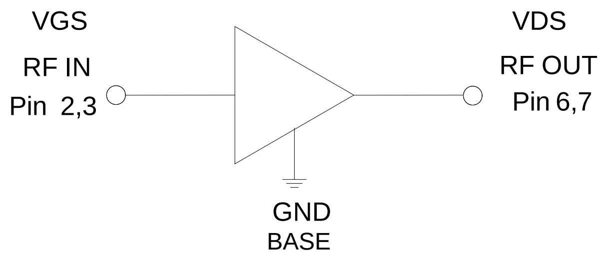
RFHA3960

28V/48V 3Watts/6.3Watts GaN RF Power Amplifier

The RFHA3960 is a 28V, 3W and 48V, 6.3W High Power discrete Amplifier designed for commercial Wireless Infrastructure, Cellular and WiMAX Infrastructure, Industrial/Scientific/Medical and General Purpose broadband Amplifier application. Using an advanced high power density Gallium Nitride (GaN) semiconductor process, these high-performance amplifiers achieve high efficiency, linearity and flat gain over a broad frequency range in a single amplifier design. The RFHA3960 is an unmatched GaN transistor packaged in a plastic over-molded SOIC, 8 pin package. The package provides excellent thermal stability through the use of advanced heat sink and power dissipation technologies.



Functional Block Diagram

Ordering Information

RFHA3960S2	Sample bag with 2 pieces
RFHA3960SB	Bag with 5 pieces
RFHA3960SQ	Bag with 25 pieces
RFHA3960SR	Short reel with 100 pieces
RFHA3960TR7	7” reel with 500 pieces
RFHA3960TR13	13” reel with 2500 pieces
RFHA3960PCBA-410	Fully assembled evaluation board 2400 to 2600MHz, 28V and 48V operation

Package: Plastic Over Molded, 8-pin, SOIC8

Features

- Broadband Operation DC to 6GHz
- Advanced GaN HEMT Technology
- Advanced Heat-Sink Technology
- 28V Operation Typical P3dB Performance at 2.5GHz
  - Output Power 3W at 2.5GHz
  - Drain Efficiency 57%
  - Small Signal Gain = 16dB
- 48V Operation Typical P3dB Performance at 2.5GHz
  - Output Power 6.3W at 2.5GHz
  - Drain Efficiency 50%
  - Small Signal Gain = 15.5dB
- -40°C to 85°C Operating Temperature

Applications

- Commercial Wireless Infrastructure
- Cellular and WiMAX.Infrastructure
- Civilian and Military Radar
- General Purpose Broadband Amplifier
- Public Mobile Radio
- Industrial, Scientific and Medical

RF Micro Devices Inc.   7628 Thorndike Road, Greensboro, NC 27409-9421
For sales or technical support, contact RFMD at +1.336.678.5570 or customerservice@rfmd.com.
DS131206

Absolute Maximum Ratings

Parameter	Rating	Unit
Drain Voltage (V_D)	150	V
Gate Voltage (V_G)	-8 to +2	V
Operational Voltage	50	V
Ruggedness (VSWR)	10:1	
Storage Temperature Range	-55 to +125	°C
Operating Temperature Range (T_C)	-40 to +85	°C
Operating Junction Temperature (T_J)	200	°C
Human Body Model	Class 1A	
MTTF (T_J < 200°C, 95% Confidence Limits)*	1.8E + 07	Hours
MTTF (T_J < 250°C, 95% Confidence Limits)*	1.4E + 05	
Thermal Resistance, R_{TH} (junction to case) measured at T_C = 85°C, DC bias only	TBD	°C/W

Caution! ESD sensitive device.

RFMD Green: RoHS status based on EU Directive 2011/65/EU (at time of this document revision), 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.

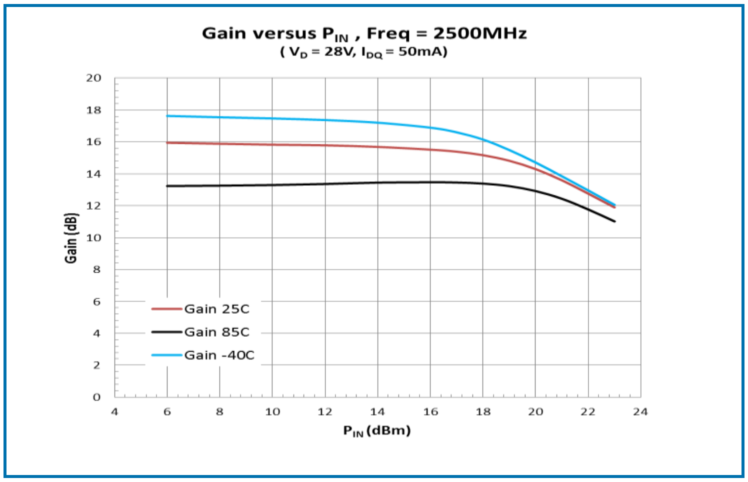
Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

