

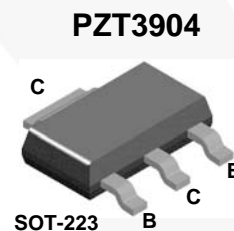
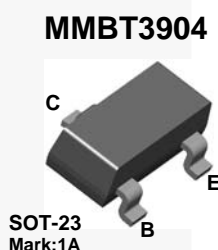
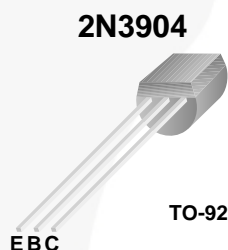


October 2014

## 2N3904 / MMBT3904 / PZT3904 NPN General-Purpose Amplifier

### Description

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.



### Ordering Information

Part Number	Marking	Package	Packing Method	Pack Quantity
2N3904BU	2N3904	TO-92 3L	Bulk	10000
2N3904TA	2N3904	TO-92 3L	Ammo	2000
2N3904TAR	2N3904	TO-92 3L	Ammo	2000
2N3904TF	2N3904	TO-92 3L	Tape and Reel	2000
2N3904TFR	2N3904	TO-92 3L	Tape and Reel	2000
MMBT3904	1A	SOT-23 3L	Tape and Reel	3000
PZT3904	3904	SOT-223 4L	Tape and Reel	2500

2N3904 / MMBT3904 / PZT3904 — NPN General-Purpose Amplifier

## Absolute Maximum Ratings<sup>(1), (2)</sup>

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Value	Unit
$V_{CEO}$	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	$^\circ\text{C}$

### Notes:

1. These ratings are based on a maximum junction temperature of  $150^\circ\text{C}$ .
2. These are steady-state limits. Fairchild Semiconductor should be consulted on applications involving pulsed or low-duty cycle operations.

## Thermal Characteristics

Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Maximum			Unit
		2N3904	MMBT3904 <sup>(3)</sup>	PZT3904 <sup>(4)</sup>	
$P_D$	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			$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	200	357	125	$^\circ\text{C/W}$

### Notes:

3. Device is mounted on FR-4 PCB 1.6 inch X 1.6 inch X 0.06 inch.
4. Device is mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm, mounting pad for the collector lead minimum  $6\text{ cm}^2$ .

## Electrical Characteristics

Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Max.	Unit
OFF CHARACTERISTICS					
V <sub>(BR)CEO</sub>	Collector-Emitter Breakdown Voltage	I <sub>C</sub> = 1.0 mA, I <sub>B</sub> = 0	40		V
V <sub>(BR)CBO</sub>	Collector-Base Breakdown Voltage	I <sub>C</sub> = 10 μA, I <sub>E</sub> = 0	60		V
V <sub>(BR)EBO</sub>	Emitter-Base Breakdown Voltage	I <sub>E</sub> = 10 μA, I <sub>C</sub> = 0	6.0		V
I <sub>BL</sub>	Base Cut-Off Current	V <sub>CE</sub> = 30 V, V <sub>EB</sub> = 3 V		50	nA
I <sub>CEX</sub>	Collector Cut-Off Current	V <sub>CE</sub> = 30 V, V <sub>EB</sub> = 3 V		50	nA
ON CHARACTERISTICS <sup>(5)</sup>					
h <sub>FE</sub>	DC Current Gain	I <sub>C</sub> = 0.1 mA, V <sub>CE</sub> = 1.0 V	40		
		I <sub>C</sub> = 1.0 mA, V <sub>CE</sub> = 1.0 V	70		
		I <sub>C</sub> = 10 mA, V <sub>CE</sub> = 1.0 V	100	300	
		I <sub>C</sub> = 50 mA, V <sub>CE</sub> = 1.0 V	60		
		I <sub>C</sub> = 100 mA, V <sub>CE</sub> = 1.0V	30		
V <sub>CE</sub> (sat)	Collector-Emitter Saturation Voltage	I <sub>C</sub> = 10 mA, I <sub>B</sub> = 1.0 mA		0.2	V
		I <sub>C</sub> = 50 mA, I <sub>B</sub> = 5.0 mA		0.3	
V <sub>BE</sub> (sat)	Base-Emitter Saturation Voltage	I <sub>C</sub> = 10 mA, I <sub>B</sub> = 1.0 mA	0.65	0.85	V
		I <sub>C</sub> = 50 mA, I <sub>B</sub> = 5.0 mA		0.95	
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 = 100 kHz		4.0	pF
C <sub>ibo</sub>	Input Capacitance	V <sub>EB</sub> = 0.5 V, I <sub>C</sub> = 0, f = 100 kHz		8.0	pF
NF	Noise Figure	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					
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

