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October 2014

2N3904 / MMBT3904 / PZT3904 NPN General-Purpose Amplifier

Description

This device is designed as a general-purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.



Ordering Information

| Part Number | Marking | Package | Packing Method | Pack Quantity |
|-------------|---------|------------|----------------|---------------|
| 2N3904BU | 2N3904 | TO-92 3L | Bulk | 10000 |
| 2N3904TA | 2N3904 | TO-92 3L | Ammo | 2000 |
| 2N3904TAR | 2N3904 | TO-92 3L | Ammo | 2000 |
| 2N3904TF | 2N3904 | TO-92 3L | Tape and Reel | 2000 |
| 2N3904TFR | 2N3904 | TO-92 3L | Tape and Reel | 2000 |
| MMBT3904 | 1A | SOT-23 3L | Tape and Reel | 3000 |
| PZT3904 | 3904 | SOT-223 4L | Tape and Reel | 2500 |

2N3904 / MMBT3904 / PZT3904 — NPN General-Purpose Amplifier

Absolute Maximum Ratings^{(1), (2)}

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Value | Unit |
|----------------|--|------------|------------------|
| V_{CEO} | Collector-Emitter Voltage | 40 | V |
| V_{CBO} | Collector-Base Voltage | 60 | V |
| V_{EBO} | Emitter-Base Voltage | 6.0 | V |
| I_C | Collector Current - Continuous | 200 | mA |
| T_J, T_{STG} | Operating and Storage Junction Temperature Range | -55 to 150 | $^\circ\text{C}$ |

Notes:

1. These ratings are based on a maximum junction temperature of 150°C .
2. These are steady-state limits. Fairchild Semiconductor should be consulted on applications involving pulsed or low-duty cycle operations.

Thermal Characteristics

Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Maximum | | | Unit |
|-----------------|---|---------|-------------------------|------------------------|----------------------------|
| | | 2N3904 | MMBT3904 ⁽³⁾ | PZT3904 ⁽⁴⁾ | |
| P_D | Total Device Dissipation | 625 | 350 | 1,000 | mW |
| | Derate Above 25°C | 5.0 | 2.8 | 8.0 | $\text{mW}/^\circ\text{C}$ |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | 83.3 | | | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 200 | 357 | 125 | $^\circ\text{C}/\text{W}$ |

Notes:

3. Device is mounted on FR-4 PCB 1.6 inch X 1.6 inch X 0.06 inch.
4. Device is mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm, mounting pad for the collector lead minimum 6 cm^2 .

Electrical Characteristics

Values are at $T_A = 25^\circ\text{C}$ unless otherwise noted.

| Symbol | Parameter | Conditions | Min. | Max. | Unit |
|---|--------------------------------------|--|------|------|------|
| OFF CHARACTERISTICS | | | | | |
| $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage | $I_C = 1.0\text{ mA}, I_B = 0$ | 40 | | V |
| $V_{(BR)CBO}$ | Collector-Base Breakdown Voltage | $I_C = 10\text{ }\mu\text{A}, I_E = 0$ | 60 | | V |
| $V_{(BR)EBO}$ | Emitter-Base Breakdown Voltage | $I_E = 10\text{ }\mu\text{A}, I_C = 0$ | 6.0 | | V |
| I_{BL} | Base Cut-Off Current | $V_{CE} = 30\text{ V}, V_{EB} = 3\text{ V}$ | | 50 | nA |
| I_{CEX} | Collector Cut-Off Current | $V_{CE} = 30\text{ V}, V_{EB} = 3\text{ V}$ | | 50 | nA |
| ON CHARACTERISTICS⁽⁵⁾ | | | | | |
| h_{FE} | DC Current Gain | $I_C = 0.1\text{ mA}, V_{CE} = 1.0\text{ V}$ | 40 | | |
| | | $I_C = 1.0\text{ mA}, V_{CE} = 1.0\text{ V}$ | 70 | | |
| | | $I_C = 10\text{ mA}, V_{CE} = 1.0\text{ V}$ | 100 | 300 | |
| | | $I_C = 50\text{ mA}, V_{CE} = 1.0\text{ V}$ | 60 | | |
| | | $I_C = 100\text{ mA}, V_{CE} = 1.0\text{ V}$ | 30 | | |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$ | | 0.2 | V |
| | | $I_C = 50\text{ mA}, I_B = 5.0\text{ mA}$ | | 0.3 | |
| $V_{BE(sat)}$ | Base-Emitter Saturation Voltage | $I_C = 10\text{ mA}, I_B = 1.0\text{ mA}$ | 0.65 | 0.85 | V |
| | | $I_C = 50\text{ mA}, I_B = 5.0\text{ mA}$ | | 0.95 | |
| SMALL SIGNAL CHARACTERISTICS | | | | | |
| f_T | Current Gain - Bandwidth Product | $I_C = 10\text{ mA}, V_{CE} = 20\text{ V},$ $f = 100\text{ MHz}$ | 300 | | MHz |
| C_{obo} | Output Capacitance | $V_{CB} = 5.0\text{ V}, I_E = 0,$ $f = 100\text{ kHz}$ | | 4.0 | pF |
| C_{ibo} | Input Capacitance | $V_{EB} = 0.5\text{ V}, I_C = 0,$ $f = 100\text{ kHz}$ | | 8.0 | pF |
| NF | Noise Figure | $I_C = 100\text{ }\mu\text{A}, V_{CE} = 5.0\text{ V},$ $R_S = 1.0\text{ k}\Omega,$ $f = 10\text{ Hz to }15.7\text{ kHz}$ | | 5.0 | dB |
| SWITCHING CHARACTERISTICS | | | | | |
| t_d | Delay Time | $V_{CC} = 3.0\text{ V}, V_{BE} = 0.5\text{ V}$ $I_C = 10\text{ mA}, I_{B1} = 1.0\text{ mA}$ | | 35 | ns |
| t_r | Rise Time | | | 35 | ns |
| t_s | Storage Time | $V_{CC} = 3.0\text{ V}, I_C = 10\text{ mA},$ $I_{B1} = I_{B2} = 1.0\text{ mA}$ | | 200 | ns |
| t_f | Fall Time | | | 50 | ns |

Note:

5. Pulse test: pulse width $\leq 300\text{ }\mu\text{s}$, duty cycle $\leq 2.0\%$.

Typical Performance Characteristics



Figure 1. Typical Pulsed Current Gain vs. Collector Current



Figure 2. Collector-Emitter Saturation Voltage vs. Collector Current



Figure 3. Base-Emitter Saturation Voltage vs. Collector Current



Figure 4. Base-Emitter On Voltage vs. Collector Current

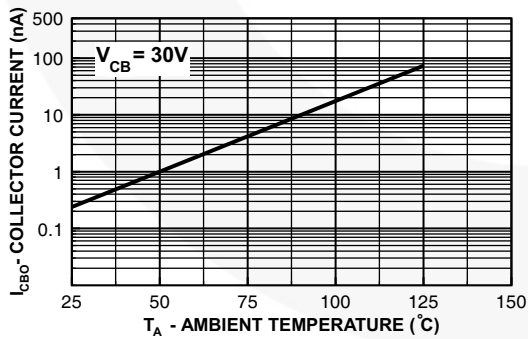


Figure 5. Collector Cut-Off Current vs. Ambient Temperature

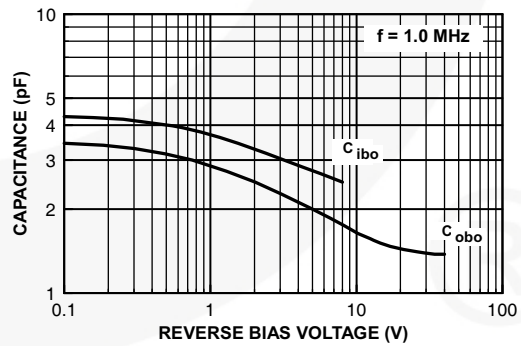


Figure 6. Capacitance vs. Reverse Bias Voltage

Typical Performance Characteristics (Continued)



Figure 7. Noise Figure vs. Frequency

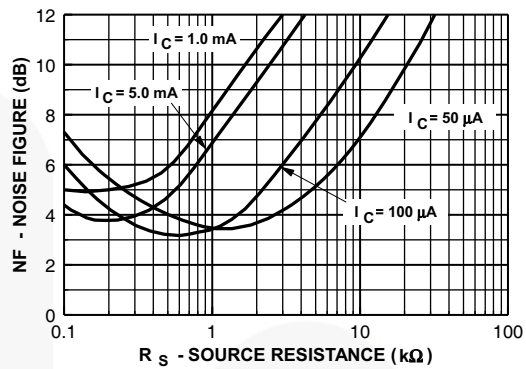


Figure 8. Noise Figure vs. Source Resistance



Figure 9. Current Gain and Phase Angle vs. Frequency

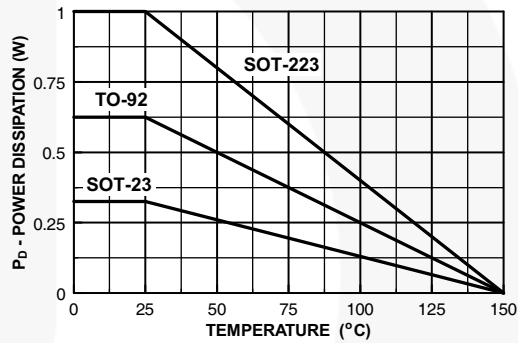


Figure 10. Power Dissipation vs. Ambient Temperature



Figure 11. Turn-On Time vs. Collector Current



Figure 12. Rise Time vs. Collector Current

Typical Performance Characteristics (Continued)

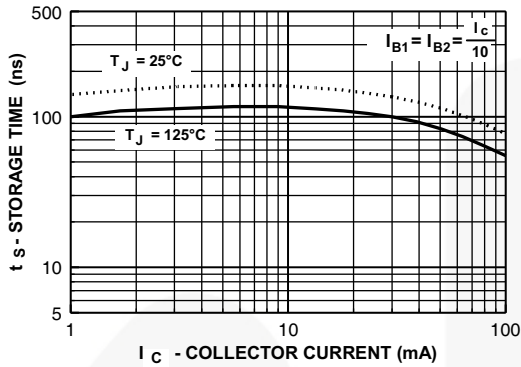


Figure 13. Storage Time vs. Collector Current



Figure 14. Fall Time vs. Collector Current



Figure 15. Current Gain



Figure 16. Output Admittance

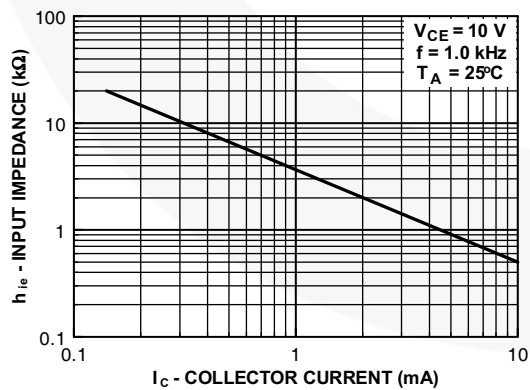


Figure 17. Input Impedance



Figure 18. Voltage Feedback Ratio

Test Circuits



Figure 19. Delay and Rise Time Equivalent Test Circuit



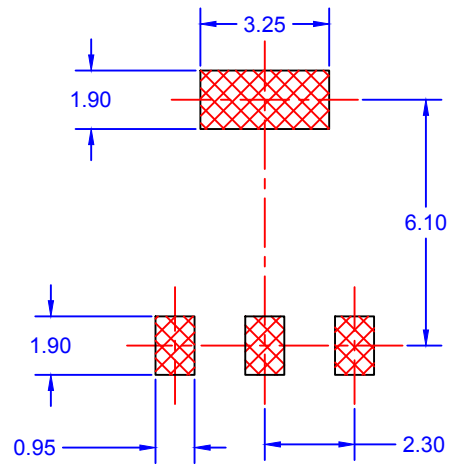
Figure 20. Storage and Fall Time Equivalent Test Circuit



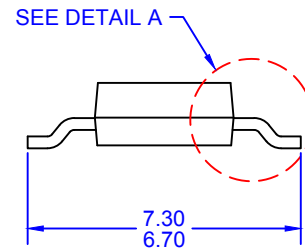
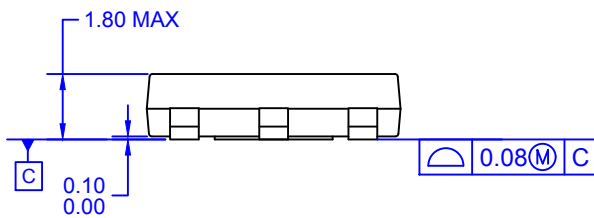


NOTES: UNLESS OTHERWISE SPECIFIED

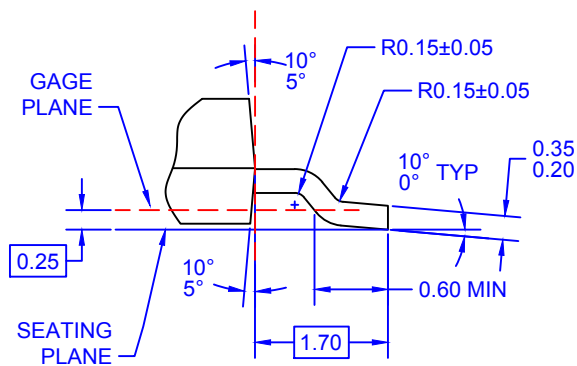
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- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. DRAWING CONFORMS TO ASME Y14.5M-2009.
- D. DRAWING FILENAME: MKT-ZA03FREV3.
- E. FAIRCHILD SEMICONDUCTOR.



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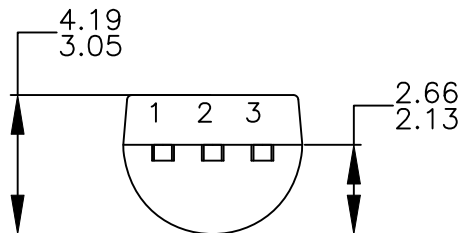


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 B) ALL DIMENSIONS ARE IN MILLIMETERS.
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DETAIL A
 SCALE: 2:1





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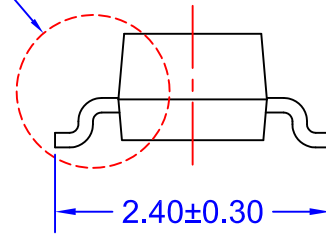




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SEE DETAIL A



DETAIL A
SCALE: 2X

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