

# RF LDMOS Wideband Integrated Power Amplifiers

The MW4IC2230N wideband integrated circuit is designed for W-CDMA base station applications. It uses Freescale's newest High Voltage (26 to 28 Volts) LDMOS IC technology and integrates a multi-stage structure. Its wideband on-chip design makes it usable from 1600 to 2400 MHz. The linearity performances cover all modulations for cellular applications: GSM, GSM EDGE, TDMA, CDMA and W-CDMA.

## Final Application

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ1} = 60$  mA,  $I_{DQ2} = 350$  mA,  $P_{out} = 5$  Watts Avg.,  $f = 2140$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 31 dB  
Drain Efficiency — 15%  
ACPR @ 5 MHz = -45 dBc in 3.84 MHz Bandwidth

## Driver Application

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ1} = 60$  mA,  $I_{DQ2} = 350$  mA,  $P_{out} = 0.4$  Watts Avg.,  $f = 2140$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 31.5 dB  
ACPR @ 5 MHz = -53.5 dBc in 3.84 MHz Bandwidth
- Capable of Handling 3:1 VSWR, @ 28 Vdc, 2170 MHz, 5 Watts CW Output Power
- Stable into a 3:1 VSWR. All Spurs Below -60 dBc @ 10 mW to 5 W CW  $P_{out}$ .

## Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- On-Chip Matching (50 Ohm Input, DC Blocked, >5 Ohm Output)
- Integrated Quiescent Current Temperature Compensation with Enable/Disable Function
- On-Chip Current Mirror  $g_m$  Reference FET for Self Biasing Application (1)
- Integrated ESD Protection
- 200°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel

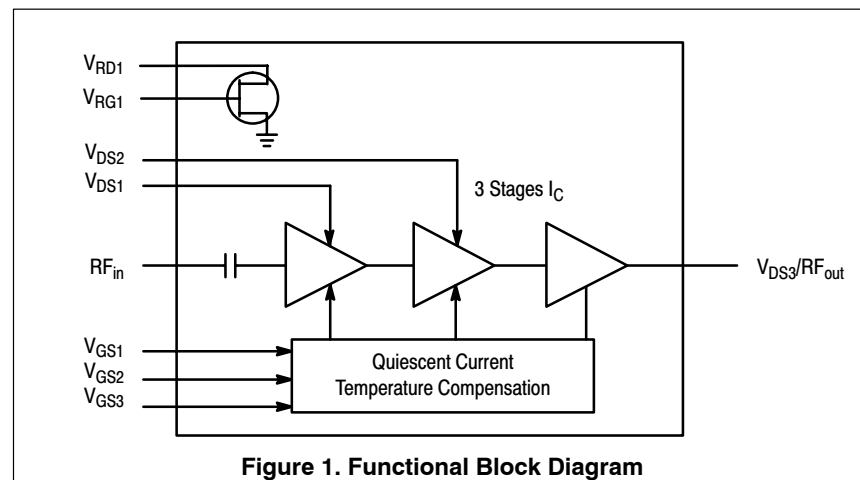
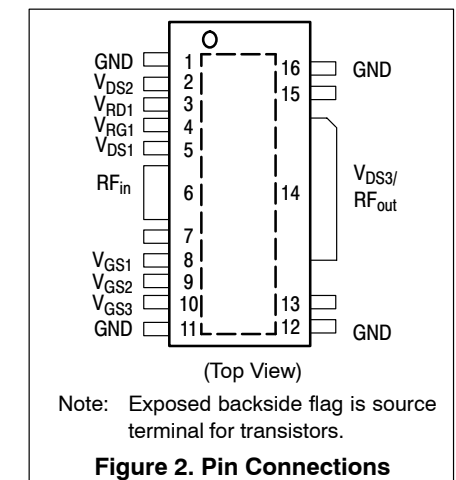


Figure 1. Functional Block Diagram



Note: Exposed backside flag is source terminal for transistors.

Figure 2. Pin Connections

1. Refer to AN1987, Quiescent Current Control for the RF Integrated Circuit Device Family. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1987.

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +8	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +175	°C
Operating Channel Temperature	$T_J$	200	°C
Input Power	$P_{in}$	20	dBm

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	10.5 5.1 2.3	°C/W
Stage 1			
Stage 2			
Stage 3			

**Table 3. ESD Protection Characteristics**

Test Conditions	Class
Human Body Model	2 (Minimum)
Machine Model	M3 (Minimum)
Charge Device Model	C5 (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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**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ1} = 60\text{ mA}$ ,  $I_{DQ2} = 350\text{ mA}$ ,  $I_{DQ3} = 265\text{ mA}$ ,  $P_{out} = 0.4\text{ W Avg.}$ ,  $f = 2110\text{ MHz}$ ,  $f = 2170\text{ MHz}$ , Single-carrier W-CDMA. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	29	31.5	—	dB
Input Return Loss	IRL	—	-25	-10	dB
Adjacent Channel Power Ratio	ACPR	—	-53.5	-50	dBc
$P_{out} = 0.4\text{ W Avg.}$		—	-52	—	
$P_{out} = 1.26\text{ W Avg.}$		—			

**Typical Performances** (In Freescale Test Fixture tuned for 0.4 W Avg. W-CDMA driver)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ1} = 60\text{ mA}$ ,  $I_{DQ2} = 350\text{ mA}$ ,  $I_{DQ3} = 265\text{ mA}$ , 2110 MHz < Frequency < 2170 MHz

Saturated Pulsed Output Power ( $f = 1\text{ kHz}$ , Duty Cycle 10%)	$P_{sat}$	—	43	—	W
Quiescent Current Accuracy over Temperature (-10 to 85°C) (2)	$\Delta I_{QT}$	—	$\pm 5$	—	%
Gain Flatness in 30 MHz Bandwidth	$G_F$	—	0.13	—	dB
Deviation from Linear Phase in 30 MHz Bandwidth	$\Phi$	—	$\pm 1$	—	°
Delay @ $P_{out} = 0.4\text{ W CW}$ Including Output Matching	Delay	—	1.6	—	ns
Part-to-Part Phase Variation	$\Delta\Phi$	—	$\pm 15$	—	°

1. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>.

