

## 20 A, 600 V fast IGBT with Ultrafast diode

### Features

- Very low on-voltage drop ( $V_{CE(sat)}$ )
- Minimum power losses at 5 kHz in hard switching
- Optimized performance for medium operating frequencies.
- IGBT co-packaged with Ultrafast freewheeling diode

### Application

Medium frequency motor drives

### Description

This IGBT utilizes the advanced PowerMESH™ process resulting in an excellent trade-off between switching performance and low on-state behavior.

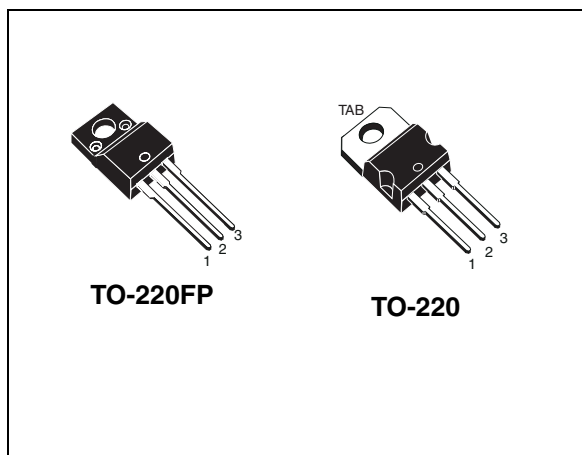


Figure 1. Internal schematic diagram

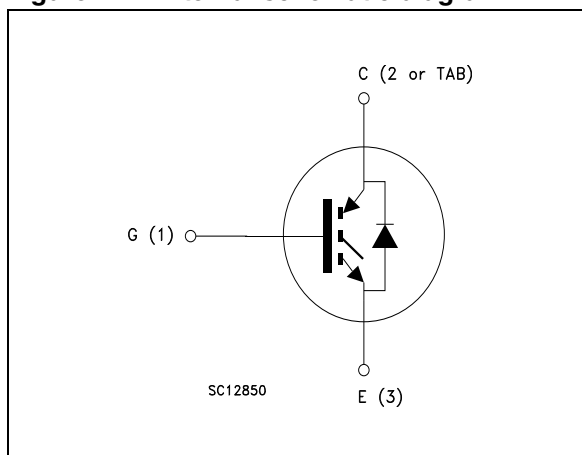


Table 1. Device summary

Order codes	Marking	Package	Packaging
STGF19NC60SD	GF19NC60SD	TO-220FP	Tube
STGP19NC60SD	GP19NC60SD	TO-220	Tube

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	600		V
$I_C^{(1)}$	Continuous collector current at $T_C = 25^\circ\text{C}$	40	17	A
$I_C^{(1)}$	Continuous collector current at $T_C = 100^\circ\text{C}$	20	11	A
$I_{CP}^{(2)}$	Pulsed collector current	80		A
$I_{CL}^{(3)}$	Turn-off latching current	80		A
$I_F$	Diode RMS forward current at $T_C = 25^\circ\text{C}$	20		A
$I_{FSM}$	Surge non repetitive forward current $t_p = 10\text{ms}$ sinusoidal	50		A
$V_{GE}$	Gate-emitter voltage	$\pm 20$		V
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ ; $T_C = 25^\circ\text{C}$ )		2500	V
$P_{TOT}$	Total dissipation at $T_C = 25^\circ\text{C}$	130	32	W
$T_j$	Operating junction temperature	- 55 to 150		$^\circ\text{C}$

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

3.  $V_{clamp} = 80\%$  of  $V_{CES}$ ,  $T_j = 150^\circ\text{C}$ ,  $R_G = 10\ \Omega$ ,  $V_{GE} = 15\text{ V}$

**Table 3. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$R_{thj-c}$	Thermal resistance junction-case IGBT	0.96	3.9	$^\circ\text{C/W}$
	Thermal resistance junction-case diode	3	5.5	$^\circ\text{C/W}$
$R_{thj-a}$	Thermal resistance junction-ambient	62.5		$^\circ\text{C/W}$

## 2 Electrical characteristics

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

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage ( $V_{GE} = 0$ )	$I_C = 1\text{mA}$	600			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{V}$ , $I_C = 12\text{A}$ $V_{GE} = 15\text{V}$ , $I_C = 12\text{A}$ , $T_j = 125^\circ\text{C}$		1.55 1.35	1.9	V V
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 250\ \mu\text{A}$	4.2		6.2	V
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 600\ \text{V}$ $V_{CE} = 600\ \text{V}$ , $T_j = 125^\circ\text{C}$			150 1	$\mu\text{A}$ mA
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{V}$ , $V_{CE} = 0$			$\pm 100$	nA
$g_{fs}$	Forward transconductance	$V_{CE} = 15\text{V}$ , $I_C = 12\text{A}$		10		S

