Product Technical Specification

AirPrime AR7550

4114188
0.4
March 29, 2013

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Contact Information

Sales Desk:	Phone:	1-604-232-1488
	Hours:	8:00 AM to 5:00 PM Pacific Time
	E-mail:	sales@sierrawireless.com
Post:	Sierra Wireless 13811 Wireless Way Richmond, BC Canada V6V 3A4	
Technical Support:	support@sierrawireless.com	
RMA Support:	repairs@sierrawireless.com	
Fax:	1-604-231-1109	
Web:	www.sierrawireless.com	

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Document History

Version	Date	Updates
0.1	March 29, 2013	Creation based on document 4112476: AirePrime – AR755x Series – Product Technical Specification – Rev0.4.

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1. Introduction

1.1. General Features

The AirPrime AR7550 embedded modules are designed for the automotive industry. They support LTE, CDMA, WCDMA air interface standards and shares hardware and firmware interfaces with the AirPrime AR5550 and AR855x. They also have Global Navigation Satellite System (GNSS) capabilities including GPS and GLONASS.

The AirPrime AR7550 embedded modules are based on the Qualcomm MDM9615 wireless chipset and support the following bands.

Table 1. AirPrime AR7550 Embedded Modules

Product	Description	Band Support
AirPrime AR7550	LTE/CDMA2000/ /WCDMA embedded module	LTE: B4, B7*, B13 CDMA: BC0, BC1 WCDMA: B2, B5

* LTE B7 for AirPrime AR7550 is optional.

2. Functional Specifications

This chapter highlights the features of the AirPrime AR7550 series of embedded modules.

2.1. Modes of Operation

The AirPrime AR7550 supports 2G/3G/4G operations and also supports GNSS operation. For complete details, refer to the table below.

Table 2. AirPrime AR7550 Modes of Operation

Mode	Band	Frequency (MHz)	
		Downlink (DL) UE Receive	Uplink (UL) UE Transmit
LTE	Band 4	2110 MHz to 2155 MHz	1710 MHz to 1755 MHz
	Band 7	2620MHz to 2690 MHz	2500 MHz to 2570 MHz
	Band 13	746 MHz to 756 MHz	777 MHz to 787 MHz
CDMA2000 – 1xRTT & 1xEVDO	Band Class 0	869 MHz to 894 MHz	824 MHz to 849 MHz
	Band Class 1	1930 MHz to 1990 MHz	1850 MHz to 1910 MHz
WCDMA/HSPA	II (1900/PCS)	1930 MHz to 1990 MHz	1850 MHz to 1910 MHz
	V (850/CELL)	869 MHz to 894 MHz	824 MHz to 849 MHz
GNSS	GPS L1	1574.42 – 1576.42	---
	GLONASS L1 FDMA	1597.5 – 1605.8	---

Note: Supported bands vary depending on product. Refer to Table 1 AirPrime AR7550 Embedded Modules for the list of bands supported by each module variant.

2.2. Communications Functions

The AirPrime AR7550 provides the following communications functions via the LTE, CDMAand UMTS networks.

Table 3. Communications Functions

Communications Function		LTE	CDMA	WCDMA	GSM/GPRS/EDGE
Voice	Circuit Switched		EVRC, EVRC-B	AMR, AMR-WB	FR, EFR, HR
	VoLTE	✓			
Packet Data		✓	✓	✓	✓
Short Message Service (SMS)			✓	✓	✓
OTA	OTAPA		✓		
	OTASP		✓		
DTMF			✓	✓	✓

2.3. Block Diagrams

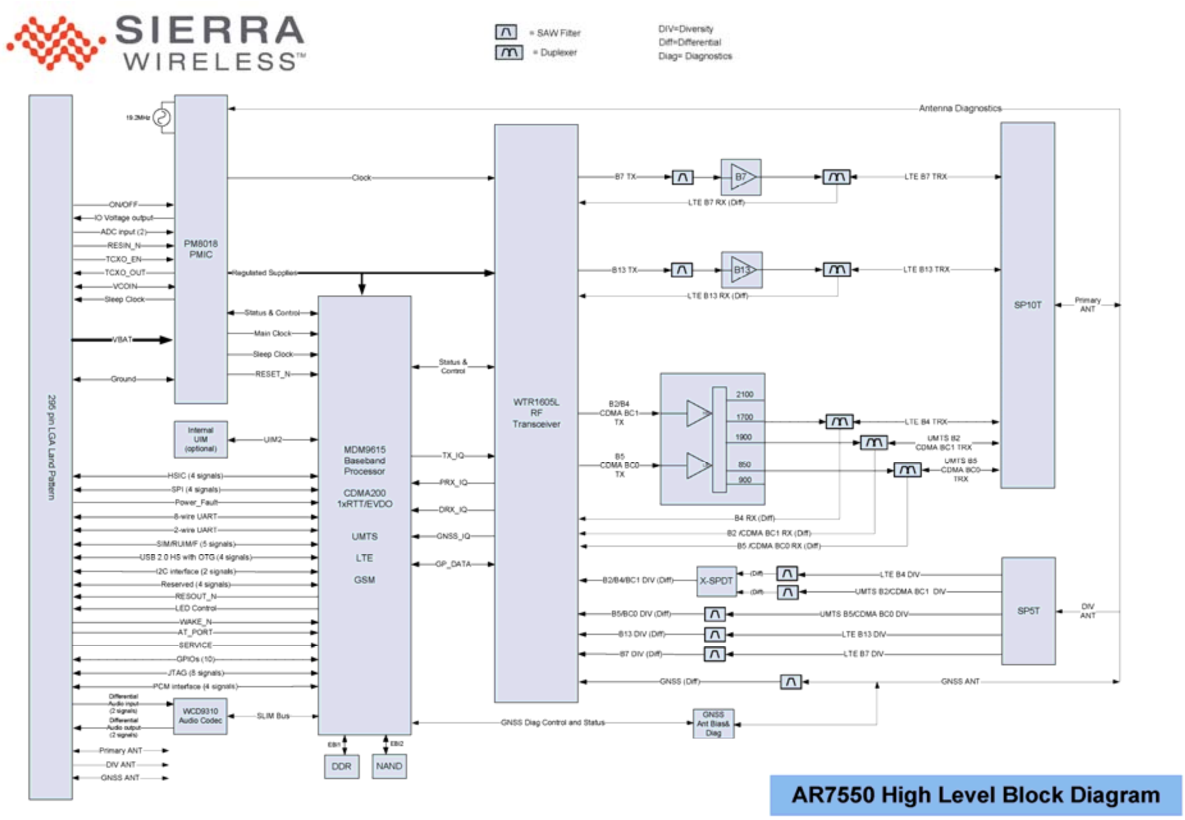


Figure 1. AirPrime AR7550 Block Diagram

3. Hardware Specifications

3.1. Environmental Specifications

The environmental specification for both operating and storage of the AirPrime AR7550 embedded modules are defined in the table below.

Table 4. AirPrime AR7550 Environmental Specifications

Parameter	Temperature Range	Operating Class
Ambient Operating Temperature	-30°C to +75°C	Class A
	-40°C to -30°C +75°C to +85°C	Class B
Ambient Storage Temperature	-40°C to +90°C	---
Ambient Humidity	95% or less	---

Class A is defined as the operating temperature range that the device:

- Shall exhibit normal function during and after environmental exposure.
- Shall meet the minimum requirements of 3GPP, 3GPP2 or appropriate wireless standards.

Class B is defined as the operating temperature range that the device:

- Shall remain fully functional during and after environmental exposure
- Shall exhibit the ability to establish a voice, SMS or DATA call (emergency call) at all times even when one or more environmental constraint exceeds the specified tolerance.
- Unless otherwise stated, full performance should return to normal after the excessive constraint(s) have been removed.

3.2. Electrical Specifications

This section provides details for some of the key electrical specifications of the AirPrime AR7550 embedded modules.

3.2.1. Absolute Maximum and ESD Ratings

This section defines the Absolute Maximum and Electrostatic Discharge (ESD) Ratings of the AirPrime AR7550 embedded modules.

Warning: *If these parameters are exceeded, even momentarily, damage may occur to the device.*

Table 5. AirPrime AR7550 Absolute Maximum Ratings

Parameter		Min	Max	Units
VBATT	Power Supply Input	-	5.0	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
Maximum Voltage applied to antenna interface pins				
VANT	Primary Antenna	-	36	V
	RX2 Antenna	-	36	V
	GNSS Antenna	-	36	V
ESD Ratings				
ESD[1]	Primary, RX2 and GNSS antenna pads - Contact	-	± 8	kV
	All other signal pads - Contact	-	± 1.5	kV

1 The ESD Simulator configured with 330pF, 1000Ω.

Caution: *The AirPrime AR7550 embedded modules are sensitive to Electrostatic Discharge. ESD countermeasures and handling methods must be used when handling the AirPrime AR7550 devices.*

3.3. Mechanical Specifications

3.3.1. Physical Dimensions and Connection Interface

The AirPrime AR7550 embedded modules are a Land Grid Array (LGA) form factor device. The device does not have a System or RF connectors. All electrical and mechanical connections are made via the 303 pad LGA on the underside of the PCB.

Table 6. AirPrime AR7550 Embedded Module Dimensions

Parameter	Nominal	Max	Units
Overall Dimension	32 x 37	32.25 x 37.25	mm
Overall Module Height	3.64	3.89	mm
PCB Thickness	1.6	1.76	mm
Flatness Specification	-	0.1	mm
Weight	tbd	-	g

Note: *The dimensions in* ***Error! Reference source not found.*** *are accurate as of the release date of this document.*

3.3.2. Mechanical Drawing

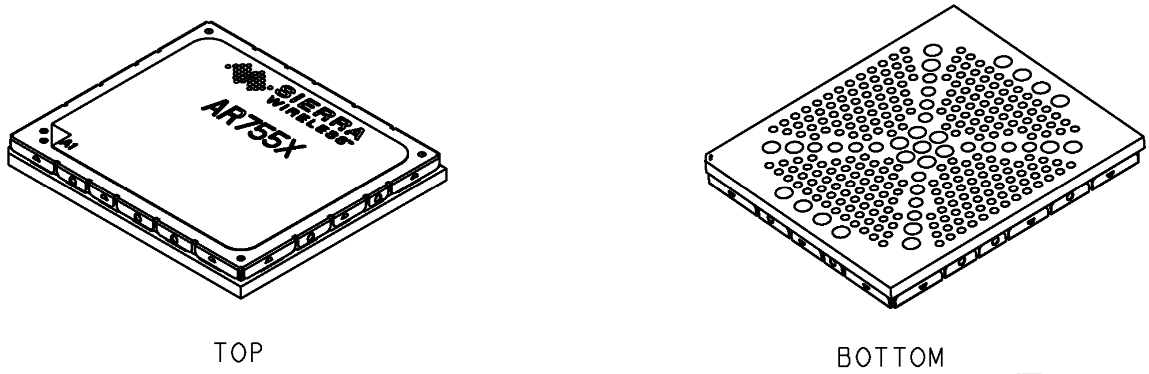


Figure 2. AR55x Assembly Drawing

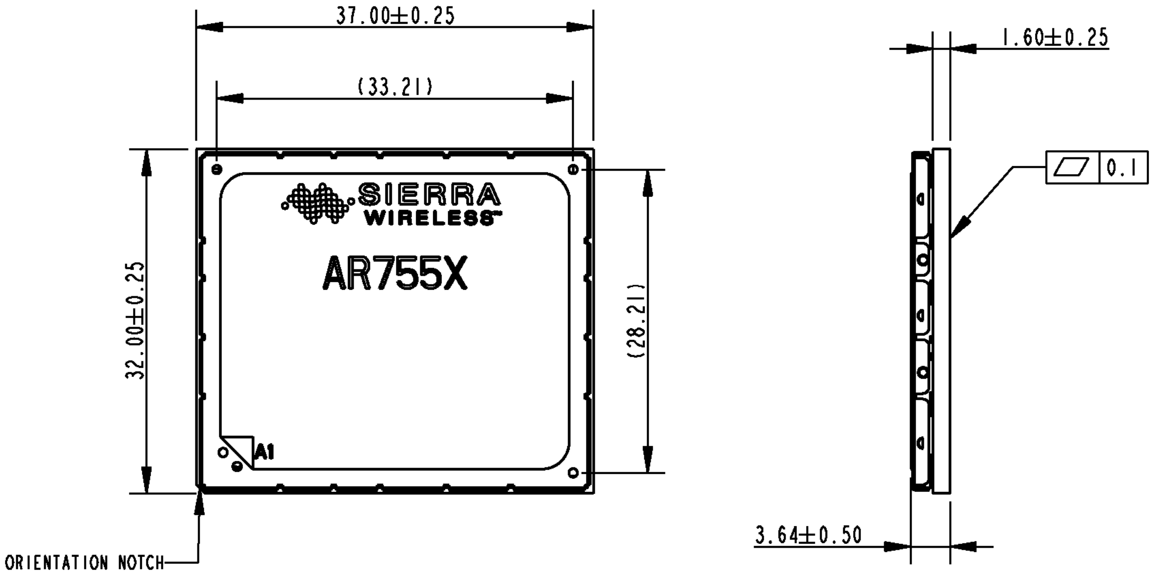


Figure 3. AirPrime AR7550 Mechanical Dimensions Drawing

*Note: The dimensions in **Error! Reference source not found.** are preliminary and subject to change.*

3.3.3. Footprint

The AirPrime AR7550 device LGA footprint is a 303 pad array of 0.9mm, 1.45mm, and 1.90mm pads. The following drawing illustrates the device footprint. The application footprint is recommended to mirror the device footprint as illustrated in the following drawing (subject to change).

