

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

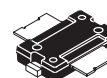
Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 26 volt base station equipment.

- Typical Performance at 945 MHz, 26 Volts
  - Output Power — 30 Watts PEP
  - Power Gain — 20 dB
  - Efficiency — 41% (Two Tones)
  - IMD — -31 dBc
- Integrated ESD Protection
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 945 MHz, 30 Watts CW Output Power
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Dual-Lead Boltdown Plastic Package Can Also Be Used As Surface Mount.
- N Suffix Indicates Lead-Free Terminations
- 200°C Capable Plastic Package
- TO-272-2 in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.
- TO-270-2 in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.

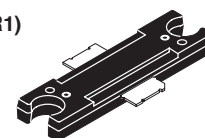
**MRF9030NR1**  
**MRF9030NBR1**  
**MRF9030MR1**  
**MRF9030MBR1**

**945 MHz, 30 W, 26 V**  
**LATERAL N-CHANNEL**  
**BROADBAND**  
**RF POWER MOSFETs**

**CASE 1265-08, STYLE 1**  
**TO-270-2**  
**PLASTIC**  
**MRF9030NR1(MR1)**



**CASE 1337-03, STYLE 1**  
**TO-272-2**  
**PLASTIC**  
**MRF9030NBR1(MBR1)**



**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 @ $T_C = 25^\circ\text{C}$<br>Derate above 25°C | $P_D$     | 139<br>0.93 | 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 | $R_{\theta JC}$ | 1.08  | °C/W |

**Table 3. ESD Protection Characteristics**

| Test Conditions                                             | Class                        |
|-------------------------------------------------------------|------------------------------|
| Human Body Model                                            | 1 (Minimum)                  |
| Machine Model                                               | M2 (Minimum)                 |
| Charge Device Model<br>MRF9030NR1(MR1)<br>MRF9030NBR1(MBR1) | C7 (Minimum)<br>C6 (Minimum) |

**Table 4. Moisture Sensitivity Level**

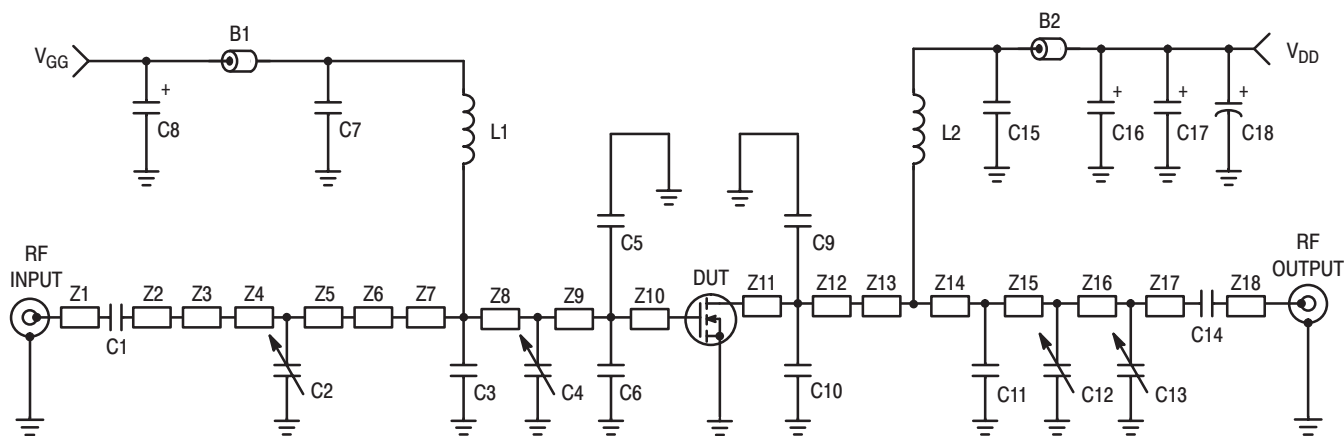
| Test Methodology                      | Rating | Package Peak Temperature | Unit |
|---------------------------------------|--------|--------------------------|------|
| Per JESD 22-A113, IPC/JEDEC J-STD-020 | 3      | 260                      | °C   |

