

# 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 @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	625 5.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	1.5 12	W mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	$T_J, T_{stg}$	-55 to +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	$^\circ\text{C}/\text{W}$

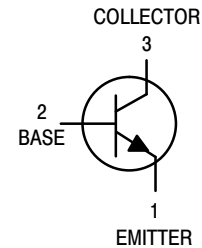
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

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

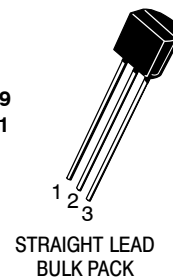


ON Semiconductor®

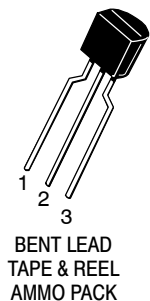
<http://onsemi.com>



TO-92  
CASE 29  
STYLE 1

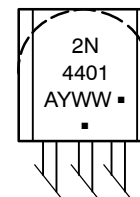


STRAIGHT LEAD  
BULK PACK



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<sub>A</sub> = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
<b>OFF CHARACTERISTICS</b>				
Collector–Emitter Breakdown Voltage (Note 1) (I <sub>C</sub> = 1.0 mAdc, I <sub>B</sub> = 0)	V <sub>(BR)CEO</sub>	40	–	Vdc
Collector–Base Breakdown Voltage (I <sub>C</sub> = 0.1 mAdc, I <sub>E</sub> = 0)	V <sub>(BR)CBO</sub>	60	–	Vdc
Emitter–Base Breakdown Voltage (I <sub>E</sub> = 0.1 mAdc, I <sub>C</sub> = 0)	V <sub>(BR)EBO</sub>	6.0	–	Vdc
Base Cutoff Current (V <sub>CE</sub> = 35 Vdc, V <sub>EB</sub> = 0.4 Vdc)	I <sub>BEV</sub>	–	0.1	μAdc
Collector Cutoff Current (V <sub>CE</sub> = 35 Vdc, V <sub>EB</sub> = 0.4 Vdc)	I <sub>CEX</sub>	–	0.1	μAdc

## ON CHARACTERISTICS (Note 1)

DC Current Gain (I <sub>C</sub> = 0.1 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 150 mAdc, V <sub>CE</sub> = 1.0 Vdc) (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> = 2.0 Vdc)	h <sub>FE</sub>	20 40 80 100 40	– – – 300 –	–
Collector–Emitter Saturation Voltage (I <sub>C</sub> = 150 mAdc, I <sub>B</sub> = 15 mAdc) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc)	V <sub>CE(sat)</sub>	– –	0.4 0.75	Vdc
Base–Emitter Saturation Voltage (I <sub>C</sub> = 150 mAdc, I <sub>B</sub> = 15 mAdc) (I <sub>C</sub> = 500 mAdc, I <sub>B</sub> = 50 mAdc)	V <sub>BE(sat)</sub>	0.75 –	0.95 1.2	Vdc

## SMALL-SIGNAL CHARACTERISTICS

Current–Gain – Bandwidth Product (I <sub>C</sub> = 20 mAdc, V <sub>CE</sub> = 10 Vdc, f = 100 MHz)	f <sub>T</sub>	250	–	MHz
Collector–Base Capacitance (V <sub>CB</sub> = 5.0 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)	C <sub>cb</sub>	–	6.5	pF
Emitter–Base Capacitance (V <sub>EB</sub> = 0.5 Vdc, I <sub>C</sub> = 0, f = 1.0 MHz)	C <sub>eb</sub>	–	30	pF
Input Impedance (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	h <sub>ie</sub>	1.0	15	k Ω
Voltage Feedback Ratio (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	h <sub>re</sub>	0.1	8.0	X 10 <sup>-4</sup>
Small–Signal Current Gain (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	h <sub>fe</sub>	40	500	–
Output Admittance (I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)	h <sub>oe</sub>	1.0	30	μmhos

## SWITCHING CHARACTERISTICS

Delay Time	(V <sub>CC</sub> = 30 Vdc, V <sub>BE</sub> = 2.0 Vdc, I <sub>C</sub> = 150 mAdc, I <sub>B1</sub> = 15 mAdc)	t <sub>d</sub>	–	15	ns
Rise Time		t <sub>r</sub>	–	20	ns
Storage Time	(V <sub>CC</sub> = 30 Vdc, I <sub>C</sub> = 150 mAdc, I <sub>B1</sub> = I <sub>B2</sub> = 15 mAdc)	t <sub>s</sub>	–	225	ns
Fall Time		t <sub>f</sub>	–	30	ns

