

# RFFM4293

3.0V to 5.0V, 2.4GHz to 2.5GHz 802.11b/g/n/ac WiFi Front End Module

The RFFM4293 provides a complete integrated solution in a single front end module (FEM) for WiFi 802.11b/g/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 manufacturability cost. The RFFM4293 integrates a 2.4GHz to 2.5GHz power amplifier (PA), low noise amplifier (LNA) with bypass mode, power detector coupler for improved accuracy, and some filtering for harmonic rejection. The device is provided in a 3mm x 3mm x 1.05mm, 16-pin package. This module meets or exceeds the RF front end needs of IEEE 802.11b/g/n/ac WiFi RF systems.



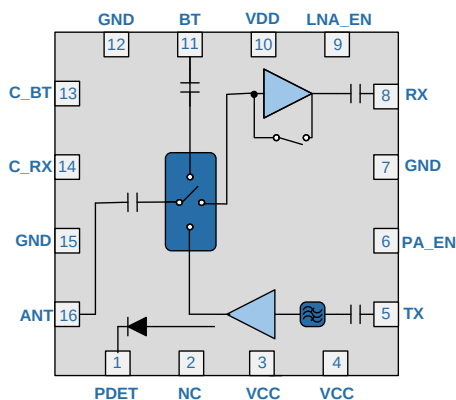
Package: Laminate, 16-pin,  
3.0mm x 3.0mm x 1.05mm

## Features

- Integrated 2.4GHz to 2.5GHz b/g/n/ac Amplifier, LNA with bypass mode, SP3T Switch, and Power Detector Coupler
- Single Supply Voltage 3.0V to 5.0V  
 $P_{OUT} = 19\text{dBm}$ , 3.3V @ 3% Dynamic EVM.  
 $P_{OUT} = 21\text{dBm}$ , 5.0V @ 3% Dynamic EVM

## Applications

- IEEE802.11b/g/n/ac WiFi Applications
- 2.4GHz to 2.5GHz ISM Band Solutions
- Portable Battery-Powered Equipment
- WiFi Access Points, Gateways, and Set Top Boxes



Functional Block Diagram

## Ordering Information

|                 |                                                |
|-----------------|------------------------------------------------|
| RFFM4293SB      | Standard 5-piece bag                           |
| RFFM4293SQ      | Standard 25-piece bag                          |
| RFFM4293SR      | Standard 100-piece reel                        |
| RFFM4293TR7     | Standard 2500-piece reel                       |
| RFFM4293PCK-410 | Fully assembled evaluation board w/5-piece bag |

## Absolute Maximum Ratings

| Parameter                                             | Rating      | Unit |
|-------------------------------------------------------|-------------|------|
| DC Supply Voltage (Continuous with No Damage)         | 5.4         | V    |
| DC Supply Current                                     | 500         | mA   |
| Operating Case Temperature                            | -20 to +85  | °C   |
| Extended Temperature Range (with Reduced Performance) | -40 to -20  | °C   |
| Storage Temperature                                   | -40 to +150 | °C   |
| Maximum Tx Input Power into 50Ω Load                  | +12         | dBm  |
| Maximum Rx Input Power (No Damage)                    | +12         | dBm  |
| Moisture Sensitivity                                  | MSL3        |      |