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{V}$ , $f = 1\text{MHz}$ , $V_{GE} = 0$	-	1190	-	pF
$C_{oes}$	Output capacitance			135		pF
$C_{res}$	Reverse transfer capacitance			28.5		pF
$Q_g$	Total gate charge	$V_{CE} = 480\text{V}$ , $I_C = 12\text{A}$ ,	-	54.5	-	nC
$Q_{ge}$	Gate-emitter charge	$V_{GE} = 15\text{V}$ ,		8.7		nC
$Q_{gc}$	Gate-collector charge	<a href="#">Figure 20</a>		25.8		nC

**Table 6. Switching on/off (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $t_r$ (di/dt) <sub>on</sub>	Turn-on delay time Current rise time Turn-on current slope	$V_{CC} = 480V, I_C = 12A$ $R_G = 10\Omega, V_{GE} = 15V,$ <i>Figure 21</i>	-	17.5 6.2 1870	-	ns ns A/ $\mu$ s
$t_{d(on)}$ $t_r$ (di/dt) <sub>on</sub>	Turn-on delay time Current rise time Turn-on current slope	$V_{CC} = 480V, I_C = 12A$ $R_G = 10\Omega, V_{GE} = 15V,$ $T_j = 125^\circ C$ <i>Figure 21</i>	-	17 6.5 1700	-	ns ns A/ $\mu$ s
$t_{r(Voff)}$ $t_{d(Voff)}$ $t_f$	Off voltage rise time Turn-off delay time Current fall time	$V_{CC} = 480V, I_C = 12A$ $R_G = 10\Omega, V_{GE} = 15V,$ <i>Figure 21</i>	-	90 175 215	-	ns ns ns
$t_{r(Voff)}$ $t_{d(Voff)}$ $t_f$	Off voltage rise time Turn-off delay time Current fall time	$V_{CC} = 480V, I_C = 12A$ $R_G = 10\Omega, V_{GE} = 15V,$ $T_j = 125^\circ C$ <i>Figure 21</i>	-	155 245 290	-	ns ns ns

**Table 7. Switching energy (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}$ $E_{off}^{(1)}$ $E_{ts}$	Turn-on switching losses Turn-off switching losses Total switching losses	$V_{CC} = 480 V, I_C = 12 A$ $R_G = 10 \Omega, V_{GE} = 15 V,$ <i>Figure 19</i>	-	135 815 995	-	$\mu$ J $\mu$ J $\mu$ J
$E_{on}$ $E_{off}^{(1)}$ $E_{ts}$	Turn-on switching losses Turn-off switching losses Total switching losses	$V_{CC} = 480 V, I_C = 12 A$ $R_G = 10 \Omega, V_{GE} = 15 V,$ $T_j = 125^\circ C$ <i>Figure 19</i>	-	200 1175 1375	-	$\mu$ J $\mu$ J $\mu$ J

1. 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	$I_F = 12 A$ $I_F = 12 A, T_j = 125^\circ C$		2.3 2.0		V V
$t_{rr}$ $Q_{rr}$ $I_{rrm}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_F = 12 A, V_R = 40 V,$ $di/dt = 100 A/\mu s$ <i>Figure 22</i>		31 29.5 1.9		ns nC A
$t_{rr}$ $Q_{rr}$ $I_{rrm}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_F = 12 A, V_R = 40 V,$ $di/dt = 100 A/\mu s, T_j = 125^\circ C$ <i>Figure 22</i>		48.5 70.5 3		ns nC A

