

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed primarily for pulsed wideband applications with frequencies up to 235 MHz. Device is unmatched and is suitable for use in industrial, medical and scientific applications.

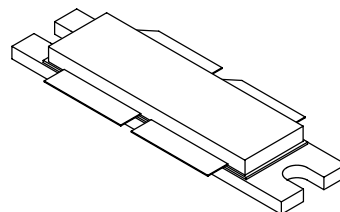
- Typical Pulsed Performance at 225 MHz:  $V_{DD} = 50$  Volts,  $I_{DQ} = 150$  mA,  $P_{out} = 1000$  Watts Peak (200 W Avg.), Pulse Width = 100  $\mu$ sec, Duty Cycle = 20%  
Power Gain — 24 dB  
Drain Efficiency — 67.5%
- Capable of Handling 10:1 VSWR, @ 50 Vdc, 225 MHz, 1000 Watts Peak Power

### Features

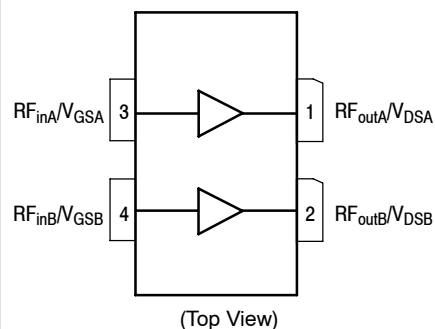
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- CW Operation Capability with Adequate Cooling
- Qualified Up to a Maximum of 50  $V_{DD}$  Operation
- Integrated ESD Protection
- Designed for Push-Pull Operation
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel.

**MRF6VP21KHR6**

**10-235 MHz, 1000 W, 50 V  
LATERAL N-CHANNEL  
BROADBAND  
RF POWER MOSFET**



**CASE 375D-05, STYLE 1  
NI-1230  
PART IS PUSH-PULL**



**Figure 1. Pin Connections**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +110	Vdc
Gate-Source Voltage	$V_{GS}$	-6, +10	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	$^{\circ}$ C
Case Operating Temperature	$T_C$	150	$^{\circ}$ C
Operating Junction Temperature (1,2)	$T_J$	225	$^{\circ}$ C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80 $^{\circ}$ C, 1000 W Pulsed, 100 $\mu$ sec Pulse Width, 20% Duty Cycle	$Z_{\theta JC}$	0.03	$^{\circ}$ C/W

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	2 (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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**Off Characteristics** <sup>(1)</sup>

Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	20	$\mu\text{Adc}$
Drain-Source Breakdown Voltage ( $I_D = 300\text{ mA}$ , $V_{GS} = 0\text{ Vdc}$ )	$V_{(BR)DSS}$	110	—	—	Vdc
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 50\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	100	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 100\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	5	mA

**On Characteristics**

Gate Threshold Voltage <sup>(1)</sup> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 1600\ \mu\text{Adc}$ )	$V_{GS(th)}$	1	1.68	3	Vdc
Gate Quiescent Voltage <sup>(2)</sup> ( $V_{DD} = 50\text{ Vdc}$ , $I_D = 150\text{ mA}$ , Measured in Functional Test)	$V_{GS(Q)}$	1.5	2.2	3.5	Vdc
Drain-Source On-Voltage <sup>(1)</sup> ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 4\text{ Adc}$ )	$V_{DS(on)}$	—	0.28	—	Vdc

