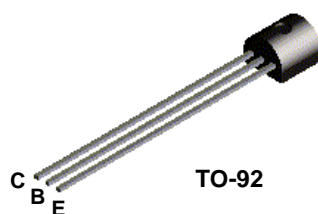
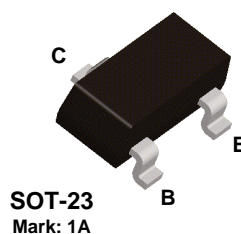


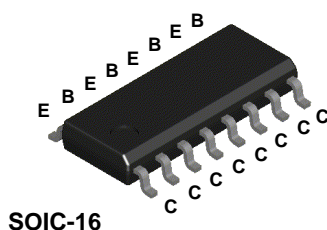
## 2N3904



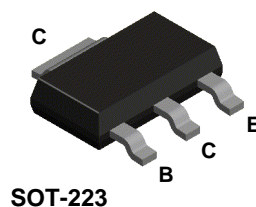
## MMBT3904



## 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
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### OFF CHARACTERISTICS

$V_{(BR)CEO}$	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	$I_C = 0.1 \text{ mA}$ , $V_{CE} = 1.0 \text{ V}$ $I_C = 1.0 \text{ mA}$ , $V_{CE} = 1.0 \text{ V}$ $I_C = 10 \text{ mA}$ , $V_{CE} = 1.0 \text{ V}$ $I_C = 50 \text{ mA}$ , $V_{CE} = 1.0 \text{ V}$ $I_C = 100 \text{ mA}$ , $V_{CE} = 1.0 \text{ V}$	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 (except MMPQ3904)	$I_C = 100 \text{ }\mu\text{A}$ , $V_{CE} = 5.0 \text{ V}$ , $R_s = 1.0 \text{ k}\Omega$ , $f = 10 \text{ Hz to } 15.7 \text{ kHz}$		5.0	dB

### SWITCHING CHARACTERISTICS (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 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 / 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 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

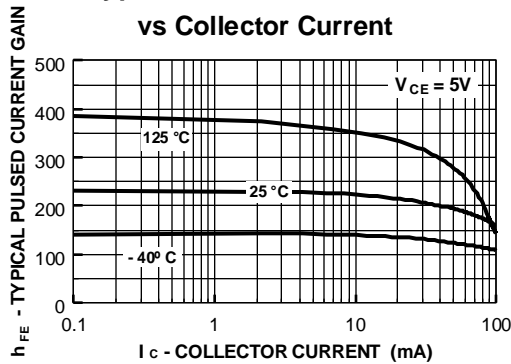
Symbol	Characteristic	Max		Units
		**MMBT3904	MMPQ3904	
P <sub>D</sub>	Total Device Dissipation Derate above 25°C	350	1,000	mW
		2.8	8.0	mW/°C
R <sub>θJA</sub>	Thermal Resistance, Junction to Ambient Effective 4 Die Each Die	357		°C/W
			125	°C/W
			240	°C/W

\* 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>.

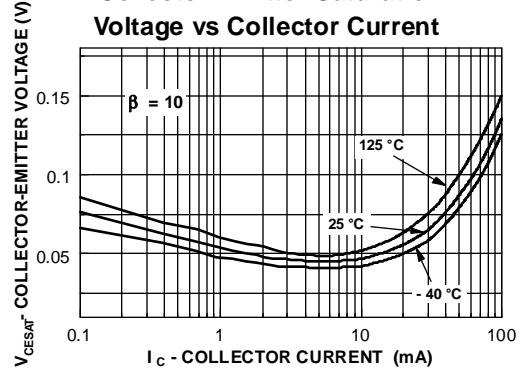
\*\* Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

## Typical Characteristics

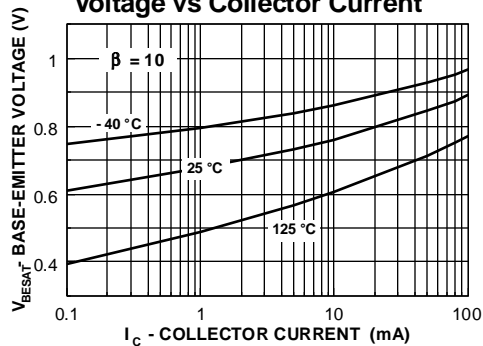
Typical Pulsed Current Gain  
vs Collector Current



