RFMD
rfmd.com

Proposed

RFG1M09090

700MHz TO 1000MHz 90W GaN POWER AMPLIFIER

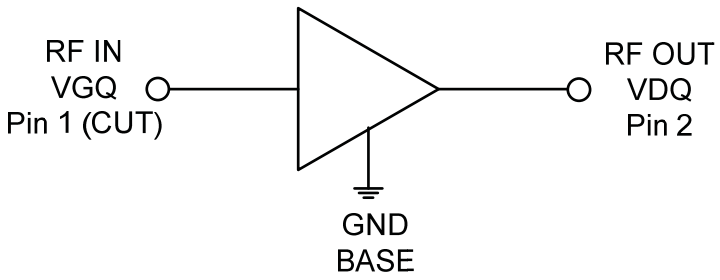
Package: Flanged Ceramic, 2-pin, RF400-2

Features

- Advanced GaN HEMT Technology
- Typical Peak Modulated Power >120W
- Advanced Heat-Sink Technology
- Single Circuit for 865MHz To 960MHz
- 48V Operation Typical Performance:
  - P_{OUT} = 44dBm
  - Gain = 20dB
  - Drain Efficiency = 38%
  - ACP = -33.5dBc
  - Linearizable to -55dBc with DPD
- -25°C To 85°C Operating Temperature
- Optimized for Video Bandwidth and Minimized Memory Effects
- RF Tested for 3GPP Performance
- RF Tested for Peak Power Using IS95
- Large Signal Models Available

Applications

- Commercial Wireless Infrastructure
- High Efficiency Doherty
- High Efficiency Envelope Tracking



Functional Block Diagram

Product Description

The RFG1M09090 is optimized for commercial infrastructure applications in the 700MHz to 1000MHz frequency band, ideal for WCDMA and LTE applications. Using an advanced 48V high power density Gallium Nitride (GaN) semiconductor process optimized for high peak-to-average ratio applications, these high performance amplifiers achieve high efficiency and flat gain over a broad frequency range in a single amplifier design. The RFG1M09090 is an input-matched GaN transistor packaged in an air cavity ceramic package which provides excellent thermal stability. Ease of integration is accomplished through the incorporation of simple, optimized matching networks external to the package that provide wideband gain, efficiency, and linearizable performance in a single amplifier.

Ordering Information

RFG1M09090	700MHz to 1000MHz 90W GaN Power Amplifier
RFG1M09090PCBA-410	865MHz to 960MHz, Fully Assembled Evaluation Board

Optimum Technology Matching® Applied

☐ GaAs HBT	☐ SiGe BiCMOS	☐ GaAs pHEMT	☑ GaN HEMT
☐ GaAs MESFET	☐ Si BiCMOS	☐ Si CMOS	☐ BiFET HBT
☐ InGaP HBT	☐ SiGe HBT	☐ Si BJT	

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

Absolute Maximum Ratings

Parameter	Rating	Unit
Drain Voltage (V_D)	150	V
Gate Voltage (V_G)	-8 to +2	V
Gate Current (I_G)	105	mA
Operational Voltage	50	V
Ruggedness (VSWR)	10:1	
Storage Temperature Range	-65 to +125	°C
Operating Temperature Range (T_L)	-25 to +85	°C
Operating Junction Temperature (T_J)	200	°C
Human Body Model	Class 1A	
MTTF (T_J < 200 °C, 95% Confidence Limits)*	3E + 06	Hours
Thermal Resistance, R_{TH} (junction to case) measured at T_C = 85 °C, DC bias only)	2.7	°C/W

*MTTF - median time to failure for wear-out failure mode (30% I_{DSS} degradation) which is determined by the technology process 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:
$P_{DISS} < (T_J - T_C)/R_{TH}$ 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.

