

### 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 (including hard switching)

### Description

This series of hyper fast IGBT is based on PowerMESH technology and exhibits very low turn-off energy, thanks to a new lifetime control system. This results in an optimized trade-off between on-state voltage and switching losses, allowing very high operating frequencies.

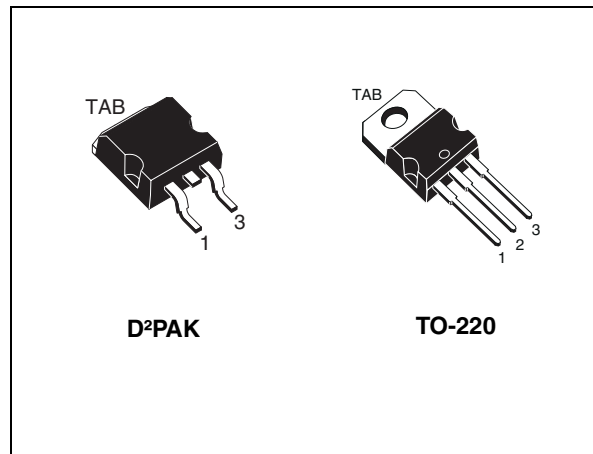


Figure 1. Internal schematic diagram

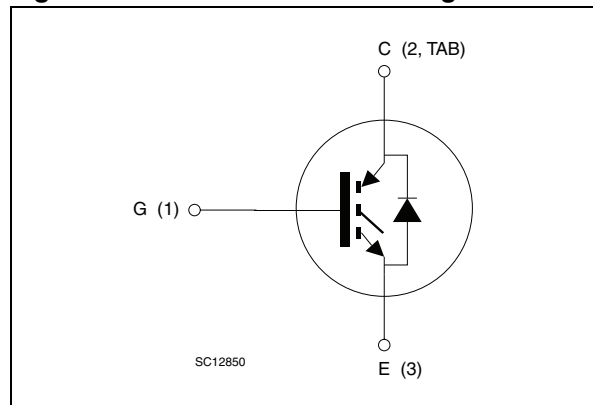


Table 1. Device summary

Order codes	Marking	Package	Packaging
STGBL6NC60DT4	GBL6NC60D	D <sup>2</sup> PAK	Tape and reel
STGPL6NC60D	GPL6NC60D	TO-220	Tube

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	600	V
$I_C^{(1)}$	Collector current (continuous) at $T_C = 25\text{ °C}$	14	A
$I_C^{(1)}$	Collector current (continuous) at $T_C = 100\text{ °C}$	6	A
$I_{CL}^{(2)}$	Turn-off latching current	18	A
$I_{CP}^{(3)}$	Pulsed collector current	18	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$I_F$	Diode RMS forward current at $T_C = 25\text{ °C}$	7	A
$I_{FSM}$	Surge non repetitive forward current $t_p = 10\text{ ms}$ sinusoidal	20	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	56	W
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t = 1\text{ s}$ ; $T_C = 25\text{ °C}$ )	--	V
$T_j$	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.  $V_{\text{clamp}} = 80\%, (V_{CES}), T_j = 150^{\circ}\text{C}, R_G = 10\ \Omega, V_{GE} = 15\text{ V}$
3. Pulse width limited by max junction temperature allowed

**Table 3. Thermal resistance**

Symbol	Parameter	Value	Unit
$R_{thj\text{-case}}$	Thermal resistance junction-case IGBT max.	2.2	$^{\circ}\text{C/W}$
	Thermal resistance junction-case diode max.	4	$^{\circ}\text{C/W}$
$R_{thj\text{-amb}}$	Thermal resistance junction-ambient max.	62.5	$^{\circ}\text{C/W}$

