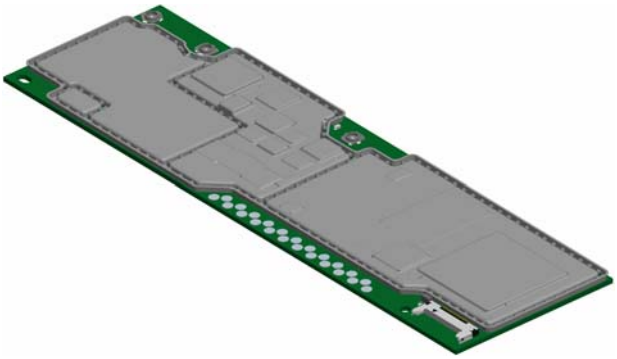
GSM Embedded Modules

Hardware Integration Guide

Proprietary and Confidential

EM8780/
EM8781



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1: Introduction

Sierra Wireless' embedded modules form the radio component for the products in which they are embedded. The embedded modules are available for use on GSM networks, and include these products:

- **EM8780** and **EM8781**—operate on GSM networks using the GSM / GPRS / EDGE / UMTS / HSDPA network standards

Note: Throughout this document, EM878x refer to the entire suite of GSM embedded modules.

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 Lab Adapter Board

Sierra Wireless manufactures a Lab Adapter Board that facilitates all phases of the integration process.

The Lab Adapter Board 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:

- Lab Adapter Board
- Cables
- Antennas
- Other accessories

Required connectors

Note: Contact the vendors before you choose 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 IPEX MHF-A13 connector (model 20428-001R)
- IPEX 15 pin CABLINE cable connector(part number 20347-015E-01).
- 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 Lab Adapter Board is an ITT CCM03-3518.

Guide organization

This guide includes the following sections:

1. **Introduction** (this section)
2. **Power Interface** (page 11)
   Describes power control signals used by the module and discusses design issues related to power supply integration.
3. **RF Integration** (page 15)
   Describes antenna connection methods and grounding issues, RF interference and desense issues.
4. **Regulatory Information** (page 21)
   Describes regulatory approvals and regulatory information requirements.
5. **Acronyms and Definitions** (page 23)
   Lists acronyms and definitions used throughout this guide.
6. **Index** (page 101)

