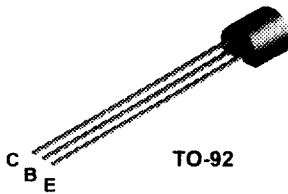
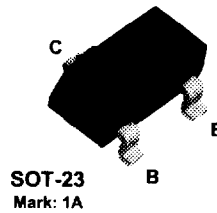


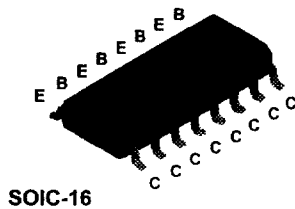
**2N3904**



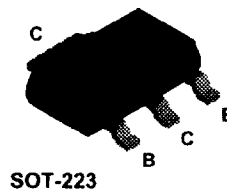
**MMBT3904**



**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 <sub>BRICEO</sub>	Collector-Emitter Breakdown Voltage	I <sub>C</sub> = 1.0 mA, I <sub>B</sub> = 0	40		V
V <sub>BRICBO</sub>	Collector-Base Breakdown Voltage	I <sub>C</sub> = 10 μA, I <sub>E</sub> = 0	60		V
V <sub>BRIEBO</sub>	Emitter-Base Breakdown Voltage	I <sub>E</sub> = 10 μA, I <sub>C</sub> = 0	6.0		V
I <sub>BL</sub>	Base Cutoff Current	V <sub>CE</sub> = 30 V, V <sub>EB</sub> = 0		50	nA
I <sub>CEX</sub>	Collector Cutoff Current	V <sub>CE</sub> = 30 V, V <sub>EB</sub> = 0		50	nA

### ON CHARACTERISTICS\*

h <sub>FE</sub>	DC Current Gain	I <sub>C</sub> = 0.1 mA, V <sub>CE</sub> = 1.0 V I <sub>C</sub> = 1.0 mA, V <sub>CE</sub> = 1.0 V I <sub>C</sub> = 10 mA, V <sub>CE</sub> = 1.0 V I <sub>C</sub> = 50 mA, V <sub>CE</sub> = 1.0 V I <sub>C</sub> = 100 mA, V <sub>CE</sub> = 1.0 V	40 70 100 60 30	300	
V <sub>CE(sat)</sub>	Collector-Emitter Saturation Voltage	I <sub>C</sub> = 10 mA, I <sub>B</sub> = 1.0 mA I <sub>C</sub> = 50 mA, I <sub>B</sub> = 5.0 mA		0.2 0.3	V V
V <sub>BE(sat)</sub>	Base-Emitter Saturation Voltage	I <sub>C</sub> = 10 mA, I <sub>B</sub> = 1.0 mA I <sub>C</sub> = 50 mA, I <sub>B</sub> = 5.0 mA	0.65	0.85 0.95	V V

### SMALL SIGNAL CHARACTERISTICS

f <sub>T</sub>	Current Gain - Bandwidth Product	I <sub>C</sub> = 10 mA, V <sub>CE</sub> = 20 V, f = 100 MHz	300		MHz
C <sub>obo</sub>	Output Capacitance	V <sub>CB</sub> = 5.0 V, I <sub>E</sub> = 0, f = 1.0 MHz		4.0	pF
C <sub>ibo</sub>	Input Capacitance	V <sub>EB</sub> = 0.5 V, I <sub>C</sub> = 0, f = 1.0 MHz		8.0	pF
NF	Noise Figure (except MMPQ3904)	I <sub>C</sub> = 100 μA, V <sub>CE</sub> = 5.0 V, R <sub>S</sub> = 1.0 kΩ, f = 10 Hz to 15.7 kHz		5.0	dB

### SWITCHING CHARACTERISTICS (except MMPQ3904)

t <sub>d</sub>	Delay Time	V <sub>CC</sub> = 3.0 V, V <sub>BE</sub> = 0.5 V,		35	ns
t <sub>r</sub>	Rise Time	I <sub>C</sub> = 10 mA, I <sub>B1</sub> = 1.0 mA		35	ns
t <sub>s</sub>	Storage Time	V <sub>CC</sub> = 3.0 V, I <sub>C</sub> = 10 mA		200	ns
t <sub>f</sub>	Fall Time	I <sub>B1</sub> = I <sub>B2</sub> = 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 Vitf=4 Xtf=2 Rb=10)

# 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 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

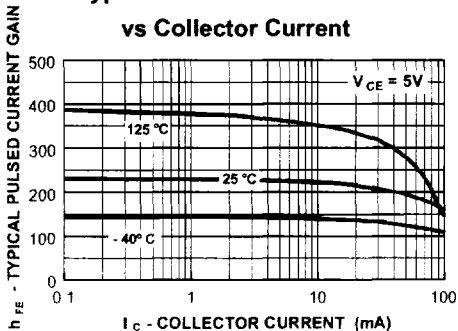
Symbol	Characteristic	Max		Units
		**MMBT3904	MMPQ3904	
P <sub>D</sub>	Total Device Dissipation Derate above 25°C	350	1,000	mW
		2.8	8.0	mW/°C
R <sub>θJA</sub>	Thermal Resistance, Junction to Ambient Effective 4 Die Each Die	357		°C/W
			125	°C/W
			240	°C/W

\* 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>.

