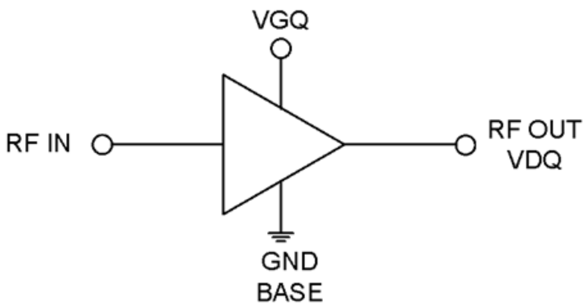
RFHA1004

25W GaN Wide-Band Power Amplifier
700MHz to 2500MHz

The RFHA1004 is a wideband Power Amplifier designed for CW and pulsed applications such as wireless infrastructure, RADAR, military communication radios and general purpose amplification. Using an advanced high power density Gallium Nitride (GaN) semiconductor process, these high-performance amplifiers achieve high efficiency, flat gain and large instantaneous bandwidth in a single amplifier design. The RFHA1004 is an input matched GaN transistor packaged in an air cavity copper package which provides excellent thermal stability through the use of advanced heat sink and power dissipation technologies. Ease of integration is accomplished through the incorporation of optimized input matching network within the package that provides wideband gain and power performance in a single amplifier. An external output match offers the flexibility of further optimizing power and efficiency for any sub-band within the overall bandwidth.

Functional B



Functional Block Diagram

Package: Air-Cavity Cu

Features

- Advanced GaN HEMT Technology
- Output Power of 25W
- Advanced Heat-Sink Technology
- 700MHz to 2500MHz Instantaneous Bandwidth
- Input Internally Matched to 50Ω
- 52V Operation Typical Performance
  - P_{OUT} 43dBm
  - Gain 11dB
  - Power Added Efficiency 45% (700MHz to 2500MHz)
- -40°C to 85°C Operating Temperature
- Large Signal Models Available
- EAR99 Export Control

Applications

- Class AB Operation for Public Mobile Radio
- Power Amplifier Stage for Commercial Wireless Infrastructure
- General Purpose Tx Amplification
- Test and Instrumentation
- Civilian and Military Radar

Ordering Information

RFHA1004S2	Sample bag with 2 pieces
RFHA1004SB	Bag with 5 pieces
RFHA1004SQ	Bag with 25 pieces
RFHA1004SR	Short Reel with 100 pieces
RFHA1004TR7	7" Reel with 750 pieces
RFHA1004PCBA-410	Evaluation Board: 700MHz to 2500MHz; 52V Operation

Absolute Maximum Ratings

Parameter	Rating	Unit
Drain Voltage (V_D)	150	V
Gate Voltage (V_G)	-8 to +2	V
Operational Voltage	54	V
RF - Input Power	38	dBm
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)*	3E + 06	Hours
Thermal Resistance, R_{TH} (junction to case) measured at T_C = 85°C, DC bias only	5.2	°C/W

Caution! ESD sensitive device.

RoHS (Restriction of Hazardous Substances): Compliant per EU Directive 2011/65/EU.

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.

* 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.

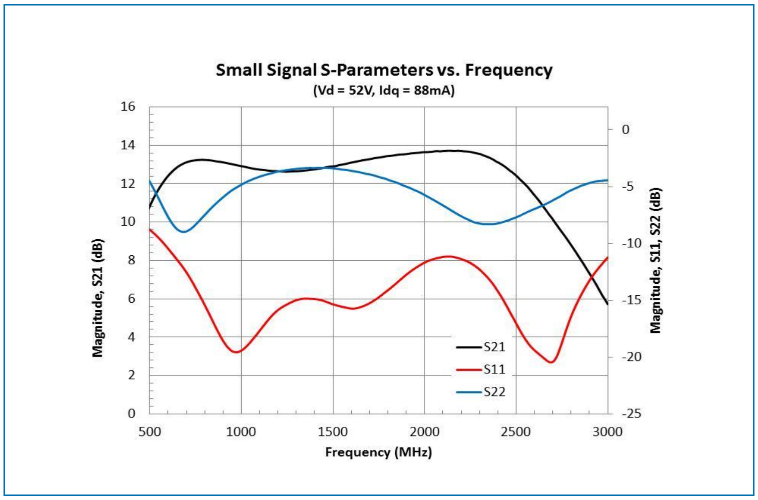
Bias Conditions should also satisfy the following expression: $P_{DISS} < (T_J – T_C) / R_{TH}$ J - C and $T_C = T_{CASE}$

