Freescale Semiconductor
Technical Data

Document Number: MRF8S9220H
Rev. 0, 11/2009

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MRF8S9220HR3
MRF8S9220HSR3

Designed for CDMA base station applications with frequencies from 920 to 960 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

- Typical Single-Carrier W-CDMA Performance: V_{DD} = 28 Volts, I_{DQ} = 1600 mA, P_{out} = 65 Watts Avg., IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.

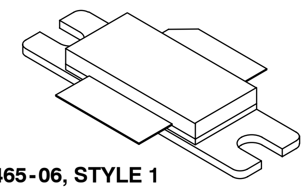
Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dBc)
920 MHz	19.7	35.1	6.1	-37.4
940 MHz	19.8	35.3	6.2	-37.5
960 MHz	19.4	35.7	6.1	-37.4

- Capable of Handling 10:1 VSWR, @ 32 Vdc, 940 MHz, 317 Watts CW Output Power (3 dB Input Overdrive from Rated P_{out}), Designed for Enhanced Ruggedness
- Typical P_{out} @ 1 dB Compression Point ≃ 220 Watts CW

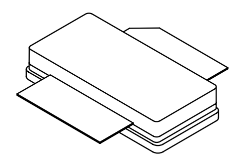
Features

- 100% PAR Tested for Guaranteed Output Power Capability
- 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
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

920-960 MHz, 65 W AVG., 28 V
SINGLE W-CDMA
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 465-06, STYLE 1
NI-780
MRF8S9220HR3



CASE 465A-06, STYLE 1
NI-780S
MRF8S9220HSR3

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

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 81°C, 65 W CW, 28 Vdc, I_{DQ} = 1600 mA Case Temperature 81°C, 220 W CW, 28 Vdc, I_{DQ} = 1600 mA	$R_{\theta JC}$	 0.39 0.32	°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.

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Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	1C (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

Table 4. Electrical Characteristics (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 70 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 400 μAdc)	$V_{GS(th)}$	1.5	2.2	3	Vdc
Gate Quiescent Voltage (V_{DD} = 28 Vdc, I_D = 1600 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	2.3	3.1	3.8	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 4 Adc)	$V_{DS(on)}$	0.1	0.2	0.3	Vdc

Functional Tests [(1)] (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1600 mA, P_{out} = 65 W Avg., f = 960 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	18.0	19.4	21.0	dB
Drain Efficiency	η_D	34.0	35.7	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.1	—	dB
Adjacent Channel Power Ratio	ACPR	—	-37.4	-35	dBc
Input Return Loss	IRL	—	-13	-8	dB

Typical Broadband Performance (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1600 mA, P_{out} = 65 W Avg., Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.

