

About SmartMesh IA-510

Dust Networks' SmartMesh[®] IA-510 is an industry-leading wireless networking solution designed for critical monitoring and control applications. IA-510 serves a wide range of applications from renewable energy generation, such as solar and wind power, to factory machine health monitoring and data center HVAC energy management. The SmartMesh IA-510 system delivers dynamic network optimization and intelligent routing to achieve unsurpassed levels of wireless network scalability, system-wide reliability and low latency, coupled with industrial-class security. Additionally, ultra-low power operation permits even greater deployment flexibility for wire-free applications.

Product Description—M2510

The M2510 mote module combines Dust Networks' robust sensor networking solution with industry-leading low-power radio technology in an easy-to-integrate 22-pin module. As part of the SmartMesh IA-510 system, the M2510 enables customers to integrate a standards-based wireless network into sensors and actuators to provide scalable bidirectional communications.

The M2510 is designed for use in line-powered, battery-powered, or energy-scavenging sensor and actuator applications that demand reliable performance and ultra-low power operation. With Dust Networks' innovative IEEE 802.15.4-compliant design and integrated power amplifier, the M2510 enables a decade of battery life on two AA batteries. All motes function as wireless routers, enabling a redundant, high performance, full-mesh topology.

The M2510 integrates all radio circuitry components, including an MMCX-type antenna connector to eliminate the need for complex RF design. To accelerate customer development time and reduce development costs, Dust Networks provides a fully engineered RF solution, comprehensive APIs, and complete development documentation.

Key Product Features

Highly Scalable

- Automatic network formation—new motes join automatically from anywhere in the network
- All motes are wireless routers, providing a full-mesh network that easily scales to tens of thousands of motes per square kilometer
- Time-synchronized communication across 15 channels virtually eliminates in-network collisions, allowing for dense deployments in overlapping radio space

Superior Reliability

- SmartMesh IA-510 Intelligent Networking Platform enables greater than 99.99% network reliability even in the most challenging monitoring and control environments
- Time-synchronized channel hopping minimizes the impact of crippling multipath interference in dynamic RF environments

Ultra-low Power Operation

- Industry-leading radio technology capable of line-powered, battery-powered, or energy-scavenging operation
- Automatic network-wide coordination optimizes power consumption, enabling a decade of network operation on two Lithium AA batteries

Easy to Integrate and Deploy

- Fully engineered RF, with power amplifier (PA), balun, crystals, antenna matching circuitry and antenna connector
- Comprehensive APIs provide rich and flexible functionality to ease software development and device integration

Secure Global Market Solution

- Modular 2.4GHz band RF certifications for FCC, IC and CE dramatically reduce cost and complexity of global wireless device certification
- AES-128 bit encryption (certified NIST FIPS-197 compliant)

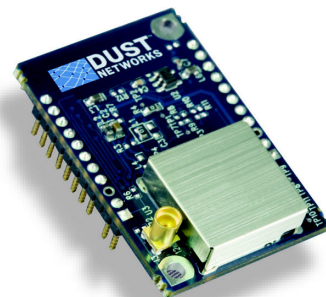
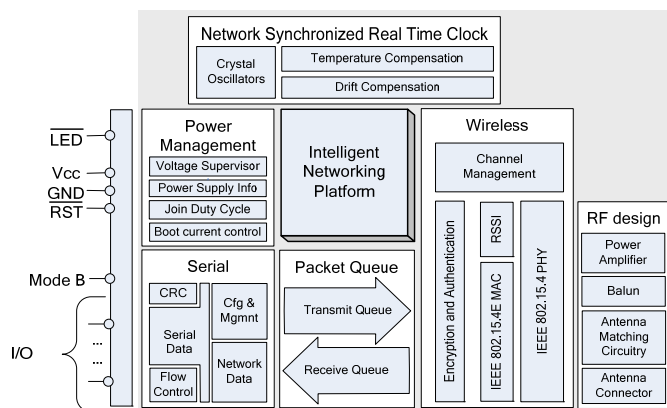


Table of Contents

1.0	Absolute Maximum Ratings	4
2.0	Normal Operating Conditions	4
3.0	Electrical Specifications	5
4.0	Radio	6
4.1	Detailed Radio Specifications	6
4.2	Antenna Specifications	7
5.0	Pinout	7
5.1	M2510 Pinout	7
6.0	Power Supply Design	8
7.0	Mote Boot Up	9
7.1	Power-on Sequence	9
7.2	Inrush Current	9
7.3	Mote Boot Sequence	10
7.3.1	Standard Boot	10
7.3.2	Low Current Boot	10
7.4	Serial Interface Boot Up	10
7.4.1	M2510 Serial Interface Boot Up	10
8.0	Interfaces	11
8.1	Reset Pin	11
8.2	Timestamps	11
8.3	Settable I/O Modes	11
8.3.1	Mode 1: Three/Four/Five-signal Serial Interface (9600 bps)	12
8.3.2	Mode 3: Five-signal Serial Interface (115.2 kbps)	12
8.3.3	UART AC Timing	13
8.4	Mote Serial API	16
8.5	Temperature Sensor	16
9.0	Packaging Description	17
9.1	Mechanical Drawing	17
9.2	Soldering Information	18
10.0	Regulatory and Standards Compliance	18
10.1	FCC Compliance	18
10.1.1	FCC Testing	18
10.1.2	FCC-approved Antennae	19
10.1.3	OEM Labeling Requirements	19
10.2	Industry Canada (IC) Compliance	19
10.2.1	IC Testing	19
10.2.2	IC-approved Antennae	19
10.2.3	OEM Labeling Requirements	19
10.3	CE Compliance	20
10.3.1	Declaration of Conformity	20

10.3.2 European Compliance	20
10.3.3 OEM Labeling Requirements	20
10.3.4 Restrictions	20
10.4 Compliance to Restriction of Hazardous Substances (RoHS)	20
10.5 Industrial Environment Operation	21
10.6 Encryption Cipher	21
11.0 Related Documentation	21
12.0 Ordering Information	21

1.0 Absolute Maximum Ratings

The absolute maximum ratings shown below should not be violated under any circumstances. Permanent damage to the device may be caused by exceeding one or more of these parameters.

Unless otherwise noted, all voltages in Table 1 are made relative to V_{SS} .

Table 1 Absolute Maximum Ratings

Parameter	Min	Typ	Max	Units	Comments
Supply voltage (V_{DD} to V_{SS})	-0.3		3.6	V	
Voltage on any digital I/O pin	-0.3		$V_{DD} + 0.3$ up to 3.6	V	
Input RF level			10	dBm	Input power at antenna connector
Storage temperature range	-40		+85	°C	
Lead temperature			+245	°C	For 10 seconds
VSWR of antenna			3:1		
ESD protection					
Antenna pad			±250	V	HBM
All other pads			±2	kV	HBM
			±200	V	CDM



Caution! ESD sensitive device. Precaution should be used when handling the device to prevent permanent damage.

2.0 Normal Operating Conditions

Unless otherwise noted, Table 2 assumes V_{DD} is 3.0 V and temperature is 25 °C.

Table 2 Normal Operating Conditions

Parameter	Min	Typ	Max	Units	Comments
Operational supply voltage range (between V_{DD} and V_{SS})	2.75		3.6	V	Including noise and load regulation
Voltage supply noise			150	mV _{p-p}	50 Hz to 2 MHz
Voltage supervisor trip point		2.64		V	Reset trip point
Peak current		6		mA	Searching for network, typically 150 ms on and 2850 ms in doze*
Power amplifier enabled		18	12	mA	Mote boot, see section 6.0
Power amplifier enabled			24	mA	TX, 5 ms maximum
Power amplifier disabled		7		mA	TX, 5 ms maximum
Reset			1.25	mA	\overline{RST} asserted
Operating temperatures	-40		+85	°C	
Maximum allowed temperature ramp during operation			8	°C/min	-40 °C to +85 °C
Operating relative humidity	10		90	% RH	Non-condensing

* The duration of doze time and “on” time is determined by the joinDutyCycle command in the mote serial API. Refer to the *SmartMesh IA-510 Mote Serial API Guide* for details.

