

## Features

- GaN on Si HEMT Depletion Mode Transistor
- Suitable for Linear and Saturated Applications
- Tunable from DC - 3.5 GHz
- 48 V Operation
- 13.5 dB Gain at 3.5 GHz
- 55 % Drain Efficiency at 3.5 GHz
- 100 % RF Tested
- Standard package with bolt down flange
- RoHS\* Compliant and 260°C reflow compatible



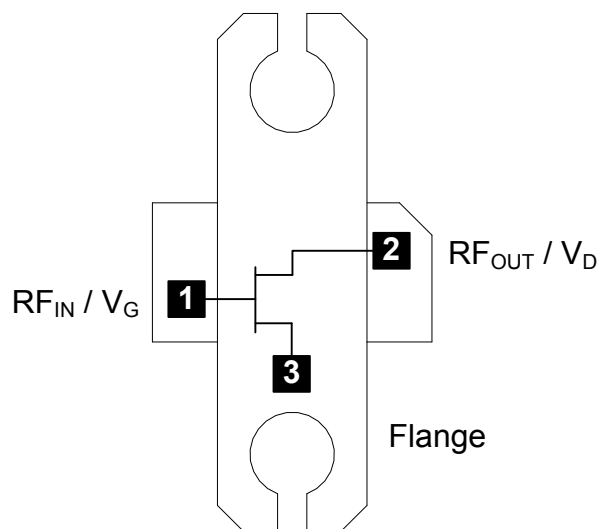
## Description

The NPT2020 GaN HEMT is a wideband transistor optimized for DC - 3.5 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 50 W (47 dBm) in an industry standard surface mount package.

The NPT2020 is ideally suited for defense communications, land mobile radio, avionics, wireless infrastructure, ISM applications and VHF/UHF/L/S-band radar.

Built using the SIGANTIC® process - a proprietary GaN-on-Silicon technology.

## Functional Schematic



## Ordering Information

| Part Number    | Package                          |
|----------------|----------------------------------|
| NPT2020        | Bulk Quantity                    |
| NPT2020-SMBPPR | Custom Sample Board <sup>1</sup> |
| NPT2020-SMB2   | 1250-1850 MHz Sample Board       |

1. When ordering, specify application requirements (frequency, linearity, etc.)

## Pin Configuration

| Pin No. | Pin Name                           | Function          |
|---------|------------------------------------|-------------------|
| 1       | RF <sub>IN</sub> / V <sub>G</sub>  | RF Input / Gate   |
| 2       | RF <sub>OUT</sub> / V <sub>D</sub> | RF Output / Drain |
| 3       | Flange <sup>2</sup>                | Ground / Source   |

2. The Flange must be connected to RF and DC ground. This path must also provide a low thermal resistance heat path.

\* Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

## GaN Wideband Transistor 48 V, 50 W DC - 3.5 GHz

Rev. V1

### RF Electrical Specifications: $T_A = 25\text{ }^\circ\text{C}$ , $V_{DS} = 48\text{ V}$ , $I_{DQ} = 350\text{ mA}$

| Parameter                      | Test Conditions                  | Symbol       | Min.                          | Typ. | Max. | Units |
|--------------------------------|----------------------------------|--------------|-------------------------------|------|------|-------|
| Small Signal Gain              | CW, 3.5 GHz                      | $G_{SS}$     | -                             | 14.5 | -    | dB    |
| Saturated Output Power         | CW, 3.5 GHz                      | $P_{SAT}$    | -                             | 48   | -    | dBm   |
| Drain Efficiency at Saturation | CW, 3.5 GHz                      | $\eta_{SAT}$ | -                             | 60   | -    | %     |
| Power Gain                     | 3.5 GHz, $P_{OUT} = 50\text{ W}$ | $G_P$        | 12                            | 13.5 | -    | dB    |
| Drain Efficiency               | 3.5 GHz, $P_{OUT} = 50\text{ W}$ | $\eta$       | 50                            | 55   | -    | %     |
| Ruggedness: Output Mismatch    | All phase angles                 | $\Psi$       | VSWR = 10:1, No Device Damage |      |      |       |

### DC Electrical Characteristics: $T_A = 25\text{ }^\circ\text{C}$

| Parameter                    | Test Conditions   | Symbol      | Min. | Typ. | Max. | Units    |
|------------------------------|---|-------------|------|------|------|----------|
| Drain-Source Leakage Current | $V_{GS} = -8\text{ V}$ , $V_{DS} = 160\text{ V}$            | $I_{DLK}$   | -    | -    | 14   | mA       |
| Gate-Source Leakage Current  | $V_{GS} = -8\text{ V}$ , $V_{DS} = 0\text{ V}$              | $I_{GLK}$   | -    | -    | 7    | mA       |
| Gate Threshold Voltage       | $V_{DS} = 48\text{ V}$ , $I_D = 14\text{ mA}$               | $V_T$       | -2.5 | -1.5 | -0.5 | V        |
| Gate Quiescent Voltage       | $V_{DS} = 48\text{ V}$ , $I_D = 350\text{ mA}$              | $V_{GSQ}$   | -2.1 | -1.2 | -0.3 | V        |
| On Resistance                | $V_{DS} = 2\text{ V}$ , $I_D = 105\text{ mA}$               | $R_{ON}$    | -    | 0.34 | -    | $\Omega$ |
| Saturated Drain Current      | $V_{DS} = 7\text{ V}$ pulsed, pulse width 300 $\mu\text{s}$ | $I_{D,MAX}$ | -    | 8.2  | -    | A        |

