



# STGB10NC60HD - STGD10NC60HD STGF10NC60HD - STGP10NC60HD

600 V - 10 A - very fast IGBT

## Features

- Low on-voltage drop ( $V_{CE(sat)}$ )
- Low  $C_{RES} / C_{IES}$  ratio (no cross-conduction susceptibility)
- Very soft ultra fast recovery antiparallel diode

## Applications

- High frequency motor controls
- SMPS and PFC in both hard switch and resonant topologies
- Motor drivers

## Description

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

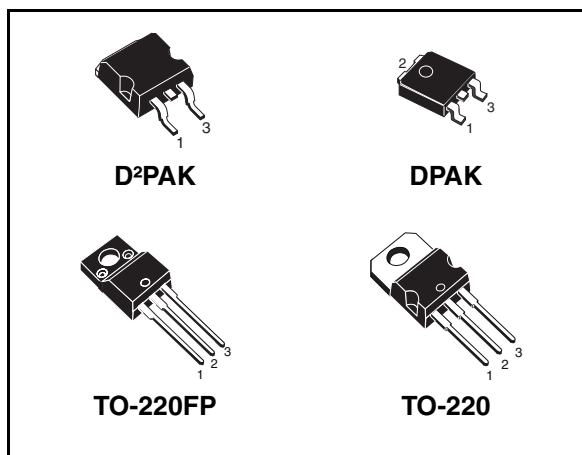


Figure 1. Internal schematic diagram

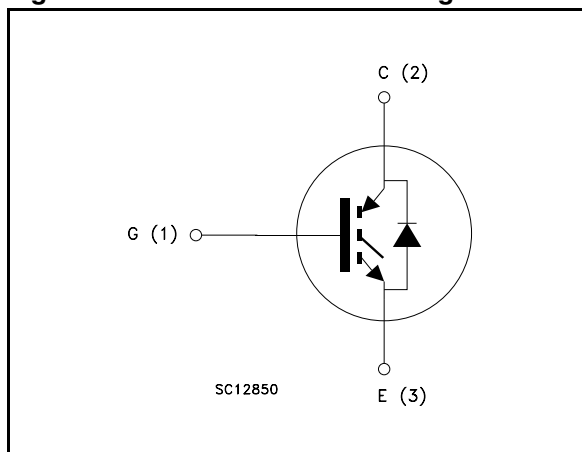


Table 1. Device summary

Order codes	Marking	Package	Packaging
STGB10NC60HDT4	GB10NC60HD	D <sup>2</sup> PAK	Tape and reel
STGD10NC60HDT4	GD10NC60HD	DPAK	
STGF10NC60HD	GF10NC60HD	TO-220FP	Tube
STGP10NC60HD	GP10NC60HD	TO-220	

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		TO-220 / D <sup>2</sup> PAK	DPAK	TO-220FP	
V <sub>CES</sub>	Collector-emitter voltage (V <sub>GE</sub> = 0)	600			V
I <sub>C</sub> <sup>(1)</sup>	Collector current (continuous) at T <sub>C</sub> = 25 °C	20		9	A
I <sub>C</sub> <sup>(1)</sup>	Collector current (continuous) at T <sub>C</sub> = 100 °C	10		6	A
I <sub>CL</sub> <sup>(2)</sup>	Turn-off latching current	30			A
I <sub>CP</sub> <sup>(3)</sup>	Pulsed collector current	30			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	10			A
I <sub>FSM</sub>	Surge not repetitive forward current t <sub>p</sub> = 10 ms sinusoidal	20			A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	65	62	24	W
V <sub>ISO</sub>	Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; T <sub>C</sub> = 25 °C)			2500	V
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 % (V<sub>CES</sub>), V<sub>GE</sub> = 15 V, R<sub>G</sub> = 10 Ω, T<sub>J</sub> = 150 °C

3. Pulse width limited by max junction temperature allowed

**Table 3. Thermal resistance**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK TO-220	DPAK	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case IGBT max.	1.9	2.0	5.1	°C/W
R <sub>thj-case</sub>	Thermal resistance junction-case diode max.	4	4.5	7	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max.	62.5	100	62.5	°C/W

## 2 Electrical characteristics

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

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage ( $V_{GE} = 0$ )	$I_C = 1\text{ mA}$	600			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}, I_C = 5\text{ A}$		1.9	2.5	V
		$V_{GE} = 15\text{ V}, I_C = 5\text{ A}, T_C = 125\text{ °C}$		1.7		V
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}, I_C = 250\text{ }\mu\text{A}$	3.75		5.75	V
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 600\text{ V}$			150	$\mu\text{A}$
		$V_{CE} = 600\text{ V}, T_C = 125\text{ °C}$			1	mA
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$			$\pm 100$	nA
$g_{fs}^{(1)}$	Forward transconductance	$V_{CE} = 15\text{ V}, I_C = 5\text{ A}$		3.5		S

1. 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	$V_{CE} = 25\text{ V}, f = 1\text{ MHz}, V_{GE} = 0$		365		pF
$C_{oes}$	Output capacitance			43		pF
$C_{res}$	Reverse transfer capacitance				8.3	pF
$Q_g$	Total gate charge	$V_{CE} = 390\text{ V}, I_C = 5\text{ A},$		19.2		nC
$Q_{ge}$	Gate-emitter charge	$V_{GE} = 15\text{ V}$		4.5		nC
$Q_{gc}$	Gate-collector charge	(see Figure 19)		7		nC