**Note:**

5. Pulse test: pulse width  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2.0\%$ .

## Typical Performance Characteristics

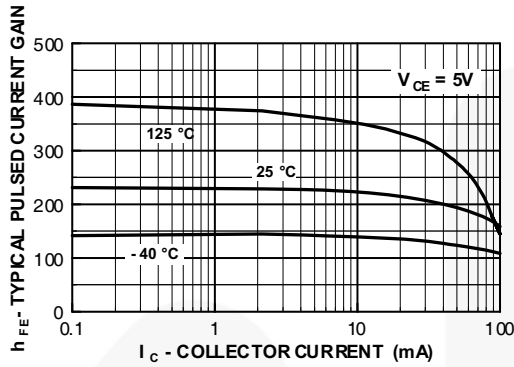


Figure 1. Typical Pulsed Current Gain vs. Collector Current

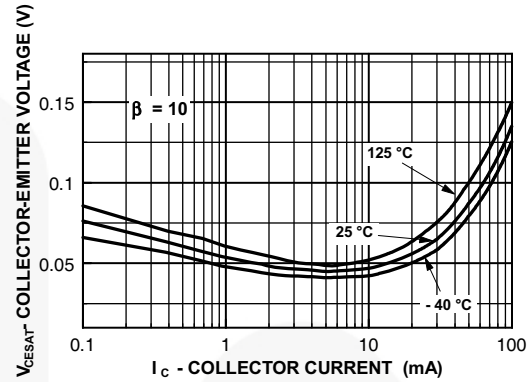


Figure 2. Collector-Emitter Saturation Voltage vs. Collector Current

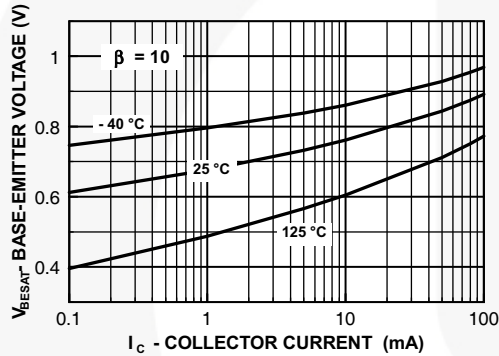


Figure 3. Base-Emitter Saturation Voltage vs. Collector Current

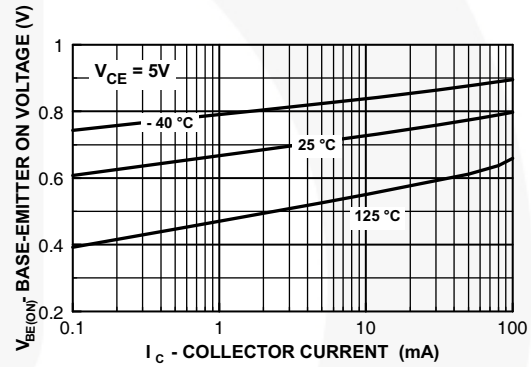


Figure 4. Base-Emitter On Voltage vs. Collector Current

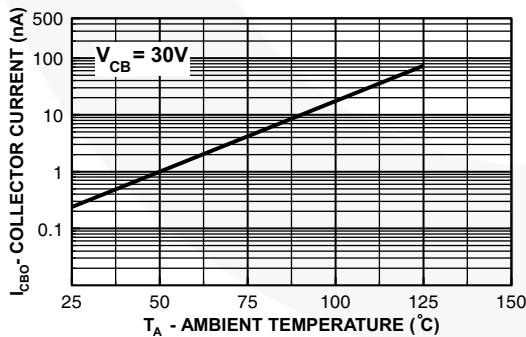


Figure 5. Collector Cut-Off Current vs. Ambient Temperature

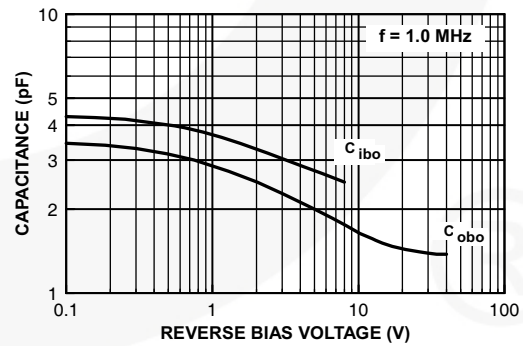