## Absolute Maximum Ratings<sup>3,4,5</sup>

| Parameter                      | Absolute Maximum |
|--------------------------------|------------------|
| Drain Source Voltage, $V_{DS}$ | 160 V            |
| Gate Source Voltage, $V_{GS}$  | -10 to 3 V       |
| Gate Current, $I_G$            | 28 mA            |
| Junction Temperature, $T_J$    | +200°C           |
| Operating Temperature          | -40°C to +55°C   |
| Storage Temperature            | -65°C to +150°C  |

3. Exceeding any one or combination of these limits may cause permanent damage to this device.
4. MACOM does not recommend sustained operation near these survivability limits.
5. Operating at nominal conditions with  $T_J \leq 200^\circ\text{C}$  will ensure  $\text{MTTF} > 1 \times 10^6$  hours.

## Thermal Characteristics<sup>6</sup>

| Parameter          | Test Conditions                                  | Symbol          | Typical | Units |
|--------------------|--|-----------------|---------|-------|
| Thermal Resistance | $V_{DS} = 48 \text{ V}, T_J = 200^\circ\text{C}$ | $R_{\theta JC}$ | 2.1     | °C/W  |

6. Junction temperature ( $T_J$ ) measured using IR Microscopy. Case temperature measured using thermocouple embedded in heat-sink.

## Handling Procedures

Please observe the following precautions to avoid damage:

## Static Sensitivity

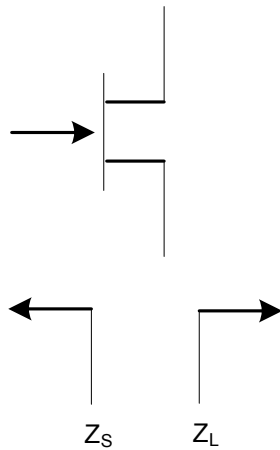
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

**Load-Pull Performance:  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 350\text{ mA}$ ,  $T_C = 25\text{ }^\circ\text{C}$**

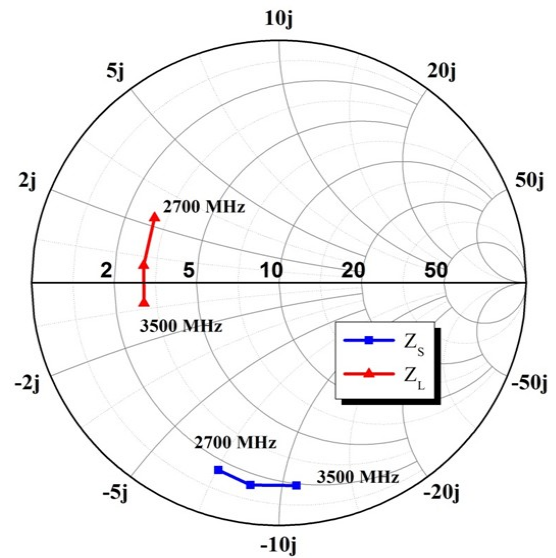
**Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance**

| Frequency (MHz) | $Z_S$ ( $\Omega$ ) | $Z_L$ ( $\Omega$ ) | $P_{SAT}$ (W) | $G_{SS}$ (dB) | Drain Efficiency at $P_{SAT}$ (%) |
|-----------------|--------------------|--------------------|---------------|---------------|-----------------------------------|
| 2700            | $1.6 - j7.2$       | $2.9 + j2.3$       | 65            | 16.2          | 58                                |
| 3100            | $1.5 - j8.6$       | $2.9 + j0.6$       | 64            | 16.1          | 55                                |
| 3500            | $1.9 - j10.7$      | $2.9 - j0.7$       | 62            | 15.7          | 53                                |

