



# STGBL6NC60D - STGDL6NC60D STGFL6NC60D - STGPL6NC60D

600 V - 6 A hyper fast IGBT

## Features

- Low  $C_{RES} / C_{IES}$  ratio (no cross-conduction susceptibility)
- Very soft ultra fast recovery antiparallel diode

## Applications

- Very high frequency operation
- High frequency lamp ballast
- SMPS and PFC (hard switching too)

## Description

Based on PowerMESH technology and thanks to a new lifetime control system, this new series exhibits very low turn-off energy realizing the best trade-off between on-state voltage and switching losses and so allowing very high operating frequencies.

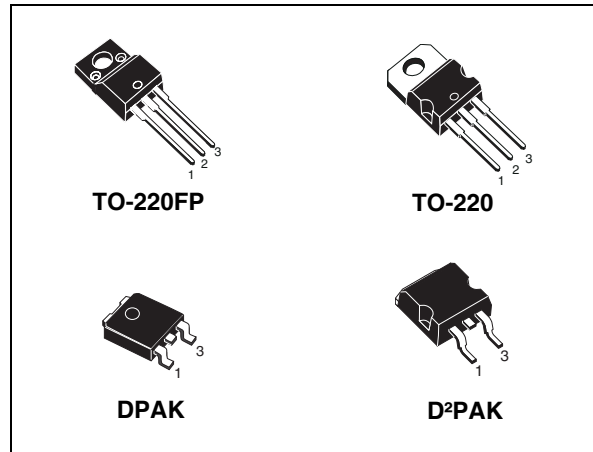


Figure 1. Internal schematic diagram

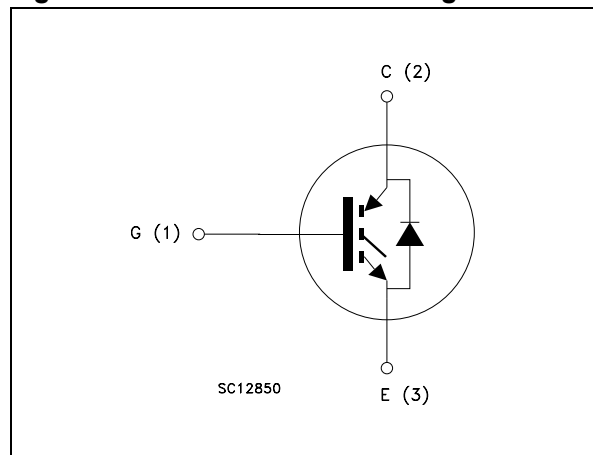


Table 1. Device summary

Order codes	Marking	Package	Packaging
STGBL6NC60DT4	GBL6NC60D	D <sup>2</sup> PAK	Tape and reel
STGDL6NC60DT4	GDL6NC60D	DPAK	Tape and reel
STGPL6NC60D	GPL6NC60D	TO-220	Tube
STGFL6NC60D	GFL6NC60D	TO-220FP	Tube

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		DPAK	TO-220 D <sup>2</sup> PAK	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	13	14	7	A
I <sub>C</sub> <sup>(1)</sup>	Collector current (continuous) at T <sub>C</sub> = 100 °C	7	8	4	A
I <sub>CP</sub> <sup>(2)</sup>	Pulsed collector current	15			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	7			A
I <sub>FSM</sub>	Surge non repetitive forward current tp=10ms sinusoidal	20			A
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	50	56	22	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:

$$I_C(T_C) = \frac{T_{JMAX} - T_C}{R_{THJ-C} \times V_{CESAT(MAX)}(T_C \cdot I_C)}$$

2. Pulsed: width limited by max junction temperature allowed

**Table 3. Thermal resistance**

Symbol	Parameter	Value			Unit
		TO-220 D <sup>2</sup> PAK	DPAK	TO-220FP	
R <sub>thj-case</sub>	Thermal resistance junction-case IGBT max	2.2	2.5	5.6	°C/W
	Thermal resistance junction-case diode max	4	4.5	7	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient max	62.5			°C/W

## 2 Electrical characteristics

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

**Table 4. Static electrical characteristics**

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	$V_{GE} = 15\text{ V}, I_C = 3\text{ A}$ $V_{GE} = 15\text{ V}, I_C = 3\text{ A}, @ 125\text{ °C}$ $V_{GE} = 15\text{ V}, I_C = 1.5\text{ A}$		2.3 2.1 2.0	2.9	V V 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 ( $V_{GE} = 0$ )	$V_{CE} = 600\text{ V}$ $V_{CE} = 600\text{ V}, T_C = 125\text{ °C}$			50 5	$\mu\text{A}$ mA
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$			$\pm 100$	nA
$g_{fs}$	Forward transconductance	$V_{CE} = 15\text{ V}, I_C = 3\text{ A}$		3		S

**Table 5. Dynamic electrical characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}, f = 1\text{ MHz},$ $V_{GE} = 0$		208		pF
$C_{oes}$	Output capacitance			32.5		pF
$C_{res}$	Reverse transfer capacitance			5.4		pF
$Q_g$	Total gate charge	$V_{CE} = 390\text{ V}, I_C = 3\text{ A},$ $V_{GE} = 15\text{ V}$ <i>(see Figure 17)</i>		12		nC
$Q_{ge}$	Gate-emitter charge			2.6		nC
$Q_{gc}$	Gate-collector charge			4.9		nC