RFMD Green: RoHS compliant per EU Directive 2002/95/EC, halogen free per IEC 61249-2-21, < 1000 ppm 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 Condition					
Drain Voltage (V_{DSQ})	28		48	V	
Gate Voltage (V_{GSQ})	-4.5	-3.2	-2.0	V	
Drain Bias Current		300		mA	
Frequency of Operation	700		1000	MHz	
DC Function Test					
I_G (off) - Gate Leakage			2	mA	V_G = -8V, V_D = 0V
I_D (off) - Drain Leakage			2.5	mA	V_G = -8V, V_D = 48V
V_{GS} (th) - Threshold Voltage		-3.6		V	V_D = 48V, I_D = 14mA
V_{DS} (on) - Drain Voltage at High Current		0.45		V	V_G = 0V, I_D = 1.5mA
Capacitance					
C_{RSS}		5.4		pF	V_G = -8V, V_D = 0V
C_{ISS}		77.6		pF	V_G = -8V, V_D = 0V
C_{OSS}		15.1		pF	V_G = -8V, V_D = 0V

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

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
RF Functional Test					[1], [2]
V_{GS} (q)		-3.2		V	V_D = 48V, I_D = 300mA
Gain	18	19.8		dB	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 960MHz
	17	19		dB	IS95 (9-channel model, 9.8dB PAR at 0.01% CCDF), P_{OUT} = 45dBm, f = 960MHz
Drain Efficiency	38	39		%	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 960MHz
	44	46.5		%	IS95 (9-channel model, 9.8dB PAR at 0.01% CCDF), P_{OUT} = 45dBm, f = 960MHz
Input Return Loss		-11	-8	dB	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 960MHz
Output PAR (CCDF at 0.01%)	5.8	6.1		dB	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 960MHz
	5	5.8		dB	IS95 (9-channel model, 9.8dB PAR at 0.01% CCDF), P_{OUT} = 45dBm, f = 960MHz
Adjacent Channel Power		-33.5	-28.5	dBc	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 960MHz

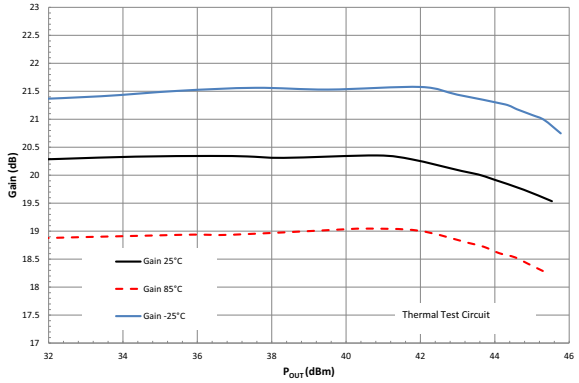
[1] Test Conditions: V_{DSQ} = 48V, I_{DQ} = 300mA, T = 25 °C

[2] Performance in a standard tuned test fixture

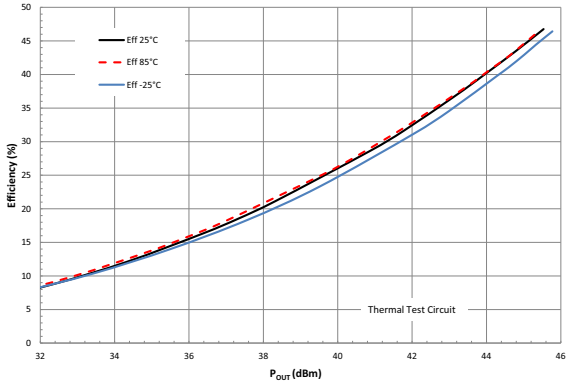
Typical Performance in Standard Fixed Tuned Test Fixture

(T = 25°C, unless noted)

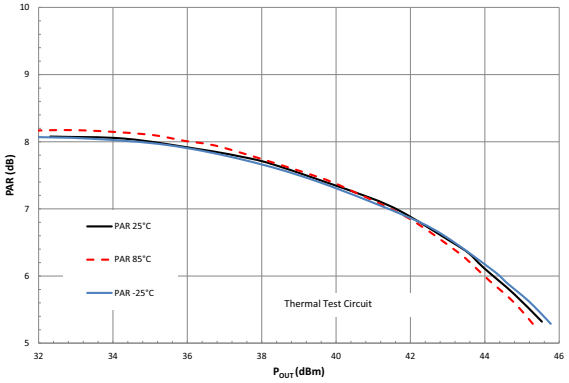
Gain versus P_{OUT} , Freq = 960MHz)
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



