Hardware Integration Guide

AirPrime SL8084T

SIERRA WIRELESS

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

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Note: *Some airlines may permit the use of cellular phones while the aircraft is on the ground and the door is open. Sierra Wireless modems may be used at this time.*

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Document History

Version	Date	Updates
1.0	October 17, 2012	Document creation
1.1	October 17, 2012	Updated Table 6 RF Bands
2.0	January 07, 2013	Added sections: • 4 RF Circuit Routing Constraints • 6.3 Important Compliance Information for North American Users
		Updated section 2.1 Power Supply
2.1		Updated Table 2 Averaged Call Mode Data DC Power Consumption

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1. Introduction

The Sierra Wireless AirPrime SL8084T soldered-down module forms the radio component for the products in which it is embedded.

Module-specific performance and physical characteristics are described in document [2] AirPrime SL808x Product Technical Specification and Customer Design Guidelines.

Note: An understanding of network technology, and experience in integrating hardware components into electronic equipment is assumed.

1.1. Hardware Development Components

Sierra Wireless manufactures two hardware development components to facilitate the hardware integration process:

- AirPrime SL Socket Board – Adapter board into which an SL module is embedded. This board may be used as a stand-alone platform for basic hardware development.
- AirPrime SL Development Kit – Hardware development platform that integrates with the socket-up board. The development kit provides access to all of the interfaces supported by the SL module.

For instructions on using the SL Development Kit, see document [1] Universal AirPrime SL Series Development Kit User Guide.

2. Power Interface

2.1. Power Supply

Power is provided to the SL8084T through power and ground pins as detailed in the following table.

Table 1. Power and Ground Specifications

Signal/Pin Name	Pins	Type	Specification	Parameter	Min	Typ	Max	Units
VCC_3V6[a]	42, 44	V	Voltage range	VCC	3.30	3.60	4.30	V
			Ripple voltage (U_{ripp})				100	mVpp
VREF_1V8	10	V	Maximum supply current = 1 mA		1.62	1.80	1.98	V
GND	19, 20, 21, 23, 28, 30, 35, 37, 38, 39, 52	V			-	0	-	V

a. Host-provided input voltage should provide 3A instantaneous (lasting 5ms) current. See the table below for band-specific continuous current requirements.

Table 2. Averaged Call Mode Data DC Power Consumption[a]

Mode	Band	Tx Power	Current (at 3.6V)					Conditions
			Peak (mA)[b]	Average (mA)				
WCDMA[c]	Band 1	+23	550	500				
		0	190	190				
	Band 5 or 6	+23	550	500				
		0	180	180				
HSDPA[c]	Band 1	+23	570	520				
		0	210	210				
	Band 5 or 6	+23	570	520				
		0	200	200				
GSM / GPRS[d]				1 slot	2 slots	3 slots	4 slots	
	850	+32	1320	220	360	-	-	• Class 10 • 50Ω
	900	+32	1610	260	425	-	-	
	1800	+30	1000	180	285	-	-	
	1900	+30	860	165	260	-	-	

Mode	Band	Tx Power	Current (at 3.6V)					Conditions
			Peak (mA)[b]	Average (mA)				
EDGE	850	+27	860	170	260	340	400	• Class 12 • 50Ω
	900	+27	960	180	280	360	430	
	1800	+26	740	150	230	290	340	
	1900	+26	660	150	220	270	300	

a. Includes USB bus current.

b. Peak consumption averaged over 100µs.

c. Current consumption increases by 50mA with a 6dB return loss-based load-pull.

d. GSM mode peak current increases to 2.2A (from nominal 1.6–1.7A) with 6dB return loss-based load-pull.

The host device must provide power to the AirPrime soldered-down module over pins 42 and 44 (VCC_3V6) as detailed in the following table.

Table 3. Power Supply Requirements

Requirement Type	Value
Power Supply	3.6V (nominal)
Voltage Range (V_{MIN} – V_{MAX})	3.3V – 4.3V
Current (instantaneous (≤5ms))	3A
Current (continuous)	700mA

Note: The host must provide safe and continuous power to the module; the module does NOT have protection circuits to guard against electrical overstress.

2.2. Electrostatic Discharge (ESD)

The host device must provide adequate ESD protection on digital circuits and antenna ports as detailed in the following table.

Note: The level of protection required depends on the application.