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

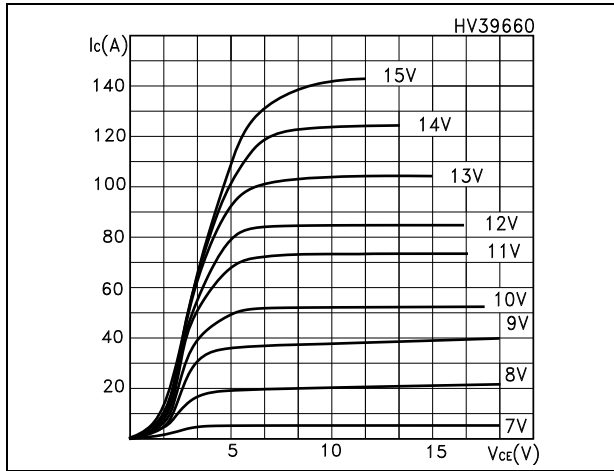


Figure 3. Transfer characteristics

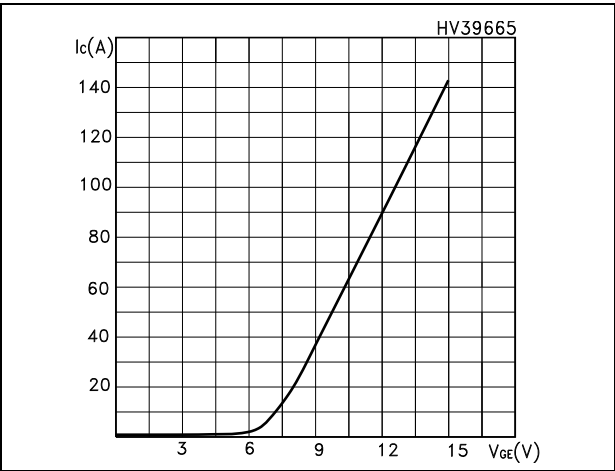


Figure 4. Transconductance

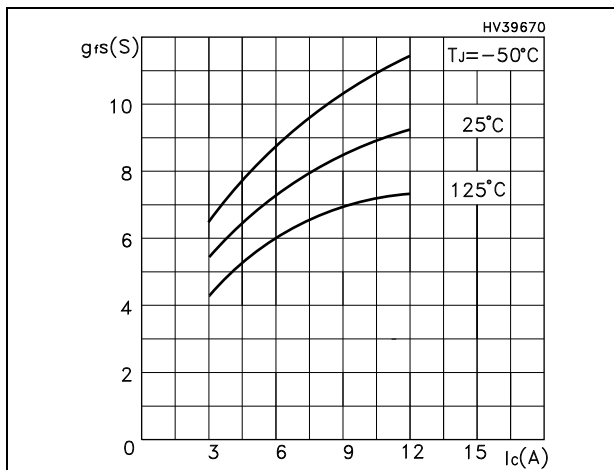


Figure 5. Collector-emitter on voltage vs temperature

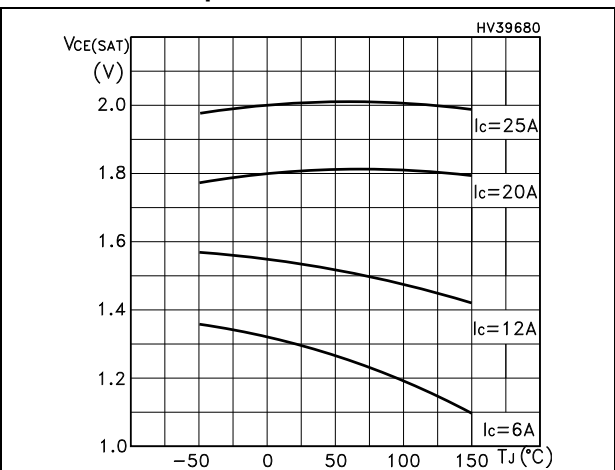


Figure 6. Gate charge vs gate-source voltage

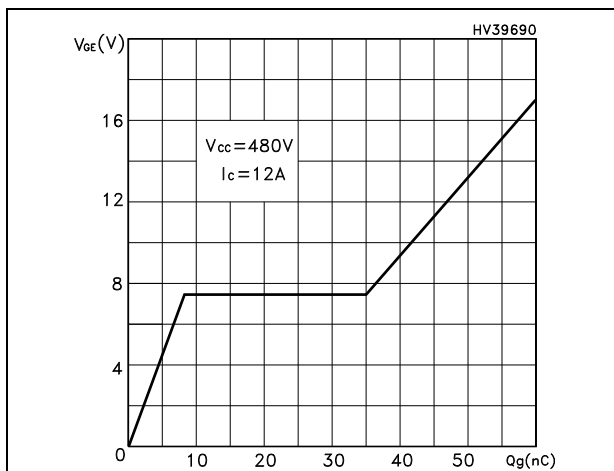
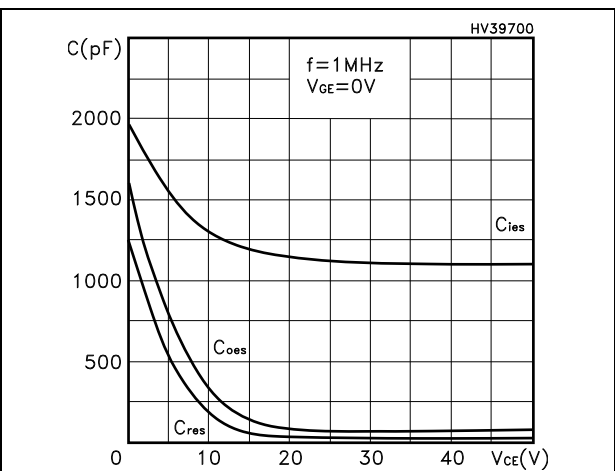
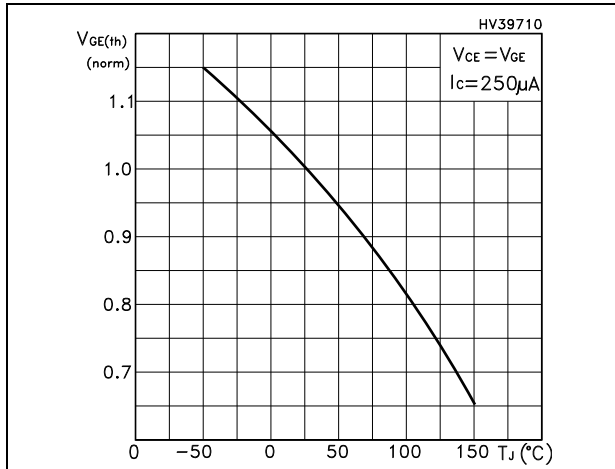