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $t_r$ $(di/dt)_{on}$	Turn-on delay time Current rise time Turn-on current slope	$V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , <i>(see Figure 18)</i> <i>(see Figure 20)</i>		14.2 5 1000		ns ns A/ $\mu$ s
$t_{d(on)}$ $t_r$ $(di/dt)_{on}$	Turn-on delay time Current rise time Turn-on current slope	$V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_C = 125\text{ }^\circ\text{C}$ <i>(see Figure 18)</i> <i>(see Figure 20)</i>		14 5 920		ns ns A/ $\mu$ s
$t_r(V_{off})$ $t_{d(off)}$ $t_f$	Off voltage rise time Turn-off delay time Current fall time	$V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ , $R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ <i>(see Figure 18)</i> <i>(see Figure 20)</i>		27 72 85		ns ns ns
$t_r(V_{off})$ $t_{d(off)}$ $t_f$	Off voltage rise time Turn-off delay time Current fall time	$V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ , $R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_C = 125\text{ }^\circ\text{C}$ <i>(see Figure 18)</i> <i>(see Figure 20)</i>		50 108 139		ns ns ns

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$ $E_{off}^{(2)}$ $E_{ts}$	Turn-on switching losses Turn-off switching losses Total switching losses	$V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , <i>(see Figure 18)</i>		31.8 95 126.8		$\mu$ J $\mu$ J $\mu$ J
$E_{on}^{(1)}$ $E_{off}^{(2)}$ $E_{ts}$	Turn-on switching losses Turn-off switching losses Total switching losses	$V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_C = 125\text{ }^\circ\text{C}$ <i>(see Figure 18)</i>		61.8 173 234.8		$\mu$ J $\mu$ J $\mu$ J

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in [Figure 18](#). If the IGBT is offered in a package with a co-pak diode, the co-pak diode is used as external diode. IGBTs & 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	$I_F = 5 \text{ A}$		2	2.45	V
		$I_F = 5 \text{ A}, T_C = 125 \text{ }^\circ\text{C}$		1.7		V
$t_{rr}$	Reverse recovery time	$I_F = 5 \text{ A}, V_R = 40 \text{ V},$ $di/dt = 100 \text{ A}/\mu\text{s}$		22		ns
$Q_{rr}$	Reverse recovery charge	$di/dt = 100 \text{ A}/\mu\text{s}$		14		nC
$I_{rrm}$	Reverse recovery current	(see Figure 21)		1.3		A
$t_{rr}$	Reverse recovery time	$I_F = 5 \text{ A}, V_R = 40 \text{ V},$ $T_C = 125 \text{ }^\circ\text{C}, di/dt = 100 \text{ A}/\mu\text{s}$		33		ns
$Q_{rr}$	Reverse recovery charge	$T_C = 125 \text{ }^\circ\text{C}, di/dt = 100 \text{ A}/\mu\text{s}$		30		nC
$I_{rrm}$	Reverse recovery current	(see Figure 21)		1.85		A

