

## 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.

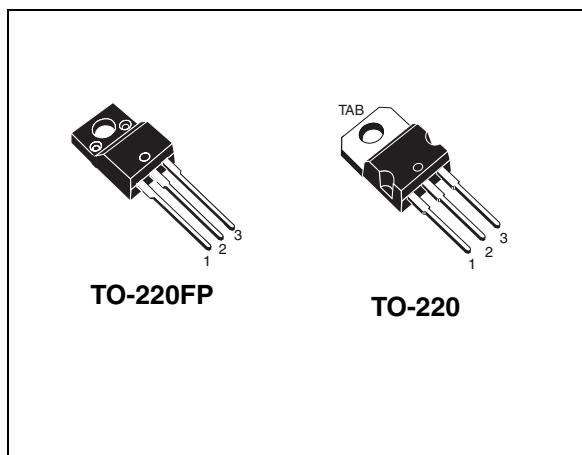


Figure 1. Internal schematic diagram

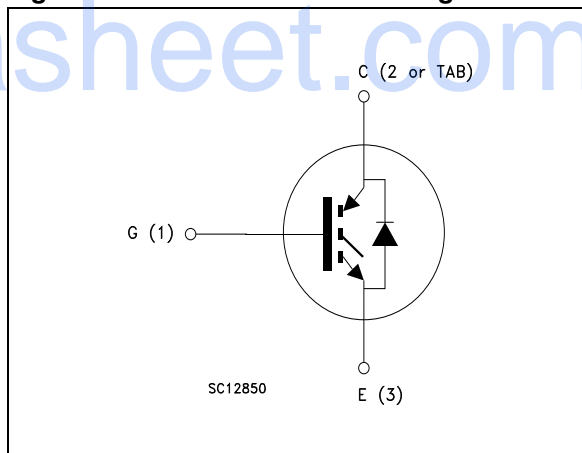


Table 1. Device summary

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

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

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

3.  $V_{\text{clamp}} = 80\%$  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