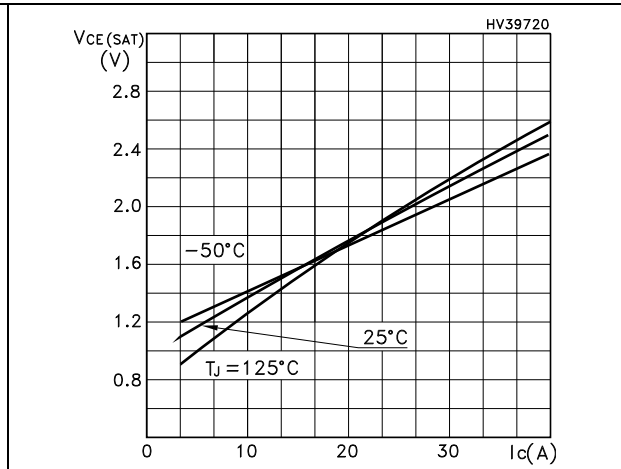
Figure 7. Capacitance variations



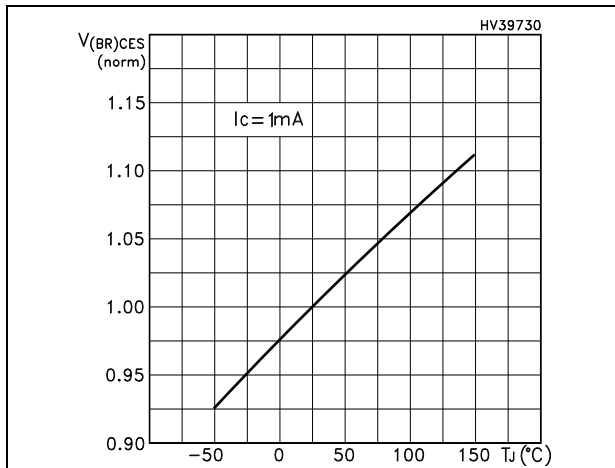
**Figure 8. Normalized gate threshold voltage vs temperature**



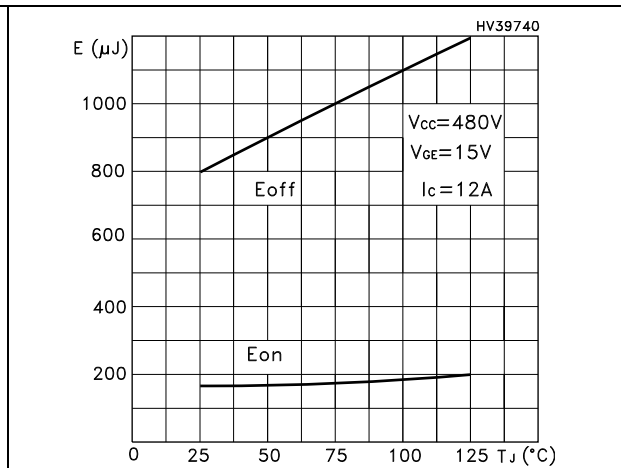
**Figure 9. Collector-emitter on voltage vs collector current**



