ZigBee- Ready RF Transceiver Modules

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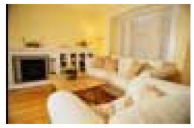
1.0 General Description

The CT-EM260 RF Transceiver Modules is compact surface mounted modules specially designed for Ember ZigBee™ protocol stack for wireless networks, EmberZNet, based on IEEE 802.15.4 standard in the 2.4GHz world-wide ISM band. The complete module is only 20.32 x 25.52 x 3 mm（integrated antenna version）and 20.32 x 19.53 x 3mm (external antenna version).They both integrate a 2.4GHz, IEEE 802.15.4-compliant transceiver with a 16-bit network processor (XAP2b core) to run EmberZNet. They contain embedded Flash and integrated RAM for program and data storage. It utilizes the non-intrusive SIF module for powerful software debugging and programming of the network processor.

2.0 Applications

Home automation & building control

Home appliances & alarms



Monitoring of remote systems

Security systems & lighting controls

Sensor data capture in embedded networks

3.0 Features

- Complete ZigBee-ready module with or without integrated chip antenna
- Integrated IEEE 802.15.4 PHY and MAC layer
- 12MHz XAP2b 16-bit network processor core
- Non-intrusive debug interface (SIF)
- SPI interface for communication and controlled by the Host using the EmberZNet Serial Protocol (EZSP)
- Internal RC oscillator for timer
- High performance direct sequence spread spectrum (DSSS) RF transceiver
- 16 channels in the 2.4 GHz ISM band
- On-chip regulator for 2.1-3.6V operation , three sleep low power modes

4.0 Absolute Maximum Ratings

Parameter	Test Conditions	Min.	Max.	Unit
Regulator voltage (VDD_PADS)		- 0.3	3.6	V
Voltage on nSSEL INT, MOSI, MISO, SCLK, nSSEL, PTI_EN, PTI_DATA, nHOST_INT, SIF_CLK, SIF_MISO, SIF_MOSI, nSIF_LOAD, SDBG, LINK_ACTIVITY, nWAKE, nRESET		- 0.3	VDD_PADS+0.3	V
Storage temperature		- 40	+ 140	°C

Under no circumstances should the absolute maximum ratings given above be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

5.0 Recommended Operating Conditions

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Regulator input voltage (VDD_PADS)		2.1		3.6	V
Core input voltage (VDD_24MHZ, VDD_VCO, VDD_RF, VDD_IF, VDD_PADSA, VDD_FLASH, VDD_SYNTH_PRE, VDD_CORE)		1.7	1.8	1.9	V
Temperature range		- 40		+ 85	°C

6.0 Electrical Specifications

T=25℃, VCC = 3.0V, Fo =2450MHZ, if nothing else stated.

Parameter	Min	Typ.	Max	Unit	Condition / Note
Operating frequency	2400		2450	MHz	Programmable in 5MHz steps, 5 MHz steps for IEEE 802.15.4 compliance
Number of channels		16			For IEEE 802.15.4 compliance
Channel spacing		5		MHz	For IEEE 802.15.4 compliance
Input/output impedance		50		Ohm	
Data rate		250		kbit/s	
DSSS chip rate		2		Mc/s	
Frequency stability			+/-40	ppm	
Transmit power	-32		5	dBm	Programmable from firmware

Parameter	Min	Typ.	Max	Unit	Condition / Note
Harmonic:					
2nd harmonic		TBD			
3rd harmonic		TBD		dBm	
Spurious emission:					Complies with EN 300 328, EN 300 440, FCC CRF47 Part 15 and ARIB STD-T66
TX 30 – 1000 MHz					
1-12.75 GHz			TBD	dBm	
1.8-1.9 GHz			TBD		
5.15-5.3 GHz			TBD		
Sensitivity		-98		dBm	PER = 1% PER, 20byte packet defined by IEEE 802.15.4 Boost mode
Adjacent channel rejection +/-5 MHz		35/35		dB	IEEE 802.15.4 compliance at -82 dBm
Adjacent channel rejection +/-10 MHz		40/40		dB	IEEE 802.15.4 compliance at -82 dBm
Co-channel rejection		-6		dB	
Spurious emission, RX 30 -1000 MHz			-57	dBm	Complies with EN 300 328, EN 300 440, FCC CRF47 Part 15 and ARIB STD-T66
1-12.75 GHz			-47		
Supply voltage	2.1		3.6	V	
Current consumption, RX		36		mA	Max RX sensitivity (boost mode)
Current consumption, TX		36		mA	At max. TX power (+ 5dBm boost)
Quiescent current		1.0		µA	including internal RC oscillator
Flash Memory		1		Kbit	

