LumenRadio

CRMX™

CORE module design guidelines

Part # 200-1901

Revision: PA6 – Jan 28, 2015

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ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Minimum	Maximum	Units
Supply Voltage	VCC	-0.3	3.6	V
Peak current	I_{MAX}		250	mA
Voltage on any digital pin	V_{IO}	-0.3	VCC+0.3 <3.9	V
Storage temperature range	T_{STG}	–40	125	°C
Input RF level	P_{IN}		10	dBm
Electrostatic discharge voltage (human body model) model, JEDEC STD 22, method A114	V_{ESD}		1	kV

Recommended operating conditions

Parameter	Symbol	Minimum	Maximum	Units
Operating Supply Voltage	VCC	2.3	3.6	V
Operating ambient temperature range	T_A	–40	80	°C

Electrical characteristics

Measured at 3.3V, 25°C. Limits apply over entire frequency range 2405-2480MHz (Channel 11-26).

Parameter	Symbol	MIN	TYP	MAX	Unit
Peak current consumption, continuous transmission, 17dBm output power, no peripherals active.	I_{TX_PEAK}		120	150	mA
Peak current consumption, continuous transmission, -2.7dBm output power, no peripherals active	I_{TX_PEAK}		60	80	mA
Peak current consumption, battery mode[1]. +2.5dBm output power, no peripherals active	$I_{TX\_BATT\_PEAK}$		60	80	mA
Peak current consumption in RX mode, -50dBm input power, no peripherals active	I_{RX}		40	60	mA
Peak current consumption in RX battery mode, -50dBm input power, no peripherals active	I_{RX_BATT}		35	55	mA
Average current consumption, high power mode, 17dBm output power, no peripherals active	I_{TX_MIN}		45	50	mA
Average current consumption[2], battery mode, +2.5dBm output power, no peripherals active	I_{TX_AVG}		35	40	mA
SPI current consumption	I_{SPI}		300		µA
I^2C current consumption	I_{I2C}		100		µA
UART current consumption	I_{UART}		700		µA
USB current consumption	I_{USB}		3.8		mA
ADC current consumption when converting	I_{ADC}		1.2		mA
Flash erase	I_{FL_ER}		12		mA
Flash burst-write peak current	I_{FL_W}		8		mA
Deep sleep current consumption	I_{SLEEP}		10.5	11.1	µA

[1] Transmitting one burst on 16 frequencies
[2] One burst transmission including CSMA-CA, TX, MAC ACK, duration 4.9ms

General characteristics

Measured at 3.3V, 25°C.

Parameter	Symbol	MIN	TYP	MAX	Unit
Wake up time from deep sleep to active	T_{WAKE_UP}		136		µs
Time from active to TX or RX				192	µs
RF frequency range		2405		2480	MHz

RF characteristics

Measured at 3.3V, 25°C. Limits apply over entire frequency range 2405-2480MHz (Channel 11-26)

Parameter		Symbol	MIN	TYP	MAX	Unit
Receiver sensitivity, PER = 1%		RX_{SENS}		-101		dBm
Receiver sensitivity battery mode, PER = 1%		RX_{SENS_BATT}		-92		dBm
Receiver saturation (maximum input level) , PER = 1%		RX_{SAT}			-5	dBm
Transmitter max output power	VCC = 3.6V		16.5	17	17.5	dBm
	VCC = 3.3V		15.8	16.3	16.8	dBm
	VCC = 3.0V		14.6	15.1	15.6	dBm
	VCC = 2.7V		13.2	13.7	14.2	dBm
	VCC = 2.3V		10.3	10.8	11.3	dBm
Transmitter min output power	VCC = 3.6V		-3.1	-2.6	-2.1	dBm
	VCC = 3.3V		-3.5	-3	-2.5	dBm
	VCC = 3.0V		-3.8	-3.3	-2.8	dBm
	VCC = 2.7V		-5.6	-5.1	-4.6	dBm
	VCC = 2.3V		-10.7	-9.2	-8.7	dBm
Output return loss at U.FL. antenna connector		S22		-10	-5	dB

ADC characteristics

TA = 25°C and V_{CC} = 3 V, unless otherwise noted.

Parameter			MIN	TYP	MAX	Unit
Input voltage			0		Vcc	V
Input resistance, signal				197		kΩ
ENOB	Effective number of bits			10.2		Bits
Useful power bandwidth				20		kHz
THD	Total harmonic distortion			-75.2		dB
	Signal to non-harmonic ratio			78.8		dB
CMRR	Common-mode rejection ratio			84		dB
	Crosstalk			-84		dB
	Offset			-3		mV
	Gain Error			0.68		%
DNL	Differential nonlinearity	Mean		0.05		LSB
		Maximum		0.9		
INL	Integral nonlinearity	Mean		4.6		LSB
		Maximum		13.3		
SINAD (–THD+N)	Signal-to-noise-and-distortion	Single-ended input		66.6		dB
		Differential input		70.8		
Conversion time				TBD		µs
Current consumption				1.2		mA
Internal reference temperature coefficient				0.4		mV/10°C

Control input AC characteristics

TA = –40°C to 125°C, V_{CC} = 2 V to 3.6 V, unless otherwise noted.

Parameter	MIN	TYP	MAX	Unit
nRESET low duration, shortest pulse recognized as reset request	1			µs

DC characteristics

T_A = 25°C, V_{CC} = 3 V

Parameter	MIN	TYP	MAX	Unit
Logic 0 input voltage			0.5	V
Logic 1 input voltage	2.5			V
Logic-0 input current	-300		300	nA
Logic-1 input current	-300		300	nA

USB interface DC characteristics

T_A = 25°C, unless otherwise noted.

