SMARTMESH-XT™ M1030-2

900 MHz Wireless Analog / Digital / Serial Mote

Product Description

The SmartMesh-XT™ M1030-2 embedded wireless mote uses Time Synchronized Mesh Protocol (TSMP) to enable low-power wireless sensors and actuators with highly reliable wireless mesh networking. The M1030-2 is tailored for use in battery- and line-powered wireless devices for applications that demand proven performance, scalability, and reliability.

The M1030-2 uses a 900 MHz radio to achieve more than 200-meter communication distance outdoors, while consuming down to 30 µA in a typical network deployment. The combination of extremely high reliability and low power consumption enables applications that require very low installation cost and low-maintenance, long-term deployments.

The standard serial and discrete input/output interfaces of the M1030-2 give it flexibility to be used in a wide variety of different applications, from industrial process control to security, to lighting. When integrated into a product, the M1030-2 acts like a network interface card (NIC)—it takes a data packet and makes sure that it successfully traverses the network. By isolating the wireless mesh networking protocols from the user, the M1030-2 simplifies the development process and reduces development risk.

Key Features

Reliable Networking

- Uses Time Synchronized Mesh Protocol (TSMP) for high reliability (>99.9% typical network reliability)
- Frequency hopping for interference rejection
- Mesh networking for built-in redundancy
- Every M1030-2 acts as both an endpoint and a router, increasing network reliability: “mesh-to-the-edge™”
- Automatic self-organizing mesh is built in

Low Power Consumption

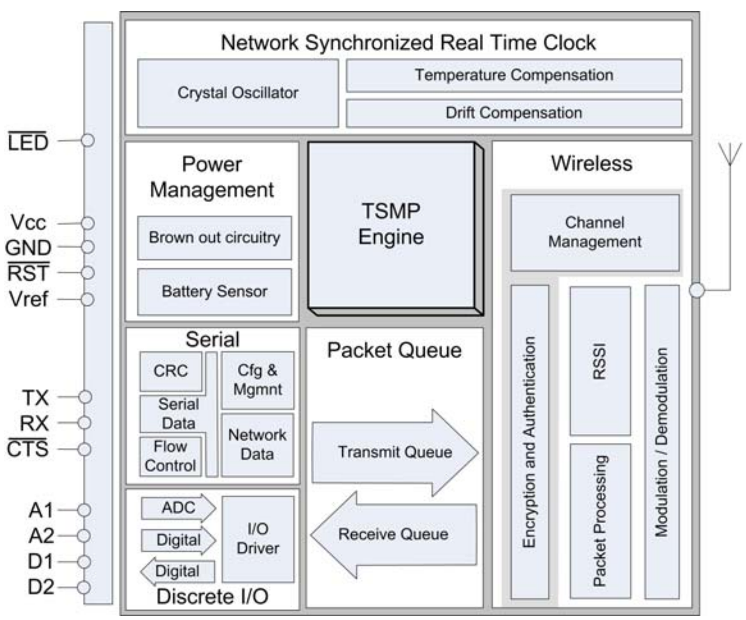
- Ultra-low power components for long battery life
- Network-wide coordination for efficient power usage
- Down to 30 µA typical power consumption

Efficient Radio

- 2.5 mW (+4 dBm) RF output power
- –88 dBm receiver sensitivity
- Outdoor range >200 m typical

Predictable Integration

- Standard High-level Data Link Control (HDLC) serial interface with flow control in the receive direction
- Discrete analog inputs and digital I/O for continuous or event-based monitoring
- FCC modular certification
- Industrial temperature range –40 °C to +85 °C
- Supports socket or solder assembly
- Rugged design for Class I Division I environments



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1.0 Absolute Maximum Ratings

The absolute maximum ratings shown below should under no circumstances be violated. Permanent damage to the device may be caused by exceeding one or more of these parameters.

Table 1 Absolute Maximum Ratings

Parameter	Min	Typ	Max	Units	Comments
Supply voltage (Vcc to GND)	–0.3		3.6	V	
Voltage on digital I/O pin	–0.3		V_{CC} + 0.3 up to 3.6	V	
Input RF level			10	dBm	Input power at antenna connector
Storage temperature range	–45		+85	°C	
Lead temperature			+230	°C	For 10 seconds
VSWR of antenna			3:1		
* All voltages are referenced to GND					

The M1030-2 can withstand an electrostatic discharge of up to 2 kV Human Body Model (HBM) or 200 V Machine Model (MM) applied to any header pin, except the antenna connector. The antenna input can withstand a discharge of 50 V.

2.0 Normal Operating Conditions

Table 2 Normal Operating Conditions

Parameter	Min	Typ	Max	Units	Comments
Operational supply voltage range (between Vcc and GND)	2.7		3.3	V	Including noise and load regulation
Voltage on analog input pins	0		1.5	V	
Voltage supply noise			10	mVp-p	50 Hz–2 GHz
Peak current			40 18	mA mA	Tx, 14 ms maximum Rx, searching for network, 60 minutes, maximum
Average current		30		µA	Assuming 80-byte packets, 1 per minute, data only mote, 3 V, 25 °C
Storage and operating temperatures	–40		+85	°C	
Maximum allowed temperature ramp			8	°C/min	–40 °C to +85 °C

Unless otherwise noted, Table 3 assumes Vcc is 3.0 V.

Table 3 Current Consumption

Parameter	Min	Typ	Max	Units	Comments
Transmit		28	40	mA	
Receive		14	18	mA	
Sleep		8	18	µA	

3.0 Electrical Specifications

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Table 4 Device Load

Parameter	Min	Typ	Max	Units	Comments
Input capacitance (clamped)			24.2	µF	
Input capacitance (unclamped)			15.1	µF	

Unless otherwise noted, Vcc is 3.0 V and temperature is –40 °C to +85 °C.

Table 5 Digital I/O

Digital signal	Min	Typ	Max	Units	Comments
V_{IH} (logical high input)	0.8 x Vcc	Vcc	Vcc + 0.3	V	
V_{IL} (logical low input)	GND – 0.3	GND	GND + 0.6	V	
V_{OH} (logical high output)	0.7 x Vcc	Vcc	Vcc	V	
V_{OL} (logical low output)	GND	GND	0.25 x Vcc	V	
Digital current*					
Output source (single pin)		0.6		mA	V_{OH} = 2.3 V, 25 °C
Output sink (single pin)		0.6		mA	V_{OL} = 0.5 V, 25 °C
Input leakage current			50	nA	

* This current level guarantees that the output voltage meets V_{OL} of 0.25 x Vcc and V_{OH} of 0.7 x Vcc.

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Table 6 Analog Inputs

Analog Signal	Min	Typ	Max	Units	Comments
Vref					
Source current			1	mA	
Output level	1.44	1.5	1.56	V	
Analog input					
Input impedance			2	kΩ	
Input capacitance*			40	pF	
Input voltage	0		Vref	V	

* In order to ensure that the input capacitance can charge quickly enough to get an accurate reading, the total input impedance, including source, should be less than 75 kΩ.

The voltage reference source Vref is powered on before taking analog readings and complies with the timing diagram below.

