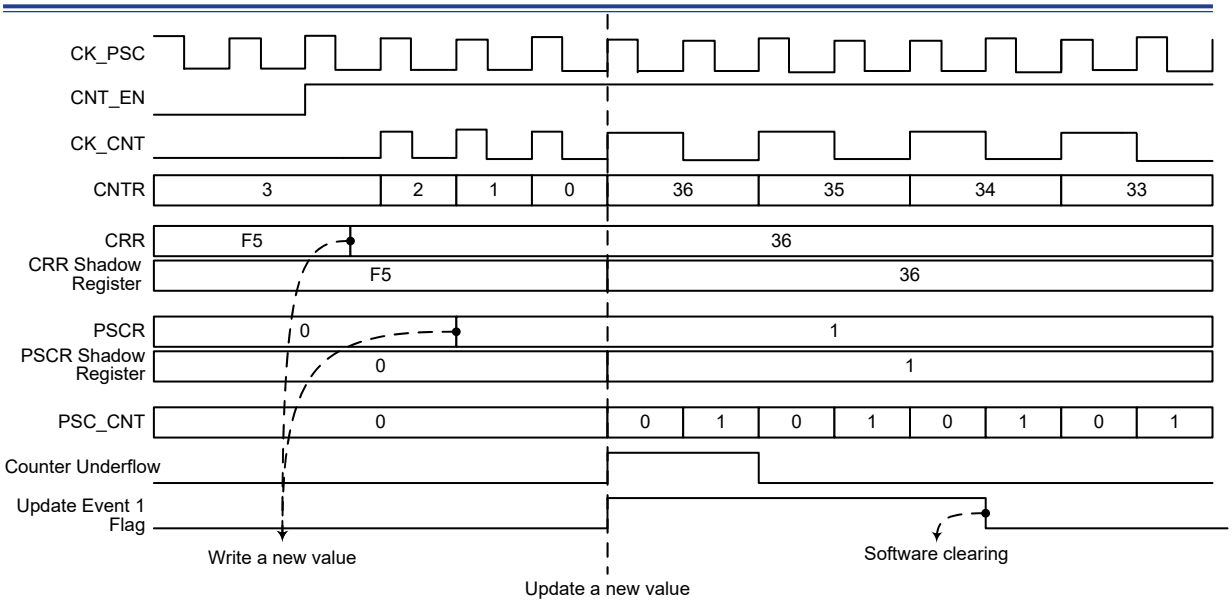


Figure 97. Down-counting Example

Center-Aligned Counting

In the center-aligned counting mode, the counter counts up from 0 to the counter-reload value and then counts down to 0 alternatively. The Timer Module generates an overflow event when the counter counts to the counter-reload value in the up-counting mode and generates an underflow event when the counter counts to 0 in the down-counting mode. The counting direction bit DIR in the CNTCFR register is read-only and indicates the count direction when in the center-aligned counting mode. The count direction is updated by hardware automatically.

Setting the UEV1G bit in the EVGR register will initialise the counter value to 0 irrespective of whether the counter is counting up or down in the center-aligned counting mode.

The update event interrupt flag bit in the INTSR register will be set to 1, when an overflow or underflow event occurs.

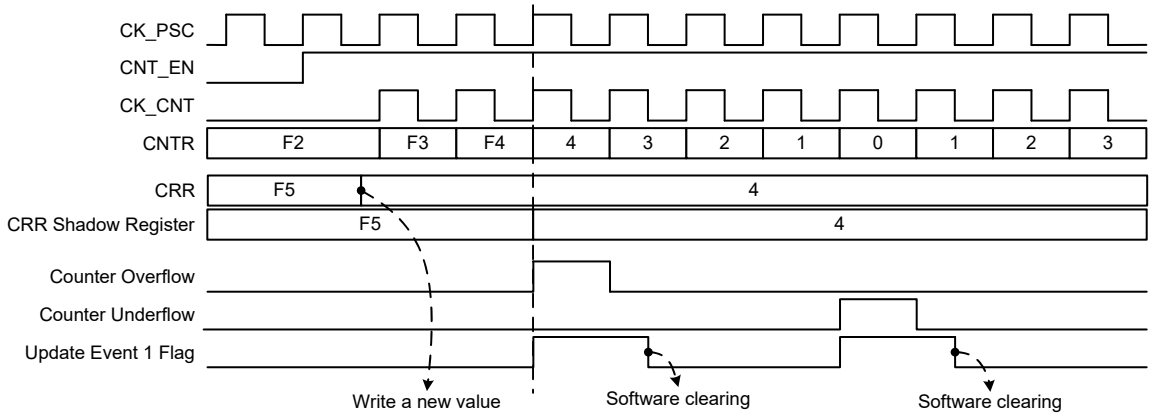


Figure 98. Center-aligned Counting Example

Repetition Down-counter Operation

The update event 1 is usually generated at each overflow or underflow event occurrence. However, when the repetition operation is active by assigning a non-zero value into the REPR register, the update event is only generated if the REPR counter has reached zero. The REPR value is decreased when the following conditions occur:

- At each counter overflow in the up-counting mode
- At each counter underflow in the down-counting mode
- At each counter overflow and underflow in the center-aligned counting mode

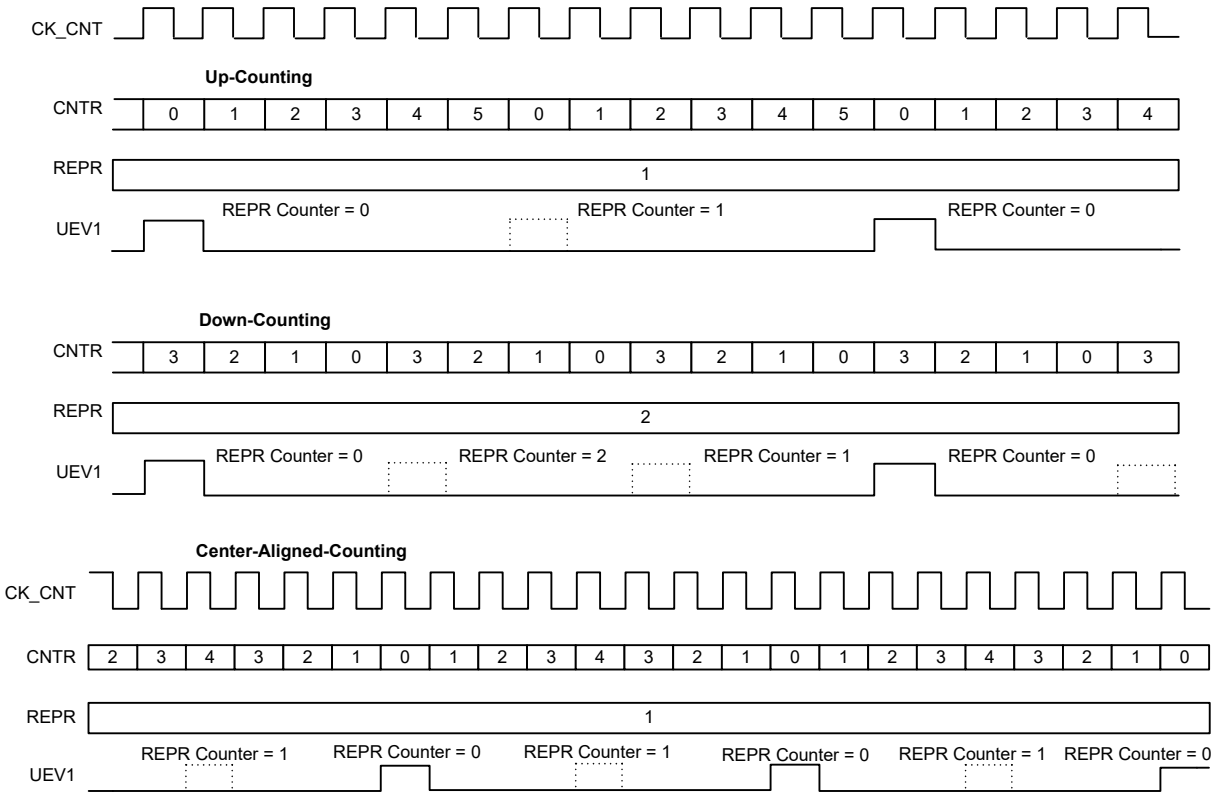


Figure 99. Update Event 1 Dependent Repetition Mechanism Example

Clock Controller

The following describes the Timer Module clock controller which determines the internal prescaler counter clock source.

- Internal APB clock f_{CLKIN}:

  The default internal clock source is the APB clock f_{CLKIN} which is used to drive the counter prescaler when the slave mode is disabled. When the slave mode selection bits SMSEL are set to 0x4, 0x5 or 0x6, the internal APB clock f_{CLKIN} is the counter prescaler driving clock source.

- STIED:

  The counter prescaler can count during each rising edge of the STI signal. This mode can be selected by setting the SMSEL field to 0x7 in the MDCFR register. Here the counter will act as an event counter. The input event, known as STI here, can be selected by setting the TRSEL field to an available value except the value of 0x0. When the STI signal is selected as the clock source, the internal edge detection circuitry will generate a clock pulse during each STI signal rising edge to drive the counter prescaler. It is important to note that if the TRSEL field is set to 0x0 to select the software UEV1G bit as the trigger source, then when the SMSEL field is set to 0x7, the counter will be updated instead of counting.

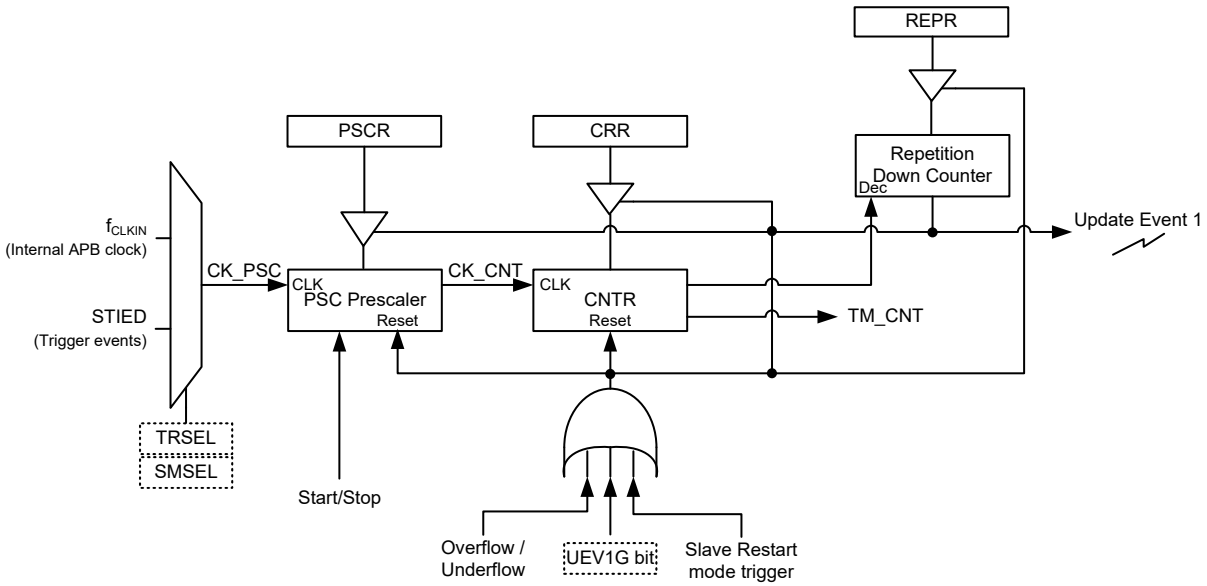


Figure 100. MCTM Clock Source Selection

Trigger Controller

The trigger controller is used to select the trigger source and setup the trigger level and edge trigger conditions. For the internal trigger input (ITIx), it can be selected by the Trigger Selection bits, TRSEL, in the TRCFR register. For all the trigger sources except the UEV1G bit software trigger, the internal edge detection circuitry will generate a clock pulse at each trigger signal rising edge to activate some MCTM functions which are triggered by a trigger signal rising edge.

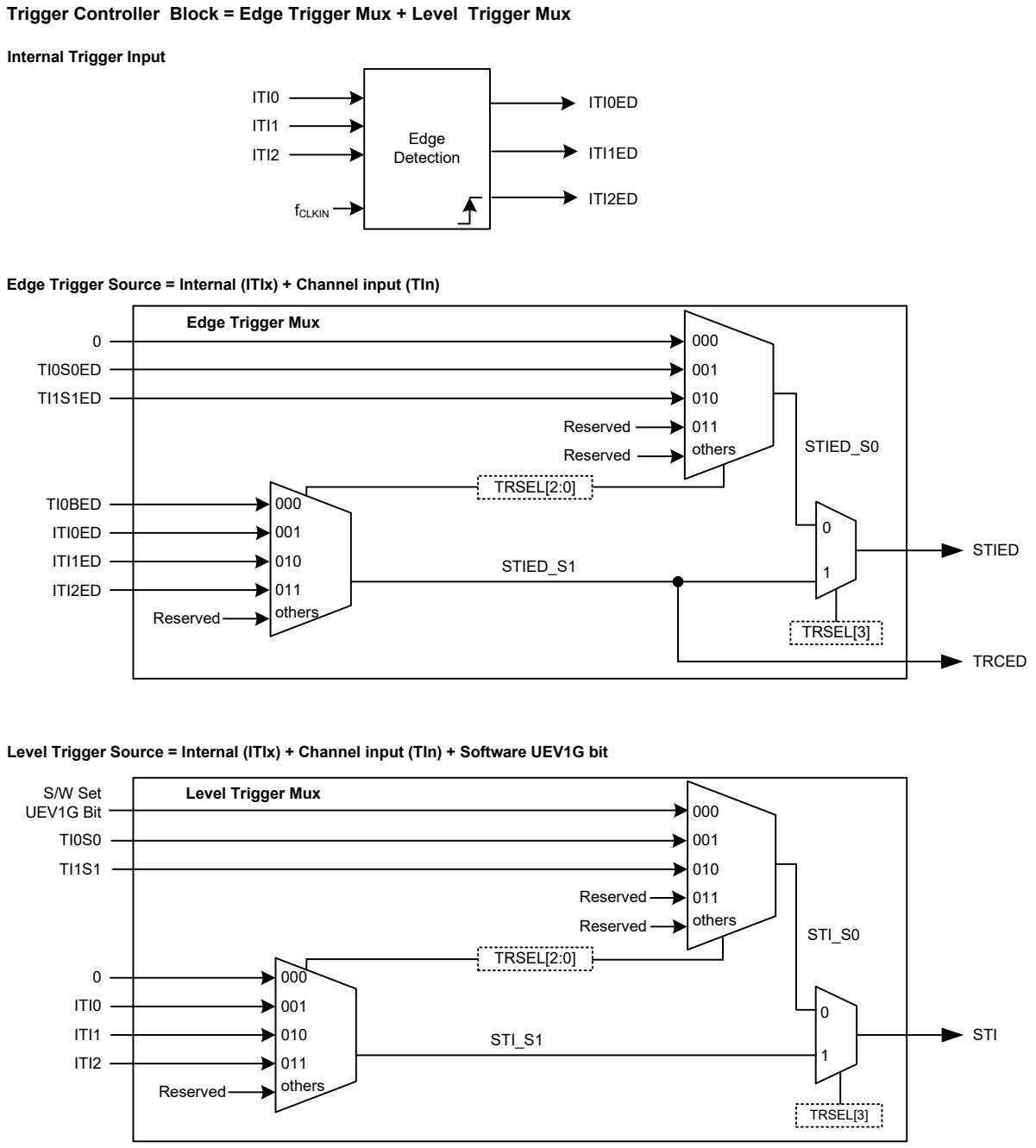


Figure 101. Trigger Controller Block

Slave Controller

The MCTM can be synchronised with an internal/external trigger in several modes including the Restart mode, the Pause mode and the Trigger mode which are selected by the SMSEL field in the MDCFR register. The trigger input of these modes comes from the STI signal which is selected by the TRSEL field in the TRCFR register. The operation modes in the Slave Controller are described in the accompanying sections.

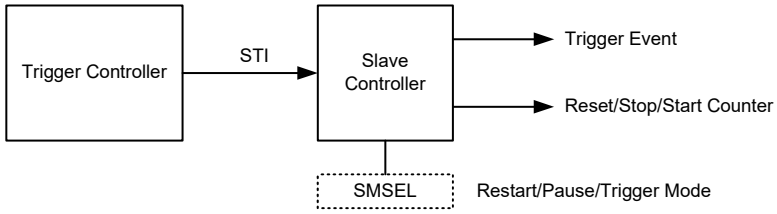


Figure 102. Slave Controller Diagram

Restart Mode

The counter and its prescaler can be reinitialised in response to an STI signal rising edge. If the UEV1DIS bit is set to 1 to disable the update event, then no update event will be generated, however the counter and prescaler are still reinitialized when an STI rising edge occurs. If the UEV1DIS bit in the CNTCFR register is cleared to enable the update event, then an update event will be generated together with the STI rising edge and all the preloaded registers will be updated.

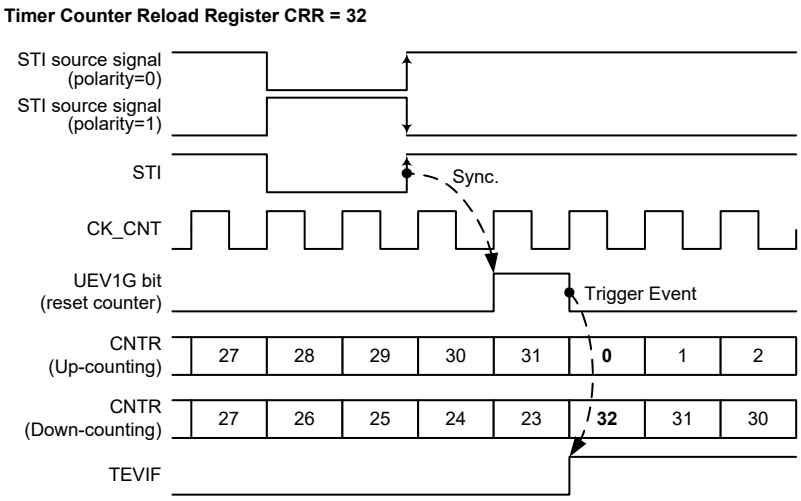


Figure 103. MCTM in Restart Mode

Pause Mode

In the Pause Mode, the selected STI input signal level is used to control the counter start/stop operation. The counter starts to count when the selected STI signal is at a high level and stops counting when the STI signal is changed to a low level. When the counter stops, it will maintain its present value and not be reset. Since the Pause function depends upon the STI level to control the counter stop/start operation, the selected STI trigger signal can not be derived from the TI0BED signal.

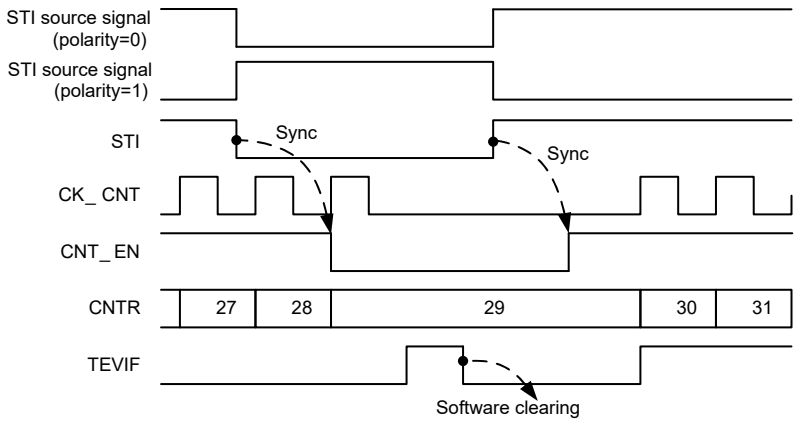


Figure 104. MCTM in Pause Mode

Trigger Mode

After the counter is disabled to count, the counter can resume counting when an STI rising edge signal occurs. When an STI rising edge occurs, the counter will start to count from the current value in the counter. Note that if the STI signal is selected to be sourced from the UEV1G bit software trigger, the counter will not resume counting. When software triggering using the UEV1G bit is selected as the STI source signal, there will be no clock pulse generated which can be used to make the counter resume counting. Note that the STI signal is only used to enable the counter to resume counting and has no effect to stop counting.

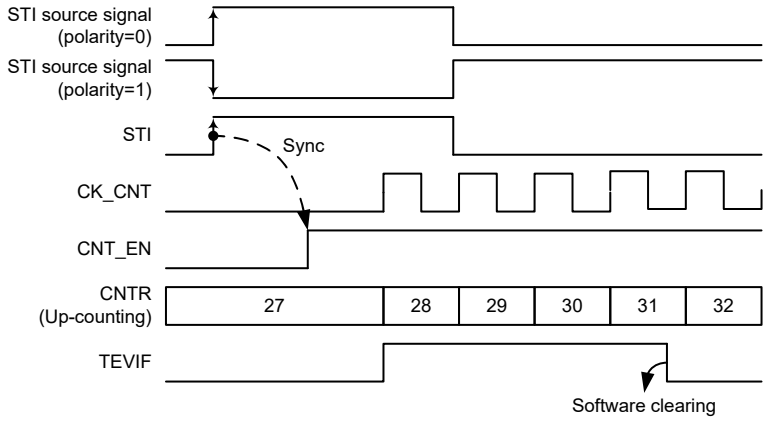


Figure 105. MCTM in Trigger Mode

Master Controller

The MCTMs and GPTMs can be linked together internally for timer synchronisation or chaining. When one MCTM is configured to be in the Master Mode, the MCTM Master Controller will generate a Master Trigger Output (MTO) signal which can reset, restart, stop the Slave counter or be a clock source of the Slave Counter. This can be selected by the MMSEL field in the MDCFR register to trigger or drive another MCTM or GPTM, if exists, which should be configured in the Slave Mode.

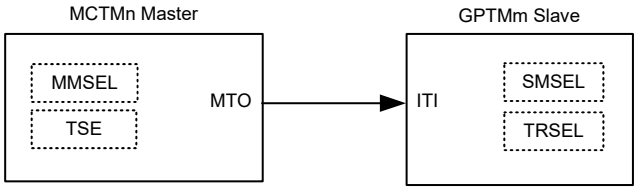


Figure 106. Master MCTMn and Slave GPTMm Connection

The Master Mode Selection bits, MMSEL, in the MDCFR register are used to select the MTO source for synchronising another slave MCTM or GPTM if exists.

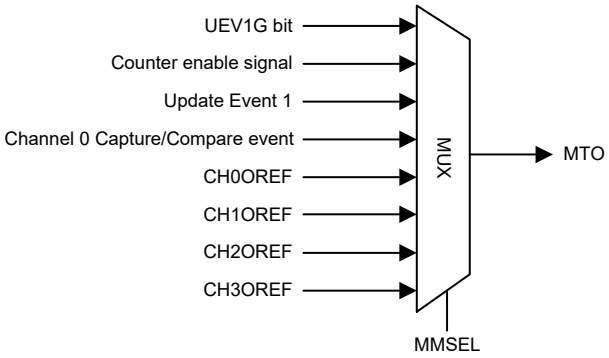


Figure 107. MTO Selection

For example, setting the MMSEL field to 0x5 is to select the CH1OREF signal as the MTO signal to synchronise another slave MCTM or GPTM. For a more detailed description, refer to the related MMSEL field definitions in the MDCFR register.

Channel Controller

The MCTM has four independent channels which can be used as capture inputs or compare match outputs. Each capture input or compare match output channel is composed of a preload register and a shadow register. Data access of the APB bus is always implemented by reading/writing the preload register.

When used in the input capture mode, the counter value is captured into the CHxCCR shadow register first and then transferred into the CHxCCR preload register when the capture event occurs.

When used in the compare match output mode, the contents of the CHxCCR preload register is copied into the associated shadow register, the counter value is then compared with the register value.

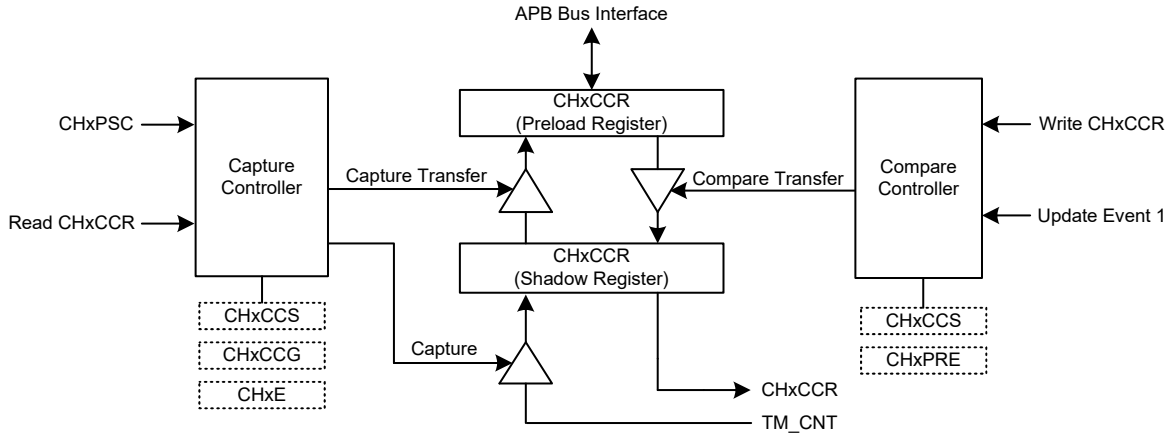


Figure 108. Capture/Compare Block Diagram

Capture Counter Value Transferred to CHxCCR

When the channel is used as a capture input, the counter value is captured into the Channel Capture/Compare Register (CHxCCR) when an effective input signal transition occurs. Once the capture event occurs, the CHxCCIF flag in the INTSR register is set accordingly. If the CHxCCIF bit is already set, i.e., the flag has not yet been cleared by software, and another capture event on this channel occurs, the corresponding channel Over-Capture flag, named CHxOCF, will be set.

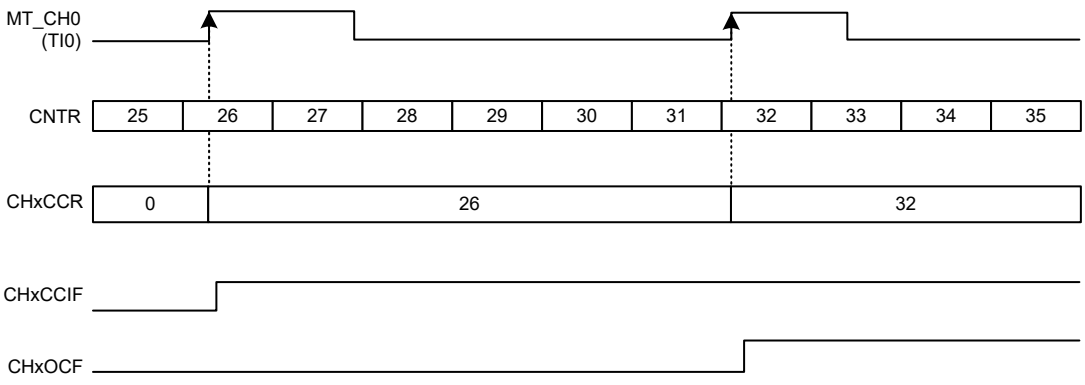


Figure 109. Input Capture Mode

Pulse Width Measurement

The input capture mode can be also used for pulse width measurement from signals on the MT_CHx pins, TIx. The following example shows how to configure the MCTM when operated in the input capture mode to measure the high pulse width and the input period on the MT_CH0 pin using channel 0 and channel 1. The basic steps are shown as follows.

- Configure the capture channel 0 (CH0CCS = 0x1) to select the TI0 signal as the capture input.
- Configure the CH0P bit to 0 to choose the rising edge of the TI0 input as the active polarity.
- Configure the capture channel 1 (CH1CCS = 0x2) to select the TI0 signal as the capture input.
- Set the CH1P bit to 1 to choose the falling edge of the TI0 input as the active polarity.
- Setup the TRSEL bits to 0x1 to select TI0S0 as the trigger input.
- Configure the Slave controller to operate in the Restart mode by setting the SMSEL field in the MDCFR register to 0x4.
- Enable the input capture mode by setting the CH0E and CH1E bits in the CHCTR register to 1.

As the following diagram shows, the high pulse width on the MT_CH0 pin will be captured into the CH1CCR register while the input period will be captured into the CH0CCR register after an input capture operation.

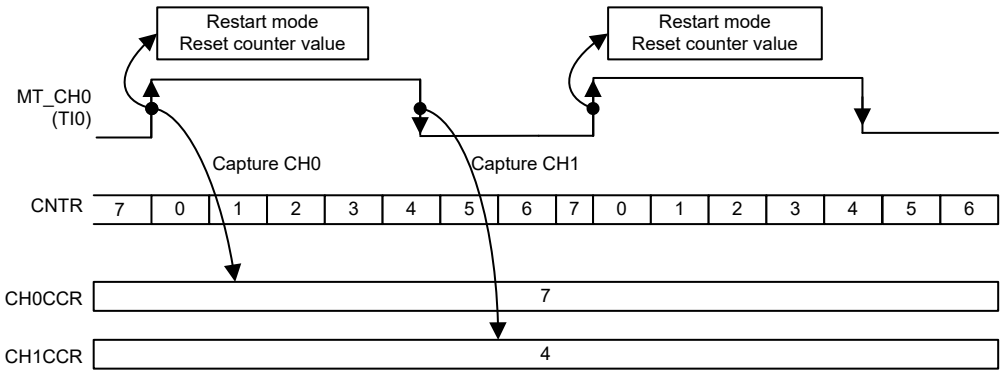


Figure 110. PWM Pulse Width Measurement Example

Input Stage

The input stage consists of a digital filter, a channel polarity selection, edge detection and a channel prescaler. The channel 0 input signal TI0 can be chosen to come from the MT_CH0 signal or the Excusive-OR function of the MT_CH0, MT_CH1 and MT_CH2 signals. The channel input signal TIx is sampled by a digital filter to generate a filtered input signal TIxFP. Then the channel polarity and the edge detection block can generate a TIxSxED signal for the input capture function. The effective input event number can be set by the channel capture input source prescaler setting field CHxPSC.

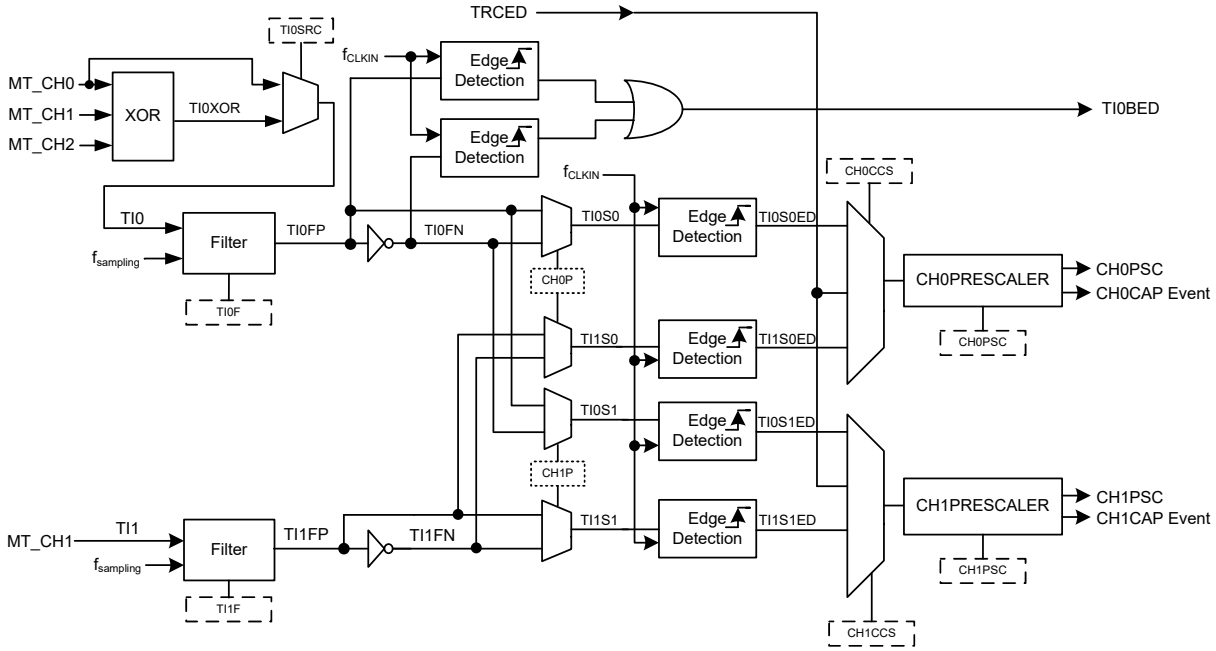


Figure 111. Channel 0 and Channel 1 Input Stages

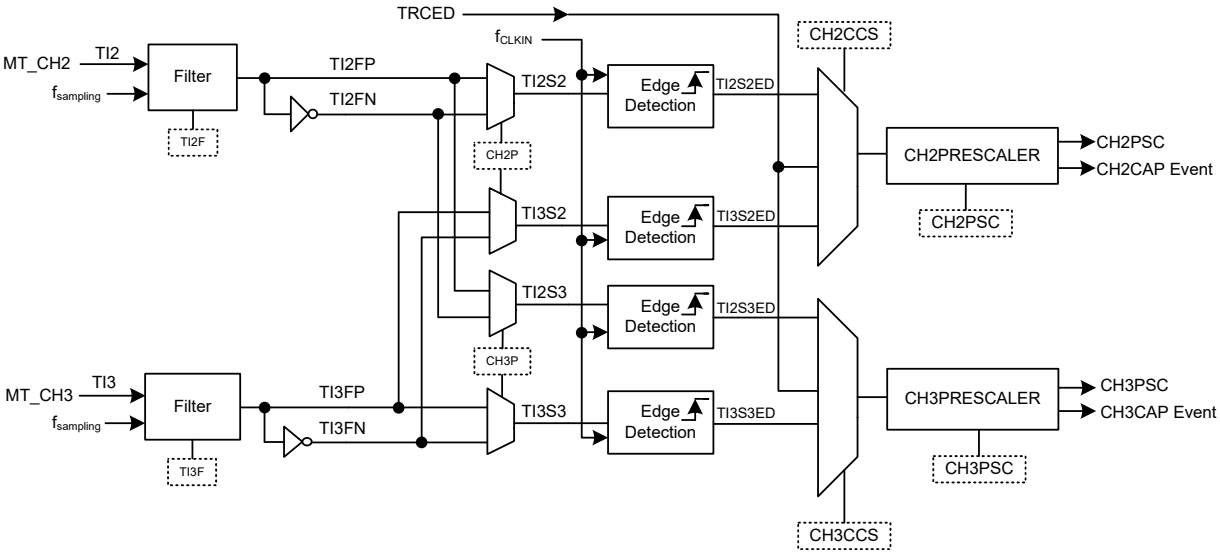


Figure 112. Channel 2 and Channel 3 Input Stages

Digital Filter

The digital filters are embedded in the input stage and clock controller block for the MT_CH0 ~ MT_CH3 pins. The digital filter in the MCTM is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal. The N value can be 0, 2, 4, 5, 6 or 8 according to the selection for each filter.

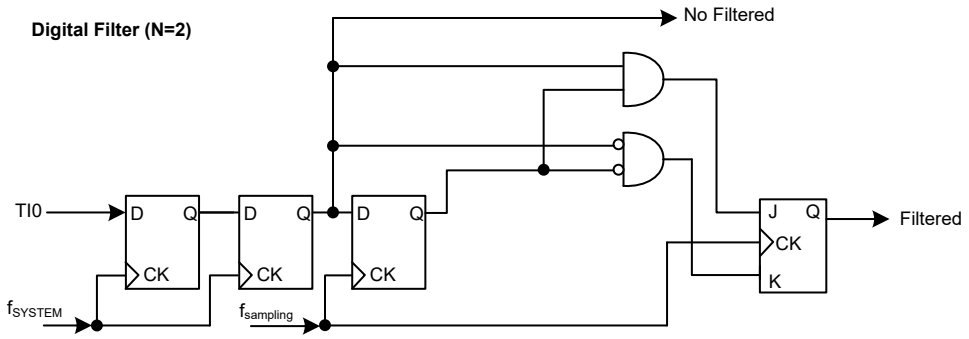


Figure 113. TI0 Digital Filter Diagram with N = 2

Output Stage

The MCTM supports complementary outputs for channels 0, 1 and 2 with dead time insertion. The MCTM channel 3 output function is almost the same as that of GPTM channel 3 except for the break function.

The channel outputs, CHxO and CHxNO, are referenced to the CHxOREF signal. These channel outputs generate a wide variety of wide waveforms according to the configuration values of corresponding control bits, as shown by the dashed box in the diagram.

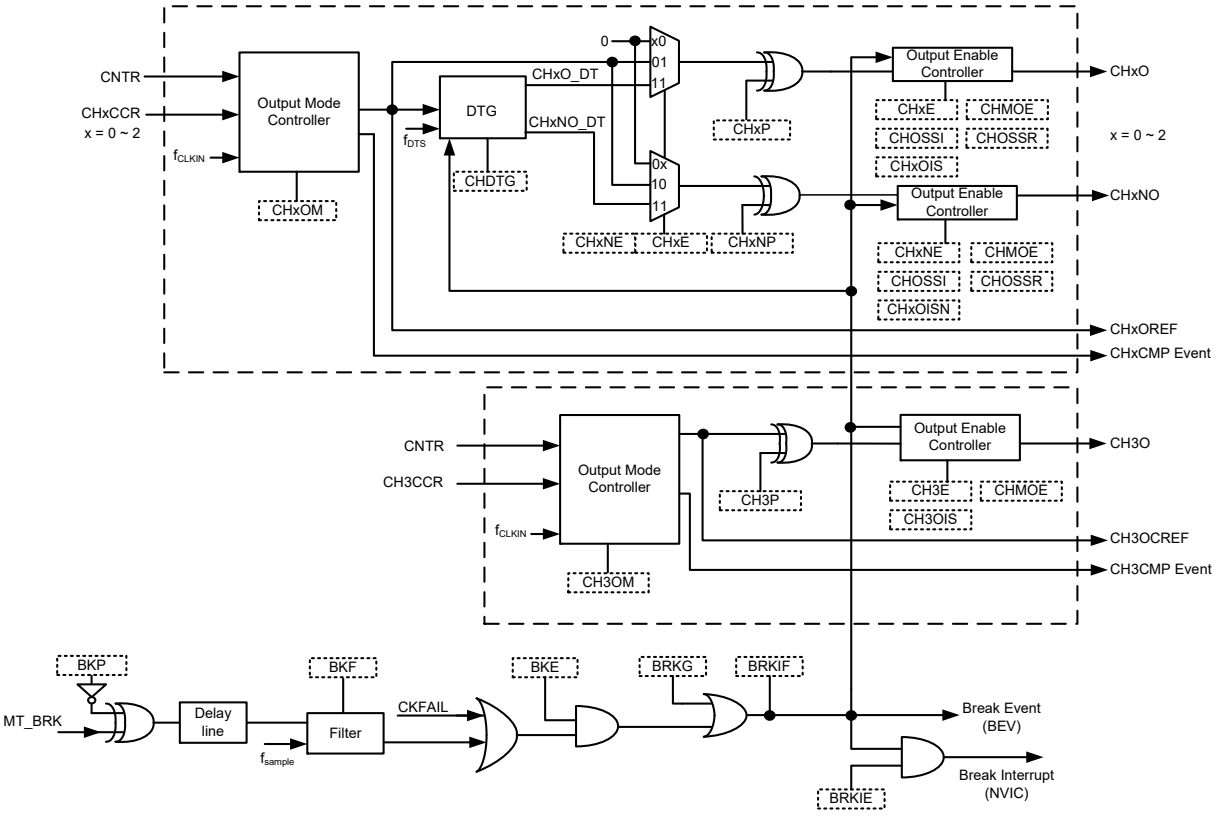


Figure 114. Output Stage Block Diagram

Channel Output Reference Signal

When the MCTM is used in the compare match output mode, the CHxOREF signal (Channel x Output Reference signal) is defined by the CHxOM bit setup. The CHxOREF signal has several types of output function which defines what happens to the output when the counter value matches the contents of the CHxCCR register. In addition to the low, high and toggle CHxOREF output types; there are also PWM mode 1 and PWM mode 2 outputs. In these modes, the CHxOREF signal level is changed according to the count direction and the relationship between the counter value and the CHxCCR content. There are also two modes which will force the output into an inactive or active state irrespective of the CHxCCR content or counter values. With regard to a more detailed description refer to the relative bit definition. The Table 34 shows a summary of the output type setup.

