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RF2172

ISM BAND 3.6V, 250mW AMP WITH ANALOG GAIN CONTROL

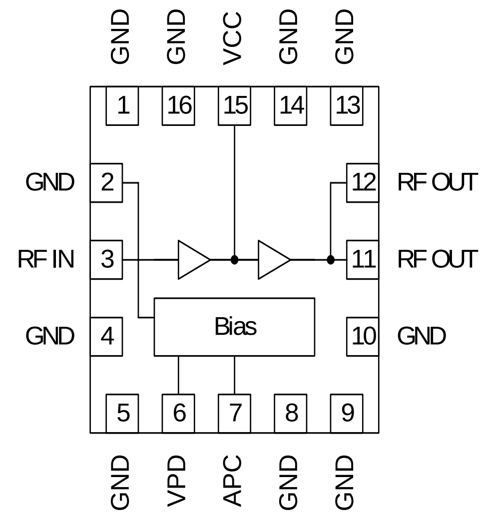
RoHS Compliant and Pb-Free Product
Package Style: QFN, 16-Pin, 4x4

Features

- 23.5dBm Typical Output Power
- 0dB to 28dB Variable Gain
- 45% Efficiency at Max Output
- On-Board Power Down Mode
- 2.4GHz to 2.5GHz Operation
- 902MHz to 928MHz Operation

Applications

- *Bluetooth*™ PA
- 2.4GHz to 2.5GHz ISM Band Systems
- 902MHz to 928MHz ISM Band Systems
- 3.6V Spread-Spectrum Cordless Phones
- Portable Battery-Powered Equipment
- Spread-Spectrum Systems



Functional Block Diagram

Product Description

The RF2172 is a medium-power high efficiency amplifier IC targeting 3.6V handheld systems. The device is manufactured on an advanced Gallium Arsenide Heterojunction Bipolar Transistor (HBT) process, and has been designed for use as the final RF amplifier in 2.45GHz Bluetooth applications and frequency hopping/direct sequence spread-spectrum cordless telephones or other applications in the 902MHz to 928MHz ISM band. The device is packaged in a compact 4mmx4mm QFN. The device features analog gain control to optimize transmit power while maximizing battery life in portable equipment requiring up to 100mW transmit power at the antenna port.

BLUETOOTH is a trademark owned by the Bluetooth SIG, Inc., and licensed to RF Micro Devices, Inc.

Ordering Information

RF2172	ISM Band 3.6V, 250mW Amp with Analog Gain Control
RF2172PCBA411	Fully Assembled Evaluation Board 2.4 to 2.5GHz
RF2172PCBA410	Fully Assembled Evaluation Board 908 to 928MHz

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
Supply Voltage (RF off)	-0.5 to +6.0	V_{DC}
APC Current (Maximum)	+10	mA
Control Voltage (V_{PD})	-0.5 to +6.0	V_{DC}
Input RF Power	+10	dBm
Operating Case Temperature	-40 to +85	°C
Storage Temperature	-55 to +155	°C

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.		
Overall					T=25°C, V_{CC}=3.6V, V_{PD}=3.6V, V_{APC}=2.5V
Usable Frequency Range		500 to 2500		MHz	
Input Impedance		50		Ω	
Input VSWR		1.8:1			Without Input Match
Output Load VSWR	<10:1				$0 \leq V_{APC} \leq 3.0V$
	<6:1				$0 \leq V_{APC} \leq 3.6V$
2.45GHz Operation					Freq=2.4GHz to 2.5GHz, P_{IN}=0dBm
Operating Frequency		2.4 to 2.5		GHz	
Maximum Output Power	22	+23.5	24.5	dBm	
Total Efficiency		45		%	
Reverse Isolation		-25		dB	
Second Harmonic		-45		dBc	
Third Harmonic		-40		dBc	
All Other Spurious		-50		dBc	
Output Load Impedance		20-j4.5			Present to part
Gain Control Voltage		0 to V_{CC}		V	
High Gain	+22			dB	V_{APC}=3.6V, V_{CC}=3.6V, P_{IN}=0dBm
Low Gain			-10	dB	V_{APC}=0V, V_{CC}=3.6V, P_{IN}=0dBm
902MHz Operation					Freq=902MHz to 928MHz, P_{IN}=-3.0dBm
Operating Frequency		902 to 928		MHz	
Maximum Output Power		+24		dBm	
Total Efficiency		58		%	
Reverse Isolation		-35		dB	
Second Harmonic		-40		dBc	
Third Harmonic		-40		dBc	
All Other Spurious		-50		dBc	
Output Load Impedence		20-j1.6		W	Present to part
Gain Control Voltage		0 to V_{CC}		V	
Gain Control Slope		20	dB/V		
Gain		0 to 28	dB		
Power Supply					
Power Supply Voltage		3.6		V	
Power Supply Current		145		mA	V_{CC}=3.6V, V_{APC}=3.6V, P_{IN}=-3dBm, V_{PD}=3.6V
Idle Current		35	65	mA	V_{PD}=3.6V, V_{APC}=3.6V, RF $P_{IN} \leq$-30dBm

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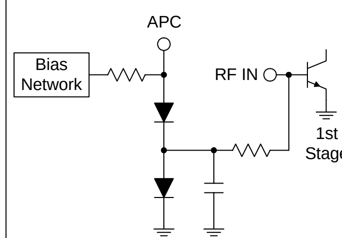
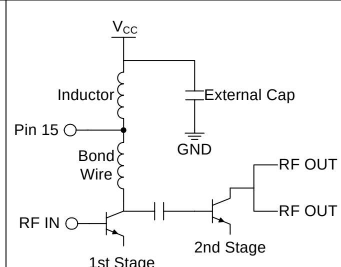
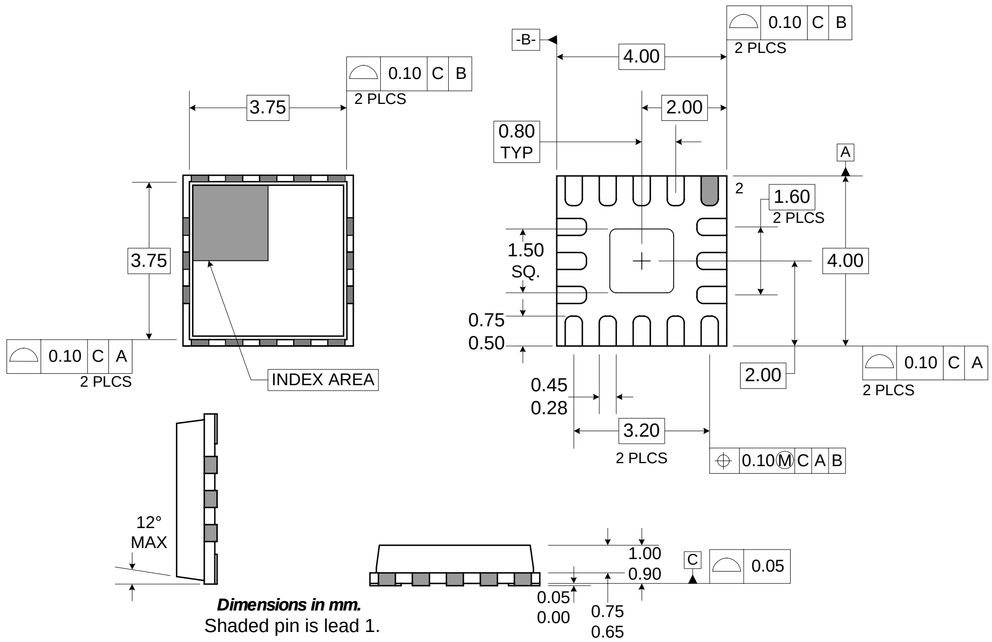
Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Power Down Current		2.8	10	μA	V_{CC}=3.6V, V_{APC}=0V, V_{PD}=0V total I_{CC}
I(PD)		4.5		mA	V_{CC}=3.6V, V_{PD}=3.6V into PD pin
I(PD)		2.25		mA	V_{CC}=3.0V, V_{PD}=3.0V into PD pin

