



Package Style: QFN, 16-pin, 3mmx3mmx0.45mm

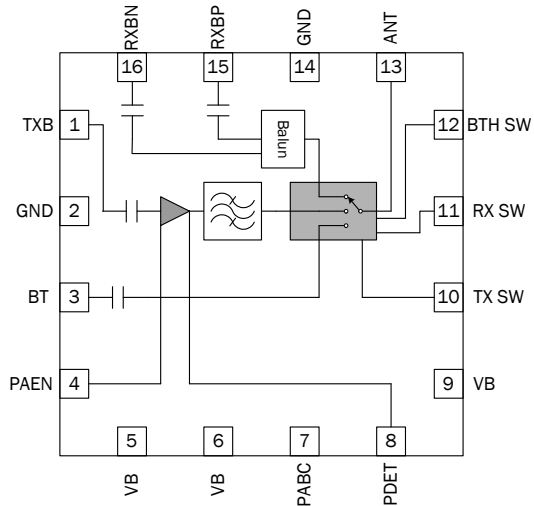


Features

- Single Module Radio Front End
- Single Voltage Supply 3.0V to 4.8V
- Integrated 2.4GHz to 2.5GHz b/g/n Amplifier, Rx Balun and Tx/Rx Switch and Directional Power Detector
- $P_{OUT} = 17\text{ dBm}$, 11g, OFDM at $<2.4\%$ EVM and $P_{OUT} = 21.5\text{ dBm}$, 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 RFFM3482E 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/n front end design and greatly reduces the number of components outside of the core chipset. The FEM has integrated b/g/n power amplifier, directional 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/n WiFi RF systems.

Ordering Information

| | |
|------------------|--|
| RFFM3482ETR13X | Standard 1-piece |
| RFFM3482ESQ | Standard 25-piece bag |
| RFFM3482ESR | Standard 100-piece bag |
| RFFM3482ETR7 | Standard 2500-piece reel |
| RFFM3482EPCK-41X | Fully Assembled Evaluation Board and 5 loose sample pieces |

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"/> BIFET HBT |
| <input 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 | 5.6 | V _{DC} |
| Full Specification Temp Range (Full Spec. Compliant) | -10 to +75 | °C |
| Extreme Operating Temperature Range (Reduced Performance) | -40 to -10 and +75 to +85 | °C |
| Storage Temperature | -40 to +150 | °C |
| Maximum Tx Input Power for 11b (No Damage) | +10 | dBm |
| Maximum Tx Input Power for 11g (No Damage) | +10 | dBm |
| Moisture Sensitivity | MSL1 | |



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.

The information in this publication is believed to be accurate and reliable. However, no responsibility is assumed by RF Micro Devices, Inc. ("RFMD") for its use, nor for any infringement of patents, or other rights of third parties, resulting from its use. No license is granted by implication or otherwise under any patent or patent rights of RFMD. RFMD reserves the right to change component circuitry, recommended application circuitry and specifications at any time without prior notice.



RFMD Green: RoHS compliant per EU Directive 2002/95/EC, 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.

| 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} = 3.6V, PAEN = 1.8V 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 | 15.5 | 17 | dBm | 54 Mbps, OFDM, 64QAM meeting EVM requirement ¹ | |
| | 11b | 20.5 | 21.5 | dBm | Measured at 1Mbps meeting ACP1/ACP2 requirements | |
| | 11n | 14.5 | 16 | dBm | MCS7, OFDM | |
| EVM* 11g | | 2.4 | 3.5 | % | RMS, mean, P _{OUT(g)} = 15.5dBm | |
| EVM* 11n | | 2.2 | 2.8 | % | RMS, mean, P _{OUT(n)} = 14.5dBm | |
| | ACP1 | | -36 | -33 | dBc | P _{OUT} = 20.5dBm, IEEE802.11b, 11Mbps CCK, 1Mbps BPSK modulation |
| | ACP2 | | -56 | -53 | dBc | P _{OUT} = 20.5dBm, IEEE802.11b, 11Mbps CCK, 1Mbps BPSK modulation |
| Gain | 28 | 33 | 38 | dB | | |
| Gain Variation | -2 | | +2 | dB | Over temperature and voltage | |
| Frequency | -1.0 | | +1.0 | dB | 2.4GHz to 2.5GHz | |

