Freescale Semiconductor
Technical Data

Document Number: MRF6S9060N
Rev. 3, 5/2006

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 28 volt base station equipment.

- Typical Single-Carrier N-CDMA Performance @ 880 MHz, V_{DD} = 28 Volts, I_{DQ} = 450 mA, P_{out} = 14 Watts Avg., IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13) Channel Bandwidth = 1.2288 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF.
  Power Gain — 21.4 dB
  Drain Efficiency — 32.1%
  ACPR @ 750 kHz Offset — -47.6 dBc in 30 kHz Bandwidth

GSM EDGE Application

- Typical GSM EDGE Performance: V_{DD} = 28 Volts, I_{DQ} = 500 mA, P_{out} = 21 Watts Avg., Full Frequency Band (921-960 MHz)
  Power Gain — 20 dB
  Drain Efficiency — 46%
  Spectral Regrowth @ 400 kHz Offset = -62 dBc
  Spectral Regrowth @ 600 kHz Offset = -78 dBc
  EVM — 1.5% rms

GSM Application

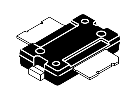
- Typical GSM Performance: V_{DD} = 28 Volts, I_{DQ} = 500 mA, P_{out} = 60 Watts, Full Frequency Band (921-960 MHz)
  Power Gain — 20 dB
  Drain Efficiency — 63%
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 880 MHz, 60 Watts CW Output Power

Features

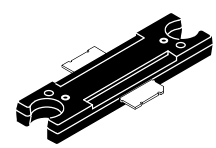
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Integrated ESD Protection
- 200°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- TO-270-2 in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.
- TO-272-2 in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

MRF6S9060NR1
MRF6S9060NBR1

880 MHz, 14 W AVG., 28 V
SINGLE N-CDMA
LATERAL N-CHANNEL
BROADBAND RF POWER MOSFETs



CASE 1265-08, STYLE 1
TO-270-2
PLASTIC
MRF6S9060NR1



CASE 1337-03, STYLE 1
TO-272-2
PLASTIC
MRF6S9060NBR1

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	-0.5, +68	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +12	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	227 1.3	W W/°C
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 80°C, 60 W CW Case Temperature 80°C, 14 W CW	$R_{\theta JC}$	 0.77 0.88	°C/W

Table 3. ESD Protection Characteristics

Test Methodology	Class
Human Body Model (per JESD22-A114)	1A (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°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 68 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 = 200 μA)	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 450 mAdc)	$V_{GS(Q)}$	—	2.9	—	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1.5 Adc)	$V_{DS(on)}$	—	0.18	0.4	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3 Adc)	g_{fs}	—	4.2	—	S
Dynamic Characteristics					
Input Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{iss}	—	106	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	33	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.4	—	pF

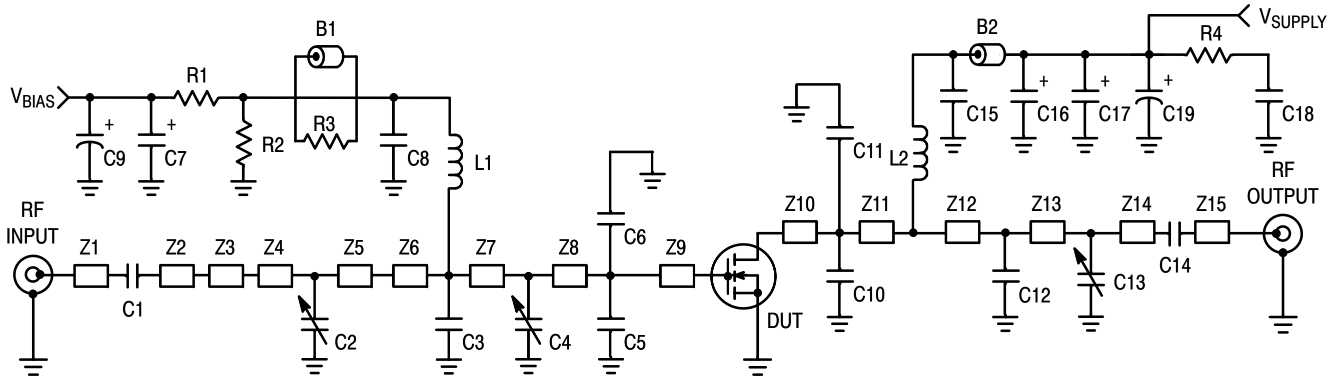
Functional Tests (In Freescale Test Fixture, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 450 mA, P_{out} = 14 W Avg., f = 880 MHz, Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @ ±750 kHz Offset. PAR = 9.8 dB @ 0.01% Probability on CCDF

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain	G_{ps}	20.5	21.4	23.5	dB
Drain Efficiency	η_D	30.5	32.1	—	%
Adjacent Channel Power Ratio	ACPR	—	-47.6	-45	dBc
Input Return Loss	IRL	—	-15.3	-9	dB

1. MTTF calculator available at http://www.freescale.com/rf. 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/rf. Select Documentation/Application Notes - AN1955.

