Freescale Semiconductor
Technical Data

Document Number: MMRF1011H
Rev. 0, 7/2014

RoHS

RF Power LDMOS Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

MMRF1011HR5
MMRF1011HSR5

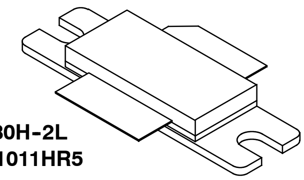
RF power transistors designed for applications operating at frequencies between 1200 and 1400 MHz, 1% to 12% duty cycle. These devices are suitable for use in pulse applications, such as L- Band radar.

- Typical Pulse Performance: V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 330 W Peak (39.6 W Avg.), f = 1400 MHz, Pulse Width = 300 μsec, Duty Cycle = 12%
  - Power Gain — 18 dB
  - Drain Efficiency — 60.5%
- Capable of Handling 5:1 VSWR @ 50 Vdc, 1400 MHz, 330 W Peak Power

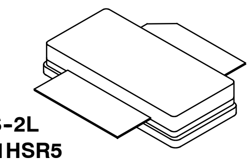
Features

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

1400 MHz, 330 W, 50 V
PULSE L-BAND
RF POWER MOSFETs



NI-780H-2L
MMRF1011HR5



NI-780S-2L
MMRF1011HSR5

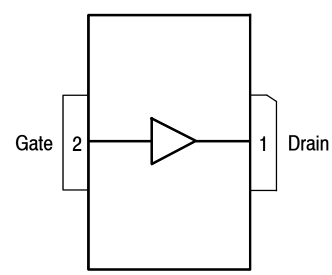


Figure 1. Pin Connections

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 65°C, 330 W Peak, 300 μsec Pulse Width, 12% Duty Cycle	$Z_{\theta JC}$	0.13	°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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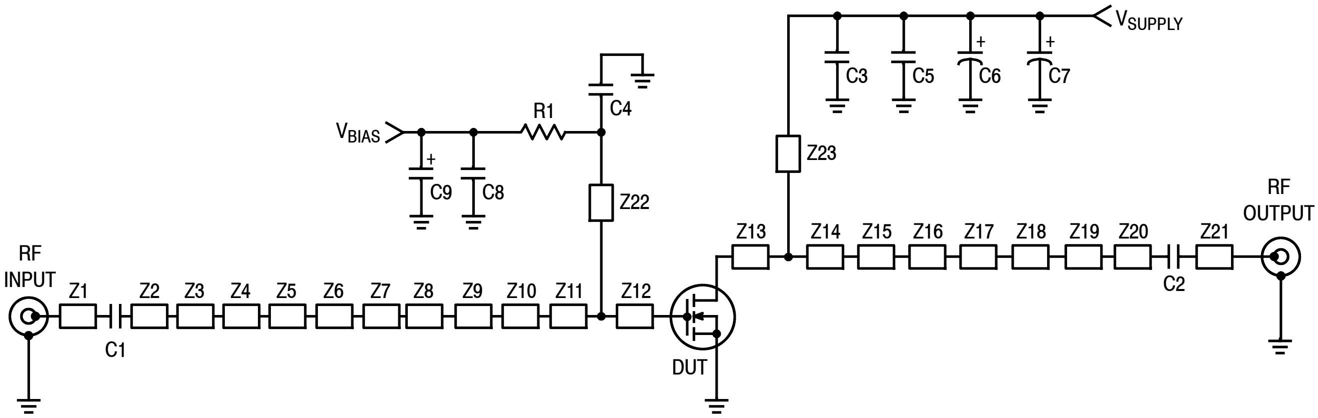
Table 3. ESD Protection Characteristics

