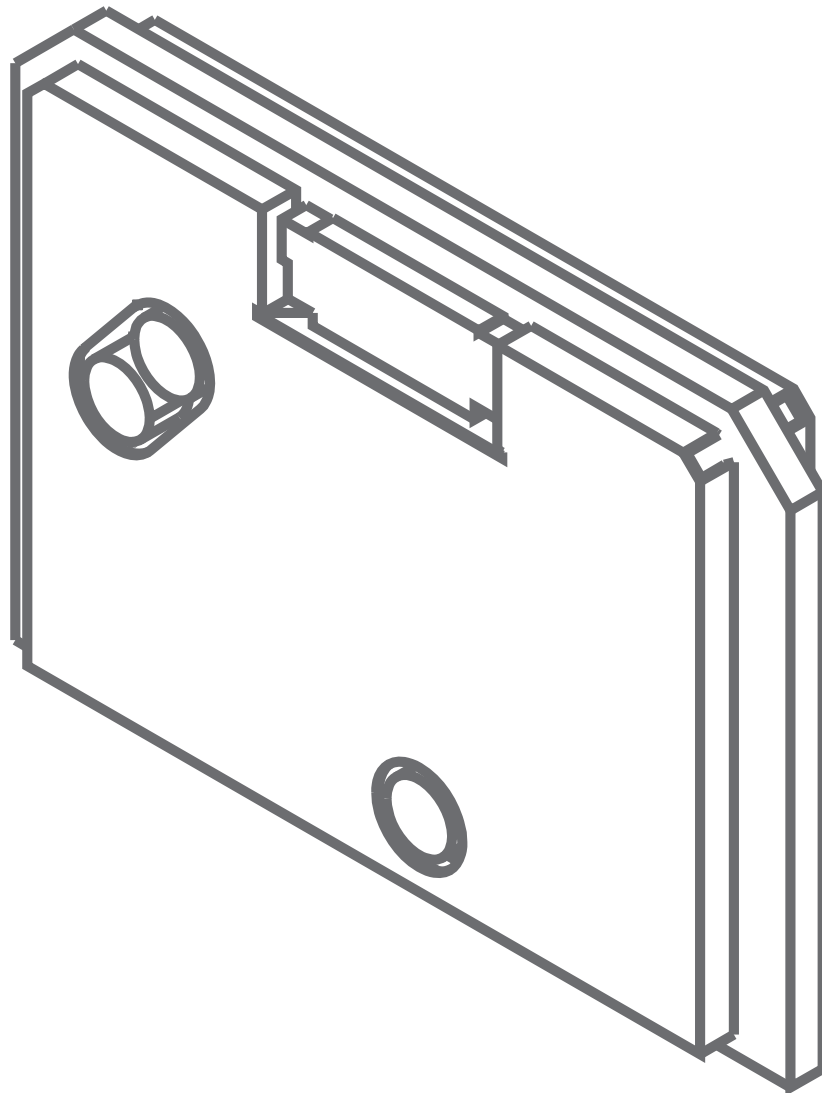# RFID Reader Module
21-121559-01 and 21-121560-01
Integration Guide (For Motorola Internal Use Only)

RFID Reader Module
21-121559-01 and 21-121560-01
Integration Guide

Patents

This product is covered by one or more of the patents listed on the web site: http://www.symbol.com/patents

Revision History

Changes to the original manual are listed below:

Change	Date	Description
-01 Rev A	4/2009	Initial Release

Table of Contents

About This Guide

Introduction

This guide provides information about configuring and installing the RFID Reader Module into a final product.

Documentation Set

This document for the RFID Reader Module provides information for the integrator.

Configurations

This guide covers the following configurations:

Configuration	
US RFID Reader Module	21-121559-01
EU RFID Reader Module	21-121560-01

Chapter Descriptions

Topics covered in this guide are as follows:

- *Chapter 1, Introduction*, provides information on the RFID Reader Module.
- *Chapter 2, Installation*, provides information on configuring and installing the RFID Reader Module.
- *Appendix A, Technical Specifications*, includes the technical specifications for the RFID reader
- *Appendix B, Timing*, provides the RFID Reader Module timing diagrams.
- *Appendix C, Regulatory Requirements*, provides the RFID Reader Module regulatory requirements.

Notational Conventions

The following conventions are used in this document:

- "RFID Reader", "reader" or "reader module" refers to the Motorola RFID Reader Module.
- *Italics* are used to highlight the following:
  - Chapters and sections in this guide
  - Related documents and links
- **Bold** text is used to highlight the following:
  - Dialog box, window and screen names
  - Drop-down list and list box names
  - Check box and radio button names
  - Icons on a screen
  - Key names on a keypad
  - Button names on a screen.
- Bullets (•) indicate:
  - Action items
  - Lists of alternatives
  - Lists of required steps that are not necessarily sequential.
- Sequential lists (e.g., those that describe step-by-step procedures) appear as numbered lists.

Service Information

If an equipment problem occurs, contact the appropriate regional Support Center for contact information. Before calling, locate the model number and serial number.

Call the Support Center from a phone near the equipment so that the service person can try to talk through the problem.

If the problem cannot be solved over the phone, the equipment may need to be returned for servicing. If that is necessary, specific directions will be provided.

> ✓ **NOTE** Motorola is not responsible for any damages incurred during shipment if the approved shipping container is not used. Shipping the units improperly can possibly void the warranty.

Support Information

For service information, warranty information or technical assistance contact or call the Support Center. Contact information is provided on the Motorola contact web site go to: http://support.symbol.com.

If the Motorola product was purchased from a Motorola Business Partner, contact that Business Partner for service.

Chapter 1 Introduction

Introduction

This chapter provides an overview of the RFID Reader Module. Product specifications are provided in *Table A-1 on page A-1*.

The module is a RFID Reader Engine module that supports EPC Gen2 protocol in the UHF frequency band. There are two versions of the module:

- 10 mWatt to 1 Watt US (part No. 21-121559-01)

- 10 mWatt to 1 Watt EU (part No. 21-121560-01)

The differences between the US and EU module are Pre-PA Saw Filter and PA matching components and OEM F/W settings.

The RFID Reader Module is based on the Intel R1000 reference design and has been modified for power efficiency and size.

The RFID Reader Module is a RFID Radio Engine which supports ISO 18000-6C and Electronic Product Code (EPC) Gen2 reader applications. RFID Reader Module is intended to enable Mobile Computers and Barcode Scanners to read EPC Gen2 UHF RFID tags. The RFID Reader Module is a very small form-factor RFID Reader engine, that when used with a high performance RFID antenna(s), can be commanded to perform EPC Gen2 RFID Reader operations.

This document defines the RFID Reader Module functional characteristics (electrical, mechanical) and provides information required by the system integrators to embed the RFID Reader Module in a variety of systems. A section outlining good design practices is also incorporated to help with the overall integration of the device.

The RFID Reader Module supports all EPC Gen2 Link Profiles of the R1000 Reference Design. The RFID Reader Module is a EPC Gen2 Compliant Mono-static Reader Module that operates in the 902MHz-928MHz ISM band in US and Canada, and 865.6MHz - 867.6 MHz in Europe. For details see *Technical Specifications on page A-1*

The RFID Reader Module reference performance specifications are provided in *Appendix A, Technical Specifications* on *page A-7*.

Sailfish Integration

In the early stages of Sailfish integration, the integrators need focus on key design areas to achieve the best RFID reader performance. Some key areas that should be focused on are:

1. The power supply capacity must be sufficient for the power requirements at the targeted RF power levels. Be sure to account for:

    *   Voltage drops from your 5V supply to the Sailfish Module inputs

    *   The 5V supply must stay within the range of 5V +/- 5% at the Sailfish host connector after all of the voltage drops of battery impedances, connector contacts, flex cables, pc traces etc. The max currents of the module are specified at 5.0V.

    *   Sailfish creates very long pulses (up to 400ms) of current peaks. These current surges (that Sailfish requires) must not create a low battery event in the power micro circuit.

2. RFID Antenna

    *   The read performance of the Sailfish Module depends on not only the gain of the antenna but more importantly the Return Loss or VSWR of the antenna across the entire bandwidth of the radio (unlike 802.11 or Bluetooth). The radio must receive a tag response while it is transmitting, and the more signal that is reflected back from the antenna, the more blinded the receiver becomes. Also, RFID tags are not always polarized the same way as the antenna and a robust antenna design could greatly improve read performance.   Antenna performance depends on the application requirements but must also meet the requirements stated in *Appendix C, Regulatory Requirements*.

