AirPrime MC7750

Hardware Integration Guide

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Rev 3.0.3

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 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.

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 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 is on the ground or in flight. In aircraft, the Sierra Wireless modem **MUST BE 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
3.0.1	January 2011	• MC7750 FCC submission
3.0.2	March 2011	• Revised regulatory details
3.0.3	March 2011	• Revised regulatory details (Simultaneous Transmission Evaluation)

Contents

1: Introduction

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Sierra Wireless' AirPrime Intelligent Embedded Modules form the radio component for the products in which they are embedded.

The AirPrime MC7750 is available for use on LTE, CDMA, and GSM networks.

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

Purpose of this guide

This guide addresses issues that affect the integration of AirPrime embedded modules into host products, and includes design recommendations for the host products.

The Universal Development Kit

Sierra Wireless manufactures a Universal Development Kit (UDK) that facilitates all phases of the integration process.

This kit is a hardware development platform that is designed to support AirPrime Mini Card embedded modules. It contains the hardware components that are typically necessary for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas
- Other accessories

For instructions on setting up the UDK, see *PCI Express Mini Card Dev Kit Quick Start Guide (Document 2130705)*.

Required connectors

Note: Contact vendors before choosing your connectors—the numbers included here are for reference only. Choose connectors that are appropriate to your design.

When integrating AirPrime embedded modules into your host device, you need the following connector types:

- RF cables that mate with Hirose U.FL connectors (model U.FL #CL331-0471-0-10). Modules include one to three connector jacks depending on individual module support for diversity or GPS functionality.
- Industry-standard mating connector for 52-pin EDGE—some manufacturers include Tyco, Foxconn, and Molex. For example, the connector used on the Mini Card Dev Kit board is a Molex 67910-0001.

- Industry-standard USIM connector—the actual connector you use depends on how your device exposes the USIM socket. For example, the USIM connector used on the Mini Card Dev Kit board is an ITT CCM03-3518.

2: Power Interface

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Overview of operation

AirPrime embedded modules are designed to use a 3.3V (nominal) power supply provided by the host. It is the host's responsibility to provide safe and continuous power to the module at all times; the module does NOT have an independent power supply, or protection circuits to guard against electrical issues.

The module's power state is controlled by the host's assertion/deassertion of W_Disable#. The module also monitors its supply voltage and requests shutdown if the supply is insufficient.

Power signals

The module must be connected to a 3.3V power supply, as described in *PCI Express Mini Card Electromechanical Specification Revision 1.1*.

For detailed pinout and voltage/current requirements, see the Product Specification Document for your AirPrime embedded module.

Power supply

Table 2-1: Power supply requirements

Requirement type	Value
Power supply	3.3 V (nominal)
Voltage range	3.0–3.6 V
Maximum peak current (worst-case)	2.75 A

Electrostatic discharge (ESD)

You are responsible for ensuring that the host has adequate ESD protection on digital circuits and antenna ports as described by the following specifications:

- (Operational) RF port (antenna launch and RF connector): *IEC-61000-4-2—Level (Electrostatic Discharge Immunity Test)*
- (Non-operational) Host connector interface: *JESD22-A114-B +/- 1kV Human Body Model* and *JESD22-C101 +/- 125 V Charged Device Model*

This guide provides specific recommendations where needed, however, the level of protection required depends on your application.

Note: ESD protection is highly recommended for the USIM connector at the point where the contacts are exposed, and for any other signals from the host interface that would be subjected to ESD by the user of the product.

Module power states

Note: The module unit defaults to the Normal state when VCC is first applied in the absence of W_Disable# control.

The module has five power states:

- Disconnected
  No power to the module.
- Off
  Power to the module, but the module is powered off.
- Sleep
  State between calls or data connections. Module cycles between wake and sleep.
- Normal
  The module is active. Several modes are possible (Receive, Transmit, Sleep, Shutdown).
- Low power (“airplane mode”)
  The module is active, but RF is disabled.

State machines are implemented in the module to monitor the power supply and operating temperature.

Disconnected state

Note: The difference between the Disconnected and Off states is that, in the Off state, the module is still connected to the power source and draws minimal current.

This state occurs when there is no power to the module—the host power source is disconnected from the module and all voltages associated with the module are at 0 V.

Whether the host device is also powered off depends on the power rail design:

- If the connection between the power rail and the module is controlled by the host, the host can stay powered on and cut the power to put the module into the disconnected state.
- If the power rail is shared between the host device and the module, the module is powered off when the host is powered off.

Off state

In this state, the host is powered up and the module is powered down (but still connected to the power source).

The host keeps the module powered off by driving the W_Disable# signal low. In this state, the module draws minimal current.

Sleep state

In this state, the host and module are powered up, and the module cycles between wake (polling the network) and sleep, at network provider-determined interval. This is the normal state of the module between calls or data connections.

Note: This is the default state when VCC is first applied in the absence of W_Disable# control.

Normal state

This is the active state of the module. In this state:

- The module is fully powered.
- The module is capable of placing/receiving calls or establishing data connections on the wireless network.
- The USB interface is fully active.

