SmartMesh® LM2610

2.4 GHz Ultra Low-power Embedded Network Manager User's Guide

Product Description—LM2610

The LM2610 ultra low-power embedded network manager is ideal for small, remote wireless network applications that require both motes and the network manager to operate on battery or solar power. The LM2610 combines Dust Networks' robust, Intelligent Networking Platform and industry-leading low-power radio technology in an easy-to-integrate embedded subsystem. The ultra low-power LM2610 is tailored for use in battery and solar powered gateways and controllers, and enables the deployment of low-power wireless sensor networks that deliver proven performance in the face of harsh RF and environmental conditions, enabling unattended operation for years at a time. Sophisticated network management algorithms deliver dynamic network optimization and intelligent routing to achieve carrier class reliability, lower latency, and deterministic power management. Additionally, the embedded network manager offers a comprehensive serial API to deliver rich and flexible functionality without complex coding. This API also provides full visibility and control over network configuration, security administration, network status, and performance statistics. The network-ready ultra low-power embedded manager enables OEMs to integrate advanced wireless sensor networking intelligence into monitoring and control solutions with low risk and rapid time-to-market.

Key Features

Ultra-Low Power Operation

- Low power consumption enables the manager to operate in solar or battery powered applications
- Ideal for small, remote wireless network applications

Intelligent Network Management

- Dynamic network optimization—maintains network health and provides deterministic power management
- Intelligent routing—lowers latency, reduces network power consumption and eliminates in-network collisions
- Enables >99.9% network reliability even in the most challenging industrial environments

Global Market Solution

- IEEE 802.15.4-certified radio operates on 2.4 GHz global license-free band
- Configurable radio output—meets RF emission limits for different regions with a single product
- Modular RF certifications pending for FCC, IC, CE

Fast and Low Risk Integration

- Comprehensive APIs deliver flexible functionality without complex coding
- Fully integrated and certified RF capabilities—simply add an antenna

Table of Contents

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.

Table 1 Absolute Maximum Ratings

Parameter	Min	Typ	Max	Units	Comments
Supply voltage	–0.3		3.6	V	
Voltage on Input Pins	–0.3		3.6	V	
Input RF level			10	dBm	Input power at antenna connector
Storage temperature range	–40		+85	°C	
VSWR of antenna			3:1		
ESD protection					
Antenna connector			±250	V	HBM
All other connectors			±TBD	kV	HBM
			±TBD	V	CDM
All voltages are referenced to V_{SS}					

Caution! This is an ESD sensitive device. Use proper ESD handling procedures when working with the device to prevent permanent damage.

2.0 Normal Operating Conditions

Table 2 Normal Operating Conditions

Parameter	Min	Typ	Max	Units	Comments
Operational supply voltage range (between V_{DD} and V_{SS})	3.0	3.3	3.6	V	This includes noise and load regulation. During power on, it is essential that the maximum V_{DD} rise time defined in section **Error! Reference source not found.** is met.
Voltage supply noise			100	mV_{p-p}	50 Hz–50 MHz
Peak current			TBD	mA	
Average current		TBD		mA	+3.3V, 25 °C
Operating temperature range	–40		+85	°C	
Maximum allowed temperature ramp during operation			8	°C/min	–40 °C to +85 °C
Operating relative humidity	10		95	% RH	Non-condensing
The specifications listed are for the power supply connected to V_{DD} and V_{SS} and apply over the operating temperature range unless otherwise specified.					

3.0 Electrical Specifications

I/O specifications are given below for each I/O level type given in the board-to-board connector tables in sections 4.1 and 4.2.1. Unless otherwise noted, supply voltage is 3.3 V and temperature range is –40 °C to +85 °C.

