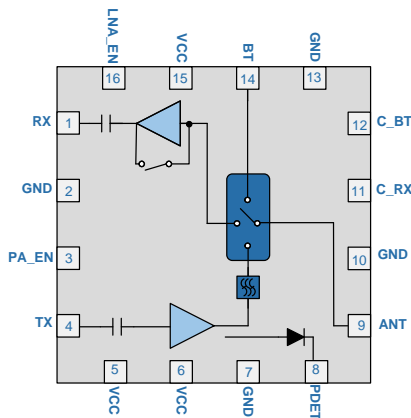


# RFFM8209

## WiFi Front-End Module 2.4GHz to 2.5GHz

The RFFM8209 provides a complete Front-End integrated solution in a single module for WiFi 802.11g/n/ac and Bluetooth systems. The ultra-small form factor and integrated matching greatly reduces the number of external components and layout area in the customer application. This simplifies the total front end solution by reducing the bill of materials, system footprint, and manufacturing cost. The RFFM8209 integrates a power amplifier (PA), a low noise amplifier (LNA) with bypass mode, a power detector coupler for improved accuracy, and a Single Pole 3-Throw (SP3T) switch. The device is provided in a 2.5mm x 2.5mm x 0.40mm 16-pin QFN package. This module meets or exceeds the RF front end needs of IEEE802.11b/g/n/ac WiFi RF systems.



Functional Block Diagram



Package: QFN, 16-pin,  
2.5mm x 2.5mm x 0.40mm

### Features

- Pout = 18dBm 256QAM 20MHz at 1.8% (-35dB) Dynamic EVM, V<sub>CC</sub> = 3.6V
- P<sub>OUT</sub> = 20dBm 64QAM 20MHz at 3.0% (-30.5dB) Dynamic EVM, V<sub>CC</sub> = 3.6V
- Gain = 26dB
- Input and Output Matched to 50Ω
- Supports Wide Voltage Supply Range 3V to 5V

### Applications

- Cellular Handsets
- Mobile Devices
- Tablets
- Consumer Electronics
- Gaming
- Netbooks/Notebooks
- TV/Monitors/Video

### Ordering Information

RFFM8209SB	Standard 5-piece sample bag
RFFM8209SQ	Standard 25-piece sample bag
RFFM8209SR	Standard 100-piece reel
RFFM8209TR7	Standard 2500-piece reel
RFFM8209PCK-410	Fully assembled evaluation board w/ 5-piece bag

## Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage (No RF Applied)	6	V
PA Enable Voltage	-0.5 to 5	V <sub>DC</sub>
DC Supply Current	500	mA
Operating Ambient Temperature (Ta)	-40 to +85	°C
Storage Temperature	-40 to +150	°C
Maximum TX Input Power into 50Ω Load (No Damage)	+12	dBm
Maximum RX Input Power (No Damage)	+12	dBm
Moisture Sensitivity	MSL2	



**Caution!** ESD sensitive device.



RFMD Green: RoHS status based on EU Directive 2011/65/EU (at time of this document revision), halogen free per IEC 61249-2-21, < 1000ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony in solder.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

## Nominal Operating Parameters

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
<b>Compliance</b>					<b>802.11b, 802.11g, 802.11n, 802.11ac</b>
Operating Frequency	2.412		2.484	GHz	
Operating Temperature	-40		85	°C	
Power Supply V <sub>CC</sub>	3.3	3.6	4.2	V	
Extended V <sub>CC</sub>	3		5		
Control Voltage - High	2.8	3.1	V <sub>CC</sub>	V	PA_EN, CRX, CBT, LNA_EN
Control Voltage - Low		0	0.2	V	
<b>Transmit (TX-ANT)</b>					<b>Temp= 25°C, V<sub>CC</sub> = 3.6V, 50% duty cycle unless otherwise noted</b>
11ac Output Power	17.5	18.0		dBm	HT20 / HT40
	15.5	16.0		dBm	Temp = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V
11ac Dynamic EVM		1.5	1.8	%	At Rated Power; HT20 / HT40; 256QAM
		-36.5	-35.0	dB	
11n Output Power	19.5	20		dBm	HT20 / HT40
	17.5	18			Temp = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V
11n Dynamic EVM		2.5	3	%	At Rated Power; HT20 / HT40; 64QAM
		-32.0	-30.5	dB	
Spectral Mask	20	22		dBm	MCS0; HT20 / HT40
TX Port Return Loss	10	13		dB	
ANT Port Return Loss	9.6	12		dB	
Large Signal Gain	23.5	26	30	dB	T = -10°C, to +70°C, V <sub>CC</sub> = 3.3V to 4.2
	22.5	26	31	dB	
Gain Flatness - 20MHz Channel	-0.25	0	0.25	dB	
Gain Flatness - Across Band	-1	0	1	dB	
Operating Current		225		mA	P <sub>OUT</sub> = 15.5dBm
		245		mA	P <sub>OUT</sub> = 18dBm
		265		mA	P <sub>OUT</sub> = 20dBm
Quiescent Current		210		mA	
PA_EN Current		55	80	μA	

