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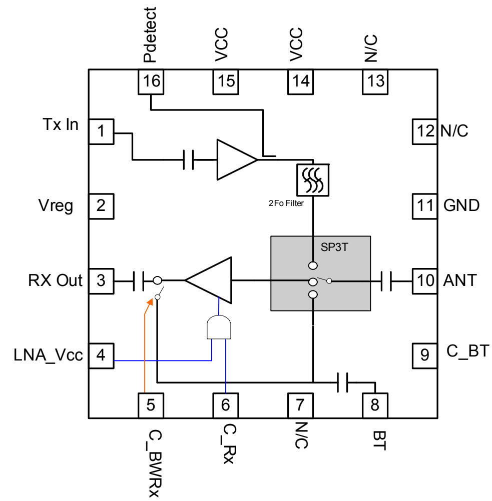
RF5765

2.4GHz to 2.5GHz 802.11b/g/n WiFi FRONT-END MODULE

Package Style: QFN, 16-pin, 3mmx3mmx0.5mm



Functional Block Diagram

Features

- Integrated 2.4GHz to 2.45GHz b/g/n Amplifier, LNA, SP3T Switch, and Power Detector Coupler
- Single Supply Voltage 3.0V to 4.8V
- P_{OUT}=20dBm, 11g, OFDM at <3.3% EVM, 23dBm 11b Meeting 11b Spectral 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

Product Description

The RF5765 provides a complete 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 RF5765 integrates a 2.4GHz Power Amplifier (PA), Low Noise Amplifier (LNA), power detector coupler for improved accuracy, and some filtering for harmonic rejection. The RF5765 is capable of receiving WiFi and *Bluetooth*® simultaneously. The device is provided in a 3mmx3mmx0.5mm, 16-pin package. This module meets or exceeds the RF Front End needs of IEEE 802.11b/g/n WiFi RF systems.

Ordering Information

RF5765SQ	Standard 25 piece bag
RF5765SR	Standard 100 piece reel
RF5765TR7	Standard 2500 piece reel (13")
RF5765PCK-410	Fully Assembled Evaluation Board with 5piece Sample

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

Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage (Continuous with No Damage)	5.4	V
DC Supply Current	500	mA
Full Specification Temp Range (Full Spec. Compliant)	-10 to +70	°C
Extreme Operating (Reduced Performance)	-40 to -10 +70 to +85	°C
Storage Temperature	-40 to +150	°C
Antenna Port Nominal Impedance	50	Ω
Maximum TX Input Power into 50Ω Load for 11b/g/n (No Damage)	0	dBm
Maximum RX Input Power (No Damage)	0	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).

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4 GHz Transmit Parameters					
Compliance					IEEE802.11b, IEEE802.11g, FCC CFG 15.247, .205, .209, EN, and JDEC
Operating Conditions					V_{CC}=3.0V to 4.2V (Spec Compliant); V_{CC} > 4.2V to 4.8V (Reduced Performance); V_{REG}=3.0V to 3.2V; Switch Control voltage = 3.0V to 3.6V; Temp=-10 °C to +70 °C (Spec Compliant); Temp=-30 °C to -10 °C and +70 °C to +85 °C (Reduced Performance). Unless noted otherwise.
Frequency	2.4		2.5	GHz	
Power Supply	3.0	3.3	4.2	V	Power Amplifier Voltage Supply (V_{CC})
V_{REG} Voltage					
ON	3.0	3.1	3.2	V	PA in “ON” state
OFF		0.00	0.20	V	PA in “OFF” state
Output Power					
11g	18	19.5		dBm	54 Mbps OFDM 64 QAM, V_{CC} > 3.0V, Temp=25 °C
	19	20		dBm	54 Mbps OFDM 64 QAM, V_{CC} > 3.3V, Temp=25 °C
11b	20	23		dBm	11 Mbps CCK signal, BT=0.45, V_{CC}>=3.3V, Temp=25 °C
EVM		3.3	4.0	%	P_{OUT}(g) = Rated Output Power, 54 Mbps OFDM, 50Ω, see note 1
Adjacent Channel Power					P_{OUT}(b) = 23 dBm, 11 Mbps CCK signal, V_{CC}>=3.3V, see note 4
ACP1		-36	-33	dBc	+/- 11 MHz Offset from carrier
ACP2		-56	-51	dBc	+/- 22 MHz Offset from carrier
Gain	26	30	34.5	dB	
Gain Variation Slope					At rated power and a given supply voltage
Range	3.0		4.8	V	
V_{CC} (Average)			0.5	dB/V	
V_{CC} (Instantaneous)			1	dB/V	
Frequency	-0.5		+0.5	dB	2.4 GHz to 2.5 GHz
Over Temperature	-1.75		+1.75	dB	V_{CC}=3.3V, V_{REG}=3.1V, Freq=2.45 GHz

