

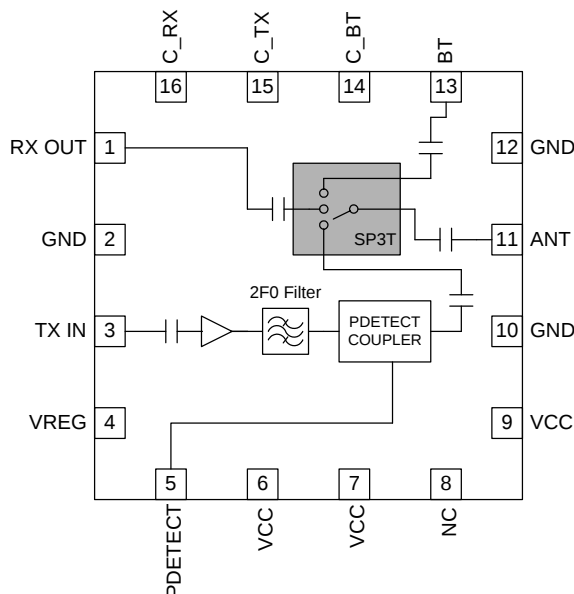


### Features

- Integrated 2.5GHz b/g/n Amplifier, SP3T Switch, Power Detector Coupler
- Single Supply Voltage 3.0V to 4.5V
- $P_{OUT}$  = 18dBm, 11g, OFDM @ <4% EVM, 20dBm 11b Meeting 11b Spectral Mask

### Applications

- IEEE802.11b/g/n WiFi Solutions
- 2.5GHz ISM Band Solutions
- Portable Battery-Powered Equipment



Functional Block Diagram

### Product Description

The RF5325 provides an integrated solution in a single Front End Module (FEM) for WiFi 802.11b/g/n 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 integrated SP3T switch of the RF5325 is capable of receiving WiFi and *Bluetooth*® simultaneously. The device is provided in a 3.0mmx3.0mmx0.5mm, 16-pin package. This module meets or exceeds the RF front end needs of IEEE802.11b/g/n WiFi RF systems.

### Ordering Information

|               |                                                                                 |
|---------------|---------------------------------------------------------------------------------|
| RF5325SQ      | Standard 25 piece bag                                                           |
| RF5325SR      | Standard 100 piece reel                                                         |
| RF5325TR7     | Standard 2500 piece reel                                                        |
| RF5325PCK-410 | Fully assembled evaluation board tuned for 2.4GHz to 2.5GHz and 5 loose samples |

### Optimum Technology Matching® Applied

|                                               |                                      |                                                |                                   |
|-----------------------------------------------|--------------------------------------|------------------------------------------------|-----------------------------------|
| <input type="checkbox"/> GaAs HBT             | <input type="checkbox"/> SiGe BiCMOS | <input checked="" type="checkbox"/> GaAs pHEMT | <input type="checkbox"/> GaN HEMT |
| <input type="checkbox"/> GaAs MESFET          | <input type="checkbox"/> Si BiCMOS   | <input type="checkbox"/> Si CMOS               | <input type="checkbox"/> RF MEMS  |
| <input checked="" type="checkbox"/> InGaP HBT | <input type="checkbox"/> SiGe HBT    | <input type="checkbox"/> Si BJT                | <input type="checkbox"/> LDMOS    |

## Absolute Maximum Ratings

| Parameter                                            | Rating                   | Unit     |
|------------------------------------------------------|--------------------------|----------|
| DC Supply Voltage                                    | 5.0                      | V        |
| DC Supply Current                                    | 240                      | mA       |
| Full Specification Temp Range (Full Spec. Compliant) | -15 to +75               | °C       |
| Extreme Operating (Reduced Performance)              | +75 to +85<br>-30 to -15 | °C       |
| Storage Temperature                                  | -40 to +150              | °C       |
| Antenna Port Nominal Impedance                       | 50                       | $\Omega$ |
| Maximum TX Input Power for 11b/g (No Damage)         | +5                       | dBm      |
| Moisture Sensitivity                                 | MSL2                     |          |



Caution! ESD sensitive device.

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.

RoHS status based on EUDirective2002/95/EC (at time of this document revision).

