## The RF Line

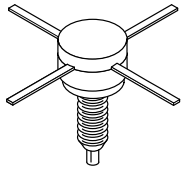
# NPN Silicon High-Frequency Transistor

**MRF587**

. . . designed for use in high–gain, low–noise, ultra–linear, tuned and wideband amplifiers. Ideal for use in CATV, MATV, and instrumentation applications.

- Low Noise Figure —
  NF = 3.0 dB (Typ) @ f = 500 MHz, $I_C$ = 90 mA
- High Power Gain —
  $G_{U(max)}$ = 16.5 dB (Typ) @ f = 500 MHz
- Ion Implanted
- All Gold Metal System
- High $f_T$ — 5.5 GHz
- Low Intermodulation Distortion:
  $TB_3$ = –70 dB
  DIN = 125 dB μV
- Nichrome Emitter Ballast Resistors

**NF = 3.0 dB @ 0.5 GHz**
**HIGH–FREQUENCY TRANSISTOR**
**NPN SILICON**



**CASE 244A–01, STYLE 1**

**MAXIMUM RATINGS**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Collector–Emitter Voltage | $V_{CEO}$ | 17 | Vdc |
| Collector–Base Voltage | $V_{CBO}$ | 34 | Vdc |
| Emitter–Base Voltage | $V_{EBO}$ | 2.5 | Vdc |
| Collector Current — Continuous | $I_C$ | 200 | mAdc |
| Total Device Dissipation @ $T_C$ = 50°C<br>Derate above $T_C$ = 50°C | $P_D$ | 5.0<br>33 | Watts<br>mW/°C |
| Storage Temperature Range | $T_{stg}$ | – 65 to +150 | °C |
| Junction Temperature | $T_J$ | 200 | °C |

**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted.)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| Collector–Emitter Breakdown Voltage ($I_C$ = 5.0 mAdc, $I_B$ = 0) | $V_{(BR)CEO}$ | 17 | — | — | Vdc |
| Collector–Base Breakdown Voltage ($I_C$ = 1.0 mAdc, $I_E$ = 0) | $V_{(BR)CBO}$ | 34 | — | — | Vdc |
| Emitter–Base Breakdown Voltage ($I_C$ = 0, $I_E$ = 0.1 mAdc) | $V_{(BR)EBO}$ | 2.5 | — | — | Vdc |
| Collector Cutoff Current ($V_{CB}$ = 10 Vdc, $I_E$ = 0) | $I_{CBO}$ | — | — | 50 | μAdc |
| **ON CHARACTERISTICS** | | | | | |
| DC Current Gain (1) ($I_C$ = 50 mAdc, $V_{CE}$ = 5.0 Vdc) | $h_{FE}$ | 50 | — | 200 | — |

NOTE:
1. 300 μs pulse on Tektronix 576 or equivalent.

(continued)

**ELECTRICAL CHARACTERISTICS — continued** ($T_C$ = 25°C unless otherwise noted.)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **DYNAMIC CHARACTERISTICS** | | | | | |
| Current–Gain — Bandwidth Product (2)<br>($I_C$ = 90 mAdc, $V_{CE}$ = 15 Vdc, f = 0.5 GHz) | $f_T$ | — | 5.5 | — | GHz |
| Collector–Base Capacitance<br>($V_{CB}$ = 10 Vdc, $I_E$ = 0, f = 1.0 MHz) | $C_{cb}$ | — | 1.7 | 2.2 | pF |
| **FUNCTIONAL TESTS** | | | | | |
| Narrowband — Figure 15<br>($I_C$ = 90 mA, $V_{CC}$ = 15 V, f = 0.5 GHz)<br>Noise Figure<br>Power Gain at Optimum Noise Figure | <br><br>NF<br>$G_{NF}$ | <br><br>—<br>11 | <br><br>3.0<br>13 | <br><br>4.0<br>— | dB |
| Broadband — Figure 16<br>($I_C$ = 90 mA, $V_{CC}$ = 15 V, f = 0.3 GHz)<br>Noise Figure<br>Power Gain at Optimum Noise Figure | <br><br>NF<br>$G_{NF}$ | <br><br>—<br>— | <br><br>6.3<br>11 | <br><br>—<br>— | dB |
| Triple Beat Distortion<br>($I_C$ = 50 mA, $V_{CC}$ = 15 V, $P_{Ref}$ = 50 dBmV)<br>($I_C$ = 90 mA, $V_{CC}$ = 15 V, $P_{Ref}$ = 50 dBmV) | $TB_3$ | — | –70 | — | dB |
| DIN 45004<br>($I_C$ = 90 mA, $V_{CC}$ = 15 V)<br>($I_C$ = 90 mA, $V_{CC}$ = 15 V) | DIN | — | 125 | — | dBμV |
| Maximum Available Power Gain (3)<br>($I_C$ = 90 mA, $V_{CE}$ = 15 Vdc, f = 0.5 GHz) | $G_{Umax}$ | — | 16.5 | — | dB |