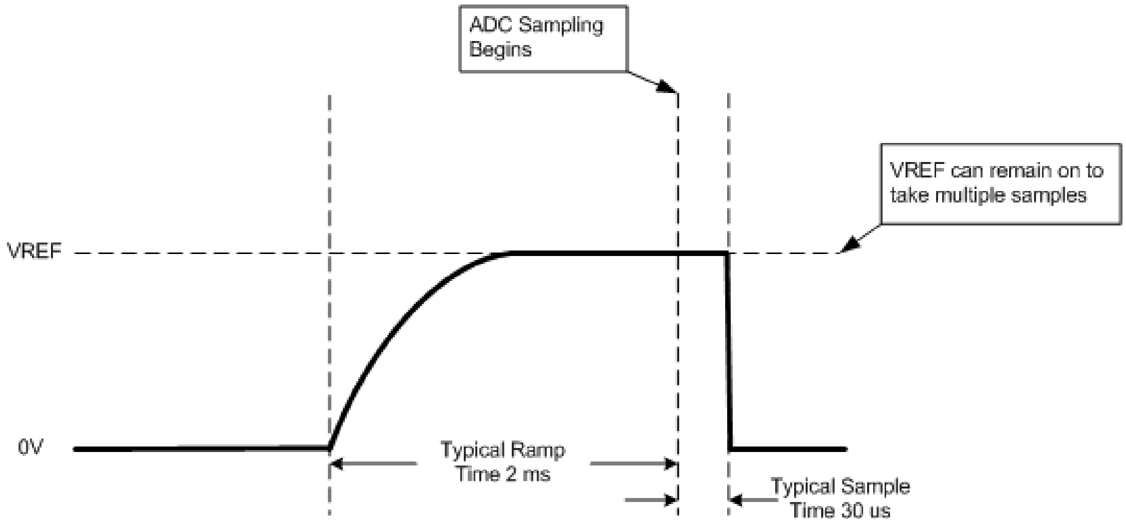

Figure 1 Vref Timing Diagram

3.1 Application Circuit

The following schematic shows how the M1030-2 mote can be used in a circuit.

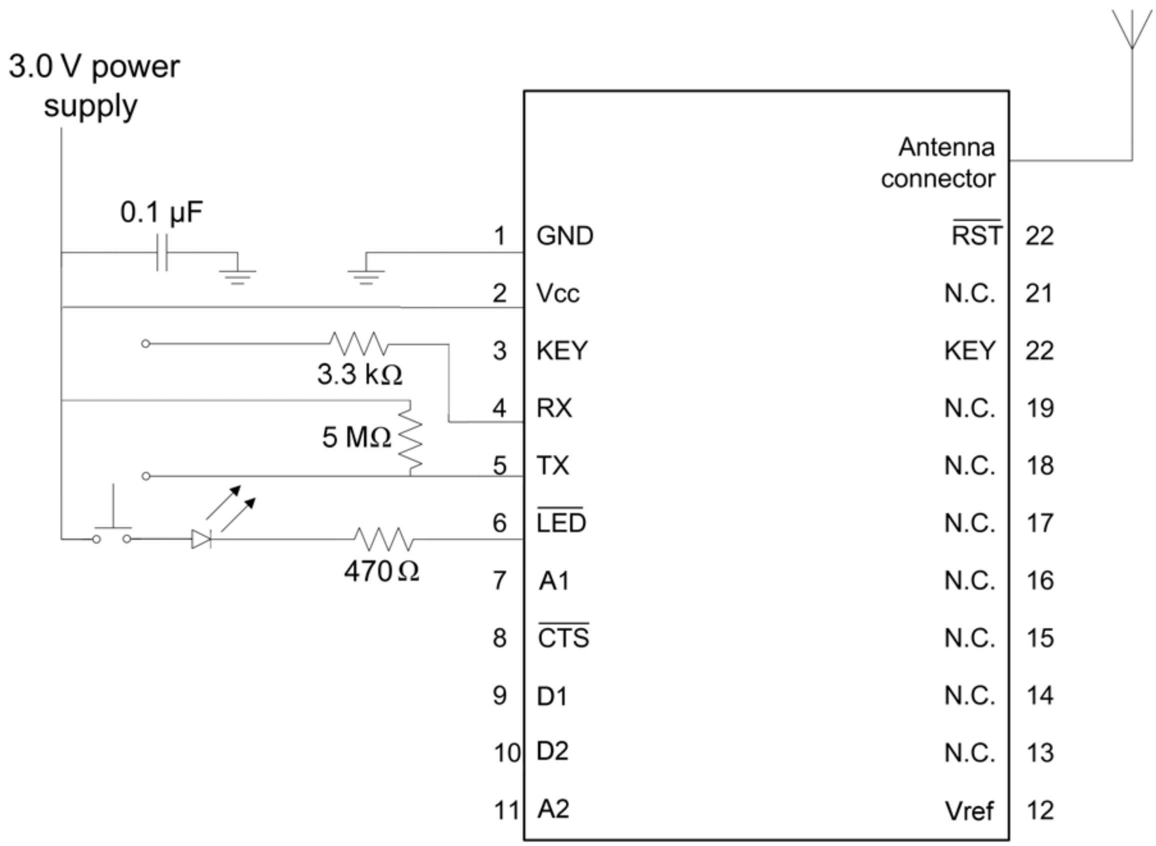

Figure 2 M1030-2 Mote in Application Circuit

4.0 Radio

4.1 Detailed Radio Specifications

Table 7 Radio Specifications

Parameter	Min	Typ	Max	Units	Comments
Operating frequency	902		928	MHz	
Number of channels		50			
Channel separation		470		kHz	
Channel bandwidth		170		kHz	At –20 dBc
Modulation					Binary FSK (NRZ)
Raw data rate		76.8		kbps	
Receiver sensitivity					At 10^{-3} BER, Vcc = 3 V
At 25 °C, –40 °C	–85	–88		dBm	
At 85 °C	–83			dBm	
Output power (conducted)					Vcc = 3 V
At 25 °C, –40 °C	+3	+4	+7	dBm	
At 85 °C	+1		+7	dBm	
Range*					25 °C, 50% RH, 1 meter above ground, +2 dBi omni-directional antenna
Indoor		80		m	
Outdoor		200		m	

* Actual RF range performance is subject to a number of installation-specific variables including, but not restricted to ambient temperature, relative humidity, presence of active interference sources, line-of-sight obstacles, near-presence of objects (for example, trees, walls, signage, and so on) that may induce multipath fading. As a result, actual performance varies for each instance.

4.2 Antenna Specifications

A MMCX-compatible male connector is provided on board for the antenna connection. The antenna must meet specifications in Table 8. For a list of FCC-approved antennae see 9.1.2.

Table 8 Antenna Specifications

Parameter	Value
Frequency range	902-928 MHz
Impedance	50 Ω
Gain	+6 dBi maximum
Pattern	Omni-directional
Maximum VSWR	3:1
Connector	MMCX*

* The M1030-2 can accommodate the following RF mating connectors:
- MMCX straight connector such as Johnson 135-3402-001, or equivalent
- MMCX right angle connector such as Tyco 1408149-1, or equivalent

When the mote is placed inside an enclosure, the antenna should be mounted such that the radiating portion of the antenna protrudes from the enclosure. The antenna should be connected using a MMCX connector on a coaxial cable. For optimum performance, allow the antenna to be positioned vertically when installed.

5.0 Pinout

The M1030-2 has two 11-pin Samtec MTMM-111-04-S-S-175-3 (or equivalent) connectors on the bottom side for handling all of the I/O. The third pin in each of the connectors is not populated, and serves as a key for alignment. The connectors are mounted on opposite edges of the long axis of the M1030-2.

The M1030-2 serial interface (serial protocol is specified in 7.4.1) provides flow control in the receive direction only.