Low power state

In this state (also called “airplane mode”), RF (both Rx and Tx) is disabled in the module, but the USB interface is still active.

3: RF Integration

The AirPrime MC7750 operates on the following frequencies:

Table 3-1: Supported RF bands (MC7750)

Technology	Band	Frequency range (MHz)
LTE	13	Tx: 777–787 Rx: 746–756
WCDMA[a]	1 (UMTS 2100)	Tx: 1920–1980 Rx: 2110–2170
	2 (UMTS 1900)	Tx: 1850–1910 Rx: 1930–1990
	5 (UMTS 850)	Tx: 824–849 Rx: 869–894
	8 (UMTS 900)	Tx: 880–915 Rx: 925–960
GSM	GSM 850	Tx: 824–849 Rx: 869–894
	EGSM 900	Tx: 880–915 Rx: 925–960
	DCS 1800	Tx: 1710–1785 Rx: 1805–1880
	PCS 1900	Tx: 1850–1910 Rx: 1930–1990
CDMA	PCS	Tx: 1850–1910 Rx: 1930–1990
	Cellular	Tx: 824–849 Rx: 869–894
GPS	GPS	1575.42

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

RF connection

When attaching an antenna to the module:

- Use a Hirose U.FL connector (model U.FL #CL331-0471-0-10) to attach an antenna to a connection point on the module.
- 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.

*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.*

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.
- 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.

Shielding

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: The module shields 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: Values in this guide are taken from the appropriate product specification documents (PSDs)—in the case of a discrepancy between this document and the relevant PSD, use the value listed in the PSD.

Choosing the correct antenna and cabling

Consider the following points for proper matching of 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.

Developing custom antennas

Consider the following points when developing custom-designed antennas:

- A skilled RF engineer should do the development to ensure that the RF performance is maintained.
- Identify the bands that need to be supported.

Determining the antenna's location

Consider the following points when deciding where to put 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 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.

Interference and sensitivity

Note: The MC7750 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.

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

RF desense can be addressed through a combination of mitigation techniques and radiated sensitivity measurement.

Power supply noise

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

Note: Values in this guide are taken from the MC7750 product technical specification (PTS) —in the case of a discrepancy between this document and the PTS, use the value listed in the PTS.

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.

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.

Device-generated RF

Note: The module can cause interference with other devices such as hearing aids and on-board speakers.

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.

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

The 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

A: Regulatory Information

A

Important notice

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Safety and hazards

Do not operate your MC7750 modem:

- In areas where blasting is in progress
- Where explosive atmospheres may be present including refuelling points, fuel depots, and chemical plants
- Near medical equipment, life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the MC7750 modem **MUST BE POWERED OFF**. Otherwise, the MC7750 modem can transmit signals that could interfere with this equipment.

In an aircraft, the MC7750 modem **MUST BE POWERED OFF**. Otherwise, the MC7750 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 MC7750 modem may be used normally at this time.

Important compliance information for North American users

The MC7750 modem has been granted modular approval for mobile applications. Integrators may use the MC7750 modem in their final products without additional FCC/IC (Industry Canada) certification if the following conditions are met. Otherwise, additional FCC/IC approvals must be obtained.

- Although the MC7750 modem has been granted module approval, there are many conditions attached to this approval; final host integration will likely require additional testing. Detailed guidelines are described in OEM device classification process on page 19 to assist OEM module integrators in determining the extent of additional testing necessary to comply with FCC requirements.
- The end product with an embedded MC7750 modem must be evaluated for simultaneous transmission requirements. See Simultaneous transmission evaluation on page 20 for details.
- 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. See OEM product instruction manual content on page 21 for details.
- 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:
  - Part 22 (Cellular): 7.0 dBi
  - Part 24 (PCS): 3.0 dBi
  - Part 27 (Band 13): 9.0 dBi
- A label must be affixed to the outside of the end product into which the MC7750 modem is incorporated, with a statement similar to the following:
  - **This device contains FCC ID: N7NMC7750.**
    Contains transmitter module IC: 2417C-MC7750 where 2417C-MC7750 is the module's certification number.

The end product with an embedded MC7750 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.

OEM integration

Application of regulatory guidelines

Because 'near-body' devices (handhelds, laptops, tablets, scanners, etc.) vary widely in design features, physical configurations, and use-models, module integrators shall follow the guidelines below regarding device classification and simultaneous transmission, and seek guidance from their preferred regulatory

test lab to determine how regulatory guidelines will impact the device compliance. Proactive management of the regulatory process will minimize unexpected schedule delays and costs due to unplanned testing activities.

Device classifications

The OEM integrator must determine the minimum distance required between their device and the user's body.

The FCC provides device classification definitions to assist in making the correct determination. Note that these classifications are guidelines only; strict adherence to a device classification may not satisfy the regulatory requirement as near-body device design details may vary widely.

FCC definitions:

> Portable: (§2.1093)—A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.
>
> Mobile: (§2.1091)(b)—A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.