Parameter	MIN	TYP	MAX	Unit
USB pad voltage output, high, V_{CC} 3.6 V, 4-mA load		3.4		V
USB pad voltage output, low, V_{CC} 3.6 V, 4-mA load		0.2		V

Pin assignments and functions

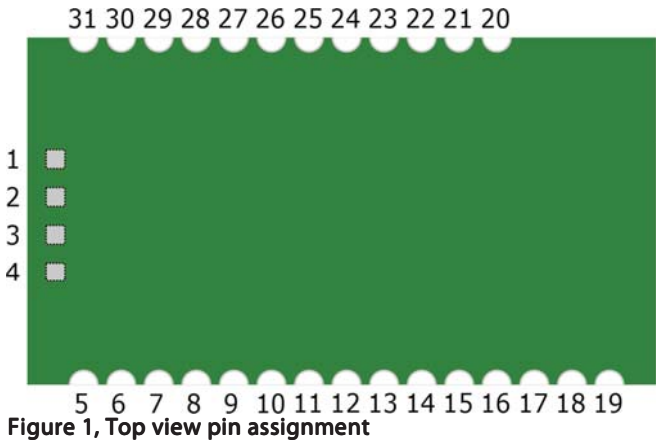


Figure 1, Top view pin assignment

PIN	PIN NAME	PIN TYPE	DESCRIPTION
1			Do not connect
2			Do not connect
3			Do not connect
4			Do not connect
5	PC7	Digital I/O	UART RXD
6	PC6	Digital I/O	UART TXD
7	PC5	Digital I/O	I2C SDA
8	PC4	Digital I/O	I2S SCA
9	PC3	Digital O	High current pin, 20 mA sink/source capability
10	PC2	Digital O	High current pin, 20 mA sink/source capability
11	PC1	Digital O	High current pin, 20 mA sink/source capability
12	PA0	Analog I	ADC0
13	PA1	Analog I	ADC1
14	PA2	Digital I/O	SPI CLK
15	PA3	Digital I	/SPI SS
16	PA4	Digital I/O	SPI MOSI
17	PA5	Digital I/O	SSI MISO
18	PA6	Analog I	ADC2
19	PA7	Analog I	ADC3
20	GND		
21	GND		
22	PB5	Digital O	PWM A
23	PB4	Digital O	PWM B
24	PB3	Digital I	GPT A Trigger / Cycle measurement
25	PB2	Digital I	GPT B Trigger / Cycle measurement
26	PB1	Digital I/O	GPIO port B pin 1
27	RESET	Digital input	Device reset, active-low
28	USB_N	USB I/O	USB differential data minus (D–)
29	USB_P	USB I/O	USB differential data plus (D+)
30	GND		
31	VCC		2.3 - 3.6VDC power supply connection

Application information

Core module current ramps in TX (transmit) high power mode

All measurements done in high power mode, i.e. RF power amplifier enabled in transmit.
Current consumption can be calculated using the formula:

$$I = \frac{V_{osc}}{30}$$

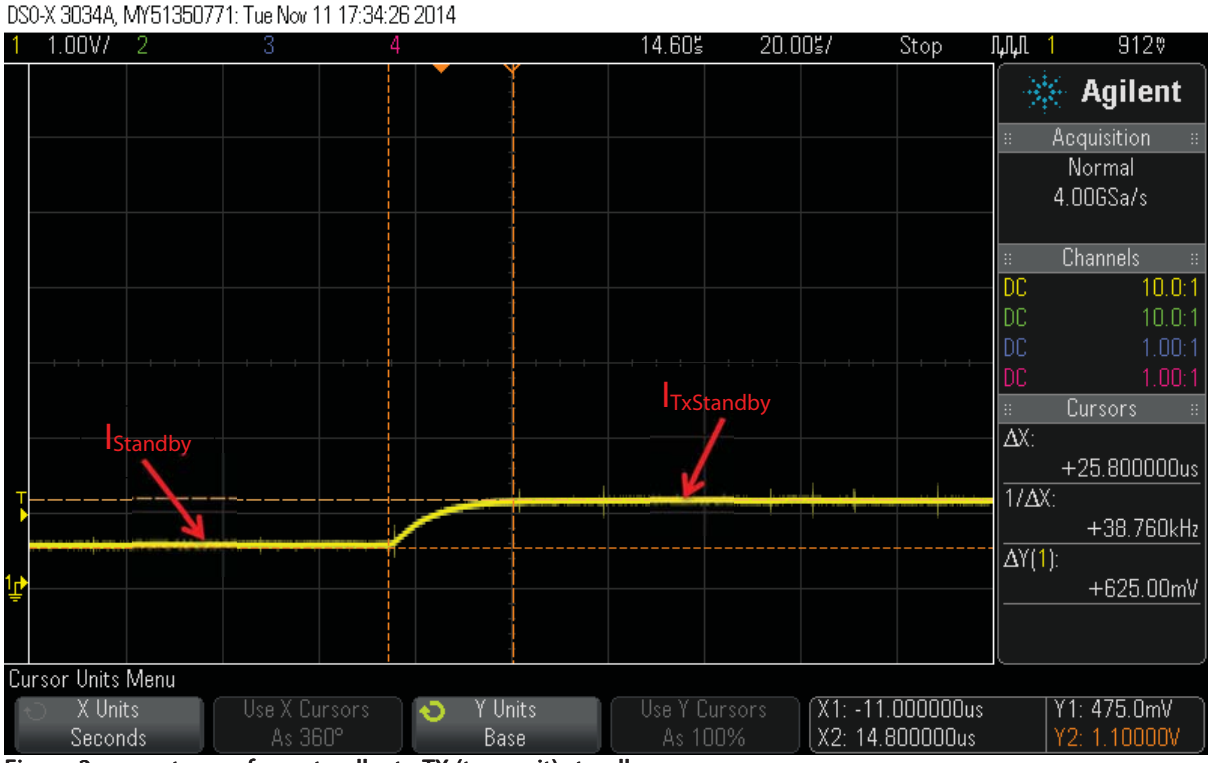


Figure 2, current ramp from standby to TX (transmit) standby

$$I_{Standby} = \frac{0.475}{30} \approx 15.8mA$$

$$I_{TxStandby} = \frac{1.10}{30} \approx 36.7mA$$

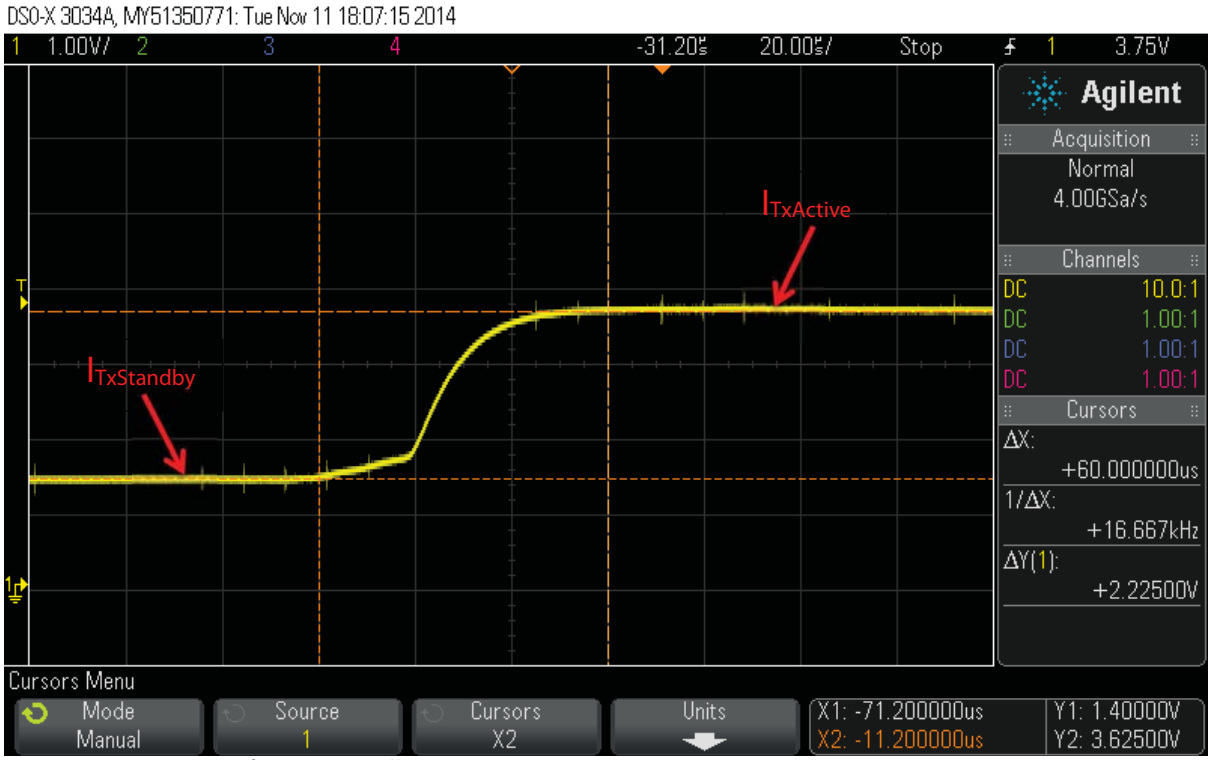


Figure 3, current ramp from TX standby to TX active

$$I_{TxActive} = \frac{3.625}{30} \approx 121mA$$

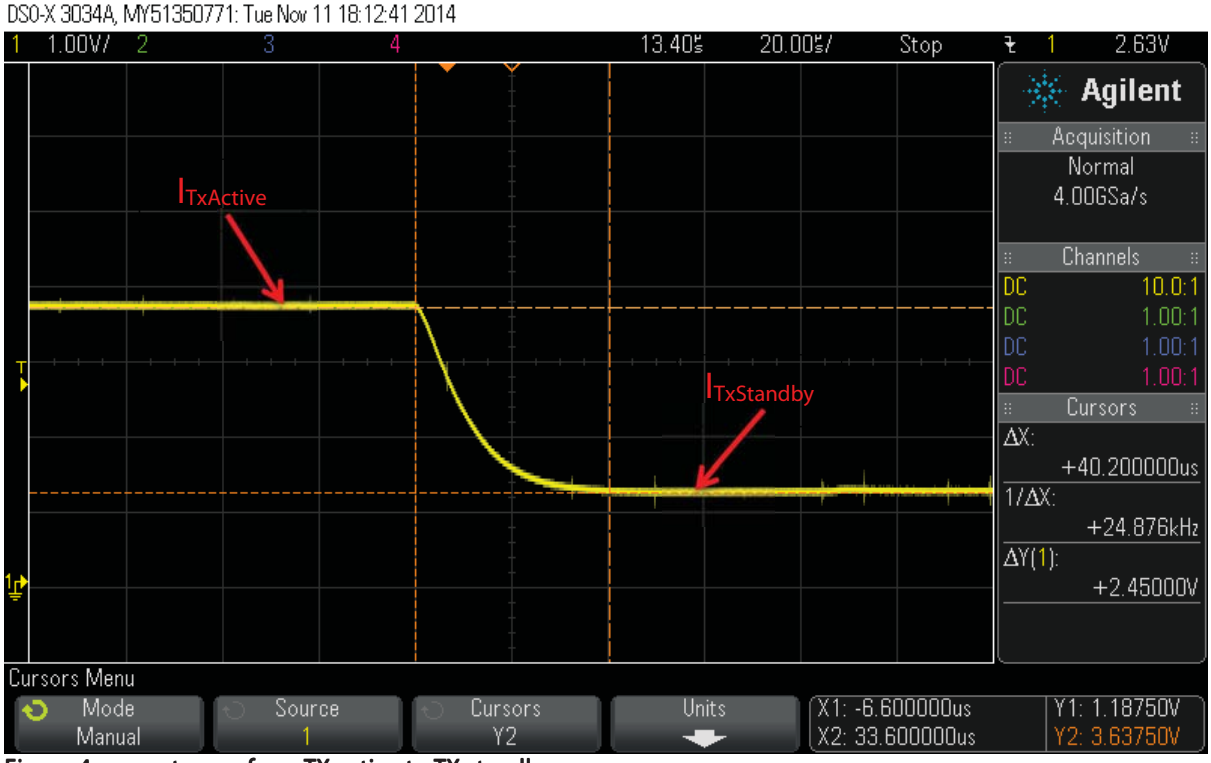


Figure 4, current ramp from TX active to TX standby

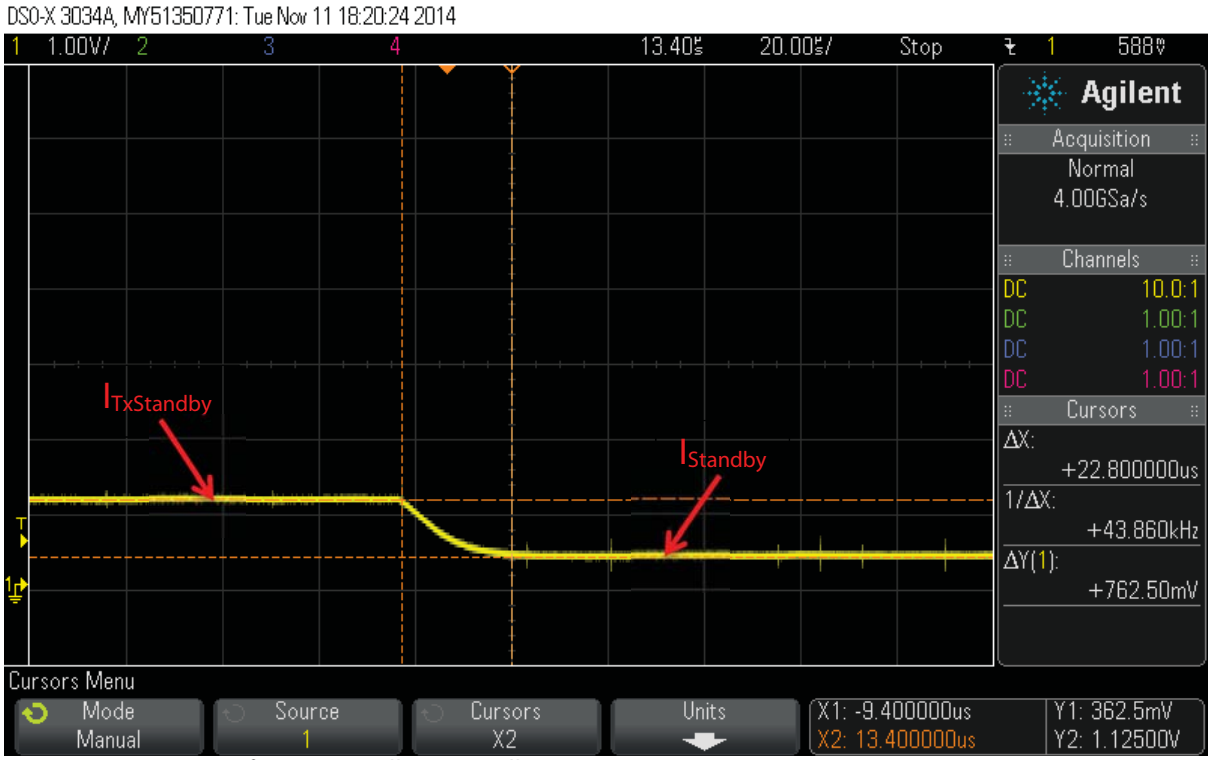


Figure 5, current ramp from TX standby to standby

Internal or External Antenna?

For short distances the internal antenna will perform well. But if the design is to be placed inside a metal enclosure, or if there is a need to cover large distances, an external antenna is necessary. An external antenna MUST at least be designed for operation between 2.4 – 2.48GHz

Always use external antennas with a 50 Ω characteristic impedance.

Internal Antenna

If the internal antenna is considered, the product case needs to be of a RF transparent plastic material. The circuit board that will hold the CORE module needs to be designed so that the internal chip antenna radiates efficiently. Avoid any ground planes near the antenna chip.

