

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

### Features

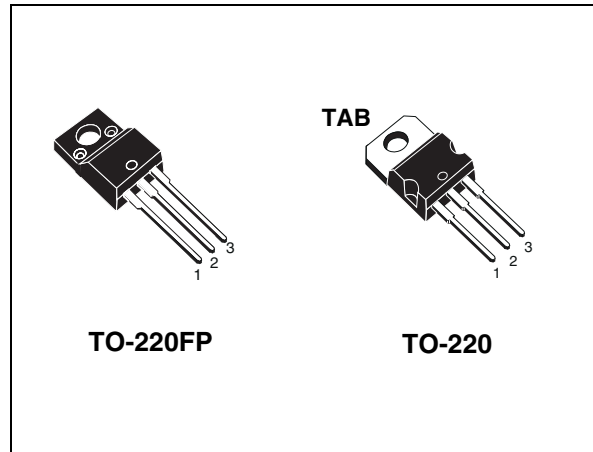
- Low on-voltage drop ( $V_{CE(sat)}$ )
- High current capability
- Very soft ultra fast recovery antiparallel diode

### Applications

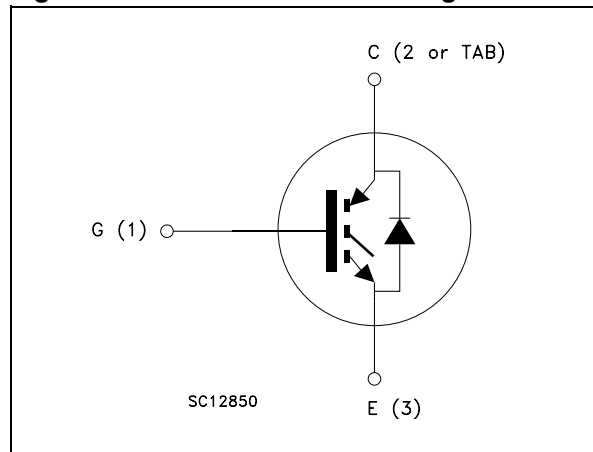
- Light dimmer
- Static relays
- Motor drive

### 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	$V_{CE} = 25\ \text{V}, f = 1\ \text{MHz}, V_{GE} = 0$	-	610	-	pF
$C_{oes}$	Output capacitance			65		
$C_{res}$	Reverse transfer capacitance			12		
$Q_g$	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	$V_{CC} = 480\text{ V}, I_C = 10\text{ A}$ $R_G = 1\text{ k}\Omega, V_{GE} = 15\text{ V},$ $T_j = 125\text{ }^\circ\text{C}$	-	8	-	mJ
		(see Figure 18)				

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	$I_F = 7\text{ A}, V_R = 40\text{ V},$ $di/dt = 100\text{ A}/\mu\text{s}$		37		ns
$Q_{rr}$	Reverse recovery charge	(see Figure 21)		40		nC
$I_{rrm}$	Reverse recovery current			2.1		A
$t_{rr}$	Reverse recovery time	$I_F = 7\text{ A}, V_R = 40\text{ V},$ $T_j = 125\text{ }^\circ\text{C},$ $di/dt = 100\text{ A}/\mu\text{s}$		61		ns
$Q_{rr}$	Reverse recovery charge	(see Figure 21)		98		nC
$I_{rrm}$	Reverse recovery current			3.2		A

