Replaced by MRF9060NR1/NBR1. There are no form, fit or function changes with this part replacement. N suffix added to part number to indicate transition to lead-free terminations.

# RF Power Field Effect Transistors

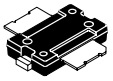
## N-Channel Enhancement-Mode Lateral MOSFETs

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 26 volt base station equipment.

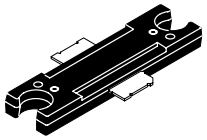
- Typical Performance at 945 MHz, 26 Volts
  Output Power — 60 Watts PEP
  Power Gain — 18.0 dB
  Efficiency — 40% (Two Tones)
  IMD — -31.5 dBc
- Integrated ESD Protection
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 945 MHz, 60 Watts CW Output Power
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- 200°C Capable Plastic Package
- TO-270-2 Available in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.
- TO-272-2 Available in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

**MRF9060MR1**
**MRF9060MBR1**

**945 MHz, 60 W, 26 V**
**LATERAL N-CHANNEL**
**BROADBAND**
**RF POWER MOSFETs**



**CASE 1265-08, STYLE 1**
**TO-270-2**
**PLASTIC**
**MRF9060MR1**



**CASE 1337-03, STYLE 1**
**TO-272-2**
**PLASTIC**
**MRF9060MBR1**



ARCHIVE INFORMATION

**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 |
| Total Device Dissipation @ $T_C$ = 25°C<br>Derate above 25°C | $P_D$ | 223<br>1.79 | W<br>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 | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 0.56 | °C/W |

NOTE - **CAUTION** - MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

**Table 3. ESD Protection Characteristics**

| Test Conditions | | Class |
|---|---|---|
| Human Body Model | | 1 (Minimum) |
| Machine Model | | M2 (Minimum) |
| Charge Device Model | MRF9060MR1<br>MRF9060MBR1 | C6 (Minimum)<br>C5 (Minimum) |

**Table 4. Moisture Sensitivity Level**

| Test Methodology | Rating | Package Peak Temperature | Unit |
|---|---|---|---|
| Per JESD 22-A113, IPC/JEDEC J-STD-020 | | | °C |
| MRF9060MR1 | 1 | 260 | |
| MRF9060MBR1 | 3 | 260 | |

**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 ($V_{DS}$ = 65 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 26 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 μAdc) | $V_{GS(th)}$ | 2 | 2.8 | 4 | Vdc |
| Gate Quiescent Voltage ($V_{DS}$ = 26 Vdc, $I_D$ = 450 mAdc) | $V_{GS(Q)}$ | 3 | 3.7 | 5 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 1.3 Adc) | $V_{DS(on)}$ | — | 0.21 | 0.4 | Vdc |
| Forward Transconductance ($V_{DS}$ = 10 Vdc, $I_D$ = 4 Adc) | $g_{fs}$ | — | 5.3 | — | S |
| **Dynamic Characteristics** | | | | | |
| Input Capacitance ($V_{DS}$ = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{iss}$ | — | 101 | — | pF |
| Output Capacitance ($V_{DS}$ = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{oss}$ | — | 53 | — | pF |
| Reverse Transfer Capacitance ($V_{DS}$ = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 2.5 | — | pF |

(continued)

