RFMD + TriQuint = Qorvo

RFFM8506

4.9 GHz to 5.85 GHz 802.11a/n/ac WiFi Front End Module

Package: QFN, 16-pin,
2.5 mm x 2.5 mm x 0.45 mm

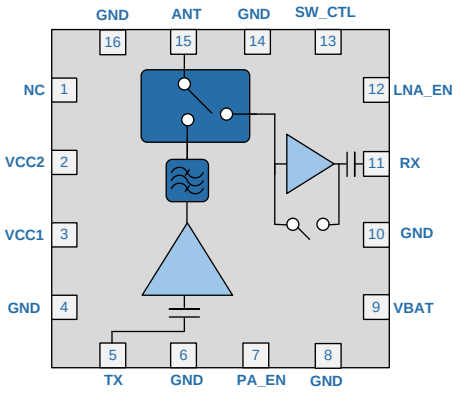
The RFFM8506 provides a complete integrated solution in a single front end module (FEM) for WiFi 802.11a/n/ac systems. The ultra-small factor and integrated matching minimizes layout area in the customer's application and greatly reduces the number of external components. This simplifies the total front end solution by reducing the bill of materials, system footprint, and manufacturing cost. The RFFM8506 integrates a 5 GHz power amplifier (PA), single pole double throw switch (SP2T) and an LNA with bypass. The device is provided in a 2.5 mm x 2.5 mm x 0.45 mm, 16-pin QFN package. This module meets or exceeds the RF front end needs of IEEE 802.11a/n/ac WiFi RF systems.

Features

- P_{OUT}=+17.5 dBm, 11ac, 80 MHz MCS9 at −36.5dB (1.5%) EVM
- Small Size
- High performance FEM
- Input and Output Matched to 50 Ω
- Integrated 5 GHz PA, SP2T, Switch, and LNA (with Bypass if required)
- Low Height Package, Suited for SiP and CoB designs

Applications

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



Functional Block Diagram

Ordering Information

RFFM8506SB	Standard 5-piece sample bag
RFFM8506SQ	Standard 25-piece sample bag
RFFM8506SR	Standard 100-pieces reel
RFFM8506TR7	Standard 2500-piece reel
RFFM8506PCK-410	Fully assembled eval board w/ 5-piece sample bag

Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage	−0.5 to +5.4	V_{DC}
PA Enable Voltage	−0.5 to 5	V_{DC}
DC Supply Current	500	mA
Storage Temperature	−40 to +150	°C
Maximum TX Input Power into 50Ω Load for 11a/n/ac (No Damage)	+12	dBm
Moisture Sensitivity	MSL1	

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		
Compliance					**802.11a, 802.11n, 802.11ac**
Operating Frequency	5.15		5.85	GHz	
Extended Frequency	4.9		5.15	GHz	Functional with reduced performance
Operating Temperature	−30		+85	°C	
Power Supply V_{CC} (V_{CC1}, V_{CC2}, V_{BAT})	3.0	3.6	4.2	V	
Switch Control Voltage – SW_CTL High	2.75	2.9	4.2	V	TX switch “ON” at high control voltage
Switch Control Voltage – SW_CTL Low		0.1	0.4	V	RX switch “ON” with low control voltage
PA Enable – High	2.75	2.9	4.2	V	PA in “ON” state
PA Enable voltage – Low		0.1	0.4	V	PA in “OFF” state, do not leave floating
Transmit (TX-ANT) Mode					**T= +25 °C; V_{CC}=+3.6 V; PA_EN=High; SW_CTL=High; LNA_EN=Low; Unless otherwise noted**
Gain (5.15 to 5.85 GHz)	25.5	29		dB	
20 MHz Output Power*	18.5	19		dBm	802.11ac HT20 MCS7
11ac 20 MHz Dynamic EVM		−33	−30	dB	
		2.2	3.2	%	
40 MHz Output Power*	17.5	18		dBm	802.11ac VHT40 MCS9
11ac 40 MHz Dynamic EVM		−36.5	−35.0	dB	
		1.5	1.8	%	
80 MHz Output Power*	16.5	17		dBm	802.11ac VHT80 MCS9
11ac 80 MHz Dynamic EVM		−36.5	−35.0	dB	
		1.5	1.8	%	
80 MHz Output Power*		13.5		dBm	802.11ac VHT80 MCS9
11ac 80 MHz Dynamic EVM		−40		dB	

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
		1.0		%	
Spectral Mask 20 MHz Output Power*		22		dBm	802.11ac HT20 with 3dB margin
Spectral Mask 40 MHz Output Power*		21		dBm	802.11ac VHT40 with 3dB margin
Spectral Mask 80 MHz Output Power*		20		dBm	802.11ac VHT80 with 3dB margin
Operating Current - Nominal		270	330	mA	P_{OUT} = +19 dBm
Transmit (TX-ANT) Mode (continued)					**T= +25 °C; V_{CC}=+3.6 V; PA_EN=High; SW_CTL=High; LNA_EN=Low; Unless otherwise noted**
Second Harmonic			−40	dBm/MHz	Fundamental frequency is between 4900 and 5850 MHz; RF P_{OUT} = +19 dBm; Measured in 1 MHz resolution bandwidth (FCC limit max = −30 dBm)
Third Harmonic			−38	dBm/MHz	
PA Selectivity/Out of Band Gain					
30 to 2900 MHz		−6		dB	
3600 to 4400 MHz		20		dB	
7250 to 7750 MHz		16		dB	
TX Port Return Loss	10	12		dB	
ANT Port Return Loss	12	15		dB	
Noise Figure			6	dB	
Receive (ANT-RX) LNA On					**T= +25 °C; V_{CC}=+3.6 V; PA_EN=Low; SW_CTL=Low; LNA_EN=High; Unless otherwise noted**
Gain	10	12		dB	
Noise Figure		2.5		dB	
Rx Port Return Loss	8	10		dB	
ANT Port Return Loss	8	10		dB	
Input IP2		50		dBm	
Input IP3	5	6		dBm	
Current Consumption		12		mA	
LNA_EN Control Current		75	120	µA	
LNA Turn On Time			300	nS	
Receive (ANT-RX) Bypass Mode					**T = +25 °C; V_{CC}=+3.6 V; PA_EN=Low; SW_CTL=Low; LNA_EN=Low; Unless otherwise noted**
Insertion Loss		3.5		dB	
Noise Figure		3.5		dB	
RX Port Return Loss	8	10		dB	
ANT Port Return Loss	8	10		dB	
ANT-RX Isolation	26			dB	Transmit Mode; PA_EN=High; Maximum Power
Input IP3	18	20		dBm	
LNA Bypass Current		15		µA	
General Specifications					

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Switch Control Current – High			2	µA	
Switch Control Current – Low			0.1	µA	Do not leave floating
PA_EN Current		30		µA	
Leakage Current – Nominal		2	15	µA	RF Off; PA_EN=Low; SW_CTL=Low, LNA_EN=Low
Switching Speed			200	nS	
PA Turn-On Time from PA_EN edge			300	nS	Output stable within 90 % of final gain
PA Turn-Off Time from PA_EN edge			300	nS	Output stable within 90% of final gain
ESD – Human Body Model	1000			V	EIA/JESD22-114A all pins
ESD – Charge Device Model	1000			V	EIA/JESD22-101C all pins
Ruggedness			10:1	VSWR	With nominal input power

*For 4900 MHz to 5150 MHz, P_{OUT} is reduced by 1dB

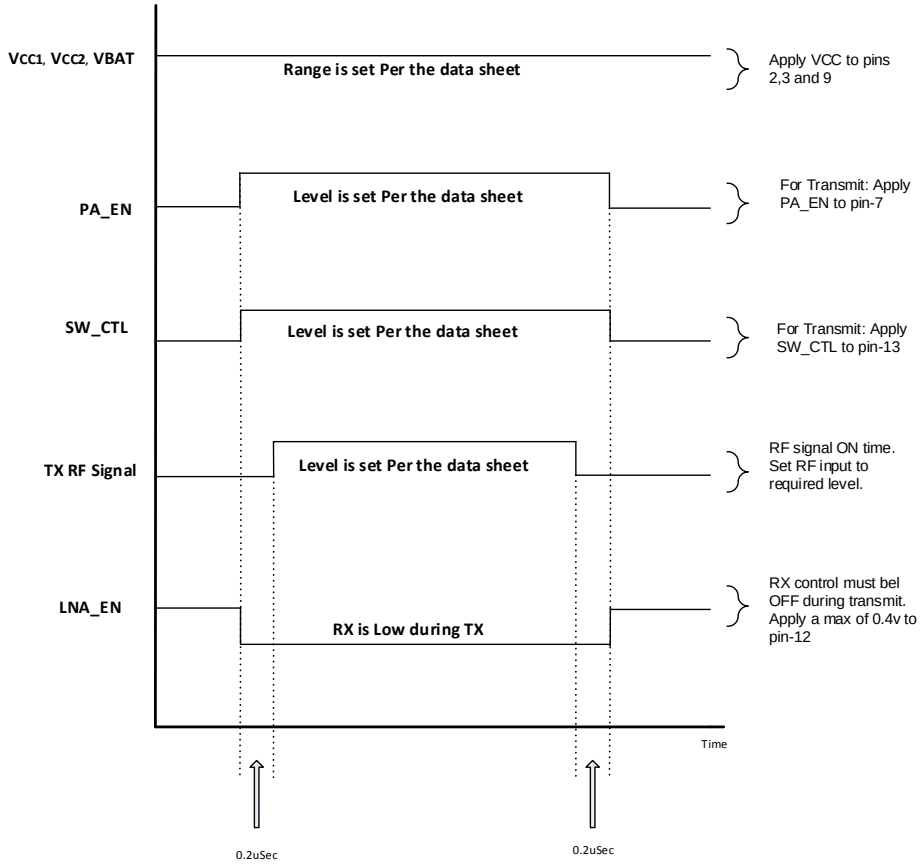
Switch Control Logic Truth Table

Operating Mode	PA_EN	SW_CTL	LNA_EN
802.11a/n/ac TX	High	High	Low
802.11a/n/ac RX Gain	Low	Low	High
802.11a/n/ac RX Bypass	Low	Low	Low

Note: All Logic Low pins ≤ 0.4V

Timing Diagram

Transmit Timing Diagram
Power ON / OFF Sequence



Note:
1. RF Signal for each specific mode is applied after the DC bias is applied.
2. Total ON/OFF time includes from 10% of control switching to 90% of RF power.
3. Listed values on diagram are typical. Tx/Rx simultaneous transition is allowed.
4. For DC voltage levels use the values indicated in the datasheet.

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 +3.0 V to +4.2 V first with PA_EN < 0.4 V. Leakage current will be <15 uA typical.
3. Refer to switch operational truth table to set the control lines at the proper levels for WiFi TX. All OFF voltages must be < 0.4 V (do not leave 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 ~200 mA +/- 20 mA for a typical part but the actual operating current will be based on the output power desired. Be extremely careful not to exceed 5.0 V on the PA_EN pin or the part may exceed device current limits.

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

1. Turn ON power supply.
2. Turn ON PA_EN.
3. Turn ON SW_CLT
4. Apply RF.

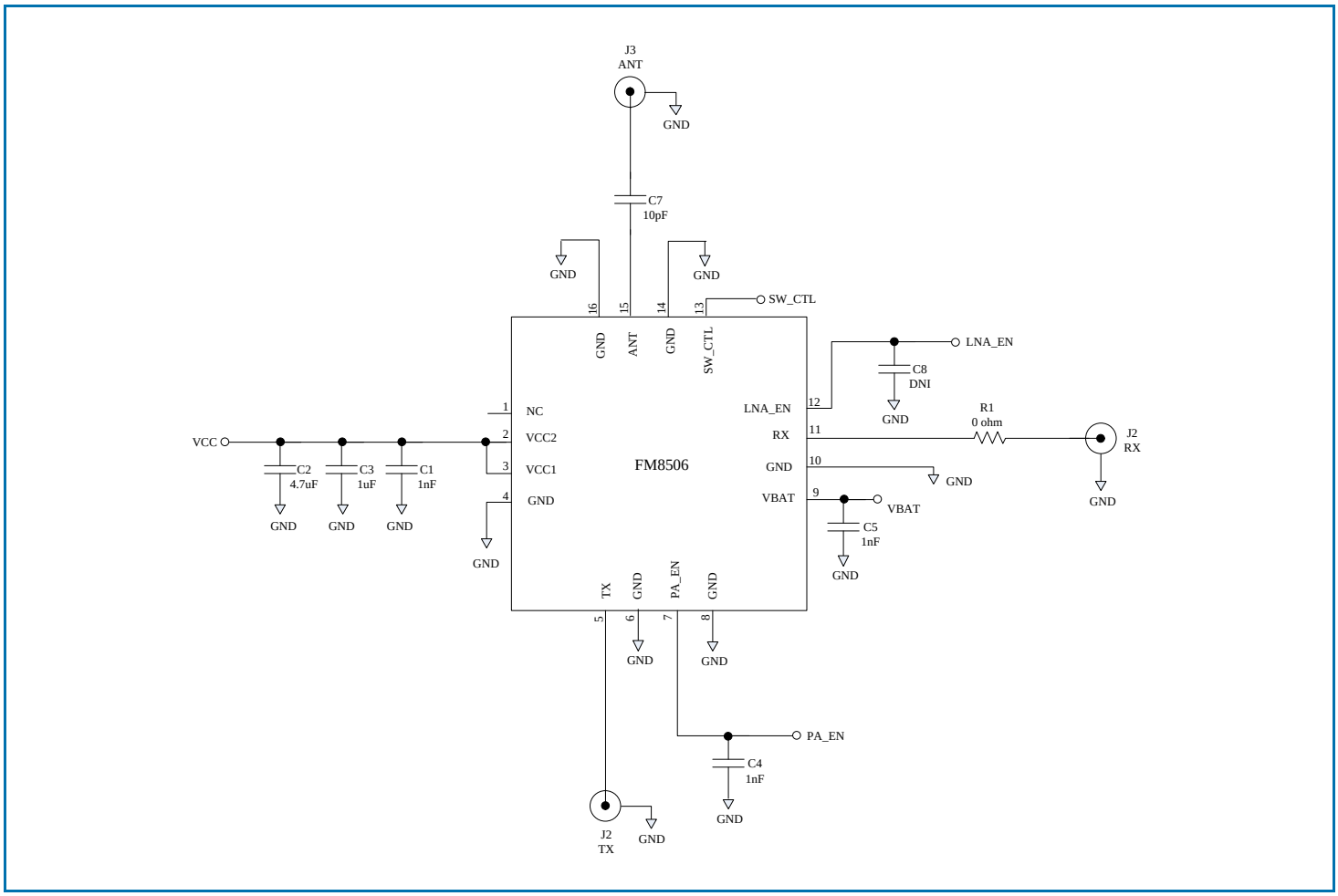
802.11a/n/ac Transmit Turn OFF Sequence

1. Turn OFF RF.
2. Turn OFF SW_CLT
3. Turn OFF PA_EN.
4. Turn OFF power supply.

802.11a/n/ac Receive

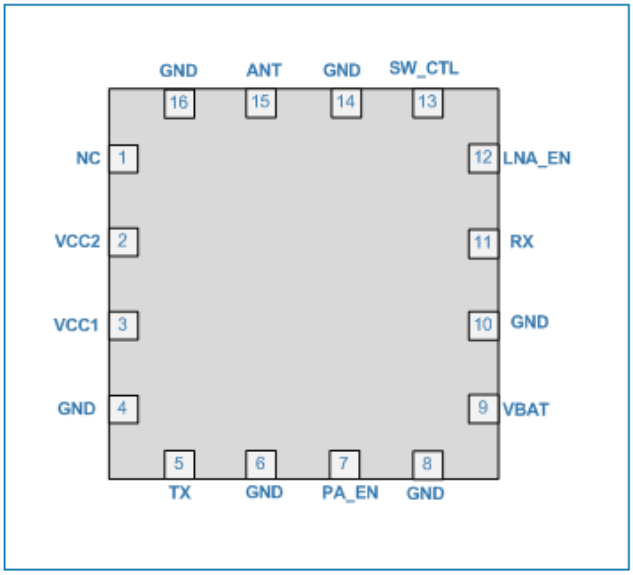
1. To receive WiFi set the switch control lines per the truth table.
2. Antenna port is input and RX port is output for this test.
3. Follow Timing Diagram for biasing instructions.

