

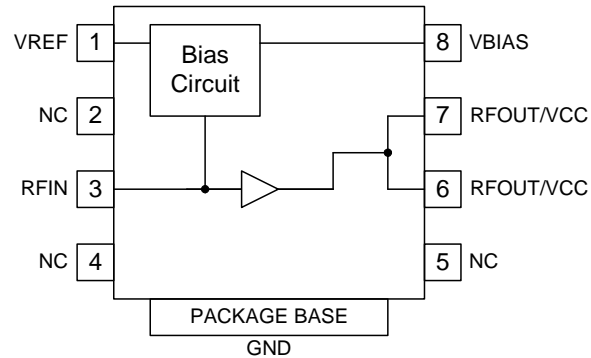


**Features**

- High Output Power of 2.0W P1dB
- High Linearity
- High Power-Added Efficiency
- Thermally-Enhanced Packaging
- Broadband Platform Design Approach, 450MHz to 2500MHz

**Applications**

- GaAs Pre-Driver for Basestation Amplifiers
- PA Stage for Commercial Wireless Infrastructure
- Class AB Operation for NMT, GSM, DCS, PCS, and UMTS Transceiver Applications
- 2nd/3rd Stage LNA for Wireless Infrastructure



Functional Block Diagram

**Product Description**

The RF3809 is a GaAs pre-driver power amplifier, specifically designed for wireless infrastructure applications. Using a highly reliable GaAs HBT fabrication process, this high-performance single-stage amplifier achieves high output power over a broad frequency range. The RF3809 also provides excellent efficiency and thermal stability through the use of a thermally-enhanced surface-mount plastic-slug package. Ease of integration is accomplished through the incorporation of an optimized evaluation board design provided to achieve proper 50Ω operation. Various evaluation boards are available to address a broad range of wireless infrastructure applications: NMT 450MHz; GSM850MHz; GSM900MHz; DCS1800MHz; PCS1900MHz; and, UMTS2200MHz.

**Ordering Information**

RF3809	GaAs HBT Pre-Driver Amplifier
RF3809PCK-410	Fully Assembled Evaluation Board, 450MHz
RF3809PCK-411	Fully Assembled Evaluation Board, 869MHz to 894MHz
RF3809PCK-412	Fully Assembled Evaluation Board, 920MHz to 960MHz
RF3809PCK-413	Fully Assembled Evaluation Board, 1800MHz to 1880MHz
RF3809PCK-414	Fully Assembled Evaluation Board, 1930MHz to 1990MHz
RF3809PCK-415	Fully Assembled Evaluation Board, UMTS

**Optimum Technology Matching® Applied**

- |                                              |                                      |                                     |                                   |
|----------------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|
| <input checked="" type="checkbox"/> GaAs HBT | <input type="checkbox"/> SiGe BiCMOS | <input 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"/> InGaP HBT           | <input type="checkbox"/> SiGe HBT    | <input type="checkbox"/> Si BJT     |                                   |

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## Absolute Maximum Ratings

Parameter	Rating	Unit
Supply Voltage	9.0	V
Reference Current ( $I_{REF}$ )	30	mA
RF - Input Power	See below	
Operating Current	750	mA
Load VSWR	4:1	
Operating Temperature	-40 to +85	°C
Storage Temperature	-40 to +105	°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).

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
<b>Overall - 450MHz</b>					
Frequency	420		480	MHz	$I_{REF} = 15\text{ mA}$ , $V_{CC} = 8\text{ V}$ , $V_{REF} = 8\text{ V}$ , $V_{BIAS} = 8\text{ V}$ , Temp = +25 °C
P1dB		+33.0		dBm	
$P_{IN}$ , Maximum			24.0	dBm	
Total Efficiency		45.0		%	@ P1dB
Total Power Added Efficiency		44.0		%	@ P1dB
Gain (S21)		13		dB	
Second Harmonic (2fo)		-27		dBc	@ P1dB
Third Harmonic (3fo)		-36		dBc	@ P1dB
Input Return Loss (S11)		-16		dB	
Output Return Loss (S22)		-5.5		dB	
<b>Two-Tone Specification</b>					
OIP3		46.5		dBm	19 dBm/tone
		48.0		dBm	21 dBm/tone
		50.0		dBm	23 dBm/tone
		48.0		dBm	25 dBm/tone

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
<b>Overall - GSM800</b>					
Frequency	869		894	MHz	$I_{REF}=15\text{ mA}$ , $V_{CC}=8\text{ V}$ , $V_{REF}=8\text{ V}$ , $V_{BIAS}=8\text{ V}$ , Temp=+25 °C
P1dB		+35.5		dBm	
$P_{IN}$ , Maximum			24	dBm	
Total Efficiency		50.5		%	@P1dB
Total Power Added Efficiency		49.5		%	@P1dB
Gain (S21)		13.5		dB	
Second Harmonic (2fo)		-28.0		dBc	@P1dB
Third Harmonic (3fo)		-38.0		dBc	@P1dB
Input Return Loss (S11)		-18.0		dB	
Output Return Loss (S22)		-13.0		dB	
<b>Two-Tone Specification</b>					
OIP3		45.5		dBm	19 dBm/tone
		46.5		dBm	21 dBm/tone
		47.0		dBm	23 dBm/tone
		48.0		dBm	25 dBm/tone
<b>Overall - GSM900</b>					
Frequency	920		960	MHz	$I_{REF}=14\text{ mA}$ , $V_{CC}=8\text{ V}$ , $V_{REF}=8\text{ V}$ , $V_{BIAS}=8\text{ V}$ , Temp=+25 °C
P1dB		+34.5		dBm	
$P_{IN}$ , Maximum			24	dBm	
Total Efficiency		49.0		%	@P1dB
Total Power Added Efficiency		48.0		%	@P1dB
Gain (S21)		13.5		dB	
Second Harmonic (2fo)		-28.0		dBc	@P1dB
Third Harmonic (3fo)		-29.5		dBc	@P1dB
Input Return Loss (S11)		-21.0		dB	
Output Return Loss (S22)		-8.0		dB	
<b>Two-Tone Specification</b>					
OIP3		48.5		dBm	19 dBm/tone
		48.0		dBm	21 dBm/tone
		47.0		dBm	23 dBm/tone
		47.5		dBm	25 dBm/tone

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
<b>Overall - DCS1800</b>					
Frequency	1805		1880	MHz	$I_{REF}=15\text{ mA}$ , $V_{CC}=8\text{ V}$ , $V_{REF}=8\text{ V}$ , $V_{BIAS}=8\text{ V}$ , Temp = +25 °C
P1dB		+34.0		dBm	
$P_{IN}$ , Maximum			26	dBm	
Total Efficiency		50.0		%	@P1dB
Total Power Added Efficiency		49.0		%	@P1dB
Gain (S21)		11.5		dB	
Second Harmonic (2fo)		-24.0		dBc	@P1dB
Third Harmonic (3fo)		-48.0		dBc	@P1dB
Input Return Loss (S11)		-15.0		dB	
Output Return Loss (S22)		-12.0		dB	
<b>Two-Tone Specification</b>					
OIP3		45.5		dBm	15 dBm/tone
		46.5		dBm	17 dBm/tone
		47.0		dBm	19 dBm/tone
		48.0		dBm	21 dBm/tone
<b>Overall - PCS1900</b>					
Frequency	1930		1990	MHz	$I_{REF}=15\text{ mA}$ , $V_{CC}=8\text{ V}$ , $V_{REF}=8\text{ V}$ , $V_{BIAS}=8\text{ V}$ , Temp = +25 °C
P1dB		+32.5		dBm	
$P_{IN}$ , Maximum			26	dBm	
Total Efficiency		47.5		%	@P1dB
Total Power Added Efficiency		46.5		%	@P1dB
Gain (S21)		10.5		dB	
Second Harmonic (2fo)		-26.0		dBc	@P1dB
Third Harmonic (3fo)		-65.0		dBc	@P1dB
Input Return Loss (S11)		-12.0		dB	
Output Return Loss (S22)		-9.0		dB	
<b>Two-Tone Specification</b>					
OIP3		45.5		dBm	19 dBm/tone
		45.5		dBm	21 dBm/tone
		46.0		dBm	23 dBm/tone
		48.0		dBm	25 dBm/tone