Figure 3 M1030-2 Package with Pin Labels

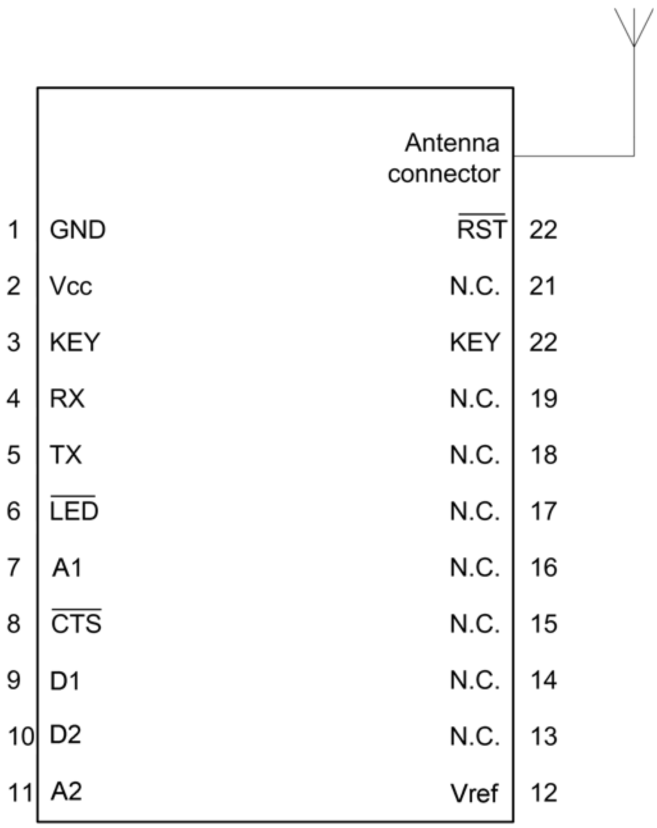

Table 9 M1030-2 Pin Functions

Pin Number	Name	Mote I/O Direction	Internal Pull Up/ Down
1	GND	In	None
2	VCC	In	None
3	KEY (no pin)	-	None
4	RX	In	None
5	TX	Out	None
6	$\overline{\text{LED}}$	Out	None
7	A1	In	None
8	$\overline{\text{CTS}}$	Out	None
9	D1	Out	None
10	D2	In	None
11	A2	In	None
12	VRef	Out	None
13	*No Connection*	-	None
14	*No Connection*	-	None
15	*No Connection*	-	None
16	*No Connection*	-	None
17	*No Connection*	-	None
18	*No Connection*	-	None
19	*No Connection*	-	None
20	KEY (no pin)	-	None
21	*No Connection*	-	None
22	$\overline{\text{RST}}$	In	100 kΩ pull up

The $\overline{\text{RST}}$ input pin is internally pulled up, and is optional. When driven active low, the mote is hardware reset until the signal is deasserted. Refer to section 6.1 for timing requirements on the $\overline{\text{RST}}$ pin. Note that the mote may also be reset using the mote serial command (see section 7.4.3.8).

6.0 Mote Boot Up

6.1 Power-on Sequence

The M1030-2 mote has internal power on reset circuits that ensure that the mote will properly boot. However, for the power on reset circuitry to function properly the external power supply must meet the timing shown in Figure 4 and specified in Table 10.

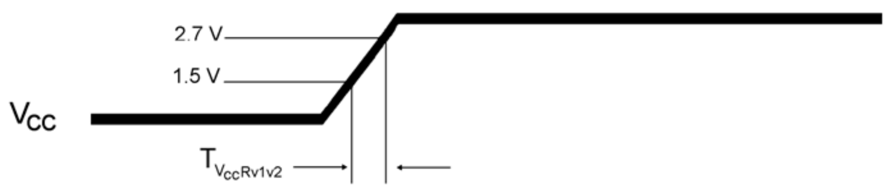

Figure 4 External Power Supply Timing Requirements

The following reset sequence (shown in Figure 5 and specified in Table 10) is required for external power supplies that fail to meet the requirements above.

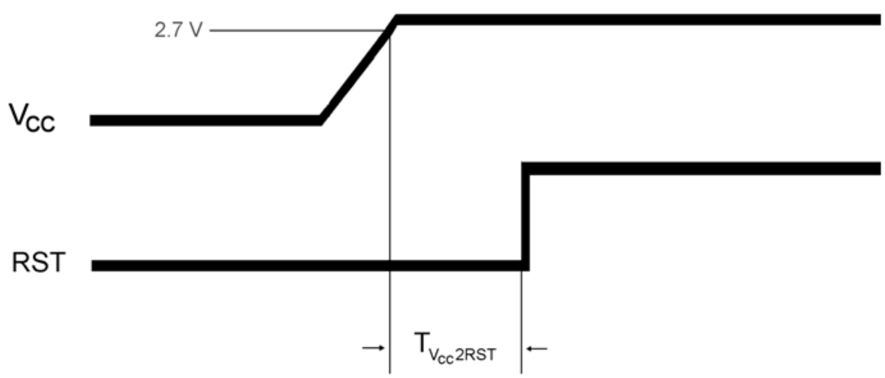

Figure 5 Power-on Sequence

Table 10 Power-on Sequence

Parameter	Min	Typ	Max	Units	Comments
$T_{Vcc2RST}$	10			ms	
$T_{VccRv1v2}$			485	µs	

6.2 Inrush Current

During power on, the mote can be modeled as a lumped impedance of 1 Ω and 27 µF, as shown in Figure 6. With a source impedance (R_{src}) of 1 Ω, the inrush current on the mote appears as shown in Figure 7.

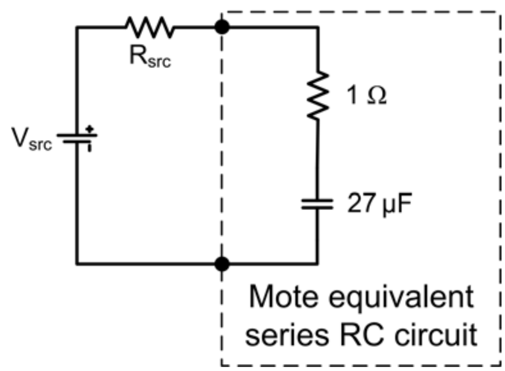

Figure 6 M1030 Equivalent Series RC Circuit

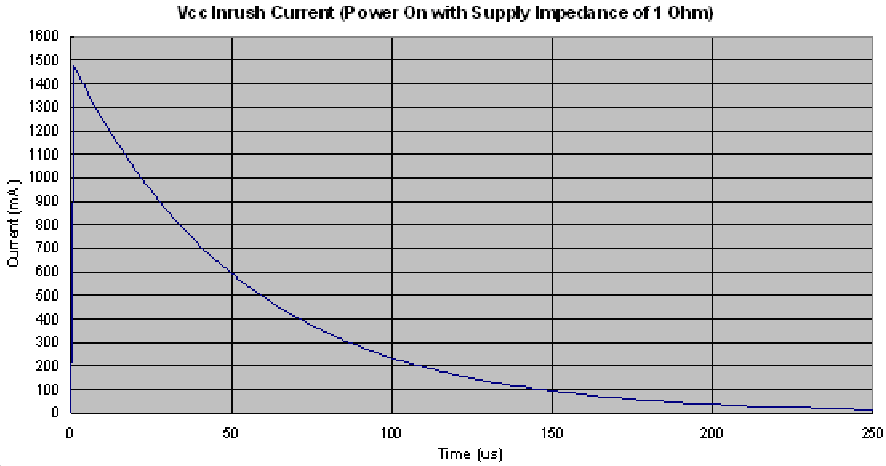

Figure 7 Vcc Inrush Current

6.3 Serial Interface Boot Up

Upon mote power up, the $\overline{\text{CTS}}$ line is high (inactive). The mote serial interface boots within boot_delay (see Table 13) of the mote powering up, at which time the mote transmits an HDLC Mote Information packet, as described in section 7.4.3.7.

Once the mote has established wireless network connection, it uses the $\overline{\text{CTS}}$ pin to signify availability to accept serial packets for wireless transmission. At certain critical times during communication, the mote may bring $\overline{\text{CTS}}$ high. $\overline{\text{CTS}}$ remains high if the mote does not have enough buffer space to accept another packet. It also remains high if the mote is not part of the network. Sensor processors must check that the $\overline{\text{CTS}}$ pin is low before initiating each serial packet for wireless transmission. Note that the mote may receive local serial packets at any time regardless of the $\overline{\text{CTS}}$ state.

7.0 Interfaces

7.1 Status $\overline{\text{LED}}$ Signal

The M1030-2 provides an output that can be used to drive a status LED. This signal indicates network connectivity information which is useful during mote installation. Alternatively, the mote’s network status may be polled via serial using the Get Parameter request (see 7.4.3.6) with the mote state parameter (see 7.4.4.3). See Figure 2 for an example application circuit.