3.1 Radio

3.1.1 Radio Specifications

Table 3 Radio Specifications

Parameter	Min	Typ	Max	Units	Comments
Frequency band	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 input level		0		dBm	
Receiver sensitivity		TBD TBD		dBm dBm	At 50% PER, V_{DD} = 3 V, 25 °C At 1% PER, V_{DD} = 3 V, 25 °C, (inferred by 50% PER measurement)
Output power, conducted Power amplifier enabled: At 25 °C Power amplifier disabled: At 25 °C		 +8 –2		 dBm dBm	
Range* Power amplifier enabled: Indoor Outdoor Power amplifier disabled: Indoor Outdoor		 100 300 25 200		 m m m m	25 °C, 50% RH, 1 meter above ground, +2 dBi omnidirectional antenna

* 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.

3.1.2 Antenna Specifications

A MMCX-compatible jack receptacle is provided on board for the antenna connection. For antenna location, refer to the mechanical drawing in section 5.1. The antenna must meet specifications in Table 4. For a list of antennae pre-approved for RF certification, see section 6.1.2.

Table 4 Antenna Specifications

Parameter	Value
Frequency range	2.4–2.4835 GHz
Impedance	50 Ω
Gain LM2610-1	 +2 dBi maximum
Pattern	Omni-directional
Maximum VSWR	3:1
Connector	MMCX*
* The LM2610 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 LM2610 is placed inside an enclosure, the antenna should be mounted such that the radiating portion of the antenna protrudes from the enclosure, and connected using a MMCX connector on a coaxial cable. For optimum performance, allow the antenna to be positioned vertically when installed.

4.0 Interfaces

4.1 Hardware Interfaces

Table 5 Hardware Interface Summary

Port	Description	Pins
Serial	UART 6-pin	$\overline{\text{RTS\_T}}$, $\overline{\text{CTS\_T}}$, TX, $\overline{\text{RTS\_R}}$, $\overline{\text{CTS\_R}}$, RX, VSS
Reset	Active low reset input	$\overline{\text{RST}}$
MuP JTAG	Programming & development of LM2610 code	$\overline{\text{TMS}}$, TCK TDI, TDO, V_{SS}
AP SPI+	Programming of the AP	$\overline{\text{FLASH\_P\_EN}}$, SCK, MOSI, MISO, $\overline{\text{SPI\_CS}}$, V_{DD}, V_{SS}

4.1.1 3V RS232 Interface

The serial interface is designed for embedded integration with controllers. This serial interface provides programmatic access for configuration, management, and data access to the LM2610. The port is a 6-pin flow-controlled LVTTL (3.3 V) serial interface accessible through the board-to-board connector.

Table 6 Serial Parameters

Parameter	Value
Bit rate	115200
Parity	N
Data bits	8
Stop bit	1
Flow control	Hardware handshake

Figure 1 illustrates the process that the LM2610 uses to transmit serial data:

1. The LM2610 ensures the interpacket_delay time has passed since the last transmission.
2. The LM2610 drives $\overline{\text{RTS\_T}}$ to active, waits for a falling edge on $\overline{\text{CTS\_T}}$. Timeout is defined as ack_delay, and is long enough to handle the worst-case response.

3. If the LM2610 times out before the $\overline{\text{CTS\_T}}$ becomes active, the LM2610 restores $\overline{\text{RTS\_T}}$ to inactive and drops the packet.
4. If $\overline{\text{CTS\_T}}$ is active, the LM2610 transmits the packet.
5. $\overline{\text{RTS\_T}}$ is restored to inactive by the LM2610 after the ack_delay timeout has expired.

