



# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

RF Power transistors designed for applications operating at 1300 MHz. These devices are suitable for use in pulsed and CW applications.

- Typical Performance:  $V_{DD} = 50$  Volts,  $I_{DQ} = 100$  mA

Signal Type	$P_{out}$ (W)	f (MHz)	$G_{ps}$ (dB)	$\eta_D$ (%)	IRL (dB)
Pulsed (200 $\mu$ sec, 10% Duty Cycle)	250 Peak	1300	22.7	57.0	-18

- Typical Performance:  $V_{DD} = 50$  Volts,  $I_{DQ} = 10$  mA,  $T_C = 25^\circ\text{C}$

Signal Type	$P_{out}$ (W)	f (MHz)	$G_{ps}$ (dB)	$\eta_D$ (%)	IRL (dB)
CW	230 CW	1300	21.0	55.0	-17

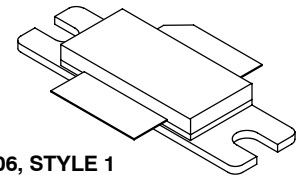
- Capable of Handling a Load Mismatch of 10:1 VSWR, @ 50 Vdc, 1300 MHz at all Phase Angles
  - 250 Watts Pulsed Peak Power, 10% Duty Cycle, 200  $\mu$ sec
- CW Capable

### Features

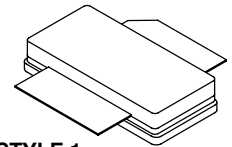
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 50  $V_{DD}$  Operation
- Characterized from 20 V to 50 V for Extended Power Range
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel. For R5 Tape and Reel options, see p. 12.

**MRF6V13250HR3**  
**MRF6V13250HSR3**

**1300 MHz, 250 W, 50 V**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF6V13250HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF6V13250HSR3**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +120	Vdc
Gate-Source Voltage	$V_{GS}$	-6.0, +10	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	$^\circ\text{C}$
Case Operating Temperature	$T_C$	150	$^\circ\text{C}$
Operating Junction Temperature (1,2)	$T_J$	225	$^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	476 2.38	W W/ $^\circ\text{C}$

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Pulsed: Case Temperature $65^\circ\text{C}$ , 250 W Pulsed, 200 $\mu$ sec Pulse Width, 10% Duty Cycle, 50 Vdc, $I_{DQ} = 100$ mA, 1300 MHz CW: Case Temperature $77^\circ\text{C}$ , 235 W CW, 50 Vdc, $I_{DQ} = 10$ mA, 1300 MHz	$Z_{\theta JC}$ $R_{\theta JC}$	0.07 0.42	$^\circ\text{C}/\text{W}$

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)	B (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**

Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{A dc}$
Drain-Source Breakdown Voltage ( $V_{GS} = 0\text{ Vdc}$ , $I_D = 50\text{ mA}$ )	$V_{(BR)DSS}$	120	—	—	Vdc
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 50\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{A dc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 90\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	20	$\mu\text{A dc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 640\ \mu\text{A dc}$ )	$V_{GS(th)}$	1.0	1.8	2.7	Vdc
Gate Quiescent Voltage ( $V_{DD} = 50\text{ Vdc}$ , $I_D = 100\text{ mA dc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2.0	2.4	3.0	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.58\text{ A dc}$ )	$V_{DS(on)}$	0.1	0.25	0.3	Vdc

**Dynamic Characteristics** (1)

Reverse Transfer Capacitance ( $V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	1.2	—	pF
Output Capacitance ( $V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	58	—	pF
Input Capacitance ( $V_{DS} = 50\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	$C_{iss}$	—	340	—	pF

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 50\text{ Vdc}$ ,  $I_{DQ} = 100\text{ mA}$ ,  $P_{out} = 250\text{ W Peak}$  (25 W Avg.),  $f = 1300\text{ MHz}$  Pulsed, 200  $\mu\text{sec}$  Pulse Width, 10% Duty Cycle

Power Gain	$G_{ps}$	21.5	22.7	24.0	dB
Drain Efficiency	$\eta_D$	53.5	57.0	—	%
Input Return Loss	IRL	—	-18	-9	dB

