

RF Power Field Effect Transistor

N-Channel Enhancement-Mode Lateral MOSFETs

Designed primarily for CW large-signal output and driver applications with frequencies up to 450 MHz. Devices are unmatched and are suitable for use in industrial, medical and scientific applications.

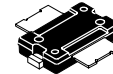
- Typical CW Performance at 220 MHz: $V_{DD} = 50$ Volts, $I_{DQ} = 30$ mA, $P_{out} = 10$ Watts
Power Gain — 23.9 dB
Drain Efficiency — 62%
- Capable of Handling 10:1 VSWR, @ 50 Vdc, 220 MHz, 10 Watts CW Output Power

Features

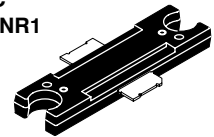
- Integrated ESD Protection
- Excellent Thermal Stability
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 200°C Capable Plastic Package
- RoHS Compliant
- TO-270-2 in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.
- TO-272-2 in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

MRF6V2010NR1
MRF6V2010NBR1

10-450 MHz, 10 W, 50 V
LATERAL N-CHANNEL
BROADBAND
RF POWER MOSFETs



CASE 1265-08, STYLE 1
TO-270-2
PLASTIC
MRF6V2010NR1



CASE 1337-03, STYLE 1
TO-272-2
PLASTIC
MRF6V2010NBR1

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +110	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +10	Vdc
Storage Temperature Range	T_{stg}	- 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 81°C, 10 W CW	$R_{\theta JC}$	3.0	°C/W

1. MTTF calculator available at <http://www.freescale.com/rtf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rtf>. 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)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-A113, IPC/JEDEC J-STD-020	3	260	°C

Table 5. Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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Off Characteristics

Zero Gate Voltage Drain Leakage Current ($V_{DS} = 100\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	2.5	mA
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 50\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	50	μAdc
Drain-Source Breakdown Voltage ($I_D = 5\text{ mA}$, $V_{GS} = 0\text{ Vdc}$)	$V_{(BR)DSS}$	110	—	—	Vdc
Gate-Source Leakage Current ($V_{GS} = 5\text{ Vdc}$, $V_{DS} = 0\text{ Vdc}$)	I_{GSS}	—	—	10	μAdc

On Characteristics

Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 28\ \mu\text{Adc}$)	$V_{GS(th)}$	1	1.68	3	Vdc
Gate Quiescent Voltage ($V_{DD} = 50\text{ Vdc}$, $I_D = 30\text{ mAdc}$, Measured in Functional Test)	$V_{GS(Q)}$	1.5	2.68	3.5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 70\text{ mAdc}$)	$V_{DS(on)}$	—	0.26	—	Vdc

Dynamic Characteristics

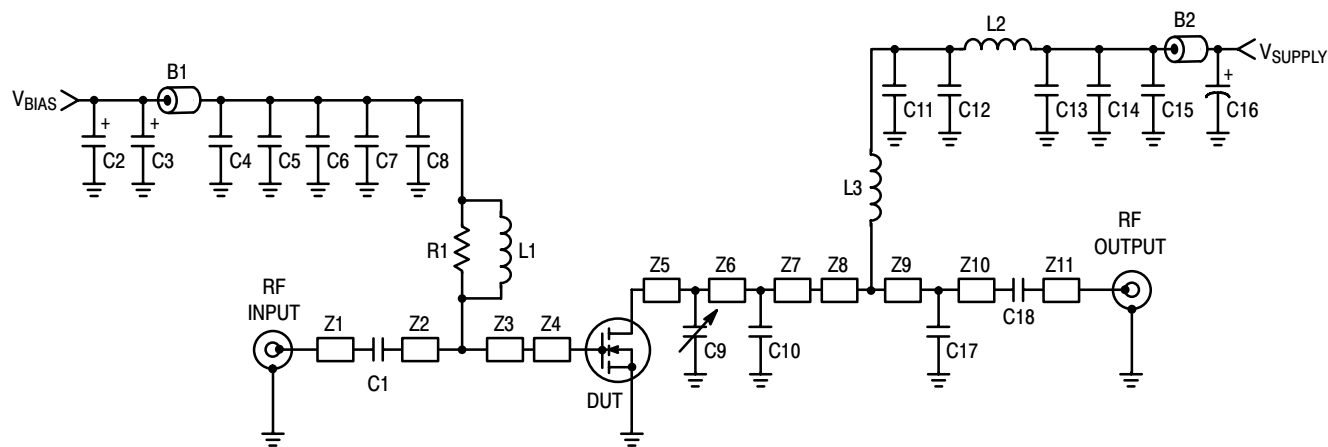
Reverse Transfer Capacitance ($V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	0.13	—	pF
Output Capacitance ($V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	7.3	—	pF
Input Capacitance ($V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{iss}	—	16.3	—	pF

Functional Tests (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 50\text{ Vdc}$, $I_{DQ} = 30\text{ mA}$, $P_{out} = 10\text{ W}$, $f = 220\text{ MHz}$, CW

Power Gain	G_{ps}	22.5	23.9	25.5	dB
Drain Efficiency	η_D	58	62	—	%
Input Return Loss	IRL	—	-14	-9	dB



ATTENTION: The MRF6V2010N and MRF6V2010NB are high power devices and special considerations must be followed in board design and mounting. Incorrect mounting can lead to internal temperatures which exceed the maximum allowable operating junction temperature. Refer to Freescale Application Note AN3263 (for bolt down mounting) or AN1907 (for solder reflow mounting) **PRIOR TO STARTING SYSTEM DESIGN** to ensure proper mounting of these devices.