**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>Typical Conditions 3.3V</b> |               |       |       |         | <b>Temperature = -10°C to +70°C, V<sub>CC</sub> = 3.3V, PA_EN = high, P<sub>OUT</sub> = 19dBm using an IEEE802.11n MCS7 waveform unless otherwise noted.</b> |
| Tx Performance - 11g/n/ac      |               |       |       |         | Compliance with standard 802.11g/n/ac                                                                                                                        |
| Frequency                      | 2412          |       | 2484  | MHz     |                                                                                                                                                              |
| 802.11n Output Power           | 18.5          | 19.0  |       | dBm     | 802.11n HT20 and HT40 MCS7 at 25°C                                                                                                                           |
| 11n Dynamic EVM                |               | 2.5   | 3     | %       |                                                                                                                                                              |
|                                |               | -32.0 | -30.5 | dB      |                                                                                                                                                              |
| 802.11ac Output Power          | 16.5          | 17.0  |       | dBm     | 802.11ac HT40 MCS9 at 25°C                                                                                                                                   |
| 11ac Dynamic EVM               |               | 1.5   | 1.8   | %       |                                                                                                                                                              |
|                                |               | -36.0 | -35.0 | dB      |                                                                                                                                                              |
| Tx Performance - Spectral Mask |               |       |       |         |                                                                                                                                                              |
| 802.11n Output Power           |               | 21    |       | dBm     | 802.11n HT20 and HT40 MCS7 at 25°C                                                                                                                           |
| 802.11b Output Power           |               | 24    |       | dBm     | Meet 802.11b DSSS 1Mbps Spectral Mask                                                                                                                        |
| General Tx Performance         |               |       |       |         |                                                                                                                                                              |
| Second Harmonic                |               | -24   | -20   | dBm/MHz | At P <sub>OUT</sub> = 19dBm                                                                                                                                  |
| Third Harmonic                 |               | -50   | -42   | dBm/MHz |                                                                                                                                                              |
| Gain                           | 25            | 27    | 29    | dB      |                                                                                                                                                              |
| Gain Variation Over Temp       | -2            |       | +2    | dB      |                                                                                                                                                              |
| Power Detect Voltage           | 0.11          | 0.125 | 0.14  | V       | RF = off                                                                                                                                                     |
|                                | 0.7           | 0.8   | 0.9   | V       | At rated P <sub>OUT</sub>                                                                                                                                    |
| Power Detect Accuracy          | -2.0          |       | +2.0  | dB      | Into 3:1 VSWR load at 25°C                                                                                                                                   |
| Input Return Loss - Tx_in pin  |               | -13   | -10   | dB      | In specified frequency band                                                                                                                                  |
| Output Return Loss at ANT pin  |               | -15   | -10   | dB      |                                                                                                                                                              |
| Operating Current              |               | 210   | 230   | mA      | At rated P <sub>OUT</sub> 19dBm                                                                                                                              |
|                                |               | 195   | 215   | mA      | At rated P <sub>OUT</sub> 17dBm                                                                                                                              |
| Quiescent Current              |               | 170   |       | mA      | Nominal conditions; no RF applied                                                                                                                            |
| Leakage Current                |               | 2     | 10    | μA      | V <sub>CC</sub> = 3.3V, PA_EN = low, C_RX = low, LNA_EN = low                                                                                                |
| Power Added Efficiency         |               | 10.5  |       | %       | Nominal conditions                                                                                                                                           |
| Power Supply - V <sub>CC</sub> | 3.0           | 3.3   | 3.6   | V       |                                                                                                                                                              |