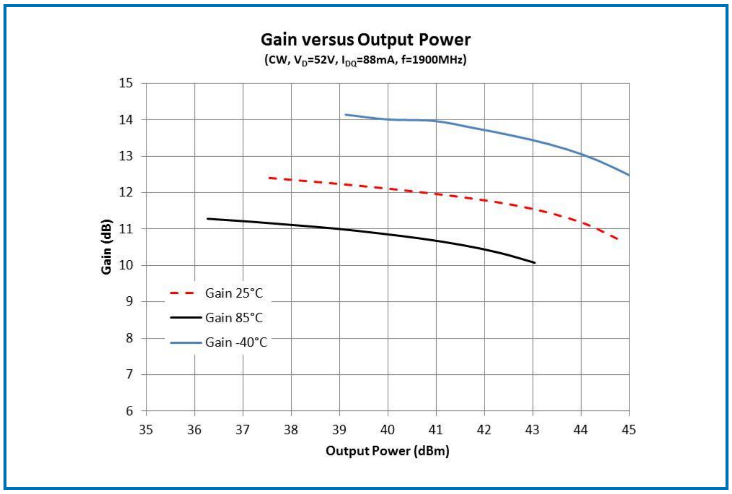
Nominal Operating Parameters

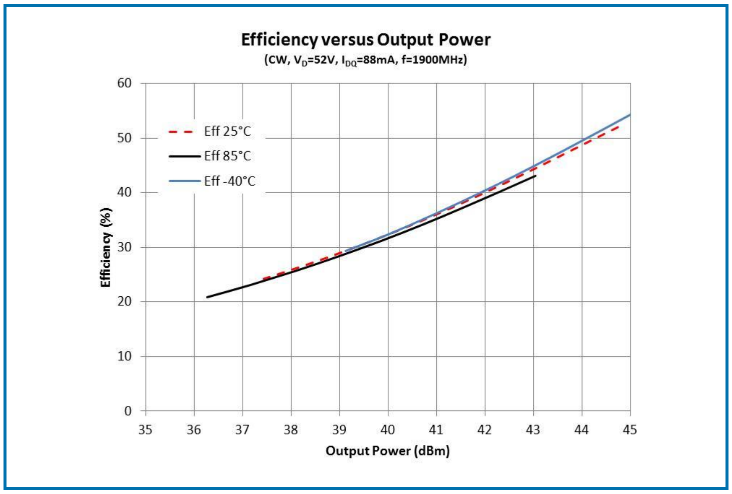
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Recommended Operating Conditions					
Drain Voltage (V_{DSQ})		52		V	
Gate Voltage (V_{GSQ})	-4	-3.2	-2.5	V	
Drain Bias Current		88		mA	
RF Input Power (P_{IN})			35	dBm	
Input Source VSWR			10:1		
Maximum Gate Current (I_g)			15.25	mA	P3dB, CW
RF Performance Characteristics					
Frequency Range	700		2500	MHz	Small signal 3dB bandwidth
Linear Gain		11.5		dB	P_{IN} = 0dBm, 700MHz to 2500MHz
Power Gain		10		dB	P_{IN} = 33dBm, 700MHz to 2500MHz
Gain Variation with Temperature		-0.02		dB/ºC	
Input Return Loss (S11)		-10		dB	
Output Power (P3dB)		43		dBm	700MHz to 2500MHz
Power Added Efficiency (PAE)		43		%	700MHz to 2500MHz

