

## Features

- GaN on SiC D-Mode Transistor Technology
- Common-Source Configuration
- Unmatched, Coupled DC and RF
- Ideal for Pulsed and CW Applications up to 50 V
- 50 V Typical Bias, Class AB
- Excellent Thermal Resistance
- Thermally-Enhanced Plastic SOT-89 Package
- MTTF = 600 years ( $T_J < 200^\circ\text{C}$ )
- Halogen-Free “Green” Mold Compound
- RoHS\* Compliant and  $260^\circ\text{C}$  Reflow Compatible
- MSL1

## Description

The MAGX-000040-00500P is a GaN on SiC unmatched power device offering the widest RF frequency capability, most reliable high voltage operation, lowest overall transistor size, cost and weight in a “TRUE SMT”™ plastic package.

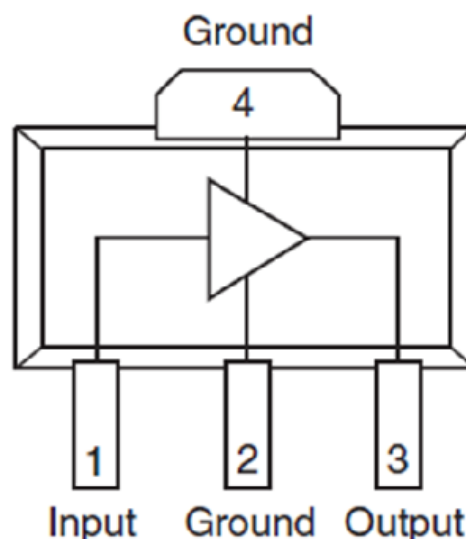
Use of an internal stress buffer technology allows reliable operation at junction temperatures up to  $200^\circ\text{C}$ . The small package size and excellent RF performance make it an ideal replacement for costly flanged or metal-backed module components.

## Ordering Information<sup>1</sup>

Part Number	Package
MAGX-000040-00500P	Bulk Packaging
MAGX-000040-SB2PPR	Sample Board

1. Reference Application Note M513 for reel size information.

## Functional Schematic



## Pin Configuration

Pin No.	Function
1	$V_{GG}/RF_{IN}$
2	GND
3	$V_{DD}/RF_{OUT}$
4	GND

\* Restrictions on Hazardous Substances, European Union Directive 2002/95/EC.

## GaN Wideband 5 W Pulsed Transistor in Plastic Package DC - 4.0 GHz

Rev. V1

### Typical Narrowband RF Performance<sup>2</sup>: $V_{DD} = 50\text{ V}$ , $I_{DQ} = 17\text{ mA}$ , $T_A = 25^\circ\text{C}$

Parameter	1 GHz	1.6 GHz	3.0 GHz	3.5 GHz	Units
Linear Gain	18	17	14	13.5	dB
Pulsed Peak Output Power (P3dB)	5.3	5.3	5.3	5.3	W
Pulsed Power Gain (P3dB)	15	14	11	10.5	dB
Drain Efficiency (P3dB)	61	55	53	50	%

2. Device optimally matched in narrowband load-pull test system.

### Electrical Specifications<sup>3</sup>: Freq. = 1.6 GHz, $V_{DD} = 50\text{ V}$ , $I_{DQ} = 17\text{ mA}$ , $T_A = 25^\circ\text{C}$ , $Z_0 = 50\ \Omega$

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
<b>RF FUNCTIONAL TESTS: Pulse Width = 1 ms, 10% Duty Cycle</b>						
Pulsed Peak Output Power	$P_{IN} = 0.28\text{ W Peak}$	$P_{OUT}$	4.5	5.3	-	Wpk
Pulsed Power Gain	$P_{IN} = 0.28\text{ W Peak}$	$G_P$	12	13	-	dB
Pulsed Drain Efficiency	$P_{IN} = 0.28\text{ W Peak}$	$\eta_D$	47	51.3	-	%
Load Mismatch Stability	$P_{IN} = 0.28\text{ W Peak}$	VSWR-S	-	5:1	-	-
Load Mismatch Tolerance	$P_{IN} = 0.28\text{ W Peak}$	VSWR-T	-	10:1	-	-
<b>RF FUNCTIONAL TESTS: CW</b>						
CW Output Power	P3dB	$P_{OUT}$	-	4	-	W

