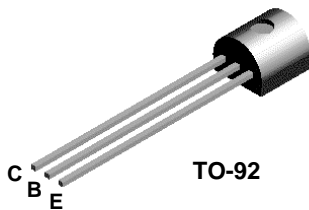
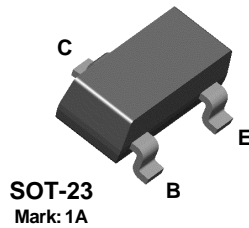


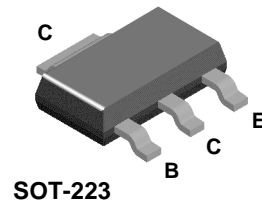
2N3904



MMBT3904



PZT3904



NPN General Purpose Amplifier

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_{CE0} | 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 | Characteristic | 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.

NPN General Purpose Amplifier

(continued)

Electrical Characteristics

$T_A = 25^\circ\text{C}$ unless otherwise noted

| Symbol | Parameter | Test Conditions | 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 | $I_C = 10\text{ }\mu\text{A}, I_E = 0$ | 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 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 | $I_C = 100\text{ }\mu\text{A}, V_{CE} = 5.0\text{ V},$ $R_S = 1.0\text{ k}\Omega, f = 10\text{ Hz to }15.7\text{ kHz}$ | | 5.0 | dB |

SWITCHING CHARACTERISTICS

| | | | | | |
|-------|--------------|---|--|-----|----|
| t_d | Delay Time | $V_{CC} = 3.0\text{ V}, V_{BE} = 0.5\text{ V},$ | | 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 |

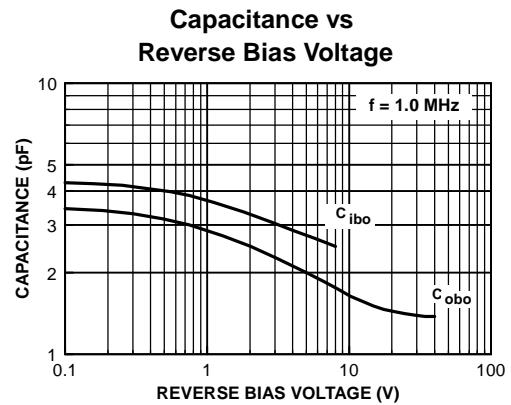
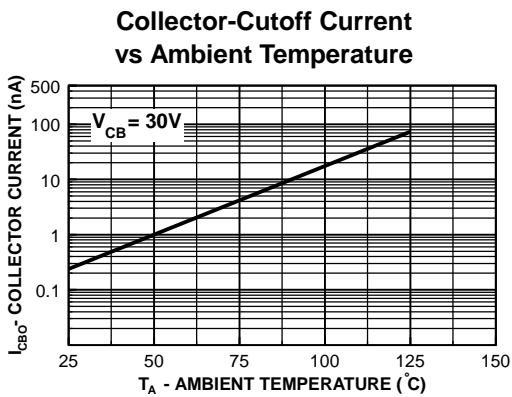
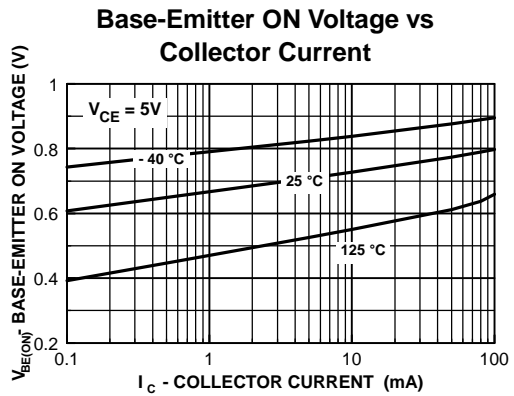
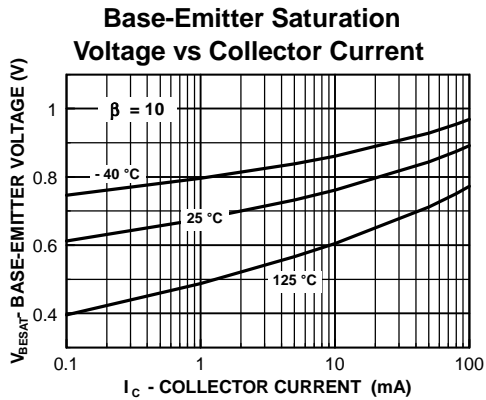
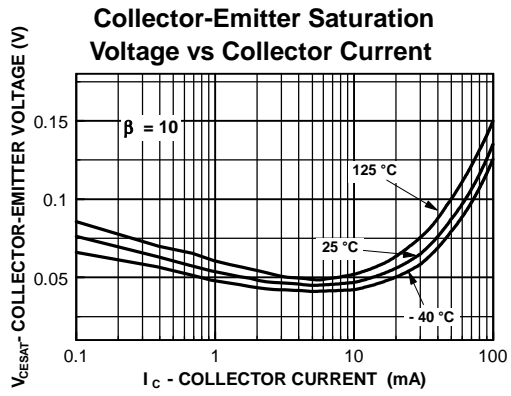
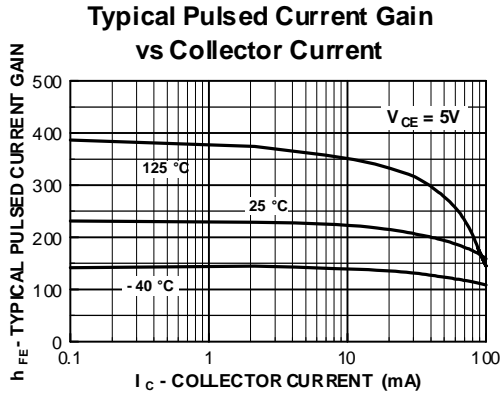
*Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$