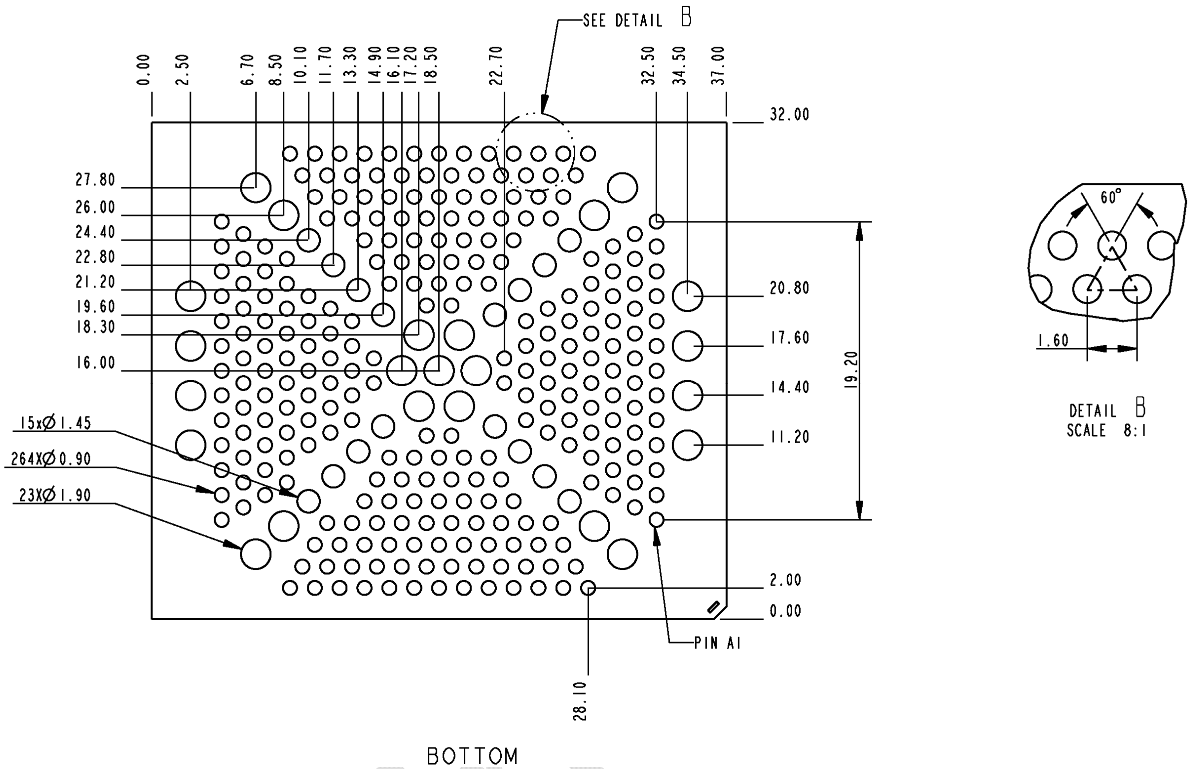


Figure 4. AirPrime AR7550 Footprint

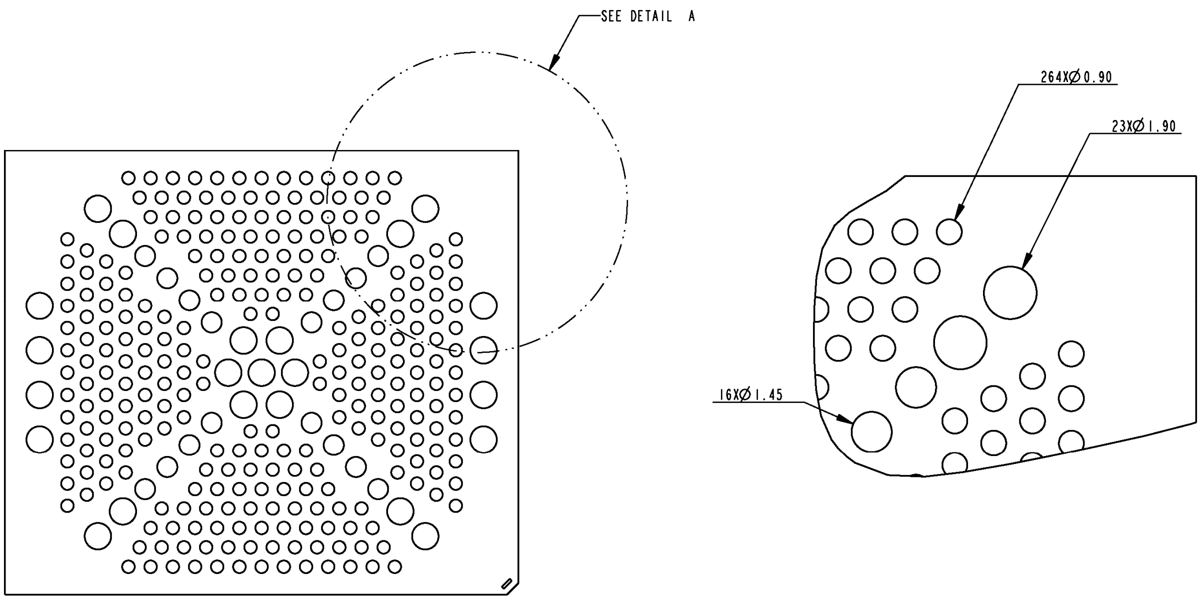


Figure 5. AirPrime AR7550 Recommended Application Land Pattern

3.3.4. Thermal Consideration

The AirPrime AR7550 device is designed to work over an extended temperature range. In order to do this efficiently a method of sinking heat from the product is recommended.

Refer to application notes (TBD) for details.

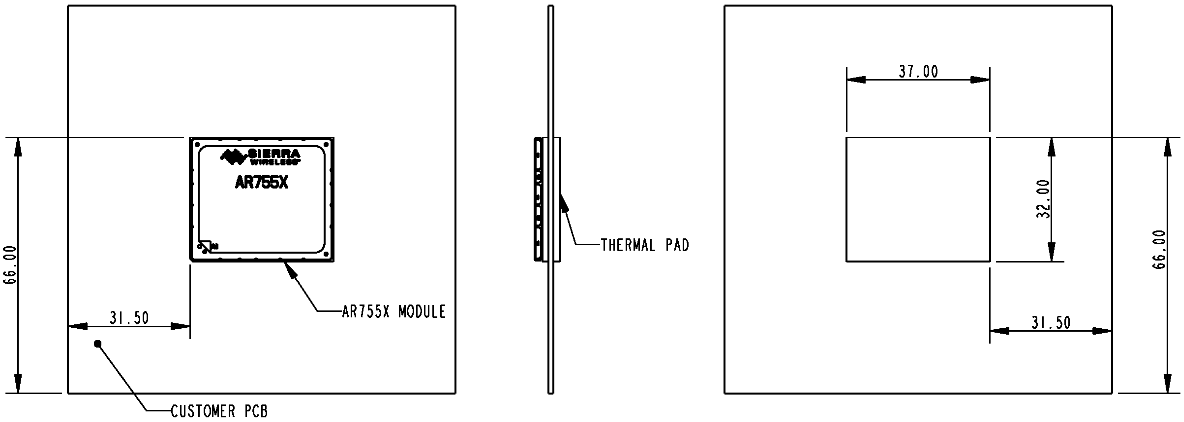


Figure 6. AirPrime AR7550 Heatsink Contact Area

4. RF Specification

This section presents the WWAN RF interface of the AirPrime AR7550 series of embedded modules. The specifications for the LTE, CDMA and WCDMA interfaces are defined.

4.1. LTE RF Interface

This section presents the LTE RF Specification for the AirPrime AR7550.

4.1.1. LTE Max TX Output Power

The Maximum Transmitter Output Power of the AirPrime AR7550 embedded modules are specified in the following table.

Table 7. AirPrime AR7550 Maximum LTE Transmitter Output Power

Band	Frequency Band	Nominal Max TX Output Power	Tolerance
Band 4		+23 dB	+1/-2 dB

Band	Frequency Band	Nominal Max TX Output Power	Tolerance
Band 13	776 MHz to 787 MHz		

4.1.2. LTE RX Sensitivity

The Minimum Receiver Sensitivity of the AirPrime AR7550 embedded modules are specified in the following table.

Table 8. AirPrime AR7550 Minimum LTE Receiver Sensitivity

Band	Frequency Band	Minimum RX Downlink	Criteria
Band 4	1710 MHz to 1755 MHz	tbd	tbd
Band 7	2500 MHz to 2570 MHz	tbd	tbd
Band 13	746 MHz to 757 MHz	tbd	tbd

4.2. CDMA RF Interface

This section presents the CDMA RF Specification for the AirPrime AR7550 embedded modules. AirPrime AR7550 devices are designed to be compliant with 3GPP2 C.S0011 Rev A and 3GPP2 C.S0033 Rev A v1.0. Parameters specified differently for the reference standard are identified below.

4.2.1. CDMA Max TX Output Power

The Maximum Transmitter Output Power of the AirPrime AR7550 embedded module is specified in the following table.

Table 9. AirPrime AR7550 Maximum CDMA Transmitter Output Power

Band Class	Frequency Band	Nominal Max TX Output Power	Tolerance
BC0	800 MHz	+24 dBm	+1.5/-1 dB (Class A) +1.5/-2 dB (Class B)
BC1	1900 MHz		

4.2.2. CDMA RX Sensitivity

The Minimum Receiver Sensitivity of the AirPrime AR7550 embedded module is specified in the following table.

Table 10. AirPrime AR7550 Minimum CDMA Receiver Sensitivity

Band Class	Frequency Band	Minimum RX downlink	Criteria
BC0	800 MHz	-106 dBm (Class A) -104 dBm (Class B)	Less than 0.5% FER
BC1	1900 MHz		

4.3. WCDMA RF Interface

This section presents the WCDMA RF Specification for the AirPrime AirPrime AR7550 embedded modules.

4.3.1. WCDMA Max TX Output Power

The Maximum Transmitter Output Power of the AirPrime AR7550 embedded module are specified in the following table.

Table 11. AirPrime AR7550 Maximum WCDMA Transmitter Output Power

Band	Frequency Band	Nominal Max TX Output Power	Tolerance
II (1900/PCS)	1850 MHz to 1910 MHz	+23.5 dBm	+1.5/-1 dB (Class A) +1.5/-2 dB (Class B)
V (850/CELL)	824 MHz to 849 MHz		

4.3.2. WCDMA RX Sensitivity

The Minimum Receiver Sensitivity of the AirPrime AR7550A embedded module are specified in the following table.

Table 12. AirPrime AR7550 Minimum WCDMA Receiver Sensitivity

Band	Frequency Band	Minimum RX Downlink	Criteria
II (1900/PCS)	1930 MHz to 1990 MHz	-106 dBm (Class A) -105 dBm (Class B)	BER < 0.001
V (850/CELL)	869 MHz to 894 MHz	-107 dBm (Class A) -106 dBm (Class B)	

4.4. WWAN Antenna Interface

The specification for the WWAN Antenna Interface of the AirPrime AR7550 embedded modules are defined in the table below.

Table 13. AirPrime AR7550 WWAN Antenna Characteristics

Characteristics		CDMA BC0, WCDMA B5	CDMA BC1, WCDMA B2	LTE B4	LTE B13
Frequency (MHz)	TX	824-849	1850-1910	1710 – 1755	777 – 787
	RX	869-894	1930-1990	2110 – 2155	746 – 756
Impedance	RF	50 Ω			
VSWR max	RX	2:1			
	TX	2:1			
Maximum Voltage		Primary Antenna – 36 Volts			
		RX2 Antenna – 36 Volts (LTE MIMO: tbd)			

Note: RX2 Antenna port is RX only, RX parameters in the above tables are also applicable.

Table 14. 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
BA7	GND		Diversity Antenna Ground
BA8	DIVERSITY_ANT	Input	Diversity Antenna Interface
BA9	GND		Diversity Antenna Ground

4.4.1. WWAN Antenna Recommendations

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

Table 15. AirPrime AR7550 WWAN Antenna Recommendations

Characteristics		CDMA BC0, WCDMA B5	CDMA BC1, WCDMA B2	LTE B4	LTE B13
Frequency (MHz)	TX	824-849	1850-1910	1710 – 1755	777 – 787
	RX	869-894	1930-1990	2110 – 2155	746 – 756
Impedance	RF	50 Ω			
	DC	10 kΩ ±1k			
VSWR max	RX	1.5: 1			
	TX	1.5: 1			
Polarization		Linear, vertical			
Typical radiated gain		0 dBi in one direction at least			

4.5. Primary Antenna Diagnostics

The primary antenna diagnostic feature allows the AirPrime AR7550 embedded module to determine if the primary antenna connected to the module is: open, shorted or normal. The antenna connected to this interface needs to have a DC resistance to ground of 10 kΩ ± 1k embedded inside.

The ARx55x FW accepts two limits which are used to evaluate the status of the antenna, representing the short and open thresholds. Refer to [7] for the syntax of **AT+ANTLIMT**.

Table 16. Primary Antenna ADC Characteristics

	Min	Nom	Max	Units
ADC Voltage Range	0	0.9	1.8	Volts
Resolution	-		15	Bit
ADC Values	0		16383	
Voltage/ADC step		~0.0011		Volts

1 Assumes 10kΩ Nominal DC resistance in the attached antenna and internal to AirPrime AR7550 device

The following example illustrates the Antenna states and resistance values for a typical limit setting.

AT+ANTLIMT=1,839,1088

Table 17. Primary Antenna Diagnostics Ranges

Antenna State	Min ADC	Max ADC	Antenna Resistance Range
Short	0	839	~ ≤ 7 kΩ
Normal	841	1086	7 kΩ < x < 13 kΩ
Open	1088	1900	≥ 13 kΩ

Note: Highlighted numbers in the table above are programmed as shortLim and openLim using the +ANTLIMT command.

4.6. RX2 Antenna Diagnostics

The RX2 antenna diagnostic feature allows the AirPrime AR75500 to determine if the RX2 antenna connected to the module is: open, shorted or normal. The antenna connected to this interface needs to have a DC resistance to ground of 10 kΩ ± 1k embedded inside.

The AirPrime AR7550 FW accepts two limits which are used to evaluate the status of the antenna, representing the short and open thresholds. Refer to [7] for the syntax of **AT+ANTLIMT**.

Table 18. RX2 Antenna ADC Characteristics

	Min	Nom	Max	Units
ADC Voltage Range	0	0.9	1.8	Volts
Resolution	-		15	Bit
ADC Values	0		16383	
Voltage/ADC step		~0.0011		Volts

1 Assumes 10kΩ Nominal DC resistance in the attached antenna and internal to AirPrime AR7550 device

The following example illustrates the Antenna states and resistance values for a typical limit setting.

AT+ANTLIMT=2,839,1088

Table 19. RX2 Antenna Diagnostics Ranges

Antenna State	Min ADC	Max ADC	Antenna Resistance Range
Short	0	839	~ ≤ 7 kΩ
Normal	841	1086	7 kΩ < x < 13 kΩ
Open	1088	1900	≥ 13 kΩ

Note: Highlighted numbers in the table above are programmed as shortLim and openLim using the +ANTLIMT command.

5. GNSS Specification

The AirPrime AR7550 embedded module includes optional Global Navigation Satellite System (GNSS) capabilities via the Qualcomm gpsOne Gen8 Engine, capable of operation in assisted and stand-alone GPS modes as well as GPS+GLONASS mode.

5.1. GNSS

The GNSS implementation supports GPS L1 operation and GLONASS L1 FDMA operation.

Table 20. GNSS Characteristics

Parameter		Value
Sensitivity	Standalone or MS Based Tracking Sensitivity	tbd
	Cold Start Sensitivity	tbd
	MS Assisted Synchronous A-GNSS Acquisition Sensitivity	tbd
Accuracy in Open Sky (1 Hz tracking)		<2m CEP-50
Total number of SV available		~30 SVs
Support for Predicted Orbits		Yes
Predicted Orbit CEP-50 Accuracy		5 m
Standalone Time To First Fix (TTFF)	Super Hot	1 s
	Warm	29 s
	Cold	32 s
Number of channels		tbd
GNSS Message Protocols		NMEA

Note: *Acquisition/Tracking Sensitivity performance figures assume open sky w/ active patch GNSS antenna and a 2.5 dB Noise Figure.*

5.2. GNSS Antenna Interface

The specification for GNSS Antenna Interface is defined in the table below. The AirPrime AR7550 provides biasing for an active antenna as well as onboard circuitry for diagnostics of this antenna interface.