Unless otherwise noted, Table 3 assumes V_{DD} is 3.0 V.

Table 3 Current Consumption

Parameter	Min	Typ	Max	Units	Comments
Transmit					
Power amplifier enabled		18		mA	
Power amplifier disabled		7		mA	
Receive		6		mA	

3.0 Electrical Specifications

Table 4 Device Load

Parameter	Min	Typ	Max	Units	Comments
Total capacitance			6	μF	V_{DD} to V_{SS}
Total inductance			4.9	μH	V_{DD} to V_{SS}

Unless otherwise noted, V_{DD} is 3.0 V and temperature is $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$.

Table 5 Digital I/O Type 1

Digital Signal	Min	Typ	Max	Units	Comments
V_{IL} (low-level input voltage)	-0.3		0.6	V	
V_{IH} (high-level input voltage)	$0.8 \times V_{DD}$		$V_{DD} + 0.3$	V	
V_{OL} (low-level output voltage)			0.4	V	
V_{OH} (high-level output voltage)	2.4			V	
Digital current*					
Output source (single pin)		3.7		mA	$25\text{ }^{\circ}\text{C}$
Output sink (single pin)		2.0		mA	$25\text{ }^{\circ}\text{C}$
Input leakage current		50		nA	$25\text{ }^{\circ}\text{C}$

* This current level guarantees that the output voltage meets V_{OH} and V_{OL} specifications above.

Table 6 Digital I/O Type 2

Digital Signal	Min	Typ	Max	Units	Comments
V_{IL} (low-level input voltage)	-0.3		0.6	V	
V_{IH} (high-level input voltage)	$0.8 \times V_{DD}$		$V_{DD} + 0.3$	V	
V_{OL} (low-level output voltage, multi-function I/O configured as output)	-0.3		0.6	V	$I_{OL} < 0.6\text{ mA}$, $85\text{ }^{\circ}\text{C}$
V_{OH} (high-level output voltage, multi-function I/O configured as output)	$V_{DD} - 0.6$		V_{DD}	V	$I_{OH} > -0.6\text{ mA}$, $85\text{ }^{\circ}\text{C}$
Digital current*					
Output source (single pin, multifunction I/O configured as output)		0.4		mA	$25\text{ }^{\circ}\text{C}$
Output sink (single pin, multifunction I/O configured as output)		0.6		mA	$25\text{ }^{\circ}\text{C}$
Input leakage current		50		nA	$25\text{ }^{\circ}\text{C}$

* This current level guarantees that the output voltage meets V_{OH} and V_{OL} specifications above.

Table 7 Digital I/O Type 3

Digital Signal	Min	Typ	Max	Units	Comments
V _{IL} (low-level input voltage)	-0.3		0.6	V	
V _{IH} (high-level input voltage)	2.0		V _{DD} + 0.3	V	
V _{OL} (low-level output voltage)			0.4	V	
V _{OH} (high-level output voltage)	V _{DD} - 0.2			V	
Digital current*					
Output source (single pin)		100		μA	25 °C
Output sink (single pin)		1.6		mA	25 °C
Input leakage current		50		nA	25 °C

* This current level guarantees that the output voltage meets V_{OH} and V_{OL} specifications above.

4.0 Radio

4.1 Detailed Radio Specifications

Table 8 Detailed Radio Specifications

Parameter	Min	Typ	Max	Units	Comments
Operating frequency	2.4000		2.4835	GHz	
Number of channels		15			
Channel separation		5		MHz	
Occupied channel bandwidth		2.7		MHz	At -20 dBc
Frequency Accuracy	-40		+40	ppm	
Modulation					IEEE 802.15.4 DSSS
Raw data rate		250		kbps	
Receiver operating maximum input level		0		dBm	
Receiver sensitivity		-92.5		dBm	At 50% PER, V _{DD} = 3 V, 25 °C
		-90		dBm	At 1% PER, V _{DD} = 3 V, 25 °C
Output power, conducted					
Power amplifier enabled		+8		dBm	V _{DD} = 3 V, 25 °C
Power amplifier disabled		-2		dBm	V _{DD} = 3 V, 25 °C
Range*					
Power amplifier enabled:					
Indoor [†]		100		m	25 °C, 50% RH, +2 dBi omni-directional antenna
Outdoor [†]		300		m	
Free space		1200		m	
Power amplifier disabled:					
Indoor [†]		25		m	
Outdoor [†]		200		m	
Free space		350		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.

[†] 1 meter above ground.

4.2 Antenna Specifications

A MMCX-compatible male connector is provided on board for the antenna connection. The antenna must meet specifications in Table 9. For a list of FCC-approved antennae, see section 10.1.2.

Table 9 Antenna Specifications

Parameter	Value
Frequency range	2.4 – 2.4835 GHz
Impedance	50 Ω
Maximum VSWR	3:1
Connector	MMCX*
* The M2510 can accommodate the following RF mating connectors: <ul style="list-style-type: none"> • 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, the antenna should be positioned vertically when installed.

5.0 Pinout

The M2510 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 M2510.

5.1 M2510 Pinout

The M2510 provides a bidirectional flow-controlled serial interface (see section 8.3 Settable I/O Modes).

Table 10 M2510 Pin Functions

Pin Number	Pin Name	Description	I/O Type	Direction	Pin State in Deep Sleep [†]
1	V _{SS}	Ground	Power	–	–
2	V _{DD}	Power	Power	–	–
3	KEY (no pin)	–	–	–	–
4	RX	UART Rx	2	In	–
5	TX	UART Tx	2	Out	V _{DD}
6	<i>Reserved</i>	No connect	–	–	–
7	$\overline{\text{MT_RTS}}$	UART active low mote ready to send	2	Out	V _{DD}
8	$\overline{\text{MT_CTS}}$	UART active low mote clear to send	1	Out	V _{DD}
9	$\overline{\text{SP_CTS}}$	UART active low serial peripheral clear to send	2	In	–
10	$\overline{\text{TIME}}$	Falling edge time request	2	In	–
11	Mode_pin_B	Selects between Mode 1 & Mode 3 operation	2	In	–
12	$\overline{\text{FLASH_P_EN}}$	Active low flash power enable	1	In*	–
13	<i>Reserved</i>	No connect	–	–	–
14	<i>Reserved</i>	No connect	–	–	–
15	<i>Reserved</i>	No connect	–	–	–
16	<i>Reserved</i>	No connect	–	–	–
17	SCK	SPI clock	3	In*	–
18	MOSI	SPI master out slave in serial data	3	In*	–

Pin Number	Pin Name	Description	I/O Type	Direction	Pin State in Deep Sleep [†]
19	MISO	SPI master in slave out serial data	3	Out*	V _{DD} **
20	KEY (no pin)	–	–	–	–
21	$\overline{\text{SPI_CS}}$	Active low flash chip select	3	In*	–
22	$\overline{\text{RST}}$	Active low reset	1	In	–

* The direction associated with the flash interface is defined when the device is held in reset and is intended solely for the use of in circuit programming of the device. Following reset, all inputs will become outputs and must not be driven externally.

** Weakly pulled to V_{DD}.

[†] Deep sleep is the lowest possible power state, with V_{DD} and GND connected. The mote microprocessor and radio are inactive, and the mote must be awakened using the /RST signal (for more information see the lowPowerSleep command in the *IA-510 Mote Serial API Guide*).

The $\overline{\text{RST}}$ input pin is internally pulled up and connecting it is optional. When driven active low, the mote is hardware reset until the signal is de-asserted. Refer to section 7.1 for timing requirements on the $\overline{\text{RST}}$ pin. Note that the mote may also be reset using the mote serial command (see the *SmartMesh IA-510 Mote Serial API Guide*).

The $\overline{\text{TIME}}$ input pin is optional, and must either be driven or pulled up with a 5.1 M Ω resistor. Unless noted otherwise, all signals are active low.

