# RF5225

## 2.4GHz TO 2.5GHz, 802.11B/G/N WiFi FRONT END MODULE

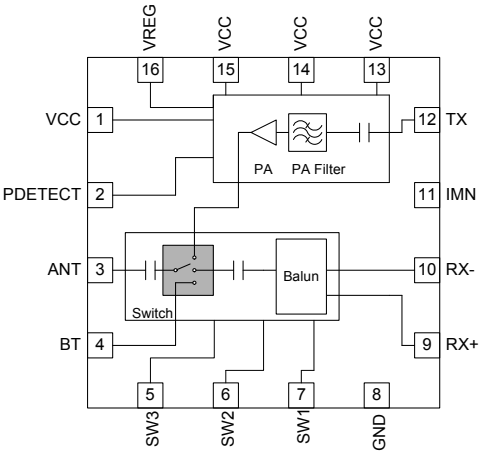
Package Style: QFN, 16-pin, 3 x 3 x 0.45 mm


### Features

- Single Supply Voltage 3.1V to 4.5V
- Integrated 2.4GHz to 2.5GHz b/g Amplifier, RX Balun and TX/RX Switch
- $P_{OUT}$=16dBm, 11g, OFDM at 3.0% EVM and $P_{OUT}$=19dBm, Meeting 11b Mask
- Low Height Package, Suited for SiP and CoB Designs

### Applications

- Cellular handsets
- Mobile devices
- Tablets
- Consumer electronics
- Gaming
- Netbooks/Notebooks
- TV/monitors/video
- SmartEnergy




Functional Block Diagram

### Product Description

The RF5225 FEM is a single-chip integrated front-end module (FEM) for high-performance WiFi applications in the 2.4GHz to 2.5GHz ISM band. The FEM addresses the need for aggressive size reduction for a typical 802.11b/g front-end design and greatly reduces the number of components outside of the core chipset. The FEM has integrated b/g power amplifier, power detector, RX balun, and some TX filtering. It is also capable of switching between WiFi RX, WiFi TX and BTH RX/TX operations. The device is provided in a 3mmx3mmx0.45mm, 16-pin package. This module meets or exceeds the RF front-end needs of 802.11b/g WiFi RF systems.

### Ordering Information

| | |
|---|---|
| RF5225 | Standard 25 piece bag |
| RF5225SR | Standard 100 piece reel |
| RF5225TR7 | Standard 2500 piece reel |
| RF5225PCK-410 | Fully assembled evaluation board tuned for 2.4GHz to 2.5GHz and 5 piece loose samples |

### Optimum Technology Matching® Applied

| | | | |
|---|---|---|---|
| ☐ GaAs HBT | ☐ SiGe BiCMOS | ☑ GaAs pHEMT | ☐ GaN HEMT |
| ☐ GaAs MESFET | ☐ Si BiCMOS | ☐ Si CMOS | |
| ☑ InGaP HBT | ☐ SiGe HBT | ☐ Si BJT | |





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## Absolute Maximum Ratings

| Parameter | Rating | Unit |
|---|---|---|
| DC Supply Voltage | 5.4 | $V_{DC}$ |
| DC Supply Current | 400 | mA |
| Full Specification Temp Range (Full Spec. Compliant) | -15 to +65 | °C |
| Extreme Operating Temperature Range (Reduced Performance) | +65 to +85<br>-40 to -15 | °C |
| Storage Temperature | -40 to +85 | °C |
| Antenna Port Nominal Impedance | 50 | Ω |
| Maximum TX Input Power for 11b (No Damage) | +5 | dBm |
| Maximum TX Input Power for 11g (No Damage) | +5 | dBm |
| Moisture Sensitivity | JEDEC Level 3 | |

