RFFM3482Q

2.4GHz to 2.5GHz, Automotive WiFi Front End Module

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

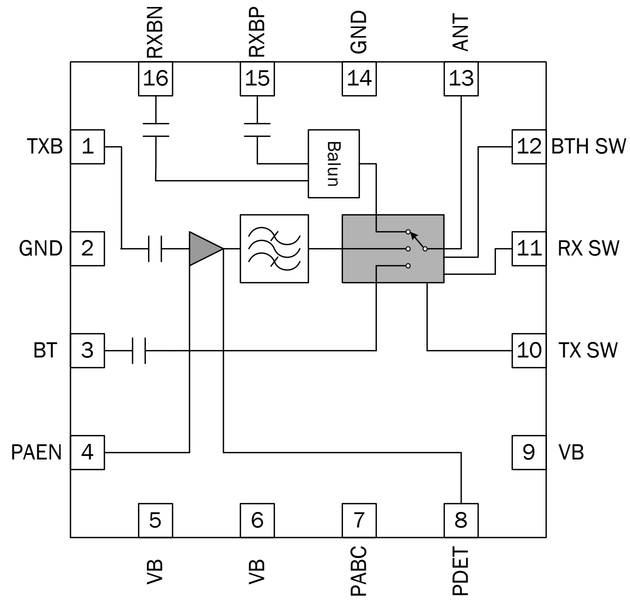
Features

- Single Voltage Supply 3.3V to 4.2V
- Integrated 2.5GHz b/g/n Amplifier, Rx Balun and Tx/Rx Switch and Directional Power Detector
- P_{OUT} = 17dBm, 11g, OFDM at ≤2.4% EVM and P_{OUT} = 21.5dBm, Meeting 11b Mask

Applications

Automotive WiFi

- Diagnostic
- Data
- Infotainment



Functional Block Diagram

Product Description

The RFFM3842Q FEM is a single-chip integrated front end module (FEM) for automotive WiFi. 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 front end module 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 3mm x 3mm x 0.45mm, 16-pin package. This module meets or exceeds the RF front end needs of 802.11b/g/n WiFi RF systems.

Ordering Information

RFFM3482QTR13X	Standard 1 piece
RFFM3482QSQ	Standard 25 piece bag
RFFM3482QSR	Standard 100 piece bag
RFFM3482QTR7	Standard 2500 piece reel
RFFM3482QPCK-41X	Fully Assembled Evaluation Board and 5 loose sample pieces

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Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage	5.6	V_{DC}
Full Specification Temp Range (Full Spec. Compliant)	-40 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	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.

RFMD Green: RoHS compliant per EU Directive 2002/95/EC, halogen free per IEC 61249-2-21, < 1000 ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony in solder.

Nominal Operating Parameters

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	17		dBm	54Mbps, OFDM, 64QAM meeting EVM requirement[1]
11b	19.5	21.5		dBm	Measured at 1Mbps meeting ACP1/ACP2 requirements
11n	13.5	16		dBm	MCS7, OFDM
EVM* 11g		2.4	3.5	%	RMS, mean, $P_{OUT(g)}$ = 15dBm
EVM* 11n		2.2	2.8	%	RMS, mean, $P_{OUT(n)}$ = 13.5dBm
ACP1		-36	-31	dBc	P_{OUT} = 19.5dBm, IEEE802.11b, 11Mbps CCK, 1Mbps BPSK modulation
ACP2		-56	-51	dBc	
Gain	26.5	33	38	dB	
Gain Variation	-3		+3	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} >3.0V to 3.3V there will be a 0.5dB degradation in 11g linear output power.
2. The Typical parameters are at nominal conditions. Min/Max parameters are over all conditions.