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| Parameter                       | Specification |      |      | Unit  | Condition                                                                                              |
|---------------------------------|---------------|------|------|-------|--------------------------------------------------------------------------------------------------------|
|                                 | Min.          | Typ. | Max. |       |                                                                                                        |
| 2.4GHz Transmit Parameters      |               |      |      |       |                                                                                                        |
| Compliance                      |               |      |      |       | IEEE802.11b, IEEE802.11g/n, FCC CFG 15.247, .205, .209                                                 |
| Conditions                      |               |      |      |       | Specifications met across V <sub>CC</sub> , V <sub>REG</sub> , and Temperature unless noted otherwise. |
| Frequency                       | 2.4           |      | 2.5  | GHz   |                                                                                                        |
| Output Power                    |               |      |      |       |                                                                                                        |
| 11g                             | 17            |      |      | dBm   | V <sub>CC</sub> ≥3.3V, 54Mbps, OFDM, 64QAM meeting EVM requirement                                     |
| 11b                             | 20.5          |      |      | dBm   | V <sub>CC</sub> ≥3.3V, Measured at 1Mbps meeting ACP1/ACP2 requirements                                |
| EVM*                            |               | 3.0  | 4.0  | %     | P <sub>OUT(g)</sub> = 17 dBm, 54Mbps OFDM V <sub>CC</sub> ≥3.3V, 50Ω                                   |
| Adjacent Channel Power          |               |      |      |       |                                                                                                        |
| ACP1                            |               | -38  | -32  | dBc   | P <sub>OUT</sub> =20.5dBm, IEEE802.11b, 1Mbps CCK modulation                                           |
| ACP2                            |               | -56  | -52  | dBc   | P <sub>OUT</sub> =20.5dBm, IEEE802.11b, 1Mbps CCK modulation                                           |
| Gain                            | 25            | 27   |      | dB    |                                                                                                        |
| Gain Variation                  |               |      |      |       |                                                                                                        |
| V <sub>CC</sub> (instantaneous) |               |      | 0.7  | dB/V  | V <sub>CC</sub> range: 3.0V to 4.5V                                                                    |
| Frequency                       | -0.5          |      | +0.5 | dB    | 2.4GHz to 2.5GHz                                                                                       |
| Power Detect                    |               |      |      |       |                                                                                                        |
| Voltage Detect                  | 0.1           |      | 1.4  | V     | Over P <sub>OUT</sub> range 0dBm to 23dBm                                                              |
| Input Resistance                |               | 10   |      | kΩ    |                                                                                                        |
| Input Capacitance               |               |      | 5    | pF    |                                                                                                        |
| Sensitivity                     |               |      |      |       |                                                                                                        |
| P <sub>OUT</sub> > 10dBm        | 25            |      |      | mV/dB |                                                                                                        |
| 0 < P <sub>OUT</sub> < 10dBm    | 8             |      |      | mV/dB |                                                                                                        |

\*The EVM specification is obtained with a signal generator that has an EVM level <0.7%.