Table 5. Electrical Characteristics (T_C = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Typical GSM EDGE Performances (In Freescale GSM EDGE Test Fixture Optimized for 921-960 MHz, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 500 mA, P_{out} = 21 W Avg., f = 921-960 MHz, GSM EDGE Signal					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	46	—	%
Error Vector Magnitude	EVM	—	1.5	—	%
Spectral Regrowth at 400 kHz Offset	SR1	—	-62	—	dBc
Spectral Regrowth at 600 kHz Offset	SR2	—	-78	—	dBc
Typical CW Performances (In Freescale GSM Test Fixture Optimized for 921-960 MHz, 50 ohm system) V_{DD} = 28 Vdc, I_{DQ} = 500 mA, P_{out} = 60 W, f = 921-960 MHz					
Power Gain	G_{ps}	—	20	—	dB
Drain Efficiency	η_D	—	63	—	%
Input Return Loss	IRL	—	-12	—	dB
P_{out} @ 1 dB Compression Point (f = 940 MHz)	P1dB	—	67	—	W



Z1	0.215″ x 0.065″ Microstrip	Z9	0.057″ x 0.525″ Microstrip
Z2	0.221″ x 0.065″ Microstrip	Z10	0.360″ x 0.270″ Microstrip
Z3	0.500″ x 0.100″ Microstrip	Z11	0.063″ x 0.270″ Microstrip
Z4	0.460″ x 0.270″ Microstrip	Z12	0.360″ x 0.065″ Microstrip
Z5	0.040″ x 0.270″ Microstrip	Z13	0.170″ x 0.065″ Microstrip
Z6	0.280″ x 0.270″ x 0.530″ Taper	Z14	0.880″ x 0.065″ Microstrip
Z7	0.087″ x 0.525″ Microstrip	Z15	0.260″ x 0.065″ Microstrip
Z8	0.435″ x 0.525″ Microstrip	PCB	Taconic RF-35 0.030″, ε_r = 3.5

Figure 1. MRF6S9060NR1(NBR1) Test Circuit Schematic

Table 6. MRF6S9060NR1(NBR1) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Ferrite Bead	95F786	Newark
B2	Ferrite Bead	95F787	Newark
C1, C8, C14, C15	47 pF Chip Capacitors	100B470JP500X	Newark
C2, C4, C13	0.8-8.0 pF Variable Capacitors, Gigatrim	44F3360	Newark
C3	3.0 pF Chip Capacitor	100B3R0JP500X	Newark
C5, C6	15 pF Chip Capacitors	100B150JP500X	Newark
C7, C16, C17	10 μF, 35 V Tantalum Capacitors	93F2975	Newark
C9	100 μF, 50 V Electrolytic Capacitor	51F2913	Newark
C10, C11	13 pF Chip Capacitors	100B130JP500X	Newark
C12	3.9 pF Chip Capacitor	100B3R9JP500X	Newark
C18	0.56 μF Chip Capacitor	700A561MP150X	Newark
C19	470 μF, 63 V Electrolytic Capacitor	95F4579	Newark
L1, L2	12.5 nH Inductor	A04T-5	Coilcraft
R1	1 kΩ Chip Resistor		
R2	560 kΩ Chip Resistor		
R3	12 Ω Chip Resistor		
R4	27 Ω Chip Resistor		

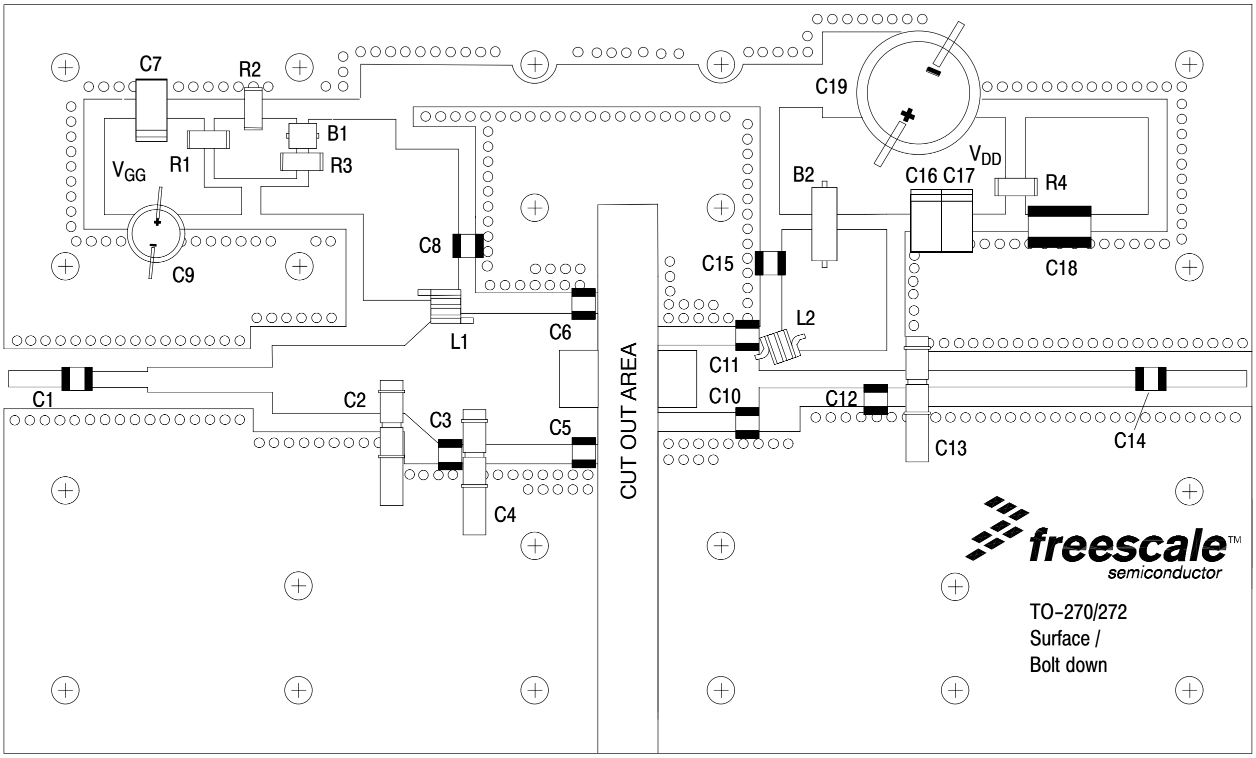


Figure 2. MRF6S9060NR1(NBR1) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

