2N3904 / MMBT3904 / PZT3904
NPN General Purpose Amplifier

Features

- 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.

Absolute Maximum Ratings*  $T_a = 25^\circ C$ unless otherwise noted

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CEO}$</td>
<td>Collector-Emitter Voltage</td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CBO}$</td>
<td>Collector-Base Voltage</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EBO}$</td>
<td>Emitter-Base Voltage</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>$I_C$</td>
<td>Collector Current - Continuous</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>$T_J, T_{stg}$</td>
<td>Operating and Storage Junction Temperature Range</td>
<td>-55 to +150</td>
<td>°C</td>
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</tbody>
</table>

* These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:
1) These ratings are based on a maximum junction temperature of 150 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Thermal Characteristics  $T_a = 25^\circ C$ unless otherwise noted

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Max.</th>
<th>Units</th>
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<tbody>
<tr>
<td>$P_D$</td>
<td>Total Device Dissipation</td>
<td>625</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Derate above 25°C</td>
<td>5.0</td>
<td>mW/°C</td>
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<tr>
<td>$R_{JUC}$</td>
<td>Thermal Resistance, Junction to Case</td>
<td>83.3</td>
<td>°C/W</td>
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<tr>
<td>$R_{JUA}$</td>
<td>Thermal Resistance, Junction to Ambient</td>
<td>200</td>
<td>°C/W</td>
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<tr>
<td></td>
<td></td>
<td>357</td>
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* Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06".
** Device mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm; mounting pad for the collector lead min. 6 cm².
## Electrical Characteristics

$T_a = 25^\circ C$ unless otherwise noted

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test Condition</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>$V_{\text{BR}CEO}$</td>
<td>Collector-Emitter Breakdown Voltage</td>
<td>$I_C = 1.0mA, I_B = 0$</td>
<td>40</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{BR}CBO}$</td>
<td>Collector-Base Breakdown Voltage</td>
<td>$I_C = 10\mu A, I_C = 0$</td>
<td>60</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{BR}EBO}$</td>
<td>Emitter-Base Breakdown Voltage</td>
<td>$I_E = 10\mu A, I_E = 0$</td>
<td>6.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{BL}$</td>
<td>Base Cutoff Current</td>
<td>$V_{CE} = 30V, V_{EB} = 3V$</td>
<td>50</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>$I_{CEX}$</td>
<td>Collector Cutoff Current</td>
<td>$V_{CE} = 30V, V_{EB} = 3V$</td>
<td>50</td>
<td>nA</td>
<td></td>
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### ON CHARACTERISTICS*  

<table>
<thead>
<tr>
<th>Symbol</th>
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<th>Test Condition</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>$h_{FE}$</td>
<td>DC Current Gain</td>
<td>$I_C = 0.1mA, V_{CE} = 1.0V$</td>
<td>40</td>
<td>70</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 10mA, V_{CE} = 1.0V$</td>
<td>100</td>
<td>300</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CE(sat)}$</td>
<td>Collector-Emitter Saturation Voltage</td>
<td>$I_C = 10mA, I_B = 1.0mA$</td>
<td>0.2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 50mA, I_B = 5.0mA$</td>
<td>0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{BE(sat)}$</td>
<td>Base-Emitter Saturation Voltage</td>
<td>$I_C = 10mA, I_B = 1.0mA$</td>
<td>0.65</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 50mA, I_B = 5.0mA$</td>
<td>0.85</td>
<td>V</td>
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### SMALL SIGNAL CHARACTERISTICS  

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<tr>
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<th>Test Condition</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
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<tbody>
<tr>
<td>$f_T$</td>
<td>Current Gain - Bandwidth Product</td>
<td>$I_C = 10mA, V_{CE} = 20V, f = 100MHz$</td>
<td>300</td>
<td>MHz</td>
<td></td>
</tr>
<tr>
<td>$C_{oBo}$</td>
<td>Output Capacitance</td>
<td>$V_{CB} = 0.5V, I_E = 0, f = 1.0MHz$</td>
<td>4.0</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>$C_{iBo}$</td>
<td>Input Capacitance</td>
<td>$V_{EB} = 0.5V, I_C = 0, f = 1.0MHz$</td>
<td>8.0</td>
<td>pF</td>
<td></td>
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<tr>
<td>NF</td>
<td>Noise Figure</td>
<td>$I_C = 100\mu A, V_{CE} = 5.0V, R_S = 1.0k\Omega, f = 10Hz to 15.7kHz$</td>
<td>5.0</td>
<td>dB</td>
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### SWITCHING CHARACTERISTICS  