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4GHz Transmit Parameters, continued					
Typical Input Power					
11g		-9		dBm	
11b		-5		dBm	
Power Detect					
Power Range	0		23	dBm	
Voltage Range	0.1		1.5	V	
Resistance		10		kΩ	
Capacitance			10	pF	
Sensitivity					
$0 < P_{OUT} < 6$ dBm	3			mV/dB	
$6 < P_{OUT} < 23$ dBm	8		350	mV/dB	
Current Consumption (I_{CC})					V_{CC}=3.3V, V_{REG}=3.1V, T=25°C
Quiescent Current		90		mA	RF="OFF" I_{CQ} variation from nominal +/- 20mA
11g		170	200	mA	RF P_{OUT}=18.5dBm, 11g, 50Ω
11b		220	290	mA	11Mbps CCK signal, BT=0.45, Rated Output Power, V_{CC}=3.3V, Temp=25°C, 50Ω
I_{REG}			3	mA	V_{REG}>3.0V
V_{CC} Leakage Current		2	10	µA	V_{CC}=4.8V, V_{REG}=C_BT=C_RX=C_BWRX≤0.2V
Input Port Impedance		50		Ω	
Input Port Return Loss	10	15		dB	
Ruggedness					No Damage Conditions: max operating voltage, max input power, max temperature
Output VSWR			10:1		
Input Power			-5	dBm	
Stability					PA must be stable from 0dBm to 20dBm. No spurs above -41.25dBm for non-harmonic related signals.
Output VSWR	6:1				CW signal, P_{OUT}=20dBm, all phases
Out-of-Band Emissions 2310MHz to 2390MHz and 2483.5MHz to 2500MHz (FCC restricted bands)			-41.25	dBm/MHz	P_{OUT}=16.5dBm, 54Mbps OFDM Modulation, 64QAM, RBW=1MHz, VBW=100kHz, V_{CC}=3.3V, V_{REG}=3.1V
			-41.25	dBm/MHz	P_{OUT}=20.5dBm, 11Mbps CCK Modulation, BT=0.45, RBW=1MHz, VBW=100kHz, V_{CC}=3.3V, V_{REG}=3.1V
Thermal Resistance		20			V_{CC}=4.8V, V_{REG}=3.2, P_{OUT}=20dBm, T_{REF}=85°C
Harmonics					11b modulation, 1Mbps, BW=1MHz, up to 3:1 load, P_{OUT}=20dBm
Second			-23	dBm	4.80GHz to 5.00GHz
Third			-20	dBm	7.20GHz to 7.50GHz
Turn-on/off Time		0.5	1.0	µS	Output stable to within 90% of final gain, Note 1

