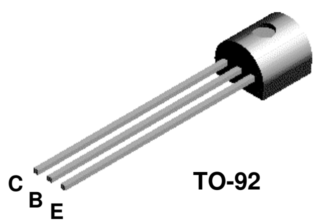
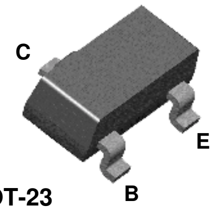
FAIRCHILD SEMICONDUCTOR ™

# 2N4401 MMBT4401




TO-92




SOT-23
Mark: 2X

## NPN General Pupose Amplifier

This device is designed for use as a medium power amplifier and switch requiring collector currents up to 500 mA.

## Absolute Maximum Ratings*

TA = 25°C unless otherwise noted

| Symbol | Parameter | Value | Units |
|---|---|---|---|
| $V_{CEO}$ | 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 | 600 | mA |
| $T_J$, $T_{stg}$ | Operating and Storage Junction Temperature Range | -55 to +150 | °C |

*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

TA = 25°C unless otherwise noted

| Symbol | Characteristic | Max | | Units |
|---|---|---|---|---|
| | | **2N4401** | ***MMBT4401** | |
| $P_D$ | Total Device Dissipation<br>Derate above 25°C | 625<br>5.0 | 350<br>2.8 | mW<br>mW/°C |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | 83.3 | | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 200 | 357 | °C/W |

*Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."

## NPN General Purpose Amplifier
(continued)

### Electrical Characteristics
TA = 25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| **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 | $I_C$ = 0.1 mA, $I_E$ = 0 | 60 | | V |
| $V_{(BR)EBO}$ | Emitter-Base Breakdown Voltage | $I_E$ = 0.1 mA, $I_C$ = 0 | 6.0 | | V |
| $I_{BL}$ | Base Cutoff Current | $V_{CE}$ = 35 V, $V_{EB}$ = 0.4 V | | 0.1 | µA |
| $I_{CEX}$ | Collector Cutoff Current | $V_{CE}$ = 35 V, $V_{EB}$ = 0.4 V | | 0.1 | µA |
| **ON CHARACTERISTICS*** | | | | | |
| $h_{FE}$ | DC Current Gain | $I_C$ = 0.1 mA, $V_{CE}$ = 1.0 V<br>$I_C$ = 1.0 mA, $V_{CE}$ = 1.0 V<br>$I_C$ = 10 mA, $V_{CE}$ = 1.0 V<br>$I_C$ = 150 mA, $V_{CE}$ = 1.0 V<br>$I_C$ = 500 mA, $V_{CE}$ = 2.0 V | 20<br>40<br>80<br>100<br>40 | <br><br><br>300<br> | |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $I_C$ = 150 mA, $I_B$ = 15 mA<br>$I_C$ = 500 mA, $I_B$ = 50 mA | | 0.4<br>0.75 | V<br>V |
| $V_{BE(sat)}$ | Base-Emitter Saturation Voltage | $I_C$ = 150 mA, $I_B$ = 15 mA<br>$I_C$ = 500 mA, $I_B$ = 50 mA | 0.75 | 0.95<br>1.2 | V<br>V |
| **SMALL SIGNAL CHARACTERISTICS** | | | | | |
| $f_T$ | Current Gain - Bandwidth Product | $I_C$ = 20 mA, $V_{CE}$ = 10 V,<br>f = 100 MHz | 250 | | MHz |
| $C_{cb}$ | Collector-Base Capacitance | $V_{CB}$ = 5.0 V, $I_E$ = 0,<br>f = 140 kHz | | 6.5 | pF |
| $C_{eb}$ | Emitter-Base Capacitance | $V_{BE}$ = 0.5 V, $I_C$ = 0,<br>f = 140 kHz | | 30 | pF |
| $h_{ie}$ | Input Impedance | $I_C$ = 1.0 mA, $V_{CE}$ = 10 V,<br>f = 1.0 kHz | 1.0 | 15 | kΩ |
| $h_{re}$ | Voltage Feedback Ratio | $I_C$ = 1.0 mA, $V_{CE}$ = 10 V,<br>f = 1.0 kHz | 0.1 | 8.0 | $x\ 10^{-4}$ |
| $h_{fe}$ | Small-Signal Current Gain | $I_C$ = 1.0 mA, $V_{CE}$ = 10 V,<br>f = 1.0 kHz | 40 | 500 | |
| $h_{oe}$ | Output Admittance | $I_C$ = 1.0 mA, $V_{CE}$ = 10 V,<br>f = 1.0 kHz | 1.0 | 30 | µmhos |
| **SWITCHING CHARACTERISTICS** | | | | | |
| $t_d$ | Delay Time | $V_{CC}$ = 30 V, $V_{EB}$ = 2 V, | | 15 | ns |
| $t_r$ | Rise Time | $I_C$ = 150 mA, $I_{B1}$ = 15 mA | | 20 | ns |
| $t_s$ | Storage Time | $V_{CC}$ = 30 V, $I_C$ = 150 mA | | 225 | ns |
| $t_f$ | Fall Time | $I_{B1}$ = $I_{B2}$ = 15 mA | | 30 | ns |