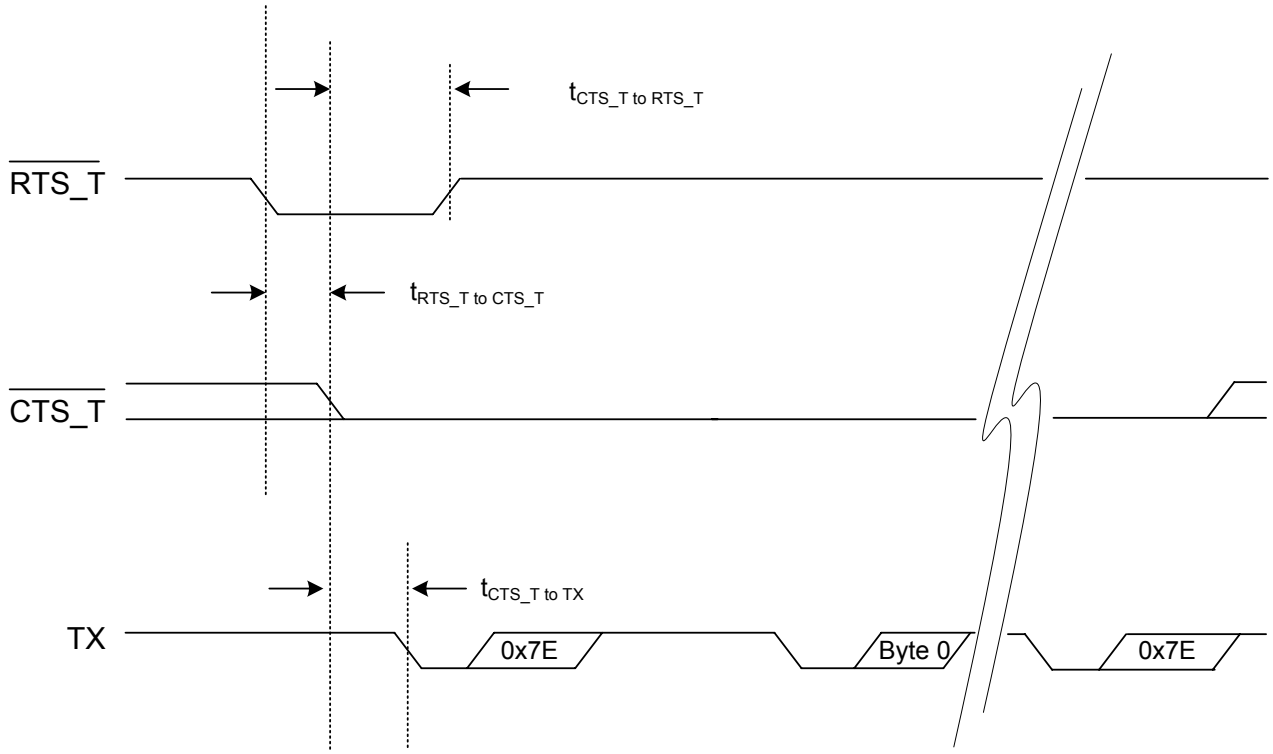


Figure 1 Packet Transmission from LM2610

Figure 2 illustrates the process that the LM2610 uses to receive serial data:

1. The Customer Premise Equipment (CPE), ensures the interpacket_delay time has passed since the last transmission.
2. The CPE drives $\overline{\text{RTS\_R}}$ to active, waits for a falling edge on $\overline{\text{CTS\_R}}$. Timeout is defined as ack_delay, and is long enough to handle the worst-case response.
3. If the CPE times out before the $\overline{\text{CTS\_R}}$ becomes active, the CPE restores $\overline{\text{RTS\_R}}$ to inactive and drops the packet.
4. If $\overline{\text{CTS\_R}}$ is active, then the CPE transmits the packet.
5. $\overline{\text{RTS\_R}}$ is restored to inactive by the CPE after the ack_delay timeout has expired.

