

## 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).

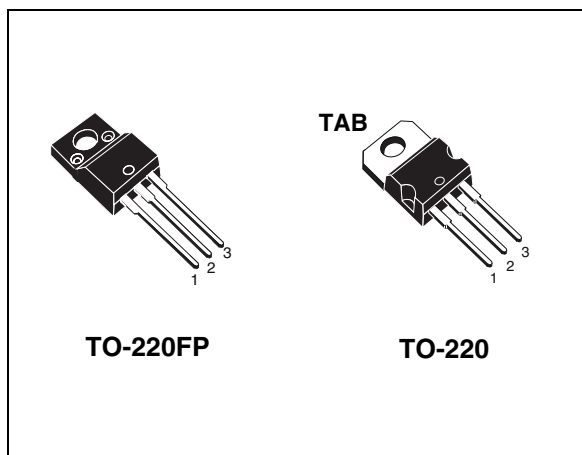


Figure 1. Internal schematic diagram

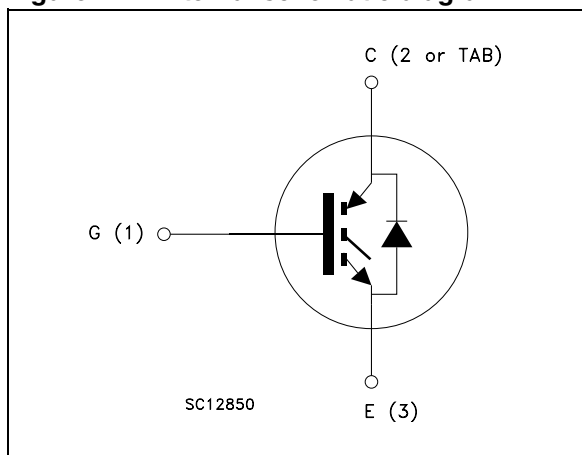


Table 1. Device summary

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

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		STGF10NB60SD	STGP10NB60SD	
V <sub>CES</sub>	Collector-emitter voltage (V <sub>GE</sub> = 0)	600		V
I <sub>C</sub> <sup>(1)</sup>	Continuous collector current at T <sub>C</sub> = 25 °C	23	29	A
I <sub>C</sub> <sup>(1)</sup>	Continuous collector current at T <sub>C</sub> = 100 °C	12	16	A
I <sub>CL</sub> <sup>(2)</sup>	Turn-off latching current	20		A
I <sub>CP</sub> <sup>(3)</sup>	Pulsed collector current	80		A
V <sub>GE</sub>	Gate-emitter voltage	±20		V
I <sub>F</sub>	Diode RMS forward current at T <sub>C</sub> = 25 °C	20		A
I <sub>FSM</sub>	Surge non repetitive forward current t <sub>p</sub> = 10 ms sinusoidal	55		A
V <sub>ISO</sub>	Isolation withstand voltage (RMS) from all three leads to external heatsink (t=1 s; T <sub>C</sub> = 25 °C)	2500		V
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	25	80	W
T <sub>j</sub>	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<sub>clamp</sub> = 80% of V<sub>CES</sub>, T<sub>j</sub> = 150 °C, R<sub>G</sub> = 1kΩ, V<sub>GE</sub> = 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 <sub>thj-case</sub>	Thermal resistance junction-case IGBT	5	1.56	°C/W
R <sub>thj-case</sub>	Thermal resistance junction-case diode	5.6	2.2	°C/W
R <sub>thj-amb</sub>	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 ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\ \text{V}$			$\pm 100$	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	$\mu\text{A}$ $\mu\text{A}$
$V_{GE(th)}$	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  $\mu\text{s}$ , 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		$\mu\text{s}$
$t_r$	Current rise time	$R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V}$	-	0.46	-	$\mu\text{s}$
$(di/dt)_{on}$	Turn-on current slope	(see Figure 18)		8		A/ $\mu\text{s}$
$t_r(V_{off})$	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	-	$\mu\text{s}$
$t_f$	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	-	$\mu\text{s}$
$t_f$	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