When placing the CORE module on a circuit board:

- Place the module as close to the (main) circuit board edge as possible with the antenna pointing outward.
- Note the absence of ground plane near the chip antenna on the modules´ circuit board.
- Remove any copper from the main board as specified in section “Layout Example”
- Avoid using metal structures such as mounting hardware close to the antenna chip.

	Brand	Model Name	Gain(dBi)	Photo
External Antenna	CRMX	104-1001	2.15	
Internal Antenna	JOHANSON TECHNOLOGY	2450AT18A100	0.5	

Layout considerations for the main (Customer) board.

The CORE module has been specifically designed in order to achieve good RF performance. In order to maintain this, there are some guidelines that we would like to stress:

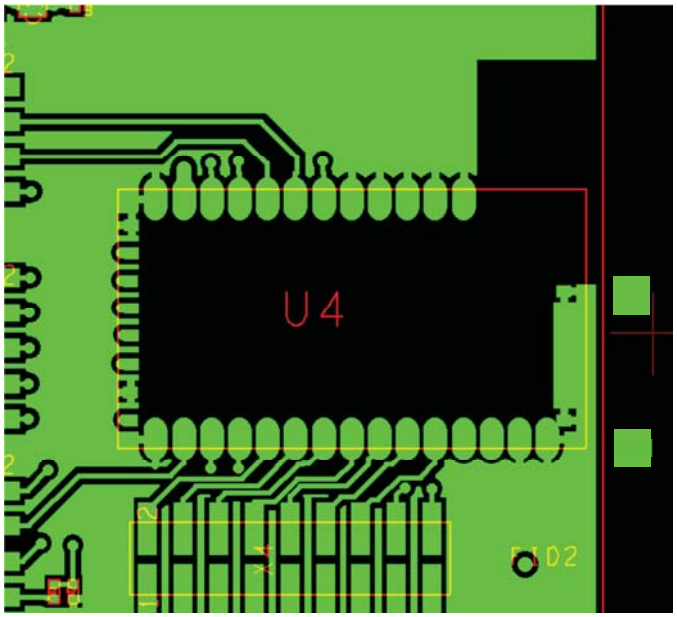
The use of ground planes also on the main board cannot be overemphasized. Good decoupling of any high speed digital circuitry is a must. Many embedded type micro processors today has clock frequencies with clocks or over tones that reaches well into the GHz range. It is perfectly possible for an embedded design to pass any EMC certification and still cause disturbances that will block the RF reception of the CORE module. The sensitivity of the CORE module receiver is better than -100dBm ___ therefore it is recommended to keep disturbances below this level in the frequency range of operation.

A near field probe connected to a spectrum analyzer will show if there are any disturbances present on the 2.45 GHz band generated by the micro processor or any other device that is placed on the main board. Pay special attention to readymade LAN-products "Server in a RJ connector". They pass EMC certifications, but some of them radiates badly on 2.45 GHz. If disturbances can be seen on a spectrum analyzer - then the CORE module will have impaired reception.

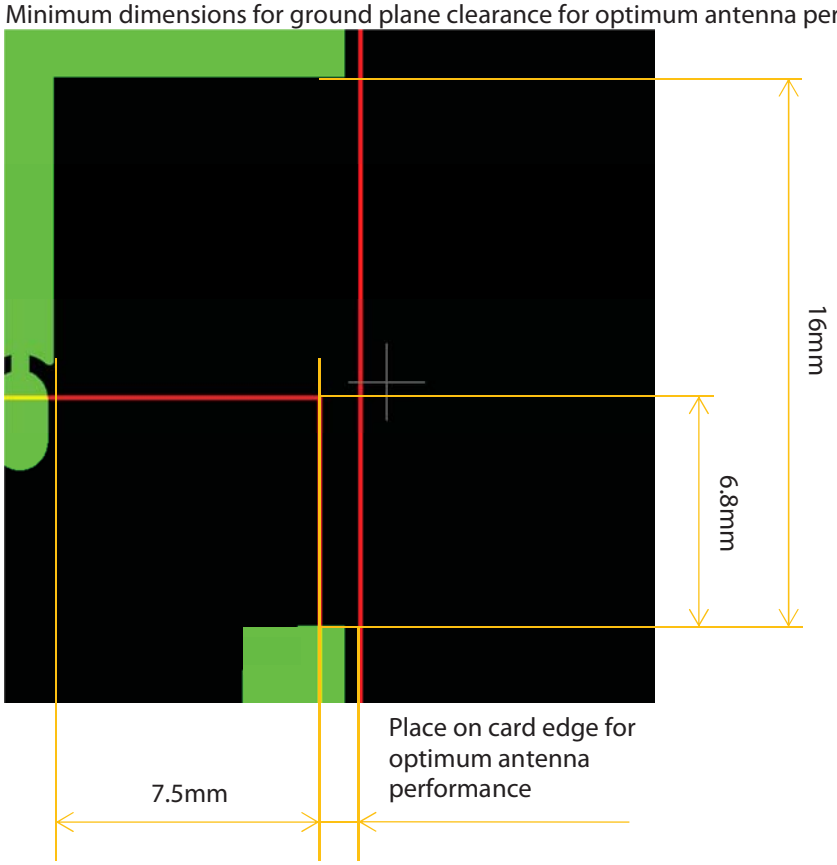
The CORE module has a supply voltage decoupling on the circuit board. The supply voltage still needs to be adequately filtered. If any disturbance or intermittent communication failures occur, as one of the trouble shooting steps - check the supply voltage for drop-outs, switch supply ripple etc.

