

# RF LDMOS Wideband Integrated Power Amplifiers

The MW4IC2230M 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

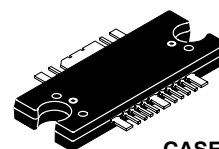
- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ1} = 60$  mA,  $I_{DQ2} = 350$  mA,  $P_{out} = 5$  Watts Avg.,  $f = 2140$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 31 dB  
Drain Efficiency — 15%  
ACPR @ 5 MHz = -45 dBc in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

## Driver Application

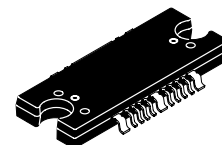
- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ1} = 60$  mA,  $I_{DQ2} = 350$  mA,  $P_{out} = 0.4$  Watts Avg.,  $f = 2140$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 31.5 dB  
ACPR @ 5 MHz = -53.5 dBc in 3.84 MHz Bandwidth
- 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  $P_{out}$ .
- 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
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel

**MW4IC2230MBR1**  
**MW4IC2230GMBR1**

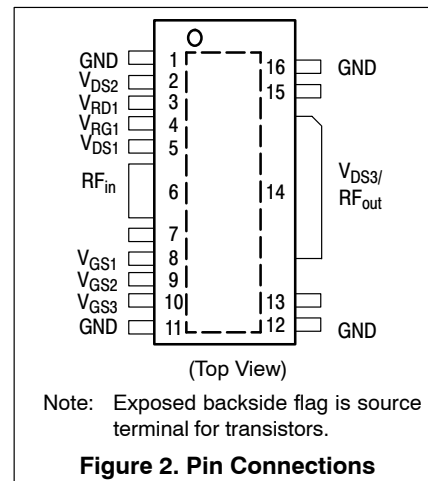
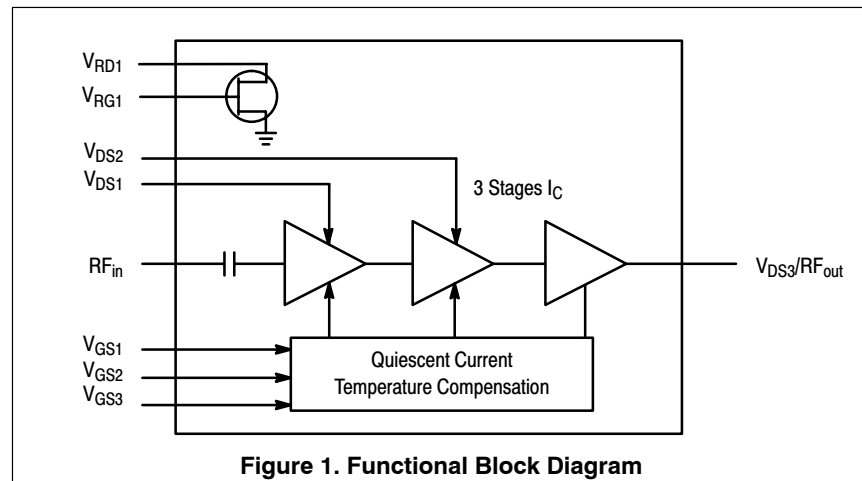
**2110-2170 MHz, 30 W, 28 V**  
**SINGLE W-CDMA**  
**RF LDMOS WIDEBAND**  
**INTEGRATED POWER AMPLIFIERS**



**CASE 1329-09**  
**TO-272 WB-16**  
**PLASTIC**  
**MW4IC2230MBR1**



**CASE 1329A-03**  
**TO-272 WB-16 GULL**  
**PLASTIC**  
**MW4IC2230GMBR1**



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<br>5.1<br>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 |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

**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<br>( $f = 1\text{ kHz}$ , 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>.