| Parameter                          | Specification |      |      | Unit | Condition                                                                              |
|------------------------------------|---------------|------|------|------|----------------------------------------------------------------------------------------|
|                                    | Min.          | Typ. | Max. |      |                                                                                        |
| 2.4GHz Transmit Parameters, cont'd |               |      |      |      |                                                                                        |
| Current Consumption                |               |      |      |      |                                                                                        |
| I <sub>CC</sub>                    |               | 130  | 160  | mA   | V <sub>CC</sub> =3.3V, V <sub>REG</sub> =2.85V, RF P <sub>OUT</sub> =17 dBm, 11g, 50Ω  |
|                                    |               | 160  | 200  | mA   | V <sub>CC</sub> =3.3V, V <sub>REG</sub> =2.85V, RF P <sub>OUT</sub> =20.5dBm, 11b, 50Ω |
| Idle                               |               | 110  |      | mA   | V <sub>CC</sub> =3.3V, V <sub>REG</sub> =2.85V, and RF=OFF                             |
| I <sub>REG</sub>                   |               | 2    | 5    | mA   | V <sub>REG</sub> =2.85V Typical                                                        |
| Leakage                            |               | 5    | 10   | μA   | V <sub>REG</sub> <0.2V                                                                 |
| Power Supply                       | 3.0           | 3.3  | 4.5  | V    |                                                                                        |
| V <sub>REG</sub>                   | 2.75          | 2.85 | 2.95 | V    | PA On                                                                                  |
|                                    |               |      | 0.2  | V    | PA Off                                                                                 |
| Input/Output Impedance             |               | 50   |      | Ω    |                                                                                        |
| Ruggedness                         |               |      |      |      | No damage                                                                              |
| Output VSWR                        | 10:1          |      |      |      | Maximum: operating voltage, input power, temperature                                   |
| Stability                          |               |      |      |      |                                                                                        |
| Output VSWR                        | 5:1           |      |      |      |                                                                                        |
| Harmonics                          |               |      |      |      | RBW=1MHz. Measured at 1Mbps.                                                           |
| Second                             |               | -33  | -27  | dBm  | 11b CCK BW=1MHz, P <sub>OUT</sub> =20.5dBm, 4.80GHz to 5.00GHz                         |
| Third                              |               | -43  | -40  | dBm  | 11b CCK BW=1MHz, P <sub>OUT</sub> =20.5dBm, 7.20GHz to 7.50GHz                         |
| Second                             |               | -33  | -30  | dBm  | 11g 6Mbps. OFDM, P <sub>OUT</sub> =17 dBm, 4.80GHz to 5.00GHz                          |
| Third                              |               | -48  | -45  | dBm  | 11g 6Mbps. OFDM, P <sub>OUT</sub> =17 dBm, 7.20GHz to 7.50GHz                          |
| Turn-On/Off Time                   |               |      | 1.0  | μS   | Output stable to within 90% of final gain                                              |
| Antenna Port Impedance             |               |      |      |      | Antenna port is a DC short to ground                                                   |
| Input                              |               | 50   |      | Ω    | Receive                                                                                |
| Output                             |               | 50   |      | Ω    | Transmit                                                                               |
| Switch Control Voltage             |               |      |      |      |                                                                                        |
| Low                                |               | 0    | 0.2  | V    |                                                                                        |
| High                               | 2.70          |      | 4.50 | V    |                                                                                        |
| Switch Control Current             |               |      | 10   | μA   | Per control line                                                                       |
| Switch Control Speed               |               |      | 100  | nsec |                                                                                        |
| ESD                                |               |      |      |      |                                                                                        |
| Human Body Model                   | TBD           |      |      | V    | EIA/JESD22-114A                                                                        |
| Machine Model                      | TBD           |      |      | V    | EIA/JESD22-115A                                                                        |

| Parameter                 | Specification |      |      | Unit | Condition                                                                                   |
|---------------------------|---------------|------|------|------|---------------------------------------------------------------------------------------------|
|                           | Min.          | Typ. | Max. |      |                                                                                             |
| 2.4GHz Receive Parameters |               |      |      |      |                                                                                             |
| Frequency                 | 2.4           |      | 2.5  | GHz  |                                                                                             |
| Insertion Loss            |               | 0.5  | 0.8  | dB   | WiFi RX mode only                                                                           |
|                           |               | 3.5  | 4.0  | dB   | WiFi RX and BT RX mode                                                                      |
| Noise Figure              |               | 0.5  | 0.8  | dB   | WiFi RX mode only                                                                           |
|                           |               | 3.5  | 4.0  | dB   | WiFi RX and BT RX mode                                                                      |
| Passband Ripple           | -0.2          |      | +0.2 | dB   |                                                                                             |
| Output Return Loss        |               |      | -9.6 | dB   |                                                                                             |
| Output Impedance          |               | 50   |      | Ω    | No external matching                                                                        |
| Current Consumption       |               |      | 30   | μA   |                                                                                             |
| Bluetooth® Parameters     |               |      |      |      |                                                                                             |
| Frequency                 | 2.4           |      | 2.5  | GHz  |                                                                                             |
| Insertion Loss            |               | 0.5  | 0.8  | dB   | SP3T switch, all unused ports terminated into their nominal impedance. Bluetooth® mode only |
|                           |               | 3.5  | 4.0  | dB   | WiFi RX and BT RX mode                                                                      |
| Passband Ripple           | -0.2          |      | +0.2 | dB   |                                                                                             |
| Input/Output Power        |               |      | 8    | dBm  |                                                                                             |
| Output Return Loss        |               |      | -10  | dB   |                                                                                             |
| Output Impedance          |               | 50   |      | Ω    | No external matching                                                                        |
| Current Consumption       |               |      | 30   | μA   | Switch leakage current                                                                      |

\*The EVM specification is obtained with a signal generator that has an EVM level <0.7%.

