13.56MHz RFID Reader/Writer

ISO-15693   ISO-14443
ISO-18000   EPC™

PRODUCT REFERENCE GUIDE

SkyeRead™ M1-Mini

SkyeTek
RFID ENGINEERING

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	These devices have limited built-in ESD protection

Life Support Policy and Use in Safety Critical Applications

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1 Product Overview

1.1 General Description

The SkyeRead Mini is the smallest multi-protocol RFID read/write module in the market.

Built to mate directly with the Xbow mica2dot miniature wireless sensor boards (http://www.xbow.com), the SkyeRead Mini can be used as a completely self-sufficient standalone device. The extremely low profile and low power consumption of the mini makes it a suitable candidate for space constrained, power sensitive applications. An internal LDO regulator provides a low noise 3V system voltage.

The SkyeTek mini offers multiple antenna connection options including an onboard antenna, the ability to hook up a custom external antenna, and pads for connection to the SkyeTek Flex antennas using anisotropic tapes.
The mini shares the same protocol stack as the M1 and therefore it follows the M1 on all its firmware features.

1.2 Features

- Tiny Footprint – 2.54 mm (1 inch) diameter
- Ultra low profile (2.8 mm)
- Multi-protocol HF RFID Tag support including ISO15693, ISO14443 and others
- Mates directly with Crossbow's Mica2Dot™ for mesh network applications
- Onboard multipurpose tactile switches
- Supports SkyeTek protocol version 2.0
- Flash Upgradable in the field for product updates and future tag protocols
- Standard Host Interface options include TTL, SPI, and I^{2}C
- Networkable with up to 255 Reader addresses on a single network (i.e. RS-485)
- On-board antenna provides up to 2 inches (90mm) range with credit card size tags
- External antenna option with 50 Ohms output
- Low voltage 3V operation for Li-Ion battery-powered and handheld devices
- Low current – 50mA active mode, 10ma idle mode, 60uA standby mode
- Enhanced Noise Filtering for better RF performance
- Reads and writes multiple tags simultaneously
- Easy Connection to Flex antenna
- 180 mW maximum output power (without external amplifier)

2 Mechanical Characteristics

2.1 Dimensions

Figure 1 Dimensions of the M1-mini

Table 1 M1-mini Pin Locations

Pin	Name		x loc	y loc		Pin	Name		x loc	y loc
1	GND		-0.290	0.315		8	SDO		0.120	-0.420
2	ANT		-0.370	0.230		9	RB6		0.255	-0.375
3	RB7		-0.420	-0.120		10	SW1		0.420	0.120
4	RST/		-0.335	-0.275		11	SW2		0.370	0.230
5	RSSI		-0.225	-0.375		12	Vin		0.100	0.420
6	TX_TTL		-0.120	-0.420		13	GND		0.000	0.430
7	RX_TTL		0.000	-0.430		14	Vout		-0.100	0.420
						15	INT			

3 Electrical Characteristics

3.1 Absolute Maximum Ratings[†]

Input Voltage Range ………………………………………..... −0.3V to 5.5V
Continuous total current consumption………………………....…..……..…200mA
GPIO sink current (each)…………………………………………………..25mA
GPIO source current (each)…………………………………………….....15mA
Storage Temperature ………………………..……………………... −20°C to +85°C
Operating Temperature Range……………………………………….. 0°C to -70°C

† Stresses beyond these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These maximum stress ratings do not imply maximum operating conditions.

3.2 Operating Conditions

Input voltage………………….................… ~3.2V to 5.5V (1 Li-Ion, 2 AA or 5VDC typical)
Supply Current ……………………..40 mA scanning, 10mA idle, 50uA sleep
GPIO sink current (each)…………………………..15mA
GPIO source current (each)……………………..15mA
Logic 0 threshold ……..……………..1.0V
Logic 1 threshold ……………………..2.0V

4 RF Characteristics

4.1 Operating Conditions

RF Operating Frequency ………………................… 13.56MHz +/- 7kHz (nominal)
RF Output Power ……………………..180mW (maximum)
GPIO sink current (each)…………………………..(50 + j0) ohms at 13.56MHz
GPIO source current (each)……………………..30 ppm

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5 Power and Host Interface Connections

