



# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for GSM and GSM EDGE base station applications with frequencies from 865 to 960 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

- Typical GSM Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 500$  mA,  $P_{out} = 72$  Watts CW

Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)
920 MHz	19.3	51.6
940 MHz	19.3	52.9
960 MHz	19.1	54.1

- Capable of Handling 10:1 VSWR, @ 32 Vdc, 940 MHz, 133 Watts CW Output Power (3 dB Input Overdrive from Rated  $P_{out}$ )
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx 108$  Watts CW
- Typical GSM EDGE Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 700$  mA,  $P_{out} = 45$  Watts Avg.

Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	SR1 @ 400 kHz (dBc)	SR2 @ 600 kHz (dBc)	EVM (% rms)
920 MHz	19.1	43	-64.1	-74.5	1.8
940 MHz	19.1	44	-63.6	-74.6	2.0
960 MHz	19.0	45	-62.8	-75.1	2.3

### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- 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.

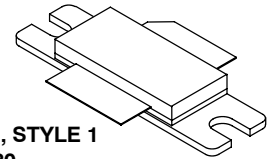
**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +70	Vdc
Gate-Source Voltage	$V_{GS}$	-6.0, +10	Vdc
Operating Voltage	$V_{DD}$	32, +0	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

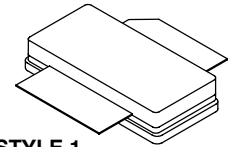
1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

**MRF8S9100HR3**  
**MRF8S9100HSR3**

**920-960 MHz, 72 W CW, 28 V**  
**GSM, GSM EDGE**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF8S9100HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF8S9100HSR3**

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 100 W CW, 28 Vdc, I <sub>DQ</sub> = 500 mA Case Temperature 81°C, 72 W CW, 28 Vdc, I <sub>DQ</sub> = 500 mA Case Temperature 82°C, 45 W CW, 28 Vdc, I <sub>DQ</sub> = 700 mA	R <sub>θJC</sub>	0.60 0.65 0.69	°C/W

**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<sub>A</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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**Off Characteristics**

Zero Gate Voltage Drain Leakage Current (V <sub>DS</sub> = 70 Vdc, V <sub>GS</sub> = 0 Vdc)	I <sub>DSS</sub>	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V <sub>DS</sub> = 28 Vdc, V <sub>GS</sub> = 0 Vdc)	I <sub>DSS</sub>	—	—	1	μAdc
Gate-Source Leakage Current (V <sub>GS</sub> = 5 Vdc, V <sub>DS</sub> = 0 Vdc)	I <sub>GSS</sub>	—	—	1	μAdc

**On Characteristics**

Gate Threshold Voltage (V <sub>DS</sub> = 10 Vdc, I <sub>D</sub> = 460 μAdc)	V <sub>GS(th)</sub>	1.4	2.2	2.9	Vdc
Gate Quiescent Voltage (V <sub>DD</sub> = 28 Vdc, I <sub>D</sub> = 500 mAdc, Measured in Functional Test)	V <sub>GS(Q)</sub>	2.1	2.9	3.6	Vdc
Drain-Source On-Voltage (V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 1.7 Adc)	V <sub>DS(on)</sub>	0.1	0.17	0.3	Vdc

**Functional Tests** <sup>(3)</sup> (In Freescale Test Fixture, 50 ohm system) V<sub>DD</sub> = 28 Vdc, I<sub>DQ</sub> = 500 mA, P<sub>out</sub> = 72 W CW, f = 920 MHz

Power Gain	G <sub>ps</sub>	18	19.3	23	dB
Drain Efficiency	η <sub>D</sub>	50	51.6	—	%
Input Return Loss	IRL	—	-12.4	-9	dB
P <sub>out</sub> @ 1 dB Compression Point, CW	P1dB	100	—	—	W

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system) V<sub>DD</sub> = 28 Vdc, I<sub>DQ</sub> = 500 mA, P<sub>out</sub> = 72 W CW