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
<b>Transmit (TX-ANT) (continued)</b>					<b>Temp= 25°C, V<sub>CC</sub> = 3.6V, 50% duty cycle unless otherwise noted</b>
Second Harmonic		-10	-5	dBm/MHz	P <sub>OUT</sub> = 22dBm, T = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V, Measured with a standard IEEE802.11b, 1Mbps waveform
Third Harmonic		-44	-35	dBm/MHz	
Power Detector Voltage	0	0.05	0.1	V	P <sub>OUT</sub> = 0dBm (No RF)
	0.35	0.4	0.45	V	P <sub>OUT</sub> = 18.0dBm (see evaluation board schematic)
	0.5	0.6	0.7	V	P <sub>OUT</sub> = 22dBm (see evaluation board schematic)
Variation from 0-360 load pull	-1.5		1.5	dB	3:1 VSWR
ANT-RX Isolation	30	32	35	dB	FEM is operating in TX mode
<b>Receive (ANT-RX)-LNA On</b>					<b>Temp= 25°C, V<sub>CC</sub> = 3.6V, 50% duty cycle unless otherwise noted</b>
Gain (S <sub>21</sub> )	9	11	13	dB	
	8	11	14	dB	Temp = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V
RX Gain Flatness over any 20MHz BW	-0.25		0.25	dB	
Gain flatness across band	-1		1	dB	
Noise Figure		2.5	3	dB	
		2.5	3.7	dB	Temp = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V
Rx Port Return Loss	12	17		dB	
ANT Port Return Loss	3	4		dB	
Current Consumption	7.5	12		mA	
		12	18	mA	Temp = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V
LNA_EN Control Current		350	500	μA	
LNA Turn On Time		200	500	nS	
<b>Receive (ANT-RX)-Bypass Mode</b>					<b>Temp= 25°C, V<sub>CC</sub> = 3.6V, 50% duty cycle unless otherwise noted</b>
Insertion Loss		6	7	dB	
	4	6	8	dB	T = -10°C to 70°C, V <sub>CC</sub> = 3.3V to 4.2V
RX Port Return Loss	10	14		dB	
ANT Port Return Loss	10	12		dB	
Input P1dB	22	27		dBm	
<b>Bluetooth TX/RX</b>					<b>Temp= 25°C, V<sub>CC</sub> = 3.6V, 50% duty cycle unless otherwise noted</b>
Insertion Loss		0.8	1.2	dB	
Nominal Input P1dB	24	28		dBm	
BT Port Return Loss	10	16		dB	
ANT Port Return Loss	10	17		dB	
<b>General Specifications</b>					
Leakage Current		0.5	10	μA	V <sub>CC</sub> = 4.8V, RF OFF, All control lines floating
Switch Control Current-High - Each Line		5	100	μA	
Switch Control Current-Low - Each Line		0.5	5	μA	
Switching Speed		100	400	ns	
ESD - Human Body Model		1000		V	
ESD - Charge Device Model		1000		V	
PA +TX Switch Turn-on Time		200	500	ns	10% to 90%

