

# General Purpose Transistors

NPN Silicon

## 2N3903, 2N3904

### Features

- Pb-Free Packages are Available\*

### MAXIMUM RATINGS

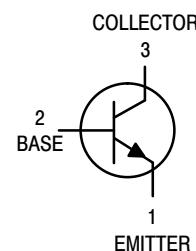
Rating	Symbol	Value	Unit
Collector – Emitter Voltage	$V_{CEO}$	40	Vdc
Collector – Base Voltage	$V_{CBO}$	60	Vdc
Emitter – Base Voltage	$V_{EBO}$	6.0	Vdc
Collector Current – Continuous	$I_C$	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above $25^\circ\text{C}$	$P_D$	625 5.0	mW mW/ $^\circ\text{C}$
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 (Note 1)

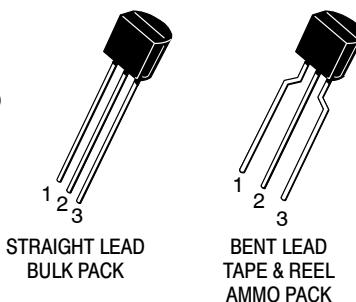
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	200	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	83.3	$^\circ\text{C}/\text{W}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

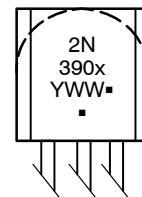
1. Indicates Data in addition to JEDEC Requirements.



TO-92  
CASE 29  
STYLE 1



### MARKING DIAGRAMS



X = 3 or 4  
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 3 of this data sheet.

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

# 2N3903, 2N3904

**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 2) ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $I_B = 0$ )	$V_{(\text{BR})\text{CEO}}$	40	–	Vdc
Collector – Base Breakdown Voltage ( $I_C = 10 \mu\text{A}_\text{dc}$ , $I_E = 0$ )	$V_{(\text{BR})\text{CBO}}$	60	–	Vdc
Emitter – Base Breakdown Voltage ( $I_E = 10 \mu\text{A}_\text{dc}$ , $I_C = 0$ )	$V_{(\text{BR})\text{EBO}}$	6.0	–	Vdc
Base Cutoff Current ( $V_{\text{CE}} = 30 \text{ Vdc}$ , $V_{\text{EB}} = 3.0 \text{ Vdc}$ )	$I_{BL}$	–	50	nAdc
Collector Cutoff Current ( $V_{\text{CE}} = 30 \text{ Vdc}$ , $V_{\text{EB}} = 3.0 \text{ Vdc}$ )	$I_{\text{CEX}}$	–	50	nAdc

## ON CHARACTERISTICS

DC Current Gain (Note 2) ( $I_C = 0.1 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 1.0 \text{ Vdc}$ )  ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 1.0 \text{ Vdc}$ )  ( $I_C = 10 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 1.0 \text{ Vdc}$ )  ( $I_C = 50 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 1.0 \text{ Vdc}$ )  ( $I_C = 100 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 1.0 \text{ Vdc}$ )	2N3903 2N3904  2N3903 2N3904  2N3903 2N3904  2N3903 2N3904  2N3903 2N3904	$h_{FE}$	20 40 35 70 50 100 30 60 15 30	– – – – 150 300 – – – –	– – – – –
Collector – Emitter Saturation Voltage (Note 2) ( $I_C = 10 \text{ mA}_\text{dc}$ , $I_B = 1.0 \text{ mA}_\text{dc}$ ) ( $I_C = 50 \text{ mA}_\text{dc}$ , $I_B = 5.0 \text{ mA}_\text{dc}$ )		$V_{\text{CE}(\text{sat})}$	– –	0.2 0.3	Vdc
Base – Emitter Saturation Voltage (Note 2) ( $I_C = 10 \text{ mA}_\text{dc}$ , $I_B = 1.0 \text{ mA}_\text{dc}$ ) ( $I_C = 50 \text{ mA}_\text{dc}$ , $I_B = 5.0 \text{ mA}_\text{dc}$ )		$V_{\text{BE}(\text{sat})}$	0.65 –	0.85 0.95	Vdc