Table 34. Compare Match Output Setup

CHxOM Value	Compare Match Level
0x0	No change
0x1	Clear Output to 0
0x2	Set Output to 1
0x3	Toggle Output
0x4	Force Inactive Level
0x5	Force Active Level
0x6	PWM Mode 1
0x7	PWM Mode 2

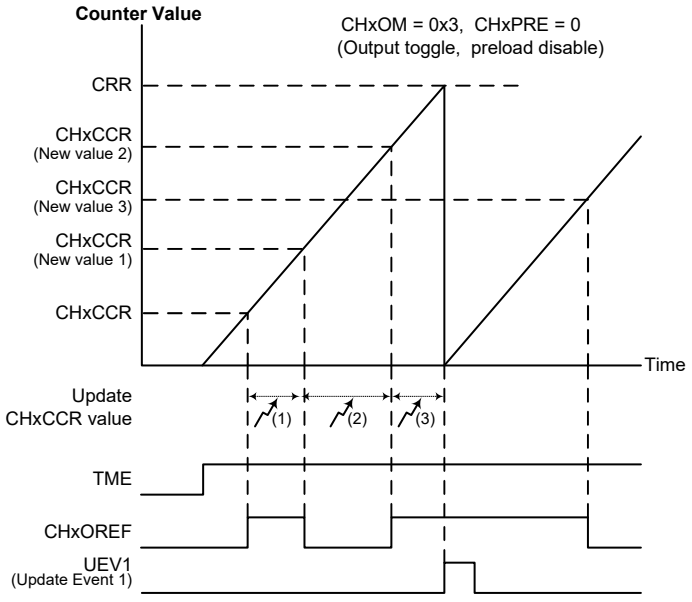


Figure 115. Toggle Mode Channel Output Reference Signal – CHxPRE = 0

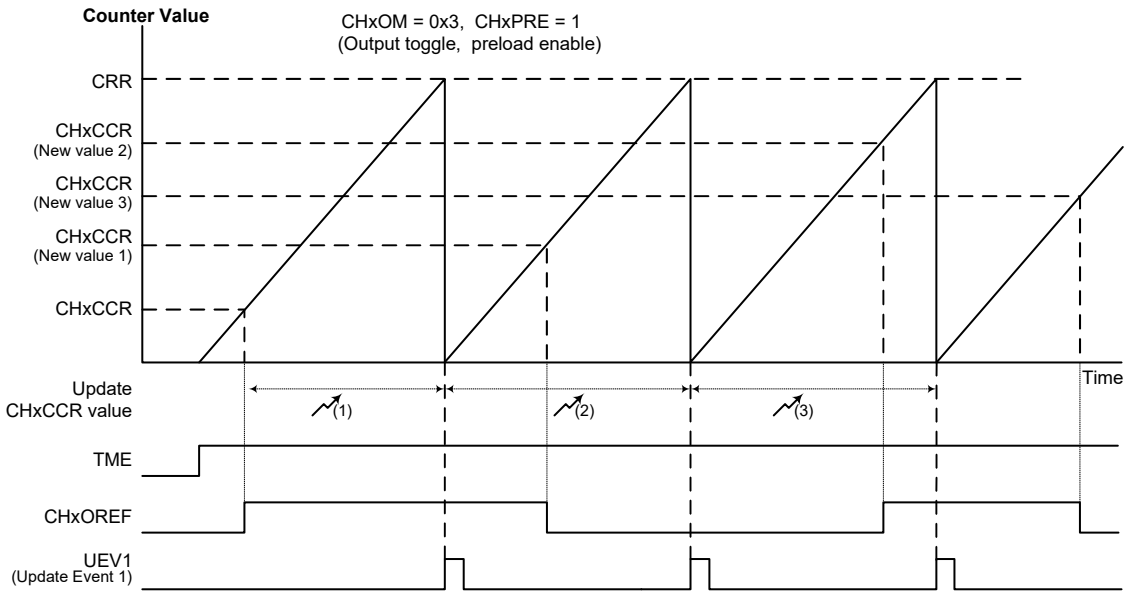


Figure 116. Toggle Mode Channel Output Reference Signal – CHxPRE = 1

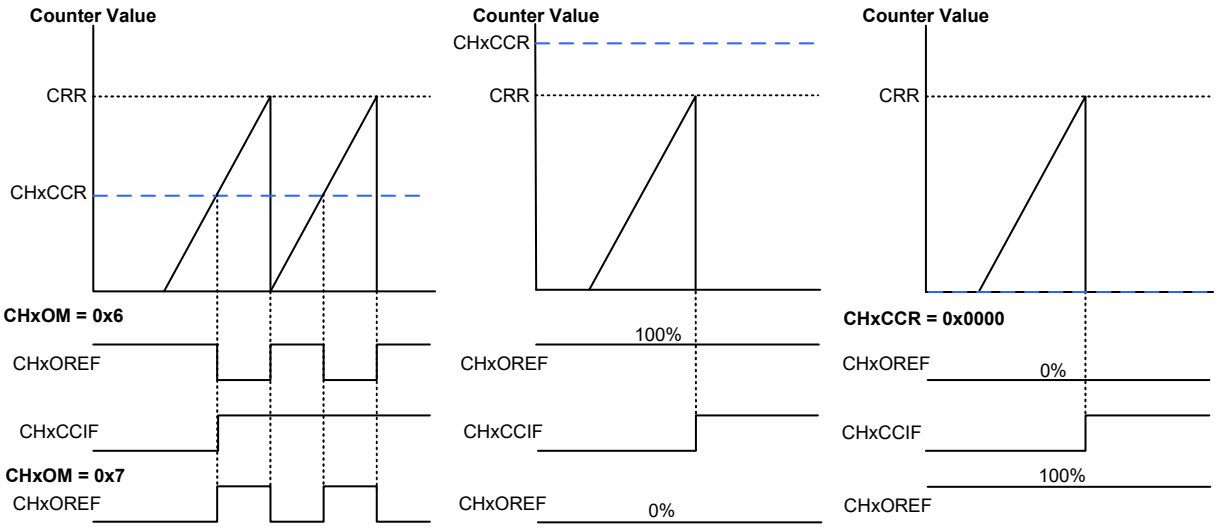


Figure 117. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode

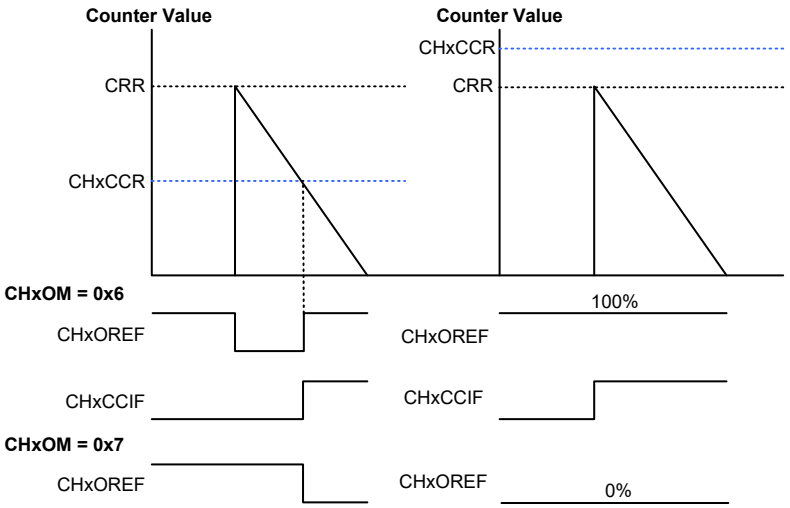


Figure 118. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode

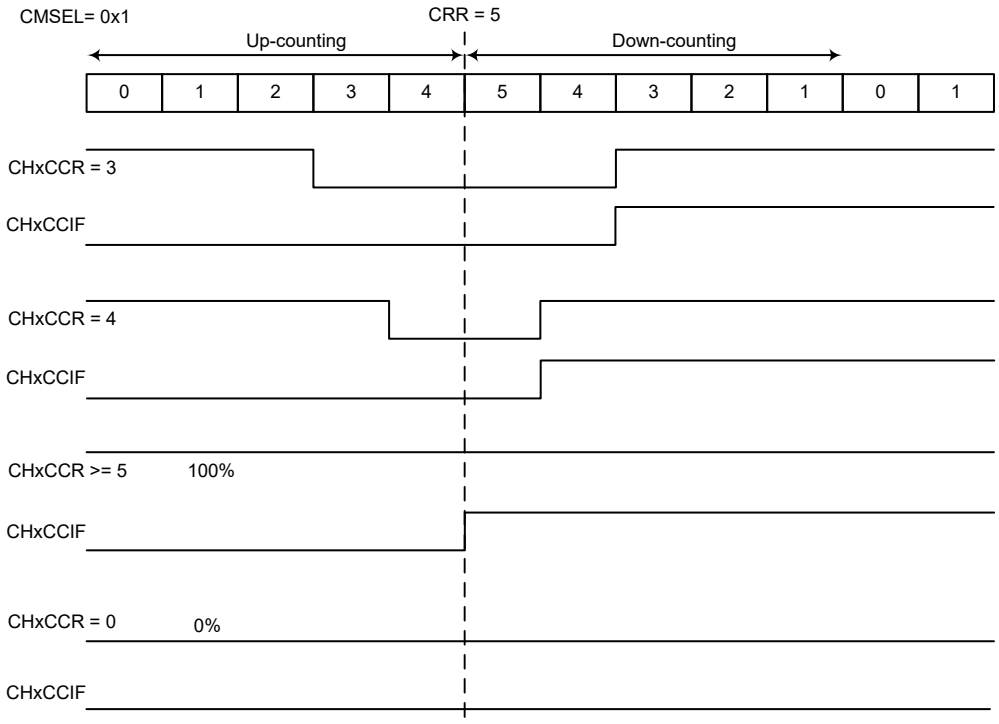


Figure 119. PWM Mode 1 Channel Output Reference Signal and Counter in Centre-aligned Counting Mode

Dead Time Generator

An 8-bit dead time generator function is included for channels 0 ~ 2. The dead time insertion is enabled by setting both the CHxE and CHxNE bits. The relationship between the CHxO and CHxNO signals with respect to the CHxOREF signal is as follows:

- The CHxO signal is the same as the CHxOREF signal except for the rising edge which is delayed with a dead time relative to the reference signal rising edge.
- The CHxNO is the opposite of the CHxOREF signal except for the rising edge which is delayed with a dead time relative to the reference signal falling edge.

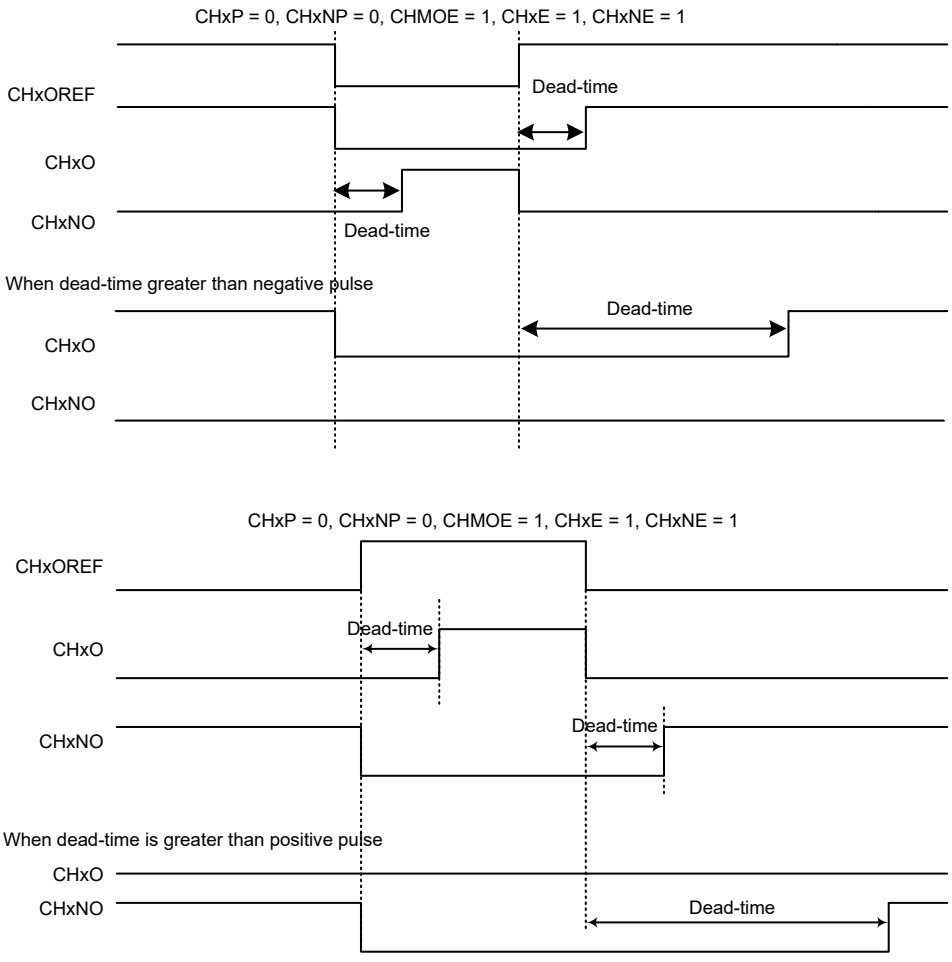


Figure 120. Dead-time Insertion Performed for Complementary Outputs

If the delay is greater than the width of the active output of CHxO or CHxNO, then the corresponding PWM pulses will not be generated.

Break Function

The MCTM includes break function and one input signal for MCTM break. The MT_BRK is default function and from the external MT_BRK pin. The detailed block diagram is shown as below.

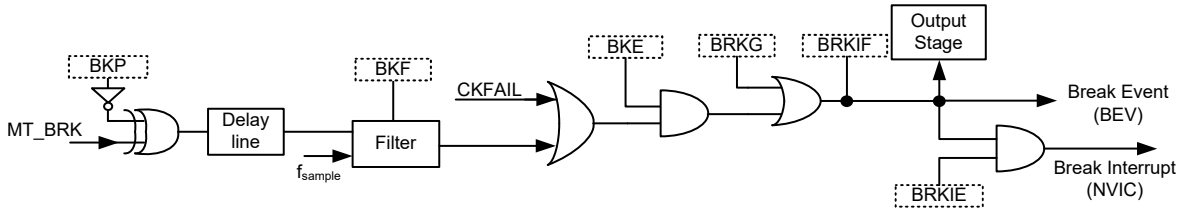


Figure 121. MCTM Break Signal Bolck Diagram

When the MT_BRK input has an active level or the Clock Monitor Circuitry detects a clock failure event, a break event will be generated if the break function is enabled. Meanwhile, each channel output will be forced to a reset state, an inactive or idle state. Moreover, a break event can also be generated by the software asserting the BRKG bit in the EVGR register even if the break function is disabled.

The MT_BRK input signal can be enabled by setting the BKE bit in the CHBRKCTR register. The internal polarity of break activity function is logic high. So the break input polarity can be selected by setting the BKP bit in CHBRKCTR register. The BKE and BKP bits can be modified at the same time.

The digital filters are embedded in the input stage and clock controller block for the break signal. The input filter of the MT_BRK signal can be enabled by setting the BKF bits in the CHBRKCTR register. The digital filter is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal.

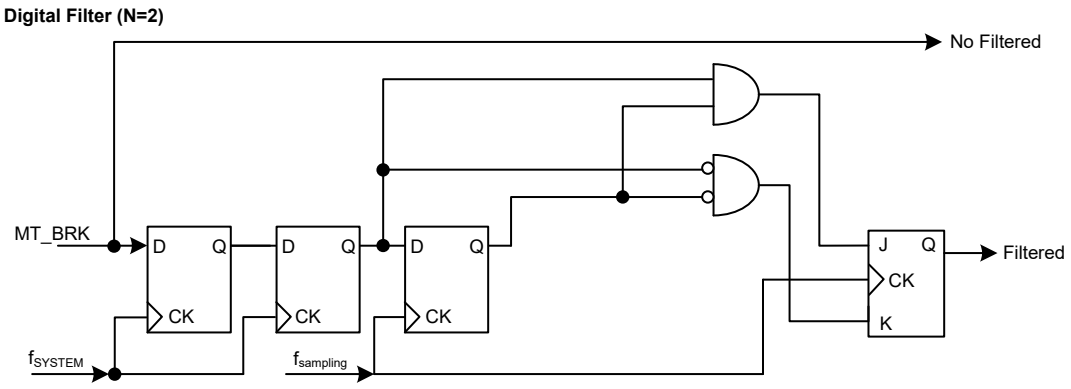


Figure 122. MT_BRK Pin Digital Filter Diagram with N = 2

When using the break function, the channel output enable signals and output levels are changed depending on several control bits which include the CHMOE, CHOSSI, CHOSSR, CHxOIS and CHxOISN bits. Once a break event occurs, the output enable bit CHMOE will be cleared asynchronously. The break interrupt flag, BRKIF, will be set and then an interrupt will be generated if the break function interrupt is enabled by setting the BRKIE bit to 1. The channel output behavior is as described below:

- If complementary outputs are used, the channel outputs a level signal first which can be selected to be either a disable or inactive level, selected by configuring the CHOSSI bit in the CHBRKCTR register. After the dead-time duration, the outputs will be changed to the idle state. The idle state is determined by the CHxOIS/CHxOISN bits in the CHBRKCFR register.
- If complementary outputs are not used (Channel 3), the channel will output an idle state.

The main output enable control bit CHMOE can not be set until the break event is cleared.

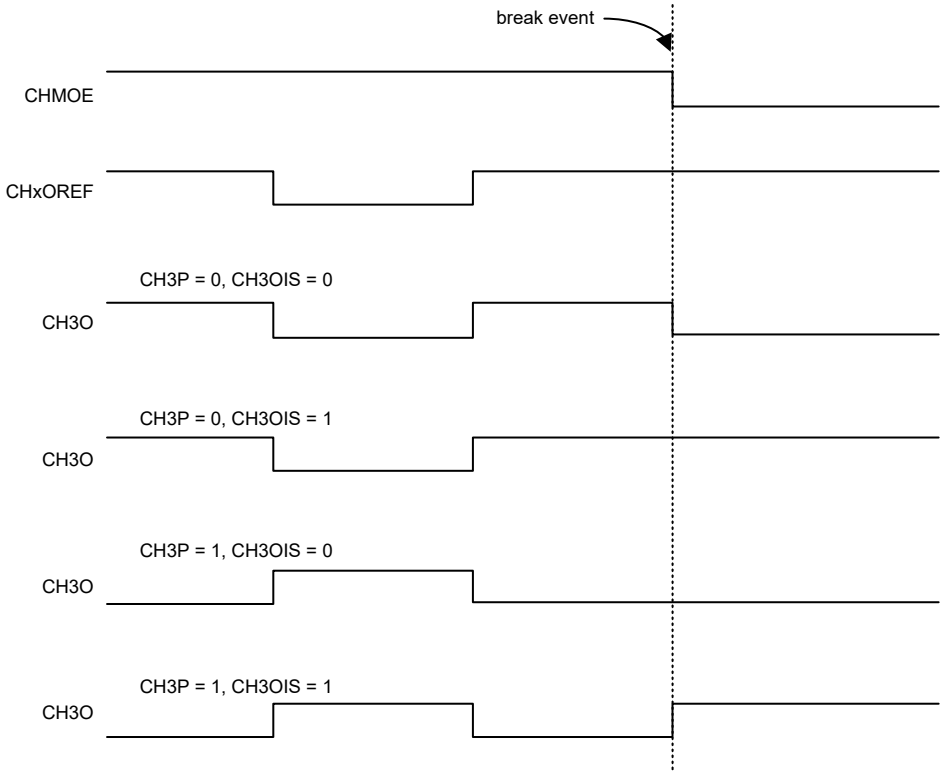


Figure 123. Channel 3 Output with a Break Event Occurrence

The accompanying diagram shows that the complementary output states when a break event occurs where the complementary outputs are enabled by setting both the CHxE and CHxNE bits to 1.

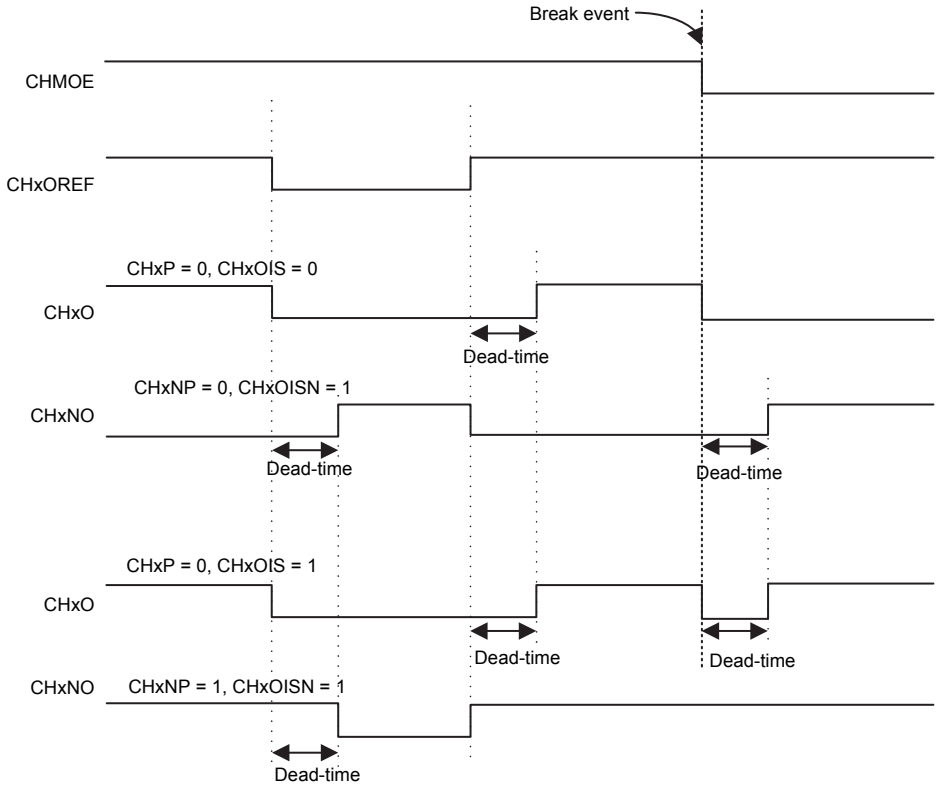


Figure 124. Channel 0 ~ 2 Complementary Outputs with a Break Event Occurrence

The accompanying diagram shows the output states in the case of the output being enabled by setting the CHxE bit to 1 and the complementary output being disabled by clearing the CHxNE to 0 when a break event occurs.

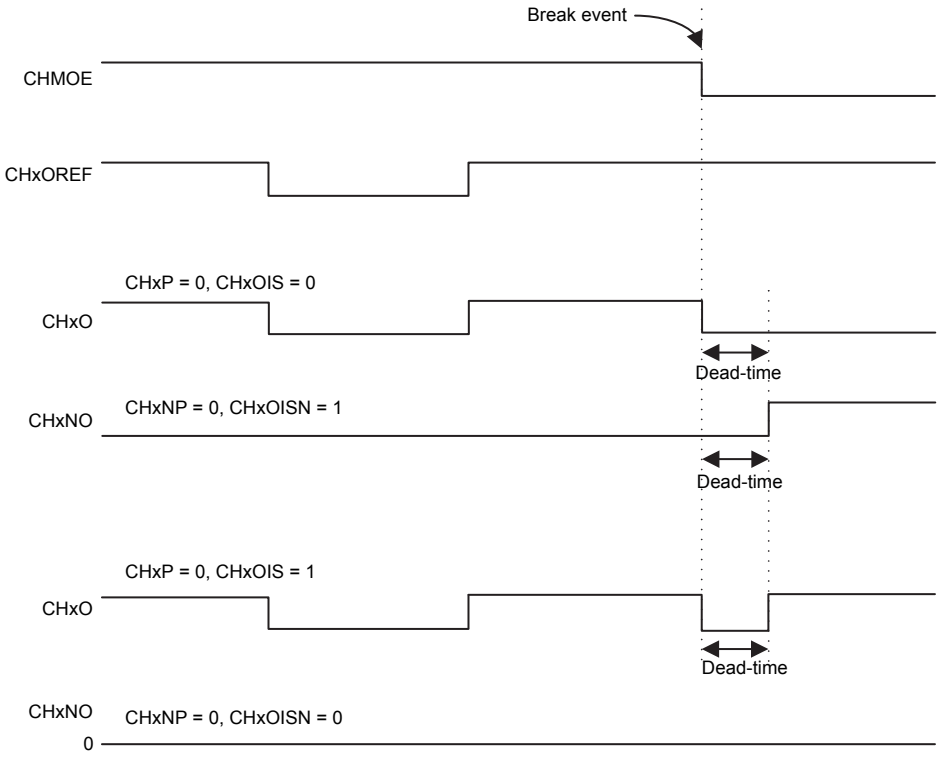


Figure 125. Channel 0 ~ 2 Only One Output Enabled when Break Event Occurs

The CHxO and CHxNO complementary outputs should not be set to an active level at the same time. The hardware will protect the MCTM circuitry to force only one channel output to be in the active state.

Example: Both CHxOIS and CHxOISN are set to active levels after a break event; only the CHxO waveform is generated.

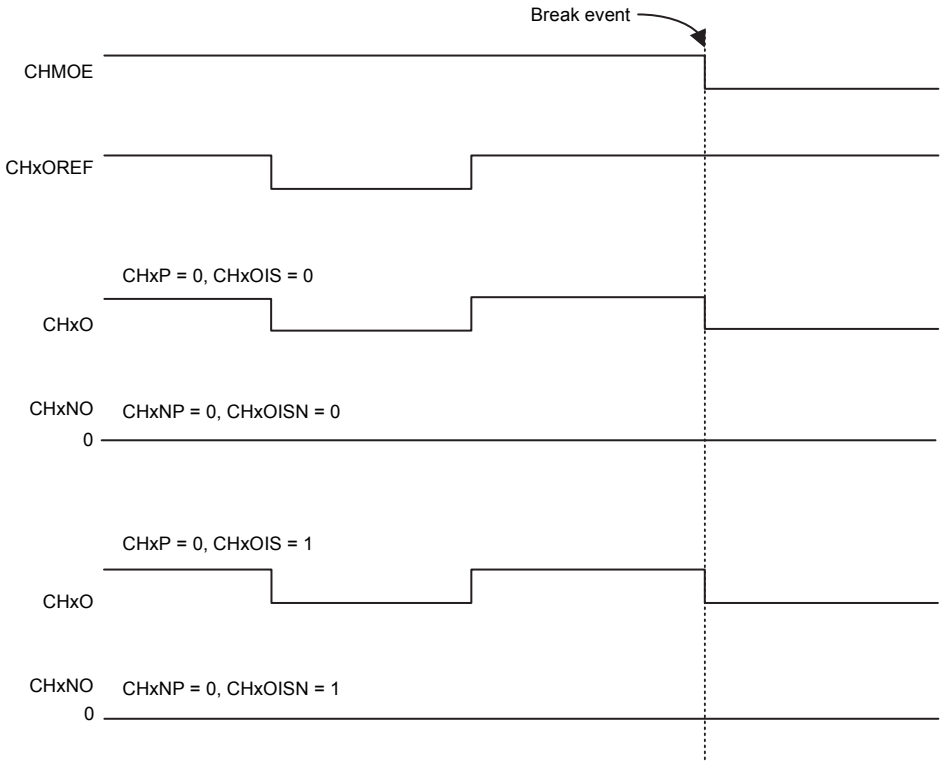


Figure 126. Hardware Protection When Both CHxO and CHxNO are in Active Condition

CHMOE can be set automatically by update event 1 if the automatic output enable function is enabled by setting the CHAOE bit in the CHBRKCTR register to 1.

Channel Complementary Output with Break Function

The Channel complementary outputs, CHxO and CHxNO, are enabled by a combination of the CHxE, CHxNE, CHMOE, CHOSSR, CHOSSI control bits.

Table 35. Output Control Bits for Complementary Output with a Break Event Occurrence

Control bit					Output status	
CHMOE	CHOSSI	CHOSSR	CHxE	CHxNE	MT_CHx Pin output state	MT_CHxN Pin output state
1 (Run)	x	0	0	0	Output disabled – floating - not driven by the timer MT_CHx (Note 1) = floating MT_CHx_OEN (Note 2) = 1	Output disabled – floating - not driven by the timer MT_CHxN = floating MT_CHxN_OEN = 1
		0	0	1	Output disable – floating - not driven by the timer MT_CHx_OEN = 1	Output enbaled MT_CHxN = CHx_OREF xor CHxNP MT_CHxN_OEN = 0
		0	1	0	Output enabled MT_CHx = CHx_OREF xor CHxP MT_CHx_OEN = 0	Output disabled – floating - not driven by the timer MT_CHxN = floating MT_CHxN_OEN = 1
		0	1	1	Output enabled MT_CHx = CHx_OREF xor CHxP + dead-time MT_CHx_OEN = 0	Output enabled MT_CHxN = not CHx_OREF xor CHxNP + dead-time MT_CHxN_OEN = 0
		1	0	0	Output disabled – floating - not driven by the timer MT_CHx = floating MT_CHx_OEN = 1	Output disabled – floating - not driven by the timer MT_CHxN = floating MT_CHxN_OEN = 1
		1	0	1	Off-State MT_CHx = CHxP MT_CHx_OEN = 0	Output enabled MT_CHxN = CHx_OREF xor CHxNP MT_CHxN_OEN = 0
		1	1	0	Output enbaled MT_CHx = CHx_OCREF xor CHxP MT_CHx_OEN = 0	Off-State MT_CHxN = CHxNP MT_CHxN_OEN = 0
		1	1	1	Output enabled MT_CHx = CHx_OREF xor CHxP + dead-time MT_CHx_OEN = 0	Output enabled MT_CHxN = not CHx_OREF xor CHxNP + dead-time MT_CHxN_OEN = 0
0 (Idle)	0	x	0	0	Before dead-time: Output disabled – floating MT_CHx = floating, MT_CHxN = floating MT_CHx_OEN = 1, MT_CHxN_OEN = 1	
	0		0	1		
	0		1	0		
	0		1	1		
	1		0	0		
	1		0	1	Before dead-time: Off state MT_CHx = CHxP, MT_CHxN = CHxNP MT_CHx_OEN = 0, MT_CHxN_OEN = 0 After dead-time: Output enabled MT_CHx = CHxOIS, MT_CHxN = CHxOISN MT_CHx_OEN = 0, MT_CHxN_OEN = 0	
	1		1	0		
	1		1	1		

Notes: 1. The MT_CHx pin is the MCTM I/O Pin.

2. The MT_CHx_OEN and MT_CHxN_OEN signals are the MCTM I/O pin output enable combinational logic control signals which are active low.

Update Management

The update events are categorised into two different types which are the update event 1, UEV1, and update event 2, UEV2. The update event 1 is used to update the CRR, the PSCR, the CHxACR and the CHxCCR values from the actual registers to the corresponding shadow registers. An update event 1 occurs when the counter overflows or underflows, the UEV1G bit is set or the slave restart mode is triggered. The update event 2 is used to update the CHxE, CHxNE and CHxOM control bits. An update event 2 is generated when a rising edge on the STI occurs or the corresponding software update control bit is set.

Update Event 1

The UEV1DIS bit in the CNTCFR register can determine whether an update event 1 occurs or not. When the update event 1 occurs, the corresponding update event interrupt will be generated depending upon whether the update event 1 interrupt generation function is enabled or not by configuring the UGDIS bit in the CNTCFR register. For a more detailed description, refer to the UEV1DIS and UGDIS bit definition in the CNTCFR register.

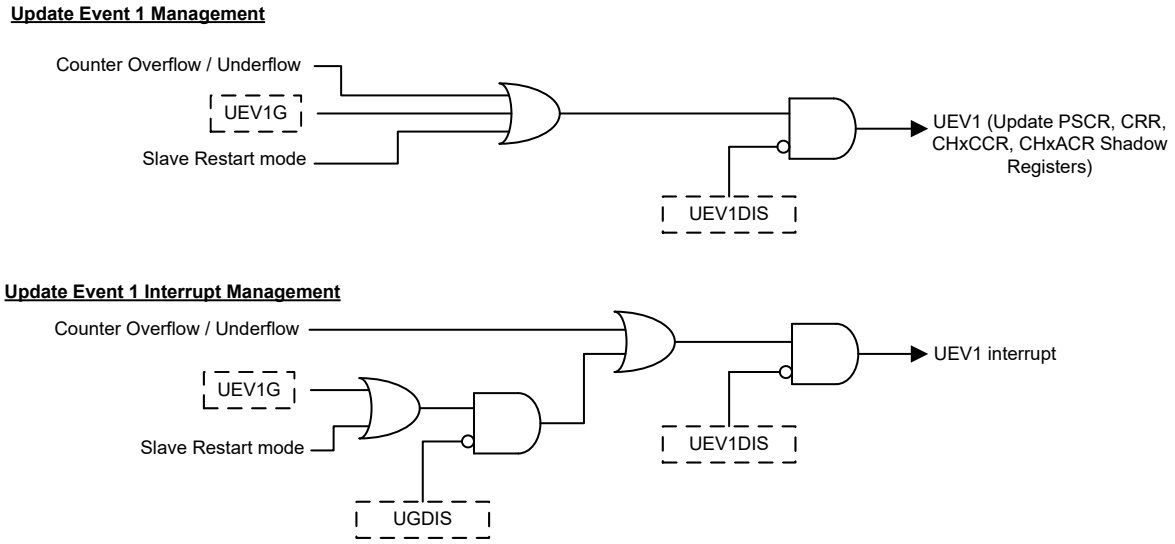


Figure 127. Update Event 1 Setup Diagram

Update Event 2

The CHxE, CHxNE, CHxOM control bits for the complementary outputs can be preloaded by setting the COMPRE bit in the CTR register. Here the shadow bits of the CHxE, CHxNE, and CHxOM bits will be updated when an update event 2 occurs.

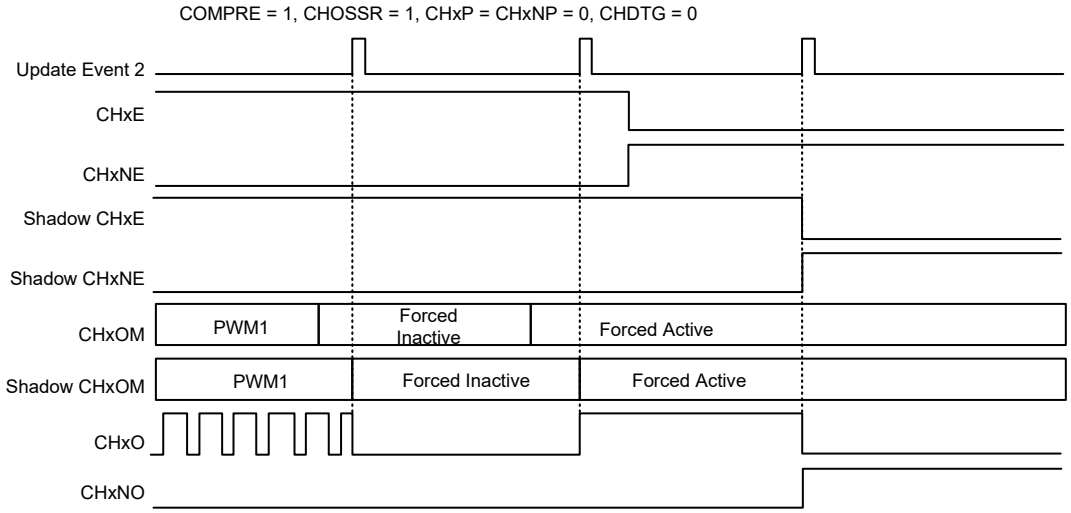


Figure 128. CHxE, CHxNE and CHxOM Updated by Update Event 2

An update event 2 can be generated by setting the software update bit, UEV2G, in the EVGR register or by the rising edge of the STI signal if the COMUS bit is set in the CTR register.

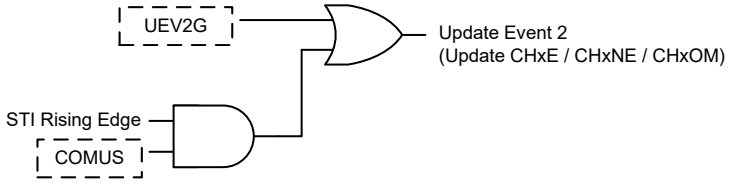


Figure 129. Update Event 2 Setup Diagram

Single Pulse Mode

Once the timer is set to operate in the single pulse mode, it is not necessary to set the timer enable bit TME in the CTR register to 1 to enable the counter. The trigger to generate a pulse can be sourced from the STI signal rising edge or by setting the TME bit to 1 using software. Setting the TME bit to 1 or a trigger from the STI signal rising edge can generate a pulse and then keep the TME bit at a high state until the update event 1 occurs or the TME bit is cleared to 0 by software. If the TME bit is cleared to 0 using software, the counter will be stopped and its value held. If the TME bit is automatically cleared to 0 by a hardware update event 1, the counter will be reinitialised.

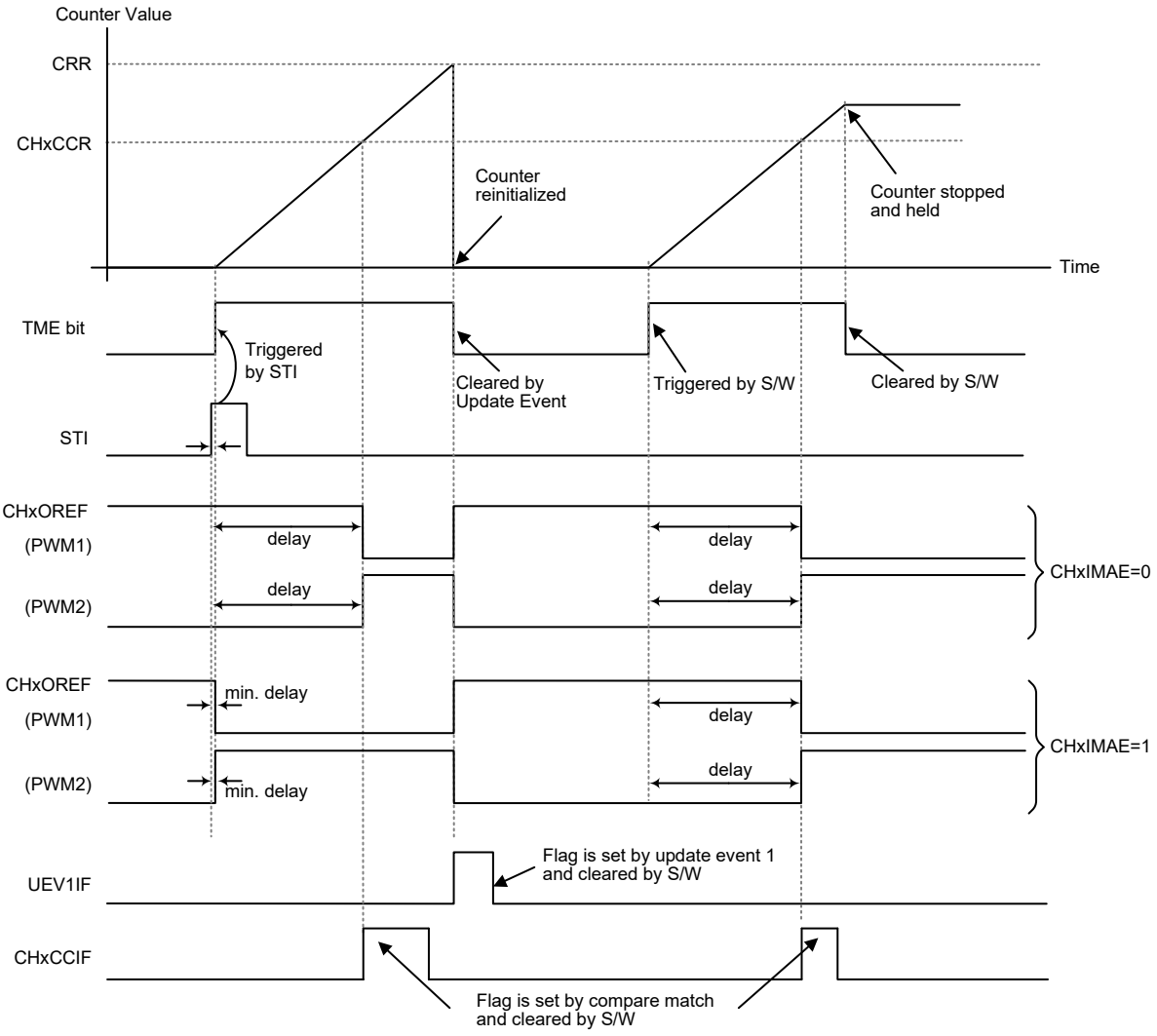


Figure 130. Single Pulse Mode

In the Single Pulse mode, the STI active edge which sets the TME bit to 1 will enable the counter. However, there exist several clock delays to perform the comparison result between the counter value and the CHxCCR value. In order to reduce the delay to a minimum value, users can set the CHxIMAE bit in each CHxOCFR register. After an STI rising edge trigger occurs in the single pulse mode, the CHxOREF signal will immediately be forced to the state to which the CHxOREF signal will change to as the compare match event occurs without taking the comparison result into account. The CHxIMAE bit is available only when the output channel is configured to operate in the PWM mode 1 or PWM mode 2 and the trigger source is derived from the STI signal.

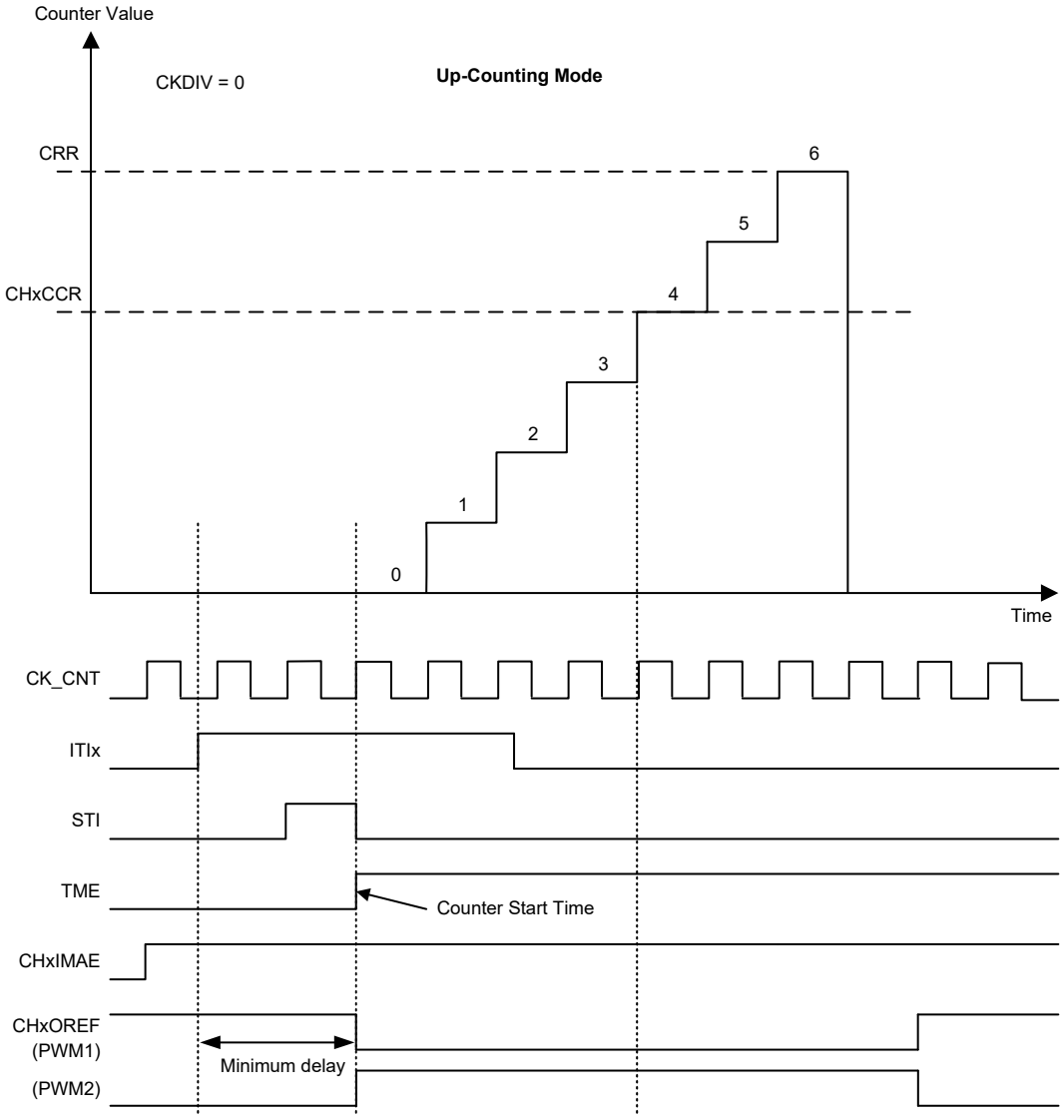


Figure 131. Immediate Active Mode Minimum Delay

Asymmetric PWM Mode

Asymmetric PWM mode allows two center-aligned PWM signals to be genetated with a programmable phase shift. While the PWM frequency is determined by the value of the CRR register, the duty cycle and the phase-shift are determined by the CHxCCR and CHxACR register. When the counter is counting up, the PWM uses the value in CHxCCR as up-count compare value. When the counter is into the counting down stage, the PWM uses the value in CHxACR as down-count compare value. The figure 132 is shown as an example for asymmetric PWM mode in Center-aligned Counting mode.

Note: Asymmetric PWM mode can only be operated in Center-aligned Counting mode.

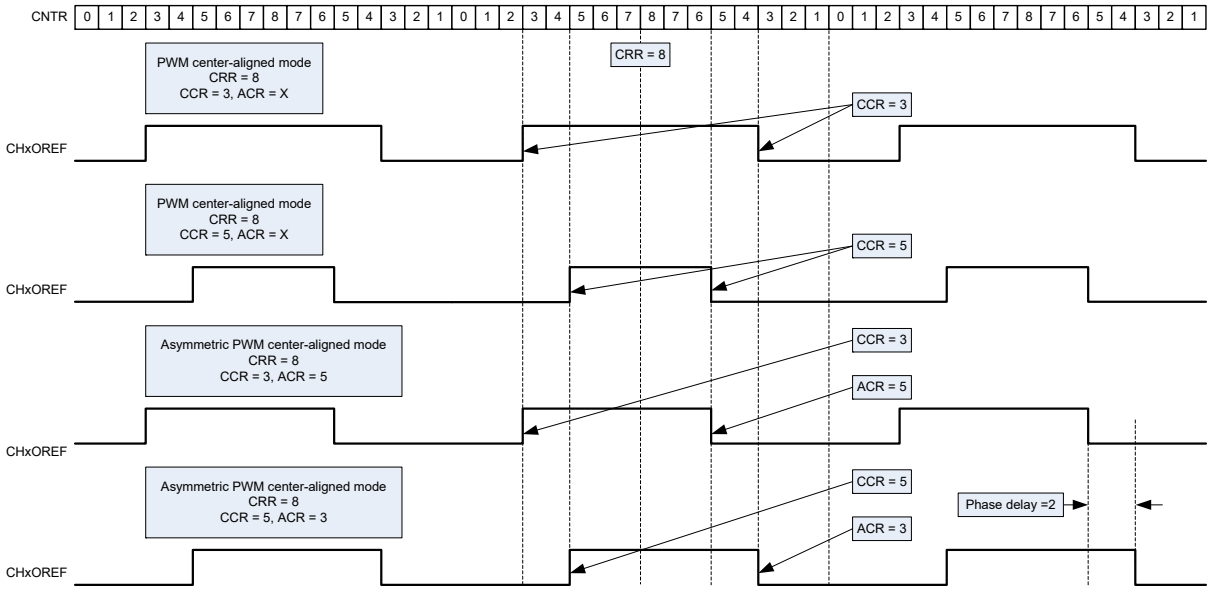


Figure 132. Asymmetric PWM Mode versus Center-aligned Counting Mode

Timer Interconnection

The timers can be internally connected together for timer chaining or synchronization. This can be implemented by configuring one timer to operate in the master mode while configuring another timer to be in the slave mode. The following figures present several examples of trigger selection for the master and slave modes.

Using One Timer to Trigger Another Timer to Start or Stop Counting

- Configure MCTM to be in the master mode and to send its channel 0 Output Reference signal CH0OREF as a trigger output (MMSEL = 0x4).
- Configure the MCTM CH0OREF waveform.
- Configure the GPTM to receive its input trigger source from the MCTM trigger output (TRSEL = 0xA).
- Configure GPTM to operate in the pause mode (SMSEL = 0x5).
- Enable GPTM by writing '1' to the TME bit.
- Enable MCTM by writing '1' to the TME bit.