Table 4. ESD Specifications

Category	Connection	Specification
Operational	RF port (antenna launch and RF connector)	IEC-61000-4-2 — Level (Electrostatic Discharge Immunity Test)
Non-operational	Host connector interface	Unless otherwise specified: • JESD22-A114-B +/- 2kV Human Body Model • JESD22-C101 +/- 300V Charged Device
Signals	USIM connector	ESD protection is highly recommended at the point where the USIM contacts are exposed, and for any other signals that would be subjected to ESD by the user.
	Other host signals	

2.3. Power States

The SL8084T module has five power states as detailed in the following table.

Table 5. Supported SL8084T Power States

State	Description	Host Powered	Module Powered	USB Interface Active	RF Enabled
Normal (Default state)	• Capable of placing / receiving calls or establishing data connections on network • USB interface is fully active • Current consumption in a call or data connection is affected by: ▪ Radio band in use ▪ Tx power ▪ Receive gain settings ▪ Data rate ▪ Number of active Tx time slots	✓	✓	✓	✓
Low Power	• 'Airplane' mode — Rx / Tx are disabled; USB interface is active • State entered automatically when critical voltage / temperature thresholds are exceeded. Host should consider powering off module to prevent damage to unit.	✓	✓	✓	×
Sleep	• Normal state of module between calls or data connections. • Module cycles between wake (polling the network) and sleep, at network provider-determined interval.	✓	✓	×	×
Off	• Host power is connected • Module is powered down (drawing minimal current from host power supply)	✓	×	×	×
Disconnected	• Host power is disconnected from module • All module-related voltages are at 0V	×	×	×	×

3. RF Integration

3.1. Supported RF Bands

Table 6. RF Bands

Technology	Band	Tx Frequency (MHz)	Rx Frequency (MHz)
GSM	GSM 850	824 – 849	869 – 894
	EGSM 900	880 – 915	925 – 960
	DCS 1800	1710 – 1785	1805 – 1880
	PCS 1900	1850 – 1910	1930 – 1990
WCDMA[1]	Band I (WCDMA 2100)	1920–1980	2110–2170
	Band V (WCDMA 850)	824 – 849	869 – 894
	Band VI (WCDMA 800)	830–840	875–885

1 WCDMA channel spacing is 5 MHz, but this can be adjusted to optimize performance in a particular deployment scenario.

3.1.1. Ground Connection Guidelines

When connecting the module to system ground:

- Prevent noise leakage by establishing a very good ground connection to the module through the host connector.
- 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.

3.1.2. Shielding Guidelines

The module is fully shielded to protect against EMI and to ensure compliance with FCC Part 15 - “Radio Frequency Devices” (or equivalent regulations in other jurisdictions).

Note: This shielding must NOT be removed.

3.2. Antenna Guidelines

3.2.1. Choosing the Correct Antenna and Cabling

Consider the following points for appropriate antenna selection:

- The antenna (and associated circuitry) should have a nominal impedance of 50Ω 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.

3.2.2. Determining the Antenna's Location

Consider the following points when deciding where to place the antenna:

- 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 50Ω 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.

3.3. RF Desense Sources

Common sources of interference that may affect the module's RF performance (RF desense) include

- Power supply noise
  - Can lead to noise in the RF signal
  - Module power supply ripple limit <= 100 mV_{p-p} 1 Hz–100 kHz
- Interference from other embedded wireless devices
  - Any harmonics, sub-harmonics, or cross-products of signals that fall in the module's Rx range may cause spurious response, resulting in decreased Rx performance.
  - Tx power and corresponding broadband noise may overload or increase the noise floor of the module's receiver, resulting in RF desense.
  - Severity of interference depends on proximity of other antennas to the module's antennas.
- Host electronic device-generated RF
  - Proximity of host electronics to the module's antenna can contribute to decreased Rx performance.
  - Some devices include microprocessor and memory, display panel and display drivers, and switching mode power supplies.

Note: *In practice, there are usually numerous interfering frequencies and harmonics. The net effect can be a series of desensitized receive channels.*