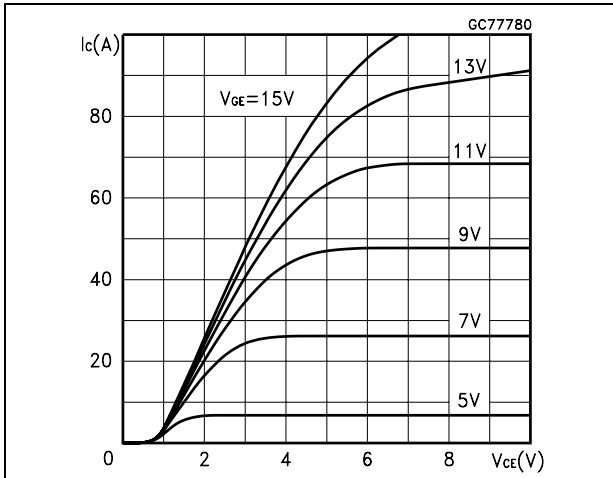


Figure 3. Transfer characteristics

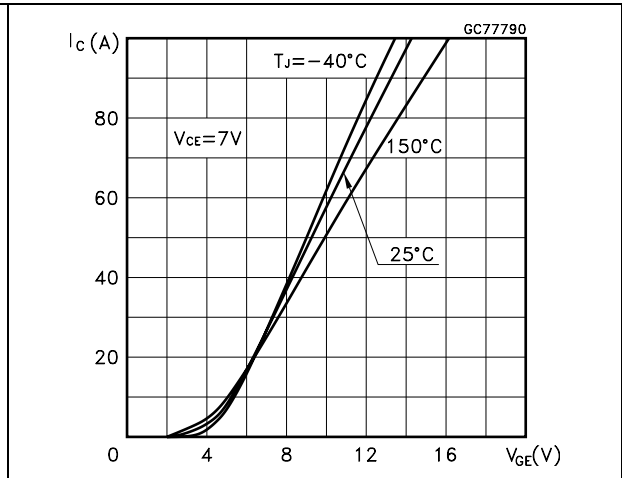


Figure 4. Transconductance

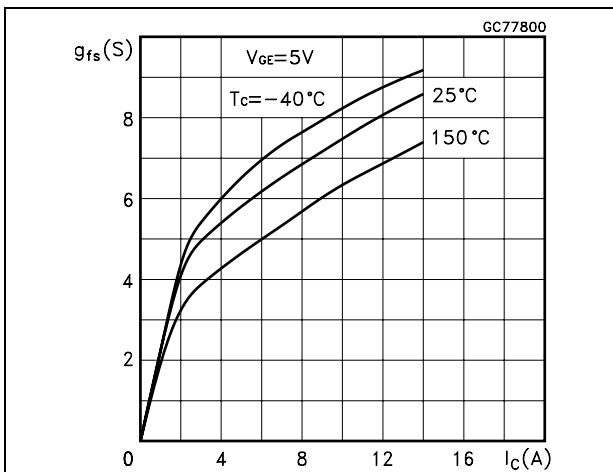


Figure 5. Collector-emitter on voltage vs. temperature

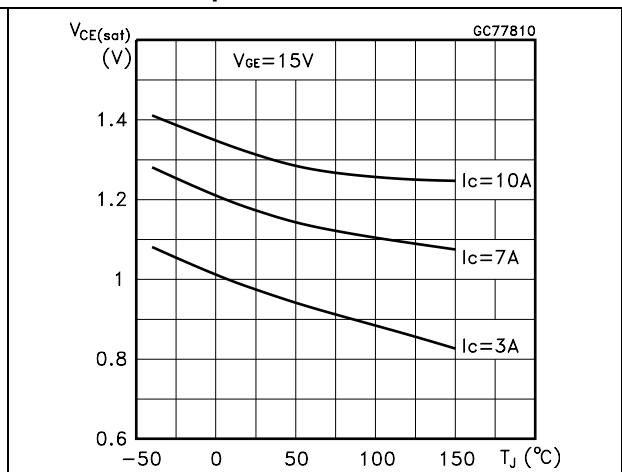


Figure 6. Collector-emitter on voltage vs. collector current

