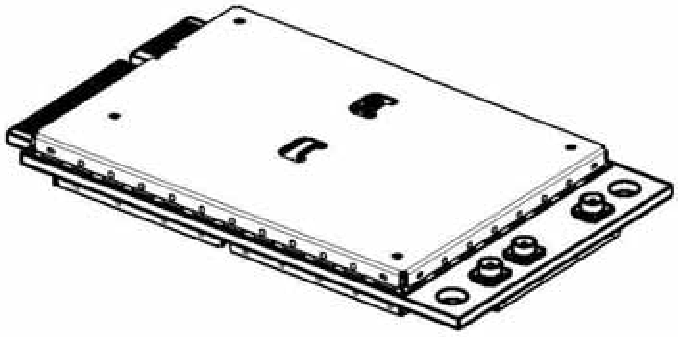
Product Technical Specification & Customer Design Guidelines

LTE7750



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1: Introduction

The Sierra Wireless LTE7750 PCI Express Mini Card is a compact, lightweight, wireless LTE- and CDMA-based modem, designed to be Verizon Wireless certified.

The LTE7750 provides LTE, CDMA, and GPS connectivity for portable and handheld computers, point-of-sale devices, telemetry products and other machine-to-machine and vertical applications over several radio frequency bands.

Supported RF bands

The modem, based on Qualcomm's MDM9600 baseband processor, supports data operation on LTE and CDMA networks.

Table 1-1: Supported RF bands

Technology	Bands	Diversity
LTE	• Band 13: 700 MHz	✔ (MIMO)
CDMA	• Cellular (800 MHz) • PCS (1900 MHz)	✔
GPS	• 1575.42 MHz	n/a

Physical features

- Small form factor—conforms to F1 as specified in *PCI Express Mini Card Electromechanical Specification Revision 1.2.*
- Operating temperature range: -30 °C to +60 °C

Application interface features

- USB interface (QMI)
- NDIS NIC interface support for Windows 7, Windows Vista, and Windows XP platforms
- Multiple non-multiplexed USB channel support
- USB selective suspend to maximize power savings
- AT command interface (*[1] AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)*, plus proprietary extended AT commands)
- Software Development Kit (SDK) including a Linux API (Application Program Interface)

- WMC DLL support for Verizon Wireless PC-OEM (Windows)OMA DM (Open Mobile Alliance Device Management)FOTA (Firmware Over The Air)

Packet mode features

- LTE data rates (category 3, MIMO)
  - 100 Mbps DL within 20 MHz bandwidth
  - 50 Mbps UL within 20 MHz bandwidth
- CDMA IS-856 (1xEV-DO Rev. A) data rates
  - Up to 3.1 Mbps forward channel
  - Up to 1.8 Mbps reverse channel
- CDMA IS-2000 data rates—Up to 153 kbps, simultaneous forward and reverse channel
- Circuit-switched data bearers (up to 14.4 for CDMA)

LTE features

- Basic cell selection and system acquisition
  - PSS/SSS/MIB decode
  - SIB1, SIB2, SIB3 decoding
- NAS/AS security procedures
  - Snow 3G/AES security
- CQI/RI 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)
- Connected mode intra-LTE mobility
- Idle mode intra-LTE mobility
- iRAT between LTE/2G (future release)
  iRAT between LTE/3G for idle and connection release with redirection (future release)
- Detach procedure
  - Network-initiated detach with reattach required
  - Network-initiated detach followed by connection release
- LTE → eHRPD redirection with data continuity (IPv4/IPv6)

Short Message Service (SMS) features

- Mobile-terminated SMS for CDMA
- Mobile-originated SMS for CDMA
- Mobile-terminated SMS over IMS for LTE/eHRPD

- Mobile-originated SMS over IMS for LTE/eHRPD

Position location (GPS)

- Standalone mode
- GLONASS support on GPS connector 1 (future release)
- DC bias on GPS connector 1 to support external active GPS antenna

Warranty and support

The LTE7750 offers the following support features:

- Standard 1-year warranty
- Enabling software (drivers, SDK, etc.) for Android, Linux, Windows 7, Windows Vista, and Windows XP

Supporting documents

Several additional documents describe Mini Card design, usage, integration, and other features. See References on page 87.

Accessories

The Universal Development Kit (UDK) is a hardware development platform for AirPrime MC-series modules. It contains hardware components for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas (Bands 17, 13, and 7 are not supported by supplied antennas)
- Documentation suite
- Initial allotment of support hours
- Other accessories

For instructions on setting up the UDK, see *[4] PCI Express Mini Card Dev Kit Quick Start Guide (Doc# 2130705).*

For over-the-air LTE testing, ensure that suitable antennas are used. (Two antennas are required for this testing; Sierra Wireless offers an LTE-capable antenna covering 700–2600 MHz BW—please order part number 6000492 (Qty 1—this contains two antennas).)

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[1]

Connector type	Description
RF cables	• Mate with Hirose U.FL connectors (model U.FL #CL331-0471-0-10) • Two or three connector jacks, depending on module support for diversity and GPS functionality. (Note: The UDK has two 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

1. 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 LTE7750 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 and Industry Approvals on page 59.
- **Service provisioning**—Manufacturing process
- **Software**—As discussed in Software Interface on page 51.
- **Host Interface**, compliance with interface voltage levels

2: Technology Overview

2

LTE

LTE (Long Term Evolution) is a 4th-generation wireless standard. The 3GPP Release 8 specification outlines the features and requirements.

Key features include.

- Peak data rate:
  - 100 Mbps DL within 20 MHz bandwidth
    (Peak DL data rate in 10 MHz bandwidth: 70 Mbps (approx.) for Cat 3 device)
  - 50 Mbps UL within 20 MHz bandwidth

  Actual throughput is dependent on the network configuration, bandwidth assigned to the UE, the number of users, and RF signal conditions.
- Up to 200 active users in a cell (5 MHz)
- Less than 5 ms user-plane latency
- Supported bandwidths: 5 MHz/10 MHz
- Spectrum flexibility: 1.4–20 MHz (3–20 MHz in future F/W release)
- Enhanced support for end-to-end QOS
- Physical layer uses:
  - DL: OFDMA (Orthogonal Frequency Division Multiple Access). Modulation: QPSK, 16QAM, and 64QAM
  - UL: Single Carrier FDMA (single carrier modulation and orthogonal frequency multiplexing)
    Modulation: QPSK, 16QAM
- MIMO (Multi-Input Multi-Output) antenna support

CDMA

1xEV-DO

1xEV-DO is backwards compatible to both 1X and IS-95A/B standards. However, 1xEV-DO represents an evolutionary enhancement, specifically designed and optimized for high-speed wireless data access. This was driven by fundamental differences between voice and data traffic characteristics.

eHRPD (Enhanced High Rate Packet Data) is an enhancement of 1xEV-DO that enables LTE to CDMA handover.