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 390\text{ V}, I_C = 3\text{ A}$		6.7		ns
$t_r$	Current rise time	$R_G = 10\ \Omega, V_{GE} = 15\text{ V}$		3.7		ns
$(di/dt)_{on}$	Turn-on current slope	(see Figure 18)		930		A/ $\mu$ s
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 390\text{ V}, I_C = 3\text{ A}$		6.5		ns
$t_r$	Current rise time	$R_G = 10\ \Omega, V_{GE} = 15\text{ V},$		4		ns
$(di/dt)_{on}$	Turn-on current slope	$T_C = 125\text{ }^\circ\text{C}$ (see Figure 18)		820		A/ $\mu$ s
$t_r(V_{off})$	Off voltage rise time	$V_{CC} = 390\text{ V}, I_C = 3\text{ A},$		17		ns
$t_{d(off)}$	Turn-off delay time	$R_{GE} = 10\ \Omega, V_{GE} = 15\text{ V}$		46		ns
$t_f$	Current fall time	(see Figure 18)		47		ns
$t_r(V_{off})$	Off voltage rise time	$V_{CC} = 390\text{ V}, I_C = 3\text{ A},$		35		ns
$t_{d(off)}$	Turn-off delay time	$R_{GE} = 10\ \Omega, V_{GE} = 15\text{ V},$		67		ns
$t_f$	Current fall time	$T_C = 125\text{ }^\circ\text{C}$ (see Figure 18)		55		ns

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 390\text{ V}, I_C = 3\text{ A}$		46.5		$\mu$ J
$E_{off}^{(2)}$	Turn-off switching losses	$R_G = 10\ \Omega, V_{GE} = 15\text{ V}$		23.5		$\mu$ J
$E_{ts}$	Total switching losses	(see Figure 18)		70		$\mu$ J
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 390\text{ V}, I_C = 3\text{ A}$		67.5		$\mu$ J
$E_{off}^{(2)}$	Turn-off switching losses	$R_G = 10\ \Omega, V_{GE} = 15\text{ V},$		46		$\mu$ J
$E_{ts}$	Total switching losses	$T_C = 125\text{ }^\circ\text{C}$ (see Figure 18)		113.5		$\mu$ J

- $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in (see Figure 19). 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)
- Turn-off losses include also the tail of the collector current

**Table 8. Turn-off with snubber**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_f$ $E_{off}^{(1)}$	Current fall time Turn-off switching losses	$V_{CC} = 200\text{ V}$ , $I_C = 1.5\text{ A}$ $R_G = 22\ \Omega$ , $V_{clamp}=400\text{ V}$ , $L=1\text{ mH}$ , C-snubber=2.7 nF <i>(see Figure 18)</i>		16 1.6		ns $\mu\text{J}$
$t_f$ $E_{off}^{(1)}$	Current fall time Turn-off switching losses	$V_{CC} = 200\text{ V}$ , $I_C = 1.5\text{ A}$ $R_G = 22\ \Omega$ , $V_{clamp}=400\text{ V}$ , $L=1\text{ mH}$ , C-snubber=2.7 nF, $T_j = 100\text{ }^\circ\text{C}$ <i>(see Figure 18)</i>		19 3.5		ns $\mu\text{J}$

1. Turn-off losses include also the tail of the collector current

**Table 9. Collector-emitter diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_F$	Forward on-voltage	$I_F = 1\text{ A}$ $I_F=3\text{ A}$ $I_F=3\text{ A}, T_c=125\text{ }^\circ\text{C}$		1.7 1.5	1.7	V V V
$t_{rr}$ $Q_{rr}$ $I_{rrm}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_F = 3\text{ A}$ , $V_R = 40\text{ V}$ , $di/dt = 100\text{ A}/\mu\text{s}$ <i>(see Figure 19)</i>		30 33.5 2.2		ns nC A
$t_{rr}$ $Q_{rr}$ $I_{rrm}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_F = 3\text{ A}$ , $V_R = 40\text{ V}$ , $T_c = 125\text{ }^\circ\text{C}$ , $di/dt = 100\text{ A}/\mu\text{s}$ <i>(see Figure 19)</i>		65 94 2.9		ns nC A

