RF5325

3.3V, 2.4GHZ 802.11b/g/n WIFI FRONT END MODULE

Package Style: QFN, 16-pin, 3.0mm x 3.0mm x 0.5mm
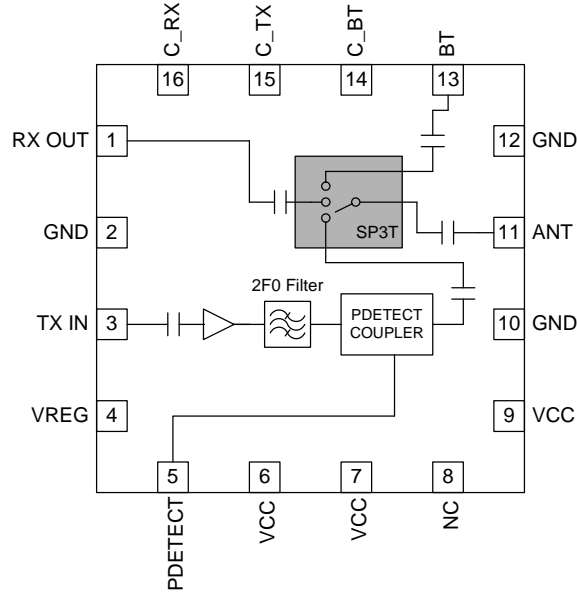
RoHS

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 3.0mm x 3.0mm x 0.5mm, 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

☐ GaAs HBT	☐ SiGe BiCMOS	☑ GaAs pHEMT	☐ GaN HEMT
☐ GaAs MESFET	☐ Si BiCMOS	☐ Si CMOS	☐ RF MEMS
☑ InGaP HBT	☐ SiGe HBT	☐ Si BJT	☐ LDMOS

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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 -30 to -15	°C
Storage Temperature	-40 to +150	°C
Antenna Port Nominal Impedance	50	Ω
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 EU Directive 2002/95/EC (at time of this document revision).

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4 GHz Transmit Parameters					
Compliance					IEEE802.11b, IEEE802.11g/n, FCC CFG 15.247, .205, .209
Conditions					Specifications met across V_{CC}, V_{REG}, and Temperature unless noted otherwise.
Frequency	2.4		2.5	GHz	
Output Power					
11g	17			dBm	$V_{CC} \geq 3.3\,V$, 54 Mbps, OFDM, 64 QAM meeting EVM requirement
11b	20.5			dBm	$V_{CC} \geq 3.3\,V$, Measured at 1 Mbps meeting ACP1/ACP2 requirements
EVM*		3.0	4.0	%	$P_{OUT(g)} = 17\,dBm$, 54 Mbps OFDM $V_{CC} \geq 3.3\,V$, 50 Ω
Adjacent Channel Power					
ACP1		-38	-32	dBc	$P_{OUT} = 20.5\,dBm$, IEEE802.11b, 1 Mbps CCK modulation
ACP2		-56	-52	dBc	$P_{OUT} = 20.5\,dBm$, IEEE802.11b, 1 Mbps CCK modulation
Gain	25	27		dB	
Gain Variation					
V_{CC} (instantaneous)			0.7	dB/V	V_{CC} range: 3.0 V to 4.5 V
Frequency	-0.5		+0.5	dB	2.4 GHz to 2.5 GHz
Power Detect					
Voltage Detect	0.1		1.4	V	Over P_{OUT} range 0 dBm to 23 dBm
Input Resistance		10		kΩ	
Input Capacitance			5	pF	
Sensitivity					
$P_{OUT} > 10\,dBm$	25			mV/dB	
$0 < P_{OUT} < 10\,dBm$	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.		
2.4 GHz Transmit Parameters, cont'd					
Current Consumption					
I_{CC}		130	160	mA	V_{CC}=3.3V, V_{REG}=2.85V, RF P_{OUT}=17 dBm, 11g, 50Ω
		160	200	mA	V_{CC}=3.3V, V_{REG}=2.85V, RF P_{OUT}=20.5 dBm, 11b, 50Ω
Idle		110		mA	V_{CC}=3.3V, V_{REG}=2.85V, and RF=OFF
I_{REG}		2	5	mA	V_{REG}=2.85V Typical
Leakage		5	10	µA	V_{REG}<0.2V
Power Supply	3.0	3.3	4.5	V	
V_{REG}	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=1 MHz. Measured at 1 Mbps.
Second		-33	-27	dBm	11b CCK BW=1 MHz, P_{OUT}=20.5 dBm, 4.80 GHz to 5.00 GHz
Third		-43	-40	dBm	11b CCK BW=1 MHz, P_{OUT}=20.5 dBm, 7.20 GHz to 7.50 GHz
Second		-33	-30	dBm	11g 6 Mbps. OFDM, P_{OUT}=17 dBm, 4.80 GHz to 5.00 GHz
Third		-48	-45	dBm	11g 6 Mbps. OFDM, P_{OUT}=17 dBm, 7.20 GHz to 7.50 GHz
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.		
2.4 GHz 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