3. Device measured in MACOM 1.4-1.6 GHz evaluation board. See tuning information on page 4.

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

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
<b>DC CHARACTERISTICS</b>						
Drain-Source Leakage Current	$V_{GS} = -8\text{ V}$ , $V_{DS} = 175\text{ V}$	$I_{DS}$	-	-	200	$\mu\text{A}$
Gate Threshold Voltage	$V_{DS} = 5\text{ V}$ , $I_D = 0.6\text{ mA}$	$V_{GS(TH)}$	-5	-3	-2	V
Forward Transconductance	$V_{DS} = 5\text{ V}$ , $I_D = 1500\text{ mA}$	$G_M$	0.1	-	-	S
<b>DYNAMIC CHARACTERISTICS</b>						
Input Capacitance	$V_{DS} = 0\text{ V}$ , $V_{GS} = -8\text{ V}$ , $F = 1\text{ MHz}$	$C_{ISS}$	-	0.5	-	pF
Output Capacitance	$V_{DS} = 50\text{ V}$ , $V_{GS} = -8\text{ V}$ , $F = 1\text{ MHz}$	$C_{OSS}$	-	0.18	-	pF
Reverse Transfer Capacitance	$V_{DS} = 50\text{ V}$ , $V_{GS} = -8\text{ V}$ , $F = 1\text{ MHz}$	$C_{RSS}$	-	0.05	-	pF

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## Absolute Maximum Ratings <sup>4,5,6,7,8</sup>

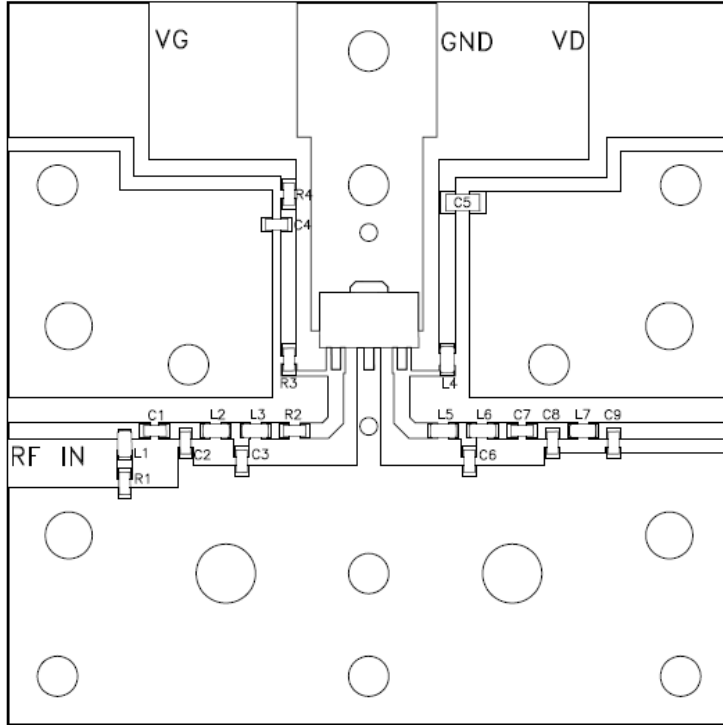
Parameter	Absolute Max.
Input Power	30 dBm
Drain Supply Voltage, $V_{DD}$	+65 V
Gate Supply Voltage, $V_{GG}$	-8 V to 0 V
Supply Current, $I_{DD}$	300 mA
Power Dissipation, CW (85°C)	12 W
Power Dissipation, Pulsed Mode (85°C)	31 W
Junction Temperature <sup>7</sup>	200°C
Operating Temperature	-40°C to +95°C
Storage Temperature	-65°C to +150°C