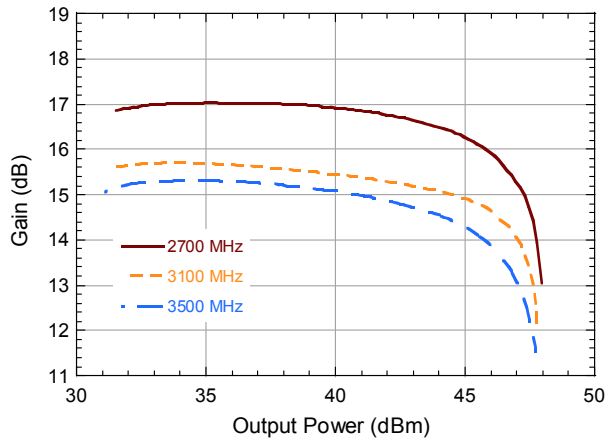
### Impedance Reference



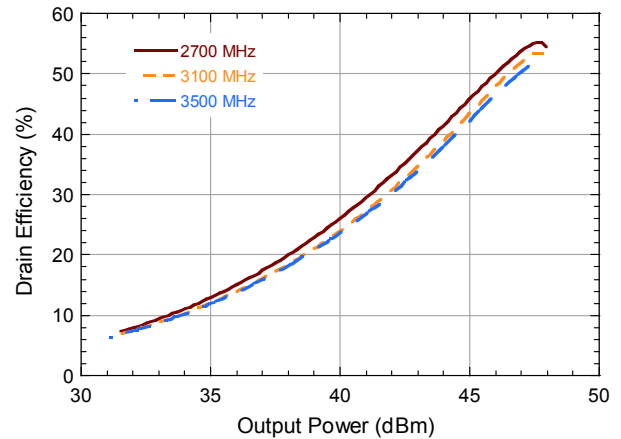
### $Z_S$ and $Z_L$ vs. Frequency



### Gain vs. Output Power

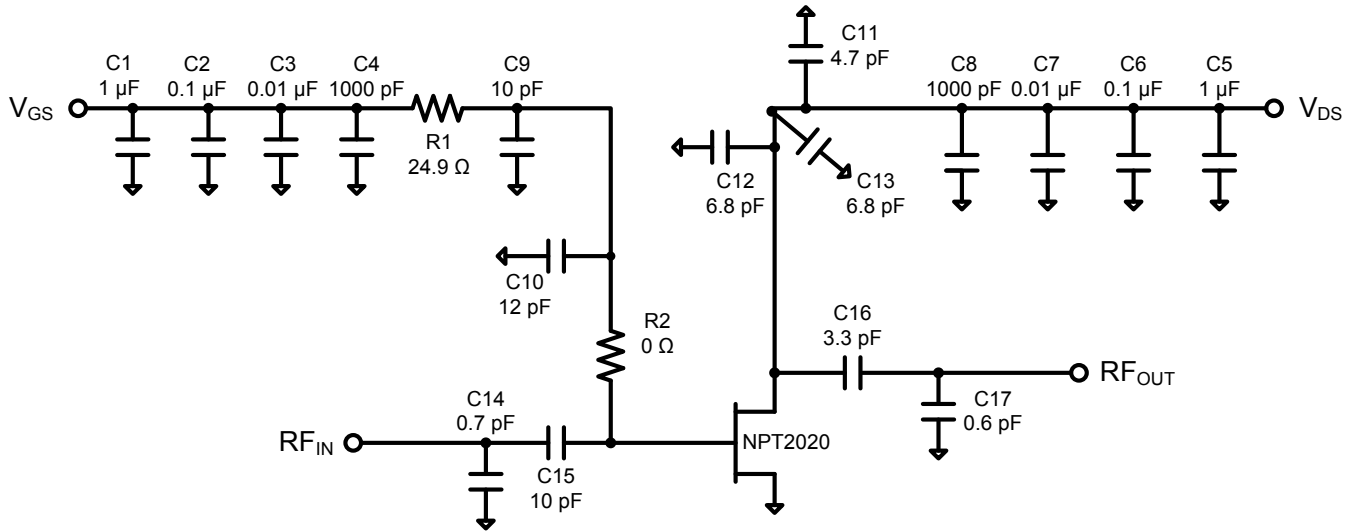


### Drain Efficiency vs. Output Power



## Evaluation Board and Recommended Tuning Solution

### 3.5 GHz Narrowband Circuit



## Description

Parts measured on evaluation board (20-mil thick RO4350). Matching is provided using a combination of lumped elements and transmission lines as shown in the simplified schematic above. Recommended tuning solution component placement, transmission lines, and details are shown on the next page.