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

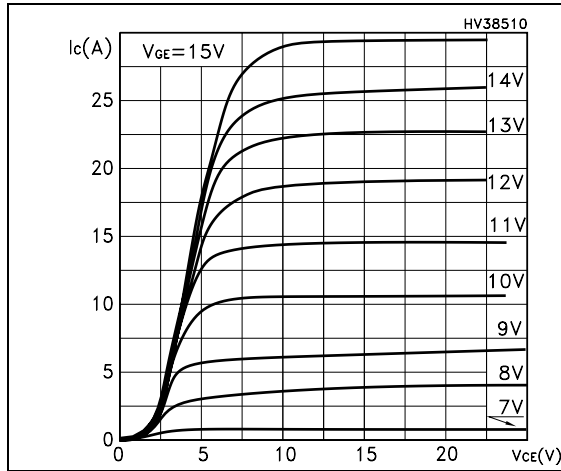


Figure 3. Transfer characteristics

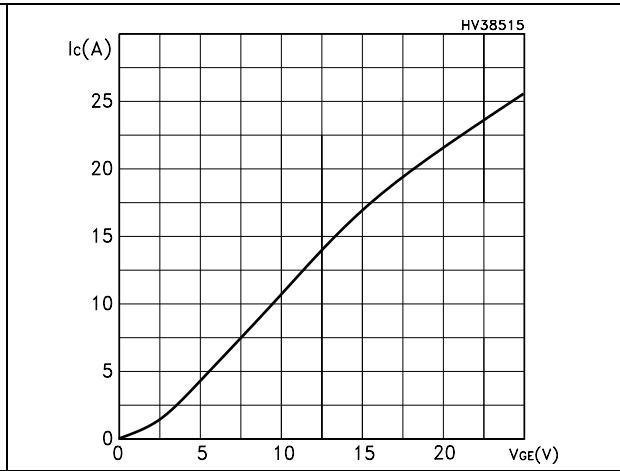


Figure 4. Transconductance

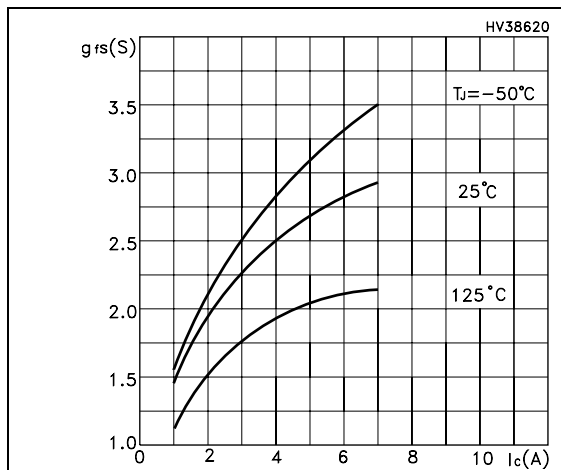


Figure 5. Collector-emitter on voltage vs temperature

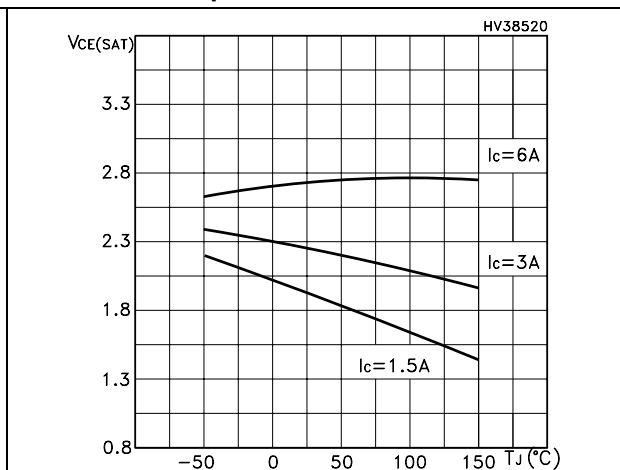


Figure 6. Gate charge vs gate-source voltage