Table 11 Status $\overline{\text{LED}}$

$\overline{\text{LED}}$ Signal Behavior	Mote State
High	Off, or in sleep mode
Slow single blink (100 ms low, 900 ms high)	On, and searching for potential network
Single blink (100 ms low, 400 ms high)	On, and attempting to join network
Double blink (100 ms low, 100 ms high, 100 ms low, 700 ms high)	On, connected to network, attempting to establish redundant links
Low	On, fully configured into network with redundant parents

7.2 Discrete Input/Output (I/O)

The M1030-2 has the ability to perform discrete sensor sampling and digital output actuating.
The M1030-2 has two analog inputs (A1, A2), one digital input (D2), one digital output (D1), and a voltage reference (Vref) output to allow for ratiometric sensors. Refer to section 3.0 for electrical specifications.

The mote buffers individual sensor readings and may perform the following functions:

- Concatenate individual readings into a report and send it into the network
- Summarize the readings into a report and send a it into the network
- Compare readings against threshold values and send a report into the network only if a limit is violated (event-based monitoring)
- Compare readings against threshold values and locally actuate the digital output

The TSMP 1.0 compliant wireless interface allows a remote monitoring/control application to configure the parameters (such as sample rate, report rate, and thresholds), receive sensor data and to actuate the digital output. For details on integration with remote applications, please refer to a Dust SmartMesh-XT Manager datasheet.

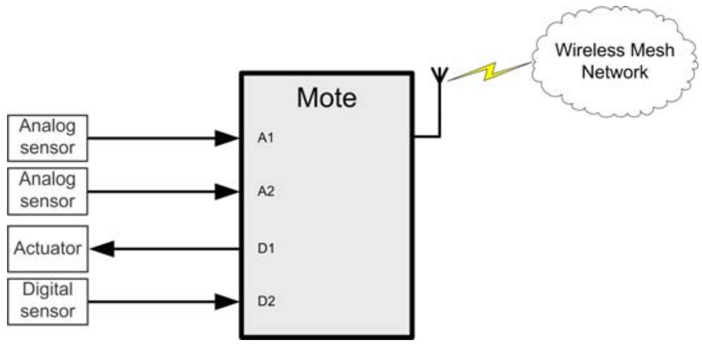

Figure 8 Discrete I/O

7.3 Deep Sleep

When the device is powered, the mote has the capability to go into deep sleep, which puts the mote into a non-functional, lowest-power consumption state with current draw on the order of a few microamps. Deep sleep is ideal when the mote is connected to its power source (power cannot be externally disconnected from the mote), but must be stored for extended periods . To put a mote into deep sleep, assert $\overline{RST}$ active low while shorting the serial TX and RX pins. To wake a mote out of deep sleep, simply assert $\overline{RST}$ active low with TX and RX no longer shorted.

The deep sleep detection algorithm relies upon actively driving a signal on the RX port and monitoring the TX port. To prevent signal contention on the RX port of the mote, it is recommended that a 3.3 kΩ resistor be placed in series, with the output of the signal driving into the RX port unless the microprocessor (see Figure 9) is inactive on this port for the first 23 ms following the negation of reset. To prevent unintentional detection of deep sleep, all systems incorporating the mote should place a 5 MΩ pull-up resistor on the TX port of the mote. See the application circuit in Figure 2.

7.4 Serial Interface

The M1030-2 offers a well-defined serial interface that is optimized for low-powered embedded applications. This serial interface offers a serial port comprised of the data pins (TX, RX) as well as the flow control pin, $\overline{CTS}$. Through this port, the M1030-2 provides a means of transmitting and receiving serial data through the wireless network, as well as a command interface which provides synchronized time stamping, local configuration and diagnostics.

The following sections detail the Serial Interface Protocol, the Mote Command Interface, and the timestamping capability of the M1030-2 serial interface.

7.4.1 Serial Flow Control

The Serial Interface Protocol provides for flow control of packets flowing into the M1030-2 serial interface. Packet delineation and error control are handled separately.

7.4.1.1 Serial Port

The three-pin serial port is comprised of the data pins (TX, RX) as well as the $\overline{CTS}$ flow control pin used to prevent the microprocessor from overflowing the mote. This port supports 4800 bps operation. The $\overline{CTS}$ signal is active low.

Table 12 Serial Parameters

Parameter	Value
Bit rate	4800
Stop bit	1
Data bits	8
Parity	None

The following diagram illustrates the pins used in the handshaking protocol:

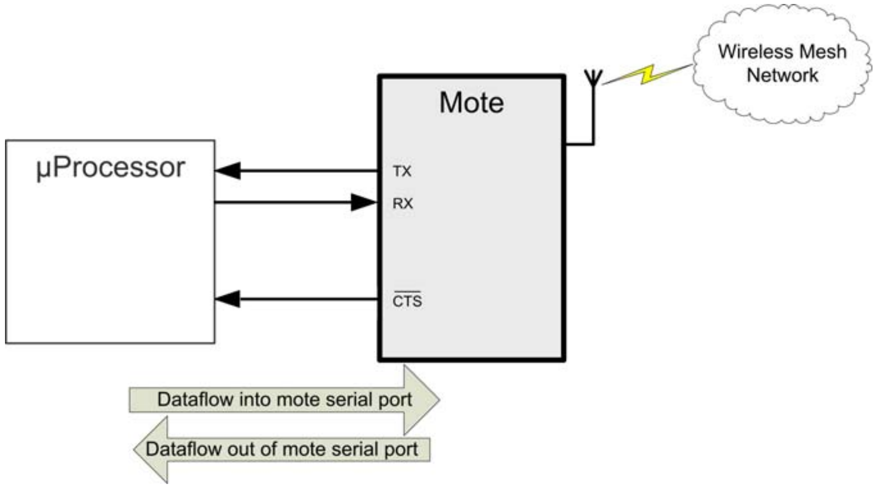

Figure 9 Diagram of Pins Used in Handshaking Protocol

7.4.1.2 Serial Interface Timing Requirements

The following diagram shows interpacket timing.

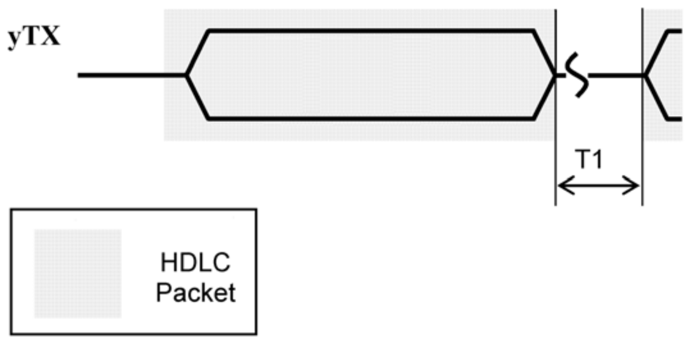

Figure 10 Serial Interpacket Timing Diagram

Timout (T1) is the interpacket_delay for communications into the mote, and is defined as the minimum time after the mote receives the last byte of a packet before it can start receiving the next packet (see Table 13 for values).

Table 13 Timing Values

Variable	Meaning	Min	Max	Unit
diag_ack_timeout	The mote responds to all requests within this time.		125	ms
boot_delay	The time between mote power up and serial interface availability.		250	ms
interpacket_delay	The sender of an HDLC packet must wait at least this amount of time before sending another packet.	20		ms

7.4.2 Mote Command Data Types

Table 14 defines the command data types used in the commands.

Table 14 Command Data Types

Data Type	Description
unsigned long	4 bytes
unsigned short	2 bytes
unsigned char	1 byte

7.4.3 Mote Commands

The mote command interface provides a way to send and receive network packets, access local configuration and diagnostics, and receive time stamps. All packets between the microprocessor and the mote are encapsulated in the HDLC format (RFC 1662) and have the following structure (see Figure 11).

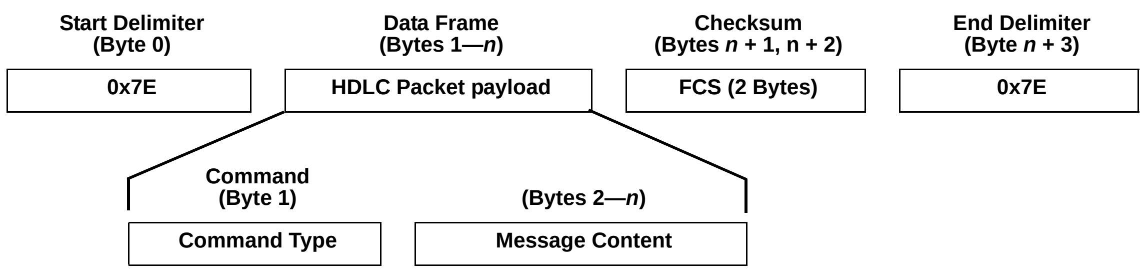

Figure 11 HDLC Packet Structure

The command type indicates which API message is contained in the message content. The message content for each command type is described within the following sections.