Frequency	G <sub>ps</sub> (dB)	η <sub>D</sub> (%)	IRL (dB)
920 MHz	19.3	51.6	-12.4
940 MHz	19.3	52.9	-14.3
960 MHz	19.1	54.1	-12.2

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

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 500\text{ mA}$ , 920-960 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	$P_{1dB}$	—	108	—	W
IMD Symmetry @ 100 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$ (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands $> 2\text{ dB}$ )	$IMD_{sym}$	—	4	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	$VBW_{res}$	—	30	—	MHz
Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 72\text{ W CW}$	$G_F$	—	0.13	—	dB
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.02	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.005	—	dB/ $^\circ\text{C}$

**Typical GSM EDGE Performances** (In Freescale GSM EDGE Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 700\text{ mA}$ ,  $P_{out} = 45\text{ W Avg.}$ , 920-960 MHz EDGE Modulation

Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	SR1 @ 400 kHz (dBc)	SR2 @ 600 kHz (dBc)	EVM (% rms)
920 MHz	19.1	43	-64.1	-74.5	1.8
940 MHz	19.1	44	-63.6	-74.6	2.0
960 MHz	19.0	45	-62.8	-75.1	2.3

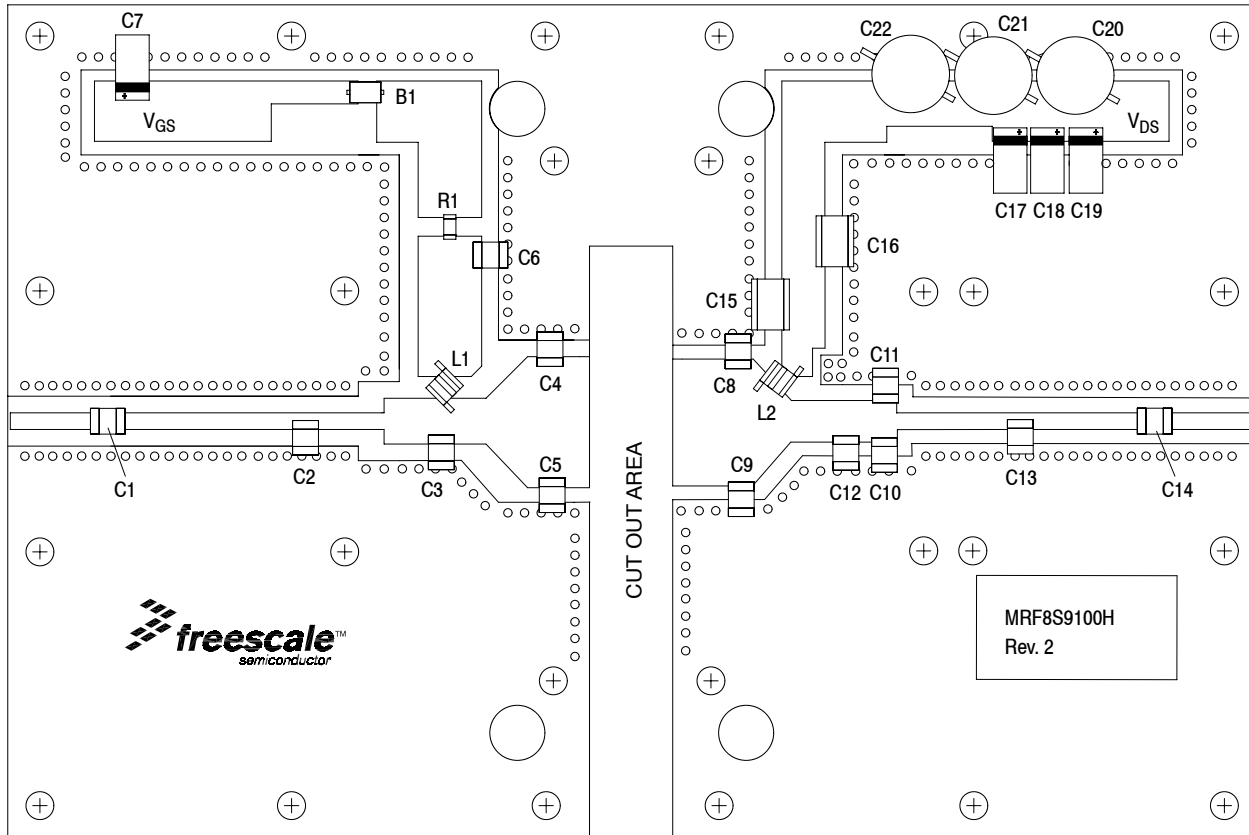
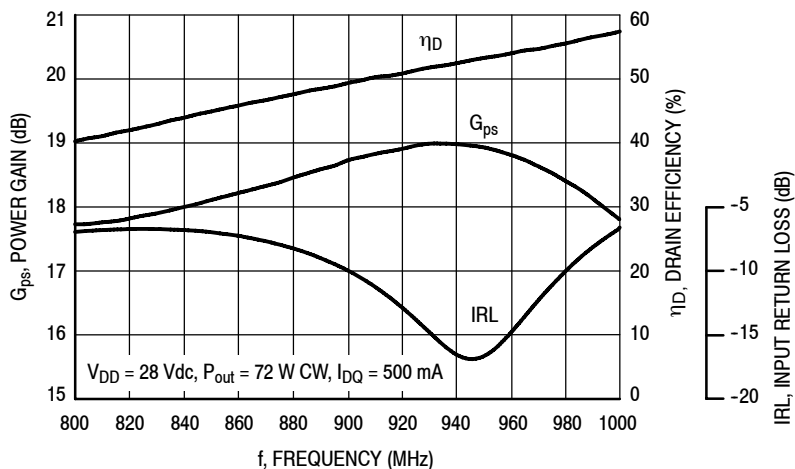