4. RF Circuit Routing Constraints

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

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

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

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

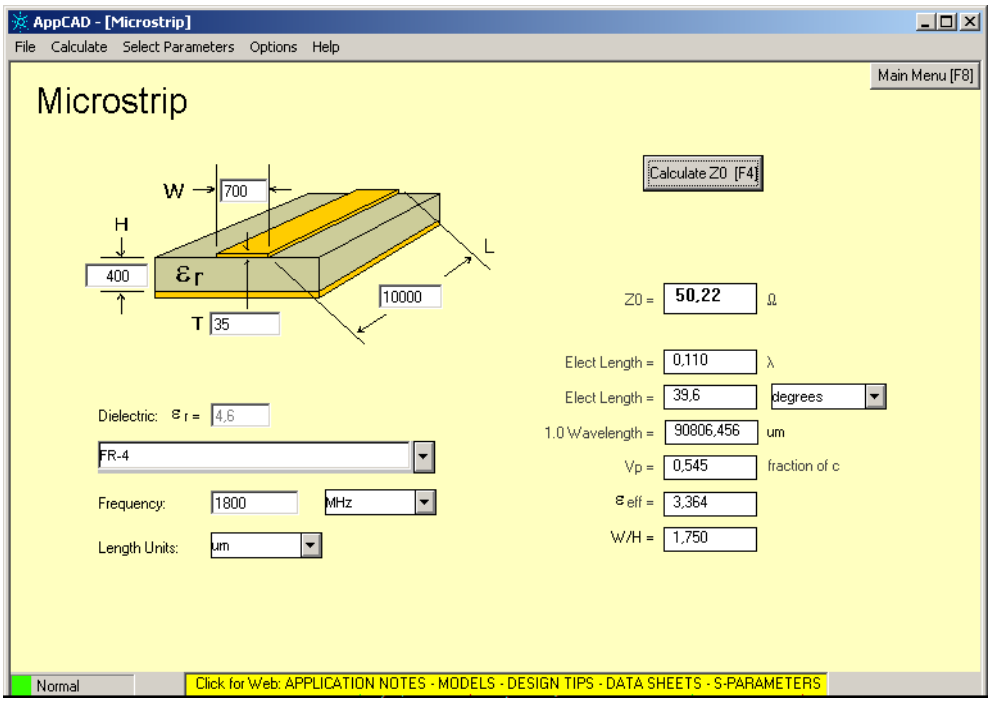

Figure 1. AppCAD Screenshot for MicroStrip Design Power Mode Diagram

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

Caution: *It is critical that no other signals (digital, analog, or supply) cross under the RF path. The figures below show generic examples of good routing techniques.*

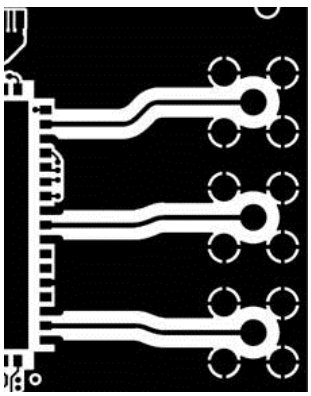

Figure 2. RF Routing Example with Lead Type RF Connectors

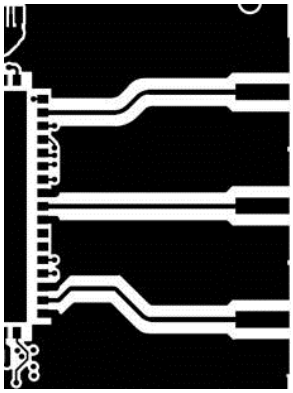

Figure 3. RF Routing Example with SMT Type RF Connectors

- Fill the area around the RF traces with ground and ground vias to connect inner ground layers for isolation.
- Cut out ground fill under RF signal pads to reduce stray capacitance losses.
- Avoid routing RF traces with sharp corners. A smooth radius is recommended.
- The ground reference plane should be a solid continuous plane under the trace.
- The coplanar clearance (G, below) from the trace to the ground should be at least the trace width (W) and at least twice the height (H). This reduces the parasitic capacitance, which potentially alters the trace impedance and increases the losses. Note the figure below shows several internal ground layers cutout, which may not be necessary for every application.

