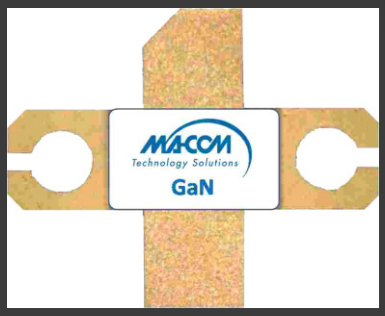
MACOM Technology Solutions

GaN RF Power Products

January 4, 2011

GaN RF Power Products

- M/A COM Technology Solutions is excited to introduce gallium nitride (GaN) RF power transistors. Our initial product offerings target S-Band pulsed applications and leverage M/A COM Tech's 60 year heritage of providing both standard and custom solutions to meet the most demanding customer needs.



- Our GaN on Silicon Carbide (SiC) products utilize a 0.5 micron HEMT process exhibit superior rf performance (power, gain, gain flatness, efficiency, ruggedness) over wide operating bandwidths.

- Additional products targeting applications such as L-Band radar, avionics, EW, MILCOM as well as general purpose devices others will be released in 2011.

Why GaN?

- GaN RF power devices combine the best of two technologies: high power handling and high-voltage operation of silicon LDMOS devices with the high-frequency performance of GaAs
- GaN RF power devices also have improved linearity and efficiency performance when compared to Si LDMOS.

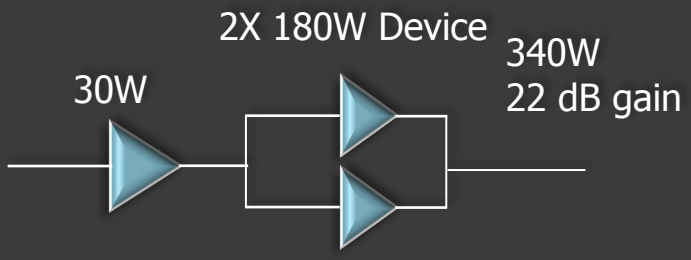
  - High breakdown voltage
  - High power density
  - High RF gain
  - High efficiency
  - High frequency operation
  - Excellent thermal conductivity properties

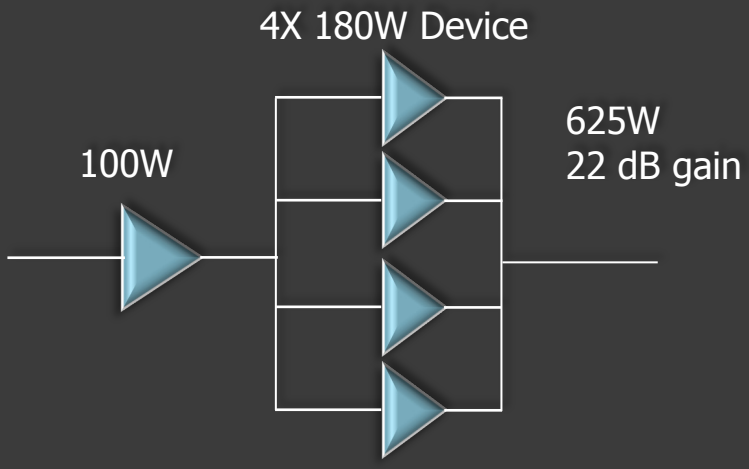
GaN Short Form

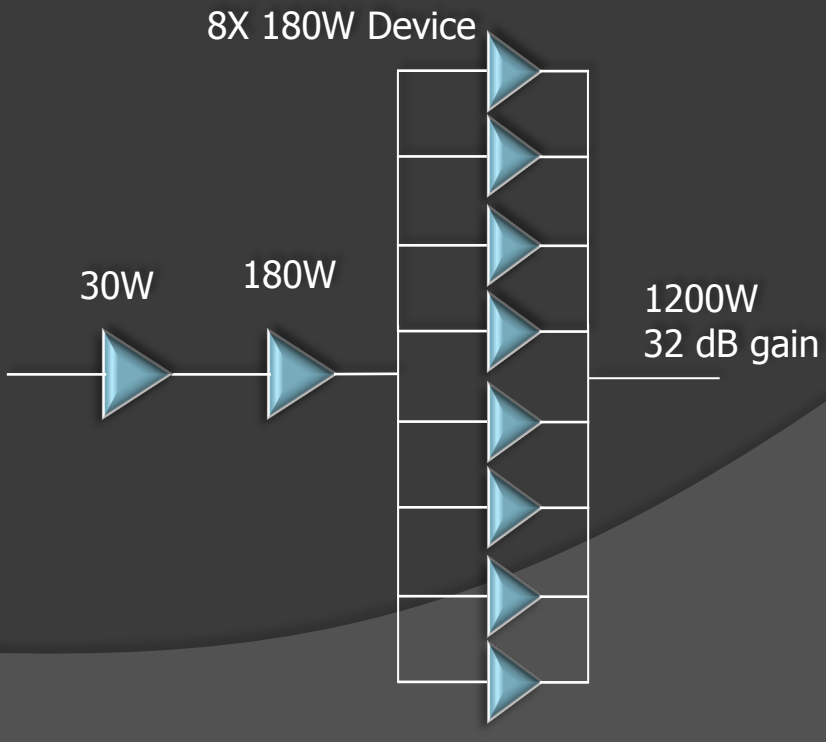
Part Number	Frequency (MHz)	Pout (W)	Pulse/Duty	Type
MAGX-002731-030L00	2700 - 3100	30	500us / 10%	Transistor
MAGX-002731-100L00	2700 - 3100	100	500us / 10%	Transistor
MAGX-002731-180L00	2700 - 3100	180	500us / 10%	Transistor
MAGX-003135-030L00	3100 - 3500	30	500us / 10%	Transistor
MAGX-003135-090L00	3100 - 3500	90	300us / 10%	Transistor
MAGX-003135-150L00	3100 - 3500	150	300us / 10%	Transistor
MAGX-001220-100L00	1200 - 2000	100	500us / 10%	Transistor

Part Number	Frequency (MHz)	Pout (W)	Pulse/Duty	Type
MAPG-002731-030L00	2700 - 3100	30	500us / 10%	Pallet
MAPG-002731-100L00	2700 - 3100	100	500us / 10%	Pallet
MAPG-002731-180L00	2700 - 3100	180	500us / 10%	Pallet
MAPG-003135-030L00	3100 - 3500	30	300us / 10%	Pallet

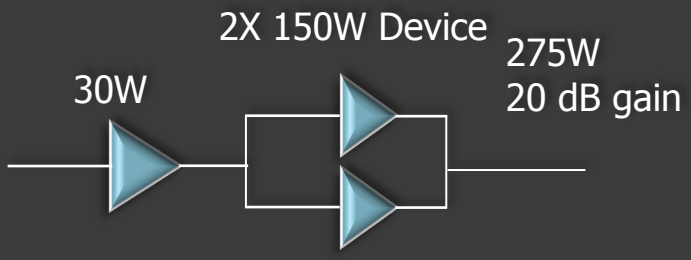
2.7 – 3.1 GHz Line-ups

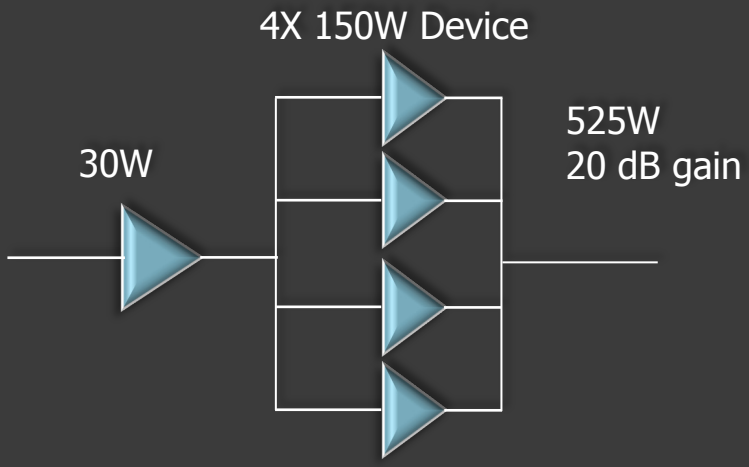


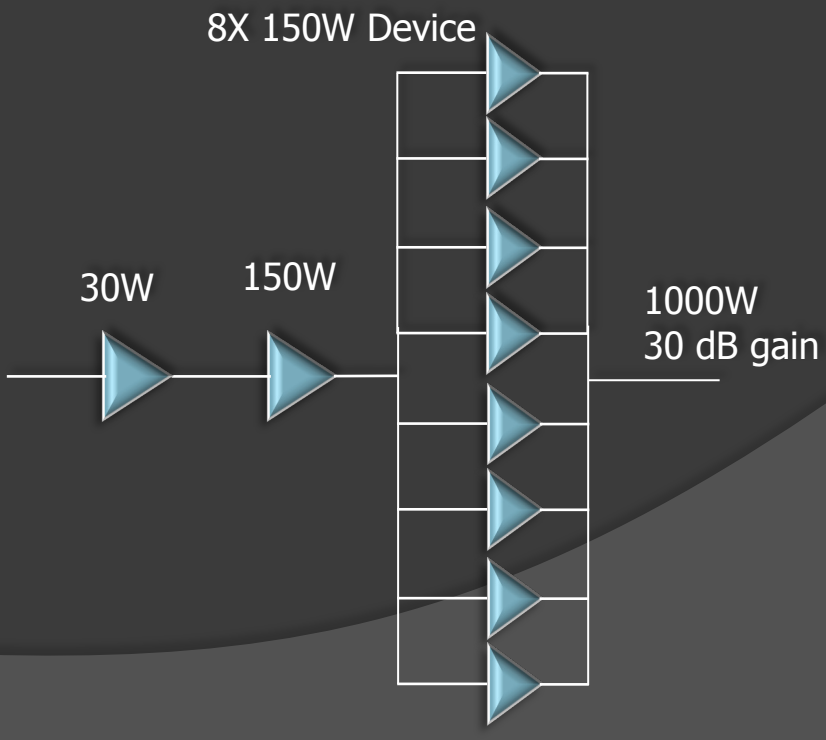




3.1 – 3.5 GHz Line-ups







Upcoming Devices

- Transistors
  - 2.7 – 3.5 GHz, 65V, 30W
  - 2.7 – 3.5 GHz, 65V, 80-100W
  - 2.7 – 3.5 GHz, 65V,150 - 180W
  - 3.1 – 3.5 GHz, 50V, 100W
  - 1.2 – 1.4 GHz, 65V, 250W
  - General Purpose Unmatched Devices
    - 1 – 3.5 GHz
    - 2, 10, 30, 100W
    - 28, 50V, 65V
  - C-Band
- Pallets
  - 2.7 – 3.1 GHz, 50V, 320 - 350W
  - 2.7 – 3.5 GHz, 65V, 320 - 350W
- Modules
  - 30 – 512 MHz, 28V, 70W

MAGX-002731-030L00

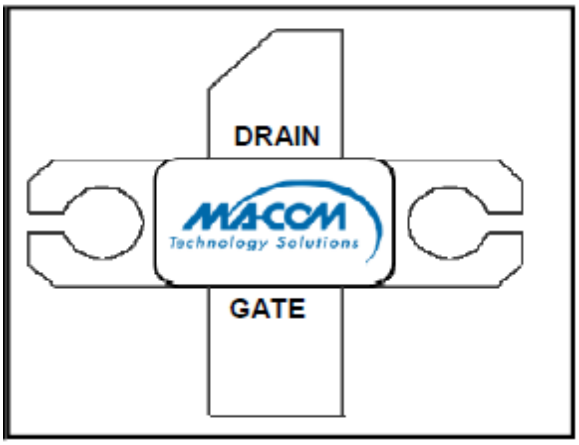
GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 13 Dec 10

Features

- GaN HEMT microwave power transistor
- Common source configuration
- Broadband Class AB operation
- No internal matching
- Thermally enhanced Cu/Mo/Cu package
- RoHS Compliant
- Designed for pulsed or CW applications

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	45	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 250mA, Pout = 30Wpk	$R_{TH(JC)}$	2.0	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	Id-Pk (A)	Eff (%)
2700	3	46	11.8	1.7	56
2900	3	43	11.6	1.6	53
3100	3	41	11.2	1.5	56

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=250mA (pulsed), F=2.7—3.1 GHz, Pulse=500ms, Duty=10%.

- **North America** Tel: 800.366.2266 / Fax: 978.366.2266
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GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

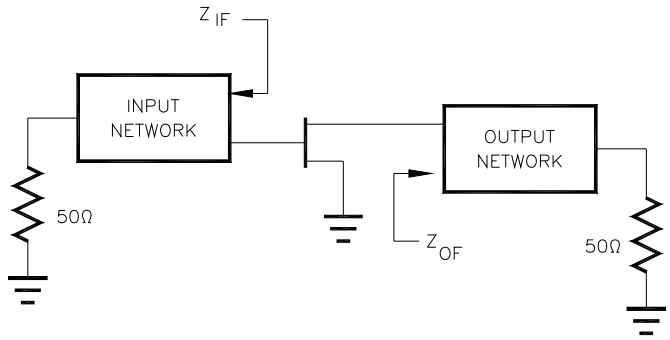
Preliminary, 13 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	300	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	4	5	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	1	3	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 5.0mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 3A	G_M	1	1.4	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	V_{DS} = 0v, V_{GS} = -8V, F = 1MHz	C_{ISS}	-	13.2	15	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	5.6	6.5	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	0.5	1.0	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	P_{OUT}	30	40	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	G_P	10	11.4	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	η_D	50	55	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	VSWR-T	10:1	-	-	-

Test Fixture Impedance

F (MHz)	Z_{IF} (Ω)	Z_{OF} (Ω)
2700	9.2 - j10.7	4.21 - j0.06
2900	7.7 - j7.3	5.58 + j0.07
3100	8.3 - j8.4	4.82 - j0.8



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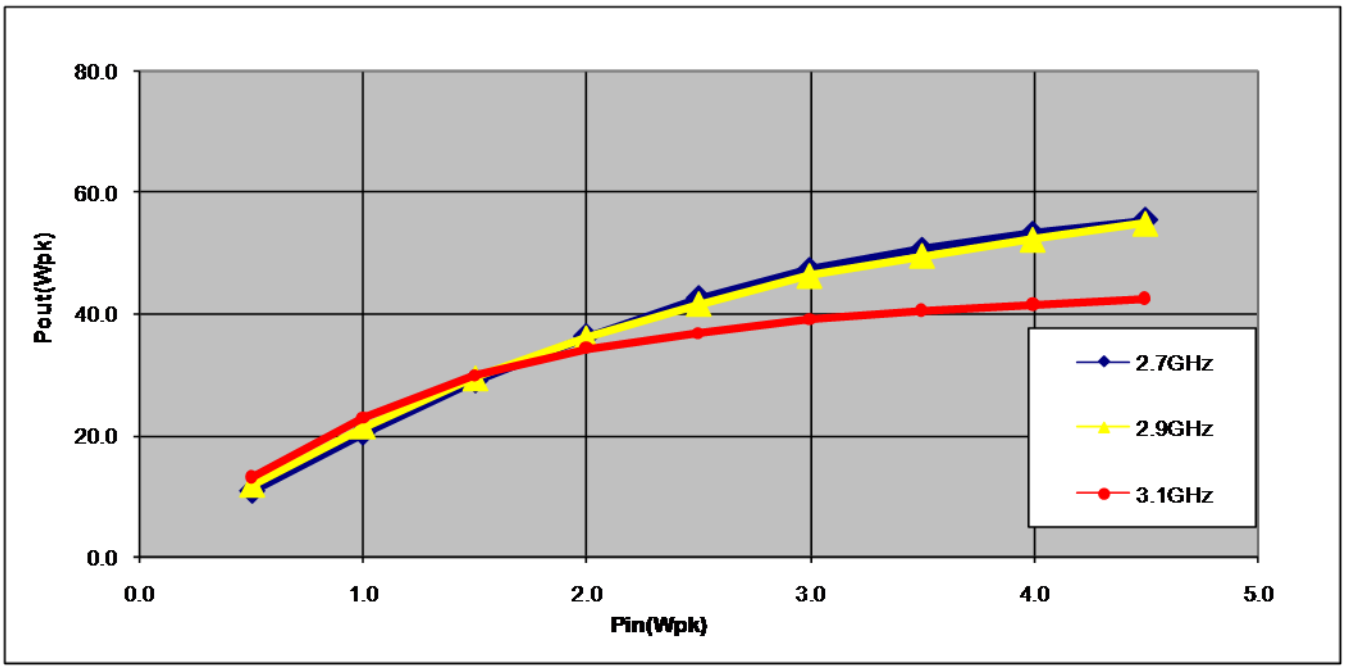
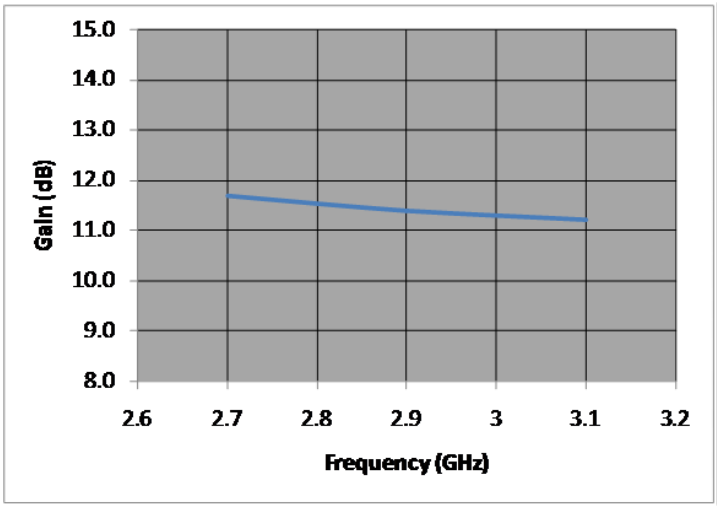
GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 13 Dec 10

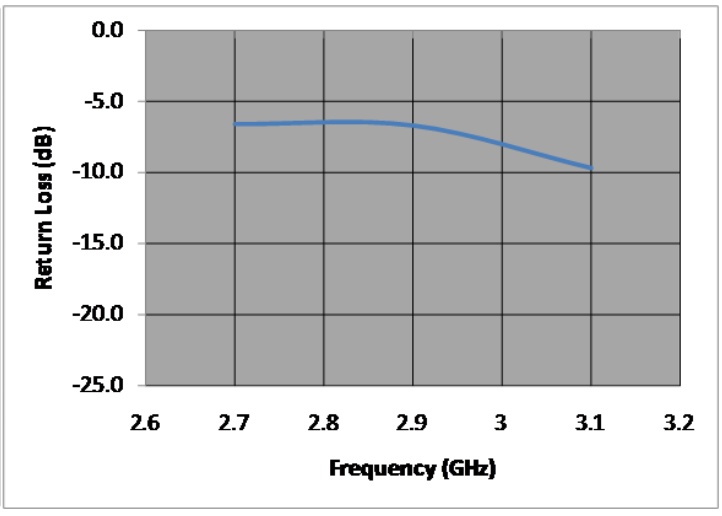
RF Power Transfer Curve at 50V Drain Bias, Idq=0.25A
Output Power vs. Input Power



Gain vs. Frequency
50V Drain Bias, Idq=0.25A



Return Loss vs. Frequency
50V Drain Bias, Idq=0.25A



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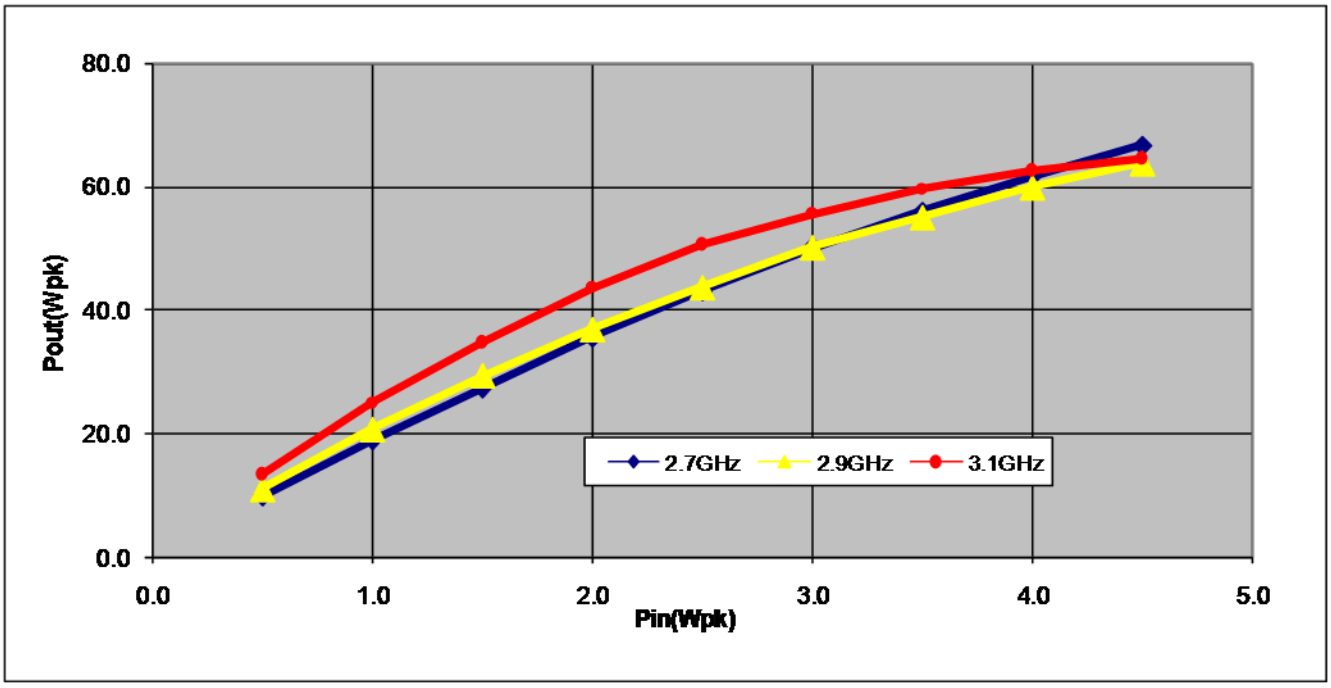
2.7 - 3.1 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 13 Dec 10

RF Power Transfer Curve at 65V Drain Bias, Idq=0.25A
Output Power vs. Input Power



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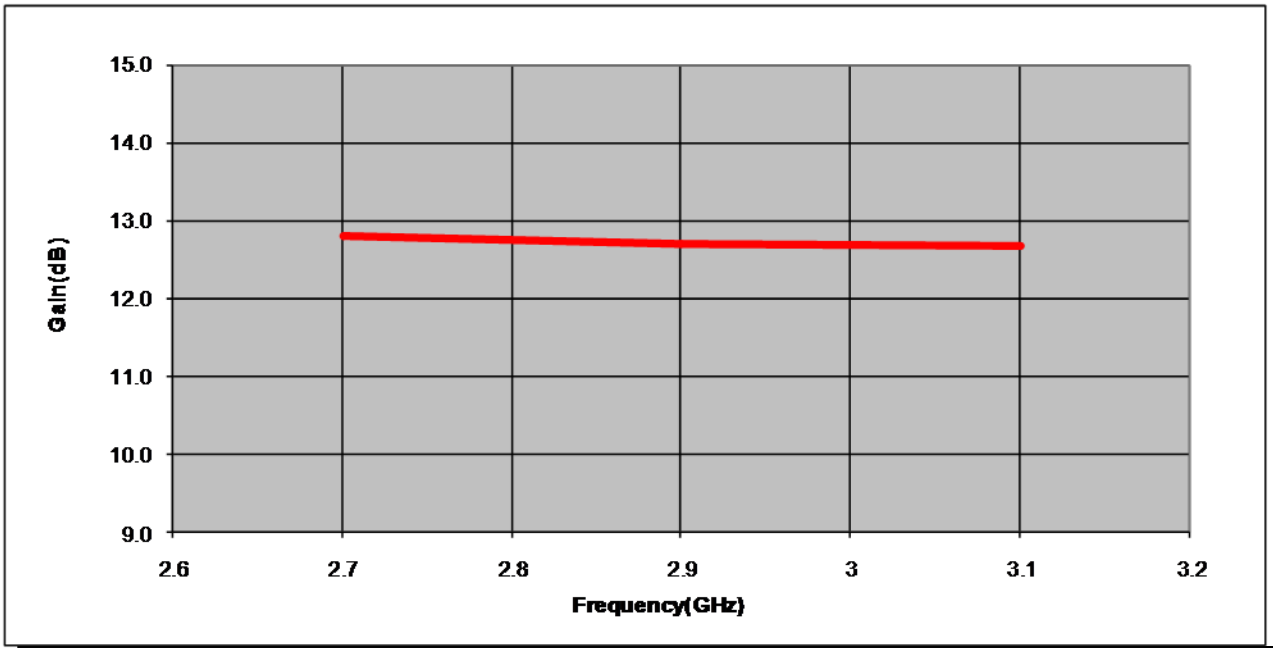

