



Package Style: Hermetic 2-Pin Flanged Ceramic

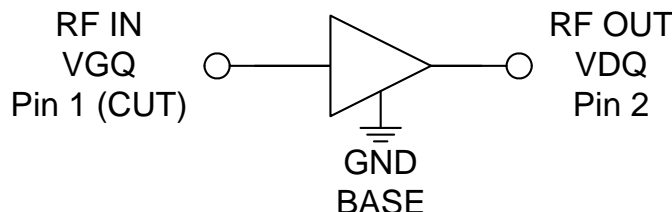


### Features

- Broadband Operation DC to 3.5GHz
- Advanced GaN HEMT Technology
- Advanced Heat-Sink Technology
- Gain = 15dB at 2GHz
- 48V Operation Typical Performance at 900MHz
  - Output Power 50W
  - Drain Efficiency 65%
  - -40 °C to 85 °C Operation

### Applications

- Commercial Wireless Infrastructure
- Cellular and WiMAX Infrastructure
- Civilian and Military Radar
- General Purpose Broadband Amplifiers
- Public Mobile Radios
- Industrial, Scientific and Medical



Functional Block Diagram

### Product Description

The RF3931 is a 48V 30W high power discrete amplifier designed for commercial wireless infrastructure, cellular and WiMAX infrastructure, industrial/scientific/medical, and general purpose broadband amplifier applications. Using an advanced high power density Gallium Nitride (GaN) semiconductor process, these high-performance amplifiers achieve high efficiency and flat gain over a broad frequency range in a single amplifier design. The RF3931 is an unmatched GaN transistor packaged in a hermetic, flanged ceramic package. This package provides excellent thermal stability through the use of advanced heat sink and power dissipation technologies. Ease of integration is accomplished through the incorporation of simple, optimized matching networks external to the package that provide wide-band gain and power performance in a single amplifier.

### Ordering Information

RF3931S2	2-Piece sample bag
RF3931SB	5-Piece bag
RF3931SQ	25-Piece bag
RF3931SR	100 Pieces on 7" short reel
RF3931TR7	750 Pieces on 7" reel
RF3931PCK-411	Fully assembled evaluation board optimized for 2.14GHz; 48V

### Optimum Technology Matching® Applied

<input type="checkbox"/> GaAs HBT	<input type="checkbox"/> SiGe BiCMOS	<input type="checkbox"/> GaAs pHEMT	<input checked="" type="checkbox"/> GaN HEMT
<input type="checkbox"/> GaAs MESFET	<input type="checkbox"/> Si BiCMOS	<input type="checkbox"/> Si CMOS	<input type="checkbox"/> BiFET HBT
<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
Drain Voltage ( $V_D$ )	150	V
Gate Voltage ( $V_G$ )	-8 to +2	V
Gate Current	23	mA
Operational Voltage	65	V
Ruggedness (VSWR)	10:1	
Storage Temperature Range	-55 to +125	°C
Operating Temperature Range ( $T_L$ )	-40 to +85	°C
Operating Junction Temperature ( $T_J$ )	200	°C
Human Body Model	Class 1A	
MTTF ( $T_J < 200^\circ\text{C}$ , 95% Confidence Limits)*	$3 \times 10^6$	hours
Thermal Resistance, $R_{TH}$ (junction to case) measured at $T_C = 85^\circ\text{C}$ , DC bias only	3.6	°C/W

\*MTTF - median time to failure for wear-out failure mode (30% $I_{dss}$  degradation) which is determined by the technology reliability. Refer to product qualification report for FIT (random) Failure rate.

Operation of this device beyond any one of these limits may cause permanent damage. For reliable continuous operation, the device voltage and current must not exceed the maximum operating values specified in the table on page two.

Bias Conditions should also satisfy the following expression:

$$P_{DISS} < (T_J - T_C) / R_{TH} \text{ J-C and } T_C = T_{CASE}$$



**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.

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

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Recommended Operating Conditions					
Drain Voltage (V <sub>DSQ</sub> )	28		48	V	
Gate Voltage (V <sub>GSQ</sub> )	-5	-3	-2.5	V	
Drain Bias Current		130		mA	
Frequency of Operation	DC		3500	MHz	
Capacitance					
C <sub>RSS</sub>		4		pF	V <sub>G</sub> = -8V, V <sub>D</sub> = 0V
C <sub>ISS</sub>		17		pF	V <sub>G</sub> = -8V, V <sub>D</sub> = 0V
C <sub>OSS</sub>		12		pF	V <sub>G</sub> = -8V, V <sub>D</sub> = 0V
DC Function Test					
I <sub>G (OFF)</sub> - Gate Leakage			2	mA	V <sub>G</sub> = -8V, V <sub>D</sub> = 0V
I <sub>D (OFF)</sub> - Drain Leakage			2.5	mA	V <sub>G</sub> = -8V, V <sub>D</sub> = 48V
V <sub>GS (TH)</sub> - Threshold Voltage		-4.2		V	V <sub>G</sub> = -8V, I <sub>D</sub> = 6.6mA
V <sub>DS (ON)</sub> - Drain Voltage at high current		0.25		V	V <sub>G</sub> = 0V, I <sub>D</sub> = 1.5A
RF Function Test					[1],[2]
V <sub>GS (Q)</sub>		-3.5		V	V <sub>D</sub> = 48V, I <sub>D</sub> = 130mA
Gain	10	12		dB	CW, P <sub>OUT</sub> = 45.8dBm, f = 2140MHz
Drain efficiency	55	60		%	CW, P <sub>OUT</sub> = 45.8dBm, f = 2140MHz
Input Return Loss		-12	-10	dB	CW, P <sub>OUT</sub> = 45.8dBm, f = 2140MHz

