Hardware Integration Guide

AirPrime AR7592

SIERRA WIRELESS®

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Important Notice

Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

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1. Introduction

1.1. General Features

The AirPrime AR7592 embedded modules are designed for the automotive industry. They support LTE, WCDMA air interface standards and shares hardware and firmware interfaces with the AirPrime AR755x and AR758x. They also have Global Navigation Satellite System (GNSS) capabilities including GPS and GLONASS.

The AirPrime AR7592 embedded modules are based on the Qualcomm MDM9640 wireless chipset and support the following bands.

Table 1. AirPrime AR759x Series Embedded Modules

Product	Description	Band Support	Target Region[1]
AR7592	LTE-CA / WCDMA / GSM / GPRS / EDGE embedded module	LTE: B2, B4, B5, B7*, B12, B13*, B17, B29 WCDMA: B2, B4, B5, B6 GSM/GPRS/EDGE: 850/1900	North America (Canada, US, Mexico)

1 Other regions or operators which use the same frequency bands may also be supported, subject to review and confirmation by Sierra Wireless.

* Optional band

Table 2. AirPrime AR759x Series Supported Carrier Aggregation Combinations[1]

Mode	AR7592
Intra-band CA (2CC), Non contiguous	4A+4A, (7A+7A) 2
Intra-band CA (2CC), Contiguous	(7C) 2
Inter-band CA (2CC)	2A+5A, 2A+12A, (2A+13A) 2, 2A+17A, 2A+29A, 4A+5A, 4A+12A, (4A+13A) 2, 4A+17A, 4A+29A

1 Refer to 3GPP

2 Optional Band

1.2. Power

The AirPrime AR7592 are powered via a single regulated DC power supply, 3.7V nominal.

Table 3. Power Supply Requirements

Power Supply		Min	Typ	Max	Units
Main DC Power Input Range (VBATT)		3.4	3.7	4.2	V
Power Supply Ripple	0 to 1kHz	-	-	200	mVpp
	>1kHz	-	-	50	mVpp
Peak Current	AR759X	-	2000	3000	mA

Table 4. Power Supply Pads

Pad	Name	Direction	Function	If Unused
EA2	VBATT	Input	Power Supply Input	Must Be Used
EB2	VBATT	Input	Power Supply Input	Must Be Used
EC2	VBATT	Input	Power Supply Input	Must Be Used

1.3. RF

This section presents the WWAN RF interface of the AirPrime AR7592. The specifications for the LTE, GSM and WCDMA interfaces are defined.

1.3.1. GSM RF Interface

This section presents the GSM RF Specification for the AirPrime AR7592.

1.3.1.1. GSM TX Output Power

The GSM Maximum Transmitter Output Power of the AirPrime AR7592 are specified in the following table.

Note: All values presented in the table below are preliminary.

Table 5. Conducted TX (Transmit) Max output Power Tolerances – GSM/EDGE Bands

Band	Standard 1 (dBm)[1]	Standard 2 (dBm)[2]	TX Power @ +25°C (dBm)	TX Power @ Class A (dBm)[3]	Notes
GSM 850	33± 2dB	33± 2.5dB	33± 2dB	33± 2.5dB	GMSK mode, connectorized(Class 4; 2 W, 33 dBm)
GSM 1900	30± 2dB	30± 2.5dB	30± 2dB	30± 2.5dB	GMSK mode
GSM 850	27± 3dB	27± 4dB	27± 3dB	27± 4dB	8PSK mode, connectorized(Class E2; 0.5 W, 27 dBm)
GSM 1900	26± 3dB	26± 4dB	26± 3dB	26± 4dB	8PSK mode

1 Per 3GPP TS 51.010-1 Requirement for Normal condition.

2 Per 3GPP TS 51.010-1 Requirement for Extreme conditions

3 Test at Class A extreme condition

1.3.1.2. GSM RX Sensitivity

The GSM Receiver Sensitivities of the AirPrime AR759x Series are specified in the following table.

Table 6. Conducted RX (Receive) Sensitivity – GSM/EDGE Bands

GSM/EDGE Bands			Limit (dBm)[1]	Room Typical (dBm)	Class A (Extreme) Typical (dBm)[2]	Class A Limit (dBm)
GSM 850	2% BER CS	CS	-102	−109	tbd	-103
	10% BLER	GMSK CS1	-104	Tbd	tbd	-105
	10% BLER	EDGE MCS5	-98	Tbd	tbd	-99
PCS 1900	2% BER CS	CS	-102	−108.5	tbd	-103
	10% BLER	GMSK CS1	-104	Tbd	tbd	-105
	10% BLER	EDGE MCS5	-98	Tbd	tbd	-99

1 Per 3GPP specification

2 Test at Class A extreme condition

1.3.2. WCDMA RF Interface

This section presents the WCDMA RF Specification for the AirPrime AR759x Series.

1.3.2.1. WCDMA TX Output Power

The WCDMA Maximum Transmitter Output Power of the AirPrime AR759x Series is specified in the following table.

Note: All values presented in the table below are preliminary.

Table 7. Conducted TX (Transmit) Max output Power Tolerances – WCDMA Bands

Band[1]	Limit (dBm)[2]	Room (dBm)	Class A (Extreme) (dBm)[3]
B2	24 +1.7/-3.7dB	23.5 +2.2/-2.7dB	tbd
B4	24 +1.7/-3.7dB	23.5 +2.2/-2.7dB	tbd
B5	24 +1.7/-3.7dB	23.5 +2.2/-2.7dB	tbd
B6	24 +1.7/-3.7dB	23.5 +2.2/-2.7dB	tbd

1 Connectorized (Class 3)

2 Per 3GPP TS 34.121-1 Specification

3 Test at Class A extreme condition

1.3.2.2. WCDMA RX Sensitivity

The WCDMA Receiver Sensitivities of the AirPrime AR759x Series are specified in the following table.

