



ON Semiconductor®

# 2N4401 / MMBT4401 NPN General-Purpose Amplifier

## Description

This device is designed for use as a medium power amplifier and switch requiring collector currents up to 500 mA.

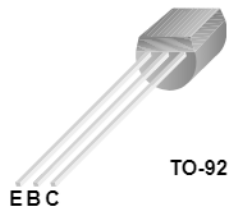


Figure 1. 2N4401 Device Package

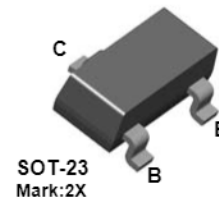


Figure 2. MMBT4401 Device Package

## Ordering Information

| Part Number | Marking | Package   | Packing Method |
|-------------|---------|-----------|----------------|
| 2N4401BU    | 2N4401  | TO-92 3L  | Bulk           |
| 2N4401TF    | 2N4401  | TO-92 3L  | Tape and Reel  |
| 2N4401TFR   | 2N4401  | TO-92 3L  | Tape and Reel  |
| 2N4401TA    | 2N4401  | TO-92 3L  | Ammo           |
| 2N4401TAR   | 2N4401  | TO-92 3L  | Ammo           |
| MMBT4401    | 2X      | SOT-23 3L | Tape and Reel  |

## 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                   | 600         | 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. ON 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                               | Max.                  |                         | Unit                      |
|-----------------|---|-----------------------|-------------------------|---------------------------|
|                 |   | 2N4401 <sup>(3)</sup> | MMBT4401 <sup>(4)</sup> |                           |
| $P_D$           | Total Device Dissipation                | 625                   | 350                     | mW                        |
|                 | Derate Above $25^\circ\text{C}$         | 5.0                   | 2.8                     | 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                     | $^\circ\text{C}/\text{W}$ |

### Notes:

3. PCB size: FR-4, 76 mm x 114 mm x 1.57 mm (3.0 inch x 4.5 inch x 0.062 inch) with minimum land pattern size.
4. Device mounted on FR-4 PCB 1.6 inch x 1.6 inch x 0.06 inch.