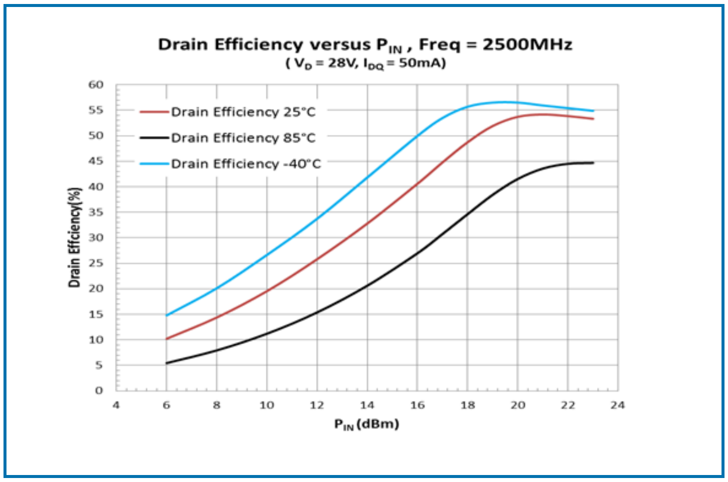
Nominal Operating Parameters

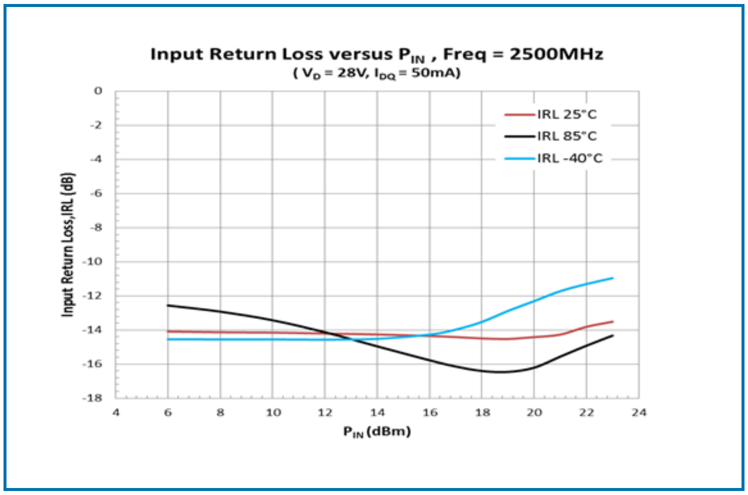
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Recommended Operating Conditions					
Drain Voltage (V_{DSQ})		28		V	
Gate Voltage (V_{GSQ})	-4.5	-1.11		V	
Drain Bias Current		50		mA	
Frequency of Operation		2500		MHz	
Recommended Operating Conditions					
Drain Voltage (V_{DSQ})		48		V	
Gate Voltage (V_{GSQ})	-4.5	-1.12		V	
Drain Bias Current		50		mA	
Frequency of Operation		2500		MHz	
Capacitance					
C_{RSS}		TBD		pF	V_G = -4V, V_D = 0V
C_{ISS}		TBD		pF	
C_{OSS}		TBD		pF	
DC Functional Test					
$I_{G\ (OFF)}$ - Gate Leakage		0.05		mA	V_G = -4V, V_D = 0V
$I_{D\ (OFF)}$ - Drain Leakage		0.01		mA	V_G = -4V, V_D = 18V
$V_{GS\ (TH)}$ - Threshold Voltage		0.95		V	V_D = 48V, I_D = 2.2mA
$I_{G\ (stress)}$ – Gate Leakage at high Drain Voltage		0.1		mA	V_G = -4V, V_D = 150V

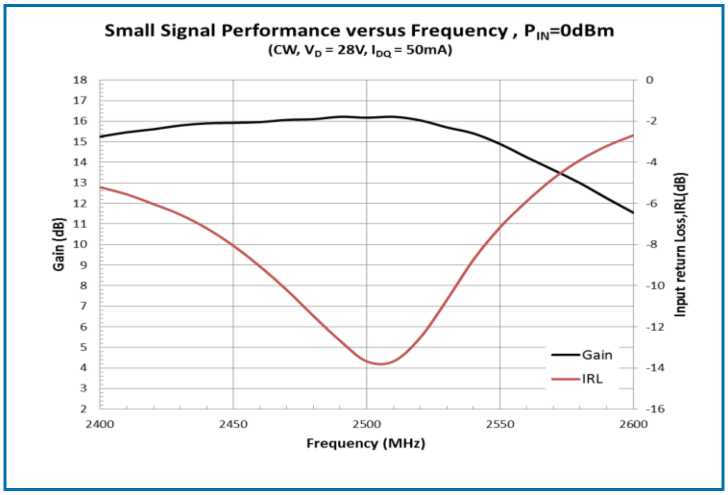
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
RF Functional Test					**Test Conditions: V_{DSQ} = 28V, I_{DQ} = 50mA, T = 25°C, Performance in a standard tuned test fixture**
$V_{GS\ (Q)}$		-1.1		V	V_{DSQ} = 28V, I_{DQ} = 50mA
Linear Gain		16		dB	CW,P_{IN} = 0dBm, f = 2500MHz
Power Gain		13		dB	CW,P_{IN} = 22dBm, f = 2500MHz
Drain Efficiency		TBD		%	
PAE		TBD		%	
Input Return Loss		-12		dB	
ACP		TBD		dBc	
RF Typical Performance					**Test Conditions: CW operation, V_{DSQ} = 28V, I_{DQ} = 50mA, T = 25°C, Performance in a standard tuned test fixture**
Small Signal Gain		16		dB	CW, f = 2500MHz
Output Power at P3dB		35		dBm	CW, f = 2500MHz
Drain Efficiency at P3dB		57		%	CW, f = 2500MHz
PAE		54		%	CW, f = 2500MHz
Input Return Loss		-17		dB	CW, f = 2500MHz
IMD3		-40		dBc	2-Tone, fc = 2500MHz,1MHz Tone spacing, **V_{DSQ} = 28V, I_{DQ} = 50mA**
RF Typical Performance					**Test Conditions: CW operation, V_{DSQ} = 48V, I_{DQ} = 50mA, T = 25°C, Performance in a standard tuned test fixture**
Small Signal Gain		15.5		dB	CW, f = 2500MHz
Output Power at P3dB		38		dBm	CW, f = 2500MHz
Drain Efficiency at P3dB		50		%	CW, f = 2500MHz
PAE		47		%	CW, f = 2500MHz
Input Return Loss		-23		dB	CW, f = 2500MHz
IMD3		-45		dBc	2-Tone, fc = 2500MHz,1MHz Tone spacing, **V_{DSQ} = 48V, I_{DQ} = 80mA**