1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

## ORDERING INFORMATION

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

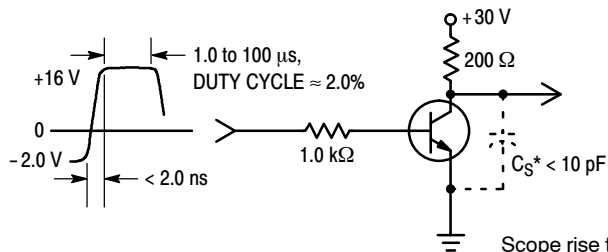


Figure 1. Turn-On Time

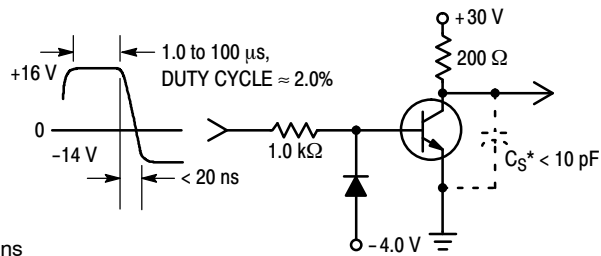


Figure 2. Turn-Off Time

Scope rise time < 4.0 ns  
\*Total shunt capacitance of test jig connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

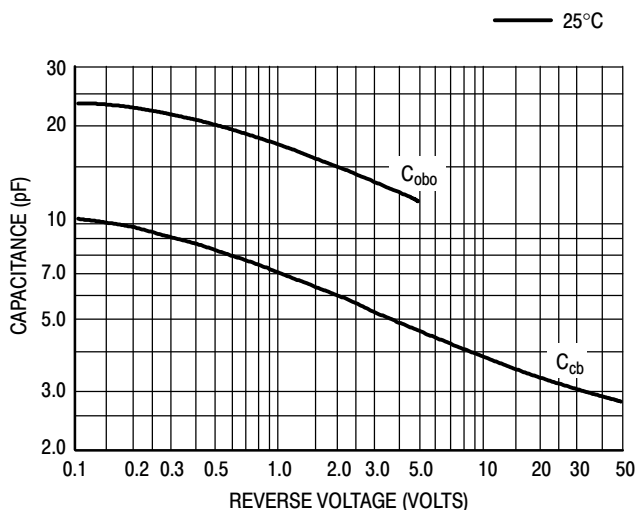


Figure 3. Capacitances

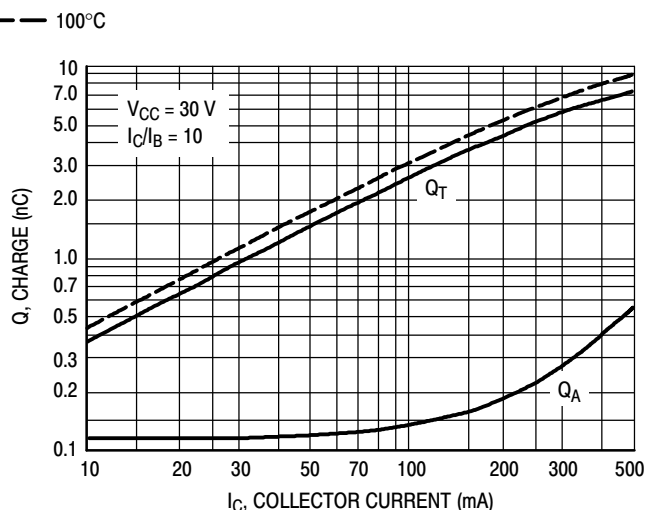


Figure 4. Charge Data

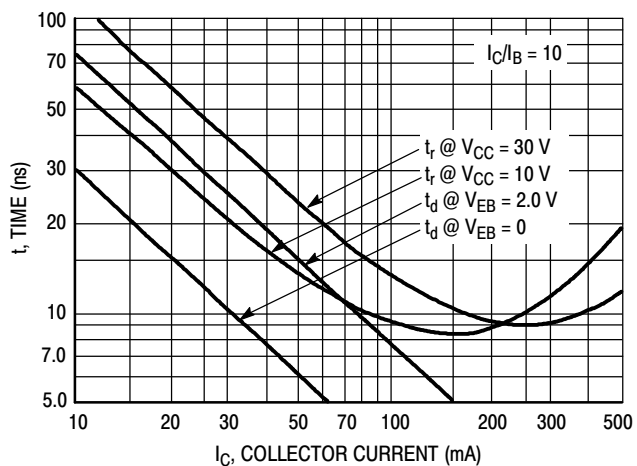


Figure 5. Turn-On Time

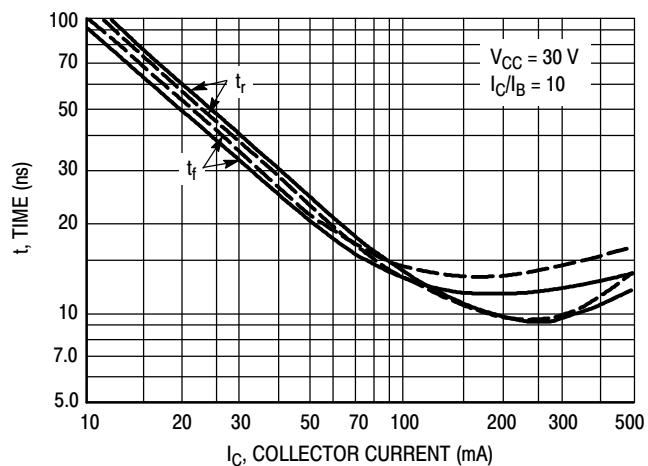


Figure 6. Rise and Fall Times

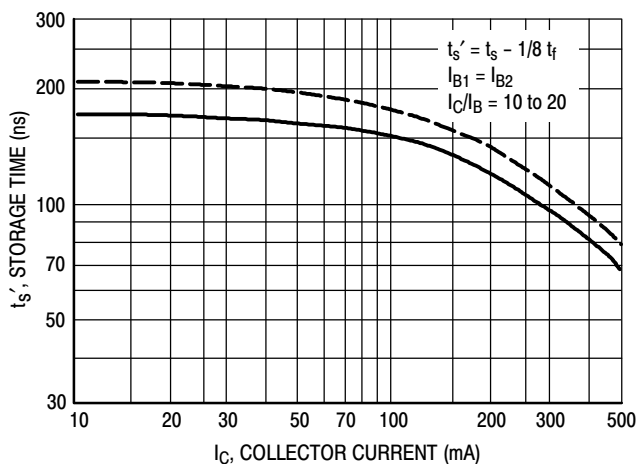