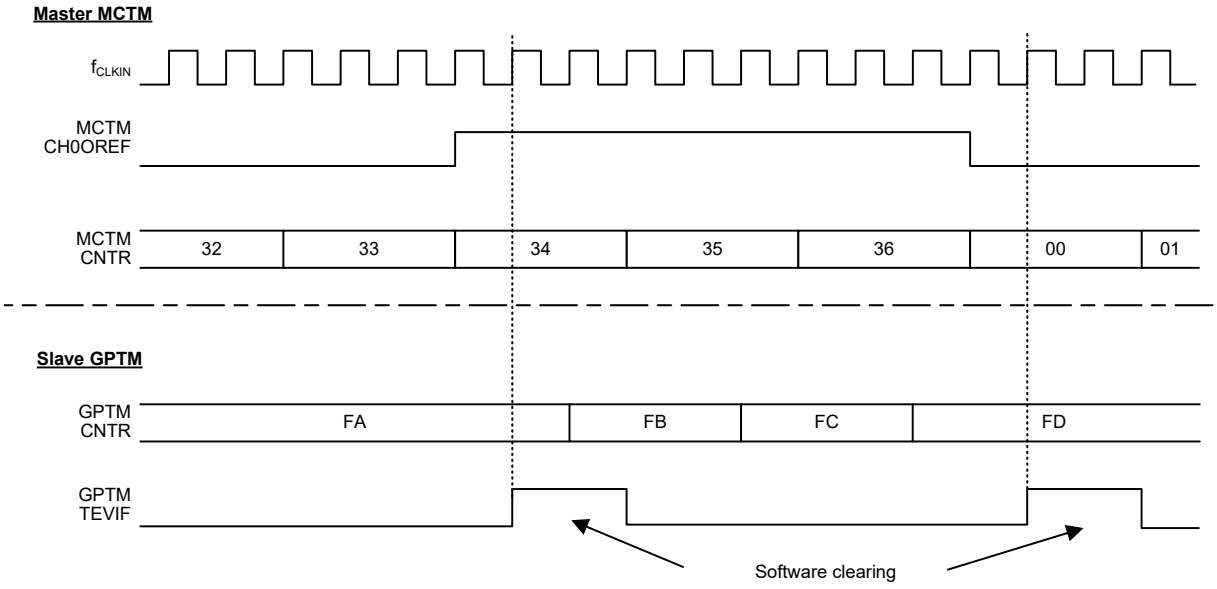


Figure 133. Pausing GPTM using the MCTM CH0OREF Signal

Using One Timer to Trigger Another Timer to Start Counting

- Configure MCTM to operate in the master mode and to send its Update Event UEV as the trigger output (MMSEL = 0x2).
- Configure the MCTM period by setting the CRR register.
- Configure GPTM to get the input trigger source from the MCTM trigger output (TRSEL = 0xA).
- Configure GPTM to be in the slave trigger mode (SMSEL = 0x6).
- Start MCTM by writing '1' to the TME bit.

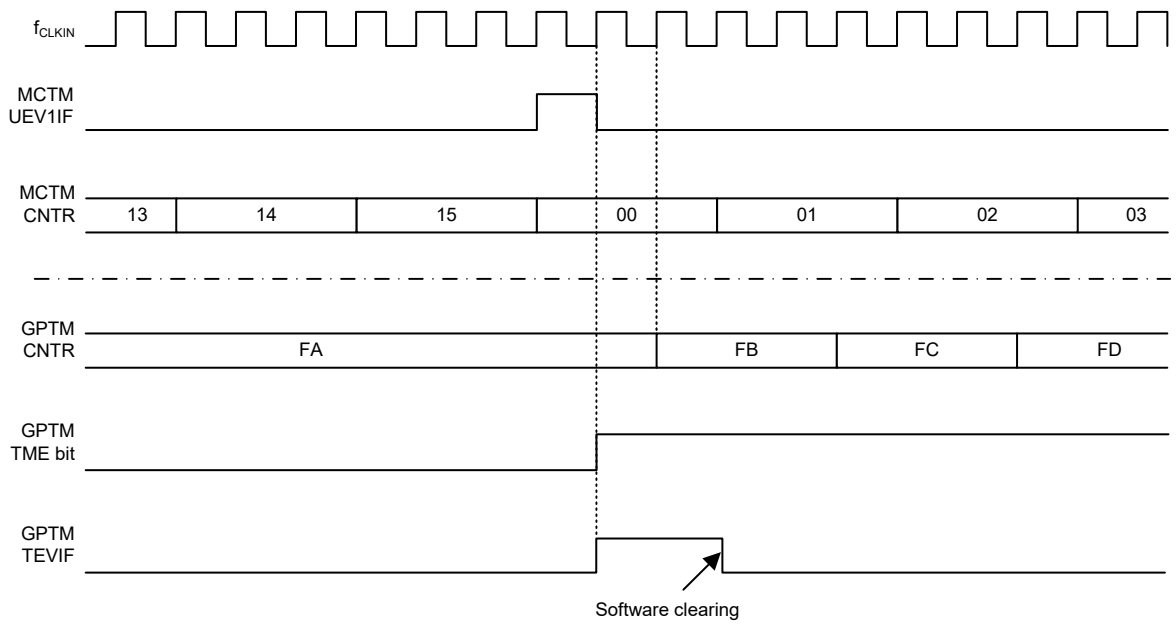


Figure 134. Triggering GPTM with MCTM Update Event 1

Starting Two Timers Synchronously in Response to an External Trigger

- Configure MCTM to operate in the master mode to send its enable signal as a trigger output (MMSEL = 0x1).
- Configure MCTM slave mode to receive its input trigger source from MT_CH0 pin (TRSEL = 0x1).
- Configure MCTM to be in the slave trigger mode (SMSEL = 0x6).
- Enable the MCTM master timer synchronisation function by setting the TSE bit in the MDCFR register to 1 to synchronise the slave timer.
- Configure GPTM to receive its input trigger source from the MCTM trigger output (TRSEL = 0xA).
- Configure GPTM to be in the slave trigger mode (SMSEL = 0x6).

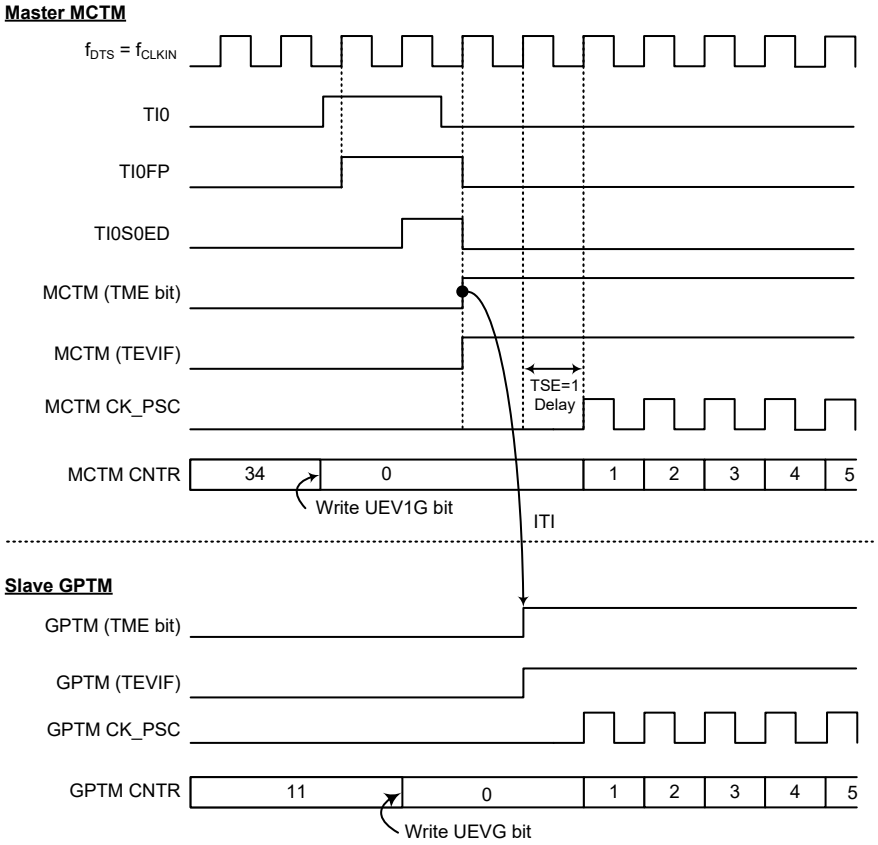


Figure 135. Trigger MCTM and GPTM with the MCTM CH0 Input

Using One Timer as a Hall Sensor Interface to Trigger Another Timer with Update Event 2

GPTM

- Configure channel 0 to choose an input XOR function (TI0SRC = 1)
- Configure channel 0 to be in the input capture mode and TRCED as capture source (CH0CCS = 0x3) and Enable channel 0 (CH0E = 1)
- Configure the UEVG bit as the source of MTO (MMSEL = 0x0)
- Configure TI0BED to be connected to STI (TRSEL = 0x8)
- Configure the counter to be in the slave restart mode (SMSEL = 0x4)
- Enable GPTM (TME = 1)

MCTM

- Select GPTM MTO to be the STI source of MCTM (TRSEL = 0xA)
- Enable the CHxE, CHxNE and CHxOM preload function (COMPRE = 1)
- Select the rising edge on STI to generate an update event 2 (COMUS = 1)
- Enable the update event 2 interrupt (UEV2IE = 1)
- In the update event 2 ISR: write CHxE, CHxNE and CHxOM register for the next step

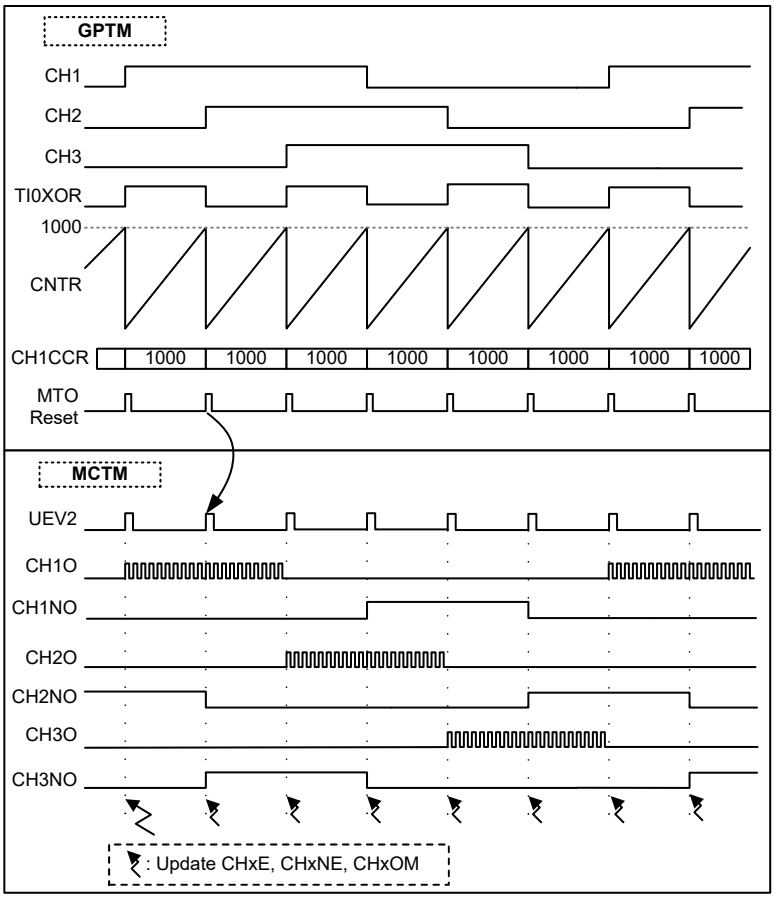


Figure 136. CH1XOR Input as Hall Sensor Interface

Trigger Peripherals Start

To interconnect to the peripherals, such as ADC, Timer and so on, the MCTM could output the MTO signal or the channel compare match output signal CHxOREF (x = 0 ~ 3) to be used as peripherals input trigger signal, depending on the MCU specification.

Lock Level Table

In addition to the break input and output management, a write protection has been internally implemented in the break circuitry to safeguard the application. Users can choose one protection level selected by the LOCKLV bits to protect the relative control bits of the registers. The LOCKLV bits can only be written once after an MCTM or system reset. Then the protected bits will be locked and can not be changed anymore except by the MCTM reset or when the system is reset.

Table 36. Lock Level Table

Lock Configuration	Protected Bits					
Lock Level 1 (LOCKLV = '01')	CHDTG	CHxOIS	CHxOISN	BKE	BKP	CHAOE
Lock Level 2 (LOCKLV = '10')	CHDTG	CHxOIS	CHxOISN	BKE	BKP	CHAOE
	CHxP	CHxNP	CHOSSI	CHOSSR	MCTMEN(1)	CKMEN(2)
Lock Level 3 (LOCKLV = '11')	CHDTG	CHxOIS	CHxOISN	BKE	BKP	CHAOE
	CHxP	CHxNP	CHOSSI	CHOSSR	MCTMEN(1)	CKMEN(2)
	CHxPRE	CHxOM				

Notes: 1. The MCTMEN bit of the APBCCR1 register is located in the CKCU unit and use to control the clock source of the MCTM unit.
2. The CKMEN bit of the GCCR register is located in the CKCU unit and use to monitor the high speed external clock (HSE) source. If the CKMEN bit is enabled and when hardware detects HSE clock stuck at low/high state, internal hardware will automatically switch the system clock to internal high speed RC clock (HSI) to protect the system safety.
3. When the MCTMEN and CKMEN control bits of the CKCU lock protection mode is enabled in the MCTM unit, the bits will be allowed to enable only and inhibited to disable again.

Register Map

The following table shows the MCTM registers and reset values.

Table 37. MCTM Register Map

Register	Offset	Description	Reset Value
CNTCFR	0x000	Timer Counter Configuration Register	0x0000_0000
MDCFR	0x004	Timer Mode Configuration Register	0x0000_0000
TRCFR	0x008	Timer Trigger Configuration Register	0x0000_0000
CTR	0x010	Timer Control Register	0x0000_0000
CH0ICFR	0x020	Channel 0 Input Configuration Register	0x0000_0000
CH1ICFR	0x024	Channel 1 Input Configuration Register	0x0000_0000
CH2ICFR	0x028	Channel 2 Input Configuration Register	0x0000_0000
CH3ICFR	0x02C	Channel 3 Input Configuration Register	0x0000_0000
CH0OCFR	0x040	Channel 0 Output Configuration Register	0x0000_0000
CH1OCFR	0x044	Channel 1 Output Configuration Register	0x0000_0000
CH2OCFR	0x048	Channel 2 Output Configuration Register	0x0000_0000
CH3OCFR	0x04C	Channel 3 Output Configuration Register	0x0000_0000
CHCTR	0x050	Channel Control Register	0x0000_0000
CHPOLR	0x054	Channel Polarity Configuration Register	0x0000_0000

Register	Offset	Description	Reset Value
CHBRKCFR	0x06C	Channel Break Configuration Register	0x0000_0000
CHBRKCTR	0x070	Channel Break Control Register	0x0000_0002
DICTR	0x074	Timer Interrupt Control Register	0x0000_0000
EVGR	0x078	Timer Event Generator Register	0x0000_0000
INTSR	0x07C	Timer Interrupt Status Register	0x0000_0000
CNTR	0x080	Timer Counter Register	0x0000_0000
PSCR	0x084	Timer Prescaler Register	0x0000_0000
CRR	0x088	Timer Counter Reload Register	0x0000_FFFF
REPR	0x08C	Timer Repetition Register	0x0000_0000
CH0CCR	0x090	Channel 0 Capture/Compare Register	0x0000_0000
CH1CCR	0x094	Channel 1 Capture/Compare Register	0x0000_0000
CH2CCR	0x098	Channel 2 Capture/Compare Register	0x0000_0000
CH3CCR	0x09C	Channel 3 Capture/Compare Register	0x0000_0000
CH0ACR	0x0A0	Channel 0 Asymmetric Compare Register	0x0000_0000
CH1ACR	0x0A4	Channel 1 Asymmetric Compare Register	0x0000_0000
CH2ACR	0x0A8	Channel 2 Asymmetric Compare Register	0x0000_0000
CH3ACR	0x0AC	Channel 3 Asymmetric Compare Register	0x0000_0000

Register Descriptions

Timer Counter Configuration Register – CNTCFR

This register specifies the MCTM counter configuration.

Offset: 0x000
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							DIR
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved							CMSEL
Type/Reset							RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							CKDIV
Type/Reset							RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved						UGDIS	UEV1DIS
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[24]	DIR	Counting Direction 0: Count-up 1: Count-down Note: This bit is read only when the Timer is configured to be in the Center-aligned counting mode.

Bits	Field	Descriptions
[17:16]	CMSEL	Counter Mode Selection 00: Edge-aligned counting mode. Normal up-counting and down-counting available for this mode. Counting direction is defined by the DIR bit. 01: Center-aligned counting mode 1. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-down period. 10: Center-aligned counting mode 2. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up period. 11: Center-aligned counting mode 3. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up and count-down period.
[9:8]	CKDIV	Clock Division These two bits define the frequency ratio between the timer clock (f_{CLKIN}) and the dead-time clock (f_{DTS}). The dead-time clock is also used as the digital filter sampling clock 00: $f_{DTS} = f_{CLKIN}$ 01: $f_{DTS} = f_{CLKIN} / 2$ 10: $f_{DTS} = f_{CLKIN} / 4$ 11: Reserved
[1]	UGDIS	Update event 1 interrupt generation disable control 0: Any of the following events will generate an update interrupt - Counter overflow / underflow - Setting the UEV1G bit - Update generation through the slave mode 1: Only counter overflow/underflow generates an update interrupt
[0]	UEV1DIS	Update event 1 Disable control 0: Enable the update event 1 request by one of following events - Counter overflow / underflow - Setting the UEV1G bit - Update generation through the slave mode 1: Disable the update event 1 (However the counter and the prescaler are reinitialised if the UEV1G bit is set or if a hardware restart is received from the slave mode)

Timer Mode Configuration Register – MDCFR

This register specifies the MCTM master and slave mode selection and single pulse mode.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							SPMSET
Type/Reset								RW 0
	23	22	21	20	19	18	17	16
	Reserved					MMSEL		
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved					SMSEL		
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved							TSE
Type/Reset								RW 0

Bits	Field	Descriptions
[24]	SPMSET	Single Pulse Mode Setting 0: Counter counts normally irrespective of whether a update event occurred or not 1: Counter stops counting at the next update event and then the TME bit is cleared by hardware

Bits	Field	Descriptions
[18:16]	MMSEL	Master Mode Selection Master mode selection is used to select the MTO signal source which is used to synchronize the other slave timer.

MMSEL [2:0]	Mode	Descriptions
000	Reset Mode	The MTO in the Reset mode is an output derived from one of the following cases: Software setting UEV1G bit Slave has trigger input when used in slave restart mode
001	Enable Mode	The Counter Enable signal is used as the trigger output.
010	Update Mode	The update event 1 is used as the trigger output according to one of the following cases when the UEV1DIS bit is cleared to 0: Counter overflow/underflow Software setting UEV1G Slave has trigger input when used in slave restart mode
011	Capture/Compare Mode	When a Channel 0 capture or compare match event occurs, it will generate a positive pulse which is used as the master trigger output.
100	Compare output 0	The Channel 0 Output reference signal named CH0OREF is used as the trigger output.
101	Compare output 1	The Channel 1 Output reference signal named CH1OREF is used as the trigger output.
110	Compare output 2	The Channel 2 Output reference signal named CH2OREF is used as the trigger output.
111	Compare output 3	The Channel 3 Output reference signal named CH3OREF is used as the trigger output.

<table>
<tr><th>Bits</th><th>Field</th><th>Descriptions</th></tr>
<tr><td>[10:8]</td><td>SMSEL</td><td>Slave Mode Selection
<table>
<tr><th>SMSEL [2:0]</th><th>Mode</th><th>Descriptions</th></tr>
<tr><td>000</td><td>Disable mode</td><td>The prescaler is clocked directly by the internal clock.</td></tr>
<tr><td>001</td><td>Reserved</td><td></td></tr>
<tr><td>010</td><td>Reserved</td><td></td></tr>
<tr><td>011</td><td>Reserved</td><td></td></tr>
<tr><td>100</td><td>Restart Mode</td><td>The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.</td></tr>
<tr><td>101</td><td>Pause Mode</td><td>The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal.</td></tr>
<tr><td>110</td><td>Trigger Mode</td><td>The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the start of counter is controlled.</td></tr>
<tr><td>111</td><td>STIED</td><td>The rising edge of the selected trigger signal STI will be the counter clock.</td></tr>
</table></td></tr>
<tr><td>[0]</td><td>TSE</td><td>Timer Synchronisation Enable
0: No action
1: Master timer (current timer) will generate a delay to synchronise its slave timer through the MTO signal.</td></tr>
</table>

Timer Trigger Configuration Register – TRCFR

This register specifies the trigger source selection of MCTM.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TRSEL			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[3:0]	TRSEL	Trigger Source Selection These bits are used to select the trigger input (STI) for counter synchronization. 0000: Software Trigger by setting the UEV1G bit 0001: Channel 0 filtered input – TI0S0 0010: Channel 1 filtered input – TI1S1 0011: Reserved 1000: Channel 0 Edge Detector – TI0BED 1001: Internal Timer Trigger 0 – ITI0 1010: Internal Timer Trigger 1 – ITI1 1011: Internal Timer Trigger 2 – ITI2 Others: Reserved Note: These bits must be updated only when they are not in use, i.e. the slave mode is disabled by setting the SMSEL field to 0x0.

Table 38. MCTM Internal Trigger Connection

Slave Timing Module	ITI0	ITI1	ITI2
MCTM	PWM0	GPTM	PWM1

Timer Control Register – CTR

This register specifies the timer enable bit (TME), CRR buffer enable bit (CRBE) and Capture/compare control bit.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved						COMUS	COMPRE
Type/Reset							RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved						CRBE	TME
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[9]	COMUS	Capture/Compare Control Update Selection 0: Updated by setting the UEV2G bit only 1: Updated by setting the UEV2G bit or when an STI signal rising edge occurs This bit is only available when the capture/compare preload function is enabled by setting the COMPRE bit to 1.
[8]	COMPRE	Capture/Compare Preload Enable Control 0: CHxE, CHxNE and CHxOM bits are not preloaded 1: CHxE, CHxNE and CHxOM bits are preloaded If this bit is set to 1, the corresponding capture/compare control bits including the CHxE, CHxNE and CHxOM bits will be updated when the update event 2 occurs.
[1]	CRBE	Counter Reload register Buffer Enable 0: Counter reload register can be updated immediately 1: Counter reload register can not be updated until the update event occurs
[0]	TME	Timer Enable bit 0: MCTM off 1: MCTM on – MCTM functions normally When the TME bit is cleared to 0, the counter is stopped and the MCTM consumes no power in any operational mode except for the single pulse mode and the slave trigger mode. In these two modes the TME bit can automatically be set to 1 by hardware which permits all the MCTM registers to function normally.

Channel 0 Input Configuration Register – CH0ICFR

This register specifies the channel 0 input mode configuration.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	TI0SRC	Reserved						
Type/Reset	RW 0							
	23	22	21	20	19	18	17	16
	Reserved				CH0PSC		CH0CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI0F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31]	TI0SRC	Channel 0 Input Source TI0 Selection 0: The MT_CH0 pin is connected to the channel 0 input TI0 1: The XOR operation output of the MT_CH0, MT_CH1, and MT_CH2 pins are connected to the channel 0 input TI0
[19:18]	CH0PSC	Channel 0 Capture Input Source Prescaler Setting These bits define the effective events of the channel 0 capture input. Note that the prescaler is reset once the Channel 0 Capture/Compare Enable bit, CH0E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 0 capture input signal is chosen for each active event 01: Channel 0 Capture input signal is chosen for every 2 events 10: Channel 0 Capture input signal is chosen for every 4 events 11: Channel 0 Capture input signal is chosen for every 8 events
[17:16]	CH0CCS	Channel 0 Capture/Compare Selection 00: Channel 0 is configured as an output 01: Channel 0 is configured as an input derived from the TI0 signal 10: Channel 0 is configured as an input derived from the TI1 signal 11: Channel 0 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH0CCS field can be accessed only when the CH0E bit is cleared to 0.

Bits	Field	Descriptions
[3:0]	TI0F	Channel 0 Input Source TI0 Filter Setting These bits define the frequency divided ratio used to sample the TI0 signal. The Digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS} / 2$, N = 6 0101: $f_{sampling} = f_{DTS} / 2$, N = 8 0110: $f_{sampling} = f_{DTS} / 4$, N = 6 0111: $f_{sampling} = f_{DTS} / 4$, N = 8 1000: $f_{sampling} = f_{DTS} / 8$, N = 6 1001: $f_{sampling} = f_{DTS} / 8$, N = 8 1010: $f_{sampling} = f_{DTS} / 16$, N = 5 1011: $f_{sampling} = f_{DTS} / 16$, N = 6 1100: $f_{sampling} = f_{DTS} / 16$, N = 8 1101: $f_{sampling} = f_{DTS} / 32$, N = 5 1110: $f_{sampling} = f_{DTS} / 32$, N = 6 1111: $f_{sampling} = f_{DTS} / 32$, N = 8

Channel 1 Input Configuration Register – CH1ICFR

This register specifies the channel 1 input mode configuration.

Offset: 0x024

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				CH1PSC		CH1CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI1F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[19:18]	CH1PSC	Channel 1 Capture Input Source Prescaler Setting These bits define the effective events of the channel 1 capture input. Note that the prescaler is reset once the Channel 1 Capture/Compare Enable bit, CH1E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 1 capture input signal is chosen for each active event 01: Channel 1 Capture input signal is chosen for every 2 events 10: Channel 1 Capture input signal is chosen for every 4 events 11: Channel 1 Capture input signal is chosen for every 8 events
[17:16]	CH1CCS	Channel 1 Capture/Compare Selection 00: Channel 1 is configured as an output 01: Channel 1 is configured as an input derived from the TI1 signal 10: Channel 1 is configured as an input derived from the TI0 signal 11: Channel 1 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH1CCS field can be accessed only when the CH1E bit is cleared to 0.
[3:0]	TI1F	Channel 1 Input Source TI1 Filter Setting These bits define the frequency divide ratio used to sample the TI1 signal. The Digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS}$ / 2, N = 6 0101: $f_{sampling} = f_{DTS}$ / 2, N = 8 0110: $f_{sampling} = f_{DTS}$ / 4, N = 6 0111: $f_{sampling} = f_{DTS}$ / 4, N = 8 1000: $f_{sampling} = f_{DTS}$ / 8, N = 6 1001: $f_{sampling} = f_{DTS}$ / 8, N = 8 1010: $f_{sampling} = f_{DTS}$ / 16, N = 5 1011: $f_{sampling} = f_{DTS}$ / 16, N = 6 1100: $f_{sampling} = f_{DTS}$ / 16, N = 8 1101: $f_{sampling} = f_{DTS}$ / 32, N = 5 1110: $f_{sampling} = f_{DTS}$ / 32, N = 6 1111: $f_{sampling} = f_{DTS}$ / 32, N = 8

Channel 2 Input Configuration Register – CH2ICFR

This register specifies the channel 2 input mode configuration.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				CH2PSC		CH2CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI2F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[19:18]	CH2PSC	Channel 2 Capture Input Source Prescaler Setting These bits define the effective events of the channel 2 capture input. Note that the prescaler is reset once the Channel 2 Capture/Compare Enable bit, CH2E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 2 capture input signal is chosen for each active event 01: Channel 2 Capture input signal is chosen for every 2 events 10: Channel 2 Capture input signal is chosen for every 4 events 11: Channel 2 Capture input signal is chosen for every 8 events
[17:16]	CH2CCS	Channel 2 Capture/Compare Selection 00: Channel 2 is configured as an output 01: Channel 2 is configured as an input derived from the TI2 signal 10: Channel 2 is configured as an input derived from the TI3 signal 11: Channel 2 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH2CCS field can be accessed only when the CH2E bit is cleared to 0.

Bits	Field	Descriptions
[3:0]	TI2F	Channel 2 Input Source TI2 Filter Setting These bits define the frequency divide ratio used to sample the TI2 signal. The Digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS} / 2$, N = 6 0101: $f_{sampling} = f_{DTS} / 2$, N = 8 0110: $f_{sampling} = f_{DTS} / 4$, N = 6 0111: $f_{sampling} = f_{DTS} / 4$, N = 8 1000: $f_{sampling} = f_{DTS} / 8$, N = 6 1001: $f_{sampling} = f_{DTS} / 8$, N = 8 1010: $f_{sampling} = f_{DTS} / 16$, N = 5 1011: $f_{sampling} = f_{DTS} / 16$, N = 6 1100: $f_{sampling} = f_{DTS} / 16$, N = 8 1101: $f_{sampling} = f_{DTS} / 32$, N = 5 1110: $f_{sampling} = f_{DTS} / 32$, N = 6 1111: $f_{sampling} = f_{DTS} / 32$, N = 8

Channel 3 Input Configuration Register – CH3ICFR

This register specifies the channel 3 input mode configuration.

Offset: 0x02C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved				CH3PSC		CH3CCS	
Type/Reset					RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				TI3F			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[19:18]	CH3PSC	Channel 3 Capture Input Source Prescaler Setting These bits define the effective events of the channel 3 capture input. Note that the prescaler is reset once the Channel 3 Capture/Compare Enable bit, CH3E, in the Channel Control register named CHCTR is cleared to 0. 00: No prescaler, channel 3 capture input signal is chosen for each active event 01: Channel 3 Capture input signal is chosen for every 2 events 10: Channel 3 Capture input signal is chosen for every 4 events 11: Channel 3 Capture input signal is chosen for every 8 events
[17:16]	CH3CCS	Channel 3 Capture/Compare Selection 00: Channel 3 is configured as an output 01: Channel 3 is configured as an input derived from the TI3 signal 10: Channel 3 is configured as an input derived from the TI2 signal 11: Channel 3 is configured as an input which comes from the TRCED signal derived from the Trigger Controller Note: The CH3CCS field can be accessed only when the CH3E bit is cleared to 0.
[3:0]	TI3F	Channel 3 Input Source TI3 Filter Setting These bits define the frequency divide ratio used to sample the TI3 signal. The digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal 0000: No filter, the sampling clock is f_{SYSTEM} 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS}$ / 2, N = 6 0101: $f_{sampling} = f_{DTS}$ / 2, N = 8 0110: $f_{sampling} = f_{DTS}$ / 4, N = 6 0111: $f_{sampling} = f_{DTS}$ / 4, N = 8 1000: $f_{sampling} = f_{DTS}$ / 8, N = 6 1001: $f_{sampling} = f_{DTS}$ / 8, N = 8 1010: $f_{sampling} = f_{DTS}$ / 16, N = 5 1011: $f_{sampling} = f_{DTS}$ / 16, N = 6 1100: $f_{sampling} = f_{DTS}$ / 16, N = 8 1101: $f_{sampling} = f_{DTS}$ / 32, N = 5 1110: $f_{sampling} = f_{DTS}$ / 32, N = 6 1111: $f_{sampling} = f_{DTS}$ / 32, N = 8

Channel 0 Output Configuration Register – CH0OCFR

This register specifies the channel 0 output mode configuration.

Offset: 0x040

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH0OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH0IMAE	CH0PRE	Reserved	CH0OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH0IMAE	Channel 0 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH0OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH0CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH0IMAE bit is available only if channel 0 is configured operate in PWM mode 1 or PWM mode 2.
[4]	CH0PRE	Channel 0 Capture/Compare Register (CH0CCR) Preload Enable 0: CH0CCR preload function is disabled The CH0CCR register can be immediately assigned a new value when the CH0PRE bit is cleared to 0 and the updated CH0CCR value is used immediately. 1: CH0CCR preload function is enabled The new CH0CCR value will not be transferred to its shadow register until an update event 1 occurs.

Bits	Field	Descriptions
[8][2:0]	CH0OM[3:0]	Channel 0 Output Mode Setting These bits define the functional types of the output reference signal CH0OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH0OREF is forced to 0 0101: Force active – CH0OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 0 has an active level when CNTR < CH0CCR or otherwise has an inactive level. - During down-counting, channel 0 has an inactive level when CNTR > CH0CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 0 is has an inactive level when CNTR < CH0CCR or otherwise has an active level. - During down-counting, channel 0 has an active level when CNTR > CH0CCR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 0 has an active level when CNTR < CH0CCR or otherwise has an inactive level. - During down-counting, channel 0 has an inactive level when CNTR > CH0ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 0 has an inactive level when CNTR < CH0CCR or otherwise has an active level. - During down-counting, channel 0 has an active level when CNTR > CH0ACR or otherwise has an inactive level Note: When channel 0 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1 / 0x2 / 0x3).

Channel 1 Output Configuration Register – CH1OCFR

This register specifies the channel 1 output mode configuration.

Offset: 0x044

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH1OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH1IMAE	CH1PRE	Reserved	CH1OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH1IMAE	Channel 1 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH1OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH1CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH1IMAE bit is available only if channel 1 is configured to be operated in PWM mode 1 or PWM mode 2.
[4]	CH1PRE	Channel 1 Capture/Compare Register (CH1CCR) Preload Enable 0: CH1CCR preload function is disabled. The CH1CCR register can be immediately assigned a new value when the CH1PRE bit is cleared to 0 and the updated CH1CCR value is used immediately. 1: CH1CCR preload function is enabled The new CH1CCR value will not be transferred to its shadow register until an update event 1 occurs.

Bits	Field	Descriptions
[8][2:0]	CH1OM[3:0]	Channel 1 Output Mode Setting These bits define the functional types of the output reference signal CH1OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH1OREF is forced to 0 0101: Force active – CH1OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 1 has an active level when CNTR < CH1CCR or otherwise has an inactive level. - During down-counting, channel 1 has an inactive level when CNTR > CH1CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 1 has an inactive level when CNTR < CH1CCR or otherwise has an active level. - During down-counting, channel 1 has an active level when CNTR > CH1CCR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 1 has an active level when CNTR < CH1CCR or otherwise has an inactive level. - During down-counting, channel 1 has an inactive level when CNTR > CH1ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 1 has an inactive level when CNTR < CH1CCR or otherwise has an active level. - During down-counting, channel 1 has an active level when CNTR > CH1ACR or otherwise has an inactive level Note: When channel 1 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1 / 0x2 / 0x3).

Channel 2 Output Configuration Register – CH2OCFR

This register specifies the channel 2 output mode configuration.

Offset: 0x048

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH2OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH2IMAE	CH2PRE	Reserved	CH2OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH2IMAE	Channel 2 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH2OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH2CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH2IMAE bit is available only if the channel 2 is configured to be operated in PWM mode 1 or PWM mode 2.
[4]	CH2PRE	Channel 2 Capture/Compare Register (CH2CCR) Preload Enable 0: CH2CCR preload function is disabled. The CH2CCR register can be immediately assigned a new value when the CH2PRE bit is cleared to 0 and the updated CH2CCR value is used immediately. 1: CH2CCR preload function is enabled The new CH2CCR value will not be transferred to its shadow register until an update event 1 occurs.

Bits	Field	Descriptions
[8][2:0]	CH2OM[3:0]	Channel 2 Output Mode Setting These bits define the functional types of the output reference signal CH2OREF. 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH2OREF is forced to 0 0101: Force active – CH2OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 2 has an active level when CNTR < CH2CCR or otherwise has an inactive level. - During down-counting, channel 2 has an inactive level when CNTR > CH2CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 2 has an inactive level when CNTR < CH2CCR or otherwise has an active level. - During down-counting, channel 2 has an active level when CNTR > CH2CCR or otherwise has an inactive level. 1110: Asymmetric PWM mode 1 - During up-counting, channel 2 has an active level when CNTR < CH2CCR or otherwise has an inactive level. - During down-counting, channel 2 has an inactive level when CNTR > CH2ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 2 has an inactive level when CNTR < CH2CCR or otherwise has an active level. - During down-counting, channel 2 has an active level when CNTR > CH2ACR or otherwise has an inactive level Note: When channel 2 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1 / 0x2 / 0x3).

Channel 3 Output Configuration Register – CH3OCFR

This register specifies the channel 3 output mode configuration.

Offset: 0x04C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							CH3OM[3]
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
		Reserved	CH3IMAE	CH3PRE	Reserved	CH3OM[2:0]		
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0

Bits	Field	Descriptions
[5]	CH3IMAE	Channel 3 Immediate Active Enable 0: No action 1: Single pulse Immediate Active Mode is enabled The CH3OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH3CCR values. The effective duration ends automatically at the next overflow or underflow event. Note: The CH3IMAE bit is available only if channel 3 is configured to be operated in PWM mode 1 or PWM mode 2.
[4]	CH3PRE	Channel 3 Capture/Compare Register (CH3CCR) Preload Enable 0: CH3CCR preload function is disabled. The CH3CCR register can be immediately assigned a new value when the CH3PRE bit is cleared to 0 and the updated CH3CCR value is used immediately. 1: CH3CCR preload function is enabled The new CH3CCR value will not be transferred to its shadow register until an update event 1 occurs.

Bits	Field	Descriptions
[8][2:0]	CH3OM[3:0]	Channel 3 Output Mode Setting These bits define the functional types of the output reference signal CH3OREF 0000: No Change 0001: Output 0 on compare match 0010: Output 1 on compare match 0011: Output toggles on compare match 0100: Force inactive – CH3OREF is forced to 0 0101: Force active – CH3OREF is forced to 1 0110: PWM mode 1 - During up-counting, channel 3 has an active level when CNTR < CH3CCR or otherwise has an inactive level. - During down-counting, channel 3 has an inactive level when CNTR > CH3CCR or otherwise has an active level. 0111: PWM mode 2 - During up-counting, channel 3 has an inactive level when CNTR < CH3CCR or otherwise has an active level. - During down-counting, channel 3 has an active level when CNTR > CH3CCR or otherwise has an inactive level 1110: Asymmetric PWM mode 1 - During up-counting, channel 3 has an active level when CNTR < CH3CCR or otherwise has an inactive level. - During down-counting, channel 3 has an inactive level when CNTR > CH3ACR or otherwise has an active level. 1111: Asymmetric PWM mode 2 - During up-counting, channel 3 has an inactive level when CNTR < CH3CCR or otherwise has an active level. - During down-counting, channel 3 has an active level when CNTR > CH3ACR or otherwise has an inactive level Note: When channel 3 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 0x1 / 0x2 / 0x3)

Channel Control Register – CHCTR

This register contains the channel capture input or compare output function enable control bits.

Offset: 0x050

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	CH3E	CH2NE	CH2E	CH1NE	CH1E	CH0NE	CH0E
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[6]	CH3E	Channel 3 Capture/Compare Enable - Channel 3 is configured as an input (CH3CCS = 0x1 / 0x2 / 0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 3 is configured as an output (CH3CCS = 0x0) 0: Off – Channel 3 output signal CH3O is not active 1: On – Channel 3 output signal CH3O is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR and CH3OIS bits.
[5]	CH2NE	Channel 2 Capture/Compare Complementary Enable 0: Off – Channel 2 complementary output CH2NO is not active. The CH2NO level is then determined by the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2E bits. 1: On – Channel 2 complementary output CH2NO is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2E bits.
[4]	CH2E	Channel 2 Capture/Compare Enable - Channel 2 is configured as an input (CH2CCS = 0x1 / 0x2 / 0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 2 is configured as an output (CH2CCS = 0x0) 0: Off – Channel 2 output signal CH2O is not active. The CH2O level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2NE bits. 1: On – Channel 2 output signal CH2O is generated on the corresponding output pin determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2NE bits.

Bits	Field	Descriptions
[3]	CH1NE	Channel 1 Capture/Compare Complementary Enable 0: Off – Channel 1 complementary output CH1NO is not active. The CH1NO level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1E bits. 1: On – Channel 1 complementary output CH1NO is generated on the corresponding output pin determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1E bits.
[2]	CH1E	Channel 1 Capture/Compare Enable - Channel 1 is configured as an input (CH1CCS = 0x1 / 0x2 / 0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 1 is configured as an output (CH1CCS = 0x0) 0: Off – Channel 1 output signal CH1O is not active. The CH1O level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1NE bits. 1: On – Channel 1 output signal CH1O is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1NE bits.
[1]	CH0NE	Channel 0 Capture/Compare Complementary Enable 0: Off – Channel 0 complementary output CH0NO is not active. The CH0NO level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0E bits. 1: On – Channel 0 complementary output CH0NO is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0E bits.
[0]	CH0E	Channel 0 Capture/Compare Enable - Channel 0 is configured as an input (CH0CCS = 0x1 / 0x2 / 0x3) 0: Input Capture Mode is disabled 1: Input Capture Mode is enabled - Channel 0 is configured as an output (CH0CCS = 0x0) 0: Off – Channel 0 output signal CH0O is not active. The CH0O level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0NE bits. 1: On – Channel 0 output signal CH0O is generated on the corresponding output pin determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0NE bits.

Channel Polarity Configuration Register – CHPOLR

This register contains the channel capture input or compare output polarity control.

Offset: 0x054

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	CH3P	CH2NP	CH2P	CH1NP	CH1P	CH0NP	CH0P
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[6]	CH3P	Channel 3 Capture/Compare Polarity - When Channel 3 is configured as an input (CH3CCS = 0x1 / 0x2 / 0x3) 0: capture event occurs on a Channel 3 rising edge 1: capture event occurs on a Channel 3 falling edge - When Channel 3 is configured as an output (CH3CCS = 0x0) 0: Channel 3 Output is active high 1: Channel 3 Output is active low
[5]	CH2NP	Channel 2 Capture/Compare Complementary Polarity 0: Channel 2 Output is active high 1: Channel 2 Output is active low
[4]	CH2P	Channel 2 Capture/Compare Polarity - When Channel 2 is configured as an input (CH2CCS = 0x1 / 0x2 / 0x3) 0: capture event occurs on a Channel 2 rising edge 1: capture event occurs on a Channel 2 falling edge - When Channel 2 is configured as an output (CH2CCS = 0x0) 0: Channel 2 Output is active high 1: Channel 2 Output is active low
[3]	CH1NP	Channel 1 Capture/Compare Complementary Polarity 0: Channel 1 Output is active high 1: Channel 1 Output is active low
[2]	CH1P	Channel 1 Capture/Compare Polarity - When Channel 1 is configured as an input (CH1CCS = 0x1 / 0x2 / 0x3) 0: capture event occurs on a Channel 1 rising edge 1: capture event occurs on a Channel 1 falling edge - When Channel 1 is configured as an output (CH1CCS = 0x0) 0: Channel 1 Output is active high 1: Channel 1 Output is active low

Bits	Field	Descriptions
[1]	CH0NP	Channel 0 Capture/Compare Complementary Polarity 0: Channel 0 Output is active high 1: Channel 0 Output is active low
[0]	CH0P	Channel 0 Capture/Compare Polarity - When Channel 0 is configured as an input (CH0CCS = 0x1 / 0x2 / 0x3) 0: capture event occurs on a Channel 0 rising edge 1: capture event occurs on a Channel 0 falling edge - When Channel 0 is configured as an output (CH0CCS = 0x0) 0: Channel 0 Output is active high 1: Channel 0 Output is active low

Channel Break Configuration Register – CHBRKCFR

This register specifies the channel output idle state when using the break function.

Offset: 0x06C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved	CH3OIS	CH2OISN	CH2OIS	CH1OISN	CH1OIS	CH0OISN	CH0OIS
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[6]	CH3OIS	MT_CH3O Output Idle State 0: Channel 3 output CH3O = 0 when CHMOE = 0 1: Channel 3 output CH3O = 1 when CHMOE = 0
[5]	CH2OISN	MT_CH2NO Output Idle State 0: Channel 2 complementary output CH2NO = 0 after a dead time when CHMOE = 0 1: Channel 2 complementary output CH2NO = 1 after a dead time when CHMOE = 0
[4]	CH2OIS	MT_CH2O Output Idle State 0: Channel 2 output CH2O = 0 after a dead time when CHMOE = 0 1: Channel 2 output CH2O = 1 after a dead time when CHMOE = 0

Bits	Field	Descriptions
[3]	CH1OISN	MT_CH1NO Output Idle State 0: Channel 1 complementary output CH1NO = 0 after a dead time when CHMOE = 0 1: Channel 1 complementary output CH1NO = 1 after a dead time when CHMOE = 0
[2]	CH1OIS	MT_CH1O Output Idle State 0: Channel 1 output CH1O = 0 after a dead time when CHMOE = 0 1: Channel 1 output CH1O = 1 after a dead time when CHMOE = 0
[1]	CH0OISN	MT_CH0NO Output Idle State 0: Channel 0 complementary output CH1NO = 0 after a dead time when CHMOE = 0 1: Channel 0 complementary output CH1NO = 1 after a dead time when CHMOE = 0
[0]	CH0OIS	MT_CH0O Output Idle State 0: Channel 0 output CH0O = 0 after a dead time when CHMOE = 0 1: Channel 0 output CH0O = 1 after a dead time when CHMOE = 0

Channel Break Control Register – CHBRKCTR

This register specifies the channel break control bits.