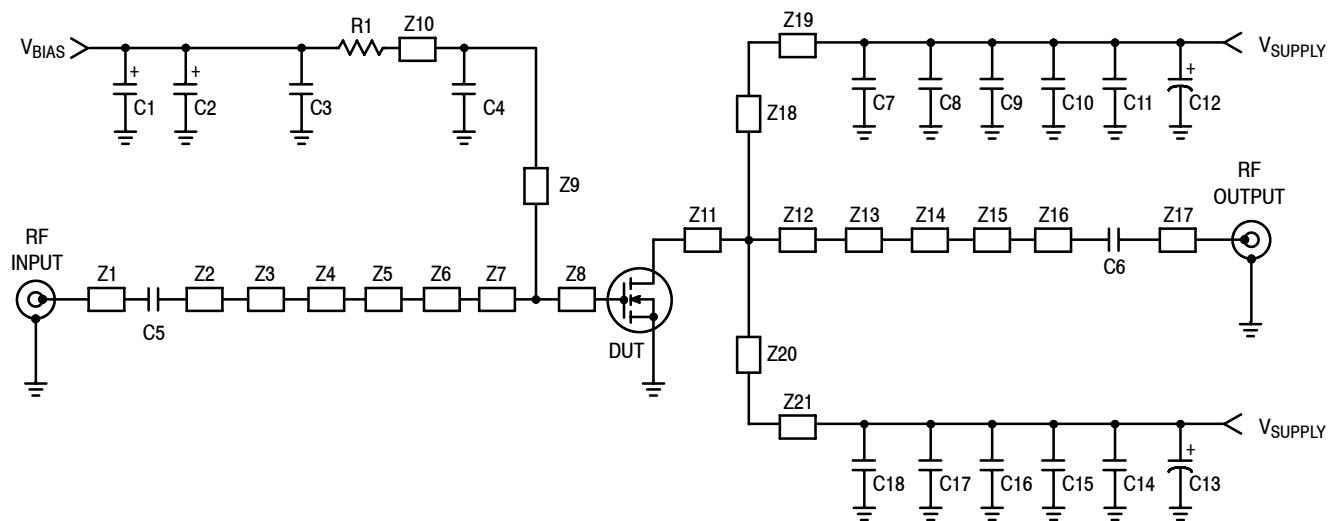
**Typical Performance** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 50\text{ Vdc}$ ,  $I_{DQ} = 10\text{ mA}$ ,  $P_{out} = 230\text{ W CW}$ ,  $f = 1300\text{ MHz}$ ,  $T_C = 25^\circ\text{C}$

Power Gain	$G_{ps}$	—	21.0	—	dB
Drain Efficiency	$\eta_D$	—	55.0	—	%
Input Return Loss	IRL	—	-17	—	dB

**Load Mismatch** (In Freescale Application Test Fixture, 50 ohm system)  $V_{DD} = 50\text{ Vdc}$ ,  $I_{DQ} = 100\text{ mA}$ ,  $P_{out} = 250\text{ W Peak}$  (25 W Avg.),  $f = 1300\text{ MHz}$ , Pulsed, 200  $\mu\text{sec}$  Pulse Width, 10% Duty Cycle

VSWR 10:1 at all Phase Angles	$\Psi$	No Degradation in Output Power			
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1. Part internally input matched.



Z1	0.447" x 0.063" Microstrip	Z11	0.162" x 1.160" Microstrip
Z2	0.030" x 0.084" Microstrip	Z12	0.419" x 1.160" Microstrip
Z3	0.120" x 0.063" Microstrip	Z13	0.468" x 0.994" Microstrip
Z4	0.855" x 0.293" Microstrip	Z14	0.131" x 0.472" Microstrip
Z5	0.369" x 0.825" Microstrip	Z15	0.264" x 0.222" Microstrip
Z6	0.203" x 0.516" Microstrip	Z16	0.500" x 0.111" Microstrip
Z7	0.105" x 0.530" Microstrip	Z17	0.291" x 0.063" Microstrip
Z8	0.105" x 0.530" Microstrip	Z18, Z20	0.105" x 0.388" Microstrip
Z9*	0.116" x 0.050" Microstrip	Z19*, Z21*	0.854" x 0.052" Microstrip
Z10	0.122" x 0.050" Microstrip		

\*Line length includes microstrip bends.