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

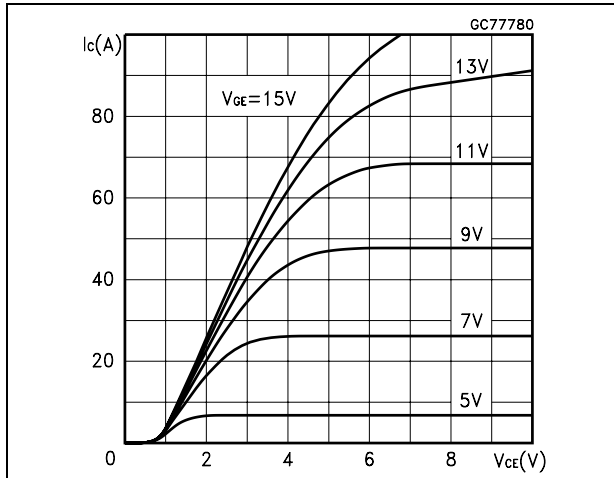


Figure 3. Transfer characteristics

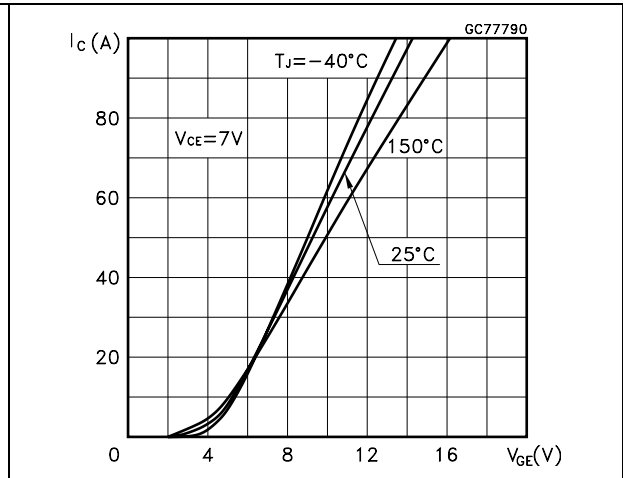


Figure 4. Transconductance

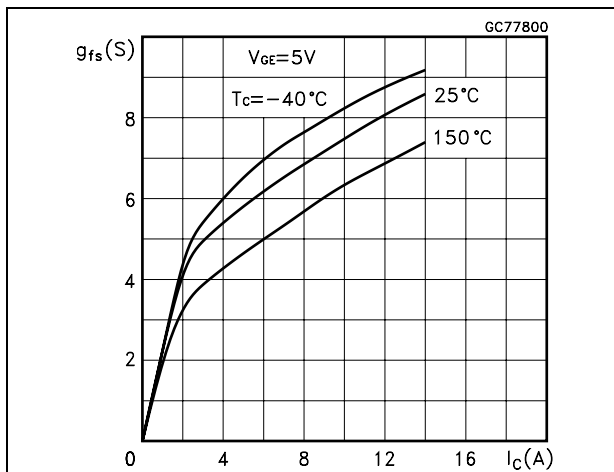


Figure 5. Collector-emitter on voltage vs. temperature

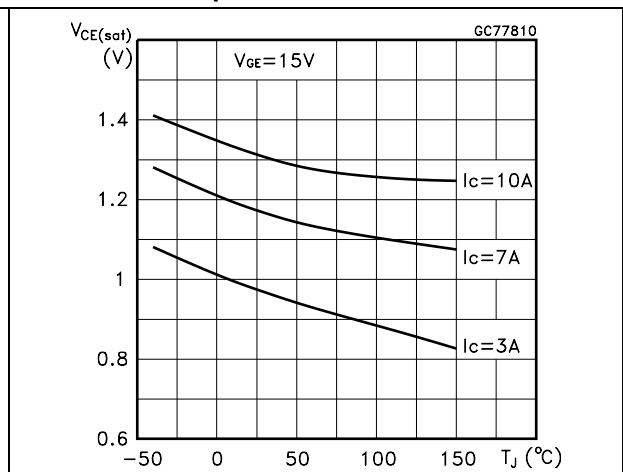