MCU clock frequency		12		MHz	
RC OSCILATOR frequency		10		KHZ	

7.0 Introduction

The CT-EM260 series of modules are specially designed for ZigBee application. They provide a fast jump start design for system integrators or electronic designers wishing to use ZigBee wireless technologies. The module contains qualified RF hardware and enough processor power to run the EmberZNet stack or other ZigBee network stack (depending on version), making it a powerful platform for building wireless networking products. ZigBee Coordinators (ZC), ZigBee Routers (ZR), and ZigBee End Devices (ZED) are all supported and are programmed onto the module together with a custom application. Minimal RF design experience is need to use CT-EM260 modules.

8.0 Typical application block

Figure 1: Example of application circuit

9.0 Pin Assignment

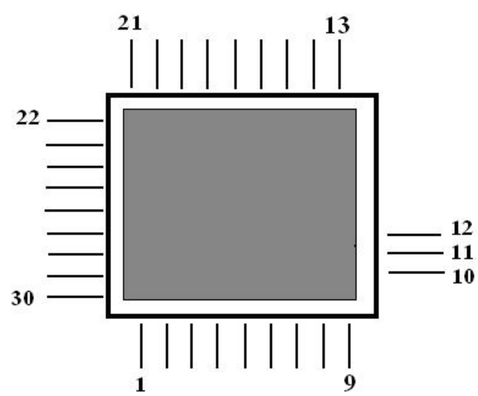


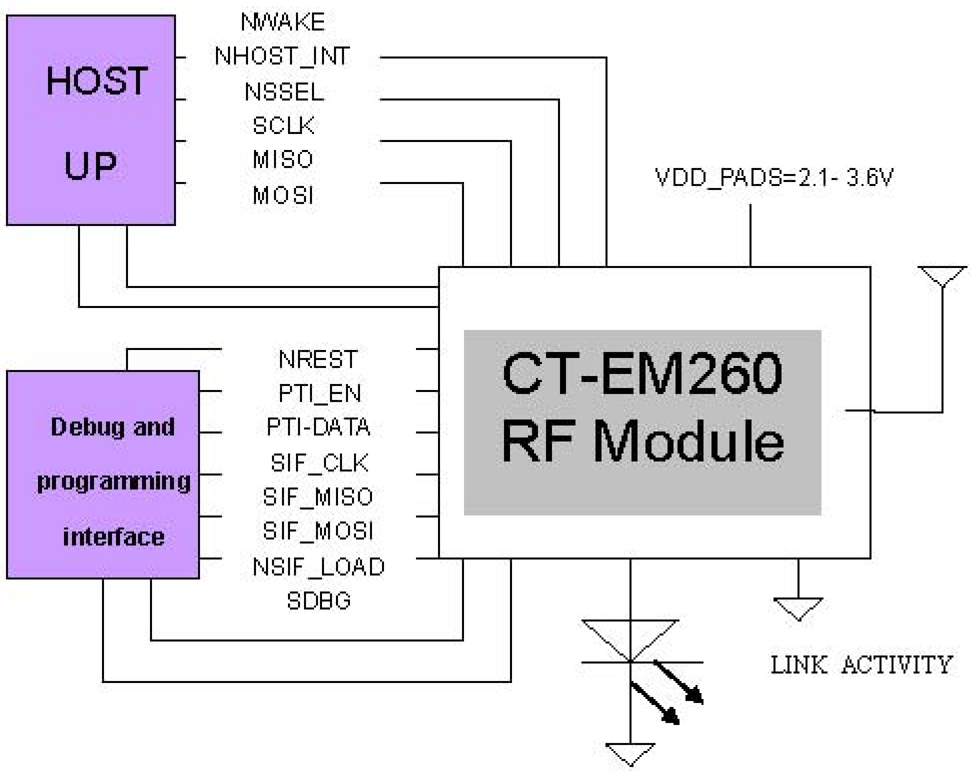
Figure 2: CT-EM26500

NWAKE

NHOST_INT

NSSEL
SCLK

MISO
MOSI



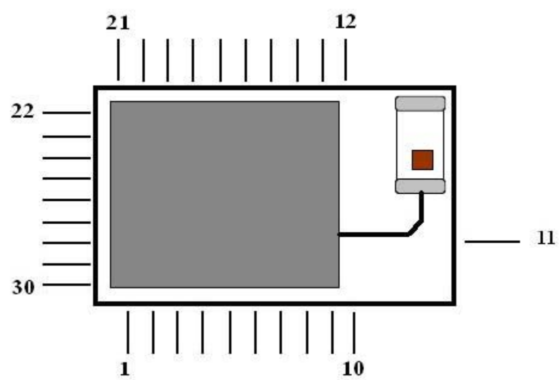


Figure 3: CT-EM2601

10.0 Pin Description

Pin#	Signal	Direction	Description
1	SIFMISO	O	Serial interface, master in/slave out
2	SIFMOSI	I	Serial interface, master out/slave in
3	SIFLOADB	I/O	Serial interface, load strobe (open-collector with internal pull-up)
4	GND	Ground	Ground
5	SDBG	O	Spare Debug signal
6	LINKACTIVITY	O	Link and Activity signal
7	NWAKE	I	Wake Interrupt signal (from Host to EM260)
8	NC		
9	GND	Ground	Ground supply

10	GND	Ground	Ground supply
11	ANT	ANT	receiver input/transmitter output
12	GND	Ground	Ground supply
13	nRESET	I	Active low chip reset (internal pull-up)
14	NC		
15	NC		

Pin#	Signal	Direction	Description
16	VBRD	Power	Pads supply (2.1-3.6V)
17	NC		
18	NC		
19	MOSI	I	SPI Data, Master Out / Slave In (from Host to EM260
20	MISO	O	SPI Data, Master In / Slave Out (from EM260 to Host)
21	SCLK	I	SPI Clock (from Host to EM260)
22	NSSEL	I	SPI Slave Select (from Host to EM260)
23	PTIEN	O	Frame signal of Packet Trace Interface (PTI)
24	PTIDATA	O	Data signal of Packet Trace Interface (PTI)
25	NHOSTINT	O	Host Interrupt signal (from EM260 to Host)
26	NC		
27	NC		
28	NC		
29	NC		
30	SIFCLK	I	Serial interface, clock (internal pull-down)