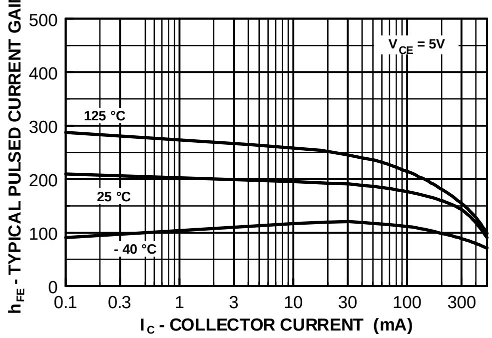
*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

# NPN General Purpose Amplifier

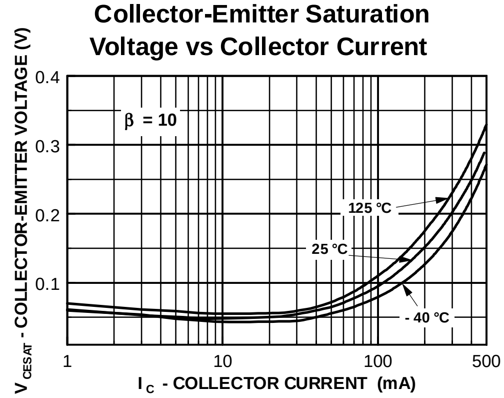
(continued)

## Typical Characteristics

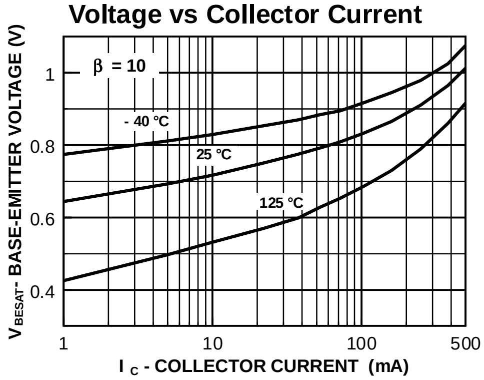
**Typical Pulsed Current Gain vs Collector Current**



