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32176 Group

Application of Timer TIO (PWM output Mode)

1. Overview

The following article shows sample program of 32176 group using timer TIO.

2. Introduction

The sample task described here uses the following microcomputer, under the respective conditions.

- Microcomputer: 32176 Group (M32176FnVFP, M32176FnTFP)
- Operating frequency: 20 to 40MHz (The sample program is compiled assuming a frequency of 40 MHz.)
- Operating Board: Starter kit for 32176 Group

3. Explanation of an applied technology

3.1 Outline of Multijunction Timers

The multijunction timers (abbreviated MJT) have input event buses and output event buses. Therefore, in addition to be used as a single unit, the timers can be internally connected to each other. This capability allows for highly flexible timer configuration, making it possible to meet various applications needs. It is because the timers are connected to internal event bus at multiple points that they are called the “multijunction” timers.

MJT is detailed in 32176 Group User's Manual.

4. PWM Output mode Sample Program

4.1 Outline of the sample program

The sample program here starts the timer to output PWM waveforms by specifying the PWM cycle and duty with arguments by using TIO0 is output to external terminal TO11. Interrupt by underflow is not used here.

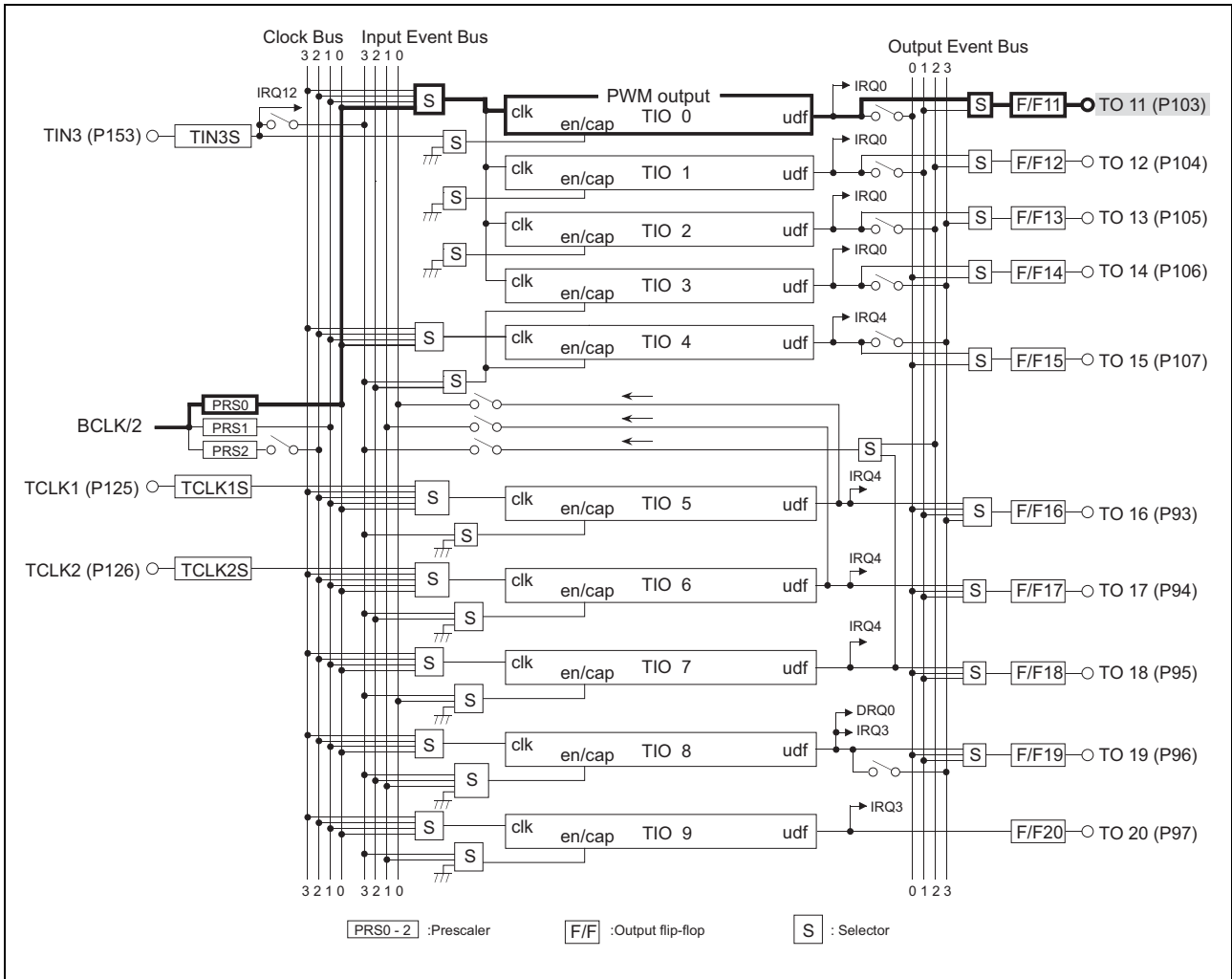


Figure 4.1.1 Configuration of TIO PWM Output Timer

4.2 Processing procedure

The basic processing flow of a timer setup is shown in Figure 4.2.1.