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	10	μAdc
Drain-Source Breakdown Voltage (V_{GS} = 0 Vdc, I_D = 100 mA)	$V_{(BR)DSS}$	100	—	—	Vdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	50	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 90 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	2.5	mA
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 662 μAdc)	$V_{GS(th)}$	0.9	1.6	2.4	Vdc
Gate Quiescent Voltage (V_{DD} = 50 Vdc, I_D = 150 mAdc, Measured in Functional Test)	$V_{GS(Q)}$	1.5	2.4	3	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1.63 Adc)	$V_{DS(on)}$	—	0.26	—	Vdc
Dynamic Characteristics (1)					
Reverse Transfer Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	0.6	—	pF
Output Capacitance (V_{DS} = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	350	—	pF
Input Capacitance (V_{DS} = 50 Vdc, V_{GS} = 0 Vdc ± 30 mV(rms)ac @ 1 MHz)	C_{iss}	—	330	—	pF
Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 330 W Peak (39.6 W Avg.), f = 1400 MHz, Pulsed, 300 μsec Pulse Width, 12% Duty Cycle					
Power Gain	G_{ps}	16.5	18	19.5	dB
Drain Efficiency	η_D	59(2)	60.5(2)	—	%
Input Return Loss	IRL	—	-12	-9	dB
Pulse RF Performance (In Freescale Application Test Fixture, 50 ohm system) V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 330 W Peak (39.6 W Avg.), f1 = 1200 MHz, f2 = 1300 MHz and f3 = 1400 MHz, 300 μsec Pulse Width, 12% Duty Cycle, t_r = 50 ns					
Relative Insertion Phase	$\lvert\Delta\Phi\rvert$	—	10	—	°
Gain Flatness	G_F	—	0.5	—	dB
Pulse Amplitude Droop	D_{rp}	—	0.3	—	dB
Harmonic 2nd and 3rd	H2 & H3	—	-20	—	dBc
Spurious Response		—	-65	—	dBc
Load Mismatch Stability (VSWR = 3:1 at all Phase Angles)	VSWR-S	All Spurs Below -60 dBc			
Load Mismatch Tolerance (VSWR = 5:1 at all Phase Angles)	VSWR-T	No Degradation in Output Power			

1. Part internally matched both on input and output.
2. Drain efficiency is calculated by: $\eta_D = \frac{100 \times P_{out}}{V_{DD} \times I_{peak}}$ where: $I_{peak} = (I_{AVG} - I_{DQ})$ / Duty Cycle (%) + I_{DQ}.



Z1	0.205″ x 0.080″ Microstrip	Z13	0.110″ x 0.866″ Microstrip
Z2	0.721″ x 0.022″ Microstrip	Z14	0.630″ x 0.866″ Microstrip
Z3	0.080″ x 0.104″ Microstrip	Z15	0.307″ x 0.470″ Microstrip
Z4	0.128″ x 0.022″ Microstrip	Z16	0.045″ x 0.221″ Microstrip
Z5	0.062″ x 0.134″ Microstrip	Z17	0.171″ x 0.136″ Microstrip
Z6	0.440″ x 0.022″ Microstrip	Z18	0.120″ x 0.430″ Microstrip
Z7	0.262″ x 0.496″ Microstrip	Z19	0.964″ x 0.136″ Microstrip
Z8	0.030″ x 0.138″ Microstrip	Z20	0.177″ x 0.078″ Microstrip
Z9	0.256″ x 0.028″ Microstrip	Z21	0.215″ x 0.078″ Microstrip
Z10	0.058″ x 0.254″ Microstrip	Z22	1.577″ x 0.070″ Microstrip
Z11	0.344″ x 0.087″ Microstrip	Z23	1.459″ x 0.070″ Microstrip
Z12	0.110″ x 0.087″ Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030″, ε_r = 2.55

Figure 2. MMRF1011HR5(HSR5) Test Circuit Schematic

Table 5. MMRF1011HR5(HSR5) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1	43 pF Chip Capacitor	ATC100B430JT500XT	ATC
C2	18 pF Chip Capacitor	ATC100B180JT500XT	ATC
C3	33 pF Chip Capacitor	ATC100B330JT500XT	ATC
C4	27 pF Chip Capacitor	ATC100B270JT500XT	ATC
C5	2.2 μF, 100 V Chip Capacitor	2225X7R225KT3AB	ATC
C6	470 μF, 63 V Electrolytic Capacitor	EMVY630GTR471MMH0S	Multicomp
C7	330 pF, 63 V Electrolytic Capacitor	EMVY630GTR331MMH0S	Multicomp
C8	0.1 μF, 35 V Chip Capacitor	CDR33BX104AKYS	Kemet
C9	10 μF, 35 V Tantalum Capacitor	T491D106K035AT	Kemet
R1	10 Ω, 1/4 W Chip Resistor	CRCW120610R0FKEA	Vishay