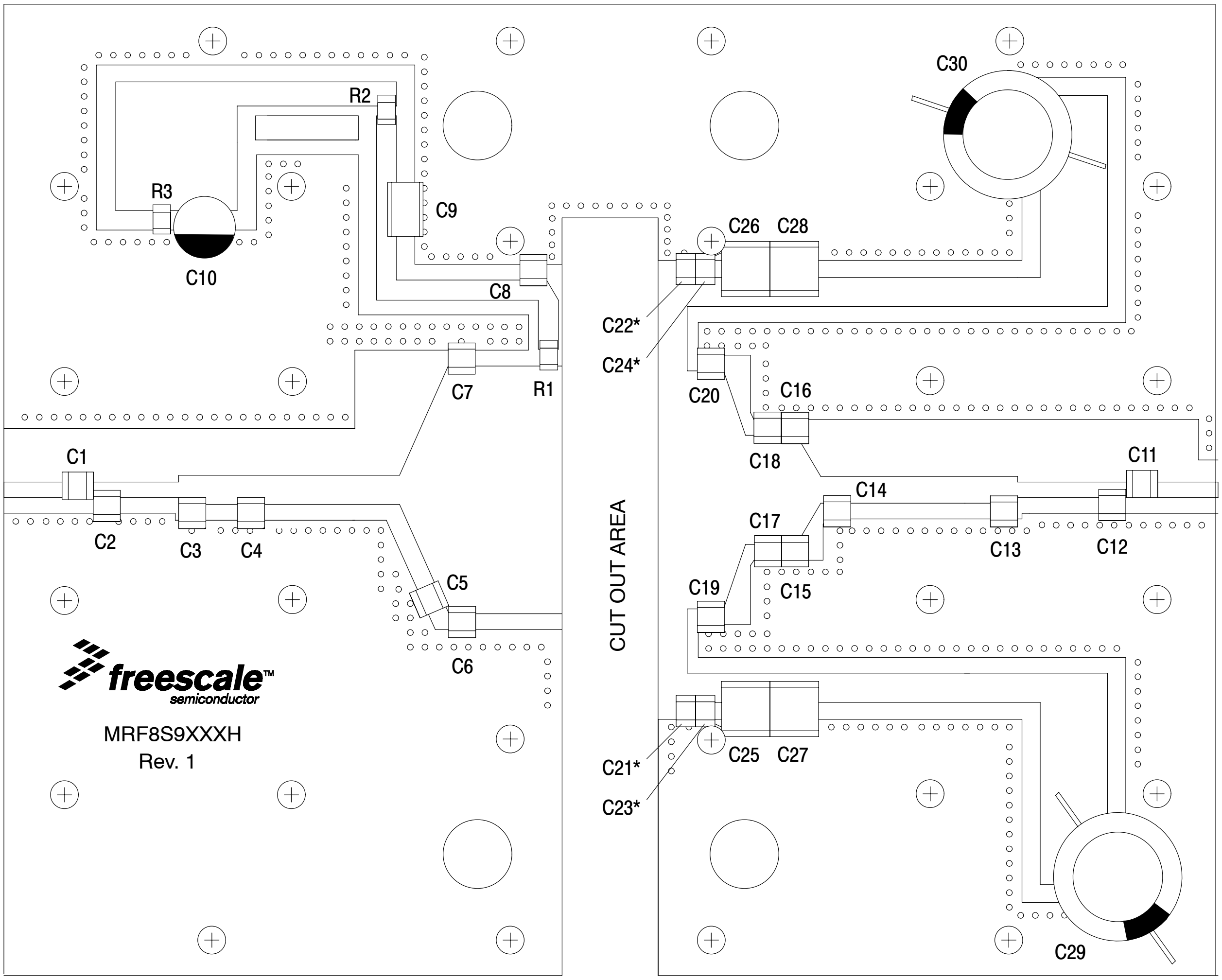
Frequency	G_{ps} (dB)	η_D (%)	Output PAR (dB)	ACPR (dB)	IRL (dB)
920 MHz	19.7	35.1	6.1	-37.4	-13
940 MHz	19.8	35.3	6.2	-37.5	-24
960 MHz	19.4	35.7	6.1	-37.4	-13

1. Part internally matched both on input and output.

(continued)

Table 4. Electrical Characteristics (T_A = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Typical Performances (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 1600 mA, 920-960 MHz Bandwidth					
P_{out} @ 1 dB Compression Point, CW	P1dB	—	220	—	W
IMD Symmetry @ 200 W PEP, P_{out} where IMD Third Order Intermodulation ≅ 30 dBc (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB)	IMD_{sym}	—	12	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW_{res}	—	40	—	MHz
Gain Flatness in 40 MHz Bandwidth @ P_{out} = 65 W Avg.	G_F	—	0.3	—	dB
Gain Variation over Temperature (-30°C to +85°C)	ΔG	—	0.017	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	ΔP1dB	—	0.016	—	dBm/°C



*C21, C22, C23, and C24 are mounted vertically.

Figure 1. MRF8S9220HR3(HSR3) Test Circuit Component Layout

Table 5. MRF8S9220HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C8, C11, C23, C24	39 pF Chip Capacitors	ATC100B390JT500XT	ATC
C2	0.3 pF Chip Capacitor	ATC100B0R3BT500XT	ATC
C3, C12	1.0 pF Chip Capacitors	ATC100B1R0BT500XT	ATC
C4, C14	1.2 pF Chip Capacitors	ATC100B1R2BT500XT	ATC
C5	0.7 pF Chip Capacitor	ATC100B0R7BT500XT	ATC
C6, C7, C21, C22	10 pF Chip Capacitors	ATC100B100JT500XT	ATC
C9	2.2 μF, 50 V Chip Capacitor	C1825C225J5RAC-TU	Kemet
C10	47 μF, 50 V Electrolytic Capacitor	476KXM050M	Illinois Capacitor
C13	1.3 pF Chip Capacitor	ATC100B1R3BT500XT	ATC
C15, C16	5.1 pF Chip Capacitors	ATC100B5R1CT500XT	ATC
C17	5.6 pF Chip Capacitor	ATC100B5R6CT500XT	ATC
C18	6.2 pF Chip Capacitor	ATC100B6R2BT500XT	ATC
C19, C20	6.8 pF Chip Capacitors	ATC100B6R8CT500XT	ATC
C25, C26, C27, C28	10 μF, 50 V Chip Capacitors	GRM55DR61H106KA88L	Murata
C29, C30	470 μF, 63 V Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
R1	0 Ω, 3 A Chip Resistor	CRCW12060000Z0EA	Vishay
R2	3.3 Ω, 1/2 W Chip Resistor	P3.3VCT-ND	Panasonic
R3	2.2 kΩ, 1/4 W Chip Resistor	CRCW12062K20FKEA	Vishay
PCB	0.030″, ε_r = 3.5	RF-35	Taconic