Table 21. GNSS Antenna Interface Characteristics

Characteristics		GNSS
Frequency	GPS L1 (Wideband)	1575.42 ± 20 MHz
	Glonass L1 FDMA	1597.5 – 1605.8 MHz
RF Impedance		50 Ω
VSWR max	RX	2:1
LNA Bias Voltage		4.4 – 4.9V, 5.25V (No Load)
LNA Current Consumption		50 mA Max
Maximum Voltage applied to antenna		36 Volts

Minimum isolation between the GNSS and WWAN Antenna must be 10 dB for the AirPrime AR7550.

Table 22. 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

5.2.1. GNSS Antenna Recommendations

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

Table 23. GNSS Recommended Antenna Characteristics

Characteristics		GNSS
Frequency	GPS L1 (Wideband)	1575.42 ± 20 MHz
	Glonass L1 FDMA	1597.5 – 1605.8 MHz
RF Impedance		50 Ω
VSWR max	RX	1.5: 1
LNA Bias Voltage		4.4 – 4.9V
LNA Noise Figure		2.0 dB Max
LNA Current Consumption		50 mA Max
Antenna System Gain (Antenna + LNA - Cable)		20 – 24 dB
Polarization		Right Hand Circular Polarization

5.3. GNSS Antenna Diagnostics

The GNSS Antenna Diagnostic feature measures the current drawn by an active GNSS antenna to determine the state of this antenna interface. Based on the current draw an assessment of open, short, normal or over-current is made. If an over-current is detected, the bias for the active antenna is removed to eliminate the fault for drawing excess current which could potentially damage the antenna.

The limits between open/normal and normal/short can be set by the application through an AT Command.

ADC Value	<	openLim	< >	shortLim	>
GNSS Antenna State	Open		Normal		Short

The Over Current limit is set by hardware and cannot be altered.

Table 24. GNSS Antenna Diagnostics Ranges

Control	State	Min	Max	Units
HW	Over Current	78	100	mA

The GNSS antenna supply is powered from VBATT through a boost regulator.

The following table identifies some key VGNSS_ANT current draw values and the associated ADC values.

Table 25. VGNSS_ANT Current Draw

I (mA)	Nominal
0	337
5	612
10	936
15	1242
20	1558
25	1877
30	2194
35	2494
40	2821
45	3188
50	3444
55	3747
60	4065
65	4292
70	4319

The graph below illustrates the relationship between current drawn on VGNSS_ANT vs the ADC readings used to monitor the GNSS Antenna status.

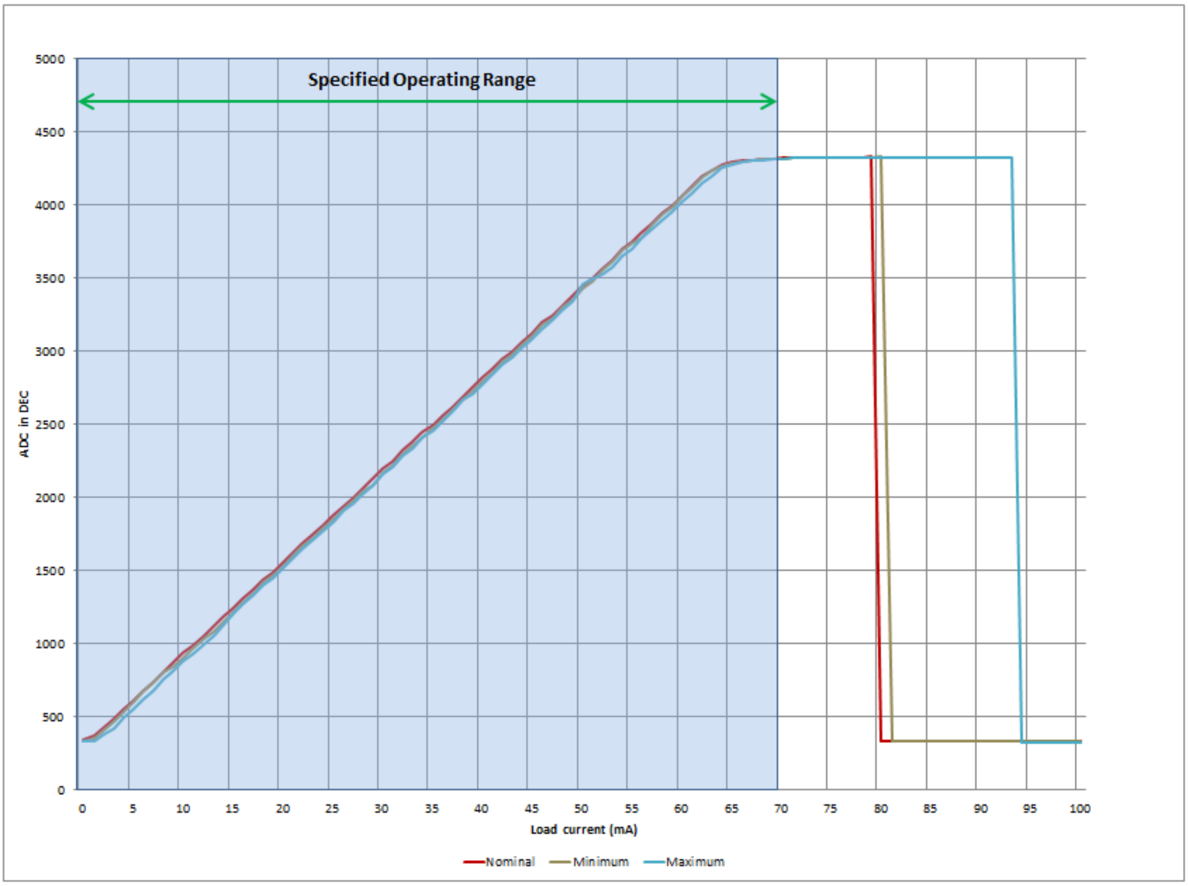


Figure 7. VGNSS_ANT vs. ADC Readings Relationship

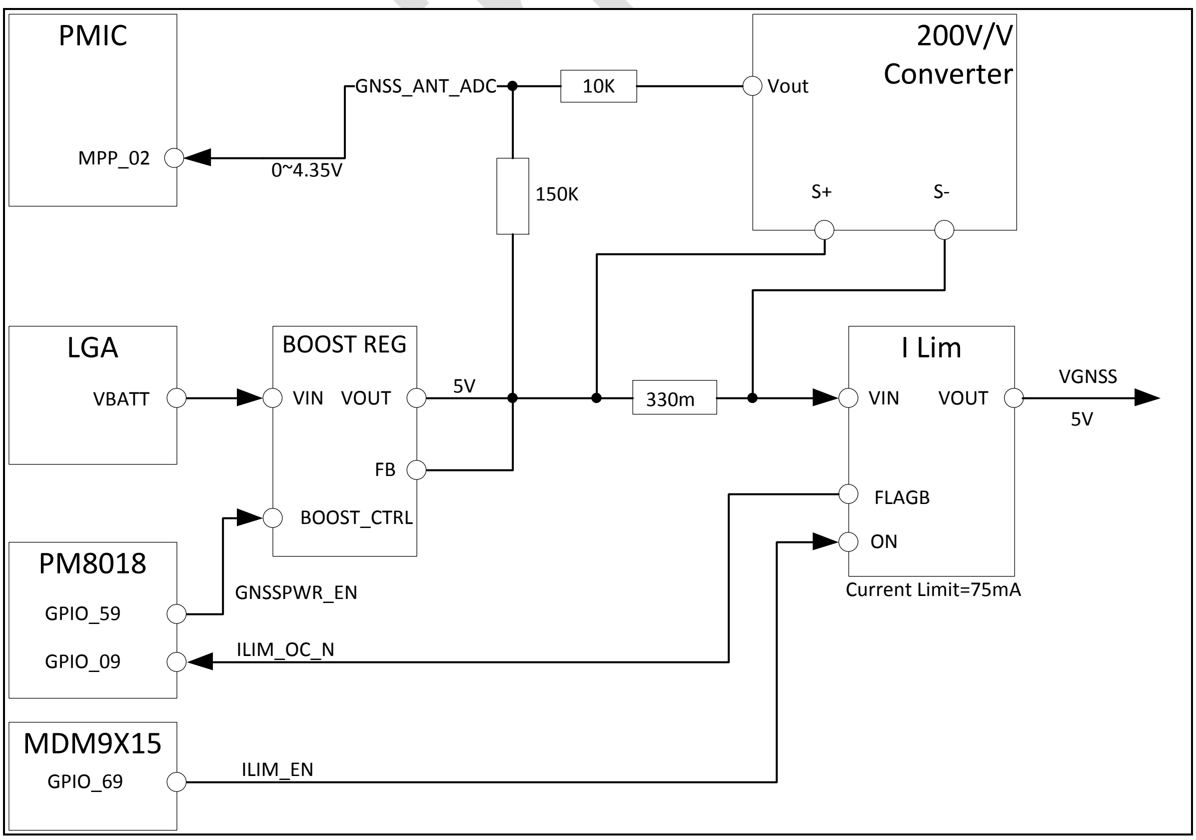


Figure 8. GNSS Power Supply and Antenna Diagnostics Block Diagram

5.4. Current Consumption

The table below summarizes some key current consumption values for various modes of the AirPrime AR7550 devices.

Table 26. AirPrime AR7550 Current Consumption Values

Mode	Parameter		Typical	Max	Units
On Call – CDMA	Maximum TX Output – 1xRTT/1xEVDO		-	tbd	mA
	+0dBm TX Output – 1xRTT		tbd	-	mA
	+0dBm TX Output – 1xEVDO		tbd	-	mA
On Call – WCDMA	Maximum TX Output – WCDMA/HSPA		-	tbd	mA
	+0dBm TX Output – WCDMA		tbd	-	mA
	+0dBm TX Output – HSPA		tbd	-	mA
On Call – LTE	Maximum TX Output		-	tbd	mA
	+0dBm TX Output		tbd	-	mA
Idle – CDMA	Registered	USB Enumerated	tbd	-	mA
		USB Not Enumerated	tbd	-	mA
	Searching for network – CDMA		tbd	-	mA
Idle – WCDMA	Registered	USB Enumerated	tbd	-	mA
		USB Not Enumerated	tbd	-	mA
	Searching for network – WCDMA		tbd	-	mA
Idle – LTE	Registered	USB Enumerated	tbd	-	mA
		USB Not Enumerated	tbd	-	mA
	Searching for network – LTE		tbd	-	mA
Sleep Mode	Average current, QPCH, SCI=2		-	tbd	mA
	Average current, WCDMA, DRX=8		-	tbd	mA
	Average current, LTE		-	tbd	mA
Off	Power OFF Current		tbd	tbd	µA
GNSS	Acquisition (Airplane mode, cold start)		tbd		mA
	Tracking (Registered)		tbd		mA
	Powering an Active Antenna from VGNSS_ANT			tbd	mA

1 This is the additional current draw on VBATT for 10mA consumption by Active LNA from VGNSS_ANT. Higher current consumption by the antenna will result in higher consumption on VBATT.

5.5. Digital IO Characteristics

The Digital IO characteristics are defined in the table below. These apply to GPIOs, UART, LED, SDIO and PCM/I2S.

Table 27. Digital IO Characteristics

Parameter		Comments	Min	Typ	Max	Units
V_{IH}	High level input voltage	CMOS/Schmitt	0.65* VCC_1V8	–	VCC_1V8+0.3	V

Parameter		Comments	Min	Typ	Max	Units
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
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-LED}	High level output current	LED signal only	–	–	–	mA
I_{OL-LED}	Low Level output current	LED signal only	-3	–	20	mA
I_{IHPD}	Input high leakage current	With pull-down	5		30	µA
I_{ILPU}	Input low leakage current	With pull-up	-30		-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		–	–	7	pF
C_{IN-LED}	Input capacitance	LED signal only	–	–	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 AR7550 device is powered down. Also, this would partially bias the AirPrime AR7550 device which could potentially damage the device or result in GPIOs being set to undetermined levels.*

5.6. Internal Device Frequencies

The table below summarizes the frequencies generated within the AirPrime AR7550. This table is provided for reference only to the device integrator.

Table 28. Internal Device Frequencies

Subsystem/Feature	Frequency	Units
Real Time Clock	32.768	kHz
PCM Audio interface (Primary PCM Master Mode) [TBD]	8, 128, 2048	kHz
I2C Interface	400	kHz
PMIC switching power supplies	tbd	MHz
GNSS Antenna bias switching supply	3.5	MHz

Subsystem/Feature	Frequency	Units
Fundamental clock, codec, TCXO_OUT	19.2	MHz
PLL	tbd	MHz
USB	12, 480	Mb/s

6. Baseband Specification

6.1. Power Supply

The AirPrime AR7550 embedded module is powered via a single regulated DC power supply, 3.7V nominal. The power supply requirements can be found in the following table.

Table 29. Power Supply Requirements

Power Supply		Min	Typ	Max	Units
Main DC Power Input Range		3.4	3.7	4.2	V
Power Supply Ripple	0 to 1kHz	-	-	200	mVpp
	>1kHz	-	-	50	mVpp
Maximum Current draw	AR7550	-	-	tbd	mA

AirPrime AR7550 does not support USB bus-powered operation. DC power must be supplied via the VBATT input.

Table 30. 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

6.1.1. Under-Voltage Lockout (UVLO)

The power management section of the AirPrime AR7550 includes an under-voltage lockout circuit that monitors supply and shuts down when VBATT falls below the threshold.

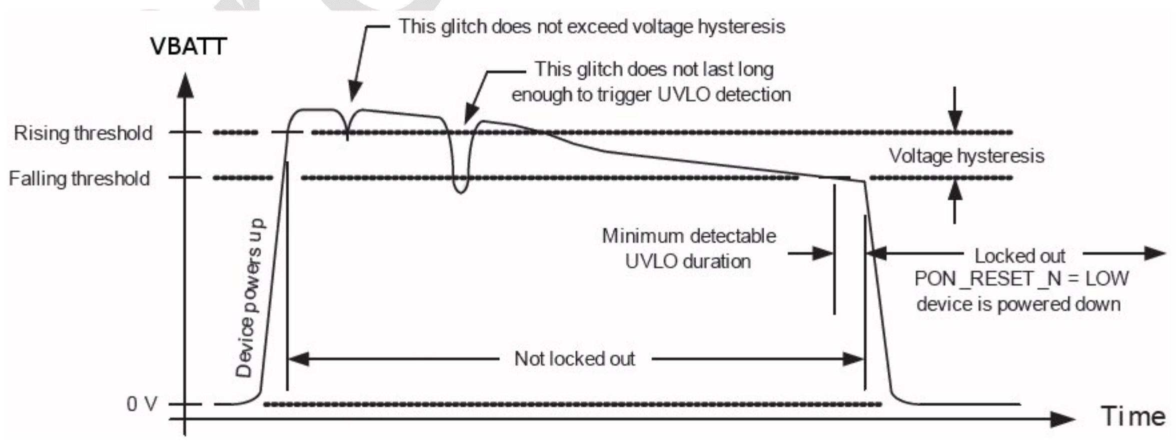


Figure 9. Under-Voltage Lockout (UVLO) Diagram

The AirPrime AR7550 will power down and remain off until the level of VBATT returns to the valid range and the ON/OFF signal is active.

Note: If the AirPrime AR7550 device has 6 UVLO events without a valid power down or reset sequence, it enters a mode in which only the DM port enumerates on the USB.