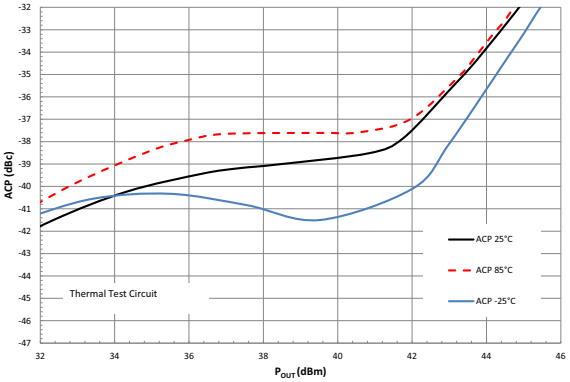
Efficiency versus P_{OUT} , Freq = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



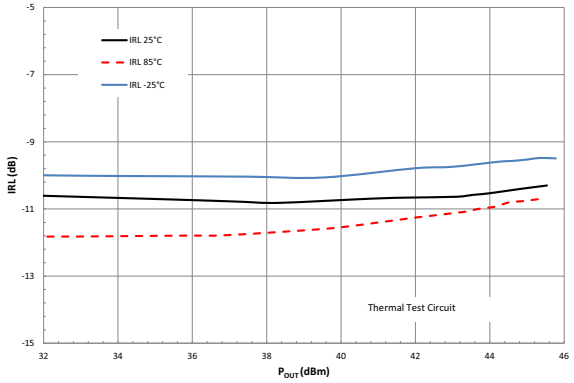
PAR versus P_{OUT} , Freq = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



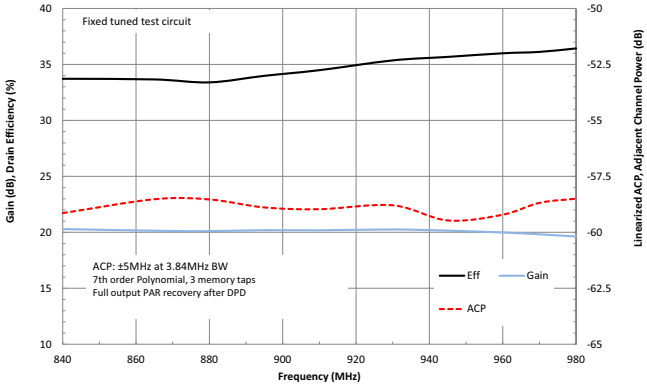
Adjacent Channel Power versus P_{OUT} , Freq = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



IRL versus P_{OUT} , Freq = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



3GPP DPD Linearized Performance, P_{OUT} = 43dBm
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)

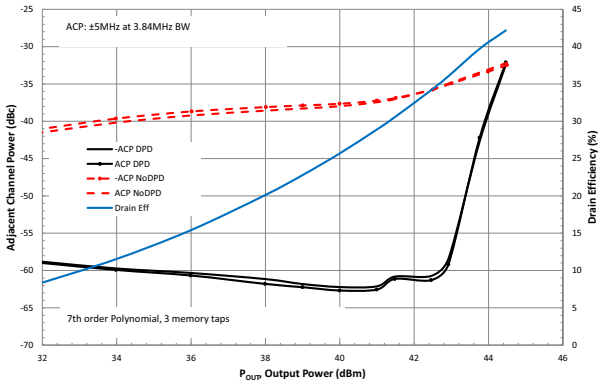


7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at **(+1) 336-678-5570** or **customerservice@rfmd.com**.

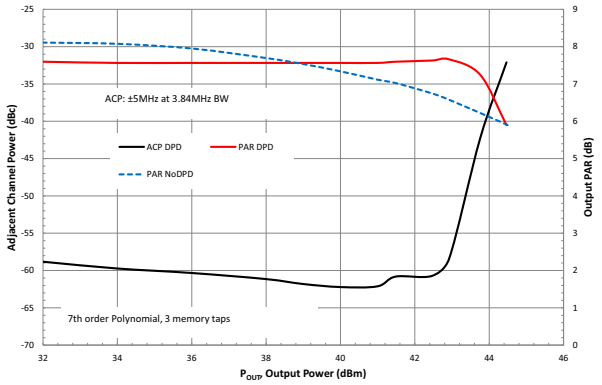
Typical Performance in Standard Fixed Tuned Test Fixture

