

## The RF Sub-Micron Bipolar Line RF Power Bipolar Transistors

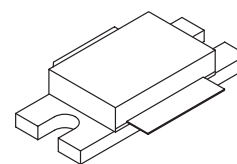
The MRF20060R and MRF20060RS are designed for class AB broadband commercial and industrial applications at frequencies from 1800 to 2000 MHz. The high gain, excellent linearity and broadband performance of these devices make them ideal for large-signal, common emitter class AB amplifier applications. These devices are suitable for frequency modulated, amplitude modulated and multi-carrier base station RF power amplifiers.

- Guaranteed Two-tone Performance at 2000 MHz, 26 Volts  
Output Power — 60 Watts (PEP)  
Power Gain — 9 dB  
Efficiency — 33%  
Intermodulation Distortion — -30 dBc
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- S-Parameter Characterization at High Bias Levels
- Excellent Thermal Stability
- Capable of Handling 3:1 VSWR @ 26 Vdc, 2000 MHz, 60 Watts (PEP) Output Power
- Designed for FM, TDMA, CDMA and Multi-Carrier Applications
- Test Fixtures Available at: <http://mot-sps.com/rf/designtds/>

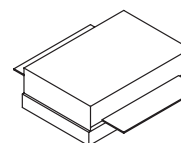
**Note:** Not suitable for class A operation.

**MRF20060R**  
**MRF20060RS**

**60 W, 2000 MHz**  
**RF POWER**  
**BROADBAND**  
**NPN BIPOLAR**



**CASE 451-06, STYLE 1**  
**(MRF20060R)**



**CASE 451A-03, STYLE 1**  
**(MRF20060RS)**

### MAXIMUM RATINGS

| Rating   | Symbol    | Value        | Unit                         |
|--|-----------|--------------|------------------------------|
| Collector-Emitter Voltage ( $I_B = 0$ mA)  | $V_{CEO}$ | 25           | Vdc                          |
| Collector-Emitter Voltage  | $V_{CES}$ | 60           | Vdc                          |
| Collector-Base Voltage   | $V_{CBO}$ | 60           | Vdc                          |
| Collector-Emitter Voltage ( $R_{BE} = 100$ Ohm)  | $V_{CER}$ | 30           | Vdc                          |
| Base-Emitter Voltage   | $V_{EB}$  | - 3          | Vdc                          |
| Collector Current - Continuous   | $I_C$     | 8            | Adc                          |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 250<br>1.43  | Watts<br>W/ $^\circ\text{C}$ |
| Storage Temperature Range  | $T_{stg}$ | - 65 to +150 | $^\circ\text{C}$             |
| Operating Junction Temperature   | $T_J$     | 200          | $^\circ\text{C}$             |

### THERMAL CHARACTERISTICS

| Rating                               | Symbol          | Max | Unit               |
|--------------------------------------|-----------------|-----|--------------------|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 0.7 | $^\circ\text{C/W}$ |

**ELECTRICAL CHARACTERISTICS** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

**OFF CHARACTERISTICS**

|  |               |    |     |    |      |
|--|---------------|----|-----|----|------|
| Collector–Emitter Breakdown Voltage<br>( $I_C = 50\text{ mAdc}$ , $I_B = 0$ )              | $V_{(BR)CEO}$ | 25 | 28  | —  | Vdc  |
| Collector–Emitter Breakdown Voltage<br>( $I_C = 50\text{ mAdc}$ , $V_{BE} = 0$ )           | $V_{(BR)CES}$ | 60 | 69  | —  | Vdc  |
| Collector–Base Breakdown Voltage<br>( $I_C = 50\text{ mAdc}$ , $I_E = 0$ )                 | $V_{(BR)CBO}$ | 60 | 69  | —  | Vdc  |
| Reverse Base–Emitter Breakdown Voltage<br>( $I_B = 10\text{ mAdc}$ , $I_C = 0$ )           | $V_{(BR)EBO}$ | 3  | 3.5 | —  | Vdc  |
| Zero Base Voltage Collector Leakage Current<br>( $V_{CE} = 30\text{ Vdc}$ , $V_{BE} = 0$ ) | $I_{CES}$     | —  | —   | 10 | mAdc |