Table 31. UVLO Thresholds

	Description	Value	Units
UVLO	Rising threshold	2.725	V
	Falling threshold	2.55	V
	Minimum Duration below Falling threshold	1.0	uS

6.2. VCOIN

The AirPrime AR7550 provides an interface for a coin cell to maintain the internal RTC when VBATT is removed from the AirPrime AR7550 device. Whenever VBATT is applied the RTC is powered from the VBATT supply. The AirPrime AR7550 also supports charging of a coin cell if connected to this interface.

Table 32. VCOIN Pad

Pad	Name	Direction	Function	If Unused
AC11	VCOIN	Input /Output	Voltage Input/Charging output	Leave Open

The table below defines the specifications of this interface.

Table 33. VCOIN Interface Specification

VCOIN	Min	Typ	Max	Units
DC Power Input Range	TBD	TBD	TBD	V
Current Draw		1.1	2.0	µA

The table below defines the VCOIN charging specifications.

Table 34. VCOIN Charging Specifications

VCOIN Charging Specs	Comments	Min	Typ	Max	Units
Target regulator voltage[1]	VIN > 2.5 V, ICHG = 100 µA	TBD	TBD	TBD	V
Target series resistance[2]		800	–	2100	Ω
Coin cell charger voltage error	ICHG = 0 µA	-5	–	+5	%
Coin cell charger resistor error		-20	–	+20	%
Dropout voltage[3]	ICHG = 2 mA	–	–	200	mV
Ground current, charger enabled	IC = off; VCOIN = open				
VBAT = 3.6 V, T = 27 ºC		–	4.5	–	µA
VBAT = 3.2 to 4.2 V		–	–	8	µA

1. Valid regulator voltage settings are 2.5, 3.0, 3.1, and 3.2 V.

2. Valid series resistor settings are 800, 1200, 1700, and 2100 Ω.

3. Set the input voltage (VBAT) to 3.5 V. Note the charger output voltage; call this value V0. Decrease the input voltage until the regulated output voltage drops 100 mV (until the charger output voltage = V0 - 0.1 V). The voltage drop across the regulator under this condition is the dropout voltage (Vdropout = VBAT - the charger output voltage).

6.3. ON/OFF Control

The AirPrime AR7550 provides an interface for controlling the device ON/OFF state.

Table 35. ON/OFF Control Pads

Pad	Name	Direction	Function	If Unused
BB1	ON/OFF	Input	ON/OFF Control	Must Be Used

The ON/OFF signal is internally pulled up to an internal 1.8V reference voltage. An open drain transistor should be connected to this pin to generate a low pulse. This pin should not be driven high external to the AirPrime AR7550 embedded module.

Table 36. ON/OFF Internal Pull-Up

Signal	Parameter	Min	Typ	Max	Units
ON/OFF	Internal Pull-up	-	200	-	kΩ

6.3.1. ON/OFF Timing

The ON/OFF pin is a low pulse toggle control. The first pulse powers the AirPrime AR7550 ON, a second pulse instructs the AirPrime AR7550 to begin the Shutdown process.

The diagram below illustrates the recommended application implementation for ON/OFF control.

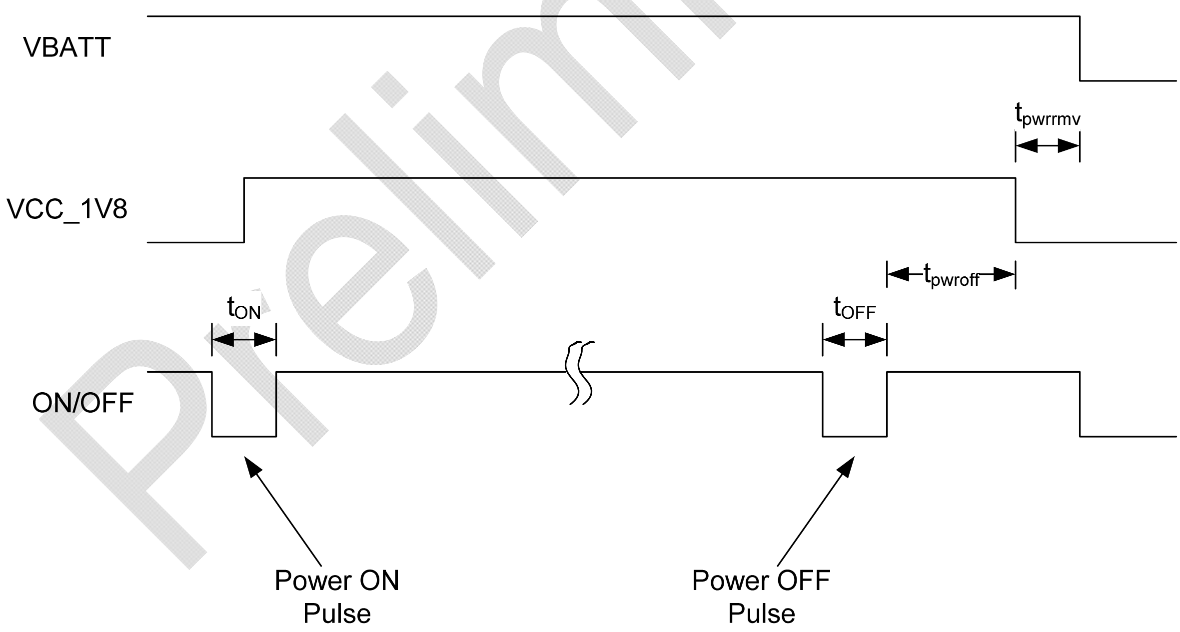


Figure 10. Recommended ON/OFF Control

The diagram below illustrates an alternate application implementation that holds ON/OFF low during operation.

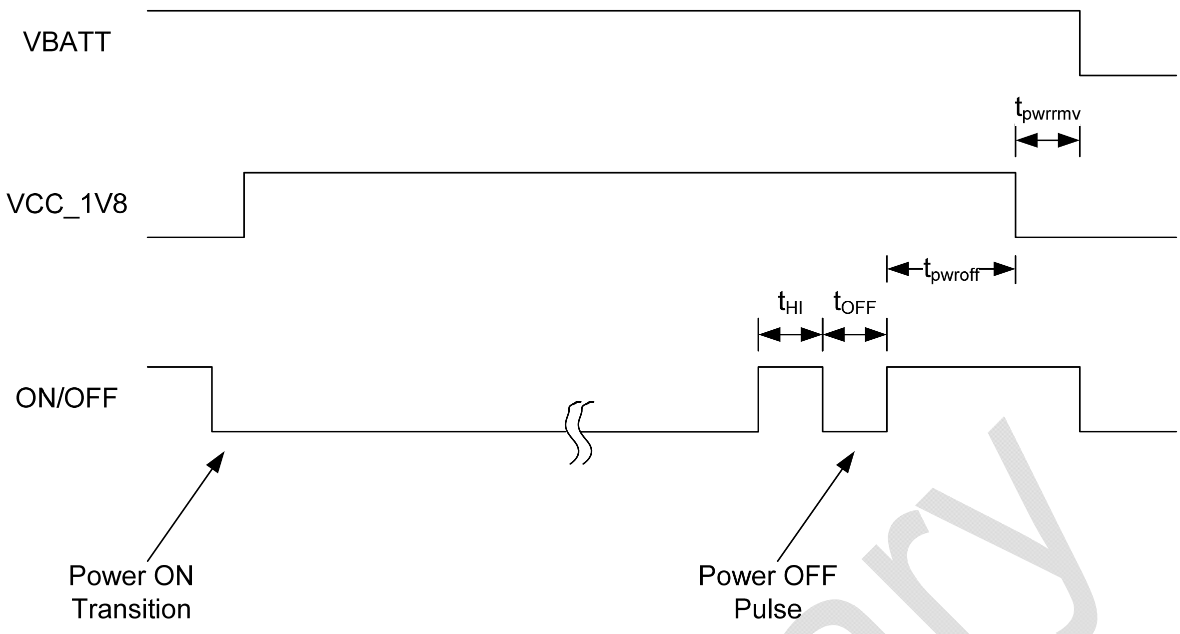


Figure 11. Alternate ON/OFF Control

Table 37. Power-ON Sequence Symbol Definitions

Symbol	Parameter	Boot	Min	Typ	Max
t_{ON}	Turn ON Pulse duration		50 ms	100 ms	∞
t_{OFF}	Turn OFF Pulse duration		50 ms	100 ms	500 ms
t_{pwroff}	Time to Power OFF		-	5 s	-
t_{pwrrmv}	Time VBATT must be maintained after VCC_1V8 goes inactive		0 s	-	-
t_{HI}	Time required for ON/OFF to be high prior to OFF pulse.	In process	10 s	-	
		Complete	50 ms		

T_{pwroff} is the time between when a power OFF pulse is complete and when shutdown is completed by the AirPrime AR7550 devices. This duration is network and device dependent, i.e. in a CDMA network a power down registration is initiated by the AirPrime AR7550 device, when the acknowledgement is received from the network power OFF completes.

Detection of power down can be accomplished by monitoring for one of the following:

- +WIND: 10 output on the AT Command interface
- USB ports are de-enumerated

The application must wait for a power down to be detected prior to removing power from the AirPrime AR7550 device. If a timeout is required, it is recommended to be in excess of 30s prior to removing power from the AirPrime AR7550 device.

Note: Refer to [7] for details on enabling the +WIND message for power down and +USLGRPMSK and +USLEVTMSK for unsolicited message output.

6.3.3. Software-Initiated Power Down

The host application may choose to use the AT Command AT!POWERDOWN to initiate a power down of the AirPrime AR7550 device instead of using an OFF pulse. In this scenario the ON/OFF signal should be left open by the application. The AirPrime AR7550 device will initiate a power up after completion of the power down if ON/OFF is low.

6.3.4. Deep Sleep

The AirPrime AR7550 embedded modules support a low power mode in which the device is registered on the LTE/CDMA/GSM/WCDMA network and sleeps in between wake intervals where it listens for pages.

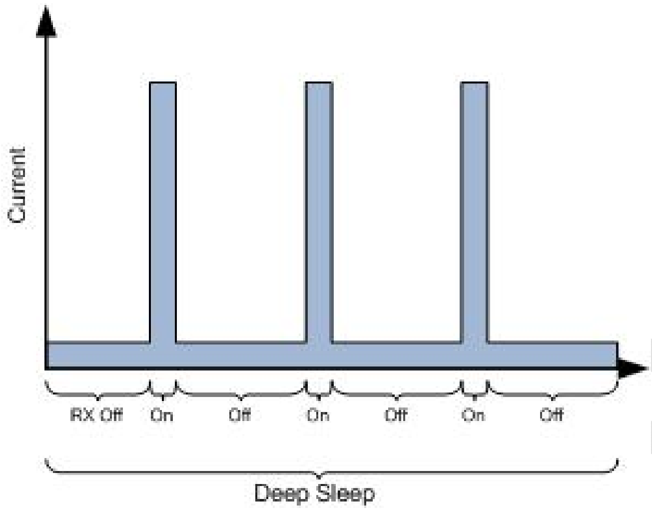


Figure 12. Power Mode Diagram

The following table lists the parameter that defines the wake interval period for the various devices.

Table 38. Period of Wake Intervals

AR Series Device	Network Standard	Parameter
AR7550	CDMA	SCI
	WCDMA	DRX
	LTE	DRX

The average current consumption of the AirPrime AR7550 while in this mode is defined in the Sleep Mode portion of the current consumption tables in section 5.4 Current Consumption.

The Slot Cycle Index is the lower of the values stored in the AirPrime AR7550 or the value being broadcast by the wireless network that the AirPrime AR7550 is registered on.

The MFRM and DRX cycle index values are broadcast by the wireless network on which the AirPrime AR7550 embedded module is registered.

While in Deep Sleep mode the functions of the AirPrime AR7550 are limited as defined in the following table.

Table 39. Deep Sleep Function Availability

Function	Availability	Conditions
Paging	✓	

Function	Availability	Conditions
GNSS	-	GNSS is powered down
Time measurement	✓	
USB	-	USB_VBUS is not applied
UART	-	
Digital IO	-	Digital IO pins maintained last state

Events that cause the AirPrime AR7550 to wake-up from Deep Sleep mode include:

- Incoming call
- Expiration of an internal timer in the AirPrime AR7550
- USB_VBUS is applied to the AirPrime AR7550
- WAKE_N is asserted (low)
- UART1 DTR is asserted (high) if UART1 DTR has been enabled as a sleep control (AT+W32K=1,1) and AT Command Service is mapped to UART1
- GNSS location fix request is initiated from an Embedded Application

See the Ring Indicator section for more information about configuring the RI signal to notify an external application of a wake-up event while the AR device is in sleep mode.

6.3.4.1. Sequence to Enter Deep Sleep Mode

The following list defines the sequence needed by the application to allow the AirPrime AR7550 to enter Deep Sleep mode:

1. AR7550 has registered on the WWAN network (or callbox), and is not in a call.
2. End GNSS Tracking session.
3. Turn off GNSS Antenna bias.
4. Confirm WAKE_N is not held low (pulled-up in AirPrime AR7550).
5. Issue AT command to request AR device to enter deep sleep (AT+W32K=1,x).
6. If AT+W32K=1,1 is used, DTR must also be de-asserted to allow sleep.
7. Ensure UARTs are in the inactive state.
8. Remove VBUS from being applied to the AR device.

6.4. USB

The AirPrime AR7550 has a High Speed USB2.0 compliant, peripheral only interface.

Table 40. USB Pad Details

Pad	Name	Direction	Function
DA7	USB_VBUS	Input	USB Power Supply
DB6	USB_D_P	In/Out	Differential data interface positive
DA6	USB_D_M	In/Out	Differential data interface negative
DD5	USB_ID	In/Out	USB ID

The AR7550 will not be damaged if a valid USB_VBUS is supplied while the main DC power is not supplied.

Table 41. USB Characteristics

USB		Value	Units
USB_VBUS	Voltage range	2.0 – 5.25	V
	Maximum Current draw[1]	1	mA
	Maximum Input Capacitance (Min ESR = 50 mΩ)	10	µF

1 With the AirPrime AR7550 device powered ON.

6.5. UART

The AirPrime AR7550 has two UART interfaces. The primary UART is an 8-wire[1] electrical interface and the secondary UART is a 2-wire electrical interface.

Table 42. UART Pads

Pad	Name	Direction	Function	Interface	If Unused
AD9	RXD1	Output	Receive Data (UART1)	UART1	Leave Open
AE6	RTS1	Input	Ready To Send (UART1)	UART1	Leave Open1
AD8	TXD1	Input	Transmit Data (UART1)	UART1	Leave Open
AE7	CTS1	Output	Clear To Send (UART1)	UART1	Leave Open
AF6	DCD1	Output	Data Carrier Detect (UART1)	UART1	Leave Open
AE5	DTR1	Input	Data Terminal Ready (UART1)	UART1	Leave Open
AF5	DSR1	Output	Data Set Ready (UART1)	UART1	Leave Open
DB2	RXD2	Output	UART2 Receive Data	UART2	Leave Open
DA2	TXD2	Input	UART2 Transmit Data	UART2	Leave Open

1 If UART1 is implemented as a 2-wire interface, RTS1 should be pulled low to disable flow control.

6.6. Ring Indicator

The Ring Indicator (RI) may be used to notify an external application of several events such as an incoming call, timer expiration or incoming SMS.