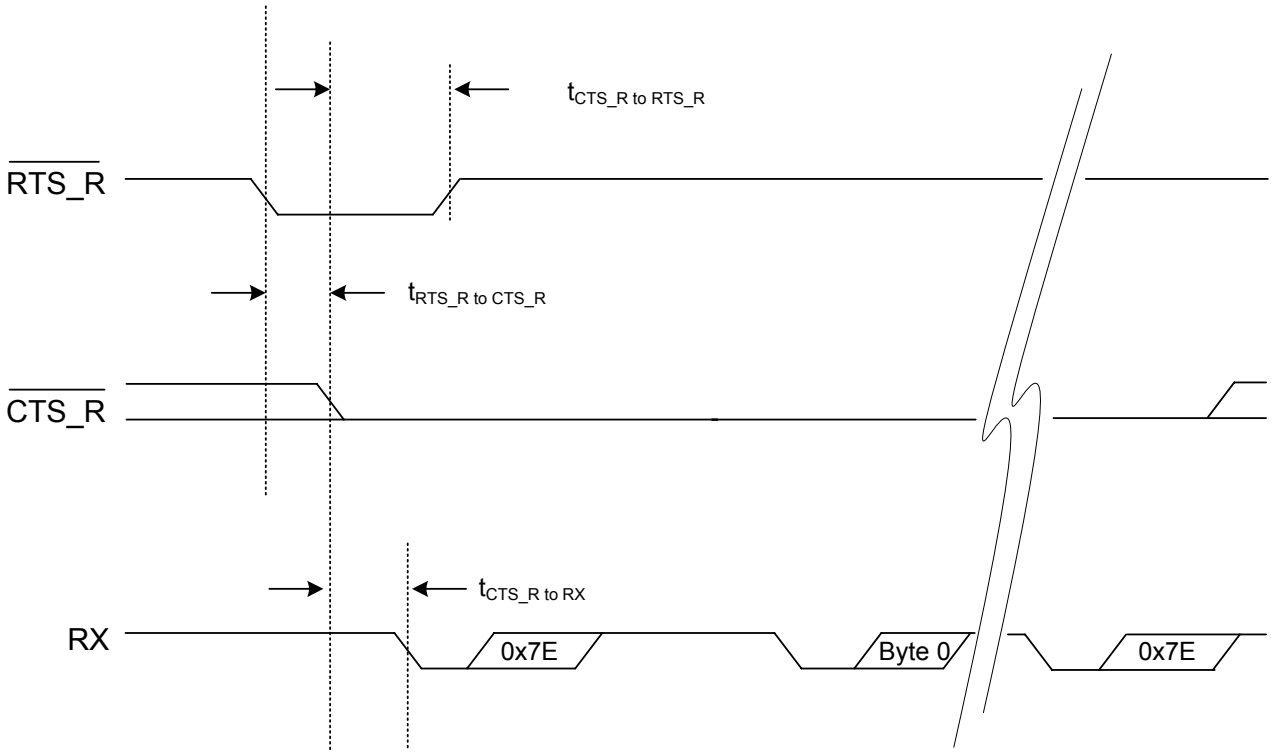


Figure 2 Packet Transmission to LM2610

Table 7 UART Timing Values

Variable	Description	Min	Max	Units
t_{RX_BAUD}	Deviation from baud rate	-2	+2	%
t_{RX_STOP}	Number of stop bits (115.2 kbps)	1		bit period
t_{TX_BAUD}	Deviation from baud rate	-1	+1	%
t_{TX_STOP}	Number of stop bits	1		bit period
$t_{CTS\_R\ to\ RTS\_R}$	Assertion of $\overline{CTS\_R}$ to negation of $\overline{RTS\_R}$	0	10	ms
$t_{RTS\_R\ to\ CTS\_R}$	Assertion of $\overline{RTS\_R}$ to assertion of $\overline{CTS\_R}$		22	ms
$t_{CTS\_R\ to\ RX}$	Assertion of $\overline{CTS\_R}$ to start of byte	0	10	ms
$t_{CTS\_T\ to\ RTS\_T}$	Assertion of $\overline{CTS\_T}$ to negation of $\overline{RTS\_T}$	0	10	ms
$t_{RTS\_T\ to\ CTS\_T}$	Assertion of $\overline{RTS\_T}$ to assertion of $\overline{CTS\_T}$		22	ms
$t_{CTS\_T\ to\ TX}$	Assertion of $\overline{CTS\_T}$ to start of byte	0	10	ms
$t_{interpacket\_delay}$	The sender of an HDLC packet must wait at least this amount of time before sending another packet	20		ms

4.1.2 MuP JTAG

This interface can be used for programming the manager micro-processor (MuP) code image before an LM2610 is installed. The LM2610 J3 connector and pinout is compatible with the AT91SAM-ICE JTAG emulator, as described in http://www.atmel.com/dyn/resources/prod_documents/doc6206.pdf.