Figure 1. MRF8S9100HR3(HSR3) Test Circuit Component Layout

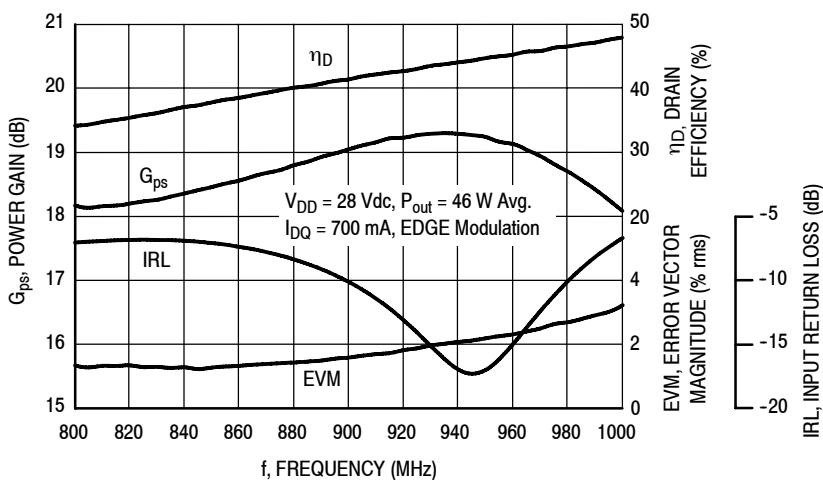
Table 5. MRF8S9100HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Short RF Bead	2743019447	Fair-Rite
C1, C6	47 pF Chip Capacitors	ATC100B470JT500XT	ATC
C2	5.6 pF Chip Capacitor	ATC100B5R6BT500XT	ATC
C3	7.5 pF Chip Capacitor	ATC100B7R5BT500XT	ATC
C4, C5	9.1 pF Chip Capacitors	ATC100B9R1BT500XT	ATC
C7, C17, C18, C19	10 $\mu$ F, 35 V Tantalum Capacitors	T491D106K035AT	Kemet
C8, C9	13 pF Chip Capacitors	ATC100B130BT500XT	ATC
C10, C11	2.7 pF Chip Capacitors	ATC100B2R7BT500XT	ATC
C12	6.2 pF Chip Capacitor	ATC100B6R2BT500XT	ATC
C13	1.8 pF Chip Capacitor	ATC100B1R8BT500XT	ATC
C14	20 pF Chip Capacitor	ATC100B200JT500XT	ATC
C15, C16	0.56 $\mu$ F, 50 V Chip Capacitors	C1825C564J5RAC-TU	Kemet
C20, C21, C22	470 $\mu$ F, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
L1, L2	12.5 nH, 4 Turn Inductors	A04TJLC	Coilcraft
R1	0 $\Omega$ , 3 A Chip Resistor	CRCW12060000Z0EA	Vishay
PCB	0.030", $\epsilon_r = 2.55$	AD255A-0300-55-11	Arlon