Table 43. Ring Indicator Pad

Pad	Name	Direction	Function	If Unused
AD7	RI1	Output	Ring Indicator	Leave Open

The events which toggle the RI signal can be configured using the AT+WWAKESET command. The duration of the RI pulse can be configured using the AT+WRID command.

The reason for the RI signal being activated can be queried using the AT+WWAKE command. Refer to [7] for details of these AT Commands.

The RI signal is independent of the UART.

[1] Includes Ring Indicator which may also be used independently of UART1.

6.7. UIM Interface

The UIM interface of the AirPrime AR7550 supports a USIM/CSIM for LTE, WCDMA, GSM and CDMA. The UIM can be embedded internally in AR7550 and can be external to AR7550.

Table 44. UIM Pads

Pad	Name	Direction	Function	If Unused
DA5	UIM_DETECT	Input	Detection of an external UIM card	Leave Open
DB4	UIM_VCC	Output	Supply output for an external UIM card	Leave Open
DC3	UIM_RST	Output	Reset output to an external UIM card	Leave Open
DA4	UIM_DAT	Input /Output	Data connection with an external UIM card	Leave Open
DE1	UIM_CLK	Output	Clock output to an external UIM card	Leave Open

The diagram below illustrates the recommended implementation of a UIM holder on the application.

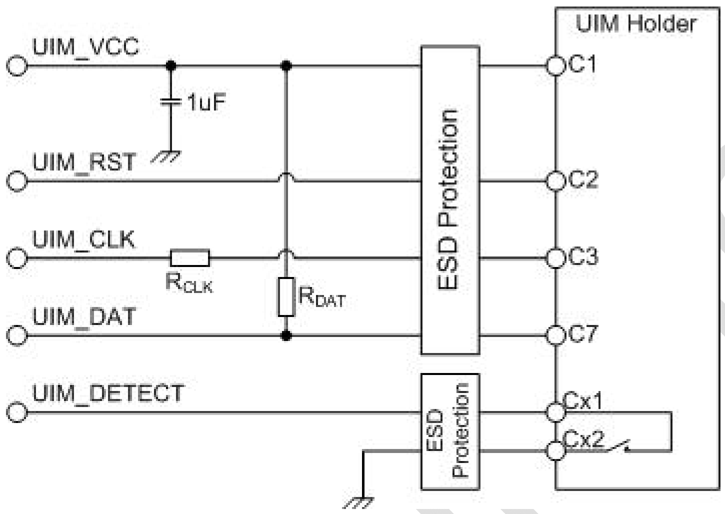


Figure 13. Recommended UIM Holder Implementation

UIM_DETECT is used to detect the physical presence of a SIM/UIM card in the holder. It has a 3.0uA to 30µA pull-up to 1.8V inside the AirPrime AR7550. It should be set to GND if a SIM/UIM is present. All signals must be ESD-protected near the UIM holder.

The capacitor and two resistors should be added as placeholders to compensate for potential layout issues. UIM_DAT trace should be routed away from the UIM_CLK trace. Keep distance from AirPrime AR7550 to UIM-Holder as short as possible.

An ESD device specifically designed for SIM/UIM cards is recommended for UIM_VCC, UIM_RST, UIM_CLK and UIM_DAT. i.e. SEMTECH EClamp2455K, Infineon BGF106C or NXP IP4264CZ8-20-TTL. For UIM_DETECT a low leakage ESD suppressor should be selected.

6.7.1. Internal UIM

Alternatively, a hardware option is available that includes a UIM device mounted on the AirPrime AR7550 PCB thus eliminating the need for an external UIM holder

6.8. General Purpose IO

The AirPrime AR7550 defines 10 GPIOs for customer use.

Table 45. GPIO Interface Pads

Pad	Name	Pull State	Function	If Unused	Multiplexed Function
CA10	GPIO1	Pull-Down	Available-GPIO	Leave Open	
CA11	GPIO2	Pull-Down	Available-GPIO	Leave Open	
CB10	GPIO3	Pull-Down	Available-GPIO	Leave Open	
CB11	GPIO4	Pull-Down	Available-GPIO	Leave Open	
CC7	GPIO5	Pull-Down	Available-GPIO	Leave Open	
CC8	GPIO6	Pull-Down	Available-GPIO	Leave Open	
CC9	GPIO7	Pull-Down	Available-GPIO	Leave Open	
CD7	GPIO8	Pull-Down	Available-GPIO	Leave Open	Band indicator1
CE5	GPIO9	Pull-Down	Available-GPIO	Leave Open	Band indicator2
CF5	GPIO10	Pull-Down	Available-GPIO	Leave Open	Band indicator3

Refer to the Digital IO Characteristics section for electrical characteristics of these signals.

6.8.1. AT Port Switch

The AirPrime AR7550 supports switching the active AT command port between USB and UART.

Table 46. AT Port Switch States

Pad	Name	State	AT Port
AB5	AT_PORT_SW	Low (default)	Available on USB
		High	Available on UART1

6.9. Secure Digital IO

The AirPrime AR7550 defines a 1.8V SDIO interface for future use.

Table 47. SDIO Interface Pads

Pad	Name	Direction	Function	If Unused
AA11	SDIO_DATA0	Input/Output	SDIO Data bit 0	Leave Open
AA10	SDIO_DATA1	Input/Output	SDIO Data bit 1	Leave Open
AB9	SDIO_DATA2	Input/Output	SDIO Data bit 2	Leave Open
AB10	SDIO_DATA3	Input/Output	SDIO Data bit 3	Leave Open
AB8	SDIO_CMD	Output	SDIO Command	Leave Open
AA9	SDIO_CLK	Output	SDIO Clock	Leave Open

6.10. I2C

The AirPrime AR7550 provides an I2C interface.

Table 48. I2C Interface Pads

Pad	Name	Direction	Function	If Unused
CD6	I2C_CLK	Output	I2C Clock output	Leave Open
CC6	I2C_SDA	Input/Output	I2C Data	Leave Open

The I2C signals are open drain outputs with 2.2 kΩ pull-up resistors to VCC_1V8 internal to the AirPrime AR7550.

6.11. Voltage Reference

The AirPrime AR7550 utilizes 1.8V logic. A voltage reference output for this rail is provided below.

Table 49. Voltage Reference Pad

Pad	Name	Direction	Function	If Unused
AA12	VCC_1V8	Output	Voltage Reference Output	Leave Open
AB12	VCC_1V8	Output	Voltage Reference Output	Leave Open

Table 50. Voltage Reference Characteristics

Parameter		Min	Typ	Max	Units
VCC_1V8	Voltage Level	1.746	1.8	1.854	V
	Output Current			25	mA

The VCC_1V8 signal can be used to power external circuitry and/or detect the power state of the AirPrime AR7550 device.

Using VCC_1V8 to determine the power state is recommended when the user application wants to disable VBATT. VBATT should not be disabled before VCC_1V8 goes inactive. To be able to detect the power state on VCC_1V8, all logic input signals to the AirPrime AR7550device must be set low (see Digital IO Characteristics for affected signal groups).

The VCC_1V8 signal is High-Z when the AirPrime AR7550 embedded module is powered down.

6.12. RESET

The AirPrime AR7550 provides an interface to allow an external application to RESET the module as well as an output to indicate the current RESET state or control an external device.

Table 51. Reset Interface Pads

Pad	Name	Direction	Function	If Unused
AH2	RESIN_N	Input	External Reset Input	Leave Open
AG4	RESOUT_N	Output	Reset Output	Leave Open

The RESIN_N signal is pulled-up internal to the AirPrime AR7550. An open collector transistor or equivalent should be used to Ground the signal when necessary to RESET the module.

Note: Use of the RESIN_N signal to RESET the AirPrime AR7550 could result in memory corruption if used inappropriately. This signal should only be used if the AirPrime AR7550 has become unresponsive and it is not possible to perform a power cycle.

Table 52. Reset Timing

Symbol	Parameter	Min	Typ	Max
Trdet	Duration of RESIN_N signal before firmware detects it (debounce timer)	-	32 ms	-
Trlen	Duration reset asserted	40 ms	-	∞
Trdel	Delay between minimum Reset duration and Internal Reset generated	-	500 ms	-

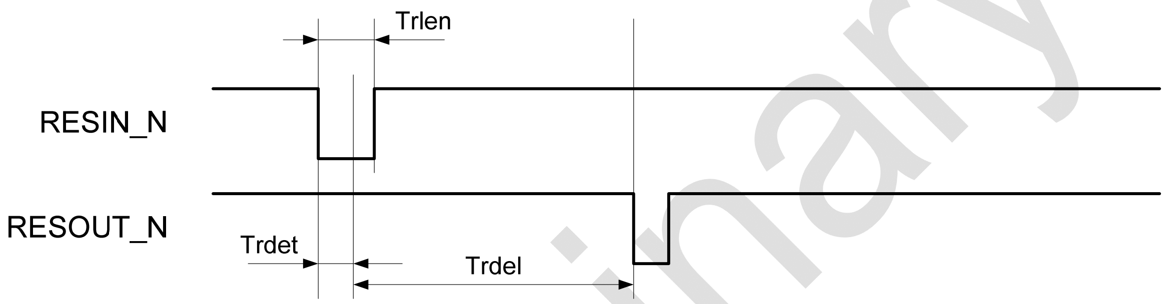


Figure 14. Illustration of Reset Timing When RESIN_N < Trdel

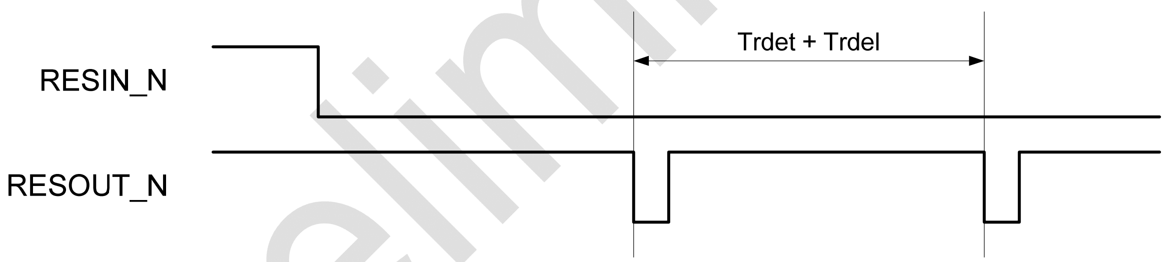


Figure 15. Illustration of Reset Timing When RESIN_N Held Low > Trdet+Trdel

6.13. ADC

The AirPrime AR7550 provides two ADC inputs. The interface information is provided in the tables below.

Table 53. ADC Interface Pads

Pad	Name	Direction	Function	If Unused
DE3	ADC0	Input	Analog to Digital Converter Input	Leave Open or Ground
DF2	ADC1	Input	Analog to Digital Converter Input	Leave Open or Ground

Table 54. ADC Interface Characteristics

ADC		Value	Units
ADCx	Full-Scale Voltage Level	1.8	V
	Resolution	15	bit
	Input Impedance	>4	MΩ

6.14. LED

The AirPrime AR7550 provides an LED control output signal pad. This signal is an open drain input.

Table 55. LED Interface Pad

Pad	Name	Direction	Function	If Unused
AA6	LED	Output	LED driver control	Leave Open

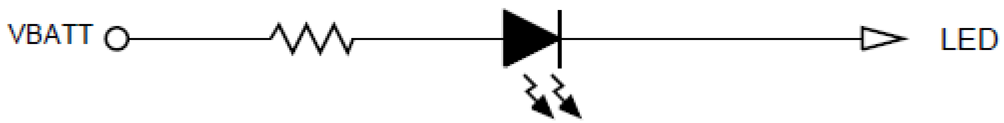


Figure 16. LED Reference Circuit

The behavior of the LED signal can be modified using the AT command AT!LEDCTRL.

6.15. Audio

The AirPrime AR7550 supports both Analog and Digital audio interfaces. The following diagram illustrates the Audio subsystem and identifies where various AT commands affect the audio subsystem. Refer to [7] for details of the AT commands.

[Diagram tbd]

Figure 17. Audio Block Diagram

6.15.1. Analog Audio

The AirPrime AR7550 provides a mono differential analog audio interface.

Table 56. Analog Audio Interface Pads

Pad	Name	Direction	Function	Interface
CD9	AUDIO1_IN_P	Input	Microphone 1 input positive	Primary
CC10	AUDIO1_IN_M		Microphone 1 input negative	
CE6	AUDIO1_OUT_P	Output	Speaker 1 output positive	
CE8	AUDIO1_OUT_M		Speaker 1 output negative	

Table 57. Analog Audio Interface Characteristics

Analog Audio		Min.	Typ.	Max.	Units
Audio IN	Input Impedance	16	20	24	kΩ
	Signal Level – Differential	-0.3	-	2.9	dBV
	Signal Level – Single-ended (the unused audio signal must be tied to GND or analog reference)	-0.3	-	2.9	dBV
Audio OUT	Signal Level – Differential	-	-		dBV
	Signal Level – Single-ended	-0.3	-	2.9	dBV
	Output Impedance	-0.3	-	2.9	Ω
	Signal Drive Strength – Application Load	-	600	1M	kΩ

6.15.2. Digital Audio

The AirPrime AR7550 provides a 4-wire digital audio interface. This interface can be configured as either a PCM or an I2S.

Table 58. Digital Audio Interface Pads

Pad	Name	Direction[1]	PCM Function	Direction	I2S Function	If Unused
DB3	PCM_FS	Output	PCM Frame Sync	Input/Output	I2S_WS	Leave Open
DA3	PCM_CLK	Output	PCM Clock	Input/Output	I2S_SCLK	Leave Open
DC2	PCM_DOUT	Output	PCM Data Out	Output	I2S_DOUT	Leave Open
DD2	PCM_DIN	Input	PCM Data In	Input	I2S_DIN	Leave Open

1 Direction when defined in Master mode.

6.15.2.1. PCM

The AirPrime AR7550 PCM interface can be configured in one of two modes: primary PCM or auxiliary PCM mode. The table below defines the configurations for each of these two modes.

Table 59. PCM Interface Configurations

Element	Primary PCM	Auxiliary PCM
Slot Configuration	Slot-based	Single
Sync type	Short	Long
Frequency		8 kHz
Duty Cycle		50%
Clock (Master)	2.048 MHz	128 kHz
Data formats	16-bit linear, 8-bit A-law, 8-bit m-law	
AirPrime AR7550 Master/Slave	Master or Slave	Master

6.15.2.1.1. PCM Data format

The PCM data is 8 kHz and 16 bits with the following PDM bit format:

- PCM_DIN – SDDD DDDD DDDD DDVV
- PCM_DOUT – SDDD DDDD DDDD DDVV

Where:

- S – Signed bit
- D – Data
- V – Volume padding

6.15.2.1.2. Primary PCM Timing

The table and drawings below illustrate the PCM signals timing when the AirPrime AR7550 module is operating in Primary PCM mode.