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4GHz Receive Parameters					
Compliance					IEEE802.11b, IEEE802.11g, FCC CFG 15.247,.205,.209, EN, and JDEC
Frequency	2.4		2.5	GHz	
LNA Voltage Supply (LNA V_{CC})	3.0	3.3	4.2	V	LNA V_{CC} can be tied to V_{BATT} at all times
LNA Current		10		mA	LNA in “ON” state
	0		5	μA	LNA in “OFF” state (C_RX=low, LNA V_{CC}=ON)
LNA Input P1dB	-8	-7		dBm	
Gain					
WiFi RX Gain	16	18	20	dB	WiFi RX mode
Simultaneous WiFi/BT RX Mode	11	13	15	dB	WiFi RX/BT Mode, LNA “ON”
Noise Figure					$V_{CC} \geq 3.3V$, including switch
WiFi RX		2.1	3.5	dB	WiFi RX mode (LNA “ON”)
Simultaneous WiFi/BT RX Mode		3	4	dB	WiFi RX/BT Mode (LNA “ON”)
Passband Ripple	-0.2		+0.2	dB	WiFi RX Mode
	-0.5		+0.5	dB	WiFi RX/BT Mode
WiFi RX Port Return Loss	9.6			dB	
	5			dB	Switch in WiFi RX/Bluetooth Mode
WiFi RX Port Impedance		50		Ω	No external matching
Bluetooth Parameters					
Frequency	2.4		2.5	GHz	
Insertion Loss					
BT TX/RX only		1.2	1.5	dB	Bluetooth mode
BT/WiFi RX GAIN (simultaneous mode)	11	13	15	dB	WiFi RX/BT Mode, LNA “ON”
Passband Ripple	-0.2		+0.2	dB	Bluetooth mode
	-0.5		+0.5	dB	WiFi RX/BT mode
Input P1dB	27	30		dB	BT Mode, over temp, C_BT=3.3V to 3.6V
Bluetooth Port Return Loss	9.6			dB	Switch in Bluetooth Mode
	7			dB	Switch in WiFi RX/Bluetooth Mode
Other Requirements					
Antenna Port Impedance					
Output		50		Ω	
Return Loss		10		dB	
Isolation					
Antenna to Receive	20			dB	In BT Mode (measured from ANT to RX port)
Antenna to *Bluetooth*®	20			dB	In TX Mode (measured from ANT to BT port)
Antenna to Receive	20			dB	In TX Mode (measured from ANT to RX port)
Switch Control Voltage					C RX, C BT, and C BW RX control lines
Low		0	0.2	V	Switch is in the low state (L)
High	1.7	3.3	3.6	V	Switch is in the high state (H)
Switch Control Current		2	10	μA	Per control line (C_BT, C_BWRX)
C_RX Current			100	μA	Over V_{CC}, Frequency and Temperature.
Switch Control Speed			100	μs	
Switch P1dB		28		dBm	

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Other Requirements, continued					
ESD					
Human Body Model	500			V	EIA/JESD22-114A RF pins
	1000			V	EIA/JESD22-114A DC pins
Charge Device Model	500			V	JESD22-C101C all pins

Note 1: The PA module must operate with gated bias voltage input at 1% to 99% duty cycle.
Note 3: Values to be agreed to upon characterization data review: current, gain, return loss, detector sensitivity and output power.
Note 4: The output power for channels 1 and 11 may be reduced to meet FCC restricted band requirements.

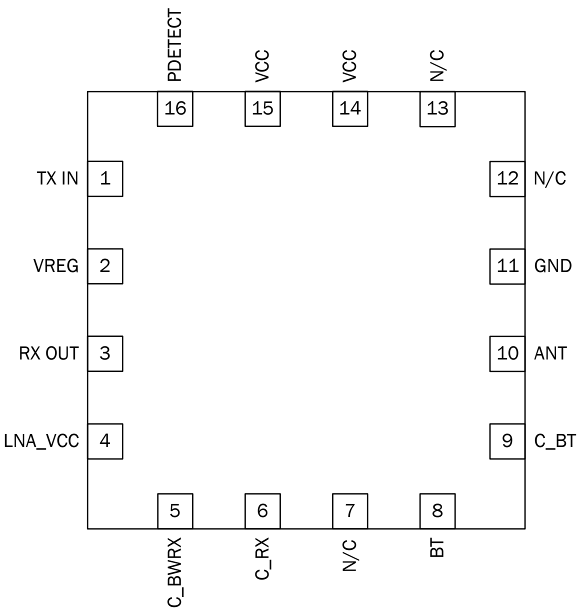
Switch Control Logic

Mode	VREG	C RX	C BT	C BWRx
Standby	L	L	L	L
WiFi TX	H	L	L	L
WiFi RX	L	H	L	L
WiFi RX/BT*	L	H	L	H
BT RX	L	L	H	L
BT TX	L	L	H	L

*The FEM can be placed in receive WiFi and *Bluetooth*® modes simultaneously with increased insertion loss.

Pin	Function	Description
1	TX_IN	RF input for the 802.11b/g PA. Input is matched to 50Ω and DC block is provided.
2	VREG	Regulated voltage for the bias control circuit, and the TX control port of the SP3T which is also tied to this pin. An external bypass capacitor may be needed on the V_{REG} line for decoupling purposes.
3	RX OUT	Receive port for 802.11b/g band. Internally matched to 50Ω. DC block provided.
4	LNA VDD	Voltage supply for the LNA.
5	C_BWRX	SPST switch control pin. (Simultaneous WiFi and BT receive.) See truth table for proper level.
6	C RX	Receive switch control pin. See switch truth table for proper level.
7	N/C	No connect.
8	BT	RF bidirectional port for *Bluetooth*®. Input is matched to 50Ω and DC block is provided.
9	C_BT	*Bluetooth*® switch control pin. See truth table for proper level.
10	ANT	Port matched to 50Ω and is DC blocked internally.
11	GND	Ground.
12	N/C	No connect.
13	N/C	No connect.
14	VCC	Supply voltage for the PA.
15	VCC	Supply voltage for the bias circuit of the PA.
16	PDETECT	Power detector voltage for TX section. PDET voltage varies with output power. May need external decoupling capacitor for noise bypassing. May need external circuitry to bring output voltage to desired level.