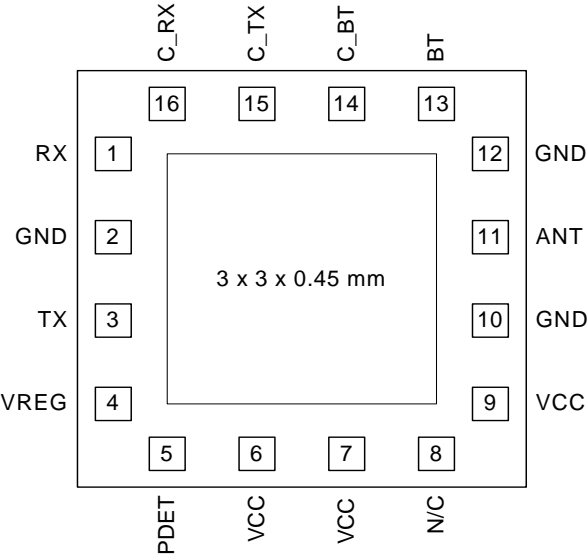*The FEM can simultaneously receive WiFi and _Bluetooth_® in the WiFi RX and BT RX Mode.

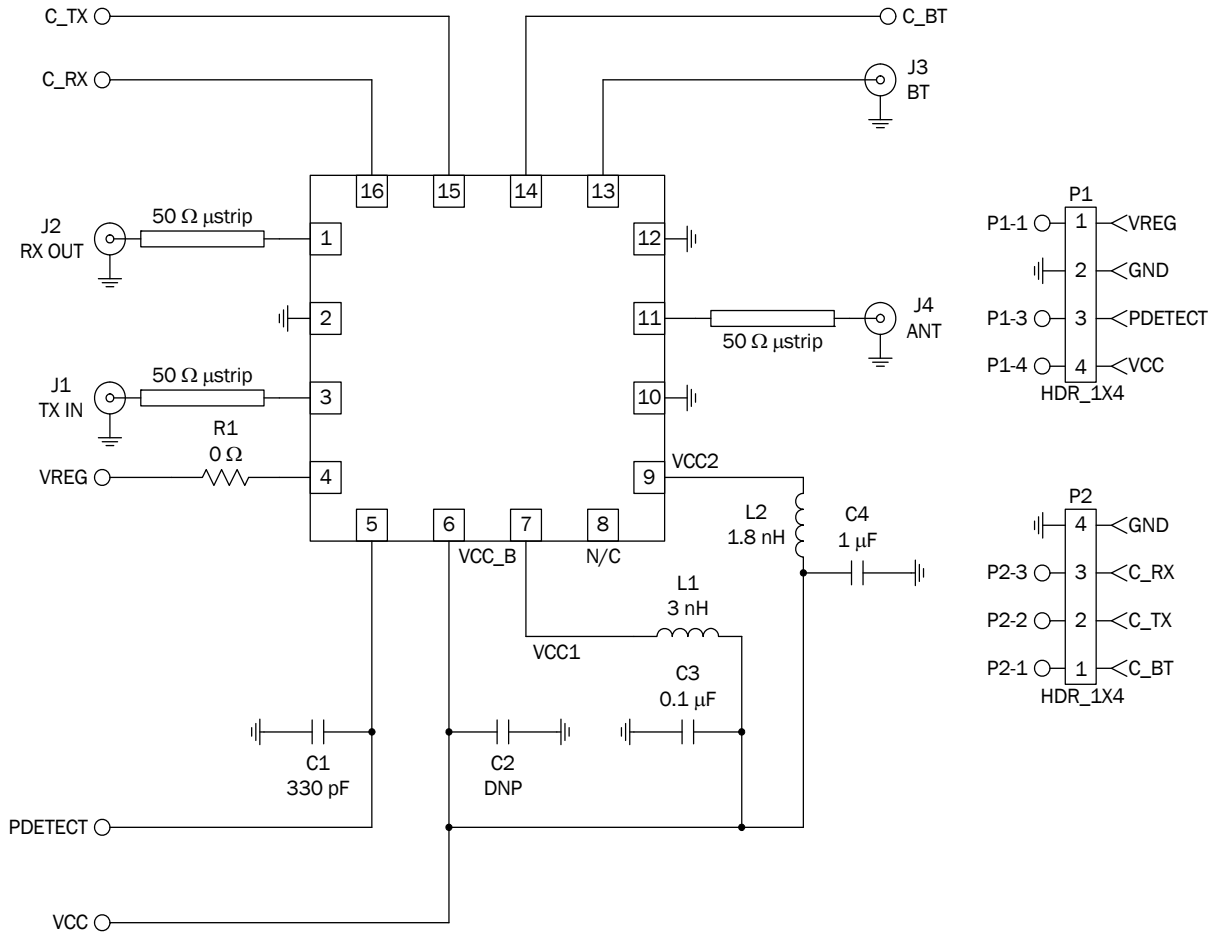| Pin	Function	Description
1	RX	Receive port for 802.11b/g/n band. Internally matched to 50Ω. DC block provided.
2	GND	Ground.
