# NPN General - Purpose Amplifier

# 2N3904

**TO−92 3**
**CASE 135AN**

**TO−92 3**
**LEADFORMED**
**CASE 135AR**

### Description

This device is designed as a general−purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.

### MAXIMUM RATINGS

(Values are at $T_A$ = 25°C unless otherwise noted.) (Note 1, Note 2)

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CEO}$ | Collector − Emitter Voltage | 40 | V |
| $V_{CBO}$ | Collector − Base Voltage | 60 | V |
| $V_{EBO}$ | Emitter − Base Voltage | 6.0 | V |
| $I_C$ | Collector Current − Continuous | 200 | mA |
| $T_J$, $T_{STG}$ | Operating and Storage Junction Temperature Range | −55 to +150 | °C |

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.

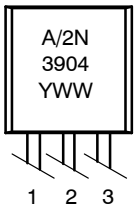
1. These ratings are based on a maximum junction temperature of 150°C.
2. These are steady−state limits. **onsemi** should be consulted on applications involving pulsed orlow−duty cycle operations.

### THERMAL CHARACTERISTICS

(Values are at $T_A$ = 25°C unless otherwise noted.)

| Symbol | Parameter | Max | Unit |
|---|---|---|---|
| $P_D$ | Total Device Dissipation | 625 | mW |
| | Derate Above 25°C | 5.0 | mW/°C |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | 83.3 | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 200 | °C/W |

### MARKING DIAGRAM




1: Emitter
2: Base
3: Collector

A = Assembly Code
2N3904 = Device Code
YWW = Date Code

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 6 of this data sheet.

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**ELECTRICAL CHARACTERISTICS** (Values are at $T_A$ = 25°C unless otherwise noted.)

| Symbol | Parametr | Conditions | Min | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| $V_{(BR)CEO}$ | Collector – Emitter Breakdown Voltage | $I_C$ = 1.0 mA, $I_B$ = 0 | 40 | – | V |
| $V_{(BR)CBO}$ | Collector – Base Breakdown Voltage | $I_C$ = 10 μA, $I_E$ = 0 | 60 | – | V |
| $V_{(BR)EBO}$ | Emitter – Base Breakdown Voltage | $I_E$ = 10 μA, $I_C$ = 0 | 6.0 | – | V |
| $I_{BL}$ | Base Cutoff Current | $V_{CE}$ = 30 V, $V_{EB}$ = 3 V | – | 50 | nA |
| $I_{CEX}$ | Collector Cut–Off Current | $V_{CE}$ = 30 V, $V_{EB}$ = 3 V | – | 50 | nA |
| **ON CHARACTERISTICS** (Note 3) | | | | | |
| $h_{FE}$ | DC Current Gain | $I_C$ = 0.1 mA, $V_{CE}$ = 1.0 V | 40 | – | – |
| | | $I_C$ = 1.0 mA, $V_{CE}$ = 1.0 V | 70 | – | |
| | | $I_C$ = 10 mA, $V_{CE}$ = 1.0 V | 100 | 300 | |
| | | $I_C$ = 50 mA, $V_{CE}$ = 1.0 V | 60 | – | |
| | | $I_C$ = 100 mA, $V_{CE}$ = 1.0 V | 30 | – | |
| $V_{CE(sat)}$ | Collector – Emitter Saturation Voltage | $I_C$ = 10 mA, $I_B$ = 1.0 mA | – | 0.2 | V |
| | | $I_C$ = 50.0 mA, $I_B$ = 5.0 mA | – | 0.3 | |
| $V_{BE(sat)}$ | Base – Emitter Saturation Voltage | $I_C$ = 10.0 mA, $I_B$ = 1.0 mA | 0.65 | 0.85 | V |
| | | $I_C$ = 50.0 mA, $I_B$ = 5.0 mA | – | 0.95 | |
| **SMALL– SIGNAL CHARACTERISTICS** | | | | | |
| $f_T$ | Current – Gain – Bandwidth Product | $I_C$ = 10 mA, $V_{CE}$ = 20 V, f = 100 MHz | 300 | – | MHz |
| $C_{obo}$ | Output Capacitance | $V_{CB}$ = 5.0 V, $I_E$ = 0, f = 100 kHz | – | 4.0 | pF |
| $C_{ibo}$ | Input Capacitance | $V_{EB}$ = 0.5 V, $I_C$ = 0, f = 100 kHz | – | 8.0 | pF |
| NF | Noise Figure | $I_C$ = 100 μA, $V_{CE}$ = 5.0 V, $R_S$ = 1.0 kΩ, f = 10 Hz to 15.7 kHz | – | 5.0 | dB |
| **SWITCHING CHARACTERISTICS** | | | | | |
| $t_d$ | Delay Time | $V_{CC}$ = 3.0 V, $V_{BE}$ = 0.5 V, $I_C$ = 10 mA, $I_{B1}$ = 1.0 mA | – | 35 | ns |
| $t_r$ | Rise Time | | – | 35 | ns |
| $t_s$ | Storage Time | $V_{CC}$ = 3.0 V, $I_C$ = 10 mA, $I_{B1}$ = $I_{B2}$ = 1.0 mA | – | 200 | ns |
| $t_f$ | Fall Time | | – | 50 | ns |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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