NOTES:

2. Characterized on HP8542 Automatic Network Analyzer

3. $G_{Umax} = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

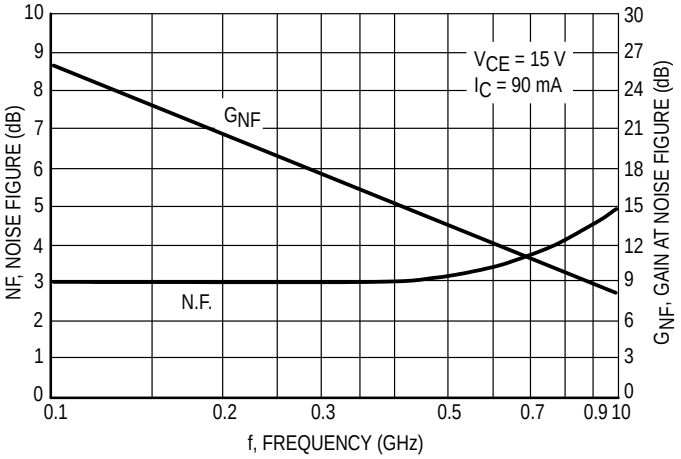



**Figure 1. Typical Noise Figure and Associated Gain versus Frequency**

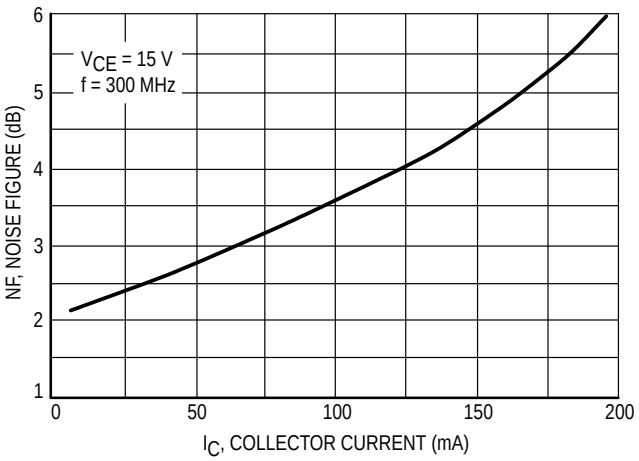



**Figure 2. Noise Figure versus Collector Current**

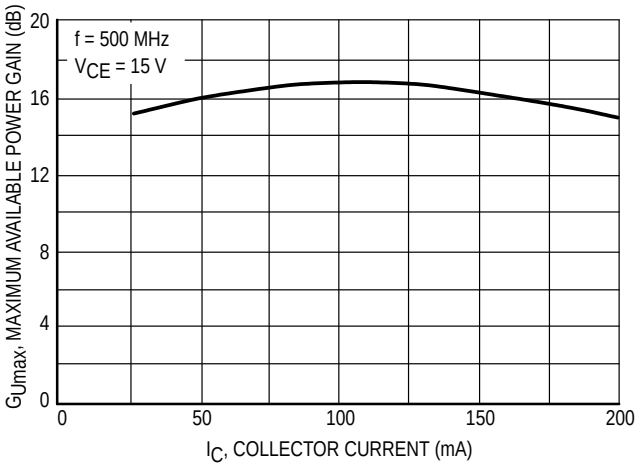



**Figure 3. $G_{Umax}$ versus Collector Current**

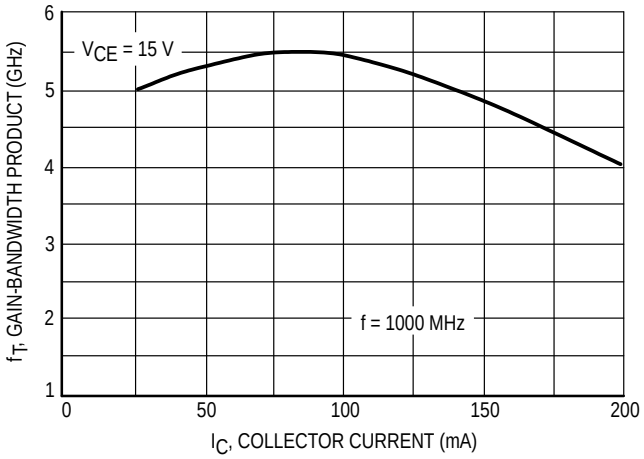



**Figure 4. Gain–Bandwidth Product versus Collector Current**

## TYPICAL PERFORMANCE

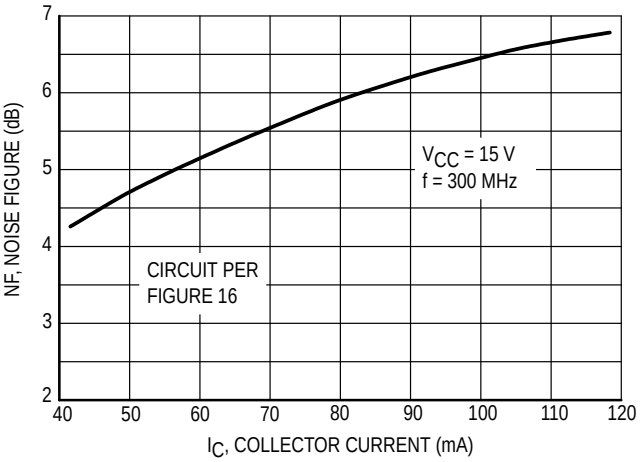



**Figure 5. Broadband Noise Figure**

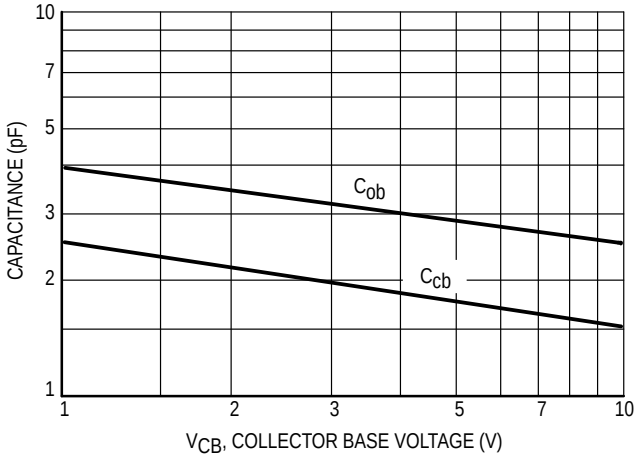



**Figure 6. Junction Capacitance versus Voltage**

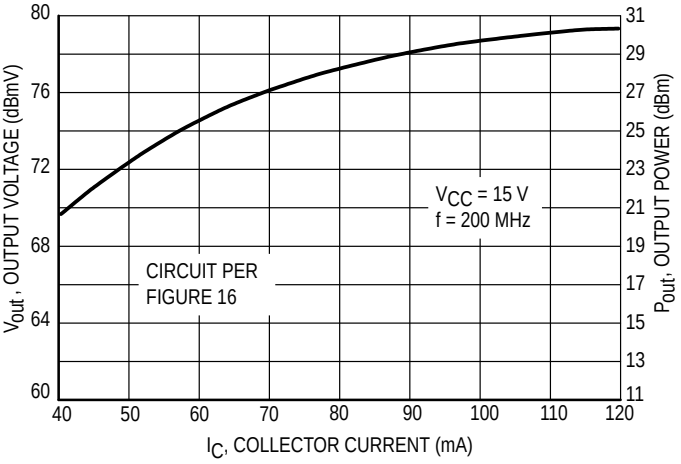