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

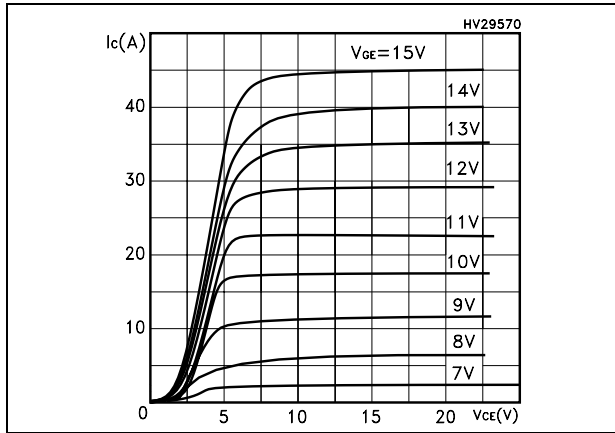


Figure 3. Transfer characteristics

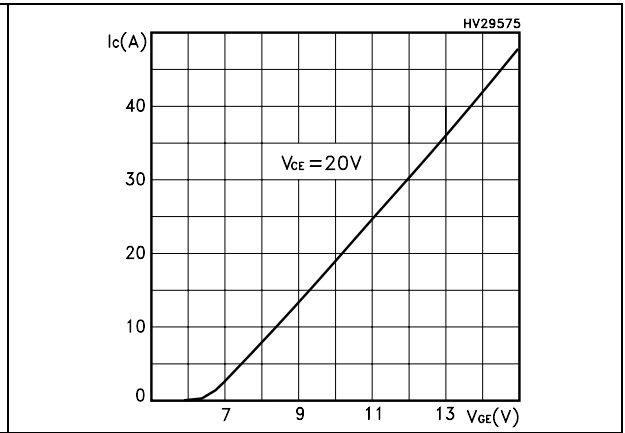


Figure 4. Transconductance

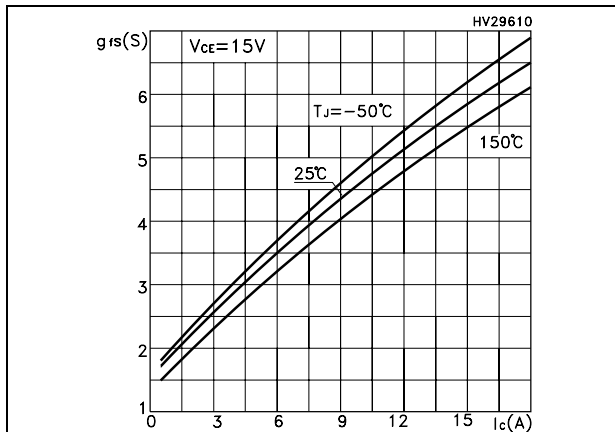


Figure 5. Collector-emitter on voltage vs temperature

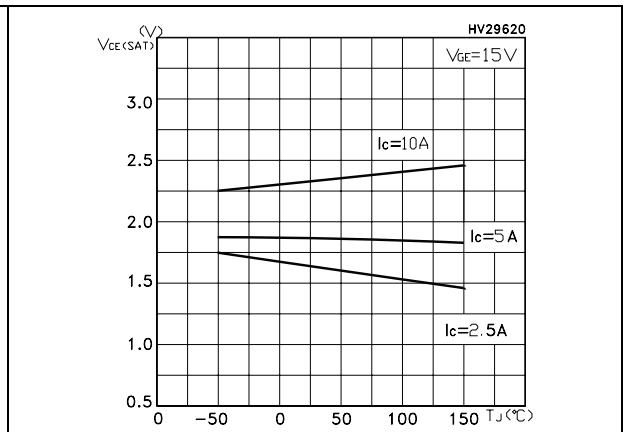


Figure 6. Gate charge vs gate-source voltage Figure 7. Capacitance variations

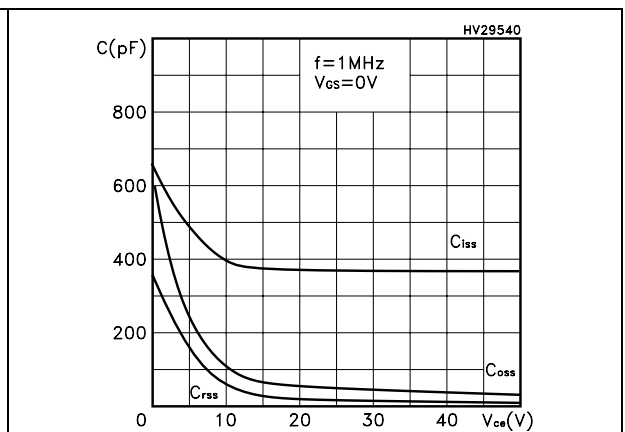
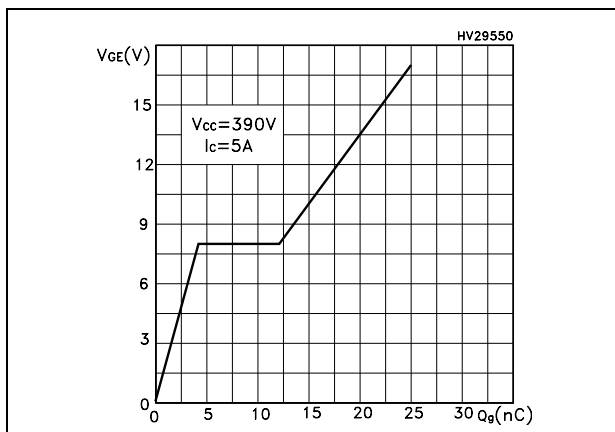