Per §2.1091d(d)(4) In some cases (for example, modular or desktop transmitters), the potential conditions of use of a device may not allow easy classification of that device as either Mobile or Portable. In these cases, applicants are responsible for determining minimum distances for compliance for the intended use and installation of the device based on evaluation of either specific absorption rate (SAR), field strength, or power density, whichever is most appropriate.

OEM device classification process

The primary factor in determining whether a device will be classified as a Portable product or as a Mobile product is antenna separation distance (body to radiating antenna element).

The review process between the OEM module integrator and the preferred regulatory test lab is a crucial step in determining the appropriate device classification, as it is impractical for Sierra Wireless to define all possible combinations of design features, antennas, physical configurations, and use-models.

1. Perform a device review with the preferred regulatory test lab to confirm device classification.
2. Determine the Certification type (Standalone or C2PC from an existing Modular Grant).
3. If the device classification is:
   - Portable: Preferred regulatory test lab to determine if a PBA or KDB is required.
   - Mobile: Preferred regulatory test lab to determine if a PBA is required.

   (Note: A PBA or KDB will likely be required for new technologies such as LTE or WiMAX.)

4. If the device classification is Mobile, confirm the antenna does not violate the Gain Limits specific to the module grant as specified in Important compliance information for North American users on page 18.
5. Outline and execute a test plan with the preferred regulatory test lab. Testing is likely to include some or all of Parts 15, 22, 24, 27, and either SAR (for Portable devices) or MPE (for Mobile devices).
6. Follow product labeling requirements as described in Important compliance information for North American users on page 18. (Ref §2.925)
7. Include the OEM product instruction manual content on page 21 boilerplate text within the host product's instruction manual.

Simultaneous transmission evaluation

The MC7750 modem has been evaluated for collocated transmission and may transmit simultaneously with other collocated radio transmitters within a host device provided the following conditions are met:

- All antennas (MC7750 transmit antenna and other collocated transmit antennas) provide > 20 cm separation distance to the end user (FCC mobile categorization), and
- The collocated transmitter maximum average transmit power and maximum antenna gain do not exceed the levels listed in Table A-1 per the MC7750 platform module-level maximum permissible exposure (MPE) report, or the power defined in a subsequently issued host-specific MPE report.

Table A-1: Summary of Maximum Conducted Power and Antenna Gain

Device	Technology	Frequency (MHz)	Conducted Power Limit (dBm)	Antenna Gain Limit (dBi)
MC7750	GPRS/EDGE	824–849	33	5.0
	UMTS	824–849	24	5.0
	CDMA	824–849	25	5.0
	GPRS/EDGE	1850–1910	30	3.0
	UMTS	1850–1910	24	3.0
	CDMA	1850–1910	25	3.0
	LTE	777–787	24	7.0
Collocated radio transmitters	WLAN	2400–2500	29	4.0
	WLAN	5150–5850	29	4.0
	WiMAX	2300–2400	27	5.0
	WiMAX	2500–2700	27	5.0
	WiMAX	3300–3800	27	5.0
	BT	2400–2500	15	5.0

OEM product instruction manual content

Consistent with §2.909(a), the following text must be included within the user's manual or operator instruction guide for the final commercial product. (OEM-specific content is *displayed in italics*.)

Operating Requirements and Conditions

The design of *(Product Name)* complies with U.S. Federal Communications Commission (FCC) guidelines respecting safety levels of radio frequency (RF) exposure for *(OEM to insert device classification: Mobile or Portable)* devices.

FCC ID: *(Include Standalone FCC ID or Module FCC ID as required)*

Note: Include the following RF Exposure statement for Mobile devices only.

RF Exposure - This device is only authorized for use in a mobile application. At least 20 cm (8 inches) of separation distance between the *(Product Name)* device and the user's body must be maintained at all times.

Note: Include the following RF Exposure statement for Portable devices only.

RF Exposure - This device has been tested for compliance with FCC RF exposure limits in a portable configuration. At least *(Insert Required Separation Distance from RF Exposure Evaluation)* cm of separation distance between the *(Product Name)* device and the user's body must be maintained at all times. This device must not be used with any other antenna or transmitter that has not been approved to operate in conjunction with this device.

Note: Always include the following Caution statement.

CAUTION: Any changes or modifications not expressly approved by *(Company Name)* or Sierra Wireless could void the user's authority to operate the equipment.

Note: Include the following statement if Part 15 of the FCC Rules is required. Integration into host devices containing unlicensed devices may require additional comments in this section. The OEM should confirm the extent of their user's guide content with their preferred regulatory test lab.

Note: This equipment has been tested and found to comply with the limits for a *(OEM to insert device type: Class A or Class B)* digital device, pursuant to Part 15 of the FCC Rules. *(OEM must follow Part 15 guidelines (§15.105 and §15.19) to determine additional statements required in this section for their device class)*

B: Acronyms and Definitions

B

Table B-1: 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

Table B-1: Acronyms and definitions

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
SNR	Signal to Noise Ratio
SOF	Start of Frame - a USB function
UART	Universal Asynchronous Receiver Transmitter
UDK	Universal Development Kit (PCI Express Mini Card Dev Kit)
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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