Sierra Wireless EM7590

Hardware Integration Guide

SIERRA WIRELESS®

Rev 1

Important Notice

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

Safety and Hazards

Do not operate the Sierra Wireless modem in areas where blasting is in progress, where explosive atmospheres may be present, near medical equipment, near life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the Sierra Wireless modem **MUST BE IN AIRPLANE MODE OR POWERED OFF**. The Sierra Wireless modem can transmit signals that could interfere with this equipment.

Do not operate the Sierra Wireless modem in any aircraft, whether the aircraft ison the ground or in flight. In aircraft, the Sierra Wireless modem **MUST BE IN AIRPLANE MODE OR POWERED OFF**. When operating, the Sierra Wireless modem can transmit signals that could interfere with various onboard systems.

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.

The driver or operator of any vehicle should not operate the Sierra Wireless modem while in control of a vehicle. Doing so will detract from the driver or operator's control and operation of that vehicle. In some states and provinces, operating such communications devices while in control of a vehicle is an offence.

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Revision History

Revision Number	Release Date	Changes
1	July 2022	Creation

Contents

Introduction

The Sierra Wireless EM7590 is a compact, lightweight, wireless modem that provides LTE, UMTS, and GNSS connectivity for M2M applications, notebook, ultrabook and tablet computers over several radio frequency bands.

Accessories

A hardware development kit is available for MC-series modules. The kit contains hardware components for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas (Additional antennas may be required to support all bands.)
- Initial allotment of support hours
- Other accessories
- For over-the-air LTE testing, ensure that suitable antennas are used.

Required Connectors

Table 1-1 describes the connectors used to integrate the EM7590 PCI Express Mini Card into your host device.

Table 1-1: Required host-module connectors[a]

Connnector Type	Description
RF cables	• Mate with M.2-spec connectors • Three connector jacks (I-PEX 20448-001R-081 or equivalent)
EDGE (52-pin)	• Slot B compatible—Per the M.2 standard ([8] PCI Express NGFF (M.2) Electromechanical Specification Revision 1.0), a generic 75 pin position EDGE connector on the motherboard uses a mechanical key to mate with the 67 pin notched module connector. • Recommended part# AS0BC21-S30BB-7H
SIM	• Industry-standard connector. Type depends on how host device exposes the SIM socket

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

Power

Power Supply

The host provides power to the Sierra Wireless EM7590 through multiple power and ground pins. 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.

For detailed pinout and voltage/current requirements of this module, refer to the EM7590 Product Technical Specification.

Module Power States

The module has four basic power states, as described in Table 2-1.

Table 2-1: Module Power States

State	Details	Host is powered	Module is powered	USB interface active	Radio 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
	• Module enters this state:
	  ▪ Under host interface control:
	  ▪ Host issues AT+CFUN=0, or
	  ▪ Host issues AT!PCOFFEN=0 (configures the modem to enter low power mode when W_DISABLE_N is asserted), and then asserts W_DISABLE_N
	  ▪ Automatically, when critical temperature or voltage trigger limits have been reached
		□	□	□	□

Table 2-1: Module Power States (Continued)

State	Details	Host is powered	Module is powered	USB interface active	Radio enabled
Sleep	• Normal state of module between calls or data connections • Module cycles between wake (polling the network) and sleep, at network provider-determined interval.	□	□	□[a]	□
Disconnected	• Host power source is disconnected from the module and all voltages associated with the module are at 0 V.	□	□	□[b]	□

a. USB interface is suspended.
b. USB interface is disconnected.

RF Specifications

The module, based on Qualcomm's MDM9250 baseband processor, supports data operation on LTE and UMTS networks over the bands described in Table 3-1, with LTE carrier aggregation (CA) as described in Table 3-2and Table 3-3.

Table 3-1: Supported RF Bands

RAT	Bands																													
	1	2	3	4	5	6	7	8	9	12	13	14	18	19	20	25	26	28	29	32	38	39	40	41	42	43	48	66	71
LTE[a]	F	F	F	F	F		F	F		F	F	F	F	F	F	F	F	F	F[b]	F[b]	T	T	T	T	T	T	T	F	F
UMTS[c]	Y	Y		Y	Y	Y		Y	Y					Y															
GNSS	• GPS: 1575.42 MHz • GLONASS: 1602 MHz • BeiDou: 1561.098 MHz • Galileo: 1575.42 MHz • QZSS: 1575.42 MHz																												

a. (LTE) Downlink MIMO support (2x2; 4x2) F=FDD; T=TDD
Data rates: Downlink (Cat 13 with 2CA, 256QAM=400 Mbps), Uplink (Cat 13 with 2CA contiguous, 64QAM=150 Mbps)
b. Downlink only
c. UMTS (DC-HSPA+, HSPA+, HSPA, UMTS) Diversity support
Data rates: Downlink (Cat 24, up to 42 Mbps), Uplink (Cat 6, up to 5.76 Mbps)