Evaluation Board Schematic

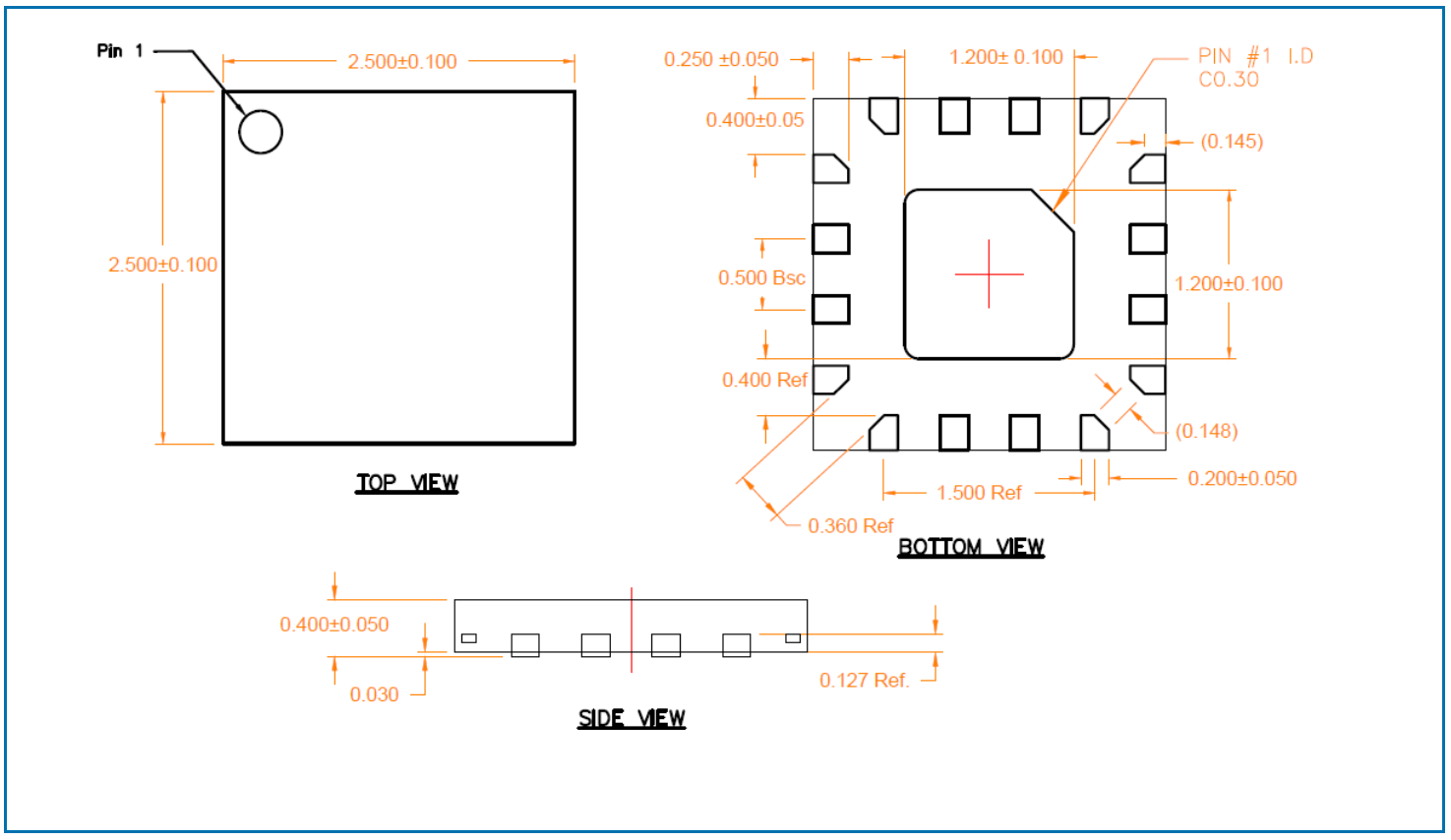


ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

Pin Out

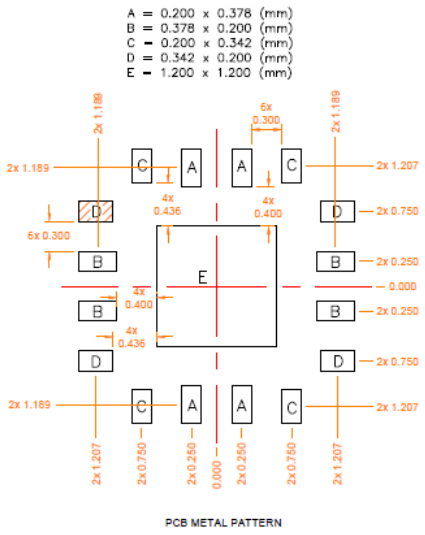


Package Outline and Branding Drawing (Dimension in millimeters)

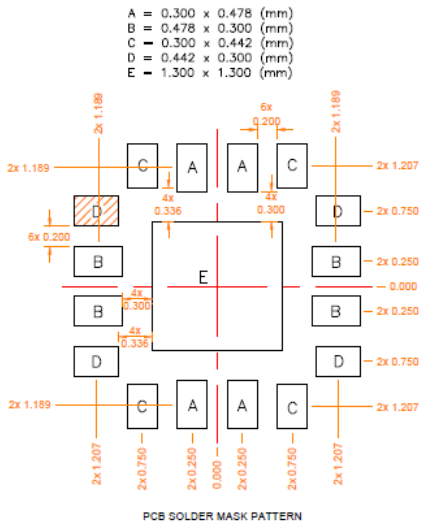


ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

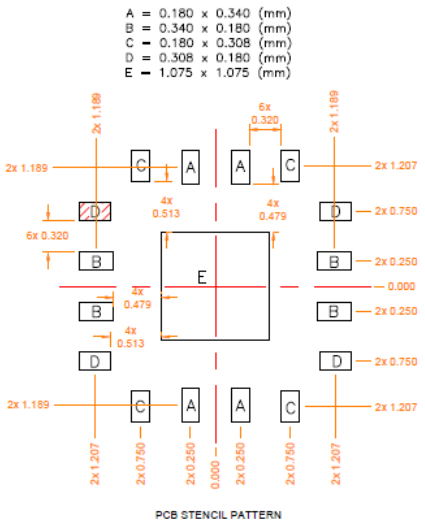
PCB Patterns



PCB METAL PATTERN



PCB SOLDER MASK PATTERN



PCB STENCIL PATTERN

Thermal vias for center slug "E" should be incorporated into the PCB design. The number and size of thermal vias will depend on the application, the power dissipation, and the electrical requirements. Example of the number and size of vias can be found on the RFMD evaluation board layout.

Note: Shaded area represents Pin 1 location

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

Pin Names and Descriptions

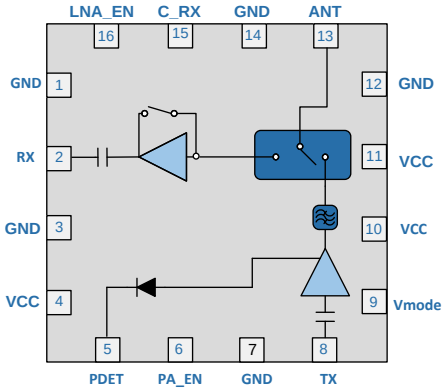
Pin	Name	Description
1	NC	This pin is not connected internally and can be left floating but is recommended to connect to ground.
2	VCC2	Supply voltage for the PA. See applications schematic for biasing and bypassing components.
3	VCC1	Supply voltage for the PA. See applications schematic for biasing and bypassing components.
4	GND	Ground Connection. This pin is not connected internally and can be left floating or connected to ground.
5	TX	RF input port for the 802.11a/n/ac PA. Input is matched to 50Ω and DC blocked internally
6	GND	Ground Connection. This pin is not connected internally and can be left floating or connected to ground.
7	PA_EN	Control voltage for the PA. See “Switch Control Truth Table” for proper settings.
8	GND	No Connect. This pin is not connected internally and can be left floating or connected to ground.
9	VBAT	Supply voltage for the LNA, Switch & Bias Regulator. See applications schematic for biasing and bypassing components.
10	GND	Ground Connection. This pin is not connected internally and can be left floating or connected to ground.
11	RX	RF output port for the 802.11a/n/ac LNA. This port is matched to 50Ω and DC blocked internally.
12	LNA_EN	Control voltage for the LNA. When this pin is set to a LOW logic state, the bypass mode is enabled.
13	SW_CTL	Switch control voltage. High control voltage turns ON the TX path and low control voltage turns on the RX path (see “Switch Control Truth Table”)
14	GND	Ground Connection. This pin is not connected internally and can be left floating or connected to ground.
15	ANT	RF bidirectional antenna port matched to 50Ω.
16	GND	Ground Connection. This pin is not connected internally and can be left floating or connected to ground.
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.

RFFM8511

4.9GHz to 5.85GHz 802.11a/n/ac WiFi Front End Module

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

The RFFM8511 provides a complete integrated solution in a single front end module (FEM) for WiFi 802.11a/n/ac systems. The ultra-small factor and integrated matching minimizes layout area in the customer's application and greatly reduces the number of external components. This simplifies the total front end solution by reducing the bill of materials, system footprint, and manufacturing cost. The RFFM8511 integrates a 5GHz power amplifier (PA), single pole double throw switch (SP2T), LNA with bypass, and a power detector coupler for improved accuracy. The device is provided in a 2.5mm x 2.5mm x 0.40mm, 16-pin QFN package.



Functional Block Diagram

Features

- P_{OUT} = +18.0dBm at 3.6V, 802.11ac 80MHz MCS9 256QAM at 1.8% Dynamic EVM Compliance
- P_{OUT} = +19.0dBm, 11n 20MHz 2.5% (-32dB)EVM
- P_{OUT} = +21.0dBm at 3.6V, 802.11ac 80MHz MCS0 at Spectral Mask Compliance
- Input and Output Matched to 50Ω
- Integrated 5GHz PA, SP2T Switch, LNA, and PDET
- Low Height Package, Suited for Module and Chip On Board (CoB) designs
- Supports low power mode for improved efficiency

Applications

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

Ordering Information

RFFM8511SB	Standard 5-piece sample bag
RFFM8511SQ	Standard 25-piece bag
RFFM8511SR	Standard 100-piece reel
RFFM8511TR7	Standard 2500-piece reel
RFFM8511PCK-410	Fully assembled eval board w/ 5-piece bag

RF Micro Devices Inc. 7628 Thorndike Road, Greensboro, NC 27409-9421
For sales or technical support, contact RFMD at +1.336.678.5570 or customerservice@rfmd.com.

DS140711

Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage (No RF Applied)	6	V
PA Enable Voltage	-0.5 to 5	V_{DC}
DC Supply Current	500	mA
Operating Temperature Range	-40 to +85	ºC
Storage Temperature	-40 to +150	ºC
Maximum TX Input Power for 11a/n (No Damage)	+12	dBm
LNA On Maximum RX input power (No damage)	+12	dBm
Bypass Mode Maximum RX input power (No damage)	+25	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		
Compliance					**802.11a, 802.11n, 802.11ac**
Operating Frequency	5.18		5.825	GHz	
Extended Frequency	4.9		5.925	GHz	
Nominal Operating Temperature	-10		70	ºC	
Operating Temperature	-40		85	ºC	
Power Supply V_{CC}	3.0	3.6	4.2	V	
Control Voltage-high	2.8	3.1	V_{CC}	V	PA_EN, C_RX, LNA_EN, V_{MODE}
Control Voltage-low		0	0.2	V	
Transmit (TX-ANT) High Power Mode					**T = -10°C to +70°C, V_{CC} = 3.3V to 4.2V, 50% Duty Cycle unless otherwise noted**
Output Power	17.0	18.0		dBm	T = 25°C, V_{CC} = 3.6V
80MHZ 802.11ac Dynamic EVM		1.5	1.8	%	
		-36.5	-35.0	dB	
Output Power	15.0	16.0		dBm	T = -10°C to +70°C, V_{CC} = 3.0V to 4.2V
80MHZ 802.11ac Dynamic EVM		1.5	1.8	%	
		-36.5	-35.0	dB	
Output Power		19.0		dBm	T = 25°C, V_{CC} = 3.6V
20/40MHz 802.11n Dynamic EVM		2.5	3	%	
		-32.0	-30.5	dB	
Output Power	16.5	17.5		dBm	T = -10°C to +70°C, V_{CC} = 3.0V to 4.2V
20/40MHz 802.11n Dynamic EVM		2.5	3	%	
		-32.0	-30.5	dB	
40MHz 802.11n Spectral mask Output Power		20		dBm	T = 25°C, V_{CC} = 3.6V
20/80MHz 802.11ac Spectral mask Output Power		21		dBm	
TX Port Return Loss	10	18		dB	
ANT Port Return Loss	10	18		dB	

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Transmit (TX-ANT) High Power Mode (continued)					**T = -10°C to +70°C, V_{CC} = 3.3V to 4.2V, 50% Duty Cycle unless otherwise noted**
Large Signal Gain	25	28		dB	T = 25°C, V_{CC} = 3.6V
	23	28		dB	T = -10°C to +70°C, V_{CC} = 3.0 to 4.2V
Gain flatness over any 80MHz BW	-0.5		0.5	dB	
Gain flatness across band	-1		1	dB	
Operating Current		210	250	mA	P_{OUT} = +17dBm, T = 25°C, V_{CC} = 3.6V
		240	280	mA	P_{OUT} = +19dBm, T = 25°C, V_{CC} = 3.6V
		280		mA	P_{OUT} = 21dBm, T = 25°C, V_{CC} = 3.6V
Quiescent Current		150		mA	
PA_EN Current		70	150	uA	
Second Harmonic		-45	-30	dBm/MHz	P_{OUT} = +21dBm, T = 25°C, V_{CC} = 3.6V, 6Mbps 802.11a
Third Harmonic		-45	-30	dBm/MHz	
Power Detector Voltage		0.27		V	P_{OUT} = 0dBm
		0.81		V	P_{OUT} = +17dBm
		0.98		V	P_{OUT} = +21dBm
Variation from 0-360° load pull	-1.5		1.5	dB	3:1 VSWR
ANT-RX Isolation (TX enabled and maximum power)		28		dB	
Transmit (TX-ANT) Low Power Mode					**T= 25°C, V_{CC}= 3.6V,50% Duty Cycle unless otherwise noted**
Output Power		10.0		dBm	T = 25°C, V_{CC} = 3.6V
40/80MHz 802.11ac Dynamic EVM		1.5	1.8	%	
		-36.5	-35.0	dB	
Output Power		12.0		dBm	T = 25°C, V_{CC} = 3.6V
20MHz 802.11n Dynamic EVM		2.5	3.0	%	
		-32.0	-30.5	dB	
40MHz 802.11n Spectral mask Output Power		11.0		dBm	T = 25°C, V_{CC} = 3.6V
20/80MHz 802.11ac Spectral mask Output Power		12.0		dBm	
Power Detector Voltage		0.27		V	P_{OUT} = 0dBm
		0.50		V	P_{OUT} = +10dBm
		0.58		V	P_{OUT} = +12dBm
80MHz 802.11ac Operating Current		150		mA	P_{OUT} = +10dBm
20MHz 802.11n Operating Current		160		mA	P_{OUT} = +12dBm
V_{MODE} Control Line Current		160	500	µA	
Gain	24	27		dB	P_{OUT} = +10dBm, 80MHz 802.11ac
Receive (ANT-RX)-LNA On					**T = +25°C, V_{CC} = 3.0 to 4.2V, C_RX=LNA_EN=High, PA_EN=Low, Unless otherwise noted.**
Gain	10	14	16	dB	T = 25°C, V_{CC} = 3.6V
Gain flatness over any 80MHz BW	-0.5		0.5	dB	
Gain flatness across band	-1		1	dB	
Noise Figure		2.5	3	dB	

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Rx Port Return Loss	9	12		dB	
ANT Port Return Loss	6	10		dB	
Nominal Input P1dB	-8	-4		dBm	T = 25°C, V_{CC} = 3.6V
Current Consumption		10	18	mA	
LNA_EN Control Current		130	200	µA	
LNA Turn On Time		400	600	nS	
Receive (ANT-RX)-Bypass Mode					**T = +25°C, V_{CC} = 3.3to 4.2V, C_RX=LNA_EN=High, PA_EN=Low, Unless otherwise noted.**
LNA Bypass Current		2.0	10	µA	
Nominal Insertion Loss		6	10	dB	T = 25°C, V_{CC} = 3.6V
RX Port Return Loss	10	20		dB	
ANT Port Return Loss	9	20		dB	
Nominal Input P1dB	15	20		dBm	T = 25°C, V_{CC} = 3.6V
General Specifications					
Control Line Impedance-PA_EN		75		kΩ	
Control Line Impedance-LNA_EN		78		kΩ	
Control Line Impedance-C_RX		27		MΩ	
Switch Control Current – High - Each Line		5	100	µA	
Switch Control Current – Low - Each Line		0.5	10	µA	
Switching Speed		100	500	ns	
ESD – Human Body Model		1000		V	
ESD – Charge Device Model		500		V	
PA Turn-on Time		200	500	ns	10% to 90%
PA Stability		+20		dBm	No spurious above -41.25dBm/MHz up to 4:1 VSWR
Maximum Input Power			12	dBm	Into 50Ω, V_{CC} = 3.3V, 25°C
			12	dBm	6:1 VSWR, V_{CC} = 3.3V, 25°C
			5	dBm	10:1 VSWR, V_{CC} = 3.3V, 25°C
Ruggedness			10:1	VSWR	At typical operating conditions
Leakage Current		2	10	uA	V_{CC} = 4.8V, T = 25°C, RF OFF, All control lines floating

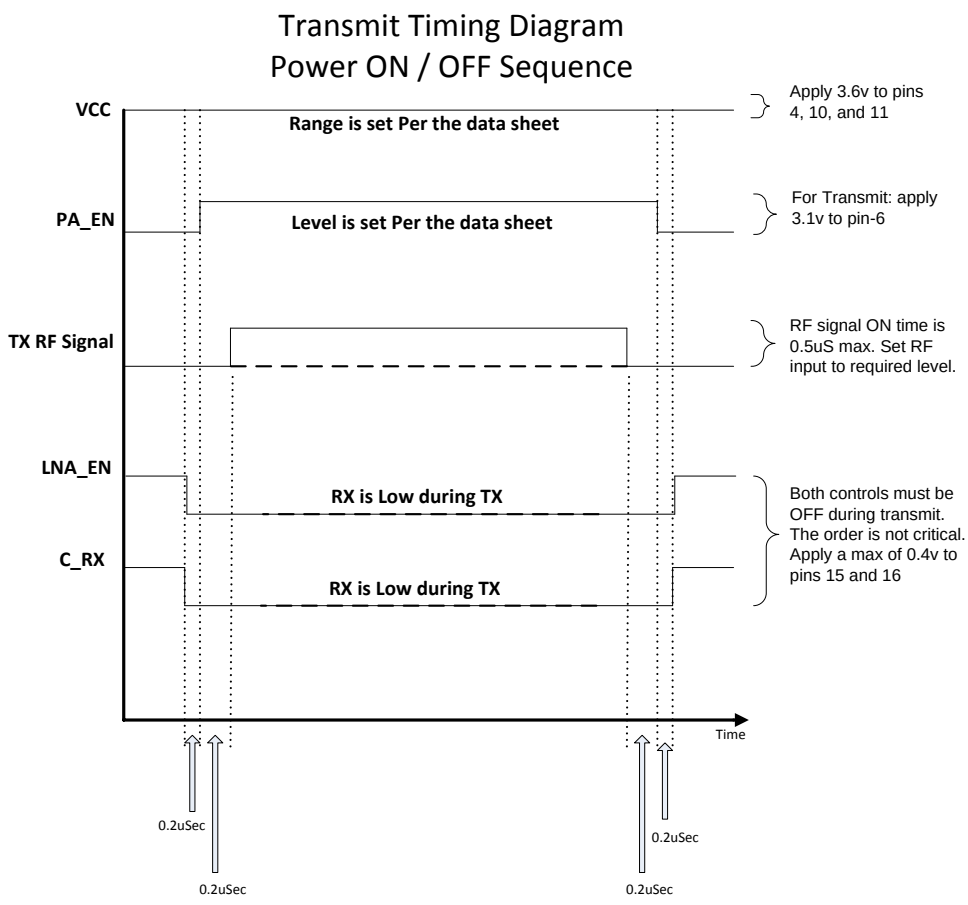
Switch Control Logic Truth Table

Operating Mode	PA_EN	LNA_EN	C_RX	Vmode
Standby	Low	Low	Low	Low
802.11a/n/ac TX High Power	High	Low	Low	Low
802.11a/n/ac TX Low Power	High	Low	Low	High
802.11a/n/ac RX Gain	Low	High	High	Low
802.11a/n/ac RX Bypass	Low	Low	High	Low

Notes:

