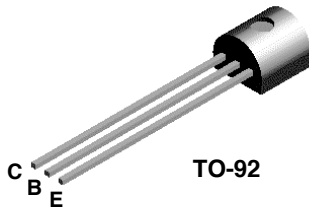
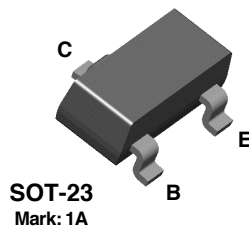


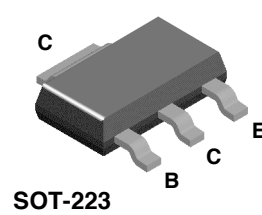
2N3904



MMBT3904



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.

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	350	1,000	mW
		5.0	2.8	8.0	mW/ $^\circ\text{C}$
$R_{\theta JC}$	Thermal Resistance, Junction to Case	83.3			$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	200	357	125	$^\circ\text{C}/\text{W}$

* 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
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 $\leq 2.0\%$

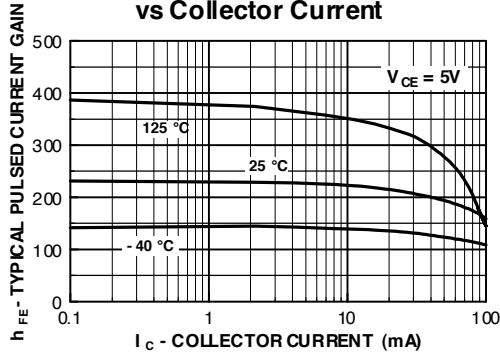
Spice Model

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)

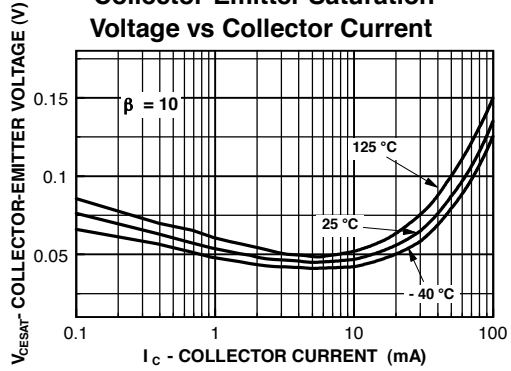
2N3904 / MMBT3904 / PZT3904

Typical Characteristics

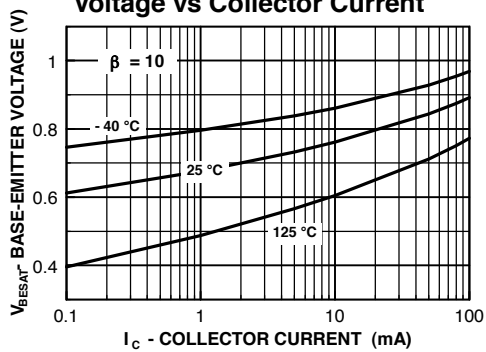
Typical Pulsed Current Gain vs Collector Current



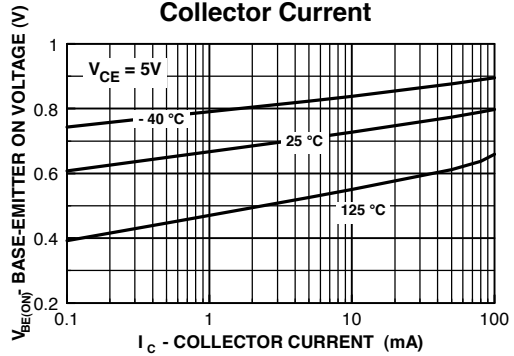
Collector-Emitter Saturation Voltage vs Collector Current



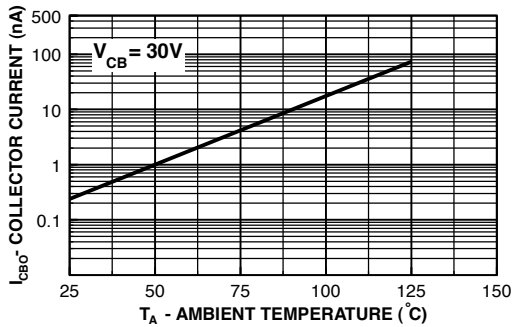
Base-Emitter Saturation Voltage vs Collector Current



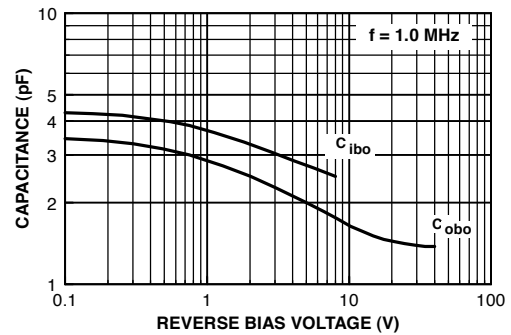
Base-Emitter ON Voltage vs Collector Current



