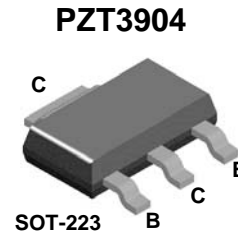
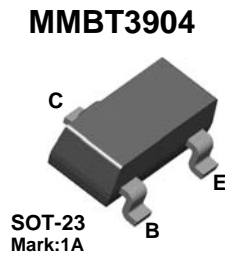
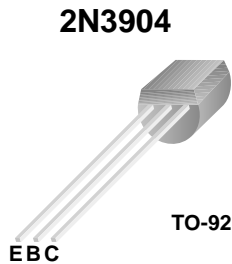


2N3904 / MMBT3904 / PZT3904 NPN General Purpose Amplifier

Features

- 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.



Absolute Maximum Ratings* $T_a = 25^\circ\text{C}$ unless otherwise noted

| Symbol | Parameter | Value | Units |
|----------------|--|-------------|------------------|
| 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 | $^\circ\text{C}$ |

* These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:

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

Thermal Characteristics $T_a = 25^\circ\text{C}$ unless otherwise noted

| Symbol | Parameter | Max. | | | Units |
|-----------------|---|--------|-----------|-----------|---------------------------|
| | | 2N3904 | *MMBT3904 | **PZT3904 | |
| P_D | Total Device Dissipation | 625 | 350 | 1,000 | mW |
| | Derate above 25°C | 5.0 | 2.8 | 8.0 | 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 | $^\circ\text{C}/\text{W}$ |

* Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06".

** Device mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm; mounting pad for the collector lead min. 6 cm².

Electrical Characteristics $T_a = 25^\circ\text{C}$ unless otherwise noted

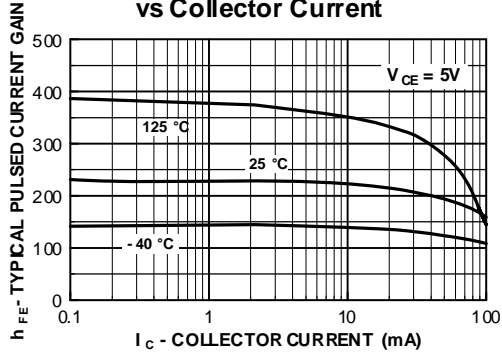
| Symbol | Parameter | Test Condition | Min. | Max. | Units |
|-------------------------------------|--------------------------------------|--|-----------------------------|--------------|--------|
| OFF CHARACTERISTICS | | | | | |
| $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage | $I_C = 1.0\text{mA},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

* Pulse Test: Pulse Width $\leq 300\mu\text{s}$, Duty Cycle $\leq 2.0\%$ **Ordering Information**

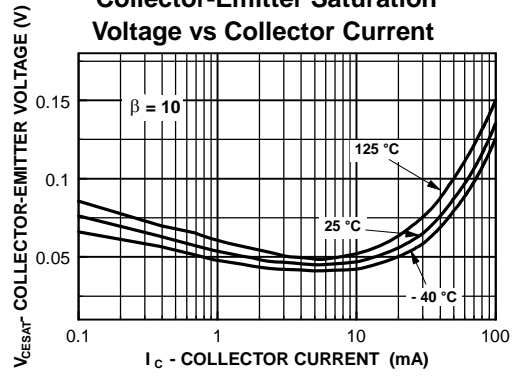
| Part Number | Marking | Package | Packing Method | Pack Qty |
|---------------|---------|---------|----------------|----------|
| 2N3904BU | 2N3904 | TO-92 | BULK | 10000 |
| 2N3904TA | 2N3904 | TO-92 | AMMO | 2000 |
| 2N3904TAR | 2N3904 | TO-92 | AMMO | 2000 |
| 2N3904TF | 2N3904 | TO-92 | TAPE REEL | 2000 |
| 2N3904TFR | 2N3904 | TO-92 | TAPE REEL | 2000 |
| MMBT3904 | 1A | SOT-23 | TAPE REEL | 3000 |
| MMBT3904_D87Z | 1A | SOT-23 | TAPE REEL | 10000 |
| PZT3904 | 3904 | SOT-223 | TAPE REEL | 2500 |