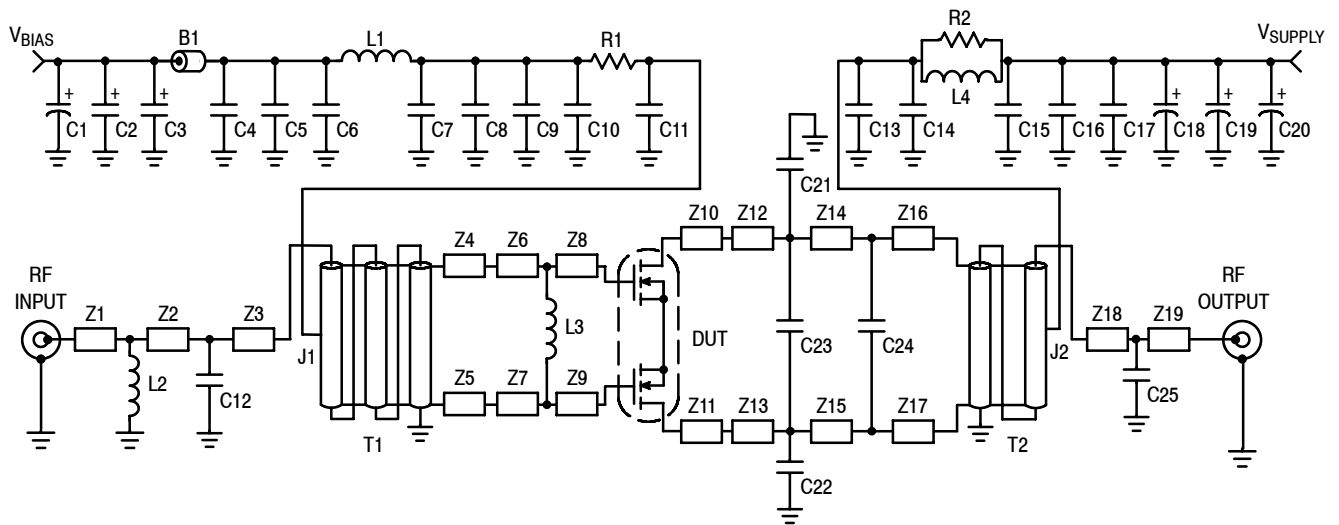
**Dynamic Characteristics** <sup>(1)</sup>

Reverse Transfer Capacitance ( $V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	3.3	—	pF
Output Capacitance ( $V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	147	—	pF
Input Capacitance ( $V_{DS} = 50\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	$C_{iss}$	—	506	—	pF

**Functional Tests** <sup>(2)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 50\text{ Vdc}$ ,  $I_{DQ} = 150\text{ mA}$ ,  $P_{out} = 1000\text{ W Peak}$  (200 W Avg.),  $f = 225\text{ MHz}$ , 100  $\mu\text{sec}$  Pulse Width, 20% Duty Cycle

Power Gain	$G_{ps}$	22	24	26	dB
Drain Efficiency	$\eta_D$	65	67.5	—	%
Input Return Loss	IRL	—	-15	-9	dB

- Each side of device measured separately.
- Measurement made with device in push-pull configuration.



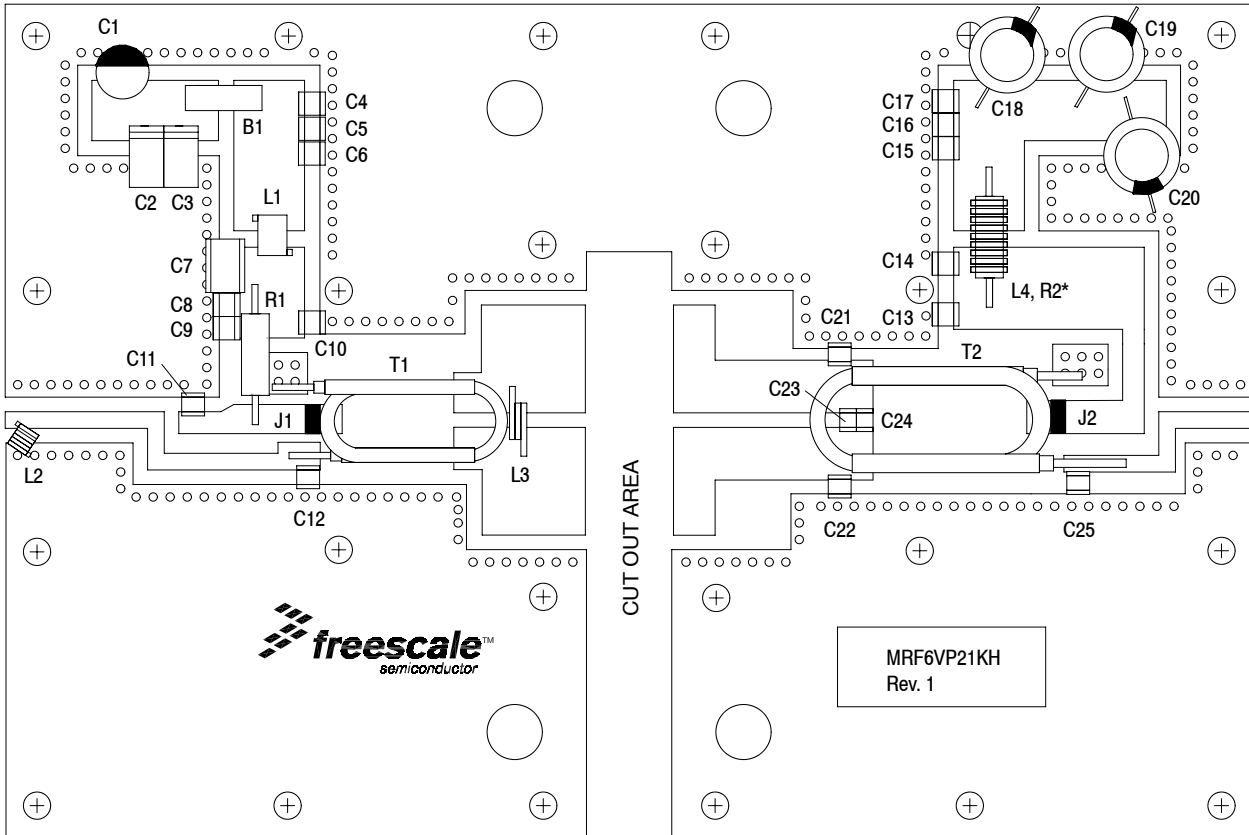
Z1	0.100" x 0.082" Microstrip	Z12, Z13	0.599" x 0.253" Microstrip
Z2*	1.557" x 0.082" Microstrip	Z14, Z15	0.110" x 0.253" Microstrip
Z3*	0.055" x 0.082" Microstrip	Z16*, Z17*	0.055" x 0.253" Microstrip
Z4, Z5	0.133" x 0.193" Microstrip	Z18	0.069" x 0.082" Microstrip
Z6, Z7	0.143" x 0.518" Microstrip	Z19	1.050" x 0.082" Microstrip
Z8, Z9	0.357" x 0.518" Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$
Z10, Z11	0.200" x 0.518" Microstrip		
		*Line length includes microstrip bends.	

