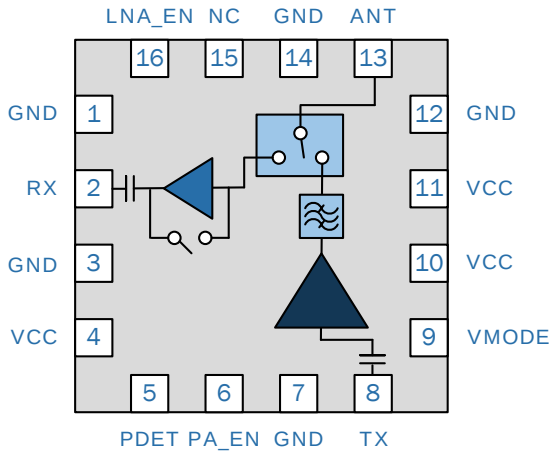
# RFFM8528

## WiFi Front End Module
## 5180MHz to 5825MHz

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


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

## 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 |

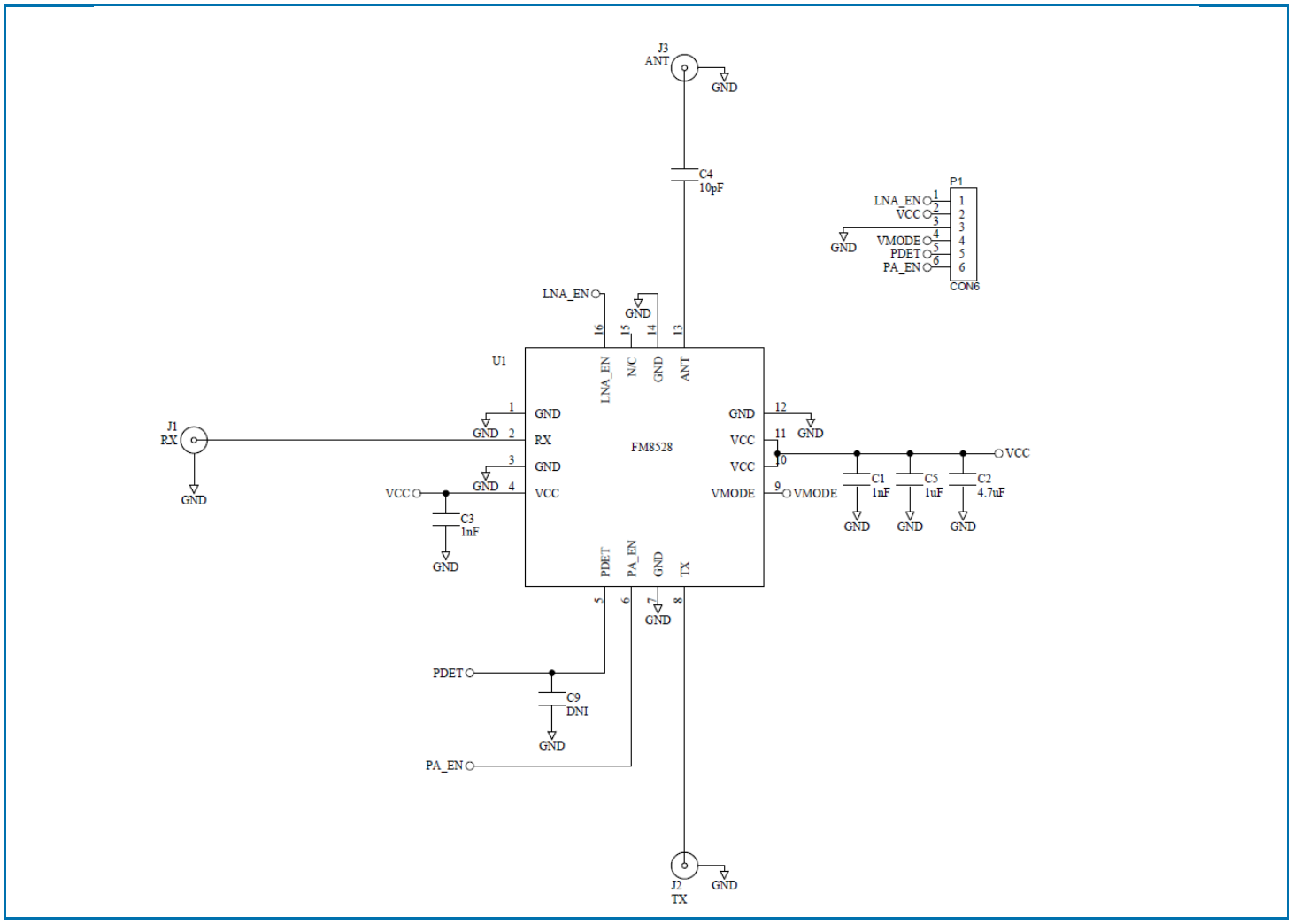
*For 4900MHz to 5150MHz, $P_{OUT}$ is reduced by 1dB