3	TX	RF input for the 802.11b/g/n PA. Input is matched to 50Ω and DC block is provided.
4	VREG	Digital enable pin for the 802.11b/g/n PA. This is an active high control. An external bypass capacitor may be needed on the V_{REG} 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
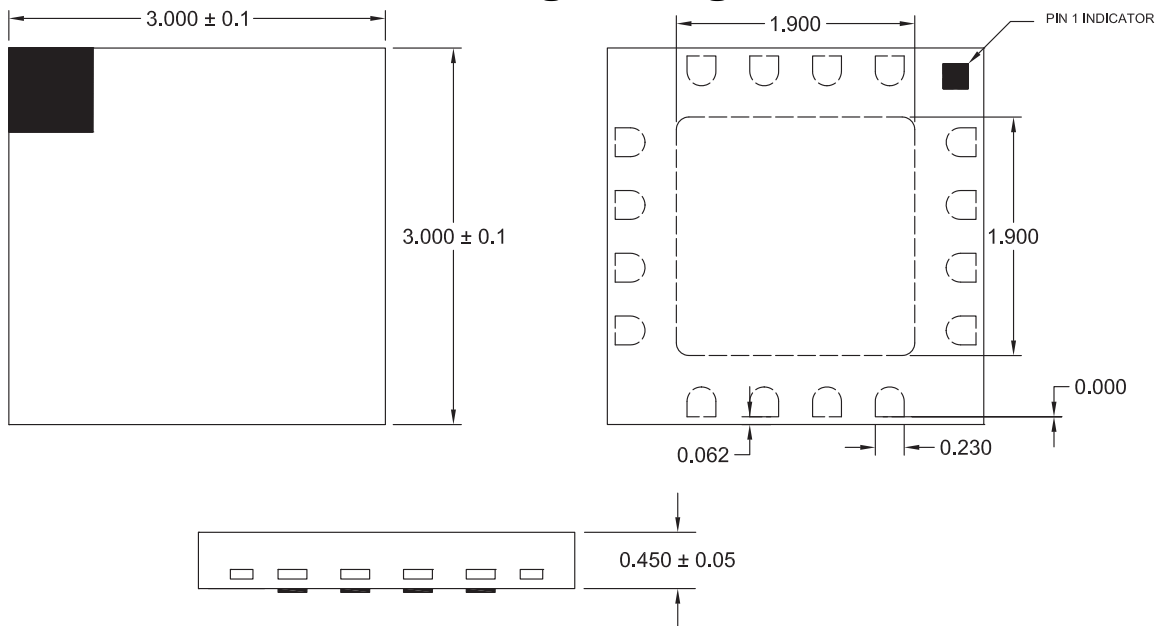
NOTES:
1   Shaded Area is Pin 1 Indicator