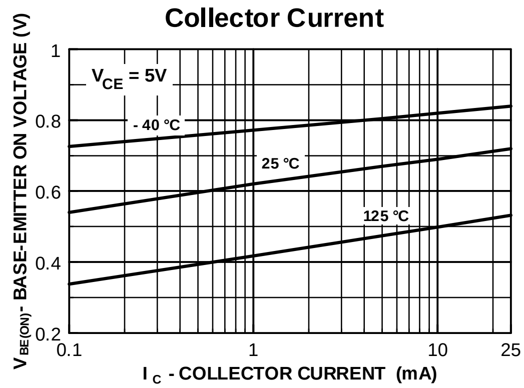

**Collector-Emitter Saturation Voltage vs Collector Current**



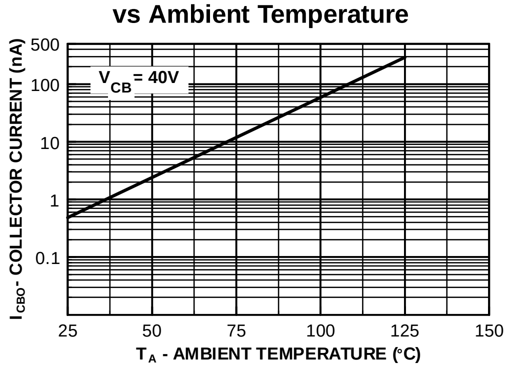

**Base-Emitter Saturation Voltage vs Collector Current**



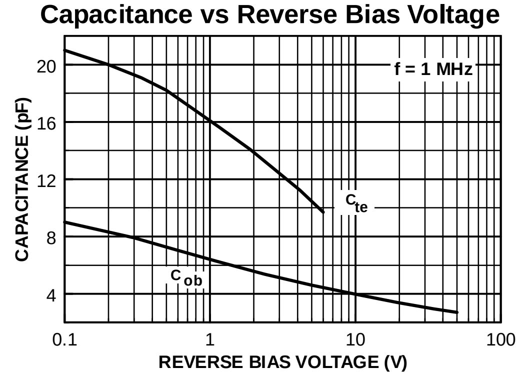

**Base-Emitter ON Voltage vs Collector Current**




**Collector-Cutoff Current vs Ambient Temperature**

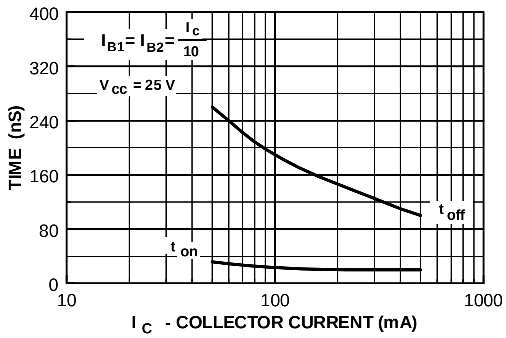



**Emitter Transition and Output Capacitance vs Reverse Bias Voltage**

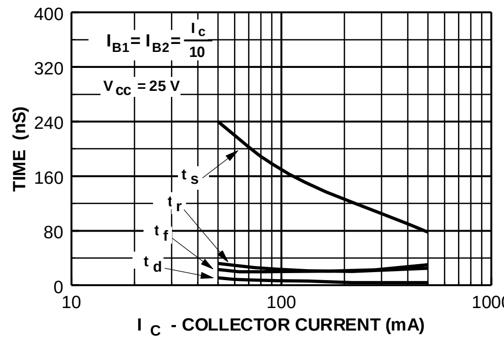


## Typical Characteristics (continued)

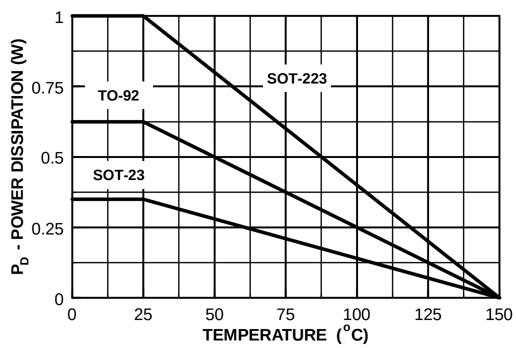
**Turn On and Turn Off Times vs Collector Current**