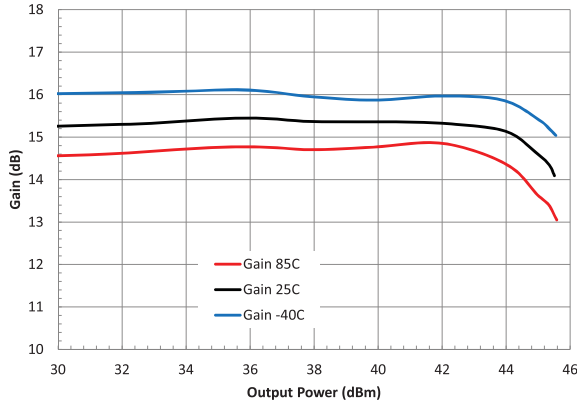
Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
RF Typical Performance					[1],[2]
Small Signal Gain		20		dB	CW, f = 900MHz
Small Signal Gain		14		dB	CW, f = 2140MHz
Output Power at P3dB		47		dBm	CW, f = 900MHz
Output Power at P3dB		46.5		dBm	CW, f = 2140MHz
Drain Efficiency at P3dB		65		%	CW, f = 900MHz
Drain Efficiency at P3dB		65		%	CW, f = 2140MHz

[1] Test Conditions: CW Operation,  $V_{DSQ} = 48V$ ,  $I_{DQ} = 130mA$ ,  $T = 25^{\circ}C$

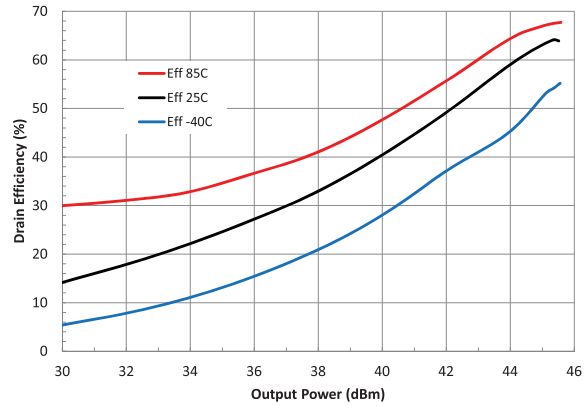
[2] Performance in a standard tuned test fixture

## Typical Performance in standard 2.14GHz fixed tuned test fixture (CW, T = 25 °C, unless noted)

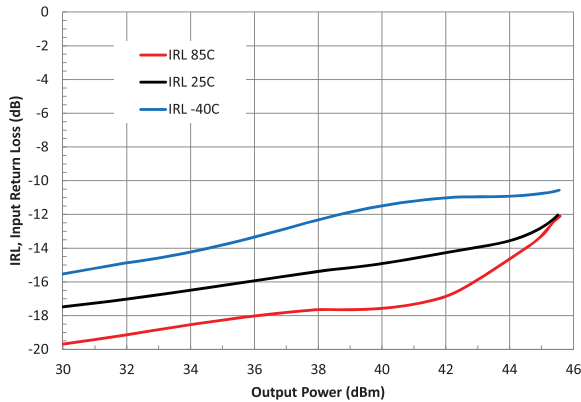
**Gain vs. Output Power (f = 2140MHz)**  
(Pulsed 10% duty cycle, 10uS, Vd = 48V, Idq = 130mA)



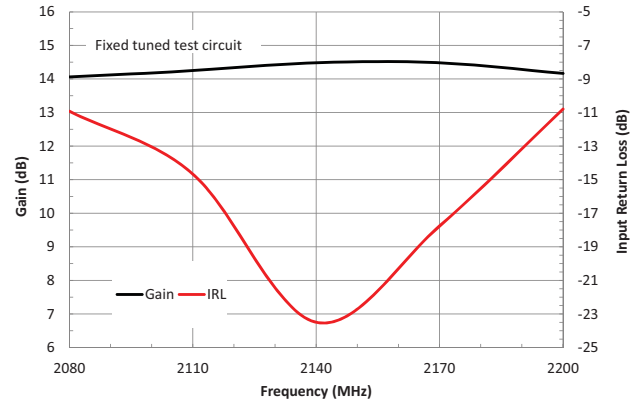
**Efficiency vs. Output Power (f = 2140MHz)**  
(Pulsed 10% duty cycle, 10uS, Vd = 48V, Idq = 130mA)



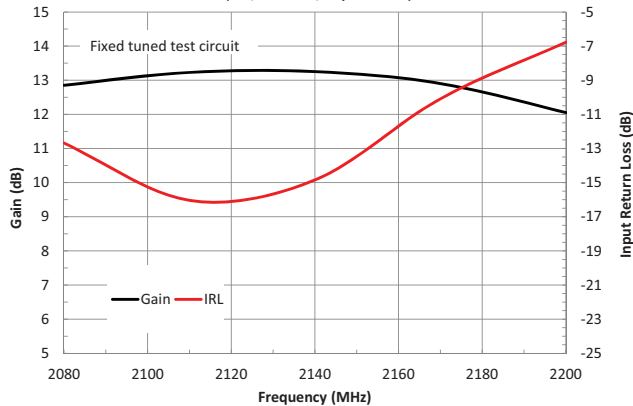
**Input Return Loss vs. Output Power (f = 2140MHz)**  
(Pulsed 10% duty cycle, 10uS, Vd = 48V, Idq = 130mA)