FCS is calculated based on 16-bit FCS computation method (RFC 1662). The mote checks the FCS and drops packets that have FCS errors. There is no mechanism for the mote to tell the microprocessor that a packet has been discarded, so the applications layer must implement reliable delivery, if desired. All numerical fields in a packet are in big endian order (MSB first), unless otherwise noted. Section 7.4.5 provides an example of HDLC packet construction and HDLC packet decoding.

Table 15 provides a summary of mote commands, which are described in detail in the following sections. For error handling, all other packet types should be ignored. The Destination column indicates whether the packet is sent (or received) through the network or processed locally by the mote.

Table 15 Mote Command Summary

Command Type (HEX)	Direction	Destination	Description
0x80	Microprocessor to mote	Network	Packet destined for the network
0x81	Mote to microprocessor	Network	Unacknowledged packet received from the network and destined for microprocessor
0x82	Mote to microprocessor	Network	Acknowledged packet received from the network and destined for microprocessor
0x83	--	–	Reserved
0x84	Mote to microprocessor	Local	Time and mote state information
0x85	--	–	Reserved
0x86	--	–	Reserved
0x87	Microprocessor to mote	Local	Set Parameter request
0x88	Mote to microprocessor	Local	Set Parameter response
0x89	Microprocessor to mote	Local	Get Parameter request
0x8A	Mote to microprocessor	Local	Get Parameter response

Table 15 Mote Command Summary

Command Type (HEX)	Direction	Destination	Description
0x8C	Mote to microprocessor	Local	Mote information
0x8D	Microprocessor to mote	Local	Reset mote

7.4.3.1 Command 0x80 Serial Payload Sent to Mote Serial

Serial Data Packets going into the mote serial port use the command type 0x80. Upon reception of the packet, the mote forwards it to the network. The format of the serial packet payload is transparent to the mote. The maximum length of the payload is 80 bytes (excluding byte-stuffing bytes). There is no response by the mote upon reception of this command.

Table 16 Command 0x80 Serial Payload to Mote

Msg Byte	Description	Data Type	Request (Sent to Mote)
1	Cmd type	unsigned char	0x80
2		(Transparent to mote)	First byte of data
...2+n		(Transparent to mote)	Up to n–1 additional bytes of data

7.4.3.2 Command 0x81 Unacknowledged Serial Payload Received from Mote Serial

Unacknowledged serial data packets going out of the mote serial port use command type 0x81. The network uses this command to send data out through the mote serial interface. Upon receiving this packet from the network, the mote forwards it to the microprocessor without sending acknowledgement to Manager. The format of the serial packet payload is transparent to the mote. The maximum length of the payload is 80 bytes (excluding byte-stuffing bytes).

Table 17 Command 0x81 Unacknowledged Serial Payload from Mote

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x81
2		(Transparent to mote)	First byte of data
...2+n		(Transparent to mote)	Up to n–1 additional bytes of data

7.4.3.3 Command 0x82 Acknowledged Serial Payload Received from Mote Serial

Acknowledged serial data packets going out of the mote use command type 0x82. The network uses this command to send data out through the mote serial interface. Upon receiving this packet from the network, the mote forwards it to the microprocessor and sends an acknowledgement back to Manager. The format of the serial packet payload is transparent to the mote. The maximum length of the payload is 80 bytes (excluding byte-stuffing bytes). The microprocessor receives exactly one copy of the message that was sent through the network.

Table 18 Command 0x82 Acknowledged Serial Payload Downstream

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x82
2		(Transparent to mote)	First byte of data
...2+n		(Transparent to mote)	Up to n–1 additional bytes of data

7.4.3.4 Command 0x84 Time/State Packet

Time data packets use the command type 0x84. The time packet includes the network time and the current real time relative to the Manager. The mote sends this response when it receives a Get Parameter request with time as the parameter (described later).

Table 19 Command 0x84 Time/State Packet

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x84
2-5	The sequential number of the frame	unsigned long	Cycle
6-9	The offset from start of frame	unsigned long	Offset (μsec)
10-11	Frame length	unsigned short	Frame length (slots)
12-15	UTC time	unsigned long	Real time part 1 (sec)
16-19	UTC time	unsigned long	Real time part 2 (μsec)
20-23	Time from the last mote reset	unsigned long	Mote uptime (ms)
24	Mote state	unsigned char	Mote state (see Table 34)
25	Mote diagnostics status	unsigned char	Mote diagnostics status (see Table 35)

7.4.3.5 Commands 0x87 and 0x88 Set Parameter Request/Response

The Set Parameter command allows the setting of a number of configuration parameters in the mote. When the Set Parameter Request command is sent, the response to the request is sent within the diag_ack_timeout (see Table 13). The command structure for individual Parameter Types and can be found in section 7.4.4. The length of payload (n) depends on the Parameter Type and is specified in the Parameter Data Packet section of this document.

Table 20 Command 0x87 Set Parameter Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x87
2		unsigned char	Parameter type
3	Data		First byte of data
...3+n	Data		Up to n–1 additional bytes of data

.

Table 21 Command 0x88 Set Parameter Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x88
2		unsigned char	Parameter type
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	0x00

7.4.3.6 Commands 0x89 and 0x8A Get Parameter Request/Response

The Get Parameter command allows a number of configuration parameters in the mote to be read by serial. When a Get Parameter Request command is sent, the response to the request is sent within the diag_ack_timeout (see Table 13). The command structure for individual parameter types can be found in section 7.4.4. The length of payload (n) depends on the parameter type and is specified in that section. If the error code is not equal to 0, then no data is returned in the response. Error codes are described in Table 29.

Table 22 Command 0x89 Get Parameter Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x89
2		unsigned char	Parameter type
3	Data		First byte of data
...3+n	Data		Up to n–1 additional bytes of data

Table 23 Command 0x8A Get Parameter Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x8A
2		unsigned char	Parameter type
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	n
5	Data		First byte of data
...5+n	Data		Up to n–1 additional bytes of data

7.4.3.7 Command 0x8C Mote Information

The mote sends this packet on bootup, supplying information about mote properties. For details on bootup, see section 6.3.

Table 24 Command 0x8C – M1030-1 Information

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x8C
2-4	HW model	Array of 3 unsigned char	00109
5-6	HW revision	Array of 2 unsigned char	HW revision
7-10	SW revision	Array of 4 unsigned char	SW revision
11-18	MAC address	Array of 8 unsigned char	MAC addr
19	Networking type	unsigned char	1 = 900 MHz network
20-21	Network ID	unsigned short	Network ID
22-29	Datasheet ID	Array of 8 unsigned char	000_0001
30-31	Mote ID	unsigned short	Mote ID
32			Reserved
33	Mote diagnostics status	unsigned char	Mote diagnostics status (see Table 35)

7.4.3.8 Command 0x8D Reset Mote

Upon receiving this command, the mote notifies its children about an upcoming reset, then proceeds to reset itself. The delay to the actual reset depends on the network configuration.

Table 25 Command 0x8D Reset Mote

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x8D

7.4.4 Mote Get/Set Command Parameters

This section specifies the parameters that may be used with the Set and Get Commands. Table 26 provides an overview of the these parameters.

