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RFG1M20090

1.8GHz TO 2.2GHz 90W GaN POWER AMPLIFIER

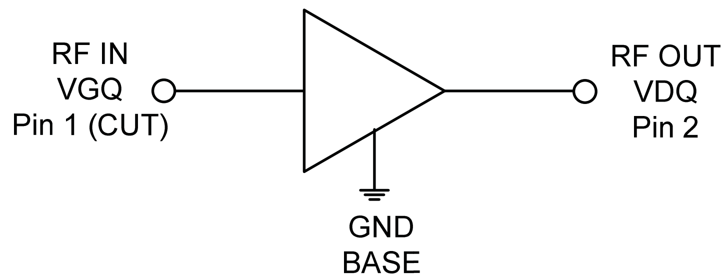
Package: Flanged Ceramic, 2 pin, RF400-2

Features

- Advanced GaN HEMT Technology
- Peak Modulated Power >90W
- Advanced Heat-Sink Technology
- Single Circuit for 1.9GHz to 2.2GHz
- 48V Operation Typical Performance
  - P_{OUT} = 44dBm
  - Gain = 14.5dB
  - Drain Efficiency = 35%
  - ACP = -35dBc
  - 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 RFG1M20090 is optimized for commercial infrastructure, military communication and general purpose amplifier applications in the 1.8GHz to 2.2GHz frequency band, ideal for constant envelope, pulsed and 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 RFG1M20090 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

RFG1M20090	1.8GHz to 2.2GHz 90W GaN Power Amplifier
RFG1M20090PCBA-410	1.93GHz to 2.17GHz, 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	

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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 (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% Idss 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	-1.8	V	
Drain Bias Current		300		mA	
Frequency of Operation	1.8		2.2	GHz	
DC Function Test					
I_G (off)			2	mA	V_G = -8V, V_D = 0V
I_D (off) - Operation Voltage			2	mA	V_G = -8V, V_D = 48V
I_D (off) - High Voltage			5	mA	V_G = -8V, V_D = 175V
V_{GS} (th)		-3.5		V	V_D = 48V, I_D = 14mA
Capacitance					
C_{RSS}		5.5		pF	V_G = -8V, V_D = 0V
C_{ISS}		68		pF	V_G = -8V, V_D = 0V
C_{OSS}		15		pF	V_G = -8V, V_D = 0V

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
RF Functional Test					[1], [2]
V_{GS} (q)		-3.1		V	V_D = 48V, I_D = 300mA
Gain	14	15.1		dB	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Drain Efficiency	32	35		%	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Input Return Loss		-12	-8	dB	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Output PAR (CCDF at 0.01%)	5.7	6.1		dB	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Adjacent Channel Power		-35.4	-33	dBc	3GPP (TM1, 7.5dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Gain	13	14.8		dB	IS95 (9-channel model, 9.8dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Drain Efficiency	36	39.8		%	IS95 (9-channel model, 9.8dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz
Output PAR (CCDF at 0.01%)	5.9	6.6		dB	IS95 (9-channel model, 9.8dB PAR at 0.01% CCDF), P_{OUT} = 44dBm, f = 2170MHz