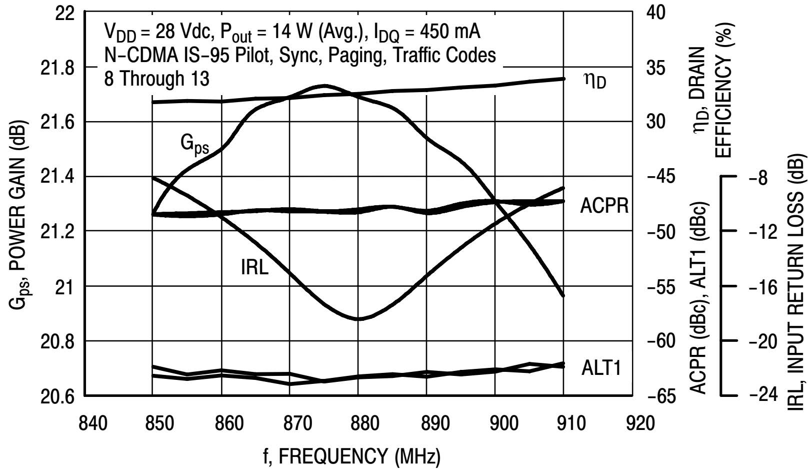


Figure 3. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 14 Watts Avg.

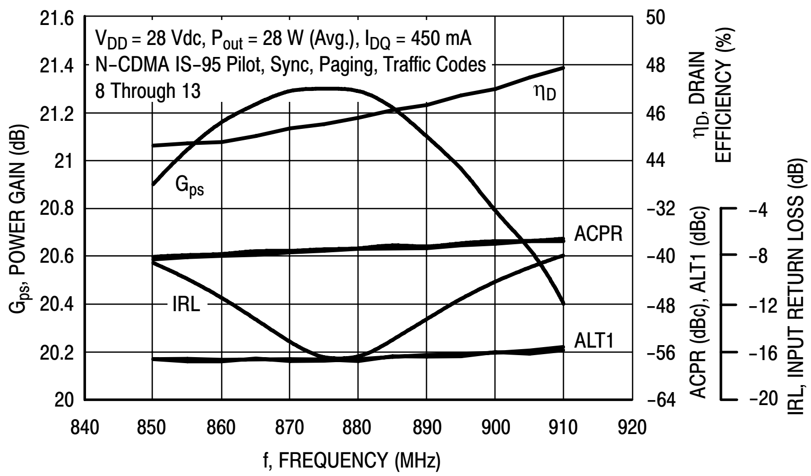


Figure 4. Single-Carrier N-CDMA Broadband Performance @ P_{out} = 28 Watts Avg.