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## TYPICAL PERFORMANCE CHARACTERISTICS

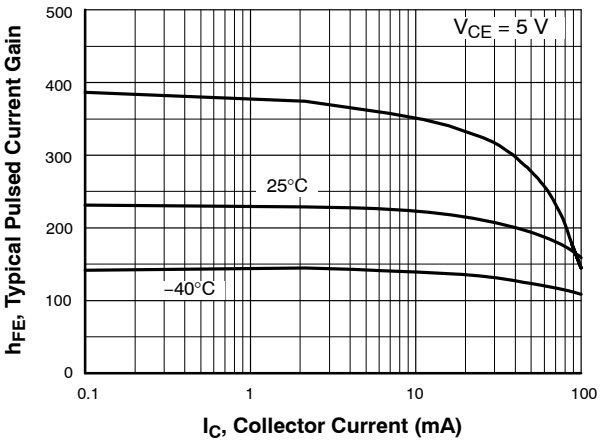


**Figure 1. Typical Pulsed Current Gain vs. Collector Current**

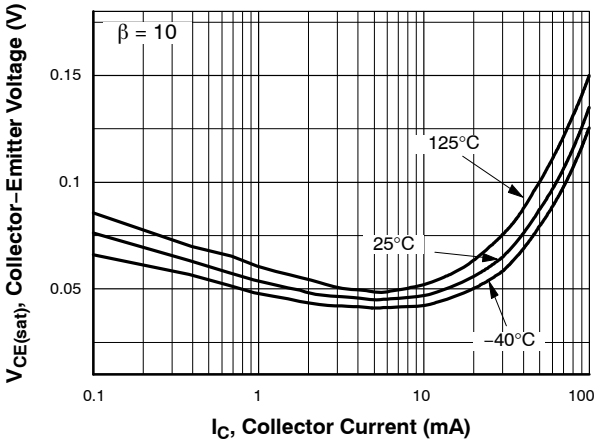


**Figure 2. Collector−Emitter Saturation Voltage vs. Collector Current**

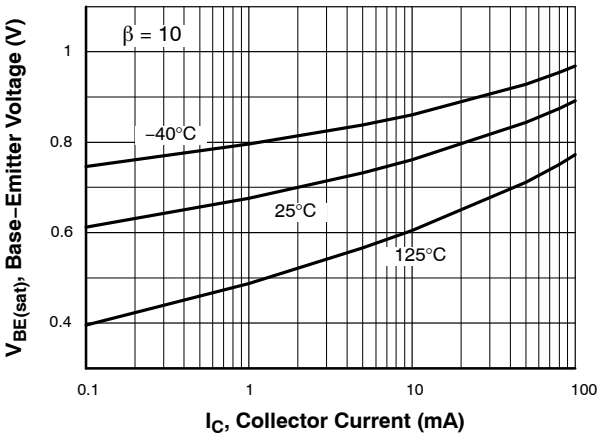


**Figure 3. Base−Emitter Saturation Voltage vs. Collector Current**

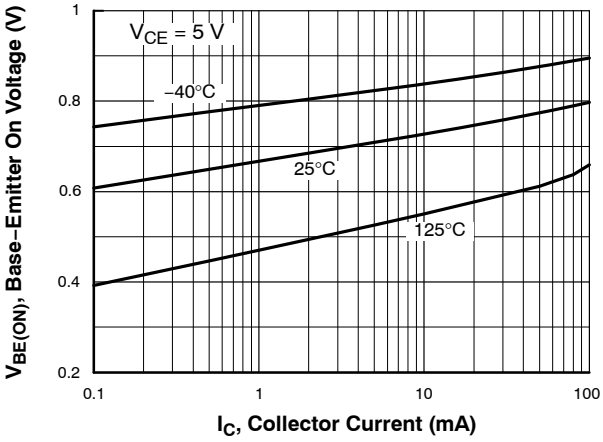