Layout Example

1. The TOP layer inside the footprint must be free from copper. There is a ground plane on the transceiver module, but there are also supply lines. It is an unnecessary risk to rely on solder mask lacquer for isolation.
2. The area around the antenna must be kept clear from copper on all layers. This is shown in the picture below. This shows inner layer 1 (next to TOP)



Minimum dimensions for ground plane clearance for optimum antenna performance is shown below:

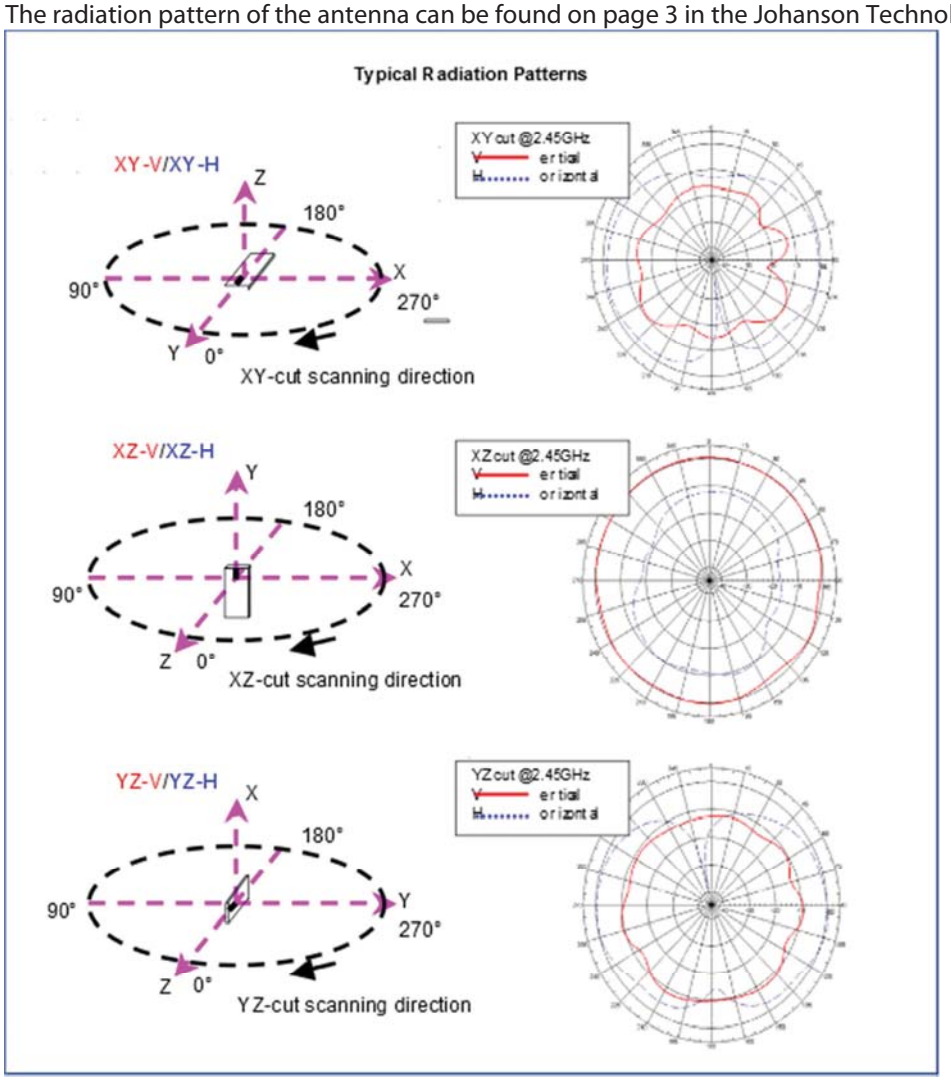


Internal antenna radiation pattern

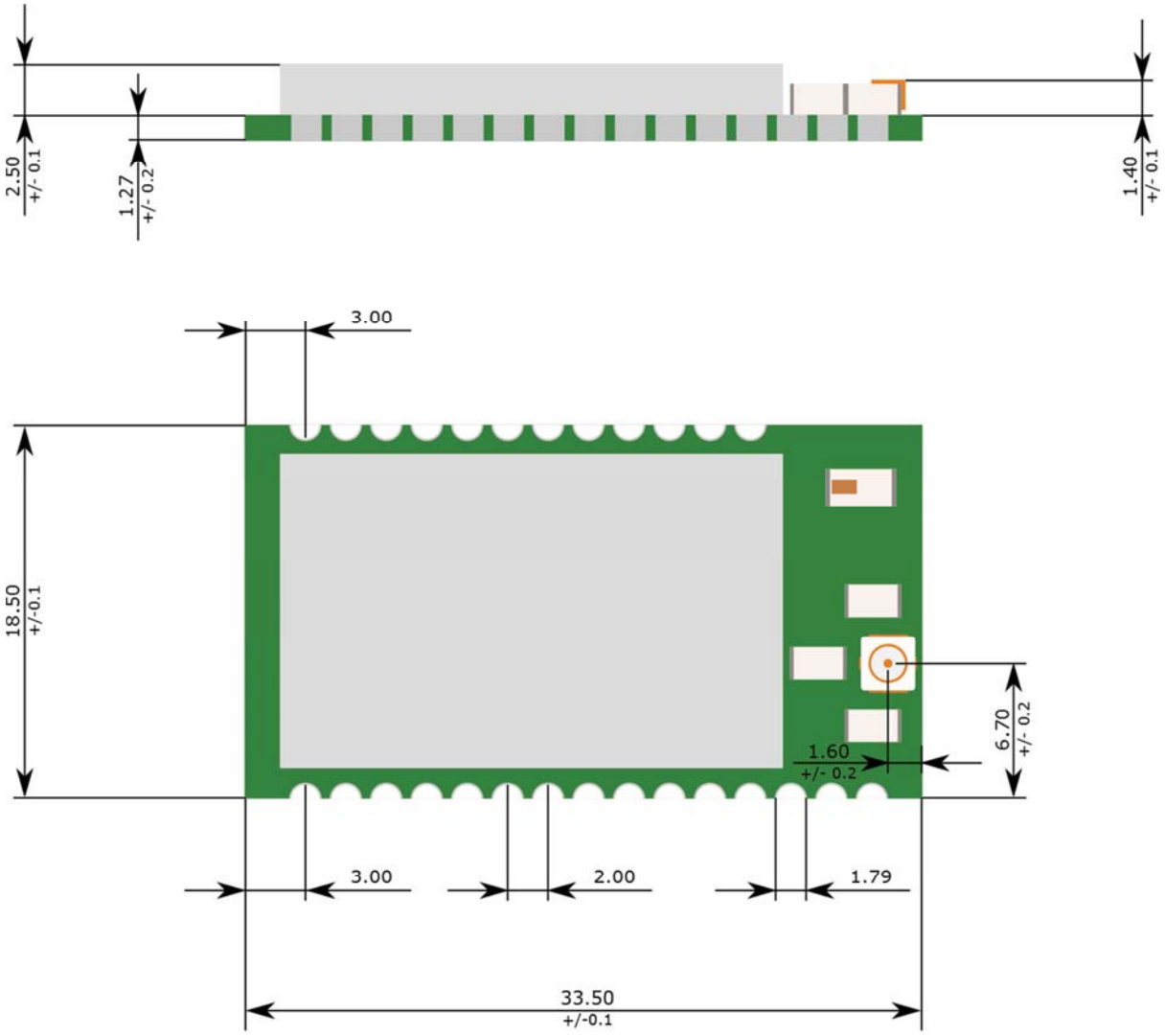
The Core module is utilizing an internal RF Ceramic Chip Antenna from Johanson Technology Inc part number 2450AT18A100E.