Figure 7. Storage Time

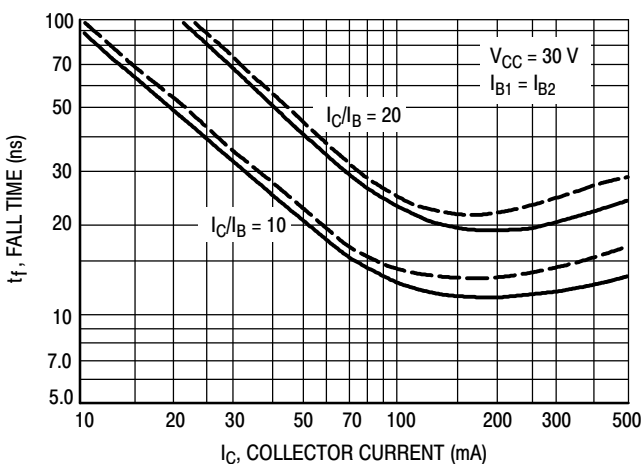


Figure 8. Fall Time

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

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

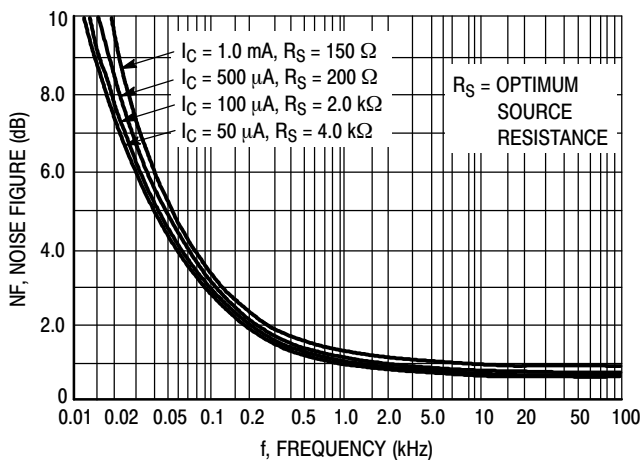


Figure 9. Frequency Effects

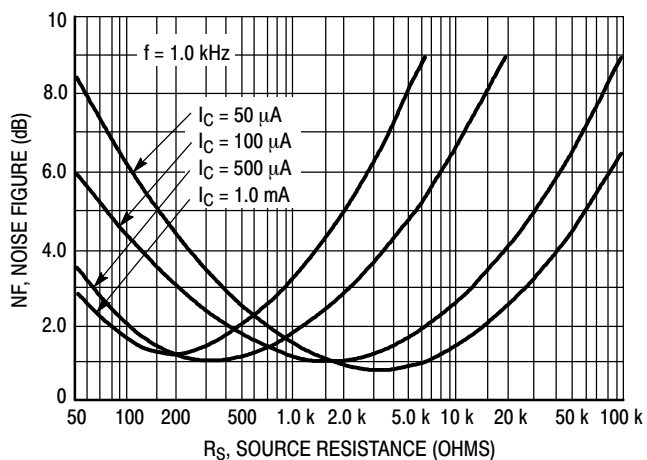


Figure 10. Source Resistance Effects