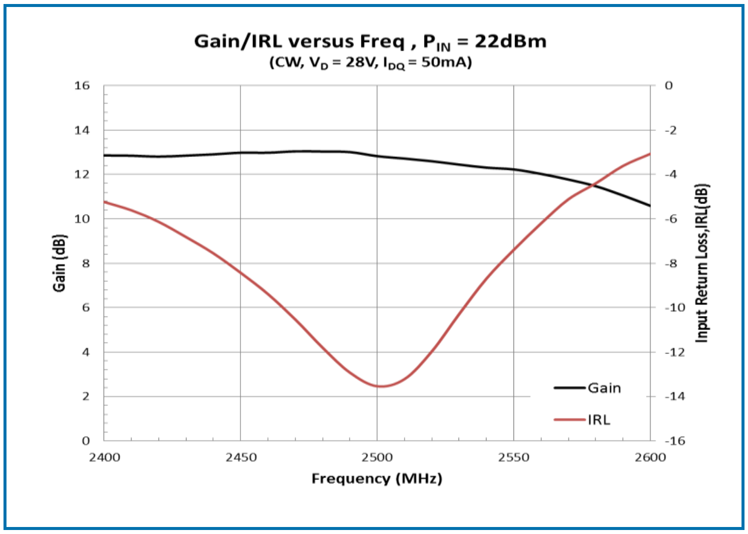
Typical Performance in standard 2.5GHz fixed tuned test fixture, (CW, T = 25°C, unless noted)

