NPT2020

GaN on Silicon General Purpose Amplifier
DC - 3.5 GHz, 48 V, 50 W

Rev. V3

Features

- GaN on Si HEMT Depletion Mode Amplifier
- Suitable for Linear & Saturated Applications
- Tunable from DC - 3.5 GHz
- 48 V Operation
- 13.5 dB Gain @ 3.5 GHz
- 55% Drain Efficiency @ 3.5 GHz
- 100% RF Tested
- Standard Package with Bolt Down Flange
- RoHS* Compliant and 260°C Reflow Compatible

Description

The NPT2020 is a GaN on silicon HEMT general purpose amplifier 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.

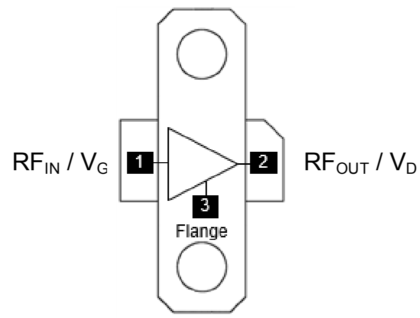
Built using the SIGANTIC® process - a proprietary GaN-on-Silicon technology.

Ordering Information

Part Number	Package
NPT2020	Bulk Quantity
NPT2020-SMBPPR	Custom Sample Board[1]
NPT2020-SMB2	1250 - 1850 MHz Sample Board

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

Functional Schematic



Pin Configuration

Pin #	Pin Name	Function
1	RF_{IN} / V_G	RF Input / Gate
2	RF_{OUT} / V_D	RF Output / Drain
3	Flange[2]	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, compliant to current RoHS EU directive.

RF Electrical Specifications: T_A = 25°C, V_{DS} = 48 V, I_{DQ} = 350 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	η_{SAT}	-	60	-	%
Power Gain	3.5 GHz, P_{OUT} = 50 W	G_P	12	13.5	-	dB
Drain Efficiency	3.5 GHz, P_{OUT} = 50 W	η	50	55	-	%
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 10:1, No Device Damage			

DC Electrical Characteristics: T_A = 25°C

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

Absolute Maximum Ratings[3,4,5]

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 $T_J \leq 200°C$ will ensure MTTF > 1 x 10^6 hours.

Thermal Characteristics[6]

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance	V_{DS} = 48 V, T_J = 200°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

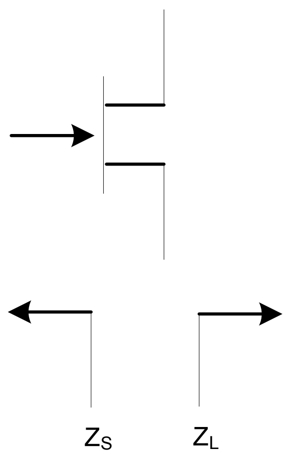
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

Load-Pull Performance: V_{DS} = 48 V, I_{DQ} = 350 mA, T_C = 25 °C

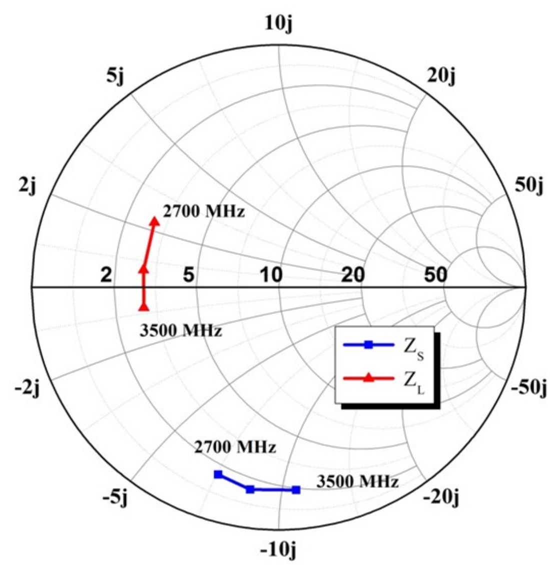
Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance

Frequency (MHz)	Z_S (Ω)	Z_L (Ω)	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