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Functional Tests** (In Freescale Test Fixture, 50 ohm system) | | | | | |
| Two-Tone Common-Source Amplifier Power Gain ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz) | $G_{ps}$ | 17 | 18 | — | dB |
| Two-Tone Drain Efficiency ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz) | η | 37 | 40 | — | % |
| 3rd Order Intermodulation Distortion ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz) | IMD | — | -31.5 | -28 | dBc |
| Input Return Loss ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz) | IRL | — | -14.5 | -9 | dB |
| Two-Tone Common-Source Amplifier Power Gain ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHZ) | $G_{ps}$ | — | 18 | — | dB |
| Two-Tone Drain Efficiency ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHZ) | η | — | 40 | — | % |
| 3rd Order Intermodulation Distortion ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHZ) | IMD | — | -31 | — | dBc |
| Input Return Loss ($V_{DD}$ = 26 Vdc, $P_{out}$ = 60 W PEP, $I_{DQ}$ = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHZ) | IRL | — | -12.5 | — | dB |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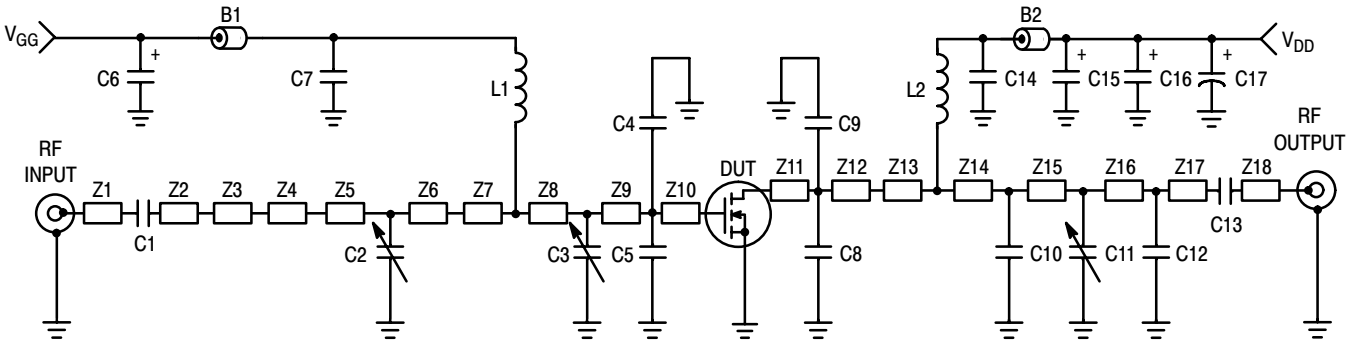


| | | | |
|---|---|---|---|
| Z1 | 0.240″ x 0.060″ Microstrip | Z10 | 0.060″ x 0.520″ Microstrip |
| Z2 | 0.240″ x 0.060″ Microstrip | Z11 | 0.360″ x 0.270″ Microstrip |
| Z3 | 0.500″ x 0.100″ Microstrip | Z12 | 0.060″ x 0.270″ Microstrip |
| Z4 | 0.100″ x 0.270″ x 0.080″, Taper | Z13 | 0.130″ x 0.060″ Microstrip |
| Z5 | 0.330″ x 0.270″ Microstrip | Z14 | 0.300″ x 0.060″ Microstrip |
| Z6 | 0.120″ x 0.270″ Microstrip | Z15 | 0.210″ x 0.060″ Microstrip |
| Z7 | 0.270″ x 0.520″ x 0.140″, Taper | Z16 | 0.600″ x 0.060″ Microstrip |
| Z8 | 0.240″ x 0.520″ Microstrip | Z17 | 0.290″ x 0.060″ Microstrip |
| Z9 | 0.340″ x 0.520″ Microstrip | Z18 | 0.340″ x 0.060″ Microstrip |

**Figure 1. 930-960 MHz Broadband Test Circuit Schematic**

**Table 6. 930-960 MHz Broadband Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| B1 | Short Ferrite Bead | 95F786 | Newark |
| B2 | Long Ferrite Bead | 95F787 | Newark |
| C1, C7, C13, C14 | 47 pF Chip Capacitors | 100B470JP 500X | ATC |
| C2, C3, C11 | 0.8-8.0 Gigatrim Variable Capacitors | 44F3360 | Newark |
| C4, C5 | 11 pF Chip Capacitors (MRF9060MR1)<br>10 pF Chip Capacitors (MRF9060MBR1) | 100B110JP 500X<br>100B100JP 500X | ATC |
| C6, C15, C16 | 10 μF, 35 V Tantalum Chip Capacitors | 93F2975 | Newark |
| C8, C9 | 10 pF Chip Capacitors | 100B100JP 500X | Newark |
| C10 | 3.9 pF Chip Capacitor | 100B3R9CP 500X | ATC |
| C12 | 1.7 pF Chip Capacitor | 100B1R7BP 500X | ATC |
| C17 | 220 μF Electrolytic Chip Capacitor | 14F185 | Newark |
| L1, L2 | 12.5 nH Inductors | A04T-5 | Coilcraft |
| N1, N2 | N-Type Panel Mount, Stripline | 3052-1648-10 | Avnet |
| WB1, WB2 | 15 mil Brass Wear Blocks | | |
| Board Material | 30 mil Glass Teflon®, $\varepsilon_r$ = 2.55 Copper Clad, 2 oz Cu | RF-35-0300 | Taconic |
| PCB | Etched Circuit Board | TO-270/TO-272 Surface/Bolt | DSelectronics |