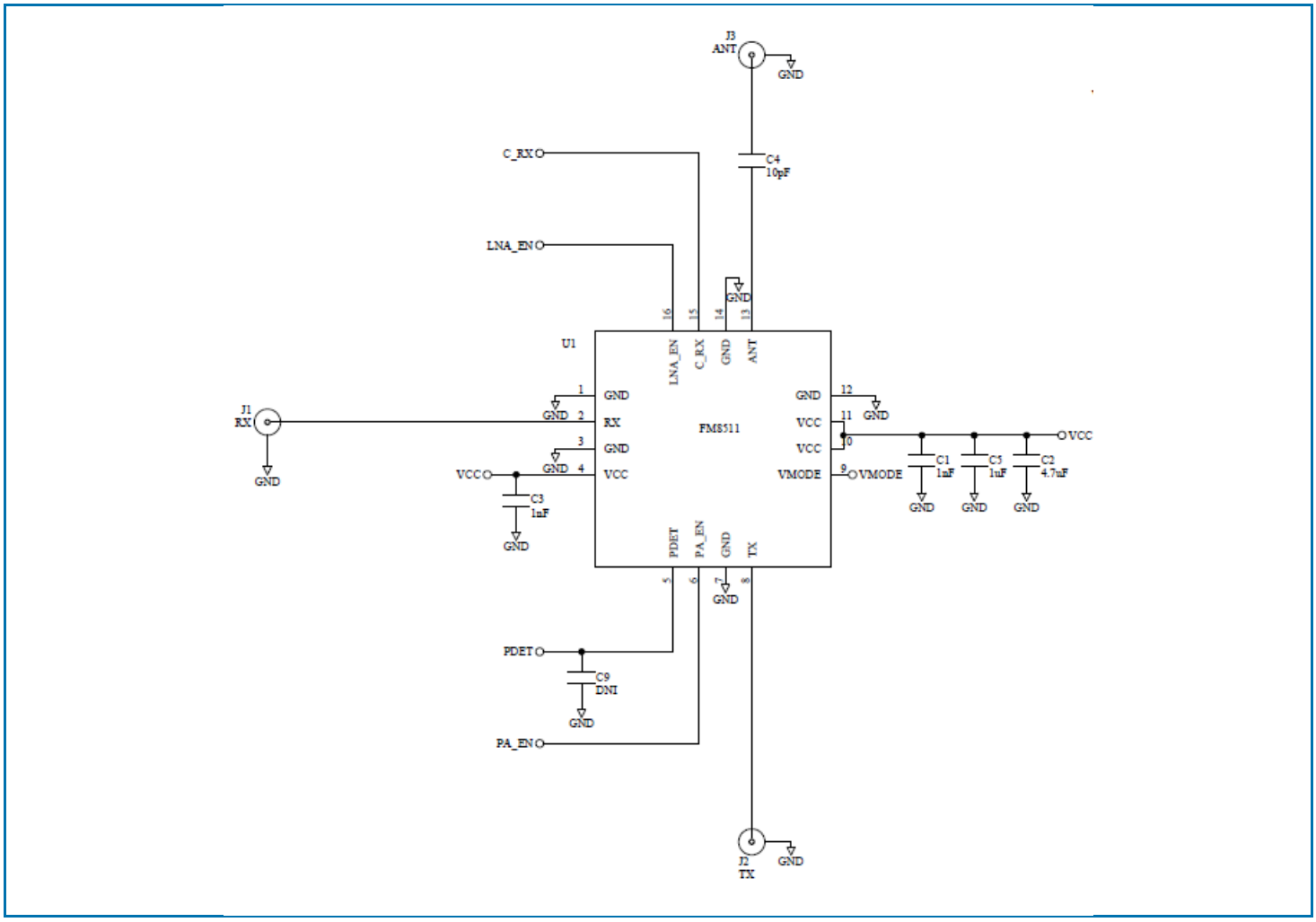
- PA_EN and TX switch control are tied together internally.
- High = 2.8 to V_{CC}. Low = 0V to 0.2V

Timing Diagram

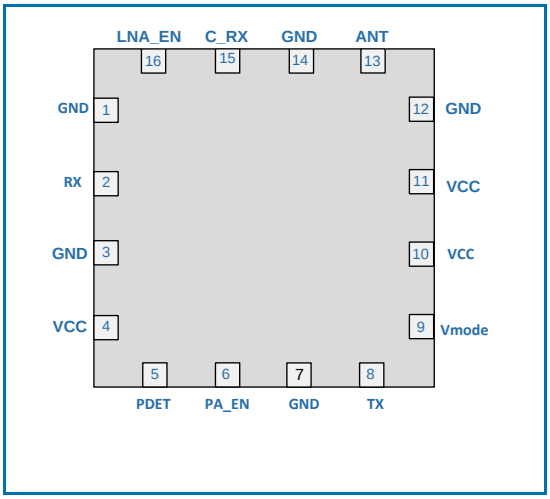


Note1: RF Signal for each specific mode is applied after the DC bias is applied
Note2: Total ON/OFF time includes from 10% of control switching to 90% of RF power
Note3: Listed values on diagram are typical. The maximum is 0.5us for each mode

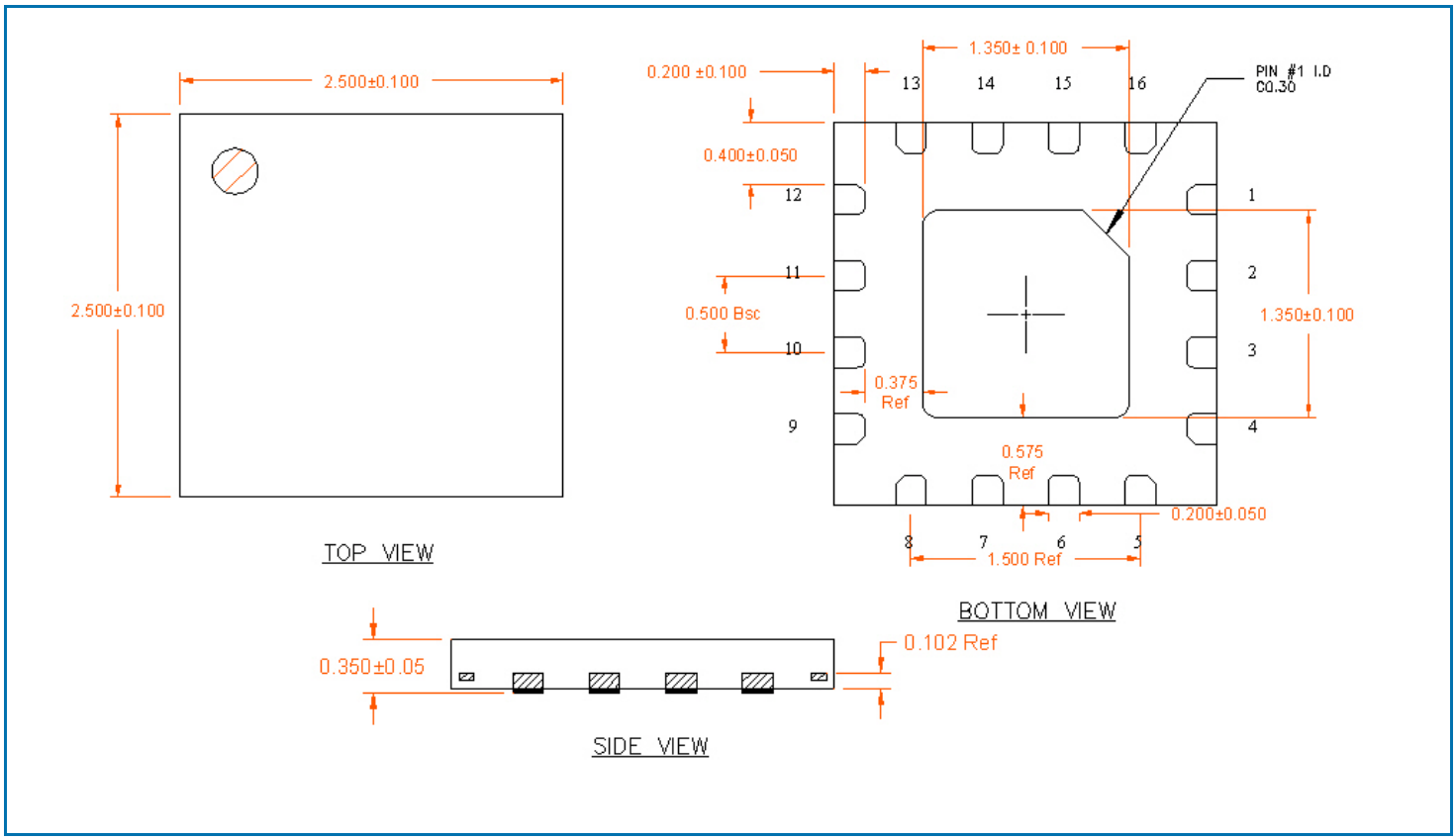
Evaluation Board Schematic



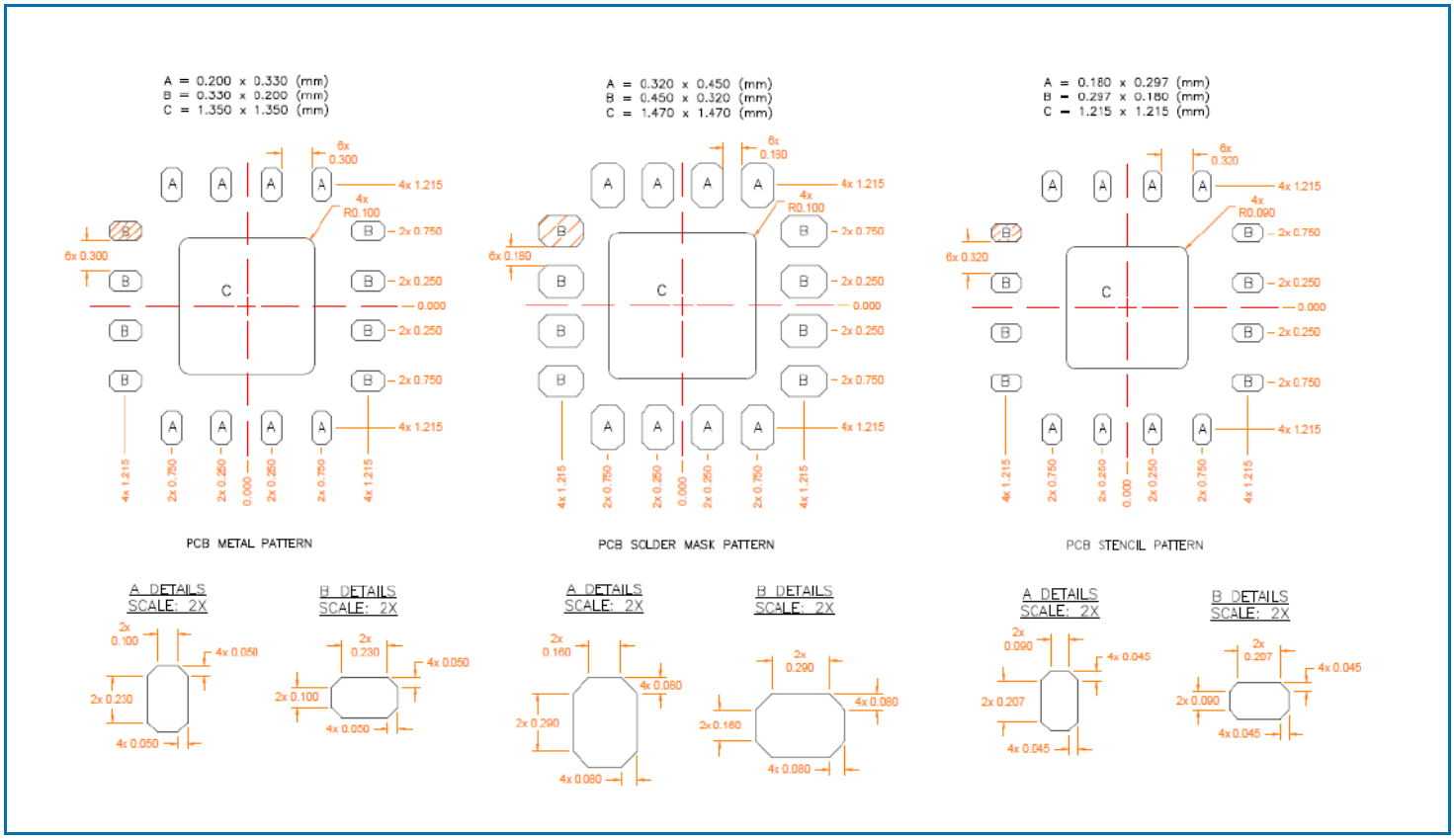
Pin Out



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

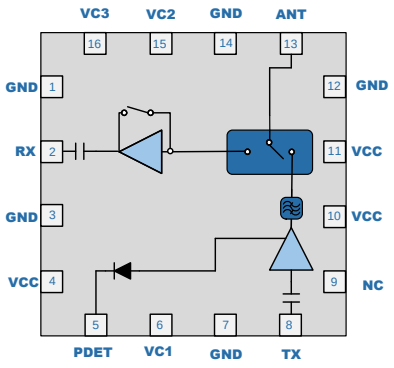
Pin	Name	Description
1	GND	This pin is not connected internally and can be left floating or connected to ground.
2	RX	RF output port for the 802.11a/n/ac LNA. This port is matched to 50Ω and DC blocked internally.
3	GND	This pin is not connected internally and can be left floating or connected to ground.
4	VCC	Supply voltage for the LNA and PA Regulator. See applications schematic for biasing and bypassing components.
5	PDET	Power detector voltage for the TX path. May need external series R/shunt C to adjust voltage level and to filter RF noise.
6	PA_EN	Control voltage for the PA and TX switch. See truth table for proper settings.
7	GND	This pin is not connected internally and can be left floating or connected to ground.
8	TX	RF input port for the 802.11a/n/ac PA. Input is matched to 50Ω and DC blocked internally
9	VMODE	High/Low power mode control signal. V_{MODE} can be low or floating for nominal conditions (high power mode). Applying 2.8V or greater to this pin enables low power mode.
10	VCC	Supply voltage for the first and second stage of the PA. See applications schematic for biasing and bypassing components.
11	VCC	Supply voltage for the final stage of the PA. See applications schematic for biasing and bypassing components.
12	GND	This pin is not connected internally and can be left floating or connected to ground.
13	ANT	RF bidirectional antenna port matched to 50Ω. An External DC block is required
14	GND	This pin is not connected internally and can be left floating or connected to ground.
15	C_RX	Receive switch control pin. See switch truth table for proper level.
16	LNA_EN	Control voltage for the LNA. When this pin is set to a LOW logic state, the bypass mode is enabled.
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.

RFFM8515

4.9GHz to 5.85GHz 802.11a/n/ac WiFi Front End Module

Package: QFN, 16-pin,
2.3mm x 2.3mm x 0.33mm

The RFFM8515 provides a complete integrated solution in a single front end module (FEM) for WiFi 802.11a/n/ac systems. The ultra-small form factor and integrated matching minimizes layout area in the customer's application and greatly reduces the number of external components. This simplifies the total front end solution by reducing the bill of materials, system footprint, and manufacturing cost. The RFFM8515 integrates a 5GHz power amplifier (PA), single pole double throw switch (SP2T), LNA with bypass, and a power detector coupler for improved accuracy. The device is provided in a 2.3mm x 2.3mm x 0.33mm, 16-pin QFN package.



Functional Block Diagram

Features

- P_{OUT} = +17.0dBm at 3.3V, 802.11ac 80MHz MCS9 256QAM at 1.8% Dynamic EVM Compliance
- P_{OUT} = +19dBm at 3.3V, 802.11ac 80MHz MCS0 at Spectral Mask Compliance
- Input and Output Matched to 50Ω
- Integrated 5GHz PA, SP2T Switch, LNA, and PDET
- Low Height Package, Suited for Module and Chip On Board (CoB) designs
- Supports low power mode for improved efficiency

Applications

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

Ordering Information

RFFM8515SB	Standard 5-piece sample bag
RFFM8515SQ	Standard 25-piece sample bag
RFFM8515SR	Standard 100-piece on 7 inch diameter reel
RFFM8515TR7	Standard 2500-piece on 7 inch diameter reel
RFFM8515PCK-410	Fully assembled evaluation board w/ 5 pc bag

RF Micro Devices Inc. 7628 Thorndike Road, Greensboro, NC 27409-9421
For sales or technical support, contact RFMD at +1.336.678.5570 or customerservice@rfmd.com.