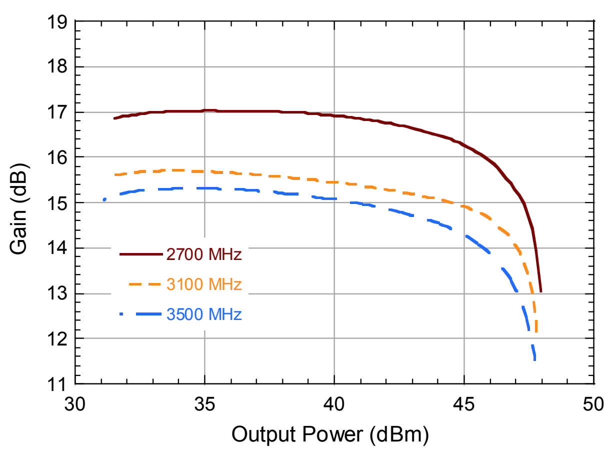
Impedance Reference



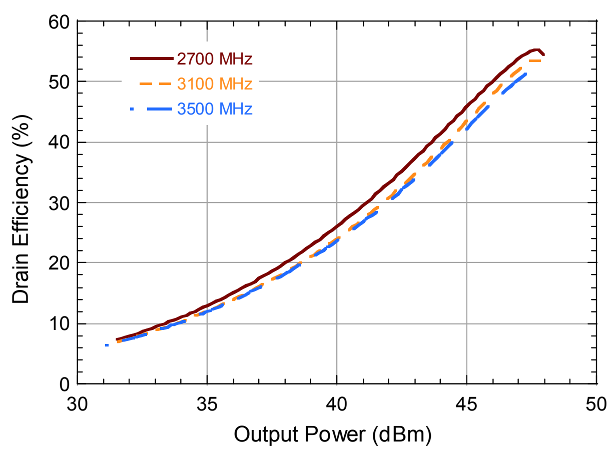
Z_S and Z_L vs. Frequency



Gain vs. Output Power

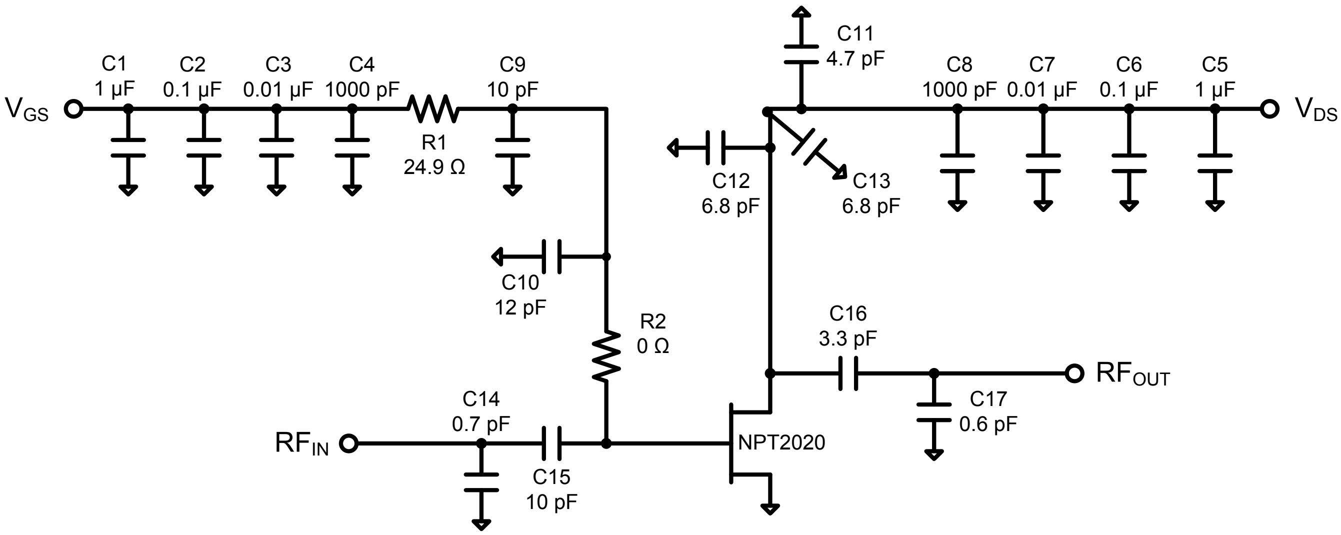


Drain Efficiency vs. Output Power