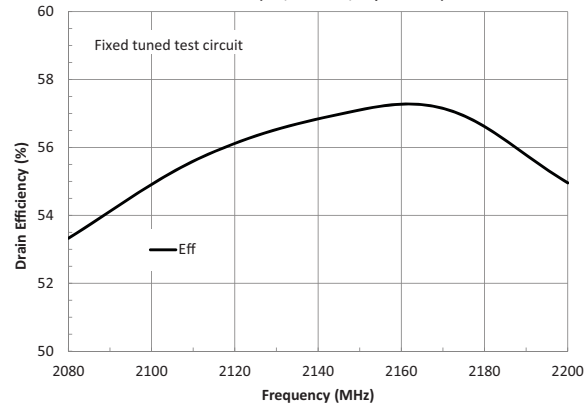
**Small Signal Performance vs. Frequency, Pout = 30dBm**  
(Vd = 48V, Idq = 130mA)

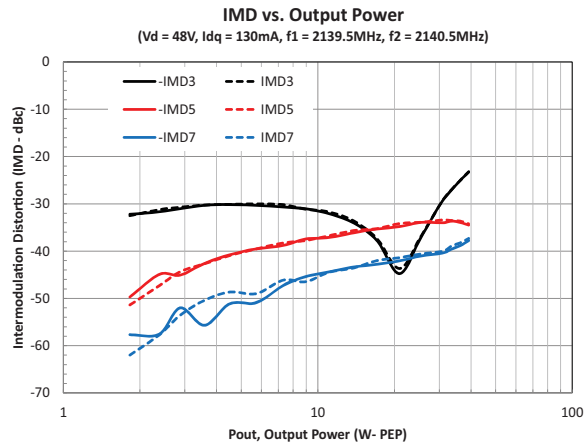
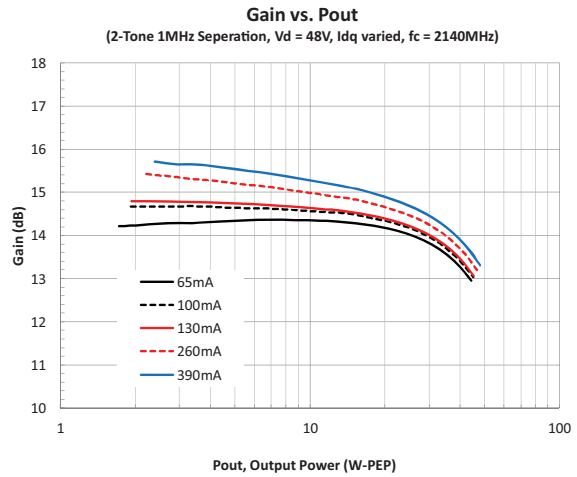
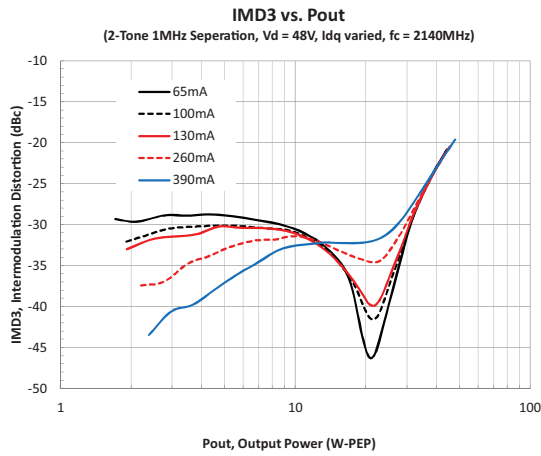
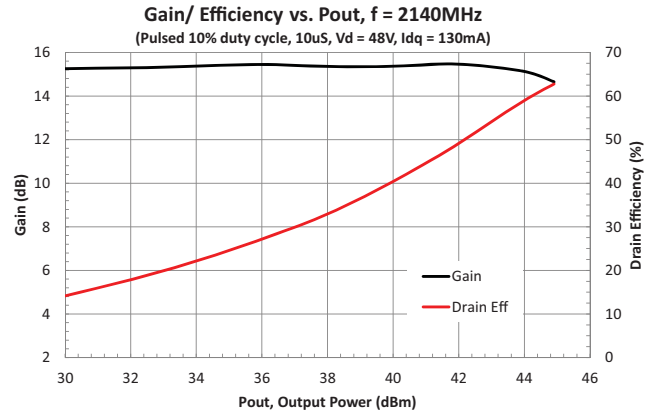
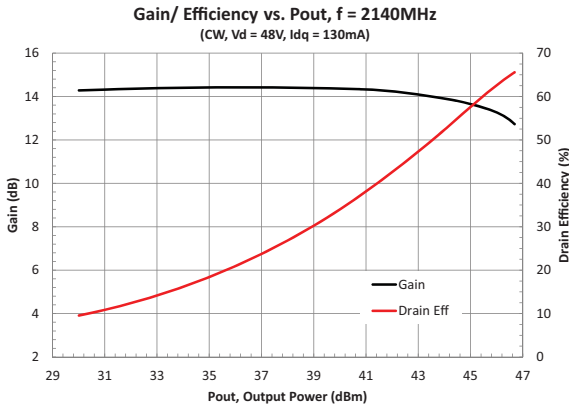


**Gain/IRL vs. Frequency, Pout = 46dBm**  
(CW, Vd = 48V, Idq = 130mA)



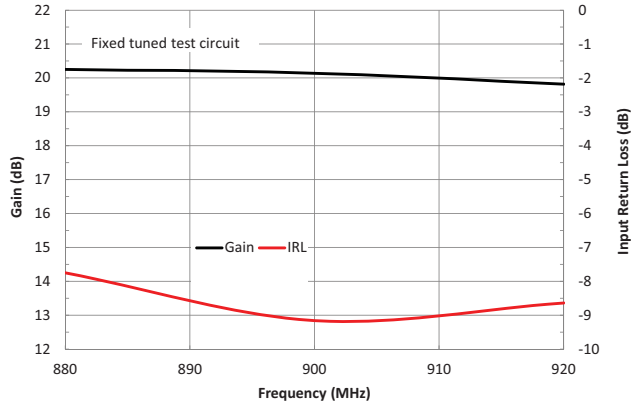
**Drain Efficiency vs. Frequency, Pout = 46dBm**  
(CW, Vd = 48V, Idq = 130mA)