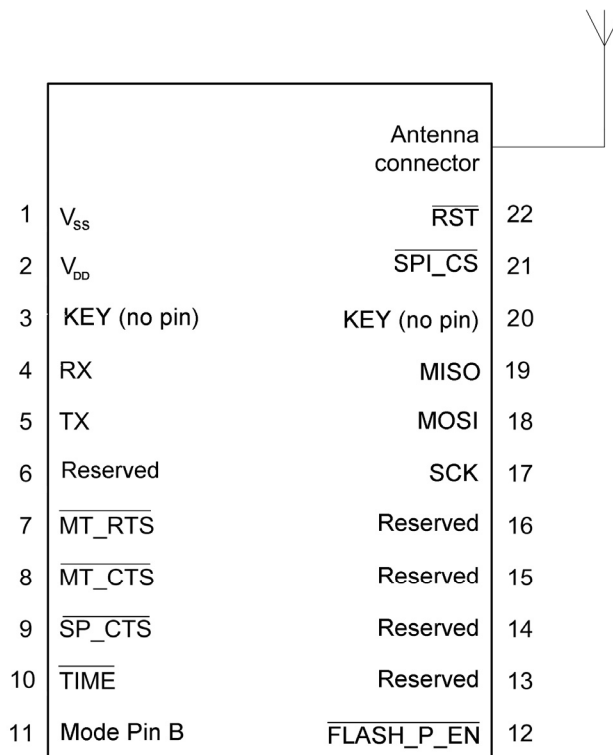


Figure 1 M2510 Package with Pin Labels

6.0 Power Supply Design

The M2510 can be sensitive to instantaneous power supply ramp rates between 20 V/ms and 60 V/ms as the supply ramps through the 200 mV to 2.2 V range. As a result, designs should avoid instantaneous power supply ramp rates that fall within the 20 V/ms to 60 V/ms range.

Care should be taken in cases where the mote inputs will be driven to logic level high. Refer to the *040-0067 SmartMesh IA-510 Mote Serial API Guide* for information on mote bring-up and power cycling.

7.0 Mote Boot Up

7.1 Power-on Sequence

The M2510 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 2 and specified in Table 11.

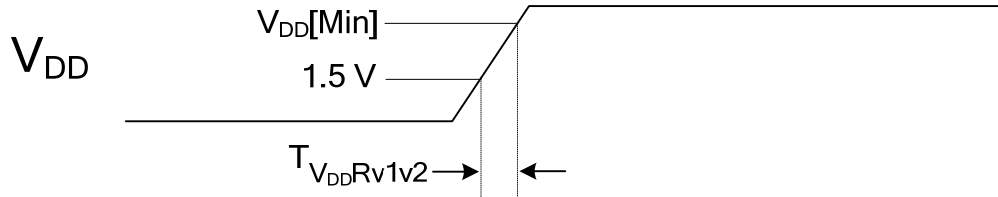


Figure 2 External Power Supply Timing Requirement

The following reset sequence (shown in Figure 3 and specified in Table 11) is required for external power supplies that fail to meet the requirement above.

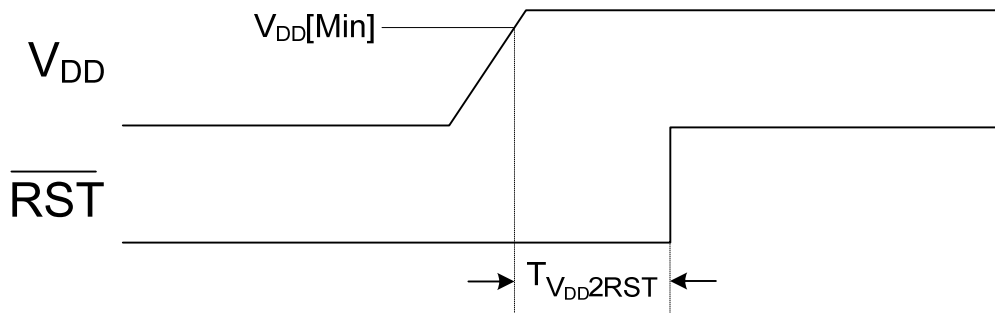


Figure 3 Power-on Sequence

Table 11 Power-on Sequence

Parameter	Min	Typ	Max	Units	Comments
$T_{V_{DD}2RST}$	125			μs	
$T_{V_{DD}Rv1v2}$			1	ms	
\overline{RST} pulse width	125			μs	Reset timing

7.2 Inrush Current

During power on, the mote can be modeled as a lumped impedance, as shown in Figure 4. With a source impedance (R_{src}) of 1Ω , the inrush current on the mote appears as shown in Figure 5.

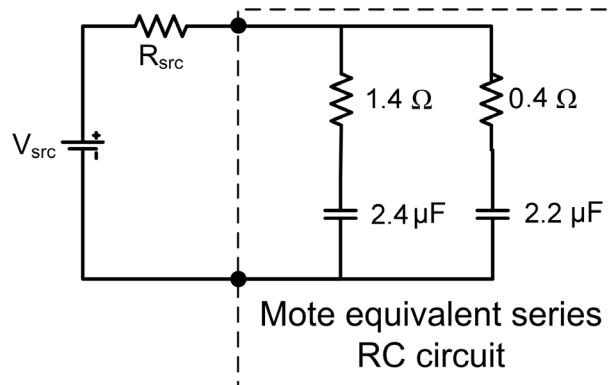


Figure 4 M2510 Equivalent Series RC Circuit

V_{DD} Inrush Current (Power On with Supply Impedance of 1 Ohm)

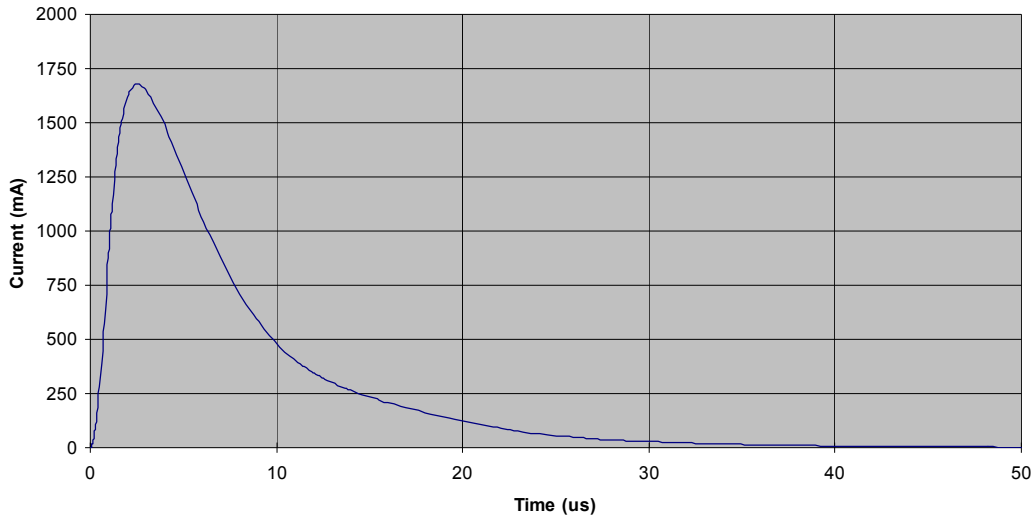


Figure 5 V_{DD} Inrush Current

7.3 Mote Boot Sequence

Following the negation of \overline{RST} the mote completes its boot-up process by loading and decrypting the application image and loading the operating parameters. During the boot-up process, the mote’s output signals are not actively driven and the input signals are ignored.

The M2510 supports two mote boot modes: standard boot (M2510-1) and low current boot (M2510-2). Standard boot is optimized for quick boot time. Low current boot lowers the average current but at a longer boot time. The mote boot mode is determined by the software executable loaded onto the M2510.

7.3.1 Standard Boot

When the M2510-1 operates in standard boot, the time between the mote power up and the serial interface availability is defined as t_{boot_delay} and specified in Table 12 Standard Boot Sequence below. The peak current during mote boot is specified under Peak Current in Section 2.0 Normal Operating Conditions.

Table 12 Standard Boot Sequence

Parameter	Min	Typ	Max	Units	Comments
t_{boot_delay}			6	s	The time between mote power up and serial interface availability.