**Figure 7. 1.0 dB Compression Point versus Collector Current**

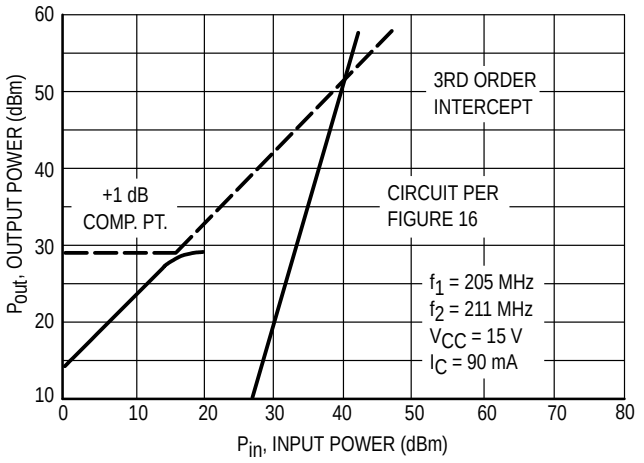



**Figure 8. Third Order Intercept Point**

## TYPICAL PERFORMANCE (continued)

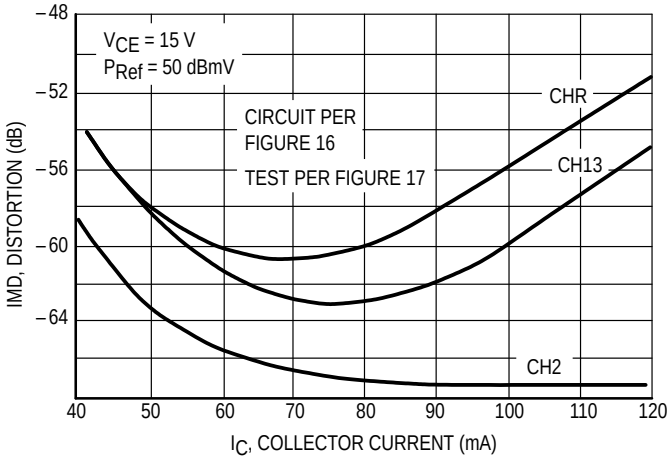



**Figure 9. Second Order Distortion versus Collector Current**

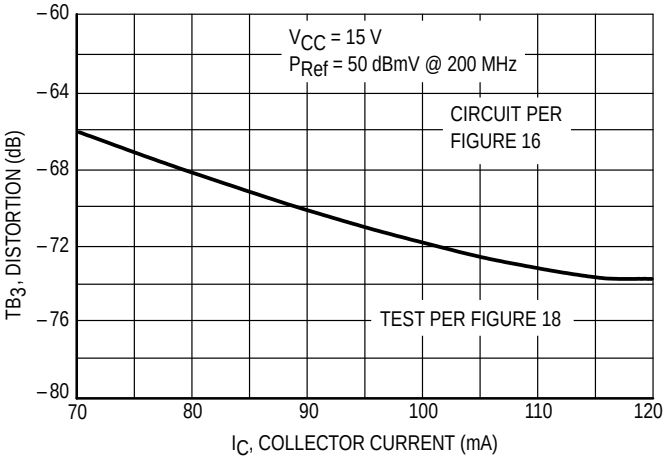



**Figure 10. Triple Beat Distortion versus Collector Current**

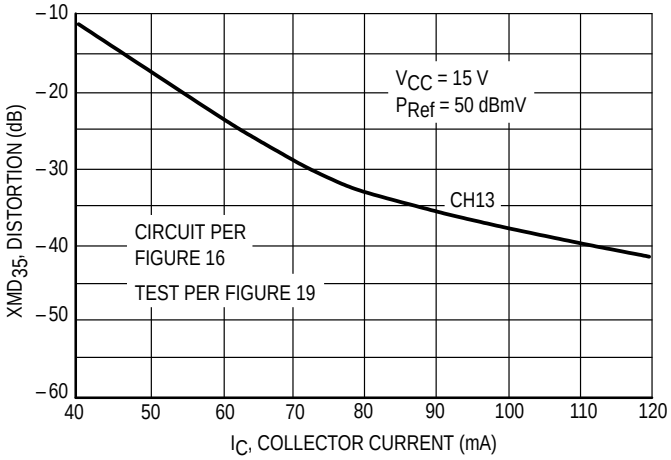



**Figure 11. 35–Channel X–Modulation Distortion versus Collector Current**

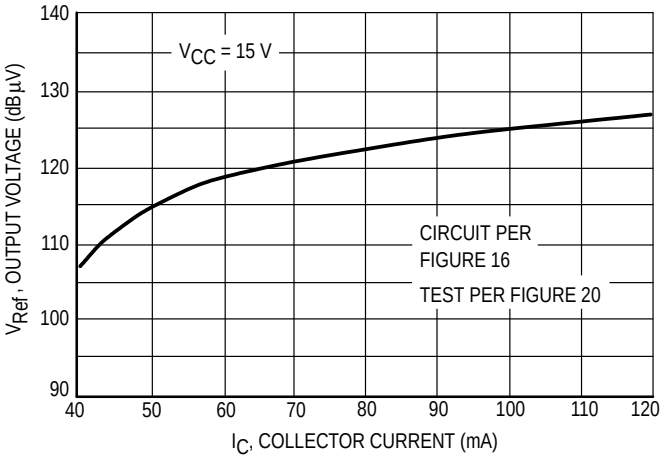



**Figure 12. DIN 45004B versus Collector Current**

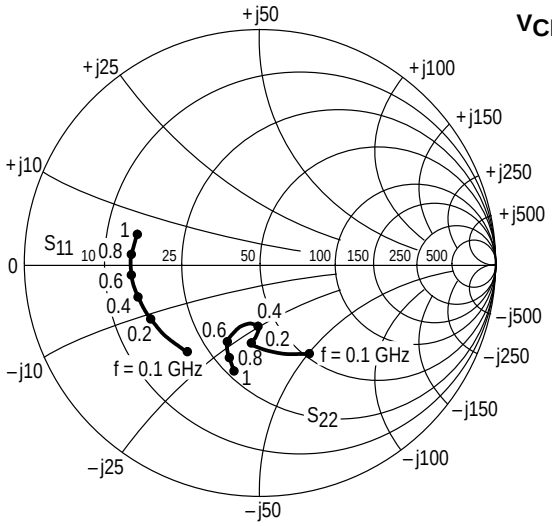



**Figure 13. Input/Output Reflection Coefficient versus Frequency (GHz)**

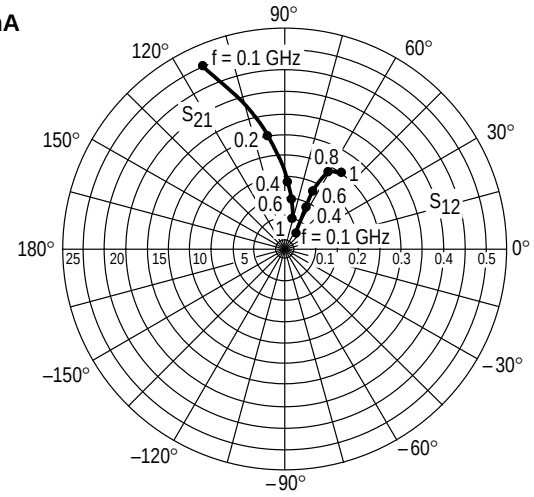



**Figure 14. Forward/Reverse Transmission Coefficients versus Frequency (GHz)**

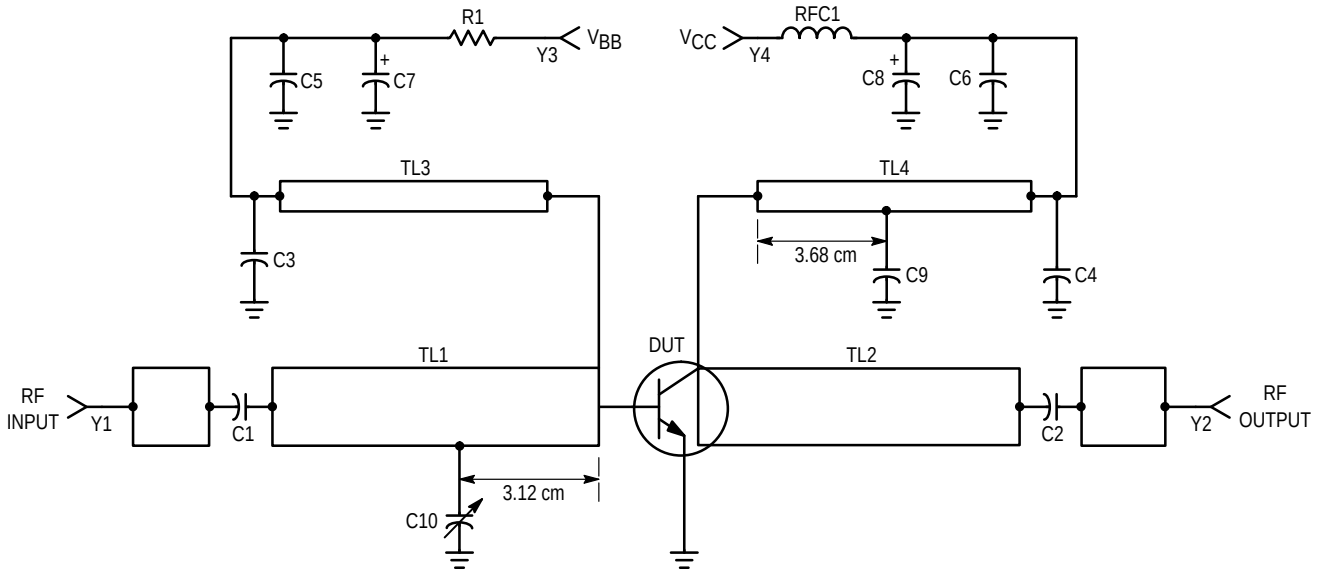