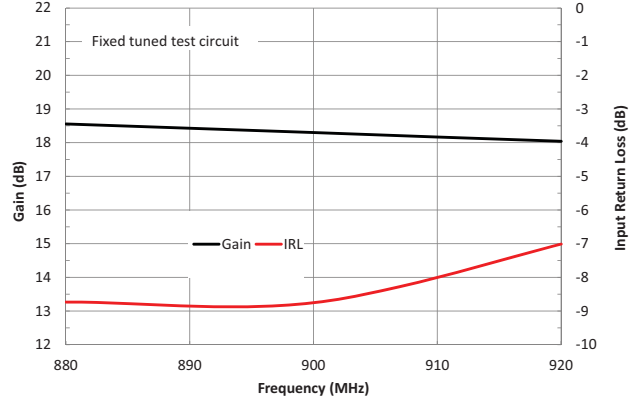


## Typical Performance in standard 900MHz fixed tuned test fixture (CW, T = 25 °C, unless noted)

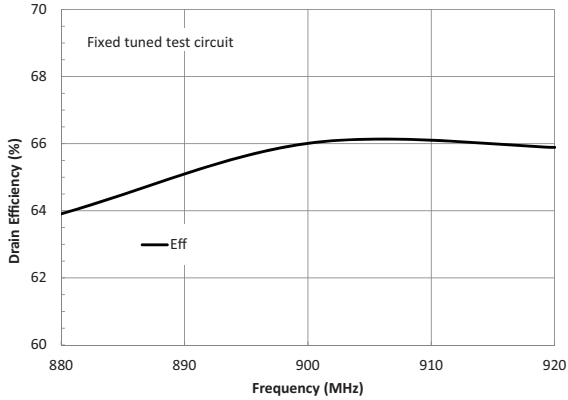
**Small Signal Performance vs. Frequency, Pout = 30dBm**  
(Vd = 48V, Idq = 130mA)



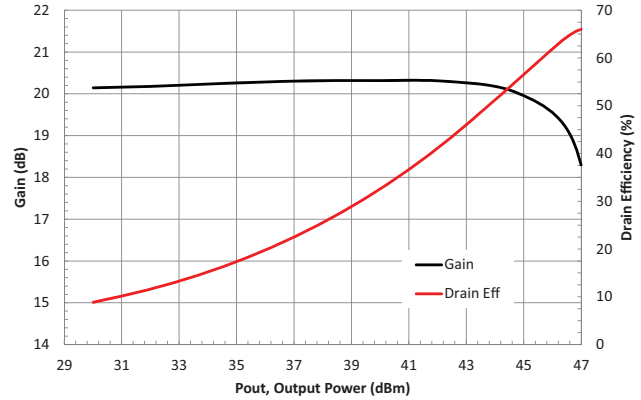
**Gain/IRL vs. Frequency, Pout = 47dBm**  
(CW, Vd = 48V, Idq = 130mA)

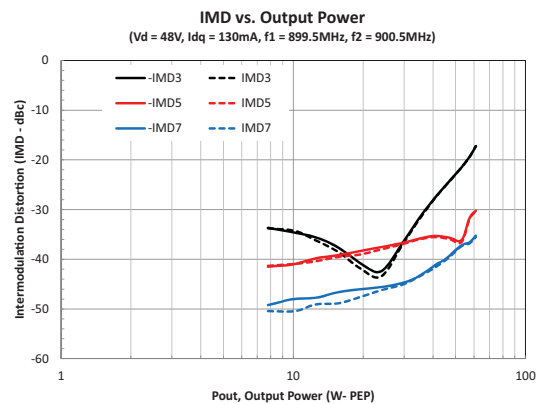
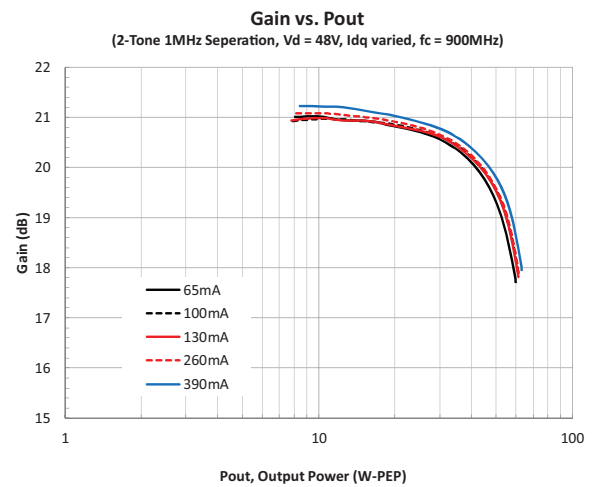
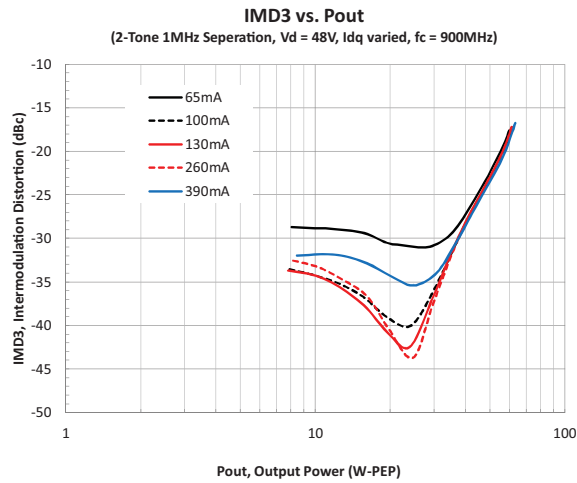


