SKYEMODULE M9 DATASHEET

VERSION 081313

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Version 081313

TECHNICAL SUPPORT AND CONTACT INFORMATION

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1 About this Document

This is the datasheet for the SkyeModule M9 UHF RFID reader module. This document contains all of the mechanical and electrical specifications, as well as functional description that users will need to properly integrate and use the M9 in their system.

1.1 Revision History

Version	Author	Changes
103112	Josh Peifer	Initial Release
081313	Brad Alcorn	Fix to MH pin table.

2 Definition of Terms

3DES	Triple Data Encryption Standard
AES	Advanced Encryption Standard
API	Application Programming Interface
DES	Data Encryption Standard
GPIO	General Purpose Input/Output
HID	Human Interface Device
HMAC	Hash-based message authentication code
I^2C	Inter-integrated Circuit
LSB	Least Significant Bit
MD5	Message-Digest Algorithm
MSB	Most Significant Bit
NC	No Connect
PRNG	Pseudo-Random Number Generator
RoHS	Reduction of Hazardous Substances
SHA	Secure Hash Algorithm
SPI	Serial Peripheral Interface
SSEL	Slave Select
STP V3	SkyeTek Protocol Version 3
TTL	Transistor-transistor Logic

3 Applications

The SkyeModule M9 is a small and inexpensive RFID reader module with support for a wide variety of tags and regions. The small size and wide feature set of the M9 lends itself well to the following types of applications:

- RFID Handhelds
- Machine Safety
- Integrated RFID Readers
- Label and Airline Tag Printers

4 Ordering Information

The M9 part number is constructed according to the SkyeTek part number specification below.

As of the date of this document, the most current part numbers for the M9 are

Module	Part Number
SkyeModule M9-MH	SM-M9-MH-3.5-00D7-T0
SkyeModule M9-CF	SM-M9-CF-3.5-00D7-T0

To purchase, please contact a SkyeTek Representative through our website (www.skyetek.com) or over the phone at +1-720-328-3425. You may also contact your local SkyeTek reseller.

5 SkyeModule M9 Overview

The M9 is an incredibly small multi-protocol ETSI 302 208 compliant UHF (862 - 955 MHz) RFID reader platform that supports a wide variety of UHF RFID tags. The SkyeModule M9 can read and write to transponders based on the EPC Class1 Gen1, ISO 18000-6B and ISO 18000-6C (EPC C1G2/Gen2) air interface and communications standards. The RF output power of the M9 is software-adjustable from 10-500 mW. The M9 has been tested for regulatory compliance for the world's major markets including North America, Europe (ETSI 302 208) and Korea. The M9 is RoHS compliant.

Figure 5-1 SkyeModule M9-CF

5.1 Features

Designed for item-level tagging, consumables, handhelds, and label printers, the SkyeModule M9 offers the following features:

- Common communications protocol—All SkyeTek readers use the SkyeTek Protocol v3 (STPv3) to drive low level communications. SkyeTek APIs built on top of STPv3 provide methods for exercising readers and reading tags.
- Multiple communications interfaces: TTL Serial, SPI, I^2C, and native USB for connection to a host PC with or without a serial port. These options are software-selectable to support both loosely and tightly coupled integrations. The SkyeModule M9 also has seven programmable GPIO pins for I/O connections to peripherals.
- The SkyeModule M9 is optimized to support a communication rate of 40/80 kbps. A standard 50 Ω antenna output enables use of an external antenna to optimize the read range/rate.
- Serial data rates are adjustable from 9.6 to 115.2 kbps. Field-upgradable firmware provides forward compatibility for adding future tag protocols, security features, and customized enhancements.

5.2 SkyeWare™ Software

All SkyeModule M9 developer kits ship with the SkyeWare 4 software package for Microsoft® Windows® to aid your RFID development process. This package includes:

- **Setup Wizard** – This Wizard guides you through the setup, configuration, and testing of your new SkyeModule reader. It takes you through all the steps necessary for connecting your hardware, running diagnostic tests, and optimizing your reader configuration. It concludes with useful links to additional SkyeTek software and documentation.
- **Capabilities Functions** – This utility offers a quick way to perform high-level demonstrations of the basic functionality of the SkyeModule M9. You can test read range, anti-collision (singulation) capabilities, and use inventory selection and memory functions.
- **Configuration** – You can easily view and change reader configuration parameters, configure tags, and update or change firmware.
- **Protocol Command Builder** – The test utility provides a GUI interface for constructing the SkyeTek Protocol v3 commands in either ASCII or binary format, based on tag type and selected flags. You can build and test low-level SkyeTek protocol commands and use all the features of the reader at the protocol level. It is an excellent way to learn more about SkyeTek Protocol v3 commands. For more information, see the *SkyeTek Protocol v3 Guide*.
- **APIs** – SkyeTek offers C and .NET APIs so that you can easily create interfaces between your programming language and any SkyeTek reader modules that communicate using SkyeTek Protocol v3. The APIs provide a rich assortment of functions that allows complete access to and manipulation of your SkyeModule M9. Refer to the *SkyeTek API Developer Guide*, installed in the Documentation folder installed with SkyeWare.

6 Mechanical Specifications

The SkyeModule M9 has Mounting Hole (MH) and CompactFlash (CF) variants.

6.1 Mounting Hole Variant

Figure 6-1 shows the dimensions of the MH variant.

Outside dimensions: 53.0 mm x 70.0 mm = 3710 mm^2

Height: 7.7 mm

Mounting holes: 3.0 mm diameter
45.0 mm center-to-center (width)
40.0 mm center-to-center (length)

Clearance: Approx 2.5 mm between edge of mounting hole and edge of printed circuit board (PCB) (width/side-to-side direction)

Approx. 13.2 mm between the edge of mounting hole and front of PCB (main connector side)

Approx. 14.0 mm between the edge of mounting hole and back of PCB (antenna connector side)

Weight 17.9 grams

NOTE – All drawing dimensions are in millimeters. Production units may vary slightly from the measurements given.

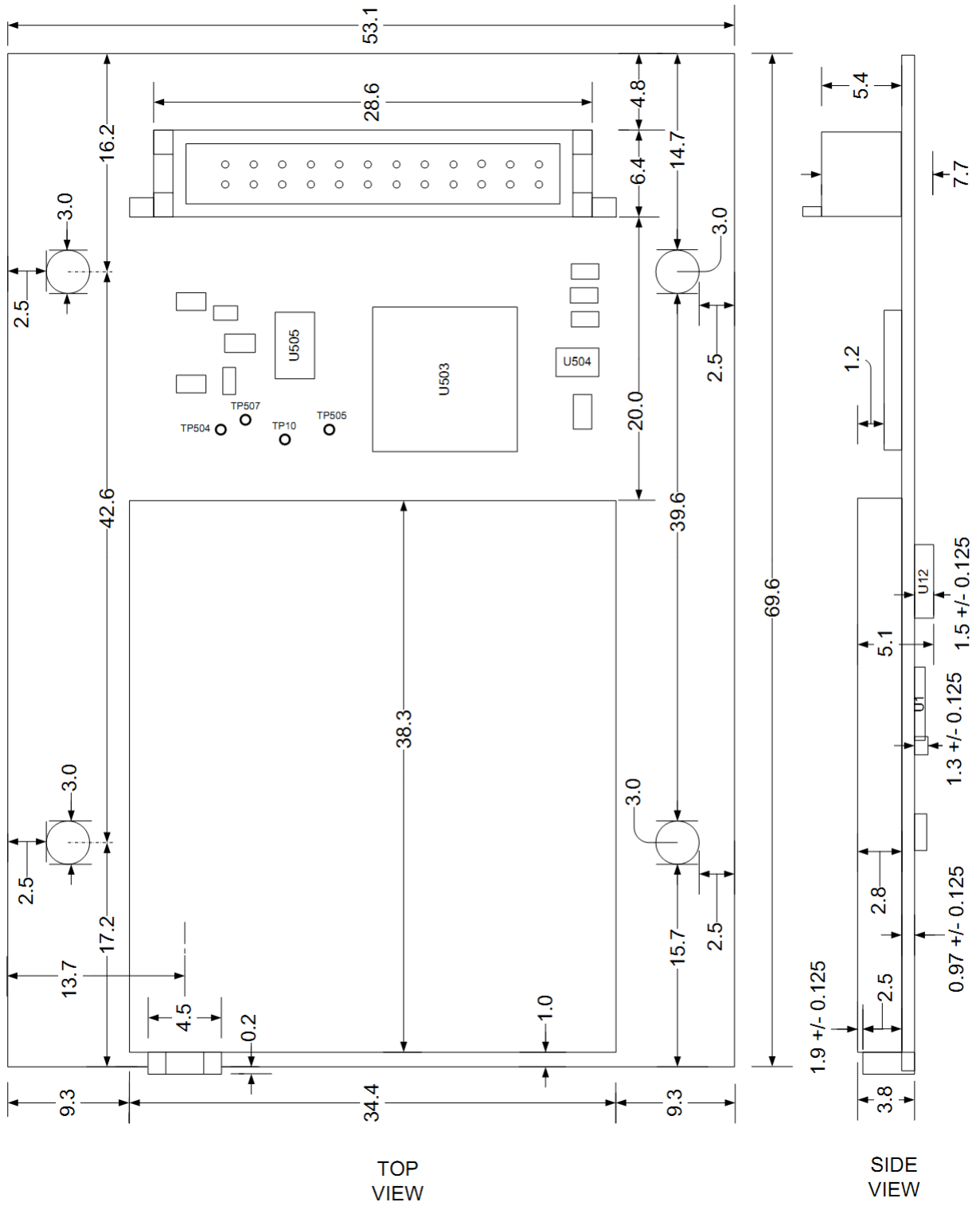

Figure 6-1: SkyeModule M9 Dimensions (MH Variant)

6.2 Compact Flash Variant

Figure 6-2 shows the dimensions of the compact flash (CF) variant.
Dimensions: 66.1mm x 32.5 mm = 2148.25 mm^2
Height: 6.35 mm
Weight 14.2 grams

NOTE – All drawing dimensions are in millimeters. Production units may vary slightly from the measurements given.