11.0 Block Diagram

Figure 4: Block Diagram

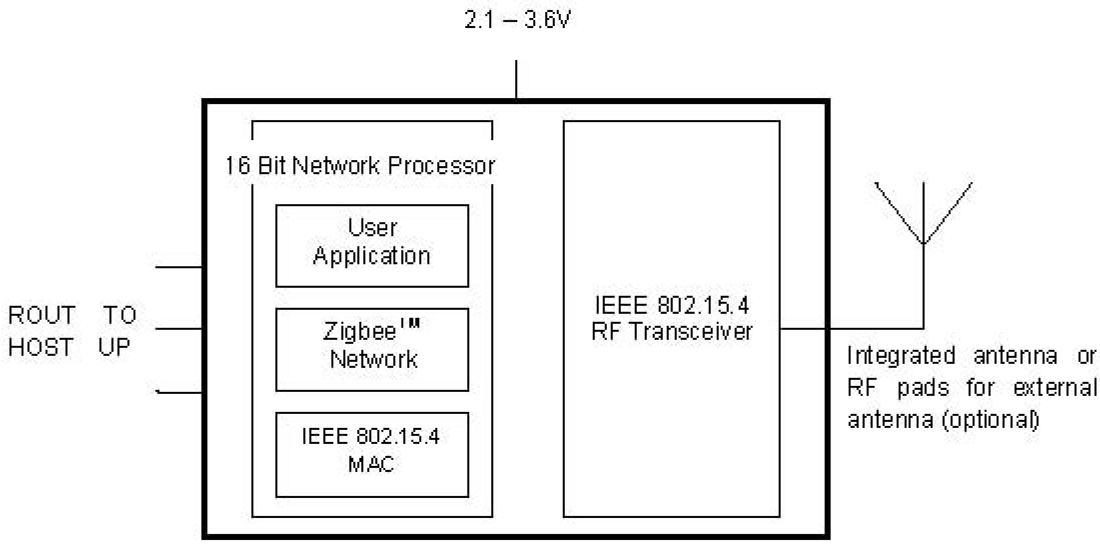
12.0 Circuit Description

The module contains an IEEE 802.15.4 compliant RF transceiver, high speed oscillator, RC oscillator. The module is intended to running the Ember ZigBee software or other ZigBee network implementation, depending on the specific version.

The application software together with the ZigBee protocol software stack can be programmed in Flash memory through SIF module, using an evaluation board from Ember InSight Desktop.

To support user-defined applications, the module exposes the Ember Serial API over the SPI, which allows application development to occur on a Host microcontroller of choice. In addition to the four SPI signals, two additional signals, nHOST_INT and nWAKE, provide an easy-to-use handshake mechanism between the Host and the module. Also, an integrated voltage regulator, power-on-reset circuitry, sleep timer, and low-power sleep modes are available. The deep sleep mode draws less than 1µA need to further verification), allowing products to achieve long battery life.

For further details on the transceiver (Ember EM260), please consult data sheet at http://www.ember.com



13.0 SIF Module Programming and Debug Interface

SIF is a synchronous serial interface developed by Cambridge Consultants Ltd. It is the primary programming and debug interface of the CT-260. The SIF module allows external devices to read and write memory-mapped registers in real-time without changing the functionality or timing of the XAP2b core.

The SIF interface provides the following:

IC production test (especially analog)
PCB production test
Firmware download
Product control and characterization

The pins are:

SIF_LOADB
SIF_CLK
SIF_MOSI
SIF_MISO

The maximum serial shift speed for the SIF interface is 48MHz. SIF interface accesses can be initiated even when the chip is in idle, deep sleep or power down modes. An edge on nSIF_LOAD wakes the chip to allow SIF cycles.

14.0 Power Management

The module supports four different power modes: active, idle, deep sleep, and power down.

Active mode is the normal, operating state of the module.

While in idle mode, code execution halts until any interrupt occurs. All modules including the radio continue to operate normally. The EmberZNet stack automatically invokes idle as appropriate.

Deep sleep mode and power down mode both power off most of the functions, including the radio, and leave only the critical chip functions powered. The internal regulator is disabled. All output signals are maintained in a frozen state. Upon waking from deep sleep or power down mode, the internal regulator is re_enabled. Deep sleep and power down result in the same sleep current consumption. The two sleep modes differ as follows: the module can wake on both an internal timer and an external signal from deep sleep mode; power down mode can only wake on an external signal.

15.0 RF Frequency Detail

The following table shows the RF channels as defined by the IEEE 802.15.4 standard.

RF channel	Frequency
11	2405MHz
12	2410MHz
13	2415MHz
14	2420MHz
15	2425MHz
16	2430MHz
17	2435MHz
18	2440MHz
19	2445MHz
20	2450MHz
21	2455MHz
22	2460MHz
23	2465MHz
24	2470MHz
25	2475MHz
26	2480MHz

The output power level can be configured in the range -32 to 5 dBm. The RF transceiver uses direct sequence spread spectrum (DSSS) with 2 Mchip/s chip rate, giving a raw data rate of 250 kbit/s. The modulation format is Offset – Quadrature Phase Shift Keying (O-QPSK). It is robust even under noisy environments when sharing the same frequency band with other applications.

The use of RF frequencies and maximum allowed RF power should according to different national regulations. The CT-260 is complying with the applicable regulations for the world wide 2.4GHz ISM band.

[Subject to final approval: Specifically it complies with the European Union R&TTE directive meeting EN 300 328 and EN300 440 class 2. It also meets the FCC CFR47 Part15 regulations for use in the US and the ARIB T-66 for use in Japan.]

