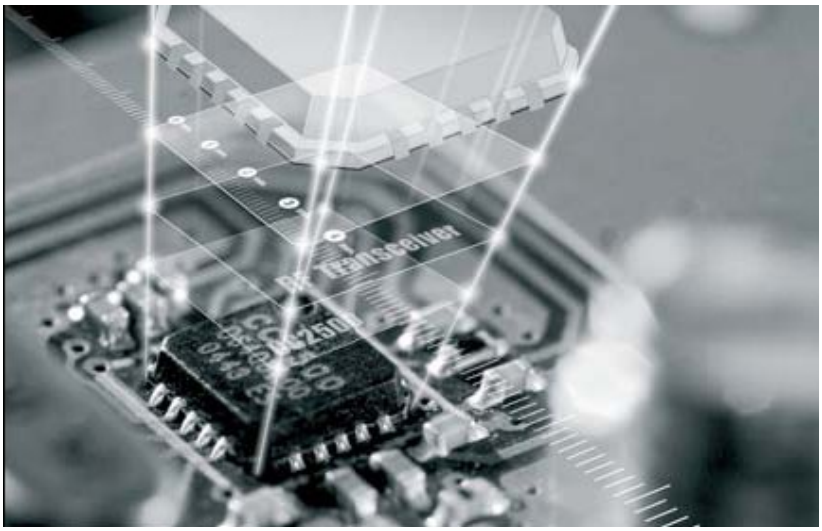
SPECIFICATION

Single Chip Low Cost / Low Power
RF Transceiver



Model : **Sub. 1GHz RF Module**

Part No : TC110x-RTIx-x

Version : V2.1

Date : 2013.11.2

■ Function Description

The **TC110x-RTIx-x** is a low-cost sub-1 GHz transceiver designed for very low-power wireless applications. The circuit is mainly intended for the ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency bands at 315, 433, 868, and 915 MHz, but can easily be programmed for operation at other frequencies in the 300-348 MHz, 387-464 MHz and 779-928 MHz bands.

■ Applications

- ***Ultra low-power wireless applications operating in the 315/433/868/915 MHz ISM/SRD bands***
- ***Wireless alarm and security systems***
- ***Industrial monitoring and control***
- ***Wireless sensor networks***
- ***AMR – Automatic Meter Reading***
- ***Home and building automation***
- ***Wireless MBUS***

■ Selection Guide

Denomination ：Sub. 1GHz Transceiver Module
Part No. ：TC110**x**-RTI**x** - **x**

1: CC1101 / L: CC110L

3: 3xx MHz / **4**: 4xx MHz / **8**:8xx MHz / **9**:9xxMHz

S: include 180°Antenna / SR:include 90°Antenna /
Nc: not include Antenna

Absolute Maximum Ratings

Under no circumstances must the absolute maximum ratings given in Table 1 be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

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

Parameter	Min	Max	Units	Condition
Supply voltage	- 0.3	3.6	V	All supply pins must have the same voltage
Voltage on any digital pin	- 0.3	VDD + 0.3, max 3.9	V	
Voltage on the pins	- 0.3	2.0	V	
Voltage ramp-up rate		120	kV/µs	
Input RF level		+10	dBm	
Storage temperature range	- 50	150	°C	
Solder reflow temperature		260	°C	According to IPC/JEDEC J-STD

Operating Conditions

Parameter	Min	Max	Units	Condition
Operating temperature	- 40	85	°C	
Operating supply voltage	1.8	3.6	V	All supply pins must have the same voltage

General Characteristics

Parameter	Min	Typ	Max	Units	Condition/Note
Frequency range	300		348	MHz	
	387		464		If using a 27 MHz crystal, the lower frequency limit for this band is 392 MHz
	779		928		
Tolerance		±20		ppm	This is the total tolerance including a) initial tolerance, b) crystal loading, c) aging, and d) temperature dependence. The acceptable crystal tolerance depends on RF frequency and channel spacing / bandwidth.
Data rate	0.6		500	kbps	2-FSK
	0.6		250	kbps	GFSK and OOK
	0.6		500	kbps	Optional Manchester encoding (the data rate in kbps will be half the baud rate)

■ Electrical Specifications

● Current Consumption

Tc = 25°C, VDD = 3.0 V if nothing else stated. All measurement results obtained using the CC1101/CC110L EM reference design

