## The RF Line

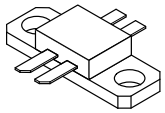
# NPN Silicon RF Power Transistor

**MRF860**

**CLASS A**
**800 – 960 MHz**
**13.7 W (CW), 24 V**
**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 – 960 MHz.

- Specified for $V_{CE}$ = 24 Vdc, $I_C$ = 1.9 Adc Characteristics
  Output Power = 13.7 Watts CW
  Minimum Power Gain = 11 dB
  Minimum ITO = +51.5 dBm
  Typical Noise Figure = 6.5 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800 – 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, $I_C$ = 1.9 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 3.25 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



**CASE 395B–01, STYLE 1**

**MAXIMUM RATINGS**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Collector–Emitter Voltage | $V_{CEO}$ | 30 | Vdc |
| Collector–Base Voltage | $V_{CBO}$ | 60 | Vdc |
| Emitter–Base Voltage | $V_{EBO}$ | 4 | Vdc |
| Total Device Dissipation @ $T_C$ = 60°C<br>Derate above 60°C | $P_D$ | 71<br>0.51 | Watts<br>W/°C |
| Operating Junction Temperature | $T_J$ | 200 | °C |
| Storage Temperature Range | $T_{stg}$ | –65 to +150 | °C |

**THERMAL CHARACTERISTICS**

| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Thermal Resistance ($T_J$ = 150°C, $T_C$ = 60°C) | $R_{\theta JC}$ | 1.9 | °C/W |

**ELECTRICAL CHARACTERISTICS**

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS (1)** | | | | | |
| Collector–Emitter Breakdown Voltage ($I_C$ = 50 mA, $I_B$ = 0) | $V_{(BR)CEO}$ | 28 | 33 | — | Vdc |
| Collector–Emitter Breakdown Voltage ($I_C$ = 50 mA, $V_{BE}$ = 0) | $V_{(BR)CES}$ | 60 | 80 | — | Vdc |
| Collector–Base Breakdown Voltage ($I_C$ = 50 mA, $I_E$ = 0) | $V_{(BR)CBO}$ | 60 | 80 | — | Vdc |
| Emitter–Base Breakdown Voltage ($I_E$ = 5 mA, $I_C$ = 0) | $V_{(BR)EBO}$ | 4 | 4.7 | — | Vdc |
| Collector Cutoff Current ($V_{CB}$ = 24 V, $I_E$ = 0) | $I_{CES}$ | — | — | 10 | mA |

(1) All DC tests are per side.

(continued)

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**ELECTRICAL CHARACTERISTICS — continued**

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **ON CHARACTERISTICS (1)** | | | | | |
| DC Current Gain ($I_C$ = 1 A, $V_{CE}$ = 5 V) | $h_{FE}$ | 30 | 80 | 120 | — |
| **DYNAMIC CHARACTERISTICS (1)** | | | | | |
| Output Capacitance ($V_{CB}$ = 24 V, f = 1 MHz) | $C_{ob}$ | 14 | 21 | 28 | pF |
| **FUNCTIONAL CHARACTERISTICS (2)** | | | | | |
| Common–Emitter Power Gain ($V_{CE}$ = 24 V, $I_C$ = 1.9 A, f = 900 MHz, Power Output = 13.7 W) | $P_g$ | 11 | 12.5 | — | dB |
| Load Mismatch ($V_{CE}$ = 24 V, $I_C$ = 1.9 A, f = 900 MHz, Power Output = 13.7 W, Load VSWR = 30:1, All Phase Angles) | ψ | No Degradation in Output Power | | | |
| RF Input Overdrive ($V_{CE}$ = 24 V, $I_C$ = 1.9 A, f = 900 MHz) No degradation | $P_{in(over)}$ | — | — | 3.25 | W |
| Third Order Intercept Point ($V_{CE}$ = 24 V, $I_C$ = 1.9 A, f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = –40 dBc) | ITO | +51.5 | +52.5 | — | dBm |
| Noise Figure ($V_{CE}$ = 24 V, $I_C$ = 1.9 A, f = 900 MHz) | NF | — | 6.5 | — | dB |
| Input Return Loss ($V_{CE}$ = 24 V, $I_C$ = 1.9 A, f = 900 MHz, Power Output = 13.7 W) | IRL | — | — | –10 | dB |

(1) All DC tests are per side.
(2) Operating bias point $I_C$ is the total for both halves.

**Table 1. MRF860 Common Emitter S–Parameters (Per Side)**

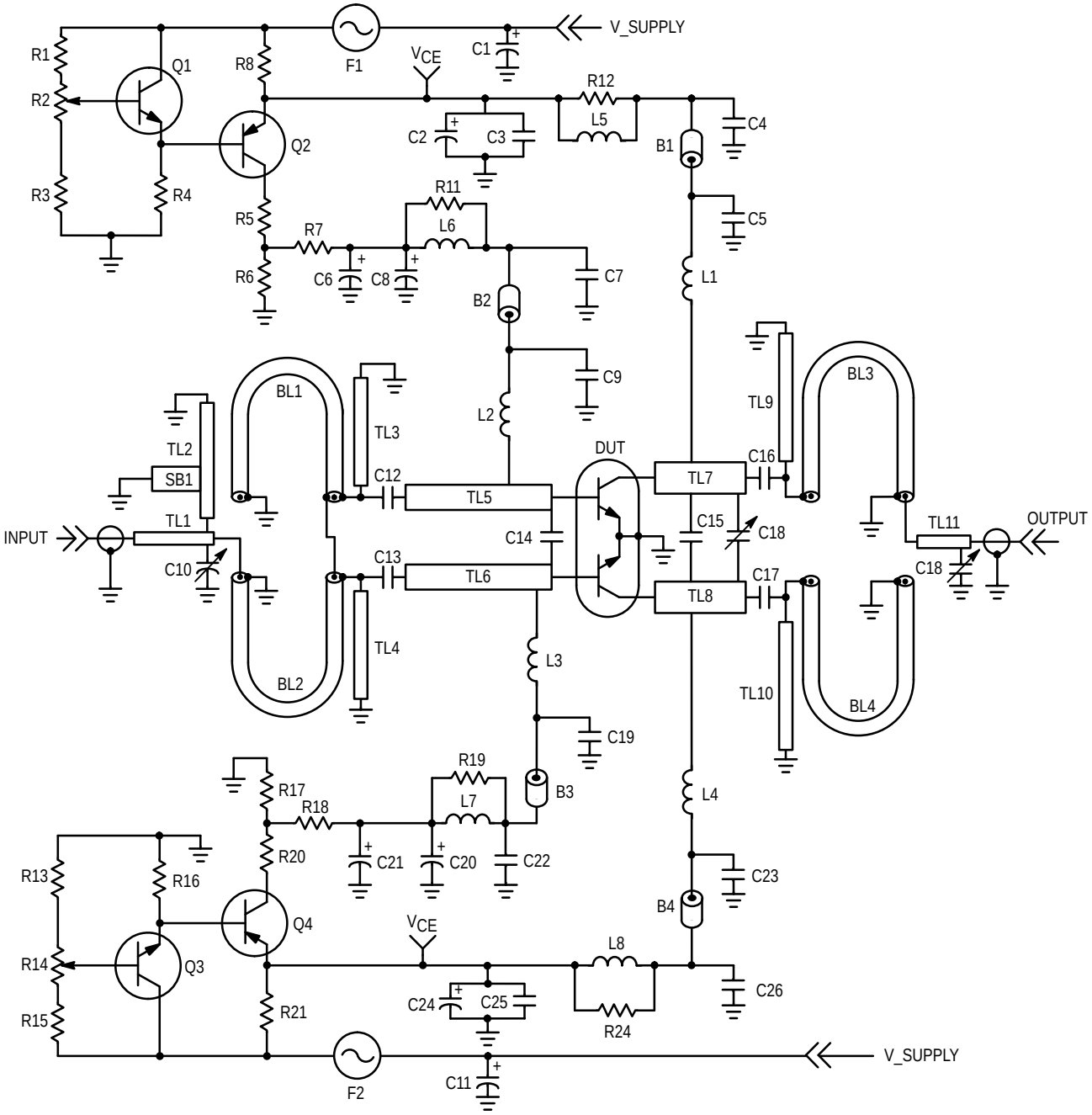
| $V_{CE}$ (V) | $I_C$ (A) | f (MHz) | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\|S_{11}\|$ | ∠ϕ | $\|S_{21}\|$ | ∠ϕ | $\|S_{12}\|$ | ∠ϕ | $\|S_{22}\|$ | ∠ϕ |
| 24 | 0.95 | 800 | 0.964 | 171 | 0.829 | 45 | 0.012 | 15 | 0.781 | 174 |
| | | 820 | 0.963 | 170 | 0.831 | 43 | 0.012 | 15 | 0.779 | 174 |
| | | 840 | 0.963 | 170 | 0.839 | 42 | 0.013 | 13 | 0.779 | 173 |
| | | 860 | 0.959 | 169 | 0.844 | 40 | 0.013 | 13 | 0.778 | 173 |
| | | 880 | 0.957 | 169 | 0.856 | 38 | 0.014 | 12 | 0.779 | 173 |
| | | 900 | 0.952 | 169 | 0.870 | 36 | 0.014 | 11 | 0.778 | 173 |
| | | 920 | 0.951 | 168 | 0.884 | 34 | 0.015 | 9 | 0.778 | 173 |
| | | 940 | 0.944 | 168 | 0.897 | 32 | 0.015 | 8 | 0.774 | 173 |
| | | 960 | 0.941 | 168 | 0.917 | 30 | 0.016 | 7 | 0.774 | 173 |