**ON CHARACTERISTICS**

|   |          |    |    |    |   |
|---|----------|----|----|----|---|
| DC Current Gain<br>( $V_{CE} = 5\text{ Vdc}$ , $I_C = 1\text{ Adc}$ ) | $h_{FE}$ | 20 | 40 | 80 | — |
|---|----------|----|----|----|---|

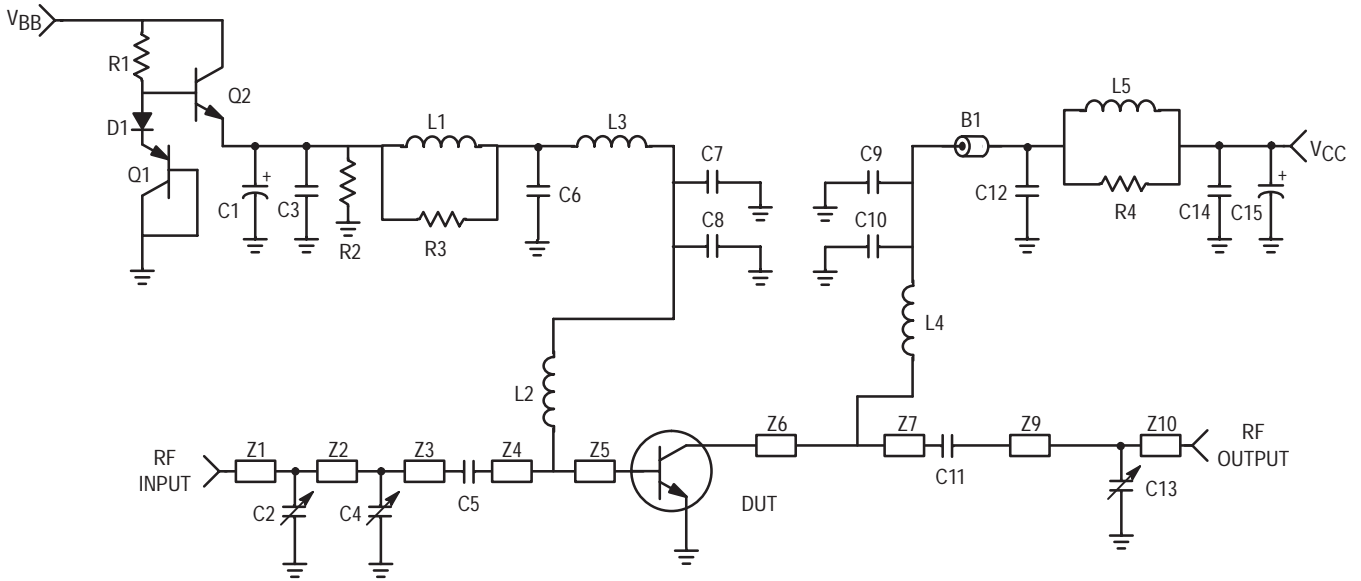
**DYNAMIC CHARACTERISTICS**

|   |          |   |    |   |    |
|---|----------|---|----|---|----|
| Output Capacitance<br>( $V_{CB} = 26\text{ Vdc}$ , $I_E = 0$ , $f = 1.0\text{ MHz}$ ) (1) | $C_{ob}$ | — | 55 | — | pF |
|---|----------|---|----|---|----|