Parameter	Min	Typ	Max	Units	Condition/Note
Current consumption in power down modes		0.2		µA	Voltage regulator to digital part off, register values retained (SLEEP state). All GDO pins programmed to 0x2F (HW to 0)
		100		µA	Voltage regulator to digital part off, register values retained, XOSC running (SLEEP state with MCSM0. OSC_FORCE_ON set)
		165		µA	Voltage regulator to digital part on, all other modules in power down (XOFF state)
Current consumption		9.8		µA	Automatic RX polling once each second, using low-power RC oscillator, with 460 kHz filter bandwidth and 250 kBaud data rate, PLL calibration every 4th wakeup. Average current with signal in channel *below* carrier sense level (MCSM2. RX_TIME_RSSI=1)
		34.2		µA	Same as above, but with signal in channel *above* carrier sense level, 1.95 ms RX timeout, and no preamble/sync word found
		1.5		µA	Automatic RX polling every 15th second, using low-power RC oscillator, with 460kHz filter bandwidth and 250 kBaud data rate, PLL calibration every 4th wakeup. Average current with signal in channel below carrier sense level (MCSM2. RX_TIME_RSSI=1)
		39.3		µA	Same as above, but with signal in channel *above* carrier sense level, 29.3 ms RX timeout, and no preamble/sync word found
		1.7		mA	Only voltage regulator to digital part and crystal oscillator running (IDLE state)
		8.4		mA	Only the frequency synthesizer is running (FSTXON state). This currents consumption is also representative for the other intermediate states when going from IDLE to RX or TX, including the calibration state
Current consumption, 433 MHz		16.0		mA	Receive mode, 1.2 kBaud, register settings optimized for reduced current, input at sensitivity limit
		15.0		mA	Receive mode, 1.2 kBaud, register settings optimized for reduced current, input well above sensitivity limit
		15.7		mA	Receive mode, 38.4 kBaud, register settings optimized for reduced current, input at sensitivity limit
		15.0		mA	Receive mode, 38.4 kBaud, register settings optimized for reduced current, input well above sensitivity limit
		17.1		mA	Receive mode, 250 kBaud, register settings optimized for reduced current, input at sensitivity limit
		15.7		mA	Receive mode, 250 kBaud, register settings optimized for reduced current, input well above sensitivity limit
		29.2		mA	Transmit mode, +10 dBm output power
		16.0		mA	Transmit mode, 0 dBm output power
		13.1		mA	Transmit mode, –6 dBm output power

Current consumption, 868/915 MHz		15.7		mA	Receive mode, 1.2 kBaud, register settings optimized for reduced current, input at sensitivity limit. See Figure 1 for current consumption with register settings optimized for sensitivity
		14.7		mA	Receive mode, 1.2 kBaud, register settings optimized for reduced current, input well above sensitivity limit. See Figure 1 for current consumption with register settings optimized for sensitivity.
		15.6		mA	Receive mode, 38.4 kBaud, register settings optimized for reduced current, input at sensitivity limit. See Figure 1 for current consumption with register settings optimized for sensitivity.
		14.6		mA	Receive mode, 38.4 kBaud, register settings optimized for reduced current, input well above sensitivity limit. See Figure 1 for current consumption with register settings optimized for sensitivity.
		16.9		mA	Receive mode, 250 kBaud, register settings optimized for reduced current, input at sensitivity limit. See Figure 1 for current consumption with register settings optimized for sensitivity.
		15.6		mA	Receive mode, 250 kBaud, register settings optimized for reduced current, input well above sensitivity limit. See Figure 1 for current consumption with register settings optimized for sensitivity.
		34.2		mA	Transmit mode, +12 dBm output power, 868 MHz
		30.0		mA	Transmit mode, +10 dBm output power, 868 MHz
		16.8		mA	Transmit mode, 0 dBm output power, 868 MHz
		16.4		mA	Transmit mode, –6 dBm output power, 868 MHz.
		33.4		mA	Transmit mode, +11 dBm output power, 915 MHz
		30.7		mA	Transmit mode, +10 dBm output power, 915 MHz
		17.2		mA	Transmit mode, 0 dBm output power, 915 MHz
		17.0		mA	Transmit mode, –6 dBm output power, 915 MHz

◆Typical TX Current Consumption over Temperature and Supply Voltage, 868 MHz

	Supply Voltage VDD = 1.8 V			Supply Voltage VDD= 3.0 V			Supply Voltage VDD = 3.6v		
Temperature [°C]	-40.0	25.0	85.0	-40.0	25.0	85.0	-40.0	25.0	85.0
Current [mA], PATABLE=0xC0, +12 dBm	32.7	31.5	30.5	35.3	34.2	33.3	35.5	34.4	33.5
Current [mA], PATABLE=0xC5, +10 dBm	30.1	29.2	28.3	30.9	30.0	29.4	31.1	30.3	29.6
Current [mA], PATABLE=0x50, 0 dBm	16.4	16.0	15.6	17.3	16.8	16.4	17.6	17.1	16.7

◆Typical TX Current Consumption over Temperature and Supply Voltage, 915 MHz

	Supply Voltage VDD = 1.8 V			Supply Voltage VDD= 3.0 V			Supply Voltage VDD = 3.6v		
Temperature [°C]	-40	25	85	-40	25	85	-40	25	85

Current [mA], PATABLE=0xC0, +12 dBm	31.9	30.7	29.8	34.6	33.4	32.5	34.8	33.6	32.7
Current [mA], PATABLE=0xC5, +10 dBm	30.9	29.8	28.9	31.7	30.7	30.0	31.9	31	30.2
Current [mA], PATABLE=0x50, 0 dBm	17.2	16.8	16.4	17.6	17.2	16.9	17.8	17.4	17.1

● RF Receive Section

Tc = 25°C, VDD = 3.0 V if nothing else stated. All measurement results obtained using the CC1101/CC110L EM reference design.