Figure 1. MRF6V13250HR3(HSR3) Test Circuit Schematic — 1300 MHz

Table 5. MRF6V13250HR3(HSR3) Test Circuit Component Designations and Values — 1300 MHz

Part	Description	Part Number	Manufacturer
C1, C2	22 $\mu$ F, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C3, C11, C14	0.1 $\mu$ F, 50 V Chip Capacitors	CDR33BX104AKWS	AVX
C4, C6, C7, C18	100 pF Chip Capacitors	ATC800B101JT500XT	ATC
C5	4.7 pF Chip Capacitor	ATC100B4R7CT500XT	ATC
C8, C17	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C9, C16	1000 pF Chip Capacitors	ATC700B102FT50XT	ATC
C10, C15	10K pF Chip Capacitors	ATC200B103KT50XT	ATC
C12, C13	470 $\mu$ F, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
R1	15 $\Omega$ , 1/4 W Chip Resistor	CRCW120615R0FKEA	Vishay
PCB	0.030", $\epsilon_r = 3.50$	RO4350B	Rogers

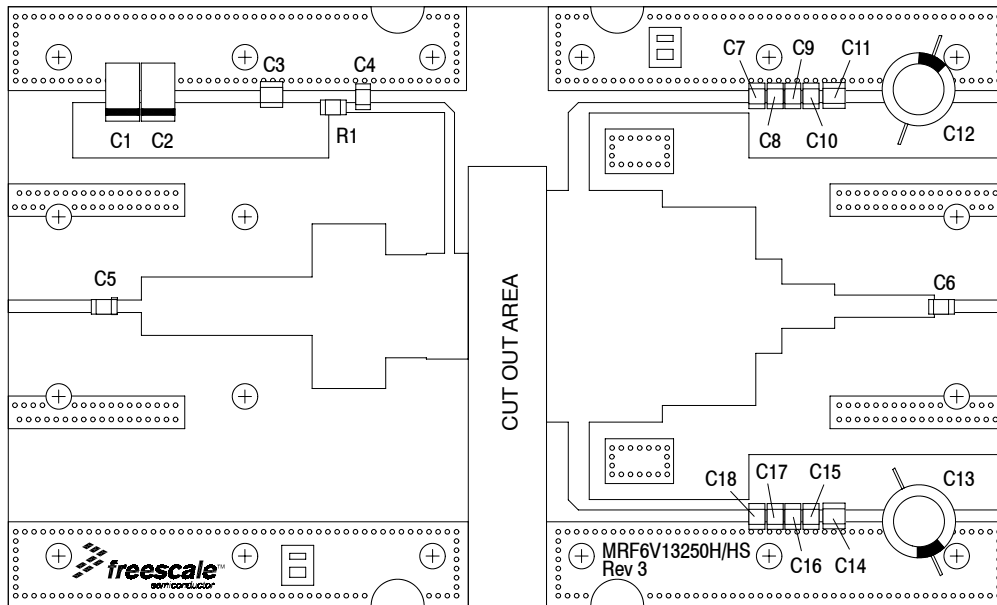
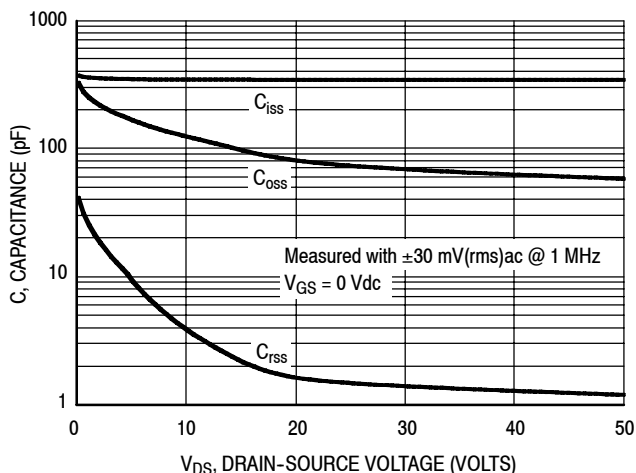
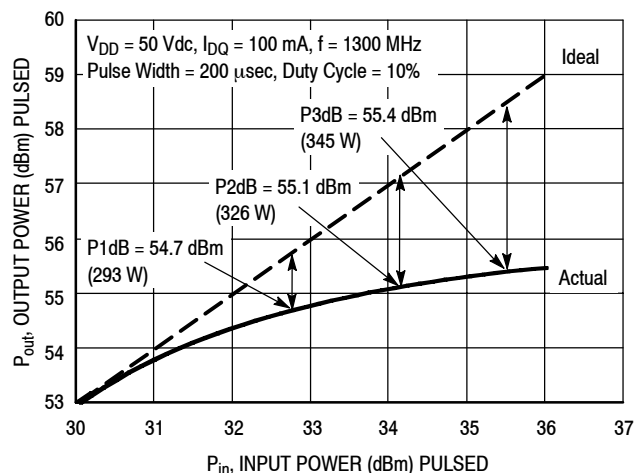


