Hittite MICROWAVE CORPORATION v00.0611

# HMC999

RoHS EARTH FRIENDLY

## GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz

### Typical Applications

The HMC999 is ideal for:

- Test Instrumentation
- Military Communications
- Jammers and Decoys
- Radar, EW & ECM Subsystems
- Space

### Features

High P1dB Output Power: 38 dBm

High Psat Output Power: 40 dBm

High Output IP3: 47 dBm

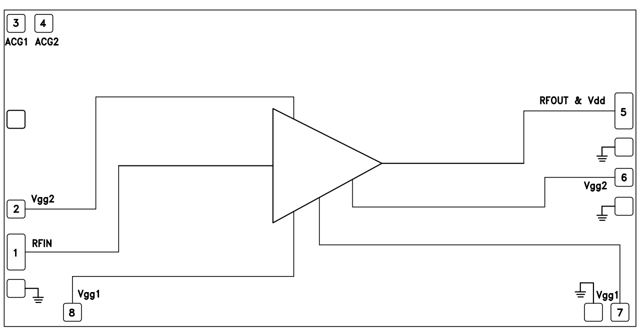
High Gain: 11 dB

Supply Voltage: +28V, +40V or +48V @ 1100 mA

50 Ohm Matched Input/Output

Die Size: 3.66 x 1.91 x 0.1 mm

### Functional Diagram




### General Description

The HMC999 is a GaN HEMT MMIC Distributed Power Amplifier which operates between 0.01 and 10 GHz. The amplifier provides 11 dB of gain, 47 dBm output IP3 and 38 dBm of output power at 1 dB gain compression while requiring 1100 mA from a +48 V supply. The HMC999 amplifier provides 10 Watts of saturated power in a chip area only 7 $mm^2$, equating to a power density of 1.5 W/$mm^2$ over 3 decades of bandwidth. All data is taken with the chip connected via two 25 mm (1 mil) wire bonds of minimal length 0.31 mm (12 mils).

### Electrical Specifications, $T_A$ = +25°C [2], Vdd = +48 V, Vgg2 = +22 V, Idd = 1100 mA* [1]

| Parameter | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency Range | | 0.01 - 2 | | | 2 - 6 | | | 6 - 10 | | GHz |
| Gain | 10.5 | 12.5 | | 9 | 11 | | 8.5 | 10.5 | | dB |
| Gain Flatness | | ±0.8 | | | ±0.4 | | | ±0.7 | | dB |
| Gain Variation Over Temperature | | 0.017 | | | 0.02 | | | 0.025 | | dB/ °C |
| Input Return Loss | | 20 | | | 18 | | | 15 | | dB |
| Output Return Loss | | 13 | | | 15 | | | 14 | | dB |
| Output Power for 1 dB Compression (P1dB) | 36.5 | 38.5 | | 36 | 38 | | 34.5 | 36.5 | | dBm |
| Saturated Output Power (Psat) | | 40.5 | | | 40 | | | 39.5 | | dBm |
| Output Third Order Intercept (IP3) | | 48 | | | 47 | | | 45.5 | | dBm |
| Supply Current<br>(Idd) (Vdd = 48V, Vgg = 22V Typ.) | | 1100 | | | 1100 | | | 1100 | | mA |

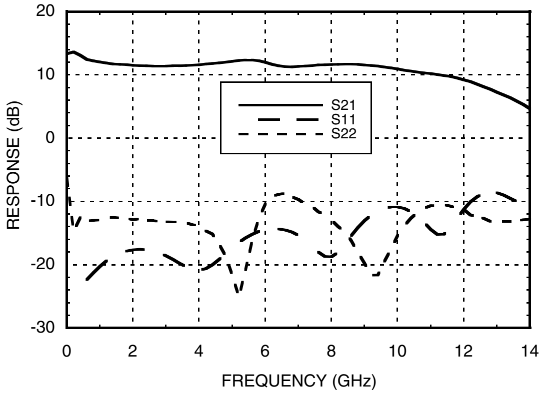
** Adjust Vgg1 between -5 to 0 V to achieve Idd = 1100 mA typical.*

*[1] S parameter and OIP3 data taken at Idd=1000mA*

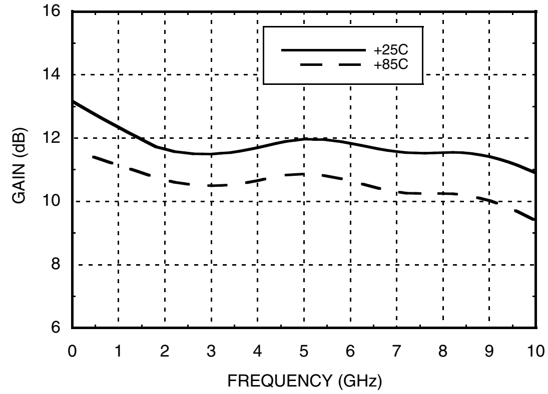
*[2] Probe station chuck temperature adjusted to bring backside of die to +25°C*