Parameter	Min	Typ	Max	Units	Condition/Note
Digital channel filter bandwidth	58		812	kHz	User programmable. The bandwidth limits are proportional to crystal frequency
Spurious emissions		-68 -66	-57 -47	dBm dBm	25 MHz – 1 GHz (Maximum figure is the ETSI EN 300 220 limit) Above 1 GHz (Maximum figure is the ETSI EN 300 220 limit) Typical radiated spurious emission is -49 dBm measured at the VCO frequency
RX latency		9		bit	Serial operation. Time from start of reception until data is available on the receiver data output pin is equal to 9 bit

315 MHz

Parameter	Min	Typ	Max	Units	Condition/Note
1.2 kBaud data rate, sensitivity optimized, `MDMCFG2.DEM_DCFILT_OFF=0` (2-FSK, 1% packet error rate, 20 bytes packet length, 5.2 kHz deviation, 58 kHz digital channel filter bandwidth)					
Receiver sensitivity		-111		dBm	Sensitivity can be traded for current consumption by setting MDMCFG2.DEM_DCFILT_OFF=1. The typical current consumption is then reduced from 17.2 mA to 15.4 mA at the sensitivity limit. The sensitivity is typically reduced to -109 dBm
500 kBaud data rate, sensitivity optimized, `MDMCFG2.DEM_DCFILT_OFF=0` (MSK, 1% packet error rate, 20 bytes packet length, 812 kHz digital channel filter band					
Receiver sensitivity		-88		dBm	MDMCFG2.DEM_DCFILT_OFF=1 cannot be used for data rates > 250 kBaud

433 MHz

Parameter	Min	Typ	Max	Units	Condition/Note
1.2 kBaud data rate, sensitivity optimized, `MDMCFG2.DEM_DCFILT_OFF=0` (GFSK, 1% packet error rate, 20 bytes packet length, 5.2 kHz deviation, 58 kHz digital channel					
Receiver sensitivity		-112		dBm	Sensitivity can be traded for current consumption by setting MDMCFG2.DEM_DCFILT_OFF=1. The typical current consumption is then reduced from 18.0 mA to 16.0 mA at the sensitivity limit. The sensitivity is typically reduced to
38.4 kBaud data rate, sensitivity optimized, `MDMCFG2.DEM_DCFILT_OFF=0` (GFSK, 1% packet error rate, 20 bytes packet length, 20 kHz deviation, 100					
Receiver sensitivity		-104		dBm	MDMCFG2.DEM_DCFILT_OFF=1 cannot be used for data rates > 250 kBaud
250 kBaud data rate, sensitivity optimized, `MDMCFG2.DEM_DCFILT_OFF=0` (GFSK, 1% packet error rate, 20 bytes packet length, 127 kHz deviation, 540 kHz					
Receiver sensitivity		-95		dBm	

868/915 MHz

Parameter	Min	Typ	Max	Units	Condition/Note
868 MHz, 1.2 kBaud data rate, sensitivity optimized, `MDMCFG2.DEM_DCFILT_OFF=0` (GFSK, 1% packet error rate, 20 bytes packet length, 5.2 kHz deviation, 58 kHz digital channel					
Receiver sensitivity		-112		dBm	Sensitivity can be traded for current consumption by setting MDMCFG2.DEM_DCFILT_OFF=1. The typical current consumption is then reduced from 18.0 mA to 16.0 mA at the sensitivity limit. The sensitivity is typically reduced to
Saturation		-14		dBm	FIFOTHR.CLOSE_IN_RX=0. See more in DN010 [11]
Adjacent channel rejection ±100 kHz offset		37		dBm	Desired channel 3 dB above the sensitivity limit. 100 kHz channel spacing See Figure 2 for selectivity performance at other offset frequencies
Image channel rejection		31		dBm	IF frequency 152 kHz Desired channel 3 dB above the sensitivity limit
Blocking ±2 MHz offset ±10 MHz offset		-50 -40		dBm dBm	Desired channel 3 dB above the sensitivity limit See Figure 2 for blocking performance at other offset frequencies
38.4 kBaud data rate, sensitivity optimized, MDMCFG2.DEM_DCFILT_OFF=0 (GFSK, 1% packet error rate, 20 bytes packet length, 20 kHz deviation, 100					
Receiver sensitivity		-104		dBm	Sensitivity can be traded for current consumption by setting MDMCFG2.DEM_DCFILT_OFF=1. The typical current consumption is then reduced from 17.7 mA to 15.6 mA at the sensitivity limit. The sensitivity is typically reduced to -102 dBm
Saturation		-16		dBm	FIFOTHR.CLOSE_IN_RX=0. See more in DN010 [11]
Adjacent channel rejection -200 kHz offset +200 kHz offset		12 25		dBm dBm	Desired channel 3 dB above the sensitivity limit. 200 kHz channel spacing See Figure 3 for blocking performance at other offset frequencies
Image channel rejection		23		dBm	IF frequency 152 kHz Desired channel 3
Blocking ±2 MHz offset ±10 MHz offset		-50 -40		dBm dBm	Desired channel 3 dB above the sensitivity limit See Figure 3 for blocking performance at other offset frequencies
250 kBaud data rate, sensitivity optimized, MDMCFG2.DEM_DCFILT_OFF=0 (GFSK, 1% packet error rate, 20 bytes packet length, 127 kHz deviation, 540 kHz digital channel					
Receiver sensitivity		-95		dBm	Sensitivity can be traded for current consumption by setting MDMCFG2.DEM_DCFILT_OFF=1. The typical current consumption is then reduced from 18.9 mA to 16.9 mA at the sensitivity limit. The
Saturation		-17		dBm	FIFOTHR.CLOSE_IN_RX=0. See
Adjacent channel rejection		25		dB	Desired channel 3 dB above the sensitivity limit. 750 kHz channel spacing See Figure 4 for blocking performance at other offset frequencies
Image channel rejection		14		dB	IF frequency 304 kHz Desired channel 3 dB above the
Blocking ±2 MHz offset ±10 MHz offset		-50		dBm	Desired channel 3 dB above the sensitivity limit See Figure 4 for blocking performance at other offset frequencies