| $V_{CE}$ (Volts) | $I_C$ (mA) | f (MHz) | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\|S_{11}\|$ | $\phi$ | $\|S_{21}\|$ | $\phi$ | $\|S_{12}\|$ | $\phi$ | $\|S_{22}\|$ | $\phi$ |
| 5.0 | 30 | 100 | 0.56 | −131 | 16.45 | 113 | 0.04 | 45 | 0.49 | −91 |
| | | 200 | 0.58 | −159 | 9.42 | 98 | 0.06 | 49 | 0.38 | −116 |
| | | 400 | 0.60 | −178 | 5.00 | 86 | 0.08 | 55 | 0.35 | −132 |
| | | 600 | 0.64 | 170 | 3.61 | 76 | 0.11 | 56 | 0.38 | −138 |
| | | 800 | 0.67 | 162 | 2.92 | 67 | 0.14 | 55 | 0.41 | −144 |
| | | 1000 | 0.70 | 155 | 2.55 | 58 | 0.17 | 54 | 0.44 | −152 |
| | 60 | 100 | 0.53 | −141 | 17.89 | 110 | 0.04 | 50 | 0.47 | −102 |
| | | 200 | 0.56 | −164 | 10.05 | 97 | 0.05 | 55 | 0.39 | −126 |
| | | 400 | 0.59 | 178 | 5.31 | 85 | 0.09 | 60 | 0.38 | −141 |
| | | 600 | 0.63 | 169 | 3.82 | 76 | 0.12 | 59 | 0.40 | −146 |
| | | 800 | 0.66 | 161 | 3.09 | 67 | 0.15 | 57 | 0.44 | −153 |
| | | 1000 | 0.69 | 155 | 2.67 | 58 | 0.18 | 55 | 0.47 | −160 |
| | 90 | 100 | 0.52 | −145 | 18.26 | 109 | 0.04 | 52 | 0.47 | −106 |
| | | 200 | 0.56 | −166 | 10.20 | 96 | 0.05 | 57 | 0.39 | −130 |
| | | 400 | 0.59 | 177 | 5.38 | 85 | 0.09 | 62 | 0.39 | −144 |
| | | 600 | 0.63 | 168 | 3.86 | 76 | 0.12 | 60 | 0.41 | −149 |
| | | 800 | 0.66 | 161 | 3.12 | 67 | 0.15 | 58 | 0.45 | −155 |
| | | 1000 | 0.69 | 155 | 2.70 | 58 | 0.19 | 55 | 0.48 | −162 |
| 10 | 30 | 100 | 0.53 | −122 | 18.36 | 115 | 0.04 | 48 | 0.50 | −75 |
| | | 200 | 0.53 | −153 | 10.63 | 100 | 0.05 | 51 | 0.36 | −96 |
| | | 400 | 0.55 | 175 | 5.71 | 87 | 0.08 | 57 | 0.33 | −112 |
| | | 600 | 0.59 | 173 | 4.16 | 78 | 0.10 | 58 | 0.35 | −119 |
| | | 800 | 0.62 | 165 | 3.37 | 68 | 0.13 | 57 | 0.39 | −127 |
| | | 1000 | 0.65 | 158 | 2.95 | 59 | 0.15 | 55 | 0.42 | −136 |
| | 60 | 100 | 0.49 | −132 | 20.19 | 112 | 0.03 | 51 | 0.46 | −85 |
| | | 200 | 0.51 | −158 | 11.54 | 99 | 0.05 | 57 | 0.35 | −107 |
| | | 400 | 0.53 | −178 | 6.12 | 87 | 0.08 | 61 | 0.33 | −123 |
| | | 600 | 0.58 | 171 | 4.43 | 78 | 0.11 | 60 | 0.36 | −129 |
| | | 800 | 0.60 | 164 | 3.58 | 68 | 0.14 | 59 | 0.40 | −136 |
| | | 1000 | 0.63 | 157 | 3.12 | 60 | 0.16 | 57 | 0.44 | −144 |
| | 90 | 100 | 0.48 | −135 | 20.82 | 111 | 0.03 | 53 | 0.45 | −88 |
| | | 200 | 0.50 | −160 | 11.77 | 98 | 0.05 | 59 | 0.34 | −111 |
| | | 400 | 0.53 | −179 | 6.22 | 86 | 0.08 | 63 | 0.33 | −126 |
| | | 600 | 0.57 | 171 | 4.50 | 78 | 0.11 | 62 | 0.36 | −131 |
| | | 800 | 0.60 | 164 | 3.64 | 68 | 0.14 | 59 | 0.41 | −139 |
| | | 1000 | 0.63 | 157 | 3.18 | 60 | 0.17 | 57 | 0.44 | −147 |