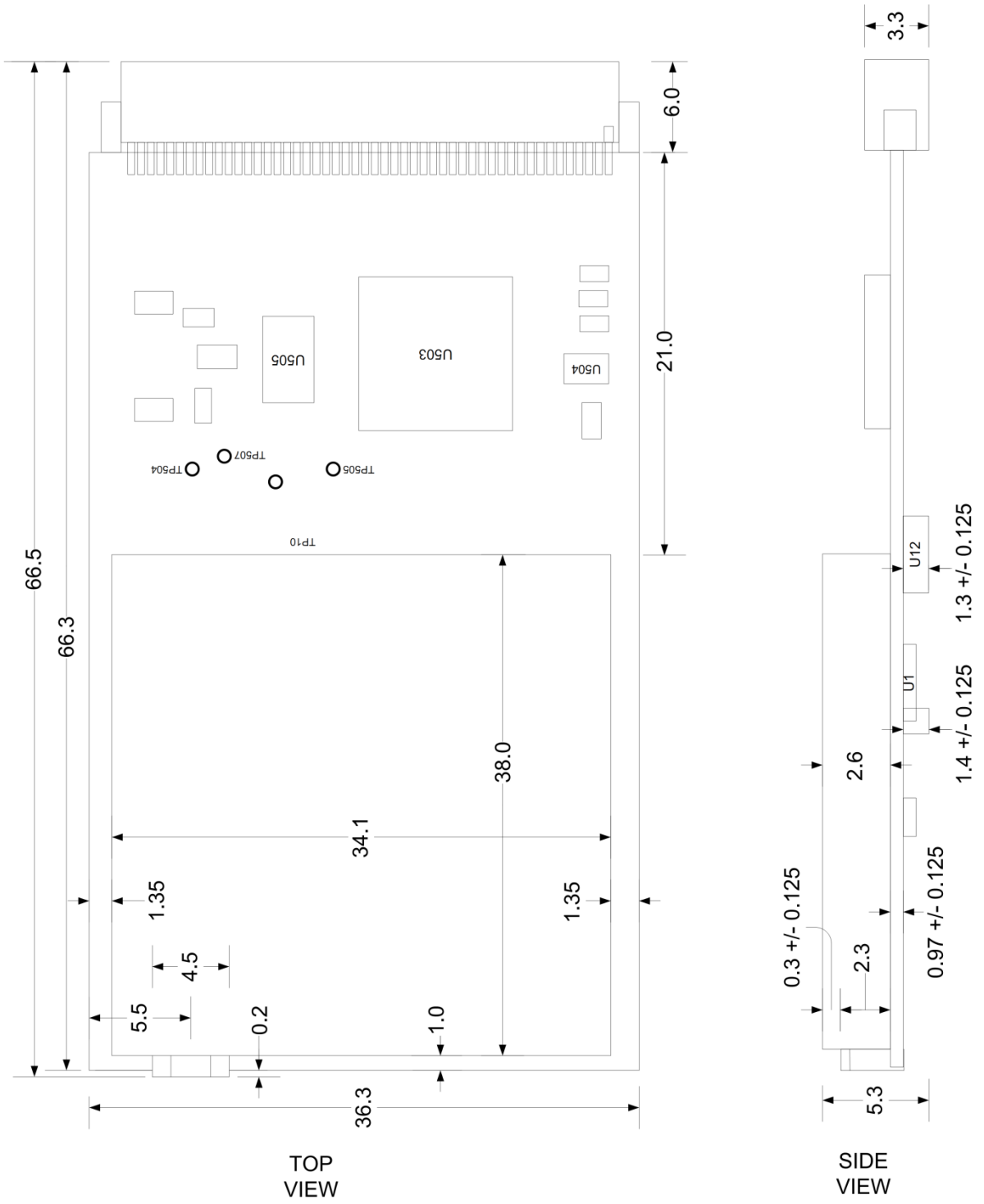

Figure 6-2: SkyeModule M9 Dimensions (CF Variant)

7 Pinning Information

Table 7-1: SkyeModule M9 Connector Specifications

SkyeModule Type	Connector Type	Manufacturer	Manufacturer's Part Number
M9-CF	Compact flash type II (receptacle on module)	Molex	67799-0011
	CF mating connector	Molex	67155-0002
M9-MH	Surface-mount protected header (receptacle on module)	Hirose	DF11Z-24DP-2V
	MH mating connector	Hirose	DF11Z-24DS-2V

7.1 Pin Mapping for the SkyeModule M9-MH Variant

The SkyeModule M9-MH host connector is a standard 24-pin male header connector. Figure 7-1 shows the pinout locations for the connector, and Table 7-2 lists the connector pin mapping.

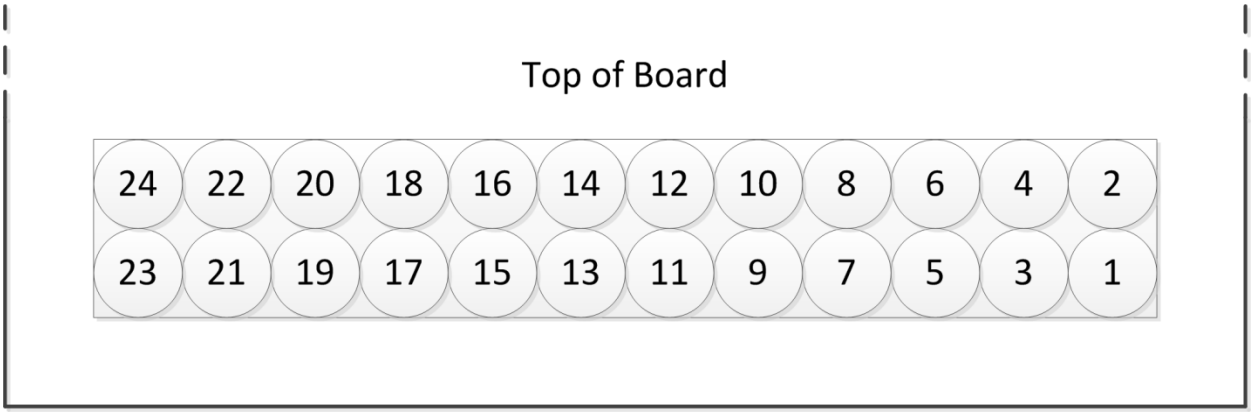

Figure 7-1: M9-MH Connector Pinouts

Table 7-2: SkyeModule M9-MH Pinout

Pin	Name	Description	Pin	Name	Description
1	GPIO0	General-purpose I/O	13	DNEG	USB negative
2	RXD	UART receive to module	14	SDA	I²C Data
3	GPIO1	General-purpose I/O	15	VCC	Supply voltage
4	TXD	UART transmit from module	16	GND	Ground
5	GPIO2	General-purpose I/O	17	NC	Not connected
6	NC	Not connected	18	MISO	SPI master in, slave out
7	GPIO3	General-purpose I/O	19	RESET_N	Active low reset
8	NC	Not connected	20	MOSI	SPI master out, slave in
9	VCC	Supply voltage	21	NC	Reserved
10	GND	Ground	22	SCK	SPI clock in
11	DPOS	USB positive	23	NC	Reserved
12	SCL	I²C Clock	24	NC	Reserved

CAUTION – If you perform custom integration work on your SkyeModule M9, make sure that you connect all available power and ground pins. Failure to do so will reduce read range and could cause failure of the module. Pins listed as not connected can be left floating.

7.2 Pin Mapping of the SkyeModule M9-CF Variant

The SkyeModule M9-CF host connector is a standard 50-pin CF female connector. Figure 7-2 shows the connector pinout, and table 7-2 lists the connector pin mappings.