**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).



| Parameter | Specification | | | Unit | Condition |
|---|---|---|---|---|---|
| | Min. | Typ. | Max. | | |
| **2.4GHz Transmit Parameters** | | | | | |
| Compliance | | | | | IEEE802.11b, IEEE802.11g, FCC CFG 15.247, .205, .209 |
| Nominal Conditions | | | | | $V_{CC}$=3.7V, $V_{REG}$=2.8V pulsed at 1% to 100% duty cycle, Temp=+25°C, Freq=2.4GHz to 2.5GHz, unless otherwise noted |
| Frequency | 2.4 | | 2.5 | GHz | |
| Output Power | | | | | |
| 11g | | 16.0 | | dBm | 54Mbps, OFDM, 64QAM meeting EVM requirement |
| 11b | | 19.0 | | dBm | Measured at 1Mbps meeting ACP1/ACP2 requirements |
| EVM* | | 3.0 | | % | RMS, mean, $P_{OUT(g)}$=16dBm |
| Adjacent Channel Power | | | | | |
| ACP1 | | -38 | -34 | dBc | $P_{OUT}$=19dBm, IEEE802.11b, 1Mbps CCK modulation |
| ACP2 | | -56 | -53 | dBc | $P_{OUT}$=19dBm, IEEE802.11b, 1Mbps CCK modulation |
| Gain | 26.5 | 30 | | dB | |
| Gain Variation | | | | | |
| $V_{CC}$ | | | 0.7 | dB/V | |
| Frequency | -0.5 | | +0.5 | dB | 2.4GHz to 2.5GHz |

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





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| Parameter | Specification | | | Unit | Condition |
|---|---|---|---|---|---|
| | Min. | Typ. | Max. | | |
| **2.4GHz Transmit Parameters, cont'd** | | | | | |
| Power Detect | | | | | |
| Voltage Detect | 0.1 | | 1.6 | V | |
| $P_{OUT}$=16dBm | | 1.0 | | V | IEEE802.11g, 54Mbps 64QAM modulation |
| $P_{OUT}$=19dBm | | 1.2 | | V | IEEE802.11b, 11Mbps CCK modulation |
| Input Resistance | | 10 | | kΩ | |
| Input Capacitance | | | 5 | pF | |
| Bandwidth | 800 | 1000 | | kHz | |
| Sensitivity | | | | | |
| >10dBm | 25 | | | mV/dB | |
| $0<P_{OUT}<10$dBm | 8 | | | mV/dB | |
| Current Consumption | | | | | |
| IEEE802.11g $I_{CC}$ | | 160 | | mA | RF $P_{OUT}$=16dBm, 54Mbps IEEE802.11g |
| IEEE802.11b $I_{CC}$ | | 190 | | mA | RF $P_{OUT}$=19dBm, 11Mbps IEEE802.11b |
| Idle | | 140 | | mA | $V_{CC}$=3.7V, $V_{REG}$=2.8V, and RF=OFF |
| $I_{REG}$ | | 3 | 10 | mA | $V_{REG}<0.2$V |
| Leakage | | 5 | 10 | µA | |
| Power Supply | 3.15 | 3.7 | 4.5 | V | |
| $V_{REG}$ Voltage ON | 2.7 | 2.8 | 2.88 | V | |
| Input/Output Impedance | | 50 | | Ω | |
| Ruggedness | | | | | No damage |
| Output VSWR | 10:1 | | | | Maximum: operating voltage, input power, temperature |
| Stability | | | | | |
| Output VSWR | 4:1 | | | | |
| Out of Band Performance | | | | | |
| S21 (DC to 960MHz) | | | 25 | dB | |
| S21 (1570MHz to 1580MHz) | | | 14 | dB | |
| S21 (1805MHz to 1990MHz) | | | 20 | dB | |
| S21 (2110MHz to 2170MHz) | | | 15 | dB | All other ports terminated in their nominal impedances |
| Harmonics | | | | | RBW=1MHz. Measured at 1Mbps. |
| Second | | | -18 | dBm | 4.80GHz to 5.00GHz |
| Third | | | -18 | dBm | 7.20GHz to 7.50GHz |
| Turn-On/Off Time | | 0.5 | 2.0 | µS | Output stable to within 90% of final gain |
| Antenna Port Impedance | | | | | |
| Input | | 50 | | Ω | Receive |
| Output | | 50 | | Ω | Transmit |
| Switch Control Voltage | | | | | |
| Low | | 0 | 0.2 | V | |
| High | 2.7 | 3.6 | 5.4 | V | |
| Switch Control Current | | | 10 | µA | Per control line |
| Switch Control Speed | | | 100 | nsec | |



