

16 A, 600 V, low drop IGBT with soft and fast recovery diode

Features

- Low on-voltage drop ($V_{CE(sat)}$)
- High current capability
- Very soft ultra fast recovery antiparallel diode

Applications

- Light dimmer
- Static relays
- Motor drive

Description

This IGBT utilizes the advanced Power MESH™ process featuring extremely low on-state voltage drop in low-frequency working conditions (up to 1 kHz).

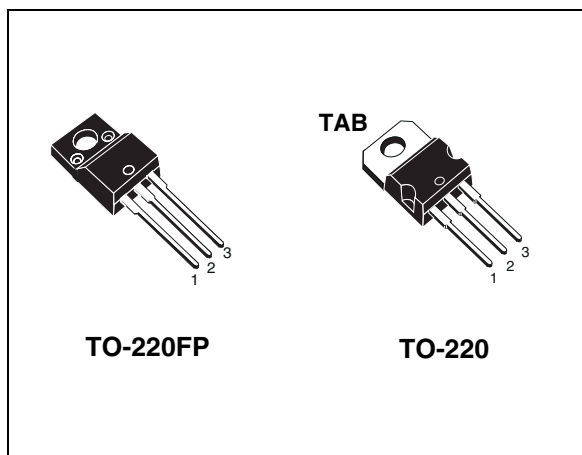


Figure 1. Internal schematic diagram

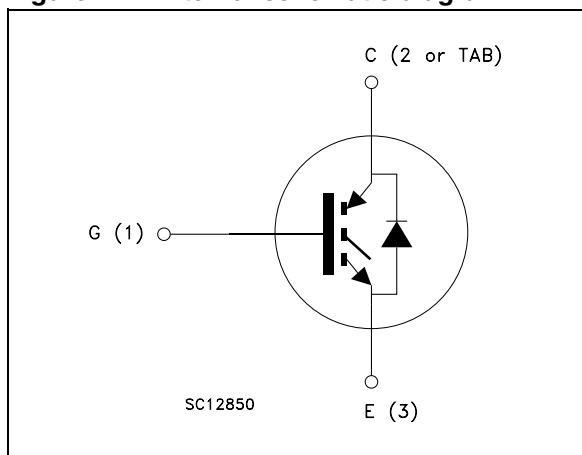


Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|--------------|------------|----------|-----------|
| STGF10NB60SD | GF10NB60SD | TO-220FP | Tube |
| STGP10NB60SD | GP10NB60SD | TO-220 | Tube |

Contents

| | | |
|----------|---|-----------|
| 1 | Electrical ratings | 3 |
| 2 | Electrical characteristics | 4 |
| | 2.1 Electrical characteristics (curves) | 6 |
| 3 | Test circuits | 9 |
| 4 | Package mechanical data | 10 |
| 5 | Revision history | 14 |

1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|--------------------------------|---|--------------|--------------|------|
| | | STGF10NB60SD | STGP10NB60SD | |
| V _{CES} | Collector-emitter voltage (V _{GE} = 0) | 600 | | V |
| I _C ⁽¹⁾ | Continuous collector current at T _C = 25 °C | 23 | 29 | A |
| I _C ⁽¹⁾ | Continuous collector current at T _C = 100 °C | 12 | 16 | A |
| I _{CL} ⁽²⁾ | Turn-off latching current | 20 | | A |
| I _{CP} ⁽³⁾ | Pulsed collector current | 80 | | A |
| V _{GE} | Gate-emitter voltage | ±20 | | V |
| I _F | Diode RMS forward current at T _C = 25 °C | 20 | | A |
| I _{FSM} | Surge non repetitive forward current t _p = 10 ms sinusoidal | 55 | | A |
| V _{ISO} | Isolation withstand voltage (RMS) from all three leads to external heatsink (t=1 s; T _C = 25 °C) | 2500 | | V |
| P _{TOT} | Total dissipation at T _C = 25 °C | 25 | 80 | W |
| T _j | Operating junction temperature | – 55 to 150 | | °C |

1. Calculated according to the iterative formula

$$I_C(T_C) = \frac{T_{j(max)} - T_C}{R_{thj-c} \times V_{CE(sat)(max)}(T_{j(max)}, I_C(T_C))}$$

2. V_{clamp} = 80% of V_{CES}, T_j = 150 °C, R_G = 1kΩ, V_{GE} = 15 V

3. Pulse width limited by maximum junction temperature and turn-off within RBSOA

Table 3. Thermal data

| Symbol | Parameter | Value | | Unit |
|-----------------------|--|--------------|--------------|------|
| | | STGF10NB60SD | STGP10NB60SD | |
| R _{thj-case} | Thermal resistance junction-case IGBT | 5 | 1.56 | °C/W |
| R _{thj-case} | Thermal resistance junction-case diode | 5.6 | 2.2 | °C/W |
| R _{thj-amb} | Thermal resistance junction-ambient | 62.5 | | °C/W |

