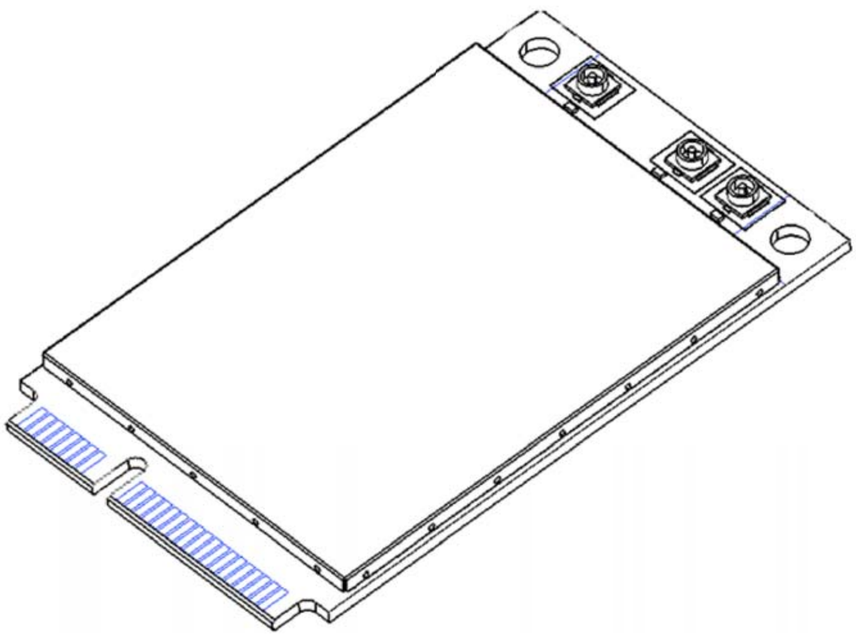
AirPrime MC7475

Product Technical Specification



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Revision History

Revision number	Release date	Changes
1	June 2017	Initial release
2	June 2017	Updated Miscellaneous DC Power Consumption table: • Updated notes, corrected module number typo
3	August 2017	Updated Regulatory section (antenna gain, EIRP limit, FCC ID)

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1: Introduction

The Sierra Wireless MC7475 PCI Express Mini Card is a compact, lightweight, wireless modem that provides LTE and GPS connectivity for M2M applications, notebook, ultrabook and tablet computers over several radio frequency bands.

Supported RF Bands

The modem, based on the Altair FourGee6300 baseband processor, supports data operation on LTE networks over the bands described in Table 1-1.

Table 1-1: Supported RF Bands

Technology	Bands	Notes
LTE	2, 4, 12, 125	Data rates: • Downlink (Cat 4): FDD: 150 Mbps • Uplink (Cat 4): FDD: 50 Mbps
GPS	1575.42 MHz	

Physical Features

- Small form factor—conforms to type F2 as specified in *PCI Express Mini Card Electromechanical Specification Revision 1.2*.
- Ambient operating temperature range:
  - Class A (3GPP compliant): -20°C to +70°C
  - Class B (operational, non-3GPP compliant): -30°C to +85°C (reduced operating parameters required)

Important: *The internal module temperature must be kept below 90°C. For best performance, the internal module temperature should be kept below 80°C. Proper mounting, heat sinks, and active cooling may be required, depending on the integrated application.*

Application Interface Features

- USB interface
- AT command interface
- Support for active antenna control via dedicated antenna control signals (ANT_CTRL0:3)
- Dynamic power reduction support via software and dedicated signal (DPR)

Modem Features

- Traditional modem COM port support for AT commands
- USB suspend / resume
- Sleep mode for minimum idle power draw
- Enhanced Operator Name String (EONS)
- Mobile-originated PDP context activation / deactivation
- Static and Dynamic IP address. The network may assign a fixed IP address or dynamically assign one using DHCP (Dynamic Host Configuration Protocol).
- PAP and CHAP support
- PDP context type (IPv4, IPv6, or IPv4v6). IP Packet Data Protocol context supports dual IPv4v6.

LTE Features

- CQI/RI/PMI reporting
- Paging procedures
  - Paging in Idle and Connected mode
- Dedicated bearer
  - Network-initiated dedicated bearer
  - UE-initiated dedicated bearer
- Multiple PDN connections (IPv4 and IPv6 combinations), subject to operating system support.
- Connected mode intra-LTE mobility
- Idle mode intra-LTE mobility
- Detach procedure
  - Network-initiated detach with reattach required
  - Network-initiated detach followed by connection release

Position Location (GPS)

- Customizable tracking session
- Automatic tracking session on startup

Supporting Documents

Several additional documents describe Mini Card design, usage, integration, and other features. See References on page 51.

Required Connectors

Table 1-2 describes the connectors used to integrate AirPrime MC-series modules into your host device.

Table 1-2: Required Host-Module Connectors[a]

Connector type	Description
RF cables	• Mate with Hirose U.FL connectors (model U.FL #CL331-0471-0-10) • Three connector jacks
EDGE (52-pin)	• Industry-standard mating connector • Some manufacturers include Tyco, Foxconn, Molex • Example: UDK board uses Molex 67910-0001
SIM	• Industry-standard connector. Type depends on how host device exposes the SIM socket • Example: UDK board uses ITT CCM03-3518

a. Manufacturers/part numbers are for reference only and are subject to change. Choose connectors that are appropriate for your own design.

Ordering Information

To order, contact the Sierra Wireless Sales Desk at +1 (604) 232-1488 between 8 AM and 5 PM Pacific Time.

Integration Requirements

Sierra Wireless provides, in the document suite, guidelines for successful Mini Card integration and offers integration support services as necessary.

When integrating the MC7475 PCI-Express Mini Card, the following items need to be addressed:

- Mounting—Effect on temperature, shock, and vibration performance
- Power supply—Impact on battery drain and possible RF interference
- Antenna location and type—Impact on RF performance
- Regulatory approvals—As discussed in Regulatory Compliance and Industry Certifications on page 40.
- Service provisioning—Manufacturing process
- Host Interface—Compliance with interface voltage levels

2: Standards Compliance

The MC7475 Mini Card complies with the mandatory requirements described in the following standards. The exact set of requirements supported is network operator-dependent.

Table 2-1: Standards Compliance

Technology	Standards
LTE	• 3GPP Release 11

3: Electrical Specifications

The system block diagram in Figure 3-1 on page 13 represents the MC7475 module integrated into a host system. The module includes the following interfaces to the host:

- Power—Supplied to the module by the host.
- WAKE_N— Signal used to wake the host when specific events occur.
- WAN_LED_N—Active-low LED drive signal provides an indication of RADIO ON state, either WAN or GPS.
- SYSTEM_RESET_N—Active-low reset input.
- Antenna—Three U.FL RF connectors (main (Rx/Tx), GPS, and auxiliary (Rx diversity). For details, see RF Specifications on page 24.
- Antenna control—Three signals that can be used to control external antenna switches.
- Dual SIM—Supported through the interface connector. The SIM cavities / connectors must be placed on the host device for this feature.
- USB—USB 2.0 interface to the host for data, control, and status information.

The MC7475 has two main interface areas—the host I/O connector and the RF ports. Details of these interfaces are described in the sections that follow.

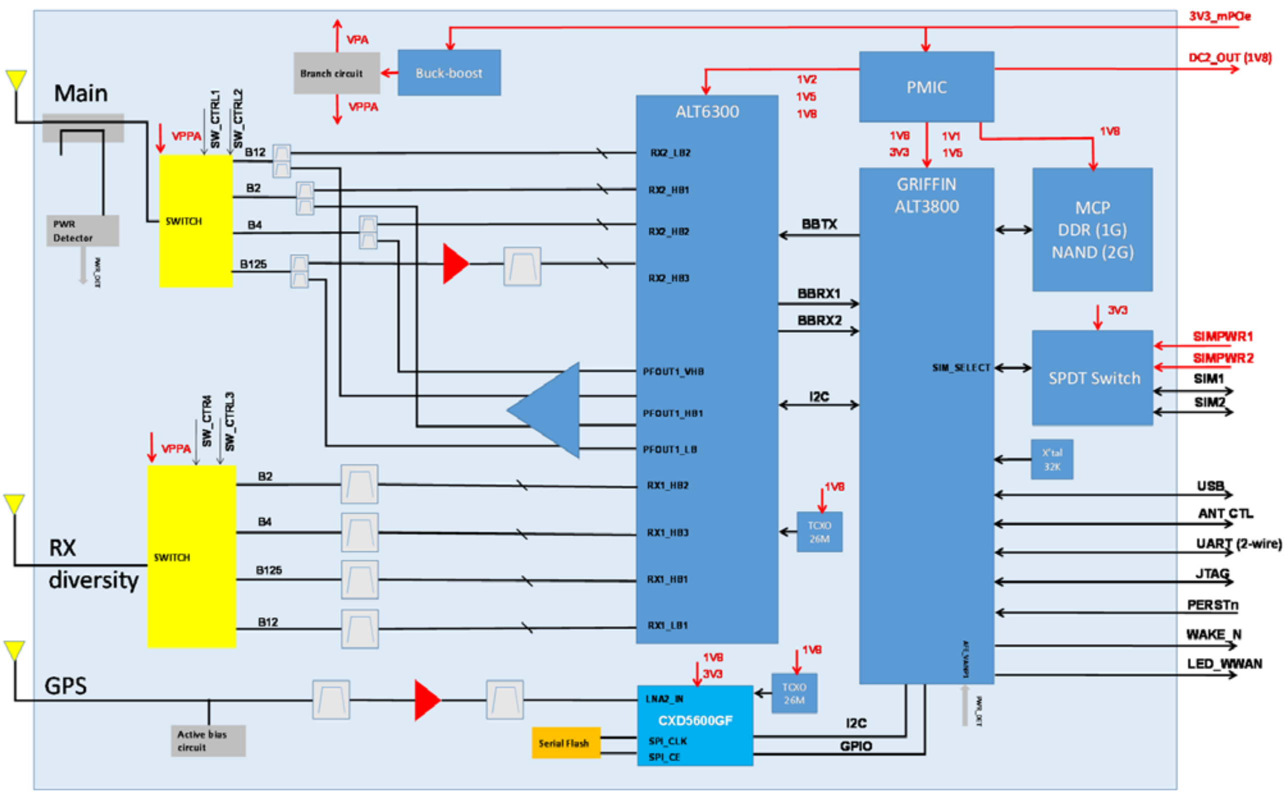

Figure 3-1: System Block Diagram

Host Interface Pin Assignments

The MC7475 host I/O connector provides pins for power, serial communications, and control. Pin assignments are listed in Table 3-1.

