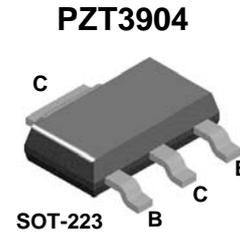
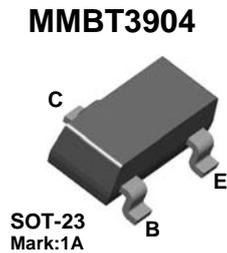


# 2N3904 / MMBT3904 / PZT3904 NPN General Purpose Amplifier

## Features

- 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
$V_{CEO}$	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	$^\circ\text{C}$

\* 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	Parameter	Max.			Units
		2N3904	*MMBT3904	**PZT3904	
$P_D$	Total Device Dissipation	625	350	1,000	mW
	Derate above $25^\circ\text{C}$	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<sup>2</sup>.

**Electrical Characteristics**  $T_a = 25^\circ\text{C}$  unless otherwise noted

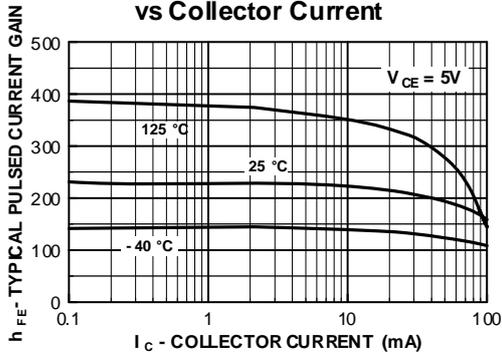
Symbol	Parameter	Test Condition	Min.	Max.	Units
<b>OFF CHARACTERISTICS</b>					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1.0\text{mA}, I_B = 0$	40		V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\mu\text{A}, I_E = 0$	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}, I_C = 0$	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
<b>ON CHARACTERISTICS*</b>					
$h_{FE}$	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
<b>SMALL SIGNAL CHARACTERISTICS</b>					
$f_T$	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	$I_C = 100\mu\text{A}, V_{CE} = 5.0\text{V},$ $R_S = 1.0\text{k}\Omega,$ $f = 10\text{Hz to } 15.7\text{kHz}$		5.0	dB
<b>SWITCHING CHARACTERISTICS</b>					
$t_d$	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  $\leq 300\mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ **Ordering Information**

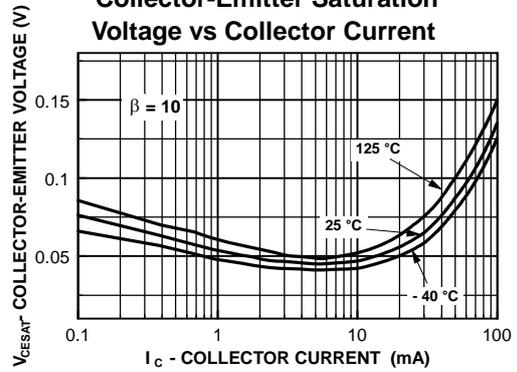
Part Number	Marking	Package	Packing Method	Pack Qty
2N3904BU	2N3904	TO-92	BULK	10000
2N3904TA	2N3904	TO-92	AMMO	2000
2N3904TAR	2N3904	TO-92	AMMO	2000
2N3904TF	2N3904	TO-92	TAPE REEL	2000
2N3904TFR	2N3904	TO-92	TAPE REEL	2000
MMBT3904	1A	SOT-23	TAPE REEL	3000
MMBT3904_D87Z	1A	SOT-23	TAPE REEL	10000
PZT3904	3904	SOT-223	TAPE REEL	2500

## Typical Performance Characteristics

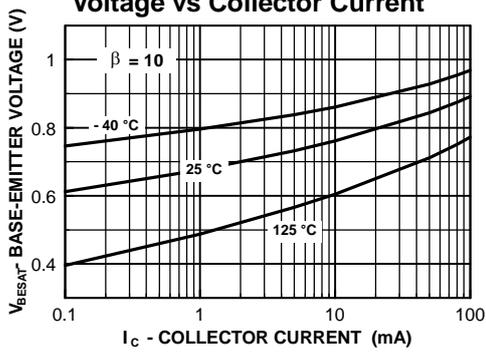
**Typical Pulsed Current Gain vs Collector Current**