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
General Specification (continued)					
Maximum Input Power			12	dBm	Into 50Ω, V <sub>CC</sub> = 3.6V, 25°C
			12	dBm	6:1 VSWR, V <sub>CC</sub> = 3.6V, 25°C
			5	dBm	10:1 VSWR, V <sub>CC</sub> = 3.6V, 25°C
PA Stability	4:1 VSWR			No harmonically related spurious above -41.25dBm/MHz	
Ruggedness	10:1 VSWR			At typical operating conditions	
Transmit (TX-ANT) – 5V					Temp= 25°C, V <sub>CC</sub> = 5V, 50% duty cycle unless otherwise noted
11ac Output Power	19.5	20		dBm	HT20 / HT40
11ac Dynamic EVM		1.5	1.8	%	At Rated Power; HT20 / HT40; 256QAM
		-36.5	-35.0	dB	
11n Output Power	20.5	21		dBm	HT20 / HT40
11n Dynamic EVM		2.5	3	%	At Rated Power; HT20 / HT40; 64QAM
		-32.0	-30.5	dB	
Spectral Mask		22		dBm	MCS0; HT20 / HT40
Operating Current		295		mA	P <sub>OUT</sub> =20dBm
		315		mA	P <sub>OUT</sub> = 21dBm
Quiescent Current		255		mA	No RF signal
Large Signal Gain	23.5	26	30.0	dB	