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

| f (MHz) | $Z_{in}$ (Ohms) | | $Z_{OL}$* (Ohms) | |
|---|---|---|---|---|
| 840 | 1.6 | 9 | 3.6 | –2.1 |
| 870 | 1.4 | 9.7 | 4.4 | –2.3 |
| 900 | 1.7 | 9.9 | 4.9 | –2.3 |

$V_{CE}$ = 24 V, $I_C$ = 1.9 A, $P_o$ = 13.7 W

Notes: $Z_{in}$ is a balanced base–to–base measurement.
$Z_{OL}$* = Conjugate of optimum load impedance, collector to collector, into which the device operates at a given output power, bias current, voltage and frequency.




| | | | |
|---|---|---|---|
| B1, B2, B3, B4 | Short Ferrite Bead, Fair Rite (2743019447) | R1, R15 | 470 Ω, 1/4 W |
| BL1–BL4 | 2.20″ 50 Ω 0.085″ OD Semi–Rigid Coax | R2, R14 | 500 Ω Potentiometer, 1/4 W |
| C1, C11 | 470 μF, 50 Vdc Electrolytic Capacitor | R3, R13 | 4.7K Ω, 1/4 W |
| C6, C21 | 220 μF, 50 Vdc Electrolytic Capacitor | R4, R16 | 2 x 4.7K Ω, 1/4 W |
| C2, C8, C20, C24 | 10 μF, 50 Vdc Electrolytic Capacitor | R5, R20 | 47 Ω, 2 W |
| C3, C7, C22, C25 | 0.1 μF, Chip Capacitor | R6, R17 | 75 Ω, 1/4 W |
| C4, C26 | 1000 pF, Chip Capacitor | R7, R18 | 4.7 Ω, 1/4 W |
| C5, C9, C19, C23 | 100 pF, Chip Capacitor | R8, R21 | 4 Ω, 10 W |
| C10, C18 | 0.8–8.0 pF, Johanson Gigatrim | R11, R12, R19, R24 | 4 x 39 Ω, 1/8 W Chip Resistors in Parallel |
| C12, C13, C16, C17 | 43 pF, 100 Mil Chip Capacitor | SB1 | Copper 0.500″ x 0.200″ x 0.050″ |
| C14 | 13 pF, 50 Mil Chip Capacitor | TL1, TL11 | 50 Ω, Microstrip Transmission Line |
| C15 | 7.5 pF, 100 Mil Chip Capacitor | TL2–TL10 | Microstrip Transmission Line |
| F1, F2 | 3 A Micro–Fuse | V_Supply | +27.8 Vdc ±0.5 Vdc Due to Resistor Tolerance |
| L1–L8 | 5 Turns 18 AWG 0.142″ ID (47.5 nH) | | |
| Q1, Q3 | MMBT2222ALT1, NPN Transistor | $V_{CE}$ | +24 Vdc @ 0.95 A |
| Q2, Q4 | BD136, PNP Transistor | Board | 0.030″ Glass–Teflon® 2 oz. Cu, $\varepsilon_r$ = 2.55 |