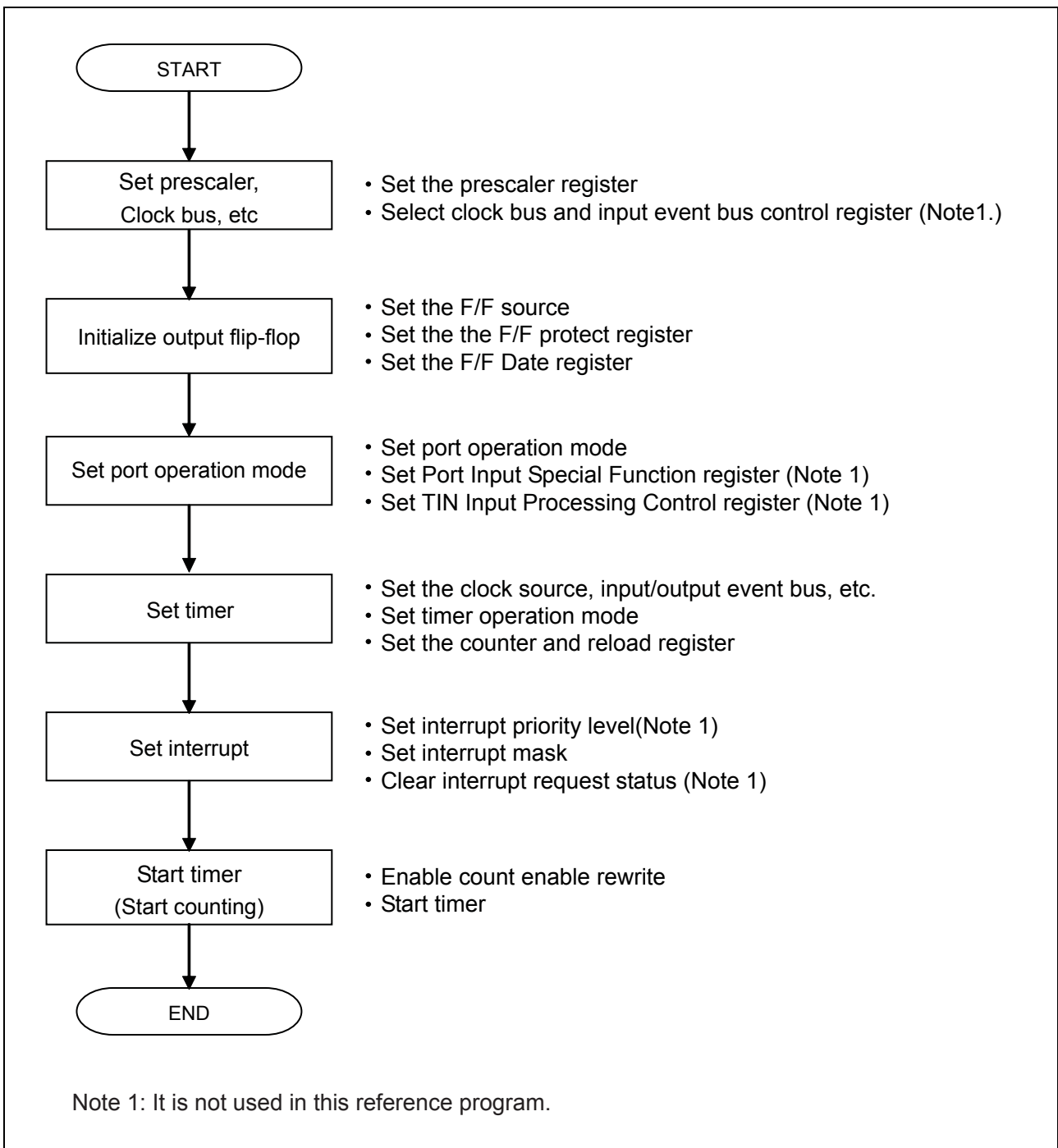


Figure 4.2.1 Basic Timer Setup Flow

4.3 Description of a reference program

Note. The registers used are indicated as (register name: bit name)

4.3.1 Timer initialization function (timer_init())

- (1) Set the prescaler's divide-by value
 - Set prescaler register 0 as “the prescaler's divide-by value-1”. (PRS0)

4.3.2 Various initialization function (init_func())

- (1) Call the timer initialization function

4.3.3 Main function (main())

- (1) Call the interrupt disable function
- (2) Call the various initialization function
- (3) Call the TIO0 PWM output mode Initial setting function
- (4) Call the interrupt enable function
- (5) Call the TIO0 PWM output start function
(PWM cycle and duty value are given)
- (6) Infinite loop waiting for Interrupt

4.3.4 TIO0 PWM output mode initial setting function (TIO0_PWM_init())

(1) Initializing the timer output pin

- Select TIO0 output in F/F11 source selection. (FFS0: FF11)
- Enable writing to the F/F11 output bit. (FFP0: FP11)
- Set the F/F11 output initial value to “0”. (FFD0: FD11)
- Set P103 operation mode bit of P10 Operation Mode Register to TO11. (P10MOD: P103MOD)

(2) Setting timer TIO0

- Select clock bus 0 for the clock source. (TIO03CR1: TIO03CKS)
