

# MJE18002G

## Switch-mode

### NPN Bipolar Power Transistor For Switching Power Supply Applications

The MJE18002G have an applications specific state-of-the-art die designed for use in 220 V line operated Switch-mode Power supplies and electronic light ballasts.

#### Features

- Improved Efficiency Due to Low Base Drive Requirements:
  - ♦ High and Flat DC Current Gain  $h_{FE}$
  - ♦ Fast Switching
  - ♦ No Coil Required in Base Circuit for Turn-Off (No Current Tail)
- Tight Parametric Distributions are Consistent Lot-to-Lot
- Standard TO-220
- These Devices are Pb-Free and are RoHS Compliant\*

#### MAXIMUM RATINGS

| Rating                                                                                 | Symbol         | Value      | Unit                     |
|----------------------------------------------------------------------------------------|----------------|------------|--------------------------|
| Collector-Emitter Sustaining Voltage                                                   | $V_{CEO}$      | 450        | Vdc                      |
| Collector-Emitter Breakdown Voltage                                                    | $V_{CES}$      | 1000       | Vdc                      |
| Emitter-Base Voltage                                                                   | $V_{EBO}$      | 9.0        | Vdc                      |
| Collector Current – Continuous                                                         | $I_C$          | 2.0        | Adc                      |
| – Peak (Note 1)                                                                        | $I_{CM}$       | 5.0        |                          |
| Base Current – Continuous                                                              | $I_B$          | 1.0        | Adc                      |
| – Peak (Note 1)                                                                        | $I_{BM}$       | 2.0        |                          |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$          | 50<br>0.4  | W<br>W/ $^\circ\text{C}$ |
| Operating and Storage Temperature                                                      | $T_J, T_{stg}$ | -65 to 150 | $^\circ\text{C}$         |

#### THERMAL CHARACTERISTICS

| Characteristics                                                                 | Symbol          | Max  | Unit               |
|---------------------------------------------------------------------------------|-----------------|------|--------------------|
| Thermal Resistance, Junction-to-Case                                            | $R_{\theta JC}$ | 2.5  | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction-to-Ambient                                         | $R_{\theta JA}$ | 62.5 | $^\circ\text{C/W}$ |
| Maximum Lead Temperature for Soldering<br>Purposes 1/8" from Case for 5 Seconds | $T_L$           | 260  | $^\circ\text{C}$   |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

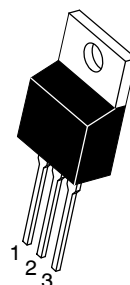
1. Pulse Test: Pulse Width = 5 ms, Duty Cycle  $\leq 10\%$ .



ON Semiconductor®

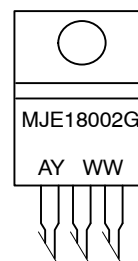
<http://onsemi.com>

**POWER TRANSISTOR  
2.0 AMPERES  
100 VOLTS – 50 WATTS**



TO-220AB  
CASE 221A-09  
STYLE 1

#### MARKING DIAGRAM



A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

#### ORDERING INFORMATION

| Device    | Package             | Shipping        |
|-----------|---------------------|-----------------|
| MJE18002G | TO-220<br>(Pb-Free) | 50 Units / Rail |