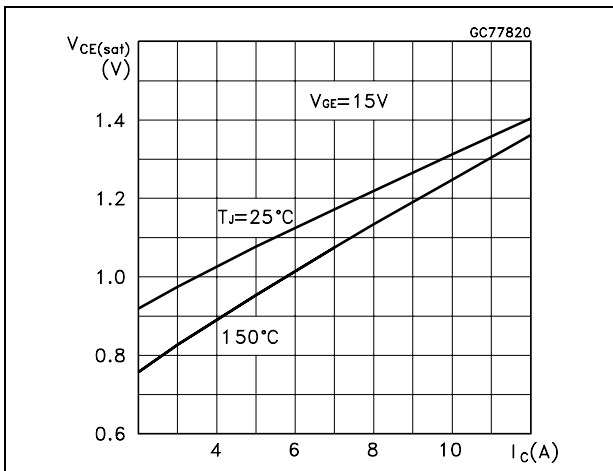


Figure 7. Normalized gate threshold vs. temperature

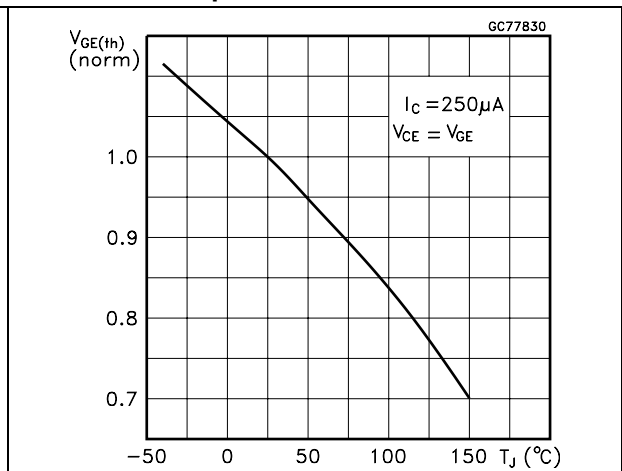


Figure 8. Normalized breakdown voltage vs. temperature

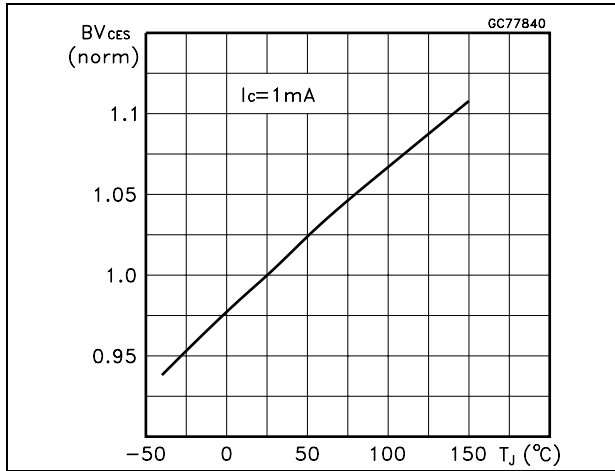


Figure 9. Gate charge vs. gate-emitter voltage