To optimize for data, there are some fundamental characteristics and differences between 1X and 1xEV-DO, including:

- The network has dedicated spectrum (1.25 MHz) for data traffic using 1xEV-DO standard, so resources don't compete with 1X data/voice (hybrid mode used to monitor 1X carriers)
- BTS always transmits at maximum available power
- Each user receives data from only one base station at a time (no forward link soft handoff)
- 1xEV-DO lets each user use 100% of available resources, while dynamically allocating time resources among users for maximum efficiency
- 1xEV-DO uses time-division multiplexing of users on forward link (slots assigned for packet transmission)
- Forward link supports higher order modulation (QPSK, 8-PSK and 16-QAM)
- Reverse link (1xEV-DO Revision A) supports higher order modulation (8-PSK)
- Mobile supports dynamic channel estimation using measured S/N to set the highest rate it can decode (uses Data Rate Control channel to communicate to network access point)
- Mobiles can support Rx diversity for S/N enhancements particularly in multi-path/fading environments

1X and IS-95A

The type of data connection made at any given time depends on the services available from the carrier in the given coverage area. If 1X packet services are not available, the modem connects using circuit-switched data over IS-95A technology. The modem automatically selects the fastest connection mode available when a data call is connecting.

When roaming, the modem **does not** automatically change connection modes. If the modem connects using 1X and then roams outside of the packet service area, the connection is dropped. To resume data communication, a new connection using IS-95A has to be created. Similarly, an IS-95A call established in one area does not automatically transition to 1X when the unit enters the 3G coverage area.

3: Standards Compliance

The LTE7750 Mini Card complies with the mandatory requirements described in the following standards. The exact set of requirements supported is carrier-dependent.

Table 3-1: Standards compliance

Technology	Standards
LTE	• 3GPP Release 8
CDMA	• TIA/EIA/IS-2000.1 through .6. *cdma2000® Standards for Spread Spectrum Systems. Release 0.* April 2000 • TIA/EIA/IS-2000.1-1 through .6-1. *cdma2000® Addendum 1.* April 2000 • TIA/EIA/IS-2000.1-2 through .6-2. *cdma2000® Addendum 2.* June 2001 • TIA/EIA/IS-95-B. *Mobile Station-Base Station Compatibility Standard for Dual-Mode Spread Spectrum Systems.* December 4, 1998 • TIA/EIA/IS-. *cdma2000® High Rate Packet Data Air Interface Specification.* November 2000

4: Electrical Specifications

4

The system block diagram in Figure 4-1 represents the LTE7750 module integrated into a host system. The module includes the following interfaces to the host:

- **Power**—Supplied to the module by the host.
- **W_DISABLE_N**—Active low input from a hardware switch to the LTE7750 that disables the main RF radio.
- **WLAN_LED_N**—Active-low LED drive signal provides an indication of RADIO ON state, either WAN or GPS.
- **Antenna**—Three U.FL RF connectors (two for Rx/Tx, and one for GPS). For details, see RF Specifications on page 37.
  Note that GPS can use either the dedicated GPS port, or the diversity/MIMO port. GLONASS is supported only on the dedicated GPS port.
- **SIM**—Supported through the interface connector. The SIM cavity / connector must be placed on the host device for this feature.
- **USB**—Interface to the host for data, control, and status information.
- **GPIO**—Six GPIOs reserved for future use.

The LTE7750 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.