Typical Performance Characteristics

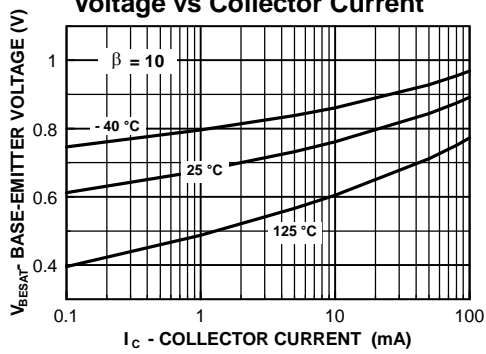
Typical Pulsed Current Gain vs Collector Current



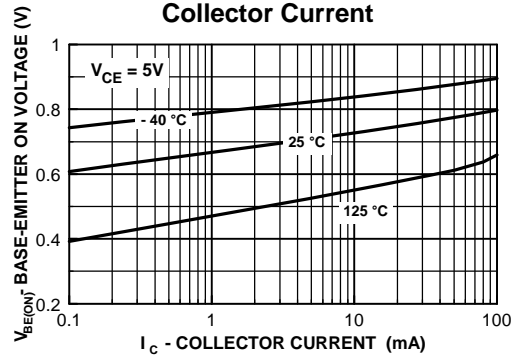
Collector-Emitter Saturation Voltage vs Collector Current



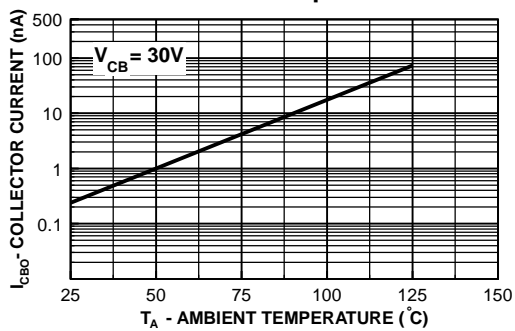
Base-Emitter Saturation Voltage vs Collector Current



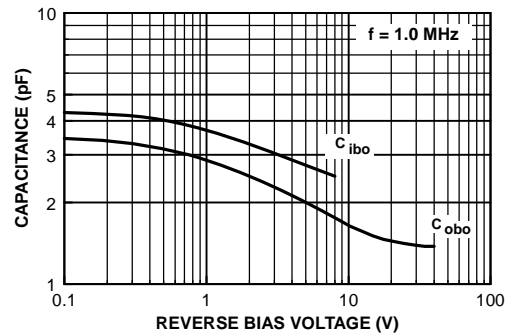
Base-Emitter ON Voltage vs Collector Current