**FUNCTIONAL TESTS** (In Motorola Test Fixture)

|  |          |                                |      |      |    |
|--|----------|--------------------------------|------|------|----|
| Common–Emitter Amplifier Power Gain<br>( $V_{CC} = 26\text{ Vdc}$ , $P_{out} = 60\text{ Watts (PEP)}$ , $I_{CQ} = 200\text{ mA}$ ,<br>$f_1 = 2000.0\text{ MHz}$ , $f_2 = 2000.1\text{ MHz}$ )  | $G_{pe}$ | 9                              | 9.8  | —    | dB |
| Collector Efficiency<br>( $V_{CC} = 26\text{ Vdc}$ , $P_{out} = 60\text{ Watts (PEP)}$ , $I_{CQ} = 200\text{ mA}$ ,<br>$f_1 = 2000.0\text{ MHz}$ , $f_2 = 2000.1\text{ MHz}$ )   | $\eta$   | 33                             | 35   | —    | %  |
| Intermodulation Distortion<br>( $V_{CC} = 26\text{ Vdc}$ , $P_{out} = 60\text{ Watts (PEP)}$ , $I_{CQ} = 200\text{ mA}$ ,<br>$f_1 = 2000.0\text{ MHz}$ , $f_2 = 2000.1\text{ MHz}$ )   | IMD      | —                              | – 32 | – 30 | dB |
| Input Return Loss<br>( $V_{CC} = 26\text{ Vdc}$ , $P_{out} = 60\text{ Watts (PEP)}$ , $I_{CQ} = 200\text{ mA}$ ,<br>$f_1 = 2000.0\text{ MHz}$ , $f_2 = 2000.1\text{ MHz}$ )  | IRL      | 12                             | 19   | —    | dB |
| Output Mismatch Stress<br>( $V_{CC} = 26\text{ Vdc}$ , $P_{out} = 60\text{ Watts (PEP)}$ , $I_{CQ} = 200\text{ mA}$ ,<br>$f_1 = 2000.0\text{ MHz}$ , $f_2 = 2000.1\text{ MHz}$ , $V_{SWR} = 3:1$ , All Phase<br>Angles at Frequency of Test) | $\psi$   | No Degradation in Output Power |      |      |    |

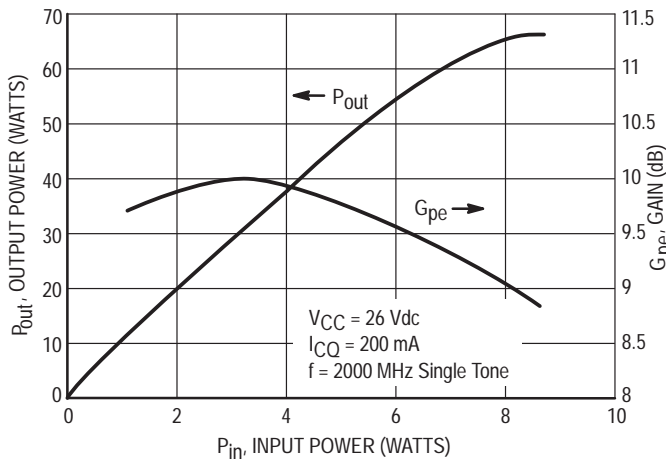
(1) For Information Only. This Part Is Collector Matched.



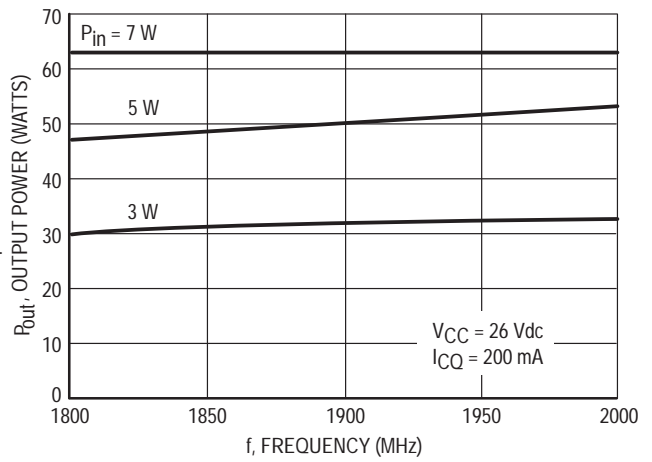
|             |  |        |   |
|-------------|--|--------|---|
| B1          | Ferrite Bead, P/N 5659065/3B, Ferroxcube           | D1     | Diode, Motorola (MURS160T3)                                   |
| C1          | 100 $\mu$ F, 50 V, Electrolytic Capacitor, Mallory | L1, L5 | 12 Turns, 22 AWG, 0.140" Choke                                |
| C2, C4, C13 | 0.6–4.0 pF, Variable Capacitor, Gigatrim, Johanson | L2, L4 | .5 inch of 20 AWG   |
| C3, C14     | 0.1 $\mu$ F, Chip Capacitor, Kemit                 | L3     | 12.5 nH Inductor  |
| C5          | 15 pF, B Case Chip Capacitor, ATC                  | R1     | 2 x 130 $\Omega$ , 1/8 W Chip Resistor, Rohm                  |
| C6, C12     | 1000 pF, B Case Chip Capacitor, ATC                | R2     | 2 x 100 $\Omega$ , 1/8 W Chip Resistor, Rohm                  |
| C7, C9      | 91 pF, B Case Chip Capacitor, ATC                  | R3, R4 | 10 $\Omega$ , 1/2 W, Resistor                                 |
| C8, C10     | 24 pF, B Case Chip Capacitor, ATC                  | Q1     | Transistor, PNP Motorola (BD136)                              |
| C11         | 13 pF, B Case Chip Capacitor, ATC                  | Q2     | Transistor, NPN Motorola (MJD47)                              |
| C15         | 470 $\mu$ F, 50 V, Electrolytic Capacitor, Mallory | Board  | Glass Teflon <sup>®</sup> , Arlon GX-0300-55-22, $\epsilon_r$ |