16.0 Antenna Design Considerations

CT-EM260 provides an integrated antenna. The design should be effective for many applications requiring a compact solution containing all the critical RF parts within the module. Applications requiring better range may consider an external antenna or possibly even an external booster circuit (power amplifier).

The range testing using the integrated antenna shows a typical distance of 100 m outdoor line-of-sight (LOS). If the application is used indoor, the range will be around 10 to 30 m, depending on structure and building materials.

The module with antenna is matched for use in the 2.4 GHz band. Due to the dielectric ceramic material the antenna is shorter than a normal quarter wave antenna. However, it can still provide high radiation efficiency (typical 1 dBi). The radiating part of the antenna is located on one side of the PCB. The radiation pattern from the antenna is shown in figure 5. The maximum radiation is in the plane normal to the length axis of the antenna. For best possible omni-directional radiation the module should be oriented so that the antenna is vertical. In order to achieve best range the transmitting and receiving antenna should be oriented the same way with same polarity. Indoors reflections of the radio waves will affect the range.

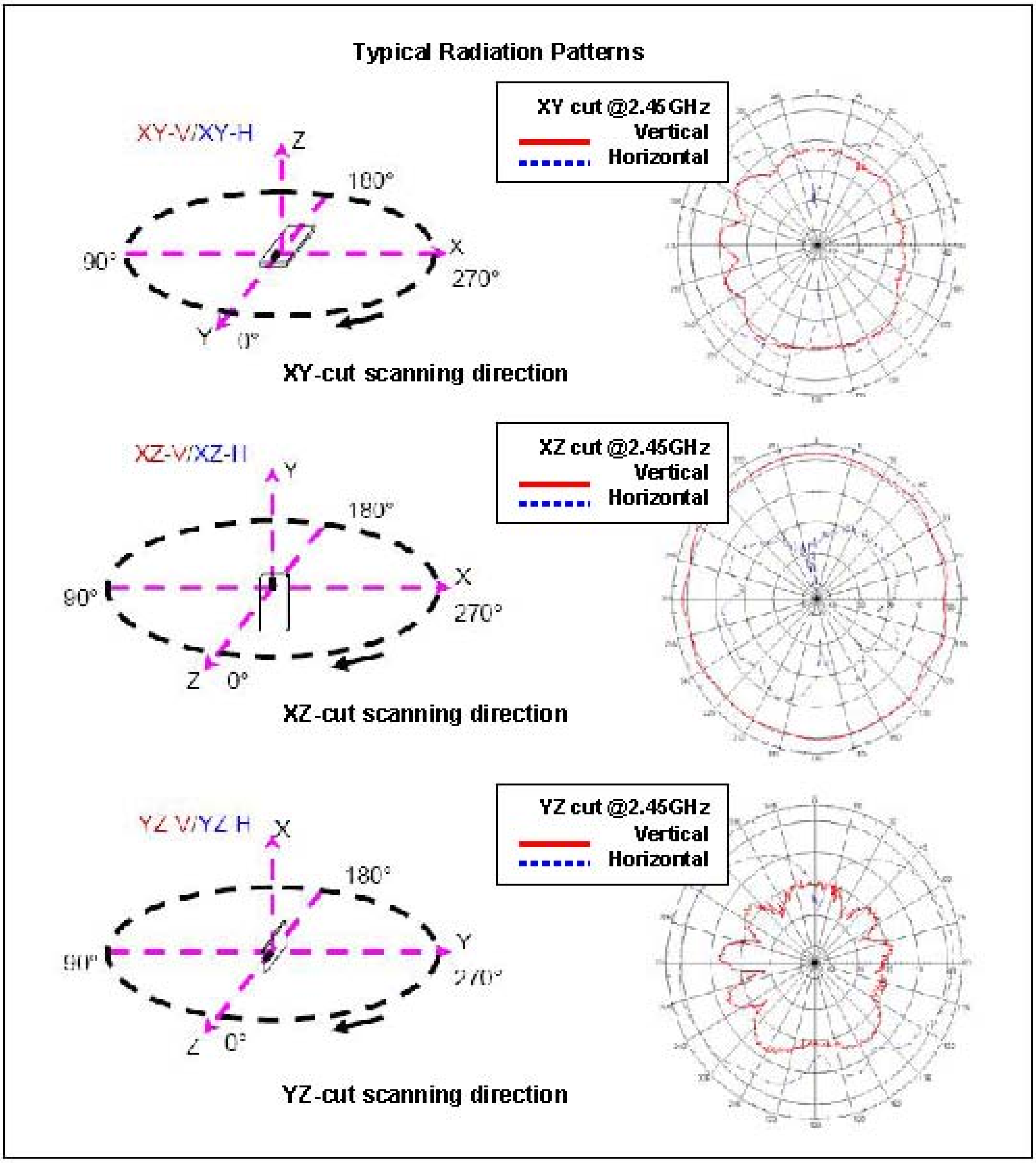
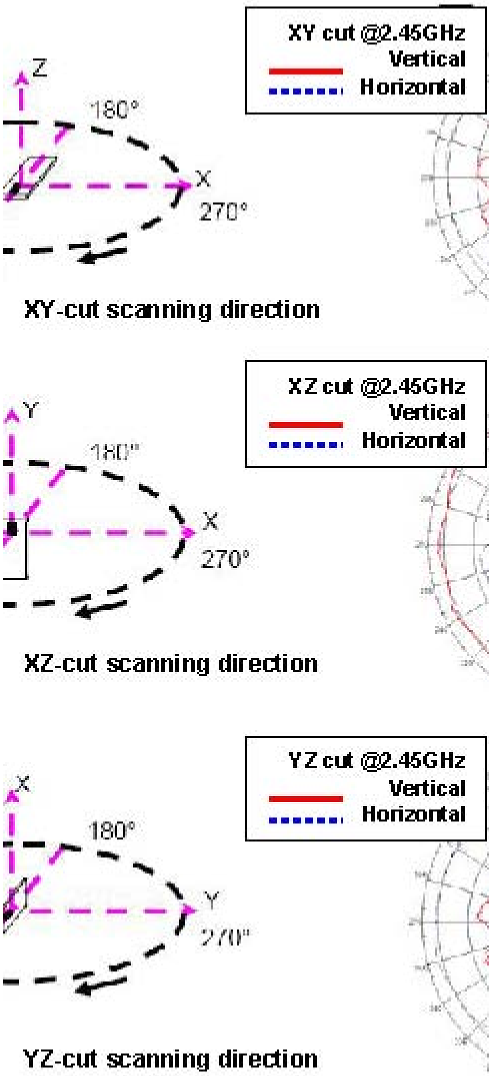