    *   The antenna features that must be emphasized are bandwidth, return loss, and gain.   If the return loss can be optimized over the entire bandwidth of the radio, the radio will accomplish its reading of the tag population in the least amount of time and for the least amount of battery power.

    *   With a Motorola designed application, the Sailfish Module can be used to evaluate the VSWR or return loss characteristic of the embedded antenna system for WinCE products. This application is called RFID Demo and is demonstration software which can exercise the sailfish module for various test purposes.

3. Thermal Management

    *   Since Sailfish has been packaged in a very small form factor, thermal management is critical during the integration phase of this module. The Module has been designed to expose the hottest points of the module to a cold-plate or heat-sink through thermal interface material. Proper heat sinking significantly increases the time that the radio can operate without entering a thermal back-off mode. Once in this mode, the radio continues to operate, but at reduced duty cycle and read rates.

    *   Most applications will use some initial duty-cycle (such as 50%) for power management reasons, however this should be considered on an individual application basis.

4. Flex Cable interface

    *   The host interface is a 16 pin flex. Use heavy traces for the VCC and ground traces and it is recommended that an outer ground plane is used to shield the control signals from system noise and ESD. The flex should be kept as short as possible in order to reduce voltage drops to the module.

    *   Once the module and corresponding host connector have been located, it is important to confirm that the signals have not been crossed at the flex connection. This is a common error and should be considered as part of an required design check.

Unpacking the Reader Module

Carefully remove all protective material from around the reader and save the shipping container for later use.

Verify that all equipment was received:

- RFID Reader Module

Inspect the equipment for damage. If any equipment is missing or if any equipment is damaged, contact the Motorola Technologies Support Center immediately. See *Service Information on page viii* for contact information.

Note: Observe ESD precautions. Exercise care when handling the module. Use grounding wrist straps and handle in a properly grounded work area. for
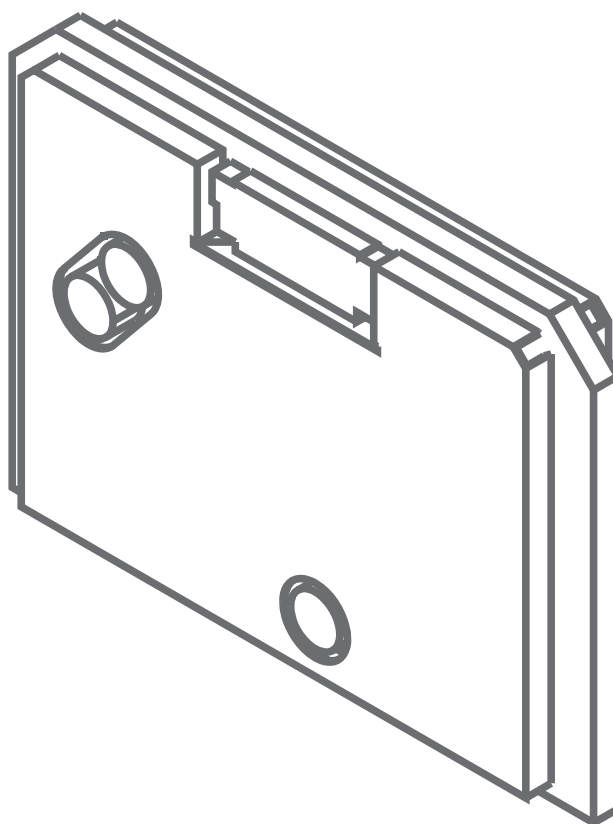
Figure 1-1   *RFID Reader Module*

Connections and Ports

See Table *Table 2-1 on page 2-4* for a detailed list of the RFID Reader Module connections. The RFID Reader Module has connections for:

- Host Port Interface
- External antenna(s)
- Thermal Contact Points

Theory of Operation

The RFID Reader Module is a UHF, US (902 – 928MHz) and EU (865.6 – 867.6MHz), RFID reader module. The RFID Reader Module can read and write UHF passive RFID tags complying to EPCglobal Gen2 standard. Commands from the reader are broadcast to the tags on the transmit carrier followed by a CW transmission. Passive tags are powered by reader energy before communication between the reader to the tag starts. After decoding the command data, the tags respond by back scattering with encoded data, modulated on the CW transmission.

The RFID Reader Module can be used in mobile devices to provide the capability for reading EPC Gen2 RFID tags in the UHF band. Once commanded, the RFID Reader Module interrogates the intended field and listen for RFID tag backscatter. The RFID Reader Module is a mono-static RFID transceiver module using frequency hopping spread Spectrum (FHSS) in order to interrogate tags. For normal operating modes, there are 50 US channels over the 902 to 928MHz ISM Band, and four European channels in the ETSI(EU) 865.6-867.6MHz band that the radio hops over in order to communicate to the tags. The read range of the radio is highly dependant on both the RFID antenna performance, and RF output power.

The RFID Reader Module is designed as an embedded module and is intended to be used as an integral part of an RFID system.

- Handheld or portable devices
- Printers

Block Diagram

The RFID Reader Module consists of a UHF transceiver and a processor with interfaces to external antenna(s) and a host system.

The RFID Reader Module consists of all of the components necessary to make up an RFID Reader Radio for the 915MHz band. The RFID Transceiver IC (R1000) and the Atmel ARM7 Microprocessor (AT91SAM7S256) make up the major portion of the RFID Reader Radio. In addition, the Power Amplifier (MAAP0007649), RF detectors, and other RF components complete the EPC Gen2 compliant module.

There are two oscillators on the RFID Reader Module that are used to create the Local Oscillator, and digital timing clocks for the radio. The 24MHz Oscillator provides a reference clock for both the RF PLL and the RF Transceiver. The 18.432MHz Oscillator provides the primary clock for the Arm Processor including a reference for the processors internal PLL.

The Impinj R1000 RFIC (U2) implements a UHF RFID transceiver supporting both 868MHz and 915MHz ISM bands. The chip set uses a "Zero Intermediate Frequency (ZIF), high intercept point I/Q architecture for the radio. The architecture contains low-noise, high IP3 amplifiers, quad up/down converters, frequency synthesizers, low-pass filters, AGC receiver amplifiers, transmit/receive switches, and transmitter power amplifiers.

The Radio control and EPC Gen2 link protocol is implemented in firmware and is in the Atmel AT91SAM7S256(U12) Arm processor.
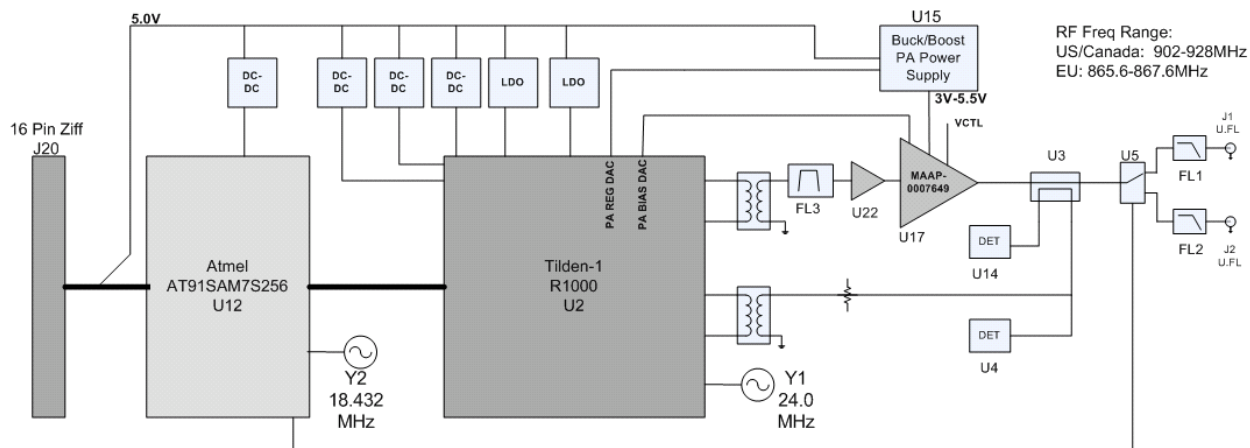
Figure 1-2 *RFID Reader Module Ports/Connectors and Antenna Locations*

Receive Path

The received signal from the antenna is fed to directional coupler (U3) and is coupled through the reverse path to the receive balun, and also to the reverse power detector (U4). The reverse power detector senses RF energy that is reflected from the antenna and compares it to a threshold each time the transmitter ramps. If the threshold is exceeded, the transmitter is halted and the RF energy is turned off in order to protect the PA during a fault event.