Offset: 0x070

Reset value: 0x0000_0002

	31	30	29	28	27	26	25	24
	CHDTG							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	Reserved		CHOSSR	CHOSSI	Reserved	GFSEL		LOCKLV
Type/Reset			RW 0	RW 0		RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved				BKF			
Type/Reset					RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved		CHAOE	CHMOE	Reserved		BKP	BKE
Type/Reset			RW 0	RW 0			RW 1	RW 0

Bits	Field	Descriptions
[31:24]	CHDTG	Channel Dead Time Duration Definition CHDTG[7:5] = 0xx: Channel Dead Time = CHDTG [7:0] × t_{dtg} , with t_{dtg} = t_{DTS} CHDTG[7:5] = 10x: Channel Dead Time = (64 + CHDTG [5:0]) × t_{dtg} , with t_{dtg} = 2 × t_{DTS} CHDTG[7:5] = 110: Channel Dead Time = (32 + CHDTG [4:0]) × t_{dtg} , with t_{dtg} = 8 × t_{DTS} CHDTG[7:5] = 111: Channel Dead Time = (32 + CHDTG [4:0]) × t_{dtg} , with t_{dtg} = 16 × t_{DTS}

Bits	Field	Descriptions
[21]	CHOSSR	Channel Off State (CHxE, CHxNE = 0) Selection for Normal Run State (CHMOE = 1) 0: When inactive, MT_CHxO/MT_CHxNO output is disabled - not driven by timer 1: When inactive, MT_CHxO/MT_CHxNO output is enabled with their inactive level
[20]	CHOSSI	Channel Off State Selection for Idle Mode (CHMOE = 0) 0: When inactive, MT_CHxO/MT_CHxNO output is disable – not driven by timer 1: When inactive, MT_CHxO/MT_CHxNO output is enabled with their idle level depending upon the condition of the the CHxOIS and CHxOISN bits
[18]	GFSEL	Deglitch Filter Selection for Break 0: No input deglitch filter 1: 50 ns deglitch filter
[17:16]	LOCKLV	Lock Level Setting These bits offer write protection against software errors. The bits can be written only once after a reset. 00: LOCK OFF, Register write protected function is disabled 01: LOCK Level 1 10: LOCK Level 2 11: LOCK Level 3
[11:8]	BKF	Break Input Filter Setting These bits define the frequency ratio used to sample the MT_BRK signal. The digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal. 0000: No filter – do not need sample clock 0001: $f_{sampling} = f_{CLKIN}$, N = 2 0010: $f_{sampling} = f_{CLKIN}$, N = 4 0011: $f_{sampling} = f_{CLKIN}$, N = 8 0100: $f_{sampling} = f_{DTS}$ / 2, N = 6 0101: $f_{sampling} = f_{DTS}$ / 2, N = 8 0110: $f_{sampling} = f_{DTS}$ / 4, N = 6 0111: $f_{sampling} = f_{DTS}$ / 4, N = 8 1000: $f_{sampling} = f_{DTS}$ / 8, N = 6 1001: $f_{sampling} = f_{DTS}$ / 8, N = 8 1010: $f_{sampling} = f_{DTS}$ / 16, N = 5 1011: $f_{sampling} = f_{DTS}$ / 16, N = 6 1100: $f_{sampling} = f_{DTS}$ / 16, N = 8 1101: $f_{sampling} = f_{DTS}$ / 32, N = 5 1110: $f_{sampling} = f_{DTS}$ / 32, N = 6 1111: $f_{sampling} = f_{DTS}$ / 32, N = 8
[5]	CHAOE	Channel Automatic Output Enable 0: CHMOE can be set only by software 1: CHMOE can be set by software or automatically by an update event 1
[4]	CHMOE	Channel Main Output Enable Cleared asynchronously by hardware on a break event occurrence. 0: MT_CHxO and MT_CHxNO are disabled or forced to idle states 1: MT_CHxO and MT_CHxNO are enabled if the enable bits (CHxE, CHxNE) are set
[1]	BKP	Break Input Polarity 0: Break input is active low 1: Break input is active high
[0]	BKE	Break Enable 0: Break inputs is disabled 1: Break inputs is enabled

Timer Interrupt Control Register – DICTR

This register contains the timer interrupt enable control bits.

Offset: 0x074

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved				BRKIE	TEVIE	UEV2IE	UEV1IE
Type/Reset					RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CCIE	CH2CCIE	CH1CCIE	CH0CCIE
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[11]	BRKIE	Break event Interrupt Enable 0: Break event interrupt is disabled 1: Break event interrupt is enabled
[10]	TEVIE	Trigger event Interrupt Enable 0: Trigger event interrupt is disabled 1: Trigger event interrupt is enabled
[9]	UEV2IE	Update event 2 Interrupt Enable 0: Update event 2 interrupt is disabled 1: Update event 2 interrupt is enabled
[8]	UEV1IE	Update event 1 Interrupt Enable 0: Update event 1 interrupt is disabled 1: Update event 1 interrupt is enabled
[3]	CH3CCIE	Channel 3 Capture/Compare Interrupt Enable 0: Channel 3 interrupt is disabled 1: Channel 3 interrupt is enabled
[2]	CH2CCIE	Channel 2 Capture/Compare Interrupt Enable 0: Channel 2 interrupt is disabled 1: Channel 2 interrupt is enabled
[1]	CH1CCIE	Channel 1 Capture/Compare Interrupt Enable 0: Channel 1 interrupt is disabled 1: Channel 1 interrupt is enabled
[0]	CH0CCIE	Channel 0 Capture/Compare Interrupt Enable 0: Channel 0 interrupt is disabled 1: Channel 0 interrupt is enabled

Timer Event Generator Register – EVGR

This register contains the software event generation bits.

Offset: 0x078

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved				BRKG	TEVG	UEV2G	UEV1G
Type/Reset					WO 0	WO 0	WO 0	WO 0
	7	6	5	4	3	2	1	0
	Reserved				CH3CCG	CH2CCG	CH1CCG	CH0CCG
Type/Reset					WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[11]	BRKG	Software Break Event Generation The break event BEV can be generated by setting this bit. It is automatically cleared by hardware. 0: No action 1: The BRKIF flag is set and then the CHMOE bit will be cleared
[10]	TEVG	Trigger Event Generation The trigger event TEV can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: The TEVIF flag is set
[9]	UEV2G	Update Event 2 Generation The update event 2 UEV2 can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Update the CHxE, CHxNE, and CHxOM bits when COMPRE bit in CTR Register is set to 1
[8]	UEV1G	Update Event 1 Generation The update event 1 UEV1 can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Reinitialise the counter The counter value returns to 0 or the CRR preload value, depending on the counter mode in which the current timer is being used. An update operation on any related registers will also be executed. For a more detailed description, refer to the corresponding section.

Bits	Field	Descriptions
[3]	CH3CCG	Channel 3 Capture/Compare Generation A Channel 3 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 3 If Channel 3 is configured as an input, the counter value is captured into the CH3CCR register and then the CH3CCIF bit is set. If Channel 3 is configured as an output, the CH3CCIF bit is set.
[2]	CH2CCG	Channel 2 Capture/Compare Generation A Channel 2 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 2 If Channel 2 is configured as an input, the counter value is captured into the CH2CCR register and then the CH2CCIF bit is set. If Channel 2 is configured as an output, the CH2CCIF bit is set.
[1]	CH1CCG	Channel 1 Capture/Compare Generation A Channel 1 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 1 If Channel 1 is configured as an input, the counter value is captured into the CH1CCR register and then the CH1CCIF bit is set. If Channel 1 is configured as an output, the CH1CCIF bit is set.
[0]	CH0CCG	Channel 0 Capture/Compare Generation A Channel 0 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically. 0: No action 1: Capture/compare event is generated on channel 0 If Channel 0 is configured as an input, the counter value is captured into the CH0CCR register and then the CH0CCIF bit is set. If Channel 0 is configured as an output, the CH0CCIF bit is set.

Timer Interrupt Status Register – INTSR

This register stores the timer interrupt status.

Offset: 0x07C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved				BRKIF	TEVIF	UEV2IF	UEV1IF
Type/Reset					W0C 0	W0C 0	W0C 0	W0C 0
	7	6	5	4	3	2	1	0
	CH3OCF	CH2OCF	CH1OCF	CH0OCF	CH3CCIF	CH2CCIF	CH1CCIF	CH0CCIF
Type/Reset	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0	W0C 0

Bits	Field	Descriptions
[11]	BRKIF	Break Event Interrupt Flag This flag is set by hardware when a break event occurs and is cleared by software. 0: No break event occurs 1: Break event occurs
[10]	TEVIF	Trigger Event Interrupt Flag This flag is set by hardware when a trigger event occurs and is cleared by software. 0: No trigger event occurs 1: Trigger event occurs
[9]	UEV2IF	Update Event 2 Interrupt Flag This bit is set by hardware when an update event 2 occurs and is cleared by software. 0: No update event 2 occurs 1: Update event 2 occurs
[8]	UEV1IF	Update Event 1 Interrupt Flag This bit is set by hardware when an update event 1 occurs and is cleared by software. 0: No update event 1 occurs 1: Update event 1 occurs Note: The update event 1 is sourced from the following conditions: - A counter overflow or underflow - The UEV1G bit is set with UEV1DIS = 0 - An STI rising edge is received in slave restart mode with UEV1DIS = 0
[7]	CH3OCF	Channel 3 Over-capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH3CCIF bit is already set and it is not yet cleared by software

Bits	Field	Descriptions
[6]	CH2OCF	Channel 2 Over-capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH2CCIF bit is already set and it is not cleared yet by software
[5]	CH1OCF	Channel 1 Over-capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH1CCIF bit is already set and it is not cleared yet by software
[4]	CH0OCF	Channel 0 Over-capture Flag This flag is set by hardware and cleared by software. 0: No over-capture event is detected 1: Capture event occurs again when the CH0CCIF bit is already set and it is not yet cleared by software
[3]	CH3CCIF	Channel 3 Capture/Compare Interrupt Flag - Channel 3 is configured as an output 0: No match event occurs 1: The contents of the counter CNTR have matched the contents of the CH3CCR register This flag is set by hardware when the counter value matches the CH3CCR value with exception in the center-aligned counting mode. It is cleared by software. - Channel 3 is configured as an input 0: No input capture occurs 1: Input capture occurs This bit is set by hardware when a capture event occurs. It is cleared by software or by reading the CH3CCR register.
[2]	CH2CCIF	Channel 2 Capture/Compare Interrupt Flag - Channel 2 is configured as an output 0: No match event occurs 1: The contents of the counter CNTR have matched the contents of the CH2CCR register This flag is set by hardware when the counter value matches the CH2CCR value with exception in the center-aligned counting mode. It is cleared by software. - Channel 2 is configured as an input 0: No input capture occurs 1: Input capture occurs This bit is set by hardware on a capture event. It is cleared by software or by reading the CH2CCR register.

Bits	Field	Descriptions
[1]	CH1CCIF	Channel 1 Capture/Compare Interrupt Flag - Channel 1 is configured as an output 0: No match event occurs 1: The contents of the counter CNTR have matched the contents of the CH1CCR register This flag is set by hardware when the counter value matches the CH1CCR value with exception in the center-aligned counting mode. It is cleared by software. - Channel 1 is configured as an input 0: No input capture occurs 1: Input capture occurs This bit is set by hardware on a capture event. It is cleared by software or by reading the CH1CCR register.
[0]	CH0CCIF	Channel 0 Capture/Compare Interrupt Flag - Channel 0 is configured as an output 0: No match event occurs 1: The contents of the counter CNTR have matched the content of the CH0CCR register This flag is set by hardware when the counter value matches the CH0CCR value with exception in the center-aligned counting mode. It is cleared by software. - Channel 0 is configured as an input 0: No input capture occurs 1: Input capture occurs This bit is set by hardware on a capture event. It is cleared by software or by reading the CH0CCR register.

Timer Counter Register – CNTR

This register stores the timer counter value.

Offset: 0x080

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CNTV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CNTV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CNTV	Counter Value

Timer Prescaler Register – PSCR

This register specifies the timer prescaler value to generate the counter clock.

Offset: 0x084

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PSCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PSCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PSCV	Prescaler Value These bits are used to specify the prescaler value to generate the counter clock frequency f_{CK_CNT}. $f_{CK\_CNT} = \frac{f_{CK\_PSC}}{PSCV[15:0]+1}$, where the f_{CK_PSC} is the prescaler input clock source.

Timer Counter Reload Register – CRR

This register specifies the timer counter reload value.

Offset: 0x088

Reset value: 0x0000_FFFF

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CRV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
	CRV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1

Bits	Field	Descriptions
[15:0]	CRV	Counter Reload Value The CRV is the reload value which is loaded into the actual counter register.

Timer Repetition Register – REPR

This register specifies the timer repetition counter value.

Offset: 0x08C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	REPV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	REPV	Repetition Counter Value These bits allow the user to specify the update rate of the compare registers.

Channel 0 Capture/Compare Register – CH0CCR

This register specifies the timer channel 0 capture/compare value.

Offset: 0x090

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH0CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH0CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH0CCV	Channel 0 Capture/Compare Value - When Channel 0 is configured as an output The CH0CCR value is compared with the counter value and the comparison result is used to trigger the CH0OREF output signal. - When Channel 0 is configured as an input The CH0CCR register stores the counter value captured by the last channel 0 capture event.

Channel 1 Capture/Compare Register – CH1CCR

This register specifies the timer channel 1 capture/compare value.

Offset: 0x094

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH1CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH1CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH1CCV	Channel 1 Capture/Compare Value - When Channel 1 is configured as an output The CH1CCR value is compared with the counter value and the comparison result is used to trigger the CH1OREF output signal. - When Channel 1 is configured as an input The CH1CCR register stores the counter value captured by the last channel 1 capture event.

Channel 2 Capture/Compare Register – CH2CCR

This register specifies the timer channel 2 capture/compare value.

Offset: 0x098

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH2CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH2CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH2CCV	Channel 2 Capture/Compare Value - When Channel 2 is configured as an output The CH2CCR value is compared with the counter value and the comparison result is used to trigger the CH2OREF output signal. - When Channel 2 is configured as an input The CH2CCR register stores the counter value captured by the last channel 2 capture event.

Channel 3 Capture/Compare Register – CH3CCR

This register specifies the timer channel 3 capture/compare value.

Offset: 0x09C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH3CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH3CCV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH3CCV	Channel 3 Capture/Compare Value - When Channel 3 is configured as an output The CH3CCR value is compared with the counter value and the comparison result is used to trigger the CH3OREF output signal. - When Channel 3 is configured as an input The CH3CCR register stores the counter value captured by the last channel 3 capture event.

Channel 0 Asymmetric Compare Register – CH0ACR

This register specifies the timer channel 0 asymmetric compare value.

Offset: 0x0A0

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH0ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH0ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH0ACV	Channel 0 Asymmetric Compare Value When channel 0 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter.

Channel 1 Asymmetric Compare Register – CH1ACR

This register specifies the timer channel 1 asymmetric compare value.

Offset: 0x0A4

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH1ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH1ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH1ACV	Channel 1 Asymmetric Compare Value When channel 1 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter.

Channel 2 Asymmetric Compare Register – CH2ACR

This register specifies the timer channel 2 asymmetric compare value.

Offset: 0x0A8

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH2ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH2ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH2ACV	Channel 2 Asymmetric Compare Value When channel 2 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter.

Channel 3 Asymmetric Compare Register – CH3ACR

This register specifies the timer channel 3 asymmetric compare value.

Offset: 0x0AC

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CH3ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CH3ACV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CH3ACV	Channel 3 Asymmetric Compare Value When channel 3 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter.

17 Real Time Clock (RTC)

Introduction

The Real Time Clock, RTC, circuitry includes the APB interface, a 24-bit up-counter, a control register, a prescaler, a compare register and a status register. The RTC circuits are located in the V_{DD15} Domain, as shown in the accompanying figure. The RTC counter is used as a wakeup timer to let the system resume from the power saving modes. The detailed RTC function will be described in the following sections.

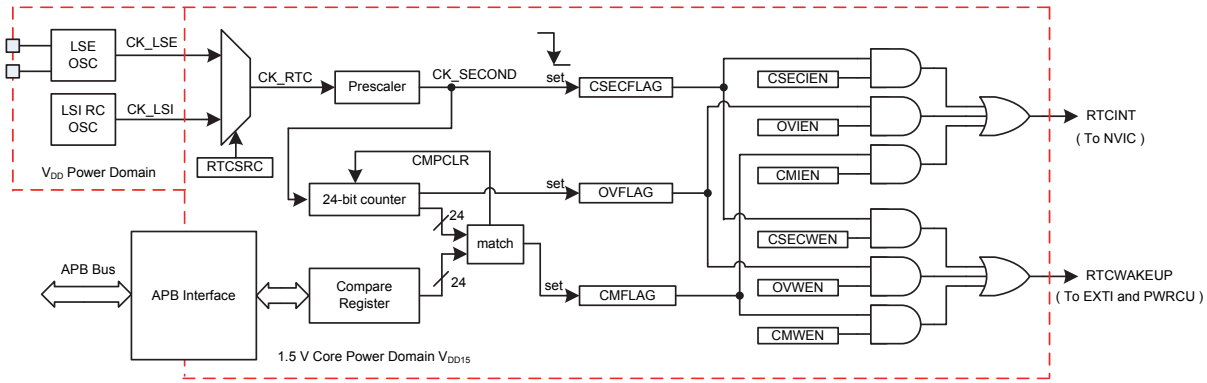


Figure 137. RTC Block Diagram

Features

- 24-bit up-counter for counting elapsed time
- Programmable clock prescaler
  - Division factor: 1, 2, 4, 8…, 32768
- 24-bit compare register for alarm usage
- RTC clock source
  - LSE oscillator clock
  - LSI oscillator clock
- Three RTC Interrupt / wakeup settings
  - RTC second clock interrupt / wakeup
  - RTC compare match interrupt / wakeup
  - RTC counter overflow interrupt / wakeup
- The RTC interrupt / wakeup event can work together with power management to wake up the chip from power saving modes

Functional Descriptions

RTC Related Register Reset

The RTC registers can only be reset by either a V_{DD15} Domain power on reset, POR15, or by a PWRCU software reset by setting the PWCURST bit in the PWRCR register. Other reset events have no effect to clear the RTC registers.

Low Speed Clock Configuration

The default RTC clock source, CK_RTC, is derived from the LSI oscillator. The CK_RTC clock can be derived from either the external 32,768 Hz crystal oscillator, named the LSE oscillator, or the internal 32 kHz RC oscillator named the LSI oscillator, by setting the RTCSRC bit in the RTCCR register. A prescaler is provided to divide the CK_RTC by a ratio ranged from 2^0 to 2^{15} determined by the RPRE [3:0] field. For instance, setting the prescaler value RPRE [3:0] to 0xF will generate an exact 1 Hz CK_SECOND clock if the CK_RTC clock frequency is equal to 32,768 Hz. The LSE oscillator can be enabled by the LSEEN control bits in the RTCCR register. In addition, the LSE oscillator startup mode can be selected by configuring the LSESM bit in the RTCCR register. This enables the LSE oscillator to have either a shorter startup time or a lower power consumption, both of which are traded off depending upon specific application requirements. An example of the startup time and the power consumption for different startup modes are shown in the accompanying table for reference.

Table 39. LSE Startup Mode Operating Current and Startup Time

Startup Mode	LSESM Setting in the RTCCR Register	Operating Current	Startup Time
Normal startup	0	2.0 μA	Above 500 ms
Fast startup	1	3.5 μA	Below 300 ms

@ V_{DD} = 3.3 V and LSE clock = 32,768 Hz; these values are only for reference, actual values are dependent on the specification of the external 32.768 kHz crystal.

RTC Counter Operation

The RTC provides a 24-bit up-counter which increments at the falling edge of the CK_SECOND clock and whose value can be read from the RTCCNT register asynchronously via the APB bus. A 24-bit compare register, RTCCMP, is provided to store the specific value to be compared with the RTCCNT content. This is used to define a pre-determined time interval. When the RTCCNT register content is equal to the RTCCMP register value, the match flag CMFLAG in the RTCSR register will be set by hardware and an interrupt or wakeup event can be sent according to the corresponding enable bits in the RTCIWEN register. The RTC counter will be either reset to zero or keep counting when the compare match event occurs, dependent upon the CMPCLR bit in the RTCCR register. For example, if the RPRE [3:0] is set to 0xF, the RTCCMP register content is set to a decimal value of 60 and the CMPCLR bit is set to 1, then the CMFLAG bit will be set every minute. In addition, the OVFLAG bit in the RTCSR register will be set when the RTC counter overflows. A read operation on the RTCSR register clears the status flags including the CSECFLAG, CMFLAG and OVFLAG bits.

Interrupt and Wakeup Control

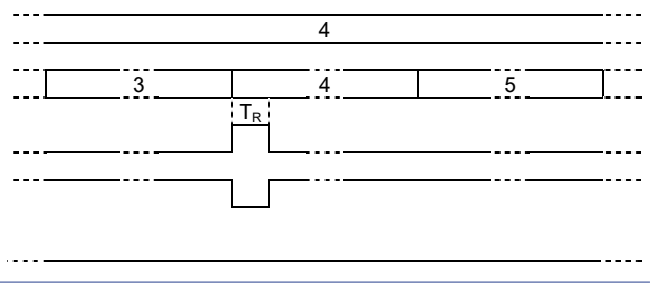
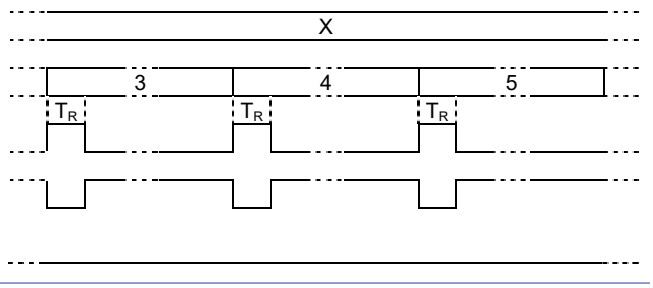
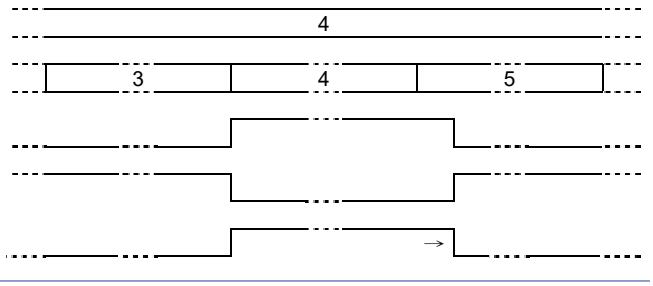
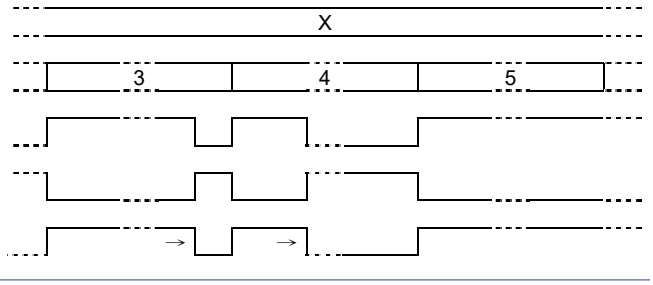
The falling edge of the CK_SECOND clock causes the CSECFLAG bit in the RTCSR register to be set and generates an interrupt if the corresponding interrupt enable bit, CSECIEN, in the RTCIWEN register is set. The wakeup event can also be generated to wake up the HSI / HSE

oscillators, the LDO and the CPU core if the corresponding wakeup enable bit CSECWEN is set. When the RTC counter overflows or a compare match event occurs, it will generate an interrupt or a wake up event determined by the corresponding interrupt or wakeup enable control bits, OVIEN / OVWEN or CMIEN / CMWEN bits, in the RTCIWEN register. Refer to the related register definitions for more details.

RTCOUT Output Pin Configuration

The following table shows RTCOUT output format according to the mode, polarity and event selection setting.

Table 40. RTCOUT Output Mode and Active Level Setting

ROWM	ROES	RTCOUT Output Waveform
0 (Pulse mode)	0 Compare match	
	1 Second clock	
1 (Level mode)	0 Compare match	
	1 Second clock	

T_R: RTCOUT output pulse time = 1 / f_{CK_RTC}
→: Cleared by software reading ROLF bit

Register Map

The following table shows the RTC registers and reset values. Note all the registers in this unit are located at the V_{DD15} power domain.

Table 41. RTC Register Map

Register	Offset	Description	Reset Value
RTCCNT	0x000	RTC Counter Register	0x0000_0000
RTCCMP	0x004	RTC Compare Register	0x0000_0000
RTCCR	0x008	RTC Control Register	0x0000_0F04
RTCSR	0x00C	RTC Status Register	0x0000_0000
RTCIWEN	0x010	RTC Interrupt and Wakeup Enable Register	0x0000_0000

Register Descriptions

RTC Counter Register – RTCCNT

This register defines a 24-bit up-counter which is incremented by the CK_SECOND clock.

Offset: 0x000

Reset value: 0x0000_0000 (Reset by V_{DD15} Power Domain reset only)

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	RTCCNTV							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	RTCCNTV							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	7	6	5	4	3	2	1	0
	RTCCNTV							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[23:0]	RTCCNTV	RTC Counter Value The current value of the RTC counter is returned when reading the RTCCNT register. The RTCCNT register is updated during the falling edge of the CK_SECOND. This register is reset by one of the following conditions: - Software reset – Set the PWCURST bit in the PWRCR register - V_{DD15} Power Domain power on reset – POR15 - Compare match (RTCCNT = RTCCMP) when CMPCLR = 1 (in the RTCCR register) - RTCEN bit changed from 0 to 1

RTC Compare Register – RTCCMP

This register defines a specific value to be compared with the RTC counter value.

Offset: 0x004

Reset value: 0x0000_0000 (Reset by V_{DD15} Power Domain reset only)

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	RTCCMPV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	RTCCMPV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	RTCCMPV							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[23:0]	RTCCMPV	RTC Compare Match Value A match condition happens when the value in the RTCCNT register is equal to RTCCMP value. An interrupt can be generated if the CMIEN bit in the RTCIWEN register is set. When the CMPCLR bit in the RTCCR register is set to 0 and a match condition happens, the CMFLAG bit in the RTCSR register is set while the value in the RTCCNT register is not affected and will continue to count until overflow. When the CMPCLR bit is set to 1 and a match condition happens, the CMFLAG bit in the RTCSR register is set and the RTCCNT register will be reset to zero and then the counter continues to count.

RTC Control Register – RTCCR

This register specifies a range of RTC circuitry control bits.

Offset: 0x008

Reset value: 0x0000_0F04 (Reset by V_{DD15} Power Domain reset only)

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved			ROLF	ROAP	ROWM	ROES	ROEN
Type/Reset				RC 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved				RPRE			
Type/Reset					RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
		Reserved	LSESM	CMPCLR	LSEEN	Reserved	RTCSRC	RTCEN
Type/Reset			RW 0	RW 0	RW 0		RW 0	RW 0

Bits	Field	Descriptions
[20]	ROLF	RTCOUT Level Mode Flag 0: RTCOUT Output is inactive 1: RTCOUT Output is holding as active level Set by hardware when in the level mode (ROWM = 1) and an RTCOUT output event occurred. Cleared by software reading this flag. The RTCOUT signal will return to the inactive level after software has read this bit.
[19]	ROAP	RTCOUT Output Active Polarity 0: Active level is high 1: Active level is low
[18]	ROWM	RTCOUT Output Waveform Mode 0: Pulse mode The output pulse duration is one RTC clock (CK_RTC) period. 1: Level mode The RTCOUT signal will remain at an active level until the ROLF bit is cleared by software reading the ROLF bit.
[17]	ROES	RTCOUT Output Event Selection 0: RTC compare match is selected 1: RTC second clock (CK_SECOND) event is selected The ROES bit can be used to select whether the RTCOUT signal is output on the RTCOUT pin when an RTC compare match event or the RTC second clock (CK_SECOND) event occurs.
[16]	ROEN	RTCOUT Output Pin Enable 0: Disable RTCOUT output pin 1: Enable RTCOUT output pin When the ROEN bit is set to 1, the RTCOUT signal will be at an active level once a RTC compare match or the RTC second clock (CK_SECOND) event occurs. The active polarity and output waveform mode can be configured by the ROAP and ROWM bits respectively. When the ROEN bit is cleared to 0, the RTCOUT pin will be in a floating state.

Bits	Field	Descriptions
[11:8]	RPRE	RTC Clock Prescaler Select CK_SECOND = CK_RTC / 2^{RPRE} 0000: CK_SECOND = CK_RTC / 2^0 0001: CK_SECOND = CK_RTC / 2^1 0010: CK_SECOND = CK_RTC / 2^2 … 1111: CK_SECOND = CK_RTC / 2^{15}
[5]	LSESM	LSE oscillator Startup Mode 0: Normal startup and requires less operating power 1: Fast startup but requires higher operating current
[4]	CMPCLR	Compare Match Counter Clear 0: RTC counter is not affected when compare match condition occurs 1: RTC counter is cleared when compare match condition occurs
[3]	LSEEN	LSE oscillator Enable Control 0: LSE oscillator is disabled 1: LSE oscillator is enabled
[1]	RTCSRC	RTC Clock Source Selection 0: LSI oscillator is selected as the RTC clock source 1: LSE oscillator is selected as the RTC clock source
[0]	RTCEN	RTC Enable Control 0: RTC is disabled 1: RTC is enabled

RTC Status Register – RTCSR

This register stores the counter flags.

Offset: 0x00C

Reset value: 0x0000_0000 (Reset by V_{DD15} Power Domain reset and RTCEN bit change from 1 to 0)

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved					OVFLAG	CMFLAG	CSECFLAG
Type/Reset						RC 0	RC 0	RC 0

Bits	Field	Descriptions
[2]	OVFLAG	Counter Overflow Flag 0: Counter overflow does not occur since the last RTCSR register read operation 1: Counter overflow has occurred since the last RTCSR register read operation This bit is set by hardware when the counter value in the RTCCNT register changes from 0xFF_FFFF to 0x00_0000 and cleared by read operation. This bit is suggested to read in the RTC IRQ handler and should be taken care when software polling is used.
[1]	CMFLAG	Compare Match Condition Flag 0: Compare match condition does not occur since the last RTCSR register read operation 1: Compare match condition has occurred since the last RTCSR register read operation. This bit is set by hardware on the CK_SECOND clock falling edge when the RTCCNT register value is equal to the RTCCMP register content. It is cleared by software reading this bit. This bit is suggested for access in the corresponding RTC interrupt routine – do not use software polling during software free running.
[0]	CSECFLAG	CK_SECOND Occurrence Flag 0: CK_SECOND does not occur since the last RTCSR register read operation 1: CK_SECOND has occurred since the last RTCSR register read operation This bit is set by hardware on the CK_SECOND clock falling edge. It is cleared by software reading this bit. This bit is suggested for access in the corresponding RTC interrupt routine – do not use software polling during software free running.

RTC Interrupt and Wakeup Enable Register – RTCIWEN

This register contains the interrupt and wakeup enable bits.

Offset: 0x010

Reset value: 0x0000_0000 (Reset by V_{DD15} Power Domain reset only)

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					OVWEN	CMWEN	CSECWEN
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved					OVIEN	CMIEN	CSECIEN
Type/Reset						RW 0	RW 0	RW 0

Bits	Field	Descriptions
[10]	OVWEN	Counter Overflow Wakeup Enable 0: Counter overflow wakeup is disabled 1: Counter overflow wakeup is enabled
[9]	CMWEN	Compare Match Wakeup Enable 0: Compare match wakeup is disabled 1: Compare match wakeup is enabled
[8]	CSECWEN	Counter Clock CK_SECOND Wakeup Enable 0: Counter Clock CK_SECOND wakeup is disabled 1: Counter Clock CK_SECOND wakeup is enabled
[2]	OVIEN	Counter Overflow Interrupt Enable 0: Counter Overflow Interrupt is disabled 1: Counter Overflow Interrupt is enabled
[1]	CMIEN	Compare Match Interrupt Enable 0: Compare Match Interrupt is disabled 1: Compare Match Interrupt is enabled
[0]	CSECIEN	Counter Clock CK_SECOND Interrupt Enable 0: Counter Clock CK_SECOND Interrupt is disabled 1: Counter Clock CK_SECOND Interrupt is enabled

18 Watchdog Timer (WDT)

Introduction

The Watchdog Timer is a hardware timing circuitry that can be used to detect a system lock-up due to software trapped in a deadlock. The Watchdog Timer can be operated in a reset mode. The Watchdog Timer will generate a reset when the counter counts down to a zero value. Therefore, the software should reload the counter value before a Watchdog Timer underflow occurs. In addition, a reset is also generated if the software reloads the counter before it reaches a delta value. That means that the Watchdog Timer prevents a software deadlock that continuously triggers the Watchdog, the reload must occur when the Watchdog Timer value has a value within a limited window of 0 and WDTD. The Watchdog Timer counter can be stopped when the processor is in the debug or the three sleep modes. The register write protection function can be enabled to prevent an unexpected change in the Watchdog Timer configuration.

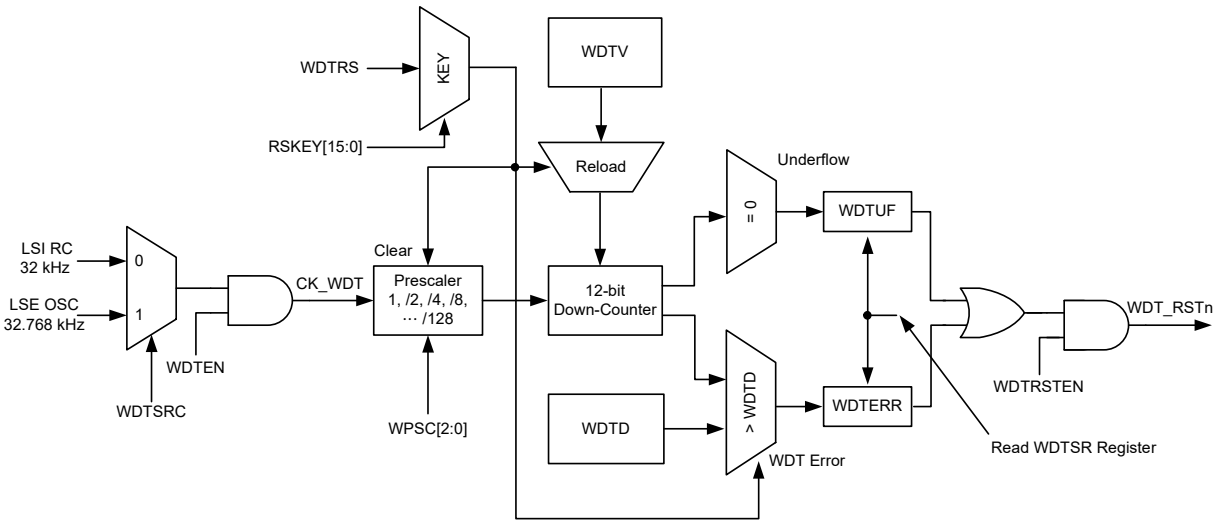


Figure 138. Watchdog Timer Block Diagram

Features

- Clock source from either the internal 32 kHz RC oscillator (LSI) or the external 32,768 Hz oscillator (LSE)
- Can be independently setup to keep running or to stop when entering the Sleep or Deep-Sleep1 mode
- 12-bit down-counter with 3-bit prescaler structure
- Provides reset to the system
- Limited reload window setup function for custom Watchdog Timer reload times
- Watchdog Timer may be stopped when the processor is in the debug mode
- Reload lock key to prevent unexpected operation
- Configuration register write protection function for counter value, reset enable, delta value, and prescaler value

Functional Description

The Watchdog Timer is formed from a 12-bit count-down counter and a fixed 3-bit prescaler. The largest time-out period is 16 seconds, using the LSE or LSI clock and a 1/128 maximum prescaler value.

The Watchdog Timer configuration setup includes programmable counter reload value, reset enable, window value and prescaler value. These configurations are set using the WDTMR0 and WDTMR1 registers which must be properly programmed before the Watchdog Timer starts counting. In order to prevent unexpected write operations to those configurations, a register write protection function can be enabled by writing any value, other than 0x35CA to PROTECT[15:0], in the WDTPR register. A value of 0x35CA can be written to PROTECT[15:0] to disable the register write protection function before accessing any configuration register. A read operation on PROTECT[0] can obtain the enable/disable status of the register write protection function.

During normal operation, the Watchdog Timer counter should be reloaded before it underflows to prevent the generation of a Watchdog reset. The 12-bit count-down counter can be reloaded with the required Watchdog Timer Counter Value (WDTV) by first setting the WDTRS bit to1 with the correct key, which is 0x5FA0 in the WDTCR register.

If a software deadlock occurs during a Watchdog Timer reload routine, the reload operation will still go ahead and therefore the software deadlock cannot be detected. To prevent this situation from occurring, the reload operation must be executed in such a way that the value of the Watchdog Timer counter is limited to within a delta value (WDTD). If the Watchdog Timer counter value is greater than the delta value and a reload operation is executed, a Watchdog Timer error will occur. The Watchdog Timer error will cause a Watchdog reset if the related functional control is enabled. Additionally, the above features can be disabled by programming a WDTD value greater than or equal to the WDTV value.

The WDTERR and WDTUF flags in the WDTSR register will be set respectively when the Watchdog Timer error occurs or when a Watchdog Timer underflows. A system reset or writing “1” operation on the WDTSR register will clear the WDTERR and WDTUF flags.

The Watchdog Timer uses two clocks: PCLK and CK_WDT. The PCLK clock is used for APB access to the watchdog registers. The CK_WDT clock is used for the Watchdog Timer functionality and counting. There is some synchronization logic between these two clock domains.

When the system enters the Sleep mode or Deep-Sleep1 mode, the Watchdog Timer counter will either continue to count or stop depending on the WDTSHLT field setup in the WDTMR0 register. However, the Watchdog Timer will always stop when the system is in the Deep-Sleep2 mode. When the Watchdog stops counting, the count value is retained so that it continues counting after the system is woken up from these three sleep modes. A Watchdog reset will occur any time when the Watchdog Timer is running and when it has an operating clock source. When the system enters the debug mode, the Watchdog Timer counter will either continue to count or stop depending on the DBWDT bit of the MCUDBGCR register in the Clock Control Unit.

The Watchdog timer should be used in the following manners:

- Set the Watchdog Timer reload value (WDTV) and reset in the WDTMR0 register.
- Set the Watchdog Timer delta value (WDTD) and prescaler in the WDTMR1 register.
- Start the Watchdog Timer by writing to the WDTCR register with WDTRS = 1 and RSKEY = 0x5FA0.
- Write to the WDTPR register to lock all the Watchdog Timer registers except for WDTCR and WDTPR.
- The Watchdog Timer counter should be reloaded again within the delta value (WDTD).

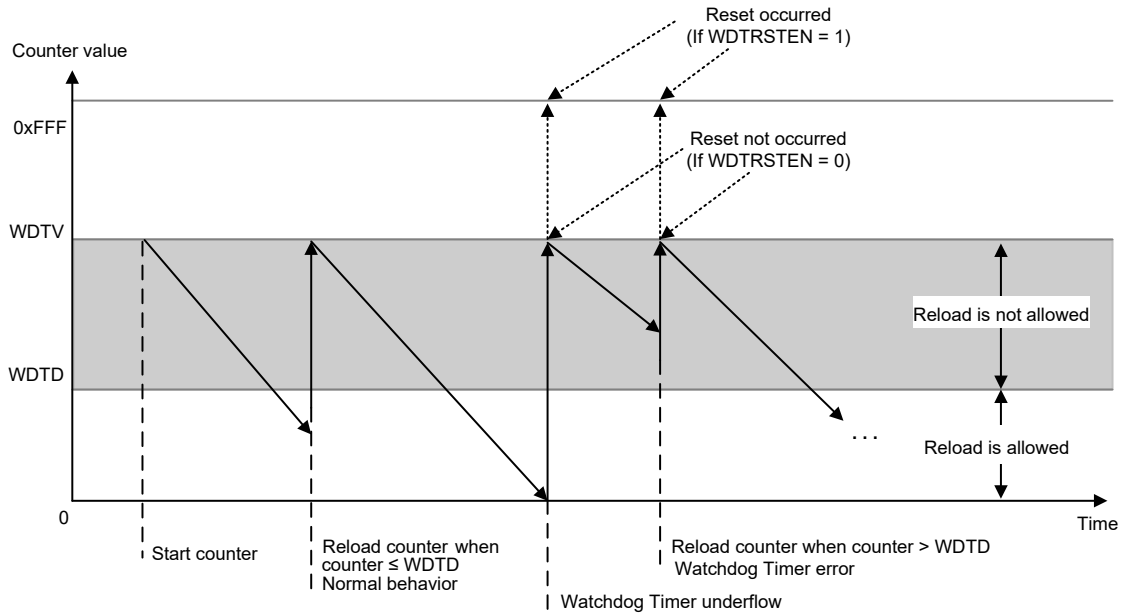


Figure 139. Watchdog Timer Behavior

Register Map

The following table shows the Watchdog Timer registers and reset values.

Table 42. Watchdog Timer Register Map

Register	Offset	Description	Reset Value
WDTCR	0x000	Watchdog Timer Control Register	0x0000_0000
WDTMR0	0x004	Watchdog Timer Mode Register 0	0x0000_0FFF
WDTMR1	0x008	Watchdog Timer Mode Register 1	0x0000_7FFF
WDTSR	0x00C	Watchdog Timer Status Register	0x0000_0000
WDTPR	0x010	Watchdog Timer Protection Register	0x0000_0000
WDTCSR	0x018	Watchdog Timer Clock Selection Register	0x0000_0000

Register Descriptions

Watchdog Timer Control Register – WDTCR

This register is used to reload the Watchdog timer.

Offset: 0x000
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	RSKEY							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	23	**22**	**21**	**20**	**19**	**18**	**17**	**16**
	RSKEY							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
	Reserved							
Type/Reset								
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	Reserved							WDTRS
Type/Reset								WO 0

Bits	Field	Descriptions
[31:16]	RSKEY	Watchdog Timer Reload Lock Key The RSKEY [15:0] bits should be written with a 0x5FA0 value to enable the WDT reload operation function. Writing any other value except 0x5FA0 in this field will abort the write operation.
[0]	WDTRS	Watchdog Timer Reload 0: No effect 1: Reload Watchdog Timer This bit is used to reload the Watchdog timer counter as a WDTV value which is stored in the WDTMR0 register. It is set to 1 by software and cleared to 0 by hardware automatically.

Watchdog Timer Mode Register 0 – WDTMR0

This register specifies the Watchdog timer counter reload value and reset enable control.

Offset: 0x004

Reset value: 0x0000_0FFF

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							WDTEN
Type/Reset								RW 0
	15	14	13	12	11	10	9	8
		WDTSHLT	WDTRSTEN	Reserved	WDTV			
Type/Reset	RW 0	RW 0	RW 0		RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
	WDTV							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1

Bits	Field	Descriptions
[16]	WDTEN	Watchdog Timer Running Enable 0: Watchdog Timer is disabled 1: Watchdog Timer is enabled to run When the Watchdog Timer is disabled, the counter will be reset to its hardware default condition. When the WDTEN bit is set, the Watchdog Timer will be reloaded with the WDTV value and count down.
[15:14]	WDTSHLT	Watchdog Timer Sleep Halt 00: The Watchdog runs when the system is in the Sleep mode or Deep-Sleep1 mode 01: The Watchdog runs when the system is in the Sleep mode and halts in Deep-Sleep1 mode 10 or 11: The Watchdog halts when the system is in the Sleep mode and Deep-Sleep1 mode Note that the Watchdog timer always halts when the system is in the Deep-Sleep2 mode. The Watchdog stops counting when the WDTSHLT field is properly configured in the Sleep mode or Deep-Sleep1 mode. When the Watchdog stops counting, the count value is retained so that it continues counting after the system wakes up from these three sleep modes. If a Watchdog reset occurs in the Sleep or Deep-Sleep1 mode, it will wake up the device.
[13]	WDTRSTEN	Watchdog Timer Reset Enable 0: A Watchdog Timer underflow or error has no effect on the system reset 1: A Watchdog Timer underflow or error triggers a Watchdog Timer system reset
[11:0]	WDTV	Watchdog Timer Counter Value WDTV defines the value loaded into the 12-bit Watchdog down-counter.

Watchdog Timer Mode Register 1 – WDTMR1

This register specifies the Watchdog delta value and the prescaler selection.

Offset: 0x008

Reset value: 0x0000_7FFF

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved	WPSC			WDTD			
Type/Reset		RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1
	7	6	5	4	3	2	1	0
	WDTD							
Type/Reset	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1	RW 1

Bits	Field	Descriptions
[14:12]	WPSC	Watchdog Timer Prescaler Selection 000: 1/1 001: 1/2 010: 1/4 011: 1/8 100: 1/16 101: 1/32 110: 1/64 111: 1/128
[11:0]	WDTD	Watchdog Timer Delta Value Define the permitted range to reload the Watchdog Timer. If the Watchdog Timer counter value is less than or equal to WDTD, writing to the WDTCR register with WDTRS = 1 and RSKEY = 0x5FA0 will reload the timer. If the Watchdog Timer value is greater than WDTD, then writing WDTCR with WDTRS = 1 and RSKEY = 0x5FA0 will cause a Watchdog Timer error. This feature can be disabled by programming a WDTD value greater then or equal to the WDTV value.

