

# 2N4401

## General Purpose Transistors

### NPN Silicon

#### Features

- Pb-Free Packages are Available\*

#### MAXIMUM RATINGS

| Rating                                                                                    | Symbol         | Value          | Unit                       |
|-------------------------------------------------------------------------------------------|----------------|----------------|----------------------------|
| Collector – Emitter Voltage                                                               | $V_{CEO}$      | 40             | Vdc                        |
| Collector – Base Voltage                                                                  | $V_{CBO}$      | 60             | Vdc                        |
| Emitter – Base Voltage                                                                    | $V_{EBO}$      | 6.0            | Vdc                        |
| Collector Current – Continuous                                                            | $I_C$          | 600            | mAdc                       |
| Total Device Dissipation<br>@ $T_A = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$          | 625<br>5.0     | mW<br>mW/ $^\circ\text{C}$ |
| Total Device Dissipation<br>@ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$          | 1.5<br>12      | W<br>mW/ $^\circ\text{C}$  |
| Operating and Storage Junction<br>Temperature Range                                       | $T_J, T_{stg}$ | -55 to<br>+150 | $^\circ\text{C}$           |

#### THERMAL CHARACTERISTICS

| Characteristic                          | Symbol          | Max  | Unit                      |
|-----------------------------------------|-----------------|------|---------------------------|
| Thermal Resistance, Junction-to-Ambient | $R_{\theta JA}$ | 200  | $^\circ\text{C}/\text{W}$ |
| Thermal Resistance, Junction-to-Case    | $R_{\theta JC}$ | 83.3 | $^\circ\text{C}/\text{W}$ |

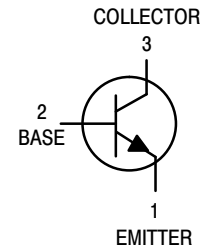
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

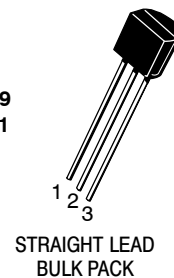


ON Semiconductor®

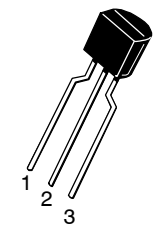
<http://onsemi.com>



TO-92  
CASE 29  
STYLE 1

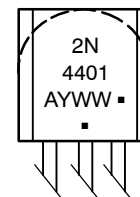


STRAIGHT LEAD  
BULK PACK



BENT LEAD  
TAPE & REEL  
AMMO PACK

#### MARKING DIAGRAM



2N4401 = Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

#### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

# 2N4401

## ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ unless otherwise noted)

| Characteristic                                                                       | Symbol        | Min | Max | Unit            |
|--------------------------------------------------------------------------------------|---------------|-----|-----|-----------------|
| <b>OFF CHARACTERISTICS</b>                                                           |               |     |     |                 |
| Collector–Emitter Breakdown Voltage (Note 1)<br>( $I_C = 1.0\text{ mAdc}, I_B = 0$ ) | $V_{(BR)CEO}$ | 40  | –   | Vdc             |
| Collector–Base Breakdown Voltage<br>( $I_C = 0.1\text{ mAdc}, I_E = 0$ )             | $V_{(BR)CBO}$ | 60  | –   | Vdc             |
| Emitter–Base Breakdown Voltage<br>( $I_E = 0.1\text{ mAdc}, I_C = 0$ )               | $V_{(BR)EBO}$ | 6.0 | –   | Vdc             |
| Base Cutoff Current<br>( $V_{CE} = 35\text{ Vdc}, V_{EB} = 0.4\text{ Vdc}$ )         | $I_{BEV}$     | –   | 0.1 | $\mu\text{Adc}$ |
| Collector Cutoff Current<br>( $V_{CE} = 35\text{ Vdc}, V_{EB} = 0.4\text{ Vdc}$ )    | $I_{CEX}$     | –   | 0.1 | $\mu\text{Adc}$ |