**Switching Times vs Collector Current**

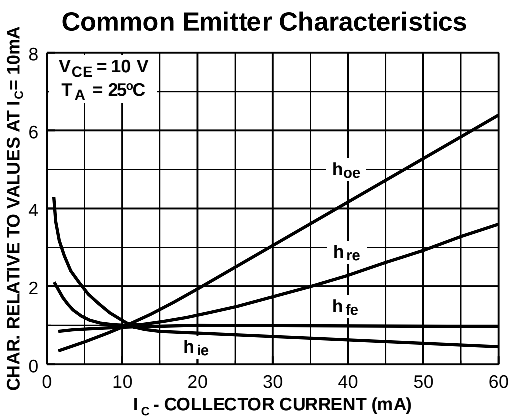


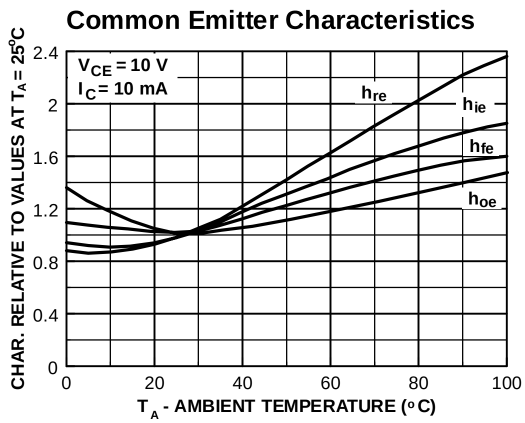

**Power Dissipation vs Ambient Temperature**

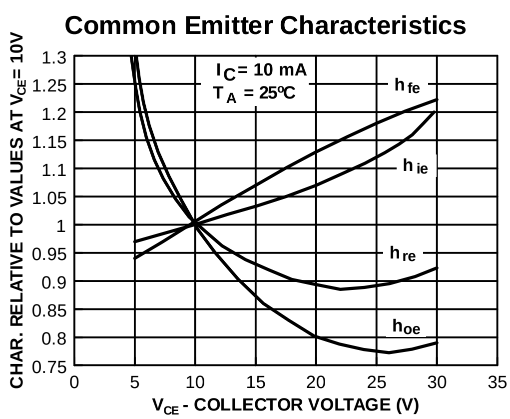


## NPN General Purpose Amplifier
(continued)

## Typical Common Emitter Characteristics (f = 1.0kHz)



## Test Circuits

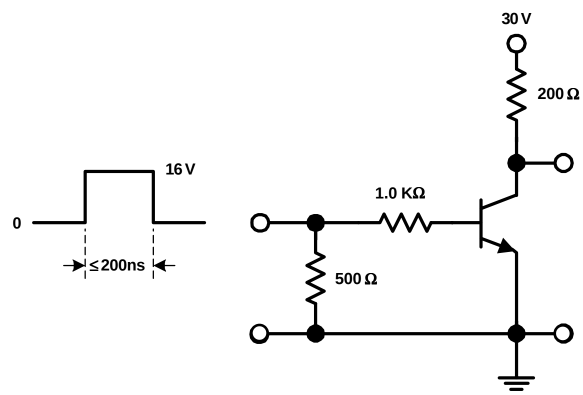



**FIGURE 1: Saturated Turn-On Switching Timer**

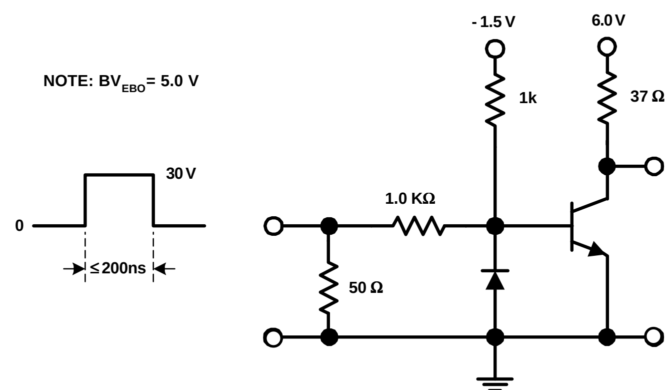



**FIGURE 2: Saturated Turn-Off Switching Time**

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