**Figure 2. MRF6VP21KHR6 Test Circuit Schematic**

**Table 5. MRF6VP21KHR6 Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
B1	95 $\Omega$ , 100 MHz Long Ferrite Bead	2743021447	Fair-Rite
C1	47 $\mu$ F, 50 V Electrolytic Capacitor	476KXM050M	Illinois Cap
C2	22 $\mu$ F, 35 V Tantalum Capacitor	T491X226K035AT	Kemet
C3	10 $\mu$ F, 35 V Tantalum Capacitor	T491D106K035AT	Kemet
C4, C9, C17	10K pF Chip Capacitors	ATC200B103KT50XT	ATC
C5, C16	20K pF Chip Capacitors	ATC200B203KT50XT	ATC
C6, C15	0.1 $\mu$ F, 50 V Chip Capacitors	CDR33BX104AKYS	Kemet
C7	2.2 $\mu$ F, 50 V Chip Capacitor	C1825C225J5RAC	Kemet
C8	0.22 $\mu$ F, 100 V Chip Capacitor	C1825C223K1GAC	Kemet
C10, C11, C13, C14	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C12, C21, C22	27 pF Chip Capacitors	ATC100B270JT500XT	ATC
C18, C19, C20	470 $\mu$ F, 63 V Electrolytic Capacitors	EKME630ELL471MK25S	Multicomp
C23, C24	68 pF Chip Capacitors	ATC100B680JT500XT	ATC
C25	4.7 pF Chip Capacitor	ATC100B4R7JT500XT	ATC
J1, J2	Jumpers from PCB to T1 and T2	Copper Foil	
L1	82 nH Inductor	1812SMS-82NJC	CoilCraft
L2	8 nH Inductor	A03TKLC	CoilCraft
L3	1 Turn Inductor, Red Coil	GA3092-AL	CoilCraft
L4*	10 Turn, #18 AWG Inductor, Hand Wound	Copper Wire	
R1	1 K $\Omega$ , 1/4 W Axial Leaded Resistor	CMF601000R0FKEK	Vishay
R2	20 $\Omega$ , 3 W Chip Resistor	CPF320R000FKE14	Vishay
T1	Balun	TUI-9	Comm Concepts
T2	Balun	TUO-4	Comm Concepts