Collector-Cutoff Current vs Ambient Temperature

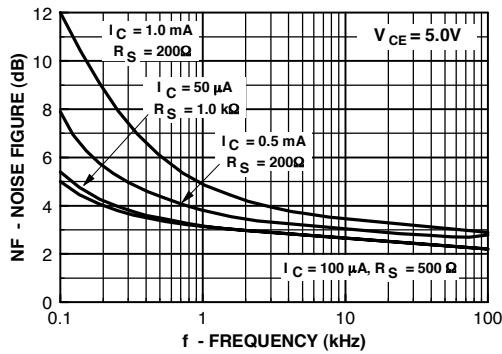


Capacitance vs Reverse Bias Voltage

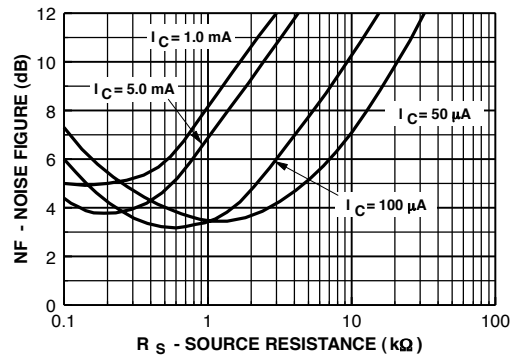


Typical Characteristics (continued)

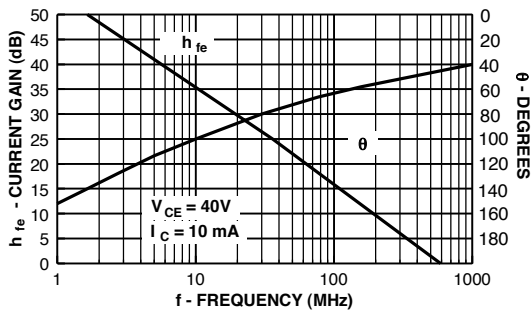
Noise Figure vs Frequency



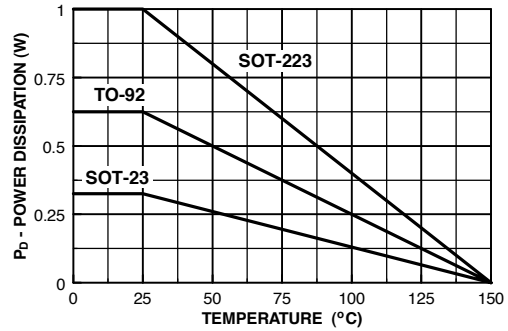
Noise Figure vs Source Resistance



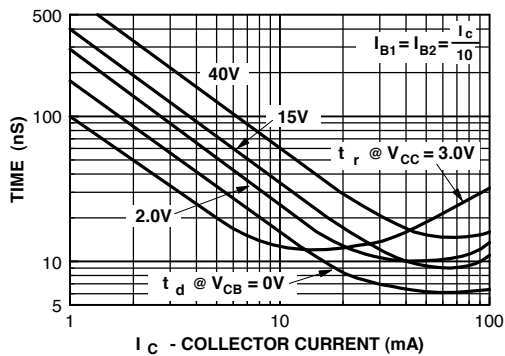
Current Gain and Phase Angle vs Frequency



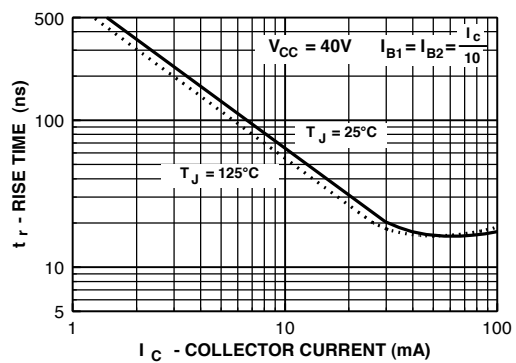
Power Dissipation vs Ambient Temperature



Turn-On Time vs Collector Current



Rise Time vs Collector Current



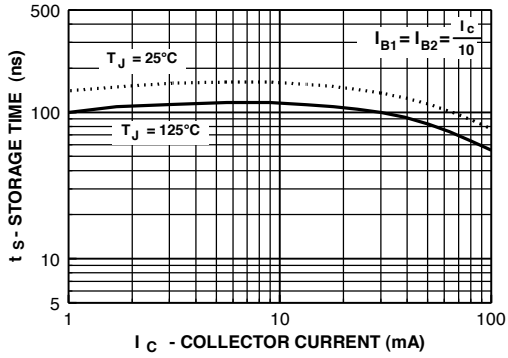
NPN General Purpose Amplifier

(continued)

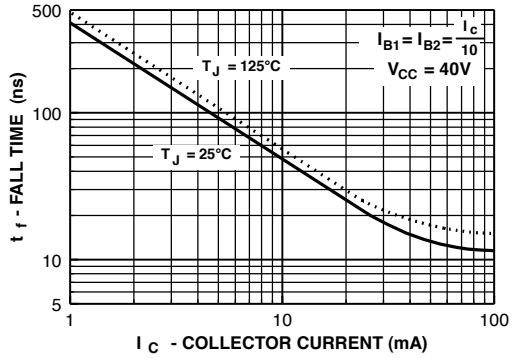
2N3904 / MMBT3904 / PZT3904

Typical Characteristics (continued)