Figure 2. MRF6V13250HR3(HSR3) Test Circuit Component Layout — 1300 MHz

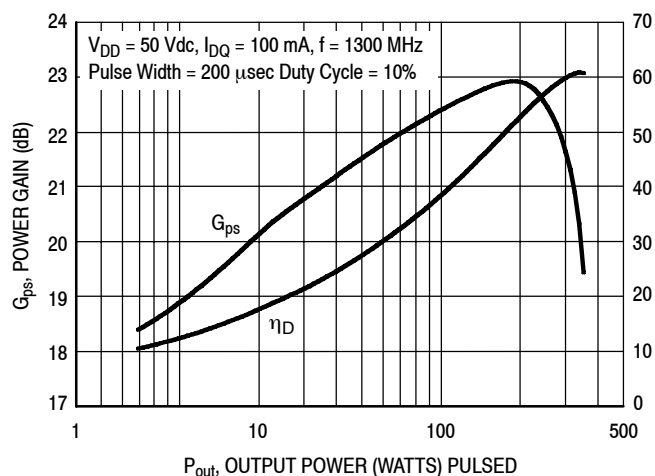
## TYPICAL CHARACTERISTICS — PULSED



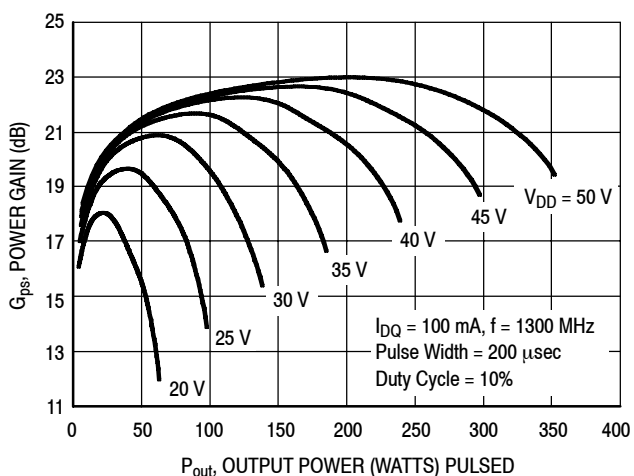
**Figure 3. Capacitance versus Drain-Source Voltage**



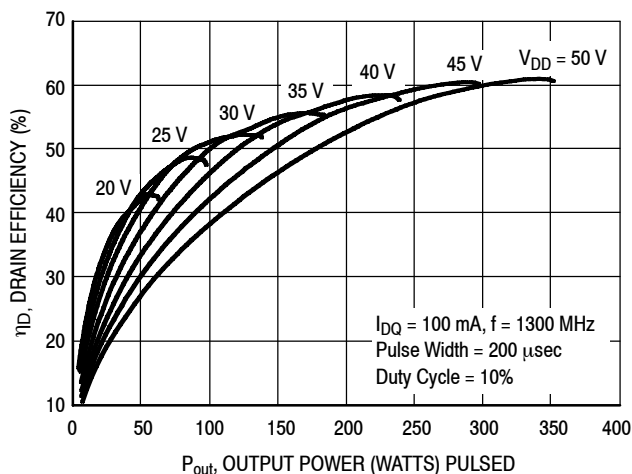
**Figure 4. Pulsed Output Power versus Input Power**



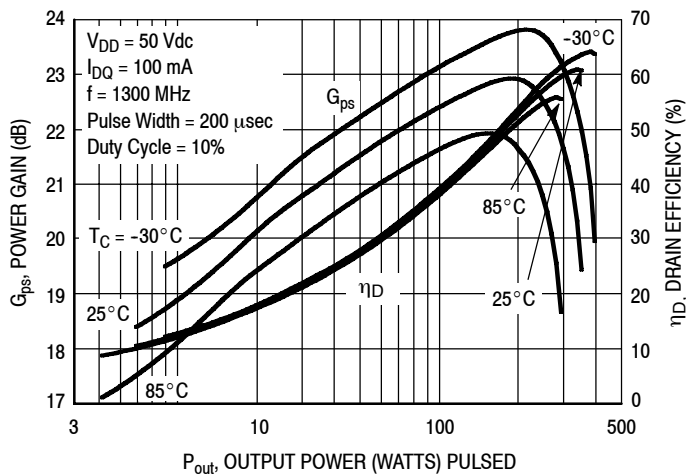
**Figure 5. Pulsed Power Gain and Drain Efficiency versus Output Power**