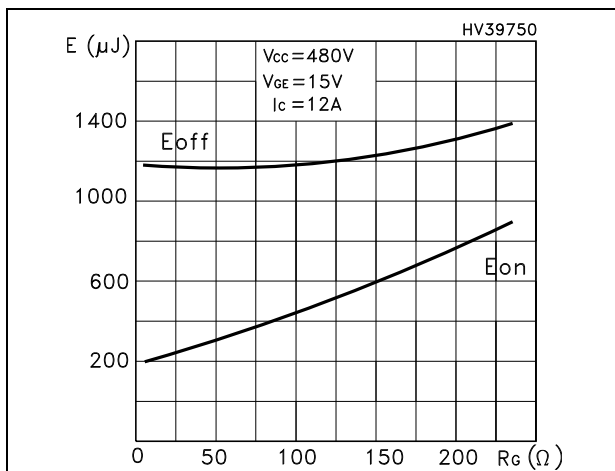
**Figure 10. Normalized breakdown voltage vs temperature**



**Figure 11. Switching losses vs temperature**



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



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

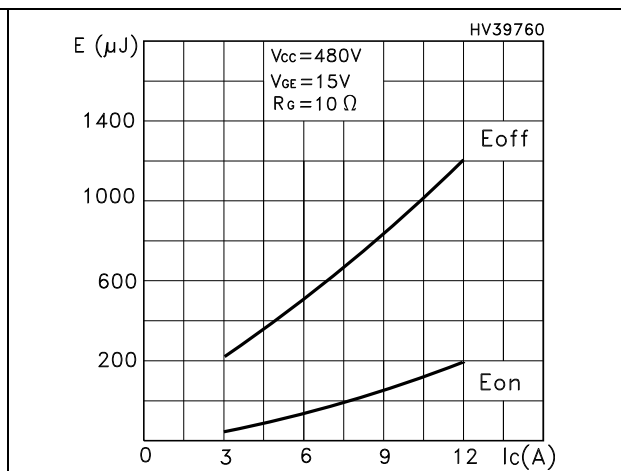


Figure 14. Turn-off SOA

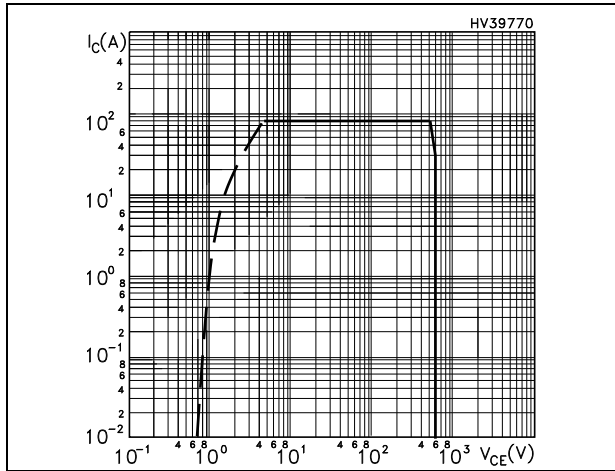


Figure 15. Thermal impedance for TO-220

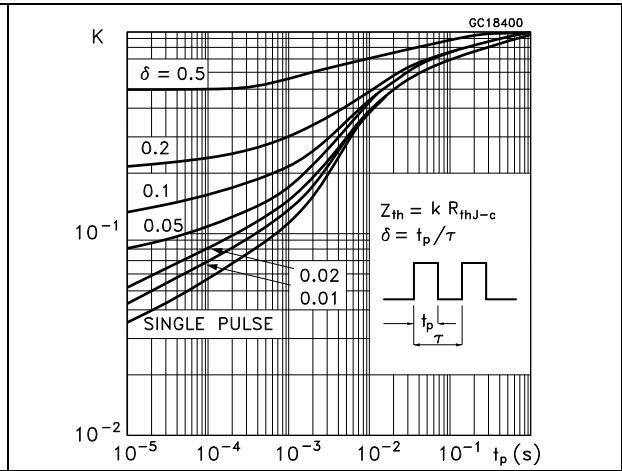


Figure 16. Thermal impedance for TO-220FP

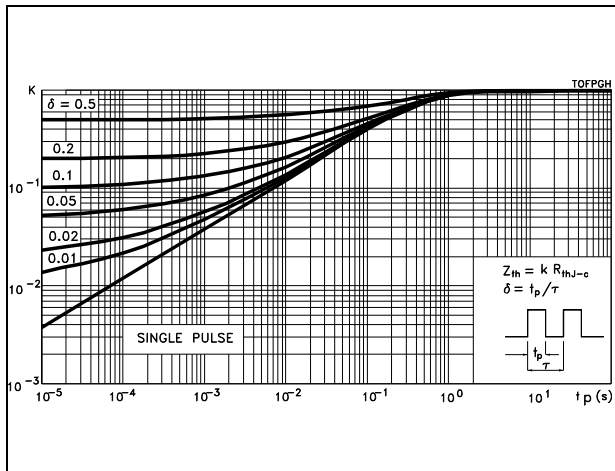


Figure 17. Forward voltage drop versus forward current

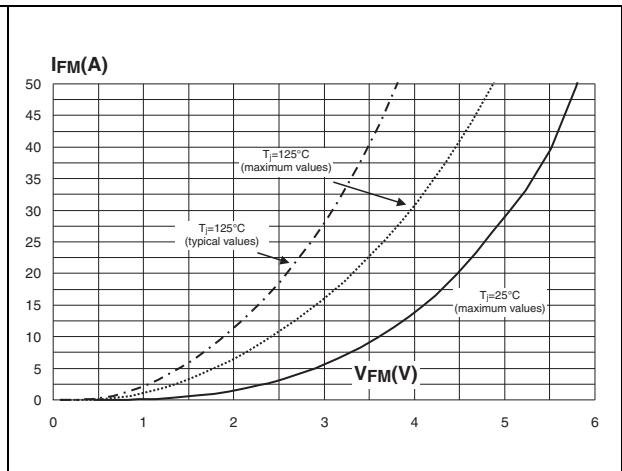
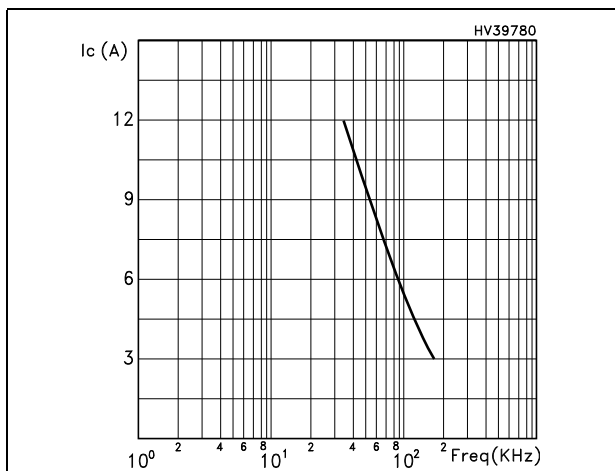


Figure 18. Ic vs. frequency





## 2.2 Frequency applications

For a fast IGBT suitable for high frequency applications, the typical collector current vs. maximum operating frequency curve is reported. That frequency is defined as follows:

$$f_{MAX} = (P_D - P_C) / (E_{ON} + E_{OFF})$$

- The maximum power dissipation is limited by maximum junction to case thermal resistance:

### Equation 1

$$P_D = \Delta T / R_{THJ-C}$$

considering  $\Delta T = T_J - T_C = 125\text{ °C} - 75\text{ °C} = 50\text{ °C}$

- The conduction losses are:

### Equation 2

$$P_C = I_C * V_{CE(SAT)} * \delta$$

with 50% of duty cycle,  $V_{CESAT}$  typical value @ 125°C.

- Power dissipation during ON & OFF commutations is due to the switching frequency:

### Equation 3

$$P_{SW} = (E_{ON} + E_{OFF}) * \text{freq.}$$

Typical values @ 125°C for switching losses are used (test conditions:  $V_{CE} = 480\text{V}$ ,  $V_{GE} = 15\text{V}$ ,  $R_G = 10\text{ Ohm}$ ). Furthermore, diode recovery energy is included in the  $E_{ON}$  (see [Note 1](#)), while the tail of the collector current is included in the  $E_{OFF}$  measurements.