**Figure 4. Base−Emitter On Voltage vs. Collector Current**

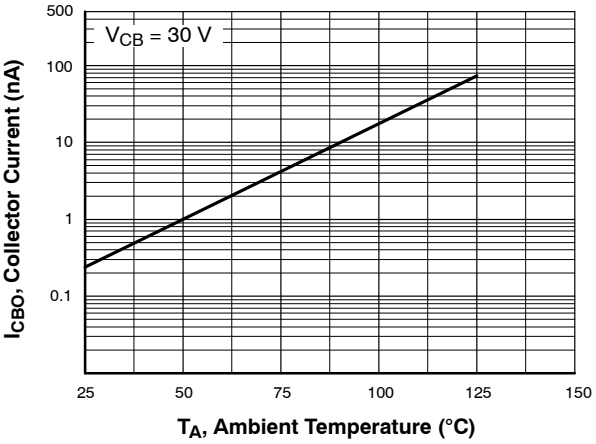


**Figure 5. Collector Cut−Off Current vs. Ambient Temperature**

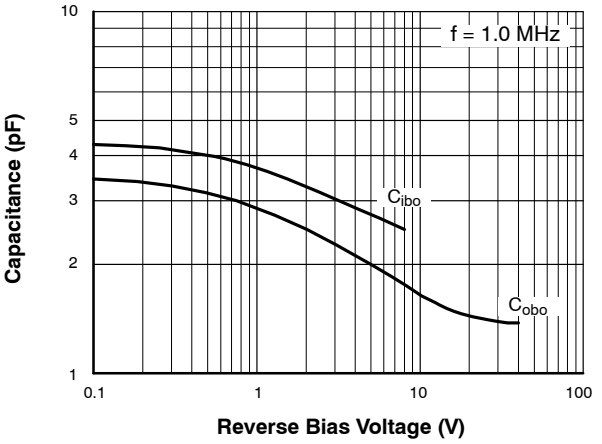


**Figure 6. Capacitance vs. Reverse Bias Voltage**



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## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