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# MJE18002G

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

| Characteristic                                                                                                                                |                                                                              |        |                          | Symbol                | Min    | Typ           | Max         | Unit |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------|--------------------------|-----------------------|--------|---------------|-------------|------|--|
| OFF CHARACTERISTICS                                                                                                                           |                                                                              |        |                          |                       |        |               |             |      |  |
| Collector–Emitter Sustaining Voltage (I <sub>C</sub> = 100 mA, L = 25 mH)                                                                     |                                                                              |        |                          | V <sub>CEO(sus)</sub> | 450    | –             | –           | Vdc  |  |
| Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CEO</sub> , I <sub>B</sub> = 0)                                                      |                                                                              |        |                          | I <sub>CEO</sub>      | –      | –             | 100         | μAdc |  |
| Collector Cutoff Current (V <sub>CE</sub> = Rated V <sub>CES</sub> , V <sub>EB</sub> = 0)<br>(V <sub>CE</sub> = 800 V, V <sub>EB</sub> = 0)   |                                                                              |        |                          | I <sub>CES</sub>      | –      | –             | 100         | μAdc |  |
|                                                                                                                                               |                                                                              |        |                          |                       | –      | –             | 500         |      |  |
|                                                                                                                                               |                                                                              |        |                          |                       | –      | –             | 100         |      |  |
| Emitter Cutoff Current<br>(V <sub>EB</sub> = 9.0 Vdc, I <sub>C</sub> = 0)                                                                     |                                                                              |        |                          | I <sub>EBO</sub>      | –      | –             | 100         | μAdc |  |
| ON CHARACTERISTICS                                                                                                                            |                                                                              |        |                          |                       |        |               |             |      |  |
| Base–Emitter Saturation Voltage (I <sub>C</sub> = 0.4 Adc, I <sub>B</sub> = 40 mAdc)<br>(I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.2 Adc)  |                                                                              |        |                          | V <sub>BE(sat)</sub>  | –<br>– | 0.825<br>0.92 | 1.1<br>1.25 | Vdc  |  |
| Collector–Emitter Saturation Voltage<br>(I <sub>C</sub> = 0.4 Adc, I <sub>B</sub> = 40 mAdc)                                                  |                                                                              |        |                          | V <sub>CE(sat)</sub>  | –      | 0.2           | 0.5         | Vdc  |  |
| @ T <sub>C</sub> = 125°C                                                                                                                      |                                                                              |        |                          |                       | –      | 0.2           | 0.5         |      |  |
| (I <sub>C</sub> = 1.0 Adc, I <sub>B</sub> = 0.2 Adc)                                                                                          |                                                                              |        |                          |                       | –      | 0.25          | 0.5         |      |  |
| @ T <sub>C</sub> = 125°C                                                                                                                      |                                                                              |        |                          |                       | –      | 0.3           | 0.6         |      |  |
| DC Current Gain (I <sub>C</sub> = 0.2 Adc, V <sub>CE</sub> = 5.0 Vdc)                                                                         |                                                                              |        |                          | h <sub>FE</sub>       | 14     | –             | 34          | –    |  |
| @ T <sub>C</sub> = 125°C                                                                                                                      |                                                                              |        |                          |                       | –      | 27            | –           |      |  |
| (I <sub>C</sub> = 0.4 Adc, V <sub>CE</sub> = 1.0 Vdc)                                                                                         |                                                                              |        |                          |                       | 11     | 17            | –           |      |  |
| @ T <sub>C</sub> = 125°C                                                                                                                      |                                                                              |        |                          |                       | 11     | 20            | –           |      |  |
| (I <sub>C</sub> = 1.0 Adc, V <sub>CE</sub> = 1.0 Vdc)                                                                                         |                                                                              |        |                          |                       | 6.0    | 8.0           | –           |      |  |
| @ T <sub>C</sub> = 125°C                                                                                                                      |                                                                              |        |                          |                       | 5.0    | 8.0           | –           |      |  |
| (I <sub>C</sub> = 10 mAdc, V <sub>CE</sub> = 5.0 Vdc)                                                                                         |                                                                              |        |                          |                       | 10     | 20            | –           |      |  |
| DYNAMIC CHARACTERISTICS                                                                                                                       |                                                                              |        |                          |                       |        |               |             |      |  |
| Current Gain Bandwidth<br>(I <sub>C</sub> = 0.2 Adc, V <sub>CE</sub> = 10 Vdc, f = 1.0 MHz)                                                   |                                                                              |        |                          | f <sub>T</sub>        | –      | 13            | –           | MHz  |  |
| Output Capacitance<br>(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 1.0 MHz)                                                             |                                                                              |        |                          | C <sub>ob</sub>       | –      | 35            | 60          | pF   |  |
| Input Capacitance<br>(V <sub>EB</sub> = 8.0 V)                                                                                                |                                                                              |        |                          | C <sub>ib</sub>       | –      | 400           | 600         | pF   |  |
| Dynamic Saturation:<br><br>determined 1.0 μs and<br>3.0 μs after rising I <sub>B1</sub><br>reach 0.9 final I <sub>B1</sub><br>(see Figure 18) | I <sub>C</sub> = 0.4 A<br>I <sub>B1</sub> = 40 mA<br>V <sub>CC</sub> = 300 V | 1.0 μs | @ T <sub>C</sub> = 125°C | V <sub>CE(dsat)</sub> | –<br>– | 3.5<br>8.0    | –<br>–      | Vdc  |  |
|                                                                                                                                               |                                                                              | 3.0 μs | @ T <sub>C</sub> = 125°C |                       | –<br>– | 1.5<br>3.8    | –<br>–      |      |  |
|                                                                                                                                               | I <sub>C</sub> = 1.0 A<br>I <sub>B1</sub> = 0.2 A<br>V <sub>CC</sub> = 300 V | 1.0 μs | @ T <sub>C</sub> = 125°C |                       | –<br>– | 8.0<br>14     | –<br>–      |      |  |
|                                                                                                                                               |                                                                              | 3.0 μs | @ T <sub>C</sub> = 125°C |                       | –<br>– | 2.0<br>7.0    | –<br>–      |      |  |
|                                                                                                                                               |                                                                              |        |                          |                       |        |               |             |      |  |
|                                                                                                                                               |                                                                              |        |                          |                       |        |               |             |      |  |