Figure 8. Normalized gate threshold voltage vs temperature

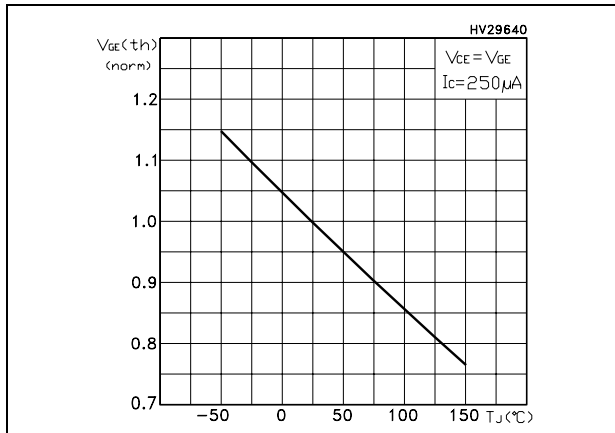


Figure 9. Collector-emitter on voltage vs collector current

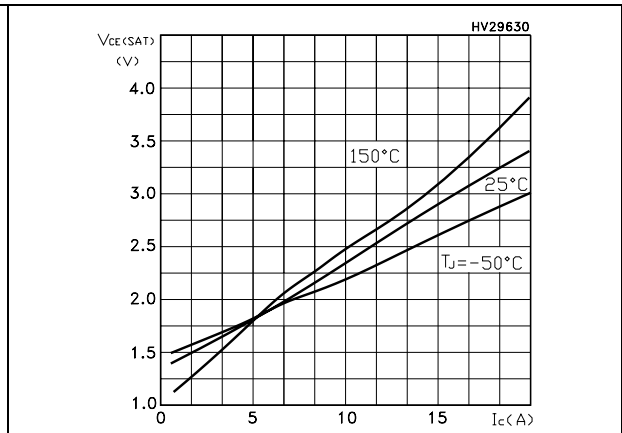


Figure 10. Normalized breakdown voltage vs temperature

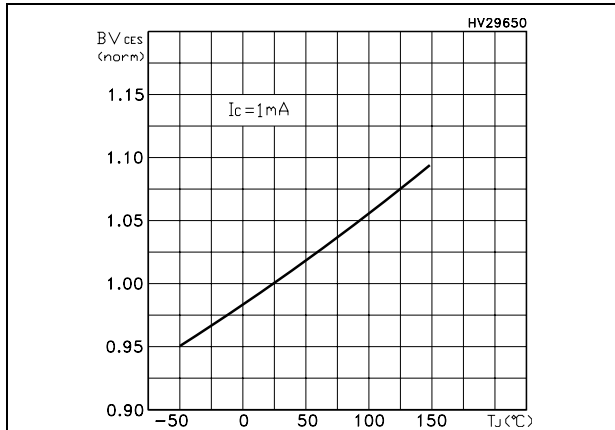


Figure 11. Switching losses vs temperature

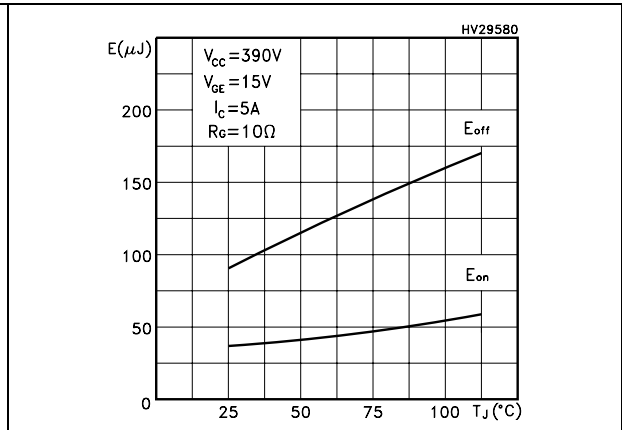


Figure 12. Switching losses vs gate resistance

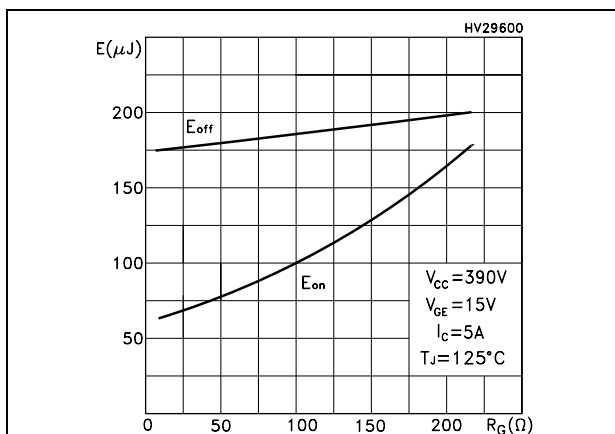