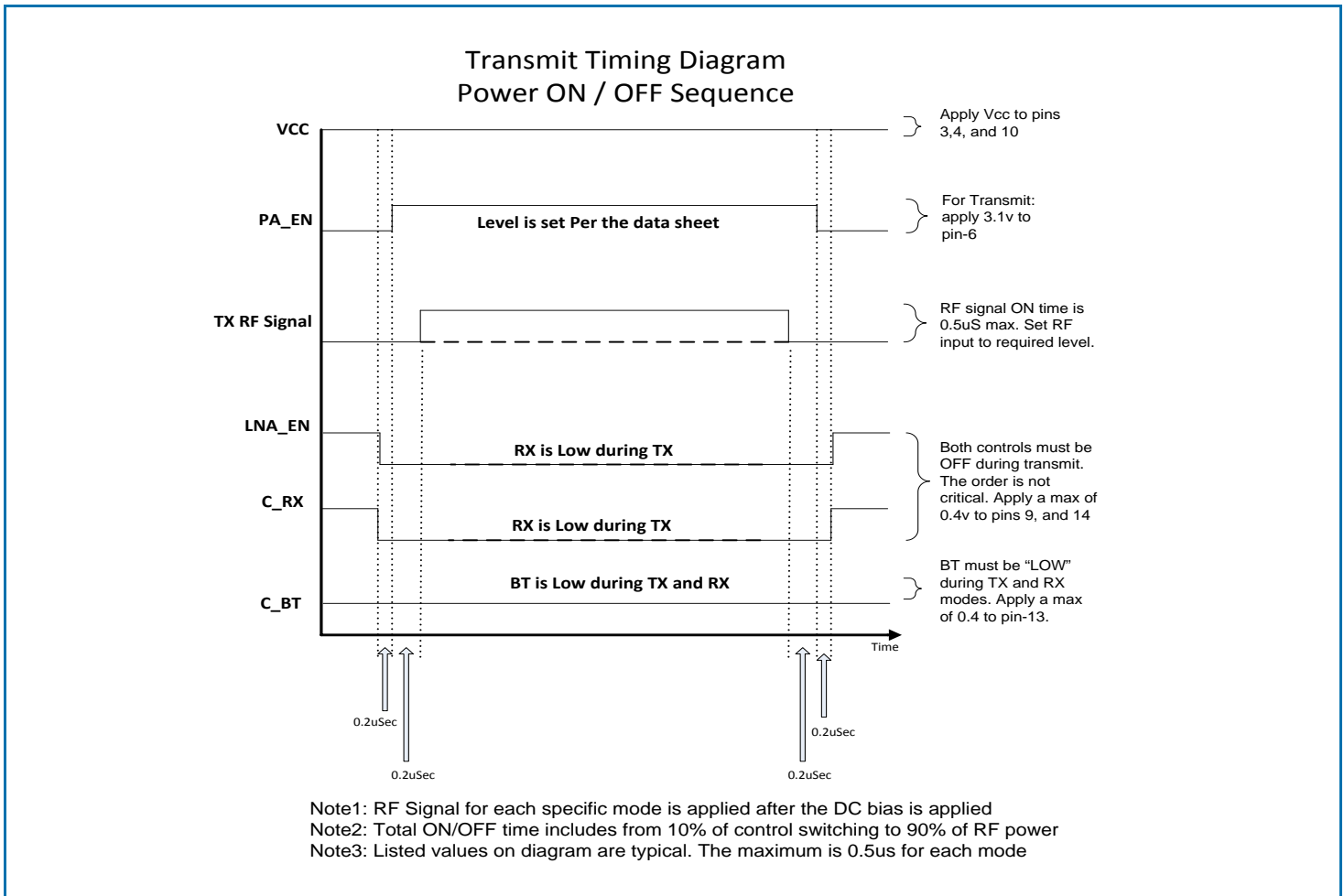
## Switch Control Logic Table

Operating Mode	PA_EN	LNA_EN	C_RX	C_BT
Standby	Low	Low	Low	Low
802.11b/g/n/ac TX High Power	High	Low	Low	Low
802.11b/g/n/ac RX Gain	Low	High	High	Low
802.11b/g/n/ac RX Bypass	Low	Low	High	Low
BT RX/TX	Low	Low	Low	High

### Notes:

- PA\_EN and TX switch control are tied together internally.
- High = 2.8 to  $V_{CC}$ . Low = 0V to 0.2V.

## Timing Diagram



## Timing Sequence Notes:

### 802.11a/n/ac Transmit Biasing Instructions

1. Connect the FEM to a signal generator at the input and a spectrum analyzer at the output. Terminate unused ports with 50 Ohms
2. Set the power supply voltage to 3.6V first with PA\_EN < 0.4V. Leakage current should be <10uA.