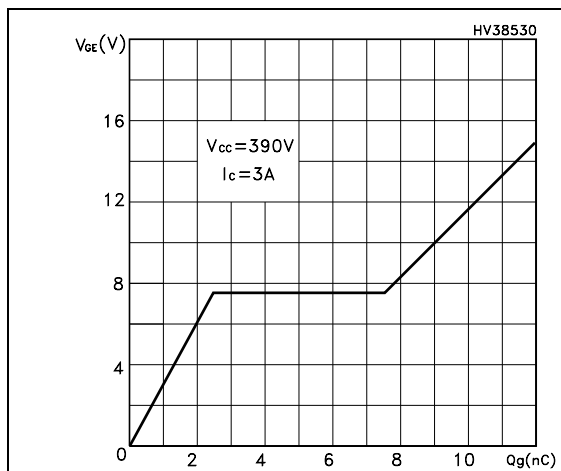


Figure 7. Capacitance variations

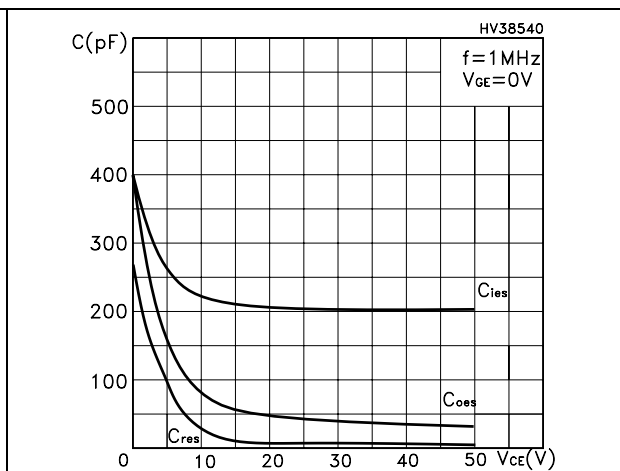


Figure 8. Normalized gate threshold voltage vs temperature

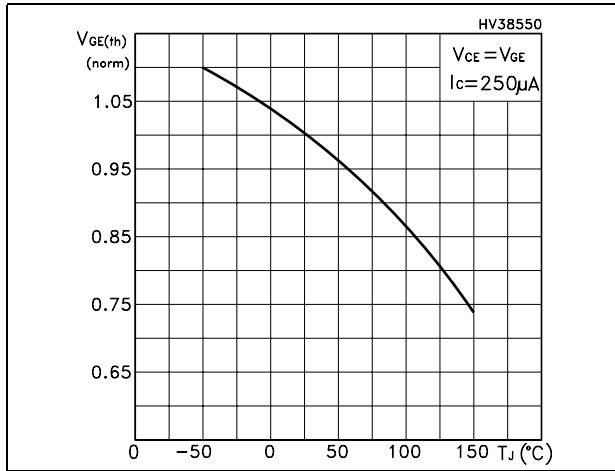


Figure 9. Collector-emitter on voltage vs collector current

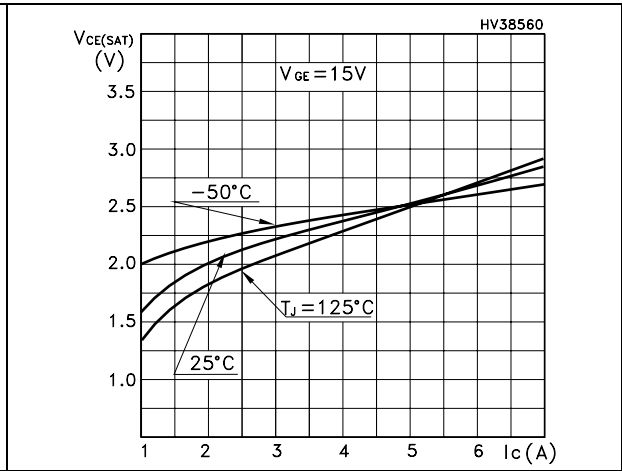


Figure 10. Normalized breakdown voltage vs temperature

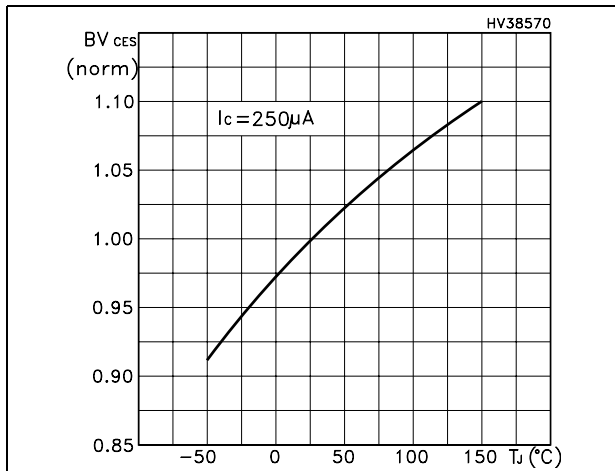