The receive balun converts the single ended RF signal to a balanced or differential signal before passing it to the R1000 receive pins for demodulation.

Transmit Path

The transmit path begins with the internal waveform generator in the R1000 (U2) which is up converted and amplified before leaving the R1000 in a differential/balanced format. The transmit signal is converted to a single ended format and passed through a Surface Acoustic Wave (SAW) band pass filter (FL3), and then amplified by a driver amplifier (U22), and finally a Power Amplifier (U17). The output of the power amplifier feeds the input to a dual directional coupler. The coupler samples the transmitted RF signal using a forward RF power detector (U14). This detector has a calibrated output that the radio uses to automatically level the transmitter output. Once the transmit signal leaves the directional coupler, it is fed to a SPDT RF Switch (U5) that is used to feed one of two identical RF paths. The RF path after the switch passes through a Low Pass Filter (FL1, FL2) and then to the RF connector (J1, J2).

Microprocessor Control

The RFID Reader Module Atmel processor (AT91SAM7S256, U12) is a memory-integrated microcontroller which contains the RFID radio system firmware. The primary function of the processor is interfacing with the RF ASIC to drive the RFID protocol at the MAC level. The Atmel also controls and regulates additional electronics, such as radio power supplies, final stage signal amplification hardware, and sensors for closed loop functionalities. In addition, this controller executes host layer communications to receive /interpret/respond to commands, up-transfer radio link data, as well as store and adjust to radio parameters.

Frequency Generation

The Frequency generation on the RFID Reader Module is derived from a 24MHz crystal oscillator (Y1) reference that is used to generate the local oscillator (LO) using the internal PLL of the R1000. This LO is used to both up convert the transmit baseband signal and used to down convert the receive RF signal to baseband for detection. This LO is in the range of 902MHz to 928MHz for the US module and 865.6-867.6 for the EU module.

Chapter 2 Installation

Overview

This chapter provides information for configuration, mounting and installing the RFID Reader Module. Physical and electrical considerations are presented, together with recommended window properties and housing designs.

Mounting Considerations

The RFID reader module housing design must protect the module from impact and adverse environments.

The host housing that integrates the RFID Reader Module must be designed so that it can draw the generated heat off the radio and out of the host unit. The module has been designed to be efficient in conducting heat from point of generation to the outside. Thermal slugs are mounted to the board which draw heat from the board to the outside of the EMI shields. This allows the host device to pull the heat off of the module. Additionally, there are two thermally conductive channels on the two side edges of the module which are designed to transfer heat from the module to a thermally conductive bracket. The thermally conductive bracket must be able to dissipate the heat to the outside of the host device.

Environment

The RFID reader module must be sufficiently enclosed to prevent moisture and/or dust from interfering with the RFID Reader Module operation.

Grounding

The RFID reader module is grounded through the host interface connector (see *Host Interface on page 2-4*).

ESD

Always exercise care when handling the module. Use grounding wrist straps and handle in a properly grounded work area for ESD specifications.

Location and Positioning

The general location and positioning guidelines provided do not consider unique application characteristics. It is recommended that an RFID engineer perform an analysis prior to integration.

Using the RFID Reader Module

Identify the capabilities scope and the inputs/commands required to access them.

Some applications require the RFID Reader Module be mounted to read tags that are automatically presented, or that are presented in a pre-determined location. In these applications RFID reader antenna positioning (with respect to the tag) is critical. Failure to properly position the RFID reader antenna with respect to the tag may lead to degraded or unsatisfactory reading performance.
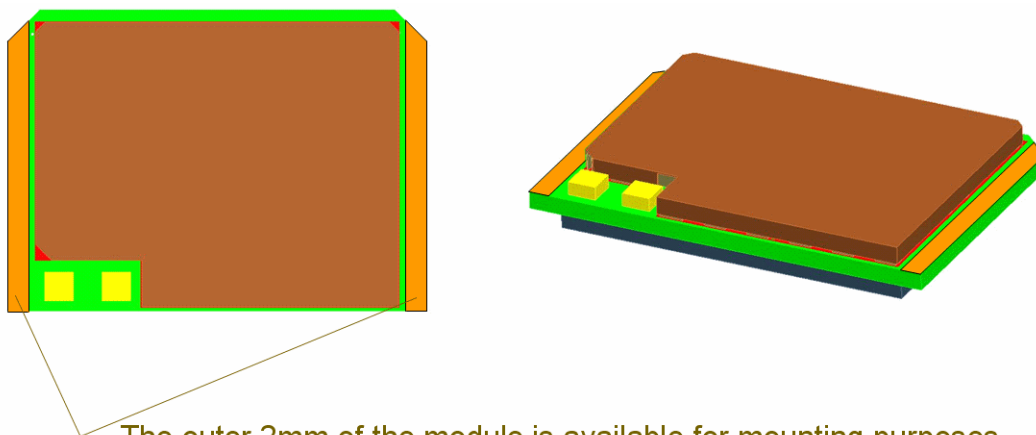
The outer 2mm of the module is available for mounting purposes.
• Product teams should use these surfaces to capture the module in their designs.
• Also note that these surfaces include exposed ground pads, which can be
incorporated in the overall thermal management strategy.

Figure 2-1   *Mounting*

External Hardware Interfaces

The RFID Reader Module hardware interface include the input voltage, antenna interface and the host interface. Refer to *Appendix A, Technical Specifications* for detailed product specifications.

Antenna Interface

Two bi-directional mono-static antenna ports, user selects transceiver port via host command. U.FL- surface mount coaxial male connector.

Antenna diversity is supported on RFID Reader Module. Two antenna connectors allow for the use of horizontal and vertical polarized antennas (optional) in order to achieve optimal read performance for multiple tag orientations.

The reference antenna specifications are provided in *Table C-1 on page C-4*.

Thermal Interface

Need engineering input for heat dissipation rate.

• A thermally conductive path is provided from the hottest components to the surface of the module.
• Product teams need to thermally connect to this outside surface to transfer the heat away
    from the module.

Micro side

RF side

Copper slugs transferring
the heat to the surface

Cross-Section

At minimum, product teams should thermally connect
their designs to the micro side of the module.

Copper slug

Shields connected to ground

Thermal vias connected to ground
Hot component
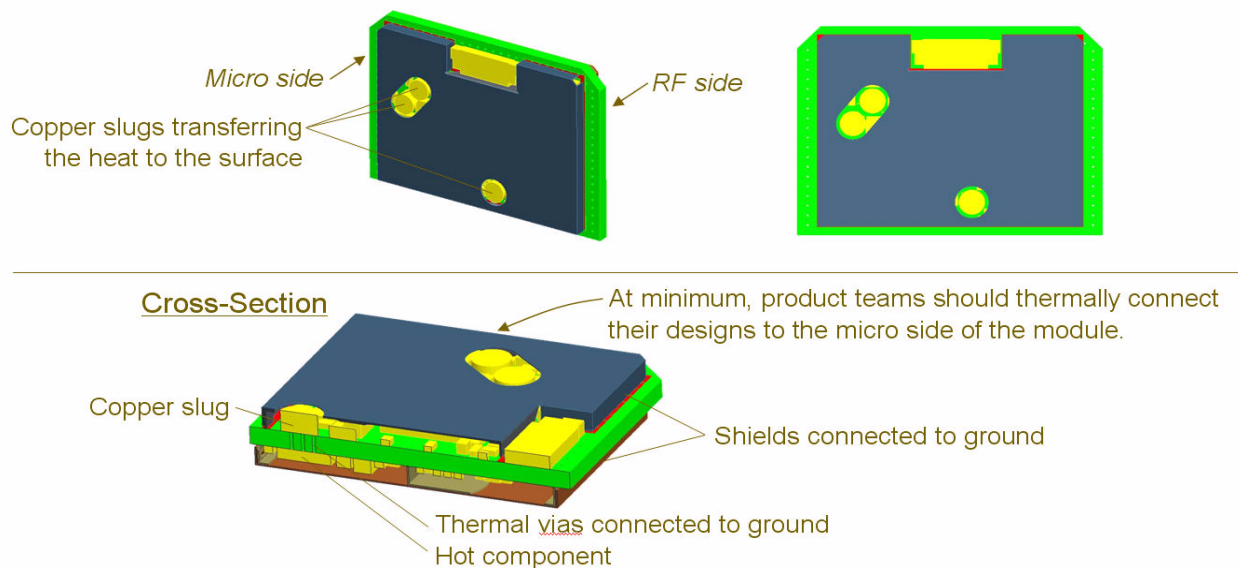
Figure 2-2   *Thermal Management*