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

**Table 5. Electrical Characteristics** ( $T_c = 25^\circ\text{C}$  Unless Otherwise Noted)

| Characteristic                                                                                                                                                                                                                                           | Symbol       | Min | Typ  | Max | Unit            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----|------|-----|-----------------|
| <b>Off Characteristics</b>                                                                                                                                                                                                                               |              |     |      |     |                 |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )                                                                                                                                                        | $I_{DSS}$    | —   | —    | 10  | $\mu\text{Adc}$ |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 26\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )                                                                                                                                                        | $I_{DSS}$    | —   | —    | 1   | $\mu\text{Adc}$ |
| Gate–Source Leakage Current<br>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )                                                                                                                                                                     | $I_{GSS}$    | —   | —    | 1   | $\mu\text{Adc}$ |
| <b>On Characteristics</b>                                                                                                                                                                                                                                |              |     |      |     |                 |
| Gate Threshold Voltage<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 100\text{ }\mu\text{Adc}$ )                                                                                                                                                                | $V_{GS(th)}$ | 2   | 2.9  | 4   | Vdc             |
| Gate Quiescent Voltage<br>( $V_{DS} = 26\text{ Vdc}$ , $I_D = 250\text{ mAdc}$ )                                                                                                                                                                         | $V_{GS(Q)}$  | 3   | 3.8  | 5   | Vdc             |
| Drain–Source On–Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 0.7\text{ Adc}$ )                                                                                                                                                                         | $V_{DS(on)}$ | —   | 0.23 | 0.4 | Vdc             |
| Forward Transconductance<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 2\text{ Adc}$ )                                                                                                                                                                          | $g_{fs}$     | —   | 2.7  | —   | S               |
| <b>Dynamic Characteristics</b>                                                                                                                                                                                                                           |              |     |      |     |                 |
| Input Capacitance<br>( $V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )                                                                                                                                               | $C_{iss}$    | —   | 49   | —   | pF              |
| Output Capacitance<br>( $V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )                                                                                                                                              | $C_{oss}$    | —   | 27   | —   | pF              |
| Reverse Transfer Capacitance<br>( $V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )                                                                                                                                    | $C_{rss}$    | —   | 1.2  | —   | pF              |
| <b>Functional Tests</b> (In Freescale Test Fixture)                                                                                                                                                                                                      |              |     |      |     |                 |
| Two–Tone Common–Source Amplifier Power Gain<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 945.0\text{ MHz}$ , $f_2 = 945.1\text{ MHz}$ )                                                            | $G_{ps}$     | 18  | 20   | —   | dB              |
| Two–Tone Drain Efficiency<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 945.0\text{ MHz}$ , $f_2 = 945.1\text{ MHz}$ )                                                                              | $\eta$       | 37  | 41   | —   | %               |
| 3rd Order Intermodulation Distortion<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 945.0\text{ MHz}$ , $f_2 = 945.1\text{ MHz}$ )                                                                   | IMD          | —   | –31  | –28 | dBc             |
| Input Return Loss<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 945.0\text{ MHz}$ , $f_2 = 945.1\text{ MHz}$ )                                                                                      | IRL          | —   | –13  | –9  | dB              |
| Two–Tone Common–Source Amplifier Power Gain<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 930.0\text{ MHz}$ , $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$ ,<br>$f_2 = 960.1\text{ MHz}$ ) | $G_{ps}$     | —   | 20   | —   | dB              |
| Two–Tone Drain Efficiency<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 930.0\text{ MHz}$ , $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$ ,<br>$f_2 = 960.1\text{ MHz}$ )                   | $\eta$       | —   | 40.5 | —   | %               |
| 3rd Order Intermodulation Distortion<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 930.0\text{ MHz}$ , $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$ ,<br>$f_2 = 960.1\text{ MHz}$ )        | IMD          | —   | –31  | —   | dBc             |
| Input Return Loss<br>( $V_{DD} = 26\text{ Vdc}$ , $P_{out} = 30\text{ W PEP}$ , $I_{DQ} = 250\text{ mA}$ ,<br>$f_1 = 930.0\text{ MHz}$ , $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$ ,<br>$f_2 = 960.1\text{ MHz}$ )                           | IRL          | —   | –12  | —   | dB              |