Figure 5: Integrated chip antenna radiation pattern at different orientations

The antenna should be kept away (> 10mm) from metallic or other conductive and dielectric materials, and should never be used inside a metallic enclosure.

Compared to lower frequencies, operation at 2.4GHz usually has a shorter LOS. However, the ZigBee mesh network topology provides a more flexible and reliable network topology to end users. The farther end device can easily be reached over a mesh network through other full function (routing) devices. Reflections from walls and other objects may give multi-path fading resulting in dead-zones. With mesh network, other nodes in the network can reach devices in dead-zones. Furthermore, in the case of any failure of a single node, the system can easily reroute to other paths. The mesh network is therefore highly recommended for increased reliability and extended coverage.

Typical Radiation Patterns



In applications where the module must be placed in a metallic enclosure, an external antenna must be used. The external antenna must match to 50 Ohm.

A PCB antenna can be made as a copper track where the ground plane is removed on the back side. The rest of the PCB board should have a ground plane as large as possible, preferably as large (in one dimension) as the antenna itself, to make it act as a reflector mirror to the antenna. A quarter-wavelength antenna on a PCB must be shorter than the wire antenna due to the influence of the dielectric material of the PCB. The length reduction depends on the PCB thickness and material, as well as how close to the edge of the board the antenna is placed. Typical reduction is to 75-90 % but specific results may vary.

The length of a quarter-wave antenna is given in the table below.

Frequency (MHz)	Length of whip antenna (cm)	Length of PCB track (cm)
2450	2.9	2.2 – 2.7

If, for space reasons, the track is made even shorter than the resonating quarter of wavelength, the antenna should be matched to 50 ohms using a series inductor and a shunt capacitor.