## ON CHARACTERISTICS (Note 1)

|                                                                                                                                                                                                                                                                                                            |               |                             |                         |     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------------|-------------------------|-----|
| DC Current Gain<br><br>( $I_C = 0.1\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 1.0\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 10\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 150\text{ mAdc}, V_{CE} = 1.0\text{ Vdc}$ )<br>( $I_C = 500\text{ mAdc}, V_{CE} = 2.0\text{ Vdc}$ ) | $h_{FE}$      | 20<br>40<br>80<br>100<br>40 | –<br>–<br>–<br>300<br>– | –   |
| Collector–Emitter Saturation Voltage<br>( $I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$ )<br>( $I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$ )                                                                                                                                                             | $V_{CE(sat)}$ | –<br>–                      | 0.4<br>0.75             | Vdc |
| Base–Emitter Saturation Voltage<br>( $I_C = 150\text{ mAdc}, I_B = 15\text{ mAdc}$ )<br>( $I_C = 500\text{ mAdc}, I_B = 50\text{ mAdc}$ )                                                                                                                                                                  | $V_{BE(sat)}$ | 0.75<br>–                   | 0.95<br>1.2             | Vdc |

## SMALL-SIGNAL CHARACTERISTICS

|                                                                                                            |          |     |     |                  |
|------------------------------------------------------------------------------------------------------------|----------|-----|-----|------------------|
| Current–Gain – Bandwidth Product<br>( $I_C = 20\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 100\text{ MHz}$ ) | $f_T$    | 250 | –   | MHz              |
| Collector–Base Capacitance<br>( $V_{CB} = 5.0\text{ Vdc}, I_E = 0, f = 1.0\text{ MHz}$ )                   | $C_{cb}$ | –   | 6.5 | pF               |
| Emitter–Base Capacitance<br>( $V_{EB} = 0.5\text{ Vdc}, I_C = 0, f = 1.0\text{ MHz}$ )                     | $C_{eb}$ | –   | 30  | pF               |
| Input Impedance<br>( $I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$ )                 | $h_{ie}$ | 1.0 | 15  | k $\Omega$       |
| Voltage Feedback Ratio<br>( $I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$ )          | $h_{re}$ | 0.1 | 8.0 | $\times 10^{-4}$ |
| Small–Signal Current Gain<br>( $I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$ )       | $h_{fe}$ | 40  | 500 | –                |
| Output Admittance<br>( $I_C = 1.0\text{ mAdc}, V_{CE} = 10\text{ Vdc}, f = 1.0\text{ kHz}$ )               | $h_{oe}$ | 1.0 | 30  | $\mu\text{mhos}$ |

## SWITCHING CHARACTERISTICS

|              |                                                                                                     |       |   |     |    |
|--------------|-----------------------------------------------------------------------------------------------------|-------|---|-----|----|
| Delay Time   | $(V_{CC} = 30\text{ Vdc}, V_{BE} = 2.0\text{ Vdc}, I_C = 150\text{ mAdc}, I_{B1} = 15\text{ mAdc})$ | $t_d$ | – | 15  | ns |
| Rise Time    |                                                                                                     | $t_r$ | – | 20  | ns |
| Storage Time | $(V_{CC} = 30\text{ Vdc}, I_C = 150\text{ mAdc}, I_{B1} = I_{B2} = 15\text{ mAdc})$                 | $t_s$ | – | 225 | ns |
| Fall Time    |                                                                                                     | $t_f$ | – | 30  | ns |

1. Pulse Test: Pulse Width  $\leq 300\ \mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ .

## ORDERING INFORMATION

| Device      | Package            | Shipping <sup>†</sup>  |
|-------------|--------------------|------------------------|
| 2N4401      | TO–92              | 5000 Units / Bulk      |
| 2N4401G     | TO–92<br>(Pb–Free) | 5000 Units / Bulk      |
| 2N4401RLRA  | TO–92              | 2000 / Tape & Reel     |
| 2N4401RLRAG | TO–92<br>(Pb–Free) | 2000 / Tape & Reel     |
| 2N4401RLRMG | TO–92<br>(Pb–Free) | 2000 / Tape & Ammo Box |
| 2N4401RLRP  | TO–92              | 2000 / Tape & Ammo Box |
| 2N4401RLRPG | TO–92<br>(Pb–Free) | 2000 / Tape & Ammo Box |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