Table 8. Conducted Primary RX (Receive) Sensitivity – UMTS Bands[1]

Band	Limit (dBm)[2]	Room Typical (dBm)	Class A (Extreme) Typical (dBm)[3]	Class A Limit (dBm)
B2	-104.7	−109	Tbd	-105.5
B4	-106.7	−110	Tbd	-107.5

Band	Limit (dBm)[2]	Room Typical (dBm)	Class A (Extreme) Typical (dBm)[3]	Class A Limit (dBm)
B5	-104.7	–110.5	Tbd	-105.5
B6	-106.7	–110.5	tbd	-107.5

1 1: CS 0.1% BER 12.2 kbps

2 Per 3GPP specification

3 Test at Class A extreme condition

Table 9. Conducted Secondary RX (Receive) Sensitivity – UMTS Bands[1]

Band	Room Typical (dBm)	Class A (Extreme) Typical (dBm)[2]	Class A Limit (dBm)
B2	tbd	tbd	-105.5
B4	tbd	tbd	-107.5
B5	tbd	tbd	-105.5
B6	tbd	tbd	-107.5

1 CS 0.1% BER 12.2 kbps

2 Test at Class A extreme condition

1.3.3. LTE RF Interface

This section presents the LTE RF Specification for the AirPrime AR759x Series.

1.3.3.1. LTE TX Output Power

The LTE Maximum Transmitter Output Power of the AirPrime AR759x Series are specified in the following table.

Note: The test configuration for all of the entries in the table below is per 3GPP specification, Connectorized (Class 3).

Note: All values in the table below are preliminary.

Table 10. Conducted TX (Transmit) Max output Power Tolerances – LTE Bands

Band	Standard (dBm) (Note 2)	Class A (dBm) (Note 3)	Notes
B2	23 ±2.7dB	23 ±2.2dB	Note 1,4
B4	23 ±2.7dB	23 ±2.2dB	Note 1
B5	23 ±2.7dB	23 ±2.2dB	Note 1
B7	23 ±2.7dB	23 ±2.2dB	Note 1,4
B12	23 ±2.7dB	23 ±2.2dB	Note 1,4
B13	23 +2.7/-1.7 dB	23 ±2.2dB	Note 1
B17	23 ±2.7dB	23 ±2.2dB	Note 1

Note 1: The test configurations for all of the entries in the table above are per 3GPP specification, Connectorized (Class 3).

Note 2: Per 3GPP TS 36.521-1 6.2.2 UE Maximum Output Power (No MPR);and for B13,Per VzW's Supplementary_RF_Conformance. 2.1 Maximum Output Power – No MPR Or A-MPR

Note 3: Class A is defined in 3.3 Environmental

Note 4: For transmission bandwidths (Figure 5.4.2-1 in 3GPP TS 36.521-1) confined within FUL_low and FUL_low + 4 MHz or FUL_high – 4 MHz and FUL_high, the maximum output power requirement is relaxed by reducing the lower tolerance limit by 1.5 dB.

1.3.3.2. LTE RX Sensitivity

The LTE Receiver Sensitivities of the AirPrime AR759x Series are specified in the following table.

Note: For the table below:

Dual receiver (SIMO) per 3GPP TS 36.521-1 Rx Sensitivity Specification.
Sensitivity values scale with bandwidth:
`x_MHz_Sensitivity = 10 MHz_Sensitivity – 10*log(10 MHz/x_MHz)`
10 MHz BW,and 50 RB DownLink and Up Link RB configuration is as 3GPP TS 36.521-1 Table 7.3.5-2.
All values are preliminary pending transceiver matching and testing.

Table 11. Conducted RX Sensitivity 3GPP (BW: 10MHz) – LTE Bands[1, 4]

Band	Standard (dBm)[2]	Room Typical (dBm)	Class A (Extreme) Typical (dBm)[5]	Class A Limit (dBm)[5]
B2	-94.3	–100	tbd	-95
B4	-96.3	–100	tbd	-97
B7	-94.3	–100	tbd	-95
B12	-93.3	–101	tbd	-94
B13	-93.3	–101	tbd	-94
B17	-93.3	–101	tbd	-94

1: Dual receiver (SIMO) per 3GPP TS 36.521-1 Rx Sensitivity Specification for Non-CA Configuration

2: Per 3GPP Specification.

3: Sensitivity values scale with bandwidth: x_MHz_Sensitivity = 10 MHz_Sensitivity – 10*log(10 MHz/x_MHz)

4: 10 MHz BW,and 50 RB DownLink and Up Link RB configuration is as 3GPP TS 36.521-1 Table 7.3.5-2.

5: Class A is defined in 3.3 Environmental

Note: For the table below:

Sensitivity values scale with bandwidth:
`x_MHz_Sensitivity = 10 MHz_Sensitivity – 10*log(10 MHz/x_MHz)`
10 MHz BW,and 50 RB DownLink and Up Link as 3GPP TS 36.521-1 Table 7.3.5-2.
All values are preliminary pending transceiver matching and testing.

Table 12. Conducted RX Sensitivity SISO (BW: 10MHz) – LTE Bands[1]

Band	Room Typical (dBm)		Class A (Extreme)Typical (dBm)[1]		Class A Limit (dBm)[1]	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
B2	–97	–98	tbd	tbd	-92	-92
B4	–97.5	–98	tbd	tbd	-94	-94
B5	–98	–98.5	tbd	tbd	-92	-92

Band	Room Typical (dBm)		Class A (Extreme)Typical (dBm)[1]		Class A Limit (dBm)[1]	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
B7	−96.5	−97.5	tbd	tbd	-92	-92
B12	−98	−99	tbd	tbd	-91	-91
B13	−97	−98	tbd	tbd	-91	-91
B17	−98	−99	tbd	tbd	-91	-91

1: Class A is defined in 3.3 Environmental

1.3.4. WWAN Antenna Interface

The WWAN Antenna Interfaces of the AirPrime AR759x Series are defined in the table below.

