Freescale Semiconductor
Technical Data

Document Number: MW5IC970N
Rev. 2, 4/2008

RoHS

# RF LDMOS Wideband 2-Stage Power Amplifiers

**MW5IC970NBR1**
**MW5IC970GNBR1**

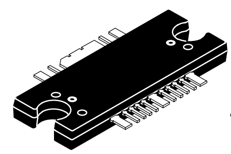
Designed for broadband commercial and industrial applications with frequencies from 132 MHz to 960 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 28 volt base station equipment. These devices have a 2-stage design with off-chip matching for the input, interstage and output networks to cover the desired frequency band.

- Typical Performance: 800 MHz, 28 Volts, $I_{DQ1}$ = 80 mA, $I_{DQ2}$ = 650 mA, $P_{out}$ = 70 Watts PEP
  - Power Gain — 30 dB
  - Drain Efficiency — 48%
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 850 MHz, 70 Watts CW Output Power

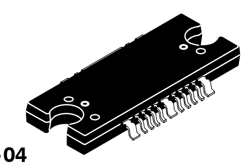
**Features**

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- 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
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

**800-900 MHz, 70 W, 28 V**
**RF LDMOS WIDEBAND**
**2-STAGE POWER AMPLIFIERS**



**CASE 1329-09**
**TO-272 WB-16**
**PLASTIC**
**MW5IC970NBR1**



**CASE 1329A-04**
**TO-272 WB-16 GULL**
**PLASTIC**
**MW5IC970GNBR1**

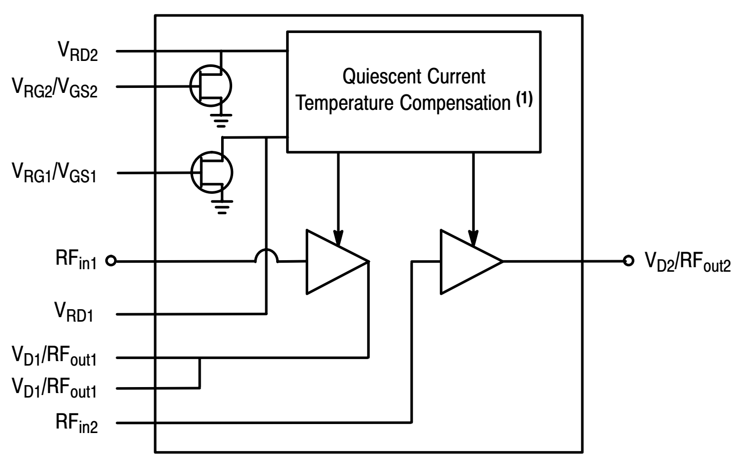
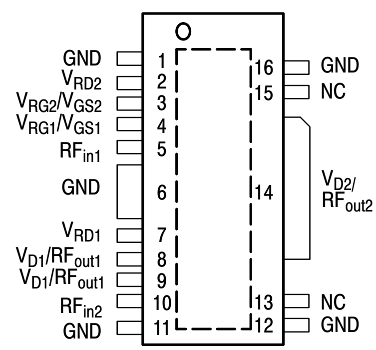



**Figure 1. Functional Block Diagram**




(Top View)

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.



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**Table 1. Maximum Ratings**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | -0.5, +65 | Vdc |
| Gate-Source Voltage | $V_{GS}$ | -0.5, +15 | Vdc |
| Storage Temperature Range | $T_{stg}$ | -65 to +200 | °C |
| Case Operating Temperature | $T_C$ | 150 | °C |
| Operating Junction Temperature | $T_J$ | 200 | °C |

**Table 2. Thermal Characteristics**

| Characteristic | | Symbol | Value (1) | Unit |
|---|---|---|---|---|
| Thermal Resistance, Junction to Case | | $R_{\theta JC}$ | | °C/W |
| Final Application ($P_{out}$ = 70 W CW) | Stage 1, 28 Vdc, $I_{DQ}$ = 80 mA | | 5.2 | |
| | Stage 2, 28 Vdc, $I_{DQ}$ = 650 mA | | 0.8 | |
| EDGE Application ($P_{out}$ = 35 W CW) | Stage 1, 28 Vdc, $I_{DQ}$ = 80 mA | | 5.3 | |
| | Stage 2, 28 Vdc, $I_{DQ}$ = 650 mA | | 0.8 | |