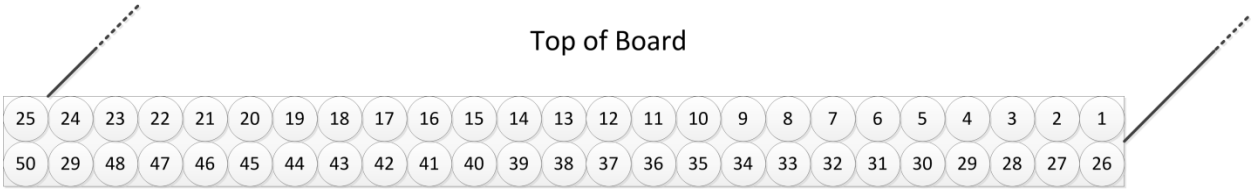

Figure 7-2: M9-CF Connector Pinout

Table 7-3: SkyeModule M9-CF Connector Pinout

Pin	Name	Description	Pin	Name	Description
1	GND	Ground	26	GND	Ground
2	VCC	Supply voltage	27	GND	Ground
3	VCC	Supply voltage	28	CTS_SCL_HOST	I^2C Clock
4	DPOS	USB positive	29	SDA_HOST	I^2C Data
5	DNEG	USB negative	30	NC	Not connected
6	GND	Ground	31	NC	Not connected
7	MISO	SPI master-in, slave-out	32	GPIO0	General-purpose I/O
8	MOSI	Master-out, slave-in for SPI	33	GPIO1	General-purpose I/O
9	SSEL	Slave select for SPI	34	GPIO2	General-purpose I/O
10	SCK	SPI clock	35	Reserved	NC
11	Reserved	NC	36	Reserved	NC
12	Reserved	NC	37	NC	Not connected
13	NC	Not connected	38	NC	Not connected
14	RXD	UART receive	39	NC	Not connected
15	TXD	UART transmit	40	Reserved	NC
16	Reserved	NC	41	RESET_N	Reset (active low)
17	Reserved	NC	42	NC	Not connected
18	NC	Not connected	43	GPIO3_MUX_EN	General-purpose I/O
19	Reserved	NC	44	GPIO4_MUX_CNTRL2	General-purpose I/O
20	Reserved	NC	45	GPIO5_MUX_CNTRL1	General-purpose I/O
21	Reserved	NC	46	GPIO6_MUX_CNTRL0	General-purpose I/O
22	Reserved	NC	47	NC	Not connected
23	Reserved	NC	48	NC	Not connected
24	Reserved	NC	49	GND	Ground
25	GND	Ground	50	NC	Not connected

CAUTION – If you perform custom integration work on your SkyeModule M9, make sure that you connect all available power and ground pins. Failure to do so will reduce read range and could cause failure of the module. Pins listed as not connected can be left floating.

7.3 Using the GPIO Pins

You can use the User Port Direction and User Port Value system parameters to address the GPIO pins to set the user port direction (input or output) and the user port value (high or low). For more information, see the following:

- “User Port Direction” on page 50
- “User Port Value” on page 50

NOTE – GPIO 3 is not available for user I/O; it is connected to the on-board amber LED, which indicates when a successful tag command occurs.

8 Environmental Specifications

8.1 Electrostatic Precautions

CAUTION – Failure to take proper electrostatic precautions may result in damage to or failure of your SkyeModule M9.

The SkyeModule M9 contains static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- Wear a static grounding strap when handling electronic control components
- Keep all plastic, vinyl, and Styrofoam (except antistatic versions) away from printed circuit boards.
- Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.

8.2 General Ratings and Operating Conditions

Table 8-1: Environmental Ratings/Operating Conditions

Specification	**Rating**
Temperature range	Temperature is 25 degrees Celsius unless otherwise noted
Operating	-20 to +70 degrees C
Storage	-30 to +85 degrees C
Humidity	
Operating, continuous storage	10-90 percent (non-condensing)
Transient storage (<24 hours)	5-95 percent maximum (non-condensing)
ESD protection	<1kV (ESD HBM 15500 Ω, 100pF) -or- 100V (ESD MM 0.75uH, 200pF)

9 Electrical Specifications

This chapter discusses the electrical specifications of the SkyeModule M9. Unless otherwise noted, the following assumptions apply to these specifications:

- Temperature is 25 degrees Celsius.
- Frequency is 915.0 MHz.
- Supply voltage (VCC) is 5 V.

The SkyeModule M9 works under normal duty cycles at full output power without the need for external fans, additional heat sinks, etc., under the operating conditions described in these specifications.

NOTE – See "Electrostatic Precautions" on page 22 for electrical safety information.

Table 9-1: SkyeModule M9 Electrical Specifications

Specification	Min	Typical	Max	Units/Notes
Logic Inputs				
High state input voltage	2			V
Low state input voltage			0.8	V
Input Current (I_{INH}/I_{INL})		4	25	mA
Logic Outputs				
Output High Voltage (V_{OH})	2.9			V
Output Low Voltage (V_{OL})			0.4	V
Output Current (I_{INH}/I_{INL})		4	25	mA
Power Supplies				
Voltage Supply	3.5	5.0	5.5	V
Peak Transmit Current Consumption				
10 dBm	200		300	mA
21 dBm	200		500	mA

Specification	Min	Typical	Max	Units/Notes
24 dBm	200		650	mA
27 dBm	200		800	mA
Low Power Sleep Mode		5		mA

9.1 Absolute Maximum Range

Temperature for these specifications is assumed to be 25 degrees Celsius unless otherwise noted.

Table 9-2: Absolute Maximum Ratings/Operating Conditions

Specification	Rating
Maximum input voltage, high (V_{INH})	5.5 V
V_{SUPPLY} to GND	5.5 V
Digital I/O voltage to GND	5.5 V
Antenna VSWR characteristic	2:1 or better, as desirable for optimum performance

10 Host Interface Specifications

The following sections describe the power and host communication connections for the SkyeModule M9.

10.1 Host to Reader Interfaces

The SkyeModule M9 supports the following microcontroller host interfaces for easy integration into existing systems:

- TTL (RS-232 can be supported with additional circuitry)
- SPI
- I^2C
- USB

The SkyeModule M9, when used with the SkyeTek Host Interface Board, supports RS-232 and USB communications. The host interface board provides a USB connector and a TTL-to-RS-232-level converter for the TTL host interface. Each interface is software selectable and only one host interface is active at a time. The host interface is selected based on the power-up default value and can be changed at run time using the Host Interface Type system parameter. The SkyeModule M9 operates under host control using SkyeTek Protocol v3 sent over one of the host interfaces described in this chapter.

NOTE – SkyeModule M9s shipped with the SkyeTek Development Kit are preset to use USB communications and a power level of 27 dBm.

10.2 TTL

A two-wire serial connection (no handshaking) is provided on the Transmit (TXD)and Receive (RXD) lines with TXD and RXD labeled from the module's point of view. Data exchange between the host and the SkyeModule M9 occurs according to SkyeTek Protocol v3 (ASCII or Binary mode). Figure 10-1 shows examples of typical communication.

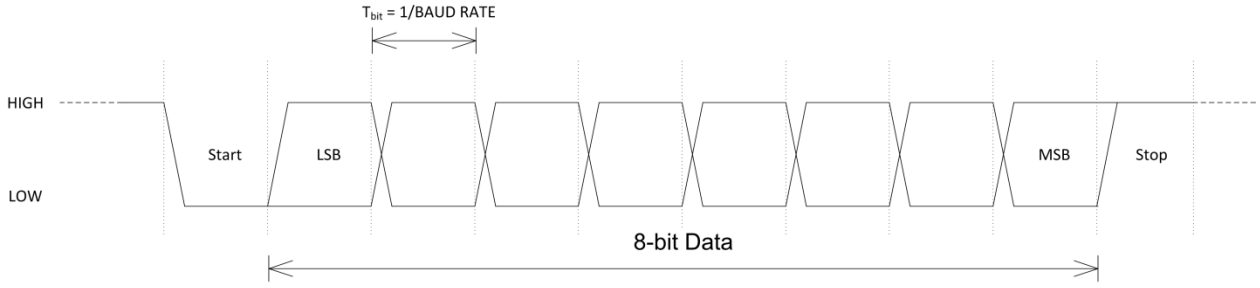

Figure 10-1: TTL Timing

- Baud rate is selectable via the appropriate system parameter. Pre-programmed factory default baud rate is 38,400 Baud, N, 8, 1 (no parity bit, 8 data bits, 1 stop bit).
- Bytes are transmitted least-significant bit (LSB) first using the typical serial data format of *Start Bit* followed by *8 data bits* followed by a *Stop Bit*.
- The TTL connection supports bit rates from 9,600 to 115,200 baud, 8 data bits, no parity, 1 stop bit.
- The option to add hardware flow control is not supported in this release.
- Host to reader interface shall be RS-232 TTL level (non-inverted).
- TTL low = 0 to 0.8V; TTL high = 2.0 to 5V.

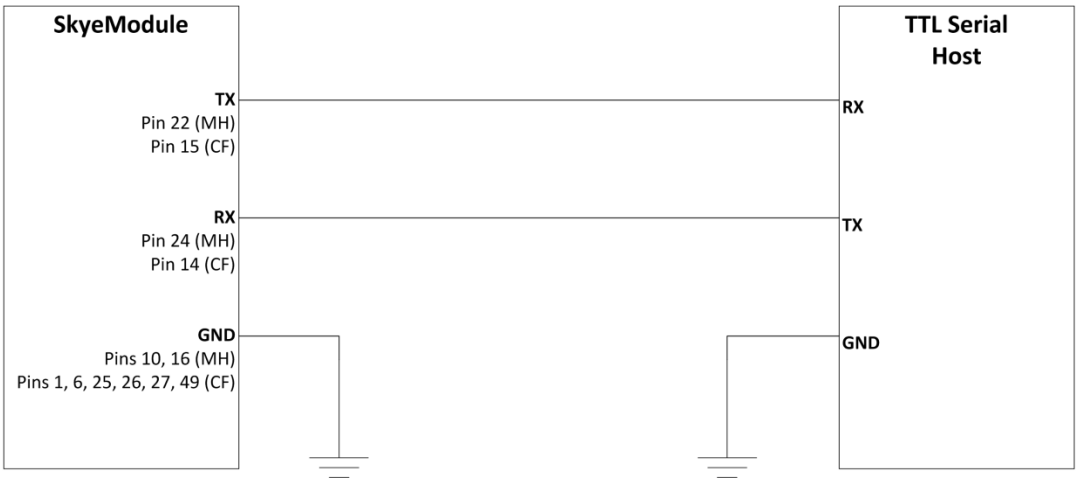

Figure 10-2: TTL Connection Diagram

10.3 SPI

The SkyeModule M9 provides a simple four-wire SPI host interface. Figure 10-3 shows an example of a host interface connection using SPI.