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

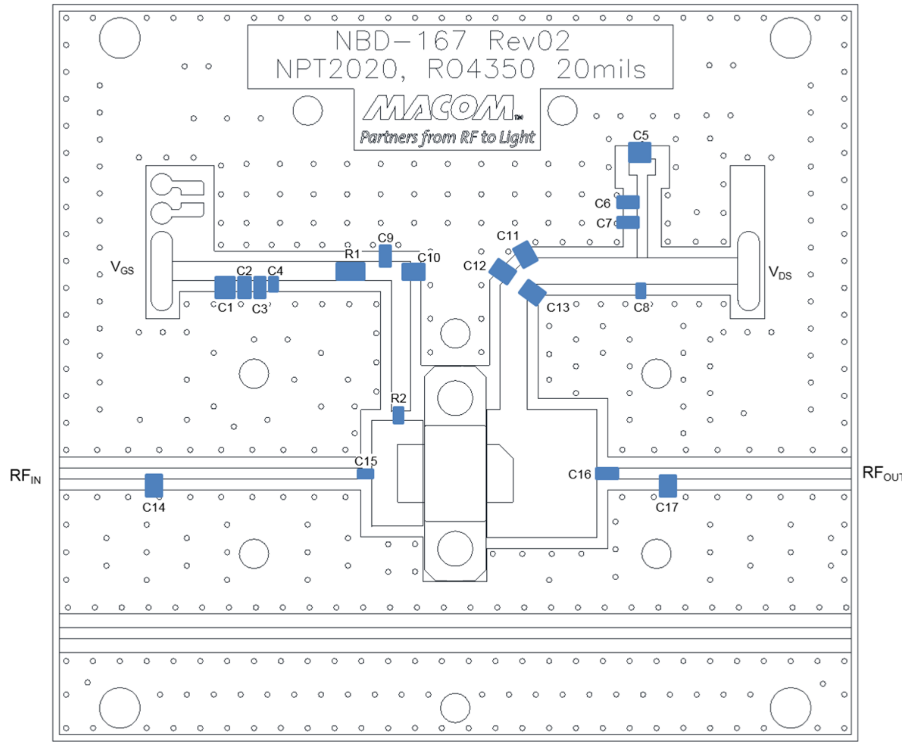
1. Set V_{GS} to the pinch-off (V_P), typically -5 V.
2. Turn on V_{DS} to nominal voltage (48 V).
3. Increase V_{GS} until the I_{DS} current is reached.
4. Apply RF power to desired level.