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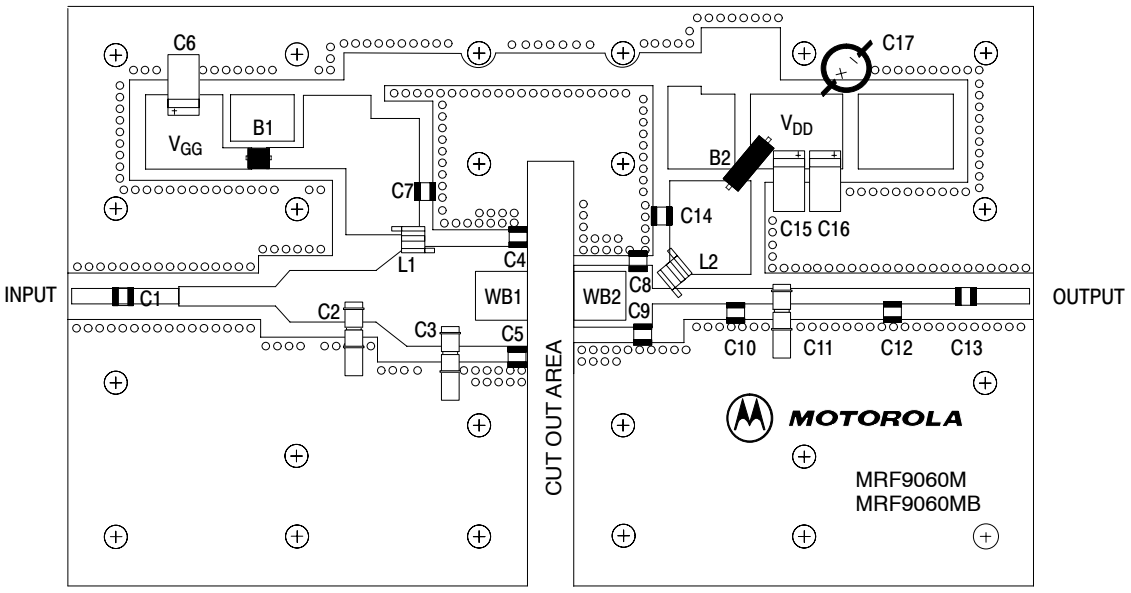



Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. 930-960 MHz Broadband Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS

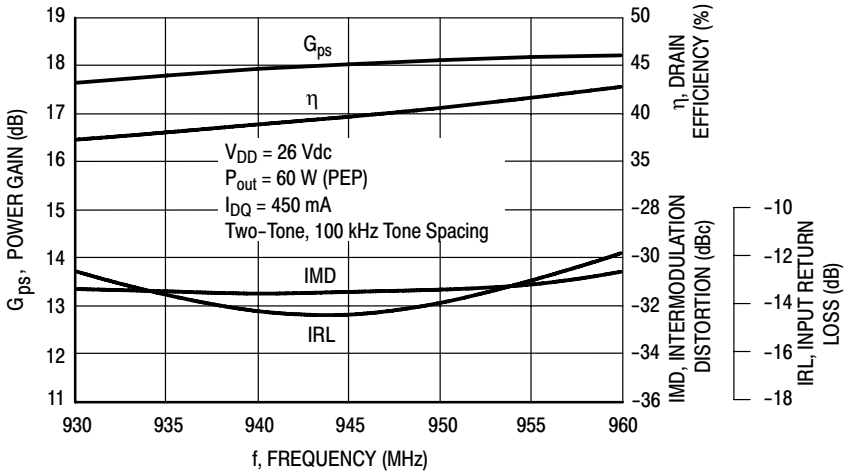



**Figure 3. Class AB Broadband Circuit Performance**

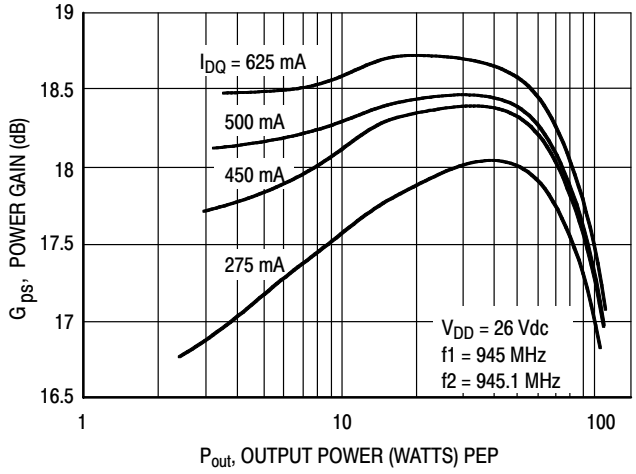



**Figure 4. Power Gain versus Output Power**

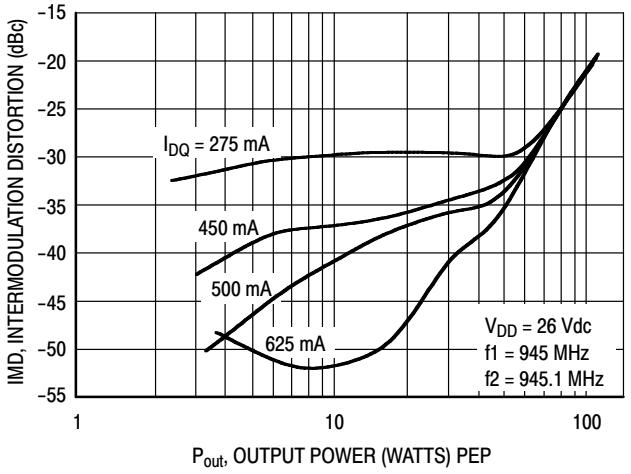



**Figure 5. Intermodulation Distortion versus Output Power**

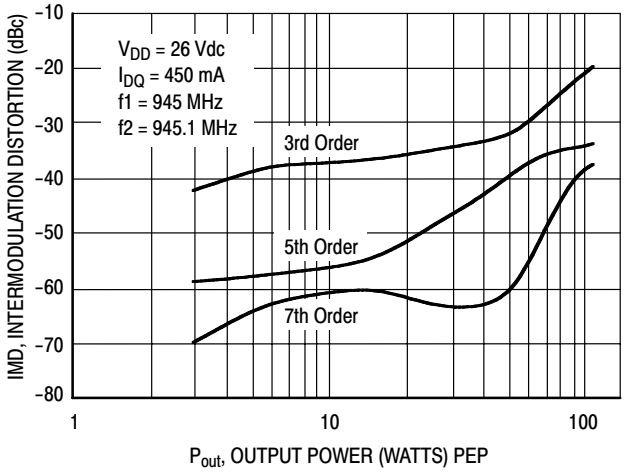



**Figure 6. Intermodulation Distortion Products versus Output Power**

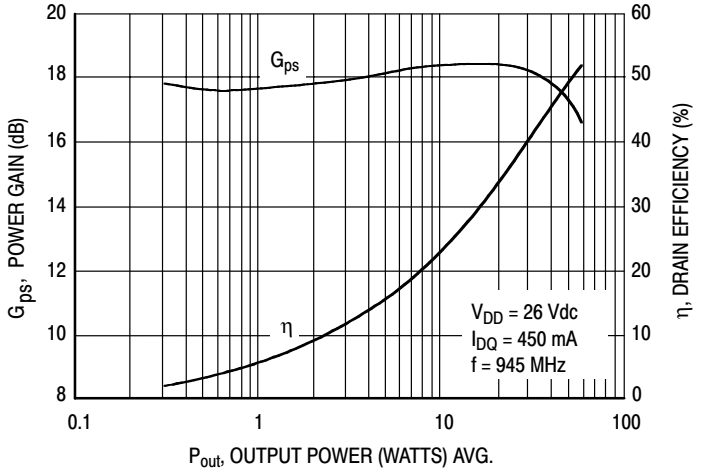