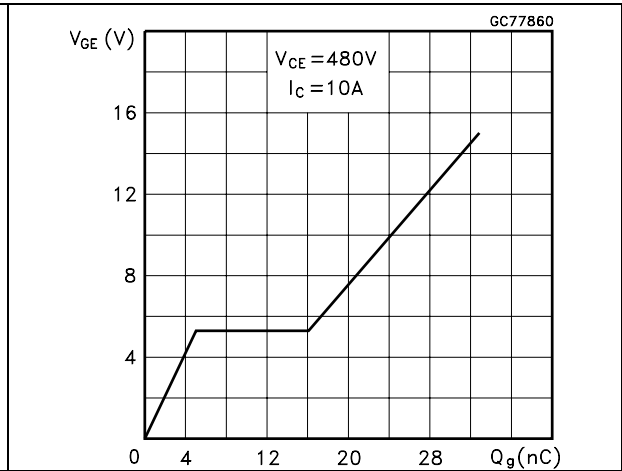


Figure 10. Capacitance variations

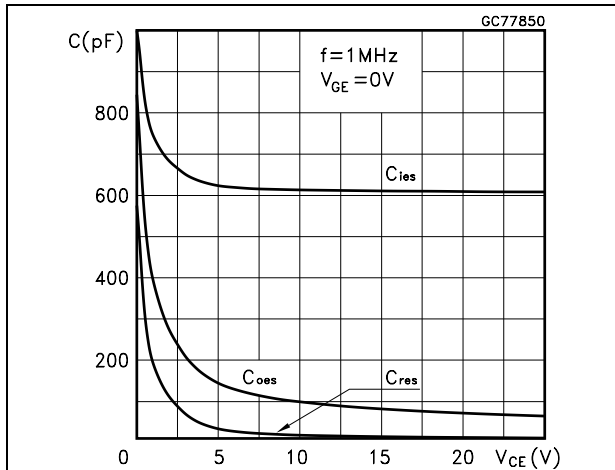


Figure 11. Switching losses vs. temperature

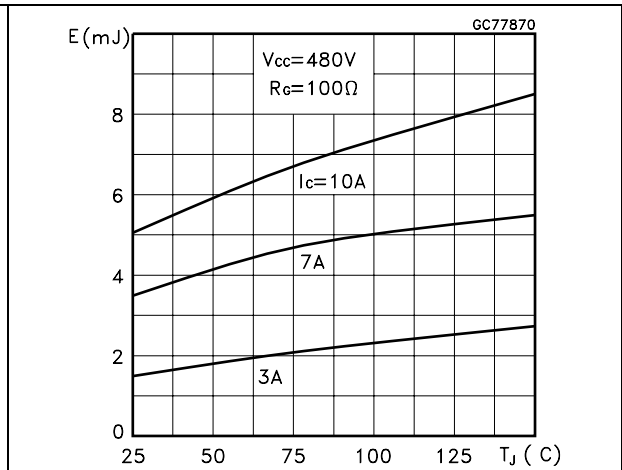


Figure 12. Switching losses vs. gate resistance

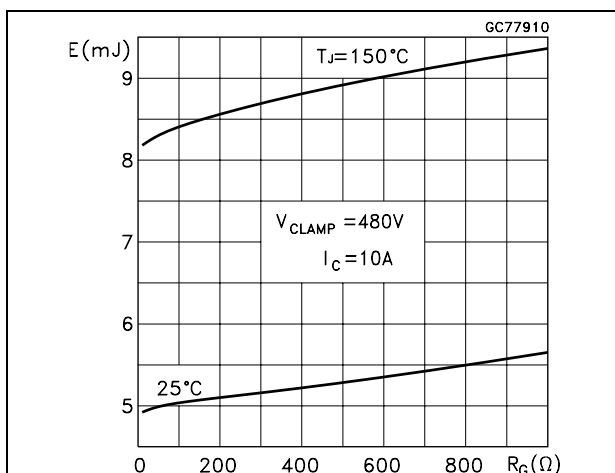


Figure 13. Switching losses vs. collector current