Figure 13. Switching losses vs collector current

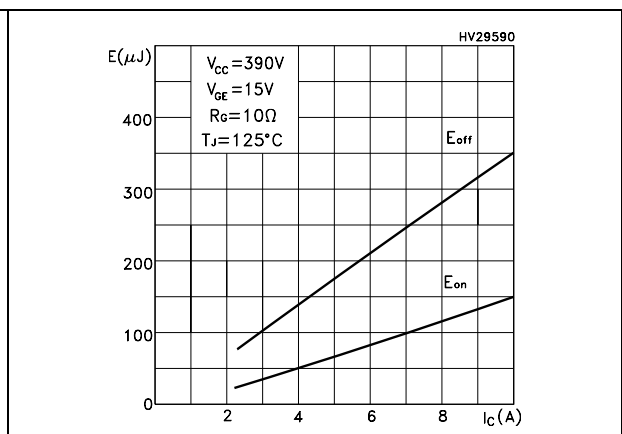




Figure 14. Thermal impedance for TO-220 / D<sup>2</sup>PAK / DPAK

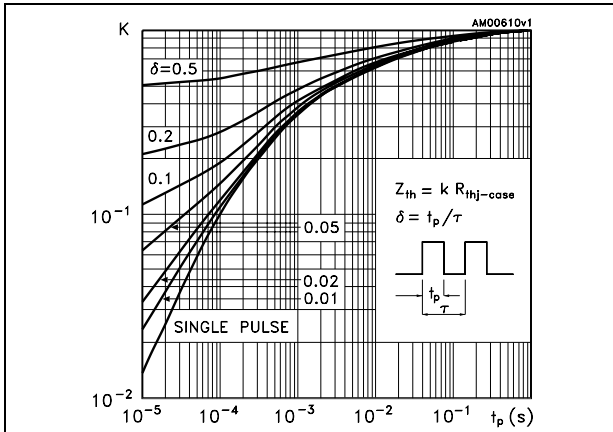


Figure 15. Turn-off SOA

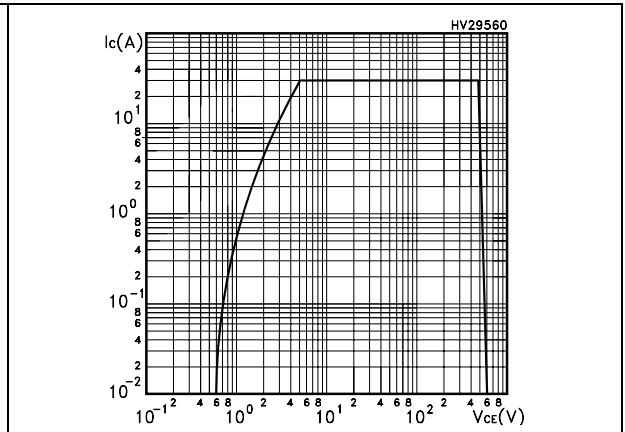
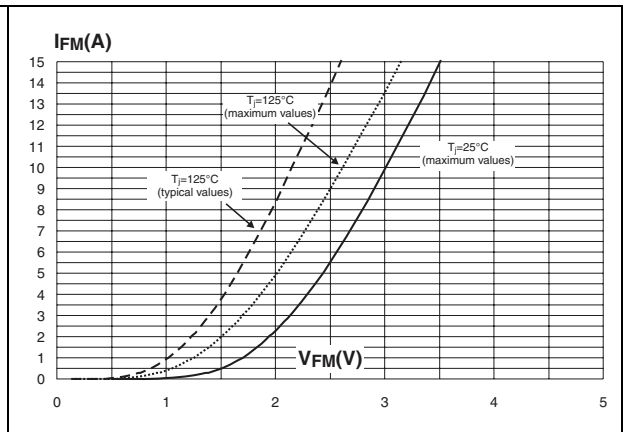
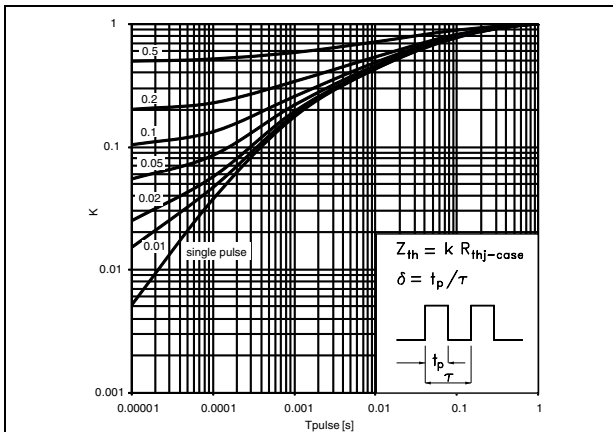


Figure 16. Thermal impedance for TO-220FP Figure 17. Emitter-collector diode characteristics