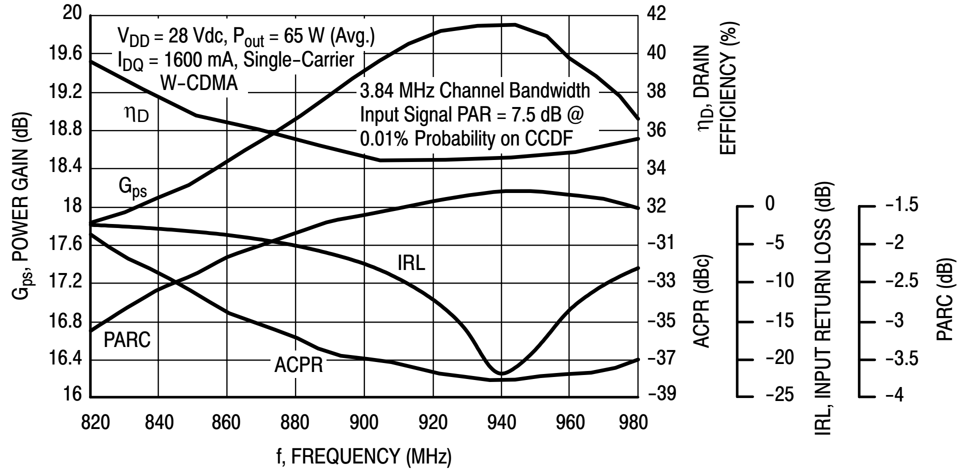


Figure 2. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ P_{out} = 65 Watts Avg.