| Parameter                                                  | Specification |       |          | Unit    | Condition                                                                                                                                                                                  |
|------------------------------------------------------------|---------------|-------|----------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                            | Min           | Typ   | Max      |         |                                                                                                                                                                                            |
| <b>Typical Conditions 3.3V (continued)</b>                 |               |       |          |         | <b>Temperature = -10°C to +70°C, <math>V_{CC} = 3.3V</math>,<br/><math>PA\_EN</math> = high, <math>P_{OUT} = 19dBm</math> using an IEEE802.11n MCS7 waveform unless otherwise noted.</b>   |
| VCONTROL High ( $PA\_EN$ , $C\_RX$ , $C\_BT$ , $LNA\_EN$ ) | 2.8           | 3     | $V_{CC}$ | V       |                                                                                                                                                                                            |
| VCONTROL Low ( $PA\_EN$ , $C\_RX$ , $C\_BT$ , $LNA\_EN$ )  | 0             |       | 0.2      | V       |                                                                                                                                                                                            |
| Turn-on time from $PA\_EN$ edge                            |               |       | 500      | ns      | Output stable to within 90% of final gain                                                                                                                                                  |
| Turn-off time from $PA\_EN$ edge                           |               |       | 500      | ns      |                                                                                                                                                                                            |
| Stability                                                  | -25           |       | 24       | dBm     | No spurs above -47dBm into 4:1 VSWR                                                                                                                                                        |
| CW P1dB                                                    | 26            | 27    |          | dBm     | Tx mode in 50% Duty Cycle                                                                                                                                                                  |
| <b>Rx Performance</b>                                      |               |       |          |         | <b>Temperature = -10°C to +70°C, <math>V_{DD} = 3.3V</math>,<br/><math>C\_RX</math> = high, <math>LNA\_EN</math> = high</b>                                                                |
| Gain                                                       | 11            | 13    | 15       | dB      |                                                                                                                                                                                            |
| NF                                                         |               | 2.3   | 3        | dB      | In specified frequency band                                                                                                                                                                |
| RX Port Return Loss                                        |               |       | -9.6     | dB      |                                                                                                                                                                                            |
| ANT Port Return Loss                                       |               |       | -4       | dB      |                                                                                                                                                                                            |
| Input IP3                                                  | 4             | 8     |          | dBm     |                                                                                                                                                                                            |
| Input P1dB                                                 | -6            | -2    |          | dBm     |                                                                                                                                                                                            |
| $I_{DD}$                                                   |               | 10    | 15       | mA      |                                                                                                                                                                                            |
| $LNA\_EN$ Control Current                                  |               | 30    | 50       | $\mu A$ |                                                                                                                                                                                            |
| <b>Rx Bypass Mode</b>                                      |               |       |          |         | <b>Temperature = -10°C to +70°C, <math>V_{DD} = 3.3V</math>,<br/><math>C\_RX</math> = high, <math>LNA\_EN</math> = low</b>                                                                 |
| Insertion Loss                                             | -8.5          | -7.5  | -6.5     | dB      |                                                                                                                                                                                            |
| RX Port Return Loss                                        |               |       | -9.6     | dB      |                                                                                                                                                                                            |
| ANT Port Return Loss                                       |               |       | -4       | dB      |                                                                                                                                                                                            |
| Input IP3                                                  | 4             | 8     |          | dB      |                                                                                                                                                                                            |
| Input P1dB                                                 | -6            | -2    |          | dBm     |                                                                                                                                                                                            |
| <b>Typical Conditions 5.0V</b>                             |               |       |          |         | <b>Temperature = -10°C to +70°C, <math>V_{CC} = 5.0V</math>,<br/><math>PA\_EN</math> = high, <math>P_{OUT} = 21.5dBm</math> using an IEEE802.11n MCS7 waveform unless otherwise noted.</b> |
| Tx Performance - 11g/n/ac                                  |               |       |          |         | Compliance with standard 802.11g/n/ac                                                                                                                                                      |
| Frequency                                                  | 2412          |       | 2484     | MHz     |                                                                                                                                                                                            |
| 802.11n Output Power                                       | 21            | 21.5  |          | dBm     | 802.11n HT20 and HT40 MCS7 at $T=25^{\circ}C$ , $V_{CC} = 5.0V$                                                                                                                            |
| 11n Dynamic EVM                                            |               | 2.5   | 3        | %       |                                                                                                                                                                                            |
|                                                            |               | -32   | -30.5    | dB      |                                                                                                                                                                                            |
| 802.11ac Output Power                                      | 17            | 18    |          | dBm     | 802.11ac HT40 MCS9 at $T=25^{\circ}C$ , $V_{CC} = 5.0V$                                                                                                                                    |
| 11ac Dynamic EVM                                           |               | 1.5   | 1.8      | %       |                                                                                                                                                                                            |
|                                                            |               | -36.0 | -35.0    | dB      |                                                                                                                                                                                            |
| Tx Performance - Spectral Mask                             |               |       |          |         |                                                                                                                                                                                            |
| 802.11n output power                                       |               | 22    |          | dBm     | 802.11n HT20 and HT40 MCS7 $T=25^{\circ}C$ , $V_{CC} = 5.0V$                                                                                                                               |
| 802.11b output power                                       |               | 26    |          | dBm     | Meet 802.11b DSSS 1Mbps spectral mask                                                                                                                                                      |