Figure 6. Collector-emitter on voltage vs. collector current

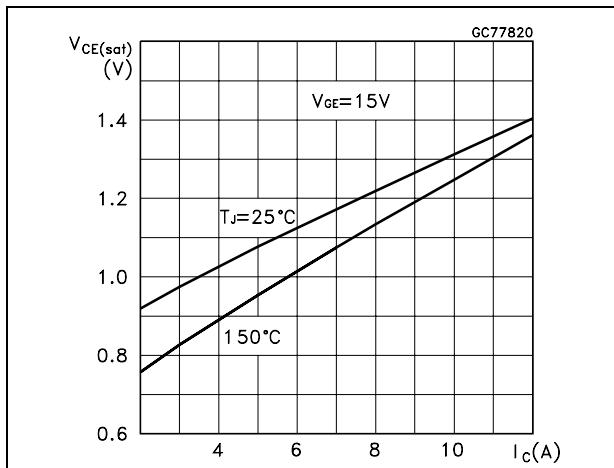
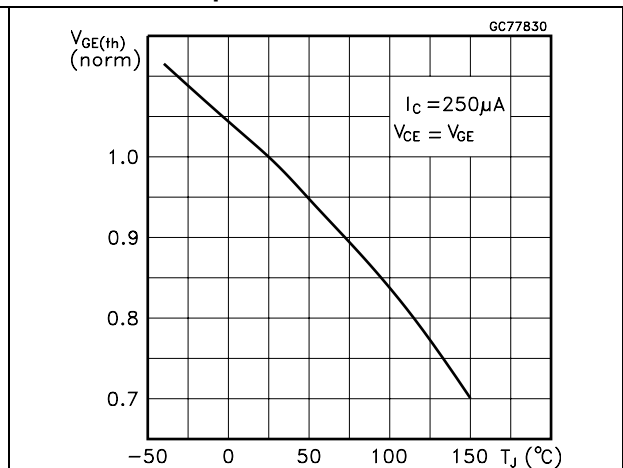
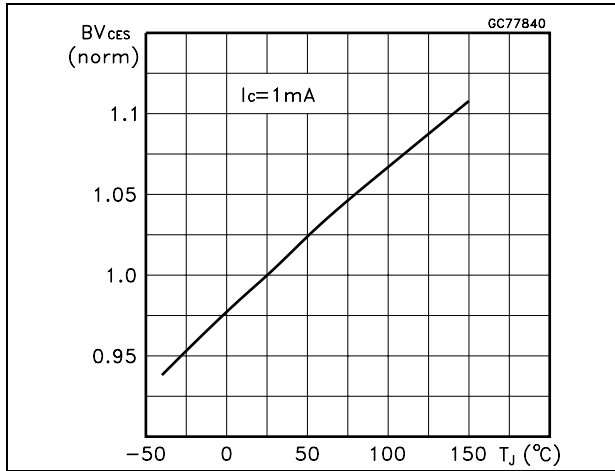


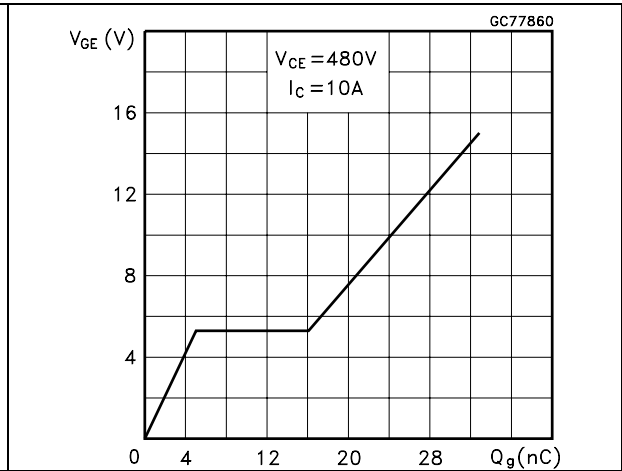
Figure 7. Normalized gate threshold vs. temperature



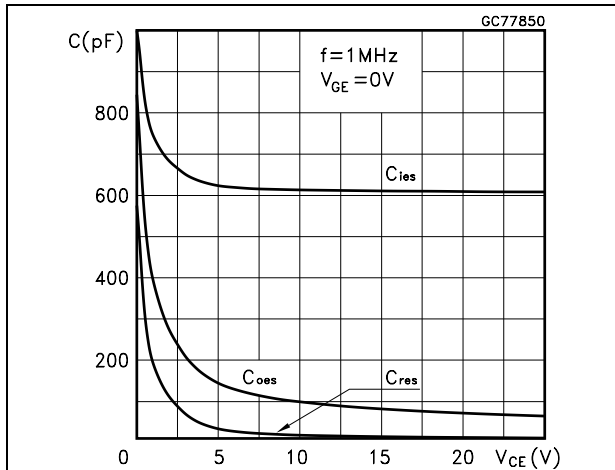
**Figure 8. Normalized breakdown voltage vs. temperature**