Table 3-2: Carrier Aggregation Downlink Combinations

1 Band / 2CC	2 Bands / 2CC	2 Bands / 2CC
CA_1A-1A	CA_1A-3A	CA_5A-7A
CA_1C	CA_1A-5A	CA_5A-25A
CA_2A-2A	CA_1A-7A	CA_5A-38A
CA_2C	CA_1A-8A	CA_5A-40A
CA_3A-3A	CA_1A-18A	CA_5A-41A
CA_3C	CA_1A-19A	CA_5A-66A
CA_4A-4A	CA_1A-20A	CA_7A-8A
CA_5A-5A	CA_1A-26A	CA_7A-12A

Table 3-2: Carrier Aggregation Downlink Combinations (Continued)

1 Band / 2CC	2 Bands / 2CC	2 Bands / 2CC
CA_5B	CA_1A-28A	CA_7A-20A
CA_7A-7A	CA_1A-32A	CA_7A-28A
CA_7B	CA_1A-38A	CA_7A-32A
CA_7C	CA_1A-40A	CA_7A-42A
CA_8B	CA_1A-41A	CA_8A-32A
CA_12A-12A	CA_1A-42A	CA_8A-38A
CA_12B	CA_2A-4A	CA_8A-39A
CA_25A-25A	CA_2A-5A	CA_8A-40A
CA_38C	CA_2A-7A	CA_8A-41A
CA_39C	CA_2A-12A	CA_8A-42A
CA_40A-40A	CA_2A-13A	CA_12A-25A
CA_40C	CA_2A-14A	CA_12A-66A
CA_41A-41A	CA_2A-28A	CA_13A-66A
CA_41C	CA_2A-66A	CA_14A-66A
CA_42C	CA_2A-71A	CA_19A-1A
CA_43C	CA_3A-5A	CA_19A-3A
CA_48C	CA_3A-7A	CA_19A-42A
CA_66A-66A	CA_3A-8A	CA_20A-32A
CA_66B	CA_3A-19A	CA_20A-40A
CA_66C	CA_3A-20A	CA_20A-42A
	CA_3A-26A	CA_25A-26A
	CA_3A-28A	CA_26A-41A
	CA_3A-38A	CA_28A-38A
	CA_3A-40A	CA_28A-40A
	CA_3A-41A	CA_28A-41A
	CA_3A-42A	CA_28A-42A
	CA_4A-5A	CA_39A-41A
	CA_4A-7A	CA_41A-42A
	CA_4A-12A	CA_66A-71A
	CA_4A-13A	
	CA_4A-28A	
	CA_4A-71A	

Table 3-3: Carrier Aggregation Uplink Combinations.

CA_1C
CA_3C
CA_5B
CA_7C
CA_39C
CA_41C
CA_42C
CA_43C
CA_48C

RF Connections

When attaching antennas to the module:

- Use IPEX (20449-001E (MHF4))to attach antennas to connection points on the module.

*Note: To **disconnect** the antenna, make sure you use the IPEX MHF4 connector removal tool to prevent damage to the module or coaxial cable assembly.*

- Match coaxial connections between the module and the antenna to 50 □.
- Minimize RF cable losses to the antenna; the recommended maximum cableloss 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 beremoved.

Antenna and Cabling

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

Choosing the Correct Antenna and Cabling

When matching antennas and cabling:

- The antenna (and associated circuitry) should have a nominal impedance of50 □ 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, 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.

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 perfor-mance.
- Connecting cables between the module and the antenna must have 50 □ impedance. If the impedance of the module is mismatched, RF performanceis reduced significantly.
- Antenna cables should be routed, if possible, away from noise sources (switching power supplies, LCD assemblies, etc.). If the cables are near thenoise sources, the noise may be coupled into the RF cable and into the antenna.

Disabling the Diversity Antenna

Certification testing of a device with an integrated EM7590 may require the module's main and diversity antennas to be tested separately.

To facilitate this testing, receive diversity can be enabled/disabled using

AT commands:

- AT!RXDEN— Used to enable/disable diversity for single-cell call (no carrier aggregation).
- AT!LTERXCONTROL— Used to enable/disable paths (in carrier aggregation scenarios) after a call is set up.

Important: *LTE networks expect modules to have more than one antenna enabled for proper operation. Therefore, customers must not commercially deploy their systems with the diversity antenna disabled.*

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 themodule through the host connector.
- Connect to system ground using the two mounting holes at the top of themodule.
- 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 13) and radiated sensitivity measurement (Radiated Sensitivity Measurement on page 14).

Note: The EM7590 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 bywireless 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 antennasto 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. Thedrawback 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-layerPCBs.
- 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 reductionin 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.

Regulatory Compliance and Industry Certifications

The EM7590 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
- The Certification and Engineering Bureau of Industry Canada (IC)
- The National Communications Commission (NCC) of Taiwan, Republic of China

The EM7590 Embedded Module complies with the mandatory requirements described in the following standards. The exact set of requirements supported is network operator-dependent.