## 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 |

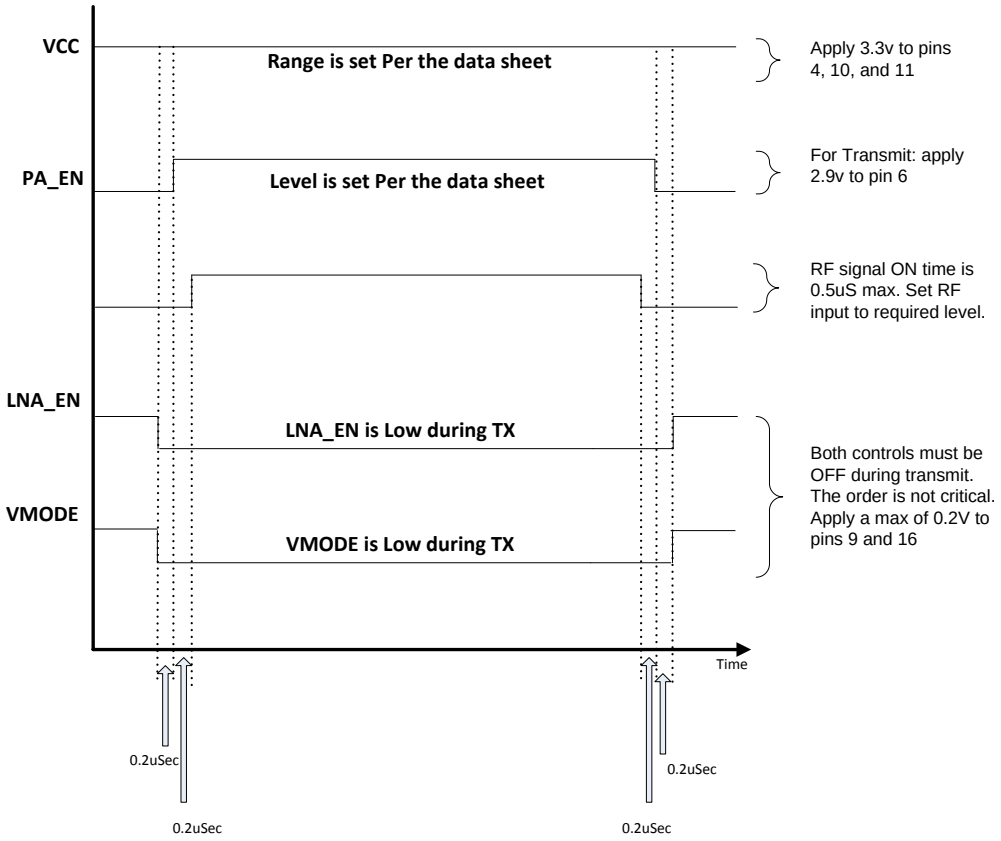
Note:
1. TX Low Power Mode is enabled either internally or with an option for external VMODE.
2. High = 2.8V to $V_{CC}$, Low = 0V to 0.2V.