**MRF9030NR1 MRF9030NBR1 MRF9030MR1 MRF9030MBR1**



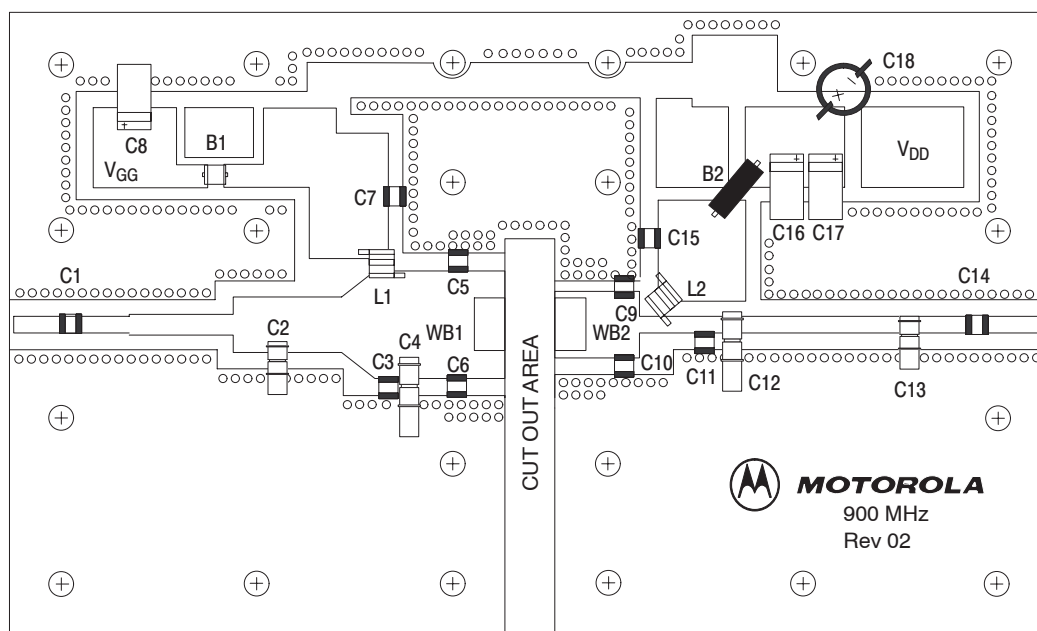
|     |                                               |       |                                        |
|-----|-----------------------------------------------|-------|----------------------------------------|
| Z1  | 0.260" x 0.060" Microstrip                    | Z11   | 0.360" x 0.270" Microstrip             |
| Z2  | 0.240" x 0.060" Microstrip                    | Z12   | 0.050" x 0.270" Microstrip             |
| Z3  | 0.500" x 0.100" Microstrip                    | Z13   | 0.110" x 0.060" Microstrip             |
| Z4  | 0.200" x 0.270" Microstrip                    | Z14   | 0.220" x 0.060" Microstrip             |
| Z5  | 0.330" x 0.270" Microstrip                    | Z15   | 0.100" x 0.060" Microstrip             |
| Z6  | 0.140" x 0.270" x 0.520", Taper               | Z16   | 0.870" x 0.060" Microstrip             |
| Z7  | 0.040" x 0.520" Microstrip                    | Z17   | 0.240" x 0.060" Microstrip             |
| Z8  | 0.090" x 0.520" Microstrip                    | Z18   | 0.340" x 0.060" Microstrip             |
| Z9  | 0.370" x 0.520" Microstrip (MRF9030NR1/MR1)   | Board | Taconic RF-35-0300, $\epsilon_r = 3.5$ |
|     | 0.290" x 0.520" Microstrip (MRF9030NBR1/MBR1) |       |                                        |
| Z10 | 0.130" x 0.520" Microstrip (MRF9030NR1/MR1)   |       |                                        |
|     | 0.210" x 0.520" Microstrip (MRF9030NBR1/MBR1) |       |                                        |

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

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

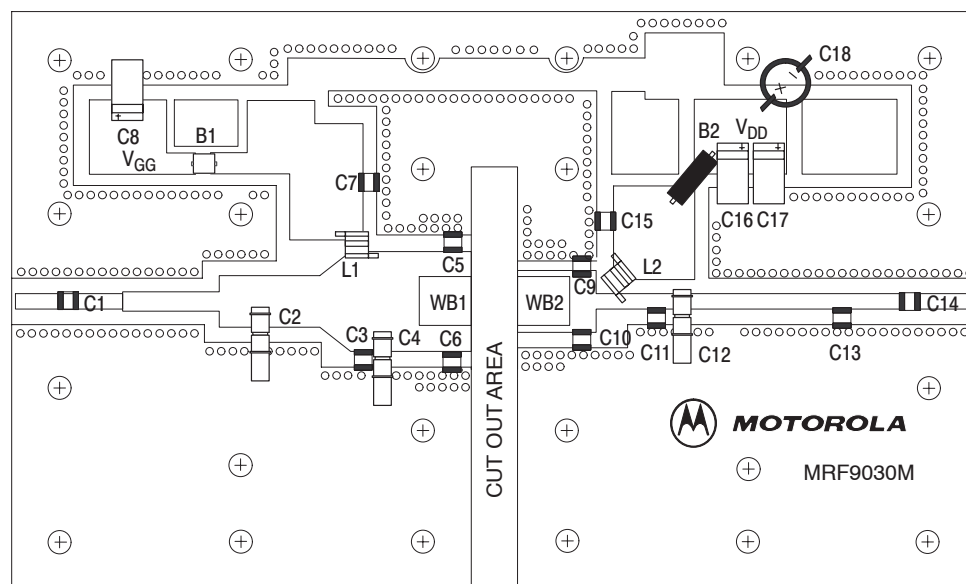
| Part             | Description                                                                                       | Part Number                    | Manufacturer  |
|------------------|---------------------------------------------------------------------------------------------------|--------------------------------|---------------|
| B1               | Short Ferrite Bead, Surface Mount                                                                 | 95F786                         | Newark        |
| B2               | Long Ferrite Bead, Surface Mount                                                                  | 95F787                         | Newark        |
| C1, C7, C14, C15 | 47 pF Chip Capacitors                                                                             | 100B470JP 500X                 | ATC           |
| C2               | 0.6–4.5 Variable Capacitor, Gigatrim                                                              | 44F3360                        | Newark        |
| C3, C11          | 3.9 pF Chip Capacitors                                                                            | 100B3R6BP 500X                 | ATC           |
| C4, C12          | 0.8–8.0 Variable Capacitors, Gigatrim                                                             | 44F3360                        | Newark        |
| C5, C6           | 6.8 pF Chip Capacitors                                                                            | 100B7R5JP 500X                 | ATC           |
| C8, C16, C17     | 10 $\mu$ F, 35 V Tantalum Chip Capacitors                                                         | 93F2975                        | Newark        |
| C9, C10          | 10 pF Chip Capacitors                                                                             | 100B100JP 500X                 | ATC           |
| C13              | 1.8 pF Chip Capacitor (MRF9030NR1/MR1)<br>0.6–4.5 Variable Capacitor, Gigatrim (MRF9030NBR1/MBR1) | 100B1R8BP<br>44F3360           | ATC<br>Newark |
| C18              | 220 $\mu$ F Electrolytic Chip Capacitor                                                           | 14F185                         | Newark        |
| L1, L2           | 12.5 nH Coilcraft Inductors                                                                       | A04T-5                         | Coilcraft     |
| WB1, WB2         | 20 mil Brass Shim (0.250 x 0.250)                                                                 | RF-Design Lab                  | RF-Design Lab |
| PCB              | Etched Circuit Board                                                                              | 900 MHz $\mu$ 250/Viper Rev 02 | DSelectronics |