(T = 25°C, unless noted)

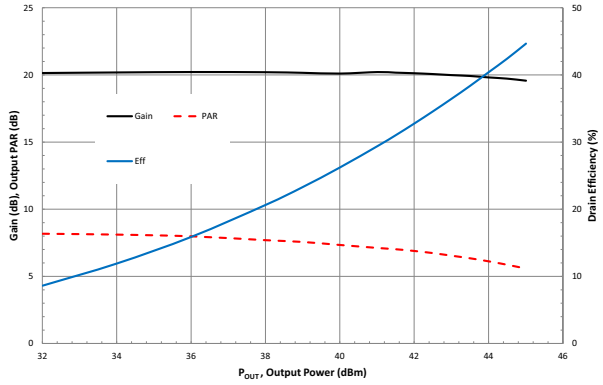
3GPP DPD Performance versus P_{OUT}, f = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



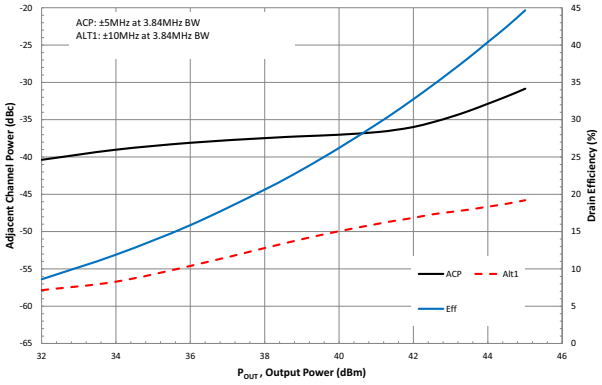
3GPP DPD Performance versus P_{OUT}, f = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



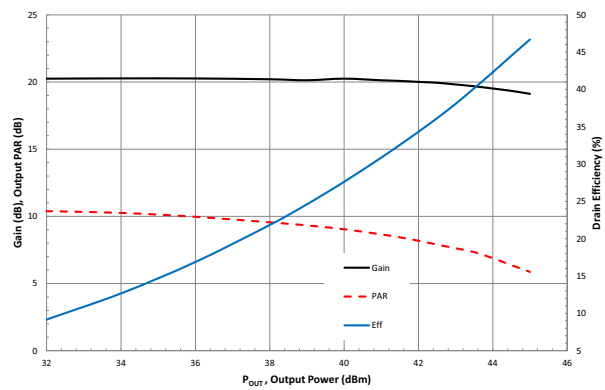
3GPP Performance versus P_{OUT}, f = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



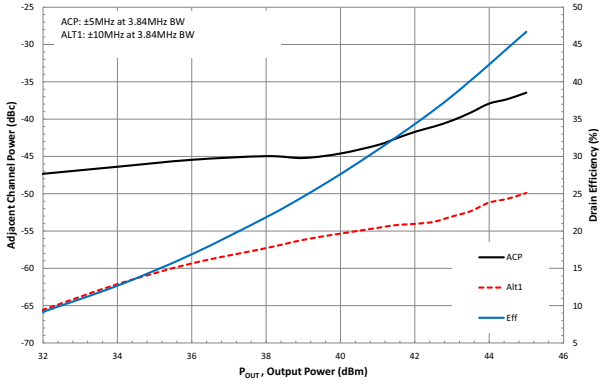
3GPP Performance versus P_{OUT}, f = 960MHz
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



IS95 Performance versus P_{OUT}, f = 960MHz
(IS95 9 Channel 9.8dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



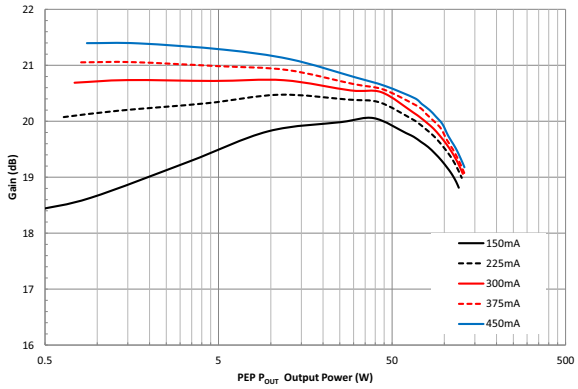
IS95 Performance versus P_{OUT}, f = 960MHz
(IS95 9 Channel 9.8dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA)