Refer to the following tables for pin details based on interface types:

- Table 3-2, Power and Ground Specifications, on page 18
- Table 3-3, USB Interfaces, on page 18
- Table 3-4, SIM Interface Signals, on page 19
- Table 3-5, Module Control Signals, on page 22

Note: On any given interface (USB, SIM, etc.), leave unused inputs and outputs as no-connects.

Note: The host should not drive any signals to the module until the power-on sequence is complete.

Table 3-1: Connector Pin Assignments[a]

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
1	WAKE_N	OC	Wake host	Output	Low	-	-	0.10
2	VCC	V	Power supply	Input	Power	3.135	3.30	3.60
3	ANT_CTRL0 / GPIO1	-	(ANT_CTRL0) Customer-defined external switch control for multiple antennas	Output	High	1.35	1.80	1.90
				Output	Low	0	-	0.8
			(GPIO1) General purpose I/O	Input High		1.53	1.80	2.10
				Input Low		-0.30		0.45
				Output High		1.35	1.80	1.90
				Output Low		0.00		0.8
4	GND	V	Ground	Input	Power	-	0	-
5	ANT_CTRL1 / GPIO2	-	(ANT_CTRL1) Customer-defined external switch control for multiple antennas	Output	High	1.35	1.80	1.90
				Output	Low	0	-	0.8
			(GPIO2) General purpose I/O	Input High		1.53	1.80	2.10
				Input Low		-0.30		0.45
				Output High		1.35	1.80	1.90
				Output Low		0.00		0.8
6	NC	-	No connect	-	-	-	-	-

Table 3-1: Connector Pin Assignments[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
7	USIM2_RST	-	SIM 2 Reset	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	-	3.10 (3V SIM) 1.90 (1.8V SIM)
8	USIM_PWR	-	SIM VCC supply	Output	Power	2.90 (3V SIM) 1.75 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.85 (1.8V SIM)
9	GND	V	Ground	Input	Power	-	0	-
10	USIM_DATA	-	SIM IO pin	Input	Low	-0.30 (3V SIM) -0.30 (1.8V SIM)	-	0.60 (3V SIM) 0.35 (1.8V SIM)
					High	2.10 (3V SIM) 1.17 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.30 (3V SIM) 2.10 (1.8V SIM)
				Output	Low	0	-	0.40
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
11	VREF_1.8V[d]	-	1.8V reference voltage output	Output	Power	1.75	1.80	1.85
12	USIM_CLK	-	SIM Clock	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
13	USIM2_PWR	-	SIM 2 VCC supply	Output	Power	2.90 (3V SIM) 1.75 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.85 (1.8V SIM)
14	USIM_RST	-	SIM Reset	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
15	GND	V	Ground	Input	Power	-	0	-
16	NC	-	No connect	-	-	-	-	-
17	USIM2_CLK	-	SIM 2 Clock	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
18	GND	V	Ground	Input	Power	-	0	-

Table 3-1: Connector Pin Assignments[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
19	USIM2_DATA	-	SIM 2 IO pin	Input	Low	-0.30 (3V SIM) -0.30 (1.8V SIM)	-	0.60 (3V SIM) 0.35 (1.8V SIM)
					High	2.10 (3V SIM) 1.17 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.30 (3V SIM) 2.10 (1.8V SIM)
				Output	Low	0	-	0.40
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
20	NC	-	No connect	-	-	-	-	-
21	GND	V	Ground	Input	Power	-	0	-
22	SYSTEM_RESET_N[e]	OC	Reset	Input	Low	-0.30	-	0.63
23	Reserved							
24	VCC	V	Power supply	Input	Power	3.135	3.30	3.60
25	Reserved							
26	GND	V	Ground	Input	Power	-	0	-
27	GND	V	Ground	Input	Power	-	0	-
28	NC	-	No connect	-	-	-	-	-
29	GND	V	Ground	Input	Power	-	0	-
30	NC (For audio interface pin usage, see Audio Support on page 15.)		Reserved—Host must not repurpose this pin.					
31	Reserved							
32	NC (For audio interface pin usage, see Audio Support on page 15.)		Reserved—Host must not repurpose this pin.					
33	Reserved							
34	GND	V	Ground	Input	Power	-	0	-
35	GND	V	Ground	Input	Power	-	0	-
36	USB_D-	-	USB data negative	Input/Output	Differential	-	-	-
37	GND	V	Ground	Input	Power	-	0	-
38	USB_D+	-	USB data positive	Input/Output	Differential	-	-	-
39	VCC	V	Power supply	Input	Power	3.135	3.30	3.60
40	GND	V	Ground	Input	Power	-	0	-

Table 3-1: Connector Pin Assignments[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
41	VCC	V	Power supply	Input	Power	3.135	3.30	3.60
42	WAN_LED_N	OC	LED Driver	Output	Low	0	-	0.15[f]
43	GND	V	Ground	Input	Power	-	0	-
44	ANT_CTRL2 / GPIO3	-	(ANT_CTRL2) Customer-defined external switch control for multiple antennas	Output	High	1.35	1.80	1.90
				Output	Low	0	-	0.8
			(GPIO3) General purpose I/O	Input High		1.53	1.80	2.10
				Input Low		-0.30		0.45
				Output High		1.35	1.80	1.90
				Output Low		0.00		0.8
45	NC (For audio interface pin usage, see Audio Support on page 15.)		Reserved—Host must not repurpose this pin.					
46	ANT_CTRL3/ GPIO4	-	(ANT_CTRL3) Customer-defined external switch	Input High		1.35	1.80	1.90
				Input Low		0	-	0.8
			(GPIO4) General purpose I/O	Input High		1.53	1.80	2.10
				Input Low		-0.30		0.45
				Output High		1.35	1.80	1.90
				Output Low		0.00		0.8
47	NC (For audio interface pin usage, see Audio Support on page 15.)		Reserved—Host must not repurpose this pin.					
48	NC	-	No connect	-	-	-	-	-
49	NC (For audio interface pin usage, see Audio Support on page 15.)		Reserved—Host must not repurpose this pin.					
50	GND	V	Ground	Input	Power	-	0	-
51	NC (For audio interface pin usage, see Audio Support on page 15.)		Reserved—Host must not repurpose this pin.					
52	VCC	V	Power supply	Input	Power	3.135	3.30	3.60

a. The host should leave all 'NC' ('no connect) pins unconnected.
b. A—Analog; I—Input; NP—No pull; O—Digital output; OC—Open Collector; PU—Digital input (internal pull up); PD—Digital output (internal pull down); V—Power or ground

c. Signal directions are from module's point of view (e.g. 'Output' from module to host, 'Input' to module from host.)
d. To avoid adverse effects on module operation, do not draw more than 10 mA current on pin 11.
e. The module must not be plugged into a port that supports PCI Express—the pin is used by a PCIE signal, which can cause the module to be in reset state or occasionally reset.
f. Max voltage level when current < 100 mA.

Power Supply

The host provides power to the MC7475 through multiple power and ground pins as summarized in Table 3-2.

The host must provide safe and continuous power at all times; the module does not have an independent power supply, or protection circuits to guard against electrical issues.

Table 3-2: Power and Ground Specifications

Name	Pins	Specification	Min	Typ	Max	Units
VCC	2, 24, 39, 41, 52	Voltage range	See Table 3-1 on page 14.			
		Ripple voltage	-	-	100	mV_{pp}
GND	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43, 50	-	-	0	-	V

USB Interface

Important: *Host support for USB 2.0 signals is required.*

The device supports a USB 2.0 interface for communication between the host and module.

The interface complies with the *[7] Universal Serial Bus Specification, Rev 2.0*, and the host device must be designed to the same standards (subject to details shown in Table 3-3 below). (Note: When designing the host device, careful PCB layout practices must be followed.)

Table 3-3: USB Interfaces

	Name	Pin	Description
USB 2.0	USB_D-	36	USB data negative
	USB_D+	38	USB data positive

USB Throughput Performance

This device has been designed to achieve optimal performance and maximum throughput using USB high-speed mode (USB 2.0). Although the device may operate with a high speed host, throughput performance will be on an "as is" basis and needs to be characterized by the OEM. Note that throughput will be reduced and may vary significantly based on packet size, host interface, and firmware revision.

SIM Interface

Note: Host support for SIM interface signals is required.

The module supports up to two SIMs (Subscriber Identity Module) (1.8 V or 3 V). Each SIM holds information for a unique account, allowing users to optimize their use of each account on multiple devices.

The SIM pins (Table 3-4) provide the connections necessary to interface to SIM sockets located on the host device as shown in Figure 3-2 on page 20. Voltage levels over this interface comply with 3GPP standards.

The types of SIM connectors used depends on how the host device exposes the SIM sockets.

Table 3-4: SIM Interface Signals

SIM	Name	Pin	Description	SIM contact number[a]	Notes
Primary	USIM_PWR	8	SIM voltage	1	Power supply for SIM
	USIM_DATA	10	Data I/O	7	Bi-directional SIM data line
	USIM_CLK	12	Serial clock	3	Serial clock for SIM data
	USIM_RST	14	Reset	2	Active low SIM reset
	USIM_GND		Ground	5	Ground reference USIM_GND is common to module ground
Secondary	USIM2_PWR	13	SIM voltage	2	Power supply for SIM 2
	USIM2_DATA	19	Data I/O	3	Bi-directional SIM 2 data line
	USIM2_CLK	17	Serial clock	7	Serial clock for SIM 2 data
	USIM2_RST	7	Reset	1	Active low SIM 2 reset
	USIM2_GND		SIM indication	-	Ground reference USIM2_GND is common to module ground

a. See Figure 3-3 on page 20 for SIM card contacts.