Host Interface

The host interface connector consists of a 16 pin ZIF connector:

Table 2-1   *RFID Reader Module Host Interface Connector Description*

Pin	Module Signal	Direction	Description
1	GND	Input	GND
2	TST	Input	Drive this signal high during reset to copy the ROM boot loader into Flash. Care MUST be taken to not inadvertently set this signal.
3	UAR-TRXD	Input	3.3V, 5V tolerant, RS-232 Serial data to radio module from host.
4	UAR-TTXD	Output	3.3V RS-232 Serial data from radio module to host
5	UAR-TRTS	Output	3.3V RS-232
6	UAR-TCTS	Input	3.3V, 5V tolerant, RS-232
7	VCC	Input	+5VDC
8	VCC	Input	+5VDC
9	VCC	Input	+5VDC
10	WAKE/GPIO1	Input/Output	Primary Function: Wake line (edge sensitive). Can be configured as general purpose output.
11	TX_MUTE_N	Input	Primary function: logic 0 on this line shuts down the power amplifier
12	RESET_N	Input-	Reset Line (level sensitive), pull low to reset radio module
13	GPIO2	Input/Output	General Purpose I/O
14	GPIO3	Input/Output	General Purpose I/O
15	GND	Input	GND
16	GND	Input	GND

Module Control Signals

TST Signal:

The TST signal forces the module microcontroller into a firmware recovery state, which copies a boot loader into the microcontroller Flash from ROM. Best practices indicate that the correct use of this signal is to follow this sequence:

Power Off -> Assert TST -> Power On (10 seconds) -> Power Off -> Deassert TST.

Because this state is only recoverable by reprogramming the firmware image, strong caution needs be taken to not inadvertently assert this signal. Refer to Atmel AT91SAM7S documentation (e.g Atmel 6175H-ATARM-03-Dec-07) for more in depth documentation on microcontroller function.

UART Signals:

The module communicates in RS-232 timing and protocol, but single ended 3.3V and 0V referenced to ground. Data rate is 115.2kbaud, 8 data bits, No parity, and one stop bit.

UAR-TRX:

This is the primary signal for serial communications going to the module.

This signal is 3.3V input or 0V input (referenced to ground), and is 5V tolerant.

UAR-TTX:

This is the primary signal for serial communications coming from the module.

This signal is driven actively to 3.3V or 0V referenced level.

UAR-TRTS:

This signal can be optionally enabled or disabled. This signal is flow control output from the module. This signal is driven actively to 3.3V or 0V referenced to ground.

This signal defaults high for those systems that use flow control as DTEs and wired by null modem type configuration.

UAR-TCTS:

This signal can be enabled or disabled. This signal is flow control input to the module. This signal is 3.3V input or 0V input (referenced to ground), and is 5V tolerant.

Note that when the module is actively reading, and CTS is asserted, data will necessarily be buffered. This buffer is finite, and when it runs out of space, the reader will no longer read more tags into the buffer.

WAKE/GPIO1:

The primary function of this pin is to remove the module from sleep state. Either transition edge (positive or negative) will effect this change. Typical systems will generate a pulse (two successive transitions), the second edge will be ignored. There is a slight power advantage to maintain this signal at a high level (avoids fighting against a pull-up resistor). If a pulse is used to wake the module, its width should be much narrower than the wake time-out interval.

The WAKE functionality of this signal is in multiplex with the GPIO1 signal. Care should be taken by the module integrator not to cause contention on this signal (i.e. making GPIO direction output, when WAKE is also actively driven.

The Wake timing diagram is provided in *Appendix B-1, Timing Requirements for RF Activity*.

Mechanical Characteristics

The RFID Reader Module mechanical characteristics include the physical dimensions, the weight and the enclosure, and EMI shielding. Dimensions: 38mm long, by 27mm wide, by 6mm thick.

Enclosure and EMI Shielding

The RFID Reader Module is shielded on both side using two internal removable EMI shields, one on each side of the board to compartment isolate the RF and digital circuits on the PCB. Each shield consists of a frame soldered to the PCB and a removable cover.

Thermal Management

A thermally conductive path using copper slugs is provided from the hottest components to the outer surface of the module. The RFID Reader Module should be thermally integrated to allow heat from the micro side of the module to be thermally connected to this outside surface to transfer the heat away from the module.

Mounting

The RFID Reader Module is intended to be captured along the side edges. The bracket should be designed of a thermally conductive material so that it can transfer heat off the board and into the host system which in turn should be designed to transfer heat out of the host system.

The outer 2mm of the module is available for mounting. These surfaces should be used to capture the module in the host product.

In addition these surfaces include exposed ground pads, which can be incorporated in the overall thermal management strategy.

1.290
[32.8]

.450
[11.4]

.451
[11.5]

HOST INTERFACE
CONNECTOR

.062
[1.6]

.183
[4.7]

.983
[25.0]

.075
[1.9]

.075
[1.9]

THERMAL SLUGS

1.487
[37.8]

1.262
[32.1]

1.013
[25.7]

.959
[24.4]

1.071
[27.2]

.167
[4.2]

.378
[9.6]

ANTENNA PORTS

1.290
[32.8]
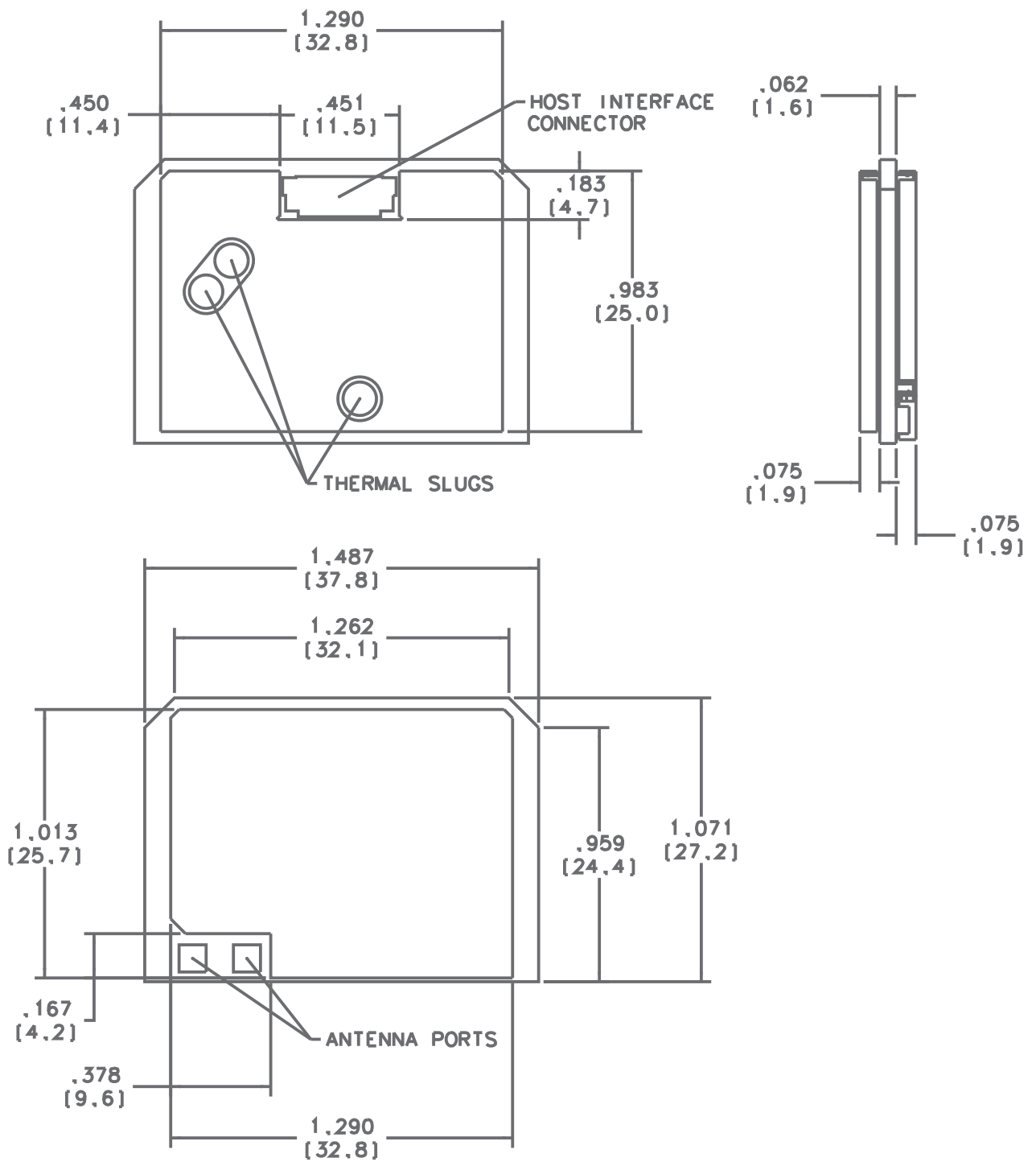
Note: All dimensions have a 5% tolerthat

Figure 2-3   *RFID Reader Module Outline Drawing*

Environmental Characteristics

Thermal Management

The RFID Reader Module shuts down and turns off should the module temperature exceed 80°C. It turns back on after the module cools off.