		-40		dBm	
sensitivity optimized, MDMCFG2.DEM_DCFILT_OFF=0 (MSK, 1% packet error rate, 20 bytes packet length, 812 kHz digital channel filter bandwidth)					
Receiver sensitivity		-90		dBm	MDMCFG2.DEM_DCFILT_OFF=1 cannot be used for data rates > 250 kBaud
Image channel rejection		1		dB	IF frequency 355 kHz Desired channel 3 dB above the sensitivity limit
Blocking ±2 MHz offset ±10 MHz offset		-50 -40		dBm dBm	Desired channel 3 dB above the sensitivity limit See Figure 5 for blocking performance at other offset frequencies

◆Typical Sensitivity over Temperature and Supply Voltage, 868 MHz, Sensitivity Optimized Setting

	Supply Voltage VDD = 1.8 V			Supply Voltage VDD= 3.0 V			Supply Voltage VDD = 3.6v		
Temperature [°C]	-40	25	85	-40	25	85	-40	25	85
Sensitivity [dBm] 1.2 kBaud	-113	-112	-110	-113	-112	-110	-113	-112	-110
Sensitivity [dBm] 38.4 kBaud	-105	-104	-102	-105	-104	-102	-105	-104	-102
Sensitivity [dBm] 250 kBaud	-97	-96	-92	-97	-95	-92	-97	-94	-92
Sensitivity [dBm] 500 kBaud	-91	-90	-86	-91	-90	-86	-91	-90	-86

◆Typical Sensitivity over Temperature and Supply Voltage, 915 MHz, Sensitivity Optimized Setting

	Supply Voltage VDD = 1.8 V			Supply Voltage VDD= 3.0 V			Supply Voltage VDD = 3.6v		
Temperature [°C]	-40	25	85	-40	25	85	-40	25	85
Sensitivity [dBm] 1.2 kBaud	-113	-112	-110	-113	-112	-110	-113	-112	-110
Sensitivity [dBm] 38.4 kBaud	-105	-104	-102	-104	-104	-102	-105	-104	-102
Sensitivity [dBm] 250 kBaud	-97	-94	-92	-97	-95	-92	-97	-95	-92
Sensitivity [dBm] 500 kBaud	-91	-89	-86	-91	-90	-86	-91	-89	-86

● RF Transmit Section

TA = 25 C, VDD = 3.0 V, +10 dBm if nothing else stated. .

Parameter	Min	Typ	Max	Units	Condition/Note
Differential load impedance 315 MHz 433 MHz 868/915 MHz		 122 + j31 116 + j41 86.5 + j43		 Ω Ω Ω	Differential impedance as seen from the RF-port (RF_P and RF_N) towards the antenna.

Output power, highest setting 315 MHz 433 MHz 868 MHz 915 MHz		 +10 +10 +12 +11		 dBm dBm dBm dBm	Output power is programmable, and full range is available in all frequency bands. Output power may be restricted by regulatory limits. See Design Note DN013 [10] for output power and harmonics figures when using *multi-layer* inductors. The output power is then typically +10 dBm when operating at 868/915 MHz. Delivered to a 50 single-ended load via the RF matching network in [1] and [2]
Output power, lowest setting		-30		dBm	Output power is programmable, and full range is available in all frequency bands Delivered to a 50 single-ended load via the RF matching network in [1] and [2]

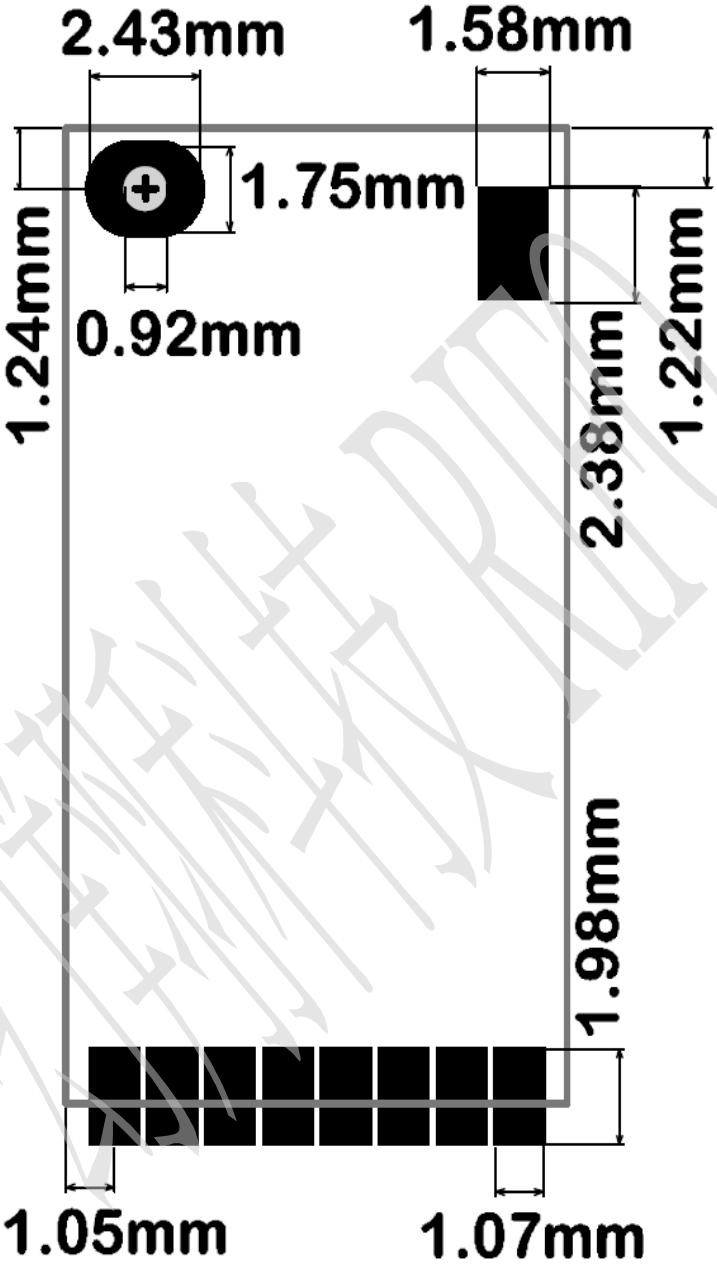
	Supply Voltage VDD = 1.8 V			Supply Voltage VDD= 3.0 V			Supply Voltage VDD = 3.6v		
Temperature [°C]	-40	25	85	-40	25	85	-40	25	85
Output Power [dBm], PATABLE=0xC0, +12 dBm	12	11	10	12	12	11	12	12	11
Output Power [dBm], PATABLE=0xC5, +10 dBm	11	10	9	11	10	10	11	10	10
Output Power [dBm], PATABLE=0x50, +0 dBm	1	0	-1	2	1	0	2	1	0