**Figure 7. Power Gain and Efficiency versus Output Power**


ARCHIVE INFORMATION

## TYPICAL CHARACTERISTICS

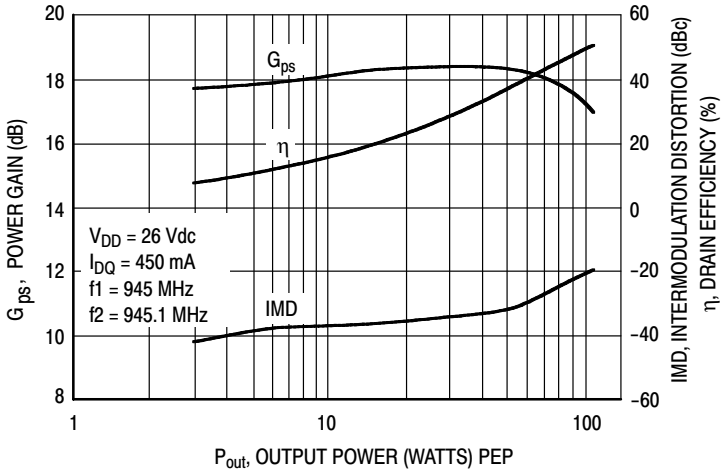
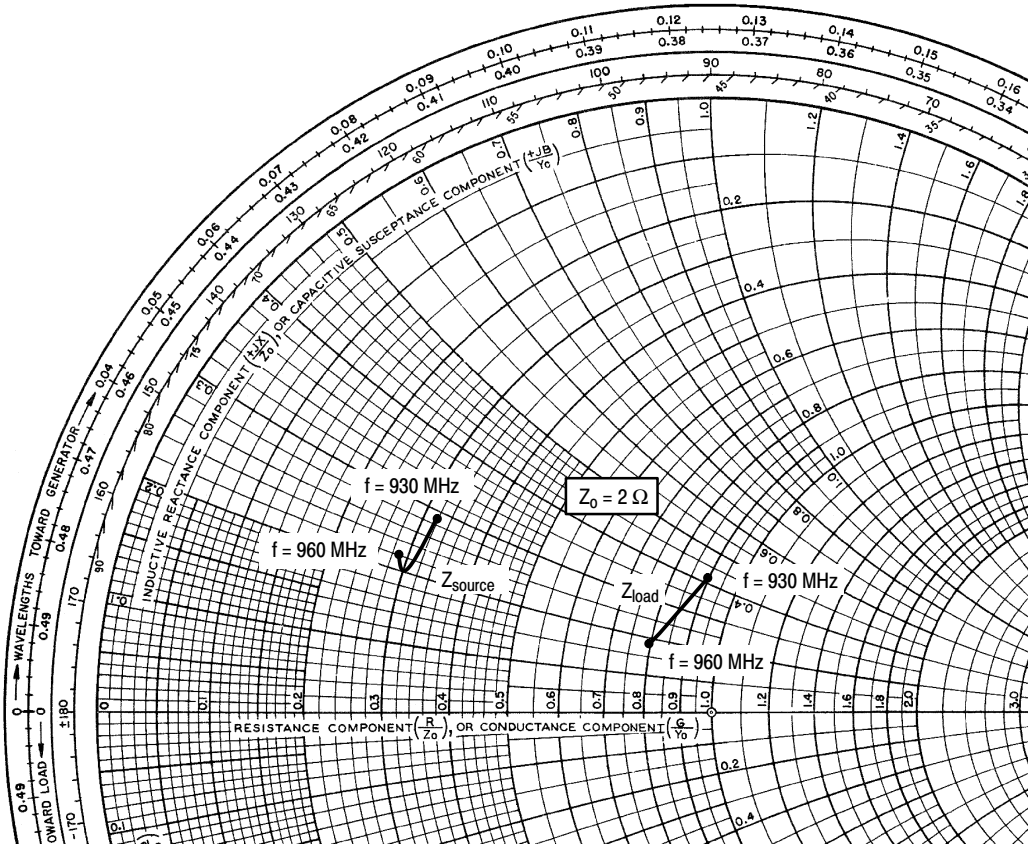



**Figure 8. Power Gain, Efficiency, and IMD versus Output Power**

ARCHIVE INFORMATION




$V_{DD}$ = 26 V, $I_{DQ}$ = 450 mA, $P_{out}$ = 60 W PEP

| f MHz | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|
| 930 | 0.63 + j0.57 | 1.8 + j0.84 |
| 945 | 0.60 + j0.41 | 1.7 + j0.55 |
| 960 | 0.57 + j0.45 | 1.6 + j0.36 |

