

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

RF Power transistors designed for applications operating at frequencies between 960 and 1215 MHz. These devices are suitable for use in pulsed applications.

- Typical Pulsed Performance: $V_{DD} = 50$ Volts, $I_{DQ} = 100$ mA, $P_{out} = 275$ Watts Peak (27.5 Watts Avg.), $f = 1030$ MHz, Pulse Width = 128 μ sec, Duty Cycle = 10%
Power Gain — 20.3 dB
Drain Efficiency — 65.5%
- Capable of Handling 10:1 VSWR, @ 50 Vdc, 1030 MHz, 275 Watts Peak Power
- Typical Broadband Performance: $V_{DD} = 50$ Volts, $I_{DQ} = 100$ mA, $P_{out} = 250$ Watts Peak (25 Watts Avg.), $f = 960$ –1215 MHz, Pulse Width = 128 μ sec, Duty Cycle = 10%
Power Gain — 19.8 dB
Drain Efficiency — 58%

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
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

MRF6V12250HR3
MRF6V12250HSR3

960–1215 MHz, 275 W, 50 V
PULSED
LATERAL N-CHANNEL
RF POWER MOSFETs

CASE 465-06, STYLE 1
NI-780
MRF6V12250HR3

CASE 465A-06, STYLE 1
NI-780S
MRF6V12250HSR3

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +100	Vdc
Gate-Source Voltage	V_{GS}	-6.0, +10	Vdc
Storage Temperature Range	T_{stg}	- 65 to +150	°C
Case Operating Temperature	T_C	150	°C
Operating Junction Temperature (1,2)	T_J	225	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 275 W Pulsed, 128 μ sec Pulse Width, 10% Duty Cycle	$Z_{\theta JC}$	0.08	°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)	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}	—	—	10	μAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0\text{ Vdc}$, $I_D = 100\text{ mA}$)	$V_{(BR)DSS}$	110	—	—	Vdc
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 50\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 90\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	100	μAdc

On Characteristics

Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 662\text{ }\mu\text{Adc}$)	$V_{GS(th)}$	0.9	1.7	2.4	Vdc
Gate Quiescent Voltage ($V_{DD} = 50\text{ Vdc}$, $I_D = 100\text{ mAdc}$, Measured in Functional Test)	$V_{GS(Q)}$	1.7	2.4	3.2	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 1.6\text{ Adc}$)	$V_{DS(on)}$	—	0.25	—	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}	—	0.46	—	pF
Output Capacitance ($V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	352	—	pF
Input Capacitance ($V_{DS} = 50\text{ Vdc}$, $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	C_{iss}	—	695	—	pF

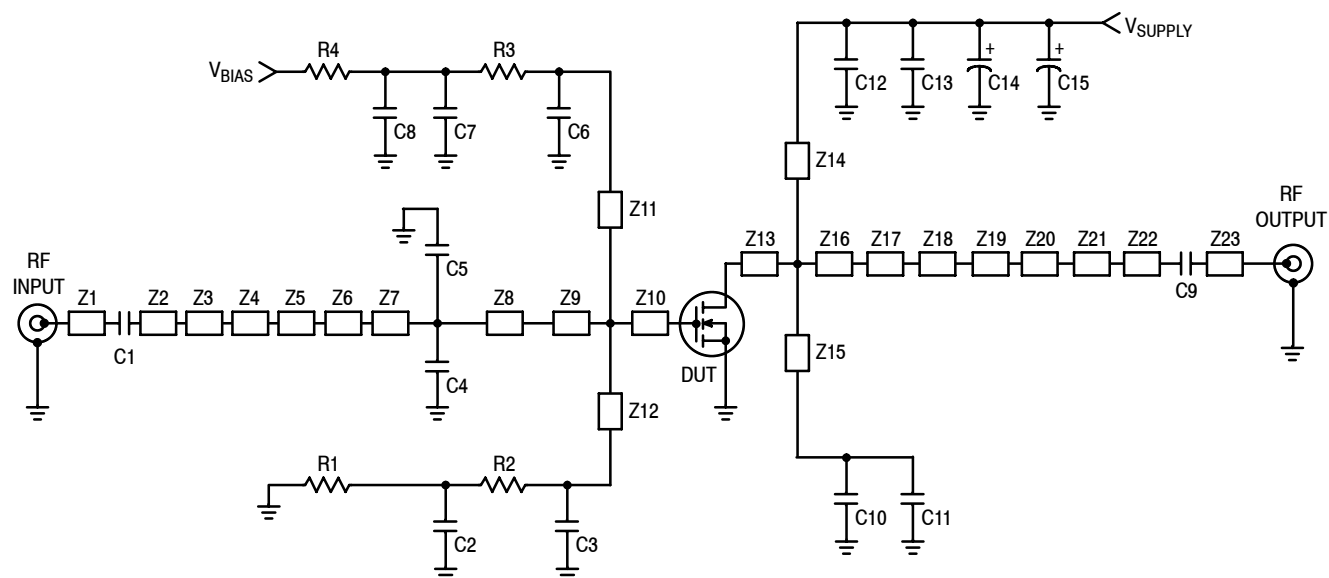
Functional Tests (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 50\text{ Vdc}$, $I_{DQ} = 100\text{ mA}$, $P_{out} = 275\text{ W Peak}$ (27.5 W Avg.), $f = 1030\text{ MHz}$, Pulsed, 128 μsec Pulse Width, 10% Duty Cycle