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Pin Out

Pin layout (3 x 3 x 0.45 mm):

- 16 — C_RX
- 15 — C_TX
- 14 — C_BT
- 13 — BT
- 1 — RX
- 2 — GND
- 3 — TX
- 4 — VREG
- 5 — PDET
- 6 — VCC
- 7 — VCC
- 8 — N/C
- 9 — VCC
- 10 — GND
- 11 — ANT
- 12 — GND

Evaluation Board Schematic

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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 (VREG). 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.

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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 ~100mA±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*® Receive
   - To Receive *Bluetooth*® set the switch control lines per the truth table below.

Switch Control Logic

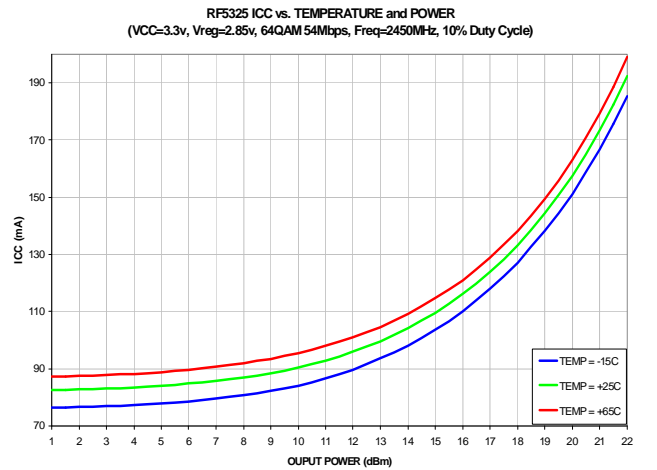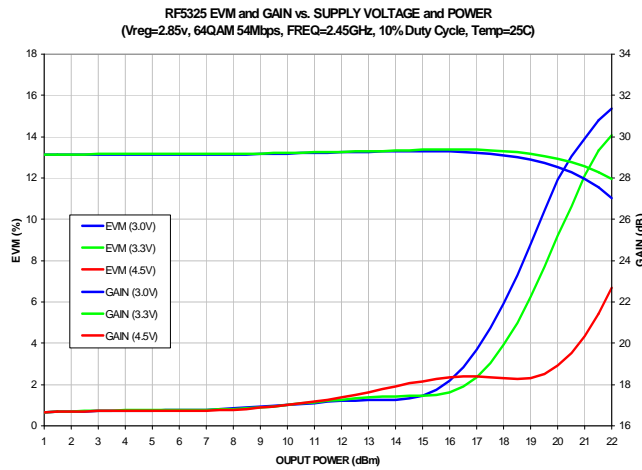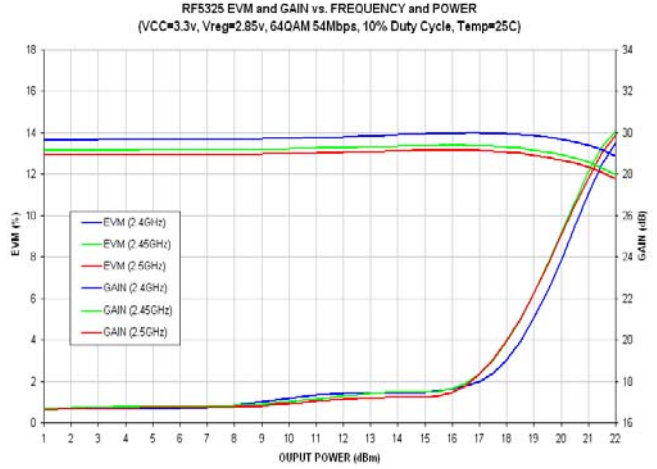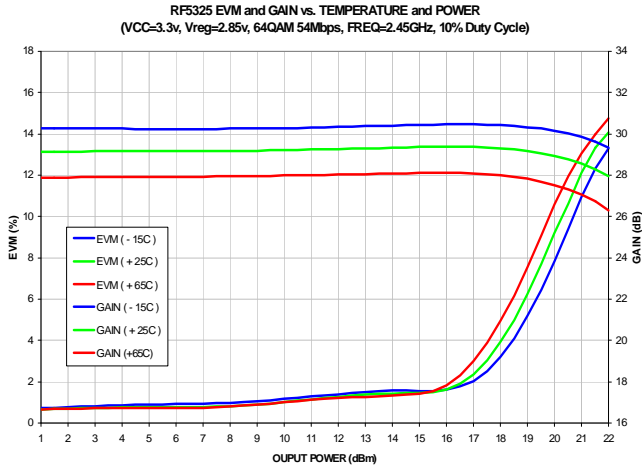| C_RX	C_TX	C_BT	Mode
L	L	H	Bluetooth®
L	H	L	WiFi TX
H	L	L	WiFi RX
H	L	H	WiFi RX and BT RX mode