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
<b>UMTS 2100</b>					
Frequency	2110		2170	MHz	$I_{REF}=15\text{ mA}$ , $V_{CC}=8\text{ V}$ , $V_{REF}=8\text{ V}$ , $V_{BIAS}=8\text{ V}$ , Temp= $+25\text{ }^{\circ}\text{C}$
P1dB	+32.0	+32.5		dBm	
$P_{IN}$ , Maximum			26	dBm	
Total Efficiency		47.5		%	@P1dB
Total Power Added Efficiency		46.5		%	@P1dB
Gain (S21)	9.0	10	11.5	dB	
Second Harmonic (2fo)		-32.0		dBc	@P1dB
Third Harmonic (3fo)		-52.0		dBc	@P1dB
Input Return Loss (S11)		-15.0		dB	
Output Return Loss (S22)		-11.0		dB	
<b>Two-Tone Specification</b>					
OIP3		44.5		dBm	19 dBm/tone
		44.5		dBm	21 dBm/tone
		45.5		dBm	23 dBm/tone
		46.5		dBm	25 dBm/tone
<b>Power Supply</b>					
Power Supply Voltage	4.5	8	9	V	
Supply Current ( $I_{CC}+I_{BIAS}$ )	225	270	316	mA	$V_{CC}=V_{REF}=V_{BIAS}=8\text{ V}$ , $R_{BIAS}=300\Omega$
Control Current ( $I_{REF}$ )		15		mA	$V_{CC}=V_{REF}=V_{BIAS}=8\text{ V}$ , $R_{BIAS}=300\Omega$
Power Down Current			30	$\mu\text{A}$	$V_{REF}=0\text{ V}$ , $V_{CC}=8\text{ V}$

**Bias Table**

$V_{CC}$	$V_{BIAS}$	$V_{REF}$	$V_{REF\_PIN}$	$R_{BIAS}$	$I_{REF}$	$I_{CQ}$	Comments
8	8	8	3.5	300	15	258	
5	5	5	3.825	47	25	265	For equivalent $I_{CQ}$ to 8V case

Pin	Function	Description
1	VREF	Control input to internal bias circuitry.
2	NC	No connection.
3	RFIN	Input for RF signal.
4	NC	No connection.
5	NC	No connection.
6	RFOUT/VCC	RF output pin and V <sub>CC</sub> supply pin.
7	RFOUT/VCC	RF output pin and V <sub>CC</sub> supply pin.
8	VBIAS	RF supply to internal bias circuitry.
Pkg Base	GND	Backside of package should be connected to a short path to ground.

## Theory of Operation and Application Information

RF3809 design accommodates use in a variety of applications:

- Linear driver from 450MHz to 2500MHz
- 2nd/3rd stage high linearity LNA, with noise figure in the 3dB to 4dB range from 800MHz to 2200MHz
- High efficiency (>50%) output stage for non-linear applications

Nominal data sheet shows specification for  $V_{CC}=V_{BIAS}=V_{REF}=8V$ . RF3809 can easily be configured for 5V operation, with a simple bias resistor change at  $V_{REF}$ . “Bias Table” on page 5 shows resistor values for  $V_{CC}=V_{BIAS}=V_{REF}=5V$ . Generally speaking, 5V data will compare to that for 8V as follows:

- 3dB to 3.5dB reduction in OP1dB
- 0.4dB to 0.5dB increase in small signal gain

For operation at other than 5V, bias R can be calculated as follows ( $V_{CC}=V_{BIAS}=V_{REF}=5V$  is used here to illustrate, operation at different voltage is determined with same methodology).

1. Use nominal 8V case as a starting point:  $V_{CC}=V_{BIAS}=V_{REF}=8V$ ,  $I_{REF}=15mA$ ,  $I_{CQ}=258mA$ . Target condition will be to achieve same  $I_{CQ}$  with  $V_{CC}=V_{BIAS}=V_{REF}=5V$ .
2. Using evaluation board with separate lab supplies on ( $V_{CC}/V_{BIAS}$ ) and ( $V_{REF}$ ), set  $V_{CC}/V_{BIAS}=5V$ ,  $V_{REF}=8V$ .  $I_{REF}$  is maintained at 15mA, and  $I_{CQ}$  drops from nominal value of 258mA.
3.  $V_{REF}$  can then be increased >8V until  $I_{CQ}$  is restored.  $I_{REF}$  increase to 23mA is required (as seen in “Bias Table” on page 5).
4. At this point, pin voltage at  $V_{REF}$  is calculated (or measured with DVM):  $V_{PIN}=V_{REF}$  at eval board input -  $I_{REF} * \text{bias R} = 10.8 - 0.023 * 300 = 3.9V$ .
5. Next, calculate new bias R for  $V_{REF}=5V$ :  $\text{Bias R} = (5 - 3.9) / 0.023 = 47.8\Omega$ . See “Bias Table” on page 5, standard resistor value = 47Ω is called out. In this way, bias R can be calculated for any  $V_{CC}=V_{BIAS}=V_{REF}$  configuration. The maximum  $I_{REF}$  limit for RF3809 = 30mA.

Junction-to-case thermal resistance ( $R_{TH_{JC}}$ ) is shown versus output power in the graph section of this data sheet. The graph was generated with nominal  $V_{CC}=V_{BIAS}=V_{REF}=8V$ ,  $I_{REF}=15mA$ , where ambient temperature = 85°C. Using this curve along with operating condition, junction temperature can be calculated. Resultant  $T_j$  for this case yields  $MTTF \geq 100$  years. Standard RF3809 evaluation boards are matched for high efficiency at  $O_{P1dB}$ . To ensure reliability for operation at high power, output match achieving equivalent or better efficiency on system board should be the goal.

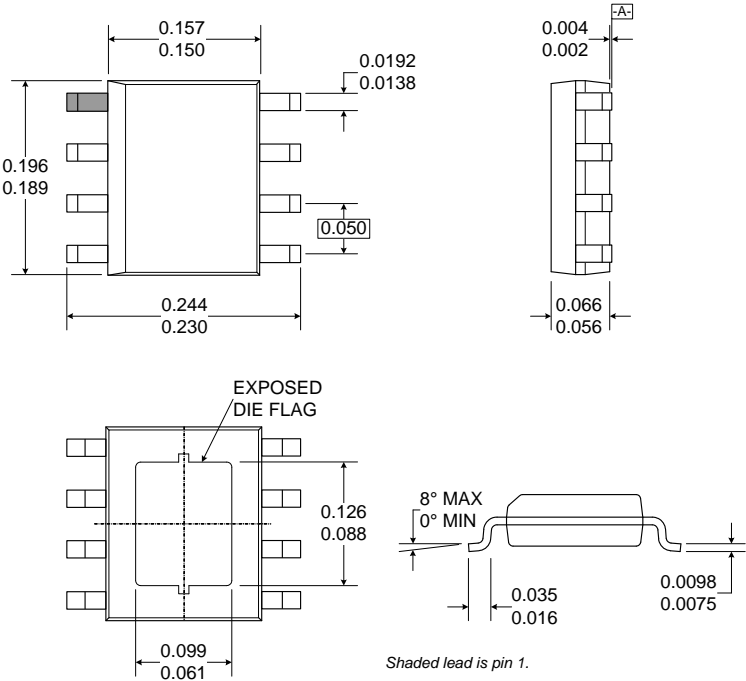
Typical s-parameter responses for each evaluation board are shown within the data sheet. These boards were matched with two specifications in mind:

- Output load impedance set for optimum  $OIP_3/ACP$  (Adjacent Channel Power for commonly used modulation standards).
- Output load impedance set for high efficiency at  $O_{P1dB}$ , with ruggedness (survival) into output 4:1 VSWR.

In some cases, low power operation being one, it may be desirable to improve output return loss seen on evaluation board. This can be done with output match adjust. The result will be an increase in small signal gain. Tradeoffs between return loss, gain,  $OIP_3$ , and compression point can then be considered in obtaining optimum performance for a particular application.