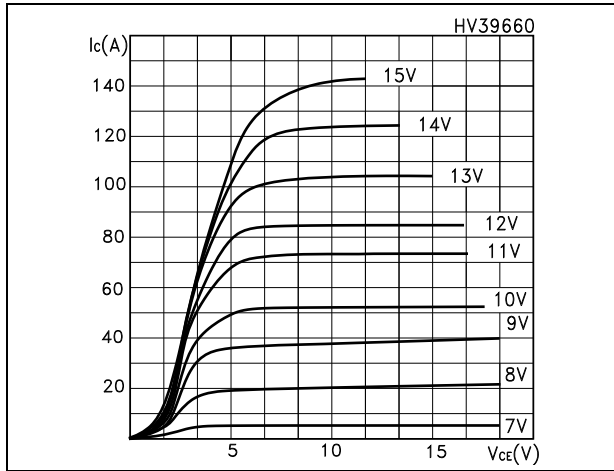


Figure 3. Transfer characteristics

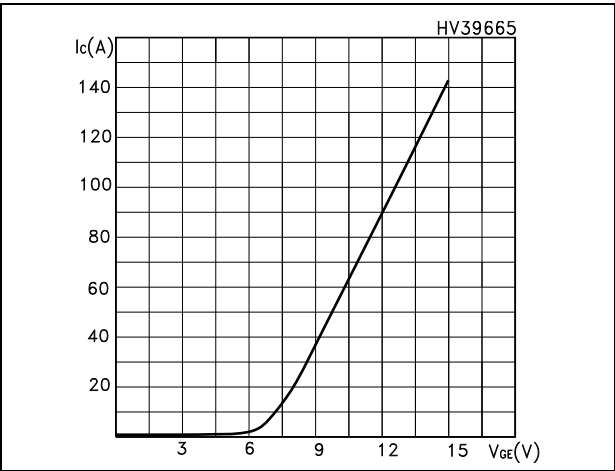


Figure 4. Transconductance

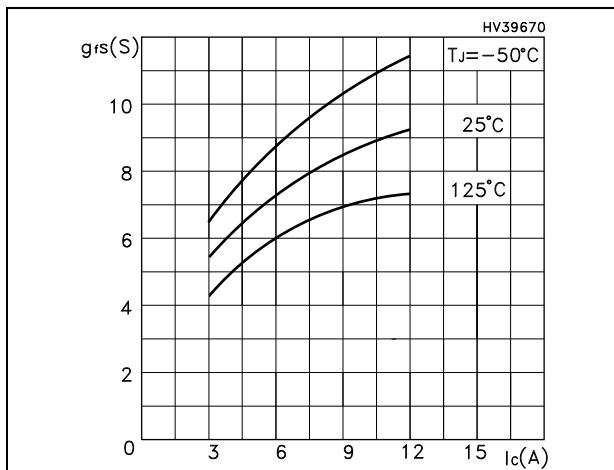


Figure 5. Collector-emitter on voltage vs temperature

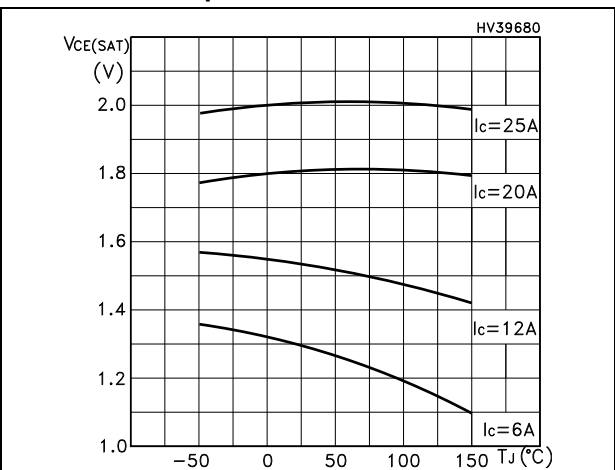


Figure 6. Gate charge vs gate-source voltage

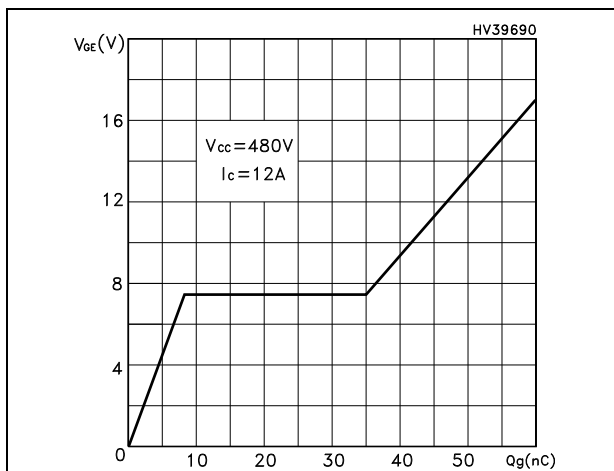


Figure 7. Capacitance variations

