MC5720, MC8755, MC8765 MiniCard

Hardware Integration Guide

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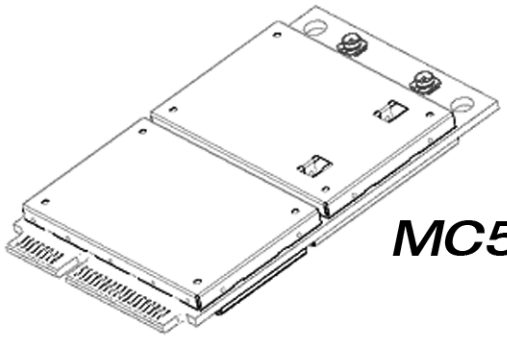
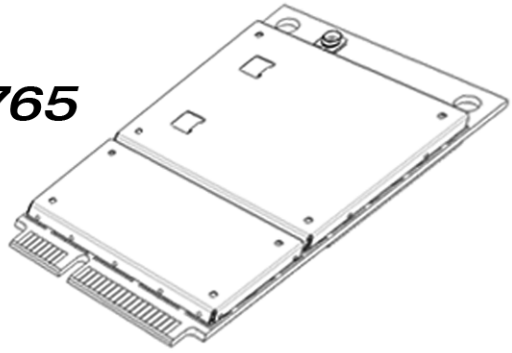


MC5720

MC8755/8765



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1: Introduction

Sierra Wireless' MiniCard modules form the radio component for the products in which they are embedded. MiniCards are available for use on CDMA and GSM networks, including:

- **MC5720** — operates on CDMA networks using the IS-95A and CDMA 1X, and 1xEV-DO (IS-866) network standards
- **MC8755** and **MC8765** — operates on GSM networks using the GSM/GPRS/EDGE/UMTS/HSDPA network standards

Purpose of this guide

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

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

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 multiple members of the Wireless Embedded Module product family. It contains the hardware components that are typically necessary for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas
- Other accessories

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 these modules into your host device, you need the following connector types:

- RF cable that mates with Hirose U.FL connector (model U.FL #CL331-0471-0-10)
- Industry-standard mating connector for 52-pin EDGE: Some manufacturers include Tyco, Foxconn, and Molex. For example, the connector used on the MC5720/MC8755/

MC8765 Universal Development Kit board is a Molex 67910-0001.

- Industry-standard USIM/RUIM connector: The actual connector you use depends on how your device exposes the USIM/RUIM socket. For example, the USIM/RUIM connector used on the MC5720/MC8755/MC8765 Universal Development Kit is an ITT CCM03-3518.

Guide Organization

This guide includes the following sections:

1. **Introduction** (this section)
2. Power Interface (p.9)
   Describes power control signals used by the module and discusses design issues related to power supply integration.
3. RF Integration (p.13)
   Describes antenna connection methods and grounding issues, RF interference and desense issues.
4. Host/Module Communication Interface (p.17)
   Describes the USB interface for host/module communication, and the USIM/RUIM interface for host/module integration.
5. Acronyms and Definitions (p.23)
   Lists acronyms and definitions used throughout this guide.
6. Regulatory Information (p.19)
   Describes regulatory approvals and regulatory information requirements.

Note: The term "host" always refers to the host device.

Related documents

This guide deals specifically with hardware integration issues that are unique to the MC5720 and MC8755/8765 modules.

Table 1-1 lists other documents referenced in this guide.

Table 1-1: Related documentation

Document title	Description
AT Command Set for User Equipment (UE) (Release 6)	This 3GPP technical specification describes standard AT commands for GSM/UMTS devices. The document (3GPP TS 27.007) can be downloaded from www.3gpp.org.
CDMA 1X Standard	This standard describes the technical requirements for CDMA systems, including details on sleep cycle index (SCI) values. The document, CDMA 2000 Series Release A (2000) (document # TIA/EIA/IS-2000 Series, Release A) can be ordered from www.tiaonline.org.
EM5625/MC5720 CnS Reference (Document 2130643)	This document describes the CnS (Control and Status) messages that are available for use with the MC5720.
EMXXXX Embedded Modem Extended AT Command Reference (Document 2130395)	This document describes proprietary AT commands for the MC5720. For MC8755/MC8765-specific commands, see *MC87xx Modem Extended AT Command Reference (Document 2130616)*
FCC Regulations - Part 15 - Radio Frequency Devices	This section of the FCC Code of Federal Regulations, Title 47 deals with radio frequency devices, including EM shielding requirements. The regulation can be downloaded from http://wireless.fcc.gov.
IEC-61000-4-2 level 3	This document describes techniques for testing and measuring electrostatic discharge (ESD) immunity. The document can be ordered from www.iec.ch.
MC5720 MiniCard Product Specification (Document 2130599)	This document describes the mechanical and electrical specifications, and standards compliance of the MC5720.
MC8755/MC8765 PCI Express MiniCard Product Specification (Document 2130637)	This document describes the mechanical and electrical specifications, and standards compliance of the MC8755/ MC8765.
MC87xx Modem CnS Reference (Document 2130602)	This document describes the CnS (Control and Status) messages that are available for use with the MC8755/ MC8765.
MC87xx Modem Extended AT Command Reference (Document 2130616)	This document describes proprietary AT commands for the MC8755/MC8765. For MC5720-specific commands, see the *EMXXXX Embedded Modem Extended AT Command Reference (Document 2130395)*