DS20160429

Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage (No RF Applied)	6	V
PA Enable Voltage	-0.5 to 5	V_{DC}
DC Supply Current	500	mA
Operating Temperature Range	-40 to +85	ºC
Storage Temperature	-40 to +150	ºC
Maximum TX Input Power into 50Ω Load for 11a/n (No Damage)	+10	dBm
LNA On Maximum RX input power (No damage)	+5	dBm
Bypass Mode Maximum RX input power (No damage)	+25	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		
Compliance					**802.11a, 802.11n, 802.11ac**
Operating Frequency	5.18		5.825	GHz	
Extended Frequency	4.9		5.925	GHz	
Operating Temperature	-40		85	ºC	
Power Supply V_{CC}	3.0	3.3	4.2	V	
Extended V_{CC}	3		4.8	V	
Control Voltage-high	2.8	3.1	V_{CC}	V	VC1, VC2, VC3
Control Voltage-low		0	0.2	V	
Transmit (TX-ANT) TX High Power Mode					**T = 25°C, V_{CC} = 3.3V, 50% Duty Cycle unless otherwise noted**
HT80 / HT40 Output Power	16.0	17.0		dBm	T= 25°C, V_{CC}= 3.3V
80MHz /40MHz 802.11ac - Dynamic EVM		1.5	1.8	%	
		-36.5	-35.0	dB	
HT80 / HT40 Output Power	15.0	16.0		dBm	T= -10°C to +70°C, V_{CC}=3.3V
80MHz / 40MHz 802.11ac - Dynamic EVM		1.5	1.8	%	
		-36.5	-35.0	dB	
HT20 Output Power	17.0	18.0		dBm	T= 25°C, V_{CC}= 3.3V
20MHz 802.11n - Dynamic EVM		2.5	3	%	
		-32	-30.5	dB	
HT20 Output Power	16.0	17.0		dBm	T= -10°C to +70°C, V_{CC}=3.3V
20MHz 802.11n - Dynamic EVM		2.5	3	%	
		-32	-30.5	dB	
20MHz 802.11n - Spectral Mask Power		21		dBm	T= 25°C, V_{CC}= 3.3V
40MHz / 80 MHz 802.11 ac Spectral Mask Power		19		dBm	
TX Port Return Loss	10	20		dB	
ANT Port Return Loss	10	15		dB	
Large Signal Gain		28	32	dB	T = 25°C, V_{CC} = 3.3V
	24	28			T= -10°C to +70°C, V_{CC}=3.3V
Gain flatness over any 80MHz BW	-0.5		0.5	dB	

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Transmit (TX-ANT) TX High Power Mode (continued)					**T = 25°C, V_{CC} = 3.3V, 50% Duty Cycle unless otherwise noted**
Gain flatness across band	-1		1	dB	
Operating Current		170	215	mA	P_{OUT} = +16.0dBm, T = 25°C, V_{CC} = 3.3V
		180	220	mA	P_{OUT} = +17.0dBm, T = 25°C, V_{CC} = 3.3V
		230		mA	P_{OUT} = +21dBm, T = 25°C, V_{CC} = 3.3V
Quiescent current		140	175	mA	RF=Off, V_{CC} = 3.3V
Second Harmonic		-30	-20	dBm/MHz	P_{OUT} = +21dBm, T = 25°C, V_{CC} = 3.3V, using a standard IEEE802.11 11a, 6Mbps waveform.
Third Harmonic		-45	-35	dBm/MHz	
Power Detector Voltage		0.25		V	P_{OUT} = 0dBm
		0.76		V	P_{OUT} = +16dBm
		0.97		V	P_{OUT} = +21dBm
Variation from 0-360° load pull	-1.5		1.5	dB	3:1 VSWR
ANT-RX Isolation (TX Mode-TX enabled and maximum power)	27			dB	
Transmit (TX-ANT) TX Low Power Mode					**T= 25°C, V_{CC}= 3.3V, 50% Duty Cycle unless otherwise noted**
HT80 / HT40 Output Power	10	11		dBm	T = 25°C, V_{CC} = 3.3V
80MHZ 802.11ac Dynamic EVM		1.5	1.8	%	
		-36.5	-35.0	dB	
HT20 Output Power	12	13		dBm	T = 25°C, V_{CC} = 3.3V
20MHz 802.11n Dynamic EVM		2.5	3	%	
		-32.0	-30.5	dB	
TX Performance – Spectral Mask				dBm	
20 MHz 802.11n / ac Output Power		15		dBm	T = 25°C, V_{CC} = 3.3V
40MHz / 80 MHz 802.11 ac Spectral Mask Power		13		dBm	
Operating Current		120	170	mA	P_{OUT}= 10dBm
		130	180	mA	P_{OUT}= 12dBm
		145	195	mA	Pout =15dBm
Large Signal Gain	24	27		dB	P_{OUT}= 10dBm, T = 25°C, V_{CC} = 3.3V
Gain flatness over any 80MHz BW	-0.5		0.5	dB	
Power Detector Voltage		0.25		V	P_{OUT} = 0dBm
		0.53		V	P_{OUT} = +10dBm
		0.73		V	P_{OUT} = +15dBm
Receive (ANT-RX)-RX Gain Mode					**T = +25°C, V_{CC} = 3.3V, unless otherwise noted**
Gain	11	14		dB	T = 25°C, V_{CC} = 3.3V
	10	14			T= -10°C to +70°C, V_{CC}=3.0 to 4.2V
Gain flatness over any 80MHz BW	-0.25		0.25	dB	
Gain flatness across band	-0.75		0.75	dB	
Noise Figure		2.5	3.0	dB	
Rx Port Return Loss	9	15		dB	
ANT Port Return Loss	6	10		dB	
Input P1dB	-6	-3		dBm	
Current Consumption		10	17	mA	T = 25°C, V_{CC} = 3.3V

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
LNA Turn On Time		400	600	nS	

Receive (ANT-RX)- RX Bypass Mode					**T = +25°C, V_{CC} = 3.3V, unless otherwise noted**
LNA Bypass Current		2	10	µA	
Nominal Insertion Loss		6	10	dB	T = 25°C, V_{CC} = 3.3V
RX Port Return Loss	10	15		dB	
ANT Port Return Loss	10	15		dB	
Input P1dB	20	23		dBm	T = 25°C, V_{CC} = 3.3V
General Specifications					
Control Line Impedance-VC1		75		kΩ	
Control Line Impedance-VC2		78		kΩ	
Control Line Impedance-VC3		27		MΩ	
Control Line VC1 Current- Nominal	0	0.5	1	mA	T = 25°C, V_{CC} = 3.3V RF OFF
Control Line VC2 Current- Nominal	0	0.1	1	mA	T = 25°C, V_{CC} = 3.3V RF OFF
Control Line VC3 Current- Nominal	0	0.1	1	mA	T = 25°C, V_{CC} = 3.3V RF OFF
Switching Speed		100	500	ns	
ESD – Human Body Model		1000		V	
ESD – Charge Device Model		1000		V	
PA Turn-on Time		200	500	ns	10% to 90%
FEM Leakage Current		2	15		VCC=4.8V, RF = Off
PA Stability		+20	+22	dBm	No spurious above -41.25dBm/MHz up to 4:1 VSWR
Ruggedness			12	dBm	6:1 VSWR, V_{CC} = 3.3V, 25°C; No damage
			5	dBm	10:1 VSWR, V_{CC} = 3.3V, 25°C; No damage
			10:1	VSWR	At typical operating conditions; No damage

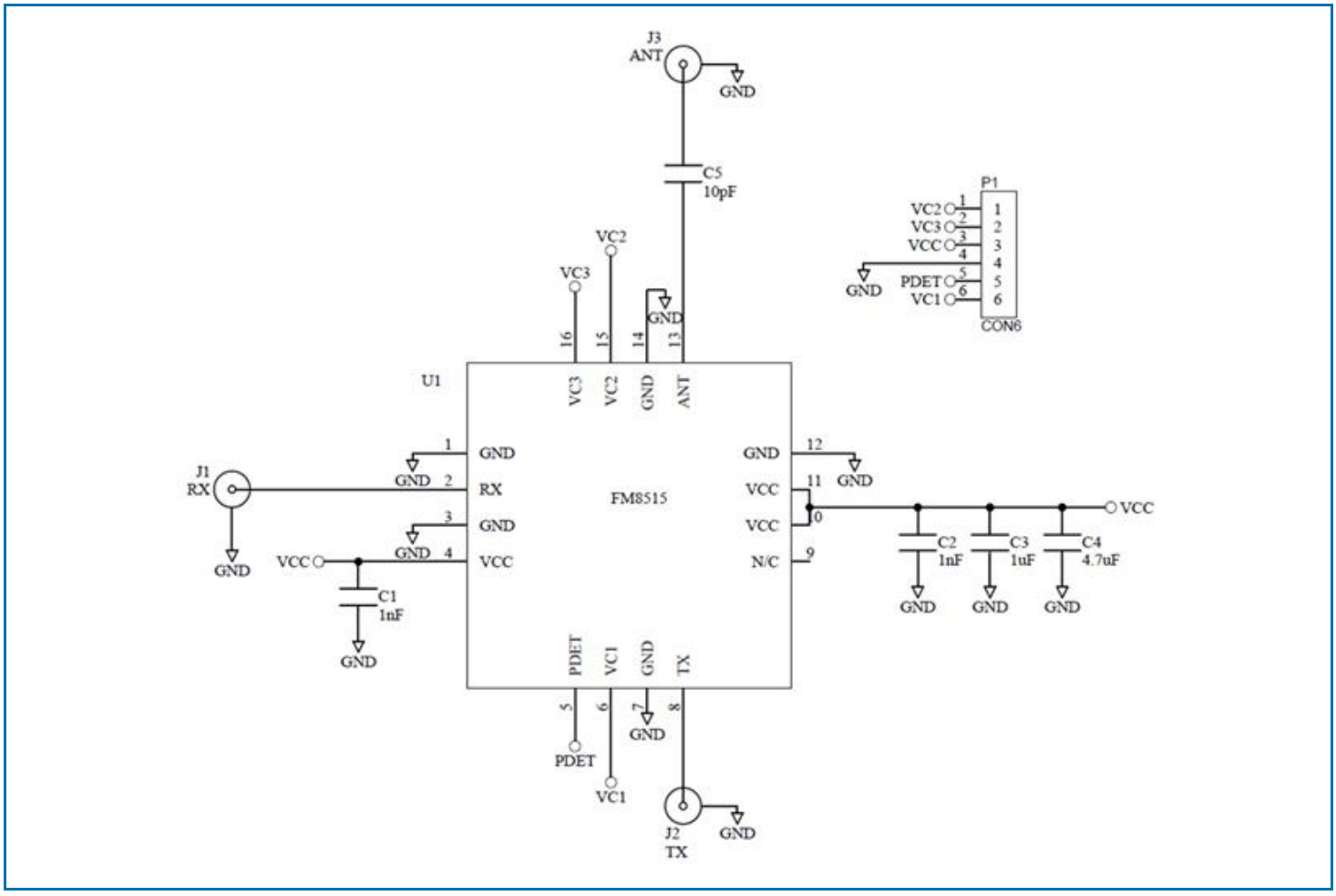
Switch Control Logic Truth Table

Operating Mode	VC1	VC2	VC3
Standby	Low	Low	Low
802.11a/n/ac TX High Power Mode	High	Low	High
802.11a/n/ac TX Low Power Mode	High	Low	Low
802.11a/n/ac RX Gain	Low	High	Low
802.11a/n/ac RX Bypass	Low	High	High

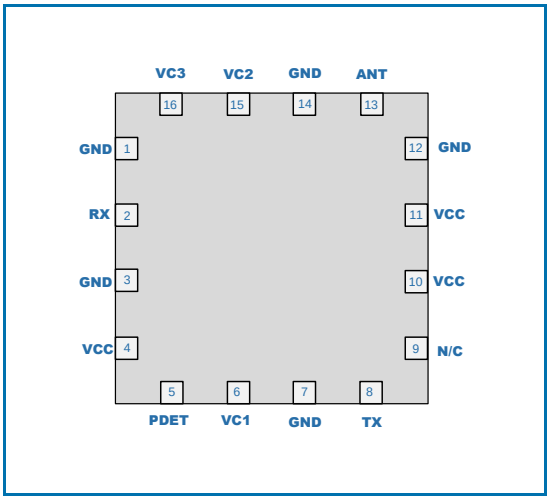
Notes:

- High = 2.8 to V_{CC}. Low = 0V to 0.2V

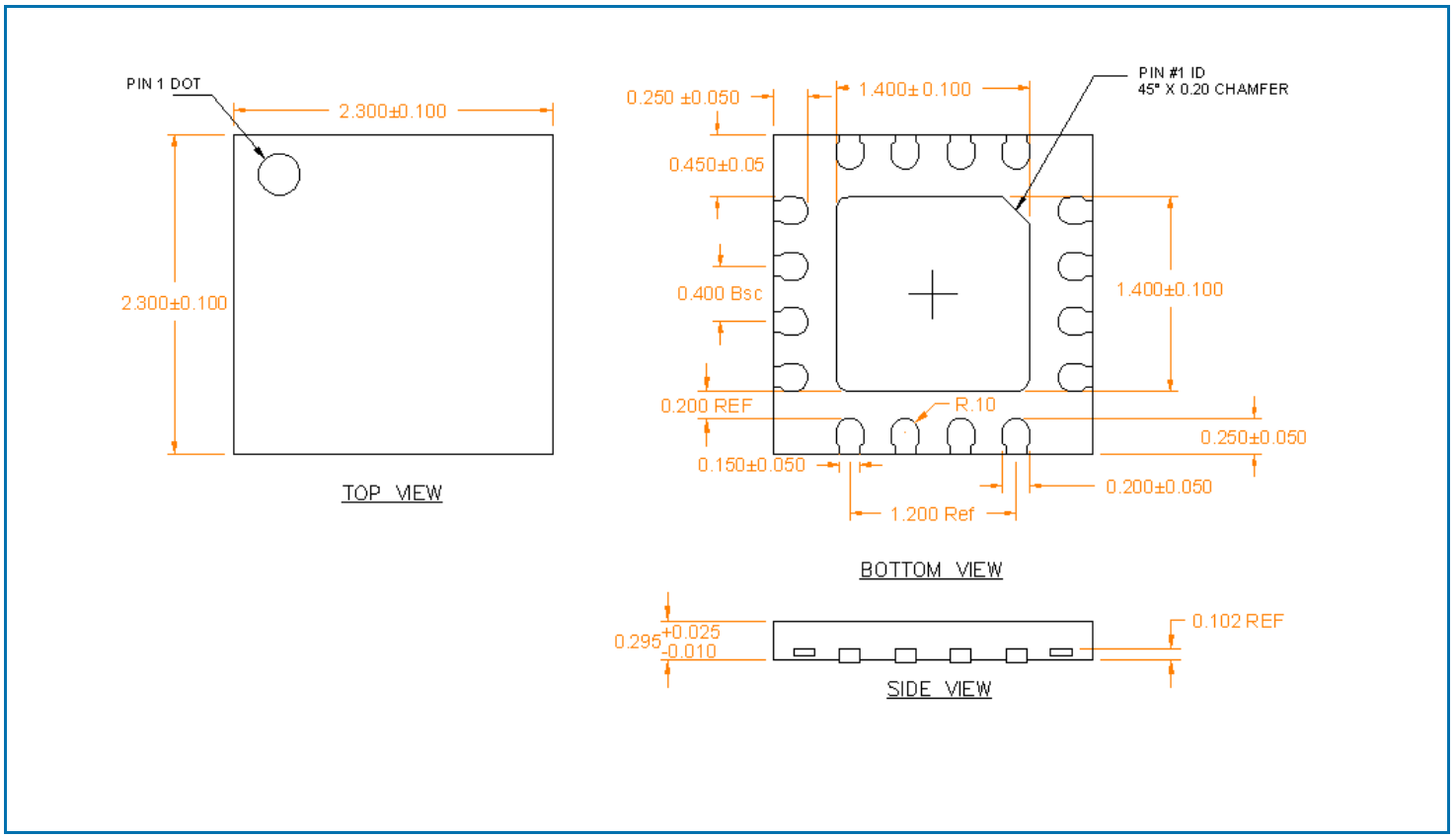
Applications Schematic



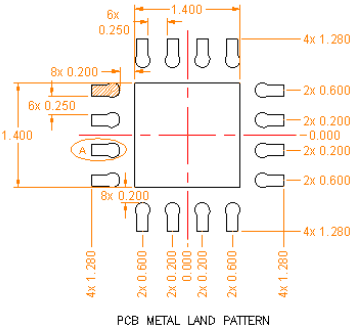
Pin Out



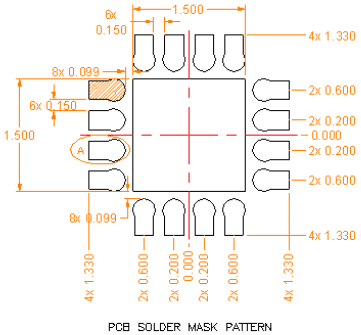
Package Drawing



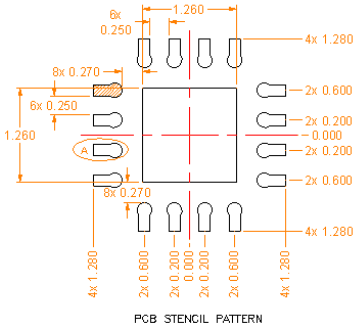
PCB Patterns



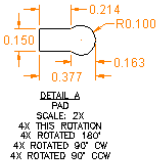
PCB METAL LAND PATTERN

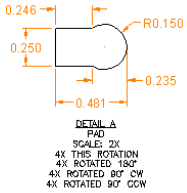


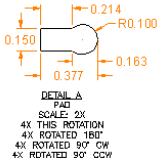
PCB SOLDER MASK PATTERN



PCB STENCIL PATTERN







Thermal vias for center slug should be incorporated into the PCB design. The number and size of thermal vias will depend on the application, the power dissipation, and the electrical requirements. Example of the number and size of vias can be found on the RFMD evaluation board layout.

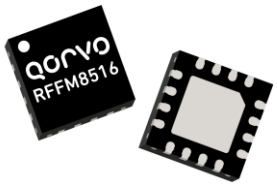
Pin Names and Descriptions

Pin	Name	Description
1	GND	This pin is not connected internally and can be left floating or connected to ground.
2	RX	RF output port for the 802.11a/n LNA. This port is matched to 50Ω and DC blocked internally
3	GND	This pin is not connected internally and can be left floating or connected to ground.
4	VCC	Supply voltage for the LNA and PA Regulator. See applications schematic for biasing and bypassing components.
5	PDET	Power detector voltage for the TX path. May need external series R/shunt C to adjust voltage level and to filter RF noise
6	VC1	Control Logic Pin - Refer to Logic Table
7	GND	This pin is not connected internally and can be left floating or connected to ground.
8	TX	RF input port for the 802.11a/n PA. Input is matched to 50Ω and DC blocked internally
9	N/C	This pin is not connected internally and can be left floating or connected to ground.
10	VCC	Supply voltage for the first and second stage of the PA. See applications schematic for biasing and bypassing components.
11	VCC	Supply voltage for the final stage of the PA. See applications schematic for biasing and bypassing components.
12	GND	This pin is not connected internally and can be left floating or connected to ground.
13	ANT	RF bidirectional antenna port matched to 50Ω and external DC block is required
14	GND	This pin is not connected internally and can be left floating or connected to ground.
15	VC2	Control Logic Pin - Refer to Logic Table
16	VC3	Control Logic Pin - Refer to Logic Table
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.

RFFM8516

5.0 GHz Wi-Fi Front-End Module

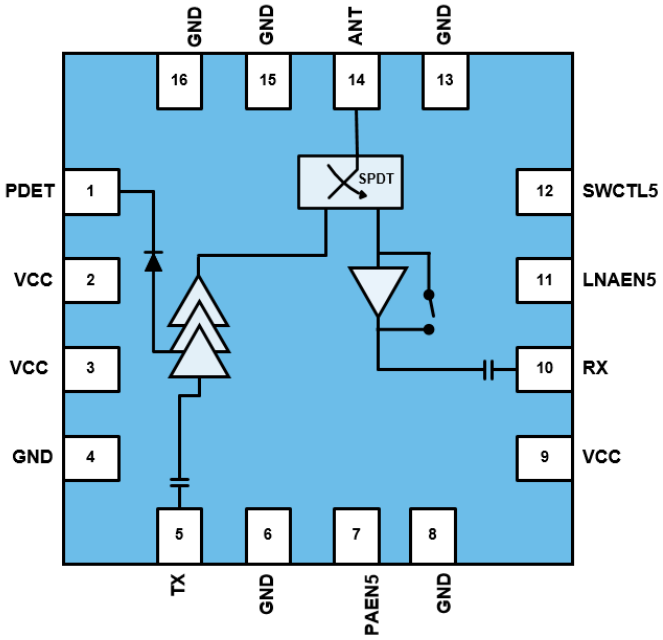
16 Pin 2.3 x 2.3 mm QFN Package



Product Overview

The RFFM8516 provides a complete integrated solution in a single front end module (FEM) for WiFi 802.11a/n/ac systems. Performance is focused on a balance of efficiency to enable long battery life and linear power that increases the range of connection. It is specifically designed to work with the RFFM8216 to greatly reduce BOM cost in dual band applications.The RFFM8516 integrates a 5 GHz power amplifier (PA), single pole double throw switch (SP2T), LNA with bypass, harmonic and 2.4 GHz Rx filtering and a power detector coupler for improved accuracy.