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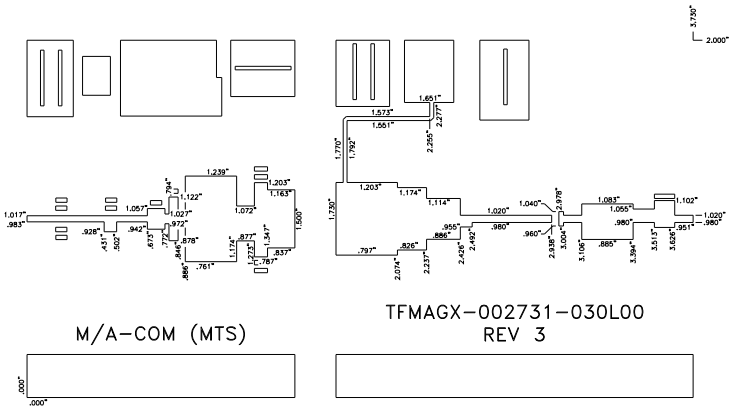
GaN HEMT Pulsed Power Transistor **Preliminary, 13 Dec 10**
2.7 - 3.1 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

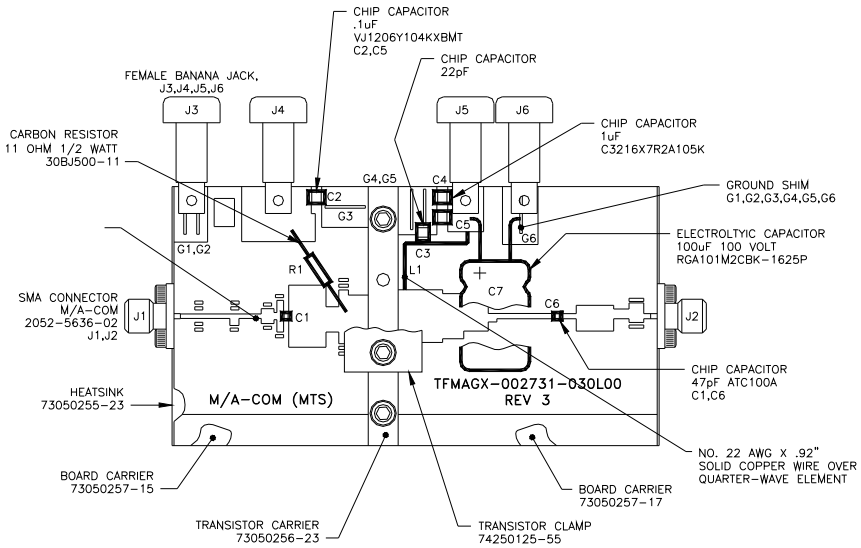
Test Fixture Circuit Dimensions

Note: A dwg circuit drawing is available upon request



CIRCUIT DIMENSIONS SCALE = 1:1

Test Fixture Assembly



ASSEMBLY VIEW

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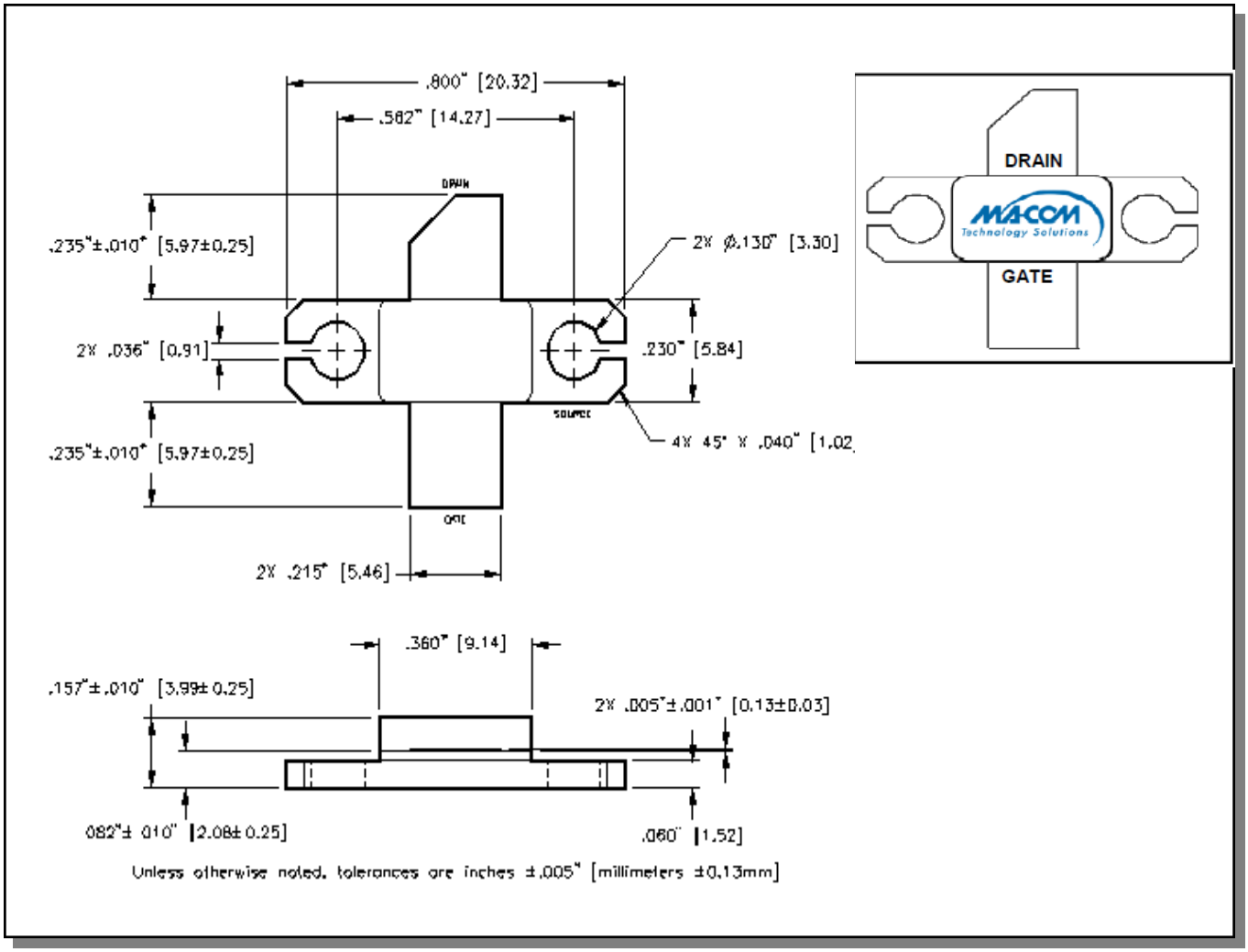
Outline Drawing



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAGX-002731-100L00

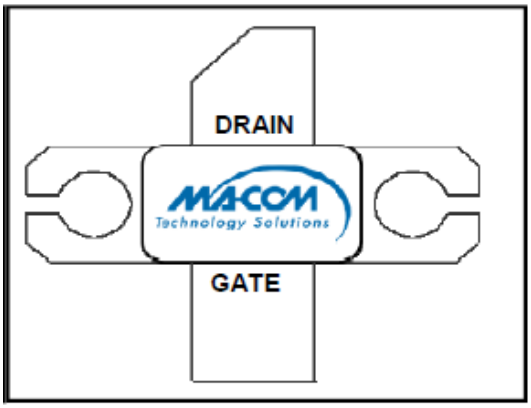
GaN HEMT Pulsed Power Transistor
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 16 Dec 10

Features

- GaN HEMT microwave power transistor
- Common source configuration
- Broadband Class AB operation
- Internally matched
- Thermally enhanced Cu/Mo/Cu package
- RoHS Compliant
- Designed for pulsed and CW applications

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	195	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 100W	$R_{TH(JC)}$	0.9	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	Id-Pk (A)	Eff (%)
2700	6.0	103.7	12.4	3.9	52.7
2800	6.0	108.6	12.6	4.0	54.5
2900	6.0	103.2	12.4	3.9	52.8
3000	6.0	106.7	12.5	4.0	52.7
3100	6.0	101.3	12.3	3.9	52.6

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=500mA (pulsed), F=2.7—3.1 GHz, Pulse=500us, Duty=10%.

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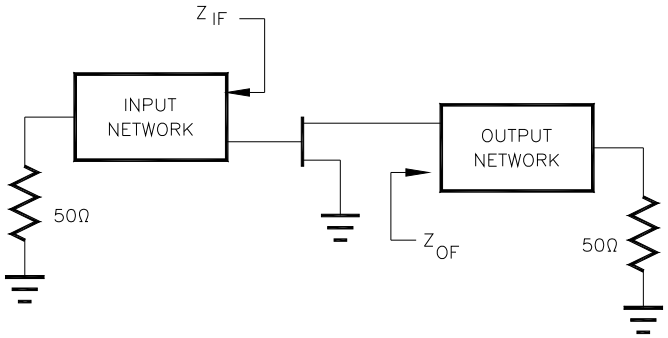
Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	600	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	9.3	11.7	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	2.3	7	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 5.0mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 7A	G_M	0.4	0.6	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable—Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{DS}	-	30.3	35.4	pF
Feedback Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{GD}	-	2.8	5.4	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	P_{OUT}	100	105	-	W
Power Gain	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 100Wpk	G_P	12	12.6	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	η_D	50	53	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-T	10:1	-	-	-

Test Fixture Impedance

F (MHz)	Z_{IF} (Ω)	Z_{OF} (Ω)
2700	3.54 - j7.46	3.43 + j0.399
2800	3.00 - j6.21	4.41 + j0.26
2900	2.66 - j5.26	4.73 - j0.781
3000	2.33 - j4.64	3.77 - j1.79
3100	1.96 - j4.13	2.52-j1.67



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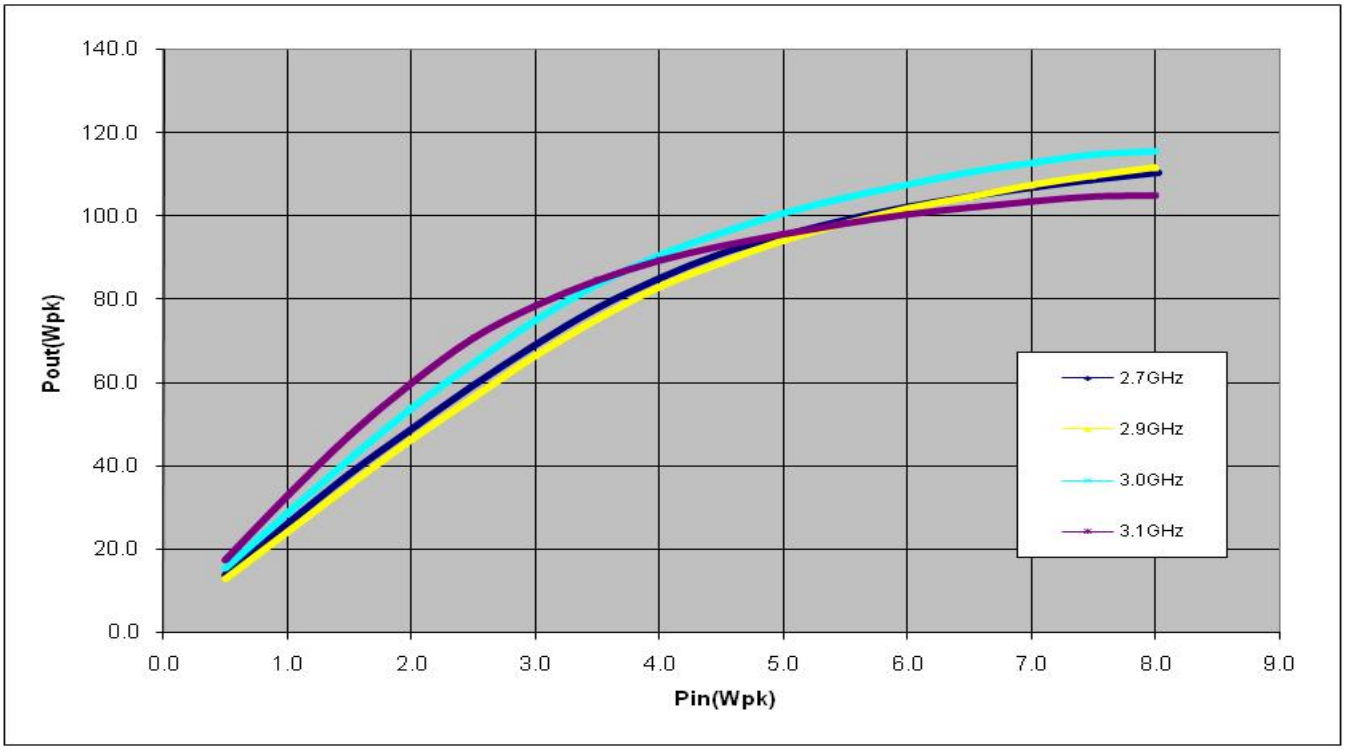
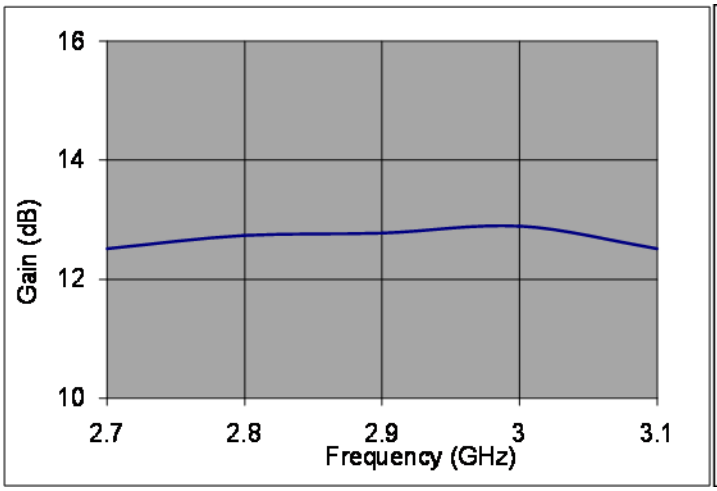
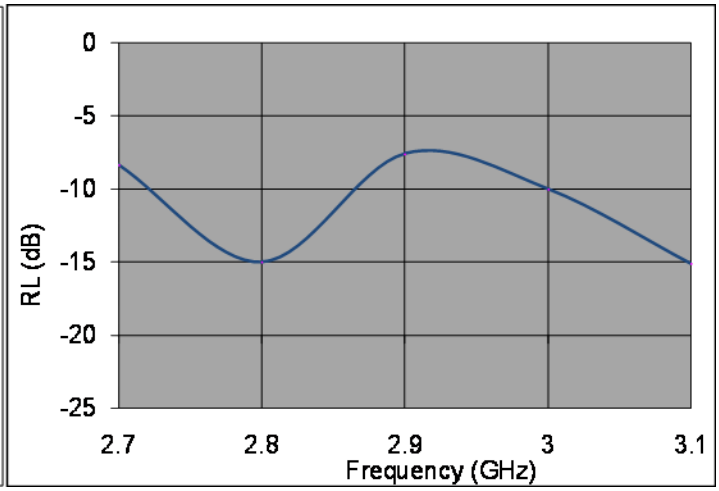
Output Power vs. Input Power



Gain vs. Frequency
50V Drain Bias, Idq=0.5A



Return Loss vs. Frequency
50V Drain Bias, Idq=0.5A



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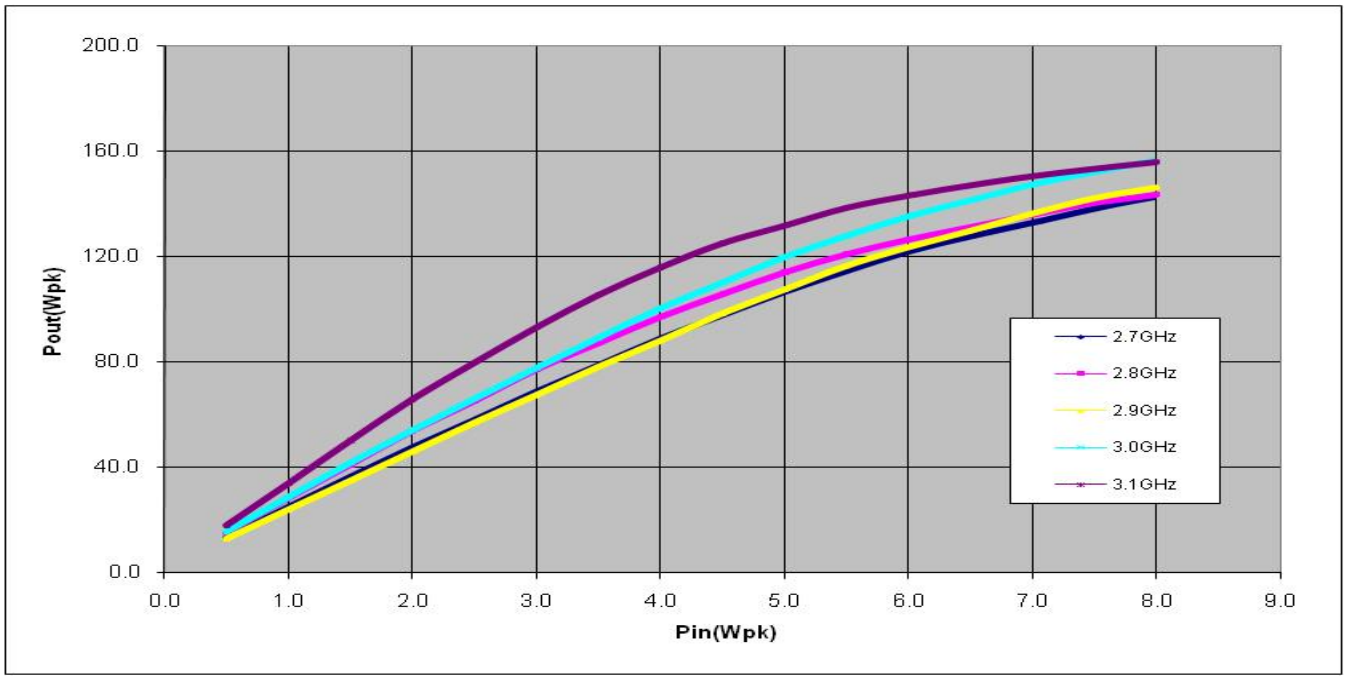
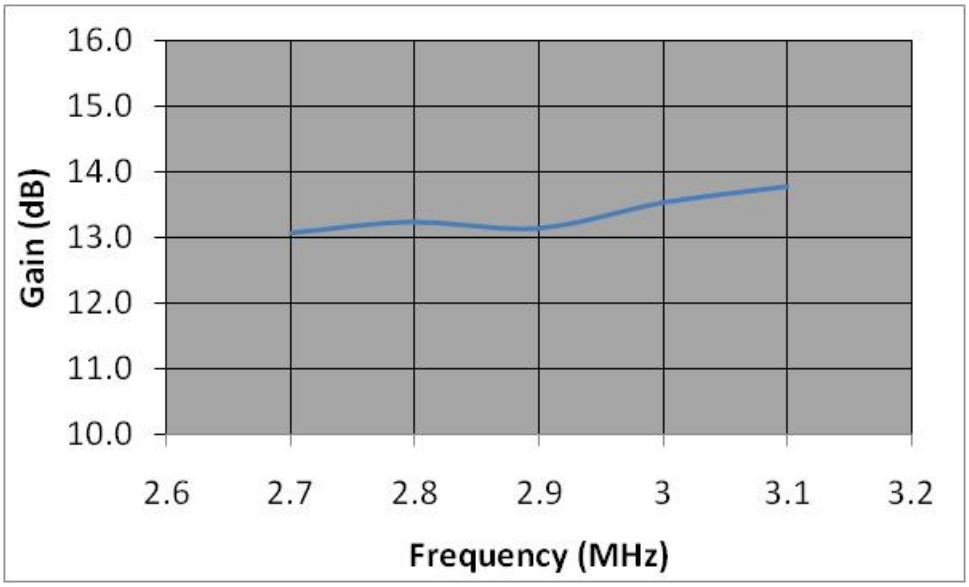
GaN HEMT Pulsed Power Transistor
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 16 Dec 10

RF Power Transfer Curve at 65V Drain Bias, Idq=0.5A
Output Power vs. Input Power



Gain vs. Frequency
65V Drain Bias, Idq=0.5A



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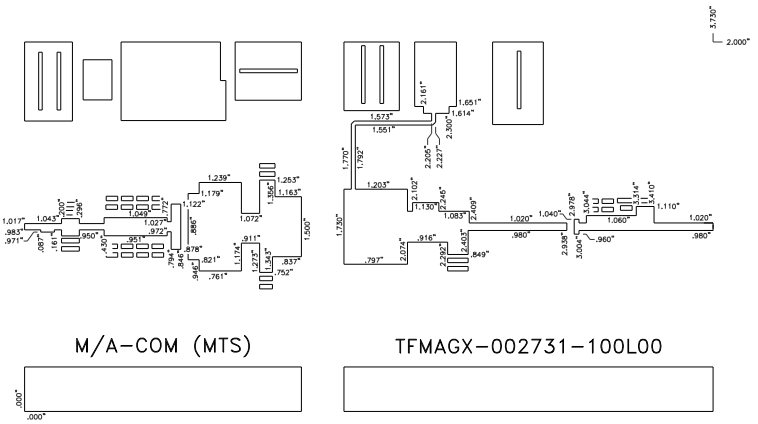
GaN HEMT Pulsed Power Transistor
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 16 Dec 10

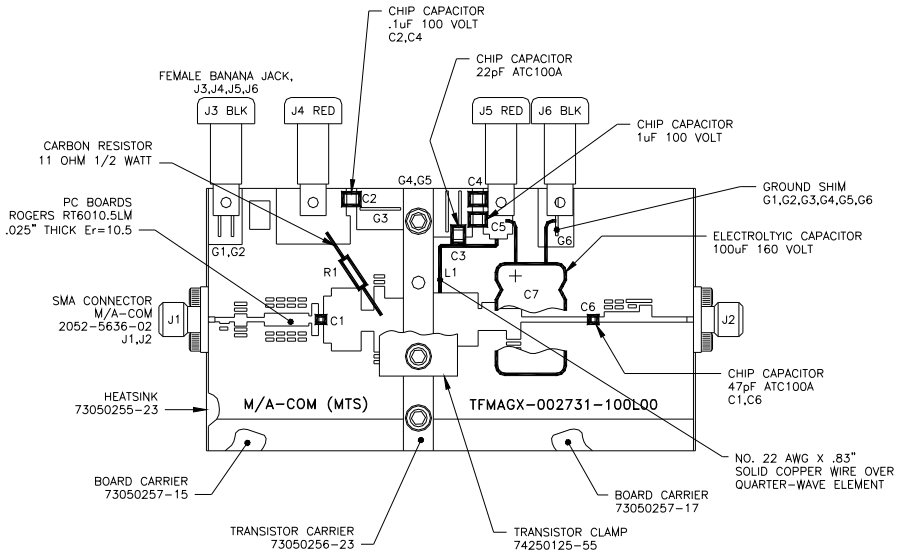
Test Fixture Circuit Dimensions



CIRCUIT DIMENSIONS SCALE = 1:1

Note: A dwg circuit drawing is available upon request

Test Fixture Assembly



ASSEMBLY VIEW

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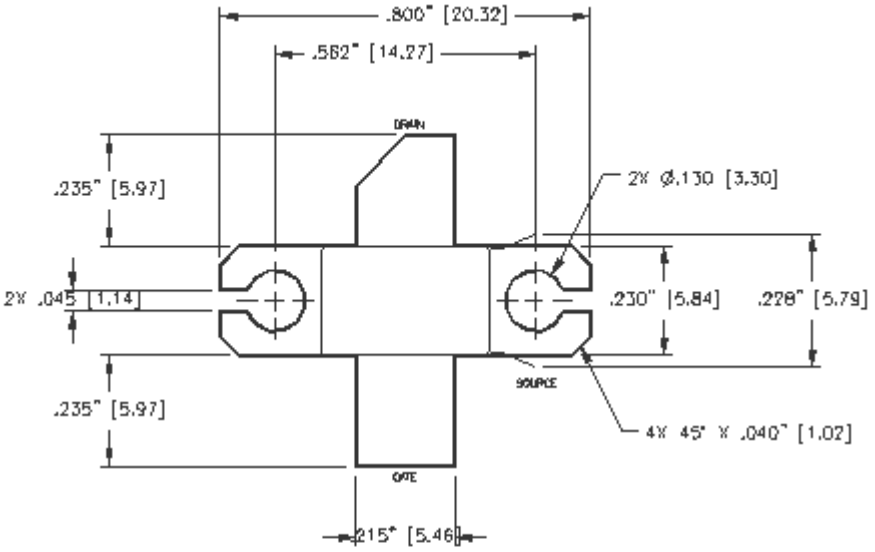
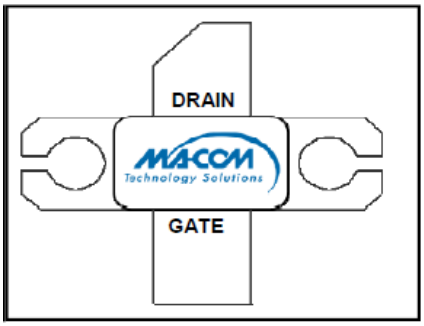
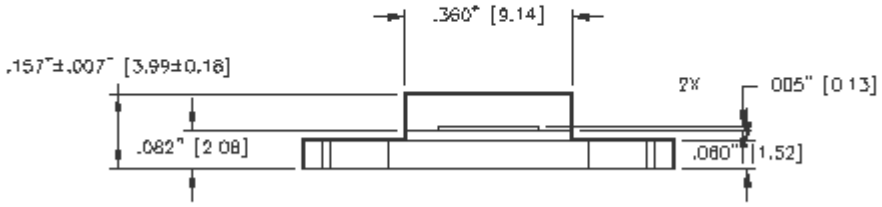
Outline Drawings







Unless otherwise noted, tolerances are Inches ±.005" [millimeters ±0.13mm]

CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAGX-002731-180L00

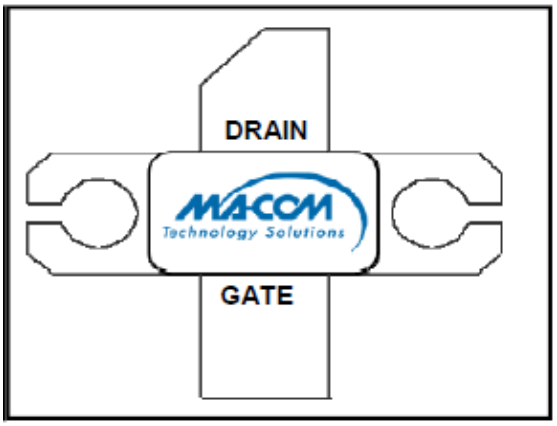
GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Thermally Enhanced Cu/Mo/Cu Package
- RoHS Compliant
- Designed for pulsed or CW applications

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	330	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	$R_{TH(JC)}$	0.6	°C/W

Typical RF Performance

50V, 500us, 10%

Freq (MHz)	Pin (Wpk)	Pout (Wpk)	Gain (dB)	Flat (dB)	Eff (%)	Droop (dB)
2700	14	198.2	11.5	- -	50.4	0.58
2800	14	213.1	11.8	- -	49.9	0.55
2900	14	203.2	11.6	- -	46.8	0.58
3000	14	201.2	11.6	- -	48.8	0.53
3100	14	183.2	11.2	0.65	48.3	0.53

50V, 300us, 10%

Freq (MHz)	Pin (Wpk)	Pout (Wpk)	Gain (dB)	Flat (dB)	Eff (%)	Droop (dB)
2700	14	193.6	11.4	- -	48.9	0.45
2800	14	208.0	11.7	- -	48.6	0.43
2900	14	199.3	11.5	- -	45.8	0.44
3000	14	199.3	11.5	- -	47.7	0.45
3100	14	185.8	11.2	0.52	47.5	0.41

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=500mA (pulsed gate bias), F=2.7- 3.1 GHz, Pulse Width=300ms, Duty=10%.