# MJE18002G

## ELECTRICAL CHARACTERISTICS – continued ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

### SWITCHING CHARACTERISTICS: Resistive Load ( $D.C. \leq 10\%$ , Pulse Width = 20 $\mu\text{s}$ )

|               |                                                                                                                 |                             |           |   |            |          |               |
|---------------|-----------------------------------------------------------------------------------------------------------------|-----------------------------|-----------|---|------------|----------|---------------|
| Turn-On Time  | $I_C = 0.4 \text{ Adc}$<br>$I_{B1} = 40 \text{ mAdc}$<br>$I_{B2} = 0.2 \text{ Adc}$<br>$V_{CC} = 300 \text{ V}$ | @ $T_C = 125^\circ\text{C}$ | $t_{on}$  | – | 200<br>130 | 300<br>– | ns            |
| Turn-Off Time |                                                                                                                 | @ $T_C = 125^\circ\text{C}$ | $t_{off}$ | – | 1.2<br>1.5 | 2.5<br>– | $\mu\text{s}$ |
| Turn-On Time  | $I_C = 1.0 \text{ Adc}$<br>$I_{B1} = 0.2 \text{ Adc}$<br>$I_{B2} = 0.5 \text{ Adc}$<br>$V_{CC} = 300 \text{ V}$ | @ $T_C = 125^\circ\text{C}$ | $t_{on}$  | – | 85<br>95   | 150<br>– | ns            |
| Turn-Off Time |                                                                                                                 | @ $T_C = 125^\circ\text{C}$ | $t_{off}$ | – | 1.7<br>2.1 | 2.5<br>– | $\mu\text{s}$ |

### SWITCHING CHARACTERISTICS: Inductive Load ( $V_{clamp} = 300 \text{ V}$ , $V_{CC} = 15 \text{ V}$ , $L = 200 \mu\text{H}$ )

|                |                                                                                      |                             |          |   |             |           |               |
|----------------|--------------------------------------------------------------------------------------|-----------------------------|----------|---|-------------|-----------|---------------|
| Fall Time      | $I_C = 0.4 \text{ Adc}$ , $I_{B1} = 40 \text{ mAdc}$ ,<br>$I_{B2} = 0.2 \text{ Adc}$ | @ $T_C = 125^\circ\text{C}$ | $t_{fi}$ | – | 125<br>120  | 200<br>–  | ns            |
| Storage Time   |                                                                                      | @ $T_C = 125^\circ\text{C}$ | $t_{si}$ | – | 0.7<br>0.8  | 1.25<br>– | $\mu\text{s}$ |
| Crossover Time |                                                                                      | @ $T_C = 125^\circ\text{C}$ | $t_c$    | – | 110<br>110  | 200<br>–  | ns            |
| Fall Time      | $I_C = 1.0 \text{ Adc}$ , $I_{B1} = 0.2 \text{ Adc}$ ,<br>$I_{B2} = 0.5 \text{ Adc}$ | @ $T_C = 125^\circ\text{C}$ | $t_{fi}$ | – | 110<br>120  | 175<br>–  | ns            |
| Storage Time   |                                                                                      | @ $T_C = 125^\circ\text{C}$ | $t_{si}$ | – | 1.7<br>2.25 | 2.75<br>– | $\mu\text{s}$ |
| Crossover Time |                                                                                      | @ $T_C = 125^\circ\text{C}$ | $t_c$    | – | 200<br>250  | 300<br>–  | ns            |
| Fall Time      | $I_C = 0.4 \text{ Adc}$ , $I_{B1} = 50 \text{ mAdc}$ ,<br>$I_{B2} = 50 \text{ mAdc}$ | @ $T_C = 125^\circ\text{C}$ | $t_{fi}$ | – | 140<br>185  | 200<br>–  | ns            |
| Storage Time   |                                                                                      | @ $T_C = 125^\circ\text{C}$ | $t_{si}$ | – | 2.2<br>2.5  | 3.0<br>–  | $\mu\text{s}$ |
| Crossover Time |                                                                                      | @ $T_C = 125^\circ\text{C}$ | $t_c$    | – | 140<br>220  | 250<br>–  | ns            |