Functional Block Diagram



Top View

Key Features

- P_{out} = 17 dBm, 802.11ac, 80MHz MCS9 at 1.4% (-37 dB)
- High Efficiency
- Internally matched RF input/output to 50 ohms
- Integrated 5 GHz PA, SP2T, LNA with Bypass and PDET
- Integrated 2.4 GHz Rx Filter
- Integrated Power Detector
- High Impedance PA Enable

Applications

- IEEE 802.11a/n/ac WLAN Applications
- Single-Placement RF Front-End Module
- Single-band and Dual-band Wireless LAN Systems
- Portable Battery-Powered Equipment

Ordering Information

Part Number	Description
RFFM8516SB	5 piece sample bag
RFFM8516SQ	25 piece sample bag
RFFM8516SR	7” Reel with 100 pieces
RFFM8516TR7	7” Reel with 2500 pieces
RFFM8516TR7-5K	7” Reel with 5000 pieces
RFFM8516PCB-410	Fully Assembled Evaluation Board w/ 5-pieces bag

Absolute Maximum Ratings

PARAMETER	CONDITIONS	RATING
Storage Temperature		-40 to 150 ºC
DC Supply Voltage	No RF Applied	−0.5 to +6.0 V
PA Enable Voltage		−0.5 to +5.0 V
DC Supply Current		800mA
RF Maximum Input Power (Tx Mode/RX Mode)	CW, 50Ω, VCC = 3.6 V, T = 25 ºC	+10 dBm
RF Maximum Input Power (Rx Bypass Mode)	CW, 50Ω, VCC = 3.6 V, T = 25 ºC	+25 dBm

Operation of this device outside the parameter ranges given above may cause permanent damage.

Recommended Operating Conditions

PARAMETER	CON	MIN.	TYP.	MAX.	UNITS
Operating Temperature		−20	25	60	ºC
Extended Operating Temperature	Functional with reduced performance	−40	-	85	ºC
Operating Voltage V_{CC}		3.0	3.6	4.2	V
Extended Operating Voltage V_{CC}	Functional with reduced performance	3.0	-	4.8	V
RF Impedance	All RF ports (single-ended)	-	50	-	Ω
Control Voltage (V-high)	PAEN5 / SWCTL5	2.75	2.9	3.6	V
Control Voltage (V-High)	LNAEN5	2.75	3.3	3.6	V
Control Voltage (V-Low)	PAEN5 / LNAEN5	0	0.1	0.4	V
Control Current (I-High)	PAEN5 / LNAEN5	-	5	135	uA
Control Current (I-Low)	PAEN5 / LNAEN5	-	0.5	1	uA
Leakage/Sleep/Bypass Mode Current	PAEN5 / LNAEN5/SWCTL5 = Low Vcc=4.2V	-	2	12	uA

Electrical specifications are measured at nominal operating conditions. Unless noted otherwise.

Logic Truth Table

MODE	PAEN5	LNAEN5	SWCTL5
802.11a/n/ac TX Mode	High	Low	High
802.11a/n/ac RX Gain	Low	High	Low
802.11a/n/ac RX Bypass	Low	Low	Low

Note: PAEN5 pin 7 and SWCTL5 pin 12 can be tied together for all operating modes.

Electrical Specifications – 5 GHz Transmit

(V_{CC}=3.6V; Temp=25°C; unless noted otherwise)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Operating Frequency		5180	-	5825	MHz
Small Signal Gain		25	29	-	dB
Gain Flatness	For any 80 MHz bandwidth	−0.5	-	+0.5	dB
Gain Flatness	For entire frequency band	−1.5	-	+1.5	dB
Margin to Spectrum Emission Mask 11a, 6 Mbps	Pout = 21.0 dBm	-	3.0	-	dB
Margin to Spectrum Emission Mask 11n, MCS0 HT20	Pout = 21.0 dBm	-	3.0	-	dB
Margin to Spectrum Emission Mask 11ac, MCS0 VTH80	Pout = 20.0 dBm	-	3.0	-	dB
11n, MCS7 HT20	Output Power	+18.5	+19	-	dBm
	DEVM	-	−34	−29.6	dB
11ac, MCS9 VTH80	Output Power	+16.5	+17	-	dBm
	DEVM	-	−37	−35	dB
Current 11a, 6 Mbps	Pout = 21.0 dBm	-	300	350	mA
Current 11n, MCS7 HT20	Pout = 19.0 dBm	-	270	320	mA
Current 11ac, MCS9 VHT80	Pout = 17.0 dBm	-	250	300	mA
Harmonics ($2f_0$)	Pout = 21.0 dBm; 6 Mbps	-	-	−30	dBm/MHz
Harmonics ($3f_0$)	Pout = 21.0 dBm; 6 Mbps	-	-	−38	dBm/MHz
PA Switching Speed	TX Normal Mode	-	400	-	nS
ANT to RX Isolation	TX Normal Mode	24	28	-	dB
Return Loss – TX Port		10	15	-	dB
Return Loss – ANT Port		10	20	-	dB
Power Detector Voltage Low	Pout = 5 dBm	-	0.2	-	V
Power Detector Voltage High	Pout = 22 dBm	-	-	0.8	V

Operating condition is +25degC at 3.6V unless otherwise noted.

Electrical Specifications – 5.0 GHz Receive
(V_{CC}=3.6V; Temp=25°C; unless noted otherwise)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Operating Frequency		5180	-	5825	MHz
Gain		10	12.5	-	dB
Gain Flatness	For any 80 MHz bandwidth	−1.5	-	+1.5	dB
Noise Figure		-	2.5	3.5	dB
Current		-	9	16	mA
P1dB		−8	−5	-	dBm
LNA Switching Speed		-	400	-	nS
Return Loss RX Port		10	20	-	dB
Return Loss ANT Port		5	8	-	dB

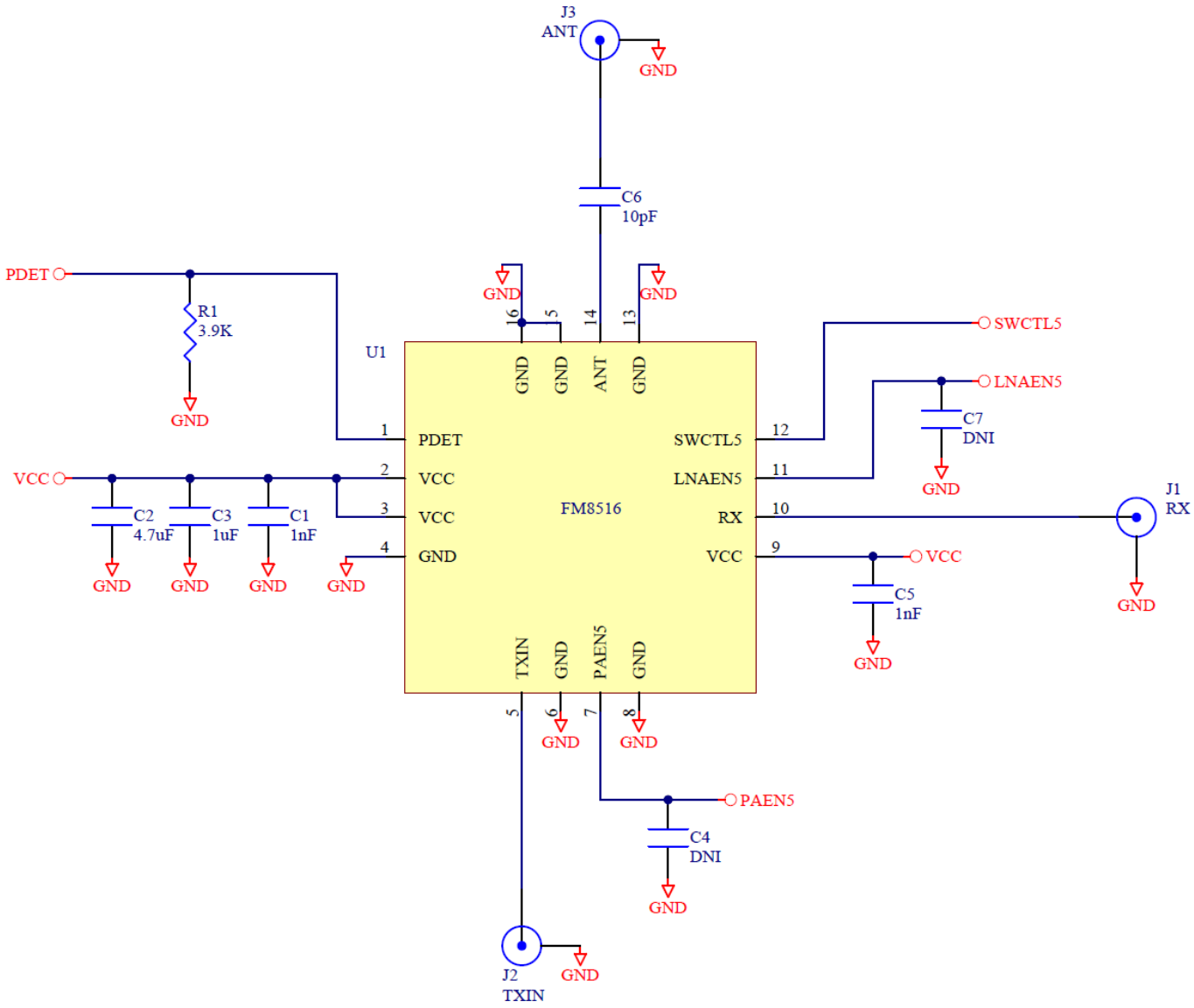
Operating condition is +25degC at +3.6 V unless otherwise noted.

Electrical Specifications – 5.0 GHz Rx Bypass
(Vcc=3.6V; Temp=25°C; unless noted otherwise)

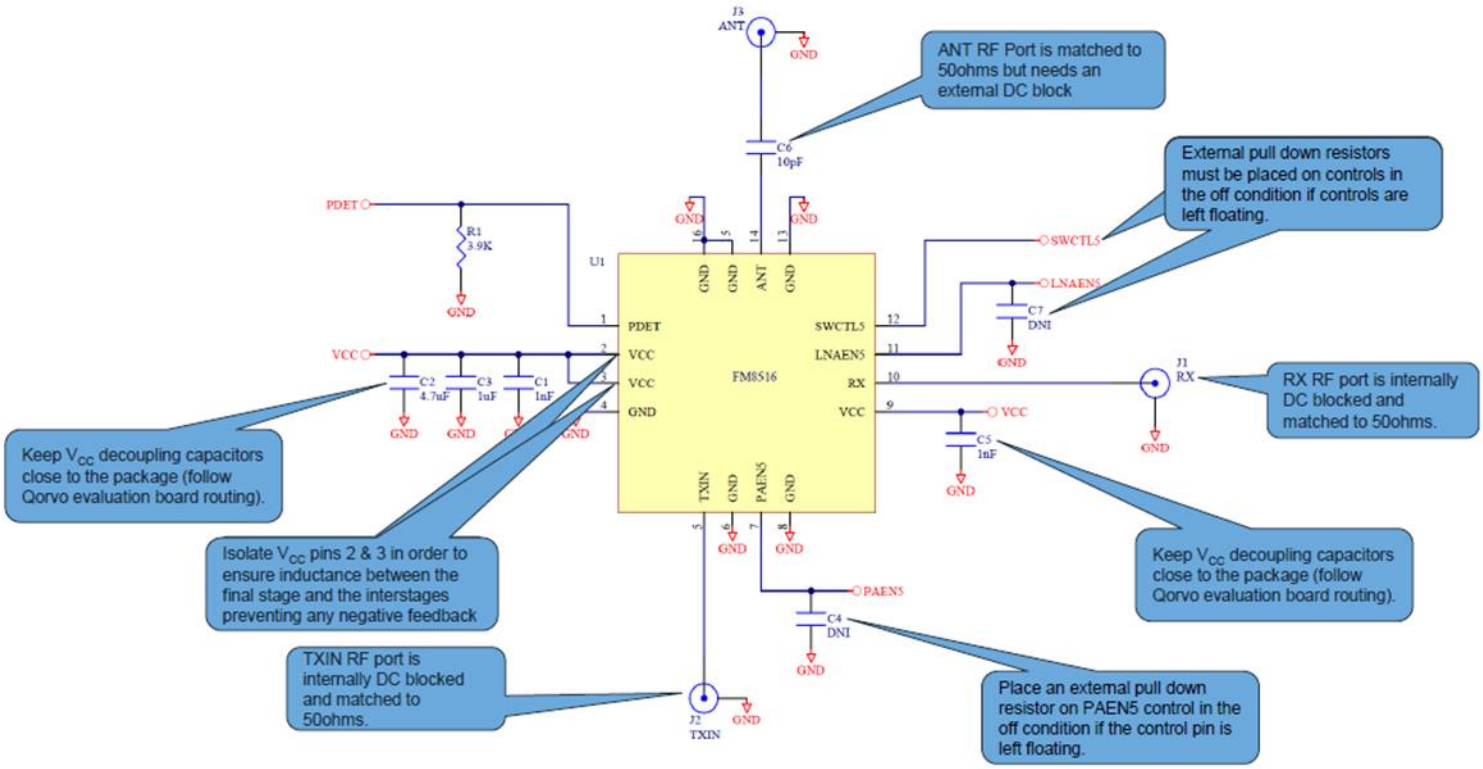
PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Operating Frequency		5180	-	5825	MHz
Gain		−3.5	− 4.5	−7	dB
Gain Flatness	For any 80 MHz bandwidth over the frequency range. LNA Disabled.	−1.0	-	+1.0	dB
Return Loss – RX Port		10	12	-	dB
Return Loss – ANT Port		14	20	-	dB

Test condition is +25°C at +3.6V unless otherwise noted.

Application Circuit Schematic



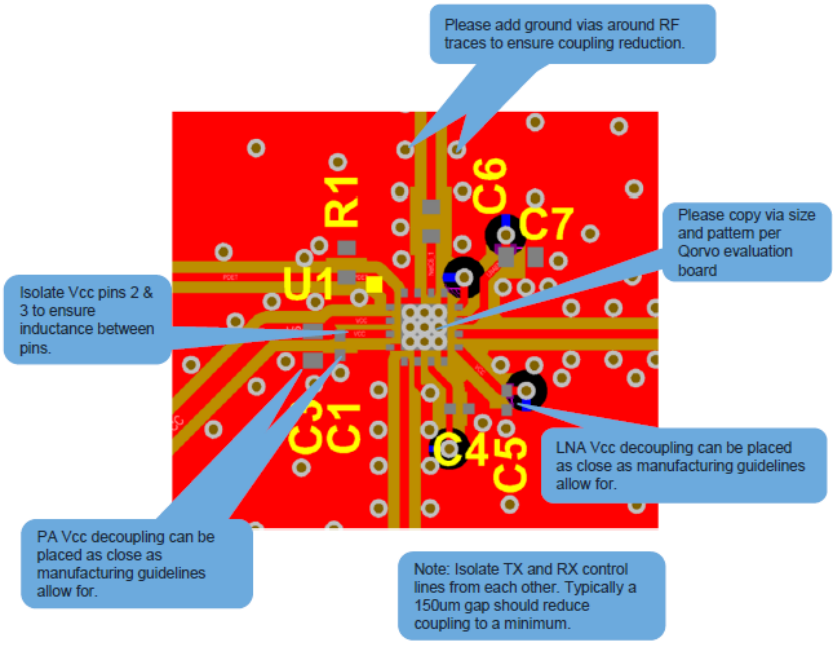
Application Circuit Schematic



Evaluation Board Layout

Key Notes:

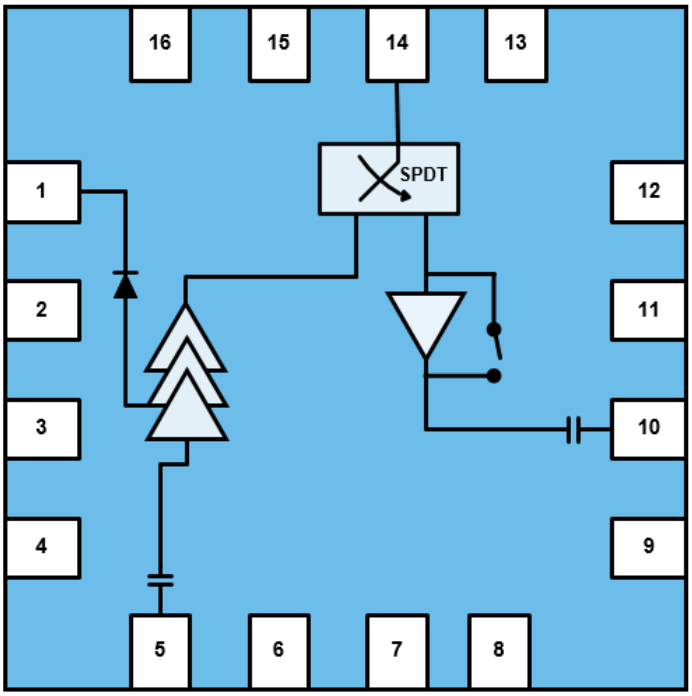
1. It is recommended to fully populate the ground slug with as many thermal vias as possible and to add ground vias around RF traces. The vias size used on the QORVO evaluation board is 12mil hole size and 22mil diameter.
2. Isolate Vcc pins 2 & 3 to ensure inductance between the final stage(pin2) and the interstages(pin3) to prevent negative feedbacks.
3. Route control lines on separate layer, other than the signal layer, whenever possible.
4. Keep a minimum distance of 150um between TX and RX control lines to minimize coupling.
5. In general, follow QORVO evaluation board layout as close as possible. Gerber files are available upon request.