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GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

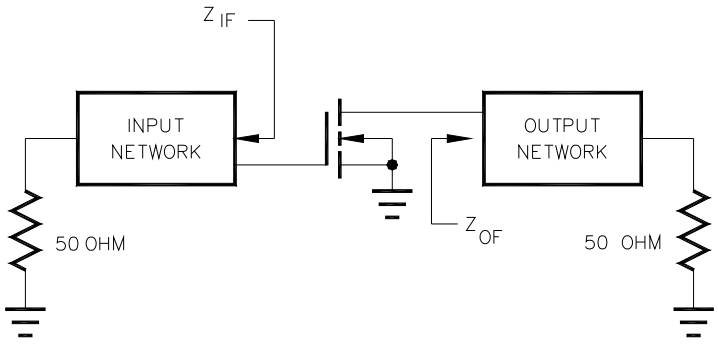
Preliminary, 20 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	1.4	mA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	18.7	23.3	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	4.7	14	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 23mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 14A	G_M	1.7	6.5	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable - Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	26.1	30.3	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	2.3	4.7	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	P_{OUT}	180	190	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 180Wpk	G_P	10.5	11.5	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	η_D	43	50	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	VSWR-S	5:1	-		-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	VSWR-T	10:1	-		-

Test Fixture Impedance

Freq	Zin	Zout
2.7	2.04 – j 5.75	2.82 – j 2.00
2.8	1.61 – j 5.40	3.08 – j 2.73
2.9	1.28 – j 4.98	2.88 – j 3.30
3.0	1.13 – j 4.51	2.49 – j 3.49
3.1	1.19 – j 4.18	2.21 – j 3.64



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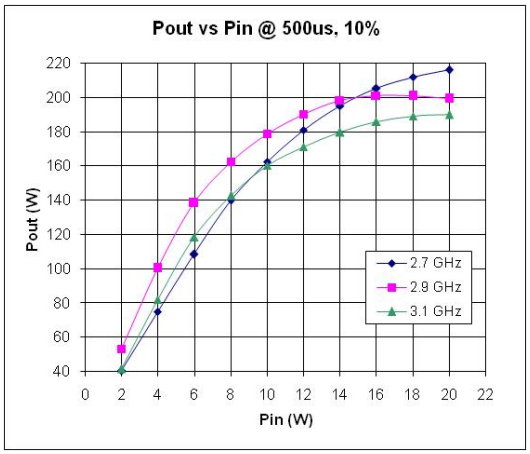
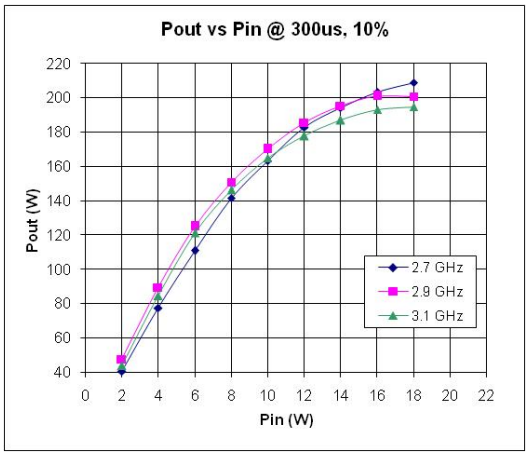
GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

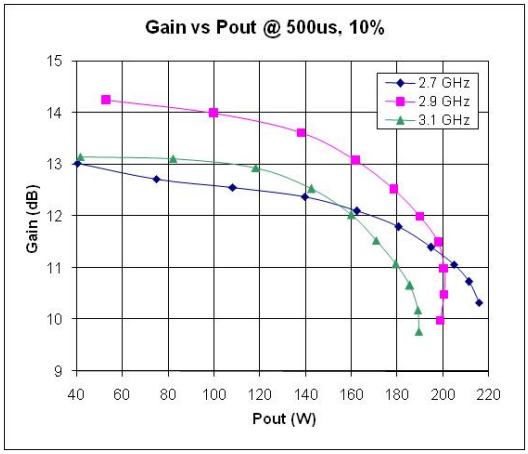
Preliminary, 20 Dec 10

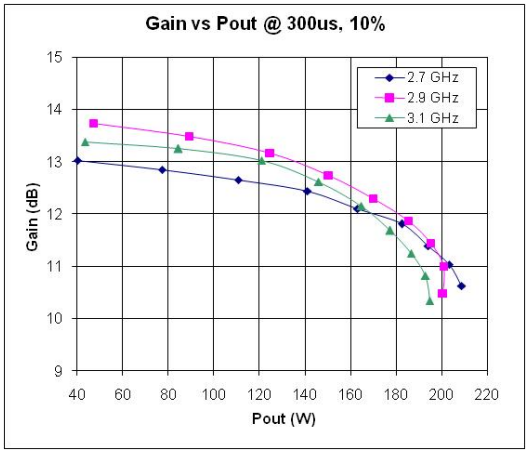
RF Power Transfer Curve
Output Power vs. Input Power



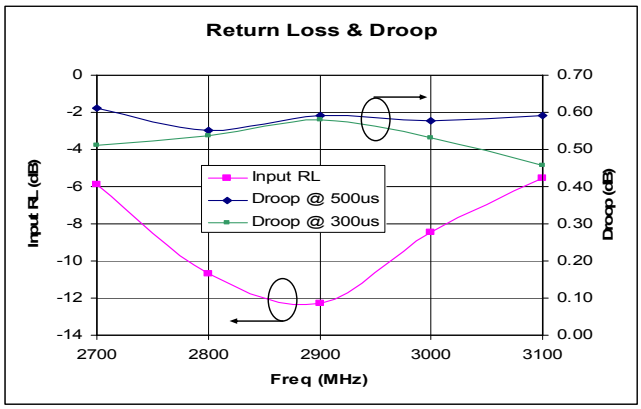


RF Power Transfer Curve
Power Gain vs. Output Power





Input VSWR & Droop (Typ)



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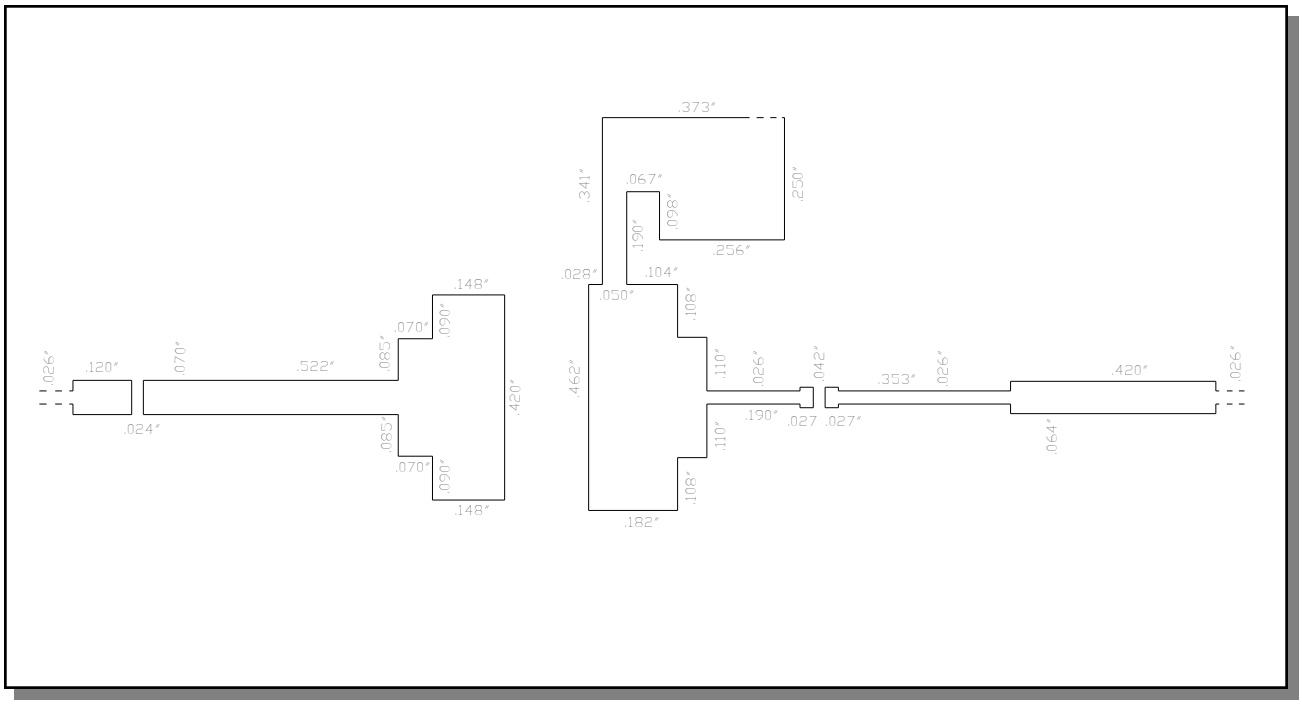
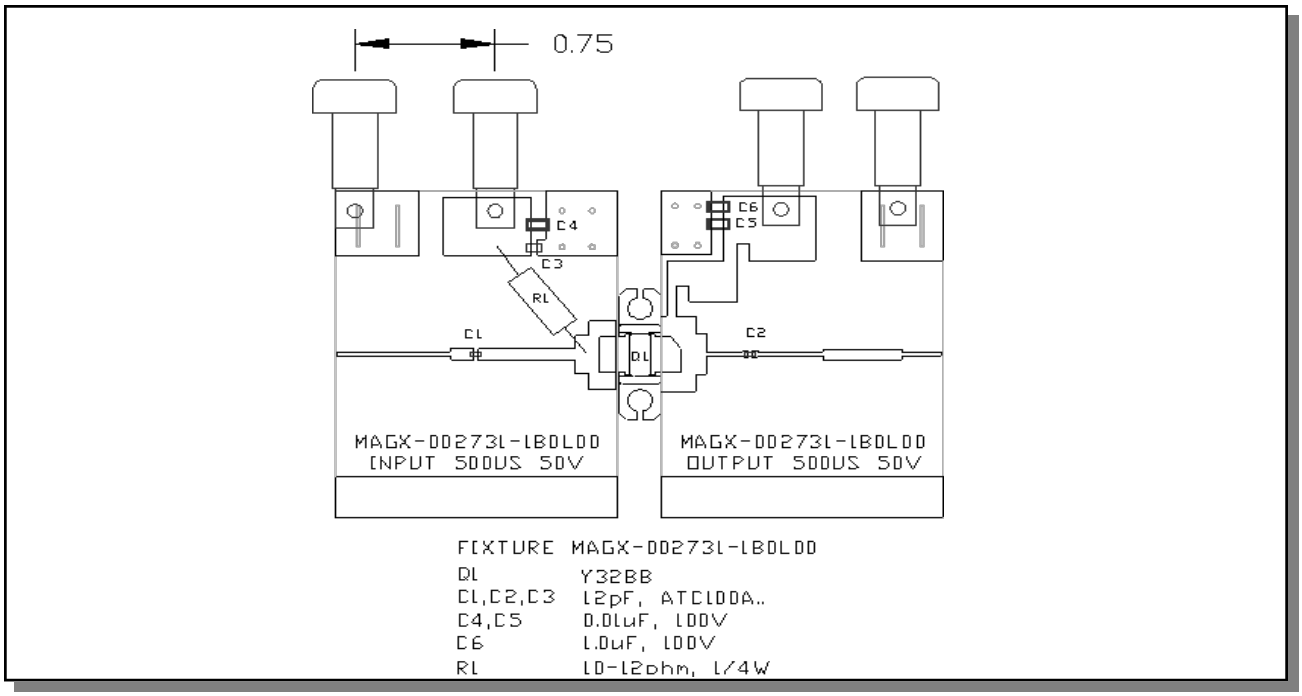
GaN HEMT Pulsed Power Transistor
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Test Fixture Circuit Dimensions (inches)



Test Fixture Assembly



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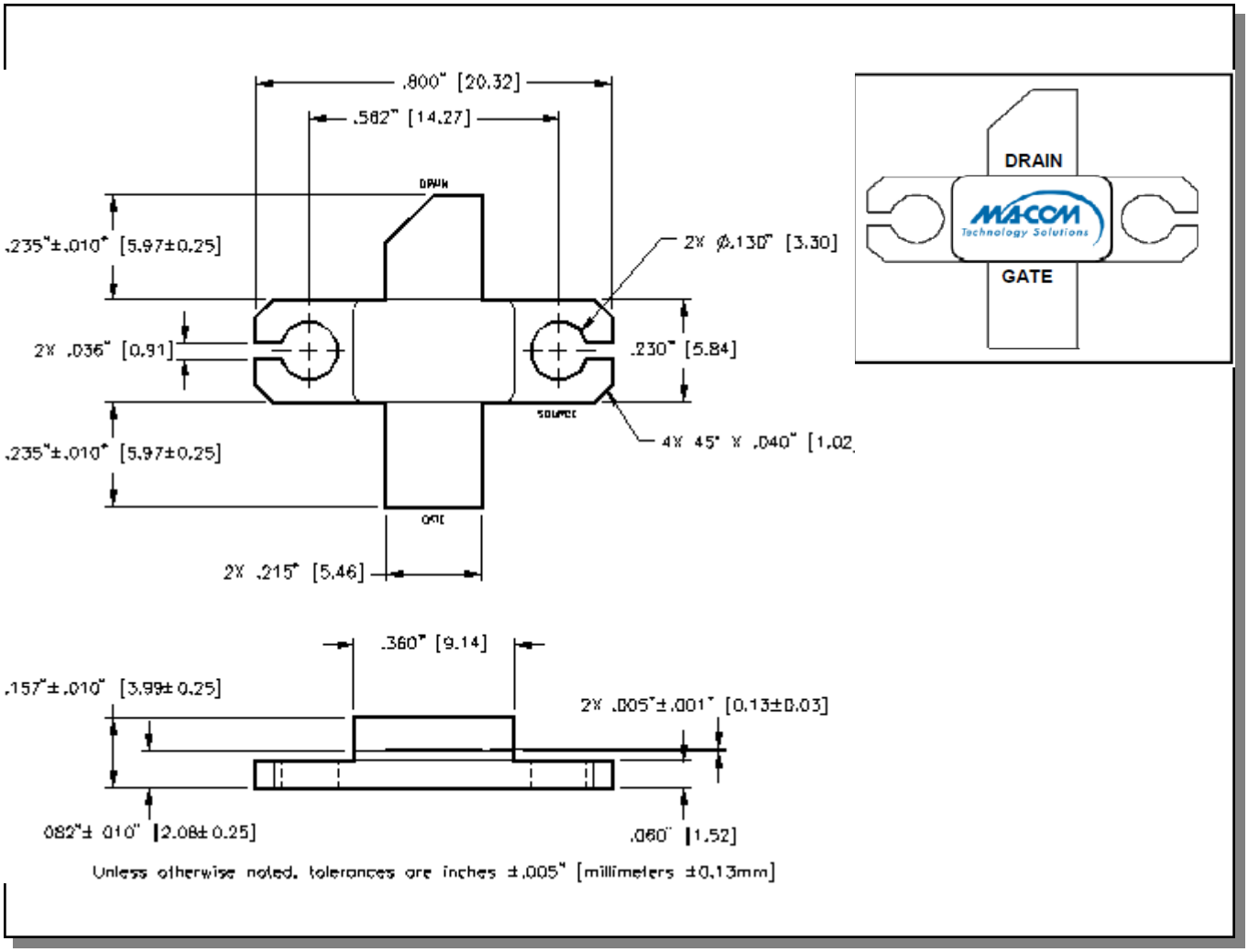
GaN HEMT Pulsed Power Transistor **Preliminary, 20 Dec 10**
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

Outline Drawing



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAGX-003135-030L00

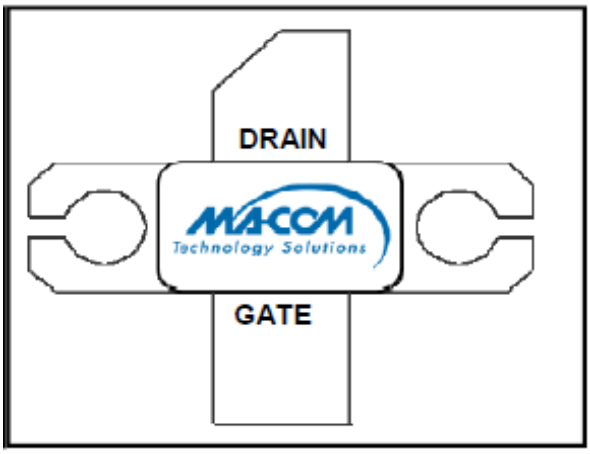
GaN HEMT Pulsed Power Transistor
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 08 Dec 10

Features

- GaN HEMT microwave power transistor
- Common source configuration
- Broadband Class AB operation
- No internal matching
- Thermally enhanced Cu/Mo/Cu package
- RoHS Compliant
- Designed for pulsed or CW applications

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	200	V
Gate-Source Voltage	V_{GS}	+0.7 to -15	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	45	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (Tj<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 130mA, Pout = 30Wpk	$R_{TH(JC)}$	2.0	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	RL (dB)	Eff (%)
3100	3	40	11.2	6.4	59.3
3300	3	40	11.2	10.4	57.7
3500	3	34	10.5	16.2	51.2

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=250mA (pulsed), F=3.1-3.5GHz, Pulse=500ms, Duty=10%.

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GaN HEMT Pulsed Power Transistor
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

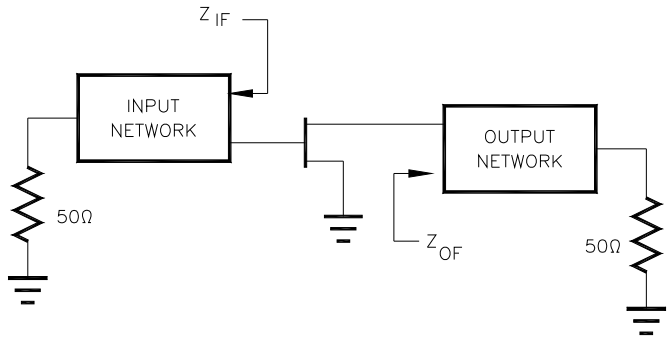
Preliminary, 08 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	300	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	4	5	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	1	3	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 5.0mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 3A	G_M	1	1.4	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	V_{DS} = 0v, V_{GS} = -8V, F = 1MHz	C_{ISS}	-	13.2	15	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	5.6	6.5	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	0.5	1.0	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	P_{OUT}	30	40	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 130mA, Pout = 30Wpk	G_P	10.0	11.0	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	η_D	50	55	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	VSWR-S	5:1	-		-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	VSWR-T	10:1	-		-

Test Fixture Impedance

F (MHz)	Z_{IF} (Ω)	Z_{OF} (Ω)
3100	7.6 - j12.5	5.2 - j0.2
3200	7.7 - j11.9	5.6 + j0.1
3300	7.5 - j11.4	6.0 + j0.2
3400	7.4 - j10.7	6.4 + j0.3
3500	7.2 - j10.2	6.7 + j0.1



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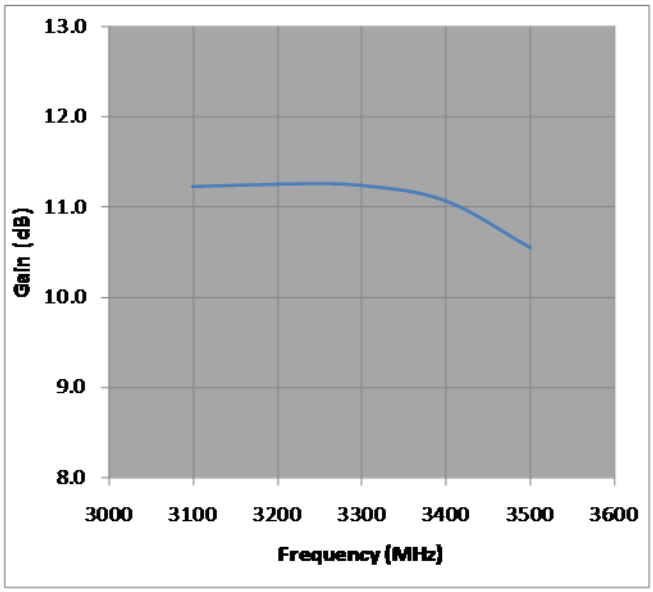
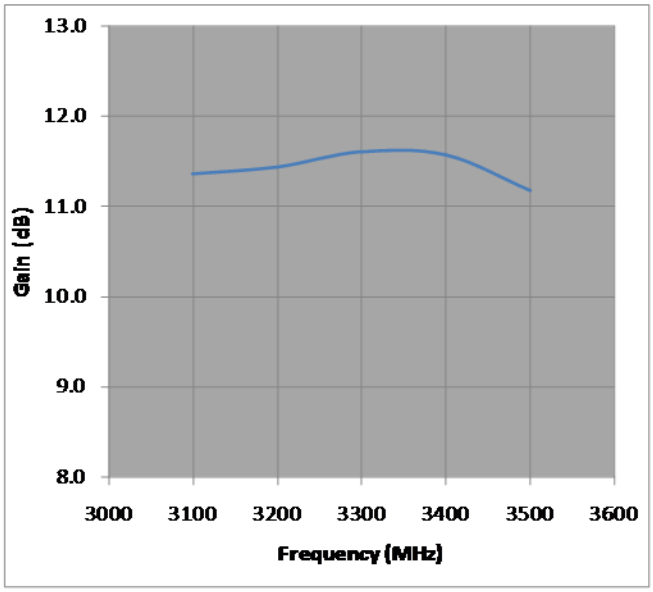
GaN HEMT Pulsed Power Transistor
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 08 Dec 10

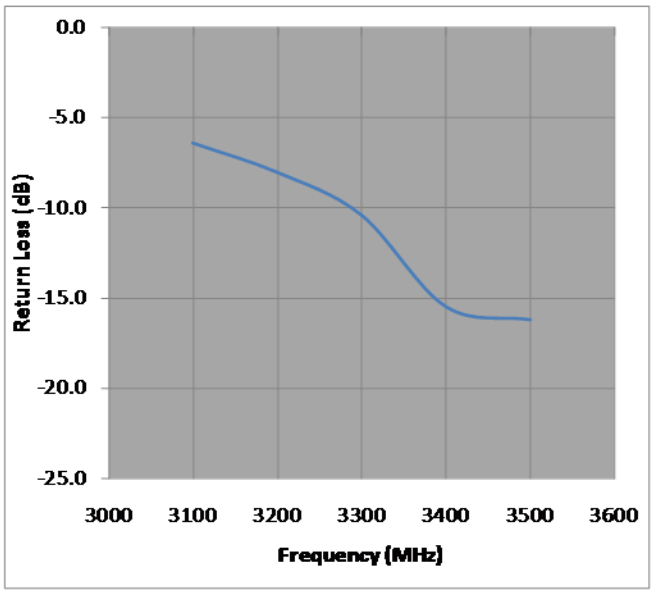
Gain vs. Frequency
50V Drain Bias, Idq=0.13A