7.3.2 Low Current Boot

When operating in low current boot, the M2510-2 lowers average current consumption by spreading the boot operation over a longer time. This mode is intended to support systems with supplies having a maximum DC current less than the peak current required by the M2510-2. These systems must store enough charge to maintain the supply through the M2510-2’s peak current consumption. For more information, contact your Dust Networks applications engineer.

7.4 Serial Interface Boot Up

7.4.1 M2510 Serial Interface Boot Up

Upon M2510 power up, the $\overline{MT_CTS}$ line is high (inactive). The M2510 serial interface boots within t_{boot_delay} (see 7.3 Mote Boot Sequence) of the mote powering up, at which time the M2510 will transmit an HDLC boot event packet. Note that full handshake is in effect and is required to receive this packet.

8.0 Interfaces

8.1 Reset Pin

The /RST input pin is internally pulled up. Connecting it is optional; however, in applications operating in the presence of EMI, /RST should be actively driven high. When driven low, the mote hardware is in reset. Note that the mote may also be reset using the mote reset command (0x08). For requirements on reset timing, see section 7.1.

The M2510 is a highly sophisticated device and Dust Networks recommends doing resets gracefully. If the device is in the network, a disconnect command (0x07) should be issued before the /RST signal is asserted. This will result in the device rebooting and sending the “boot” event.

The /RST signal may then be asserted since the device is not in the network.

Refer to the *SmartMesh IA-510 M2510 Integration Guide* for recommendations on how to connect to the /RST pin, including voltage supervision. For detailed information about mote serial commands, refer to the *SmartMesh IA-510 Mote Serial API Guide*.

8.2 Timestamps

The M2510 has the ability to deliver network-wide synchronized timestamps. The M2510 sends a time packet (as described in the *SmartMesh IA-510 Mote Serial API Guide*) through its serial interface when one of the following occurs:

- Mote receives an HDLC request to read time
- The $\overline{\text{TIME}}$ signal is asserted

The $\overline{\text{TIME}}$ pin is optional and has the advantage of being more accurate. The value of the timestamp is taken within approximately 1 ms of receiving a $\overline{\text{TIME}}$ signal activation. If the HDLC request is used, due to packet processing the value of the timestamp may be captured several milliseconds after receipt of the packet. Refer to the *IA-510 Mote Serial API Guide* for more information on timestamps.

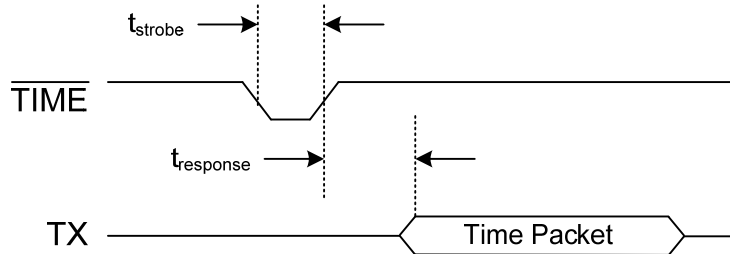


Figure 7 Operation of $\overline{\text{TIME}}$ Pin

Table 14 $\overline{\text{TIME}}$ Timing Values

Variable	Description	Min	Max	Units
t_{strobe}	$\overline{\text{TIME}}$ strobe pulse width	125		μs
t_{response}	Negation of Time strobe to start of time packet		100	ms

8.3 Settable I/O Modes

The M2510 offers a choice of two I/O modes. The functionality of the interface will be determined by the setting of Mode pin B whose pinout is described in 5.0 Pinout.

Table 15 Mode Pin Settings

Pin	Mode 1	Mode 3
Mode pin B	Externally tied low	Externally tied high

All modes provide a means of transmitting and receiving serial data through the wireless network, as well as a command interface that provides synchronized time stamping, local configuration, and diagnostics.

Mode 1 implements an 8-bit, no parity, 9600 bps baud three, four or five-signal serial interface with bidirectional packet-level flow control operating at 9600 bps. In certain OEM designs, one or two of the serial handshake signals may be optional for reduced pin count, as described in Table 16.

Mode 3 implements an 8-bit, no parity, 115.2 kbps baud five-signal serial interface with bidirectional packet-level flow control and byte-level flow control in the mote-to-microprocessor direction only.

8.3.1 Mode 1: Three/Four/Five-signal Serial Interface (9600 bps)

The M2510 mode 1 provides a three, four, or five-signal serial interface that is optimized for low-powered embedded applications (and in certain designs may provide a low pin count serial solution). The mode 1 serial interface is comprised of the data pins (TX, RX) as well as handshake pins ($\overline{MT_RTS}$, $\overline{MT_CTS}$, $\overline{SP_CTS}$) used for bidirectional flow control. The $\overline{MT_RTS}$ signal is ideal for designs where the microprocessor requires extra time to prepare to receive a packet (for example, the OEM microprocessor sleeps periodically, but requires a wake-up signal prior to receiving a packet). Refer to Table 16 for information on each handshake pin, including details on which pins are optional.

Table 16 Mode 1 Pin Usage

Pin	I/O	Usage
RX	Input	Serial data moving from the microprocessor to the mote.
TX	Output	Serial data moving from the mote to the microprocessor.
$\overline{MT_RTS}$	Output	$\overline{MT_RTS}$ provides a mechanism to wake up the microprocessor in order to receive a packet. This signal is asserted when the mote is ready to send a serial packet. The signal stays low until the $\overline{SP_CTS}$ signal from the microprocessor is detected low by the mote (indicating readiness to receive a packet) or the $t_{\overline{MT_RTS} \text{ to } \overline{SP_CTS}}$ timeout defined in Section 8.3.3 expires. If $\overline{MT_RTS}$ times out, it will de-assert $\overline{MT_RTS}$, wait for $t_{\overline{MT_RTS} \text{ retry}}$ and then re-assert $\overline{MT_RTS}$ to attempt to send the serial packet again (see Figure 11). $\overline{MT_RTS}$ may be ignored by the microprocessor only if $\overline{SP_CTS}$ always stays low.
$\overline{SP_CTS}$	Input	$\overline{SP_CTS}$ provides packet-level flow control for packets transferred from the mote to the microprocessor. When the microprocessor is capable of receiving a packet it should assert the $\overline{SP_CTS}$ signal. $\overline{SP_CTS}$ may be externally tied low (reducing pin count) only if the microprocessor is always ready to receive a serial packet.
$\overline{MT_CTS}$	Output	$\overline{MT_CTS}$ provides packet-level flow control for packets transferred from the microprocessor to the mote that are destined for transfer over the network. Upon reset, following boot the mote will negate $\overline{MT_CTS}$ until the mote establishes a wireless network connection. During operation, the mote will negate $\overline{MT_CTS}$ if the mote does not have sufficient buffering to accept another packet. $\overline{MT_CTS}$ will also remain high if the mote is not part of the network. The microprocessor must check that the $\overline{MT_CTS}$ 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 $\overline{MT_CTS}$ state. (For a list of local commands, see the <i>SmartMesh IA-510 Mote Serial API Guide</i> .)
\overline{TIME}	Input	The \overline{TIME} pin can be used for triggering a timestamp packet. Its usage is optional.

8.3.2 Mode 3: Five-signal Serial Interface (115.2 kbps)

The M2510 mode 3 provides a five-signal serial interface with byte-level flow control on transfers from the mote to the microprocessor. The mode 3 serial interface is comprised of the data pins (TX, RX) as well as handshake pins ($\overline{MT_RTS}$, $\overline{MT_CTS}$, $\overline{SP_CTS}$) used for bidirectional flow control. The $\overline{MT_RTS}$ signal is ideal for designs where the microprocessor requires extra time to prepare to receive a packet (for example, the OEM microprocessor sleeps periodically, but requires a wake-up signal prior to receiving a packet). In order to support 115.2 kbps the microprocessor must include two framing bytes, 0x7E, at the start of each packet sent from the microprocessor to the mote. Refer to Table 17 for information on each handshake pin, including details on which pins are optional.