**Figure 6. Pulsed Power Gain versus Output Power**



**Figure 7. Pulsed Efficiency versus Output Power**



**Figure 8. Pulsed Power Gain and Drain Efficiency versus Output Power**

## TYPICAL CHARACTERISTICS — CW

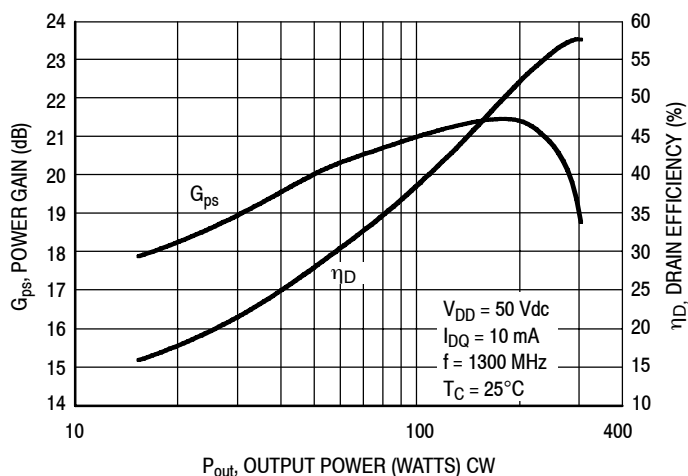


Figure 9. CW Power Gain and Drain Efficiency versus Output Power

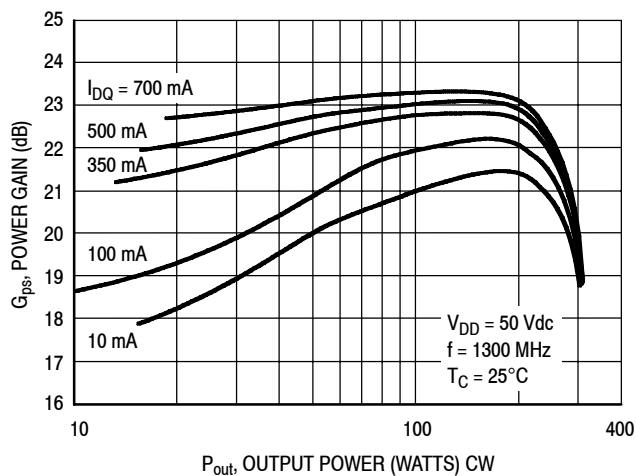


Figure 10. CW Power Gain versus Output Power

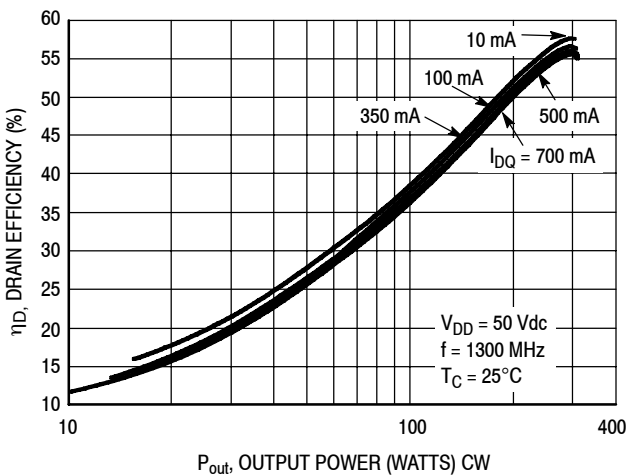
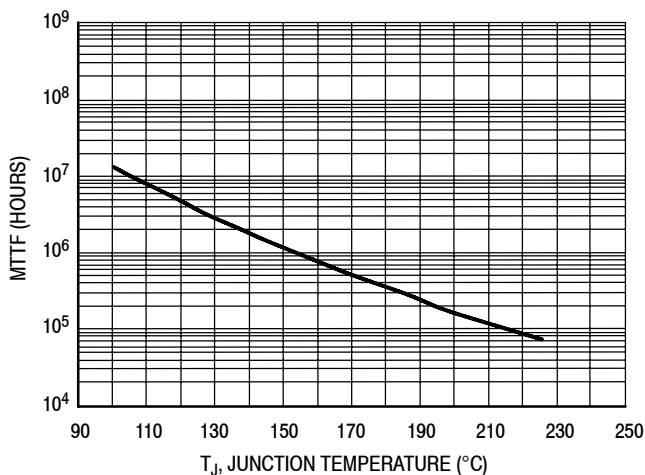


