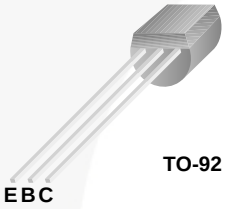
October 2014

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

## Description

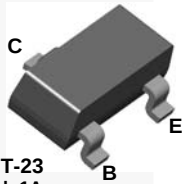
This device is designed as a general-purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.

**2N3904**



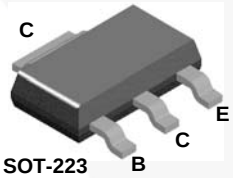

TO-92

**MMBT3904**




SOT-23
Mark:1A

**PZT3904**




SOT-223

## 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 |

## Absolute Maximum Ratings(1), (2)

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°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 | °C |

**Notes:**

1. These ratings are based on a maximum junction temperature of 150°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°C unless otherwise noted.

| Symbol | Parameter | Maximum | | | Unit |
|---|---|---|---|---|---|
| | | 2N3904 | MMBT3904(3) | PZT3904(4) | |
| $P_D$ | Total Device Dissipation | 625 | 350 | 1,000 | mW |
| | Derate Above 25°C | 5.0 | 2.8 | 8.0 | mW/°C |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | 83.3 | | | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 200 | 357 | 125 | °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 $cm^2$.

## Electrical Characteristics

Values are at $T_A$ = 25°C unless otherwise noted.

| Symbol | Parameter | Conditions | Min. | Max. | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage | $I_C$ = 1.0 mA, $I_B$ = 0 | 40 | | V |
| $V_{(BR)CBO}$ | Collector-Base Breakdown Voltage | $I_C$ = 10 μA, $I_E$ = 0 | 60 | | V |
| $V_{(BR)EBO}$ | Emitter-Base Breakdown Voltage | $I_E$ = 10 μA, $I_C$ = 0 | 6.0 | | V |
| $I_{BL}$ | Base Cut-Off Current | $V_{CE}$ = 30 V, $V_{EB}$ = 3 V | | 50 | nA |
| $I_{CEX}$ | Collector Cut-Off Current | $V_{CE}$ = 30 V, $V_{EB}$ = 3 V | | 50 | nA |
| **ON CHARACTERISTICS**[5] | | | | | |
| $h_{FE}$ | DC Current Gain | $I_C$ = 0.1 mA, $V_{CE}$ = 1.0 V | 40 | | |
| | | $I_C$ = 1.0 mA, $V_{CE}$ = 1.0 V | 70 | | |
| | | $I_C$ = 10 mA, $V_{CE}$ = 1.0 V | 100 | 300 | |
| | | $I_C$ = 50 mA, $V_{CE}$ = 1.0 V | 60 | | |
| | | $I_C$ =100 mA, $V_{CE}$ = 1.0V | 30 | | |
| $V_{CE}$(sat) | Collector-Emitter Saturation Voltage | $I_C$ = 10 mA, $I_B$ = 1.0 mA | | 0.2 | V |
| | | $I_C$ = 50 mA, $I_B$ = 5.0 mA | | 0.3 | |
| $V_{BE}$(sat) | Base-Emitter Saturation Voltage | $I_C$ = 10 mA, $I_B$ = 1.0 mA | 0.65 | 0.85 | V |
| | | $I_C$ = 50 mA, $I_B$ = 5.0 mA | | 0.95 | |
| **SMALL SIGNAL CHARACTERISTICS** | | | | | |
| $f_T$ | Current Gain - Bandwidth Product | $I_C$ = 10 mA, $V_{CE}$ = 20 V, f = 100 MHz | 300 | | MHz |
| $C_{obo}$ | Output Capacitance | $V_{CB}$ = 5.0 V, $I_E$ = 0, f = 100 kHz | | 4.0 | pF |
| $C_{ibo}$ | Input Capacitance | $V_{EB}$ = 0.5 V, $I_C$ = 0, f = 100 kHz | | 8.0 | pF |
| NF | Noise Figure | $I_C$ = 100 μA, $V_{CE}$ = 5.0 V, $R_S$ = 1.0 kΩ, f = 10 Hz to 15.7 kHz | | 5.0 | dB |
| **SWITCHING CHARACTERISTICS** | | | | | |
| $t_d$ | Delay Time | $V_{CC}$ = 3.0 V, $V_{BE}$ = 0.5 V $I_C$ = 10 mA, $I_{B1}$ = 1.0 mA | | 35 | ns |
| $t_r$ | Rise Time | | | 35 | ns |
| $t_s$ | Storage Time | $V_{CC}$ = 3.0 V, $I_C$ = 10 mA, $I_{B1}$ = $I_{B2}$ = 1.0 mA | | 200 | ns |
| $t_f$ | Fall Time | | | 50 | ns |