Power Gain	G_{ps}	19	20.3	22	dB
Drain Efficiency	η_D	63	65.5	—	%
Input Return Loss	IRL	—	-14	-9	dB

Typical Broadband Performance — 960-1215 MHz (In Freescale 960-1215 MHz Test Fixture, 50 ohm system) $V_{DD} = 50\text{ Vdc}$, $I_{DQ} = 100\text{ mA}$, $P_{out} = 250\text{ W Peak}$ (25 W Avg.), $f = 960\text{--}1215\text{ MHz}$, Pulsed, 128 μsec Pulse Width, 10% Duty Cycle

Power Gain	G_{ps}	—	19.8	—	dB
Drain Efficiency	η_D	—	58	—	%

1. Part internally matched both on input and output.



Z1	1.055" x 0.082" Microstrip	Z13	0.190" x 1.250" Microstrip
Z2	0.100" x 0.082" Microstrip	Z14, Z15	0.517" x 0.080" Microstrip
Z3	0.084" x 0.395" Microstrip	Z16	0.225" x 1.250" Microstrip
Z4	0.419" x 0.040" Microstrip	Z17	0.860" x 0.975" Microstrip
Z5	0.498" x 0.466" Microstrip	Z18	0.140" x 0.950" Microstrip
Z6	0.110" x 1.060" Microstrip	Z19	0.028" x 0.110" Microstrip
Z7	0.050" x 1.300" Microstrip	Z20	0.397" x 0.040" Microstrip
Z8	0.092" x 1.300" Microstrip	Z21	0.264" x 0.480" Microstrip
Z9	0.219" x 1.420" Microstrip	Z22	0.100" x 0.082" Microstrip
Z10	0.087" x 1.420" Microstrip	Z23	0.521" x 0.082" Microstrip
Z11, Z12	0.187" x 0.050" Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$

Figure 1. MRF6V12250HR3(HSR3) Test Circuit Schematic

Table 5. MRF6V12250HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C4, C5	1.5 pF Chip Capacitors	ATC100B1R5BT500XT	ATC
C2, C7, C11, C13	2.2 μ F, 100 V Chip Capacitors	G2225X7R225KT3AB	ATC
C3, C6, C10, C12	33 pF Chip Capacitors	ATC100B330JT500XT	ATC
C8	22 μ F, 25 V Chip Capacitor	TPSD226M025R0200	AVX
C9	9.1 pF Chip Capacitor	ATC100B9R1CT500XT	ATC
C14, C15	470 μ F, 63 V Electrolytic Capacitors	MCGPA63V477M13X26-RH	Multicomp
R1, R2, R3, R4	0 Ω , 3.5 A Chip Resistors	CRCW12060000Z0EA	Vishay