TYPICAL STATIC CHARACTERISTICS

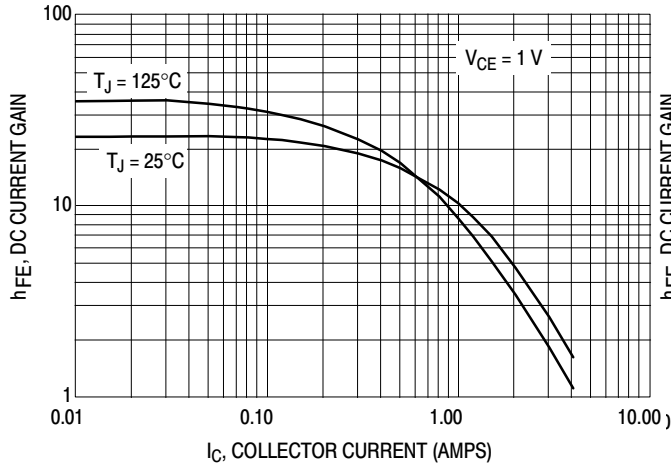


Figure 1. DC Current Gain @ 1 Volt

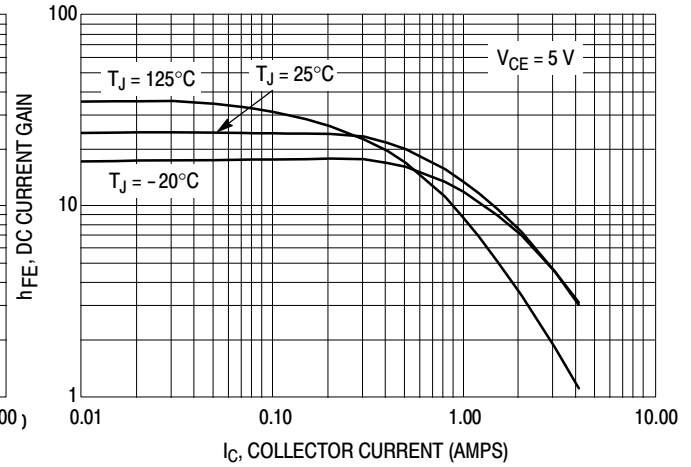


Figure 2. DC Current Gain @ 5 Volts

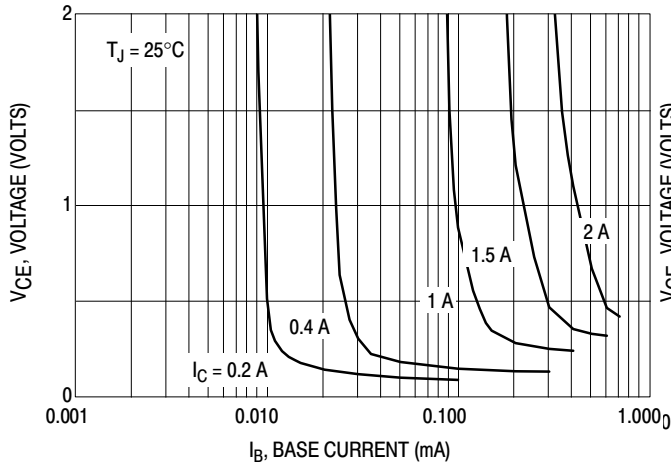


Figure 3. Collector Saturation Region

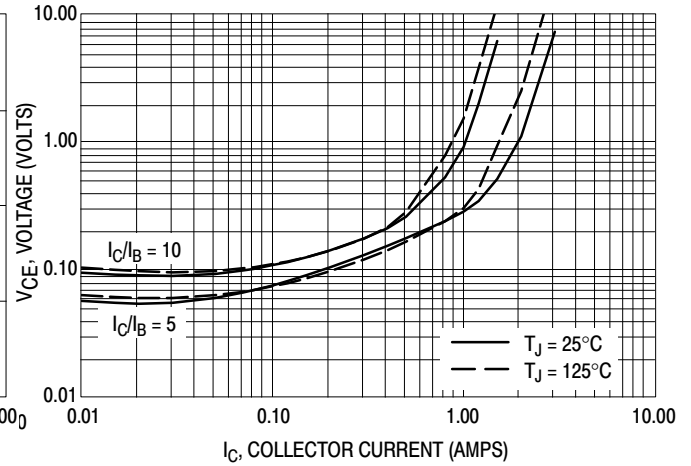


Figure 4. Collector-Emitter Saturation Voltage

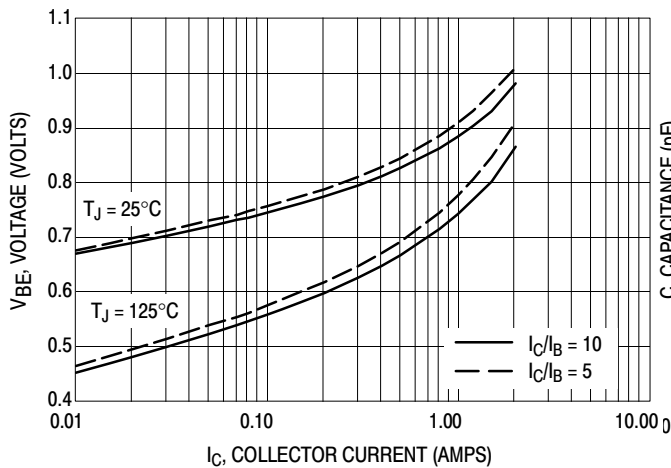


Figure 5. Base-Emitter Saturation Region

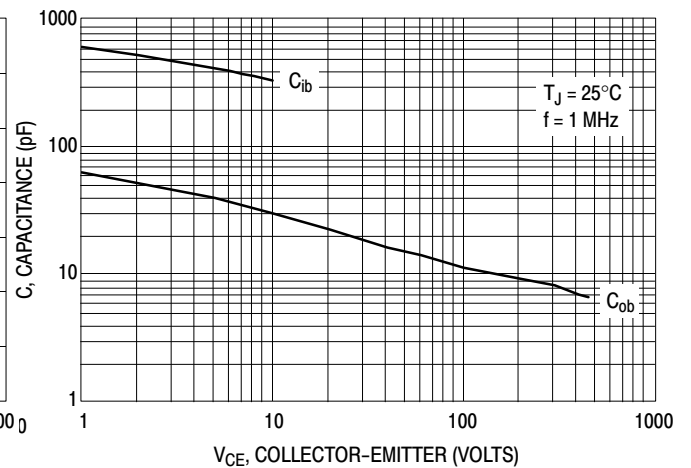


Figure 6. Capacitance

**TYPICAL SWITCHING CHARACTERISTICS**  
( $I_{B2} = I_C/2$  for all switching)

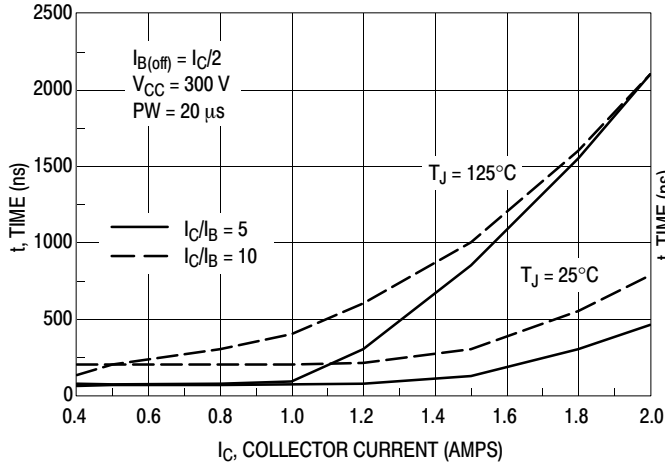