Figure 10-3: SPI Connection Diagram

The protocol for requests to the SkyeModule M9 is as follows:

- The host must implement SPI master functionality.
- The data packet exchange between the host (SPI Master) and the M9 (SPI Slave) uses SkyeTek Protocol v3 (Binary Mode only).
- The SCK line is the master clock controlled by the host and should remain low during idle state.
- The slave select line is active low.
- The data is setup on the rising edge of SCK.
- The message data is sampled on the falling edge of SCK.
- The MOSI signal line provides the data from the host to the SkyeModule M2.
- Low = 0 to 0.8 V; High = 2.0 to 5 V.

The timing diagram in Figure 10-4 illustrates this behavior.

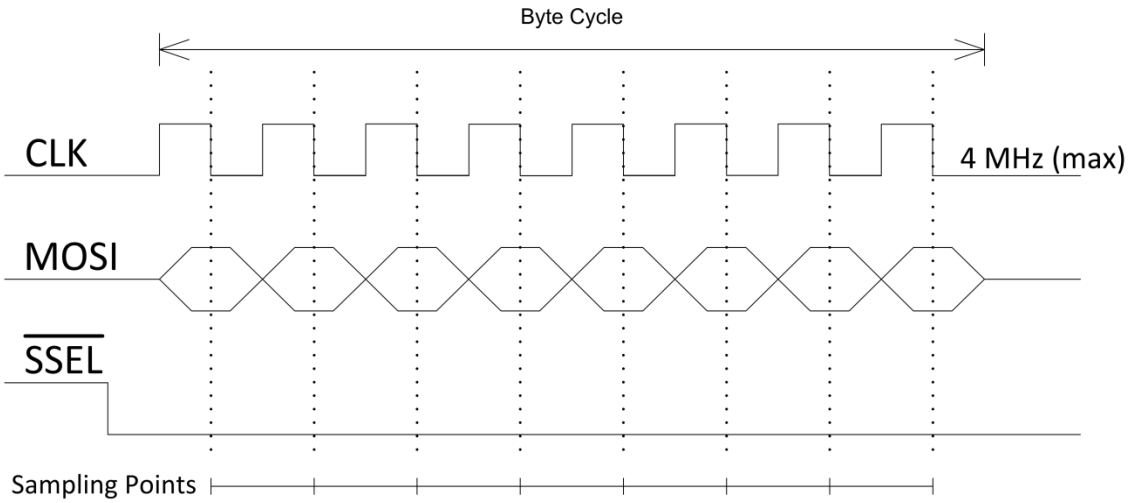

Figure 10-4: SPI Request Setup and Sample Timing

- For the request data on the MOSI line, the host software should keep the SSEL pin at steady state low as shown in Figure 10-5 below.
- The time delay $T_{d,MAX}$ between byte cycles in a request should not exceed 5 ms. After 5 ms the SkyeModule M9 will timeout signifying the end of the request.

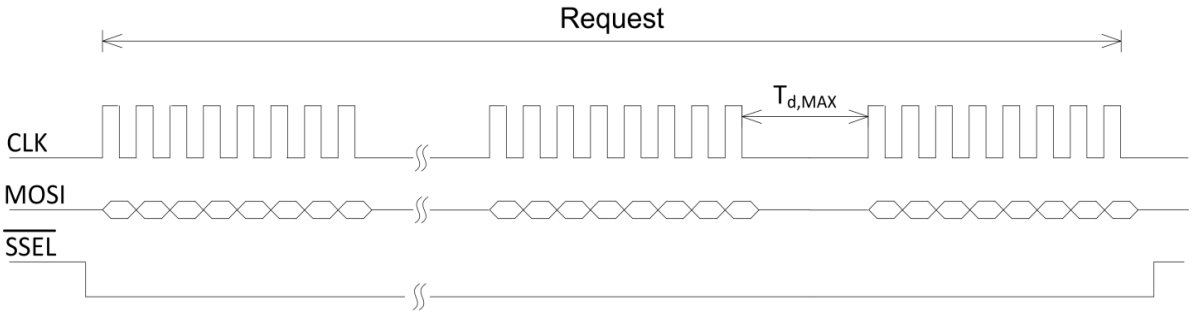

Figure 10-5: SPI Request Timing

The protocol for retrieving the response data is outlined below.

- The SkyeModule M9 is half duplex, so the response data must be retrieved after the request has been sent.
- The MISO signal provides the response data from SkyeModule M9 to host.
- To retrieve data on the MISO line, the SSEL (Slave Select) signal must toggle low-high-low between clocked-back bytes.

Figure 10-6 below shows the timing required to retrieve data on the MISO line.

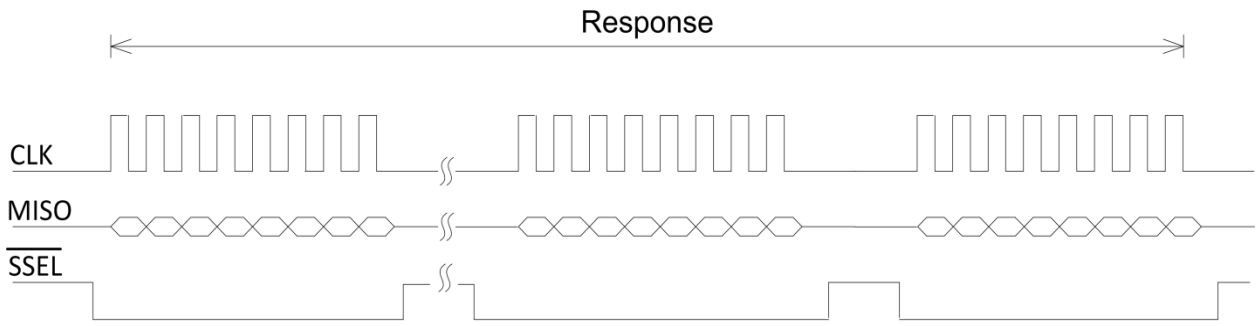

Figure 10-6: SPI Response Timing

10.4 I²C

The SkyeModule M9 supports the I²C standard for connecting to a host controller. The device connection requires that external pull up resistors be added to the SDA and SCL lines as shown in Figure 10-7.

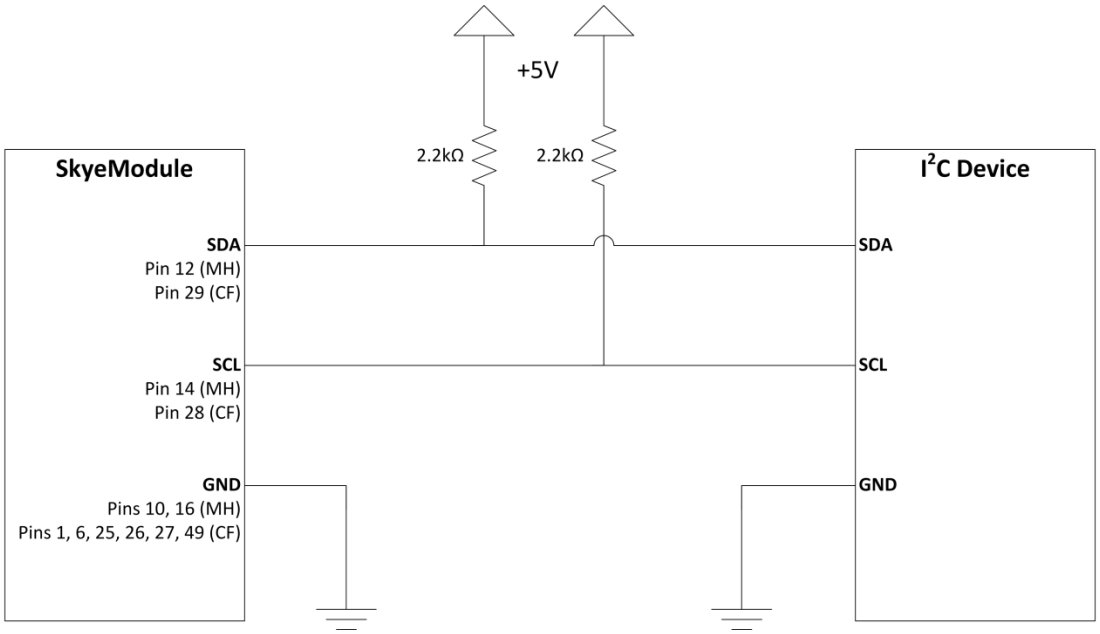

Figure 10-7: I2C Connection Diagram

NOTE – The SkyeTek Host Interface Board includes these pull-up resistors.