A detailed specification of the antenna can be found here:
http://www.johansontechnology.com/images/stories/ip/rf-antennas/JTI_Antenna-2450AT18A100_10-03.pdf

The radiation pattern of the antenna can be found on page 3 in the Johanson Technology Inc:



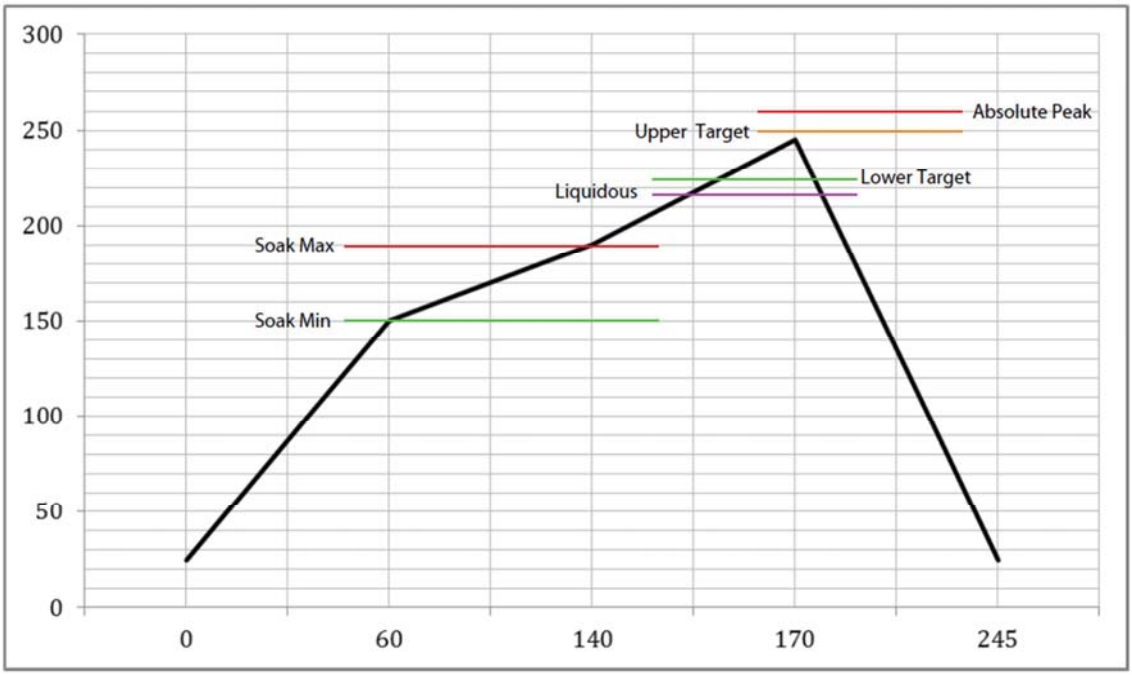
Mechanical dimensions



CORE reflow soldering specification

The CORE module is a surface mount device (SMD) designed to be easily manufactured including reflow soldering to a PCB. It is ultimately the responsibility of the customer to choose the appropriate solder paste and to ensure oven temperatures during reflow meet the requirements of the solder paste. CORE surface mount module conforms to JSTD-020D1 standards for reflow temperatures.