3. Refer to switch operational truth table to set the control lines at the proper levels for TX High Power. All OFF voltages must be < 0.2V (cannot be floating.)
4. Turn on PA\_EN with levels indicated in the datasheet. PA\_EN controls the current drawn by the 802.11a/n/ac power amplifier and the current should quickly rise to ~200mA (or 255mA @ 5V) +/- 20mA for a typical part but the actual operating current will be based on the output power desired.

### 802.11a/n/ac Transmit Turn On Sequence (See Transmit Timing Diagram)

1. Turn ON power supply.
2. Turn ON PA\_EN.
3. Apply RF.

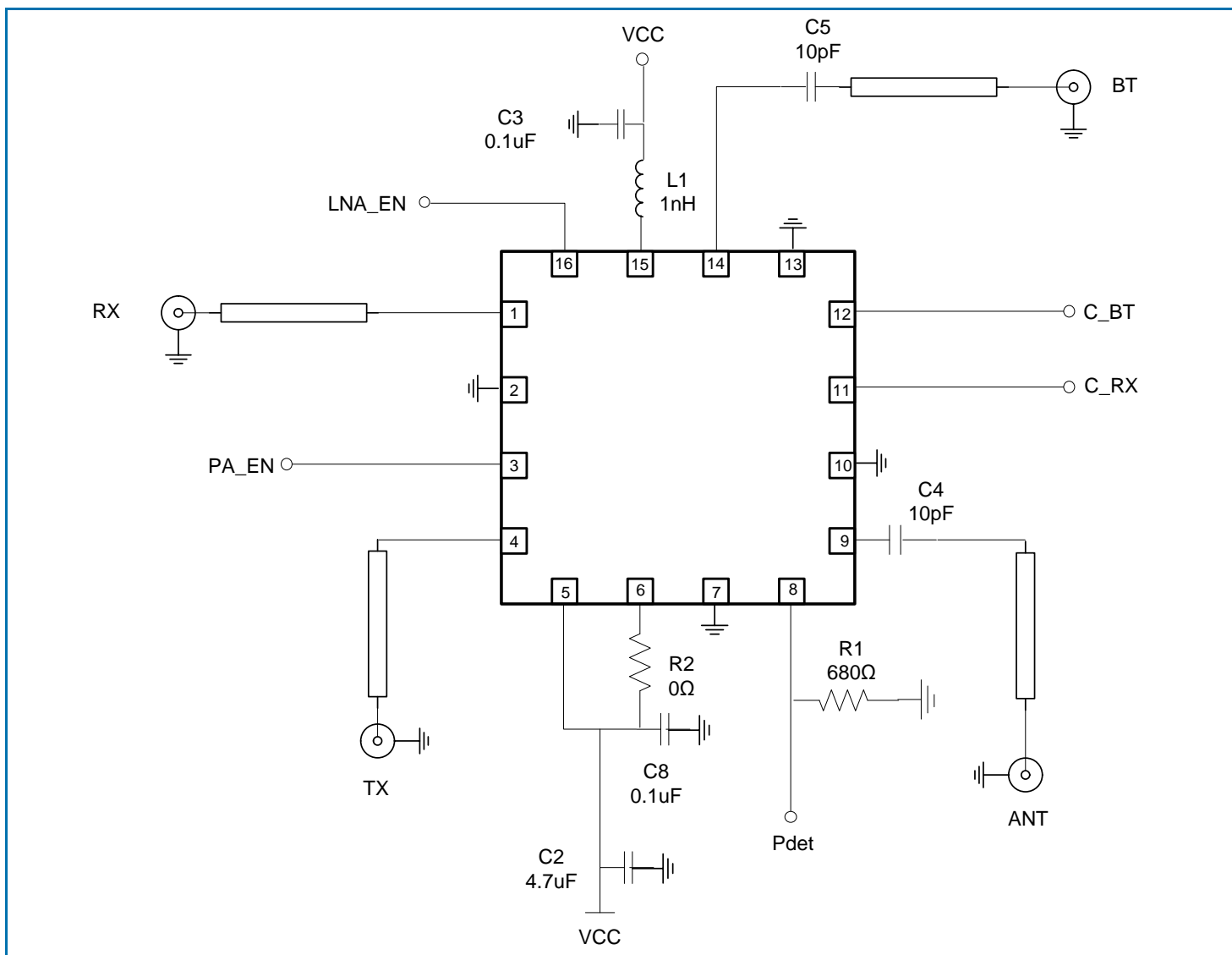
### 802.11a/n/ac Transmit Turn Off Sequence