#### Isolation Table

| Parameter              | Min. | Typ. | Max. | Unit |
|------------------------|------|------|------|------|
| WiFi RX to BT RX/TX    | 20   |      |      | dB   |
| WiFi TX to BT RX/TX    | 20   |      |      | dB   |
| WiFi RX to WiFi TX     | 20   |      |      | dB   |
| WiFi RX and BT RX Mode | 9    |      |      | dB   |

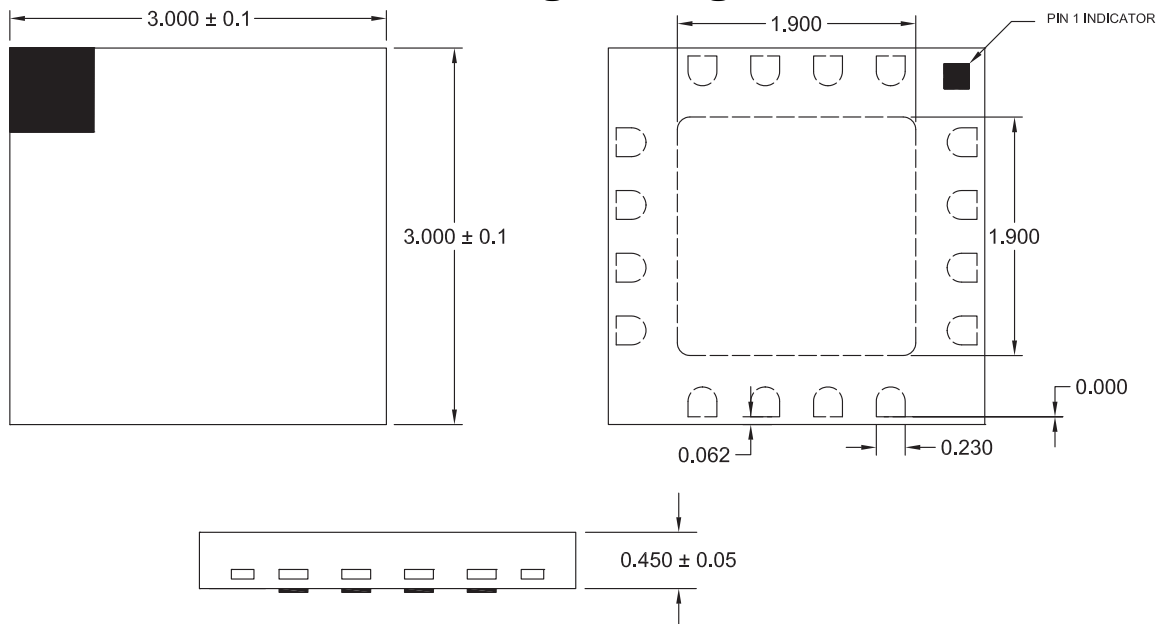
#### Switch Control Logic

| C_RX | C_TX | C_BT | Mode                   |
|------|------|------|------------------------|
| L    | L    | H    | Bluetooth®             |
| L    | H    | L    | WiFi TX                |
| H    | L    | L    | WiFi RX                |
| H    | L    | H    | WiFi RX and BT RX mode |

\*The FEM can simultaneously receive WiFi and *Bluetooth®* in the WiFi RX and BT RX Mode.

