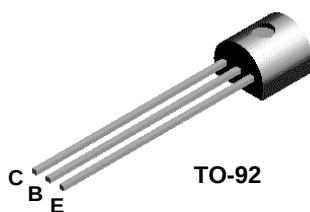
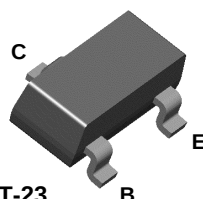


2N3904



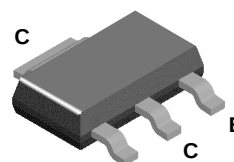
TO-92

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 Derate above 25°C	625 5.0	350 2.8	1,000 8.0	mW 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 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
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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	$I_C = 0.1\text{ mA}$, $V_{CE} = 1.0\text{ V}$ $I_C = 1.0\text{ mA}$, $V_{CE} = 1.0\text{ V}$ $I_C = 10\text{ mA}$, $V_{CE} = 1.0\text{ V}$ $I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ V}$ $I_C = 100\text{ mA}$, $V_{CE} = 1.0\text{ V}$	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	$I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ V}$, $R_S = 1.0\text{ k}\Omega$, $f = 10\text{ Hz to }15.7\text{ kHz}$		5.0	dB

SWITCHING CHARACTERISTICS

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)

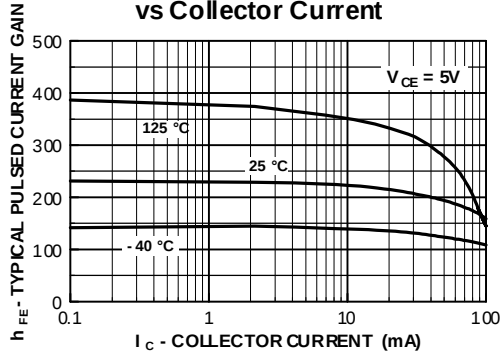
2N3904 / MMBT3904 / PZT3904

NPN General Purpose Amplifier (continued)

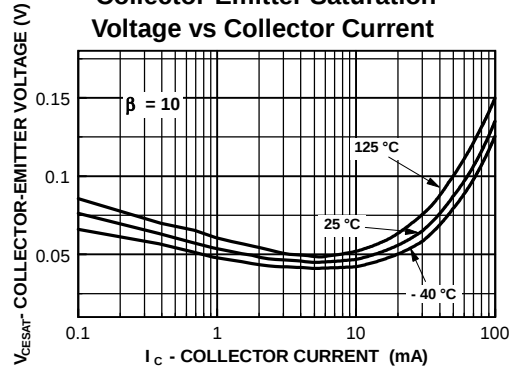
2N3904 / MMBT3904 / PZT3904

Typical Characteristics

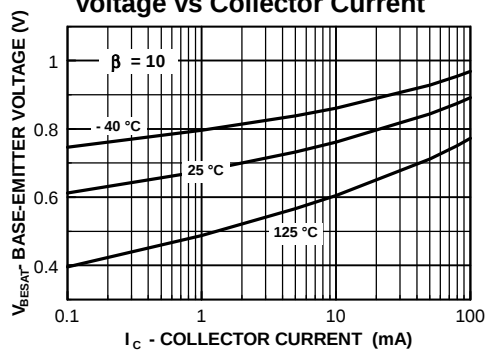
Typical Pulsed Current Gain
vs Collector Current



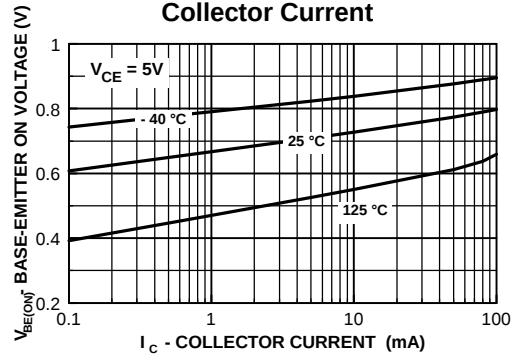
Collector-Emitter Saturation
Voltage vs Collector Current