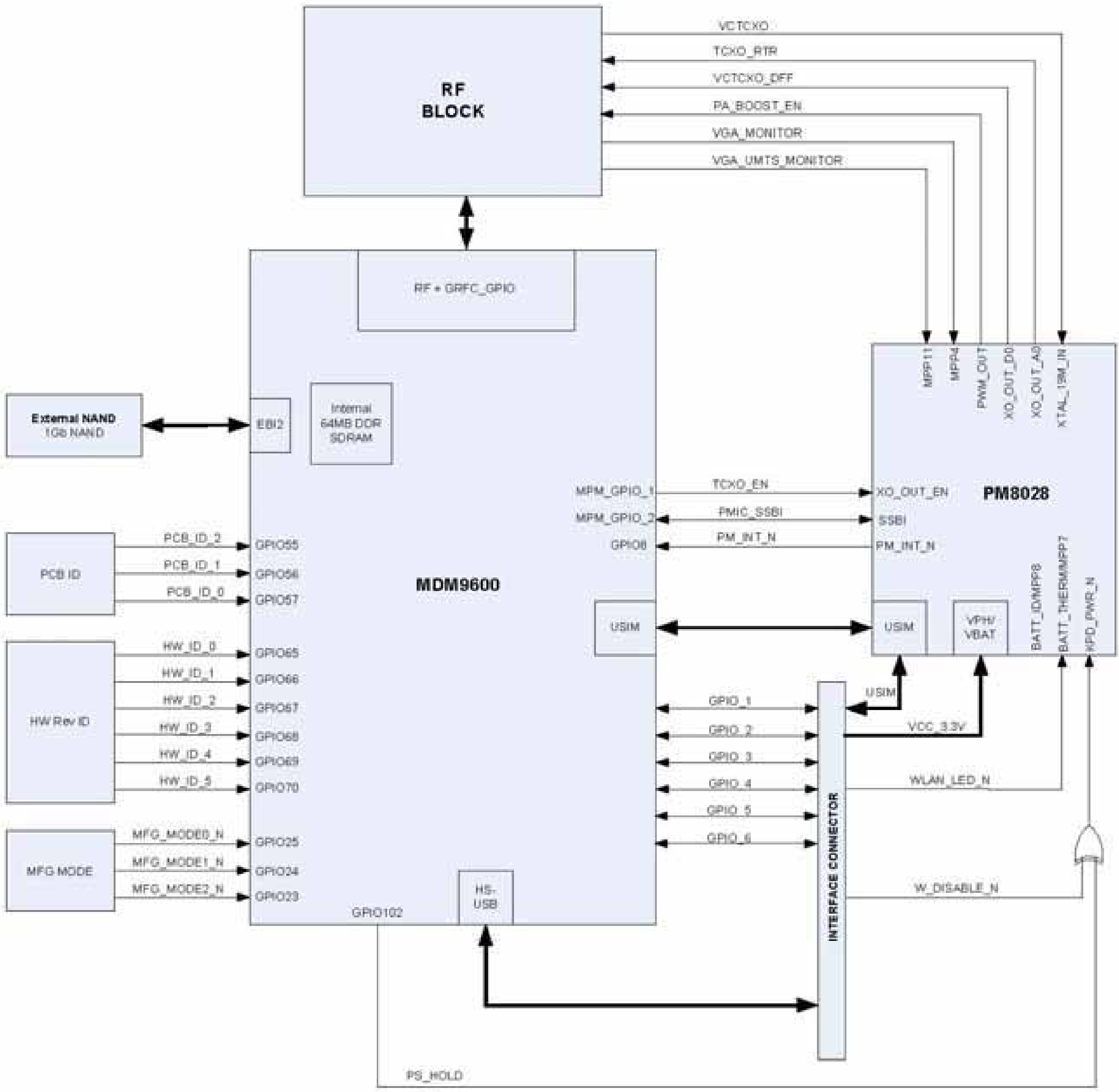

Figure 4-1: System block diagram

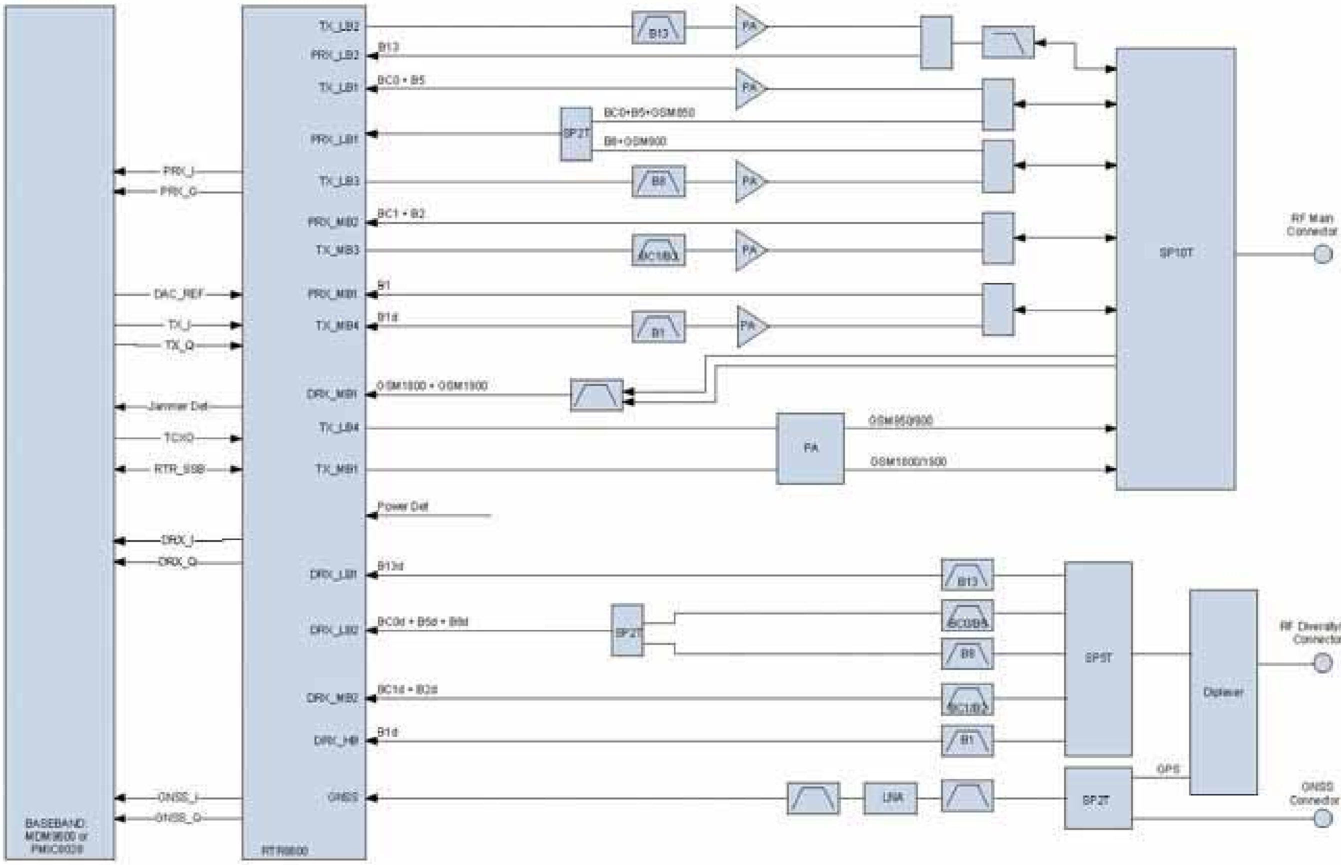

Figure 4-2: Expanded RF block diagram

Host interface pin assignments

The LTE7750 host I/O connector provides pins for power, serial communications, and control. Pin assignments are listed in Table 4-1. See the following tables for pin details based on interface types:

- Table 4-2, Power and ground specifications, on page 29
- Table 4-3, USB interface, on page 29
- Table 4-4, SIM interface signal, on page 30
- Table 4-5, Module control signals, on page 33

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

*Note: The following table describes the **internal** structure of the module.*
GPIO pins are reserved for future use. For applications not requiring GPIO functionality, leave these pins not connected on the host.

Table 4-1: Connector pin assignments[1]

Pin	Signal name	Pin type[2]	Description	Direction to module	Active state	Voltage levels (V)		
						Min	Typ	Max
1	NC	-	No connect Reserved for future use.	-	-	-	-	-
2	VCC	V	3.3 V supply	Input	Power	3.0	3.3	3.6
3	NC	-	No connect Reserved for future use	-	-	-	-	-
4	GND	V	Ground	Input	Power	-	0	-
5	NC	-	No connect Reserved for future use	-	-	-	-	-
6	GPIO1	-	General purpose I/O	Input high	-	1.17	1.80	2.10
				Input low	-	-0.3	-	0.63
				Output high	-	1.35	-	1.80
				Output low	-	0	-	0.45
7	NC	-	No connect	-	-	-	-	-
8	USIM_PWR	-	SIM VCC supply	Output	Power	2.95 (3V SIM) 1.75 (1.8V SIM)	3.00 (3V SIM) 1.8 (1.8V SIM)	3.05 (3V SIM) 1.85 (1.8V SIM)
9	GND	V	Ground	Input	Power	-	0	-
10	USIM_DATA	-	SIM IO pin	Input	Low	-0.3 (3V SIM) -0.3 (1.8V SIM)	-	1.05 (3V SIM) 0.63 (1.8V SIM)
					High	1.95 (3V SIM) 1.17 (1.8V SIM)	3.0 (3V SIM) 1.8 (1.8V SIM)	3.3 (3V SIM) 2.1 (1.8V SIM)
				Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	-	3.0 (3V SIM) 1.8 (1.8V SIM)
11	NC	-	No connect	-	-	-	-	-
12	USIM_CLK	-	SIM Clock	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	-	3.0 (3V SIM) 1.8 (1.8V SIM)
13	NC	-	No connect	-	-	-	-	-