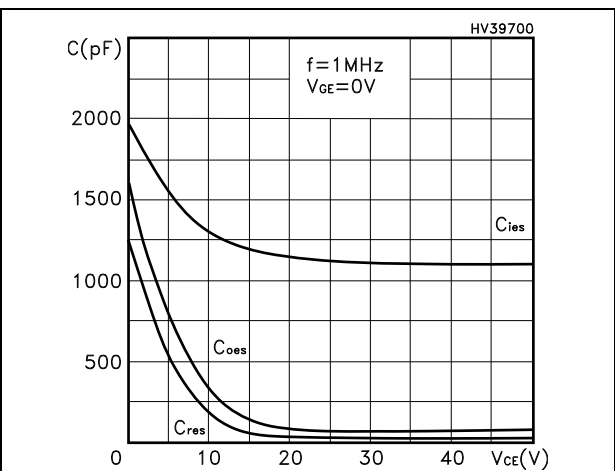


Figure 8. Normalized gate threshold voltage vs temperature

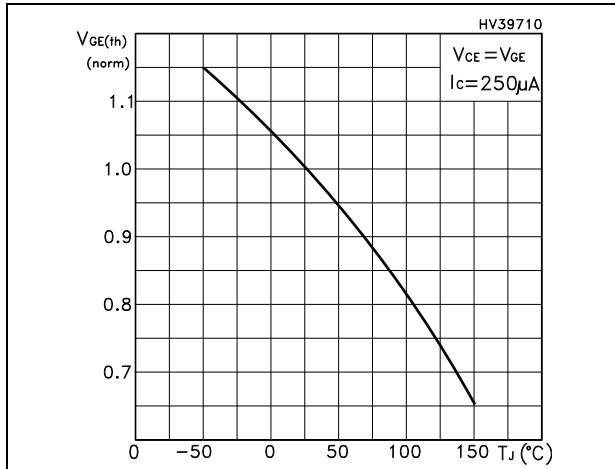


Figure 9. Collector-emitter on voltage vs collector current

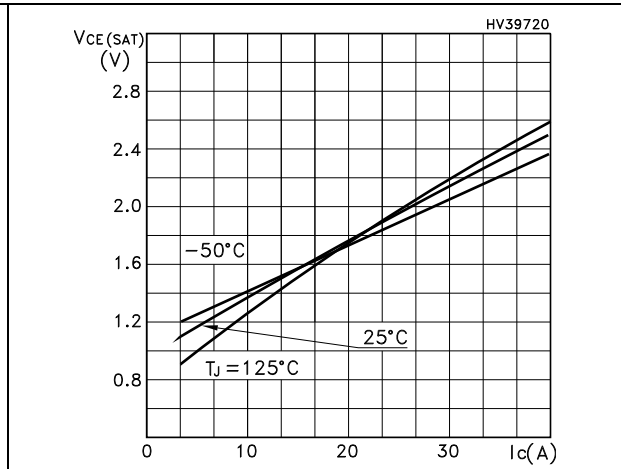


Figure 10. Normalized breakdown voltage vs temperature

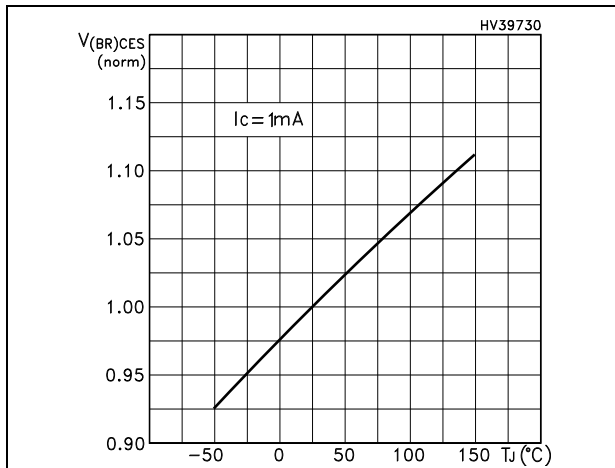


Figure 11. Switching losses vs temperature