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

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

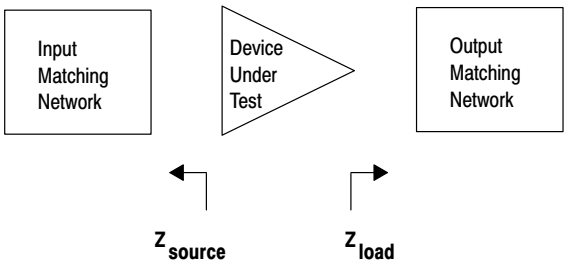


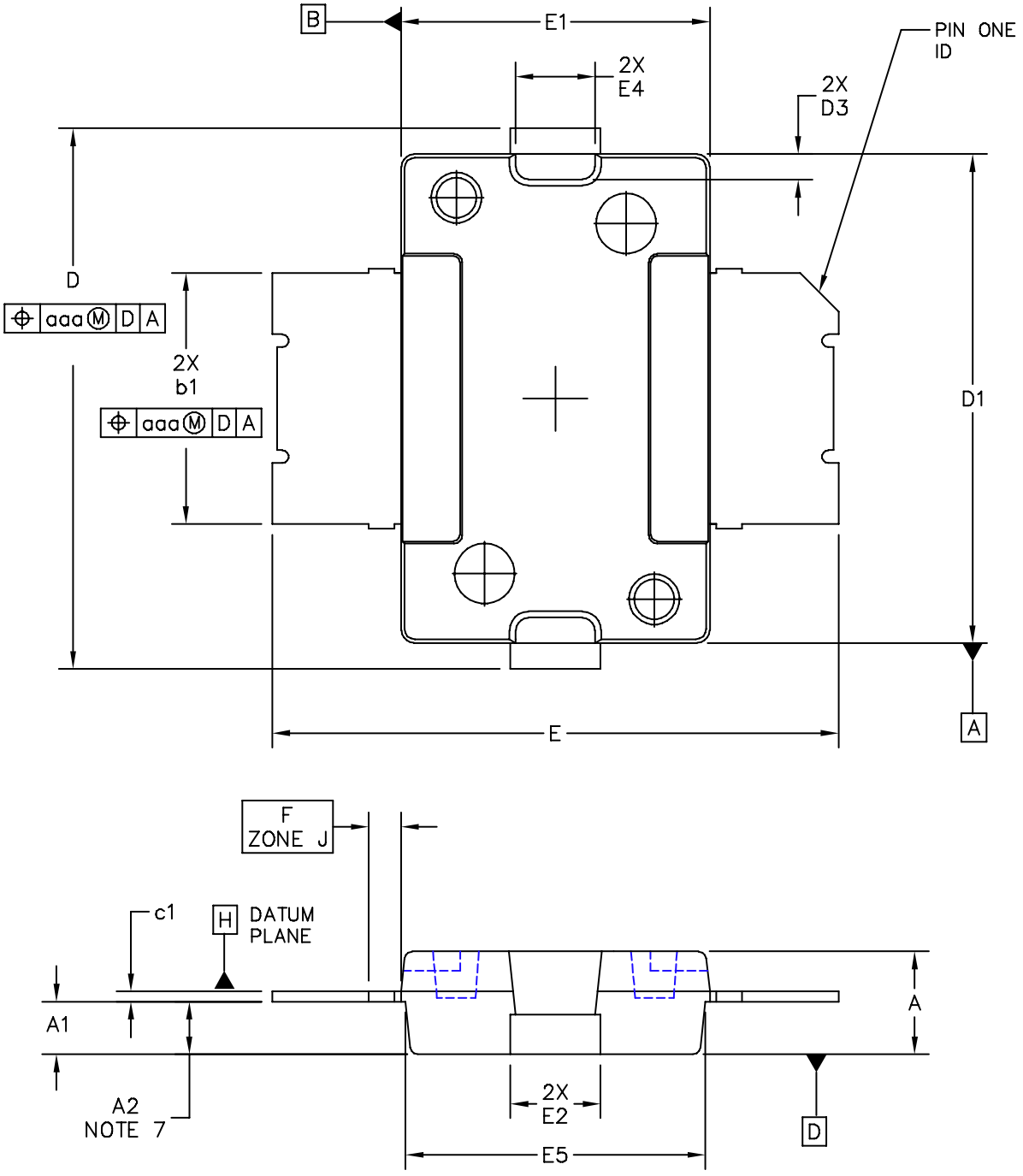

**Figure 9. Series Equivalent Source and Load Impedance**

# NOTES

# NOTES

# NOTES

## PACKAGE