Table 4-1: Connector pin assignments[1] (Continued)

Pin	Signal name	Pin type[2]	Description	Direction to module	Active state	Voltage levels (V)		
						Min	Typ	Max
14	USIM_RST	-	SIM Reset	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	-	3.0 (3V SIM) 1.8 (1.8V SIM)
15	GND	V	Ground	Input	Power	-	0	-
16	GPIO2	-	General purpose I/O	Input high	-	1.17	1.80	2.10
				Input low	-	-0.3	-	0.63
				Output high	-	1.35	-	1.80
				Output low	-	0	-	0.45
17	NC	-	No connect	-	-	-	-	-
18	GND	V	Ground	Input	Power	-	0	-
19	NC	-	No connect	-	-	-	-	-
20	W_DISABLE_N	-	Wireless Disable (main RF radio)	Input	Low	-	-	0.4
21	GND	V	Ground	Input	Power	-	0	-
22	NC	-	No connect	-	-	-	-	-
23	NC	-	No connect	-	-	-	-	-
24	VCC	V	3.3 V supply	Input	Power	3.0	3.3	3.6
25	NC	-	No connect	-	-	-	-	-
26	GND	V	Ground	Input	Power	-	0	-
27	GND	V	Ground	Input	Power	-	0	-
28	GPIO3	-	General purpose I/O	Input high	-	1.17	1.80	2.10
				Input low	-	-0.3	-	0.63
				Output high	-	1.35	-	1.80
				Output low	-	0	-	0.45
29	GND	V	Ground	Input	Power	-	0	-
30	NC	-	No connect	-	-	-	-	-
31	NC	-	No connect	-	-	-	-	-
32	NC	-	No connect	-	-	-	-	-
33	NC	-	No connect	-	-	-	-	-
34	GND	V	Ground	Input	Power	-	0	-
35	GND	V	Ground	Input	Power	-	0	-
36	USB_D-	-	USB data negative	Input/Output	Differential	-	-	-

Table 4-1: Connector pin assignments[1] (Continued)

Pin	Signal name	Pin type[2]	Description	Direction to module	Active state	Voltage levels (V)		
						Min	Typ	Max
37	GND	V	Ground	Input	Power	-	0	-
38	USB_D+	-	USB data positive	Input/Output	Differential	-	-	-
39	VCC	V	3.3 V supply	Input	Power	3.0	3.3	3.6
40	GND	V	Ground	Input	Power	-	0	-
41	VCC	V	3.3 V supply	Input	Power	3.0	3.3	3.6
42	WLAN_LED_N	-	LED Driver	Output	Low	0	-	0.45
43	GND	V	Ground	Input	Power	-	0	-
44	GPIO4	-	General purpose I/O	Input high	-	1.17	1.80	2.10
				Input low	-	-0.3	-	0.63
				Output high	-	1.35	-	1.80
				Output low	-	0	-	0.45
45	NC	-	No connect	-	-	-	-	-
46	GPIO5	-	General purpose I/O	Input high	-	1.17	1.80	2.10
				Input low	-	-0.3	-	0.63
				Output high	-	1.35	-	1.80
				Output low	-	0	-	0.45
47	NC	-	No connect	-	-	-	-	-
48	GPIO6	-	General purpose I/O	Input high	-	1.17	1.80	2.10
				Input low	-	-0.3	-	0.63
				Output high	-	1.35	-	1.80
				Output low	-	0	-	0.45
49	NC	-	No connect	-	-	-	-	-
50	GND	V	Ground	Input	Power	-	0	-
51	NC	-	No connect Reserved for future use	-	-	-	-	-
52	VCC	V	3.3 V supply	Input	Power	3.0	3.3	3.6

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

Power supply

The host provides power to the LTE7750 through multiple power and ground pins as summarized in Table 4-2.

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 4-2: Power and ground specifications

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

USB interface

The USB interface is the path for communication between the host and module.

The interface complies with the *[12] Universal Serial Bus Specification, Rev 2.0*, and the host device must be designed to the same standard. (When designing the host device, careful PCB layout practices must be followed.)

Table 4-3: USB interface

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

USB interface features include:

- Data rate: Full-speed (12 Mbps)/High-speed (480 Mbps)
- Module enumeration:
  - Windows: Modem or COM ports, using host Windows drivers
  - Linux: /dev/ttyUSB*n* devices for Linux systems with the Sierra Wireless driver installed
- USB-compliant transceivers
- Selective suspend mode
- Resumption initiated by host or module

USB high/full speed throughput performance

This device has been designed to achieve optimal performance and maximum throughput using USB high speed mode. Although the device may operate with a full 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. Sierra Wireless does not recommend using this device in USB full speed mode.

User-developed drivers

If you will be developing your own USB drivers, see *[5] AirCard/AirPrime USB Driver Developer's Guide (Doc# 2130634)*.

SIM interface

The module supports one SIM (Subscriber Identity Module) (1.8 V or 3 V). The SIM holds account information, allowing users to use their account on multiple devices.

The SIM pins (Table 4-4) provide the connections necessary to interface to a SIM socket located on the host device as shown in Figure 4-3 on page 31. Voltage levels over this interface comply with 3GPP standards.

Table 4-4: SIM interface signal

Name	Pin	Description	SIM contact number[1]	Notes
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