Table 1-1: Related documentation

Document title	Description
Mobile Station (MS) Conformance Specification; Part 4: Subscriber Interface Module	This 3GPP technical specification describes SIM testing methods. The document (3GPP TS 11.10-4) can be downloaded from www.3gpp.org.
PCI Express Mini Card Electromechanical Specification Revision 1.1	The document can be downloaded from www.pcisig.com.
Universal Serial Bus Specification, Rev 2.0	The specification can be downloaded from www.usb.org.

2: Power Interface

Overview of operation

Note: This chapter contains information for both the CDMA (MC5720) and GSM (MC8755/8765) modules.

*Information that is **unique** to one module type is clearly identified.*

The module is 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/de-assertion of the W_Disable# signal. 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 indicated in *PCI Express Mini Card Electromechanical Specification Revision 1.1*).

The MC8755/8765 has more power pins than the MC5720 due to higher peak current requirements for GSM devices.

For detailed pinout and voltage / current requirements of these modules, refer to *MC5720 MiniCard Product Specification (Document 2130599)* and *MC8755/MC8765 PCI Express MiniCard Product Specification (Document 2130637)*.

Electrostatic discharge (ESD)

You are responsible for ensuring that the host has adequate ESD protection on digital circuits and antenna ports:

- (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*

Specific recommendations are provided where needed in this guide, however, the level of protection required depends on your application.

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

Module power states

Note: The module unit defaults to the Normal state when VCC3.3 is first applied in the absence of W_Disable# control.

At any time, the module will be in one of 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 modem into the disconnected state. If the power rail is shared between the host device and the module, the host is powered off when the module 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 asserting (driving low) the W_Disable# signal. In this state, the module draws minimal current.

Normal state

Note: This is the default state when VCC3.3 is first applied in the absence of W_Disable# control.

This is the active state of the module. While 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 mode

In this power state, RF (both Rx and Tx) is disabled in the module, but the USB interface is still active. This low power mode ("airplane mode") is controlled by a software command through the host interface.

For instructions on using appropriate commands, refer to *AT Command Set for User Equipment (UE) (Release 6) (+CFUN=0 command)*, *EM5625/MC5720 CnS Reference (Document 2130643) (CNS_RADIO_POWER [0x1075])*, or *MC87xx Modem CnS Reference (Document 2130602) (Disable Modem)*.

Usage models

Usage models can be used to calculate expected current consumption. A sample usage model is provided in Table 2-1.

Table 2-1: Power consumption of a sample application

	Used by a field worker (data only)	Used for remote data logging
Upload (module Tx)	1000 kB/day	40 kB/h
Download (module Rx)	500 kB/day	100 kB/day
Coverage / data rate	1X / 80 kbps	IS-95 / 14.4 kbps
Hours of operation	8 / day (off 16 hrs / day)	24 / day
Total power consumed over 24 hours	60 mAh	200 mAh

This example model applies to a battery-operated device. In practice, because the module will be isolated from the battery (the host device manages the power source), the mAh ratings will depend on the device's supply efficiency.

The module automatically enters slotted sleep mode when there is no transmission or reception occurring (SCI = 2).

Transmit power is assumed to be +3 dBm .

3: RF Integration

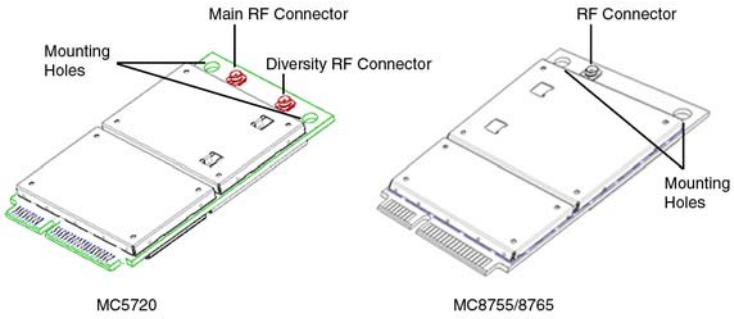
RF connection

Consider the following 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, as shown in Figure 3-1 (The main RF connector on the top side; the diversity RF connector on the bottom side).
- 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.*

Figure 3-1: Antenna connection points and mounting holes



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 (as shown in Figure 3-1).
- 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.