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

[2] Performance in a standard tuned test fixture

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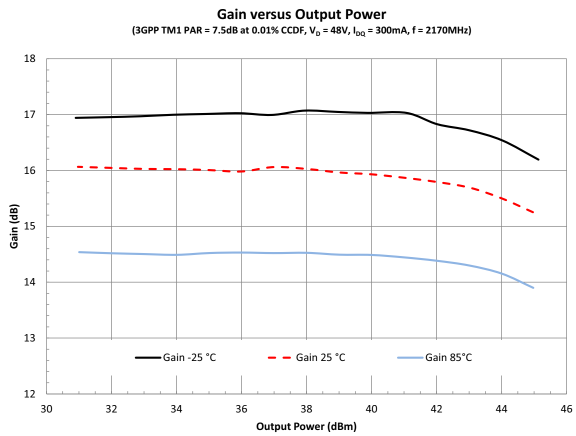
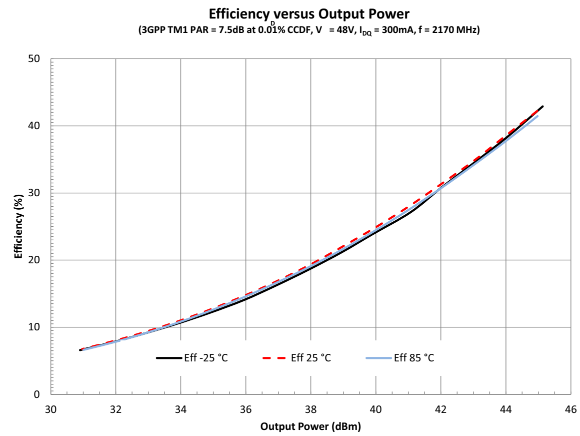
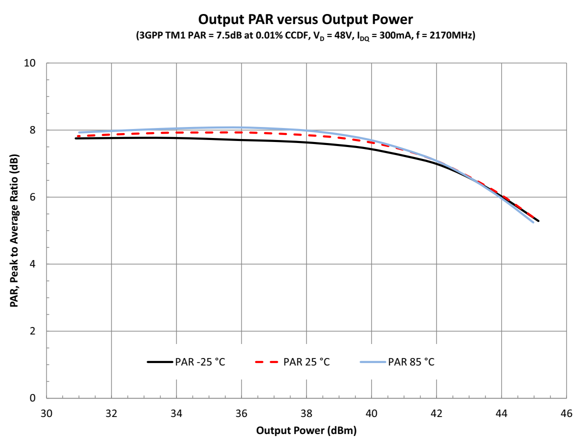
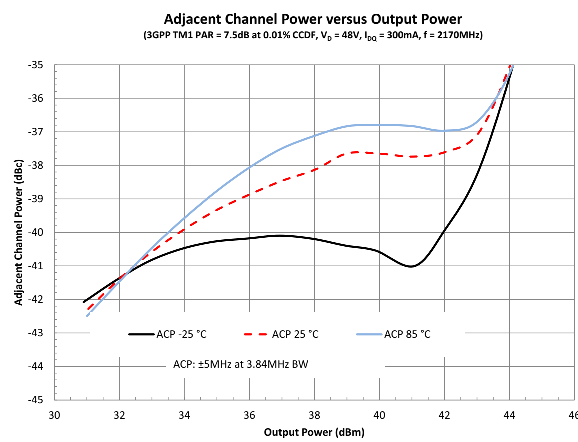
Typical Performance In Standard Fixed Tuned Test Fixture

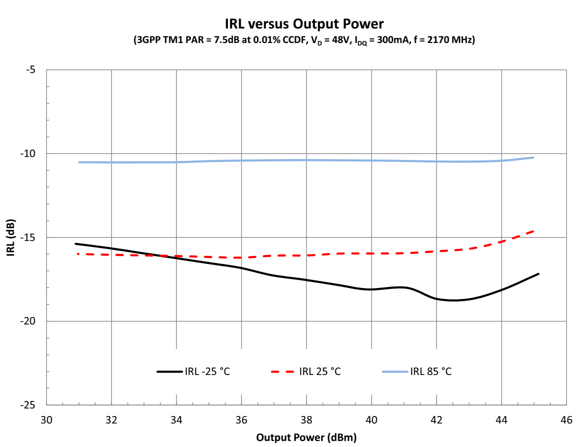
(T = 25°C, unless noted)