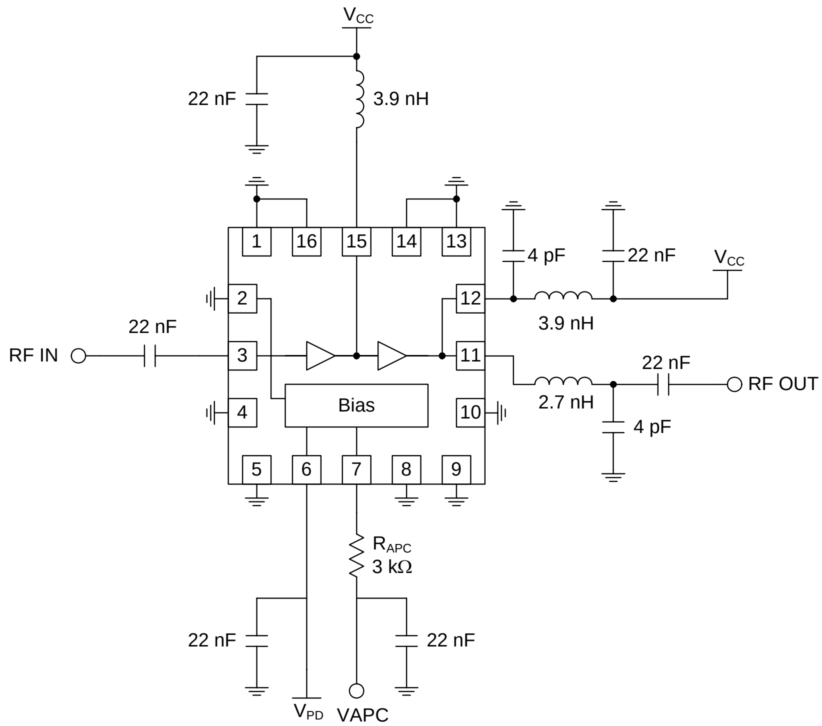
Pin	Function	Description	Interface Schematic
1	GND	Ground connection. For best performance, keep traces physically short and connect immediately to the ground plane.	
2	GND	Ground connection for the driver stage. For best performance, keep traces physically short and connect immediately to the ground plane.	
3	RF IN	RF input. This is a 50Ω input. No external matching is needed. An external DC blocking capacitor is required if this port is connected to a DC path to ground or a DC voltage.	See pin 15.
4	GND	See pin 1.	
5	GND	See pin 1.	
6	VPD	Power down pin. When this pin is 0V, the device will be in power down mode, dissipating minimum DC power. This pin also serves as the V_{CC} supply pin for the bias circuitry. V_{PD} should be at the supply voltage when the part is not in power down mode.	
7	APC	Analog power control. Output power varies as a function of the voltage on this pin. See graph. This pin must be driven through a series resistor with a voltage between 0V and V_{CC}. Series resistor determines dynamic range of power control. See plot "P_{OUT} versus Gain Control versus Gain Control Resistor".	
8	GND	See pin 1.	
9	GND	See pin 1.	
10	GND	See pin 1.	
11	RF OUT	RF output. An external matching network is required to provide the optimum load impedance at this pin.	See pin 15.
12	RF OUT	RF output and power supply for the output stage. Bias voltage for the output stage is provided through this pin. A shunt cap resonating with the bond wire inductance at $2xf_0$ can also be used at this pin to provide a second harmonic trap.	See pin 15.
13	GND	See pin 1.	
14	GND	See pin 1.	
15	VCC	Power supply for driver stage and interstage matching. This pin forms the shunt inductance needed for proper tuning of the interstage. Refer to the application schematic for the proper configuration. Note: Position and value of the components are important.	
16	GND	See pin 1.	
Pkg Base	GND	Ground connection for the output stage. This pad should be connected to the groundplane by vias directly under the device. A short path is required to obtain optimum performance, as well as provide a good thermal path to the PCB for maximum heat dissipation.	

Package Drawing

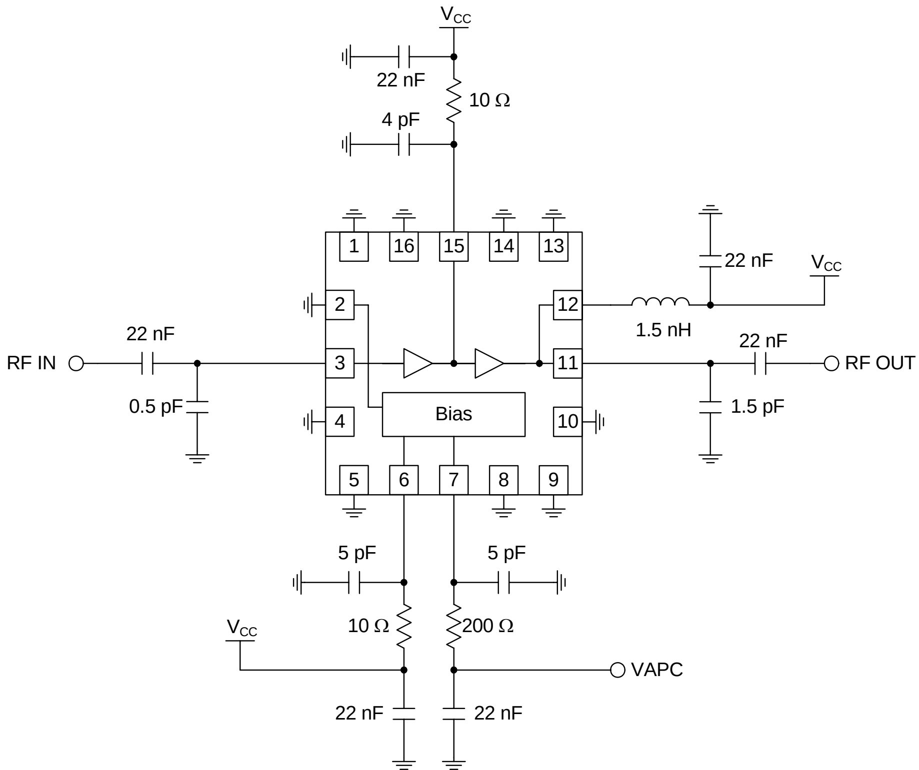


Dimensions in mm.
Shaded pin is lead 1.