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4GHz Transmit Parameters (continued)					
Power Detect					
Voltage Detect	0		0.8	V	≤21dBm output power
P_{OUT} = 16dBm	0.260	0.31	0.380	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	RF P_{OUT} = 15dBm, 54Mbps IEEE802.11g
IEEE802.11b I_{CC}	200	220	240	mA	RF P_{OUT} = 19.5dBm, 11Mbps 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	3.3	3.6	4.2	V	
PA EN Voltage ON	1.6	1.8	2.0	V	PA is turned ON
PA EN Voltage OFF		0		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})					at 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	
Harmonics					RBW = 1MHz. Measured in CW.
Second			-30	dBc	4.80GHz to 5.00GHz
Third			-50	dBc	7.20GHz to 7.50GHz
Fourth			-60	dBc	
2.4GHz Receive Parameters					
Frequency	2.4		2.5	GHz	
Insertion Loss		2.1	2.5	dB	Switch and Balun
Noise Figure			2.5	dB	
Passband Ripple			0.3	dB	
Output Return Loss			-9	dB	
Output Impedance		100		Ω	No external matching

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4GHz Receive Parameters (continued)					
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	1.5	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		0.1	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
Simultation BT/RX	1	1	0	0
Calibration	0	1	0	1
	1	0	0	1
	1	1	0	1

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Pin Names and Descriptions

Pin	Name	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.

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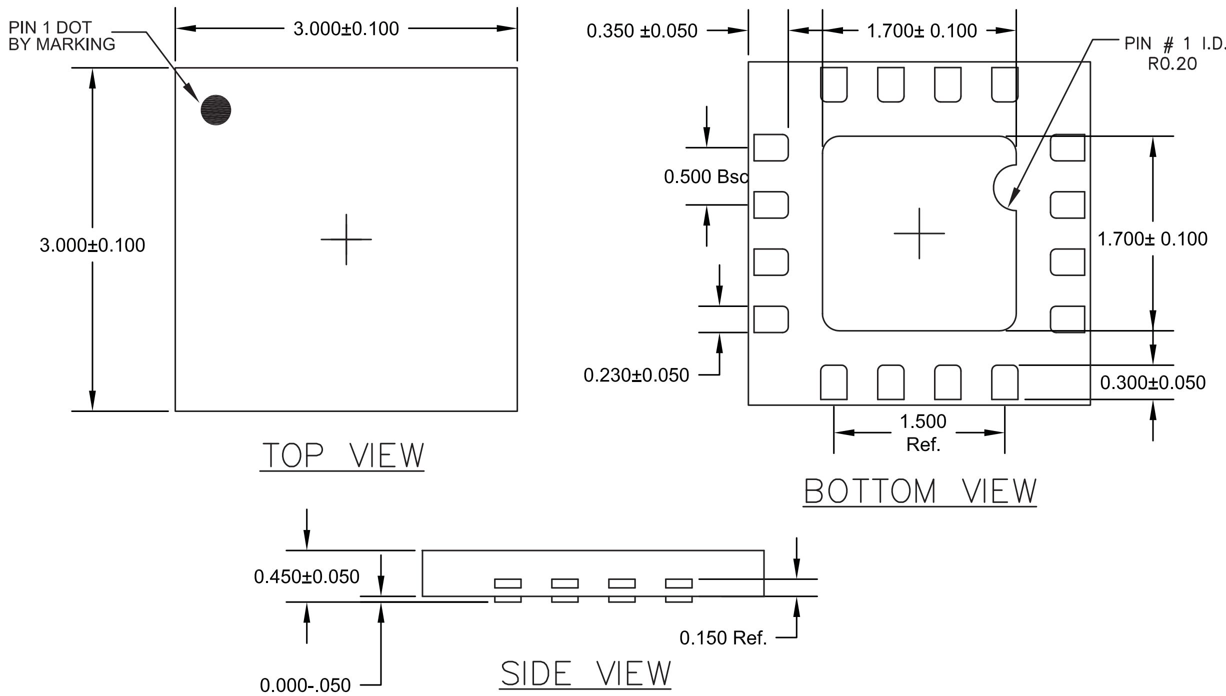
Package Drawing

QFN, 16-pin, 3mm x 3mm x 0.45mm



Notes:

1. Dimension applies to metallized terminal and is measured 0.25mm and 0.30mm from terminal tip.
2. Dimension represents terminal pull back from pacikage edge up to 0.1mm is acceptable.
3. Coplanarity applies to the exposed heat slug as well as hte terminal.