	Supply Voltage VDD = 1.8 V			Supply Voltage VDD= 3.0 V			Supply Voltage VDD = 3.6v		
Temperature [°C]	-40	25	85	-40	25	85	-40	25	85
Output Power [dBm], PATABLE=0xC0, +11dBm	11	10	10	12	11	11	12	11	11
Output Power [dBm], PATABLE=0x8E, +0 dBm	2	1	0	2	1	0	2	1	0

■ TC110x-RTIx-x RF Module Pin Configuration

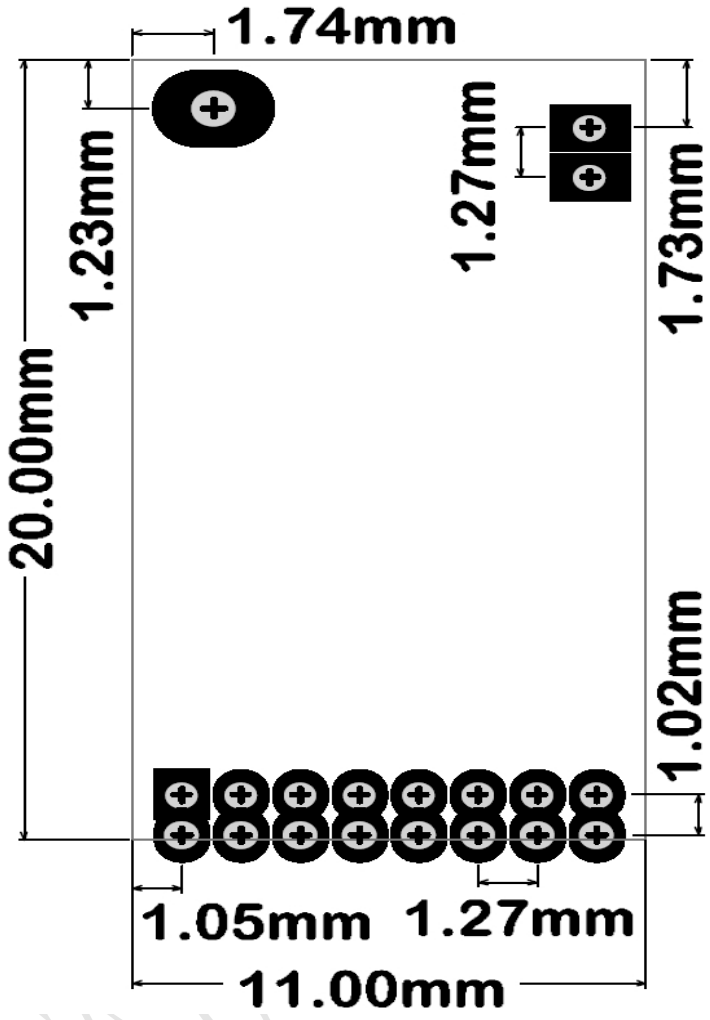
Pin #	Pin name	Pin type	Description
1	VCC	Power (Digital)	Power supply 3.3V
2	SI	Digital Input	Serial configuration interface, data input
3	SCLK	Digital Input	Serial configuration interface, clock input
4	SO	Digital Output	Serial configuration interface, data output. Optional general output pin when CSN is high
5	GDO2	Digital Output	Digital output pin for general use: • Test signals • FIFO status signals • Clear Channel Indicator • Clock output, down-divided from XOSC • Serial output RX data
6	GDO0	Digital I/O	Digital output pin for general use: • Test signals • FIFO status signals • Clear Channel Indicator • Clock output, down-divided from XOSC • Serial output RX data • Serial input TX data Also used as analog test I/O for prototype/production testing
7	CSN	Digital Input	Serial configuration interface, chip select
8	GND	Ground	Ground
9	ANT	RF I/O	External Antenna (50 Ohm)