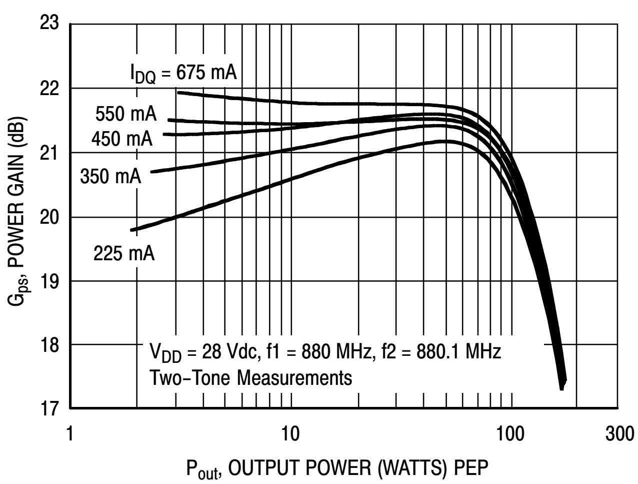


Figure 5. Two-Tone Power Gain versus Output Power

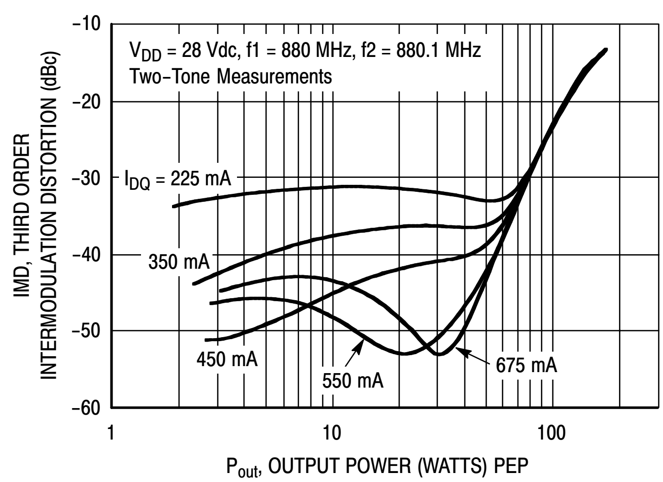


Figure 6. Third Order Intermodulation Distortion versus Output Power

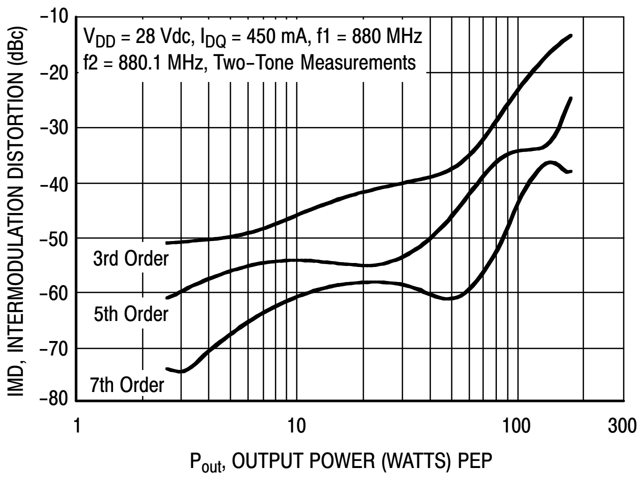


Figure 7. Intermodulation Distortion Products versus Output Power

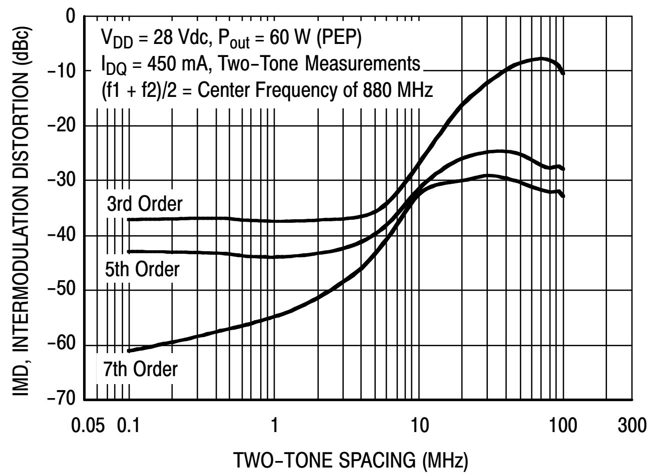


Figure 8. Intermodulation Distortion Products versus Tone Spacing

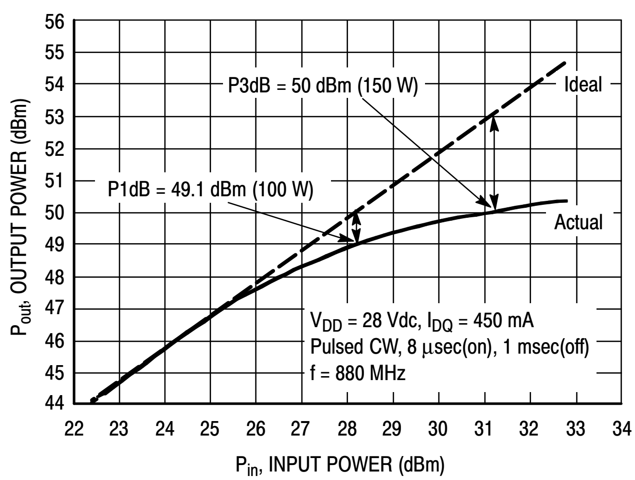


Figure 9. Pulse CW Output Power versus Input Power

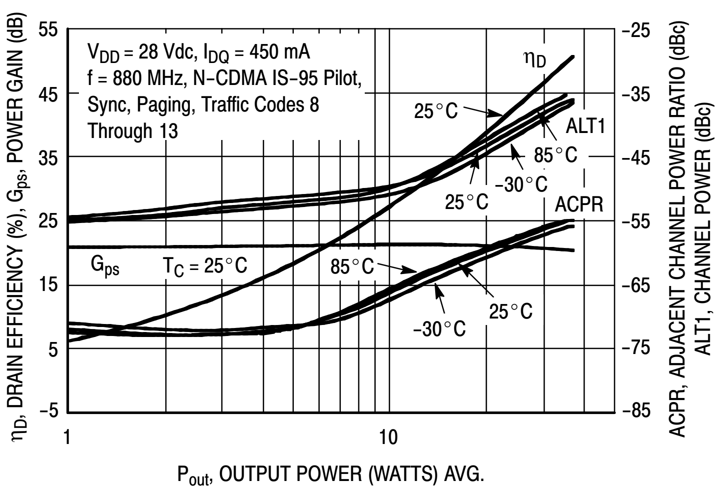


Figure 10. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power

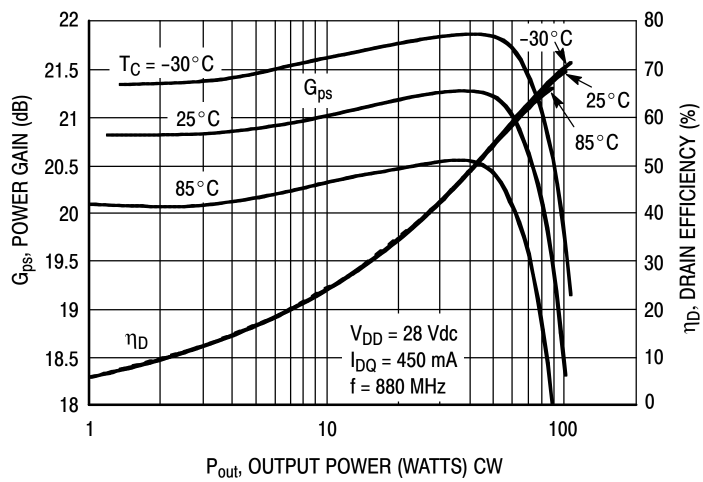


Figure 11. Power Gain and Drain Efficiency versus CW Output Power

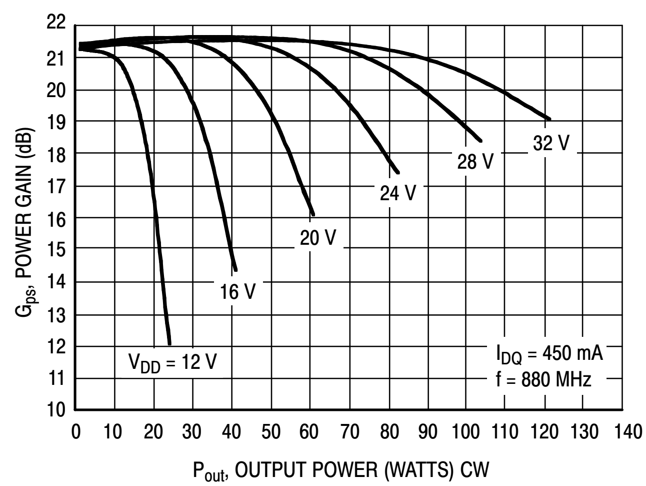
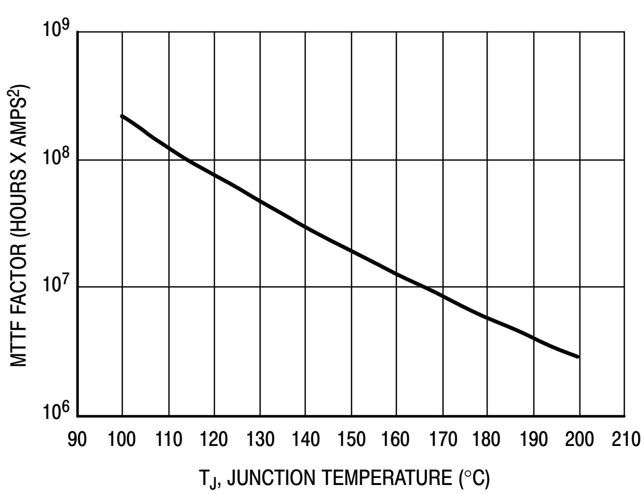


Figure 12. Power Gain versus Output Power



This above graph displays calculated MTTF in hours x ampere^2 drain current. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTTF factor by I_D^2 for MTTF in a particular application.