Bill of Material

REF. DES.	QTY	DESCRIPTION	MANUF.	PART NUMBER
PCB	1	PCB, FM8516	Performance Micro	RFFM8516-410(A)
C3	1	CAP, 1uF, 10%, 6.3V, X5R, 0402	Murata	GRM155R60J105KE19D
C1, C5	2	CAP, 1000pF, 10%, 16V, X7R, 0201	Murata	GRM033R71C102KA01D
C2	1	CAP, 4.7uF, +80/-20%, 10V, Y5V, 0805	Taiyo Yuden	CE LMK212F475ZG-T
C6	1	CAP, 10pF, 5%, 50V, COG, 0402	Murata	GRM1555C1H100JZ01E
R1	1	RES, 3.9K, 5%, 1/16W, 0402	Kamaya	RMC1/16S-392JTH
J1, J2, J3	3	CONN, SMA, END LNCH, UNIV, HYB MNT, FLT	Molex	SD-73251-4000
P1	1	CONN, HDR, ST, PLRZD, 6-PIN, 0.100"	AMP	640454-6
C4, C7	N/A	Not Populated	N/A	N/A

Pin Configuration and Description

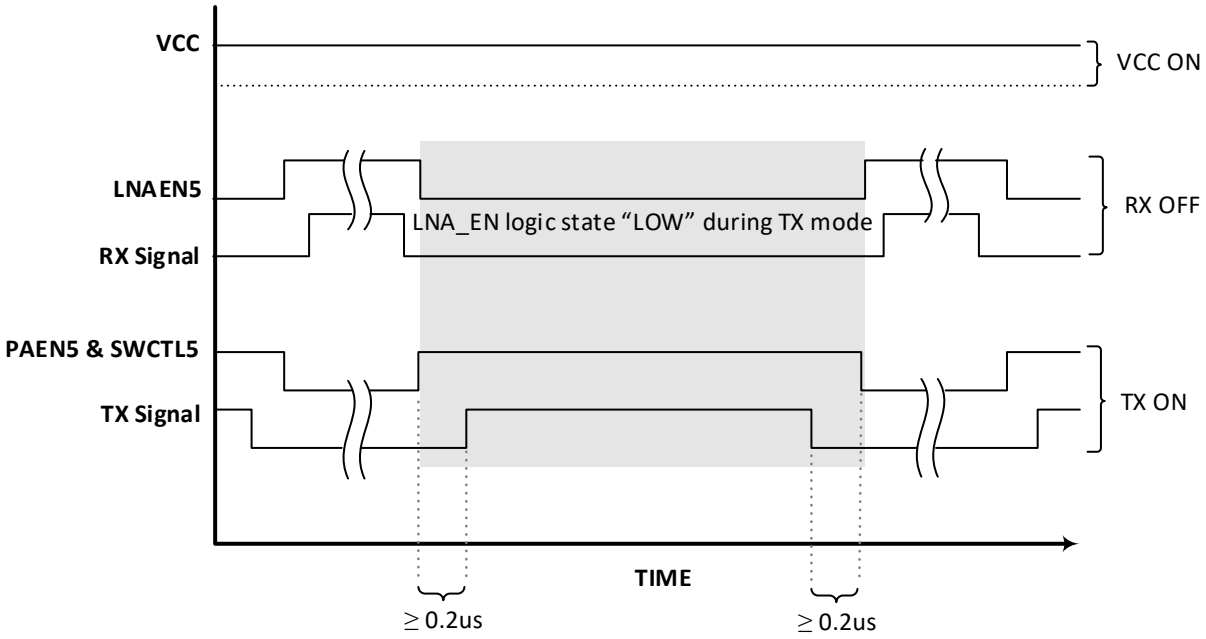


Top View

Pin Number	Label	Description
1	PDET	Power detector output
2,3,9	VCC	DC Power Supply voltage
4,6,8,13,15,16	GND	Ground connection
5	TX	RF input port for the 802.11a/n/ac PA. This port is matched to 50Ω and DC blocked internally
7	PAEN5	Logic control voltage 1. See truth table for proper voltage settings
10	RX	RF output port for the 802.11a/n/ac PA. This port is matched to 50Ω and DC blocked internally
11	LNAEN5	Logic control voltage 2. See truth table for proper voltage settings
12	SWCTL5	Logic control voltage 3. See truth table for proper voltage settings
14	ANT	RF bidirectional antenna port matched to 50Ω. An external DC block is required
Backside Pad	GND	Ground connection. The back side of the package should be connected to the ground plan though as short of a connection as possible. PCB vias under the device are required.

Timing Diagram

RFFM8516 Transmit Mode
RF/DC Power ON/OFF Sequence



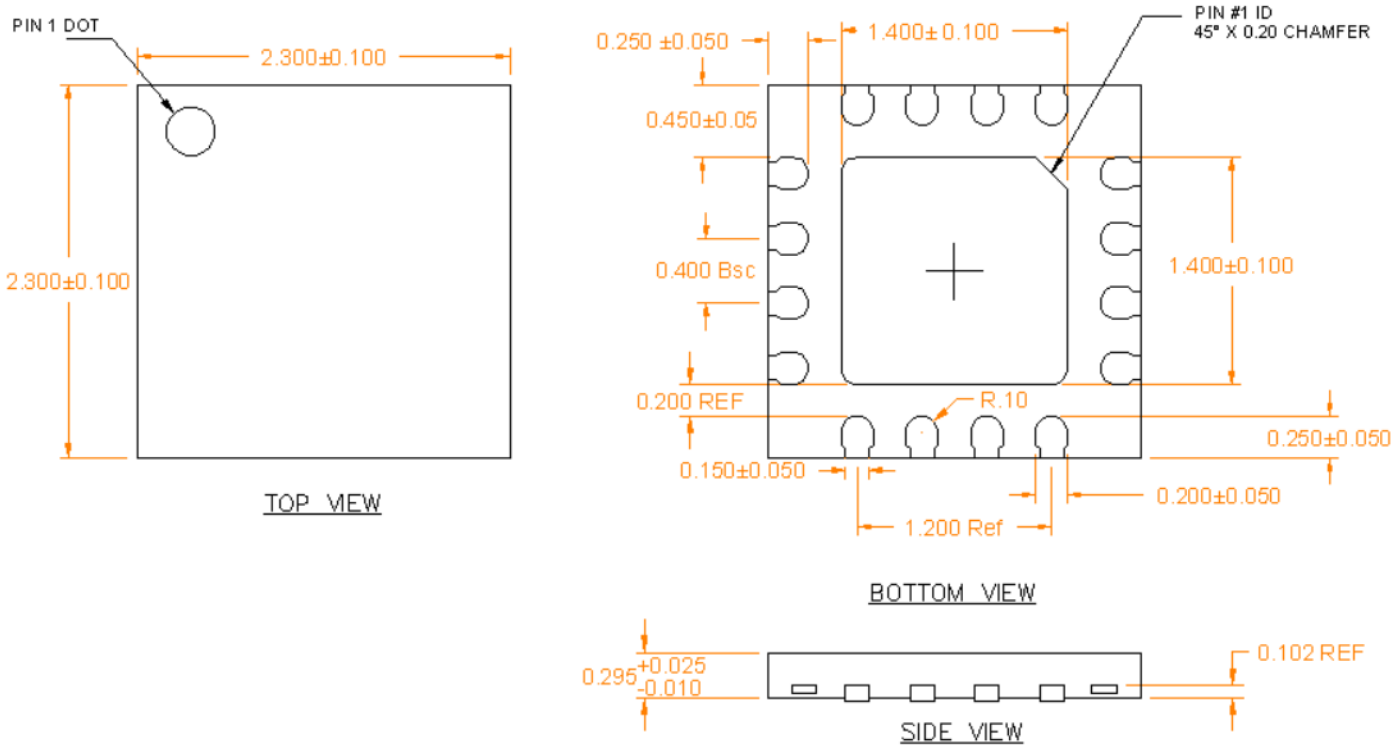
Note:
Observe the timing sequence shown in the diagram above and described below. DC, RF, and ON/OFF Time signal levels per datasheet specifications.

- Apply VCC prior to turning PA enable ON
- Turn PA enable ON prior to applying RF signal
- Turn RF signal OFF prior to turning PA enable OFF
- Turn PA enable OFF prior to turning VCC OFF
- TX/RX simultaneous transition is allowed

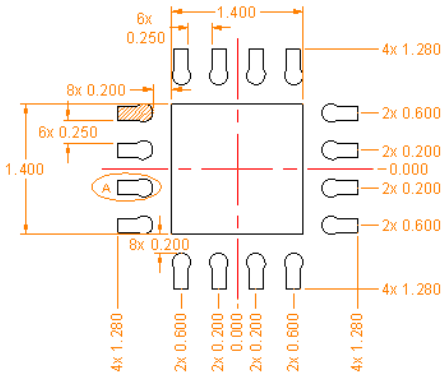
Package Outline Drawing

Marking: Part number – RFFM8516

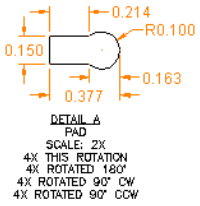
Trace code – XXXX

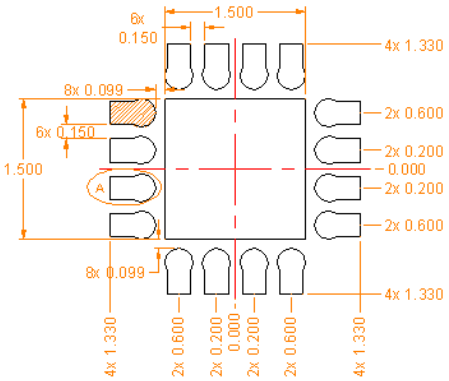


Recommended PCB Patterns

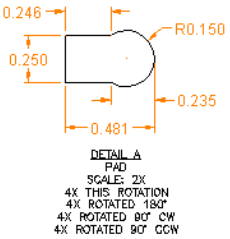


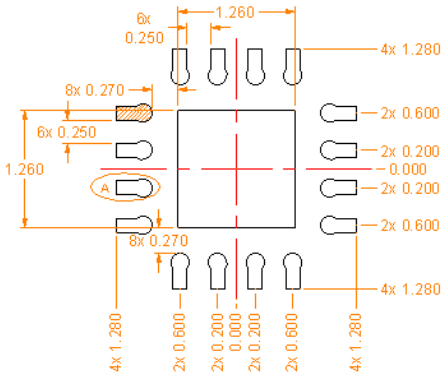
PCB METAL LAND PATTERN



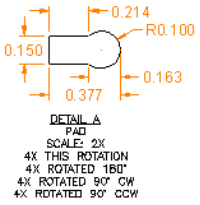


PCB SOLDER MASK PATTERN





PCB STENCIL PATTERN



Thermal vias for center slug should be incorporated into the PCB design. The number and size of thermal vias will depend on the application, the power dissipation, and the electrical requirements. Example of the number and size of vias can be found on the RFMD evaluation board layout.

Notes:

1. All dimensions are in microns. Angles are in degrees.
2. Dimension and tolerance formats conform to ASME Y14.4M-1994.
3. The terminal #1 identifier and terminal numbering conform to JESD 95-1 SPP-012.

Handling Precautions

Parameter	Rating	Standard
ESD – Human Body Model (HBM)	Class 1C	ESD/JEDEC JS-001-2012
ESD – Charged Device Model (CDM)	Class C3	JESD22-C101

Caution!

ESD sensitive device

Solderability

Compatible with both lead-free (260 °C max. reflow temperature) and tin/lead (245 °C max. reflow temperature) soldering processes.

Package lead plating: NiPdAu

RoHS Compliance

This part is compliant with the 2011/65/EU RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment), as amended by Directive 2015/863/EU.

This product also has the following attributes:

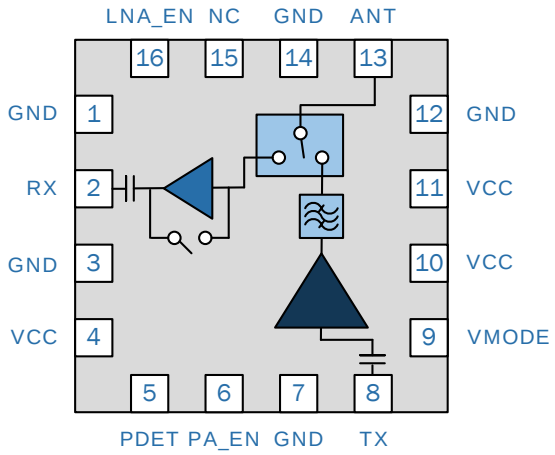
- Lead free
- Halogen Free (Chlorine, Bromine)
- Antimony Free
- TBBP-A ($C_{15}H_{12}Br_4O_2$) Free
- SVHC Free

RFFM8528

WiFi Front End Module
5180MHz to 5825MHz

Package: QFN, 16-pin,
2.3mm x 2.3mm x 0.33mm max

The RFFM8528 provides a complete integrated solution in a single front end module (FEM) for WiFi 802.11a/n/ac systems. The next generation ultra-small factor and integrated matching minimizes layout area in the customer's application, reduces the bill of materials and greatly reduces the number of external components. Performance is focused on a balance of efficiency to enable long battery life and linear power that increases the range of connection. The RFFM8528 integrates a 5GHz power amplifier (PA), single pole double throw switch (SP2T), LNA with bypass, and a power detector coupler for improved accuracy. The device is provided in a 2.3mm x 2.3mm x 0.33mm, 16-pin QFN package.



Functional Block Diagram

Features

- P_{OUT} = +17.5dBm, 802.11ac, 80MHz MCS9 at 1.8% (-35dB) Dynamic EVM
- High efficiency
- Input and Output Matched to 50Ω
- Integrated 5GHz PA, SP2T, LNA with Bypass and P_{DET}
- Supports low power mode for increased efficiency operation
- Optional logic schemes for control
- Low Height Package, Suited for SiP and CoB designs

Applications

- Smartphones
- Tablets
- Netbooks/Notebooks
- Mobile Devices
- Automotive

Ordering Information

RFFM8528SB	Standard 5-piece bag
RFFM8528SQ	Standard 25-piece bag
RFFM8528SR	Standard 100-piece reel
RFFM8528TR7	Standard 2500-piece reel
RFFM8528TR7-5K	Standard 5000-piece reel
RFFM8528PCK-410	Fully assembled evaluation board w/ 5-piece bag

RF Micro Devices Inc. 7628 Thorndike Road, Greensboro, NC 27409-9421
For sales or technical support, contact RFMD at +1.336.678.5570 or customerservice@rfmd.com.

DS140731

Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage (No RF Applied)	-0.5 to +6.0	V_{DC}
PA Enable Voltage	-0.5 to 5	V_{DC}
DC Supply Current	500	mA
Storage Temperature	-40 to +150	ºC
Maximum TX Input Power into 50Ω Load for 11a/n (No Damage)	+12	dBm
LNA On Maximum RX input power (No damage)	+12	dBm
Bypass Mode Maximum RX input power (No damage)	+25	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		
Compliance					**802.11a, 802.11n, 802.11ac**
Operating Frequency	5.18		5.825	GHz	
Extended Frequency	4.9		5.925	GHz	Functional with reduced performance
Operating Temperature	-20	25	+65	ºC	
Extended Operating Temperature	-40	25	+85	ºC	Functional with reduced performance
Power Supply V_{CC}	3.0	3.3	3.6	V	
Extended V_{CC}	3.0		4.2	V	Functional with reduced performance
Control Voltage-High	2.8	2.95	V_{CC}	V	For PA_EN, LNA_EN, VMODE
Control Voltage-Low		0	0.2	V	For PA_EN, LNA_EN, VMODE
Transmit (TX-ANT) High Power Mode					**V_{CC}=3.3V; PA_EN = High; LNA_EN = Low; VMODE = Low; T=+25ºC; Unless otherwise noted**
Small Signal Gain (5.18 to 5.85GHz)		28		dB	
Gain Flatness Across the Band	-1		1	dB	
Gain flatness Across Any 80MHz Channel	-0.5		0.5	dB	
20MHz Output Power*		19		dBm	
11n 20MHz Dynamic EVM		2.5		%	802.11n HT20 MCS7
		-32		dB	
80MHz Output Power*		17.5		dBm	
11ac 80MHz Dynamic EVM		1.8		%	802.11ac VHT80 MCS9
		-35		dB	
TX Port Return Loss	12	18		dB	
ANT Port Return Loss	14	20		dB	
802.11a 6Mbps Operating Current		328		mA	P_{OUT} = +22dBm
20MHz 802.11n Operating Current		250		mA	P_{OUT} = +19dBm
80MHz 802.11ac Operating Current		225		mA	P_{OUT} = +17.5dBm
Second Harmonic			-33	dBm/MHz	Fundamental frequency is between 4900 and 5850MHz; RF P_{OUT} = +22dBm. Measured in 1MHz resolution bandwidth (FCC limit max = -30dBm)
Third Harmonic			-33	dBm/MHz	

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Transmit (TX-ANT) High Power Mode (continued)					**V_{CC}=3.3V; PA_EN = High; LNA_EN = Low; VMODE = Low; T=+25ºC; Unless otherwise noted**
Margin to 20Mhz Spectral Mask*		2		dBc	802.11n HT20 at P_{OUT} = +20dBm
Margin to 80MHz Spectral Mask*		2		dBc	802.11ac VHT80 at P_{OUT} = +20dBm
Power Detector Voltage	0.8		1.05	V	P_{OUT} = +17.5dBm
Variation Across Band	-0.5		0.5	dB	
Variation Over Temperature	-1.5		1.5	dB	
Transmit (TX-ANT) Low Power Mode					**V_{CC}=3.3V; PA_EN = High; LNA_EN = Low; VMODE = High; T=+25ºC; Unless otherwise noted**
20MHz Output Power*		9		dBm	
11n 20MHz Dynamic EVM		1		%	802.11n HT20 MCS7
		-40		dB	
80MHz Output Power*	9	10		dBm	
11ac 80MHz Dynamic EVM		1.2		%	802.11ac VHT80 MCS9
		-38.5		dB	
20 MHz 802.11n Current		145		mA	P_{OUT} = +9dBm
80 MHz 802.11ac Current		145		mA	P_{OUT} = +9dBm
Receive (ANT-RX) LNA On					**V_{CC}=3.3V; PA_EN = Low; LNA_EN = High; VMODE = Low; T=+25ºC; Unless otherwise noted**
Gain	11	13	15	dB	
Gain Flatness Across Band	-1		1	dB	
Noise Figure		2.5	3	dB	
Rx Port Return Loss		12		dB	
ANT Port Return Loss		8		dB	
RX Current		10		mA	
Input P1dB		-4		dBm	
Receive (ANT-RX) Bypass Mode					**V_{CC}=3.3V; PA_EN = Low; LNA_EN = Low; VMODE = Low; T=+25ºC; Unless otherwise noted**
Bypass Loss	2	3	4.5	dB	
Gain Flatness Across Band	-1		1	dB	
RX Port Return Loss		7		dB	
ANT Port Return Loss		11		dB	
General Specifications					
ANT to RX Isolation		38		dB	Switch in TX Mode
TX to RX Isolation		25		dB	
PA_EN Current		250		uA	
LNA_EN current		83		uA	
Leakage Current	0.1	2	5	uA	V_{CC}=3.3V, No RF applied, PA_EN=LNA_EN=VMODE=Low
Switch Control Current – High		5	100	uA	Per line
Switch Control Current – Low		0.5	2	uA	
Switching Speed		100	200	nS	
ESD – Human Body Model		1000		V	
ESD – Charge Device Model		1000		V	
PA Turn-on Time from PA_EN edge		150	200	nS	10% to 90% of final gain

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
General Specifications					
PA Turn-off Time from PA_EN edge		150	200	nS	90% to 10% of final gain
Ruggedness			10:1	VSWR	At typical operating conditions

