# MJE13003

# SWITCHMODE™ Series NPN Silicon Power Transistor

These devices are designed for high−voltage, high−speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V SWITCHMODE applications such as Switching Regulators, Inverters, Motor Controls, Solenoid/Relay drivers and Deflection circuits.

### Features

- Reverse Biased SOA with Inductive Loads @ $T_C$ = 100°C
- Inductive Switching Matrix 0.5 to 1.5 A, 25 and 100°C
  $t_c$ @ 1 A, 100°C is 290 ns (Typ)
- 700 V Blocking Capability
- SOA and Switching Applications Information
- Pb−Free Package is Available*

### MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Collector−Emitter Voltage | $V_{CEO(sus)}$ | 400 | Vdc |
| Collector−Emitter Voltage | $V_{CEV}$ | 700 | Vdc |
| Emitter Base Voltage | $V_{EBO}$ | 9 | Vdc |
| Collector Current − Continuous<br>− Peak (Note 1) | $I_C$<br>$I_{CM}$ | 1.5<br>3 | Adc |
| Base Current − Continuous<br>− Peak (Note 1) | $I_B$<br>$I_{BM}$ | 0.75<br>1.5 | Adc |
| Emitter Current − Continuous<br>− Peak (Note 1) | $I_E$<br>$I_{EM}$ | 2.25<br>4.5 | Adc |
| Total Power Dissipation @ $T_A$ = 25°C<br>Derate above 25°C | $P_D$ | 1.4<br>11.2 | W<br>mW/°C |
| Total Power Dissipation @ $T_C$ = 25°C<br>Derate above 25°C | $P_D$ | 40<br>320 | W<br>mW/°C |
| Operating and Storage Junction Temperature Range | $T_J$, $T_{stg}$ | –65 to +150 | °C |

### THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Thermal Resistance, Junction−to−Case | $R_{\theta JC}$ | 3.12 | °C/W |
| Thermal Resistance, Junction−to−Ambient | $R_{\theta JA}$ | 89 | °C/W |
| Maximum Load Temperature for Soldering Purposes: 1/8″ from Case for 5 Seconds | $T_L$ | 275 | °C |

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.

*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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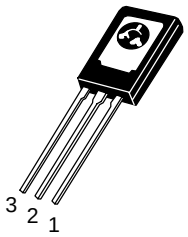
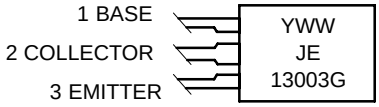
## 1.5 AMPERES NPN SILICON POWER TRANSISTORS 300 AND 400 VOLTS 40 WATTS




**TO−225**
**CASE 77**
**STYLE 3**

### MARKING DIAGRAM




Y = Year
WW = Work Week
JE13003 = Device Code
G = Pb−Free Package

### ORDERING INFORMATION

| Device | Package | Shipping |
|---|---|---|
| MJE13003 | TO−225 | 500 Units/Box |
| MJE13003G | TO−225 (Pb−Free) | 500 Units/Box |