Application Schematic - 915 MHz



Application Schematic - 2.45 GHz



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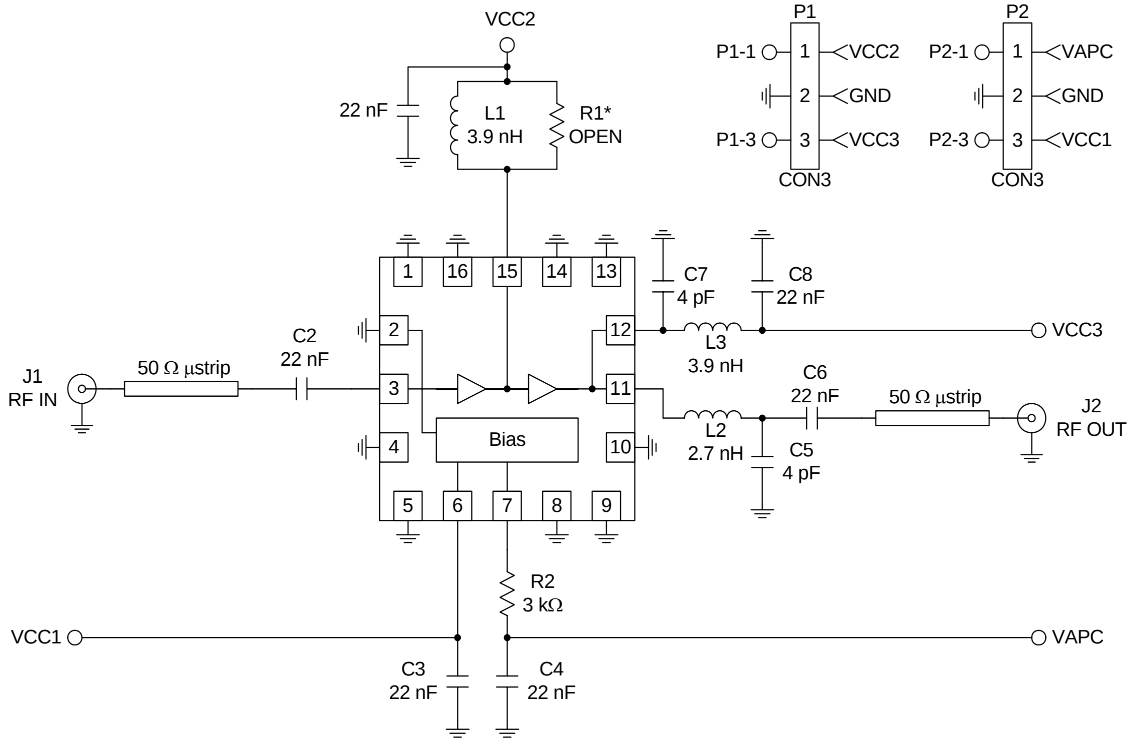
Evaluation Board Schematic - 915 MHz



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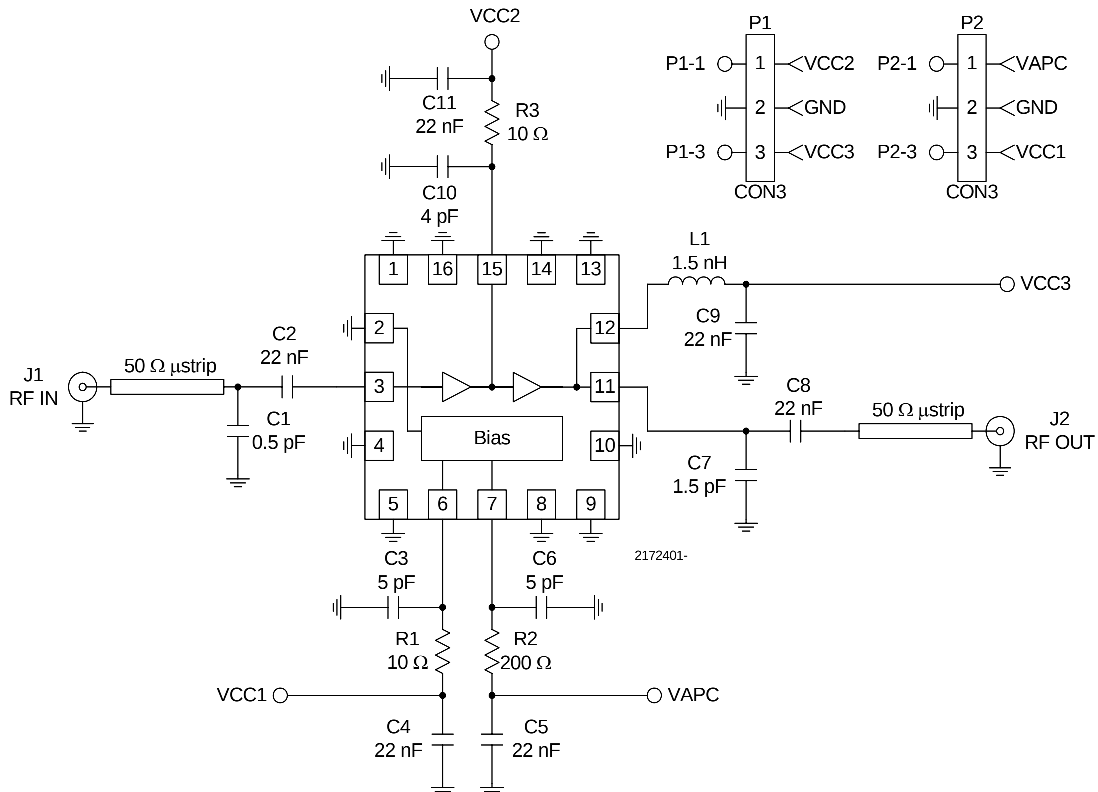
Evaluation Board Schematic - 2.45 GHz



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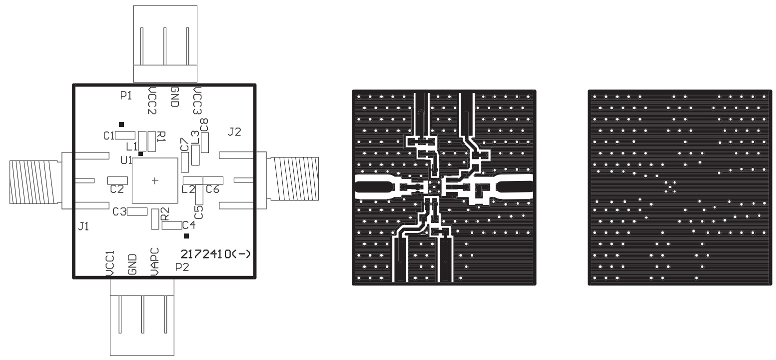
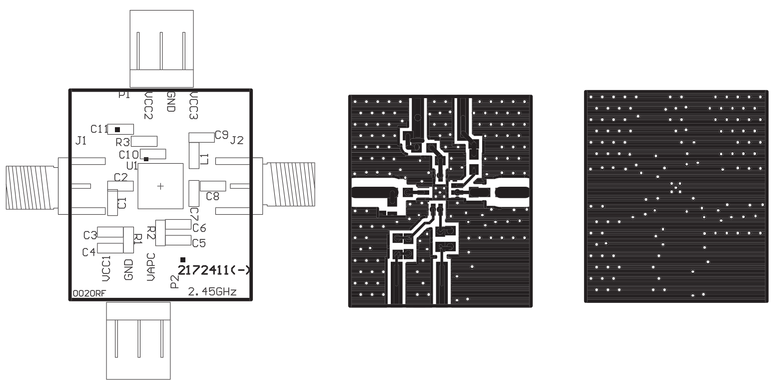
Evaluation Board Layout - 915 MHz
Board Size 0.80" x 0.85"
Board Thickness 0.031”, Board Material FR-4



Evaluation Board Layout - 2.45 GHz
Board Size 0.800" x 0.924"
Board Thickness 0.031”, Board Material FR-4



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PCB Design Requirements

PCB Surface Finish

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

PCB Land Pattern Recommendation

PCB land patterns are based on IPC-SM-782 standards when possible. The pad pattern shown has been developed and tested for optimized assembly at RFMD; however, it may require some modifications to address company specific assembly processes. The PCB land pattern has been developed to accommodate lead and package tolerances.