Figure 11. Switching losses vs temperature

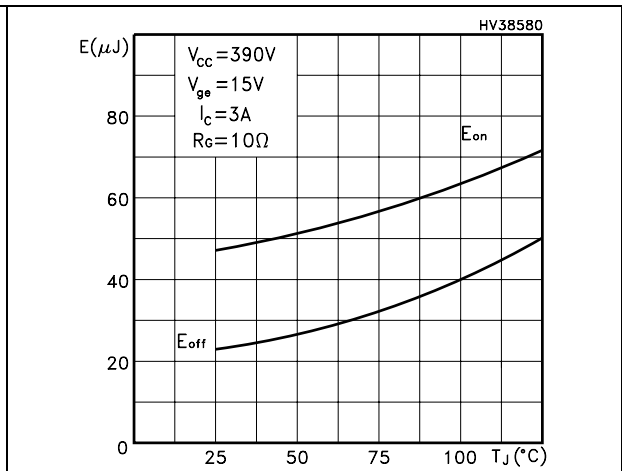


Figure 12. Switching losses vs gate resistance

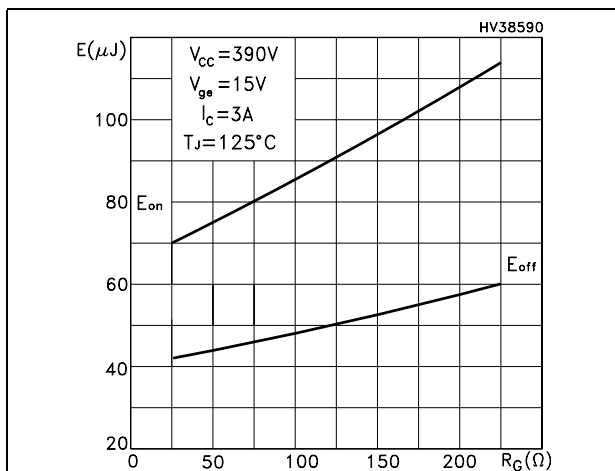


Figure 13. Switching losses vs collector current

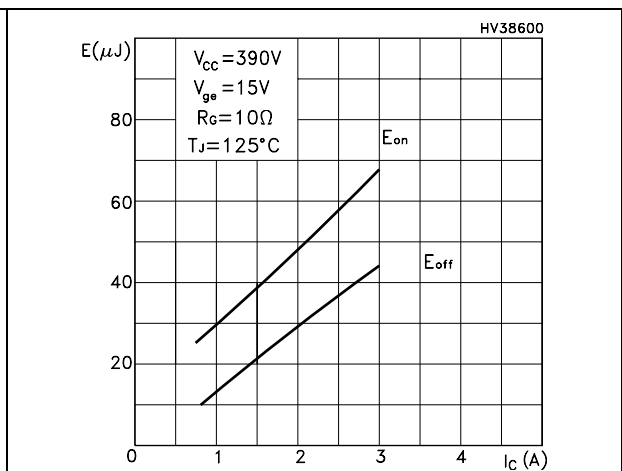




Figure 14. Turn-off SOA

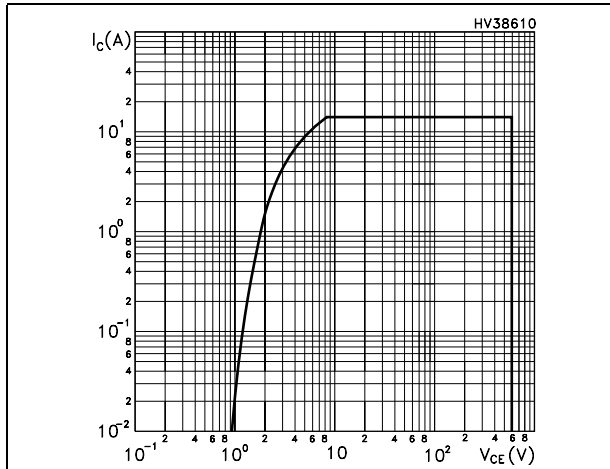
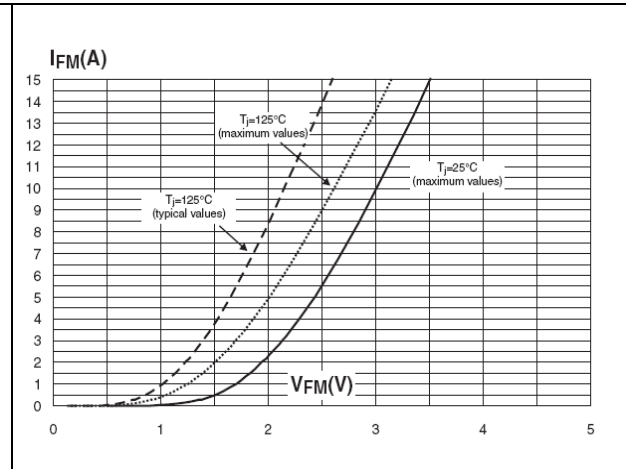