## Electrical Characteristics

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

| Symbol        | Parameter   | Conditions   | Min. | Max. | Unit             |
|---------------|---|--|------|------|------------------|
| $V_{(BR)CEO}$ | Collector-Emitter Breakdown Voltage <sup>(5)</sup>  | $I_C = 1.0\text{ mA}, I_B = 0$   | 40   |      | V                |
| $V_{(BR)CBO}$ | Collector-Base Breakdown Voltage                    | $I_C = 0.1\text{ mA}, I_E = 0$   | 60   |      | V                |
| $V_{(BR)EBO}$ | Emitter-Base Breakdown Voltage                      | $I_E = 0.1\text{ mA}, I_C = 0$   | 6.0  |      | V                |
| $I_{BL}$      | Base Cut-Off Current                                | $V_{CE} = 35\text{ V}, V_{EB} = 0.4\text{ V}$  |      | 0.1  | $\mu\text{A}$    |
| $I_{CEX}$     | Collector Cut-Off Current                           | $V_{CE} = 35\text{ V}, V_{EB} = 0.4\text{ V}$  |      | 0.1  | $\mu\text{A}$    |
| $h_{FE}$      | DC Current Gain <sup>(5)</sup>                      | $I_C = 0.1\text{ mA}, V_{CE} = 1.0\text{ V}$   | 20   |      |                  |
|               |   | $I_C = 1.0\text{ mA}, V_{CE} = 1.0\text{ V}$   | 40   |      |                  |
|               |   | $I_C = 10\text{ mA}, V_{CE} = 1.0\text{ V}$  | 80   |      |                  |
|               |   | $I_C = 150\text{ mA}, V_{CE} = 1.0\text{ V}$   | 100  | 300  |                  |
|               |   | $I_C = 500\text{ mA}, V_{CE} = 2.0\text{ V}$   | 40   |      |                  |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage <sup>(5)</sup> | $I_C = 150\text{ mA}, I_B = 15\text{ mA}$  |      | 0.40 | V                |
|               |   | $I_C = 500\text{ mA}, I_B = 50\text{ mA}$  |      | 0.75 |                  |
| $V_{BE(sat)}$ | Base-Emitter Saturation Voltage <sup>(5)</sup>      | $I_C = 150\text{ mA}, I_B = 15\text{ mA}$  | 0.75 | 0.95 | V                |
|               |   | $I_C = 500\text{ mA}, I_B = 50\text{ mA}$  |      | 1.20 |                  |
| $f_T$         | Current Gain - Bandwidth Product                    | $I_C = 20\text{ mA}, V_{CE} = 10\text{ V},$<br>$f = 100\text{ MHz}$                          | 250  |      | MHz              |
| $C_{cb}$      | Collector-Base Capacitance                          | $V_{CB} = 5.0\text{ V}, I_E = 0,$<br>$f = 140\text{ kHz}$                                    |      | 6.5  | pF               |
| $C_{eb}$      | Emitter-Base Capacitance                            | $V_{BE} = 0.5\text{ V}, I_C = 0,$<br>$f = 140\text{ kHz}$                                    |      | 30   | pF               |
| $h_{ie}$      | Input Impedance                                     | $I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V},$<br>$f = 1.0\text{ kHz}$                         | 1.0  | 15.0 | $k\Omega$        |
| $h_{re}$      | Voltage Feedback Ratio                              | $I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V},$<br>$f = 1.0\text{ kHz}$                         | 0.1  | 8.0  | $\times 10^{-4}$ |
| $h_{fe}$      | Small-Signal Current Gain                           | $I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V},$<br>$f = 1.0\text{ kHz}$                         | 40   | 500  |                  |
| $h_{oe}$      | Output Admittance                                   | $I_C = 1.0\text{ mA}, V_{CE} = 10\text{ V},$<br>$f = 1.0\text{ kHz}$                         | 1.0  | 30   | $\mu\text{mhos}$ |
| $t_d$         | Delay Time  | $V_{CC} = 30\text{ V}, V_{EB} = 2\text{ V},$<br>$I_C = 150\text{ mA}, I_{B1} = 15\text{ mA}$ |      | 15   | ns               |
| $t_r$         | Rise Time   |  |      | 20   | ns               |
| $t_s$         | Storage Time  | $V_{CC} = 30\text{ V}, I_C = 150\text{ mA},$<br>$I_{B1} = I_{B2} = 15\text{ mA}$             |      | 225  | ns               |
| $t_f$         | Fall Time   |  |      | 30   | ns               |

