

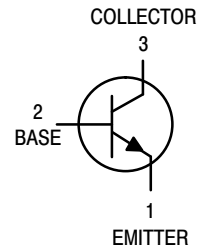
# General Purpose Transistors

## 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<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 Temperature Range  | $T_J, T_{stg}$ | -55 to +150 | $^\circ\text{C}$           |

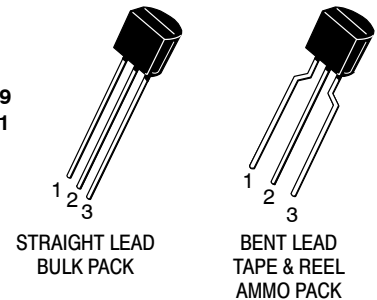
#### THERMAL CHARACTERISTICS (Note 1)

| 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 | $^\circ\text{C}/\text{W}$ |

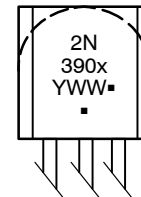
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

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

| Characteristic   | Symbol               | Min | Max | Unit |
|--|----------------------|-----|-----|------|
| <b>OFF CHARACTERISTICS</b>   |                      |     |     |      |
| Collector – Emitter Breakdown Voltage (Note 2) (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> = 10 μAdc, I <sub>E</sub> = 0)              | V <sub>(BR)CBO</sub> | 60  | –   | Vdc  |
| Emitter – Base Breakdown Voltage (I <sub>E</sub> = 10 μAdc, I <sub>C</sub> = 0)                | V <sub>(BR)EBO</sub> | 6.0 | –   | Vdc  |
| Base Cutoff Current (V <sub>CE</sub> = 30 Vdc, V <sub>EB</sub> = 3.0 Vdc)                      | I <sub>BL</sub>      | –   | 50  | nAdc |
| Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, V <sub>EB</sub> = 3.0 Vdc)                 | I <sub>CEX</sub>     | –   | 50  | nAdc |

### ON CHARACTERISTICS

|  |        |                      |      |      |     |
|--|--------|----------------------|------|------|-----|
| DC Current Gain (Note 2)<br>(I <sub>C</sub> = 0.1 mAdc, V <sub>CE</sub> = 1.0 Vdc)<br><br>(I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 1.0 Vdc)<br><br>(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 1.0 Vdc)<br><br>(I <sub>C</sub> = 50 mAdc, V <sub>CE</sub> = 1.0 Vdc)<br><br>(I <sub>C</sub> = 100 mAdc, V <sub>CE</sub> = 1.0 Vdc) | 2N3903 | h <sub>FE</sub>      | 20   | –    | –   |
|  | 2N3904 |                      | 40   | –    | –   |
|  | 2N3903 |                      | 35   | –    | –   |
|  | 2N3904 |                      | 70   | –    | –   |
|  | 2N3903 |                      | 50   | 150  | –   |
|  | 2N3904 |                      | 100  | 300  | –   |
|  | 2N3903 |                      | 30   | –    | –   |
|  | 2N3904 |                      | 60   | –    | –   |
| Collector – Emitter Saturation Voltage (Note 2)<br>(I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 1.0 mAdc)<br>(I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 5.0 mAdc)  |        | V <sub>CE(sat)</sub> | –    | 0.2  | Vdc |
|  |        |                      | –    | 0.3  |     |
| Base – Emitter Saturation Voltage (Note 2)<br>(I <sub>C</sub> = 10 mAdc, I <sub>B</sub> = 1.0 mAdc)<br>(I <sub>C</sub> = 50 mAdc, I <sub>B</sub> = 5.0 mAdc)   |        | V <sub>BE(sat)</sub> | 0.65 | 0.85 | Vdc |
|  |        |                      | –    | 0.95 |     |

### SMALL-SIGNAL CHARACTERISTICS

|   |                  |                  |            |            |                    |
|---|------------------|------------------|------------|------------|--------------------|
| Current – Gain – Bandwidth Product<br>(I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 20 Vdc, f = 100 MHz)       | 2N3903<br>2N3904 | f <sub>T</sub>   | 250<br>300 | –<br>–     | MHz                |
| Output Capacitance (V <sub>CB</sub> = 5.0 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)                               |                  | C <sub>obo</sub> | –          | 4.0        | pF                 |
| Input Capacitance (V <sub>EB</sub> = 0.5 Vdc, I <sub>C</sub> = 0, f = 1.0 MHz)                                |                  | C <sub>ibo</sub> | –          | 8.0        | pF                 |
| Input Impedance<br>(I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)                         | 2N3903<br>2N3904 | h <sub>ie</sub>  | 1.0<br>1.0 | 8.0<br>10  | k Ω                |
| Voltage Feedback Ratio<br>(I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)                  | 2N3903<br>2N3904 | h <sub>re</sub>  | 0.1<br>0.5 | 5.0<br>8.0 | X 10 <sup>-4</sup> |
| Small-Signal Current Gain<br>(I <sub>C</sub> = 1.0 mAdc, V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)               | 2N3903<br>2N3904 | h <sub>fe</sub>  | 50<br>100  | 200<br>400 | –                  |
| 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        | 40         | μmhos              |
| Noise Figure<br>(I <sub>C</sub> = 100 μAdc, V <sub>CE</sub> = 5.0 Vdc, R <sub>S</sub> = 1.0 k Ω, f = 1.0 kHz) | 2N3903<br>2N3904 | NF               | –<br>–     | 6.0<br>5.0 | dB                 |

### SWITCHING CHARACTERISTICS

|              |   |                  |                |   |            |    |
|--------------|---|------------------|----------------|---|------------|----|
| Delay Time   | (V <sub>CC</sub> = 3.0 Vdc, V <sub>BE</sub> = 0.5 Vdc,<br>I <sub>C</sub> = 10 mAdc, I <sub>B1</sub> = 1.0 mAdc) |                  | t <sub>d</sub> | – | 35         | ns |
| Rise Time    |   |                  | t <sub>r</sub> | – | 35         | ns |
| Storage Time | (V <sub>CC</sub> = 3.0 Vdc, I <sub>C</sub> = 10 mAdc,<br>I <sub>B1</sub> = I <sub>B2</sub> = 1.0 mAdc)          | 2N3903<br>2N3904 | t <sub>s</sub> | – | 175<br>200 | ns |
| Fall Time    |   |                  | t <sub>f</sub> | – | 50         | ns |

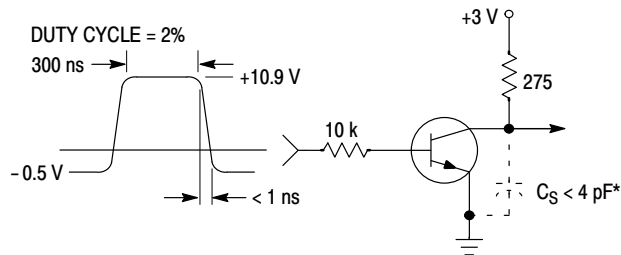
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

## 2N3903, 2N3904

### ORDERING INFORMATION

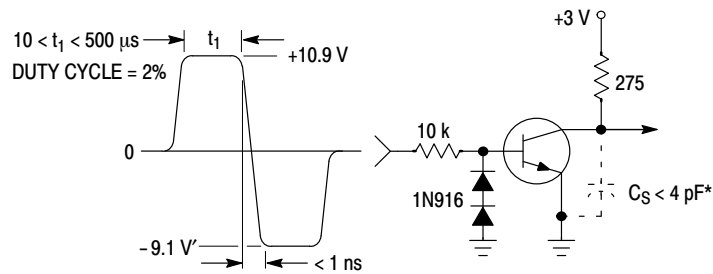
| Device      | Package            | Shipping†          |
|-------------|--------------------|--------------------|
| 2N3903RLRM  | TO-92              | 2000 / Ammo Pack   |
| 2N3904      | TO-92              | 5000 Units / Bulk  |
| 2N3904G     | TO-92<br>(Pb-Free) | 5000 Units / Bulk  |
| 2N3904RLRA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

†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**

TYPICAL TRANSIENT CHARACTERISTICS

—  $T_J = 25^\circ\text{C}$   
 - - -  $T_J = 125^\circ\text{C}$

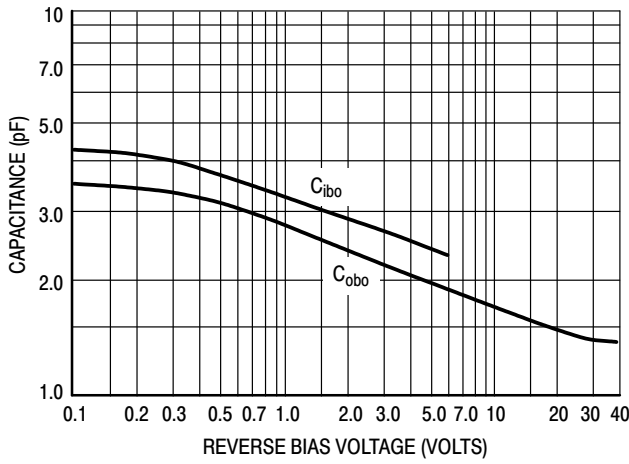


Figure 3. Capacitance

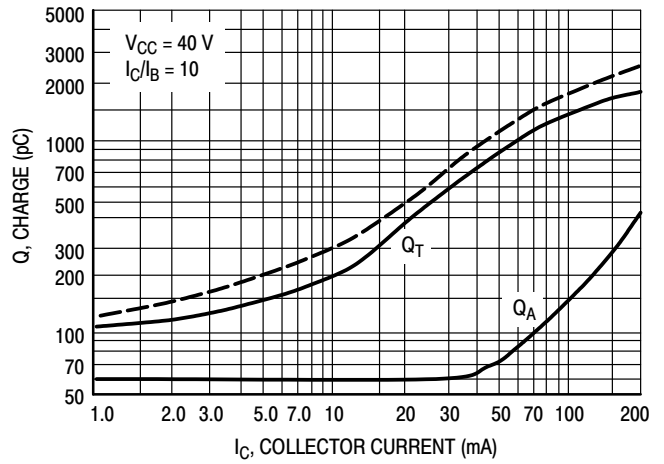


Figure 4. Charge Data

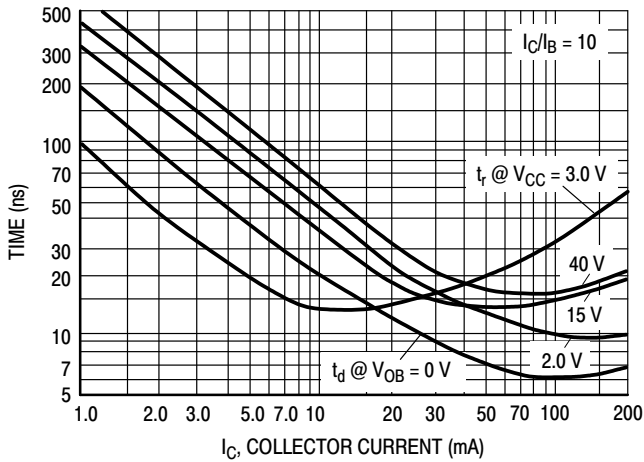


Figure 5. Turn-On Time

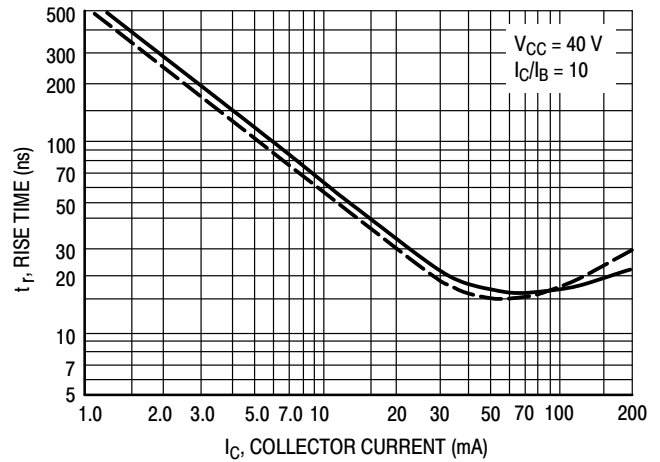


Figure 6. Rise Time

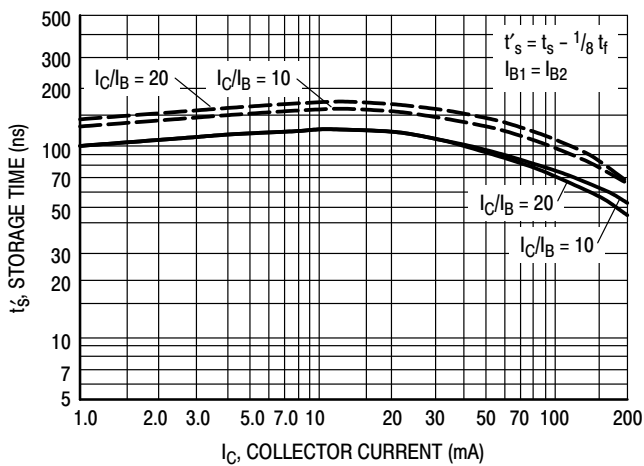


Figure 7. Storage Time

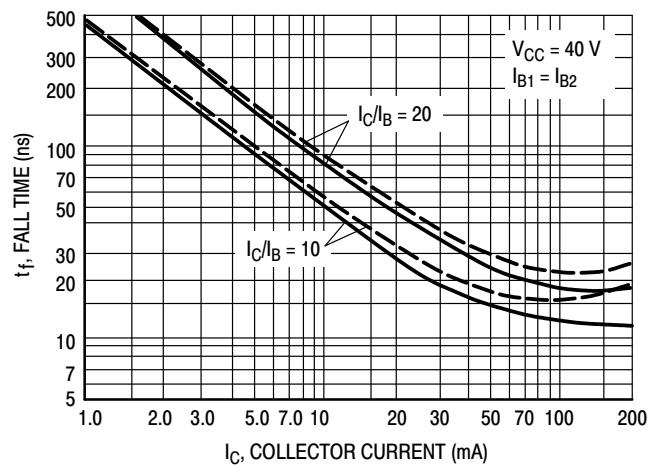


Figure 8. Fall Time

# 2N3903, 2N3904

## TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

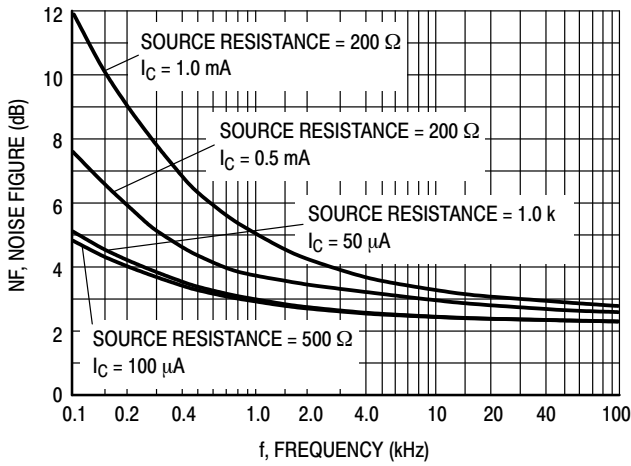


Figure 9.

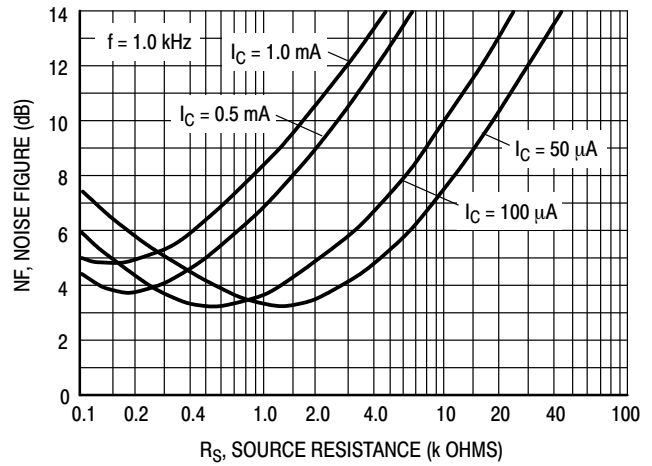


Figure 10.

## h PARAMETERS

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

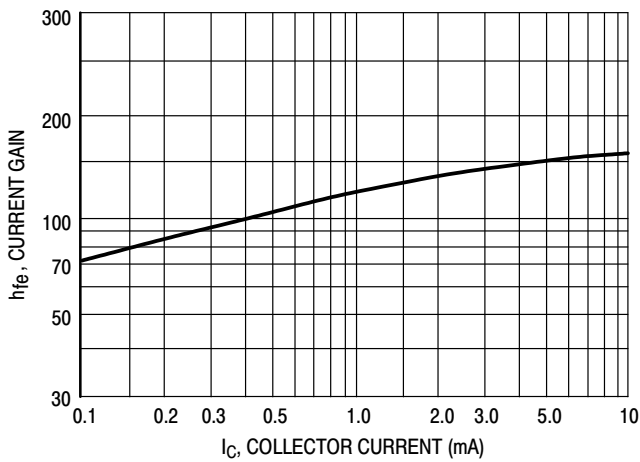


Figure 11. Current Gain

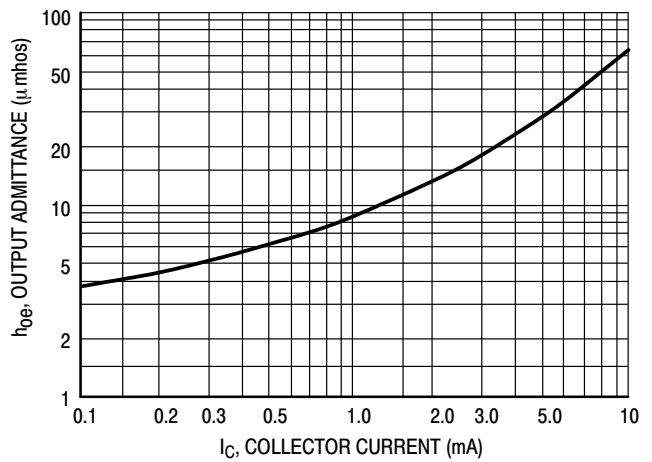


Figure 12. Output Admittance

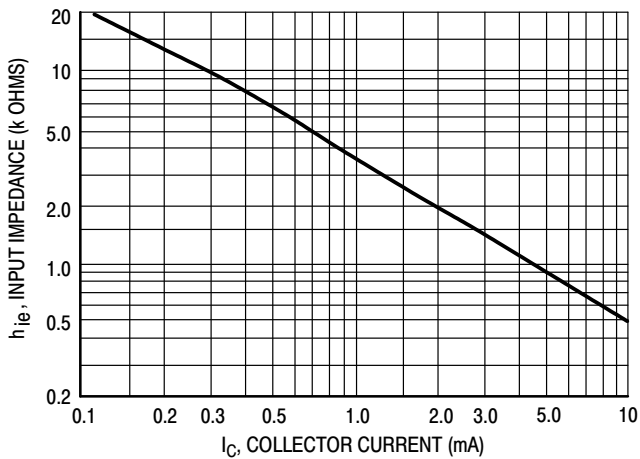


Figure 13. Input Impedance

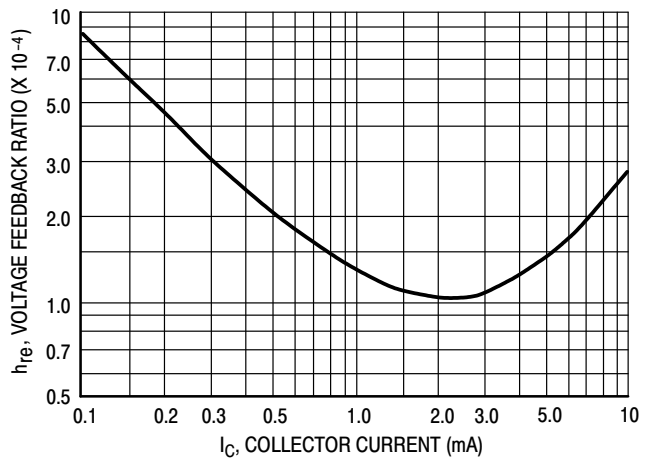


Figure 14. Voltage Feedback Ratio