**MRF9030NR1 MRF9030NBR1 MRF9030MR1 MRF9030MBR1**



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 2. 930–960 MHz Broadband Test Circuit Component Layout (MRF9030NR1/MR1)**



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 3. 930–960 MHz Broadband Test Circuit Component Layout (MRF9030NBR1/MBR1)**

## TYPICAL CHARACTERISTICS

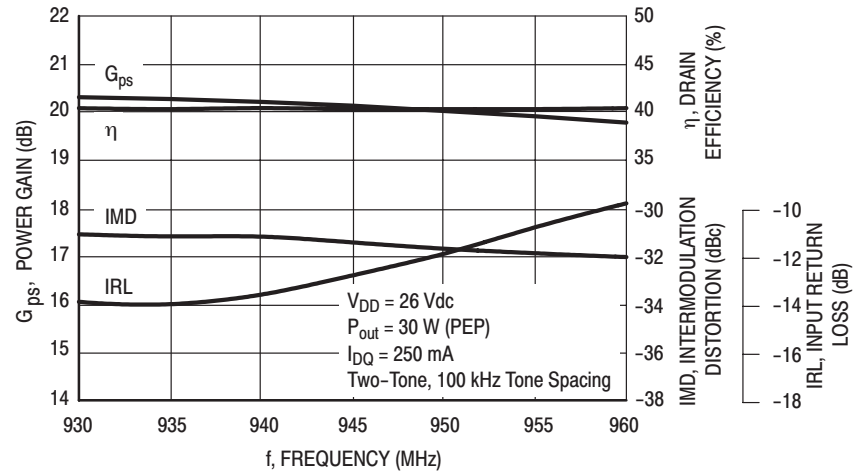


Figure 4. Class AB Broadband Circuit Performance