4. Exceeding any one or combination of these limits may cause permanent damage to this device.
5. MACOM does not recommend sustained operation near these survivability limits.
6. For saturated performance it is recommended that the sum of  $(3 * V_{DD} + \text{abs}(V_{GG})) \leq 175 \text{ V}$ .
7. Operating at nominal conditions with  $T_J \leq 200^\circ\text{C}$  will ensure  $\text{MTTF} > 1 \times 10^6$  hours. Junction temperature directly affects device MTTF and should be kept as low as possible to maximize lifetime.
8. Junction Temperature ( $T_J$ ) =  $T_C + \Theta_{JC} * ((V * I) - (P_{OUT} - P_{IN}))$ .

Typical CW thermal resistance ( $\Theta_{JC}$ ) = 10.5°C/W.

Typical transient thermal resistance ( $\Theta_{JC}$ ) =  $\Theta_{JC} = 4.0^\circ\text{C/W}$  (1 ms pulse, 10% duty cycle).

## L-Band Evaluation Board Details and Recommended Tuning Solutions



Parts measured on evaluation board (12-mil thick RO4003C). Electrical and thermal ground is provided using a copper-filled, via-hole array (not pictured), and evaluation board is mounted to a metal plate.

Matching is provided using lumped elements. Recommended tuning solutions for 2 frequency ranges are detailed in the parts list below.

### Bias Sequencing

#### Turning the device ON

1. Set  $V_G$  to the pinch-off value ( $V_P$ ), typically -5 V.
2. Turn on  $V_D$  to nominal voltage (50 V).
3. Increase  $V_{GS}$  to desired quiescent current.
4. Apply RF power to desired level.

#### Turning the device OFF

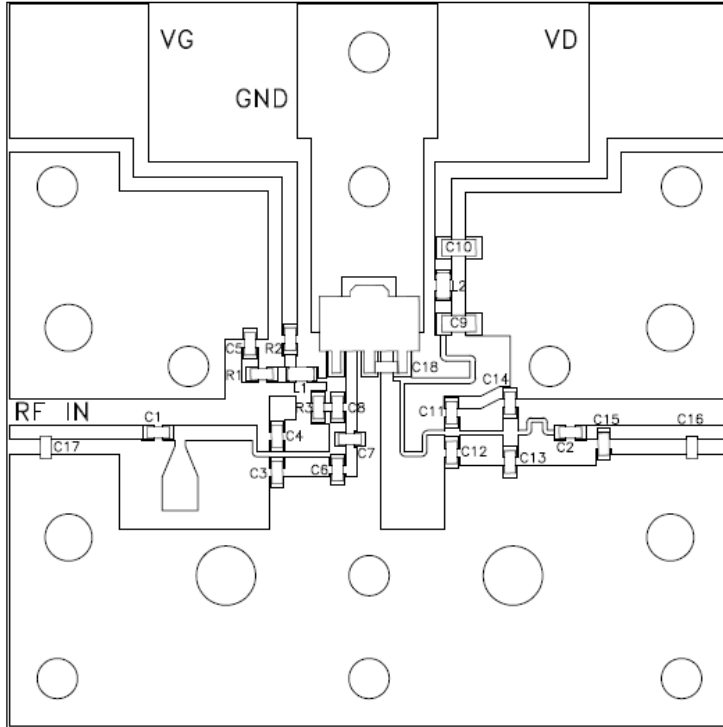
1. Turn the RF power off.
2. Decrease  $V_G$  down to  $V_P$ .
3. Turn off  $V_D$ .
4. Turn off  $V_G$ .