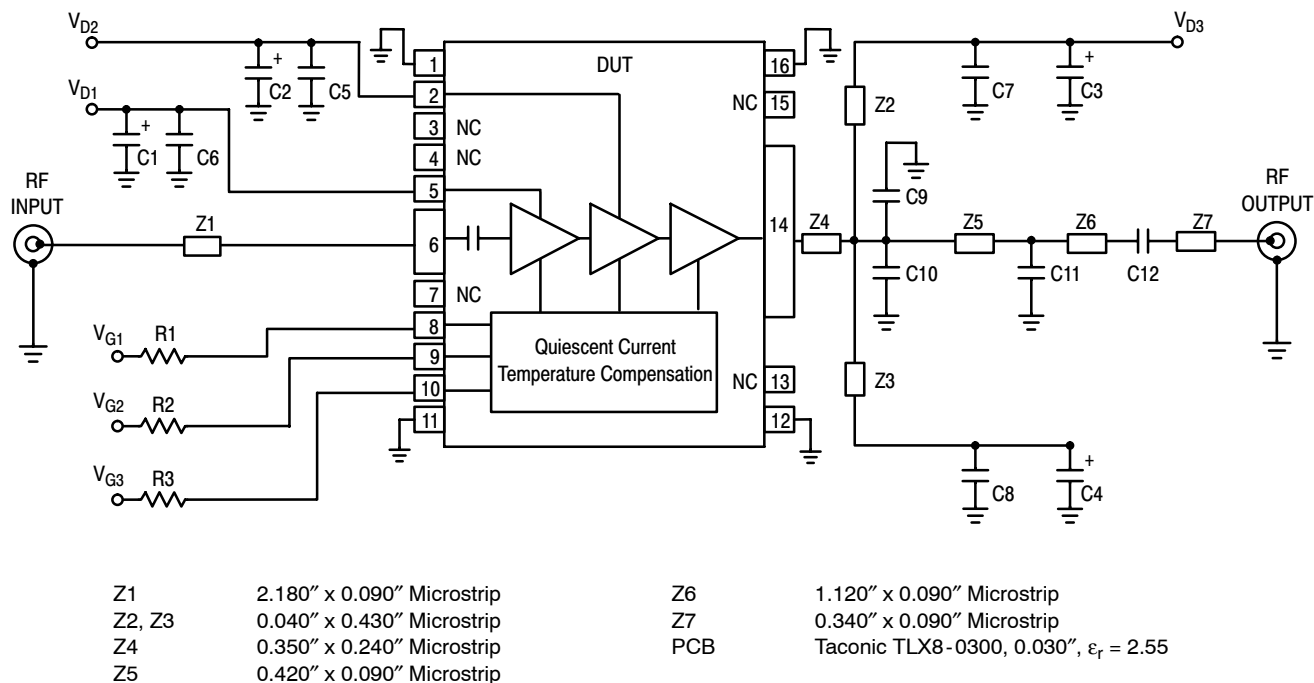
Select Documentation/Application Notes - AN1955.

2. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1977.

(continued)