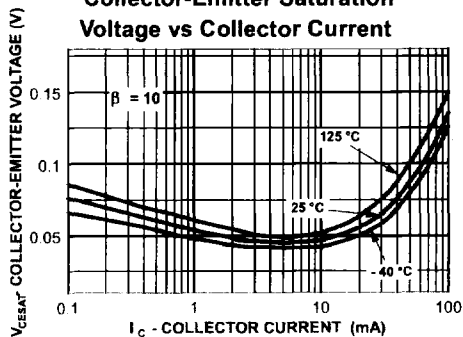
\*\* Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

## DC Typical Characteristics

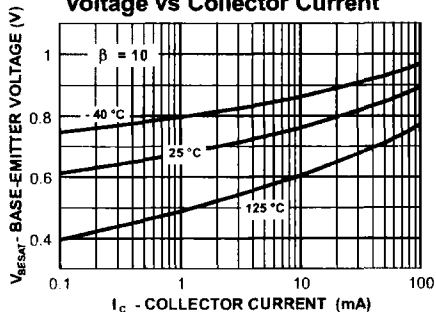
Typical Pulsed Current Gain  
vs Collector Current



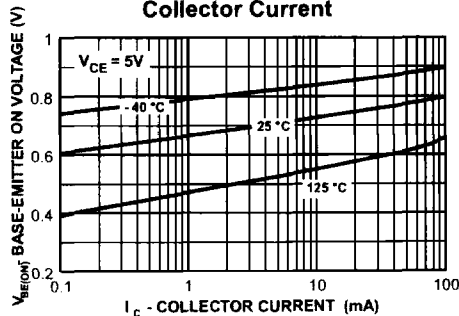
Collector-Emitter Saturation  
Voltage vs Collector Current



Base-Emitter Saturation  
Voltage vs Collector Current



Base-Emitter ON Voltage vs  
Collector Current



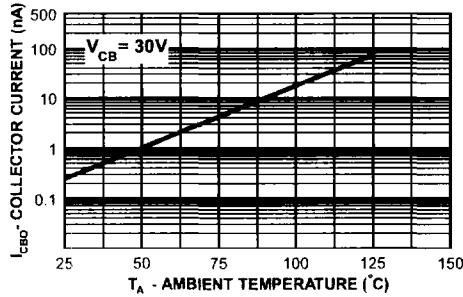
2N3904 / MMBT3904 / MMPQ3904 / PZT3904

**NPN General Purpose Amplifier**

(continued)

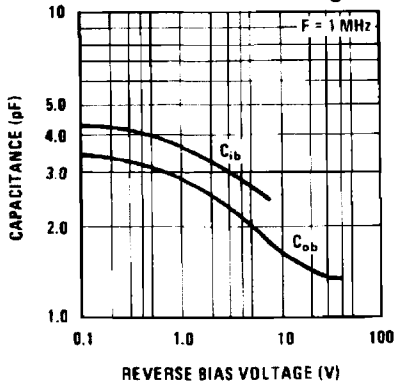
**DC Typical Characteristics (continued)**

**Collector-Cutoff Current vs Ambient Temperature**

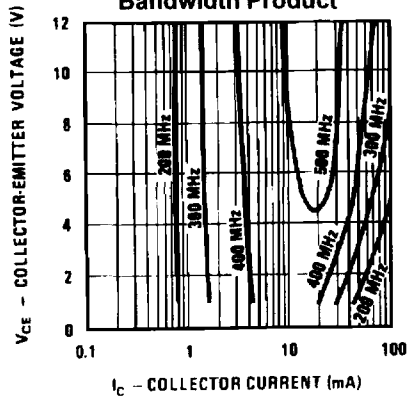


**AC Typical Characteristics**

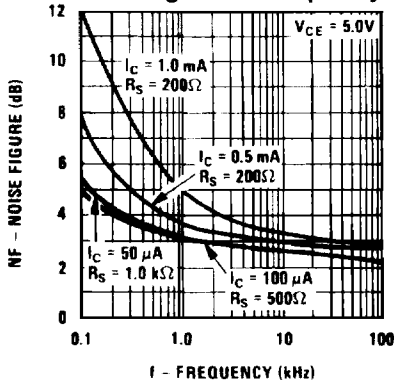
**Capacitance vs. Reverse Bias Voltage**