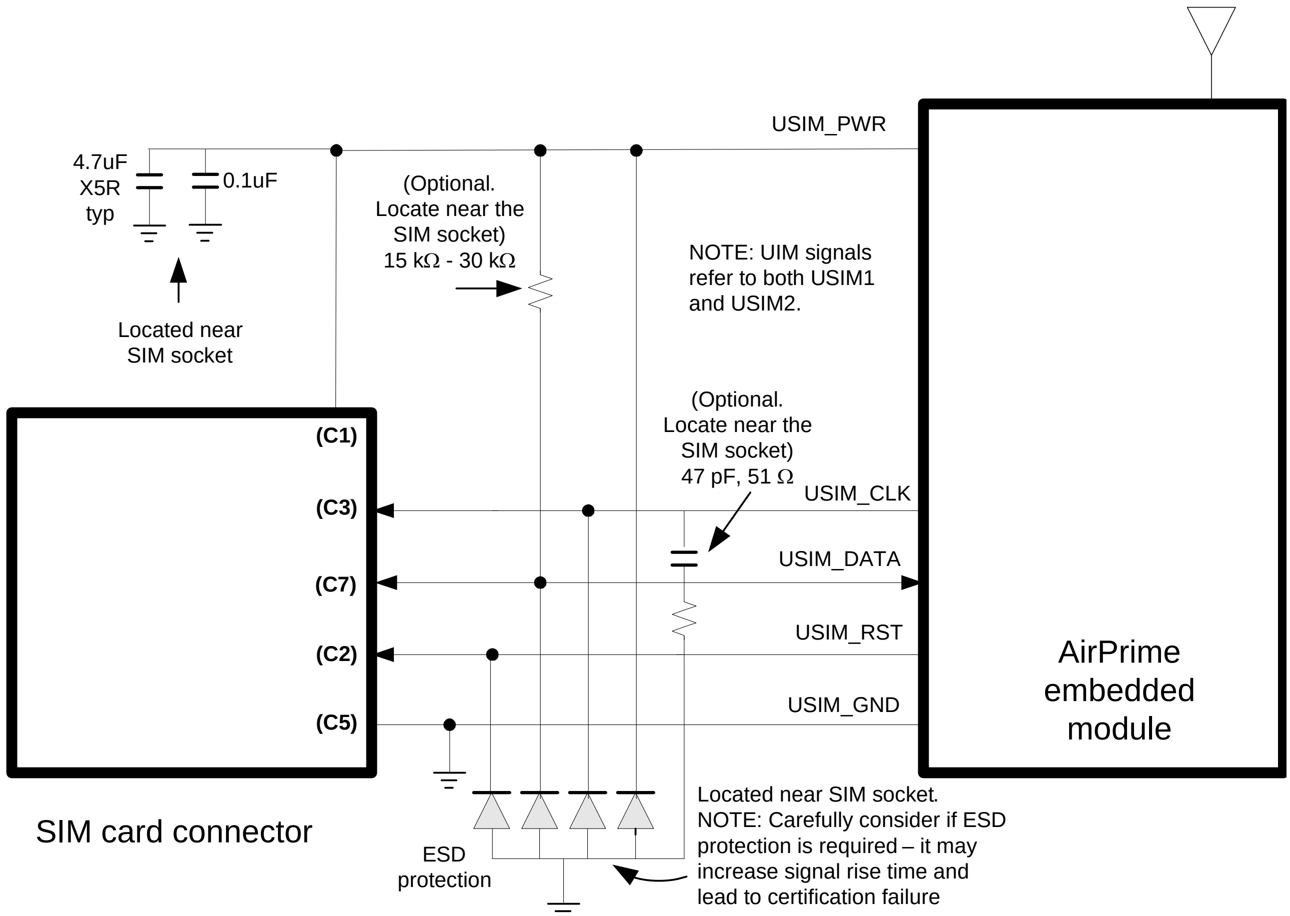

Figure 3-2: SIM Application Interface (applies to both SIM interfaces)

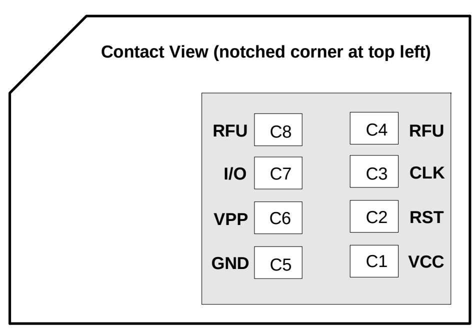

Figure 3-3: SIM Card Contacts (Contact View)

SIM Implementation

Note: For interface design requirements, refer to ETSI TS 102 230 V5.5.0, section 5.2.

When designing the remote SIM interface, you *must* make sure that SIM signal integrity is not compromised.

Some design recommendations include:

- Total impedance of the VCC and GND connections to the SIM, measured at the module connector, should be less than 1 Ω to minimize voltage drop (includes any trace impedance and lumped element components—inductors, filters, etc.).
- Position the SIM connector ≤10 cm from the module. If a longer distance is required because of the host device design, use a shielded wire assembly—connect one end as close as possible to the SIM connector and the other end as close as possible to the module connector. The shielded assembly may help shield the SIM interface from system noise.
- Avoid routing the clock and data lines for each SIM (USIM_CLK/USIM_DATA, USIM2_CLK/USIM2_DATA) in parallel over distances >2 cm—cross-coupling of a clock and data line pair can cause failures.
- 3GPP has stringent requirements for I/O rise time (<1 µs), signal level limits, and noise immunity—consider this carefully when developing your PCB layout.
  - Keep signal rise time <1 µs—keep SIM signals as short as possible, and keep very low capacitance traces on the data and clock signals (USIM_CLK, USIM_DATA, USIM2_CLK, USIM2_DATA). High capacitance increases signal rise time, potentially causing your device to fail certification tests.
- Add external pull-up resistors (15 kΩ–30 kΩ), if required, between the data and power lines for each SIM (USIM_DATA/USIM_PWR, USIM2_DATA/USIM2_PWR) to optimize the signal rise time.
- VCC line should be decoupled close to the SIM socket.
- SIM is specified to run up to 5 MHz (SIM clock rate). Take note of this speed in the placement and routing of the SIM signals and connectors.
- You must decide whether additional ESD protection is required for your product, as it is dependent on the application, mechanical enclosure, and SIM connector design. The SIM pins will require additional ESD protection if they are exposed to high ESD levels (i.e. can be touched by a user).
- Putting optional decoupling capacitors on the SIM power lines (USIM_PWR, USIM2_PWR) near the SIM sockets is recommended—the longer the trace length (impedance) from the socket to the module, the greater the capacitance requirement to meet compliance tests.
- Putting an optional series capacitor and resistor termination (to ground) on the clock lines (USIM_CLK, USIM2_CLK) at the SIM sockets to reduce EMI and increase signal integrity is recommended if the trace length between the SIM socket and module is long—47 pF and 50 Ω resistor are recommended.
- Test your first prototype host hardware with a Comprion IT^3 SIM test device at a suitable testing facility.

Control Interface (Signals)

The MC7475 provides signals for:

- Waking the host when specific events occur
- LED driver output

These signals are summarized in Table 3-5 and paragraphs that follow.

Table 3-5: Module Control Signals

Name	Pin	Description	Type[a]
WAKE_N	1	Wake host	OC
WAN_LED_N	42	LED driver	OC

a. OC—Open Collector; PU—Digital pin Input, internal pull up

WAKE_N — Wake Host

Note: Host support for WAKE_N is optional.

The module uses WAKE_N to wake the host when specific events occur.

The host must provide a 5 kΩ–100 kΩ pullup resistor that considers total line capacitance (including parasitic capacitance) such that when WAKE_N is deasserted, the line will rise to 3.3 V (Host power rail) in < 100 ns.

See Figure 3-4 on page 22 for a recommended implementation.

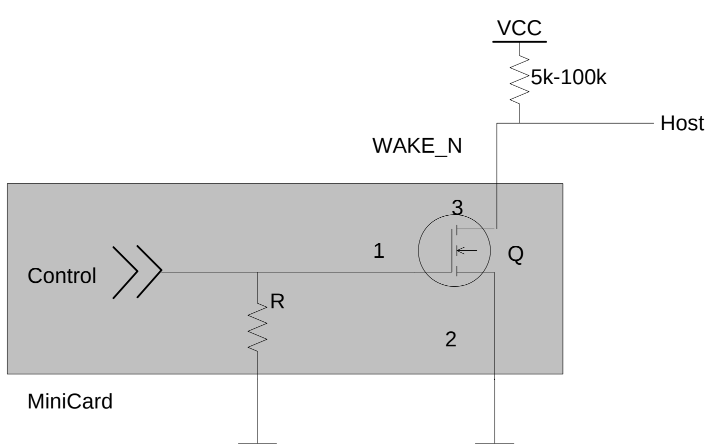

Figure 3-4: Recommended WAKE_N Connection

WAN_LED_N—LED Output

Note: Host support for WAN_LED_N is optional.

The module drives the LED output according to *[6] PCI Express Mini Card Electromechanical Specification Revision 2.1*.

Note: The LED configuration is customizable. Contact your Sierra Wireless account representative for details.

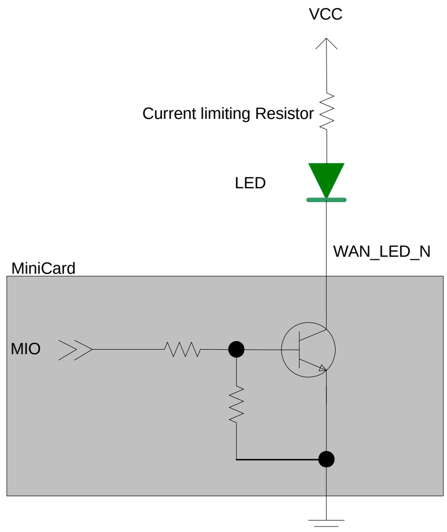

Figure 3-5: Example LED

SYSTEM_RESET_N—Reset Input

Note: Host support for SYSTEM_RESET_N is optional.

SYSTEM_RESET_N has an internal 1.8 V internal pull up that requires an open collector input from the host. Set this signal to active low to reset the device. Note that the minimum pulse width is 2 s.

Note: The module must not be plugged into a port that supports PCI Express—SYSTEM_RESET_N is carried on a pin that is used for a PCIE signal, which can cause the module to be in reset state or occasionally reset.

Antenna Control

Note: Host support for antenna control signals is optional.