**ELECTRICAL CHARACTERISTICS** ($T_C$ = 25°C unless otherwise noted)

| Characteristic | | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** (Note 2) | | | | | | |
| Collector−Emitter Sustaining Voltage ($I_C$ = 10 mA, $I_B$ = 0) | | $V_{CEO(sus)}$ | 400 | − | − | Vdc |
| Collector Cutoff Current<br>($V_{CEV}$ = Rated Value, $V_{BE(off)}$ = 1.5 Vdc)<br>($V_{CEV}$ = Rated Value, $V_{BE(off)}$ = 1.5 Vdc, $T_C$ = 100°C) | | $I_{CEV}$ | <br>−<br>− | <br>−<br>− | <br>1<br>5 | mAdc |
| Emitter Cutoff Current ($V_{EB}$ = 9 Vdc, $I_C$ = 0) | | $I_{EBO}$ | − | − | 1 | mAdc |
| **SECOND BREAKDOWN** | | | | | | |
| Second Breakdown Collector Current with bass forward biased | | $I_{S/b}$ | See Figure 11 | | | − |
| Clamped Inductive SOA with base reverse biased | | RBSOA | See Figure 12 | | | − |
| **ON CHARACTERISTICS** (Note 2) | | | | | | |
| DC Current Gain<br>($I_C$ = 0.5 Adc, $V_{CE}$ = 2 Vdc)<br>($I_C$ = 1 Adc, $V_{CE}$ = 2 Vdc) | | $h_{FE}$ | <br>8<br>5 | <br>−<br>− | <br>40<br>25 | − |
| Collector−Emitter Saturation Voltage<br>($I_C$ = 0.5 Adc, $I_B$ = 0.1 Adc)<br>($I_C$ = 1 Adc, $I_B$ = 0.25 Adc)<br>($I_C$ = 1.5 Adc, $I_B$ = 0.5 Adc)<br>($I_C$ = 1 Adc, $I_B$ = 0.25 Adc, $T_C$ = 100°C) | | $V_{CE(sat)}$ | <br>−<br>−<br>−<br>− | <br>−<br>−<br>−<br>− | <br>0.5<br>1<br>3<br>1 | Vdc |
| Base−Emitter Saturation Voltage<br>($I_C$ = 0.5 Adc, $I_B$ = 0.1 Adc)<br>($I_C$ = 1 Adc, $I_B$ = 0.25 Adc)<br>($I_C$ = 1 Adc, $I_B$ = 0.25 Adc, $T_C$ = 100°C) | | $V_{BE(sat)}$ | <br>−<br>−<br>− | <br>−<br>−<br>− | <br>1<br>1.2<br>1.1 | Vdc |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| Current−Gain − Bandwidth Product ($I_C$ = 100 mAdc, $V_{CE}$ = 10 Vdc, f = 1 MHz) | | $f_T$ | 4 | 10 | − | MHz |
| Output Capacitance ($V_{CB}$ = 10 Vdc, $I_E$ = 0, f = 0.1 MHz) | | $C_{ob}$ | − | 21 | − | pF |
| **SWITCHING CHARACTERISTICS** | | | | | | |
| Resistive Load (Table 1) | | | | | | |
| Delay Time | ($V_{CC}$ = 125 Vdc, $I_C$ = 1 A, $I_{B1}$ = $I_{B2}$ = 0.2 A, $t_p$ = 25 μs, Duty Cycle ≤ 1%) | $t_d$ | − | 0.05 | 0.1 | μs |
| Rise Time | | $t_r$ | − | 0.5 | 1 | μs |
| Storage Time | | $t_s$ | − | 2 | 4 | μs |
| Fall Time | | $t_f$ | − | 0.4 | 0.7 | μs |
| Inductive Load, Clamped (Table 1, Figure 13) | | | | | | |
| Storage Time | ($I_C$ = 1 A, $V_{clamp}$ = 300 Vdc, $I_{B1}$ = 0.2 A, $V_{BE(off)}$ = 5 Vdc, $T_C$ = 100°C) | $t_{sv}$ | − | 1.7 | 4 | μs |
| Crossover Time | | $t_c$ | − | 0.29 | 0.75 | μs |
| Fall Time | | $t_{fi}$ | − | 0.15 | − | μs |

2. Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%.