**Note:**

5. Pulse test: pulse width ≤ 300 μs, duty cycle ≤ 2.0%.

## Typical Performance Characteristics

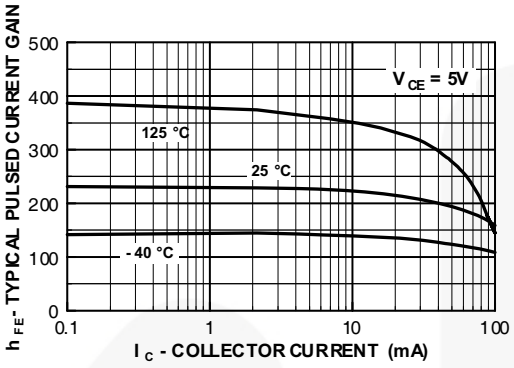



**Figure 1. Typical Pulsed Current Gain vs. Collector Current**

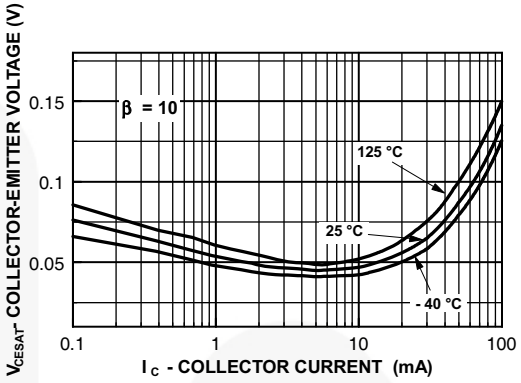



**Figure 2. Collector-Emitter Saturation Voltage vs. Collector Current**

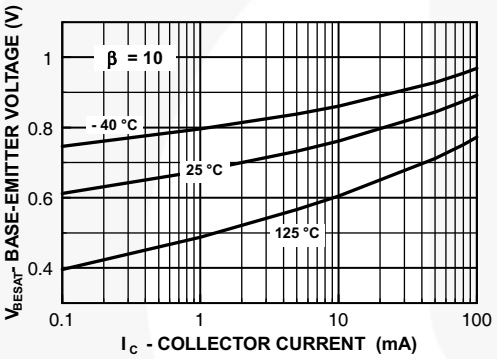



**Figure 3. Base-Emitter Saturation Voltage vs. Collector Current**

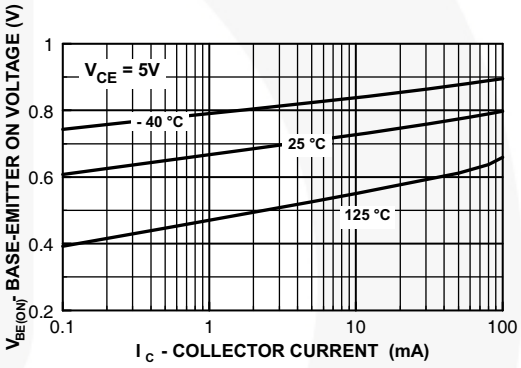



**Figure 4. Base-Emitter On Voltage vs. Collector Current**

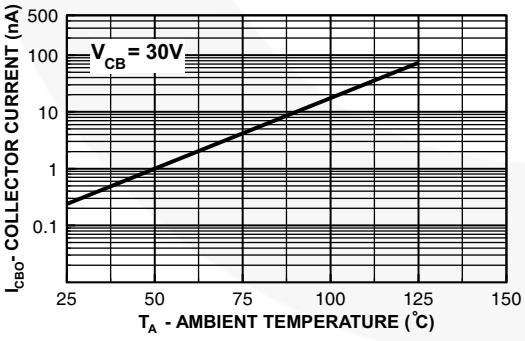