Watchdog Timer Status Register – WDTSR

This register specifies the Watchdog timer status.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						WDTERR	WDTUF
Type/Reset							WC 0	WC 0

Bits	Field	Descriptions
[1]	WDTERR	Watchdog Timer Error 0: No Watchdog Timer error has occurred since the last read of this register 1: A Watchdog Timer error has occurred since the last read of this register Note: A reload operation when the Watchdog Timer counter value is larger than WDTD causes a Watchdog Timer error. Note that this bit is a write-one-clear flag.
[0]	WDTUF	Watchdog Timer Underflow 0: No Watchdog Timer underflow has occurred since the last read of this register 1: A Watchdog Timer underflow has occurred since the last read of this register Note that this bit is a write-one-clear flag.

Watchdog Timer Protection Register – WDTPR

This register specifies the Watchdog timer protect key configuration.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	PROTECT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	PROTECT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	PROTECT	Watchdog Timer Register Protection For write operation: 0x35CA: Disable the Watchdog Timer register write protection Others: Enable the Watchdog Timer register write protection For read operation: 0x0000: Watchdog Timer register write protection is disabled 0x0001: Watchdog Timer register write protection is enabled This register is used to enable/disable the Watchdog timer configuration register write protection function. All configuration registers become read only except for WDTCR and WDTPR when the register write protection is enabled. Additionally, the read operation of PROTECT[0] can obtain the enable/disable status of the register write protection function.

Watchdog Timer Clock Selection Register – WDTCSR

This register specifies the Watchdog timer clock source selection and lock configuration.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved			WDTLOCK	Reserved			WDTSRC
Type/Reset				RW				RW
				0				0

Bits	Field	Descriptions
[4]	WDTLOCK	Watchdog Timer Lock Mode 0: This bit is only set to 0 on any reset. It can not be cleared by software. 1: This bit is set once only by software and locks the Watchdog Timer function. Software can set this bit to 1 at any time. Once the WDTLOCK bit is set, the function and registers of the Watchdog Timer cannot be modified or disabled, including the Watchdog Timer clock source. The lock mode can only be disabled until a system reset occurs.
[0]	WDTSRC	Watchdog Timer Clock Source Selection 0: Internal 32 kHz RC oscillator clock is selected (LSI) 1: External 32.768 kHz crystal oscillator clock is selected (LSE) Select using software to control the Watchdog timer clock source.

19 Inter-Integrated Circuit (I²C)

Introduction

The I²C Module is an internal circuit allowing communication with an external I²C interface which is an industry standard two-wire serial interface used for connection to external hardware. These two serial lines are known as a serial data line, SDA, and a serial clock line, SCL. The I²C module provides three data transfer rates: (1) 100 kHz in the Standard mode, (2) 400 kHz in the Fast mode and (3) 1 MHz in the Fast mode plus. The SCL period generation registers are used to setup different kinds of duty cycle implementation for the SCL pulse.

The SDA line which is connected to the whole I²C bus is a bidirectional data line between the master and slave devices used for the transmission and reception of data. The I²C module also has an arbitration detection function to prevent the situation where more than one master attempts to transmit data on the I²C bus at the same time.

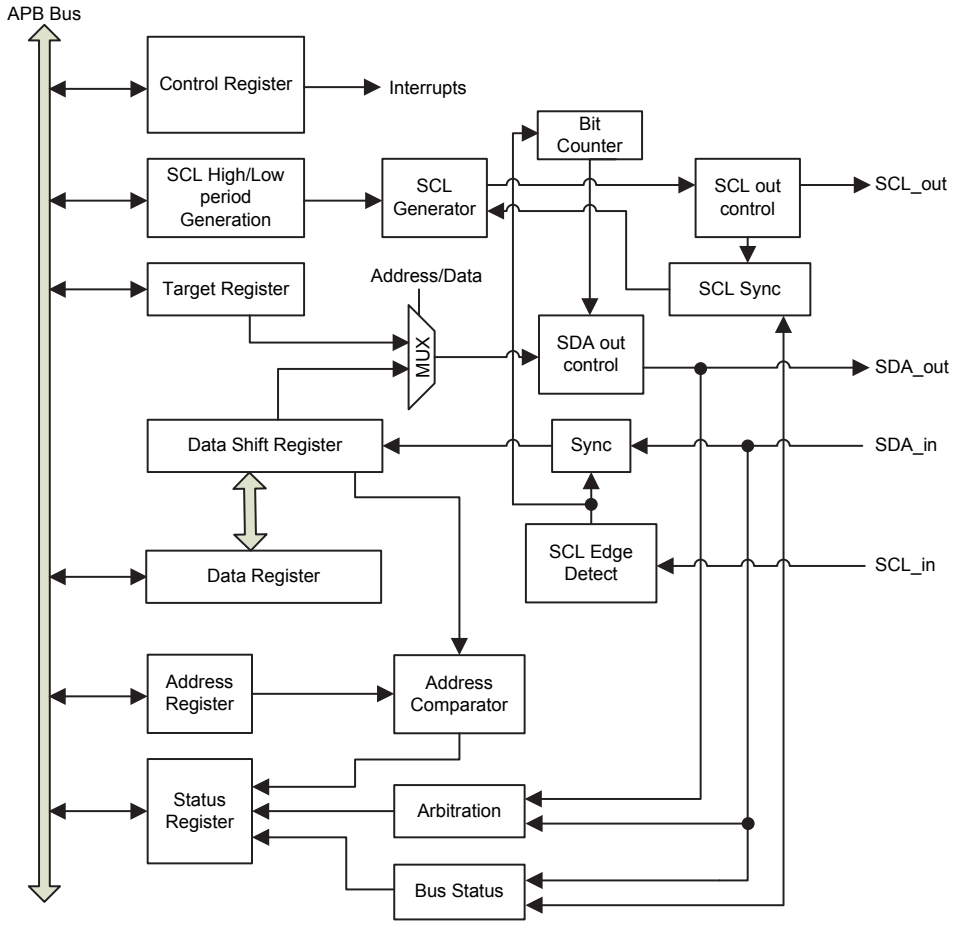


Figure 140. I²C Module Block Diagram

Features

- Two-wire I²C serial interface
  - Serial data line (SDA) and serial clock (SCL)
- Multiple speed modes
  - Standard mode – 100 kHz
  - Fast mode – 400 kHz
  - Fast mode plus – 1 MHz
- Bidirectional data transfer between master and slave
- Multi-master bus – no central master
  - The same interface can act as Master or Slave
- Arbitration among simultaneously transmitting masters without corrupting serial data on the bus
- Clock synchronization
  - Allow devices with different bit rates to communicate via one serial bus
- Supports 7-bit and 10-bit addressing mode and general call addressing
- Multiple slave addresses using address mask function
- Timeout function

Functional Descriptions

Two-Wire Serial Interface

The I²C module has two external lines, the serial data SDA and serial clock SCL lines, to carry information between the interconnected devices connected to the bus. The SCL and SDA lines are both bidirectional and must be connected to a pull-high resistor. When the I²C bus is in the free or idle state, both pins are at a high level to perform the required wired-AND function for multiple connected devices.

START and STOP Conditions

A master device can initialize a transfer by sending a START signal and terminate the transfer with a STOP signal. A START signal is usually referred to as the “S” bit, which is defined as a High to Low transition on the SDA line while the SCL line is high. A STOP signal is usually referred to as the “P” bit, which is defined as a Low to High transition on the SDA line while SCL is high.

A repeated START signal, which is denoted as the “Sr” bit, is functionally identical to the normal START condition. A repeated START signal allows the I²C interface to communicate with another slave device or with the same device but in a different transfer direction without releasing the I²C bus control.

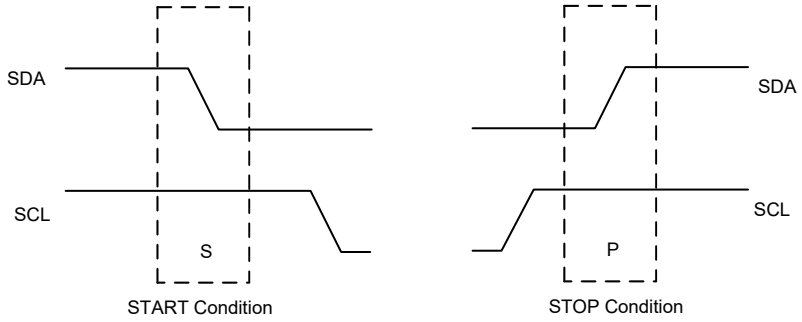


Figure 141. START and STOP Condition

Data Validity

The data on the SDA line must be stable during the high period of the SCL clock. The SDA data state can only be changed when the clock signal on the SCL line is in a low state.

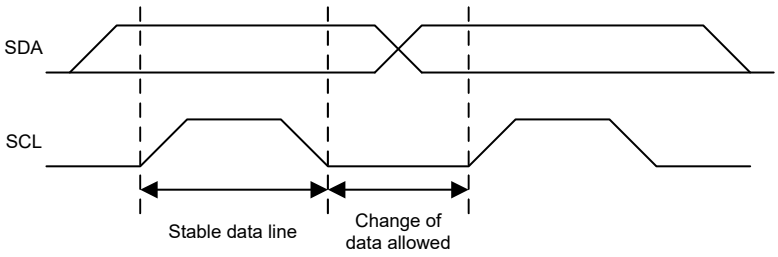


Figure 142. Data Validity

Addressing Format

The I²C interface starts to transfer data after the master device has sent the address to confirm the targeted slave device. The address frame is sent just after the START signal by the master device. The addressing mode selection bit named ADRM in the I2CCR register should be defined to choose either the 7-bit or 10-bit addressing mode.

7-bit Address Format

The 7-bit address format is composed of the 7-bit length slave address, which the master device wants to communicate, with a R/$\overline{W}$ bit and an ACK bit. The R/$\overline{W}$ bit defines the direction of the data transfer.

R/$\overline{W}$ = 0 (Write): The master transmits data to the addressed slave.

R/$\overline{W}$ = 1 (Read): The master receives data from the addressed slave.

The slave address can be assigned through the ADDR field in the I2CADDR register. The slave device sends back the acknowledge bit (ACK) if its slave address matches the transmitted address sent by master.

Note that it is forbidden to own the same address for two slave devices.

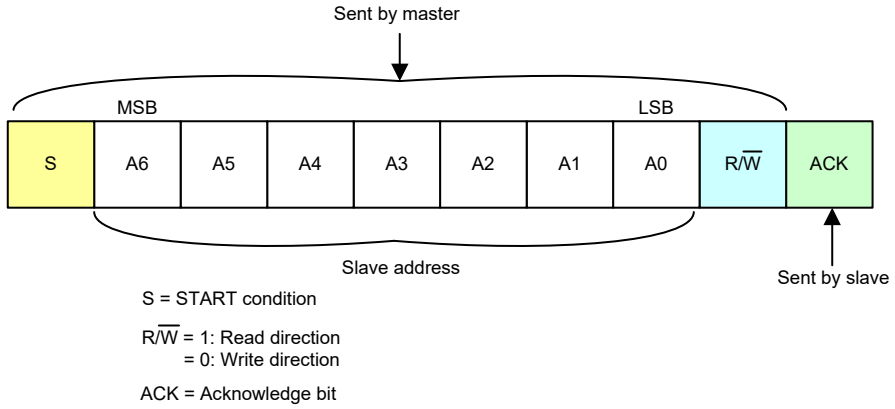


Figure 143. 7-bit Addressing Mode

10-bit Address Format

In order to prevent address clashes, due to the limited range of the 7-bit addresses, a new 10-bit address scheme has been introduced. This enhancement can be mixed with the 7-bit addressing mode which increases the available address range about ten times. For the 10-bit addressing mode, the first two bytes after a START signal include a header byte and an address byte that usually determines which slave will be selected by the master. The header byte is composed of a leading "11110", the 10th and 9th bits of the slave address. The second byte is the remaining 8 bits of the slave device address.

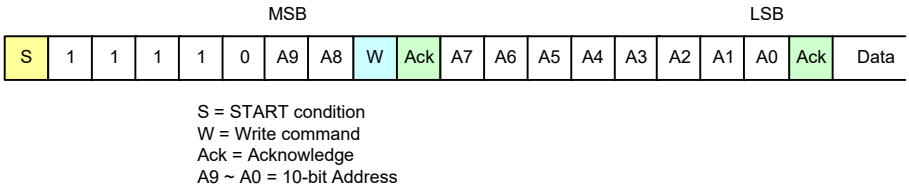


Figure 144. 10-bit Addressing Write Transmit Mode

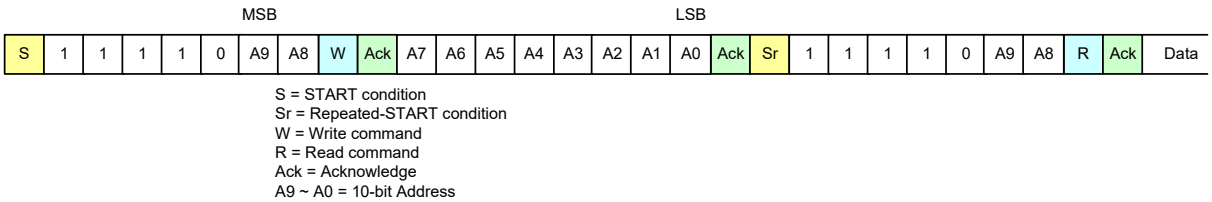


Figure 145. 10-bit Addressing Read Receive Mode

Data Transfer and Acknowledge

Once the slave device address has been matched, the data can be transmitted to or received from the slave device according to the transfer direction specified by the R/$\overline{W}$ bit. Each byte is followed by an acknowledge bit on the 9th SCL clock.

If the slave device returns a Not Acknowledge (NACK) signal to the master device, the master device can generate a STOP signal to terminate the data transfer or generate a repeated START signal to restart the transfer.

If the master device sends a Not Acknowledge (NACK) signal to the slave device, the slave device should release the SDA line for the master device to generate a STOP signal to terminate the transfer.

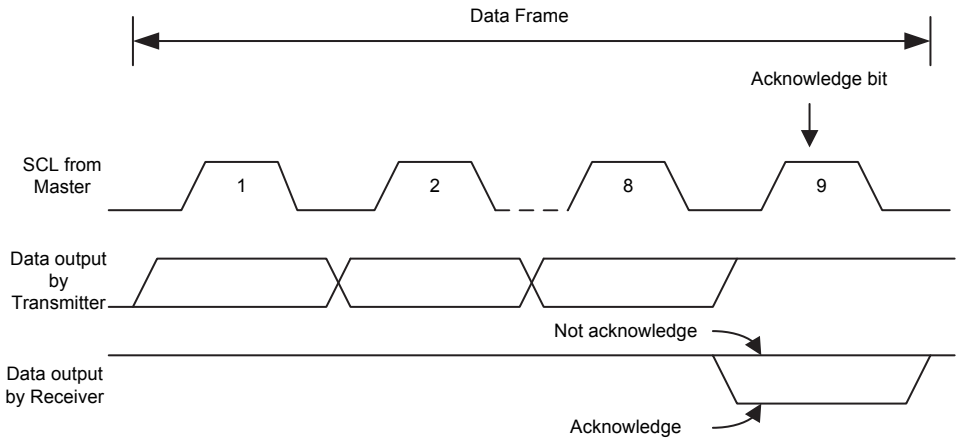


Figure 146. I²C Bus Acknowledge

Clock Synchronization

Only one master device can generate the SCL clock under normal operation. However when there is more than one master trying to generate the SCL clock, the clock should be synchronized so that the data output can be compared. Clock synchronization is performed using the wired-AND connection of the I²C interface to the SCL line.

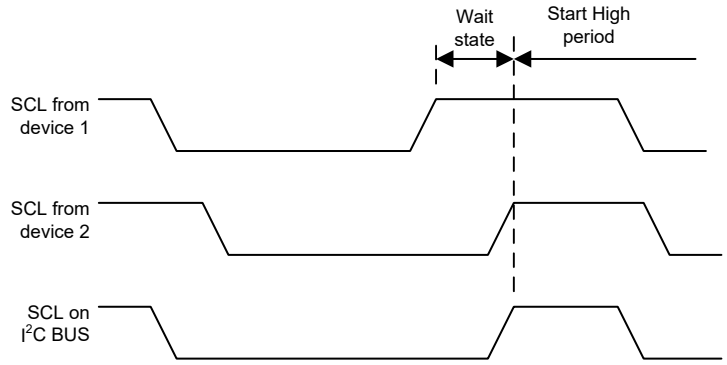


Figure 147. Clock Synchronization during Arbitration

Arbitration

A master may start a transfer only if the I²C bus line is in the free or idle mode. If two or more masters generate a START signal at approximately the same time, an arbitration procedure will occur.

Arbitration takes place on the SDA line and can continue for many bits. The arbitration procedure gives a higher priority to the device that transmits serial data with a binary low bit (logic low). Other master devices which want to transmit binary high bits (logic high) will lose the arbitration. As soon as a master loses the arbitration, the I²C module will set the ARBLOS bit in the I2CSR register and generate an interrupt if the interrupt enable bit, ARBLOSIE, in the I2CIER register is set to 1. Meanwhile, it stops sending data and listens to the bus in order to detect an I²C stop signal. When the stop signal is detected, the master which has lost the arbitration may try to access the bus again.

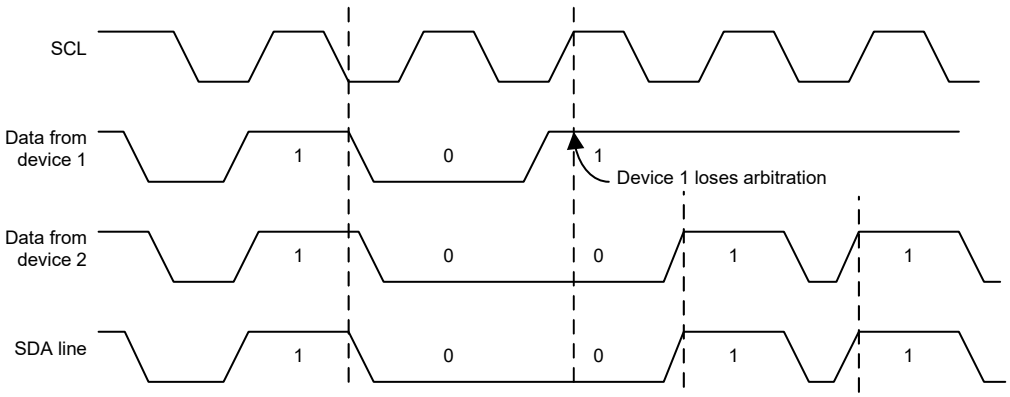


Figure 148. Two Master Arbitration Procedure

General Call Addressing

The general call addressing function can be used to address all the devices connected to the I²C bus. The master device can activate the general call function by configuring the TAR field value to zero field and clearing the RWD bit to 0 in the I2CTAR register on the addressing frame.

The device can support the general call addressing function by setting the corresponding enable control bit GCEN to 1. If the GCEN bit is set to 1 to support the general call addressing, the AA bit in the I2CCR register should also be set to 1 to send an acknowledge signal back when the device receives an address frame with a value of 00H. When this condition occurs, the general call flag, GCS, will be set to 1, but the ADRS flag will not be set.

Bus Error

If an unpredictable START or STOP condition occurs when the data is being transferred on the I²C bus, it will be considered as a bus error and the transferring data will be aborted. When a bus error event occurs, the relevant bus error flag BUSERR in the I2CSR register will set to 1 and both the SDA and SCL lines are released. The BUSERR flag should be cleared by writing a 1 to it to initiate the I²C module to an idle state.

Address Mask Enable

The I²C module provides an address mask function for users to decide which address bit can be ignored during the comparison with the address frame sent from the master. The ADRS flag will be asserted when the unmasked address bits and the address frame sent from the master are matched. Note that this function is only available in the slave mode.

For instance, the user sets a data transfer with the 7-bit addressing mode together with the I2CADDMR register value as 0x05h and the I2CADDR register value as 0x55h, this means if an address which is sent by an I²C master on the bus is equal to 0x50h, 0x51h, 0x54h or 0x55h, the I²C slave address will all be considered to be matched and the ADRS flag in the I2CSR register will be asserted after the address frame.

Address Snoop

The Address Snoop register, I2CADDSR, is used to monitor the calling address on the I²C bus during the whole data transfer operation no matter if the I²C module operates as a master or a slave device. Note that the I2CADDSR register is a read only register and each calling address on the I²C bus will be stored in the I2CADDSR register automatically even if the I²C device is not addressed.

Operation Mode

The I²C module can operate in the following modes:

- Master Transmitter
- Master Receiver
- Slave Transmitter
- Slave Receiver

The I²C module operates in the slave mode by default. The interface will switch to the master mode automatically after generating a START signal.

Master Transmitter Mode

Start Condition

Users write the target slave device address and communication direction into the I2CTAR register after setting the I2CEN bit in the I2CCR register. The STA flag in the I2CSR register is set by hardware after a start condition occurs. In order to send the following address frame, the STA flag must be cleared to 0 if it has been set to 1. The STA flag is cleared by reading the I2CSR register.

Address Frame

The ADRS flag in the I2CSR register will be set after the address frame is sent by the master device and the acknowledge signal from the address matched slave device is received. In order to send the following data frame, the ADRS flag must be cleared to 0 if it has been set to 1. The ADRS bit is cleared by reading the I2CSR register.

Data Frame

The data to be transmitted to the slave device must be transferred to the I2CDR register.

The TXDE bit in the I2CSR register is set to indicate that the I2CDR register is empty, which results in the SCL line being held at a logic low state. New data must then be transferred to the I2CDR register to continue the data transfer process. Writing a data into the I2CDR register will clear the TXDE flag.

Close / Continue Transmission

After transmitting the last data byte, the STOP bit in the I2CCR register can be set to terminate the transmission or re-assign another slave device by configuring the I2CTAR register to restart a new transfer.

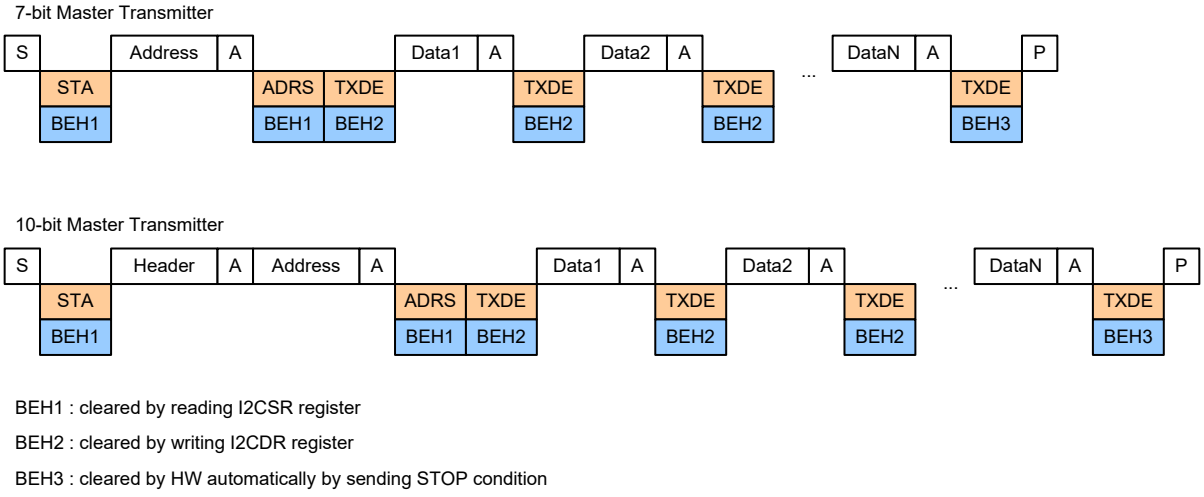


Figure 149. Master Transmitter Timing Diagram

Master Receiver Mode

Start Condition

The target slave device address and communication direction must be written into the I2CTAR register. The STA flag in the I2CSR register is set by hardware after a start condition occurs. In order to send the following address frame, the STA flag must be cleared to 0 if it has been set to 1. The STA flag is cleared by reading the I2CSR register.

Address Frame

In the 7-bit addressing mode: The ADRS flag is set after the address frame is sent by the master device and the acknowledge signal from the address matched slave device is received. In order to receive the following data frame, the ADRS bit must be cleared to 0 if it has been set to 1. The ADRS bit is cleared after reading the I2CSR register.

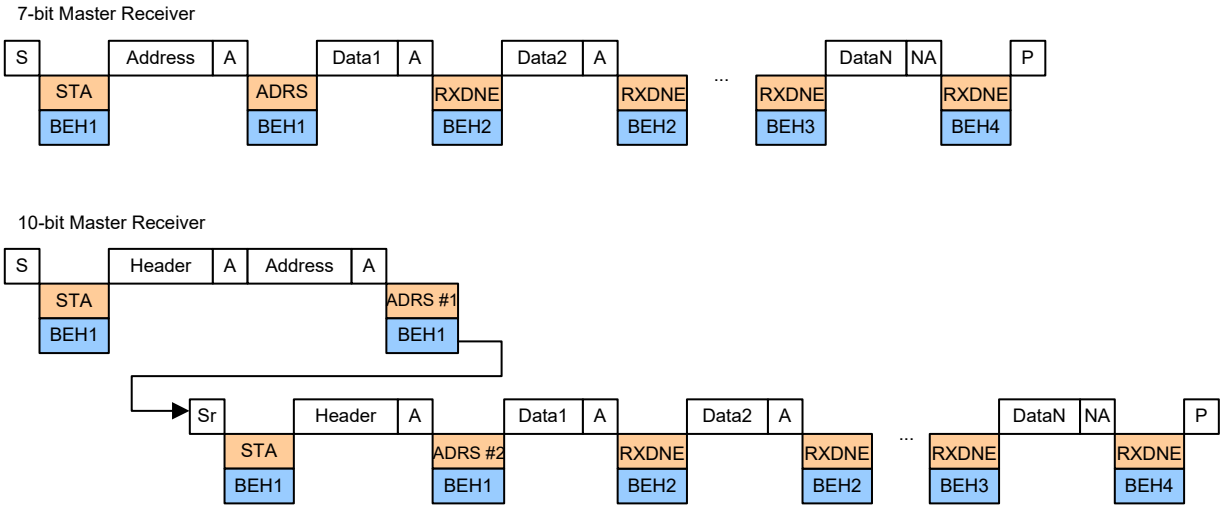
In the 10-bit addressing mode: The ADRS bit in the I2CSR register will be set twice in the 10-bit addressing mode. The first time the ADRS bit is set is when the 10-bit address is sent and the acknowledge signal from the slave device is received. The second time the ADRS bit is set is when the header byte is sent and the slave acknowledge signal is received. In order to receive the following data frame, the ADRS bit must be cleared to 0 if it has been set to 1. The ADRS bit is cleared after reading the I2CSR register. The detailed master receiver mode timing diagram is shown in the following figure.

Data Frame

In the master receiver mode, data is transmitted from the slave device. Once a data is received by the master device, the RXDNE flag in the I2CSR register is set but it will not hold the SCL line. However, if the device receives a complete new data byte and the RXDNE flag has already been set to 1, the RXBF bit in the I2CSR register will be set to 1 and the SCL line will be held at a logic low state. When this situation occurs, data from the I2CDR register should be read to continue the data transfer process. The RXDNE flag can be cleared after reading the I2CDR register.

Close / Continue Transmission

The master device needs to reset the AA bit in the I2CCR register to send a NACK signal to the slave device before the last data byte transfer has been completed. After the last data byte has been received from the slave device, the master device will hold the SCL line at a logic low state following after a NACK signal sent by the master device to the slave device. The STOP bit can be set to terminate the data transfer process or re-assign the I2CTAR register to restart a new transfer.



BEH1 : cleared by reading I2CSR register

BEH2 : cleared by reading I2CDR register

BEH3 : cleared by reading I2CDR register, set AA=0 to send NACK signal

BEH4 : cleared by reading I2CDR register, set STOP=1 to send STOP signal

Figure 150. Master Receiver Timing Diagram

Slave Transmitter Mode

Address Frame

In the 7-bit addressing mode, the ADRS bit in the I2CSR register is set after the slave device receives the calling address which matches with the slave device address. In the 10-bit addressing mode, the ADRS bit is set for the first time when the first header byte and the second address byte are both matched. Note that when the second header byte is also matched, the ADRS bit will be set again. After the ADRS bit has been set to 1, it must be cleared to 0 to continue the data transfer process. The ADRS bit is cleared after reading the I2CSR register.

Data Frame

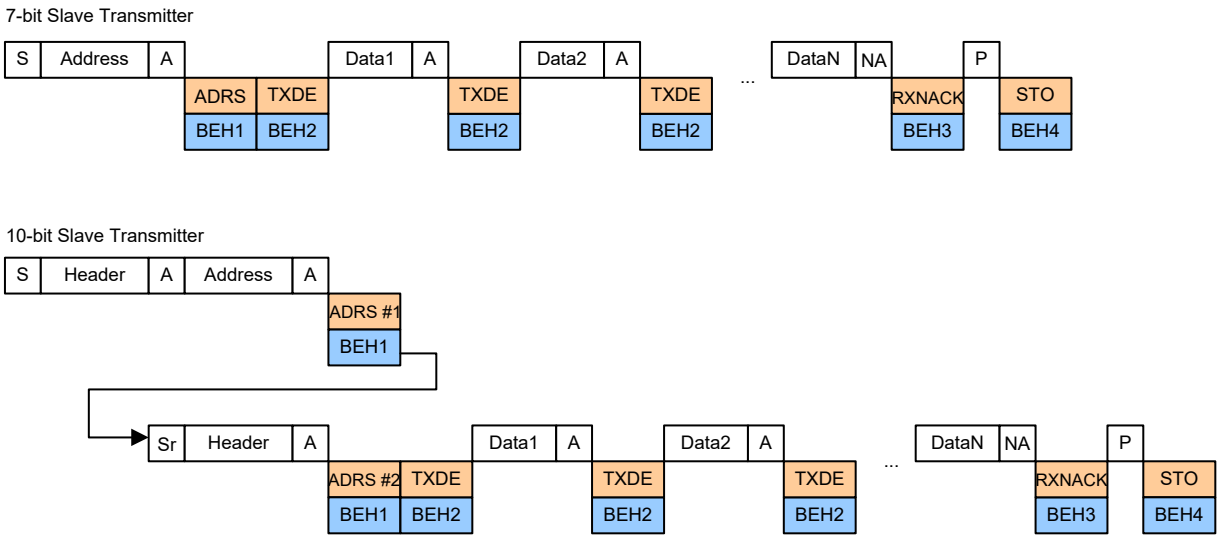
In the Slave transmitter mode, the TXDE bit is set to indicate that the I2CDR is empty, which results in the SCL line being held at a logic low state. New transmission data must then be written into the I2CDR register to continue the data transfer process. Writing a data into the I2CDR register will clear the TXDE bit.

Receive Not-Acknowledge

When the slave device receives a Not-Acknowledge signal, the RXNACK bit in the I2CSR Register is set but it will not hold the SCL line. Writing "1" to RXNACK will clear the RXNACK flag.

STOP Condition

When the slave device detects a STOP condition, the STO bit in the I2CSR register is set to indicate that the I^2C interface transmission is terminated. Reading the I2CSR register can clear the STO flag.



BEH1 : cleared by reading I2CSR register

BEH2 : cleared by writing I2CDR register

BEH3 : cleared by writing 1 clear for RXNACK flag, TXDE is not set when NACK is received.

BEH4 : cleared by reading I2CSR register

Figure 151. Slave Transmitter Timing Diagram

Slave Receiver Mode

Address Frame

The ADRS bit in the I2CSR register is set after the slave device receives the calling address which matches with the slave device address. After the ADRS bit has been set to 1, it must be cleared to 0 to continue the data transfer process. The ADRS flag is cleared after reading the I2CSR register.

Data Frame

In the slave receiver mode, the data is transmitted from the master device. Once a data byte is received by the slave device, the RXDNE flag in the I2CSR register is set but it will not hold the SCL line. However, if the device receives a complete new data byte and the RXDNE bit has been set to 1, the RXBF bit in the I2CSR register will be set to 1 and the SCL line will be held at a logic low state. When this situation occurs, data from the I2CDR register should be read to continue the data transfer process. The RXDNE flag bit can be cleared after reading the I2CDR register.

STOP Condition

When the slave device detects a STOP condition, the STO flag bit in the I2CSR register is set to indicate that the I²C interface transmission is terminated. Reading the I2CSR register can clear the STO flag bit.

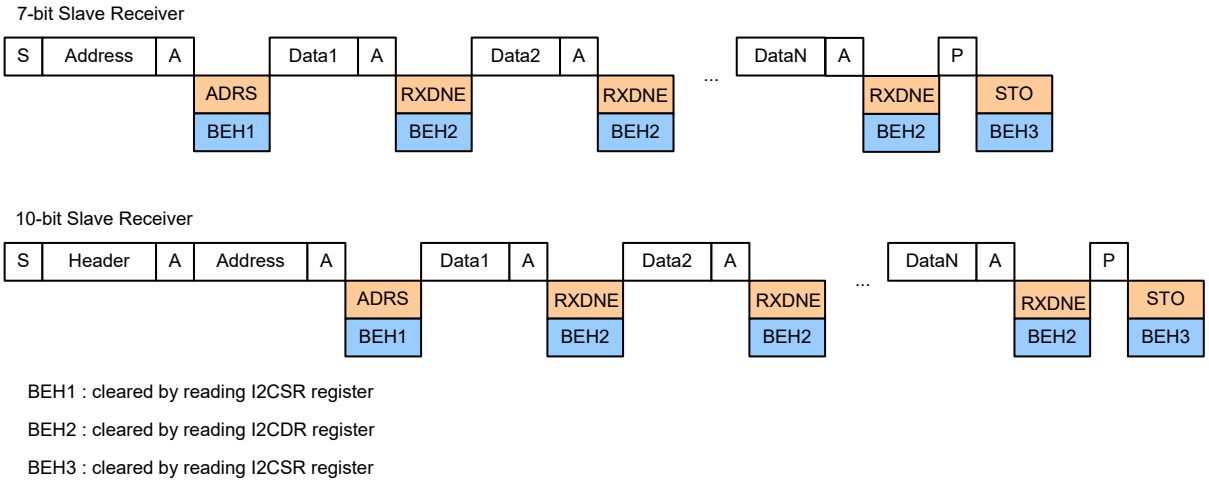


Figure 152. Slave Receiver Timing Diagram

Conditions of Holding SCL Line

The following conditions will cause the SCL line to be held at a logic low state by hardware resulting in all the I²C transfers being stopped. Data transfer will be continued after the creating conditions are eliminated.

Table 43. Conditions of Holding SCL line

Type	Condition	Description	Eliminated
Flag	TXDE	I²C is used in transmitted mode and I2CDR register needs to have data to transmit. (Note: TXDE won't be assert after receiving a NACK)	Master case: Writing data to I2CDR register Set TAR Set STOP Slave case: Writing data to I2CDR register
	GCS	I²C is addressed as slave through general call	Reading I2CSR register
	ADRS	Master: I²C is sent over address frame and is returned an ACK from slave (Note: Reference Fig.147 and Fig.148) Slave: I²C is addressed as slave device (Note: Reference Fig.149 and Fig.150)	Reading I2CSR register
	STA	Master sends a START signal	Reading I2CSR register
	RXBF	Received a complete new data and meanwhile the RXDNE flag has been set already before.	Reading I2CDR register
Event	Master receives NACK	No matter in address or data frame, once received a NACK signal will hold SCL line in master mode.	Set TAR Set STOP
	Master sends NACK used in receive mode	Occurred when receiving the last data byte in Master receive mode (Note: Reference Fig.148, and RXNACK flag won't be asserted in this case)	Set TAR Set STOP

I²C Timeout Function

In order to reduce the occurrence of I²C lockup problem due to the reception of erroneous clock source, a timeout function is provided. If the I²C bus clock source is not received for a certain timeout period, then a corresponding I²C timeout flag will be asserted. This timeout period is determined by a 16-bit down-counting counter with a programmable preload value. The timeout counter is driven by the I²C timeout clock, f_{I2CTO}, which is specified by the timeout prescaler field in the I2CTOUT register. The TOUT field in the I2CTOUT register is used to define the timeout counter preload value. The timeout function is enabled by setting the ENTOUT bit in the I2CCR register. The timeout counter will start to count down from the preloaded value if the ENTOUT bit is set to 1 and one of the following conditions occurs:

- The I²C master module sends a START signal.
- The I²C slave module detects a START signal.
- The RXBF, TXDE, RXDNE, RXNACK, GCS or ADRS flags is asserted.

The timeout counter will stop counting when the ENTOUT bit is cleared. However, the counter will also stop counting when one of the conditions, listed as follows, occurs:

- The I²C slave module is not addressed.
- The I²C slave module detects a STOP signal.
- The I²C master module sends a STOP signal.
- The ARBLOS or BUSERR flag in the I2CSR register are asserted.

If the timeout counter underflows, the corresponding timeout flag, TOUTF, in the I2CSR register will be set to 1 and a timeout interrupt will be generated if the relevant interrupt is enabled.

Register Map

The following table shows the I²C registers and reset values.

Table 44. I²C Register Map

Register	Offset	Description	Reset Value
I2CCR	0x000	I²C Control Register	0x0000_2000
I2CIER	0x004	I²C Interrupt Enable Register	0x0000_0000
I2CADDR	0x008	I²C Address Register	0x0000_0000
I2CSR	0x00C	I²C Status Register	0x0000_0000
I2CSHPGR	0x010	I²C SCL High Period Generation Register	0x0000_0000
I2CSLPGR	0x014	I²C SCL Low Period Generation Register	0x0000_0000
I2CDR	0x018	I²C Data Register	0x0000_0000
I2CTAR	0x01C	I²C Target Register	0x0000_0000
I2CADDMR	0x020	I²C Address Mask Register	0x0000_0000
I2CADDSR	0x024	I²C Address Snoop Register	0x0000_0000
I2CTOUT	0x028	I²C Timeout Register	0x0000_0000

Register Descriptions

I²C Control Register – I2CCR

This register specifies the corresponding I²C function enable control.

Offset: 0x000 (0)
Reset value: 0x0000_2000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	SEQFILTER		COMBFILTEREN	ENTOUT	Reserved			
Type/Reset	RW	0 RW 0	RW	1 RW 0				
	7	6	5	4	3	2	1	0
	ADRM	Reserved			I2CEN	GCEN	STOP	AA
Type/Reset	RW	0			RW	0 RW 0	RW	0 RW 0

Bits	Field	Descriptions
[15:14]	SEQFILTER	SDA or SCL Input Sequential Filter Configuration Bits 00: Sequential filter is disabled 01: 1 PCLK glitch filter 1x: 2 PCLK glitch filter Note: This setting would affect the frequency of SCL. Detail is described in I2CSLPGR register.
[13]	COMBFILTEREN	SDA or SCL Input Combinational Filter Enable Bit 0: Combinational filter is disabled 1: Combinational filter is enabled
[12]	ENTOUT	I²C Timeout Function Enable Control 0: Timeout Function is disabled 1: Timeout Function is enabled This bit is used to enable or disable the I²C timeout function. It is recommended that users have to properly configure the PSC and TOUT fields in the I2CTOUT register before the timeout counter starts to count by setting the ENOUT bit to 1.
[7]	ADRM	Addressing Mode 0: 7-bit addressing mode 1: 10-bit addressing mode When the I²C master / slave module operates in the 7-bit addressing mode, it can only send out and respond to a 7-bit address and vice versa.
[3]	I2CEN	I²C Interface Enable 0: I²C interface is disabled 1: I²C interface is enabled

Bits	Field	Descriptions
[2]	GCEN	General Call Enable 0: General call is disabled 1: General call is enabled When the device receives the calling address with a value of 0x00 and if both the GCEN and the AA bits are set to 1, then the I²C interface is addressed as a slave and the GCS bit in the I2CSR register is set to 1.
[1]	STOP	STOP Condition Control 0: No action 1: Send a STOP condition in master mode This bit is set to 1 by software to generate a STOP condition and automatically cleared to 0 by hardware. The STOP bit is only available for the master device.
[0]	AA	Acknowledge Bit 0: Send a Not Acknowledge (NACK) signal after a byte is received 1: Send an Acknowledge (ACK) signal after a byte is received

I²C Interrupt Enable Register – I2CIER

This register specifies the corresponding I²C interrupt enable bits.

Offset: 0x004
Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved					RXBFIE	TXDEIE	RXDNEIE
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	Reserved				TOUTIE	BUSERRIE	RXNACKIE	ARBLOSIE
Type/Reset					RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved				GCSIE	ADRSIE	STOIE	STAIE
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[18]	RXBFIE	RX Buffer Full Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled
[17]	TXDEIE	Data Register Empty Interrupt Enable Bit in Transmitter Mode 0: Interrupt is disabled 1: Interrupt is enabled
[16]	RXDNEIE	Data Register Not Empty Interrupt Enable Bit in Received Mode 0: Interrupt is disabled 1: Interrupt is enabled

Bits	Field	Descriptions
[11]	TOUTIE	Timeout Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled
[10]	BUSERRIE	Bus Error Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled
[9]	RXNACKIE	Received Not Acknowledge Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled
[8]	ARBLOSIE	Arbitration Loss Interrupt Enable Bit in the I²C multi-master mode 0: Interrupt is disabled 1: Interrupt is enabled
[3]	GCSIE	General Call Slave Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled
[2]	ADRSIE	Slave Address Match Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled
[1]	STOIE	STOP Condition Detected Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled The bit is used for the I²C slave mode only.
[0]	STAIE	START Condition Transmit Interrupt Enable Bit 0: Interrupt is disabled 1: Interrupt is enabled The bit is used for the I²C master mode only.

I²C Address Register – I2CADDR

This register specifies the I²C device address.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved						ADDR	
Type/Reset							RW 0	RW 0
	7	6	5	4	3	2	1	0
	ADDR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[9:0]	ADDR	Device Address The register indicates the I²C device address. When the I²C device is used in the 7-bit addressing mode, only the ADDR[6:0] bits will be compared with the received address sent from the I²C master device.

I²C Status Register – I2CSR

This register contains the I²C operation status.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
		Reserved	TXNRX	MASTER	BUSBUSY	RXBF	TXDE	RXDNE
Type/Reset			RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	Reserved				TOUTF	BUSERR	RXNACK	ARBLOS
Type/Reset					WC 0	WC 0	WC 0	WC 0
	7	6	5	4	3	2	1	0
	Reserved				GCS	ADRS	STO	STA
Type/Reset					RC 0	RC 0	RC 0	RC 0

Bits	Field	Descriptions
[21]	TXNRX	Transmitter / Receiver Mode 0: Receiver mode 1: Transmitter mode Read only bit.
[20]	MASTER	Master Mode 0: I²C is in the slave mode or idle 1: I²C is in the master mode The I²C interface is switched as a master device on the I²C bus when the I2CTAR register is assigned and the I²C bus is idle. The MASTER bit is cleared by hardware when software disables the I²C bus by clearing the I2CEN bit to 0 or sends a STOP condition to the I²C bus or the bus error is detected. This bit is set and cleared by hardware and is a read only bit.
[19]	BUSBUSY	Bus Busy 0: I²C bus is idle 1: I²C bus is busy The I²C interface hardware starts to detect the I²C bus status if the interface is enabled by setting the I2CEN bit to 1. It is set to 1 when the SDA or SCL signal is detected to have a logic low state and cleared when a STOP condition is detected.

Bits	Field	Descriptions
[18]	RXBF	Buffer Full Flag in Receiver Mode 0: Data buffer is not full 1: Data buffer is full This bit is set when the data register I2CDR has already stored a data byte and meanwhile the data shift register also has been received a complete new data byte. The RXBF bit is cleared by software reading the I2CDR register.
[17]	TXDE	Data Register Empty Using in Transmitter Mode 0: Data register I2CDR is not empty 1: Data register I2CDR is empty This bit is set when the I2CDR register is empty in the Transmitter mode. Note that the TXDE bit will be set after the address frame is being transmitted to inform that the data to be transmitted should be loaded into the I2CDR register. The TXDE bit is cleared by software writing data to the I2CDR register in both the master and slave mode or cleared automatically by hardware after setting the STOP signal to terminate the data transfer or setting the I2CTAR register to restart a new data transfer in the master mode.
[16]	RXDNE	Data Register Not Empty in Receiver Mode 0: Data register I2CDR is empty 1: Data register I2CDR is not empty This bit is set when the I2CDR register is not empty in the receiver mode. The RXDNE bit is cleared by software reading the data byte from the I2CDR register.
[11]	TOUTF	Timeout Counter Underflow Flag 0: No timeout counter underflow occurred 1: Timeout counter underflow occurred Writing “1” to this bit will clear the TOUTF flag.
[10]	BUSERR	Bus Error Flag 0: No bus error has occurred 1: Bus error has occurred This bit is set by hardware when the I^2C interface detects a misplaced START or STOP condition in a transfer process. Writing a “1” to this bit will clear the BUSERR flag. In Master Mode: Once the Bus Error event occurs, both the SDA and SCL lines are released by hardware and the BUSERR flag is asserted. The application software has to clear the BUSERR flag before the next address byte is transmitted. In Slave Mode: Once a misplaced START or STOP condition has been detected by the slave device, the software must clear the BUSERR flag before the next address byte is received.
[9]	RXNACK	Received Not Acknowledge Flag 0: Acknowledge is returned from receiver 1: Not Acknowledge is returned from receiver The RXNACK bit indicates that the not Acknowledge signal is received in master or slave transmitter mode. Writing “1” to this bit will clear the RXNACK flag.
[8]	ARBLOS	Arbitration Loss Flag 0: No arbitration loss is detected 1: Bit arbitration loss is detected This bit is set by hardware on the current clock which the I^2C interface loses the bus arbitration to another master during the address or data frame transmission. Writing “1” to this bit will clear the ARBLOS flag. Once the ARBLOS flag is asserted by hardware, the ARBLOS flag must be cleared before the next transmission.