5.1 Power

The SkyeRead M1-mini uses an on-board linear voltage regulator (LDO) that generates $V_{OUT} = 3.0V$ at pin 14, from supply voltage input to pin 12 within $3.2V \leq V_{IN} \leq 5.5V$.
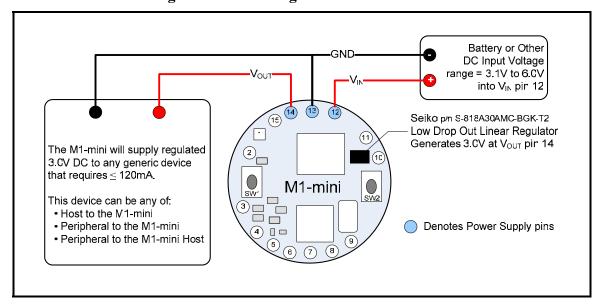
Figure 2 Connecting Power to the M1-mini

5.2 TTL

TTL signal levels of 0 to 3V are used to interface the M1-mini to a host device. A simple 3 wire serial connection is provided. The M1-mini does not support RTS and CTS handshaking signals therefore Hardware Flow Control is not available.

The M1-mini uses a PIC microcontroller whose UART's Rx and Tx pins connect directly to pins 6 and 7. Therefore TVS and ESD protection of M1-mini pins 6 and 7 are provided by the PIC microcontroller.

There are no pull-up resistors on the Rx and Tx lines internal to the M1-mini. External pull-up resistors (to 3V power supply) may be required for some embedded host devices.

Figure 3 TTL Connection: M1-mini to MCU

The serial baud rate of the M1-mini is software selectable, user configurable, and self-adaptive.

Table 2 Serial Data Rates (Baud Rates)

9600 bits/sec N,8,1* (default)	+/- 0.3% accuracy
19200 bits/sec N,8,1*	+/- 0.3% accuracy
38400 bits/sec N,8,1*	+/- 0.3% accuracy
57600 bits/sec N,8,1*	+/- 1.9% accuracy

- N,8,1 means No Parity Bit, 8 Data Bits, 1 Stop Bit

5.3 SPI

The M1-mini allows use of a standard Serial Peripheral Interface (SPI) for connecting to an embedded microcontroller unit (MCU). The M1-mini must have the proper firmware to enable SPI operation. The M1-mini operates as an SPI slave device; the clock is always controlled by the host system. Three wires are used for the SPI interface: SCK, SDI, and SDO. SDO is the serial data out (from the M1-mini to the host system). SDI is the serial data in (to the M1-mini from the host system). SCK is the serial clock (controlled by the host system). The SkyeRead M1-mini is set so that data is latched into and sent on the positive edge of the SCK signal. Data is sent from the M1-mini on the SDO signal at the same time that it is received by the M1-mini on the SDI signal. The

data is sent and received MSB first. Data exchange between the host and the M1-mini is defined according to the SkyeTek Protocol, Binary Mode.
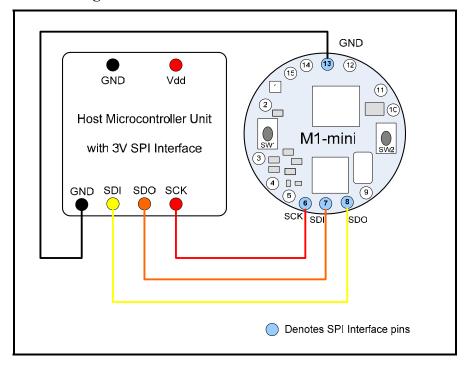
Figure 4 SPI Connection: M1-mini to MCU

The SPI provides the highest communication speed between the M1-mini and the host system, up to 3MHz data rate. Care should be taken to minimize the distance between M1-mini and host when using the high speed SPI communication (above 400kHz).

Figure 5 Details of the SPI Communication Link

Maximum Bit rate is 100KHz. Master should wait for the M1 to finish executing the command before clocking the response. A list of M1 command timings is provided above in this reference guide. It is recommended to add about 20% more time to be on the safer side. The Master should wait 100us or more between each byte. Commands should be sent to the M1 at least 6ms apart. The Clock (SCK) should be Low in the Idle condition i.e. when no data is being sent or received. The Master should send the data on MOSI at the rising edge of the clock period while sending. The Master should sample the data on MISO at the falling middle of the clock period while receiving.