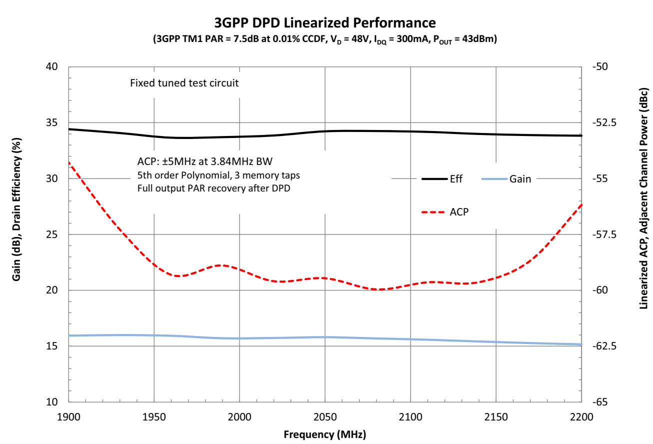












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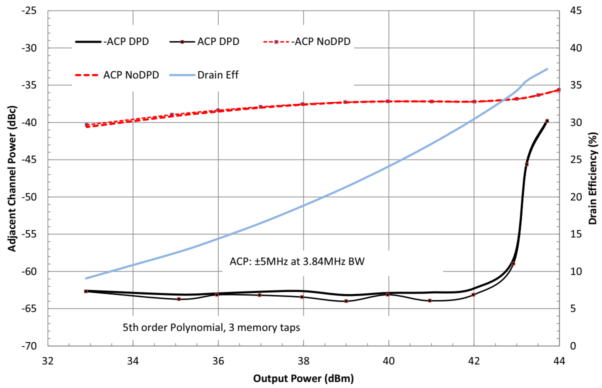
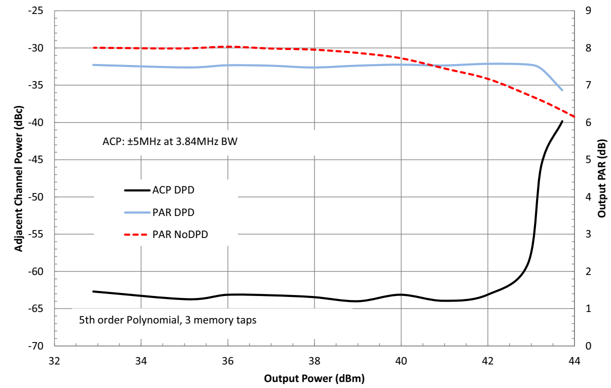
Typical Performance In Standard Fixed Tuned Test Fixture

(T = 25°C, unless noted)

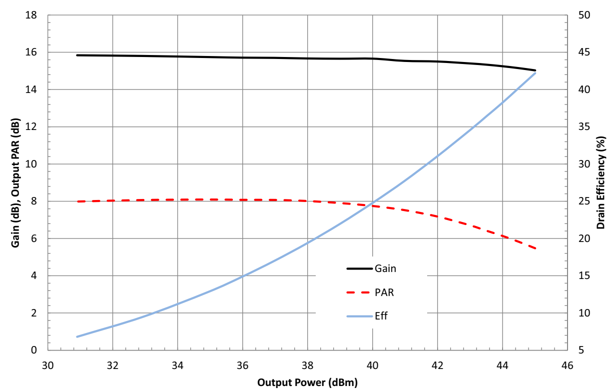
3GPP DPD Performance versus Output Power
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA, f=2170MHz)



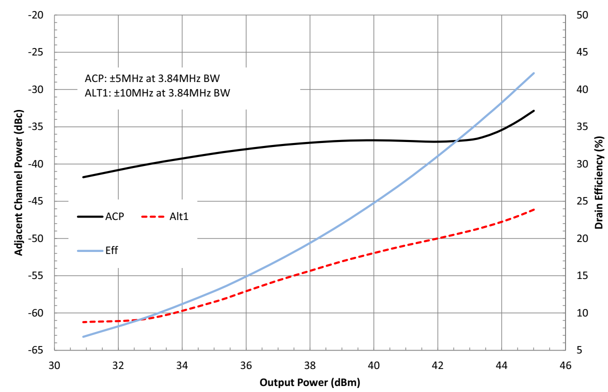
3GPP DPD Performance versus Output Power
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} =300mA, f=2170MHz)



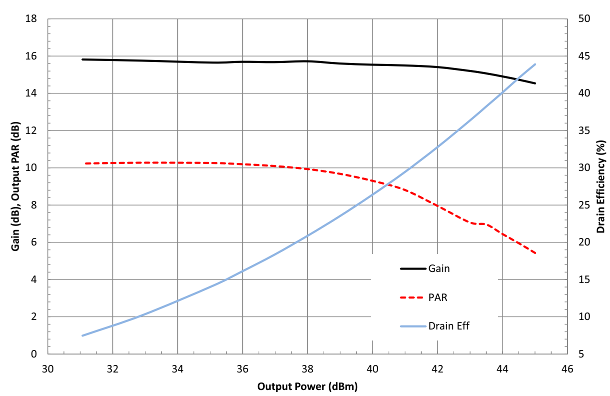
3GPP Performance versus Output Power
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA, f = 2170MHz)