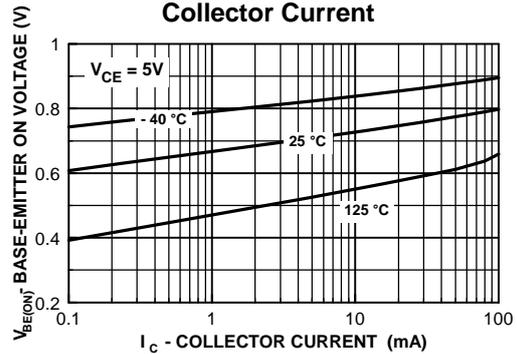
**Collector-Emitter Saturation Voltage vs Collector Current**



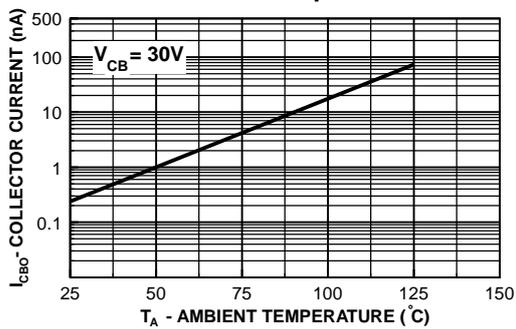
**Base-Emitter Saturation Voltage vs Collector Current**



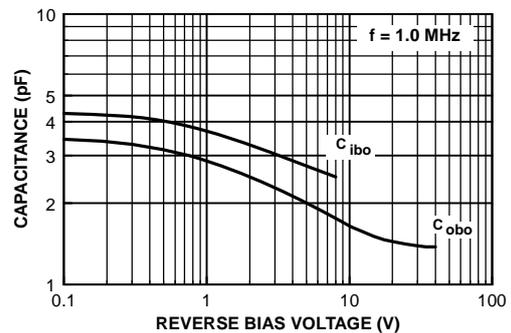
**Base-Emitter ON Voltage vs Collector Current**



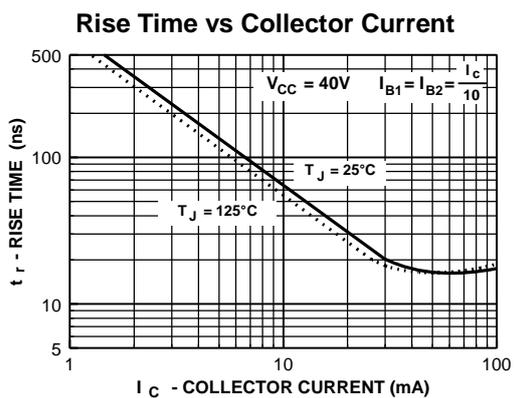
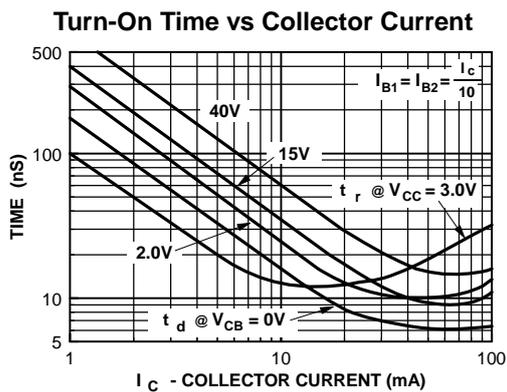
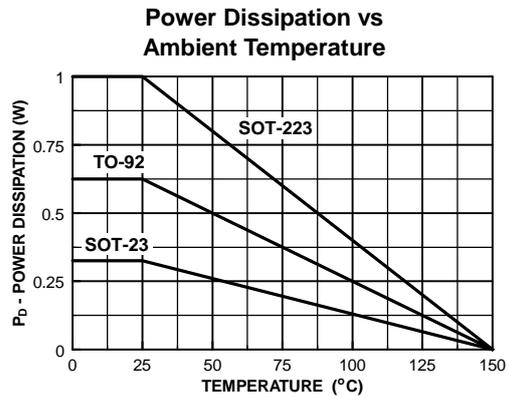
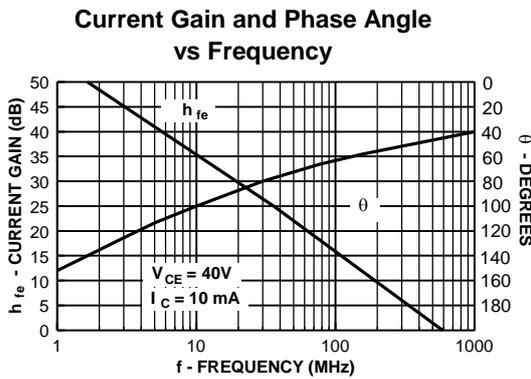
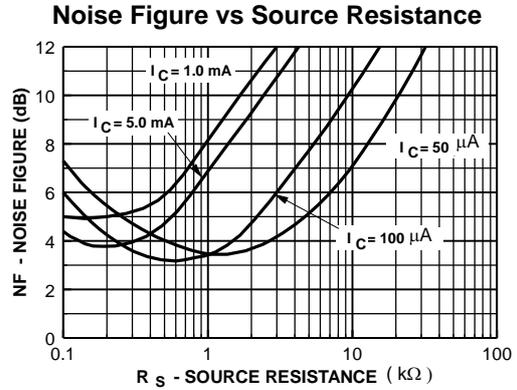
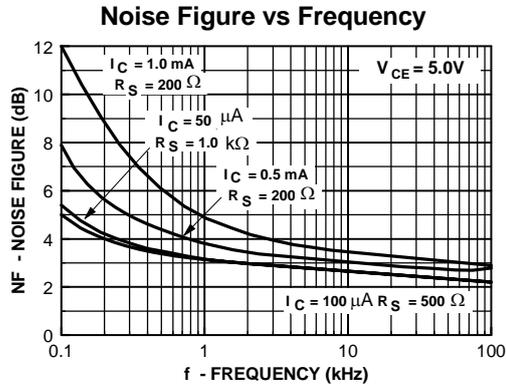
**Collector-Cutoff Current vs Ambient Temperature**