Table 13. WWAN Antenna Interface Pads

Pad	Name	Direction	Function
BA11	GND		Primary Antenna Ground
BA12	PRIMARY_ANT	Input / Output	Primary Antenna Interface
BA13	GND		Primary Antenna Ground
BB11	GND		Primary Antenna Ground
BB12	GND		Primary Antenna Ground
BA7	GND		Diversity Antenna Ground
BA8	DIVERSITY_ANT	Input	Diversity Antenna Interface
BA9	GND		Diversity Antenna Ground
BB7	GND		Diversity Antenna Ground
BB8	GND		Diversity Antenna Ground

1.3.4.1. WWAN Antenna Recommendations

The table below defines the key characteristics to consider for antenna selection.

Table 14. AirPrime AR759x Series WWAN Antenna Recommendations

Parameter	Requirements	Comments
Antenna system	External multi-band 2x2 MIMO antenna system (Ant1/Ant2)[a]	
Operating bands of Ant1 and Ant2[b]	698–960 MHz 1451–1512 MHz 1710–1995 MHz 2110–2170 MHz 2500–2700 MHz	Operating bands depend on module's supported bands/modes
VSWR of Ant1 and Ant2	1:1 (ideal) < 2.5:1 (recommended)	On all bands including band edges

Parameter	Requirements	Comments
Total radiated efficiency of Ant1 or Ant2	> 50% on all bands	• Measured at the RF connector. • Includes mismatch losses, losses in the matching circuit, and antenna losses, excluding cable loss. • Sierra Wireless recommends using antenna efficiency as the primary parameter for evaluating the antenna system. Peak gain is not a good indication of antenna performance when integrated with a host device (the antenna does not provide omni-directional gain patterns). Peak gain can be affected by antenna size, location, design type, etc. — the antenna gain patterns remain fixed unless one or more of these parameters change.
Maximum antenna gain	Must not exceed antenna gains due to RF exposure and ERP/ EIRP limits, as listed in the module's FCC grant.	
Isolation between Ant1 and Ant2 (S21)	> 10 dB	• If antennas can be moved, test all positions for both antennas. • Unless otherwise specified, this isolation requirement need to be maintained for optimum operation. • Make sure all other wireless devices (Bluetooth or WLAN antennas, etc.) are turned OFF to avoid interference.
Maximum Voltage applied to antenna	36 Volts	
Power handling	> 2 W RF power on low bands > 1 W on high bands	• Measure power endurance over 4 hours (estimated talk time) using a 2 W CW signal — set the CW test signal frequency to the middle of the PCS TX band (1880 MHz for PCS). • Visually inspect device to ensure there is no damage to the antenna structure and matching components. • VSWR / TIS / TRP measurements taken before and after this test must show similar results.

* These worst-case VSWR figures for the transmitter bands may not guarantee RSE levels to be within regulatory limits. The device alone meets all regulatory emissions limits when tested into a cabled (conducted) 50Ω system. With antenna designs with up to 2.5:1 VSWR or worse, the radiated emissions could exceed limits. The antenna system may need to be tuned in order to meet the RSE limits as the complex match between the module and antenna can cause unwanted levels of emissions. Tuning may include antenna pattern changes, phase/delay adjustment, passive component matching. Examples of the application test limits would be included in FCC Part 22, Part 24 and Part 27, test case 4.2.16 for GSM (ETSI EN 301 511), and test case 4.2.2 for WCDMA (ETSI EN 301 908-1), where applicable.

a Ant1—Primary, Ant2—Diversity (Diversity/MIMO/)

b Stated band ranges satisfy requirements for both Ant1 and Ant2.

1.4. GNSS

The AirPrime AR759x Series include optional Global Navigation Satellite System (GNSS) capabilities via the Qualcomm gpsOne Gen8C Engine, capable of operation in assisted and stand-alone modes using GPS, GLONASS, Beidou, Galileo, and QZSS SVs.

Note: Galileo support pending system / satellite deployment.

1.4.1. GNSS Receiver

The table below summarizes the GNSS capabilities of the AirPrime AR759x Series.

Table 15. GNSS Specifications

Parameter/Feature		Value
Mode	GPS	L1
	GLONASS (FDMA)	L1OF
	Beidou	B1L
	Galileo	E1
	QZSS	L1-C/A
Satellite channels	Tracking	40
	Acquisition	118
Standalone Time To First Fix (TTFF) [1,2,4,6]	Hot start:	1 second for standalone GNSS and AGNSS
	Warm start	3 seconds (with AGNSS)
	Cold start	30 seconds for standalone GNSS, and 5 seconds for AGNSS
Sensitivity (GPS, GLONASS, BeiDou)	Tracking [4,5,6]	-161 dBm
	Cold start Acquisition	-145 dBm
	Hot start Acquisition	-158 dBm
Horizontal Position accuracy [1,3,4,5,6,]		2 / 5 [7]
Altitude accuracy [1,3,4,5,6,]		4 / 8 [7]
Velocity accuracy [1,3,4,5,6]		0.1
Tracking update rates		1 Hz to 10 Hz
SBAS support [3]		WAAS, EGNOS, MSAS, SDCM, GAGAN, QZSS
Message Protocol	NMEA 0183 Version	V3.0
	Supported Sentences	GSV, GNS, GSA, GGA, GRS, RMC, VTG, GPGGA, GPGSV, GNGSA, GPGRS, GPRMC, GPVTG, GNGNS, GPGLL

Note: All GNSS characterization data are measured in conducted RF path with GNSS simulator.

Note 1: Open sky, all SV RF signal level = -130dBm, Number of SVs > 6

Note 2: TTFF values show results in worst conditions (as an external host user): timing measurement start when GPS control request is sent on AT command interface and stop when NMEA frames (1Hz update) display 2D fix information.

Note 3: Scenarios used for accuracy measurements simulate car travel including direction, altitude and speed variations.