Table 17 Mode 3 Pin Usage

Pin	I/O	Usage
RX	Input	Serial data moving from the microprocessor to the mote.
TX	Output	Serial data moving from the mote to the microprocessor.
$\overline{\text{MT_RTS}}$	Output	$\overline{\text{MT_RTS}}$ provides a mechanism to wake up the microprocessor in order to receive a packet. This signal is asserted when the mote is ready to send a serial packet. The signal stays low until the $\overline{\text{SP_CTS}}$ signal from the microprocessor is detected low by the mote (indicating readiness to receive a packet) or the $t\overline{\text{MT_RTS}}$ to $\overline{\text{SP_CTS}}$ timeout defined in Section 8.3.3 expires. If $\overline{\text{MT_RTS}}$ times out, it will de-assert $\overline{\text{MT_RTS}}$, wait for $t\overline{\text{MT_RTS}}$ retry and then re-assert $\overline{\text{MT_RTS}}$ to attempt to send the serial packet again (see Figure 11).
$\overline{\text{SP_CTS}}$	Input	$\overline{\text{SP_CTS}}$ provides byte-level flow control for packets transferred from the mote to the microprocessor. When the microprocessor is capable of receiving a packet it should assert the $\overline{\text{SP_CTS}}$ signal. In mode 3 byte-level flow control is achieved by having the microprocessor negate and then reassert the $\overline{\text{SP_CTS}}$ signal following the receipt of each byte. The mote will begin transmission of the next byte after detecting the reassertion of $\overline{\text{SP_CTS}}$.
$\overline{\text{MT_CTS}}$	Output	$\overline{\text{MT_CTS}}$ provides packet-level flow control for packets transferred from the microprocessor to the mote that are destined for transfer over the network. Upon reset, following boot the mote will negate $\overline{\text{MT_CTS}}$ until the mote establishes a wireless network connection. During operation, the mote will negate $\overline{\text{MT_CTS}}$ if the mote does not have sufficient buffering to accept another packet. $\overline{\text{MT_CTS}}$ will also remain high if the mote is not part of the network. The microprocessor must check that the $\overline{\text{MT_CTS}}$ 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 $\overline{\text{MT_CTS}}$ state. For a list of local commands, see the SmartMesh IA-510 Mote Serial API Guide.
$\overline{\text{TIME}}$	Input	The $\overline{\text{TIME}}$ pin can be used for triggering a timestamp packet. Its usage is optional.

8.3.3 UART AC Timing

Table 18 UART Timing Values

Variable	Description	Min	Max	Units
$t\overline{\text{RX_BAUD}}$	Deviation from baud rate	-2	+2	%
$t\overline{\text{RX_STOP}}$	Number of stop bits (9600 bps)	1		bit period
$t\overline{\text{RX_STOP}}$	Number of stop bits (115.2 kbps)	1.5		bit period
$t\overline{\text{TX_BAUD}}$	Deviation from baud rate	-1	+1	%
$t\overline{\text{TX_STOP}}$	Number of stop bits	1		bit period
$t\overline{\text{SP_CTS}}$ to $\overline{\text{MT_RTS}}$	Assertion of $\overline{\text{SP_CTS}}$ to negation of $\overline{\text{MT_RTS}}$	0	10	ms
$t\overline{\text{MT_RTS}}$ to $\overline{\text{SP_CTS}}$	Assertion of $\overline{\text{MT_RTS}}$ to assertion of $\overline{\text{SP_CTS}}$		500	ms
$t\overline{\text{MT_RTS}}$ retry	Time from a $\overline{\text{MT_RTS}}$ timeout to the retry.		500	ms
$t\overline{\text{SP_CTS}}$ to TX	Assertion of $\overline{\text{SP_CTS}}$ to start of byte	0	10	ms
$t\overline{\text{TX}}$ to $\overline{\text{SP_CTS}}$	Start of byte to negation of $\overline{\text{SP_CTS}}$	1		bit period
$t\overline{\text{SP_CTS}}$ ack PW	Negation pulse width of $\overline{\text{SP_CTS}}$	500		ns
$t\text{diag_ack_timeout}^*$	The mote responds to all requests within this time.		125	ms
$t\text{interbyte_timeout}$	Falling edge of TX to falling edge of $\overline{\text{SP_CTS}}$ (Mode 3 only)		7.1	ms
$t\text{interpacket_delay}$	The sender of an HDLC packet must wait at least this amount of time before sending another packet	20		ms

* For more information about supported requests and details on when $t\text{diag_ack_timeout}$ applies, refer to the *SmartMesh IA-510 Mote Serial API Guide*.

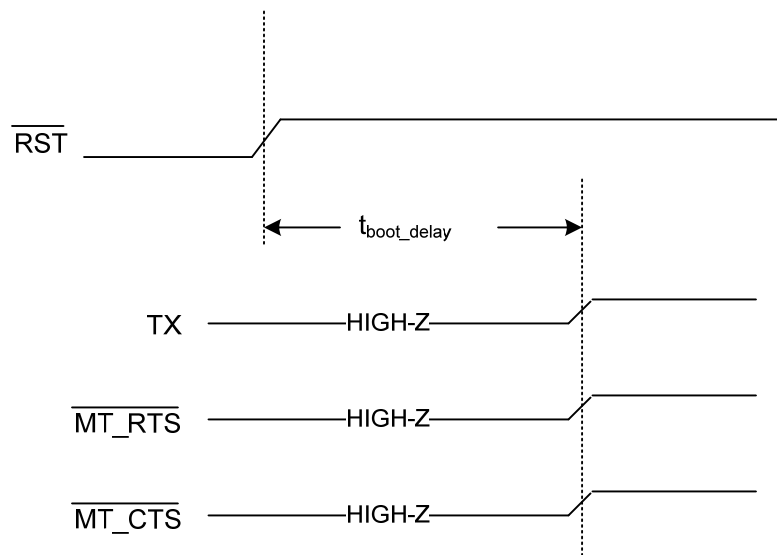


Figure 8 Power-on Sequence (see section 7.3 for value of $t_{\text{boot_delay}}$)