## SMALL-SIGNAL CHARACTERISTICS

Current-Gain – Bandwidth Product ( $I_C = 10 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 20 \text{ Vdc}$ , $f = 100 \text{ MHz}$ )	2N3903 2N3904	$f_T$	250 300	– –	MHz
Output Capacitance ( $V_{\text{CB}} = 5.0 \text{ Vdc}$ , $I_E = 0$ , $f = 1.0 \text{ MHz}$ )		$C_{obo}$	–	4.0	pF
Input Capacitance ( $V_{\text{EB}} = 0.5 \text{ Vdc}$ , $I_C = 0$ , $f = 1.0 \text{ MHz}$ )		$C_{ibo}$	–	8.0	pF
Input Impedance ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 10 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )	2N3903 2N3904	$h_{ie}$	1.0 1.0	8.0 10	k $\Omega$
Voltage Feedback Ratio ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 10 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )	2N3903 2N3904	$h_{re}$	0.1 0.5	5.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 10 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )	2N3903 2N3904	$h_{fe}$	50 100	200 400	–
Output Admittance ( $I_C = 1.0 \text{ mA}_\text{dc}$ , $V_{\text{CE}} = 10 \text{ Vdc}$ , $f = 1.0 \text{ kHz}$ )		$h_{oe}$	1.0	40	$\mu\text{mhos}$
Noise Figure ( $I_C = 100 \mu\text{A}_\text{dc}$ , $V_{\text{CE}} = 5.0 \text{ Vdc}$ , $R_S = 1.0 \text{ k } \Omega$ , $f = 1.0 \text{ kHz}$ )	2N3903 2N3904	NF	– –	6.0 5.0	dB

## SWITCHING CHARACTERISTICS

Delay Time	( $V_{\text{CC}} = 3.0 \text{ Vdc}$ , $V_{\text{BE}} = 0.5 \text{ Vdc}$ , $I_C = 10 \text{ mA}_\text{dc}$ , $I_{B1} = 1.0 \text{ mA}_\text{dc}$ )	$t_d$	–	35	ns
Rise Time		$t_r$	–	35	ns
Storage Time	( $V_{\text{CC}} = 3.0 \text{ Vdc}$ , $I_C = 10 \text{ mA}_\text{dc}$ , $I_{B1} = I_{B2} = 1.0 \text{ mA}_\text{dc}$ )	$t_s$	– –	175 200	ns
Fall Time		$t_f$	–	50	ns

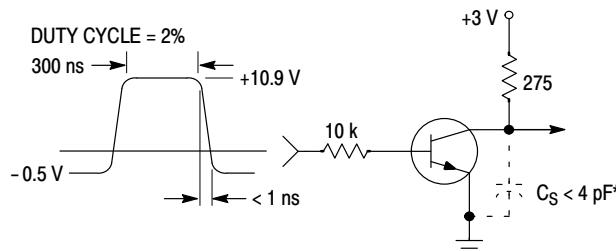
2. Pulse Test: Pulse Width  $\leq 300 \mu\text{s}$ ; Duty Cycle  $\leq 2\%$ .

# 2N3903, 2N3904

## ORDERING INFORMATION

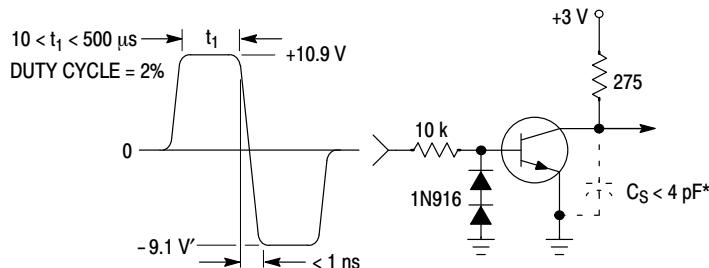
Device	Package	Shipping <sup>†</sup>
2N3903RLRM	TO-92	2000 / Ammo Pack
2N3904	TO-92	5000 Units / Bulk
2N3904G	TO-92 (Pb-Free)	5000 Units / Bulk
2N3904RLRA	TO-92	2000 / Tape & Reel
2N3904RLRAG	TO-92 (Pb-Free)	2000 / Tape & Reel
2N3904RLRM	TO-92	2000 / Ammo Pack
2N3904RLRMG	TO-92 (Pb-Free)	2000 / Ammo Pack
2N3904RLRP	TO-92	2000 / Ammo Pack
2N3904RLRPG	TO-92 (Pb-Free)	2000 / Ammo Pack
2N3904RL1G	TO-92 (Pb-Free)	2000 / Tape & Reel
2N3904ZL1	TO-92	2000 / Ammo Pack
2N3904ZL1G	TO-92 (Pb-Free)	2000 / Ammo Pack

<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.