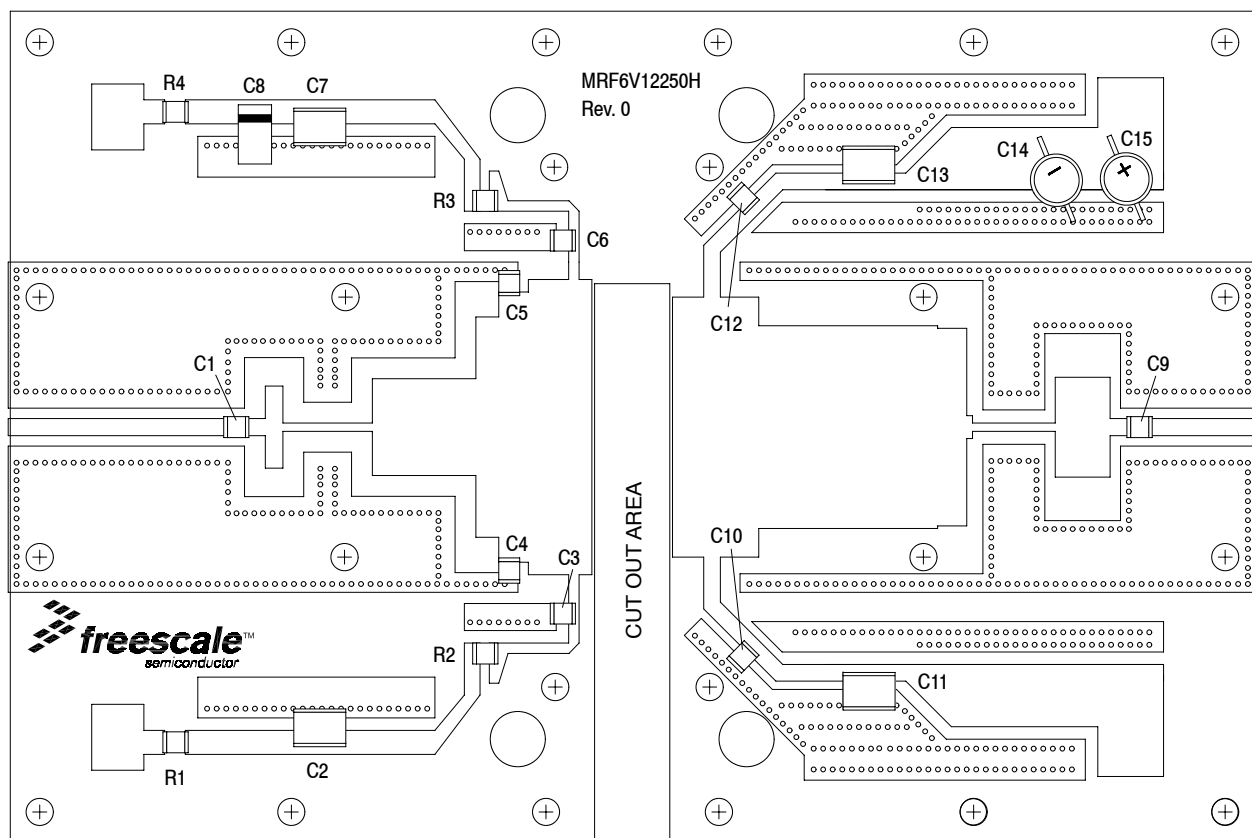


Figure 2. MRF6V12250HR3(HSR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

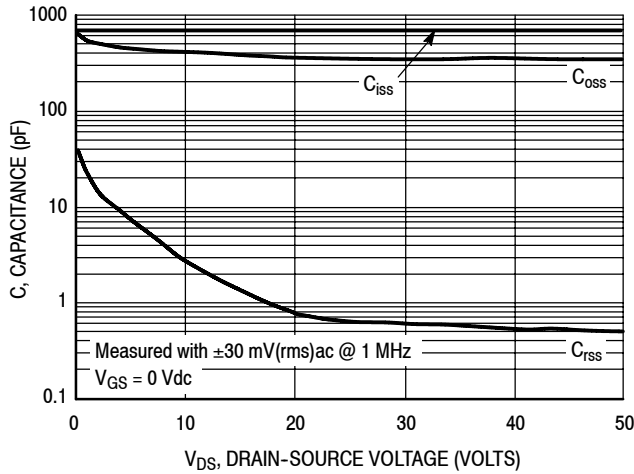


Figure 3. Capacitance versus Drain-Source Voltage

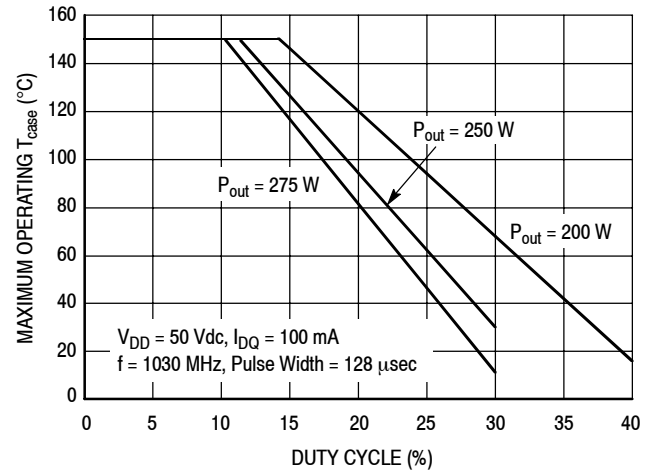


Figure 4. Safe Operating Area

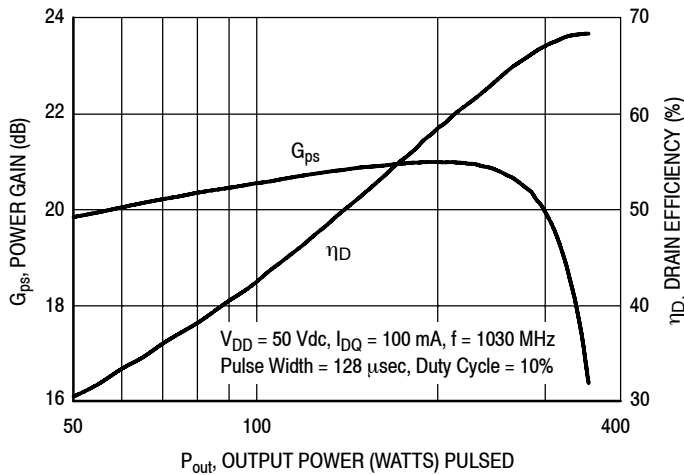


Figure 5. Pulsed Power Gain and Drain Efficiency versus Output Power

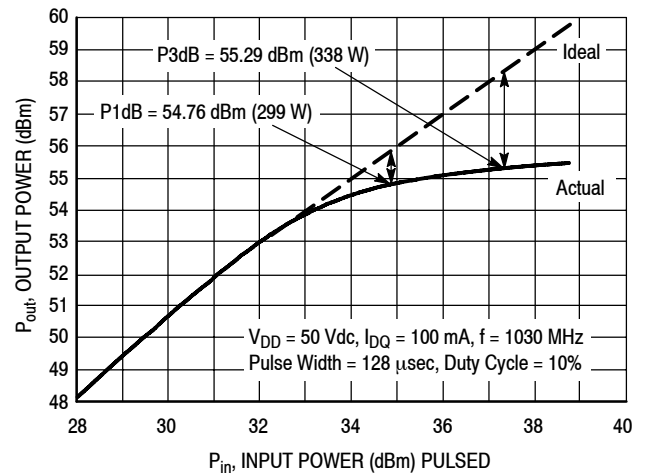