DIMENSIONS

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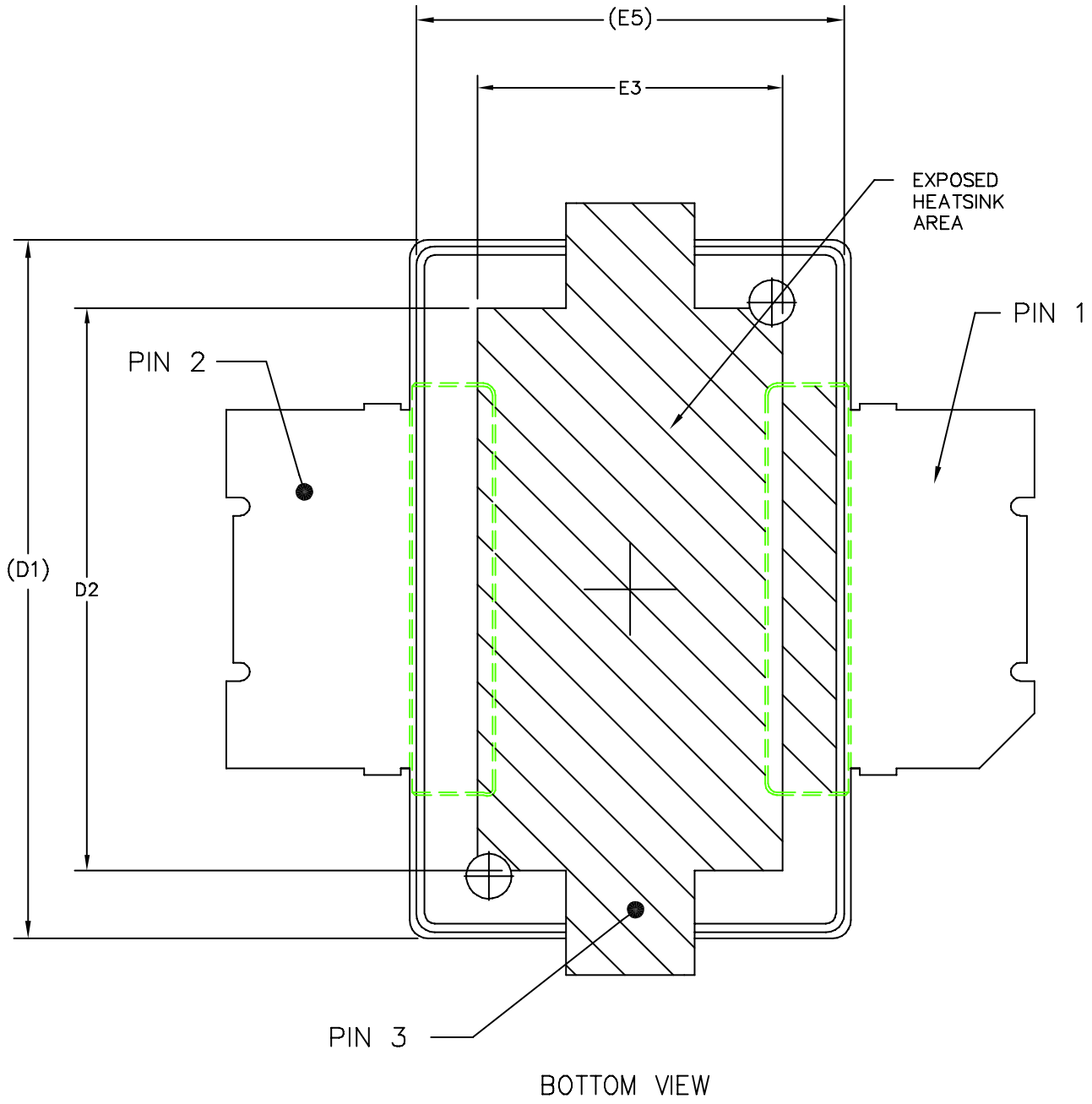
| | CASE NUMBER: 1265-08 | 01 APR 2005 |
| | STANDARD: NON-JEDEC | |

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| 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