Z1	0.235" x 0.082" Microstrip	Z7	0.062" x 0.270" Microstrip
Z2	1.190" x 0.082" Microstrip	Z8	0.198" x 0.082" Microstrip
Z3	0.619" x 0.082" Microstrip	Z9	5.600" x 0.082" Microstrip
Z4	0.190" x 0.270" Microstrip	Z10	0.442" x 0.082" Microstrip
Z5	0.293" x 0.270" Microstrip	Z11	0.341" x 0.082" Microstrip
Z6	0.120" x 0.270" Microstrip	PCB	Arlon GX-0300-55-22, 0.030", $\epsilon_r = 2.55$

Figure 1. MRF6V2010NR1(NBR1) Test Circuit Schematic

Table 6. MRF6V2010NR1(NBR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1, B2	95 Ω , 100 MHz Long Ferrite Beads	2743021447	Fair-Rite
C1, C8, C11, C18	1000 pF Chip Capacitors	ATC100B102JT50XT	ATC
C2	10 μ F, 35 V Tantalum Capacitor	T491D106K035AT	Kemet
C3	22 μ F, 35 V Tantalum Capacitor	T491X226K035AT	Kemet
C4, C13	39 K pF Chip Capacitors	ATC200B393KT50XT	ATC
C5, C14	22 K pF Chip Capacitors	ATC200B223KT50XT	ATC
C6, C15	0.1 μ F Chip Capacitors	CDR33BX104AKYS	Kemet
C7, C12	2.2 μ F, 50 V Chip Capacitors	C1825C225J5RAC	Kemet
C9	0.6-4.5 pF Variable Capacitor, Gigatrim	27271SL	Johanson
C10	12 pF Chip Capacitor	ATC100B120JT500XT	ATC
C16	470 μ F, 63 V Electrolytic Capacitor	ESMG630ELL471MK205	United Chemi-Con
C17	27 pF Chip Capacitor	ATC100B270JT500XT	ATC
L1	17.5 nH Inductor	B06T	CoilCraft
L2, L3	82 nH Inductors	1812SMS-82NJ	CoilCraft
R1	120 Ω , 1/4 W Chip Resistor	CRCW12061200FKTA	Vishay

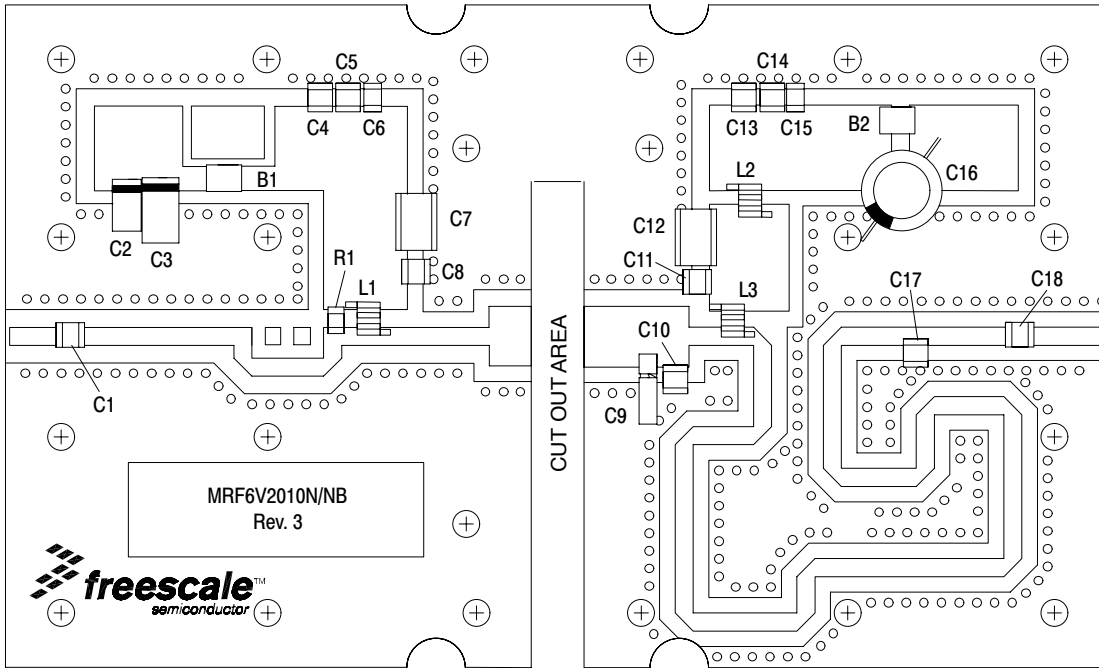


Figure 2. MRF6V2010NR1(NBR1) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