Figure 6. Pulsed Output Power versus Input Power

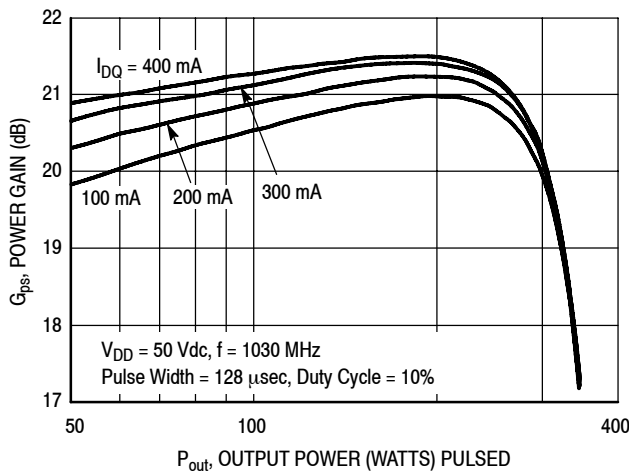


Figure 7. Pulsed Power Gain versus Output Power

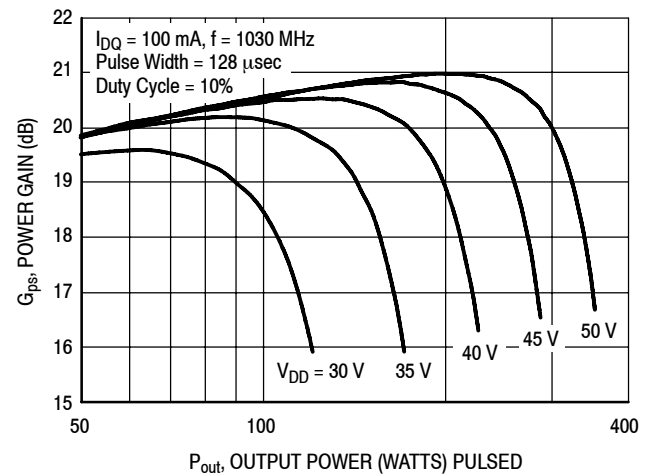


Figure 8. Pulsed Power Gain versus Output Power

TYPICAL CHARACTERISTICS

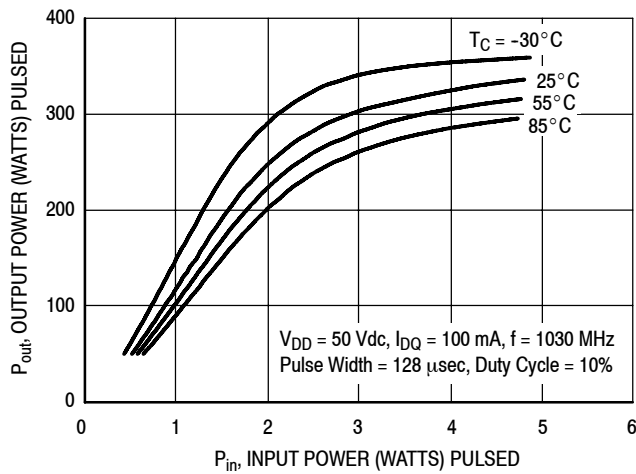


Figure 9. Pulsed Output Power versus Input Power

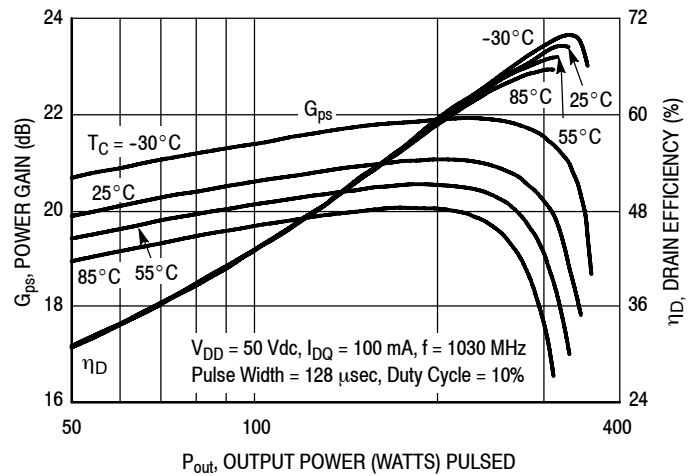
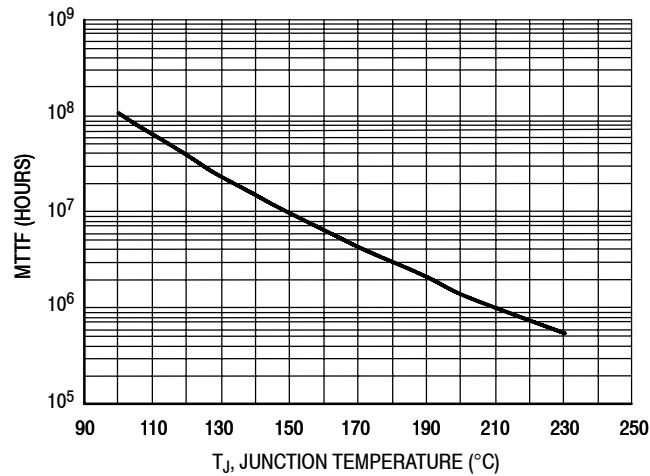