5.4   I²C

The M1 supports standard I^{2}C for connecting to an embedded microcontroller unit (MCU). The M1-mini operates in I^{2}C master mode. Standard 2-wire connection is used with SCL and SDA. SCL is the bi-directional system clock line. SDA is the bi-directional serial data line. The M1-mini must have proper firmware to enable I^{2}C operation. I^{2}C fast mode is supported to provide a 400kHz data rate. The data is sent and received MSB first. Data exchange between the host and the M1-mini is defined according to the SkyeTek Protocol, Binary Mode.
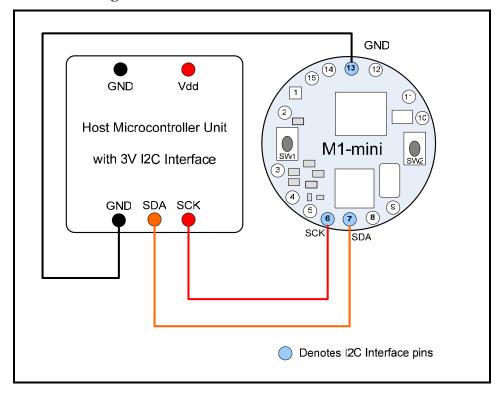
Figure 6 I²C Connection: M1-mini to MCU

6 User Interface

The M1-mini has three (3) GPIO pins and two (2) Switch Output pins for interacting with a user..

6.1 GPIO

Pins 3, 8 and 9 can be independently programmed as Inputs or Outputs. See the sections below on "Software Communications" and "System Parameters" for information on how to configure these pins as inputs or outputs, for how to write the output pins, and for how to read them as input pins. These GPIO pins can be used to drive LEDs, beepers and other external input and output peripherals.
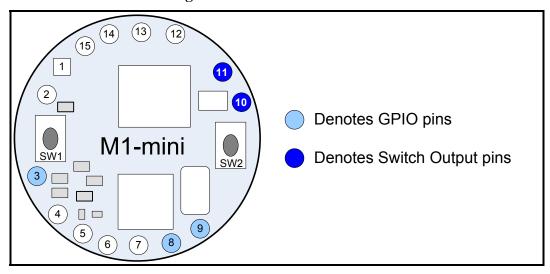
Figure 7 GPIO of the M1-mini

6.2 SW1 and SW2

Pins 10 and 11 are always Outputs. These pins are normally high (3V). When the either switch is pressed, its corresponding pin pulls low (GND).

7 Operating Modes

The M1-mini has two (2) operating modes, Command Mode and Application Mode.

7.1 Command Mode

In Command Mode the M1-mini operates under software control of a host via the SkyeTek Protocol.

7.2 Application Mode (FUTURE RELEASE)

In Application Mode the M1-mini operates under software control that resides within the M1-mini. Host communication via the SkyeTek Protocol is possible but not required. Third party application developers write dedicated code that can be loaded into the M1-mini. The RFID OS is the software layer on which the reader application code is loaded and executed. See section on RFID OS.

8 Firmware Upgrades

The M1-mini has a built in Bootloader that allows firmware to be field upgradeable through a software interface (SkyeTek Demo Software, or Separate Firmware Upgrade Utility). Firmware files will be of the type *.shf.

The Bootloader operates independently of the hardware host interface. The Bootloader gets the firmware upgrade data from a host and communicates with the BIOS via the RFID OS to perform the upgrade the FLASH memory.

Reader application developers can also upgrade the firmware.

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9 Software Communications – SkyeTek Protocol

SkyeRead M1-mini communicates with a host controller according to the SkyeTek Protocol regardless of host interface type. The following sections of this document contain examples of the REQUEST and RESPONSE exchange between a host and the M1-mini. Refer to the *SkyeTek Protocol* document for detailed protocol information.

The *SkyeTek Protocol Command Builder* software is a tool to show the software developer exactly how a REQUEST is sent to the M1-MINI and the exact RESPONSE from the M1-MINI.

The *SkyeWare RFID Demo Software* is built on the SkyeTek Protocol and is used to create presentations that demonstrate the features, functions and benefits of RFID technology.