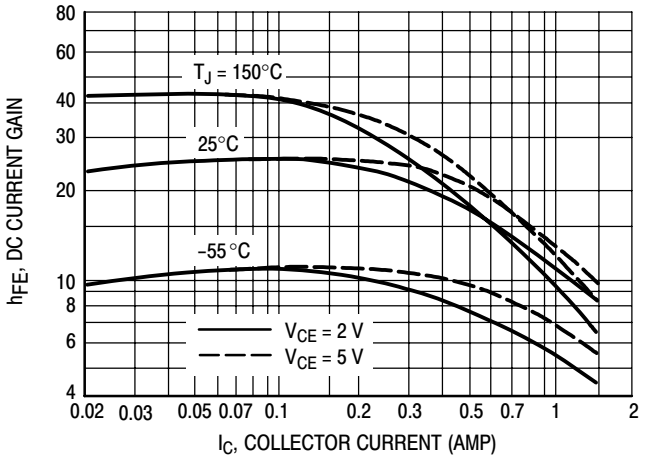



**Figure 1. DC Current Gain**

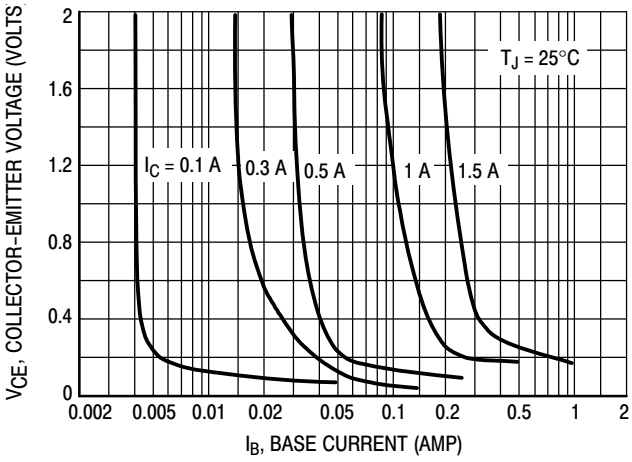



**Figure 2. Collector Saturation Region**

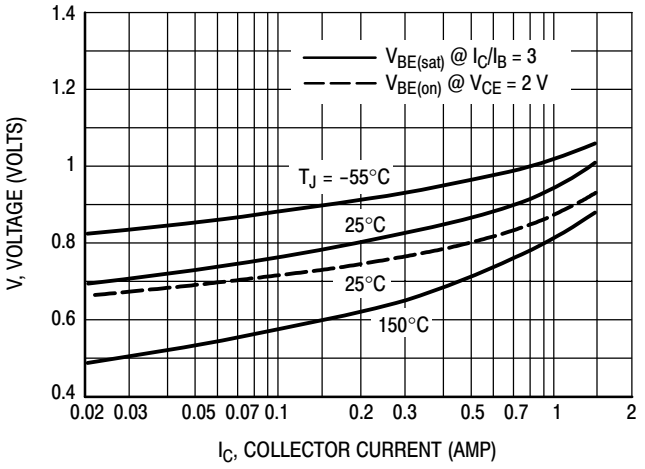



**Figure 3. Base−Emitter Voltage**

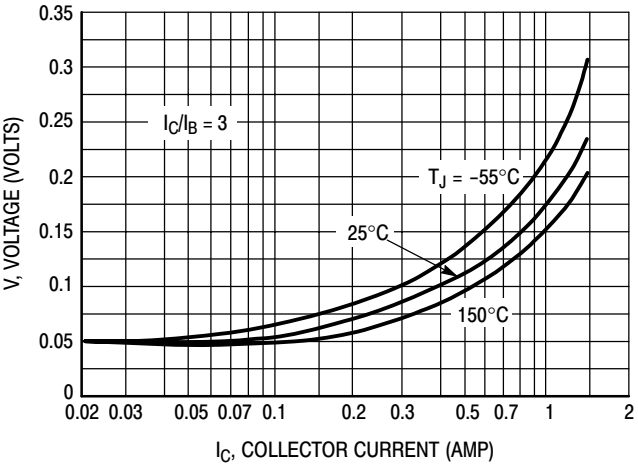



**Figure 4. Collector−Emitter Saturation Region**

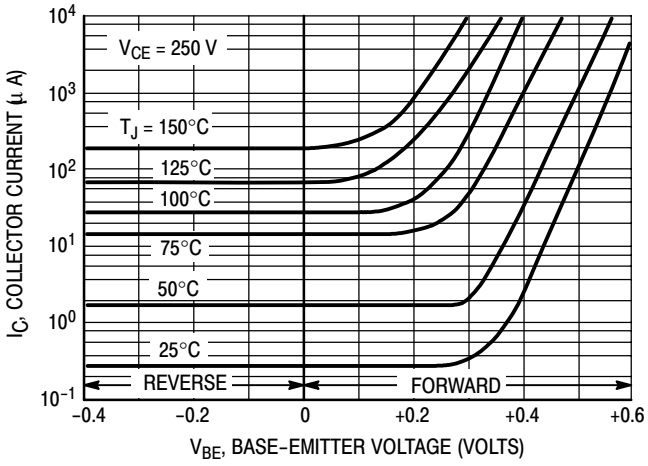



**Figure 5. Collector Cutoff Region**

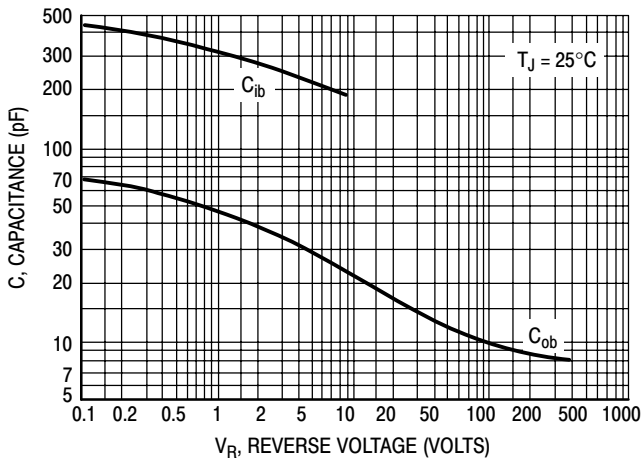
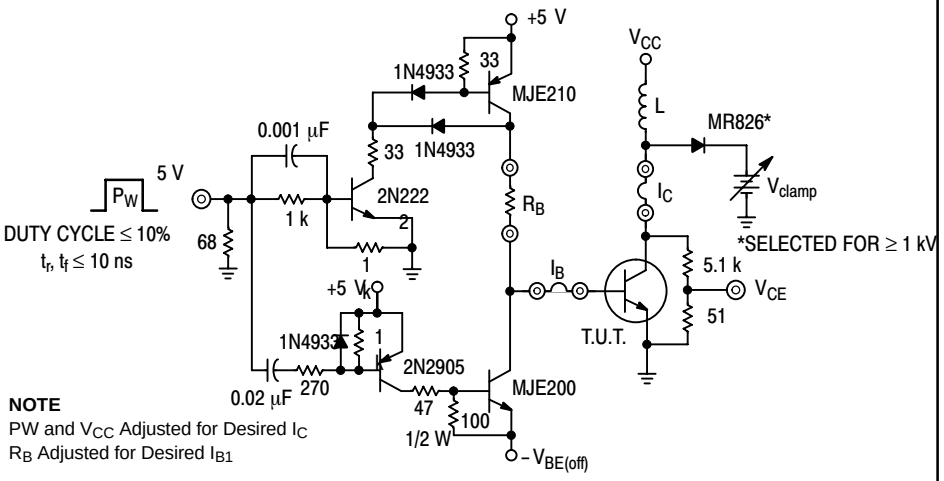
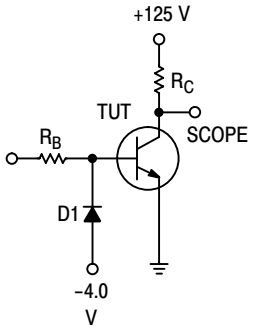
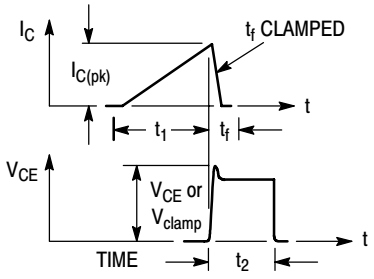
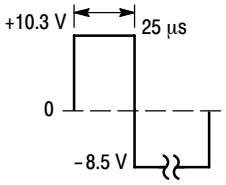



**Figure 6. Capacitance**

**Table 1. Test Conditions for Dynamic Performance**

| | REVERSE BIAS SAFE OPERATING AREA AND INDUCTIVE SWITCHING | RESISTIVE SWITCHING |
|---|---|---|
| TEST CIRCUITS |  |  |
| CIRCUIT VALUES | Coil Data:<br>Ferroxcube Core #6656<br>Full Bobbin (~200 Turns) #20<br>GAP for 30 mH/2 A<br>$L_{coil}$ = 50 mH<br>$V_{CC}$ = 20 V<br>$V_{clamp}$ = 300 Vdc | $V_{CC}$ = 125 V<br>$R_C$ = 125 Ω<br>D1 = 1N5820 or Equiv.<br>$R_B$ = 47 Ω |
| TEST WAVEFORMS | **OUTPUT WAVEFORMS**<br>  <br>$t_1$ Adjusted to Obtain $I_C$<br>$t_1 \approx \frac{L_{coil}(I_{C_{pk}})}{V_{CC}}$<br>$t_2 \approx \frac{L_{coil}(I_{C_{pk}})}{V_{clamp}}$<br>Test Equipment<br>Scope−Tektronics<br>475 or Equivalent |  <br>$t_r$, $t_f$ < 10 ns<br>Duty Cycle = 1.0%<br>$R_B$ and $R_C$ adjusted for desired $I_B$ and $I_C$ |