Bits	Field	Descriptions
[3]	GCS	General Call Slave Flag 0: No general call slave occurs 1: I²C interface is addressed by a general call command When the I²C interface receives an address with a value of 0x00 or 0x000 in the 7-bit or 10-bit addressing mode, if both the GCEN and the AA bit are set to 1, then it is switched as a general call slave. This flag is cleared automatically after being read.
[2]	ADRS	Address Transmit (master mode) / Address Receive (slave mode) Flag Address Sent in Master Mode 0: Address frame has not been transmitted 1: Address frame has been transmitted For the 7-bit addressing mode, this bit is set after the master device receives the address frame acknowledge bit sent from the slave device. For the 10-bit addressing mode, this bit is set after receiving the acknowledge bits of the first header byte and the second address. Note that when the second header byte, if exists, is acknowledged, this bit will also be set. Address Matched in Slave Mode 0: I²C interface is not addressed 1: I²C interface is addressed as slave When the I²C interface has received the calling address that matches the address defined in the I2CADDR register together with the AA bit being set to 1 in the I2CCR register, it will be switched to a slave mode. This flag is cleared automatically after the I2CSR register has been read.
[1]	STO	STOP Condition Detected Flag 0: No STOP condition detected 1: STOP condition detected in slave mode This bit is only available for the slave mode and is cleared automatically after the I2CSR register is read.
[0]	STA	START Condition Transmit 0: No START condition detected 1: START condition is transmitted in master mode This bit is only available for the master mode and is cleared automatically after the I2CSR register is read.

I²C SCL High Period Generation Register – I2CSHPGR

This register specifies the I²C SCL clock high period interval.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	SHPG							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	SHPG							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	SHPG	SCL Clock High Period Generation High period duration setting $SCL_{HIGH} = T_{PCLK} \times (SHPG + d)$ where T_{PCLK} is the APB bus peripheral clock (PCLK) period, and d value depends on the setting of the SEQFILTER field in the I²C Control Register (I2CCR). If SEQFILTER = 00, d = 6 If SEQFILTER = 01, d = 8 If SEQFILTER = 10 or 11, d = 9

I²C SCL Low Period Generation Register – I2CSLPGR

This register specifies the I²C SCL clock low period interval.

Offset: 0x014

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	SLPG							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	SLPG							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	SLPG	SCL Clock Low Period Generation Low period duration setting $SCL_{LOW} = T_{PCLK} \times (SLPG + d)$ where T_{PCLK} is the APB bus peripheral clock (PCLK) period, and d value depends on the setting of the SEQFILTER field in the I²C Control Register (I2CCR). If SEQFILTER = 00, d = 6 If SEQFILTER = 01, d = 8 If SEQFILTER = 10 or 11, d = 9

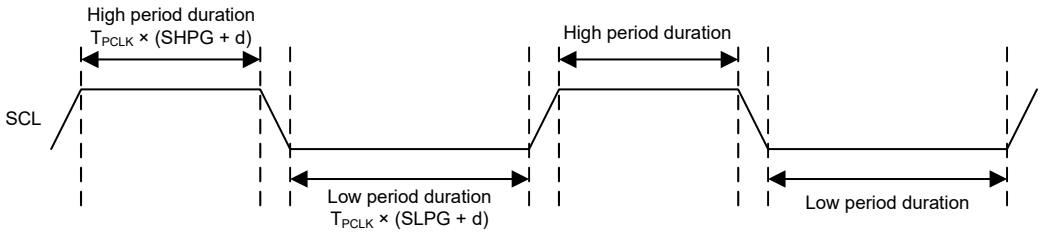


Figure 153. SCL Timing Diagram

Table 45. I²C Clock Setting Example

I²C Clock	$T_{SCL} = T_{PCLK} \times [(SHPG + d) + (SLPG + d)]$ (where d = 6) SHPG + SLPG Value at PCLK	
	10 MHz	20 MHz
100 kHz (Standard Mode)	88	188
400 kHz (Fast Mode)	13	38
1 MHz (Fast Mode Plus)	N/A	8

I²C Data Register – I2CDR

This register specifies the data to be transmitted or received by the I²C module.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	DATA							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7:0]	DATA	I²C Data Register For the transmitter mode, a data byte which is transmitted to a slave device can be assigned to these bits. The TXDE flag is cleared if the application software assigns new data to the I2CDR register. For the receiver mode, a data byte is received bit by bit from MSB to LSB through the I²C interface and stored in the data shift register. Once the acknowledge bit is given, the data shift register value is delivered into the I2CDR register if the RXDNE flag is equal to 0.

I²C Target Register – I2CTAR

This register specifies the target device address to be communicated.

Offset: 0x01C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					RWD	TAR	
Type/Reset						RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	TAR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[10]	RWD	Read or Write Direction 0: Write direction to target slave address 1: Read direction from target slave address If this bit is set to 1 in the 10-bit master receiver mode, the I²C interface will initiate a byte with a value of b11110XX0 in the first header frame and then continue to deliver a byte with a value of b11110XX1 in the second header frame by hardware automatically.
[9:0]	TAR	Target Slave Address The I²C interface will assign a START signal and send a target slave address automatically once the data is written to this register. When the system wants to send a repeated START signal to the I²C bus, the timing is suggested to set the I2CTAR register after a byte transfer is completed. It is not allowed to set TAR in the address frame. I2CTAR[9:7] is not available under the 7-bit addressing mode.

I²C Address Mask Register – I2CADDMR

This register specifies which bit of the I²C address is masked and not compared with corresponding bit of the received address frame.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved						ADDMR	
Type/Reset							RW 0	RW 0
	7	6	5	4	3	2	1	0
	ADDMR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[9:0]	ADDMR	Address Mask Control Bit The ADDMR[i] is used to specify whether the i^{th} bit of the ADDR in the I2CADDR register is masked and is compared with the received address frame or not on the I²C bus. The register is only used for the I²C slave mode only. 0: i^{th} bit of the ADDR is compared with the address frame on the I²C bus 1: i^{th} bit of the ADDR is masked and not compared with the address frame on the I²C bus

I²C Address Snoop Register – I2CADDSR

This register is used to indicate the address frame value appeared on the I²C bus.

Offset: 0x024

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved						ADDSR	
Type/Reset							RO 0	RO 0
	7	6	5	4	3	2	1	0
	ADDSR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[9:0]	ADDSR	Address Snoop Once the I2CEN bit is enabled, the calling address value on the I²C bus will automatically be loaded into this ADDSR field.

I²C Timeout Register – I2CTOUT

This register specifies the I²C Timeout counter preload value and clock prescaler ratio.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved					PSC		
Type/Reset						RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	TOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	TOUT							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[18:16]	PSC	I²C Timeout Counter Prescaler Selection This PSC field is used to specify the I²C timeout counter clock frequency, f_{I2CTO}. The timeout clock frequency is obtained using the formula. $f_{I2CTO} = \frac{f_{PCLK}}{2^{PSC}}$ PSC = 0 → $f_{I2CTO} = f_{PCLK} / 2^0 = f_{PCLK}$ PSC = 1 → $f_{I2CTO} = f_{PCLK} / 2^1 = f_{PCLK} / 2$ PSC = 2 → $f_{I2CTO} = f_{PCLK} / 2^2 = f_{PCLK} / 4$ … PSC = 7 → $f_{I2CTO} = f_{PCLK} / 2^7 = f_{PCLK} / 128$
[15:0]	TOUT	I²C Timeout Counter Preload Value. The TOUT field is used to define the counter preloaded value The counter value is reloaded when any of the following conditions occurs: 1. The RXBF, TXDE, RXDNE, RXNACK, GCS or ADRS flag in the I2CSR register is asserted. 2. The I²C master module sends a START signal. 3. The I²C slave module detects a START signal. The counter stops counting when any of the following conditions occurs: 1. The I²C slave device is not addressed. 2. The I²C master module sends a STOP signal. 3. The I²C slave module detects a STOP signal. 4. The ARBLOS or BUSERR flag in the I2CSR register is asserted.

20 Serial Peripheral Interface (SPI)

Introduction

The Serial Peripheral Interface, SPI, provides an SPI protocol data transmit and receive functions in both master or slave mode. The SPI interface uses 4 pins, among which are the serial data input and output lines SPI_MISO and SPI_MOSI, the clock line SPI_SCK, and the slave select line SPI_SEL. One SPI device acts as a master who controls the data flow using the SEL and SCK signals to indicate the start of the data communication and the data sampling rate. To receive the data bits, the streamlined data bits which range from 1 bit to 16 bits specified by the DFL field in the SPICR1 register are latched on a specific clock edge and stored in the data register or in the RX FIFO. Data transmission is carried out in a similar way but with the reverse sequence. The mode fault detection provides a capability for multi-master applications.

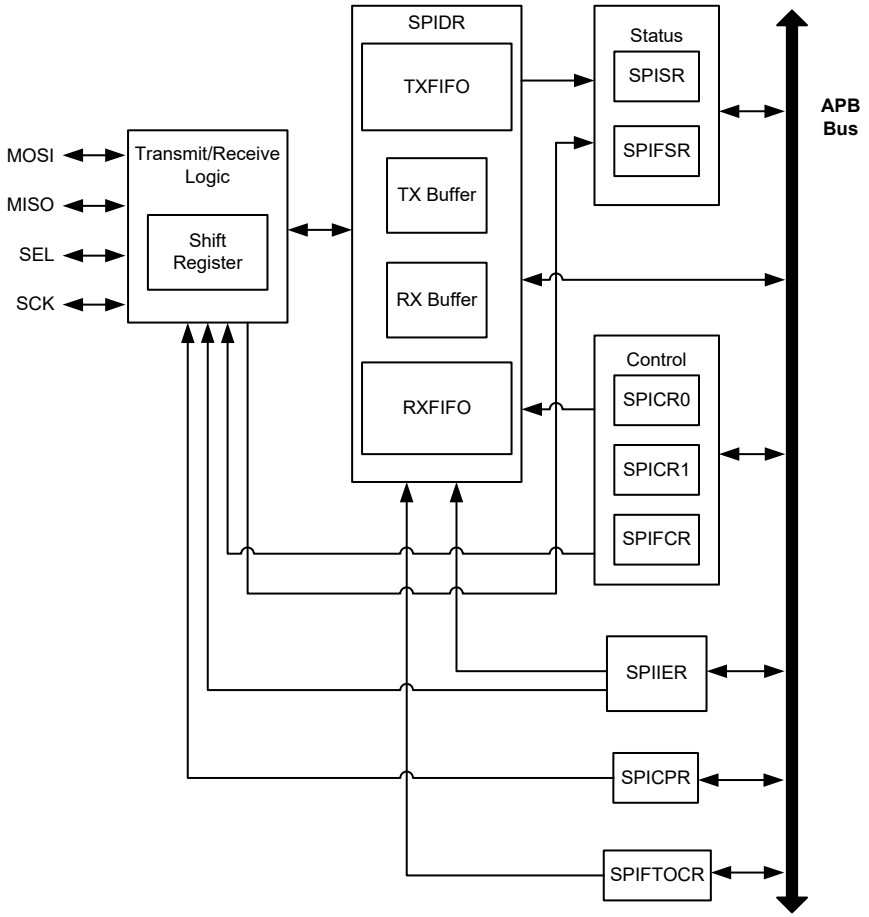


Figure 154. SPI Block Diagram

Features

- Master or slave mode
- Master mode speed up to $f_{PCLK}/2$
- Slave mode speed up to $f_{PCLK}/3$
- Programmable data frame length up to 16 bits
- FIFO Depth: 8 levels
- MSB or LSB first shift selection
- Programmable slave select high or low active polarity
- Multi-master and multi-slave operation
- Master mode supports dual output read mode of SPI series NOR Flash
- Four error flags with individual interrupt
  - Read overrun
  - Write collision
  - Mode fault
  - Slave abort
- Support PDMA interface

Functional Descriptions

Master Mode

Each data frame can range from 1 to 16 bits in data length. The first bit of the transmitted data can be either an MSB or LSB determined by the FIRSTBIT bit in the SPICR1 register. The SPI module is configured as a master or a slave by setting the MODE bit in the SPICR1 register. When the MODE bit is set, the SPI module is configured as a master and will generate the serial clock on the SPI_SCK pin. The data stream will transmit data in the shift register to the SPI_MOSI pin on the serial clock edge. The SPI_SEL pin is active during the full data transmission. When the SELAP bit in the SPICR1 register is set, the SPI_SEL pin is active high during the complete data transactions. When the SELM bit in the SPICR1 register is set, the SPI_SEL pin will be driven by the hardware automatically and the time interval between the active SEL edge and the first edge of SCK is equal to half an SCK period.

Slave Mode

In the slave mode, the SPI_SCK pin acts as an input pin and the serial clock will be derived from the external master device. The SPI_SEL pin also acts as an input. When the SELAP bit is cleared to 0, the SEL signal is active low during the full data stream reception. When the SELAP bit is set to 1, the SEL signal will be active high during the full data stream reception.

Note: For the slave mode, the APB clock, known as f_{PCLK}, must be at least 3 times faster than the external SCK clock input frequency.

SPI Serial Frame Format

The SPI interface format is based on the Clock Polarity, CPOL, and the Clock Phase, CPHA, configurations.

- Clock Polarity Bit – CPOL

  When the Clock Polarity bit is cleared to 0, the SCK line idle state is low. When the Clock Polarity bit is set to 1, the SCK line idle state is high.

■ Clock Phase Bit – CPHA

When the Clock Phase bit is cleared to 0, the data is sampled on the first SCK clock transition. When the Clock Phase bit is set to1, the data is sampled on the second SCK clock transition.

There are four formats contained in the SPI interface. Table 46 shows how to configure these formats by setting the FORMAT field in the SPICR1 register.

Table 46. SPI Interface Format Setup

FORMAT [2:0]	CPOL	CPHA
001	0	0
010	0	1
110	1	0
101	1	1
Others	Reserved	

CPOL = 0, CPHA = 0

In this format, the received data is sampled on the SCK line rising edge while the transmitted data is changed on the SCK line falling edge. In the master mode, the first bit is driven when data is written into the SPIDR Register. In the slave mode, the first bit is driven when the SEL signal goes to an active level. Figure 155 shows the single byte data transfer timing of this format.

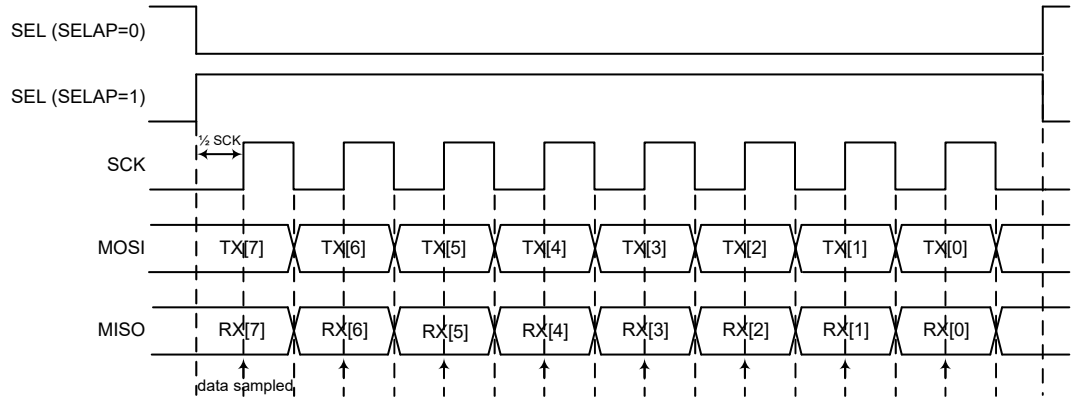


Figure 155. SPI Single Byte Transfer Timing Diagram – CPOL = 0, CPHA = 0

Figure 156 shows the continuous data transfer timing diagram of this format. Note that the SEL signal must change to an inactive level between each data frame.

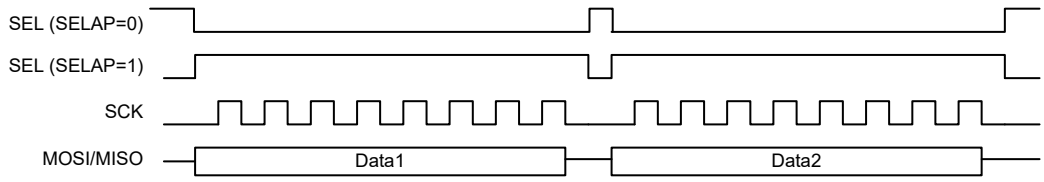


Figure 156. SPI Continuous Data Transfer Timing Diagram – CPOL = 0, CPHA = 0

CPOL = 0, CPHA = 1

In this format, the received data is sampled on the SCK line falling edge while the transmitted data is changed on the SCK line rising edge. In the master mode, the first bit is driven when data is written into the SPIDR register. In the slave mode, the first bit is driven at the first SCK clock rising edge. Figure 157 shows the single data byte transfer timing.

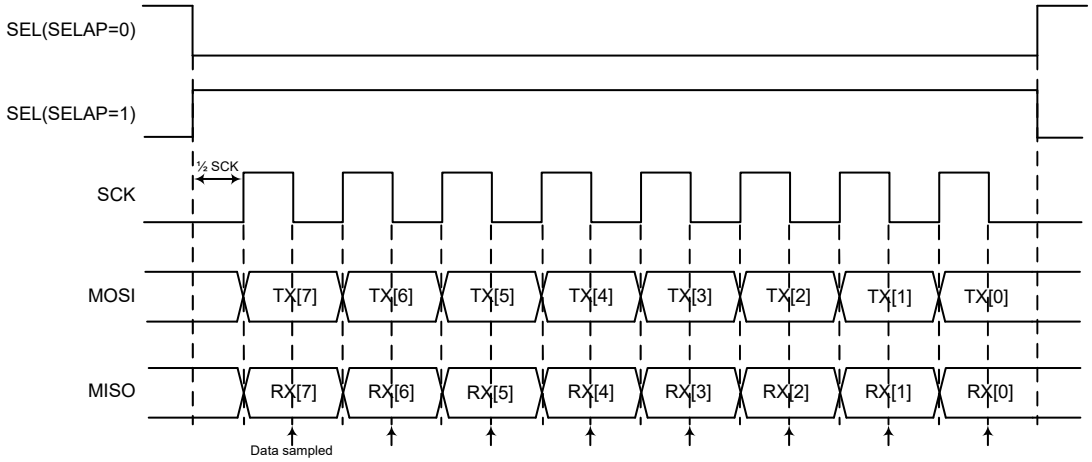


Figure 157. SPI Single Byte Transfer Timing Diagram – CPOL = 0, CPHA = 1

Figure 158 shows the continuous data transfer diagram timing. Note that the SEL signal must remain active until the last data transfer has completed.

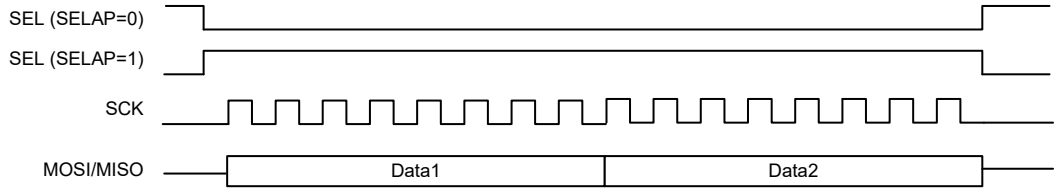


Figure 158. SPI Continuous Transfer Timing Diagram – CPOL = 0, CPHA = 1

CPOL = 1, CPHA = 0

In this format, the received data is sampled on the SCK line falling edge while the transmitted data is changed on the SCK line rising edge. In the master mode, the first bit is driven when data is written into the SPIDR register. In the slave mode, the first bit is driven when the SEL signal changes to an active level. Figure 159 shows the single byte transfer timing of this format.

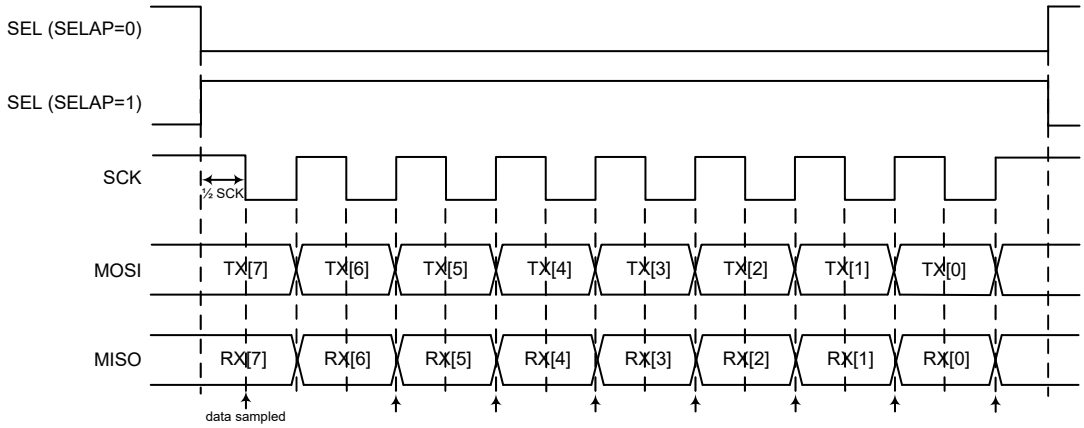


Figure 159. SPI Single Byte Transfer Timing Diagram – CPOL = 1, CPHA = 0

Figure 160 shows the continuous data transfer timing of this format. Note that the SEL signal must change to an inactive level between each data frame.

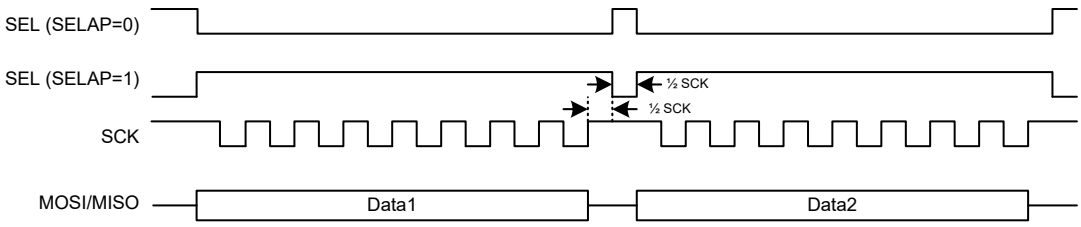


Figure 160. SPI Continuous Transfer Timing Diagram – CPOL = 1, CPHA = 0

CPOL = 1, CPHA = 1

In this format, the received data is sampled on the SCK line rising edge while the transmitted data is changed on the SCK line falling edge. In the master mode, the first bit is driven when data is written into the SPIDR register. In the slave mode, the first bit is driven at the first SCK falling edge. Figure 161 shows the single byte transfer timing of this format.

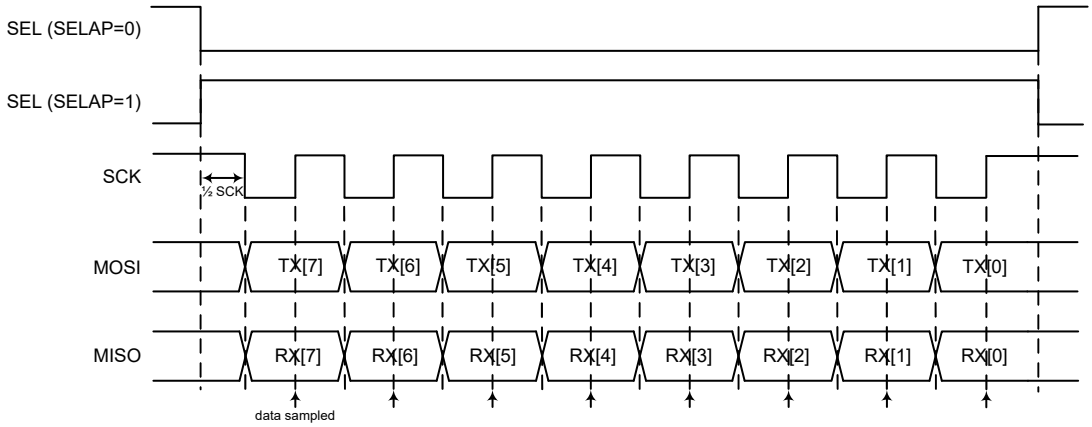


Figure 161. SPI Single Byte Transfer Timing Diagram – CPOL = 1, CPHA = 1

Figure 162 shows the continuous data transfer timing of this format. Note that the SEL signal must remain active until the last data transfer has completed.

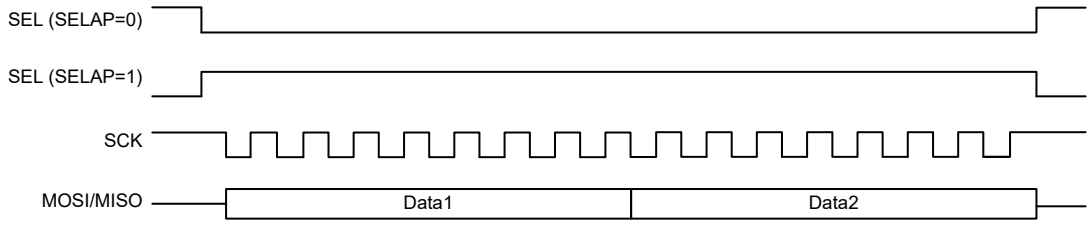


Figure 162. SPI Continuous Transfer Timing Diagram – CPOL = 1, CPHA = 1

SPI Dual Mode

When in the Master mode, the SPI interface operation can be configured to Dual mode. A more efficient data transfer can then be implemented by using this Dual mode together with the four formats described above. In the Dual mode, the SPI data transmission only supports input direction, that is, the SPI_MOSI pin is also switched from output to an input function. In this way a two-wire transfer method is formed to read data from an external device synchronously. In addition, the Dual mode only supports a data length of 16-bit (DFL = 0x8). The Dual mode is commonly used to read data from an external serial SPI Flash. The following figures show the transfer format bit sequences in the SPI Dual mode.

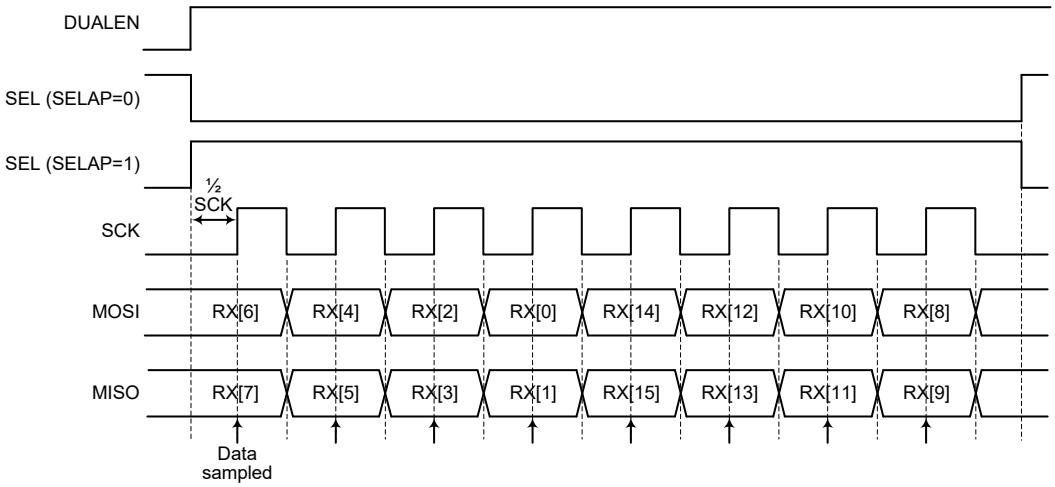


Figure 163. SPI Dual Mode Bit Sequence – CPOL = 0, CPHA = 0, DFL = 0x8 (16-bit), MSB Transmitted First

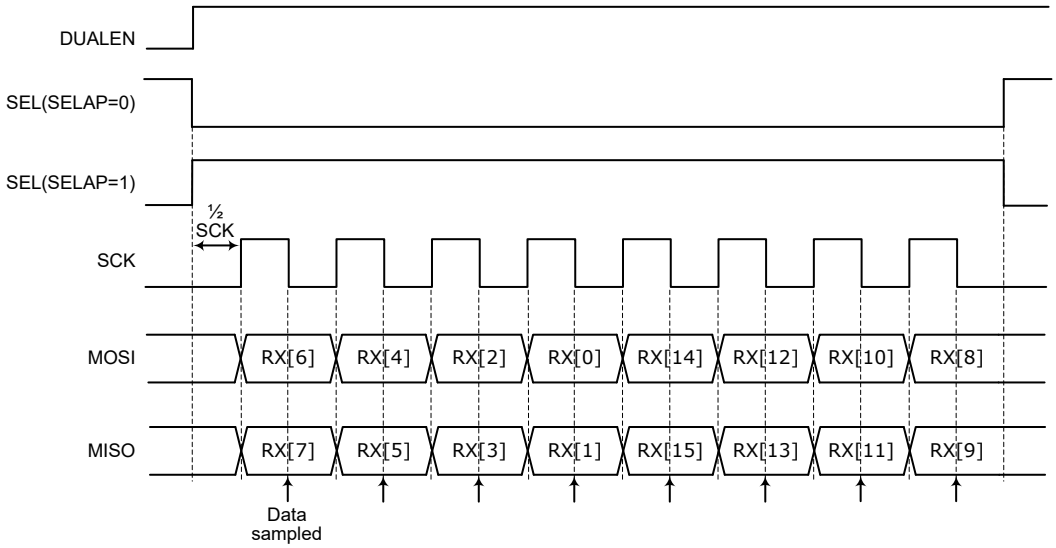


Figure 164. SPI Dual Mode Bit Sequence – CPOL = 0, CPHA = 1, DFL = 0x8 (16-bit), MSB Transmitted First

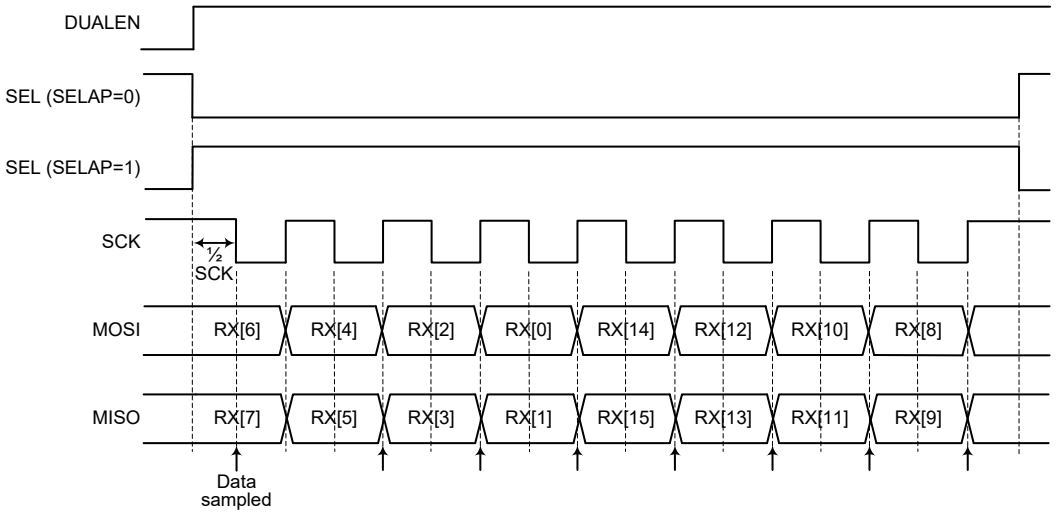


Figure 165. SPI Dual Mode Bit Sequence – CPOL = 1, CPHA = 0, DFL = 0x8 (16-bit) , MSB Transmitted First

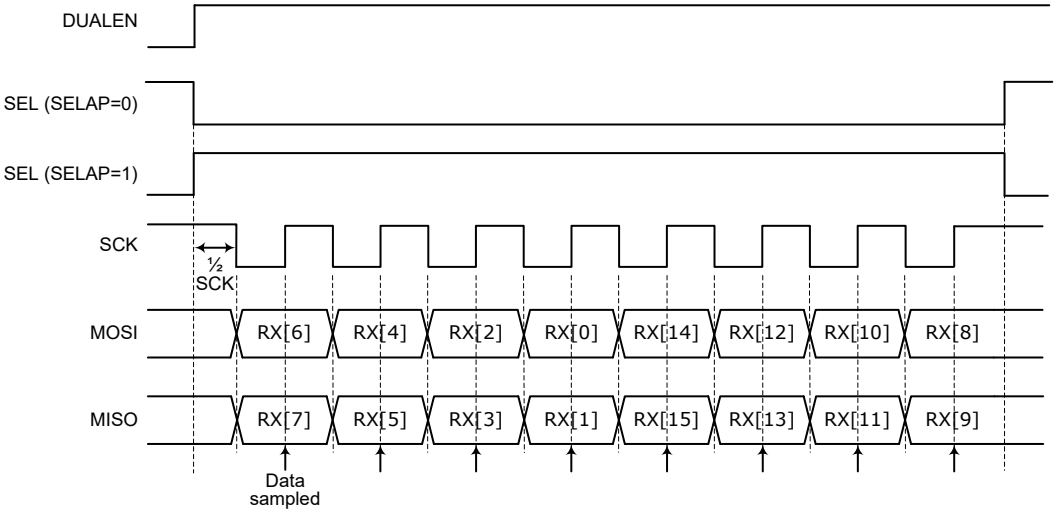


Figure 166. SPI Dual Mode Bit Sequence – CPOL = 1, CPHA = 1, DFL = 0x8 (16-bit) , MSB Transmitted First

Figure 167 shows the bit sequence of the SPI Dual mode reading data from an external serial SPI Flash.

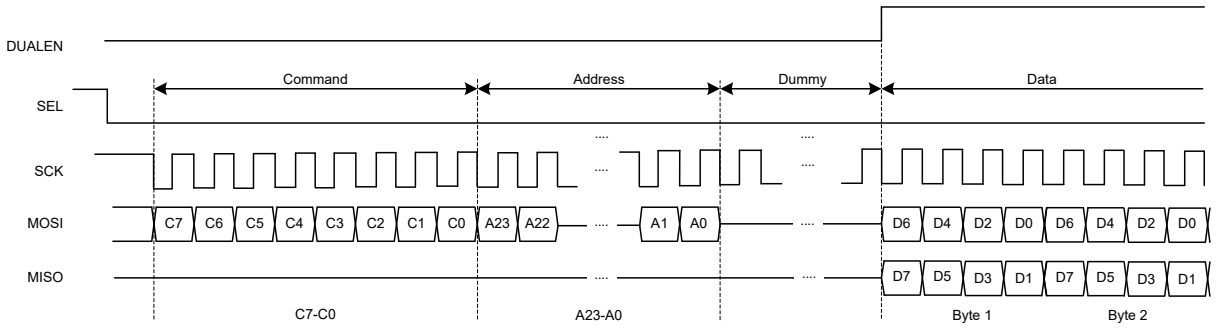


Figure 167. SPI Dual Mode Data Read Example - CPOL = 1, CPHA = 1

Status Flags

TX Buffer Empty – TXBE

This TXBE flag is set when the TX buffer is empty in the non-FIFO mode or when the TX FIFO data length is equal to or less than the TX FIFO threshold level as defined by the TXFTLS field in the SPIFCR register in the FIFO mode. The following data to be transmitted can then be loaded into the buffer again. After this, the TXBE flag will be reset when the TX buffer already contains new data in the non-FIFO mode or when the TX FIFO data length is greater than the TX FIFO threshold level determined by the TXFTLS field in FIFO mode.

Transmission Register Empty – TXE

This TXE flag is set when both the TX buffer and the TX shift registers are empty. It will be reset when the TX buffer or the TX shift register contains new transmitted data.

RX Buffer Not Empty – RXBNE

This RXBNE flag is set when there is valid received data in the RX buffer in the non-FIFO mode or the RX FIFO data length is equal to or greater than the RX FIFO threshold level as defined by the RXFTLS field in the SPIFCR register in the SPI FIFO mode. This flag will be automatically cleared by hardware when the received data have been read out from the RX buffer totally in the non-FIFO mode or when the RX FIFO data length is less than the RX FIFO threshold level set in the RXFTLS field.

Time Out Flag – TO

The time out function is only available in the SPI FIFO mode and is disabled by loading a zero value into the TOC field in the Time Out Counter register. The time out counter will start counting if the SPI RX FIFO is not empty, once data is read from the SPIDR register or new data is received, the time out counter will be reset to 0 and count again. When the time out counter value is equal to the value specified by the TOC field in the SPIFTOCR register, the TO flag will be set. The flag is cleared by writing 1 to this bit.

Mode Fault – MF

The mode fault flag can be used to detect SPI bus usage in the SPI multi-master mode. For the multi-master mode, the SPI module is configured as a master device and the SEL signal is set as an input signal. The mode fault flag is set when the SPI_SEL pin is suddenly changed to an active level by another SPI master. This means that another SPI master is requesting to use the SPI bus. Therefore, when an SPI mode fault occurs, it will force the SPI module to operate in the slave mode and also disable all of the SPI interface signals to avoid SPI bus signal collisions. For the same reason, if the SPI master wants to transfer data, it also needs to inform other SPI masters by driving their SEL signals to an active state. The detailed configuration diagram for the SPI multi-master mode is shown in the following figure.

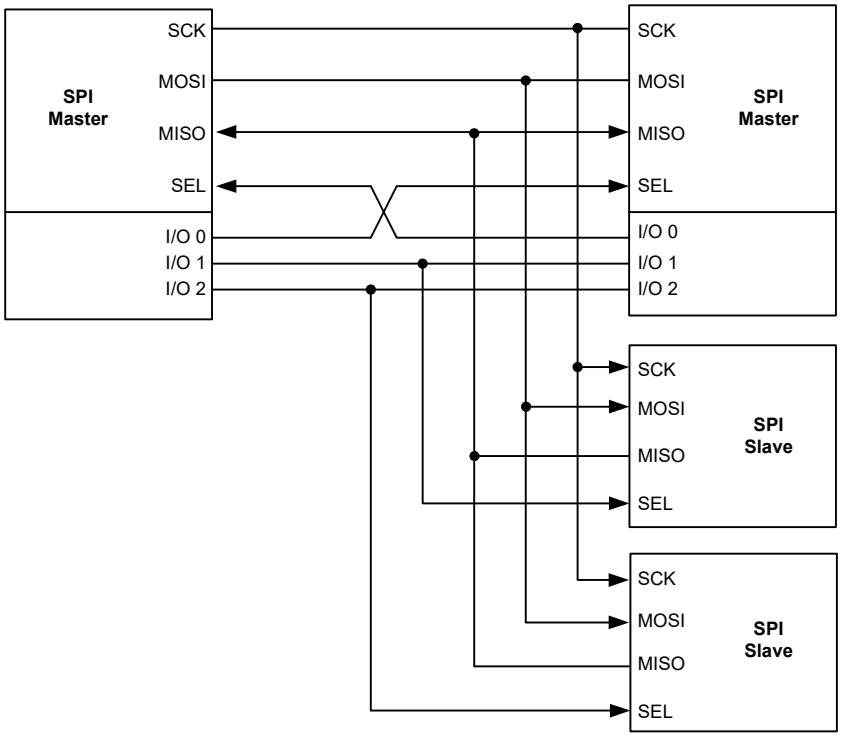


Figure 168. SPI Multi-Master Slave Environment

Table 47. SPI Mode Fault Trigger Conditions

Mode Fault	Descriptions
Trigger Condition	1. SPI Master mode. 2. SELOEN = 0 in the SPICR0 register – SPI_SEL pin is configured to be the input mode. 3. SEL signal changes to an active level when driven by the external SPI master.
SPI Behavior	1. Mode fault flag is set. 2. The SPIEN bit in the SPICR0 register is reset. This disables the SPI interface and blocks all output signals from the device. 3. The MODE bit in the SPICR1 register is reset. This forces the device into slave mode.

Table 48. SPI Master Mode SPI_SEL Pin Status

	SEL as Input – SELOEN = 0		SEL as Output – SELOEN = 1	
Multi-Master	Supported		Not supported	
SPI SEL Control Signal	Use Another GPIO to replace the SPI_SEL pin function		SPI_SEL pin in hardware or software control mode – using SELM setting	
Continuous Transfer	Case 1	Case 2	Case 1	Case 2
	Not supported	Supported	Hardware control	Hardware or software control

Case 1: SEL signal must be inactive between each data transfer.
Case 2: SEL signal will not to be inactive until the last data frame has finished.
Note: When the SPI is in the slave mode, the SEL signal is always an input and not affected by the SELOEN bit in the SPICR0 register.

Write Collision – WC

The following conditions will assert the Write Collision Flag.

- The FIFOEN bit in the SPIFCR register is cleared
  The write collision flag is asserted when new data is written into the SPIDR register while both the TX buffer and the shift register are already full. Any new data written into the TX buffer will be lost.
- The FIFOEN bit in the SPIFCR register is set
  The write collision flag is asserted to indicate that new data is written into the SPIDR register while both the TX FIFO and the TX shift register are already full. Any new data written into the TX FIFO will be lost.

Read Overrun – RO

- The FIFOEN bit in the SPIFCR register is cleared
  The read overrun flag is asserted to indicate that both the RX shift register and the RX buffer are already full, if one more data is received. This will result in the newly received data not being shifted into the SPI shift register. As a result the latest received data will be lost.
- The FIFOEN bit in the SPIFCR register is set
  The read overrun flag is set to indicate that the RX shift register and the RX FIFO are both full, if one more data is received. This means that the latest received data can not be shifted into the SPI shift register. As a result the latest received data will be lost.

Slave Abort – SA

In the SPI slave mode, the slave abort flag is set to indicate that the SPI_SEL pin suddenly changed to an inactive state during the reception of a data frame transfer. The data frame length is set by the DFL field in the SPICR1 register.

PDMA Interface

The PDMA interface is integrated in the SPI module. The PDMA function can be enabled by setting the TXDMAE or RXDMAE bit to 1 in the transmitter or receiver mode respectively. When the transmit buffer empty flag, TXBE, is asserted and the TXDMAE bit is set to 1, the PDMA function will be activated to move data from the memory location that users designated into the SPI data register or the TX FIFO until the TXBE flag is cleared to 0. The TXBE flag will be asserted when the transmit buffer is empty in the non-FIFO mode or the data contained in the TX FIFO is equal to or less than the level defined by the TXFTLS field in the FIFO mode.

Similarly, when the receive buffer not empty flag, RXBNE, is asserted and the RXDMAE bit is set to 1, the PDMA function will be activated to move data from the SPI data register or the RX FIFO to the memory location that users designated until the RXBNE flag is cleared to 0. The RXBNE flag will be asserted when the receive buffer is not empty in the non-FIFO mode or the data contained in the RX FIFO is equal to or greater than the level defined by the RXFTLS field in the FIFO mode.

For a more detailed description about the PDMA configurations, refer to the PDMA chapter.

Register Map

The following table shows the SPI registers and reset values.

Table 49. SPI Register Map

Register	Offset	Description	Reset Value
SPICR0	0x000	SPI Control Register 0	0x0000_0000
SPICR1	0x004	SPI Control Register 1	0x0000_0000
SPIIER	0x008	SPI Interrupt Enable Register	0x0000_0000
SPICPR	0x00C	SPI Clock Prescaler Register	0x0000_0000
SPIDR	0x010	SPI Data Register	0x0000_0000
SPISR	0x014	SPI Status Register	0x0000_0003
SPIFCR	0x018	SPI FIFO Control Register	0x0000_0000
SPIFSR	0x01C	SPI FIFO Status Register	0x0000_0000
SPIFTOCR	0x020	SPI FIFO Time Out Counter Register	0x0000_0000

Register Descriptions

SPI Control Register 0 – SPICR0

This register specifies the SEL control and the SPI enable bits.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	SELHT				GUADT			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	GUADTEN	DUALEN	Reserved	SSELC	SELOEN	RXDMAE	TXDMAE	SPIEN
Type/Reset	RW 0	RW 0		RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:12]	SELHT	Chip Select Hold Time 0x0: 1/2 SCK 0x1: 1 SCK 0x2: 3/2 SCK 0x3: 2 SCK .... Note that SELHT is for master mode only.
[11:8]	GUADT	Guard Time GUADTEN = 1 0x0: 1 SCK 0x1: 2 SCK 0x2: 3 SCK ... Note that GUADT is for master mode only.
[7]	GUADTEN	Guard Time Enable 0: Guard Time is 1/2 SCK 1: When this bit is set, guard time can be controlled by GUADT Note that GUADTEN is for master mode only.
[6]	DUALEN	Dual Mode Enable 0: Dual Mode is disabled 1: Dual Mode is enabled The control bit is used to support the dual output read mode of the series SPI NOR Flash. When this bit is set and the MOSI signal will change the direction from output to input and receive the series data stream. That means the DUALEN control bit is only for master mode.

