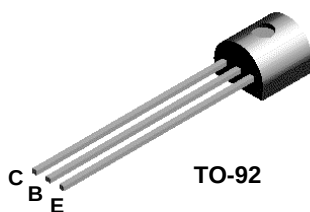
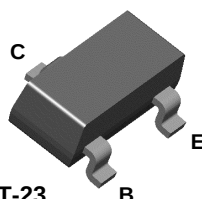


## 2N3904



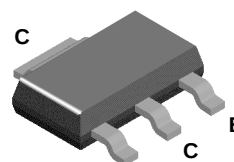
TO-92

## MMBT3904



SOT-23  
Mark: 1A

## PZT3904



SOT-223

## 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<br>Derate above $25^\circ\text{C}$ | 625<br>5.0 | 350<br>2.8 | 1,000<br>8.0 | mW<br>mW/ $^\circ\text{C}$ |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case                        | 83.3       |            |              | $^\circ\text{C/W}$         |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient                     | 200        | 357        | 125          | $^\circ\text{C/W}$         |

\*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  $\text{cm}^2$ .

# 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                      | $I_C = 0.1\text{ mA}$ , $V_{CE} = 1.0\text{ V}$<br>$I_C = 1.0\text{ mA}$ , $V_{CE} = 1.0\text{ V}$<br>$I_C = 10\text{ mA}$ , $V_{CE} = 1.0\text{ V}$<br>$I_C = 50\text{ mA}$ , $V_{CE} = 1.0\text{ V}$<br>$I_C = 100\text{ mA}$ , $V_{CE} = 1.0\text{ V}$ | 40<br>70<br>100<br>60<br>30 | 300          |        |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $I_C = 10\text{ mA}$ , $I_B = 1.0\text{ mA}$<br>$I_C = 50\text{ mA}$ , $I_B = 5.0\text{ mA}$                                                                                                                                                              |                             | 0.2<br>0.3   | V<br>V |
| $V_{BE(sat)}$ | Base-Emitter Saturation Voltage      | $I_C = 10\text{ mA}$ , $I_B = 1.0\text{ mA}$<br>$I_C = 50\text{ mA}$ , $I_B = 5.0\text{ mA}$                                                                                                                                                              | 0.65                        | 0.85<br>0.95 | V<br>V |

### SMALL SIGNAL CHARACTERISTICS

|           |                                  |                                                                                                                                  |     |     |     |
|-----------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|
| $f_T$     | Current Gain - Bandwidth Product | $I_C = 10\text{ mA}$ , $V_{CE} = 20\text{ V}$ ,<br>$f = 100\text{ MHz}$                                                          | 300 |     | MHz |
| $C_{obo}$ | Output Capacitance               | $V_{CB} = 5.0\text{ V}$ , $I_E = 0$ ,<br>$f = 1.0\text{ MHz}$                                                                    |     | 4.0 | pF  |
| $C_{ibo}$ | Input Capacitance                | $V_{EB} = 0.5\text{ V}$ , $I_C = 0$ ,<br>$f = 1.0\text{ MHz}$                                                                    |     | 8.0 | pF  |
| NF        | Noise Figure                     | $I_C = 100\text{ }\mu\text{A}$ , $V_{CE} = 5.0\text{ V}$ ,<br>$R_S = 1.0\text{ k}\Omega$ , $f = 10\text{ Hz to }15.7\text{ kHz}$ |     | 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)