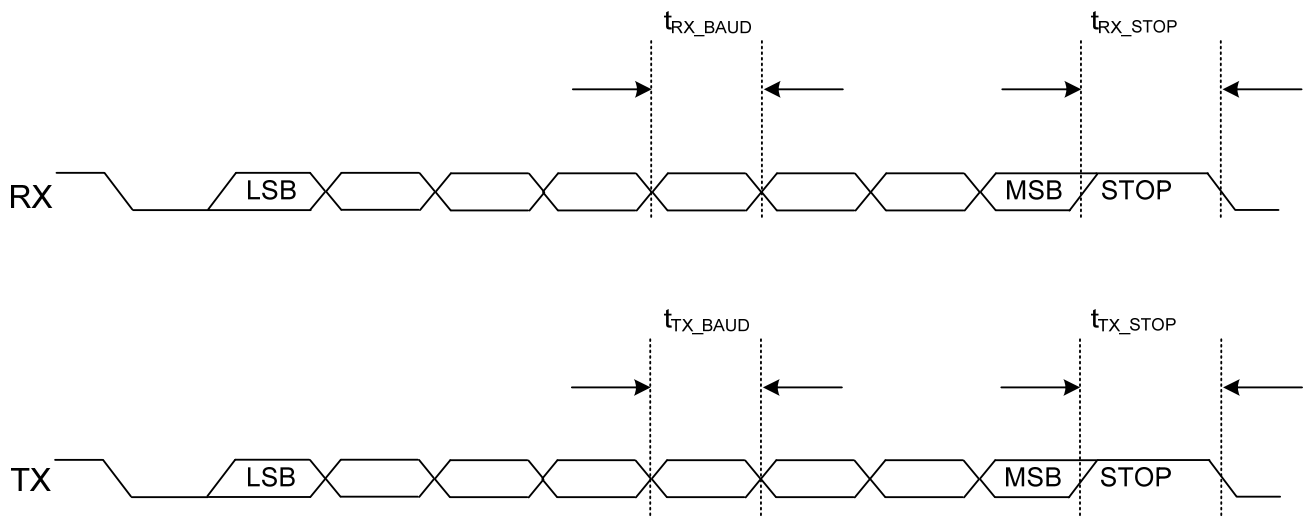


Figure 9 Byte-level Timing

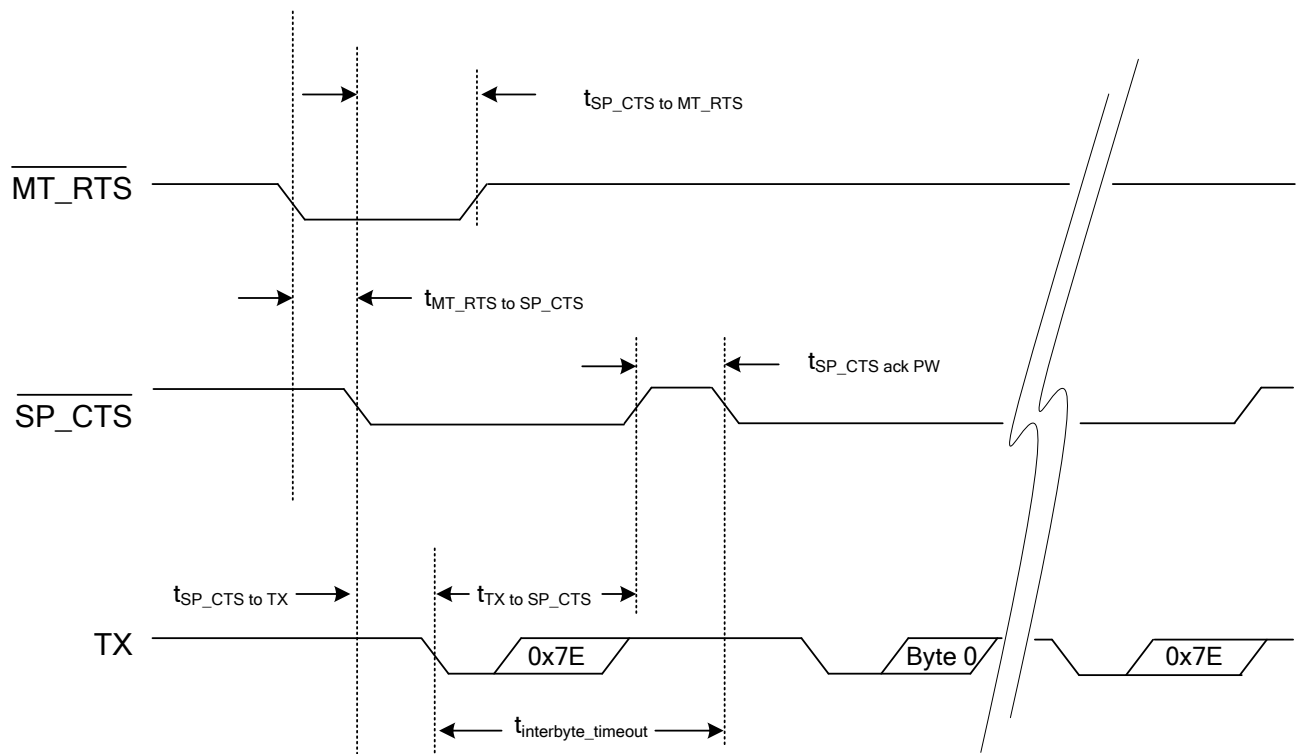


Figure 10 Flow Control Timing

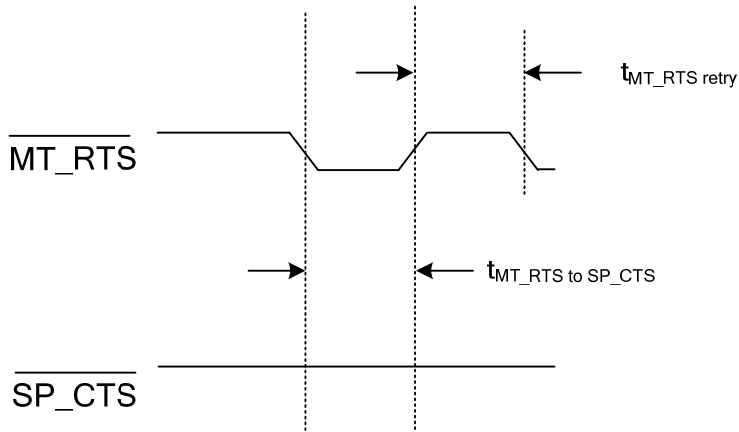


Figure 11 $\overline{\text{MT_RTS}}$ Timeout Behavior

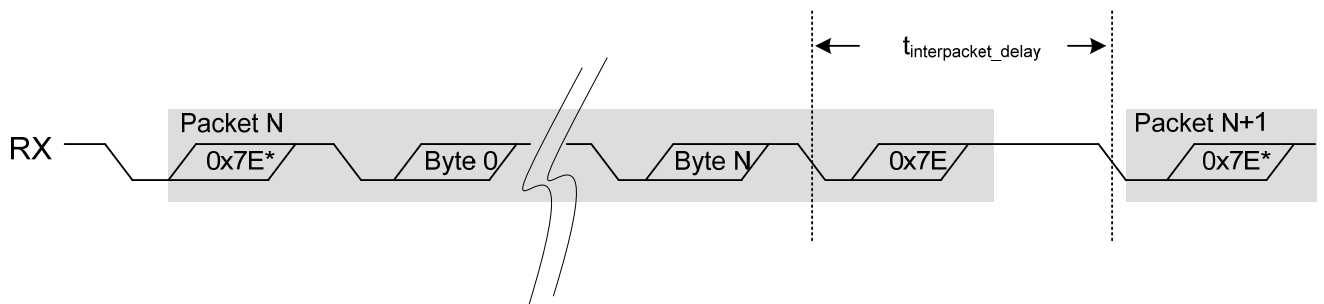


Figure 12 Packet Timing

* For Mode 3 (115.2 kbps) the framing byte, 0x7E, must be repeated at the start of each packet set to the M2510.

8.4 Mote Serial API

The M2510 offers a comprehensive application programming interface (API) that provides full programmatic access to control the mote, monitor its status (such as battery charge and network status), and provide access to the wireless mesh network. Refer to the *SmartMesh IA-510 Mote Serial API Guide* for more information.

8.5 Temperature Sensor

The M2510 has an on-board temperature sensor. The temperature readings are available locally through the mote serial API and through the network at the manager via the XML or serial API. For more information, refer to the *SmartMesh IA-510 Mote Serial API Guide*, *SmartMesh IA-510 Manager Serial API Guide*, or *SmartMesh IA-510 XML API Guide*.

Table 19 Temperature Sensor

Parameter	Min	Typ	Max	Units	Comments
Sensor input range	-40		85	°C	
Accuracy		±7		°C	