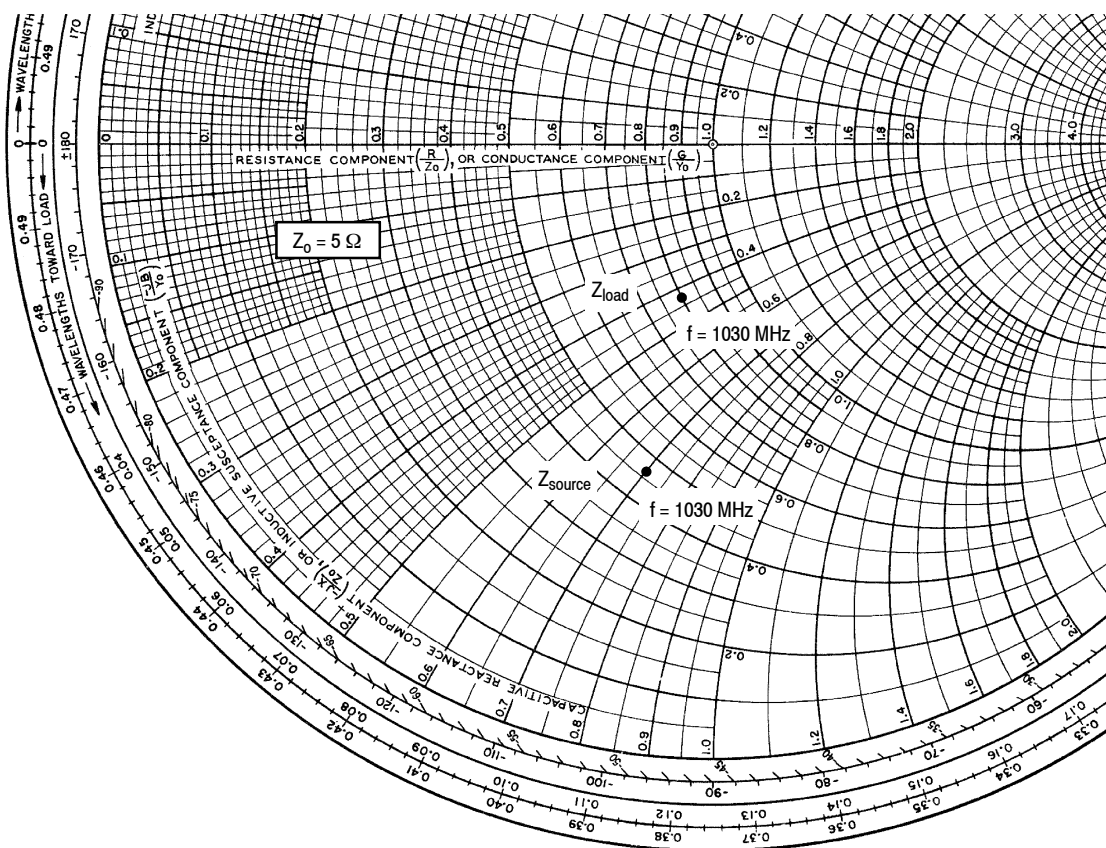
Figure 10. Pulsed Power Gain and Drain Efficiency versus Output Power



This above graph displays calculated MTTF in hours when the device is operated at $V_{DD} = 50$ Vdc, $P_{out} = 275$ W Peak, Pulse Width = 128 μ sec, Duty Cycle = 10%, and $\eta_D = 65.5\%$.

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

Figure 11. MTTF versus Junction Temperature



$V_{DD} = 50 \text{ Vdc}$, $I_{DQ} = 100 \text{ mA}$, $P_{out} = 275 \text{ W Peak}$