### 3 Test circuit

Figure 18. Test circuit for inductive load switching

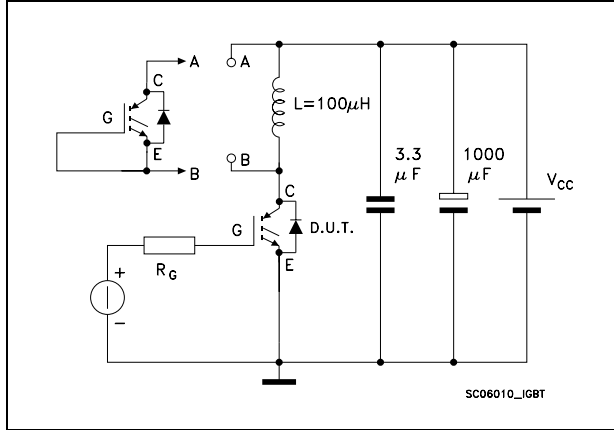


Figure 20. Switching waveform

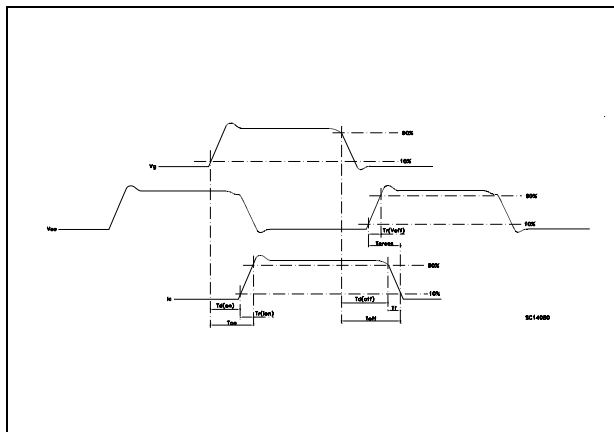


Figure 19. Gate charge test circuit

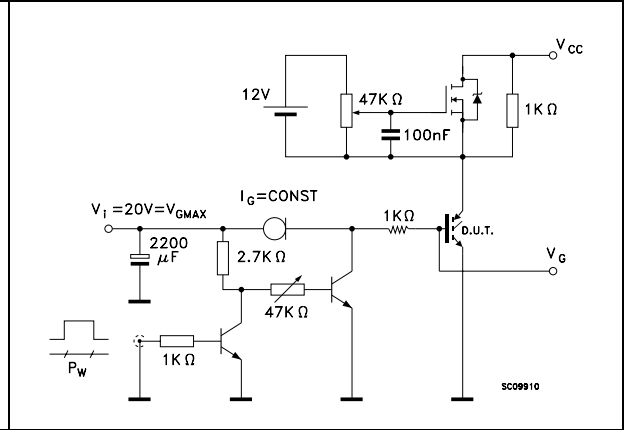
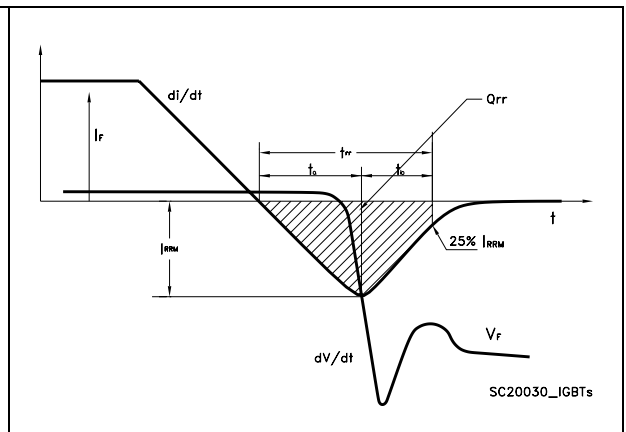


Figure 21. Diode recovery time waveform

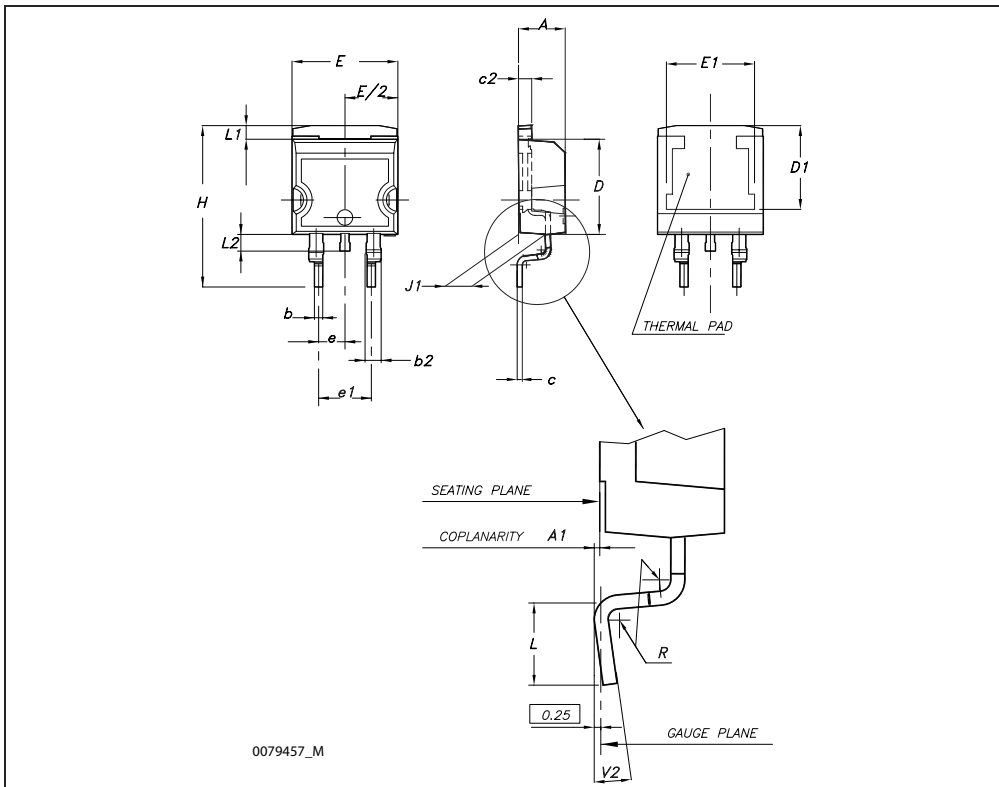


## 4 Package mechanical data

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<sup>®</sup> is an ST trademark.

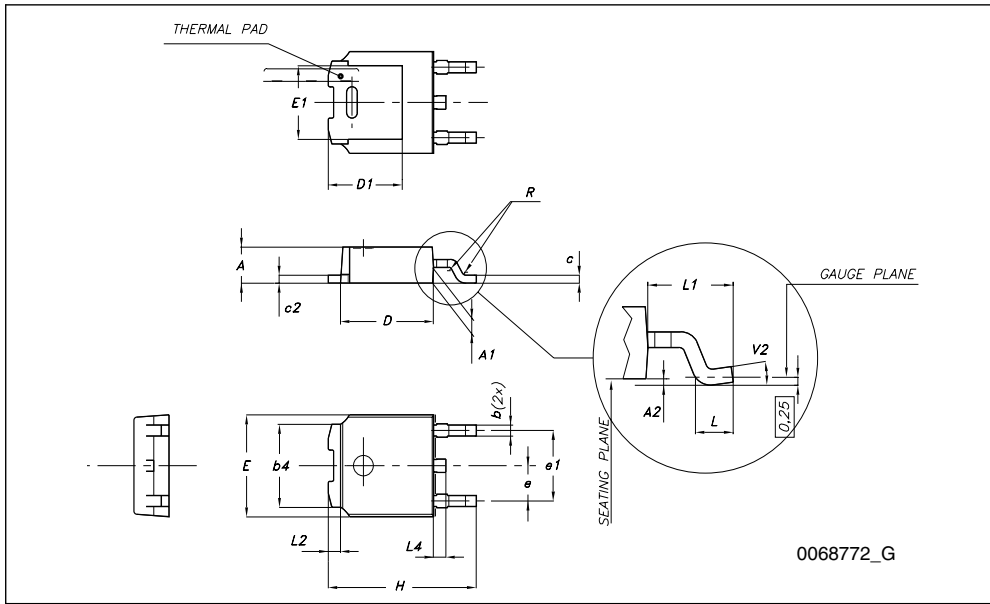
**D<sup>2</sup>PAK (TO-263) mechanical data**