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

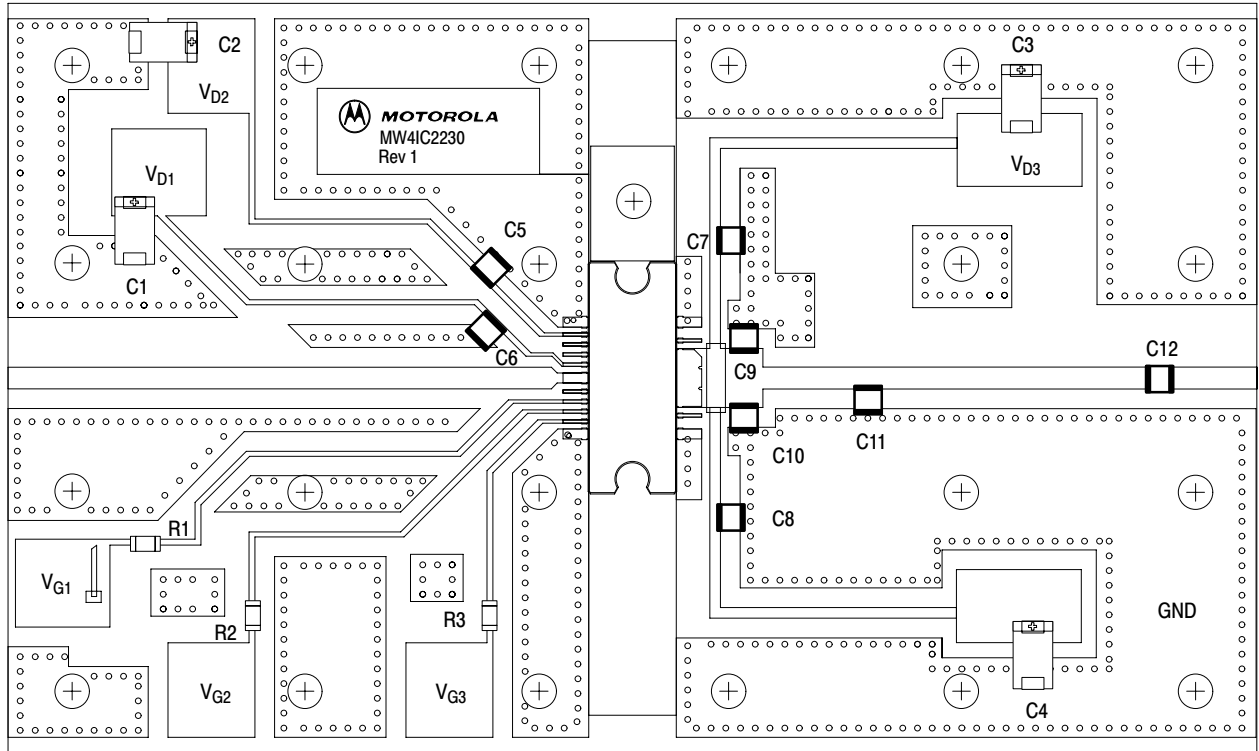
Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Reference Application Circuit tuned for 2-carrier W-CDMA signal) $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 0.4\text{ W Avg.}$ , $I_{DQ1} = 60\text{ mA}$ , $I_{DQ2} = 400\text{ mA}$ , $I_{DQ3} = 245\text{ mA}$ , $f_1 = 2112.5\text{ MHz}$ , $f_2 = 2122.5\text{ MHz}$ and $f_1 = 2157.5\text{ MHz}$ , $f_2 = 2167.5\text{ MHz}$ , 2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @ $\pm 5\text{ MHz}$ Offset. IM3 measured in 3.84 MHz Channel Bandwidth @ $\pm 10\text{ MHz}$ Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.					
Power Gain	$G_{ps}$	—	31.5	—	dB
Intermodulation Distortion	IM3	—	-52	—	dBc
Adjacent Channel Power Ratio	ACPR	—	-55	—	dBc
Input Return Loss	IRL	—	-26	—	dB



**Figure 3. MW4IC2230NBR1(GNBR1) Test Circuit Schematic**

**Table 6. MW4IC2230NBR1(GNBR1) Test Circuit Component Designations and Values**

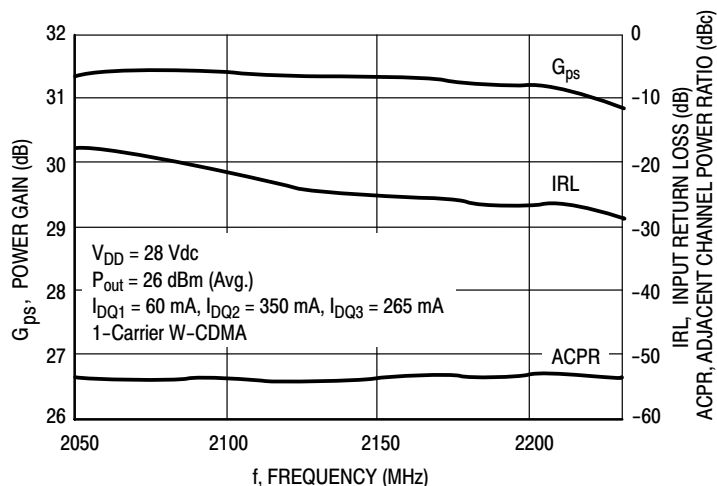
Part	Description	Part Number	Manufacturer
C1, C2, C3, C4	10 $\mu$ F, 35 V Tantalum Capacitors	TAJD106K035	AVX
C5, C6, C7, C8, C12	8.2 pF 100B Chip Capacitors	100B8R2CW	ATC
C9, C10	1.8 pF 100B Chip Capacitors	100B1R8BW	ATC
C11	0.3 pF 100B Chip Capacitor	100B0R3BW	ATC
R1, R2, R3	1.8 k $\Omega$ Chip Resistors (1206)		



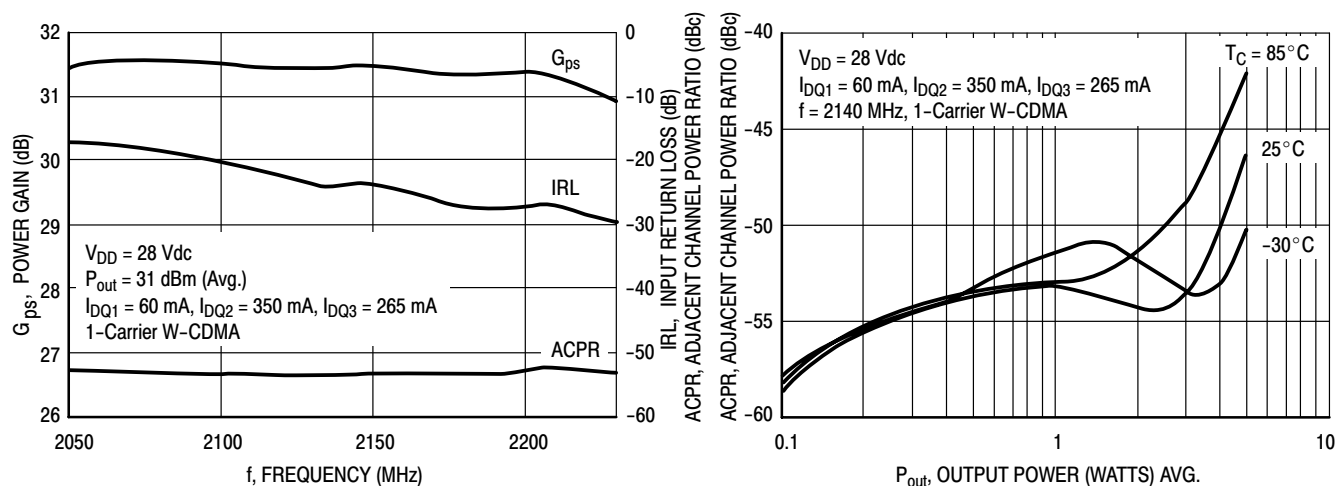
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**Figure 4. MW4IC2230NBR1(GNBR1) Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS

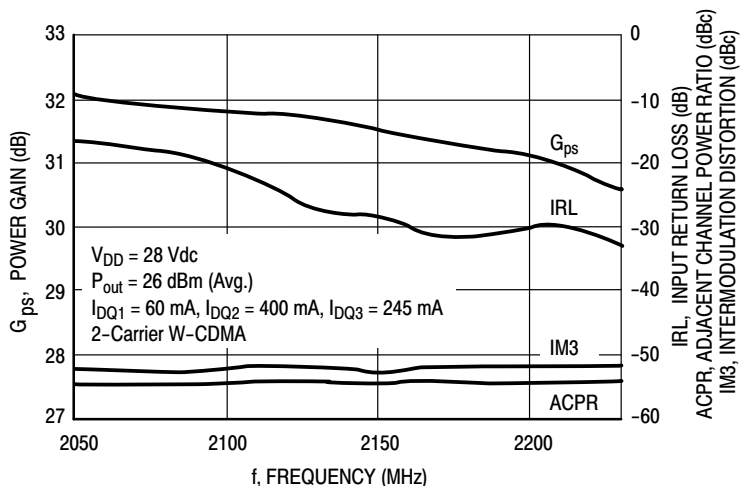


**Figure 5. Single-Carrier W-CDMA Wideband Performance @  $P_{out} = 26$  dBm**



**Figure 6. Single-Carrier W-CDMA Wideband Performance @  $P_{out} = 31$  dBm**

**Figure 7. Adjacent Channel Power Ratio versus Output Power**



**Figure 8. 2-Carrier W-CDMA Wideband Performance**

## TYPICAL CHARACTERISTICS

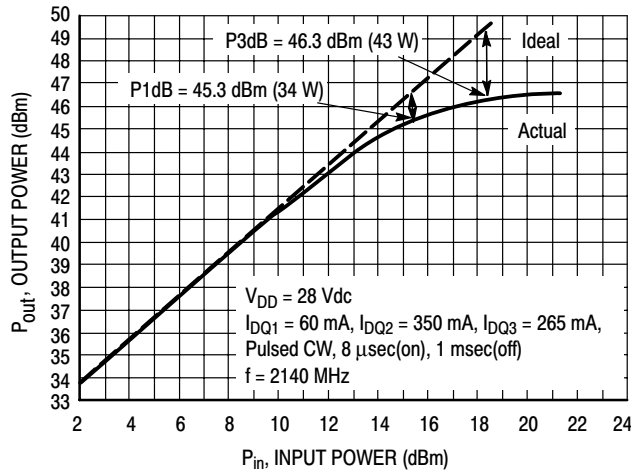


Figure 9. Output Power versus Input Power

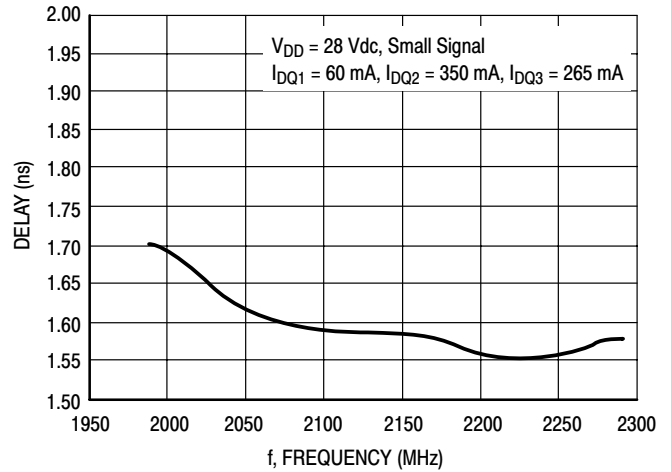
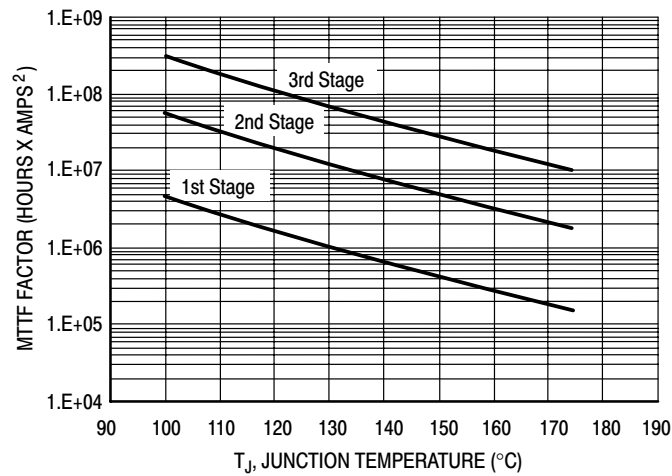
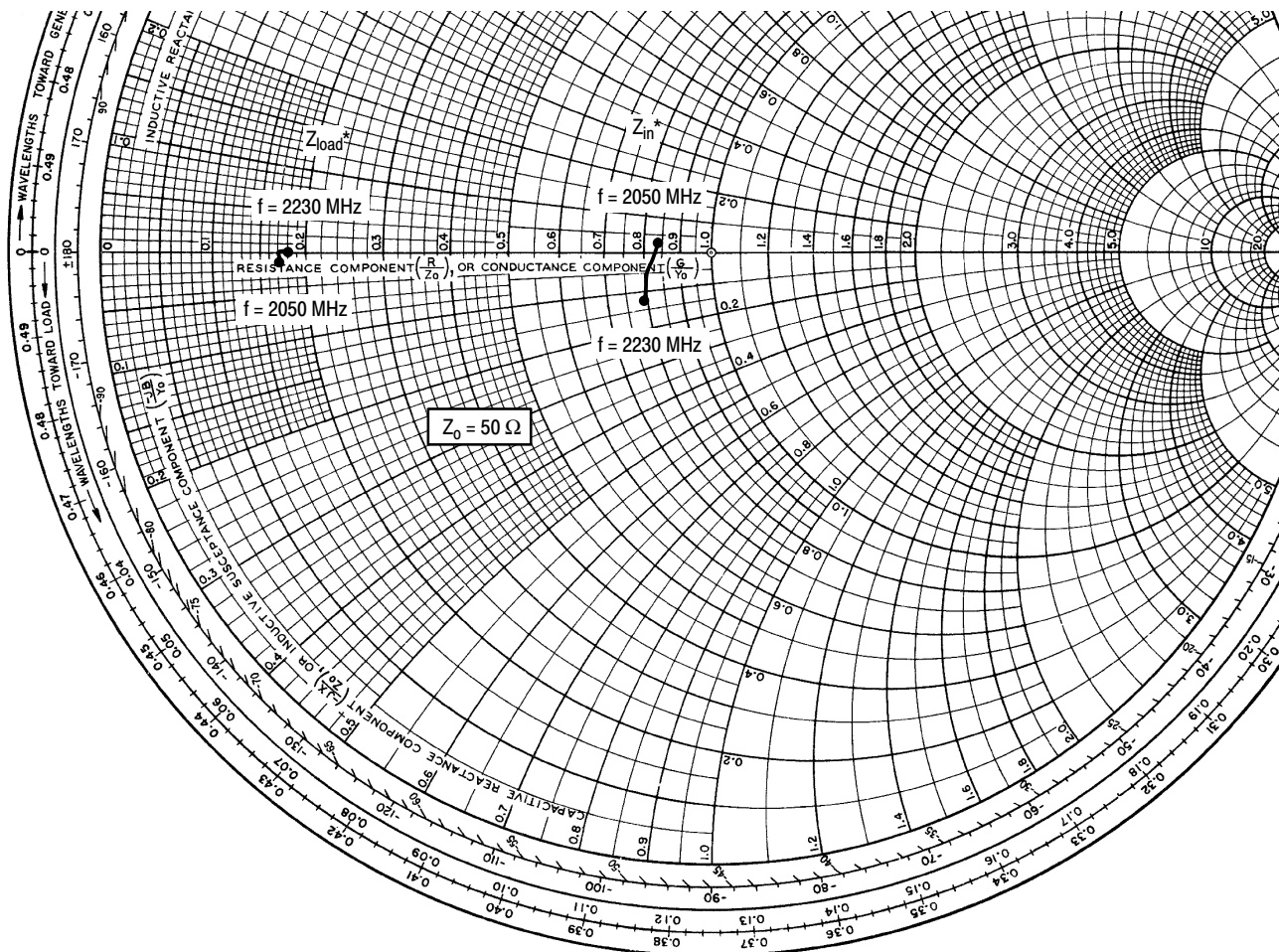


Figure 10. Delay versus Frequency



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

Figure 11. MTTF Factor versus Temperature Junction



$V_{DD} = 28\text{ V}$ ,  $I_{DQ1} = 60\text{ mA}$ ,  $I_{DQ2} = 350\text{ mA}$ ,  $I_{DQ3} = 265\text{ mA}$ ,  $P_{out} = 26\text{ dBm}$

f MHz	$Z_{in}$ $\Omega$	$Z_{load}$ $\Omega$
2050	$42.18 + j1.49$	$8.52 - j0.46$
2110	$41.06 - j1.30$	$8.58 - j0.20$
2140	$40.49 - j2.42$	$8.63 - j0.09$
2170	$40.05 - j3.45$	$8.69 - j0.01$
2230	$39.29 - j6.31$	$8.81 + j0.04$

$Z_{in}$  = Device input impedance as measured from gate to ground.

