

# 2N3903, 2N3904

2N3903 is a Preferred Device

## General Purpose Transistors

### NPN Silicon

#### Features

- Pb-Free Package May be Available. The G-Suffix Denotes a Pb-Free Lead Finish

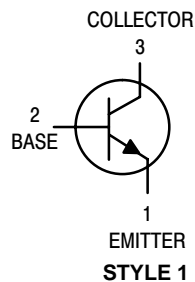
#### MAXIMUM RATINGS

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

#### THERMAL CHARACTERISTICS (Note 1)

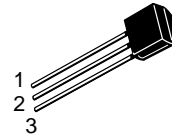
| Characteristic                             | Symbol          | Max  | Unit                      |
|--------------------------------------------|-----------------|------|---------------------------|
| Thermal Resistance,<br>Junction-to-Ambient | $R_{\theta JA}$ | 200  | $^\circ\text{C}/\text{W}$ |
|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

1. Indicates Data in addition to JEDEC Requirements.



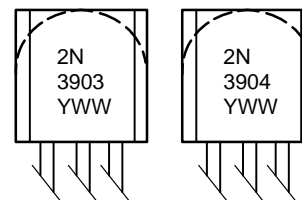
ON Semiconductor®

<http://onsemi.com>



TO-92  
CASE 29  
STYLE 1

#### MARKING DIAGRAMS



#### ORDERING INFORMATION

| Device      | Package | Shipping†        |
|-------------|---------|------------------|
| 2N3903      | TO-92   | 5000 Units/Box   |
| 2N3903RLRM  | TO-92   | 2000/Ammo Pack   |
| 2N3904      | TO-92   | 5000 Units/Box   |
| 2N3904RLRA  | TO-92   | 2000/Tape & Reel |
| 2N3904RLRE  | TO-92   | 2000/Tape & Reel |
| 2N3904RLRM  | TO-92   | 2000/Ammo Pack   |
| 2N3904RLRMG | TO-92   | 2000/Ammo Pack   |
| 2N3904RLRP  | TO-92   | 2000/Ammo Pack   |
| 2N3904RL1   | TO-92   | 2000/Tape & Reel |
| 2N3904ZL1   | TO-92   | 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.

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

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

## 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)                                                        | 2N3903<br>2N3904 | h <sub>FE</sub>      | 20   | –    | –   |
| (I <sub>C</sub> = 0.1 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)             |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 40   | –    |     |
| (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)             |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 35   | –    |     |
| (I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)              |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 70   | –    |     |
| (I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)              |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 50   | 150  |     |
| (I <sub>C</sub> = 50 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)              |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 100  | 300  |     |
| (I <sub>C</sub> = 50 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)              |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 30   | –    |     |
| (I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)             |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 60   | –    |     |
| (I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)             |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 15   | –    |     |
| (I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)             |                  |                      |      |      |     |
|                                                                                 | 2N3903<br>2N3904 |                      | 30   | –    |     |
| (I <sub>C</sub> = 100 mA <sub>dc</sub> , V <sub>CE</sub> = 1.0 Vdc)             |                  |                      |      |      |     |
| Collector–Emitter Saturation Voltage (Note 2)                                   |                  | V <sub>CE(sat)</sub> | –    | 0.2  | Vdc |
| (I <sub>C</sub> = 10 mA <sub>dc</sub> , I <sub>B</sub> = 1.0 mA <sub>dc</sub> ) |                  |                      |      |      |     |
|                                                                                 |                  |                      | –    | 0.3  |     |
|                                                                                 |                  |                      | 0.65 | 0.85 |     |
|                                                                                 |                  |                      | –    | 0.95 |     |

