

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 – 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 | mA dc |
| Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C | P_D | 625 5.0 | mW mW/ $^\circ\text{C}$ |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°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 | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction-to-Case | $R_{\theta JC}$ | 83.3 | $^\circ\text{C/W}$ |

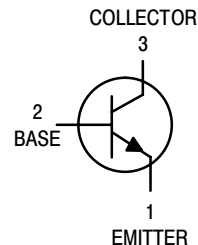
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Indicates Data in addition to JEDEC Requirements.

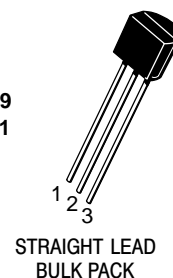


ON Semiconductor®

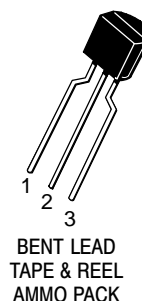
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TO-92
CASE 29
STYLE 1

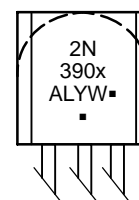


STRAIGHT LEAD
BULK PACK



BENT LEAD
TAPE & REEL
AMMO PACK

MARKING DIAGRAMS



- x = 3 or 4
- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = 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.

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.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Max | Unit |
|----------------|--------|-----|-----|------|
|----------------|--------|-----|-----|------|

OFF CHARACTERISTICS

| | | | | |
|---|----------------------|-----|----|------------------|
| Collector–Emitter Breakdown Voltage (Note 2) (I _C = 1.0 mA _{dc} , I _B = 0) | V _{(BR)CEO} | 40 | – | V _{dc} |
| Collector–Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0) | V _{(BR)CBO} | 60 | – | V _{dc} |
| Emitter–Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0) | V _{(BR)EBO} | 6.0 | – | V _{dc} |
| Base Cutoff Current (V _{CE} = 30 V _{dc} , V _{EB} = 3.0 V _{dc}) | I _{BL} | – | 50 | nA _{dc} |
| Collector Cutoff Current (V _{CE} = 30 V _{dc} , V _{EB} = 3.0 V _{dc}) | I _{CEX} | – | 50 | nA _{dc} |

ON CHARACTERISTICS

| | | | | | |
|--|--------|----------------------|------|------|-----------------|
| DC Current Gain (Note 2) (I _C = 0.1 mA _{dc} , V _{CE} = 1.0 V _{dc}) | 2N3903 | h _{FE} | 20 | – | – |
| | 2N3904 | | 40 | – | – |
| (I _C = 1.0 mA _{dc} , V _{CE} = 1.0 V _{dc}) | 2N3903 | | 35 | – | – |
| | 2N3904 | | 70 | – | – |
| (I _C = 10 mA _{dc} , V _{CE} = 1.0 V _{dc}) | 2N3903 | | 50 | 150 | – |
| | 2N3904 | | 100 | 300 | – |
| (I _C = 50 mA _{dc} , V _{CE} = 1.0 V _{dc}) | 2N3903 | | 30 | – | – |
| | 2N3904 | | 60 | – | – |
| (I _C = 100 mA _{dc} , V _{CE} = 1.0 V _{dc}) | 2N3903 | | 15 | – | – |
| | 2N3904 | | 30 | – | – |
| Collector–Emitter Saturation Voltage (Note 2) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) | | V _{CE(sat)} | – | 0.2 | V _{dc} |
| (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc}) | | | – | 0.3 | |
| Base–Emitter Saturation Voltage (Note 2) (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) | | V _{BE(sat)} | 0.65 | 0.85 | V _{dc} |
| (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc}) | | | – | 0.95 | |