f MHz	Z_{source} Ω	Z_{load} Ω
1030	$2.30 - j3.51$	$4.0 - j2.14$

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

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

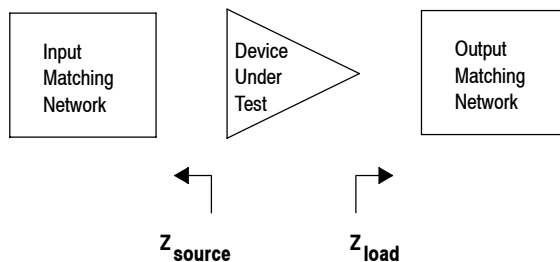


Figure 12. Series Equivalent Source and Load Impedance

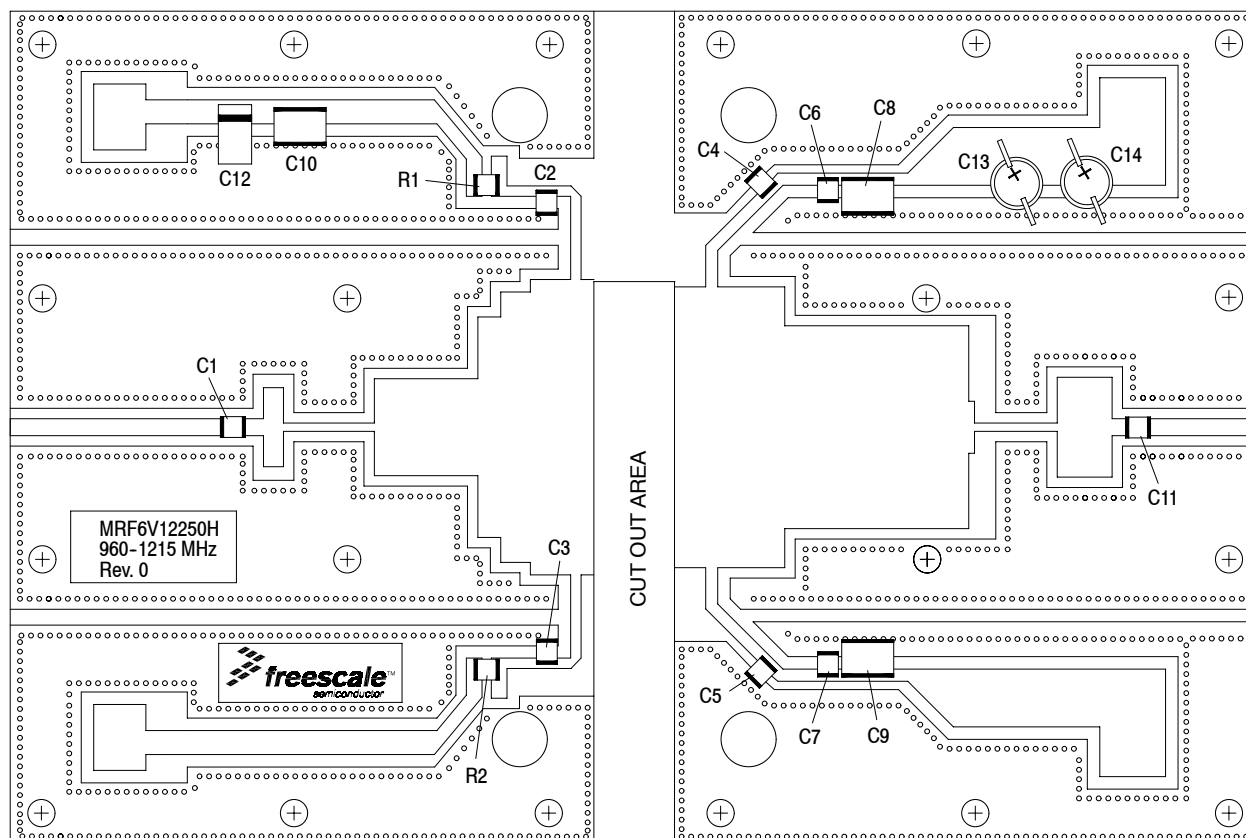


Figure 13. MRF6V12250HR3(HSR3) Test Circuit Component Layout — 960-1215 MHz

Table 6. MRF6V12250HR3(HSR3) Test Circuit Component Designations and Values — 960-1215 MHz

Part	Description	Part Number	Manufacturer
C1	2.7 pF Chip Capacitor	ATC100B2R7BT500XT	ATC
C2, C3, C4, C5	33 pF Chip Capacitors	ATC100B330JT500XT	ATC
C6, C7	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C8, C9, C10	2.2 μ F, 100 V Chip Capacitors	G2225X7R225KT3AB	ATC
C11	9.1 pF Chip Capacitor	ATC100B9R1CT500XT	ATC
C12	22 μ F, 25 V Tantalum Capacitor	TPSD226M025R0200	AVX
C13, C14	470 μ F, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
R1, R2	47 Ω , 1/4 W Chip Resistors	CRCW120647R0FKEA	Vishay
PCB	0.030", $\epsilon_r = 2.55$	AD255A	Arlon