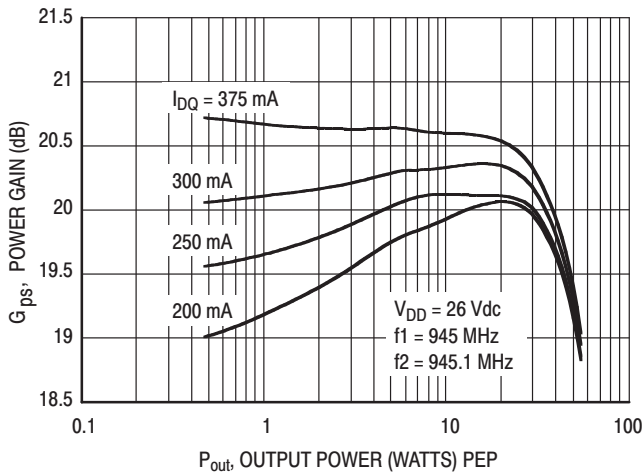


Figure 5. Power Gain versus Output Power

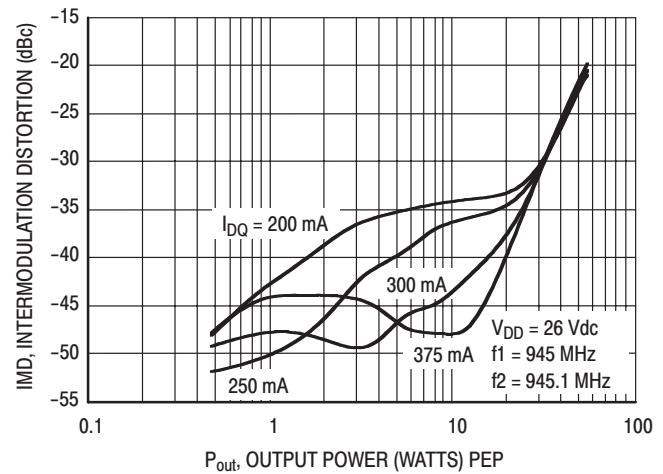


Figure 6. Intermodulation Distortion versus Output Power

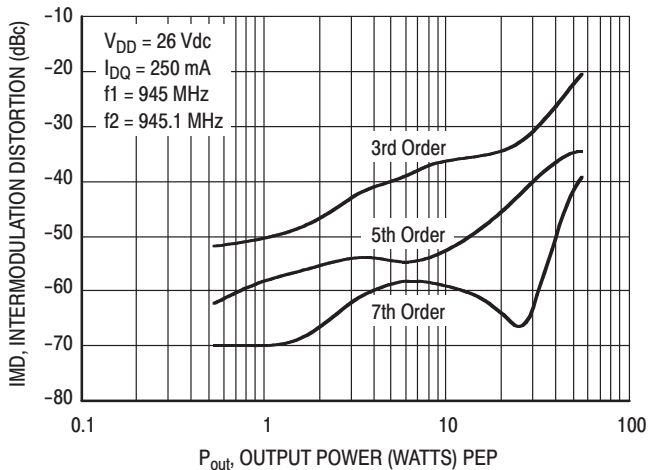


Figure 7. Intermodulation Distortion Products versus Output Power

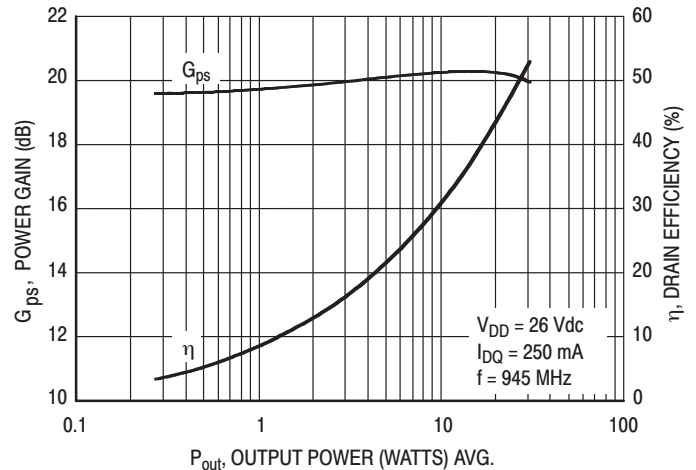
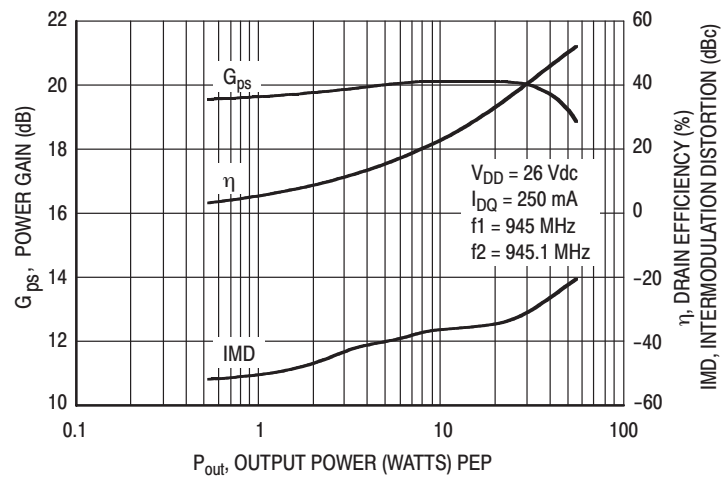
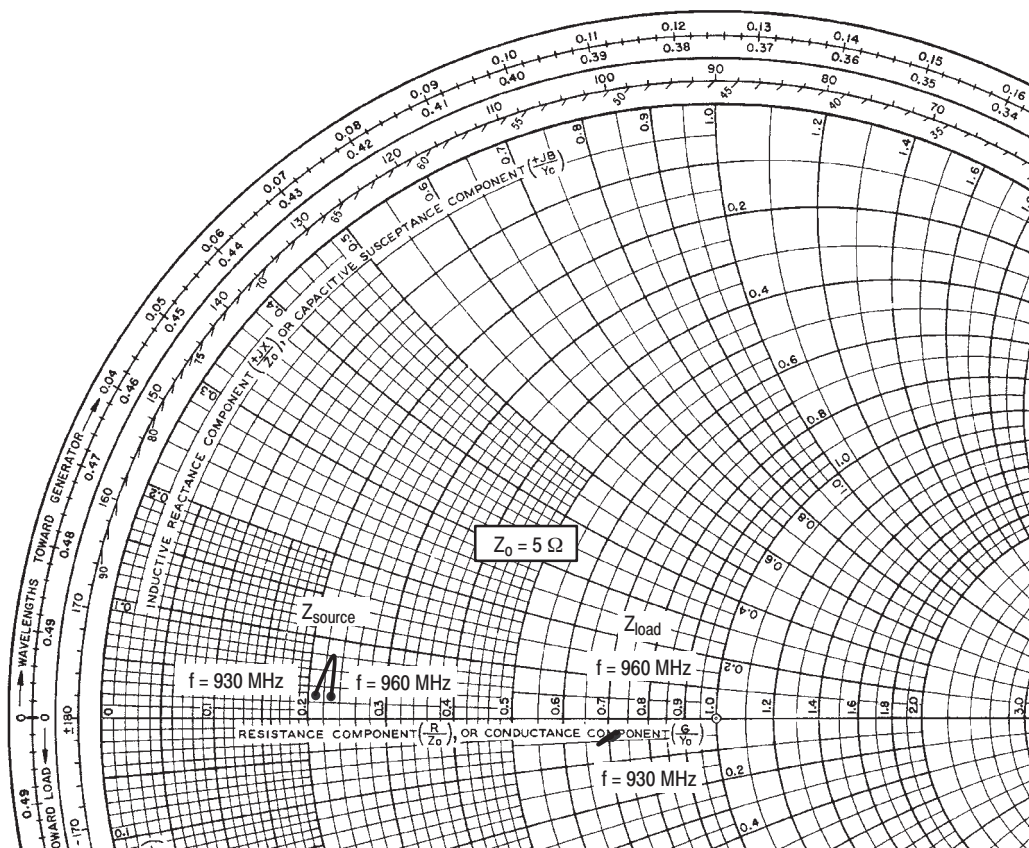