### Parts List

Part	Frequency = 1.0 - 1.2 GHz	Frequency = 1.4 - 1.6 GHz
C1	10 pF, 600L, ATC	10 pF, 600L, ATC
C2	3.9 pF    0.5 pF, 600L, ATC <sup>9</sup>	2.4 pF, 600L, ATC
C3	6.8 pF    1 pF, 600L, ATC <sup>9</sup>	5.6 pF, 600L, ATC
C4	10 nF, 0402, Murata	10 nF, 0402, Murata
C5	10 nF, 0603, Murata	10 nF, 0603, Murata
C6	3.3 pF, 600L, ATC	2.4 pF, 600L, ATC
C7	10 pF, 600L, ATC	10 pF, 600L, ATC
C8	1.3 pF, 600L, ATC	1.3 pF, 600L, ATC
C9	2 pF, 600L, ATC	1.6 pF, 600L, ATC
L1	27 nH, 0402HP, Coilcraft	27 nH, 0402HP, Coilcraft
L2	4.3 nH, 0402HP, Coilcraft	3.3 nH, 0402HP, Coilcraft
L3	3.3 nH, 0402HP, Coilcraft	1 nH, 0402HP, Coilcraft
L4	30 nH, 0402HP, Coilcraft	12 nH, 0402HP, Coilcraft
L5	16 nH, 0402HP, Coilcraft	8.2 nH, 0402HP, Coilcraft
L6	8.2 nH, 0402HP, Coilcraft	3.9 nH, 0402HP, Coilcraft
L7	2.7 nH, 0402HP, Coilcraft	3.3 nH, 0402HP, Coilcraft
R1	49.9 $\Omega$ , 0402, Panasonic	49.9 $\Omega$ , 0402, Panasonic
R2	5.1 $\Omega$ , 0402, Panasonic	5.1 $\Omega$ , 0402, Panasonic
R3	200 $\Omega$ , 0402, Panasonic	200 $\Omega$ , 0402, Panasonic
R4	1 k $\Omega$ , 0402, Panasonic	1 k $\Omega$ , 0402, Panasonic

9. Parallel combination of two capacitors.

## S-Band Evaluation Board Details and Recommended Tuning Solutions



Parts measured on evaluation board (12-mil thick RO4003C). Electrical and thermal ground is provided using a copper-filled, via-hole array (not pictured), and evaluation board is mounted to a metal plate.

Matching is provided using lumped elements. Recommended tuning solution for the 2.9-3.3 GHz frequency band is detailed in the parts list below.

### Bias Sequencing

#### Turning the device ON

1. Set  $V_G$  to the pinch-off value ( $V_P$ ), typically -5 V.
2. Turn on  $V_D$  to nominal voltage (50 V).
3. Increase  $V_{GS}$  to desired quiescent current.
4. Apply RF power to desired level.

