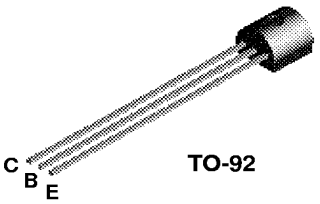
FAIRCHILD SEMICONDUCTOR

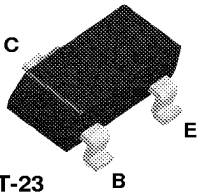
*Discrete POWER & Signal Technologies*

## 2N3904



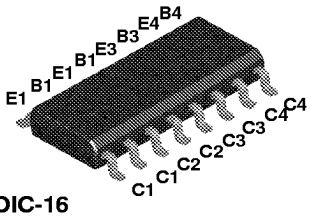

TO-92

## MMBT3904



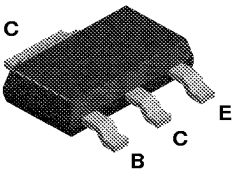

SOT-23
Mark: 1A

## MMPQ3904




SOIC-16

## 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. Sourced from Process 23.

### Absolute Maximum Ratings*

TA = 25°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 | °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.

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## NPN General Purpose Amplifier
(continued)

### Electrical Characteristics
TA = 25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage | $I_C$ = 1.0 mA, $I_B$ = 0 | 40 | | V |
| $V_{(BR)CBO}$ | Collector-Base Breakdown Voltage | $I_C$ = 10 µA, $I_E$ = 0 | 60 | | V |
| $V_{(BR)EBO}$ | Emitter-Base Breakdown Voltage | $I_E$ = 10 µA, $I_C$ = 0 | 6.0 | | V |
| $I_{BL}$ | Base Cutoff Current | $V_{CE}$ = 30 V, $V_{EB}$ = 0 | | 50 | nA |
| $I_{CEX}$ | Collector Cutoff Current | $V_{CE}$ = 30 V, $V_{EB}$ = 0 | | 50 | nA |
| **ON CHARACTERISTICS*** | | | | | |
| $h_{FE}$ | DC Current Gain | $I_C$ = 0.1 mA, $V_{CE}$ = 1.0 V | 40 | | |
| | | $I_C$ = 1.0 mA, $V_{CE}$ = 1.0 V | 70 | | |
| | | $I_C$ = 10 mA, $V_{CE}$ = 1.0 V | 100 | 300 | |
| | | $I_C$ = 50 mA, $V_{CE}$ = 1.0 V | 60 | | |
| | | $I_C$ = 100 mA, $V_{CE}$ = 1.0 V | 30 | | |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $I_C$ = 10 mA, $I_B$ = 1.0 mA | | 0.2 | V |
| | | $I_C$ = 50 mA, $I_B$ = 5.0 mA | | 0.3 | V |
| $V_{BE(sat)}$ | Base-Emitter Saturation Voltage | $I_C$ = 10 mA, $I_B$ = 1.0 mA | 0.65 | 0.85 | V |
| | | $I_C$ = 50 mA, $I_B$ = 5.0 mA | | 0.95 | V |
| **SMALL SIGNAL CHARACTERISTICS** | | | | | |
| $f_T$ | Current Gain - Bandwidth Product | $I_C$ = 10 mA, $V_{CE}$ = 20 V, f = 100 MHz | 300 | | MHz |
| $C_{obo}$ | Output Capacitance | $V_{CB}$ = 5.0 V, $I_E$ = 0, f = 1.0 MHz | | 4.0 | pF |
| $C_{ibo}$ | Input Capacitance | $V_{EB}$ = 0.5 V, $I_C$ = 0, f = 1.0 MHz | | 8.0 | pF |
| NF | Noise Figure (except MMPQ3904) | $I_C$ = 100 µA, $V_{CE}$ = 5.0 V, $R_S$ =1.0kΩ, f=10 Hz to 15.7 kHz | | 5.0 | dB |
| **SWITCHING CHARACTERISTICS** (except MMPQ3904) | | | | | |
| $t_d$ | Delay Time | $V_{CC}$ = 3.0 V, $V_{BE}$ = 0.5 V, | | 35 | ns |
| $t_r$ | Rise Time | $I_C$ = 10 mA, $I_{B1}$ = 1.0 mA | | 35 | ns |
| $t_s$ | Storage Time | $V_{CC}$ = 3.0 V, $I_C$ = 10mA | | 200 | ns |
| $t_f$ | Fall Time | $I_{B1}$ = $I_{B2}$ = 1.0 mA | | 50 | ns |