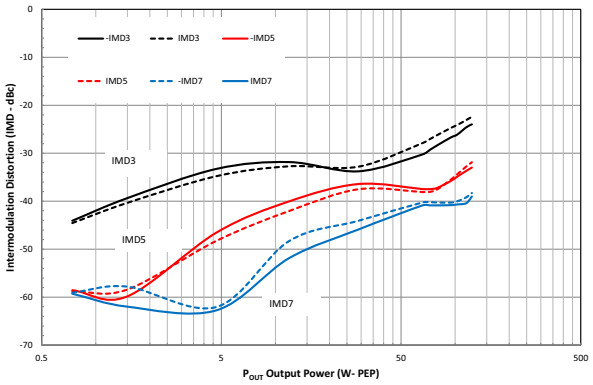
Typical Performance in Standard Fixed Tuned Test Fixture

(T = 25°C, unless noted)

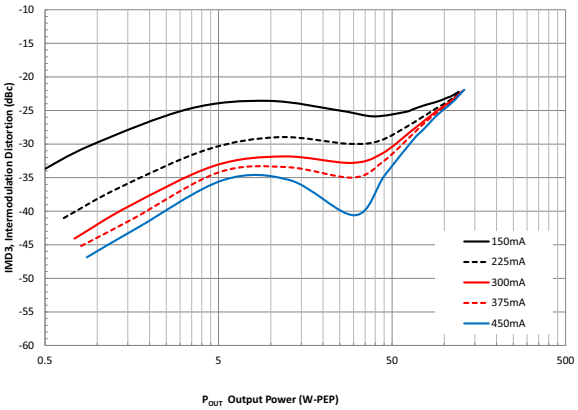
Gain versus P_{OUT}
(2-Tone 10MHz Separation, V_D = 48V, I_{DQ} varied, F_C = 900MHz)



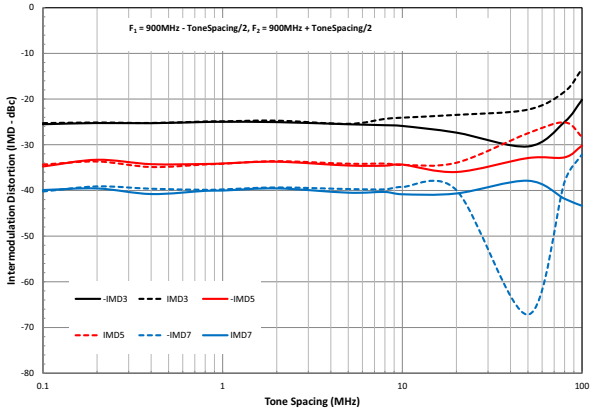
IMD versus Output Power
(V_D = 48V, I_{DQ} = 300mA, F_1 = 895MHz, F_2= 905MHz)



IMD3 versus P_{OUT}
(2-Tone 10MHz Separation, V_D = 48V, I_{DQ} varied, F_C = 900MHz)