## 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	$V_{GE} = 15\text{ V}, I_C = 1.5\text{ A}$ $V_{GE} = 15\text{ V}, I_C = 3\text{ A}$ $V_{GE} = 15\text{ V}, I_C = 3\text{ A}, T_C = 125\text{ °C}$		1.9 2.2 2	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	$V_{CE} = 390\text{ V}, I_C = 3\text{ A},$		12		nC
$Q_{ge}$	Gate-emitter charge	$V_{GE} = 15\text{ V}$		2.6		nC
$Q_{gc}$	Gate-collector charge	(see Figure 17)		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
$t_f$	Current fall time	$V_{CC} = 200\text{ V}, I_C = 1.5\text{ A}$		16		ns
$E_{off}^{(1)}$	Turn-off switching losses	$R_G = 22\ \Omega, V_{clamp} = 400\text{ V},$ $L = 1\text{ mH}, C\text{-snubber} = 2.7\text{ nF}$ (see Figure 18)		1.6		$\mu$ J
$t_f$	Current fall time	$V_{CC} = 200\text{ V}, I_C = 1.5\text{ A}$		19		ns
$E_{off}^{(1)}$	Turn-off switching losses	$R_G = 22\ \Omega, V_{clamp} = 400\text{ V},$ $L = 1\text{ mH}, C\text{-snubber} = 2.7\text{ nF},$ $T_C = 100\text{ }^\circ\text{C}$ (see Figure 18)		3.5		$\mu$ J

- 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	$I_F = 1\text{ A}$			1.3	V
		$I_F = 3\text{ A}$		1.35		V
		$I_F = 3\text{ A}, T_C = 125\text{ }^\circ\text{C}$		1.15		V
$t_{rr}$	Reverse recovery time	$I_F = 3\text{ A}, V_R = 40\text{ V},$ $di/dt = 100\text{ A}/\mu\text{s}$		50		ns
$Q_{rr}$	Reverse recovery charge	$di/dt = 100\text{ A}/\mu\text{s}$		55		nC
$I_{rrm}$	Reverse recovery current	(see Figure 19)		2.2		A
$t_{rr}$	Reverse recovery time	$I_F = 3\text{ A}, V_R = 40\text{ V},$ $T_C = 125\text{ }^\circ\text{C}, di/dt = 100$ $\text{A}/\mu\text{s}$		80		ns
$Q_{rr}$	Reverse recovery charge	(see Figure 19)		105		nC
$I_{rrm}$	Reverse recovery current	(see Figure 19)		2.7		A