SMALL–SIGNAL CHARACTERISTICS

| | | | | | |
|---|------------------|------------------|------------|--------|--------------------|
| Current–Gain – Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 20 V _{dc} , f = 100 MHz) | 2N3903 2N3904 | f _T | 250 300 | – – | MHz |
| Output Capacitance (V _{CB} = 5.0 V _{dc} , I _E = 0, f = 1.0 MHz) | | C _{obo} | – | 4.0 | pF |
| Input Capacitance (V _{EB} = 0.5 V _{dc} , I _C = 0, f = 1.0 MHz) | | C _{ibo} | – | 8.0 | pF |
| Input Impedance (I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz) | 2N3903 2N3904 | h _{ie} | 1.0 | 8.0 | k Ω |
| | | | 1.0 | 10 | |
| Voltage Feedback Ratio (I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz) | 2N3903 2N3904 | h _{re} | 0.1 | 5.0 | X 10 ^{–4} |
| | | | 0.5 | 8.0 | |
| Small–Signal Current Gain (I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz) | 2N3903 2N3904 | h _{fe} | 50 | 200 | – |
| | | | 100 | 400 | |
| Output Admittance (I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz) | | h _{oe} | 1.0 | 40 | μmhos |
| Noise Figure (I _C = 100 μA _{dc} , V _{CE} = 5.0 V _{dc} , R _S = 1.0 k Ω, f = 1.0 kHz) | 2N3903 2N3904 | NF | – | 6.0 | dB |
| | | | – | 5.0 | |

SWITCHING CHARACTERISTICS

| | | | | | |
|--------------|---|----------------|---|------------|----|
| Delay Time | (V _{CC} = 3.0 V _{dc} , V _{BE} = 0.5 V _{dc} , I _C = 10 mA _{dc} , I _{B1} = 1.0 mA _{dc}) | t _d | – | 35 | ns |
| Rise Time | | t _r | – | 35 | ns |
| Storage Time | (V _{CC} = 3.0 V _{dc} , I _C = 10 mA _{dc} , I _{B1} = I _{B2} = 1.0 mA _{dc}) | t _s | – | 175 200 | ns |
| Fall Time | | t _f | – | 50 | ns |

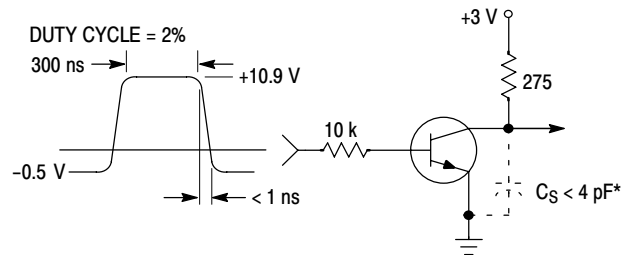
2. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

2N3903, 2N3904

ORDERING INFORMATION

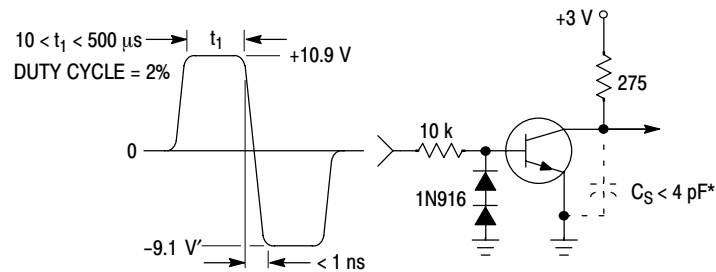
| Device | Package | Shipping [†] |
|-------------|--------------------|-----------------------|
| 2N3903RLRM | TO-92 | 2000 / Ammo Pack |
| 2N3904 | TO-92 | 5000 Units / Bulk |
| 2N3904G | TO-92 (Pb-Free) | 5000 Units / Bulk |
| 2N3904RLRA | TO-92 | 2000 / Tape & Reel |
| 2N3904RLRAG | TO-92 (Pb-Free) | 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 |