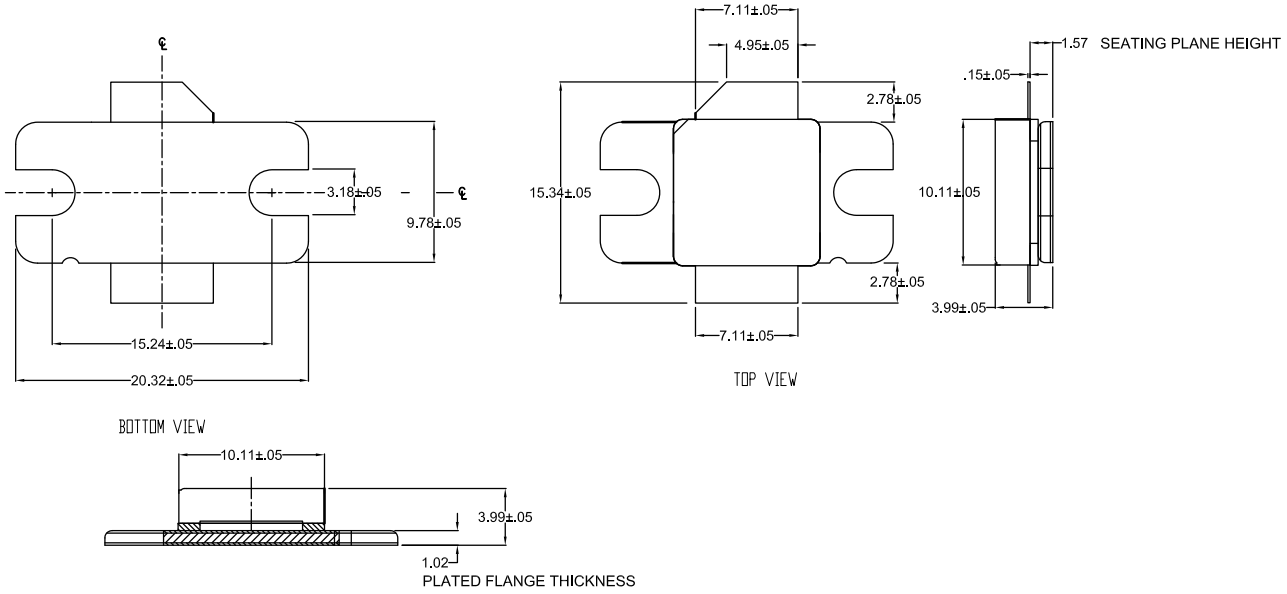
IMD versus Tone Spacing
(P_{OUT} = 100W PEP, V_D = 48V, I_{DQ} = 300mA)



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

Package Drawing

(All dimensions in mm)



Package Style: Flanged Ceramic

Pin Names and Descriptions

Pin	Name	Description
1	RF IN VGQ	Gate - V_{GQ} RF Input
2	RF OUT VDQ	Drain - V_{DQ} RF Output
3	GND BASE	Source - Ground Base