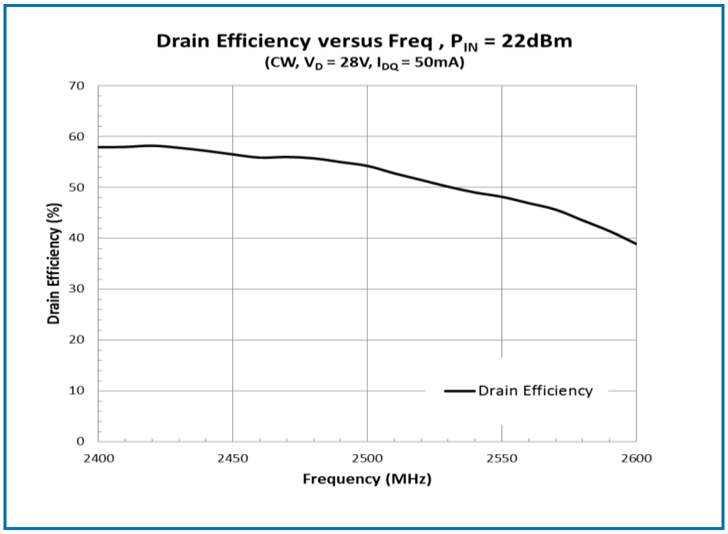




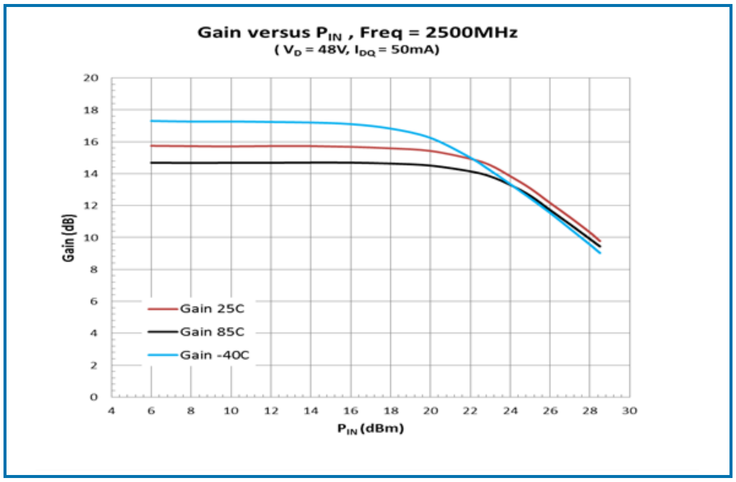


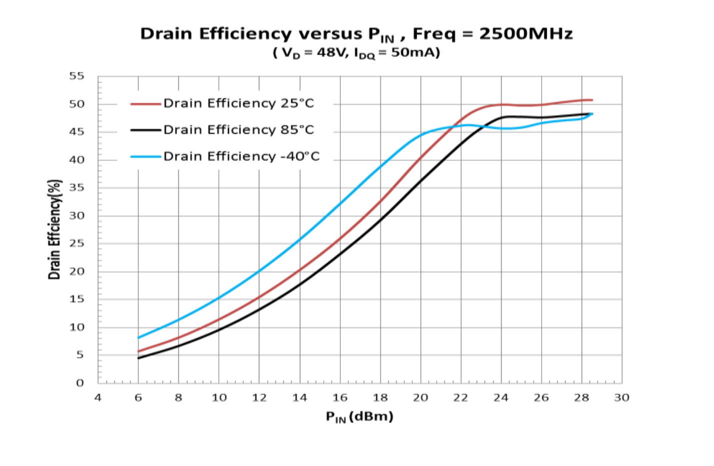


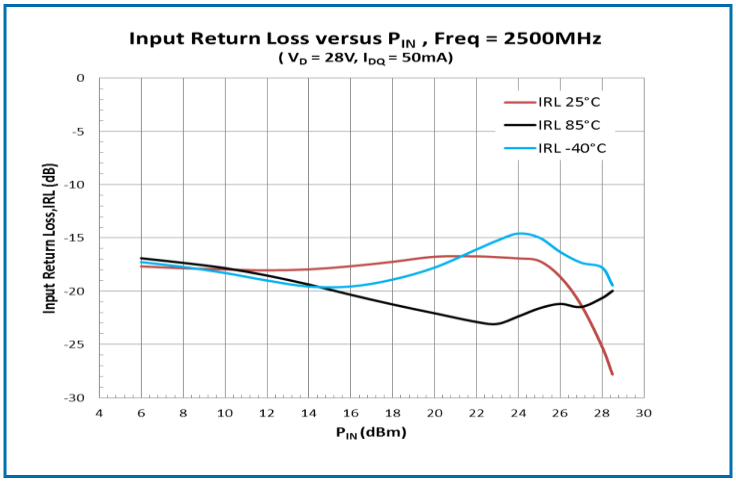


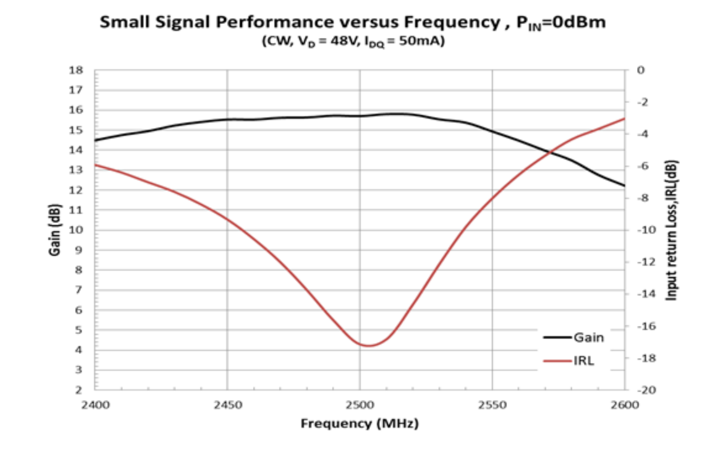


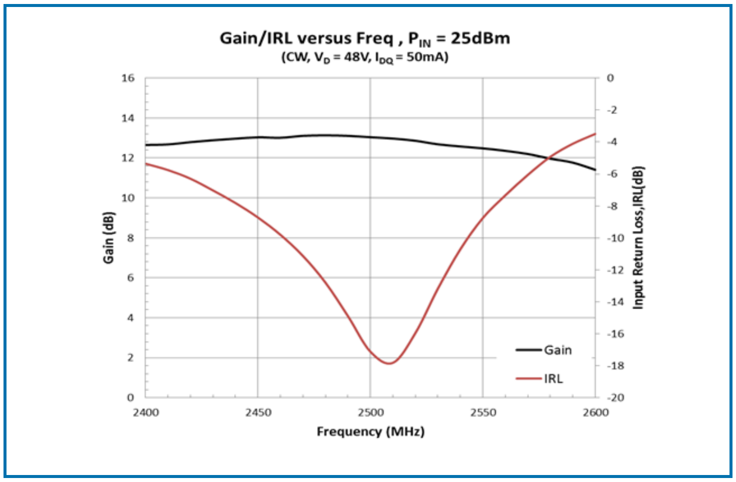
Typical Performance in standard 2.5GHz fixed tuned test fixture, (CW, T = 25°C, unless noted)