1. Turn OFF RF.
2. Turn OFF PA\_EN.
3. Turn OFF power supply.

### 802.11a/n/ac Receive

1. To receive WiFi set the switch control lines per the truth table.
2. Antenna port is input and RX port is output for this test.
3. Follow Timing Diagram for biasing instructions.

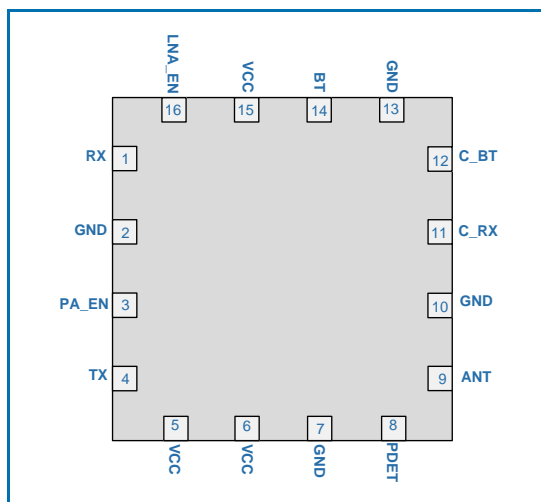
## Evaluation Board Schematic



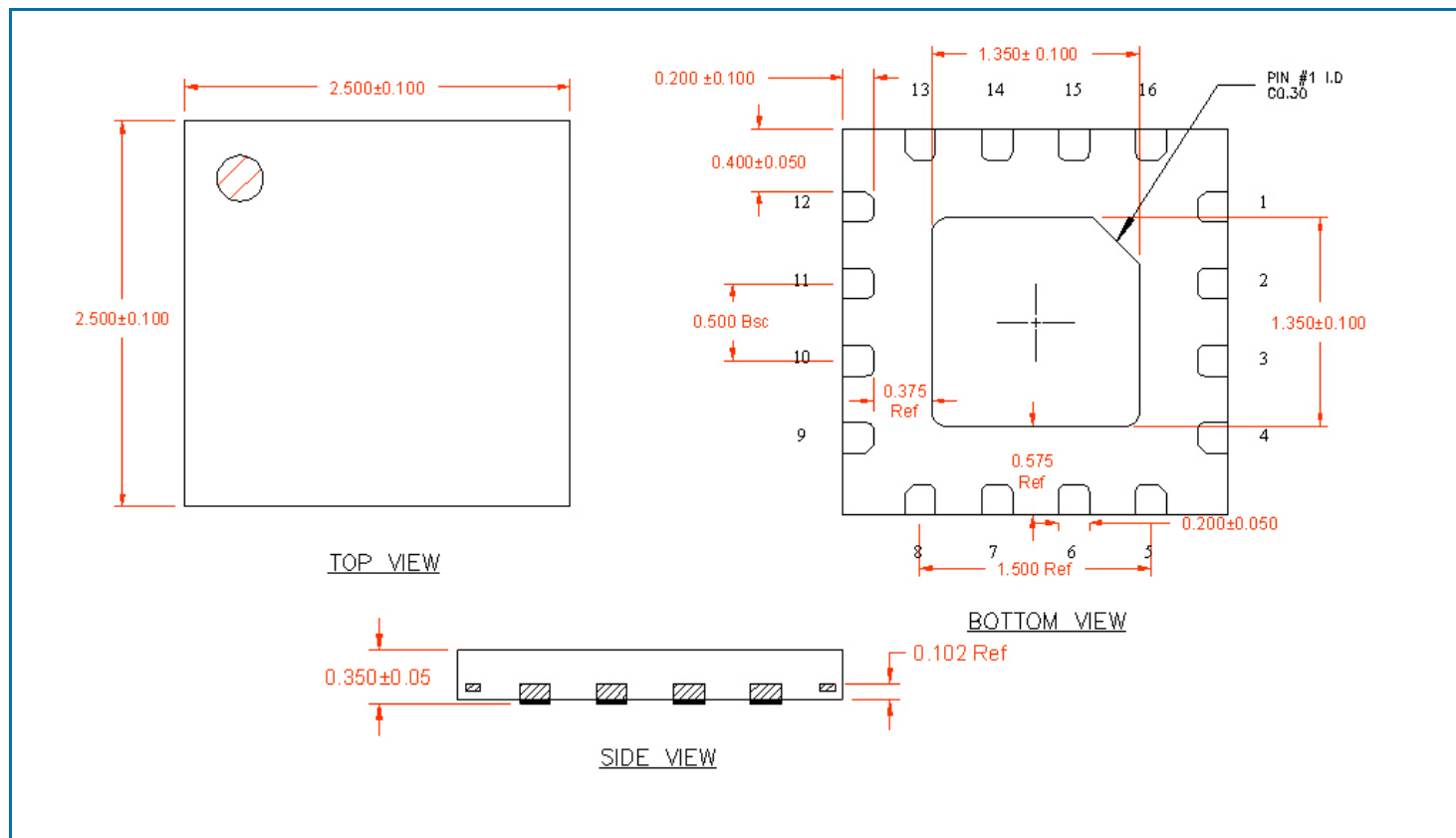
### Note:

- Based on the RFMD evaluation board, L1 in the above schematic gives best performance. Depending on the end application layout, L1 may not be required.
- Depending on the end application layout, we recommend keeping the placement of R1.