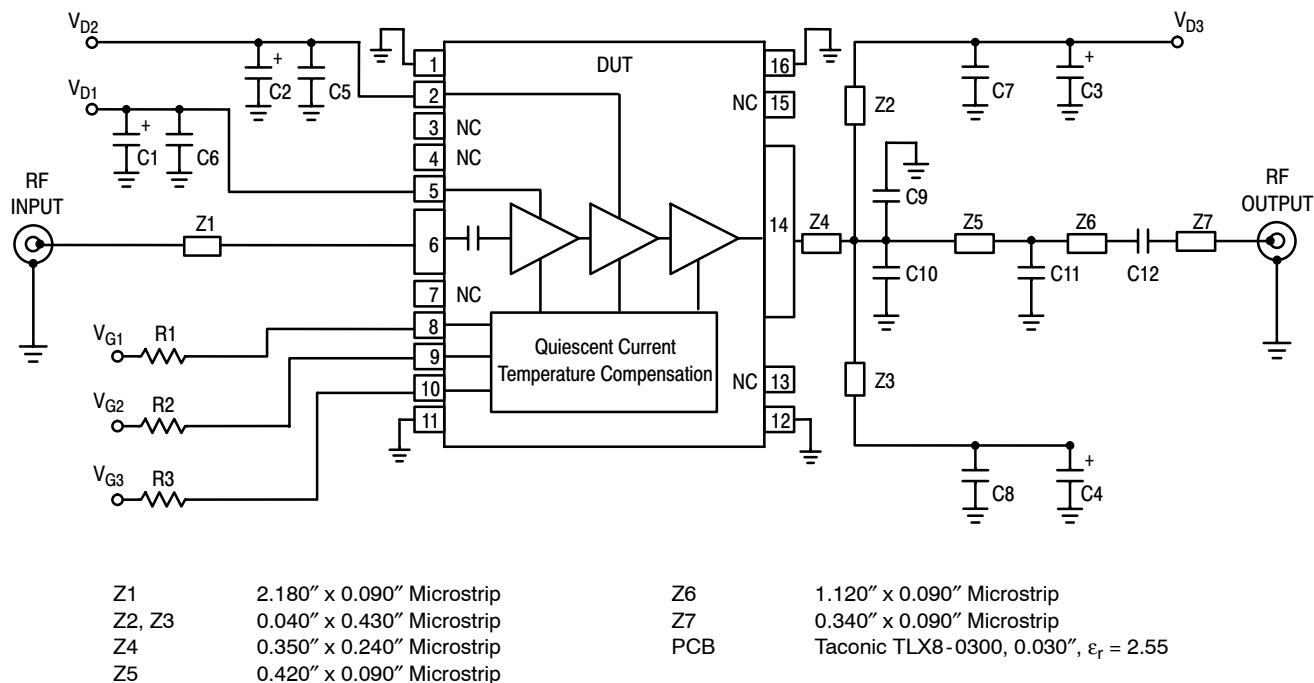
Select Documentation/Application Notes - AN1955.

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)**

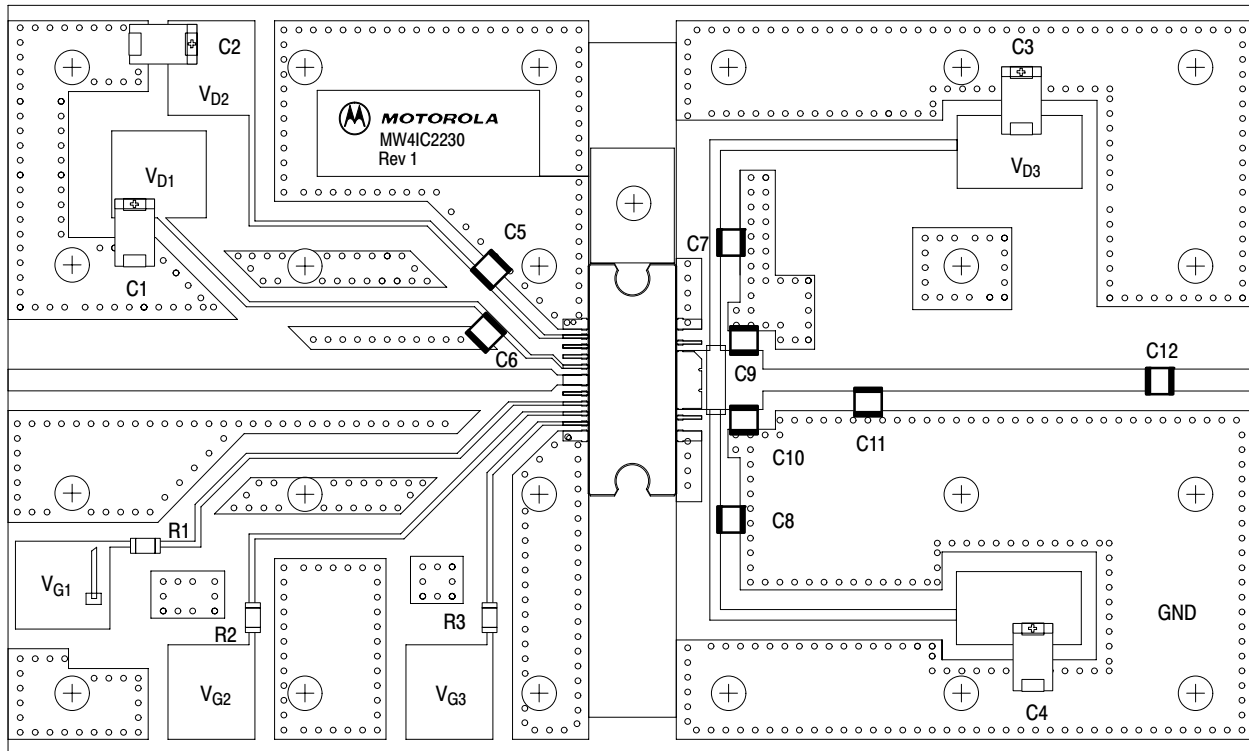
| Characteristic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Symbol   | Min | Typ  | Max | Unit |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----|------|-----|------|
| <b>Typical Performances</b> (In Freescale Reference Application Circuit tuned for 2-carrier W-CDMA signal) $V_{DD} = 28\text{ Vdc}$ ,<br>$P_{out} = 0.4\text{ W Avg.}$ , $I_{DQ1} = 60\text{ mA}$ , $I_{DQ2} = 400\text{ mA}$ , $I_{DQ3} = 245\text{ mA}$ , $f_1 = 2112.5\text{ MHz}$ , $f_2 = 2122.5\text{ MHz}$ and $f_1 = 2157.5\text{ MHz}$ , $f_2 = 2167.5\text{ MHz}$ ,<br>2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @ $\pm 5\text{ MHz}$ Offset. IM3<br>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. MW4IC2230MBR1(GMBR1) Test Circuit Schematic**