**Drain Efficiency vs. Frequency, Pout = 47dBm**  
(CW, Vd = 48V, Idq = 130mA)

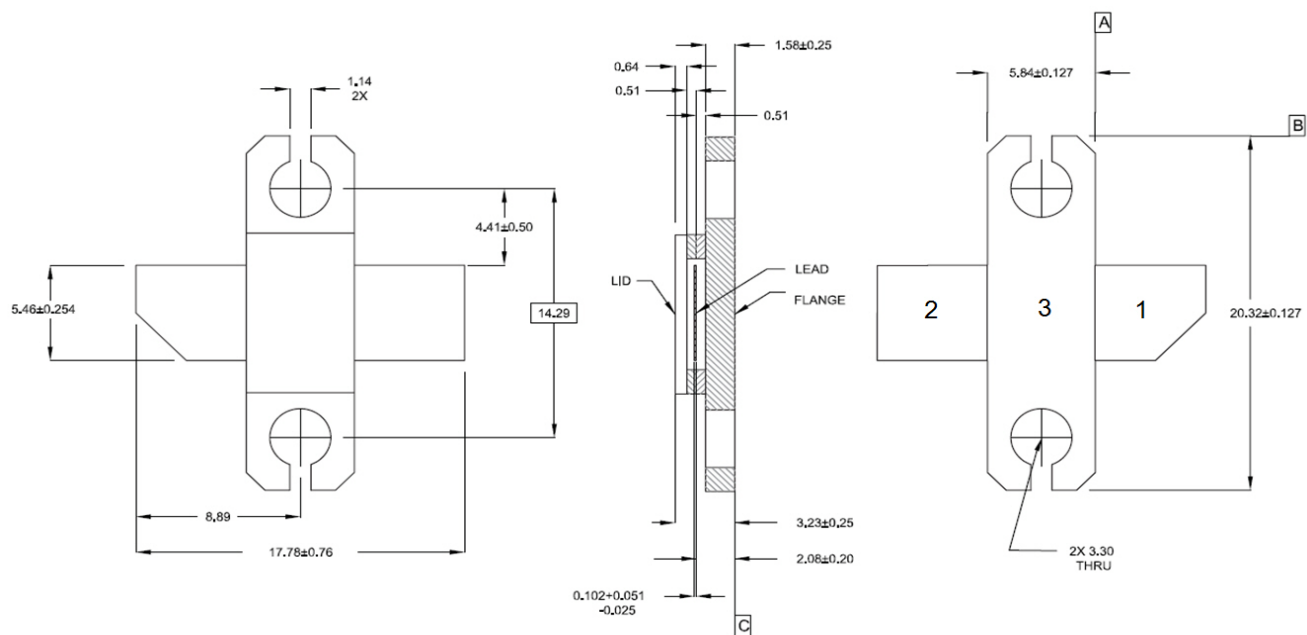


**Gain/ Efficiency vs. Pout, f = 900MHz**  
(CW, Vd = 48V, Idq = 130mA)





Package Drawing  
(Package Style: Flanged Ceramic)



Package Style: Flanged Ceramic

Pin	Function	Description
1	Gate	Gate - VG RF Input
2	Drain	Drain - VD RF Output
3	Source	Source - Ground Base



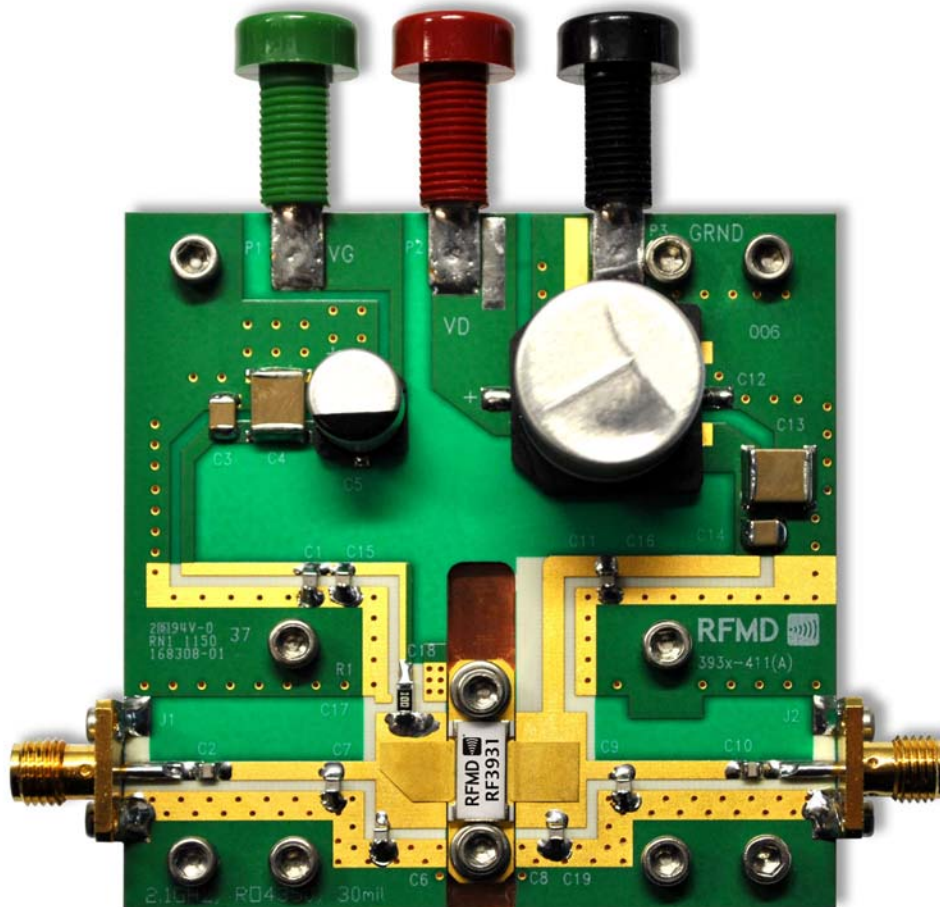
## Bias Instruction for RF3931 Evaluation Board

ESD Sensitive Material. Please use proper ESD precautions when handling devices of evaluation board.