PCB Metal Land Pattern

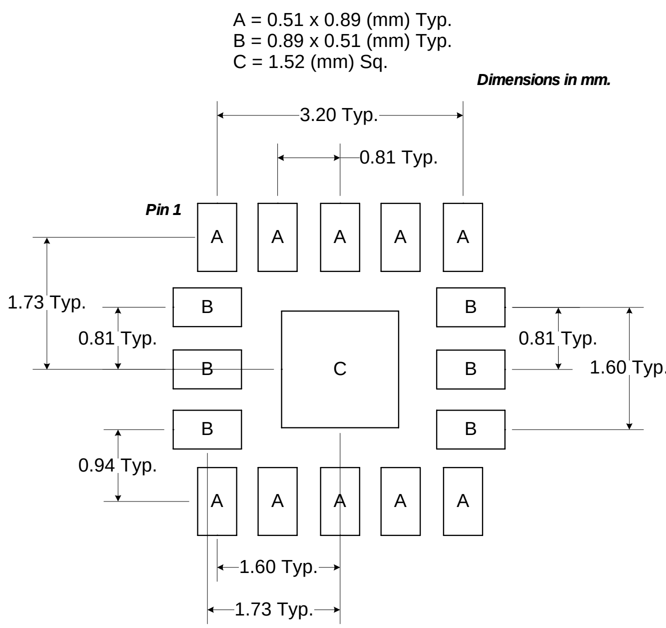


Figure 1. PCB Metal Land Pattern (Top View)

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 2mil to 3mil 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.

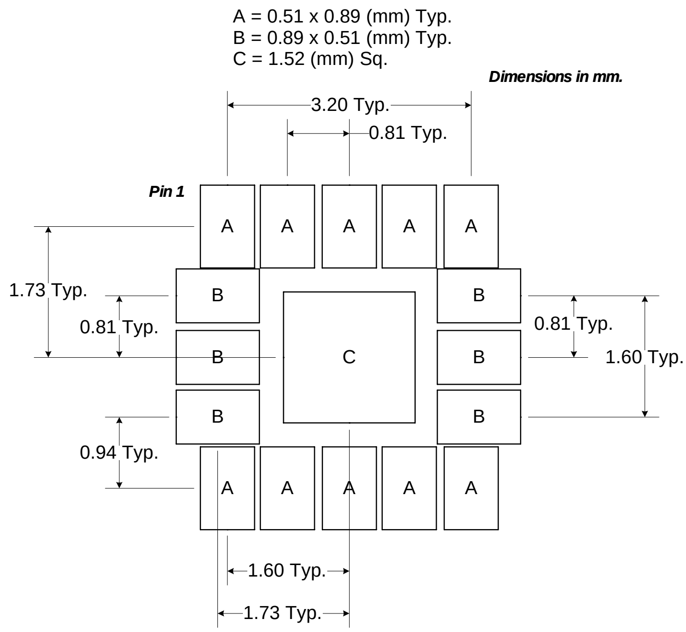


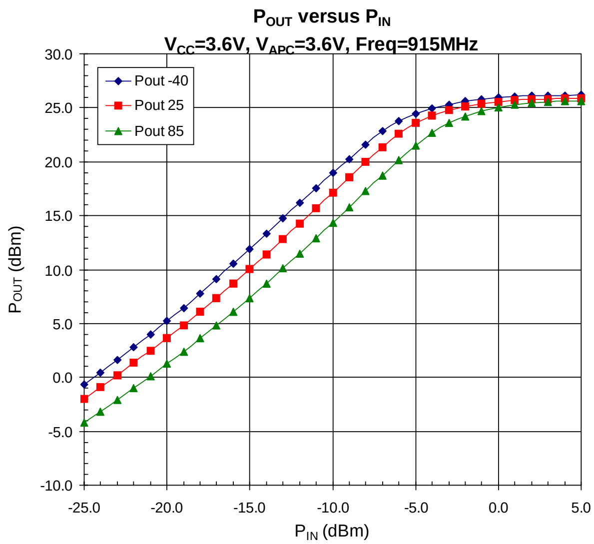
Figure 2. PCB Solder Mask (Top View)

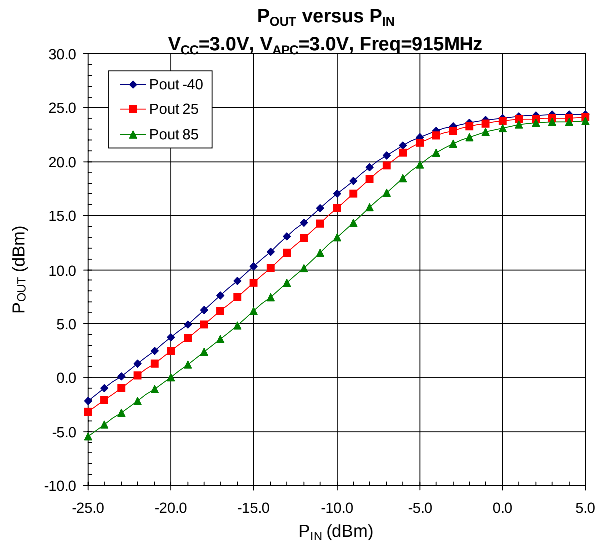
Thermal Pad and Via Design

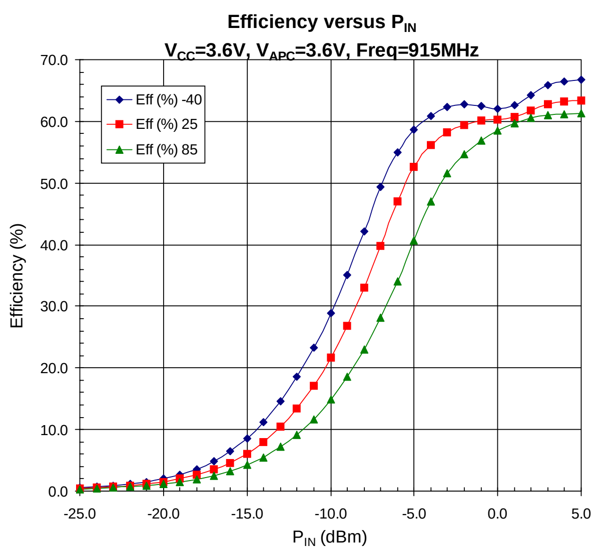
The PCB metal land pattern has been designed with a thermal pad that matches the die paddle size on the bottom of the device.