- Set TIO0 to PWM output mode. (TIO03CR0: TIO0M)
- Disable TIO0 interrupt. (TIOIR0: TIOIM0)

4.3.5 TIO0 PWM output start function (TIO0_PWM_out())

(1) Execution judgment

- If the PWM cycle is “0”, terminate abnormally.

(2) Calculating output time

- Calculate the high-level pulse width from the PWM cycle and duty.
- Call the disable interrupt function.

(3) Processing when duty is “0” or high-level pulse is “0” (Low-level is outputted)

- Enable writing to TIO0 count enable bit. (TIOPRO: TIO0PRO)
- Stop TIO0 count. (TIOCEN: TIO0CEN)
- Set P103 data bit in P10 Data Register to “0”. (P10DATA: P103DT)
- Set P103 direction bit in P10 Direction Register to output mode. (P10DIR: P103 DIR)
- Set P103 operation mode bit in P10 Operation Mode Register to input/output port. (P10MOD: P103MOD)

(4) Processing when duty is more than H'100 or high-level pulse is more than PWM cycle (High-level is outputted)

- Enable writing to TIO0 count enable bit. (TIOPRO: TIO0PRO)
- Stop TIO0 count. (TIOCEN: TIO0CEN)
- Set P103 data bit in P10 Data Register to “0”. (P10DATA: P103DT)
- Set P103 direction bit in P10 Direction Register to output mode. (P10DIR: P103 DIR)
- Set P103 operation mode bit in P10 Operation Mode Register to input/output port. (P10MOD: P103MOD)