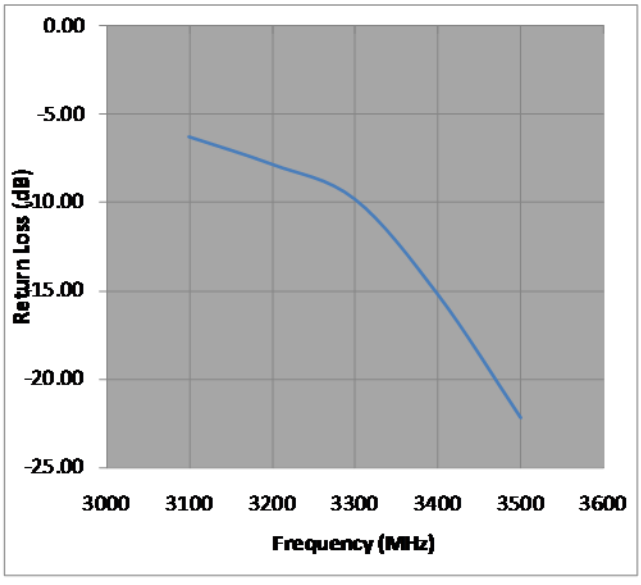
Gain vs. Frequency
65V Drain Bias, Idq=0.13A



Return Loss vs. Frequency
50V Drain Bias, Idq=0.13A



Return Loss vs. Frequency
65V Drain Bias, Idq=0.13A



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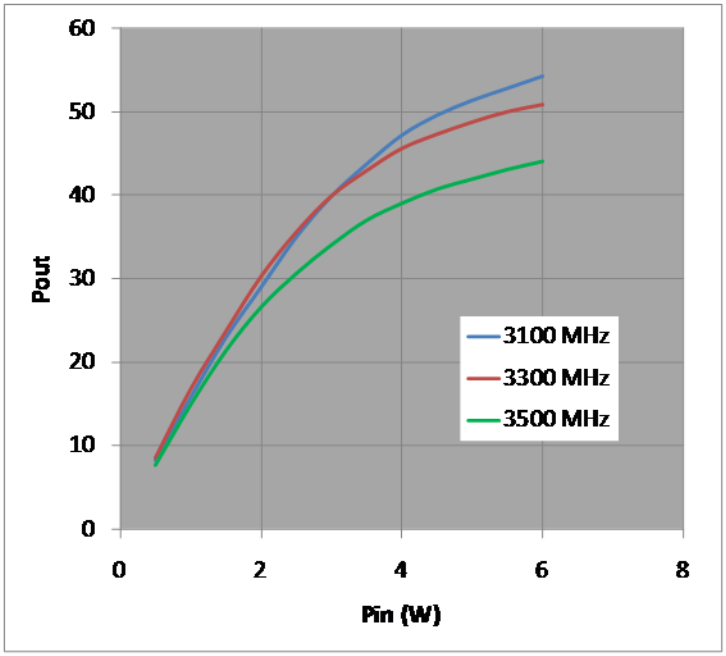
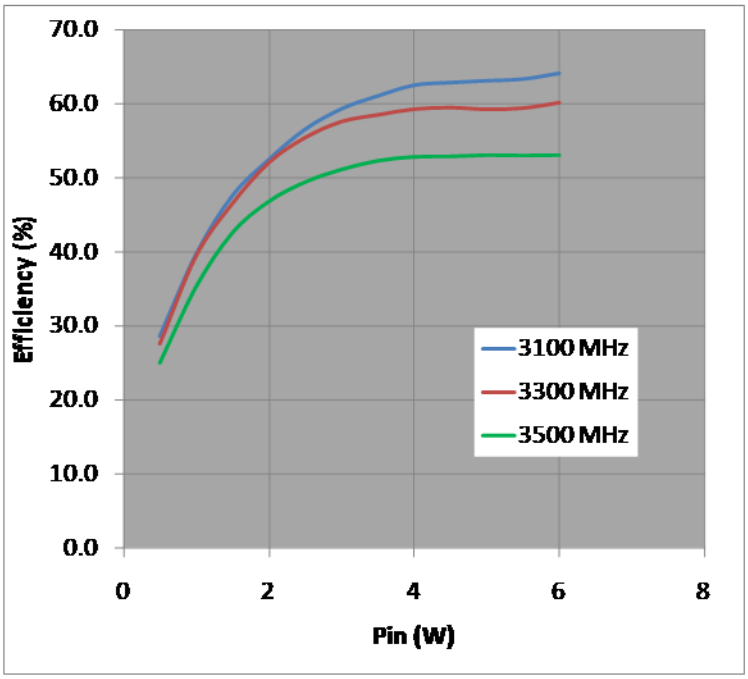
Output Power vs. Input Power
50V Drain Bias, Idq=0.13A



Drain Efficiency vs. Input Power
50V Drain Bias, Idq=0.13A



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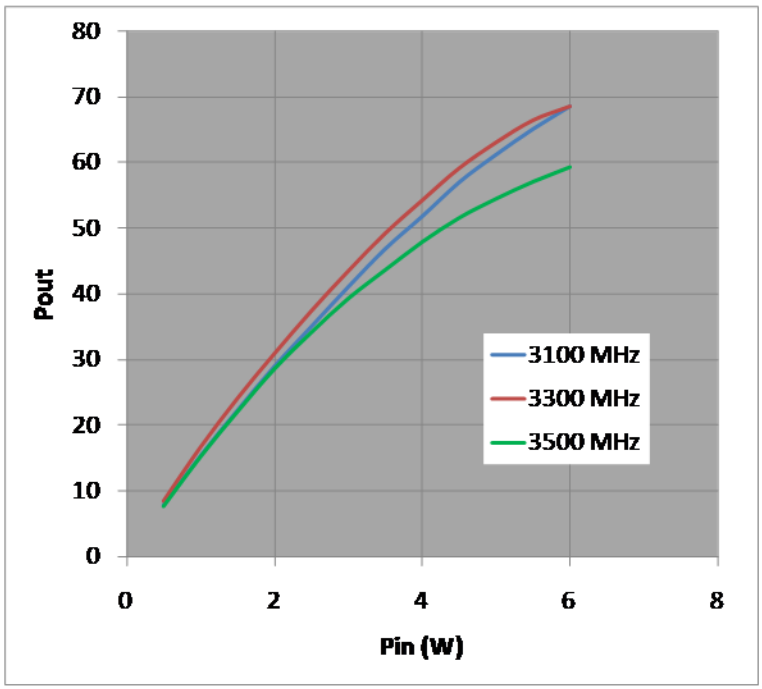
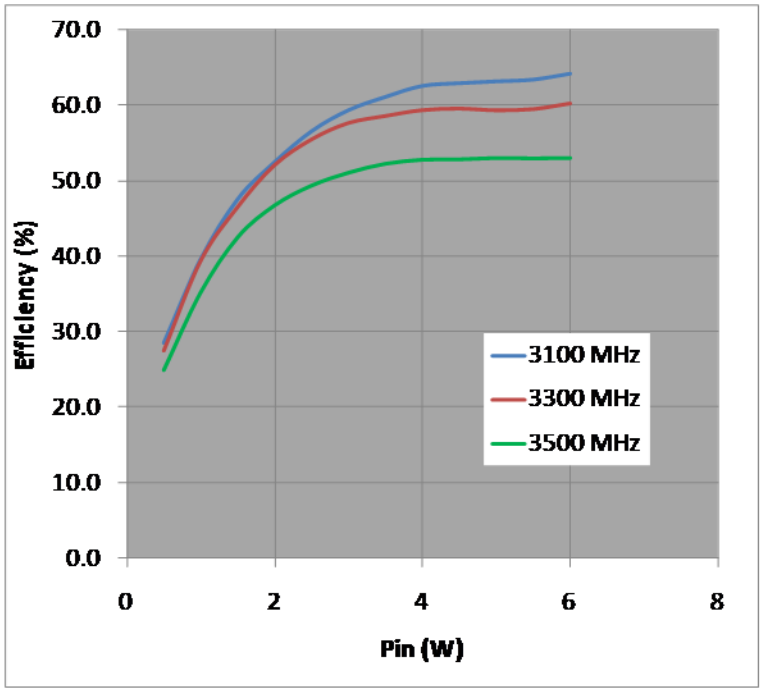
Output Power vs. Input Power
65V Drain Bias, Idq=0.13A



Drain Efficiency vs. Input Power
65V Drain Bias, Idq=0.13A



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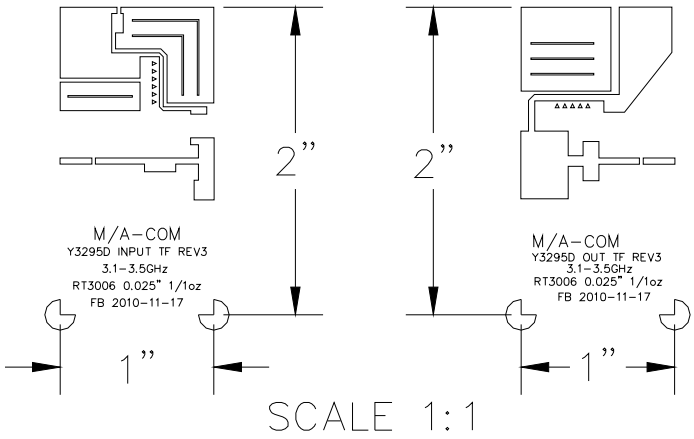
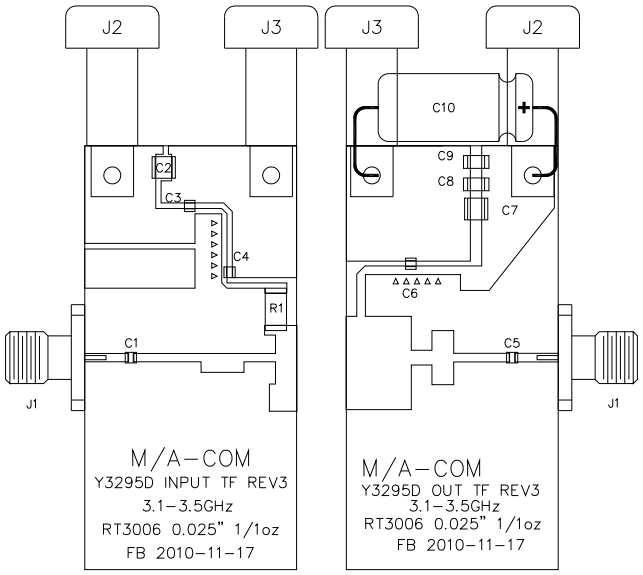
GaN HEMT Pulsed Power Transistor **Preliminary, 08 Dec 10**
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Test Fixture Circuit Dimensions



Note: A .dwg circuit drawing is available upon request

Test Fixture Assembly



C1,C4,C5,C6: 12pF (ATC100A120J)
C2,C7: 470pF/100V (ATC100B471J)
C3: 47pF (ATC100A470J)
C8: 0.1uF/100V (VJ1206Y104KXBMT)
C9: 1uF/100V (C3216X7R2A105K)
C10: 100uF/63V (Electrolytic Capacitor)
R1: 12 Ohm (CR2010-2W-120J)
J1 SMA-Female (2052-5636-02)
J2: Banana Jack Red (8059)
J3 Banana Jack Black (8100)
PCB, Rogers RT3006, Er=6.15, H=0.025"

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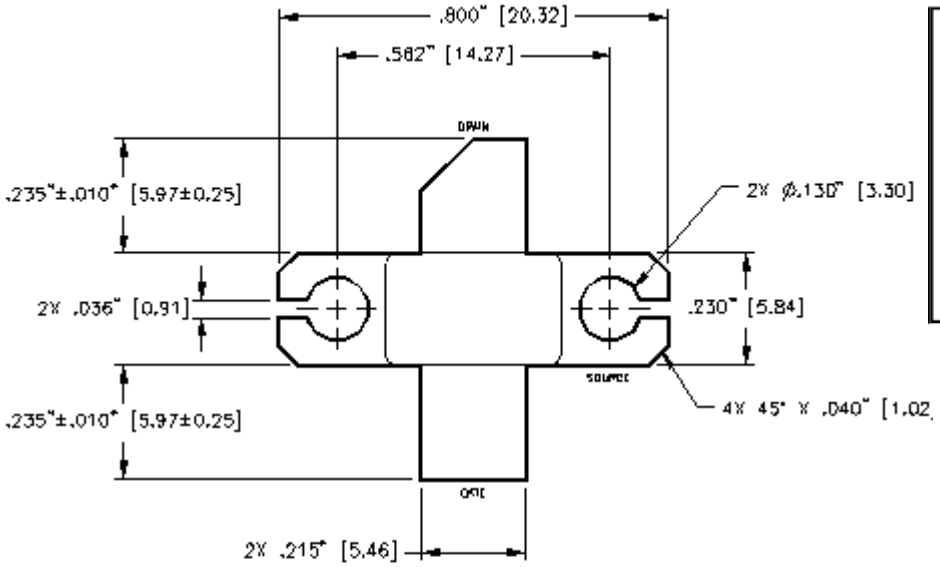
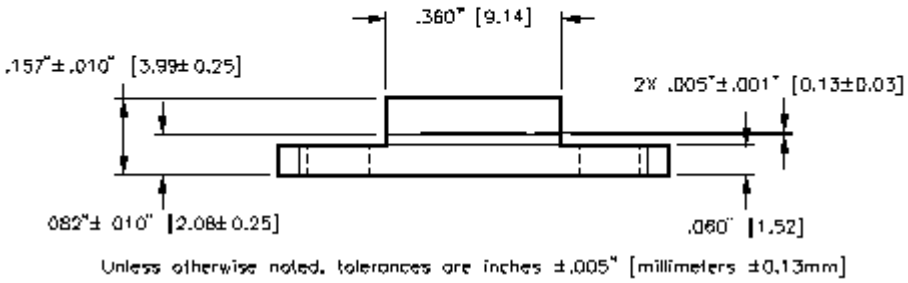
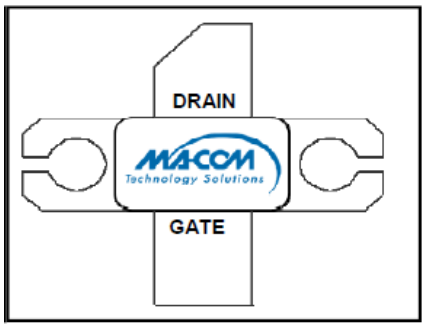
GaN HEMT Pulsed Power Transistor **Preliminary, 08 Dec 10**
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Outline Drawings





Unless otherwise noted, tolerances are inches ±.005" [millimeters ±0.13mm]



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAGX-003135-090L00

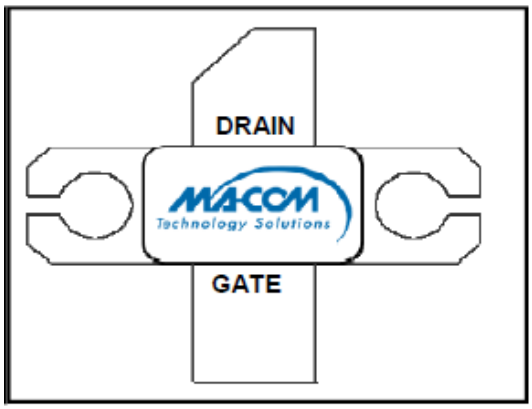
GaN HEMT Pulsed Power Transistor
90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

Preliminary, 18 Dec 10

Features

- GaN HEMT microwave power transistor
- Common source configuration
- Broadband Class AB operation
- Internally matched
- Thermally enhanced Cu/Mo/Cu package
- RoHS Compliant
- Designed for pulsed and CW applications
- 65V Operation

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	195	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 65V, I_{DQ} = 500mA, Pout = 100W	$R_{TH(JC)}$	0.9	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	RL (dB)	Eff (%)
3100	9	112	11.0	-15	46
3300	9	108	10.9	-15	49
3500	9	92	10.1	-12	43

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=65V, Idq=500mA (pulsed), F=3.1 - 3.5 GHz, Pulse=300us, Duty=10%.

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GaN HEMT Pulsed Power Transistor
90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

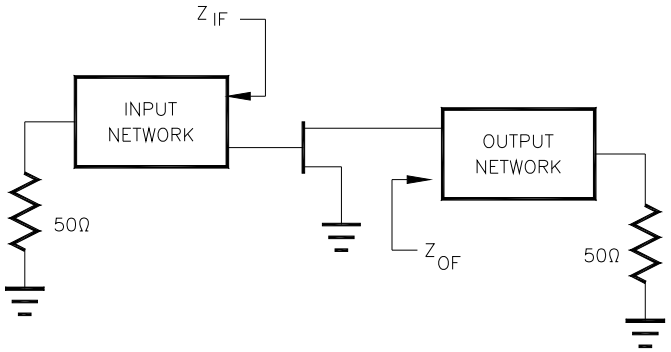
Preliminary, 18 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	600	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	9.3	11.7	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	2.3	7	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 12mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 7A	G_M	0.4	0.6	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable - Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{DS}	-	30.3	35.4	pF
Feedback Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{GD}	-	2.8	5.4	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	P_{OUT}	90	100	-	W
Power Gain	V_{DD} = 65V, I_{DQ} = 500mA, Pout = 100Wpk	G_P	10	10.5	-	dB
Drain Efficiency	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	η_D	40	43	-	%
Load Mismatch Stability	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-T	10:1	-	-	-

Test Fixture Impedance

F (MHz)	Z_{IF} (Ω)	Z_{OF} (Ω)
3100	11.2-j4.2	7.6-j1.2
3200	10.9-j4.1	5.5-j4.2
3300	11.3-j4.9	4.8-j4.9
3400	10.9-j1.3	5.7-j4.3
3500	11.0-j1.1	5.9-j5.9



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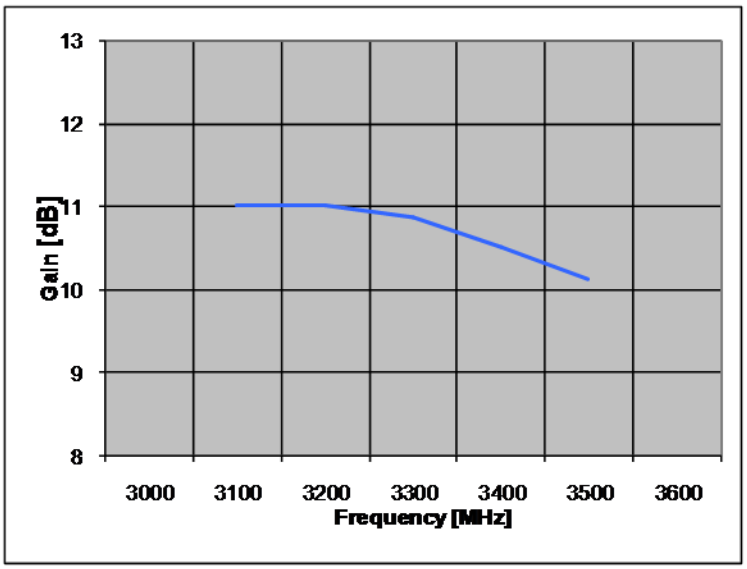
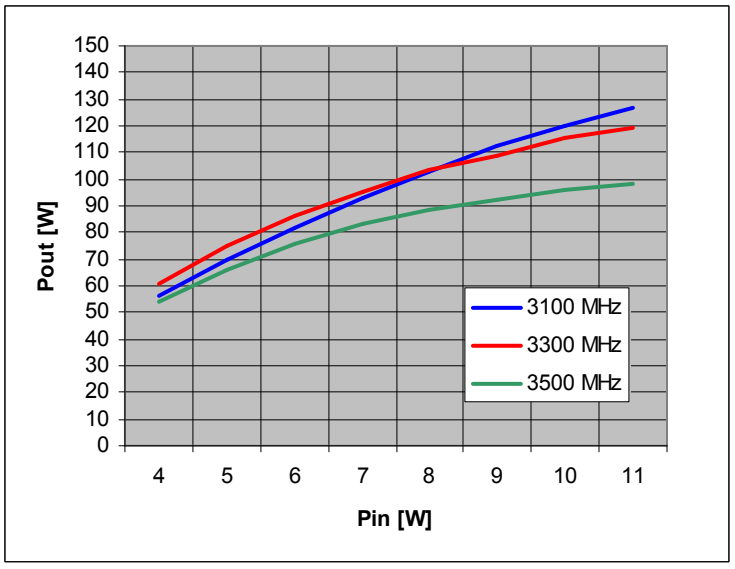
GaN HEMT Pulsed Power Transistor
90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

Preliminary, 18 Dec 10

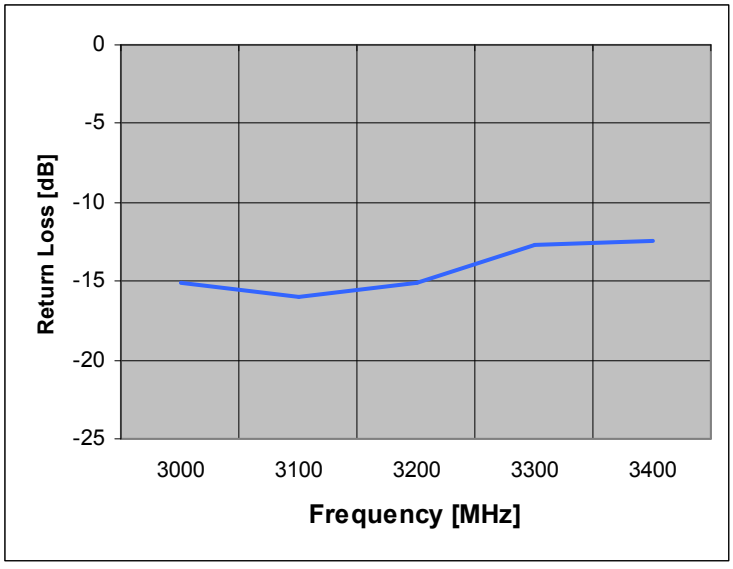
Gain vs. Frequency
65V Drain Bias, Idq=0.5A



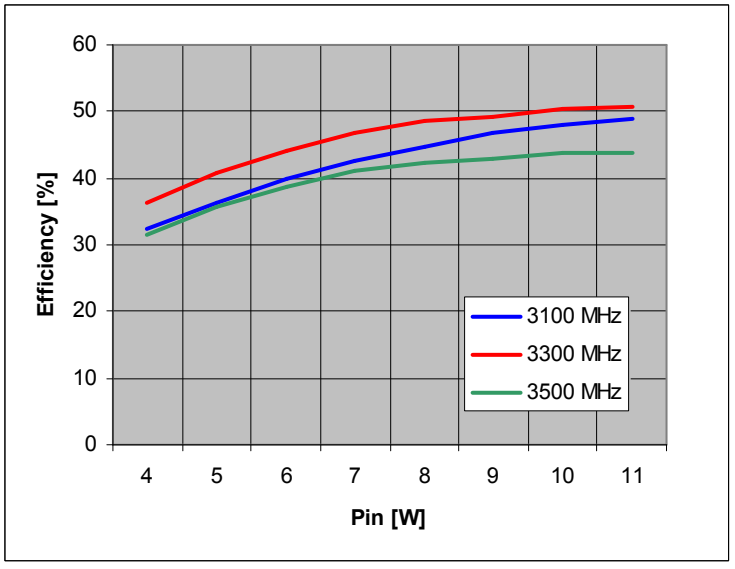
Output Power vs. Input Power
65V Drain Bias, Idq=0.5A



Return Loss vs. Frequency
65V Drain Bias, Idq=0.5A



Drain Efficiency vs. Input Power
65V Drain Bias, Idq=0.5A



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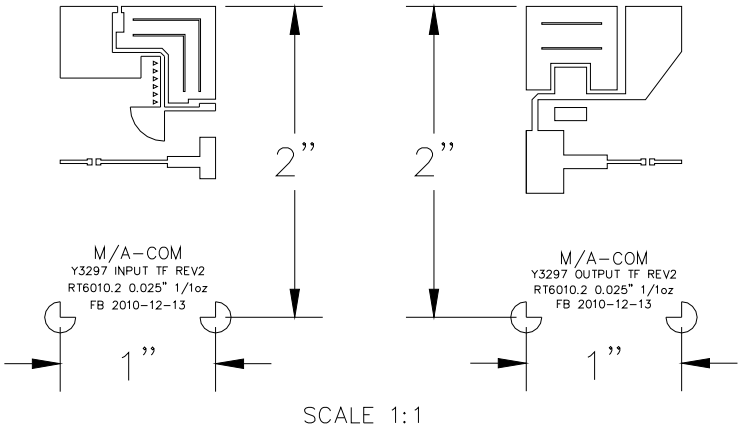
GaN HEMT Pulsed Power Transistor
90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

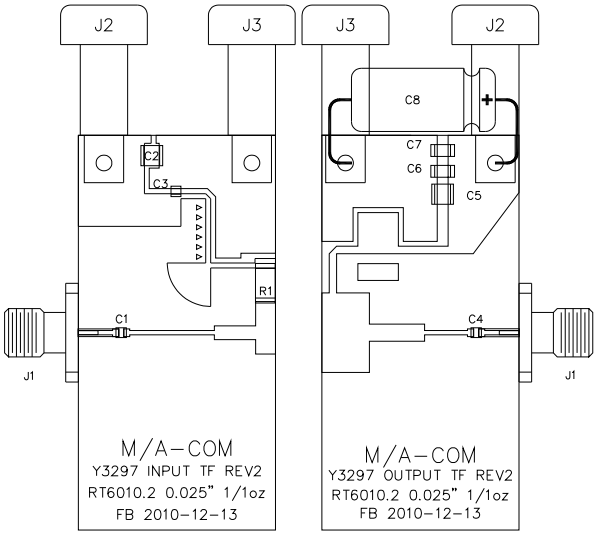
Preliminary, 18 Dec 10

Test Fixture Circuit Dimensions



Note: A dwg circuit drawing is available upon request

Test Fixture Assembly



C1,C3,C4: 12pF (ATC100A120J)
C2,C5: 470pF/100V (ATC100B471J)
C6: 0.1uF/100V (VJ1206Y104KXBMT)
C7: 1uF/100V (C3216X7R2A105K)
C8: 100uF/63V (Electrolytic Capacitor)
R1: 200 Ohm (CR2010-2W-201J)
J1 SMA-Female (2052-5636-02)
J2: Banana Jack Red (8059)
J3 Banana Jack Black (8100)
PCB, Rogers RT6010.2, Er=10.2, H=0.025"