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

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

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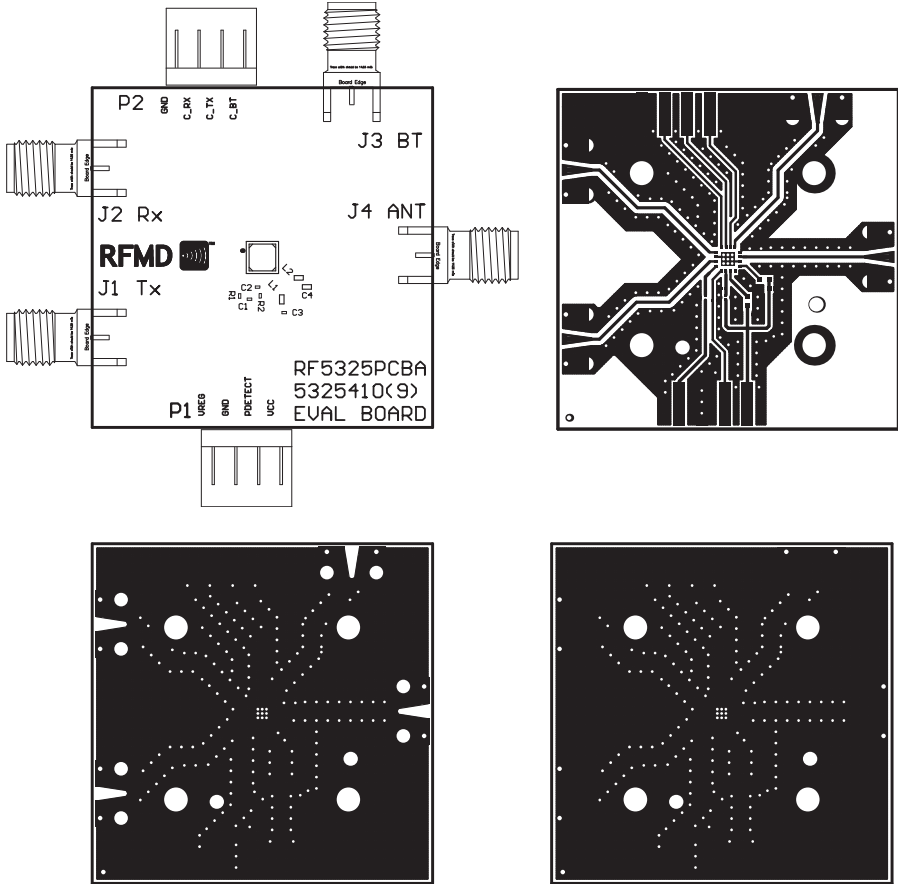
RF5325 Performance Graphs