As the module starts to get hot, the thermal PID (proportional-integral-derivative) controller kicks in. The objective of the PID controller is to keep the unit thermal temperature steady at a set point temperature below the 75°C. The module accomplishes this by over riding the reader duty cycle. When the temperature is below the set point, the PID increases the reader duty cycle close to 100%. When the temperature is above the set point temperature the duty cycle is decreased to allow the unit to cool down. If the module is too hot, read rate may decrease.

See *Appendix A, Technical Specifications* for detailed Temperature, Humidity, ESD, Shock, and Vibration specifications.

Read/Write Ranges

The reader module has typical read/write range based on a standard configuration. The detailed parameters are provided in *Table A-6 on page A-7*. These reference values may change depending on tag type, antenna and environmental conditions. The actual range values are also effected by the reflective and absorption properties of the material under the tag.

Appendix A Technical Specifications

Technical Specifications

The following tables summarize the RFID Reader Module intended operating environment and general technical hardware specifications.

RFID Reader Module

The following table summarizes the technical specifications:

Table A-1 *RFID Reader Module Technical Specifications*

Item	RFID Reader Module
Physical Characteristics	
Dimensions	~38mm x 27mm x 6mm
Compliance	
Data Capture Options	Gen2 tags ISO 18000-6C EPC Class1, Gen2
User Environment	
Operating Temperature	-4°F to 122°F (-20°C to 50°C)* *This environment is defined as the specific temperature envelope containing the Sailfish radio product. If embedded within a host product, the envelope is the internal ambient temperature of the host under the hosts operating conditions.
Storage Temperature	-40° to 158° F / -40° to 70° C
Thermal Shock	-20° C to +65° C, 30 min dwell, 100 cycles
Humidity	5% to 95% non condensing
Drop Specification	30 in. / 76.2 cm bench handling
Shock	Shock: 100g +/- 5% applied via the mounting surfaces @ -20C, 23C, and 60C for a period of 0.85 +/- 0.05 ms (3 axes), 6 shocks per axis.
Vibration	Vibration: 20Hz to 2KHz, 15gs Pk Sine.

Table A-1   *RFID Reader Module Technical Specifications (Continued)*

Item	RFID Reader Module
ESD	+/-2kVdc contact to pin
RFID Characteristics	
Frequency Range	FCC (US) 902-928MHz and Canada ETSI (EU) 865.6-867.6MHz

RF Output power	10mW to 1000mW
	    • 1000mW max (MRM, XRM)
	    • 500mW max (DRM)

Interface	
Antenna Connector	Hirose U.FL, in accordance with motorola specifications 2 monostatic antenna connectors, see *Reference Antenna on page C-4*.
UART	115.2kBPS
Host Connector	16 Pin ZIF, in accordance with motorola specifications
Power Requirements	
Input Voltage (VCC)	5.0+/- 0.25 VDC
DC Current	See *Table A-2 on page A-3*
Regulatory	
Electrical Safety	Certified to UL60950-1, CSA C22.2 No. 60950-1, EN60950-1, IEC 60950-1.
RF Exposure	USA — FCC Part 2, FCC OET Bulletin 65 Supplement C; Canada — RSS-102.
RFID	USA — FCC Part 15.247, 15.205, 15.209: Canada — RSS-210 EU EN 302 208.
EMI/RFI	USA — FCC Part 15; Canada — ICES 0003 Class B; EU: EN 301 489-1; EN 301 489-3.

Table A-2 *RFID Reader Module RF Specification(U.S. Version*

Parameter	Specification Limit	Conditions
RF Frequency Range	902-928MHz	50 channels IAW Table 1 below.
Output Power Capability	+10dBm to +30dBm in 0.1dB steps	+27dBm max in DRM, +30dBm max in MRM/XRM
Channel Spacing	500KHz(200KHz)	
Frequency Accuracy	+/- 10 ppm	RF Output Power Accuracy
RF Output Power Accuracy +30dBm +29dBm +28dBm +27dBm +24dBm +20dBm +17dBm +10dBm	 +29.7 dBm +0.2/-0.75 dB +29.0dBm +/- 0.75 dB +28.0 dBm +/- 0.75 dB +27.0 dBm +/- 0.75 dB +24.0 dBm +/- 1.0 dB +20.0 dBm +/- 1.0 dB +17.0 dBm +/- 1.0 dB +10.0 dBm +/- 2.0 dB	VCC=5.0V, Z0=50Ω, CW mode, reference to J1 or J2 of RFID Reader Module. RF Power used within 400 ms of RF ramp
Power Supply Voltage	5.0VDC +/- 0.25V	Voltage required at J20 pin 7 while transmitting
Power Supply Noise/Ripple	100 mvpk-pk max	
DC Current Requirements (CW Mode, MRM and XRM) +30.0dBm +29.0dBm +28.0dBm +27.0dBm +24.0dBm +20.0dBm +17.0dBm +10.0dBm	Typ. Max 1200mA 1400mA 1100mA 1300mA 1050mA 1200mA 950mA 1000mA 750mA 800mA 650mA 700mA 640mA 680mA 600mA 625mA	VCC=5.0V, Z0=50Ω, CW mode, MRM and XRM Profiles
DC Current Requirements (CW Mode, DRM) +27.0dBm +24.0dBm	Typ. Max 1200mA 1400mA 900mA 1100mA	VCC=5.0V, Z0=50Ω, CW mode, DRM Profiles
IDLE Current	Typical Maximum 36mA 50mA	VCC=5.0V, Tilden in reset
Ready Current	Typical Maximum 230mA 260mA	VCC=5.0V
Duty Cycle	1% to >90%	

Table A-2 *RFID Reader Module RF Specification(U.S. Version*

Parameter	Specification Limit	Conditions
Spurious 30MHz to 88MHz 88MHz to 216MHz 216MHz to 902MHz 928MHz to 960MHz	< -42.7dBm < -42.2dBm < -40.2dBm < -38.2dBm	VCC=5.0V, Z0=50Ω AT CH0(902.75MHZ), CH24(914.75MHz), CH49(927.25MHz)
Spectral Mask (Link Profile 2/DRM) +/- 100KHz +/- 200KHz +/- 300KHz	< 30 dBch < 60 dBch < 65 dBch	Measured at specified offset at Ch24, Z0=50Ω, For +27dBm and +24dBm Spec Analyzer Settings: Span=1MHz, RL=30dBm, Res BW=3KHz, Video BW=300Hz
Spectral Mask (Link Profile 1/MRM) +/- 500KHz +/- 1000KHz +/- 1500KHz	< 20 dBch < 50 dBch < 60 dBch	Measured at specified offset at Ch24, Z0=50Ω, For +30dBm and +24dBm Spec Analyzer Settings: Span=1MHz, RL=30dBm, Res BW=3KHz, Video BW=300Hz
Modulation Depth	80% ≤ Depth ≤ 100%	Ch 24, Z0=50Ω
Modulation Rise time	≤ 8.5µs	Ch 24, Z0=50Ω
Modulation Fall time	≤8.5µs	Ch 24, Z0=50Ω
RF Pulse width	6.625µs ≤PW≤13.125µs	Ch 24, Z0=50Ω
RF Power On Rise Time	≤ 500 µs	Ch 24, Z0=50Ω
RF Power On Settle Time	≤ 1500µs	Ch 24, Z0=50Ω
RF Power On Ripple	≤ 5%	Ch 24, Z0=50Ω
Harmonics, conducted 2nd Harmonic 3rd Harmonic	-60dBc max	Measured at +30dBm, Ch24, Z0=50Ω
Read Range	6ft. min while frequency hopping over all channels while reading 50% of tags using 15 Tag board array	RF Power=+24dBm, Ref +2dBi Ref Dipole Antenna with Return Loss = 10 dB min. across band, link profile 2, using AD222 15 Tag Array[1]
Operating Temperature Range	T=-20°C≤Temp≤+50° C	