TYPICAL CHARACTERISTICS — 960-1215 MHz

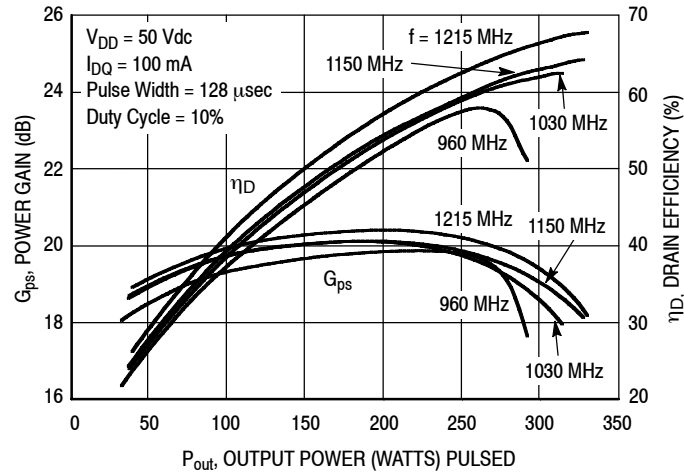


Figure 14. Pulsed Power Gain and Drain Efficiency versus Output Power

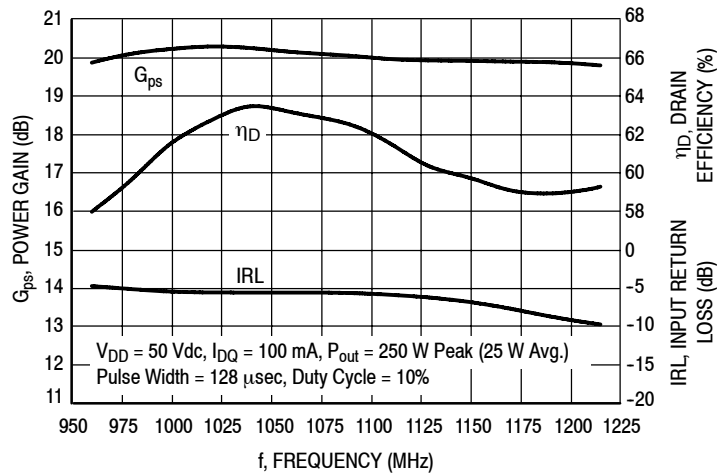
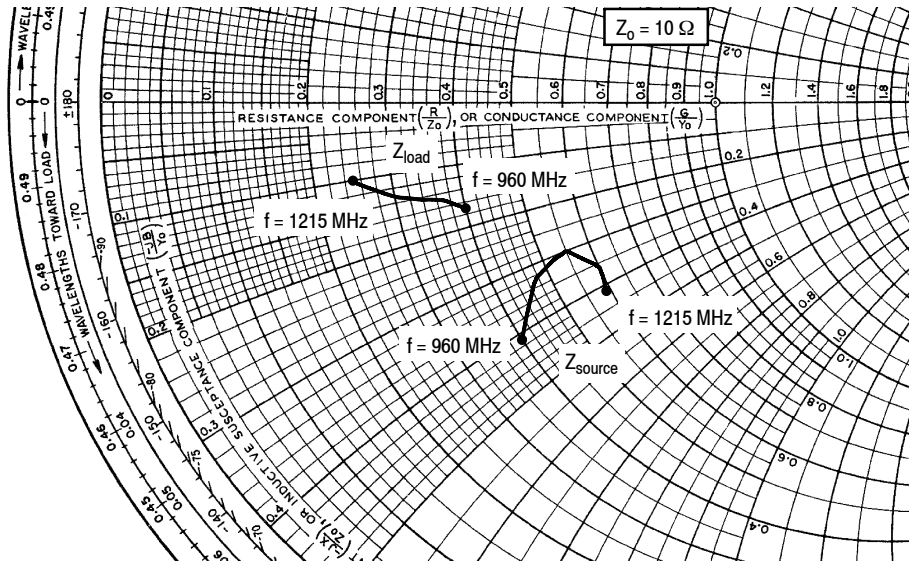


Figure 15. Broadband Performance @ $P_{out} = 250 \text{ Watts Peak}$



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

f MHz	Z_{source} Ω	Z_{load} Ω
960	4.00 - j4.14	3.96 - j1.70
970	4.05 - j3.99	3.90 - j1.67
980	4.16 - j3.86	3.83 - j1.66
990	4.33 - j3.71	3.75 - j1.66
1000	4.49 - j3.57	3.70 - j1.65
1010	4.61 - j3.43	3.68 - j1.62
1020	4.66 - j3.33	3.69 - j1.59
1030	4.68 - j3.26	3.69 - j1.54
1040	4.72 - j3.20	3.67 - j1.52
1050	4.83 - j3.13	3.59 - j1.53
1060	5.02 - j3.06	3.48 - j1.53
1070	5.24 - j2.99	3.38 - j1.53
1080	5.42 - j2.96	3.32 - j1.51
1090	5.51 - j2.99	3.30 - j1.47

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

f MHz	Z_{source} Ω	Z_{load} Ω
1100	5.49 - j3.04	3.32 - j1.43
1110	5.47 - j3.07	3.31 - j1.42
1120	5.52 - j3.09	3.24 - j1.40
1130	5.68 - j3.13	3.12 - j1.39
1140	5.89 - j3.20	2.99 - j1.36
1150	6.06 - j3.32	2.88 - j1.30
1160	6.09 - j3.47	2.83 - j1.23
1170	5.98 - j3.60	2.83 - j1.19
1180	5.85 - j3.69	2.80 - j1.15
1190	5.78 - j3.76	2.75 - j1.11
1200	5.81 - j3.87	2.65 - j1.07
1210	5.89 - j4.02	2.52 - j1.01
1215	5.91 - j4.11	2.47 - j0.97

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

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

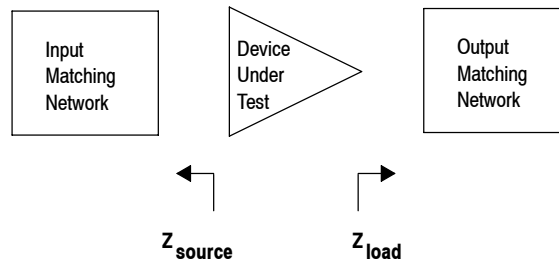
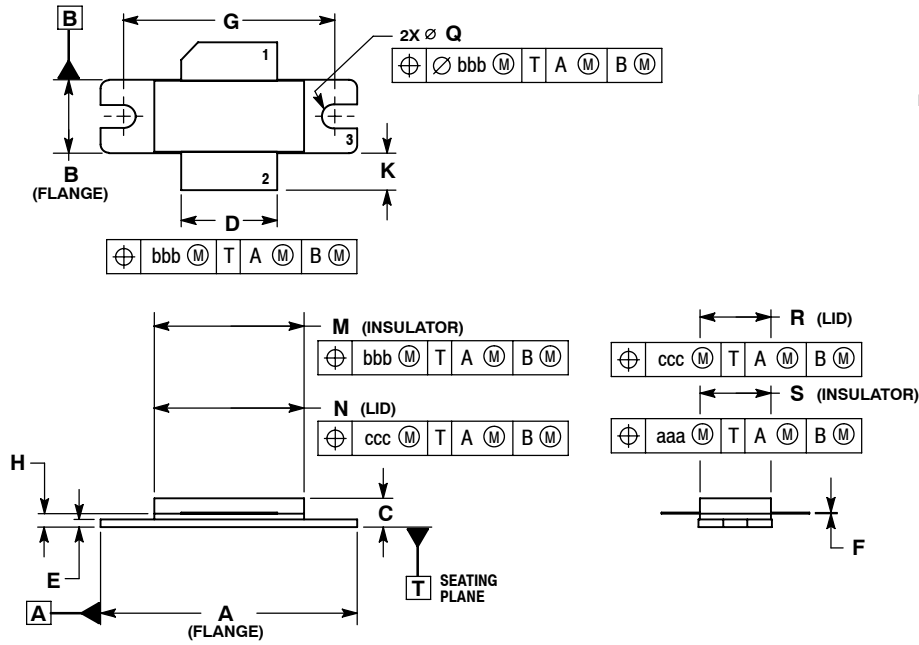