# 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.

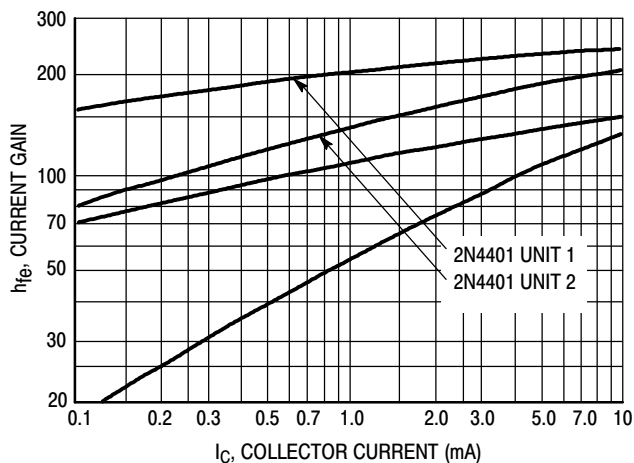


Figure 11. Current Gain

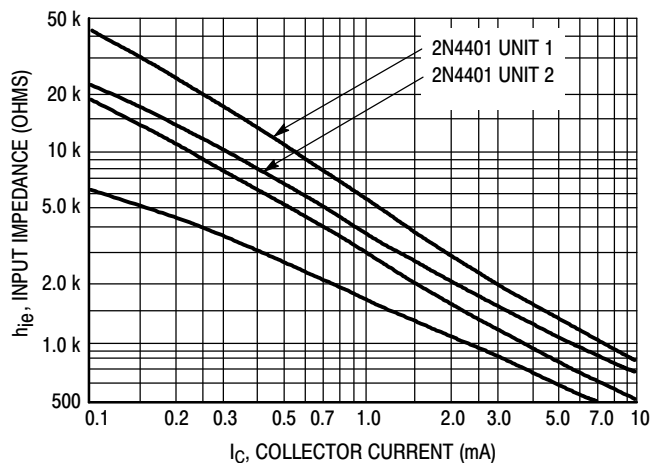


Figure 12. Input Impedance

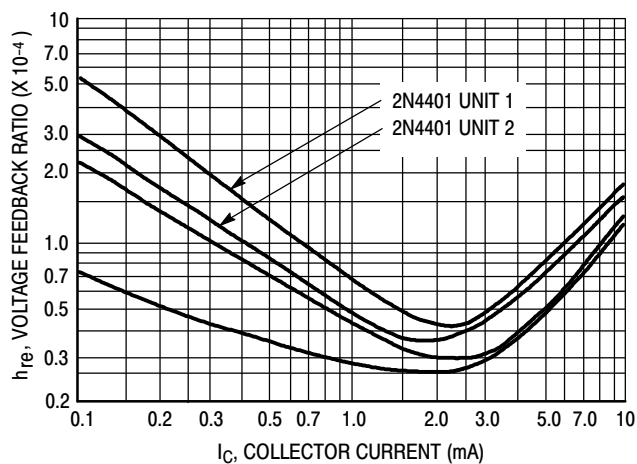


Figure 13. Voltage Feedback Ratio

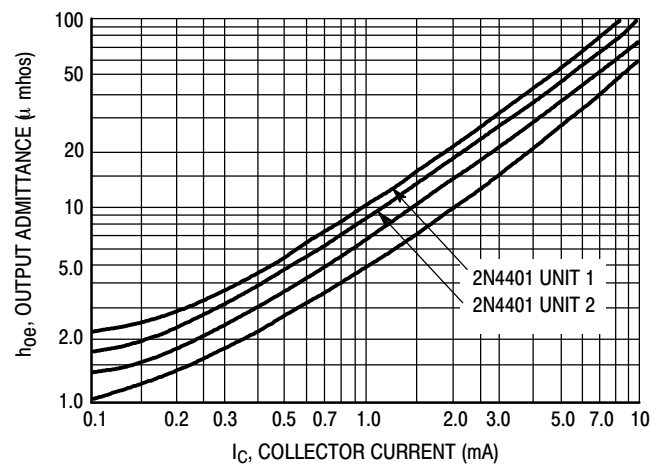


Figure 14. Output Admittance