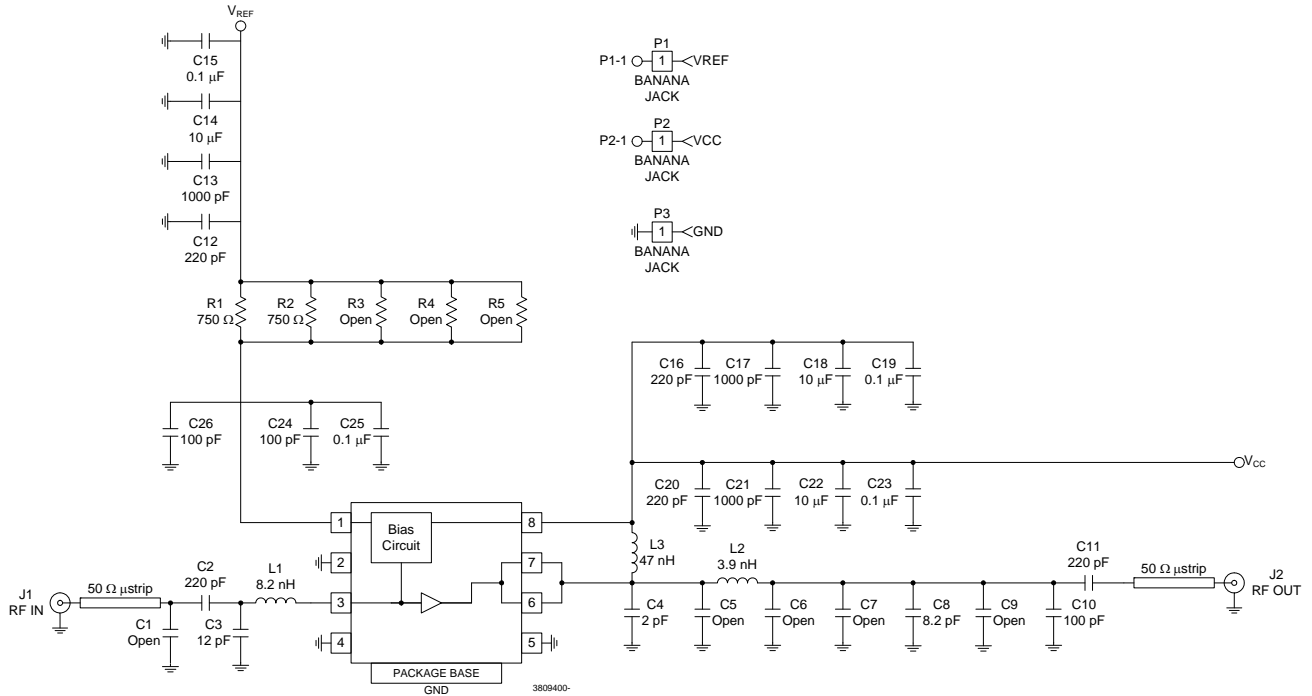
Finally, infrastructure qualification report for RF3809 can be obtained by contacting RFMD.

## Package Drawing

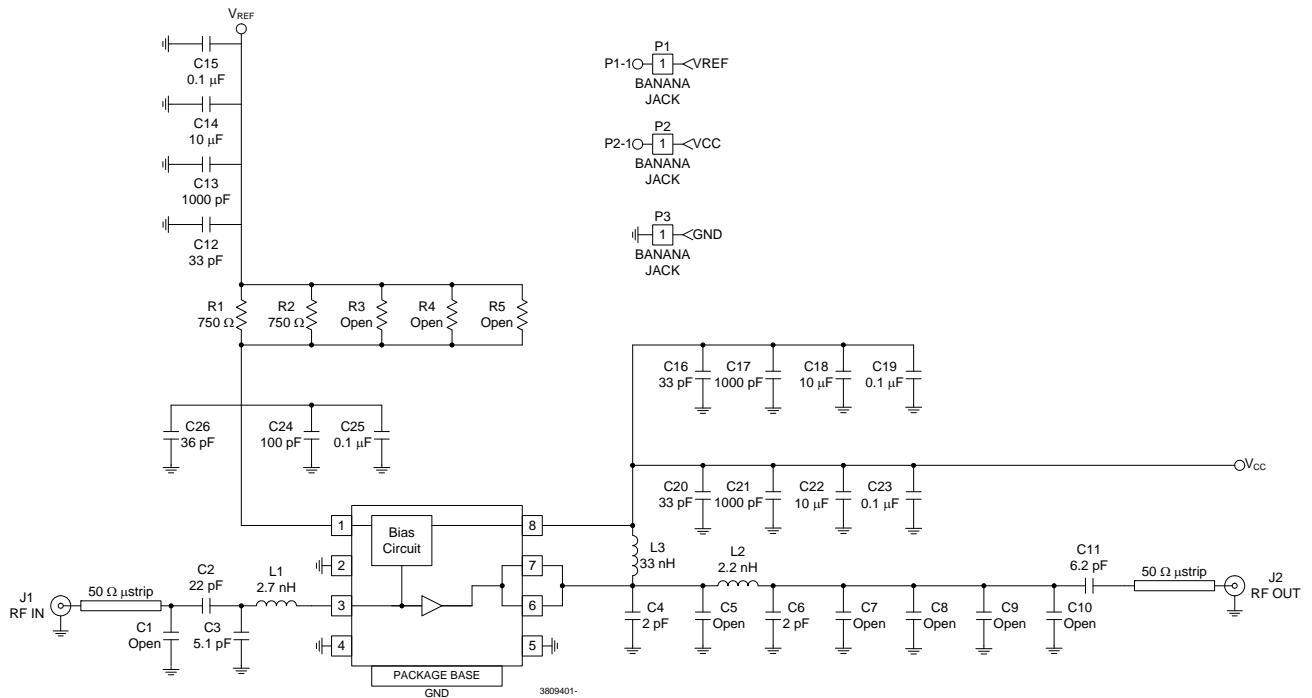




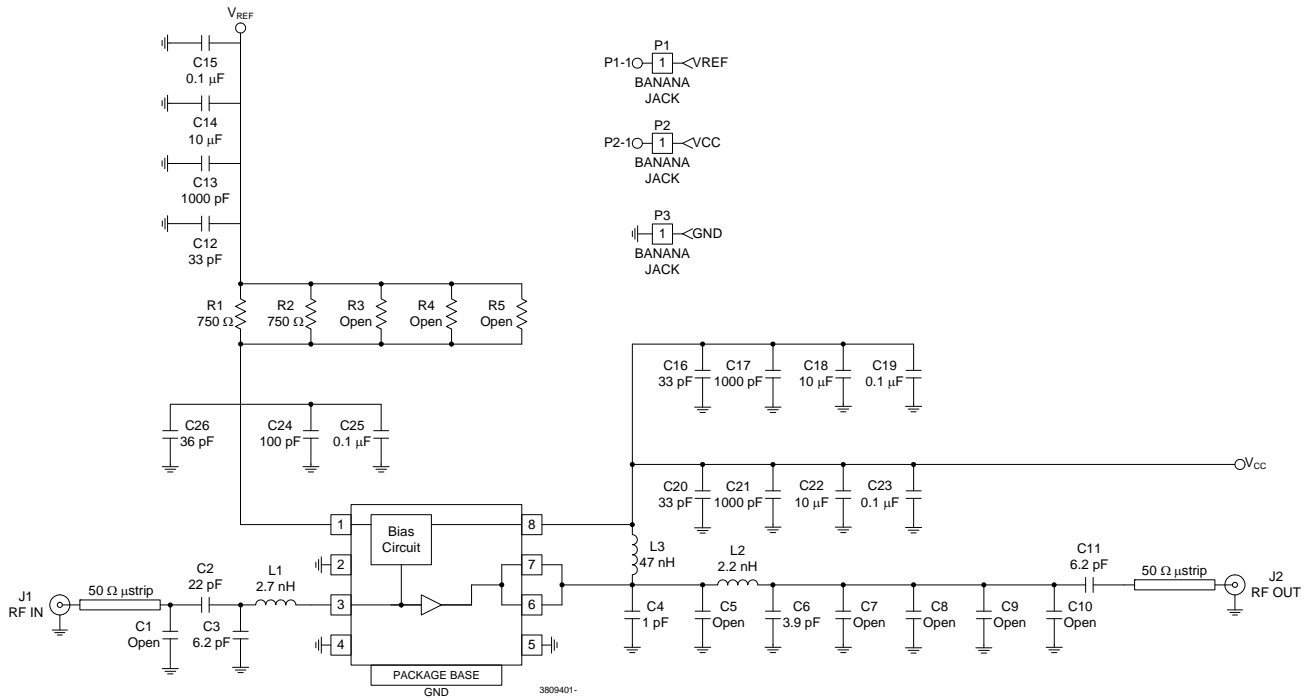
### Evaluation Board Schematic 400MHz (RF3809410)