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

1. With V_{CC} > 4.2V to 4.8V there will be a 0.5dB degradation in 11g linear output power

| Parameter | Specification | | | Unit | Condition |
|---|--|------|------|-------|---|
| | Min. | Typ. | Max. | | |
| 2.4GHz Transmit Parameters, cont'd | | | | | |
| Power Detect | | | | | |
| Voltage Detect | 0 | | 0.8 | V | ≤21dBm output power |
| P _{OUT} = 16dBm | 0.27 | 0.31 | 0.36 | V | IEEE802.11g, 54Mbps 64QAM modulation |
| Input Resistance | | 10 | | kΩ | |
| Input Capacitance | | | 5 | pF | |
| Bandwidth | 800 | 1000 | | kHz | |
| Sensitivity | | | | | |
| 0dBm to 7dBm | 2 | | | mV/dB | |
| 8dBm to 15dBm | 10 | | | mV/dB | |
| >15dBm | 20 | | | mV/dB | |
| Current Consumption | | | | | |
| IEEE802.11g I _{CC} | 140 | 160 | 180 | mA | RFP _{OUT} = 15.5dBm, 54 Mbps IEEE802.11g |
| IEEE802.11b I _{CC} | 200 | 220 | 240 | mA | RFP _{OUT} = 20.5dBm, 11 Mbps IEEE802.11b |
| I _{PAEN} | | 240 | 400 | μA | PA EN=High |
| Leakage | | 2 | 6 | μA | V _B < 4.0V all control inputs = "off", no RF at 25 °C |
| | | | 25 | μA | V _B < 4.0V all control inputs = "off", no RF at 85 °C |
| Power Supply | 3.0 | 3.6 | 4.8 | V | |
| PA EN Voltage ON | 1.6 | 1.8 | 2.0 | V | PA is turned ON |
| PA EN Voltage OFF | | 0 | 0.01 | V | PA is turned OFF |
| PABC Voltage | 0 | | 1.0 | V | Used to drive the PABC current |
| PABC Current | 0 | | 1.8 | mA | |
| Input/Output Impedance | | 50 | | Ω | |
| Output Load VSWR Ruggedness | No damage or permanent degradation to device | | | | VSWR = 10:1; all phase angles (V _{RAMP} set for P _{OUT} ≤ 22dBm into 50Ω load; load switched to VSWR = 10:1) |
| Out of Band Gain (S ₂₁) | | | | | @ 50Ω relative to minimal in-band gain |
| 86MHz to 108MHz | | 30 | | dBr | |
| 776MHz to 894MHz | | 20 | | dBr | |
| 925MHz to 980MHz | | 20 | | dBr | |
| 1570MHz to 1580MHz | | 20 | | dBr | |
| 1805MHz to 1880MHz | | 20 | | dBr | |
| 1930MHz to 1990MHz | | 20 | | dBr | |
| 2110MHz to 2170MHz | | 15 | | dBr | |
| Thermal Harmonics | | 38.5 | | °C/W | V _{CC} = 4.8, PAEN = 1.8V, C _{TX} = 1.8V, C _{RX} = C _{BT} = GND, P _{OUT} = 20.5dBm, Modulation = 802.11b, Freq = 2.45GHz, DC = 100%, T = 85 °C |
| Harmonics | | | | | RBW = 1MHz. Measured at 1Mbps. |
| Second | | -13 | -10 | dBm | 4.80GHz to 5.00GHz |
| Third | | -33 | -30 | dBm | 7.20GHz to 7.50GHz |
| Fourth | | -43 | -40 | dBm | |
| Output Return Loss | | | -9 | dB | |
| Output Impedance | | 100 | | Ω | No external matching |