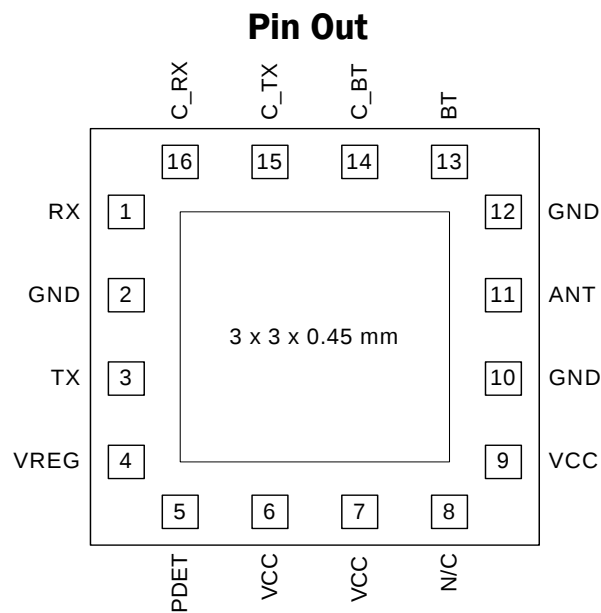
| Pin | Function | Description                                                                                                                                                                                                      |
|-----|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | RX       | Receive port for 802.11b/g/n band. Internally matched to 50Ω. DC block provided.                                                                                                                                 |
| 2   | GND      | Ground.                                                                                                                                                                                                          |
| 3   | TX       | RF input for the 802.11b/g/n PA. Input is matched to 50Ω and DC block is provided.                                                                                                                               |
| 4   | VREG     | Digital enable pin for the 802.11b/g/n PA. This is an active high control. An external bypass capacitor may be needed on the V <sub>REG</sub> line for decoupling purposes.                                      |
| 5   | PDETECT  | Power detector voltage for TX section. PDET voltage varies with output power. May need external decoupling capacitor for module stability. May need external circuitry to bring output voltage to desired level. |
| 6   | VCC      | Supply voltage for the bias circuit of the PA. Add an external 56pF bypass capacitor for low frequency decoupling.                                                                                               |
| 7   | VCC      | Supply voltage for the first stage of the PA. Add an external 1nF capacitor for low frequency decoupling.                                                                                                        |
| 8   | N/C      | No connect.                                                                                                                                                                                                      |
| 9   | VCC      | Supply voltage for the second stage of the PA. Add an external 10nF capacitor for low frequency decoupling.                                                                                                      |
| 10  | GND      | Ground.                                                                                                                                                                                                          |
| 11  | ANT      | Port matched to 50Ω and is a DC short to ground.                                                                                                                                                                 |
| 12  | GND      | Ground.                                                                                                                                                                                                          |
| 13  | BT       | RF bidirectional port for Bluetooth®. Input is matched to 50Ω and DC block is provided.                                                                                                                          |
| 14  | C_BT     | Switch control port. See switch truth table for proper level.                                                                                                                                                    |
| 15  | C_TX     | Switch control port. See switch truth table for proper level.                                                                                                                                                    |
| 16  | C_RX     | Switch control port. See switch truth table for proper level.                                                                                                                                                    |