The MC7475 Mini Card provides three output signals (listed in Table 3-6) that may be used for host designs that incorporate tunable antennas.

Table 3-6: Antenna Control Signals

Name	Pin	Description
ANT_CTRL0	3	Customer-defined external switch control for tunable antennas
ANT_CTRL1	5	
ANT_CTRL2	44	
ANT_CTRL3	46	

4: RF Specifications

The MC7475 includes three RF connectors for use with host-supplied antennas:

- Main RF connector—Tx/Rx path
- GPS RF connector—Dedicated GPS
- Auxiliary RF connector—Rx diversity

The module does not have integrated antennas.

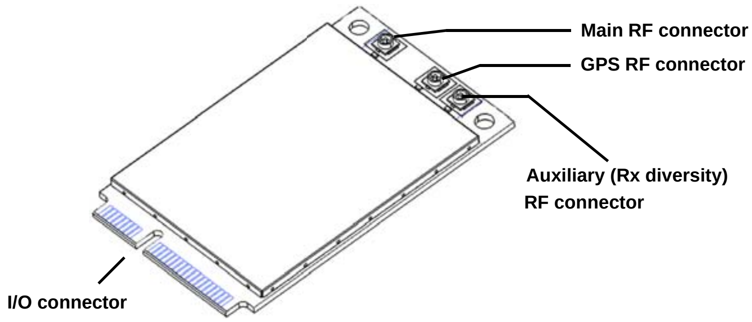

Figure 4-1: Module Connectors

RF Connections

When attaching antennas to the module:

- Use Hirose U.FL connectors (3 mm x 3 mm, low profile; model U.FL #CL331-0471-0-10) to attach antennas to connection points on the module, as shown in Figure 4-1 on page 24.

> *Note: To **disconnect** the antenna, make sure you use the Hirose U.FL connector removal tool (P/N UFL-LP-N-2(01)) to prevent damage to the module or coaxial cable assembly.*

- Match coaxial connections between the module and the antenna to 50 Ω.
- Minimize RF cable losses to the antenna; the recommended maximum cable loss for antenna cabling is 0.5 dB.
- To ensure best thermal performance, mounting holes must be used to attach (ground) the device to the main PCB ground or a metal chassis.

Note: If the antenna connection is shorted or open, the modem will not sustain permanent damage.

Shielding

The module is fully shielded to protect against EMI and the shield must not be removed.

Antenna and Cabling

When selecting the antenna and cable, it is critical to RF performance to optimize antenna gain and cable loss.

Note: For detailed electrical performance criteria, see Appendix 8: Antenna Specification on page 43.

Choosing the Correct Antenna and Cabling

When matching antennas and cabling:

- The antenna (and associated circuitry) should have a nominal impedance of 50 Ω with a recommended return loss of better than 10 dB across each frequency band of operation.
- The system gain value affects both radiated power *and* regulatory (FCC) test results.

Designing Custom Antennas

Consider the following points when designing custom antennas:

- A skilled RF engineer should do the development to ensure that the RF performance is maintained.
- If both CDMA and UMTS modules will be installed in the same platform, you may want to develop separate antennas for maximum performance.

Determining the Antenna's Location

When deciding where to put the antennas:

- Antenna location may affect RF performance. Although the module is shielded to prevent interference in most applications, the placement of the antenna is still very important—if the host device is insufficiently shielded, high levels of broadband noise or spurious interference can degrade the module's performance.
- Connecting cables between the module and the antenna must have 50 Ω impedance. If the impedance of the module is mismatched, RF performance is reduced significantly.
- Antenna cables should be routed, if possible, away from noise sources (switching power supplies, LCD assemblies, etc.). If the cables are near the noise sources, the noise may be coupled into the RF cable and into the antenna. See Interference From Other Wireless Devices on page 26.

Ground Connection

When connecting the module to system ground:

- Prevent noise leakage by establishing a very good ground connection to the module through the host connector.
- Connect to system ground using the two mounting holes at the top of the module (shown in Figure 4-1 on page 24).
- Minimize ground noise leakage into the RF.
  Depending on the host board design, noise could *potentially* be coupled to

the module from the host board. This is mainly an issue for host designs that have signals traveling along the length of the module, or circuitry operating at both ends of the module interconnects.

Interference and Sensitivity

Several interference sources can affect the module's RF performance (RF desense). Common sources include power supply noise and device-generated RF.

RF desense can be addressed through a combination of mitigation techniques (Methods to Mitigate Decreased Rx Performance on page 27) and radiated sensitivity measurement (Radiated Sensitivity Measurement on page 27).

Interference From Other Wireless Devices

Wireless devices operating inside the host device can cause interference that affects the module.

To determine the most suitable locations for antennas on your host device, evaluate each wireless device's radio system, considering the following:

- Any harmonics, sub-harmonics, or cross-products of signals generated by wireless devices that fall in the module's Rx range may cause spurious response, resulting in decreased Rx performance.
- The Tx power and corresponding broadband noise of other wireless devices may overload or increase the noise floor of the module's receiver, resulting in Rx desense.

The severity of this interference depends on the closeness of the other antennas to the module's antenna. To determine suitable locations for each wireless device's antenna, thoroughly evaluate your host device's design.

Host-generated RF Interference

All electronic computing devices generate RF interference that can negatively affect the receive sensitivity of the module.

Proximity of host electronics to the antenna in wireless devices can contribute to decreased Rx performance. Components that are most likely to cause this include:

- Microprocessor and memory
- Display panel and display drivers
- Switching-mode power supplies

Device-generated RF Interference

The module can cause interference with other devices. Wireless devices such as AirPrime embedded modules transmit in bursts (pulse transients) for set durations (RF burst frequencies). Hearing aids and speakers convert these burst frequencies into audible frequencies, resulting in audible noise.

Methods to Mitigate Decreased Rx Performance

It is important to investigate sources of localized interference early in the design cycle. To reduce the effect of device-generated RF on Rx performance:

- Put the antenna as far as possible from sources of interference. The drawback is that the module may be less convenient to use.
- Shield the host device. The module itself is well shielded to avoid external interference. However, the antenna cannot be shielded for obvious reasons. In most instances, it is necessary to employ shielding on the components of the host device (such as the main processor and parallel bus) that have the highest RF emissions.
- Filter out unwanted high-order harmonic energy by using discrete filtering on low frequency lines.
- Form shielding layers around high-speed clock traces by using multi-layer PCBs.
- Route antenna cables away from noise sources.

Radiated Spurious Emissions (RSE)

When designing an antenna for use with AirPrime embedded modules, the host device with an AirPrime embedded module must satisfy any applicable standards/local regulatory bodies for radiated spurious emission (RSE) for receive-only mode and for transmit mode (transmitter is operating).

Note that antenna impedance affects radiated emissions, which must be compared against the conducted 50-ohm emissions baseline. (AirPrime embedded modules meet the 50-ohm conducted emissions requirement.)

Radiated Sensitivity Measurement

A wireless host device contains many noise sources that contribute to a reduction in Rx performance.

To determine the extent of any receiver performance desensitization due to self-generated noise in the host device, over-the-air (OTA) or radiated testing is required. This testing can be performed by Sierra Wireless or you can use your own OTA test chamber for in-house testing.

Sierra Wireless’ Sensitivity Testing and Desensitization Investigation

Although AirPrime embedded modules are designed to meet network operator requirements for receiver performance, they are still susceptible to various performance inhibitors.

As part of the Engineering Services package, Sierra Wireless offers modem OTA sensitivity testing and desensitization (desense) investigation. For more information, contact your account manager or the Sales Desk (see Contact Information on page 3).

Note: Sierra Wireless has the capability to measure TIS (Total Isotropic Sensitivity) and TRP (Total Radiated Power) according to CTIA's published test procedure.

Sensitivity vs. Frequency

For LTE bands, sensitivity is defined as the RF level at which throughput is 95% of maximum.

Supported Frequencies

The MC7475 supports:

- Multiple-band LTE—See Table 4-1 on page 28 (supported bands)
- GPS

Table 4-1: LTE Frequency Bands

Band	Frequency (Tx)	Frequency (Rx)
Band 2	1850–1910 MHz	1930–1990 MHz
Band 4	1710–1755	2110–2155 MHz
Band 12	699–716 MHz	729–746 MHz
Band 125	2315–2318 MHz	2347–2350 MHz

Conducted Rx Sensitivity / Tx Power

Table 4-2: Conducted Rx (Receive) Sensitivity—LTE Bands

LTE bands	Bandwidth (MHz)	Conducted Rx sensitivity (dBm)
LTE Band 2	5	-100.6
LTE Band 4	5	-102.8
LTE Band 12	5	-103.2
LTE Band 125	3	-102.6

Table 4-3: Conducted Tx (Transmit) Power Tolerances

Parameter	Conducted transmit power	Notes
LTE		
LTE Band 2,4,12	+23 dBm ± 1 dB	
LTE Band 125	+13 dBm ± 1 dB	QPSK full RB

GPS Specifications

Note: For detailed electrical performance criteria, see *Recommended GPS Antenna Specifications on page 45.*

Table 4-4: GPS Specifications

Parameter/feature	Description
Satellite channels	Maximum 12 channels, simultaneous tracking
Protocols	NMEA 0183 V3.0
Acquisition time	Hot start: 4 s Cold start: 36 s *Note: Measured with signal strength = -135 dBm.*
Sensitivity	Tracking[a]: -160 dBm Acquisition (Standalone)[b]: -145 dBm
Operational limits	Altitude <6000 m or velocity <100 m/s (Either limit may be exceeded, but not both.)

a. Tracking sensitivity is the lowest GPS signal level for which the device can still detect an in-view satellite 50% of the time when in sequential tracking mode.
b. Acquisition sensitivity is the lowest GPS signal level for which the device can still detect an in-view satellite 50% of the time.

5: Power

Power Consumption

Power consumption measurements in the tables below are for the MC7475 Mini Card module connected to the host PC via USB.

The module does not have its own power source and depends on the host device for power. For a description of input voltage requirements, see Power Supply on page 18.