\* Total shunt capacitance of test jig and connectors

**Figure 1. Delay and Rise Time Equivalent Test Circuit**

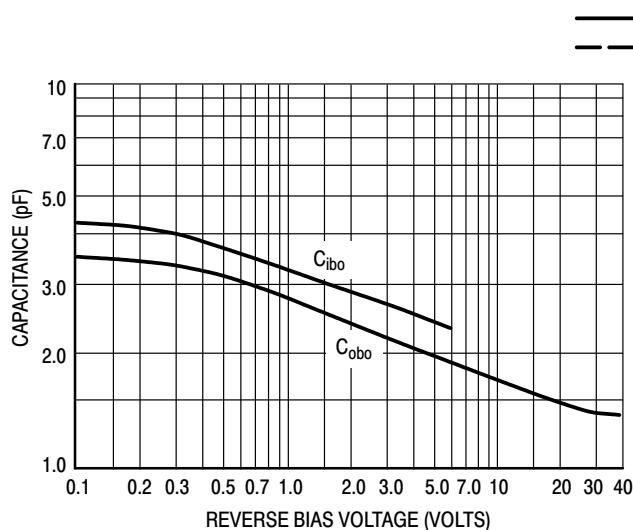


\* Total shunt capacitance of test jig and connectors

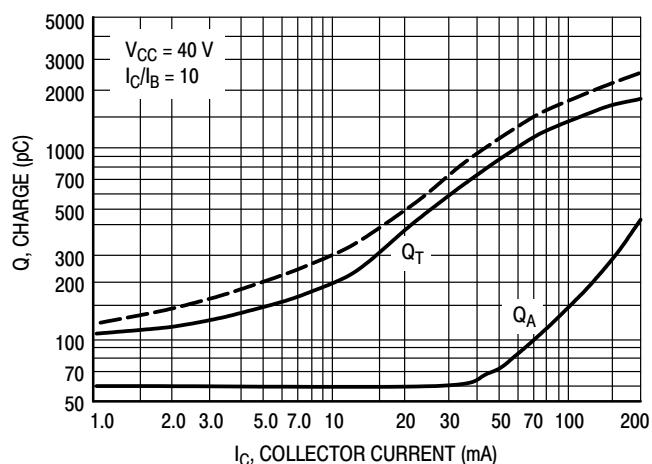
**Figure 2. Storage and Fall Time Equivalent Test Circuit**