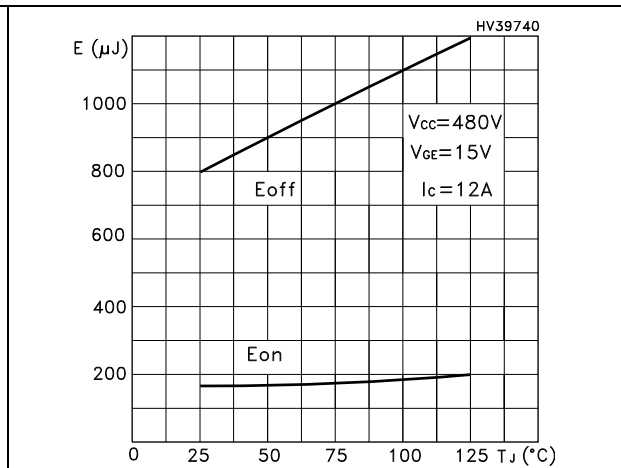


Figure 12. Switching losses vs gate resistance

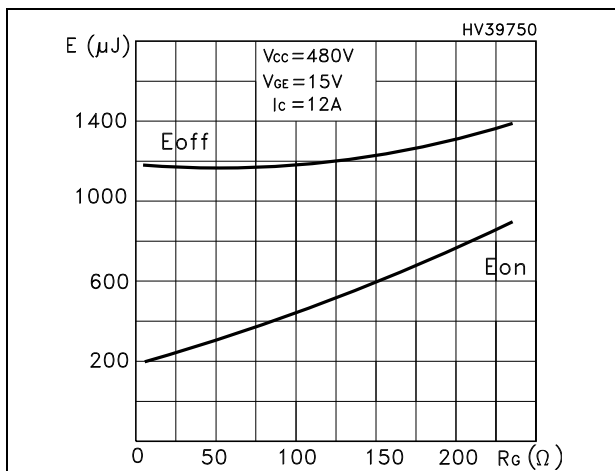


Figure 13. Switching losses vs collector current

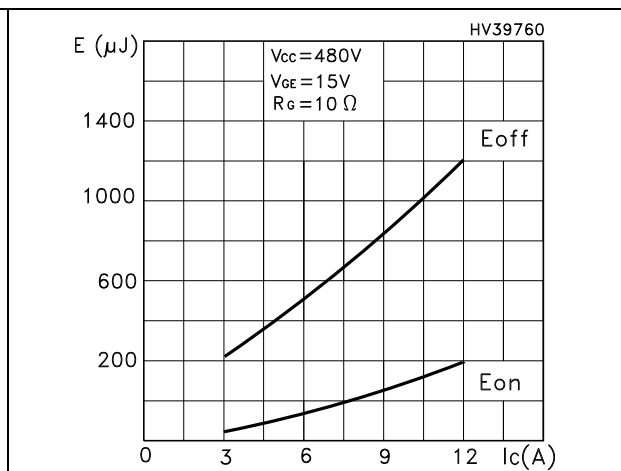


Figure 14. Turn-off SOA

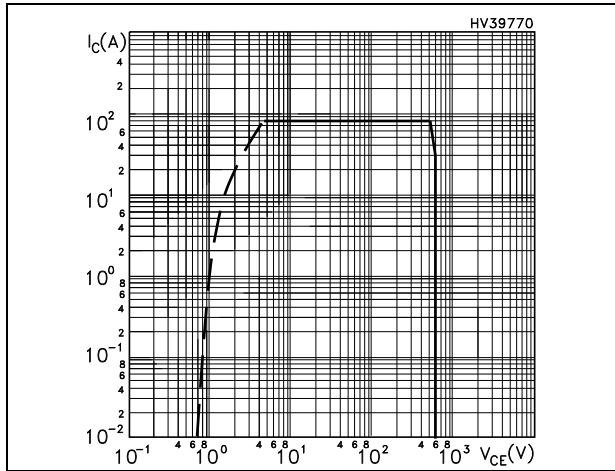


Figure 15. Thermal impedance for TO-220

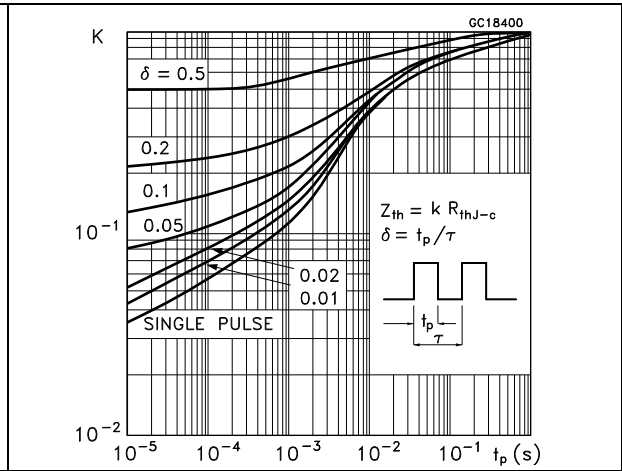


Figure 16. Thermal impedance for TO-220FP