Figure 1. 1.93 – 2 GHz Test Fixture Electrical Schematic

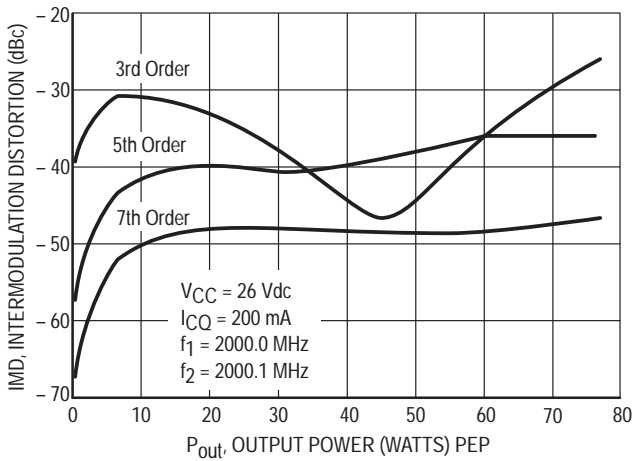
## TYPICAL CHARACTERISTICS



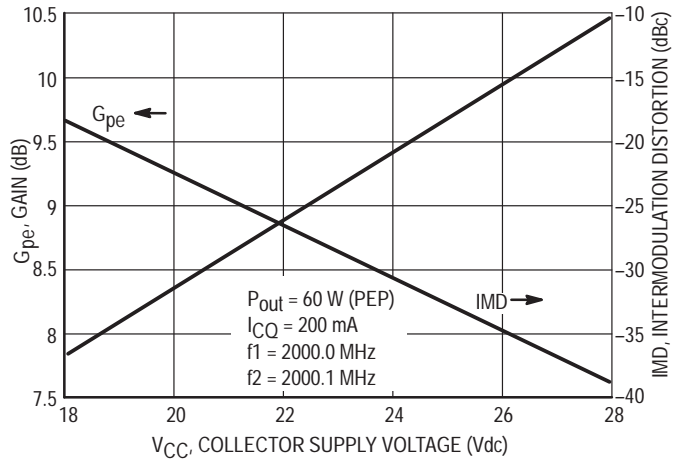
**Figure 2. Output Power & Power Gain versus Input Power**



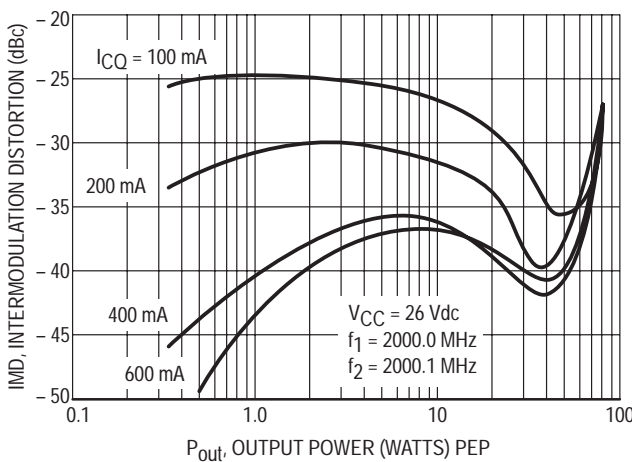
**Figure 3. Output Power versus Frequency**