*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 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)

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## NPN General Purpose Amplifier
(continued)

### Thermal Characteristics
TA = 25°C unless otherwise noted

| Symbol | Characteristic | Max | | Units |
|---|---|---|---|---|
| | | 2N3904 | *PZT3904 | |
| $P_D$ | Total Device Dissipation<br>Derate above 25°C | 625<br>5.0 | 1,000<br>8.0 | mW<br>mW/°C |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | 83.3 | | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 200 | 125 | °C/W |

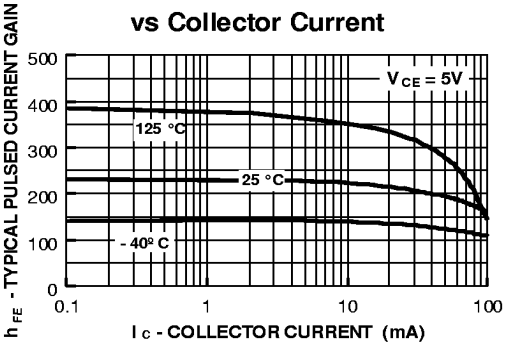
| Symbol | Characteristic | Max | | Units |
|---|---|---|---|---|
| | | **MMBT3904 | MMPQ3904 | |
| $P_D$ | Total Device Dissipation<br>Derate above 25°C | 350<br>2.8 | 1,000<br>8.0 | mW<br>mW/°C |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient<br>Effective 4 Die<br>Each Die | 357 | <br>125<br>240 | °C/W<br>°C/W<br>°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 $cm^2$.

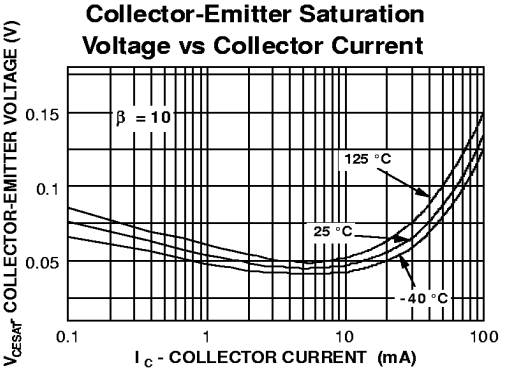
**Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

### Typical Characteristics

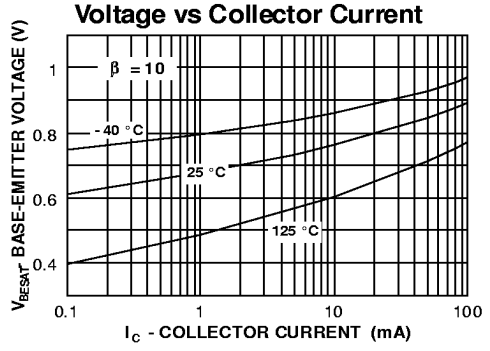
**Typical Pulsed Current Gain vs Collector Current**