# 2N3903, 2N3904

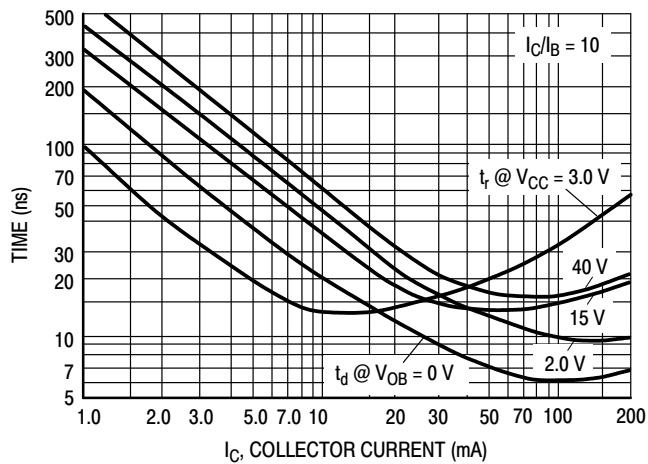
## TYPICAL TRANSIENT CHARACTERISTICS



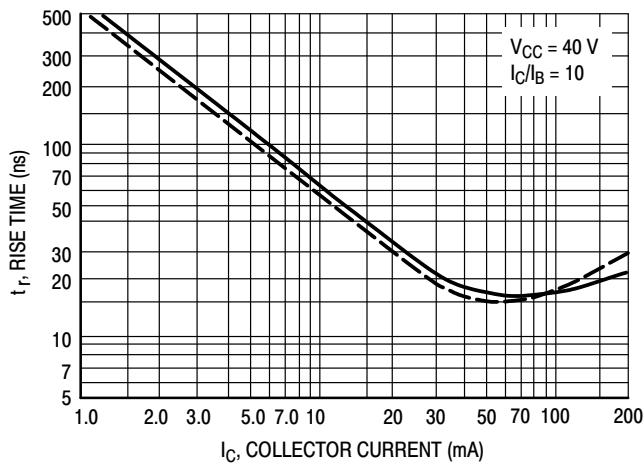
**Figure 3. Capacitance**



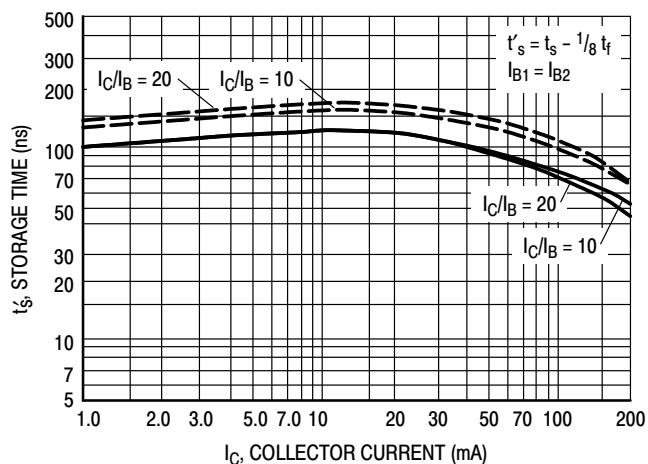
**Figure 4. Charge Data**



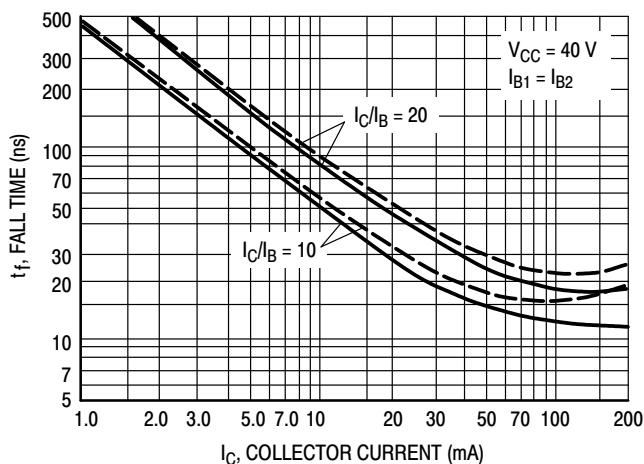
**Figure 5. Turn-On Time**



**Figure 6. Rise Time**



**Figure 7. Storage Time**



**Figure 8. Fall Time**

# 2N3903, 2N3904

## TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

( $V_{CE} = 5.0$  Vdc,  $T_A = 25^\circ\text{C}$ , Bandwidth = 1.0 Hz)

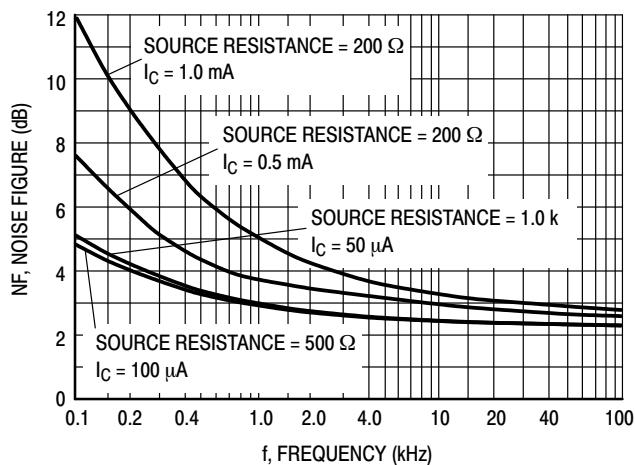


Figure 9.