1. See Figure 4-4 on page 31 for SIM card contacts.

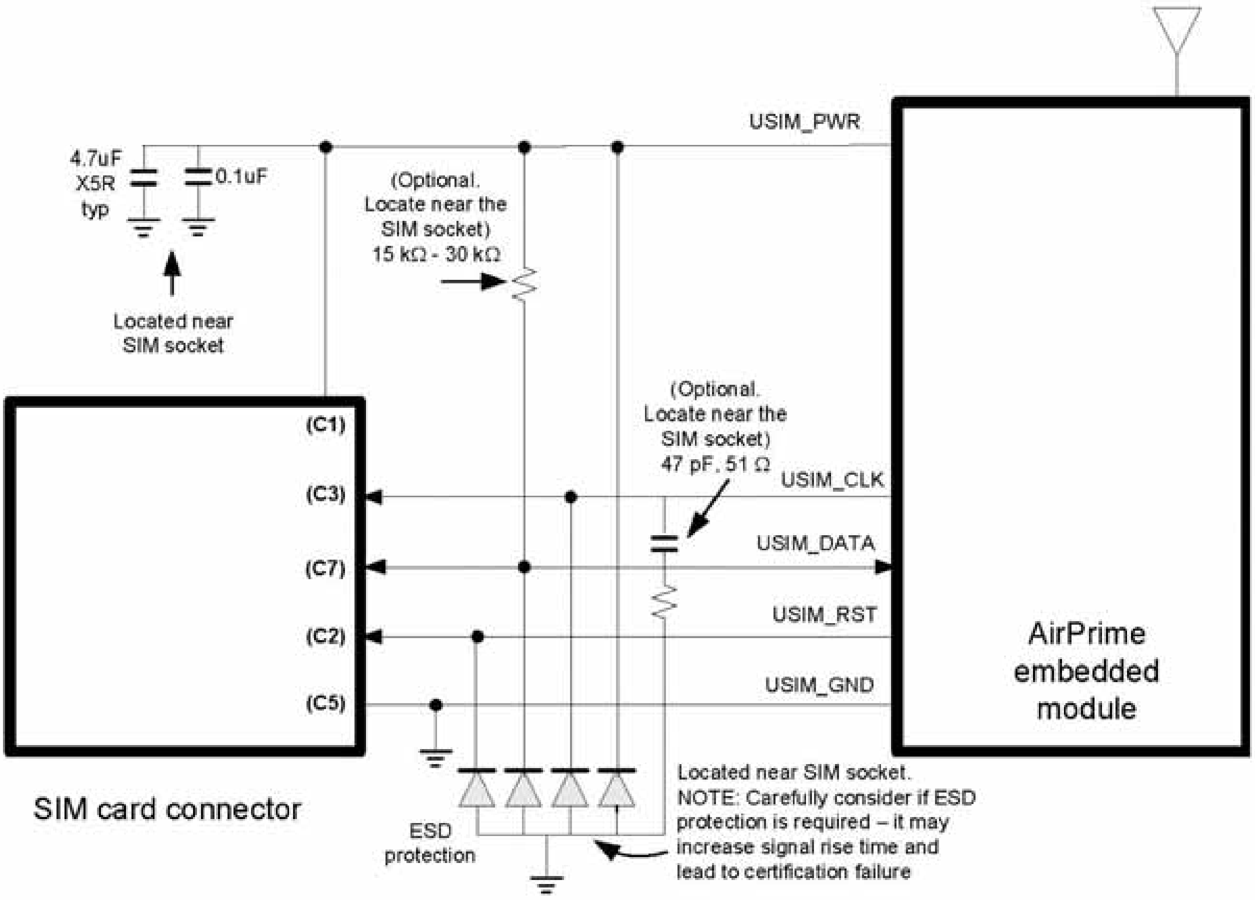

Figure 4-3: SIM application interface

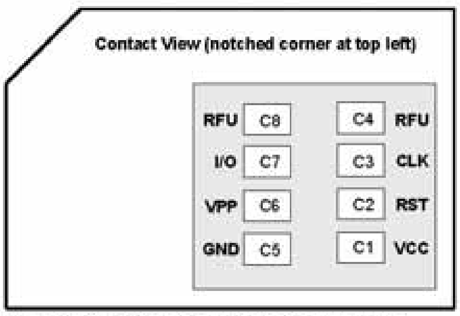

Figure 4-4: SIM card contacts (contact view)

SIM implementation

Note: For interface design requirements, refer to: (2G) 3GPP TS 51.010-1, section 27.17, or (3G) 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.
- Reduce crosstalk on the USIM_DATA line to reduce the risk of failures during GCF approval testing.
- Avoid routing the USIM_CLK and USIM_DATA lines in parallel over distances >2 cm—cross-coupling of these lines 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 USIM signals as short as possible, and keep very low capacitance traces on the USIM_DATA and USIM_CLK signals. 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 USIM_DATA and USIM_PWR lines 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 an optional decoupling capacitor at USIM_PWR near the SIM socket 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) at USIM_CLK at the SIM socket 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 LTE7750 provides signals for:

- Power control of the module from the host
- LED driver output

These signals are summarized in Table 4-5 and paragraphs that follow.

Table 4-5: Module control signals

Name	Pin	Description	Type[1]
W_DISABLE_N	20	Wireless disable (Main RF)	PU
WLAN_LED_N	42	LED driver	O

1. O—Digital pin Output; PU—Digital pin Input, internal pull up

W_DISABLE_N — Wireless disable

The host device uses W_DISABLE_N (pin 20) to enable/disable the WWAN or radio modem. When disabled, the modem cannot transmit or receive information.

Letting this signal float high allows the module to operate normally. This switch follows the behavior described in *[11] PCI Express Mini Card Electromechanical Specification Revision 1.2*. This pin has a 20 kΩ pull-up resistor. See Figure 4-5 on page 33 for a recommended implementation.

When integrating with your host device, keep the following in mind:

- The signal is an input to the module and should be driven LOW only for its active state (controlling the power state); otherwise it should be floating or (High impedance). It should never be driven to a logic high level. The module has an internal pull-up resistor to Module Power (3.3V) in place, so if the signal is floating or (high impedance), the module will power on.
- Wait for two seconds after asserting W_DISABLE_N before disconnecting power.
- If the host never needs to assert this power state control to the module, leave this signal unconnected from the host interface.

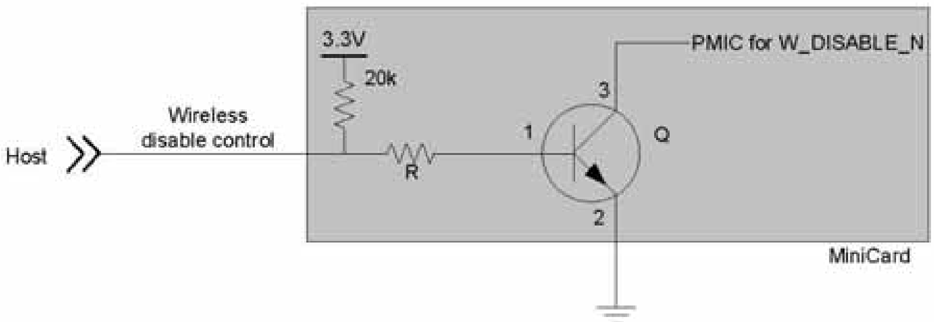

Figure 4-5: Recommended wireless disable connection

WLAN_LED_N—LED output

The module drives the LED output according to *[11] PCI Express Mini Card Electromechanical Specification Revision 1.2*, as described in Table 4-6 (below).

If desired, LED behavior can be configured using **ATILEDCTRL**.