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

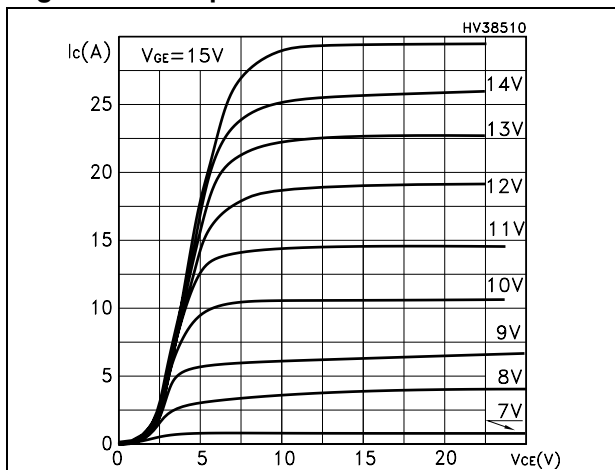


Figure 3. Transfer characteristics

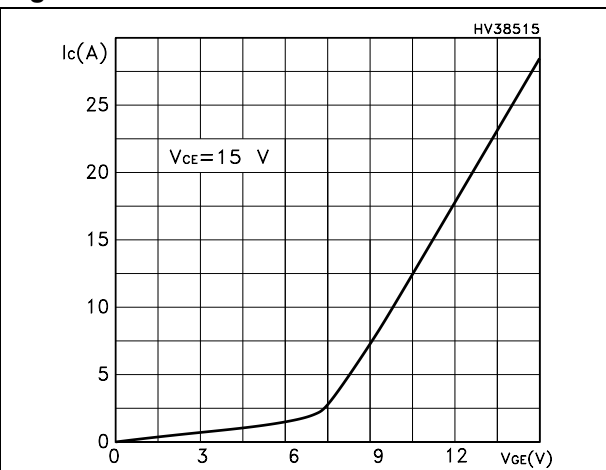


Figure 4. Transconductance

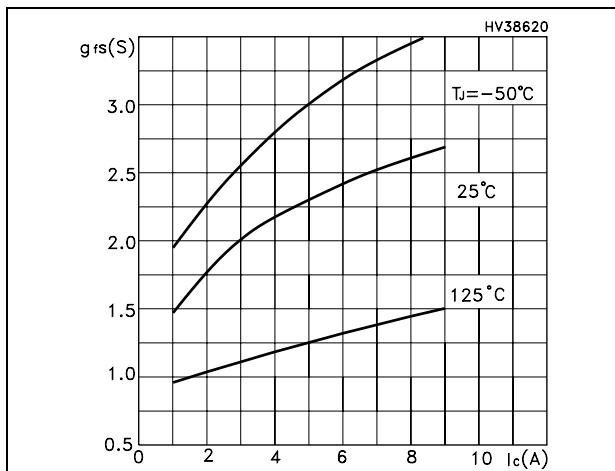


Figure 5. Collector-emitter on voltage vs. temperature

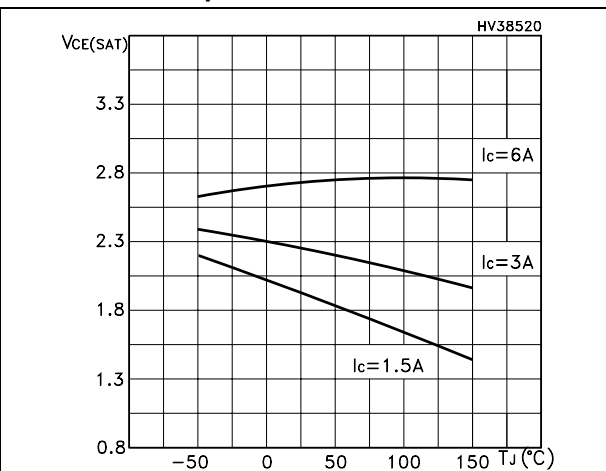


Figure 6. Gate charge vs. gate-source voltage