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

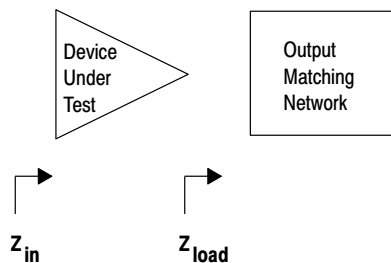
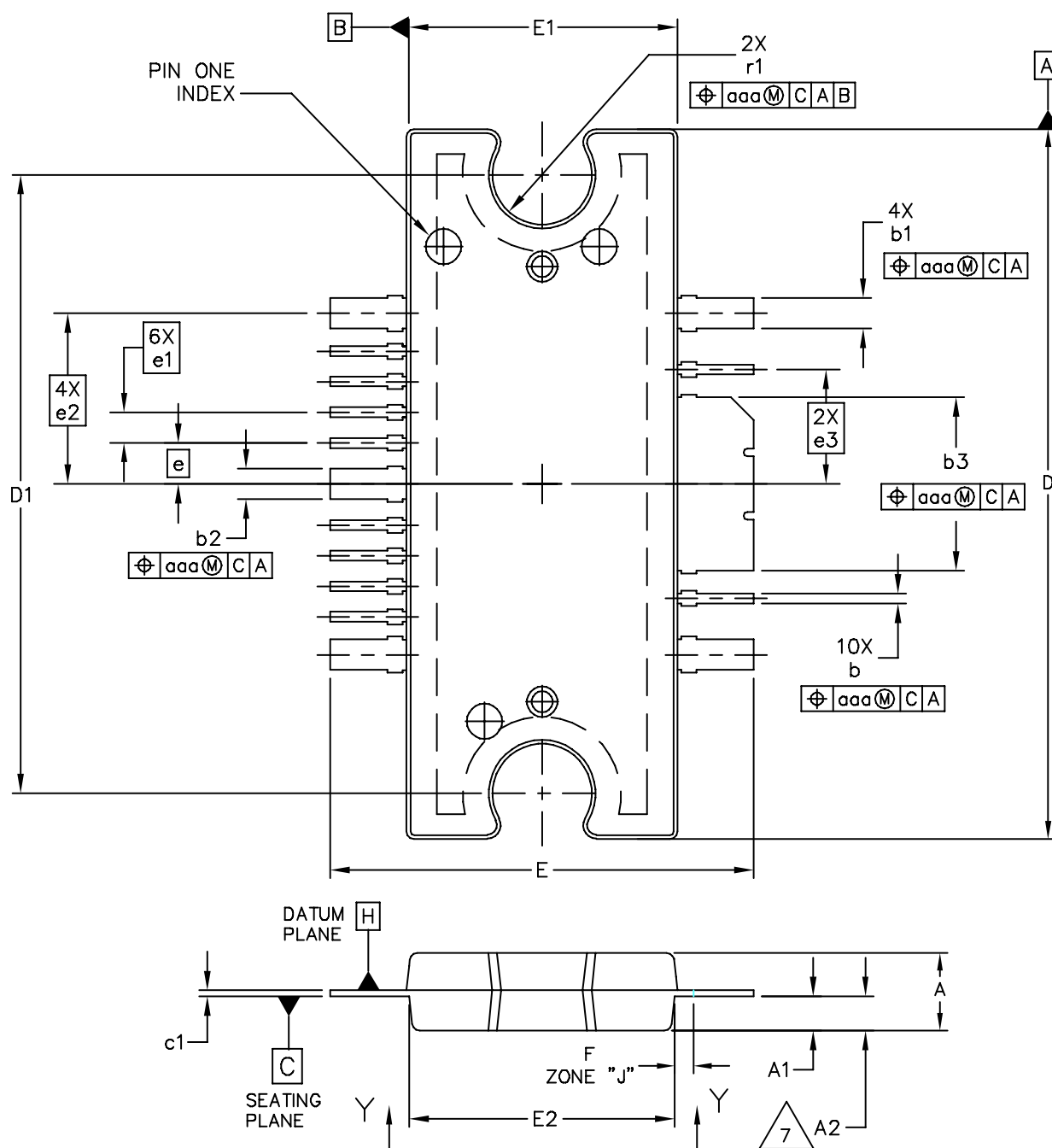