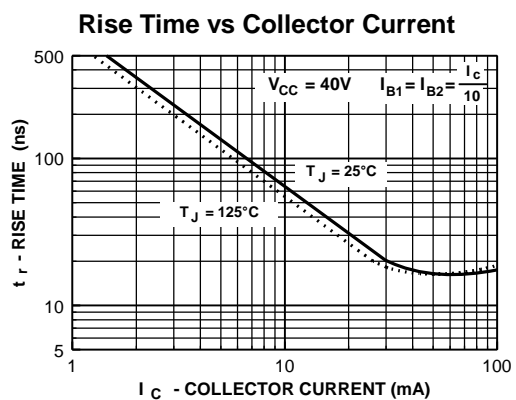
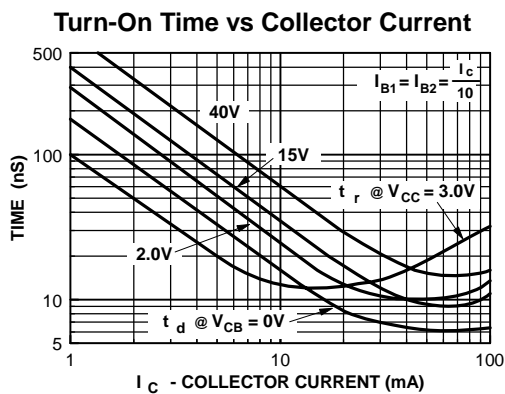
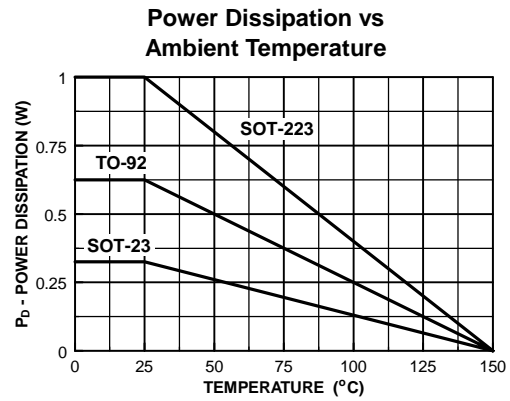
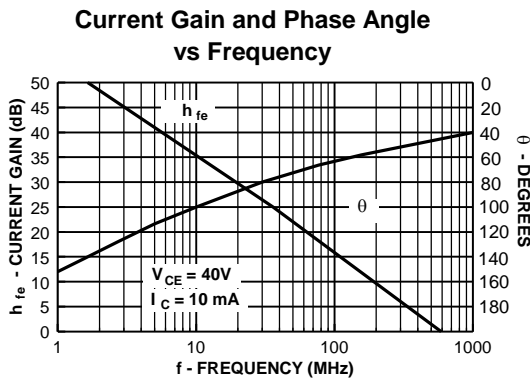
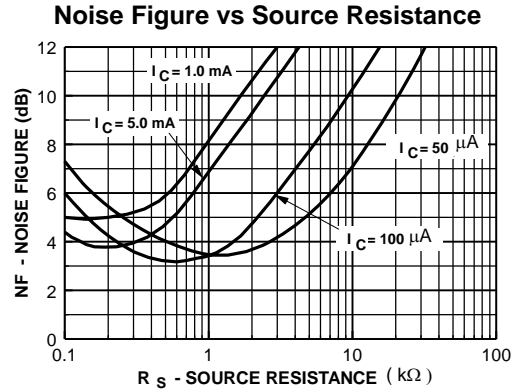
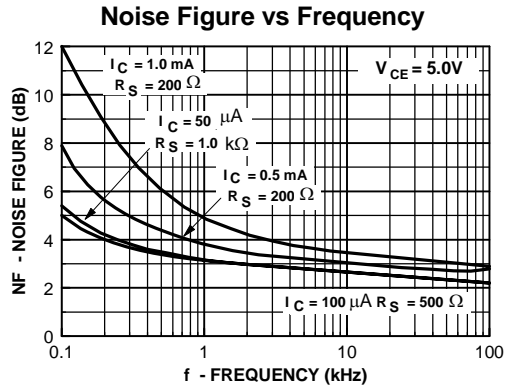
Collector-Cutoff Current vs Ambient Temperature



Capacitance vs Reverse Bias Voltage

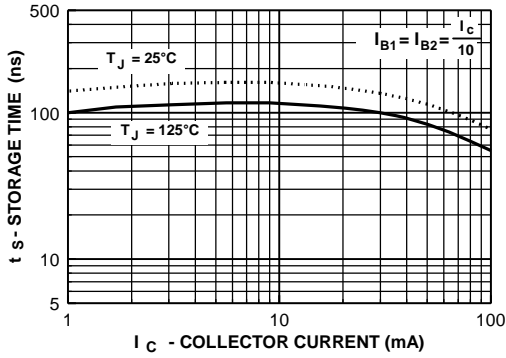


Typical Performance Characteristics (continued)

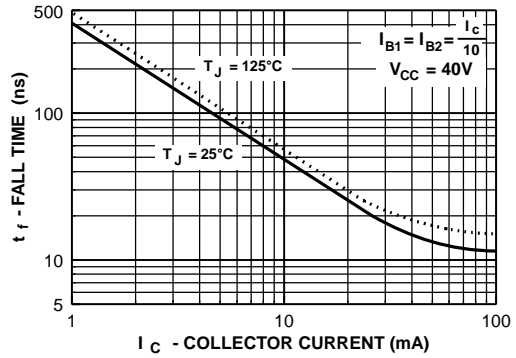


Typical Performance Characteristics (continued)