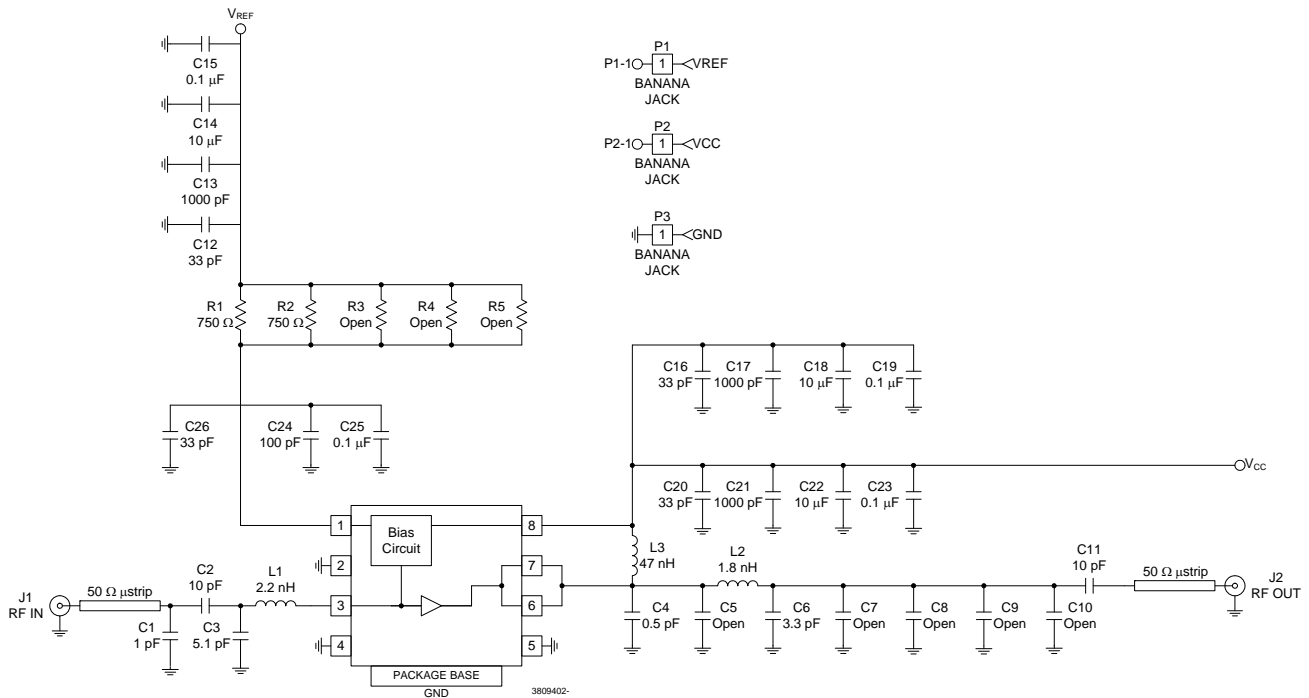
### Evaluation Board Schematic 800MHz to 1000MHz (CDMA800, ISM, EGSM)



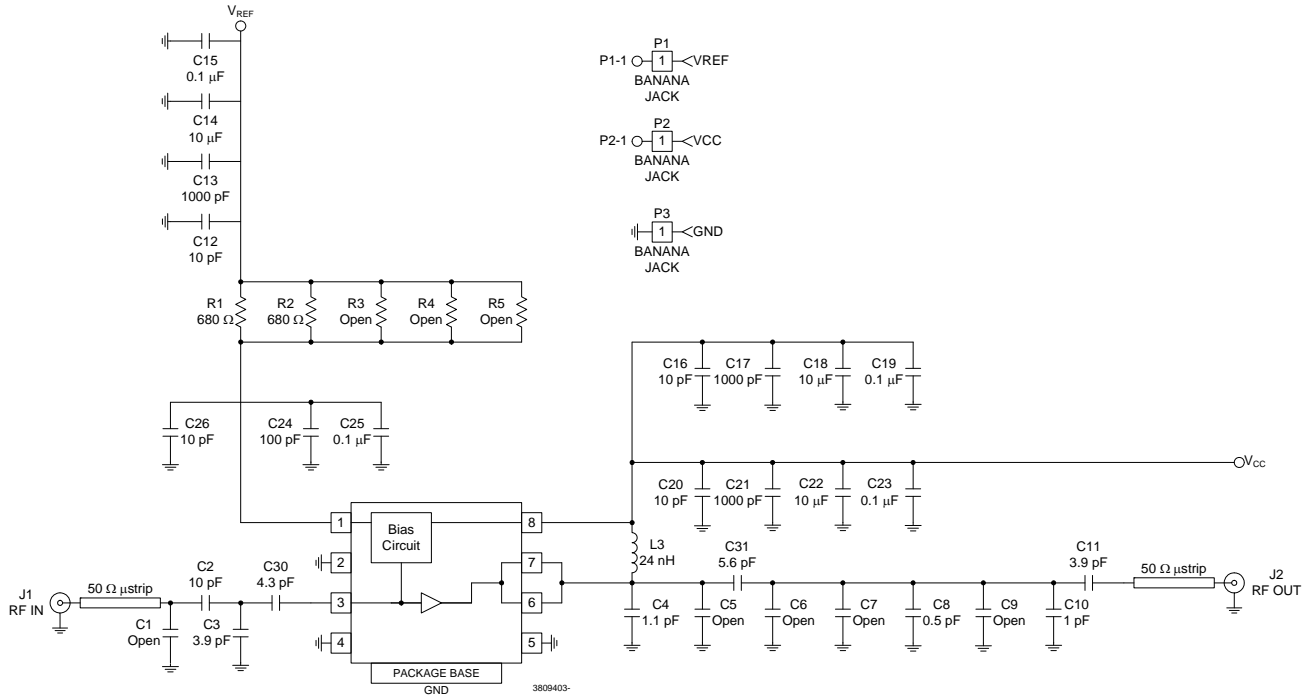
## Evaluation Board Schematic 869MHz to 894MHz (GSM800) (RF3809411)



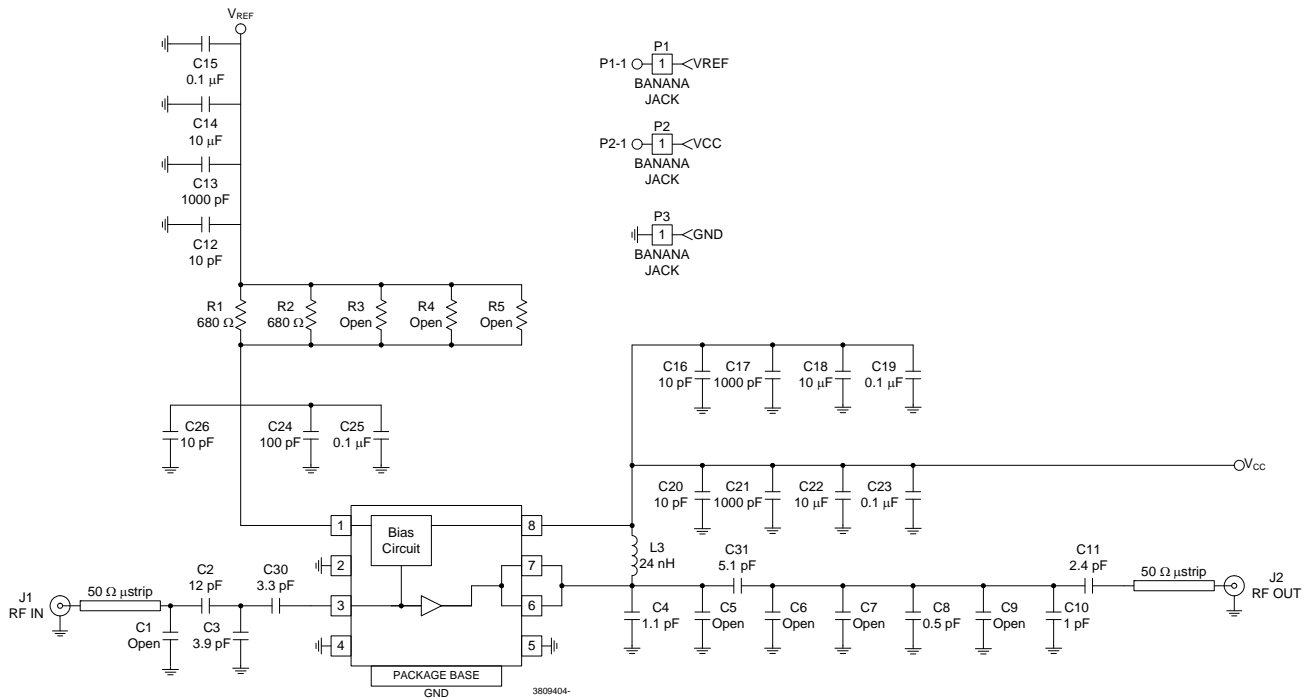
## Evaluation Board Schematic 920MHz to 960MHz (GSM900) (RF3809412)