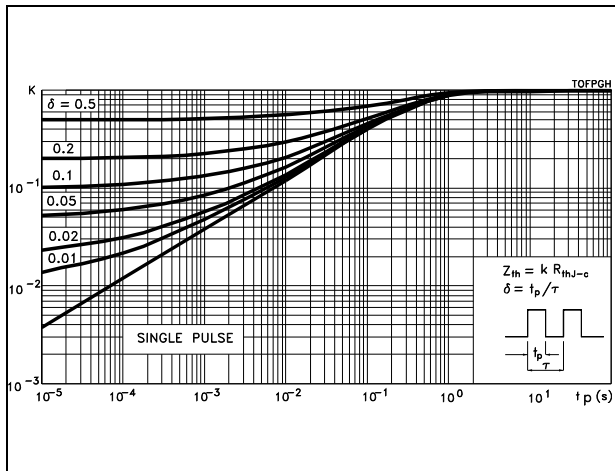


Figure 17. Forward voltage drop versus forward current

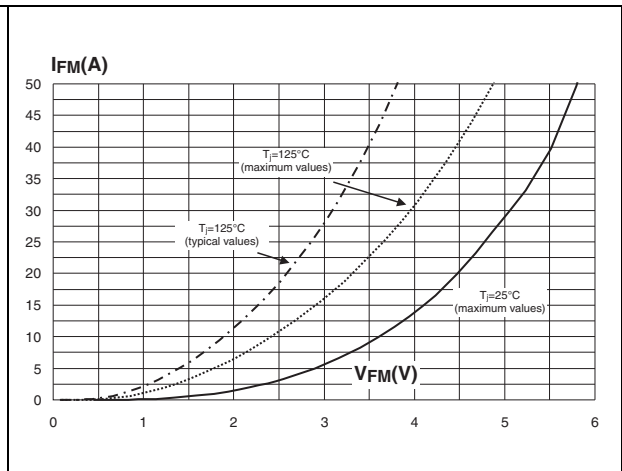
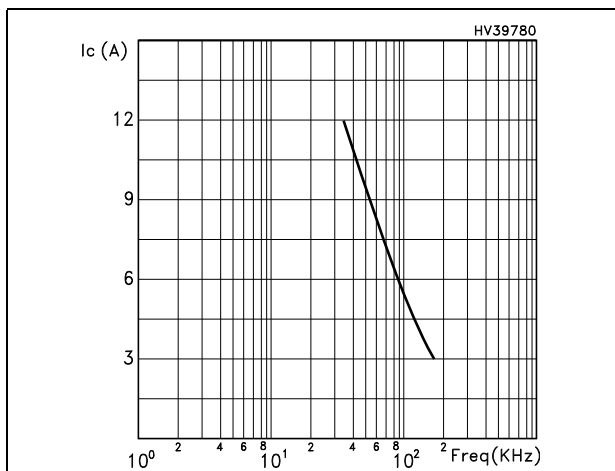


Figure 18. Ic vs. frequency





## 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:  $V_{CE} = 480V$ ,  $V_{GE} = 15V$ ,  $R_G = 10\text{ Ohm}$ ). 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