4.1.3 AP SPI+

This interface can be used for programming the LM2610 before it is installed. This interface is described in "Design for Manufacture" in the *040-0051DN2510 Integration Guide*, and is implemented on the LM2610 J4 connector.

4.2 Electrical Interface

4.2.1 J1 Board-to-board Pin Out

Table 8 J1 Board-to-board Connector

Pin Number	Pin Name	I/O Direction	I/O Type	Comment
1	V_{DD}	In	3.3 V ± 0.3V	
2	NC	-	Do Not Connect	Reserved
3	V_{SS}	-		
4	$\overline{RTS\_R}$	In	2	
5	TX	Out	4	
6	$\overline{CTS\_T}$	In	2	
7	$\overline{RTS\_T}$	Out	2	
8	V_{SS}	-		
9	$\overline{CTS\_R}$	Out	2	
10	RX	In	2	
11	V_{SS}	-		
12	$\overline{RTS\_A}$	Out	2	Reserved
13	TX_A	Out	2	Reserved
14	$\overline{CTS\_A}$	In**	2	Reserved
15	$\overline{RTS\_B}$	In**	2	Reserved
16	V_{SS}	-		
17	$\overline{CTS\_B}$	Out	2	Reserved
18	RX_B	In	2	Reserved
19	V_{SS}	-		
20	$\overline{RST}$	In*	2	Active low MuP reset

*The $\overline{RST}$ input pin is internally pulled up. When driven low, the LM2610 is hardware reset until the signal is de-asserted. Refer to section **Error! Reference source not found.** for timing requirements on the $\overline{RST}$ pin.

** These pins are internally pulled up.

4.2.1.1 Recommended Mating Connectors

The LM2610's J1 connector is FCIConnect's Rib-Cage connectors for reliability in high vibration environments (87024-610TRLF). The mating connector options for this connector are shown in the table below.

Table 9 Recommended Mating Connectors

Connector	Mated Height (mm)
FCI 87409-110LF	5.74
FCI 90098-110LF	7.57
FCI 73547-110LF	9.25

4.2.2 J2 MuP JTAG Connector

The MuP JTAG connector is provided as the mechanism for loading the MuP software in production. The interface is designed to be compatible with a programming solution provided by IAR Systems.

Table 10 J2 MuP JTAG Connector

Pin Number	Pin Name	I/O Direction	I/O Type	Comment
1	V_{DD}	In	3.3 V ± 0.3V	Supply
2	V_{DD}	In	3.3 V ± 0.3V	Supply
3	Logic 1	Out	3.3V ± 0.3V	
4	V_{SS}	-		
5	TDI	-	2	JTAG test data in
6	V_{SS}	-		
7	$\overline{TMS}$	-	2	JTAG test mode select
8	V_{SS}	-		
9	TCK	-	2	JTAG test clock
10	V_{SS}	-		
11	TCK*	-	2	JTAG test clock
12	V_{SS}	-		
13	TDO	-	2	JTAG test data out
14	V_{SS}	-		
15	$\overline{RST}$	In	2	Active low MuP reset
16	V_{SS}	-		
17	V_{SS}	-		
18	V_{SS}	-		
19	V_{SS}	-		
20	V_{SS}	-		