Spice Model

NPN (Is=6.734f Xti=3 Eg=1.11 Vaf=74.03 Bf=416.4 Ne=1.259 Ise=6.734 Ikf=66.78m Xtb=1.5 Br=.7371 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=3.638p Mjc=.3085 Vjc=.75 Fc=.5 Cje=4.493p Mje=.2593 Vje=.75 Tr=239.5n Tf=301.2p Itf=.4 Vtf=4 Xtf=2 Rb=10)

2N3904 / MMBT3904 / PZT3904

Typical Characteristics



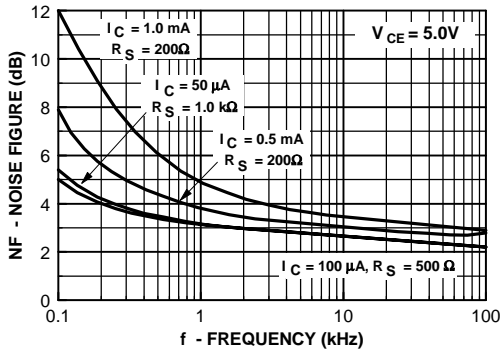
NPN General Purpose Amplifier

(continued)

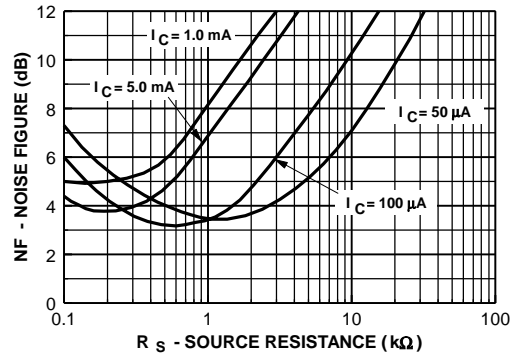
2N3904 / MMBT3904 / PZT3904

Typical Characteristics (continued)