Figure 6. Capacitance vs. Reverse Bias Voltage

## Typical Performance Characteristics (Continued)

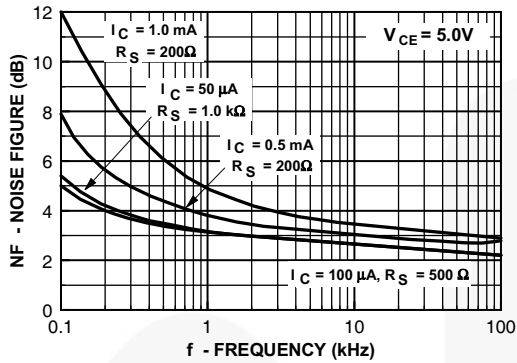


Figure 7. Noise Figure vs. Frequency

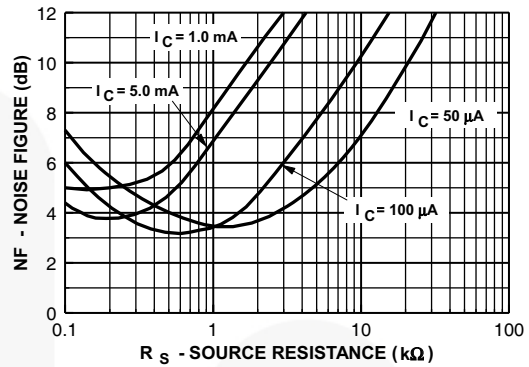


Figure 8. Noise Figure vs. Source Resistance

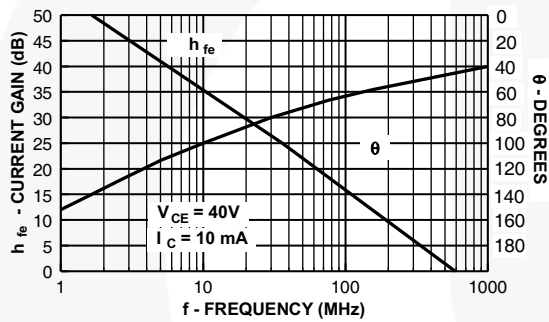


Figure 9. Current Gain and Phase Angle vs. Frequency

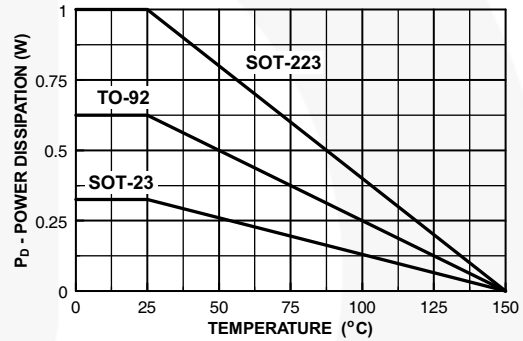


Figure 10. Power Dissipation vs. Ambient Temperature

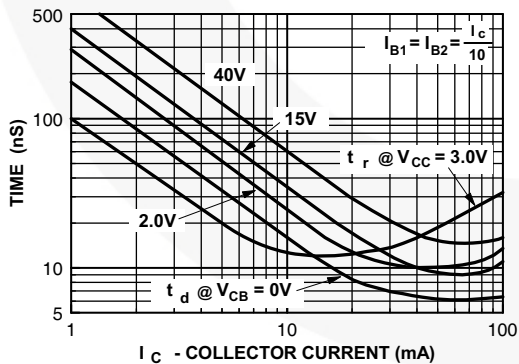


Figure 11. Turn-On Time vs. Collector Current

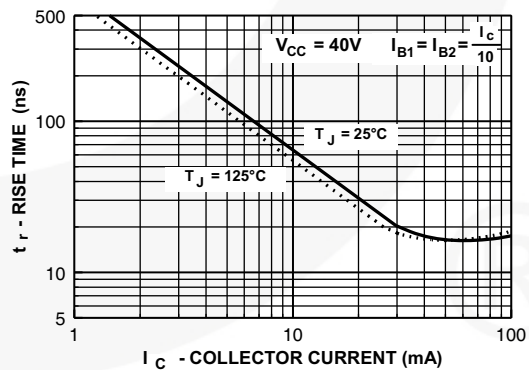


Figure 12. Rise Time vs. Collector Current

# Typical Performance Characteristics (Continued)

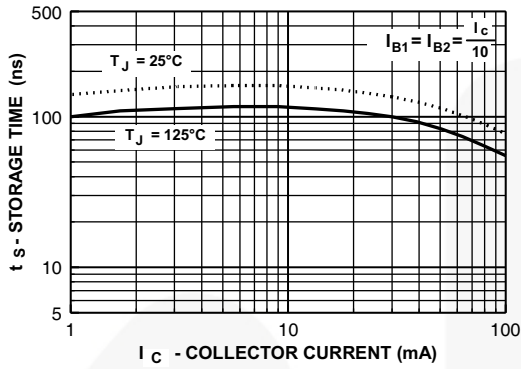