2 Electrical characteristics

($T_j = 25\text{ °C}$ unless otherwise specified)

Table 4. Static

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------|--|---|------|----------------------|-----------|--------------------------------|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage ($V_{GE} = 0$) | $I_C = 250\ \mu\text{A}$ | 600 | | | V |
| $V_{(BR)ECS}$ | Emitter-collector breakdown voltage ($V_{GE} = 0$) | $I_C = 1\ \text{mA}$ | 20 | | | V |
| I_{GES} | Gate-emitter leakage current ($V_{CE} = 0$) | $V_{GE} = \pm 20\ \text{V}$ | | | ± 100 | nA |
| I_{CES} | Collector cut-off current ($V_{GE} = 0$) | $V_{CE} = 600\ \text{V}$ $V_{CE} = 600\ \text{V}, T_j = 125\text{ °C}$ | | | 10 100 | μA μA |
| $V_{GE(th)}$ | Gate threshold voltage | $V_{CE} = V_{GE}, I_C = 250\ \mu\text{A}$ | 2.5 | | 5 | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\ \text{V}, I_C = 5\ \text{A}$ $V_{GE} = 15\ \text{V}, I_C = 10\ \text{A}$ $V_{GE} = 15\ \text{V}, I_C = 10\ \text{A}, T_j = 125\text{ °C}$ | | 1.15 1.35 1.25 | 1.75 | V |
| $g_{fs}^{(1)}$ | Forward transconductance | $V_{CE} = 15\ \text{V}, I_C = 10\ \text{A}$ | 5 | | | S |

1. Pulsed: Pulse duration = 300 μs , duty cycle 1.5%

Table 5. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|--|------|------|------|------|
| C_{ies} | Input capacitance | | | 610 | | pF |
| C_{oes} | Output capacitance | $V_{CE} = 25\ \text{V}, f = 1\ \text{MHz}, V_{GE} = 0$ | - | 65 | - | pF |
| C_{res} | Reverse transfer capacitance | | | 12 | | pF |
| Q_g | Total gate charge | $V_{CE} = 400\ \text{V}, I_C = 10\ \text{A}, V_{GE} = 15\ \text{V}$ (see Figure 19) | - | 33 | - | nC |

Table 6. Switching on/off (inductive load)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------|-----------------------|--|------|------|------|------------------|
| $t_{d(on)}$ | Turn-on delay time | $V_{CC} = 480\text{ V}, I_C = 10\text{ A}$ | | 0.7 | | μs |
| t_r | Current rise time | $R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V}$ | - | 0.46 | - | μs |
| $(di/dt)_{on}$ | Turn-on current slope | (see Figure 18) | | 8 | | A/ μs |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 480\text{ V}, I_C = 10\text{ A}$ | | 2.2 | | |
| $t_{d(off)}$ | Turn-off delay time | $R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V}$ | - | 1.2 | - | μs |
| t_f | Current fall time | (see Figure 18) | | 1.2 | | |
| $t_r(V_{off})$ | Off voltage rise time | $V_{CC} = 480\text{ V}, I_C = 10\text{ A}$ | | 3.8 | | |
| $t_{d(off)}$ | Turn-off delay time | $R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V},$ $T_j = 125\text{ }^\circ\text{C}$ | - | 1.2 | - | μs |
| t_f | Current fall time | (see Figure 18) | | 1.9 | | |

Table 7. Switching energy (inductive load)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|---------------------------|---|------|------|------|------|
| $E_{on}^{(1)}$ | Turn-on switching losses | $V_{CC} = 480\text{ V}, I_C = 10\text{ A}$ | | 0.6 | | mJ |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V}$ | - | 5 | - | mJ |
| E_{ts} | Total switching losses | (see Figure 18) | | 5.6 | | mJ |
| $E_{off}^{(2)}$ | Turn-off switching losses | $V_{CC} = 480\text{ V}, I_C = 10\text{ A}$ $R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V},$ $T_j = 125\text{ }^\circ\text{C}$ (see Figure 18) | - | 8 | - | mJ |

1. E_{on} is the turn-on losses when a typical diode is used in the test circuit. If the IGBT is offered in a package with a co-pack diode, the co-pack diode is used as external diode. IGBTs and diode are at the same temperature (25°C and 125°C)
2. Turn-off losses include also the tail of the collector current.