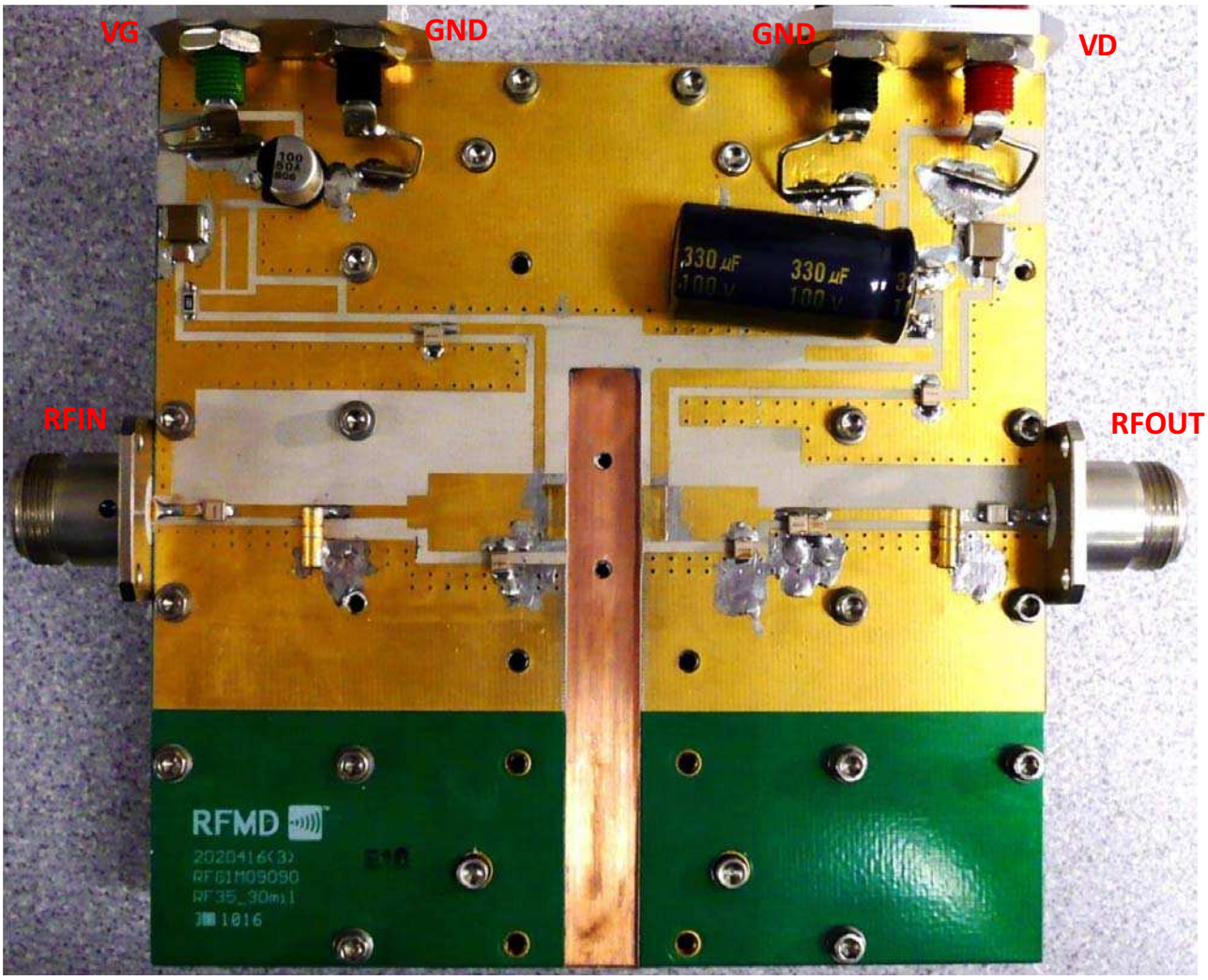
Bias Instructions for RFG1M09090 Evaluation Board

This is ESD sensitive material; please use proper ESD precautions when handling devices or the evaluation board.

The evaluation board requires additional external fan cooling.

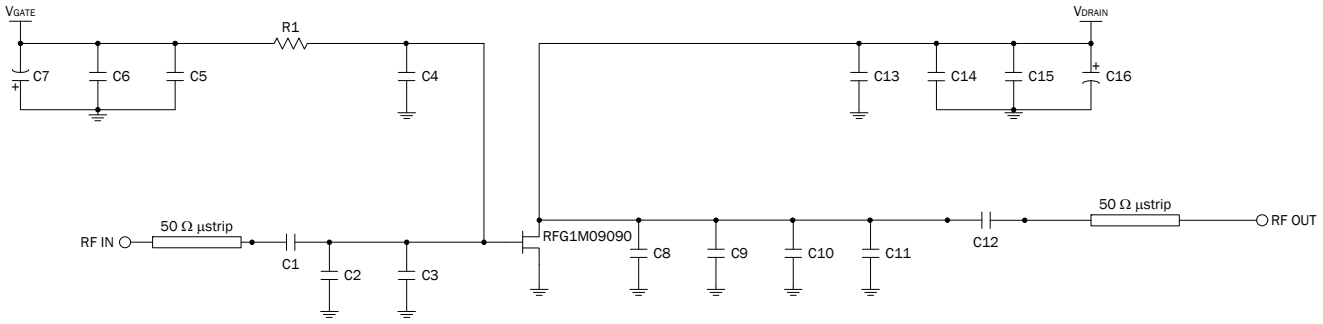
Connect all supplies before powering up the evaluation board.

1. Connect RF cables at RFIN and RFOUT.
2. Connect ground to the ground supply terminal, and ensure that both the VG and VD grounds are also connected to this ground terminal.
3. Apply -5V to VG.
4. Apply 48V to VD.
5. Increase V_G until drain current reaches 300mA or desired bias point.
6. Turn on the RF input.