Figure 13. Storage Time vs. Collector Current

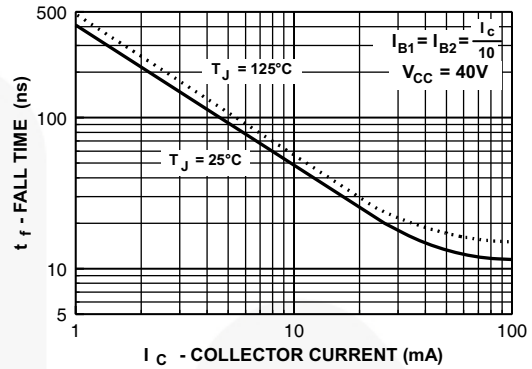


Figure 14. Fall Time vs. Collector Current

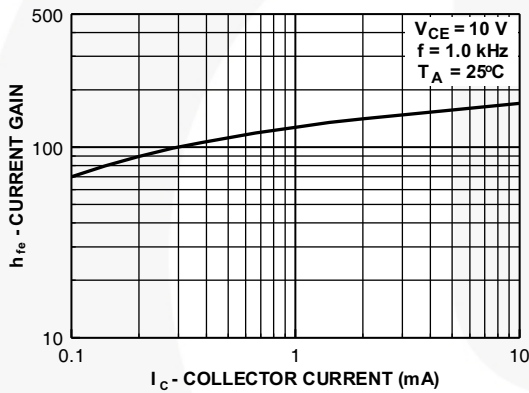


Figure 15. Current Gain

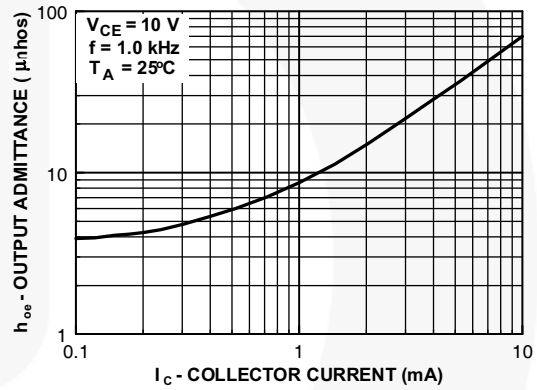


Figure 16. Output Admittance

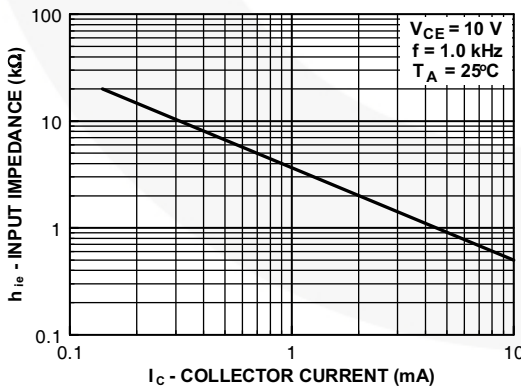


Figure 17. Input Impedance

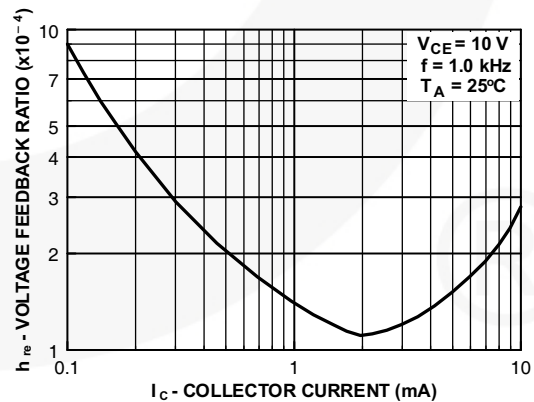


Figure 18. Voltage Feedback Ratio

## Test Circuits

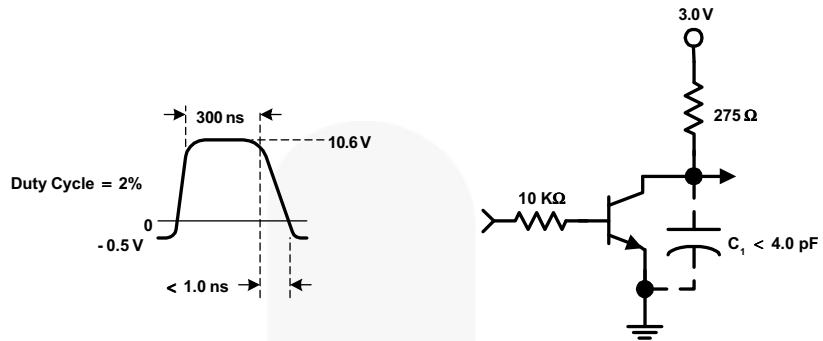


Figure 19. Delay and Rise Time Equivalent Test Circuit

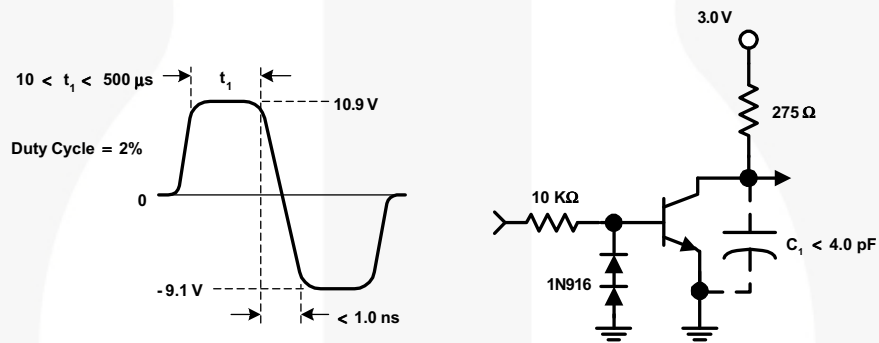
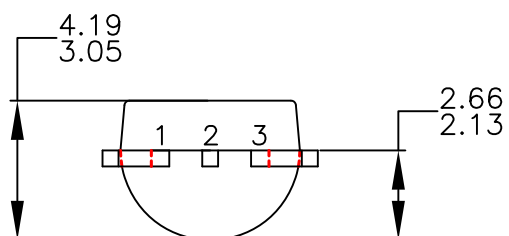
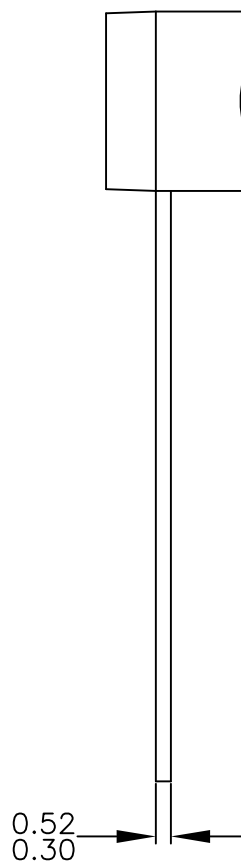
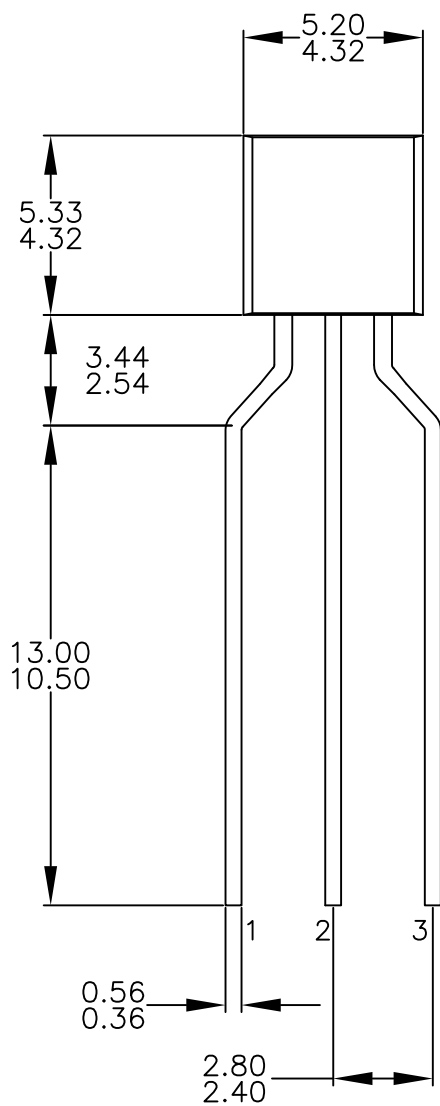