4.2.3 J6 AP SPI+ Connector

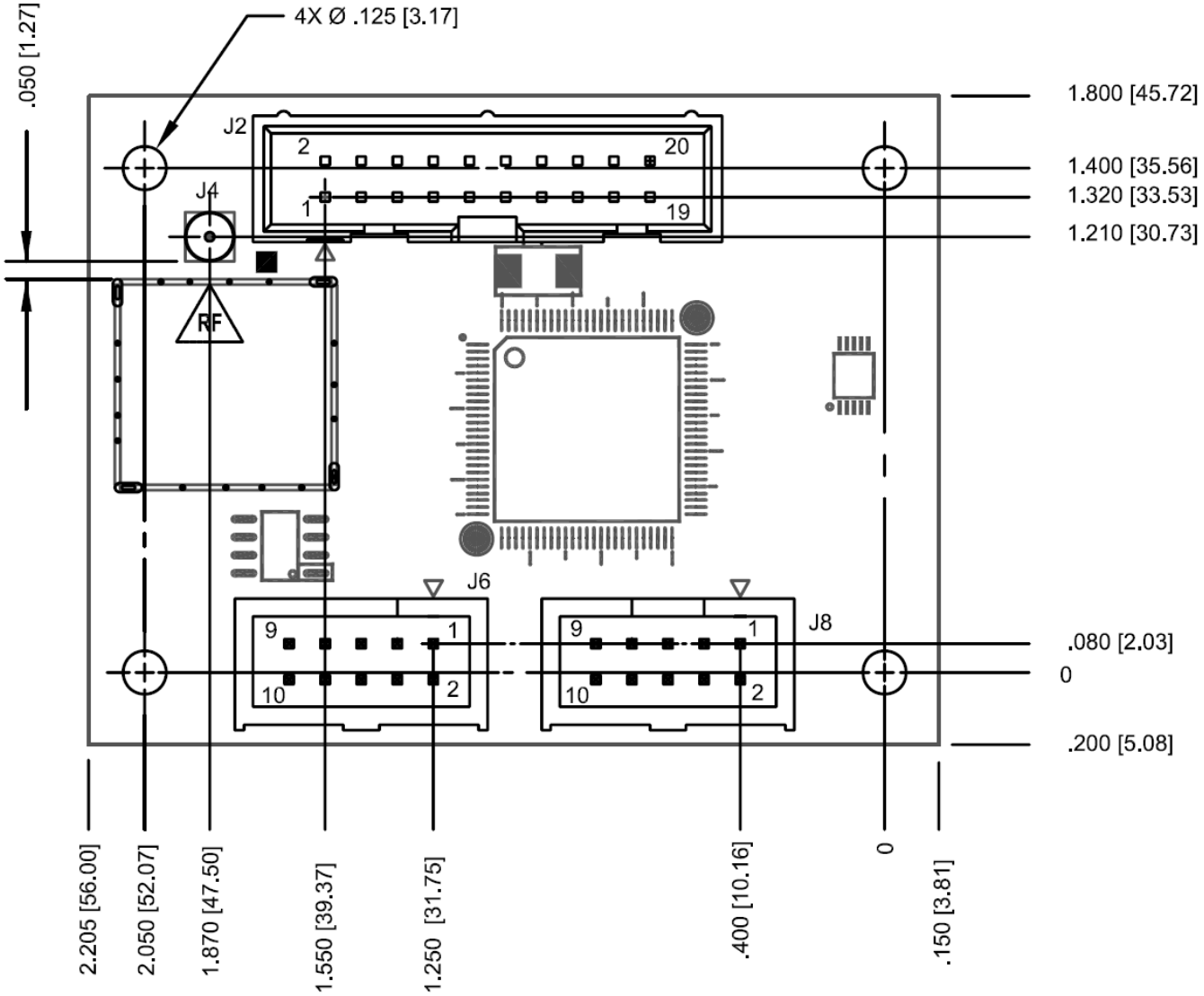
The AP SPI+ connector is provided as the mechanism for loading the AP software in production.