[†]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

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

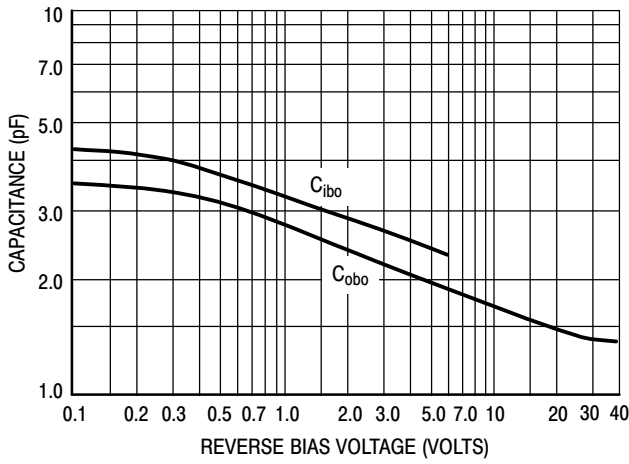


Figure 3. Capacitance

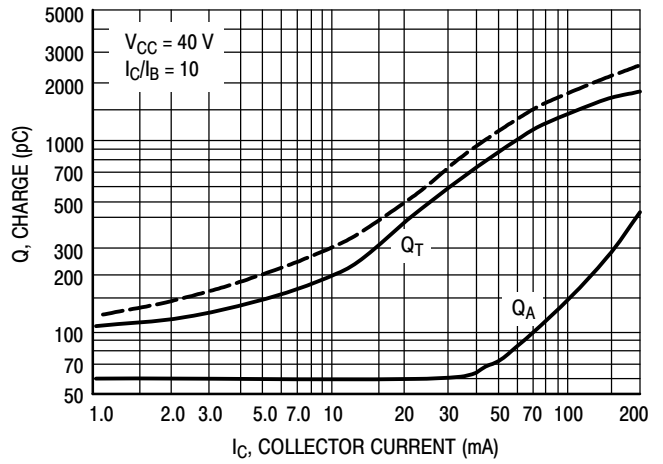


Figure 4. Charge Data

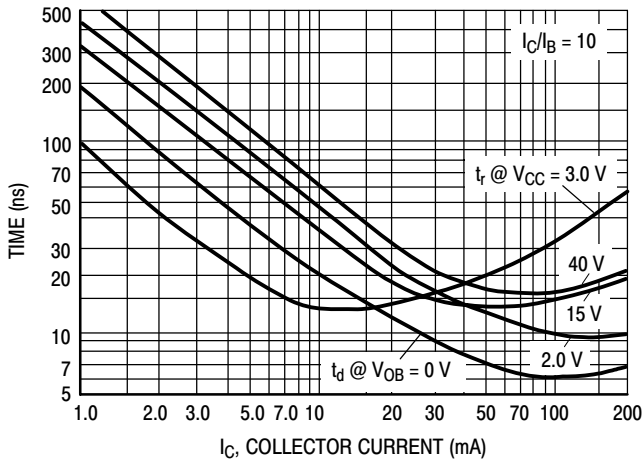


Figure 5. Turn-On Time

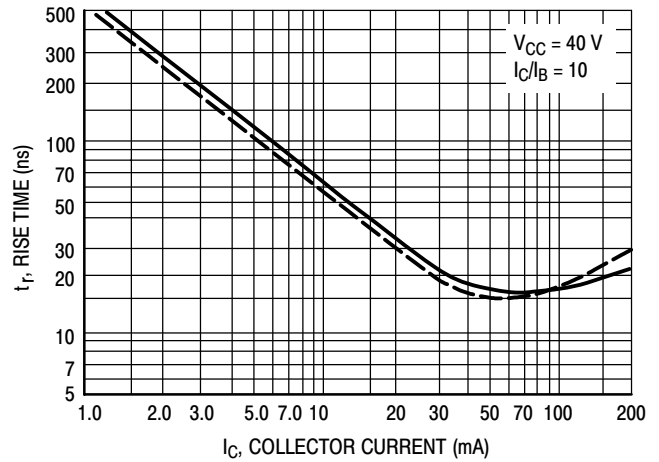