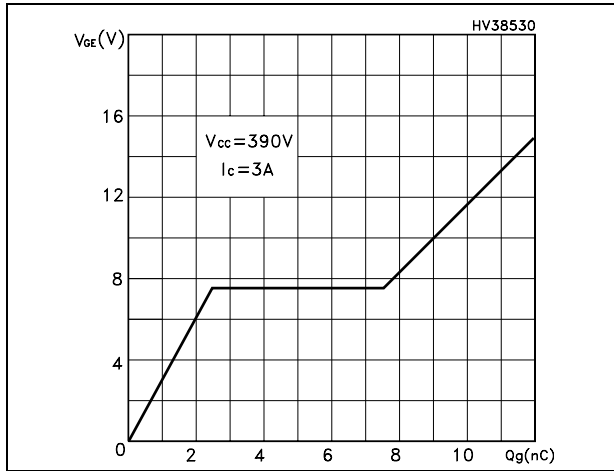


Figure 7. Capacitance variations

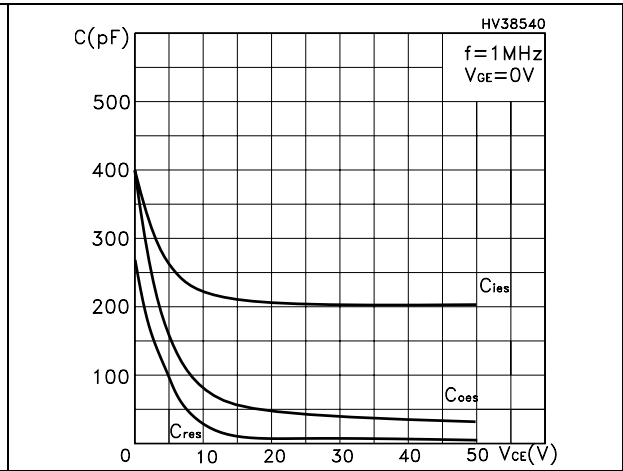


Figure 8. Normalized gate threshold voltage vs. temperature

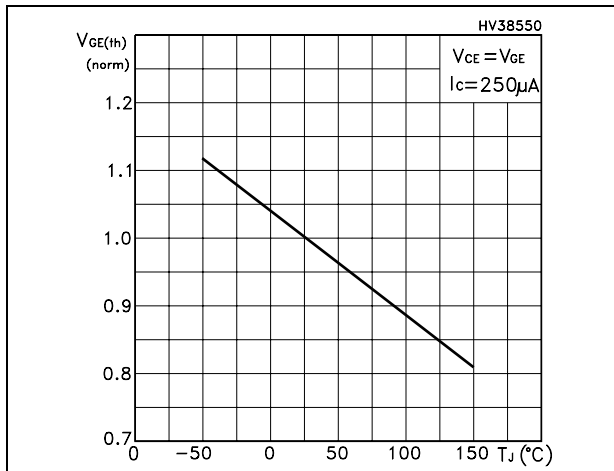


Figure 9. Collector-emitter on voltage vs. collector current

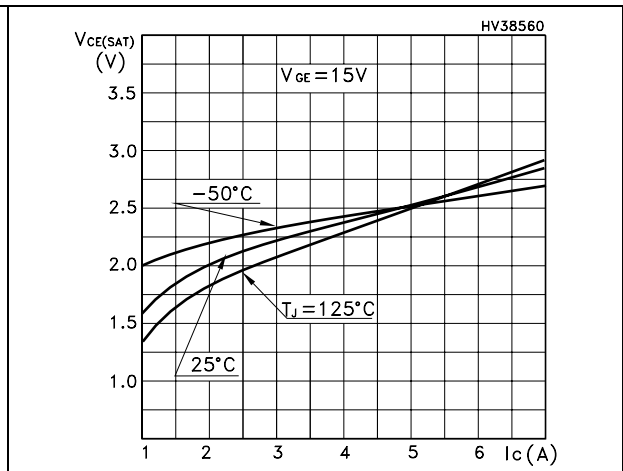


Figure 10. Normalized breakdown voltage vs. temperature

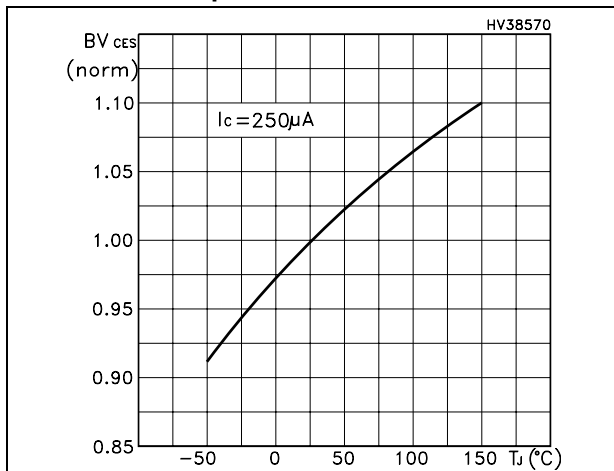