Figure 13. MTTF Factor versus Junction Temperature

N-CDMA TEST SIGNAL

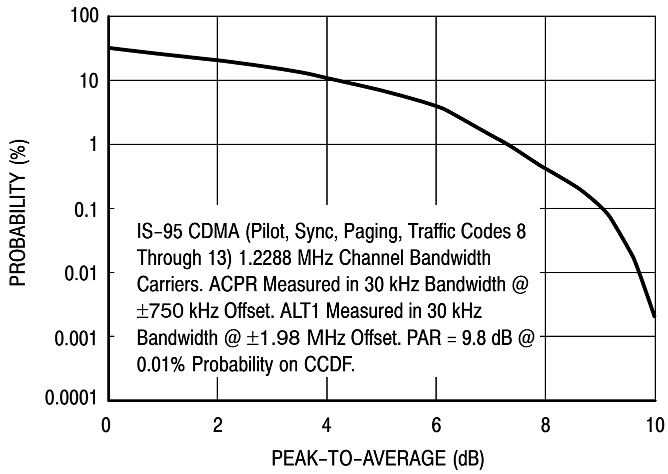


Figure 14. Single-Carrier CCDF N-CDMA

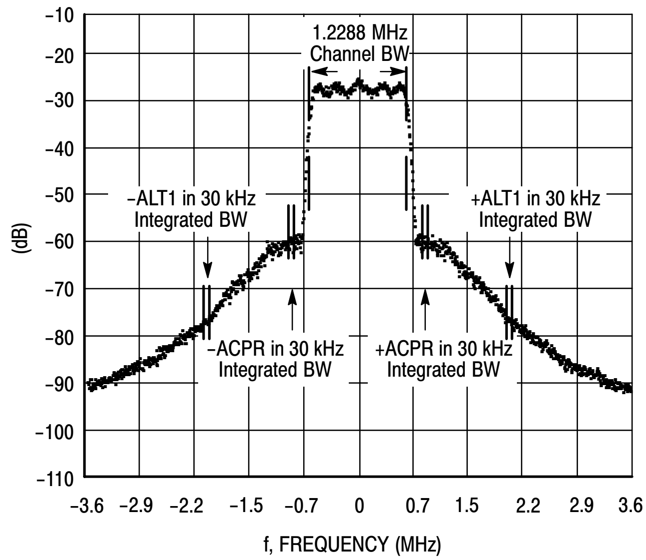
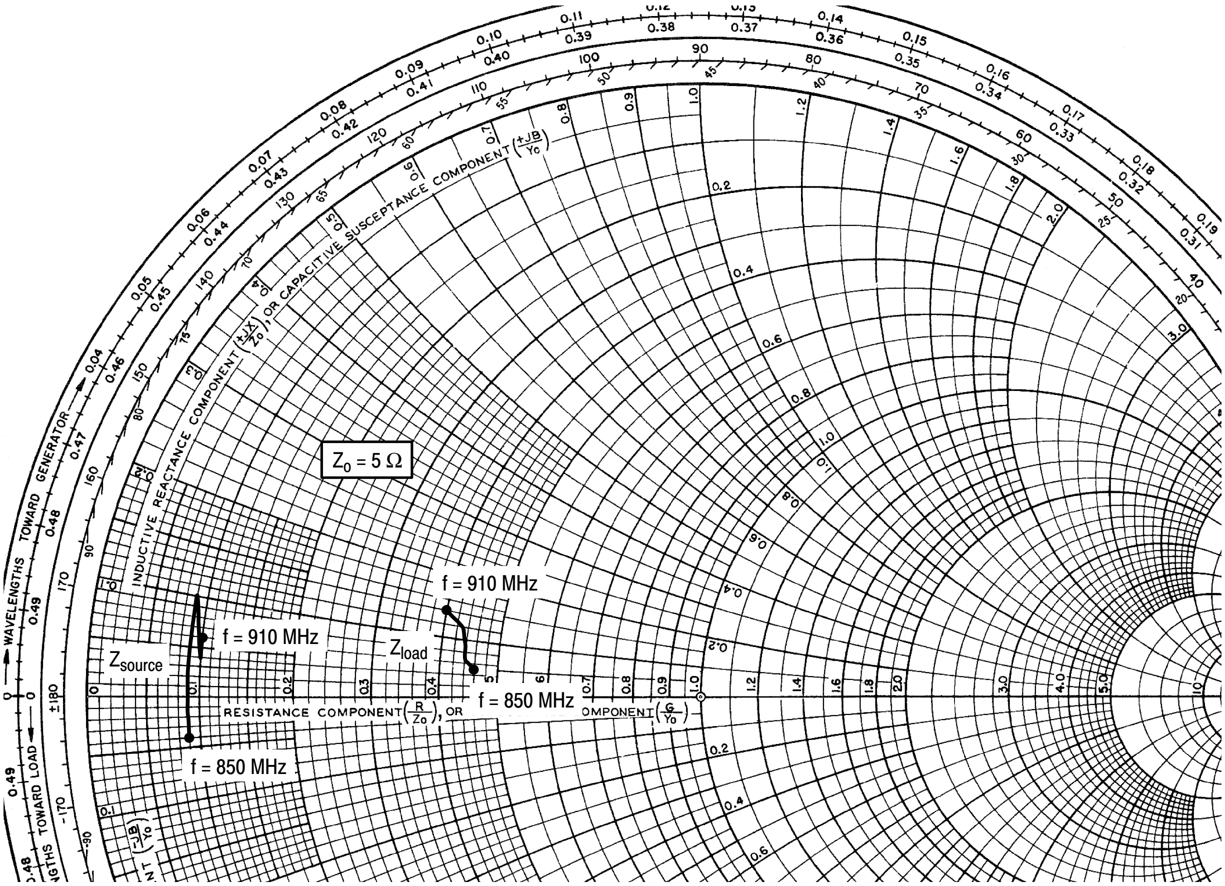


Figure 15. Single-Carrier N-CDMA Spectrum



V_{DD} = 28 Vdc, I_{DQ} = 450 mA, P_{out} = 14 W Avg.

f MHz	Z_{source} Ω	Z_{load} Ω