## Bias Sequencing

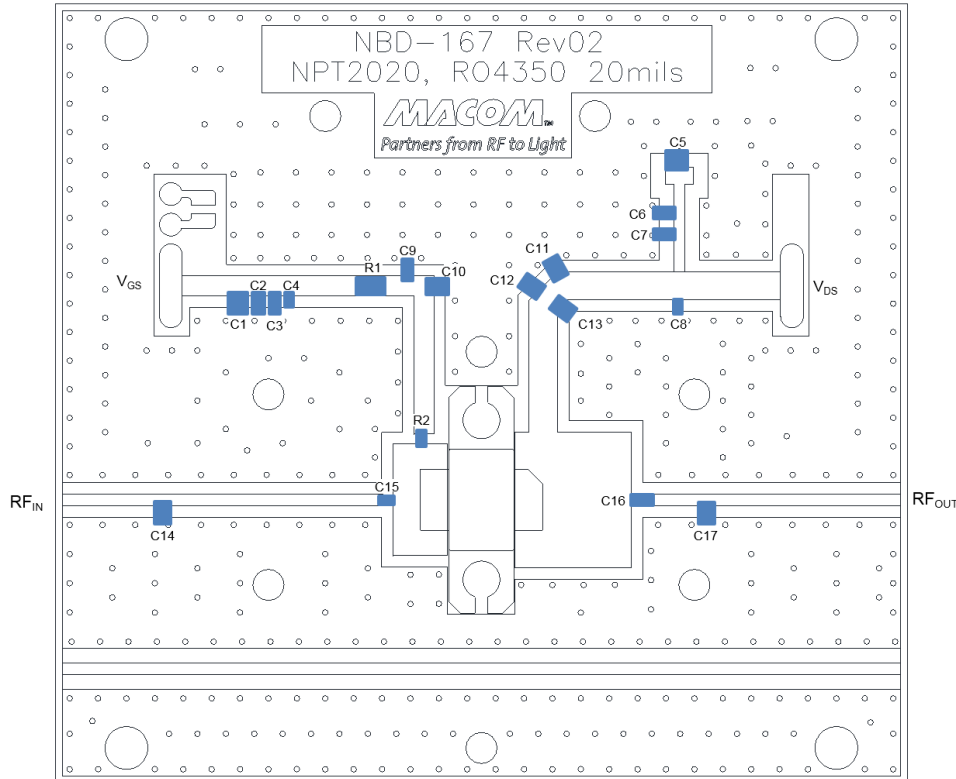
### Turning the device ON

1. Set  $V_{GS}$  to the pinch-off ( $V_P$ ), typically -5 V.
2. Turn on  $V_{DS}$  to nominal voltage (48 V).
3. Increase  $V_{GS}$  until the  $I_{DS}$  current is reached.
4. Apply RF power to desired level.

### Turning the device OFF

1. Turn the RF power off.
2. Decrease  $V_{GS}$  down to  $V_P$ .
3. Decrease  $V_{DS}$  down to 0 V.
4. Turn off  $V_{GS}$ .

## Evaluation Board and Recommended Tuning Solution 3.5 GHz Narrowband Circuit

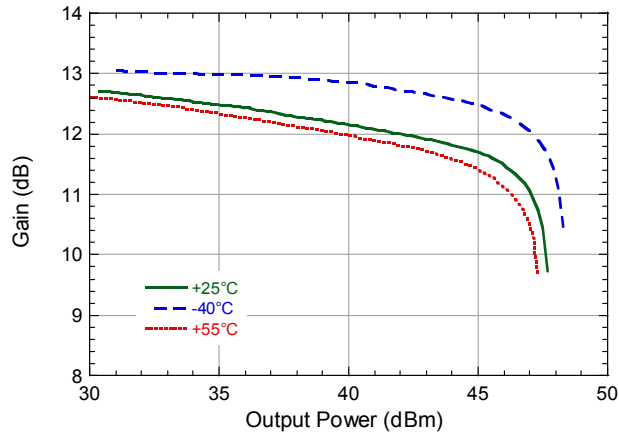


### Parts list

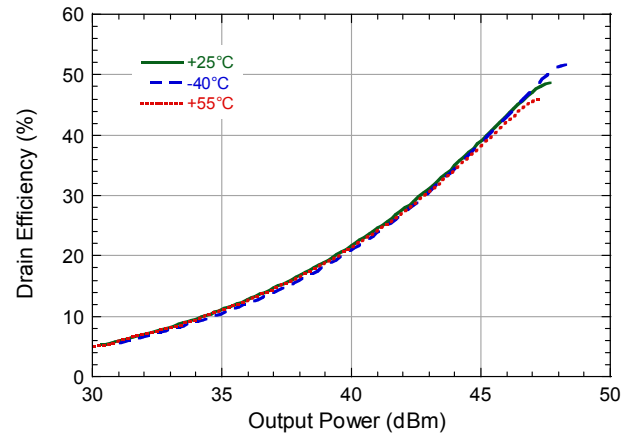
| Reference | Value                                      | Tolerance  | Manufacturer | Part Number      |
|-----------|--|------------|--------------|------------------|
| C1, C5    | 1 $\mu$ F                                  | 10%        | AVX          | 1210C105KAT2A    |
| C2, C6    | 0.1 $\mu$ F                                | 10%        | Kemet        | C1206C104K1RACTU |
| C3, C7    | 0.01 $\mu$ F                               | 10%        | AVX          | 12061C103KAT2A   |
| C4, C8    | 1000 pF                                    | 10%        | Kemet        | C0805C102K1RACTU |
| C9        | 10 pF                                      | 5%         | ATC          | ATC800B100JT500X |
| C10       | 12 pF                                      | 5%         | ATC          | ATC800B120JT500X |
| C11       | 4.7 pF                                     | +/- 0.1 pF | ATC          | ATC800B4R7BT500X |
| C12, C13  | 6.8 pF                                     | +/- 0.1 pF | ATC          | ATC800B6R8BT500X |
| C14       | 0.7 pF                                     | +/- 0.1 pF | ATC          | ATC800B0R7BT500X |
| C15       | 10 pF                                      | 5%         | ATC          | ATC800A100JT250X |
| C16       | 3.3 pF                                     | +/- 0.1 pF | ATC          | ATC800B3R3BT500X |
| C17       | 0.6 pF                                     | +/- 0.1 pF | ATC          | ATC800B0R6BT500X |
| R1        | 24.9 $\Omega$                              | 1%         | Panasonic    | ERJ-6GEY24R9V    |
| R2        | 0 $\Omega$                                 | 1%         | Panasonic    | ERJ-6ENF00R0V    |
| PCB       | Rogers RO4350, $\epsilon_r = 3.5$ , 20 mil |            |              |                  |