(5) Processing for other condition

- Set the high-level and the low-level pulse widths in reload 0 and 1 registers, respectively.
- When the timer is not operating, perform the following processing.
 - 1) Enable writing to the F/F11 output bit. (FFP0: FP11)
 - 2) Set the F/F11 output initial value to “0”. (FFD0: FD11)
 - 3) Enable writing to TIO0 count enable bit. (TIOPRO: TIO0PRO)
 - 4) Start TIO0 count. (TIOCEN: TIO0CEN)
 - 5) Wait until F/F11 output goes high-level. (Delay by count clock).
- Set P103 operation mode bit of P10 Operation Mode Register to TO11. (P10MOD: P103MOD)

(6) Call the enable interrupt function

Note. When set Direction Register to output before setting port Data Register, undefined value is outputted until finish writing to Data Register.

4.4 Sample Programming Code

The sample program of TIO0 PWM output Mode is shown below.

The sample program here starts the timer to output PWM waveforms by specifying the PWM cycle and duty with arguments. The reload register set values are calculated from the PWM cycle and duty in the program.

Note that the sample program below requires the SFR definition file. The latest SFR definition file can be downloaded from Renesas Technology website. When using the SFR definitions file, adjust the path setting to match the operating computer environment.

4.4.1 TIO0_pwm_main.c

```

1  /*"FILE COMMENT"*****
2  *      M32R C Programming          Rev. 1.01
3  *      < Sample Program for 32176 >
4  *      < TIO0 PWM output (main routine) >
5  *
6  *      Copyright (c) 2004 Renesas Technology Corporation
7  *      All Rights Reserved
8  *      *****/
9
10 /******/
11 /*      Include file                */
12 /******/
13
14 #include          "..\inc\sfr32176_pragma.h"
15
16 /******/
17 /*      Function prototype declaration */
18 /******/
19
20 void          main(void);          /* Main function */
21 void          init_func(void);     /* Initial setup function */
22 void          timer_init(void);    /* Timer initialization */
23
24 /******/
25 /*      Definition of external reference */
26 /******/
27
28 extern void          DisInt( void );          /* Interrupt disable function */
29 extern void          EnInt( void );          /* Interrupt enable function */
30
31 extern void          TIO0_PWM_init( void );   /* Initialize TIO0 PWM output mode */
32 extern ULONG          TIO0_PWM_out( USHORT cycle, USHORT duty ); /* Start TIO0 PWM output */
33
34 /*"FUNC COMMENT"*****
35 * Function name: timer_init()
36 *-----
37 * Description   : Initialize timer
38 *-----
39 * Argument     : -
40 *-----
41 * Returns      : -
42 *-----
43 * Notes        :
44 *"FUNC COMMENT END"*****/
45 void timer_init(void)
46 {
47     PRS0 = ( 100 - 1);          /* Set prescaler(10us@10MHz) */
48 }
49
50 /*"FUNC COMMENT"*****
51 * Function name: init_func()
52 *-----
53 * Description   : Call various initialization functions
54 *-----
55 * Argument     : -
56 *-----
57 * Returns      : -
58 *-----
59 * Notes        :
60 *"FUNC COMMENT END"*****/
61 void init_func(void)
62 {
63     timer_init();          /* Initialize those related to timer */
64 }
65
66 /*"FUNC COMMENT"*****
67 * Function name: main()
68 *-----
69 * Description   : While using TIO0 in PWM output mode, this program outputs a PWM waveform from the T011 pin
70 *               : with a 2ms period (when the source clock frequency = 10 MHz) and a 10/256 high duty cycle.