**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) |

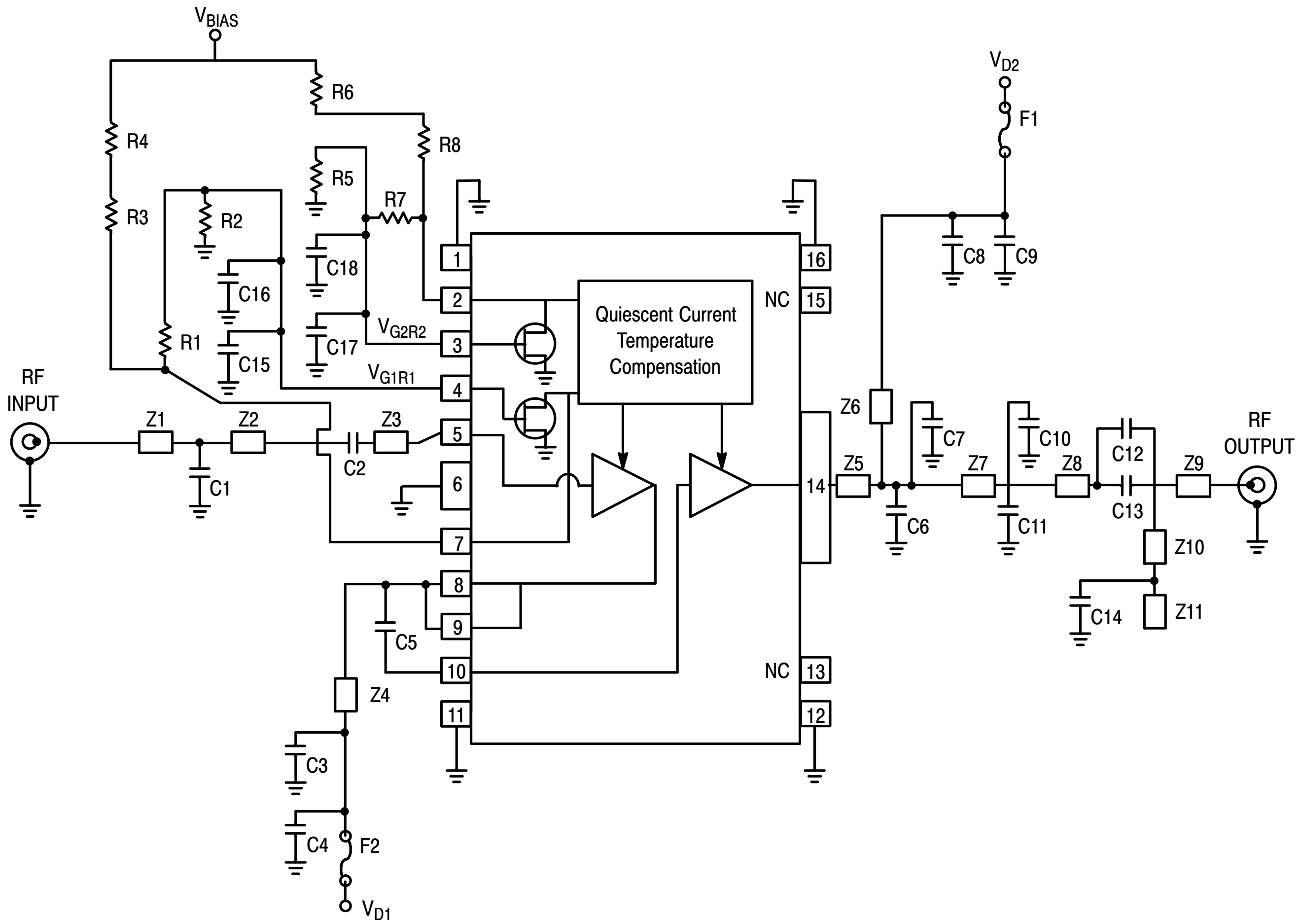
**Table 4. Moisture Sensitivity Level**

| 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 |
|---|---|---|---|---|---|
| **Functional Tests** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28.5 Vdc, $I_{DQ1}$ = 80 mA, $I_{DQ2}$ = 650 mA, $P_{out}$ = 70 W PEP, f1 = 870.0 MHz, f2 = 870.1 MHz | | | | | |
| Power Gain | $G_{ps}$ | 26.5 | 30 | 34.5 | dB |
| Drain Efficiency | $\eta_D$ | 40 | 48 | — | % |
| Input Return Loss | IRL | — | -12 | -10 | dB |
| Intermodulation Distortion | IMD | — | -33 | -28 | dBc |
| **Typical 800/900 MHz Performances** (In Freescale 800/900 MHz Reference Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ1}$ = 80 mA, $I_{DQ2}$ = 650 mA, 740-870 MHz, 870-960 MHz | | | | | |
| Gain Flatness in 30 MHz Bandwidth @ $P_{out}$ = 70 W CW | $G_F$ | — | 2 | — | dB |
| Gain Flatness in 30 MHz Instantaneous Bandwidth @ $P_{out}$ = 70 W CW | $G_F$ | — | 0.2 | — | dB |
| Delay @ $P_{out}$ = 70 W CW Including Output Matching | Delay | — | 4.5 | — | ns |
| Part-to-Part Phase Variation @ $P_{out}$ = 70 W CW | $\Delta\Phi$ | — | ±15 | — | ° |

1. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.