**Typical Performance as Measured in the 3.5 GHz Evaluation Board:  
CW,  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 350\text{ mA}$  (unless noted)**

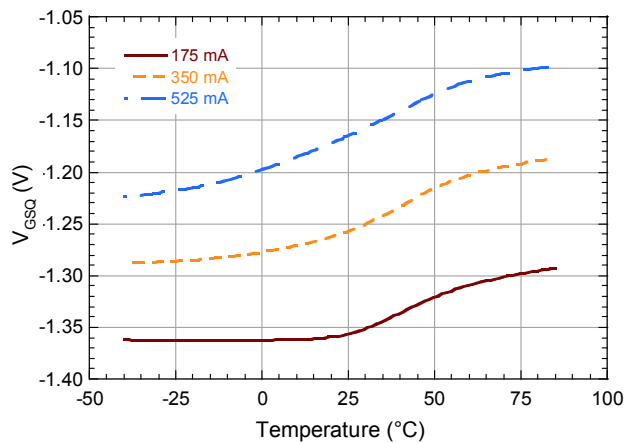
**Gain vs. Output Power over Temperature**



**Drain Efficiency vs. Output Power over Temperature**

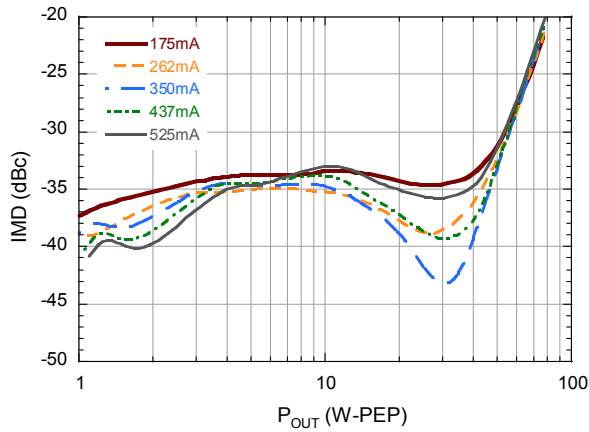


**Quiescent  $V_{GS}$  vs. Temperature**

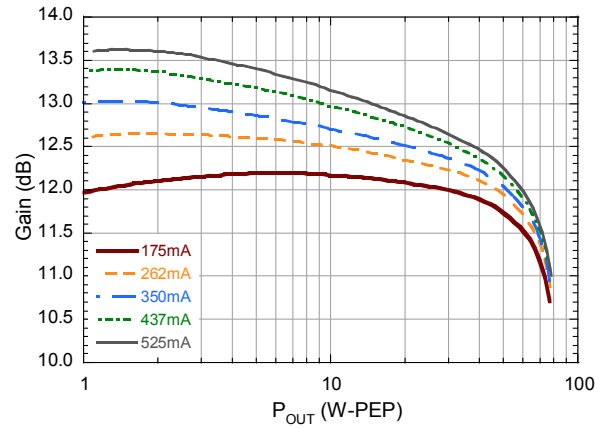


**Typical 2-Tone Performance as measured in the 3.5 GHz evaluation board:**  
**1 MHz Tone Spacing,  $V_{DS} = 48\text{ V}$ ,  $I_{DQ} = 350\text{ mA}$ ,  $T_C = 25\text{ }^\circ\text{C}$  (unless noted)**