Table 5-1: Averaged Standby DC Power Consumption

Signal	Description	Bands[a]	Current			Notes / configuration
			Typ	Max[b]	Unit	
VCC	**Standby current consumption (Sleep mode deactivated[c])**					
	LTE	Band 2	13.5	21	mA	DRX cycle = 8 (2.56 s)
		Band 4	13.5	22	mA	
		Band 12	13	22	mA	
		Band 125	13	21	mA	

a. For supported bands, see Table 4-1, LTE Frequency Bands, on page 28.
b. Measured at nominal 3.3 V voltage.
c. Assumes USB bus is fully suspended during measurements

Table 5-2: Averaged Call Mode DC Power Consumption

Description	Tx power	Band	Current[a]		Notes
			Typ	Unit	
LTE	23 dBm	B2/B4	900	mA	100/50 Mbps, 20 MHz BW
		B12	828	mA	60/25 Mbps, 10 MHz BW
		B125	647	mA	7.2/12.6 Mbps, 3 MHz BW
Peak current (averaged over 100 µs)			1012	mA	All LTE bands

a. Measured at 25ºC/nominal 3.3 V voltage

Table 5-3: Miscellaneous DC Power Consumption

Signal	Description	Current/Voltage			Unit	Notes/configuration
		Min	Typ	Max		
VCC	Maximum current	—	—	1.5	A	• Across all bands, all temperature ranges • 3.3 V supply
GPS Signal connector	Active bias on GPS port	—	—	100	mA	• See GPS RF connector in Figure 4-1 on page 24 • GNSS active antenna specifications: · DC voltage range: 3.0–3.25 V · Within specified DC voltage range, MC7475 will drive current up to 100 mA (depending on antenna load). · Specifications valid over operating input DC voltage (VCC) and temperature range.
		3.00	3.15	3.25	V	

Power Interface

Power Ramp-up

On initial power up, inrush current depends on the power supply rise time—turn on time >100 µs is required for < 3A inrush current.

The supply voltage must remain within specified tolerances while this is occurring.

Power-On/Off Timing

Figure 5-1 describes the timing sequence for powering the module on and off.

Note: The host should not drive any signals to the module until the power-on sequence is complete.

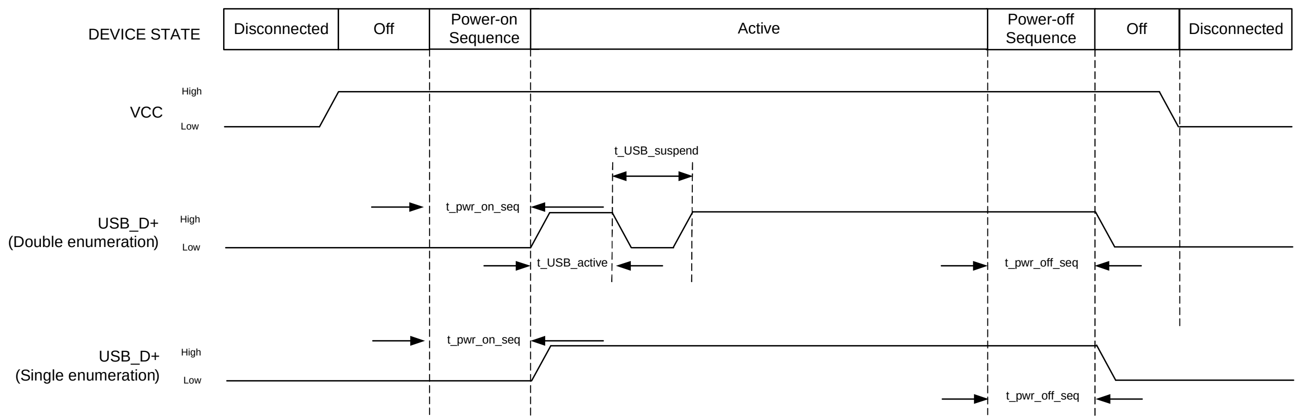

Figure 5-1: Signal Timing (USB Enumeration)

Table 5-4: USB 2.0 Power-On / Off Timing Parameters (Double Enumeration)

Parameter	Typical (s)	Maximum (s)
t_pwr_on_seq	TBD	TBD
t_USB_active	TBD	TBD
t_USB_suspend	TBD	TBD
t_pwr_off_seq	TBD	TBD

Table 5-5: USB 2.0 Power-On/Off Timing Parameters (Single Enumeration)

Parameter	Typical (s)	Maximum (s)
t_pwr_on_seq	TBD	TBD
t_pwr_off_seq	TBD	TBD

USB Enumeration

The unit supports single and double USB enumeration with the host:

- Single enumeration:
  - Enumeration starts within maximum t_pwr_on_seq seconds of power-on.
- Double enumeration—As shown in Figure 5-1 on page 32:
  - First enumeration starts within t_pwr_on_seq seconds of power-on (while USB_D+ is high)
  - Second enumeration starts after t_USB_suspend (when USB_D+ goes high again)

Power Supply Noise

Noise in the power supply can lead to noise in the RF signal.

The power supply ripple limit for the module is no more than 100 mVp-p 1 Hz to 100 kHz. This limit includes voltage ripple due to transmitter burst activity.

Additional decoupling capacitors can be added to the main VCC line to filter noise into the device.

6: Mechanical and Environmental Specifications

The MC7475 module complies with the mechanical and environmental specifications in Table 6-1. Final product conformance to these specifications depends on the OEM device implementation.

Table 6-1: Mechanical and Environmental Specifications

	Mode	Details
Ambient temperature	Operational Class A	-20ºC to +70ºC – 3GPP compliant
	Operational Class B	-30ºC to +85ºC – non-3GPP compliant (reduced operating parameters required)
	Non-operational	-40ºC to +85ºC, 96 hours (from MIL-STD 202 Method 108)
Relative humidity	Non-operational	85ºC, 85% relative humidity for 48 hours (non-condensing)
Vibration	Non-operational	Random vibration, 10 to 2000 Hz, 0.1 g^2/Hz to 0.0005 g^2/Hz, in each of three mutually perpendicular axes. Test duration of 60 minutes for each axis, for a total test time of three hours.
Shock	Non-operational	Half sine shock, 11 ms, 30 g, 8x each axis. Half sine shock, 6 ms, 100 g, 3x each axis.
Drop	Non-operational	1 m on concrete on each of six faces, two times (module only).
Thermal considerations		See Thermal Considerations on page 37.
Form factor		PCI-Express Mini Card shielded with metal and metalized fabric (F2 specification)
Dimensions		Length: 50.95 mm Width: 30 mm Thickness: 2.75 mm (max) Weight: 8.7 g

Device Views

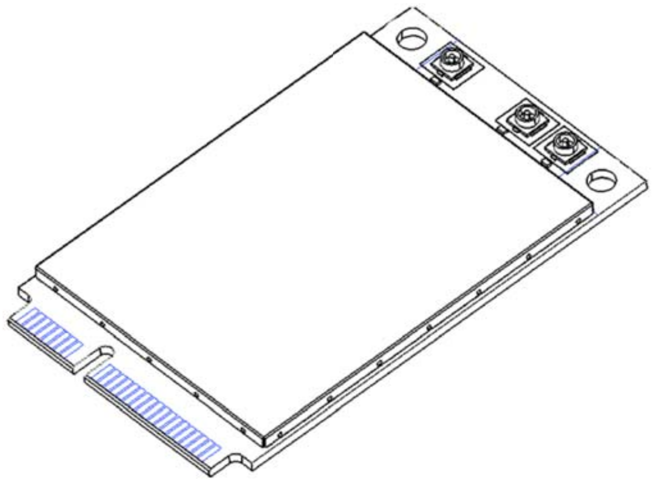

Figure 6-1: Top View

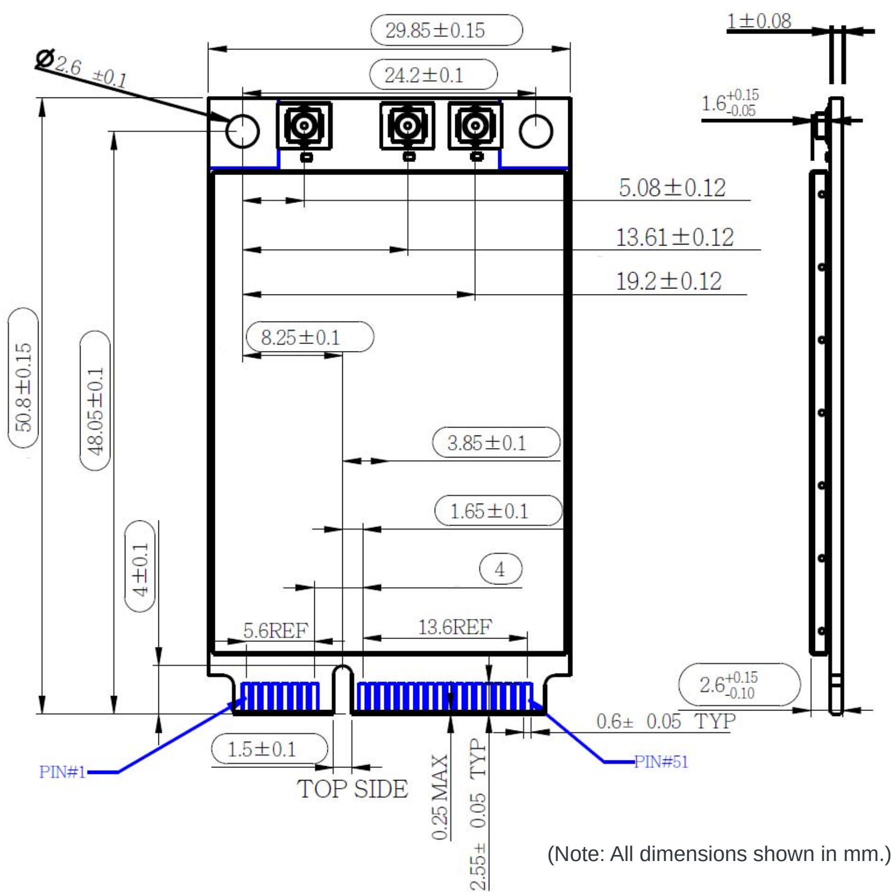

Figure 6-2: Dimensioned View

Labeling

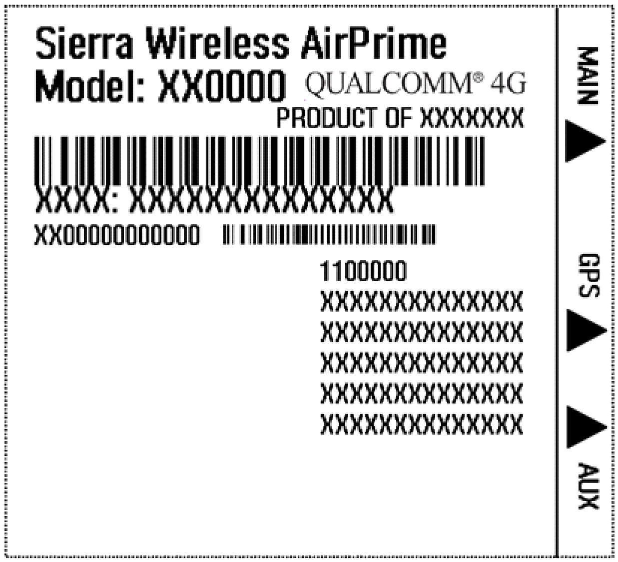

Figure 6-3: Sample Unit Label

Note: The displayed label is an example only. The production label will vary by SKU.