Table 60. Primary PCM Timing

Parameter	Description	Min	Typ	Max	unit
T(sync)	PCM_FS cycle time	-	125	-	µs
T(synch)	PCM_FS high time	-	488	-	ns
T(syncl)	PCM_FS low time	-	124.5	-	µs
T(clk)	PCM_CLK cycle time	-	488	-	ns
T(clkh)	PCM_CLK high time	-	244	-	ns
T(clkl)	PCM_CLK low time	-	244	-	ns
T(susync)	PCM_FS setup time high before falling edge of PCM_CLK	-	122	-	ns
T(hsync)	PCM_FS Hold time after falling edge of PCM_CLK	-	-	366	ns
T(sudin)	PCM_DIN setup time before falling edge of PCM_CLK	60	-	-	ns
T(hdin)	PCM_DIN hold time after falling edge of PCM_CLK	60	-	-	ns
T(pdout)	Delay from PCM_CLK rising to PCM_DOUT valid	-	-	60	ns
T(zdout)	Delay from PCM_CLK falling to PCM_DOUT HIGH-Z	-	-	60	ns

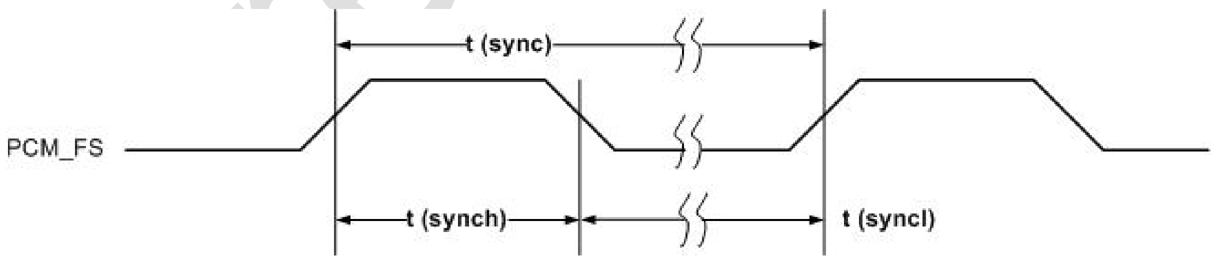


Figure 18. PCM_FS Timing Diagram (2048 kHz Clock)

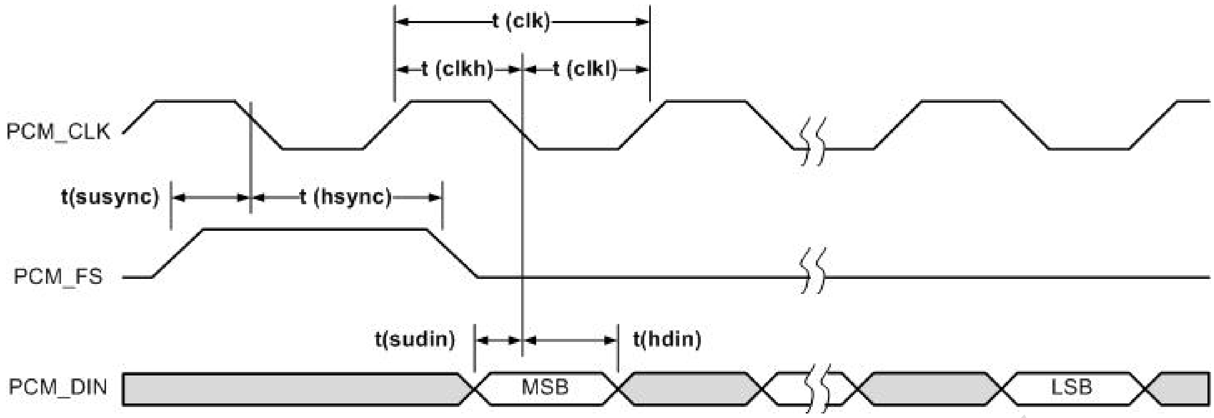


Figure 19. PCM Codec to AR Device Timing Diagram (Primary PCM)

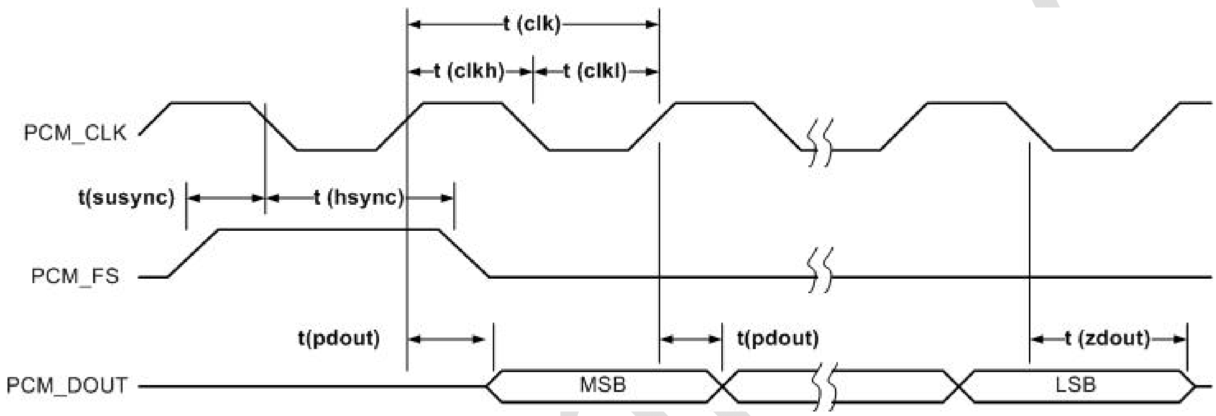


Figure 20. AR Device to PCM Codec Timing Diagram (Primary PCM)

6.15.2.1.3. Auxiliary PCM Timing

The table and drawings below illustrate the timing of the PCM signals when the AirPrime AR7550 module is operating in Auxiliary PCM mode.

Table 61. Auxiliary PCM Timing

Parameter	Description	Min	Typ	Max	unit
T(auxsync)	PCM_FS cycle time	-	125	-	µs
T(auxsynch)	PCM_FS high time	62.4	62.5	-	µs
T(auxsyncl)	PCM_FS low time	62.4	62.5	-	µs
T(auxclk)	PCM_CLK cycle time	-	7.8	-	µs
T(auxclkh)	PCM_CLK high time	3.8	3.9	-	µs
T(auxclkl)	PCM_CLK low time	3.8	3.9	-	µs
T(suauxsync)	PCM_FS setup time high before falling edge of PCM_CLK	1.95	-	-	ns
T(hauxsync)	PCM_FS Hold time after falling edge of PCM_CLK	1.95	-	-	ns
T(sudin)	PCM_DIN setup time before falling edge of PCM_CLK	70	-	-	ns
T(hauxdin)	PCM_DIN hold time after falling edge of PCM_CLK	20	-	-	ns
T(pauxdout)	Delay from PCM_CLK rising to PCM_DOUT valid	-	-	50	ns

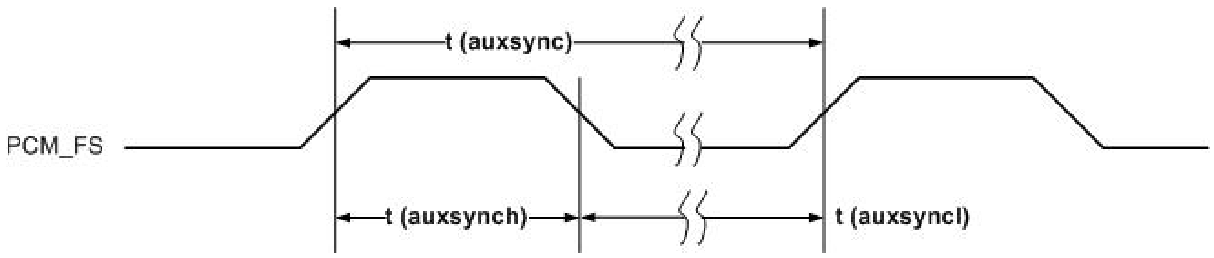


Figure 21. PCM_FS Timing Diagram (128 kHz Clock)

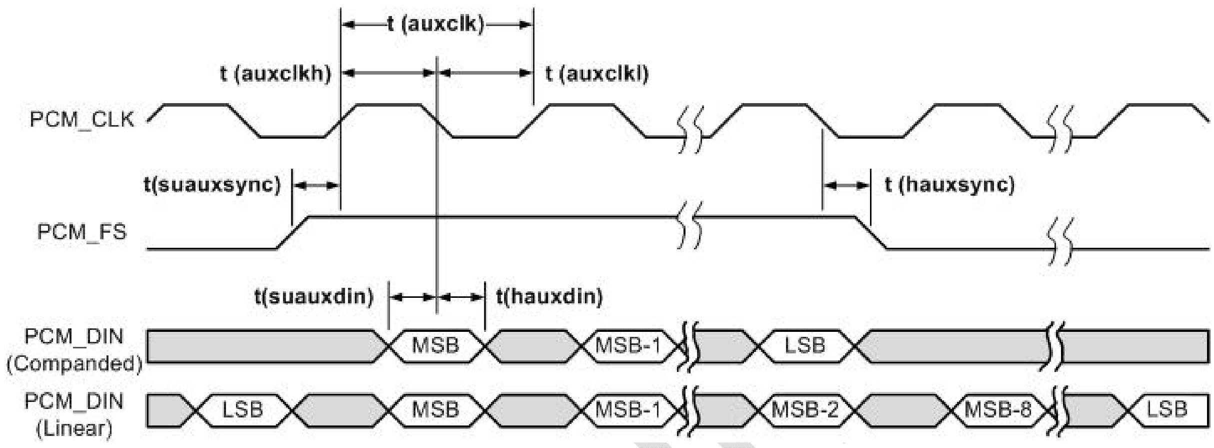


Figure 22. PCM Codec to AR Device Timing Diagram (Auxiliary PCM)

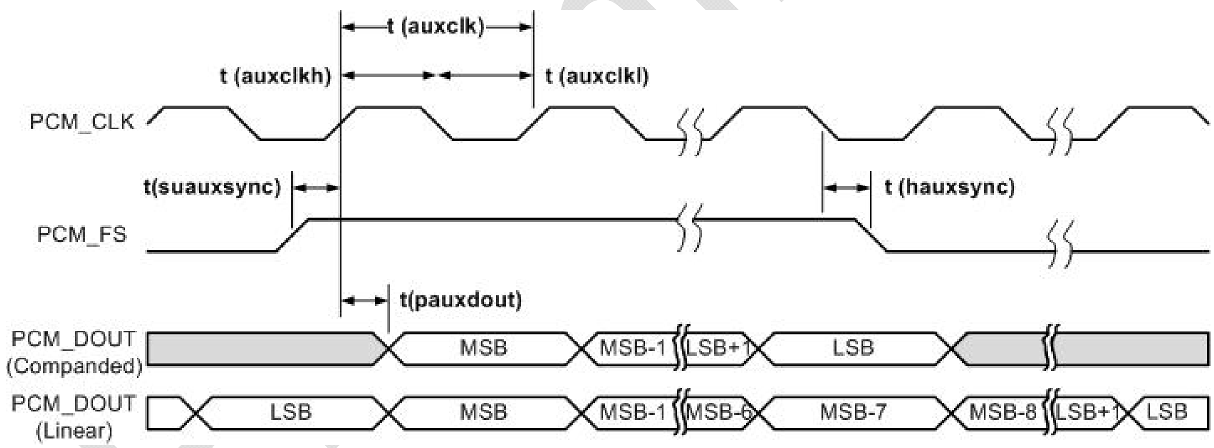


Figure 23. AR Device to PCM Codec Timing Diagram (Auxiliary PCM)

6.15.2.2. I2S

The AirPrime AR7550 I2S interface can be used to transfer serial digital audio to/from an external stereo DAC/ADC. The I2S interface is a 4-wire interface: serial clock (I2S_SCLK), word select (I2S_WS), serial uplink data (I2S_DIN), and serial downlink data (I2S_DOUT).

The AirPrime AR7550 I2S interface can be configured as a master or slave and either transmitter or receiver.

A high-level timing diagram of the I2S signals is presented below.

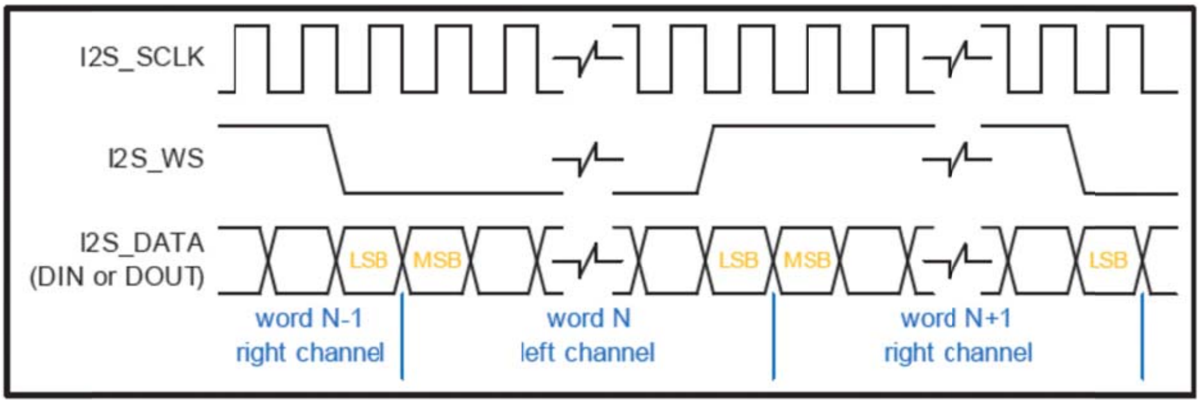


Figure 24. I2S Signals Timing Diagram

6.15.2.2.1. I2S_DIN and I2S_DOUT

The serial PCM stereo-data stream for both channels are output from the AirPrime AR7550 on the I2S_DOUT signal pin and input on the I2S_DIN signal pin. Serial data is transmitted in two's complement, with the MSB first. The transmitter and receiver are not required to have the same word length:

- When the transmitted word length is greater than the receiver word length, the bits after the receiver's LSB are ignored; the rest of the transmitter's LSBs are ignored.
- When the transmitted word length is less than the receiver word length, the receiver's missing LSB will be set to zero initially, so they will remain at zero.
- The MSB has a fixed position, whereas the LSB position depends upon word length.
- The transmitter always sends the MSB of the next word one clock period after WS changes.
- Serial data sent by the transmitter may be synchronized with either the trailing (H-to-L) or leading (L-to-H) edge of the clock signal.
- Serial data must be latched into the receiver on the leading edge of the serial clock signal.

6.15.2.2.2. I2S_WS

The word-select line indicates the channel being transmitted / received:

- 0 specifies the left channel
- 1 specifies the right channel
- The WS signal changes one clock period before the MSB is transmitted.

6.15.2.2.3. I2S_SCLK

This is the serial bit clock whose rate is a function of the data width and sample rate:

```
I2S_SCLK rate = (2 x bit_width) x FS
```

Where bit_width = 16 bits per channel and FS is the sample rate, therefore:

```
I2S_SCLK rate = 32 x FS
```

Sample rates of 8, 16, 24, 32, 44.1, and 48 kHz are supported. An example clock rate is:

```
I2S_SCLK rate = (2 x 16) x 48 kHz = 1.536 MHz
```

Where bit_width = 16 and FS = 48 kHz.