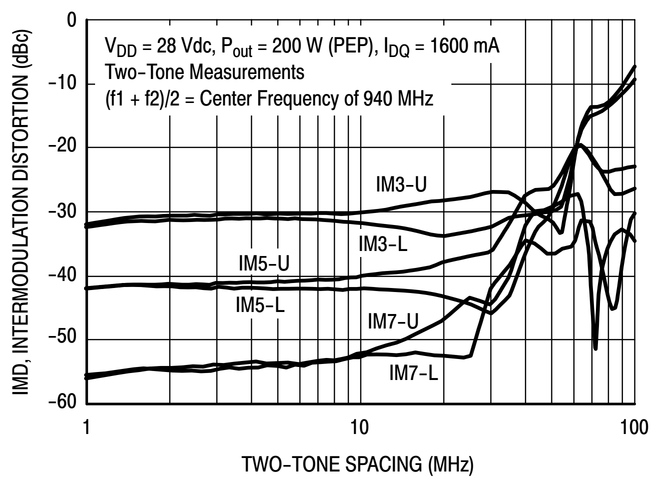


Figure 3. Intermodulation Distortion Products versus Two-Tone Spacing

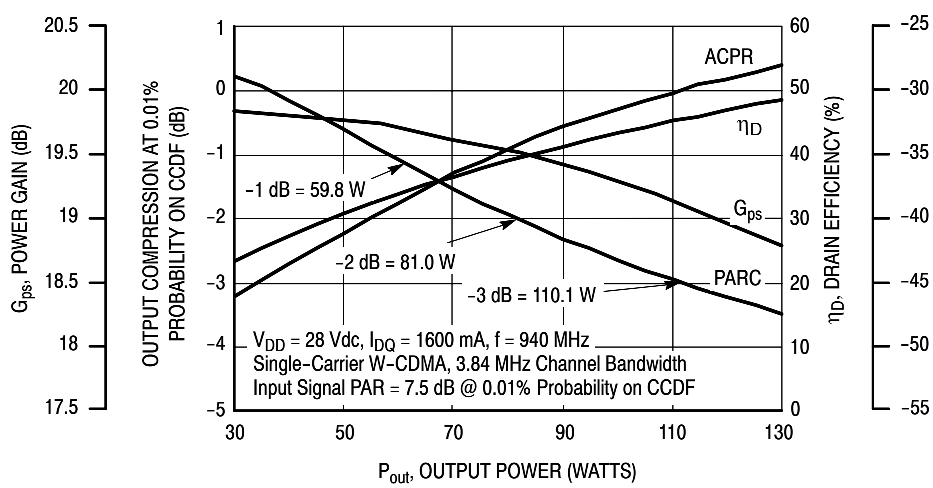


Figure 4. Output Peak-to-Average Ratio Compression (PARC) versus Output Power

TYPICAL CHARACTERISTICS

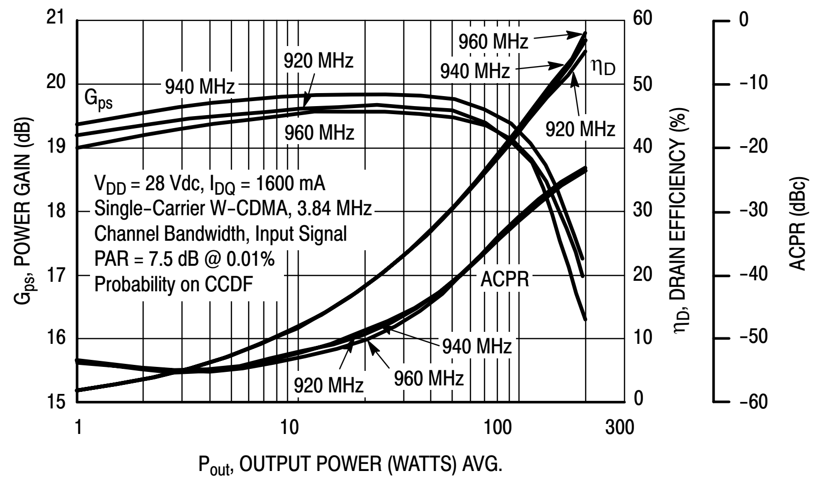


Figure 5. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power

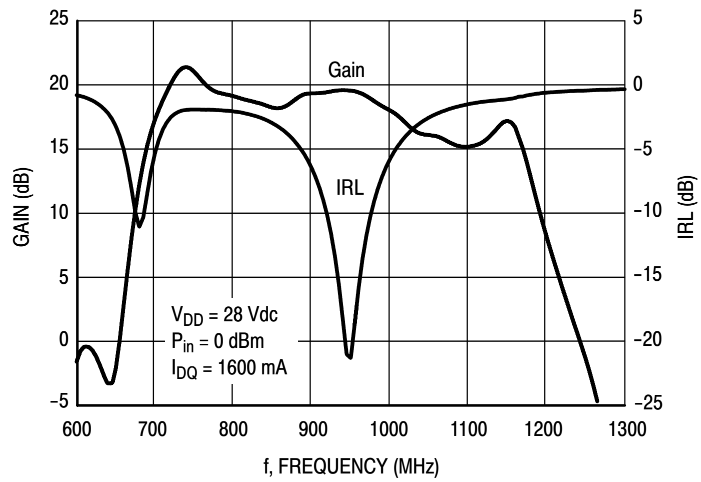


Figure 6. Broadband Frequency Response

W-CDMA TEST SIGNAL

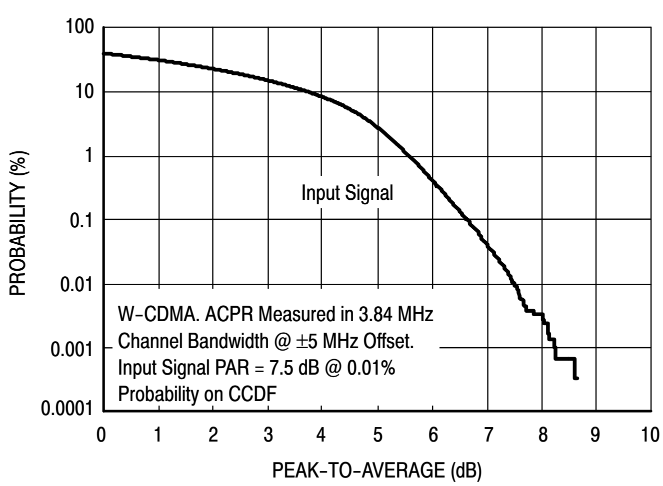


Figure 7. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal

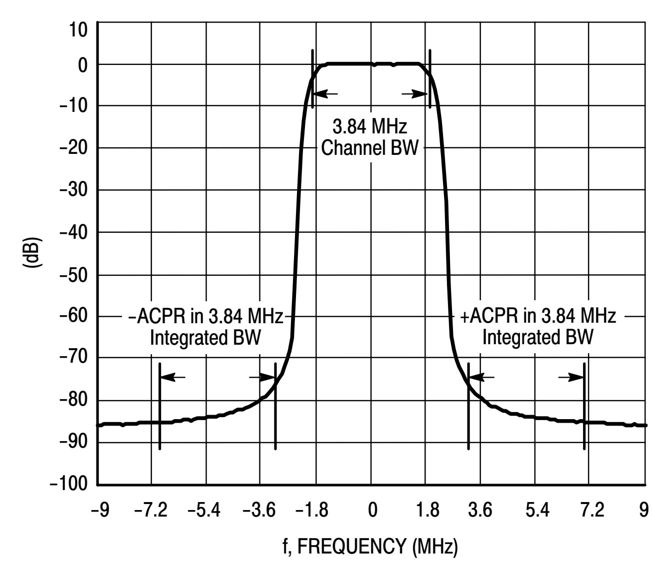