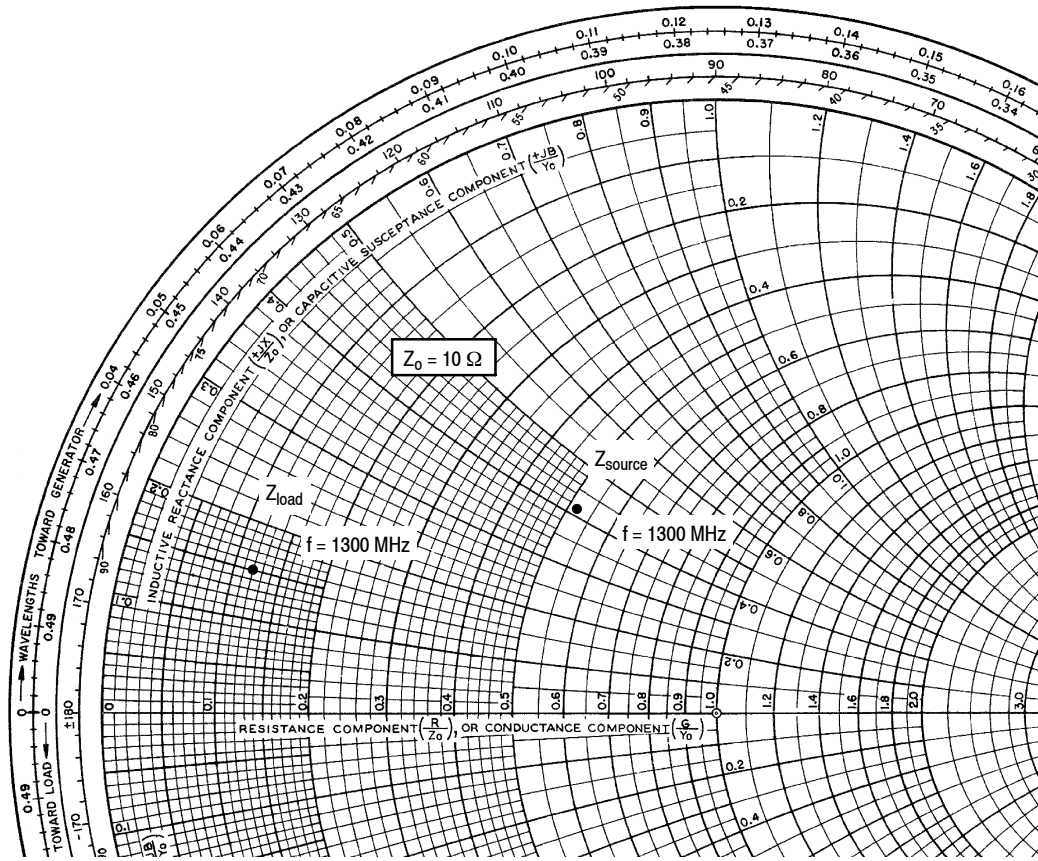
Figure 11. CW Efficiency versus Output Power



This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 50 \text{ Vdc}$ ,  $P_{out} = 230 \text{ W CW}$ , and  $\eta_D = 55\%$ .

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

Figure 12. MTTF versus Junction Temperature — CW



$V_{DD} = 50 \text{ Vdc}$ ,  $I_{DQ} = 100 \text{ mA}$ ,  $P_{out} = 250 \text{ W Peak}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
1300	$5.32 + j4.11$	$1.17 + j1.48$