**Table 6. MW4IC2230MBR1(GMBR1) Test Circuit Component Designations and Values**

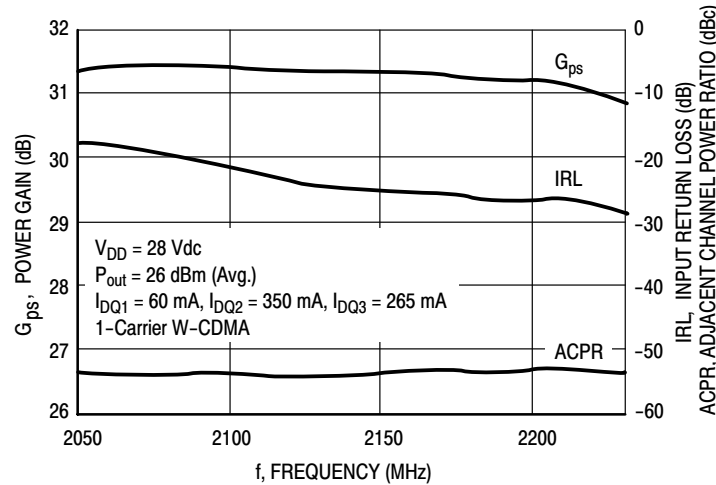
| Part                | Description                          | Part Number | Manufacturer |
|---------------------|--------------------------------------|-------------|--------------|
| C1, C2, C3, C4      | 10 $\mu$ F, 35 V Tantalum Capacitors | TAJD106K035 | AVX          |
| C5, C6, C7, C8, C12 | 8.2 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) |             |              |



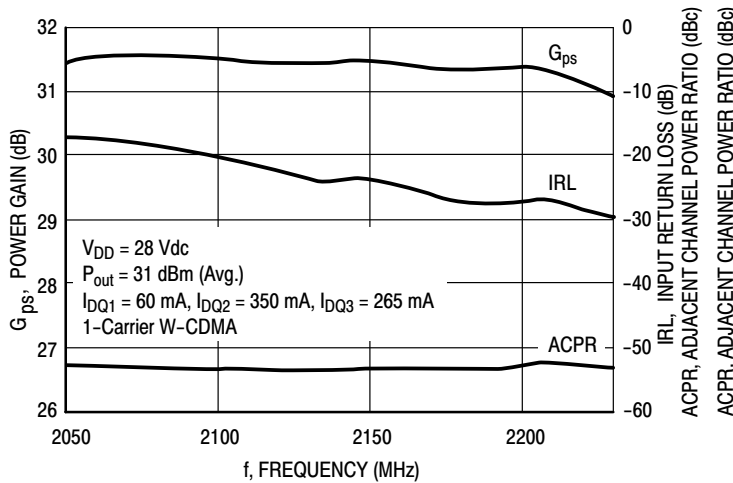
Freescall has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescall Semiconductor signature/logo. PCBs may have either Motorola or Freescall markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 4. MW4IC2230MBR1(GMBR1) Test Circuit Component Layout**