| Parameter                                             | Specification |      |      | Unit    | Condition                                                                                                                                                      |
|-------------------------------------------------------|---------------|------|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                       | Min           | Typ  | Max  |         |                                                                                                                                                                |
| <b>Typical Conditions 5.0V (continued)</b>            |               |      |      |         | <b>Temperature = -10°C to +70°C, V<sub>CC</sub> = 5.0V, PA_EN = high, P<sub>OUT</sub> = 21.5dBm using an IEEE802.11n MCS7 waveform unless otherwise noted.</b> |
| General Tx Performance                                |               |      |      |         |                                                                                                                                                                |
| Second Harmonic                                       |               | -20  | -18  | dBm/MHz | P <sub>OUT</sub> = 21.5dBm, T=25°C, V <sub>CC</sub> = 5.0V                                                                                                     |
| Third Harmonic                                        |               | -43  | -38  | dBm/MHz |                                                                                                                                                                |
| Gain                                                  | 25            | 27   | 29   | dB      | T=25°C, V <sub>CC</sub> = 5.0V                                                                                                                                 |
| Gain variation over Temp                              | -2            |      | +2   | dB      |                                                                                                                                                                |
| Power Detect Voltage                                  | 0.14          | 0.16 | 0.18 | V       | P <sub>OUT</sub> = 0dBm and also when RF = off                                                                                                                 |
| Power Detect Accuracy                                 | -2            |      | +2   | dB      | Into 3:1 VSWR load at T = 25°C                                                                                                                                 |
| Power Detect Voltage                                  | 0.95          | 1.05 | 1.20 | V       | P <sub>OUT</sub> = 21.5dBm                                                                                                                                     |
| Input Return Loss - Tx_IN pin                         |               | -13  | -10  | dB      | In specified frequency band                                                                                                                                    |
| Output Return Loss at ANT pin                         |               | -15  | -10  | dB      |                                                                                                                                                                |
| Operating Current                                     |               | 260  | 290  | mA      | At rated 11n P <sub>OUT</sub> , T=25°C, V <sub>cc</sub> = 5.0V                                                                                                 |
|                                                       |               | 230  | 260  | mA      | At rated P <sub>OUT</sub> 19dBm, T=25°C, V <sub>cc</sub> = 5.0V                                                                                                |
| Quiescent Current                                     |               | 190  |      | mA      | Nominal conditions; no RF applied                                                                                                                              |
| Leakage Current                                       |               | 2    | 10   | μA      | V <sub>CC</sub> = 5V, PA_EN = low, C_RX = low, LNA_EN = low at 25°C                                                                                            |
| V <sub>CONTROL</sub> High (PA_EN, C_BT, C_RX, LNA_EN) | 2.8           | 2.9  | 5.0  | V       |                                                                                                                                                                |
| V <sub>CONTROL</sub> Low (PA_EN, C_BT, C_RX, LNA_EN)  | 0             |      | 0.2  | V       |                                                                                                                                                                |
| Turn-on time from PA_EN edge                          |               |      | 500  | ns      | Output stable to within 90% of final gain                                                                                                                      |
| Turn-off time from PA_EN edge                         |               |      | 500  | ns      |                                                                                                                                                                |
| Stability                                             | -25           |      | 24   | dBm     | No spurs above -47dBm into 4:1 VSWR                                                                                                                            |
| CW P1dB                                               | 28.5          | 29.5 |      | dBm     | Tx mode in 50% duty cycle                                                                                                                                      |
| <b>Rx Performance</b>                                 |               |      |      |         | <b>Temperature = -10°C to +70°C, V<sub>DD</sub> = 5.0V, C_RX = high, LNA_EN = high</b>                                                                         |
| Gain                                                  | 11.5          | 14   | 16   | dB      | T=25°C, V <sub>DD</sub> = 5.0V                                                                                                                                 |
| NF                                                    |               | 2.3  | 3.0  | dB      | In specified frequency band and T=25°C, V <sub>DD</sub> = 5.0V                                                                                                 |
| RX Port Return Loss                                   |               |      | -9.6 | dB      | T=25°C, V <sub>DD</sub> = 5.0V                                                                                                                                 |
| ANT Port Return Loss                                  |               |      | -4   | dB      |                                                                                                                                                                |
| Input IP3                                             | 4             | 8    |      | dBm     |                                                                                                                                                                |
| Input P1dB                                            | -6            | -2   |      | dBm     |                                                                                                                                                                |
| IDD                                                   |               | 10   | 20   | mA      |                                                                                                                                                                |
| LNA_EN Control Current                                |               | 30   | 50   | μA      |                                                                                                                                                                |
| <b>Rx Bypass Mode</b>                                 |               |      |      |         | <b>Temperature = -10°C to +70°C, V<sub>DD</sub> = 5.0V, C_RX = high, LNA_EN = low</b>                                                                          |
| Insertion Loss                                        | -8.5          | -7.5 | -6.5 | dB      | T=25°C, V <sub>CC</sub> = 5.0V,                                                                                                                                |
| RX Port Return Loss                                   |               |      | -9.6 | dB      | T=25°C, V <sub>CC</sub> = 5.0V,                                                                                                                                |
| ANT Port Return Loss                                  |               |      | -4   | dB      |                                                                                                                                                                |
| Input IP3                                             | 4             | 8    |      | dB      |                                                                                                                                                                |
| Input P1dB                                            | -6            | -2   |      | dBm     |                                                                                                                                                                |