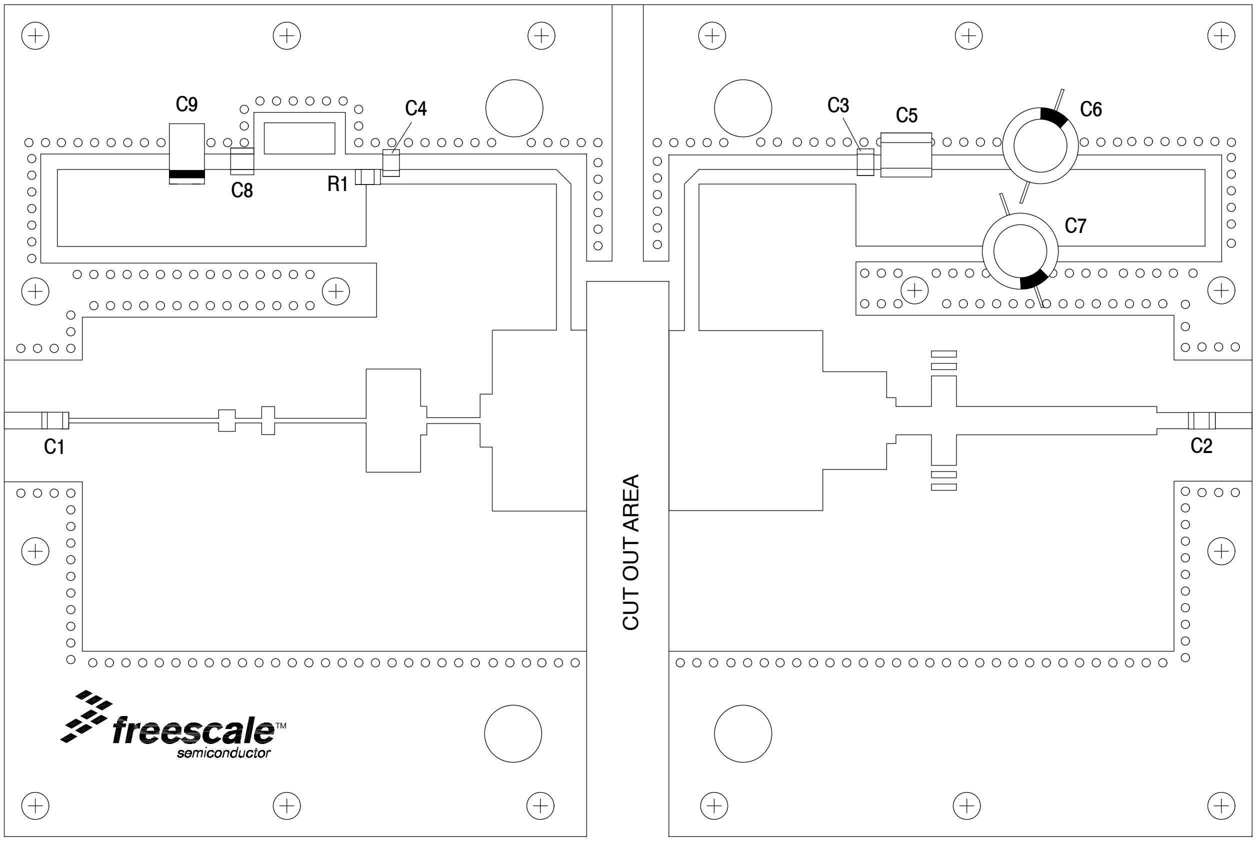


Figure 3. MMRF1011HR5(HSR5) Test Circuit Component Layout

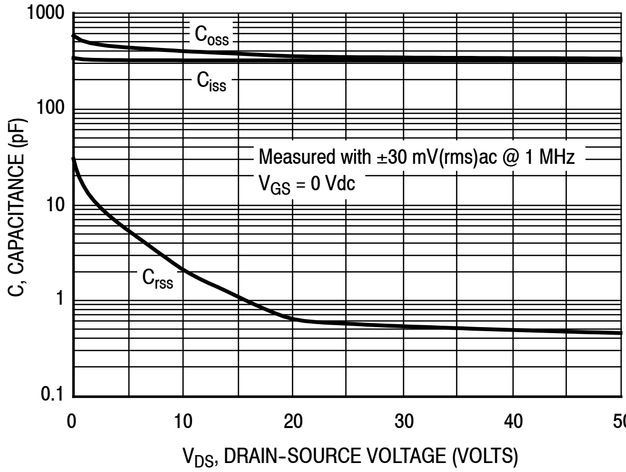


Figure 4. Capacitance versus Drain-Source Voltage

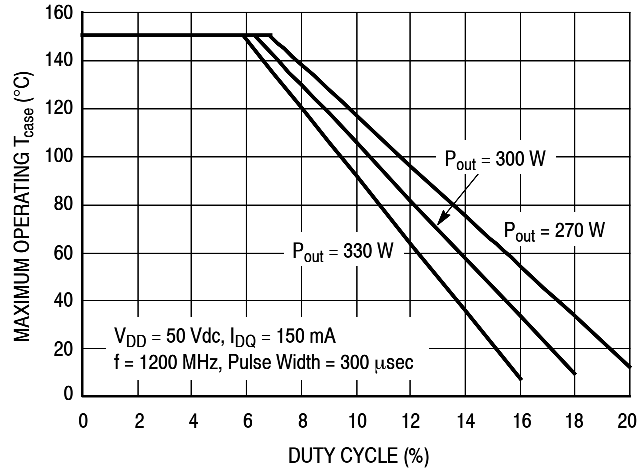


Figure 5. Safe Operating Area

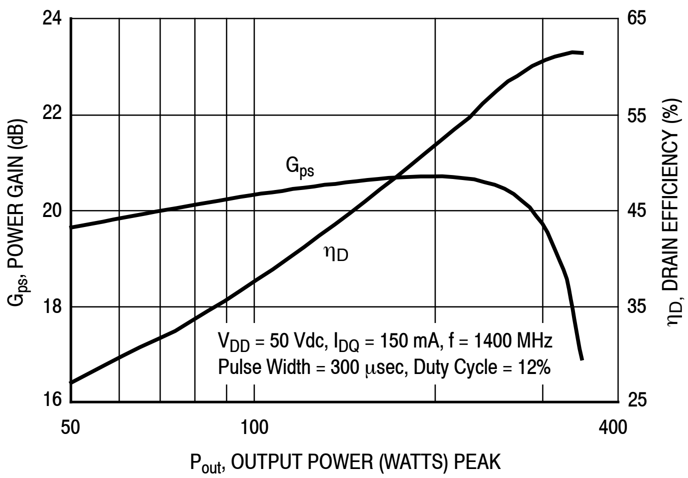