The MC7475 label is non-removable and contains:

- Sierra Wireless logo and product name
- IMEI number in Code-128 barcode format
- SKU number (when required)
- Factory Serial Number (FSN) in alphanumeric format
- Manufacturing date code (incorporated into FSN)
- Licensed vendor logo
- Applicable certification marks/details (e.g. FCC ID, etc. Example shows FCC ID.)

Note: The MC7475 supports OEM partner-specific label requirements.

Electrostatic Discharge (ESD)

The OEM is responsible for ensuring that the Mini Card host interface pins are not exposed to ESD during handling or normal operation. (See Table 6-1 on page 34 for specifications.)

ESD protection is highly recommended for the SIM connector at the point where the contacts are exposed, and for any other signals from the host interface that would be subjected to ESD by the user of the product. (The device includes ESD protection on the antenna.)

Thermal Considerations

Embedded modules can generate significant amounts of heat that must be dissipated in the host device for safety and performance reasons.

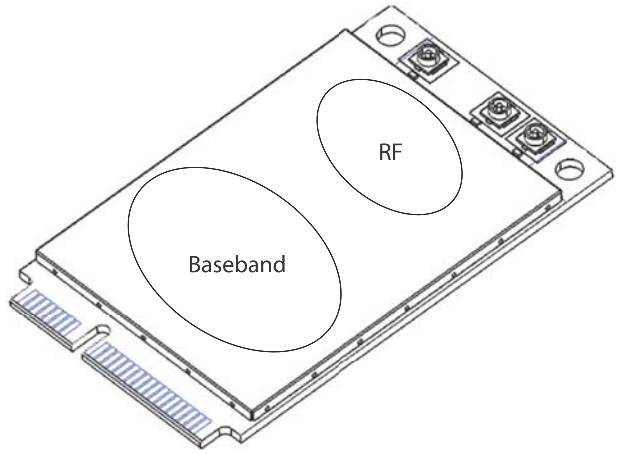

Figure 6-4: Shield locations (Top view)

The amount of thermal dissipation required depends on:

- Supply voltage—Maximum power dissipation for the module can be up to 3.5 W at voltage supply limits.
- Usage—Typical power dissipation values depend on the location within the host product, throughput, amount of data transferred, etc.

Specific areas requiring heat dissipation are shown in Figure 6-4:

- RF—Bottom face of module near RF connectors. Likely to be the hottest area.
- Baseband—Bottom face of module, below the baseband area.

To enhance heat dissipation:

- It is recommended to add a heat sink that mounts the module to the main PCB or metal chassis (a thermal compound or pads must be used between the module and the heat sink).

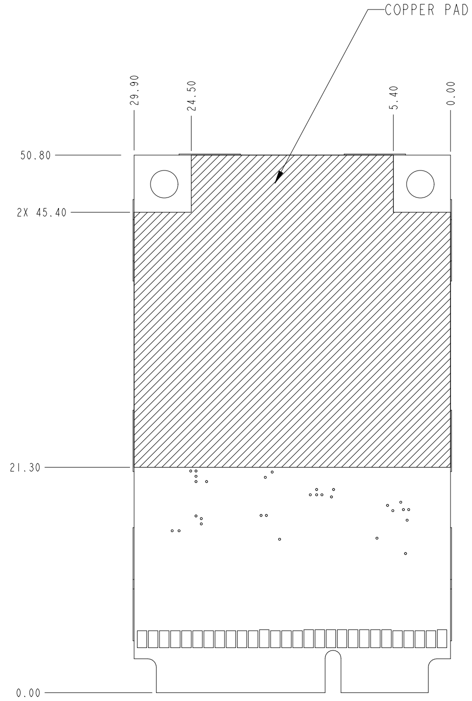

Figure 6-5: Copper Pad Location on Bottom Side of Module

- Maximize airflow over/around the module.
- Locate the module away from other hot components.
- Module mounting holes must be used to attach (ground) the device to the main PCB ground or a metal chassis.
- You may also need active cooling to pull heat away from the module.

Note: Adequate dissipation of heat is necessary to ensure that the module functions properly.

Module Integration Testing

When testing your integration design:

- Test to your worst case operating environment conditions (temperature and voltage)
- Test using worst case operation (transmitter on 100% duty cycle, maximum power)
- Monitor temperature on the underside of the module. Attach thermocouples to the areas indicated in Figure 6-4 on page 37 (Baseband, RF).

Note: Make sure that your system design provides sufficient cooling for the module—proper mounting, heat sinks, and active cooling may be required, depending on the integrated application.
The internal module temperature must be kept to <90°C when integrated to prevent damage to the module's components. For best performance, keep the internal module temperature below 80°C.

(For acceptance, certification, quality, and production (including RF) test suggestions, see Testing on page 15.)

7: Regulatory Compliance and Industry Certifications

This module is designed to meet, and upon commercial release, will meet the requirements of the following regulatory bodies and regulations, where applicable:

- Federal Communications Commission (FCC) of the United States

Upon commercial release, the following industry certifications will have been obtained, where applicable:

- PTCRB

Additional certifications and details on specific country approvals may be obtained upon customer request—contact your Sierra Wireless account representative for details.

Additional testing and certification may be required for the end product with an embedded MC7475 module and are the responsibility of the OEM. Sierra Wireless offers professional services-based assistance to OEMs with the testing and certification process, if required.

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 module are used in a normal manner with a well-constructed network, the Sierra Wireless module 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 the Sierra Wireless module, or for failure of the Sierra Wireless module to transmit or receive such data.

Safety and Hazards

Do not operate your MC7475 module:

- In areas where blasting is in progress
- Where explosive atmospheres may be present including refuelling 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 MC7475 module **MUST BE POWERED OFF**. Otherwise, the MC7475 module can transmit signals that could interfere with this equipment.

In an aircraft, the MC7475 module **MUST BE POWERED OFF**. Otherwise, the MC7475 module 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 a cellular phone in an 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 MC7475 module may be used normally at this time.

Important Compliance Information for North American Users

Note: Details are preliminary and subject to change.

The MC7475 module, upon commercial release, will have been granted modular approval for mobile applications. Integrators may use the MC7475 module in their final products without additional FCC certification if they meet the following conditions. Otherwise, additional FCC approvals must be obtained.

1. At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.
2. To comply with FCC 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 limits stipulated in Table 7-1 on page 41.

Table 7-1: Antenna Gain Specifications

Device	Technology	Band	Frequency (MHz)	Maximum antenna gain (dBi)
MC7475 Mini Card	LTE	2	1850–1910	6
		4	1710–1755	6
		12	699–716	6
		125	2315–2318	10

Important: *Mobile carriers often have limits on total radiated power (TRP), which requires an efficient antenna. The end product with an embedded module must output sufficient power to meet the TRP requirement but not too much to exceed FCC EIRP limit. If you need assistance in meeting this requirement, please contact Sierra Wireless.*

3. The MC7475 module may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:
   - Each collocated radio transmitter has been certified by FCC 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 in a collocated configuration must not exceed the limits and configurations stipulated in Table 7-2.

Table 7-2: Collocated Radio Transmitter Specifications

Device	Technology	Frequency (MHz)	EIRP Limit (dBm)
Collocated transmitters[a]	WLAN	2400–2500	23
		5150–5850	23
	WiMAX	2300–2400	25
		2500–2700	25
		3300–3800	25
	BT	2400–2500	15

a. 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 MC7475 module is incorporated, with a statement similar to the following:
   - **This device contains FCC ID: N7NMC7475.**
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 RF exposure guidelines.

The end product with an embedded MC7475 module may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC Part 15.

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.

8: Antenna Specification

8

This appendix describes recommended electrical performance criteria for main path, Rx diversity path, and GPS antennas used with AirPrime embedded modules.

The performance specifications described in this section are valid while antennas are mounted in the host device with antenna feed cables routed in their final application configuration.