**Figure 1. MRF860 Class A RF Test Fixture Schematic**

## TYPICAL CHARACTERISTICS

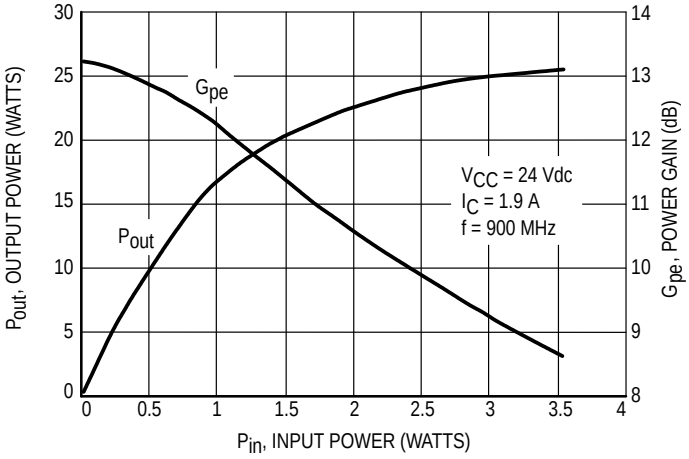



**Figure 2. Output Power & Power Gain versus Input Power**

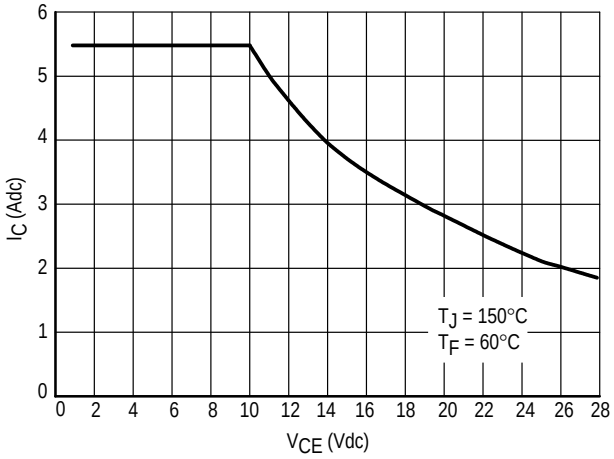



**Figure 3. DC SOA (Total $I_C$ for both halves operating.)**

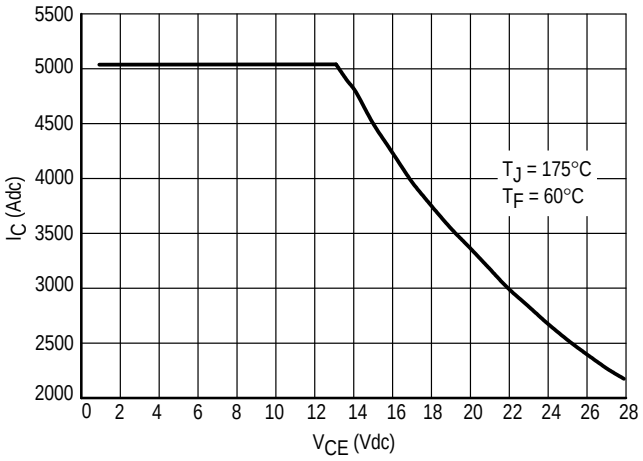



**Figure 4. DC SOA (This device is MTBF limited for $V_{CE}$ < 14 Vdc; total $I_C$ for both halves operating.)**

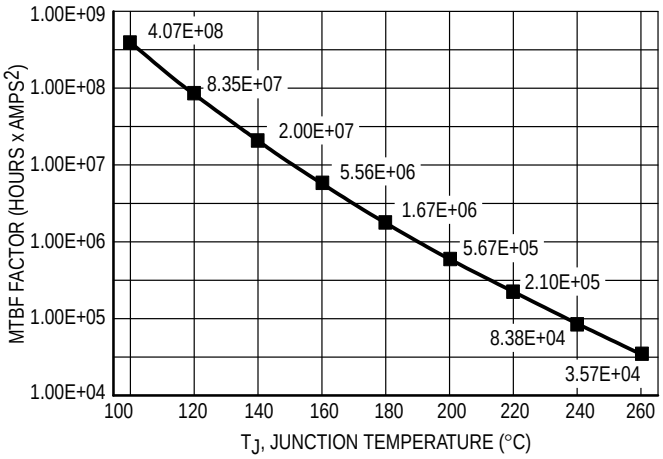



**Figure 5. MTBF Factor versus Junction Temperature**

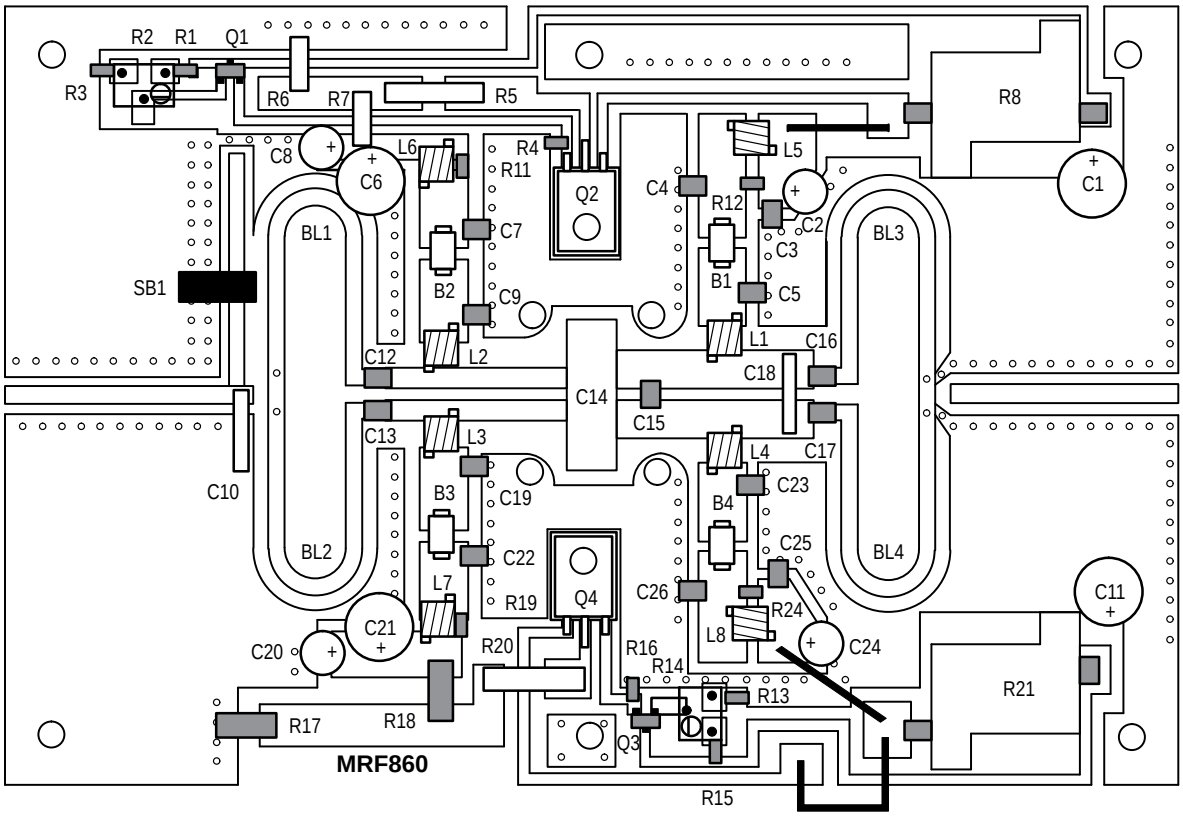
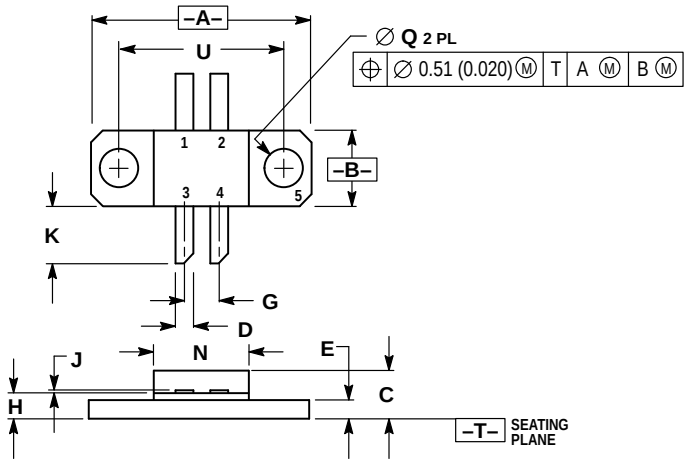



**Figure 6. MRF860 Test Fixture Component Layout**

## PACKAGE DIMENSIONS




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

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.739 | 0.750 | 18.77 | 19.05 |
| B | 0.240 | 0.260 | 6.10 | 6.60 |
| C | 0.165 | 0.198 | 4.19 | 5.03 |
| D | 0.055 | 0.065 | 1.40 | 1.65 |
| E | 0.055 | 0.070 | 1.40 | 1.78 |
| G | 0.110 | 0.130 | 2.79 | 3.30 |
| H | 0.079 | 0.091 | 2.01 | 2.31 |
| J | 0.003 | 0.005 | 0.08 | 0.13 |
| K | 0.180 | 0.220 | 4.57 | 5.59 |
| N | 0.315 | 0.330 | 8.00 | 8.38 |
| Q | 0.125 | 0.135 | 3.18 | 3.42 |
| U | 0.560 BSC | | 14.22 BSC | |

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

**CASE 395B–01**
**ISSUE A**



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