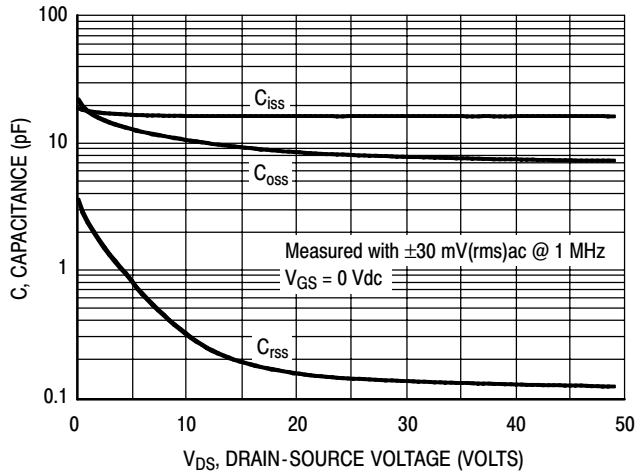


Figure 3. Capacitance versus Drain-Source Voltage

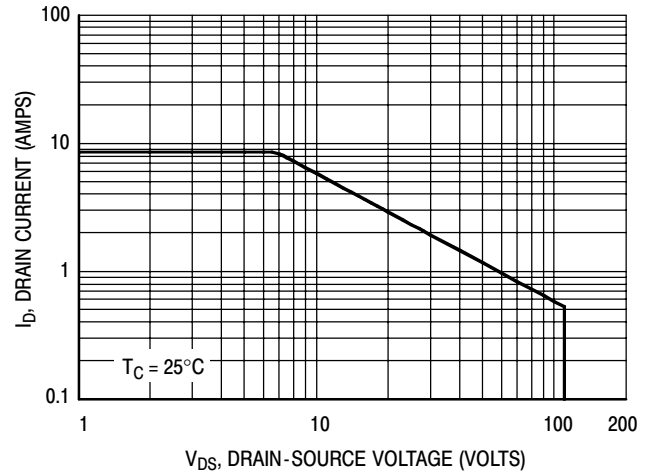


Figure 4. DC Safe Operating Area

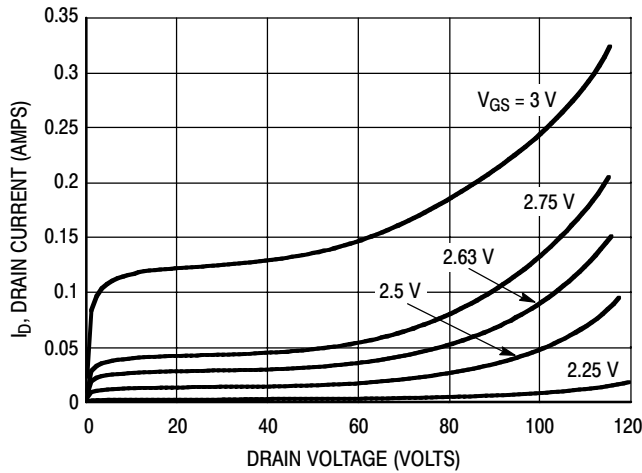


Figure 5. DC Drain Current versus Drain Voltage

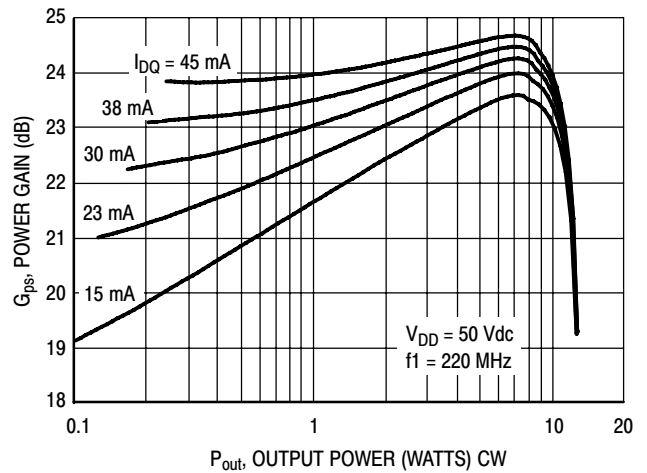


Figure 6. CW Power Gain versus Output Power

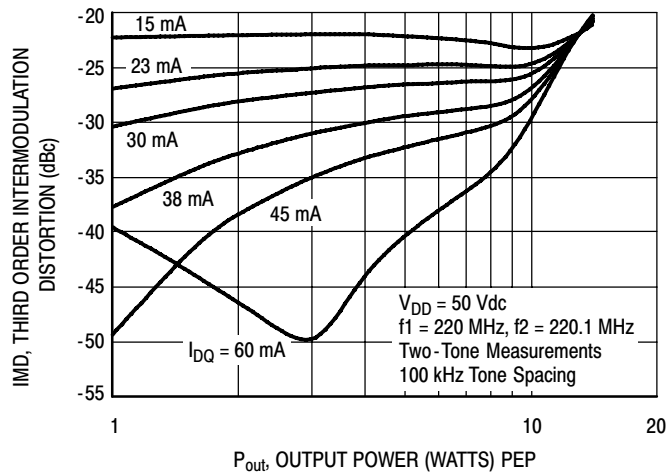


Figure 7. Third Order Intermodulation Distortion versus Output Power