```

```

71  *-----
72  * Argument      : -
73  *-----
74  * Returns      : -
75  *-----
76  * Notes        :
77  *"FUNC COMMENT END"*****
78  void main(void)
79  {
80      DisInt();                /* Disable interrupt */
81
82      init_func();
83
84      TIO0_PWM_init();        /* Initialize TIO0 PWM output mode */
85
86      EnInt();                /* Enable interrupt */
87
88      TIO0_PWM_out( (USHORT)200, (USHORT)16); /* Start TIO0 PWM output */
89
90      while( 1 ){
91          ;
92      }
93  }

```

4.4.2 TIO0_pwm.c

```

1  /*"FILE COMMENT"*****
2  *      M32R C Programming          Rev. 1.01
3  *      < Sample Program for 32176 >
4  *      < TIO0 PWM output mode >
5  *
6  *      Copyright (c) 2004 Renesas Technology Corporation
7  *      All Rights Reserved
8  *****/
9
10 *****/
11 /*      Include file          */
12 *****/
13
14 #include          "..\inc\sfr32176_pragma.h"
15
16 *****/
17 /*      Definition of external reference          */
18 *****/
19
20 extern void          DisInt( void );          /* Interrupt disable function */
21 extern void          EnInt( void );          /* Interrupt enable function */
22
23 *****/
24 /*      Function prototype declaration          */
25 *****/
26
27 void          TIO0_PWM_init( void );          /* Initialize TIO0 PWM output mode */
28 ULONG          TIO0_PWM_out( USHORT cycle, USHORT duty );          /* Start TIO0 PWM output */
29
30 *****/
31 /*      Define macro          */
32 *****/
33
34 #define OK          1ul
35 #define NG          0ul
36
37 /*** PWM(TIO0) ***/
38
39                                     /* 0123 4567          */
40 #define TIO03_ClkSrc          0x00          /* 0000 0000B          */
41                                     /* | | | | | | | | Select clock bus 0          */
42                                     /* + + + + + + + + don't care          */
43
44                                     /* 0123 4567 89AB CDEF          */
45 #define TIO0_MASK          0x000fu          /* 0000 0000 0000 1111B          */
46 #define TIO0_PWM          0x0003u          /* 0000 0000 0000 0011B          */
47                                     /*          | + + + + Set TIO0 PWM mode          */
48                                     /*          + + + + + TIO0 enable: unselected          */
49
50                                     /* 0123 4567 89AB CDEF          */
51 #define FF11_TIO0M          0x0100u          /* 0000 0001 0000 0000B          */
*/
52                                     /*          + + + + + + + + FF11 source : TIO0 unselected          */
53
54 /*"FUNC COMMENT"*****
55 * Function name: TIO0_PWM_init()
56 *-----
57 * Description : Initial settings necessary to drive TIO0 in PWM mode
58 *              : - While driving TIO0 in PWM mode, this function outputs PWM waveform from T011
59 *              : - The count source used for this operation is clock bus 0
60 *-----
61 * Argument   : -
62 *-----
63 * Returns    : -
64 *-----
65 * Notes      : The prescaler, clock bus, etc. are set separately from the above
66 *              : Must be executed while interrupts are disabled
67 *"FUNC COMMENT END"*****/
68 void          TIO0_PWM_init( void )
69 {
70     UCHAR          temp;
71     USHORT          temp16;
72
73     /*** Initializing P103 (T011) output (low-level output) ***/
74
75     FFS0 &= ~FF11_TIO0M;          /* FF11 source : TIO0 selected */
76
77     FFP0 = (~FP11) & 0xFFFFu;          /* Enable F/F11 rewrite */
78     FFD0 = 0x0000;          /* F/F11 low (0) output (inverted to high during timer
operation) */
79     P10MOD |= 0x10u;          /* Select T011 (TIO0 output) for output */
80
81     /*** PWM setting (TIO0) ***/
82

