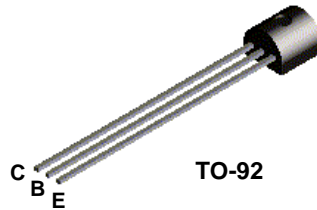
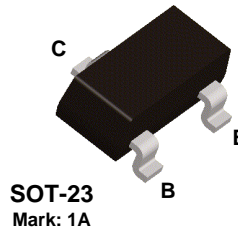


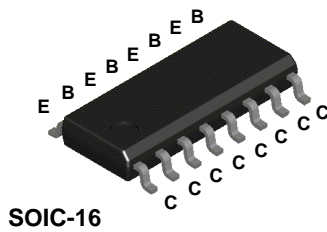
### 2N3904



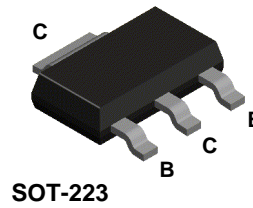
### MMBT3904



### MMPQ3904



### 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. Sourced from Process 23.

### Absolute Maximum Ratings\*

TA = 25°C unless otherwise noted

| Symbol                            | Parameter  | Value       | Units |
|-----------------------------------|--|-------------|-------|
| V <sub>CEO</sub>                  | Collector-Emitter Voltage                        | 40          | V     |
| V <sub>CBO</sub>                  | Collector-Base Voltage                           | 60          | V     |
| V <sub>EBO</sub>                  | Emitter-Base Voltage                             | 6.0         | V     |
| I <sub>C</sub>                    | Collector Current - Continuous                   | 200         | mA    |
| T <sub>J</sub> , T <sub>stg</sub> | Operating and Storage Junction Temperature Range | -55 to +150 | °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.

## NPN General Purpose Amplifier

(continued)

### Electrical Characteristics

TA = 25°C unless otherwise noted

| Symbol                     | Parameter                           | Test Conditions                          | Min | Max | Units |
|----------------------------|-------------------------------------|--|-----|-----|-------|
| <b>OFF CHARACTERISTICS</b> |                                     |  |     |     |       |
| $V_{(BR)CEO}$              | Collector-Emitter Breakdown Voltage | $I_C = 10 \text{ mA}, I_B = 0$           | 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                 | $V_{CE} = 30 \text{ V}, V_{EB} = 0$      |     | 50  | nA    |
| $I_{CEX}$                  | Collector Cutoff Current            | $V_{CE} = 30 \text{ V}, V_{EB} = 0$      |     | 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 (except MMPQ3904)   | $I_C = 100 \text{ } \mu\text{A}, V_{CE} = 5.0 \text{ V},$<br>$R_S = 1.0 \text{ k}\Omega, f = 10 \text{ Hz to } 15.7 \text{ kHz}$ |     | 5.0 | dB  |

### SWITCHING CHARACTERISTICS (except MMPQ3904)

|       |              |   |  |     |    |
|-------|--------------|---|--|-----|----|
| $t_d$ | 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 lkr=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 / MMPQ3904 / PZT3904

# NPN General Purpose Amplifier

(continued)

## Thermal Characteristics

TA = 25°C unless otherwise noted

| Symbol           | Characteristic                                | Max    |          | Units |
|------------------|---|--------|----------|-------|
|                  |   | 2N3904 | *PZT3904 |       |
| P <sub>D</sub>   | Total Device Dissipation<br>Derate above 25°C | 625    | 1,000    | mW    |
|                  |   | 5.0    | 8.0      | mW/°C |
| R <sub>θJC</sub> | Thermal Resistance, Junction to Case          | 83.3   |          | °C/W  |
| R <sub>θJA</sub> | Thermal Resistance, Junction to Ambient       | 200    | 125      | °C/W  |

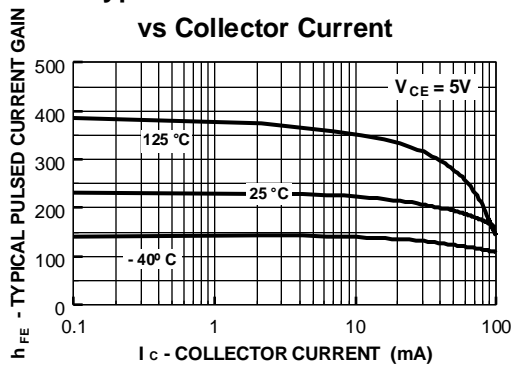
| Symbol           | Characteristic   | Max        |          | Units |
|------------------|--|------------|----------|-------|
|                  |  | **MMBT3904 | MMPQ3904 |       |
| P <sub>D</sub>   | Total Device Dissipation<br>Derate above 25°C                          | 350        | 1,000    | mW    |
|                  |  | 2.8        | 8.0      | mW/°C |
| R <sub>θJA</sub> | Thermal Resistance, Junction to Ambient<br>Effective 4 Die<br>Each Die | 357        |          | °C/W  |
|                  |  |            | 125      | °C/W  |
|                  |  |            | 240      | °C/W  |

\* Device mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm; mounting pad for the collector lead min. 6 cm<sup>2</sup>.