The SkyeModule M9 requires the host to operate as a master.

- The SPI interface uses a standard two-wire connection in which SCL is the master clock and SDA is a bidirectional serial data line.
- Data exchange between the host and the SkyeModule M9 uses SkyeTek Protocol v3 (Binary Mode only).

- I²C fast mode (400 kHz) is supported, as is the slower 100kHz data rate.
- The data is sent and received MSB first.
- Low = 0 to 0.8V; High = 2.0 to 5V.
- The device address is 0x7F.
- The communication scheme from host to module is as follows:
    - Initiate a start condition (SDA transitions low while SCL is high).
    - Send the nine bits of the initial start packet as follows:
        - Send the 7-bit address.
        - Send the read/write bit as the eighth bit (0 for writing from the host to the slave).
        - Send the ninth bit as the "acknowledge" bit (ACK), which is automatically handled.
        - If the reader recognizes the address, it pulls SDA low.
    - Use the bus to clock each byte of the SkyeTek protocol request.
    - After sending the request, initiate a stop condition. (SCL transitions high, and then SDA transitions high while SCL is high)

NOTE – You may need to include from one to a few hundred milliseconds of delay. The delay may vary for tag-specific commands.

- Communication scheme from module to host is as follows:
- Initiate a start condition. (SDA transitions low, and then SCL transitions low.)
- Send the 7-bit address.
- Send the read/write bit as the eighth bit (1 for reading from the slave to the host).
- If the reader recognizes the address, it pulls SDA low for the ACK bit.
- If the address isn't recognized or the module is busy the SDA bit will remain high during the ACK bit.
- Clock each byte of the SkyeTek protocol response from the module.
- After receiving the response, initiate a stop condition. (SDA transitions high while SCL is high.)
- SDA must transition while the clock is low and remain stable while the clock is high.

A timing diagram illustrating the data transfer is shown in the figure below.

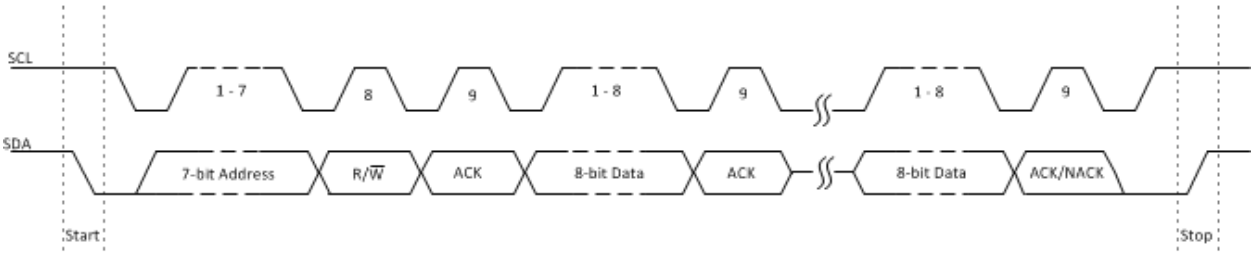

Figure 10-8: I2C Timing Diagram

NOTE – Not reading the entire response before sending another command can cause undesired behavior. Always make sure to read the entire response when using the I^2C interface.

10.5 USB 2.0

The SkyeModule M9 is seen by the host as an HID USB device.

The SkyeModule M9 is USB 2.0 Full Speed compliant.

NOTE – When the SkyeModule M9 is USB-bus powered, maximum transit power should not exceed 20dBm.

10.5.1 Bypassing the Host Interface Board

Figure 10-9 shows an example of a circuit to permit USB communications without using the host interface board.

CAUTION – If powering from the USB bus alone, Make sure the SkyeModule M9's power is turned down to at least 20dBm to prevent damage to the host USB port.

NOTE – You may need toad an additional bypass capacitor to reduce signal noise, depending on the system in which the circuit is used.

NOTE – SkyeTek Recommends that the power supply for the circuit provides 1A of current to ensure proper operation.

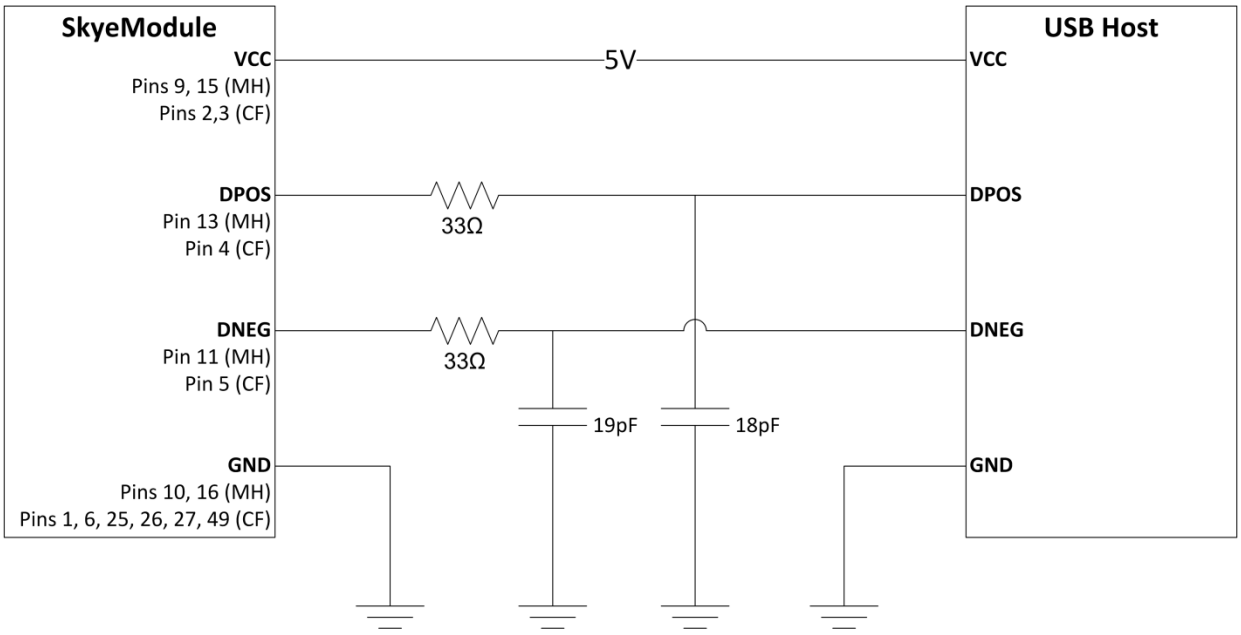

Figure 10-9: Circuit to Bypass Host Interface Board for USB Support

11 Radio Specifications and Regional Compliance

11.1 RF Radio Power

To minimize power consumption for systems that have lower power requirements, the RF transmit power of the SkyeModule M9 is user configurable from 10-27 dBm in steps of 0.1 dB with an accuracy of +/-1 dB across a temperature range of -20 to +70 degrees Celsius. The resolution steps are smaller than the accuracy so that you can fine tune the power level to lower current consumption. See Chapter 14, for information on how to change the RF power level.

11.2 Frequency Range

The M9 is a multi-frequency device that operates in the 862-955 MHz range, which spans the world's major UHF RFID bands. See "Adjusting System Parameters" below for information on changing operating frequency and region of operation of the M9. Regional frequency bands are shown below in Table 11-1.

11.3 Tag Protocols

The SkyeModule M9 supports the basic tag commands (identify, read, and write) for the following tag protocols:

- EPC C1G1
- EPC C1G2 (ISO18000-6C)
- ISO 18000-6B
- iPx

NOTE – For the most current listing of supported tags and features, see the Tag Support list included in the documentation folder installed from your distribution CD or on the SkyeTek Support Portal.

11.4 Recommended Radio Settings for Regional Compliance

The following settings are recommended to assist you in obtaining regulatory certification.

Table 11-1: Recommended Reader Settings for Regional Compliances

Region	Spectral Mask Settings (SkyeModule M9 System Parameters)								Tag Types Supported[a]
	Start Freq. (MHz)	Current (Center) Freq. (MHz)	Stop Freq. (MHz)	Output Power (conducted) (dBm)	Hop Channel Spacing (KHz)	Modulation Depth (%)	Frequency Hopping Sequence	Regulatory Mode	
Australia/New Zealand	918.3	922.0	925.7	25	200	100	0x01	0x00	all
Europe	865.7	866.7	867.9	25	200	30	0x00	0x01	ISO 18000-6B
Europe	865.7	866.7	867.9	25[b]	200	80	0x00	0x01	ISO 18000-6C (Gen2)
Hong Kong	920.3	920.5	924.7	27	200	100	0x01	0x00	all
Korea	910.3	912.0	913.7	27	200	100	0x01	0x04	all
North America	902.3	915.0	927.7	27	200	100	0x01	0x00	all
Singapore	920.5	922.5	924.7	27	200	100	0x01	0x00	all
Taiwan	922.3	925.0	927.7	27	200	100	0x01	0x00	all

a. For the most current listing of supported tags and features, see the Tag Support list included in the documentation folder installed from your distribution CD or on the SkyeTek Support Portal.
b. With firmware version 1DA and hardware version 3.0. This setting is 22 dBm for previous hardware/firmware versions.