Table 26 Set and Get Command Parameters

Parameter Type	Set Parameter	Get Parameter	Description
0x01	X		Set the mote's network ID
0x02		X	Get the mote's current network connection state
0x03		X	Get the network frame length
0x04	X		Set the network join key on the mote
0x05		X	Get the network time and mote state information
0x06			Reserved
0x07		X	Get the mote's properties
0x08			Reserved
0x09			Reserved
0x0A			Reserved

All requests have the following structure:

Table 27 Request Structure for Parameter Data Packets

Command Type	Parameter Type	Data (Optional)
1 byte	1 byte	Up to 33 bytes

All replies have the following structure:

Table 28 Reply Structure for Parameter Data Packets

Command Type	Parameter Type	Error Code	Data Length	Data (Optional)
1 byte	1 byte	1 byte	1 byte	Up to 31 bytes

Command Types, Parameter types, and error codes are discussed in the following sections. Data length is the number of bytes of following data, set to 0 in case of non-zero error code.

7.4.4.1 Error Codes

Table 29 Error Codes

Number	Error	Description
0	DIAG_NO_ERR	No Command-Specific Errors
1	DIAG_EXE_ERR	Mote unable to execute command
2	DIAG_PARAM_ERR	Illegal parameter in the request

7.4.4.2 Parameter Type 0x01 Network ID

The network ID is the identification number used to distinguish different wireless networks. In order to join a specific network, the mote must have the same network ID as the network Manager. This parameter is only valid for the Set Parameter command. Upon receiving this request, the mote stores the new network ID in its persistent storage area, but continues to use the existing network ID. The mote must be reset in order to begin using the new network ID.

Table 30 Parameter Type 0x01 Network ID Set Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x87
2	Parameter type	unsigned char	0x01
3-4	Network ID	unsigned short	Network ID

The following packet is sent in response to a request to set the network ID.

Table 31 Parameter Type 0x01 Network ID Set Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x88
2	Parameter type	unsigned char	0x01
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	0x00

7.4.4.3 Parameter Type 0x02 Mote State

This parameter is only valid for the Get Parameter command and is used to retrieve the mote's current network connection state (see Table 34).

Table 32 Parameter Type 0x02 Mote State Get Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x89
2	Parameter type	unsigned char	0x02

The following packet is sent in response to a request to retrieve the mote's current network connection state.

Table 33 Parameter Type 0x02 Mote State Get Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x8A
2	Parameter type	unsigned char	0x02
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	0x02
5		unsigned char	Mote state
6	Mote diagnostics status	unsigned char	Mote diagnostics status (see Table 35)

Table 34 Mote States

State #	Description	Details
1	ACTIVE	The mote has joined the network and is waiting to be configured.
2	JOINING	The mote has sent a join request, waiting to be activated.
3	ACT SEARCH	The mote is actively searching for neighbors.
4–5	PASS SEARCH	The mote is passively searching for neighbors.
6	SYNCHRONIZED	The mote is synchronized to a network, listening in active search.
7–8	RESETTING	The mote is going through the reset process.
9	ONLINE1	The mote has joined a network and has been fully configured, but has only one parent. The mote is ready to transmit data to the network.
10	ONLINE2	The mote has joined a network, has been fully configured, and has multiple parents. The mote is ready to transmit data to the network.

Table 35 Diagnostics Status

Bit	Name	Details
7	---	Reserved
6	---	Reserved
5	---	Reserved
4	---	Reserved
3	---	Reserved
2	---	Reserved
1	CCF	Configuration change flag (see section 7.4.4.3.1)
0	NV_ERR	Non-volatile memory error

7.4.4.3.1 Configuration Change Flag (CCF)

The Configuration Change Flag (CCF) bit is set high when the network ID is changed. Note that when the network ID is changed over the air (using the XML-API), the entire network synchronously changes over to the new network ID. There is no delay between when the XML-API command is received and when motes change over to the new network ID. The CCF bit is set high when the new network ID becomes active. The CCF bit is cleared when the mote receives a Mote Information Get request (Command 0x07) or the mote is reset.

7.4.4.4 Parameter Type 0x03 Frame Length

This parameter is only valid for the Get Parameter command and is used to retrieve the frame length of the specified frame.

Table 36 Parameter Type 0x03 Frame Length Get Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x89
2	Parameter type	unsigned char	0x03
3		unsigned char	Frame ID

The following packet is sent in response to a request to retrieve the frame length.

Table 37 Parameter Type 0x03 Frame Length Get Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x8A
2	Parameter type	unsigned char	0x03
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	0x05
5		unsigned char	Frame ID
6-9	Frame length	unsigned long	Frame length (µs)

7.4.4.5 Parameter Type 0x04 Join Key

The join key is needed to allow a mote on the network. The join key is specific for the network and used for data encryption. This parameter is only valid for a Set Parameter command. Upon receiving this request, the mote stores the new join key in its persistent storage. The mote must be reset in order to begin using the new join key.

Table 38 Parameter Type 0x04 Join Key Set Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x87
2	Parameter type	unsigned char	0x04
3-18	New join key	Array of 16 unsigned char	New join key

The following packet is sent in response to a request to set the join key.

Table 39 Parameter Type 0x04 Join Key Set Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x88
2	Parameter type	unsigned char	0x04
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	0x00

7.4.4.6 Parameter Type 0x05 Time/State

This parameter is only valid for the Get Parameter command and is used to request the network time and mote state information. The response to this command returns the same information as Command 0x84 (Time/State Packet), with the only difference being that this command can be solicited using a software Get command, rather than a hardware pin.

Table 40 Parameter Type 0x05 Time/State Get Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x89
2	Parameter type	unsigned char	0x05

The following packet is sent in response to a request for the network time and mote state information.

Table 41 Parameter Type 0x05 Time/State Get Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x8A
2	Parameter type	unsigned char	0x05
3	Error code	unsigned char	Error code (see Table 29)
4	Data length	unsigned char	0x18

Table 41 Parameter Type 0x05 Time/State Get Response

Msg Byte	Description	Data Type	Value
5-8	The sequential number of the frame	unsigned long	Cycle
9-12	The offset from start of frame	unsigned long	Offset (μsec)
13-14	Frame length	unsigned short	Frame length (slots)
15-18	UTC time	unsigned long	Real time part 1 (sec)
19-22	UTC time	unsigned long	Real time part 2 (μsec)
23-26	Time from the last mote reset	unsigned long	Mote uptime (msec)
27	Mote state	unsigned char	Mote state
28	Mote diagnostics status	unsigned char	Mote diagnostics status (see Table 35)

7.4.4.7 Parameter Type 0x07 Mote information

This parameter is only valid for the Get Parameter command. It is a local request that retrieves information about the mote's properties.

Table 42 Parameter Type 0x07 Mote Information Get Request

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	0x89
2	Parameter type	unsigned char	0x07

The following packet is sent in response to a request for information about mote properties.

Table 43 Parameter Type 0x07 Mote Information Get Response

Msg Byte	Description	Data Type	Value
1	Cmd type	unsigned char	140 (0x8A)
2	Parameter type	unsigned char	0x07
3	Error code	unsigned char	Error code
4	Data length	unsigned char	0x20
5-7	HW model	Array of 3 unsigned char	00109
8-9	HW revision	Array of 2 unsigned char	HW revision
10-13	SW revision	Array of 4 unsigned char	SW revision
14-21	MAC address	Array of 8 unsigned char	MAC addr
22	Networking type	unsigned char	1 = 900 MHz network
23-24	Network ID	unsigned short	Network ID
25-32	Datasheet ID	Array of 8 unsigned char	000_0001
33-34	Mote ID	unsigned short	Mote ID
35			Reserved
36	Mote diagnostics status	unsigned char	Mote diagnostics status (see Table 35)

7.4.5 HDLC Packet Processing Examples

Example 1: Constructing an HDLC packet to send to the mote

This example demonstrates how to construct an HDLC packet to set the network ID value to 00 7D. (All values are in hexadecimal.)

Step 1 Define HDLC packet payload:

Command type => 87
Parameter => 01
Network ID => 00 7D

Note that the additional control bytes do not count against the 80-byte payload limit.

HDLC Packet Payload	
Command Type	**Message Content**
87	01 00 7D

Step 2 Calculate FCS:

- Calculate the FCS using FCS-16 algorithm (RFC 1662) on the hexadecimal sequence '87 01 00 7D'. The FCS (including 1's complement) is 74 2F.
- Append FCS to payload, FCS is sent least significant byte first (RFC 1662):

HDLC Packet Payload	FCS
87 01 00 7D	2F 74

Step 3 Perform byte stuffing.