Figure 6. Rise Time

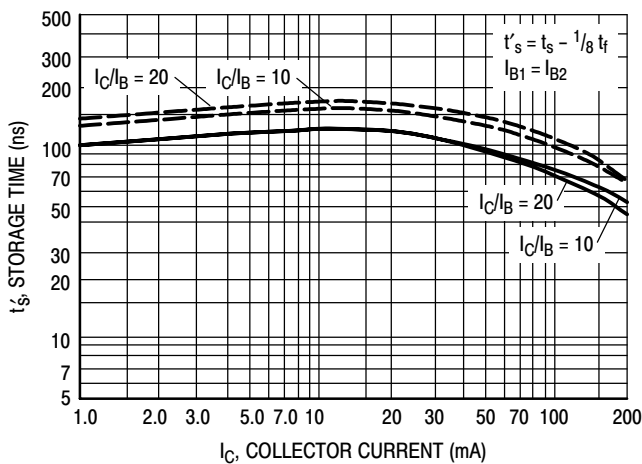


Figure 7. Storage Time

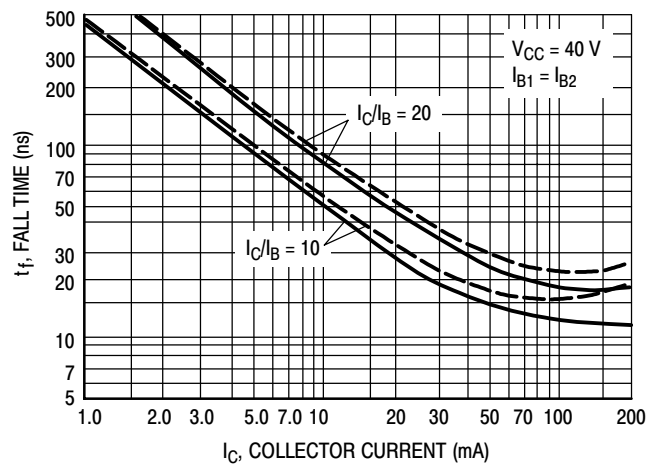


Figure 8. Fall Time

TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

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

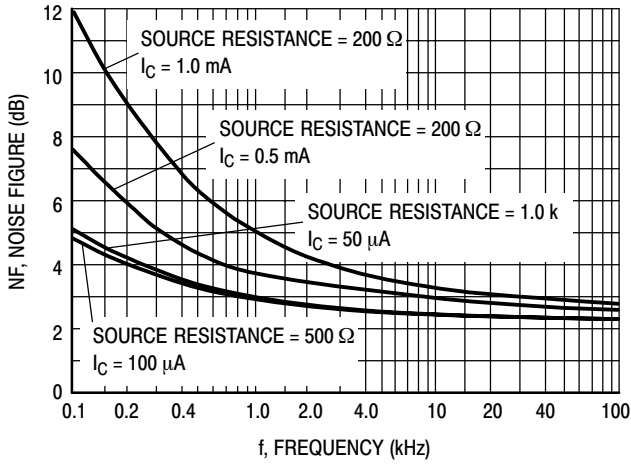


Figure 9.

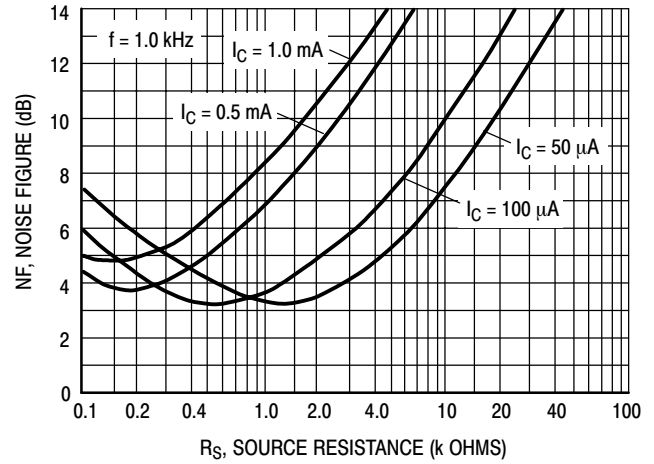


Figure 10.