Pin Out



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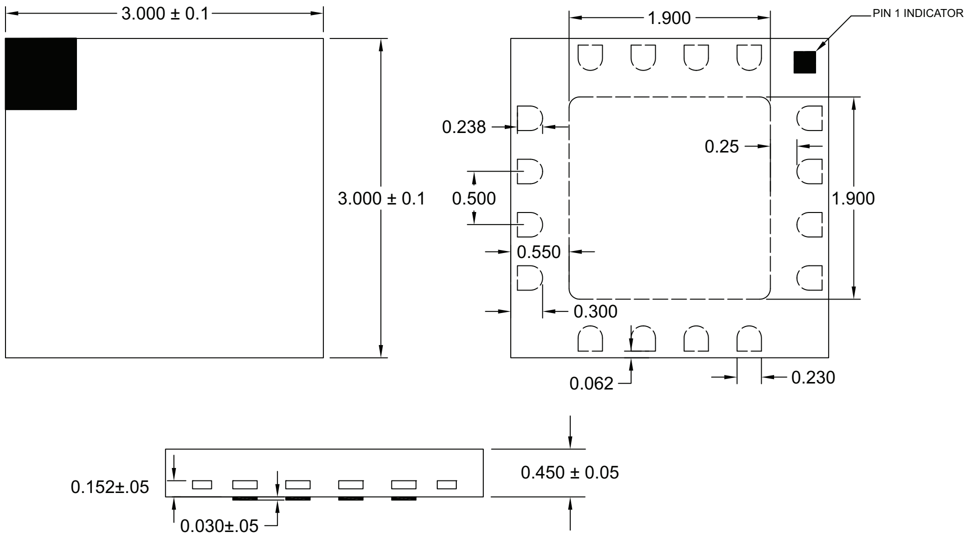
Package Drawing



NOTES:

1 Shaded Area is Pin 1 Indicator

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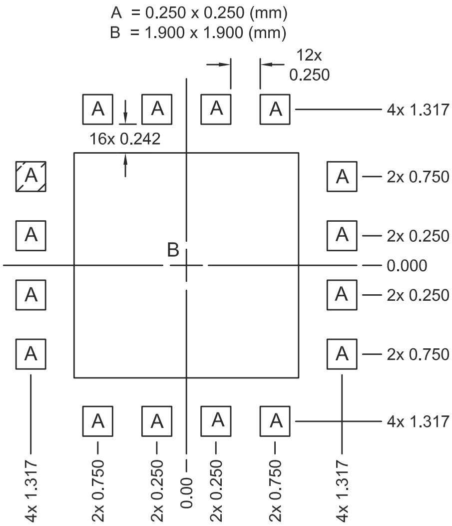
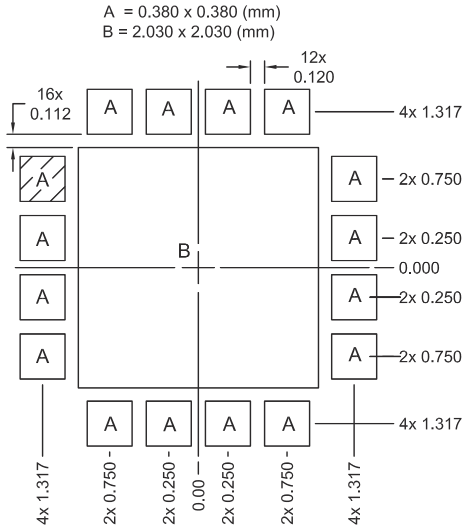
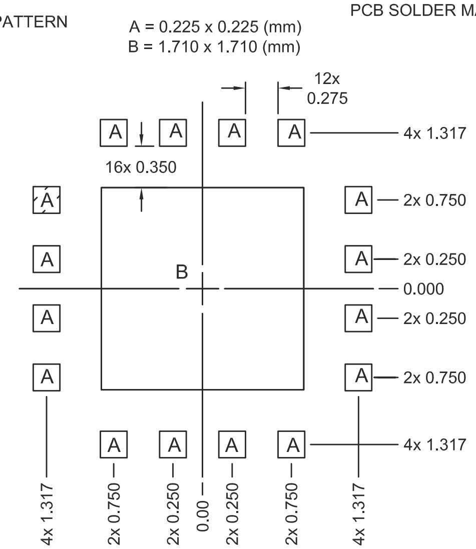
RF5765 PCB Footprint and Stencil Recommendations



PCB METAL LAND PATTERN



PCB SOLDER MASK PATTERN



PCB STENCIL PATTERN

Shaded are represents Pin 1 location.