850	0.44 - j0.20	2.28 + j0.23
865	0.44 - j0.07	2.18 + j0.33
880	0.45 + j0.50	2.20 + j0.47
895	0.48 + j0.18	2.15 + j0.61
910	0.52 + j0.29	2.00 + j0.68

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

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

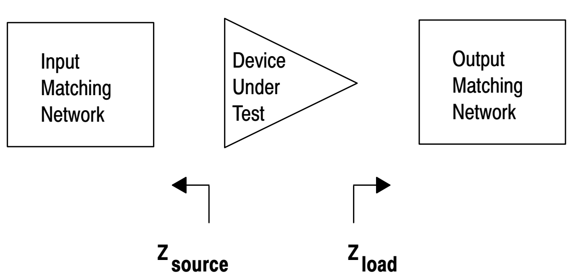
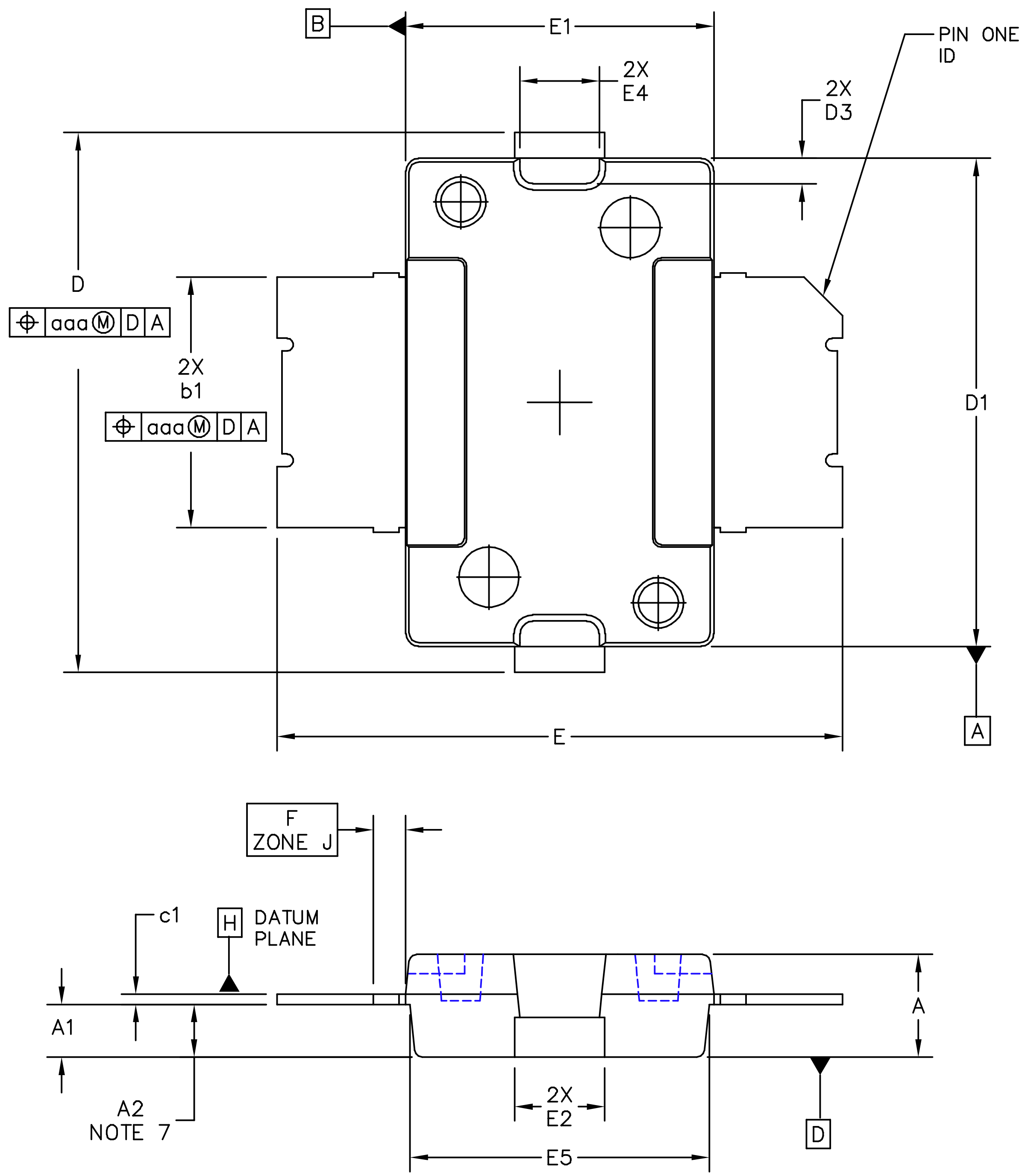