6.16. SPI Bus

The AirPrime AR7550 embedded module provides one SPI bus (4-wire interface).

SPI bus interface includes:

- A CLK signal
- An O signal
- An I signal
- A CS (Chip Select) signal

6.16.1. Characteristics

The following features are available on the SPI bus:

- Master-only mode operation
- SPI speed is from 128 kbit/s to 26 Mbit/s in master mode operation
- 4-wire interface
- 4 to 32 (TBD) bits data length.

6.16.2. SPI Configuration

Table 62. SPI Configuration

Operation	Maximum Speed	SPI-Mode	Duplex	4-wire Type
Master	26Mb/s	0,1,2,3	full	SPIx-CLK; SPIx-IO; SPIx-I; SPIx_CS

For the 4-wire configuration, SPIx-I/O is used as output only, SPIx-I is used as input only (TBC by firmware).

6.16.3. SPI Waveforms

The following figure shows waveforms for SPI transfer with 4-wire configuration.

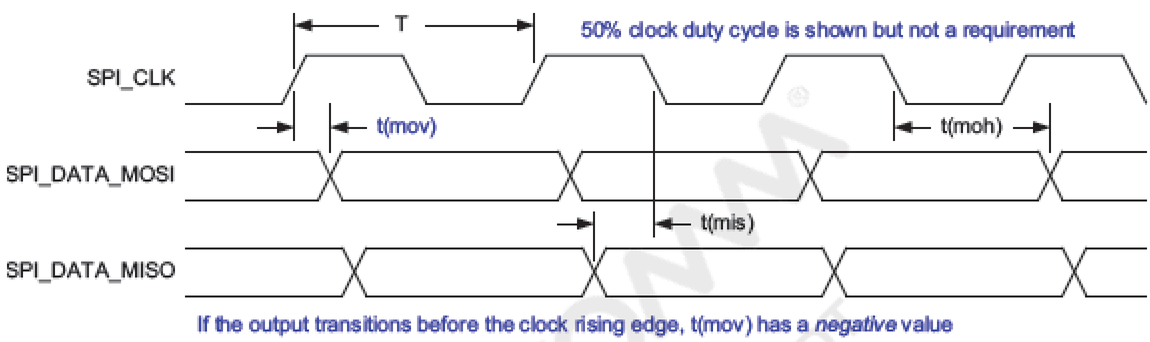


Figure 25. 4-Wire Configuration SPI Transfer

Table 63. SPI Master Timing Characteristics

Parameter		Min	Typ	Max	Unit
SPI clock frequency		–	–	26	MHz
T	SPI clock period	38	–	–	ns
t(ch)	Clock high	17	–	–	ns
t(cl)	Clock low	17	–	–	ns
t(mov)	Master output valid	-5	–	5	ns
t(mis)	Master input setup	0	–	3	ns
t(moh)	Master output hold	0	–	3	ns
t(tse)	Tri-state enable	-5	–	5	ns
t(tsd)	Tri-state disable	-5	–	5	ns

6.16.4. SPI Pin Description

Refer to the following table for the SPI interface pin description.

Table 64. SPI Pin Description

Signal	Pin #	I/O	I/O Type	Reset State	Description
SPI-CLK	CE4	O	1V8	Z	SPI Serial Clock
SPI-MISO	CE3	I	1V8	Z	SPI Serial input
SPI-MOSI	CD4	O	1V8	Z	SPI Serial output
SPI_CS	CD5	O	1V8	Z	SPI Chip Select

6.16.5. Application

A 4-wire SPI configuration has the input and output data lines disassociated.

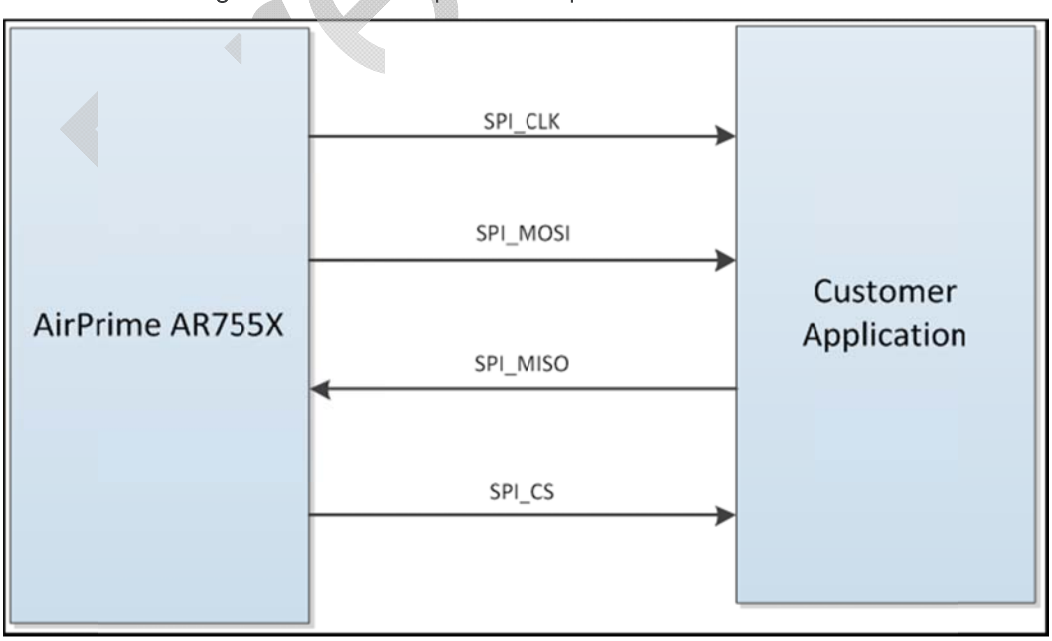


Figure 26. Example of 4-wire SPI Bus Application

6.17. HSIC Bus

The AirPrime AR7550 embedded module provides one HSIC bus (2-wire interface).

HSIC bus interface includes:

- HSIC strobe signal
- HSIC data signal
- Calibration pad for HSIC port signal

6.17.1. HSIC Pin Description

Refer to the following table for the HSIC interface pin description.

Table 65. HSIC Pin Description

Signal	Pin #	I/O	I/O Type	Reset State	Description
HSIC_STB	AA2	B	1V2	Z	HSIC strobe signal
HSIC_DATA	AA3	B	1V2	Z	HSIC data
HSIC_CAL	AA4	B	1V2	Z	HSIC calibration pad

6.17.2. HSIC Waveforms

The following figure shows waveforms for HSIC signal sample.

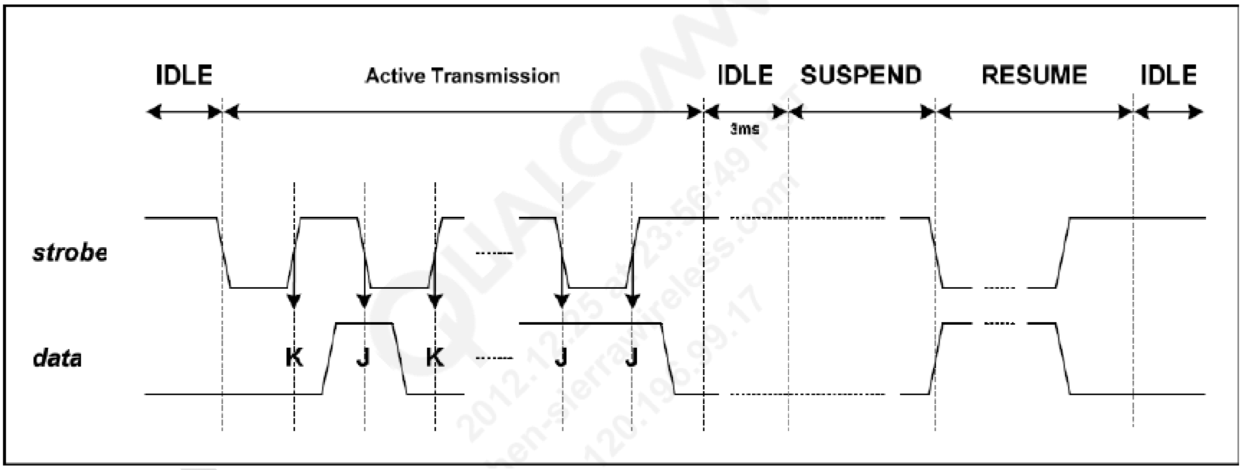


Figure 27. HSIC Signal Sample Waveforms

6.17.3. Application

A 4-wire SPI configuration has the input and output data lines disassociated.

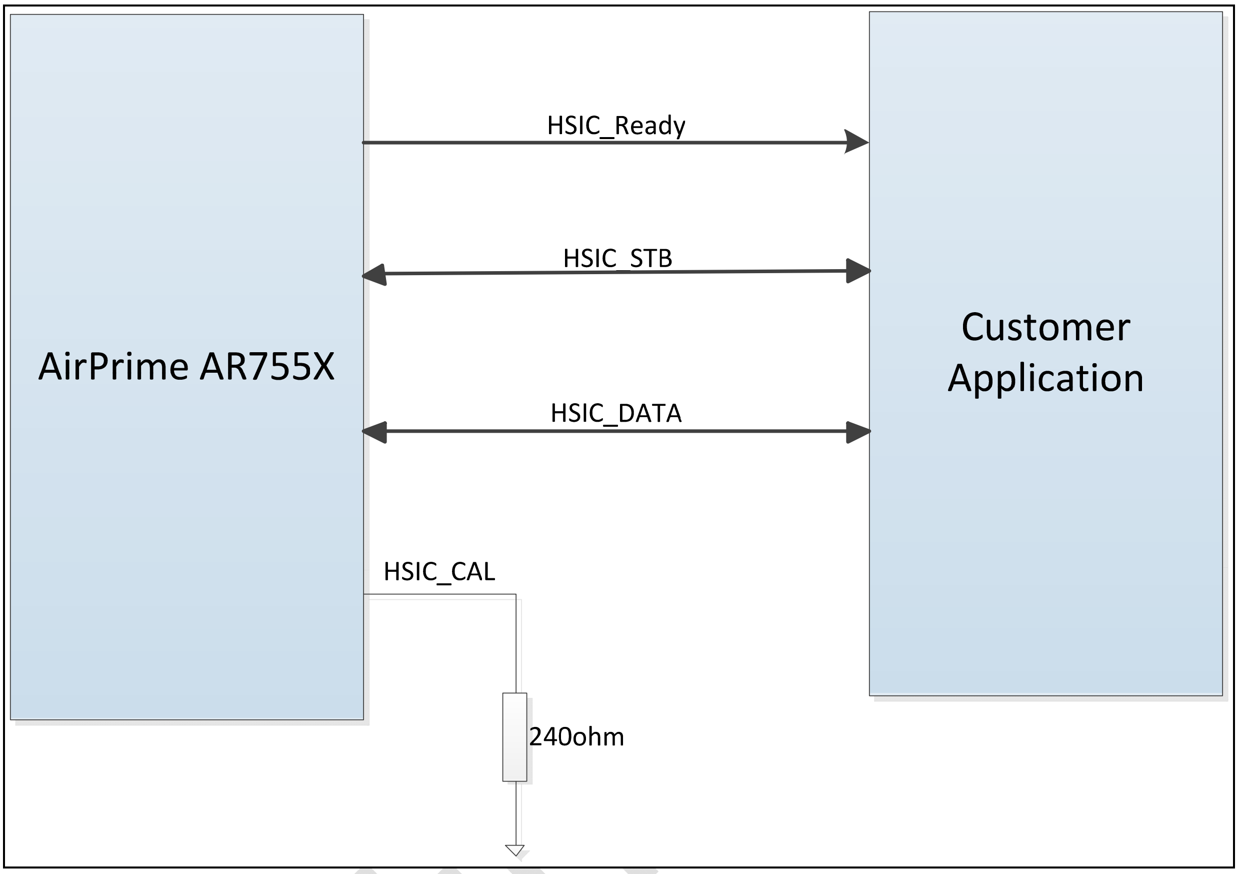


Figure 28. Example of HSIC Bus Application

Note 1: Trace length to 10cm maximum

2: Skew between data and strobe signals < 15ps, and

3: Connect HSIC_Ready to HSIC_RST_N of the HSIC device.

6.18. Temperature Monitoring

The AirPrime AR7550 has internal temperature monitoring of both the PMIC device and the Power Amplifier devices.

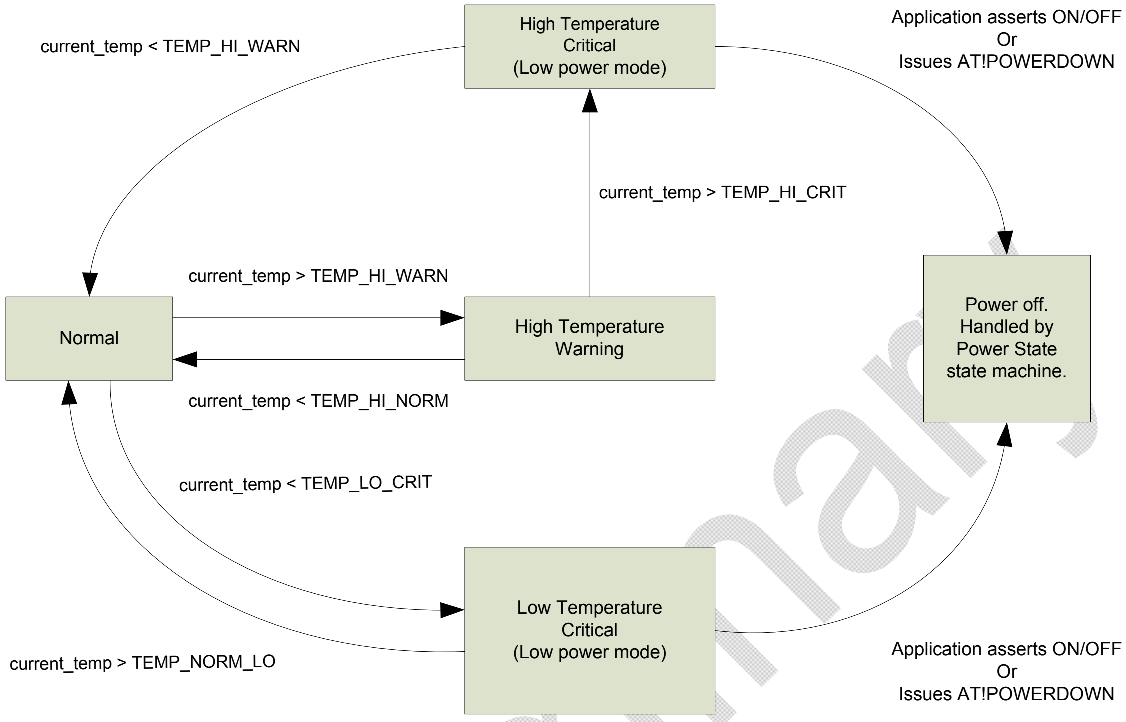


Figure 29. Temperature Monitoring State Machine

Table 66. Temperature Monitoring States

State	Description	Threshold[1]	Default Temp value (°C)	Functionality
Normal	Both PMIC and PA Thermistors are between	TEMP_HI_NORM	+85	All
		TEMP_LO_NORM	-40	
High Temperature Warning	Either PMIC or PA Thermistor has exceeded	TEMP_HI_WARN	+95	All – Warning message output on AT Command port
High Temperature Critical	Either PMIC or PA Thermistor has exceeded	TEMP_HI_CRIT	140	Low Power Mode – Device will only make Emergency calls
Low Temperature Critical	Either PMIC or PA Thermistor has descended past	TEMP_HI_CRIT	-45	Low Power Mode – Device will only make Emergency calls

1 There are two sets of thresholds: PATEMP for PA Thermistor, and PCTEMP for PMIC Thermistor.

To restore full operation, temperature readings for both the PA and PMIC Thermistors must be within the Normal or High Temperature Warning state thresholds.