Table 8. Collector-emitter diode

| Symbol | Parameter | Test conditions | Min | Typ. | Max | Unit |
|-----------|--------------------------|---|-----|------|-----|--------|
| V_F | Forward on-voltage | $I_F = 10\text{ A}$ $I_F = 10\text{ A}, T_C = 125\text{ }^\circ\text{C}$ | | 1.4 | 2.2 | V V |
| t_{rr} | Reverse recovery time | $I_F = 7\text{ A}, V_R = 40\text{ V},$ $di/dt = 100\text{ A}/\mu\text{s}$ (see Figure 21) | | 37 | | ns |
| Q_{rr} | Reverse recovery charge | | | 40 | | nC |
| I_{rrm} | Reverse recovery current | | | 2.1 | | A |
| t_{rr} | Reverse recovery time | $I_F = 7\text{ A}, V_R = 40\text{ V},$ $T_j = 125\text{ }^\circ\text{C},$ $di/dt = 100\text{ A}/\mu\text{s}$ (see Figure 21) | | 61 | | ns |
| Q_{rr} | Reverse recovery charge | | | 98 | | nC |
| I_{rrm} | Reverse recovery current | | | 3.2 | | A |

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

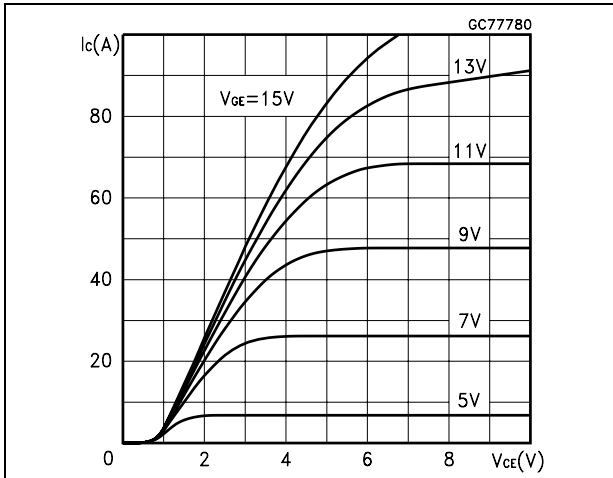


Figure 3. Transfer characteristics

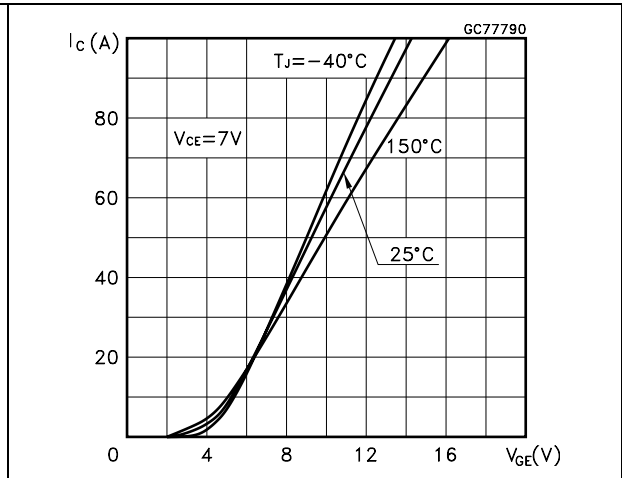


Figure 4. Transconductance

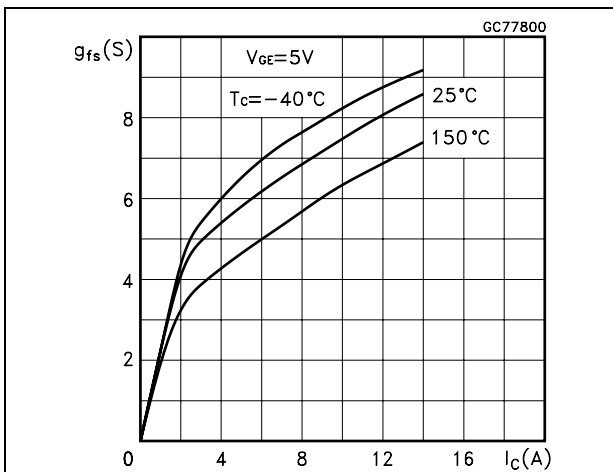