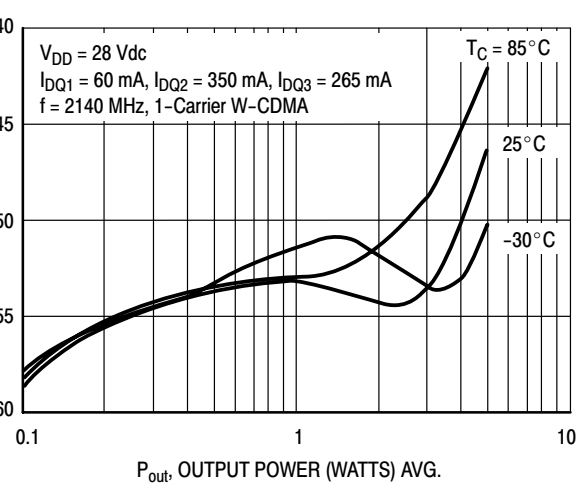
## TYPICAL CHARACTERISTICS



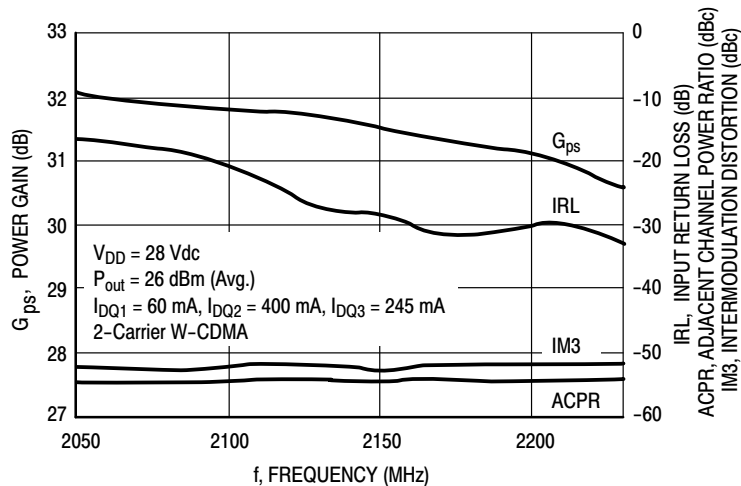
**Figure 5. Single-Carrier W-CDMA Wideband Performance @  $P_{out} = 26$  dBm**