11.5 Adjusting System Parameters

The SkyeModule M9 provides an adjustable system parameter for each spectral mask settings required to comply with the regions listed in Table 11-1. See “Customizing System Parameters” on page 41 for additional information on setting the system parameters.

11.6 Radio Test Models

For regulatory testing, the SkyeModule M9 now has a special system parameter that lets you set various test modes such as:

- Leaving the carrier on constantly, with or without closed loop power control
- Disabling listen before talk (LBT) to better view the regulatory spectrum
- Combining these test modes to best suit your test needs

Please contact SkyeTek technical support for more information.

11.7 Regional Regulations

The SkyeModule M9 has been tested at a certified testing laboratory for agency compliance with the regulations shown in the table below. All module testing is done as a pre-scan for each regulation. SkyeTek has not obtained any official agency certifications for the SkyeModule M9.

Table 11-2: SkyeModule M9 Agency Compliance

Region	Agency	Approvals	Publications/Regulations
North America	FCC	Part 15.247 and 15.109 standards	
Europe	ETSI	EN 301-489	"Electromagnetic and Radio Spectrum matters (ERM); Electromagnetic Compatibility (EMC); standard for radio equipment and services; Part 1: Common technical requirements"
		EN 61000-4-3	"Radio Frequency Electromagnetic Field"
		EN 302-208 v1.1.1	"Electromagnetic Compatibility and Radio Spectrum Matters (ERM): Radio Frequency Identification equipment operating in the band 865 MHz with power levels up to 2 W: Part 2 Harmonized EN under article 3.2 of the R&TTE directive"
Taiwan		LP002	"Low Power Radio Frequency devices"
Hong Kong		HKTA 1049	"Performance Specification for Radio Frequency Identification (RFID) Equipment Operating in the 865-868 and/or 920-925 MHz bands"
Korea	Radio Research Laboratory	Notification No. 2005-50	"Technical Requirements for the Radio Equipment for Other Services than Broadcasting, Maritime, Aeronautical and Telecommunications Service"
Singapore		IDA TS SRD	
Australia		AS/NZS 4268:2003	"Radio equipment and systems – Short range devices – Limits and methods of measurement"

11.8 Radio Specifications

Table 11-3: Radio Specifications

Specification	Min	Typical	Max	Units/Notes
RF Characteristics				
Frequency ranges (Direct output)	862.000	915.000	955.000	MHz
Hop channel spacing	100	200	300	KHz
Transmission Parameters				
Transmit Power	10	12	20/27*	dBm (See "Recommended Radio Settings for Regional Compliance" on page 34 for maximum power ratings under different regulatory environments.) * When the SkyeModule M9 is USB-bus powered, maximum transmit power should not exceed 20 dBm. SkyeModule M9s shipped with the SkyeTek Development Kit are preset to use USB communications at a 20 dBm power level.
Transmit Power Variation vs. Temperature		+/- 1		dB (Temperature range is -10 C to +55 C.)
Transmit Power Variation vs. VCC		+/- 1		dB (VCC is from 3.5-5 V)
Transmit Power Flatness vs. Frequency		+/- 1		dB (Frequency range is from 862-955 MHz)
Optimum PA Load Impedance		50		Ohms
Receiver Parameters				
Sensitivity at 40 kbps	45	50	55	dBm (at transmit power of 27 dBm and measured from 860-960 MHz)
Sensitivity at 80 kbps	40	45	50	dBm (at transmit power of 27 dBm and measured from 860-960 MHz)

12 Antenna Options

The SkyeModule M9 supports any 50 Ohm antenna tuned to the correct frequency range. Read range is highly dependent on antenna selection, tag selection, and operating environment.

Read range depends on your specific settings, including:

- Environment (to maximize accuracy for testing, SkyeTek recommends that you use an outdoor free-space test)
- Antenna gain: a higher-gain antenna provides a longer read range. However, this longer range is achieved through a smaller beam width, which in turn reduces the size of the read field, affecting read reliability.
- Antenna cable length: antenna-cable gain/loss is approximately -0.49 dB/meter (-0.15 dB/foot) for a standard RG58 coaxial cable.
- RF power: maximum RF power is 27 dBm.
- Frequency hopping settings (depends on antenna)
- Antenna polarization
- Tag orientation
- Tag type, manufacturer, and individual tag
- Tag mounting surface
- Tag dynamics (speed, moving, rotating)

NOTE – The MMCX antenna connector for the M9 allows quick connections but can let a loose antenna cable rotate, yaw, or pitch in the connector socket if you do not secure the cable. Cable motion increases the VSWR to the radio receiver and degrades performance. Make sure that you provide strain relief for the antenna cable to prevent any motion or mechanical stress at the MMCX connector.

13 Communication Specifications

13.1 Host Communication – SkyeTek Protocol v3

The SkyeModule M9 operates under host control according to the SkyeTek Protocol v3. For more information about this protocol, including commands, flags, request and response formats, please see the *SkyeTek Protocol v3 Reference Guide*.

The basic command and response format is illustrated below.

Table 13-1: Request Format (bytes), ASCII Mode

Flags	Cmd.	RID	Tag Type	TID Len.	TID	AFI	Addr.	# of Blks.	Data Len.	Data	CRC
4	4	8	4	4	32 (max)	2	4	4	4	2K	4

Table 13-2: Request format (bytes), Binary Mode

Msg. Len.	Flags	Cmd.	RID	Tag Type	TID Len.	TID	AFI	Addr.	# of Blks.	Data Len.	Data	CRC
2	2	2	4	2	1	16 (max)	1	2	2	2	1K	2

	Required Fields (must be present at all times)
	Optional fields (depending on the command and flags)
	Required fields, depending on the command

Table 13-3: Response Format (bytes), ASCII Mode

Response Code	RID	Tag Type	Data Length	Response Data	CRC
4	8	4	4	2K	4

Table 13-4: Response Format (bytes), Binary Mode

Message Length	Response Code	RID	Tag Type	Data Length	Response Data	CRC
2	2	4	2	2	1K	2

	Required Fields (must be present at all times)
	Optional fields (depending on the command and flags)
	Required fields, depending on the command

14 Customizing System Parameters

System parameters let you configure reader settings to customize them for your environment. You can temporarily alter parameters in memory or change the default values that are stored on the SkyeModule M9 EEPROM. The following table summarizes the parameters for the SkyeModule M9. (See "System Parameter Descriptions" on page 47 for detailed information on each parameter.)

Table 14-1: System Parameter Addresses, Lengths, and Default Values

Parameter	Address	Length (bytes)	Default Value
Serial Number	0x0000	0x0004	0x00000000
Firmware Version	0x0001	0x0004	0xXXXXXXXX (depends on release)
Hardware Version	0x0002	0x0004	0xXXXXXXXX (depends on release)
Product Code	0x0003	0x0002	0x0009
Reader ID	0x0004	0x0004	0xFFFFFFFF
Reader Name	0x0005	0x0020	SkyeModule M9 (in hex)
Host Interface Type	0x0006	0x0001	0x00 (TTL)
Host Interface Baud Rate	0x0007	0x0001	0x02 (38400 baud)
User Port Direction	0x0008	0x0001	0x00
User Port Value	0x0009	0x0001	0x00
MUX Control	0x000A	0x0001	0x00
Operating Mode	0x000C	0x0001	0x00
Command Retry	0x0011	0x0001	0x05
Power Level	0x0012	0x0001	0xDC (27 dBm)
Current Frequency	0x0004	0x0004	0x3689CAC0 (915 MHz)
Start Frequency	0x0031	0x0004	0x35C80160 (902.3 MHz)
Stop Frequency	0x0032	0x0004	0x374B9420 (927.7 MHz)
Hop Channel Spacing	0x0034	0x0004	0x00030D40 (200 KHz)
Frequency Hopping Sequence	0x0035	0x0001	0x01 (pseudo-random)
Modulation Depth	0x0036	0x0001	0x64 (100%)
Regulatory Mode	0x0037	0x0001	0x00
LBT Antenna Gain	0x0038	0x0001	0x00

14.1 Changing System Parameters

CAUTION – Changing system parameter values – especially the default values – can render your SkyeModule M9 nonoperational in your environment. Research, record, and test all planned changes to make sure they are compatible with your system.

You can read or write system parameters via the following commands:

- Read System Parameter – reads the current value of the system parameter at the memory address specified.
- Write System Parameter – writes a new value to the system parameter at the memory address specified.
- Store Default System Parameter – writes a new system parameter value to the EEPROM.
- Retrieve Default System Parameter – reads the system parameter value at the address specified out of EEPROM.

See the *SkyeTek Protocol v3 Reference Guide* for a complete list of commands.

See "Understanding System Parameter Formats" on page 43 for more information about using these commands.

See "System Parameter Descriptions" on page 47 for information about individual parameters.

CAUTION – Resetting (cycling power) on your SkyeModule M9 causes all system parameters to revert to their default values. Any changes made to system parameters in memory are lost at reset unless you write them to the EEPROM as the new default values. Any changes to the default values do not take effect until the reader is reset.