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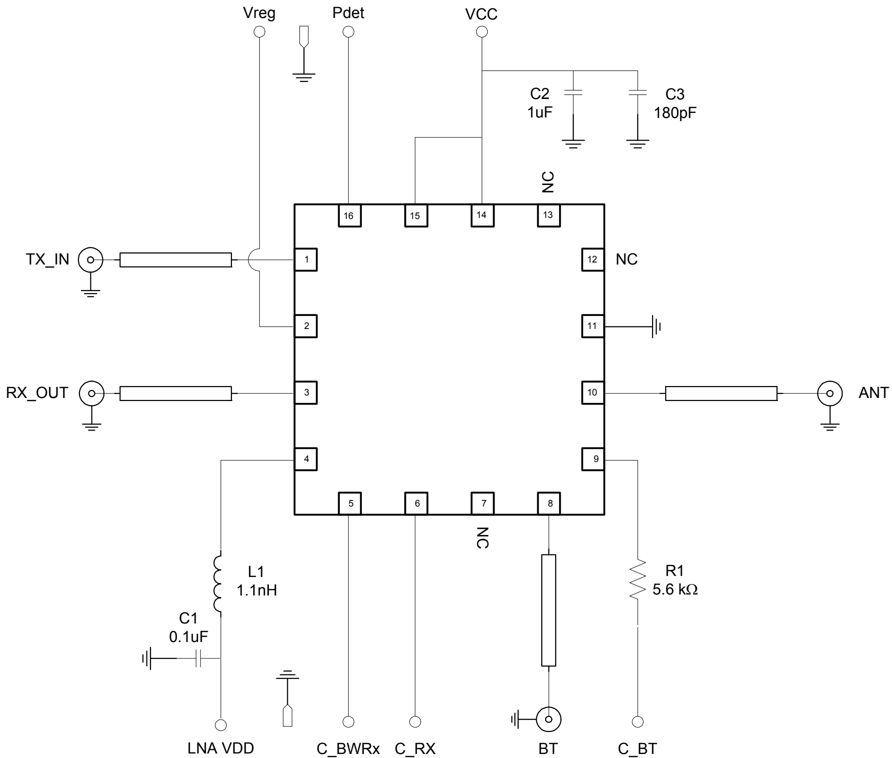
Application Schematic



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Theory of Operation

The RF5765 Front End Module (FEM) is designed for WiFi applications in the 2.5GHz ISM band. It can be applied in many portable applications such as handsets, Portable Media Players, and portable battery power equipment. This highly integrated module can be connected directly to the battery without additional voltage regulators.

WiFi TRANSMIT MODE

The RF5765 requires a single positive supply (V_{CC}), a positive supply for switch controls, and a regulated supply for the V_{REG} to maintain nominal bias current. The RF5765 transmit path has a typical gain of 30dB from 2.4GHz to 2.5GHz, and delivers 20dBm typical output power under 54Mbps OFDM modulation and 23dBm under 1Mbps 11b modulation. The RF5765 contains basic filter components to produce a bandpass response for the transmit path. Due to space constraints inside the module, filtering is limited to a few resonant poles and additional filters may be required depending upon the end-user's application. While in transmit mode, the active components are the Power Amplifier (PA) and the TX branch of the SP3T switch. Refer to the logic control table for proper settings.

TX Biasing Instructions

- Connect the TX input (pin-1) to a signal generator and a spectrum analyzer at the Antenna output (pin-10)
- Set V_{CC} to 3.3V with V_{REG} set to 0V
- Turn V_{REG} ON and set voltage to 3.1V. V_{REG} controls the current drawn by the PA and it should quickly reach a quiescent current of approximately 90mA±20mA. Care must be exercised not to exceed 3.5V on the V_{REG} pin or the part may be damaged.
- Control bias to the transmit branch of the SP3T switch is tied directly to V_{REG}
- The SP3T controls for the off branches (C_RX and C_BT) must be set to a logic "low" (0.2V max) or grounded. In the event that one of these branches is left floating or in a logic "high" the performance of the PA will degrade significantly. Likewise, unused RF Ports must be terminated in 50Ω to simulate actual system conditions and prevent RF signals from coupling back to the PA.
- Turn RF ON

WiFi RECEIVE MODE

Within the frequency band of operation 2.4GHz to 2.5GHz, the RF5765 WiFi receive path has a typical gain of 18dB and a NF of 2.1dB with about 10mA of current. In RX mode, only the RX branch of the SP3T and the LNA are active. Refer to the logic control table for proper settings.