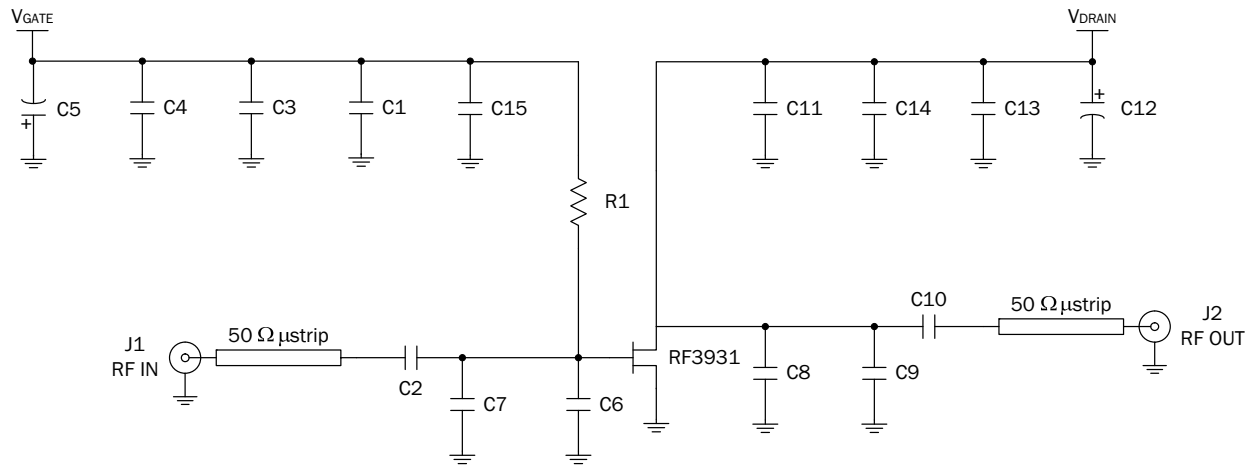
Evaluation board requires additional external fan cooling.

Connect all supplies before powering up the evaluation board.

1. Connect RF cables at RF<sub>IN</sub> and RF<sub>OUT</sub>.
2. Connect ground to the ground supply terminal, and ensure that both the V<sub>G</sub> and V<sub>D</sub> grounds are also connected to this ground terminal.
3. Apply -8V to V<sub>G</sub>.
4. Apply 48V to V<sub>D</sub>.
5. Increase V<sub>G</sub> until drain current reaches 130mA desired bias point.
6. Turn on the RF input.



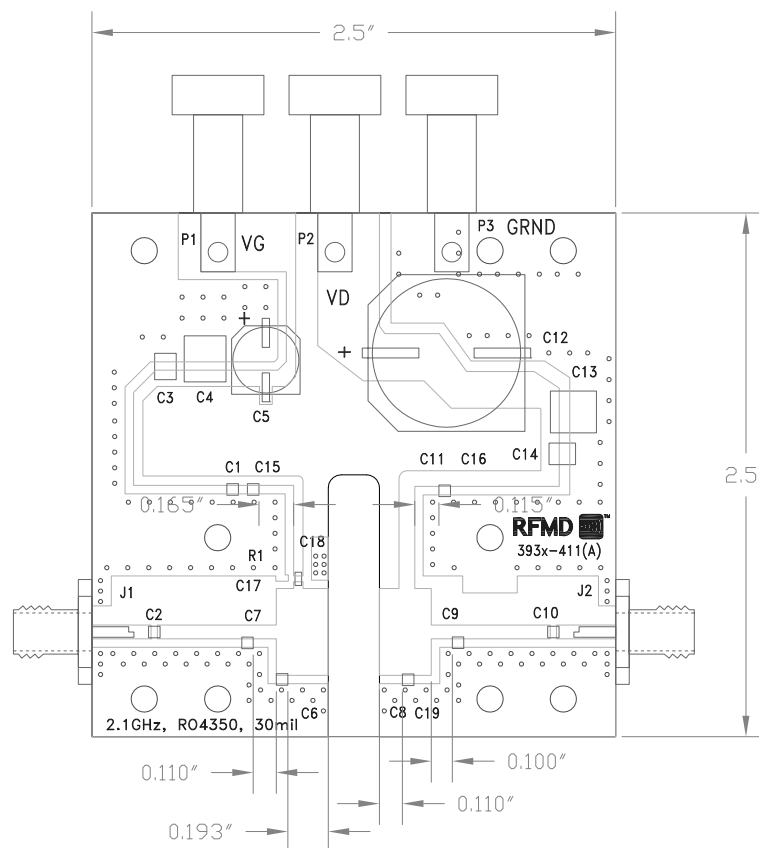
2.14GHz Evaluation Board Schematic



2.14GHz Evaluation Board Bill of Materials

Component	Value	Manufacturer	Part Number
C1, C2, C10, C11	33pF	ATC	ATC800A330JT
C3,C14	0.1μF	Murata	GRM32NR72A104KA01L
C4,C13	4.7μF	Murata	GRM55ER72A475KA01L
C5	100μF	Panasonic	ECE-V1HA101UP
C6	2.2pF	ATC	ATC800A2R2BT
C7	0.7pF	ATC	ATC800A0R7BT
C8	1.0pF	ATC	ATC800A1R0BT
C9	3.3pF	ATC	ATC800A3R3BT
C12	100μF	Panasonic	EEV-TG2A101M
C15	10pF	ATC	ATC800A100JT
R1	10Ω	Panasonic	ERJ-8GEYJ100V
C16, C17, C18, C19	Not used	-	-
PCB	R04350, 0.030" thick dielectric	Rogers	-