## *GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz*

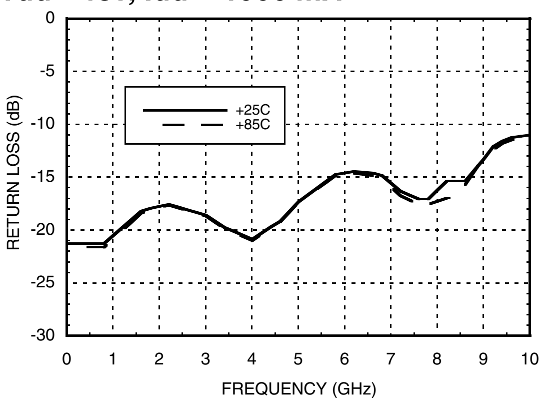
### *Gain & Return Loss @ Vdd = 48V, Idd = 1000 mA*



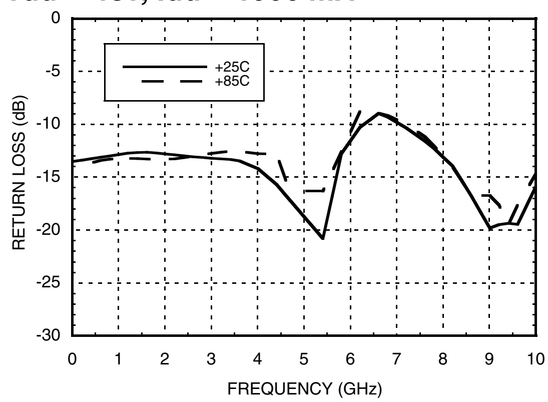

### *Gain vs. Temperature @ Vdd = 48V, Idd = 1000 mA*



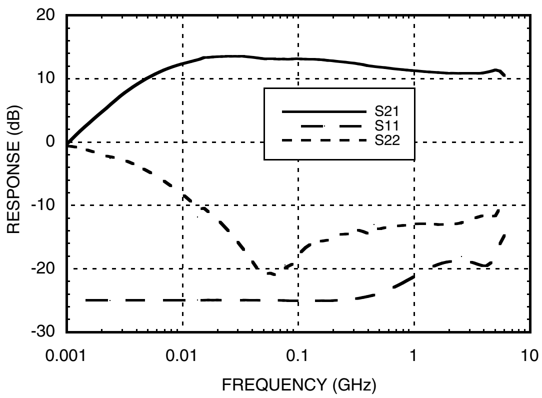

### *Input Return Loss vs. Temperature @ Vdd =48V, Idd = 1000 mA*



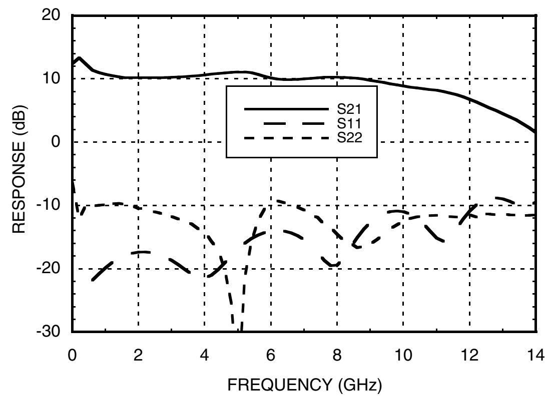

### *Output Return Loss vs. Temperature @ Vdd = 48V, Idd = 1000 mA*




### *Low Frequency Gain & Return Loss @ Vdd = 48V, Idd = 1000 mA*




### *Gain & Return Loss @ Vdd = 40V, Idd = 1000 mA*



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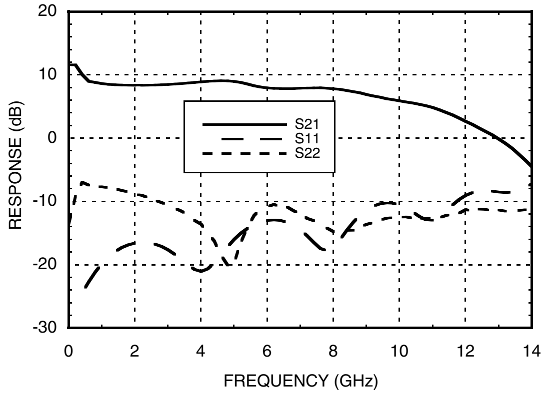
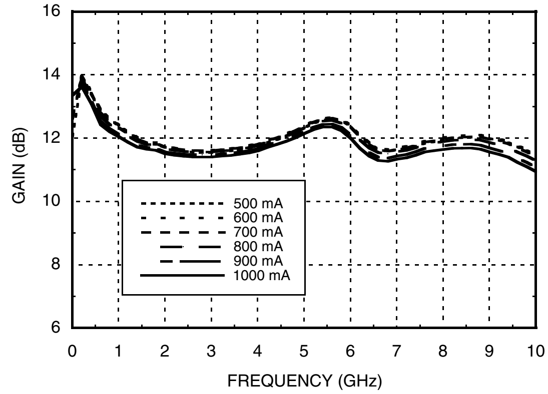
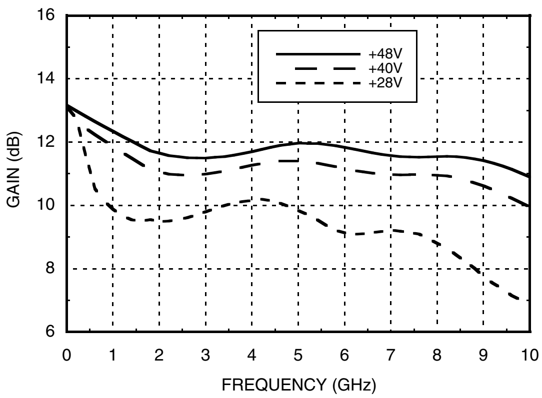
### Gain & Return Loss @ Vdd = 28V, Idd = 1000 mA