Figure 8. Power Gain and Efficiency versus Output Power

MR9030NR1 MR9030NBR1 MR9030MR1 MR9030MBR1



**Figure 9. Power Gain, Efficiency and IMD versus Output Power**



$V_{DD} = 26\text{ V}$ ,  $I_{DQ} = 250\text{ mA}$ ,  $P_{out} = 30\text{ Watts (PEP)}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 930      | $1.07 + j0.160$          | $3.53 - j0.20$         |
| 945      | $1.14 + j0.385$          | $3.41 - j0.24$         |
| 960      | $1.17 + j0.170$          | $3.60 - j0.17$         |

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

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

Note:  $Z_{load}$  was chosen based on tradeoffs between gain, output power, drain efficiency and intermodulation distortion.

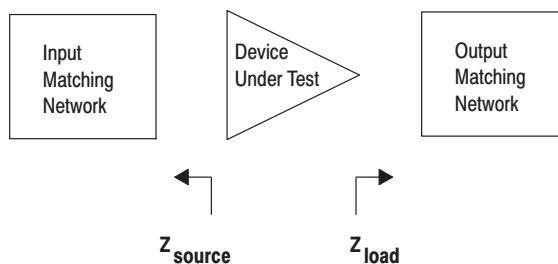
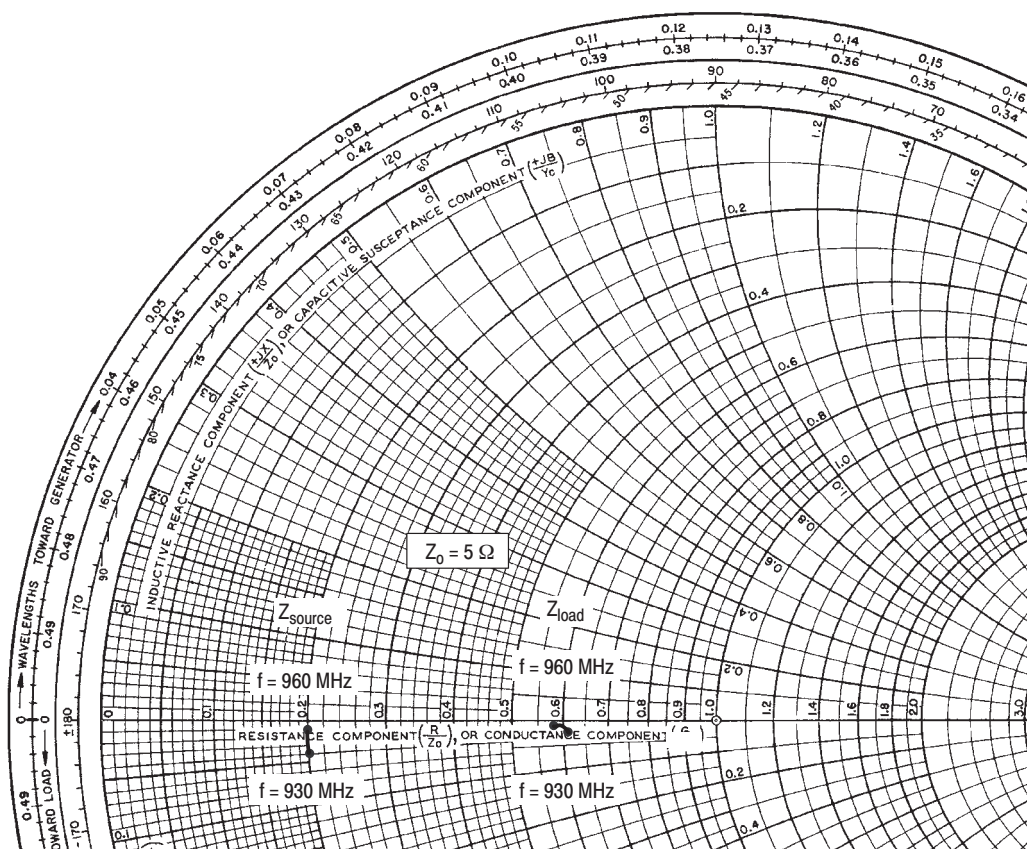