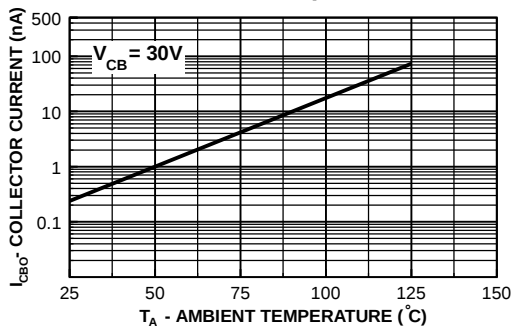
Base-Emitter Saturation
Voltage vs Collector Current



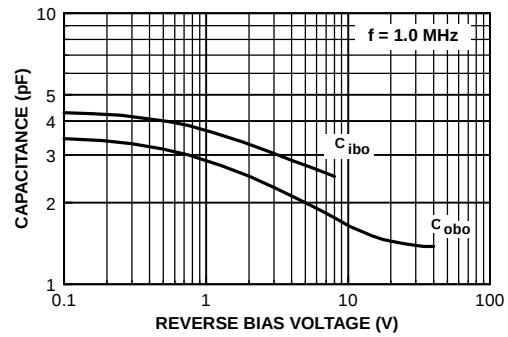
Base-Emitter ON Voltage vs
Collector Current



Collector-Cutoff Current
vs Ambient Temperature



Capacitance vs
Reverse Bias Voltage

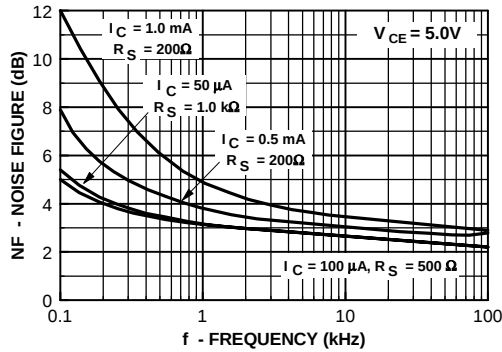


NPN General Purpose Amplifier (continued)

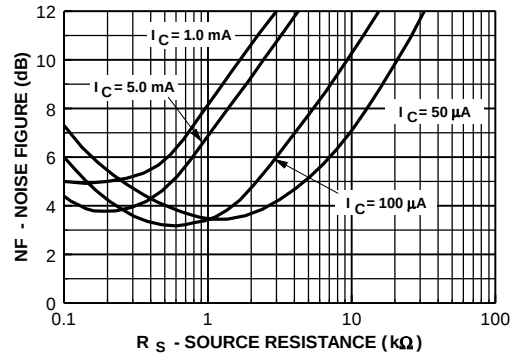
2N3904 / MMBT3904 / PZT3904

Typical Characteristics (continued)

