# AirPrime Intelligent Embedded Modules

## Hardware Integration Guide


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Rev 3.0.1

## 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 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 |

# 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 four power states:

- Disconnected
  No power to the module.
- Off
  Power to the module, but the module is powered off.
- 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.

*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<br>Rx: 746–756 |
| WCDMA[a] | 1 (UMTS 2100) | Tx: 1920–1980<br>Rx: 2110–2170 |
| | 2 (UMTS 1900) | Tx: 1850–1910<br>Rx: 1930–1990 |
| | 5 (UMTS 850) | Tx: 824–849<br>Rx: 869–894 |
| | 8 (UMTS 900) | Tx: 880–915<br>Rx: 925–960 |
| GSM | GSM 850 | Tx: 824–849<br>Rx: 869–894 |
| | EGSM_900 | Tx: 880–915<br>Rx: 925–960 |
| | DCS 1800 | Tx: 1710–1785<br>Rx: 1805–1880 |
| | PCS 1900 | Tx: 1850–1910<br>Rx: 1930–1990 |
| CDMA | PCS | Tx: 1851–1910<br>Rx: 1930–1990 |
| | Cellular | Tx: 824–849<br>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: These modules are 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 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.*

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 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 modem **MUST BE POWERED OFF**. Otherwise, the modem can transmit signals that could interfere with this equipment.

In an aircraft, the modem **MUST BE POWERED OFF**. Otherwise, the 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 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 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 7 dBi in the cellular band, 3 dBi in the PCS band, and 10 dBi in LTE Band 13.
3. The MC7750 modem and its antenna must not be co-located or operating in conjunction with any other transmitter or antenna within a host device.
4. 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:
   - For MC7750:
     **This device contains FCC ID: N7NMC7750**
     **This equipment contains equipment certified under IC: 2417C-MC7750**
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 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.

# 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)<br>*P1 is calculated power; P2 is reference power*<br>Decibel = 20 x $\log_{10}$ (V1/V2)<br>*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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## U



## W



## Z


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