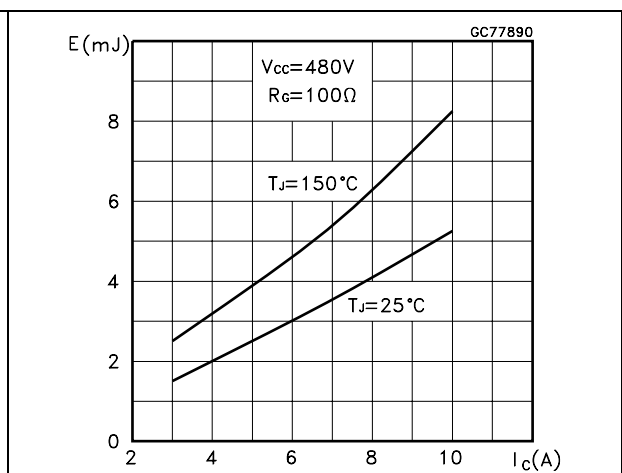


Figure 14. Thermal impedance for TO-220

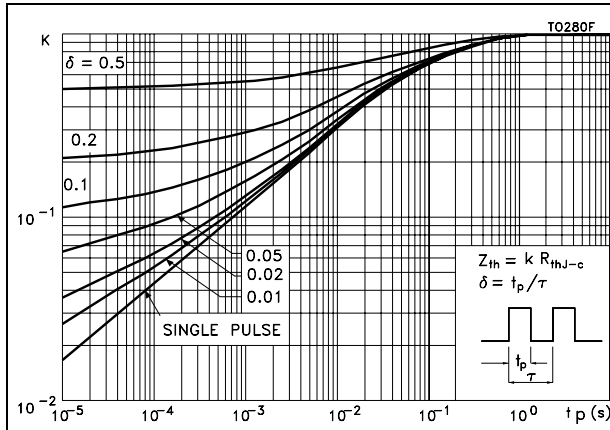


Figure 15. Thermal impedance for TO-220FP

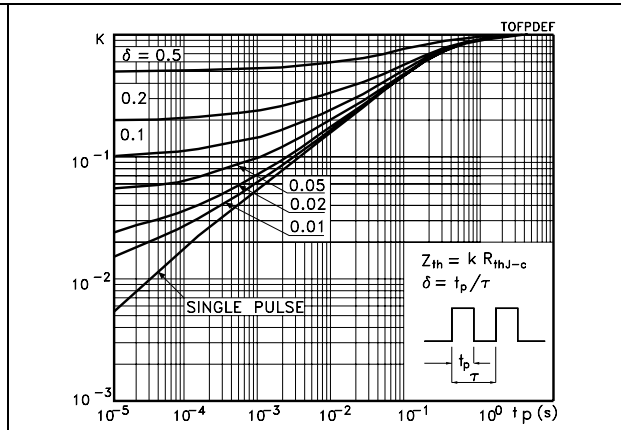


Figure 16. Turn-off SOA

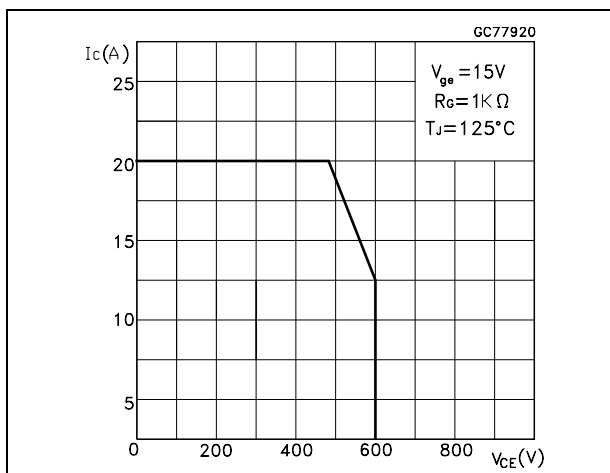
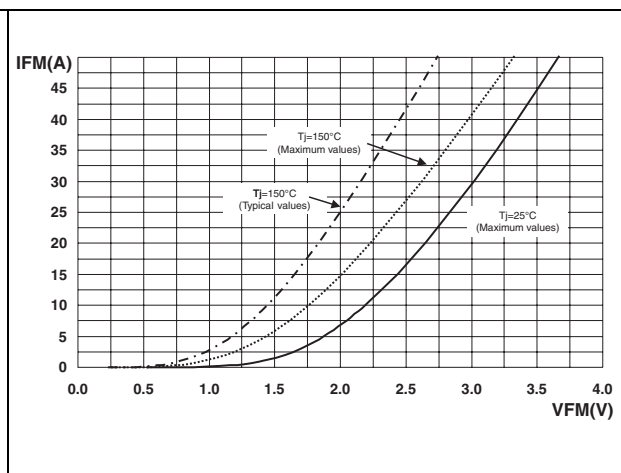