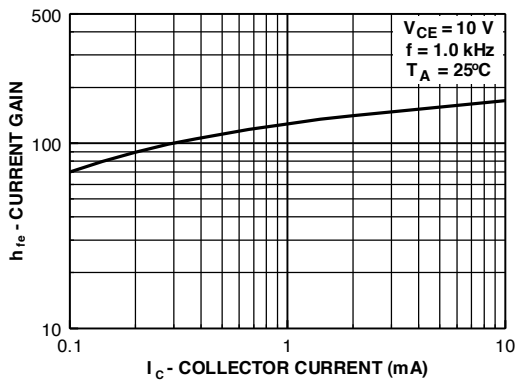
Storage Time vs Collector Current



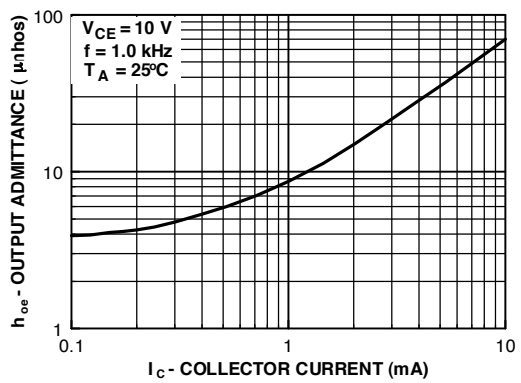
Fall Time vs Collector Current



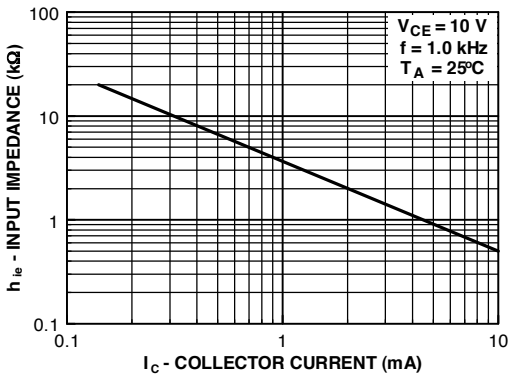
Current Gain



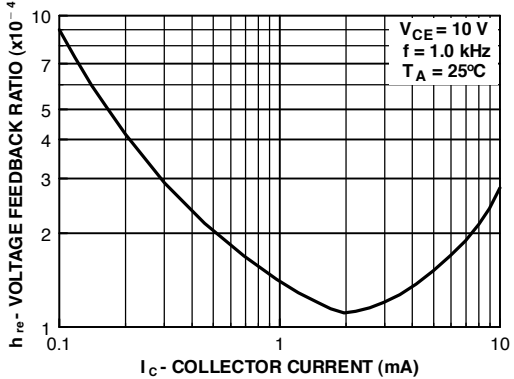
Output Admittance



Input Impedance



Voltage Feedback Ratio



Test Circuits

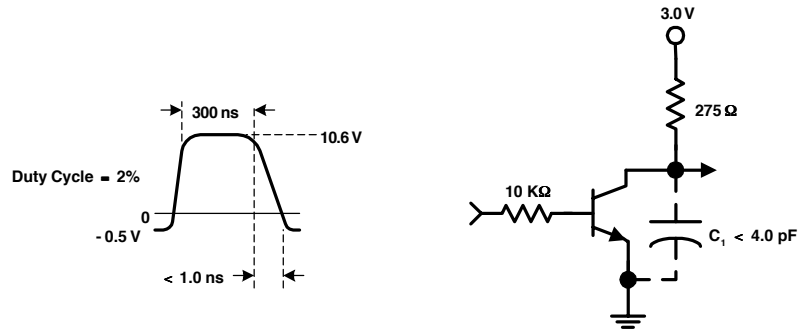


FIGURE 1: Delay and Rise Time Equivalent Test Circuit

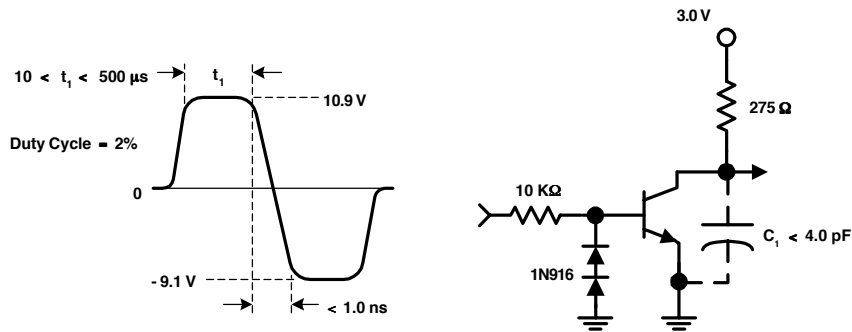


FIGURE 2: Storage and Fall Time Equivalent Test Circuit

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FAST®	POP™	SuperSOT™-8	

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