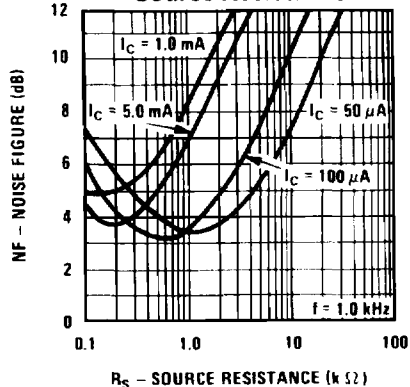
**Contours Of Constant Gain Bandwidth Product**



**Noise Figure vs. Frequency**

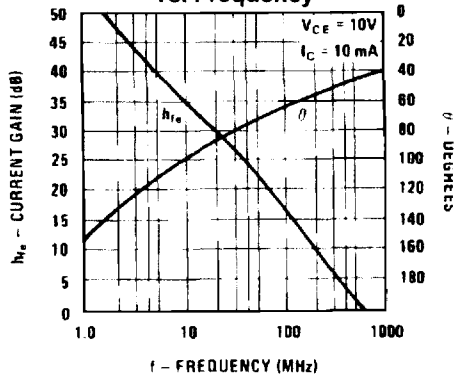


**Noise Figure vs. Source Resistance**

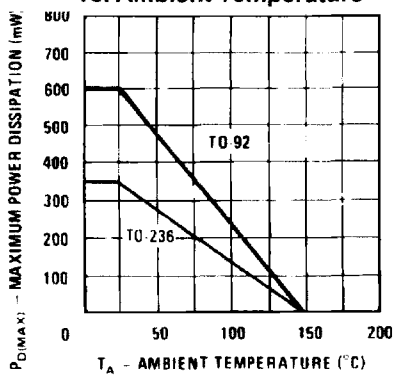


AC Typical Characteristics (continued)

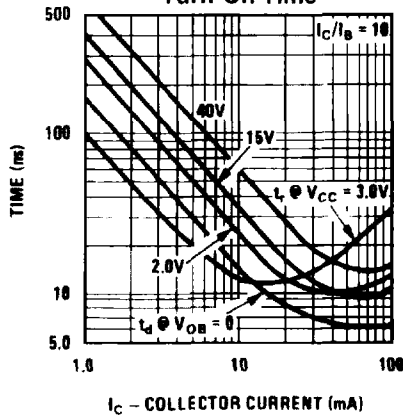
Current Gain and Phase Angle vs. Frequency



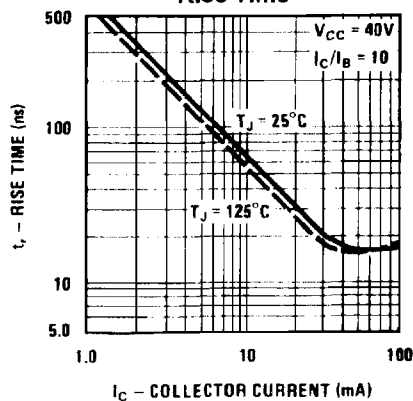
Maximum Power Dissipation vs. Ambient Temperature