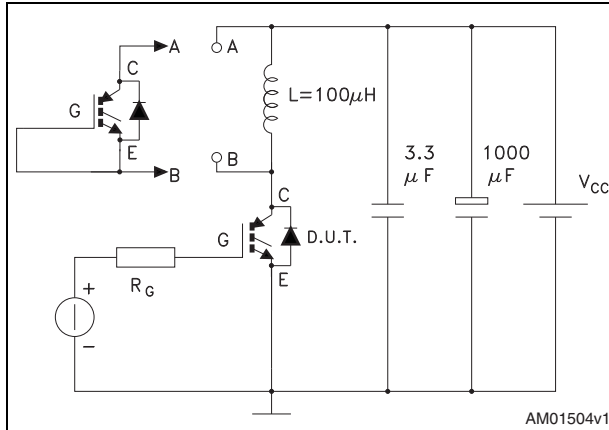


Figure 20. Gate charge test circuit

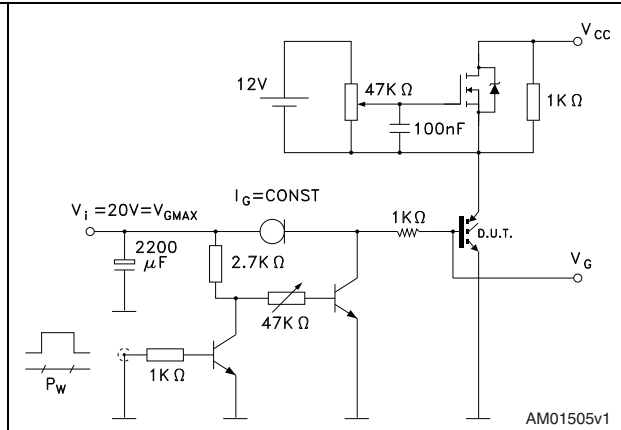


Figure 21. Switching waveform

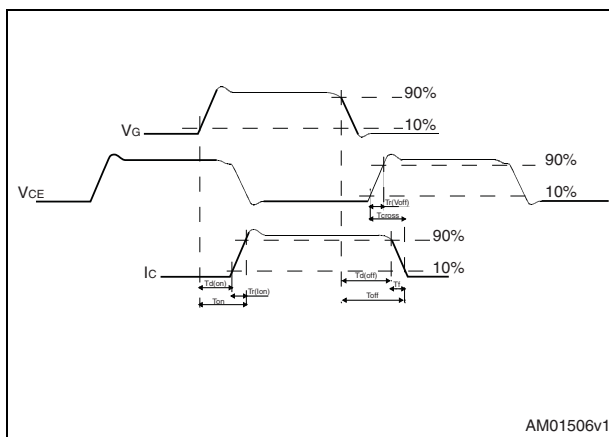
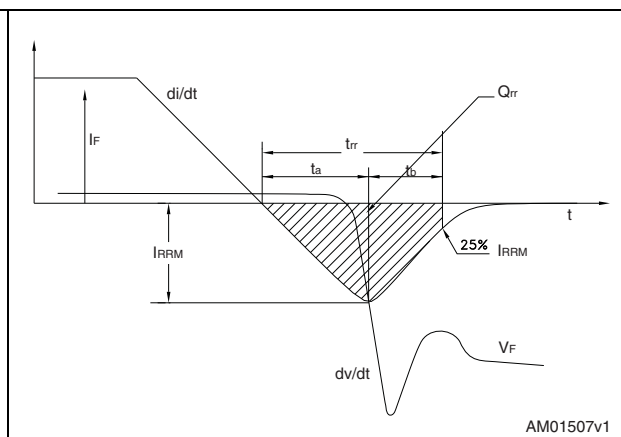