Dim	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A	4.40		4.60	0.173		0.181
A1	0.03		0.23	0.001		0.009
b	0.70		0.93	0.027		0.037
b2	1.14		1.70	0.045		0.067
c	0.45		0.60	0.017		0.024
c2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1	7.50			0.295		
E	10		10.40	0.394		0.409
E1	8.50			0.334		
e		2.54			0.1	
e1	4.88		5.28	0.192		0.208
H	15		15.85	0.590		0.624
J1	2.49		2.69	0.099		0.106
L	2.29		2.79	0.090		0.110
L1	1.27		1.40	0.05		0.055
L2	1.30		1.75	0.051		0.069
R		0.4			0.016	
V2	0°		8°	0°		8°



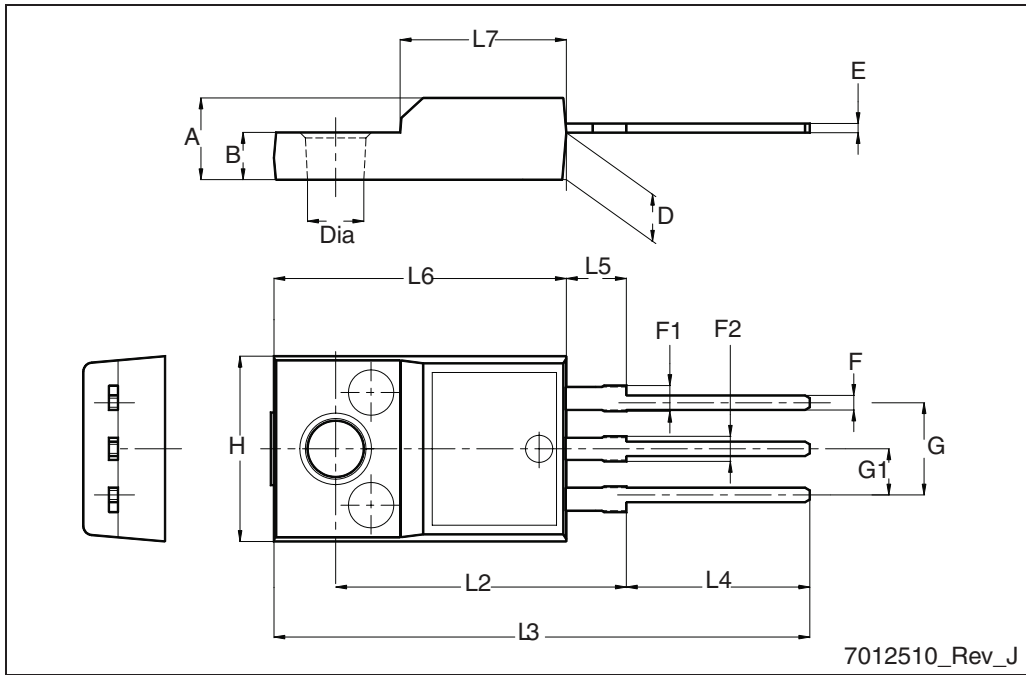
**TO-252 (DPAK) mechanical data**

DIM.	mm.		
	min.	typ	max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.64		0.90
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1		5.10	
E	6.40		6.60
E1		4.70	
e		2.28	
e1	4.40		4.60
H	9.35		10.10
L	1		
L1		2.80	
L2		0.80	
L4	0.60		1
R		0.20	
V2	0°		8°