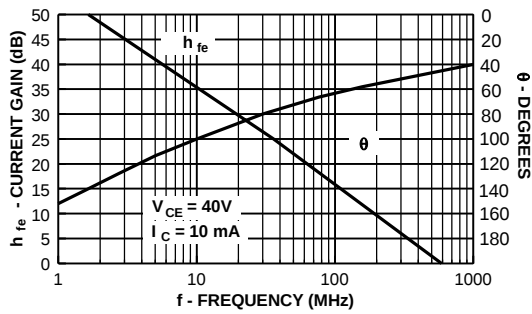
Noise Figure vs Frequency



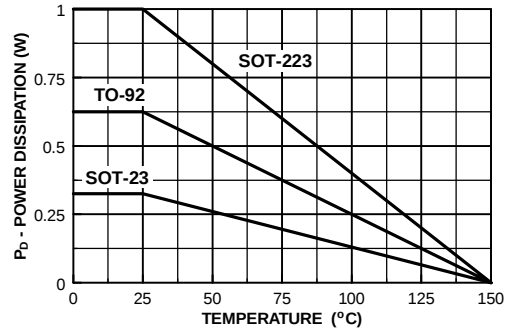
Noise Figure vs Source Resistance



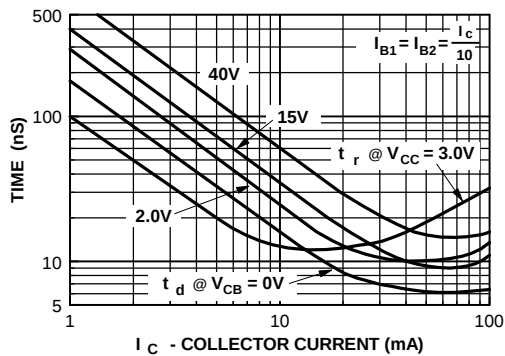
Current Gain and Phase Angle vs Frequency



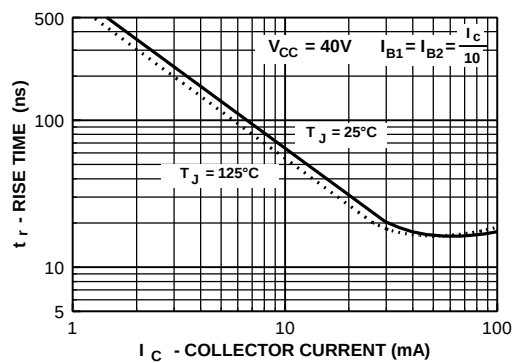
Power Dissipation vs Ambient Temperature



Turn-On Time vs Collector Current



Rise Time vs Collector Current

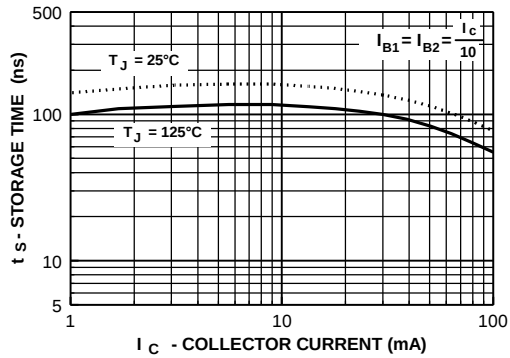


NPN General Purpose Amplifier (continued)

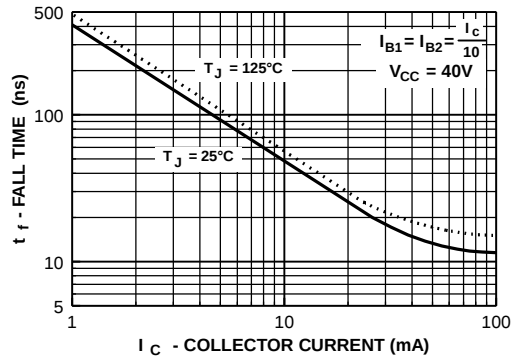
2N3904 / MMBT3904 / PZT3904

Typical Characteristics (continued)