| Parameter | Specification | | | Unit | Condition |
|----------------------------------|---------------|------|------|------|---|
| | Min. | Typ. | Max. | | |
| 2.4GHz Receive Parameters | | | | | |
| Frequency | 2.4 | | 2.5 | GHz | |
| Insertion Loss | | 2.1 | 2.4 | dB | Switch and Balun |
| Noise Figure | | | 2.4 | dB | |
| Passband Ripple | | | 0.3 | dB | |
| Balun | | | | | |
| Amplitude Balance | -1 | | 1 | dB | |
| Phase Balance | -10 | | 10 | ° | Relative to 180° |
| Bluetooth Parameters | | | | | |
| Frequency | 2.4 | | 2.5 | GHz | |
| Insertion Loss | | 1.0 | 1.4 | dB | SP3T switch, all unused ports terminated into their nominal impedance |
| Passband Ripple | -0.3 | | +0.3 | dB | |
| Input/Output Power P1dB | 20 | | | dBm | |
| Output Return Loss | | -12 | -10 | dB | |
| Output Impedance | | 50 | | Ω | No external matching |
| General Characteristics | | | | | |
| Turn-On/Off Time | | | 1.0 | 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 | | 0.01 | V | |
| High | 1.6 | | 2.0 | V | |
| Switch Control Current | | | 4 | μA | Per control lines, Tx, Rx and BT |
| Switch Control Speed | | | 100 | nsec | Per control line Tx |
| ESD | | | | | |
| Human Body Model | | 500 | | V | EIA/JESD22-114A |
| Charge Device Model | | 750 | | V | EIA/JESD22-C101 |

*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 | 22 | 29 | | dB |
| WiFi Tx to BT Rx/Tx | 22 | 25 | | dB |
| WiFi Rx to WiFi Tx | 20 | 38 | | dB |
| ANT Tx | 25 | 45 | | dB |
| ANT Rx | 25 | 28 | | dB |

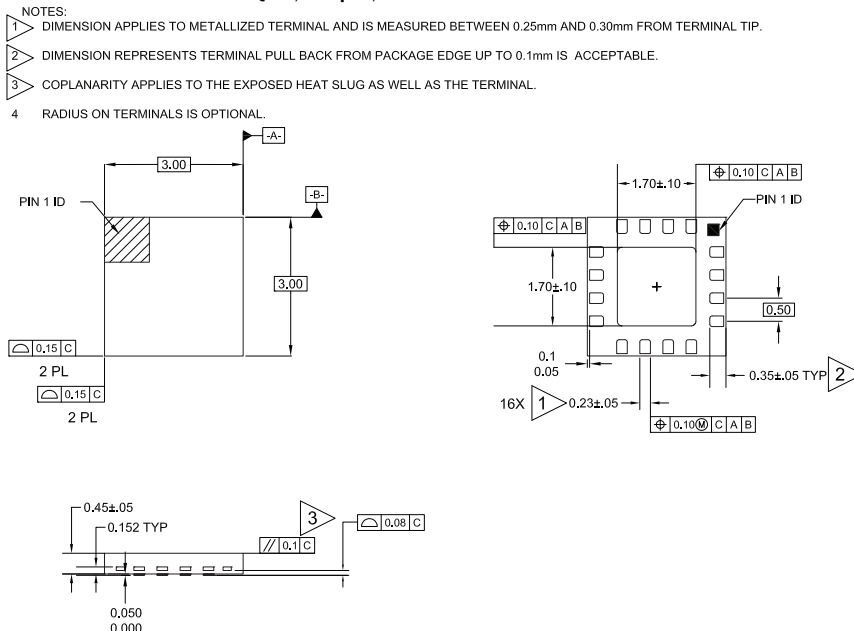
Switch Control Logic

| Mode | BTW_SW | RX_SW | TX_SW | PA_EN |
|--------------------|--------|-------|-------|-------|
| Bluetooth | 1 | 0 | 0 | 0 |
| WiFi Tx | 0 | 0 | 1 | 1 |
| WiFi Rx | 0 | 1 | 0 | 0 |
| Simultaneous BT/RX | 1 | 1 | 0 | 0 |
| Calibration | 0 | 1 | 0 | 1 |
| | 1 | 0 | 0 | 1 |
| | 1 | 1 | 0 | 1 |