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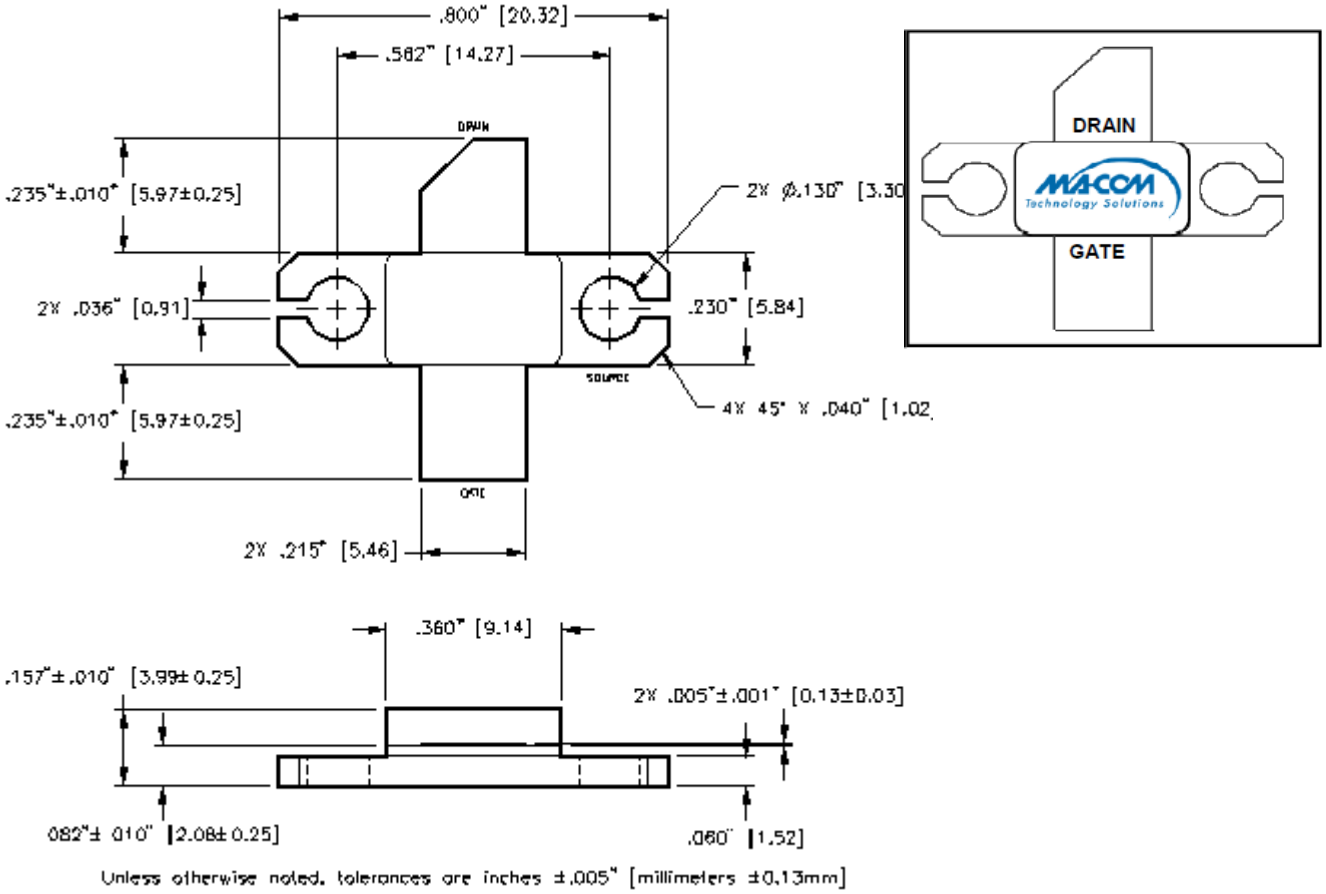
GaN HEMT Pulsed Power Transistor
90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

Preliminary, 18 Dec 10

Outline Drawings



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAGX-003135-150L00

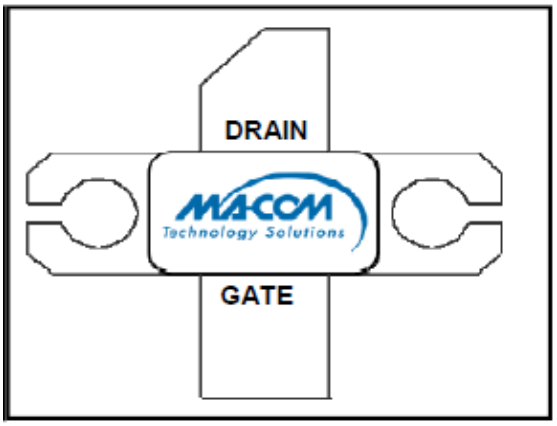
GaN HEMT Pulsed Power Transistor
3.1 - 3.5 GHz, 150Wpk, 500us Pulse, 10% Duty

Advanced, 17 Dec 10

Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Thermally Enhanced Cu/Mo/Cu Package
- RoHS Compliant
- Designed for pulsed or CW applications

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	TBD	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 12Wpk	$R_{TH(JC)}$	0.6	°C/W

Typical RF Performance - TBD

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	RL (dB)	Eff (%)
3100	TBD	TBD	TBD	TBD	TBD
3300	TBD	TBD	TBD	TBD	TBD
3500	TBD	TBD	TBD	TBD	TBD

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=500mA (pulsed gate bias), F=3.1 - 3.5 GHz, Pulse Width=500ms, Duty=10%.

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GaN HEMT Pulsed Power Transistor
3.1 - 3.5 GHz, 150Wpk, 500us Pulse, 10% Duty

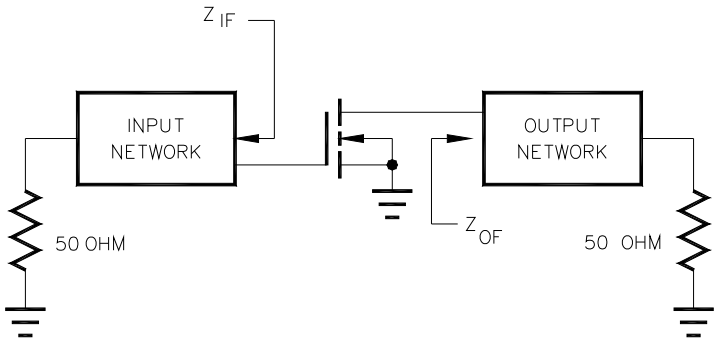
Advanced, 17 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	1.4	mA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	18.7	23.3	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	4.7	14	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 23mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 14A	G_M	1.7	6.5	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable - Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	26.1	30.3	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	2.3	4.7	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	P_{OUT}	150	160	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 180Wpk	G_P	11	12	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	η_D	50	53	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	VSWR-S	5:1	-		-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	VSWR-T	10:1	-		-

Test Fixture Impedance

F (MHz)	Z_{IF} (Ω)	Z_{OF} (Ω)
3100	TBD	TBD
3200	TBD	TBD
3300	TBD	TBD
3400	TBD	TBD
3500	TBD	TBD



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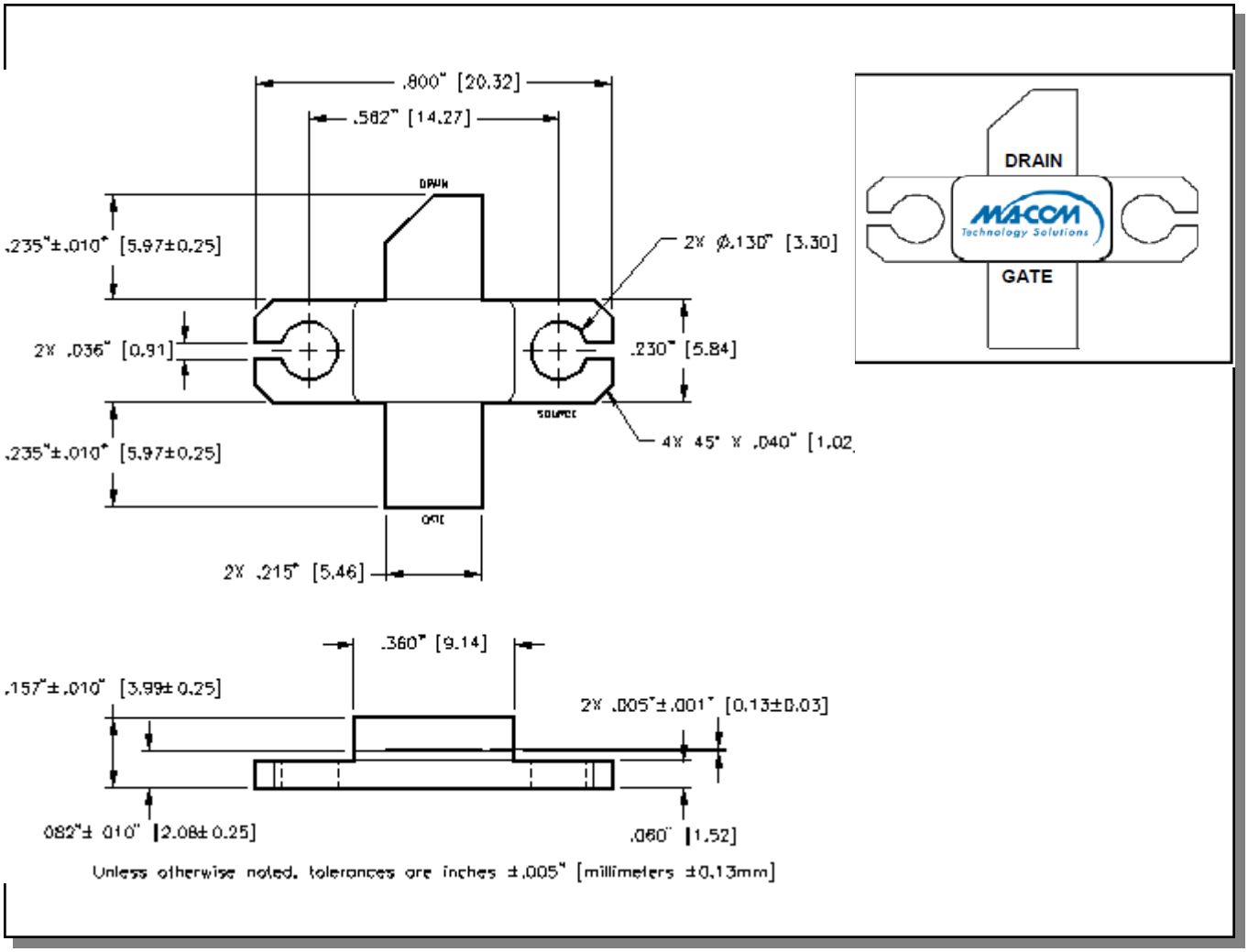
GaN HEMT Pulsed Power Transistor
3.1 - 3.5 GHz, 150Wpk, 500us Pulse, 10% Duty

Advanced, 17 Dec 10

Outline Drawing



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAPG-002731-030L00

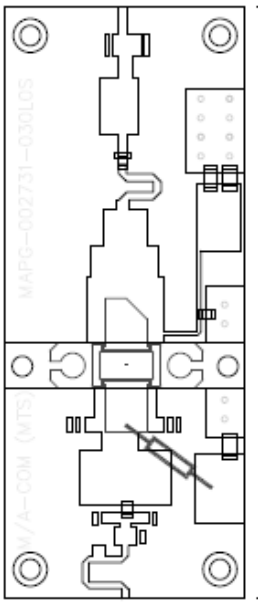
GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 30Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Input and output matched to 50Ω
- RoHS Compliant
- Designed for pulsed or CW applications

Product Image



Description

The MAPG-002731-030L00 is a common-source, Class-AB, S-Band 50Ω pallet amplifier designed to streamline time-to-market. The pallet includes a gain compensation network at the input for ultra-flat gain vs. frequency response.

Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	45	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 250mA, Pout = 30Wpk	$R_{TH(JC)}$	2.0	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	Id-Pk (A)	Eff (%)
2700	3	46	11.8	1.7	56
2900	3	43	11.6	1.6	53
3100	3	41	11.2	1.5	56

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=250mA (pulsed), F=2.7—3.1 GHz, Pulse=500ms, Duty=10%.

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GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 30Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	300	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	4	5	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	1	3	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 5.0mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 3A	G_M	1	1.4	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	V_{DS} = 0v, V_{GS} = -8V, F = 1MHz	C_{ISS}	-	13.2	15	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	5.6	6.5	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	0.5	1.0	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	P_{OUT}	30	40	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	G_P	10	11.4	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	η_D	50	55	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 250mA, Pin = 3Wpk	VSWR-T	10:1	-	-	-

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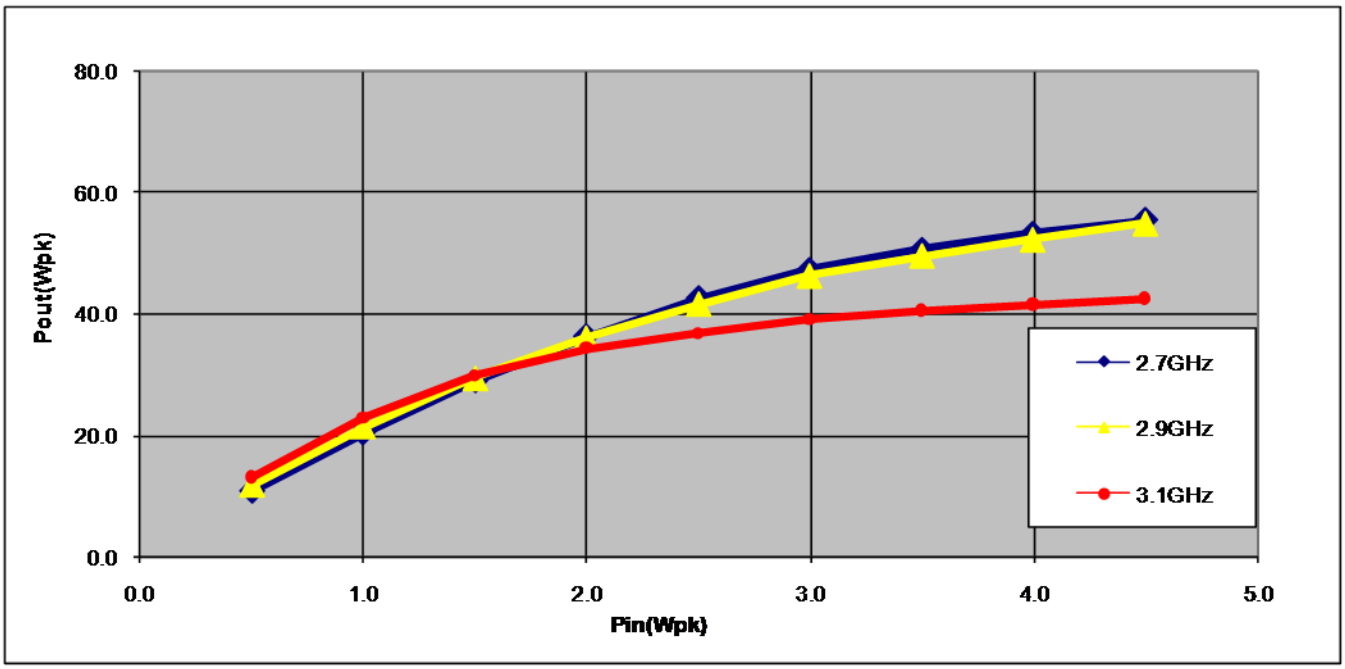
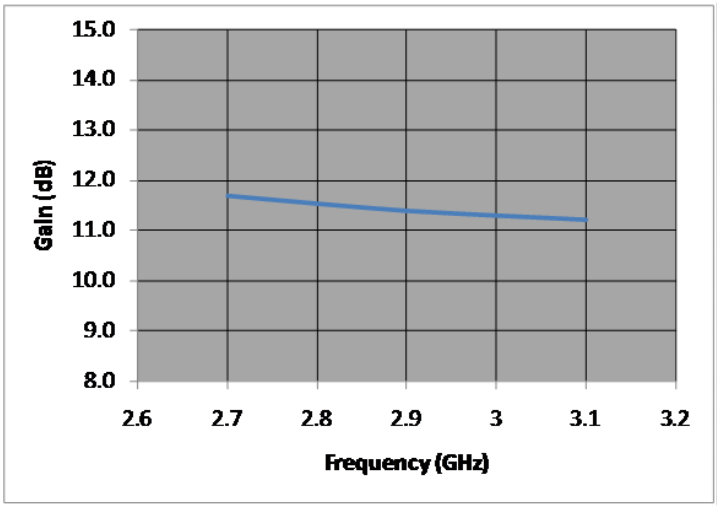
GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 30Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

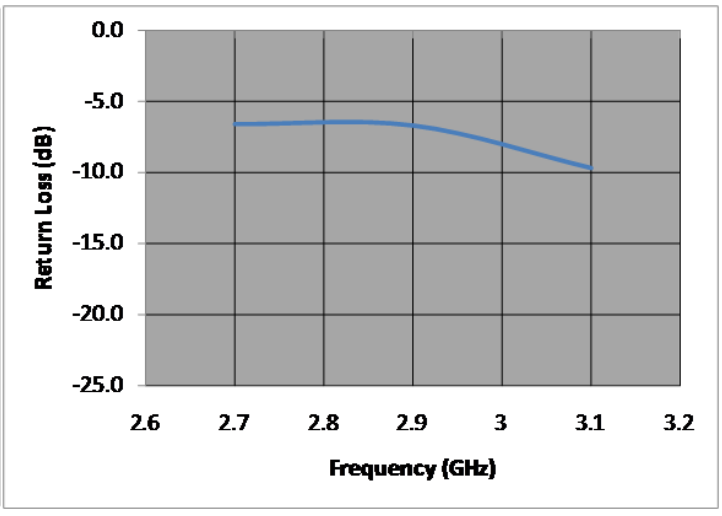
RF Power Transfer Curve at 50V Drain Bias, Idq=0.25A
Output Power vs. Input Power



Gain vs. Frequency
50V Drain Bias, Idq=0.25A



Return Loss vs. Frequency
50V Drain Bias, Idq=0.25A



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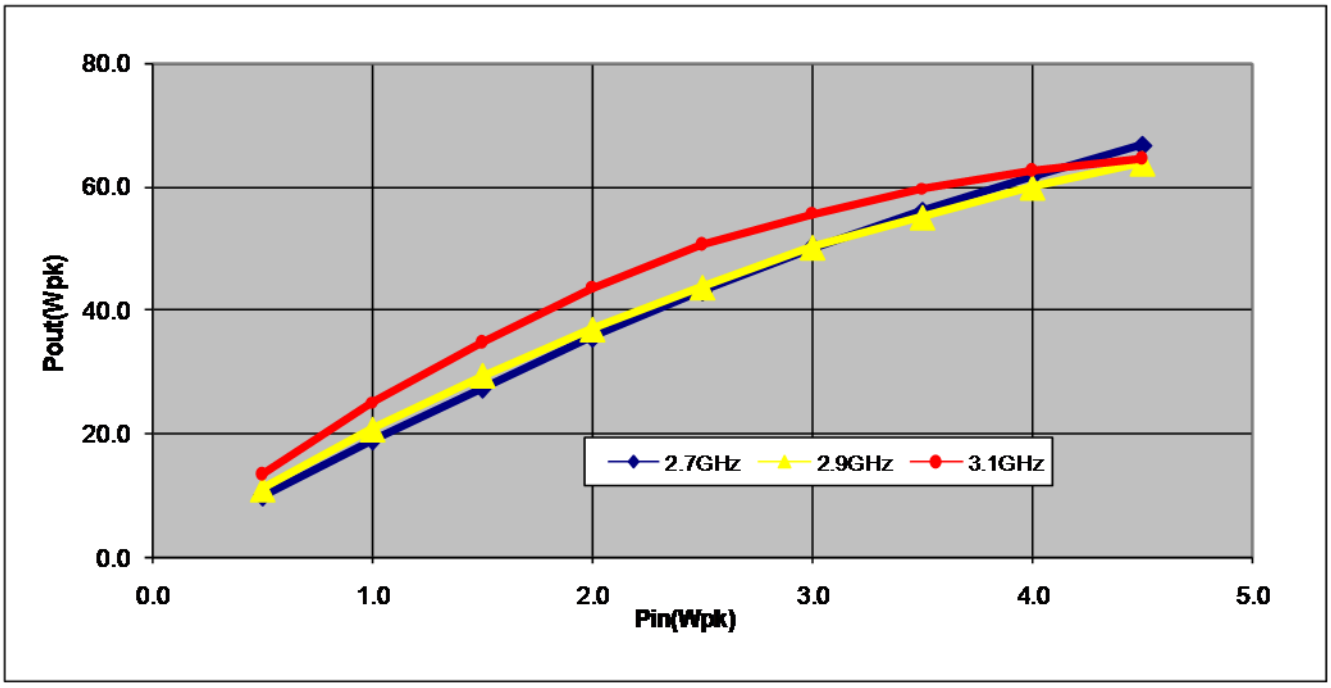
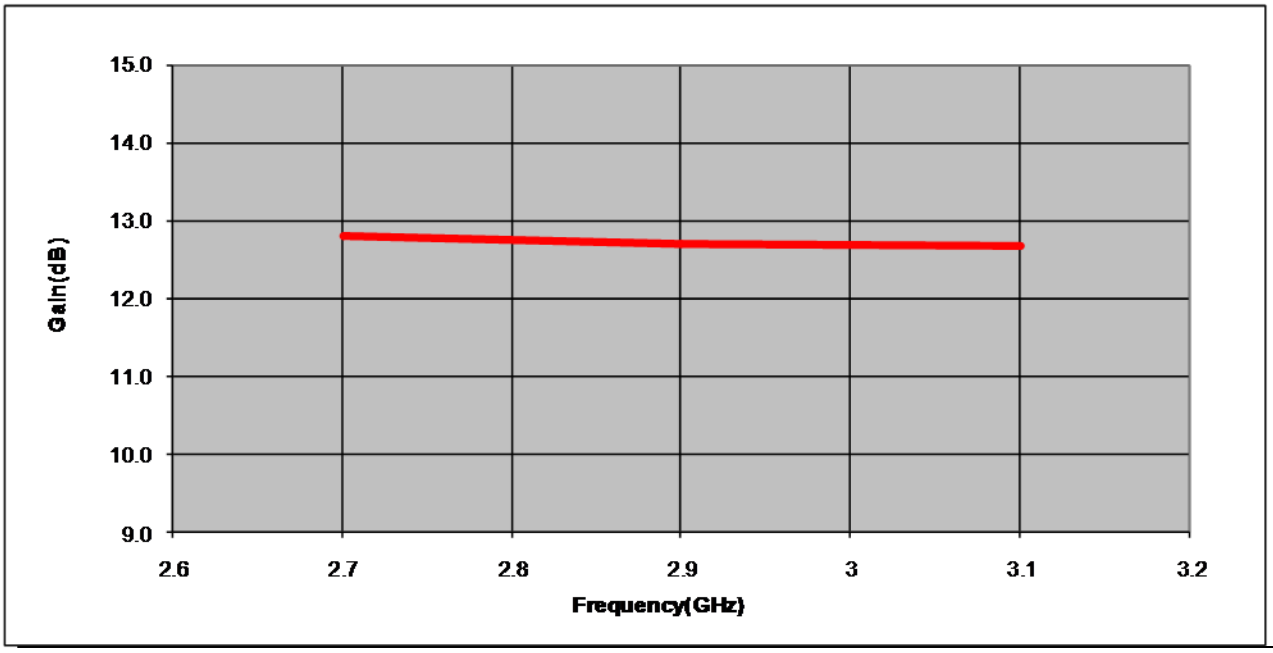
GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 30Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

RF Power Transfer Curve at 65V Drain Bias, Idq=0.25A
Output Power vs. Input Power



RF Power Transfer Curve at 65V Drain Bias, Idq=0.25A



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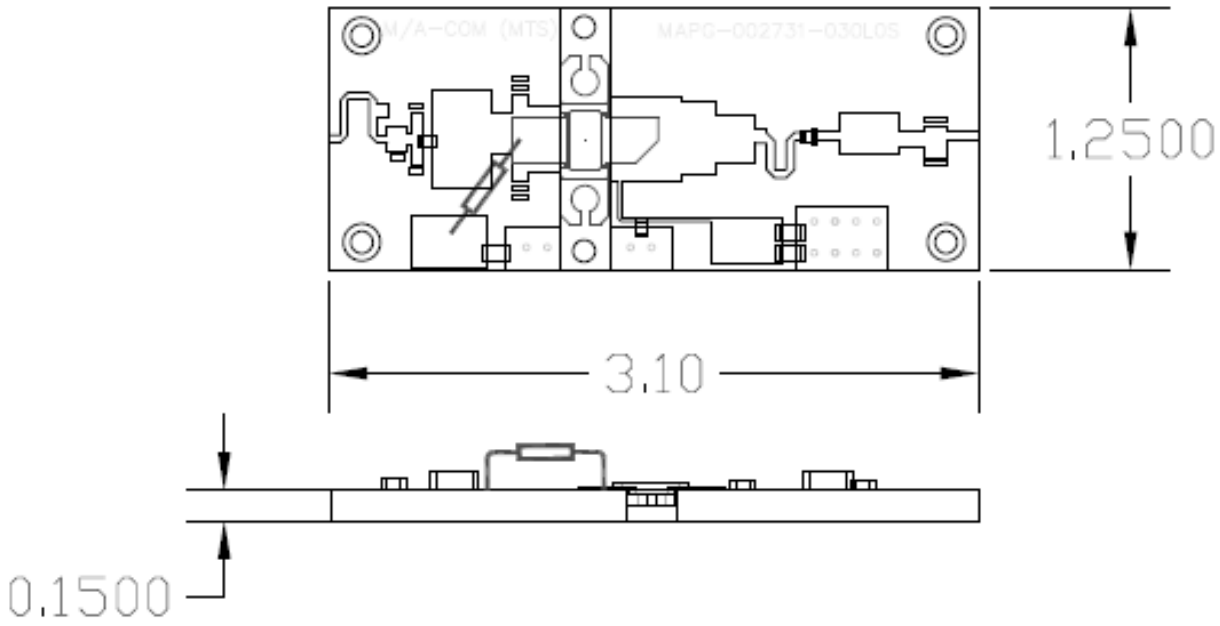
Outline Drawing



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAPG-002731-100L00

GaN HEMT Pulsed Power Pallet
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 20 Dec 10

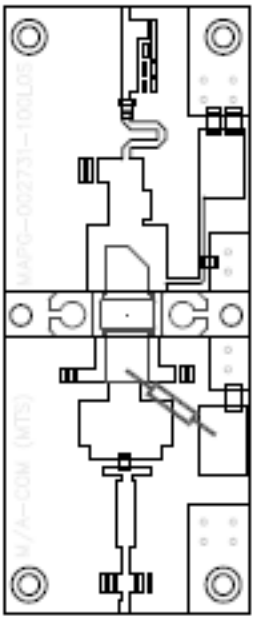
Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Input and output matched to 50Ω
- RoHS Compliant
- Designed for pulsed or CW applications

Description

The MAPG-002731-100L00 is a common-source, Class-AB, S-Band 50Ω pallet amplifier designed to streamline time-to-market. The pallet includes a gain compensation network at the input for ultra-flat gain vs. frequency response. Two mirror image configurations are available to facilitate combining.