RF5325 EVM and GAIN vs. TEMPERATURE and POWER
(VCC=3.3v, Vreg=2.85v, 64QAM 54Mbps, FREQ=2.45GHz, 10% Duty Cycle)

RF5325 EVM and GAIN vs. FREQUENCY and POWER
(VCC=3.3v, Vreg=2.85v, 64QAM 54Mbps, 10% Duty Cycle, Temp=25C)

RF5325 EVM and GAIN vs. SUPPLY VOLTAGE and POWER
(Vreg=2.85v, 64QAM 54Mbps, FREQ=2.45GHz, 10% Duty Cycle, Temp=25C)

RF5325 ICC vs. TEMPERATURE and POWER
(VCC=3.3v, Vreg=2.85v, 64QAM 54Mbps, Freq=2450MHz, 10% Duty Cycle)

RF5325 ICC vs. FREQUENCY and POWER
(VCC=3.3v, Vreg=2.85v, 64QAM 54Mbps, TEMP=25C, 10% Duty Cycle)

RF5325 ICC vs. SUPPLY VOLTAGE and POWER
(Vreg=2.85v, 64QAM 54Mbps, FREQ=2.45GHz, TEMP=25C, 10% Duty Cycle)

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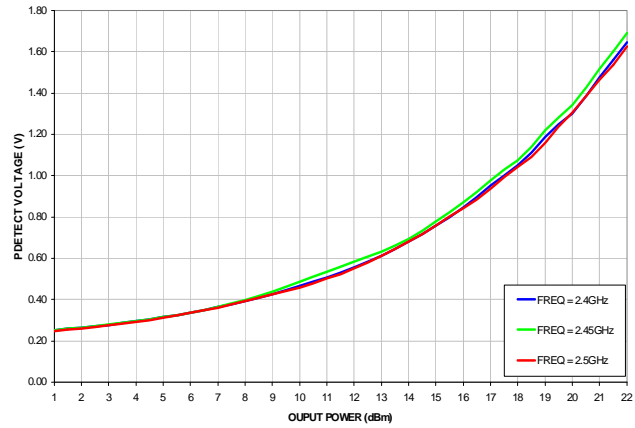
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RF5325 POWER DETECTOR VOLTAGE vs. TEMPERATURE and POWER
(VCC=3.3v, Vreg=2.85v, 64QAM 54Mbps, Freq=2450MHz, 10% Duty Cycle)
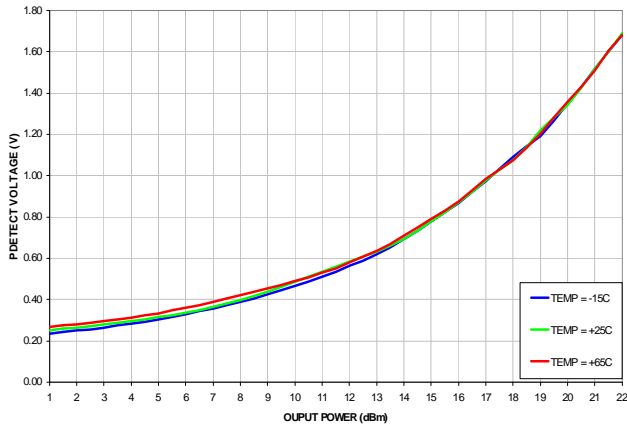
RF5325 POWER DETECTOR VOLTAGE vs. FREQUENCY and POWER
(VCC=3.3v, Vreg=2.85v, 64QAM 54Mbps, TEMP=25C, 10% Duty Cycle)

RF5325 POWER DETECTOR VOLTAGE vs. SUPPLY VOLTAGE and POWER
(Vreg=2.85v, 64QAM 54Mbps, FREQ=2.45GHz, TEMP=25C, 10% Duty Cycle)

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