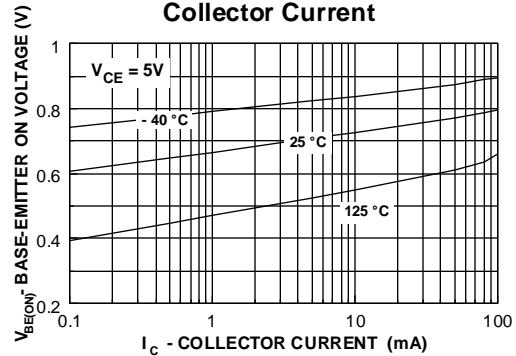
Collector-Emitter Saturation  
Voltage vs Collector Current



Base-Emitter Saturation  
Voltage vs Collector Current



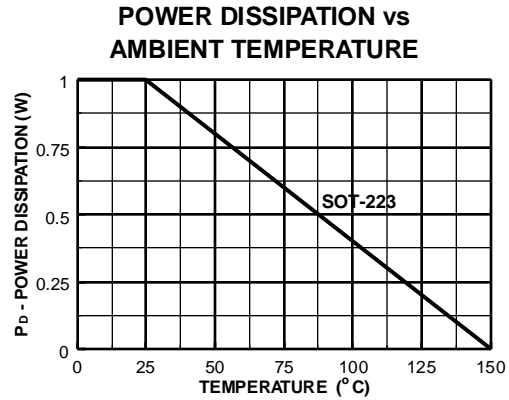
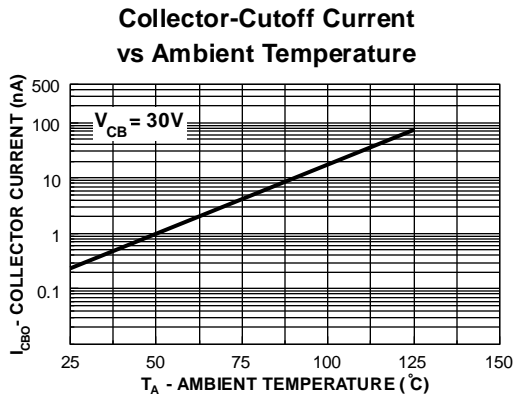
Base-Emitter ON Voltage vs  
Collector Current



# NPN General Purpose Amplifier (continued)

2N3904 / MMBT3904 / MM3PQ3904 / PZT3904

## Typical Characteristics (continued)



## Test Circuits

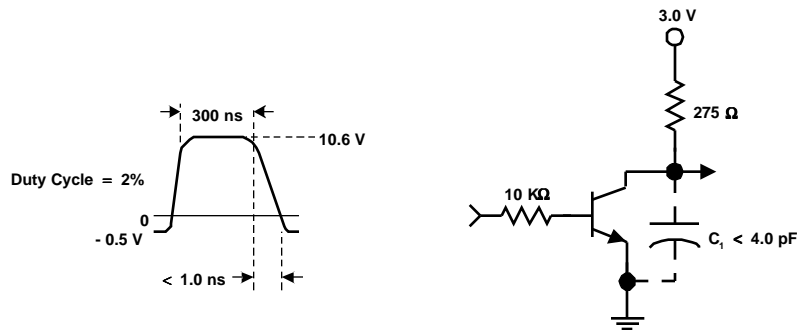


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

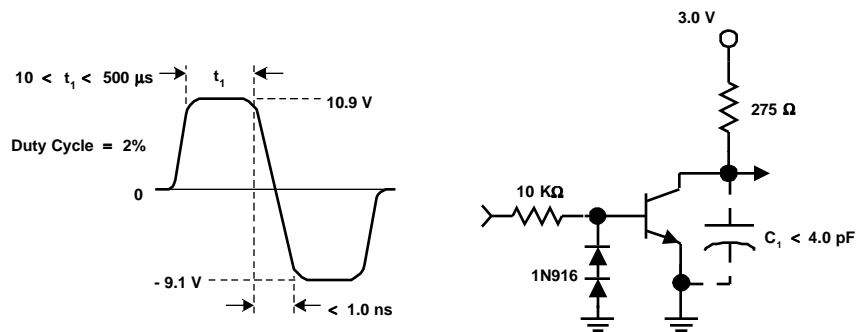


FIGURE 2: Storage and Fall Time Equivalent Test Circuit