Figure 16. Series Equivalent Source and Load Impedance

NOTES

PACKAGE DIMENSIONS



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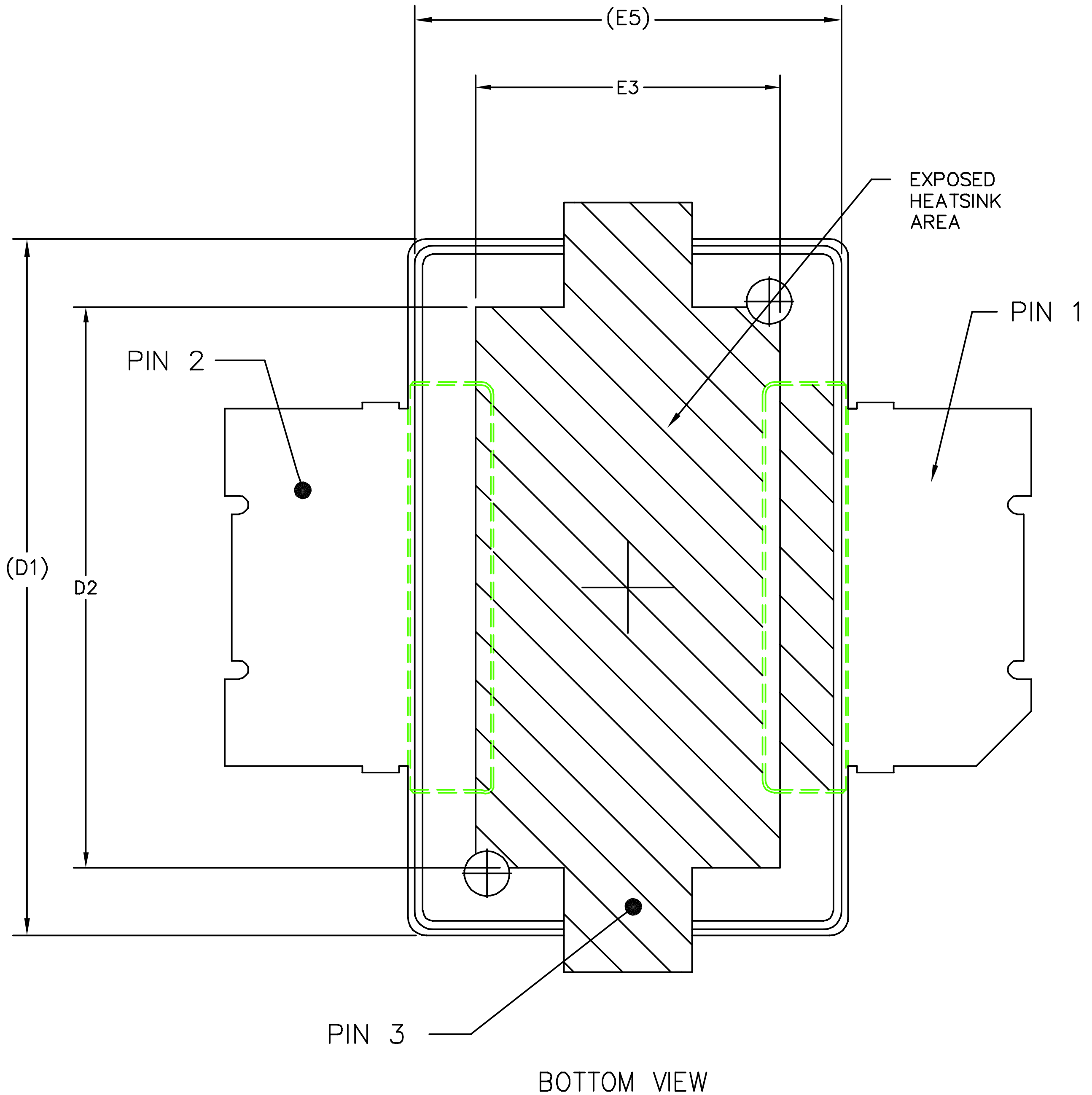
	CASE NUMBER: 1265−08	01 APR 2005
	STANDARD: NON−JEDEC	