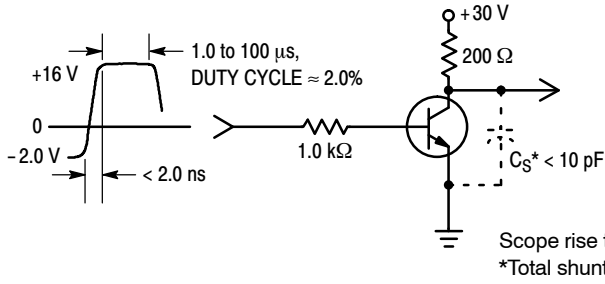


Figure 1. Turn-On Time

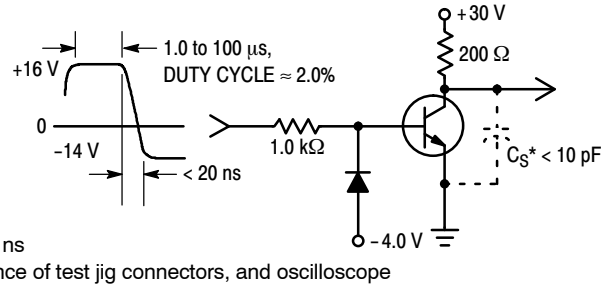


Figure 2. Turn-Off Time

TRANSIENT CHARACTERISTICS

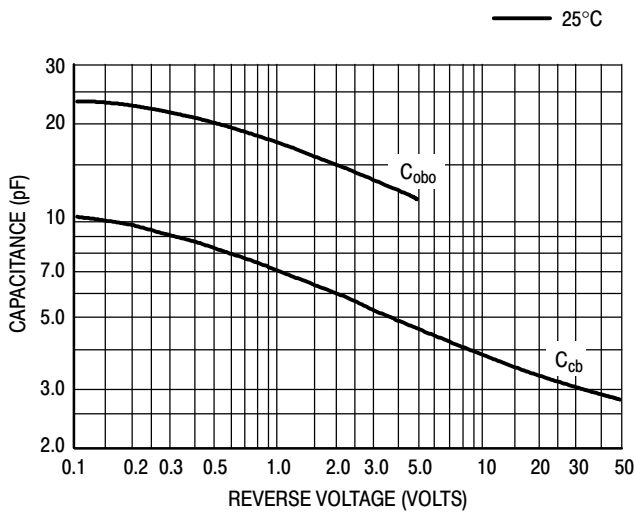


Figure 3. Capacitances

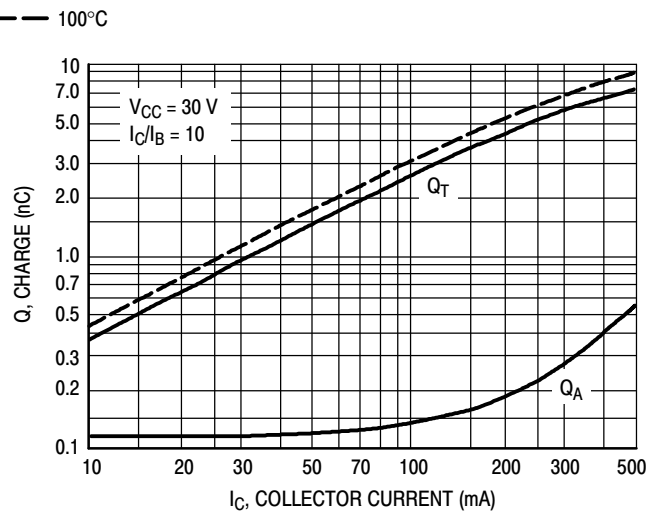


Figure 4. Charge Data

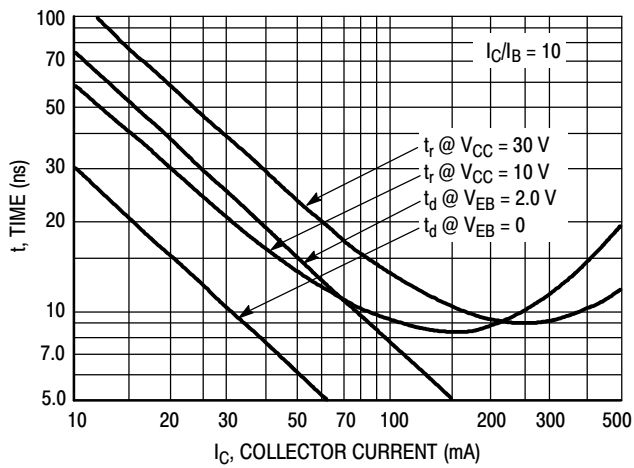


Figure 5. Turn-On Time