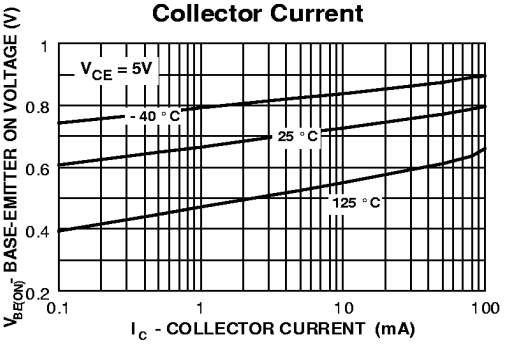

**Collector-Emitter Saturation Voltage vs Collector Current**




**Base-Emitter Saturation Voltage vs Collector Current**




**Base-Emitter ON Voltage vs Collector Current**

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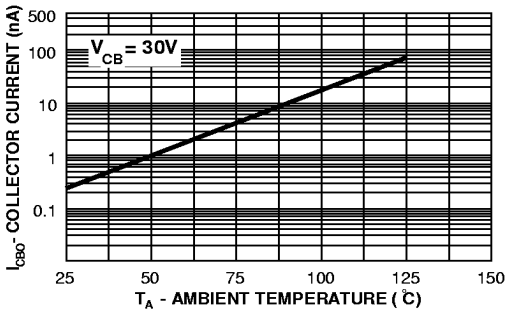
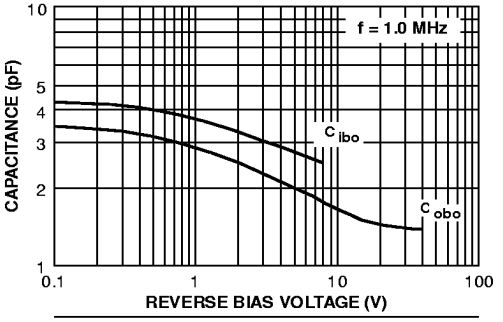
## Typical Characteristics (continued)

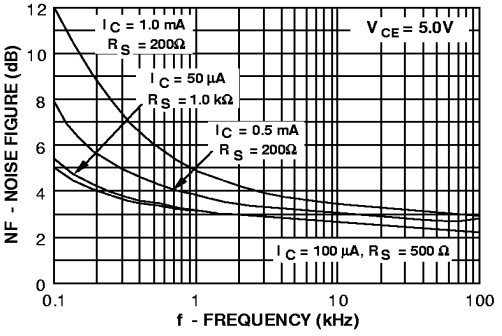
### Collector-Cutoff Current vs Ambient Temperature