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	195	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 100W	$R_{TH(JC)}$	0.9	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	Id-Pk (A)	Eff (%)
2700	6.0	103.7	12.4	3.9	52.7
2900	6.0	103.2	12.4	3.9	52.8
3100	6.0	101.3	12.3	3.9	52.6

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=500mA (pulsed), F=2.7—3.1 GHz, Pulse=500us, Duty=10%.

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GaN HEMT Pulsed Power Pallet
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 20 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	600	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	9.3	11.7	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	2.3	7	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 5.0mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 7A	G_M	0.4	0.6	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable—Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{DS}	-	30.3	35.4	pF
Feedback Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{GD}	-	2.8	5.4	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	P_{OUT}	100	105	-	W
Power Gain	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 100Wpk	G_P	12	12.6	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	η_D	50	53	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-T	10:1	-	-	-

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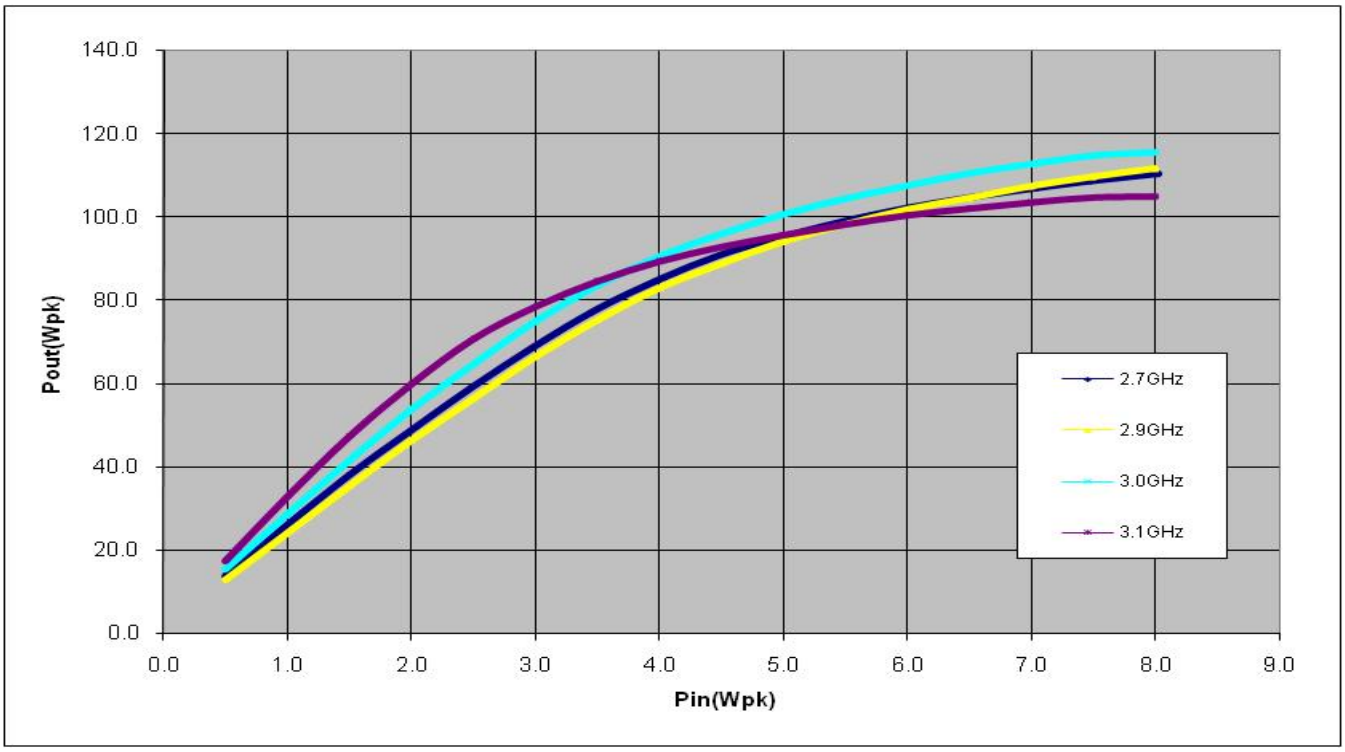
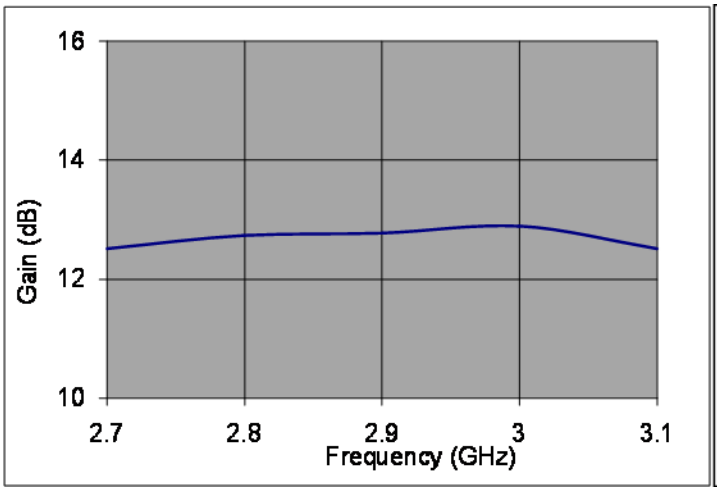
GaN HEMT Pulsed Power Pallet
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 20 Dec 10

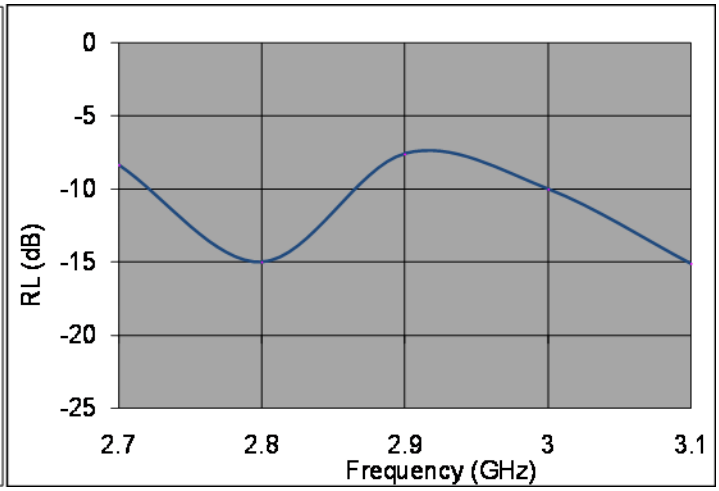
RF Power Transfer Curve at 50V Drain Bias, Idq=0.5A
Output Power vs. Input Power



Gain vs. Frequency
50V Drain Bias, Idq=0.5A



Return Loss vs. Frequency
50V Drain Bias, Idq=0.5A



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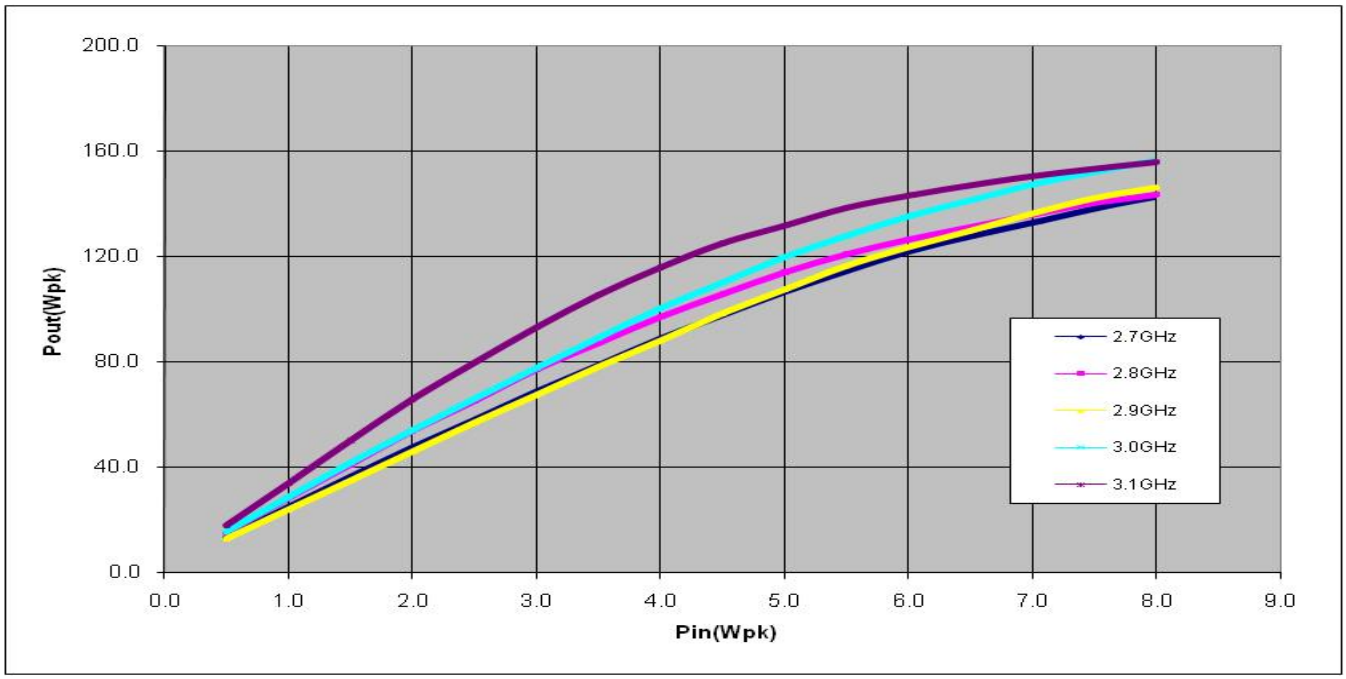
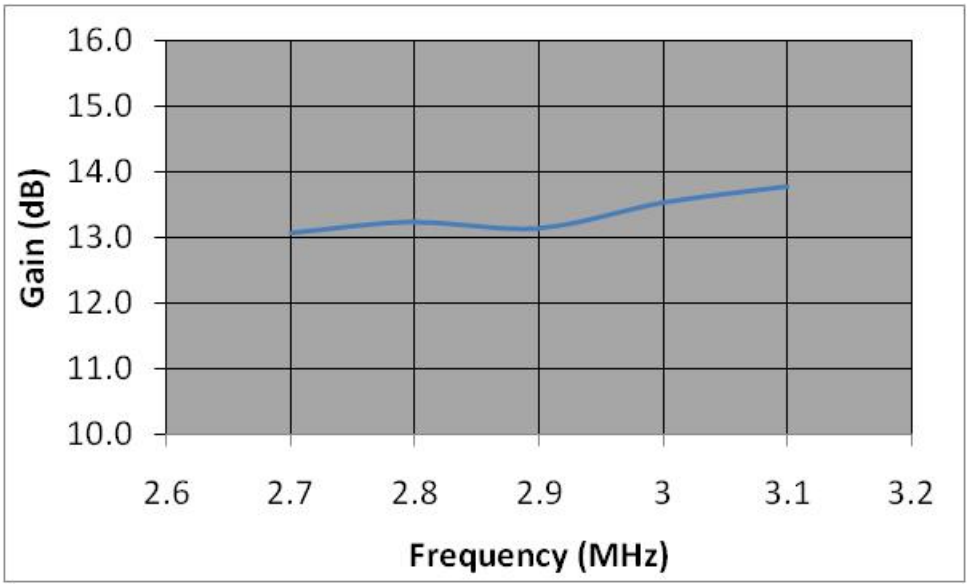
GaN HEMT Pulsed Power Pallet
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Preliminary, 20 Dec 10

RF Power Transfer Curve at 65V Drain Bias, Idq=0.5A
Output Power vs. Input Power



Gain vs. Frequency
65V Drain Bias, Idq=0.5A



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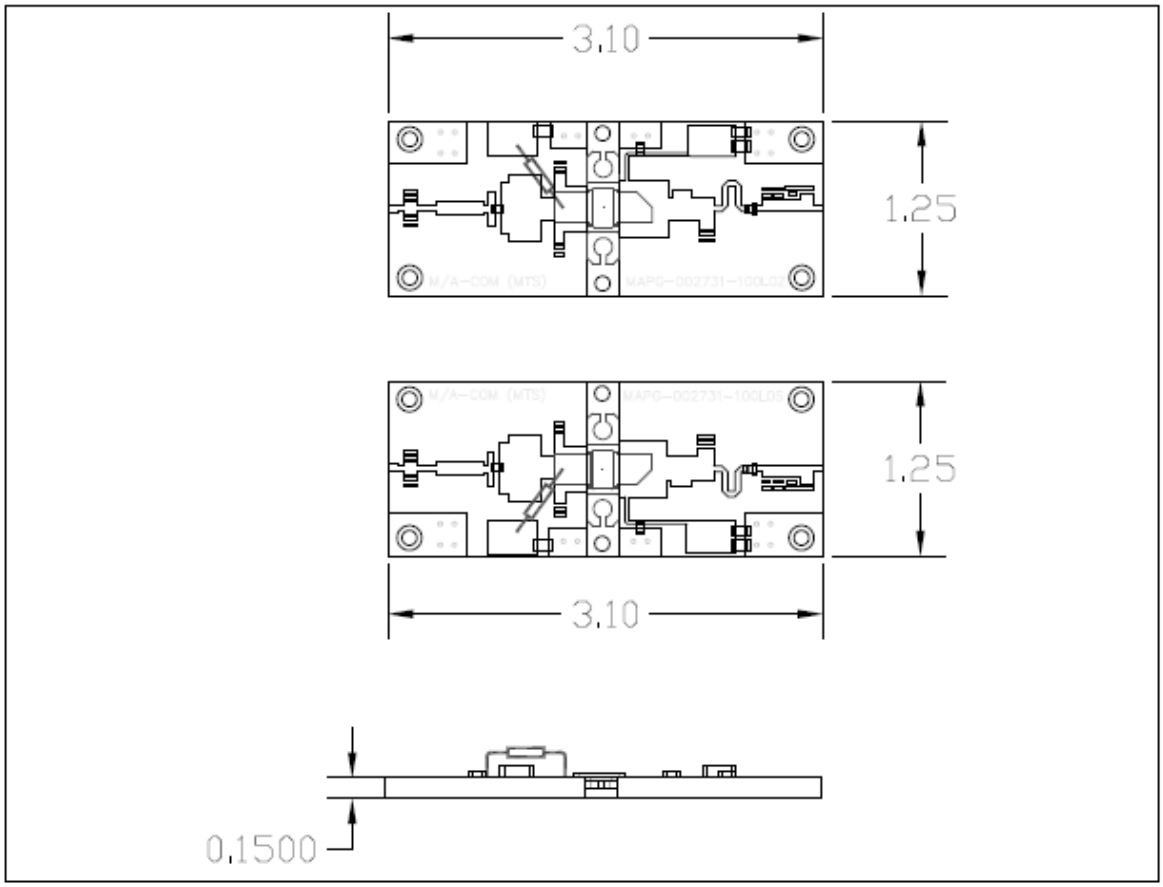
GaN HEMT Pulsed Power Pallet **Preliminary, 20 Dec 10**
100W, 2.7 - 3.1 GHz, 500us Pulse, 10% Duty

Outline Drawings



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAPG-002731-180L00

GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

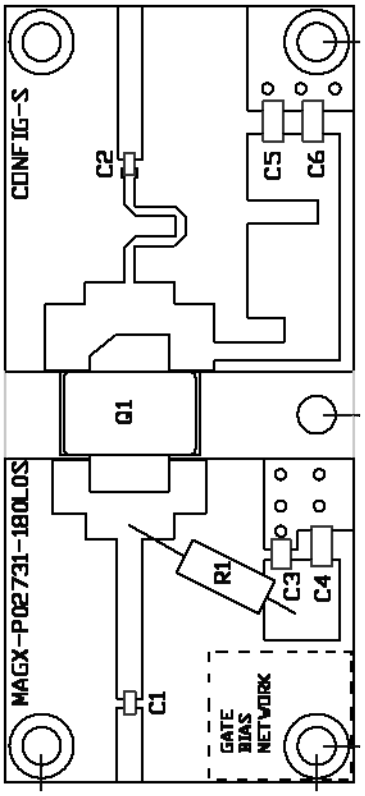
Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Input and output matched to 50Ω
- RoHS Compliant
- Designed for pulsed or CW applications

Description

The MAPG-002731-180L00 is a common-source, Class-AB, S-Band 50Ω pallet amplifier designed to streamline time-to-market. The pallet includes a gain compensation network at the input for ultra-flat gain vs. frequency response. Two mirror image configurations are available to facilitate combining.

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	330	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Typical RF Performance

50V, 500us, 10%

Freq	Pin	Pout	Gain	Flat	Eff	Droop
(MHz)	(Wpk)	(Wpk)	(dB)	(dB)	(%)	(dB)
2700	14	198.2	11.5	- -	50.4	0.58
2800	14	213.1	11.8	- -	49.9	0.55
2900	14	203.2	11.6	- -	46.8	0.58
3000	14	201.2	11.6	- -	48.8	0.53
3100	14	183.2	11.2	0.65	48.3	0.53

50V, 300us, 10%

Freq	Pin	Pout	Gain	Flat	Eff	Droop
(MHz)	(Wpk)	(Wpk)	(dB)	(dB)	(%)	(dB)
2700	14	193.6	11.4	- -	48.9	0.45
2800	14	208.0	11.7	- -	48.6	0.43
2900	14	199.3	11.5	- -	45.8	0.44
3000	14	199.3	11.5	- -	47.7	0.45
3100	14	185.8	11.2	0.52	47.5	0.41

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=500mA (pulsed gate bias), F=2.7- 3.1 GHz, Pulse Width=300ms, Duty=10%.

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GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	1.4	mA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	18.7	23.3	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	4.7	14	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 23mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 14A	G_M	1.7	6.5	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable - Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	26.1	30.3	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	2.3	4.7	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	P_{OUT}	180	190	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 180Wpk	G_P	10.5	11.5	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	η_D	43	50	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	VSWR-S	5:1	-		-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 14Wpk	VSWR-T	10:1	-		-

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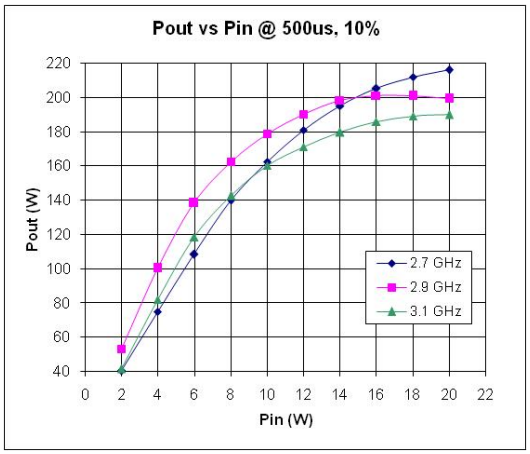
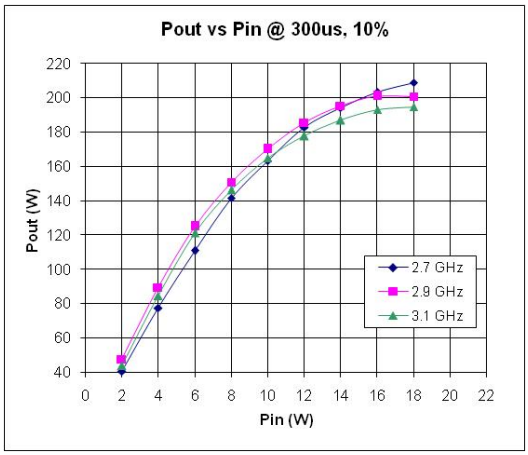
GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

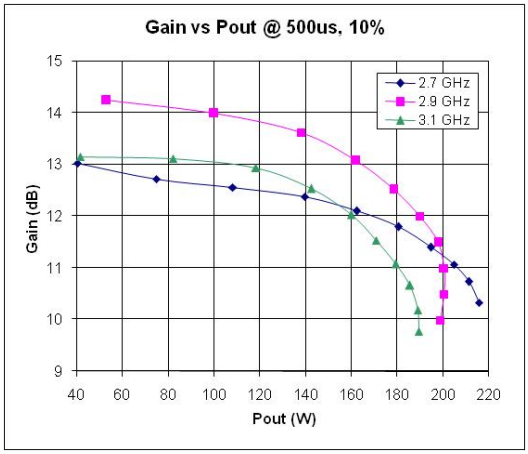
Preliminary, 20 Dec 10

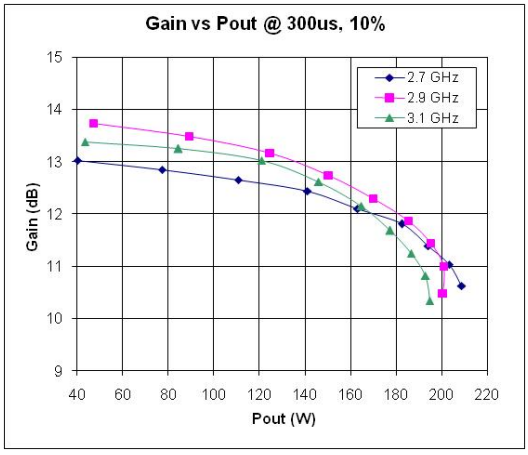
RF Power Transfer Curve
Output Power vs. Input Power



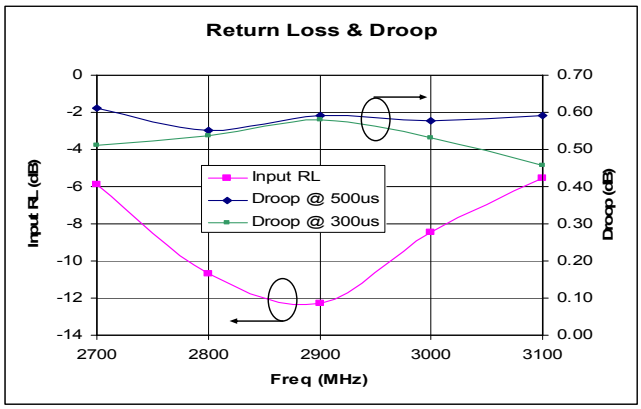


RF Power Transfer Curve
Power Gain vs. Output Power





Input VSWR & Droop (Typ)