## Package Drawing

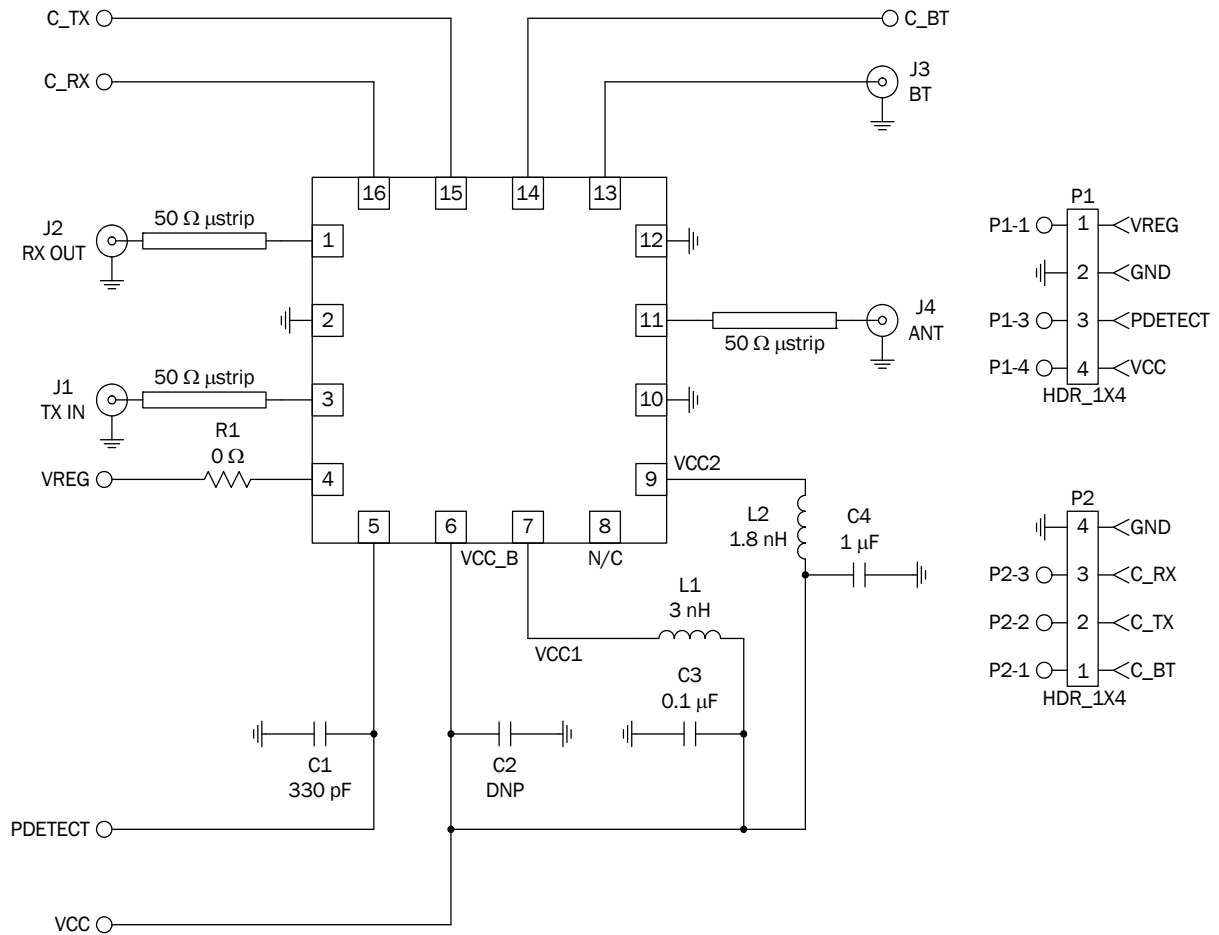


### NOTES:

- 1 Shaded Area is Pin 1 Indicator



## Evaluation Board Schematic



## Theory of Operation

The RF5325 provides an integrated solution for WiFi 802.11 b/g/n and *Bluetooth*® systems. This single package Front End Module (FEM) solution integrates the Power Amplifier (PA), Power Detector Coupler, and harmonic filtering for the transmit side. The integrated SP3T switch is capable of simultaneous operation in WiFi and *Bluetooth*® receive modes by setting two of the switch branches to a logic control "high."

The integrated harmonic filtering and matching of the RF5325 facilitates deployment on the customer's board by offering 50Ω interface at all RF ports. For best results, the board layout from the evaluation board should be copied as closely as possible in particular the ground configuration underneath the FEM and around the RF traces and decoupling capacitors. There is an indicator pin labeled P1 ID that should be left as a no-connect on the PCB. This pin is directly connected to the ground pad of the IC. For best performance it is recommended that voltage and RF lines do not cross under this pin. Gerber files of RFMD PCBA designs can be provided upon request.

The RF5325 FEM can be connected directly to the battery without additional voltage regulators. This FEM requires a single positive supply voltage ( $V_{CC}$ ), positive current control bias ( $V_{REG}$ ) supply, and a positive supply for switch controls.

### WiFi Transmit Path

The RF5325 has a typical gain of 28dB from 2.4GHz to 2.5GHz, and delivers 18dBm typical output power under 54Mbps OFDM modulation and 20dBm under 1Mbps 11b modulation. The operating voltage range to meet full specifications is from 3.0V to 4.5V. Current control optimization for the 802.11b/g/n systems is provided through one bias control input pin ( $V_{REG}$ ). The  $V_{REG}$  pin requires a regulated supply to maintain nominal bias current and a minimum voltage of 2.75V.

### Out of Band Rejection

The RF5325 contains basic filtering components to produce bandpass responses for the transmit path. Due to space constraints inside the module, filtering is limited to a few resonant poles. Additional filters may need to be added outside the module depending upon the end-user's application.

### WiFi and *Bluetooth*® Receive Paths

The 802.11b/g/n and *Bluetooth*® paths are designed to interface in a 50Ω impedance environment to minimize insertion loss. The single-ended ports provide a nominal insertion loss of 0.5dB and a VSWR of 2:1. The RF5325 is designed so that the SP3T switch allows for simultaneous operation of WiFi and *Bluetooth*® receive signals (refer to switch control table settings). In this configuration, the SP3T switch acts as a 3dB splitter adding approximately 3dB of loss to each of the receive paths.