RX Biasing Instructions

- Connect the RX input (ANT/pin-10) to a signal generator and a spectrum analyzer at the RX output (pin-3). A VNA may be used as well.
- Turn the LNA bias ON (pin-4) and set the voltage to 3.3V
- Set C_RX (pin-6) high. This turns ON the receive branch of the SP3T.
- The SP3T controls for the off branches (V_{REG} and C_BT) must be set to a logic "low" (0.2V max) or grounded. In the event that one of these branches is left floating or in a logic "high" the performance will degrade. It is recommended to terminate unused RF Ports in 50Ω.
- Set the control bias for the SPST switch (C_BWRX/pin-5) "low" during WiFi RX only mode.
- Turn RF ON

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WiFi and *BLUETOOTH*® RECEIVE (SIMULTANEOUS MODE)

The RF765 WiFi and *Bluetooth*® receive circuits were specifically designed to address issues of simultaneous operation. In this mode both signals can be received at the same time when the C_BWRX (pin-5) is set high. The typical gain for each RF path is approximately 13dB and a NF of 3dB. During simultaneous mode the active components are the LNA, the SPST switch, and only the RX branch of the SP3T. Refer to the logic control table for proper settings.

Simultaneous Mode Biasing Instructions

- Connect the RF input (ANT/pin-10) to a signal generator and a spectrum analyzer at the RX (pin-3) and BT (pin-8) RF ports. A multiport VNA may be used as well.
- Turn the LNA bias ON (pin-4) and set the voltage to 3.3V
- Set C_RX and C_BWRX high. This turns ON the receive branch of the SP3T and the SPST switch.
- The SP3T controls for the off branches (V_{REG} and C_BT) must be set to a logic "low" (0.2V max) or grounded. In the event that one of these branches is left floating or in a logic "high" the performance will degrade. It is recommended to terminate unused RF Ports in 50Ω.
- Turn RF ON

BLUETOOTH® MODE

The RF765 *Bluetooth*® only mode is implemented through the SP3T switch by setting C_BT "high." Typical insertion loss is about 1.2dB.

Bluetooth® Biasing Instructions

- Connect the RF input (ANT/pin-10) to a signal generator and a spectrum analyzer at the BT RF port. A VNA may be used in place of the Sig Gen and SA.
- Set C_BT (pin-9) "high." This turns the *Bluetooth*® branch of the SP3T switch ON.
- The SP3T controls for the off branches (V_{REG} and C_RX) must be set to a logic "low" (0.2V max) or grounded. Do not leave floating.
- Terminate unused RF Ports in 50Ω
- Turn RF ON

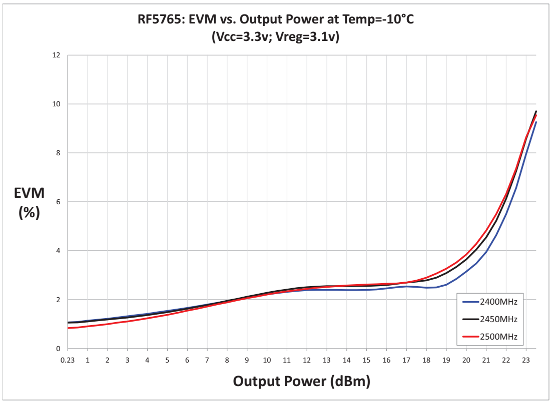
APPLICATION CIRCUIT AND LAYOUT RECOMMENDATIONS