Figure 11. Switching losses vs. temperature

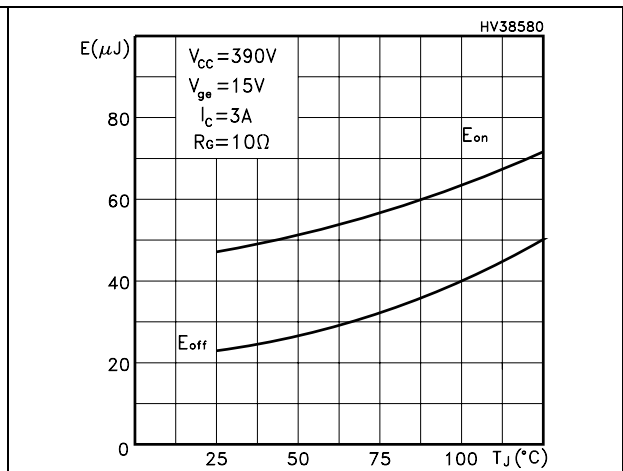


Figure 12. Switching losses vs. gate resistance

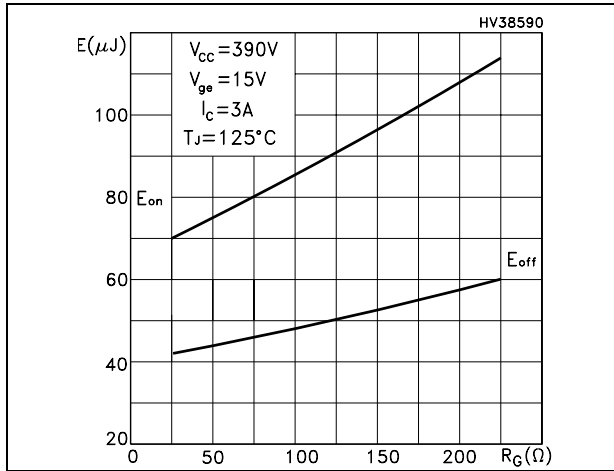


Figure 13. Switching losses vs. collector current

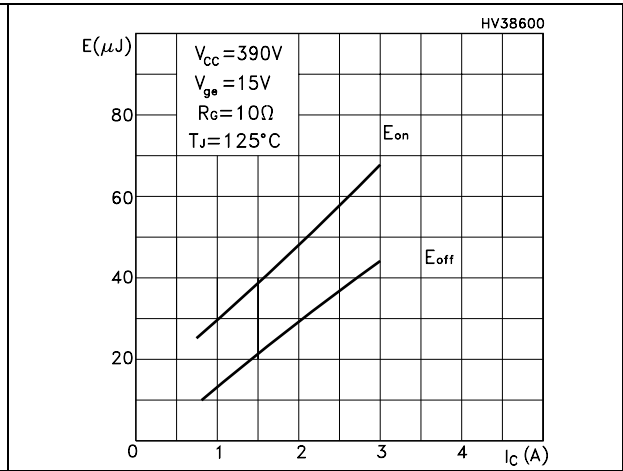


Figure 14. Turn-off SOA

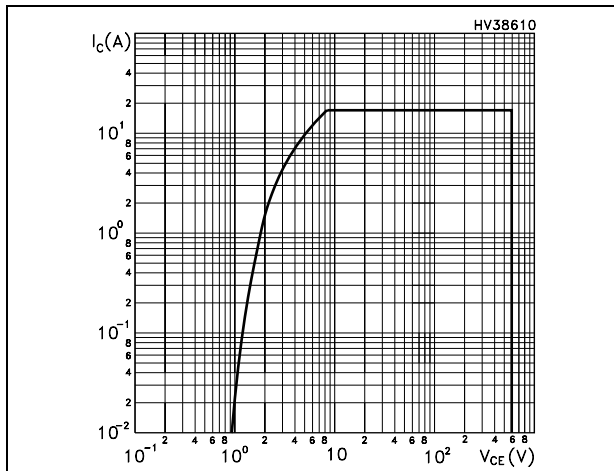
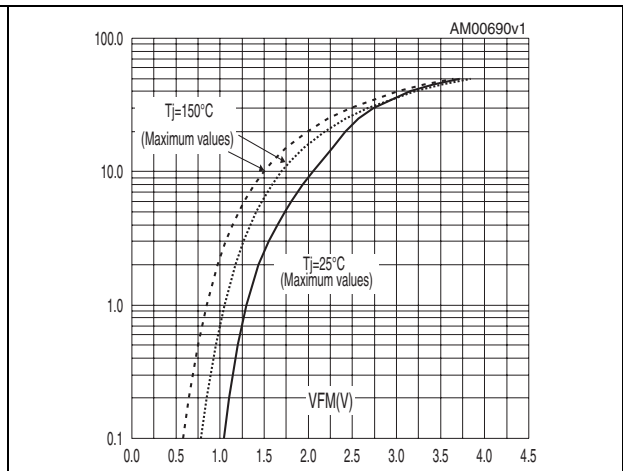