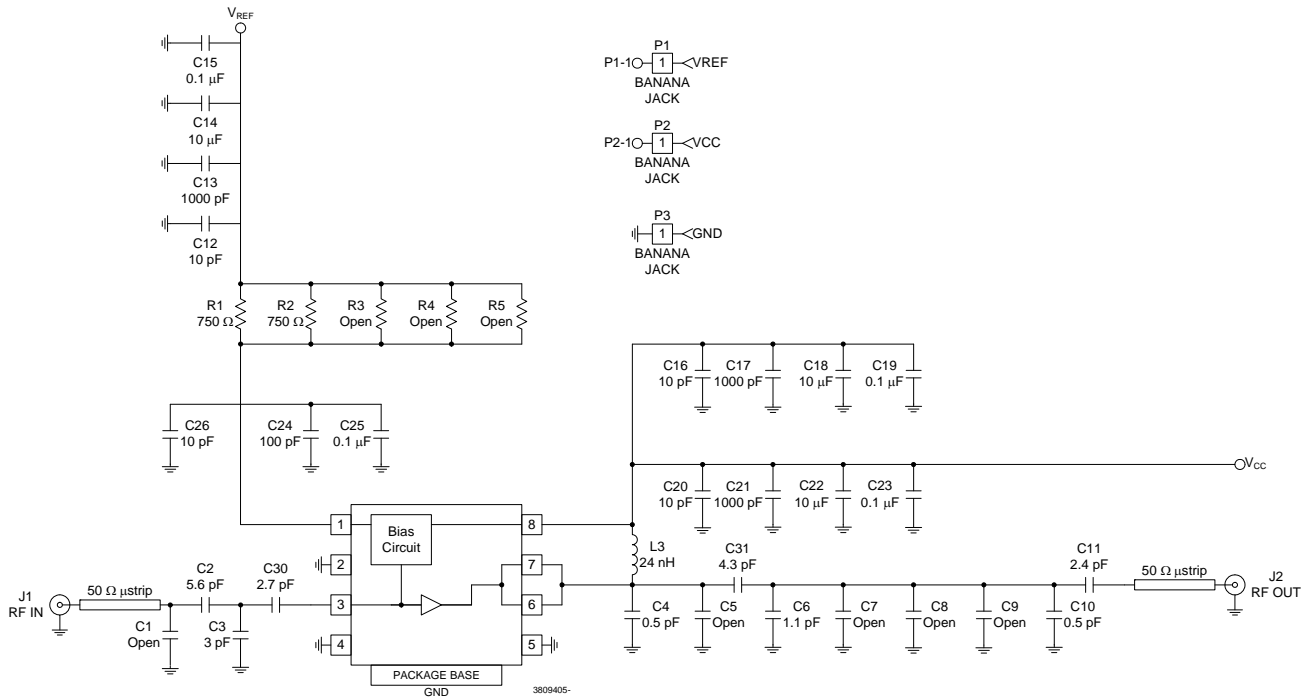
**Evaluation Board Schematic**  
1805MHz to 1880MHz (DCS1800) (RF3809413)