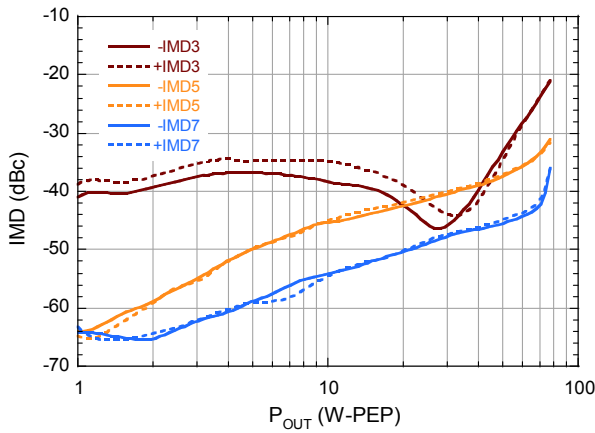
**2-Tone IMD3 vs. Output Power vs. Quiescent Current**



**2-Tone Gain vs. Output Power vs. Quiescent Current**

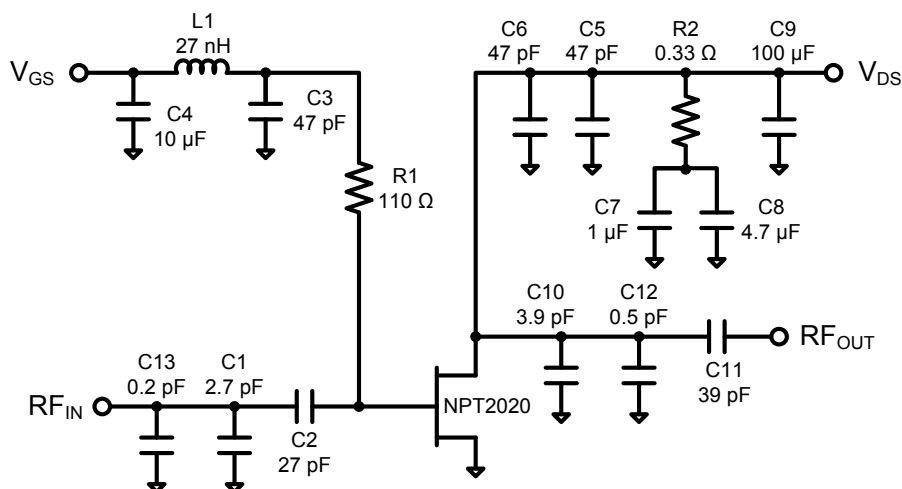


**2-Tone IMD vs. Output Power**





## Evaluation Board and Recommended Tuning Solution 1250-1850 MHz Broadband Circuit



### Description

Parts measured on evaluation board (25-mil thick 6010LM). Matching is provided using a combination of lumped elements and transmission lines as shown in the simplified schematic above. Recommended tuning solution component placement, transmission lines, and details are shown on the next page.