| | | | |
|---|---|---|---|
| Z1 | 0.485″ x 0.066″ Microstrip | Z7 | 0.040″ x 0.233″ Microstrip |
| Z2 | 0.270″ x 0.040″ Microstrip | Z8 | 0.450″ x 0.120″ Microstrip |
| Z3 | 0.068″ x 0.020″ Microstrip | Z9 | 0.100″ x 0.066″ Microstrip |
| Z4 | 0.950″ x 0.040″ Microstrip | Z10 | 1.000″ x 0.040″ Microstrip |
| Z5 | 0.131″ x 0.233″ Microstrip | Z11 | 0.148″ x 0.040″ Microstrip |
| Z6 | 0.797″ x 0.050″ Microstrip | PCB | Rogers 4350B, 0.030″, $\varepsilon_r$ = 3.5 |

**Figure 3. MW5IC970NBR1(GNBR1) Test Circuit Schematic**

**Table 6. MW5IC970NBR1(GNBR1) Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1, C10, C11 | 3.9 pF Chip Capacitor | ATC600S3R9BT250T | ATC |
| C2 | 56 pF Chip Capacitor | ATC600S560JT250T | ATC |
| C3, C8, C14, C15, C17 | 39 pF Chip Capacitors | GRM40001C0G390J050BD | Murata |
| C4, C9 | 10 μF Chip Capacitors | ECJ4YF1H106Z | Panasonic |
| C5 | 24 pF Chip Capacitor | ATC600F240JT250T | ATC |
| C6, C7 | 15 pF Chip Capacitors | ATC600F150JT250T | ATC |
| C12 | 4.7 pF Chip Capacitor | ATC600F4R7BT250T | ATC |
| C13 | 0.4 pF Chip Capacitor | ATC600F0R4BT250T | ATC |
| C16, C18, C19, C20 | 0.015 μF Chip Capacitors | GRM400X7R153J050BD | Murata |
| F1 | 5A Surface Mount Fuse | 1FT5A | Little Fuse |
| F2 | 1A Surface Mount Fuse | 1FT1A | Little Fuse |
| R1, R7 | 681 Ω, 1/8 W Chip Resistors | CRCW08056810FKEA | Vishay |
| R2, R5 | 4.75 kΩ, 1/8 W Chip Resistors | CRCW08054751FKEA | Vishay |
| R3, R4, R8 | 1.21 kΩ, 1/8 W Chip Resistors | CRCW08051211FKEA | Vishay |
| R6 | 267 Ω, 1/8 W Chip Resistor | CRCW08052670FKEA | Vishay |