TO-220FP mechanical data

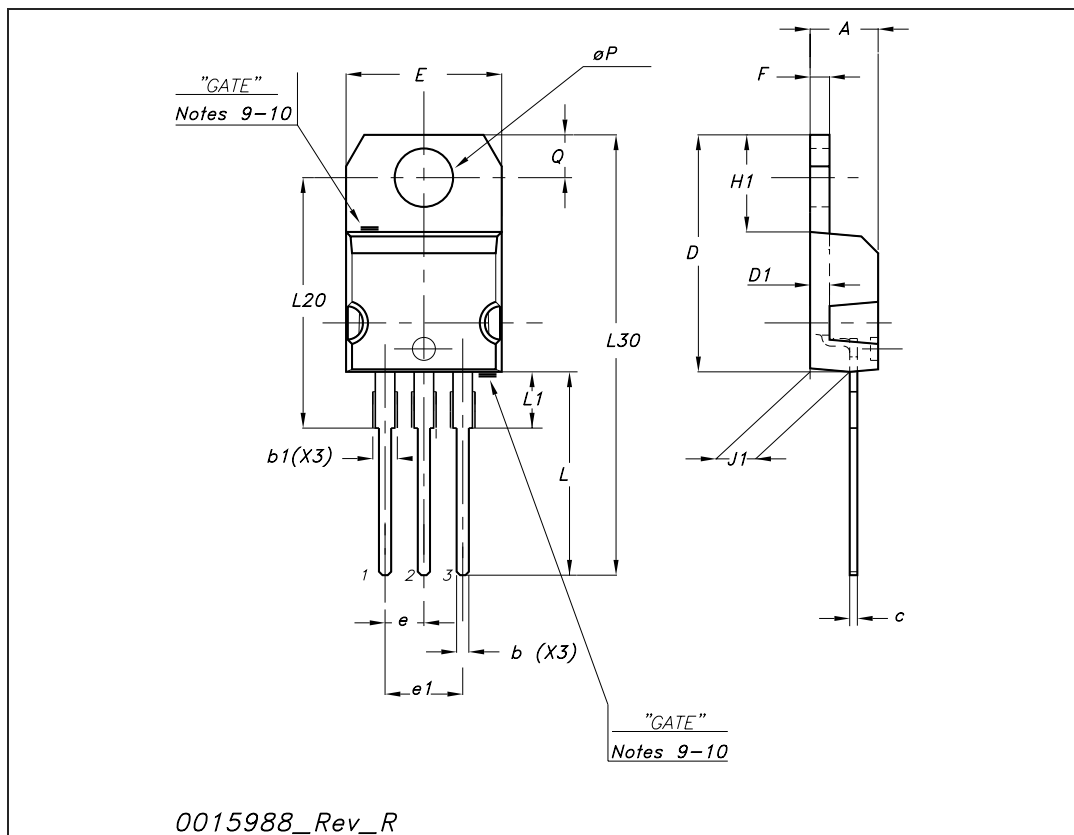
Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.5
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2



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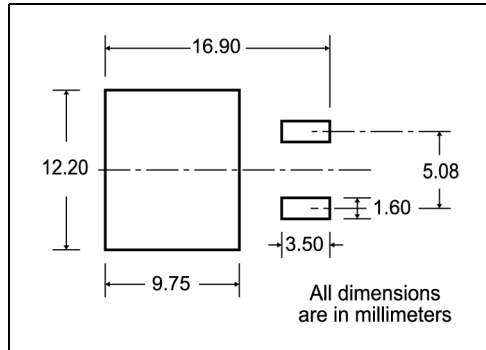
TO-220 mechanical data

Dim	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.14		1.70	0.044		0.066
c	0.48		0.70	0.019		0.027
D	15.25		15.75	0.6		0.62
D1		1.27			0.050	
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.051
H1	6.20		6.60	0.244		0.256
J1	2.40		2.72	0.094		0.107
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L20		16.40			0.645	
L30		28.90			1.137	
∅P	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



### 4.1 Packaging mechanical data

#### D<sup>2</sup>PAK FOOTPRINT



#### TAPE AND REEL SHIPMENT

**TAPE MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	10.5	10.7	0.413	0.421
B0	15.7	15.9	0.618	0.626
D	1.5	1.6	0.059	0.063
D1	1.59	1.61	0.062	0.063
E	1.65	1.85	0.065	0.073
F	11.4	11.6	0.449	0.456
K0	4.8	5.0	0.189	0.197
P0	3.9	4.1	0.153	0.161
P1	11.9	12.1	0.468	0.476
P2	1.9	2.1	0.075	0.082
R	50		1.574	
T	0.25	0.35	0.0098	0.0137
W	23.7	24.3	0.933	0.956

**REEL MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	24.4	26.4	0.960	1.039
N	100		3.937	
T		30.4		1.197

BASE QTY	BULK QTY
1000	1000

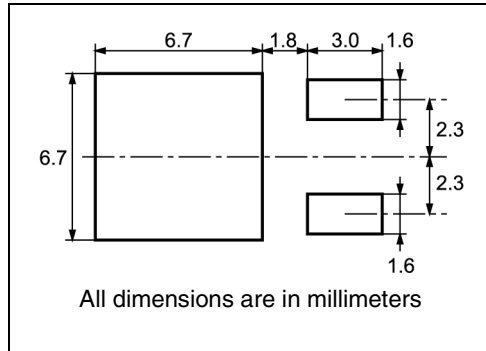
  

10 pitches cumulative tolerance on tape +/- 0.2 mm

\* on sales type



**DPAK FOOTPRINT**



**TAPE AND REEL SHIPMENT**

**REEL MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	16.4	18.4	0.645	0.724
N	50		1.968	
T		22.4		0.881

**TAPE MECHANICAL DATA**

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	6.8	7	0.267	0.275
B0	10.4	10.6	0.409	0.417
B1		12.1		0.476
D	1.5	1.6	0.059	0.063
D1	1.5		0.059	
E	1.65	1.85	0.065	0.073
F	7.4	7.6	0.291	0.299
K0	2.55	2.75	0.100	0.108
P0	3.9	4.1	0.153	0.161
P1	7.9	8.1	0.311	0.319
P2	1.9	2.1	0.075	0.082
R	40		1.574	
W	15.7	16.3	0.618	0.641

## 5 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
30-Jan-2006	1	Initial release
06-Nov-2006	2	Complete version
08-Feb-2007	3	The document has been reformatted
05-Oct-2007	4	Added TO-220FP, <a href="#">Table 2</a> has been updated
16-Dec-2008	5	Added DPAK package

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