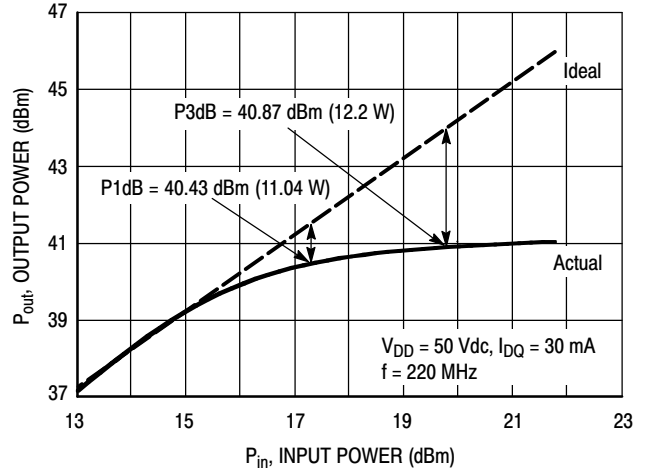


Figure 8. CW Output Power versus Input Power

TYPICAL CHARACTERISTICS

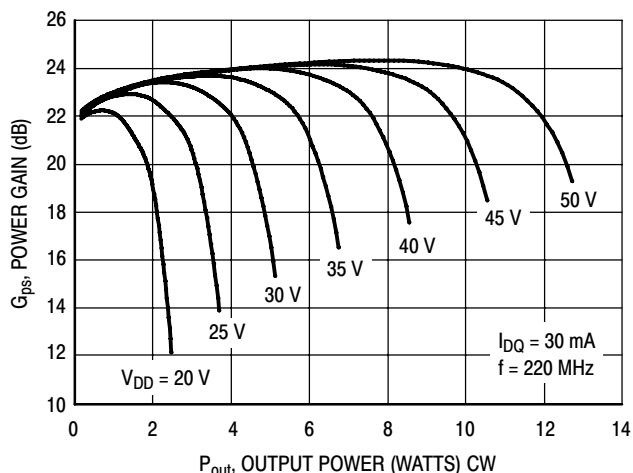


Figure 9. Power Gain versus Output Power

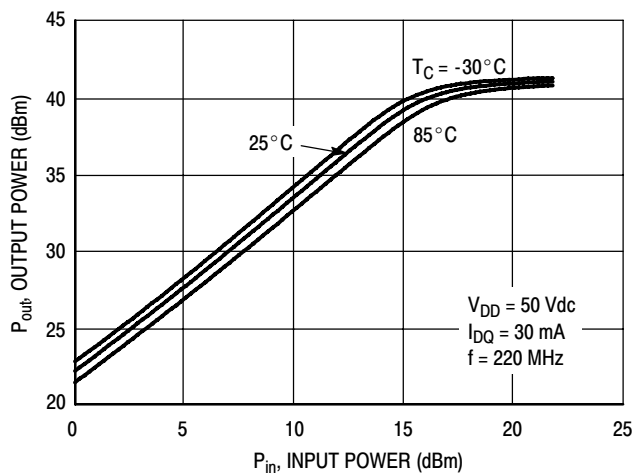


Figure 10. Power Output versus Power Input

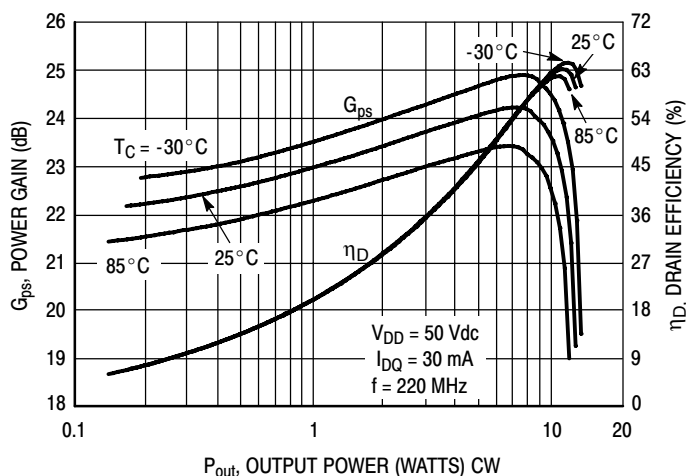
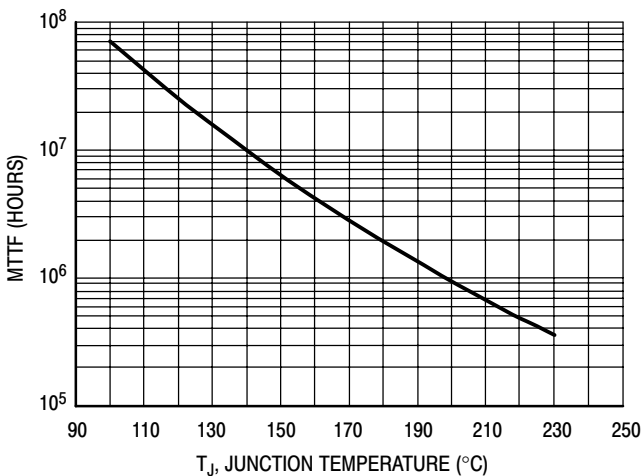


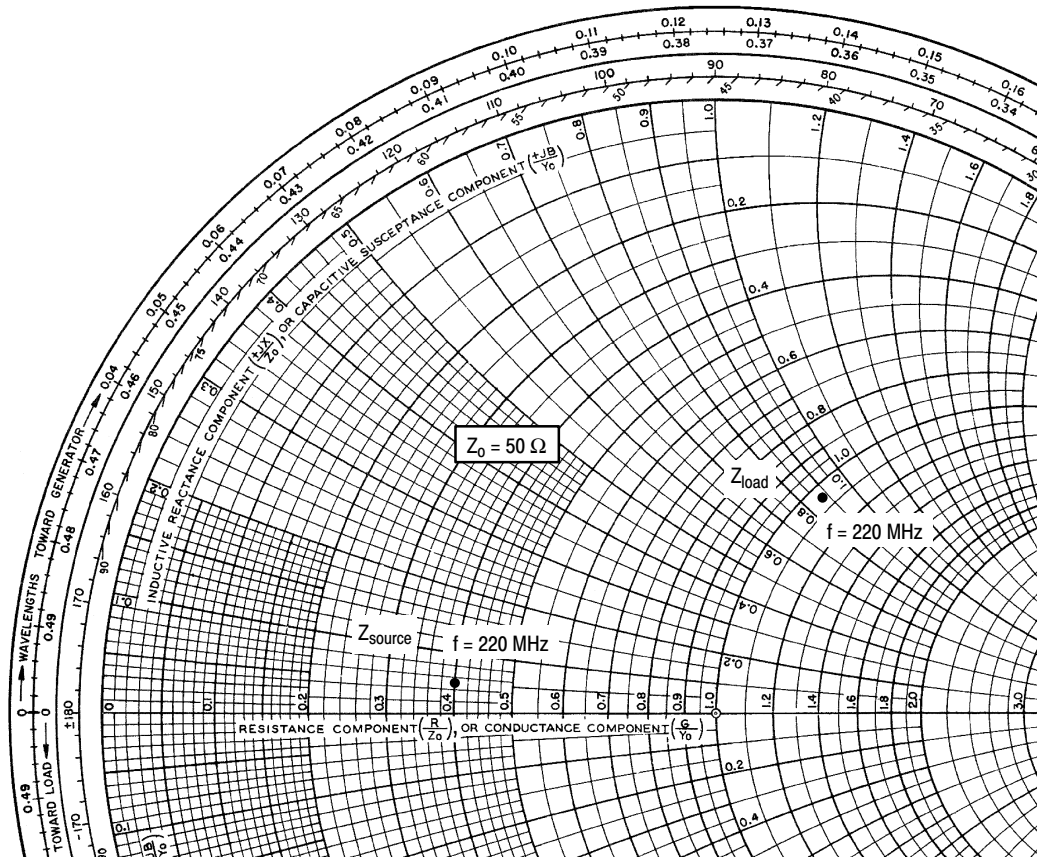
Figure 11. Power Gain and Drain Efficiency versus CW Output Power