Note: Antennas should be designed ***before*** *the industrial design is finished to make sure that the best antennas can be developed.*

Recommended Main/Rx Diversity Antenna Specifications

Table 8-1: Antenna Requirements [a]

Parameter	Requirements	Comments
Antenna system	External multi-band antenna system with Rx diversity (Ant1/ Ant2)[b]	
Operating bands—Antenna 1	669–746 MHz	
	1710–1990 MHz	
	2110–2155 MHz	
	2315–2350 MHz	
Operating bands—Antenna 2	729–746 MHz	
	1930–1990 MHz	
	2110–2155 MHz	
	2347–2350 MHz	
VSWR of Ant1 and Ant2	• < 2:1 (recommended) • < 3:1 (worst case)	On all bands including band edges

Table 8-1: Antenna Requirements (Continued)[a]

Parameter	Requirements	Comments
Total radiated efficiency of Ant1 and 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.
Radiation patterns of Ant1 and Ant2	Nominally Omni-directional radiation pattern in azimuth plane.	
Envelope correlation coefficient between Ant1 and Ant2	• < 0.4 on low Rx bands (up to 1500 MHz) • < 0.2 on high Rx bands (over 1500 MHz)	
Mean Effective Gain of Ant1 and Ant2 (MEG1, MEG2)	≥ -3 dBi	
Ant1 and Ant2 Mean Effective Gain Imbalance I MEG1 / MEG2 I	< 6 dB for Rx diversity operation	
Maximum antenna gain	Must not exceed antenna gains due to RF exposure and ERP/ EIRP limits, as listed in the module's FCC grant.	See Important Compliance Information for North American Users on page 41.
Isolation between Ant1 and Ant2 (S21)	> 10 dB	• If antennas can be moved, test all positions for both antennas. • Make sure all other wireless devices (Bluetooth or WLAN antennas, etc.) are turned OFF to avoid interference.
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.

a. 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) 50 ohm 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 4.2.2 for WCDMA (ETSI EN 301 908-1), where applicable.

b. Ant1—Primary, Ant2—Secondary (Rx Diversity)

Recommended GPS Antenna Specifications

Table 8-2: GPS Antenna Requirements

Parameter	Requirements	Comments
Frequency range	1575.42 MHz ±2 MHz minimum	
Field of view (FOV)	• Omni-directional in azimuth • -45° to +90° in elevation	
Polarization (average Gv/Gh)	> 0 dB	Vertical linear polarization is sufficient.
Free space average gain (Gv+Gh) over FOV	> -6 dBi (preferably > -3 dBi)	Gv and Gh are measured and averaged over -45° to +90° in elevation, and ±180° in azimuth.
Gain	• Maximum gain and uniform coverage in the high elevation angle and zenith. • Gain in azimuth plane is not desired.	
Average 3D gain	> -5 dBi	
Isolation between GPS and Ant1	> 10 dB in all uplink bands	
Typical VSWR	< 2.5:1	
Polarization	Any other than LHCP (left-hand circular polarized) is acceptable.	

Antenna Tests

The following guidelines apply to the requirements described in Table 8-1 on page 43 and Table 8-2 on page 45:

- Perform electrical measurements at room temperature (+20°C to +26°C) unless otherwise specified
- For main and Rx diversity path antennas, make sure the antennas (including contact device, coaxial cable, connectors, and matching circuit with no more than six components, if required) have nominal impedances of 50 Ω across supported frequency bands.

- All tests (except isolation/correlation coefficient)—Test the main or Rx diversity antenna with the other antenna terminated.
- Any metallic part of the antenna system that is exposed to the outside environment needs to meet the electrostatic discharge tests per IEC61000-4-2 (conducted discharge +8kV).
- The functional requirements of the antenna system are tested and verified while the embedded module's antenna is integrated in the host device.

Note: Additional testing, including active performance tests, mechanical, and accelerated life tests can be discussed with Sierra Wireless' engineering services. Contact your Sierra Wireless representative for assistance.

9: Design Checklist

This chapter provides a summary of the design considerations mentioned throughout this guide. This includes items relating to the power interface, RF integration, thermal considerations, cabling issues, and so on.

Note: This is NOT an exhaustive list of design considerations. It is expected that you will employ good design practices and engineering principles in your integration.

Table 9-1: Hardware Integration Design Considerations

Suggestion	Section where discussed
Component placement	
Protect the SIM socket so the SIM cannot be removed while the host is powered up.	SIM Implementation on page 21
If an ESD suppressor is not used, allow space on the SIM connector for series resistors in layout. (Up to 100 Ω may be used depending on ESD testing requirements).	SIM Implementation on page 21
Minimize RF cable losses as these affect performance values listed in product specification documents.	RF Connections on page 24
Antennas	
Match the module/antenna coax connections to 50 Ω—mismatched antenna impedance and cable loss negatively affect RF performance.	RF Connections on page 24
If installing CDMA and UMTS modules in the same device, consider using separate antennas for maximum performance.	Antenna and Cabling on page 25
Power	
Make sure the power supply can handle the maximum current specified for the module type.	Power Consumption on page 30
Limit the total impedance of VCC and GND connections to the SIM at the connector to less than 1 Ω (including any trace impedance and lumped element components—inductors, filters, etc.). All other lines must have a trace impedance less than 2 Ω.	SIM Implementation on page 21
Decouple the VCC line close to the SIM socket. The longer the trace length (impedance) from socket to module, the greater the capacitance requirement to meet compliance tests.	SIM Implementation on page 21
PCB signal routing	
USB 2.0—Route these signals over 90 Ω differential lines on the PCB.	
EMI/ESD	
Investigate sources of localized interference early in the design cycle.	Methods to Mitigate Decreased Rx Performance on page 27
Provide ESD protection for the SIM connector at the exposed contact point (in particular, the CLK, VCC, IO, and RESET lines).	SIM Implementation on page 21

Table 9-1: Hardware Integration Design Considerations (Continued)

Suggestion	Section where discussed
Keep very low capacitance traces on the USIM_DATA and USIM_CLK signals.	SIM Implementation on page 21
To minimize noise leakage, establish a very good ground connection between the module and host.	Ground Connection on page 25
Route cables away from noise sources (for example, power supplies, LCD assemblies, etc.).	Methods to Mitigate Decreased Rx Performance on page 27
Shield high RF-emitting components of the host device (for example, main processor, parallel bus, etc.).	Methods to Mitigate Decreased Rx Performance on page 27
Use discrete filtering on low frequency lines to filter out unwanted high-order harmonic energy.	Methods to Mitigate Decreased Rx Performance on page 27
Use multi-layer PCBs to form shielding layers around high-speed clock traces.	Methods to Mitigate Decreased Rx Performance on page 27
Thermal	
Test to worst case operating conditions—temperature, voltage, and operation mode (transmitter on 100% duty cycle, maximum power).	Thermal Considerations on page 37
Use appropriate techniques to reduce module temperatures (for example, airflow, heat sinks, heat-relief tape, module placement, etc.).	Thermal Considerations on page 37
Host/Modem communication	
Make sure the host USB driver supports remote wakeup, resume, and suspend operations, and serial port emulation.	
When no valid data is being sent, do not send SOF tokens from the host (causes unnecessary power consumption).	

10: Packaging

Sierra Wireless AirPrime Mini Cards are packaged in sealed manufacturing boxes, each containing a single tray with a capacity of 100 modules (Figure 10-1 and Figure 10-2). Groups of three manufacturing boxes are then inserted into an outer box for shipping (Figure 10-3).

In the standard packaging:

1. Mini Cards are inserted, system connector first, into the base portion (T1) of a two-part tray. all facing the same direction. This allows the top edge of each Mini Card to contact the top of the triangular features in the tray cover (T2) (see Detail A).
2. The tray base and tray cover snap together at four connection points.

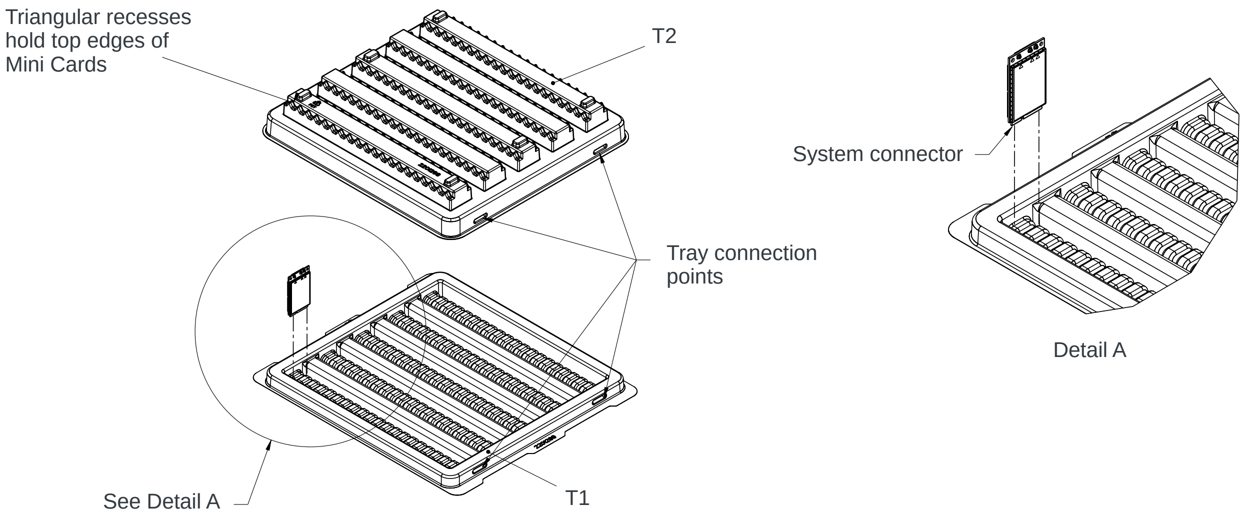

Figure 10-1: Device Placement in Module Tray

3. The tray cover (T2) is secured to the tray base (T1) with ESD-safe tape (EP1) at four locations.
4. The tray is placed in a manufacturing box (T2 at the top), sealed with a security tape (P1), and a manufacturing label (L3) is placed on the bottom-right corner, above the security tape. If required for the SKU, an additional label (L4) can be placed beside L3.

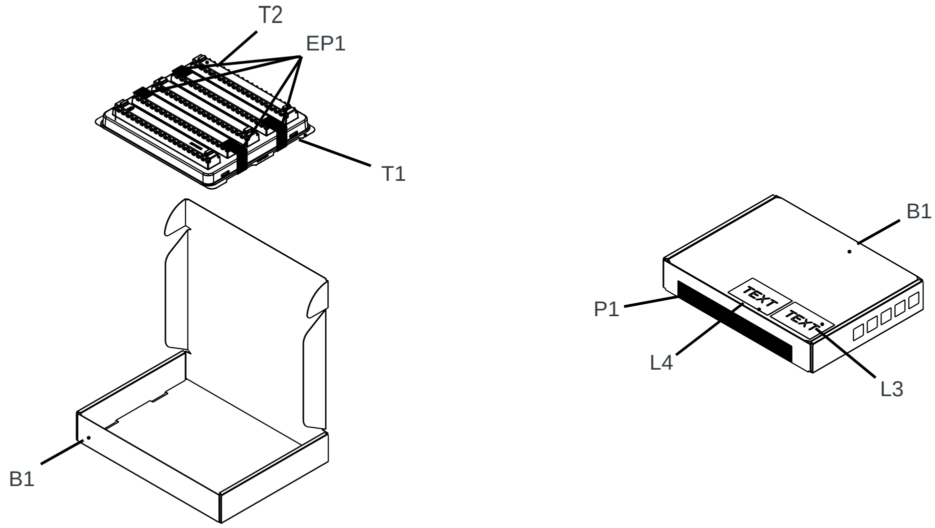

Figure 10-2: Shipping Package

5. Three manufacturing boxes are placed in an outer shipping box (B2). If fewer than three manufacturing boxes are being shipped, empty boxes are added to the outer box
6. The outer box is sealed with security tape (P1) and a label (L5) is placed on the box.