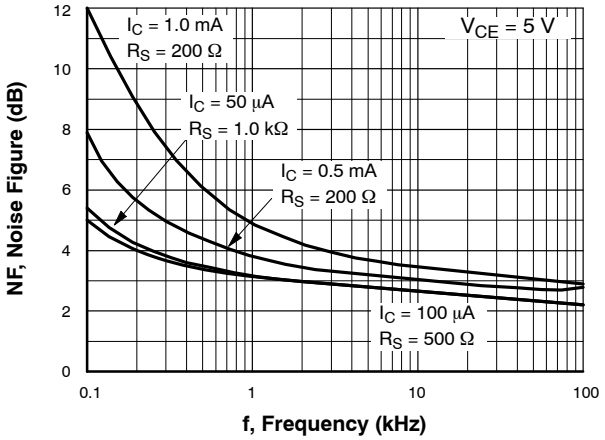


**Figure 7. Noise Figure vs. Frequency**

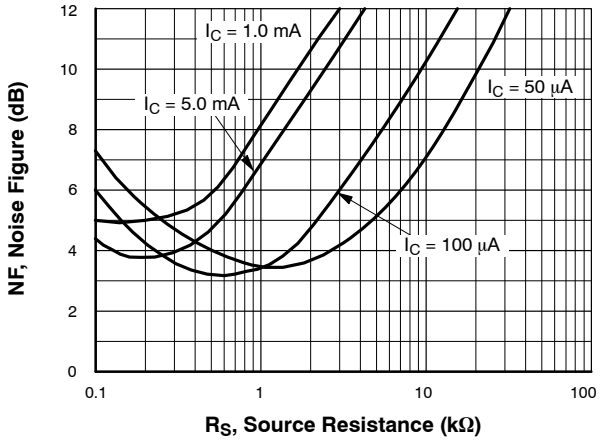


**Figure 8. Noise Figure vs. Source Resistance**

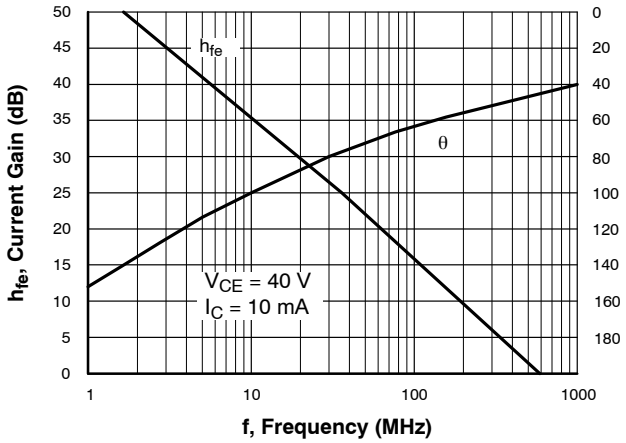


**Figure 9. Current Gain and Phase Angle vs. Frequency**

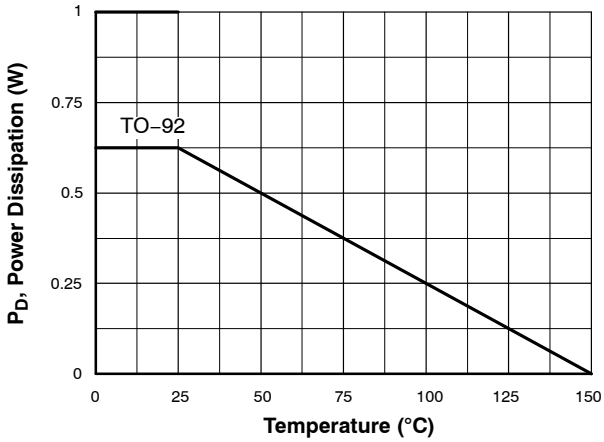


**Figure 10. Power Dissipation vs. Ambient Temperature**

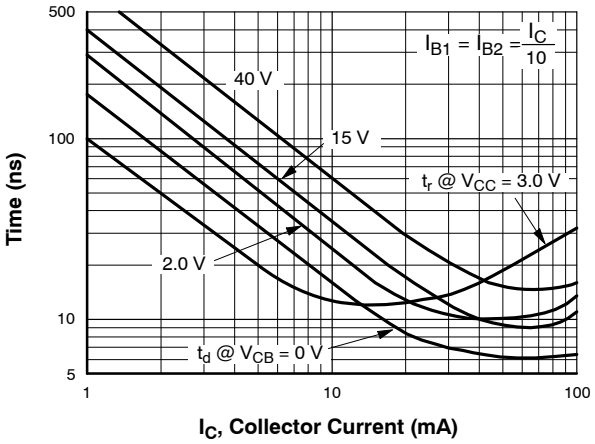


**Figure 11. Turn−On Time vs. Collector Current**

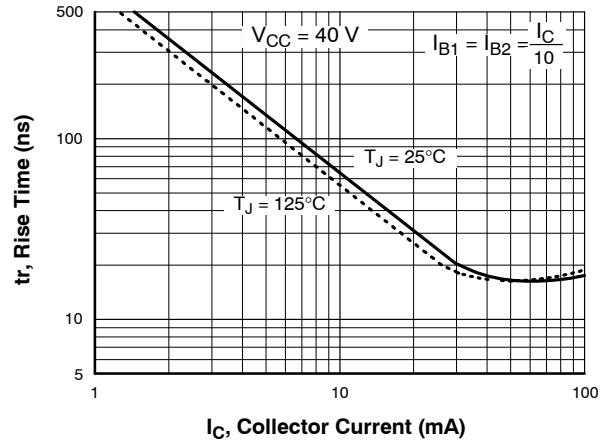


**Figure 12. Rise Time vs. Collector Current**



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## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