The SkyeRead M1-MINI has a common API that is supported over a wide variety of platforms and operating systems including:

- Windows 98
- Windows 2000
- Windows XP
- Windows CE
- Unix
- Linux

The device drivers and software libraries are available in C, Visual Basic, and Java.

A DLL is available for the Windows PC Operating Systems.

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10 System Parameters

The SkyeRead M1-mini has 16 bytes of EEPROM memory for storing System Parameters.

Figure 8 – System Parameter Memory Space

M1-mini System Parameters					
Name	**Parameter Address**	**Parameter Value**	**Specifies**	**READ**	**WRITE**
SERIAL NUMBER	0x00	0x00000000-0xFFFFFFFF	4 bytes unique hardware serial number	√	factory
FIRMWARE VERSION	0x01	0x0000-0xFFFF	2 bytes for firmware version	√	Factory or field upgrade
READER ID (RID)	0x02	0x00-0xFF	Reader Network ID	√	√
BAUD RATE	0x03	0x00 0x01 0x02 0x03 0x04 0x05-0xFF	9600 19200 38400 57600 115200 N/A		√
OPERATING MODE	0x04	0x00 0x01-0xFF	Sleep active		√
Reserved				no	no

11 RFID Operation

11.1 Read Range

Read range depends on the RFID Tag IC, the RFID tag antenna, the RFID reader and reader antenna, in addition to the system in which the

RFID read/write distance is typically greater than or equal to 2" for a Texas Instruments Tag-It HF-I ISO15693 RFID inlay with antenna dimensions 22.5mm x 38mm (TI p/n RI-I03-112A).

11.2 Antenna Configurations

By default the internal antenna of the mini is connected during production time. In the event that the user wants to connect an external antenna between the INT and ANT pins of the mini the following table needs to consulted
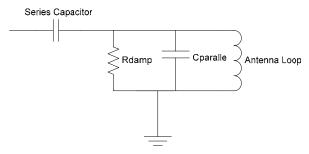
Figure 9 Mini internal antenna configuration

Internal Ant Active?	Custom External Antenna?	Remove	Populate	Short
N	N	Cseries,Rseries, Cparallel,Rdamp	-	-
N	Y	Cseries Cparallel,Rdamp	-	Rseries
N	N	Cseries,Cparallel, Rdamp		
N	Y	Cseries,Cparallel, Rdamp		Rseries
Y	N	Cseries	Cparallel,Rdamp	Rseries,
Y	Y	Cseries	Cparallel,Rdamp,	Rseries*
Y	N	Cseries	Cparallel,Rdamp,	Rseries
Y	Y	Cseries	Cparallel,Rdamp,	Rseries

In the default Mini configuration
Rseries= shorted (connects the transmit and the receive path together)
Cseries=220pF (This is essentially used to match the internal antenna to the output of the TI chip)
Cparallel = 2000pf (This is the tuning cap value for the internal antenna)
Rdamp=unpopulated (The Rdamp can be used to change the Q of the antenna circuit)

Figure 10 Component positions on the mini

.

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11.3 Tag Compatibility

Tagnostic means tag-agnostic. SkyeTek RFID reader technology provides multi-protocol support for most industry standard 13.56MHz HF RFID tag protocols including ISO and EPC.

Table 3 Tag Compatibility chart

ISO-15693   (-2 and -3 compliant)

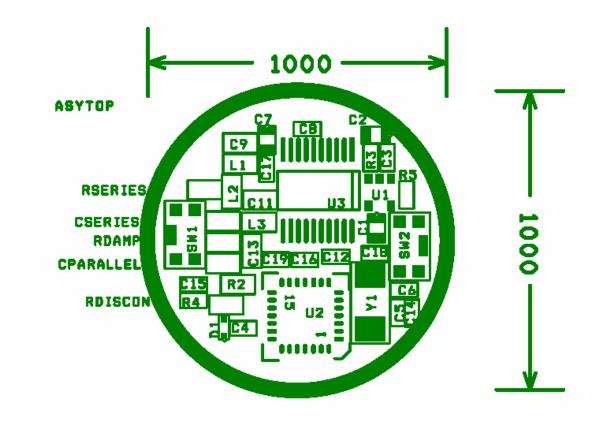| Manufacturer	Product	Memory (bits)	Anti-collision	Read	Write
Texas Instruments	Tag-It HF-I	2048	*yes*	*yes*	*yes*
Philips	I·Code SLI (SL2)	1024	*yes*	*yes*	*yes*
Infineon	my-d SRF55V02P	2.5k	*yes*	*yes*	*yes*
	my-d SRF55V02S	2.5k	*yes*	*id only*	*no*
	my-d SRF55V10P	10k	*yes*	*yes*	*yes*
	my-d SRF55V10S	10k	*yes*	*id only*	*no*
ST Microelectronics	LR512	512	*yes*	*yes*	*yes*