Figure 15. Forward voltage drop vs. forward current





### 3 Test circuit

Figure 16. Test circuit for inductive load switching

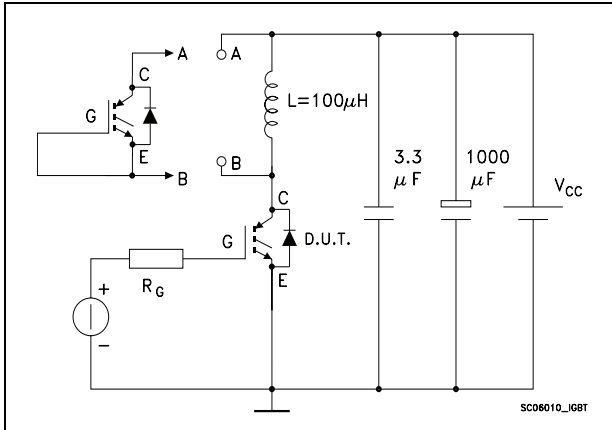


Figure 17. Gate charge test circuit

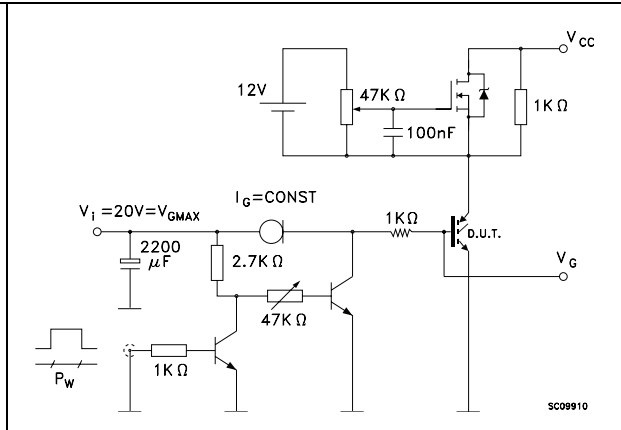


Figure 18. Switching waveform

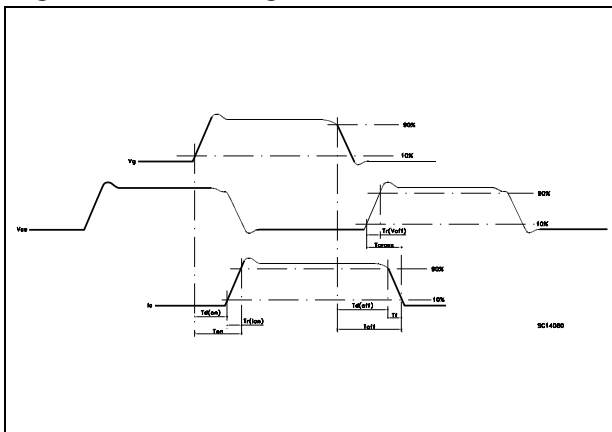
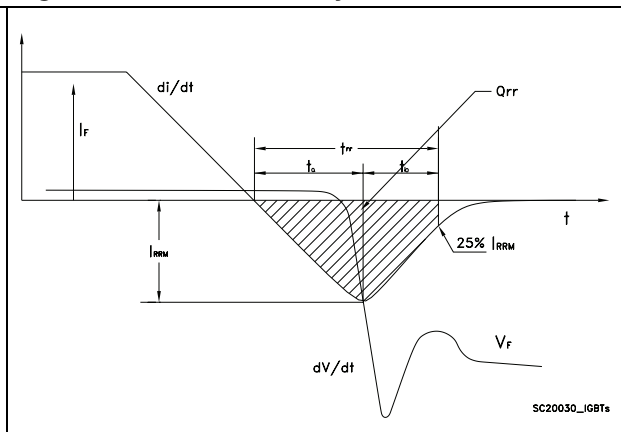