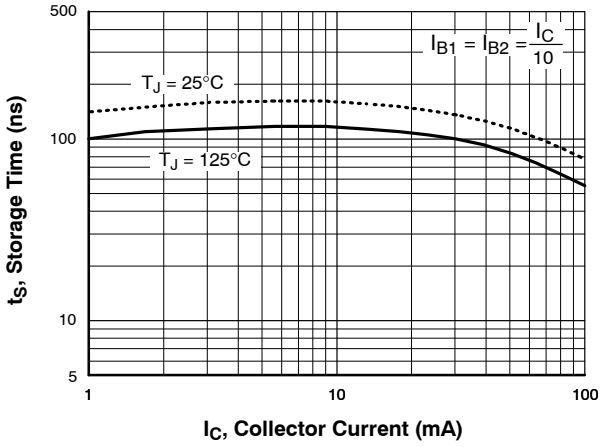


Figure 13. Storage Time vs. Collector Current

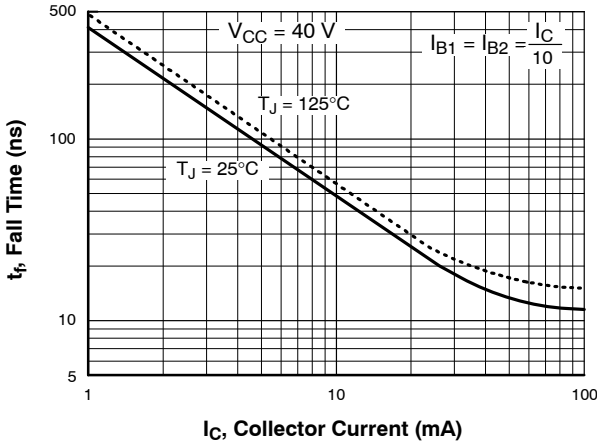


Figure 14. Fall Time vs. Collector Current

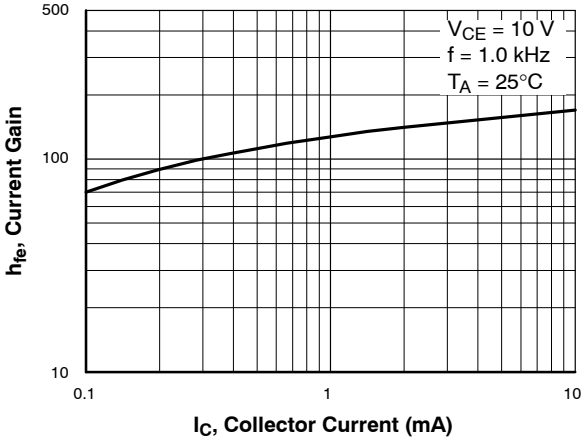


Figure 15. Current Gain

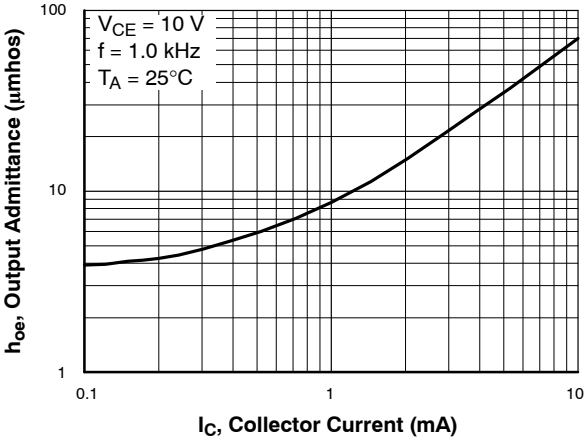


Figure 16. Output Admittance

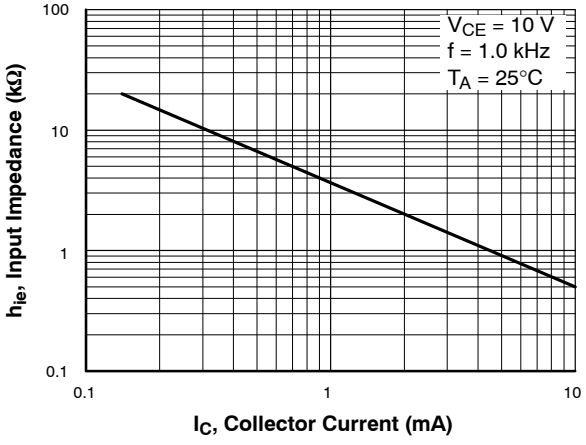


Figure 17. Input Impedance

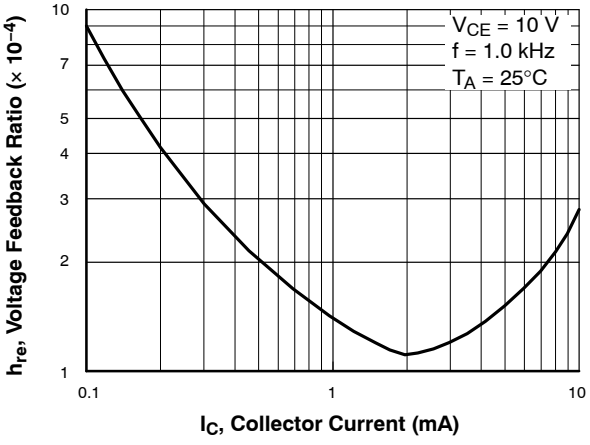


Figure 18. Voltage Feedback Ratio



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## TEST CIRCUITS

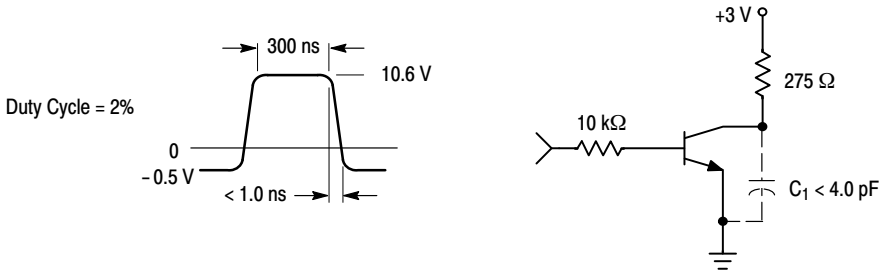