### Bias Sequencing

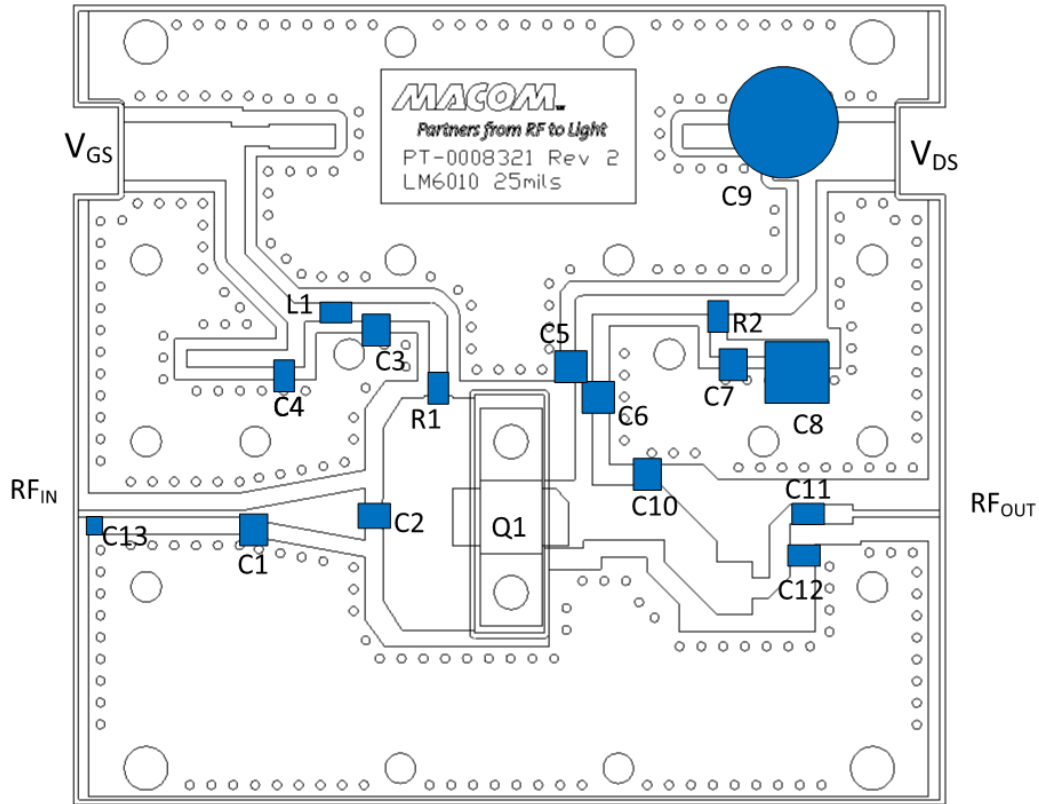
#### Turning the device ON

1. Set  $V_{GS}$  to the pinch-off ( $V_P$ ), typically -5 V.
2. Turn on  $V_{DS}$  to nominal voltage (48 V).
3. Increase  $V_{GS}$  until the  $I_{DS}$  current is reached.
4. Apply RF power to desired level.

#### Turning the device OFF

1. Turn the RF power off.
2. Decrease  $V_{GS}$  down to  $V_P$ .
3. Decrease  $V_{DS}$  down to 0 V.
4. Turn off  $V_{GS}$ .

## Evaluation Board and Recommended Tuning Solution 1250-1850 MHz Broadband Circuit

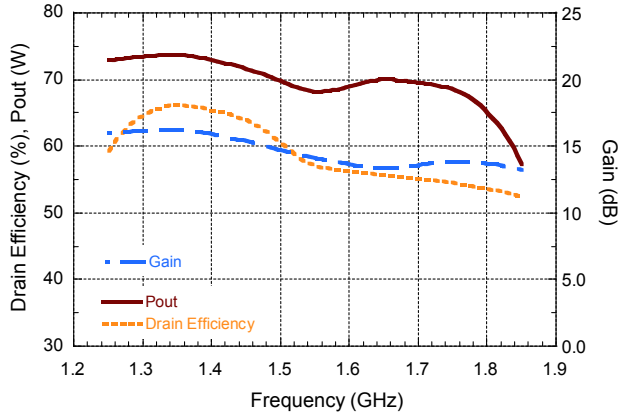


### Parts list

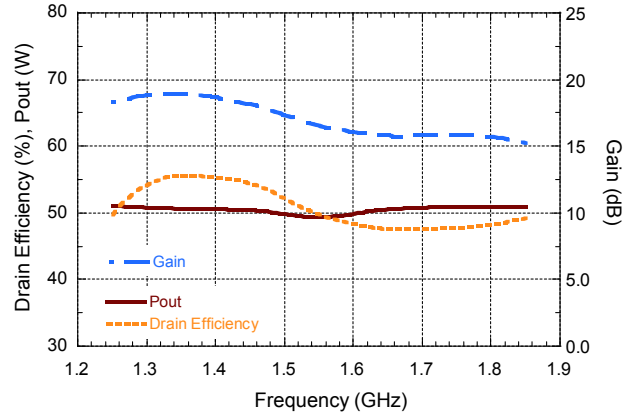
| Reference  | Value                                       | Tolerance | Vendor    | Part Number         |
|------------|---|-----------|-----------|---------------------|
| C1         | 2.7 pF                                      | +/- 0.1pF | ATC       | ATC800B2R7BT500X    |
| C2         | 27 pF                                       | 5%        | ATC       | ATC800B270JT500X    |
| C3, C5, C6 | 47pF  | 5%        | ATC       | ATC800B470JT500X    |
| C4         | 10uF-16V                                    | 5%        | Digikey   | C2012X5R1C106M085AC |
| C7         | 1.0uF-100V                                  | 5%        | Digikey   | C12101C105KAT2A     |
| C8         | 4.7uF                                       | 5%        | Digikey   | C5750X7R2A475K230KA |
| C9         | 100uF-63V                                   | 5%        | Panasonic | ECE-V1JA101P        |
| C10        | 3.9pF                                       | +/- 0.1pF | ATC       | ATC800B3R9BT500X    |
| C11        | 39pF  | 5%        | ATC       | ATC800B390JT500X    |
| C12        | 0.5pF                                       | +/- 0.1pF | ATC       | ATC800B0R5BT500X    |
| C13        | 0.2pF                                       | +/- 0.1pF | ATC       | ATC800A0R2BT250X    |
| L1         | 27nH  | 5%        | Coilcraft | 0908SQ-27N          |
| R1         | 110 Ohms                                    | 5%        | Digikey   | CR1206-JW-1100ELF   |
| R2         | 0.33 Ohms                                   | 5%        | Digikey   | ERJ-6RQFR33V        |
| PCB        | Rogers 6010LM, $\epsilon_r = 10.2$ , 25 mil |           |           |                     |

**Typical Performance as Measured in the 1250-1850 MHz Evaluation Board:  
CW, VDS = 48 V, IDQ = 350 mA, TA = 25 °C (unless noted)**