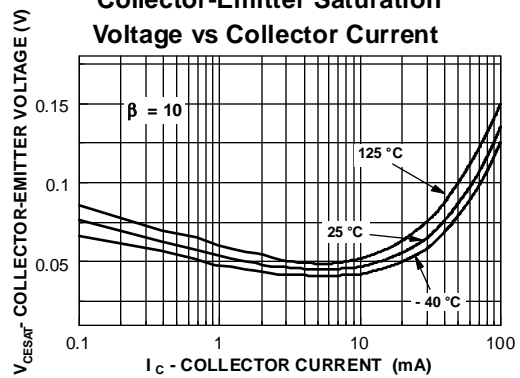
\*\* Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

## Typical Characteristics

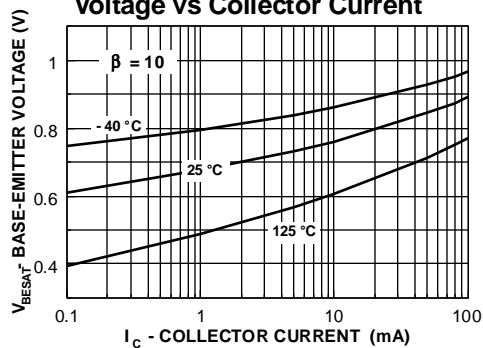
Typical Pulsed Current Gain vs Collector Current



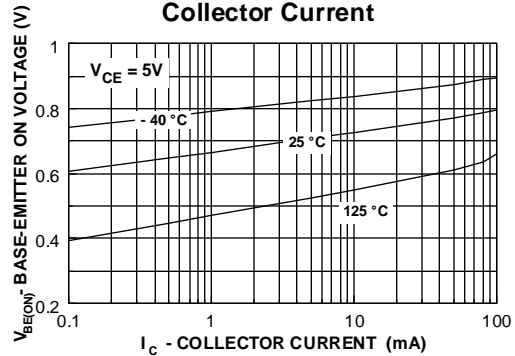
Collector-Emitter Saturation Voltage vs Collector Current



Base-Emitter Saturation Voltage vs Collector Current



Base-Emitter ON Voltage vs Collector Current

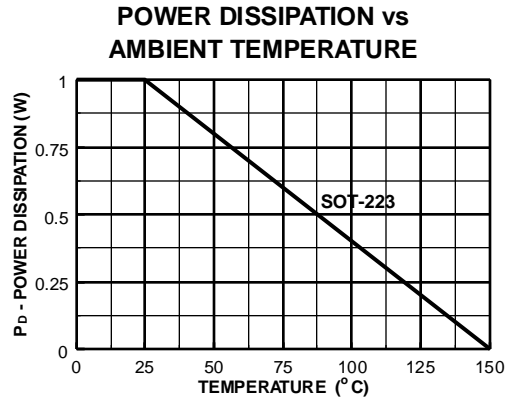
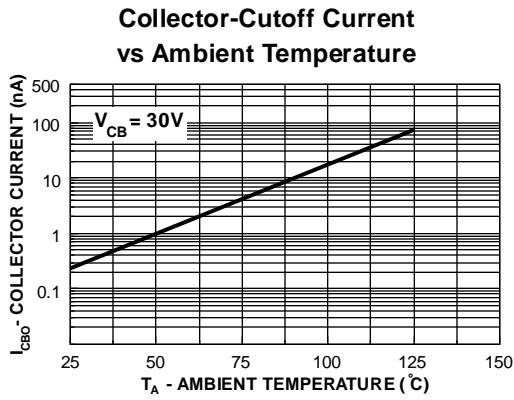


# NPN General Purpose Amplifier

(continued)

2N3904 / MMBT3904 / MMMPQ3904 / PZT3904

## Typical Characteristics (continued)



## Test Circuits

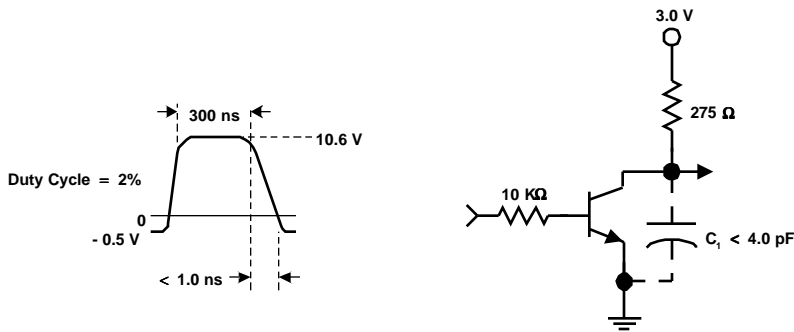


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

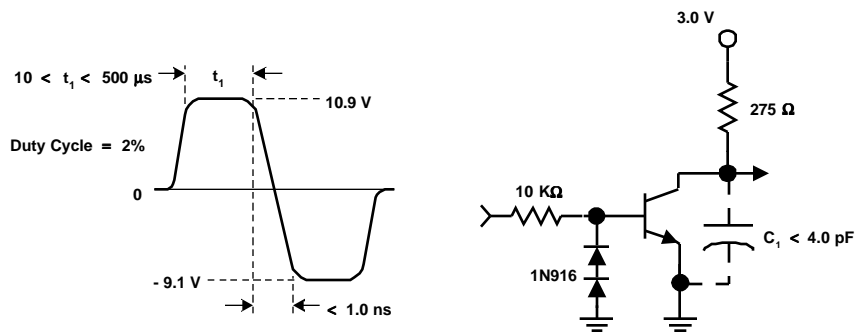


FIGURE 2: Storage and Fall Time Equivalent Test Circuit