Figure 8. Single-Carrier W-CDMA Spectrum

V_{DD} = 28 Vdc, I_{DQ} = 1600 mA, P_{out} = 65 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
820	1.27 - j1.44	2.14 - j2.23
840	1.27 - j1.15	1.97 - j1.94
860	1.23 - j0.90	1.82 - j1.65
880	1.05 - j0.68	1.54 - j1.40
900	0.95 - j0.39	1.29 - j1.11
920	0.94 - j0.15	1.26 - j0.85
940	0.90 + j0.08	1.22 - j0.69
960	0.85 + j0.31	1.11 - j0.47
980	0.78 + j0.55	1.01 - j0.23

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

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

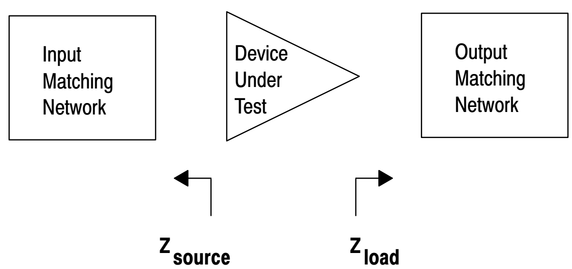
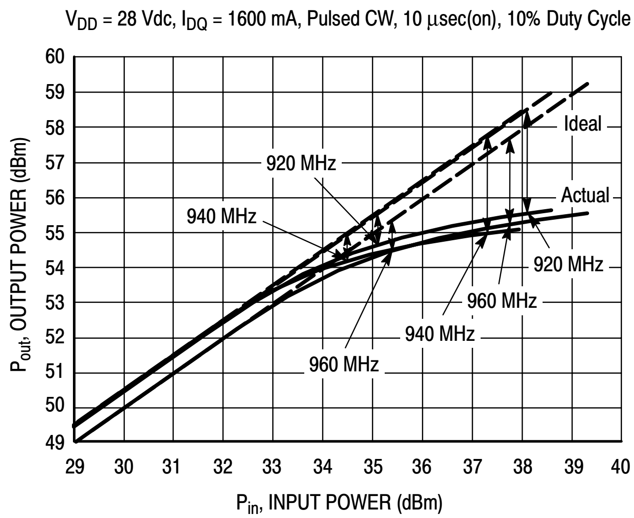