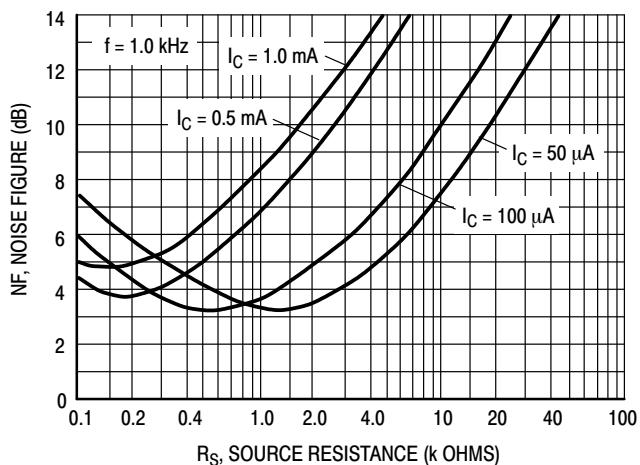


Figure 10.

## **h** PARAMETERS

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

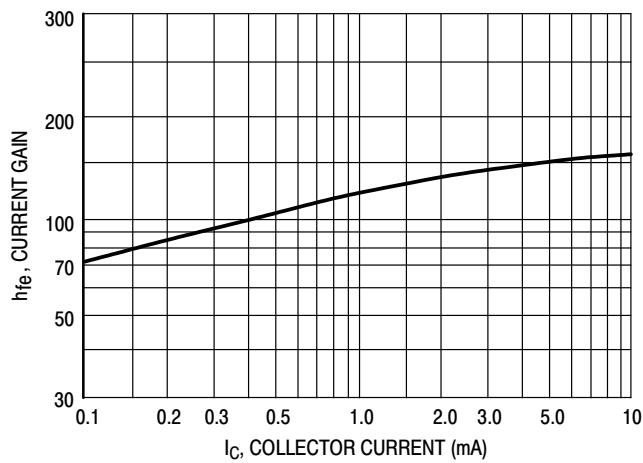


Figure 11. Current Gain

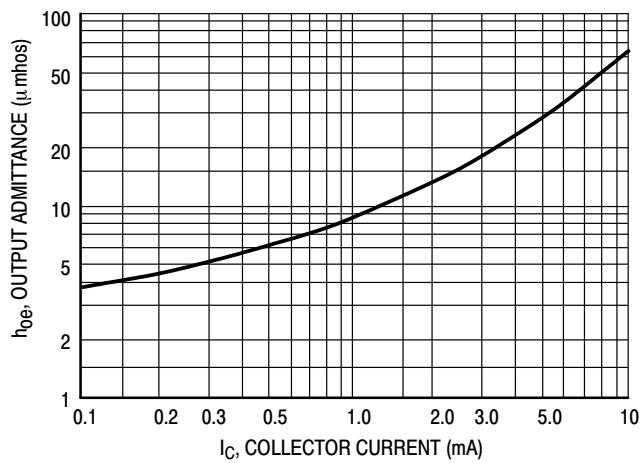


Figure 12. Output Admittance