Table 4-6: LED states (Default behavior)

State	LED behavior			Description	!LEDCTRL index
	Period (s)	On	Off		
Off	0	0%	100%	Module is not powered. (W_DISABLE_N asserted with PCOFFEN=1)	N/A
Airplane mode	2	50%	50%	Module is in low power mode. (W_DISABLE_N asserted with PCOFFEN=0)	4
Power up	5.2	96%	4%	Module is performing initial power up activities.	N/A
Searching		96%	4%	Module is searching service.	1
Connected	0.5	80%	20%	Module has an active context.	3
Connected, with data transfer occuring	0.5	80%	20%	Module has an active context and data is being transferred.	5
Error	1.6	20%	80%	Device error has occurred.	N/A
Attached	1	100%	0%	Module has attached to a network and is not currently in a call.	2

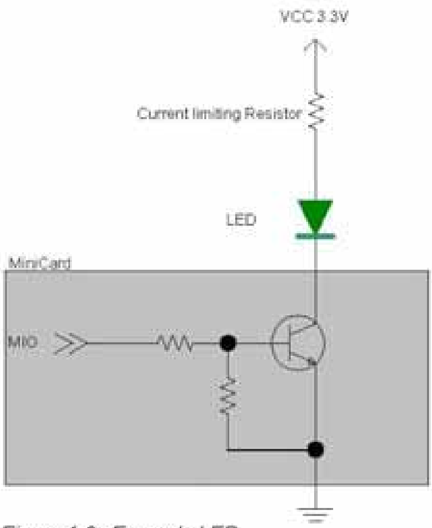

Figure 4-6: Example LED

Digital interface

The LTE7750 Mini Card provides the general purpose digital I/O (GPIO) signals listed in Table 4-7:

- By default, all GPIO pins are set as inputs.
- Voltage should not be applied until > 1s after VCC is applied to the minicard.
- GPIO pins are available for OEM-defined purposes but may, in future firmware releases, be allocated by Sierra Wireless for specific functionality.
- For applications not requiring GPIO functionality, leave these pins not connected on the host.

Table 4-7: GPIO signals

Name	Pin	Description	Type[1,2]
GPIO1	6	General purpose IO	PD
GPIO2	16	General purpose IO	PD
GPIO3	28	General purpose IO	PD
GPIO4	44	General purpose IO	PD
GPIO5	46	General purpose IO	PD
GPIO6	48	General purpose IO	PD

1. GPIO pins are initialized as PD by the firmware.
2. PD—Digital pin Input, internal pull down

5: RF Specifications

5

The LTE7750 includes three RF connectors for use with host-supplied antennas:

- Main RF connector—Rx/Tx path
- GPS connector 1—Standalone GPS
- Diversity/MIMO/GPS connector 2—Diversity, MIMO, or GPS

The module does not have integrated antennas.

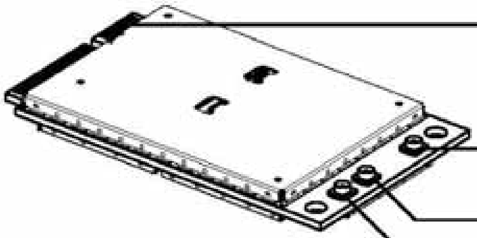

Figure 5-1: Module connectors

RF connections

When attaching antennas to the module:

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.*

- 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 5-1 on page 37.
- 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, if possible use the mounting holes 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 must not be removed.

Antenna and cabling

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

Note: For detailed electrical performance criteria, see Appendix A: Antenna Specification on page 65.

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 return loss of better than 10 dB across each frequency band of operation.
- The system gain value affects both radiated power *and* regulatory (FCC, IC, CE, etc.) 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 or spurious noise 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 39.

Disabling the diversity antenna

- For LTE bands, use the AT command **!RXDEN=0** to disable receive diversity or **!RXDEN=1** to enable receive diversity.
- For CDMA bands, use the AT command **!DIVERSITY** to enable or disable receive diversity.

Note: A diversity antenna is used to improve connection quality and reliability through redundancy. Because two antennas may experience difference interference effects (signal distortion, delay, etc.), when one antenna receives a degraded signal, the other may not be similarly affected.

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 5-1 on page 37).
- 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 40) and radiated sensitivity measurement (Radiated sensitivity measurement on page 41).

Note: The LTE7750 is based on ZIF (Zero Intermediate Frequency) technologies. When performing EMC (Electromagnetic Compatibility) tests, there are no IF (Intermediate Frequency) components from the module to consider.

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 the radiated spurious emission (RSE) test cases described in:

- (CDMA) Refer to CDMA standards for receive-only mode, and local regulatory bodies 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 carrier 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 4).

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 CDMA bands, sensitivity is defined as the input power level in dBm that produces a FER (Frame Error Rate) of 0.5%. Sensitivity should be measured at all CDMA frequencies across each band.

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

Supported frequencies

The LTE7750 supports:

- Single-band LTE—See Table 5-1 on page 42.
- Dual-band CDMA—See Table 5-3 on page 42.
- GPS
- Radio transceiver requirements for 3GPP Release 7

- Inter-RAT and inter-frequency cell reselection and handover between supported frequency bands

Table 5-1: LTE frequency band support

Band	Frequencies
Band 13	Tx: 777–787 MHz Rx: 746–756 MHz

Table 5-2: LTE bandwidth support[1]

Band	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Band 13	✘	✘	✔[2]	✔[2]	✘	✘

1. Table contents are derived from 3GPP TS 36.521-1 v9.4.1, table 5.4.2.1-1.
2. Bandwidth for which a relaxation of the specified UE receiver sensitivity requirement (Clause 7.3 of 3GPP TS 36.521-1 v9.4.1) is allowed.

Table 5-3: CDMA frequency band support

Band	Frequencies
PCS	Tx: 1850–1910 MHz Rx: 1930–1990 MHz
Cellular	Tx: 824–849 MHz Rx: 869–894 MHz

Conducted Rx sensitivity / Tx power

Table 5-4: Conducted Rx (Receive) sensitivity—LTE bands

LTE bands		Conducted Rx sensitivity (dBm)			
		Primary (Typical)	Secondary (Typical)	SIMO (Typical)	SIMO[1] (Worst case)
LTE Band 13	Full RB BW: 10 MHz[2]	-97.0[3]	-96.5[3]	-100.0[3]	-93.3

1. Per 3GPP specification
2. Sensitivity values scale with bandwidth:
   x_MHz_Sensitivity = 10 MHz_Sensitivity - 10*log(10 MHz/x_MHz)
3. Verizon Test Method

Table 5-5: Conducted Rx (Receive) sensitivity—CDMA bands

CDMA bands		Conducted Rx sensitivity (dBm)	
		Typical	Worst case
Cellular (800 MHz)	CDMA 1x 0.5% FER	-108.0	-104.0
	EVDO rev A 0.5% PER	-110.0	-105.5