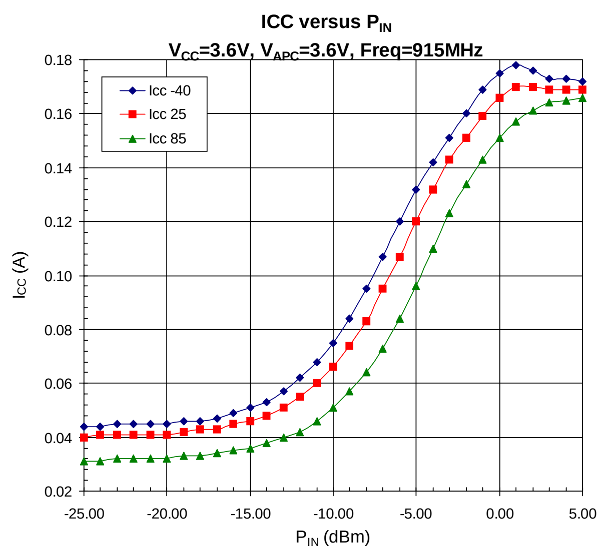
Thermal vias are required in the PCB layout to effectively conduct heat away from the package. The via pattern has been designed to address thermal, power dissipation and electrical requirements of the device as well as accommodating routing strategies.

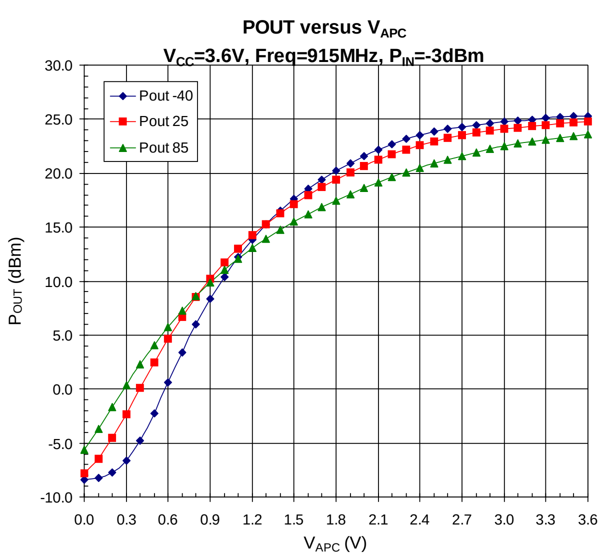
The via pattern used for the RFMD qualification is based on thru-hole vias with 0.203mm to 0.330mm finished hole size on a 0.5mm to 1.2mm grid pattern with 0.025mm plating on via walls. If micro vias are used in a design, it is suggested that the quantity of vias be increased by a 4:1 ratio to achieve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

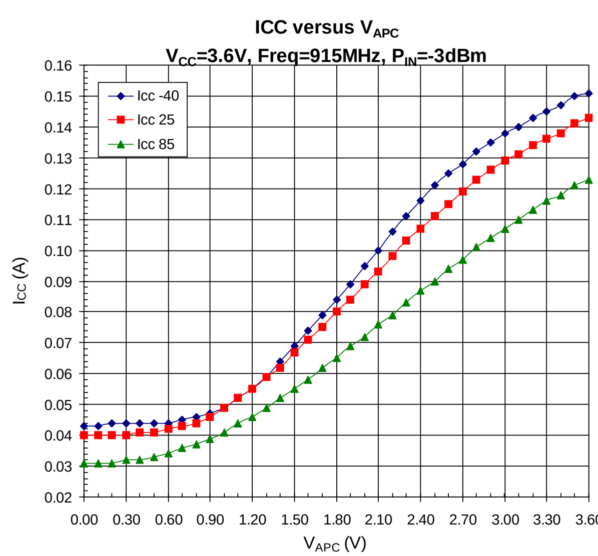

P_{OUT} versus P_{IN}
V_{CC}=3.6V, V_{APC}=3.6V, Freq=915MHz
Pout -40
Pout 25
Pout 85
P_{OUT} (dBm)
P_{IN} (dBm)

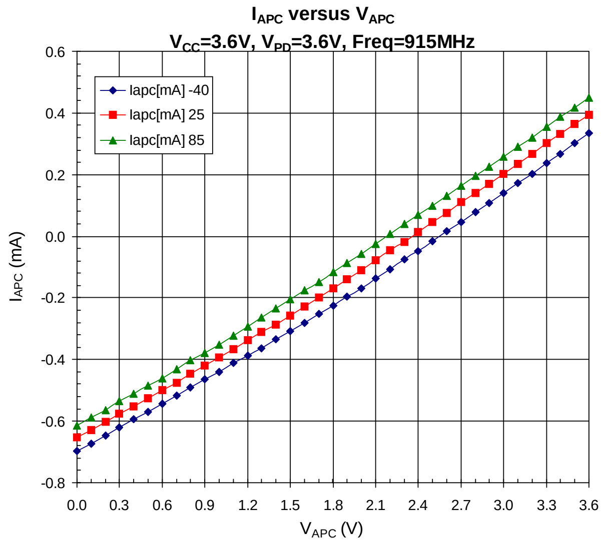

P_{OUT} versus P_{IN}
V_{CC}=3.0V, V_{APC}=3.0V, Freq=915MHz
Pout -40
Pout 25
Pout 85
P_{OUT} (dBm)
P_{IN} (dBm)


Efficiency versus P_{IN}
V_{CC}=3.6V, V_{APC}=3.6V, Freq=915MHz
Eff (%) -40
Eff (%) 25
Eff (%) 85
Efficiency (%)
P_{IN} (dBm)

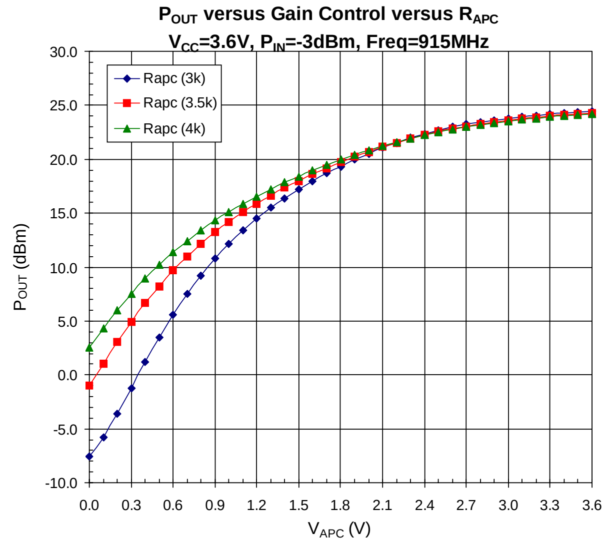

ICC versus P_{IN}
V_{CC}=3.6V, V_{APC}=3.6V, Freq=915MHz
Icc -40
Icc 25
Icc 85
I_{CC} (A)
P_{IN} (dBm)