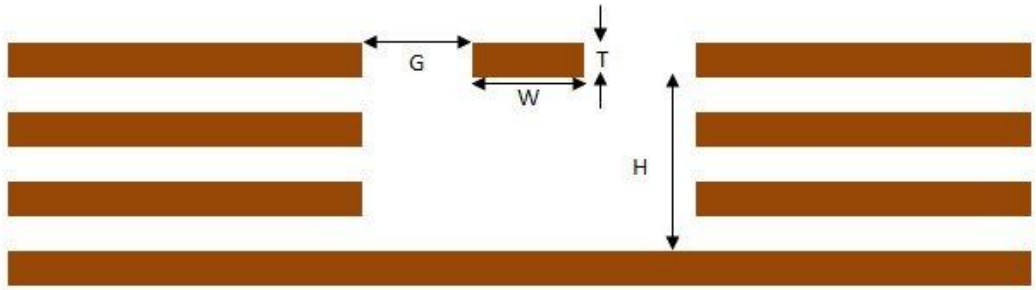

Figure 4. Coplanar Clearance Example

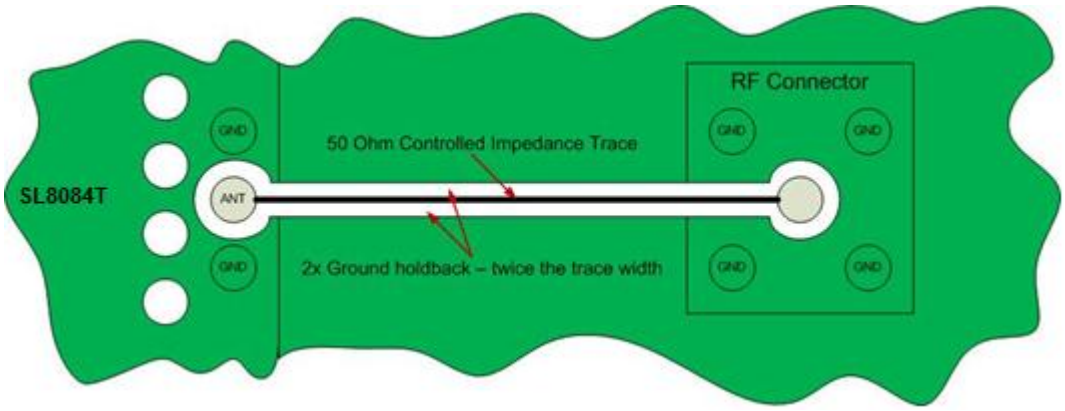

Figure 5. Antenna Microstrip Routing Example

5. Audio Interface

The AirPrime SL8084T embedded module supports analog and PCM audio as summarized in the following tables. Refer to document [2] AirPrime SL808x Product Technical Specification and Customer Design Guidelines for detailed information about the audio interfaces.

Table 7. Audio Interface Features

Audio Type	Feature	Details
Analog	Implementation	• Supports analog audio processing • Does not provide on-board filtering (except for blocking capacitors on microphone lines) • Host must provide bias and signal filters • Host should terminate unused audio lines with pull-down resistors
Digital (PCM)	Implementation	Primary PCM supported to interface with external codec
	Power	1.8V (use VREG_MSME_1V8 as logic reference)

Table 8. Audio Pin Description

Audio Type	Signal Name	Pin #	Description	Notes
Analog	MIC_P	53	Microphone positive terminal	In series with 0.1 µF DC blocking capacitor
	MIC_N	54	Microphone negative terminal	In series with 0.1 µF DC blocking capacitor
	SPK_N	56	Speaker negative terminal	
	SPK_P	57	Speaker positive terminal	
Digital	PCM_SYNC	64	PCM synchronization bit	8 kHz
	PCM_DOUT	65	PCM output	
	PCM_DIN	66	PCM input	
	PCM_CLK	67	PCM clock	2 MHz for primary PCM mode

5.1. Audio Function Codec Responsibilities

The responsibilities of the module codec and host codec for special functions are detailed in the following table.

Table 9. Codec Responsible for Special Functions

	Function	Responsible Codec
FIR filtering	Tx and Rx paths	Module
Noise suppression	Required due to high sensitivity and gain in Tx path	Module
Echo cancellation	Different for each audio path and environment (handset, headset, car kit, speakerphone)	Module
High pass filtering/slope filtering functions	Required per phone acoustic requirements	Module

	Function	Responsible Codec
AGC (Automatic Gain Control)	Normalizes audio volumes in varying acoustic environments	Module
DTMF tones	Generation and detection of DTMF tones is required in both directions of the phone Interface	Module
Comfort noise	Low level noise injected into Rx path for user ‘connection’ experience	Module
Simple ringers	Digital and analog tones, melody ringers, MIDI with limited memory storage	Module
Voice memo	Performed by host if significant memory storage is required	Host
Polyphonic ringtones	Host often supports WAV, MIDI formats with significant memory storage	Host
Path switching	Turn on audio path depending on user interface selection, or headset detection	Host
Path mixing	Required for voice memo recording and playback via multiple audio paths	Host
Transducer interfaces	Host provides acoustic drivers. Must occur outside of path switching and mixing	Host
Adjustable gain/volume settings	Based on user interface selections	Host/Module
DTMF/ringer tone generation		Host/Module

6. Regulatory Information

6.1. Important Notice

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

6.2. Safety and Hazards

Do not operate your AirPrime SL8084T modem:

- In areas where blasting is in progress
- Where explosive atmospheres may be present including refueling points, fuel depots, and chemical plants
- Near medical equipment, life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the SL8084T modem **MUST BE POWERED OFF**. Otherwise, the SL8084T modem can transmit signals that could interfere with this equipment.