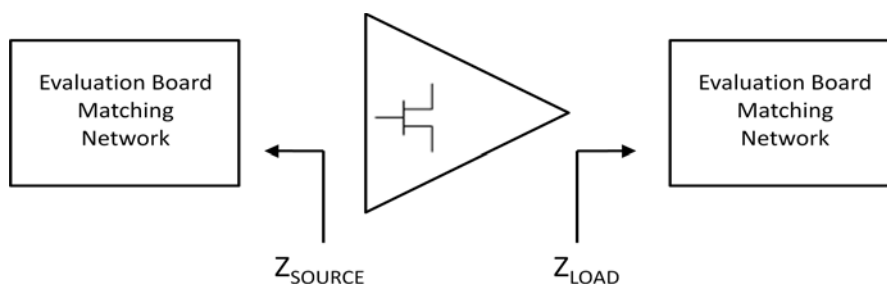
## 2.14GHz Evaluation Board Layout



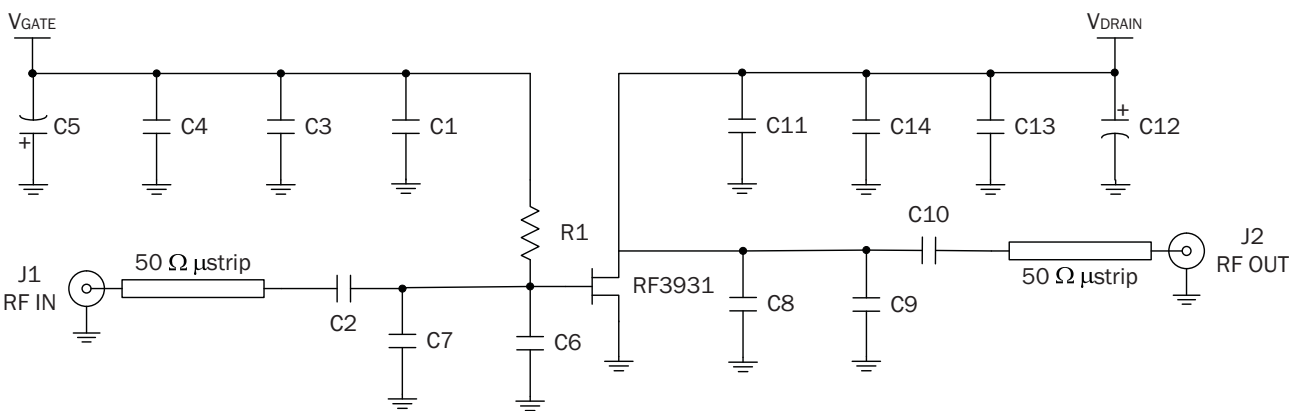
## Device Impedances

Frequency (MHz)	Z Source ( $\Omega$ )	Z Load ( $\Omega$ )
2110	2.6 - j3.1	6.5 + j5.8
2140	2.5 - j2.8	6.7 + j6.6
2170	2.4 - j2.5	7.0 + j7.4

**Note:** Device impedances reported are the measured evaluation board impedances chosen for a trade off of efficiency, peak power, and linearity performance across the entire frequency bandwidth.