	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: TO–270 SURFACE MOUNT	DOCUMENT NO: 98ASH98117A	REV: J
	CASE NUMBER: 1265–08	01 APR 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 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

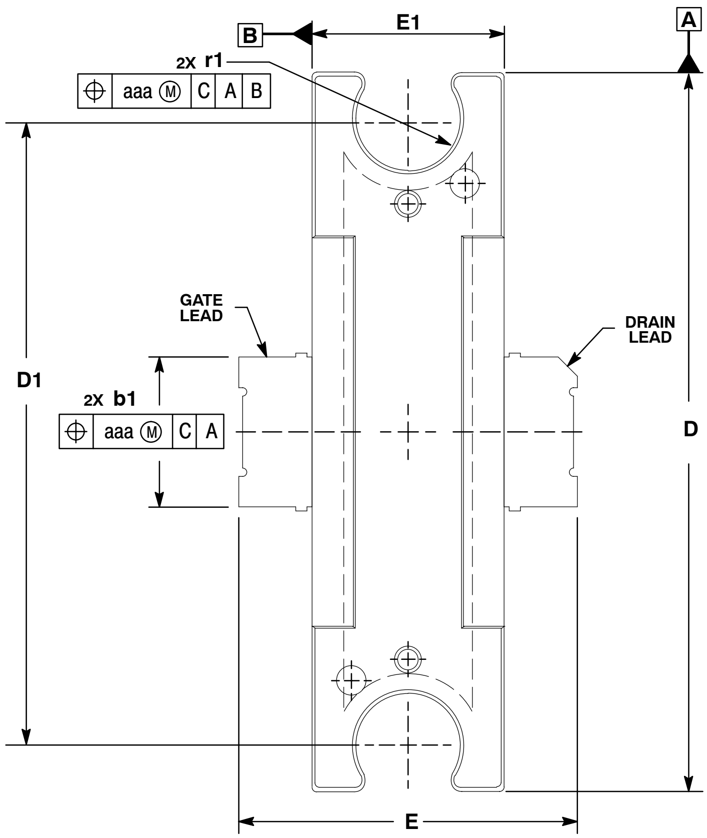
DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.078	.082	1.98	2.08	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.193	.199	4.90	5.06
A2	.040	.042	1.02	1.07	c1	.007	.011	0.18	0.28
D	.416	.424	10.57	10.77	aaa	.004		0.10	
D1	.378	.382	9.60	9.70					
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					

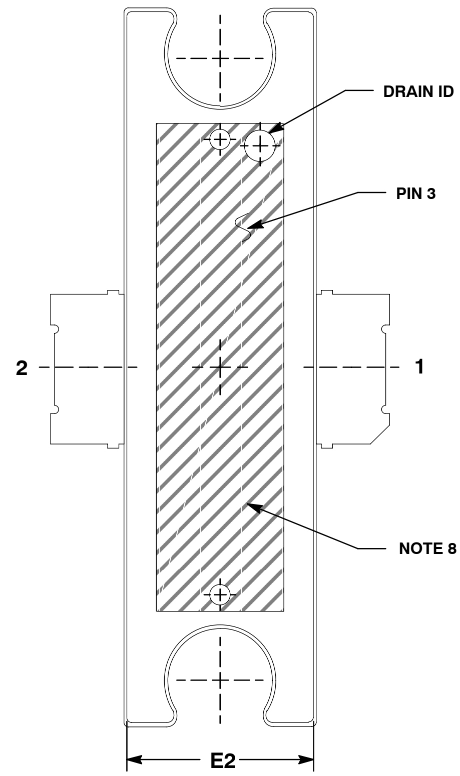
MECHANICAL OUTLINE

PRINT VERSION NOT TO SCALE

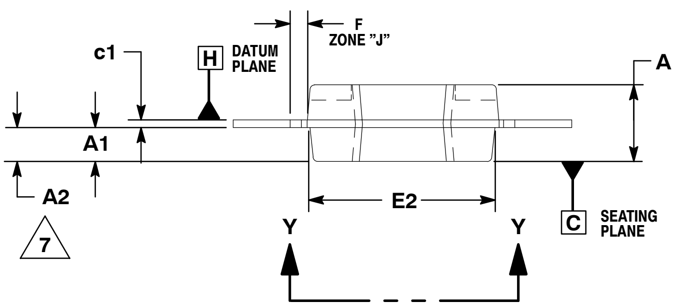
TITLE:
TO–270
SURFACE MOUNT

DOCUMENT NO: 98ASH98117A
REV: J
CASE NUMBER: 1265–08
01 APR 2005
STANDARD: NON–JEDEC





VIEW Y-Y



NOTES:
1. CONTROLLING DIMENSION: INCH.
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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. CROSSHATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64
A1	.039	.043	0.99	1.09
A2	.040	.042	1.02	1.07
D	.928	.932	23.57	23.67
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	
b1	.193	.199	4.90	5.05
c1	.007	.011	.18	.28
r1	.063	.068	1.60	1.73
aaa	.004		.10	

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

CASE 1337-03
ISSUE C
TO-272-2
PLASTIC
MRF6S9060NBR1

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Document Number: MRF6S9060N
Rev. 3, 5/2006