**Figure 19. Delay and Rise Time Equivalent Test Circuit**

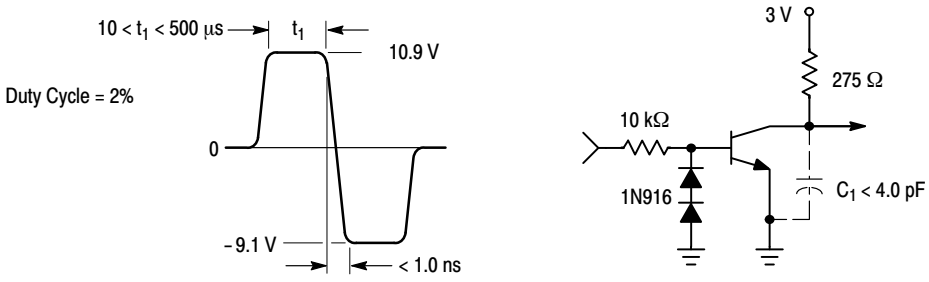


**Figure 20. Storage and Fall Time Equivalent Test Circuit**

### ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| 2N3904BU | TO−92−3 LF (Pb−Free) | 10000 Units / Bulk Bag |
| 2N3904TA | TO−92−3 LF (Pb−Free) | 2000 Units / Fan−Fold |
| 2N3904TAR | TO−92−3 LF (Pb−Free) | 2000 Units / Fan−Fold |
| 2N3904TF | TO−92−3 LF (Pb−Free) | 2000 Units / Tape & Reel |
| 2N3904TFR | TO−92−3 LF (Pb−Free) | 2000 Units / Tape & Reel |

†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.