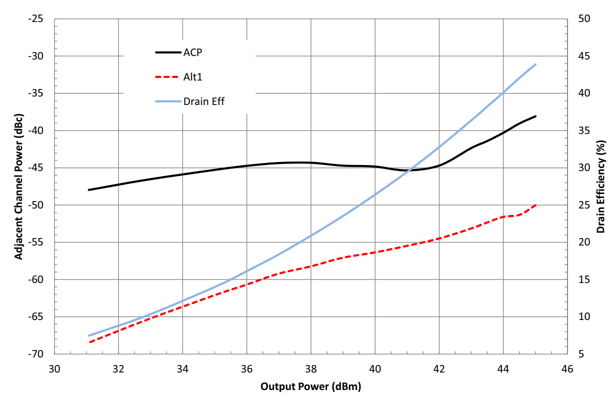
3GPP Performance versus Output Power
(3GPP TM1 PAR = 7.5dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA, f =2170 MHz)



IS95 Performance versus Output Power
(IS95 9 Channel PAR = 9.8dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA, f = 2170MHz)



IS95 Performance versus Output Power
(IS95 9 Channel 9.8dB at 0.01% CCDF, V_D = 48V, I_{DQ} = 300mA, f = 2170MHz)

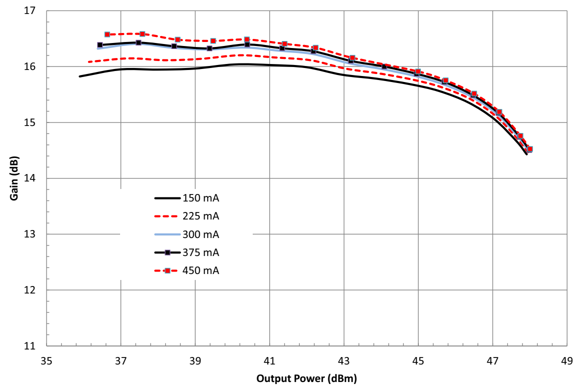


Typical Performance In Standard Fixed Tuned Test Fixture

(T = 25°C, unless noted)

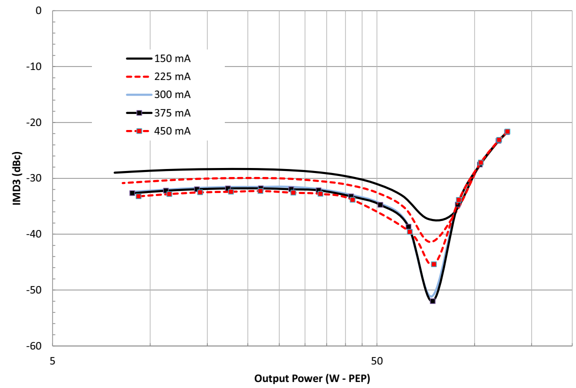
Gain versus Output Power

(2-Tone 10MHz Separation, V_D = 48V, I_{DQ} varied, f_C = 2050MHz)



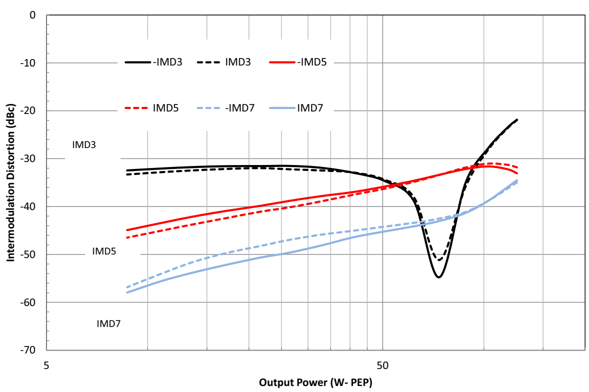
IMD3 versus Output Power

(2-Tone 10MHz Separation, V_D = 48V, I_{DQ} varied, f_C = 2050MHz)



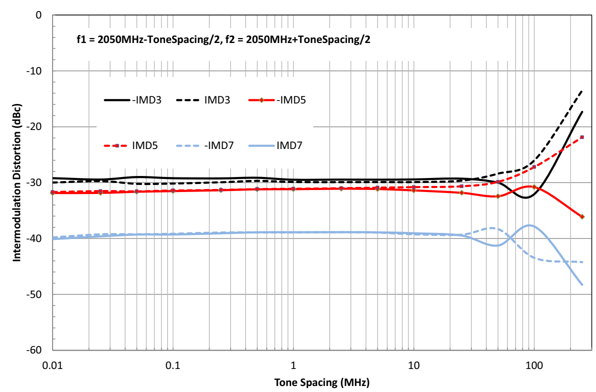
IMD versus Output Power

(2-Tone 10 MHz Separation, V_D = 48V, I_{DQ} = 300mA, f_C = 2050MHz)



