



AirPrime MC7411

Hardware Integration Guide



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>> 1: Introduction

The AirPrime MC7411 PCI Express Mini Card is a compact, lightweight, wireless modem that provides LTE, UMTS, and GNSS connectivity for M2M applications, notebook, ultra-book and tablet computers over several radio frequency bands.

Accessories

A hardware development kit is available for AirPrime 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 MC7411 PCI Express Mini Card into your host device.

Table 1-1: Required host-module connectors^a

Connector type	Description
RF cables	<ul style="list-style-type: none">• Mate with Hirose U.FL connectors (model U.FL #CL331-0471-0-10)• Three connector jacks
EDGE (52-pin)	<ul style="list-style-type: none">• Industry-standard mating connector• Some manufacturers include Tyco, Foxconn, Molex• Example: UDK board uses Molex 67910-0001
SIM	<ul style="list-style-type: none">• Industry-standard connector. Type depends on how host device exposes the SIM socket• Example: UDK board uses ITT CCM03-3518

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

>> 2: Power

Power Supply

The host provides power to the MC7411 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 *AirPrime MC7411 Product Technical Specification*.

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	Radio enabled
Normal (Default state)	<ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> Radio band being used Transmit power Receive gain settings Data rate Number of active Tx time slots 	✓	✓	✓	✓
Low power ('Airplane mode')	<ul style="list-style-type: none"> Module is active Module enters this state: <ul style="list-style-type: none"> Under host interface control: <ul style="list-style-type: none"> Host issues AT+CFUN=0 ([1] AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)), 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 	✓	✓	✓	✗
Sleep	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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

>> 3: RF Specifications

Supported RF Bands

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 3-2](#) and [Table 3-3](#).

Table 3-1: Supported RF Bands

RAT	Bands														
	2	4	5	7	12	13	14	25	26	41	42	43	48	66	71
LTE ^a	F	F	F	F	F	F	F	F	F	T	T	T	T	F	F
UMTS ^b	Y	Y	Y												
GNSS	<ul style="list-style-type: none"> 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 7 with 2CA, 64QAM=300 Mbps), Uplink (Cat 13 with 2CA contiguous, 64QAM=150 Mbps)
- b. 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
CA_2A-2A	CA_2A-5A
CA_2C	CA_2A-7A
	CA_2A-12A
	CA_2A-13A
	CA_2A-14A
	CA_2A-71A
CA_4A-4A	CA_4A-5A
	CA_4A-7A
	CA_4A-12A
	CA_4A-13A
	CA_4A-71A
CA_5B	CA_5A-66A
CA_7A-7A	CA_7A-12A

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

1 Band / 2CC	2 Bands / 2CC
CA_7B	
CA_7C	
CA_12B	CA_12A-66A
	CA_13A-66A
	CA_14A-66A
CA_25A-25A	CA_25A-26A
	CA_26A-41A
CA_41A-41A	
CA_41C	
CA_42A-42A	
CA_42C	
CA_43C	
CA_48A-48A	
CA_48C	
CA_66A-66A	CA_66A-71A
CA_66B	
CA_66C	

Table 3-3: Carrier Aggregation Uplink Combinations

CA_5B
CA_7C
CA_41C
CA_42C
CA_43C
CA_48C

RF Connections

When attaching antennas to the module:

- Use Hirose U.FL connectors (3 mm x 3 mm, low profile; model U.FL #CL331-0471-0-10) to attach antennas to connection points on the module.

*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.*

- 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, 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 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

When matching antennas and cabling:

- The antenna (and associated circuitry) should have a nominal impedance of 50 Ω 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.
- If both UMTS and CDMA modules will be installed in the same platform, you may want to develop separate antennas for maximum performance.

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 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.

Disabling the Diversity Antenna

Certification testing of a device with an integrated MC7411 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:

- `!RXDEN`—Used to enable/disable diversity for single-cell call (no carrier aggregation).
- `!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 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.

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 12) and radiated sensitivity measurement ([Radiated Sensitivity Measurement](#) on page 13).

Note: The MC7411 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 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.

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. The drawback 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-layer PCBs.
- 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 reduction in 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.

>> 4: Regulatory Compliance and Industry Certifications

This 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)
- Radio Equipment Directive (RED) of the European Union

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 MC7411 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 MC7411 module, upon commercial release, will have been granted modular approval for mobile applications. Integrators may use the MC7411 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 15.
3. The MC7411 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	
MC7431 Mini Card	WCDMA Band 2, LTE B2	1850	1910	24	6	6	30
	WCDMA Band 4, LTE B4	1710	1755	24	6	6	30
	WCDMA Band 5, LTE B5	824	849	24.3	6	4	30.3
	LTE B7	2500	2570	23.8	9	4	32.8
	LTE B12	699	716	24	6	4	30
	LTE B13	777	787	24	6	4	30
	LTE B14	788	798	24	6	4	30
	LTE B25	1850	1915	24	6	6	30
	LTE B26	814	849	24	6	4	30
	LTE B41	2496	2690	23.8	9	8	32.8
	LTE B42	3400	3600	23.8	9	8	32.8
	LTE B43	3600	3800	23.8	9	8	32.8
	LTE B48 ^a	3550	3700	23.8	9	8	32.8
	LTE B66	1710	1780	24	6	6	30
LTE B71	663	698	24	6	3	30	
Collocated transmitters	WLAN 2.4 GHz	2400	2500				30
	WLAN 5 GHz	5150	5850				30
	BT	2400	2500				16
	WiGig	58320	62640				25

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 MC7411 module is incorporated, with a statement similar to the following:
 - **This device contains FCC ID: N7NMC74B**
Contains transmitter module IC: 2417C-MC74B where 2417C-MC74B 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 MC7411 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.

>> A: Appendix

Table A-1: Acronyms and Definitions

Acronym or term	Definition
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 to provide navigational data.
BER	Bit Error Rate—A measure of receive sensitivity
BLER	Block Error Rate
dB	Decibel = $10 \times \log_{10} (P1/P2)$ <i>P1 is calculated power; P2 is reference power</i> Decibel = $20 \times \log_{10} (V1/V2)$ <i>V1 is calculated voltage, V2 is reference voltage</i>
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.
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

Table A-1: Acronyms and Definitions (Continued)

Acronym or term	Definition
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 .
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VCC	Supply voltage
WCDMA	Wideband Code Division Multiple Access (also referred to as UMTS)
WLAN	Wireless Local Area Network
ZIF	Zero Intermediate Frequency