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

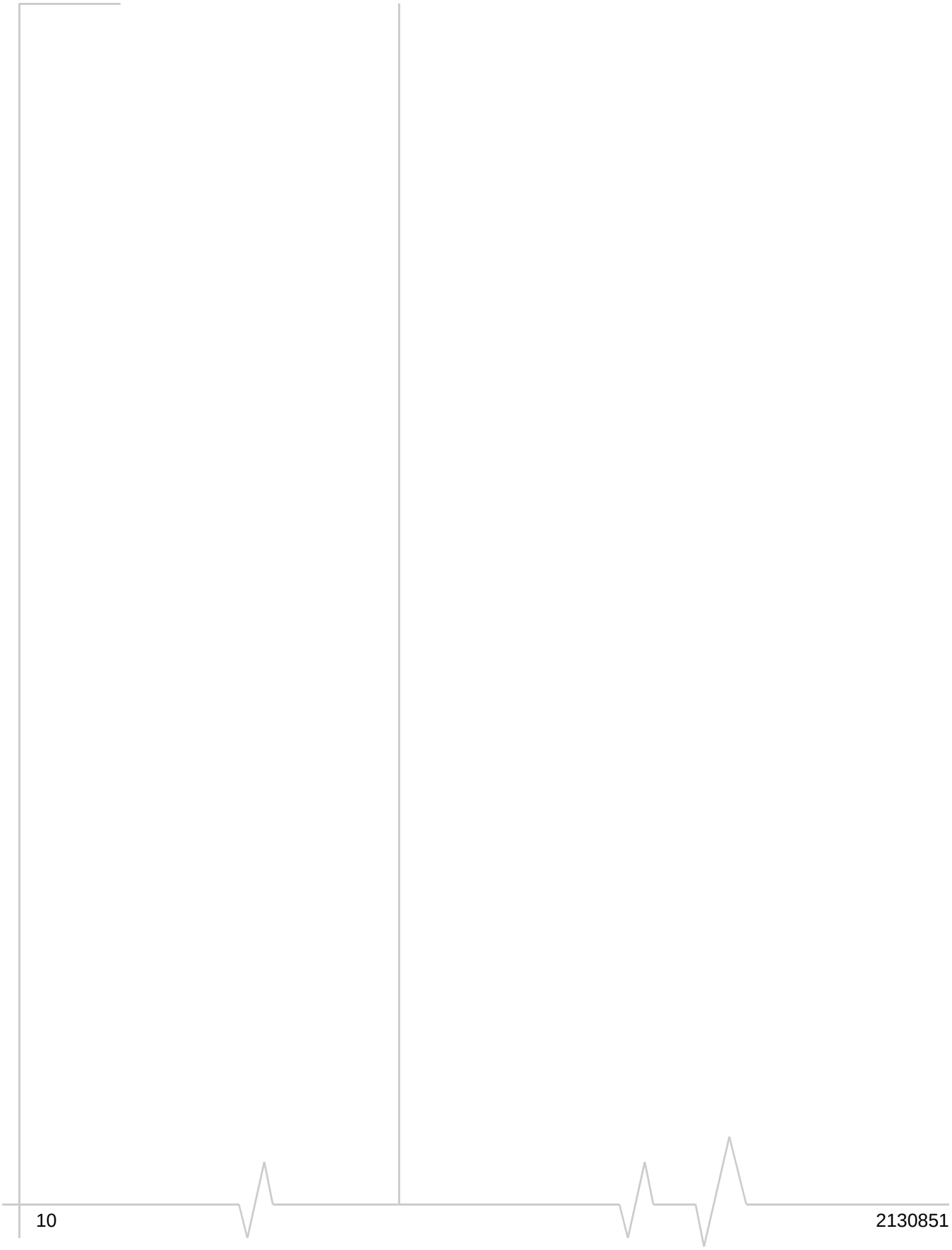
Related documents

This guide deals specifically with hardware integration issues that are unique to the EM878x 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. Download this document (3GPP TS 27.007) from www.3gpp.org.
FCC Regulations - Part 15 - Radio Frequency Devices	This section of the FCC Code of Federal Regulations, Title 47 deals with radio frequency devices, including shielding requirements for embedded modules. Download this regulation from http://wireless.fcc.gov.
IEC-61000-4-2 level 3	Techniques for testing and measuring electrostatic discharge (ESD) immunity. Order this document from www.iec.ch.
EM8780/EM8781 Product Specification (Document 2130TBD)	Features, mechanical and electrical specifications, and standards compliance of the EM8780 / EM8781.
MC87xx Modem CnS Reference (Document 2130602)	This document describes the CnS (Control and Status) messages supported by the EM8780/EM8781.
MC87xx Modem Extended AT Command Reference (Document 2130616)	Proprietary AT commands for the EM878x.
Mobile Station (MS) Conformance Specification; Part 4: Subscriber Interface Module	This 3GPP technical specification describes SIM testing methods. Download this document (3GPP TS 11.10-4) from www.3gpp.org.
UMTS Modems Supported AT Command Reference (Document 2130617)	This document describes proprietary, basic AT commands for the EM878x.
Universal Serial Bus Specification, Rev 2.0	Download this specification from www.usb.org.



2: Power Interface

Overview of operation

The module is designed to use a 5.0V (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 supply of the 5.0V power rail. When this rail is powered up, the modem is in the ON state. When this rail is powered down, the modem is in the OFF state.

Power signals

The module must be connected to a 5.0V power supply.

For detailed pinout and voltage / current requirements of these modules, see the Product Specification Document for your embedded module.

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 USIM / RUIM connector at the point where the contacts are exposed, and for any other signals from the host interface that would be subjected to ESD by the user of the product.

Module power states

Note: The module unit defaults to the Normal state when 5.0V is first applied.

The module has three power states:

- **Off**
  No power to the module.
- **Normal**
  Power is supplied to the module. The module is active. Several modes are possible (Receive, Transmit, Sleep, Shutdown).
- **Low power ("airplane mode")**
  Power is supplied to the module. The module is active, but RF is disabled.

A state machine is implemented in the module to monitor the operating temperature.

Off state

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.

Normal state

Note: This is the default state when 5.0V is first applied.

This is the active state of the module. In this state:

- The module is fully powered.
- The module is capable of placing / receiving calls or establishing data connections on the wireless network.
- The USB interface is fully active.

Low power mode

In this 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 software commands through the host interface.