# 2N4401

## STATIC CHARACTERISTICS

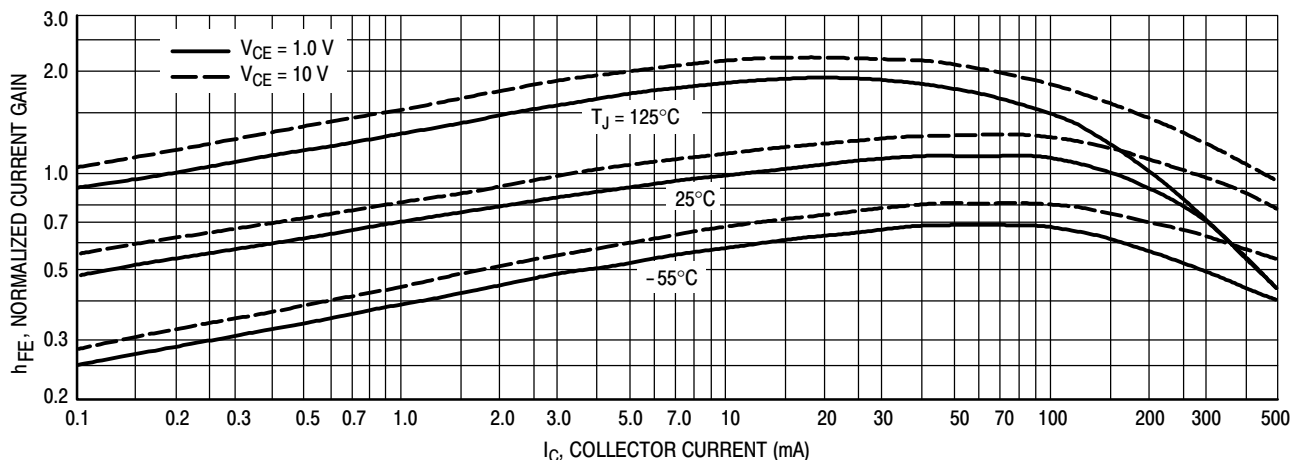


Figure 15. DC Current Gain

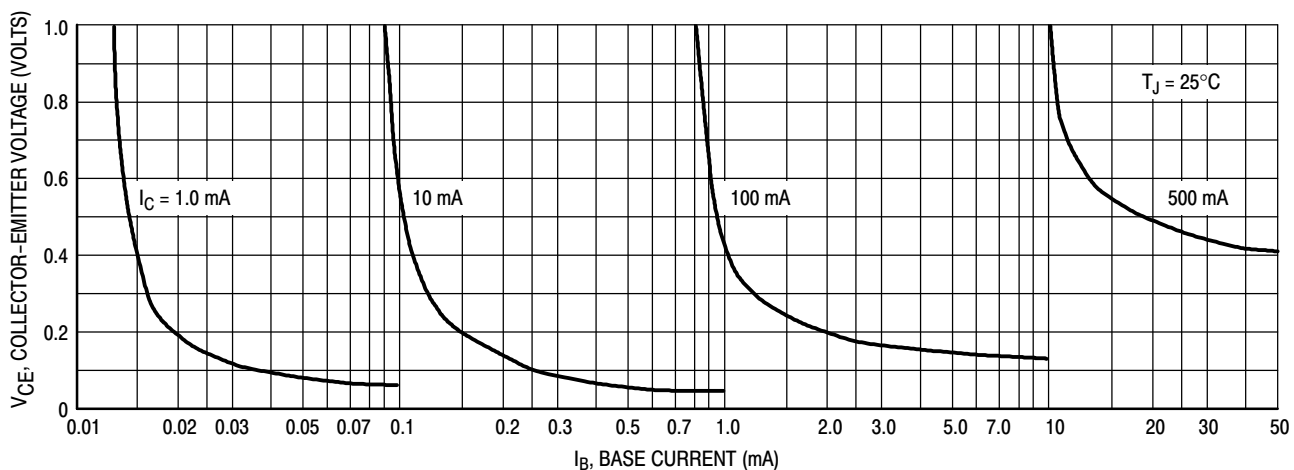


Figure 16. Collector Saturation Region

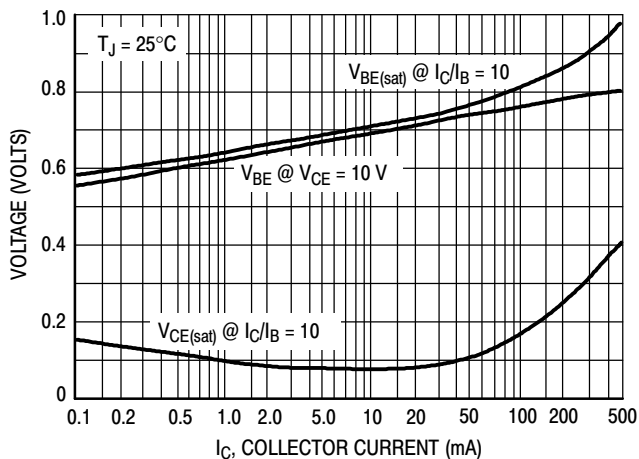


Figure 17. "On" Voltages

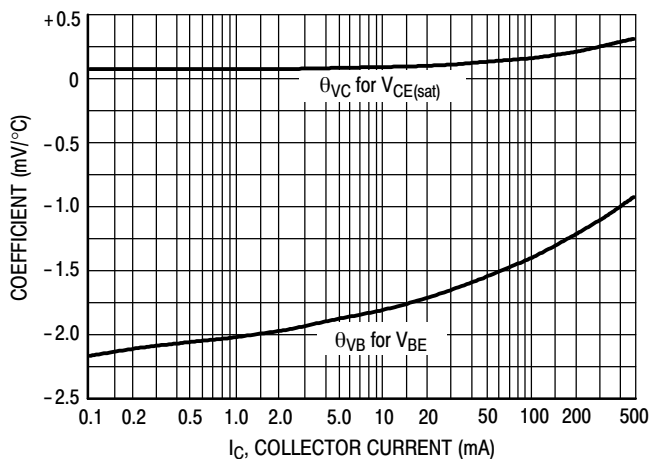
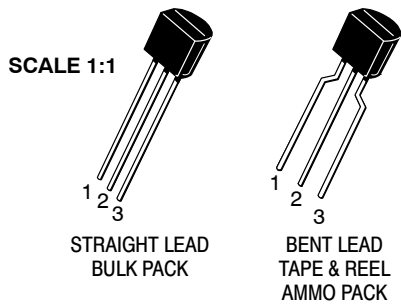
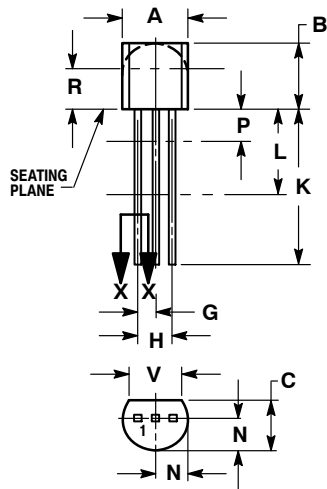