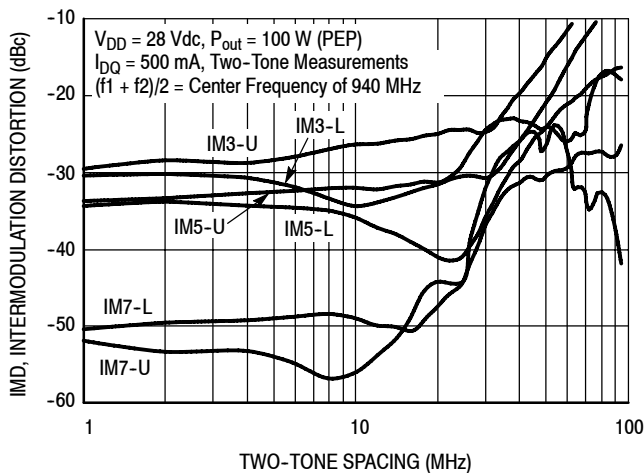
## TYPICAL CHARACTERISTICS



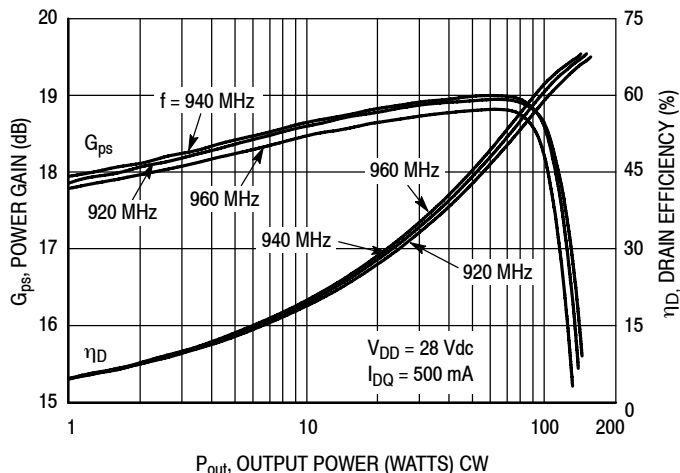
**Figure 2. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @  $P_{out} = 72$  Watts CW**