9.0 Packaging Description

9.1 Mechanical Drawing

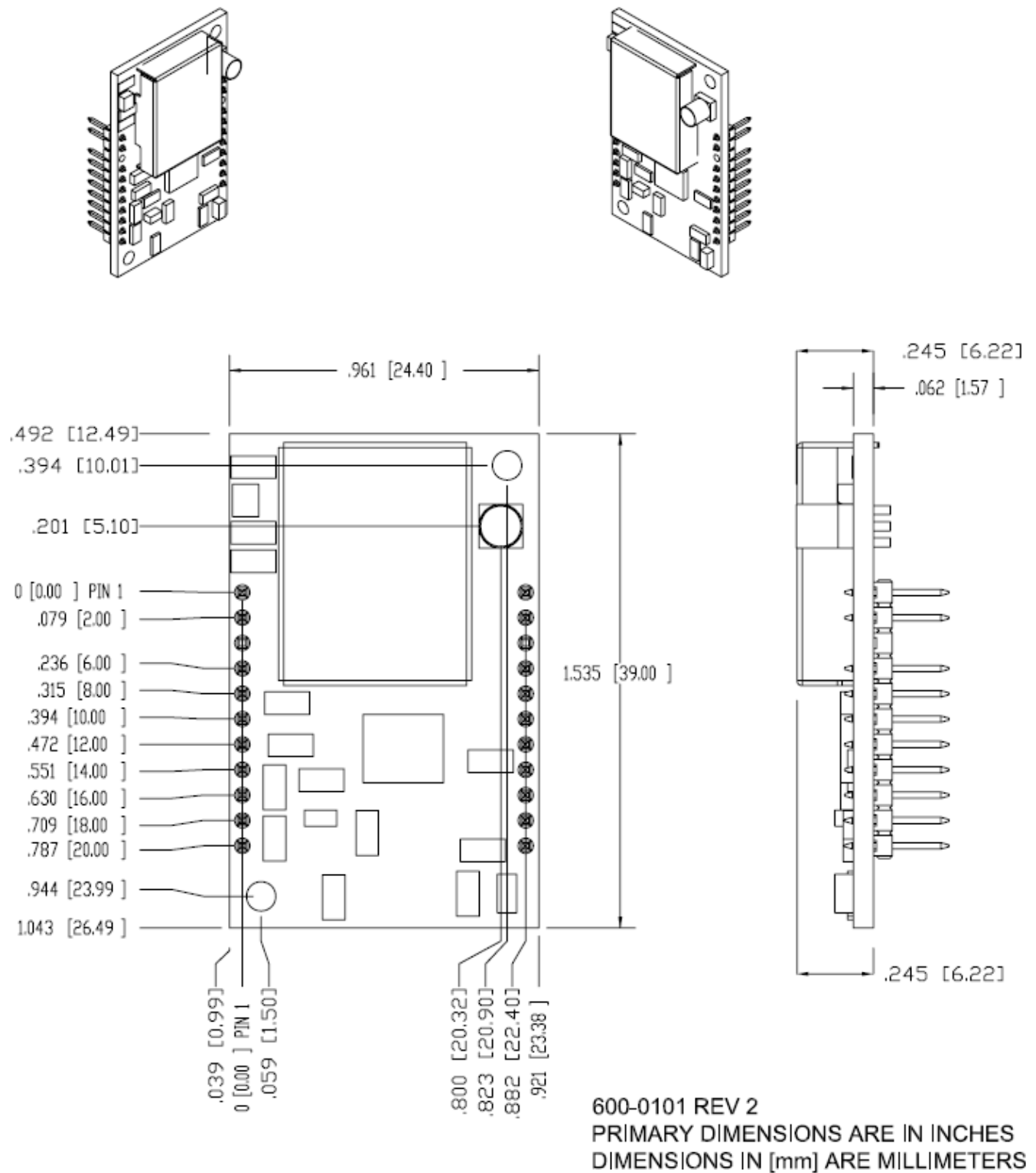


Figure 13 M2510 Mote Mechanical Drawing

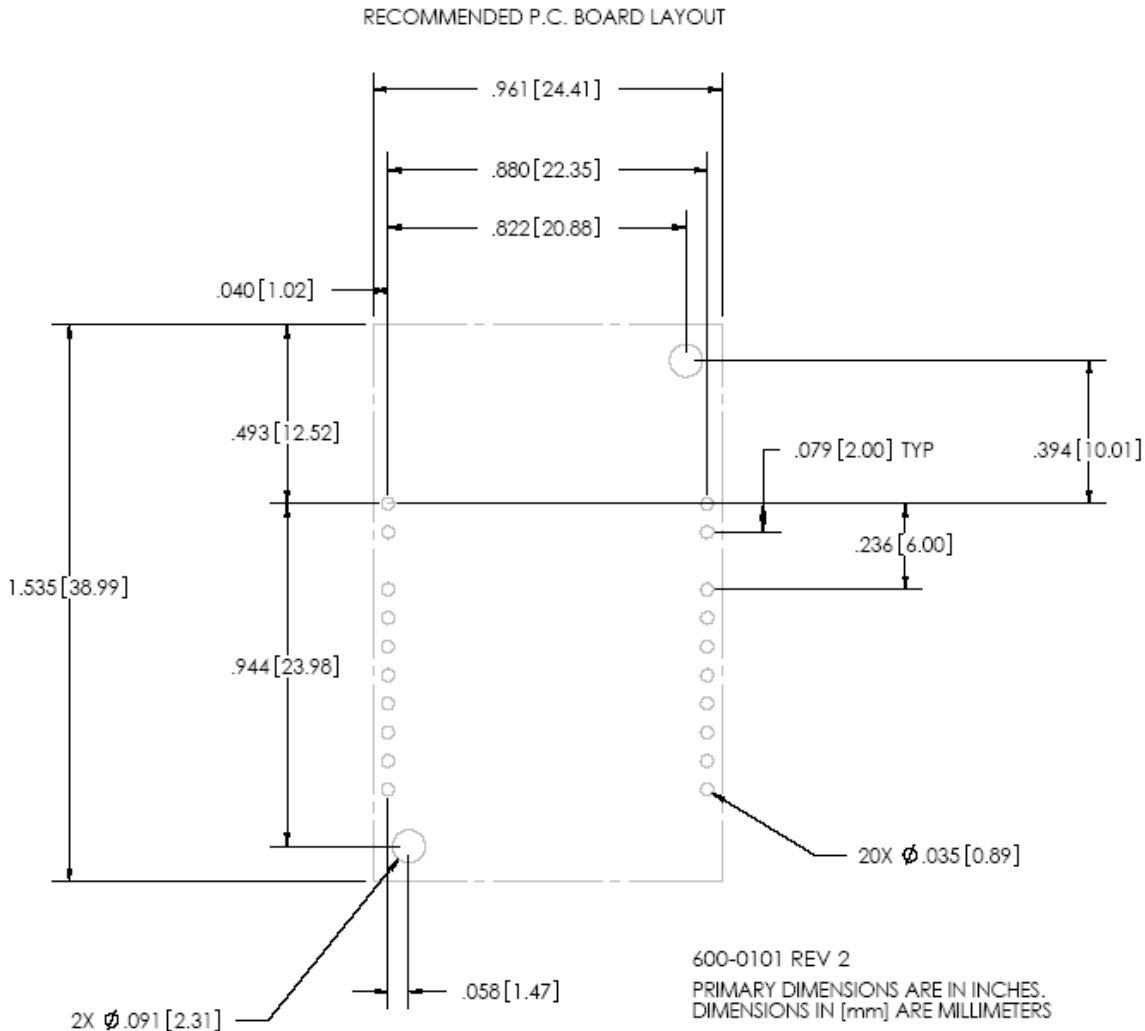


Figure 14 M2510 Mote Footprint

9.2 Soldering Information

The M2510 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.

10.0 Regulatory and Standards Compliance

10.1 FCC Compliance

10.1.1 FCC Testing

The M2510 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 M2510 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 as described in 10.1.3 below.
2. The antenna must be electrically identical to the FCC-approved antenna specifications for the M2510 as described in 10.1.2, with the exception that the gain may be lower than specified in Table 20.
3. The device integrating the M2510 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 M2510 mote, per FCC rules and regulations, CFR Title 47, Part 15, Subpart B. See FCC rules for specifics on requirements for declaration of conformity.

10.1.2 FCC-approved Antennae

The following are FCC-approved antenna specifications for the M2510.

Table 20 FCC-approved Antenna Specifications for the M2510

Gain	Type	Pattern	Polarization	Frequency	Connector
+2 dBi maximum	Dipole	Omni-directional	Vertical	2.4-2.4835 GHz	MMCX

10.1.3 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-M2140*

Or

Contains FCC ID: *SJC-M2140*

10.2 Industry Canada (IC) Compliance

10.2.1 IC Testing

The M2510 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.