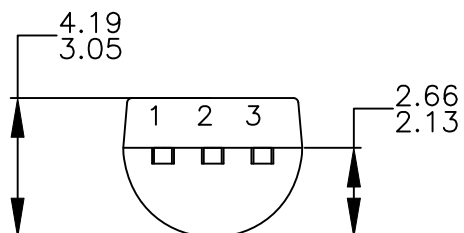
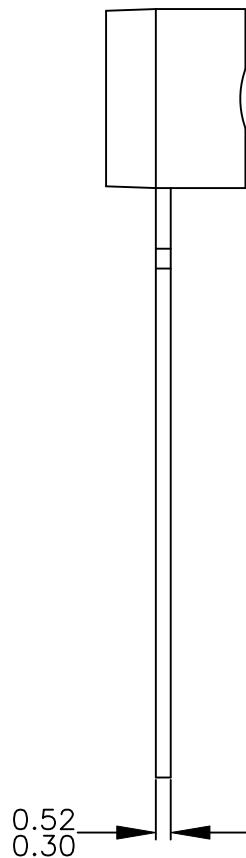
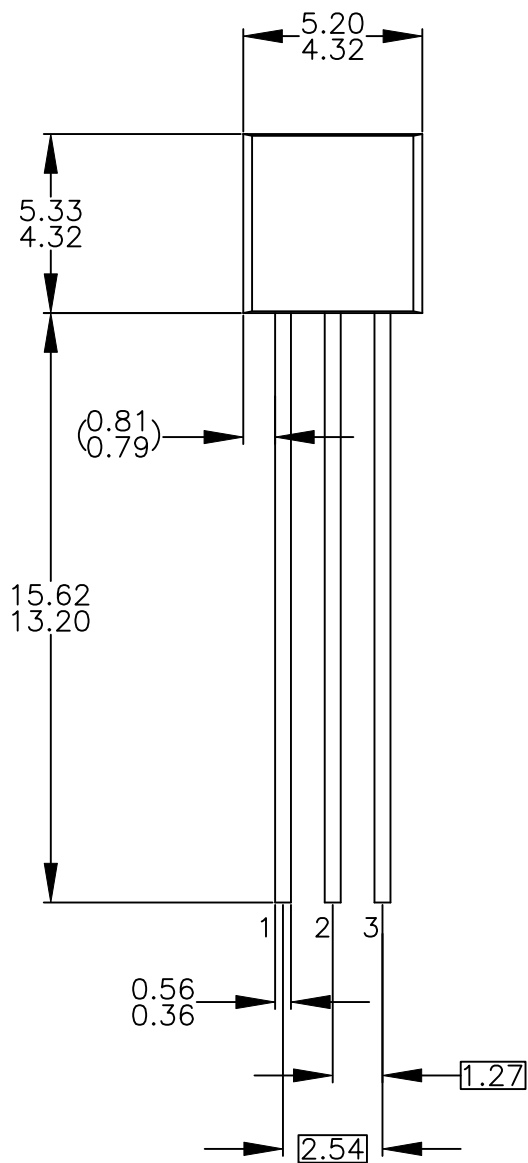
Figure 20. Storage and Fall Time Equivalent Test Circuit



NOTES: UNLESS OTHERWISE SPECIFIED

- A. DRAWING CONFORMS TO JEDEC MS-013, VARIATION AC.
- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. DRAWING CONFORMS TO ASME Y14.5M-2009.
- D. DRAWING FILENAME: MKT-ZA03FREV3.
- E. FAIRCHILD SEMICONDUCTOR.





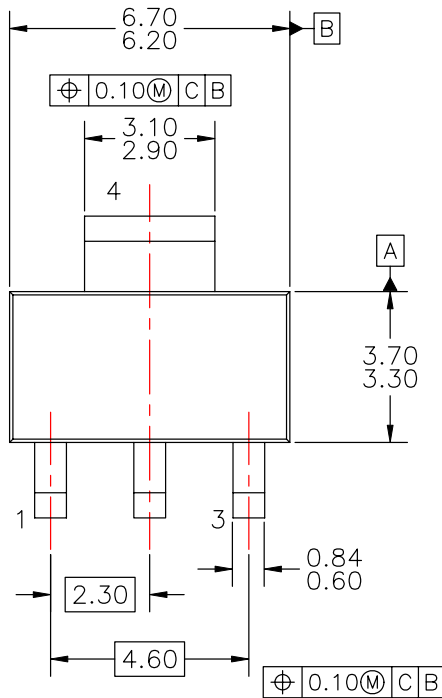
NOTES: UNLESS OTHERWISE SPECIFIED

- A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DRAWING CONFORMS TO ASME Y14.5M-2009.
- D) DRAWING FILENAME: MKT-ZA03DREV4.