**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

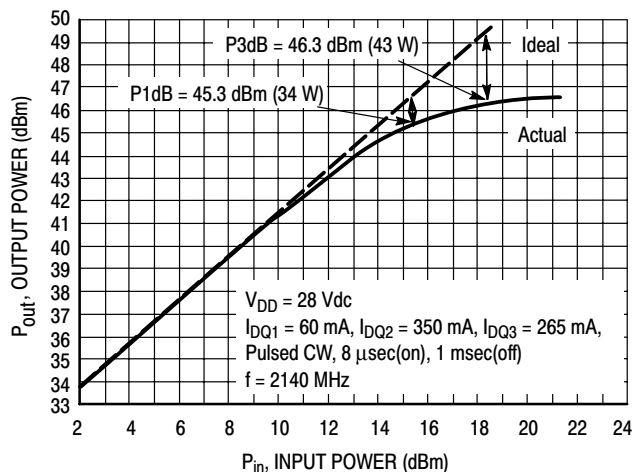


Figure 9. Output Power versus Input Power

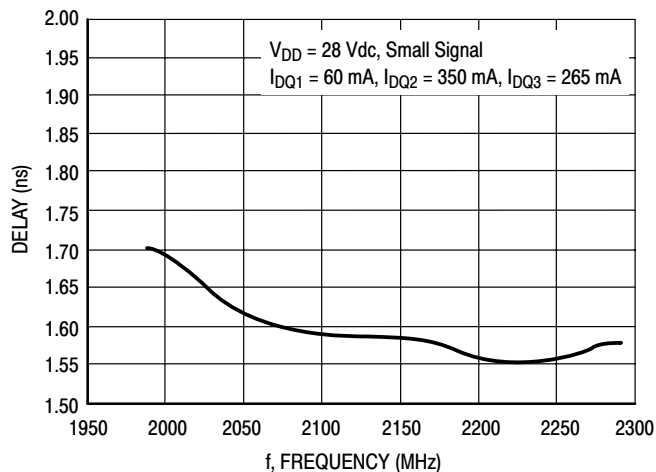
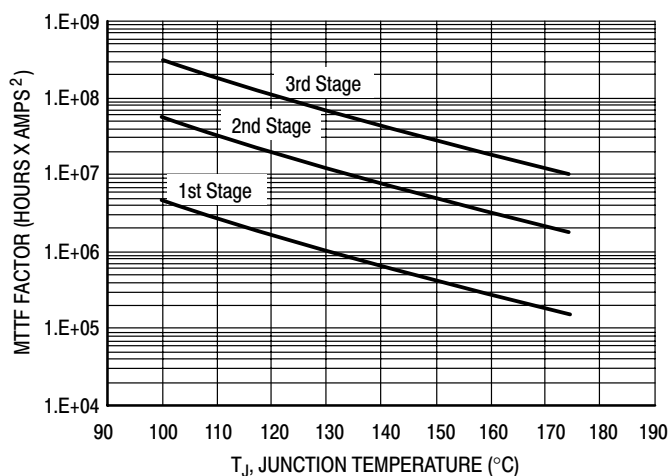
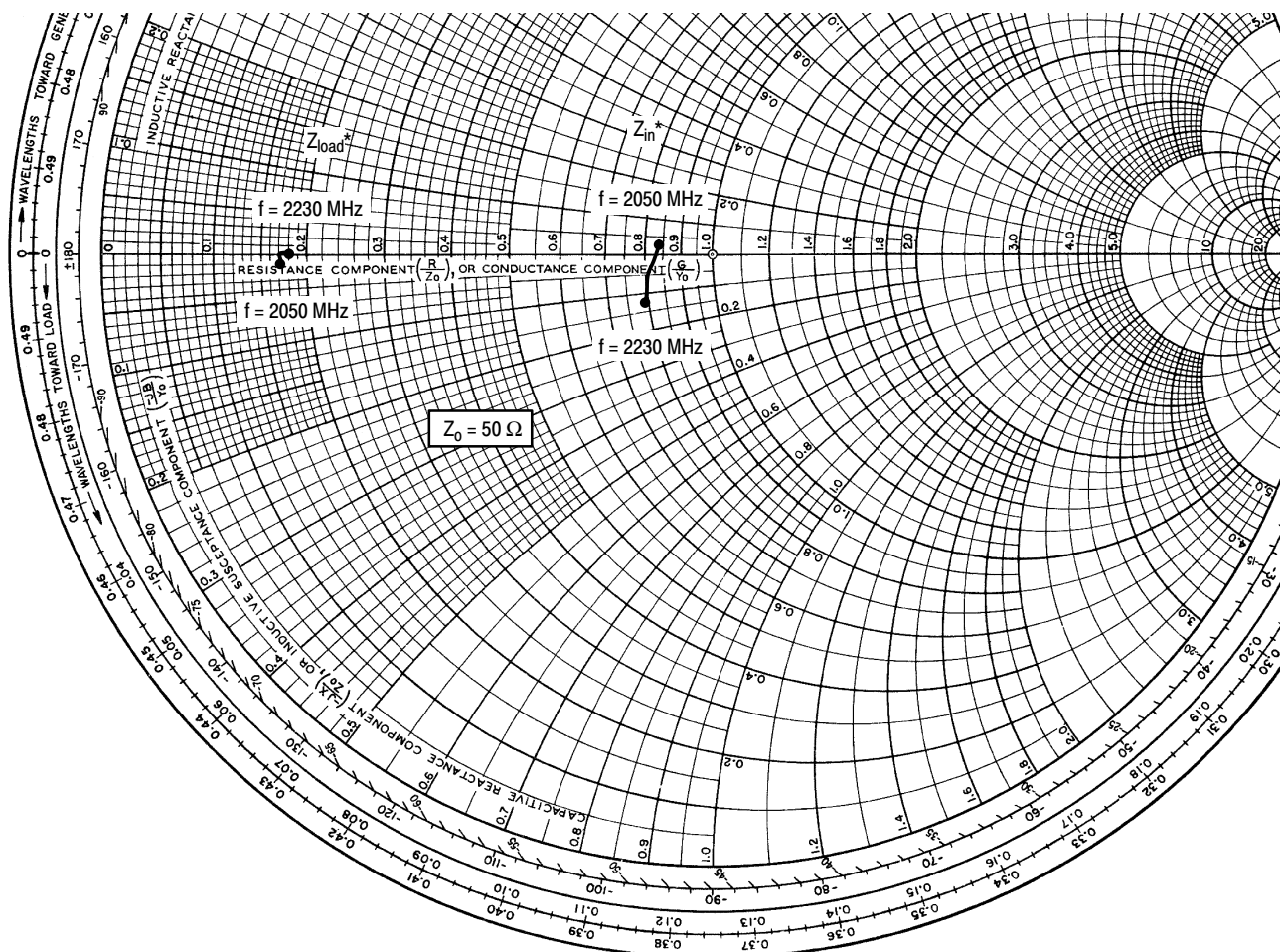


Figure 10. Delay versus Frequency



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<br>MHz | $Z_{in}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|----------------------|------------------------|
| 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.