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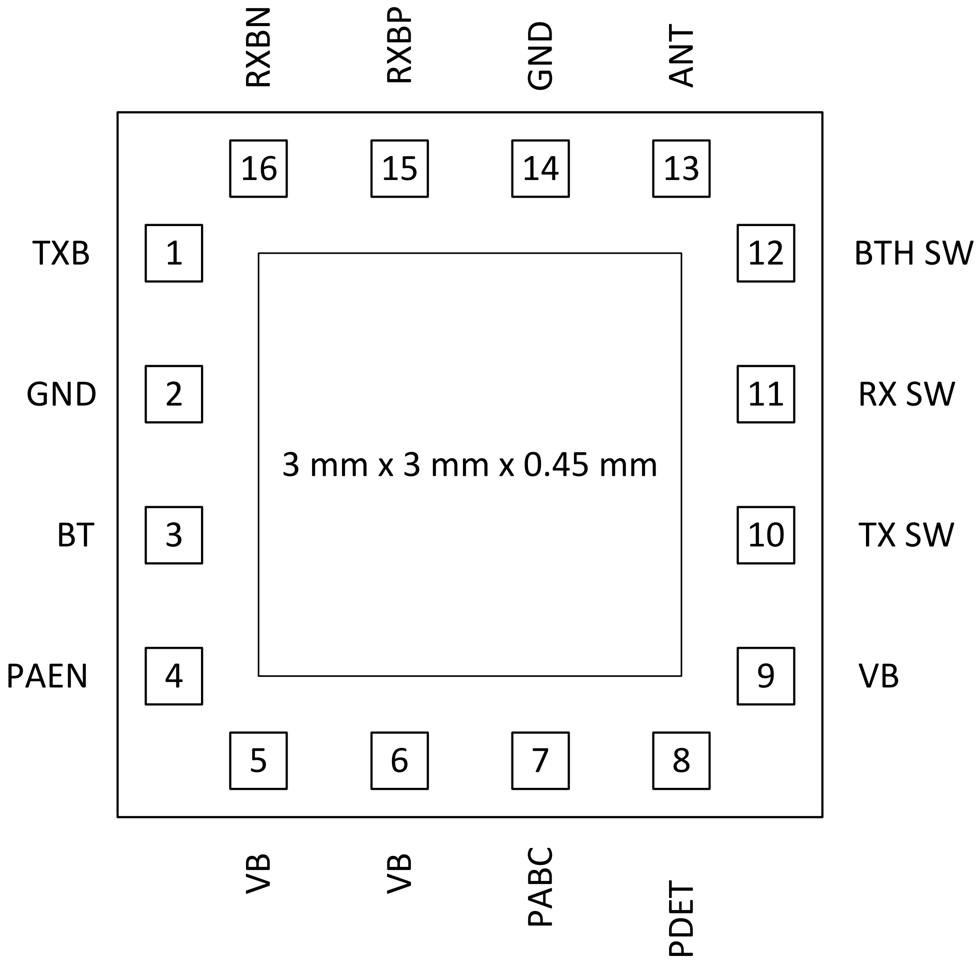
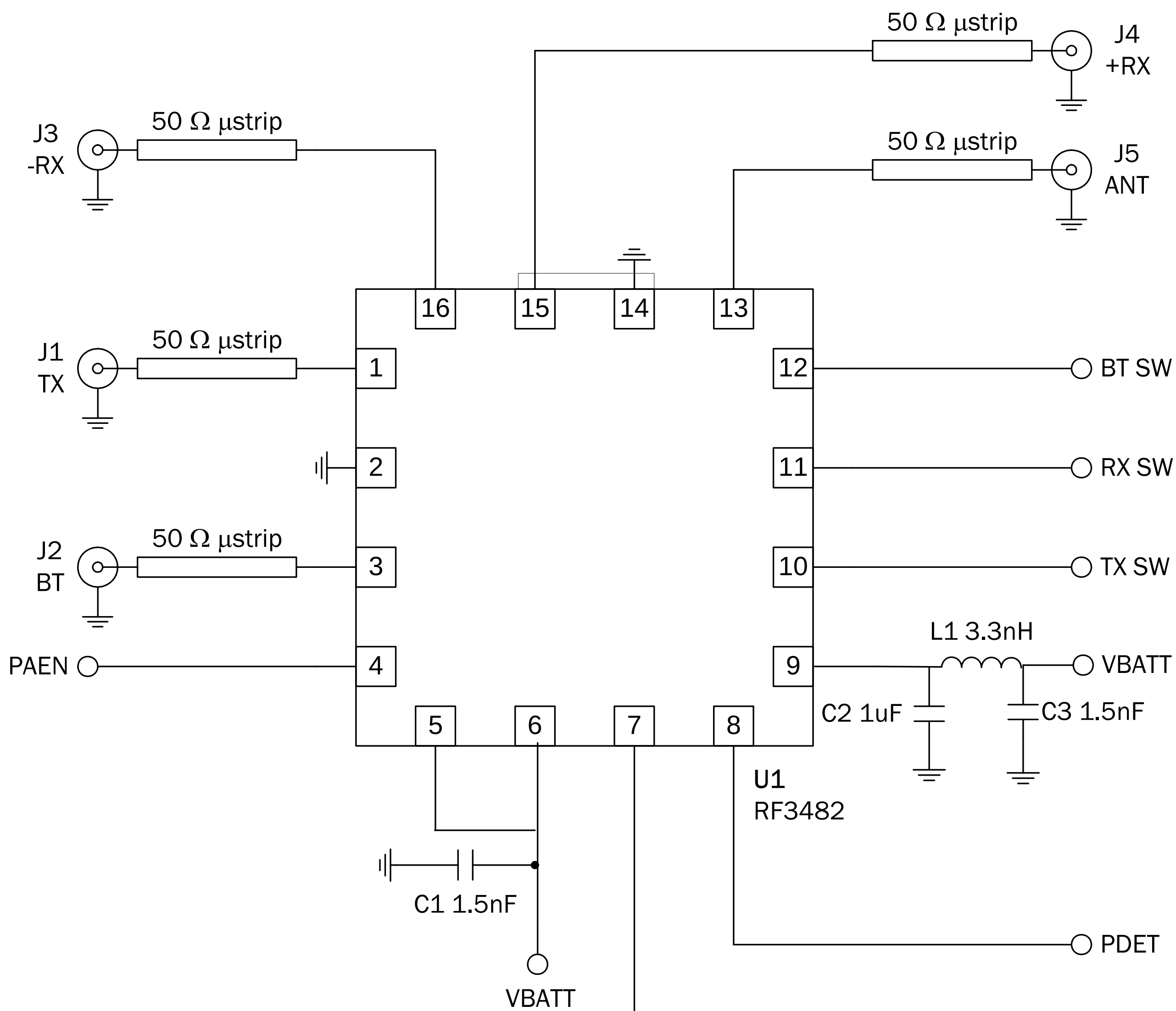
Pin Out