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

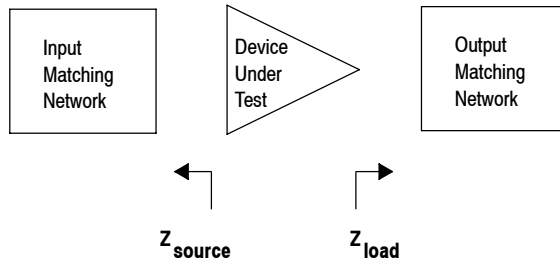
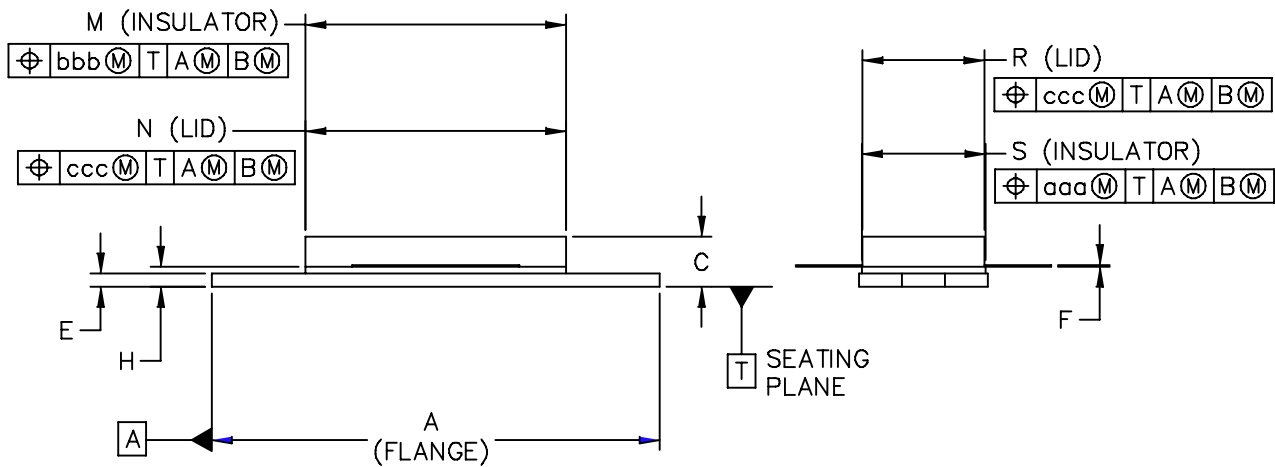
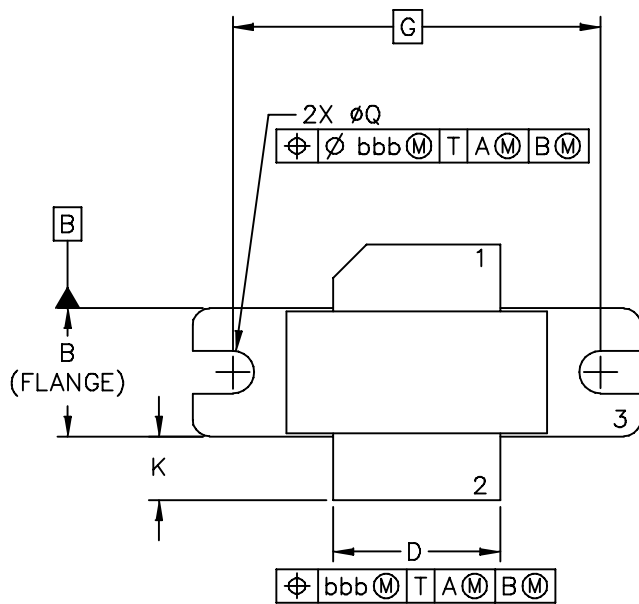


Figure 13. Series Equivalent Source and Load Impedance — Pulsed

### PACKAGE DIMENSIONS



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	CASE NUMBER: 465-06		31 MAR 2005
	STANDARD: NON-JEDEC		