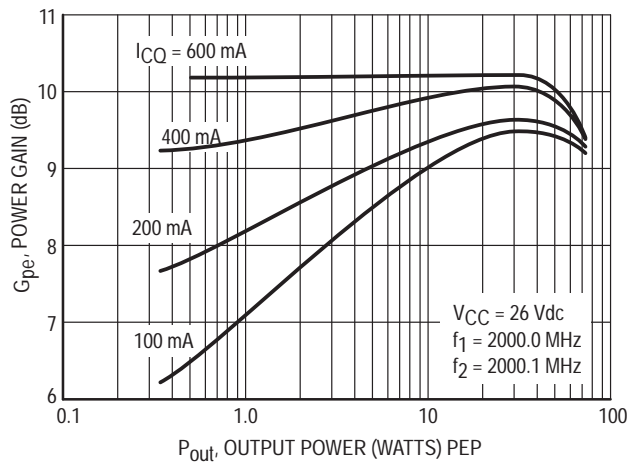
**Figure 4. Intermodulation Distortion versus Output Power**



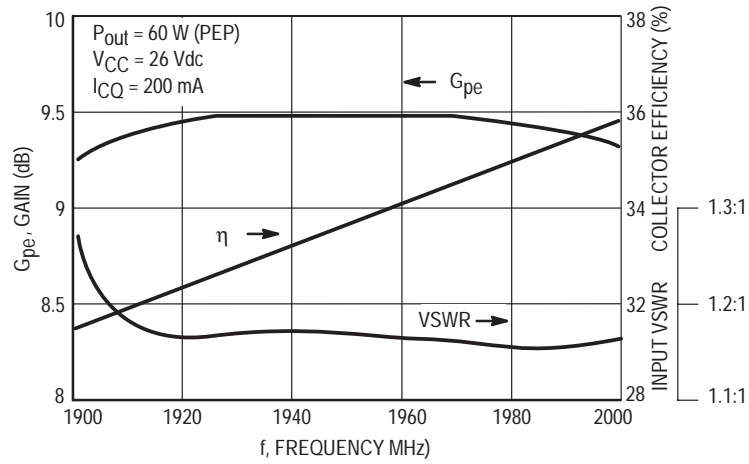
**Figure 5. Power Gain and Intermodulation Distortion versus Supply Voltage**



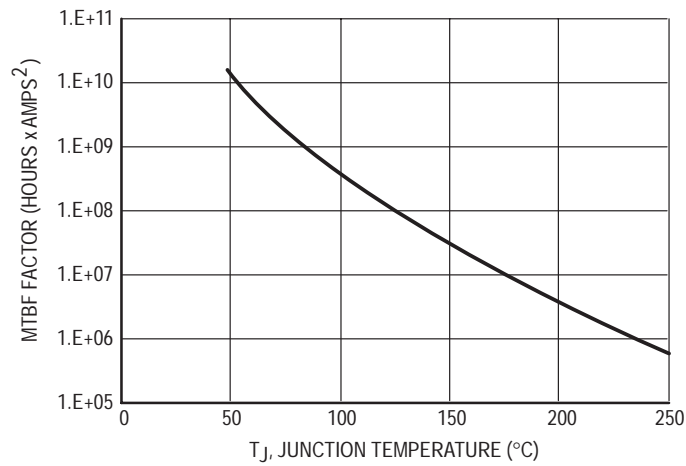
**Figure 6. Intermodulation Distortion versus Output Power**