### 3 Test circuits

Figure 19. Test circuit for inductive load switching

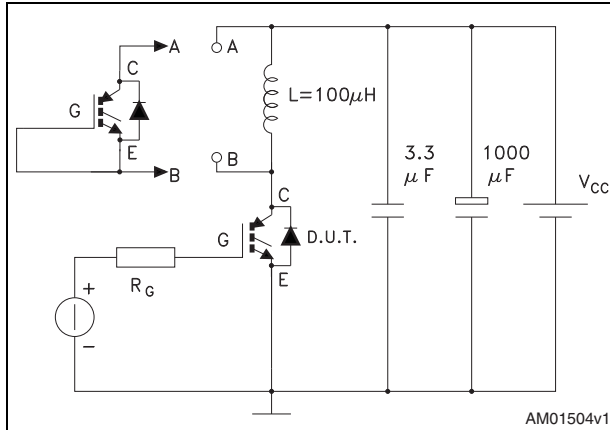


Figure 20. Gate charge test circuit

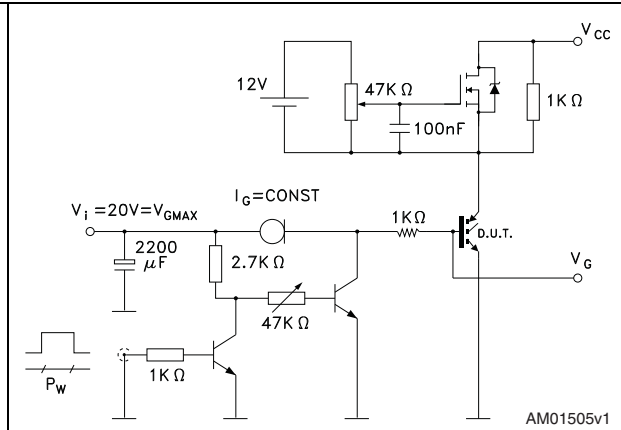


Figure 21. Switching waveform

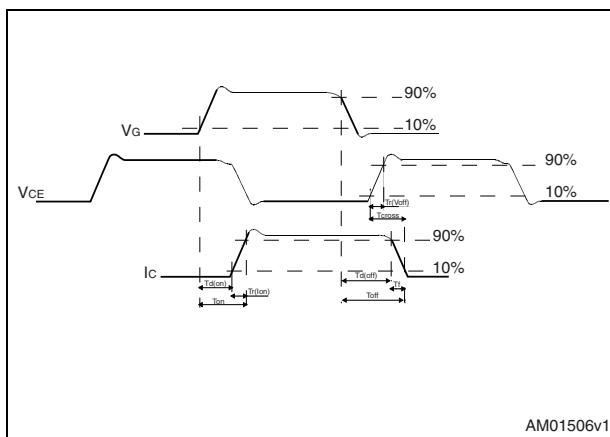
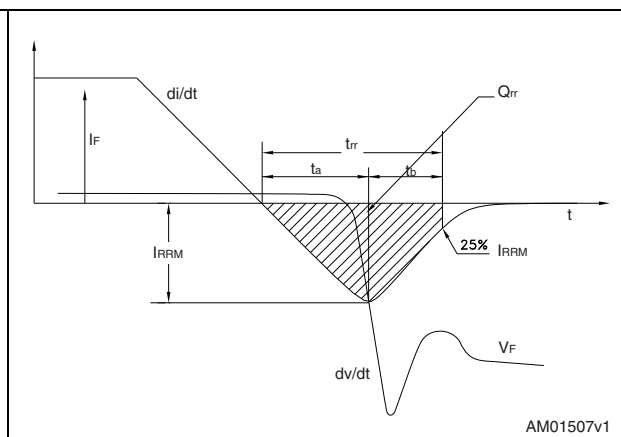