Figure 19. Diode recovery time waveform



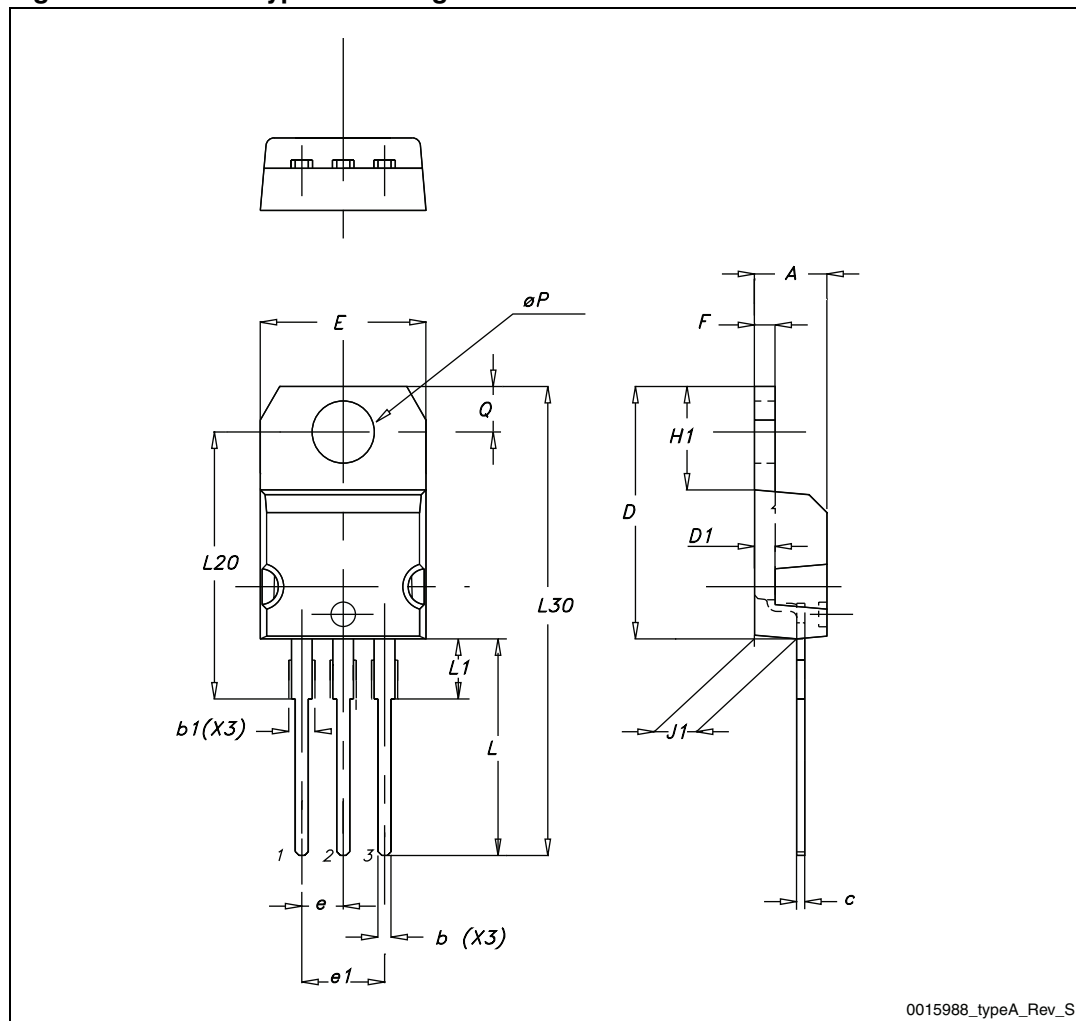
## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in 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.

**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	
∅P	3.75		3.85
Q	2.65		2.95

Figure 20. TO-220 type A drawing



0015988\_typeA\_Rev\_S

Table 11. D<sup>2</sup>PAK (TO-263) mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
c	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50		
E	10		10.40
E1	8.50		
e		2.54	
e1	4.88		5.28
H	15		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.4	
V2	0°		8°