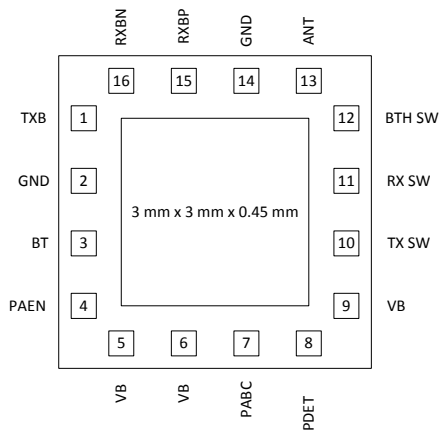
| Pin | Function | Description |
|----------|----------|--|
| 1 | TXB | RF input for the 802.11b/g/n PA. Input is matched to 50Ω and DC block is provided. |
| 2 | GND | Ground. |
| 3 | BT | RF bidirectional port for Bluetooth. Input is matched to 50Ω and DC block is provided. |
| 4 | PAEN | Digital enable pin for the 802.11b/g/n PA. This is an active high control. An external bypass capacitor may be needed on the PA EN line for decoupling purposes. |
| 5 | VB | Supply voltage for the 802.11b/g/n PA. |
| 6 | VB | Supply voltage for the 802.11b/g/n PA. |
| 7 | PABC | Linearity and Efficiency control pin, please see the Theory of Operation for more information. |
| 8 | PDET | 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. |
| 9 | VB | Supply voltage for the 802.11b/g/n PA. |
| 10 | TX SW | Switch control port. See switch truth table for proper level. |
| 11 | RX SW | Switch control port. See switch truth table for proper level. |
| 12 | BTH SW | Switch control port. See switch truth table for proper level. |
| 13 | ANT | FEM connection to filter and antenna. Port is matched to 50Ω and DC block is provided. |
| 14 | GND | Ground. |
| 15 | RX+ | Receive port for 802.11b/g/n band. Internally matched to 100Ω differential. DC block provided. |
| 16 | RX- | Receive port for 802.11b/g/n band. Internally matched to 100Ω differential. DC block provided. |
| 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