Note 4: *Best performances are obtained by using external Pre-SAW and LNA for conducted test setup, it is used to simulate the active antenna as customer's application.*

Note 5: *1Hz Navigation used for all tracking/navigation tests.*

Note 6: *GNSS constellations used: GPS + GLONASS + Galileo + Beidou*

Note 7: *Accuracy data are provided Circular Error Probable, CEP-50 / CEP-95. Means that 50%/95% of the positions returned calculated have an error lower or equal to the accuracy value.*

1.4.2. GNSS Antenna Interface

The GNSS Antenna Interface is defined in the table below.

Table 16. GNSS Antenna Interface Pads

Pad	Name	Direction	Function
BA4	GND		GNSS Antenna Ground
BA5	GNSS_ANT	Input	GNSS Antenna Interface
BA6	GND		GNSS Antenna Ground
BB4	GND		GNSS Antenna Ground
BB5	GND		GNSS Antenna Ground

1.4.2.1. GNSS Antenna Recommendations

To be added in a future revision.

1.5. Electrical Specifications

This section provides details of the key electrical specifications of the AirPrime AR759x Series.

1.5.1. Absolute Maximum Ratings

This section defines the Absolute Maximum Ratings of the AirPrime AR759x Series.

Warning: *If operating outside of the defined specifications, even momentarily, damage may occur to the device.*

Table 17. AirPrime AR759x Series Absolute Maximum Ratings

Parameter		Min	Max	Units
VBATT	Power Supply Input	-	4.5	V
VIN	Voltage on any digital input or output pin	-	VCC_1V8+0.5	V
IIN	Latch-up current	-100	100	mA

Parameter		Min	Max	Units
ESD Ratings				
ESD[1]	Primary, Secondary and GNSS antenna pads – Contact	-	± 8	kV
	All other signal pads – Contact	-	± 1.5	kV

1 The ESD Simulator configured with 150pF, 330Ω.

Caution: *The AirPrime AR759x Series are sensitive to Electrostatic Discharge. ESD countermeasures and handling methods must be used when handling the AirPrime AR759x Series.*

1.5.2. Digital IO Characteristics

The Digital IO characteristics are defined in the table below. These apply to GPIOs, UART, LED, SPI, I2C, PCM/I2S, GNSS_LNA, WAKE_N, 2G_SYNC, AT_PORT_SW, SERVICE and RESET.

Table 18. Digital IO Characteristics for VCC=1.8V Nominal

Parameter		Comments	Min	Typ	Max	Units
V_{IH}	High level input voltage	CMOS/Schmitt	0.65* VCC_1V8	–	VCC_1V8+0.3	V
V_{IL}	Low level input voltage	CMOS/Schmitt	-0.3	–	0.35* VCC_1V8	V
V_{OH}	High level output voltage	CMOS, at pin rated drive strength	VCC_1V8 – 0.45	–	VCC_1V8	V
V_{OL}	Low-level output voltage	CMOS, at pin rated drive strength	0	–	0.45	V
V_{OH-PM}	High level output voltage	CMOS, at pin rated drive strength	1.50	–	VCC_1V8	V
V_{OL-PM}	Low-level output voltage	CMOS, at pin rated drive strength	–	–	0.30	V
I_{OH}	High level output current	VOH = VCC_1V8 – 0.45 V	–	–	6	mA
I_{OL}	Low Level output current	VOL = 0.45 V	-6	–	–	mA
I_{OH-PM}	High level output current	GPIO_PMxx only	–	–	0.90	mA
I_{IHPD}	Input high leakage current	Logic High with pull-down	27.5		97.5	µA
I_{ILPU}	Input low leakage current	Logic Low with pull-up	-97.5		-27.5	µA
IL	Input leakage current	VIO = max, VIN = 0 V to VIO LED signal only	-0.3	–	+0.35	µA
C_{IN}	Input capacitance		–	–	5	pF

Caution: *Digital IOs shall not be pulled-up to an external voltage as this may cause VCC_1V8 to not go low when the AirPrime AR759x Series are powered down. Also, this would partially bias the AirPrime AR759x Series which could potentially damage the device or result in GPIOs being set to undetermined levels.*

The SDIO characteristics are defined in the table below.

Table 19. Digital IO Characteristics for SDIO VCC=1.8V Nominal

Parameter		Comments	Min	Typ	Max	Units
V_{IH}	High level input voltage	CMOS/Schmitt	1.27	–	2.0	V
V_{IL}	Low level input voltage	CMOS/Schmitt	-0.3	–	0.58	V
V_{SHYS}	Schmitt hysteresis voltage		100	–	–	mV
I_{IH}	Input high leakage current	No pull-down	–	–	5	µA
I_{IL}	Input low leakage current	No pull-up	-5	–	–	µA
V_{OH}	High-level output voltage	CMOS, at rated drive strength	1.4	–	–	V
V_{OL}	Low level output voltage	CMOS, at rated drive strength	–	–	0.45	V
I_{OZH}	Tri-state leakage current	Logic high out, no pull-down	–	–	5	µA
I_{OZL}	Tri-state leakage current	Logic High with pull-up	-5	–	–	µA

Table 20. Digital IO Characteristics for SDIO VCC=2.85V Nominal

Parameter		Comments	Min	Typ	Max	Units
V_{IH}	High level input voltage	CMOS/Schmitt	1.78	–	3.15	V
V_{IL}	Low level input voltage	CMOS/Schmitt	-0.3	–	0.71	V
V_{SHYS}	Schmitt hysteresis voltage		100	–	–	mV
I_{IH}	Input high leakage current	No pull-down	–	–	10	µA
I_{IL}	Input low leakage current	No pull-up	-10	–	–	µA
V_{OH}	High-level output voltage	CMOS, at rated drive strength	2.14	–	2.85	V
V_{OL}	Low level output voltage	CMOS, at rated drive strength	–	–	0.36	V
I_{OZH}	Tri-state leakage current	Logic high out, no pull-down	–	–	10	µA
I_{OZL}	Tri-state leakage current	Logic High with pull-up	-10	–	–	µA

The UICC characteristics are defined in the table below.