Figure 10. Series Equivalent Source and Load Impedance (MRF9030NR1/MR1)

MRF9030NR1 MRF9030NBR1 MRF9030MR1 MRF9030MBR1



$V_{DD} = 26\text{ V}$ ,  $I_{DQ} = 250\text{ mA}$ ,  $P_{out} = 30\text{ Watts (PEP)}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 930      | $1.0 - j0.18$            | $3.05 - j0.09$         |
| 945      | $1.0 - j0.10$            | $3.00 - j0.07$         |
| 960      | $1.0 - j0.03$            | $2.95 - j0.03$         |

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

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

Note:  $Z_{load}$  was chosen based on tradeoffs between gain, output power, drain efficiency and intermodulation distortion.

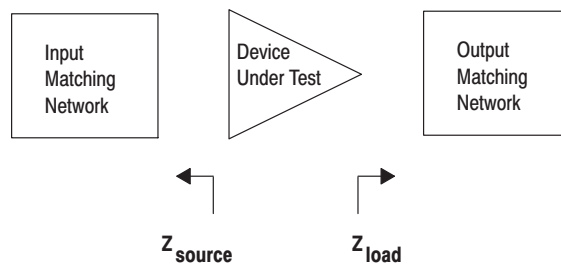
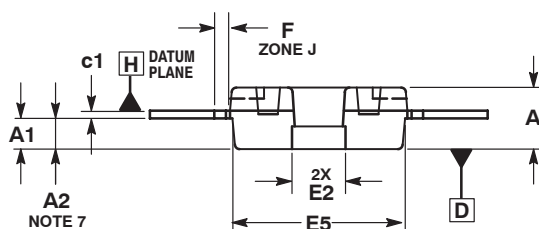
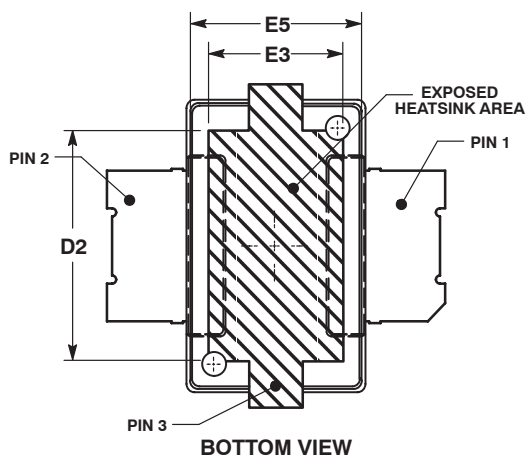
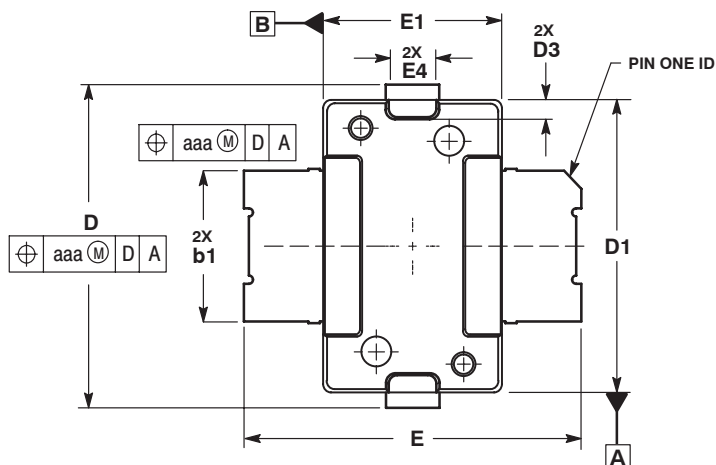


Figure 11. Series Equivalent Source and Load Impedance (MRF9030NBR1/MBR1)