POUT versus V_{APC}
V_{CC}=3.6V, Freq=915MHz, P_{IN}=-3dBm
Pout -40
Pout 25
Pout 85
P_{OUT} (dBm)
V_{APC} (V)

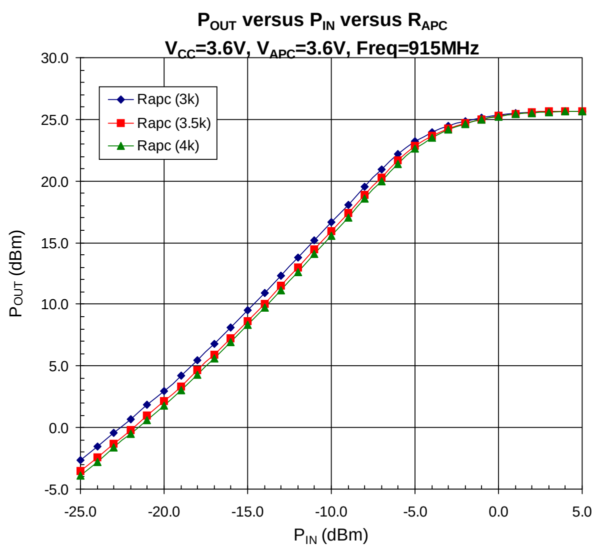

ICC versus V_{APC}
V_{CC}=3.6V, Freq=915MHz, P_{IN}=-3dBm
Icc -40
Icc 25
Icc 85
I_{CC} (A)
V_{APC} (V)



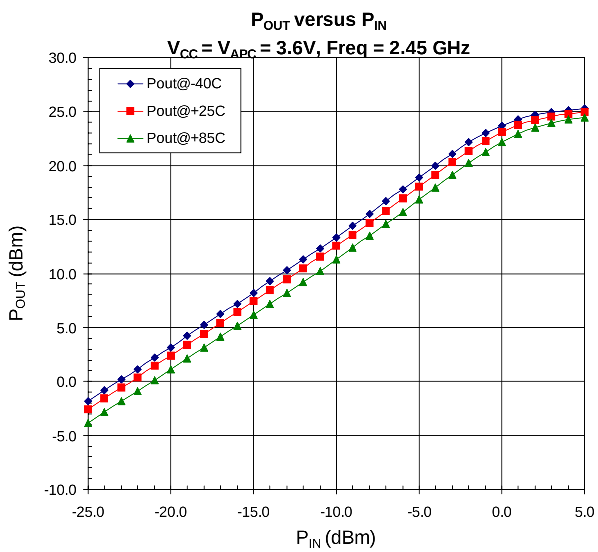
IAPC versus VAPC
VCC=3.6V, VPD=3.6V, Freq=915MHz
Iapc[mA] -40
Iapc[mA] 25
Iapc[mA] 85
IAPC (mA)
VAPC (V)



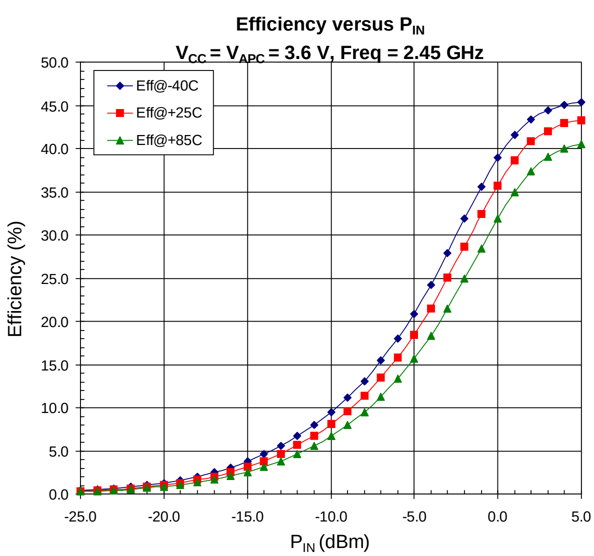
POUT versus Gain Control versus RAPC
VCC=3.6V, PIN=-3dBm, Freq=915MHz
Rapc (3k)
Rapc (3.5k)
Rapc (4k)
POUT (dBm)
VAPC (V)



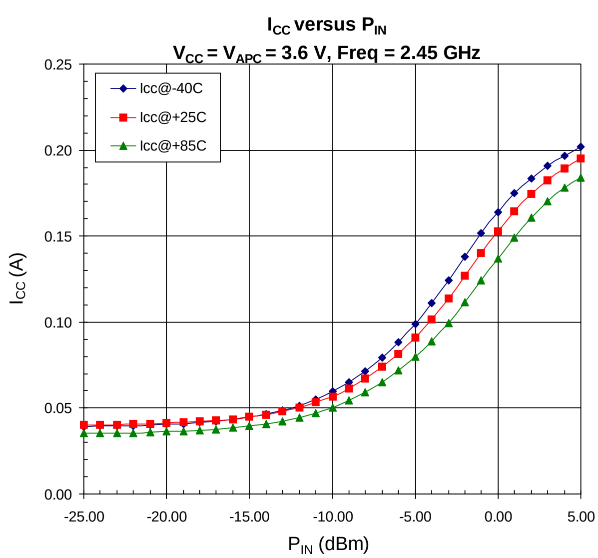
POUT versus PIN versus RAPC
VCC=3.6V, VAPC=3.6V, Freq=915MHz
Rapc (3k)
Rapc (3.5k)
Rapc (4k)
POUT (dBm)
PIN (dBm)



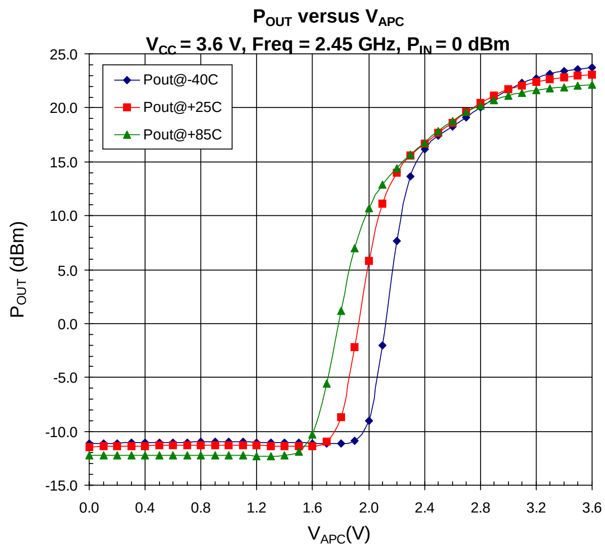
POUT versus PIN
VCC = VAPC = 3.6V, Freq = 2.45 GHz
Pout@-40C
Pout@+25C
Pout@+85C
POUT (dBm)
PIN (dBm)