This above graph displays calculated MTTF in hours when the device is operated at $V_{DD} = 50 \text{ Vdc}$, $P_{out} = 10 \text{ W CW}$, and $\eta_D = 62\%$.

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

Figure 12. MTTF versus Junction Temperature



$V_{DD} = 50 \text{ Vdc}$, $I_{DQ} = 30 \text{ mA}$, $P_{out} = 10 \text{ W CW}$

f MHz	Z_{source} Ω	Z_{load} Ω
220	$20 + j25$	$75 + j44$

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

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

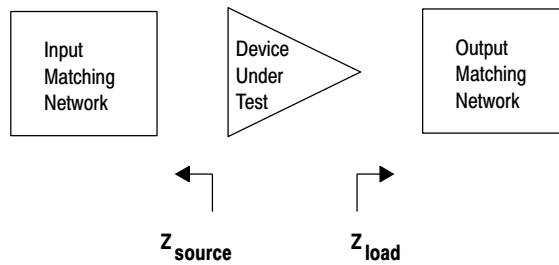
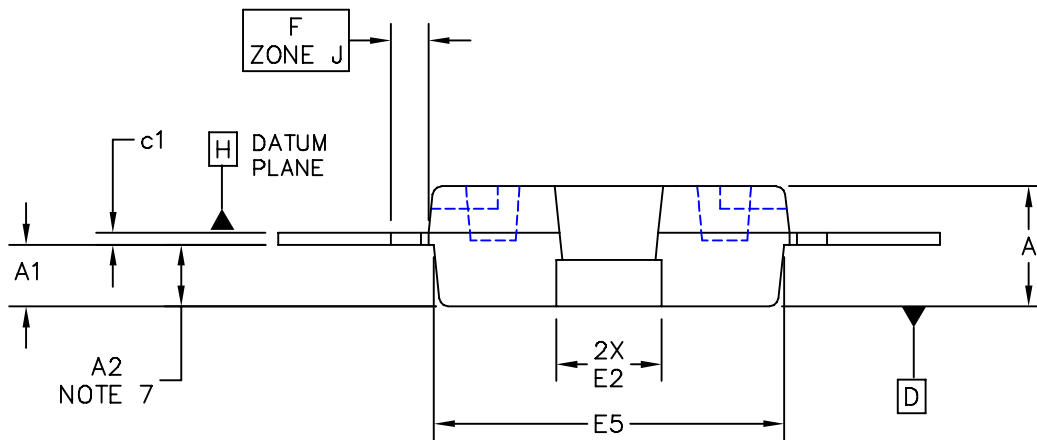
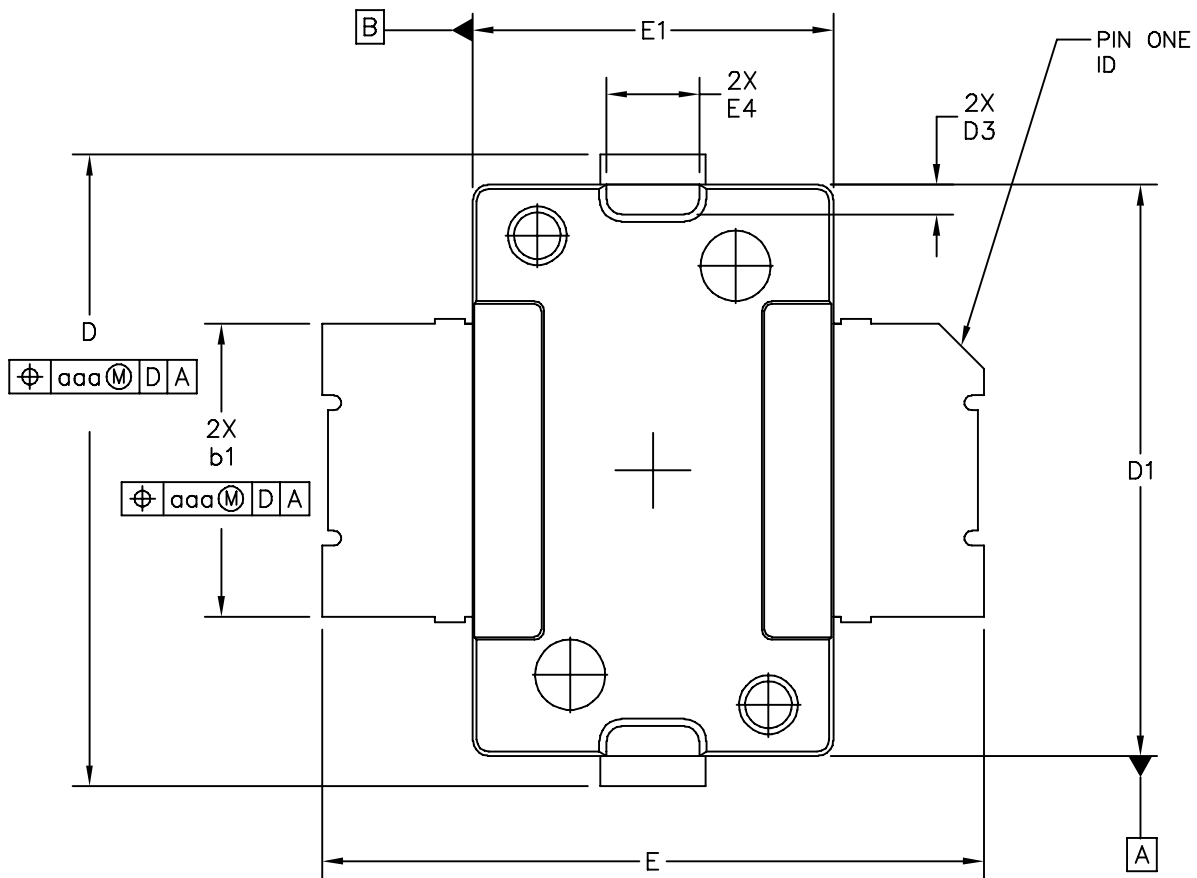
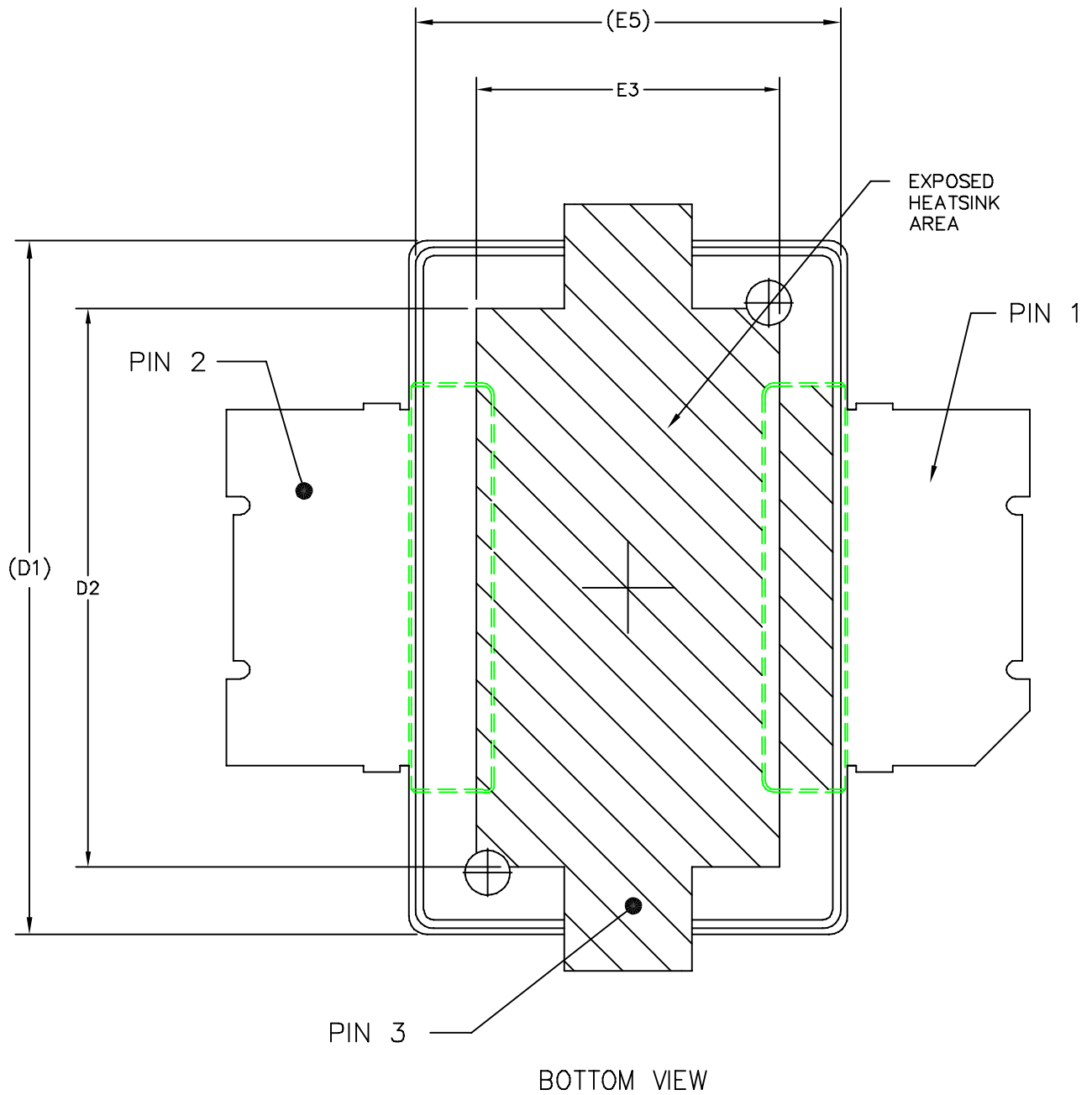