Figure 7. Resistive Switching,  $t_{on}$

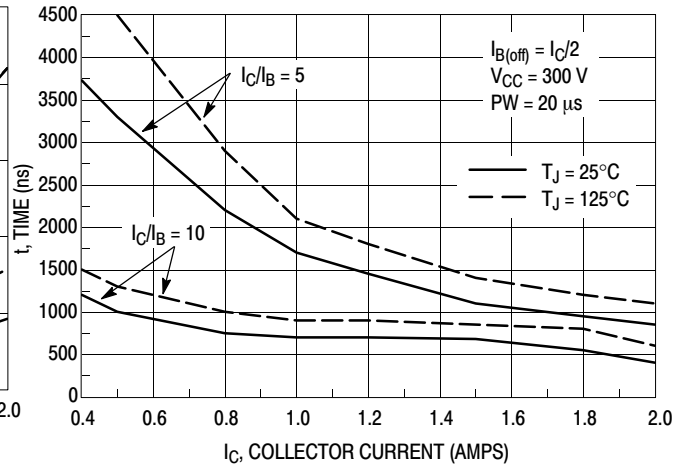


Figure 8. Resistive Switching,  $t_{off}$

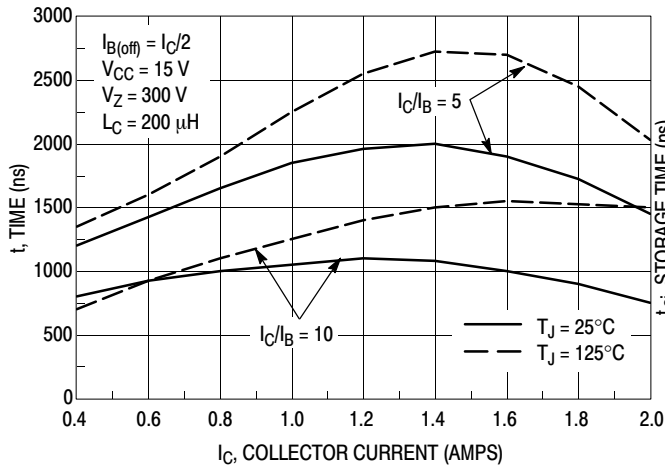


Figure 9. Inductive Storage Time,  $t_{si}$

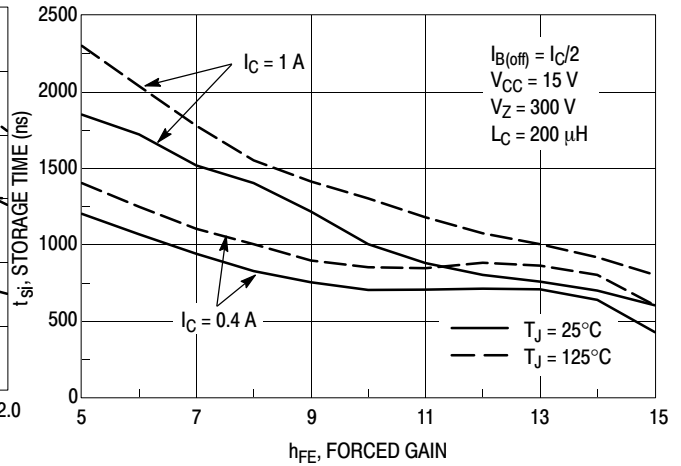


Figure 10. Inductive Storage Time

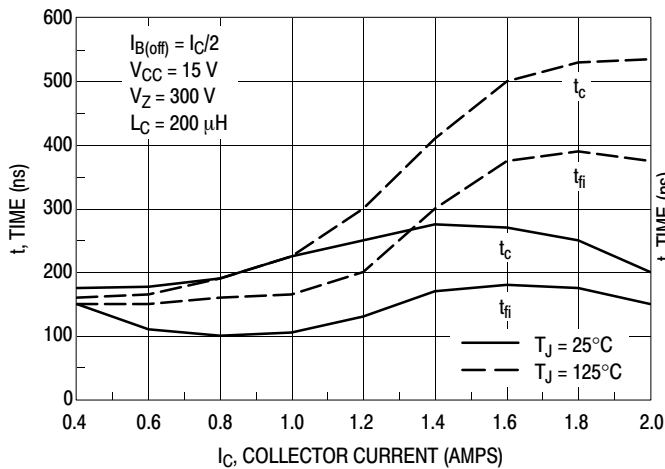


Figure 11. Inductive Switching,  $t_c$  and  $t_{fi}$ ,  $I_C/I_B = 5$

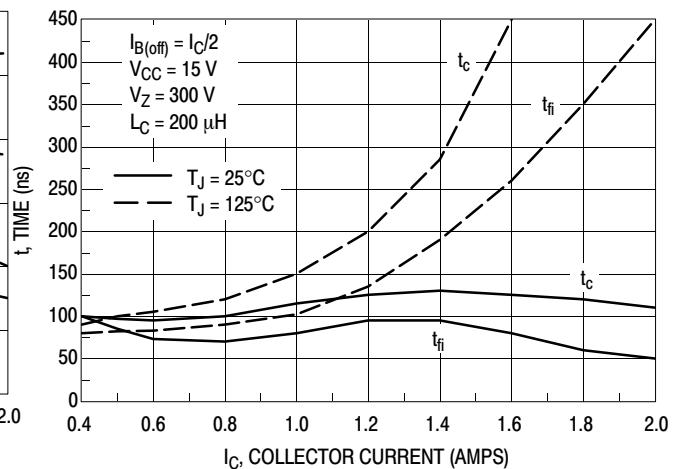


Figure 12. Inductive Switching,  $t_c$  and  $t_{fi}$ ,  $I_C/I_B = 10$

**TYPICAL SWITCHING CHARACTERISTICS**  
( $I_{B2} = I_C/2$  for all switching)