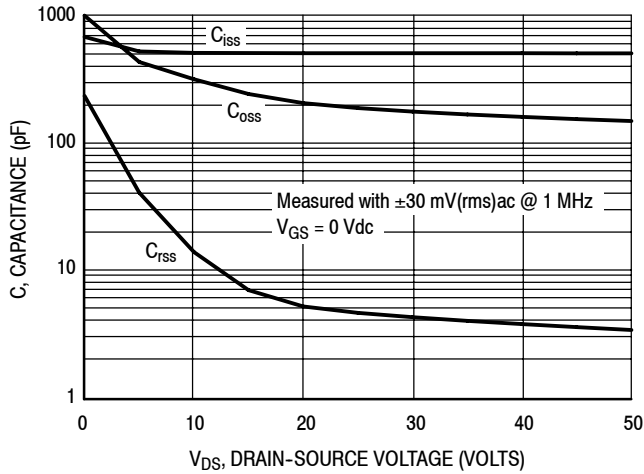
\*L4 is wrapped around R2.



\* L4 is wrapped around R2.

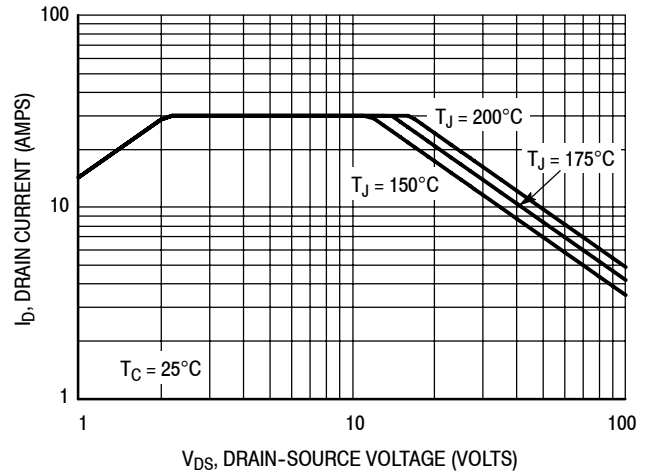
**Figure 3. MRF6VP21KHR6 Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS



Note: Each side of device measured separately.

Figure 4. Capacitance versus Drain-Source Voltage



Note: Each side of device measured separately.

