AirPrime EM8805

Hardware Integration Guide

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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 be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless wireless module are used in a normal manner with a well-constructed network, the Sierra Wireless wireless module 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 wireless module, or for failure of the Sierra Wireless wireless module to transmit or receive such data.

Safety and Hazards

Do not operate the Sierra Wireless wireless module 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 wireless module **MUST BE POWERED OFF**. The Sierra Wireless wireless module can transmit signals that could interfere with this equipment.

Do not operate the Sierra Wireless wireless module in any aircraft, whether the aircraft is on the ground or in flight. In aircraft, the Sierra Wireless wireless module **MUST BE POWERED OFF**. When operating, the Sierra Wireless wireless module 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 wireless modules may be used at this time.

The driver or operator of any vehicle should not operate the Sierra Wireless wireless module 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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Contact Information

Sales Desk:	Phone:	1-604-232-1488
	Hours:	8:00 AM to 5:00 PM Pacific Time
	E-mail:	sales@sierrawireless.com
Post:	Sierra Wireless 13811 Wireless Way Richmond, BC Canada V6V 3A4	
Technical support:	support@sierrawireless.com	
RMA support:	repairs@sierrawireless.com	
Fax:	1-604-231-1109	
Web:	www.sierrawireless.com	

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
1	January 2013	FCC submission

Contents

1: Introduction

The Sierra Wireless EM8805 Embedded Module is an M.2 wireless module that provides DC-HSPA+, HSPA+, HSDPA, HSUPA, WCDMA, GSM, GPRS, EDGE, and GNSS connectivity for notebook, ultrabook, and tablet computers over several radio frequency bands. The device also supports 2G/3G roaming.

The EM8805 is designed to be carrier-certified (AT&T), Android-compliant, and Windows 8 Mobile Broadband Interface Model (MBIM) compliant.

Accessories

A hardware development kit is available for AirPrime M.2 modules. The kit contains hardware components for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas
- Other accessories

Required connectors

Table 1-1 describes the connectors used to integrate the EM8805 Embedded Module into your host device.

Table 1-1: Required host-module connectors

Connector type	Description
RF cables	• Mate with M.2-spec connectors • Two connector jacks
EDGE (67 pin)	• Slot B compatible—Per the M.2 standard (*PCI Express NGFF (M.2) Electromechanical Specification Revision 0.7*), a generic 75 pin position EDGE connector on the motherboard uses a mechanical key to mate with the 67 pin notched module connector. • Manufacturers include LOTES (part #APCI0018-P001A01), Kyocera, JAE, Tyco, and Longwell.
SIM	• Industry-standard connector.

2: Power

Power supply

The host provides power to the EM8805 through multiple power and ground pins. The host must provide safe and continuous power (via battery or a regulated power supply) 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, see the *AirPrime EM8805 Product Technical Specification & Customer Design Guidelines*.

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. Occurs when VCC is first applied, Full_Card_Power_Off# is deasserted (pulled high), and W_DISABLE#1 is deasserted
	• 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
		✔	✔	✔	✔

Low power ('Airplane mode')	• Module is active
	• Module enters this state:
	  • Under host interface control:
	  - Host issues AT+CFUN=0 (*[1] AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)*)), or
	  - Host asserts W_DISABLE#1, after AT!PCOFFEN=0 has been issued.
	  • 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	RF 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.	✔	✔	✘	✘
Off	• Host keeps module powered off by asserting Full_Card_Power_Off# (signal pulled low or left floating) • 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 Specifications

The EM8805 operates on the frequency bands listed below:

Table 3-1: WCDMA frequency band support[1]

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 8 WCDMA 900	Tx: 880–915 MHz Rx: 925–960 MHz

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

Table 3-2: 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 3-3: GNSS frequency band support

Band	Frequencies
GPS	Rx: 1575.42 MHz
GLONASS	Rx: 1602 MHz

RF connections

When attaching antennas to the module:

- Use any of the following (or compatible) 2x2 mm RF receptacle connectors to attach antennas to the module's connection points: Foxconn (KK12011-02-7H), Longwell

(911-002-0006R), Speedtech (C87P101-00001-H), Murata (MM4829-2702RA4 (HSC)), IPEX (20449-001E (MHF4))

- 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 hole to attach (ground) the device to a metal chassis.

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

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

When matching 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.

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

- Use the AT command **!RXDEN=0** to disable receive diversity or **!RXDEN=1** to enable receive diversity.