#### Turning the device OFF

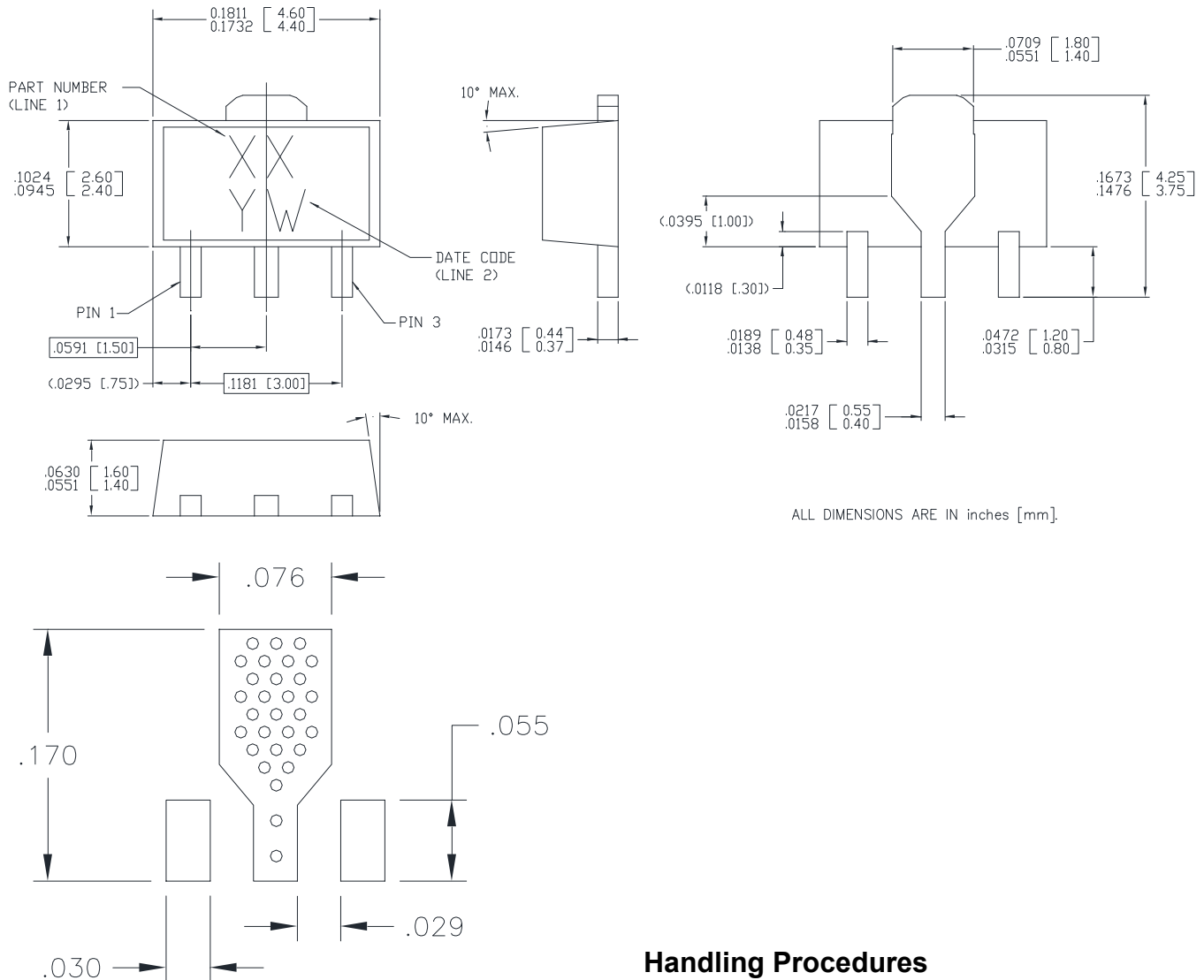
1. Turn the RF power off.
2. Decrease  $V_G$  down to  $V_P$ .
3. Turn off  $V_D$ .
4. Turn off  $V_G$ .

### Parts List, 2.9 - 3.3 GHz

Part	Description
C1	5.6 pF, 600L, ATC
C2	5.6 pF, 600L, ATC
C3	1 pF    0.02 pF, 600L, ATC <sup>10</sup>
C4	1 pF, 600L, ATC
C5	10 nF, 0402, Murata
C6	0.8 pF, 600L, ATC
C7	1.5 pF, 600L, ATC
C8	2.4 pF, 600L, ATC
C9	1 nF, 0603, Murata
C10	10 nF, 0603, Murata
C11	1.1 pF, 600L, ATC
C12	1.5 pF, 600L, ATC
C13	1.6 pF, 600L, ATC
C14	1.3 pF, 600L, ATC
C15	0.6 pF, 600L, ATC
C16	0.2 pF, 600L, ATC
C17	0.6 pF, 600L, ATC
C18	0.3 pF, 600L, ATC
L1	56 nH, 0402HP, Coilcraft
L2	12 nH, 0402HP, Coilcraft
R1	100 $\Omega$ , 0402, Panasonic
R2	1.2 k $\Omega$ , 0402, Panasonic
R3	100 $\Omega$ , 0402, Panasonic

10. Parallel combination of two capacitors.

## SOT-89 Package Outline and Landing Pattern<sup>11,12</sup>



### Handling Procedures

Please observe the following precautions to avoid damage:

### Static Sensitivity

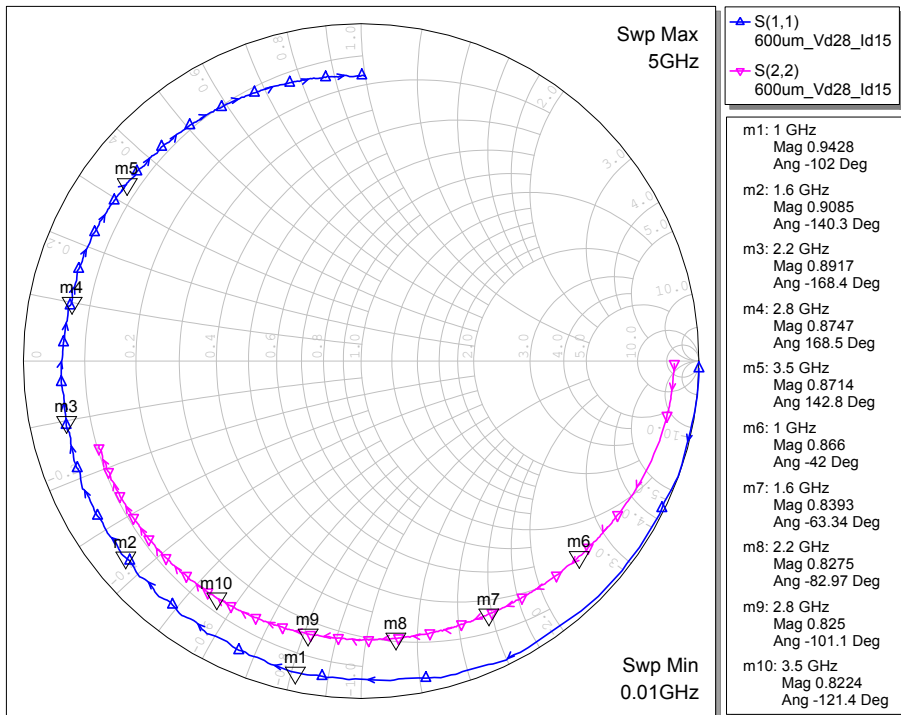
Gallium Nitride Devices and Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these Class 1A devices.

11. Reference Application Note M538 for lead-free solder reflow recommendations. Meets JEDEC moisture sensitivity level 1 requirements. Lead plating is 100% Sn matte.
12. Landing pattern indicates dimensions of solder mask opening. Cu-filled via holes under the ground are typically used for optimal thermal performance. Recommended pattern: 8 mil diameter, 8 mil spacing.