Figure 15. Forward voltage drop versus forward current



### 3 Test circuit

Figure 16. Test circuit for inductive load switching

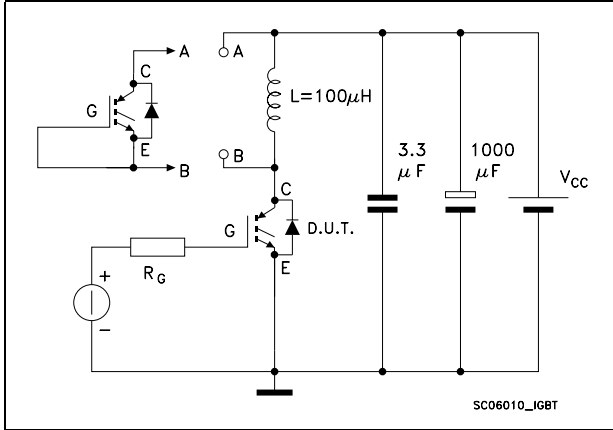


Figure 17. Gate charge test circuit

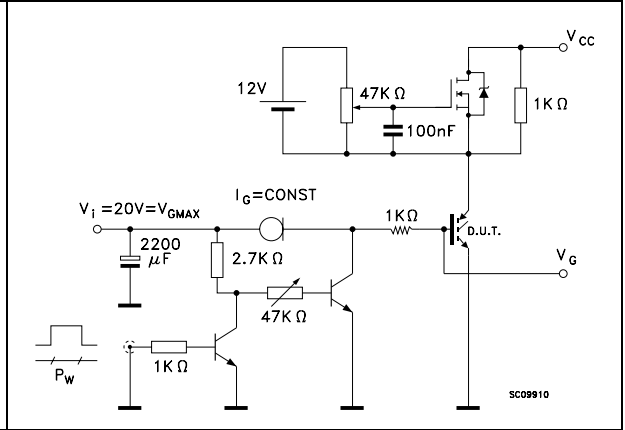


Figure 18. Switching waveform

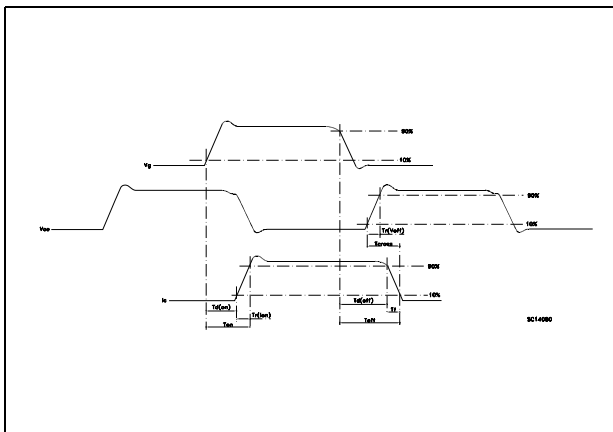
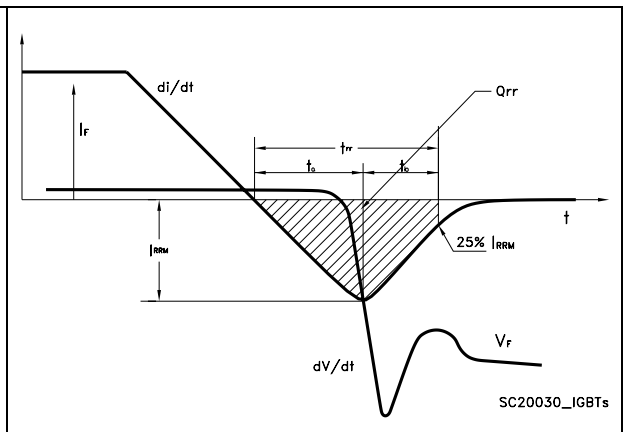