### SMALL–SIGNAL CHARACTERISTICS

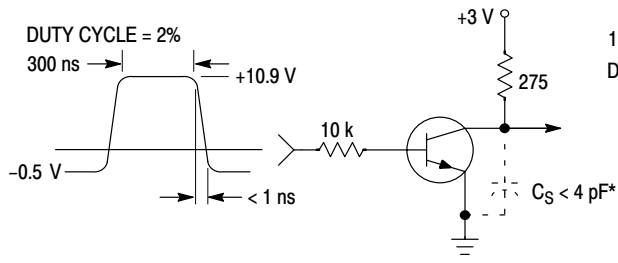
|                                                                                                            |                  |                  |     |     |                    |
|------------------------------------------------------------------------------------------------------------|------------------|------------------|-----|-----|--------------------|
| Current–Gain – Bandwidth Product                                                                           | 2N3903<br>2N3904 | f <sub>T</sub>   | 250 | –   | MHz                |
| (I <sub>C</sub> = 10 mA <sub>dc</sub> , V <sub>CE</sub> = 20 Vdc, f = 100 MHz)                             |                  |                  |     |     |                    |
|                                                                                                            |                  |                  | 300 | –   |                    |
| 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                                                                                            | 2N3903<br>2N3904 | h <sub>ie</sub>  | 1.0 | 8.0 | k Ω                |
| (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)                            |                  |                  |     |     |                    |
|                                                                                                            |                  |                  | 1.0 | 10  |                    |
| Voltage Feedback Ratio                                                                                     | 2N3903<br>2N3904 | h <sub>re</sub>  | 0.1 | 5.0 | X 10 <sup>–4</sup> |
| (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)                            |                  |                  |     |     |                    |
|                                                                                                            |                  |                  | 0.5 | 8.0 |                    |
| Small–Signal Current Gain                                                                                  | 2N3903<br>2N3904 | h <sub>fe</sub>  | 50  | 200 | –                  |
| (I <sub>C</sub> = 1.0 mA <sub>dc</sub> , V <sub>CE</sub> = 10 Vdc, f = 1.0 kHz)                            |                  |                  |     |     |                    |
|                                                                                                            |                  |                  | 100 | 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                                                                                               | 2N3903<br>2N3904 | NF               | –   | 6.0 | dB                 |
| (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) |                  |                  |     |     |                    |
|                                                                                                            |                  |                  | –   | 5.0 |                    |

### SWITCHING CHARACTERISTICS

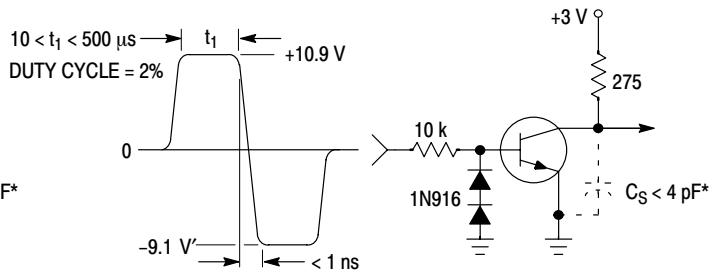
|              |                                                                                                                                           |                  |                |   |     |    |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------|----------------|---|-----|----|
| 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<br>2N3904 | t <sub>s</sub> | – | 175 | ns |
| Fall Time    |                                                                                                                                           |                  |                | – | 200 | ns |
|              |                                                                                                                                           |                  | t <sub>f</sub> | – | 50  | ns |