Figure 5. DC Safe Operating Area

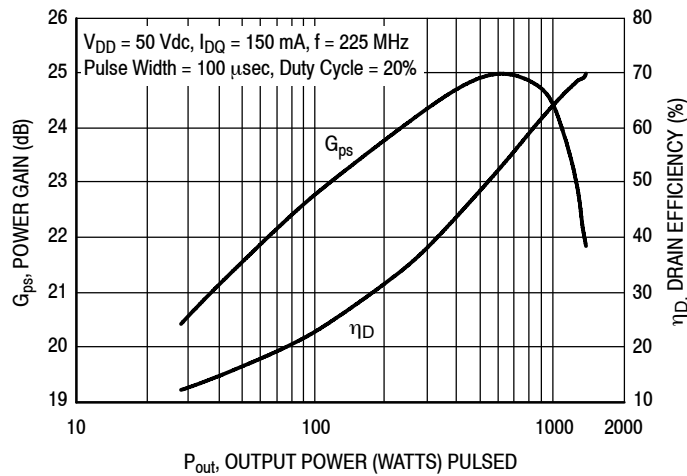


Figure 6. Pulsed Power Gain and Drain Efficiency versus Output Power

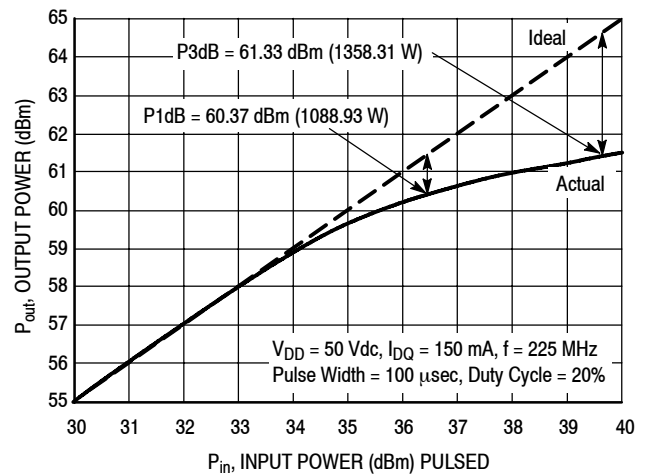


Figure 7. Pulsed Output Power versus Input Power

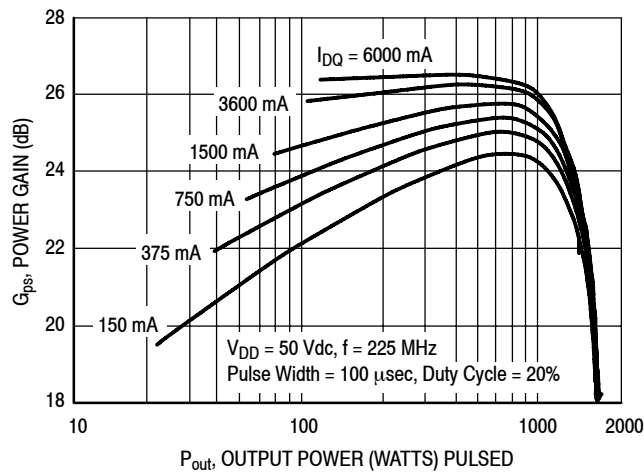


Figure 8. Pulsed Power Gain versus Output Power

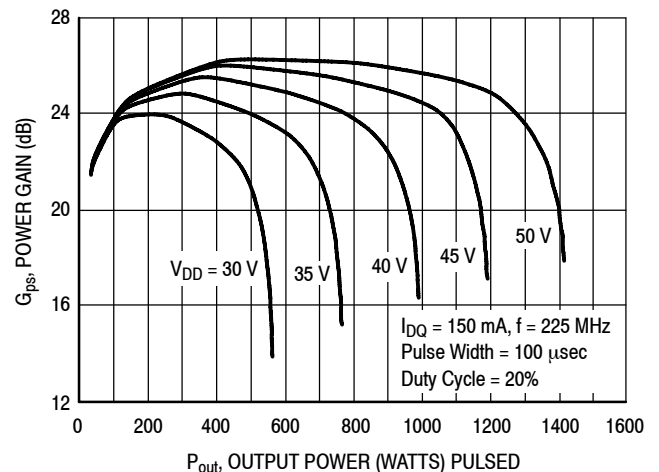
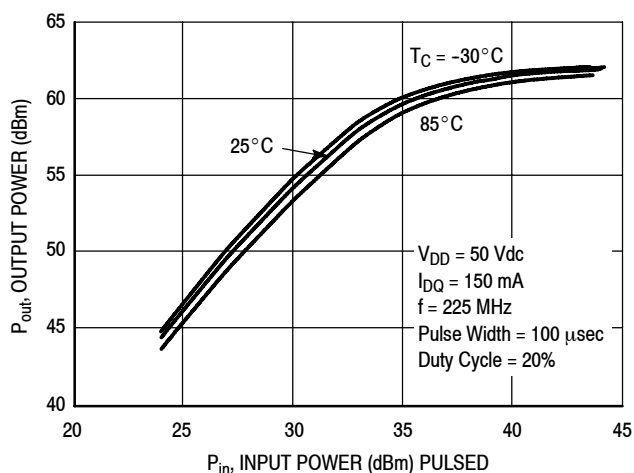
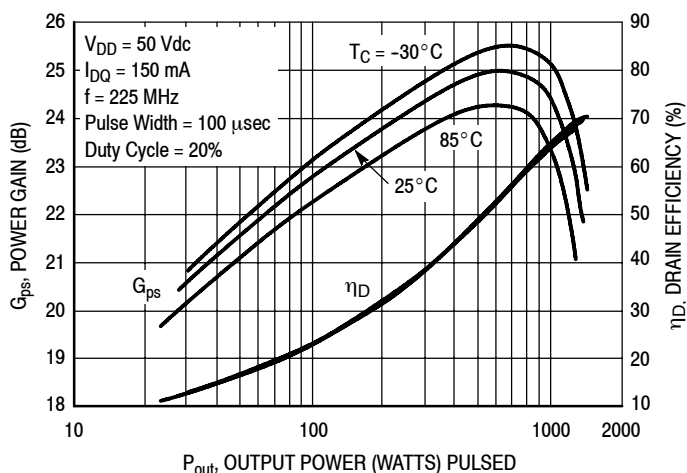