RXBN
RXBP
GND
ANT
16
15
14
13
TXB
1
12
BTH SW
GND
2
11
RX SW
3 mm x 3 mm x 0.45 mm
BT
3
10
TX SW
PAEN
4
9
VB
5
6
7
8
VB
VB
PABC
PDET

Application Schematic



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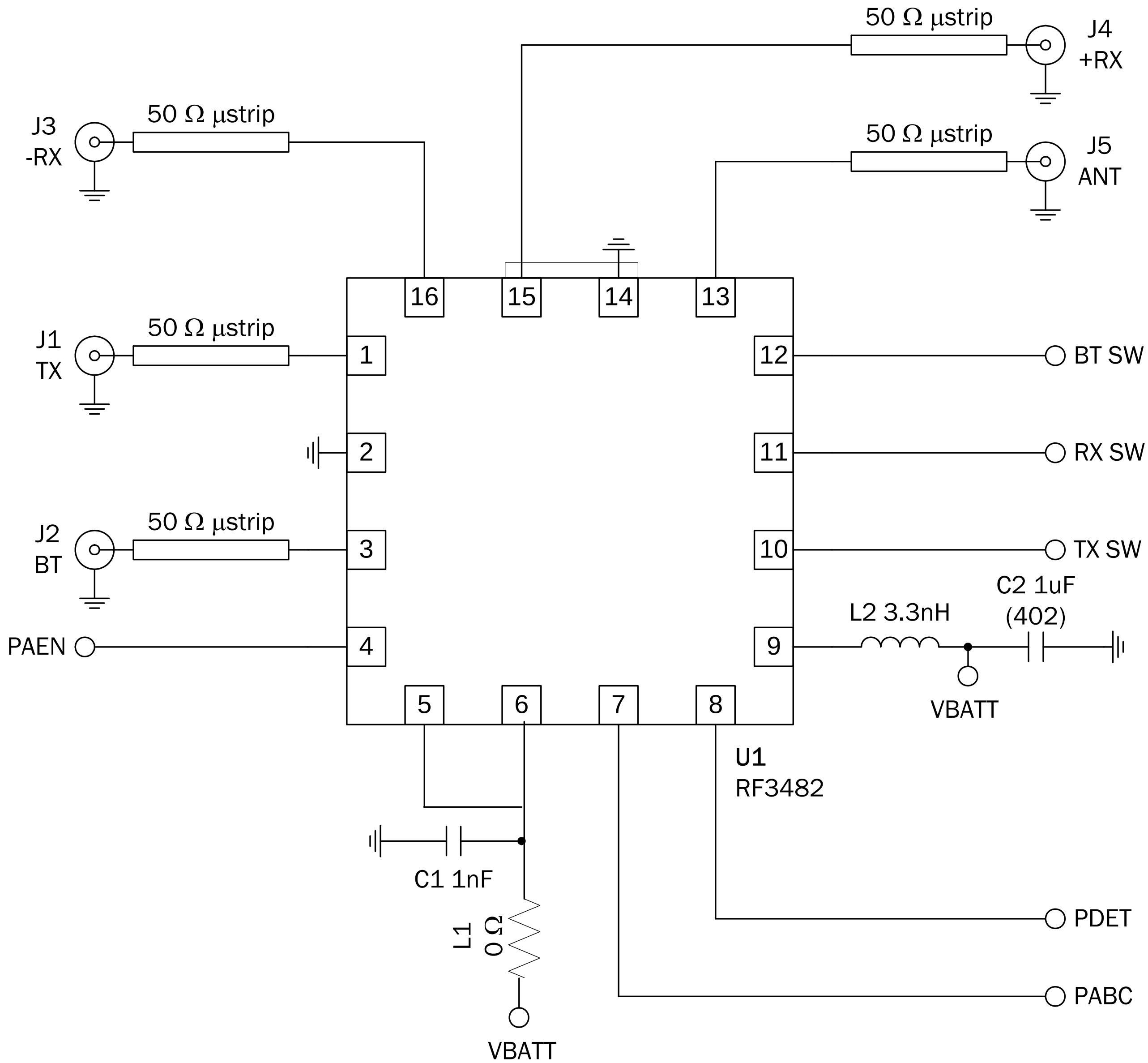
Evaluation Board Schematic



Theory of Operation

The RFFM3482Q 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 3mm x 3mm x 0.45mm, 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 RFFM3482Q 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 RFFM3482Q 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 RFFM3482Q is designed primarily for IEEE802.11 b/g/n WiFi applications where the available supply voltage and current are limited. The RFFM3482Q 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 RFFM3842Q 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 100Ω on each pin.