Table 5-5: Conducted Rx (Receive) sensitivity—CDMA bands

CDMA bands		Conducted Rx sensitivity (dBm)	
		Typical	Worst case
PCS (1900 MHz)	CDMA 1x 0.5% FER	-107.5	-104.0
	EVDO rev A 0.5% PER	-109.5	-105.5

Table 5-6: Conducted Tx (Transmit) power tolerances

Parameter	Conducted transmit power (dBm)[1]	Notes
LTE		
LTE, Band 13	+23 dBm ± 1dB	
CDMA		
CDMA Band Class 0 (Cellular)	+24 dBm ± 1dB	
CDMA Band Class 1 (PCS)	+23.5 dBm ± 1dB (channel 1175) +24 dBm ± 1dB (other channels)	

1. Preliminary values

GPS specifications

Note: For detailed electrical performance criteria, see *Recommended GPS antenna specifications on page 67.*

Table 5-7: GPS specifications [1]

Parameter/feature	Description
Satellite channels	12 channel, continuous tracking
Protocols	NMEA 0183 V3.0
Acquisition time	Hot start: 1 s Warm start: 29 s Cold start: 32 s
Accuracy	Horizontal: < 2 m (50%); < 5 m (90%) Altitude: < 4 m (50%); < 8 m (90%) Velocity: < 0.2 m/s

Table 5-7: GPS specifications (Continued)[1]

Parameter/feature	Description
Sensitivity	Tracking[2]: -161 dBm Acquisition[3] (Assisted, non-LTE): -158 dBm Acquisition (Assisted, LTE): -153 dBm Acquisition (Standalone): -145 dBm
Operational limits	Altitude <6000 m or velocity <100 m/s (Either limit may be exceeded, but not both.)

1. All values are preliminary.
2. Tracking sensitivity is the lowest GPS signal level for which the device can still detect an in-view satellite 98% of the time when in sequential tracking mode.
3. Acquisition sensitivity is the lowest GPS signal level for which the device can still detect an in-view satellite 50% of the time.

6: Power

Power consumption

Note: All specifications in these tables are preliminary, based on chipset published expectations.

Power consumption measurements in the tables below are for the LTE7750 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 29.

Table 6-1: Averaged standby DC power consumption[1]

Signal	Description	Bands[2]	Current[3]			Notes / configuration
			Typ	Max[4]	Unit	
VCC	**Standby current consumption (Sleep mode activated[5])**					
	LTE	LTE Bands	5.5	8	mA	
	CDMA EVDO	CDMA bands	6	9.5	mA	
	Standby current consumption (Sleep mode deactivated[5])					
	LTE	LTE bands	55	65	mA	
	CDMA EVDO	CDMA bands	58	65	mA	
	Low Power Mode (LPM)/Offline Mode (Sleep mode activated[5])					
	RF disabled, but module is operational		2.5	3.0	mA	
	Low Power Mode (LPM)/Offline Mode (Sleep mode deactivated[5])					
	RF disabled, but module is operational		67	80	mA	

1. 3.3V supply voltage
2. For supported bands, see Table 5-1, LTE frequency band support, on page 42 and Table 5-3, CDMA frequency band support, on page 42.
3. All measurements are preliminary.
4. Measured at 30°C/nominal voltage.
5. Assumes USB bus is fully suspended during measurements

Table 6-2: CDMA DC power consumption (+3.3V)

Description	Bands	Typ	Max	Units	Notes / configuration
IS-2000 1X Data current	PCS	366	-	mA	SO32, RC3 (Fwd) / RC3 (Rvs), 153.6 kbps (Fwd) / 76.8 kbps (Rvs), CDG Urban Profile, USB active
		423	-	mA	SO32, RC3 (Fwd) / RC3 (Rvs), 153.6 kbps (Fwd) / 76.8 kbps (Rvs), CDG Suburban Profile, USB active
	Cellular	327	-	mA	SO32, RC3 (Fwd) / RC3 (Rvs), 153.6 kbps (Fwd) / 76.8 kbps (Rvs), CDG Urban Profile, USB active
		370	-	mA	SO32, RC3 (Fwd) / RC3 (Rvs), 153.6 kbps (Fwd) / 76.8 kbps (Rvs), CDG Suburban Profile, USB active
IS-856 1xEV-DO Revision 0 Data current	PCS	404	-	mA	CDG Urban Profile, USB active
		475	-	mA	CDG Suburban Profile, USB active
	Cellular	324	-	mA	CDG Urban Profile, USB active
		377	-	mA	CDG Suburban Profile, USB active
IS-856A 1xEV-DO Revision A Data current	PCS	408	-	mA	CDG Urban Profile, USB active
		479	-	mA	CDG Suburban Profile, USB active
	Cellular	331	-	mA	CDG Urban Profile, USB active
		386	-	mA	CDG Suburban Profile, USB active
Maximum peak current – operational	PCS or Cellular		1.2	A	Max RF output power, full rate, full operating temperature range.
Maximum peak current – call connected			1.0	A	Max RF output power, full rate, full operating temperature range

Table 6-3: Averaged call mode DC power consumption (LTE)[1]

Signal	Description	Band[2]	Current		Notes / configuration
			Max[3]	Unit	
VCC	**Data current consumption** (includes USB bus current)				
	LTE category 3	LTE bands	550	mA	100/50 Mbps—0 dBm Tx power

1. All measurements are preliminary values
2. For supported bands, see Table 5-1, LTE frequency band support, on page 42 and Table 5-3, CDMA frequency band support, on page 42.
3. Measured at 30°C/nominal voltage.

Table 6-4: Miscellaneous DC power consumption[1]

Signal	Description	Current		Unit	Notes/configuration
		Typ	Max		
VCC	Module OFF leakage current	490	830	µA	Full operating temperature range
	USB active current	18	25	mA	High speed USB connection, C_L = 50 pF on D+ and D- signals
	Inrush current	750	3000	mA	• Assumes power supply turn on time > 100µs • Dependent on host power supply rise time.
GPS signal connector	Active bias on GPS port		3.3 (100 mA)	V	GPS connector 1 in Figure 5-1 on page 37.

1. All measurements are preliminary values

Module power states

The module has five power states, as described in Table 6-5.