Bits	Field	Descriptions
[4]	SSELC	Software Slave Select Control 0: Set the SEL output to an inactive state 1: Set the SEL output to an active state The application software can set the SEL output to an active or inactive state by configuring the SSELC bit. The active level is configured by the SELAP bit in the SPICR1 register. Note that the SSELC bit is only available when the SELOEN bit is set to 1 for enabling the SEL output meanwhile the SELM bit is cleared to 0 for controlling the SEL signal by software. Otherwise, the SSELC bit has no effect.
[3]	SELOEN	Slave Select Output Enable 0: Set the SEL signal to the input mode for multi-master mode 1: Set the SEL signal to the output mode for slave select The SELOEN is only available in the master mode to set the SEL signal as an input or output signal. When the SEL signal is configured to operate in the output mode, it is used as a slave select signal in either the hardware or software mode according to the SELM bit setting in the SPICR1 register. The SEL signal is used for mode fault detection in the multi-master environment when it is configured to operate in the input mode
[2]	RXDMAE	RX PDMA request enable 0: SPI RX path PDMA request is disabled 1: SPI RX path PDMA request is enabled
[1]	TXDMAE	TX PDMA request enable 0: SPI TX path PDMA request is disabled 1: SPI TX path PDMA request is enabled
[0]	SPIEN	SPI Enable 0: SPI interface is disabled 1: SPI interface is enabled

SPI Control Register 1 – SPICR1

This register specifies the SPI parameters including the data length, the transfer format, the SEL active polarity/ mode, the LSB/MSB control and the master/slave mode.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved	MODE	SELM	FIRSTBIT	SELAP	FORMAT		
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved				DFL			
Type/Reset					RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[14]	MODE	Master or Slave Mode 0: Slave mode 1: Master mode
[13]	SELM	Slave Select Mode 0: SEL signal is controlled by software – asserted or de-asserted by the SSELC bit 1: SEL signal is controlled by hardware – generated automatically by the SPI hardware Note that the SELM bit is available for master mode only, i.e., MODE = 1.
[12]	FIRSTBIT	LSB or MSB Transmitted First 0: MSB is transmitted first 1: LSB is transmitted first
[11]	SELAP	Slave Select Active Polarity 0: SEL signal is active low 1: SEL signal is active high

Bits	Field	Descriptions
[10:8]	FORMAT	SPI Data Transfer Format These three bits are used to determine the data transfer format of the SPI interface.

FORMAT [2:0]	CPOL	CPHA
001	0	0
010	0	1
110	1	0
101	1	1
Others	Reserved	

CPOL: Clock Polarity
0: SCK Idle state is low
1: SCK Idle state is high
CPHA: Clock Phase
0: Data is captured on the first SCK clock edge
1: Data is captured on the second SCK clock edge

[3:0] DFL

Data Frame Length
Selects the data transfer frame from 1 bit to 16 bits.

DFL[3:0]	SPI Serial Mode	SPI Dual Mode
0001	1 bit	—
0010	2 bits	—
0011	3 bits	—
0100	4 bits	—
0101	5 bits	—
0110	6 bits	—
0111	7 bits	—
1000	8 bits	16 bits
1001	9 bits	—
...	...	—
1111	15 bits	—
0000	16 bits	—

Notes: 1. The total number of data bits is determined by the DFL field configuration together with the selected SPI device transmission mode.
2. Taking the 16-bit data transmission for example, the DFL setting can be figured out as follows
In the Serial Mode: Data frame length = 16/1 = 16, DFL = 0x0;
In the Dual SPI Mode: Data frame length = 16/2 = 8, DFL = 0x8;
3. Dual mode only supports 16-bit data length.

SPI Interrupt Enable Register – SPIIER

This register contains the corresponding SPI interrupt enable control bit.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	TOIEN	SAIEN	MFIEN	ROIEN	WCIEN	RXBNEIEN	TXEIEN	TXBEIEN
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7]	TOIEN	Time Out Interrupt Enable 0: Disable 1: Enable
[6]	SAIEN	Slave Abort Interrupt Enable 0: Disable 1: Enable
[5]	MFIEN	Mode Fault Interrupt Enable 0: Disable 1: Enable
[4]	ROIEN	Read Overrun Interrupt Enable 0: Disable 1: Enable
[3]	WCIEN	Write Collision Interrupt Enable 0: Disable 1: Enable
[2]	RXBNEIEN	RX Buffer Not Empty Interrupt Enable 0: Disable 1: Enable An interrupt is generated when the RXBNE flag is set and RXBNEIEN is set. In the FIFO mode, the interrupt being generated depends upon the RX FIFO trigger level setting.
[1]	TXEIEN	Transmission Register Empty Interrupt Enable 0: Disable 1: Enable The transmission register empty interrupt request will be generated when the TXE flag and the TXEIEN bit are set.

Bits	Field	Descriptions
[0]	TXBEIEN	TX Buffer Empty Interrupt Enable 0: Disable 1: Enable The TX buffer empty interrupt request will be generated when the TXBE flag and the TXBEIEN bit are set. In the FIFO mode, the interrupt request being generated depends upon the TX FIFO trigger level setting.

SPI Clock Prescaler Register – SPICPR

This register specifies the SPI clock prescaler ratio.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	CP							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	CP							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	CP	SPI Clock Prescaler The SPI clock (SCK) is determined by the following equation: $f_{SCK} = f_{PCLK} / (2 \times (CP + 1))$, where the CP ranges is from 0 to 65535 Note: For the SPI master mode, the APB clock (f_{PCLK}) must be at least 2 times faster than the SPI SCK output.

SPI Data Register – SPIDR

This register stores the SPI received or transmitted Data.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	DR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	DR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	DR	Data Register The SPI data register is used to store the serial bus transmitted or received data. In the non-FIFO mode, writing data into the SPI data register will also load the data into the data transmission buffer, known as the TX buffer. Reading data from the SPI data register will return the data held in the data received buffer, named RX buffer.

SPI Status Register – SPISR

This register contains the relevant SPI status.

Offset: 0x014

Reset value: 0x0000_0003

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							BUSY
Type/Reset								RO 0
	7	6	5	4	3	2	1	0
	TO	SA	MF	RO	WC	RXBNE	TXE	TXBE
Type/Reset	WC 0	WC 0	WC 0	WC 0	WC 0	RO 0	RO 1	RO 1

Bits	Field	Descriptions
[8]	BUSY	SPI Busy flag 0: SPI not busy 1: SPI busy In the master mode, this flag is reset when the TX buffer and TX shift register are both empty and is set when the TX buffer or the TX shift register are not empty. In the slave mode, this flag is set when SEL changes to an active level and is reset when SEL changes to an inactive level.
[7]	TO	Time Out flag 0: No Rx FIFO time out 1: Rx FIFO time out has occurred Once the time out counter value is equal to the TOC field setting in the SPIFTOCR register, the time out flag will be set and an interrupt will be generated if the TOIEN bit in the SPIIER register is enabled. This bit is cleared by writing 1. Note: This Time Out flag function is only available in the SPI FIFO mode.
[6]	SA	Slave Abort flag 0: No slave abort 1: Slave abort has occurred This bit is set by hardware and cleared by writing 1.
[5]	MF	Mode Fault flag 0: No mode fault 1: Mode fault has occurred This bit is set by hardware and cleared by writing 1.
[4]	RO	Read Overrun flag 0: No read overrun 1: Read overrun has occurred This bit is set by hardware and cleared by writing 1.
[3]	WC	Write Collision flag 0: No write collision 1: Write collision has occurred This bit is set by hardware and cleared by writing 1.
[2]	RXBNE	RX Buffer Not Empty flag 0: RX buffer is empty 1: RX buffer is not empty This bit indicates the RX buffer status in the non-FIFO mode. It is also used to indicate if the RX FIFO trigger level has been reached in the FIFO mode. This bit will be cleared when the SPI RX buffer is empty in the non-FIFO mode or if the number of data contained in RX FIFO is less than the trigger level which is specified by the RXFTLS field in the SPIFCR register in the SPI FIFO mode.
[1]	TXE	Transmission Register Empty flag 0: TX buffer or TX shift register is not empty 1: TX buffer and TX shift register both are empty
[0]	TXBE	TX Buffer Empty flag 0: TX buffer is not empty 1: TX buffer is empty In the FIFO mode, this bit if set indicates that the number of data contained in TX FIFO is equal to or less than the trigger level specified by the TXFTLS field in the SPIFCR register.

SPI FIFO Control Register – SPIFCR

This register contains the related SPI FIFO control including the FIFO enable control and the FIFO trigger level selections.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved					FIFOEN	Reserved	
Type/Reset						RW 0		
	7	6	5	4	3	2	1	0
	RXFTLS				TXFTLS			
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[10]	FIFOEN	FIFO Enable 0: FIFO is disabled 1: FIFO is enabled This bit can not be set or reset when the SPI interface is in transmitting.
[7:4]	RXFTLS	RX FIFO Trigger Level Select 0000: Trigger level is 0 0001: Trigger level is 1 ... 1000: Trigger level is 8 Others: Reserved The RXFTLS field is used to specify the RX FIFO trigger level. When the number of data contained in the RX FIFO is equal to or greater than the trigger level defined by the RXFTLS field, the RXBNE flag will be set
[3:0]	TXFTLS	TX FIFO Trigger Level Select 0000: Trigger level is 0 0001: Trigger level is 1 ... 1000: Trigger level is 8 Others: Reserved The TXFTLS field is used to specify the TX FIFO trigger level. When the number of data contained in the TX FIFO is equal to or less than the trigger level defined by the TXFTLS field, the TXBE flag will be set.

SPI FIFO Status Register – SPIFSR

This register contains the relevant SPI FIFO status.

Offset: 0x01C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	RXFS				TXFS			
Type/Reset	RO	RO	RO	RO	RO	RO	RO	RO
	0	0	0	0	0	0	0	0

Bits	Field	Descriptions
[7:4]	RXFS	RX FIFO Status 0000: RX FIFO empty 0001: RX FIFO contains 1 data ... 1000: RX FIFO contains 8 data Others: Reserved
[3:0]	TXFS	TX FIFO Status 0000: TX FIFO empty 0001: TX FIFO contains 1 data … 1000: TX FIFO contains 8 data Others: Reserved

SPI FIFO Time Out Counter Register – SPIFTOCR

This register stores the SPI RX FIFO time out counter value.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	TOC							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	TOC							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	TOC	Time Out Counter Compare Value The time out counter starts to count from 0 after the SPI RX FIFO receives a data, and the counter value is reset once the data is read from the SPIDR register by software or another new data is received. If the FIFO does not receive new data or the software does not read data from the SPIDR register the time out counter value will continuously increase. When the time out counter value is equal to the TOC setting value, the TO flag in the SPISR register will be set and an interrupt will be generated if the TOIEN bit in the SPIIER register is set. The time out counter will be stopped when the RX FIFO is empty. The SPI FIFO time out function can be disabled by setting the TOC field to zero. The time out counter is driven by the system APB clock, named f_{PCLK}.

21 Universal Synchronous Asynchronous Receiver Transmitter (USART)

Introduction

The Universal Synchronous Asynchronous Receiver Transceiver, USART, provides a flexible full duplex data exchange using synchronous or asynchronous transfer. The USART is used to translate data between parallel and serial interfaces, and is also commonly used for RS232 standard communication. The USART peripheral function supports a variety of interrupts.

The USART module includes an 8-level transmit FIFO, TX FIFO, and an 8-byte receive FIFO, RX FIFO. Software can detect a USART error status by reading USART Status & Interrupt Flag Register, USRSIFR. The status includes the condition of the transfer operations as well as several error conditions resulting from Parity, Overrun, Framing and Break events.

The USART includes a programmable baud rate generator which is capable of dividing the USART clock of the CK_APB (CK_USART) to produce a baud rate clock for the USART transmitter and receiver.

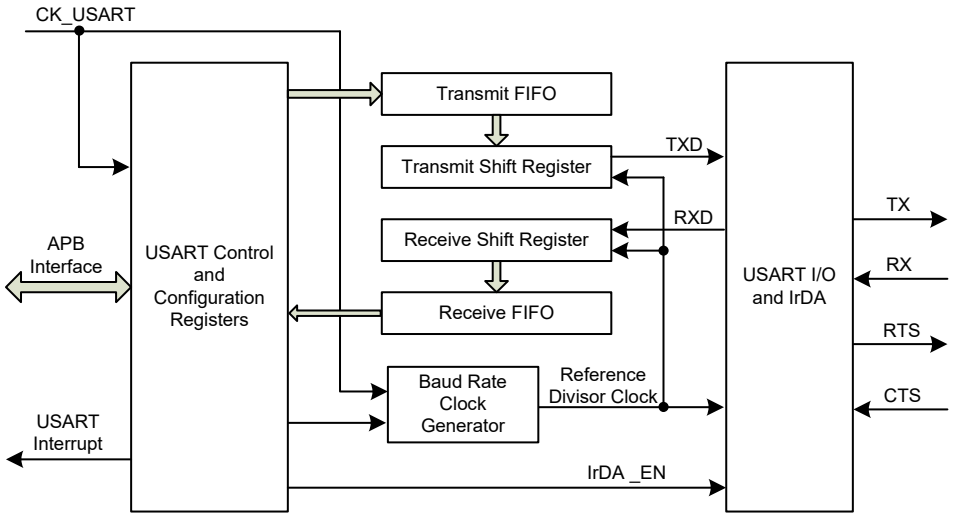


Figure 169. USART Block Diagram

Features

- Supports both asynchronous and clocked synchronous serial communication modes
- Full Duplex Communication Capability
- Programming baud rate clock frequency up to (f_{PCLK}/16) MHz for asynchronous mode and (f_{PCLK}/8) MHz for synchronous mode
- IrDA SIR encoder and decoder
  - Support of normal 3/16 bit duration and low-power (1.41 ~ 2.23 μs) durations
- Supports RS485 mode with output enable
- Auto hardware flow control mode – RTS, CTS
- Fully programmable serial communication functions including:
  - Word length: 7, 8 or 9-bit character
  - Parity: Even, odd or no-parity bit generation and detection
  - Stop bit: 1 or 2 stop bits generation
  - Bit order: LSB-first or MSB-first transfer
- Error detection: Parity, overrun and frame error
- FIFO:
  - Receive FIFO: 8 levels
  - Transmit FIFO: 8 levels

Functional Descriptions

Serial Data Format

The USART module performs a parallel-to-serial conversion on data that is written to the transmit FIFO registers and then sends the data with the following format: Start bit, 7 ~ 9 LSB/MSB first data bits, optional Parity bit and finally 1 ~ 2 Stop bits. The Start bit has the opposite polarity of the data line idle state. The Stop bit is the same as the data line idle state and provides a delay before the next start situation. Both the Start and Stop bits are used for data synchronization during the asynchronous data transmission.

The USART module also performs a serial-to-parallel conversion on the data that is read from the receive FIFO registers. It will first check the Parity bit and will then look for a Stop bit. If the Stop bit is not found, the USART module will consider the entire word transmission to have failed and respond with a Framing Error.

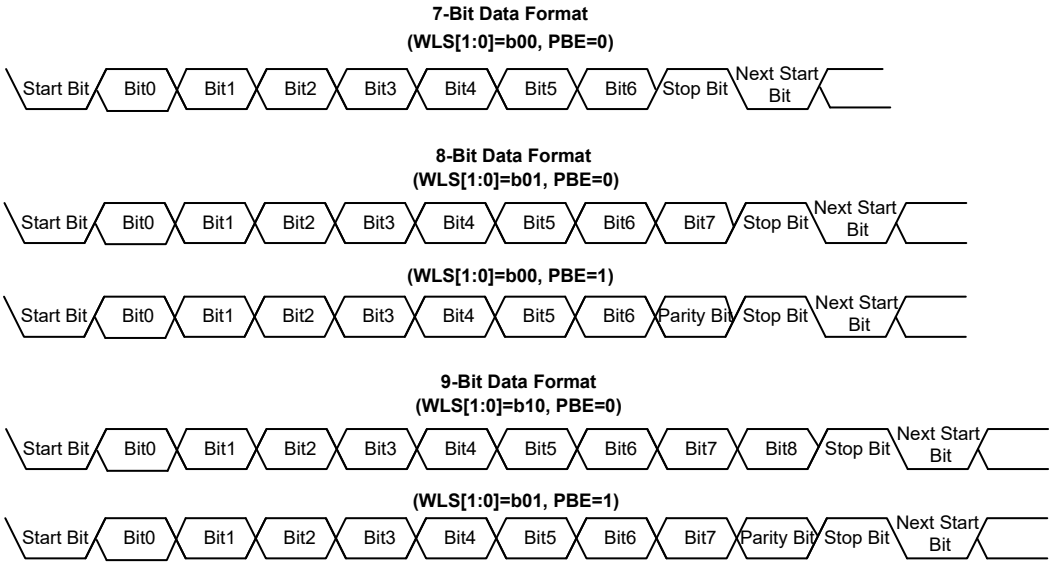


Figure 170. USART Serial Data Format

Baud Rate Generation

The baud rate for the USART receiver and transmitter are both set with the same values. The baud rate divisor, BRD, has the following relationship with the USART clock which is known as CK_USART.

$$\text{Baud Rate Clock} = \text{CK\_USART} / \text{BRD}$$

Where CK_USART clock is the APB clock connected to the USART while the BRD range is from 16 to 65535 for asynchronous mode and 8 to 65535 for synchronous mode.

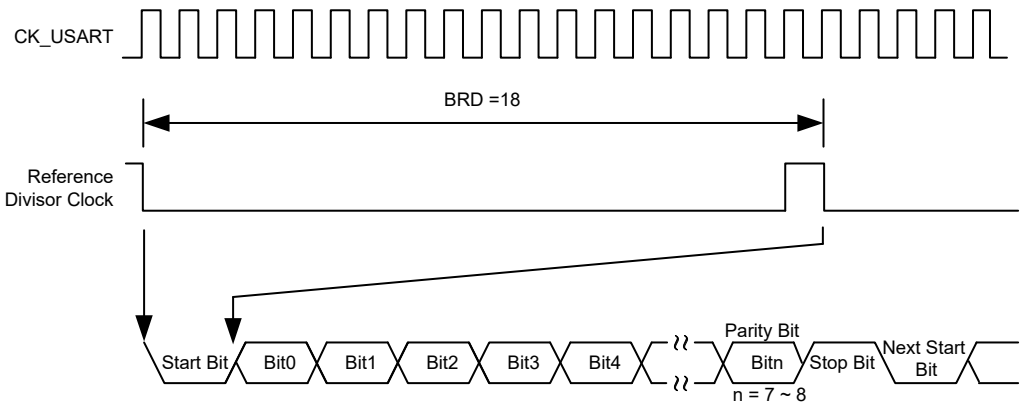


Figure 171. USART Clock CK_USART and Data Frame Timing

Table 50. Baud Rate Deviation Error Calculation – CK_USART = 20 MHz

Baud Rate		CK_USART = 20 MHz		
No.	Kbps	Actual	BRD	Deviation Error Rate
1	2.4	2.4	8333	0.00%
2	9.6	9.6	2083	0.02%
3	19.2	19.2	1042	-0.03%
4	57.6	57.6	347	0.06%
5	115.2	114.9	174	-0.22%
6	230.4	229.9	87	-0.22%
7	460.8	465.1	43	0.94%
8	921.6	909.1	22	-1.36%
9	1250	1250	16	0%

Table 51. Baud Rate Deviation Error Calculation – CK_USART = 10 MHz

Baud Rate		CK_USART = 10 MHz		
No.	Kbps	Actual	BRD	Deviation Error Rate
1	2.4	2.4	4167	-0.01%
2	9.6	9.6	1042	-0.03%
3	19.2	19.2	521	-0.03%
4	57.6	57.6	174	-0.22%
5	115.2	114.9	87	-0.22%
6	230.4	232.6	43	0.94%
7	460.8	454.5	22	-1.36%
8	625	625	16	0%

Hardware Flow Control

The USART supports the hardware flow control function which is enabled by setting the HFCEN bit in the USRCR register to 1. It is possible to control the serial data flow between 2 USART devices by using the CTS input and the RTS output. The Figure 172 shows the connection diagram in this mode. The hardware flow control function is categorized into two types. One is the RTS flow control function and the other is the CTS flow control function.

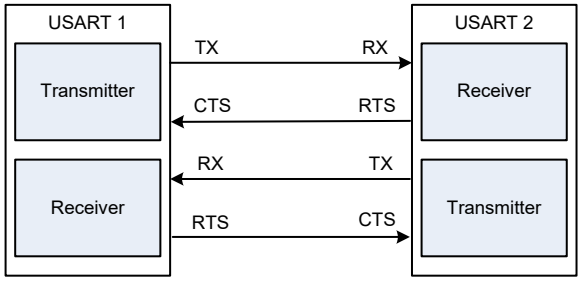


Figure 172. Hardware Flow Control between 2 USARTs

RTS Flow Control

In the RTS flow control, the USART RTS pin is active with a logic low state when the receive data register is empty. It means that the receiver is ready to receive a new data. When the RX FIFO reaches the trigger level which is specified by configuring the RXTL field in the USRFCR register, the USART RTS pin is inactive with a logic high state. Figure 173 shows the example of RTS flow control.

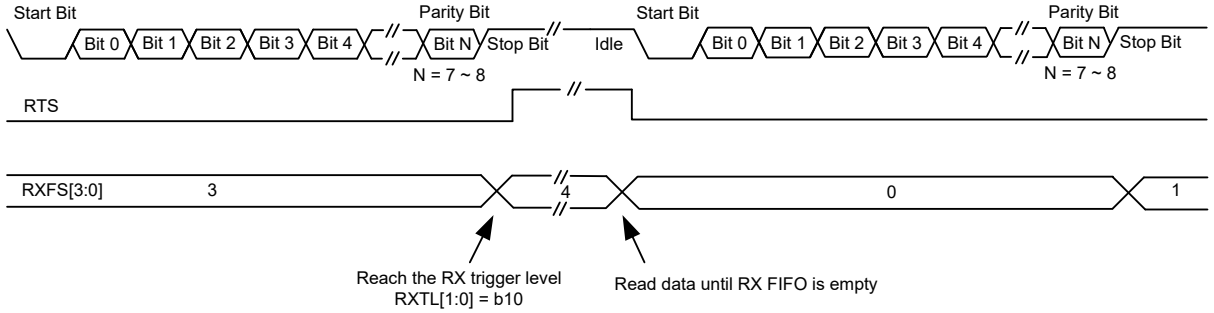


Figure 173. USART RTS Flow Control

CTS Flow Control

If the hardware flow control function is enabled, the URTXEN bit in the USRCR register will be controlled by the USART CTS input signal. If the USART CTS pin is forced to a logic low state, the URTXEN bit will automatically be set to 1 to enable the data transmission. However, if the USART CTS pin is forced to a logic high state, the URTXEN bit will be cleared to 0 and then the data transmission will also be disabled.

When the USART CTS pin is forced to a logic high state during a data transmission period, the current data transmission will be continued until the stop bit is completed. The Figure 174 shows an example of communication with CTS flow control.

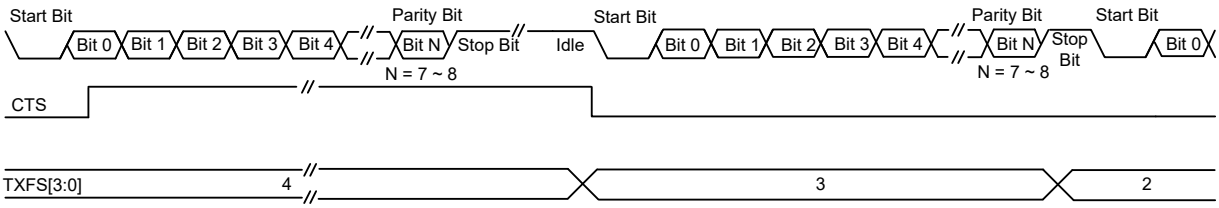


Figure 174. USART CTS Flow Control

IrDA

The USART IrDA mode is provided for half-duplex point-to-point wireless communication.

The USART module includes an integrated modulator and demodulator which allow a wireless communication using infrared transceivers. The transmitter specifies a logic data '0' as a 'high' pulse and a logic data '1' as a 'low' level while the receiver specifies a logic data '0' as a 'low' pulse and a logic data '1' as 'high' level in the IrDA mode.

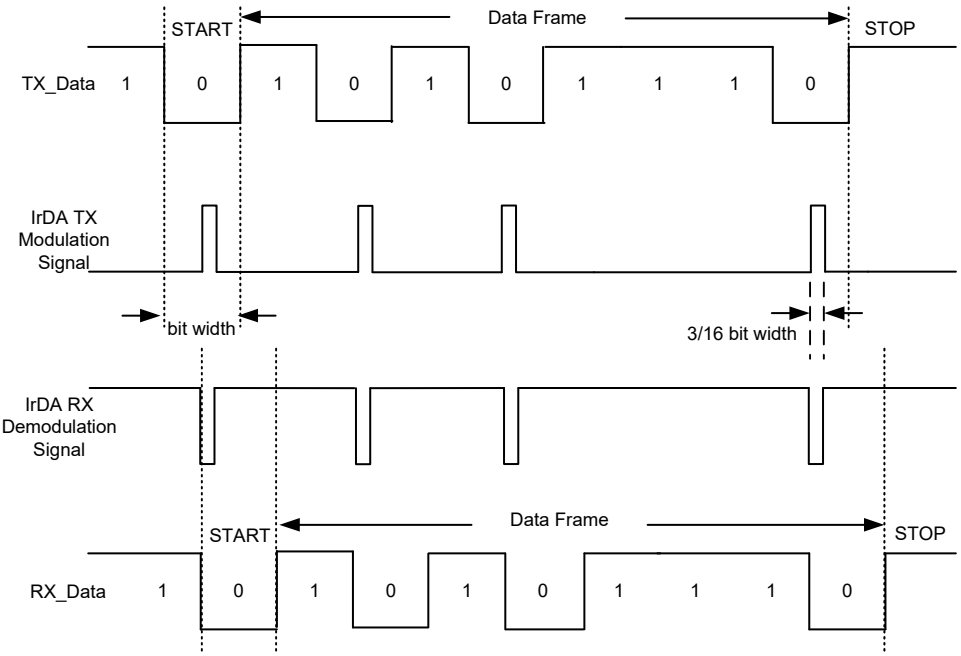


Figure 175. IrDA Modulation and Demodulation

The IrDA mode provides two operation modes, one is the normal mode and the other is the low-power mode.

IrDA Normal Mode

For the IrDA normal mode, the width of each transmitted pulse generated by the transmitter modulator is specified as 3/16 of the baud rate clock period. The receiver pulse width for the IrDA receiver demodulator is based on the IrDA receive debounce filter which is implement using an 8-bit down-counting counter. The debounce filter counter value is specified by the IrDAPSC field in the IrDACR register. When a falling edge is detected on the receiver pin, the debounce filter counter starts to count down, driven by the CK_USART clock. If a rising edge is detected on the receiver pin, the counter stops counting and is reloaded with the IrDAPSC value. When a low pulse falling edge on the receiver pin is detected and then before the debounce filter has counted down to zero, a rising edge is also detected, then this low pulse will be considered as glitch noise and will be discarded. If a low pulse falling edge appears on the receiver pin but no rising edge is detected before the debounce counter reaches 0, then the input is regarded as a valid data “0” for this bit duration. The IrDAPSC value must be set to be greater than or equal to 0x01, then the IrDA receiver demodulation operation can function properly. The IrDAPSC value can be adjusted to meet the USART baud rate setting to filter the IrDA received glitch noise of which the width is smaller than the prescaler setting duration.

IrDA Low-Power Mode

In the IrDA low-power mode, the transmitted IrDA pulse width generated by the transmitter modulator is not kept at 3/16 of the baud rate clock period. Instead, the pulse width is fixed and is calculated by the following formula. The transmitted pulse width can be adjusted by the IrDAPSC field to meet the minimum pulse width specification of the external IrDA Receiver device.

$$T_{IrDA\_L} = 3 \times IrDAPSC / CK\_USART$$

Note: T_{IrDA_L} is the transmitted pulse width in the low-power mode.
The IrDAPSC filed is the IrDA prescaler value in the IrDA Control Register IrDACR.

The debounce behavior in the IrDA low-power receiving mode is similar to the IrDA normal mode. For glitch detection, the low pulse of which the pulse width is shorter than 1 × (IrDAPSC / CK_USART) should be discarded in the IrDA receiver demodulation. A valid low data is accepted if its low pulse width is greater than 2 × (IrDAPSC / CK_USART) duration.

The IrDA physical layer specification specifies a minimum delay with a value of 10 ms between the transmission and reception switch; and this IrDA receiver set-up time also should be managed by the software.

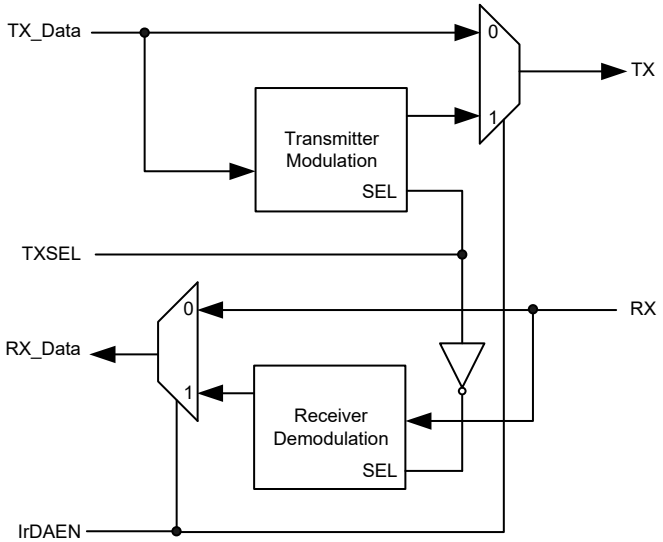


Figure 176. USART I/O and IrDA Block Diagram

RS485 Mode

The RS485 mode of the USART provides the data transmission on the interface transmitted over a 2-wire twisted pair bus. The RS485 transceiver interprets the voltage levels of the differential signals with respect to a third common voltage. Without this common reference, the transceiver may interpret the differential signals incorrectly. This enhances the noise rejection capabilities of the RS485 interface. The USART RTS pin is used to control the external RS485 transceiver whose polarity can be selected by configuring the TXENP bit in the RS485 Control Register, named RS485CR, when the USART operates in the RS485 mode.

RS485 Auto Direction Mode – AUD

When the RS485 mode is configured as a master transmitter, it will operate in the Auto Direction Mode, AUD. In the AUD mode the polarity of the USART RTS pin is configurable according to the TXENP bit in the RS485 Control Register in the RS485 mode. This pin can be used to control the external RS485 transceiver to enable the transmitter.

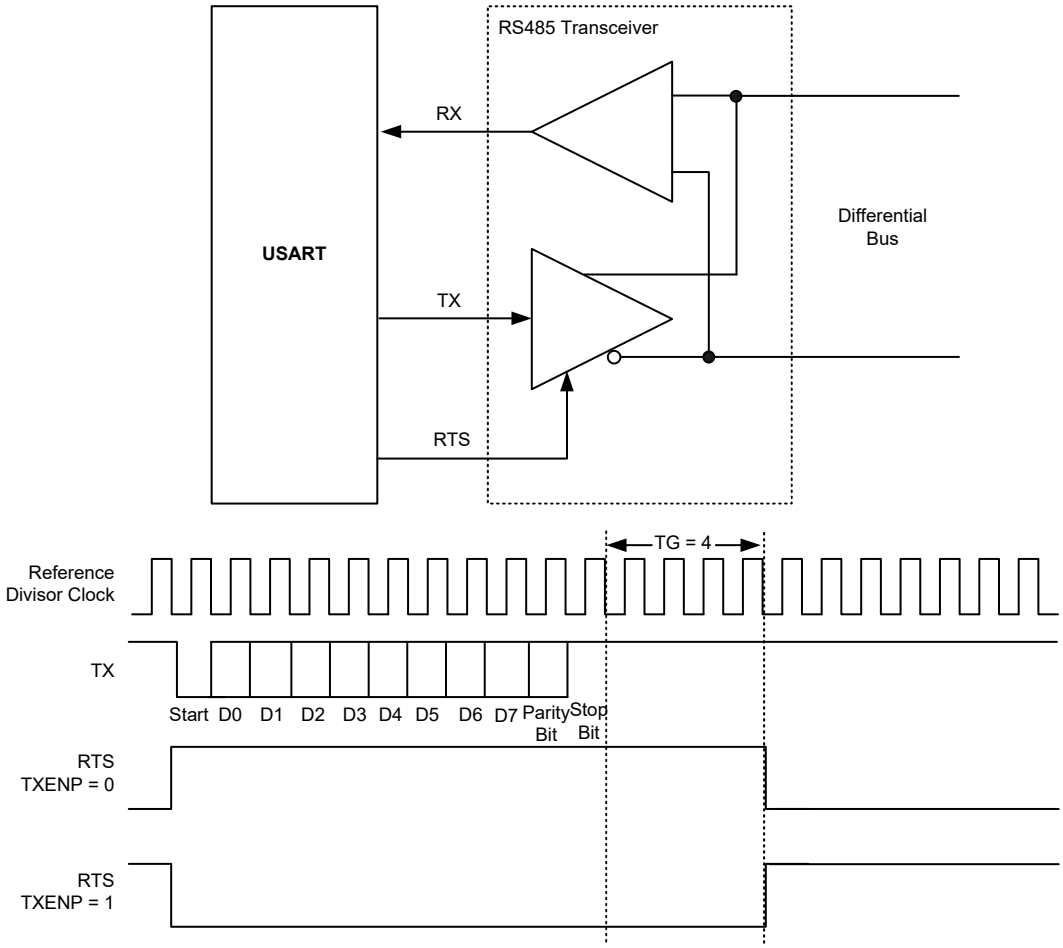


Figure 177. RS485 Interface and Waveform

RS485 Normal Multi-drop Operation Mode – NMM

When the RS485 mode is configured as an addressable slave, it will operate in the Normal Multi-drop Operation Mode, NMM. This mode is enabled when the RSNMM field is set in the RS485CR register. Regardless of the URRXEN value in the USRCR register, all the received data with a parity bit "0" will be ignored until the first address byte is detected with a parity bit "1" and then the received address byte will be stored in the RX FIFO. Once the first address data is detected and stored in the RX FIFO, the RSADD flag in the USRSIFR register will be set and generate an interrupt if the RSADDIE bit in the USRIER register is set to 1. Application software can determine whether the receiver is enabled or disabled to accept the following data by configuring the URRXEN bit. When the receiver is enabled by setting the URRXEN bit to 1, all received data will be stored in the RX FIFO. Otherwise, all received data will be ignored if the receiver is disabled by clearing the URRXEN bit to 0.

RS485 Auto Address Detection Operation Mode – AAD

Except in the Normal Multi-drop Operation Mode, the RS485 mode can operate in the Auto Address Detection Operation Mode, AAD, when it is configured as an addressable slave. This mode is enabled by setting the RSAAD filed to 1 in the RS485CR register. The receiver will detect the address frame with a parity bit "1" and then compare the received address data with the ADDMATCH field value which is a programmable 8-bit address value specified in the RS485CR register. If the address data matches the ADDMATCH value, it will be stored in the RX FIFO and the URRXEN bit will be automatically set. When the receiver is enabled, all received data will be stored in the RX FIFO until the next address frame does not match the ADDMATCH value and then the receiver will be automatically disabled. After the receiver is enabled, software can disable the receiver by setting the URRXEN bit to '0'.

Synchronous Master Mode

The data is transmitted in a full-duplex style in the USART Synchronous Master Mode, i.e., data transmission and reception both occur at the same time and only support master mode. The USART CTS pin is the synchronous USART transmitter clock output. In this mode, no clock pulses will be sent to the CTS pin during the start bit, parity bit and stop bit duration. The CPS bit in the Synchronous Control Register SYNCR, can be used to determine whether data is captured on the first or the second clock edge. The CPO bit in the SYNCR can be used to configure the clock polarity in the USART Synchronous Mode idle state. Detailed timing information is shown in Figure 178.

In the USART synchronous Mode, the USART CTS/SCK clock output pin is only used to transmit the data to slave device. If the transmission data register USRDR, is written with valid data, the USART synchronous mode will automatically transmit this data with the corresponding clock output and the USART receiver will also receive data on the RX pin. Otherwise the receiver will not obtain synchronous data if no data is transmitted.

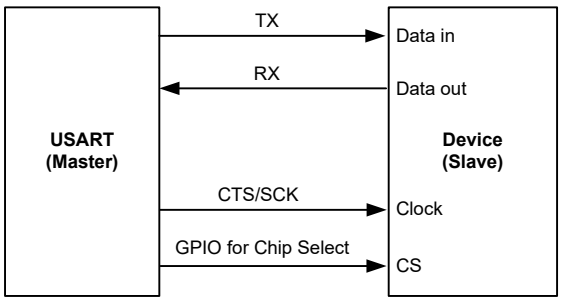


Figure 178. USART Synchronous Transmission Example

Note: The USART supports the synchronous master mode only: it cannot receive or send data related to an input clock. The USART CTS/SCK clock is always an output.

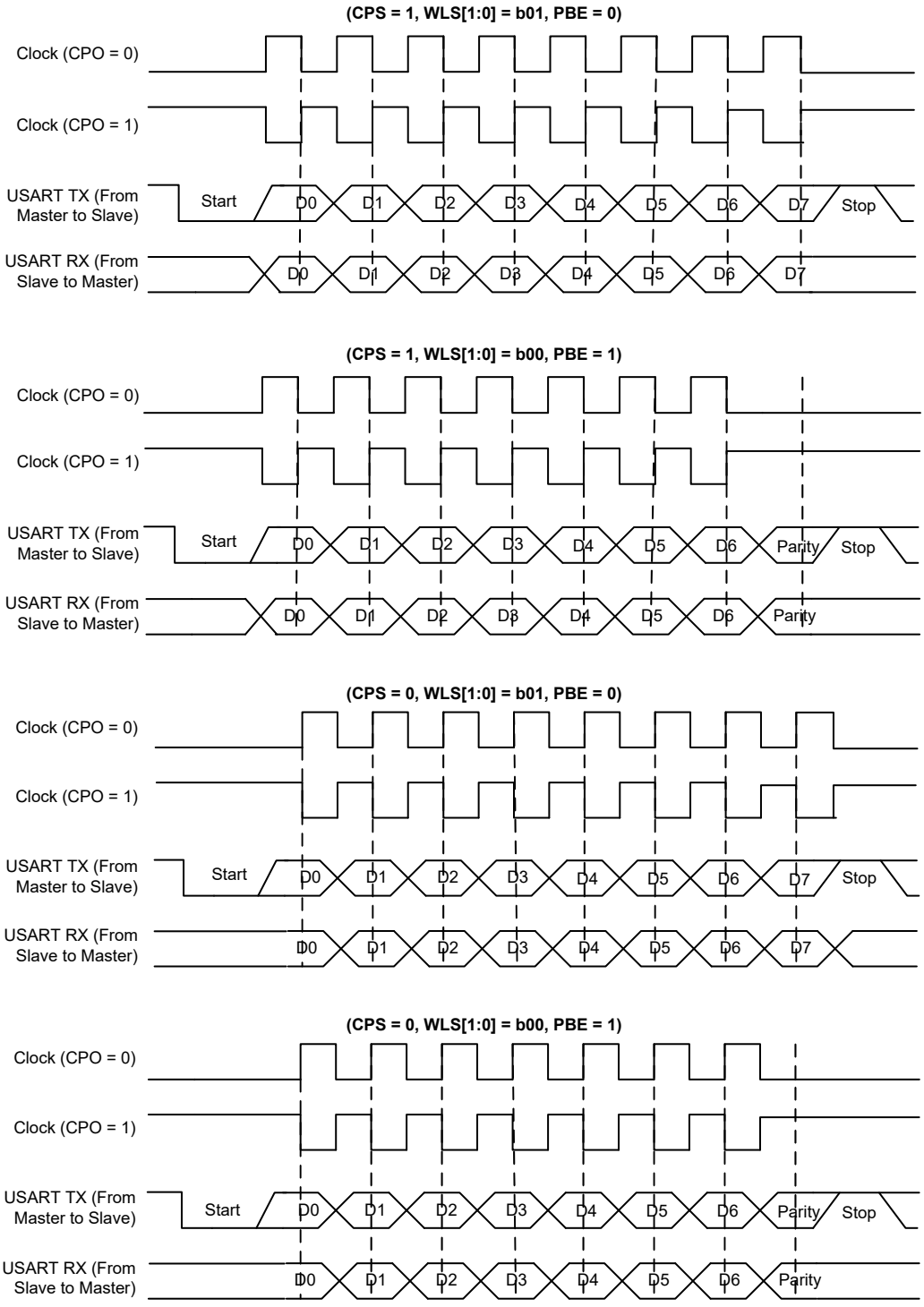


Figure 179. 8-bit Format USART Synchronous Waveform

Interrupts and Status

The USART can generate interrupts when the following event occurs and corresponding interrupt enable bits are set:

- Receive FIFO time-out interrupt: An interrupt will be generated when the USART receive FIFO is not empty and does not receive a new data package during the specified time-out interval.
- Receiver line status interrupts: The interrupts will be generated when the USART receiver overrun error, parity error, framing error and break events occur.
- Transmit FIFO threshold level interrupt: An interrupt will be generated when the data to be transmitted in the USART Transmit FIFO is less than the specified threshold level.
- Transmit complete interrupt: An interrupt will be generated when the Transmit FIFO is empty and the content of the transmit shift register (TSR) is also completely shifted.
- Receive FIFO threshold level interrupt: An interrupt will be generated when the FIFO received data amount has reached the specified threshold level.

Register Map

The following table shows the USART registers and reset values.

Table 52. USART Register Map

Register	Offset	Description	Reset Value
USRDR	0x000	USART Data Register	0x0000_0000
USRCR	0x004	USART Control Register	0x0000_0000
USRFCR	0x008	USART FIFO Control Register	0x0000_0000
USRIER	0x00C	USART Interrupt Enable Register	0x0000_0000
USRSIFR	0x010	USART Status & Interrupt Flag Register	0x0000_0980
USRTPR	0x014	USART Timing Parameter Register	0x0000_0000
IrDACR	0x018	USART IrDA Control Register	0x0000_0000
RS485CR	0x01C	USART RS485 Control Register	0x0000_0000
SYNCR	0x020	USART Synchronous Control Register	0x0000_0000
USRDLR	0x024	USART Divider Latch Register	0x0000_0010
USRTSTR	0x028	USART Test Register	0x0000_0000

Register Descriptions

USART Data Register – USRDR

The register is used to access the USART transmitted and received FIFO data.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							DB
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
	DB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[8:0]	DB	Reading data via this receiver buffer register will return the data from the receive FIFO. The receive FIFO has a capacity of up to 8 × 9 bits. By reading this register, the USART will return a 7, 8 and 9-bit received data. The DB field bit 8 is valid for 9-bit mode only and is fixed at 0 for the 8-bit mode. For the 7-bits mode, the DB[6:0] field contains the available bits. Writing data to this buffer register will load data into the Transmit FIFO. The Transmit FIFO has a capacity of up to 8 × 9 bits. By writing to this register, the USART will send out 7, 8 or 9-bit transmitted data. The DB field bit 8 is valid for the 9-bit mode only and will be ignored for the 8-bit mode. For the 7-bit mode, the DB[6:0] field contains the available bits.

USART Control Register – USRCR

The register specifies the serial parameters such as data length, parity and stop bit for the USART. It also contains the USART enable control bits together with the USART mode and data transfer mode selections.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	RTS	BCB	SPE	EPE	PBE	NSB	WLS	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved		URRXEN	URTXEN	HFCEN	TRSM	MODE	
Type/Reset			RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15]	RTS	Request-To-Send Signal 0: Drive USART RTS pin to logic 1 1: Drive USART RTS pin to logic 0 Note that the RTS bit is used to control the USART RTS pin status when the HFCEN bit is reset. When the HFCEN bit is set, this RTS bit is read only, which indicates the pin status that is controlled by hardware flow control function.
[14]	BCB	Break Control Bit When this bit is set 1, the serial data output on the USART TX pin will be forced to the Spacing State (logic 0). This bit acts only on USART TX output pin and has no effect on the transmitter logic.
[13]	SPE	Stick Parity Enable 0: Disable stick parity 1: Stick Parity bit is transmitted This bit is only available when the PBE bit is set to 1. If both the PBE and SPE bits are set to 1 and the EPE bit is cleared to 0, the transmitted parity bit will be stuck to 1. However, when the PBE and SPE bits are set to 1 and also the EPE bit is set to 1, the transmitted parity bit will be stuck to 0.
[12]	EPE	Even Parity Enable 0: Odd number of logic 1's are transmitted or checked in the data word and parity bits 1: Even number of logic 1's are transmitted or checked in the data word and parity bits This bit is only available when PBE is set to 1.