**Figure 5. Collector Cut-Off Current vs. Ambient Temperature**

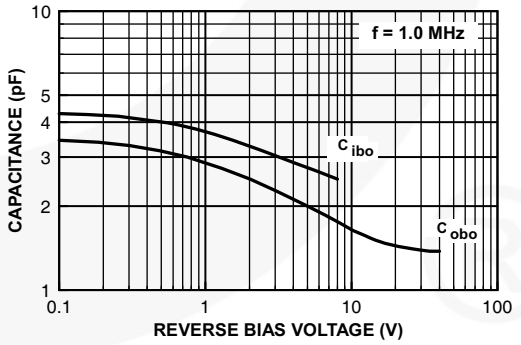



**Figure 6. Capacitance vs. Reverse Bias Voltage**

## Typical Performance Characteristics (Continued)

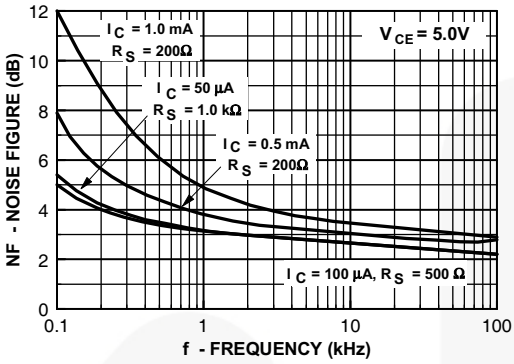



**Figure 7. Noise Figure vs. Frequency**

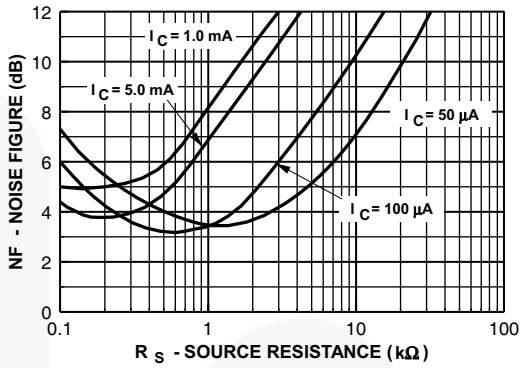



**Figure 8. Noise Figure vs. Source Resistance**

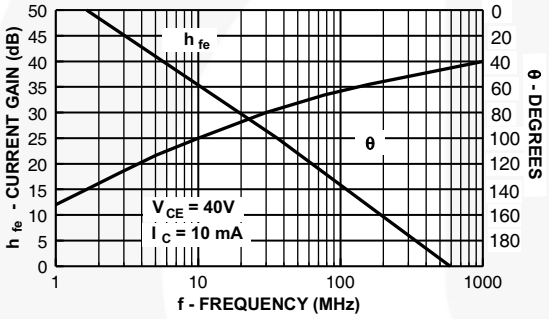



**Figure 9. Current Gain and Phase Angle vs. Frequency**

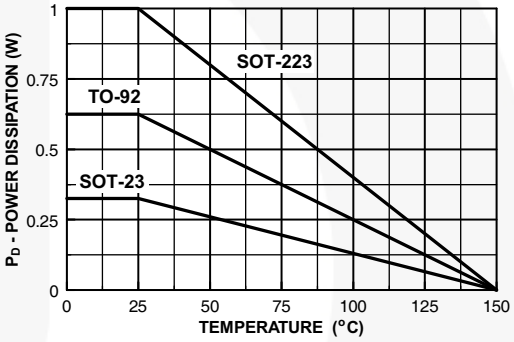