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 module's mounting hole.
- 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 14) and radiated sensitivity measurement (Radiated sensitivity measurement on page 15).

Note: The EM8805 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 the radiated spurious emission (RSE) test cases described in:

- CE/ETSI EN 301 908 (WCDMA), test numbers 5.3.1 (‘Radiated Emissions (UE)’)
- CE/ETSI EN 301 511 (GSM), test 5.2.16 (‘Radiated Spurious Emissions - MS allocated a channel’). This test uses the procedure and requirement outlined in 3GPP 51.010 (GSM) section 12.2.1 of the same test name.

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.)

Note: GSM spurious emissions are most likely to have RSE issues, but in general, RSE requirements must be met on all models with user-designed antennas.

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 National Communications Commission (NCC) of Taiwan, Republic of China
- Radio Equipment and Telecommunications Terminal Equipment (R&TTE) Directive of the European Union

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

- GCF-CC
- Full GCF

Additional certifications 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 EM8805 wireless 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 notice

Because of 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 wireless module are used in a normal manner with a well-constructed network, the Sierra Wireless wireless module 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 and its affiliates accept no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless wireless module, or for failure of the Sierra Wireless wireless module to transmit or receive such data.

Safety and hazards

Do not operate your EM8805 wireless module:

- 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 EM8805 wireless module **MUST BE POWERED OFF**. Otherwise, the EM8805 wireless module can transmit signals that could interfere with this equipment.

In an aircraft, the EM8805 wireless module **MUST BE POWERED OFF**. Otherwise, the EM8805 wireless module 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 EM8805 wireless module may be used normally at this time.

Important compliance information for North American users

Note: Details are preliminary and subject to change.

The EM8805 wireless module has been granted modular approval for mobile applications. Integrators may use the EM8805 wireless module in their final products without additional FCC certification if they meet the following conditions. Otherwise, additional FCC 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:
   - (TBD) 6.5 dBi in Cellular band
   - (TBD) 3 dBi in PCS band

   Note: Gain values are preliminary and subject to change.
3. The EM8805 wireless 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 certfied by FCC 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 output power and antenna gain must not exceed the limits and configurations stipulated in the following table.

Device	Technology	Band	Frequency (MHz)	Maximum conducted power (dBm)	Maximum antenna gain (dBi)
EM8805 Embedded Module	UMTS	2	1850–1910	23.5	3
		5	824–849	23.5	3
	GSM	850	824–849	33	3
		1900	1850–1910	30	3
Collocated transmitters[1]	WLAN		2400–2500	29	5.0
			5150–5850	29	5.0
	WiMAX		2300–2400	29	5.0
			2500–2700	29	5.0
			3300–3800	29	5.0
	BT		2400–2500	15	5.0

1. Valid collocated transmitter combinations: WLAN+BT; WiMAX+BT. (WLAN+WiMAX+BT is not permitted.)

4. A label must be affixed to the outside of the end product into which the EM8805 wireless module is incorporated, with a statement similar to the following:
   - **This device contains FCC ID: N7NEM8805**
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 EM8805 wireless 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.

5: Acronyms

Table 5-1: Acronyms and definitions

Acronym or term	Definition
3GPP	3rd Generation Partnership Project
8PSK	Octagonal Phase Shift Keying
AGC	Automatic Gain Control
A-GPS	Assisted GPS
A-GNSS	Assisted GNSS
API	Application Programming Interface
BER	Bit Error Rate—A measure of receive sensitivity
BLER	Block Error Rate
bluetooth	Wireless protocol for data exchange over short distances
CQI	Channel Quality Indication
COM	Communication port
CS	Circuit-switched
CW	Continuous waveform
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+
DCS	Digital Cellular System A cellular communication infrastructure that uses the 1.8 GHz radio spectrum.
DL	Downlink (network to mobile)
DUN	Dial-Up Networking
DRX	Discontinuous Reception
DSM	Distributed Shared Memory
DUT	Device Under Test
EDGE	Enhanced Data rates for GSM Evolution
EIRP	Effective (or Equivalent) Isotropic Radiated Power

Table 5-1: Acronyms and definitions (Continued)