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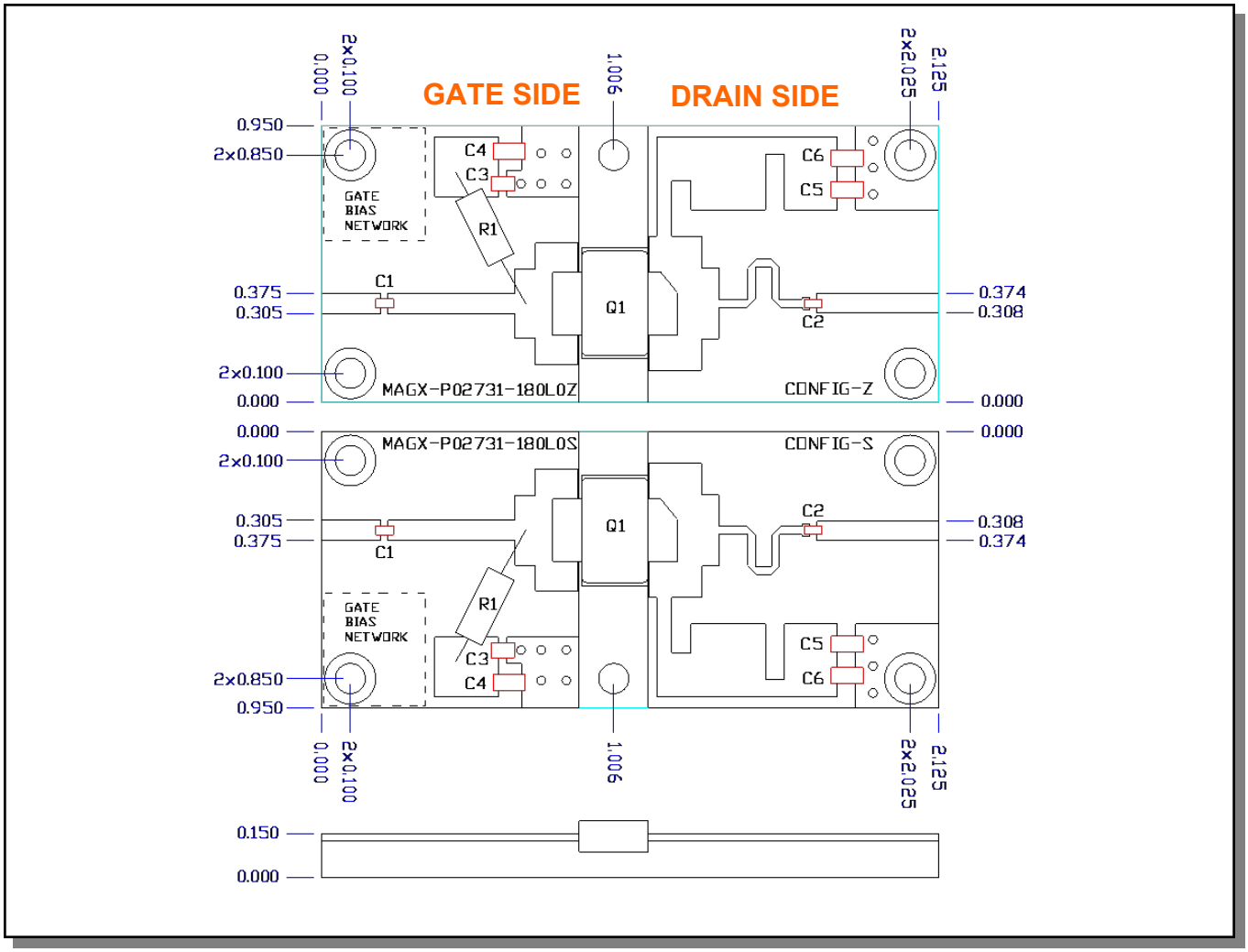
GaN HEMT Pulsed Power Pallet
2.7 - 3.1 GHz, 180Wpk, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Outline Drawing



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAPG-003135-030L00

GaN HEMT Pulsed Power Pallet
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 20 Dec 10

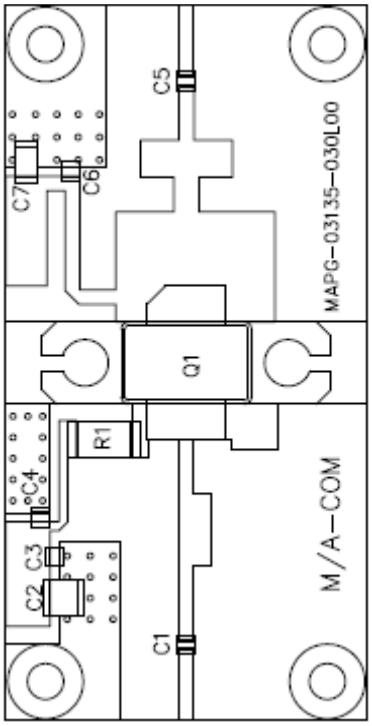
Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Input and output matched to 50Ω
- RoHS Compliant
- Designed for pulsed or CW applications

Description

The MAPG-003135-030L00 is a common-source, Class-AB, S-Band 50Ω pallet amplifier designed to streamline time-to-market. The pallet includes a gain compensation network at the input for ultra-flat gain vs. frequency response.

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	200	V
Gate-Source Voltage	V_{GS}	+0.7 to -15	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	45	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (Tj<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 130mA, Pout = 30Wpk	$R_{TH(JC)}$	2.0	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	RL (dB)	Eff (%)
3100	3	40	11.2	6.4	59.3
3300	3	40	11.2	10.4	57.7
3500	3	34	10.5	16.2	51.2

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=250mA (pulsed), F=3.1-3.5GHz, Pulse=500ms, Duty=10%.

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GaN HEMT Pulsed Power Pallet
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 20 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	300	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	4	5	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	1	3	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 5.0mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 3A	G_M	1	1.4	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	V_{DS} = 0v, V_{GS} = -8V, F = 1MHz	C_{ISS}	-	13.2	15	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	5.6	6.5	pF
Reverse Transfer Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	0.5	1.0	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	P_{OUT}	30	40	-	Wpk
Power Gain	V_{DD} = 50V, I_{DQ} = 130mA, Pout = 30Wpk	G_P	10.0	11.0	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	η_D	50	55	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	VSWR-S	5:1	-		-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 130mA, Pin = 3Wpk	VSWR-T	10:1	-		-

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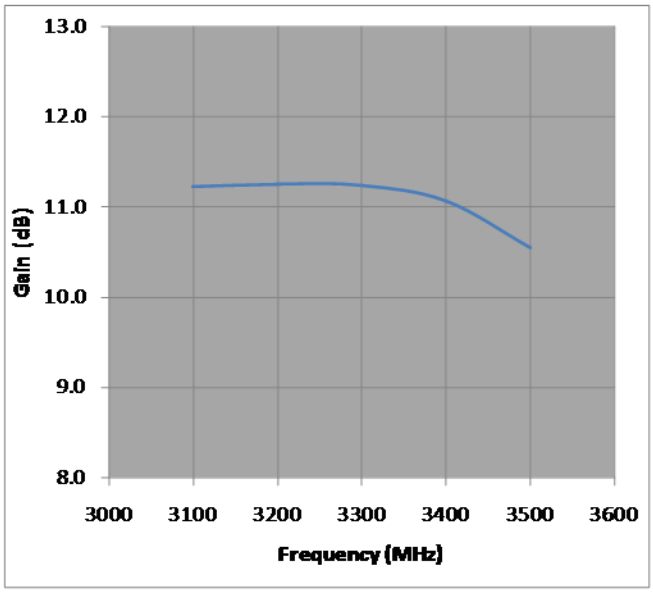
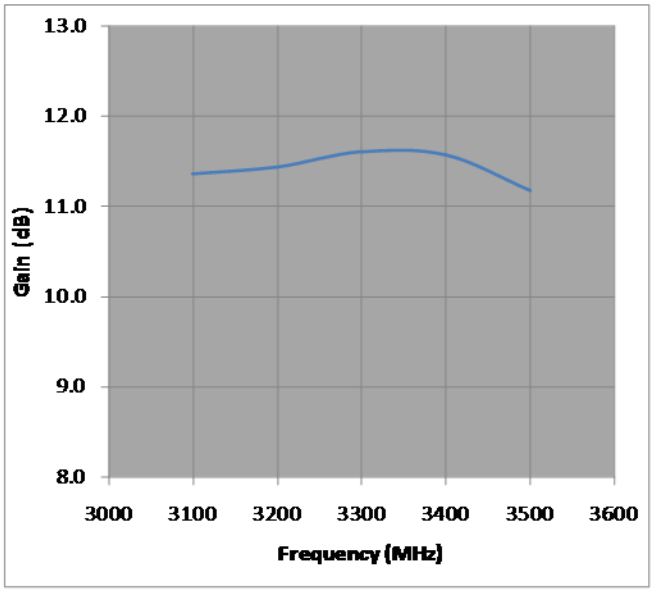
GaN HEMT Pulsed Power Pallet
3.1 - 3.5 GHz, 30Wpk, 500us Pulse, 10% Duty Cycle

Preliminary, 20 Dec 10

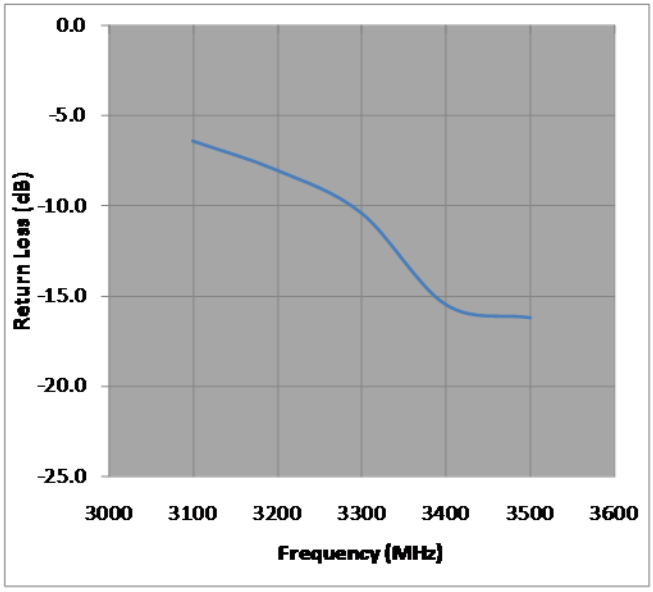
Gain vs. Frequency
50V Drain Bias, Idq=0.13A



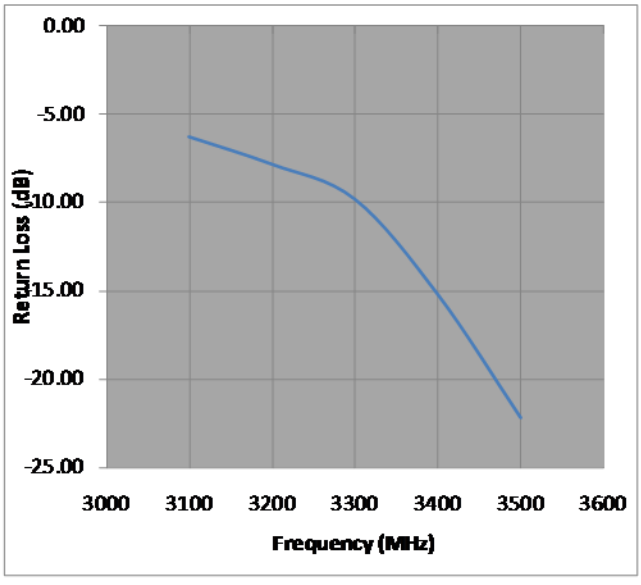
Gain vs. Frequency
65V Drain Bias, Idq=0.13A



Return Loss vs. Frequency
50V Drain Bias, Idq=0.13A



Return Loss vs. Frequency
65V Drain Bias, Idq=0.13A



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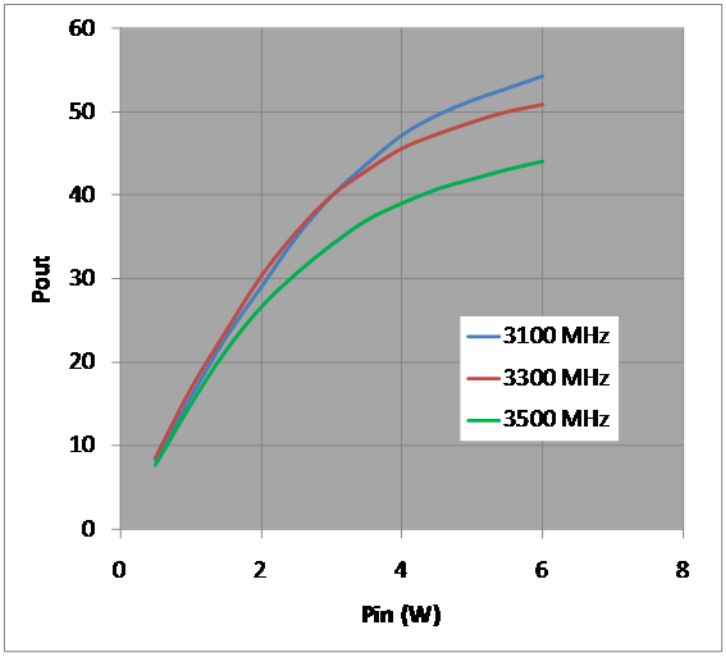
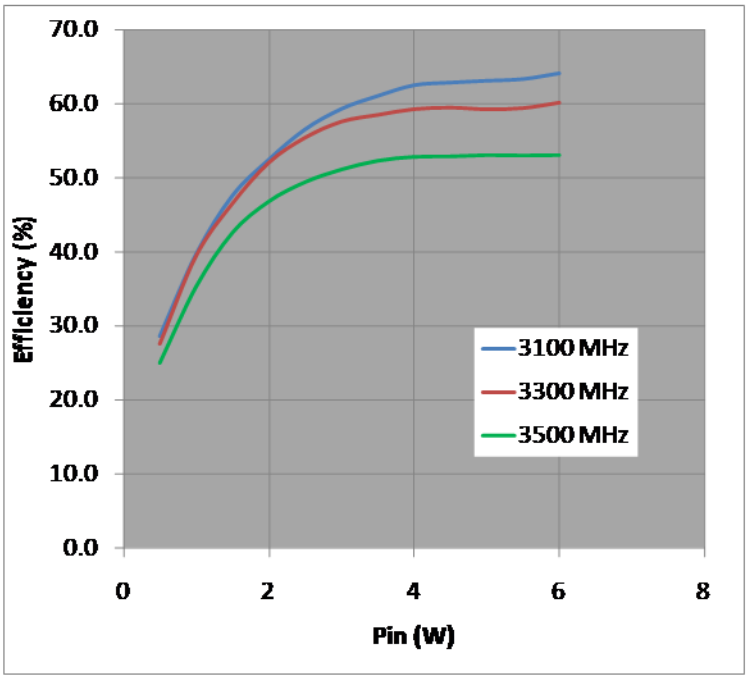
Output Power vs. Input Power
50V Drain Bias, Idq=0.13A



Drain Efficiency vs. Input Power
50V Drain Bias, Idq=0.13A



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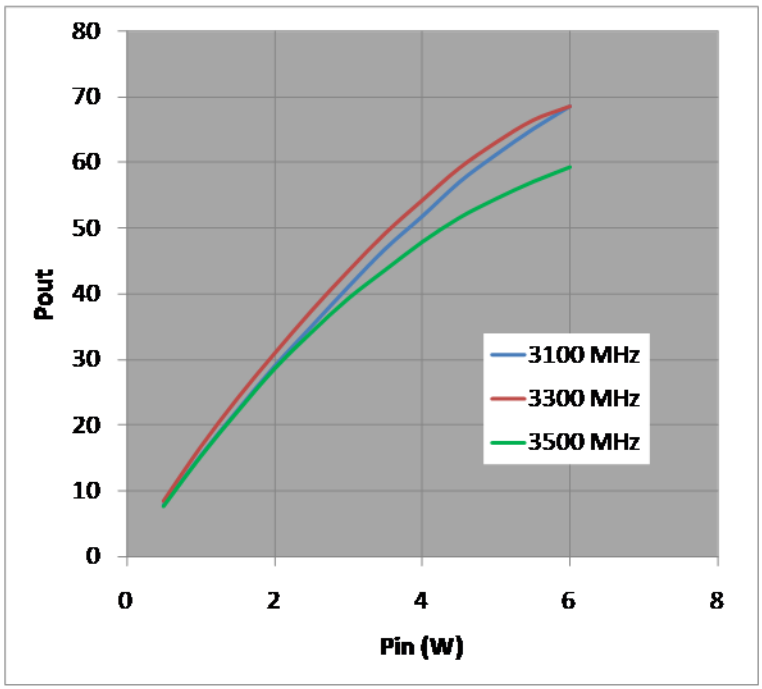
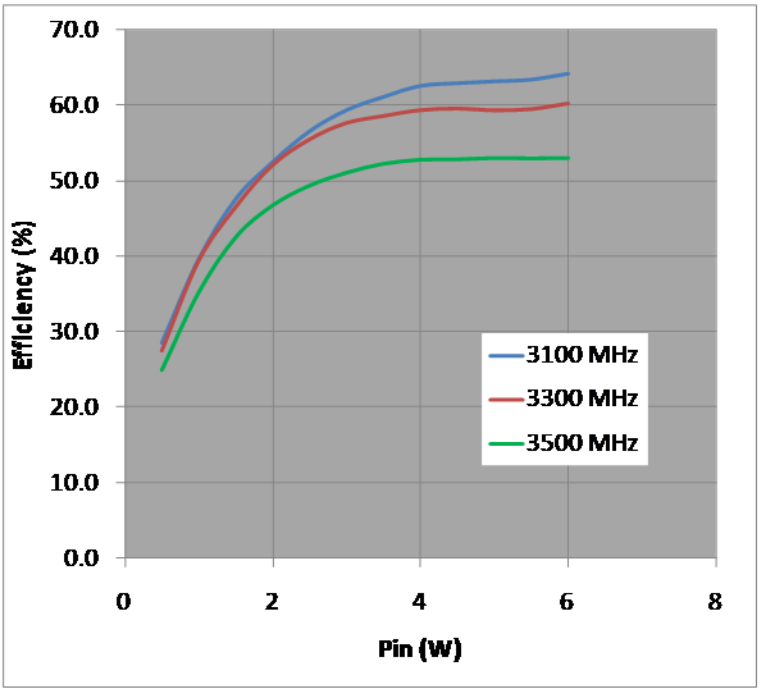
Output Power vs. Input Power
65V Drain Bias, Idq=0.13A



Drain Efficiency vs. Input Power
65V Drain Bias, Idq=0.13A



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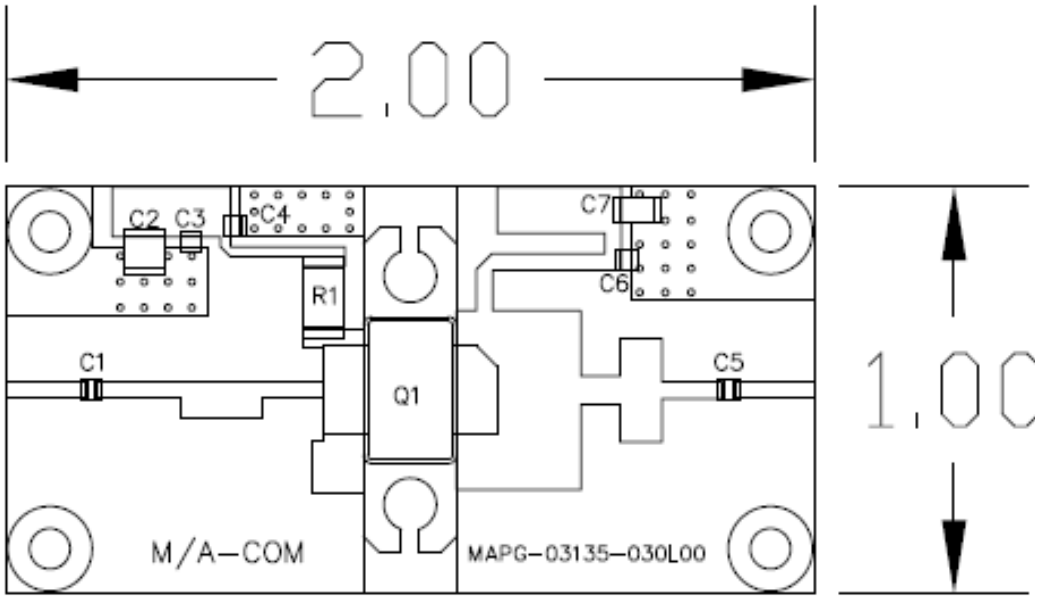
Outline Drawings



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAPG-003135-090L00

GaN HEMT Pulsed Power Pallet
90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

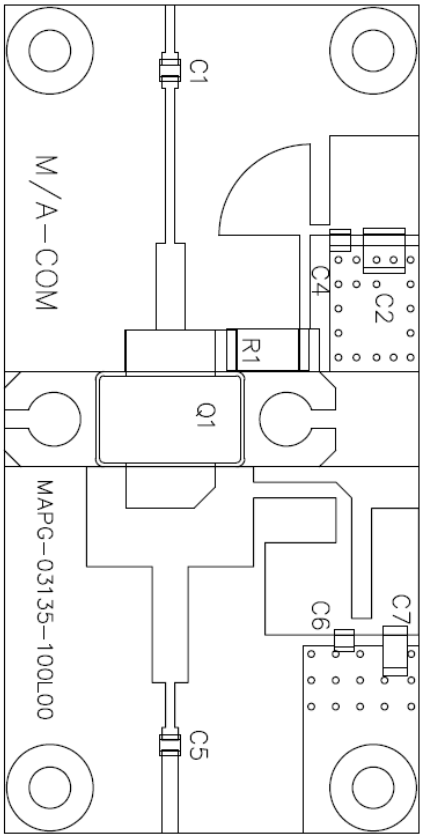
Features

- GaN HEMT S-Band Power Transistor
- Common Source Configuration
- Broadband Class AB Operation
- Input and output matched to 50Ω
- RoHS Compliant
- Designed for pulsed or CW applications
- Optimized for 65V Operation

Description

The MAPG-003135-090L00 is a common-source, Class-AB, S-Band 50Ω pallet amplifier designed to streamline time-to-market. The pallet includes a gain compensation network at the input for ultra-flat gain vs. frequency response. Two mirror image configurations are available to facilitate combining.

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	195	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 65V, I_{DQ} = 500mA, Pout = 100W	$R_{TH(JC)}$	0.9	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	RL (dB)	Eff (%)
3100	9	112	11.0	-15	46
3300	9	108	10.9	-15	49
3500	9	92	10.1	-12	43

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=65V, Idq=500mA (pulsed), F=3.1 - 3.5 GHz, Pulse=300us, Duty=10%.

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90W, 3.1 - 3.5 GHz, 300us Pulse, 10% Duty

Preliminary, 20 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	600	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	9.3	11.7	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	2.3	7	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 12mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 7A	G_M	0.4	0.6	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable - Input internally matched	C_{GS}	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{DS}	-	30.3	35.4	pF
Feedback Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{GD}	-	2.8	5.4	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	P_{OUT}	90	100	-	W
Power Gain	V_{DD} = 65V, I_{DQ} = 500mA, Pout = 100Wpk	G_P	10	10.5	-	dB
Drain Efficiency	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	η_D	40	43	-	%
Load Mismatch Stability	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 65V, I_{DQ} = 500mA, Pin = 6Wpk	VSWR-T	10:1	-	-	-

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GaN HEMT Pulsed Power Pallet
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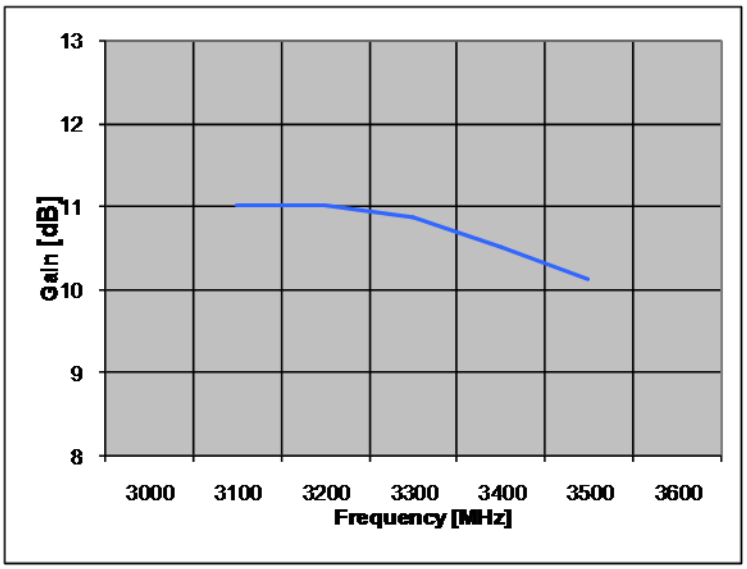
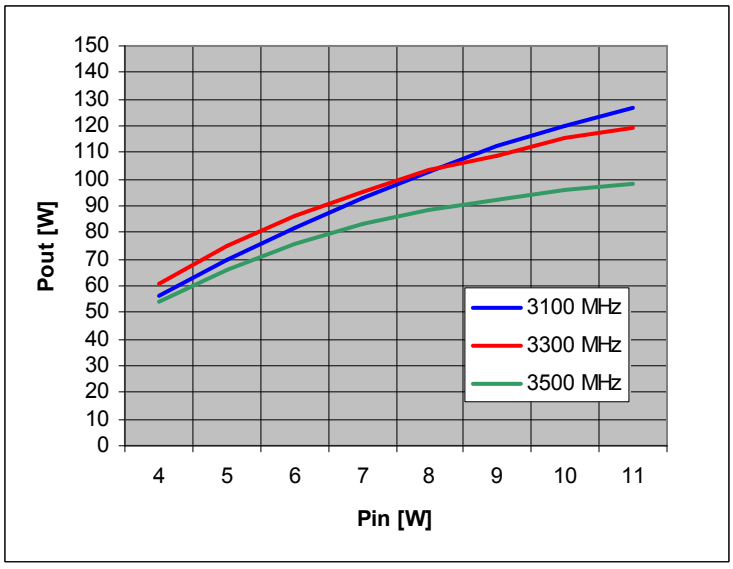
Preliminary, 20 Dec 10