**Figure 10. Power Dissipation vs. Ambient Temperature**

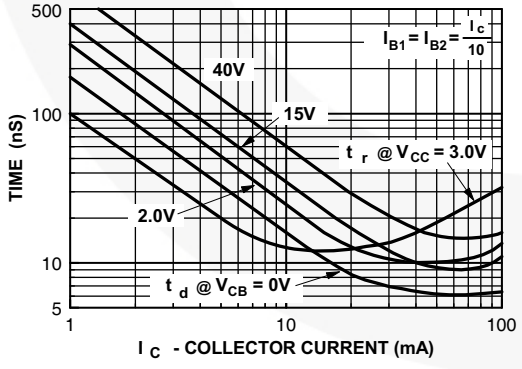



**Figure 11. Turn-On Time vs. Collector Current**

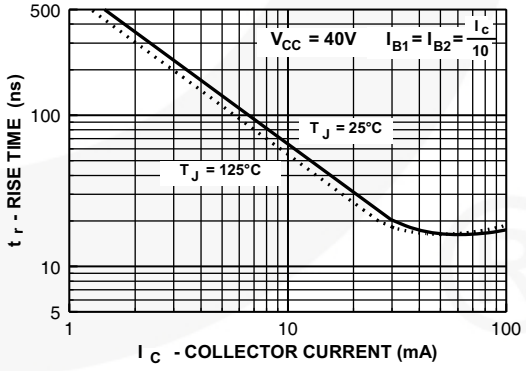



**Figure 12. Rise Time vs. Collector Current**

## Typical Performance Characteristics (Continued)

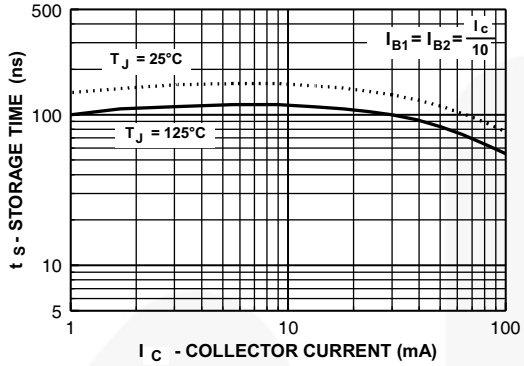



**Figure 13. Storage Time vs. Collector Current**

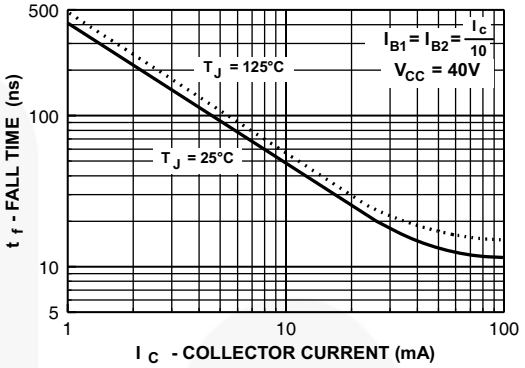



**Figure 14. Fall Time vs. Collector Current**

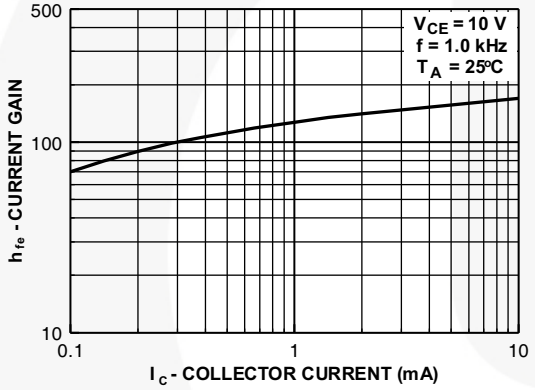