Figure 6. Power Gain and Drain Efficiency versus Output Power

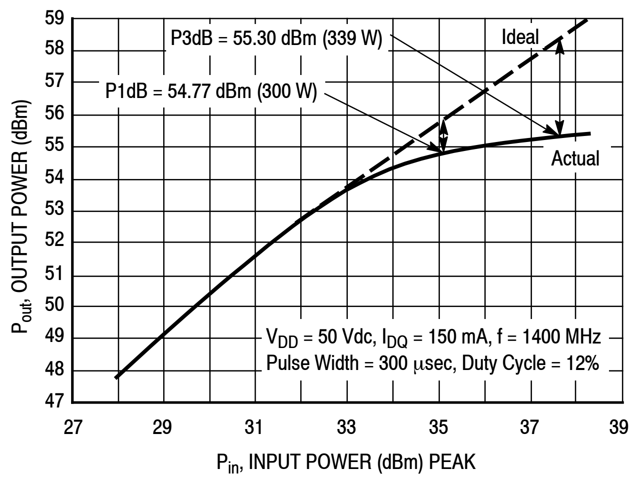


Figure 7. Output Power versus Input Power

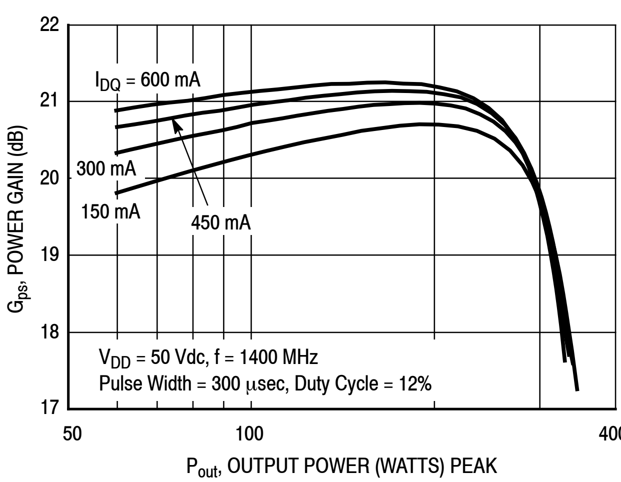


Figure 8. Power Gain versus Output Power

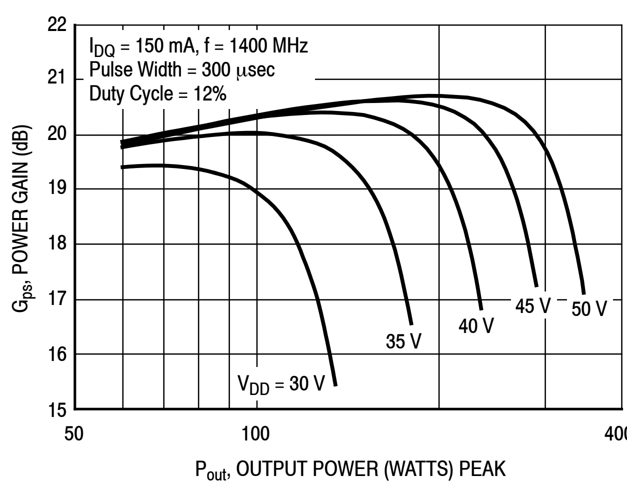


Figure 9. Power Gain versus Output Power