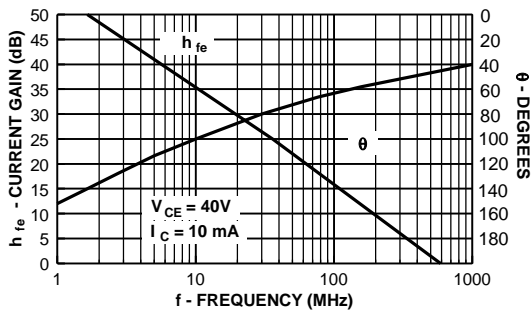
Noise Figure vs Frequency



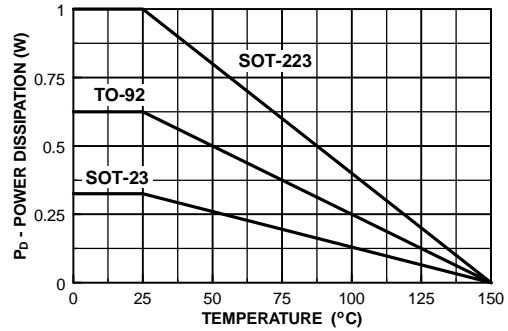
Noise Figure vs Source Resistance



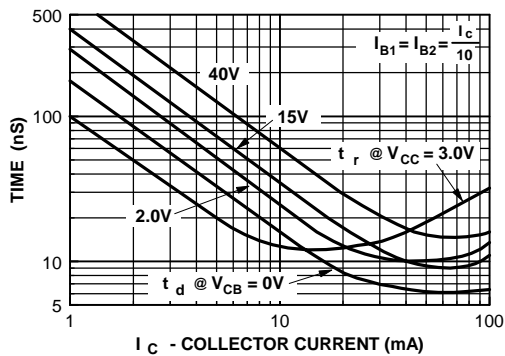
Current Gain and Phase Angle vs Frequency



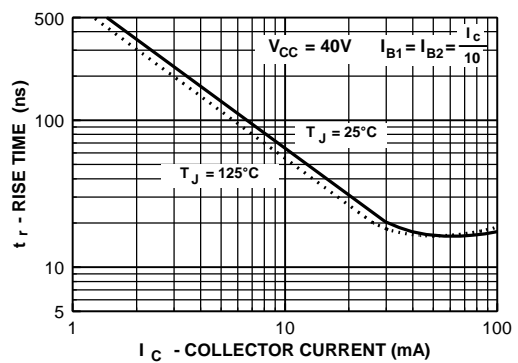
Power Dissipation vs Ambient Temperature



Turn-On Time vs Collector Current



Rise Time vs Collector Current



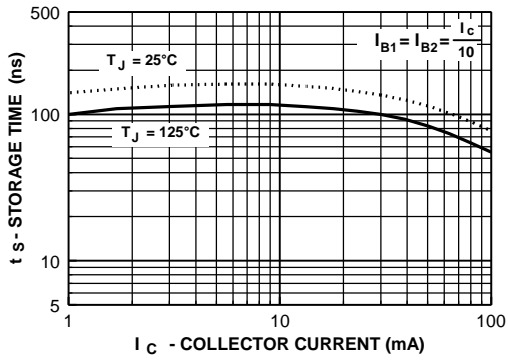
NPN General Purpose Amplifier

(continued)

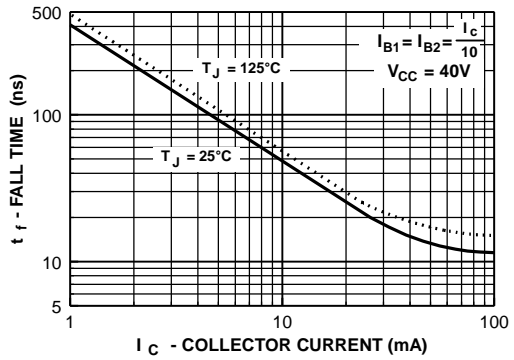
2N3904 / MMBT3904 / PZT3904

Typical Characteristics (continued)