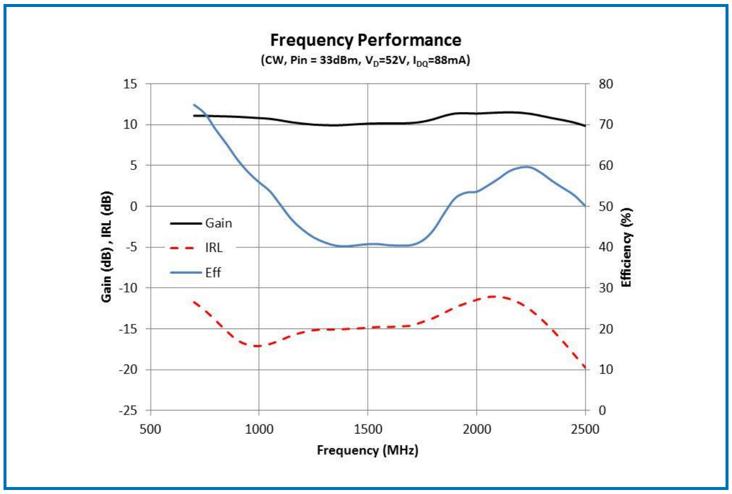
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
RF Functional Tests					**Test Conditions: V_{DSQ} = 52V, I_{DQ} = 88mA, CW, f = 1600MHz, T = 25ºC, Performance in a standard tuned test fixture**
V_{GSQ}		-3.2		V	
Power Gain		10.5		dB	P_{IN} = 33dBm
Input Return Loss		-10		dB	P_{IN} = 33dBm
Output Power		43.5		dBm	P_{IN} = 33dBm
Power Added Efficiency (PAE)		40		%	P_{IN} = 33dBm

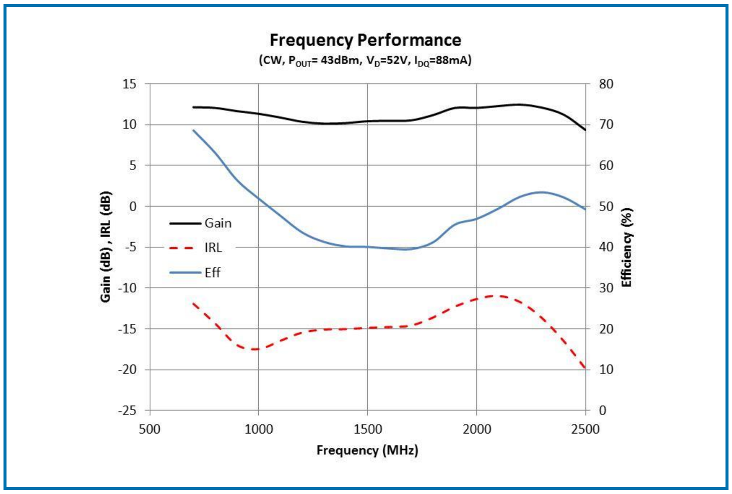
Typical Performance in standard fixed tuned test fixture matched for 700MHz to 2500MHz (T = 25°C, unless noted)