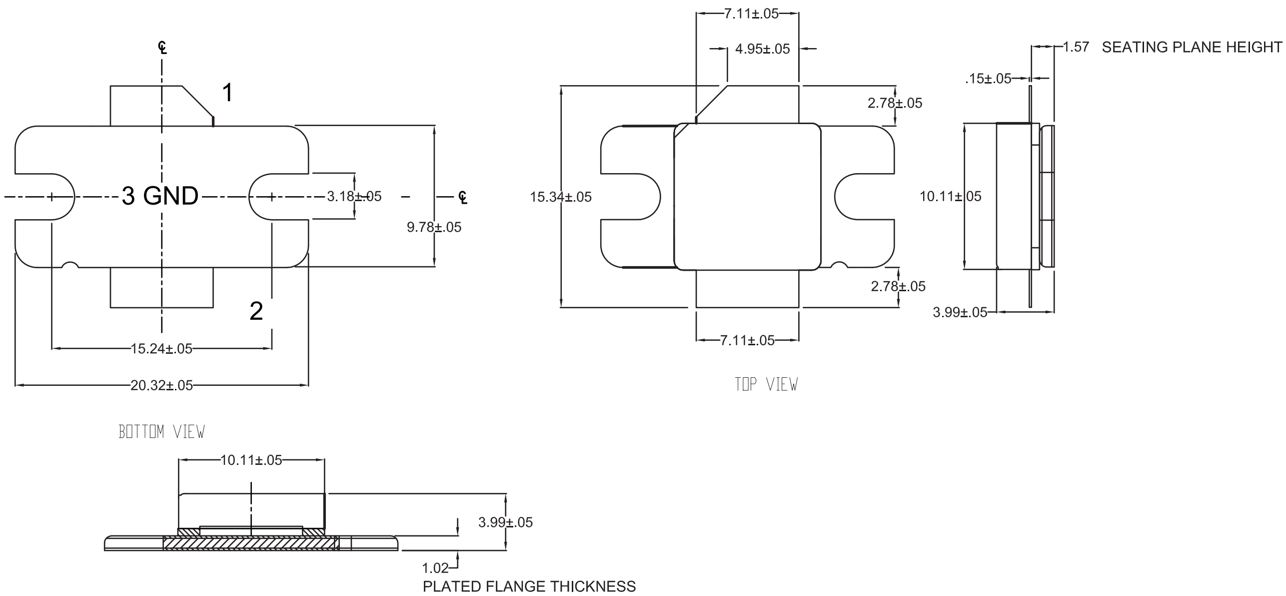
IMD versus Tone Spacing

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



Package Drawing

(All dimensions in mm)