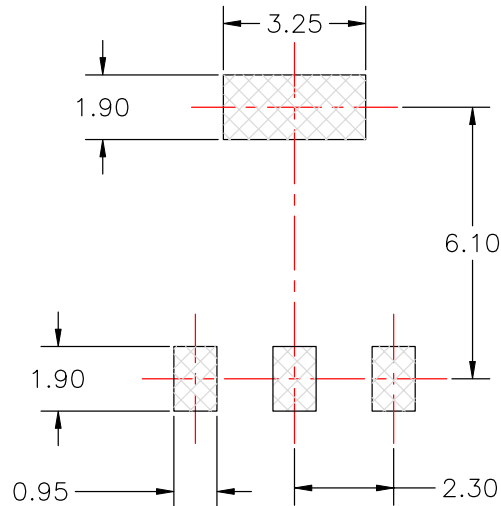


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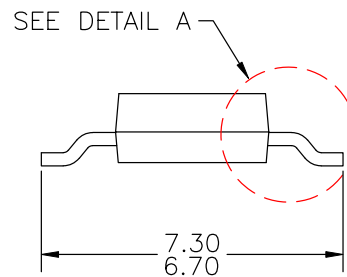
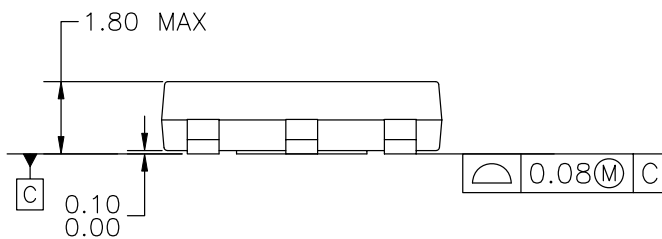
**APPROVED**  
July-14-2008



REVISIONS			
LTR	DESCRIPTION	DATE	NAME/SITE
A	RELEASE TO DOCUMENT CONTROL	JAN.25.1996	TL/FSCP
2	CHG DWG TEMPLATE FR NATIONAL TO FAIRCHILD; CHG DIM STYLE FR DUAL INCH[MM] TO SINGLE, MM; CHG LD WID FR 0.74 $\pm$ 0.05 TO 0.60-0.84; REMOVE PKG THICK DIM (1.6); CHG TOTAL PKG HT FR 1.5 TO 1.80 MAX; CHG FOOT LANDING DIM FR 0.91 MIN TO 0.60 MIN; CHG LD THICKNESS FR 0.35 $\pm$ 0.08 TO 0.20-0.35; ADD DRAFT ANGLE OF MOLDED BODY TOP & BOT; CHG LD LGTH TO PKG EDGE DIM TO BASIC; CHG LD PITCH FR 2.29 BS TO 2.30 BS; CHG BODY WID FR 3.56 $\pm$ 0.38 TO 3.30; CHG BODY LN FR 6.55 $\pm$ 0.38 TO 6.30; CHG TOTAL PKG WID FR 6.94 $\pm$ 0.38 TO 7.30; CHG PAD SIZE FR 0.99 MAX TO 0.95; CHG PAD PITCH FR 2.286 TO 2.30; CHG THERMAL TAB SIZE FR 3.28 MAX TO 3.25; CHG PAD SIZE FR 1.5 TO 1.90; CHG PAD SPACE FR 6.3 TO 6.10; CHG NOTE '2' TO 'A' W/O DATE; DEL NOTE ON LD FINISH; ADD NOTES B, C, D, E & F.	12FEB08	LZSC/FSCP