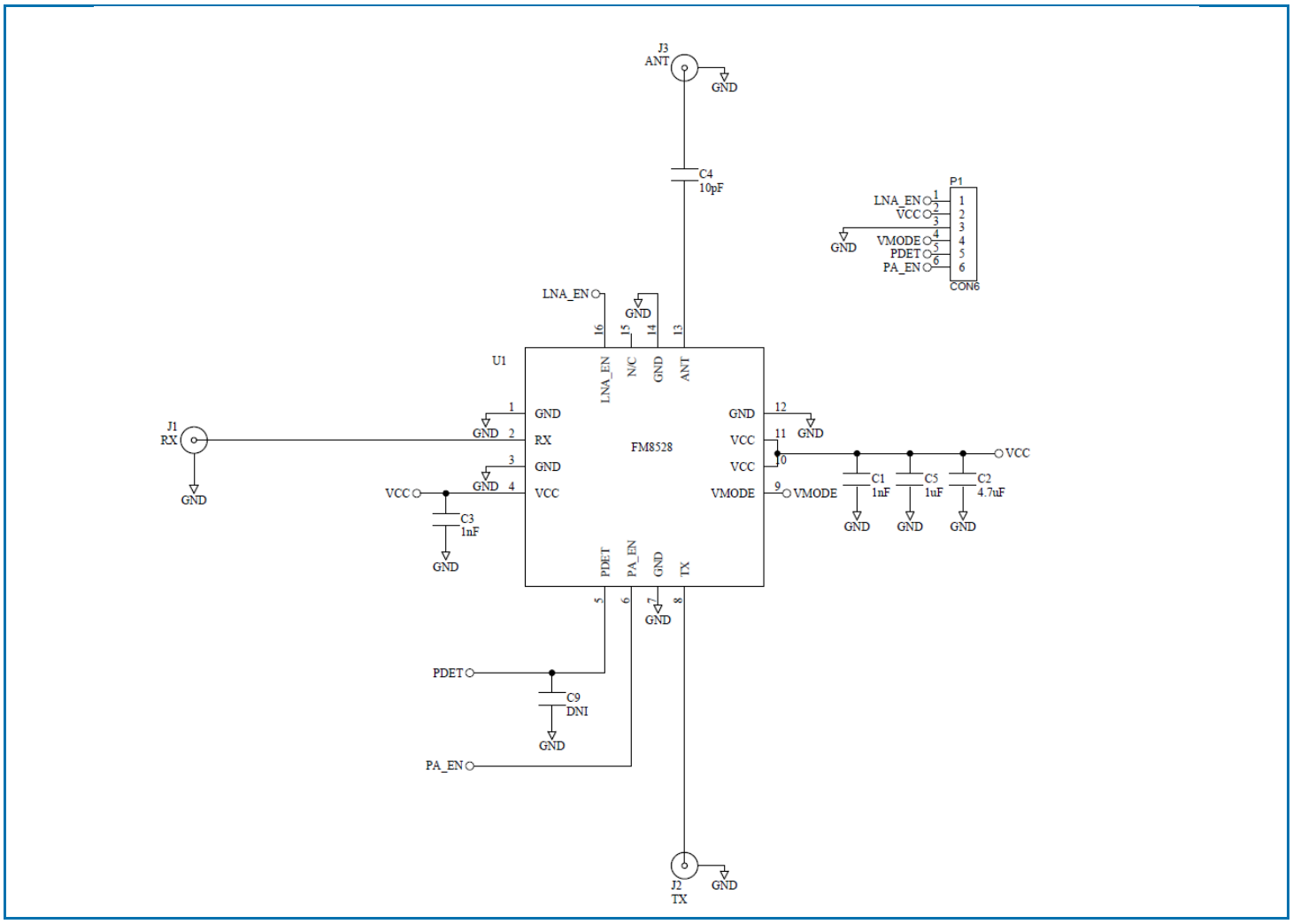
*For 4900MHz to 5150MHz, P_{OUT} is reduced by 1dB

Switch Control Logic Truth Table

Operating Mode	PA_EN	LNA_EN	VMODE
Standby	Low	Low	Low
802.11a/n/ac TX High Power Mode	High	Low	Low
802.11a/n/ac TX Low Power Mode	High	Low	High
802.11a/n/ac TX Low Power Mode (Optional)	High	High	Low
802.11a/n/ac RX Gain	Low	High	Low
802.11a/n/ac RX Bypass	Low	Low	Low

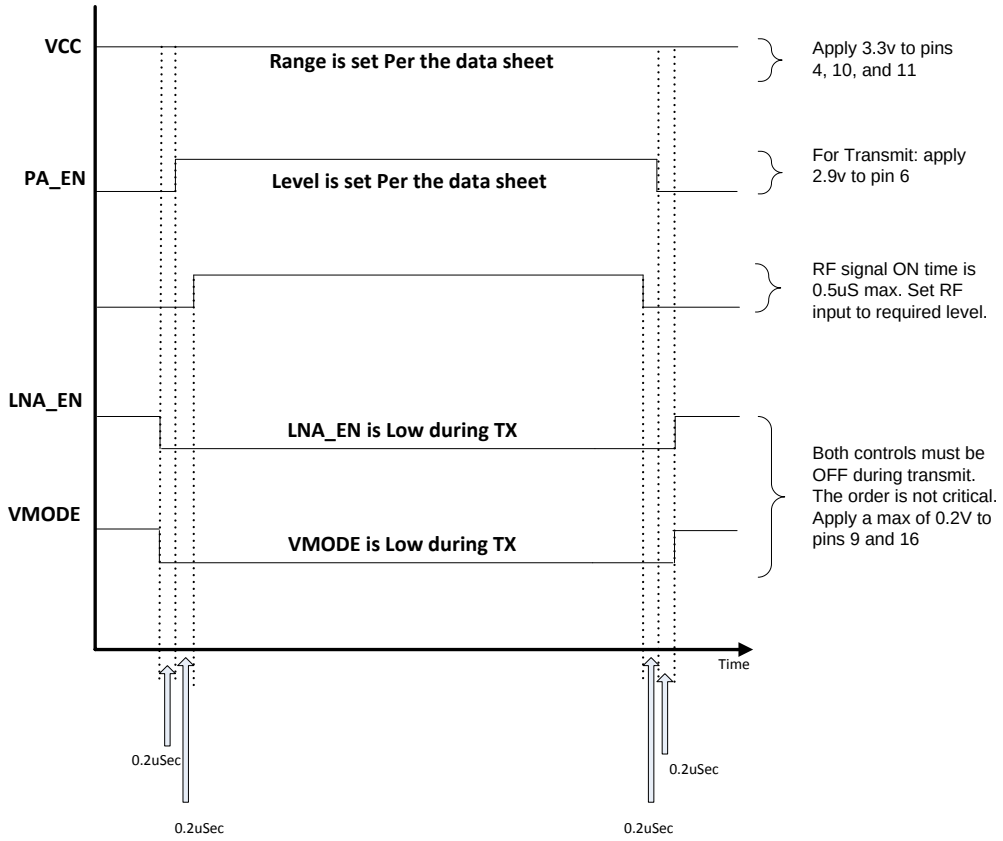
Note:
1. TX Low Power Mode is enabled either internally or with an option for external VMODE.
2. High = 2.8V to V_{CC}, Low = 0V to 0.2V.

Evaluation Board Schematic



Timing Diagram

RFFM8528 Transmit Timing Diagram
Power ON / OFF Sequence



Note:
1. RF Signal for each specific mode is applied after the DC bias is applied
2. Total ON/OFF time includes from 10% of control switching to 90% of RF power
3. Listed values on diagram are typical. The maximum is 0.5us for each mode

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 3.3V first with PA_EN ≤ 0.2V. Leakage current will be <5uA typical.
3. Refer to switch operational truth table to set the control lines at the proper levels for WiFi TX. 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 ~160mA +/- 20mA for a typical part but the actual operating current will be based on the output power desired. Be extremely careful not to exceed 5.0V on the PA_EN pin or the part may exceed device current limits.

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.

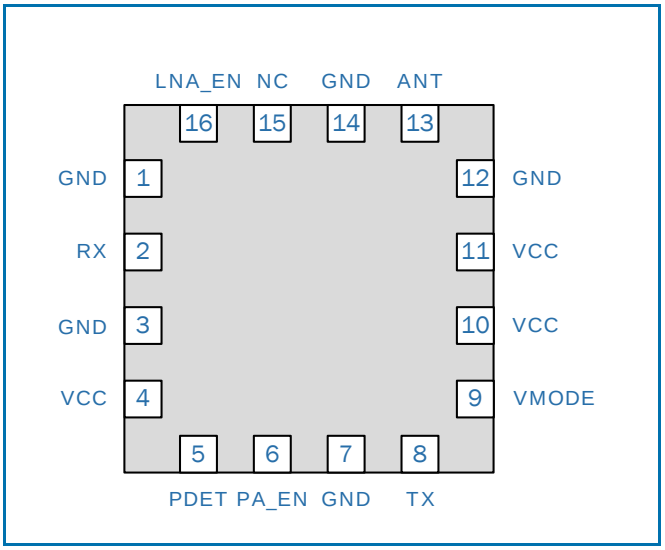
802.11a/n/ac Transmit Turn Off Sequence

1. Turn OFF RF.
2. Turn OFF PA_EN.
3. Turn OFF power supply.

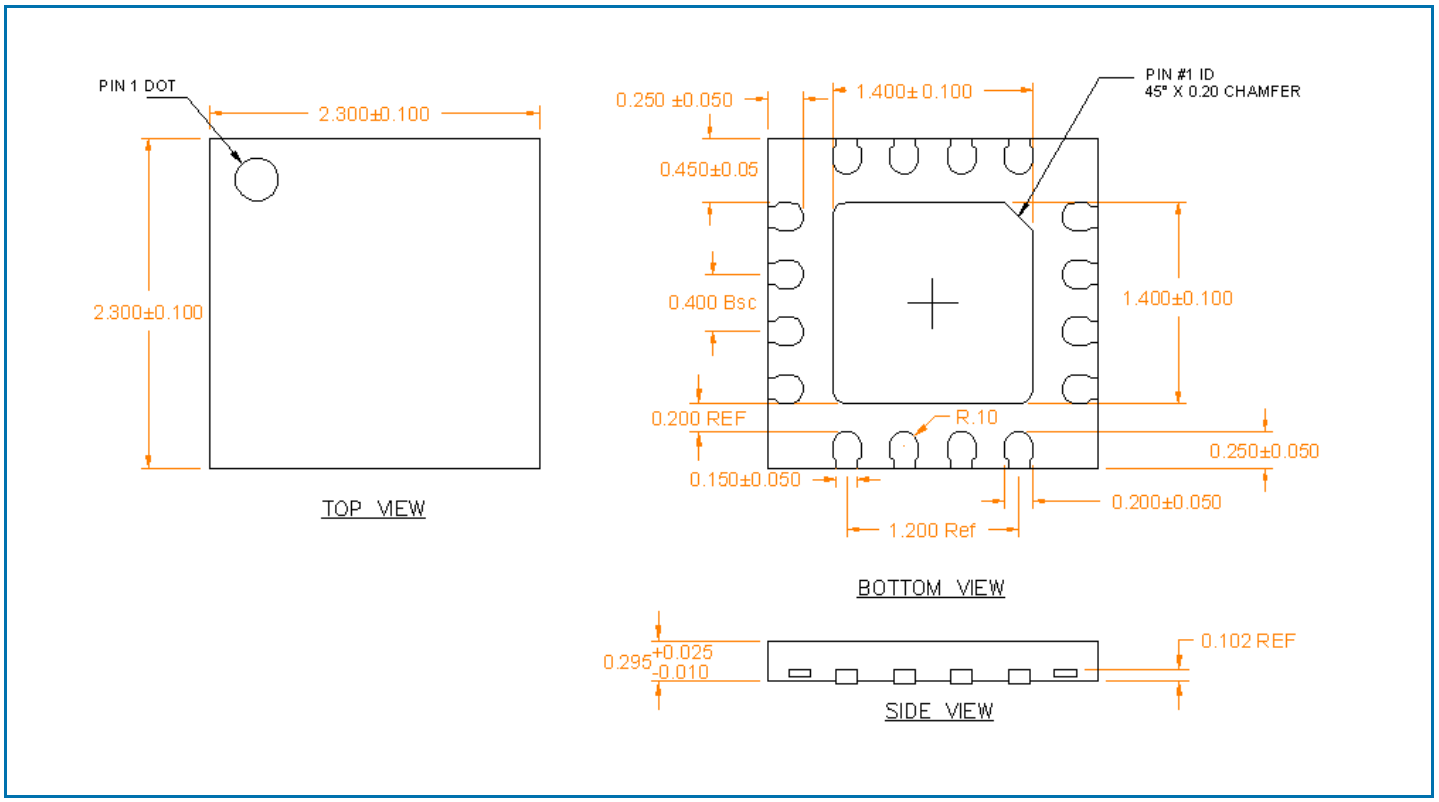
802.11a/n/ac Receive

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.

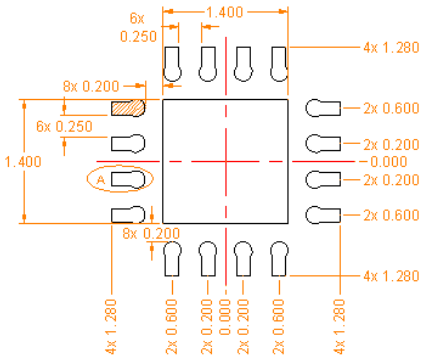
Pin Out



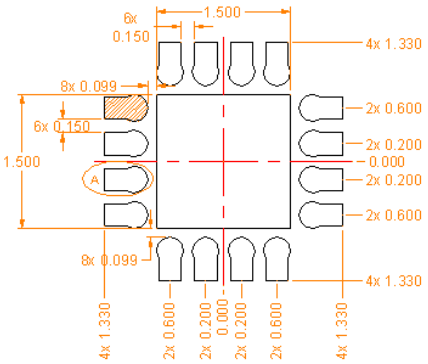
Package Outline (Dimensions in millimeters)



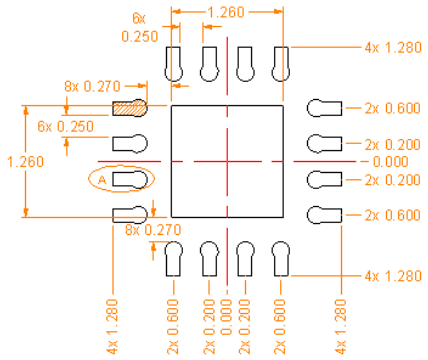
PCB Patterns



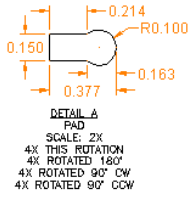
PCB METAL LAND PATTERN

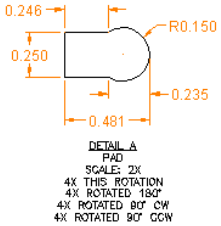


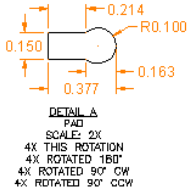
PCB SOLDER MASK PATTERN



PCB STENCIL PATTERN







Thermal vias for center slug should be incorporated into the PCB design. The number and size of thermal vias will depend on the application, the power dissipation, and the electrical requirements. Example of the number and size of vias can be found on the RFMD evaluation board layout.

Pin Names and Descriptions

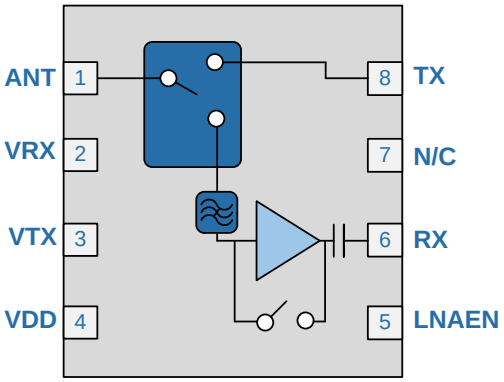
Pin	Name	Description
1	GND	Ground connection. This pin is not connected internally and can be left floating or connected to ground.
2	RX	RF output port for the 802.11a/n/ac LNA. This port is matched to 50Ω and DC blocked internally.
3	GND	Ground connection. This pin is not connected internally and can be left floating or connected to ground.
4	VCC	Supply voltage for the LNA and PA Regulator. See applications schematic for biasing and bypassing components.
5	PDET	Power Detector voltage for the TX path. May need external series R/shunt C to adjust voltage level and to filter RF noise.
6	PA_EN	Control voltage for the PA and TX switch. Optional method to enact Low Power Mode when placed in High state at same time with LNA_EN in High state. See truth table for proper voltage settings.
7	GND	Ground connection. This pin is not connected internally and can be left floating or connected to ground.
8	TX	RF input port for the 802.11a/n/ac PA. This port is matched to 50Ω and DC blocked internally.
9	VMODE	High/Low Power mode control signal. VMODE can be low or left floating for nominal conditions (High Power Mode.) Applying 2.8V or greater to this pin enables Low Power Mode
10	VCC	Supply voltage for the 1st and 2nd stage of the PA. See applications schematic for biasing and bypassing components.
11	VCC	Supply voltage for the final stage of the PA. See applications schematic for biasing and bypassing components.
12	GND	Ground connection. This pin is not connected internally and can be left floating or connected to ground.
13	ANT	RF bidirectional antenna port matched to 50Ω. An external DC block is required.
14	GND	Ground connection. This pin is not connected internally and can be left floating or connected to ground.
15	NC	No Connect. This pin is not connected internally. It can be left floating or connected to ground.
16	LNA_EN	Control voltage for the LNA. When this pin is set to a Low logic state, the Bypass Mode is enabled. Optional method to enact Low Power Mode when placed in High state at same time with PA_EN in High state. See truth table for proper voltage settings.
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.

RFFM8550

4.9GHz to 5.85GHz 802.11a/n/ac WiFi Switch + LNA Module

Package: DFN, 8-pin,
1.5mm x 1.5mm x 0.40mm

The RFFM8550 provides a complete integrated switch + LNA solution in a single Front End Module (FEM) for WiFi 802.11a/n/ac systems. The ultra-small form factor and integrated matching greatly reduces the number of external components and layout area in the customer applications. This simplifies the total front end solution by reducing the bill of materials, system footprint, and manufacturing cost. The RFFM8550 integrates a Single Pole Two Throw (SP2T) Transmit/Receive (T/R) Switch and a 5.0GHz Low Noise Amplifier (LNA) with bypass mode. The device is provided in a 1.5mm x 1.5mm x 0.40mm 8-pin DFN package.