14.2 Understanding System Parameter Formats

This section provides format details for the commands used to change system parameters.

NOTE – The number of blocks field for each command in this section should equal the byte length for each system parameter. (See "System Parameter Descriptions" on page 47 and "Communication Specifications" on page 39 for more information.)

14.2.1 Read System Parameter Command Format

Table 14-2: Read System Parameter Command, ASCII Mode Request

System Parameter	Start:	Flags:	Command:	Address (hex):	Hex # of Blocks:	CRC	End:
Serial Number	<CR>	0020	1201	0000	0004	calculated by user*	<CR>
Firmware Version				0001	0004		
Hardware Version				0002	0004		
Product Code				0003	0002		
Reader ID				0004	0004		
Reader Name				0005	0020		
Host Interface Type				0006	0001		
Host Interface Baud Rate				0007	0001		
User Port Direction				0008	0001		
User Port Value				0009	0001		
MUX Control				000A	0001		
Operating Mode				000C	0001		
Command Retry				0011	0001		
Power Level				0012	0001		
Current Frequency				0030	0004		
Start Frequency				0031	0004		
Stop Frequency				0032	0004		
Hop Channel Spacing				0034	0004		
Frequency Hopping Sequence				0035	0001		
Modulation Depth				0036	0001		
Regulatory Mode				0037	0001		
LBT Antenna Gain				0038	0001		

* Calculated as per CRC Definition. See the *SkyeTek Protocol v3 Reference Guide*.

	Values that are constant for all commands

Table 14-3: Read System Parameter Command, ASCII Mode Response

Start:	Response Code:	Data Length:	Data:	CRC:	End:
<LF>	1201	depends on system parameter		as calculated by the reader	<CR><LF>

Table 14-4: Read System Parameter Command, Binary Mode Request

System Parameter	STX:	Message Length	Flags:	Com-mand:	Address (hex):	Hex # of Blocks:	CRC
Serial Number	02	calculated by user*	0020	1201	0000	0004	calculated by user*
Firmware Version					0001	0004	
Hardware Version					0002	0004	
Product Code					0003	0002	
Reader ID					0004	0004	
Reader Name					0005	0020	
Host Interface Type					0006	0001	
Host Interface Baud Rate					0007	0001	
User Port Direction					0008	0001	
User Port Value					0009	0001	
MUX Control					000A	0001	
Operating Mode					000C	0001	
Command Retry					0011	0001	
Power Level					0012	0001	
Current Frequency					0030	0004	
Start Frequency					0031	0004	
Stop Frequency					0032	0004	
Hop Channel Spacing					0034	0004	
Frequency Hopping Sequence					0035	0001	
Modulation Depth					0036	0001	
Regulatory Mode					0037	0001	
LBT Antenna Gain					0038	0001	

* See the *SkyeTek Protocol v3 Reference Guide* for more information.

	Values that are constant for all commands

Table 14-5: Read System Parameter Command, Binary Mode Response

STX:	Message Length:	Response Code:	Data Length:	Data:	CRC:
<02>	0007	1201	varies with system parameter	varies with system parameter	calculated by the reader

14.2.2Write System Parameter Format

Table 14-6: Write System Parameter Command, ASCII Mode Request

System Command	Start	Flags	Com-mand	Address (hex)	Hex # or Blocks	Data Length	Data	CRC	End
Serial Number	<CR>	0820	1202	0000	0004	user defined*	user defined	Calculated by user	<CR>
Firmware Version				0001	0004				
Hardware Version				0002	0004				
Product Code				0003	0002				
Reader ID				0004	0004				
Reader Name				0005	0020				
Host Interface Type				0006	0001				
Host Interface Baud Rate				0007	0001				
User Port Direction				0008	0001				
User Port Value				0009	0001				
MUX Control				000A	0001				
Operating Mode				000C	0001				
Command Retry				0011	0001				
Power Level				0012	0001				
Current Frequency				0030	0004				
Start Frequency				0031	0004				
Stop Frequency				0032	0004				
Hop Channel Spacing				0034	0004				
Frequency Hopping Sequence				0035	0001				
Modulation Depth				0036	0001				
Regulatory Mode				0037	0001				
LBT Antenna Gain				0038	0001				

* See the *SkyeTek Protocol v3 Reference Guide* for more information.

	Values that are constant for all commands

Table 14-7: Write System Parameter Command, ASCII Mode Response

Action:	Start:	Response Code:	CRC:	End:
Response	<LF>	1202	<8533>	<CR><LF>

This format is the same for all write commands.

Table 14-8: Write System Parameter Command, Binary Mode Request

System Parameter	STX:	Message Length:	Flags:	Com-mand:	Address (hex):	Hex # of Blocks:	CRC
Serial Number	02	calculated by user*	0820	1202	0000	0004	calculated by user*
Firmware Version					0001	0004	
Hardware Version					0002	0004	
Product Code					0003	0002	
Reader ID					0004	0004	
Reader Name					0005	0020	
Host Interface Type					0006	0001	
Host Interface Baud Rate					0007	0001	
User Port Direction					0008	0001	
User Port Value					0009	0001	
MUX Control					000A	0001	
Operating Mode					000C	0001	
Command Retry					0011	0001	
Power Level					0012	0001	
Current Frequency					0030	0004	
Start Frequency					0031	0004	
Stop Frequency					0032	0004	
Hop Channel Spacing					0034	0004	
Frequency Hopping Sequence					0035	0001	
Modulation Depth					0036	0001	
Regulatory Mode					0037	0001	
LBT Antenna Gain					0038	0001	

* See the *SkyeTek Protocol v3 Reference Guide* for more information.

	Values that are constant for all commands

Table 14-9: Write System Parameter Command, Binary Mode Response

STX:	Message Length:	Response Code:	CRC:
<02>	0004	1202	<E652>

This format is the same for all write commands.

14.3 System Parameter Descriptions

This section describes the SkyeModule M9 system parameters. See "Understanding System Parameter Formats" on page 43 for formats to use each parameter in a system command.

14.3.1 Serial Number

- Returns the serial number of the reader
- Parameter address: 0x0000
- Length (bytes): 4
- Default value:0x00000000
- Read-only

14.3.2 Firmware Version

- Returns the firmware version currently loaded on the reader
- Refer to the *SkyeModule M9 Release Notes* for more information about the firmware release.
- Parameter address: 0x0001
- Length (bytes): 4
- Default value: 0xXXXXXXXX (depending on release)
- The firmware version uses this format:
  - Major revision (1 Byte)
  - Minor Revision (1 Byte)
  - Current build number (2 bytes)
- Read-only

14.3.3 Hardware Version

- Returns the current hardware version of the reader
- Parameter address: 0x0002
- Length (bytes): 4
- Default value 0xXXXXXXXX (depending on release)
- The hardware version uses the following format:
  - Major revision (1 Byte)
  - Minor Revision (1 Byte)
  - Current build number (2 bytes)
- Read-only

14.3.4 Product Code

- Returns the SkyeTek product code identifier. (Each SkyeTek product has a unique product code.)
- Parameter address: 0x0003
- Length (bytes): 2

- Default value 0x0009
- Read-only

14.3.5 Reader ID

- Specifies the Reader ID, which is a reader-specific identifier. It lets the reader execute and respond only to those commands intended for it. The reader determines if the Reader ID in the request matches its internal Reader ID. If the ID does not match, the reader does not respond.
- Parameter address: 0x0004
- Length (bytes): 4
- Default value: 0xFFFFFFFF (depending on release)
- Select the Reader ID functionality by specifying the RID flag in the request. This setting lets you use multiple readers on the same bus or networked together.
- Read/write

NOTE – Changing the reader ID from the factory default of FFFFFFFF to any other value disables Loop Mode, which is used for read range demonstrations. See "Selecting Any Supported Tag Continuously (Loop Mode)" for an example of using Loop Mode.

14.3.6 Reader Name

- Identifies a reader with a 32-byte user-defined name.
- Parameter address: 0x0005
- Length (bytes): 32
- Default value: SkyeModule M9 (in hex)
- Read/write

14.3.7 Host Interface Type

- Identifies the type of host interface for the reader to use.
- Parameter address: 0x0006
- Length (bytes): 1
- Default value: 0x00 (TTL)
- Valid host interface values are:
  - 0x00 – TTL
  - 0x01 – TTL Serial
  - 0x03 – SPI
  - 0x04 – I^2C
  - 0x06 – USB
- Any other values are not valid and are ignored.
- Read/write

NOTE – SkyeModule M9s shipped with SkyeTek Development Kits are preset to use USB communications.

14.3.8 Host Interface Baud Rate

- Sets the baud rate of the host interface.
- Parameter address: 0x0007
- Length (bytes): 1
- Default value: 0x02 (38,400)
- Works for the TTL Serial host interface only
- Valid baud rate values are:
  - 0x01 – 19,200
  - 0x02 – 38,400
  - 0x03 – 57,600
  - 0x04 – 115,200
  - Specifying any other value sets the baud rate to 9,600
- Write-only

NOTE – For firmware updates, you may need to limit the baud rate to 38,400.