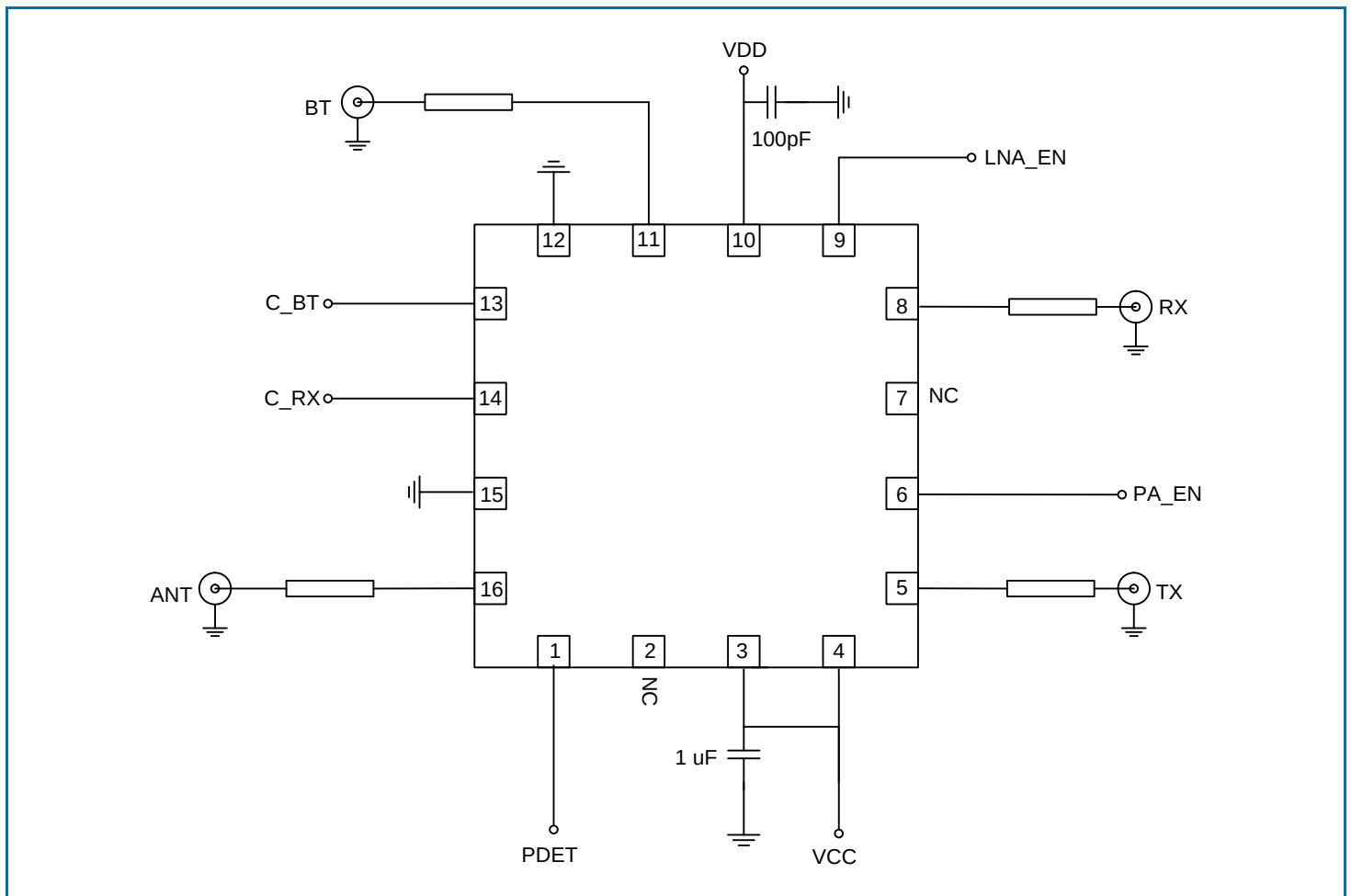
| Parameter                           | Specification |     |      | Unit | Condition                                                                                         |
|-------------------------------------|---------------|-----|------|------|---------------------------------------------------------------------------------------------------|
|                                     | Min           | Typ | Max  |      |                                                                                                   |
| General Performance                 |               |     |      |      |                                                                                                   |
| Control Current                     |               |     |      |      |                                                                                                   |
| C_RX and C_BT Current               |               | 0.5 | 1    | μA   |                                                                                                   |
| PA_EN Current                       |               | 30  | 50   | μA   |                                                                                                   |
| Switch Control Speed                |               |     | 200  | ns   |                                                                                                   |
| PA_EN Control Impedance             |               | 5.2 |      | MΩ   |                                                                                                   |
| LNA_EN Control Impedance            |               | 7.4 |      | MΩ   |                                                                                                   |
| C_RX Control Impedance              |               | 27  |      | MΩ   |                                                                                                   |
| C_BT Control Impedance              |               | 27  |      | MΩ   |                                                                                                   |
| ESD                                 |               |     |      |      |                                                                                                   |
| Human Body Model                    | 500           |     |      | V    | EIA/JESD22-114A RF pins                                                                           |
|                                     | 1000          |     |      | V    | EIA/JESD22-114A DC pins                                                                           |
| Charge Device Model                 | 250           |     |      | V    | JESD22-C101C all pins                                                                             |
| Thermal Resistance                  |               |     |      |      |                                                                                                   |
| R <sub>TH,J</sub>                   |               | 46  |      | °C/W |                                                                                                   |
| Junction Temperature T <sub>J</sub> |               | 170 |      | °C   | MTTF > 30 years                                                                                   |
| Maximum Input Power                 |               |     | 12   | dBm  | Into 50Ω, V <sub>CC</sub> = 3.3V, 25°C                                                            |
|                                     |               |     | 12   | dBm  | 6:1 VSWR, V <sub>CC</sub> = 3.3V, 25°C                                                            |
|                                     |               |     | 5    | dBm  | 10:1 VSWR, V <sub>CC</sub> = 3.3V, 25°C                                                           |
| Bluetooth                           |               |     |      |      | Temperature = -10°C to +70°C, V <sub>DD</sub> = 3.3 and 5.0V, C_BT = high, unless otherwise noted |
| Input/Output Power                  | 25            | 30  |      | dBm  |                                                                                                   |
| Insertion Loss                      |               | 0.7 | 0.9  | dB   | T=25°C                                                                                            |
| BT Port Return Loss                 |               |     | -9.6 | dB   |                                                                                                   |
| ANT Port Return Loss                |               |     | -9.6 | dB   |                                                                                                   |
| Isolation                           |               |     |      |      |                                                                                                   |
| ANT-BT; Tx Mode                     |               | 18  |      | dB   | PA_EN = High, C_BT = Low, C_RX = Low, LNA_EN = Low                                                |
| ANT-BT; Rx Gain Mode                |               | 25  |      | dB   | PA_EN = Low, C_BT = Low,C_RX = High,                                                              |
| LNA_EN = High                       |               |     |      |      |                                                                                                   |
| ANT-BT; Rx Bypass Mode              |               | 20  |      | dB   | PA_EN = Low, C_BT = Low, C_RX = High, LNA_EN = Low                                                |
| ANT-RX; Tx Mode                     |               | 35  |      | dB   | PA_EN = High, C_BT = Low, C_RX = Low, LNA_EN = Low                                                |
| ANT-RX; BT Mode                     |               | 25  |      | dB   | PA_EN = Low, C_BT = High, C_RX = Low,                                                             |