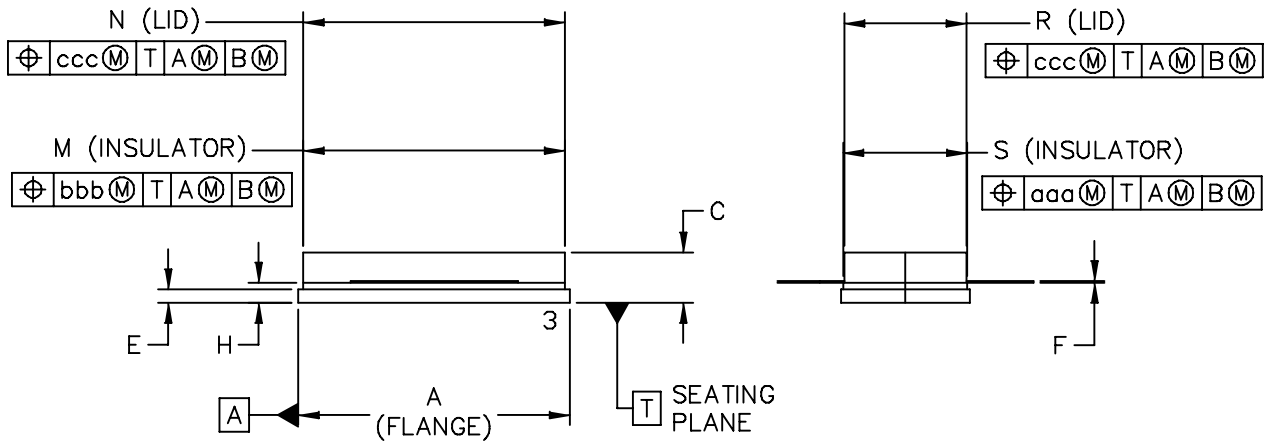
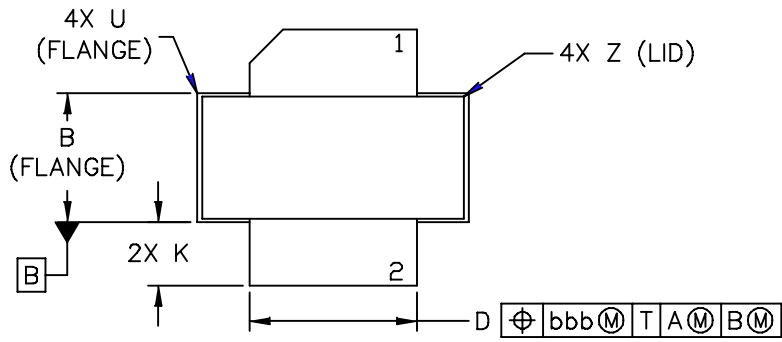
NOTES:

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2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN
1. DRAIN
  2. GATE
  3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16	R	.365	.375	9.27	9.53
B	.380	.390	9.65	9.91	S	.365	.375	9.27	9.52
C	.125	.170	3.18	4.32	aaa	—	.005	—	0.127
D	.495	.505	12.57	12.83	bbb	—	.010	—	0.254
E	.035	.045	0.89	1.14	ccc	—	.015	—	0.381
F	.003	.006	0.08	0.15	—	—	—	—	—
G	1.100 BSC		27.94 BSC		—	—	—	—	—
H	.057	.067	1.45	1.7	—	—	—	—	—
K	.170	.210	4.32	5.33	—	—	—	—	—
M	.774	.786	19.66	19.96	—	—	—	—	—
N	.772	.788	19.6	20	—	—	—	—	—
Q	∅.118	∅.138	∅3	∅3.51	—	—	—	—	—
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4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.805	-.815	20.45	20.7	U	-	-.040	-	1.02
B	.380	-.390	9.65	9.91	Z	-	-.030	-	0.76
C	.125	-.170	3.18	4.32	aaa	-	.005	-	0.127
D	.495	-.505	12.57	12.83	bbb	-	.010	-	0.254
E	.035	-.045	0.89	1.14	ccc	-	.015	-	0.381
F	.003	-.006	0.08	0.15	-	-	-	-	-
H	.057	-.067	1.45	1.7	-	-	-	-	-
K	.170	-.210	4.32	5.33	-	-	-	-	-
M	.774	-.786	19.61	20.02	-	-	-	-	-
N	.772	-.788	19.61	20.02	-	-	-	-	-
R	.365	-.375	9.27	9.53	-	-	-	-	-
S	.365	-.375	9.27	9.52	-	-	-	-	-
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## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents and software 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
- .s2p File

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.

## R5 TAPE AND REEL OPTION

R5 Suffix = 50 Units, 56 mm Tape Width, 13 inch Reel.

The R5 tape and reel option for MRF6V13250H and MRF6V13250HS parts will be available for 2 years after release of MRF6V13250H and MRF6V13250HS. Freescale Semiconductor, Inc. reserves the right to limit the quantities that will be delivered in the R5 tape and reel option. At the end of the 2 year period customers who have purchased these devices in the R5 tape and reel option will be offered MRF6V13250H and MRF6V13250HS in the R3 tape and reel option.

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	June 2011	• Initial Release of Data Sheet

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