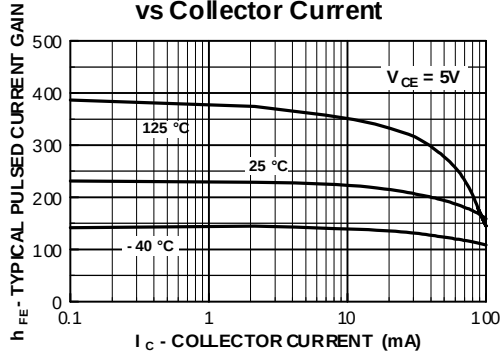
2N3904 / MMBT3904 / PZT3904

# NPN General Purpose Amplifier (continued)

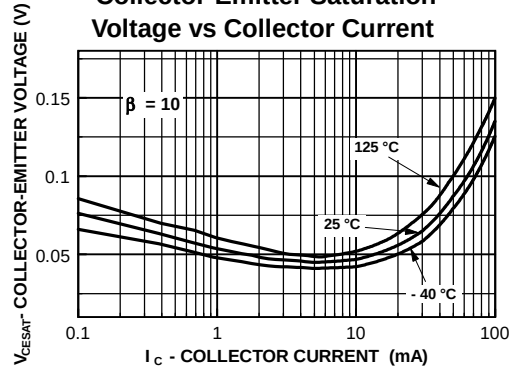
2N3904 / MMBT3904 / PZT3904

## Typical Characteristics

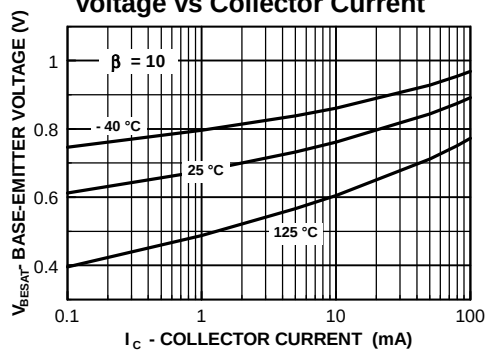
Typical Pulsed Current Gain  
vs Collector Current



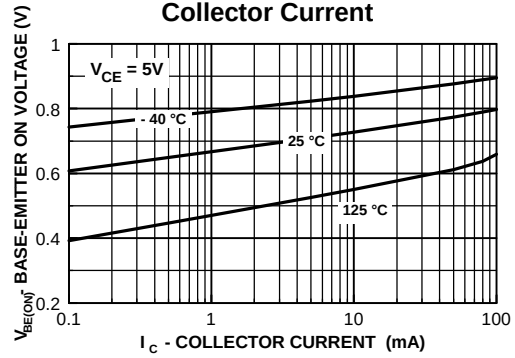
Collector-Emitter Saturation  
Voltage vs Collector Current



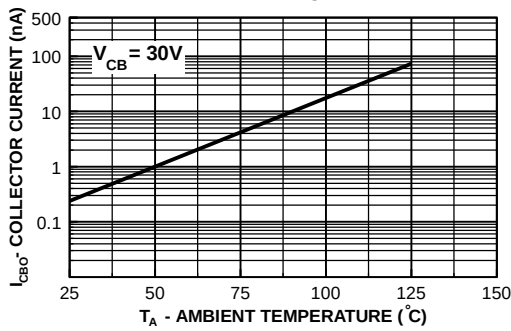
Base-Emitter Saturation  
Voltage vs Collector Current



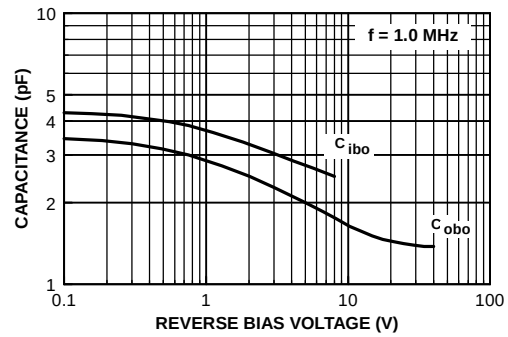
Base-Emitter ON Voltage vs  
Collector Current