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

## 2N3903, 2N3904



**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

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

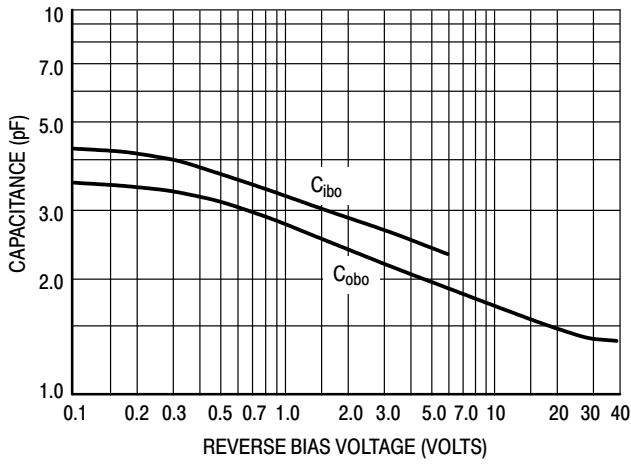


Figure 3. Capacitance

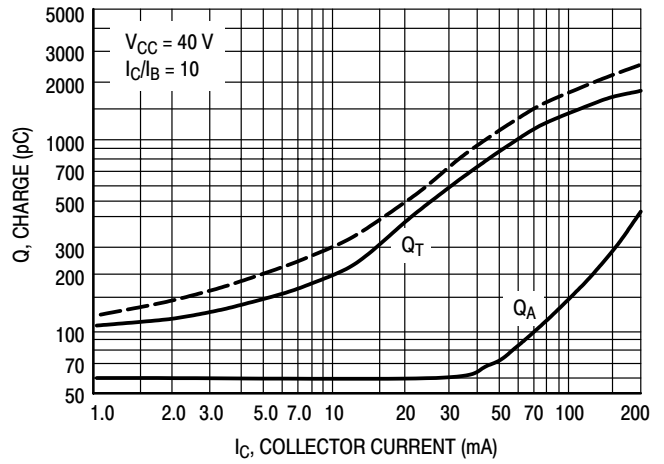


Figure 4. Charge Data

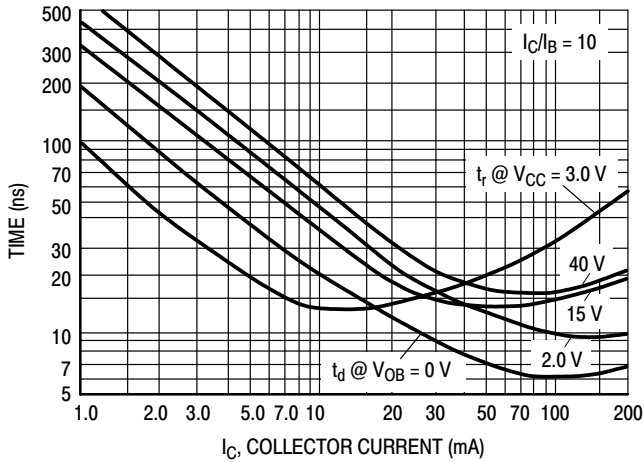