**Evaluation Board Schematic**  
1930MHz to 1990MHz (PCS1900) (RF3809414)

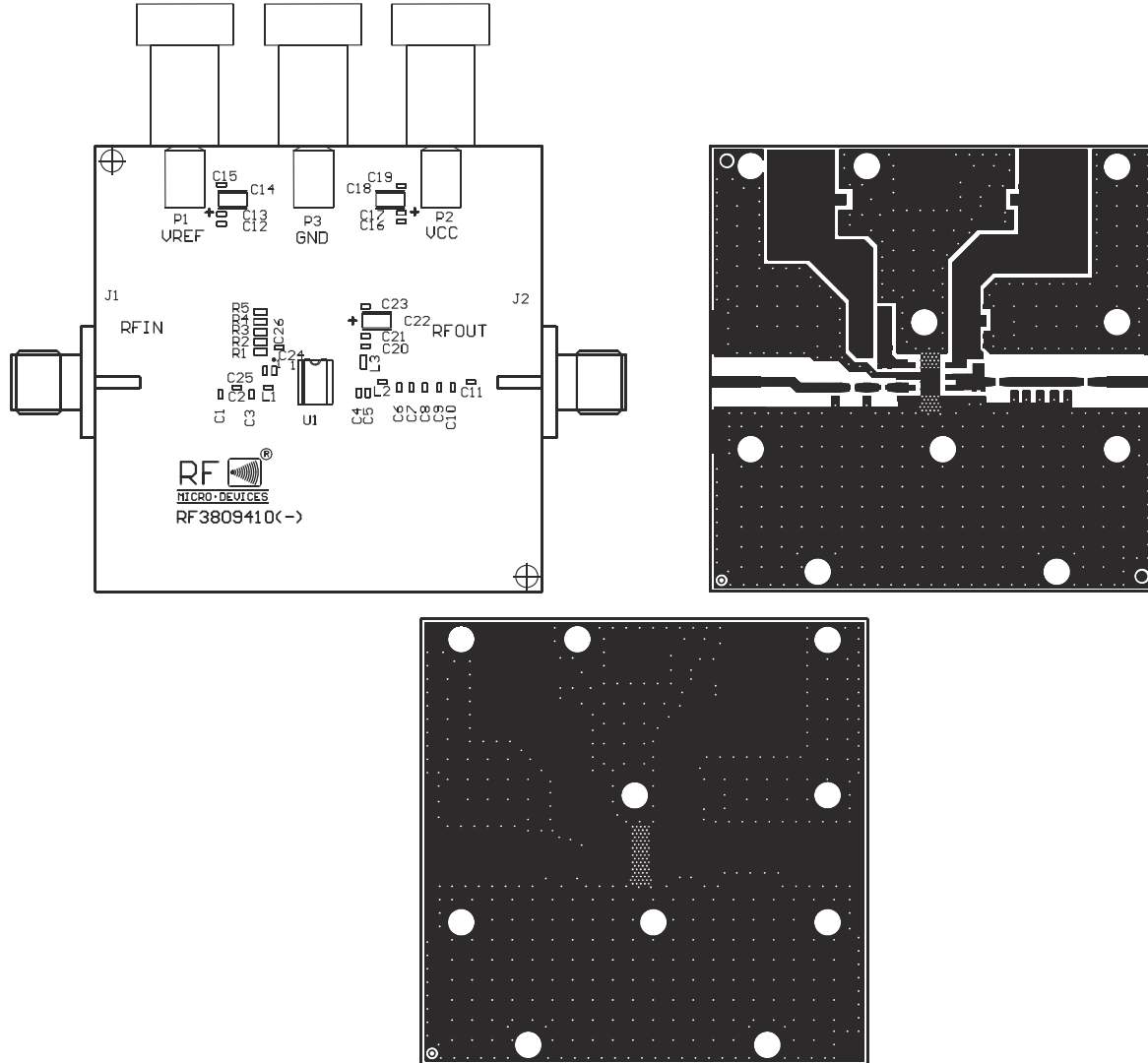


## Evaluation Board Schematic UMTS (RF3809415)



**Evaluation Board Layout**  
**Board Size 2.0" x 2.0"**

Board Thickness 0.023", Board Material Rogers 4530



## PCB Design Requirements

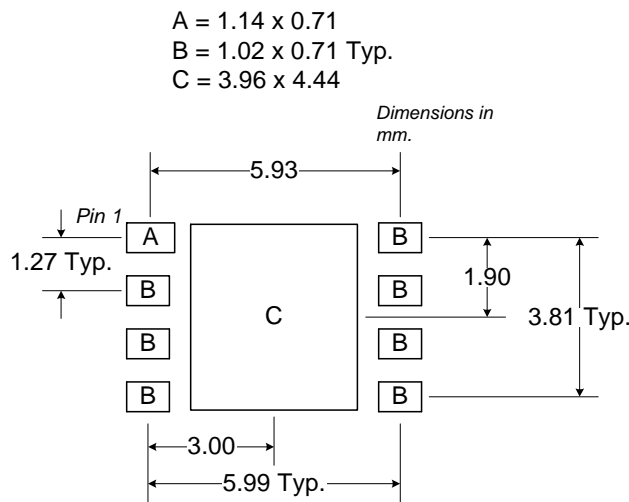
### PCB Surface Finish

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

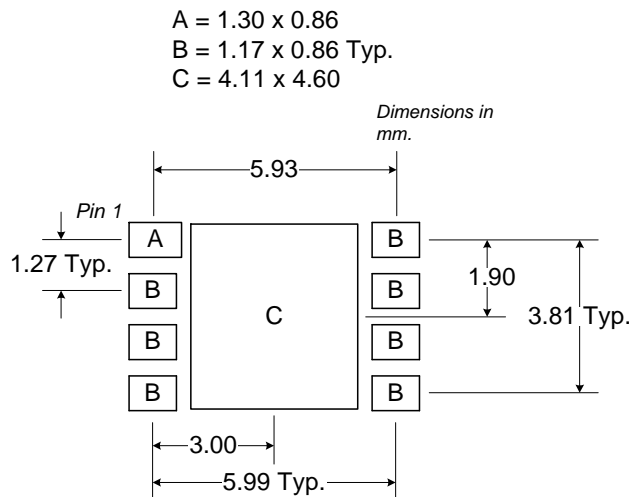
PCB land patterns for PFMD components are based on IPC-7351 standards and RFMD empirical data. The pad pattern shown has been developed and tested for optimized assembly at RFMD. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from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

### PCB Metal Land Pattern



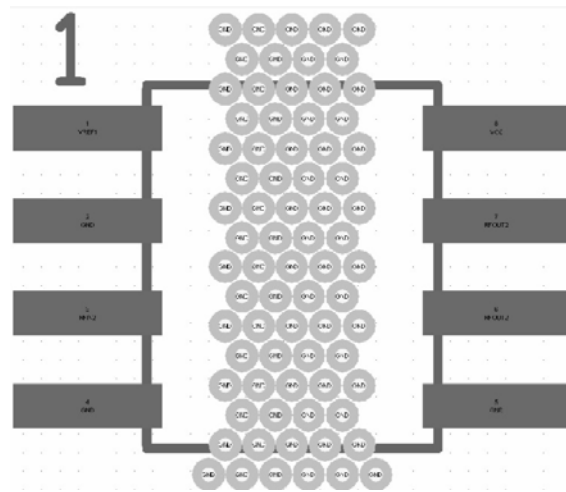
### PCB Solder Mask Pattern

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.



**Thermal Pad and Via Design**

The DUT must be connected to the PCB backside ground through a low inductance, low thermal resistance path. The required interface is achieved with the via pattern shown below for both low inductance as well as low thermal resistance. The footprint provided below worked well on the RFMD 20mil thick Rogers 4350 PCB and also standard FR4. The vias are 8mil vias that are partially plated through and are finished to 8mils±2mils with a minimum plating of 1.5mil. Failure to place these vias within the DUT mounting area on the PCB in this prescribed manner may result in electrical performance and/or reliability degradation.



## Tape and Reel Information

Carrier tape basic dimensions are based on EIA481. The pocket is designed to hold the part for shipping and loading onto SMT manufacturing equipment, while protecting the board and the solder terminals from damaging stresses. The individual pocket design can vary from vendor to vendor, but wide and pitch will be consistent.

Carrier tape is wound or placed on a shipping reel with a diameter of either 330mm (13 inches) or 178mm (7 inches). The center hub design is large enough to ensure the radius formed by the carrier tape around it does not put unnecessary stress on the parts.

Prior to shipping, moisture sensitive parts (MSL level 2a to 5a) are baked and placed into the pockets of the carrier tape. A cover tape is sealed over the top of the entire length of the carrier tape. The reel is sealed in a moisture barrier, ESD bag, which is placed in a cardboard shipping box. It is important to note that unused moisture sensitive parts need to be resealed in the moisture barrier bag. If the reels exceed the exposure limit and need to be rebaked, most carrier tape and shipping reels are not rated as bakeable at 125°C. If baking is required, devices may be baked according to section 4, table 4-1, column 8 of Joint Industry Standard IPC/JEDECJ-STD-033A.

The following table provides useful information for carrier tape and reels used for shipping the devices described in this document.

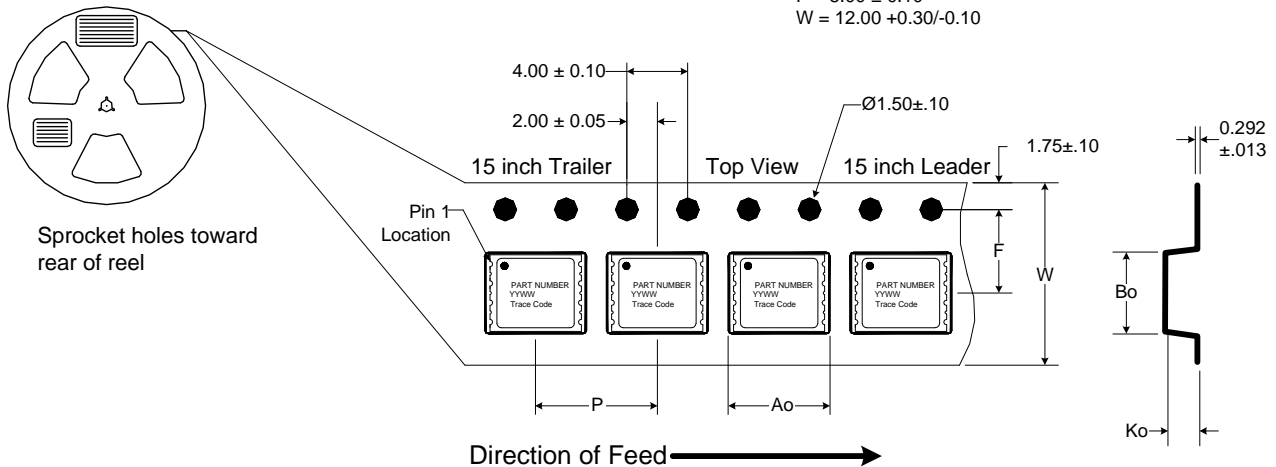
RFMD Part Number	Reel Diameter Inch (mm)	Hub Diameter Inch (mm)	Width (mm)	Pocket Pitch (mm)	Feed	Units per Reel
RF3809TR13	13 (330)	4 (102)	12	8	Single	2500
RF3809TR7	7 (178)	2.4 (61)	12	8	Single	750

### Carrier Tape Drawing with Part Orientation

Notes:

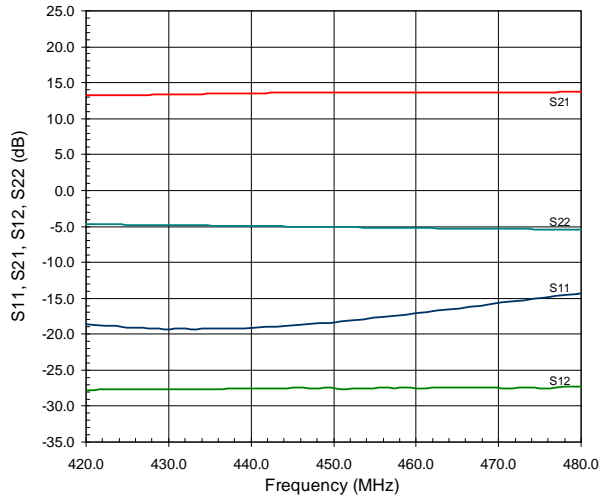
- All dimensions are in millimeters (mm).
- Unless otherwise specified, all dimension tolerances per EIA-481.