**Figure 15. Current Gain**

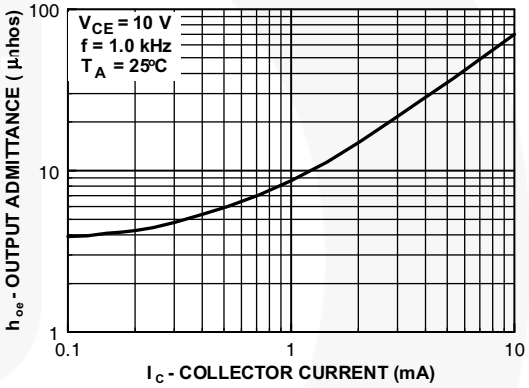



**Figure 16. Output Admittance**

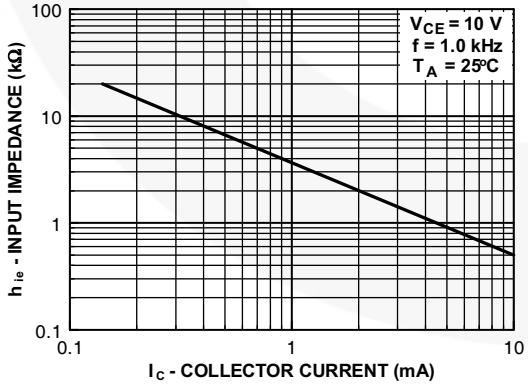



**Figure 17. Input Impedance**

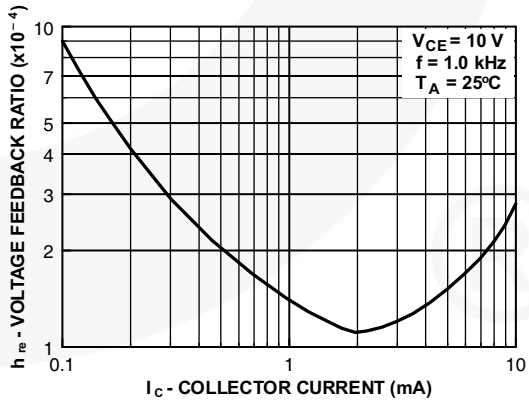



**Figure 18. Voltage Feedback Ratio**

## Test Circuits

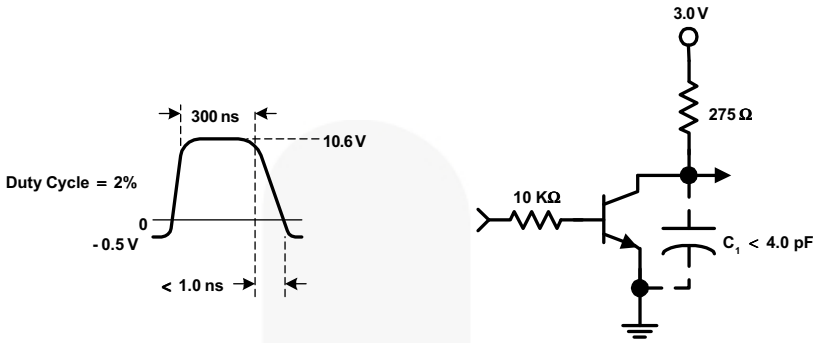



**Figure 19. Delay and Rise Time Equivalent Test Circuit**

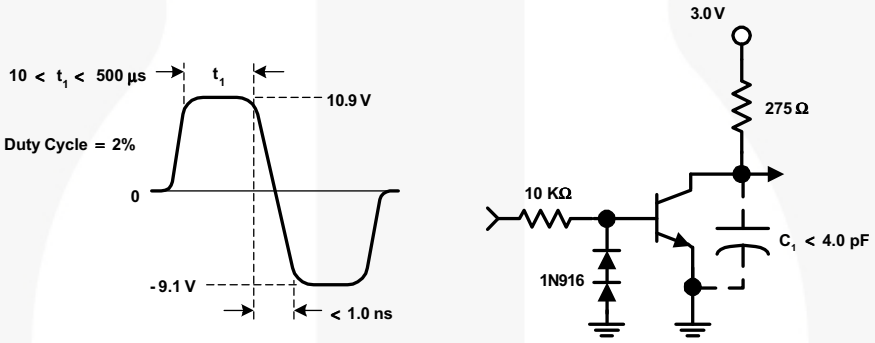
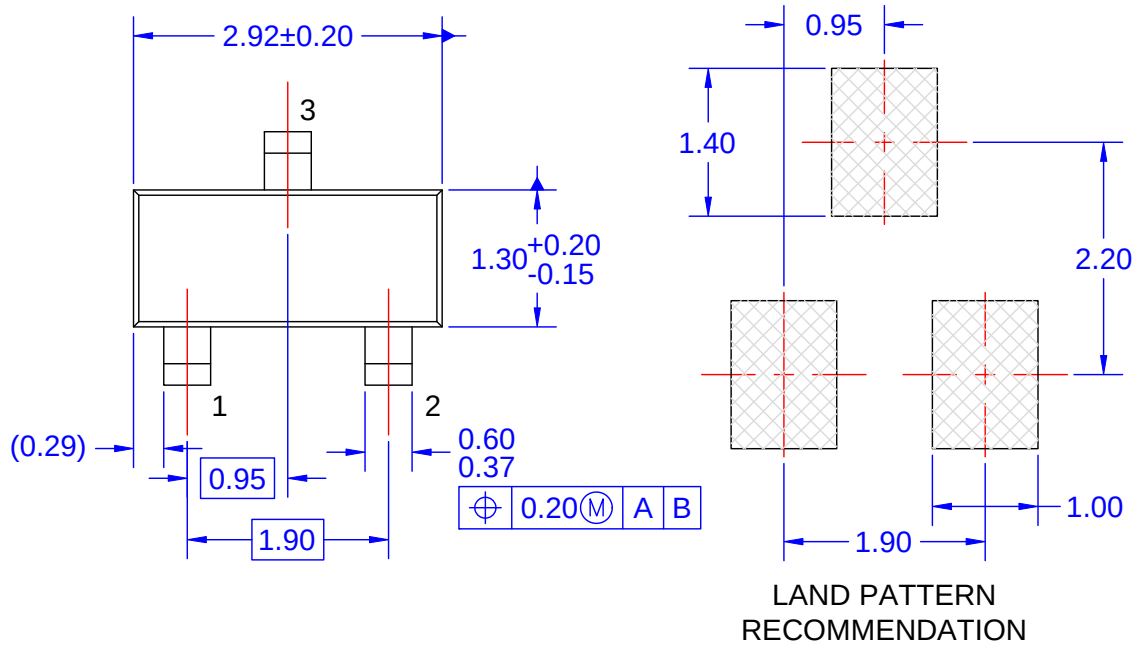
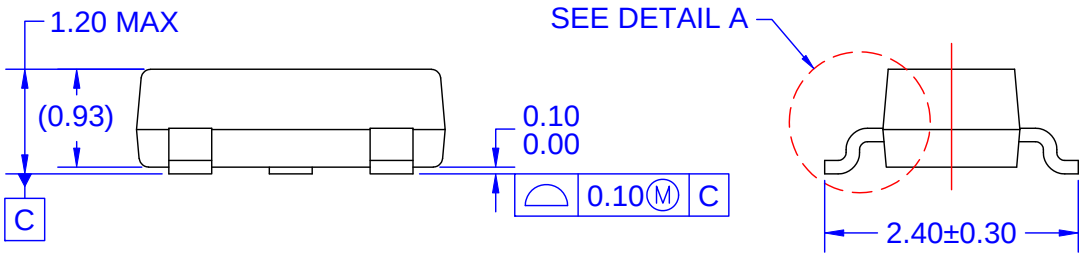
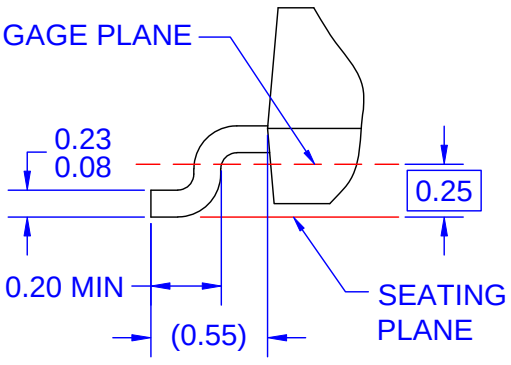