Figure 5. Turn-On Time

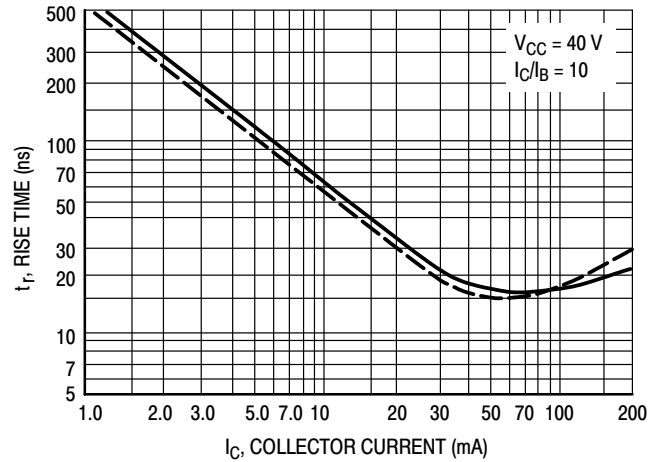


Figure 6. Rise Time

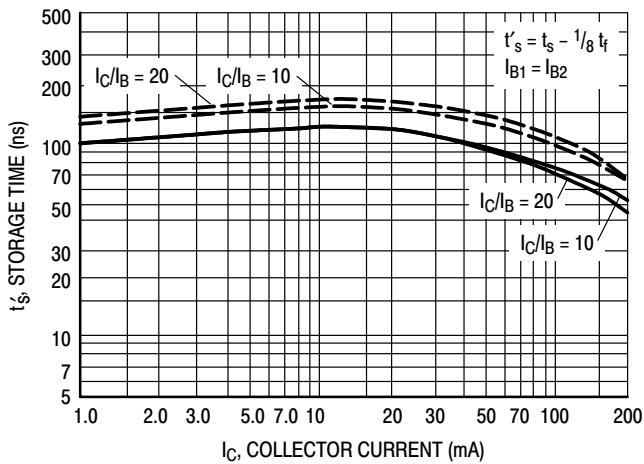


Figure 7. Storage Time

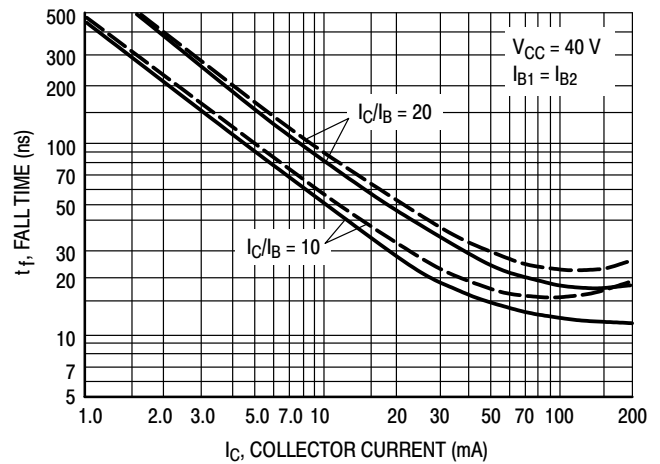


Figure 8. Fall Time

# 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)

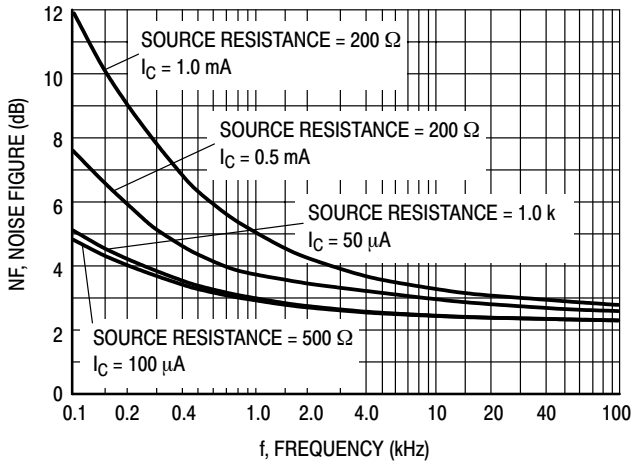


Figure 9.

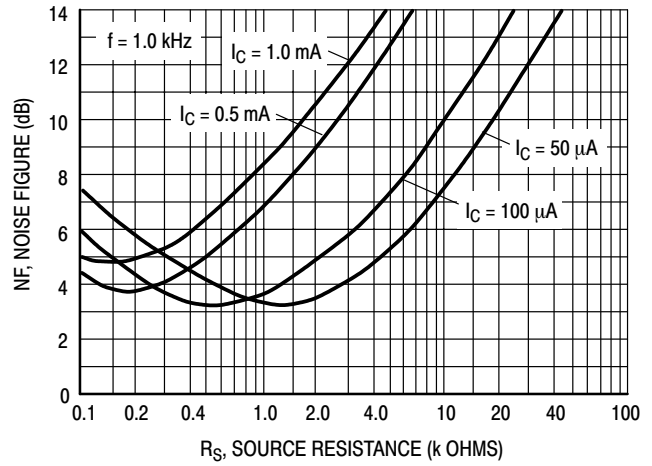


Figure 10.