For instructions on using the commands, refer to:

- *AT Command Set for User Equipment (UE) (Release 6) (+CFUN=0 command),*

- *MC87xx Modem CnS Reference (Document 2130602) (Disable Modem command).*

Usage models

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

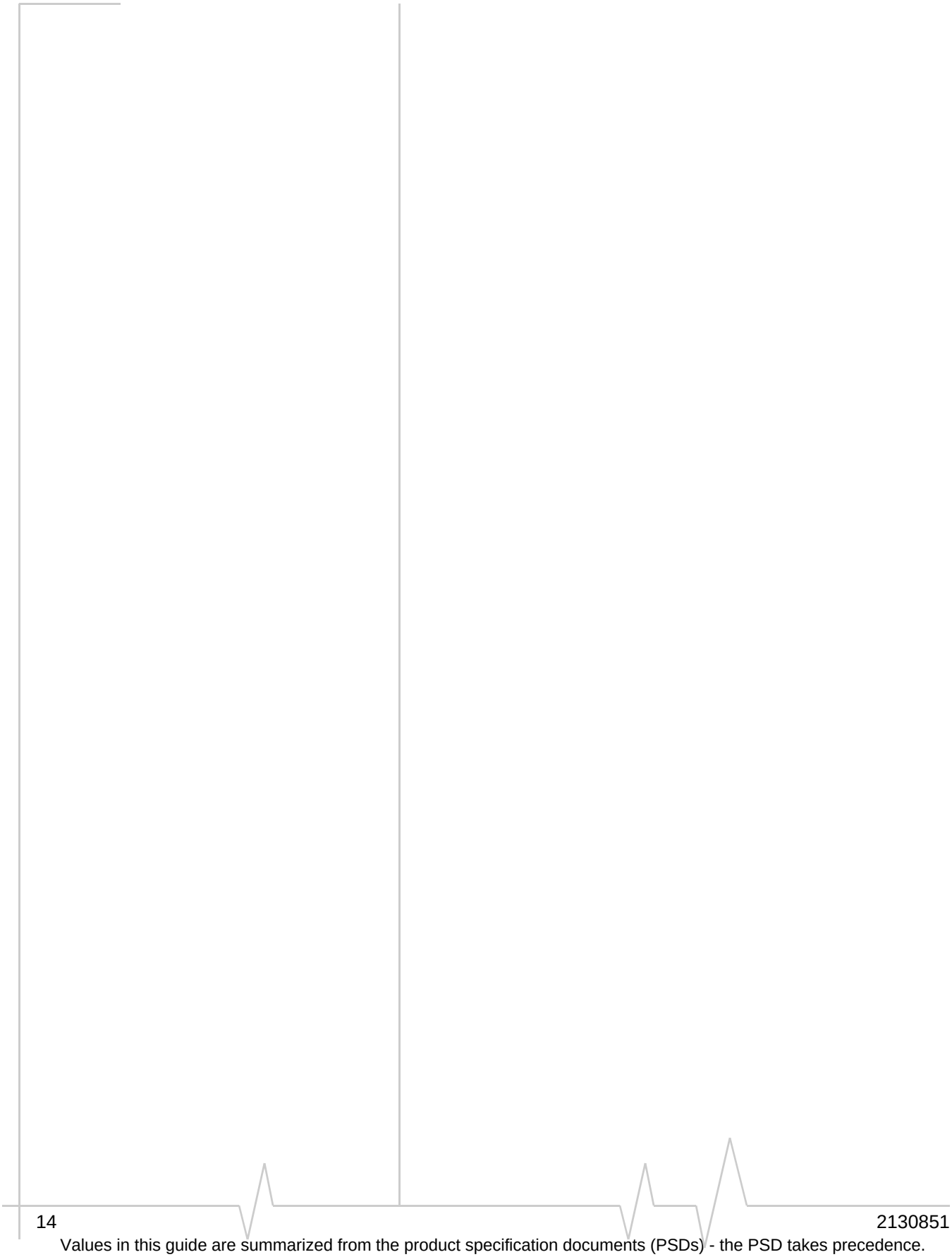
Table 2-1: Power consumption of a sample application

	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	66 mAh	220 mAh

This example model applies to a battery-operated device. In practice, because the module is isolated from the battery (the host device manages the power source), the mAh ratings 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

The **EM878x** operates on the frequencies detailed in Table 3-1.