Figure 9. Pulsed Power Gain versus Output Power

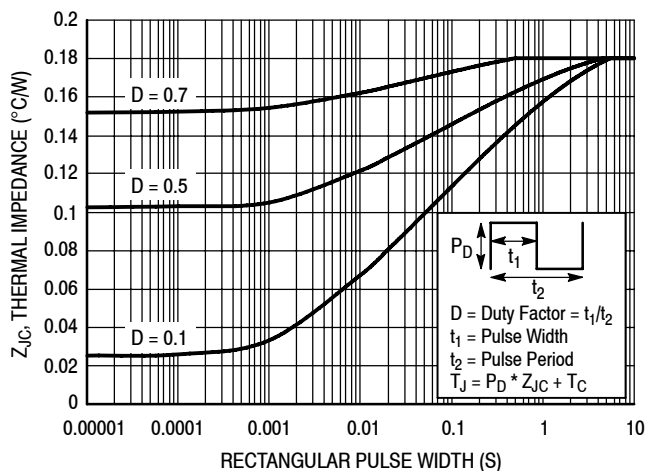
### TYPICAL CHARACTERISTICS



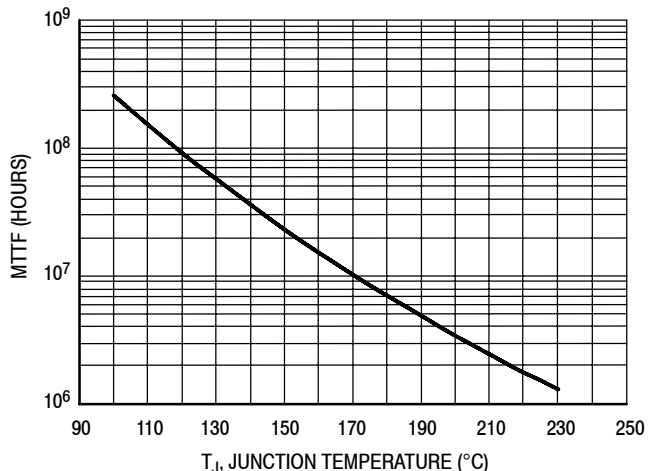
**Figure 10. Pulsed Output Power versus Input Power**



**Figure 11. Pulsed Power Gain and Drain Efficiency versus Output Power**



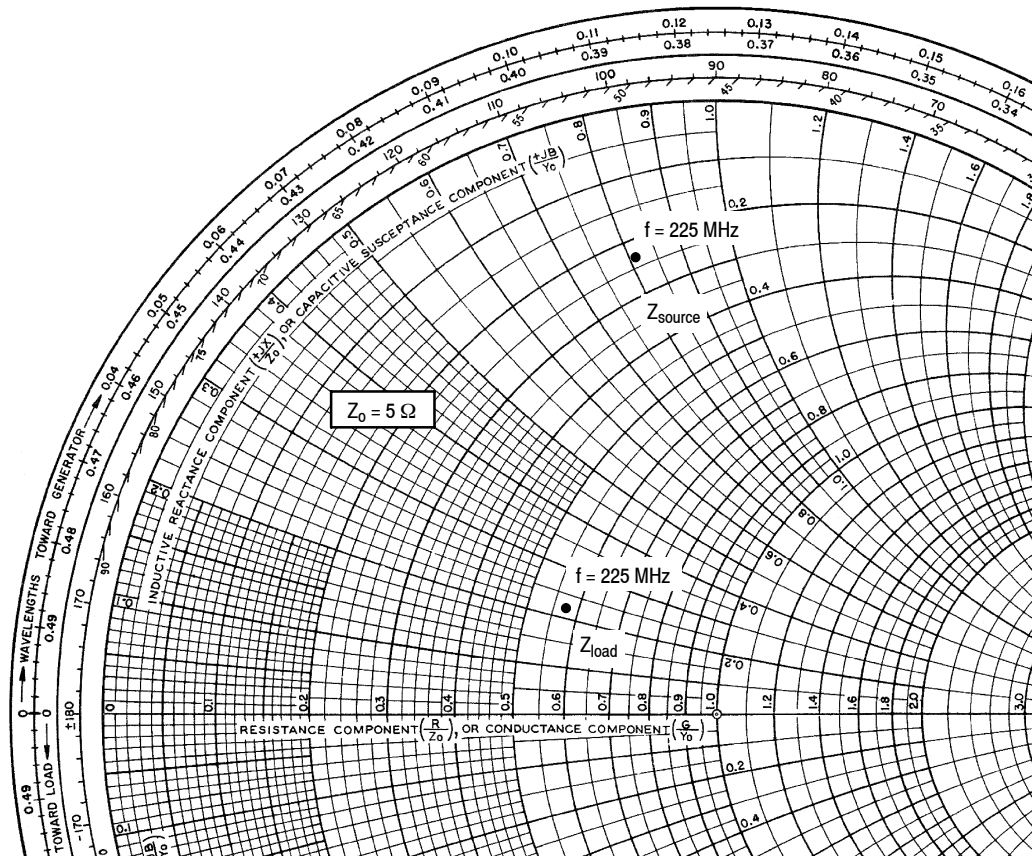
**Figure 12. Maximum Transient Thermal Impedance**