## h PARAMETERS

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

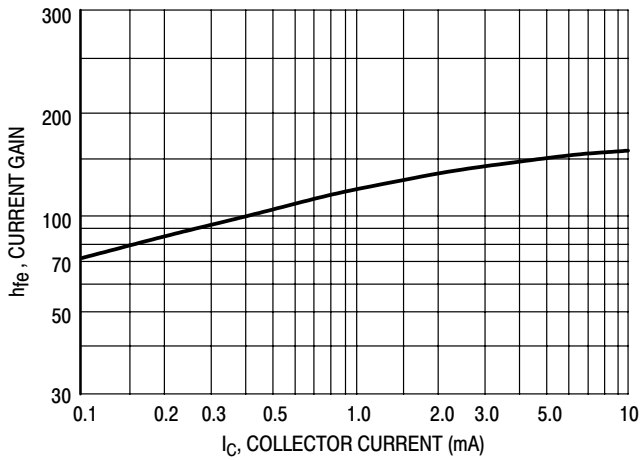


Figure 11. Current Gain

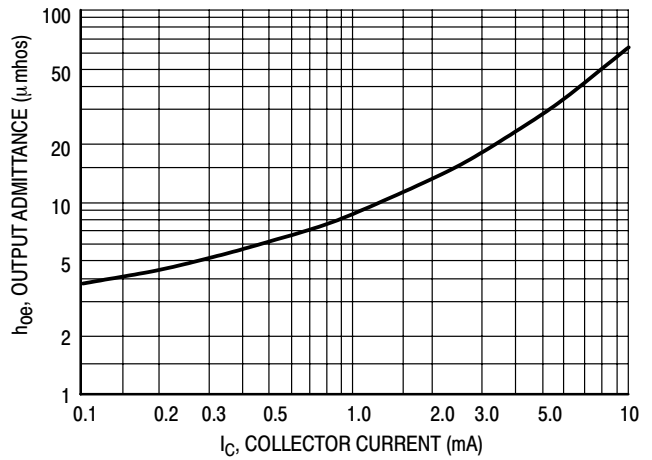


Figure 12. Output Admittance

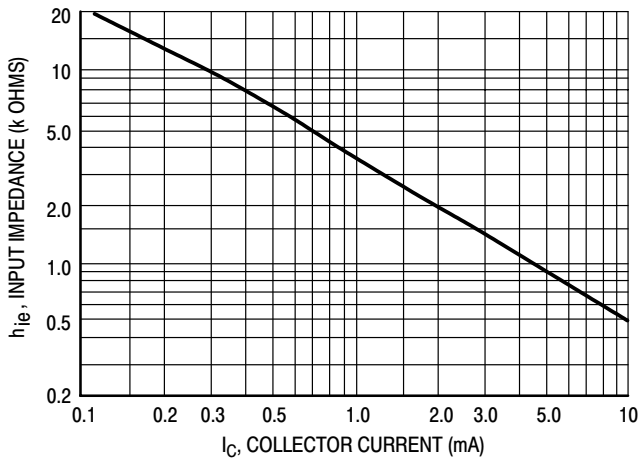


Figure 13. Input Impedance

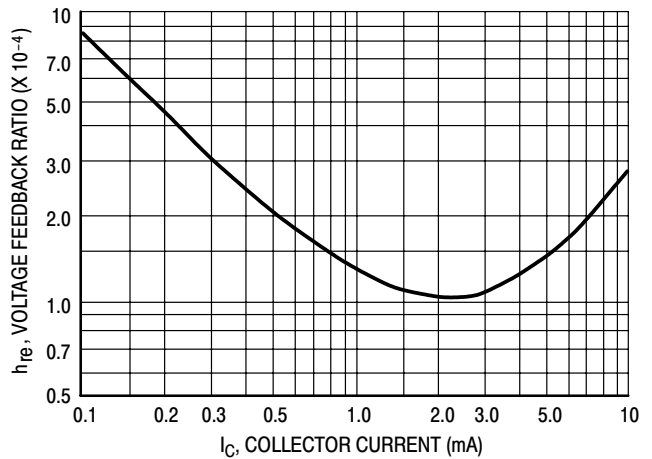


Figure 14. Voltage Feedback Ratio

# 2N3903, 2N3904

## TYPICAL STATIC CHARACTERISTICS

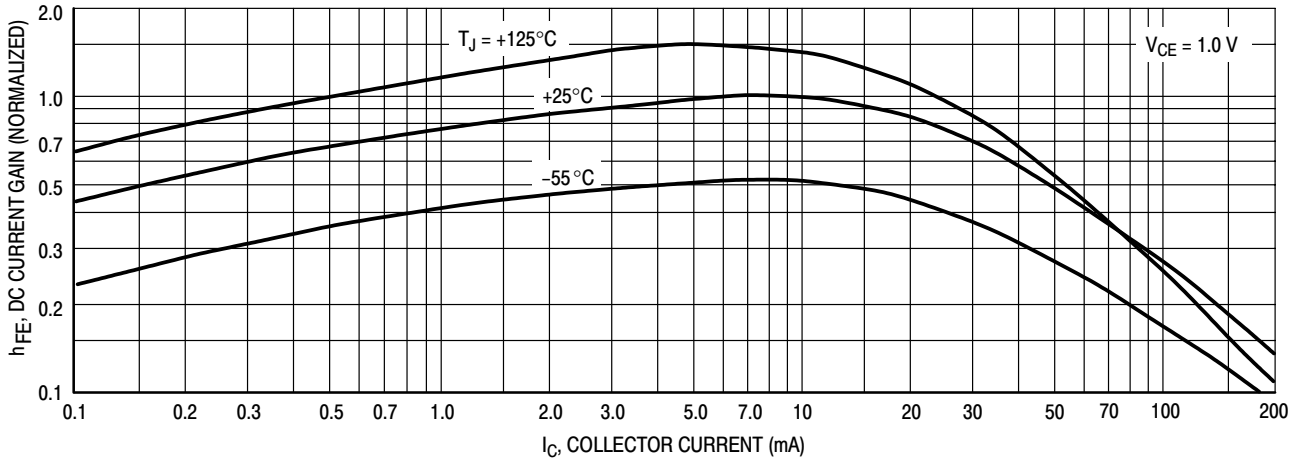