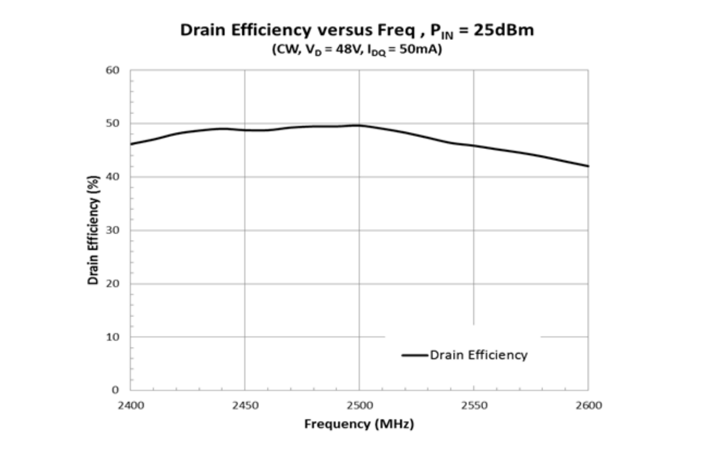




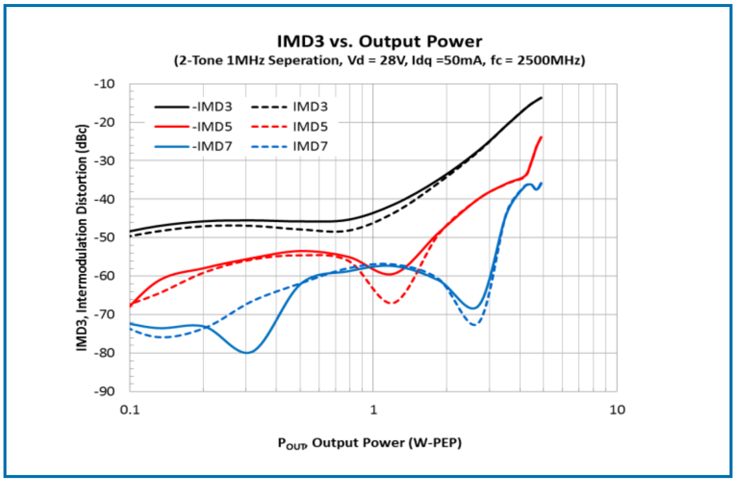


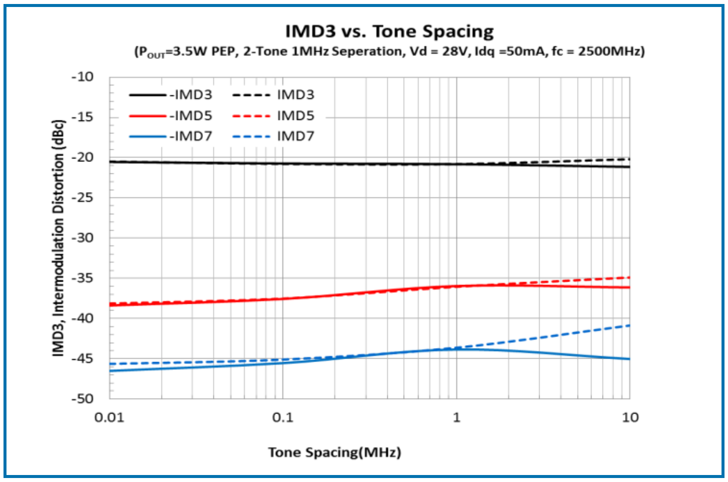


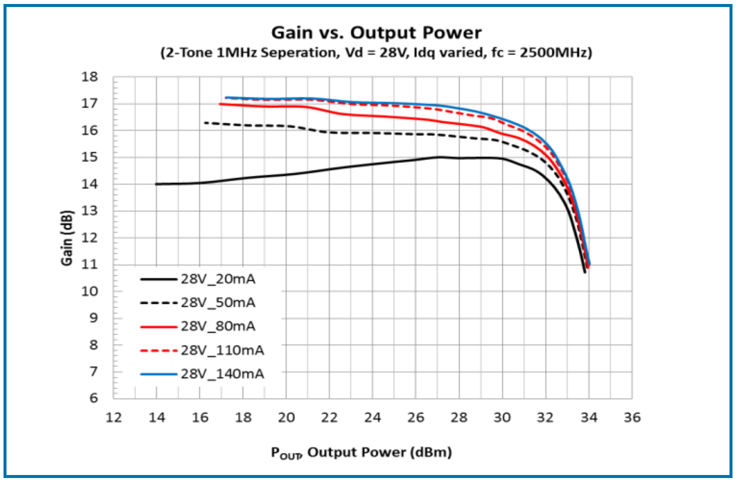


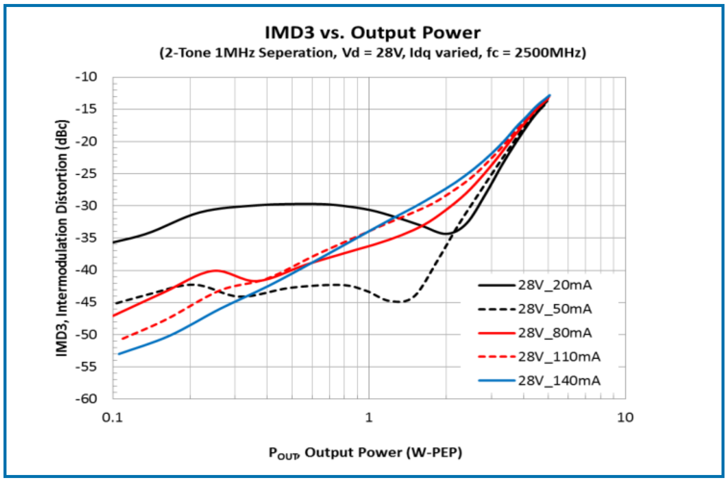


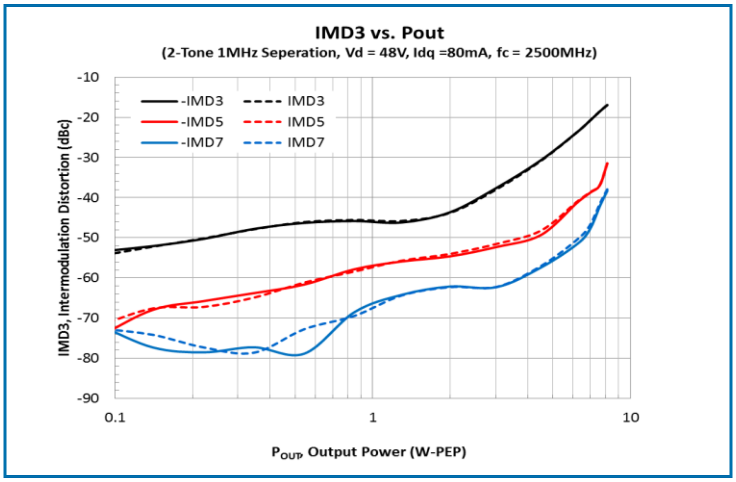
Typical Performance in standard 2.5GHz fixed tuned test fixture, (2-Tone, T = 25°C, unless noted)