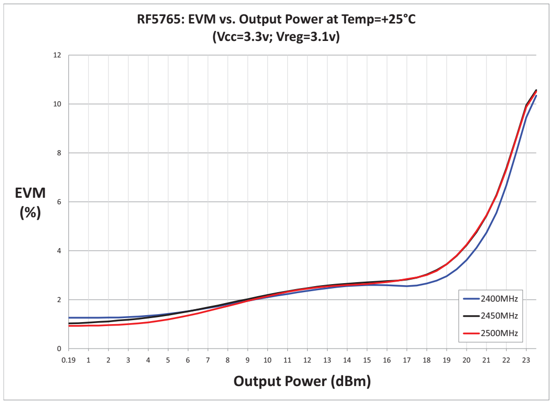
The RF5765 integrates the matching networks and DC blocking capacitors for all RF ports. This greatly reduces the number of external components and layout area needed to implement this FEM. Typically only a total of four external components are required to achieve nominal performance. However, depending on board layout and the many noise signals that could potentially couple to the RF5765, additional bypassing capacitors may be required to properly filter out unwanted signals that might degrade performance.

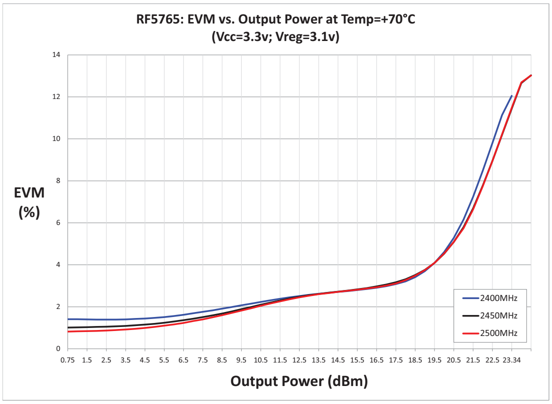
The LNA bias components consist of an inductor and a decoupling capacitor. The inductor value is critical to optimize NF and return loss at the RX output. For best performance and trade off between critical parameters such as NF, Gain, and IP3, the total inductance including board trace should be approximately 1.2nH. The 5.6kΩ series resistor for the *Bluetooth*® control line helps to prevent unwanted signal from coupling to this pin. The resistor should be place as close as possible to the package pin. The last component needed in the application circuit is a low frequency bypass capacitor on the V_{CC} line. In general, it is good RF practice to have proper decoupling of supply lines to filter out noise. Occasionally, depending on the level of coupling or parasitics of the board, a high frequency bypass capacitor must be added as well.

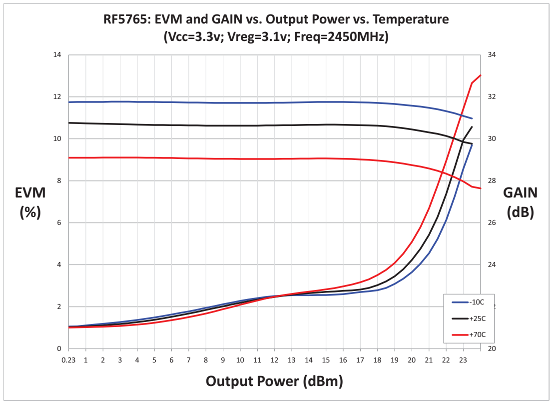
In order to optimize performance for both the Transmit and Receive paths, a good layout design must be implemented. In addition to designing 50Ω RF lines, proper grounding along the RF traces and on the FEM ground slug must be exercised. This will minimize coupling and provide good thermal dissipation when the PA is operating at high power. For reference, the RFMD evaluation board uses 9 thermal ground vias (hole/capture pad 12/22mil) on the ground slug. Additionally, if space permitted, V_{CC} and control lines must be isolated from each other with ground vias in between them. RFMD evaluation board gerbers are available upon request.