**Figure 3. Power Gain, Input Return Loss, EVM and Drain Efficiency versus Frequency @  $P_{out} = 46$  Watts Avg.**

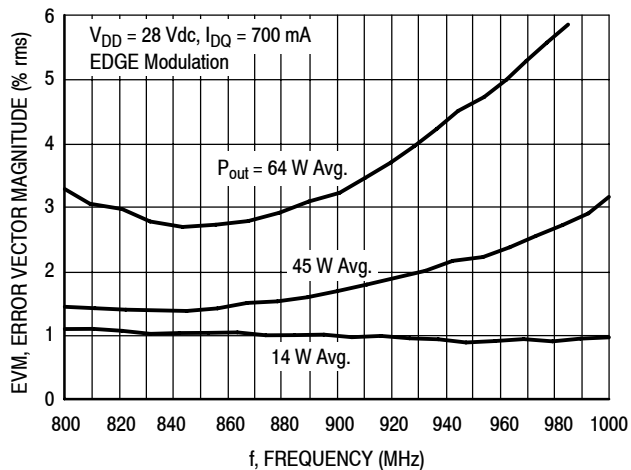


**Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing**

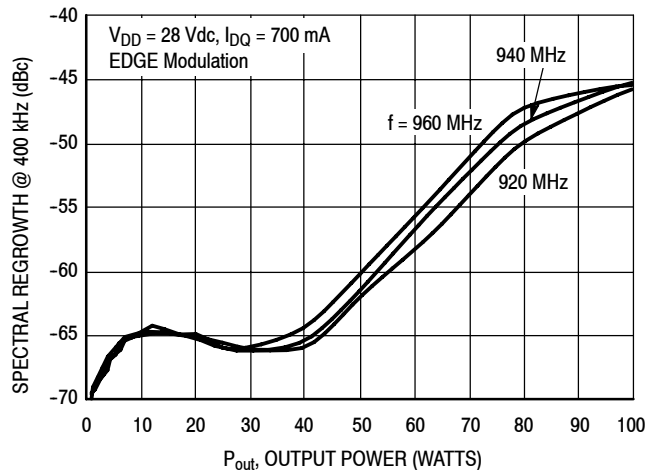


**Figure 5. Power Gain and Drain Efficiency versus Output Power**

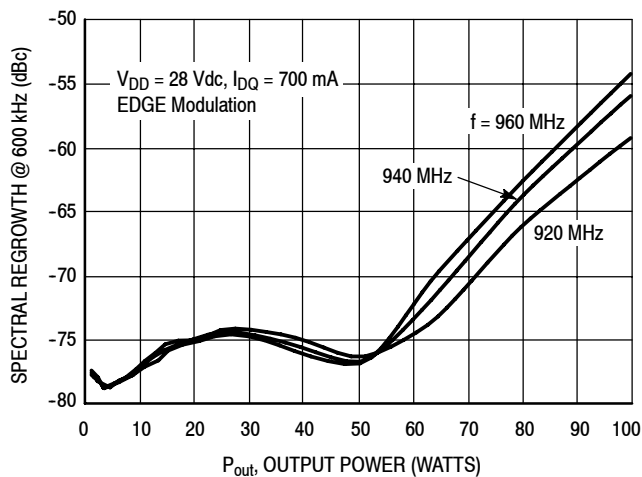
## TYPICAL CHARACTERISTICS



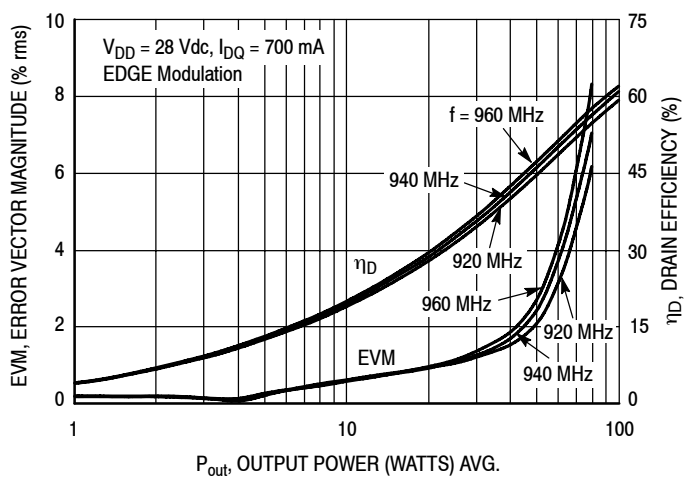
**Figure 6. EVM versus Frequency**



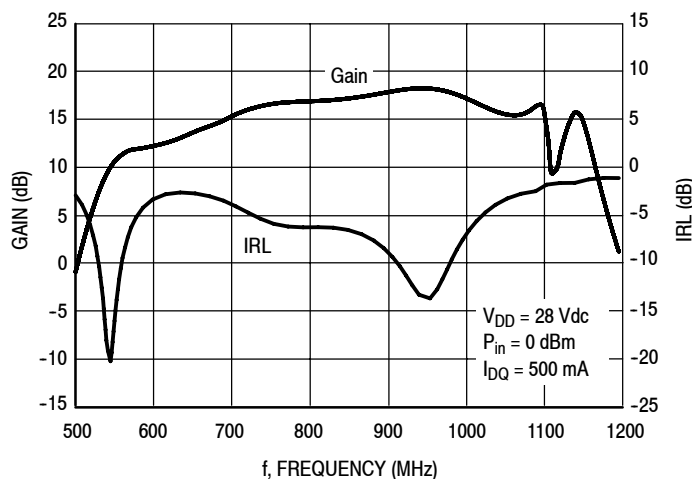
**Figure 7. Spectral Regrowth at 400 kHz versus Output Power**



**Figure 8. Spectral Regrowth at 600 kHz versus Output Power**

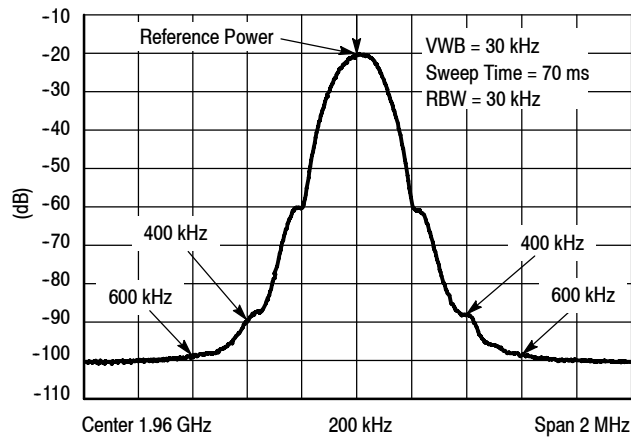


**Figure 9. EVM and Drain Efficiency versus Output Power**



**Figure 10. Broadband Frequency Response**

## GSM TEST SIGNAL



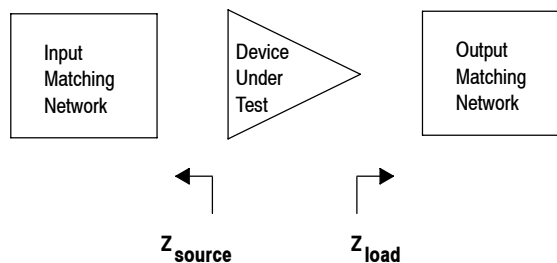
**Figure 11. EDGE Spectrum**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 500 \text{ mA}$ ,  $P_{out} = 72 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
820	3.81 - j1.72	1.61 - j0.48
840	3.99 - j1.80	1.62 - j0.34
860	4.13 - j1.97	1.62 - j0.21
880	4.20 - j2.22	1.63 - j0.09
900	4.14 - j2.49	1.62 + j0.02
920	3.96 - j2.74	1.60 + j0.12
940	3.67 - j2.95	1.57 + j0.22
960	3.31 - j3.07	1.53 + j0.32
980	2.91 - j3.09	1.47 + j0.42