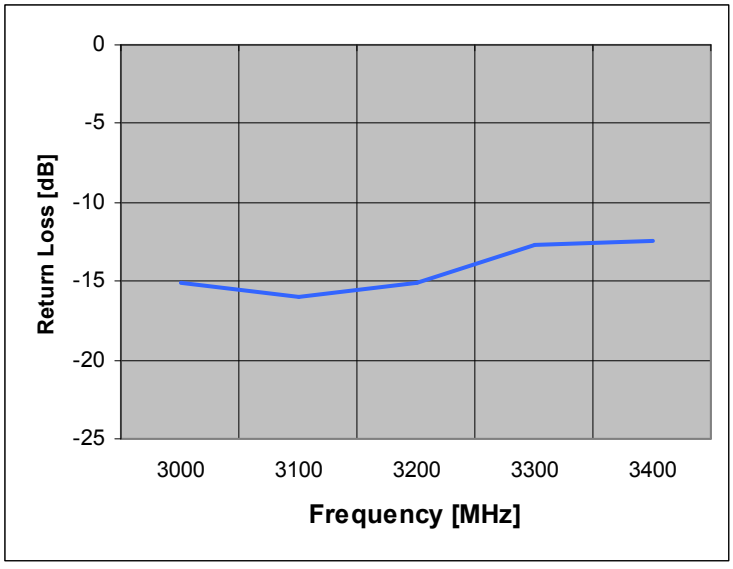
Gain vs. Frequency
65V Drain Bias, Idq=0.5A



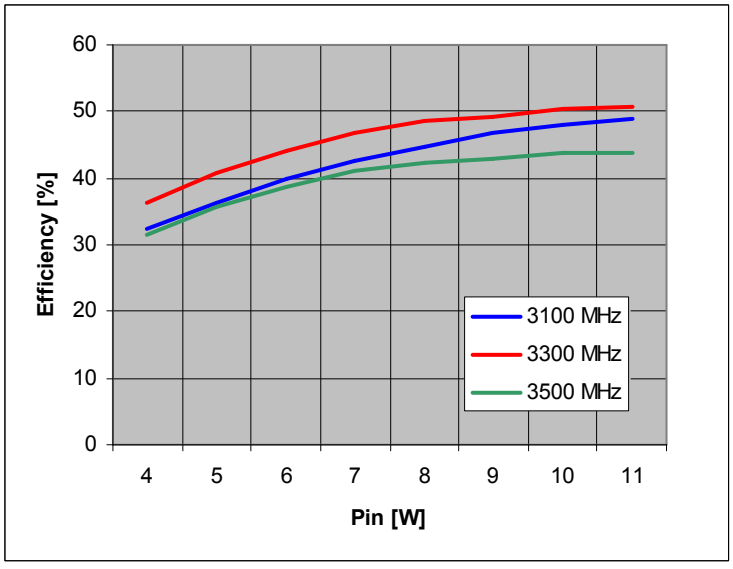
Output Power vs. Input Power
65V Drain Bias, Idq=0.5A



Return Loss vs. Frequency
65V Drain Bias, Idq=0.5A



Drain Efficiency vs. Input Power
65V Drain Bias, Idq=0.5A



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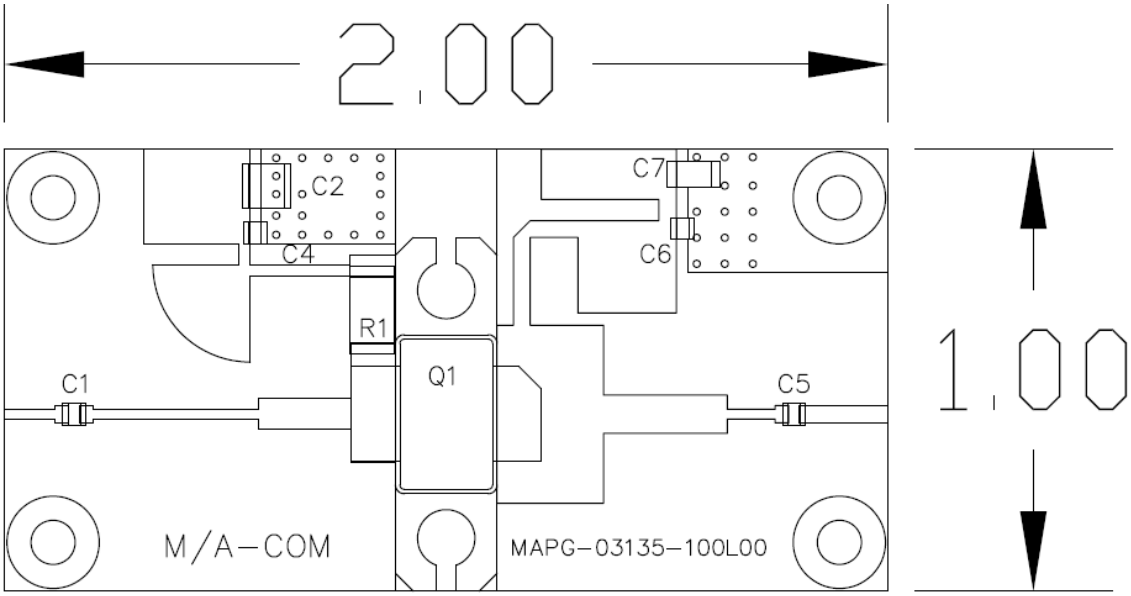
Outline Drawing



CORRECT DEVICE SEQUENCING

TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V)
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 0V
4. Turn off V_{GS}

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MAGX-001220-100

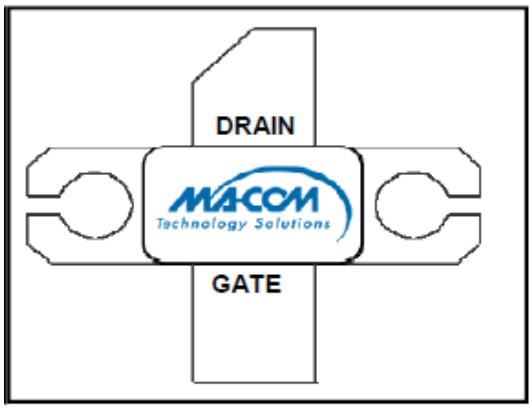
GaN HEMT Power Transistor
100W, 1.2—2.0 GHz

Preliminary, 16 Dec 10

Features

- GaN HEMT microwave power transistor
- Common source configuration
- Broadband Class AB operation
- Thermally enhanced Cu/Mo/Cu package
- RoHS Compliant
- Designed for pulsed or CW applications

Product Image



Absolute Maximum Ratings at 25°C

Parameter	Symbol	Rating	Units
Drain-Source Voltage	V_{DSS}	175	V
Gate-Source Voltage	V_{GS}	-8 to +2	V
Total Power Dissipation (T_C = 25°C)	P_{TOT}	194	W
Storage Temperature	T_{STG}	-65 to +150	°C
Junction Temperature	T_J	200	°C
ESD Classification		1A	
MTTF (T_J<200°C)		114	yrs

Thermal Characteristics

Parameter	Test Conditions	Symbol	Max	Units
Thermal Resistance, Junction to Case	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 100W	$R_{TH(JC)}$	0.9	°C/W

Typical RF Performance

Freq. (MHz)	Pin (W)	Pout (W)	Gain (dB)	Id-Pk (A)	Eff (%)
1200	4	100	13.9	3.7	55
1400	4	102	14.0	3.9	53
1600	4	106	14.2	4.0	53
1800	4	110	14.4	4.0	55
2000	4	115	14.6	4.0	57

Typical RF performance measured in M/A-COM RF test fixture. Devices tested in common source Class-AB configuration as follows: Vdd=50V, Idq=500mA (pulsed), F=1.2—2.0 GHz, Pulse=300us, Duty=10%.

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GaN HEMT Power Transistor 100W, 1.2—2.0 GHz

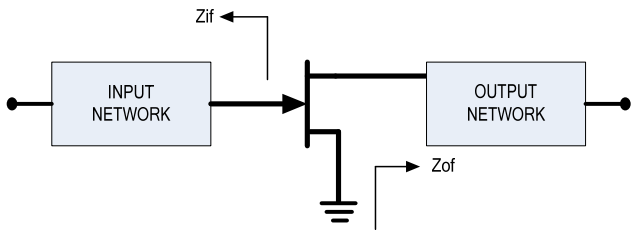
Preliminary, 16 Dec 10

Electrical Specifications: T_C = 25 ± 5°C (Room Ambient)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
DC CHARACTERISTICS						
Drain-Source Leakage Current	V_{GS} = -8V, V_{DS} = 175V	I_{DS}	-	-	600	µA
Saturated Drain Current	V_{GS} = 0V, V_{DS} = 5V	I_{DS}	-	9.3	11.7	A
Gate-Source Leakage Current	V_{GS} = -8V, V_{DS} = 0V	I_{GSO}	-	2.3	7	µA
Gate Threshold Voltage	V_{DS} = 5V, I_D = 12mA	$V_{GS\ (th)}$	-5	-3	-2	V
Forward Transconductance	V_{DS} = 5V, I_D = 7A	G_M	0.4	0.6	-	S
DYNAMIC CHARACTERISTICS						
Input Capacitance	Not applicable—Input internally matched	N/A	N/A	N/A	N/A	pF
Output Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{OSS}	-	30.3	35.4	pF
Feedback Capacitance	V_{DS} = 50V, V_{GS} = -8V, F = 1MHz	C_{RSS}	-	2.8	5.4	pF
RF FUNCTIONAL TESTS						
Output Power	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 4W	P_{OUT}	100	110	-	W
Power Gain	V_{DD} = 50V, I_{DQ} = 500mA, Pout = 100W	G_P	13.5	14.0	-	dB
Drain Efficiency	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 4W	η_D	50	55	-	%
Load Mismatch Stability	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 4W	VSWR-S	5:1	-	-	-
Load Mismatch Tolerance	V_{DD} = 50V, I_{DQ} = 500mA, Pin = 4W	VSWR-T	10:1	-	-	-

Test Fixture Impedance

F (MHz)	Z_{IF} (Ω)	Z_{OF} (Ω)
1200	4.07 - j2.35	8.6 + j1.1
1400	4.24 - j1.64	6.9 + j0.16
1600	5.39 - j2.29	6.8 + j0.7
1800	3.01 - j3.62	6.1 - j0.6
2000	1.50 - j2.02	3.2 + j0.39



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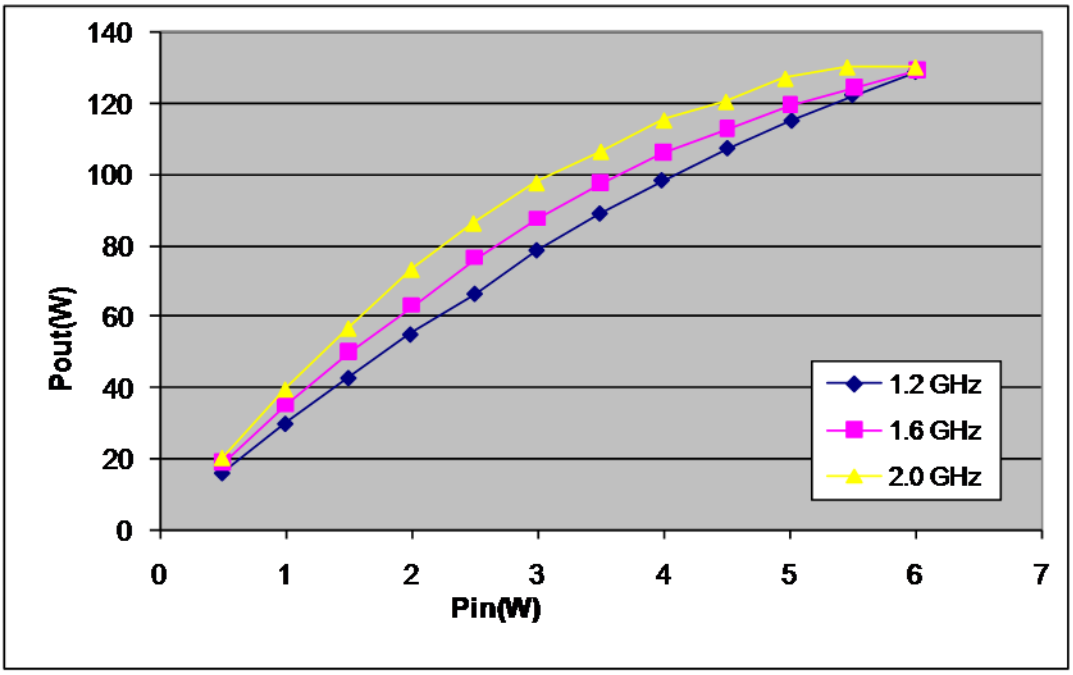
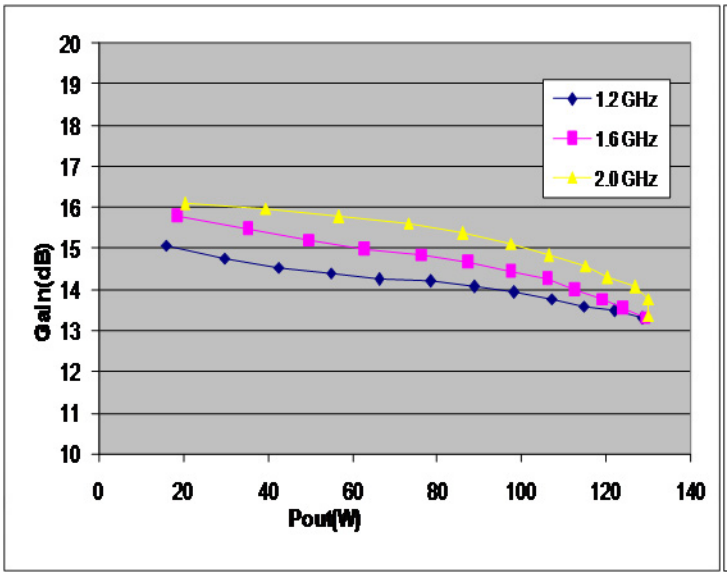
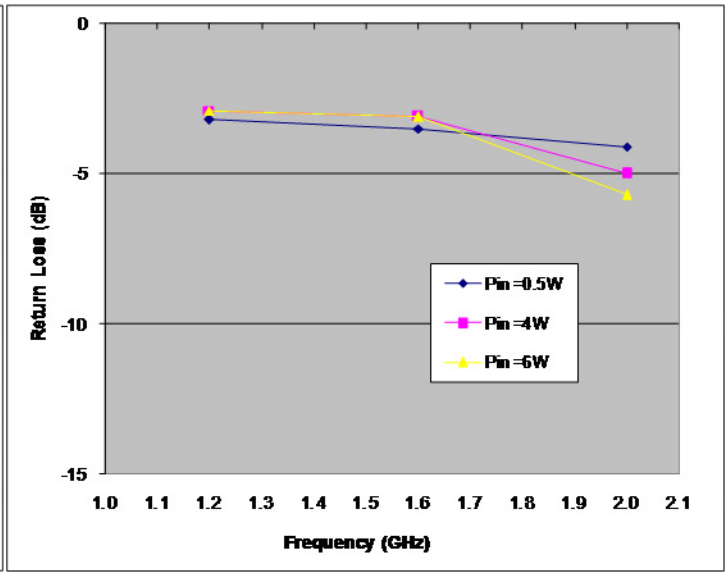
RF Power Transfer Curve
Output Power vs. Input Power



RF Power Transfer Curve
Power Gain vs. Output Power



Return Loss vs. Frequency



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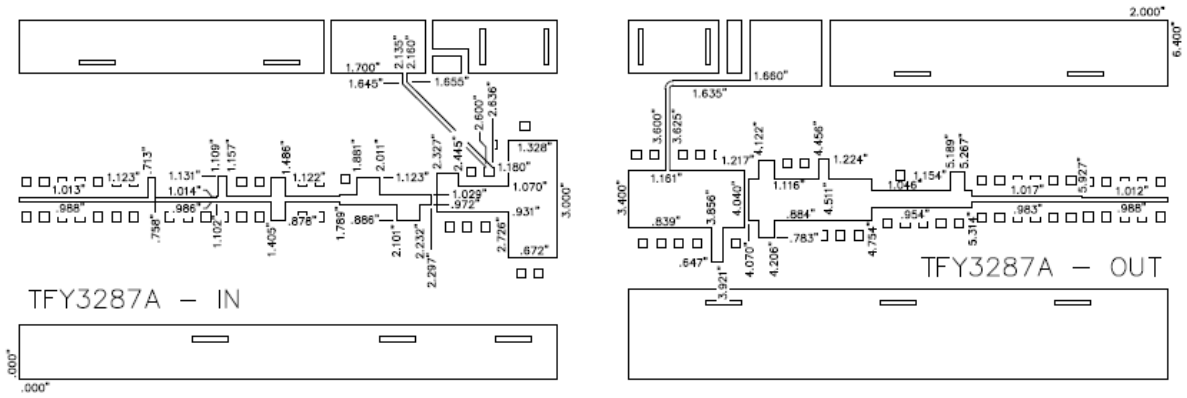
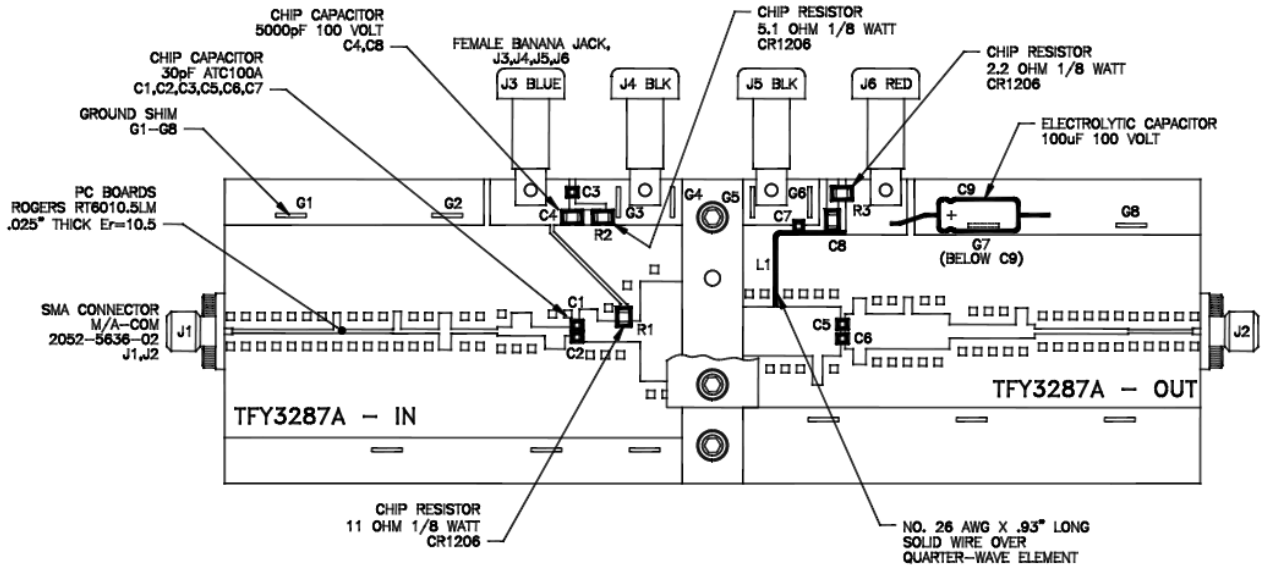
Test Fixture Circuit Dimensions



Note: A .dwg circuit drawing is available upon request

Test Fixture Assembly



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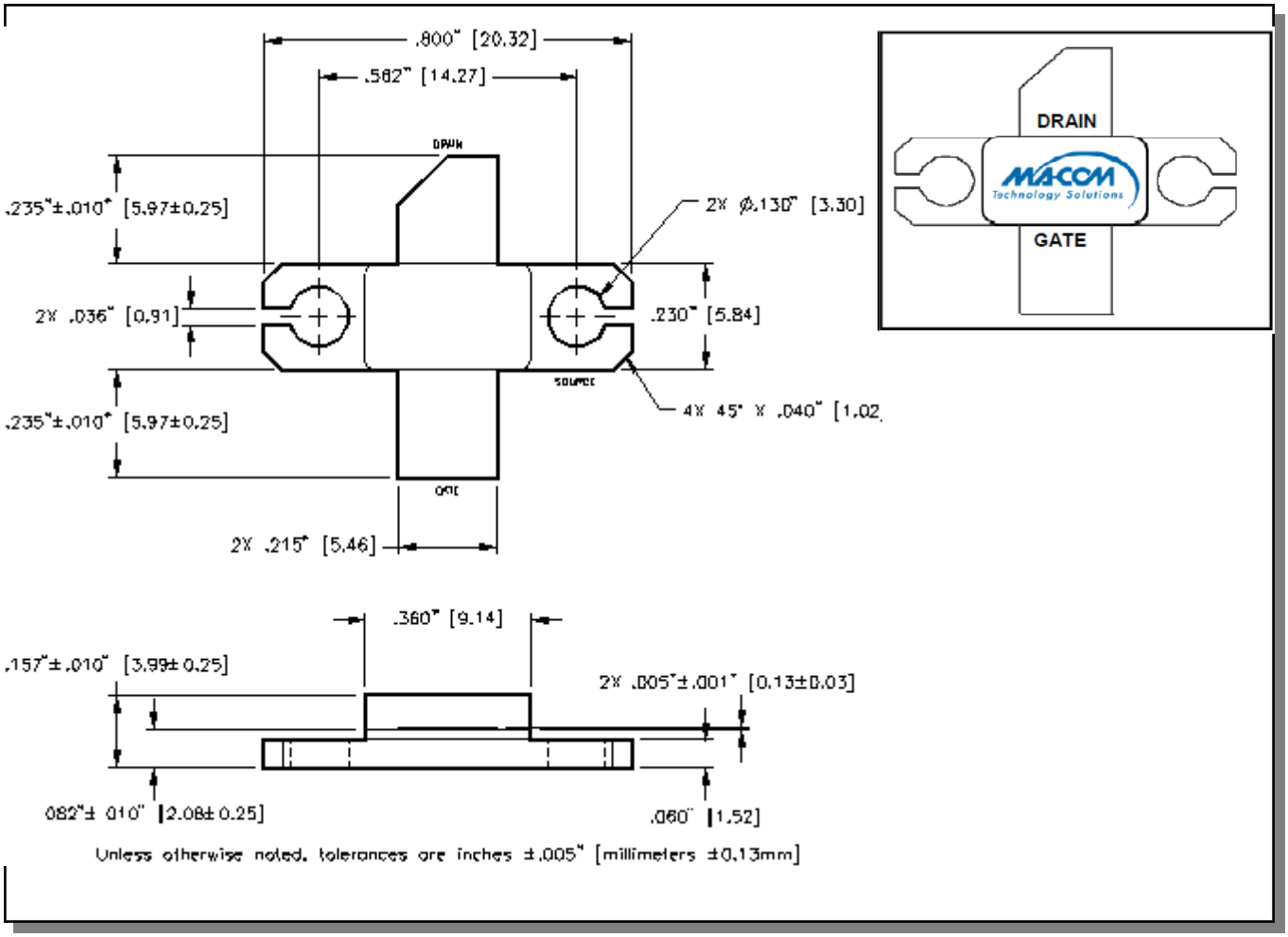
Outline Drawings



CORRECT DEVICE SEQUENCING

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1. Set V_{GS} to the pinch-off (V_P), typically -5V
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Application Note
GaN HEMT Transistor Biasing

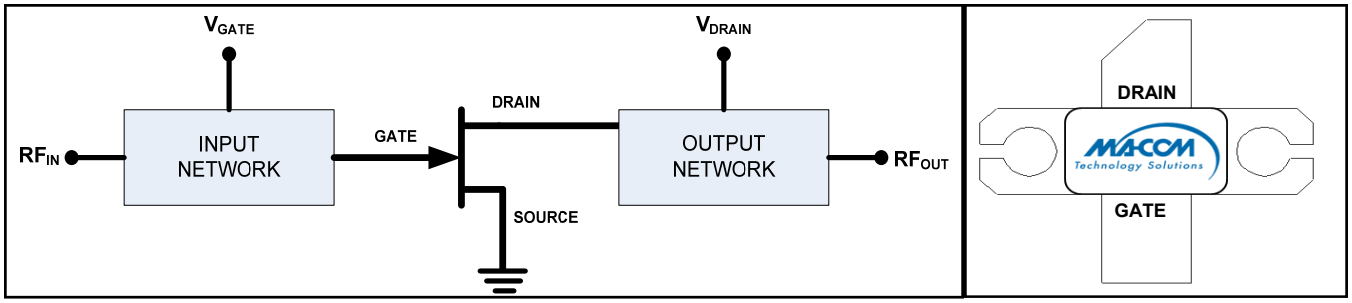
Rev. 06 Dec 10

BACKGROUND

This application note provides the correct biasing sequence for M/A COM Technology Solution's GaN HEMT power transistors.

GaN HEMTs are depletion mode devices which require both a negative voltage applied to the gate as well as a positive voltage applied to the drain. The devices are particularly sensitive to the order at which the biases are applied and removed. Failure to properly sequence the voltages will likely lead to permanent damage.

To illustrate a specific device, M/A COM Tech's MAGX-002731-0030L00 device will be considered in this application note. This 30W device is optimized for 2.7 - 3.1 GHz bandwidth and operates at 50V with 250mA quiescent current. The device is assumed to be operating with proper 50 Ohm input and output matching structures and decoupled power supplies.



TURNING THE DEVICE ON

1. Set V_{GS} to the pinch-off voltage (V_P), typically -5V
2. Turn on V_{DS} to nominal voltage (50V for MAGX-002731-0030)
3. Increase V_{GS} until the required quiescent current is reached (250mA for MAGX-002731-0030)
4. Apply RF power to desired level

TURNING THE DEVICE OFF

Similarly, the recommended turn-off sequence is equally as important as the turn-on sequence to avoid damaging the device.

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

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