17.0 PCB Layout Recommendations

For recommended layout pads for the module, please reference Mechanical Dimensions.

The area underneath the module should be covered with solder resist in order to prevent short circuiting the test pads on the back side of the module. A solid ground plane is preferred. Unconnected pins should be soldered to the pads, and the pads should be left floating. For the module version with integrated antenna, the RF pad can be soldered, but the pad should not be connected further. The two ground pads (pin10 and pin12 should be grounded for all variants.)

When using the onboard chip antenna, careful attention is required to the layout of the PCB where the module is mounted. In Figure 6 a mother PCB is shown with a recommended placement of the module.

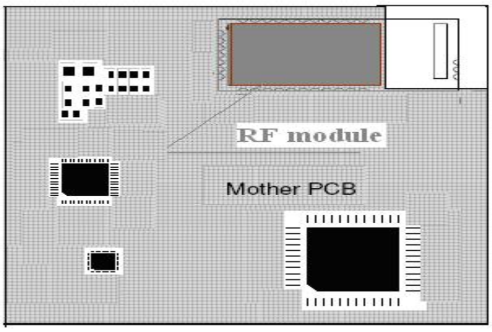


Figure 6: A recommended placement of the module on a mother PCB (Shaded area is ground-plane on mother PCB)

18.0 FCC Approvals

The CT-EM2503 has been designed to meet all national regulations for World-wide use. Using the integrated antenna it conforms to FCC CFR 47 Part 15 (USA).

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The device CT-EM2503 carries FCC authorization and is marked with the FCC ID Number. Whilst any device into which this authorized module is installed will not normally be required to obtain FCC authorization, this does not preclude the possibility that some other form of authorization or testing may be required for the finished device.
When the CT-EM2603 module is integrated inside another device/product, then the outside surface of that device/product must display a label referring to the enclosed module. This exterior label can use wording such as **"Contains Transmitter Module FCC ID:** DI2CT-EM2603**"** or **"Contains FCC ID:** DI2CT-EM2603**"**, although any similar wording that expresses the same meaning may be used.

FCC statement：
If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is

connected.
—Consult the dealer or an experienced radio/TV technician for help.
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

19.0 Mechanical Dimensions

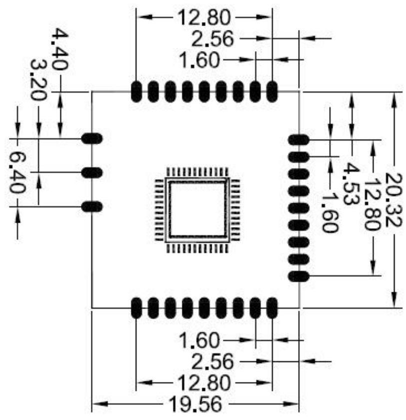


Figure 7: Mechanical Dimensions of CT-EM2600

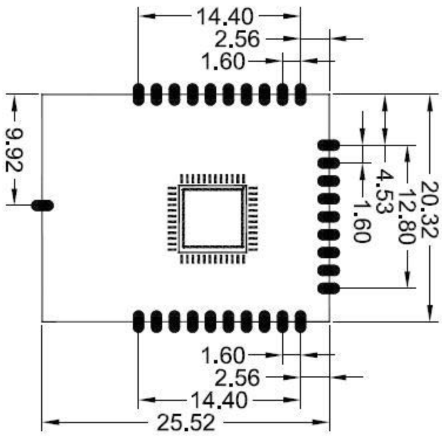


Figure 8: Mechanical Dimensions of CT-EM2601/2/3 modules

20.0 Ordering Information

Ordering Part Number	Description
CT-EM2600	ZigBee-ready RF module, 1kB Flash ,External antenna
CT-EM2601	ZigBee-ready RF module, 1kB Flash, Ceramic chip antenna
CT-EM2602	ZigBee-ready RF module, 1kB Flash, PCB trace antenna FCC/CE certificate
CT-EM2603	ZigBee-ready RF module, 1kB Flash, Ceramic chip antenna FCC/CE certificate

21.0 Document Revision History

Document Revision	change
1.0	Draft
1.1	Add FCC approval