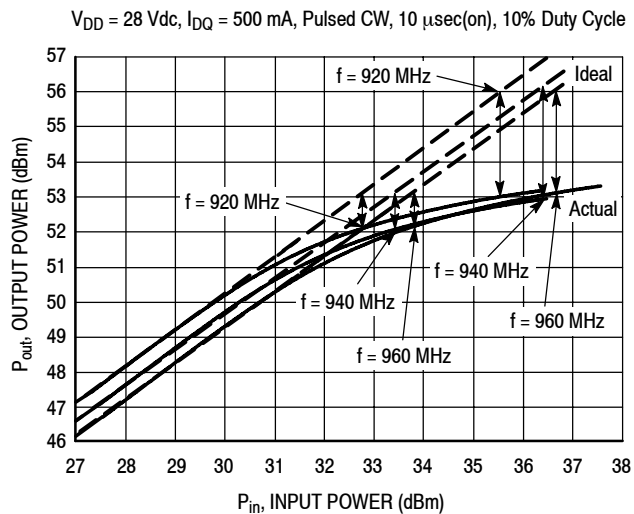
$Z_{source}$  = Test circuit impedance as measured from gate to ground.

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



**Figure 12. Series Equivalent Source and Load Impedance**

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
920	166	52.2	199	53.0
940	158	52.0	195	52.9
960	166	52.2	209	53.2

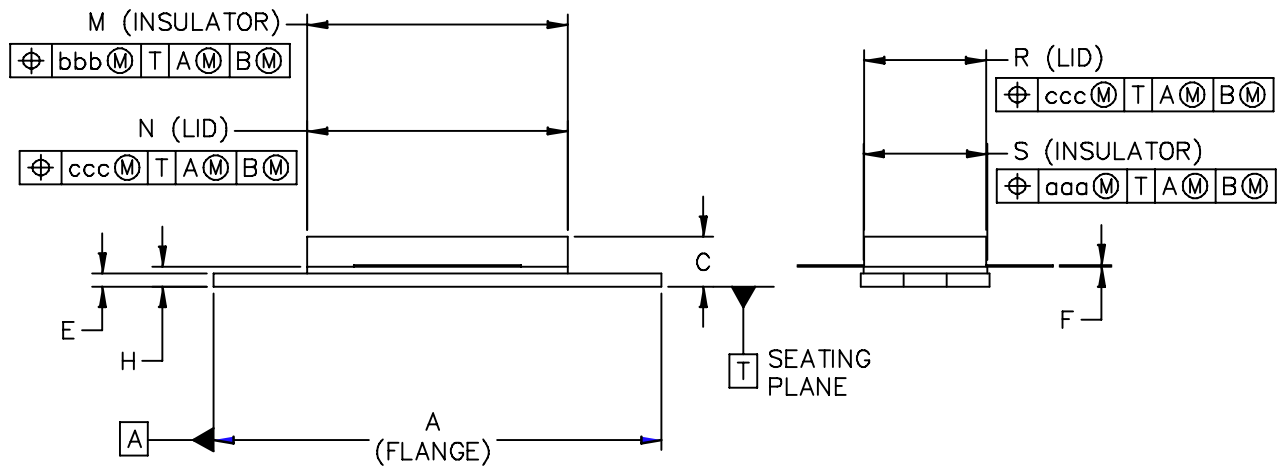
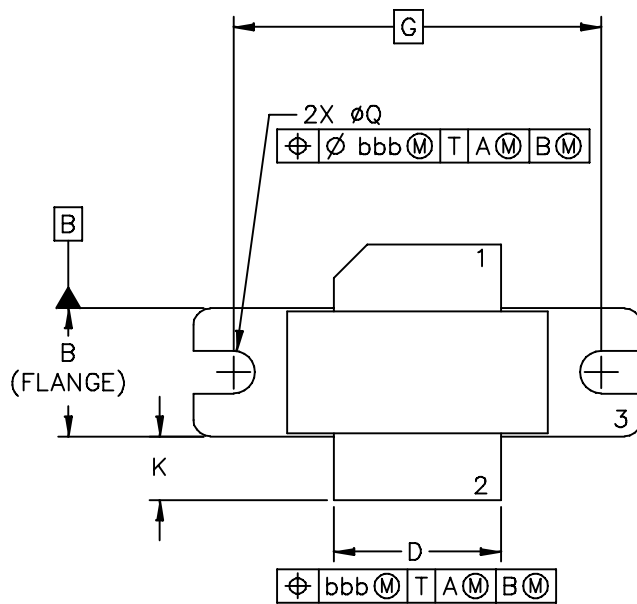
Test Impedances per Compression Level