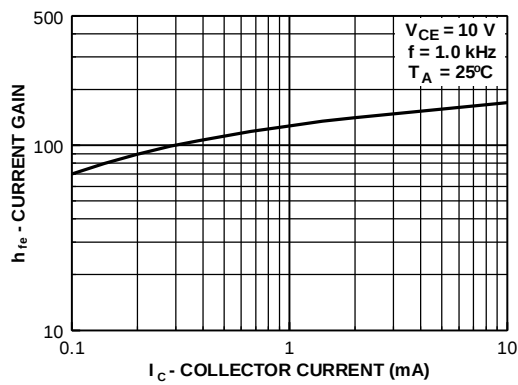
Storage Time vs Collector Current



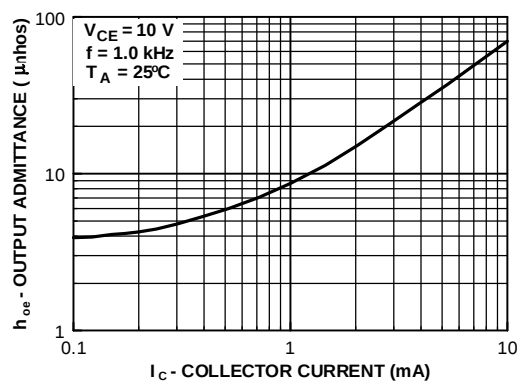
Fall Time vs Collector Current



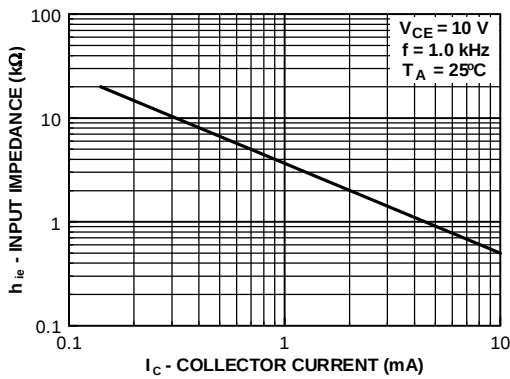
Current Gain



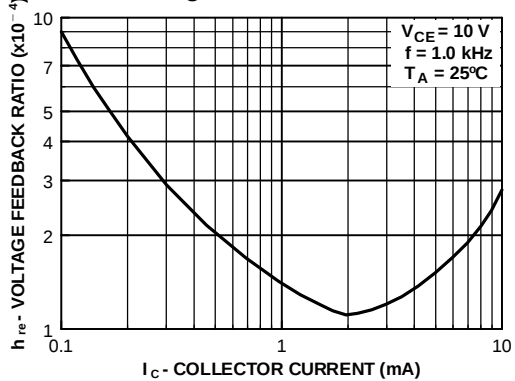
Output Admittance



Input Impedance



Voltage Feedback Ratio



Test Circuits

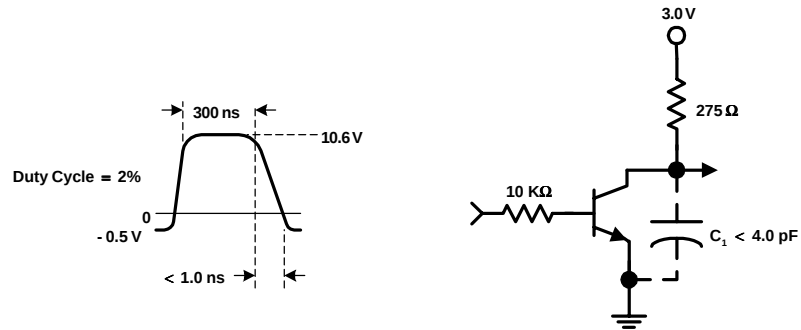


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

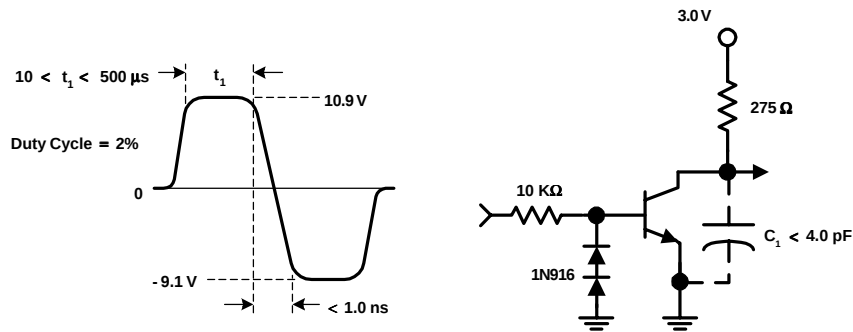


FIGURE 2: Storage and Fall Time Equivalent Test Circuit

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