

# 2N3903, 2N3904

2N3903 is a Preferred Device

## General Purpose Transistors

### NPN Silicon

#### Features

- Pb-Free Packages are Available\*

#### MAXIMUM RATINGS

| Rating  | Symbol         | Value       | Unit                       |
|---|----------------|-------------|----------------------------|
| Collector-Emmitter 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<br>Temperature Range                                       | $T_J, T_{stg}$ | -55 to +150 | $^\circ\text{C}$           |

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

#### THERMAL CHARACTERISTICS (Note 1)

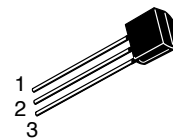
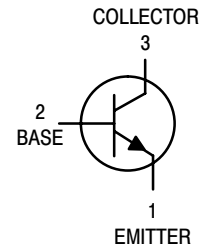
| Characteristic                             | Symbol          | Max  | Unit                      |
|--|-----------------|------|---------------------------|
| Thermal Resistance,<br>Junction-to-Ambient | $R_{\theta JA}$ | 200  | $^\circ\text{C}/\text{W}$ |
| Thermal Resistance,<br>Junction-to-Case 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

1. Indicates Data in addition to JEDEC Requirements.



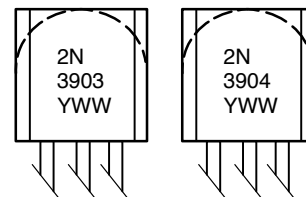
ON Semiconductor®

<http://onsemi.com>



TO-92  
CASE 29  
STYLE 1

#### MARKING DIAGRAMS



Y = Year  
WW = Work Week

#### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 3 of this data sheet.

Preferred devices are recommended choices for future use and best overall value.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor 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 mA <sub>dc</sub> , I <sub>B</sub> = 0) | V <sub>(BR)CEO</sub> | 40  | –   | Vdc              |
| Collector–Base Breakdown Voltage (I <sub>C</sub> = 10 μA <sub>dc</sub> , I <sub>E</sub> = 0)              | V <sub>(BR)CBO</sub> | 60  | –   | Vdc              |
| Emitter–Base Breakdown Voltage (I <sub>E</sub> = 10 μA <sub>dc</sub> , 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  | nA <sub>dc</sub> |
| Collector Cutoff Current (V <sub>CE</sub> = 30 Vdc, V <sub>EB</sub> = 3.0 Vdc)                            | I <sub>CEX</sub>     | –   | 50  | nA <sub>dc</sub> |

### ON CHARACTERISTICS

|   |                      |                 |      |     |   |
|---|----------------------|-----------------|------|-----|---|
| DC Current Gain (Note 2)<br>(I <sub>C</sub> = 0.1 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)   | 2N3903               | h <sub>FE</sub> | 20   | –   | – |
|   | 2N3904               |                 | 40   | –   | – |
| (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)   | 2N3903               | 35              | –    | –   |   |
|   | 2N3904               | 70              | –    | –   |   |
| (I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)  | 2N3903               | 50              | 150  | –   |   |
|   | 2N3904               | 100             | 300  | –   |   |
| (I <sub>C</sub> = 50 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)  | 2N3903               | 30              | –    | –   |   |
|   | 2N3904               | 60              | –    | –   |   |
| (I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)   | 2N3903               | 15              | –    | –   |   |
|   | 2N3904               | 30              | –    | –   |   |
| Collector–Emitter Saturation Voltage (Note 2)<br>(I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> )<br>(I <sub>C</sub> = 50 mA <sub>dc</sub> , I <sub>B</sub> = 5.0 mA <sub>dc</sub> ) | V <sub>CE(sat)</sub> | –               | 0.2  | Vdc |   |
|   |                      | –               | 0.3  |     |   |
| Base–Emitter Saturation Voltage (Note 2)<br>(I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> )<br>(I <sub>C</sub> = 50 mA <sub>dc</sub> , I <sub>B</sub> = 5.0 mA <sub>dc</sub> )      | 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 mA <sub>dc</sub> , 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 mA <sub>dc</sub> , 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 mA <sub>dc</sub> , 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 mA <sub>dc</sub> , 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 mA <sub>dc</sub> , 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 μA <sub>dc</sub> , 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 mA <sub>dc</sub> , I <sub>B1</sub> = 1.0 mA <sub>dc</sub> ) | 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 mA <sub>dc</sub> ,<br>I <sub>B1</sub> = I <sub>B2</sub> = 1.0 mA <sub>dc</sub> )          | 2N3903         | – | 175 | ns |
|              |   | 2N3904         | – | 200 | ns |
| Fall Time    |   | t <sub>f</sub> | – | 50  | ns |

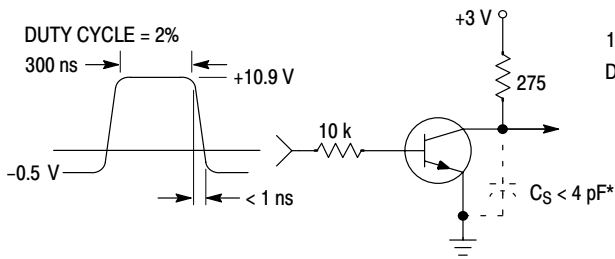
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

# 2N3903, 2N3904

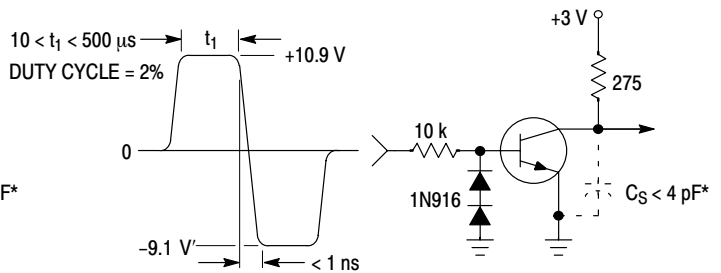
## ORDERING INFORMATION

| Device      | Package            | Shipping†           |
|-------------|--------------------|---------------------|
| 2N3903      | TO-92              | 5,000 Units / Box   |
| 2N3903RLRM  | TO-92              | 2,000 / Ammo Pack   |
| 2N3904      | TO-92              | 5,000 Units / Box   |
| 2N3904G     | TO-92<br>(Pb-Free) | 5,000 Units / Box   |
| 2N3904RLRA  | TO-92              | 2,000 / Tape & Reel |
| 2N3904RLRAG | TO-92<br>(Pb-Free) | 2,000 / Tape & Reel |
| 2N3904RLRE  | TO-92              | 2,000 / Tape & Reel |
| 2N3904RLRM  | TO-92              | 2,000 / Ammo Pack   |
| 2N3904RLRMG | TO-92<br>(Pb-Free) | 2,000 / Ammo Pack   |
| 2N3904RLRP  | TO-92              | 2,000 / Ammo Pack   |
| 2N3904RLRPG | TO-92<br>(Pb-Free) | 2,000 / Ammo Pack   |
| 2N3904RL1   | TO-92              | 2,000 / Tape & Reel |
| 2N3904ZL1   | TO-92              | 2,000 / 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.



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



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

\* Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

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

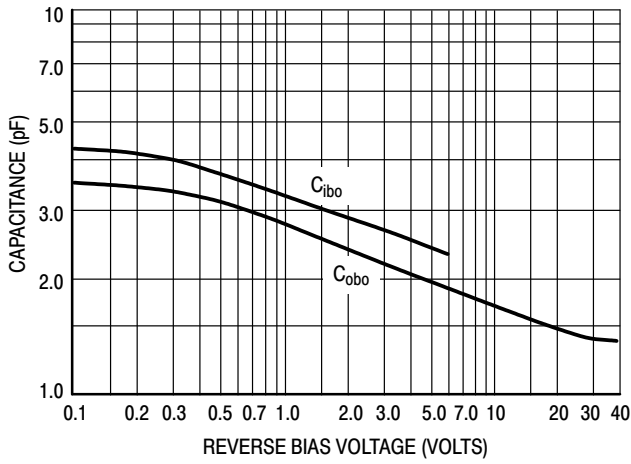


Figure 3. Capacitance

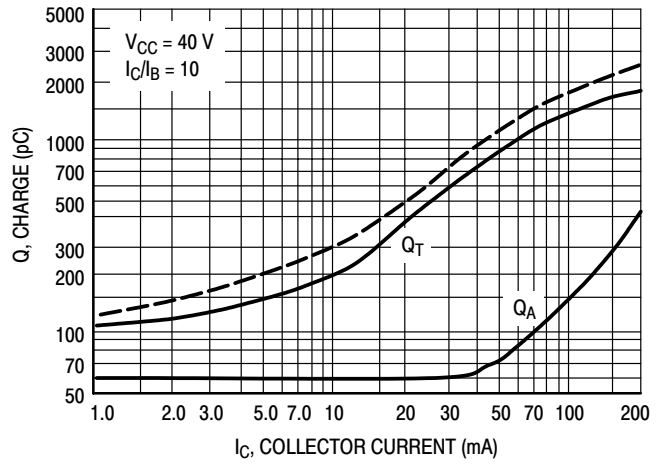


Figure 4. Charge Data

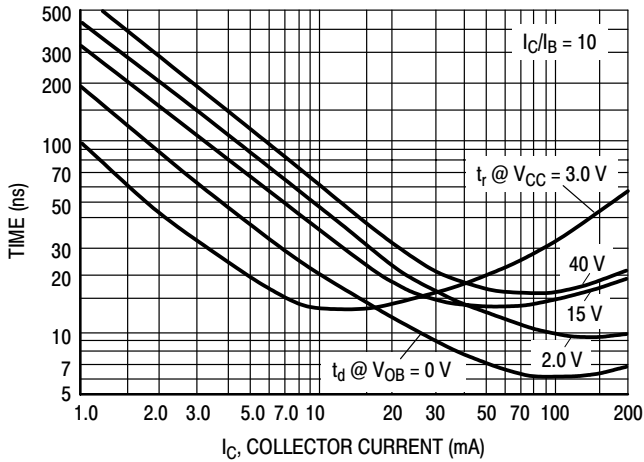


Figure 5. Turn-On Time

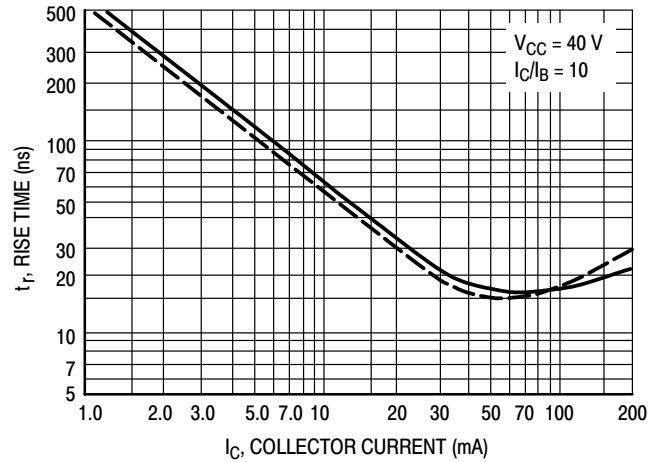


Figure 6. Rise Time

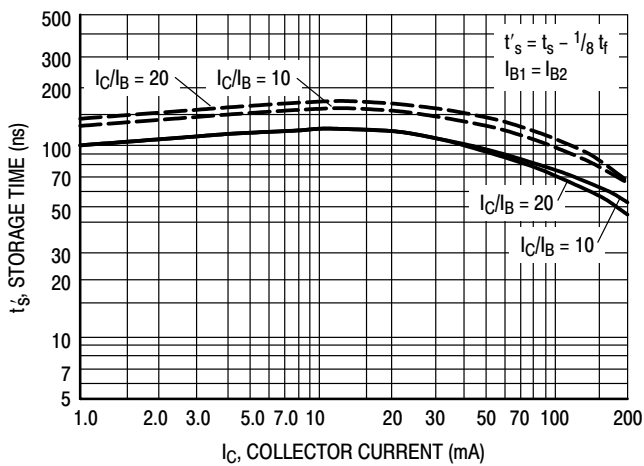


Figure 7. Storage Time

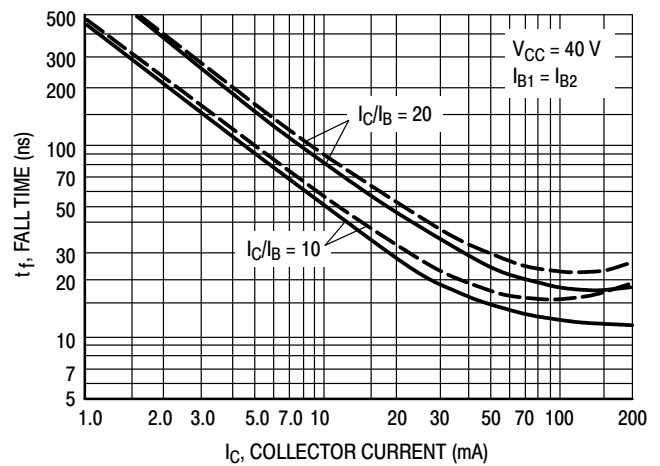


Figure 8. Fall Time

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## TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

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

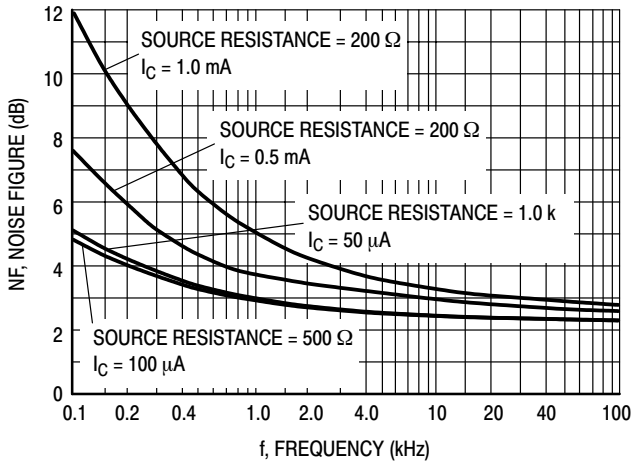


Figure 9.

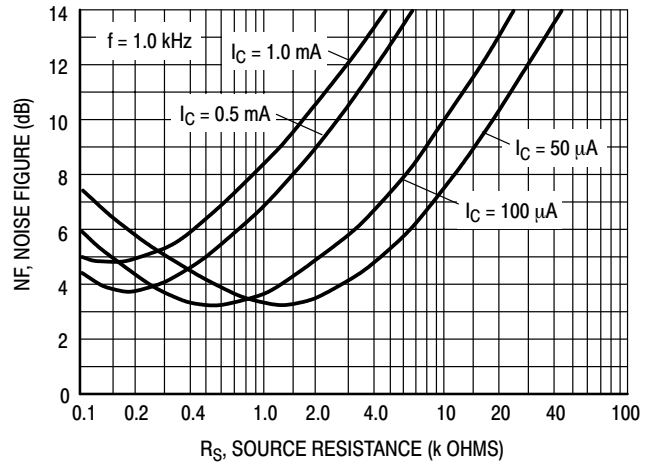


Figure 10.

## h PARAMETERS

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

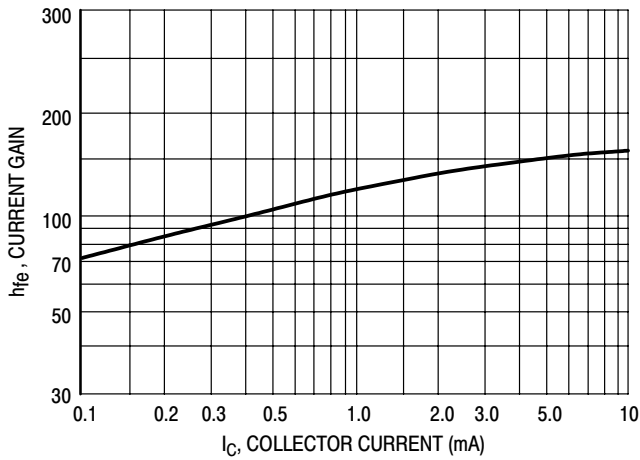


Figure 11. Current Gain

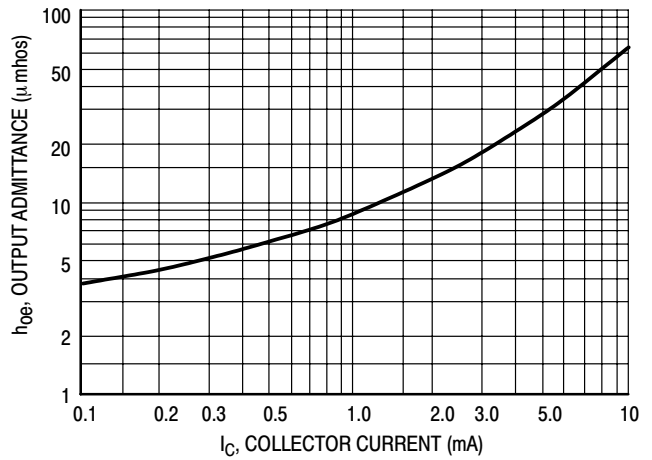


Figure 12. Output Admittance

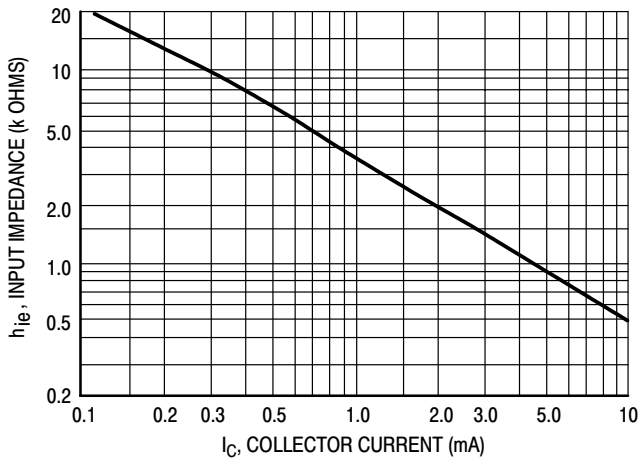


Figure 13. Input Impedance

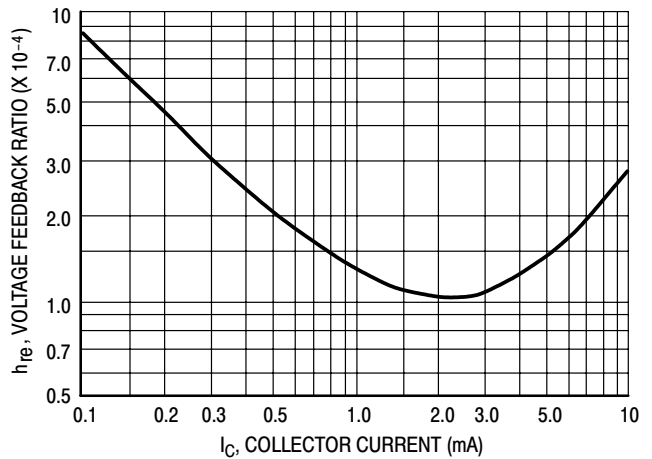


Figure 14. Voltage Feedback Ratio

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## TYPICAL STATIC CHARACTERISTICS

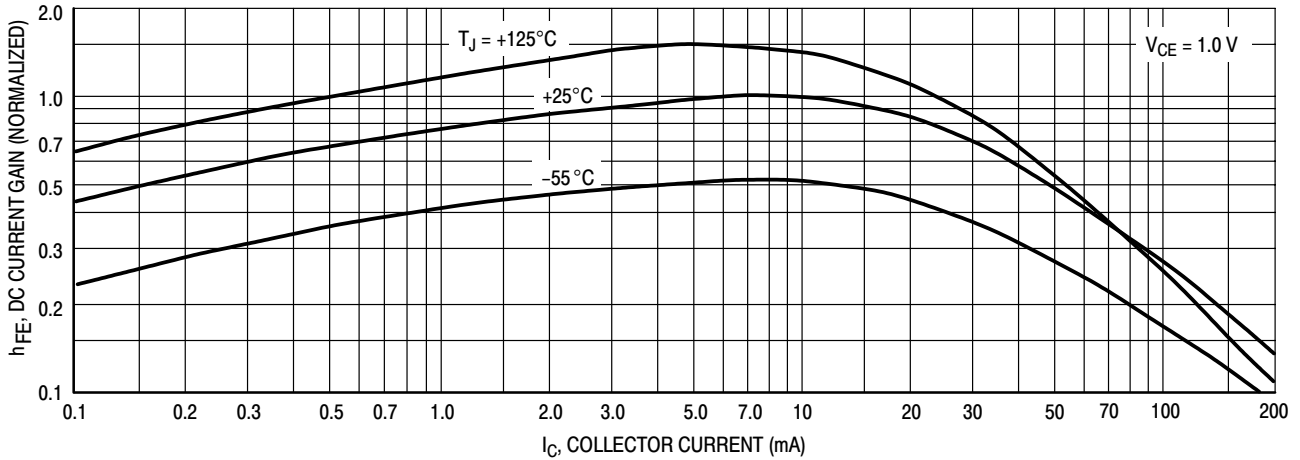


Figure 15. DC Current Gain

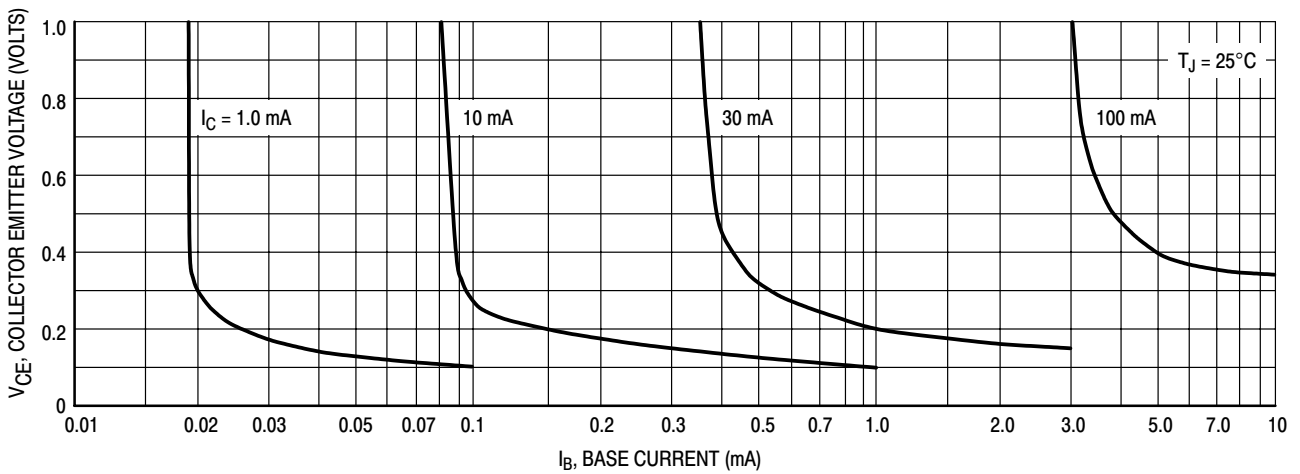


Figure 16. Collector Saturation Region

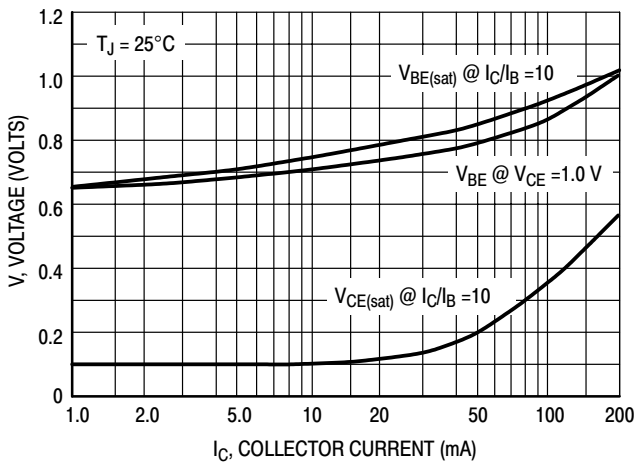


Figure 17. "ON" Voltages

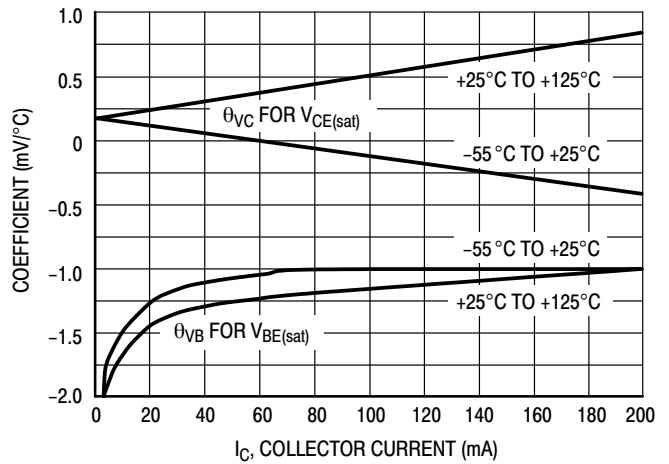
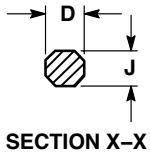
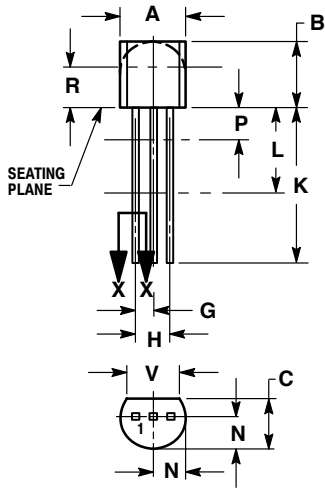


Figure 18. Temperature Coefficients

# 2N3903, 2N3904

## PACKAGE DIMENSIONS

TO-92  
TO-226AA  
CASE 29-11  
ISSUE AL



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        | ---   |

STYLE 1:

- PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 14:

- PIN 1. EMITTER
2. COLLECTOR
3. BASE

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