Table 7-1: Standards Compliance

Technology	Standards
LTE	• 3GPP Release 12[a]
UMTS	• 3GPP Release 9

a. Some auxiliary functions support Release 13

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

- GCF
- 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 EM7590 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 Compliance Information for North American Users

The EM7590 module, upon commercial release, will have been granted modular approval for mobile applications. Integrators may use the EM7590 module 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 the limits stipulated in Table 4-1 on page 17.

3. The EM7590 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/IC for mobile application.
   - At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.
   - The radiated power of a collocated transmitter must not exceed the EIRP limit stipulated in Table 4-1.

Table 4-1: Antenna Gain and Collocated Radio Transmitter Specifications

	Operating mode	Tx Freq Range (MHz)		Max Time-Avg Cond. Power (dBm)	Antenna Gain Limit (dBi)		EIRP Limits (dBm)
					Standalone	Collocated	
EM7590 Embedded Module	WCDMA Band 2, LTE B2	1850	1910	24	9.00	7.30	33.0
	WCDMA Band 4, LTE B4	1710	1755	24	6.00	6.00	30.0
	WCDMA Band 5, LTE B5	824	849	24	7.00	4.90	31.0
	LTE B7	2500	2570	24	9.00	8.20	33.0
	LTE B12	699	716	24	6.60	4.50	30.6
	LTE B13	777	787	24	6.90	4.80	30.9
	LTE B14	788	798	24	6.90	4.80	30.9
	LTE B25	1850	1915	24	9.00	7.30	33.0
	LTE B26	814	849	24	7.00	4.90	31.0
	LTE B41	2496	2690	24	9.00	8.20	33.0
	LTE B42	3400	3600	23	0.00	0.00	23.0
	LTE B43	3600	3800	23	0.00	0.00	23.0
	LTE B48[a]	3550	3700	23	0.00	0.00	23.0
	LTE B66	1710	1780	24	6.00	6.00	30.0
	LTE B71	663	698	24	6.40	4.30	30.4
Collocated transmitters	WLAN 2.4 GHz	2400	2500				30
	WLAN 5 GHz	5150	5850				30
	WLAN 6 GHz	5955	7115				30
	BT	2400	2500				16

a. **Important:** Airborne operations in LTE Band 48 are prohibited.

4. A label must be affixed to the outside of the end product into which the EM7590 module is incorporated, with a statement similar to the following:
   - **This device contains FCC ID: N7NEM75T**
     Contains transmitter module IC: 2417C-EM75T where 2417C-EM75T is the module's certification number.
5. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/IC RF exposure guidelines.

   The end product with an embedded EM7590 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 and IC RSS-102.

Appendix

For more details, several references can be consulted, as detailed below.

Website Support

Check http://source.sierrawireless.com for the latest documentation available.

Abbreviations

Table A-1: Acronyms and Definitions

Acronym or Term	Description
3GPP	3rd Generation Partnership Project
BeiDou	BeiDou Navigation Satellite System A Chinese system that uses a series of satellites in geostationary and middle earth orbits toprovide navigational data.
BER	Bit Error Rate—A measure of receive sensitivity
BLER	Block Error Rate
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+
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
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.
Galileo	A European system that uses a series of satellites in middle earth orbit to provide navigational data.
GCF	Global Certification Forum
GLONASS	Global Navigation Satellite System—A Russian system that uses a series of 24 satellites in middle circular orbit to provide navigational data.

Table A-1: Acronyms and Definitions (Continued)

Acronym or Term	Description
GNSS	Global Navigation Satellite Systems (GPS, GLONASS, BeiDou, and Galileo)
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
IC	Industry Canada
IF	Intermediate Frequency
IS	Interim Standard. After receiving industry consensus, the TIA forwards the standard to ANSI for approval.
LTE	Long Term Evolution—a high-performance air interface for cellular mobile communication systems.
MHz	Megahertz = 10e6 Hz
OEM	Original Equipment Manufacturer—a company that manufactures a product and sells it to a reseller.
OTA	'Over the air' (or radiated through the antenna)
PCB	Printed Circuit Board
PCS	Personal Communication System A cellular communication infrastructure that uses the 1.9 GHz radio spectrum.
PTCRB	PCS Type Certification Review Board
RF	Radio Frequency
RSE	Radiated Spurious Emissions
Sensitivity (RF)	Measure of lowest power signal at the receiver input that can provide a prescribed BER/BLER/SNR value at the receiver output.
SNR	Signal-to-Noise Ratio
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.

Table A-1: Acronyms and Definitions (Continued)

Acronym or Term	Description
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VCC	Supply voltage
WCDMA	Wideband Code Division Multiple Access (also referred to as UMTS)
ZIF	Zero Intermediate Frequency