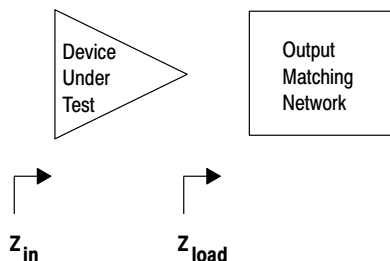
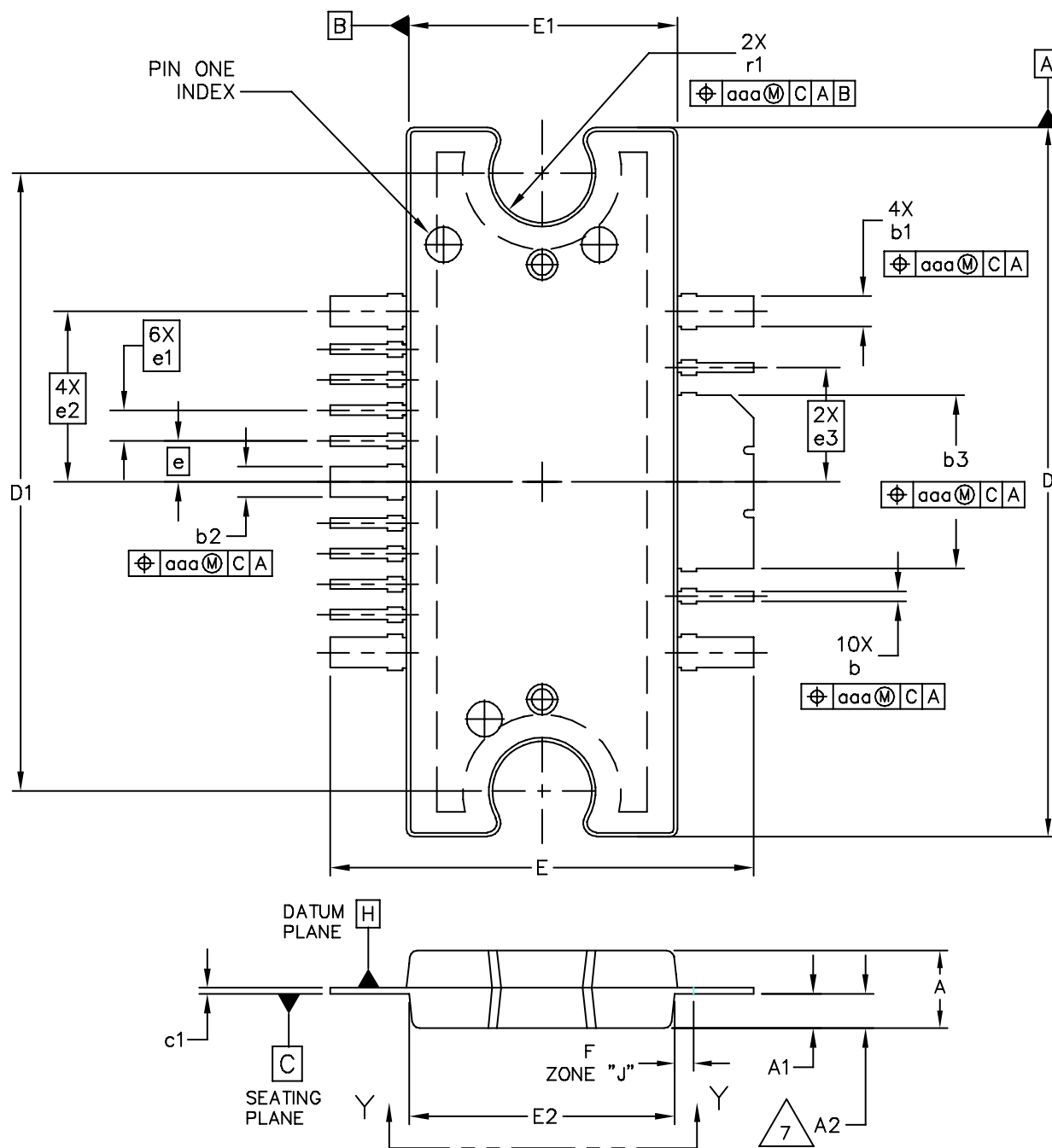


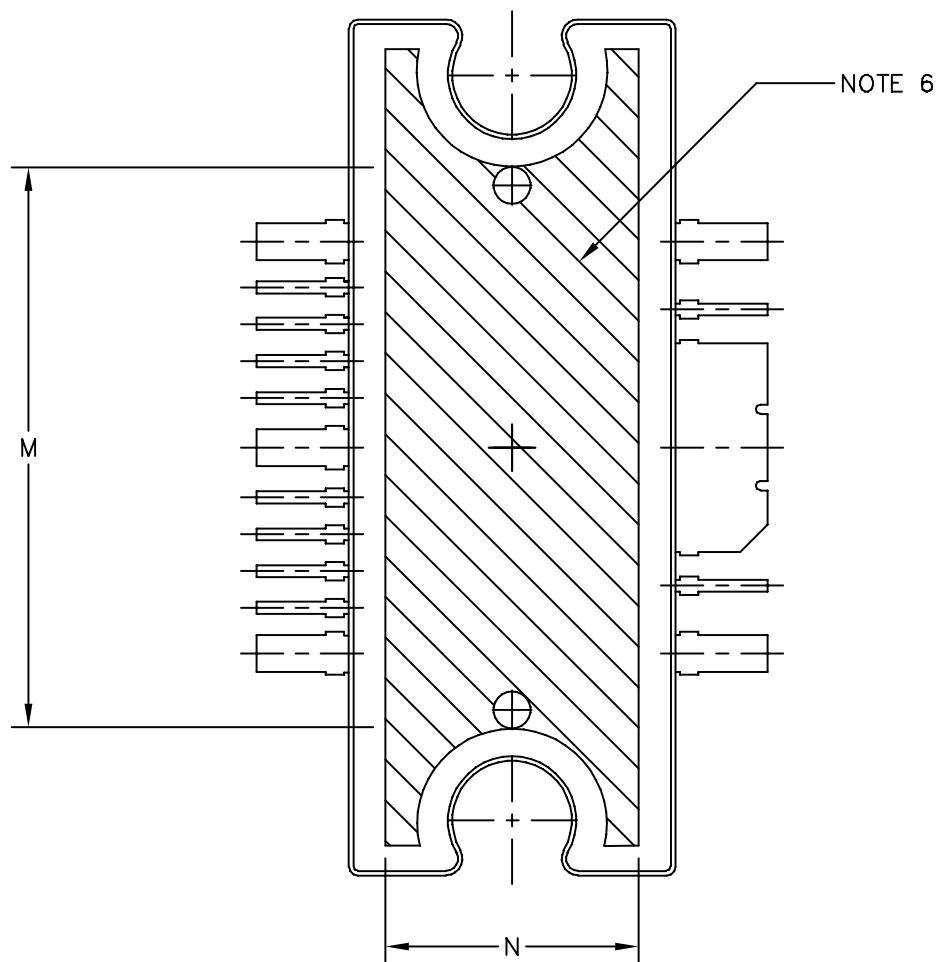
Figure 12. Series Equivalent Input and Load Impedance