This above graph displays calculated MTF in hours when the device is operated at  $V_{DD} = 50$  Vdc,  $P_{out} = 1000$  W Peak, Pulse Width = 100  $\mu$ sec, Duty Cycle = 20%, and  $\eta_D = 67.5\%$ .

MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTF calculators by product.

**Figure 13. MTF versus Junction Temperature**



$V_{DD} = 50 \text{ Vdc}$ ,  $I_{DQ} = 150 \text{ mA}$ ,  $P_{out} = 1000 \text{ W Peak}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
225	$1.16 + j4.06$	$2.86 + j1.10$

$Z_{source}$  = Test circuit impedance as measured from gate to gate, balanced configuration.

$Z_{load}$  = Test circuit impedance as measured from drain to drain, balanced configuration.

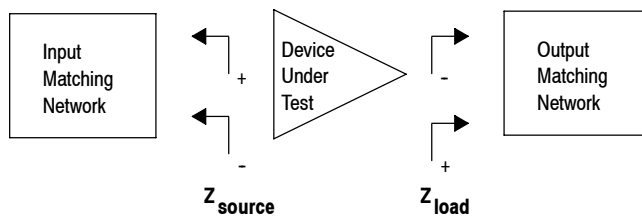
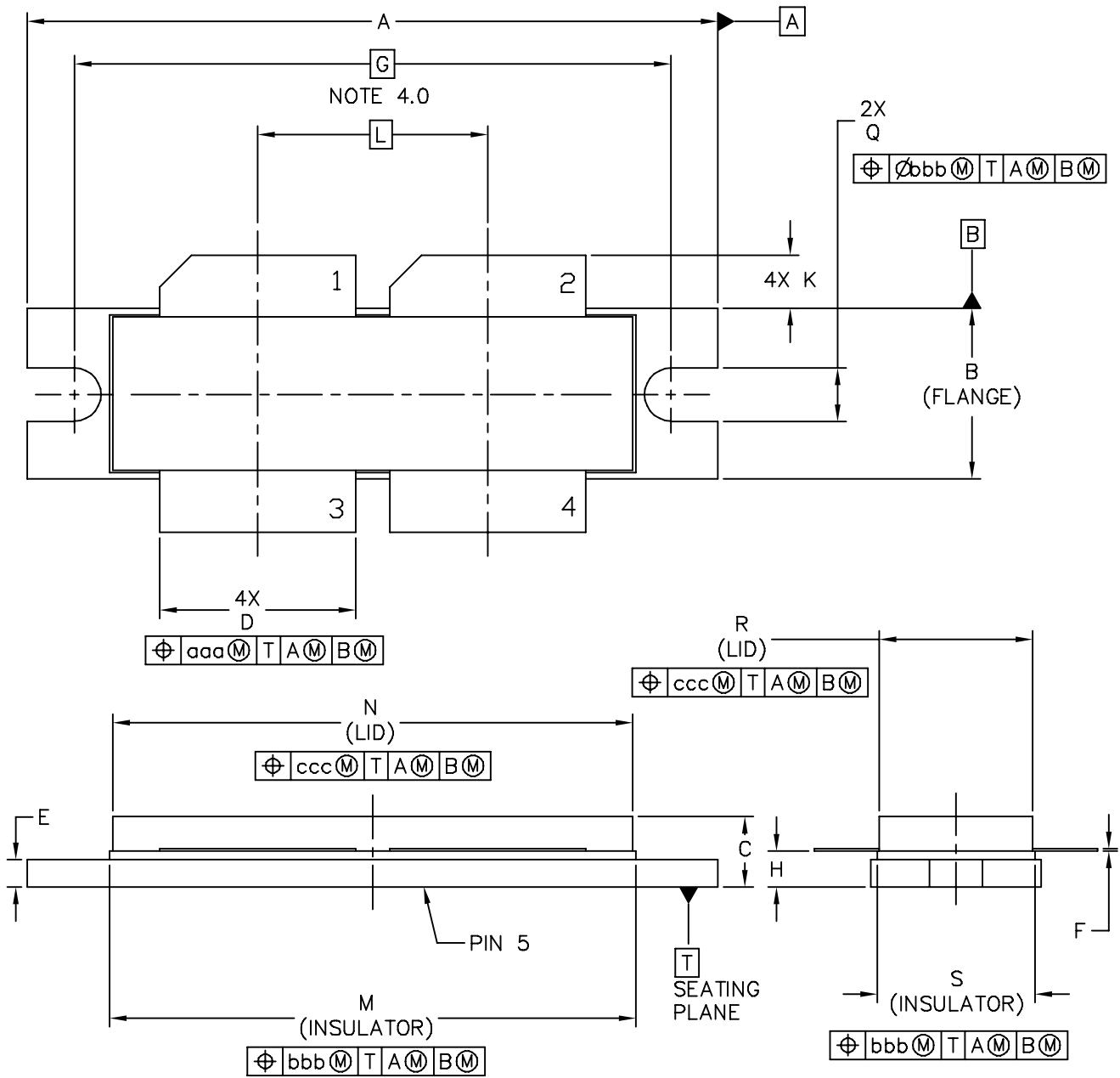