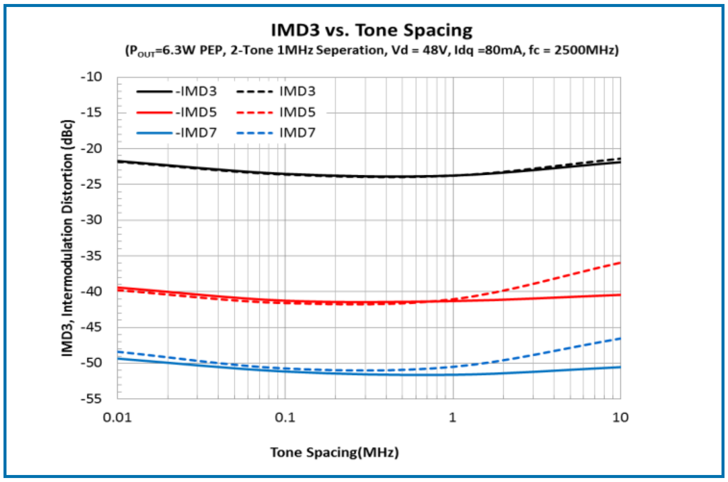




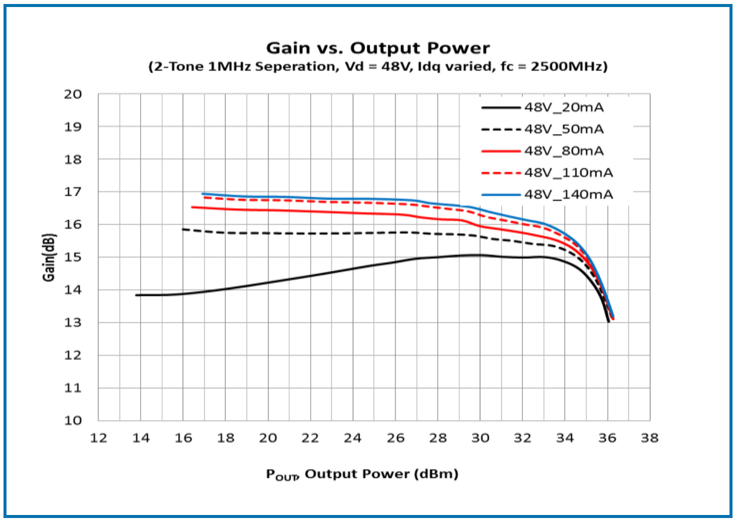


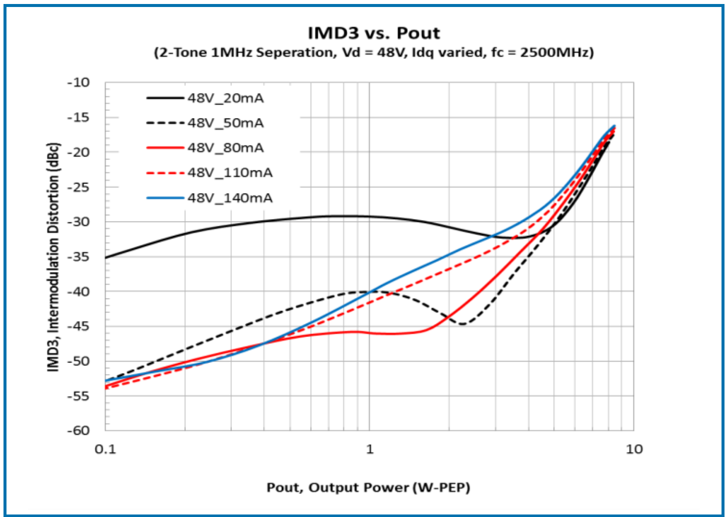




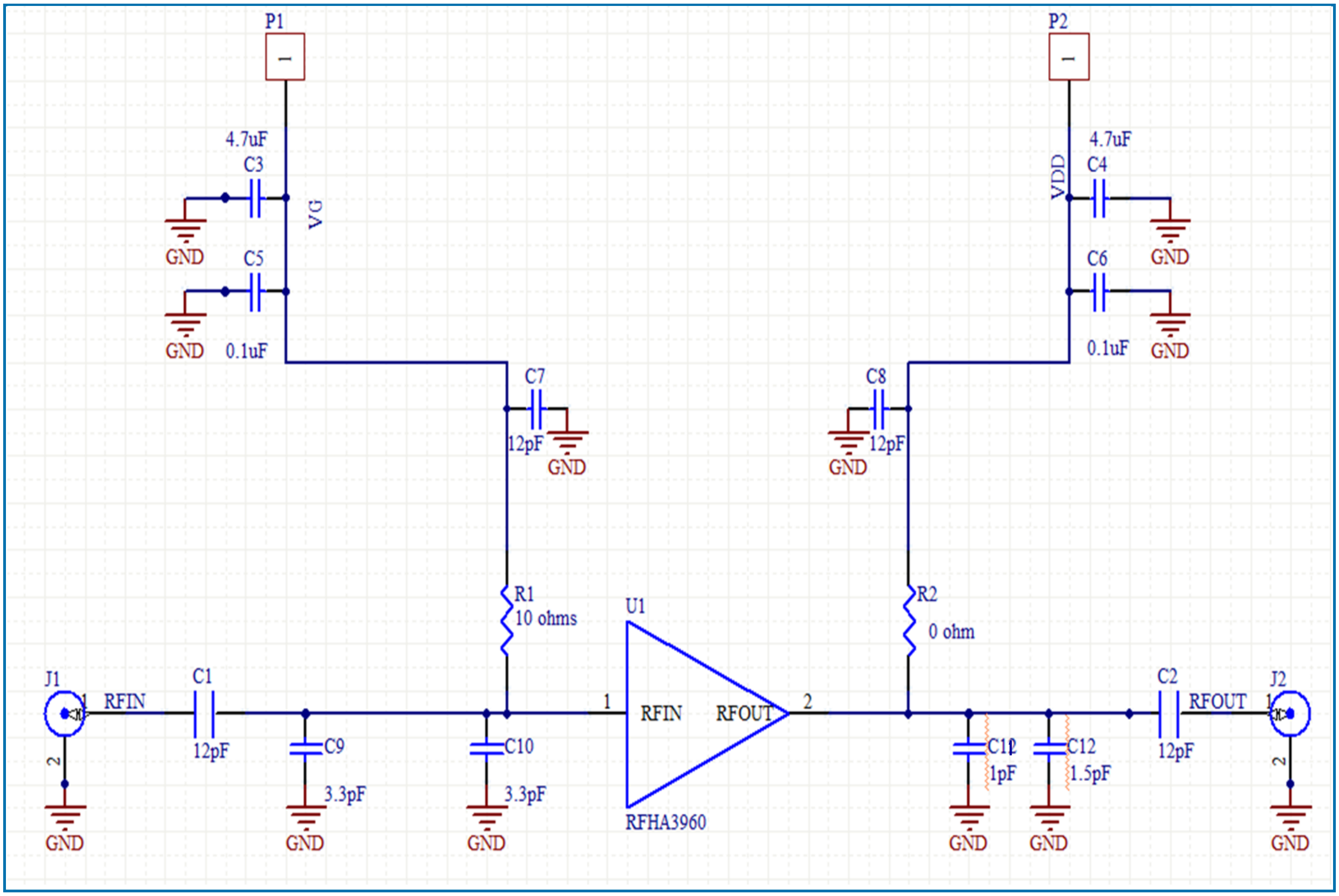


Typical Performance in standard 2.5GHz fixed tuned test fixture, (2-Tone, T = 25°C, unless noted)