Figure 19. Diode recovery time waveform

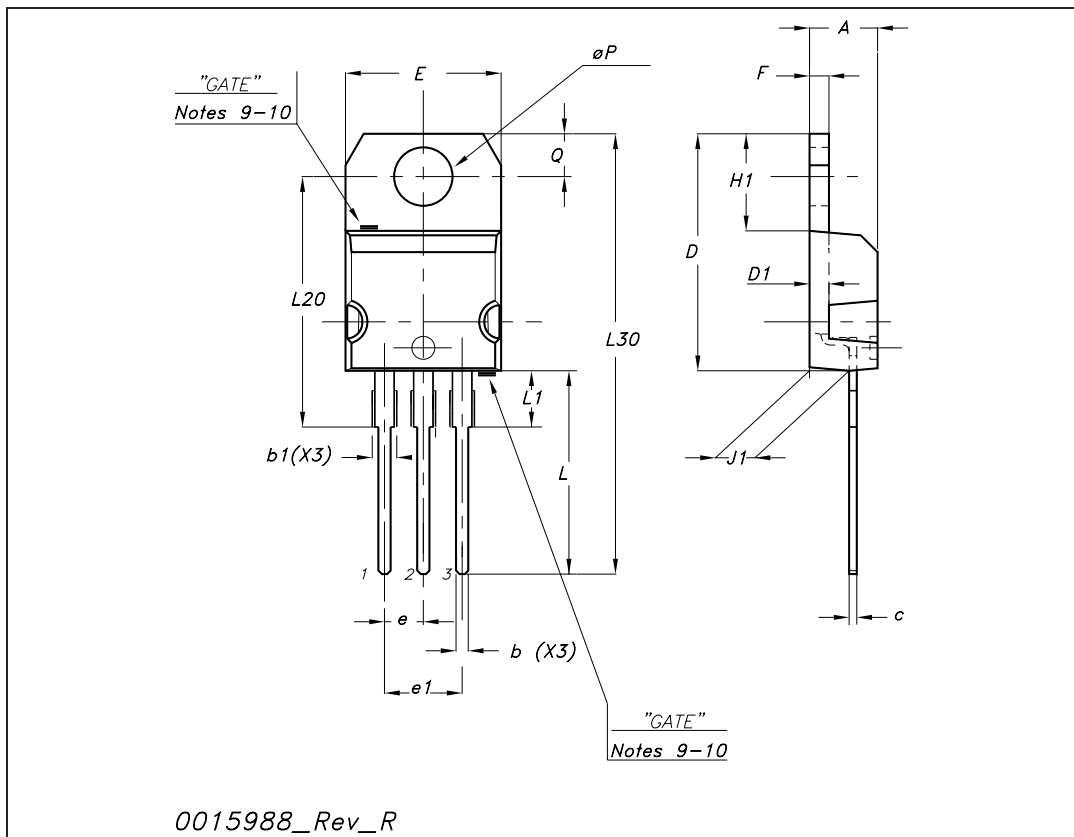


## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

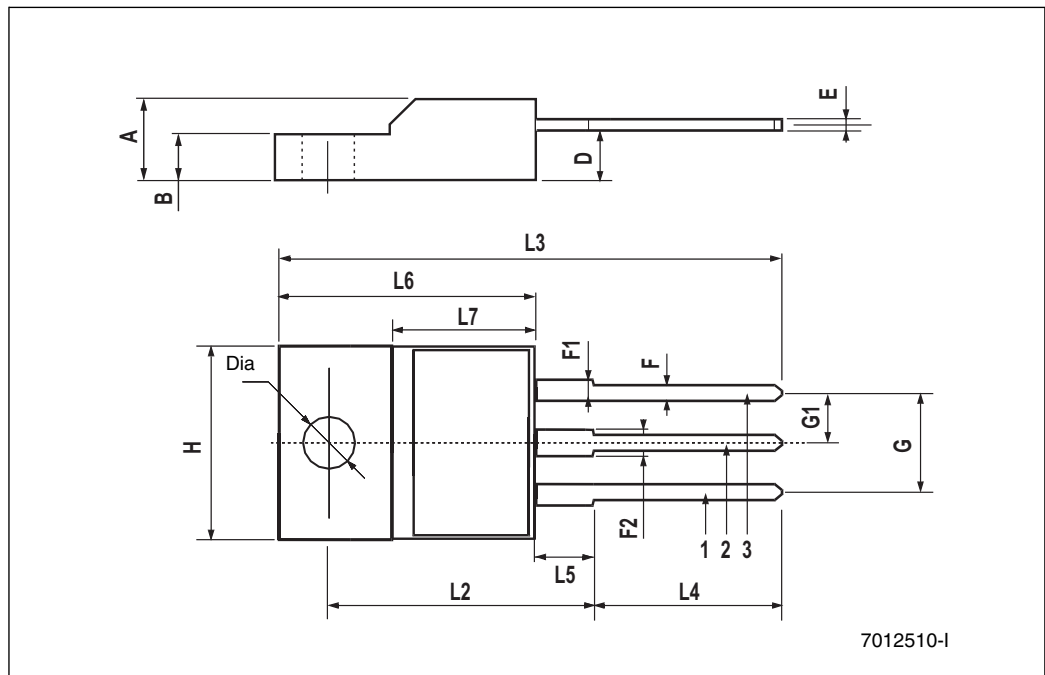
TO-220 mechanical data

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



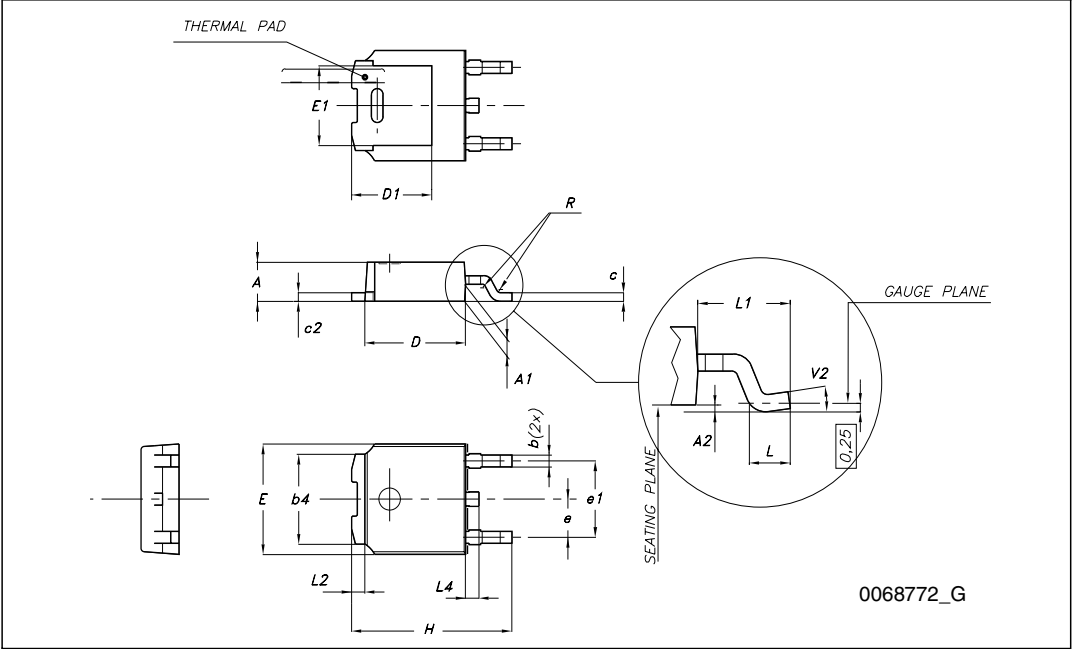
**TO-220FP mechanical data**

Dim.	mm.			inch		
	Min.	Typ	Max.	Min.	Typ.	Max.
A	4.40		4.60	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.70	0.017		0.027
F	0.75		1.00	0.030		0.039
F1	1.15		1.50	0.045		0.067
F2	1.15		1.50	0.045		0.067
G	4.95		5.20	0.195		0.204
G1	2.40		2.70	0.094		0.106
H	10		10.40	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.80		10.60	0.385		0.417
L5	2.9		3.6	0.114		0.141
L6	15.90		16.40	0.626		0.645
L7	9		9.30	0.354		0.366
Dia	3		3.2	0.118		0.126