```

```

83     TIO03CR1 = TIO03_ClkSrc;                /* Select TIO0 clock source */
84
85     templ6 = TIO03CR0;
86     TIO03CR0 = ( templ6 & ~TIO0_MASK) | TIO0_PWM;    /* Set TIO0 PWM */
87     temp = TIOIR0;
88     temp |= ( TIOIS3 | TIOIS2 | TIOIS1) | TIOIM0;    /* Disable TIO0 interrupt */
89     TIOIR0 = temp;
90 }
91
92 /*"FUNC COMMENT"*****
93 * Function name: TIO0_PWM_out()
94 *-----
95 * Description   : Drive TIO1 in PWM mode
96 *-----
97 * Argument      : unsigned short cycle  PWM period
98 *                : unsigned short duty   High duty (0~100%:0x0000~0x0100)
99 *-----
100 * Returns       : Terminated normally      1
101 *                : Terminated abnormally   0
102 *                : - PWM period = 0
103 *-----
104 * Notes         : PWM periodFor 0/100% duty cycle, OFF/ON processing is performed in port mode.
105 *"FUNC COMMENT END"*****
106 ULONG TIO0_PWM_out( USHORT cycle, USHORT duty)
107 {
108     ULONG Hwidth;
109     ULONG ret_c;
110
111     ret_c = OK;
112
113     if( cycle == 0) {                          /* Determine PWM period */
114         ret_c = NG;
115     }
116     else{
117
118     /** Calculating high-level output time ***/
119
120         Hwidth = (ULONG)duty * cycle;
121         Hwidth >>= 8;
122
123         DisInt();                               /* Disable TIO0 interrupt */
124
125     /** duty 0% ***/
126
127         if(( duty == 0) ||
128            ( Hwidth == 0u)) {
129             TIOPRO = (~TIO0PRO) & 0xFFFFu;    /* Enable TIO0 enable protect rewrite */
130             TIOCEN = 0x0000;                  /* Stop TIO0 count (PWM stop) */
131             P1ODATA &= ~0x10u;                /* P103 low(0) output */
132             P1ODIR |= 0x10u;                  /* P103 output */
133             P1OMOD &= ~0x10u;                /* Disable TO11 (TIO0 output) against output .. Port P103
output selected */
134         }
135
136     /** duty 100% ***/
137
138         else if(( duty >= 0x100) ||
139                ( Hwidth >= cycle)) {
140             TIOPRO = (~TIO0PRO) & 0xFFFFu;    /* Enable TIO0 enable protect rewrite */
141             TIOCEN = 0x0000;                  /* Stop TIO0 count (PWM stop) */
142             P1ODATA |= 0x10u;                /* P103 High(0) output */
143             P1ODIR |= 0x10u;                  /* P103 output */
144             P1OMOD &= ~0x10u;                /* Disable TO11 (TIO0 output) against output .. Port P103
output selected */
145         }
146
147     /** PWM output ***/
148
149         else {
150             TIOORL1 = cycle - (USHORT)Hwidth - 1;
151             TIOORL0 = (USHORT)Hwidth - 1;
152             if(( TIOCEN & TIOOCEN) == 0u) {    /* Start output from 0% or 100% state */
153                 FFP0 = (~FP11) & 0xFFFFu;    /* Enable F/F11 rewrite */
154                 FFD0 = 0x0000;                /* F/F11 low (0) output (inverted to high during
timer operation) */
155                 TIOPRO = (~TIO0PRO) & 0xFFFFu; /* Enable TIO0 enable protect rewrite */
156                 TIOCEN = 0xffff;              /* Start TIO0 count (PWM start) */
157
158             /** Preventing glitch generated by a prescaler equivalent delay ***/
159
160                 while(( FFD0 & FD11) == 0u){ /* Start timer and wait until F/F11 goes high
*/
161                     ;
162                 }
163             }
164         }
165     }
166     else{
167         ;
168     }
169 }

```

```
166         }  
167         P10MOD |= 0x10u;           /* Select T011 (TIO0 output) for output */  
168     }  
169     EnInt();                       /* Enable interrupt */  
170 }  
171  
172     return( ret_c );  
173 }
```

4.5 Timing of operation

Timing of operation in this reference program is shown below.
(In the program, it is considering as cycle=200, duty= 16)