TYPICAL CHARACTERISTICS

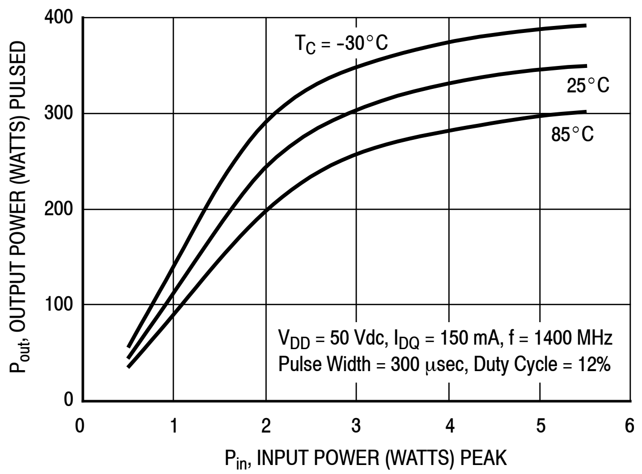


Figure 10. Output Power versus Input Power

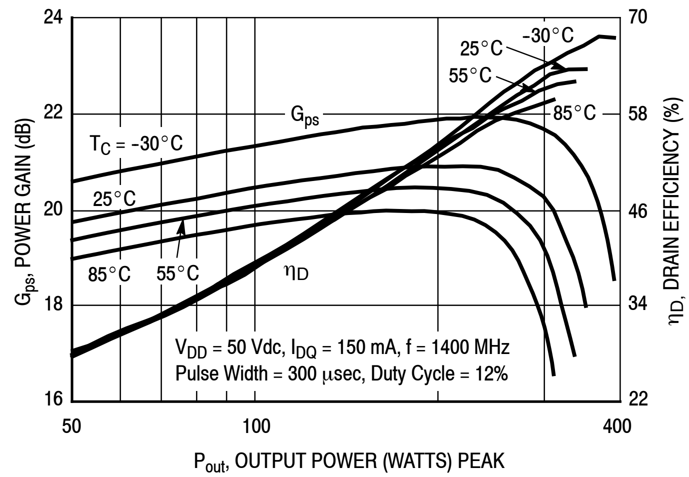


Figure 11. Power Gain and Drain Efficiency versus Output Power

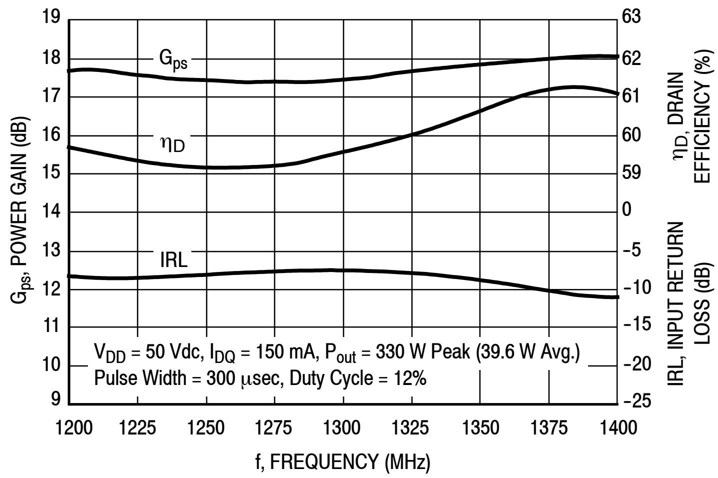
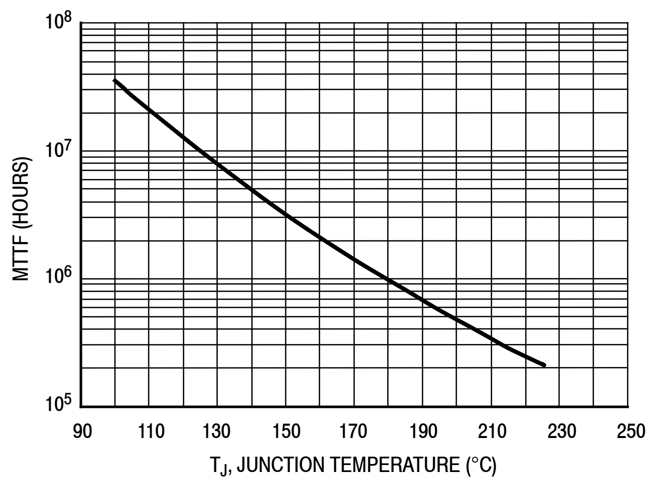