Figure 22. Diode recovery time waveform



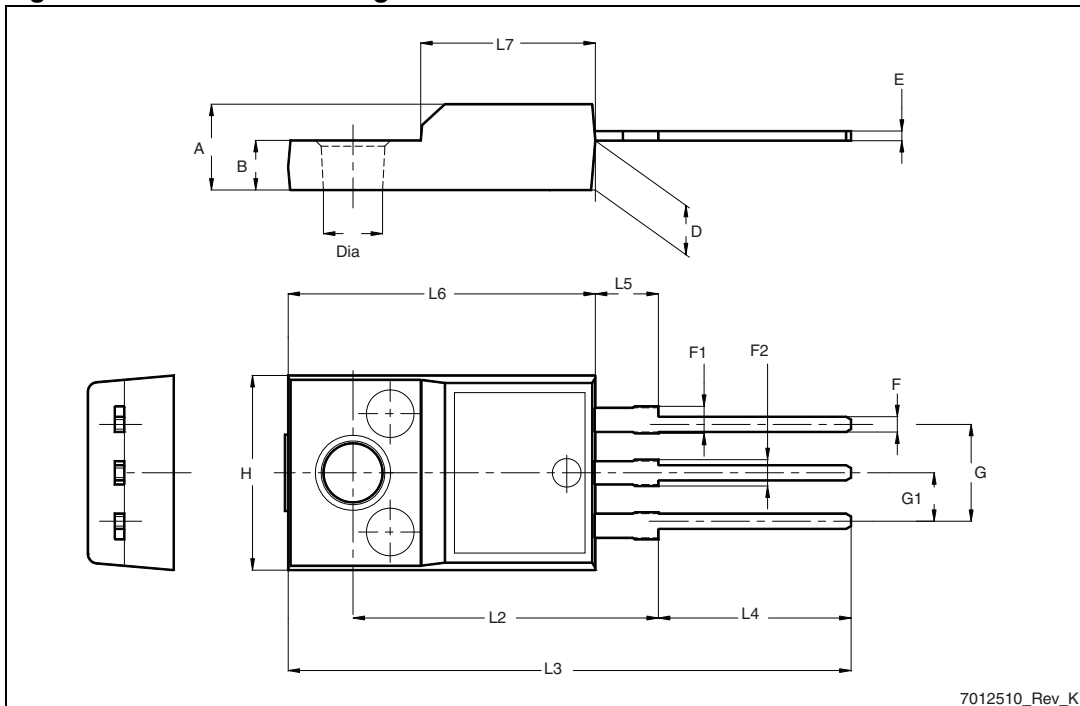
## 4 Package mechanical data

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

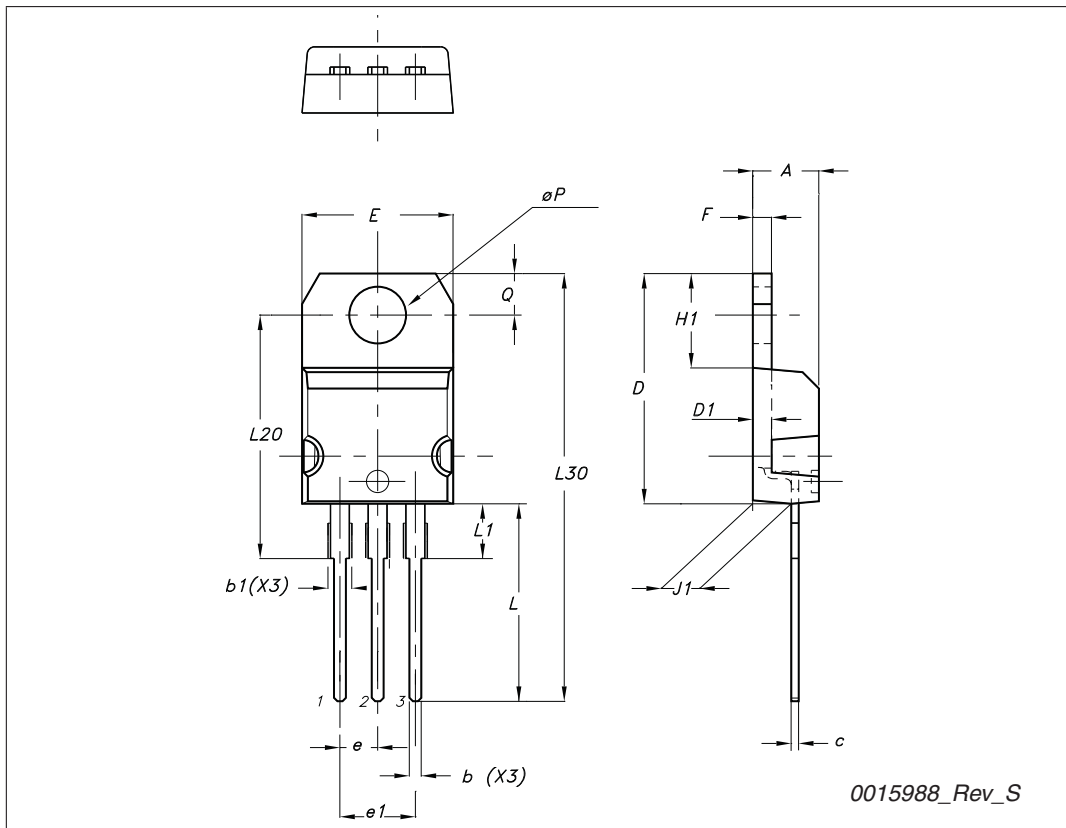
Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

Figure 23. TO-220FP drawing



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	
∅P	3.75		3.85
Q	2.65		2.95



## 5 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
02-Jul-2007	1	First release
13-Aug-2007	2	From target to preliminary version
18-Sep-2007	3	Added new section: <i>Electrical characteristics (curves)</i>
05-Nov-2010	4	<ul style="list-style-type: none"><li>– Cover page has been updated</li><li>– Modified gate threshold voltage range on <i>Table 4: Static</i></li><li>– Updated TO-220 mechanical data</li><li>– Added new package, mechanical data: TO-220FP</li></ul>

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