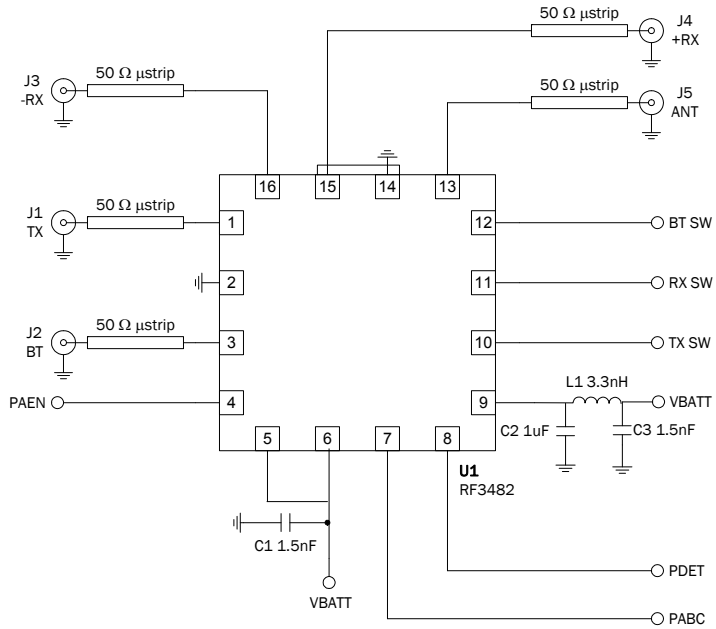
QFN, 16-pin, 3mmx3mmx0.45mm



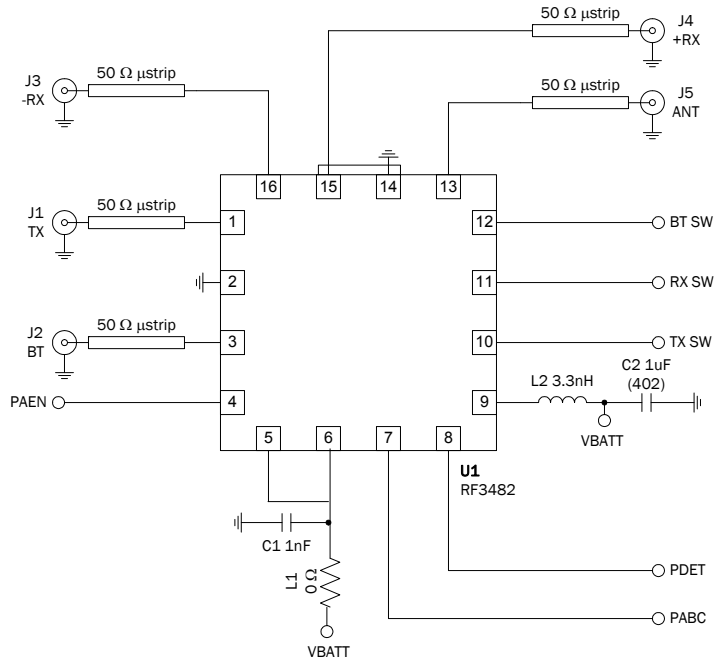
Pin Out



Application Schematic



Evaluation Board Schematic



Theory of Operation

The RFFM3482E 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/n RF front end design, and greatly reduces the number of components outside of the core chipset. Therefore, the footprint and assembly cost of the overall 802.11b/g/n solution is minimized. The FEM has integrated b/g/n 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 GaAs pHEMT processes, and provided in a 3mmx3mmx0.45mm, 16-pin package. This module meets or exceeds the RF front end needs of 802.11b/g/n 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 RFFM3482E 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 VB traces. The RFFM3482E 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 RFFM3482E is designed primarily for IEEE802.11 b/g/n WiFi applications where the available supply voltage and current are limited. The RFFM3482E requires a single positive supply voltage (VB), PA enable (PA_EN) supply, efficiency control (PABC), and a positive supply for switch control to simplify bias requirements. The RFFM3482E FEM also has built in power detection. All inputs and outputs are internally matched to 50Ω except the WiFi receive path it is differential with nominal impedance of 100Ω on each pin.

802.11b/g/n Transmit Path

The RFFM3482E has a typical gain of 33dB from 2.4GHz to 2.5GHz, and delivers 16.5dBm typical output power under 54Mbps OFDM modulation, and 21dBm under 1Mbps 11b modulation. The RFFM3482E requires a single positive supply of 3.0V to 4.8V to operate at full specifications. PA control for the 802.11b/g/n band is provided through one bias control input pin (PA_EN). The PA_EN pin requires a regulated supply to maintain nominal bias current. In general, the PABC pin controls acts as an efficiency and linearity control pin. The current or voltage applied at this pin may produce higher linear output power, higher operating current, and higher gain.

Out of Band Rejection

The RFFM3482E contains basic filtering components to produce bandpass responses for the WiFi transmit path. Due to space constraints inside the module, filtering is limited to a few resonant poles on the RF path.

802.11b/g/n Receive Path

The 802.11b/g/n path has a 100Ω differential impedance with a nominal insertion loss of 2.1dB. The Rx port return loss is -9dB maximum. Depending on the application, if filtering is required beyond what the RFFM3482E can achieve then additional external filters will need to be added outside of the RFFM3482E.

RFFM3482E Biasing Instructions:

- 802.11b/g/n Transmit (VB compliance=5.5V, 400mA, PA_EN compliance=2V, ~450µA)
 - Connect the FEM to a signal generator at the input and a spectrum analyzer at the output.
 - Bias VB to 3.6V first with PA_EN=0.0V
 - Refer to switch operational truth table to set the control lines at the proper levels for WiFi Tx.
- Turn on PA_EN to 1.8V (typ.). Be extremely careful not to exceed 3.0V on the PA_EN pin, or the part may exceed device current limits.
- Turn on PABC to 1.5mA (or 0.6V). For 11b operation Adjust PABC to 1.8mA. This controls the current drawn by the 802.11b/g/n power amplifier and the idle current should rise to ~115mA±20mA for a typical part, but it varies based on the output power desired.
- 802.11 b/g/n 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.