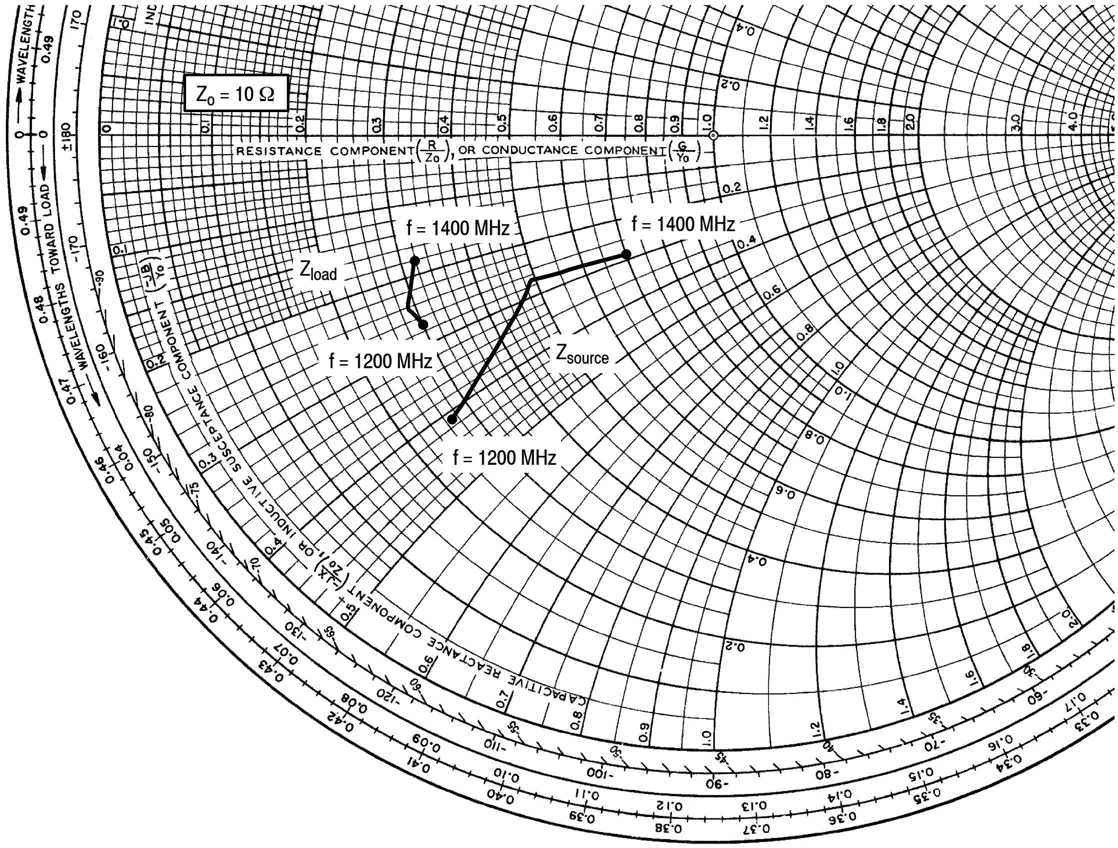
Figure 12. Broadband Performance @ P_{out} = 330 Watts Peak



This above graph displays calculated MTTF in hours when the device is operated at V_{DD} = 50 Vdc, P_{out} = 330 W Peak, Pulse Width = 300 μsec, Duty Cycle = 12%, and η_D = 60.5%.