Table A-3 *General Specifications*

Parameter	Specification	Notes
RF Output Power Range		
10mW to 1000mW	1000mW max (MRM, XRM)	
DRM	Host Programmable 250-500mW	
MRM XRM	10mW to 1W	
Antenna Interface	Hirose U.FL	2 monostatic antenna connectors
Host Interface	UART	115.2kBPS
Host Interface Connector	16 Pin ZIF, pitch	
Mechanical Dimensions	~38mm x 27mm x 6mm	See Mechanical Outline
Power Requirements		
Input Voltage (VCC)	5.0+/- 0.25 VDC	
DC Current (varies with modulation, see specification)		
250mW level	700mA nominal at 5.0V	Peak current during read
500mW level	1000mA nominal at 5.0V	Peak current during read
1000mW level	1500mA nominal at 5.0V	Peak current during read

Table A-4 *EU Channel Definition*

Channel	Frequency (MHz)
0	865.70
1	866.30
2	866.90
3	867.50

Table A-5 *U.S. Channel Definition*

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	915.75	25	912.25
1	915.25	26	906.25
2	903.25	27	917.25
3	926.75	28	914.25
4	926.25	29	907.25
5	904.25	30	918.25
6	927.25	31	916.25
7	920.25	32	910.25
8	919.25	33	910.75
9	909.25	34	907.75
10	918.75	35	924.75
11	917.75	36	909.75
12	905.25	37	919.75
13	904.75	38	916.75
14	925.25	39	913.25
15	921.75	40	923.75
16	914.75	41	908.25
17	906.75	42	925.75
18	913.75	43	912.75
19	922.25	44	924.25
20	911.25	45	921.25
21	911.75	46	920.75
22	903.75	47	922.75
23	908.75	48	902.75
24	905.75	49	923.25

Reference Performance Characteristics

The expected Reference Performance Characteristics are:

Table A-6   *RFID Reader Module reference Performance Characteristics*

Tag Type	Parameters	Expected Read Range*

* Add expected read range notes and exceptions here.

Link Profiles and XRM

The Sailfish module supports all the R1000 Reference Design EPC Gen2 Link Profiles and can be controlled by the host application to use any of the various profiles listed in *Table A-7*.

Several link profiles are selectable through a host application. This allows the reader performance to be tailored for various applications. For example, some link profiles are better suited for close range, high tag populations while others may be better for long range reading of a few tags. Some link profiles use modulation types that are better for power efficiency of the reader in that the power amplifier can be biased more efficiently and others are biased more linear so that the spectrum of the signal is well defined, requiring less bandwidth. In general, the DSB-ASK modulations used in the MRM (multi-reader mode) link profiles have better power efficiency at the expense of a broader spectral mask, while the PR-ASK modulation used by the DRM (Dense Reader Mode) link profile 2 use more power for a given transmit level, but have a tighter spectral mask in order to allow for more readers/less reader to tag interference in a smaller area.

The Sailfish Module extended the link profiles in order to take advantage of the tighter spectrum of PR-ASK while allowing for similar power efficiency of the DSB-ASK. This new mode is called XRM and is simply the PR-ASK link profiles, with the lower biasing of the MRM/DSB-ASK modulations. This is not an EPC certified mode, however it reads EPC Gen2 tags and passes the MRM spectral mask and is compliant with all the regulatory requirements.

XRM=DRM Modulation at MRM Bias Levels and MRM Spectral Mask

(Benefit of DRM Spectrum with Power Requirements of MRM)

To illustrate the three different modes, some typical peak current requirements are listed in *Table A-7*. As shown, DRM requires more current for a given power level. Also, the modulated spectrum of the three most commonly used link profiles are shown in Figure 1. It is evident, that the MRM spectrum is much broader than DRM or XRM and this MRM link profile does not offer any significant performance advantage over XRM. The power requirements for the +27dBm DRM is not significantly less than the current required for the +30dBm MRM and XRM modes, therefore for the same battery power, the user can achieve more read range and better reader density by selecting one of the XRM link profiles.

Table A-7   *Typical Peak Current for MRM, DRM, XRM for 10dB Return Loss Antenna*

RF Power Level Setting	MRM (LP 1) Peak Current, mA typ	DRM (LP 2) Peak Current, mA typ	XRM (LP 18) Peak Current, mA typ
+30 dBm	1278	N/A	1276
+27dBm	850	1054	852
+24 dBm	784	814	782
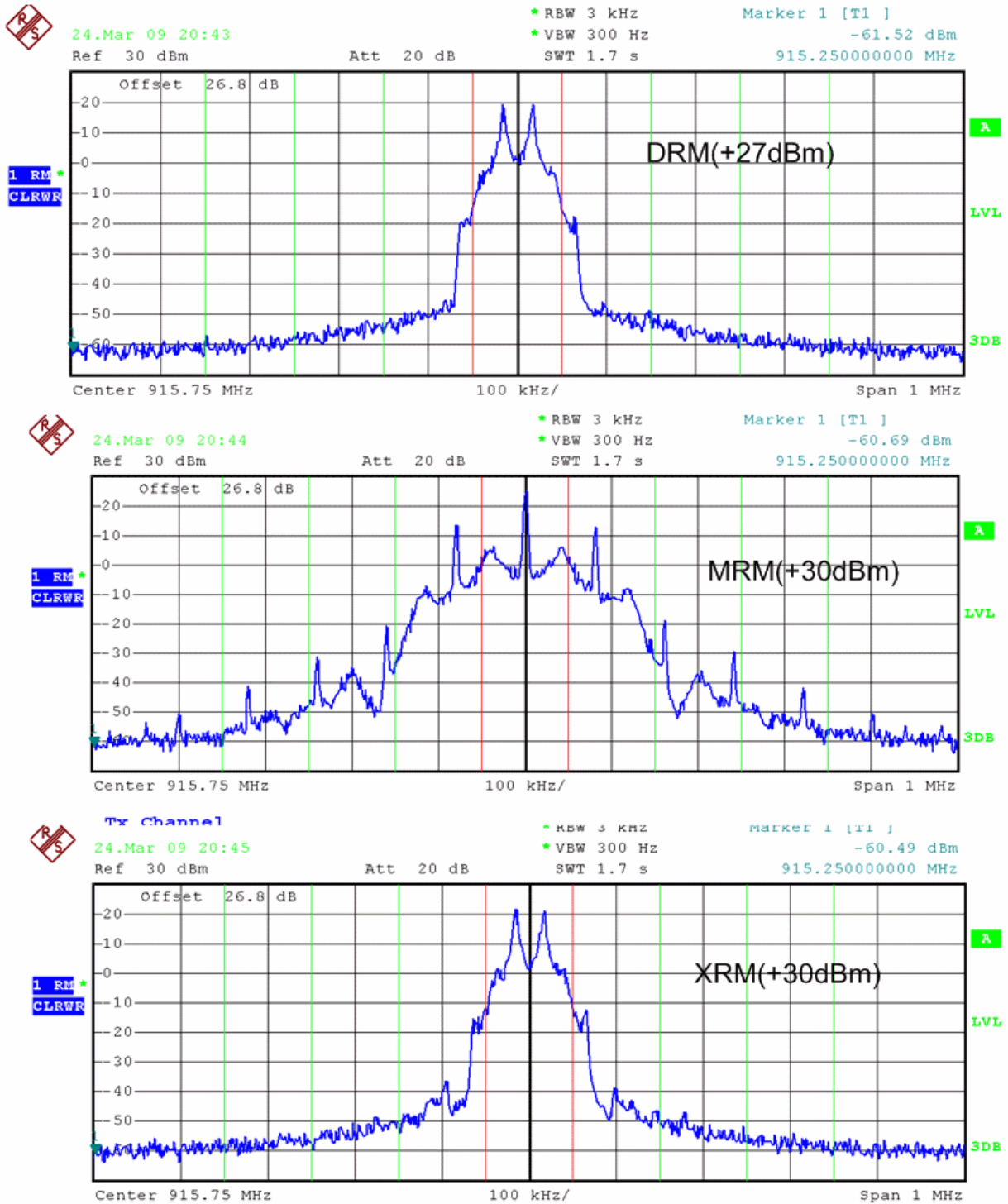
Figure A-1   *DRM, MRM and XRM Transmit Spectrums*

To summarize, there is little spectral advantage of DRM over XRM and the read rate performance are equivalent since the link parameters are identical. Also, since the XRM power requirements are basically the same as MRM (better power efficiency), the XRM mode should be the preferred mode for most mobile applications.   For this reason, the default link is link profile 18. See *Table A-8 on page A-10* for the link profile details.