7. Routing Constraints and Recommendations

Layout and routing of the AirPrime AR7550 device 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 AR7550 device and achieve optimal system performance.

7.1. 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).

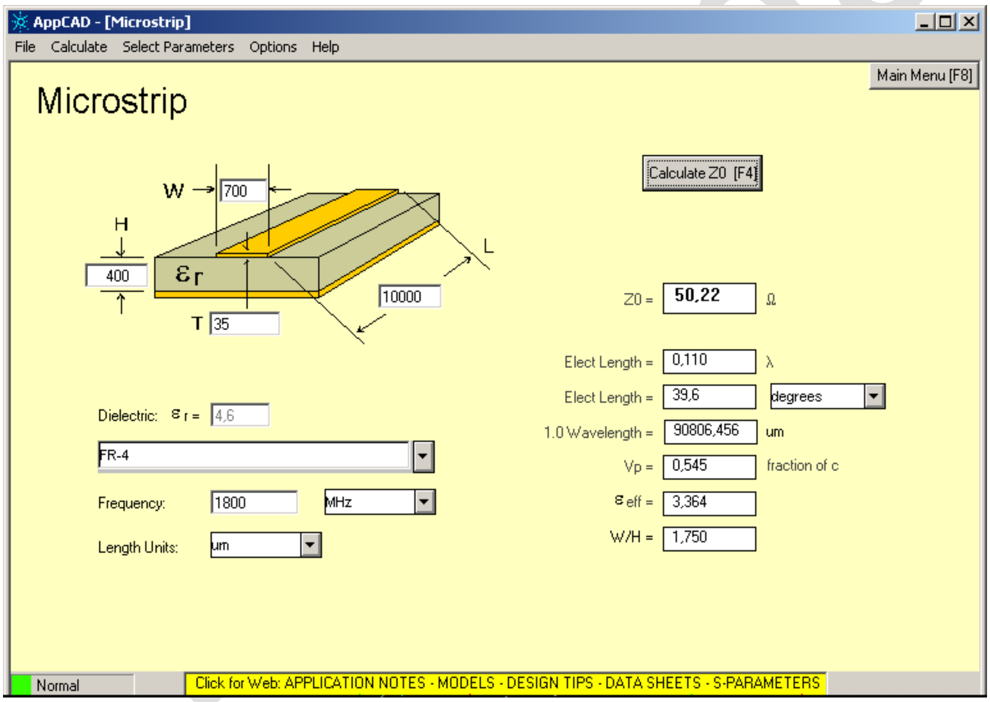


Figure 30. AppCAD Screenshot for Microstrip Design Power Mode Diagram

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.*

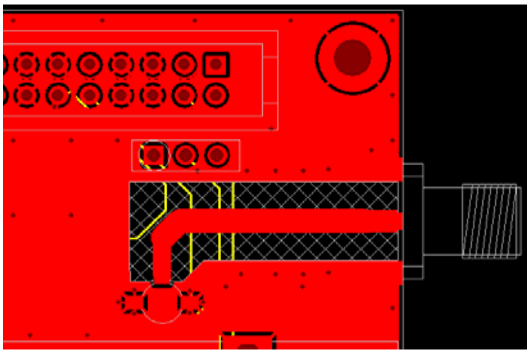
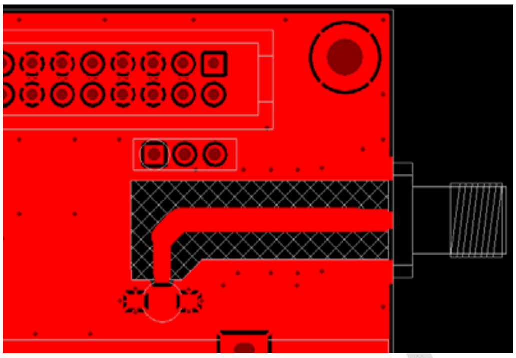
Poor routing	Correct routing
	
The yellow traces cross the RF trace.	There is no signal around the RF path.

Figure 31. 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.

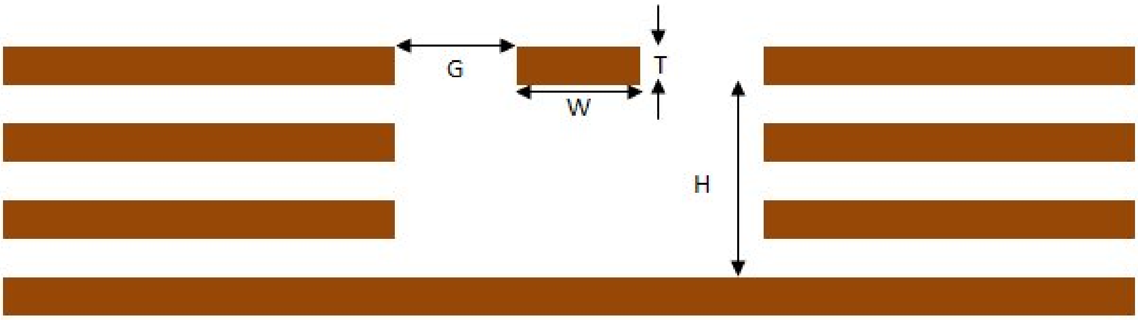


Figure 32. Coplanar Clearance Example

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

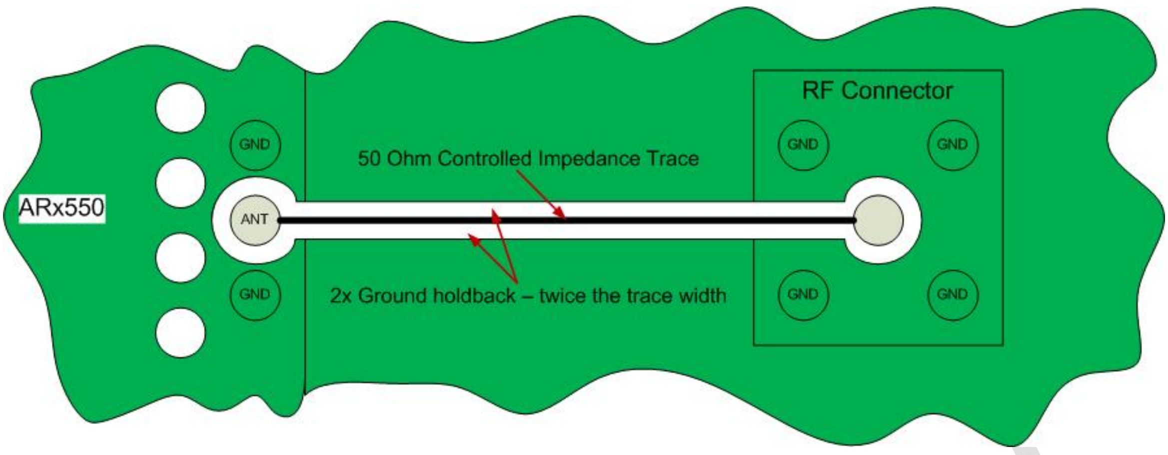


Figure 33. Antenna Microstrip Routing Example

7.2. Power and Ground Recommendations

Power and ground routing is critical to achieving optimal performance of the AirPrime AR7550 devices when integrated into an application.

Recommendations:

- Do not use a separate GND for the Antennas
- Connections to GND from the AirPrime AR7550 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 4V supply to the LGA pad.

7.3. Antenna Recommendations

The AirPrime AR7550 devices are designed to provide diagnostics status of the antennas connected to it.

- The Primary antenna interface is optimized for a multiband cellular antenna with a 10 kΩ DC impedance between the antenna element and the ground reference.
- The GNSS antenna interface is optimized for a 5V active GNSS antenna supporting the GPS L1 and GLONASS L1 FDMA bands. Refer to the GNSS Antenna Diagnostics section.

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.

7.4. Interface Circuit Recommendations

The recommended interface implementation is to use open-drain non-inverting buffers with pull-ups to the appropriate voltage reference. This allows a host processor operating at a different voltage to communicate with the AirPrime AR7550 using the appropriate voltage levels.

The figure below is a reference circuit for a digital input signal to the AirPrime AR7550 device.

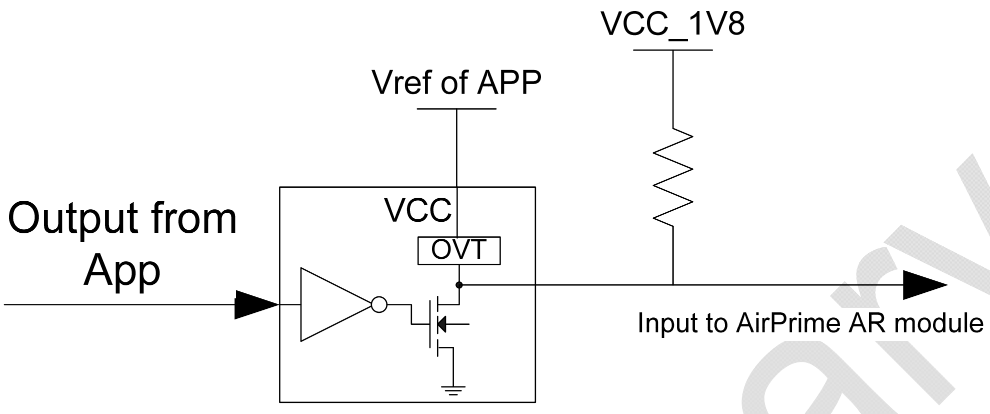


Figure 34. AirPrime AR7550 Input Reference Circuit

The figure below is a reference circuit for a digital output signal from the AirPrime AR7550 device.

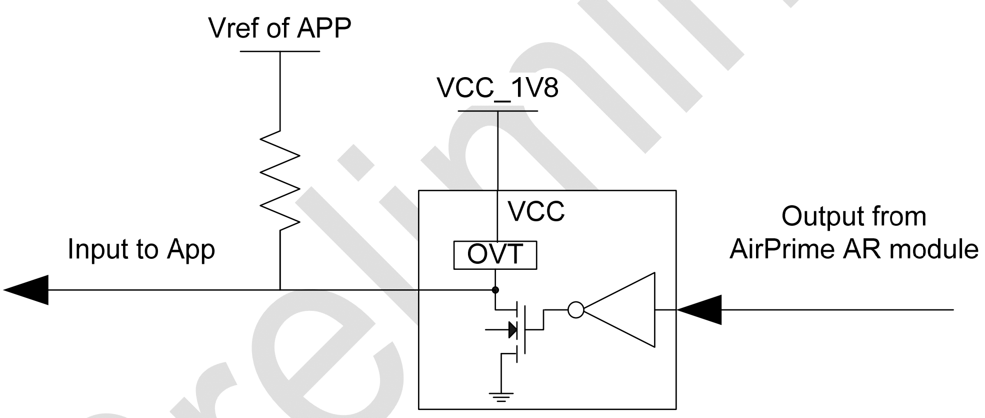


Figure 35. AirPrime AR7550 Output Reference Circuit

Refer to Chapter Error! Reference source not found. **Error! Reference source not found.** section to identify the appropriate reference voltage and direction of the specific signals.

The open-drain non-inverting buffer used in the reference circuits above is the OnSemi NL17SZ07.

Tip: *The NL17SZ07 is over-voltage tolerant on the inputs. It may be possible to power all the buffers from the 1.8V reference voltage output. Review the digital output characteristics of the applications drivers and the Input characteristics of the buffer selected to determine if this would work in your application.*

If a Digital IO signal is used bidirectional in the application then a bidirectional buffer or bidirectional level translator is needed.

8. Regulatory Information

8.1. 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.

Safety and Hazards

Do not operate the AR7550 modem:

- 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 AR Series device **MUST BE POWERED OFF**. Otherwise, the AR Series device can transmit signals that could interfere with this equipment
- In an aircraft, the AR Series device **MUST BE POWERED OFF.** Otherwise, the AR Series 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 AR Series device may be used normally at this time.

8.2. Important Compliance Information for USA OEM Integrators

The AR Series device is granted with a modular approval for mobile applications. Integrators may use the AR Series 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:

    - 6.5 dBi in Cellular band
    - 3 dBi in PCS band
    - 6.0 dBi in LTE Band 4
    - 9.0 dBi in LTE Band 7
    - 9.0 dBi in LTE Band 13 (Note: LTE Band 13 is not permitted in Canada.)

3. The AR7550 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 configurations stipulated in the following table.

Device	Technology	Band	Frequency (MHz)	Maximum conducted power	Maximum antenna gain
AR7550 Module	LTE	4	1710-1755	24	6
		7	2500 – 2570	24	9
		13	777-787	24	6
	UMTS	2	1850-1910	24	3
		5	824-849	24	3
	CDMA	BC0	824-849	25	3
		BC1	1850-1910	25	3
Collocated transmitters[1]	WLAN		2400-2500	29	5
			5150-580	29	5
	WiMAX		2300-2400	29	5
			2500-2700	29	5
			3300-3800	29	5
	BT		2400-2500	15	5

1. 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 AR7550 device is incorporated, with a statement similar to the following:

    a.
    This device contains FCC ID: N7NAR7550
    This equipment contains equipment certified under IC: 2417C-AR7550

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 AR7550 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.*

9. References

The table below lists the reference specifications for this product.

Table 67. Reference Specifications

Ref	Title	Issuer
[1]	Recommended Minimum Performance Standards for cdma2000 High Rate Packet Data Access Terminal – C.S0033	3GPP2
[2]	Recommended Minimum Performance Standards for cdma2000 Spread Spectrum Mobile Stations – C.S0011 (IS-98D)	3GPP2
[3]	Universal Serial Bus Specification	USB Implementers Forum
[4]	Universal Serial Bus CDC Subclass Specification for Wireless Mobile Communication Devices	USB Implementers Forum
[5]	Universal Serial Bus Class Definitions for Communication Devices	USB Implementers Forum
[6]	AirPrime AR Series Customer Process Guidelines	Sierra Wireless
[7]	AirPrime AR7 Series AT Command Interface Specification	Sierra Wireless
[8]	AirPrime AR7 Series Firmware Download Guide	Sierra Wireless

10. Abbreviations

The table below lists several abbreviations used in this document.

Table 68. Abbreviations

Abbreviation	Description
CDMA	Code Division Multiple Access
DRX	Discontinuous Receive
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile Communications
HSPA	High Speed Packet Access
LTE	Long Term Evolution
SCI	Slot Cycle Index
USB	Universal Serial Bus
WCDMA	Wideband Code Division Multiple Access
WWAN	Wireless Wide Area Network