2N3904 / MMBT3904 / PZT3904
NPN General-Purpose Amplifier

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.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Marking</th>
<th>Package</th>
<th>Packing Method</th>
<th>Pack Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N3904BU</td>
<td>2N3904</td>
<td>TO-92 3L</td>
<td>Bulk</td>
<td>10000</td>
</tr>
<tr>
<td>2N3904TA</td>
<td>2N3904</td>
<td>TO-92 3L</td>
<td>Ammo</td>
<td>2000</td>
</tr>
<tr>
<td>2N3904TAR</td>
<td>2N3904</td>
<td>TO-92 3L</td>
<td>Ammo</td>
<td>2000</td>
</tr>
<tr>
<td>2N3904TF</td>
<td>2N3904</td>
<td>TO-92 3L</td>
<td>Tape and Reel</td>
<td>2000</td>
</tr>
<tr>
<td>2N3904TFR</td>
<td>2N3904</td>
<td>TO-92 3L</td>
<td>Tape and Reel</td>
<td>2000</td>
</tr>
<tr>
<td>MMBT3904</td>
<td>1A</td>
<td>SOT-23 3L</td>
<td>Tape and Reel</td>
<td>3000</td>
</tr>
<tr>
<td>PZT3904</td>
<td>3904</td>
<td>SOT-223 4L</td>
<td>Tape and Reel</td>
<td>2500</td>
</tr>
</tbody>
</table>
**Absolute Maximum Ratings**

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at $T_A = 25^\circ$C unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</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>
</tr>
</tbody>
</table>

**Notes:**
1. These ratings are based on a maximum junction temperature of 150°C.
2. These are steady-state limits. Fairchild Semiconductor should be consulted on applications involving pulsed or low-duty cycle operations.

**Thermal Characteristics**

Values are at $T_A = 25^\circ$C unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Maximum</th>
<th>Unit</th>
</tr>
</thead>
<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>
</tr>
<tr>
<td>$R_{JJC}$</td>
<td>Thermal Resistance, Junction to Case</td>
<td>83.3</td>
<td>°C/W</td>
</tr>
<tr>
<td>$R_{JJA}$</td>
<td>Thermal Resistance, Junction to Ambient</td>
<td>200</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

**Notes:**
3. Device is mounted on FR-4 PCB 1.6 inch X 1.6 inch X 0.06 inch.
4. Device is mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm, mounting pad for the collector lead minimum 6 cm².
## Electrical Characteristics

Values are at $T_A = 25^\circ C$ unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OFF CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{(BR)CEO}$</td>
<td>Collector-Emitter Breakdown Voltage</td>
<td>$I_C = 1.0 , mA, I_B = 0$</td>
<td>40</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{(BR)CBO}$</td>
<td>Collector-Base Breakdown Voltage</td>
<td>$I_C = 10 , \mu A, I_E = 0$</td>
<td>60</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{(BR)EBO}$</td>
<td>Emitter-Base Breakdown Voltage</td>
<td>$I_E = 10 , \mu A, I_C = 0$</td>
<td>6.0</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$I_{BL}$</td>
<td>Base Cut-Off Current</td>
<td>$V_{CE} = 30 , V, V_{BE} = 3 , V$</td>
<td>50</td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>$I_{CEX}$</td>
<td>Collector Cut-Off Current</td>
<td>$V_{CE} = 30 , V, V_{EB} = 3 , V$</td>
<td>50</td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td><strong>ON CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>DC Current Gain</td>
<td>$I_C = 0.1 , mA, V_{CE} = 1.0 , V$</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 1.0 , mA, V_{CE} = 1.0 , V$</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 10 , mA, V_{CE} = 1.0 , V$</td>
<td>100</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 50 , mA, V_{CE} = 1.0 , V$</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 100 , mA, V_{CE} = 1.0 , V$</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{CE\text{ (sat)}}$</td>
<td>Collector-Emitter Saturation Voltage</td>
<td>$I_C = 10 , mA, I_B = 1.0 , mA$</td>
<td>0.2</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 50 , mA, I_B = 5.0 , mA$</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{BE\text{ (sat)}}$</td>
<td>Base-Emitter Saturation Voltage</td>
<td>$I_C = 10 , mA, I_B = 1.0 , mA$</td>
<td>0.65</td>
<td>0.85</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_C = 50 , mA, I_B = 5.0 , mA$</td>
<td>0.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SMALL SIGNAL CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$f_T$</td>
<td>Current Gain - Bandwidth Product</td>
<td>$I_C = 10 , mA, V_{CE} = 20 , V$, $f = 100 , MHz$</td>
<td>300</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>$C_{obo}$</td>
<td>Output Capacitance</td>
<td>$V_{CB} = 5.0 , V, I_E = 0$, $f = 100 , kHz$</td>
<td>4.0</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{ib0}$</td>
<td>Input Capacitance</td>
<td>$V_{EB} = 0.5 , V, I_C = 0$, $f = 100 , kHz$</td>
<td>8.0</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$NF$</td>
<td>Noise Figure</td>
<td>$I_C = 100 , \mu A, V_{CE} = 5.0 , V$, $R_S = 1.0 , k\Omega$, $f = 10 , Hz to 15.7 , kHz$</td>
<td>5.0</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td><strong>SWITCHING CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_d$</td>
<td>Delay Time</td>
<td>$V_{CC} = 3.0 , V, V_{BE} = 0.5 , V$</td>
<td>35</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_r$</td>
<td>Rise Time</td>
<td>$I_C = 10 , mA, I_{B1} = 1.0 , mA$</td>
<td>35</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_s$</td>
<td>Storage Time</td>
<td>$V_{CC} = 3.0 , V, I_C = 10 , mA$, $I_{B1} = I_{B2} = 1.0 , mA$</td>
<td>200</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_f$</td>
<td>Fall Time</td>
<td>$I_{B1} = I_{B2} = 1.0 , mA$</td>
<td>50</td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

Note:
5. Pulse test: pulse width $\leq 300$ $\mu s$, duty cycle $\leq 2.0\%$. 