Ibias Table

| WiFi PABC | Standard | Modulation | Units |
|--------------|----------|------------|-------|
| IEEE 802.11b | CCK | 1.8 | mA |
| IEEE 802.11g | 54OFDM | 1.5 | mA |
| IEEE 802.11n | MCS7 | 1.5 | mA |

Switch Control Logic

| Mode | BTW_SW | RX_SW | TX_SW | PA_EN |
|--------------------|--------|-------|-------|-------|
| Bluetooth | 1 | 0 | 0 | 0 |
| WiFi Tx | 0 | 0 | 1 | 1 |
| WiFi Rx | 0 | 1 | 0 | 0 |
| Simultaneous BT/RX | 1 | 1 | 0 | 1 |
| Calibration | 0 | 1 | 0 | 1 |
| | 1 | 0 | 0 | 1 |
| | 1 | 1 | 0 | 1 |

PCB Design Requirements

PCB Surface Finish

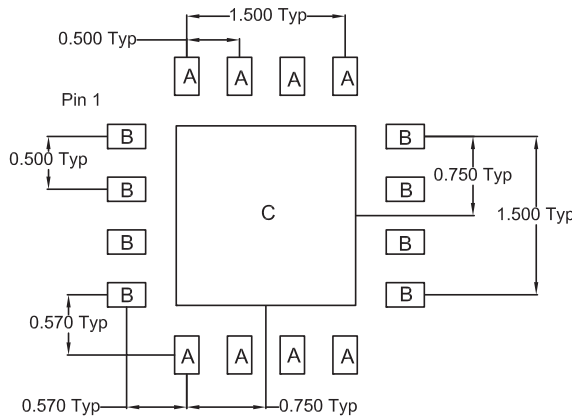
The PCB surface finish used for RFMD's qualification process is electroless nickel, immersion gold. Typical thickness is 3 micro-inch to 8 micro-inch gold over 180 micro-inch nickel.

PCB Land Pattern Recommendation *

PCB land patterns for RFMD components are based on IPC-7351 standards and RFMD empirical data. The pad pattern shown has been developed and tested for optimized assembly at RFMD. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company, careful process development is recommended.

PCB Metal Land Pattern

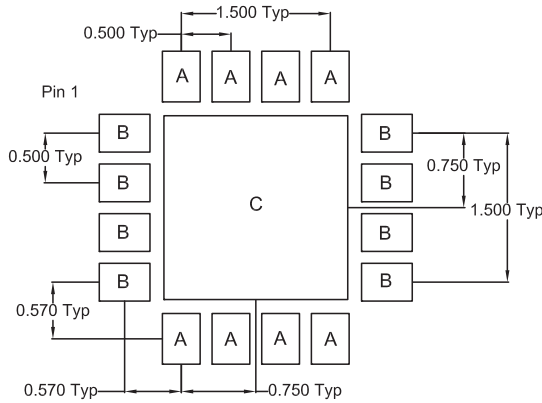
A = 0.230 x 0.360 (mm) Typ
B = 0.360 x 0.230 (mm) Typ
C = 1.700 (mm) Sq



PCB Solder Mask Pattern

Liquid Photo-Imageable (LPI) solder mask is recommended. The solder mask footprint will match what is shown for the PCB metal land pattern with a 2 mil to 3 mil expansion to accommodate solder mask registration clearance around all pads. The center-grounding pad shall also have a solder mask clearance. Expansion of the pads to create solder mask clearance can be provided in the master data or requested from the PCB fabrication supplier.

- A = 0.38 x 0.51 (mm) Typ
- B = 0.51 x 0.38 (mm) Typ
- C = 1.85 (mm) Sq



Thermal Pad and Via Design

The PCB land pattern has been designed with a thermal pad that matches the die paddle size on the bottom of the device.

Thermal vias are required in the PCB layout to effectively conduct heat away from the package. The via pattern has been designed to address thermal, power dissipation and electrical requirements of the device as well as accommodating routing strategies.

The via pattern used for the RFMD qualification is based on thru-hole vias with 0.203mm to 0.330mm finished hole size on a 0.5mm to 1.2mm grid pattern with 0.025mm plating on via walls. If micro vias are used in a design, it is suggested that the quantity of vias be increased by a 4:1 ratio to achieve similar results.

RFFM3482E Performance Plots