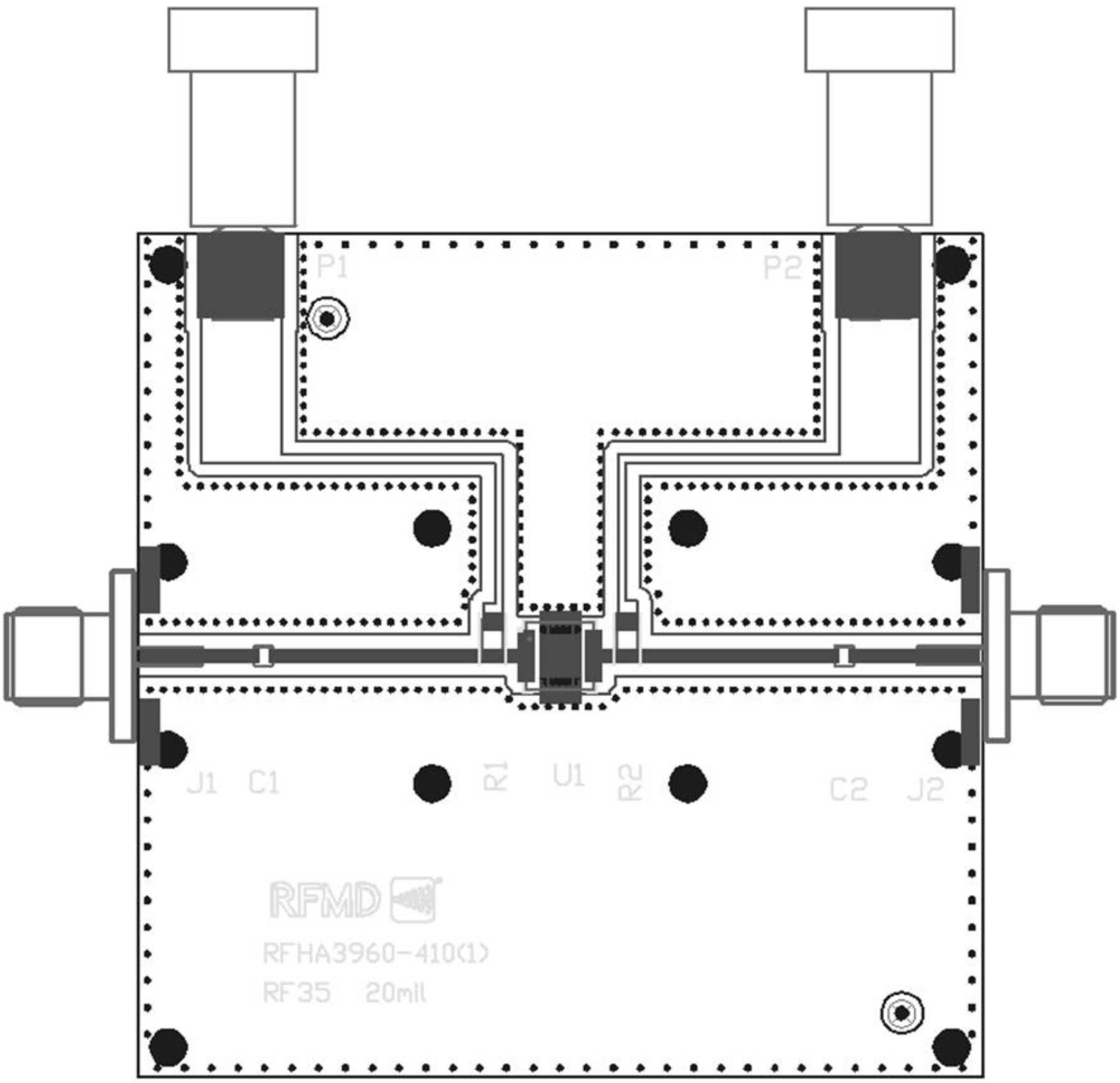
Evaluation Board Schematic 2500MHz Application Circuit



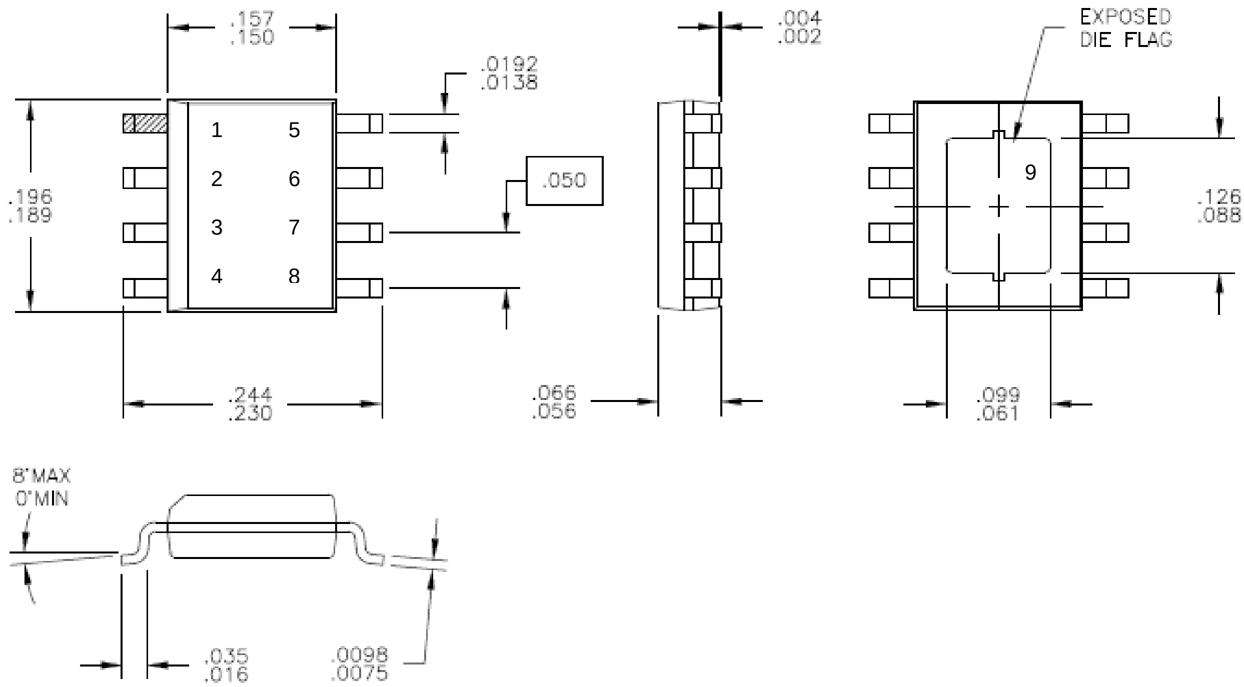
Evaluation Board Bill of Materials (BoM) 2500MHz Application Circuit