802.11b/g/n Transmit Path

The RFFM3482Q 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 RFFM3482Q requires a single positive supply of 3.3V to 4.2V 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 RFFM3482Q 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 a100Ω 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 RFFM3482Q can achieve then additional external filters will need to be added outside of the RFFM3482Q.

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RFFM3842Q Biasing Instructions:

- 802.11b/g/n Transmit (VB compliance = 5.5V, 400mA, PA EN compliance = 2V, ~450mA)
  - 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.

I_{BIAS} Table

WiFi PABC	Standard	Modulation	Units
IEEE 802.11b	CCK	1.8	mA
IEEE 802.11g	54OFDM	1.5	mA
IEEE 802.11n	MCS7	1.6	mA

PCB Design Requirements

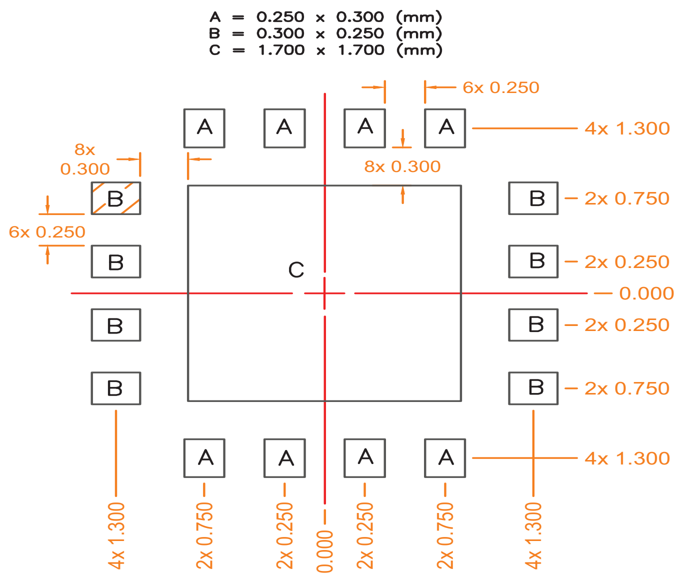
PCB Surface Finish

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



PCB METAL PATTERN

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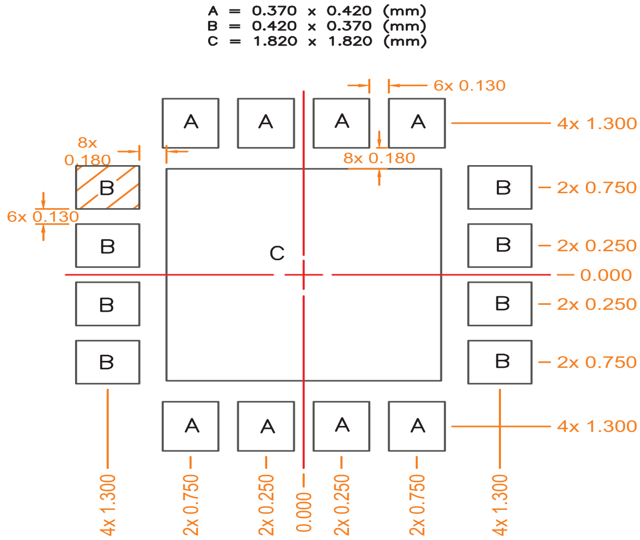
PCB Solder Mask Pattern

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.



PCB SOLDER MASK PATTERN

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.