f (MHz)		$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
920	P1dB	$3.96 - j2.74$	$1.60 + j0.12$
940	P1dB	$3.67 - j2.95$	$1.57 + j0.22$
960	P1dB	$3.31 - j3.07$	$1.53 + j0.32$

**Figure 13. Pulsed CW Output Power versus Input Power @ 28 V**



## PACKAGE DIMENSIONS



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**MRF8S9100HR3 MRF8S9100HSR3**

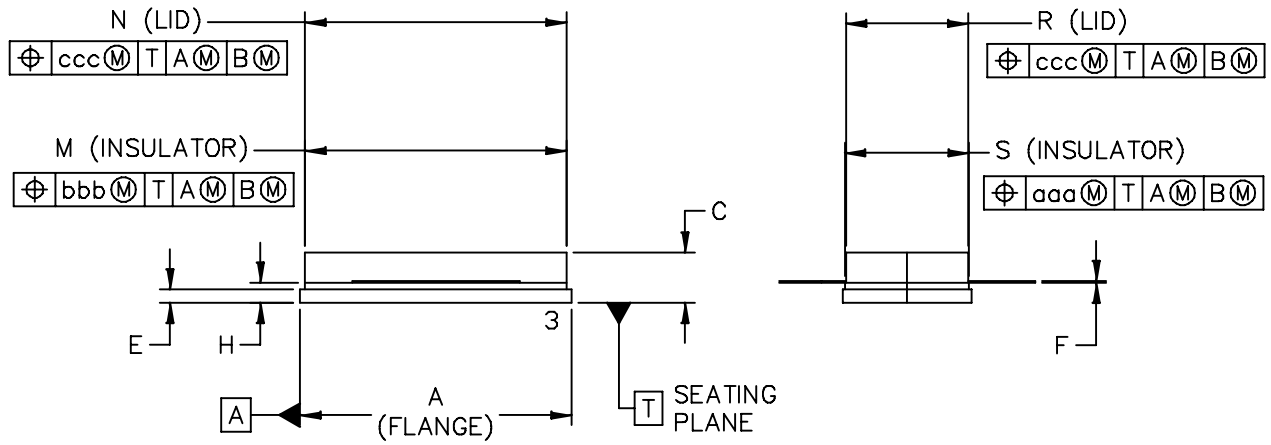
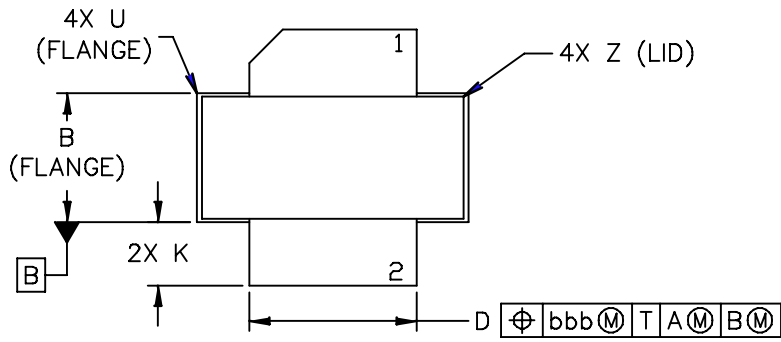
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
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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3. DELETED
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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		STANDARD: NON–JEDEC			

## 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
- .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.

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Sept. 2009	• Initial Release of Data Sheet
1	Oct. 2010	• Changed Human Body Model ESD rating from Class 1C to Class 2 to reflect recent ESD test results of the device, p. 2.

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