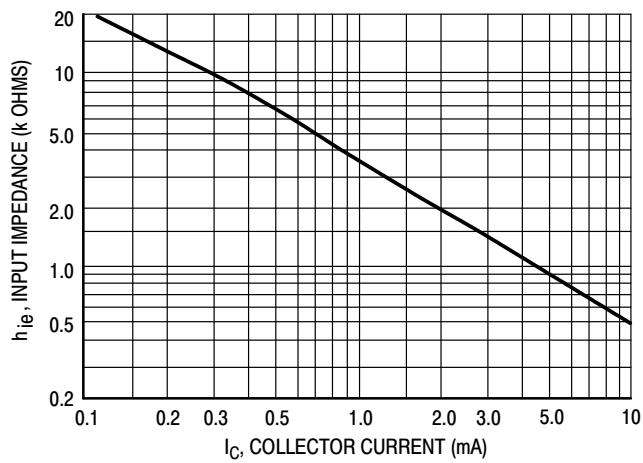


Figure 13. Input Impedance

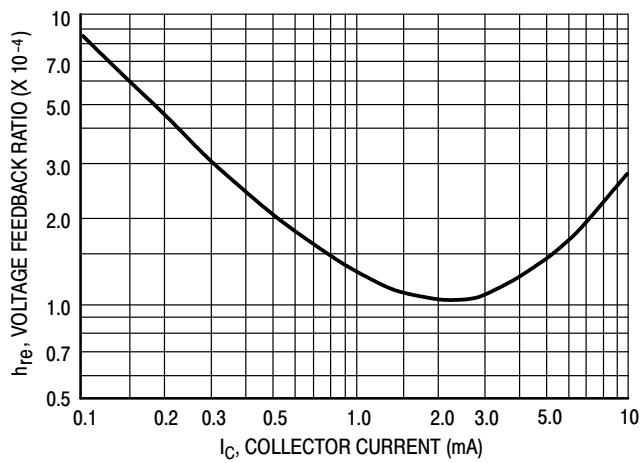


Figure 14. Voltage Feedback Ratio

# 2N3903, 2N3904

## TYPICAL STATIC CHARACTERISTICS

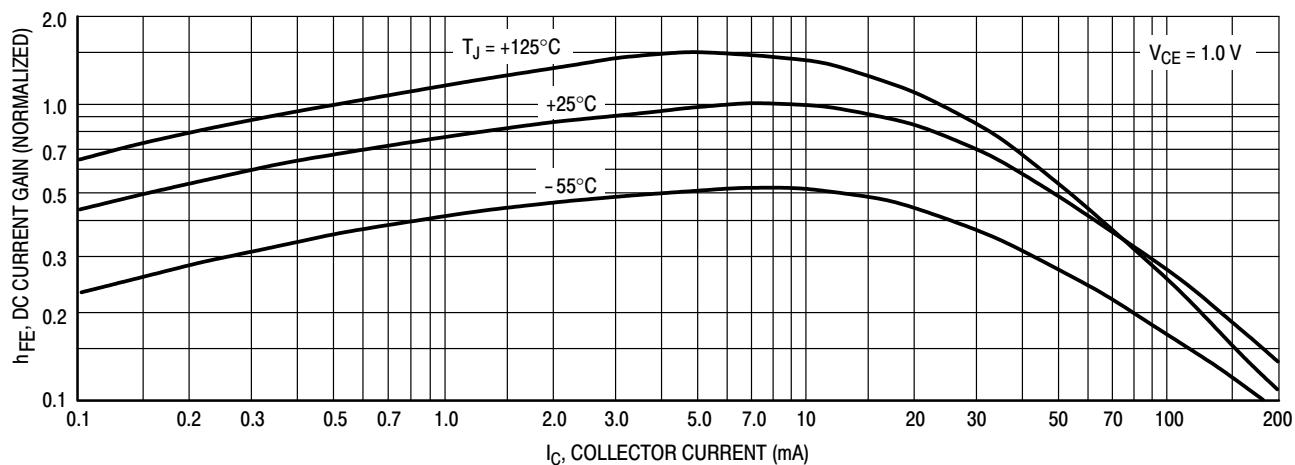


Figure 15. DC Current Gain