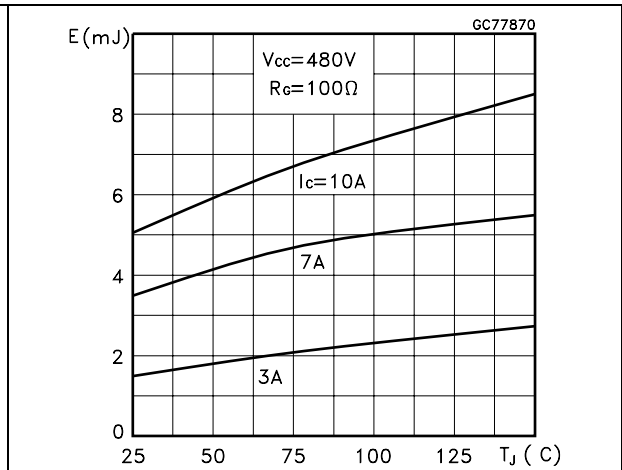
**Figure 9. Gate charge vs. gate-emitter voltage**



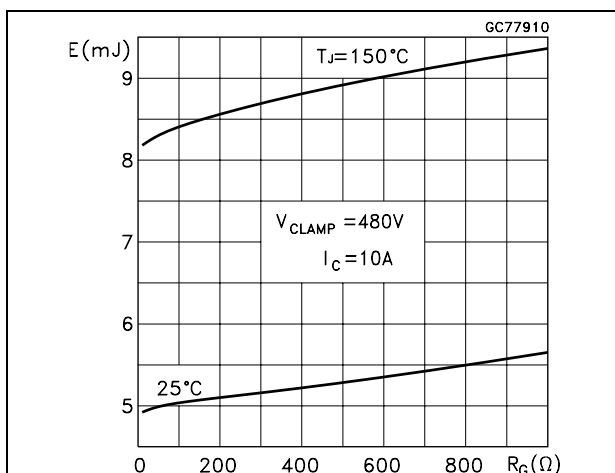
**Figure 10. Capacitance variations**



**Figure 11. Switching losses vs. temperature**



**Figure 12. Switching losses vs. gate resistance**



**Figure 13. Switching losses vs. collector