■ Recommended PCB layout for Module

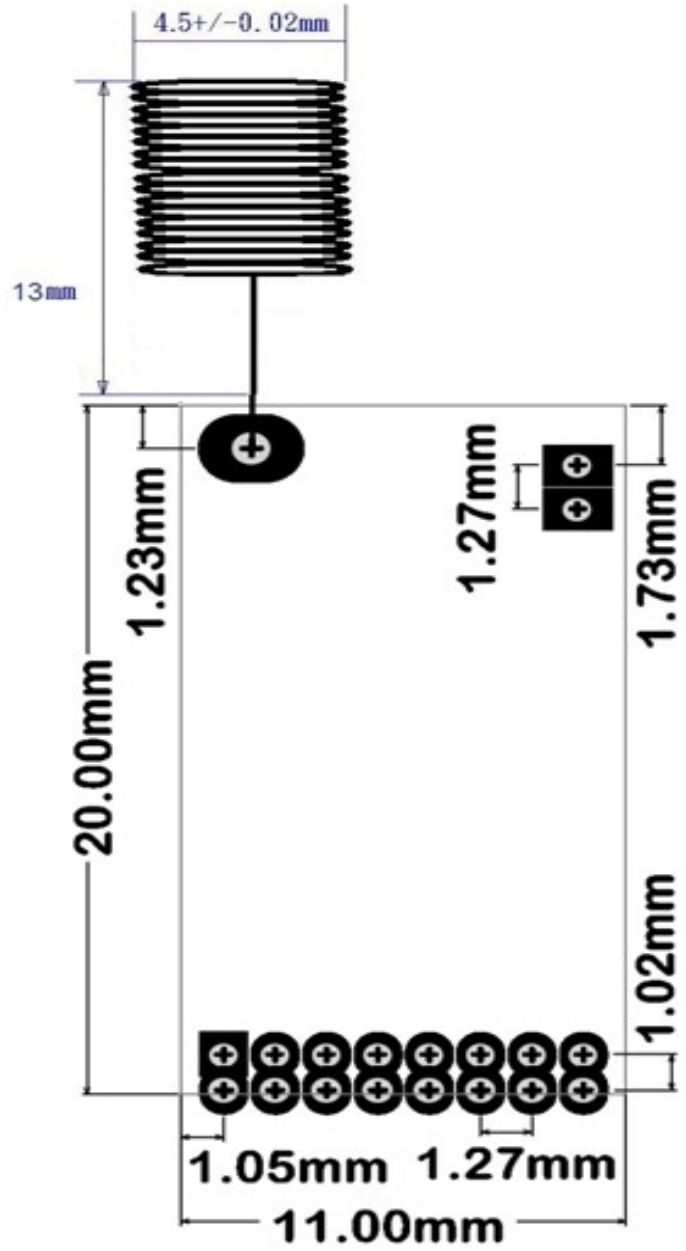


■ TC110x-RTIx-x RF Module Description

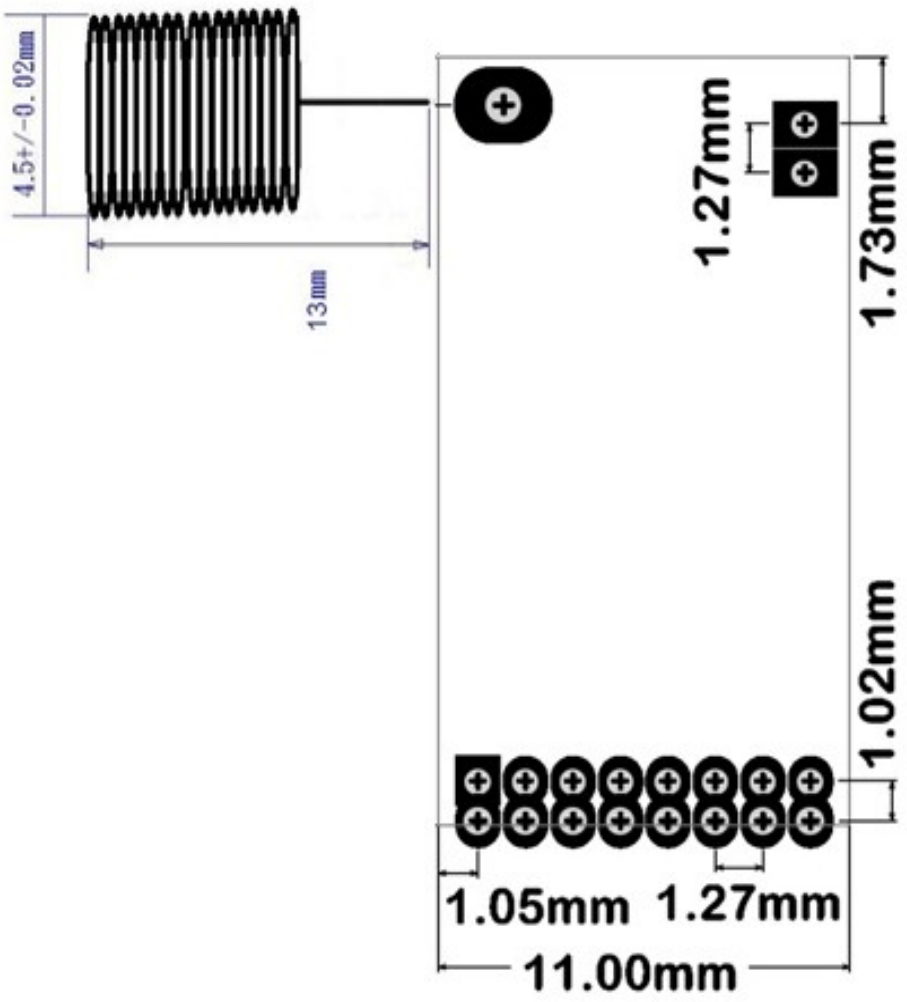
●TC110x-RTIx-Nc



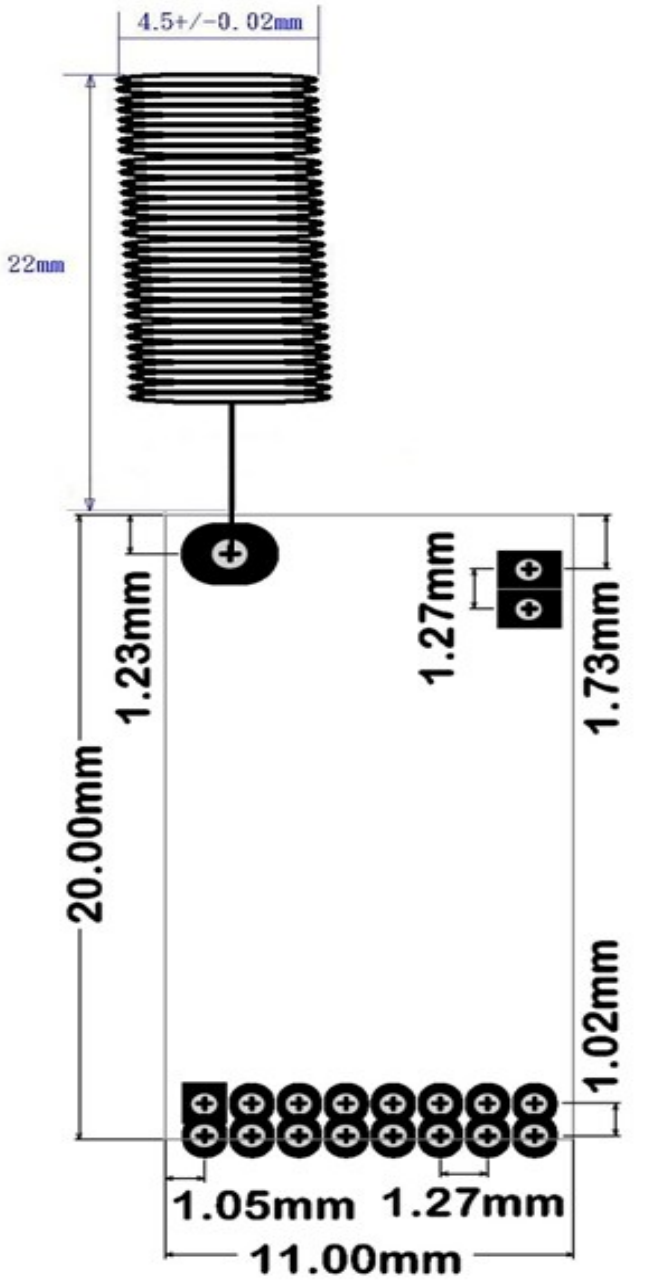
●TC110x-RTI8-S / TC110x-RTI9-S



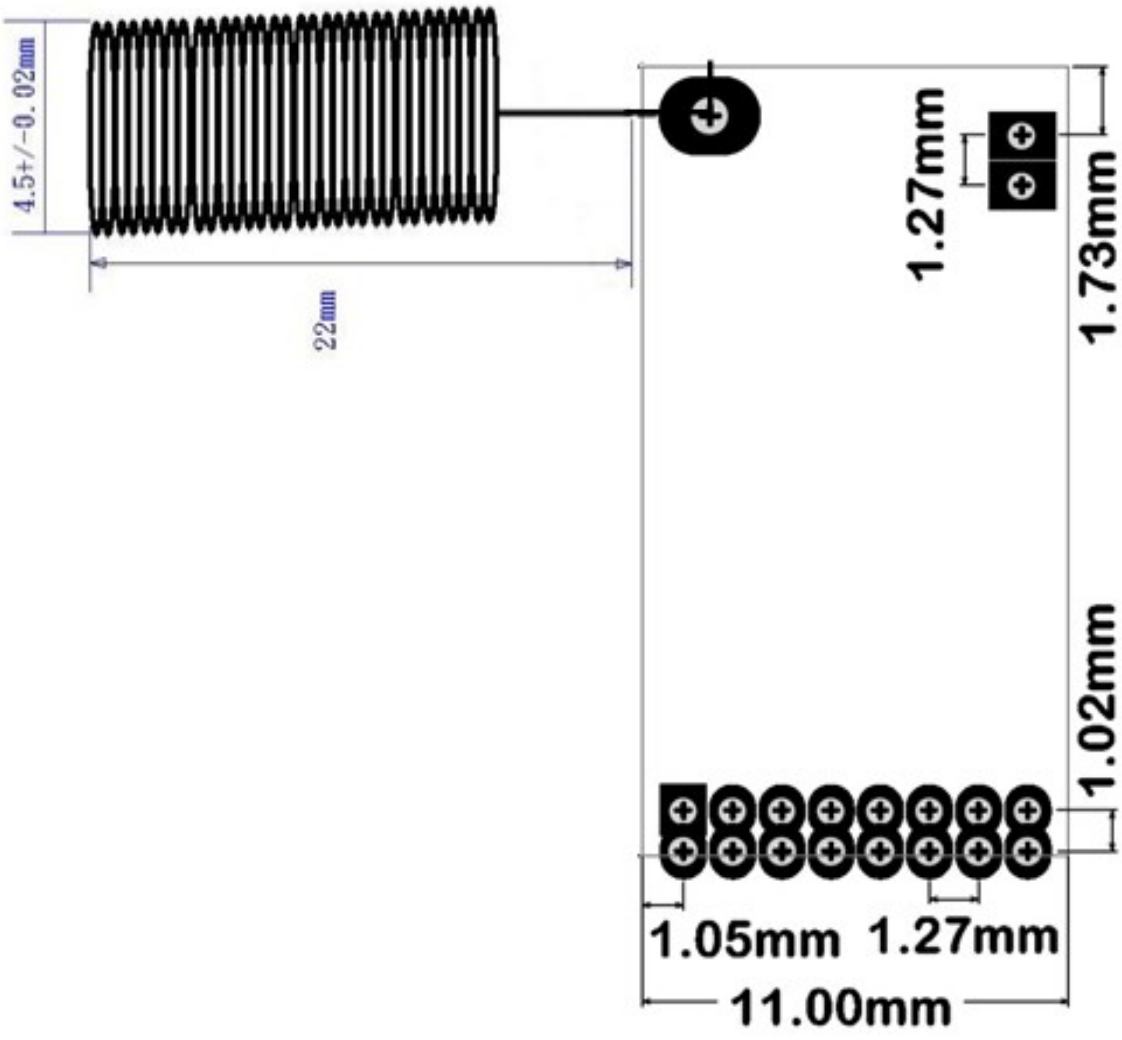
●TC110x-RTI8-SR / TC110x-RTI9-SR



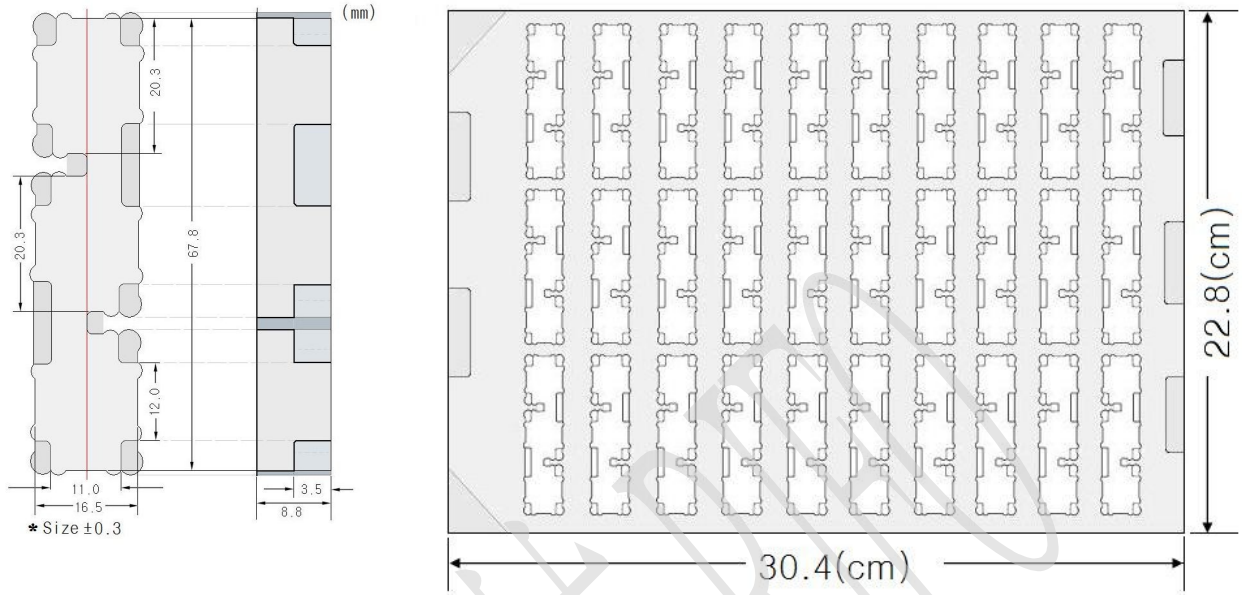