### Note:

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

## Typical Performance Characteristics

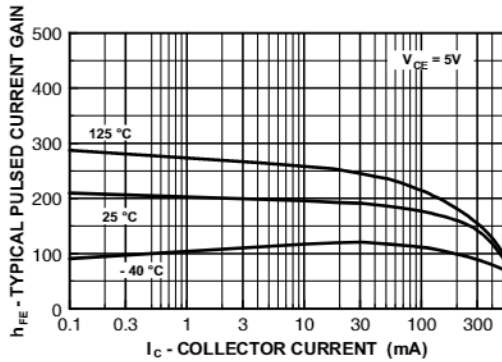


Figure 3. Typical Pulsed Current Gain vs. Collector Current

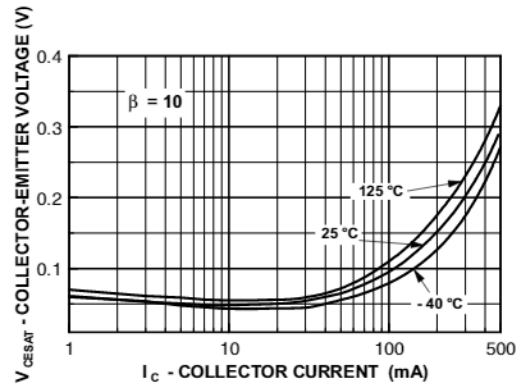


Figure 4. Collector-Emitter Saturation Voltage vs. Collector Current

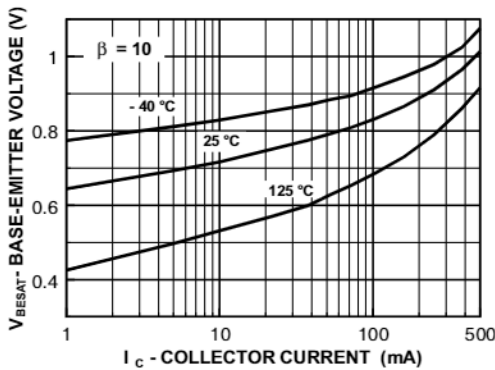


Figure 5. Base-Emitter Saturation Voltage vs. Collector Current

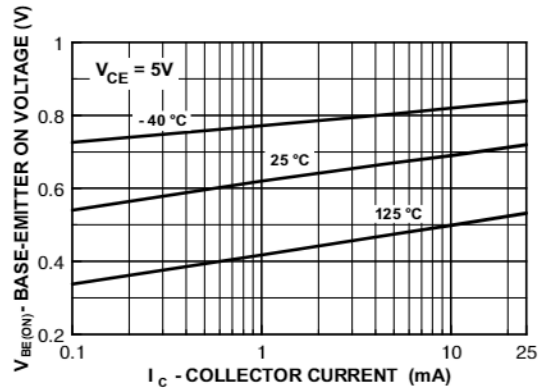


Figure 6. Base-Emitter On Voltage vs. Collector Current

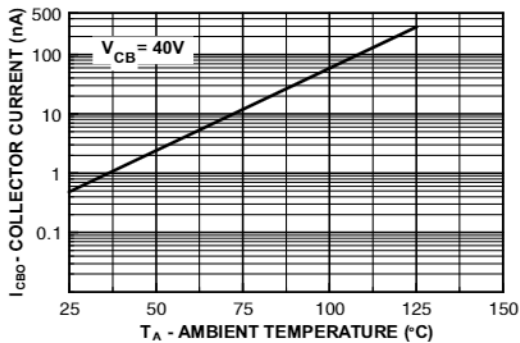


Figure 7. Collector Cut-Off Current vs. Ambient Temperature

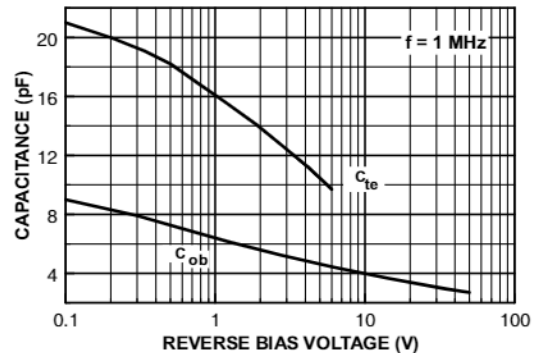
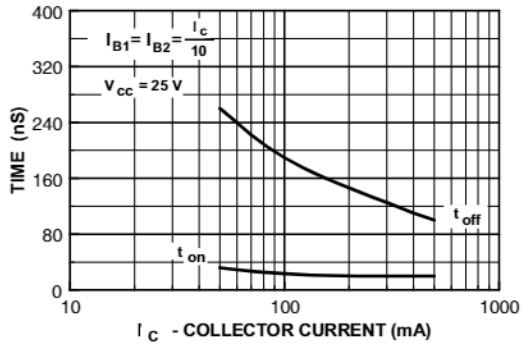
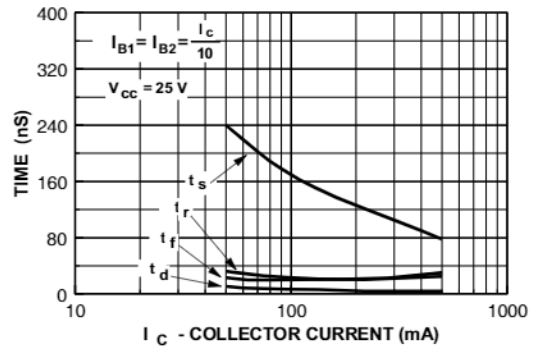