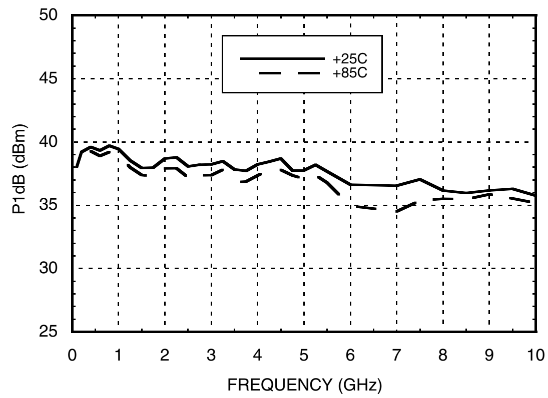

### Gain vs. Supply Current @ Vdd = 48V



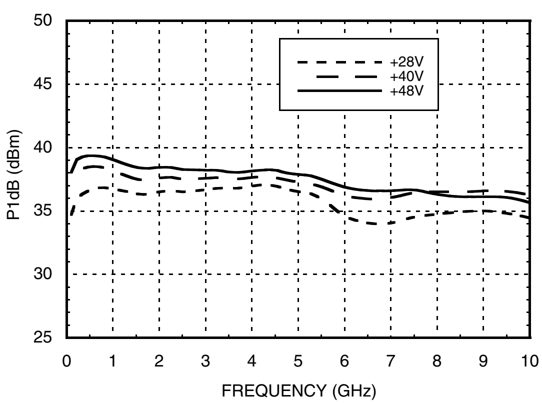

### Gain vs. Supply Voltage @ Idd = 1000 mA



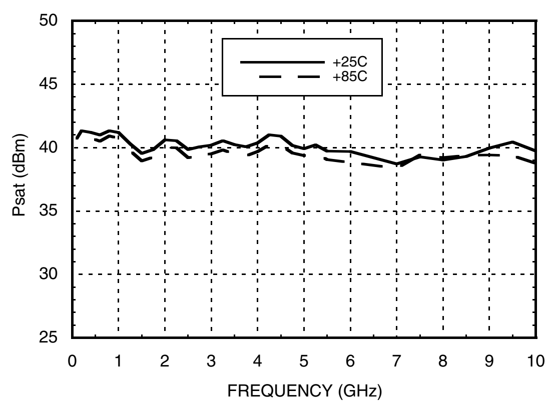

### P1dB vs. Temperature



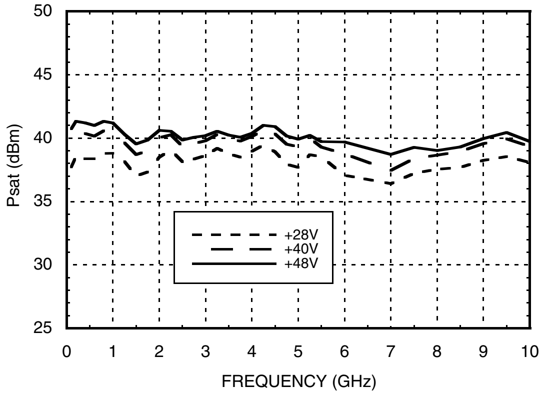

### P1dB vs. Supply Voltage



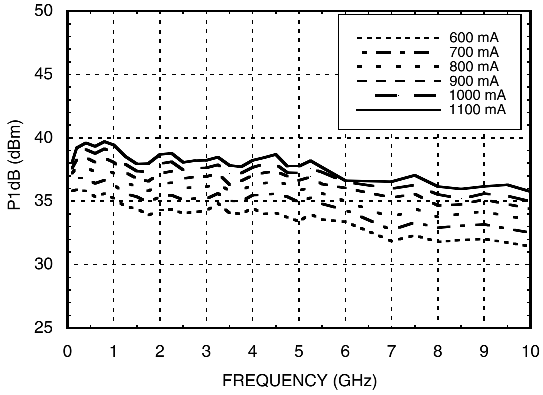

### Psat vs. Temperature



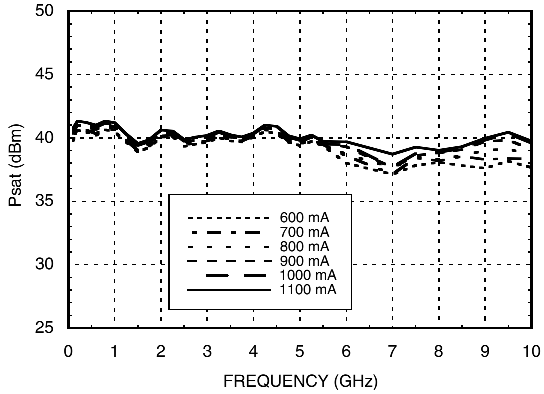
### Psat vs. Supply Voltage



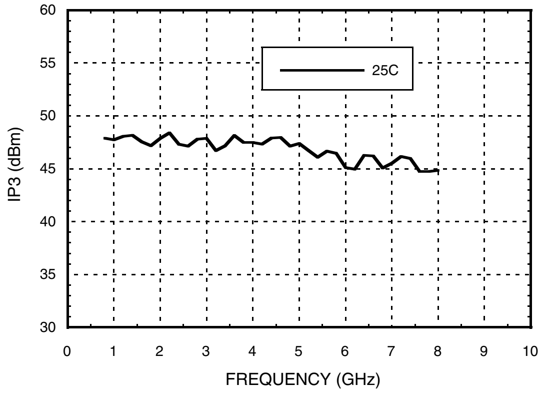

### P1dB vs. Supply Current



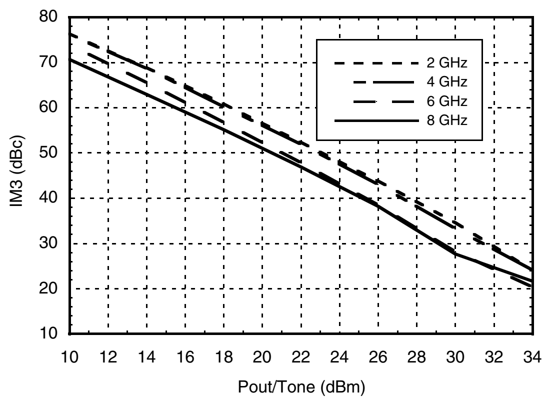

### Psat vs. Supply Current




### Output IP3 @ Pout = 26 dBm / Tone

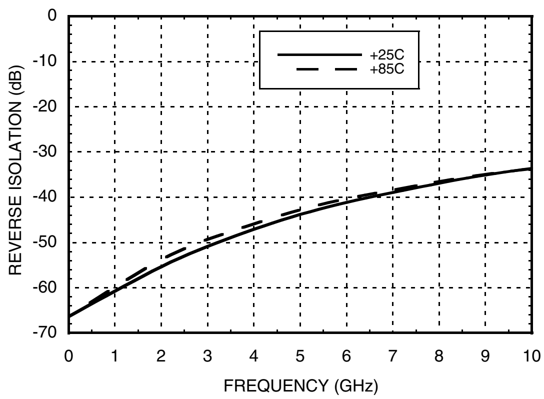