●TC110x-RTI4-S



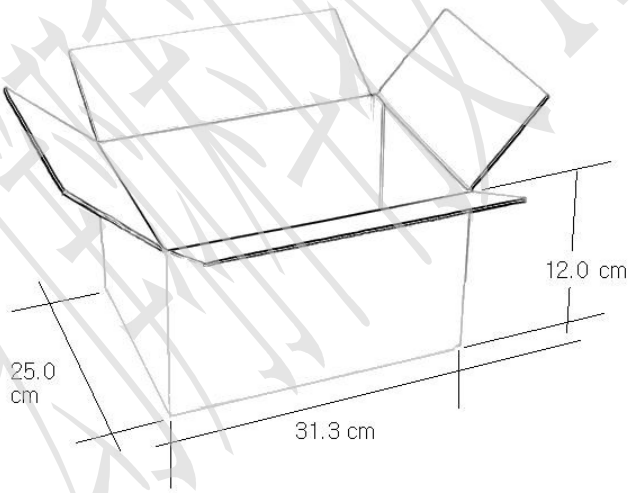
●TC110x-RTI4-SR



■ Skin packing Information



■ Skin packing box Information



Device	Type	SPQ	Length(cm)	Width(cm)	Height(cm)
TC110x-RTIx-x	Module	600	31.3	25.0	12.0

■ Document History

Revision	Date	Description/Changes
2.0	2012.10.15	CC110L ➔Added two registers (CHANNR and MDMCFG0) in addition to the MDMCFG1.CHANSPC_E register field. Changes made to Section 20. Hyperlinks added to the CC110LEM / CC115LEM 433 MHz Reference Design and the CC110LEM / CC115LEM 868 - 915 MHz Reference Design
2.1	2013.11.2	TC110x-RTIx-x RF Module Description ➔Added descriptions with spring antenna

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