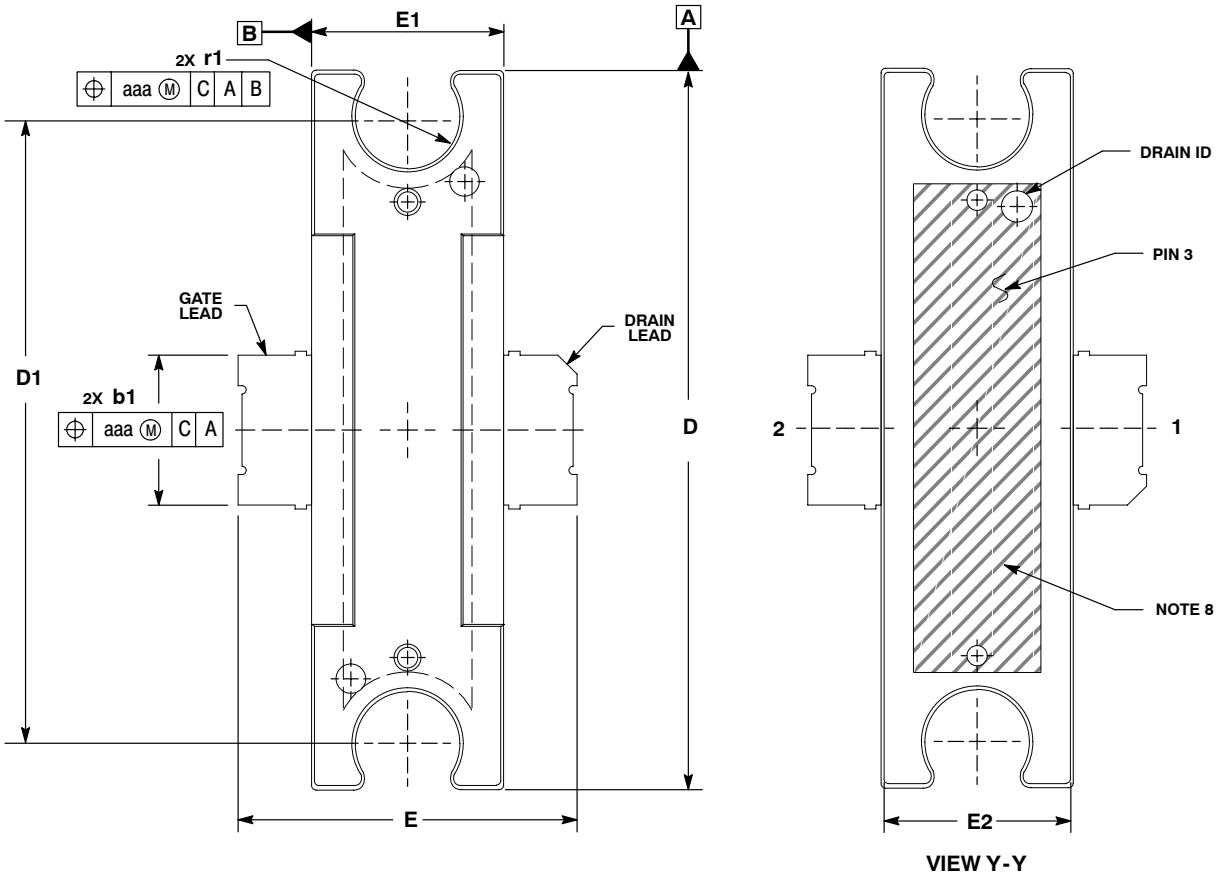
| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | .078 | .082 | 1.98 | 2.08 | F | .025 BSC | | 0.64 BSC | |
| A1 | .039 | .043 | 0.99 | 1.09 | b1 | .193 | .199 | 4.90 | 5.06 |
| 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 | | | | | |



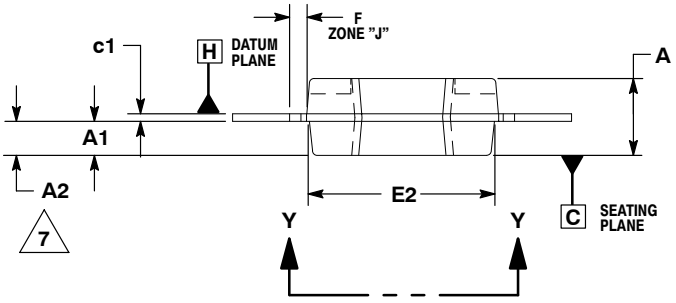
**MECHANICAL OUTLINE** | PRINT VERSION NOT TO SCALE

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

## PACKAGE DIMENSIONS




VIEW Y-Y




NOTES:
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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.
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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**
**MRF9060MBR1**

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