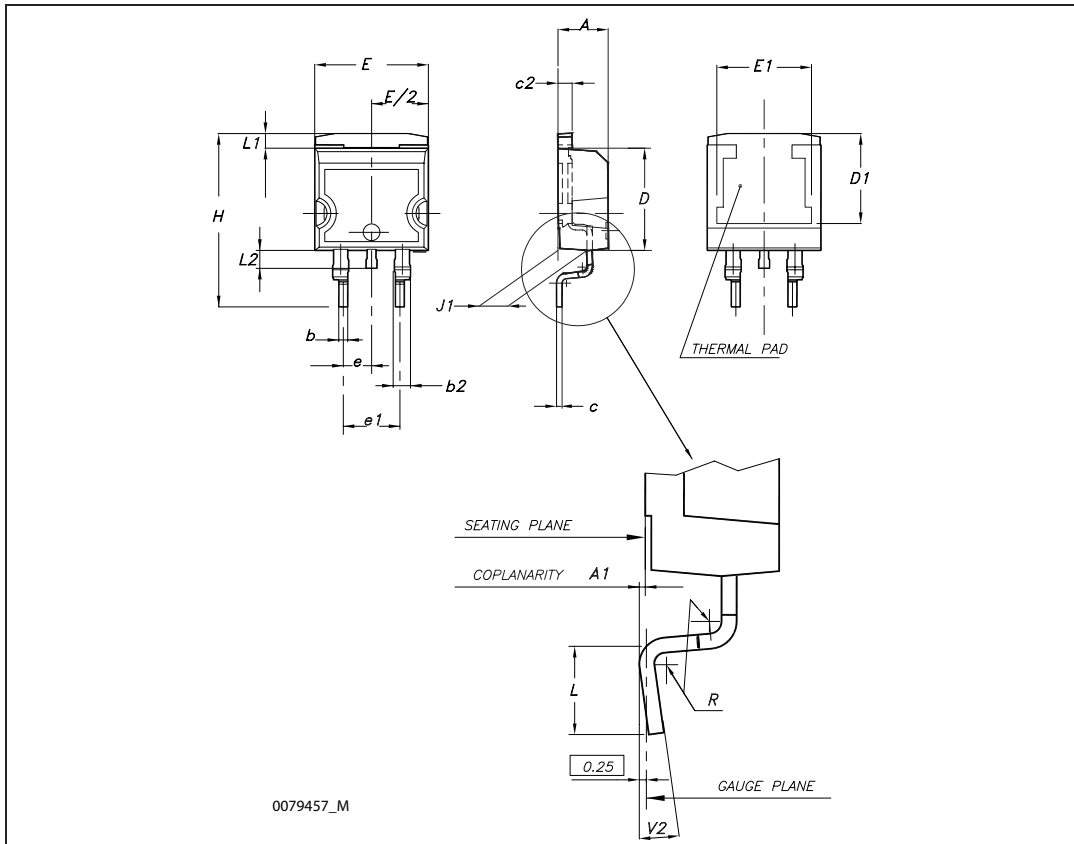
**TO-252 (DPAK) mechanical data**

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°



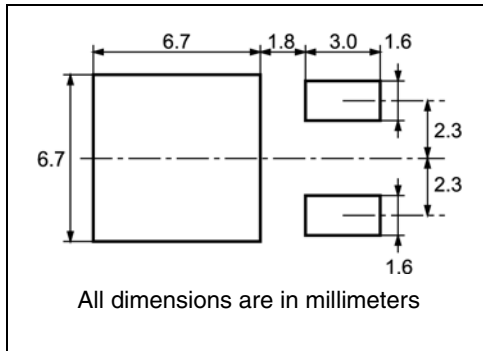
D<sup>2</sup>PAK (TO-263) mechanical data

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°



## 5 Packaging mechanical data

### DPAK FOOTPRINT



### TAPE AND REEL SHIPMENT

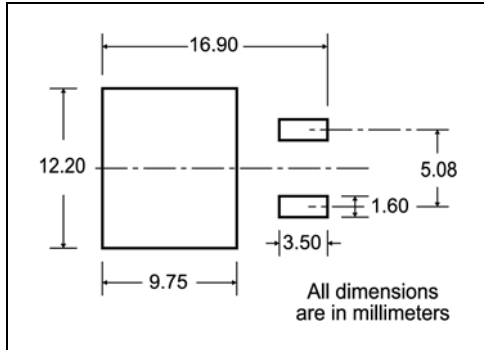
DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	16.4	18.4	0.645	0.724
N	50		1.968	
T		22.4		0.881

BASE QTY		BULK QTY	
2500		2500	

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



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



**TAPE AND REEL SHIPMENT**

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start 2.5mm min. width

**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

Center line of cavity

User Direction of Feed

FEED DIRECTION

Bending radius

R min.

\* on sales type

## 6 Revision history

Table 10. Revision history

Date	Revision	Changes
27-Jul-2007	1	First release
09-Jul-2008	2	<a href="#">4: Package mechanical data</a> has been updated.

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