Figure 5. Collector-emitter on voltage vs. temperature

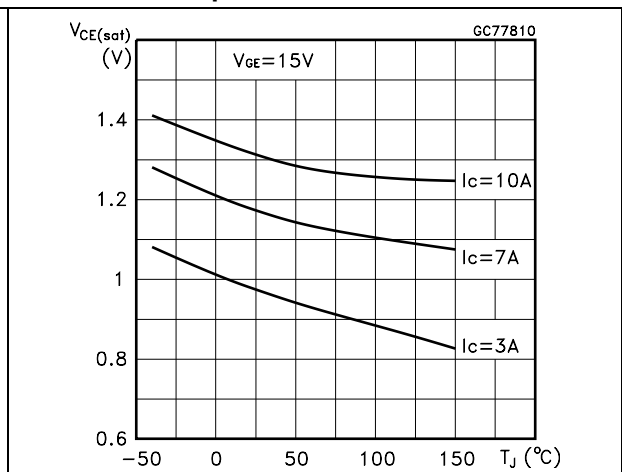


Figure 6. Collector-emitter on voltage vs. collector current

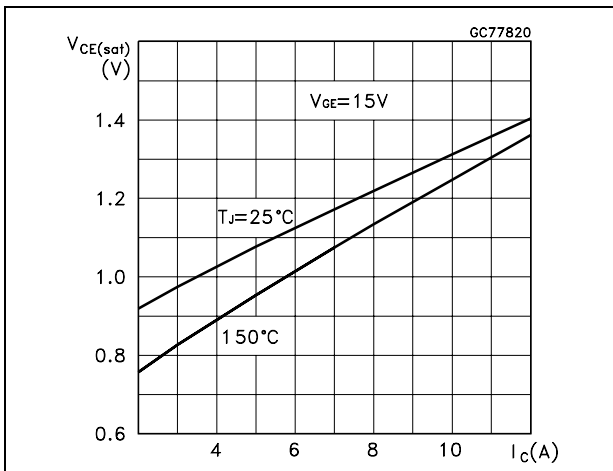


Figure 7. Normalized gate threshold vs. temperature

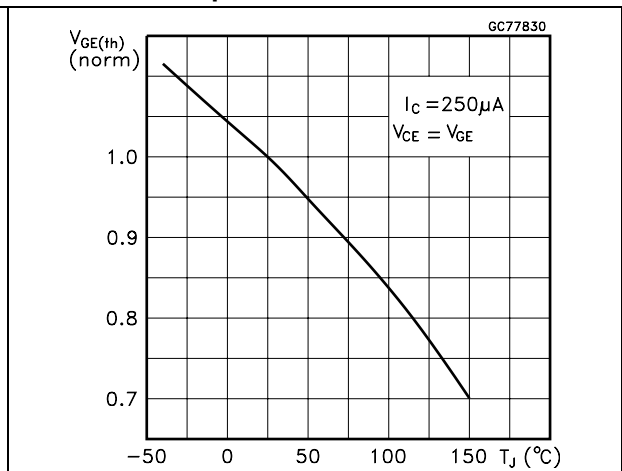


Figure 8. Normalized breakdown voltage vs. temperature

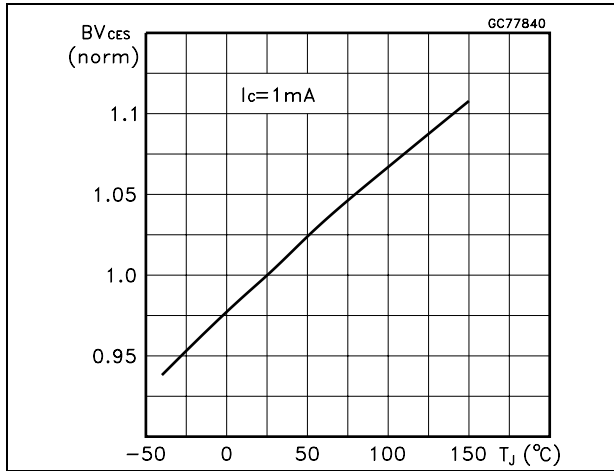


Figure 9. Gate charge vs. gate-emitter voltage

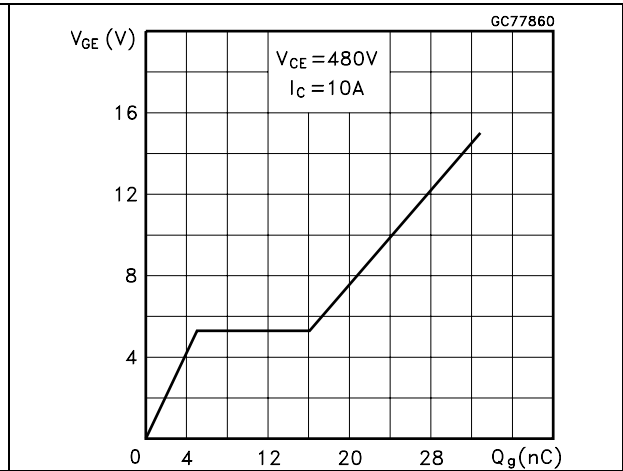


Figure 10. Capacitance variations

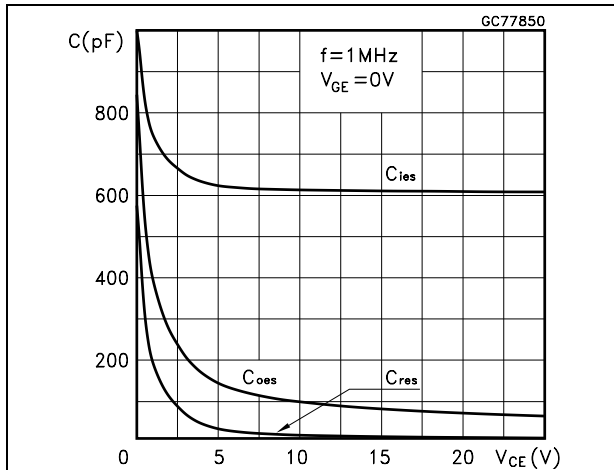