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

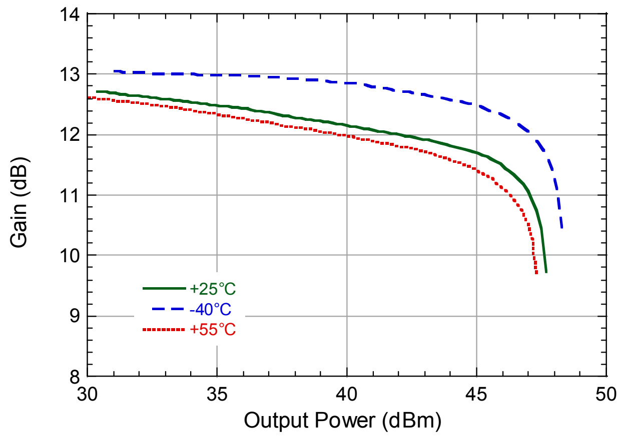


Parts list

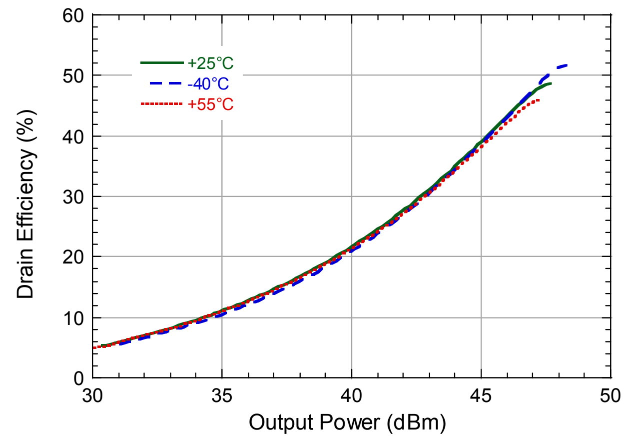
Reference	Value	Tolerance	Manufacturer	Part Number
C1, C5	1 µF	10%	AVX	1210C105KAT2A
C2, C6	0.1 µF	10%	Kemet	C1206C104K1RACTU
C3, C7	0.01 µF	10%	AVX	12061C103KAT2A
C4, C8	1000 pF	10%	Kemet	C0805C102K1RACTU
C9	10 pF	5%	ATC	ATC800B100JT500X
C10	12 pF	5%	ATC	ATC800B120JT500X
C11	4.7 pF	+/- 0.1 pF	ATC	ATC800B4R7BT500X
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 Ω	1%	Panasonic	ERJ-6GEY24R9V
R2	0 Ω	1%	Panasonic	ERJ-6ENF00R0V
PCB	Rogers RO4350, ε_r = 3.5, 20 mil			

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

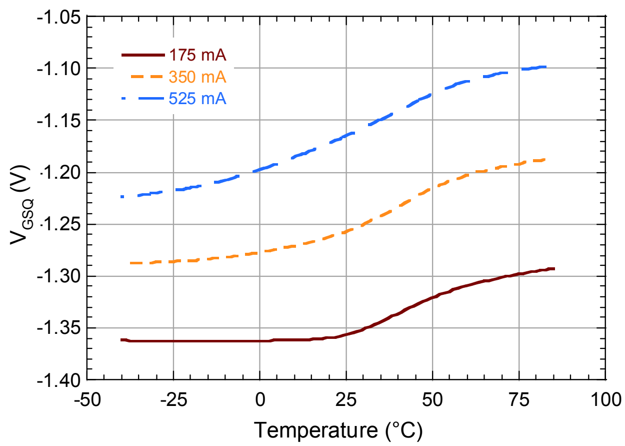
Gain vs. Output Power over Temperature



Drain Efficiency vs. Output Power over Temperature

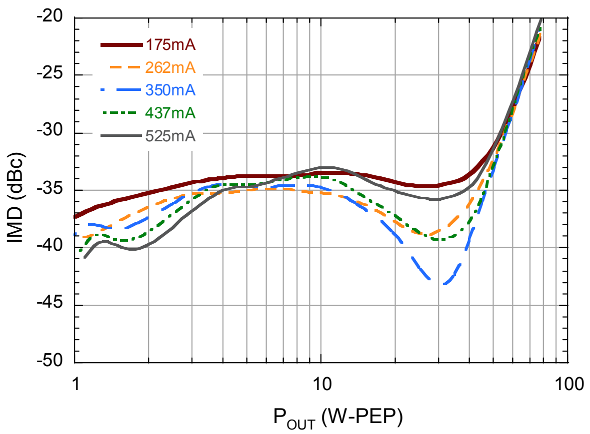


Quiescent V_{GS} vs. Temperature

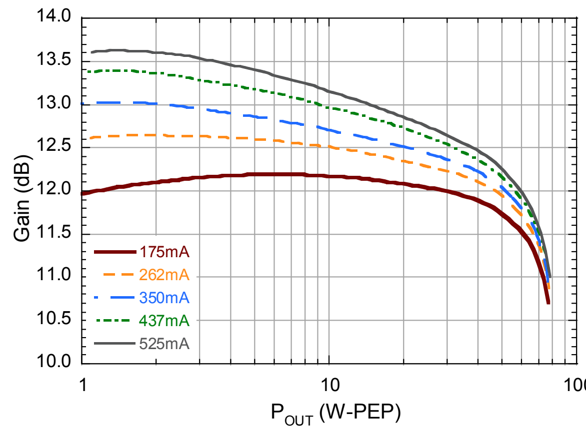


Typical 2-Tone Performance as measured in the 3.5 GHz evaluation board: 1 MHz Tone Spacing, V_{DS} = 48 V, I_{DQ} = 350 mA, T_C = 25°C (unless noted)