Figure 13. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS



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TITLE: TO-270 SURFACE MOUNT	DOCUMENT NO: 98ASH98117A	REV: J
	CASE NUMBER: 1265-08	01 APR 2005
	STANDARD: NON-JEDEC	



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	CASE NUMBER: 1265-08		01 APR 2005
	STANDARD: NON-JEDEC		

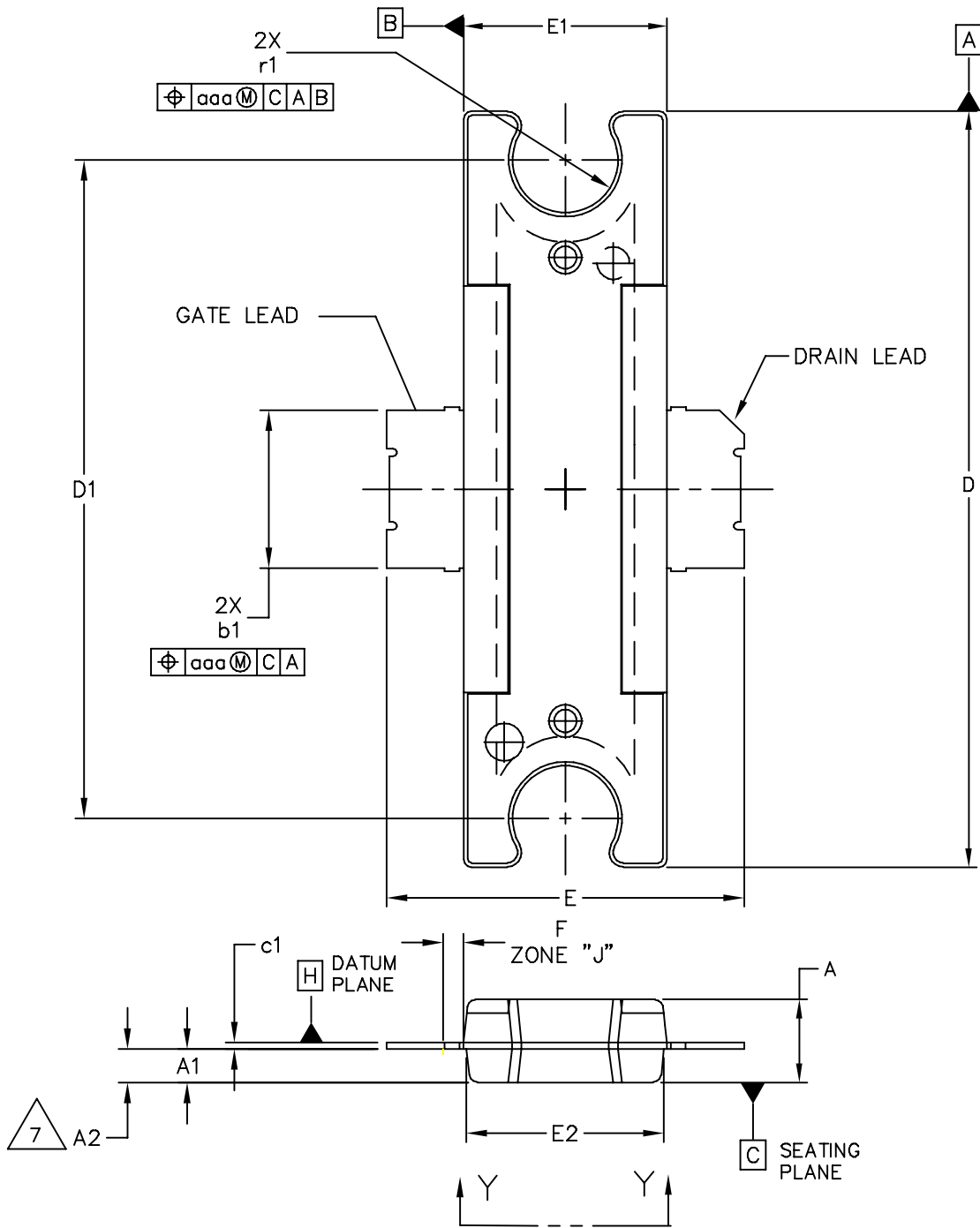
MRF6V2010NR1 MRF6V2010NBR1

NOTES:

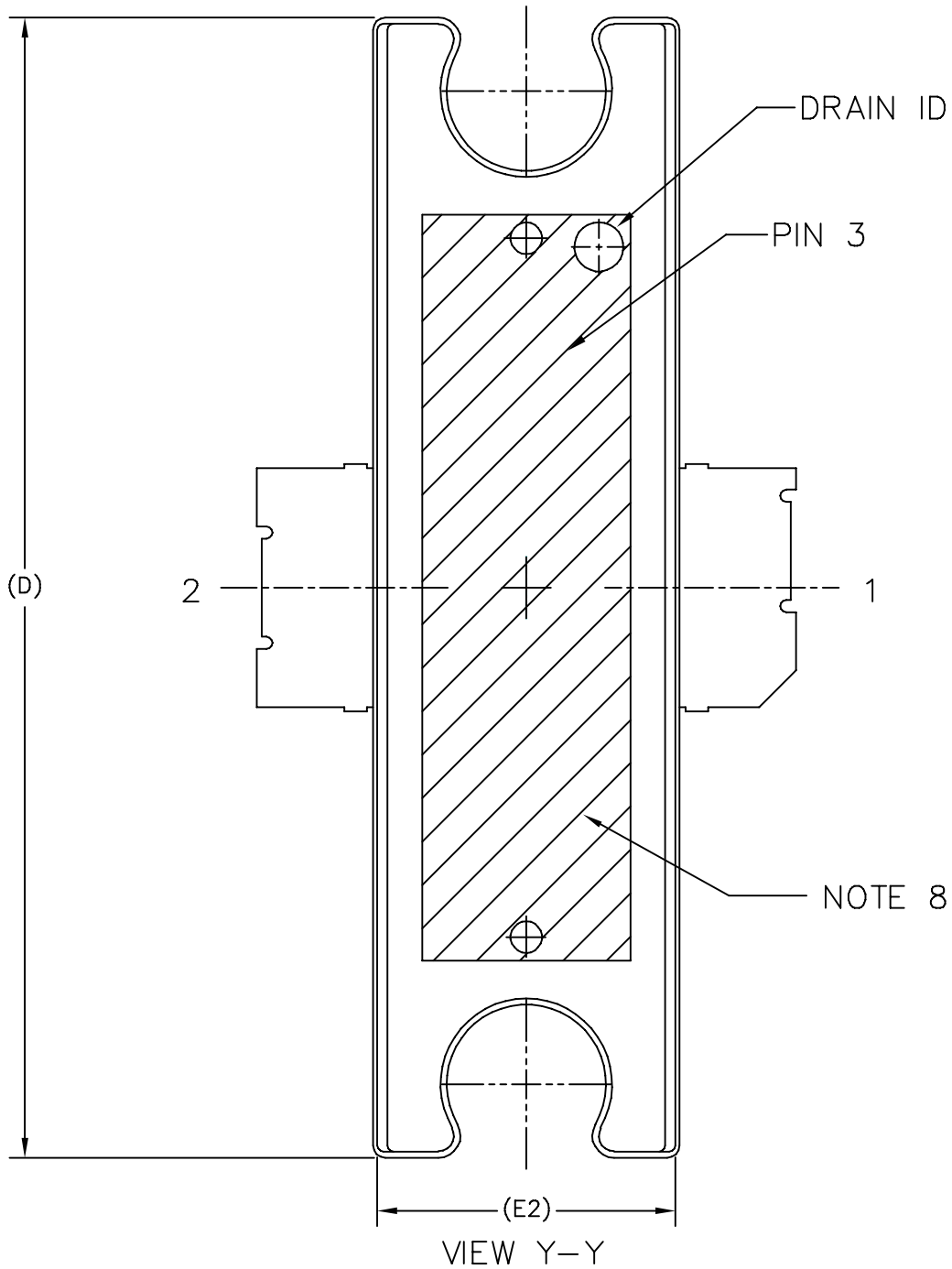
1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D1" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D1 AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSION "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION "A2" APPLIES WITHIN ZONE "J" ONLY.
8. DIMENSIONS "D" AND "E2" DO NOT INCLUDE MOLD PROTRUSION. OVERALL LENGTH INCLUDING MOLD PROTRUSION SHOULD NOT EXCEED 0.430 INCH FOR DIMENSION "D" AND 0.080 INCH FOR DIMENSION "E2". DIMENSIONS "D" AND "E2" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -D-.

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

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.078	.082	1.98	2.08	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.193	.199	4.90	5.06
A2	.040	.042	1.02	1.07	c1	.007	.011	0.18	0.28
D	.416	.424	10.57	10.77	aaa	.004		0.10	
D1	.378	.382	9.60	9.70					
D2	.290	.320	7.37	8.13					
D3	.016	.024	0.41	0.61					
E	.436	.444	11.07	11.28					
E1	.238	.242	6.04	6.15					
E2	.066	.074	1.68	1.88					
E3	.150	.180	3.81	4.57					
E4	.058	.066	1.47	1.68					
E5	.231	.235	5.87	5.97					
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		CASE NUMBER: 1337-03		21 MAR 2005	
		STANDARD: NON-JEDEC			



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TITLE: TO-272 2 LEAD	DOCUMENT NO: 98ASA99191D	REV: C	
	CASE NUMBER: 1337-03	21 MAR 2005	
	STANDARD: NON-JEDEC		

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSIONS "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

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

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b1	.193	.199	4.90	5.05
A1	.039	.043	0.99	1.09	c1	.007	.011	.18	.28
A2	.040	.042	1.02	1.07	r1	.063	.068	1.60	1.73
D	.928	.932	23.57	23.67	aaa	.004		.10	
D1	.810 BSC		20.57 BSC						
E	.438	.442	11.12	11.23					
E1	.248	.252	6.30	6.40					
E2	.241	.245	6.12	6.22					
F	.025 BSC		0.64 BSC						

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		CASE NUMBER: 1337-03		21 MAR 2005	
		STANDARD: NON-JEDEC			

PRODUCT DOCUMENTATION

Refer to the following documents to aid your design process.

Application Notes

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Plastic Packages
- AN1955: Thermal Measurement Methodology of RF Power Amplifiers
- AN3263: Bolt Down Mounting Method for High Power RF Transistors and RFICs in Over-Molded Plastic Packages

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Feb. 2007	<ul style="list-style-type: none">• Initial Release of Data Sheet
1	May 2007	<ul style="list-style-type: none">• Corrected Test Circuit Component part numbers in Table 6, Component Designations and Values for C1, C8, C11, C18, C4, C13, C5, and C14, p. 3• Corrected Series Impedance Z_{source} and Z_{load} values, Fig. 13, Series Equivalent Source and Load Impedance, p. 7

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Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
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Japan
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support.japan@freescale.com

Asia/Pacific:

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