Figure 9. Series Equivalent Source and Load Impedance

ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



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

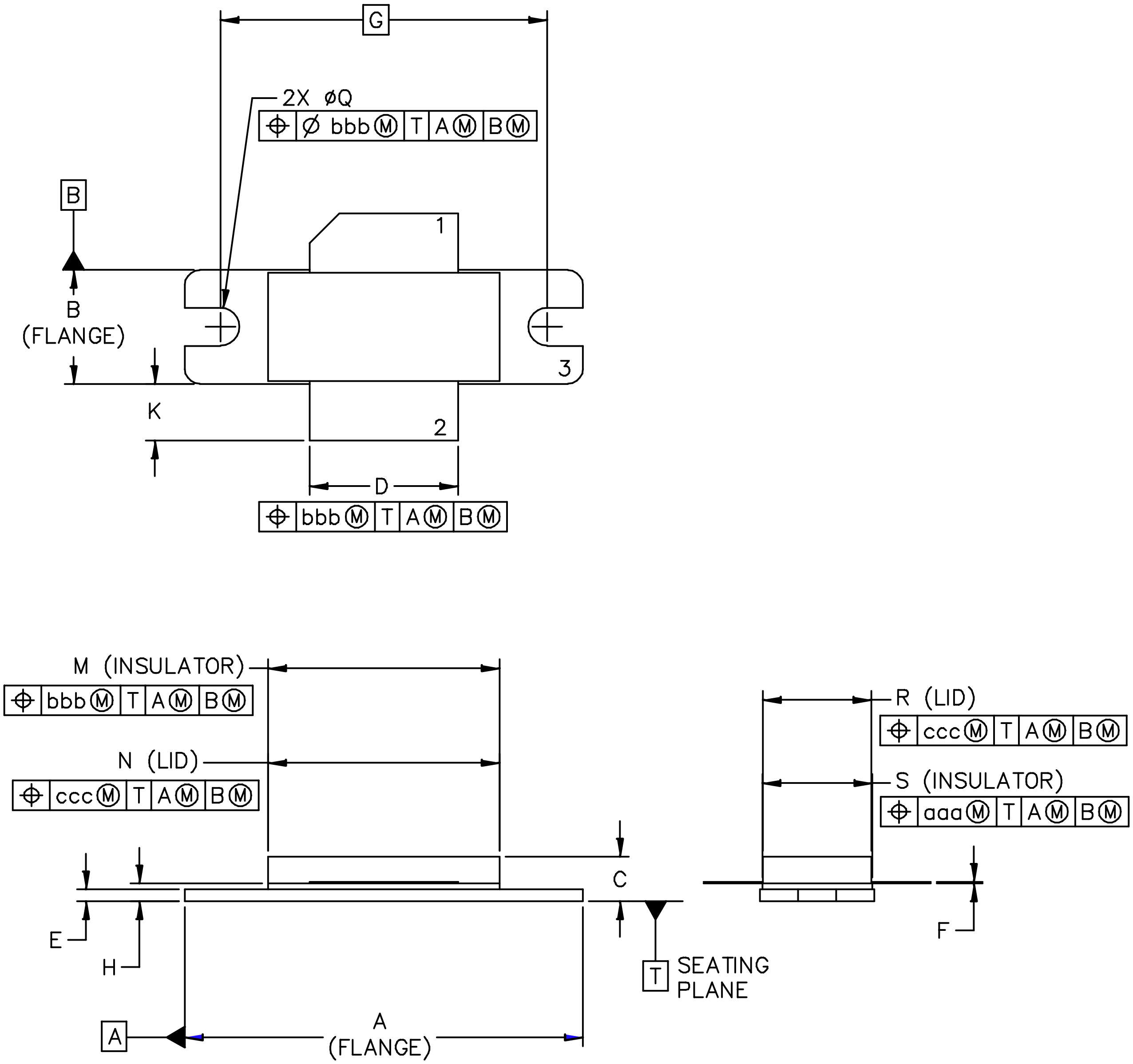
f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
920	295	54.7	357	55.5
940	270	54.3	316	55.0
960	284	54.5	344	55.4

Test Impedances per Compression Level

f (MHz)		Z_{source} Ω	Z_{load} Ω
920	P1dB	0.630 - j1.26	0.791 - j1.16
940	P1dB	0.728 - j1.43	0.809 - j1.04
960	P1dB	0.886 - j1.68	0.853 - j1.28

Figure 10. Pulsed CW Output Power versus Input Power @ 28 V

PACKAGE DIMENSIONS



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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 MIN		INCH MAX	MILLIMETER MIN		MILLIMETER MAX	DIM	INCH MIN		INCH MAX	MILLIMETER MIN		MILLIMETER 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	ø.118	–	ø.138	ø3	–	ø3.51	–	–	–	–	–	–	–