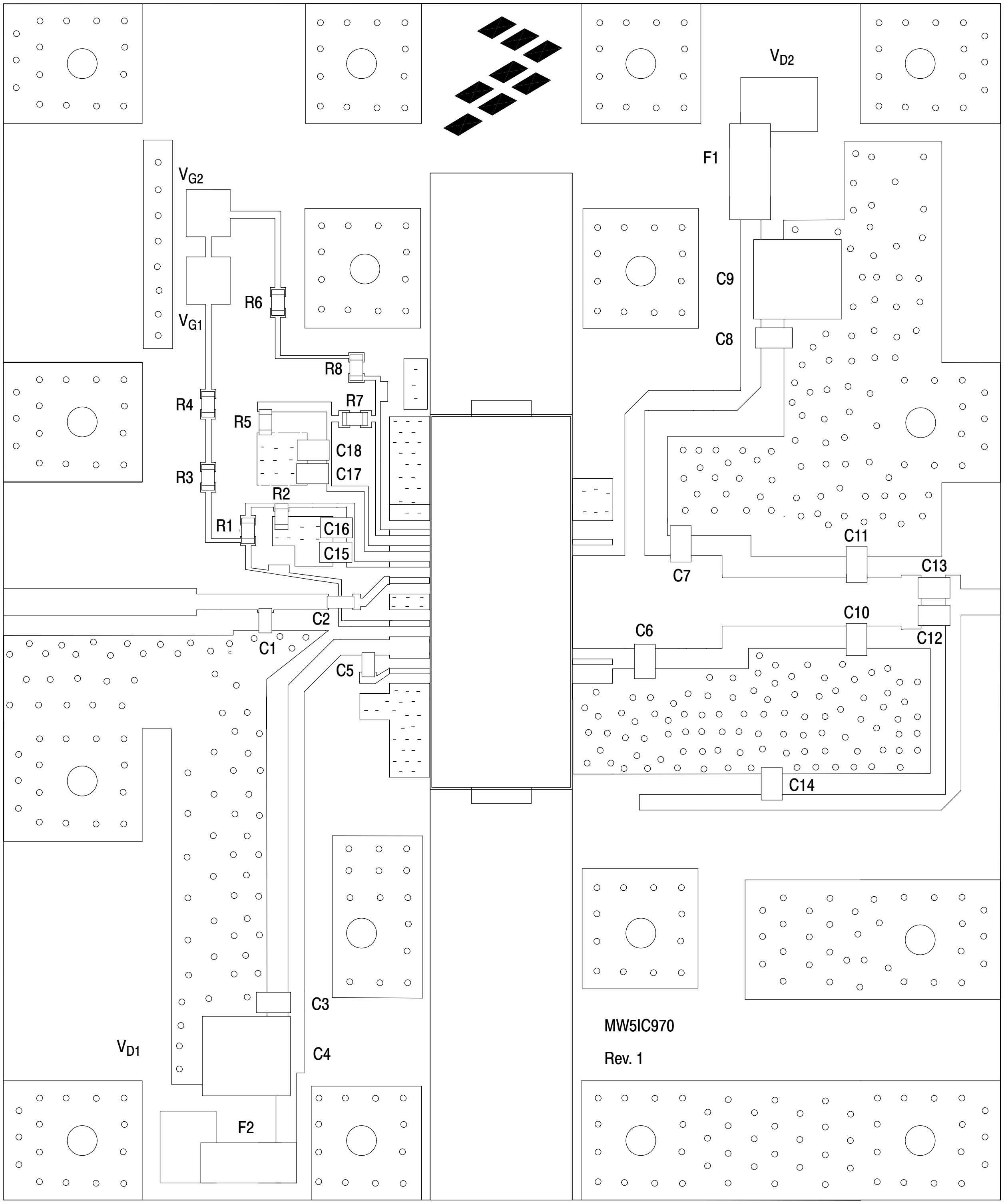



**Figure 4. MW5IC970NBR1(GNBR1) Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS

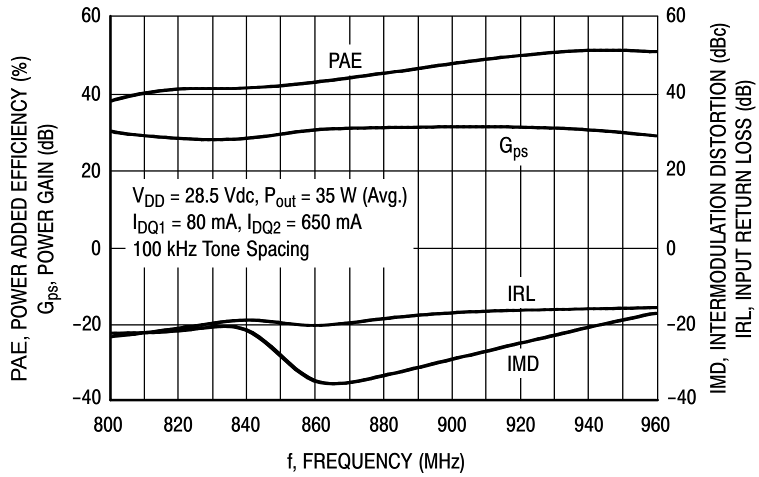



**Figure 5. Two-Tone Wideband Performance @ $P_{out}$ = 35 Watts (Avg.)**

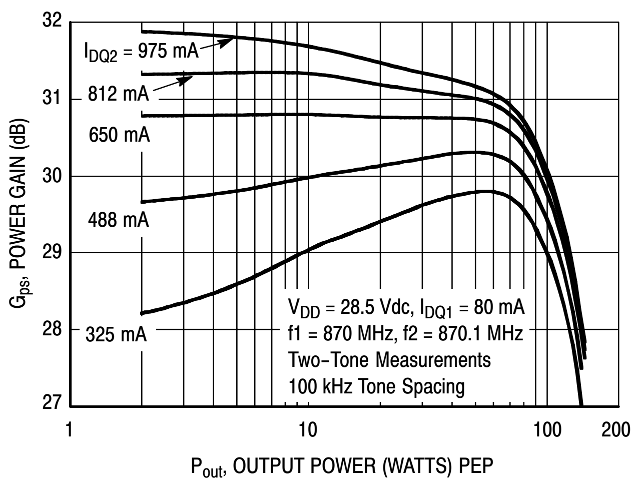



**Figure 6. Two-Tone Power Gain versus Output Power**

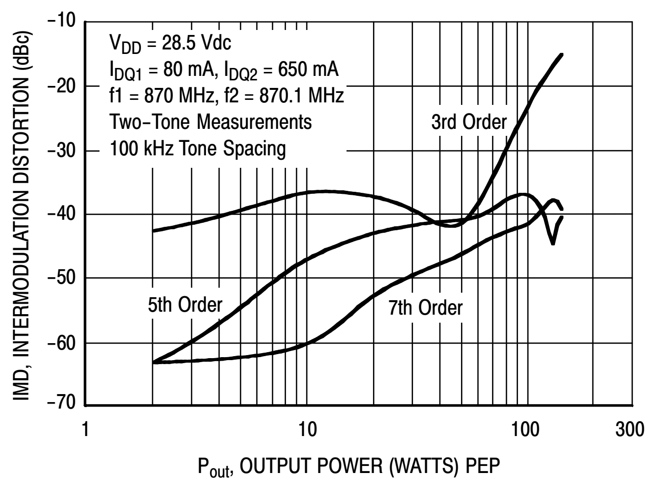