**Figure 20. Storage and Fall Time Equivalent Test Circuit**




LAND PATTERN
RECOMMENDATION

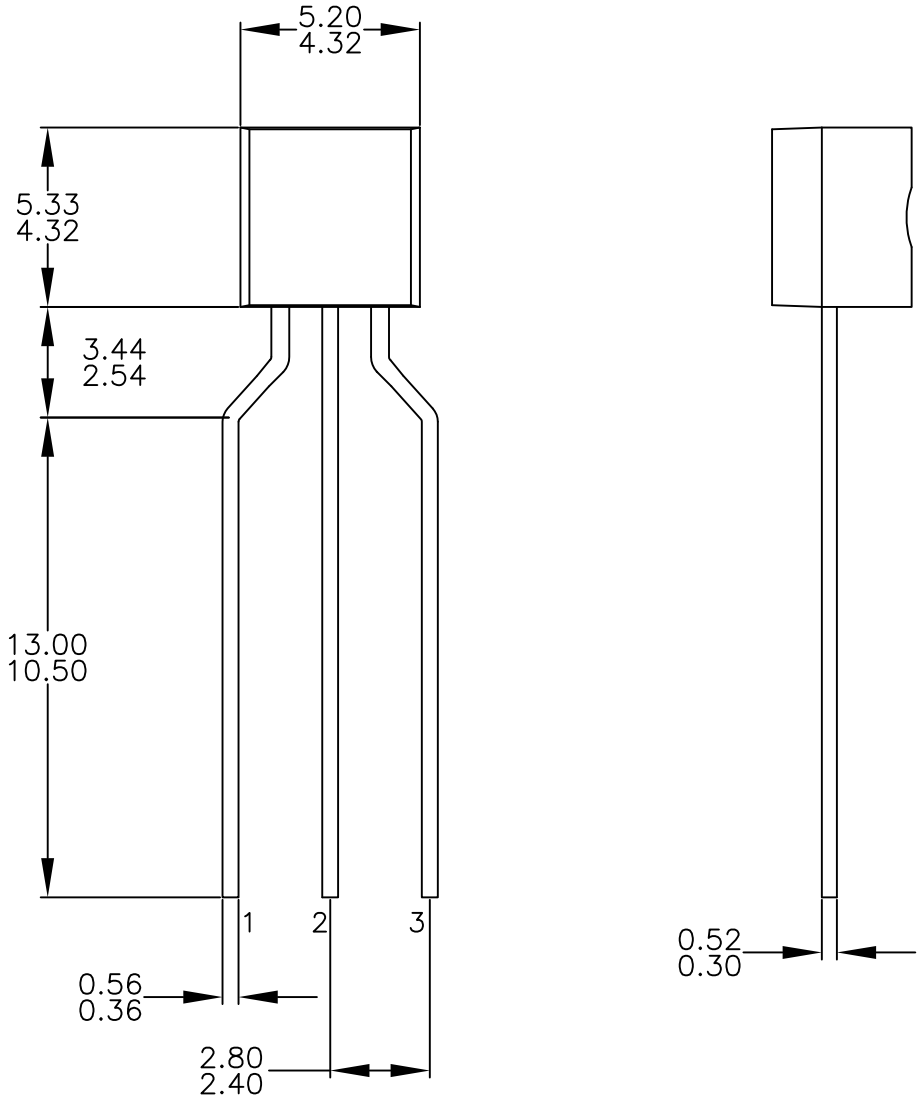


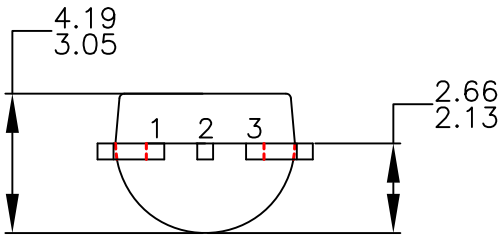




NOTES: UNLESS OTHERWISE SPECIFIED

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 - 1994.
E) DRAWING FILE NAME: MA03DREV10