### Output IM3 @ Vdd = +48V

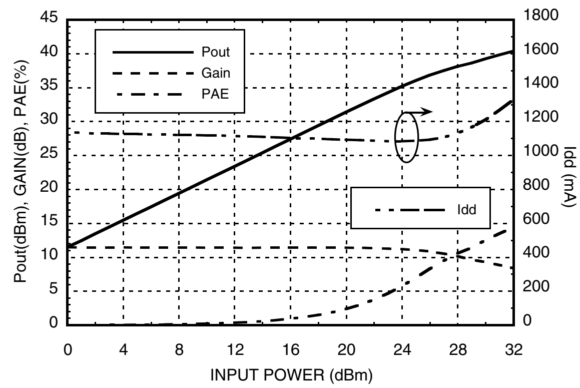


# GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz

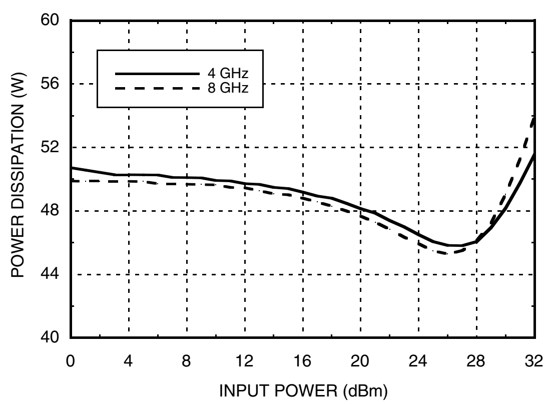
### Reverse Isolation vs. Temperature




### Power Compression @ 4 GHz

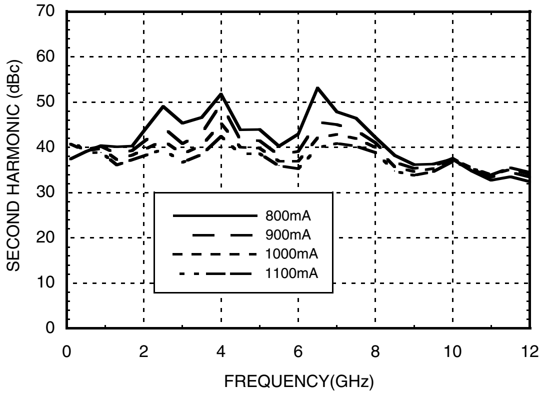



### Power Dissipation

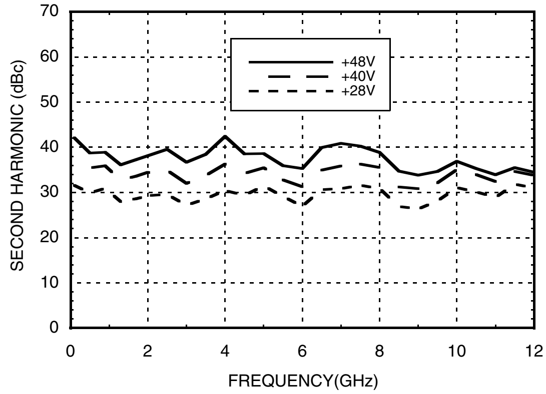


## GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz

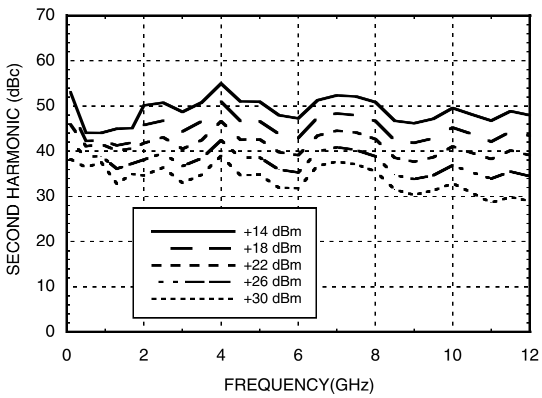
### Second Harmonics vs. Idd @ Pout = +26 dBm, Vdd = 48V



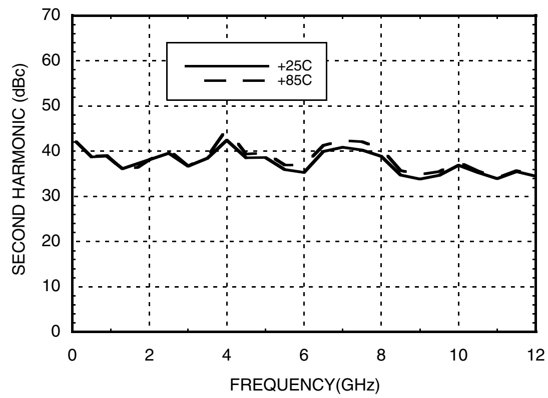

### Second Harmonics vs. Vdd @ Pout = +26 dBm, Idd = 1100 mA




### Second Harmonics vs. Pout Vdd = 48V & Vgg = 22V & Idd = 1100 mA




### Second Harmonics vs. Temperature Vdd = 48V & Vgg = 22V & Idd = 1100 mA Pout = 26 dBm




### Absolute Maximum Ratings

| | |
|---|---|
| Drain Bias Voltage (Vdd) | 56V |
| Gate Bias Voltage (Vgg1) | -5 to 0V |
| Gate Bias Voltage (Vgg2) | 6V to (Vdd - 8V) |
| RF Input Power @ Fin < 0.2GHz (RFIN) | 28 dBm |
| RF Input Power @ Fin > 0.2GHz (RFIN) | 36 dBm |
| Channel Temperature | 225 °C |
| Continuous Pdiss (T= 85 °C) (derate 729 mW/°C above 85 °C) | 102 W |
| Thermal Resistance [1] | 1.37 °C/W |
| Output Power into VSWR > 7:1 | 40 dBm |
| Storage Temperature | -65 to 150 °C |
| Operating Temperature | -55 to 85 °C |

ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

### Typical Supply Current vs. Vdd

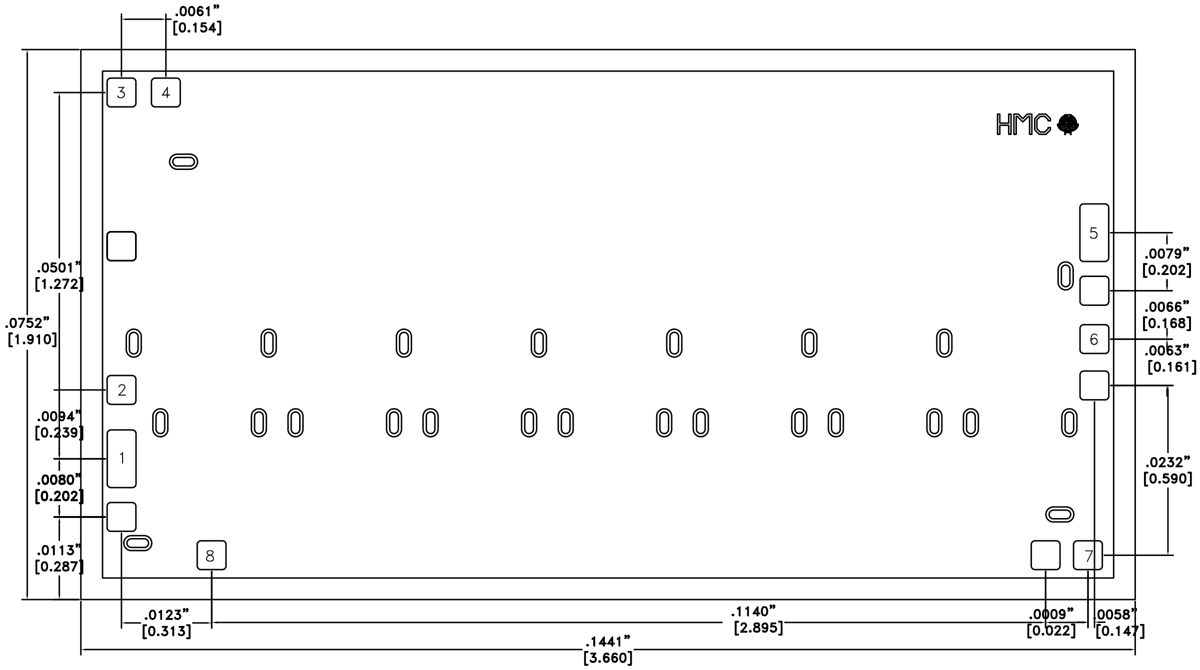
| Vdd (V) | Idd (mA) |
|---|---|
| 28 | 1100 |
| 40 | 1100 |
| 48 | 1100 |

[1] Includes 0.5 mil thick thermally conductive epoxy layer. Epoxy thermal conductivity = 60 W/mC

# GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz



## Outline Drawing




## Die Packaging Information [1]

| Standard | Alternate |
|---|---|
| GP-1 (Gel Pack) | [2] |

*[1] Refer to the "Packaging Information" section for die packaging dimensions.*

*[2] For alternate packaging information contact Hittite Microwave Corporation.*

NOTES:
1. ALL DIMENSIONS IN INCHES [MILLIMETERS]
2. DIE THICKNESS IS 0.004 (0.100)
3. TYPICAL BOND PAD IS 0.004 (0.100) SQUARE
4. BOND PAD METALIZATION: GOLD
5. BACKSIDE METALLIZATION: GOLD
6. BACKSIDE METAL IS GROUND
7. NO CONNECTION REQUIRED FOR UNLABELED BOND PADS
8. OVERALL DIE SIZE IS ±.002



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*Application Support: Phone: 978-250-3343 or apps@hittite.com*

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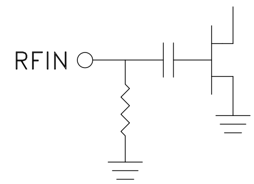
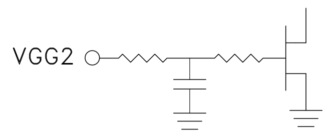
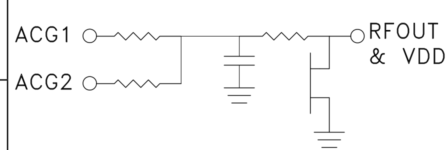
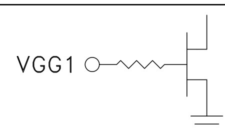
# GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz

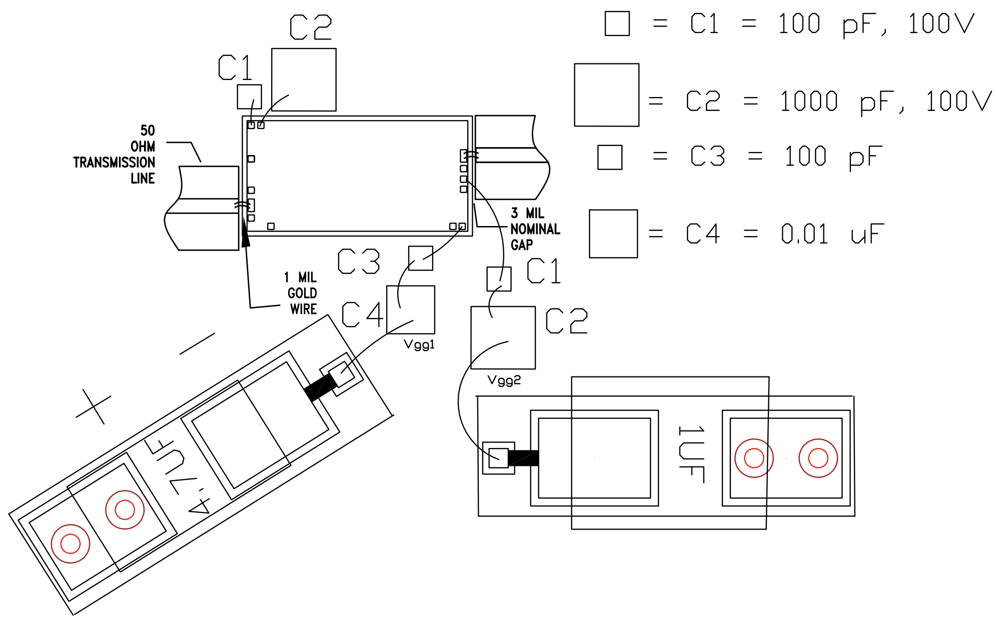
## Pad Descriptions

| Pad Number | Function | Description | Interface Schematic |
|---|---|---|---|
| 1 | RFIN | This pad is DC coupled and matched to 50 Ohms. External blocking capacitor is required |   |
| 2, 6 | VGG2 | Gate control 2 for amplifier. Attach bypass capacitor per application circuit herein. For nomiinal operation +22V should be applied to either pad 2 or pad 6. |   |
| 3, 4 | AGC1, AGC2 | Low frequency termination. Attach bypass capacitor per application circuit herein. |   |
| 6 | RFOUT & VDD | RF output for amplifier. Connect DC bias (Vdd) network to provide drain current Idd). See application circuit herein. | |
| 7, 8 | VGG1 | Gate control 1 for amplifier. Attach bypass capacitor per application circuit herein. Please follow “MMIC Amplifier Biasing Procedure” application note. This voltage may be applied to either pad. |   |
| Die Bottom | GND | Die bottom must be connected to RF/DC ground | |

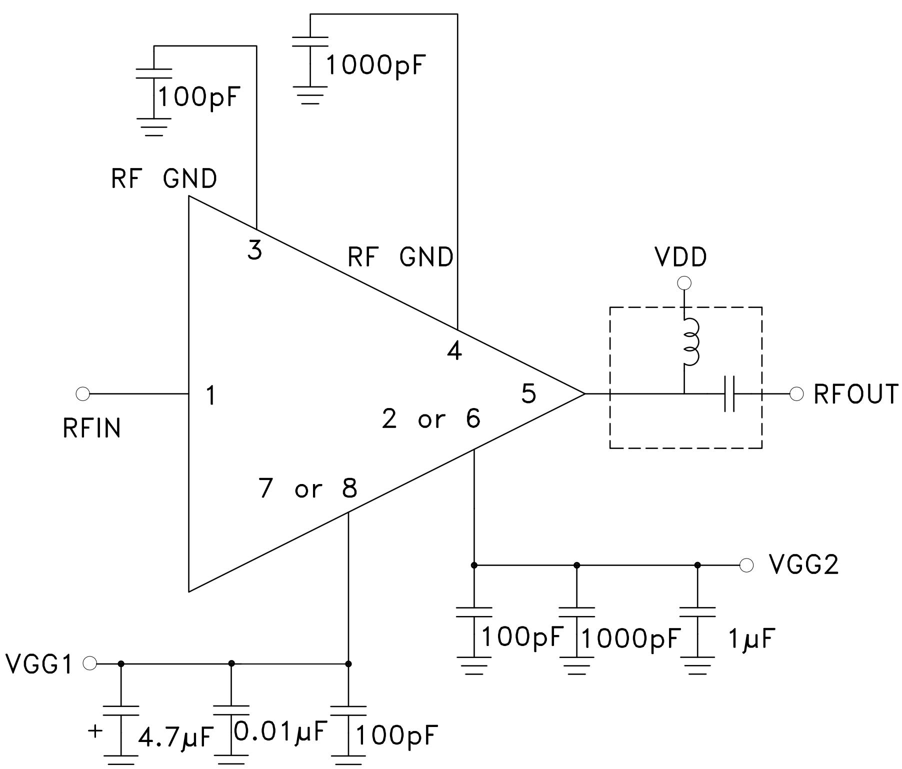
## GaN MMIC 10 WATT POWER AMPLIFIER, 0.01 - 10 GHz