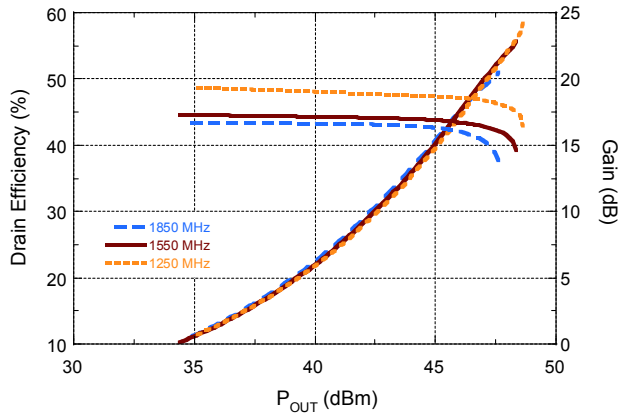
**Gain & Drain Efficiency vs. Frequency (Max Power)**



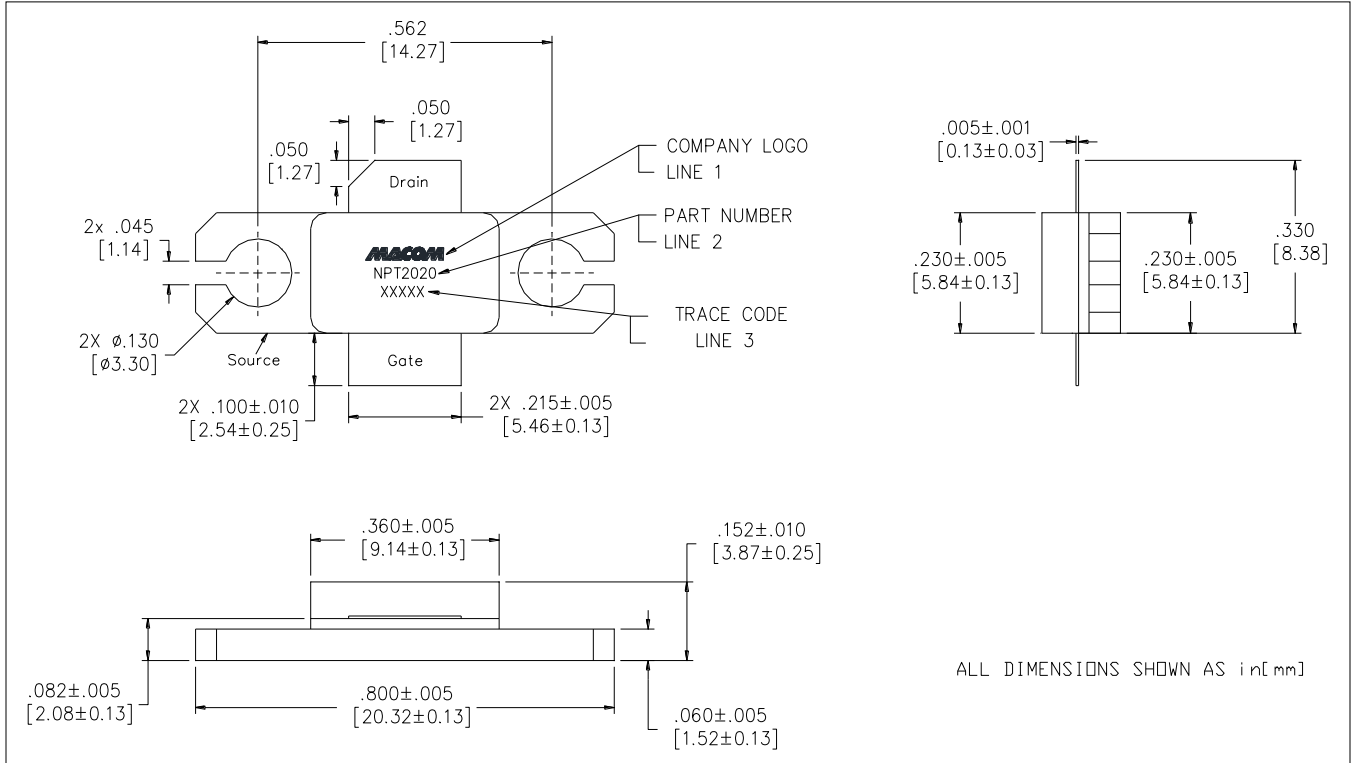
**Gain & Drain Efficiency vs. Frequency (P<sub>OUT</sub> = 50 W)**



**Gain & Drain Efficiency vs. P<sub>OUT</sub>**



## AC360B-2 Metal-Ceramic Package<sup>†</sup>



<sup>†</sup> Meets JEDEC moisture sensitivity level 1 requirements.  
Plating is Ni / Au.

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