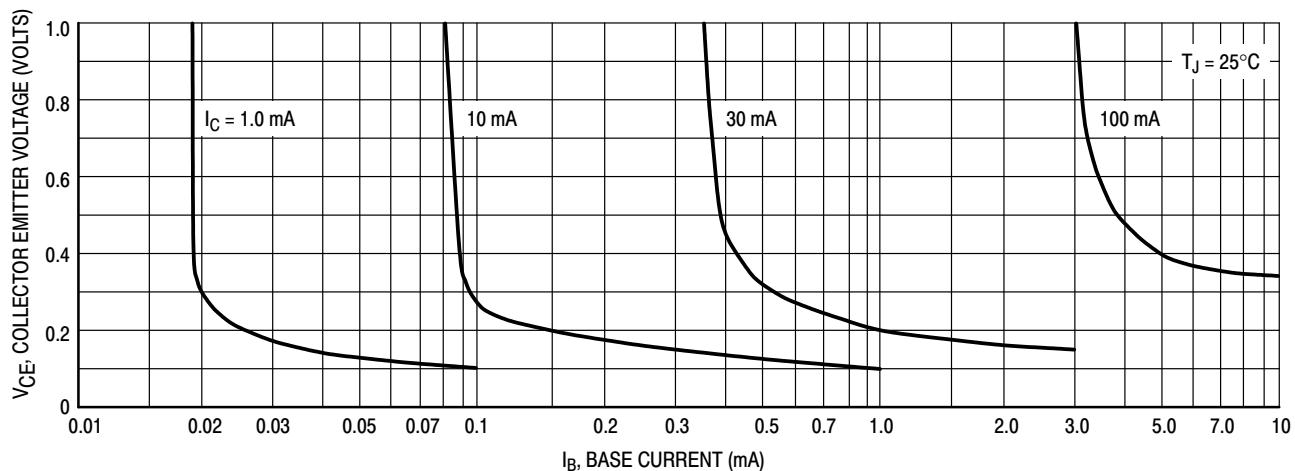


Figure 16. Collector Saturation Region

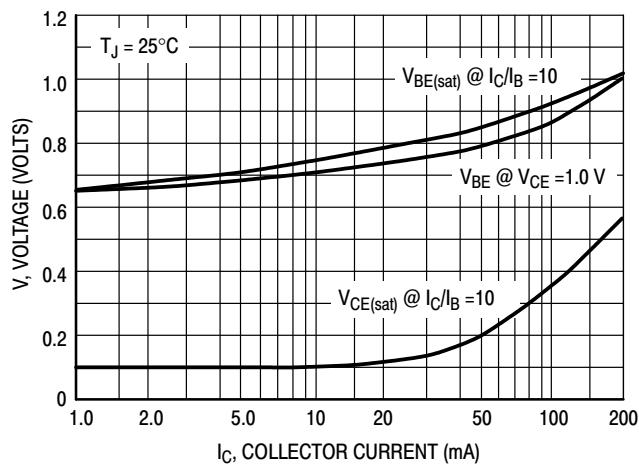


Figure 17. "ON" Voltages

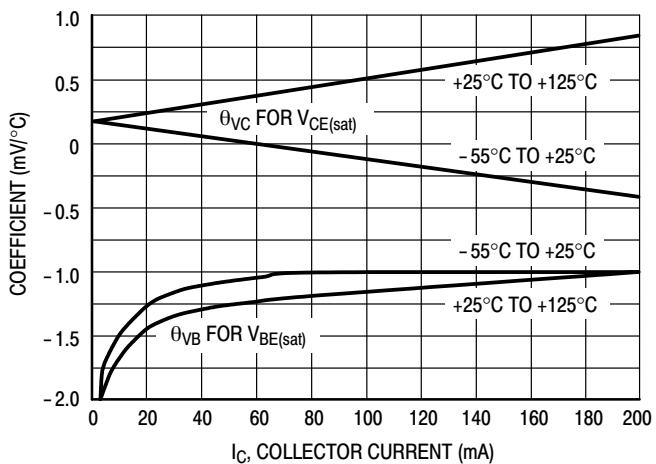
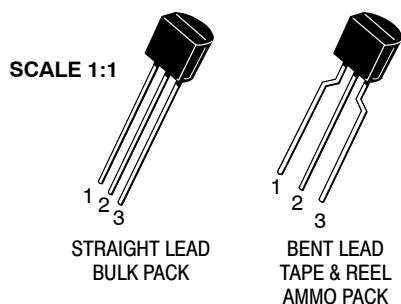
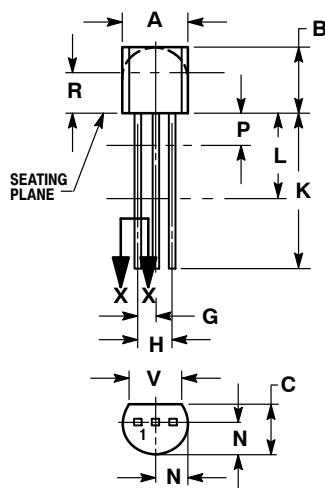