Collector-Cutoff Current  
vs Ambient Temperature

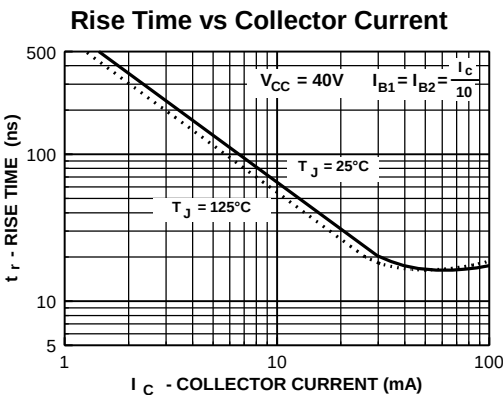
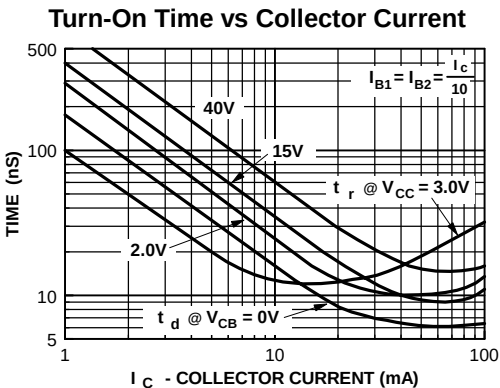
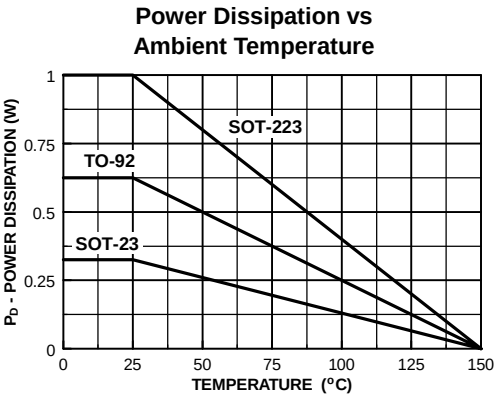
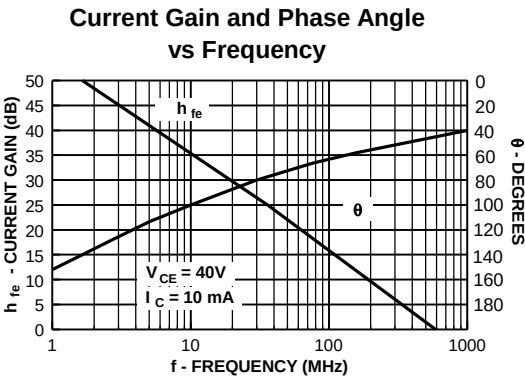
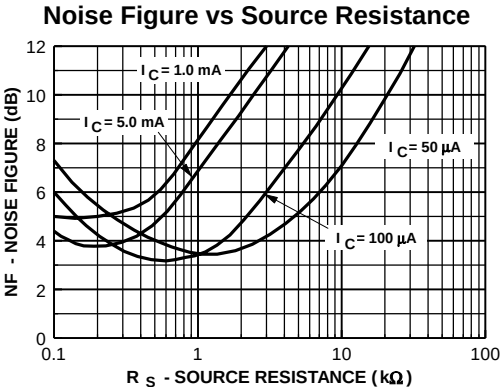
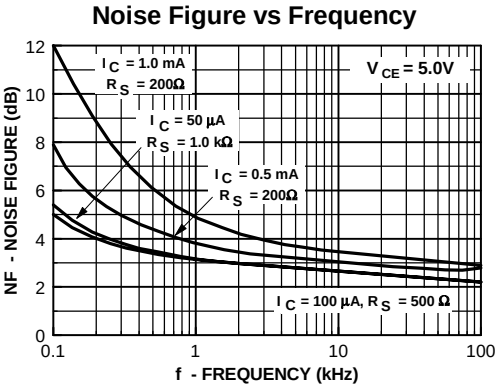


Capacitance vs  
Reverse Bias Voltage



NPN General Purpose Amplifier  
(continued)

Typical Characteristics (continued)