## 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.

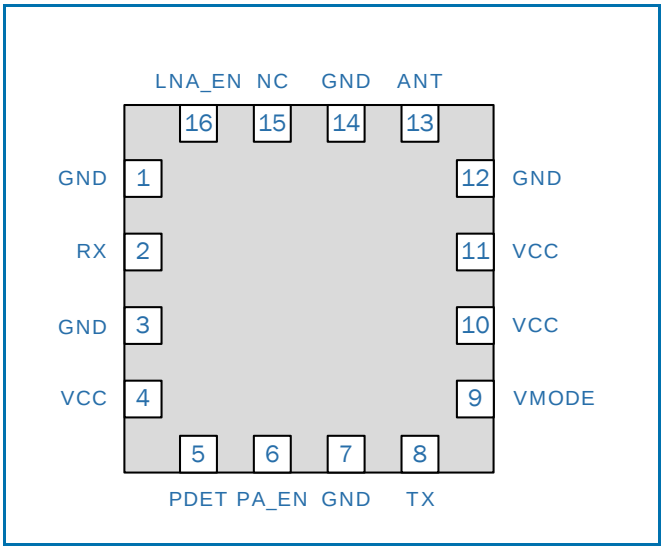
802.11a/n/ac Transmit Turn Off Sequence

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

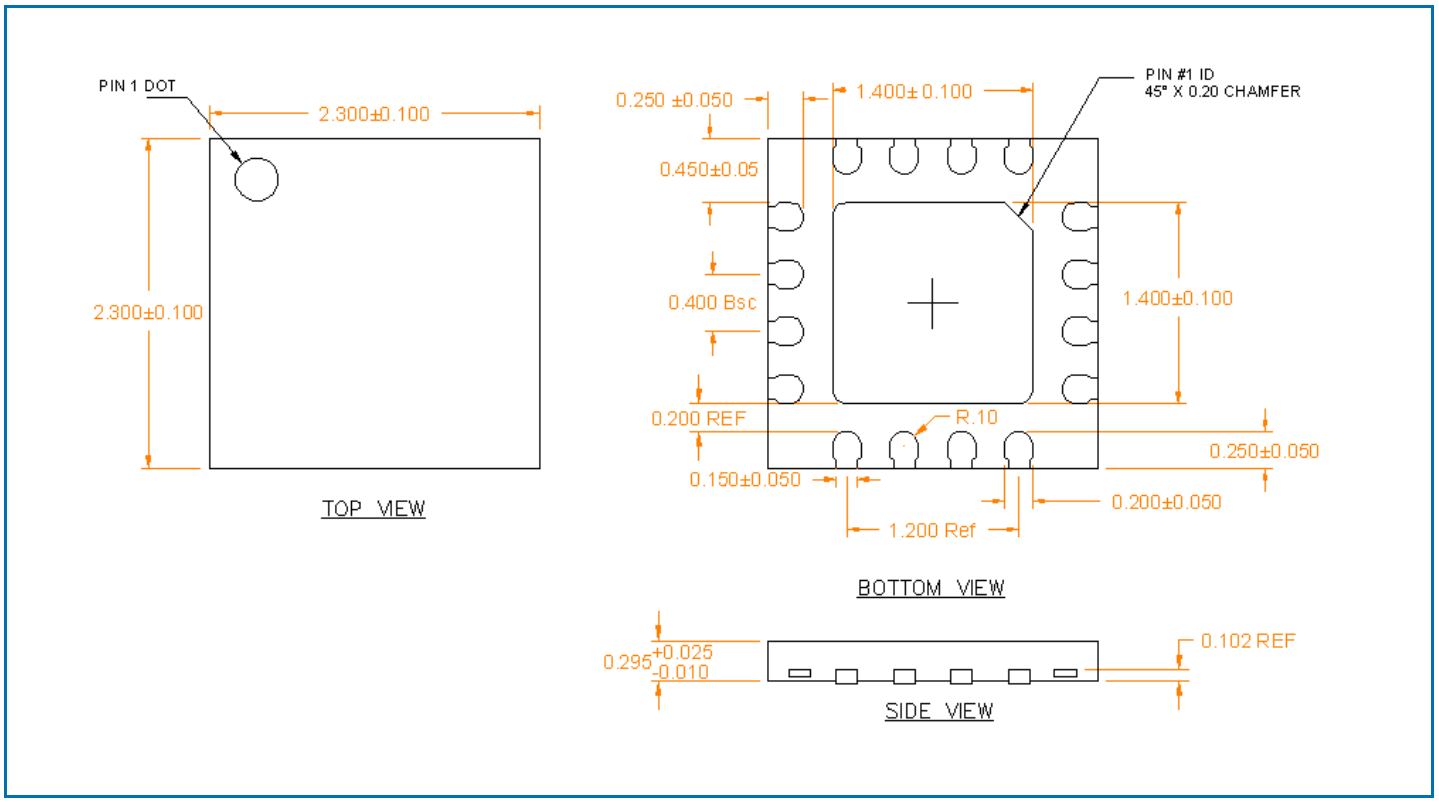
802.11a/n/ac Receive

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.

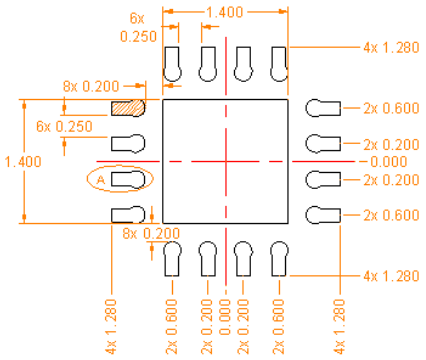
## Pin Out



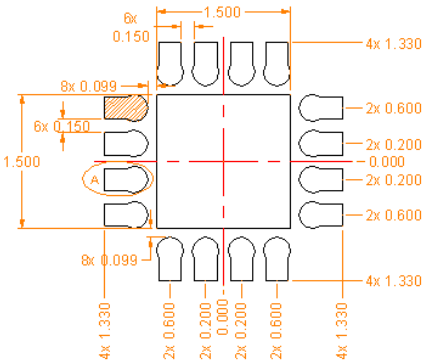

## Package Outline (Dimensions in millimeters)



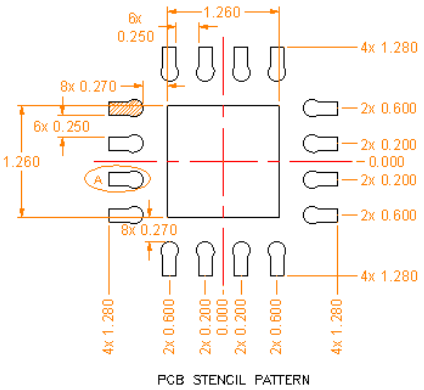
## PCB Patterns



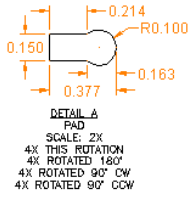

PCB METAL LAND PATTERN

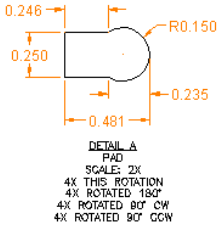


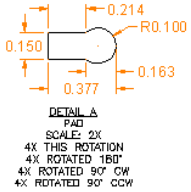

PCB SOLDER MASK PATTERN




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 1$^{st}$ and 2$^{nd}$ 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. |