Table 3-1: EM878x — Supported frequencies

Band	Frequencies (MHz)
GSM 850	Tx: 824–849 Rx: 869-894
EGSM 900	Tx: 880-915 Rx: 925-960
DCS 1800	Tx: 1710-1785 Rx: 1805-1880
PCS 1900	Tx: 1850-1910 Rx: 1930-1990
Band I UMTS 2100	Tx: 1920–1980 Rx: 2110–2170
Band II UMTS 1900	Tx: 1850–1910 Rx: 1930–1990
Band V UMTS 850	Tx: 824–849 Rx: 869–894

RF connection

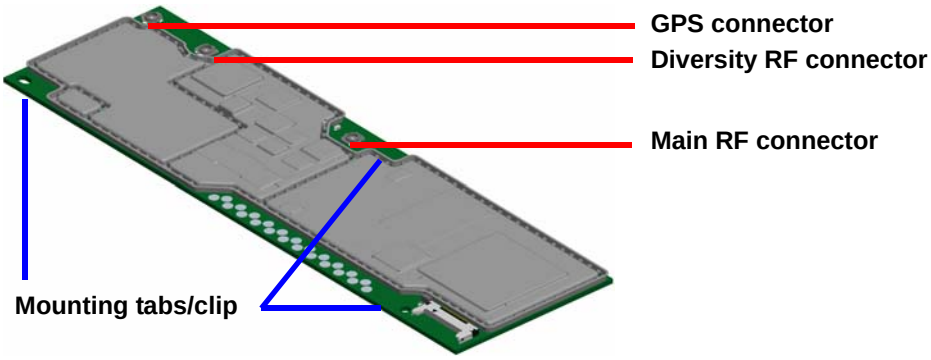
When attaching an antenna to the module:

- Use an IPEX MHF connector (model MHFA13-7G-113-60-SW) to attach an antenna to a connection point on the module, as shown in Figure 3-1 below.
- 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 IPEX MHF connector removal tool (P/N TBD) to prevent damage to the module or coaxial cable assembly.*

Figure 3-1: Antenna connection points and mounting tabs/clip

EM8780/8781:



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 mounting tabs at the top and bottom of the module (as shown in Figure 3-1 on page 16).
- 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

*Note: Values in this guide are taken from the appropriate product specification documents (PSDs) (listed in **Related documents**, page 9). In the case of a discrepancy between this document and the relevant PSD, use the value listed in the PSD.*

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.

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

If your host device is not designed to use the module's diversity antenna, terminate the interface with a 50 Ω ohm load.

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.

Note: Values in this guide are taken from the appropriate product specification documents (PSDs) (listed in ***Related documents****, page 9). In the case of a discrepancy between this document and the relevant PSD, use the value listed in the PSD.*

Interference and sensitivity

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.

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 embedded module 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:

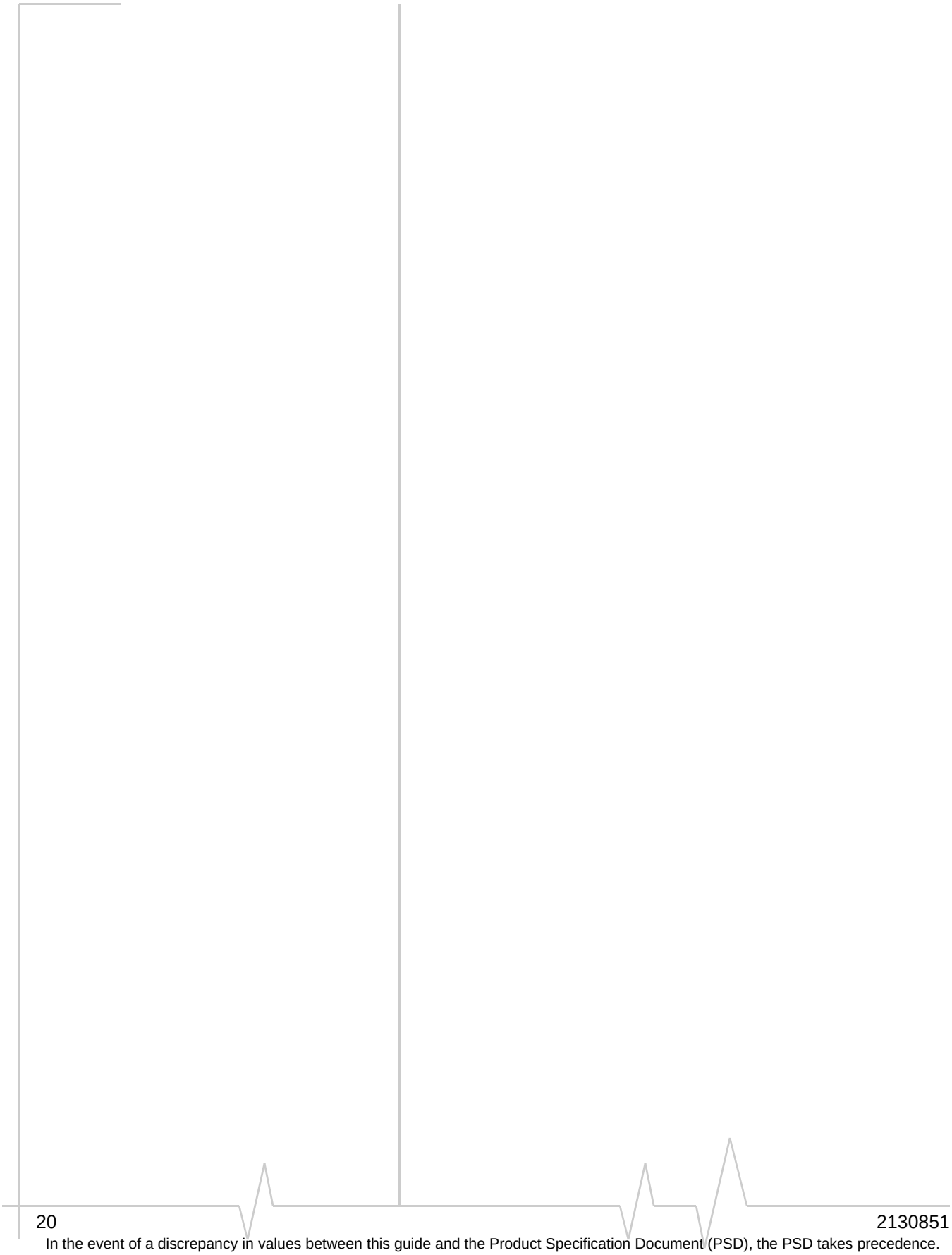
- Microprocessor and memory
- Display panel and display drivers
- Switching-mode power supplies