h PARAMETERS

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

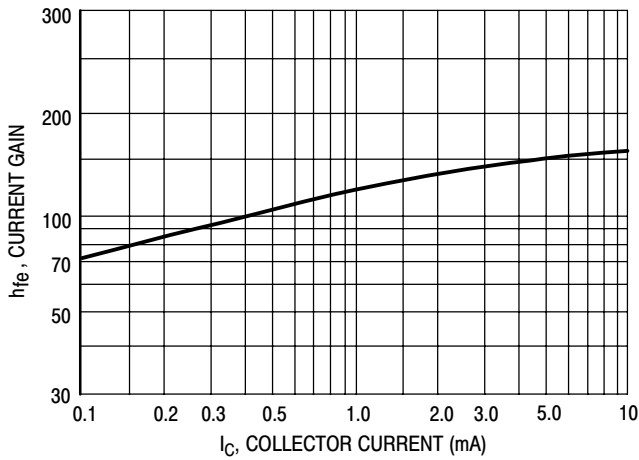


Figure 11. Current Gain

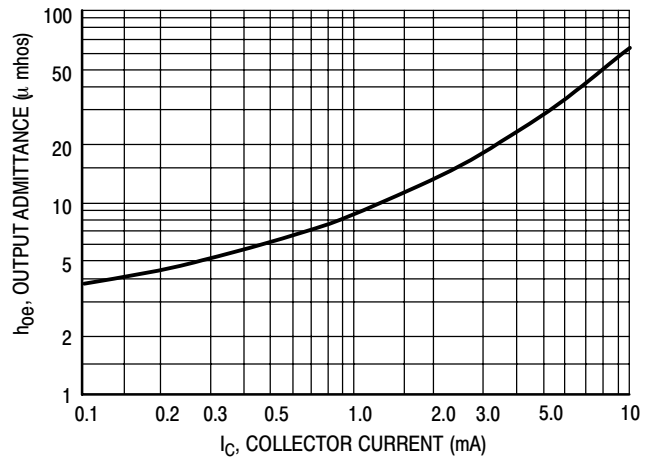


Figure 12. Output Admittance

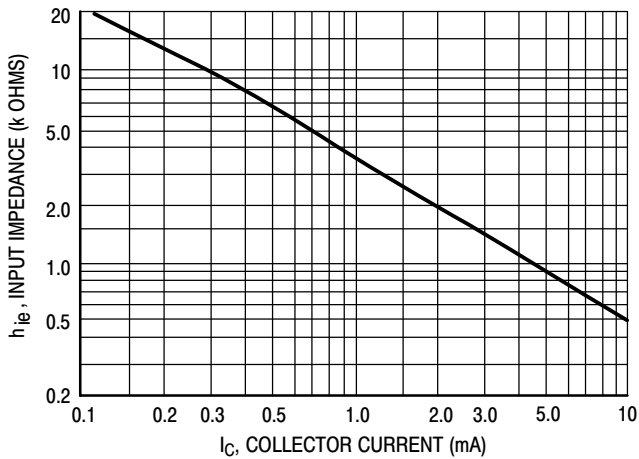


Figure 13. Input Impedance

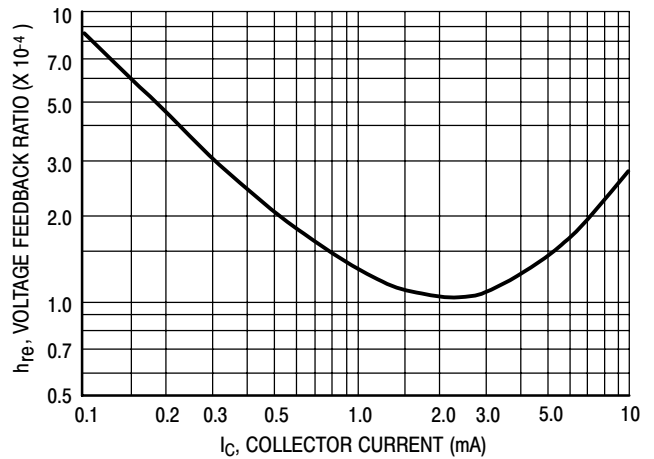


Figure 14. Voltage Feedback Ratio

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TYPICAL STATIC CHARACTERISTICS