Figure 22. Diode recovery time waveform



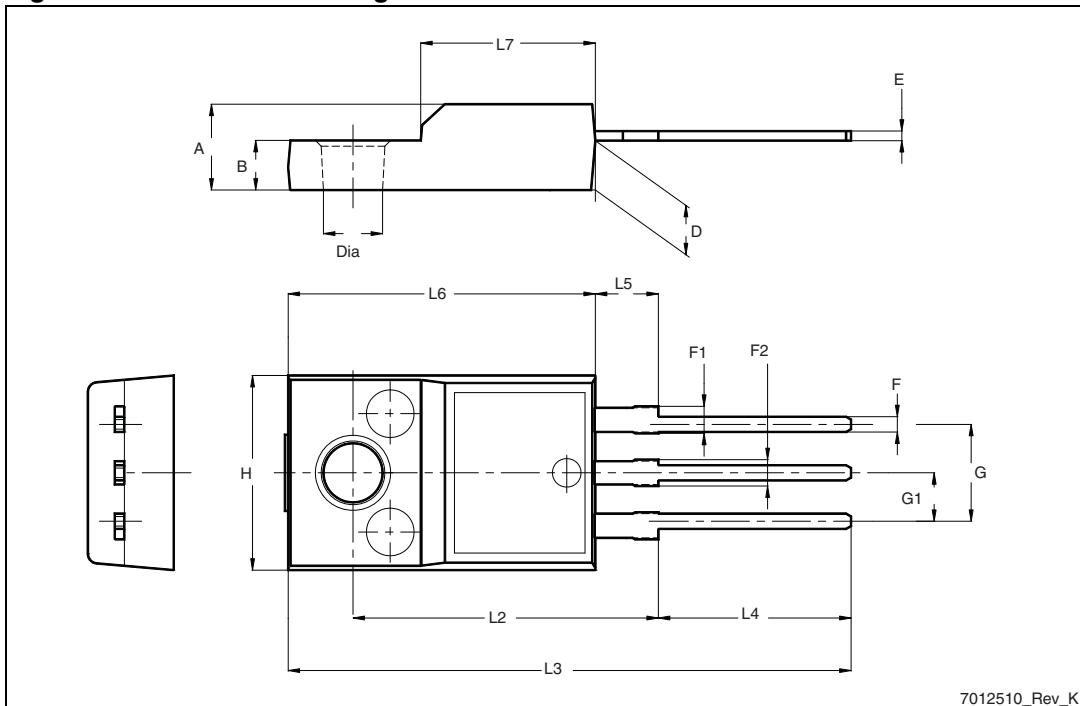
## 4 Package mechanical data

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

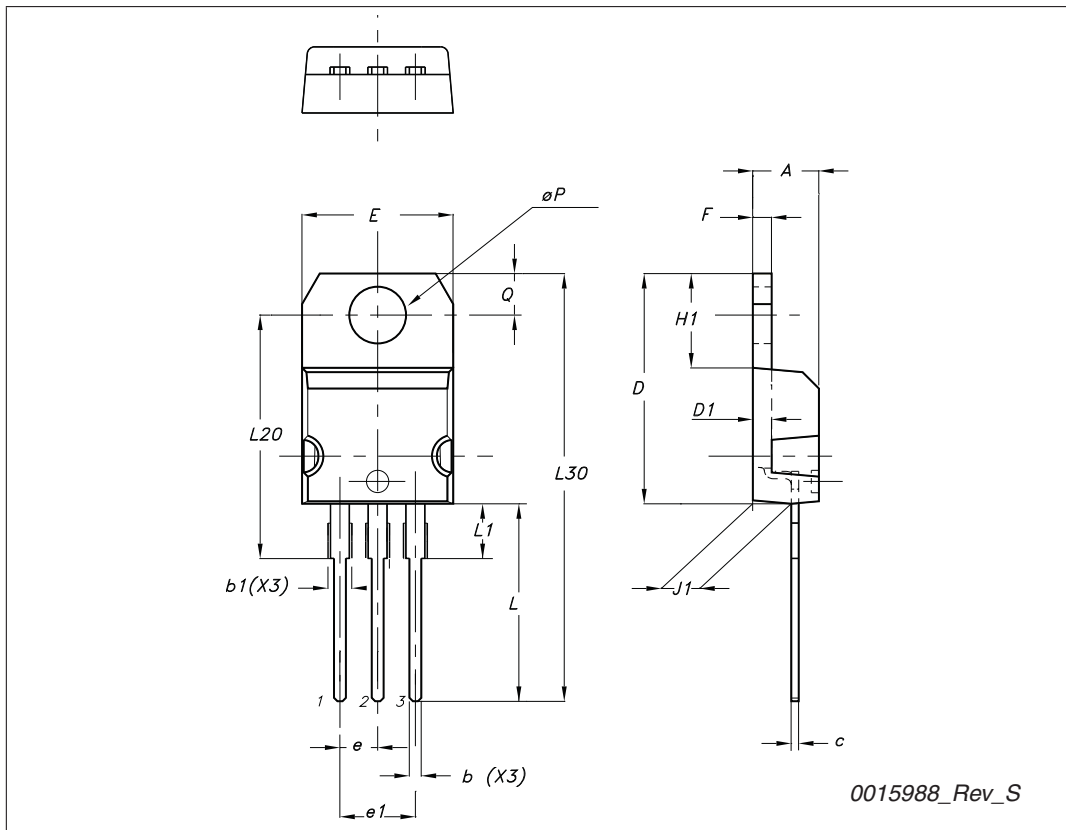
Figure 23. TO-220FP drawing



7012510\_Rev\_K

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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