Package Style: Flanged Ceramic

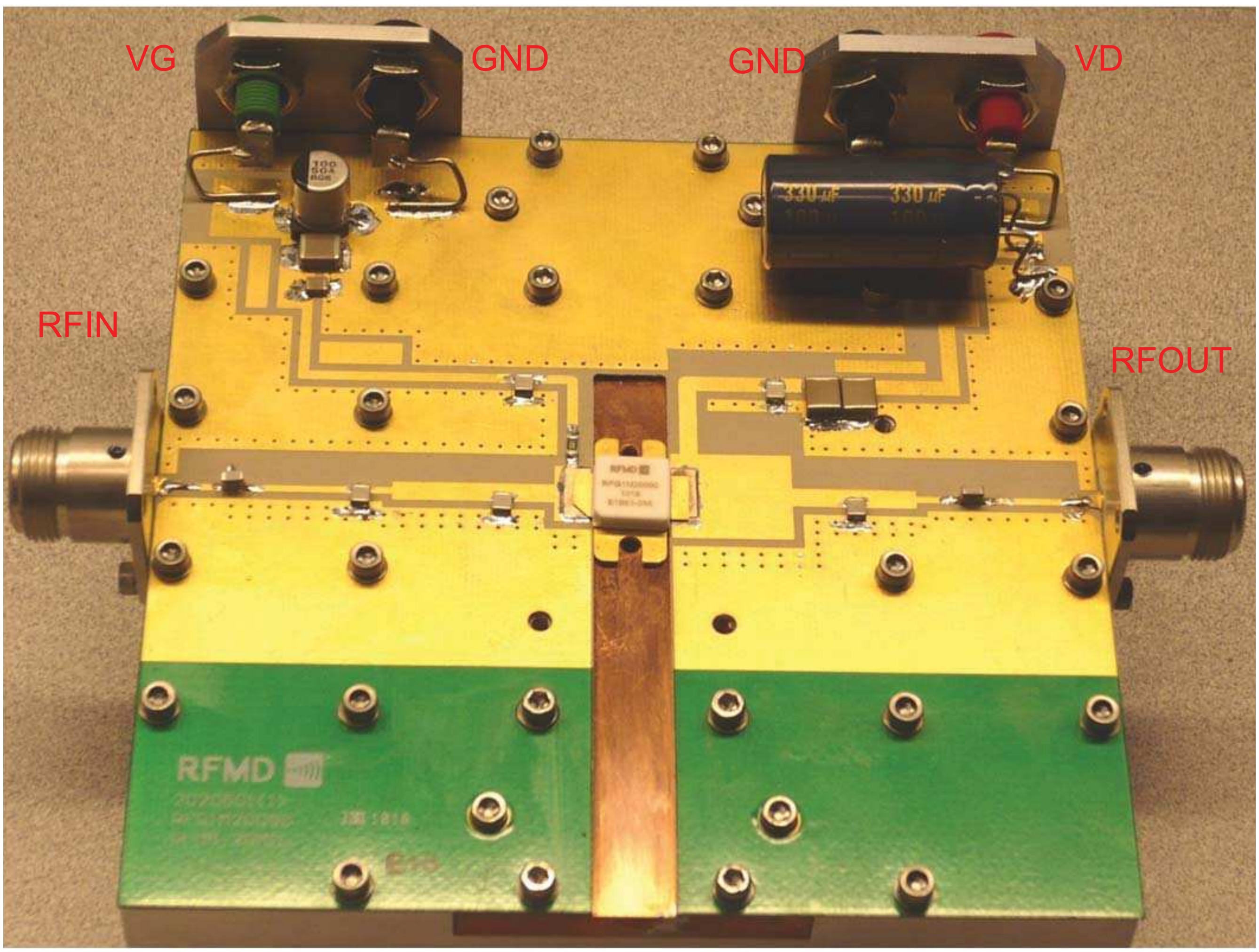
Pin Names and Descriptions

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 Instruction for RFG1M20090 1.93GHz to 2.17GHz 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 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.