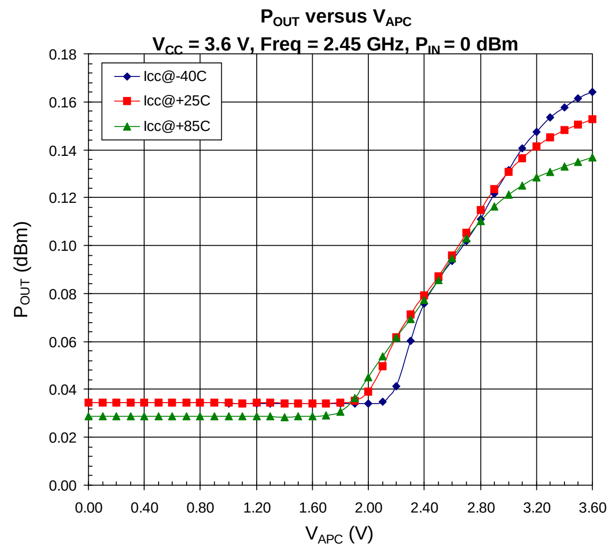


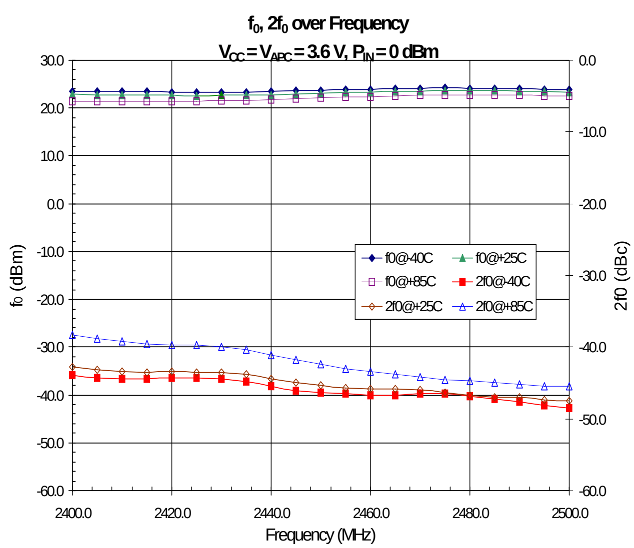
Efficiency versus PIN
VCC = VAPC = 3.6 V, Freq = 2.45 GHz
Eff@-40C
Eff@+25C
Eff@+85C
Efficiency (%)
PIN (dBm)

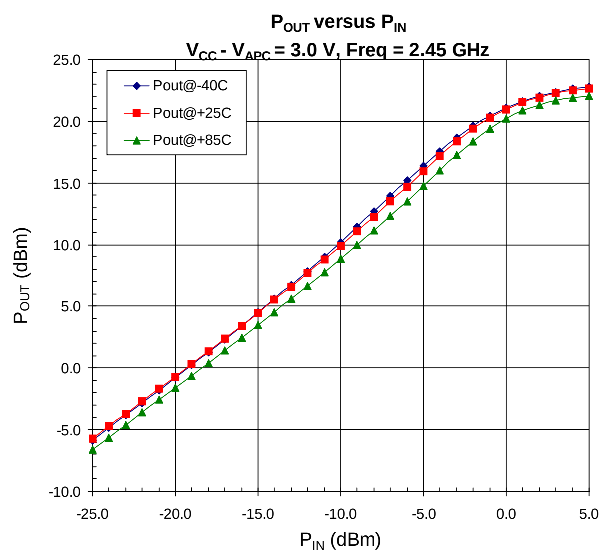


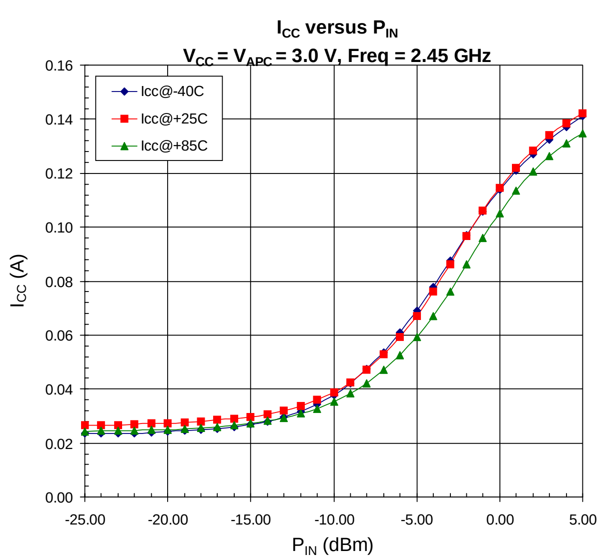
ICC versus PIN
VCC = VAPC = 3.6 V, Freq = 2.45 GHz
Icc@-40C
Icc@+25C
Icc@+85C
ICC (A)
PIN (dBm)

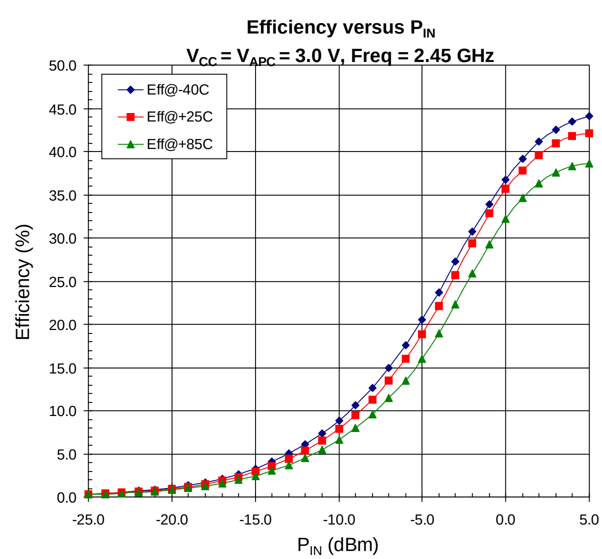

POUT versus VAPC
VCC = 3.6 V, Freq = 2.45 GHz, PIN = 0 dBm
Pout@-40C
Pout@+25C
Pout@+85C
POUT (dBm)
VAPC(V)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6


POUT versus VAPC
VCC = 3.6 V, Freq = 2.45 GHz, PIN = 0 dBm
Icc@-40C
Icc@+25C
Icc@+85C
POUT (dBm)
VAPC (V)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60


f0, 2f0 over Frequency
VCC=VAPC=3.6 V, PIN=0 dBm
f0@40C
f0@+25C
f0@+85C
2f0@40C
2f0@+25C
2f0@+85C
f0 (dBm)
2f0 (dBc)
Frequency (MHz)
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
2400.0
2420.0
2440.0
2460.0
2480.0
2500.0


POUT versus PIN
VCC - VAPC = 3.0 V, Freq = 2.45 GHz
Pout@-40C
Pout@+25C
Pout@+85C
POUT (dBm)
PIN (dBm)
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-25.0
-20.0
-15.0
-10.0
-5.0
0.0
5.0


ICC versus PIN
VCC = VAPC = 3.0 V, Freq = 2.45 GHz
Icc@-40C
Icc@+25C
Icc@+85C
ICC (A)
PIN (dBm)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-25.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00


Efficiency versus PIN
VCC = VAPC = 3.0 V, Freq = 2.45 GHz
Eff@-40C
Eff@+25C
Eff@+85C
Efficiency (%)
PIN (dBm)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-25.0
-20.0
-15.0
-10.0
-5.0
0.0
5.0