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 ≤ 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, particularly when both the MC5720 and MC8755/8765 will be installed in the same platform. In this case, you may want to develop separate antennas for maximum performance.

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.

Disabling the diversity antenna (MC5720)

If your host device is not designed to use the MC5720's diversity antenna, terminate the interface with a no-connect.

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.

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

Different wireless devices operating inside the host device can cause interference that affects the module.

To determine the most suitable locations for each antenna 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 the MiniCard 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 (RF desense).

The proximity of host electronics to the antenna in wireless devices can contribute to RF desense. Components that are most likely to cause RF desense include:

- Microprocessor and memory
- Display panel and display drivers
- Switching-mode power supplies

These, and other high-speed devices (in particular, the processor) can cause RF desense because they run at frequencies of tens of MHz. The rapid rise and fall of these clock signals generates higher-order harmonics that often fall within the operating frequency band of the module, causing RF desense.

Example

On a sub-system running at 40 MHz, the 22nd harmonic falls at 880 MHz, which is within the cellular receive frequency band.

Note: In practice, there are usually numerous interfering frequencies and harmonics. The net effect can be a series of desensitized receive channels.

4: Host/Module Communication Interface

This chapter provides information about the Host-Module communication interface (USB interface) and lists of extended AT commands that may be useful for hardware integration testing.

Note: On any given interface (USB, USIM/RUIM, etc.), leave unused inputs and outputs as no-connects.

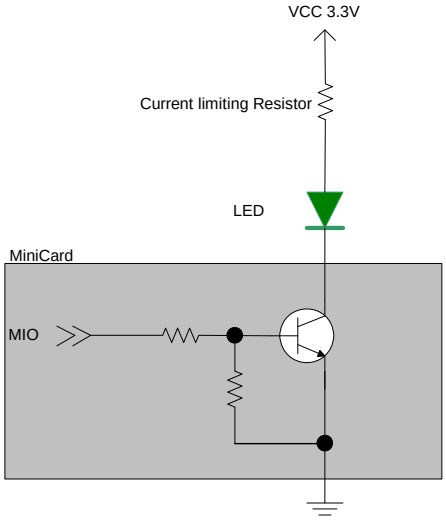
LED output

The module drives the LED output according to the *PCI-Express MiniCard specification* (summarized in Table 4-1, below).

Table 4-1: LED States

State	Indicates	Characteristics
OFF	Module is not powered.	Light is turned off.
ON	Module is powered and connected, but not transmitting or receiving.	Light is turned on.
Slow Blink	Module is powered and searching for a connection.	LED is flashing at a steady, slow rate. • 250 ms ± 25% ON period • 0.2 Hz ± 25% blink rate
Intermittent Blink	Module is transmitting or receiving.	LED is flashing intermittently, proportional to activity on the interface. • 50% duty cycle • 3 Hz minimum blink rate • 20 Hz maximum blink rate

Figure 4-1: Example LED



5: Regulatory Information

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 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 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 modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

Safety and hazards

Do not operate your MC5720/MC8755/MC8765 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
- Near life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the MC5720/MC8755/MC8765 modem **MUST BE POWERED OFF**. Otherwise, the MC5720/MC8755/MC8765 modem can transmit signals that could interfere with this equipment.

In an aircraft, the MC5720/MC8755/MC8765 modem **MUST BE POWERED OFF**. Otherwise, the MC5720/MC8755/MC8765 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 MC5720/MC8755/MC8765 modem may be used normally at this time.