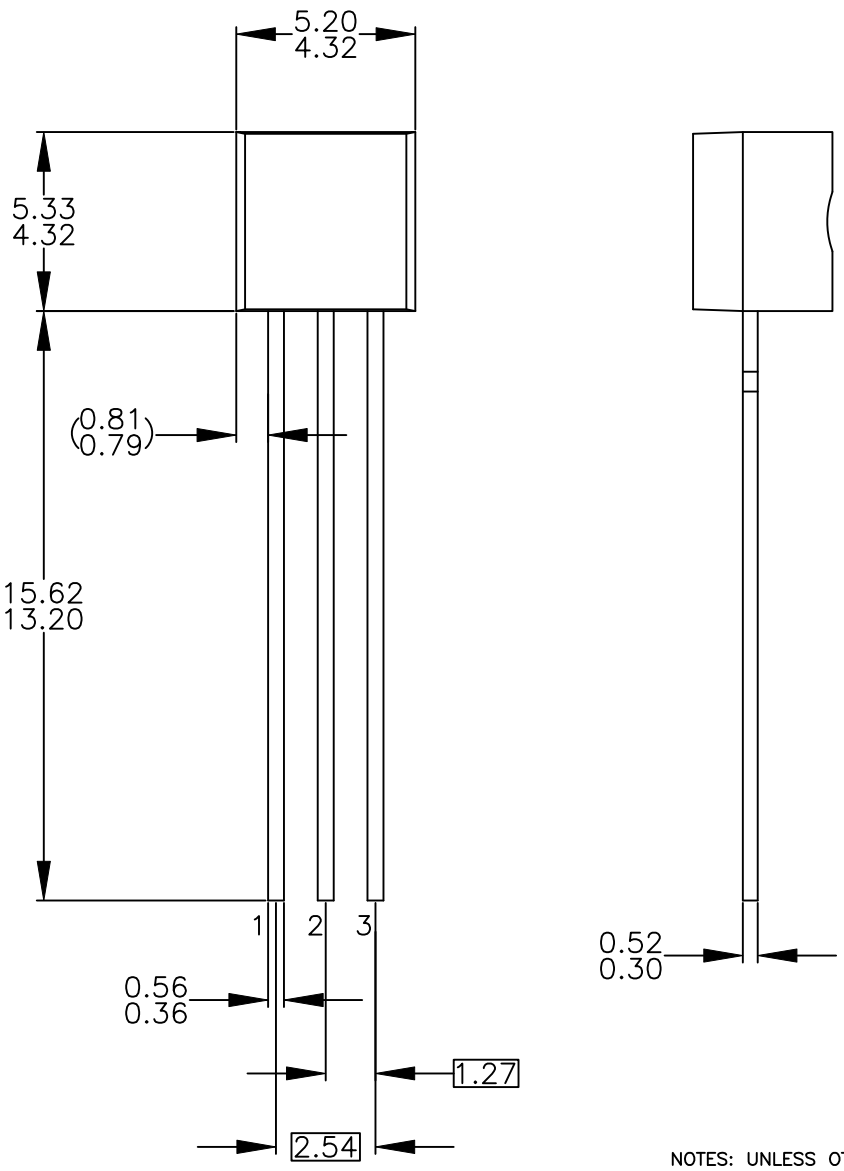
**DETAIL A**
SCALE: 2X

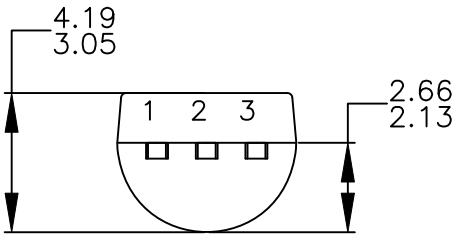



NOTES: UNLESS OTHERWISE SPECIFIED

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

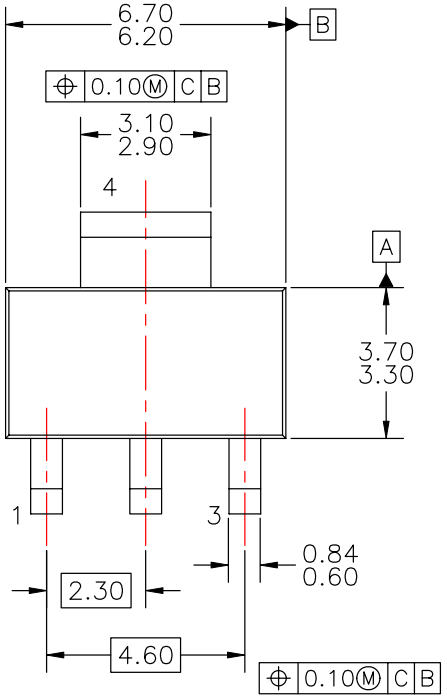
A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DRAWING CONFORMS TO ASME Y14.5M-2009.
D) DRAWING FILENAME: MKT-ZA03DREV4.