**Figure 7. Intermodulation Distortion Products versus Output Power**

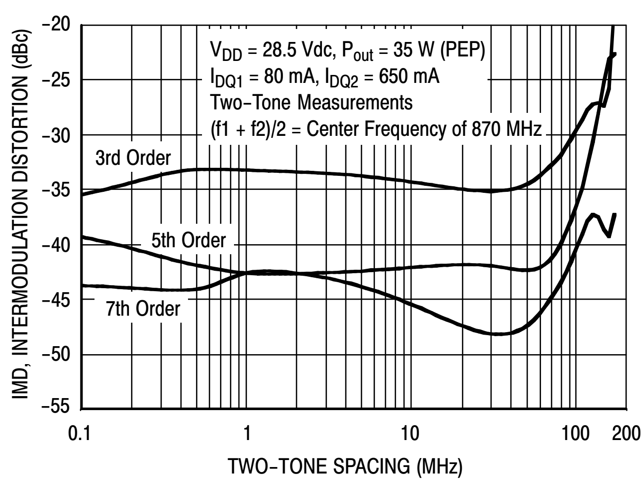



**Figure 8. Intermodulation Distortion Products versus Tone Spacing**

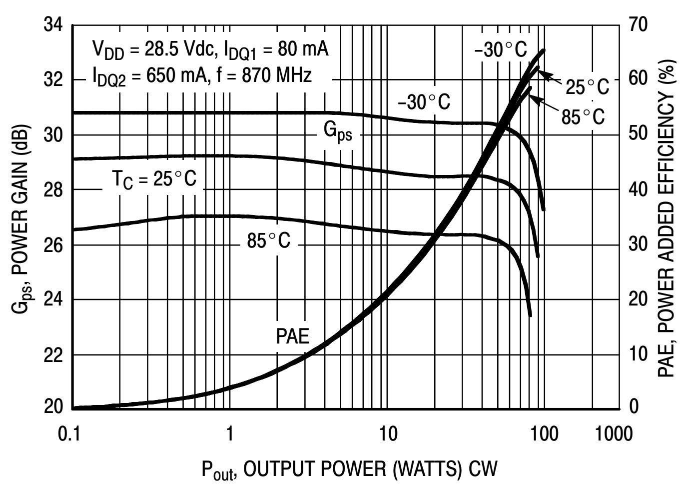



**Figure 9. Power Gain and Power Added Efficiency versus CW Output Power**

## TYPICAL CHARACTERISTICS

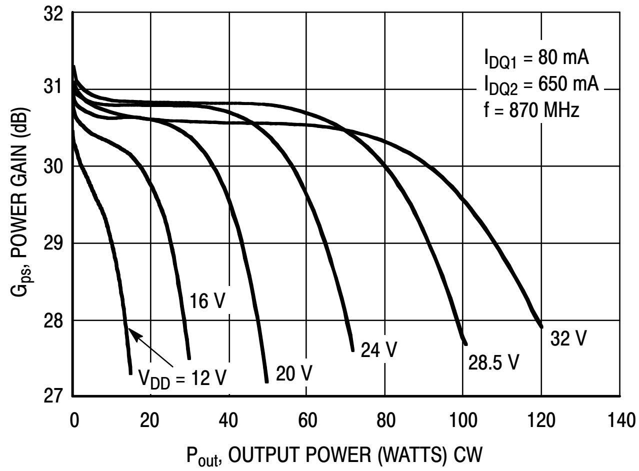
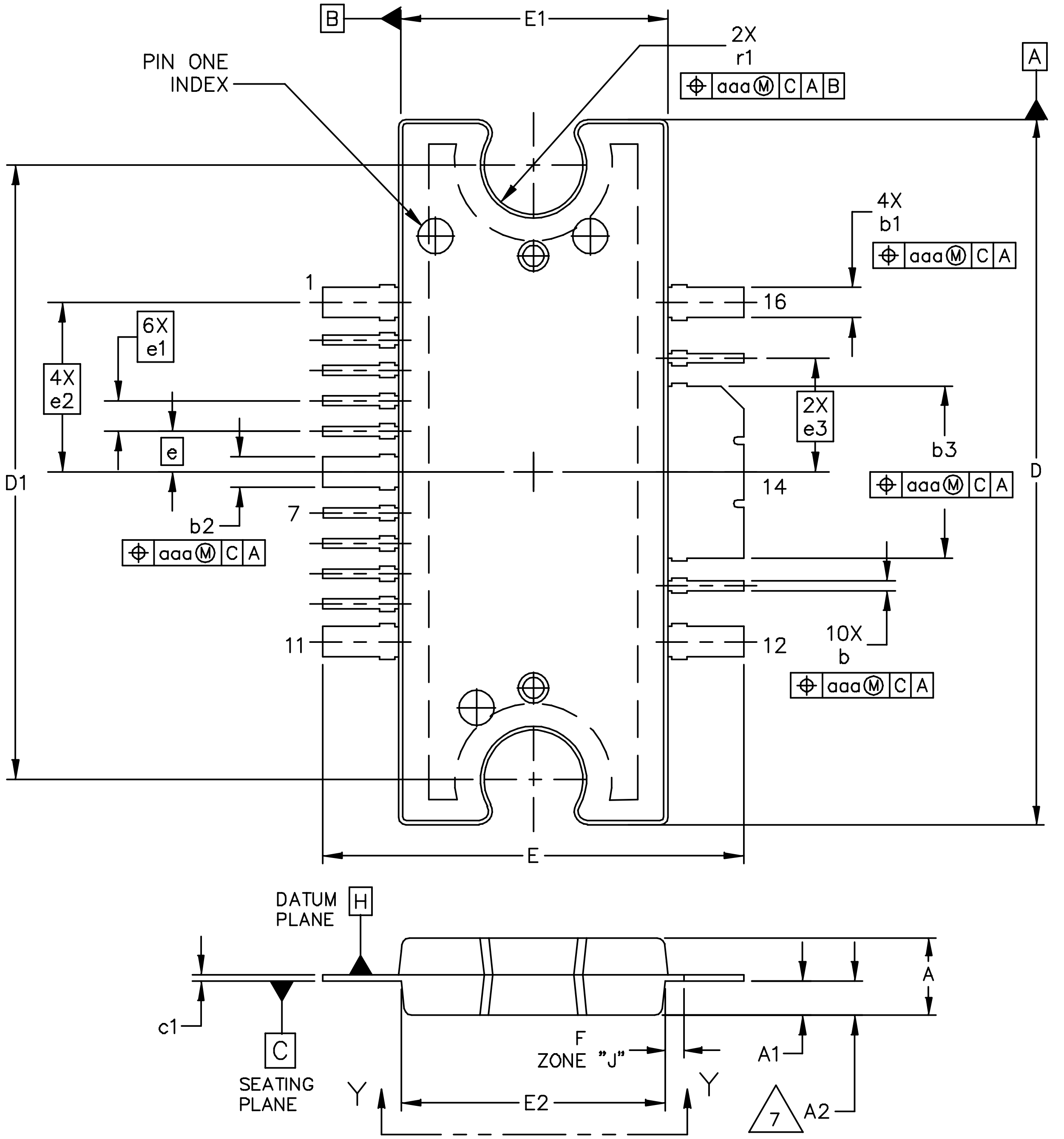