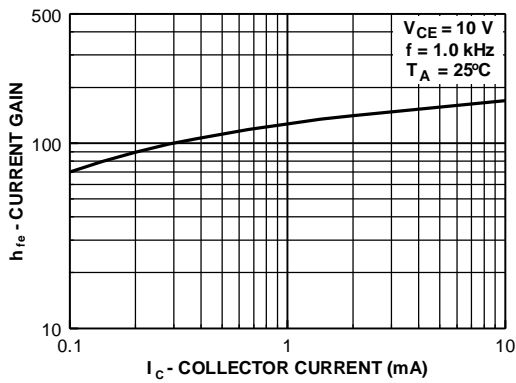
Storage Time vs Collector Current



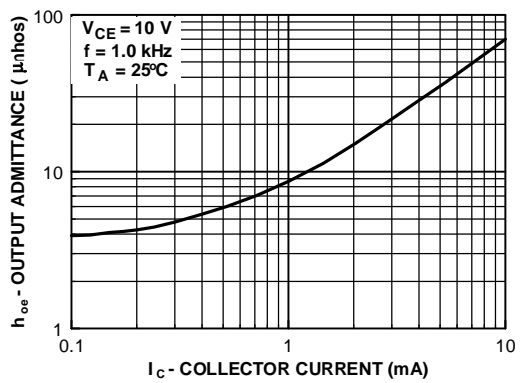
Fall Time vs Collector Current



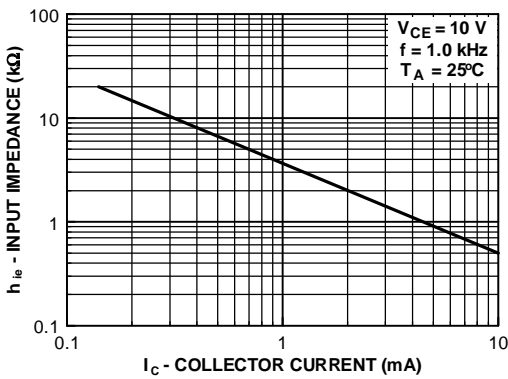
Current Gain



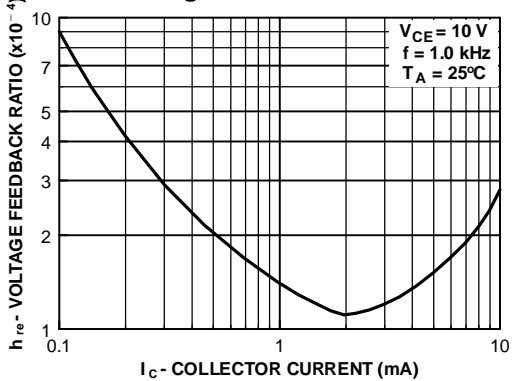
Output Admittance



Input Impedance



Voltage Feedback Ratio



Test Circuits

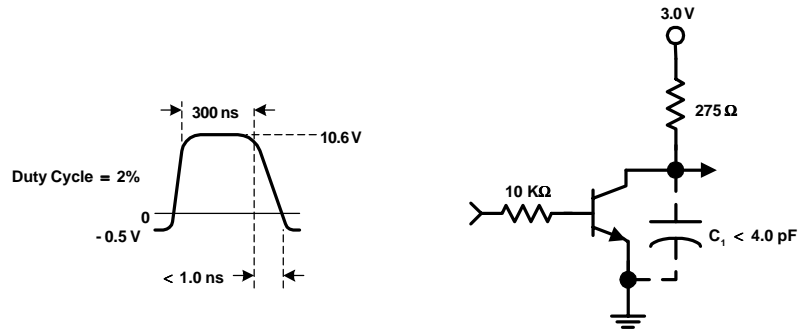


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

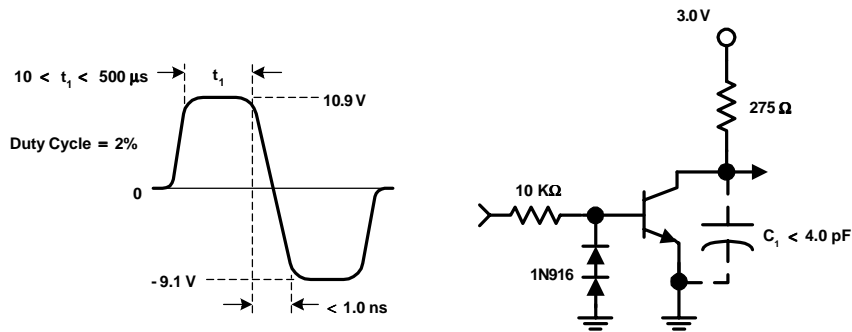


FIGURE 2: Storage and Fall Time Equivalent Test Circuit

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| EnSigna™ | OPTOLOGIC™ | SMART START™ | |
| FACT™ | OPTOPLANAR™ | SuperSOT™-3 | |
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