Acronym or term	Definition
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
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.
FDMA	Frequency Division Multiple Access
FER	Frame Error Rate—A measure of receive sensitivity.
firmware	Software stored in ROM or EEPROM; essential programs that remain even when the system is turned off. Firmware is easier to change than hardware but more permanent than software stored on disk.
FOTA	Firmware Over The Air—Technology used to download firmware upgrades directly from the service provider, over the air.
FOV	Field Of View
FSN	Factory Serial Number—A unique serial number assigned to the mini card during manufacturing.
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.
GMSK	Gaussian Minimum Shift Keying modulation
GNSS	Global Navigation Satellite Systems (GPS plus GLONASS)
GPRS	General Packet Radio Service
GPS	Global Positioning System An American system that uses a series of 24 satellites in middle circular orbit to provide navigational data.
GSM	Global System for Mobile Communications
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

Table 5-1: Acronyms and definitions (Continued)

Acronym or term	Definition
IF	Intermediate Frequency
IMEI	International Mobile Equipment Identity
IMS	IP Multimedia Subsystem—Architectural framework for delivering IP multimedia services.
inrush current	Peak current drawn when a device is connected or powered on
inter-RAT	Radio Access Technology
IOT	Interoperability Testing
IS	Interim Standard. After receiving industry consensus, the TIA forwards the standard to ANSI for approval.
IS-95	2G radio standards targeted for voice (cdmaONE)
LED	Light Emitting Diode. A semiconductor diode that emits visible or infrared light.
LHCP	Left-Hand Circular Polarized
LNA	Low Noise Amplifier
LPM	Low Power Mode
LPT	Line Print Terminal
MCS	Modulation and Coding Scheme
MHz	Megahertz = 10e6 Hz
NAS/AS	Network Access Server
NC	No Connect
NIC	Network Interface Card
NMEA	National Marine Electronics Association
OEM	Original Equipment Manufacturer—a company that manufactures a product and sells it to a reseller.
OFDMA	Orthogonal Frequency Division Multiple Access
OMA DM	Open Mobile Alliance Device Management—A device management protocol.
OTA	‘Over the air’ (or radiated through the antenna)
PA	Power Amplifier
packet	A short, fixed-length block of data, including a header, that is transmitted as a unit in a communications network.
PCB	Printed Circuit Board

Table 5-1: Acronyms and definitions (Continued)

Acronym or term	Definition
PCS	Personal Communication System A cellular communication infrastructure that uses the 1.9 GHz radio spectrum.
PDN	Packet Data Network
PMI	Pre-coding Matrix Index
PSS	Primary synchronisation signal
PST	Product Support Tools
PTCRB	PCS Type Certification Review Board
QAM	Quadrature Amplitude Modulation. This form of modulation uses amplitude, frequency, and phase to transfer data on the carrier wave.
QMI	Qualcomm MSM/Modem Interface
QOS	Quality of Service
QPSK	Quadrature Phase-Shift Keying
QPST	Qualcomm Product Support Tools
RAT	Radio Access Technology
RF	Radio Frequency
RI	Ring Indicator
roaming	A cellular subscriber is in an area where service is obtained from a cellular service provider that is not the subscriber's provider.
RSE	Radiated Spurious Emissions
RSSI	Received Signal Strength Indication
SDK	Software Development Kit
SED	Smart Error Detection
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.
SIB	System Information Block
SIM	Subscriber Identity Module. Also referred to as USIM or UICC.
SIMO	Single Input Multiple Output—smart antenna technology that uses a single antenna at the transmitter side and multiple antennas at the receiver side. This improves performance and security.
SISO	Single Input Single Output—antenna technology that uses a single antenna at both the transmitter side and the receiver side.

Table 5-1: Acronyms and definitions (Continued)

Acronym or term	Definition
SKU	Stock Keeping Unit—identifies an inventory item: a unique code, consisting of numbers or letters and numbers, assigned to a product by a retailer for purposes of identification and inventory control.
SMS	Short Message Service. A feature that allows users of a wireless device on a wireless network to receive or transmit short electronic alphanumeric messages (up to 160 characters, depending on the service provider).
S/N	Signal-to-noise (ratio)
SNR	Signal-to-Noise Ratio
SOF	Start of Frame—A USB function.
SSS	Secondary synchronisation signal.
SUPL	Secure User Plane Location
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.
TIS	Total Isotropic Sensitivity
TRP	Total Radiated Power
UDK	Universal Development Kit (for PCI Express Mini Cards)
UE	User Equipment
UICC	Universal Integrated Circuit Card (Also referred to as a SIM card.)
UL	Uplink (mobile to network)
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module (UMTS)
VCC	Supply voltage
VSWR	Voltage Standing Wave Ratio
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access (also referred to as UMTS)
WLAN	Wireless Local Area Network
ZIF	Zero Intermediate Frequency

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