**Figure 10. Power Gain versus Output Power**

## PACKAGE DIMENSIONS

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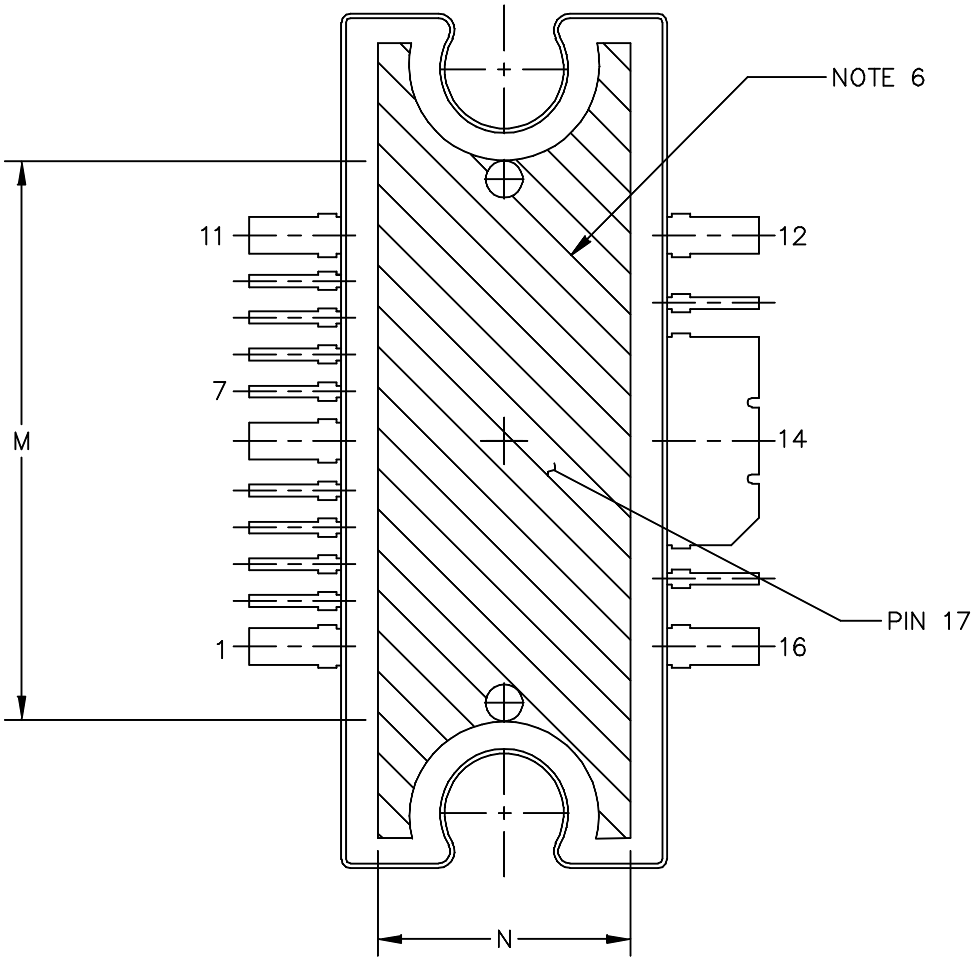
| | CASE NUMBER: 1329–09 | 23 AUG 2007 |
| | STANDARD: NON–JEDEC | |