Figure 11. Switching losses vs. temperature

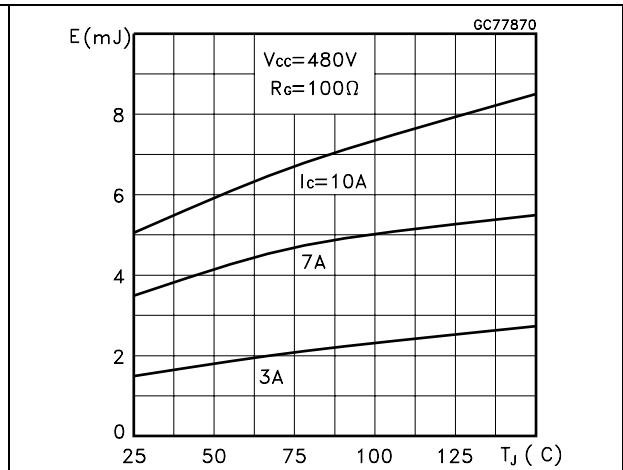


Figure 12. Switching losses vs. gate resistance

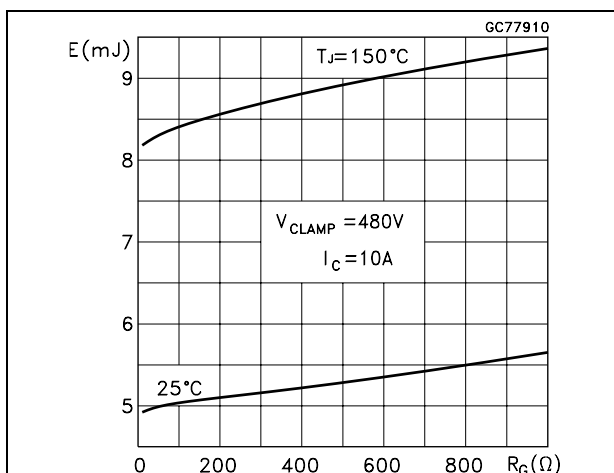


Figure 13. Switching losses vs. collector current

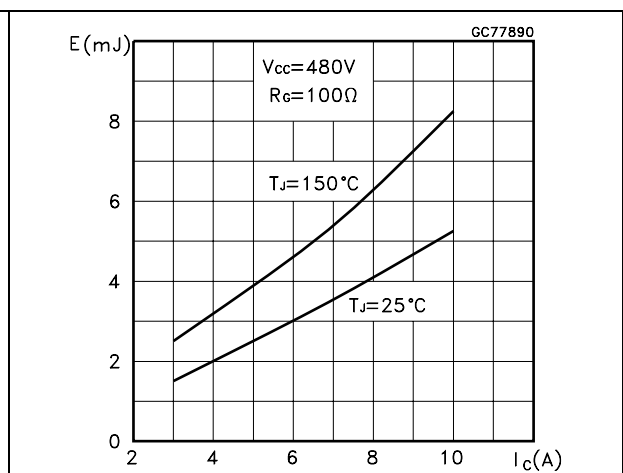


Figure 14. Thermal impedance for TO-220

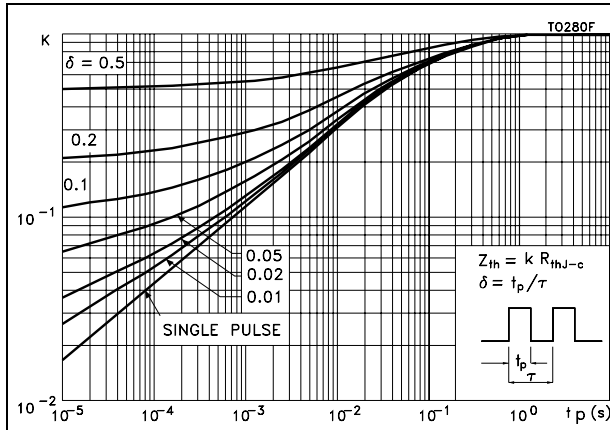


Figure 15. Thermal impedance for TO-220FP

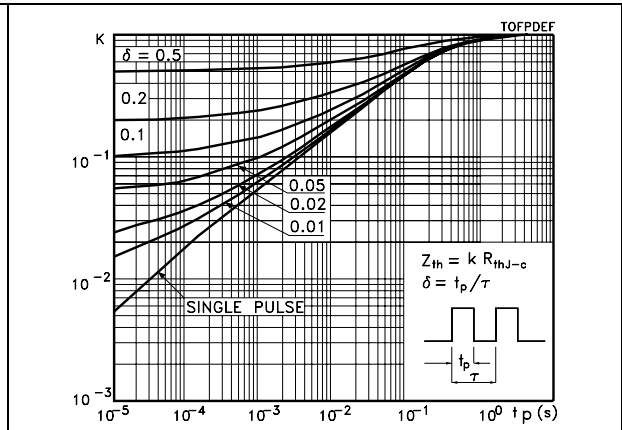


Figure 16. Turn-off SOA

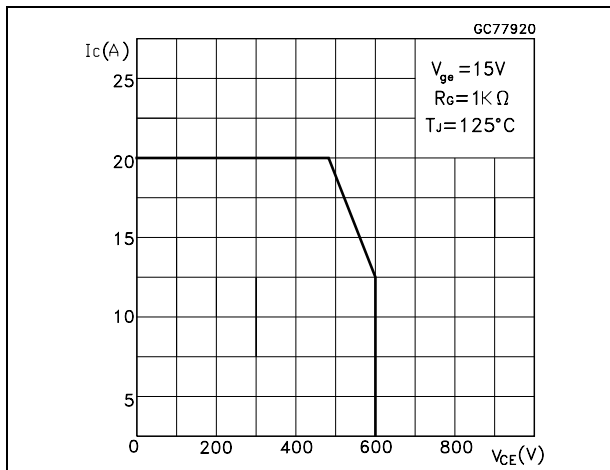
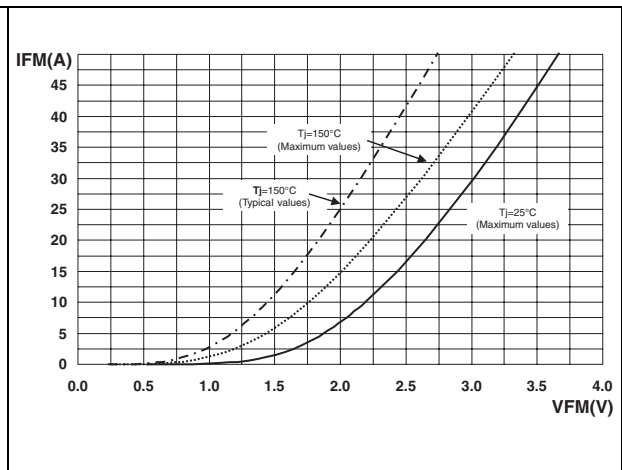