current**

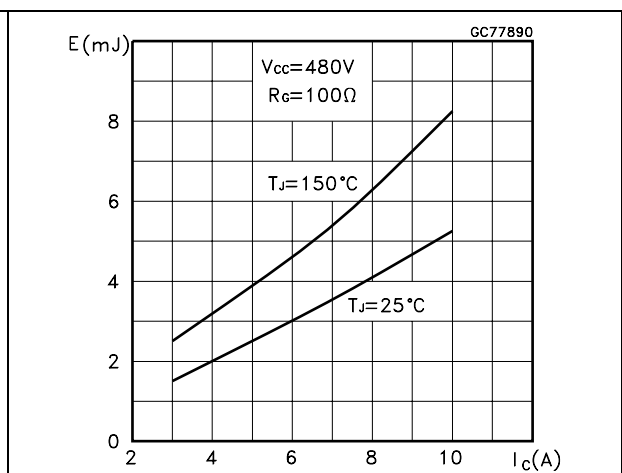


Figure 14. Thermal impedance for TO-220

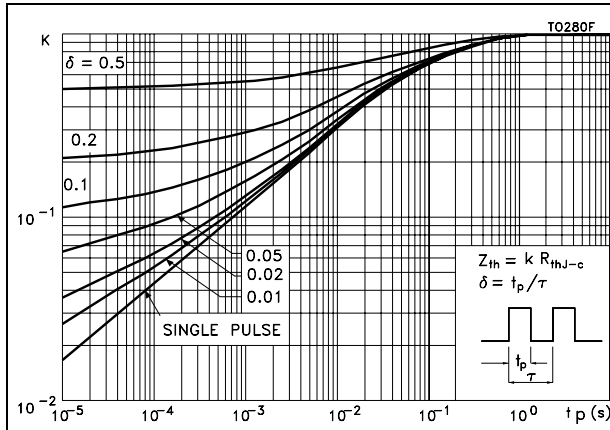


Figure 15. Thermal impedance for TO-220FP

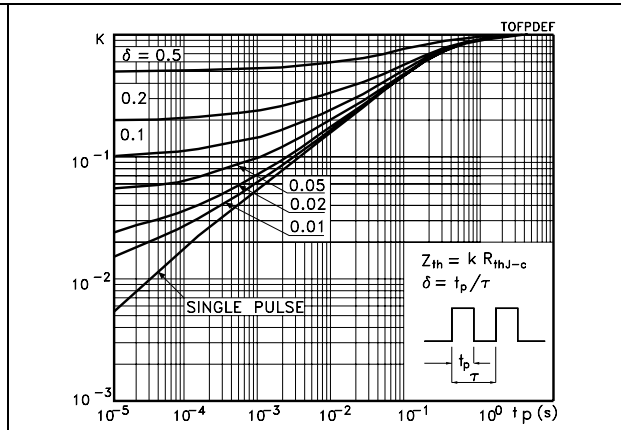


Figure 16. Turn-off SOA

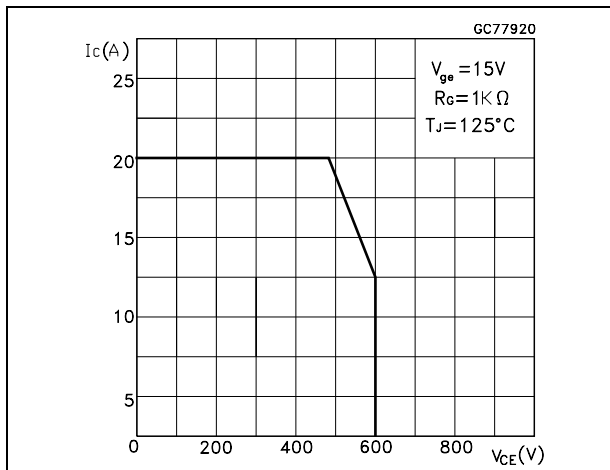
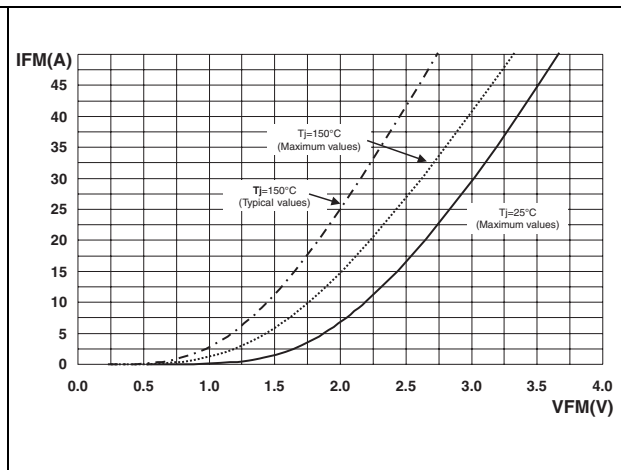