VIEW Y–Y

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| | CASE NUMBER: 1329–09 | 23 AUG 2007 |
| | 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 (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 OFTHE HEAT SLUG. HATCHED AREA SHOWN IS ON THE SAME PLANE.
7. DIM A2 APPLIES WITHIN ZONE "J" ONLY.

| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER 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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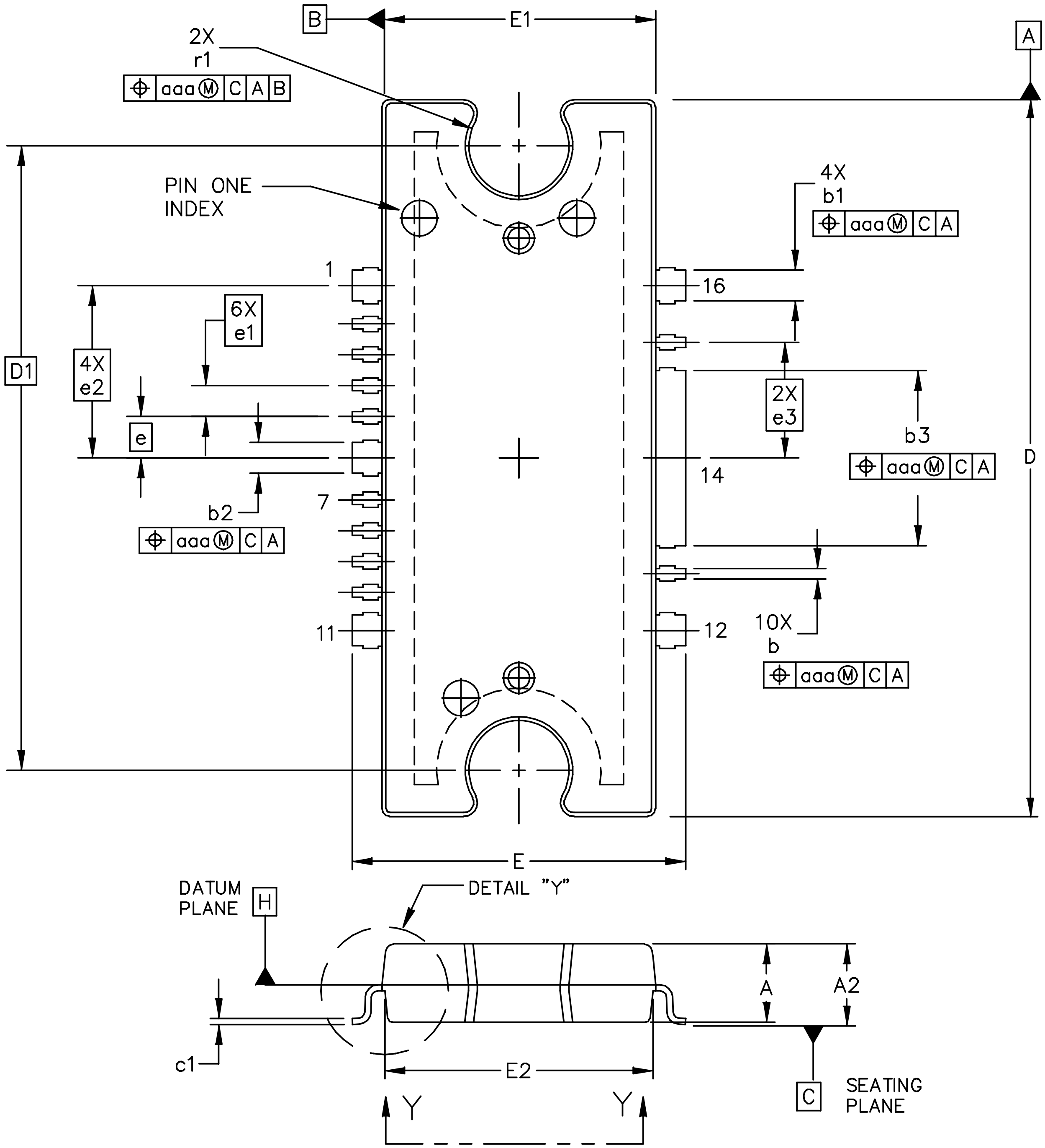