:

Table A-8   *Motorola Modified Link Profiles With Three Bias Schemes*

Selector	Mod-type	Bias	Tari (uS)	M	LF (KHz)	Data Rate (kbps)
0	DSB-ASK	MRM	25.00	FM0	40.00	40
1	DSB-ASK	MRM	12.50	M=2	160.00	80
2	PR-ASK	DRM	25.00	M=4	250.00	62.5
3	PR-ASK	DRM	25.00	M=4	300.00	75
4	DSB-ASK	MRM	6.25	FM0	400.00	400
5	PR-ASK	DRM	25.00	M=2	250.00	125
6	PR-ASK	DRM	25.00	M=4	250.00	62.5
7	PR-ASK	DRM	25.00	M=4	300.00	75
8	PR-ASK	DRM	25.00	M=4	200.00	50
16	DSB-ASK	MRM	25.00	FM0	40.00	40
17	DSB-ASK	MRM	12.50	M=2	160.00	80
18*	**PR-ASK**	**XRM**	**25.00**	**M=4**	**250.00**	**62.5**
19	PR-ASK	XRM	25.00	M=4	300.00	75
20	DSB-ASK	MRM	6.25	FM0	400.00	400
21	PR-ASK	XRM	25.00	M=2	250.00	125
22	PR-ASK	XRM	25.00	M=4	250.00	62.5
23	PR-ASK	XRM	25.00	M=4	300.00	75
24	PR-ASK	XRM	25.00	M=4	200.00	50

* Default setting

Appendix B Timing

Power Up and Reset Timing

Table B-1, shows the required timing requirements for RF activity for various modes.

Table B-1   *Timing Requirements for RF Activity*

Mode	Current (mA) Typical	Power (mW) Typical	Time to RF on, Typical (ms)
Ready	230	1150	2.9
Idle (Tilden in reset)	36	180	25.5
Relax (Lowest Pwr level with active UART)	22	110	28.5
Sleep (requires WAKE)	5	25	26.9
OFF (No 5V to RFID Reader Module)	0	0	~81

WAKE/GPIO1

The primary function of this pin is to wake the module from the sleep state. Either transition edge (positive or negative) will effect this transition. The module goes to the Ready State and waits for a command from the host system over the serial port.

Typical systems generate a pulse (two successive transitions), the second edge is ignored. There is a slight power advantage to maintain this signal at a high level (avoids fighting against a pull-up resistor). If a pulse is used to wake the module, the width must be narrower than the wake timeout interval.

The WAKE functionality of this signal is in multiplex with the GPIO1 signal. The integrator must excercise care not to cause contention on this signal (i.e. making GPIO direction output, when WAKE is also actively driven.
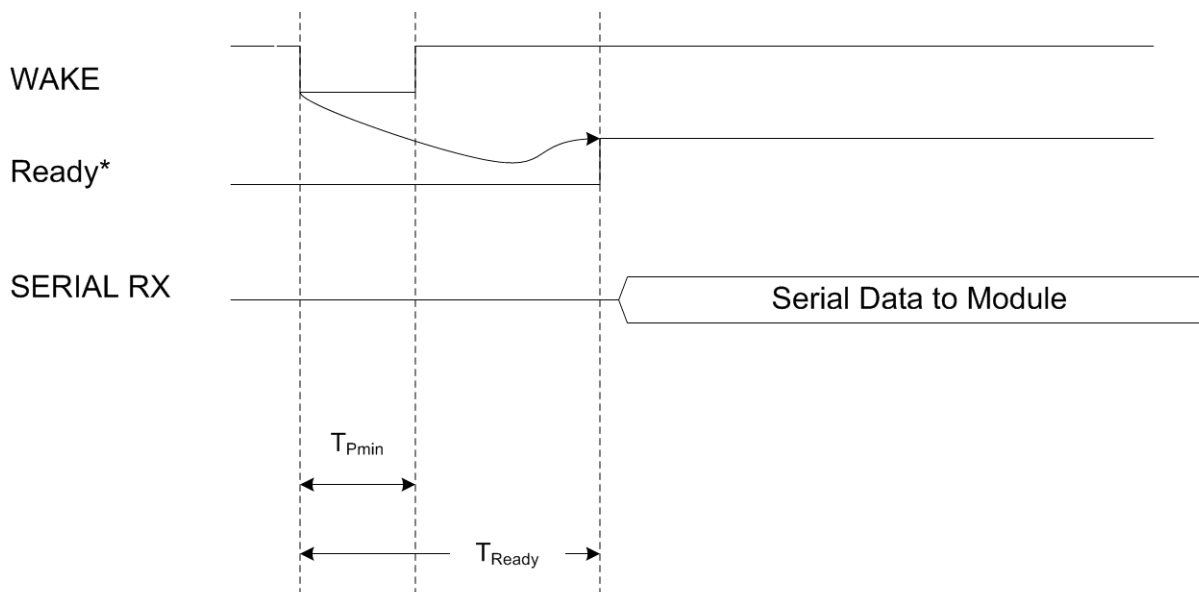
*Ready to receive command (CSM:WAIT state). Not an externally visible signal.

Figure B-1   *RFID Reader Module Wake Signals*

TX_MUTE_N

This signal provides a hard real-time method to mute the RF output of the module and is useful for rapidly reduceing module current consumption. The PA is shut down directly through hardware. A brief time later, the microcontroller acts on the TXMUTE event by shutting down other radio hardware and returning the module to Ready State.

The example (see *Figure B-2*) shows RF being on prior to assertion of TX_MUTE_N. If Module receives an RF inducing command (e.g. Inventory, Write, etc...) while TX_MUTE_N is already asserted, RF is not generated.

In both of these instances a TXMUTE error is generated in "Command End "Packet sent out through the UARTTX signal.
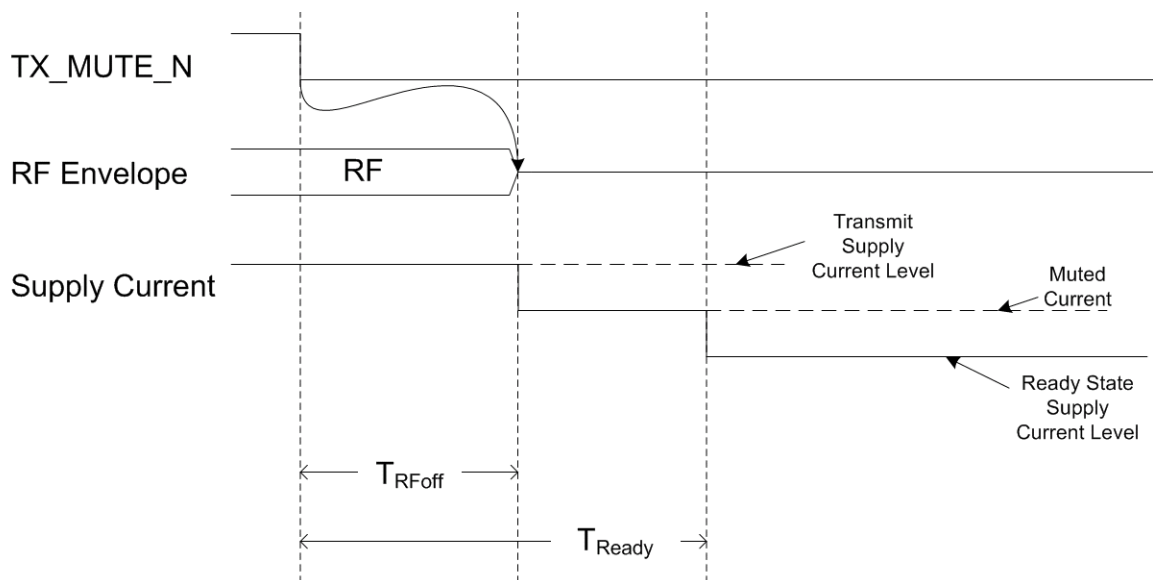
Figure B-2   *RFID Reader TX Mute Signals*

Appendix C Regulatory Requirements

User Guide Statements

Many of the regulatory statements are dependent on the final product application. Motorola recommends that the Integrator seeks the advice from an accredited test laboratory. The following statements are provided for guidance only.