Figure 17. Forward voltage drop versus forward current





### 3 Test circuits

Figure 18. Test circuit for inductive load switching

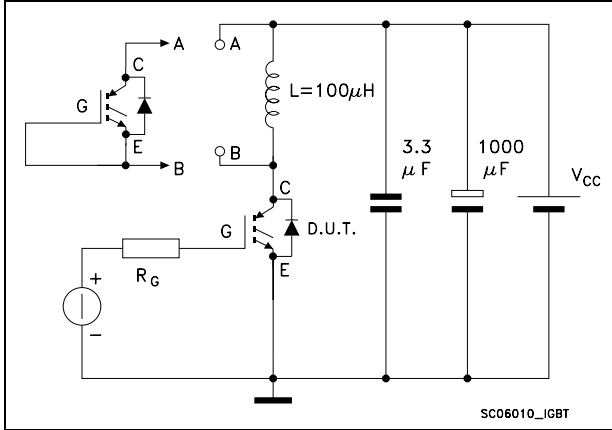


Figure 19. Gate charge test circuit

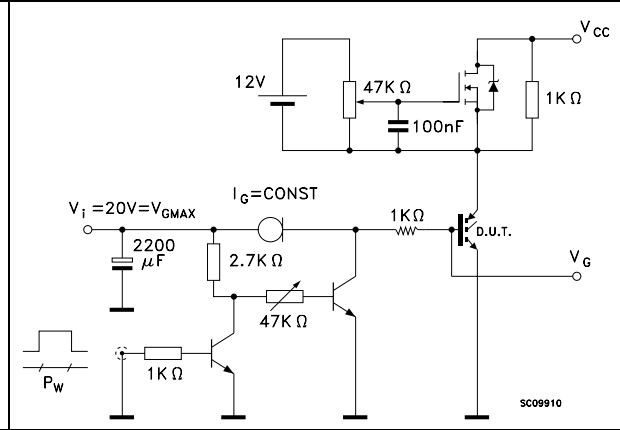


Figure 20. Switching waveforms

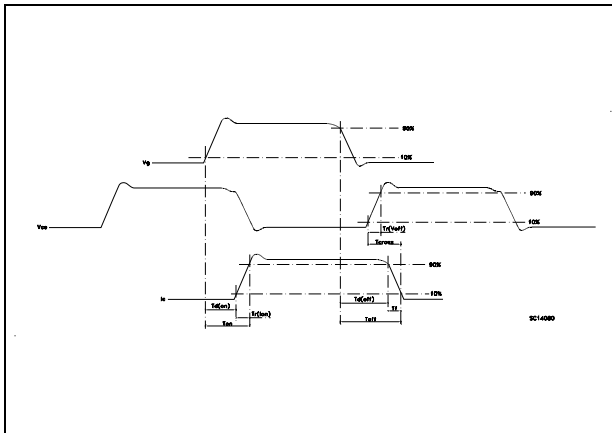
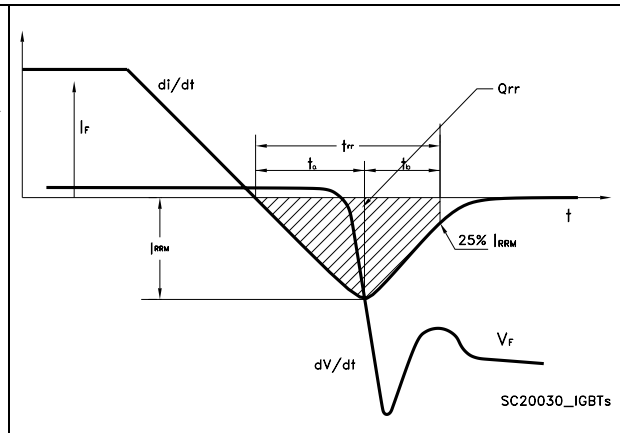