Functional Block Diagram

Features

- SP2T T/R Switch
- LNA with Bypass Mode
- Input and Output Matched to 50Ω
- Wide Voltage Supply Range
- Supports WiFi chipsets with Integrated Power Amplifier (iPA)
- Low Profile Package for Module Designs

Applications

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

Ordering Information

RFFM8550SB	Standard 5-piece sample bag
RFFM8550SQ	Standard 25-piece sample bag
RFFM8550SR	Standard 100-piece reel
RFFM8550TR7	Standard 2500-piece reel
RFFM8550PCK-410	Fully assembled evaluation board w/ 5-piece bag

RF Micro Devices Inc. 7628 Thorndike Road, Greensboro, NC 27409-9421
For sales or technical support, contact RFMD at +1.336.678.5570 or customerservice@rfmd.com.

DS20180308

Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage (No RF Applied)	-0.5 to 6	V
DC Supply Current	100	mA
Operating Case Temperature	-40 to +85	°C
Storage Temperature	-40 to +150	°C
Maximum TX Input Power for 11b/g/n/ac (No Damage)	+30	dBm
Maximum RX Input Power (No Damage)	+12	dBm
Bypass Mode Maximum RX input power (No damage)	+25	dBm
Moisture Sensitivity	MSL1	

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		
Compliance:					**4.9GHz to 5.85GHz Only**
Operating Frequency	5.18		5.825	GHz	
Extended Frequency	4.9		5.925	GHz	
Operating Temperature	-40	25	85	ºC	
Power Supply V_{DD}	3.0	3.6	5.0	V	
Control Voltage-high	2.8	3.1	V_{CC}	V	VTX, VRX, and LNA_EN Should not exceed V_{CC} voltage
Control Voltage-low		0	0.24	V	
Transmit (TX-ANT)					**V_{DD} = 3.6V, unless otherwise noted**
Insertion Loss		0.6	1.2	dB	T = 25C°, V_{DD} = 3.6V
TX Port Return Loss	12	25		dB	
ANT Port Return Loss	12	25		dB	
Input P1dB	27	30		dBm	T = 25°C, V_{DD} = 3.6V
ANT-RX Isolation	28	35		dB	TX Mode-TX enabled and maximum power
Receive (ANT-RX)-LNA On					**V_{DD} = 3.6V, unless otherwise noted**
Gain	9	12	14	dB	T = 25°C, V_{DD} = 3.6V
Gain flatness over any 80MHz BW	-0.25		+0.25	dB	
Gain flatness across band	-1		+1	dB	T = 25°C, V_{DD} = 3.6V
Noise Figure-Nominal		2.5	3	dB	

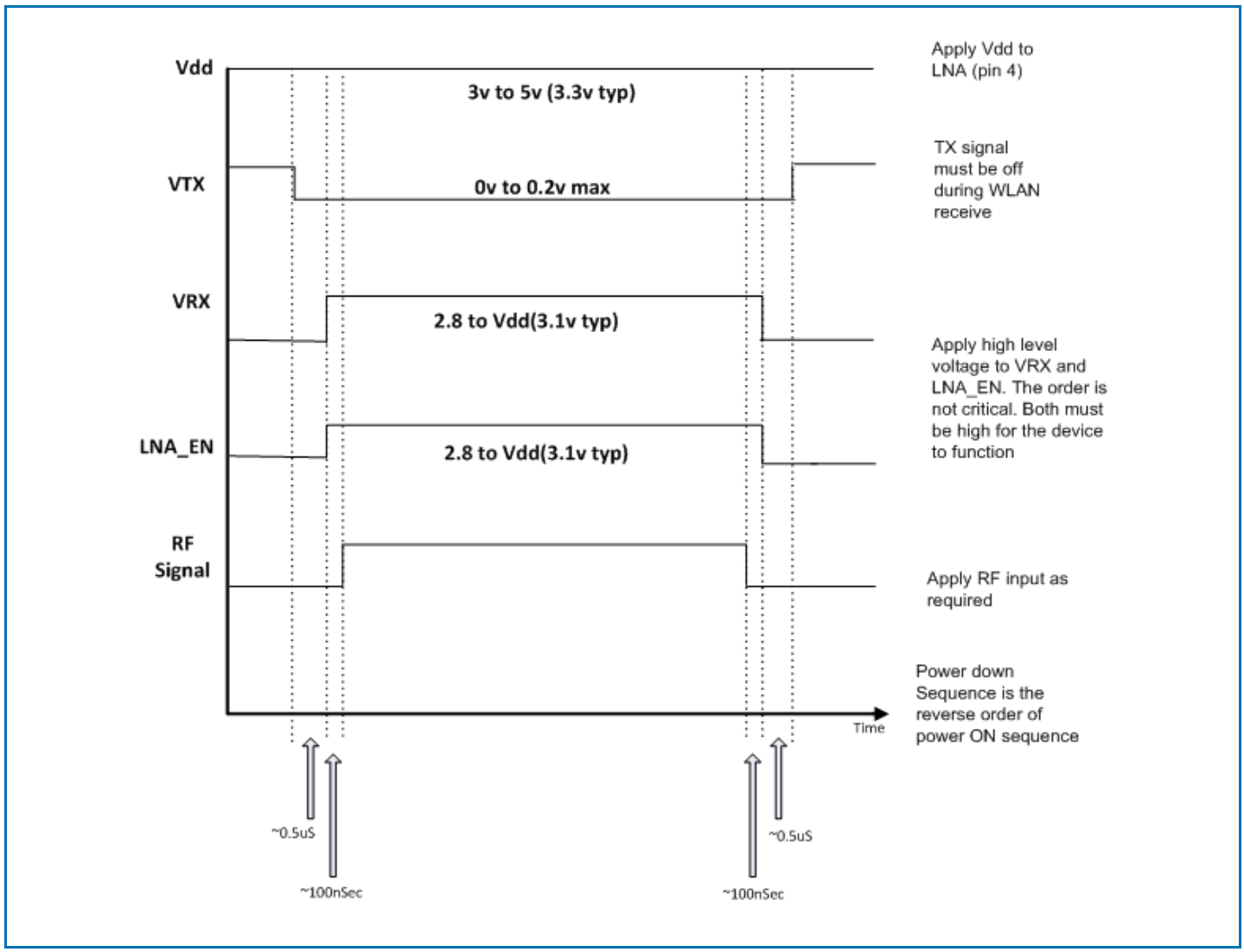
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Receive (ANT-RX)-LNA On (continued)					**V_{DD} = 3.6V, unless otherwise noted**
Rx Port Return Loss	8	12		dB	
ANT Port Return Loss	8	10		dB	
Nominal Input P1dB	-6	-3		dBm	T= 25°C, V_{DD} = 3.6V
Current Consumption	6	10	16	mA	
LNAEN Control Current		140	250	µA	
LNA Turn On Time		400	600	nS	
Receive (ANT-RX)-Bypass Mode					**V_{DD} = 3.6V, unless otherwise noted**
Insertion Loss	5	7	12	dB	T = 25°C, V_{DD} = 3.6V
RX Port Return Loss	8	12		dB	
ANT Port Return Loss	8	15		dB	
Input P1dB	15	20		dBm	T = 25°C, V_{DD} = 3.6V
General Specifications					**V_{DD} = 3.6V, unless otherwise noted**
Control Line Impedance - VTX		40		MΩ	
Control Line Impedance - LNAEN		70		kΩ	
Control Line Impedance - VRX		40		MΩ	
V_{DD} Leakage Current		0.2	10	µA	
Switch Control Current – High - Each Line		2	10	µA	
Switch Control Current – Low - Each Line		0.1	1	µA	T = 25°C, V_{DD} = 3.6V
Switching Speed		100	500	ns	
ESD – Human Body Model		1000		V	
ESD – Charge Device Model		1000		V	

Switch Control Logic Truth Table

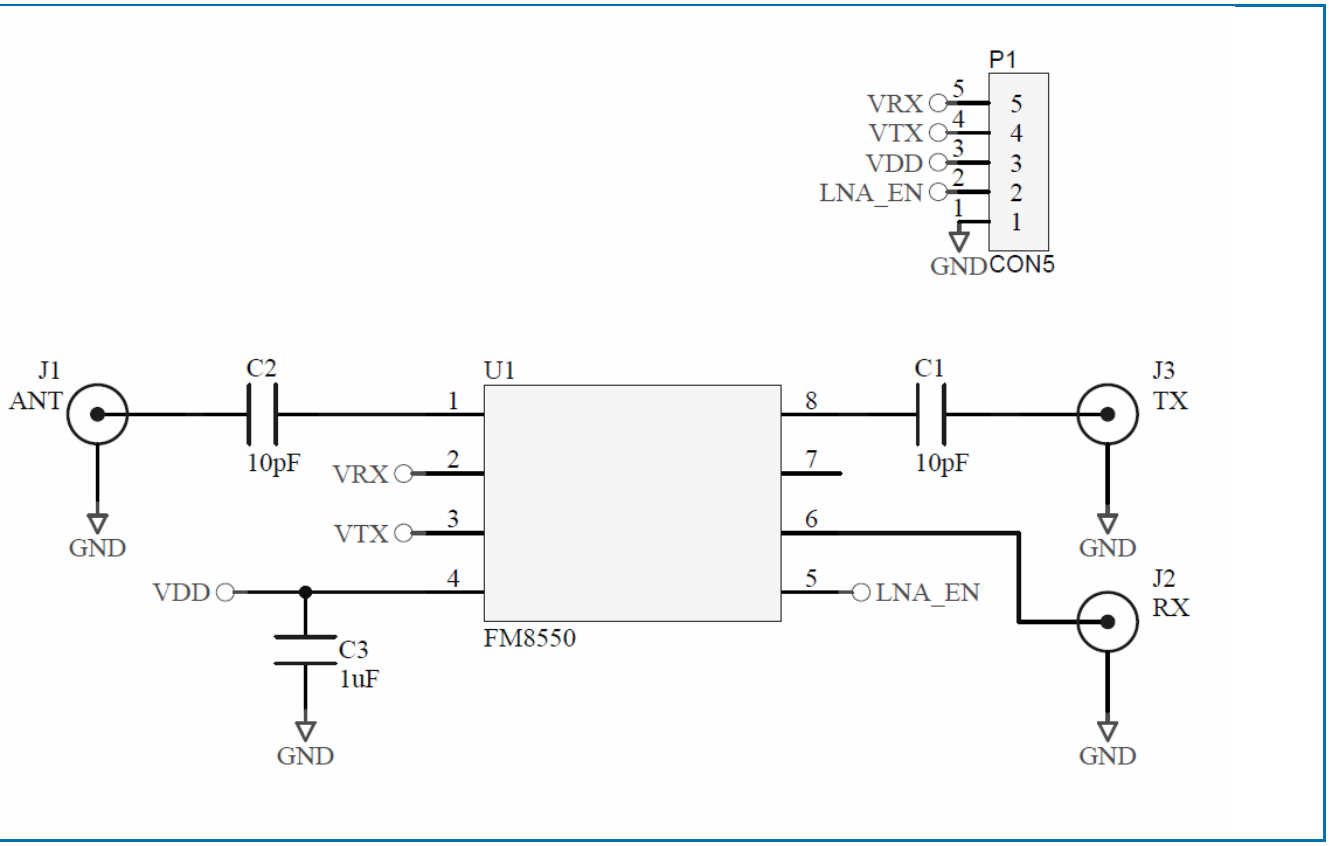
Operating Mode	VTX	LNAEN	VRX
Standby	Low	Low	Low
802.11a/n/ac TX Mode	High	Low	Low
802.11a/n/ac RX Gain	Low	High	High
802.11a/n/ac RX Bypass	Low	Low	High

Note: High = 2.8 to V_{CC}. Low = 0V to 0.2V.

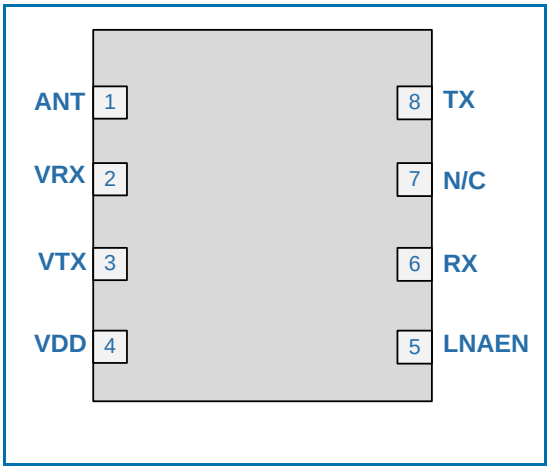
Timing Diagram



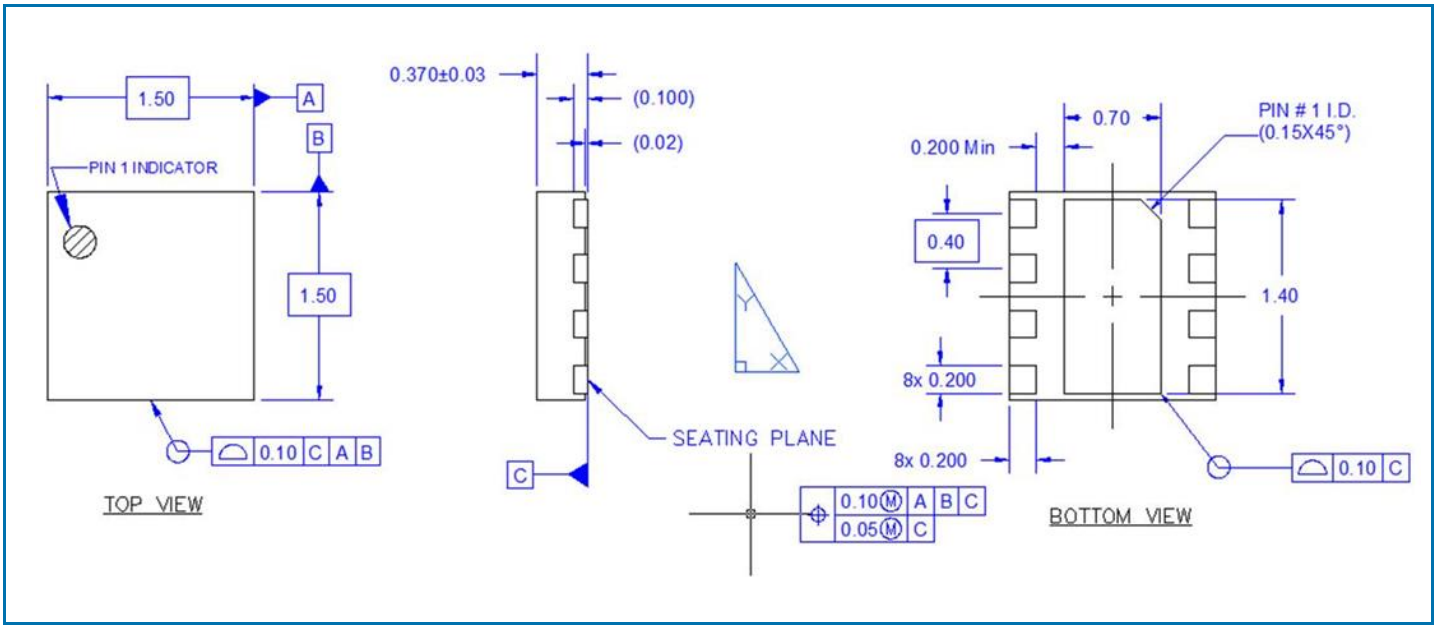
Evaluation Board Schematic



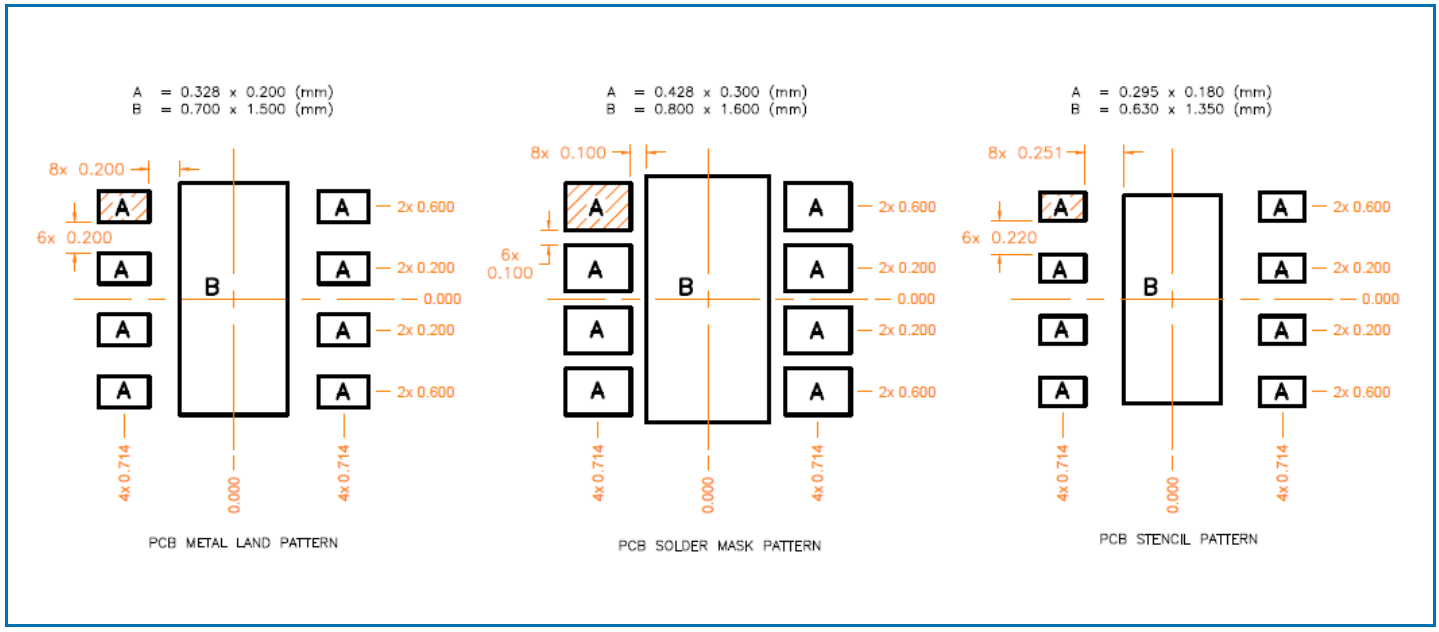
Pin Out



Package Drawing



PCB Patterns



Note: Shaded area represents Pin 1.

Pin Names and Descriptions

Pin	Name	Description
1	ANT	RF bidirectional antenna port matched to 50Ω. An external DC block is required.
2	VRX	Receive switch control pin. See switch truth table for proper voltage level.
3	VTX	Control voltage for the TX switch. See truth table for proper voltage level.
4	VDD	Supply voltage for the LNA. See applications schematic for bypassing components.
5	LNAEN	Control voltage for the LNA. When this pin is set to a LOW logic state, the bypass mode is enabled.
6	RX	RF output port for the 802.11a/n/ac LNA. This port is matched to 50Ω and DC blocked internally
7	N/C	This pin is not connected internally and can be left floating or connected to ground.
8	TX	RF input port for the TX throw of the T/R switch. An external DC block is required
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.