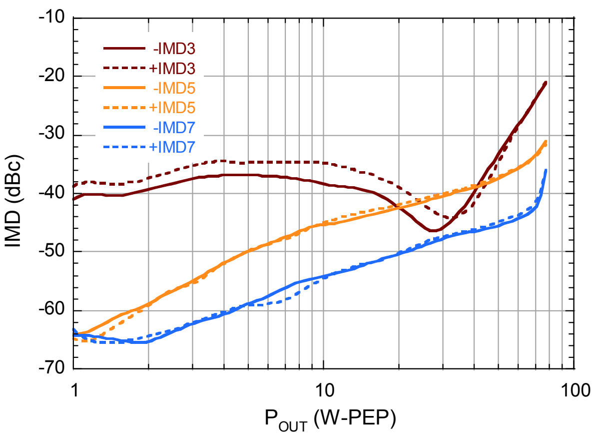
2-Tone IMD3 vs. Output Power vs. Quiescent Current



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

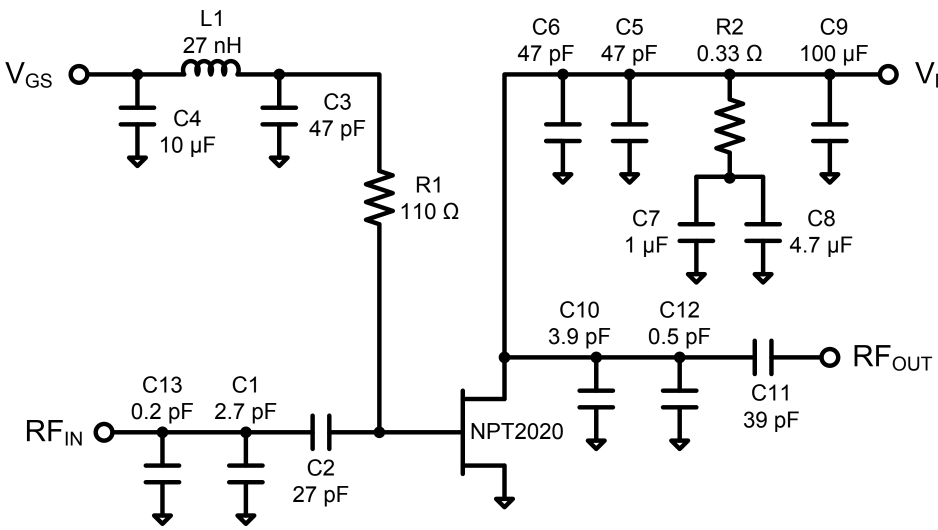


2-Tone IMD vs. Output Power



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

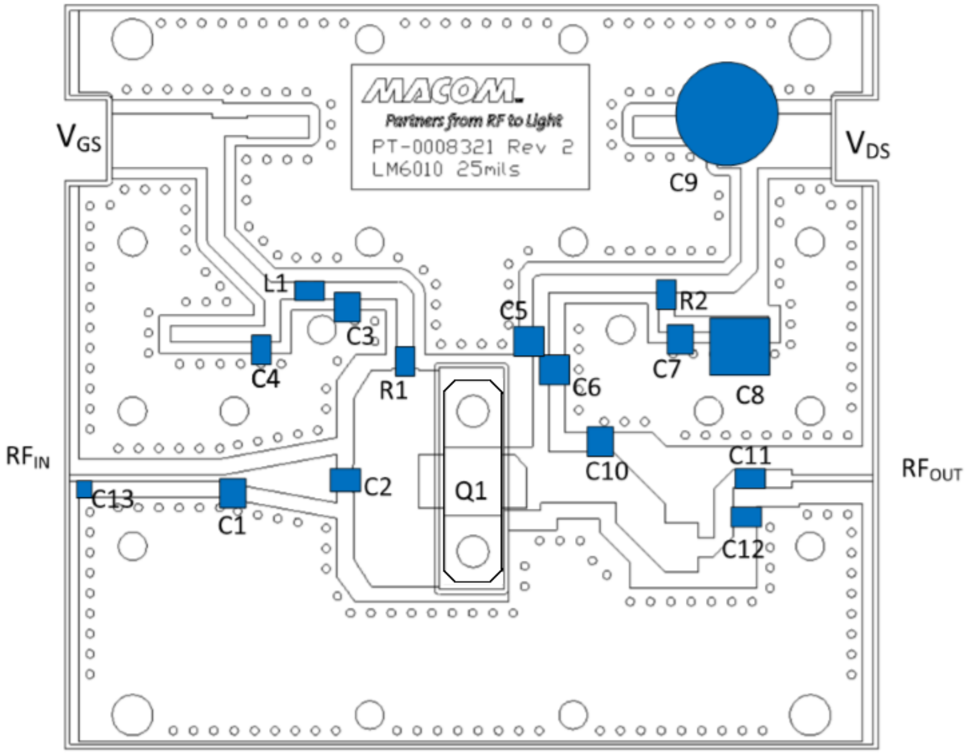
1. Set V_{GS} to the pinch-off (V_P), typically -5 V.
2. Turn on V_{DS} to nominal voltage (48 V).
3. Increase V_{GS} until the I_{DS} current is reached.
4. Apply RF power to desired level.