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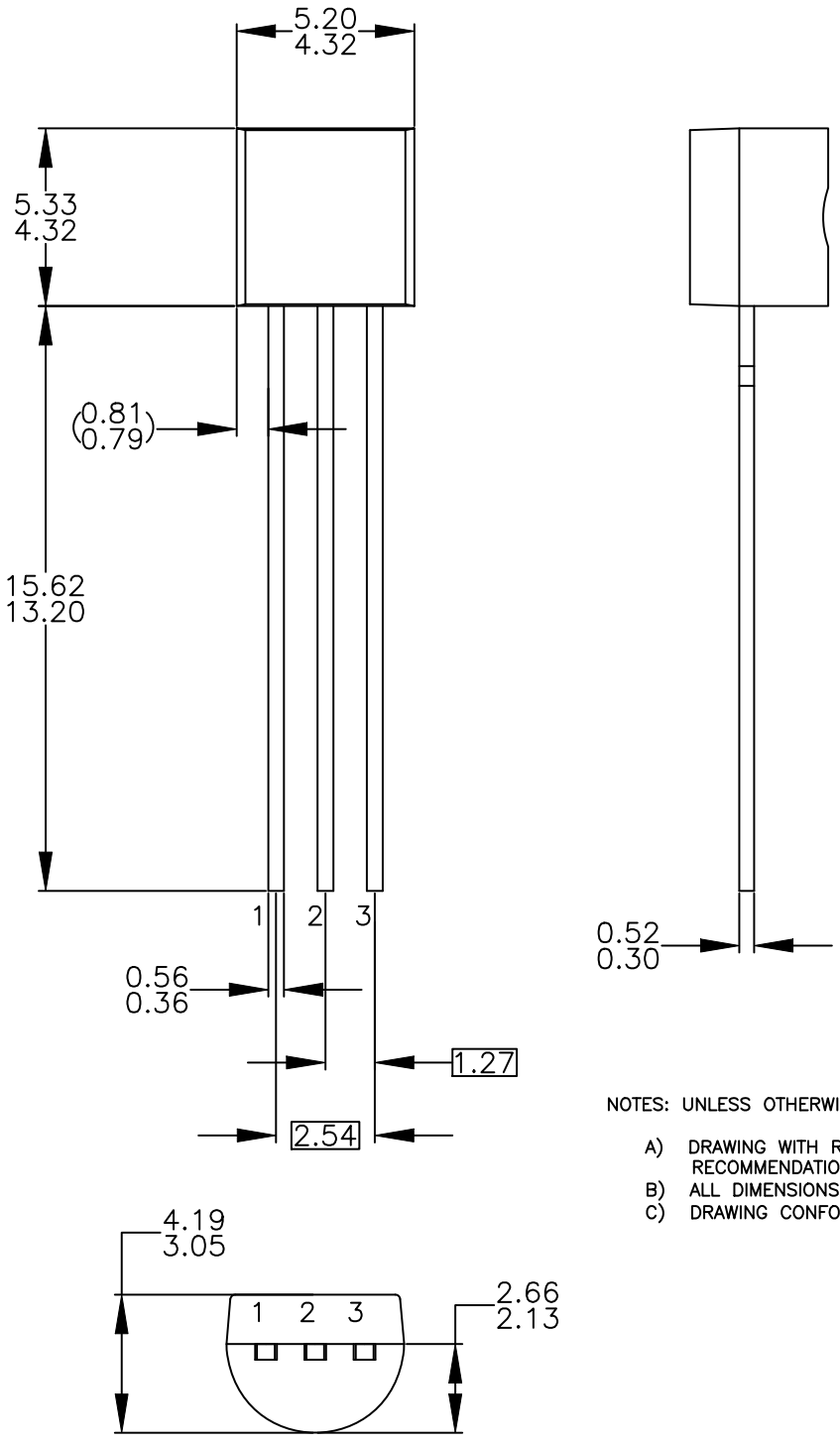
**TO−92 3 4.825x4.76**
CASE 135AN
ISSUE O