Table 6-5: Module power states

State	Details	Host is powered	Module is powered	USB interface active	RF enabled

Normal (Default state)	• Module is active
	• Default state when VCC is first applied in the absence of W_DISABLE_N control
	• Module is capable of placing/receiving calls, or establishing data connections on the wireless network
	• Current consumption is affected by several factors, including:
	  • Radio band being used
	  • Transmit power
	  • Receive gain settings
	  • Data rate
	  • Number of active Tx time slots
		✔	✔	✔	✔

Low power ('Airplane mode')	• Module is active • State is controlled by host interface using software commands: • +CFUN=0 (*[1] AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)*)	✔	✔	✔	✘
Sleep	• Normal state of module between calls or data connections • Module cycles between wake (polling the network) and sleep, at network provider-determined interval.	✔	✔	✘	✘

Table 6-5: Module power states (Continued)

State	Details	Host is powered	Module is powered	USB interface active	RF enabled
Off	• Host keeps module powered off by driving W_DISABLE_N low • Module draws minimal current • See W_DISABLE_N — Wireless disable on page 33 for more information.]	✔	✘	✘	✘
Disconnected	• Host power source is disconnected from the module and all voltages associated with the module are at 0 V.	✘	✘	✘	✘

Power state transitions

The module uses state machines to monitor supply voltage and operating temperature, and notifies the host when critical threshold limits are exceeded. (See Table 6-6 for trigger details and Figure 6-1 for state machine behavior.)

Power state transitions may occur:

- Automatically, when critical supply voltage or module temperature trigger levels are encountered.
- Under host control, using available AT commands in response to user choices (for example, opting to switch to airplane mode) or operating conditions.

Table 6-6: Power state transitions (including voltage/temperature trigger levels)

Transition	Voltage		Temperature[1]		Notes
	Trigger	V[2]	Trigger	°C	
Normal to Low Power	VOLT_HI_CRIT	3.6	TEMP_LO_CRIT	-25	• RF activity suspended
	VOLT_LO_CRIT	2.9	TEMP_HI_CRIT	95	
Low Power to Normal	VOLT_HI_NORM	3.5	TEMP_NORM_LO	-15	• RF activity resumed
Low Power to Normal or Remain in Normal (Remove warnings)	VOLT_LO_NORM	3.1	TEMP_HI_NORM	80	
Normal (Issue warning)	VOLT_LO_WARN	3.0	TEMP_HI_WARN	85	
Power off/on (Host-initiated)	-	-	-	-	• Power off recommended when supply voltage or module operating temperature is critically low or high.

1. Module-reported temperatures at the printed circuit board.
2. Supply voltage—3.3V

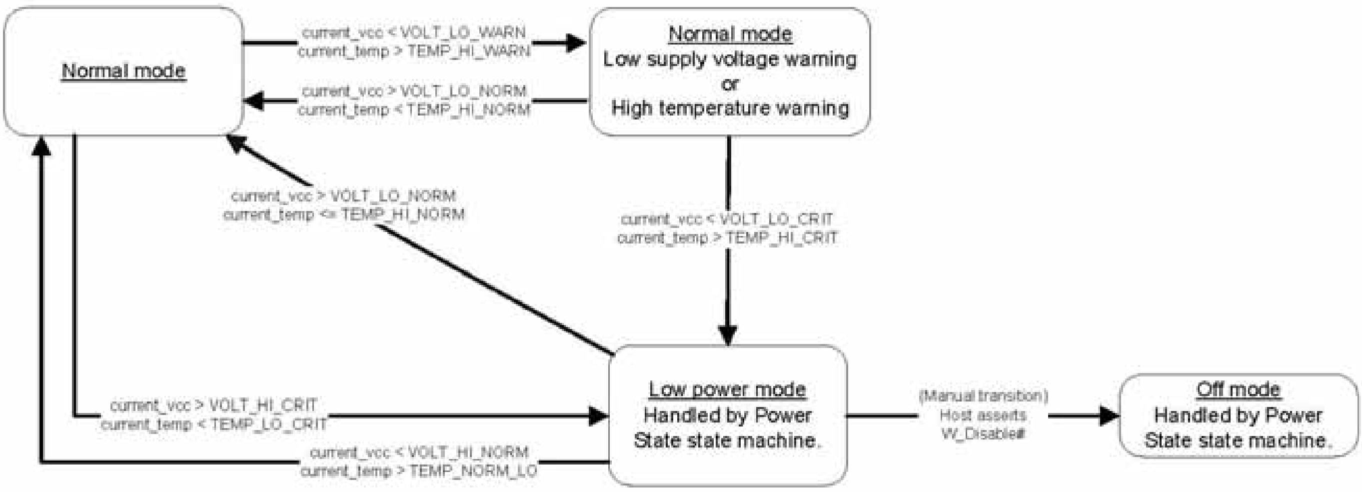

Figure 6-1: Voltage/temperature monitoring state machines

Power interface

Power ramp-up

On inital 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-up timing

The unit is ready to enumerate with a USB host within a maximum of 3–5 seconds after power-up. Figure 6-2 on page 49 illustrates the power-up timing sequence.

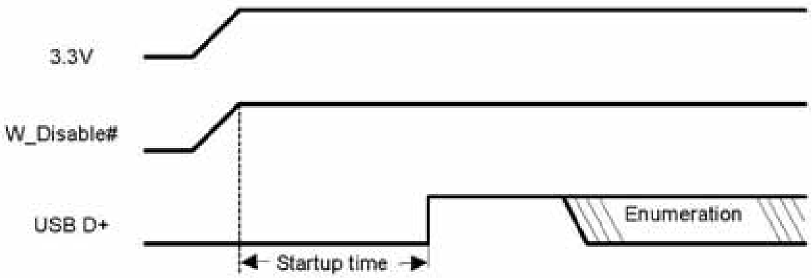

Figure 6-2: Power-up timing diagram

Note: Startup time is the time after power-up when the modem is ready to begin the enumeration sequence.

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 200 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.

SED (Smart Error Detection)

The module uses a form of SED to track premature modem resets.

- Module tracks consecutive resets occuring soon after power-on.
- After a sixth consecutive reset, the module waits in boot-and-hold mode for a firmware download to resolve the power-cycle problem.

7: Software Interface

7

Support tools

The LTE7750 is compatible with the following support tools from Sierra Wireless and authorized third parties:

- Firmware update utilities from Sierra Wireless
- Sierra Wireless Product Support Tool (SW-PST)
- CDMA Air Interface Tool (CAIT) from QUALCOMM
- QXDM from QUALCOMM
- QUALCOMM Product Support Tool (QPST)

USB interface

The device supports the Qualcomm QMI interface.

Please contact your Sierra Wireless account representative for QMI interface documentation.

MTU size

The MTU (Maximum Transmission Unit) size is configured using a driver installer command line option:

MTUSize=<value> (<value> is the size in bytes)

Verizon Wireless requires the MTU size to be 1428 bytes.

Example:

driverinstaller /MTUSize=1428

TCP window size (Windows XP)

The TCP window size for Windows XP is 128 kB (131072 bytes).