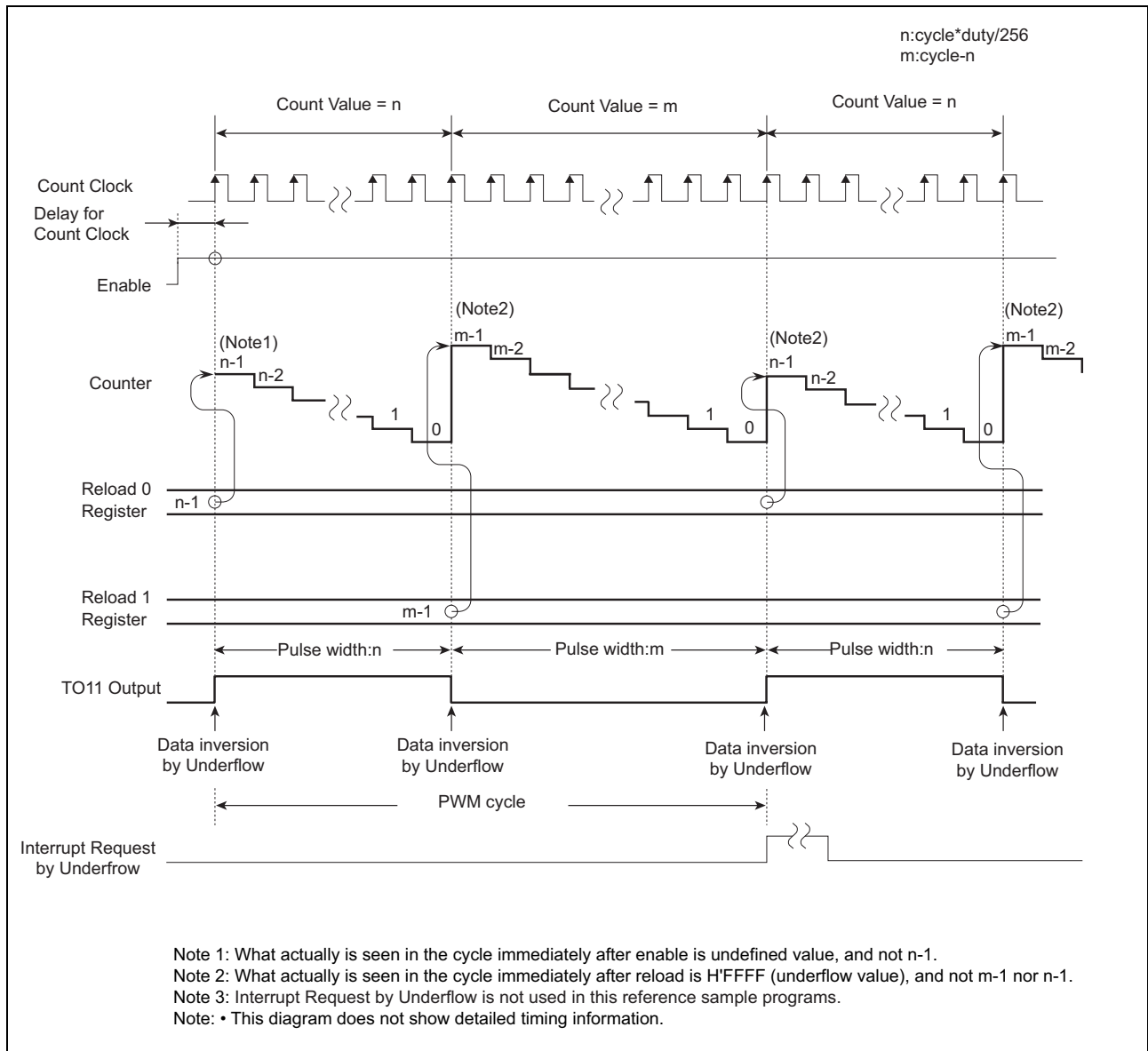


Figure 4.5.1 Timing Diagram for TIO PWM output mode

5. Reference of Document

- 32176 Group User's Manual Rev.1.01
- M32R Family Software Manual Rev.1.20
- M3T-CC32R V.4.30 User's Manual (Compiler)
- M3T-AS32R V.4.30 User's Manual (Assembler)

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