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| Parameter | Specification | | | Unit | Condition |
|---|---|---|---|---|---|
| | Min. | Typ. | Max. | | |
| **2.4GHz Transmit Parameters, cont'd** | | | | | |
| ESD | | | | | |
| Human Body Model | 500 | | | V | EIA/JESD22-114A |
| Machine Model | 75 | | | V | EIA/JESD22-115A |
| **2.4GHz Receive Parameters** | | | | | |
| Frequency | 2.4 | | 2.5 | GHz | |
| Insertion Loss | | 1.8 | 2.0 | dB | |
| Noise Figure | | 1.8 | 2.0 | dB | |
| Passband Ripple | -1 | | +1 | dB | |
| Output Return Loss | | | -9.6 | dB | |
| Output Impedance | | 100 | | Ω | No external matching |
| Balun | | | | | |
| Amplitude Balance | | | 1 | dB | |
| Phase Balance | | | 10 | ° | Relative to 180° |
| Current Consumption | | | 10 | μA | |
| **Bluetooth Parameters** | | | | | |
| Frequency | 2.4 | | 2.5 | GHz | |
| Insertion Loss | | 1.2 | 1.6 | dB | SP3T switch, all unused ports terminated into their nominal impedance |
| 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 | | | 10 | 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 | | 25 | | dB |
| WiFi TX to BT RX/TX | | 20 | | dB |
| WiFi RX to WiFi TX | | 20 | | dB |

## Switch Control Logic

| SW1 | SW2 | SW3 | Mode |
|---|---|---|---|
| L | L | H | Bluetooth |
| L | H | L | WiFi TX |
| H | L | L | WiFi RX |


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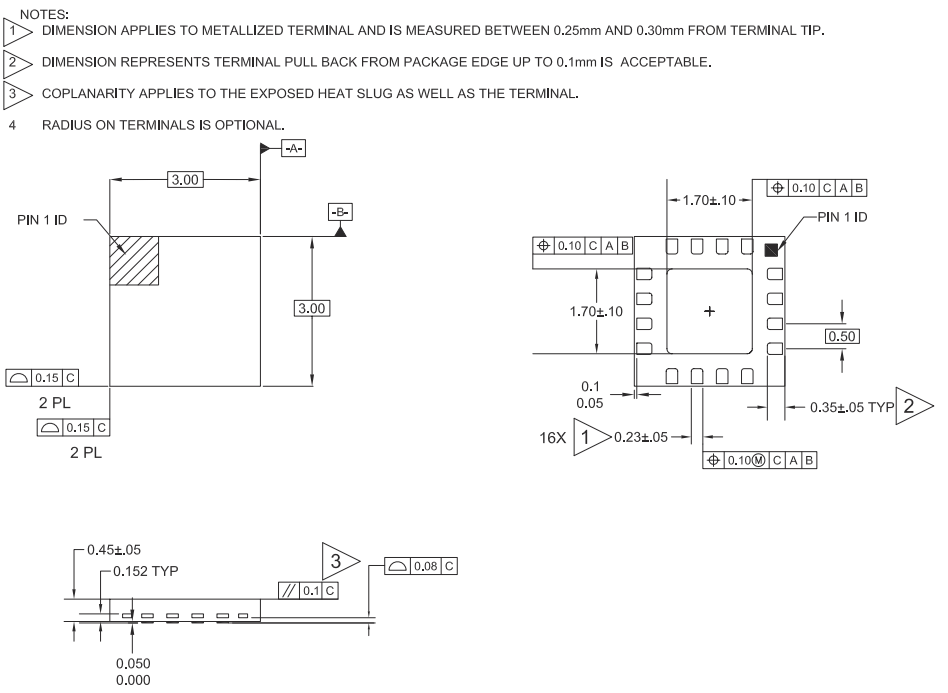
| Pin | Function | Description |
|---|---|---|
| 1 | VCC | Supply voltage for the 802.11b/g PA. Add an external 1uF capacitor for low frequency decoupling. |
| 2 | PDETECT | Power detector voltage for TX section. PDET voltage varies with output power. May need external decoupling capacitor for module stability. May need external circuitry to bring output voltage to desired level. |
| 3 | ANT | FEM connection to filter and antenna. Port is matched to 50Ω and DC block is provided. |
| 4 | BT | RF bidirectional port for Bluetooth. Input is matched to 50Ω and DC block is provided. |
| 5 | SW3 | Switch control port. See switch truth table for proper level. |
| 6 | SW2 | Switch control port. See switch truth table for proper level. |
| 7 | SW1 | Switch control port. See switch truth table for proper level. |
| 8 | GND | Ground. |
| 9 | RX+ | Receive port for 802.11b/g band. Internally matched to 100Ω differential. DC block provided. |
| 10 | RX- | Receive port for 802.11b/g band. Internally matched to 100Ω differential. DC block provided. |
| 11 | IMN | Input matching network. |
| 12 | TX | RF input for the 802.11b/g PA. Input is matched to 50Ω and DC block is provided. |
| 13 | VCC | Supply voltage for the 802.11b/g PA. Add an external 1uF capacitor for low frequency decoupling. |
| 14 | VCC | Supply voltage for the 802.11b/g PA. Add an external 1nF capacitor for low frequency decoupling. |
| 15 | VCC | Supply voltage for the 802.11b/g PA bias circuit. Add an external 10nF capacitor for low frequency decoupling. |
| 16 | $V_{REG}$ | Bias control voltage for the first, second, and third stage PA. |
| Pkg Base | GND | The center metal base of the QFN package provides DC and RF ground as well as heat sink for the front-end module. |