$A_o = 6.70 \pm 0.10$   
 $B_o = 5.40 \pm 0.10$   
 $F = 5.50 \pm 0.05$   
 $K_o = 2.10 \pm 0.10$   
 $P = 8.00 \pm 0.10$   
 $W = 12.00 +0.30/-0.10$

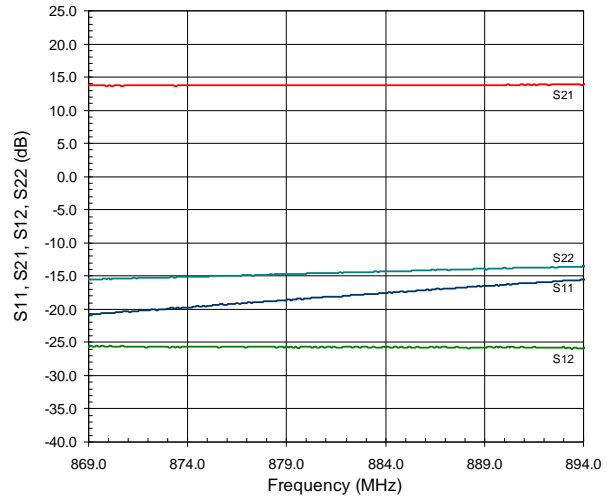




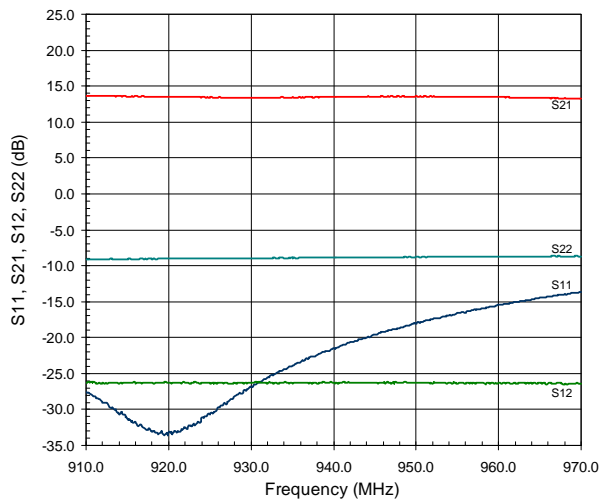
**RF3809410 Evaluation Board S-Parameters**



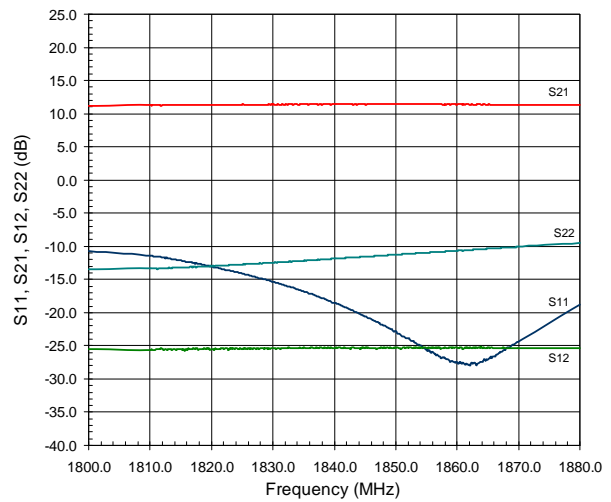
**RF3809411 Evaluation Board S-Parameters**



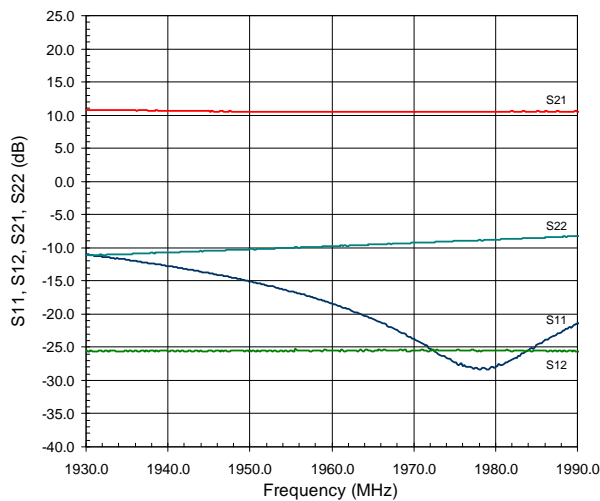
**RF3809412 Evaluation Board S-Parameters**



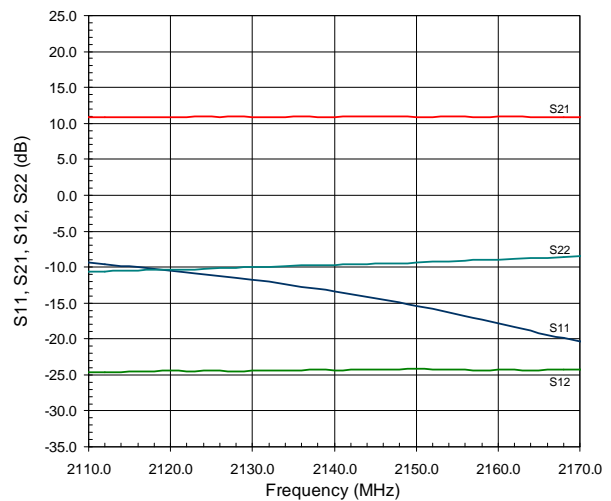
**RF3809413 Evaluation Board S-Parameters**



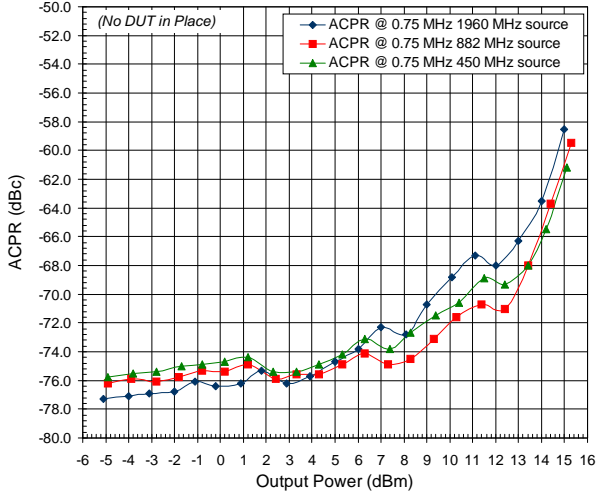
**RF3809414 Evaluation Board S-Parameters**



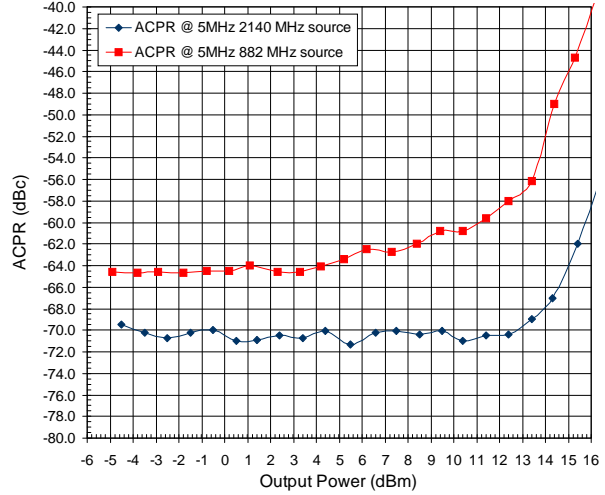
**RF3809415 Evaluation Board S-Parameters**



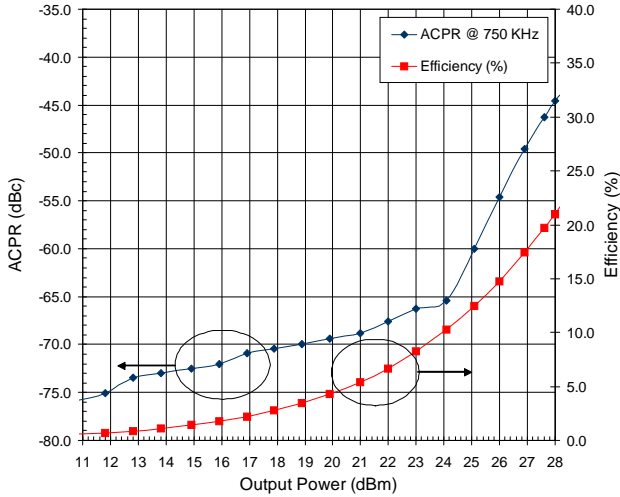
**CDMA2K ACPR Performance for RS SMIQ03HD Sig Gen & FSU8 Spec Analyzer (1960 MHz, 882 MHz, & 450 MHz Source Signals)**