<table>
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<tr>
<th>Symbol</th>
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<th>Test Condition</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
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<tbody>
<tr>
<td>$t_d$</td>
<td>Delay Time</td>
<td>$V_{CC} = 3.0V, V_{BE} = 0.5V$</td>
<td>35</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>$t_r$</td>
<td>Rise Time</td>
<td>$I_C = 10mA, I_{B1} = 1.0mA$</td>
<td>35</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>$t_s$</td>
<td>Storage Time</td>
<td>$V_{CC} = 3.0V, I_C = 10mA, I_{B1} = I_{B2} = 1.0mA$</td>
<td>200</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>$t_f$</td>
<td>Fall Time</td>
<td>$V_{CC} = 3.0V, I_C = 10mA, I_{B1} = I_{B2} = 1.0mA$</td>
<td>50</td>
<td>ns</td>
<td></td>
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* Pulse Test: Pulse Width $\leq 300\mu s$, Duty Cycle $\leq 2.0\%$

## Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Marking</th>
<th>Package</th>
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<td>TO-92</td>
<td>BULK</td>
<td>10000</td>
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<tr>
<td>2N3904TA</td>
<td>2N3904</td>
<td>TO-92</td>
<td>AMMO</td>
<td>2000</td>
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<tr>
<td>2N3904TAR</td>
<td>2N3904</td>
<td>TO-92</td>
<td>AMMO</td>
<td>2000</td>
</tr>
<tr>
<td>2N3904TF</td>
<td>2N3904</td>
<td>TO-92</td>
<td>TAPE REEL</td>
<td>2000</td>
</tr>
<tr>
<td>2N3904TFR</td>
<td>2N3904</td>
<td>TO-92</td>
<td>TAPE REEL</td>
<td>2000</td>
</tr>
<tr>
<td>MMBT3904</td>
<td>1A</td>
<td>SOT-23</td>
<td>TAPE REEL</td>
<td>3000</td>
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<tr>
<td>MMBT3904_D87Z</td>
<td>1A</td>
<td>SOT-23</td>
<td>TAPE REEL</td>
<td>10000</td>
</tr>
<tr>
<td>PZT3904</td>
<td>3904</td>
<td>SOT-223</td>
<td>TAPE REEL</td>
<td>2500</td>
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Typical Performance Characteristics

Typical Pulsed Current Gain vs Collector Current

Collector-Emitter Saturation Voltage vs Collector Current

Base-Emitter Saturation Voltage vs Collector Current

Base-Emitter ON Voltage vs Collector Current

Collector-Cutoff Current vs Ambient Temperature

Capacitance vs Reverse Bias Voltage

Typical Pulsed Current Gain

Collector-Emitter Saturation Voltage

Base-Emitter Saturation Voltage

Base-Emitter ON Voltage

Collector-Cutoff Current

Capacitance
Typical Performance Characteristics (continued)

Noise Figure vs Frequency

Noise Figure vs Source Resistance

Current Gain and Phase Angle vs Frequency

Power Dissipation vs Ambient Temperature

Turn-On Time vs Collector Current

Rise Time vs Collector Current
Typical Performance Characteristics (continued)

Storage Time vs Collector Current

Fall Time vs Collector Current

Current Gain

Output Admittance

Input Impedance

Voltage Feedback Ratio

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Test Circuits

FIGURE 1: Delay and Rise Time Equivalent Test Circuit

FIGURE 2: Storage and Fall Time Equivalent Test Circuit
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- SPM™
- STEALTH™
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- SuperSOT™
- SuperSOT™-3
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- SuperSOT™-8
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<table>
<thead>
<tr>
<th>Definition of Terms</th>
<th>Product Status</th>
<th>Definition</th>
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<tr>
<td>Advance Information</td>
<td>Formative / In Design</td>
<td>Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.</td>
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