TYPICAL STATIC CHARACTERISTICS

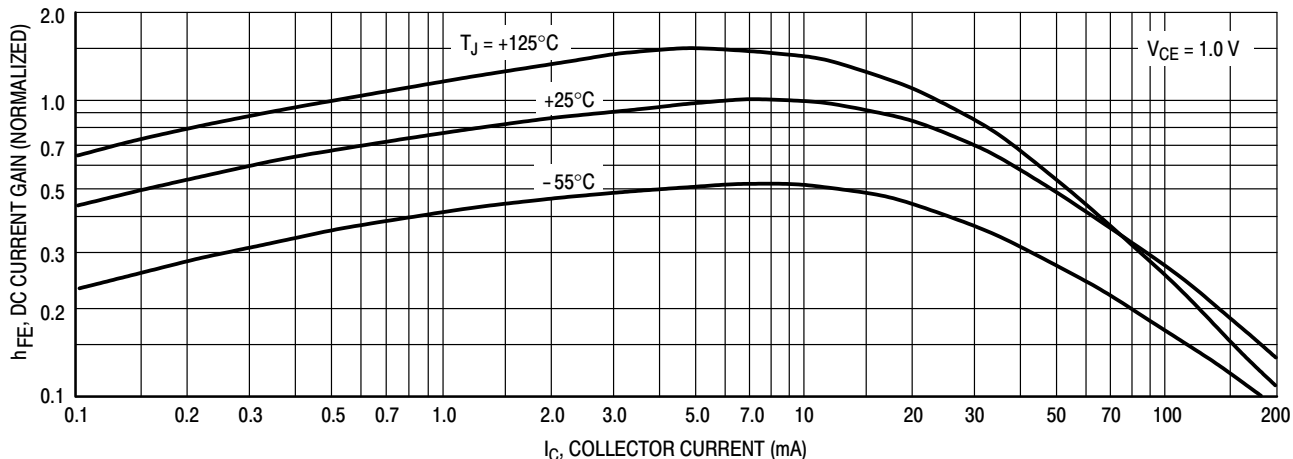


Figure 15. DC Current Gain

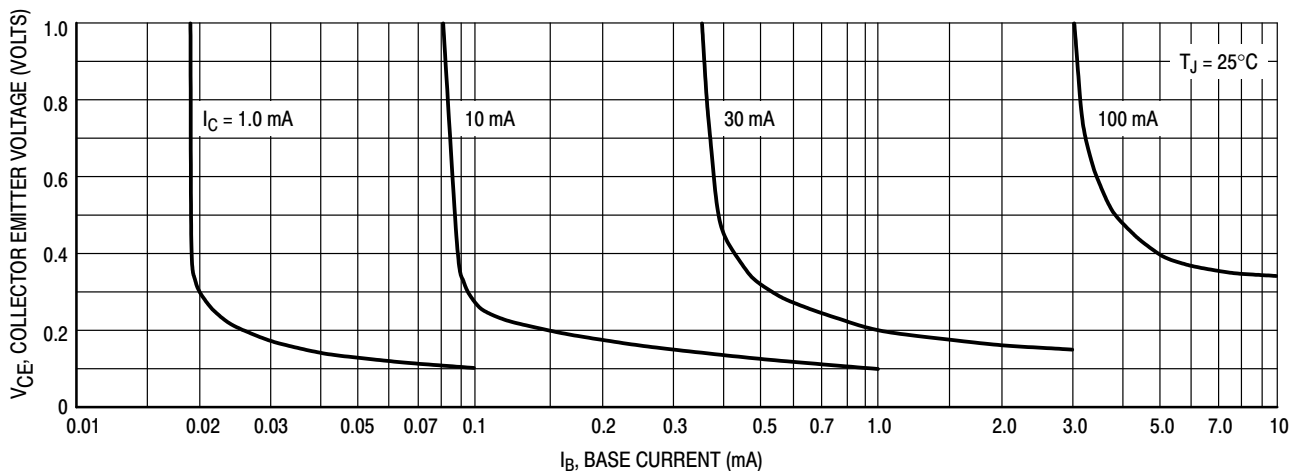


Figure 16. Collector Saturation Region

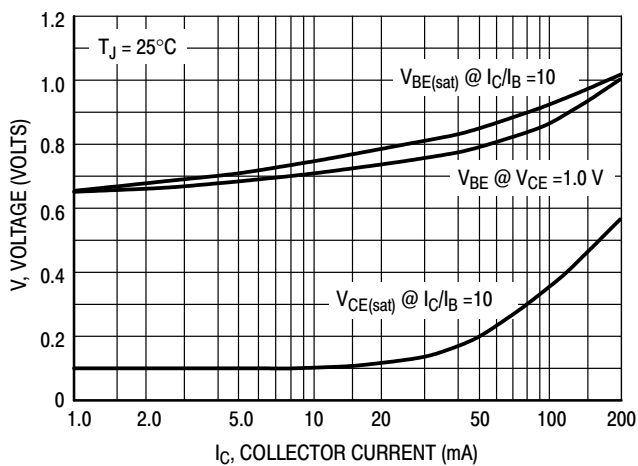


Figure 17. "ON" Voltages

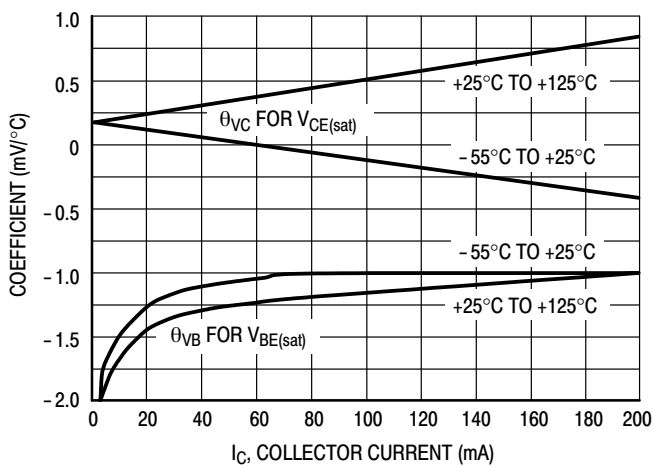


Figure 18. Temperature Coefficients

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®



SCALE 1:1



TO-92 (TO-226)  
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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| DESCRIPTION:     | TO-92 (TO-226)            | PAGE 1 OF 3  |

**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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| <b>DESCRIPTION:</b>     | <b>TO-92 (TO-226)</b>            | <b>PAGE 2 OF 3</b>   |





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