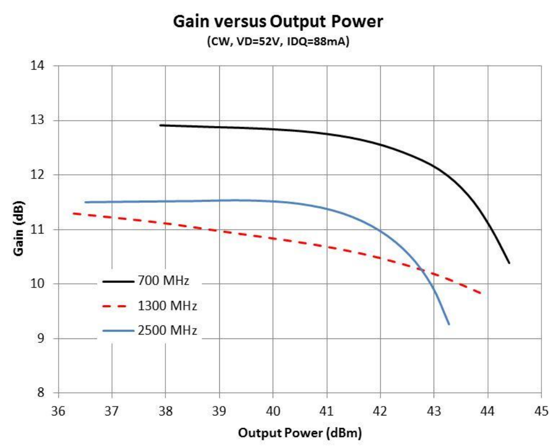


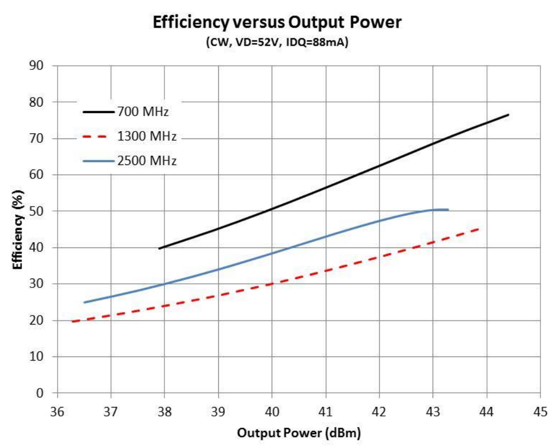


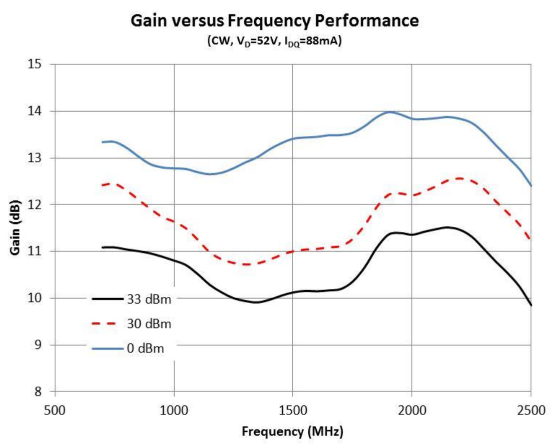


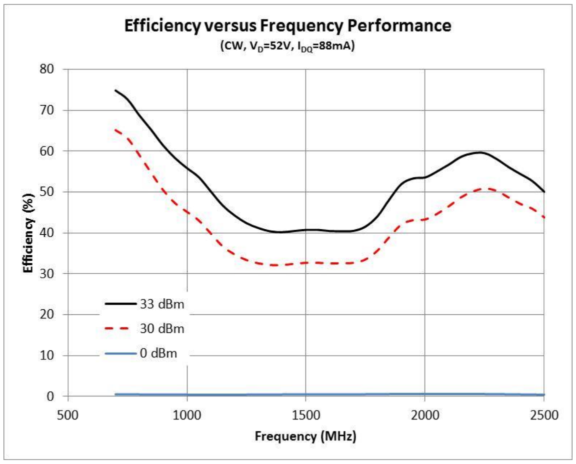


Typical Performance in standard fixed tuned test fixture matched for 700MHz to 2500MHz (T = 25°C, unless noted) (continued)