In an aircraft, the SL8084T modem **MUST BE POWERED OFF**. Otherwise, the SL8084T modem 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 SL8084T modem may be used normally at this time.

6.3. Important Compliance Information for North American Users

The SL8084T modem has been granted modular approval for mobile applications. Integrators may use the SL8084T modem in their final products without additional FCC/IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC/IC approvals must be obtained.

1. At least 20 cm separation distance between the antenna and the user’s body must be maintained at all times.
2. To comply with FCC/IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed 6 dBi in the cellular band and 3.5 dBi in the PCS band.
3. The SL8084T modem and its antenna must not be co-located or operating in conjunction with any other transmitter or antenna within a host device.

4. Refer to section 4 RF Circuit Routing Constraints for RF signal conditions.
5. A label must be affixed to the outside of the end product into which the SL8084T modem is incorporated, with a statement similar to the following:

   This device contains FCC ID: N7NSL8084T

   This equipment contains equipment certified under IC: 2417C-SL8084T
6. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/IC RF exposure guidelines.

The end product with an embedded SL8084T modem 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 and IC RSS-102.*

6.3.1. EU Regulatory Conformity

Sierra Wireless hereby declares that the SL8084T modem conforms with all essential requirements of Directive 1999/5/EC.

CE

The Declaration of Conformity made under Directive 1999/5/EC is available for viewing at the following location in the EU community:

Sierra Wireless (UK) Limited
Suite 5, The Hub
Fowler Avenue
Farnborough Business Park
Farnborough, United Kingdom GU14 7JP

7. References

7.1. Reference Documents

[1] Universal AirPrime SL Series Development Kit User Guide
Reference: WA_DEV_LG_UGD_003

[2] AirPrime SL808x Product Technical Specification and Customer Design Guidelines
Reference: 4111992

7.2. Acronyms and Definitions

Acronym or Term	Definition
AGC	Automatic Gain Control
BER	Bit Error Rate - a measure of receive sensitivity
BLER	Block Error Rate
Call Box	Base Station Simulator - Agilent E8285A or 8960, Rohde & Schwarz CMU200
CDMA	Code Division Multiple Access
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	Decibels, relative to 1 mW - Decibel(mW) = 10 x $\log_{10}$ (Pwr (mW)/1mW)
DUT	Device Under Test
EDGE	Enhanced Data rates for GSM Evolution
EM	Embedded Module
ESD	ElectroStatic Discharge
FER	Frame Error Rate - a measure of receive sensitivity
GPRS	General Packet Radio Services
GPS	Global Positioning System
GSM	Global System for Mobile communications
Hz	Hertz = 1 cycle/second
inrush current	Peak current drawn when a device is connected or powered on
IS-2000	3G radio standards for voice and data (CDMA only)
IS-95	2G radio standards targeted for voice (cdmaONE)
LDO	Low Drop Out - refers to linear regulator
MHz	MegaHertz = 10E6 Hertz (Hertz = 1 cycle/second)
MIO	Module Input/Output
MPE	Maximum Permissible Exposure—the level of radiation to which a person may be exposed without hazardous effect or adverse biological changes
OTA	Over-The-Air or Radiated through the antenna
PCS	Personal Communication System - PCS spans the 1.9 GHz radio spectrum

Acronym or Term	Definition
RF	Radio Frequency
RMS	Root Mean Square
SA	Selective Availability
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.
SIM	Subscriber Identity Module
SL8084T	Sierra Wireless AirPrime soldered-down module used on GSM/UMTS networks
SNR	Signal to Noise Ratio
SOF	Start of Frame - a USB function
UART	Universal Asynchronous Receiver Transmitter
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
VCC	Supply voltage
WCDMA	Wideband Code Division Multiple Access—In this document, the term “UMTS” is used instead of “WCDMA”.
XIM	In this document, XIM is used as part of the contact identifiers for the USIM interface (XIM_VCC, XIM_CLK, etc.).

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