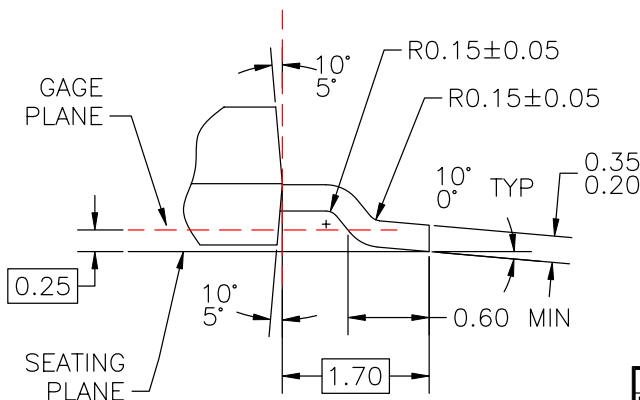


LAND PATTERN RECOMMENDATION



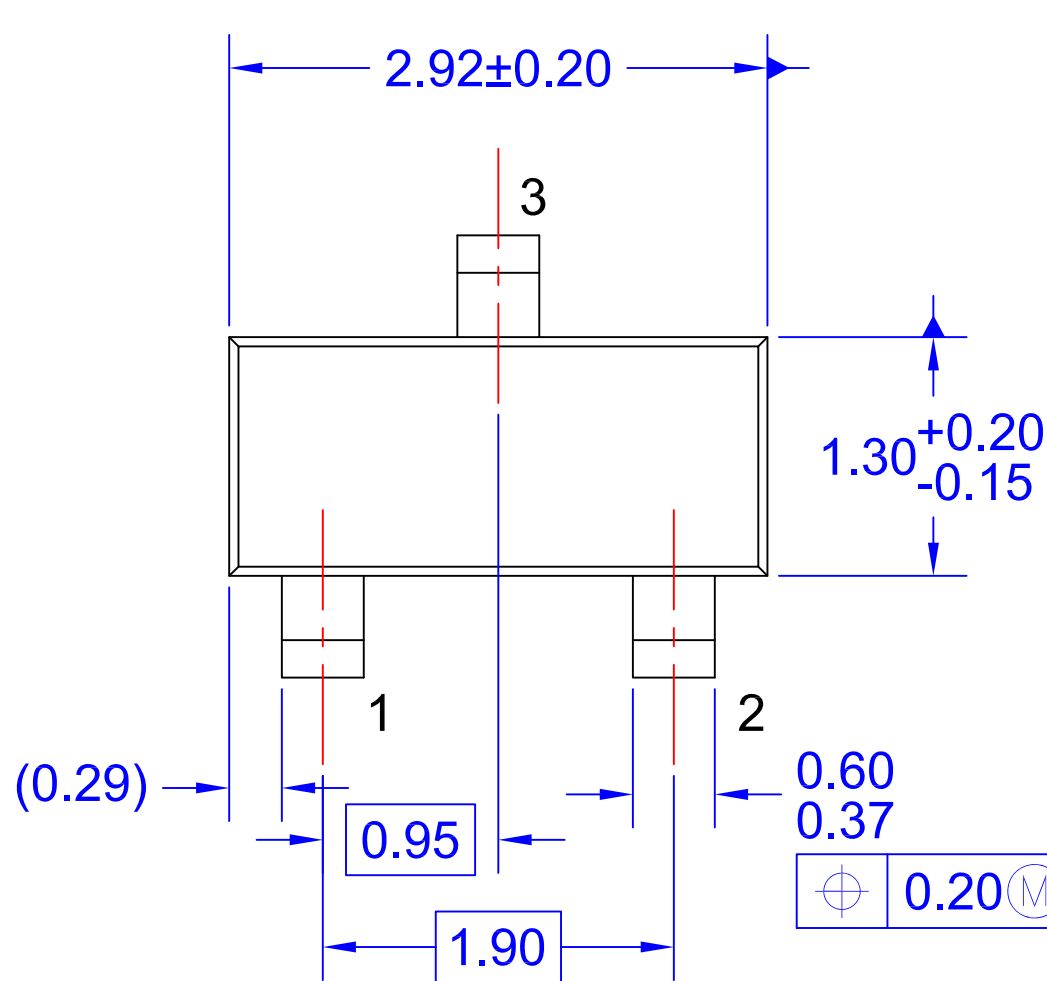
NOTES: UNLESS OTHERWISE SPECIFIED

- A) DRAWING BASED ON JEDEC REGISTRATION TO-261, VARIATION AA.
- B) DIMENSIONS ARE INCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR EXTRUSIONS.
- C) ALL DIMENSIONS ARE IN MILLIMETERS.
- D) DRAWING CONFORMS TO ASME Y14.5M-1994.
- E) LANDPATTERN NAME: SOT230P700X180-4BN
- F) DRAWING FILENAME: MKT-MA04AREV2