## NOTES

## PACKAGE DIMENSIONS



### NOTES:

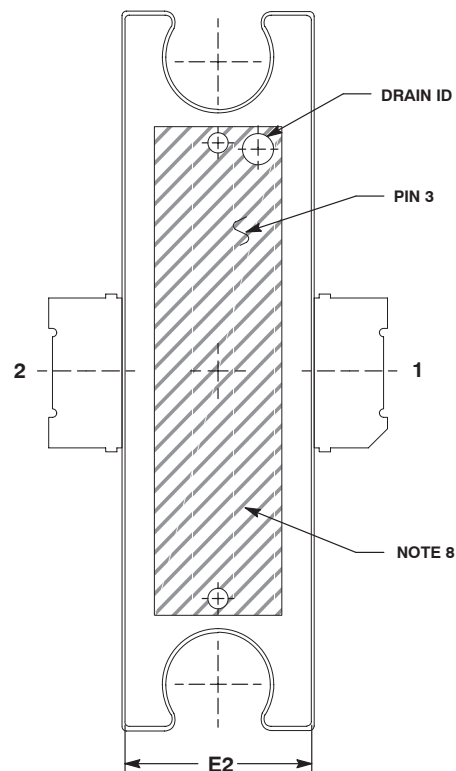
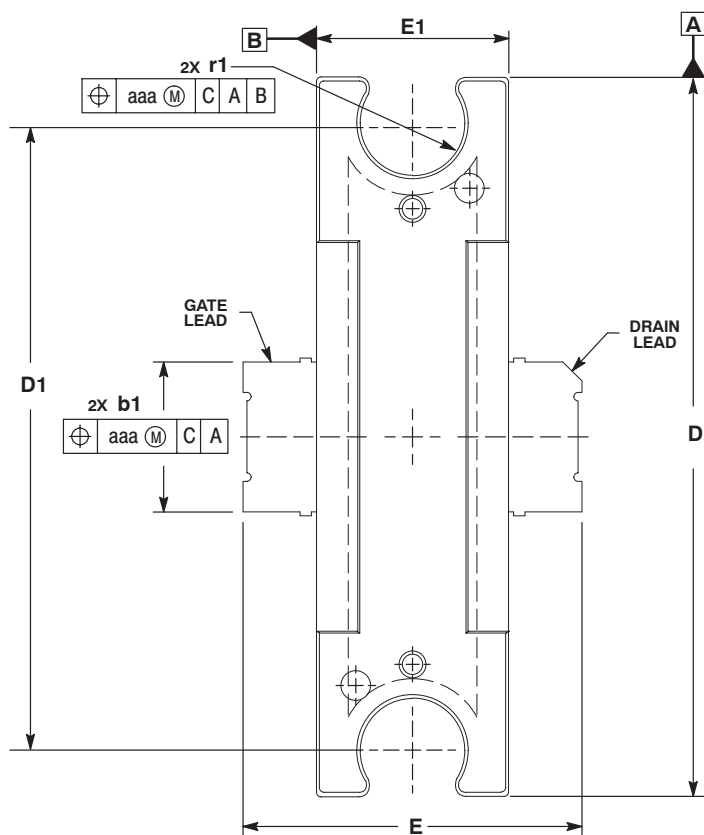
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DATUM PLANE -H- IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D1" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE 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. ALLOWABLE PROTRUSION IS .003 PER SIDE. DIMENSIONS "D" AND "E2" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -D-.

| DIM | INCHES   |      | MILLIMETERS |       |
|-----|----------|------|-------------|-------|
|     | MIN      | MAX  | MIN         | MAX   |
| A   | .078     | .082 | 1.98        | 2.08  |
| A1  | .039     | .043 | 0.99        | 1.09  |
| A2  | .040     | .042 | 1.02        | 1.07  |
| D   | .416     | .424 | 10.57       | 10.77 |
| 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  |
| F   | .025 BSC |      | 0.64 BSC    |       |
| b1  | .193     | .199 | 4.90        | 5.06  |
| c1  | .007     | .011 | 0.18        | 0.28  |
| aaa | .004     |      | 0.10        |       |

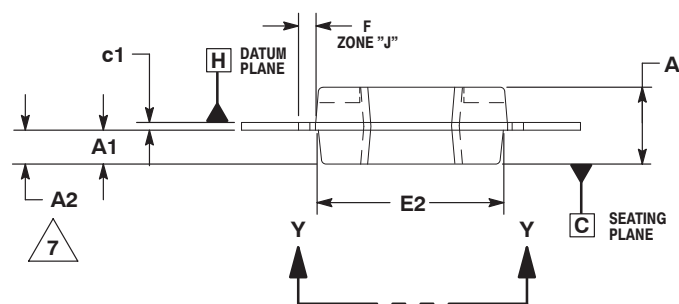
### STYLE 1:

1. DRAIN
2. GATE
3. SOURCE

CASE 1265-08  
ISSUE G  
TO-270-2  
PLASTIC  
MRF9030NR1(MR1)



VIEW Y-Y



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 PER SIDE. DIMENSIONS "D" 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. CROSSHATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

| DIM | INCHES   |      | MILLIMETERS |       |
|-----|----------|------|-------------|-------|
|     | 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 B  
TO-272-2  
PLASTIC  
MRF9030NBR1(MBR1)**

MRF9030NR1 MRF9030NBR1 MRF9030MR1 MRF9030MBR1

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