Figure 15. DC Current Gain

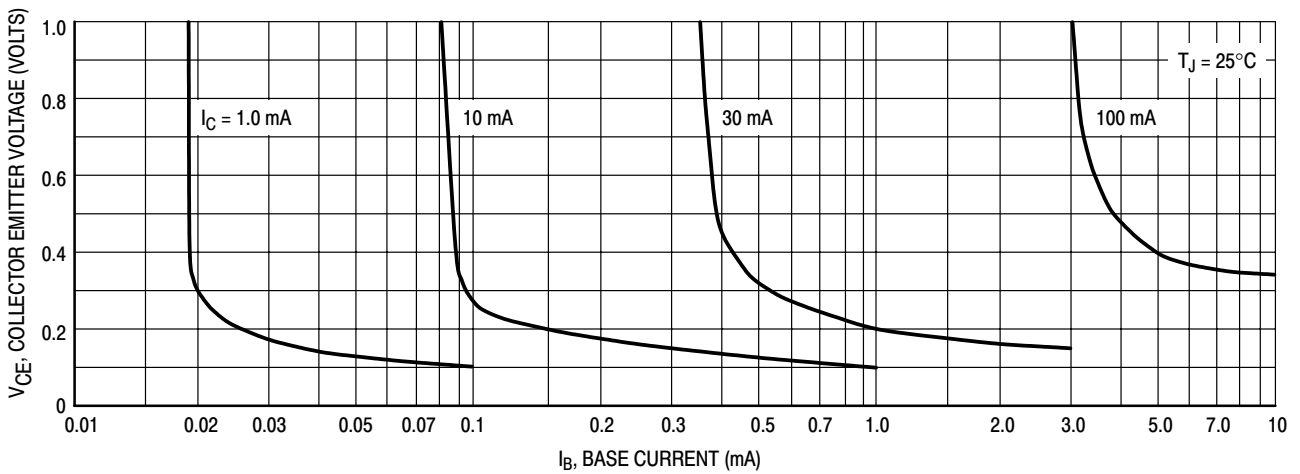


Figure 16. Collector Saturation Region

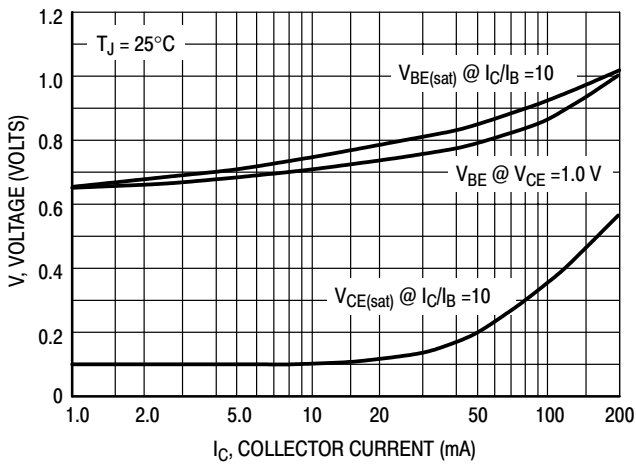


Figure 17. "ON" Voltages

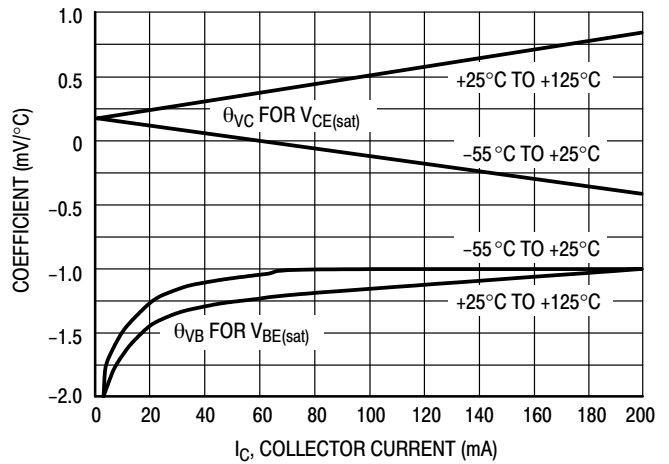
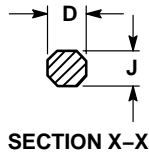
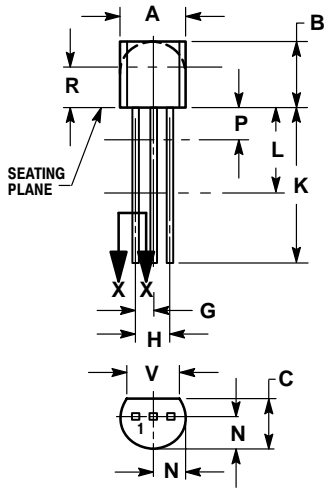


Figure 18. Temperature Coefficients

# 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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