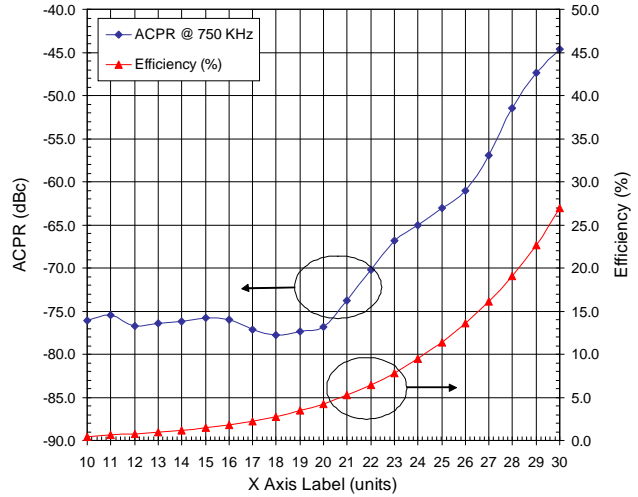
**W-CDMA ACPR Performance for RS SMIQ03HD Sig Gen & FSU8 Spec Analyzer (2140 MHz & 882 MHz Source Signals)**



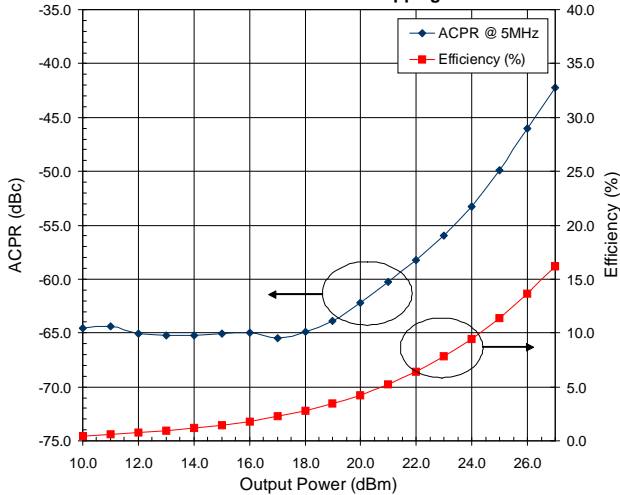
**RF3809410 @ 450 MHz CDMA2K SR1 and 9 Channels**



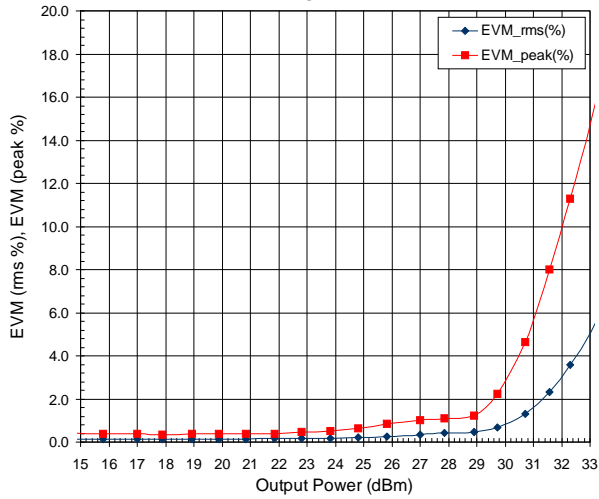
**RF3809411 @ 882 MHz CDMA2K SR1 and 9 Channels**



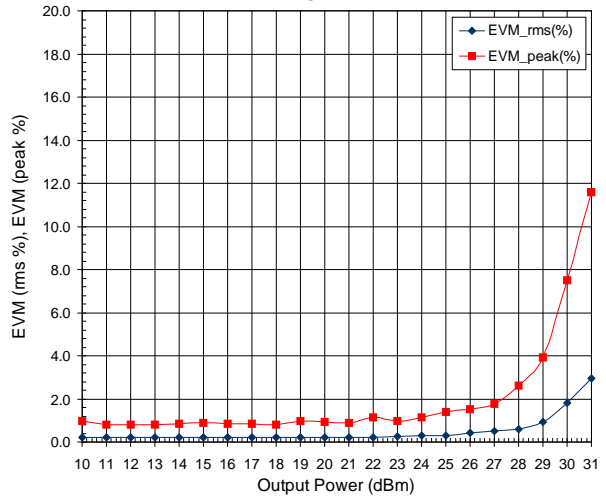
**3809411 @ 882 MHz W-CDMA 64 Channels and No Clipping**



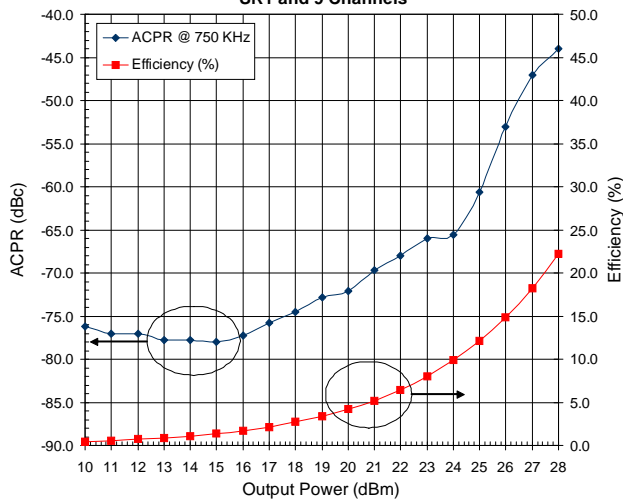
**RF3809412 @ 940 MHz**  
**EDGE EVM**



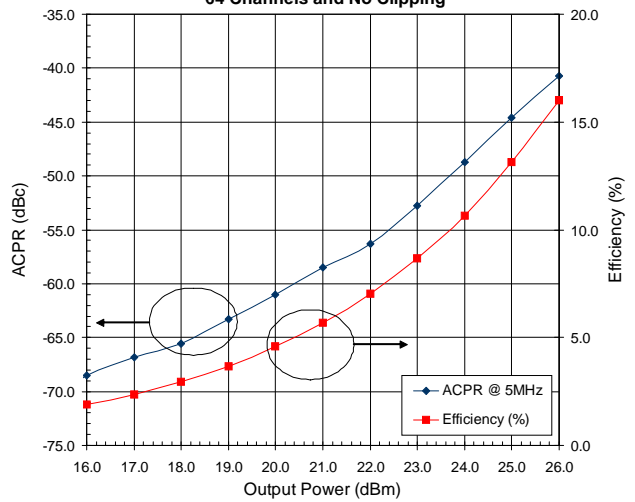
**RF3809413 @ 1840 MHz**  
**EDGE EVM**



**RF3809414 @ 1960 MHz CDMA2K**  
**SR1 and 9 Channels**



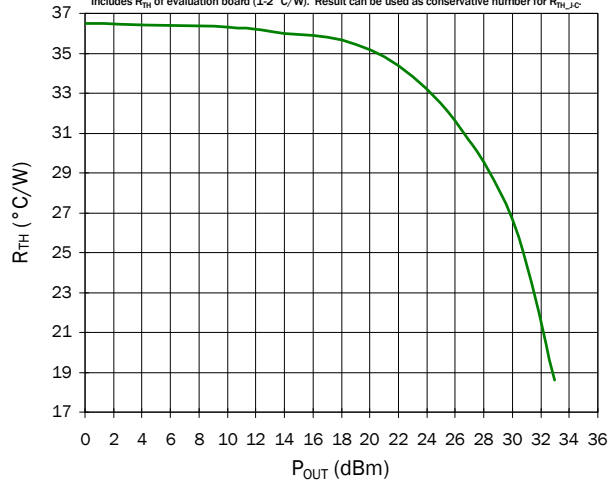
**RF3809415 @ 2140 MHz W-CDMA UMTS**  
**64 Channels and No Clipping**



### R<sub>TH</sub>J-A versus P<sub>OUT</sub>

IR scan condition: 85 °C ambient, V<sub>CC</sub>=V<sub>REF</sub>=8V, R<sub>BIAS</sub>=360Ω.

Includes R<sub>th</sub> of evaluation board (1.2 °C/W). Result can be used as conservative number for R<sub>TH</sub>J-C



### Junction Temperature versus P<sub>OUT</sub>

IR scan condition: 85 °C ambient, V<sub>CC</sub>=V<sub>REF</sub>=8V, R<sub>BIAS</sub>=360Ω