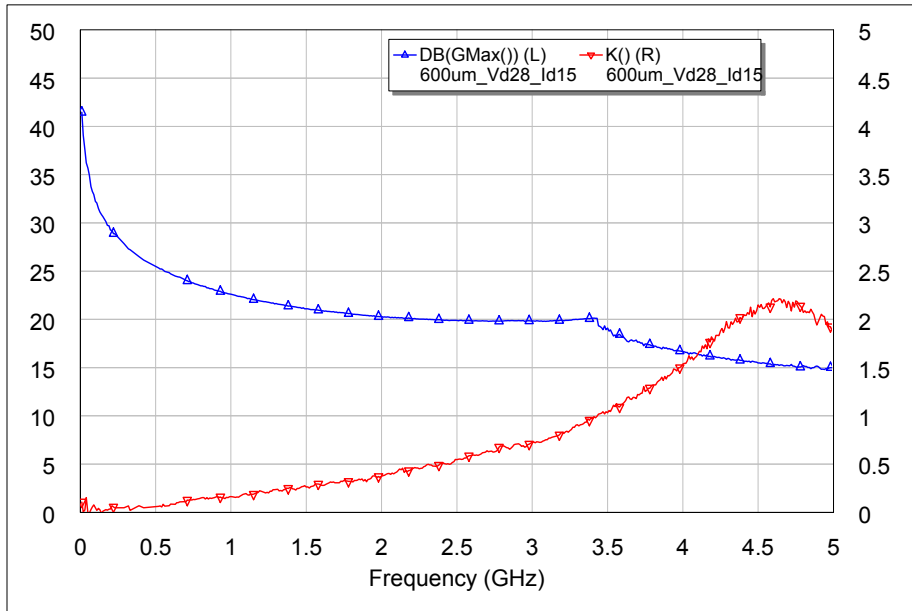
## Applications Section

**S-Parameter Data:  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 28\text{ V}$ ,  $I_{DQ} = 15\text{ mA}$**

**Device S11 and S22**



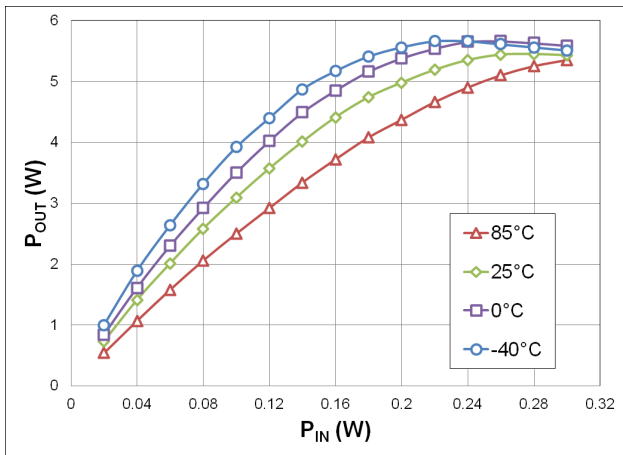
### Gmax and K-Factor vs Frequency



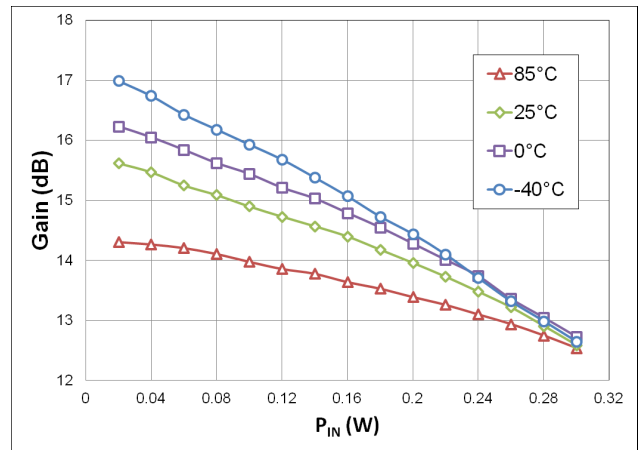
## Applications Section

**Typical Performance Curves (reference 1.4-1.6 GHz parts list):**  
**1.6 GHz, 1 ms Pulse, 10% Duty Cycle,  $V_{DD} = 50\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $Z_0 = 50\ \Omega$**