Figure 17. Forward voltage drop versus forward current



3 Test circuits

Figure 18. Test circuit for inductive load switching

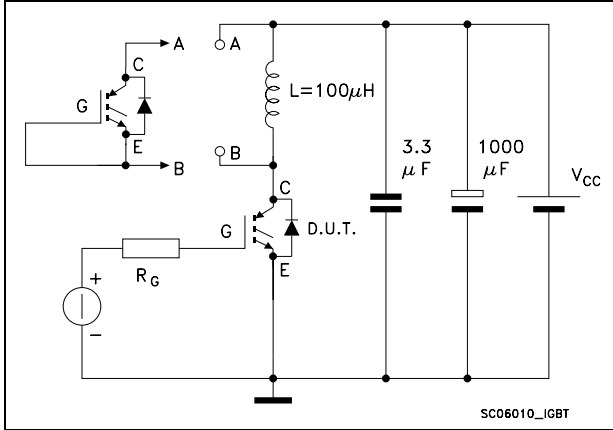


Figure 19. Gate charge test circuit

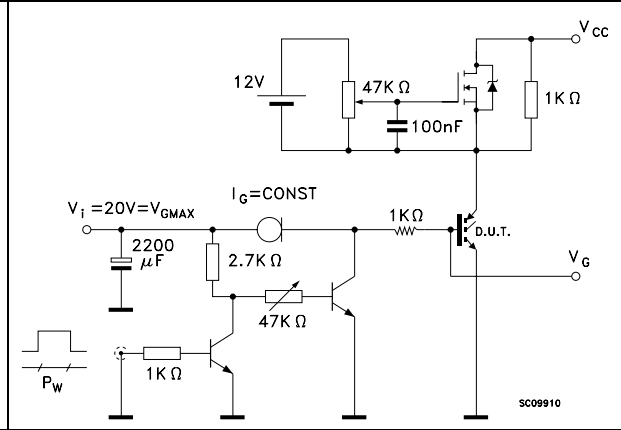


Figure 20. Switching waveforms

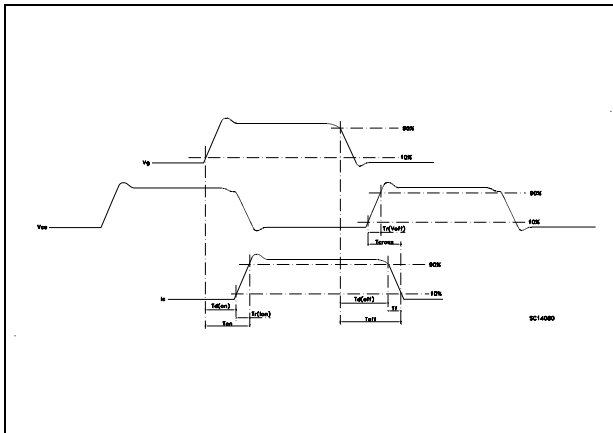
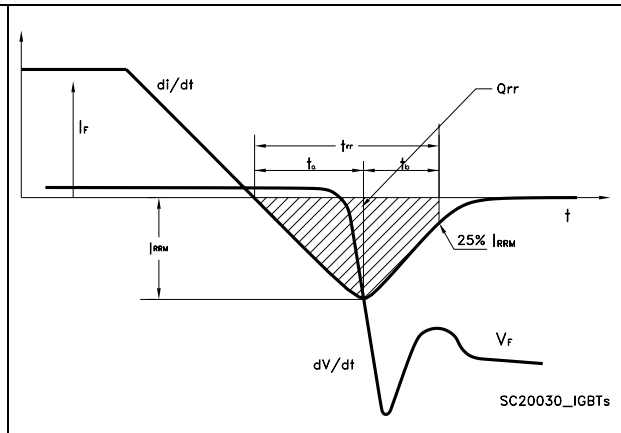


Figure 21. Diode recovery times waveform



4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK[®] packages, depending on their level of environmental compliance. ECOPACK[®] specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

Table 9. TO-220FP mechanical data

| Dim. | mm. | | |
|------|------|------|------|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 28.6 | | 30.6 |
| L4 | 9.8 | | 10.6 |
| L5 | 2.9 | | 3.6 |
| L6 | 15.9 | | 16.4 |
| L7 | 9 | | 9.3 |
| Dia | 3 | | 3.2 |