DATE 31 JUL 2016

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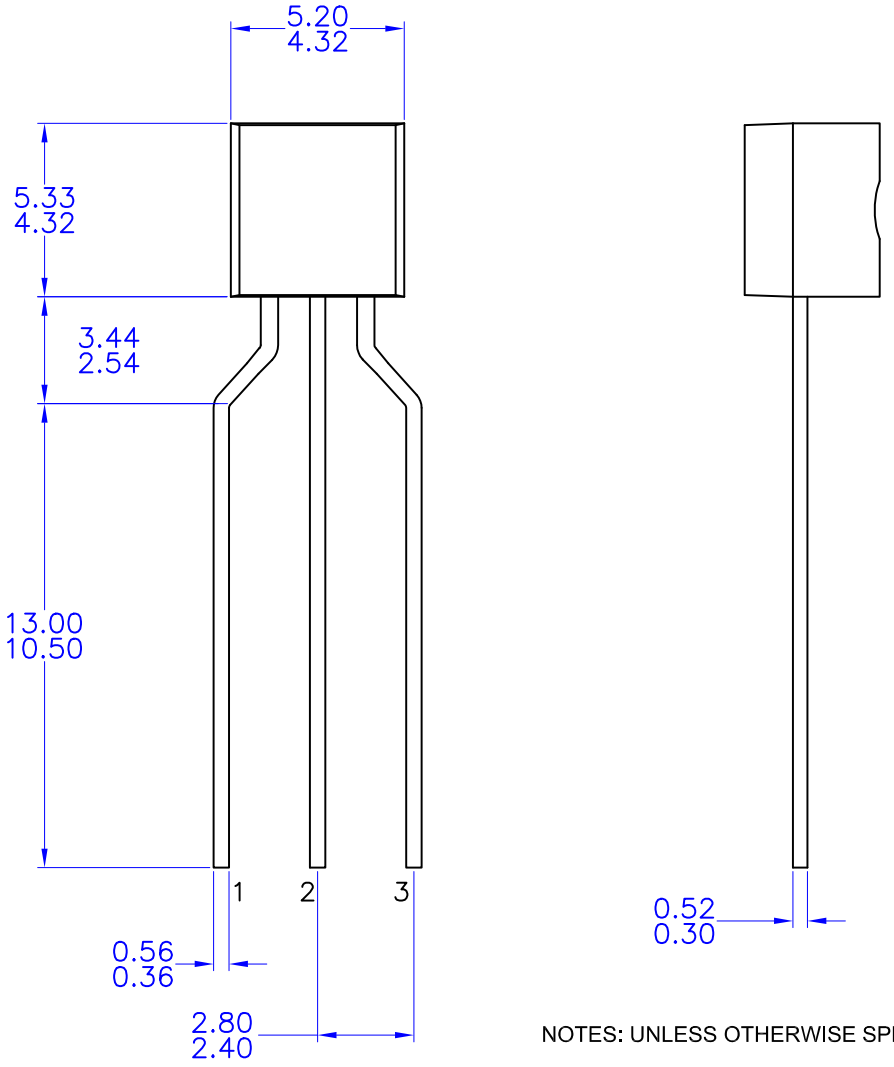
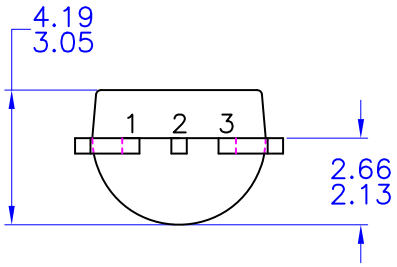
**TO−92 3 4.83x4.76 LEADFORMED**
CASE 135AR
ISSUE O

DATE 30 SEP 2016

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