### Switch Logic Control Table

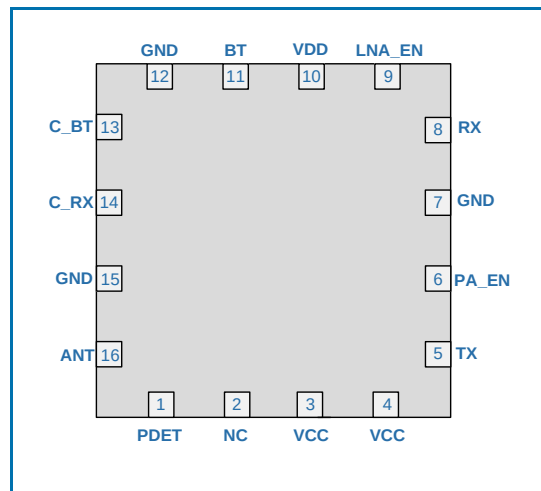
| Operating Mode           | PA_EN | LNA_EN | C_RX | C_BT |
|--------------------------|-------|--------|------|------|
| Standby                  | Low   | Low    | Low  | Low  |
| 802.11b/g/n/ac Tx        | High  | Low    | Low  | Low  |
| 802.11b/g/n/ac Rx Gain   | Low   | High   | High | Low  |
| 802.11b/g/n/ac Rx Bypass | Low   | Low    | High | Low  |
| BT Rx/Tx                 | Low   | Low    | Low  | High |

