AirPrime MC7700

Hardware Integration Guide

2130114
Rev 4.0.2

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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Consult our website for up-to-date product descriptions, documentation, application notes, firmware upgrades, troubleshooting tips, and press releases:

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Revision History

Revision number	Release date	Changes
4.0.1	May 2011	• FCC submission
4.0.2	February 2012	• Updated North American regulatory wording

Contents

1: Introduction

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

The AirPrime MC7700 is available for use on LTE, WCDMA 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 the AirPrime 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 two or three connector jacks depending on module support for diversity and 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 of these modules, see the Product Technical Specification Document for your AirPrime embedded module.

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

The module has five 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	RF enabled

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

Low power ('Airplane mode')	• Module is active • State is controlled by host interface using software commands: • +CFUN=0 (*AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)*))	✔	✔	✔	✘
Sleep	• Normal state of module between calls or data connections • Module cycles between wake (polling the network) and sleep, at network provider-determined interval.	✔	✔	✘	✘
Off	• Host keeps module powered off by driving W_DISABLE_N low • Module draws minimal current	✔	✘	✘	✘
Disconnected	• Host power source is disconnected from the module and all voltages associated with the module are at 0 V.	✘	✘	✘	✘

3: RF Integration

The AirPrime MC7700 operates on the frequency bands listed below.

Table 3-1: LTE frequency band support

Band	Frequencies
Band 4 (AWS)	Tx: 1710–1755 MHz Rx: 2110–2155 MHz
Band 17	Tx: 704–716 MHz Rx: 734–746 MHz

Table 3-2: WCDMA frequency band support[a]

Band	Frequencies
Band 1 WCDMA 2100	Tx: 1920–1980 MHz Rx: 2110–2170 MHz
Band 2 WCDMA 1900	Tx: 1850–1910 MHz Rx: 1930–1990 MHz
Band 5 WCDMA 850	Tx: 824–849 MHz Rx: 869–894 MHz
Band 6 WCDMA 800	Tx: 830–840 MHz Rx: 875–885 MHz

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

Table 3-3: GSM frequency band support

Band	Frequencies
GSM 850	Tx: 824–849 MHz Rx: 869–894 MHz
EGSM 900	Tx: 880–915 MHz Rx: 925–960 MHz
GSM 1800	Tx: 1710–1785 MHz Rx: 1805–1880 MHz
GSM 1900	Tx: 1850–1910 MHz Rx: 1930–1990 MHz

Table 3-4: GPS frequency band support

Band	Frequencies
GPS	1575.42 MHz

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.
- To ensure best thermal performance, if possible use the mounting holes to attach (ground) the device to the main PCB ground or a metal chassis.

*Note: 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.*

Note: If the antenna connection is shorted or open, the modem will not sustain permanent damage.

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 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.

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 MC7700 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.

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.

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.

A: Regulatory Information

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Important notice

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Safety and hazards

Do not operate your MC7700 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 MC7700 modem **MUST BE POWERED OFF**. Otherwise, the MC7700 modem can transmit signals that could interfere with this equipment.

In an aircraft, the MC7700 modem **MUST BE POWERED OFF**. Otherwise, the MC7700 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 MC7700 modem may be used normally at this time.

Important compliance information for North American users

The MC7700 modem has been granted modular approval for mobile applications. Integrators may use the MC7700 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.

1. At least 20 cm separation distance between the MC7700 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 stand-alone mobile-only exposure condition must not exceed:
   - 7.5 dBi in Cellular band
   - 3 dBi in PCS band
   - 5.5 dBi in LTE Band4
   - 9 dBi in LTE Band 17 (Note: LTE Band 17 is not permitted in Canada.)
3. The MC7700 modem may transmit simultaneously with other co-located radio transmitters within a host device, provided the following conditions are met:
   - Each co-located radio transmitter has been certified by FCC/IC and operates in accordance with its grant conditions.
   - At least 20 cm separation distance between the antennas of the co-located transmitters and the user's body must be maintained at all times.
   - The output power and antenna gain must not exceed the limits stipulated in the following table.

Device	Technology	Frequency (MHz)	Conducted Power Limit (dBm)	Antenna Gain Limit (dBi)
MC7700	GPRS/EDGE	824–849	33	5.0
	UMTS	824–849	25	5.0
	GPRS/EDGE	1850–1910	30	3.0
	UMTS	1850–1910	25	3.0
	LTE	704–716	25	6.0
	LTE	1710–1755	25	5.5
Co-located 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

4. A label must be affixed to the outside of the end product into which the MC7700 modem is incorporated, with a statement similar to the following:

   This device contains FCC ID: N7NMC7700.
   Contains transmitter module IC: 2417C-MC7700 where 2417C-MC7700 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 MC7700 modem may also be subject to the FCC Part 15 Subpart B requirements and must be properly authorized per FCC Part 15 where applicable.

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

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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
MC5728V	Sierra Wireless AirPrime embedded modules used on CDMA networks
MC57xx	Any of the following CDMA AirPrime embedded modules: MC5728V
MC8700/MC8704/ MC8705/MC8790/ MC8790V/MC8791V/ MC8792V/MC8795V/ MC8801	Sierra Wireless AirPrime embedded modules used on GSM/UMTS networks

Table B-1: Acronyms and definitions

Acronym or term	Definition
MC8xxx	Any of the following GSM/UMTS AirPrime embedded modules: MC8700/ MC8704/MC8705/MC8790/MC8790V/MC8791V/MC8792V/MC8795V/ MC8801
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
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 (3.3 V for these devices)
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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