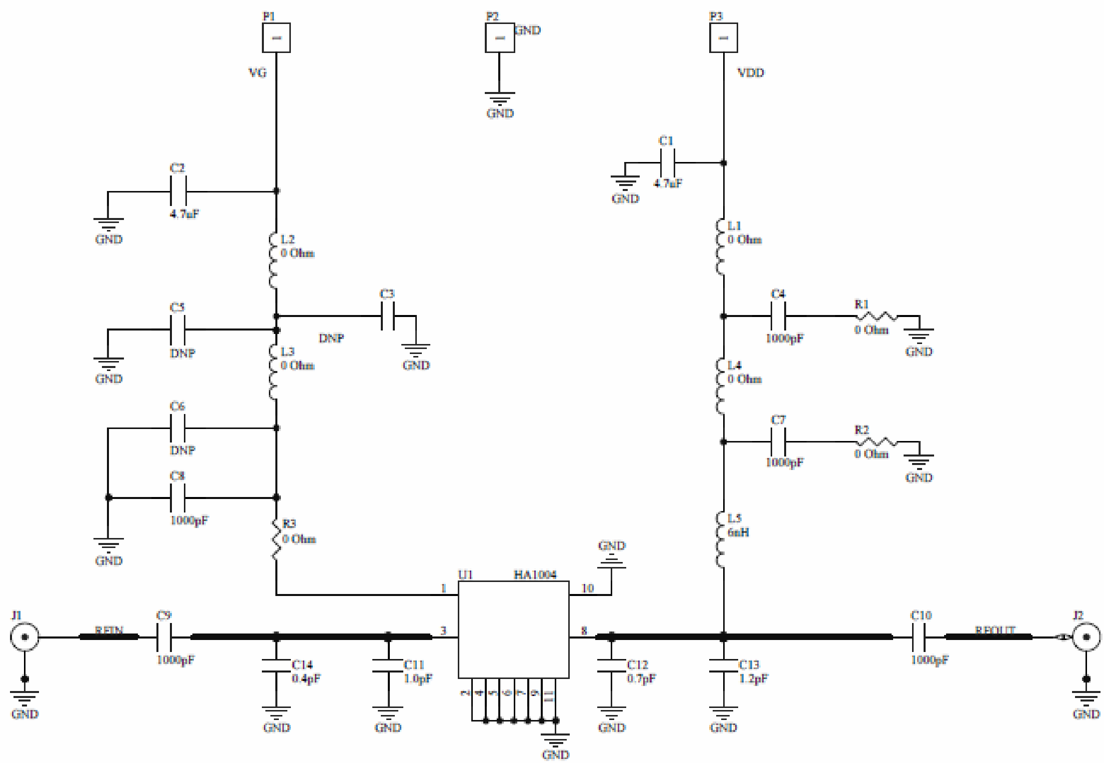








Evaluation Board Schematic

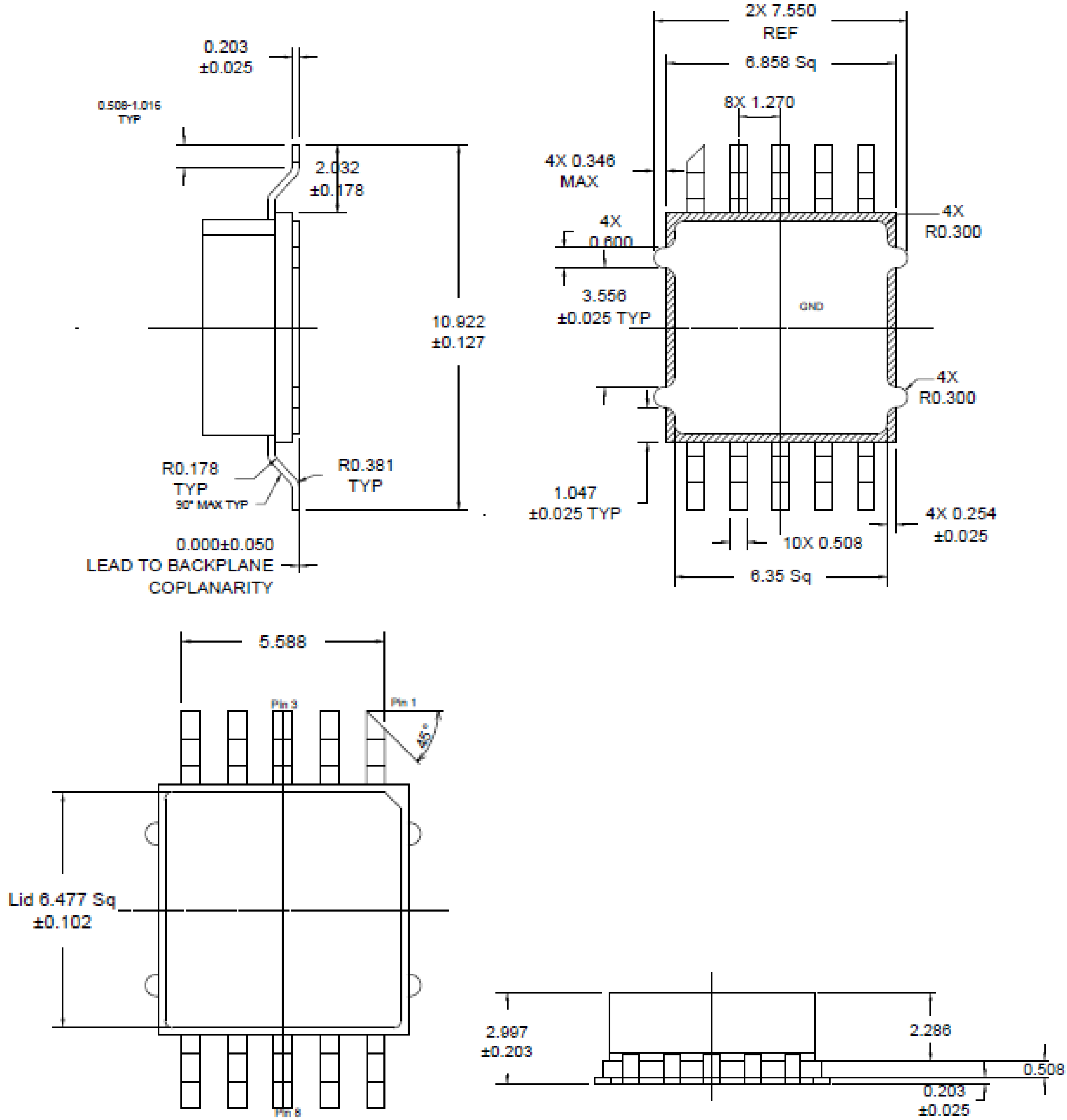


Evaluation Board Bill of Materials (BOM)*

Item	Value	Manufacturer	Manufacturer's P/N
C9,C10	1000pF	Dielectric Labs Inc	C08BL 102X-1ZN-X0T
C5	100pF	Panasonic Industrial Co	ECJ-1VC1H10J
C12	0.7pF	American Technical Ceramics	ATC800A0R7BT250X
C11	1.0pF	American Technical Ceramics	ATC800A1R0BT250X
C13	1.2pF	American Technical Ceramics	ATC800A1R2BT25X
C14	0.4pF	American Technical Ceramics	ATC800A0R4BT250X
C4,C7, C8	1000pF	Murata Electronics	GRM188R71H102KA01D