Description	Reference Designator	Manufacturer	Manufacturer's P/N
CAP, 12pF, 10%, 50V, X7R,	C1,C2,C7,C8	ATC	800A120JT
CAP, 4.7uF, 10%, 50V, X7R,	C3,C4	Murata Electronics	GRM55ER72A475KA01L
CAP, 0.1uF, 10%, 50V, X7R,	C5,C6	Murata Electronics	GRM155R71H102KA01D
CAP, 3.3pF, 10%, 50V, X7R,	C9,C10	ATC	800A3R3BT
CAP, 1.0pF, 10%, 50V, X7R,	C11	ATC	800A1R0BT
CAP, 1.5pF, 10%, 50V, X7R,	C12	ATC	800A1R5BT
RES,10 ohm	R1	Panasonic	1206
RES,0 ohm	R2	Panasonic.	0603

Evaluation Board Assembly Drawing



Package Outline and Branding Drawing (Dimensions in millimeters)



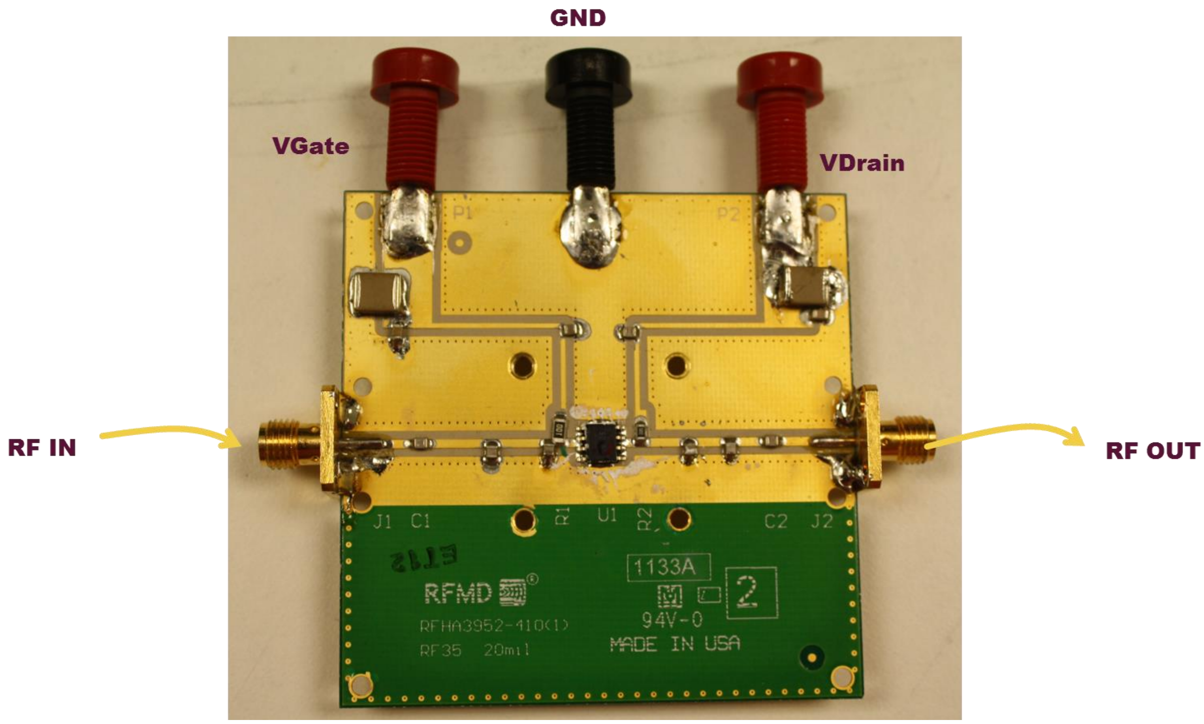
Pin Names and Descriptions

Pin	Name	Description
1	N/C	No internal connection.
2	Gate/RFIN	Gate VG-RF Input
3	Gate/RFIN	Gate VG-RF Input
4	N/C	No internal connection.
5	N/C	No internal connection.
6	Drain/RFOUT	Drain VD-RF Output
7	Drain/RFOUT	Drain VD-RF Output
8	N/C	No internal connection.
9	Source	Source-Ground Base

Bias Instruction for RFHA3960 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 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 -8V to VGate.
4. Apply 28/48V to VDrain.
5. Increase V_G until drain current reaches desired 50mA bias point.
6. Turn on RF input.



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 trade-offs.

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 heat-sink 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 heat-sinking systems and air flow mechanisms. Incorporating the dissipated DC power, it is possible to calculate the junction temperature of the device.