Figure 17. Forward voltage drop versus forward current





### 3 Test circuits

Figure 18. Test circuit for inductive load switching

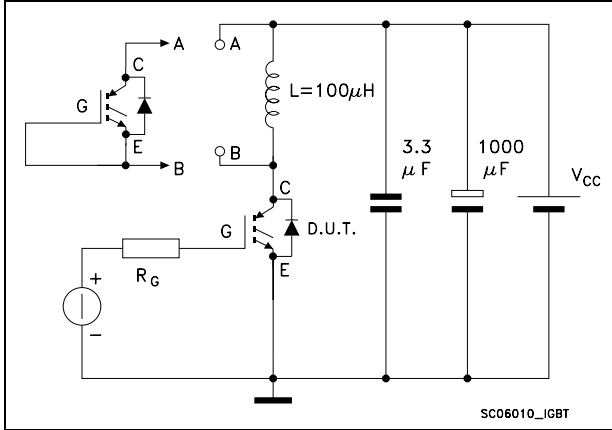


Figure 19. Gate charge test circuit

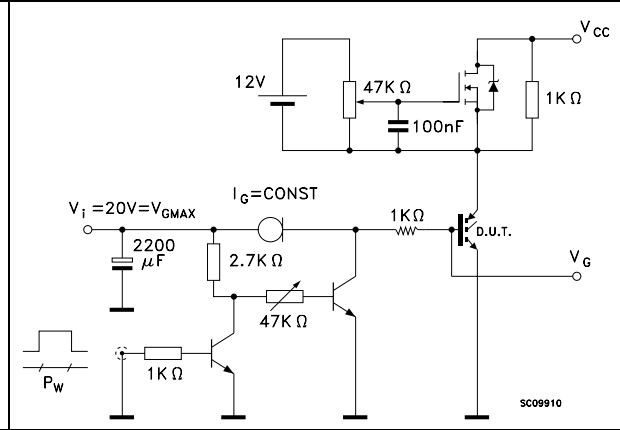


Figure 20. Switching waveforms

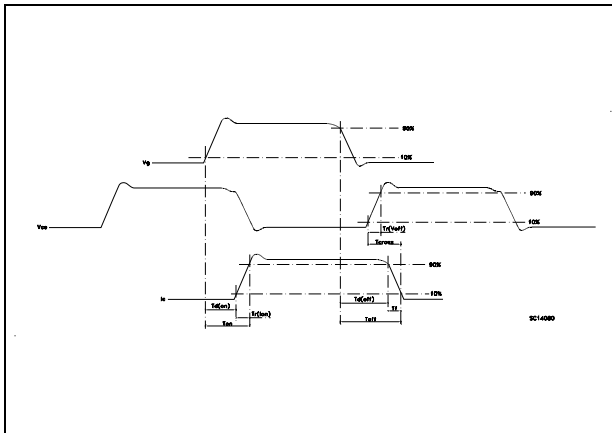
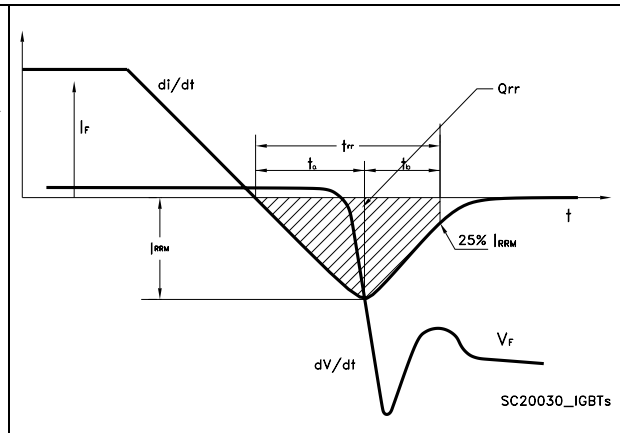