Figure 18. Temperature Coefficients

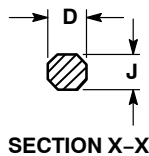


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CASE 29-11  
ISSUE AM

DATE 09 MAR 2007



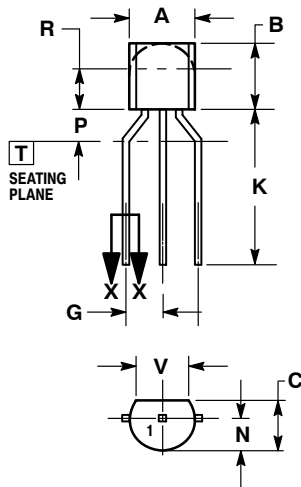
STRAIGHT LEAD  
BULK PACK



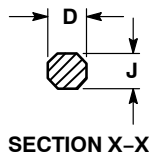
NOTES:

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



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	---

STYLES ON PAGE 2

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

DATE 09 MAR 2007

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

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

STYLE 3:  
 PIN 1. ANODE  
 2. ANODE  
 3. CATHODE

STYLE 4:  
 PIN 1. CATHODE  
 2. CATHODE  
 3. ANODE

STYLE 5:  
 PIN 1. DRAIN  
 2. SOURCE  
 3. GATE

STYLE 6:  
 PIN 1. GATE  
 2. SOURCE & SUBSTRATE  
 3. DRAIN

STYLE 7:  
 PIN 1. SOURCE  
 2. DRAIN  
 3. GATE

STYLE 8:  
 PIN 1. DRAIN  
 2. GATE  
 3. SOURCE & SUBSTRATE

STYLE 9:  
 PIN 1. BASE 1  
 2. EMITTER  
 3. BASE 2

STYLE 10:  
 PIN 1. CATHODE  
 2. GATE  
 3. ANODE

STYLE 11:  
 PIN 1. ANODE  
 2. CATHODE & ANODE  
 3. CATHODE

STYLE 12:  
 PIN 1. MAIN TERMINAL 1  
 2. GATE  
 3. MAIN TERMINAL 2

STYLE 13:  
 PIN 1. ANODE 1  
 2. GATE  
 3. CATHODE 2

STYLE 14:  
 PIN 1. EMITTER  
 2. COLLECTOR  
 3. BASE

STYLE 15:  
 PIN 1. ANODE 1  
 2. CATHODE  
 3. ANODE 2

STYLE 16:  
 PIN 1. ANODE  
 2. GATE  
 3. CATHODE

STYLE 17:  
 PIN 1. COLLECTOR  
 2. BASE  
 3. EMITTER

STYLE 18:  
 PIN 1. ANODE  
 2. CATHODE  
 3. NOT CONNECTED

STYLE 19:  
 PIN 1. GATE  
 2. ANODE  
 3. CATHODE

STYLE 20:  
 PIN 1. NOT CONNECTED  
 2. CATHODE  
 3. ANODE

STYLE 21:  
 PIN 1. COLLECTOR  
 2. EMITTER  
 3. BASE

STYLE 22:  
 PIN 1. SOURCE  
 2. GATE  
 3. DRAIN

STYLE 23:  
 PIN 1. GATE  
 2. SOURCE  
 3. DRAIN

STYLE 24:  
 PIN 1. EMITTER  
 2. COLLECTOR/ANODE  
 3. CATHODE

STYLE 25:  
 PIN 1. MT 1  
 2. GATE  
 3. MT 2

STYLE 26:  
 PIN 1. V<sub>CC</sub>  
 2. GROUND 2  
 3. OUTPUT

STYLE 27:  
 PIN 1. MT  
 2. SUBSTRATE  
 3. MT

STYLE 28:  
 PIN 1. CATHODE  
 2. ANODE  
 3. GATE

STYLE 29:  
 PIN 1. NOT CONNECTED  
 2. ANODE  
 3. CATHODE

STYLE 30:  
 PIN 1. DRAIN  
 2. GATE  
 3. SOURCE

STYLE 31:  
 PIN 1. GATE  
 2. DRAIN  
 3. SOURCE

STYLE 32:  
 PIN 1. BASE  
 2. COLLECTOR  
 3. EMITTER

STYLE 33:  
 PIN 1. RETURN  
 2. INPUT  
 3. OUTPUT

STYLE 34:  
 PIN 1. INPUT  
 2. GROUND  
 3. LOGIC

STYLE 35:  
 PIN 1. GATE  
 2. COLLECTOR  
 3. EMITTER

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