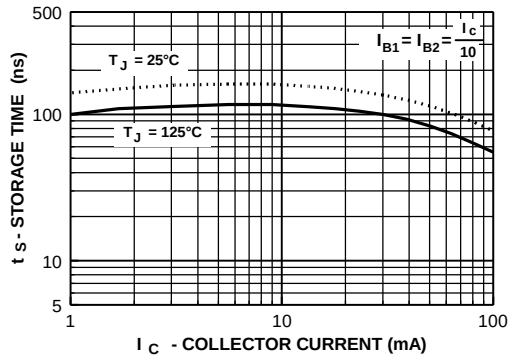


# NPN General Purpose Amplifier (continued)

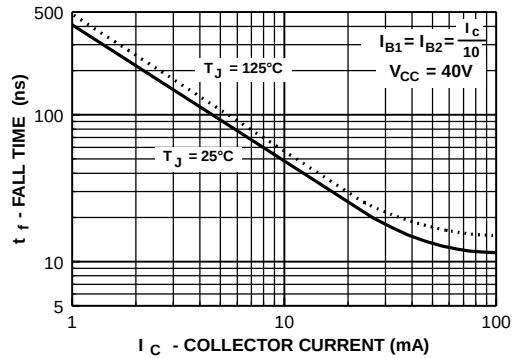
2N3904 / MMBT3904 / PZT3904

## Typical Characteristics (continued)

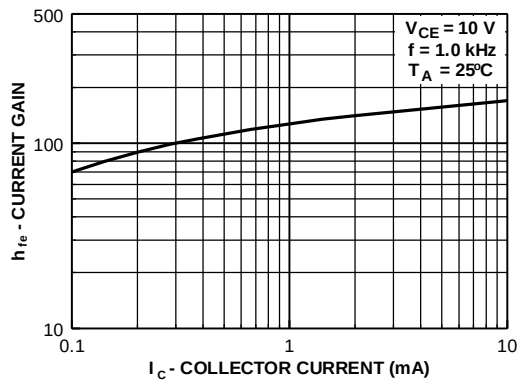
Storage Time vs Collector Current



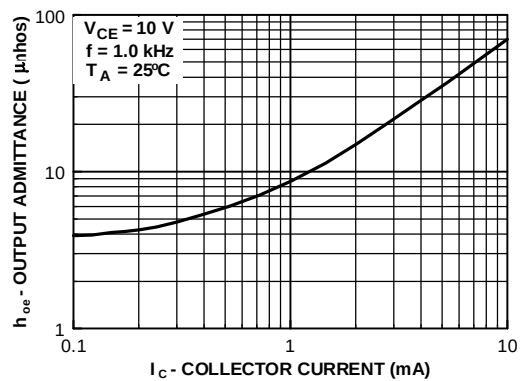
Fall Time vs Collector Current



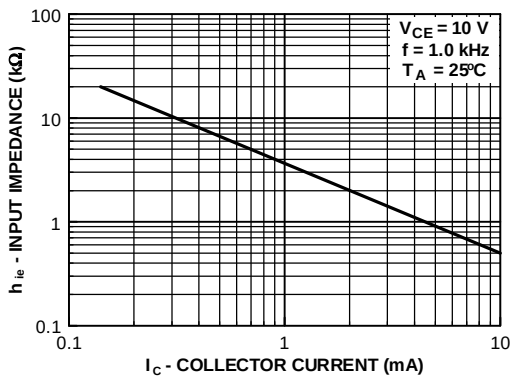
Current Gain



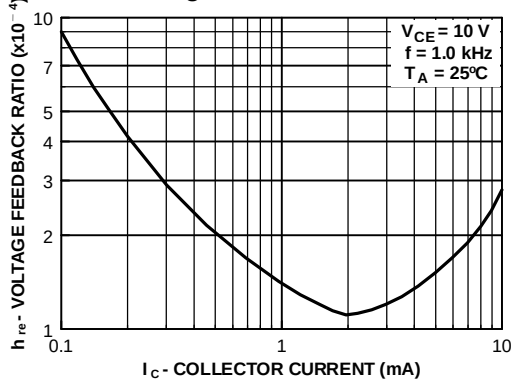
Output Admittance



Input Impedance



Voltage Feedback Ratio



## Test Circuits

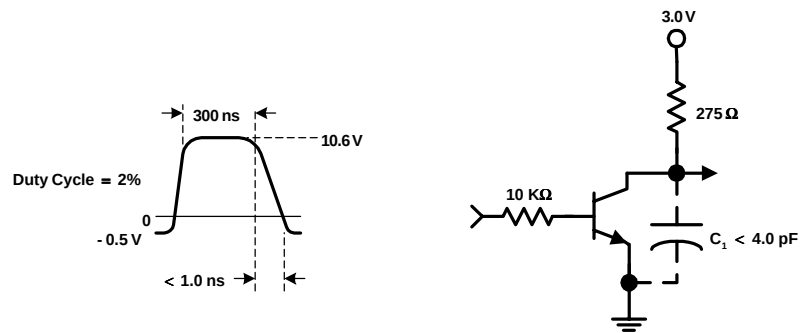


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

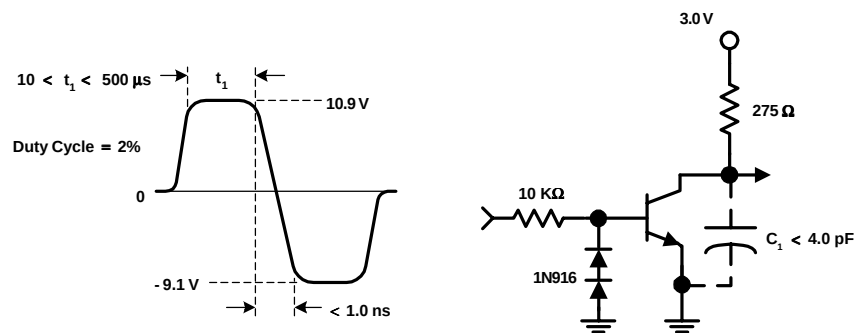


FIGURE 2: Storage and Fall Time Equivalent Test Circuit

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| FACT Quiet Series <sup>™</sup>   | PACMAN <sup>™</sup>             | SuperSOT <sup>™</sup> -6        |                        |
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