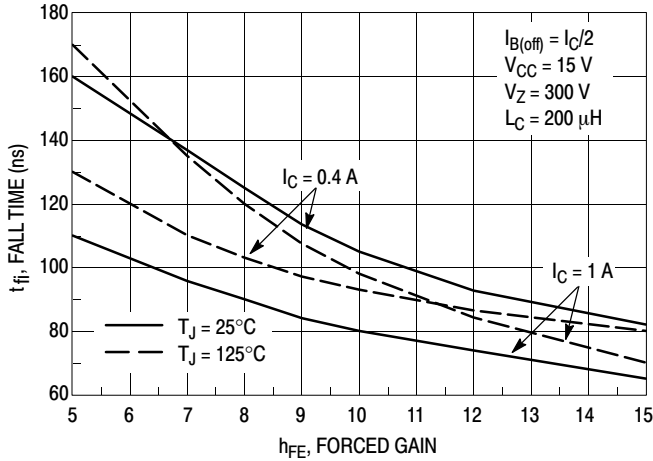


Figure 13. Inductive Fall Time

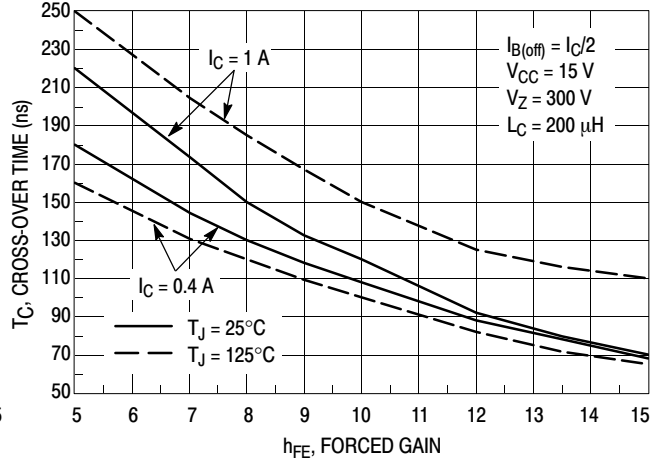


Figure 14. Inductive Crossover Time

**GUARANTEED SAFE OPERATING AREA INFORMATION**

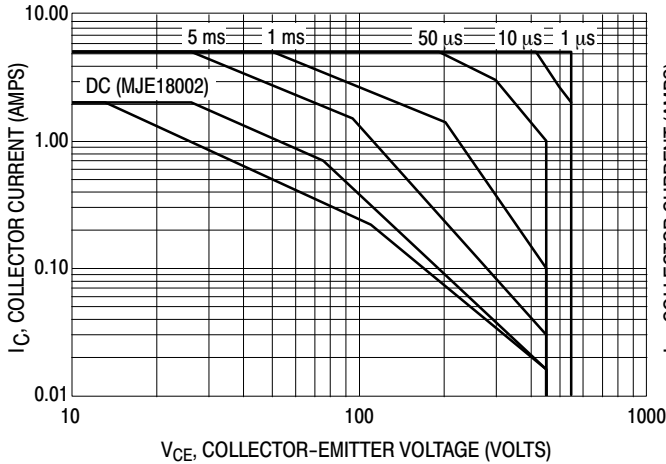


Figure 15. Forward Bias Safe Operating Area

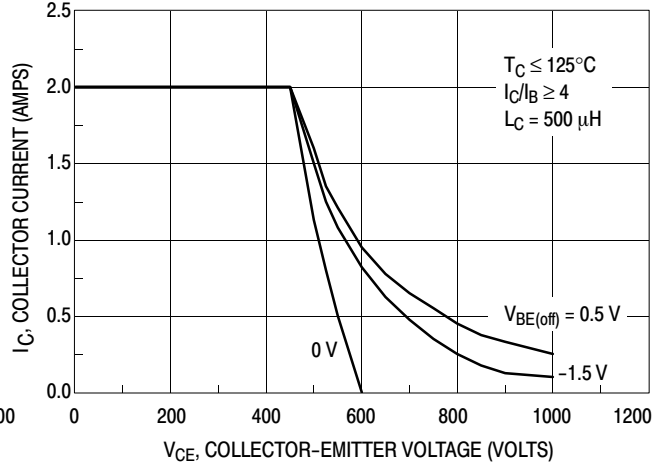


Figure 16. Reverse Bias Switching Safe Operating Area

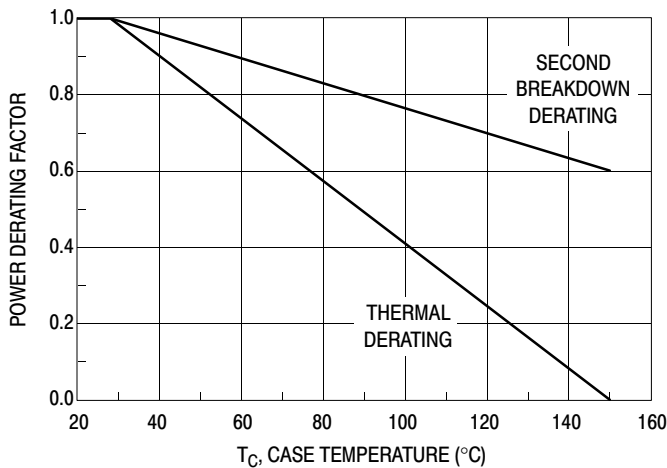


Figure 17. Forward Bias Power Derating

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C$ - $V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 15 is based on  $T_C = 25^\circ\text{C}$ ;  $T_J(\text{pk})$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C > 25^\circ\text{C}$ . Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 17.  $T_J(\text{pk})$  may be calculated from the data in Figures 20. At any case temperatures, thermal limitations will reduce the power that can be handled to values less the limitations imposed by second breakdown. For inductive loads, high voltage and current must be sustained simultaneously during turn-off with the base to emitter junction reverse biased. The safe level is specified as a reverse biased safe operating area (Figure 16). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