Figure 21. Diode recovery times waveform



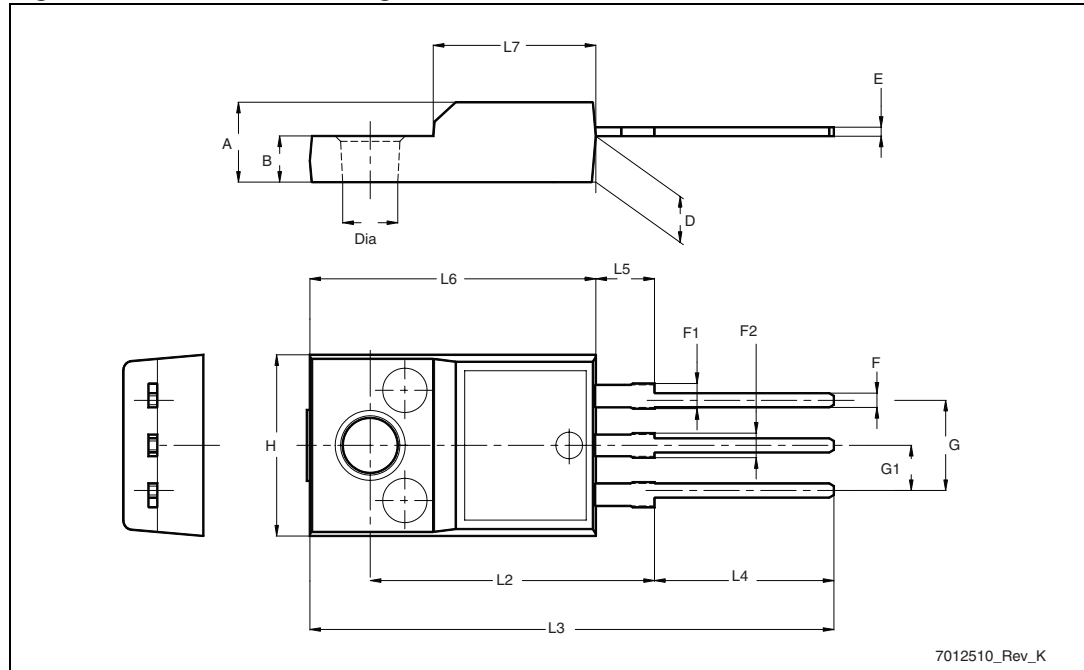
## 4 Package mechanical data

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

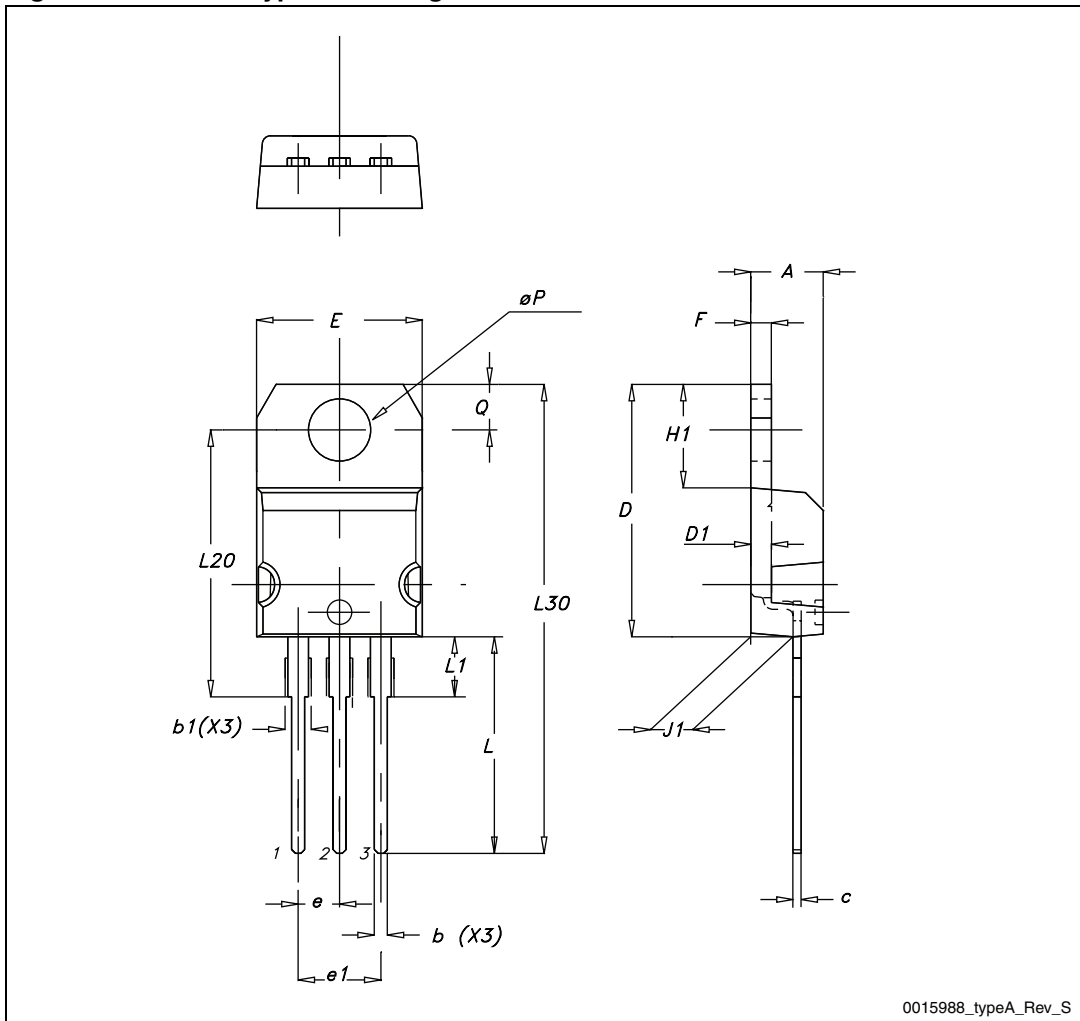


7012510\_Rev\_K

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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**Телефон:** +7 812 627 14 35

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**Адрес:** 198099, Санкт-Петербург,  
Промышленная ул, дом № 19, литера Н,  
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