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

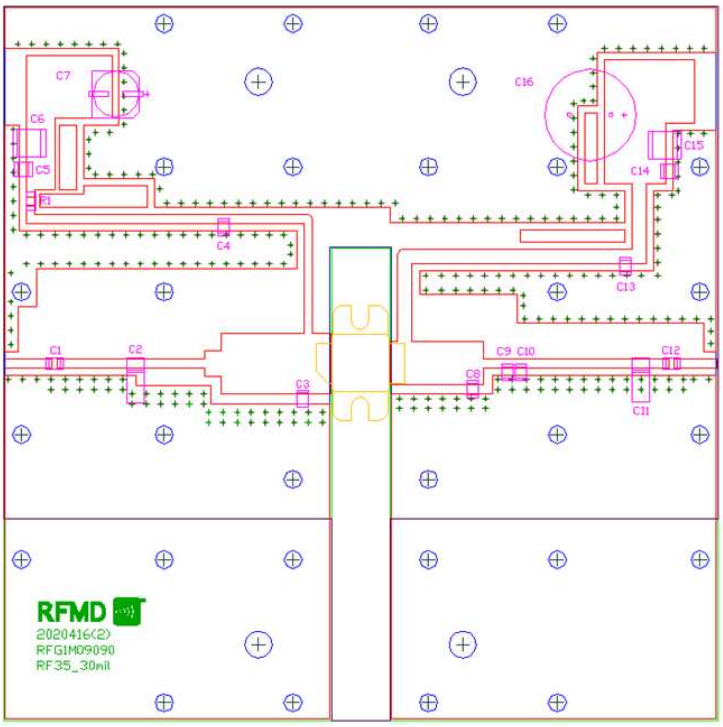
Evaluation Board Schematic



Evaluation Board Bill of Materials (BOM)

Component	Value	Manufacturer	Part Number
C1, C4, C12, C13	56pF	ATC	ATC100B560JT
C2, C11	0.6pF to 4.5pF	Johanson	27271SL
C3, C10	1.8pF	ATC	ATC100B1R8BT
C5, C14	0.1μF	Murata	GRM32NR72A104KA01L
C6, C15	4.7μF	Murata	GRM55ER72A475KA01L
C7	100μF	Panasonic	ECE-V1HA101UP
C8	5.6pF	ATC	ATC100B5R6CT
C9	10pF	ATC	ATC100B100JT
C16	330μF	Panasonic	EEU-FC2A331
R1	10Ω	Panasonic	ERJ-8GEYJ100V

Evaluation Board Layout

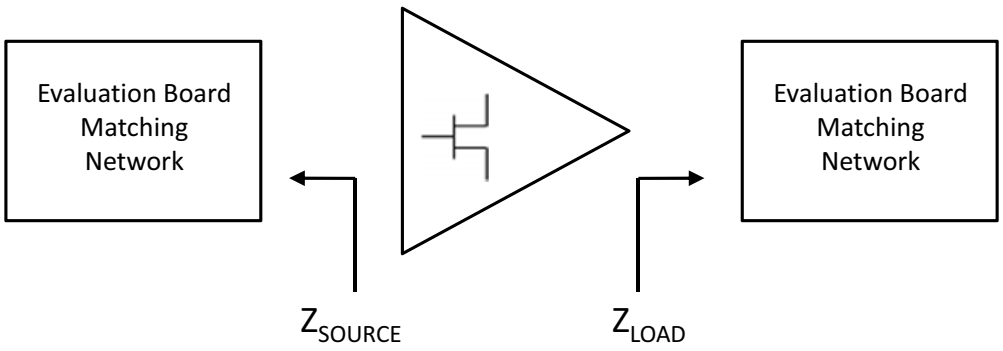


Device Impedances

Frequency (MHz)	Z Source (Ω)	Z Load (Ω)
700*	3.9 – j8.0	8.0 + j3.8
865	10.0 – j2.9	8.4 + j4.3
895	10.0 – j2.1	8.7 + j4.2
930	11.4 – j1.4	8.7 + j4.3
960	12.4 – j1.4	8.6 + j4.5

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

*700MHz impedances are based on loadpull measurements; all other impedances are the measured evaluation board impedances



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

Device Handling/Environmental Conditions

RFMD does not recommend operating this device with typical drain voltage applied and the gate pinched off in a high humidity, high temperature environment.

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 tradeoffs.

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.