# NOTES

# PACKAGE DIMENSIONS



|                                                         |                           |                            |             |
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| TITLE:<br>TO-272 WIDE BODY<br>MULTI-LEAD                | DOCUMENT NO: 98ARH99164A  |                            | REV: L      |
|                                                         | CASE NUMBER: 1329-09      |                            | 13 MAR 2006 |
|                                                         | STANDARD: NON-JEDEC       |                            |             |



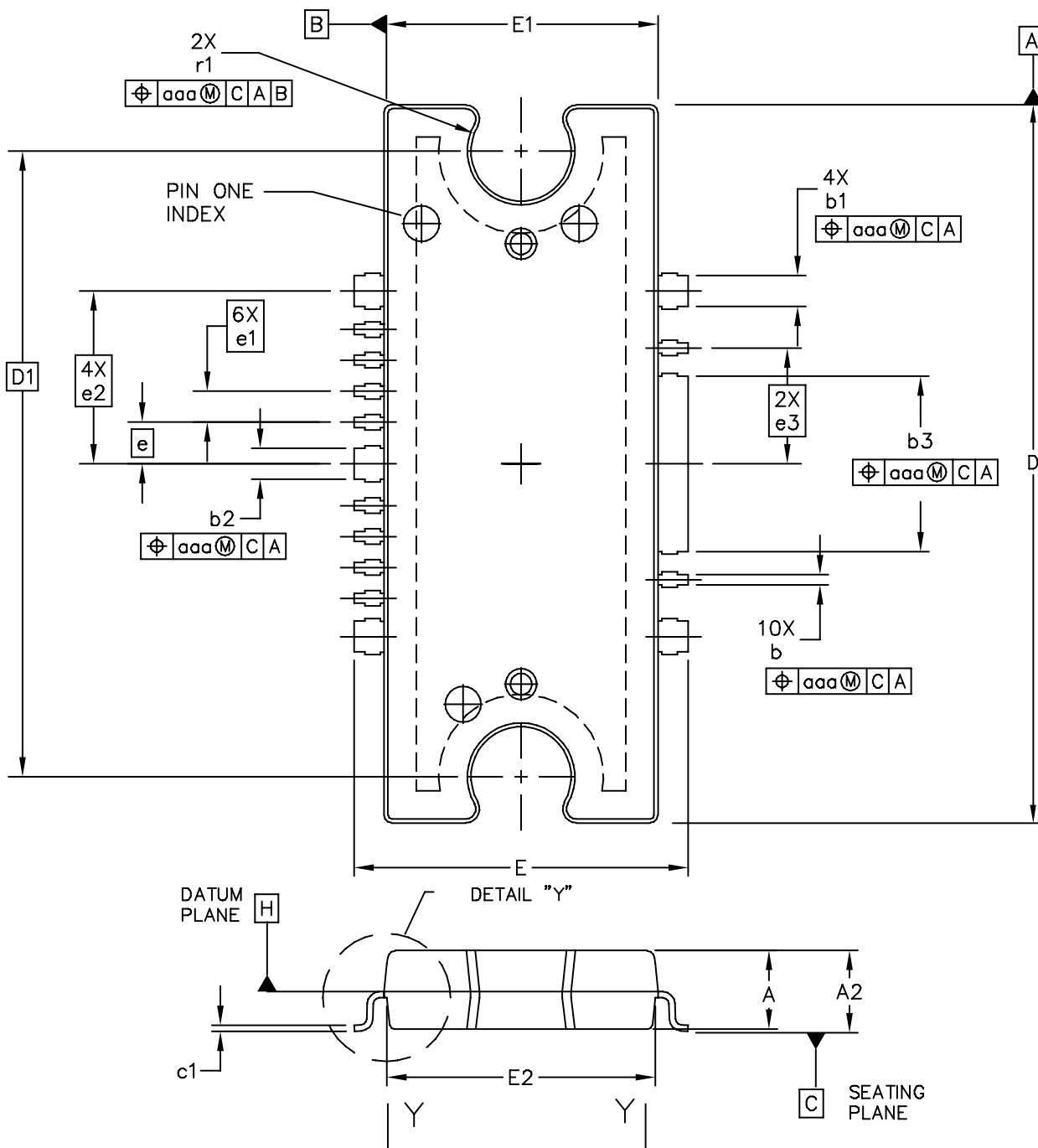
VIEW Y-Y

|                                                         |  |                          |  |                            |  |
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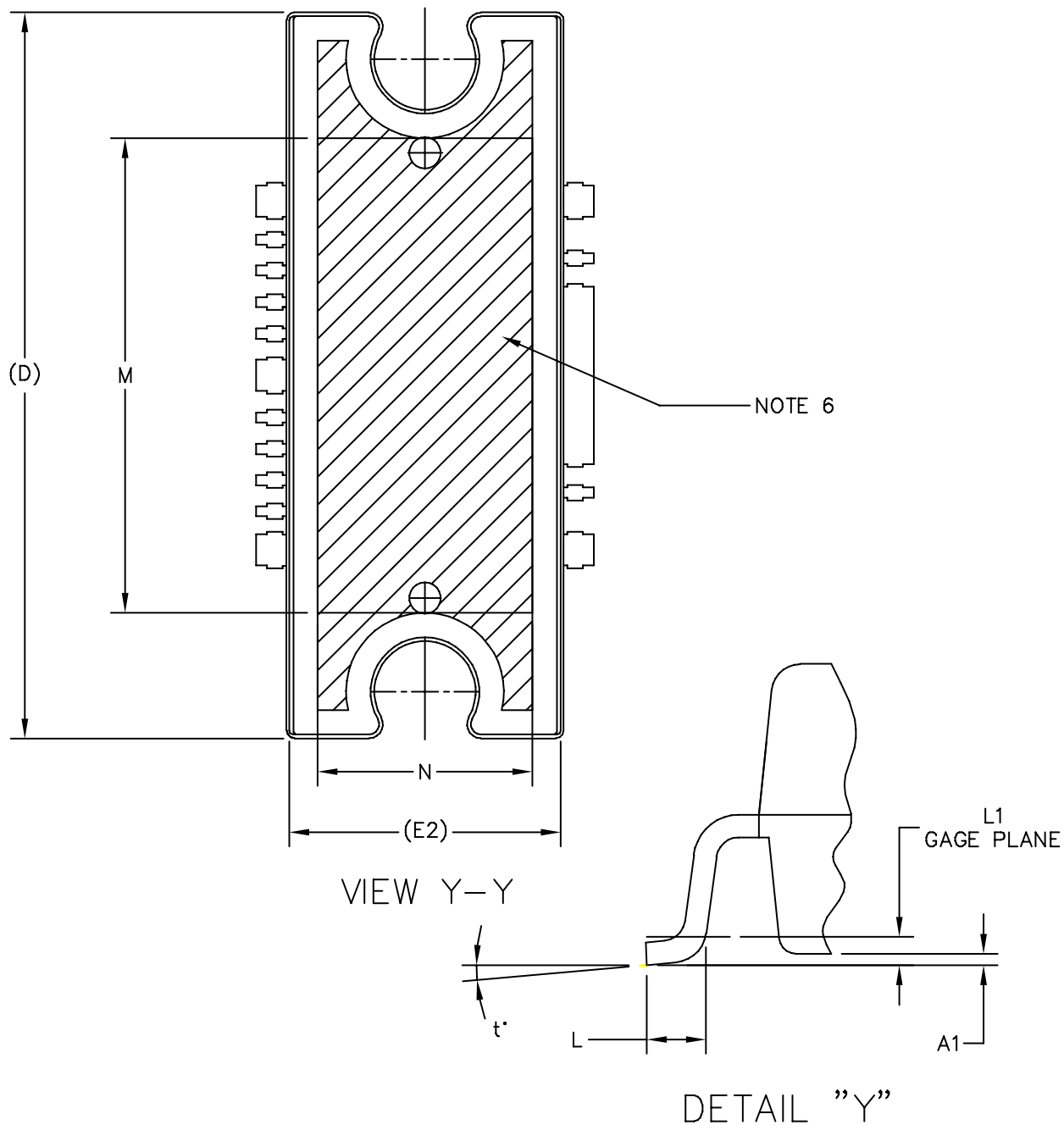
# NOTES:

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 (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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|                                                         |          |      |                    |       | CASE NUMBER: 1329-09     |                            |      | 13 MAR 2006 |      |
|                                                         |          |      |                    |       | STANDARD: NON-JEDEC      |                            |      |             |      |



|                                                         |  |                          |  |                            |  |
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|                                                         |  | CASE NUMBER: 1329A-03    |  | 3 APR 2006                 |  |
|                                                         |  | STANDARD: NON-JEDEC      |  |                            |  |



|                                                         |                           |                            |            |
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| TITLE: TO-272WB, 16 LEAD<br>GULL WING<br>PLASTIC        | DOCUMENT NO: 98ASA10532D  |                            | REV: E     |
|                                                         | CASE NUMBER: 1329A-03     |                            | 3 APR 2006 |
|                                                         | STANDARD: NON-JEDEC       |                            |            |

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| 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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