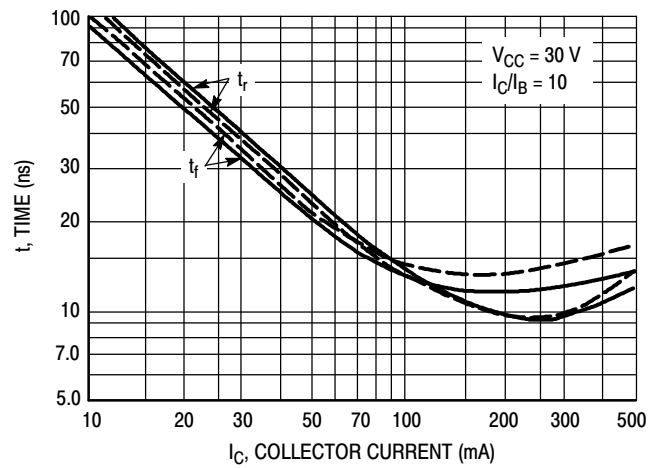


Figure 6. Rise and Fall Times

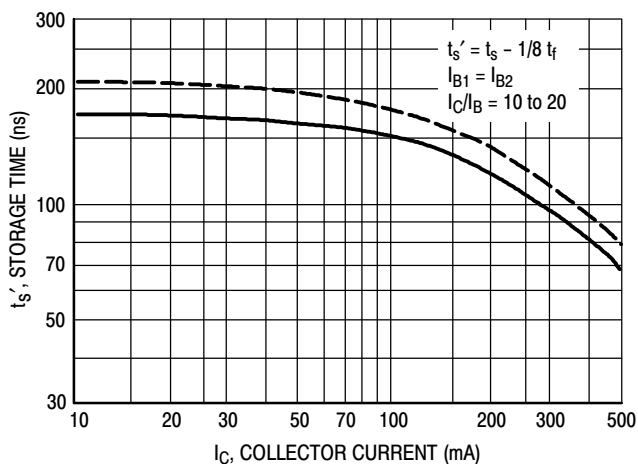


Figure 7. Storage Time

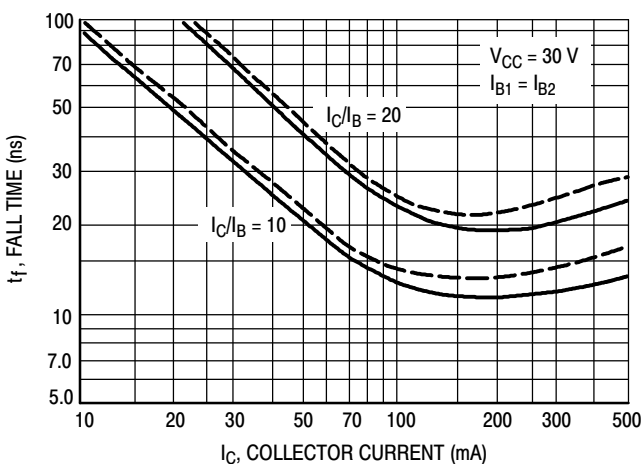


Figure 8. Fall Time

**SMALL-SIGNAL CHARACTERISTICS**  
**NOISE FIGURE**

$V_{CE} = 10 \text{ Vdc}$ ,  $T_A = 25^\circ\text{C}$ ; Bandwidth = 1.0 Hz

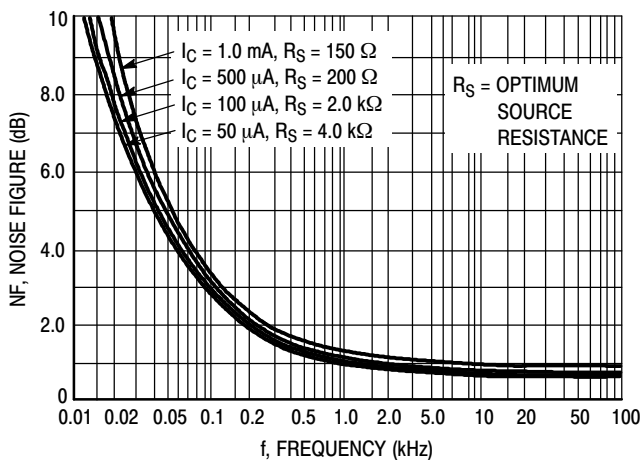


Figure 9. Frequency Effects

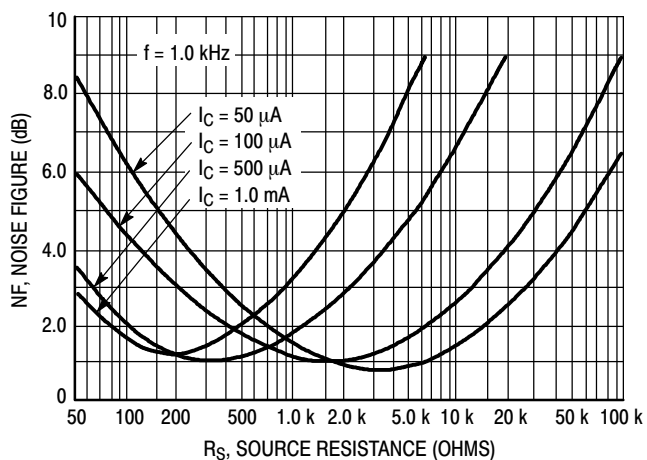


Figure 10. Source Resistance Effects

# 2N4401

## h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$ ,  $f = 1.0 \text{ kHz}$ ,  $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between  $h_{fe}$  and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were