Figure 16. Series Equivalent Source and Load Impedance — 960-1215 MHz

PACKAGE DIMENSIONS



NOTES:

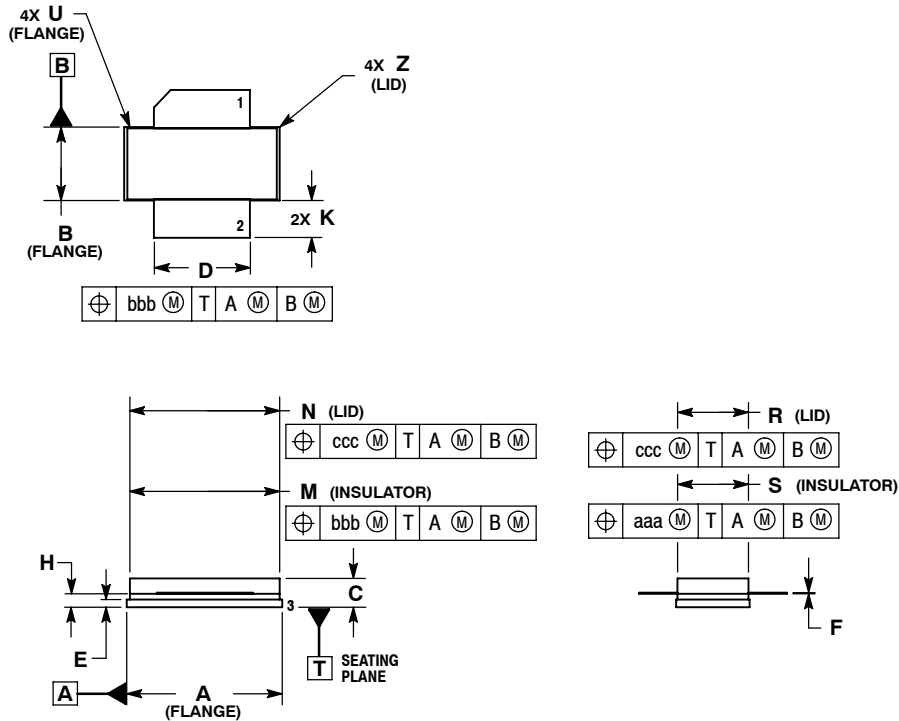
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
G	1.100	BSC	27.94	BSC
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.66	19.96
N	0.772	0.788	19.60	20.00
Q	Ø.118	Ø.138	Ø3.00	Ø3.51
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
aaa	0.005	REF	0.127	REF
bbb	0.010	REF	0.254	REF
ccc	0.015	REF	0.381	REF

STYLE 1:

- PIN 1. DRAIN
- GATE
- SOURCE

**CASE 465-06
ISSUE G
NI-780
MRF6V12250HR3**



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.805	0.815	20.45	20.70
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.61	20.02
N	0.772	0.788	19.61	20.02
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
U	---	0.040	---	1.02
Z	---	0.030	---	0.76
aaa	0.005	REF	0.127	REF
bbb	0.010	REF	0.254	REF
ccc	0.015	REF	0.381	REF

STYLE 1:

- PIN 1. DRAIN
- GATE
- SOURCE

**CASE 465A-06
ISSUE H
NI-780S
MRF6V12250HSR3**

MRF6V12250HR3 MRF6V12250HSR3

PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents, tools 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

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	May 2009	• Initial Release of Data Sheet
1	July 2009	• Updated Typical Broadband Performance bullet to include V_{DD}, I_{DQ} and Pulsed information. Provided specific values for Power Gain and Drain Efficiency, p. 1 • Added Typical Performance table for 960–1215 MHz application, p. 2 • Changed “EKMG630ELL471MK25S” part number to “MCGPA63V477M13X26–RH”, Table 5, Test Circuit Component Designations and Values, p. 3 • Added Fig. 5, Safe Operating Area, p. 5 • Added Fig. 13, Test Circuit Component Layout – 960–1215 MHz and Table 6, Test Circuit Component Designations and Values – 960–1215 MHz, p. 8 • Added Fig. 14, Power Gain and Drain Efficiency versus Output Power – 960–1215 MHz, p. 9 • Added Fig 15, Broadband Performance @ Pout = 250 Watts Peak – 960–1215 MHz, p. 9 • Added Fig. 16, Series Equivalent Source and Load Impedance – 960–1215 MHz, p. 10
2	Apr. 2010	• 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 • Reporting of pulsed thermal data now shown using the $Z_{\theta JC}$ symbol, p. 1 • Added RF High Power Model availability to Product Software, p. 12

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