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: 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 EM8780/EM8781 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 EM8780/EM8781 modem **MUST BE POWERED OFF**. Otherwise, the EM878x modem can transmit signals that could interfere with this equipment.

In an aircraft, the EM8780/EM8781 modem **MUST BE POWERED OFF**. Otherwise, the EM8780/EM8781 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 EM8780/EM8781 modem may be used normally at this time.

Important compliance information for North American users

The EM8780/EM8781 modem has been granted modular approval for mobile applications. Integrators may use the EM8780/EM8781 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:
   - 5 dBi in the Cellular band and 4 dBi in the PCS band for the EM8780/EM8781 modem
3. The EM8780/EM8781 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 EM8780/EM8781 modem is incorporated, with a statement similar to the following:
   - For EM8780:
     This device contains FCC ID: N7NEM8780
   - For EM8781:
     This device contains FCC ID: N7NEM8781
     This equipment contains equipment certified under IC: 2417C-EM8781
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 EM8780/EM8781 modem may also need to pass the FCC Part 15 unintentional emission testing requirements and 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.

A: Acronyms and Definitions

A

Table A-1: Acronyms and definitions

Acronym or term	Definition
BER	Bit Error Rate — a measure of receive sensitivity
BLER	Block Error Rate
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)
EDGE	Enhanced Data rates for GSM Evolution
EM	Embedded Module
EM8780/EM8781	Sierra Wireless embedded modules used on GSM networks
ESD	ElectroStatic Discharge
GPRS	General Packet Radio Services
GPS	Global Positioning System — a system that uses a series of 24 geosynchronous satellites to provide navigational data.
GSM	Global System for Mobile communications
HSDPA	High Speed Download Packet Access. An add-on data service to GSM mobile phone networks.
Hz	Hertz = 1 cycle/second
IS-95	2G radio standards targeted for voice (cdmaONE)
MHz	MegaHertz = 10E6 Hertz (Hertz = 1 cycle/second)
PCS	Personal Communication System — PCS spans the 1.9 GHz radio spectrum
RF	Radio Frequency
RUIM	Removable User Identity Module
SCI	Slot Cycle Index
Sensitivity (RF)	Measure of lowest power signal at the receiver input that can provide a prescribed BER/BLER/SNR value at the receiver output.

Table A-1: Acronyms and definitions

Acronym or term	Definition
SIM	Subscriber Identity Module
SNR	Signal to Noise Ratio
UMTS	Universal Mobile Telecommunications System. See also WCDMA.
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
WCDMA	Wideband Code Division Multiple Access. In this document, the term “UMTS” is used instead of “WCDMA”.

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