Figure 8. Emitter Transition and Output Capacitance vs. Reverse Bias Voltage

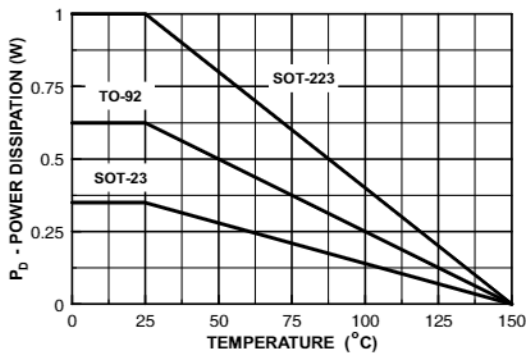
**Typical Performance Characteristics** (Continued)



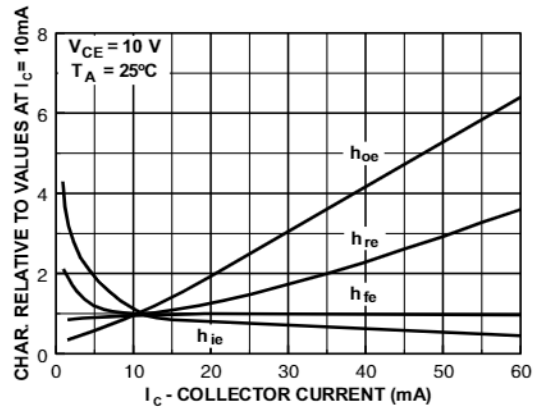
**Figure 9. Turn-On and Turn-Off Times vs. Collector Current**



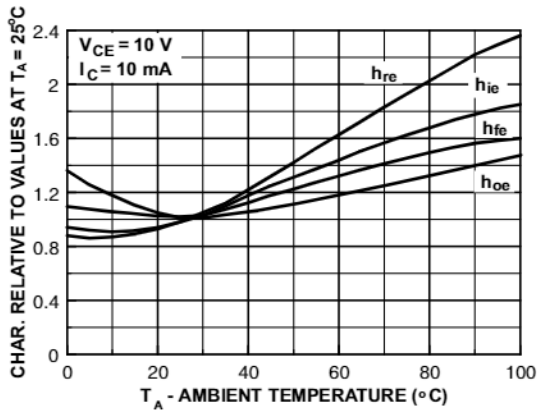
**Figure 10. Switching Times vs. Collector Current**



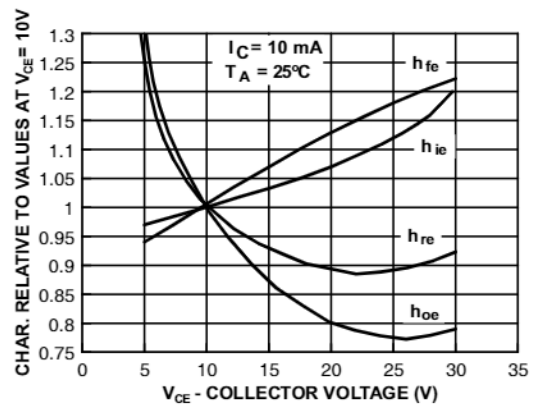
**Figure 11. Power Dissipation vs. Ambient Temperature**