Figure 12. Series Equivalent Input and Load Impedance

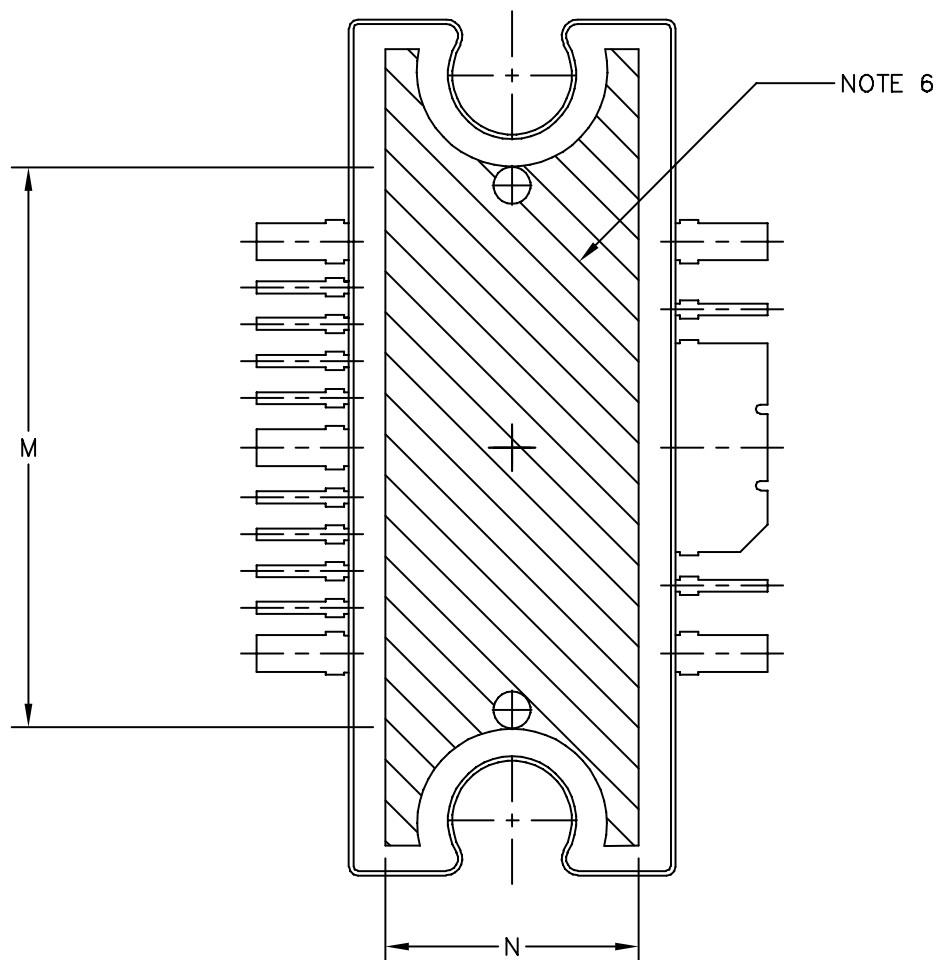


# NOTES

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	CASE NUMBER: 1329-09		13 MAR 2006
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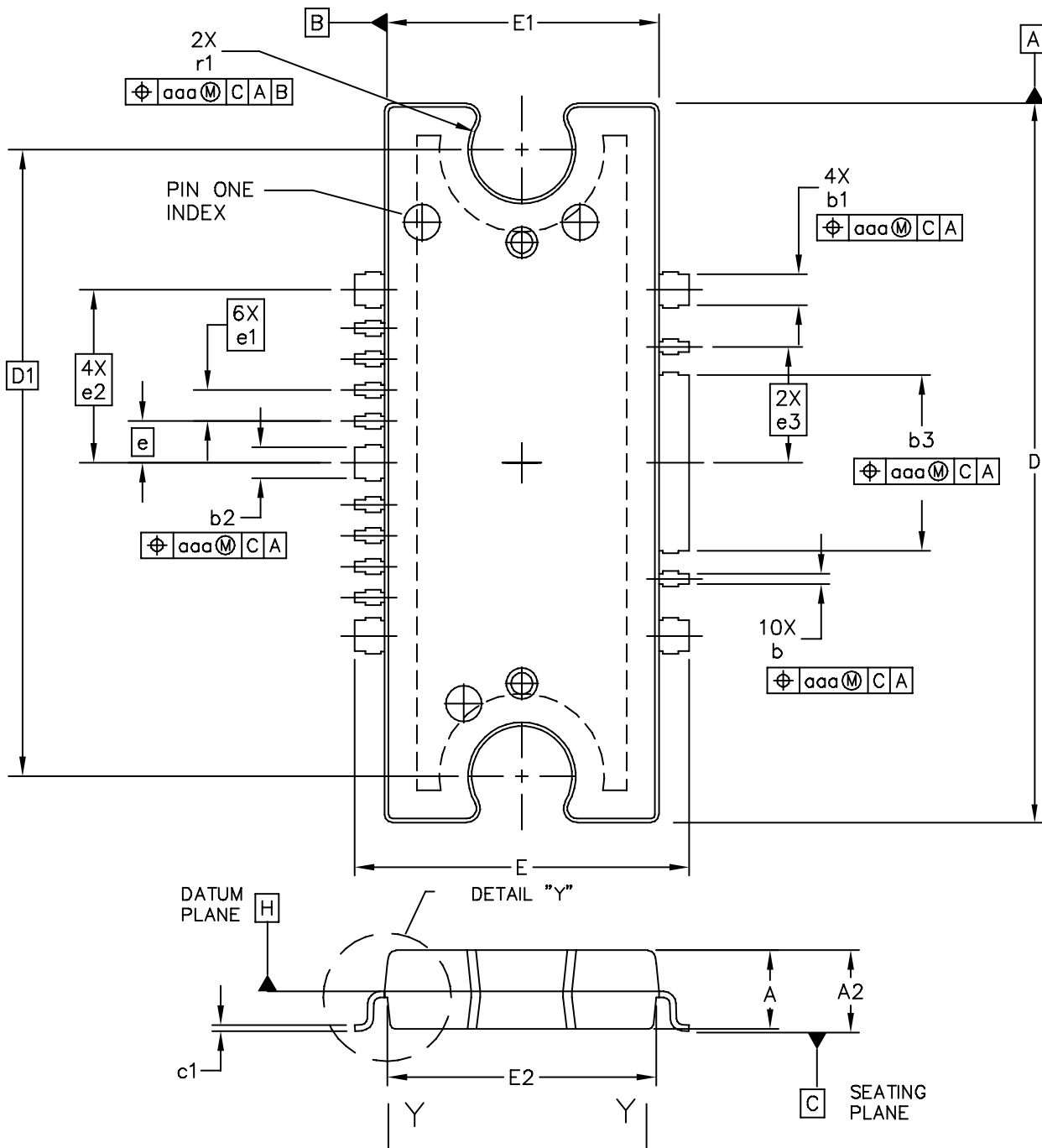
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MW4IC2230NBR1 MW4IC2230GNBR1