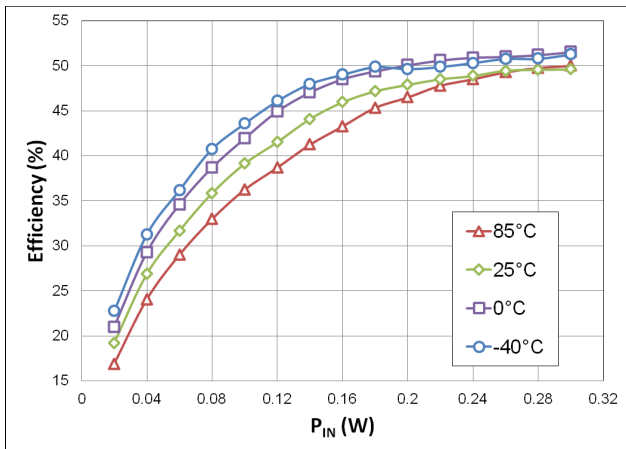
**Output Power vs. Input Power**



**Gain vs. Input Power**



**Drain Efficiency vs. Input Power**



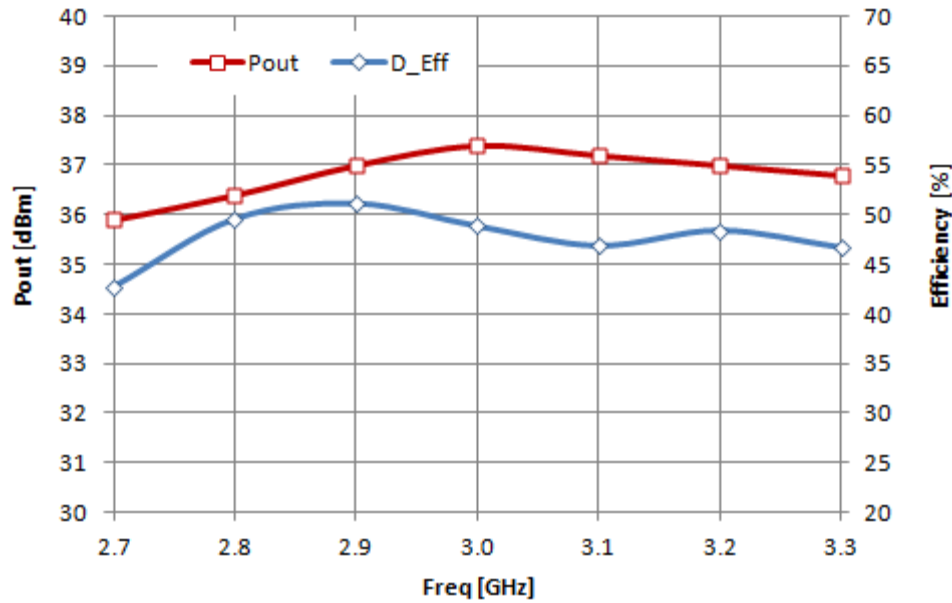


## Applications Section

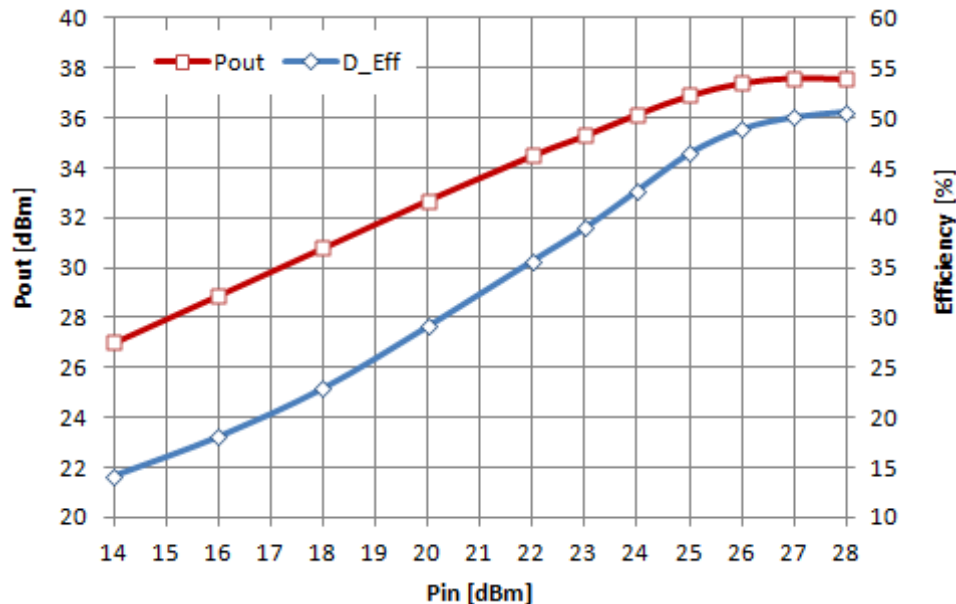
Typical Performance Curves (reference 2.9-3.3 GHz parts list):

300  $\mu$ s Pulse, 10% Duty Cycle,  $V_{DD} = 50$  V,  $T_A = 25^\circ\text{C}$ ,  $Z_0 = 50 \Omega$

Output Power and Efficiency vs. Frequency ( $P_{IN} = 26$  dBm)



Output Power and Efficiency vs. Input Power (Frequency = 3.0 GHz)



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