## Pin Out

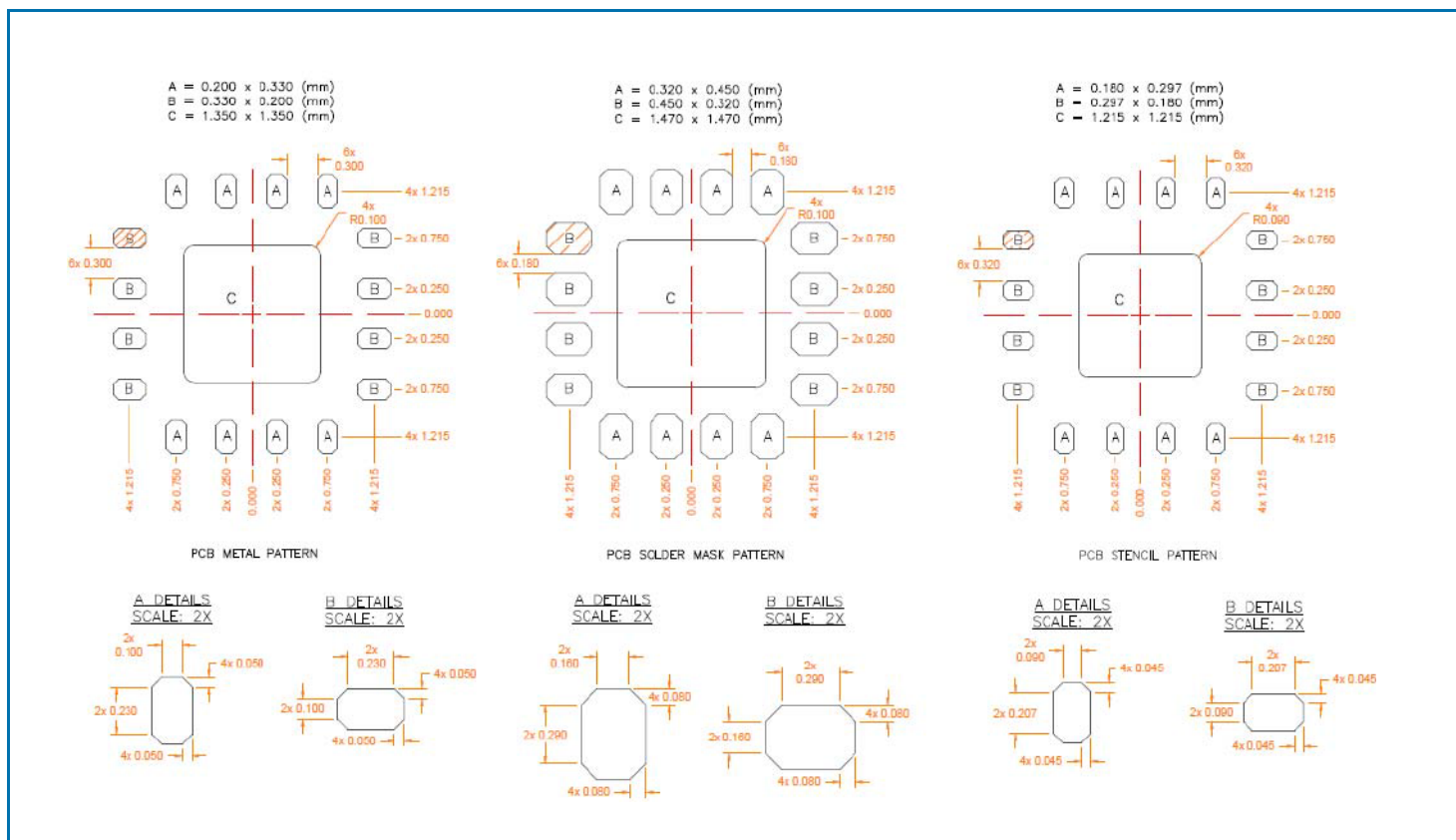


## Package Drawing





## PCB Patterns



### Notes:

1. Thermal vias for center slug "C" should be incorporated into the PCB design. The number and size of thermal vias will depend on the application, power, dissipation and electrical requirements. Example of the number and size of vias can be found on the RFMD evaluation board layout (gerber files are available upon request)

## Pin Names and Descriptions

Pin	Name	Description
1	RX	RF output port for the 802.11b/g/n LNA. Port is matched to 50Ω. This pin is DC blocked internally.
2	GND	This pin is not connected internally and can be left floating or connected to ground.
3	PA_EN	Bias voltage for the PA. This is a high impedance pin and it also controls the TX switch of the SP3T. See truth table for proper settings.
4	TX	RF input port for the 802.11b/g/n PA. Input is matched to 50Ω. This pin is DC blocked internally.
5	VCC	Supply voltage for the first stage of the Pa. See applications schematic for biasing and bypassing components.
6	VCC	Supply voltage for the output stage of the PA. See applications schematic for biasing and bypassing components.
7	GND	This pin is not connected internally and can be left floating or connected to ground.
8	PDET	Power detector voltage for the TX path. May need external series R/Shunt C to adjust voltage level and to filter RF noise.
9	ANT	RF bidirectional antenna port matched to 50Ω. An external DC block is required.
10	GND	This pin is not connected internally and can be left floating or connected to ground.
11	C_RX	Receive switch control pin. See switch truth table for proper level.
12	C_BT	Bluetooth® switch control pin. See switch truth table for proper level.
13	GND	This pin is not connected internally and can be left floating or connected to ground.
14	BT	RF bidirectional port for Bluetooth®. Input is matched to 50Ω. An external DC block is required.
15	VCC	Supply voltage for the LNA. See applications schematic for biasing and bypassing components.
16	LNA_EN	Control voltage for the LNA. See applications schematic for biasing and bypassing components.
Pkg Base	GND	Ground connection. The backside of the package should be connected to the ground plane through a short path, i.e., PCB vias under the device are recommended.