(continued)

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

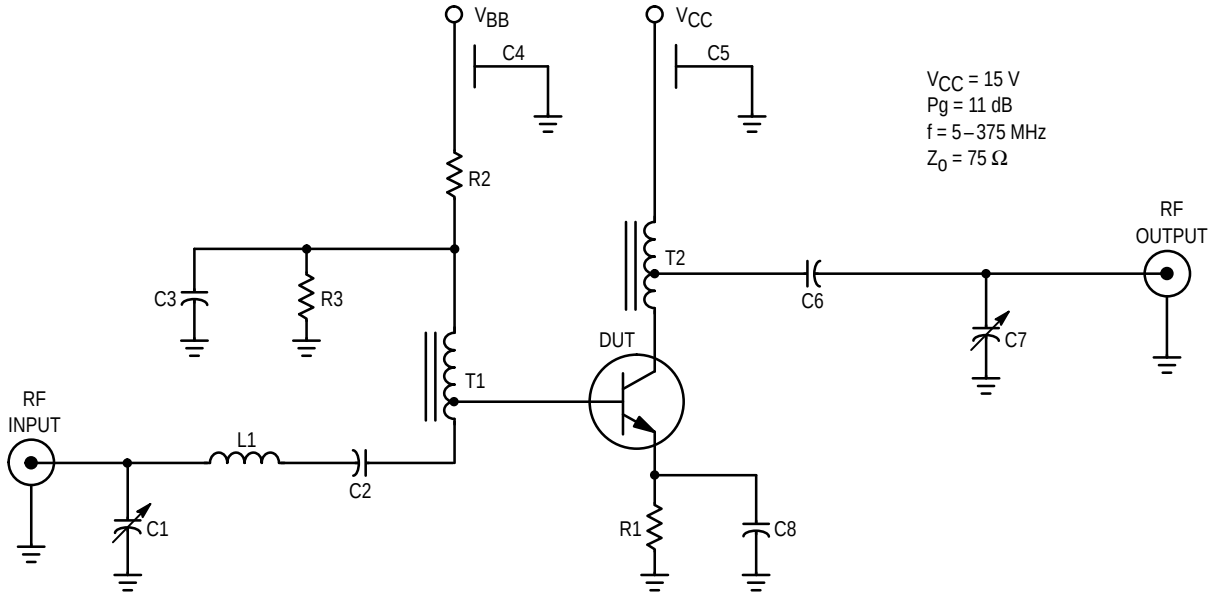
| $V_{CE}$ (Volts) | $I_C$ (mA) | f (MHz) | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\|S_{11}\|$ | $\phi$ | $\|S_{21}\|$ | $\phi$ | $\|S_{12}\|$ | $\phi$ | $\|S_{22}\|$ | $\phi$ |
| 15 | 30 | 100 | 0.49 | −112 | 20.34 | 118 | 0.04 | 54 | 0.51 | −52 |
| | | 200 | 0.52 | −145 | 11.51 | 101 | 0.05 | 56 | 0.36 | −77 |
| | | 400 | 0.48 | −164 | 6.12 | 87 | 0.09 | 63 | 0.32 | −74 |
| | | 600 | 0.52 | −174 | 4.19 | 75 | 0.12 | 62 | 0.32 | −90 |
| | | 800 | 0.53 | 177 | 3.29 | 68 | 0.16 | 61 | 0.38 | −90 |
| | | 1000 | 0.53 | 168 | 2.76 | 61 | 0.20 | 56 | 0.47 | −90 |
| | 60 | 100 | 0.45 | −122 | 22.14 | 115 | 0.03 | 56 | 0.45 | −60 |
| | | 200 | 0.49 | −150 | 12.24 | 99 | 0.05 | 60 | 0.33 | −86 |
| | | 400 | 0.45 | −166 | 6.45 | 86 | 0.09 | 65 | 0.30 | −83 |
| | | 600 | 0.50 | −175 | 4.42 | 75 | 0.13 | 63 | 0.32 | −99 |
| | | 800 | 0.51 | 177 | 3.47 | 68 | 0.16 | 61 | 0.38 | −98 |
| | | 1000 | 0.51 | 168 | 2.91 | 62 | 0.20 | 55 | 0.46 | −96 |
| | 90 | 100 | 0.44 | −127 | 22.76 | 114 | 0.03 | 58 | 0.43 | −62 |
| | | 200 | 0.48 | −152 | 12.44 | 98 | 0.05 | 62 | 0.32 | −89 |
| | | 400 | 0.44 | −167 | 6.55 | 85 | 0.09 | 66 | 0.29 | −85 |
| | | 600 | 0.50 | −176 | 4.47 | 75 | 0.13 | 64 | 0.32 | −102 |
| | | 800 | 0.51 | 176 | 3.51 | 69 | 0.17 | 61 | 0.38 | −100 |
| | | 1000 | 0.51 | 168 | 2.95 | 62 | 0.20 | 55 | 0.46 | −98 |

**Table 1. Common–Emitter S–Parameters (continued)**




C1, C2 — 470 pF Chip (Ceramic)
C3, C4 — 0.018 μF Chip Capacitor
C5, C6 — 0.1 μF Mylar
C7, C8 — 1.0 μF, 25 Vdc Electrolytic
C9 — 91 pF Mini–Unelco (C9 Taped 3.68 cm from Collector Connection on TL4 as shown)
C10 — 35–45 pF Johanson Ceramic Capacitor, JMC 5801 or Equivalent (C10 Taped 3.12 cm from Base Connection on TL1)
R1 — 2.7 kΩ, 1–1/2 W
RFC1 — 0.15 μH Molded Choke
TL1, TL2 — $Z_O$ = 26 Ω, 0.0625 TFG as shown in Photomaster
TL3, TL4 — λ/4 Microstrip, $Z_O$ = 100 Ω
Y1, Y2 — N–Type Connection (Female)
Y3, Y4 — BNC–Type Connector (Female)
Board Material — 0.0625″ Thick Glass Teflon $\varepsilon_r$ = 2.5

**Figure 15. Narrowband Test Fixture Schematic**
**500 MHz**




C1, C7 — 0.5–10 pF
C2, C6 — 0.001 μF
C3 — 0.01 μF
C4, C5 — 0.01 μF Feedthru
C8 — 12 pF

R1 — 12 Ω 1.0 W (2.0–24 Ω on each emitter port)
R2 — 1.8 k 1/8 W
R3 — 2.2 k 1/8 W
L1 — 1 Turn 0.012 dia #22 AWG
T1(1) — 5 Turns Tapped at 2 Turns, #30 AWG
T2(1) — 8 Turns Tapped at 3 Turns, #30 AWG

(1) Ferroxcube 135 CT050 3D3 Material

**Figure 16. Broadband Test Circuit Schematic**

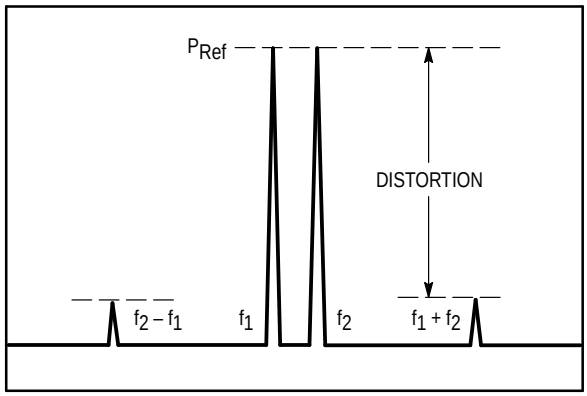



**Figure 17. Second Order Distortion Test**

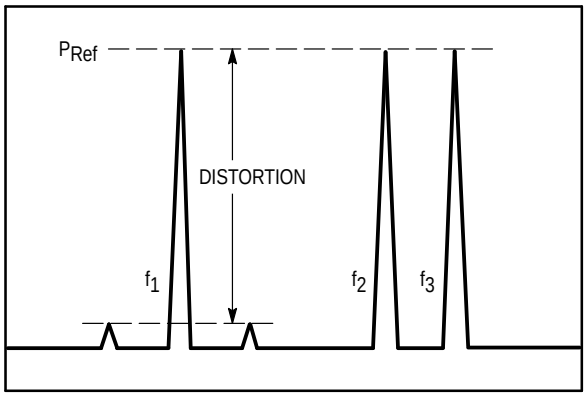



**Figure 18. Triple Beat Distortion Test**

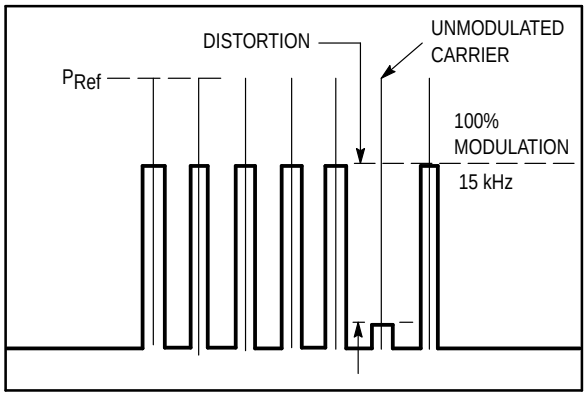



**Figure 19. Cross Modulation Distortion Test**

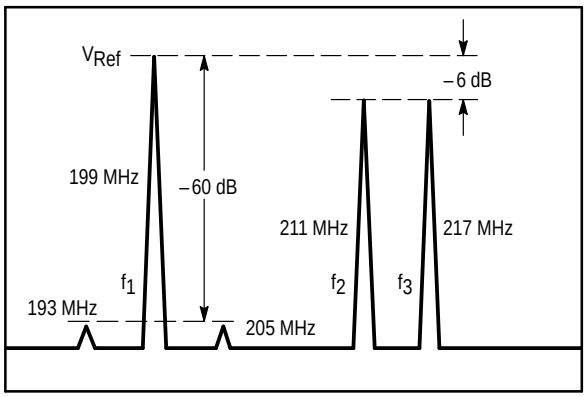
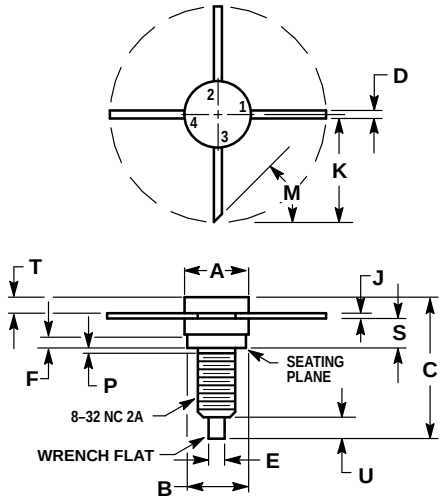



**Figure 20. DIN 45004B Intermodulation Test**

## PACKAGE DIMENSIONS




| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 7.06 | 7.26 | 0.278 | 0.286 |
| B | 6.20 | 6.50 | 0.244 | 0.256 |
| C | 15.24 | 16.51 | 0.600 | 0.650 |
| D | 0.66 | 0.86 | 0.026 | 0.034 |
| E | 1.40 | 1.65 | 0.055 | 0.065 |
| F | 1.52 | — | 0.060 | — |
| J | 0.10 | 0.15 | 0.004 | 0.006 |
| K | 11.17 | — | 0.440 | — |
| M | 45° NOM | | 45° NOM | |
| P | — | 1.27 | — | 0.050 |
| S | 2.74 | 3.35 | 0.108 | 0.132 |
| T | 1.40 | 1.78 | 0.055 | 0.070 |
| U | 2.92 | 3.68 | 0.115 | 0.145 |

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

**CASE 244A–01**
**ISSUE A**



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