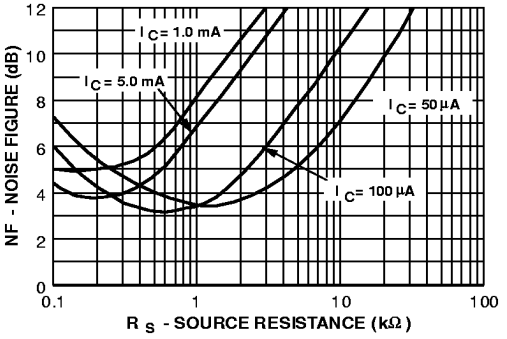

### Capacitance vs Reverse Bias Voltage



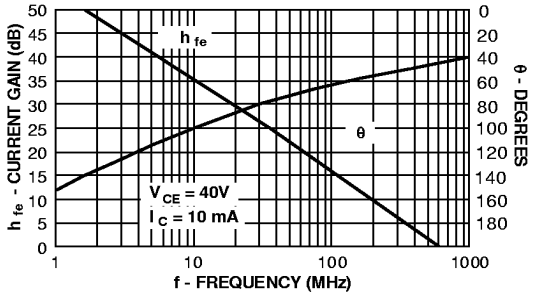

### Noise Figure vs Frequency



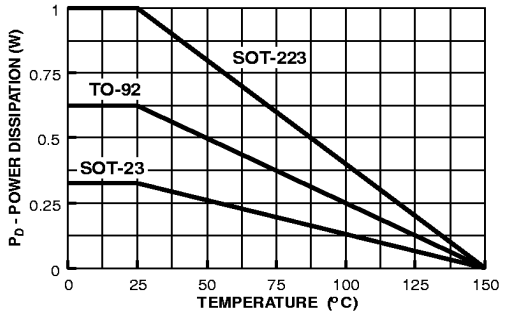

### Noise Figure vs Source Resistance




### Current Gain and Phase Angle vs Frequency




### Power Dissipation vs Ambient Temperature

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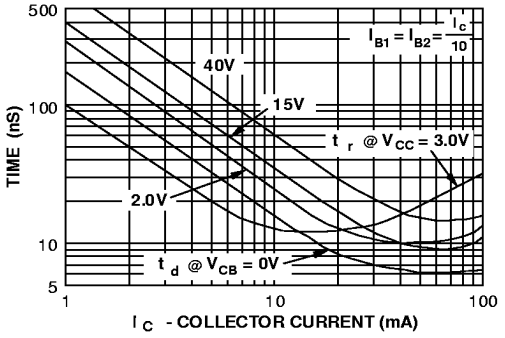
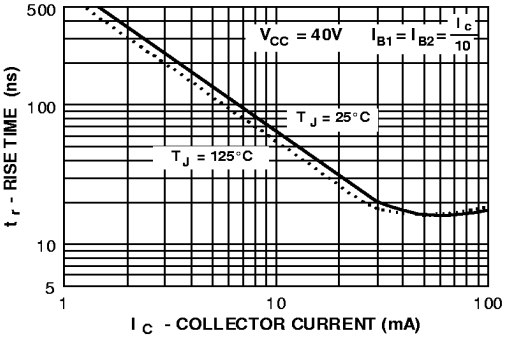
## Typical Characteristics (continued)

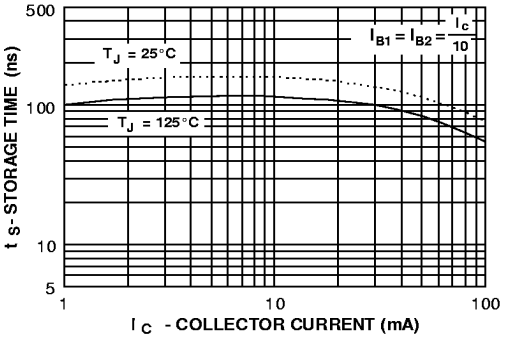
**Turn-On Time vs Collector Current**



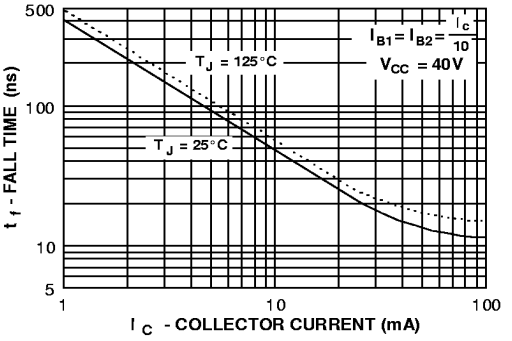

**Rise Time vs Collector Current**




**Storage Time vs Collector Current**




**Fall Time vs Collector Current**

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## NPN General Purpose Amplifier
(continued)

### Test Circuits

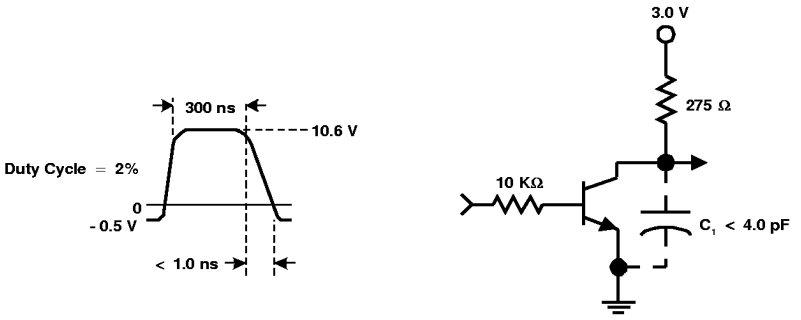


**FIGURE 1: Delay and Rise Time Equivalent Test Circuit**

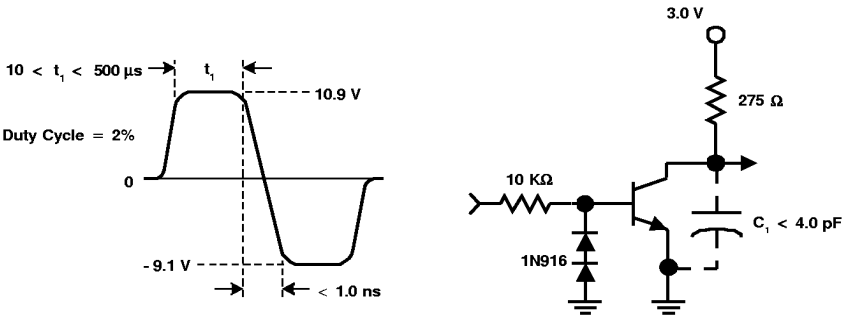


**FIGURE 2: Storage and Fall Time Equivalent Test Circuit**

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