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

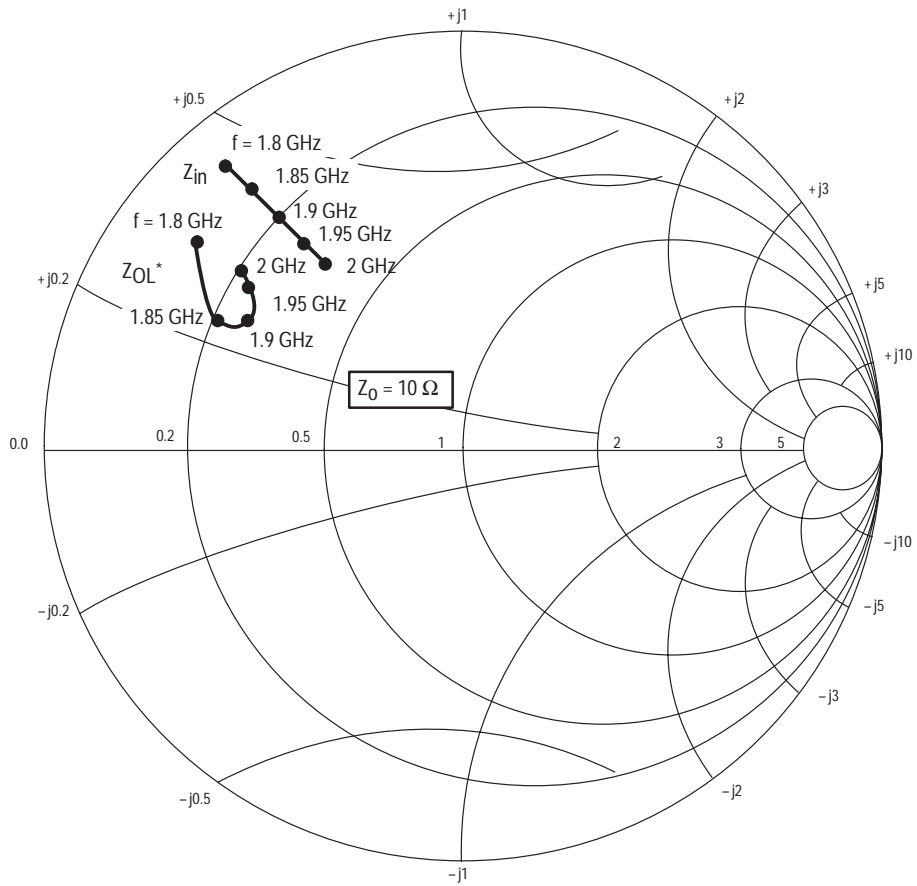


**Figure 8. Performance in Broadband Circuit**



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

**Figure 9. MTBF Factor versus Junction Temperature**



$V_{CC} = 26 \text{ V}$ ,  $I_{CQ} = 200 \text{ mA}$ ,  $P_{out} = 60 \text{ W (PEP)}$

| f<br>MHz | $Z_{in}(1)$<br>$\Omega$ | $Z_{OL}^*$<br>$\Omega$ |
|----------|-------------------------|------------------------|
| 1800     | $1.0 + j4.8$            | $1.7 + j3.3$           |
| 1850     | $1.5 + j4.8$            | $2.2 + j2.7$           |
| 1900     | $2.0 + j4.7$            | $2.4 + j3.0$           |
| 1950     | $2.5 + j4.7$            | $2.3 + j3.2$           |
| 2000     | $3.5 + j4.7$            | $2.0 + j3.4$           |

$Z_{in}(1)$  = Conjugate of fixture base terminal impedance.

$Z_{OL}^*$  = Conjugate of the optimum load impedance at given output power, voltage, bias current and frequency.

**Figure 10. Series Equivalent Input and Output Impedance**

Table 1. Common Emitter S-Parameters at  $V_{CE} = 24$  Vdc,  $I_C = 3.5$  Adc

| f<br>GHz | S11   |        | S21  |        | S12   |        | S22   |        |
|----------|-------|--------|------|--------|-------|--------|-------|--------|
|          | S11   | $\phi$ | S21  | $\phi$ | S12   | $\phi$ | S22   | $\phi$ |
| 1.5      | 0.986 | 168    | 0.32 | 81     | 0.031 | 60     | 0.923 | 169    |
| 1.55     | 0.985 | 167    | 0.35 | 76     | 0.031 | 63     | 0.918 | 169    |
| 1.6      | 0.981 | 167    | 0.40 | 70     | 0.032 | 61     | 0.908 | 169    |
| 1.65     | 0.973 | 166    | 0.45 | 63     | 0.030 | 53     | 0.897 | 169    |
| 1.7      | 0.968 | 165    | 0.52 | 56     | 0.033 | 50     | 0.889 | 168    |
| 1.75     | 0.951 | 163    | 0.62 | 46     | 0.028 | 47     | 0.880 | 169    |
| 1.8      | 0.914 | 161    | 0.76 | 32     | 0.027 | 39     | 0.871 | 170    |
| 1.85     | 0.851 | 161    | 0.91 | 12     | 0.024 | 26     | 0.863 | 171    |
| 1.9      | 0.789 | 164    | 1.02 | -15    | 0.015 | 5      | 0.888 | 174    |
| 1.95     | 0.810 | 170    | 0.94 | -44    | 0.005 | -7     | 0.931 | 174    |
| 2        | 0.880 | 172    | 0.75 | -68    | 0.006 | -151   | 0.953 | 172    |
| 2.05     | 0.934 | 170    | 0.57 | -85    | 0.010 | 152    | 0.967 | 170    |
| 2.1      | 0.964 | 168    | 0.45 | -98    | 0.015 | 158    | 0.965 | 169    |
| 2.15     | 0.977 | 165    | 0.36 | -109   | 0.022 | 164    | 0.955 | 168    |
| 2.2      | 0.975 | 163    | 0.30 | -118   | 0.033 | 165    | 0.950 | 167    |
| 2.25     | 0.961 | 161    | 0.25 | -128   | 0.049 | 160    | 0.947 | 167    |
| 2.3      | 0.942 | 160    | 0.22 | -139   | 0.066 | 149    | 0.938 | 166    |
| 2.35     | 0.919 | 157    | 0.19 | -149   | 0.077 | 142    | 0.931 | 165    |
| 2.4      | 0.860 | 156    | 0.17 | -163   | 0.100 | 137    | 0.922 | 165    |
| 2.45     | 0.821 | 159    | 0.15 | 177    | 0.128 | 122    | 0.914 | 165    |
| 2.5      | 0.781 | 161    | 0.14 | 157.0  | 0.156 | 108    | 0.907 | 165    |

# NOTES



# NOTES

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## PACKAGE DIMENSIONS

Q 2 PL

|          |           |                            |     |   |   |     |   |     |
|----------|-----------|----------------------------|-----|---|---|-----|---|-----|
| $\oplus$ | $\ominus$ | $\varnothing$ 0.25 (0.010) | (M) | T | A | (M) | B | (M) |
|----------|-----------|----------------------------|-----|---|---|-----|---|-----|

NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- CONTROLLING DIMENSION: INCH.
- DIMENSION H IS MEASURED 0.030" AWAY FROM FLANGE.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.995     | 1.005 | 25.27       | 25.53 |
| B   | 0.380     | 0.390 | 9.65        | 9.91  |
| C   | 0.156     | 0.191 | 3.96        | 4.85  |
| D   | 0.455     | 0.465 | 11.56       | 11.81 |
| E   | 0.060     | 0.075 | 1.52        | 1.91  |
| F   | 0.004     | 0.006 | 0.10        | 0.15  |
| G   | 0.800 BSC |       | 20.32 BSC   |       |
| H   | 0.078     | 0.090 | 1.98        | 2.29  |
| K   | 0.117     | 0.137 | 2.97        | 3.48  |
| N   | 0.595     | 0.605 | 15.11       | 15.37 |
| Q   | 0.120     | 0.130 | 3.05        | 3.30  |
| R   | 0.395     | 0.410 | 10.03       | 10.41 |

STYLE 1:  
PIN 1. COLLECTOR  
2. BASE  
3. EMITTER

**CASE 451-06**  
**ISSUE F**  
**(MRF20060R)**


NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- CONTROLLING DIMENSION: INCH.
- DIMENSION H IS MEASURED 0.030" AWAY FROM FLANGE.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.615  | 0.625 | 15.62       | 15.88 |
| B   | 0.395  | 0.410 | 10.03       | 10.41 |
| C   | 0.156  | 0.191 | 3.96        | 4.85  |
| D   | 0.455  | 0.465 | 11.56       | 11.81 |
| E   | 0.060  | 0.075 | 1.52        | 1.91  |
| F   | 0.004  | 0.006 | 0.10        | 0.15  |
| H   | 0.078  | 0.090 | 1.98        | 2.29  |
| K   | 0.117  | 0.137 | 2.97        | 3.48  |
| N   | 0.595  | 0.605 | 15.11       | 15.37 |

STYLE 1:  
PIN 1. COLLECTOR  
2. BASE  
3. EMITTER

**CASE 451A-03**  
**ISSUE B**  
**(MRF20060RS)**

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