selected from the 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

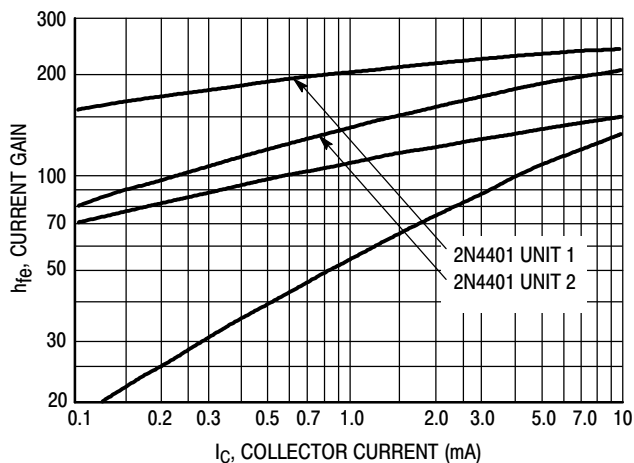


Figure 11. Current Gain

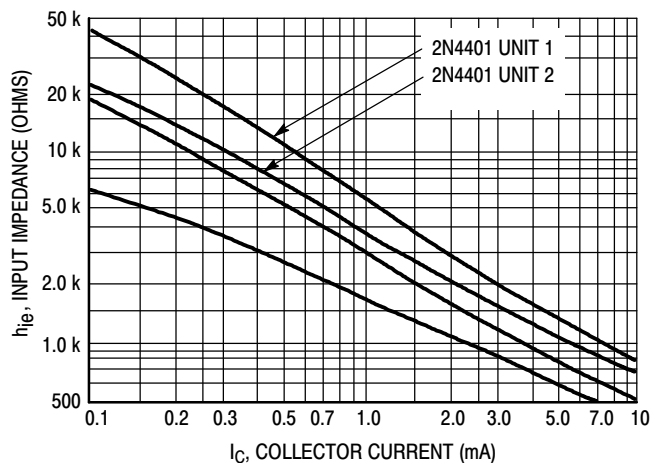


Figure 12. Input Impedance

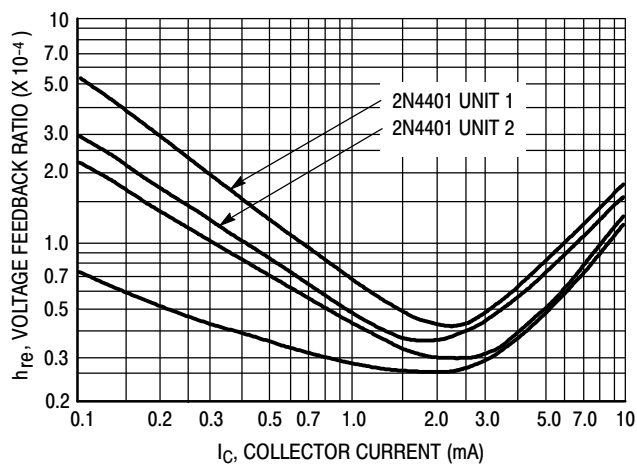


Figure 13. Voltage Feedback Ratio

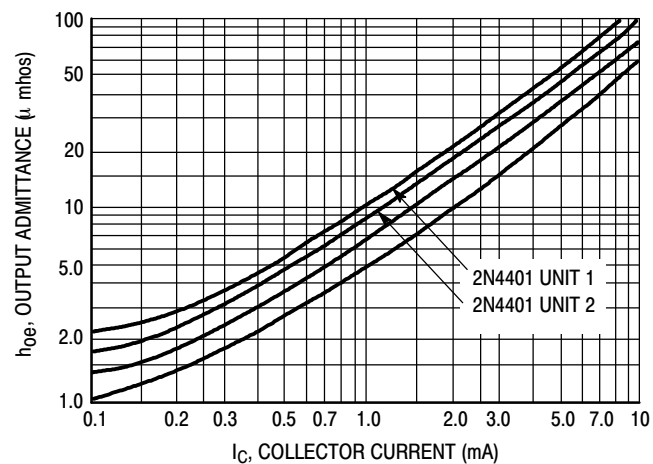


Figure 14. Output Admittance

# 2N4401

## STATIC CHARACTERISTICS

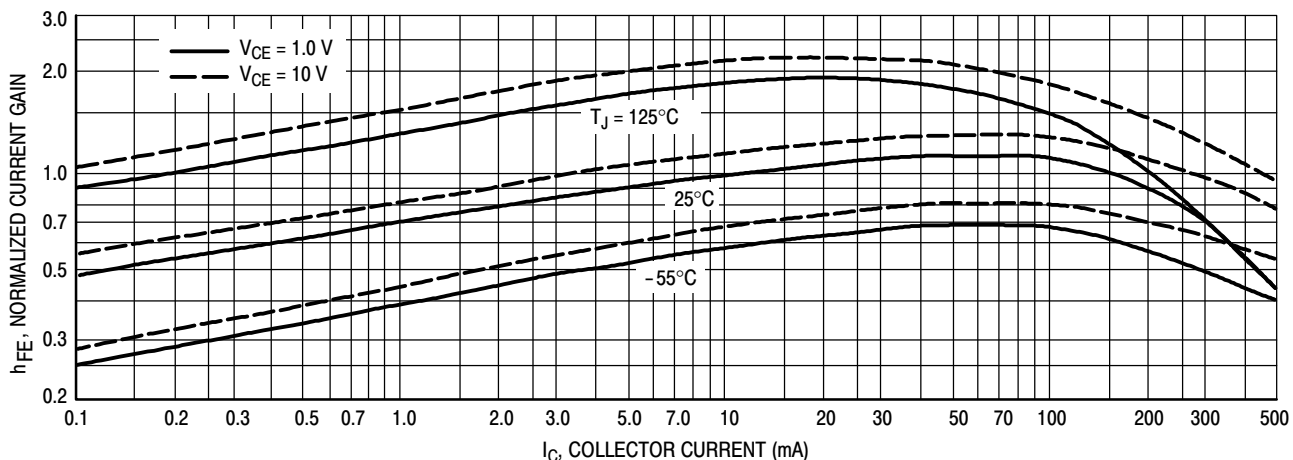


Figure 15. DC Current Gain

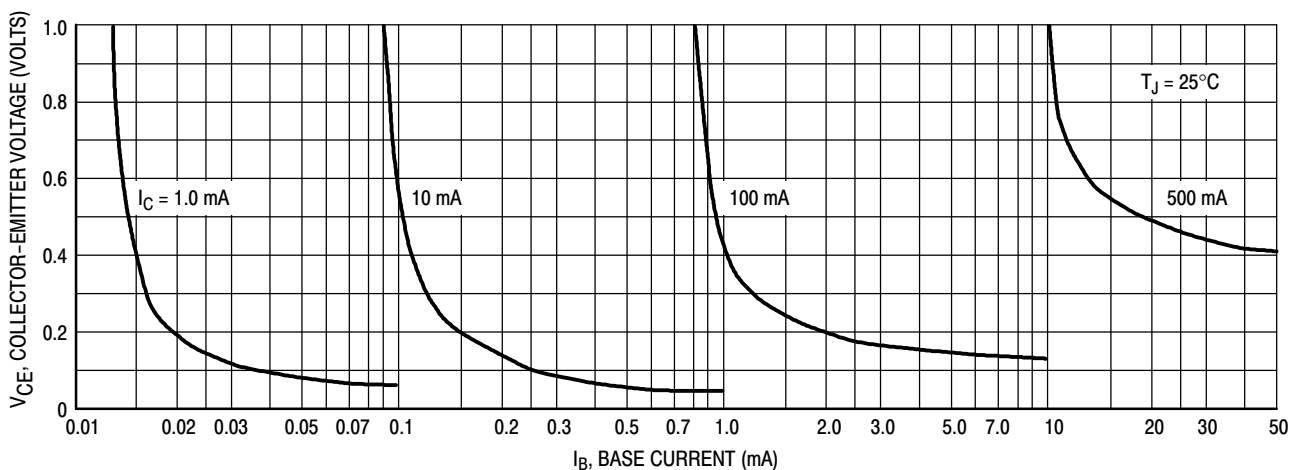


Figure 16. Collector Saturation Region

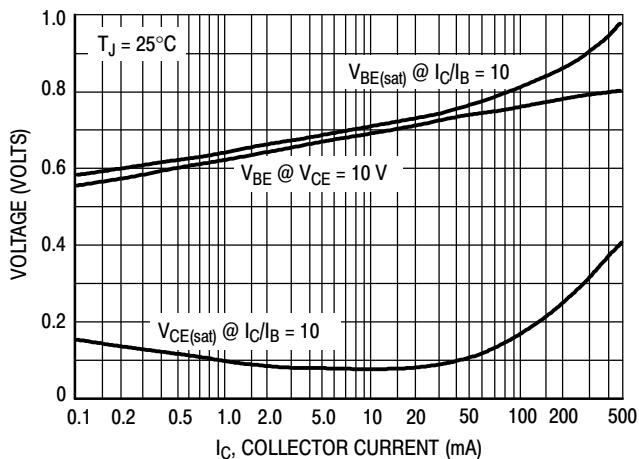


Figure 17. "On" Voltages

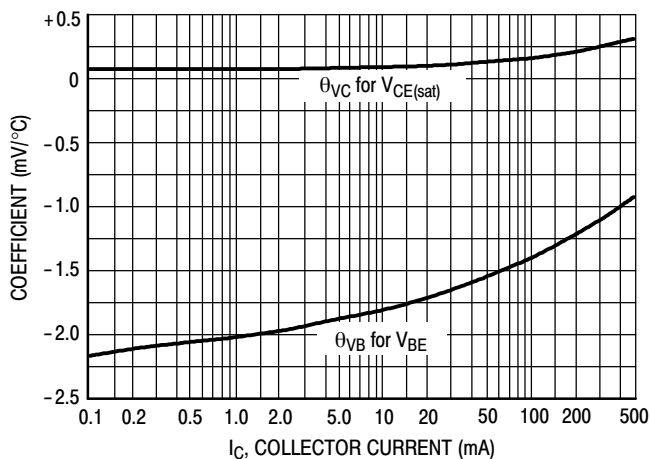
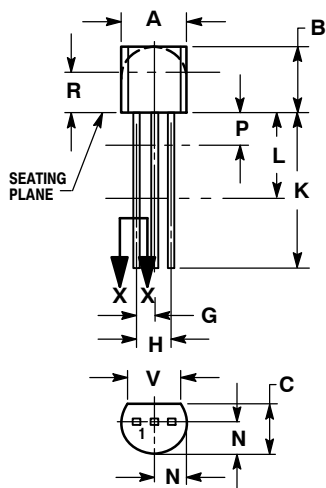