ISO-14443   (Type A)

Manufacturer	Product	Memory (bits)	Anti-collision	Read	Write
Philips	Mifare 4k	4096	*no*	*id only*	*no*
Philips	Mifare 1k	1024	*no*	*id only*	*no*
Philips	Mifare Ultra-Lite	512	*no*	*yes*	*yes*

Proprietary

Manufacturer	Product	Memory (bits)	Anti-collision	Read	Write
Texas Instruments	Tag-It HF	256	*yes*	*yes*	*yes*
Philips	I·Code1 (SL1)	1024	*yes*	*yes*	*yes*
TagSys	GemWave C210	96	*yes*	*yes*	*no*
	GemWave C220	2k	-	-	-
	GemWave C240	192	-	-	-
Inside Contactless (ISO-15693 –2)	PicoTag 2K	2k	*yes*	*yes*	*yes*
	PicoTag 2KS	2k	*yes*	*id only*	*no*
	PicoTag 16K	16k	*yes*	*yes*	*yes*
	PicoTag 16KS	16k	*yes*	*id only*	*no*

Grey = scheduled for upcoming release.

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12 Timing

RESPONSE. Timings depend on the baud rate. Exact transaction times can change depending on the firmware version. These timings are for firmware version 001E.

In general,

$$T_{COMMAND} = T_{REQUEST}(n) + T_{EXECUTE} + T_{RESPONSE}(m),$$

$T_{REQUEST}$ is a function of the number of REQUEST bytes, n

$T_{RESPONSE}$ is a function of the number of RESPONSE bytes, m

Table 4 Timing Parameters

Param	Tag Command	TAG_TYPE		Time for One Block (ms)		Time for Two Block (ms)	
				Pass	Fail	Pass	Fail
TST	SELECT_TAG	Proprietary	Tag-It HF	45.2	67.6		
			I·Code SL1	24.6	80.0		
			PicoTag	18.6	63.2		
			GemWaveC210	7.68	46.8		
			GemWaveC270	XXX	XXX		
		ISO 15693	Tag-It HF-I	36.6	68.4		
			I·Code SLI	20.6	68.4		
			My-d	40.8	68.4		
			LR 512	12.5	68.4		
		ISO 14443	Mifare Standard	XXX	XXX		
			Mifare Ultralight	XXX	XXX		
TRT$_{TID}$	READ_TAG (with TID)	Proprietary	Tag-It HF	14.9	11.5	29.2	11.5
			I·Code SL1	68.4	80.4	69.2	80.4
			PicoTag	XXX	XXX	XXX	XXX
			GemWaveC210	XXX	XXX	XXX	XXX
			GemWaveC270	XXX	XXX	XXX	XXX
		ISO 15693	Tag-It HF-I	9.56	10.2	11.2	10.2
			I·Code SLI	9.56	10.2	11.3	10.2
			My-d	11.8	10.2	23.4	10.2
			LR 512	9.6	10.2	18.8	10.2
		ISO 14443	Mifare Standard	XXX	XXX	XXX	XXX
			Mifare Ultralight	XXX	XXX	XXX	XXX