Figure 22. TO-220FP drawing

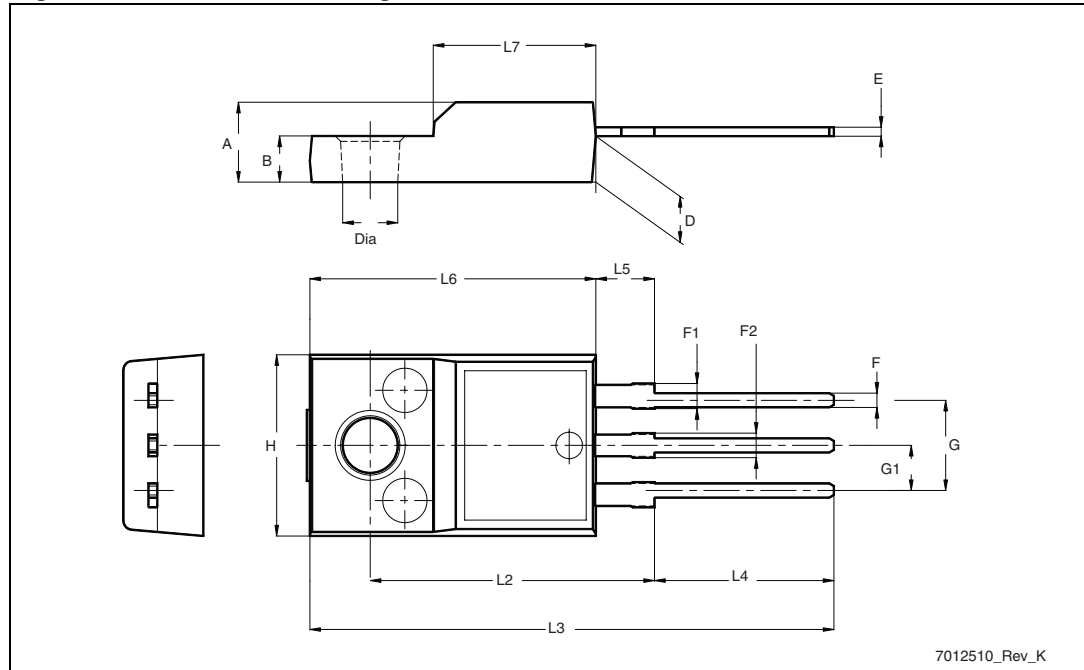
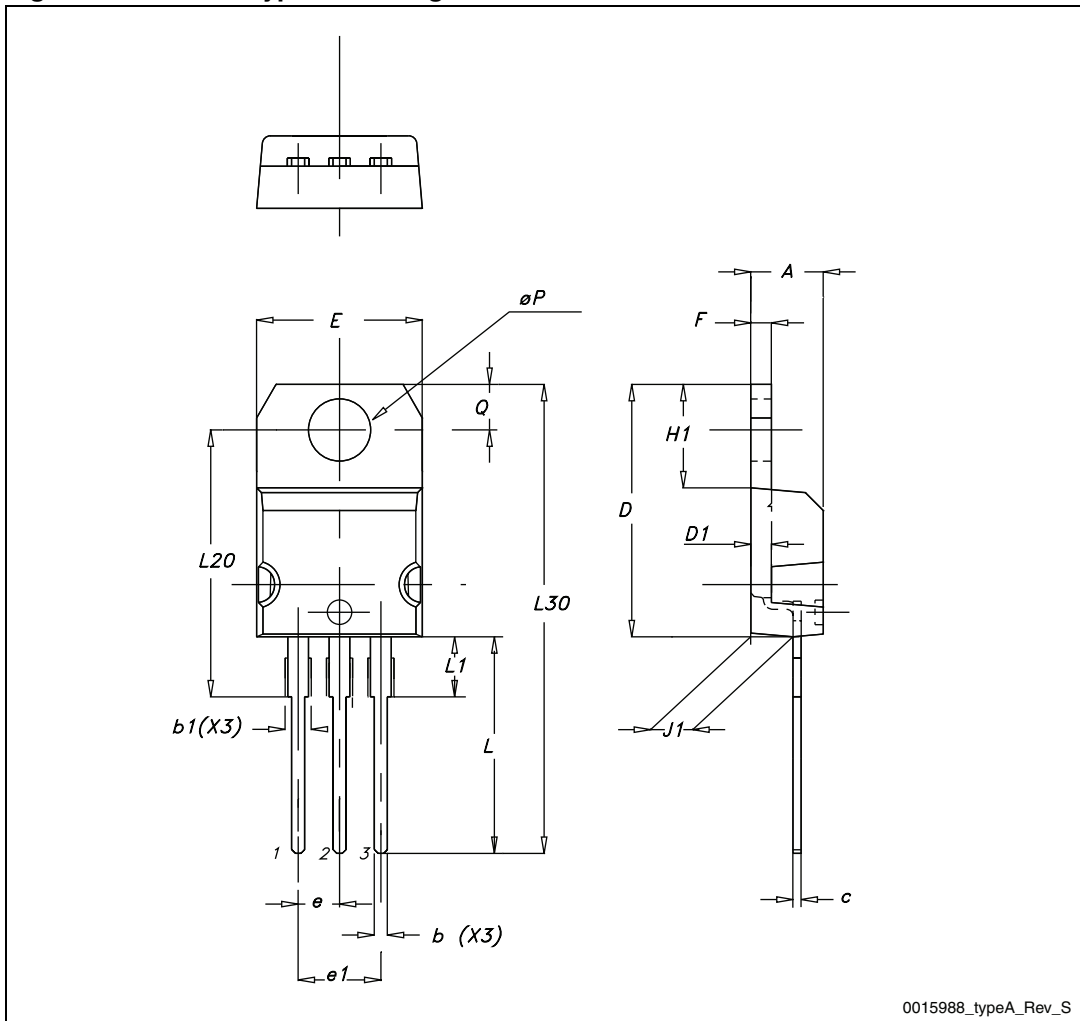


Table 10. TO-220 type A mechanical data

| Dim. | mm. | | |
|------|-------|-------|-------|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.48 | | 0.70 |
| D | 15.25 | | 15.75 |
| D1 | | 1.27 | |
| E | 10 | | 10.40 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| F | 1.23 | | 1.32 |
| H1 | 6.20 | | 6.60 |
| J1 | 2.40 | | 2.72 |
| L | 13 | | 14 |
| L1 | 3.50 | | 3.93 |
| L20 | | 16.40 | |
| L30 | | 28.90 | |
| ØP | 3.75 | | 3.85 |
| Q | 2.65 | | 2.95 |

Figure 23. TO-220 type A drawing



5 Revision history

Table 11. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 18-Nov-2005 | 1 | New release. |
| 16-Dec-2010 | 2 | Inserted device in TO-220FP. Updated Table 2: Absolute maximum ratings , Table 8: Collector-emitter diode and packages mechanical data Section 4: Package mechanical data . |
| 22-Sep-2011 | 3 | Modified: unit value Table 7 on page 5 , Figure 2 and Figure 3 on page 6 . |