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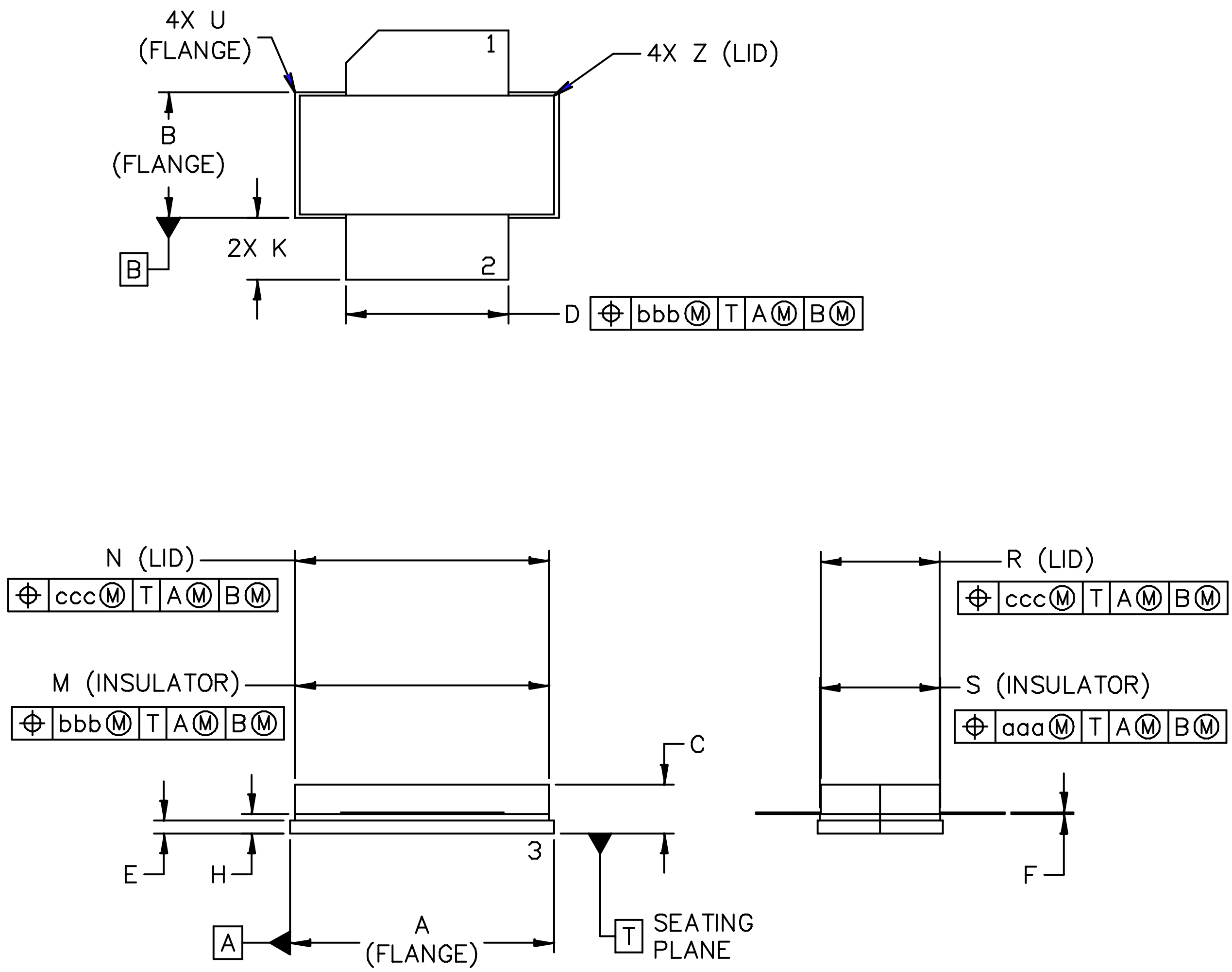

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3. DELETED

4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	INCH MIN		INCH MAX	MILLIMETER MIN		MILLIMETER MAX	DIM	INCH MIN		INCH MAX	MILLIMETER MIN		MILLIMETER 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, TOOLS 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
- .s2p File

For Software and Tools, 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	Nov. 2009	• Initial Release of Data Sheet

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Freescale Semiconductor, Inc.
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Tempe, Arizona 85284
1-800-521-6274 or +1-480-768-2130
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Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
www.freescale.com/support

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 10 5879 8000
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