10.2.2 IC-approved Antennae

The M2510 is designed to operate with antennas meeting the specifications shown in Table 21. Antennas not meeting these specifications are strictly prohibited for use with the M2510. The required antenna impedance is 50 Ohms. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Table 21 IC-approved Antenna Specifications for the M2510

Gain	Type	Pattern	Polarization	Frequency	Connector
+2 dBi maximum	Dipole	Omni-directional	Vertical	2.4-2.4835 GHz	MMCX

10.2.3 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-M2140*

10.3 CE Compliance

10.3.1 Declaration of Conformity

We, Dust Networks, of 30695 Huntwood Ave, Hayward, CA 94544 USA, declare under our sole responsibility that our product, SmartMesh IA-510 M2510, and in combination with our accessories, to which this declaration relates is in conformity with the appropriate standards ETSI EN 300 328, ETSI EN 301 489-17 and EN 60950, following the provisions of Radio Equipment and Telecommunication Terminal Equipment directive 99/5/EC with requirements covering EMC directive 89/336/EEC, and Low voltage directive 73/23/EEC.

10.3.2 European Compliance

If the M2510 mote is incorporated into a product, the manufacturer must ensure compliance of the final product to the European harmonized EMC and low-voltage/safety standards. A Declaration of Conformity must be issued for each of these standards and kept on file as described in Annex II of the R&TTE Directive. Furthermore, the manufacturer must maintain a copy of this M2510 user documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user manual. If any of these specifications are exceeded in the final product, a submission must be made to a notified body for compliance testing to all required standards.

10.3.3 OEM Labeling Requirements

The 'CE' marking must be affixed to a visible location on the OEM product. The CE mark shall consist of the initials "CE" taking the following form:

If the CE marking is reduced or enlarged, the proportions given in the drawing below must be respected.

The CE marking must have a height of at least 5 mm except where this is not possible on account of the nature of the apparatus.

The CE marking must be affixed visibly, legibly, and indelibly.

Furthermore, since the usage of the 2400 – 2483.5 MHz band is not harmonized throughout Europe, the Restriction sign must be placed to the right of the 'CE' marking as shown below. See the R&TTE Directive, Article 12 and Annex VII for more information.

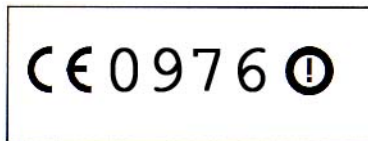


Figure 15 CE Label Requirements

10.3.4 Restrictions

Norway prohibits operation near Ny-Alesund in Svalbard. More information can be found at the Norway Posts and Telecommunications site (www.npt.no).

10.4 Compliance to Restriction of Hazardous Substances (RoHS)

Restriction of Hazardous Substances (RoHS) is a directive that places maximum concentration limits on the use of cadmium (Cd), lead (Pb), hexavalent chromium (Cr+6), mercury (Hg), Polybrominated Biphenyl (PBB) and Polybrominated Diphenyl Ethers (PBDE). Dust Networks is committed to meeting the requirements of the European Community directive 2002/95/EC.

This product has been specifically designed to utilize RoHS compliant materials and to eliminate, or reduce, the use of restricted materials to comply with 2002/95/EC.

The Dust Networks RoHS compliant design features include:

- RoHS compliant solder for solder joints
- RoHS compliant base metal alloys
- RoHS compliant precious metal plating
- RoHS compliant cable assemblies and connector choices

10.5 Industrial Environment Operation

The M2510 is designed to meet the specifications of a harsh industrial environments which includes:

- **Shock and Vibration**—The M2510 complies with high vibration pipeline testing, as specified in IEC 60770-1.
- **Temperature Extremes**—The M2510 is designed for industrial storage and operational temperature range of –40 °C to +85 °C.

10.6 Encryption Cipher

The M2510’s 128-bit Advanced Encryption Standard (AES) cipher has been certified compliant to the United States National Institute of Standards and Technology (NIST) FIPS-197 (NIST certificate number, AES: 1437). To view the FIPS-197 validation list, go to: <http://csrc.nist.gov/groups/STM/cavp/documents/aes/aesval.html>

11.0 Related Documentation

- *SmartMesh IA-510 M2510 Integration Guide*
- *SmartMesh IA-510 Mote Serial API Guide*

12.0 Ordering Information

This section explains Dust Networks’ order code format. The product order code specifies the model number, software code, production status, and any special instructions for the product. Table 22 describes the order code options. *Note that not all options are valid for every product.* Please contact your Dust Networks Sales Representative for specific product order code information.

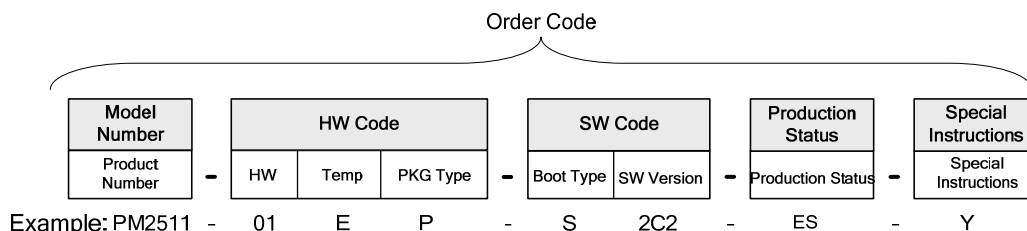


Table 22 Order Code Descriptions

Code Type	Description
Product Number	Product number
HW	Hardware revision
Temp	Temperature: C = Commercial E = Extended industrial H = High temperature industrial Z = Software only order
PKG Type	Package type: Q = QFN L = LGA P = PCA E = Packaged products K = Development or evaluation kit Z = Software only order
Boot Type	Boot type: S = Standard boot L = Low-current boot Z = Hardware only order
SW Version	Software version
Production Status	ES = Engineering sample Empty = Production
Special Instructions	Y = Special instructions Empty = No special instructions

Contact Information:

Dust Networks

30695 Huntwood Ave.

Hayward, CA 94544

Toll-Free Phone: 1 (866) 289-3878

Website: www.dustnetworks.com

Email: sales@dustnetworks.com

Trademarks

SmartMesh-XT, SmartMesh-XD, SmartMesh IA-510, mesh-to-the-edge, and Mote-on-Chip are trademarks of Dust Networks, Inc. The Dust Networks logo, Dust, Dust Networks, and SmartMesh are registered trademarks of Dust Networks, Inc. All third-party brand and product names are the trademarks of their respective owners and are used solely for informational purposes.

Copyright

This documentation is protected by United States and international copyright and other intellectual and industrial property laws. It is solely owned by Dust Networks, Inc. and its licensors and is distributed under a restrictive license. This product, or any portion thereof, may not be used, copied, modified, reverse assembled, reverse compiled, reverse engineered, distributed, or redistributed in any form by any means without the prior written authorization of Dust Networks, Inc.

RESTRICTED RIGHTS: Use, duplication, or disclosure by the U.S. Government is subject to restrictions of FAR 52.227-14(g) (2)(6/87) and FAR 52.227-19(6/87), or DFAR 252.227-7015 (b)(6/95) and DFAR 227.7202-3(a), and any and all similar and successor legislation and regulation.

Disclaimer

This documentation is provided “as is” without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for a particular purpose.

This documentation might include technical inaccuracies or other errors. Corrections and improvements might be incorporated in new versions of the documentation.

Dust Networks does not assume any liability arising out of the application or use of any products or services and specifically disclaims any and all liability, including without limitation consequential or incidental damages.

Dust Networks products are not designed for use in life support appliances, devices, or other systems where malfunction can reasonably be expected to result in significant personal injury to the user, or as a critical component in any life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness. Dust Networks customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify and hold Dust Networks and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Dust Networks was negligent regarding the design or manufacture of its products.

Dust Networks reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products or services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to Dust Network's terms and conditions of sale supplied at the time of order acknowledgment or sale.

Dust Networks does not warrant or represent that any license, either express or implied, is granted under any Dust Networks patent right, copyright, mask work right, or other Dust Networks intellectual property right relating to any combination, machine, or process in which Dust Networks products or services are used. Information published by Dust Networks regarding third-party products or services does not constitute a license from Dust Networks to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from Dust Networks under the patents or other intellectual property of Dust Networks.

© Dust Networks, Inc. 2007, 2008, 2009, and 2010. All Rights Reserved.

Document Number: 020-0037 rev 4 IA-510 (I) M2510 Datasheet

Last Revised: August 20, 2010

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.