© 2002 Fairchild Semiconductor Corporation
www.fairchildsemi.com
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
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
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
Test Circuits

Figure 19. Delay and Rise Time Equivalent Test Circuit

Figure 20. Storage and Fall Time Equivalent Test Circuit
NOTES: UNLESS OTHERWISE SPECIFIED

A. DRAWING CONFORMS TO JEDEC MS-013,
   VARIATION AC.

B. ALL DIMENSIONS ARE IN MILLIMETERS.


D. DRAWING FILENAME: MKT-2A03FREV3.

E. FAIRCHILD SEMICONDUCTOR.
NOTES: UNLESS OTHERWISE SPECIFIED
A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DRAWING CONFORMS TO ASME Y14.5M-2009.
D) DRAWING FILENAME: MKT-ZA03DREV4.
NOTES: UNLESS OTHERWISE SPECIFIED
A) REFERENCE JEDEC REGISTRATION TO-236, VARIATION AB, ISSUE H.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DIMENSIONS ARE INCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR EXTRUSIONS.
D) DIMENSIONING AND TOLERANCING PER ASME Y14.5M - 2009.
E) DRAWING FILE NAME: MA03DREV11
TRADEMARKS
The following includes registered and unregistered trademarks and service marks, owned by Fairchild Semiconductor and/or its global subsidiaries, and is not intended to be an exhaustive list of all such trademarks.

AccuPower™
AttitudeEngine™
Awinds®
AX-CAP®
BitSiC™
Build it Now™
CorePLUS™
CorePOWER™
CROSSVOLT™
CTL™
Current Transfer Logic™
DEUXPEED®
Dual Cool™
EcoSpark™
EfficientMax™
ESBC™
Fairchild®
Fairchild Semiconductor®
FACT Quiet Series™
FACT®
FastVCore™
FETBench™
FPS™
F-PS™
FRFET®
Global Power ResourceSM
GreenBridge™
Green FPS™
Green FPS™ e-Series™
Gmax™
GTO™
IntelliMAX™
IsoPlanar™
Making Small Speakers Sound Louder and Better™
MegaBuck™
MicroCoupler™
MicroFET™
MicroPak™
MicroPak2™
MillerDrive™
MotionMax™
MotionGrid®
MIT™
MTX™
MVN™
mWSaver®
OptoHiT™
OptoLogic®
OPTOPLANAR®
Power Supply WebDesigner™
PowerTrench®
PowerXS™
Programmable Active Droop™
QFET™
QS™
Quiet Series™
RapidConfigure™
Saving our world, 1mW/KW at a time™
SignalWise™
SmartMax™
SMART START™
Solutions for Your Success™
SPM™
STEALTH™
SuperFET®
SuperSOT™-3
SuperSOT™-6
SuperSOT™-8
SupreMOS®
SyncFET™
Sync-Lock™

* Trademarks of System General Corporation, used under license by Fairchild Semiconductor.

DISCLAIMER
FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. TO OBTAIN THE LATEST, MOST UP-TO-DATE DATASHEET AND PRODUCT INFORMATION, VISIT OUR WEBSITE AT HTTP://WWW.FAIRCHILDSEMI.COM. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD’S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

AUTHORIZED USE
Unless otherwise specified in this data sheet, this product is a standard commercial product and is not intended for use in applications that require extraordinary levels of quality and reliability. This product may not be used in the following applications, unless specifically approved in writing by a Fairchild officer: (1) automotive or other transportation, (2) military/aerospace, (3) any safety critical application – including life critical medical equipment – where the failure of the Fairchild product reasonably would be expected to result in personal injury, death or property damage. Customer’s use of this product is subject to agreement of this Authorized Use and other transportation, (2) military/aerospace, (3) any safety critical application – including life critical medical equipment – where the failure of the Fairchild product reasonably would be expected to result in personal injury, death or property damage. Customer’s use of this product is subject to agreement of this Authorized Use or other transportation, (2) military/aerospace, (3) any safety critical application – including life critical medical equipment – where the failure of the Fairchild product reasonably would be expected to result in personal injury, death or property damage. Customer’s use of this product is subject to agreement of this Authorized Use.

ANTI-COUNTERFEITING POLICY
Fairchild Semiconductor Corporation’s Anti-Counterfeiting Policy, Fairchild’s Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Terms of Use Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild’s quality standards for handling and storage and provide access to Fairchild’s full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

PRODUCT STATUS DEFINITIONS

<table>
<thead>
<tr>
<th>Datasheet Identification</th>
<th>Product Status</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<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>
</tr>
<tr>
<td>Preliminary</td>
<td>First Production</td>
<td>Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.</td>
</tr>
<tr>
<td>No Identification Needed</td>
<td>Full Production</td>
<td>Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.</td>
</tr>
<tr>
<td>Obsolete</td>
<td>Not In Production</td>
<td>Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.</td>
</tr>
</tbody>
</table>

Rev. I77