## RF5325 Biasing Instructions:

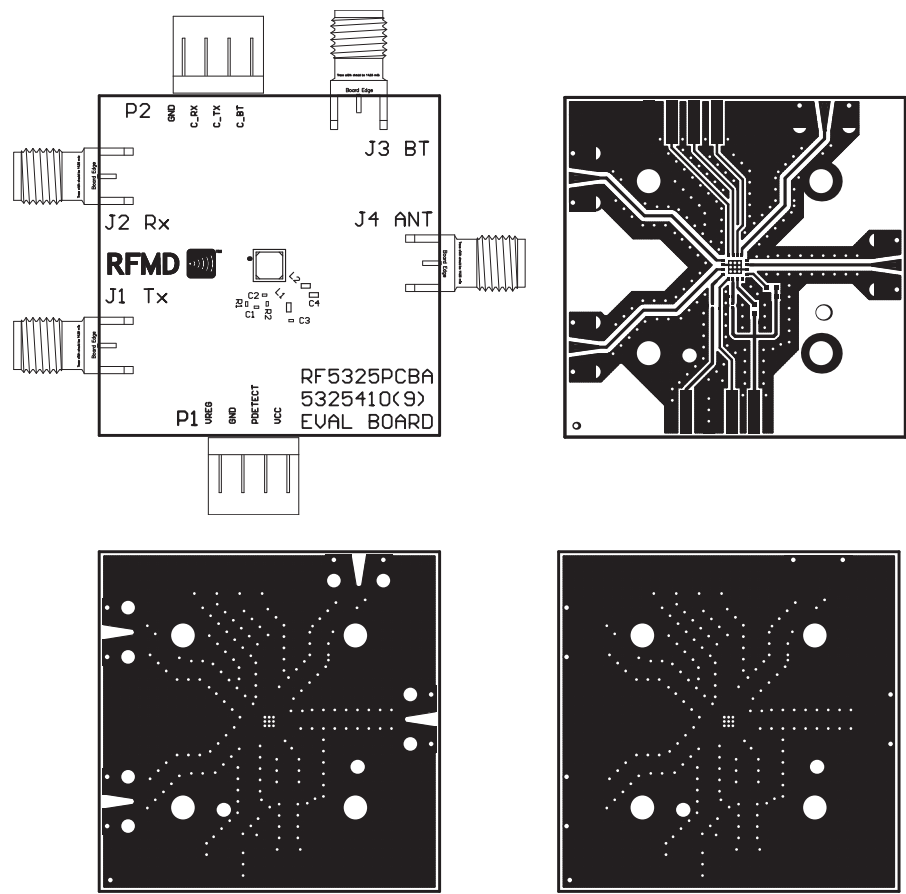
- 802.11b/g/n Transmit
  - Connect the FEM to a signal generator at the input and a spectrum analyzer at the output.
  - Bias  $V_{CC}$  to 3.3V first with  $V_{REG} = 0.0V$
  - Refer to switch operational truth table to set the control lines at the proper levels for WiFi TX.
- Turn on  $V_{REG}$  to 2.85V (typ.).  $V_{REG}$  controls the current drawn by the 802.11b/g/n power amplifier and the current should quickly rise to  $\sim 100mA \pm 20mA$  for a typical part but it varies based on the output power desired. Be extremely careful not to exceed 3.4V on the  $V_{REG}$  pin or the part may exceed device current limits.
- 802.11 b/g/n Receive
  - To Receive WiFi set the switch control lines per the truth table below.
- *Bluetooth*<sup>®</sup> Receive
  - To Receive *Bluetooth*<sup>®</sup> set the switch control lines per the truth table below.

## Switch Control Logic

| C_RX | C_TX | C_BT | Mode                   |
|------|------|------|------------------------|
| L    | L    | H    | Bluetooth <sup>®</sup> |
| L    | H    | L    | WiFi TX                |
| H    | L    | L    | WiFi RX                |
| H    | L    | H    | WiFi RX and BT RX mode |

\*The FEM can simultaneously receive WiFi and *Bluetooth*<sup>®</sup> in the WiFi RX and BT RX Mode.

Evaluation Board Layout  
Board Size 1.5" x 1.5"  
Board Thickness 0.032", Board Material FR-4, Multi-Layer



## RF5325 Performance Graphs