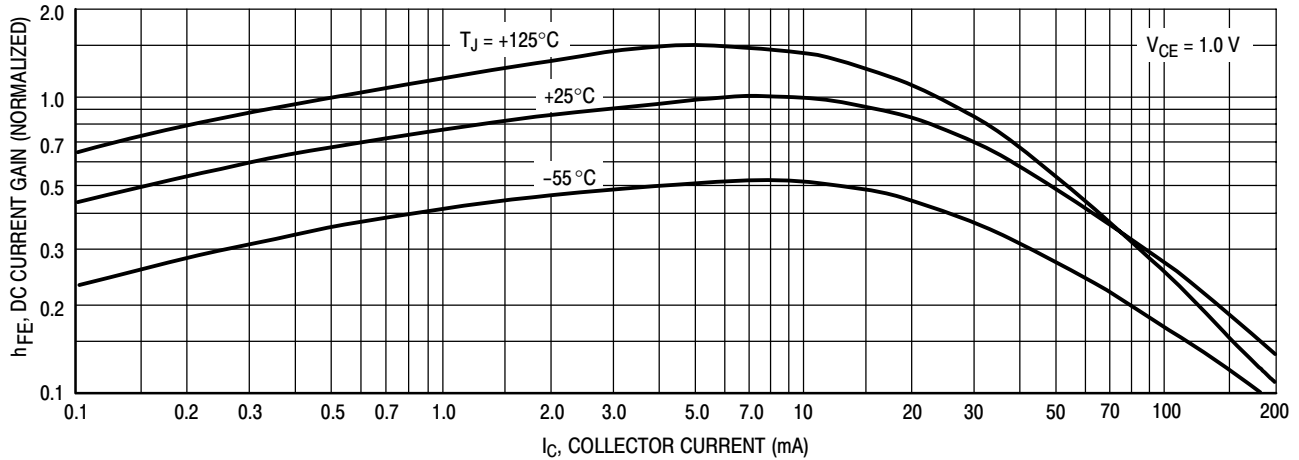


Figure 15. DC Current Gain

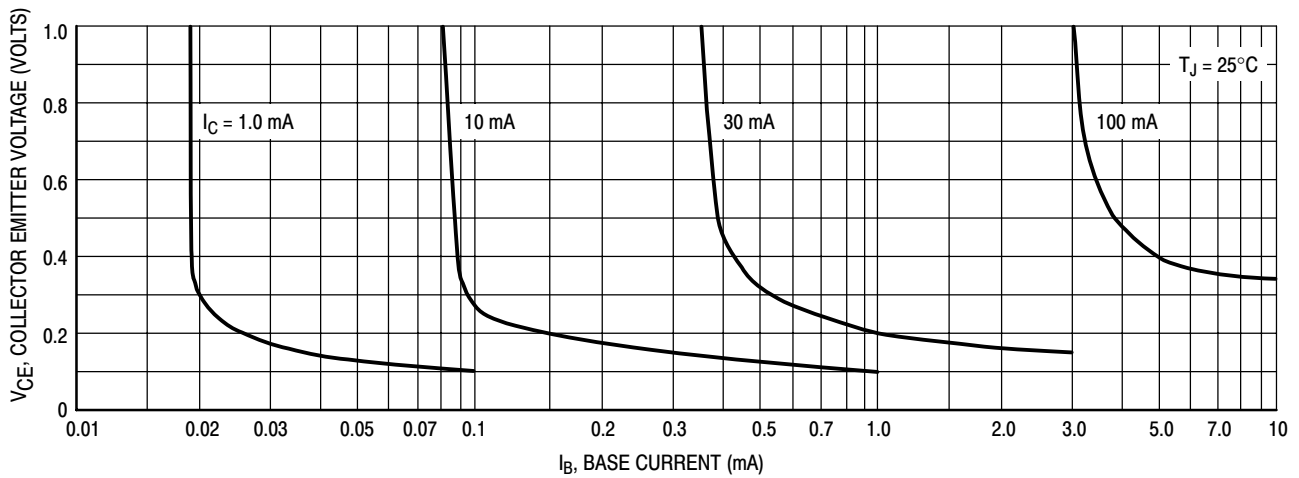


Figure 16. Collector Saturation Region

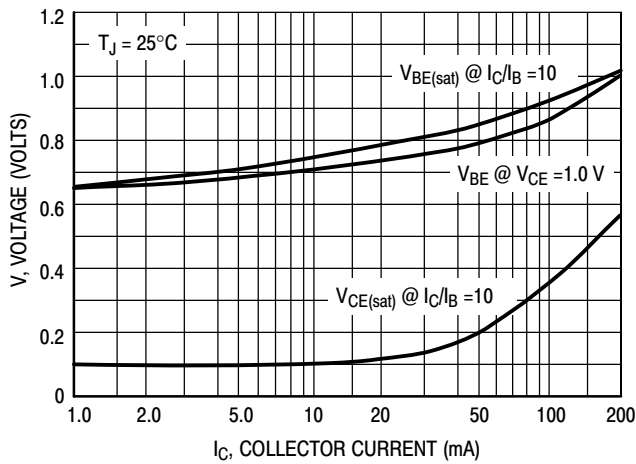


Figure 17. "ON" Voltages

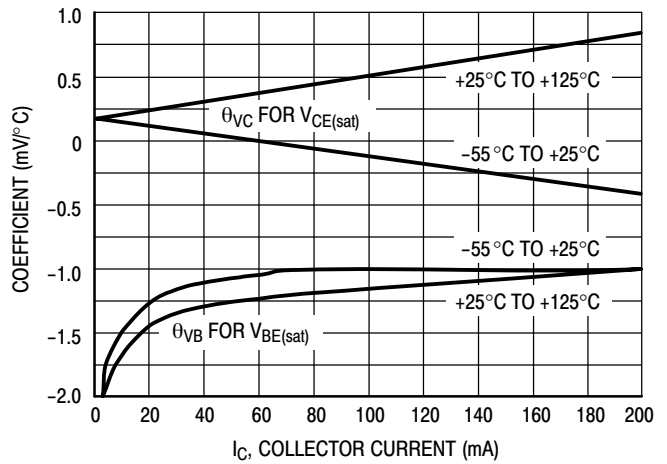
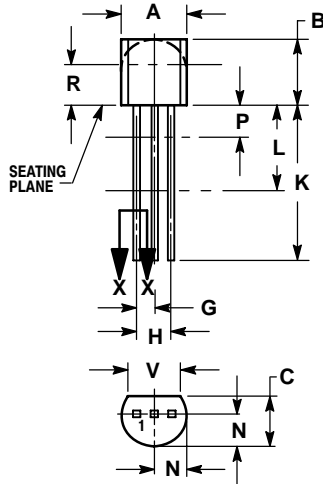


Figure 18. Temperature Coefficients

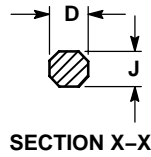
2N3903, 2N3904

PACKAGE DIMENSIONS

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



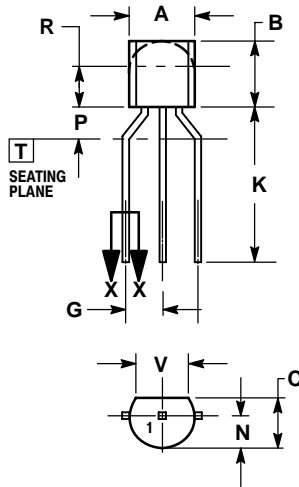
STRAIGHT LEAD
BULK PACK



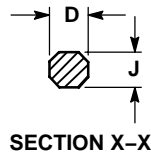
NOTES:

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 | --- |

STYLE 1:

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

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