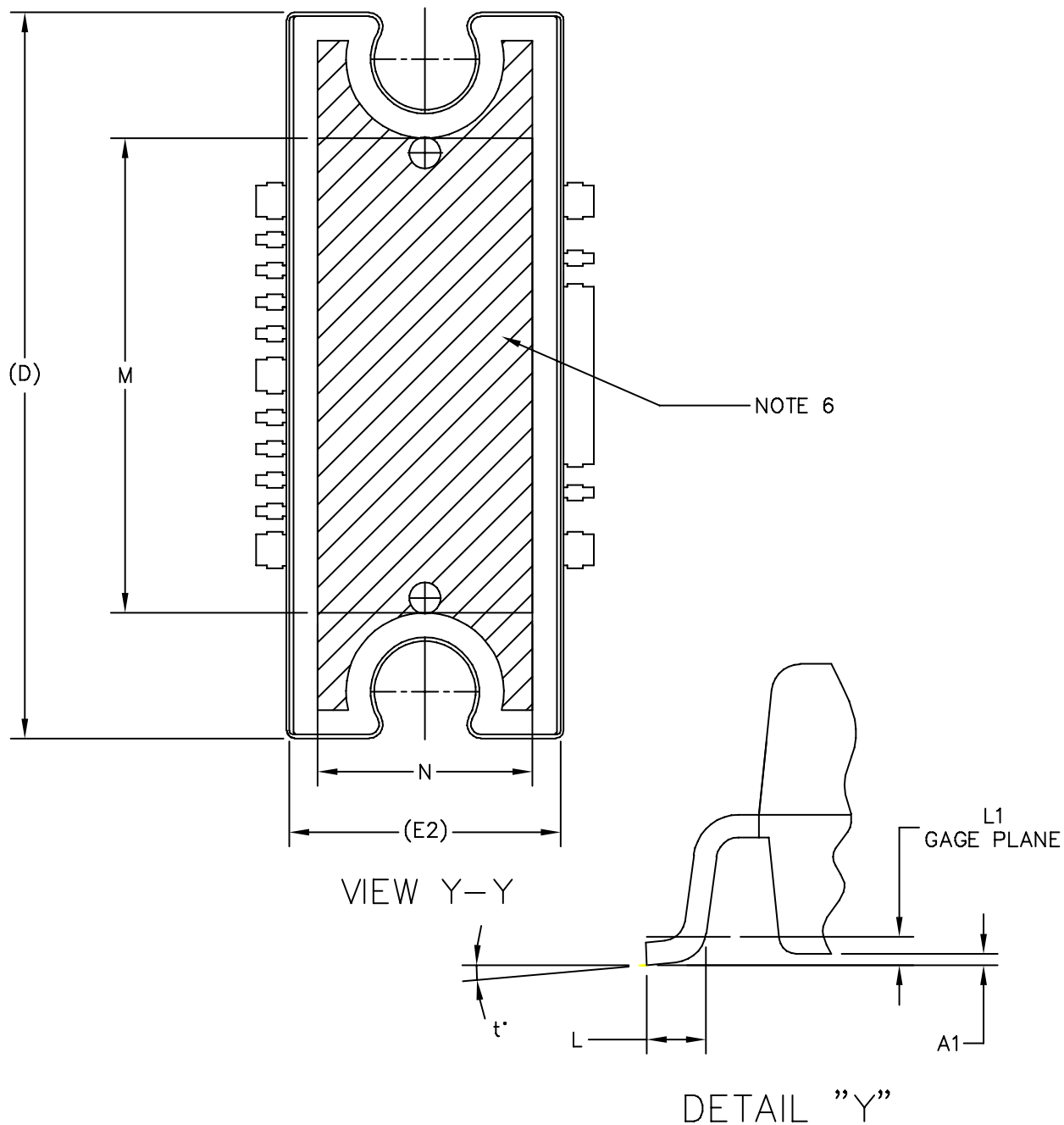
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4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 (0.15) PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSIONS "b", "b1", "b2" AND "b3" DO NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 (0.13) TOTAL IN EXCESS OF THE "b", "b1", "b2" AND "b3" DIMENSIONS AT MAXIMUM MATERIAL CONDITION.
6. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.
7. DIM A2 APPLIES WITHIN ZONE "J" ONLY.

INCH			MILLIMETER		DIM	INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b	.011	.017	0.28	0.43
A1	.038	.044	0.96	1.12	b1	.037	.043	0.94	1.09
A2	.040	.042	1.02	1.07	b2	.037	.043	0.94	1.09
D	.928	.932	23.57	23.67	b3	.225	.231	5.72	5.87
D1	.810 BSC		20.57 BSC		c1	.007	.011	.18	.28
E	.551	.559	14.00	14.20	e	.054 BSC		1.37 BSC	
E1	.353	.357	8.97	9.07	e1	.040 BSC		1.02 BSC	
E2	.346	.350	8.79	8.89	e2	.224 BSC		5.69 BSC	
F	.025 BSC		0.64 BSC		e3	.150 BSC		3.81 BSC	
M	.600	----	15.24	----	r1	.063	.068	1.6	1.73
N	.270	----	6.86	----	aaa	.004		.10	
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6. HATCHING REPRESENTS EXPOSED AREA OF THE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.

INCH			MILLIMETER		INCH			MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64	b	.011	.017	0.28	0.43
A1	.001	.004	0.02	0.10	b1	.037	.043	0.94	1.09
A2	.099	.110	2.51	2.79	b2	.037	.043	0.94	1.09
D	.928	.932	23.57	23.67	b3	.225	.231	5.72	5.87
D1	.810 BSC		20.57 BSC		c1	.007	.011	.18	.28
E	.429	.437	10.9	11.1	e	.054 BSC		1.37 BSC	
E1	.353	.357	8.97	9.07	e1	.040 BSC		1.02 BSC	
E2	.346	.350	8.79	8.89	e2	.224 BSC		5.69 BSC	
L	.018	.024	4.90	5.06	e3	.150 BSC		3.81 BSC	
L1	.01 BSC		.025 BSC		r1	.063	.068	1.6	1.73
M	.600	----	15.24	----	t	2'	8'	2'	8'
N	.270	----	6.86	----	aaa	.004		.10	
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