To perform byte stuffing, check the HDLC Packet Payload and FCS for instances of “7D” or “7E” and replace as follows:

7D => 7D 5D
7E => 7D 5E

Note that the additional control bytes do not count against the 80-byte payload limit.

HDLC Packet Payload (stuffed)	FCS (stuffed)
87 01 00 **7D 5D**	2F 74

Step 4 Add start and stop delimiters.

Enclose the above in start/stop flags (RFC 1662).

Start Delimiter	HDLC Packet Payload (stuffed)	FCS (stuffed)	Stop Delimiter
7E	87 01 00 7D 5D	2F 74	7E

Or simply, the hexadecimal sequence:

7E 87 01 00 7D 5D 2F 74 7E

Example 2: Decoding an HDLC packet received from the mote

To understand how to decode an HDLC packet sent from the mote, let’s assume that the mote received a Get command with a parameter of mote information (see section 7.4.4.7), and replied with the following HDLC Packet. (All values are in hexadecimal.)

Start Byte	HDLC Packet Payload (stuffed)	FCS (stuffed)	Stop Byte
7E	8A 07 00 20 00 00 5B 00 01 01 06 00 3C 00 00 00 00 00 00 7D 5E C3 01 00 08 30 30 30 5F 45 56 30 31 00 13 00 00	40 E8	7E

Step 1 (HDLC layer) strip off delimiters.

HDLC Packet Payload (stuffed)	FCS (stuffed)
8A 07 00 20 00 00 5B 00 01 01 06 00 3C 00 00 00 00 00 00 7D 5E C3 01 00 08 30 30 30 5F 45 56 30 31 00 13 00 00	40 E8

Step 2 Remove byte stuffing.

To remove byte stuffing, check for instances of “7D 5D” or “7D 5E” and replace as follows:

7D 5D => 7D
7D 5E => 7E

HDLC Packet Payload	FCS
8A 07 00 20 00 00 5B 00 01 01 06 00 3C 00 00 00 00 00 00 7E C3 01 00 08 30 30 30 5F 45 56 30 31 00 13 00 00	40 E8

Step 3 Confirm FCS.

Calculate the checksum for the HDLC payload.

HDLC Packet Payload
8A 07 00 20 00 00 5B 00 01 01 06 00 3C 00 00 00 00 00 00 7E C3 01 00 08 30 30 30 5F 45 56 30 31 00 13 00 00

Confirm that the FCS matches the FCS sent with the packet. Because the packet encodes FCS least significant byte first, in this example the calculated FCS should match “E8 40”.

Step 4 (Application layer) parse HDLC payload content.

The resulting packet payload is as follows.

HDLC Packet Payload
8A 07 00 20 00 00 5B 00 01 01 06 00 3C 00 00 00 00 00 00 7E C3 01 00 08 30 30 30 5F 45 56 30 31 00 13 00 00

Command Type	Message Content
8A	07 00 20 00 00 5B 00 01 01 06 00 3C 00 00 00 00 00 00 7E C3 01 00 08 30 30 30 5F 45 56 30 31 00 13 00 00

As described in section 7.4.3.6, an 0x8A command with parameter type 0x07 has the following message content structure.

Param	Error Code	Length	HW Model	HW Rev	SW Rev	MAC	Mote Type	Net ID	Datasheet ID	Mote ID	Rsvd	Status
07	00	20	00 00 5B	00 01	01 06 00 3C	00 00 00 00 00 00 7E C3	01	00 08	30 30 30 5F 45 56 30 31	00 13	00	00

Therefore, this is a mote information response with no errors (and a payload length of 32 bytes). The mote information is as follows (actual values will vary, see section 7.4.4.7).

HW Model =	00091	(00 00 5B)
HW Rev=	001	(00 01)
SW Rev=	1.6.60	(01 06 00 3C)
MAC Address=	00 00 00 00 00 00 7E 3C	
Mote Type=	01 = 900 MHz	(01)
Network ID=	8	(00 08)
Datasheet ID=	000_EV01	(30 30 30 5F 45 56 30 31)
Mote ID=	19	(00 13)
Mote Diagnostics Status=	0	(00)