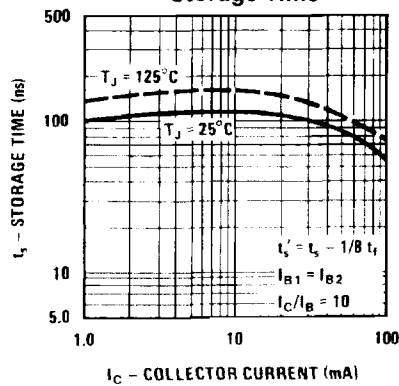
Turn-On Time



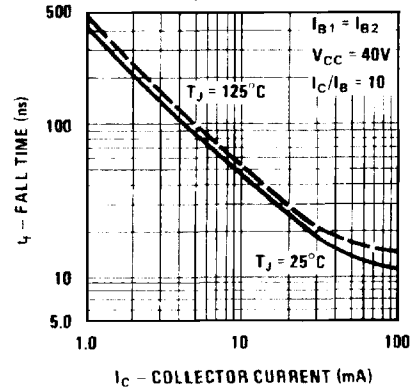
Rise Time



Storage Time



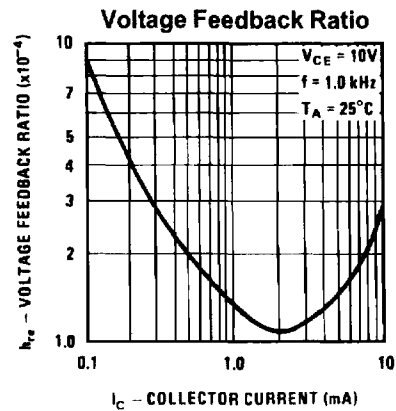
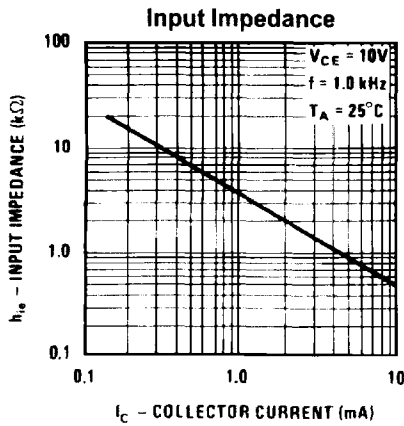
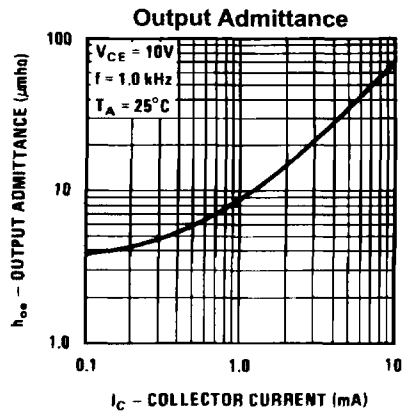
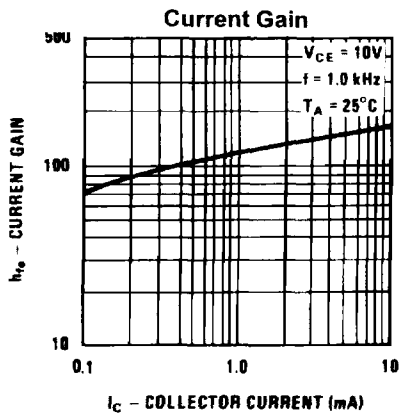
Fall Time



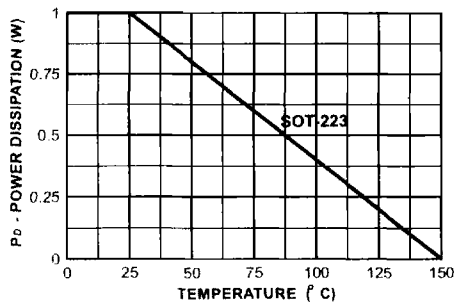
# NPN General Purpose Amplifier

(continued)

## AC Typical Characteristics (continued)



### POWER DISSIPATION vs AMBIENT TEMPERATURE



Test Circuits

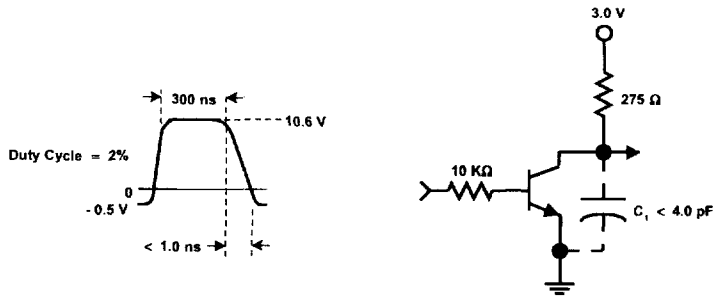


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

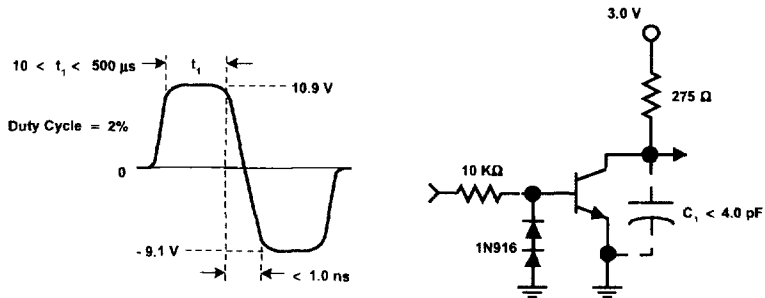


FIGURE 2: Storage and Fall Time Equivalent Test Circuit

2N3904 / MMBT3904 / MMPQ3904 / PZT3904