Figure 18. Temperature Coefficients

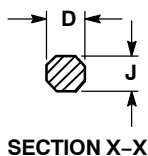
# 2N4401

## PACKAGE DIMENSIONS

TO-92 (TO-226)  
CASE 29-11  
ISSUE AM



STRAIGHT LEAD  
BULK PACK

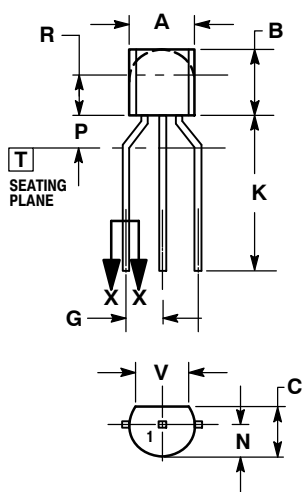


SECTION X-X

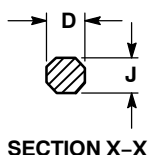
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.175  | 0.205 | 4.45        | 5.20  |
| B   | 0.170  | 0.210 | 4.32        | 5.33  |
| C   | 0.125  | 0.165 | 3.18        | 4.19  |
| D   | 0.016  | 0.021 | 0.407       | 0.533 |
| G   | 0.045  | 0.055 | 1.15        | 1.39  |
| H   | 0.095  | 0.105 | 2.42        | 2.66  |
| J   | 0.015  | 0.020 | 0.39        | 0.50  |
| K   | 0.500  | ---   | 12.70       | ---   |
| L   | 0.250  | ---   | 6.35        | ---   |
| N   | 0.080  | 0.105 | 2.04        | 2.66  |
| P   | ---    | 0.100 | ---         | 2.54  |
| R   | 0.115  | ---   | 2.93        | ---   |
| V   | 0.135  | ---   | 3.43        | ---   |



BENT LEAD  
TAPE & REEL  
AMMO PACK



SECTION X-X

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 4.45        | 5.20 |
| B   | 4.32        | 5.33 |
| C   | 3.18        | 4.19 |
| D   | 0.40        | 0.54 |
| G   | 2.40        | 2.80 |
| J   | 0.39        | 0.50 |
| K   | 12.70       | ---  |
| N   | 2.04        | 2.66 |
| P   | 1.50        | 4.00 |
| R   | 2.93        | ---  |
| V   | 3.43        | ---  |

STYLE 1:

1. PIN 1. EMITTER
2. BASE
3. COLLECTOR

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