C1,C2	4.7 uF	Murata Electronics	GRM55ER72A475KA01L
R1,R2,R3	0Ω	Panasonic Industrial Co	ERJ-3GEY0R00V
L1, L2, L3, L4	0Ω	Panasonic Industrial Co	ERJ-8GEY0R))
L5	0.6nH	Coilcraft	0806SQ-6N0JLB

*700MHz to 2500MHz RFHA1004PCBA-410

Package Drawing (Dimensions in millimeters)



Pin Names and Descriptions

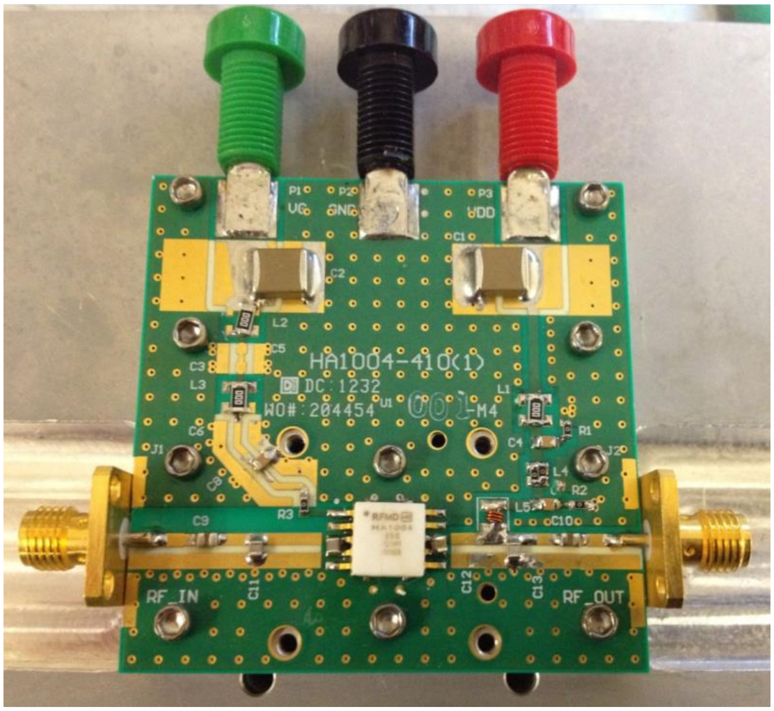
Pin	Name	Description
1	VGS	Gate DC Bias pin
2	N/C	No Internal Connection
3	RFIN	RF Input
4-7	N/C	No Internal Connection
8	RFOUT/VDS	RF Output/Drain DC Bias pin
9-10	N/C	No Internal Connection
Backside	GND	Ground