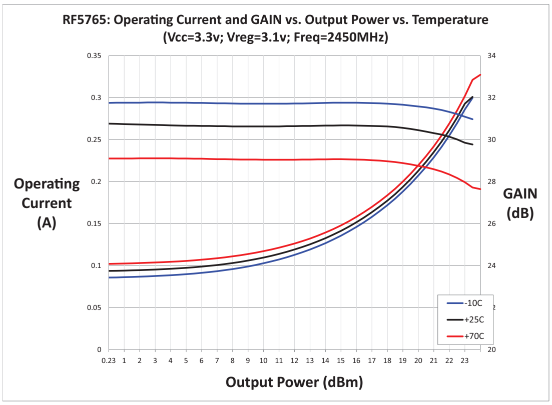
RF5765 Transmit Performance Graphs

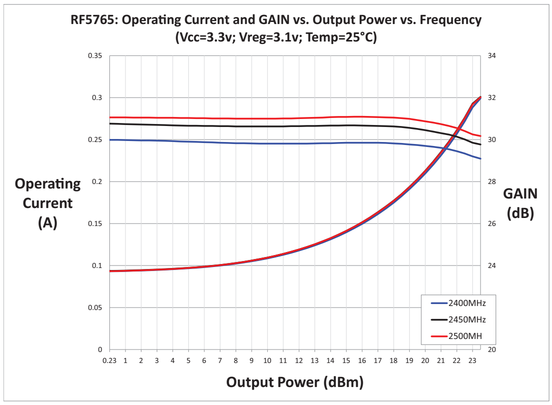




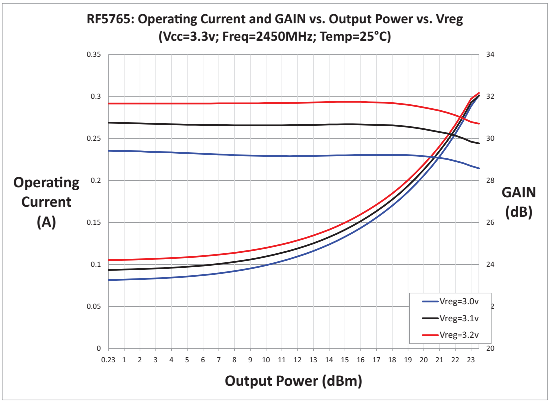


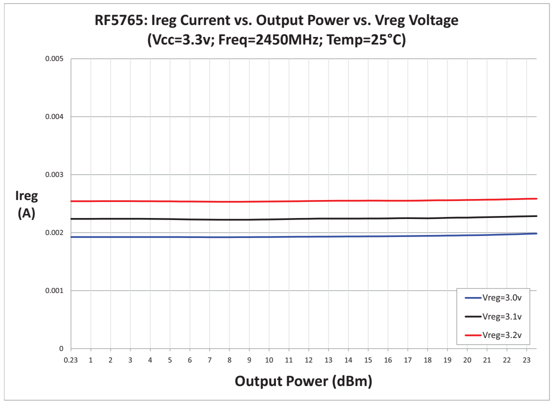


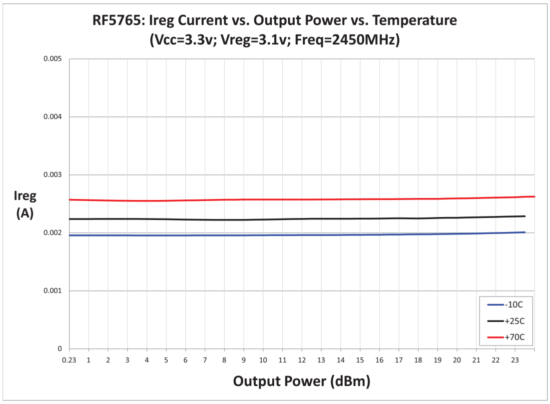


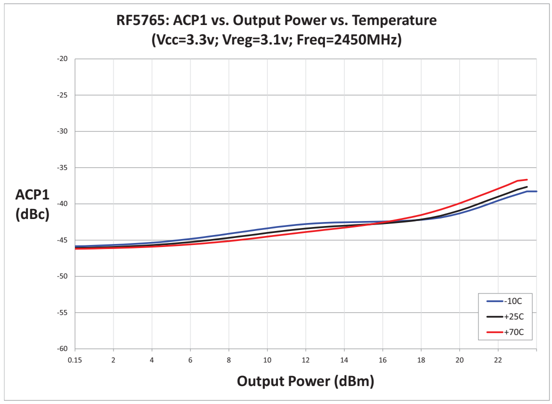


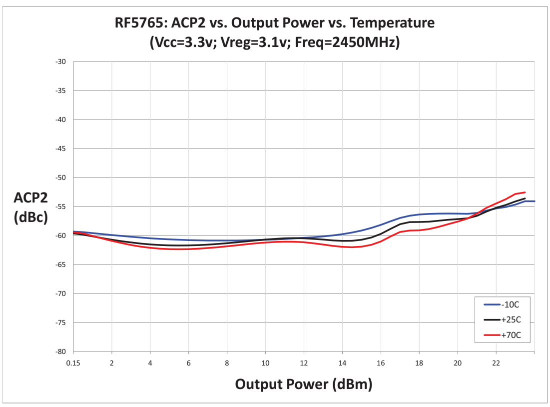
RF5765 Transmit Performance Graphs (continued)











RF5765 Receive Performance Graphs