Note: High = 2.8V to V<sub>CC</sub>, Low = 0V to 0.2V

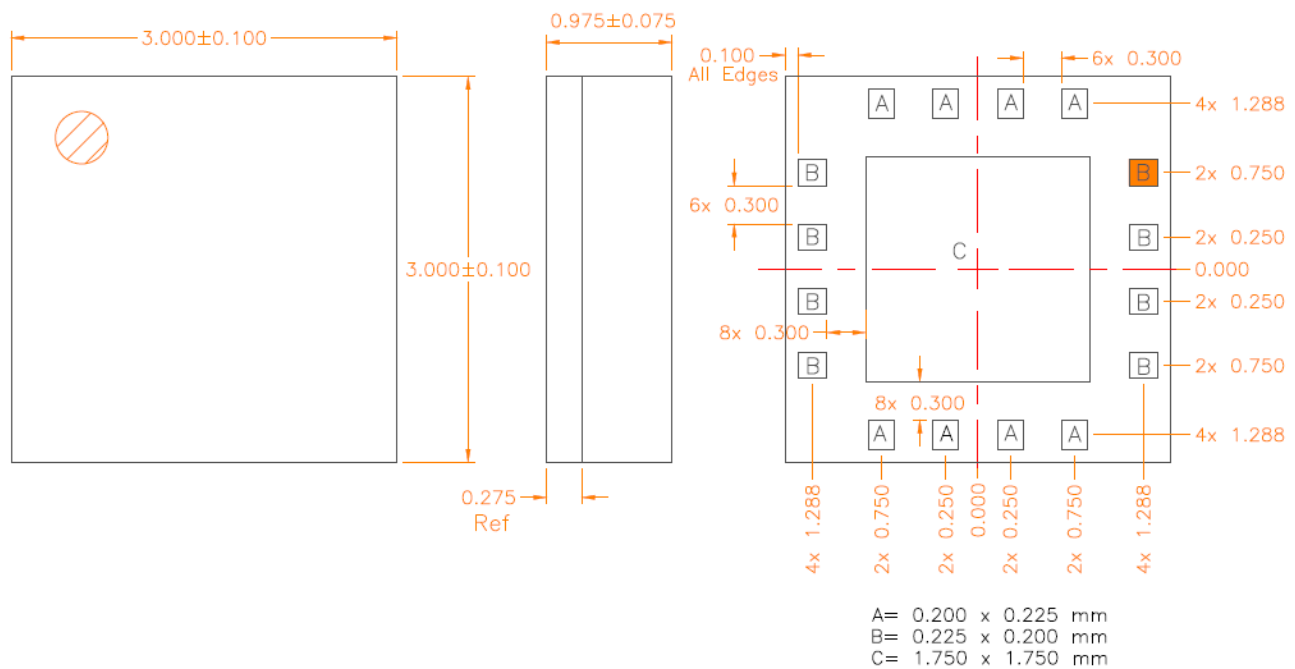
## Evaluation Board Schematic



## Pin Out



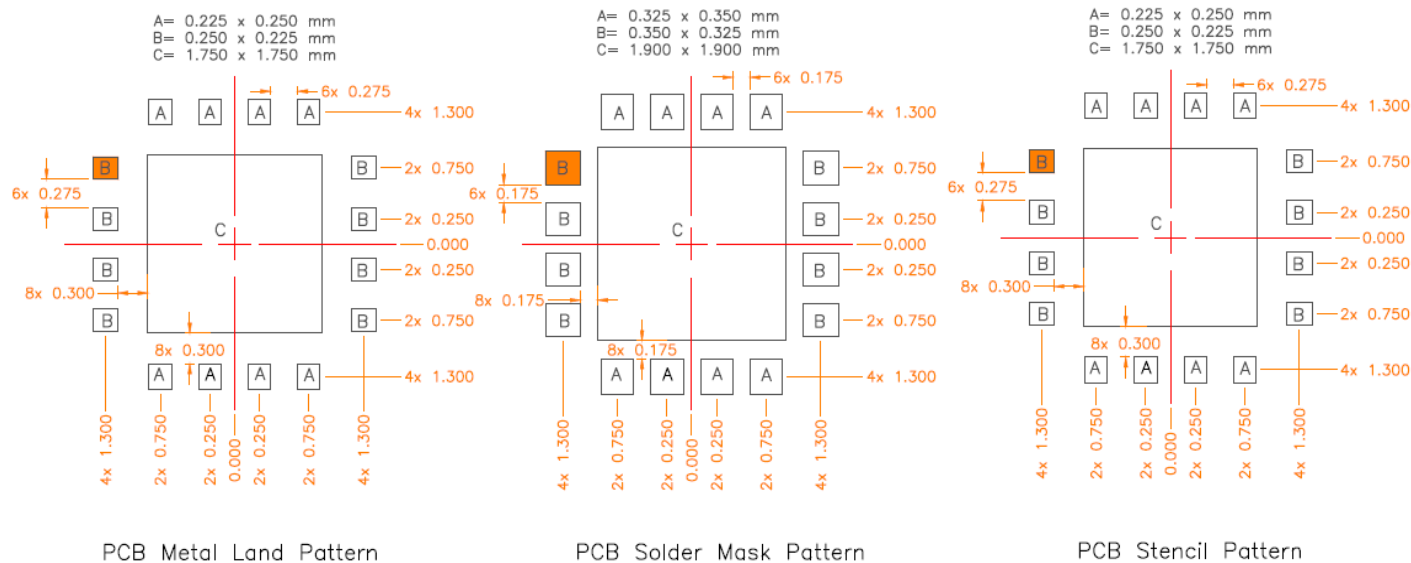
## Package Drawing



Notes:

1. Shaded area represents Pin 1 location.

## PCB Pattern



## Notes:

1. Shaded area represents Pin 1 location.



## Pin Names and Descriptions

| Pin      | Name   | Description                                                                                                                                                   |
|----------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | PDET   | Power detector voltage for Tx section. PDET voltage varies with output power. May need external decoupling for noise decoupling.                              |
| 2        | NC     | No connect pin.                                                                                                                                               |
| 3        | VCC    | Supply voltage for the PA. See applications schematic for biasing and bypassing components.                                                                   |
| 4        | VCC    | Supply voltage for the PA. See applications schematic for biasing and bypassing components.                                                                   |
| 5        | TX     | RF input port for the 802.11b/g/n/ac PA. Input is matched to 50Ω and DC block is provided internally.                                                         |
| 6        | PA_EN  | Control voltage for the PA and Tx switch. See truth table for proper settings.                                                                                |
| 7        | NC     | No connect pin.                                                                                                                                               |
| 8        | RX     | RF output port for the 802.11b/g/n/ac LNA. Input is matched to 50Ω and DC block is provided internally.                                                       |
| 9        | LNA_EN | Control voltage for the LNA. When this pin is set to a LOW logic state, the bypass mode is enabled.                                                           |
| 10       | VDD    | Supply voltage for the LNA. See applications schematic for biasing and bypassing components.                                                                  |
| 11       | BT     | RF Bidirectional port for Bluetooth®. Input is matched to 50Ω and DC block is provided internally.                                                            |
| 12       | GND    | Ground connection.                                                                                                                                            |
| 13       | C_BT   | Bluetooth® switch control pin. See Truth Table for proper level.                                                                                              |
| 14       | C_RX   | Receive switch control pin. See Switch Truth Table for proper level.                                                                                          |
| 15       | GND    | Ground connection.                                                                                                                                            |
| 16       | ANT    | RF bidirectional antenna port matched to 50Ω and is DC blocked internally.                                                                                    |
| 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. |