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

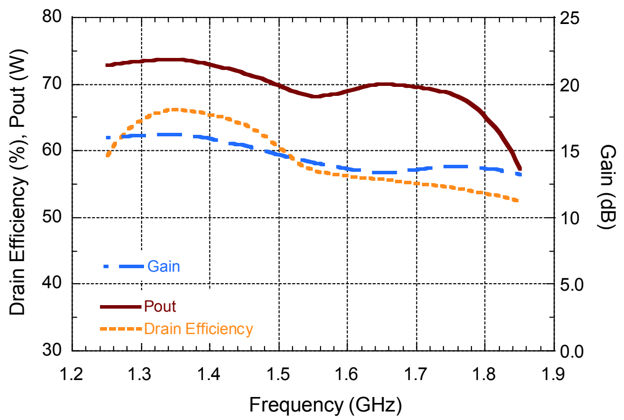


Parts list

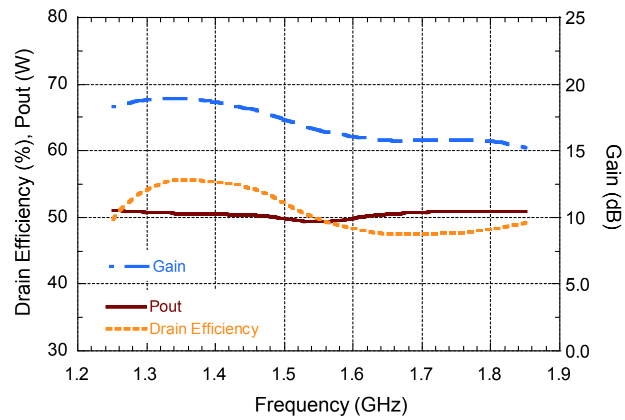
Reference	Value	Tolerance	Vendor	Part Number
C1	2.7 pF	+/- 0.1pF	ATC	ATC800B2R7BT500X
C2	27 pF	5%	ATC	ATC800B270JT500X
C3, C5, C6	47 pF	5%	ATC	ATC800B470JT500X
C4	10 µF, 16 V	5%	Digikey	C2012X5R1C106M085AC
C7	1 µF, 100 V	5%	Digikey	C12101C105KAT2A
C8	4.7 µF	5%	Digikey	C5750X7R2A475K230KA
C9	100 µF, 63 V	5%	Panasonic	ECE-V1JA101P
C10	3.9 pF	+/- 0.1 pF	ATC	ATC800B3R9BT500X
C11	39 pF	5%	ATC	ATC800B390JT500X
C12	0.5 pF	+/- 0.1 pF	ATC	ATC800B0R5BT500X
C13	0.2 pF	+/- 0.1 pF	ATC	ATC800A0R2BT250X
L1	27 nH	5%	Coilcraft	0908SQ-27N
R1	110 Ω	5%	Digikey	CR1206-JW-1100ELF
R2	0.33 Ω	5%	Digikey	ERJ-6RQFR33V
PCB	Rogers 6010LM, ε_r = 10.2, 25 mil			

Typical Performance as Measured in the 1250 - 1850 MHz Evaluation Board: CW, VDS = 48 V, I_{DQ} = 350 mA, T_A = 25°C (unless noted)