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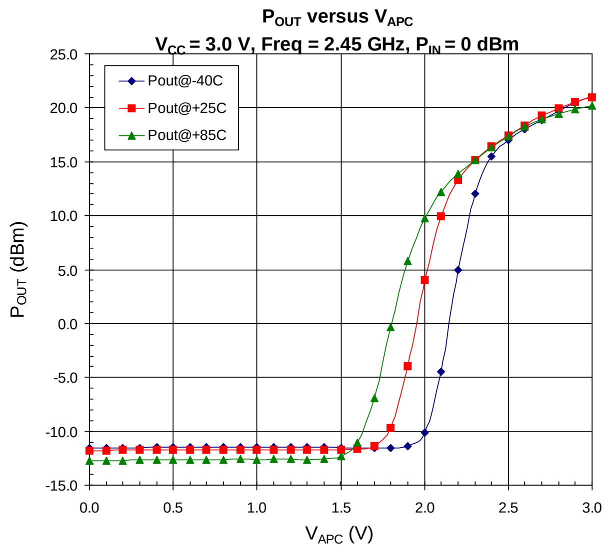

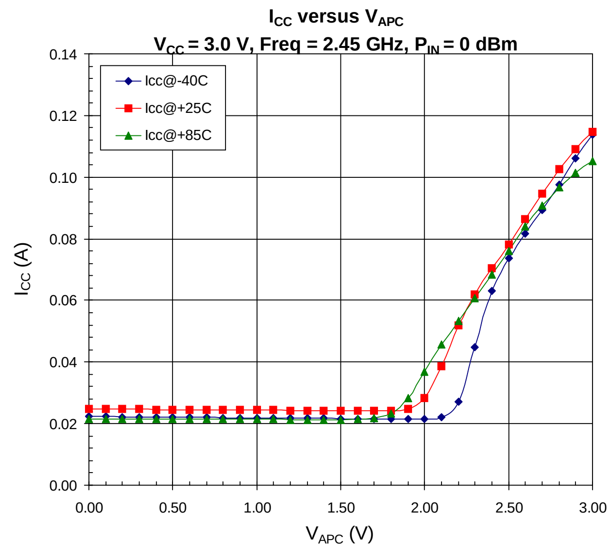

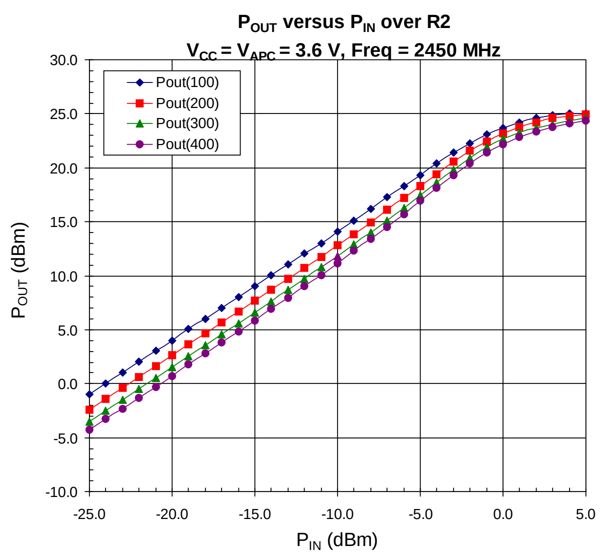

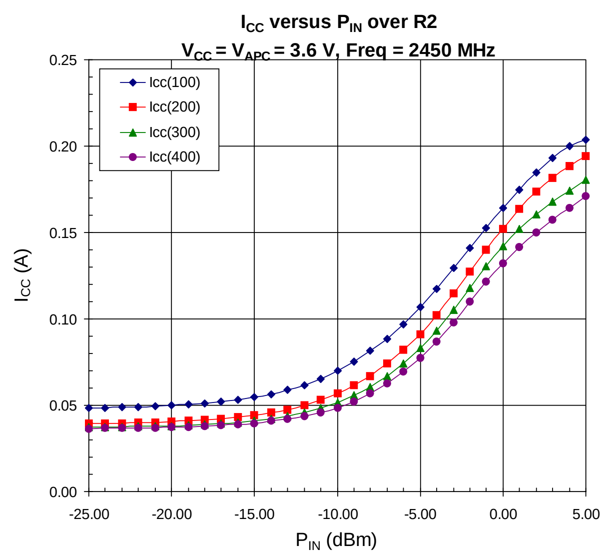

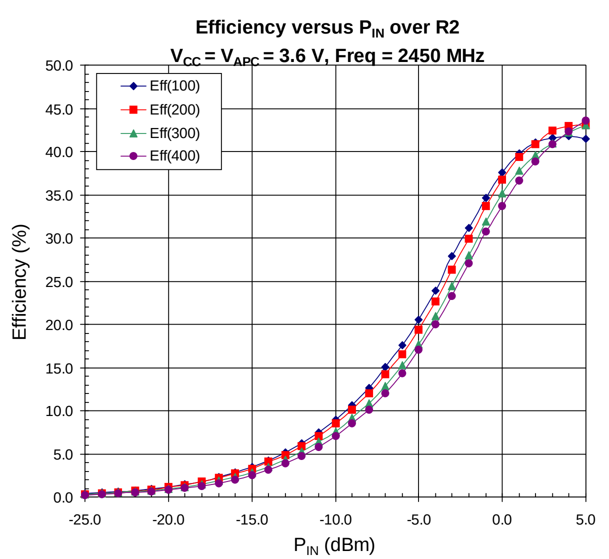

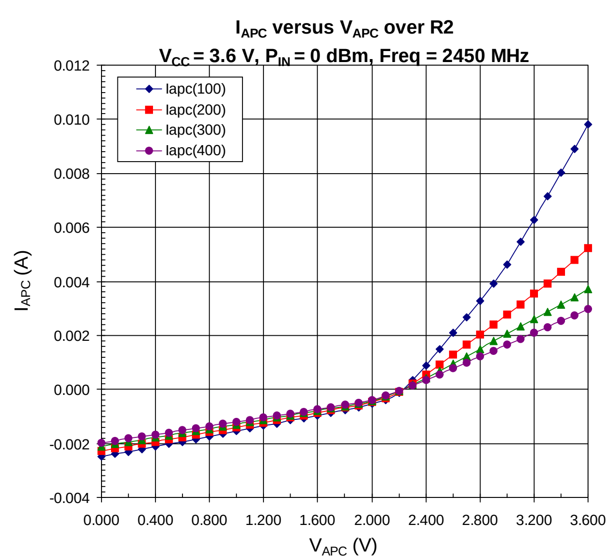

7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or sales-support@rfmd.com.

RoHS* Banned Material Content

RoHS Compliant:	Yes
Package total weight in grams (g):	0.038
Compliance Date Code:	0547
Bill of Materials Revision:	A
Pb Free Category:	e3

Bill of Materials	Parts Per Million (PPM)					
	Pb	Cd	Hg	Cr VI	PBB	PBDE
Die	0	0	0	0	0	0
Molding Compound	0	0	0	0	0	0
Lead Frame	0	0	0	0	0	0
Die Attach Epoxy	0	0	0	0	0	0
Wire	0	0	0	0	0	0
Solder Plating	0	0	0	0	0	0

This RoHS banned material content declaration was prepared solely on information, including analytical data, provided to RFMD by its suppliers, and applies to the Bill of Materials (BOM) revision noted above.

* DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment