

# The RF Line

## NPN Silicon

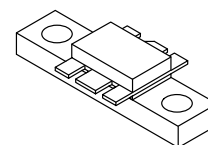
### RF Power Transistor

Designed for 24 Volt UHF large-signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800 to 960 MHz.

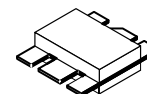
- Specified for  $V_{CE} = 24$  Vdc,  $I_C = 0.9$  Adc Characteristics
  - Output Power = 6.5 Watts CW
  - Minimum Power Gain = 11.5 dB
  - Minimum ITO = +47 dBm
  - Typical Noise Figure = 6 dB
- Characterized with Small-Signal S-Parameters and Series Equivalent Large-Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc,  $I_C = 0.9$  Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 2 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit Board Photomaster Available by Ordering Document MRF859PHT/D from Motorola Literature Distribution.

**MRF859**  
**MRF859S**

**CLASS A**  
**800–960 MHz**  
**6.5 W (CW), 24 V**  
**NPN SILICON**  
**RF POWER TRANSISTOR**



**CASE 319-07, STYLE 2**  
**MRF859**



**CASE 319A-02, STYLE 2**  
**MRF859S**

#### MAXIMUM RATINGS

| Rating   | Symbol    | Value       | Unit                         |
|--|-----------|-------------|------------------------------|
| Collector–Emitter Voltage  | $V_{CEO}$ | 30          | Vdc                          |
| Collector–Base Voltage   | $V_{CBO}$ | 55          | Vdc                          |
| Emitter–Base Voltage   | $V_{EBO}$ | 4           | Vdc                          |
| Total Device Dissipation @ $T_C = 60^\circ\text{C}$<br>Derate above $60^\circ\text{C}$ | $P_D$     | 34<br>0.24  | Watts<br>W/ $^\circ\text{C}$ |
| Operating Junction Temperature   | $T_J$     | 200         | $^\circ\text{C}$             |
| Storage Temperature Range  | $T_{stg}$ | –65 to +150 | $^\circ\text{C}$             |

#### THERMAL CHARACTERISTICS

| Characteristic  | Symbol          | Max | Unit                      |
|---|-----------------|-----|---------------------------|
| Thermal Resistance ( $T_J = 150^\circ\text{C}$ , $T_C = 60^\circ\text{C}$ ) | $R_{\theta JC}$ | 3.9 | $^\circ\text{C}/\text{W}$ |

#### ELECTRICAL CHARACTERISTICS

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

#### OFF CHARACTERISTICS

|   |               |    |    |   |     |
|---|---------------|----|----|---|-----|
| Collector–Emitter Breakdown Voltage ( $I_C = 25$ mA, $I_B = 0$ )    | $V_{(BR)CEO}$ | 28 | 32 | — | Vdc |
| Collector–Emitter Breakdown Voltage ( $I_C = 25$ mA, $V_{BE} = 0$ ) | $V_{(BR)CES}$ | 55 | 75 | — | Vdc |
| Collector–Base Breakdown Voltage ( $I_C = 25$ mA, $I_E = 0$ )       | $V_{(BR)CBO}$ | 55 | 75 | — | Vdc |
| Emitter–Base Breakdown Voltage ( $I_E = 5$ mA, $I_C = 0$ )          | $V_{(BR)EBO}$ | 4  | 5  | — | Vdc |
| Collector Cutoff Current ( $V_{CB} = 15$ V, $I_E = 0$ )             | $I_{CES}$     | —  | —  | 2 | mA  |

(continued)

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**ELECTRICAL CHARACTERISTICS — continued**

| Characteristic   | Symbol         | Min                            | Typ | Max | Unit |
|--|----------------|--------------------------------|-----|-----|------|
| <b>ON CHARACTERISTICS</b>  |                |                                |     |     |      |
| DC Current Gain<br>( $I_C = 1\text{ A}$ , $V_{CE} = 5\text{ V}$ )  | $h_{FE}$       | 20                             | 60  | 120 | —    |
| <b>DYNAMIC CHARACTERISTICS</b>   |                |                                |     |     |      |
| Output Capacitance<br>( $V_{CB} = 24\text{ V}$ , $f = 1\text{ MHz}$ )  | $C_{ob}$       | 13                             | —   | 26  | pF   |
| <b>FUNCTIONAL CHARACTERISTICS</b>  |                |                                |     |     |      |
| Common-Emitter Power Gain<br>( $V_{CE} = 24\text{ V}$ , $I_C = 0.9\text{ A}$ , $f = 840\text{--}900\text{ MHz}$ , $P_{out} = 6.5\text{ W}$ )                             | $P_g$          | 11.5                           | 13  | —   | dB   |
| Load Mismatch<br>( $V_{CE} = 24\text{ V}$ , $I_C = 0.9\text{ A}$ , $f = 840\text{ MHz}$ , $P_{out} = 6.5\text{ W}$ ,<br>Load VSWR = 30:1, All Phase Angles)              | $\psi$         | No Degradation in Output Power |     |     |      |
| RF Input Overdrive<br>( $V_{CE} = 24\text{ V}$ , $I_C = 0.9\text{ A}$ , $f = 840\text{ MHz}$ )<br>No degradation   | $P_{in(over)}$ | —                              | —   | 2   | W    |
| Third Order Intercept Point<br>( $V_{CE} = 24\text{ V}$ , $I_C = 0.9\text{ A}$ , $f_1 = 900\text{ MHz}$ , $f_2 = 900.1\text{ MHz}$ ,<br>Meas. @ IMD 3rd Order = -40 dBc) | ITO            | +47                            | +48 | —   | dBm  |
| Noise Figure<br>( $V_{CE} = 24\text{ V}$ , $I_C = 0.9\text{ A}$ , $f = 900\text{ MHz}$ )   | NF             | —                              | 6   | —   | dB   |
| Input Return Loss<br>( $V_{CE} = 24\text{ V}$ , $I_C = 0.9\text{ A}$ , $f = 840\text{--}900\text{ MHz}$ , $P_{out} = 6.5\text{ W}$ )                                     | IRL            | —                              | —   | -9  | dB   |

**Table 1. Common Emitter S-Parameters**

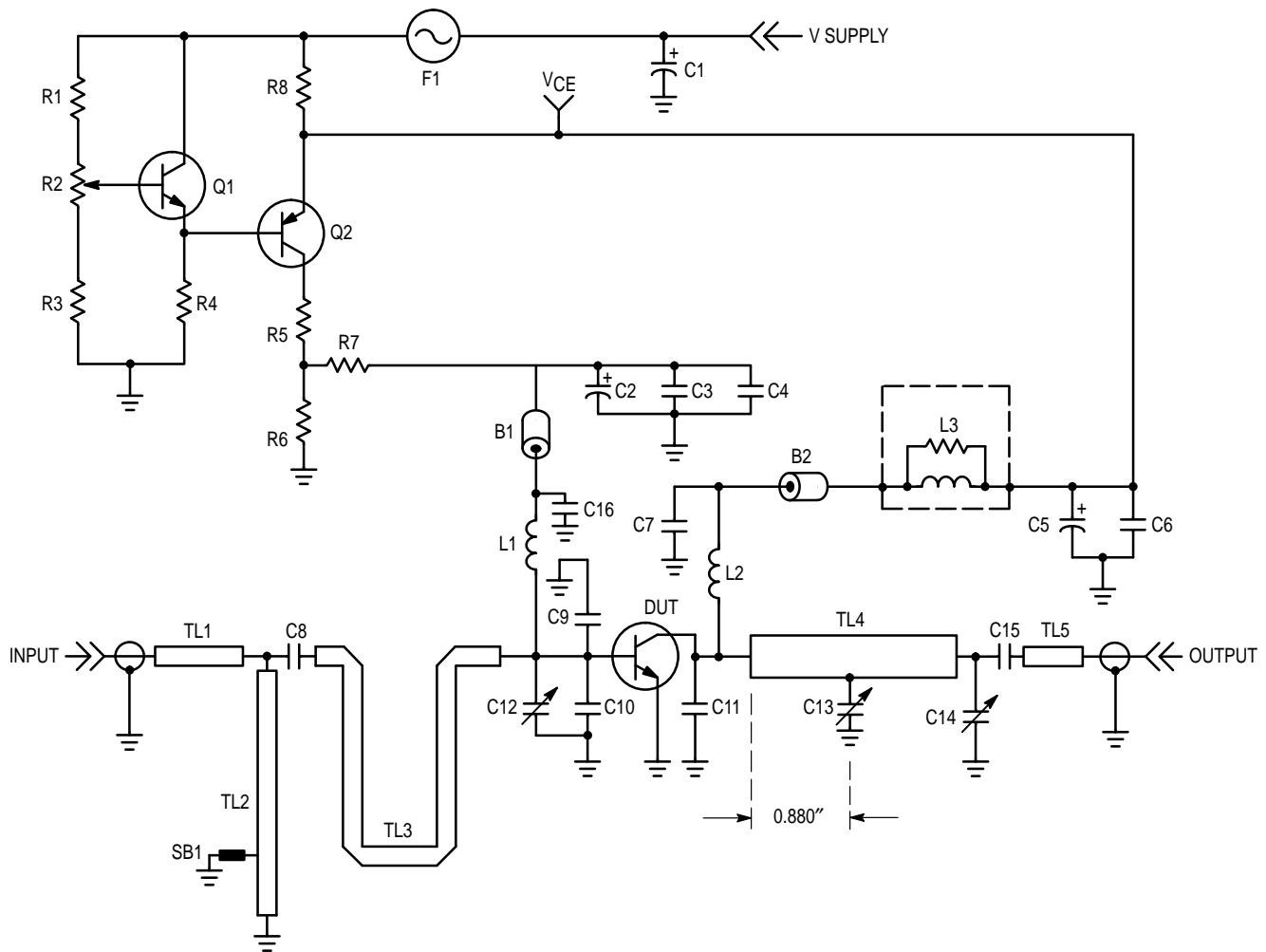
| $V_{CE}$<br>(V) | $I_C$<br>(A) | f<br>(MHz) | $S_{11}$   |               | $S_{21}$   |               | $S_{12}$   |               | $S_{22}$   |               |
|-----------------|--------------|------------|------------|---------------|------------|---------------|------------|---------------|------------|---------------|
|                 |              |            | $ S_{11} $ | $\angle \phi$ | $ S_{21} $ | $\angle \phi$ | $ S_{12} $ | $\angle \phi$ | $ S_{22} $ | $\angle \phi$ |
| 24              | 0.9          | 800        | 0.906      | 170           | 1.022      | 12            | 0.016      | 11            | 0.804      | -168          |
|                 |              | 820        | 0.902      | 170           | 1.022      | 7             | 0.015      | 8             | 0.823      | -167          |
|                 |              | 840        | 0.897      | 171           | 1.018      | 3             | 0.013      | 6             | 0.845      | -167          |
|                 |              | 860        | 0.894      | 171           | 1.012      | -3            | 0.011      | 4             | 0.870      | -167          |
|                 |              | 880        | 0.893      | 171           | 1.005      | -8            | 0.009      | 3             | 0.895      | -168          |
|                 |              | 900        | 0.893      | 171           | 0.988      | -14           | 0.007      | 5             | 0.920      | -168          |
|                 |              | 920        | 0.894      | 172           | 0.962      | -20           | 0.005      | 14            | 0.946      | -169          |
|                 |              | 940        | 0.897      | 172           | 0.924      | -26           | 0.008      | 47            | 0.969      | -170          |
|                 |              | 960        | 0.903      | 172           | 0.884      | -32           | 0.004      | 102           | 0.987      | -172          |

**Table 2.  $Z_{in}$  and  $Z_{OL}^*$  versus Frequency**

| f<br>(MHz) | $Z_{in}$<br>(Ohms) |     | $Z_{OL}^*$<br>(Ohms) |      |
|------------|--------------------|-----|----------------------|------|
| 840        | 1.6                | 3.3 | 2                    | -4.1 |
| 870        | 1.5                | 3.6 | 1.6                  | -3.3 |
| 900        | 2.2                | 3.5 | 1.7                  | -2.7 |

$V_{CE} = 24\text{ V}$ ,  $I_C = 0.9\text{ A}$ ,  $P_o = 6.5\text{ W}$

$Z_{OL}^*$  = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.



|               |  |          |  |
|---------------|--|----------|--|
| B1, B2        | Ferrite Bead, Ferroxcube (56-390-65/3B)                  | R1       | 470 $\Omega$ , 1/4 W   |
| C1            | 250 $\mu$ F, 50 Vdc, Electrolytic Capacitor              | R2       | 500 $\Omega$ Potentiometer, 1/4 W                              |
| C2, C5        | 10 $\mu$ F, 50 Vdc, Electrolytic Capacitor               | R3       | 4.7K $\Omega$ , 1/4 W  |
| C3, C6        | 0.1 $\mu$ F, Chip Capacitor                              | R4       | 2 x 4.7K $\Omega$ , 1/4 W                                      |
| C4            | 1000 pF, Chip Capacitor                                  | R5       | 50 $\Omega$ , 2 W  |
| C7, C16       | 100 pF, Chip Capacitor                                   | R6       | 75 $\Omega$ , 1/4 W  |
| C8, C15       | 43 pF, 100 Mil Chip Capacitor                            | R7       | 4.7 $\Omega$ , 1/4 W   |
| C9, C10       | 6.8 pF, Mini-Unelco                                      | R8       | 4 $\Omega$ , 10 W  |
| C11           | 18 pF, Mini-Unelco                                       | SB1      | Copper Block 0.550" x 0.180" x 0.050"                          |
| C12, C13, C14 | 0.8-8.0 pF, Johanson Gigatrim                            | TL1, TL5 | 50 $\Omega$ , Microstrip Transmission Line                     |
| F1            | 3 Amp Micro-Fuse   | TL2      | Microstrip Transmission Line                                   |
| L1, L2        | 3 Turns, 18 AWG, 0.170" ID                               | TL3      | Microstrip Transmission Line                                   |
| L3            | 12 Turns, 22 AWG, 0.150" ID (10 $\Omega$ 1/2 W Resistor) | TL4      | Microstrip Transmission Line                                   |
| Q1            | MMBT2222ALT1, NPN Transistor                             | Board    | 0.030" Glass-Teflon <sup>®</sup> 2 oz. Cu, $\epsilon_r = 2.55$ |
| Q2            | BD136, PNP Transistor                                    | V Supply | +27.6 Vdc $\pm$ 0.5 Vdc Due to Resistor Tolerance              |
|               |  | VCE      | +24 Vdc @ 0.9 A  |

**Figure 1. MRF859 Class A RF Test Fixture Schematic**

## TYPICAL CHARACTERISTICS

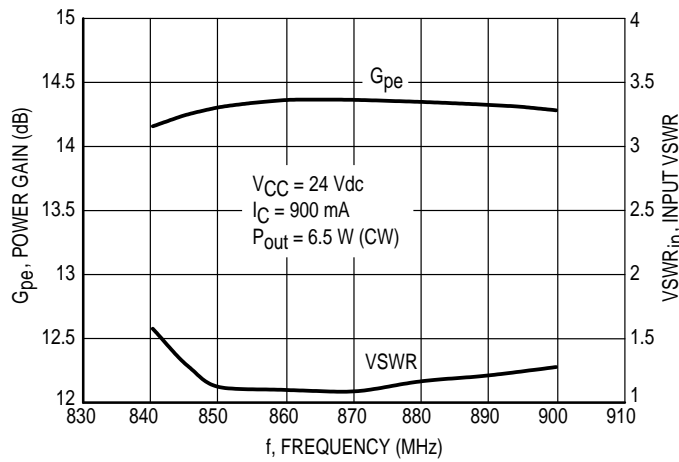


Figure 2. Performance in Broadband Circuit

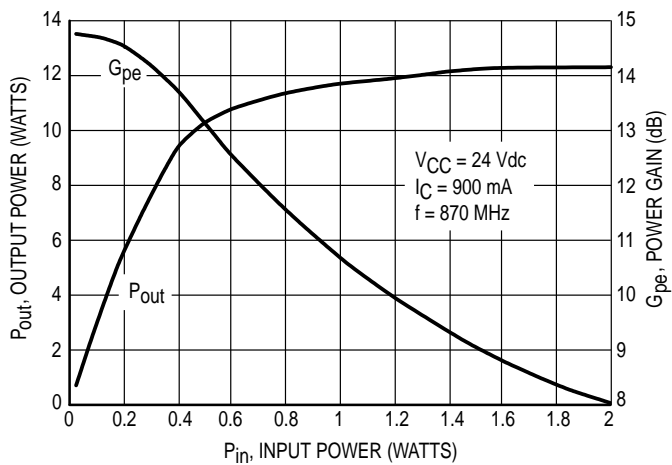


Figure 3. Output Power & Power Gain versus Input Power

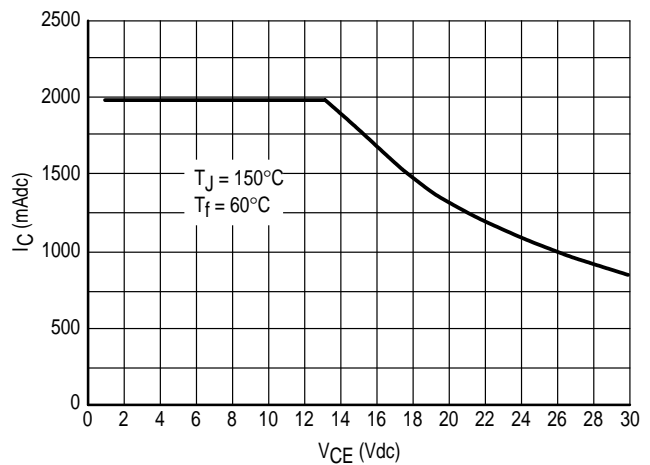


Figure 4. DC SOA

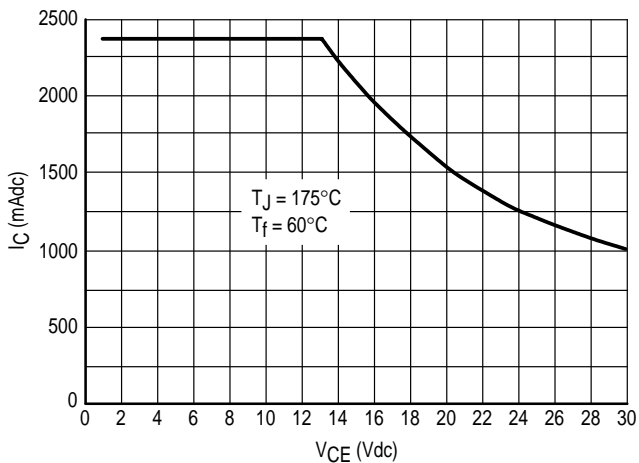


Figure 5. DC SOA

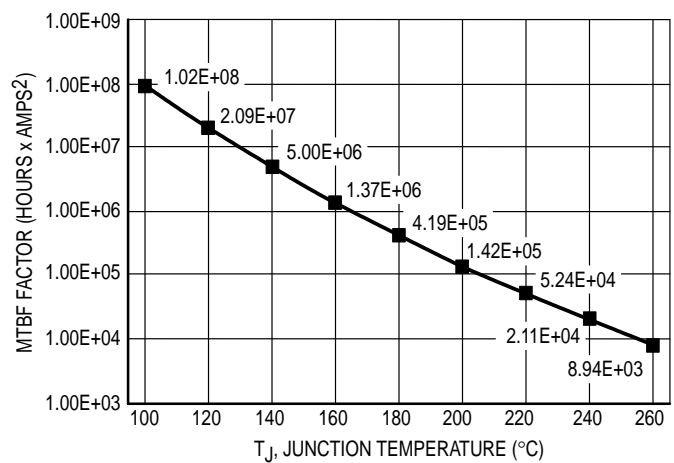


Figure 6. MTBF Factor versus Junction Temperature

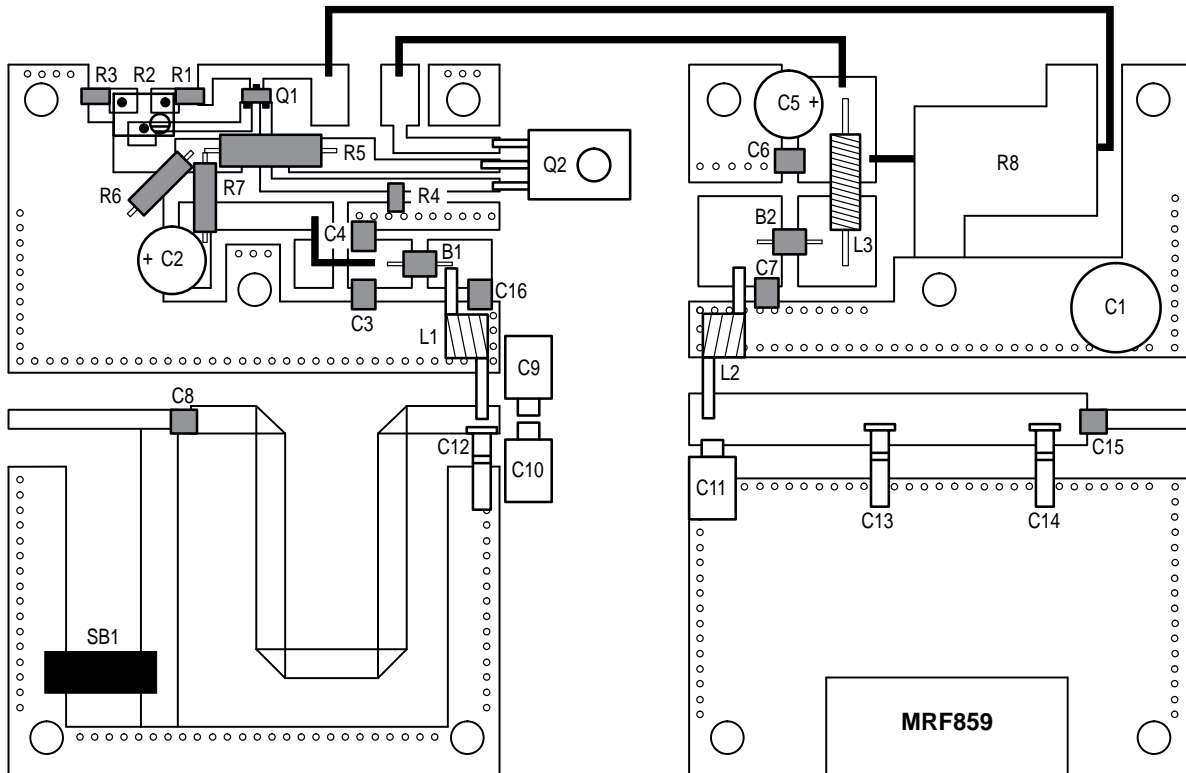

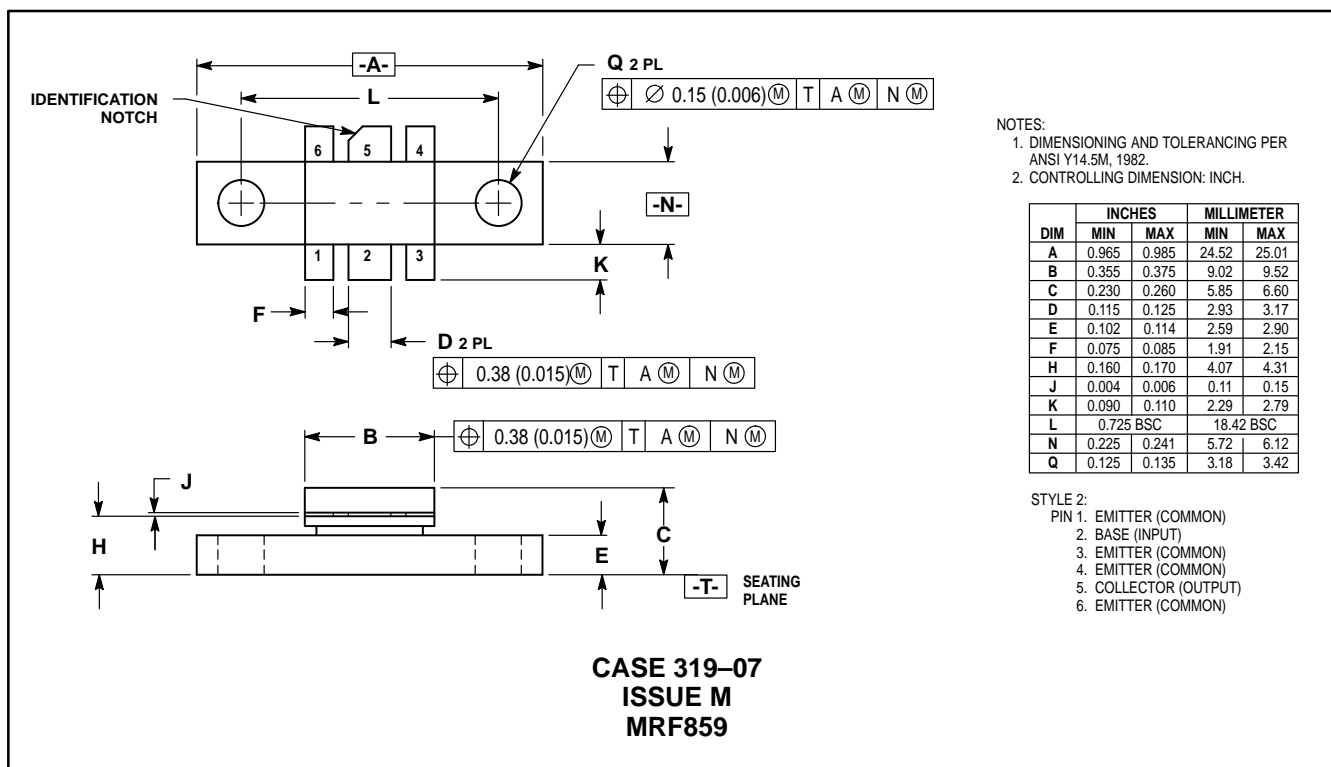


Figure 7. MRF859 Test Fixture Component Layout

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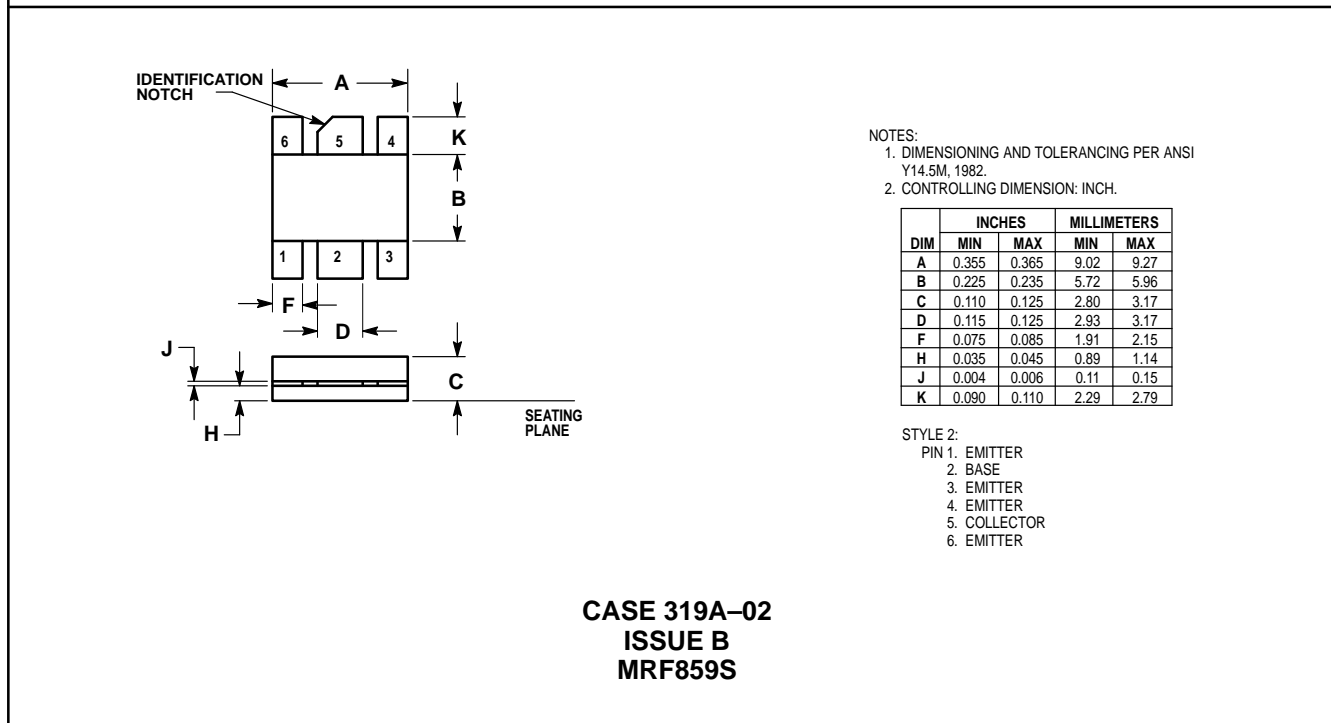
## PACKAGE DIMENSIONS



NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

| DIM | INCHES    |       | MILLIMETER |       |
|-----|-----------|-------|------------|-------|
|     | MIN       | MAX   | MIN        | MAX   |
| A   | 0.965     | 0.985 | 24.52      | 25.01 |
| B   | 0.355     | 0.375 | 9.02       | 9.52  |
| C   | 0.230     | 0.260 | 5.85       | 6.60  |
| D   | 0.115     | 0.125 | 2.93       | 3.17  |
| E   | 0.102     | 0.114 | 2.59       | 2.90  |
| F   | 0.075     | 0.085 | 1.91       | 2.15  |
| H   | 0.160     | 0.170 | 4.07       | 4.31  |
| J   | 0.004     | 0.006 | 0.11       | 0.15  |
| K   | 0.090     | 0.110 | 2.29       | 2.79  |
| L   | 0.725 BSC |       | 18.42 BSC  |       |
| N   | 0.225     | 0.241 | 5.72       | 6.12  |
| Q   | 0.125     | 0.135 | 3.18       | 3.42  |

STYLE 2:  
PIN 1. EMITTER (COMMON)  
2. BASE (INPUT)  
3. EMITTER (COMMON)  
4. EMITTER (COMMON)  
5. COLLECTOR (OUTPUT)  
6. EMITTER (COMMON)



NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

| DIM | INCHES |       | MILLIMETERS |      |
|-----|--------|-------|-------------|------|
|     | MIN    | MAX   | MIN         | MAX  |
| A   | 0.355  | 0.365 | 9.02        | 9.27 |
| B   | 0.225  | 0.235 | 5.72        | 5.96 |
| C   | 0.110  | 0.125 | 2.80        | 3.17 |
| D   | 0.115  | 0.125 | 2.93        | 3.17 |
| F   | 0.075  | 0.085 | 1.91        | 2.15 |
| H   | 0.035  | 0.045 | 0.89        | 1.14 |
| J   | 0.004  | 0.006 | 0.11        | 0.15 |
| K   | 0.090  | 0.110 | 2.29        | 2.79 |

STYLE 2:  
PIN 1. EMITTER  
2. BASE  
3. EMITTER  
4. EMITTER  
5. COLLECTOR  
6. EMITTER

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MRF859/D