Figure 14. Series Equivalent Source and Load Impedance

**PACKAGE DIMENSIONS**



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	CASE NUMBER: 375D-05	31 MAR 2005
	STANDARD: NON-JEDEC	



NOTES:

- 1.0 INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
- 2.0 CONTROLLING DIMENSION: INCH
- 3.0 DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.
- 4.0 RECOMMENDED BOLT CENTER DIMENSION OF 1.52 (38.61) BASED ON M3 SCREW.

STYLE 1:

- PIN 1 - DRAIN
- 2 - DRAIN
- 3 - GATE
- 4 - GATE
- 5 - SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	1.615	1.625	41.02	41.28	N	1.218	1.242	30.94	31.55
B	.395	.405	10.03	10.29	Q	.120	.130	3.05	3.3
C	.150	.200	3.81	5.08	R	.355	.365	9.01	9.27
D	.455	.465	11.56	11.81	S	.365	.375	9.27	9.53
E	.062	.066	1.57	1.68					
F	.004	.007	0.1	0.18					
G	1.400 BSC		35.56 BSC		aaa	.013		0.33	
H	.082	.090	2.08	2.29	bbb	.010		0.25	
K	.117	.137	2.97	3.48	ccc	.020		0.51	
L	.540 BSC		13.72 BSC						
M	1.219	1.241	30.96	31.52					

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			CASE NUMBER: 375D-05		31 MAR 2005
			STANDARD: NON-JEDEC		

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

### Software

- Electromigration MTTF Calculator
- RF High Power Model

For Software, do a Part Number search at <http://www.freescale.com>, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Jan. 2008	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>
1	Apr. 2008	<ul style="list-style-type: none"> <li>• Corrected description and part number for the R1 resistor and updated R2 resistor to latest RoHS compliant part number in Table 5, Test Circuit Component Designations and Values, and updated the footnote to read “L4” versus “L3”, p. 3.</li> <li>• Added Fig. 12, Maximum Transient Thermal Impedance, p. 6</li> </ul>
2	Sept. 2008	<ul style="list-style-type: none"> <li>• Added Note to Fig. 4, Capacitance versus Drain–Source Voltage, to denote that each side of device is measured separately, p. 5</li> <li>• Updated Fig. 5, DC Safe Operating Area, to clarify that measurement is on a per–side basis, p. 5</li> <li>• Corrected Fig. 13, MTTF versus Junction Temperature, to reflect the correct die size and increased the MTTF factor accordingly, p. 6</li> </ul>
3	Dec. 2008	<ul style="list-style-type: none"> <li>• Fig. 14, Series Equivalent Source and Load Impedance, corrected <math>Z_{source}</math> copy to read “Test circuit impedance as measured from gate to gate, balanced configuration” and <math>Z_{load}</math> copy to read “Test circuit impedance as measured from drain to drain, balanced configuration”; replaced impedance diagram to show push–pull test conditions, p. 7</li> </ul>
4	Apr. 2010	<ul style="list-style-type: none"> <li>• Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related “Continuous use at maximum temperature will affect MTTF” footnote added, p. 1</li> <li>• Reporting of pulsed thermal data now shown using the <math>Z_{\theta JC}</math> symbol, p. 1</li> <li>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 10</li> </ul>

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