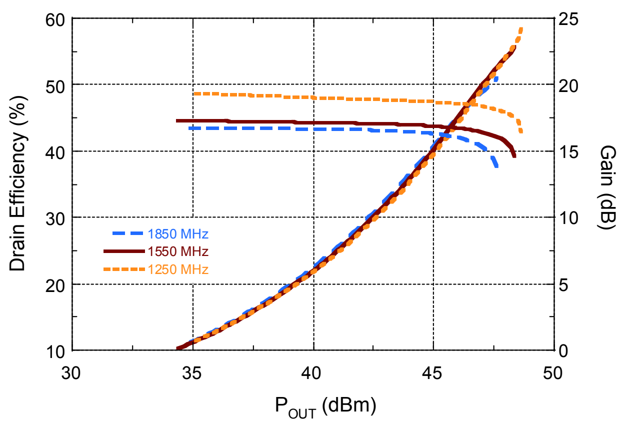
Gain & Drain Efficiency vs. Frequency (Max Power)



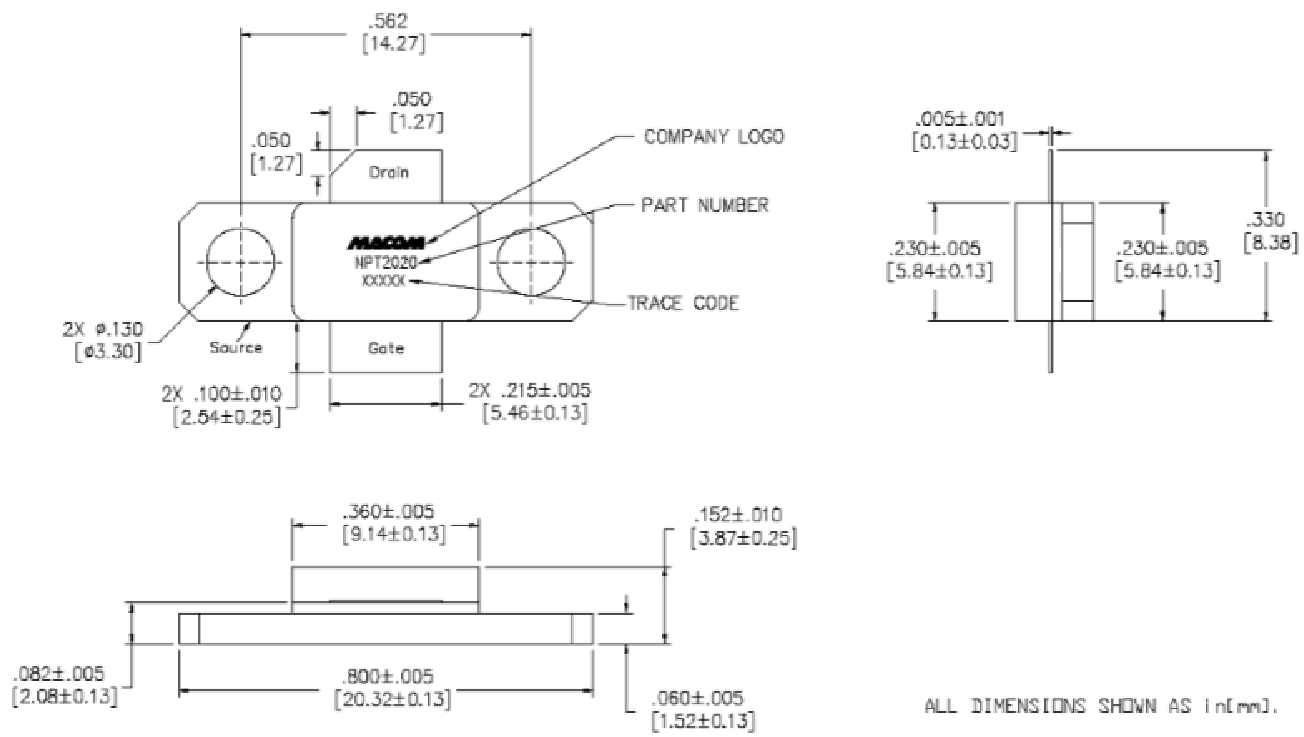
Gain & Drain Efficiency vs. Frequency (P_{OUT} = 50 W)



Gain & Drain Efficiency vs. P_{OUT}



AC360B-2 Metal-Ceramic Package†



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