Important: During reflow, modules should not be above 260° and not for more than 30 seconds



Temperatures should not exceed the minimums or maximums presented in table below:

Specification	Value	Unit
Temperature Inc./Dec. Rate (max)	1~3	°C / sec
Temperature Decrease rate (goal)	2-4	°C / sec
Soak Temp Increase rate (goal)	.5 - 1	°C / sec
Flux Soak Period (min)	70	sec
Flux Soak Period (max)	120	sec
Flux Soak Temp (min)	150	°C
Flux Soak Temp (max)	190	°C
Time Above Liquidous (max)	70	sec
Time Above Liquidous (min)	50	sec
Time In Target Reflow Range (goal)	30	sec
Time At Absolute Peak (max)	5	sec
Liquidous Temperature (SAC305)	218	°C
Lower Target Reflow Temperature	225	°C
Upper Target Reflow Temperature	250	°C
Absolute Peak Temperature	260	°C

Compliance information

FCC information

FCC Information to User

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.
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Guidelines for Human Exposure

The modular can be installed or integrated in mobile or fix devices only. This modular cannot be installed in any portable device, for example, USB dongle like transmitters is forbidden.
This modular complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This modular must be installed and operated with a minimum distance of 20 cm between the radiator and user body.

FCC Declaration of Conformity

We LumenRadio AB Svangatan2B, 41668 Gothenburg, Sweden, declare under our sole responsibility that 200-1901, CORE, complies with Part 15 of FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference, and
- This device must accept any interference received, including interference that may cause undesired operation.

FCC Radio Frequency Interference Warnings & Instructions

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. 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 methods:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and the receiver
- Connect the equipment into an electrical outlet on a circuit different from that which the radio receiver is connected
- Consult the dealer or an experienced radio/TV technician for help.

Modifications made to the product, unless expressly approved by LumenRadio AB., could void the user's right to operate the equipment.

CE

200-1901, CORE, complies with the Essential Requirements of RED (Radio Equipment Directive) of the European Union (2014/53/EU). CORE meets the ETSI EN 300 328 V1.8.1 and ETSI EN 300 328 V1.9.1 conformance standards for radio performance.

Compliance Marketing

FCC & Industrial Canada

The CORE module is certified for FCC as a single-modular transmitter.
CORE is a FCC certified radio module that carries a “Modular” grant CORE complies to the “Intentional Radiator” portion (Part 15c) for FCC certification: Part 15.247 Transmitter tests.

If the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: “Contains Transmitter Module FCC ID: XRSCRMXCORE101” or “Contains FCC ID: XRSCRMXCORE101”.
When the module is installed inside another device, the user manual of this device must contain below warning statements: 1. 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. (2) This device must accept any interference received, including interference that may cause undesired operation. 2. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
The devices must be installed and used in strict accordance with the manufacturer's instructions as described in the user documentation that comes with the product.

Other Compliances

For other local compliance regulations (CE, UL, CSA, SRRC, C-Tick, etc.) you are responsible as the product manufacturer to ensure all required compliance testing is completed. LumenRadio are happy to advise on compliance testing – please contact LumenRadio for details.

Canada Statement

This device complies with Industry Canada’s licence-exempt RSSs. 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. Le présent appareil est conforme aux CNR d’Industrie Canada applicables aux appareils radio exempts de licence. L’exploitation est autorisée aux deux conditions suivantes : (1) l’appareil ne doit pas produire de brouillage; (2) l’utilisateur de l’appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d’en compromettre le fonctionnement. The device meets the exemption from the routine evaluation limits in section 2.5 of RSS 102 and compliance with RSS-102 RF exposure, users can obtain Canadian information on RF exposure and compliance. Le dispositif rencontre l'exemption des limites courantes d'évaluation dans la section 2.5 de RSS 102 et la conformité à l'exposition de RSS-102 rf, utilisateurs peut obtenir l'information canadienne sur l'exposition et la conformité de rf. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body. Cet émetteur ne doit pas être Co-placé ou ne fonctionnant en même temps qu'aucune autre antenne ou émetteur. Cet équipement devrait être installé et actionné avec une distance minimum de 20 centimètres entre le radiateur et votre corps. If the IC number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: “Contain IC: 8879A-CRMXC101”.
When the module is installed inside another device, the user manual of this device must contain below warning statements: 1. This device complies with Industry Canada’s licence-exempt RSSs. 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. 2. Cet appareil est conforme aux CNR exemptes de licence d'Industrie Canada . Son fonctionnement est soumis aux deux conditions suivantes : (1) Ce dispositif ne peut causer d'interférences ; et (2) Ce dispositif doit accepter toute interférence , y compris les interférences qui peuvent causer un mauvais fonctionnement de l'appareil. The devices must be installed and used in strict accordance with the manufacturer's instructions as described in the user documentation that comes with the product.

The modular can be installed or integrated in mobile or fix devices only.
This modular cannot be installed in any portable device, for example,
USB dongle like transmitters is forbidden.

This modular complies with IC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This modular must be installed and operated with a minimum distance of 20 cm between the radiator and user body. Cette modulaire doit être installé et utilisé à une distance minimum de 20 cm entre le radiateur et le corps de l'utilisateur.

Revision history

Document revision	Release date	Comment	Status
PA1	2014-09-15	Initial version	Preliminary
PA2	2014-09-17	Specifications added	Preliminary
PA3	2014-09-30	Additional specifications added Layout example added Compliance information added	Preliminary
PA4	2014-11-11	Current ramps added	Preliminary
PA5	2014-12-11	Minor changes	Preliminary
PA6	2014-01-28	Pin functions specified, Mechanical dimensions drawing added	Preliminary