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TRT$_{SS}$	READ_TAG (Selected-State)	Proprietary	Tag-It HF I·Code SL1 PicoTag GemWaveC210 GemWaveC270	14.8 47.2 XXX XXX XXX	11.5 57.2 XXX XXX XXX	29.4 47.2 XXX XXX XXX	11.5 57.2 XXX XXX XXX
		ISO 15693	Tag-It HF-I I·Code SLI My-d LR 512	7.12 7.2 9.3 7.16	7.1 7.7 9.2 7.2	8.8 8.8 18.5 13.9	7.1 7.7 9.2 7.2
		ISO 14443	MifareStandard Mifare Ultralight	XXX XXX	XXX XXX	XXX XXX	XXX XXX
TWT$_{TID}$	WRITE_TAG (with TID)	Proprietary	Tag-It HF I·Code SL1 PicoTag GemWaveC210 GemWaveC270	29.2 102 XXX XXX XXX	29.8 80 XXX XXX XXX	58 160 XXX XXX XXX	29.6 80 XXX XXX XXX
		ISO 15693	Tag-It HF-I I·Code SLI My-d LR 512	20.8 13 14.7 13.2	20.8 12.9 14.8 13.2	41.4 25.6 29.4 26.2	20.9 13 14.8 13.2
		ISO 14443	Mifare Standard Mifare Ultralight	XXX XXX	XXX XXX	XXX XXX	XXX XXX
TWT$_{SS}$	WRITE_TAG (Selected-State)	Proprietary	Tag-It HF I·Code SL1 PicoTag GemWaveC210 GemWaveC270	29 83.6 XXX XXX XXX	29.2 56.8 XXX XXX XXX	57.6 148 XXX XXX XXX	29.2 56.8 XXX XXX XXX
		ISO 15693	Tag-It HF-I I·Code SLI My-d LR 512	18.5 13 n/a n/a	18.6 13 n/a n/a	36.4 25.4 n/a n/a	18.6 13 n/a n/a
		ISO 14443	Mifare Standard Mifare Ultralight	XXX XXX	XXX XXX	XXX XXX	XXX XXX

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TLT	LOCK_TAG	Proprietary	Tag-It HF I·Code SL1 PicoTag GemWaveC210 GemWaveC270	24.8 146 XXX XXX XXX	12.3 69.6 XXX XXX XXX	
		ISO 15693	Tag-It HF-I I·Code SLI My-d LR 512	13.4 12.9 9.7 XXX	13.4 12.9 9.7 XXX	
		ISO 14443	Mifare Standard Mifare Ultralight	XXX XXX	XXX XXX	

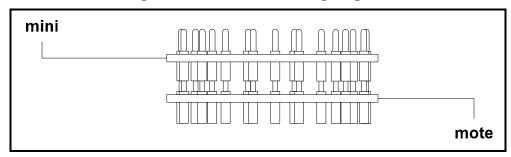| TWU	Time for Wake Up from SLEEP		<100ms	
TPU	Time for Power Up to Idle		<100ms	
TFU	Time to Update Firmware		<100 sec	

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13 Interfacing the M1-mini with the Mica2Dot

Figure 11 – mini mote interface specification

SkyeTek M1-mini							Crossbow Mica2Dot

Pin	Name	x loc	y loc	Pin	Name
1	GND	-0.290	0.315	TP1	GND
2	ANT	-0.370	0.230	TP2	ADC7
		-0.420	0.120	TP3	ADC6
		-0.430	0.000	TP4	ADC5
3	RB7	-0.420	-0.120	TP5	ADC4
4	RST/	-0.335	-0.275	TP13	ADC3
5	RSSI	-0.225	-0.375	TP14	ADC2
6	TX_TTL SCK, SCL	-0.120	-0.420	TP10	UART_RXD
7	RX_TTL SDI, SDA	0.000	-0.430	TP9	UART_TXD
8	SDO	0.120	-0.420	TP21	THERM_PWR
9	RB6	0.255	-0.375	TP15	PWM1B
		0.335	-0.275	TP11	RESETN
		0.420	-0.120	TP18	GND
		0.430	0.000	TP17	ANTENNA
10	SW1	0.420	0.120	TP19	INT0
11	SW2	0.370	0.230	TP20	INT1
		0.290	0.315	TP12	SPI_CLK
12	Vin	0.100	0.420	TP8	PW0
13	GND	0.000	0.430	TP7	PW1
14	Vout	-0.100	0.420	TP6	VCC
15	INT				

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Figure 12 –mini mote mating diagram

14 Product Selection

There is only one version of the M1-mini. Order the "SkyeRead M1-mini".

The product hardware revision (e.g. v3) is printed on PCB layout silk screen layer on the back side (antenna side) of the M1-mini PCB.

The firmware version is determined by a factory setting. The firmware version can change in the field only via a SkyeTek field upgrade.

The M1-mini has a unique factory-programmed serial number that is read-only and permanent.