**Capacitance vs Reverse Bias Voltage**

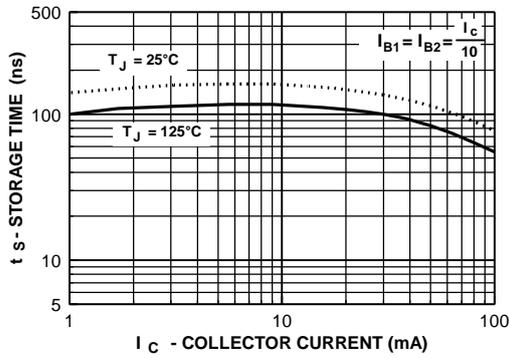


**Typical Performance Characteristics** (continued)

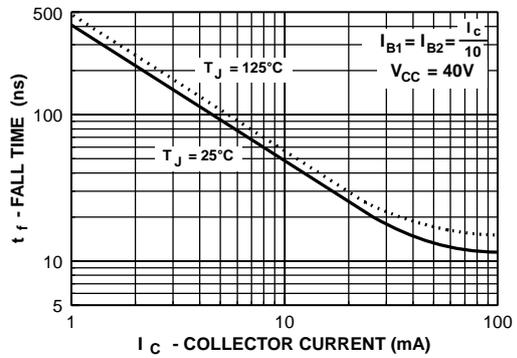


**Typical Performance Characteristics** (continued)

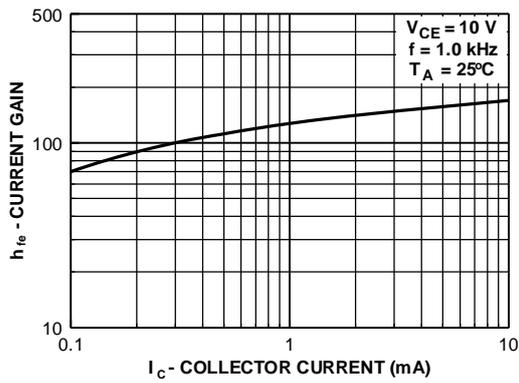
**Storage Time vs Collector Current**



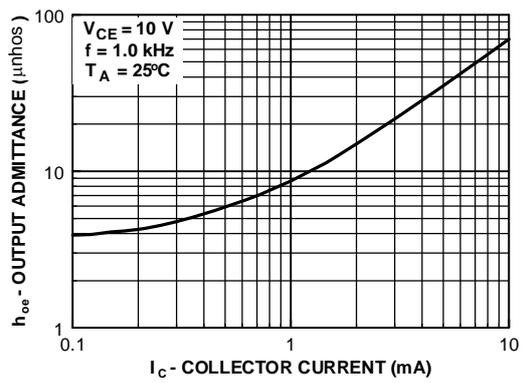
**Fall Time vs Collector Current**



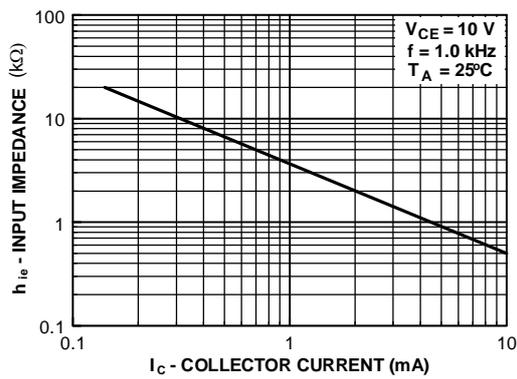
**Current Gain**



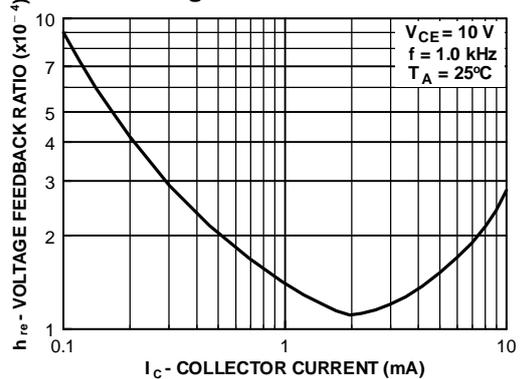
**Output Admittance**



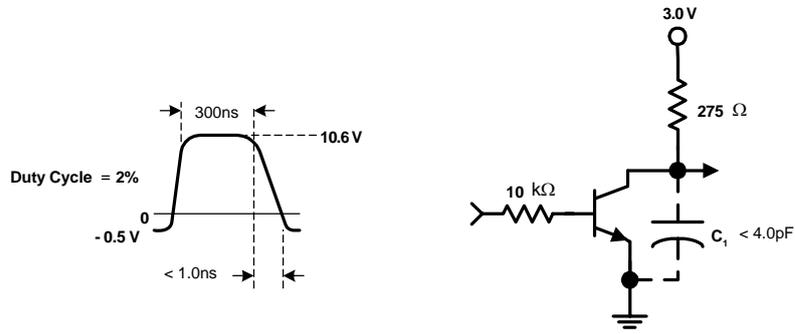
**Input Impedance**



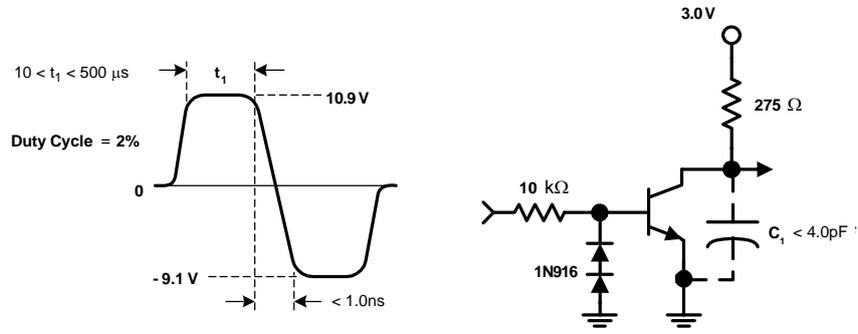
**Voltage Feedback Ratio**



## Test Circuits



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



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



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| Auto-SPM™   | FRFET®   | PowerTrench®  | franchise   |
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| BitSiC®   | Green FPS™                                     | Programmable Active Droop™  | TinyBuck™   |
| Build it Now™   | Green FPS™ e-Series™                           | QFET®   | TinyCalc™   |
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