Table 11 J6 AP SPI+ Connector

Pin Number	Pin Name	I/O Direction	I/O Level	Comment
1	$\overline{SPI\_CS}$	In*	3	SPI chip select
2	$\overline{FLASH\_P\_EN}$	In*	1	SPI flash program enable
3	SCK	In*	3	Serial clock
4	MOSI	In*	3	Serial data in
5	MISO	Out	3	Serial data out
6	$\overline{AP\_RST}$	In	1	Access point reset
7	V_{DD}	In	3.3 V ± 0.3V	Supply
8	V_{SS}	-		
9	NC	-		Reserved
10	$\overline{RST}$	In	2	Active low MuP reset

5.0 Mechanical Specifications

5.1 LM2610 Mechanical Drawings



PRIMARY DIMENSIONS ARE IN INCHES
DIMENSIONS IN [mm] ARE MILLIMETERS

UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS +/- .010 INCH.

Figure 3 LM2610 (Top)

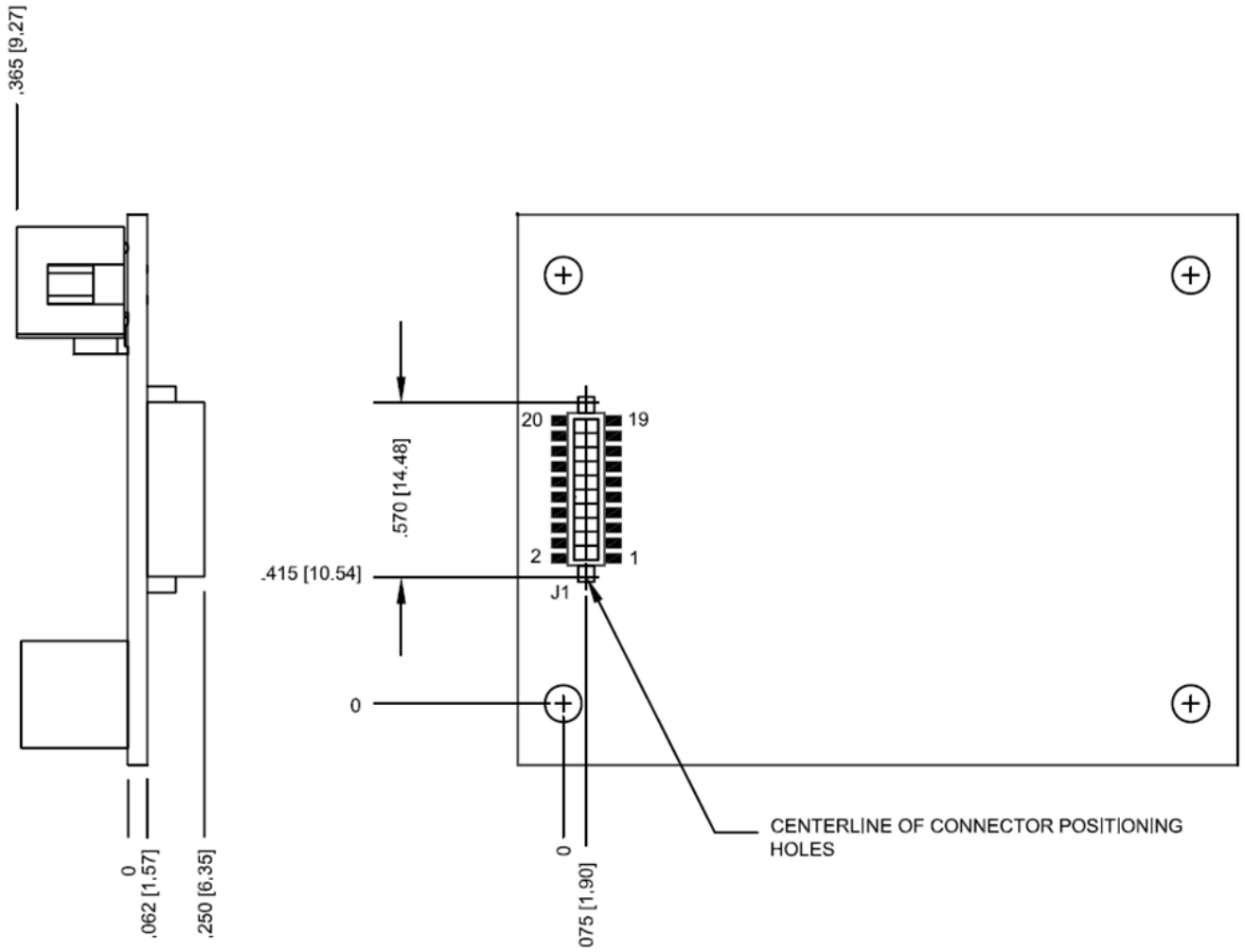


Figure 4 LM2610 (Side and Bottom)

6.0 Regulatory and Standards Compliance

6.1 FCC Compliance

6.1.1 FCC Testing

The LM2610 Embedded Manager will be tested for compliance with Part 15.247 modular (Intentional Radiator) of the FCC rules and regulations. In order to fulfill FCC certification requirements, products incorporating the LM2610 Embedded Manager 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 section 6.1.3 below.
2. The antenna must be electrically identical to the FCC-approved antenna specifications for the LM2610 as described in 6.1.2, with the exception that the gain may be lower than specified in Table 12.
3. The device integrating the LM2610 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 LM2610 Embedded Manager, per FCC rules and regulations, CFR Title 47, Part 15, Subpart B. See FCC rules for specifics on requirements for declaration of conformity.

Any changes or modifications to the LM2610 not expressly approved by the party responsible for compliance could void the authority to operate the equipment.

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6.1.2 FCC-approved Antennas

The following are FCC-approved antenna specifications for the LM2610.

Table 12 FCC-approved Antenna Specifications for the LM2610

Gain	Pattern	Polarization	Frequency	Connector
+2 dBi maximum	Omnidirectional	Vertical	2.4–2.4835 GHz	MMCX

6.1.3 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-LM2610

or

Contains FCC ID: SJC-LM2610

6.2 IC Compliance

6.2.1 IC Testing

The LM2610 will be 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.

6.2.2 IC-approved Antennas