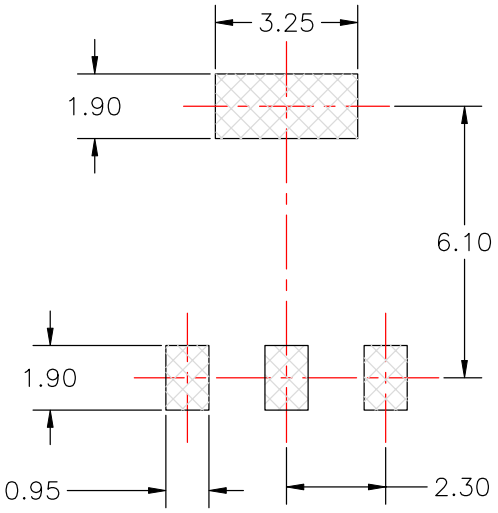
FAIRCHILD

APPROVED
July-14-2008

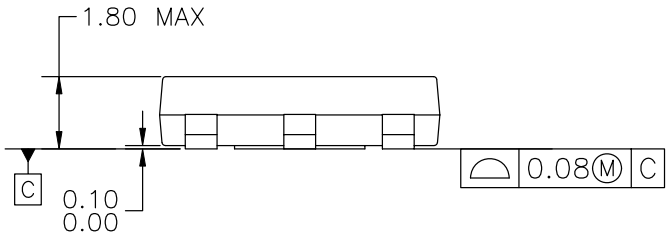
REVISIONS

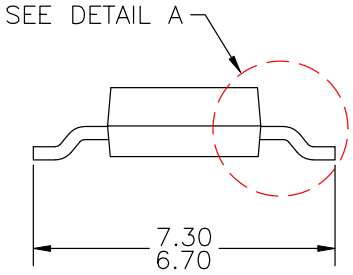
| LTR | DESCRIPTION | DATE | NAME/SITE |
|---|---|---|---|
| A | RELEASE TO DOCUMENT CONTROL | JAN.25,1996 | TL/FSCP |
| 2 | CHG DWG TEMPLATE FR NATIONAL TO FAIRCHILD; CHG DIM STYLE FR DUAL INCH[MM] TO SINGLE, MM; CHG LD WID FR $0.74^{+0.05}_{-0.07}$ TO 0.60–0.84; REMOVE PKG THICK DIM (1.6); CHG TOTAL PKG HT FR $1.80^{}_{1.20}$ TO 1.80 MAX; CHG FOOT LANDING DIM FR 0.91 MIN TO 0.60 MIN; CHG LD THICKNESS FR $0.3^{+0.09}_{-0.07}$ 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 $3.56^{+0.18}_{-0.38}$ TO $3.70^{}_{3.30}$; CHG BODY LN FR $6.5^{+0.3}_{-0.4}$ TO $6.70^{}_{6.30}$; CHG TOTAL PKG WID FR $6.96^{+0.33}_{-0.38}$ TO $7.30^{}_{6.70}$; 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 |

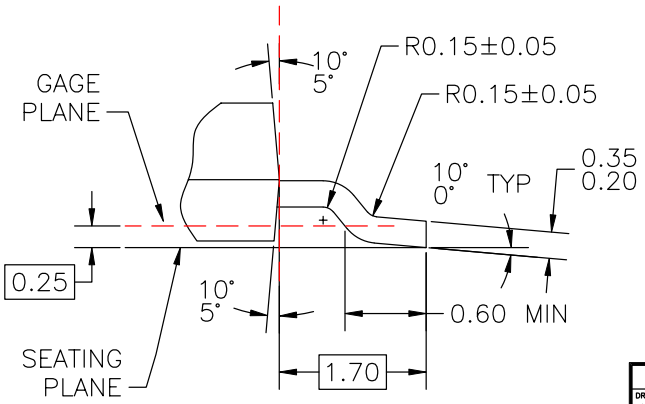



LAND PATTERN RECOMMENDATION




DETAIL A
SCALE: 2:1

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

| APPROVALS | DATE |
|---|---|
| DRAWN: J.U. COMPARATIVO JR. | 26FEB2008 |
| CHECKED: L.Z. STA CRUZ | |
| APPROVED: M.R. GESTOLE | |
| G.S. BAJE | |

PROJECTION INCH [MM]

FAIRCHILD SEMICONDUCTOR TM

MOLDED PACKAGE
SOT–223, 4 LEAD

| SCALE | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| 1:1 | A3 | MKT–MA04A | 2 |

FORMERLY: N/A

SHEET : 1 OF 1

## TRADEMARKS

The following includes registered and unregistered trademarks and service marks, owned by Fairchild Semiconductor and/or its global subsidiaries, and is not intended to be an exhaustive list of all such trademarks.

AccuPower™
AttitudeEngine™
Awinda®
AX-CAP®*
BitSiC™
Build it Now™
CorePLUS™
CorePOWER™
*CROSSVOLT*™
CTL™
Current Transfer Logic™
DEUXPEED®
Dual Cool™
EcoSPARK®
EfficientMax™
ESBC™
®
Fairchild®
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