Bias Instruction for RFHA1004 Evaluation Board

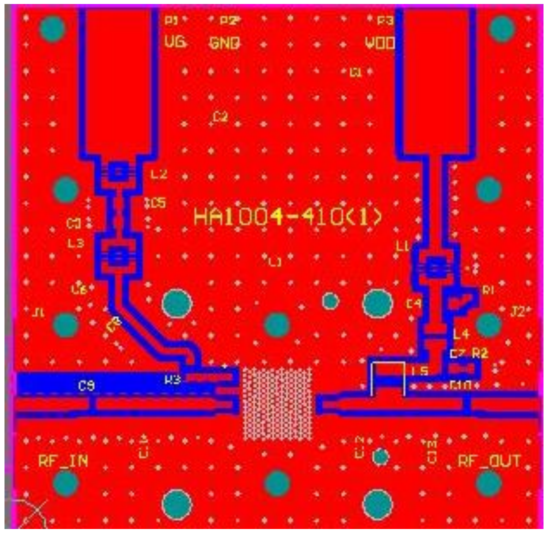
- ESD Sensitive Material. Please use proper ESD precautions when handling devices of evaluation board.
- Evaluation board requires additional external fan cooling.
- Connect all supplies before powering evaluation board.

1. Connection 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 52V to VD.
5. Increase V_{G2} until drain current reaches 88mA or desired bias point.
6. Turn on the RF input.

- Typical test data provided is measured to SMA connector reference plane, and include evaluation board/broadband bias network mismatch and losses



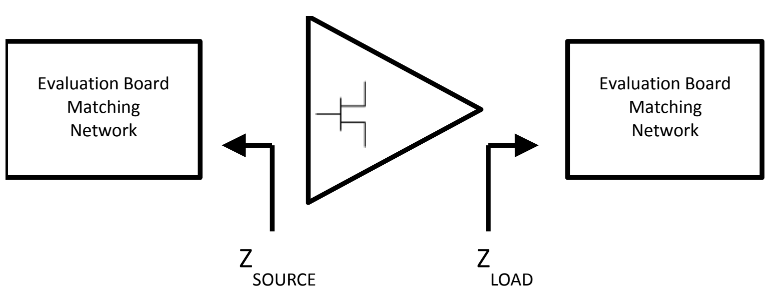
Evaluation Board Layout



Device Impedances*

Frequency	RFHA1004PCBA-410 (700MHz to 2500MHz)	
	Z Source (Ω)	Z Load (Ω)
700 MHz	39.14 –j10.56	44.05 +j40.74
900 MHz	34.12 – j9.62	60.99 +j18.87
1000 MHz	31.74 - j8.53	58.14 + j7.10
1200 MHz	27.79 - j5.35	44.33 - j2.37
1500 MHz	23.51 + j0.83	29.51 + j2.31
1800 MHz	21.23 + j8.04	23.22 +j12.81
2000 MHz	20.71 +j13.15	21.75 +j20.61
2200 MHz	20.84 +j18.44	22.07 +j 29.11
2500MHz	22.70 +j26.87	25.72 + j44.07

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



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.

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 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.