Table 21. Digital IO Characteristics for UICC_VCC=1.8V Nominal

Parameter		Comments	Min	Typ	Max	Units
V_{IH}	High level input voltage	CMOS/Schmitt	0.7* UICC_VCC	–	UICC_VCC + 0.3	V
V_{IL}	Low level input voltage	CMOS/Schmitt	-0.3	–	0.2* UICC_VCC	V
V_{SHYS}	Schmitt hysteresis voltage		100	–	–	mV
I_{IH}	Input high leakage current	No pull-down	–20	–	20	µA
I_{IL}	Input low leakage current	No pull-up	–	–	1000	µA
V_{OH}	High-level output voltage	CMOS, at rated drive strength	0.8* UICC_VCC	–	UICC_VCC	V
V_{OL}	Low level output current	CMOS, at rated drive strength	0	–	0.45	V
I_{OZH}	Tri-state leakage current	Logic high out, no pull-down	–	–	5	µA
I_{OZL}	Tri-state leakage current	Logic High with pull-up	-5	–	–	µA

Table 22. Digital IO Characteristics for UICC_VCC=2.85V Nominal

Parameter		Comments	Min	Typ	Max	Units
V_{IH}	High level input voltage	CMOS/Schmitt	0.7* UICC_VCC	–	UICC_VCC + 0.3	V
V_{IL}	Low level input voltage	CMOS/Schmitt	-0.3	–	0.2* UICC_VCC	V
V_{SHYS}	Schmitt hysteresis voltage		100	–	–	mV
I_{IH}	Input high leakage current	No pull-down	–20	–	20	µA
I_{IL}	Input low leakage current	No pull-up	–	–	1000	µA
V_{OH}	High-level output voltage	CMOS, at rated drive strength	0.8* UICC_VCC	–	UICC_VCC	V
V_{OL}	Low level output current	CMOS, at rated drive strength	0	–	0.4	V
I_{OZH}	Tri-state leakage current	Logic high out, no pull-down	–	–	10	µA
I_{OZL}	Tri-state leakage current	Logic High with pull-up	-10	–	–	µA

2. Audio Specification

2.1. Digital Audio

The AirPrime AR759x Series provides two 4-wire digital audio interfaces. Each interface can be configured as either a PCM or an I2S interface.

Table 23. Digital Audio Interface Pads[1]

Pad	Mode	Name	Direction[2]	Function	If Unused
DA3	PCM	PCM_CLK	Output	PCM Clock	Leave Open
	I^2S	I2S_SCLK		I^2S Bit Clock	
DB3	PCM	PCM_FS	Output	PCM Frame Sync	Leave Open
	I^2S	I2S_WS		I^2S Word Select	
DC2	PCM	PCM_DOUT	Output	PCM Data Out	Leave Open
	I^2S	I2S_DOUT		I^2S Data Out	
DD2	PCM	PCM_DIN	Input	PCM Data In	Leave Open
	I^2S	I2S_DIN		I^2S Data In	
DD3	PCM2	PCM_CLK	Output	PCM Clock	Leave Open
	I^2S2	I2S_SCLK		I^2S Bit Clock	
DD4	PCM2	PCM_FS	Output	PCM Frame Sync	Leave Open
	I^2S2	I2S_WS		I^2S Word Select	
DE2	PCM2	PCM_DOUT	Output	PCM Data Out	Leave Open
	I^2S2	I2S_DOUT		I^2S Data Out	
DC4	PCM2	PCM_DIN	Input	PCM Data In	Leave Open
	I^2S2	I2S_DIN		I^2S Data In	

[1] PCM2/I2S2 is multiplexed with SPI2/UART3 and is not available if either SPI2/UART3 is configured

[2] Direction when defined in Master mode.

3. Routing Constraints and Recommendations

Layout and routing of the AirPrime AR759x Series in the application is critical to maintaining the performance of the radio. The following sections provide guidance to the developer when designing their application to include an AirPrime AR759x Series and achieve optimal system performance.

3.1. RF Routing Recommendations

To route the RF antenna signals, the following recommendations must be observed for PCB layout:

The RF signals must be routed using traces with a 50 Ω characteristic impedance.

Basically, the characteristic impedance depends on the dielectric constant (εr) of the material used, trace width (W), trace thickness (T), and height (H) between the trace and the reference ground plane.

In order to respect this constraint, Sierra Wireless recommends that a MicroStrip structure be used and trace width be computed with a simulation tool (such as AppCAD, shown in the figure below and available free of charge at http://www.avagotech.com).