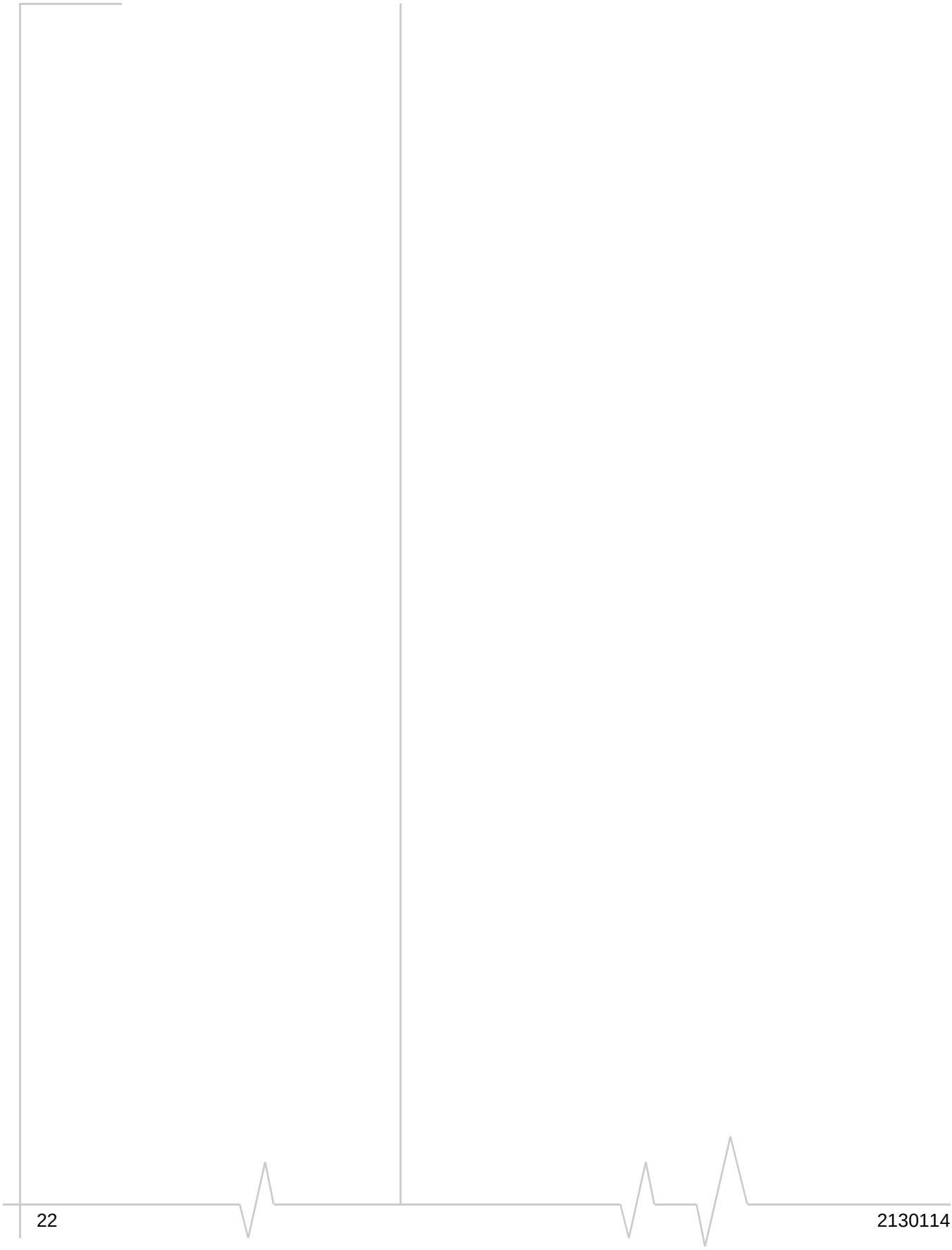
Important compliance information for North American users

The MC5720/MC8755/MC8765 modem has been granted modular approval for mobile applications. Integrators may use the MC5720/MC8755/MC8765 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:
   - 8 dBi in the Cellular band and 4 dBi in the PCS band for the MC8755/MC8765
   - 4.65 dBi in the Cellular band and 3.35 dBi in the PCS band for the MC5720
3. The MC5720/MC8755/MC8765 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 MC5720/MC8755/MC8765 modem is incorporated, with a statement similar to the following:
   - For MC5720:
     This device contains TX FCC ID: N7N-MC5720
     This equipment contains equipment certified under IC: 2417C-MC5720
   - For MC8755:
     This device contains TX FCC ID: N7NMC8755
     This equipment contains equipment certified under IC: 2417C-MC8755
   - For MC8765:
     This device contains TX FCC ID: N7NMC8765
     This equipment contains equipment certified under IC: 2417C-MC8765
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 MC5720/MC8755/MC8765 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.



A: Acronyms and Definitions

Table 5-1: 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 Service
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
MC5720	Sierra Wireless MiniCard used on CDMA networks

Table 5-1: Acronyms and definitions

Acronym or term	Definition
MC8755 / MC8765	Sierra Wireless MiniCards used on GSM networks
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
RUIM	Removable User Identity Module
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
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
VCC3.3	3.3 V 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/RUIM interface (XIM_VCC, XIM_CLK, etc.). It indicates either RUIM or USIM.

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