## Package Drawing



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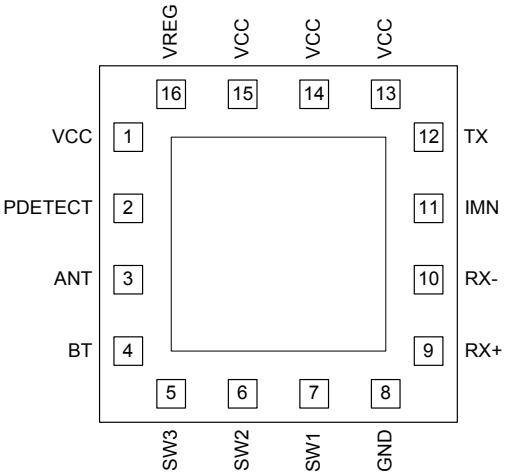
## Pin Out



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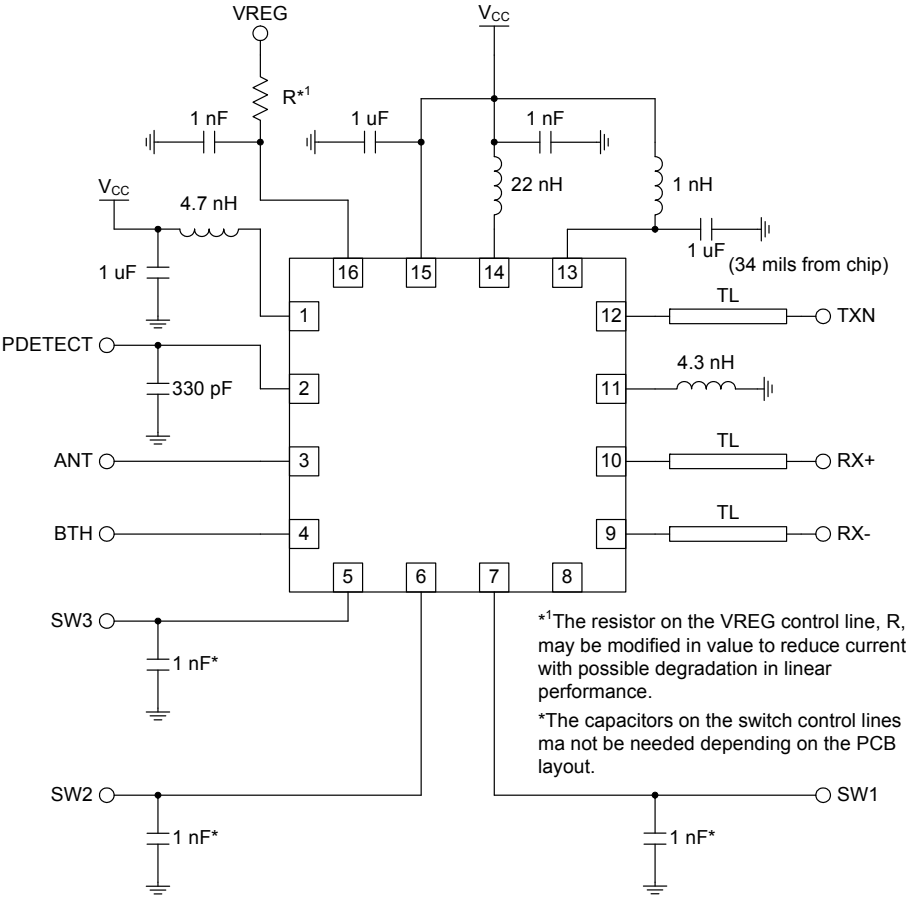
## Application Schematic



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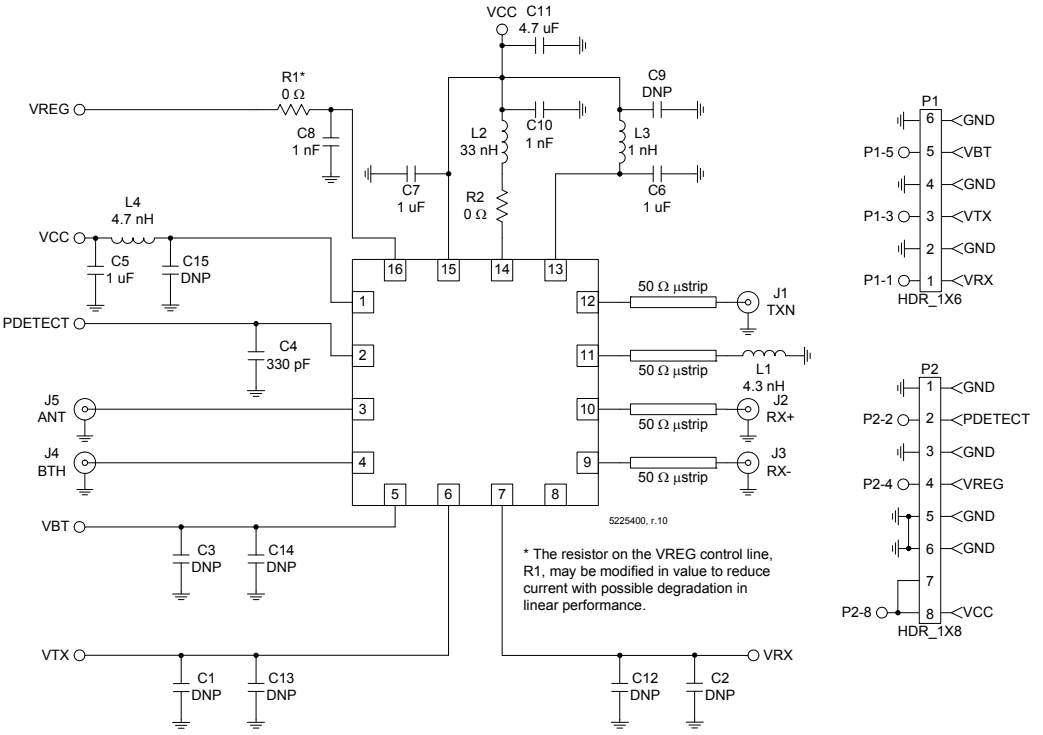
## Evaluation Board Schematic



## Theory of Operation

The RF5225 FEM is a single-chip integrated front-end module (FEM) for high performance WiFi applications in the 2.4GHz to 2.5GHz ISM band. The FEM addresses the need for aggressive size reduction for a typical 802.11b/g RF front-end design and greatly reduces the number of components outside of the core chipset therefore minimizing the footprint and assembly cost of the overall 802.11b/g solution. The FEM has integrated b/g power amplifier, power detector, RX balun and TX filtering. Also it is capable of switching between WiFi RX, WiFi TX, and BTH RX/TX operations. It has low insertion loss at the 2.4GHz to 2.5GHz WiFi and BTH paths. The device is manufactured in a QFN leadframe package and GaAs HBT processes. The device is provided in a 3mmx3mmx0.45mm, 16-pin package. This module meets or exceeds the RF front-end needs of 802.11b/g WiFi RF systems.

For best results, the PA circuit layout from the evaluation board should be copied as closely as possible, particularly the ground layout and ground vias. Other configurations may also work, but the design process is much easier and quicker if the layout is copied from the RF5225 evaluation board. 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 the 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 on request. The supply voltage lines should present an RF short to the FEM by using bypass capacitors on the $V_{CC}$ traces. The RF5225 is a very easy part to implement , but care in circuit layout and component selection is always advisable when designing circuits to operate at 2.5GHz. Please contact RFMD Sales or Application Engineering for additional data and guidance.

The RF5225 is designed primarily for IEEE802.11 b/g WiFi applications where the available supply voltage and current are limited. The RF5225 requires a single positive supply voltage ($V_{CC}$), positive current control bias ($V_{REG}$) supply, and a positive supply for switch control to simplify bias requirements. The RF5225 FEM also has built in power detection. All inputs and outputs are internally matched to 50Ω except the WiFi receive path it is deferential with nominal impedance of 100 ohm on each pin.