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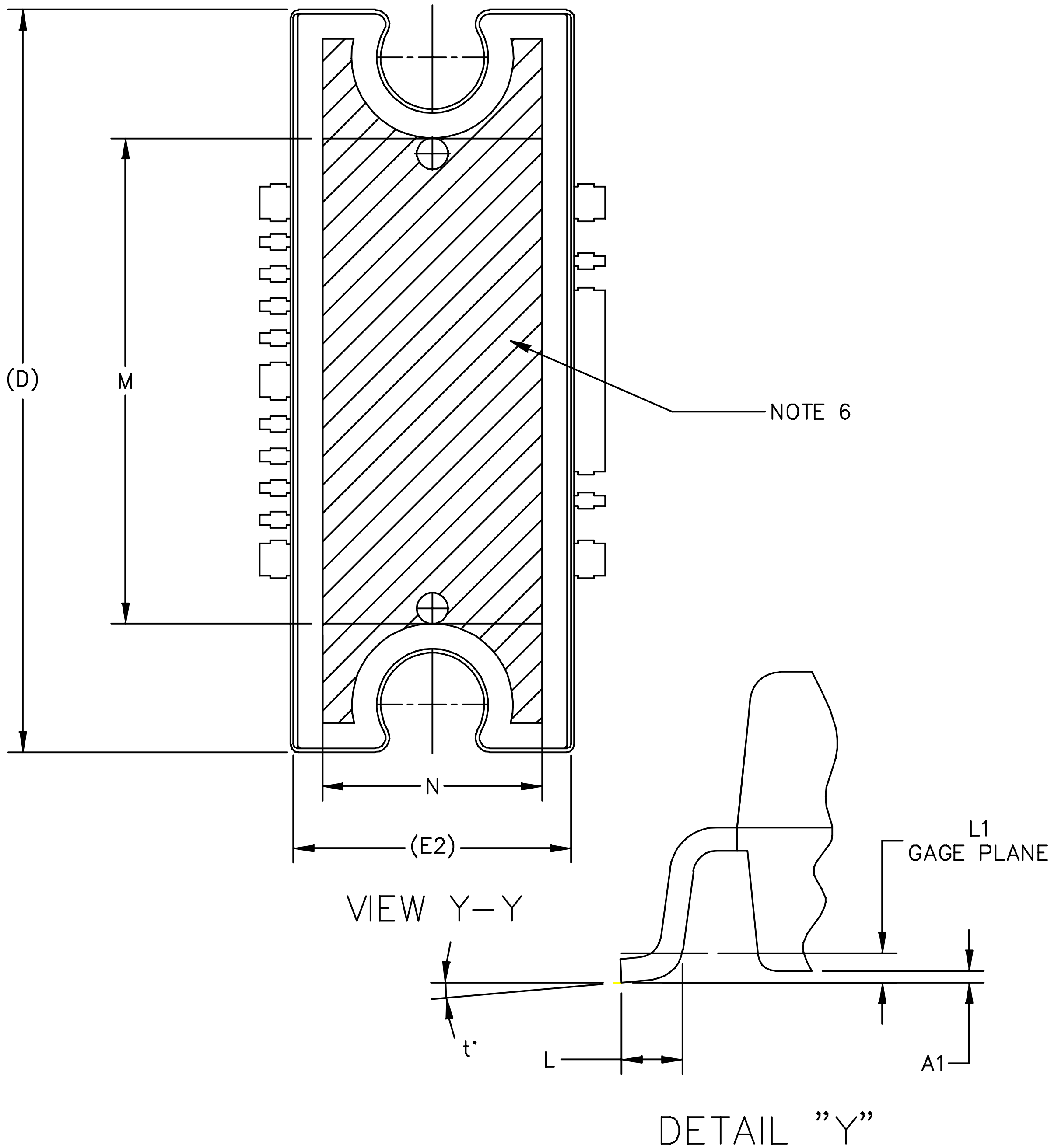
| | CASE NUMBER: 1329A–04 | 20 JUN 2007 |
| | STANDARD: JEDEC MO–253 BA | |

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NOTES:

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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 | 0.46 | 0.61 | e3 | .150 BSC | | 3.81 BSC | |
| L1 | .01 BSC | | 0.25 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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| | CASE NUMBER: 1329A–04 | 20 JUN 2007 |
| | STANDARD: JEDEC MO–253 BA | |

## 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
- AN1987: Quiescent Current Control for the RF Integrated Circuit Device Family
- 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 |
|---|---|---|
| 2 | Apr. 2008 | • Document Number changed from MW5IC970NBR1 to MW5IC970N with the addition of the MW5IC970GNBR1 part number. Revision history sequencing maintained from first release of data sheet, p. 1<br>• Added Case Operating Temperature limit to the Maximum Ratings table and set limit to 150°C, p. 2<br>• Updated Part Numbers in Table 6, Component Designations and Values, to RoHS compliant part numbers, p. 3<br>• Replaced Case Outline 1329-09, Issue L, with 1329-09, Issue M, p. 1, 7-9. Added pin numbers 1 through 17.<br>• Added Case Outline 1329A-04, Issue F, p. 1, 10-12<br>• Added Product Documentation and Revision History, p. 13 |

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