**Figure 12. Common Emitter Characteristics**

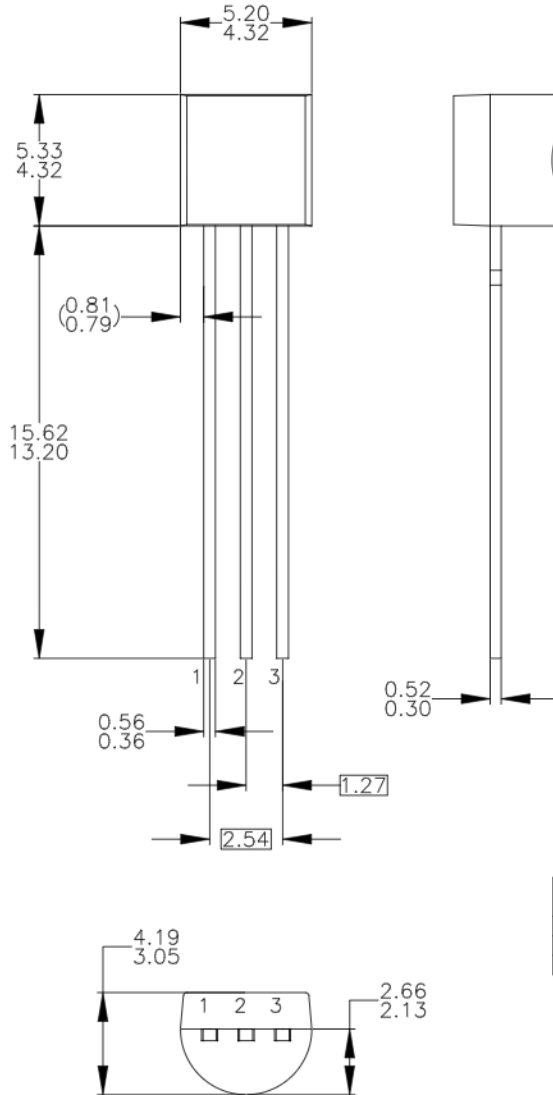


**Figure 13. Common Emitter Characteristics**



**Figure 14. Common Emitter Characteristics**

Physical Dimensions



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-1994.
- D) TO-92 (92,94,96,97,98) PIN CONFIGURATION:

| PIN | 92 |   |   | 94 |   |   | 96 |   |   | 97 |   |   | 98 |   |   |
|-----|----|---|---|----|---|---|----|---|---|----|---|---|----|---|---|
|     | P  | F | M | P  | F | M | B  | F | M | P  | F | M | P  | F | M |
| 1   | E  | S | S | E  | S | S | B  | D | G | C  | G | D | C  | G | D |
| 2   | B  | D | G | C  | G | D | E  | S | S | B  | D | G | E  | S | S |
| 3   | C  | G | D | B  | D | G | C  | G | D | E  | S | S | B  | D | G |

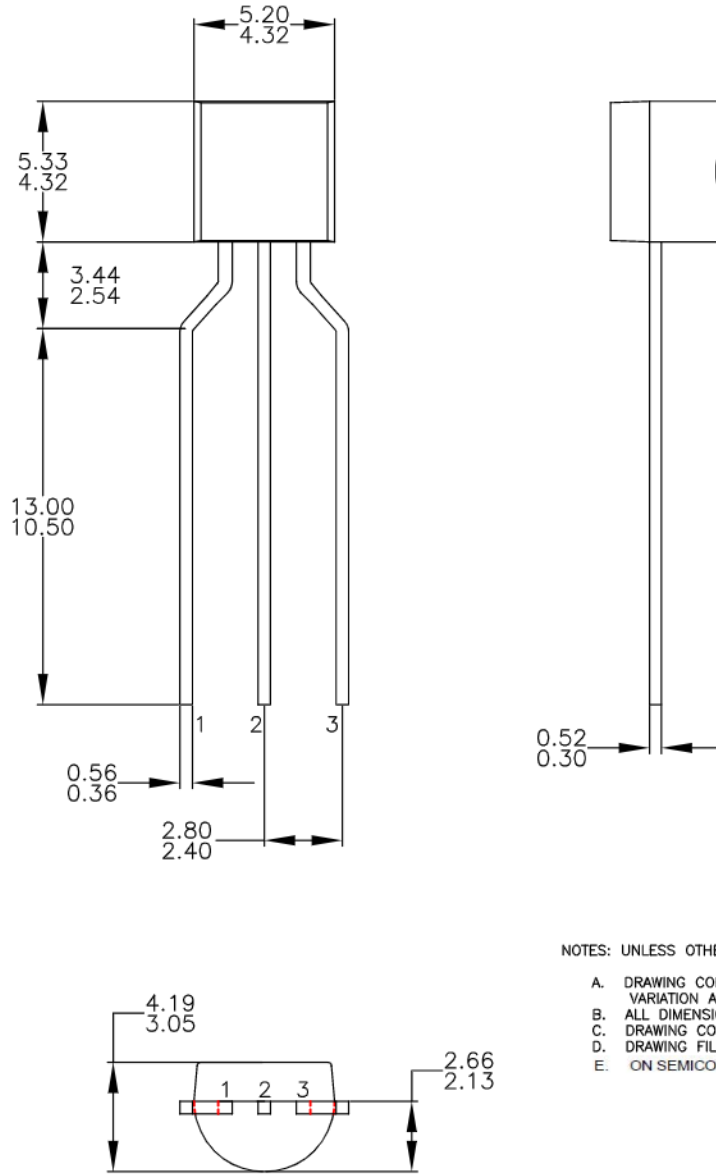
LEGEND:

P - BIPOLAR      E - EMITTER      D - DRAIN  
 F - JFET          B - BASE              S - SOURCE  
 M - DMOS        C - COLLECTOR      G - GATE

- E) FOR PACKAGE 92, 94, 96, 97 AND 98:  
 PIN CONFIGURATION DRAIN "D" AND SOURCE "S"  
 ARE INTERCHANGEABLE AT JFET "F" OPTION.
- F) DRAWING FILENAME: MKT-2A03DREV3.

Figure 15. 3-Lead, TO-92, JEDEC TO-92 Compliant Straight Lead Configuration, Bulk Type

Physical Dimensions (Continued)

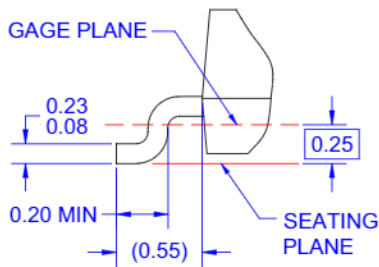
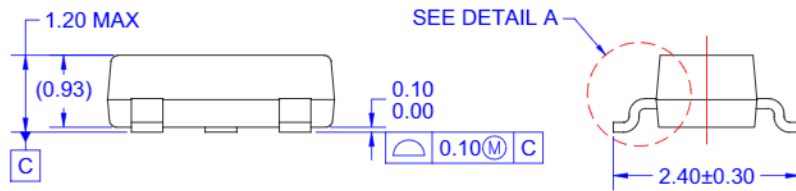
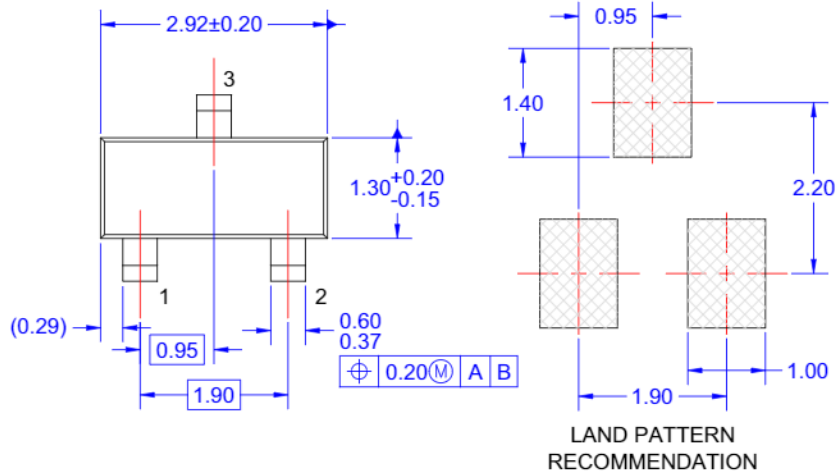


NOTES: UNLESS OTHERWISE SPECIFIED

- 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-ZA03FREVS.
- E.  $\square$  ON SEMICONDUCTOR

Figure 16. 3-Lead, TO-92, Molded, 0.2 In Line Spacing Lead Form, Ammo, Tape and Reel Type

Physical Dimensions (Continued)




**DETAIL A**  
SCALE: 2X

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

Figure 17. 3-LEAD, SOT23, JEDEC TO-236, LOW PROFILE



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