# MJE18002G

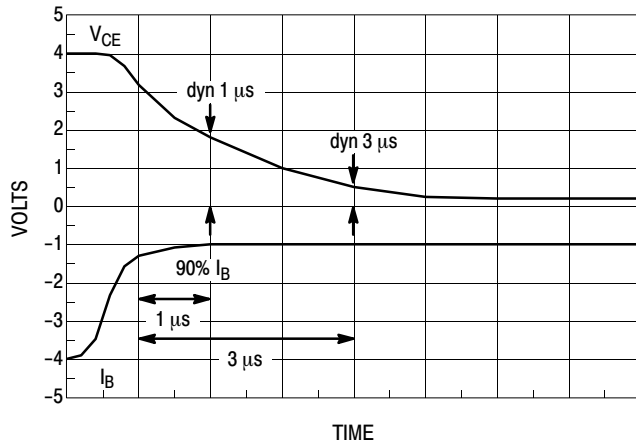


Figure 18. Dynamic Saturation Voltage Measurements

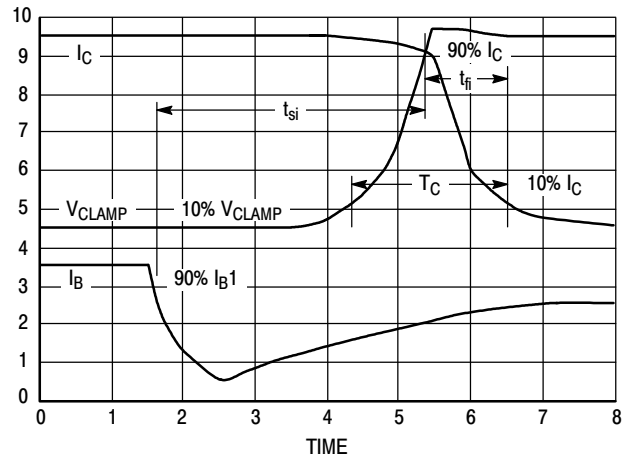
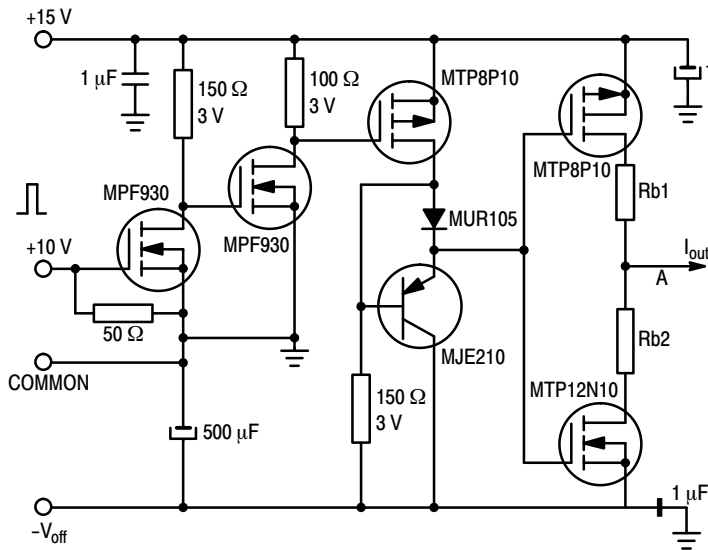


Figure 19. Inductive Switching Measurements



**V(BR)CEO(sus)**  
 $L = 10 \mu\text{H}$   
 $R_{B2} = \infty$   
 $V_{CC} = 20 \text{ VOLTS}$   
 $I_{C(pk)} = 100 \text{ mA}$

**INDUCTIVE SWITCHING**  
 $L = 200 \mu\text{H}$   
 $R_{B2} = 0$   
 $V_{CC} = 15 \text{ VOLTS}$   
 $R_{B1}$  SELECTED FOR  
 DESIRED  $I_{B1}$

**RBSOA**  
 $L = 500 \mu\text{H}$   
 $R_{B2} = 0$   
 $V_{CC} = 15 \text{ VOLTS}$   
 $R_{B1}$  SELECTED  
 FOR DESIRED  $I_{B1}$

Table 1. Inductive Load Switching Drive Circuit

## TYPICAL THERMAL RESPONSE

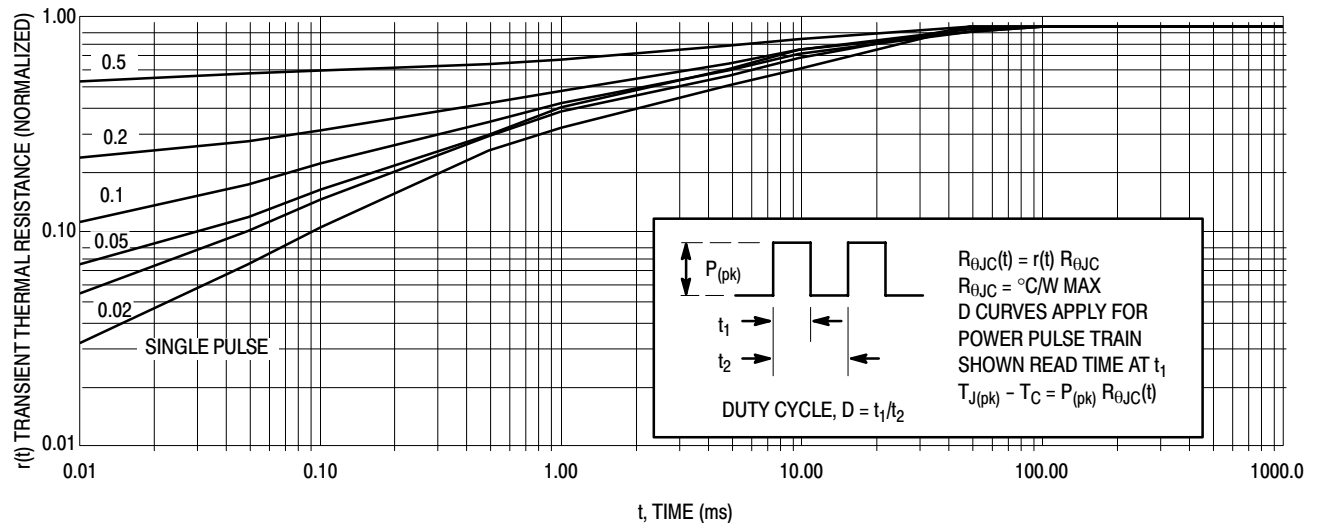


Figure 20. Typical Thermal Response ( $Z_{\theta JC}(t)$ ) for MJE18002

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