### Assembly Diagram




### Application Circuit




*NOTE 1: Drain Bias (Vdd) must be applied through a broadband bias tee with low series resistance and capable of providing ~1800 mA*

## Mounting & Bonding Techniques for Millimeterwave GaN MMICs

The die should be attached directly to the ground plane eutectically or with conductive epoxy (see HMC general Handling, Mounting, Bonding Note).

50 Ohm Microstrip transmission lines on 0.127mm (5 mil) thick alumina thin film substrates are recommended for bringing RF to and from the chip (Figure 1). If 0.254mm (10 mil) thick alumina thin film substrates must be used, the die should be raised 0.150mm (6 mils) so that the surface of the die is coplanar with the surface of the substrate. One way to accomplish this is to attach the 0.102mm (4 mil) thick die to a 0.150mm (6 mil) thick copper tungsten heat spreader which is then attached to the thermally conductive ground plane (Figure 2).

Microstrip substrates should be placed as close to the die as possible in order to minimize bond wire length. Typical die-to-substrate spacing is 0.076mm to 0.152 mm (3 to 6 mils).

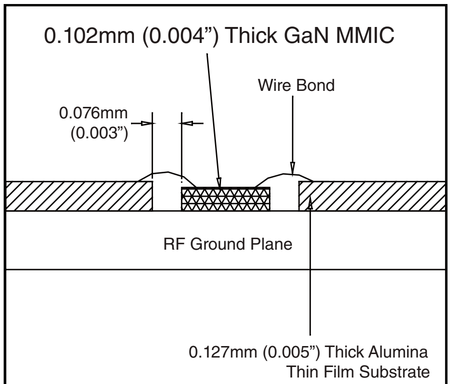



Figure 1.

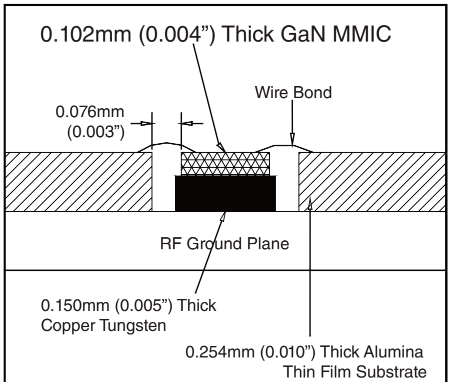



Figure 2.

### Handling Precautions

*Follow these precautions to avoid permanent damage.*

**Storage:** All bare die are placed in either Waffle or Gel based ESD protective containers, and then sealed in an ESD protective bag for shipment. Once the sealed ESD protective bag has been opened, all die should be stored in a dry nitrogen environment.

**Cleanliness:** Handle the chips in a clean environment. DO NOT attempt to clean the chip using liquid cleaning systems.

**Static Sensitivity:** Follow ESD precautions to protect against ESD strikes.

**Transients:** Suppress instrument and bias supply transients while bias is applied. Use shielded signal and bias cables to minimize inductive pick-up.

**General Handling:** Handle the chip along the edges with a vacuum collet or with a sharp pair of bent tweezers. The surface of the chip may have fragile air bridges and should not be touched with vacuum collet, tweezers, or fingers.

### Mounting

The chip is back-metallized and can be die mounted with AuSn eutectic preforms or with electrically conductive epoxy. The mounting surface should be clean and flat.

Eutectic Die Attach: A 80/20 gold tin preform is recommended with a work surface temperature of 255 °C and a tool temperature of 265 °C. When hot 90/10 nitrogen/hydrogen gas is applied, tool tip temperature should be 290 °C. DO NOT expose the chip to a temperature greater than 320 °C for more than 20 seconds. No more than 3 seconds of scrubbing should be required for attachment.

Epoxy Die Attach: Apply a minimum amount of epoxy to the mounting surface so that a thin epoxy fillet is observed around the perimeter of the chip once it is placed into position. Cure epoxy per the manufacturer’s schedule.

### Wire Bonding

RF bonds made with two 1 mil wires are recommended. These bonds should be thermosonically bonded with a force of 40-60 grams. DC bonds of 0.001” (0.025 mm) diameter, thermosonically bonded, are recommended. Ball bonds should be made with a force of 40-50 grams and wedge bonds at 18-22 grams. All bonds should be made with a nominal stage temperature of 150 °C. A minimum amount of ultrasonic energy should be applied to achieve reliable bonds. All bonds should be as short as possible, less than 12 mils (0.31 mm).