General Statements

Any changes or modifications not expressly approved by Motorola, Inc. could void the user's authority to operate the equipment.

FCC Statements

Co-located statement

To comply with FCC RF exposure compliance requirement, the antenna used for this transmitter must not be co-located or operating in conjunction with any other transmitter/antenna except those already approved in this filling.

Handheld Devices

To comply with FCC RF exposure requirements, this device must be hand operated with a minimum separation distance of 23 cm or more from a person's body. Other operating configurations should be avoided.

Remote and Standalone Antenna Configurations

To comply with FCC RF exposure requirements, antennas that are mounted externally at remote locations or operating near users at stand-alone desktop of similar configurations must operate with a minimum separation distance of 23 cm from all persons.

Radio Frequency Interference Requirements - FCC

FC Tested to comply
    with FCC Standards

FOR HOME OR OFFICE USE
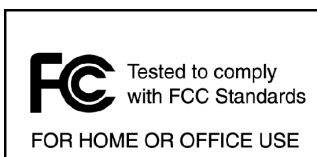
Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help.

Radio Transmitters (Part 15)

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Industry Canada Statements

Radio Frequency Interference Requirements

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Radio Transmitters

This device complies with RSS 210 of Industry & Science Canada. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

Label Marking: The Term "IC:" before the radio certification only signifies that Industry Canada technical specifications were met.

IC Radiation Exposure Statement (only applicable of mobile use only)

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 23cm between the radiator & your body.

Antenna (only if the antenna is detachable & selectable by the user)

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication.

This radio module has been designed to operate with an antenna having a maximum gain of 2dBi, requirements are detailed in *Table C-1 on page C-4*.

Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 ohms.

European Statements

CE Marking and European Economic Area (EEA)

The use of RFID for use through the EEA, have the following restrictions:

- Maximum radiated transmit power of 2W ERP on 4 channels, frequencies: 865.7MHz, 866.3MHz, 866.9MHz & 867.5MHz.

Statement of Compliance (embedded radio card, Model: 21-121560)

Motorola, Inc., hereby, declares that this device is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC. A Declaration of Conformity may be obtained from http://www2.symbol.com/doc/

Regulatory Requirements

The following information summarize the RFID Reader Module regulatory requirements.

Legal Disclaimer

This appendix contains the regulatory requirements information. The information should be used with the understanding that Motorola is not engaged in rendering any legal, regulatory or other professional opinion. Each country has specific laws and regulations governing the use of radio communications. Consult the official code for each country of interest. Motorola does not warrant the accuracy of the information contained herein and accepts no liability or responsibility for any use or misuse of the information.

Motorola's wireless devices are designed to be compliant with rules and regulations in locations they are sold.

Any changes or modifications to Motorola equipment, not expressly approved by Motorola, could void the user's authority to operate the equipment.

Final Product Compliance

This module has been regulatory approved for integrations which meet the following conditions:

1. The radio integration is embedded.

2. The antenna must be installed such that 23 cm is maintained between the antenna and users.

3. The 'Type' and 'Gain' of the antenna selected for the integration of the external antenna must meet the requirements, detailed in *Table C-1 on page C-4*.

Any use outside of these conditions will require a re-approval. Motorola can advise on the use of an accredited test laboratory for advice. The product certification process may take from a few weeks to several months.

The integrator is responsible to determine what additional specific regulatory requirements are required of the country in which the product will be marketed. Final product may require non-radio frequency approvals such as Product Safety, EMC, and SAR.

Reference Antenna

A reference antenna has been used during the approval process.

Specific details of the reference antenna used for testing is detailed in the table below.

Important Note:

Use of an antenna which is the same 'type' (e.g. Dipole) and has a gain equal to or less that the reference antenna can be used without recertification.

Use of an alternative antenna, different 'type' or same 'type' but higher gain will invalidate the country approvals. Under this instant the OEM integrator is responsible for re-evaluating the end product and obtaining separate approvals.

Antenna Type: Dipole

Antenna Characteristics:

Table C-1   *Motorola Dipole Reference Antenna, Performance Characteristics*

Parameters	Specification
Operational Frequency	FCC(US) 902-928MHz ETSI(EU) 865.6-867.6MHz
Gain (Peak)	+2 dBi Max (includes coax cable/connector RF losses, vertical component or horizontal) **Note:** This device was approved with a 2 dBi gain dipole antenna; if a higher gain or another type of antenna is used (i.e. other than a dipole) then re-testing and a FCC Type II Permissive Change submission is required.
VSWR	1.4.1 (Typ)
Polarization	Linear
Impedance	50 ohms
Dimensions	4.7 x 2.3 inches
Connector	SMA-Female
RF Power - max	1000mW

Regulatory Standards

This module has been approved to comply with the standards listed below

Table C-2 *Approved Compliance Standards*

Requirement	Compliance Standard
Electrical Safety:	Certified to UL / cUL 60950-1, IEC / EN60950-1
RF	USA: FCC 47CFR Part 15.247, 15.215, 15.205,15.203, 15.209, 15.247 Canada: RSS-210 EU: EN 302 208
EMI/EMS/EMC:	North America: FCC Part 15 Canada: ICES 003 Class B EU: EN 301 489-1, EN 310 489-3

Regulatory Approvals

This card is approved in the following countries US, Canada and the following EU countries:

Austria, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland and the United Kingdom

Radio Card Regulatory Markings

Regulatory markings are applied to the device signifying the radio (s) are approved for use in the following countries: United States, Canada, and Europe*.

Please refer to the Motorola Declaration of Conformity (DoC) for details of other country markings. This is available at http://www2.symbol.com/doc/.

*Note: Europe includes, Austria, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

National Country Requirements

United States of America

The radio card is approved under the requirements of the FCC.

End-product requirements with this module installed should include:

- FCC Part 15 (emissions class B)

Final product markings must include:

Contains an approved Radio Module
Model: 21-121559
FCC ID: UZ721121559

IMPORTANT NOTES

1. Co-location

The FCC approval EXCLUDES co-location with any other transmitter.

If this Module is co-located with another transmitter (e.g., Bluetooth module), the OEM is integrator is responsible for re-evaluating the end product and obtaining a separate FCC authorization.

Motorola recommends the use of an accredited Laboratory to carry out the necessary tasks.

2. Portable Use

The FCC approval of the module covers 'mobile' applications.

If the final product used in a manner where the antenna is closer than 23cm from the user (portable use), the OEM is integrator is responsible for re-evaluating the end product and obtaining a separate FCC authorization.

Motorola recommends the use of an accredited Laboratory to carry out the necessary tasks.

Canada

The radio part is already approved under the requirements of Industry Canada.

End-product requirements with this module installed should include:

- Canadian Interference-Causing Equipment Regulations (ICES-003).

If the final product used in a manner where the antenna is closer than 23cm from the user (portable use), the OEM is integrator is responsible for re-evaluating the end product and obtaining a separate IC approval.

Motorola recommends the use of an accredited Laboratory to carry out the necessary tasks.

Final product markings must include:

Contains an approved Radio Module
Model: 21-121559
IC ID: 109AN-21121559

European Union

The radio part is already approved under the R&TTE Directive 99/5/EC.

The final product must comply with all applicable European Directives such as EMC and Product Safety.

Care should be taken as a product might fall under the scope of other directives or standards depending on the type of product e.g. Medical Directive, Potentially Explosive Atmospheres etc.

End-product requirements with this module installed should include:

- EMC Tests (the applicable standard depends upon the intended operational environment)
- Electrical Safety Tests

EC Directives require integrators document their compliance activities in a Technical Construction File (TCF).

The following items should be included in the final product TCF:

- Notified Body Opinion (used to demonstrate compliance under the R&TTE Directive for Radio, EMC and Product Health and Safety)
- EU Declaration of Conformity

Important Note:

A 'Declaration of Conformity' must be issued to cover the final product.

Final product markings must include:

Final product markings must include:

Contains an approved Radio Module
Model: 21-121560

CE XXXX (!)

Note: The Notified Body Number that will replace XXXX.

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MOTOROLA

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