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

Figure 13. MTTF versus Junction Temperature



V_{DD} = 50 Vdc, I_{DQ} = 150 mA, P_{out} = 330 W Peak

f MHz	Z_{source} Ω	Z_{load} Ω
1200	2.70 - j4.10	2.97 - j2.66
1300	4.93 - j2.66	2.85 - j2.40
1400	7.01 - j2.87	3.17 - j1.78

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

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

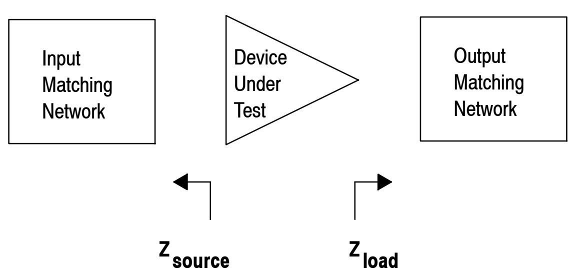
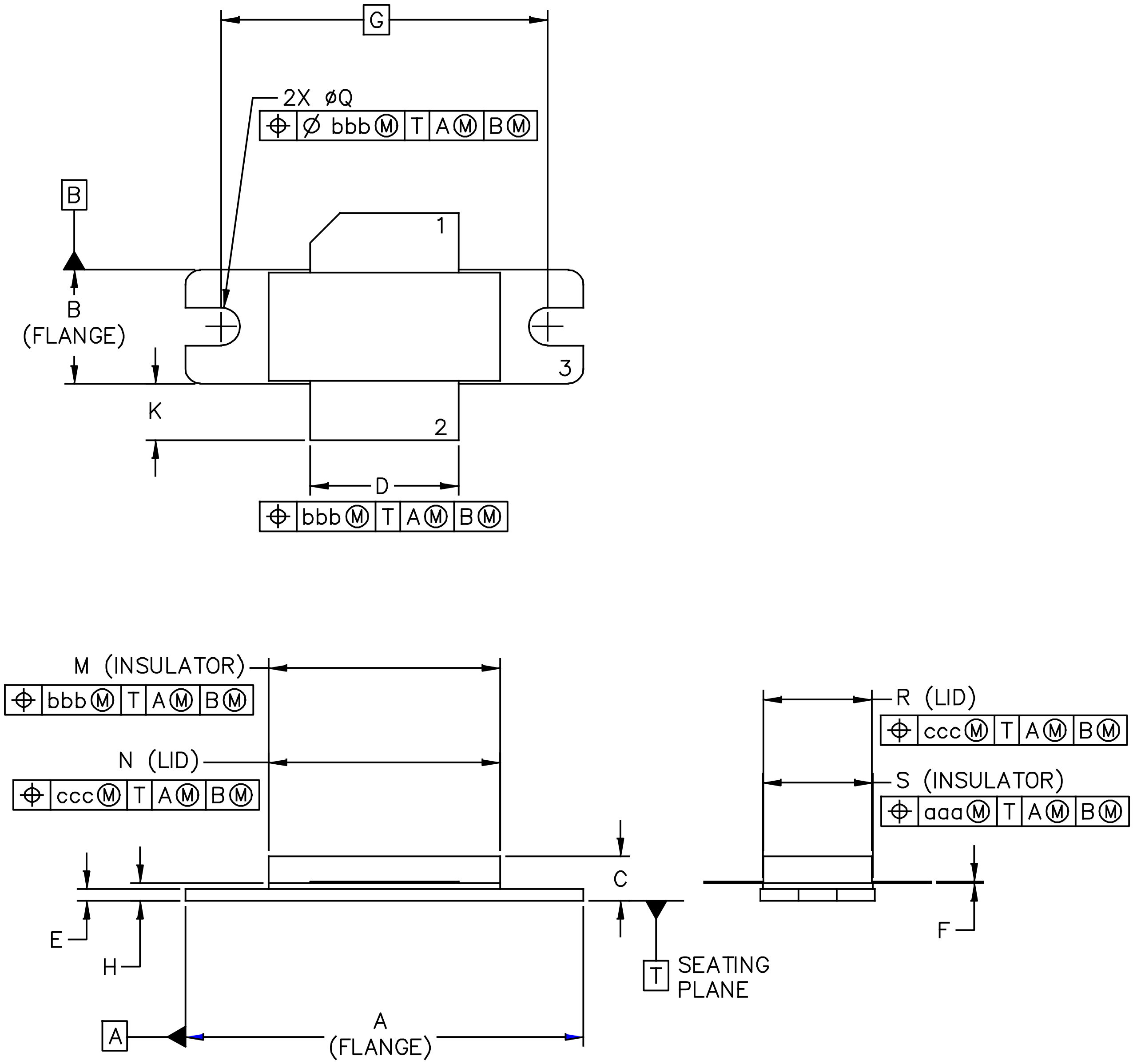