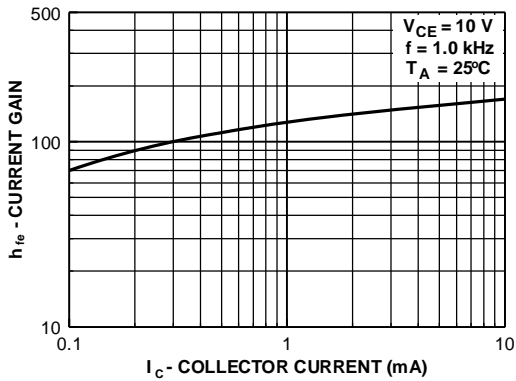
Storage Time vs Collector Current



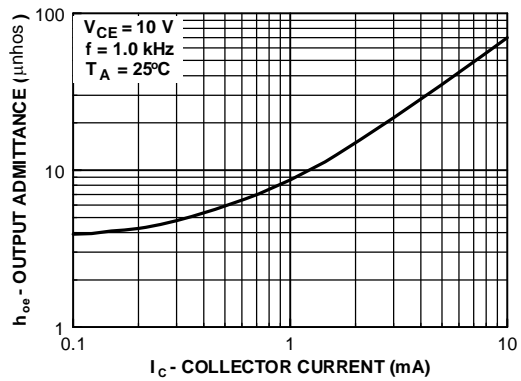
Fall Time vs Collector Current



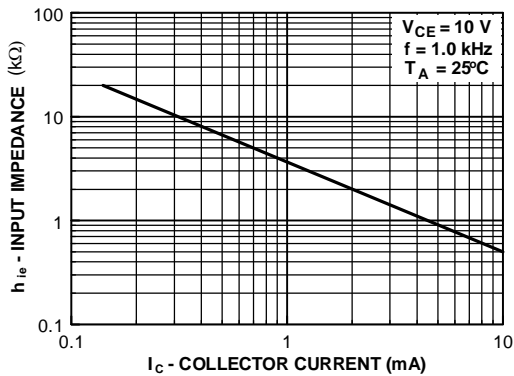
Current Gain



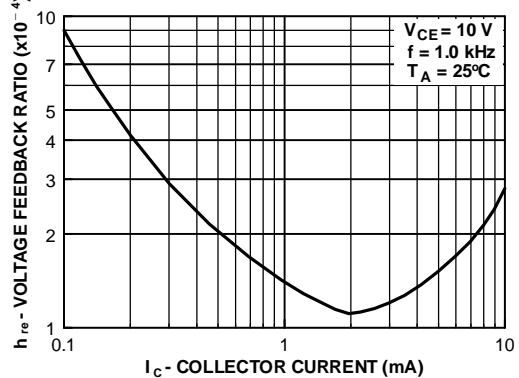
Output Admittance



Input Impedance



Voltage Feedback Ratio



Test Circuits

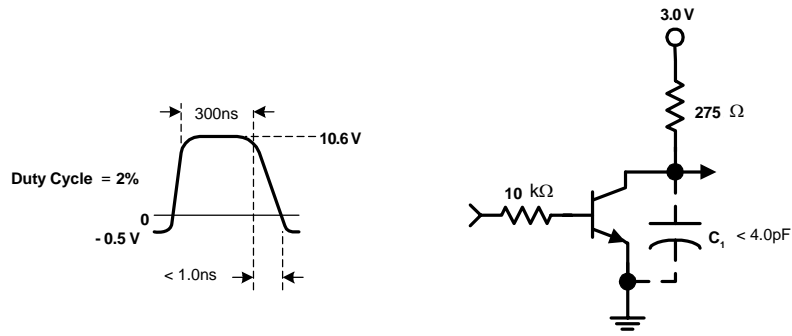


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

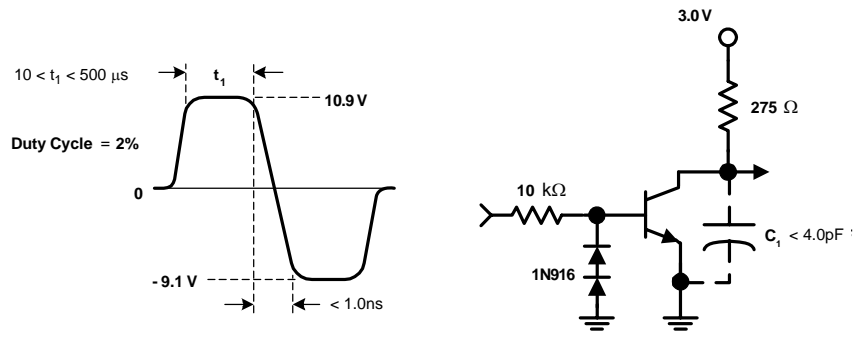






FIGURE 2: Storage and Fall Time Equivalent Test Circuit



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| Auto-SPM™ | FRFET® | PowerTrench® | franchise |
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| BitSiC® | Green FPS™ | Programmable Active Droop™ | TinyBuck™ |
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