Figure 21. Diode recovery times waveform



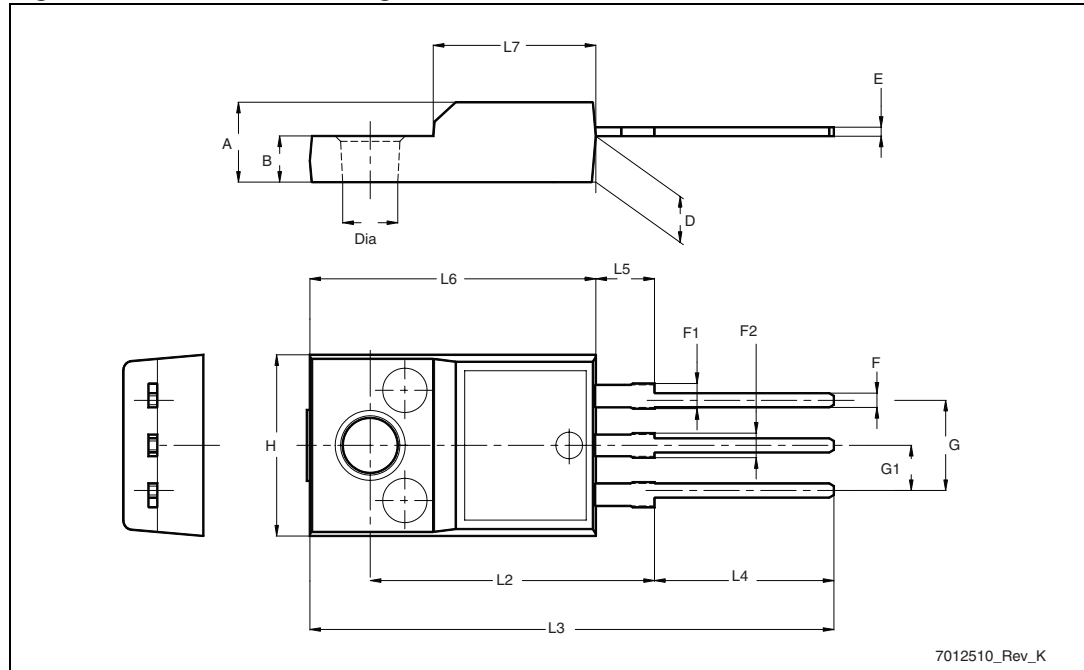
## 4 Package mechanical data

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

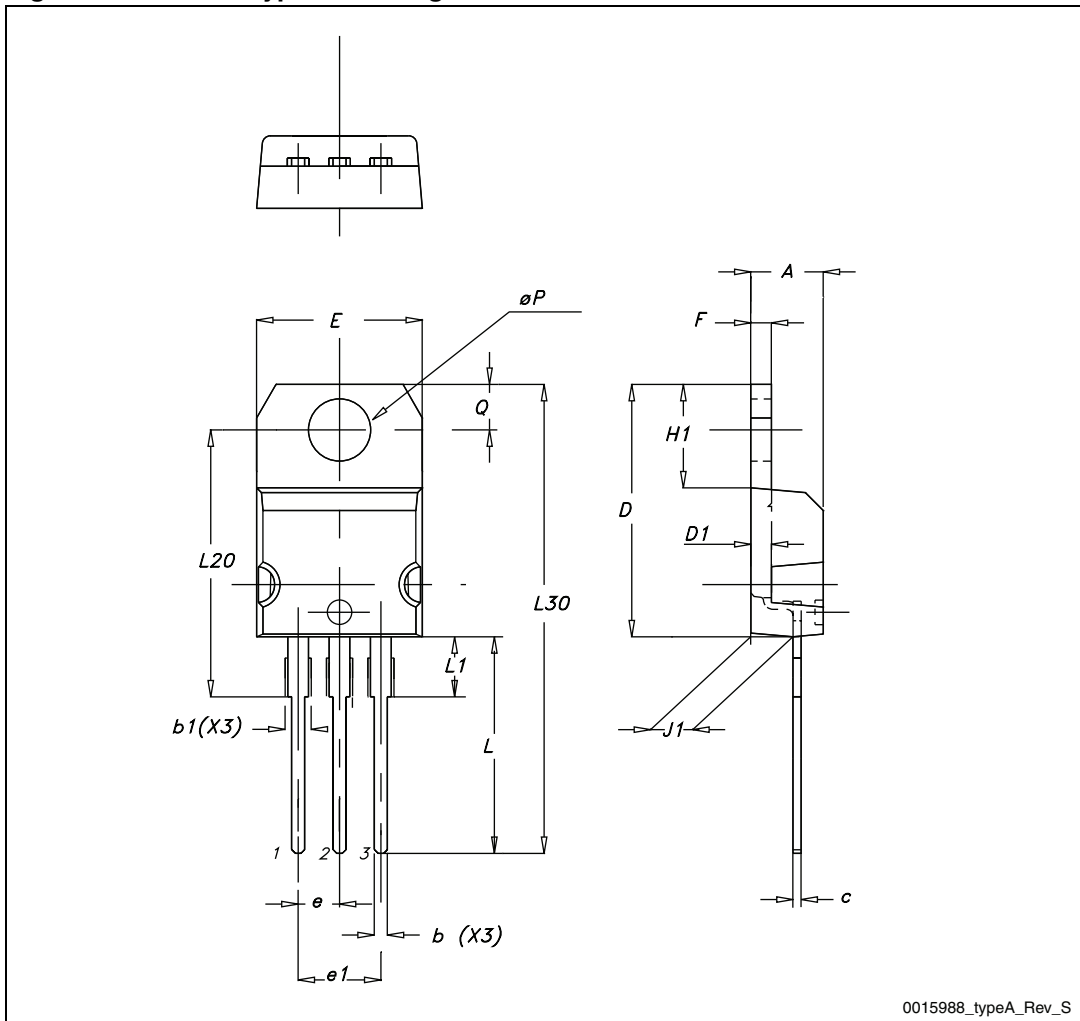


7012510\_Rev\_K

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 <a href="#">Table 2: Absolute maximum ratings</a> , <a href="#">Table 8: Collector-emitter diode</a> and packages mechanical data <a href="#">Section 4: Package mechanical data</a> .
22-Sep-2011	3	Modified: unit value <a href="#">Table 7 on page 5</a> , <a href="#">Figure 2</a> and <a href="#">Figure 3 on page 6</a> .

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