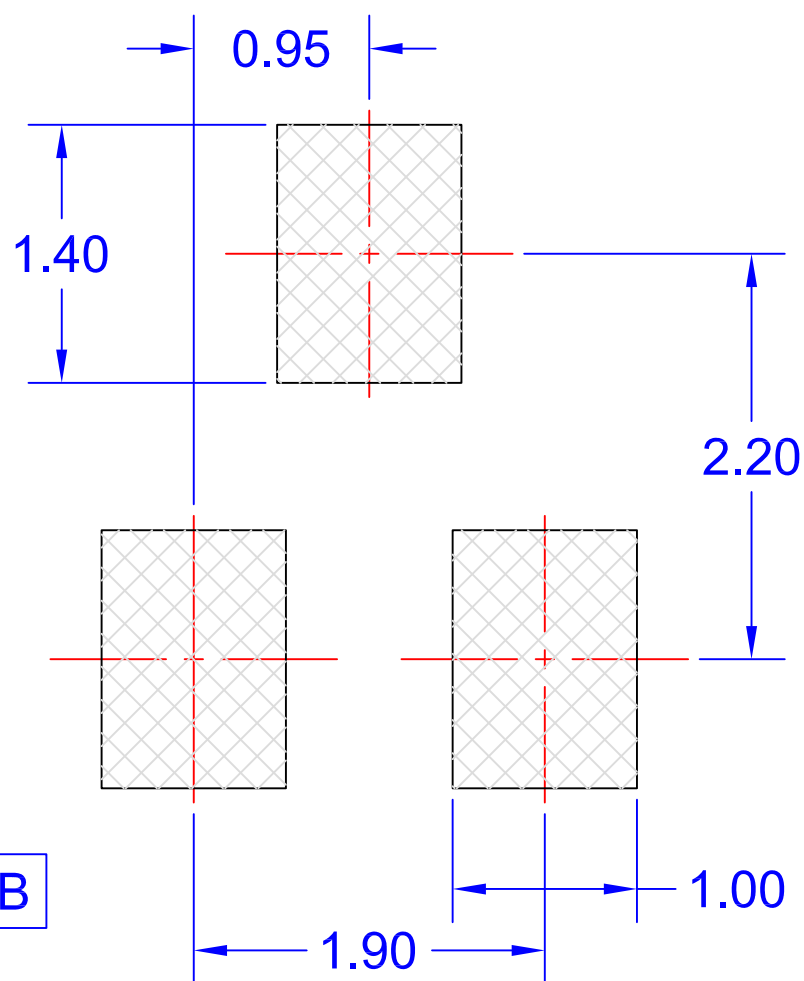


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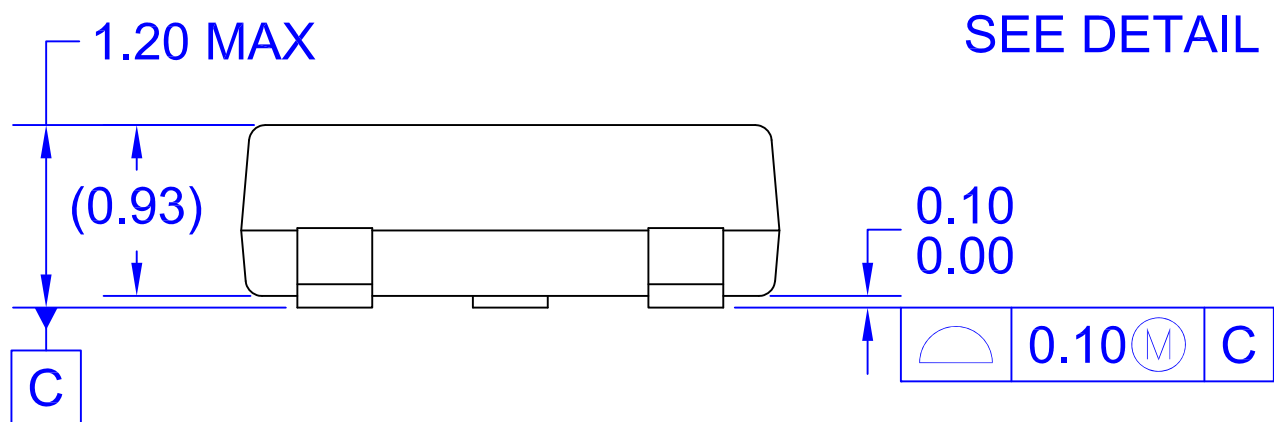
APPROVALS		DATE		
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CHECKED: L.Z. STA CRUZ			<b>MOLDED PACKAGE SOT-223, 4 LEAD</b>	
APPROVED: M.R. GESTOLE				
G.S. BAJE				
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		SHEET : 1 OF 1		



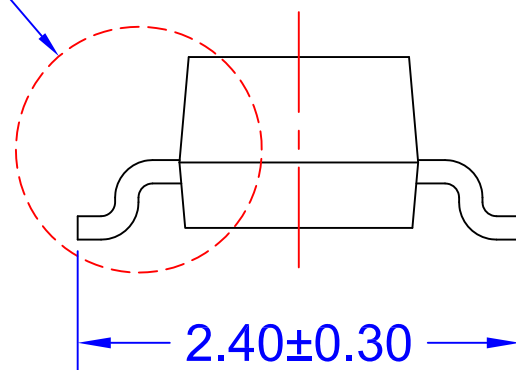
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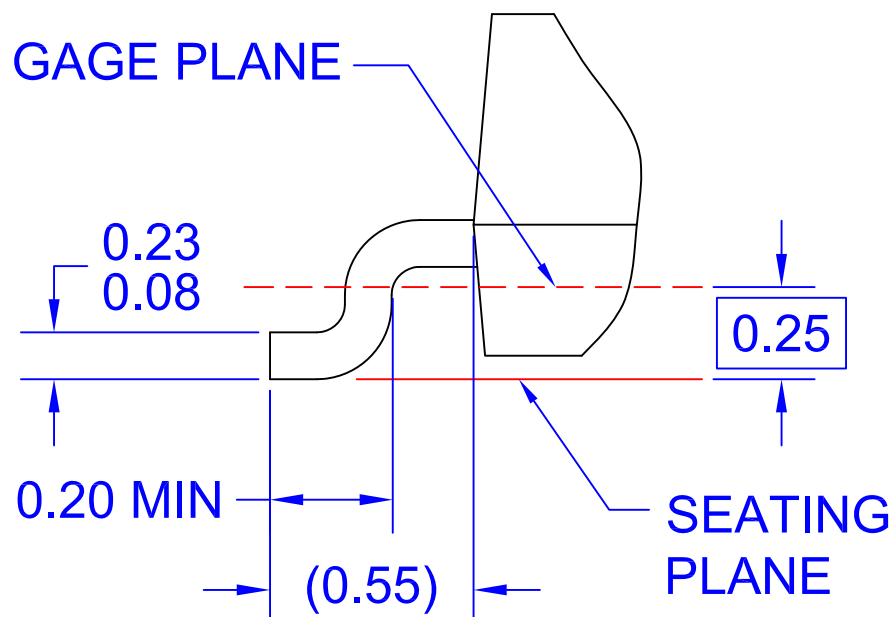
LAND PATTERN  
RECOMMENDATION



SEE DETAIL A



NOTES: UNLESS OTHERWISE SPECIFIED



DETAIL A  
SCALE: 2X

- A) REFERENCE JEDEC REGISTRATION TO-236, VARIATION AB, ISSUE H.
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS ARE INCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR EXTRUSIONS.
- D) DIMENSIONING AND TOLERANCING PER ASME Y14.5M - 2009.
- E) DRAWING FILE NAME: MA03DREV11





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EcoSPARK®  
EfficientMax™  
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Gmax™  
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STEALTH™  
SuperFET®  
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TinyBuck®  
TinyCalc™  
TinyLogic®  
TINYOPTO™  
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## ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, [www.fairchildsemi.com](http://www.fairchildsemi.com), under Terms of Use

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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