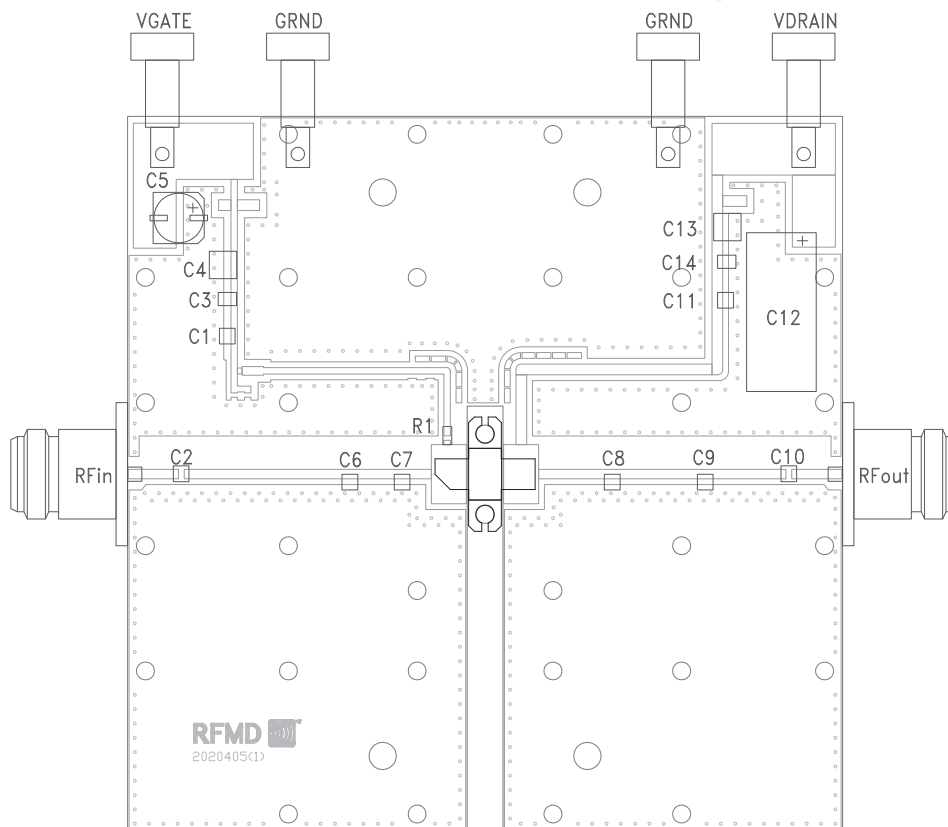
900MHz Evaluation Board Schematic



900MHz Evaluation Board Bill of Materials

Component	Value	Manufacturer	Part Number
C1, C2, C10, C11	68pF	ATC	ATC800B680JT
C3,C14	0.1μF	Murata	GRM32NR72A104KA01L
C4,C13	4.7μF	Murata	GRM55ER72A475KA01L
C5	100μF	Panasonic	ECE-V1HA101UP
C6	12pF	ATC	ATC800B120
C7	5.6pF	ATC	ATC800B5R6
C8	6.8pF	ATC	ATC800B6R8
C9	2.0pF	ATC	ATC800B2R0
C12	330μF	Panasonic	EEU-FC2A331
R1	10Ω	Panasonic	ERJ-8GEYJ100V

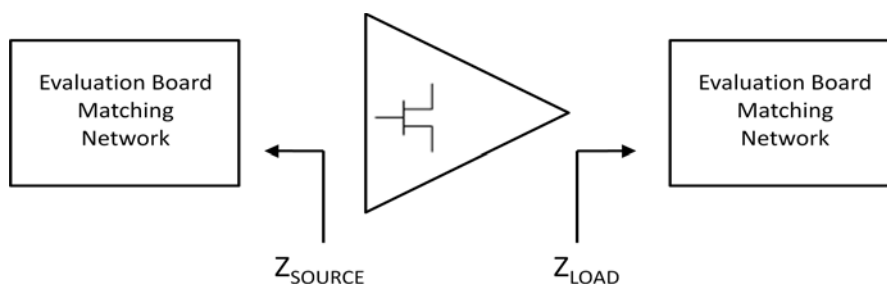
## 900MHz Evaluation Board Layout



## Device Impedances

Frequency (MHz)	Z Source ( $\Omega$ )	Z Load ( $\Omega$ )
880	$4.2 + j9.0$	$12.9 + j14.2$
900	$4.3 + j10.0$	$13.6 + j15.1$
920	$4.4 + j11.3$	$14.4 + j16.0$

**Note:** Device impedances reported are the measured evaluation board impedances chosen for a trade off of efficiency, peak power, and linearity performance across the entire frequency bandwidth.



Loadpull contours available on RFMD website.

**Device Handling/Environmental Conditions**

GaN HEMT devices are ESD sensitive materials. Please use proper ESD precautions when handling devices or evaluation boards.

**GaN HEMT Capacitances**

The physical structure of the GaN HEMT results in three terminal capacitors similar to other FET technologies. These capacitances exist across all three terminals of the device. The physical manufactured characteristics of the device determine the value of the  $C_{DS}$  (drain to source),  $C_{GS}$  (gate to source) and  $C_{GD}$  (gate to drain). These capacitances change value as the terminal voltages are varied. RFMD presents the three terminal capacitances measured with the gate pinched off ( $V_{GS} = -8V$ ) and zero volts applied to the drain. During the measurement process, the parasitic capacitances of the package that holds the amplifier is removed through a calibration step. Any internal matching is included in the terminal capacitance measurements. The capacitance values presented in the typical characteristics table of the device represent the measured input ( $C_{ISS}$ ), output ( $C_{OSS}$ ), and reverse ( $C_{RSS}$ ) capacitance at the stated bias voltages. The relationship to three terminal capacitances is as follows:

$$C_{ISS} = C_{GD} + C_{GS}$$

$$C_{OSS} = C_{GD} + C_{DS}$$

$$C_{RSS} = C_{GD}$$

**DC Bias**

The GaN HEMT device is a depletion mode high electron mobility transistor (HEMT). At zero volts  $V_{GS}$  the drain of the device is saturated and uncontrolled drain current will destroy the transistor. The gate voltage must be taken to a potential lower than the source voltage to pinch off the device prior to applying the drain voltage, taking care not to exceed the gate voltage maximum limits. RFMD recommends applying  $V_{GS} = -5V$  before applying any  $V_{DS}$ .

RF Power transistor performance capabilities are determined by the applied quiescent drain current. This drain current can be adjusted to trade off power, linearity, and efficiency characteristics of the device. The recommended quiescent drain current ( $I_{DQ}$ ) shown in the RF typical performance table is chosen to best represent the operational characteristics for this device, considering manufacturing variations and expected performance. The user may choose alternate conditions for biasing this device based on performance trade off.

**Mounting and Thermal Considerations**

The thermal resistance provided as  $R_{TH}$  (junction to case) represents only the packaged device thermal characteristics. This is measured using IR microscopy capturing the device under test temperature at the hottest spot of the die. At the same time, the package temperature is measured using a thermocouple touching the backside of the die embedded in the device heatsink but sized to prevent the measurement system from impacting the results. Knowing the dissipated power at the time of the measurement, the thermal resistance is calculated.

In order to achieve the advertised MTTF, proper heat removal must be considered to maintain the junction at or below the maximum of 200 °C. Proper thermal design includes consideration of ambient temperature and the thermal resistance from ambient to the back of the package including heatsinking systems and air flow mechanisms. Incorporating the dissipated DC power, it is possible to calculate the junction temperature of the device.