Figure 18. Temperature Coefficients

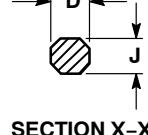


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DATE 09 MAR 2007

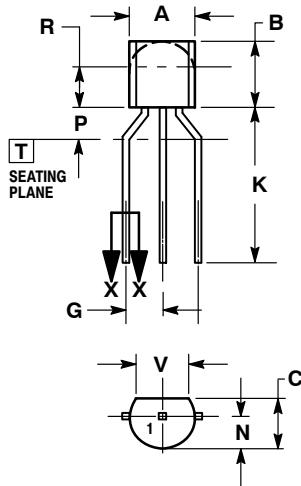


STRAIGHT LEAD  
BULK PACK

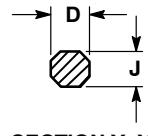


NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION: INCH.  
 3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.  
 4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

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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CASE 29-11

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DATE 09 MAR 2007

<b>STYLE 1:</b> PIN 1. Emitter 2. Base 3. Collector	<b>STYLE 2:</b> PIN 1. Base 2. Emitter 3. Collector	<b>STYLE 3:</b> PIN 1. Anode 2. Anode 3. Cathode	<b>STYLE 4:</b> PIN 1. Cathode 2. Cathode 3. Anode	<b>STYLE 5:</b> PIN 1. Drain 2. Source 3. Gate
<b>STYLE 6:</b> PIN 1. Gate 2. Source & Substrate 3. Drain	<b>STYLE 7:</b> PIN 1. Source 2. Drain 3. Gate	<b>STYLE 8:</b> PIN 1. Drain 2. Gate 3. Source & Substrate	<b>STYLE 9:</b> PIN 1. Base 1 2. Emitter 3. Base 2	<b>STYLE 10:</b> PIN 1. Cathode 2. Gate 3. Anode
<b>STYLE 11:</b> PIN 1. Anode 2. Cathode & Anode 3. Cathode	<b>STYLE 12:</b> PIN 1. Main Terminal 1 2. Gate 3. Main Terminal 2	<b>STYLE 13:</b> PIN 1. Anode 1 2. Gate 3. Cathode 2	<b>STYLE 14:</b> PIN 1. Emitter 2. Collector 3. Base	<b>STYLE 15:</b> PIN 1. Anode 1 2. Cathode 3. Anode 2
<b>STYLE 16:</b> PIN 1. Anode 2. Gate 3. Cathode	<b>STYLE 17:</b> PIN 1. Collector 2. Base 3. Emitter	<b>STYLE 18:</b> PIN 1. Anode 2. Cathode 3. Not Connected	<b>STYLE 19:</b> PIN 1. Gate 2. Anode 3. Cathode	<b>STYLE 20:</b> PIN 1. Not Connected 2. Cathode 3. Anode
<b>STYLE 21:</b> PIN 1. Collector 2. Emitter 3. Base	<b>STYLE 22:</b> PIN 1. Source 2. Gate 3. Drain	<b>STYLE 23:</b> PIN 1. Gate 2. Source 3. Drain	<b>STYLE 24:</b> PIN 1. Emitter 2. Collector/Anode 3. Cathode	<b>STYLE 25:</b> PIN 1. MT 1 2. Gate 3. MT 2
<b>STYLE 26:</b> PIN 1. V <sub>CC</sub> 2. Ground 2 3. Output	<b>STYLE 27:</b> PIN 1. MT 2. Substrate 3. MT	<b>STYLE 28:</b> PIN 1. Cathode 2. Anode 3. Gate	<b>STYLE 29:</b> PIN 1. Not Connected 2. Anode 3. Cathode	<b>STYLE 30:</b> PIN 1. Drain 2. Gate 3. Source
<b>STYLE 31:</b> PIN 1. Gate 2. Drain 3. Source	<b>STYLE 32:</b> PIN 1. Base 2. Collector 3. Emitter	<b>STYLE 33:</b> PIN 1. Return 2. Input 3. Output	<b>STYLE 34:</b> PIN 1. Input 2. Ground 3. Logic	<b>STYLE 35:</b> PIN 1. Gate 2. Collector 3. Emitter

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