Bits	Field	Descriptions
[11]	PBE	Parity Bit Enable 0: Parity bit is not generated (transmitted data) or checked (received data) during transfer 1: Parity bit is generated or checked during transfer Note: When the WLS field is set to “10” to select the 9-bit data format, writing to the PBE bit has no effect.
[10]	NSB	Number of “STOP bit” 0: One “STOP bit” is generated in the transmitted data 1: Two “STOP bit” is generated when 8-bit and 9-bit word length is selected
[9:8]	WLS	Word Length Select 00: 7 bits 01: 8 bits 10: 9 bits 11: Reserved
[5]	URRXEN	USART RX Enable 0: Disable 1: Enable
[4]	URTXEN	USART TX Enable 0: Disable 1: Enable
[3]	HFCEN	Hardware Flow Control Function Enable 0: Disable 1: Enable
[2]	TRSM	Transfer Mode Selection This bit is used to select the data transfer protocol. 0: LSB first 1: MSB first
[1:0]	MODE	USART Mode Selection 00: Normal operation 01: IrDA 10: RS485 11: Synchronous

USART FIFO Control Register – USRFCR

This register specifies the USART FIFO control and configurations including threshold level and reset function together with the USART FIFO status.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved				RXFS			
Type/Reset					RO 0	RO 0	RO 0	RO 0
	23	22	21	20	19	18	17	16
	Reserved				TXFS			
Type/Reset					RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	RXTL		TXTL		Reserved		RXR	TXR
Type/Reset	RW 0	RW 0	RW 0	RW 0			WO 0	WO 0

Bits	Field	Descriptions
[27:24]	RXFS	RX FIFO Status The RXFS field shows the current number of data contained in the RX FIFO. 0000: RX FIFO is empty 0001: RX FIFO contains 1 data ... 1000: RX FIFO contains 8 data Others: Reserved
[19:16]	TXFS	TX FIFO Status The TXFS field shows the current number of data contained in the TX FIFO. 0000: TX FIFO is empty 0001: TX FIFO contains 1 data ... 1000: TX FIFO contains 8 data Others: Reserved
[7:6]	RXTL	RX FIFO Threshold Level Setting 00: 1 byte 01: 2 bytes 10: 4 bytes 11: 6 bytes The RXTL field defines the RX FIFO trigger level.
[5:4]	TXTL	TX FIFO Threshold Level Setting 00: 0 byte 01: 2 bytes 10: 4 bytes 11: 6 bytes The TXTL field determines the TX FIFO trigger level.

Bits	Field	Descriptions
[1]	RXR	RX FIFO Reset Setting this bit will generate a reset pulse to reset the RX FIFO which will empty the RX FIFO, i.e., the RX pointer will be reset to 0 after a reset signal. This bit returns to 0 automatically after the reset pulse is generated.
[0]	TXR	TX FIFO Reset Setting this bit will generate a reset pulse to reset the TX FIFO which will empty the TX FIFO, i.e., the TX pointer will be reset to 0 after a reset signal. This bit returns to 0 automatically after the reset pulse is generated.

USART Interrupt Enable Register – USRIER

This register is used to enable the related USART interrupt function. The USART module generates interrupts to the controller when the corresponding events occur and the corresponding interrupt enable bits are set.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved						CTSIE	RXTOIE
Type/Reset							RW 0	RW 0
	7	6	5	4	3	2	1	0
	RSADDIE	BIE	FEIE	PEIE	OEIE	TXCIE	TXDEIE	RXDRIE
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[9]	CTSIE	CTS Clear-To-Send Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the CTSC bit is set in the USRSIFR register.
[8]	RXTOIE	Receive FIFO Time-Out Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the RXTOF bit is set in the USRSIFR register.
[7]	RSADDIE	RS485 Address Detection Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the RSADD bit is set in the USRSIFR register.

Bits	Field	Descriptions
[6]	BIE	Break Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the BII bit is set in the USRSIFR register.
[5]	FEIE	Framing Error Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the FEI bit is set in the URSIFR register.
[4]	PEIE	Parity Error Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the PEI bit is set in the USRSIFR register.
[3]	OEIE	Overrun Error Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the OEI bit is set in the USRSIFR register.
[2]	TXCIE	Transmit Complete Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the TXC bit is set in the USRSIFR register.
[1]	TXDEIE	Transmit Data Empty Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the TXDE bit is set in the USRSIFR register.
[0]	RXDRIE	Receive Data Ready Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt will be generated when the RXDR bit is set in the USRSIFR register.

USART Status & Interrupt Flag Register – USRSIFR

This register contains the corresponding USART status.

Offset: 0x010

Reset value: 0x0000_0980

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved				CTSS	CTSC	RSADD	TXC
Type/Reset					RO 1	WC 0	WC 0	RO 1
	7	6	5	4	3	2	1	0
	TXDE	RXTOF	RXDR	BII	FEI	PEI	OEI	RXDNE
Type/Reset	RO 1	WC 0	RO 0	WC 0	WC 0	WC 0	WC 0	RO 0

Bits	Field	Descriptions
[11]	CTSS	CTS Clear-To-Send Status 0: CTS pin is inactive 1: CTS pin is active and kept at a logic low state
[10]	CTSC	CTS Status Change Flag This bit will be set whenever the CTS input pin status is changed and an Interrupt will be generated if the CTSIE = 1 in the USRIER register. Writing 1 to this bit clears the flag.
[9]	RSADD	RS485 Address Detection 0: Address is not detected 1: Address is detected This bit will be set to 1 when the receiver detects the address. An interrupt will be generated if RSADDIE = 1 in the USRIER register. Writing 1 to this bit clears the flag. Note: This bit is only used in the RS485 mode by setting the MODE field in the USRCR register.
[8]	TXC	Transmit Complete 0: Either transmit FIFO (TX FIFO) or transmit shift register (TSR) is not empty 1: Both the TX FIFO and TSR register are empty An interrupt will be generated if TXCIE = 1 in the USRIER register. This bit is cleared by a write to the USRDR register with new data.
[7]	TXDE	Transmit Data FIFO Empty 0: TX FIFO level is higher than threshold 1: TX FIFO level is equal to or less than threshold The TXDE bit will be set when transmit FIFO level is equal to or less than the transmit FIFO threshold level setting which is set by the TXTL field in the USRFCR register. This bit will be cleared when the new data is written into the USRDR register and the TX FIFO level is higher than threshold setting.

Bits	Field	Descriptions
[6]	RXTOF	Receive FIFO Time-Out Flag 0: RX FIFO Time-Out does not occur 1: RX FIFO Time-Out occurs The RXTOF bit will be set if the RX FIFO is not empty and no activities have occurred in the RX FIFO during the time-out duration specified by the RXTOC field. If an RX FIFO time-out condition has occurred, this flag must be cleared before reading the RX FIFO. Writing 1 to this bit clears the flag.
[5]	RXDR	Receive FIFO Ready Flag 0: RX FIFO level is less than threshold 1: RX FIFO level is equal to or higher than threshold The RXDR bit will be set when the FIFO received data amount reaches the specified threshold level which is set by the RXTL field in the USRFCR register. This bit will be cleared when the data is read from the USRDR register and the RX FIFO level is less than threshold setting.
[4]	BII	Break Interrupt Indicator This bit will be set to 1 whenever the received data input is held in the “spacing state” (logic 0) for longer than a full word transmission time, which is the total time of “start bit” + “data bits” + “parity” + “stop bits” duration. Writing 1 to this bit clears the flag.
[3]	FEI	Framing Error Indicator This bit will be set to 1 whenever the received character does not have a valid “stop bit”, which means the stop bit following the last data bit or parity bit is detected as a logic 0. Writing 1 to this bit clears the flag.
[2]	PEI	Parity Error Indicator This bit will be set to 1 whenever the received character does not have a valid “parity bit”. Writing 1 to this bit clears the flag.
[1]	OEI	Overrun Error Indicator An overrun error will occur only after the RX FIFO is full and when the next character has been completely received in the RX shift register. The character in the shift register will be overwritten if a new character is received in the RX shift register after an overrun event occurs, but the data in the RX FIFO will not be overwritten. The OEI bit is used to indicate the overrun event as soon as it happens. Writing 1 to this bit clears the flag.
[0]	RXDNE	RX FIFO Data Not Empty 0: RX FIFO is empty 1: RX FIFO contains at least 1 received data word

USART Timing Parameter Register – USRTPR

This register contains the USART timing parameters including the transmitter time guard parameters and the receive FIFO time-out value together with the RX FIFO time-out function enable control.

Offset: 0x014

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	TG							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	RXTOEN	RXTOC						
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:8]	TG	Transmitter Time Guard The transmitter time guard counter is driven by the baud rate clock. When the TX FIFO transmits data, the counter will be reset and then starts to count after a word transmission has completed. Only when the counter content is equal to the TG value, are further word transmission transactions allowed.
[7]	RXTOEN	Receive FIFO Time-Out Counter Enable 0: Receive FIFO Time-Out Counter is disabled 1: Receive FIFO Time-Out Counter is enabled
[6:0]	RXTOC	Receive FIFO Time-Out Counter Compare Value The RX FIFO time-out counter is driven by the baud rate clock. When the RX FIFO receives new data, the counter will be reset and then starts to count. Once the time-out counter content is equal to the time-out counter compare value RXTOC, a receive FIFO time-out interrupt, RXTOI, will be generated if the RXTOIE bit in the USRIER register is set to 1. New received data or the empty RX FIFO after being read will clear the RX FIFO time-out counter.

USART IrDA Control Register – IrDACR

This register is used to control the IrDA mode of USART.

Offset: 0x018

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	IrDAPSC							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
		Reserved	RXINV	TXINV	LB	TXSEL	IrDALP	IrDAEN
Type/Reset			RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:8]	IrDAPSC	IrDA Prescaler value This field contains the 8-bit debounce prescaler value. The debounce count-down counter is driven by the USART clock, named as CK_USART. The counting period is specified by the IrDAPSC field. The IrDAPSC field must be set to a value equal to or greater than 0x01 for normal debounce counter operation. If the pulse width is less than the duration specified by the IrDAPSC field, the pulse will be considered as glitch noise and discarded. 00000000: Reserved – can not be used. 00000001: CK_USART clock divided by 1 00000010: CK_USART clock divided by 2 00000011: CK_USART clock divided by 3 ...
[5]	RXINV	RX Signal Inverse Control 0: No inversion 1: RX input signal is inversed
[4]	TXINV	TX Signal Inverse Control 0: No inversion 1: TX output signal is inversed
[3]	LB	IrDA Loop Back Mode 0: Disable IrDA loop back mode 1: Enable IrDA loop back mode for self-testing
[2]	TXSEL	Transmit Select 0: Enable IrDA receiver 1: Enable IrDA transmitter
[1]	IrDALP	IrDA Low Power Mode Select the IrDA operation mode. 0: Normal mode 1: IrDA low power mode

Bits	Field	Descriptions
[0]	IrDAEN	IrDA Enable control 0: Disable IrDA mode 1: Enable IrDA mode

USART RS485 Control Register – RS485CR

This register is used to control the RS485 mode of USART.

Offset: 0x01C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	ADDMATCH							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	Reserved					RSAAD	RSNMM	TXENP
Type/Reset						RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:8]	ADDMATCH	RS485 Auto Address Match value The field contains the address match value for the RS485 auto address detection operation mode.
[2]	RSAAD	RS485 Auto Address Detection Operation Mode Control 0: Disable 1: Enable
[1]	RSNMM	RS485 Normal Multi-drop Operation Mode Control 0: Disable 1: Enable
[0]	TXENP	USART RTS/TXE Pin Polarity 0: RTS/TXE is active high in the RS485 transmission mode 1: RTS/TXE is active low in the RS485 transmission mode

USART Synchronous Control Register – SYNCR

This register is used to control the USART synchronous mode.

Offset: 0x020

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				CPO	CPS	Reserved	CLKEN
Type/Reset					RW 0	RW 0		RW 0

Bits	Field	Descriptions
[3]	CPO	Clock Polarity 0: CTS/SCK pin idle state is low 1: CTS/SCK pin idle state is high Selects the polarity of the clock output on the USART CTS/SCK pin in the synchronous mode. Works in conjunction with the CPS bit to specify the desired clock idle state.
[2]	CPS	Clock Phase 0: Data is captured on the first clock edge 1: Data is captured on the second clock edge This bit allows the user to select the phase of the clock output on the USART CTS/SCK pin in the synchronous mode. Works in conjunction with the CPO bit to determine the data capture edge.
[0]	CLKEN	Clock Enable 0: CTS/SCK pin disabled 1: CTS/SCK pin enabled Enable/disable the USART CTS/SCK pin.

USART Divider Latch Register – USRDLR

The register is used to determine the USART clock divided ratio to generate the appropriate baud rate.

Offset: 0x024

Reset value: 0x0000_0010

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	BRD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	BRD							
Type/Reset	RW 0	RW 0	RW 0	RW 1	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	BRD	Baud Rate Divider The 16 bits define the USART clock divider ratio. Baud Rate = CK_USART / BRD Where the CK_USART clock is the clock connected to the USART module. BRD = 16 ~ 65535 for asynchronous mode BRD = 8 ~ 65535 for synchronous mode.

USART Test Register – USRTSTR

This register controls the USART debug mode.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						LBM	
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[1:0]	LBM	Loopback Test Mode Select 00: Normal Operation 01: Reserved 10: Automatic Echo Mode 11: Loopback Mode

22 Universal Asynchronous Receiver Transmitter (UART)

Introduction

The Universal Asynchronous Receiver Transceiver, UART, provides a flexible full duplex data exchange using asynchronous transfer. The UART is used to translate data between parallel and serial interfaces, and is also commonly used for RS232 standard communication. The UART peripheral function supports a variety of interrupts.

The UART module includes a transmit data register TDR and transmit shift register TSR, and a receive data register RDR and receive shift register RSR. Software can detect a UART error status by reading the UART Status & Interrupt Flag Register, URSIFR. The status includes the condition of the transfer operations as well as several error conditions resulting from Parity, Overrun, Framing and Break events.

The UART includes a programmable baud rate generator which is capable of dividing the UART clock of the CK_APB (CK_UART) to produce a baud rate clock for the UART transmitter and receiver.

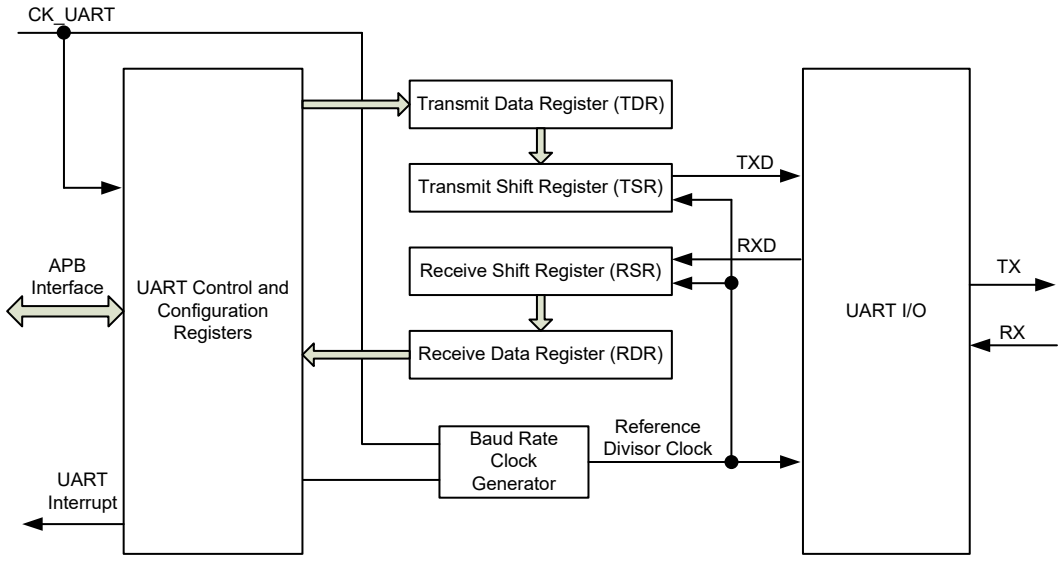


Figure 180. UART Block Diagram

Features

- Supports asynchronous serial communication modes
- Full Duplex Communication Capability
- Programming baud rate clock frequency up to (f_{PCLK}/16) MHz
- Fully programmable serial communication functions including:
  - Word length: 7, 8 or 9-bit character
  - Parity: Even, odd or no-parity bit generation and detection
  - Stop bit: 1 or 2 stop bits generation
  - Bit order: LSB-first or MSB-first transfer
- Error detection: Parity, overrun and frame error

Function Descriptions

Serial Data Format

The UART module performs a parallel-to-serial conversion on data that is written to the transmit data register and then sends the data with the following format: Start bit, 7 ~ 9 LSB / MSB first data bits, optional Parity bit and finally 1 ~ 2 Stop bits. The Start bit has the opposite polarity of the data line idle state. The Stop bit is the same as the data line idle state and provides a delay before the next start situation. Both the Start and Stop bits are used for data synchronization during the asynchronous data transmission.

The UART module also performs a serial-to-parallel conversion on the data that is read from the receive data register. It will first check the Parity bit and will then look for a Stop bit. If the Stop bit is not found, the UART module will consider the entire word transmission to have failed and respond with a Framing Error.

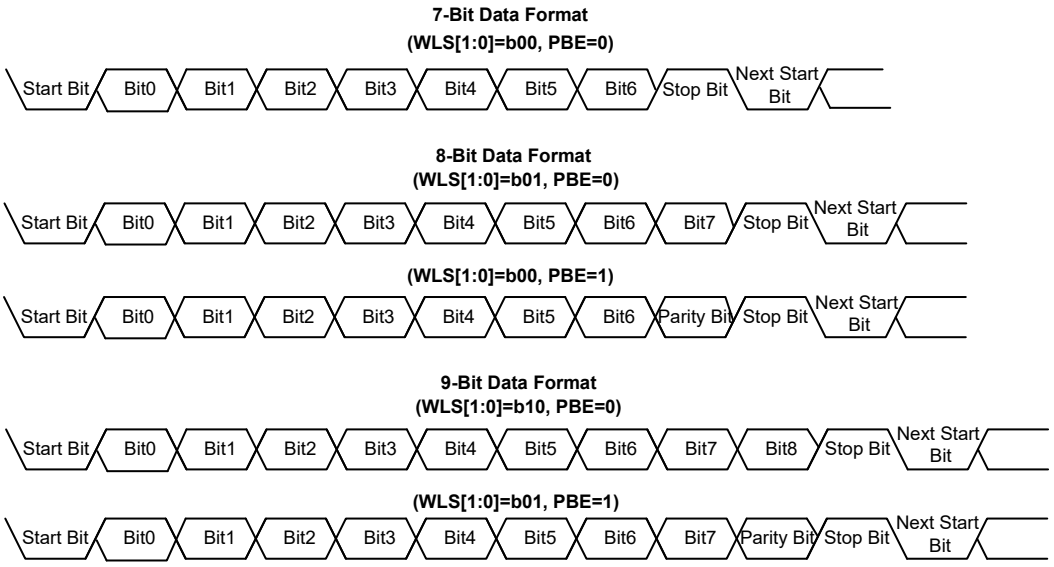


Figure 181. UART Serial Data Format

Baud Rate Generation

The baud rate for the UART receiver and transmitter are both set with the same values. The baud-rate divisor, BRD, has the following relationship with the UART clock which is known as CK_UART.

Baud Rate Clock = CK_UART / BRD

Where CK_UART clock is the APB clock connected to the UART while the BRD range is from 16 to 65535.

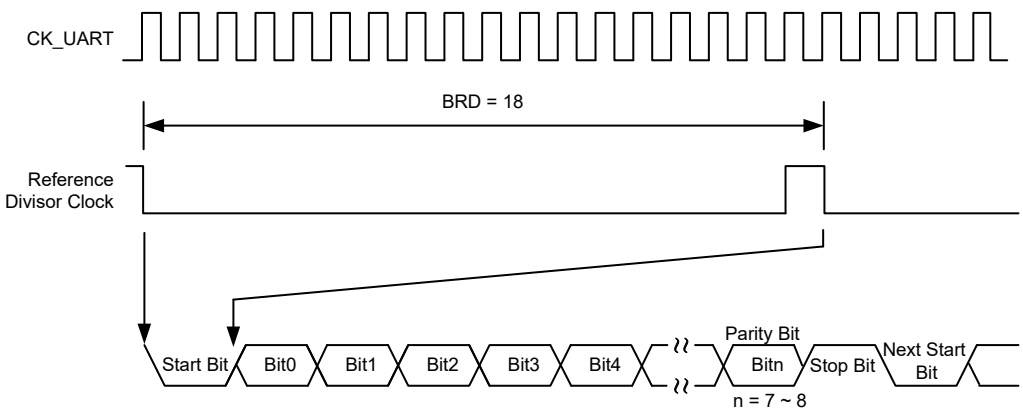


Figure 182. UART Clock CK_UART and Data Frame Timing

Table 53. Baud Rate Deviation Error Calculation – CK_UART = 20 MHz

Baud Rate		CK_UART = 20 MHz		
No.	Kbps	Actual	BRD	Deviation Error Rate
1	2.4	2.4	8333	0.00%
2	9.6	9.6	2083	0.02%
3	19.2	19.2	1042	-0.03%
4	57.6	57.6	347	0.06%
5	115.2	114.9	174	-0.22%
6	230.4	229.9	87	-0.22%
7	460.8	465.1	43	0.94%
8	921.6	909.1	22	-1.36%
9	1250	1250	16	0%

Table 54. Baud Rate Deviation Error Calculation – CK_UART = 10 MHz

Baud Rate		CK_UART = 10 MHz		
No.	Kbps	Actual	BRD	Deviation Error Rate
1	2.4	2.4	4167	-0.01%
2	9.6	9.6	1042	-0.03%
3	19.2	19.2	521	-0.03%
4	57.6	57.6	174	-0.22%
5	115.2	114.9	87	-0.22%
6	230.4	232.6	43	0.94%
7	460.8	454.5	22	-1.36%
8	625	625	16	0%

Interrupts and Status

The UART can generate interrupts when the following event occurs and the corresponding interrupt enable bits are set:

- Receiver line status interrupts: The interrupts are generated when the overrun error, parity error, framing error or break event occurs for the UART receiver.
- Transmit data register empty interrupt: An interrupt is generated when the content of the transmit data register is transferred to the transmit shift register (TSR).
- Transmit complete interrupt: An interrupt is generated when the transmit data register (TDR) is empty and the content of the transmit shift register (TSR) is also completely shifted.
- Receive data ready interrupt: An interrupt is generated when the content of the receive shift register (RSR) has been transferred to the URDR register and is ready to read.

Register Map

The following table shows the UART registers and reset values.

Table 55. UART Register Map

Register	Offset	Description	Reset Value
URDR	0x000	UART Data Register	0x0000_0000
URCR	0x004	UART Control Register	0x0000_0000
URIER	0x00C	UART Interrupt Enable Register	0x0000_0000
URSIFR	0x010	UART Status & Interrupt Flag Register	0x0000_0180
URDLR	0x024	UART Divider Latch Register	0x0000_0010
URTSTR	0x028	UART Test Register	0x0000_0000

Register Descriptions

UART Data Register – URDR

The register is used to access the UART transmitted and received data.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							DB
Type/Reset								RW 0
	7	6	5	4	3	2	1	0
	DB							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[8:0]	DB	By reading this register, the UART will return a 7, 8 and 9-bit received data. The DB field bit 8 is valid for the 9-bit mode only and is fixed at 0 for the 8-bit mode. For the 7-bit mode, the DB[6:0] contains the available bits. By writing to this register, the UART will send out 7, 8 or 9-bit transmitted data. The DB field bit 8 is valid for the 9-bit mode only and will be ignored for the 8-bit mode. For the 7-bit mode, the DB[6:0] field contains the available bits.

UART Control Register – URCR

The register specifies the serial parameters such as data length, parity and stop bit for the UART.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved	BCB	SPE	EPE	PBE	NSB	WLS	
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
		Reserved	URRXEN	URTXEN	Reserved	TRSM		Reserved
Type/Reset			RW 0	RW 0		RW 0		

Bits	Field	Descriptions
[14]	BCB	Break Control Bit When this bit is set to 1, the serial data output on the UART TX pin will be forced to the Spacing State (logic 0). This bit acts only on the UART TX output pin and has no effect on the transmitter logic.
[13]	SPE	Stick Parity Enable 0: Disable stick parity 1: Stick Parity bit is transmitted This bit is only available when the PBE bit is set to 1. If both the PBE and SPE bits are set to 1 and the EPE bit is cleared to 0, the transmitted parity bit will be stuck to 1. However, when the PBE and SPE bits are set to 1 and also the EPE bit is set to 1, the transmitted parity bit will be stuck to 0.
[12]	EPE	Even Parity Enable 0: Odd number of logic 1's are transmitted or checked in the data word and parity bits 1: Even number of logic 1's are transmitted or checked in the data word and parity bits This bit is only available when PBE is set to 1.
[11]	PBE	Parity Bit Enable 0: Parity bit is not generated (transmitted data) and checked (receive data) during transfer 1: Parity bit is generated and checked during transfer Note: When the WLS field is set to "10" to select the 9-bit data format, writing to the PBE bit has no effect.
[10]	NSB	Number of "STOP bit" 0: One "STOP bit" is generated in the transmitted data 1: Two "STOP bit" is generated when 8- and 9-bit word length is selected

Bits	Field	Descriptions
[9:8]	WLS	Word Length Select 00: 7 bits 01: 8 bits 10: 9 bits 11: Reserved
[5]	URRXEN	UART RX Enable 0: Disable 1: Enable
[4]	URTXEN	UART TX Enable 0: Disable 1: Enable
[2]	TRSM	Transfer Mode Selection This bit is used to select the data transfer protocol. 0: LSB first 1: MSB first

UART Interrupt Enable Register – URIER

This register is used to enable the related UART interrupt function. The UART module generates interrupts to the controller when the corresponding events occur and the corresponding interrupt enable bits are set.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								

	7	6	5	4	3	2	1	0
	Reserved	BIE	FEIE	PEIE	OEIE	TXCIE	TXDEIE	RXDRIE
Type/Reset		RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[6]	BIE	Break Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the break interrupt is enabled and the BII bit is set in the URSIFR register.

Bits	Field	Descriptions
[5]	FEIE	Framing Error Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the framing error interrupt is enabled and the FEI bit is set in the URSIFR register.
[4]	PEIE	Parity Error Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the parity error interrupt is enabled and the PEI bit is set in the URSIFR register.
[3]	OEIE	Overrun Error Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the overrun error interrupt is enabled and the OEI bit is set in the URSIFR register.
[2]	TXCIE	Transmit Complete Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the transmit complete interrupt is enabled and the TXC bit is set in the URSIFR register.
[1]	TXDEIE	Transmit Data Register Empty Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the transmit data register empty interrupt is enabled and the TXDE bit is set in the URSIFR register.
[0]	RXDRIE	Receive Data Ready Interrupt Enable 0: Disable interrupt 1: Enable interrupt If this bit is set, an interrupt is generated when the receive data ready interrupt is enabled and the RXDR bit is set in the URSIFR register.

UART Status & Interrupt Flag Register – URSIFR

This register contains the corresponding UART status.

Offset: 0x010

Reset value: 0x0000_0180

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							TXC
Type/Reset								RO 1
	7	6	5	4	3	2	1	0

	TXDE	Reserved	RXDR	BII	FEI	PEI	OEI	Reserved
Type/Reset	RO 1		RO 0	WC 0	WC 0	WC 0	WC 0	

Bits	Field	Descriptions
[8]	TXC	Transmit Complete 0: Either the transmit data register (TDR) or transmit shift register (TSR) is not empty 1: Both the transmit data register (TDR) and transmit shift register (TSR) are empty An interrupt is generated if TXCIE = 1 in the URIER register. This bit is cleared by a write to the URDR register with new data.
[7]	TXDE	Transmit Data Register Empty 0: Transmit data register is not empty 1: Transmit data register is empty The TXDE bit is set by hardware when the content of the transmit data register is transferred to the transmit shift register (TSR). An interrupt is generated if TXEIE = 1 in the URIER register. This bit is cleared by a write to the URDR register with a new data.
[5]	RXDR	RX Data Ready 0: Receive data register is empty 1: Received data in the receive data register is ready to read This bit is set by hardware when the content of the receive shift register (RSR) has been transferred to the URDR register. An interrupt is generated if RXDRIE = 1 in the URIER register. It is cleared by a read to the URDR register.
[4]	BII	Break Interrupt Indicator This bit is set to 1 whenever the received data input is held in the “spacing state” (logic 0) for longer than a full character transmission time, which is the total time of “start bit” + “data bits” + “parity” + “stop bits” duration. Writing 1 to this bit clears the flag.
[3]	FEI	Framing Error Indicator This bit is set 1 whenever the received character does not have a valid “stop bit”, which means the stop bit following the last data bit or parity bit is detected as logic 0. Writing 1 to this bit clears the flag.
[2]	PEI	Parity Error Indicator This bit is set to 1 whenever the received character does not have a valid “parity bit”. Writing 1 to this bit clears the flag.
[1]	OEI	Overrun Error Indicator An overrun error will occur only after the receive data register is full and when the next character has been completely received in the receive shift register. The character in the receive shift register will be overwritten when a new character is received in the receive shift register after an overrun event occurs, but the data in the receive shift register will not be transferred to the receive data register. The OEI bit is used to indicate the overrun event as soon as it happens. Writing 1 to this bit clears the flag.

UART Divider Latch Register – URDLR

The register is used to determine the UART clock divided ratio to generate the appropriate baud rate.

Offset: 0x024

Reset value: 0x0000_0010

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	BRD							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	BRD							
Type/Reset	RW 0	RW 0	RW 0	RW 1	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[15:0]	BRD	Baud Rate Divider The 16 bits define the UART clock divider ratio. Baud Rate = CK_UART / BRD Where the CK_UART clock is the clock connected to the UART module. BRD = 16 ~ 65535 for UART mode

UART Test Register – URTSTR

This register controls the UART debug mode.

Offset: 0x028

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved						LBM	
Type/Reset							RW 0	RW 0

Bits	Field	Descriptions
[1:0]	LBM	Loopback Test Mode Select 00: Normal Operation 01: Reserved 10: Automatic Echo Mode 11: Loopback Mode

23 Divider (DIV)

Introduction

In order to enhance the MCU performance, a divider is integrated in the devices. The divider can implement the signed or unsigned 32-bit data division operation. An error flag will be generated when the division by zero condition occurs.

Features

- Signed / unsigned 32-bit divider
- Calculate in 8 clock cycles and load in 1 clock cycle
- Division by zero error flag

Functional Descriptions

The division and modulus functions of the truncated division are related in the following way:

$$A / B = Q \ldots R$$

Where "A" is Dividend, "B" is Divisor, "Q" is Quotient and "R" is Remainder. The divider requires a software trigger start signal to start a calculation by setting the "START" bit in the Divider Control Register. The divider calculation complete flag will be set to 1 after 8 clock cycles, however, if the divisor register data is zero during the calculation, the division by zero error flag will be set to 1.

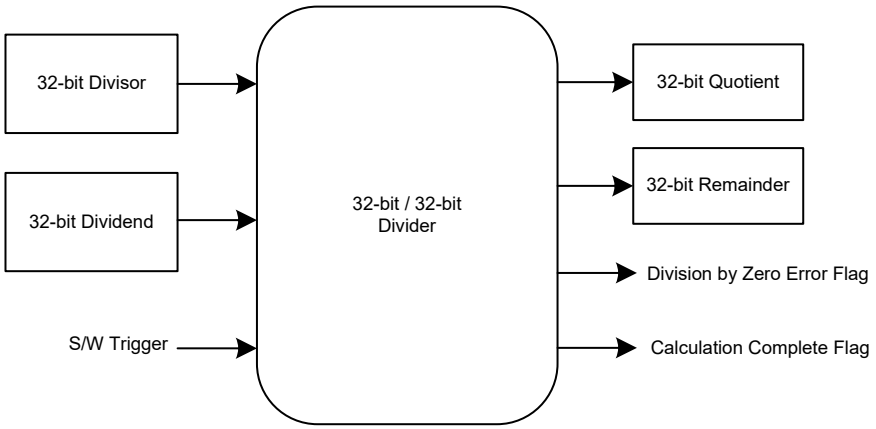


Figure 183. Divider Functional Diagram

Register Map

The following table shows the DIV registers and reset values.

Table 56. DIV Register Map

Register	Offset	Description	Reset Value
CR	0x000	Divider Control Register	0x0000_0008
DDR	0x004	Dividend Data Register	0x0000_0000
DSR	0x008	Divisor Data Register	0x0000_0000
QTR	0x00C	Quotient Data Register	0x0000_0000
RMR	0x010	Remainder Data Register	0x0000_0000

Register Descriptions

Divider Control Register – CR

This register contains the divider trigger control bit and the calculation status.

Offset: 0x000

Reset value: 0x0000_0008

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	Reserved				COM	ZEF	Reserved	START
Type/Reset					RO 1	RO 0		RW 0

Bits	Field	Descriptions
[3]	COM	Calculation Complete Flag 0: Data is invalid 1: New data is valid If this bit is set to 1, it indicates that the divider calculation is completed and data is valid. This bit is cleared to 0 by hardware after a calculation is initiated.
[2]	ZEF	Division by Zero Error Flag 0: Divisor is not zero 1: Divisor is zero This bit will be cleared to 0 by hardware after a calculation is initiated.
[0]	START	Divider calculation start trigger control bit 0: No action 1: Trigger divider to start calculation When this bit is set high, the divider will start a calculation.

Dividend Data Register – DDR

The register is used to specify the dividend data.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	DDR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	DDR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	DDR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	DDR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	DDR	Dividend Data Register This bit field is used to specify the dividend of the divider calculation.

Divisor Data Register – DSR

The register is used to specify the divisor data.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	DSR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	23	22	21	20	19	18	17	16
	DSR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	15	14	13	12	11	10	9	8
	DSR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0
	7	6	5	4	3	2	1	0
	DSR							
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[31:0]	DSR	Divisor Data Register This bit field is used to specify the divisor of the divider calculation.

Quotient Data Register – QTR

The register is used to store the quotient data.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	QTR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	23	22	21	20	19	18	17	16
	QTR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	QTR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	7	6	5	4	3	2	1	0
	QTR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[31:0]	QTR	Quotient Data Register This bit field is used to store the quotient of the divider calculation result.

Remainder Data Register – RMR

The register is used to store the remainder data.

Offset: 0x010

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	RMR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	23	22	21	20	19	18	17	16
	RMR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	RMR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	7	6	5	4	3	2	1	0
	RMR							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[31:0]	RMR	Remainder Data Register This bit field is used to store the remainder of the divider calculation result.

24 Cyclic Redundancy Check (CRC)

Introduction

The CRC (Cyclic Redundancy Check) calculation unit is an error detection technique test algorithm and is used to verify data transmission or storage data correctness. A CRC calculation takes a data stream or a block of data as input and generates a 16-bit or 32-bit output remainder. Ordinarily, a data stream is suffixed by a CRC code and used as a checksum when being sent or stored. Therefore, the received or restored data stream is calculated by the same generator polynomial as described above. If the new CRC code result does not match the one calculated earlier, that means data stream contains a data error.

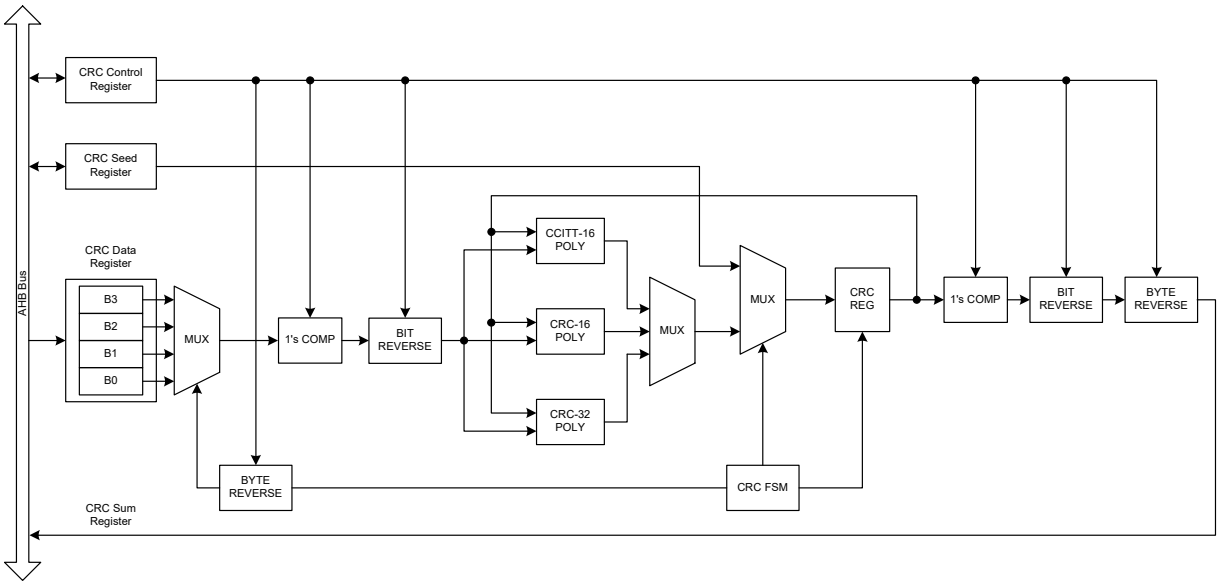


Figure 184. CRC Block Diagram

Features

- Supports CRC16 polynomial: 0x8005, $X^{16} + X^{15} + X^2 + 1$
- Supports CCITT CRC16 polynomial: 0x1021, $X^{16} + X^{12} + X^5 + 1$
- Supports IEEE-802.3 CRC32 polynomial: 0x04C11DB7, $X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$
- Supports 1's complement, byte reverse & bit reverse operation on data and checksum
- Supports byte, half-word & word data size
- Programmable CRC initial seed value
- CRC computation done in 1 AHB clock cycle for 8-bit data and 4 AHB clock cycles for 32-bit data

Functional Descriptions

This unit only enables the calculation in the CRC16, CCITT CRC16 and IEEE-802.3 CRC32 polynomials. In this unit, the generator polynomial is fixed to the numeric values for those modes; therefore, the CRC value based on other generator polynomials cannot be calculated.

CRC Computation

The CRC calculation unit has a 32-bit write CRC data register (CRCDR) and a read CRC checksum register (CRCCSR). The CRCDR register is used to input new data (write access) and the CRCCSR register is used to hold the result of the previous CRC calculation (read access). Each write operation to the CRCDR register creates a combination of the previous CRC value (stored in CRCCSR) and the new one. The CRC block diagram is shown as Figure 184. The CRC unit calculates the CRC data register (CRCDR) value byte by byte and the default byte and bit order is big-endian. The CRCDR register can be written by word, right-aligned half-word and right-aligned byte. For the other registers only 32-bit access is allowed. The duration of the computation depends on data width:

- 4 AHB clock cycles for 32-bit data input
- 2 AHB clock cycles for 16-bit data input
- 1 AHB clock cycle for 8-bit data input

Byte and Bit Reversal for CRC Computation

The byte reordering and byte-level bit reversal operation can be occurred before the data is used in the CRC calculation or after the CRC checksum output. They are configurable using the corresponding setting field of the CRCCR register. These operations occur on word or half-word writes. The hardware ignores the DATBYRV bit of the CRCCR register with any byte writes but the bit reversal setting DATBIRV are still applied to the byte. The Figure 185 is shown the byte and bit reversal operation example.

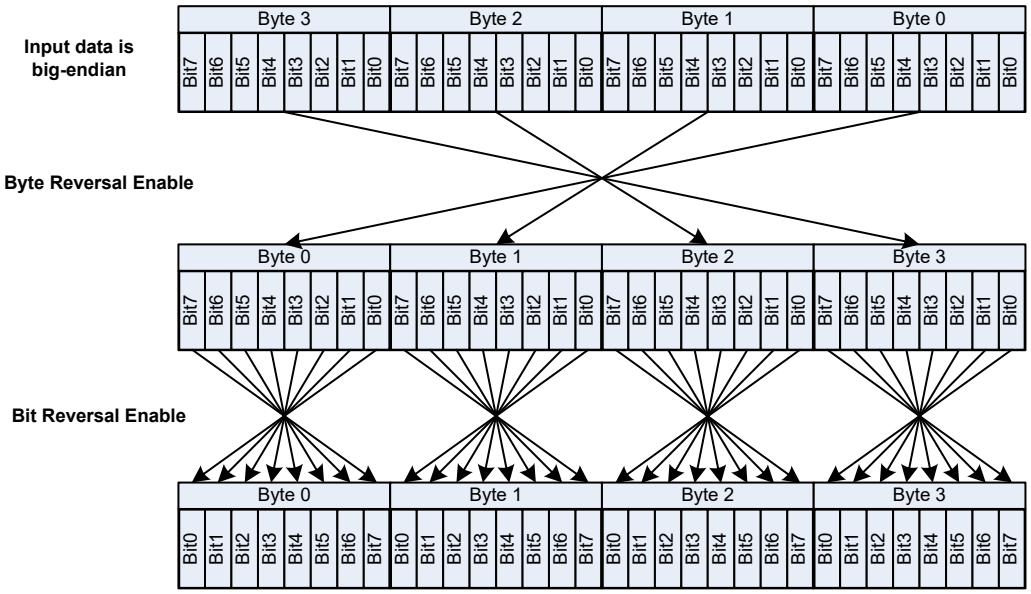


Figure 185. CRC Data Bit and Byte Reversal Example

Register Map

The following table shows the CRC registers and reset values.

Table 57. CRC Register Map

Register	Offset	Description	Reset Value
CRCCR	0x000	CRC Control Register	0x0000_0000
CRCSDR	0x004	CRC Seed Register	0x0000_0000
CRCCSR	0x008	CRC Checksum Register	0x0000_0000
CRCDR	0x00C	CRC Data Register	0x0000_0000

Register Descriptions

CRC Control Register – CRCCR

This register specifies the corresponding CRC function enable control.

Offset: 0x000

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	Reserved							
Type/Reset								
	23	22	21	20	19	18	17	16
	Reserved							
Type/Reset								
	15	14	13	12	11	10	9	8
	Reserved							
Type/Reset								
	7	6	5	4	3	2	1	0
	SUMCMPL	SUMBYRV	SUMBIRV	DATCMPL	DATBYRV	DATBIRV	POLY	
Type/Reset	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0	RW 0

Bits	Field	Descriptions
[7]	SUMCMPL	1's Complement operation on Checksum Output 0: Disable 1: Enable
[6]	SUMBYRV	Byte Reverse operation on Checksum Output 0: Disable 1: Enable
[5]	SUMBIRV	Bit Reverse operation on Checksum Output 0: Disable 1: Enable
[4]	DATCMPL	1's Complement operation on Data 0: Disable 1: Enable
[3]	DATBYRV	Byte Reverse operation on Data 0: Disable 1: Enable

Bits	Field	Descriptions
[2]	DATBIRV	Bit Reverse operation on Data 0: Disable 1: Enable
[1:0]	POLY	CRC polynomial 00: CRC-CCITT (0x1021) 01: CRC-16 (0x8005) 1x: CRC-32 (0x04C11DB7)

CRC Seed Register – CRCSDR

This register is used to specify the CRC seed.

Offset: 0x004

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	SEED							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	23	22	21	20	19	18	17	16
	SEED							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	15	14	13	12	11	10	9	8
	SEED							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	7	6	5	4	3	2	1	0
	SEED							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[31:0]	SEED	CRC Seed Data Put the 16/32-bit seed value in this register according to the polynomial setting in the CRCCR register.

CRC Checksum Register – CRCCSR

This register contains the CRC checksum output.

Offset: 0x008

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	CHKSUM							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	23	22	21	20	19	18	17	16
	CHKSUM							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	15	14	13	12	11	10	9	8
	CHKSUM							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0
	7	6	5	4	3	2	1	0
	CHKSUM							
Type/Reset	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0	RO 0

Bits	Field	Descriptions
[31:0]	CHKSUM	CRC Checksum Data Get the CRC 16 / 32-bit checksum result through this register according to the polynomial setting in the CRCCR register after all data are written to the CRCDR register.

CRC Data Register – CRCDR

This register is used to specify the CRC input data.

Offset: 0x00C

Reset value: 0x0000_0000

	31	30	29	28	27	26	25	24
	CRCDATA							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	23	22	21	20	19	18	17	16
	CRCDATA							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	15	14	13	12	11	10	9	8
	CRCDATA							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0
	7	6	5	4	3	2	1	0
	CRCDATA							
Type/Reset	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0	WO 0

Bits	Field	Descriptions
[31:0]	CRCDATA	CRC Input Data Byte, half-word and word writes are allowed. 1's complement, byte reverse and bit reverse operation can be applied.