The LM2610 has been designed to operate with the antenna characteristics shown in Table 13. Antennas not included in this list or having a gain greater than shown in Table 13 are strictly prohibited for use with this device. The required antenna impedance is 50 Ohms. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication. 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 13 IC-approved Antenna Specifications for the LM2610

Gain	Pattern	Polarization	Frequency	Connector
+2 dBi maximum	Omnidirectional	Vertical	2.4–2.4835 GHz	MMCX

6.2.3 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: 5853-LM2610

6.3 CE Compliance

6.3.1 Declaration of Conformity

The LM2610 will be tested for conformity with the appropriate standards ETSI EN 300 328, ETSI EN 301 489-17 and EN 60950-1, 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 2006/95/EEC.

6.3.2 European Compliance

If the LM2610 manager 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 LM2610 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.

6.3.3 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 because 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.

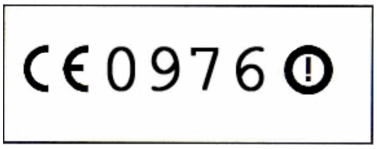

Figure 5 CE Label Requirements

6.3.4 Restrictions

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

6.4 RoHS Compliance

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

6.5 Industrial Environment Operation

The LM2610 is designed to meet the requirements of harsh industrial environments, which includes:

- **Shock and Vibration**—The LM2610 complies with high vibration pipeline testing, as specified in IEC 60770-1.
- **Temperature Extremes**—The LM2610 is designed for industrial storage and operational temperature range of –40 °C to +85 °C.

7.0 Related Documentation

- *Called out inline as referenced.*

8.0 Ordering Information

Product List:

LM2610: TBD

Contact Information:

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Document Status	Product Status	Definition
Advanced Information	Planned or under development	This document 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 document 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 document 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 document contains specifications for a product that has been discontinued by Dust Networks. The document is printed for reference information only.