Figure 14. Series Equivalent Source and Load Impedance

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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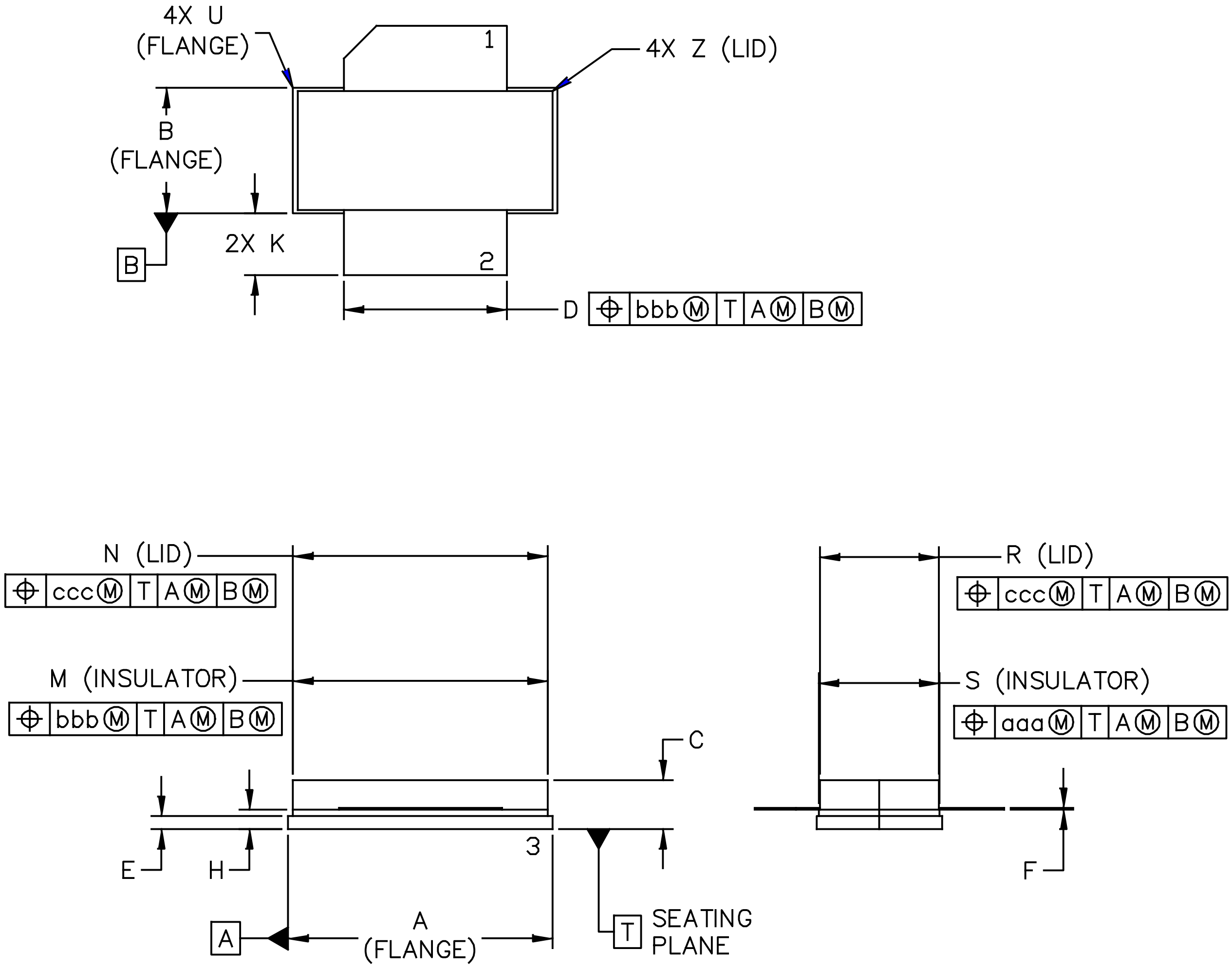

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2. CONTROLLING DIMENSION: INCH.

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 AND SOFTWARE

Refer to the following resources 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

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	July 2014	• Initial Release of Data Sheet

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