14.3.9 User Port Direction

- Sets the direction of the GPIO pins of the reader.
- Parameter address: 0x008
- Length (bytes): 1
- Default value 0x00
- A one in the bit position indicates that the corresponding GPIO pin is an input.
- A zero in the bit position indicates that the corresponding GPIO pin is an output.
- The enable bit (bit 7) must be set for the settings to take effect.
- Bits correspond to the pins as follows:
    - BIT0 – GPIO 0
    - BIT1 – GPIO 1
    - BIT2 – GPIO 2
    - BIT3 – GPIO 3 (not available for user I/O)
    - BIT4 – GPIO 4
    - BIT5 – GPIO 5
    - BIT6 – GPIO 6
    - BIT7 – enable
- Read/write

14.3.10 User Port Value

- Sets the value of the GPIO pins of the reader.
- Parameter address: 0x0009
- Length (bytes): 1
- Default value: 0x00
- A one in the bit position indicates that the corresponding GPIO pin is logic high.
- A zero in the bit position indicates that the corresponding GPIO pin is logic low.
- The enable bit (bit 7) must be set for the settings to take effect.
- Bits correspond to the pins as follows:
    - BIT0 – GPIO 0
    - BIT1 – GPIO 1
    - BIT2 – GPIO 2
    - BIT3 – GPIO 3 (not available for user I/O)
    - BIT4 – GPIO 4
    - BIT5 – GPIO 5
    - BIT6 – GPIO 6
    - BIT7 – enable
- Read/write

14.3.11 MUX Control

- Controls a SkyePlus multiplexer. See the *SkyePlus Multiplexer Reference Guide* for complete information about using this parameter.
- Parameter address: 0x000A
- Length (bytes): 1
- Default value: 0x00
- Read/write

14.3.12 Operating Mode

- Puts the reader into sleep mode.
- Parameter address: 0x000C
- Length (bytes): 1
- Default value 0x00
- Writing a value 0x01 to this parameter puts the reader into sleep mode.
- Sending any command on any interface wakes the reader from sleep mode.
- Read/write

NOTE – Sleep mode is not supported when the SkyeModule reader uses the USB host interface.

14.3.13 Command Retry

- Specifies the number of times a tag command is executed internally in the reader before responding with a failure response.
- Applies only to tag-specific SkyeTek Protocol commands.
- One-byte value.
- Parameter address: 0x0011
- Length (bytes): 1
- Default value: 0x05
- Can be set by the host.
- Valid range of values is 0-255 (0x00-0xFF).
- The command is repeated internally "n" number of times, where n is the value specified by the host, unless there is a successful response. When a successful response occurs, the reader stops repeating the command and sends a success response back to the host.
- Read/write

NOTE – Increasing the value for this parameter increases the time that the reader takes before it sends a failure message when a failure occurs. To avoid unnecessary delays, be sure to determine the optimal number of retries for your particular use.

14.3.14 Power Level

- Configures the power level for the reader.
- Parameter address: 0x0012
- Length (bytes): 1

- Default value: 0xDC (27 dBm)
- Power level is set in steps of 0.1 dB from 10 dBm to 27 dBm.
- Power levels are written in hex corresponding to a decimal value between 50 and 220 (see Table 14-10).
- Use the following equation to calculate the value to be written for a desired power level:

  (Desired power in dBm – 5)/0.1 = decimal value to write to system parameter

Table 14-10: Common Power Values

Power (dBm)	SkyeTek Decimal Value	Hex Equivalent
10	50	0x32
12	70	0x46
15	100	0x64
17	120	0x78
20	150	0x96
21	160	0xA0
24	190	0xBE
27	220	0xDC

- Read/write

NOTE – SkyeModule M9s shipped with the SkyeTek Development Kit are preset to a power level of 27 dBm.

14.3.15 Current Frequency

- Sets the current frequency with which the reader singulates a tag.
- Parameter address: 0x0030
- Length (bytes): 4
- Default value: 0x3689CAC0 (915 MHz)
- This parameter is a 4-byte hex equivalent of the frequency. Table 14-11 shows hex values for commonly used frequencies.
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

14.3.16 Start Frequency

- Sets the low end of the frequency range under which the reader operates.
- Parameter address: 0x0031
- Length (bytes): 4
- Default value: 0x35C80160 (902.3 MHz)
- This parameter is written with a 4-byte hex equivalent of the frequency desired. See Table 14-11 for commonly used frequencies and their hex values.
- To enable frequency hopping, set a frequency range using the Start Frequency and Stop Frequency system parameters. Then use the Frequency Hopping Sequence parameter to set the frequency hopping mode (either sequential or pseudo-random). To disable frequency hopping, set the Start Frequency and Stop Frequency parameter to the same value.
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

14.3.17 Stop Frequency

- Sets the high end of the frequency range under which the reader operates.
- The parameter address: 0x0032
- Length (bytes): 4
- Default value: 0x374B9420 (927.7 MHz)
- This parameter is written with a 4-byte hex equivalent of the frequency desired. See table 14-11 for commonly used frequencies and their hex values.
- To enable frequency hopping, set a frequency range using the Start Frequency and Stop Frequency system parameters. Then use the Frequency Hopping Sequence parameter to set the frequency hopping mode (either sequential or pseudo-random). To disable frequency hopping, set the Start Frequency and Stop Frequency parameter to the same value.
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

Table 14-11: Commonly Used Frequencies

Frequency (MHz)	Hex Equivalent	Description
865.7	0x339988A0	EU Start
866.7	0x33A8CAE0	EU Center
867.9	0x33BB1A60	EU Stop
902.3	0x35C80160	NA Start
915.0	0x3689CAC0	NA Center
927.7	0x374B9420	NA Stop

14.3.18 Hop Channel Spacing

- Controls the hop channel spacing when frequency hopping is enabled.
- Parameter address: 0x0034
- Length (bytes): 4
- Default value: 0x00030D40 (200 KHz)
- To enable frequency hopping, set a frequency range using the Start Frequency and Stop Frequency system parameters. Then use the Frequency Hopping Sequence parameter to set the frequency hopping mode (either sequential or pseudo-random). To disable frequency hopping, set the Start Frequency and Stop Frequency parameter to the same value.
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

14.3.19 Frequency Hopping Sequence

- Switches the hopping sequence between pseudo-random and sequential mode.
- Parameter address: 0x0035
- Length (bytes): 1
- Default value: 0x01 (pseudo-random)
- To set the reader to sequential hopping mode, write 0x00 to this parameter.
- To reset the reader to pseudo-random hopping sequence, write 0x01 to this parameter.
- To enable frequency hopping, set a frequency range using the Start Frequency and Stop Frequency system parameters. Then use the Frequency Hopping Sequence parameter to set the frequency hopping mode (either sequential or pseudo-random). To disable frequency hopping, set the Start Frequency and Stop Frequency parameter to the same value.
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

14.3.20 Modulation Depth

- Sets the modulation depth of the reader-to-tag transmissions, as calculated by the equation: $(V_{max} - V_{min})/V_{max}$
- Parameter address: 0x0036
- Length (bytes): 1
- Default value: 100%
- The values for the modulation depths are in steps of 10, ranging from 10% to 100%.
- The values are the hex equivalent of the corresponding modulation depth.

Table 14-12: Common Modulation Depth Values

Modulation Depth (%)	Hex Equivalent
30	0x1E
80	0x50
90	0x5A
100	0x64

- The modulation depth is calculated by the reader using the equation: $(V_{MAX} - V_{MIN})/V_{MAX}$ where V_{MAX} is the RF voltage when transmit power is maximum and V_{MIN} is the RF voltage when the transmit power is minimum. (For 100% modulation depth, V_{MIN} equals zero.)
- See the manufacturer's tag data sheet for the modulation depth supported for the tags in your application.
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

14.3.21 Regulatory Mode

- Enables pulse shaping, listen before talk, and timing modifications for regions with special regulatory requirements, such as Europe.
- Parameter address: 0x0037
- Length (bytes): 1
- Default value 0x00 (no pulse shaping)
- Read/write

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

Table 14-13: Regulatory Mode Values

Mode	Hex Value
No pulse shaping—Australia/New Zealand, Hong Kong, North America, Singapore, Taiwan	0x00
ETSI/Europe	0x01
Not used	0x02
Not used	0x03
Korea	0x04

14.3.22 LBT Antenna Gain

- Controls the sensitivity of the listen-before-talk receiver.
- Setting this parameter can cancel out the gain from an external antenna when listening for other transmitting signals.
- Use this parameter only with European (ETSI) regional settings when the LBT radio is on.
- Do not use this parameter with FCC regional settings.
- Parameter address: 0x0038
- Length (bytes): 1
- Default value: 0x00 (no LBT antenna gain)
- Read/write
- Possible values are 0-255 (0x00 to 0xFF), using a signed 8-bit value that represents the range of -127 dBm to +128 dBm. The values 0x00 to 0x80 represent the zero to +128 dBm range, and the values 0x81 to 0xFF represent the -127 to -1 dBm range (see table 14-14)

NOTE – See "Recommended Radio Settings for Regional Compliance" on page 34 to view compliance information and recommended reader settings.

Table 14-14: Examples of LBT Antenna Gain Adjustment Values

Hex Value	Antenna Gain (dBm)
0x81	-127
0x82	-126
. . .	. . .
0xFE	-2
0xFF	-1
0x00	0
0x01	+1
0x02	+2
. . .	. . .
0x7F	+127
0x80	+128