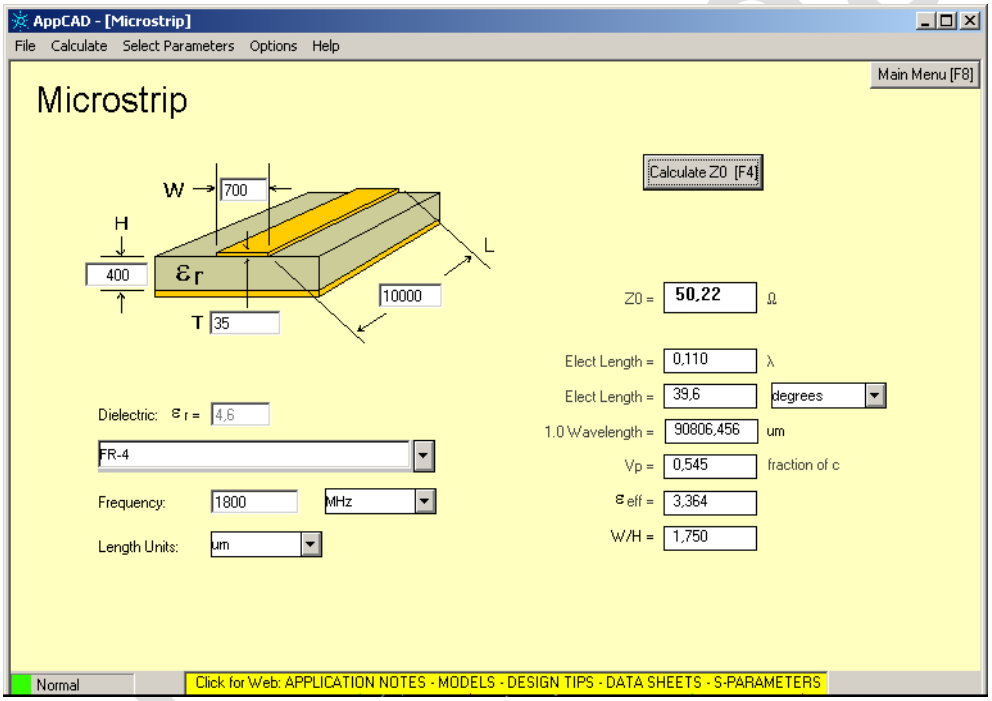


Figure 1. AppCAD Screenshot for Microstrip Design Power Mode Diagram

The trace width should be wide enough to maintain reasonable insertion loss and manufacturing reliability. Cutting out inner layers of ground under the trace will increase the effective substrate height; therefore, increasing the width of the RF trace.

Caution: *It is critical that no other signals (digital, analog, or supply) cross under the RF path. The figure below shows a generic example of good and poor routing techniques.*

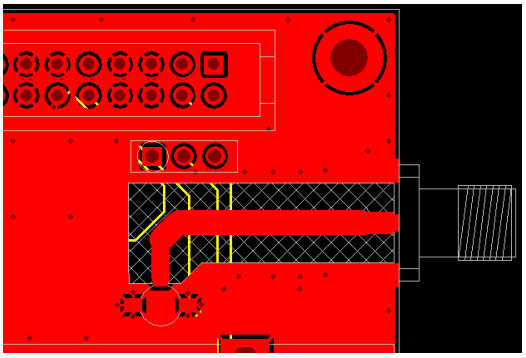
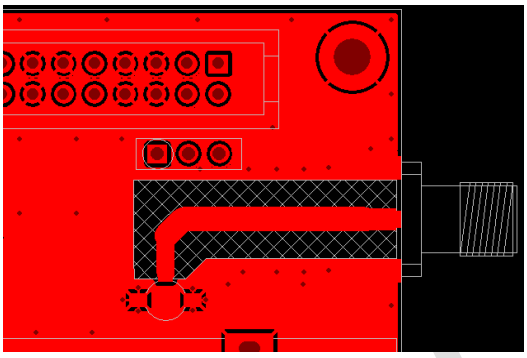
Poor routing	Correct routing
	
The yellow traces cross the RF trace.	There is no signal around the RF path.

Figure 2. RF Routing Examples

- Fill the area around the RF traces with ground and ground vias to connect inner ground layers for isolation.
- Cut out ground fill under RF signal pads to reduce stray capacitance losses.
- Avoid routing RF traces with sharp corners. A smooth radius is recommended.
  E.g. Use of 45° angles instead of 90°.
- The ground reference plane should be a solid continuous plane under the trace.
- The coplanar clearance (G, below) from the trace to the ground should be at least the trace width (W) and at least twice the height (H). This reduces the parasitic capacitance, which potentially alters the trace impedance and increases the losses.
  E.g. If W = 100 microns then G = 200 microns in an ideal setup. G = 150 microns would also be acceptable is space is limited.

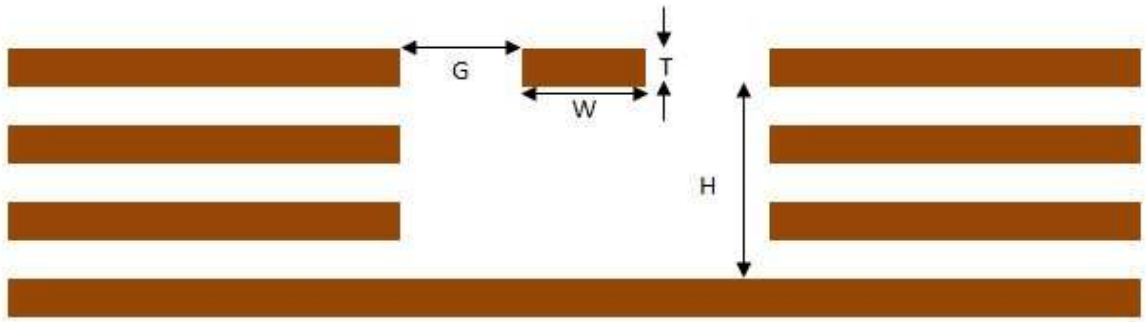


Figure 3. Coplanar Clearance Example

Note: The figure above shows several internal ground layers cut out, which may not be necessary for every application.

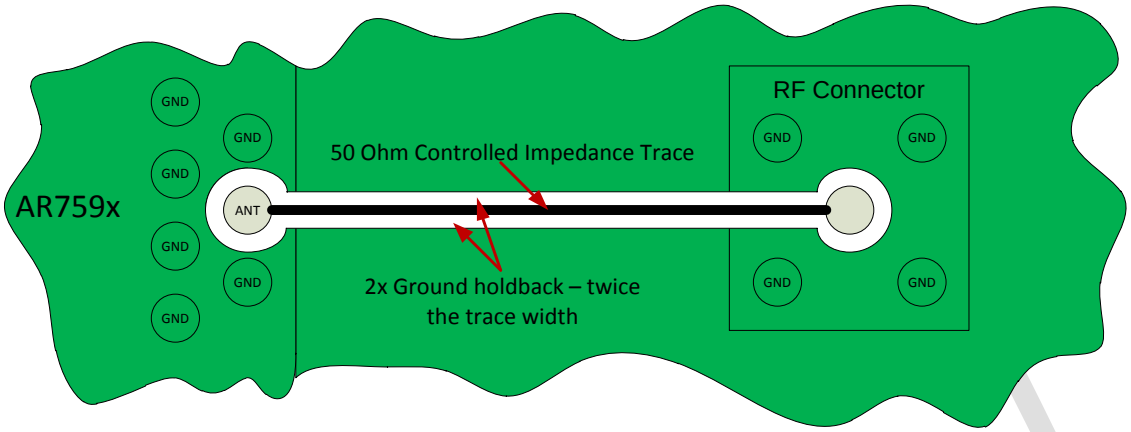


Figure 4. Antenna Microstrip Routing Example

3.2. USB Routing Recommendations

HighSpeed USB signals (USB_D_P / USB_D_M) are a differential pair and must be routed with the following considerations/constraints:

- 90 Ohm differential +/- 10% trace impedance,
- Differential trace length pair matching < 2mm (15 ps),
- Solid reference planes,
- Trace lengths < 120 mm,
- And 2x the trace width separation to all adjacent signals.

SuperSpeed USB adds two differential pairs (SSRX+ / SSRX- and SSTX+ / SSTX-). These pairs should be routed with the following considerations/constraints:

- 90 Ohm differential +/- 15% trace impedance,
- Differential trace length pair matching < 0.7mm (5 ps),
- Trace lengths < 112 mm,
- And GND isolation from other adjacent traces with minimum of 2x the SSRX/SSTX trace wdith.

3.3. Power and Ground Recommendations

Power and ground routing is critical to achieving optimal performance of the AirPrime AR759x Series when integrated into an application.

Recommendations:

- Do not use a separate GND for the Antennas.
- Connections to GND from the AirPrime AR759x Series should be flooded plane using thermal reliefs to ensure reliable solder joints.
- VBATT is recommended to be routed as a wide trace(s) directly from the power supply to the LGA pad.

3.4. Antenna Recommendations

Connecting the antenna ground reference to the vehicle chassis is not recommended since that has been known to cause noise from the engine to couple into the audio of the device. It is ultimately up to the integrator to evaluate this performance.

3.5. Interface Circuit Recommendations

The recommended interface implementation is to use a dual-supply bus transceiver with configurable voltage translation. This allows a host processor operating at a different voltage to communicate with the AirPrime AR759x Series using the appropriate voltage levels.

The figure below is a reference circuit for a digital input / output signal to / from the AirPrime AR759x Series.

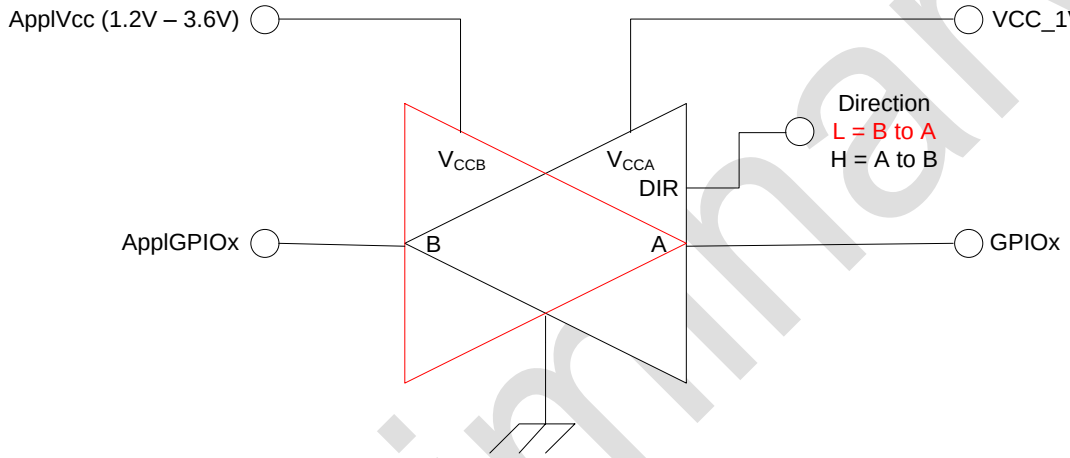


Figure 5. AirPrime AR759x Series Interface Reference Circuit

The dual-supply bus transceiver with configurable voltage translation used in the reference circuit above is the Texas Instruments SN74AVC1T45.

If a Digital IO signal is used bidirectional in the application then a bidirectional level translator, such as Texas Instruments TCA9406 is needed.

4. Firmware and Tools

The AirPrime AR7592 are designed based on Qualcomm's MDM9240 chipset, which contains a Modem Processor for running modem firmware components and an Application Processor for running embedded Linux applications. Various tools are provided by Qualcomm and developed by Sierra Wireless for developing and commercializing the AirPrime AR7592.

4.1. Modem Firmware

The MDM9240 Modem Process contains the following categories of firmware, with possible modifications/extensions by Sierra Wireless as indicated:

- LTE/ WCDMA/ TD-SCDMA air interface protocols
- GNSS engine
- IMS protocol stack
- AT Command Processor: New AT commands will be added by Sierra Wireless. See document [8] for the complete list of AT Commands for the AirPrime AR759x Series.
- Data services
- Drivers/ BSP: Some modifications will be made to ensure the firmware can communicate with the AirPrime AR759x Series hardware properly.
- UICC functions
- Memory Management: Built-in redundancy and continuous monitoring against memory corruption
- Antenna Protection
- Voice support

4.2. Tools

The following tools will be needed for the AirPrime AR7592 development, testing and commercialization.

- Firmware Update Tool
- Linux driver and Application Downloader
- Provisioning Tool
- Logging Tool
- Qualcomm's QXDM (license with Qualcomm required)
- Qualcomm's QPST (license with Qualcomm required)

5. Approval

5.1. Important Notice

Because of the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost.

Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless and its affiliates accept no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

5.2. Safety and Hazards

Do not operate the AirPrime AR7592:

- In areas where blasting is in progress
- Where explosive atmospheres may be present including refueling points, fuel depots, and chemical plants
- Near medical equipment, life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the AirPrime AR7592 device **MUST BE POWERED OFF**. Otherwise, the AirPrime AR7592 device can transmit signals that could interfere with this equipment
- In an aircraft, the AirPrime AR7592 device **MUST BE POWERED OFF.** Otherwise, the AirPrime AR7592 device can transmit signals that could interfere with various onboard systems and may be dangerous to the operation of the aircraft or disrupt the cellular network. Use of cellular phone in aircraft is illegal in some jurisdictions. Failure to observe this instruction may lead to suspension or denial of cellular telephone services to the offender, or legal action or both.
- Some airlines may permit the use of cellular phones while the aircraft is on the ground and the door is open. The AirPrime AR7592 device may be used normally at this time.

5.3. Important Compliance Information

The AirPrime AR7592 is granted with a modular approval for mobile applications. Integrators may use the AR7592 device in their final products without additional FCC/IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC/IC approvals must be obtained.

1. At least 20cm separation distance between the antenna and the user's body must be maintained at all times.
2. To comply with FCC/IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the gain values presented in the table below:
   - 4.0 dBi in Cellular band
   - 5.0 dBi in PCS band
   - 4.0 dBi in LTE Band 4/AWS band
   - 5.0 dBi in LTE Band 7
   - 4.0 dBi in LTE Band 12

- 4.0 dBi in LTE Band 13
- 4.0 dBi in LTE Band 17

3. The AR7592 modem may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:
   - Each collocated radio transmitter has been certfied by FCC / IC for mobile application.
   - At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.
   - The output power and antenna gain must not exceed the limits and configu-rations stipulated in the following table.

Device	Technology	Band	Frequency (MHz)	EIPR Limits (dbm)	Maximum antenna gain
AR7592 Module	LTE	2	1850-1910		5
		4	1710-1755		4
		5	824-849		3
		7	2500 – 2570		5
		12	699 -716		3
		13	777 - 787		3
		17	704-716		3
	UMTS	2	1850-1910		5
		4	1710-1755		4
		5	824-849		3
	GPRS	2	1850-1910		5
		5	824-849		3
	EDGE	2	1850-1910		5
		5	824-849		3
Collocated transmitters*	WLAN		2400-2500	27	
			5150-580	27	
	WiMAX		2300-2400	27	
			2500-2700	27	
			3300-3800	27	
	BT		2400-2500	20	

*. Valid collocated Transmitter combinations: WLAN+BT; WiMAX+BT. (WLAN+WiMAX+BT is not permitted.)

4. A label must be affixed to the outside of the end product into which the AirPrime AR7552 device is incorporated, with a statement similar to the following:

This device contains FCC ID: N7NAR7592 This equipment contains equipment certified under IC: 2417C-AR7592

5. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/IC RF exposure guidelines.

The end product with an embedded AirPrime AR7592 device may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized.

Note: If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093 and IC RSS-102.

5.4. IC Regulations

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:

1. This device may not cause interference; and
2. This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage;
2. L'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

5.4.1. Radiation Exposure Statement

This equipment complies with Canada radiation exposure limits set forth for an uncontrolled environment.

This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

Cet équipement est conforme Canada limites d'exposition aux radiations dans un environnement non contrôlé.

Cet équipement doit être installé et utilisé à distance minimum de 20cm entre le radiateur et votre corps.

This radio transmitter (IC: **2417C-AR7592**) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio (IC: **2417C-AR7592**) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

6. References

The table below lists the reference specifications for this product.

Table 24. Reference Specifications

Ref	Title	Rev	Issuer
[1]	3GPP TS 51.010-1	Version 7.3.1	3GPP
[2]	3GPP TS 34.121-1	V8	3GPP
[3]	3GPP TS 36.521-1	V9	3GPP
[4]	Universal Serial Bus Specification	V2.0	USB Implementers Forum
[5]	Universal Serial Bus CDC Subclass Specification for Wireless Mobile Communication Devices	V1.0	USB Implementers Forum
[6]	Universal Serial Bus Class Definitions for Communication Devices	V1.1	USB Implementers Forum
[7]	AirPrime - AR7 Series - Customer Process Guidelines	-	Sierra Wireless
[8]	AirPrime - AR75xx - AT Command Interface Specification - 4112841	V1.5	Sierra Wireless
[9]	AirPrime AR7xxx Firmware Download Guide	-	Sierra Wireless
[10]	AirPrime AR759x Thermal Management Application Note - 2174114	V1.0	Sierra Wireless
[11]	AirPrime AR759x Current Consumption Application Note - 2174115	V1.0	Sierra Wireless
[12]	AirPrime - AR Series - Hardware Compatibility APN - 4116174	V0.8	Sierra Wireless
[13]	AirPrime - AR7552 - Hardware Integration Guide – 4117336	V1.0	Sierra Wireless

7. Abbreviations

The table below lists several abbreviations used in this document.

Table 25. Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
CDMA	Code Division Multiple Access
DRX	Discontinuous Receive
EDGE	Enhanced Data rates for GSM Evolution
FDD	Frequency Division Duplex
GERAN	GSM EDGE Radio Access Network
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile Communications
HSPA	High Speed Packet Access
I2S	Inter-IC Sound
LTE	Long Term Evolution
PCIe	Peripheral Component Interconnect Express
PCM	Pulse Coded Modulation
PMIC	Power Management Integrated Circuit
SCI	Slot Cycle Index
SDIO	Secure Digital Input Output
SPI	Serial Peripheral Interface
TDD	Time Division Duplex
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
UART	Universal Asynchronous Receiver / Transmitter
UICC	Universal Integrated Circuit Card
UIM	User Identity Module
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
WCDMA	Wideband Code Division Multiple Access
WWAN	Wireless Wide Area Network