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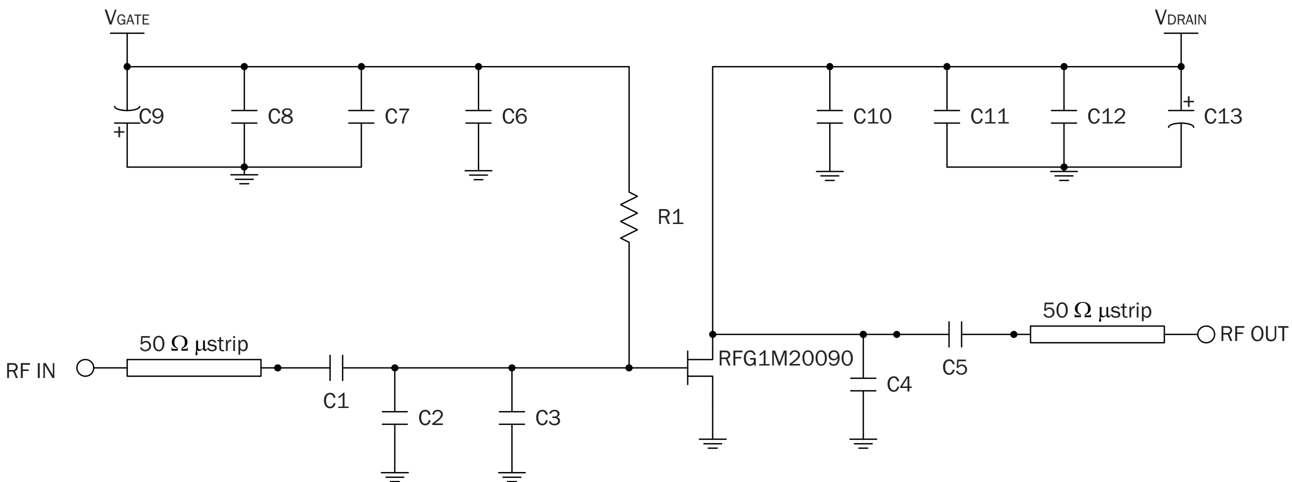
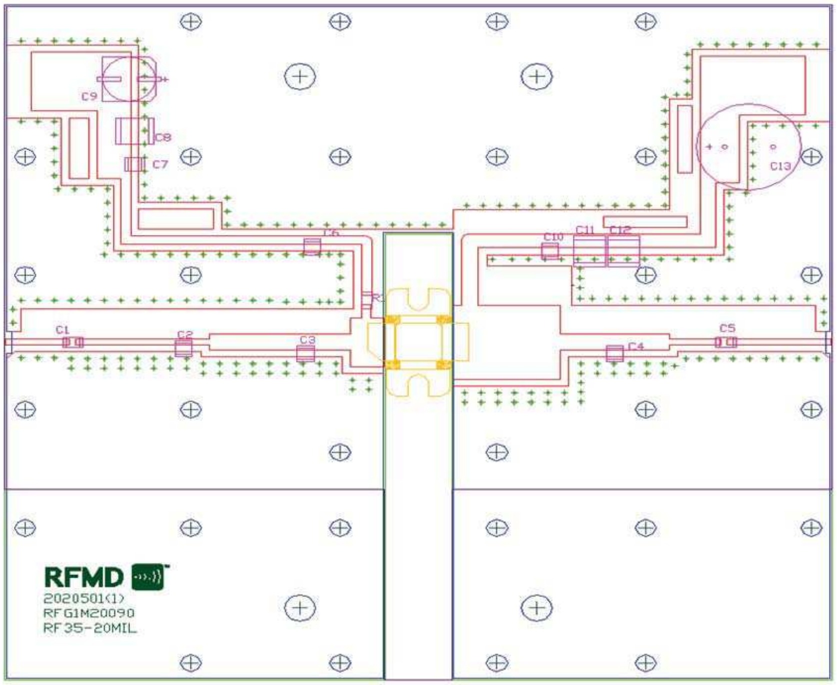
1.93GHz to 2.17GHz Evaluation Board Schematic



1.93GHz to 2.17GHz Evaluation Board Bill of Materials (BOM)

Component	Value	Manufacturer	Part Number
C1, C5, C6, C10	68pF	ATC	ATC800B680JT
C2, C3, C4	1.2pF	ATC	ATC800B1R2CT
C7	0.1µF	Murata	GRM32NR72A104KA01L
C8, C11, C12	4.7µF	Murata	GRM55ER72A475KA01L
C6	100µF	Panasonic	ECE-V1HA101UP
C13	330µF	Panasonic	EEU-FC2A331
R1	10Ω	Panasonic	ERJ-8GEYJ100V

1.93GHz to 2.17GHz Evaluation Board Layout

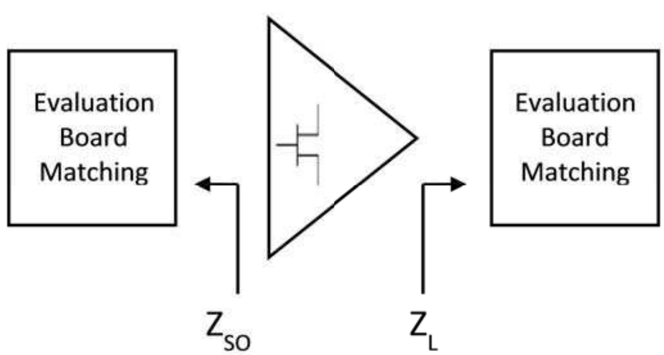


Device Impedances

Frequency (MHz)	Z Source (Ω)	Z Load (Ω)
1800*	20.4 - j14.5	4.1 + j0.9
1930	17.9 - j6.4	4.7 + j0.9
1990	15.3 - j5.5	4.8 + j0.8
2110	12.0 - j2.6	4.8 - j0.0
2170	11.7 - j1.1	4.3 - j0.4

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.

*1800MHz impedances are based on loadpull measurements; all other impedances are the measured evaluation board impedances



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 200C. 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.

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