8.0 Packaging Description

8.1 Mechanical Drawings

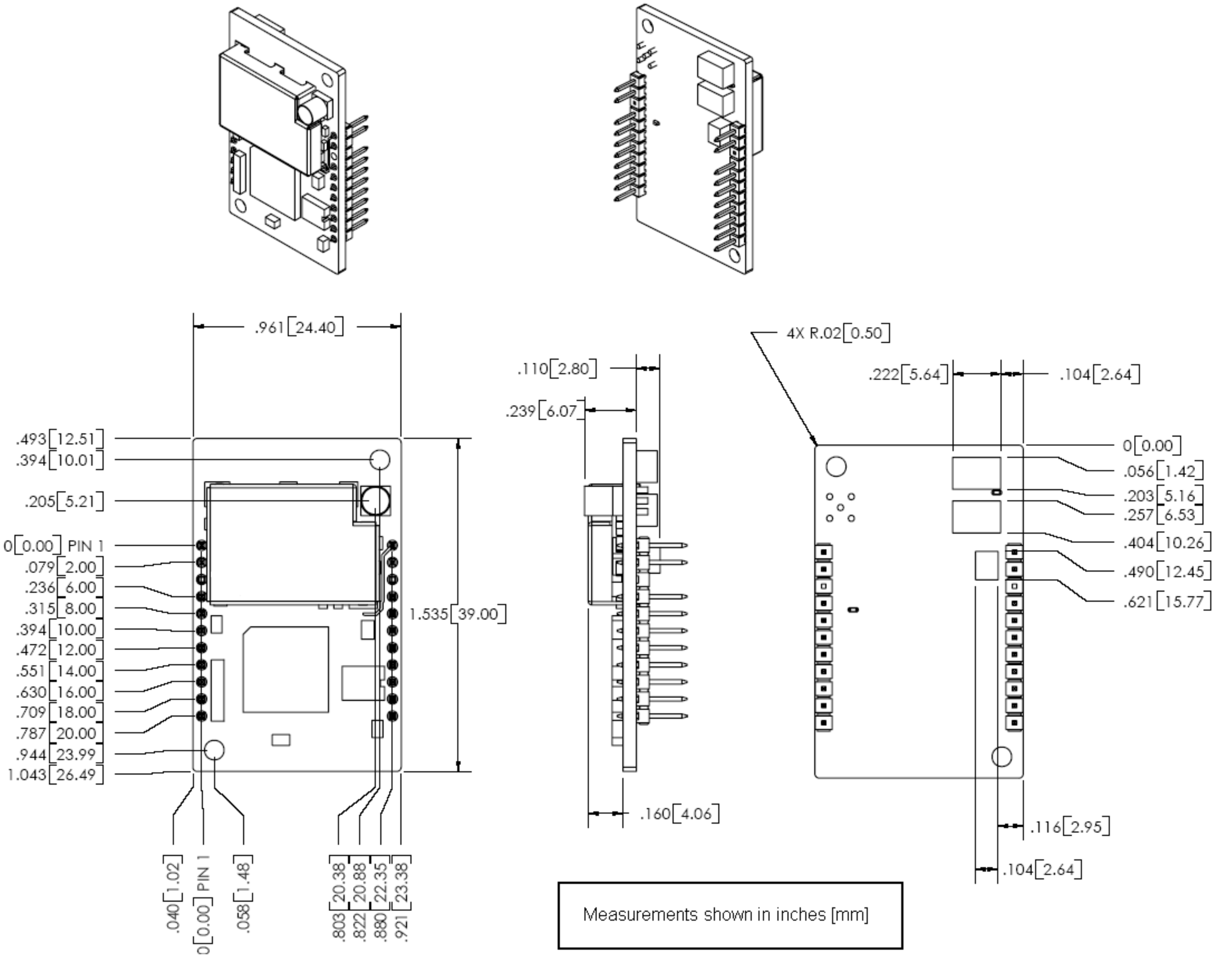

Figure 12 M1030-2 Mote—Mechanical Drawing

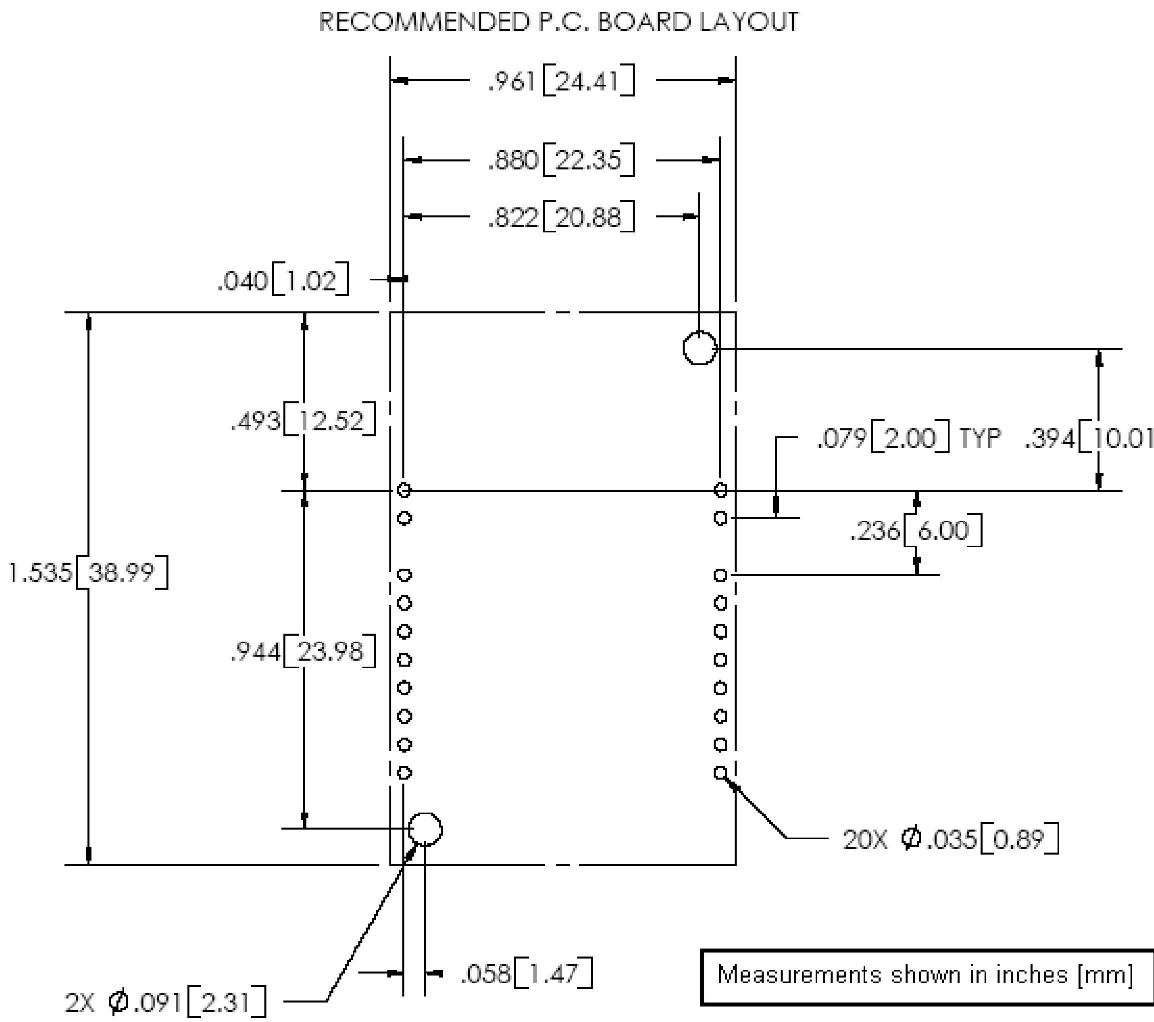

Figure 13 M1030-2 Mote Footprint—Mechanical drawing

8.2 Soldering Information

The M1030-2 can be hand soldered with a soldering iron at 230 °C. The soldering iron should be in contact with the pin for 10 seconds or less. The M1030-2 is also suitable for eutectic PbSn reflow.

9.0 Regulatory and Standards Compliance

9.1 FCC Compliance

9.1.1 FCC Testing

The M1030-2 mote complies with Part 15.247 modular (Intentional Radiator) of the FCC rules and regulations. In order to fulfill FCC certification requirements, products incorporating the M1030-2 mote must comply with the following:

1. An external label must be provided on the outside of the final product enclosure specifying the FCC identifier (SJC-M1030), as described in 9.1.3 below.
2. The antenna must be electrically identical to the FCC-approved antenna specifications for the M1030-2 as described in 9.1.2 with the exception that the gain may be lower than specified in Table 44.
3. The device integrating the M1030-2 mote may not cause harmful interference, and must accept any interference received, including interference that may cause undesired operation.
4. An unintentional radiator scan must be performed on the device integrating the M1030-2 mote, per FCC rules and regulations, CFR Title 47, Part 15, Subpart B. See FCC rules for specifics on requirements for declaration of conformity.

9.1.2 FCC-approved Antennae

The following are FCC-approved antenna specifications for the M1030-2:

Table 44 FCC-approved Antenna Specifications for the M1030-2

Gain	Pattern	Polarization	Frequency	Connector
+6 dBi maximum	Omni-directional	Vertical	902-928 MHz	MMCX

9.1.3 OEM Labeling Requirements

The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. The outside of the final product enclosure must have a label with the following (or similar) text specifying the FCC identifier. The FCC ID and certification code must be in Latin letters and Arabic numbers and visible without magnification.

Contains transmitter module FCC ID: SJC-M1030

or

Contains FCC ID: SJC-M1030

9.2 IC Compliance

9.2.1 IC Testing

The M1030-2 is certified for modular Industry Canada (IC) RSS-210 approval. The OEM is responsible for its product to comply with IC ICES-003 and FCC Part 15, Sub. B - Unintentional Radiators. The requirements of ICES-003 are equivalent to FCC Part 15 Sub. B and Industry Canada accepts FCC test reports or CISPR 22 test reports for compliance with ICES-003.

9.2.2 IC-approved Antennae

The following are IC-approved antenna specifications for the M1030-2.

Table 45 IC-approved Antenna Specifications for the M1030-2

Gain	Pattern	Polarization	Frequency	Connector
+6 dBi maximum	Omni-directional	Vertical	902-928 MHz	MMCX

9.2.3 OEM Labeling Requirements

The Original Equipment Manufacturer (OEM) must ensure that IC labeling requirements are met. The outside of the final product enclosure must have a label with the following (or similar) text specifying the IC identifier. The IC ID and certification code must be in Latin letters and Arabic numbers and visible without magnification. .

Contains IC:5853A-M1030

9.3 Industrial Environment Operation

The M1030-2 is designed to meet the specifications of a harsh industrial environments which includes:

- **Shock and Vibration**—The M1030-2 complies with high vibration pipeline testing, as specified in IEC 60770-1.
- **Hazardous Locations**—The M1030-2 design is consistent with operation in UL Class 1 Division 1 and Division 2 Hazardous Locations.
- **Temperature Extremes**—The M1030-2 is designed for industrial storage and operational temperature range of –40 °C to +85 °C.

10.0 Ordering Information

Product List:

M1030-2: SmartMesh-XT / 900 MHz Analog/Digital/Serial Mote

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Document Status	Product Status	Definition
Advanced Information	Planned or under development	This datasheet contains the design specifications for product development. Dust Networks reserves the right to change specifications in any manner without notice.
Preliminary	Engineering samples and pre-production prototypes	This datasheet contains preliminary data; supplementary data will be published at a later time. Dust Networks reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. The product is not fully qualified at this point.
No Identification Noted	Full production	This datasheet contains the final specifications. Dust Networks reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Obsolete	Not in production	This datasheet contains specifications for a product that has been discontinued by Dust Networks. The datasheet is printed for reference information only.