### 802.11b/g Transmit Path

The RF5225 has a typical gain of 30dB from 2.4GHz to 2.5GHz, and delivers 16dBm typical output power under 54Mbps OFDM modulation and 19dBm under 1Mbps 11b modulation. The RF5225 requires a single positive supply of 3.1V to 4.5V to operate at full specifications. Current control optimization for the 802.11b/g band is provided through one bias control input pin ($V_{REG}$). The $V_{REG}$ pin requires a regulated supply to maintain nominal bias current, a series resistor may be used to drop the voltage to a desired level. In general, higher $V_{REG}$ voltage produce higher linear output power, higher operating current, and higher gain.

### Out of Band Rejection

The RF5225 contains basic filtering components to produce bandpass responses for the transmit and receive paths. Due to space constraints inside the module, filtering is limited to a few resonant poles per RF path. The IMN inductor, L1 on the evaluation board schematic, optimized the input matching network. On the PCB, the value of this inductor can be modified to optimize the filtering. Additional filters may need to be added outside the module depending upon the end-user's application.

### 802.11b/g Receive Path



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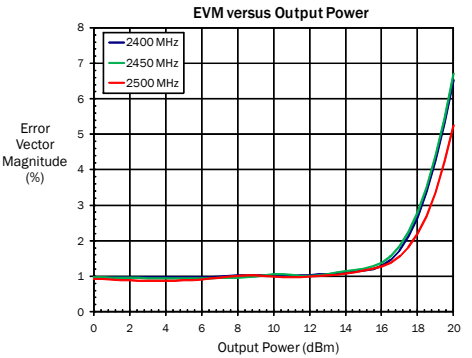
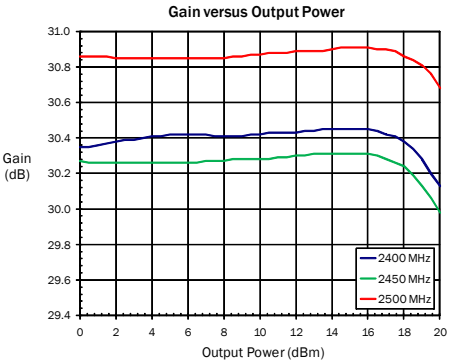
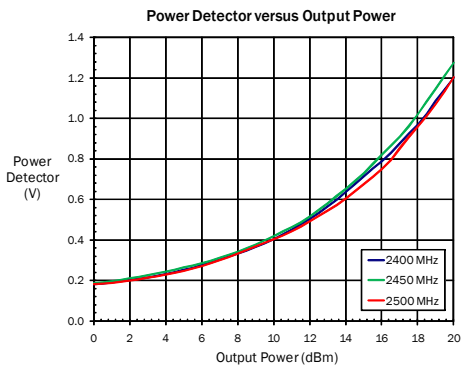
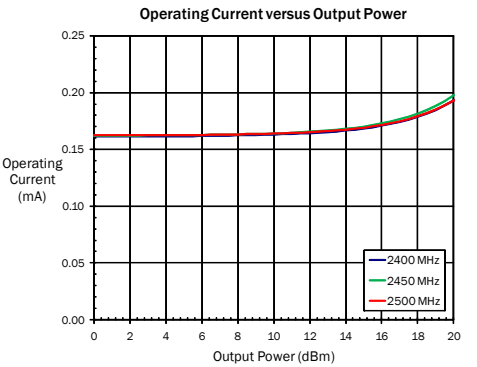
The 802.11b/g path has a100Ω differential impedance with a nominal insertion loss of 1.6dB. The RX port return loss is 10db minimum. Depending on the application, if filtering is required beyond what the RF5225 can achieve then additional external filters will need to be added outside of the RF5225.



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**RF5225 Biasing Instructions:**

- 802.11b/g Transmit ($V_{CC}$ compliance=5.4V, 400mA, $V_{REG}$ compliance=3V, 10mA)
  - Connect the FEM to a signal generator at the input and a spectrum analyzer at the output.
  - Bias $V_{CC}$ to 3.7V 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 2.8V (typ.). $V_{REG}$ controls the current drawn by the 802.11b/g power amplifier and the current should quickly rise to 145mA±20mA for a typical part but it varies based on the output power desired. Be extremely careful not to exceed 3.0V on the $V_{REG}$ pin or the part may exceed device current limits.
- 802.11 b/g Receive
  - To Receive WiFi set the switch control lines per the truth table below.
- Bluetooth Receive
  - To Receive Bluetooth set the switch control lines per the truth table below.

**Switch Control Logic**

| SW1 | SW2 | SW3 | **Mode** |
|---|---|---|---|
| L | L | H | Bluetooth |
| L | H | L | WiFi TX |
| H | L | L | WiFi RX |



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