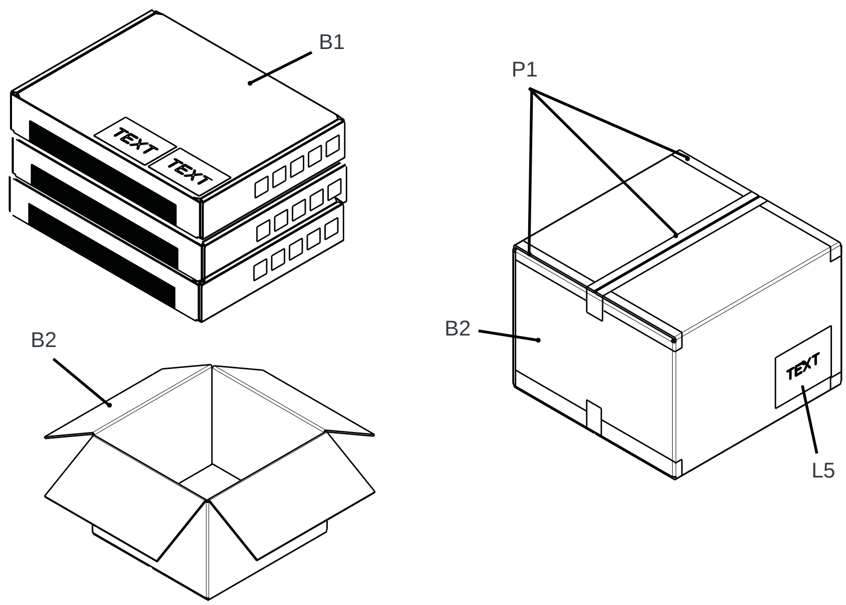

Figure 10-3: Outer (shipping) Box

11: References

This guide deals specifically with hardware integration issues that are unique to AirPrime embedded modules.

Sierra Wireless Documents

For additional documents describing embedded module design, usage, and integration issues, contact your Sierra Wireless account representative.

Command Documents

[1] AT Command Set for User Equipment (UE) (Release 6) (3GPP TS 27.007)

Industry/Other Documents

The following non-Sierra Wireless references are not included in your documentation package:

[2] FCC Regulations - Part 15 - Radio Frequency Devices

[3] IEC-61000-4-2 level 3

[4] IEC-61000-4-2 level (Electrostatic Discharge Immunity Test)

[5] Mobile Station (MS) Conformance Specification; Part 4: Subscriber Interface Module (Doc# 3GPP TS 11.10-4)

[6] PCI Express Mini Card Electromechanical Specification Revision 2.1

[7] Universal Serial Bus Specification, Rev 2.0

[8] JESD22-A114-B

[9] JESD22-C101

A: Acronyms

Table A-1: Acronyms and Definitions

Acronym or term	Definition
3GPP	3rd Generation Partnership Project
8PSK	Octagonal Phase Shift Keying
AGC	Automatic Gain Control
API	Application Programming Interface
BER	Bit Error Rate—A measure of receive sensitivity
BLER	Block Error Rate
bluetooth	Wireless protocol for data exchange over short distances
CQI	Channel Quality Indication
COM	Communication port
CS	Circuit-switched
CSG	Closed Subscriber Group
CW	Continuous waveform
dB	Decibel = 10 x $\log_{10}$ (P1/P2) *P1 is calculated power; P2 is reference power* Decibel = 20 x $\log_{10}$ (V1/V2) *V1 is calculated voltage, V2 is reference voltage*
dBm	A logarithmic (base 10) measure of relative power (dB for decibels); relative to milliwatts (m). A dBm value will be 30 units (1000 times) larger (less negative) than a dBW value, because of the difference in scale (milliwatts vs. watts).
DC-HSPA+	Dual Carrier HSPA+
DCS	Digital Cellular System A cellular communication infrastructure that uses the 1.8 GHz radio spectrum.
DL	Downlink (network to mobile)
DRX	Discontinuous Reception
DSM	Distributed Shared Memory
DUT	Device Under Test
eICIC	Enhanced Inter-Cell Interference Coordination
EIRP	Effective (or Equivalent) Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference

Table A-1: Acronyms and Definitions (Continued)

Acronym or term	Definition
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
FCC	Federal Communications Commission The U.S. federal agency that is responsible for interstate and foreign communications. The FCC regulates commercial and private radio spectrum management, sets rates for communications services, determines standards for equipment, and controls broadcast licensing. Consult www.fcc.gov.
FDD	Frequency Division Duplexing
FDMA	Frequency Division Multiple Access
feICIC	Further Enhanced Inter-Cell Interference Coordination
FER	Frame Error Rate—A measure of receive sensitivity.
firmware	Software stored in ROM or EEPROM; essential programs that remain even when the system is turned off. Firmware is easier to change than hardware but more permanent than software stored on disk.
FOTA	Firmware Over The Air—Technology used to download firmware upgrades directly from the service provider, over the air.
FOV	Field Of View
FSN	Factory Serial Number—A unique serial number assigned to the mini card during manufacturing.
GMSK	Gaussian Minimum Shift Keying modulation
GPS	Global Positioning System An American system that uses a series of 24 satellites in middle circular orbit to provide navigational data.
Host	The device into which an embedded module is integrated
HSDPA	High Speed Downlink Packet Access
HSPA+	Enhanced HSPA, as defined in 3GPP Release 7 and beyond
HSUPA	High Speed Uplink Packet Access
Hz	Hertz = 1 cycle/second
IF	Intermediate Frequency
IMEI	International Mobile Equipment Identity
IMS	IP Multimedia Subsystem—Architectural framework for delivering IP multimedia services.
inrush current	Peak current drawn when a device is connected or powered on
inter-RAT	Radio Access Technology
IOT	Interoperability Testing

Table A-1: Acronyms and Definitions (Continued)

Acronym or term	Definition
IS	Interim Standard. After receiving industry consensus, the TIA forwards the standard to ANSI for approval.
ISIM	IMS Subscriber Identity Module (Also referred to as a SIM card)
LED	Light Emitting Diode. A semiconductor diode that emits visible or infrared light.
LHCP	Left-Hand Circular Polarized
LNA	Low Noise Amplifier
LPM	Low Power Mode
LPT	Line Print Terminal
LTE	Long Term Evolution—a high-performance air interface for cellular mobile communication systems.
MCS	Modulation and Coding Scheme
MHz	Megahertz = 10e6 Hz
NAS / AS	Network Access Server
NC	No Connect
NIC	Network Interface Card
NLIC	Non-Linear Interference Cancellation
NMEA	National Marine Electronics Association
OEM	Original Equipment Manufacturer—a company that manufactures a product and sells it to a reseller.
OFDMA	Orthogonal Frequency Division Multiple Access
OMA DM	Open Mobile Alliance Device Management—A device management protocol.
OTA	‘Over the air’ (or radiated through the antenna)
PA	Power Amplifier
packet	A short, fixed-length block of data, including a header, that is transmitted as a unit in a communications network.
PCB	Printed Circuit Board
PCC	Primary Component Carrier
PCS	Personal Communication System A cellular communication infrastructure that uses the 1.9 GHz radio spectrum.
PDN	Packet Data Network
PMI	Pre-coding Matrix Index

Table A-1: Acronyms and Definitions (Continued)

Acronym or term	Definition
PSS	Primary synchronisation signal
PST	Product Support Tools
PTCRB	PCS Type Certification Review Board
QAM	Quadrature Amplitude Modulation. This form of modulation uses amplitude, frequency, and phase to transfer data on the carrier wave.
QOS	Quality of Service
QPSK	Quadrature Phase-Shift Keying
RAT	Radio Access Technology
RF	Radio Frequency
RI	Ring Indicator
roaming	A cellular subscriber is in an area where service is obtained from a cellular service provider that is not the subscriber’s provider.
RSE	Radiated Spurious Emissions
RSSI	Received Signal Strength Indication
SCC	Secondary Component Carrier
SDK	Software Development Kit
SED	Smart Error Detection
Sensitivity (Audio)	Measure of lowest power signal that the receiver can measure.
Sensitivity (RF)	Measure of lowest power signal at the receiver input that can provide a prescribed BER/BLER/SNR value at the receiver output.
SIB	System Information Block
SIM	Subscriber Identity Module. Also referred to as USIM or UICC.
SIMO	Single Input Multiple Output—smart antenna technology that uses a single antenna at the transmitter side and multiple antennas at the receiver side. This improves performance and security.
SISO	Single Input Single Output—antenna technology that uses a single antenna at both the transmitter side and the receiver side.
SKU	Stock Keeping Unit—identifies an inventory item: a unique code, consisting of numbers or letters and numbers, assigned to a product by a retailer for purposes of identification and inventory control.
S/N	Signal-to-noise (ratio)
SNR	Signal-to-Noise Ratio

Table A-1: Acronyms and Definitions (Continued)

Acronym or term	Definition
SOF	Start of Frame—A USB function.
SSS	Secondary synchronisation signal.
SUPL	Secure User Plane Location
TDD	Time Division Duplexing
TIA/EIA	Telecommunications Industry Association / Electronics Industry Association. A standards setting trade organization, whose members provide communications and information technology products, systems, distribution services and professional services in the United States and around the world. Consult www.tiaonline.org.
TIS	Total Isotropic Sensitivity
TRP	Total Radiated Power
UDK	Universal Development Kit (for PCI Express Mini Cards)
UE	User Equipment
UICC	Universal Integrated Circuit Card (Also referred to as a SIM card.)
UL	Uplink (mobile to network)
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module (UMTS)
VCC	Supply voltage
VSWR	Voltage Standing Wave Ratio
WAN	Wide Area Network
WLAN	Wireless Local Area Network
ZIF	Zero Intermediate Frequency
ZUC	ZUC stream cypher

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Numerics

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