Figure 21. D<sup>2</sup>PAK (TO-263) drawing

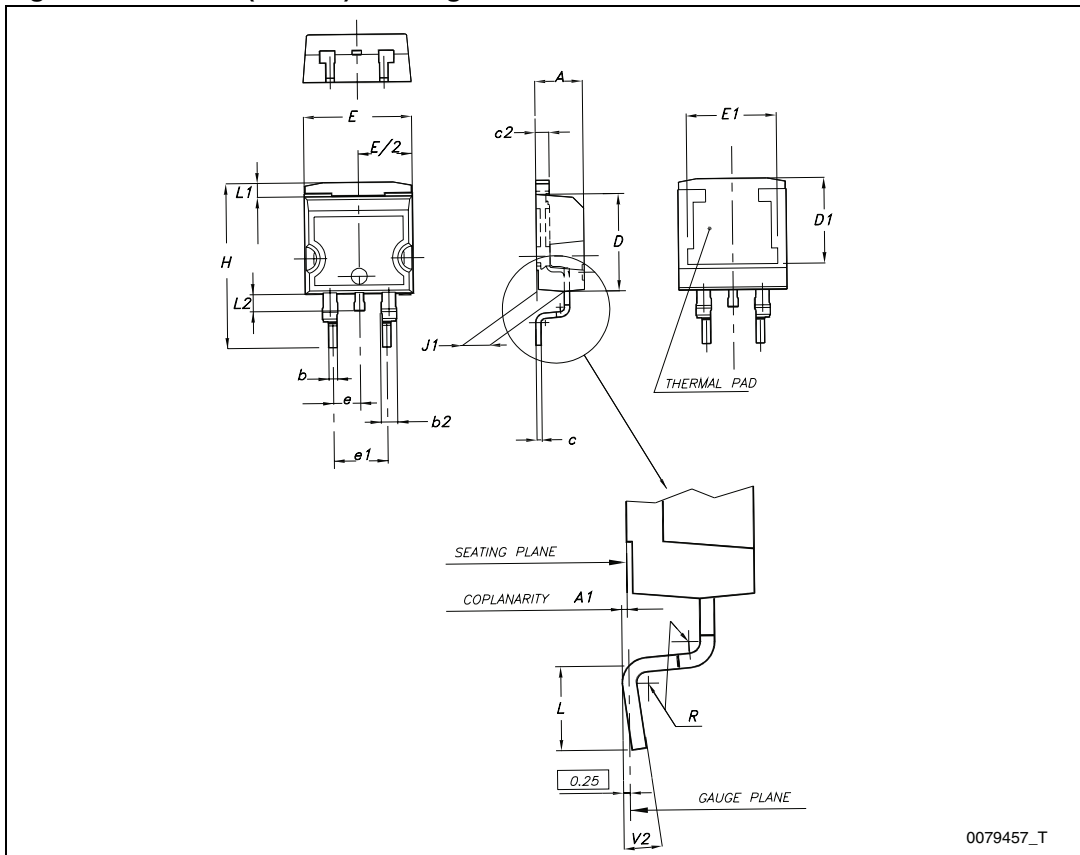
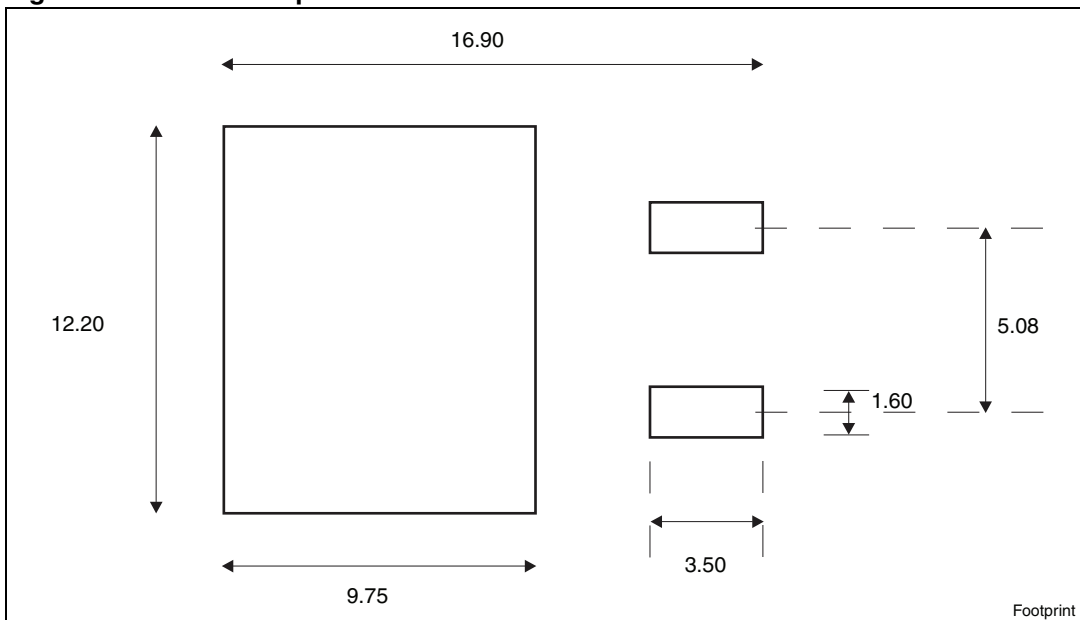


Figure 22. D<sup>2</sup>PAK footprint (a)



a. All dimension are in millimeters

## 5 Packaging mechanical data

Table 12. D<sup>2</sup>PAK (TO-263) tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	10.5	10.7	A		330
B0	15.7	15.9	B	1.5	
D	1.5	1.6	C	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	T		30.4
P0	3.9	4.1			
P1	11.9	12.1		Base qty	1000
P2	1.9	2.1		Bulk qty	1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

Figure 23. Tape

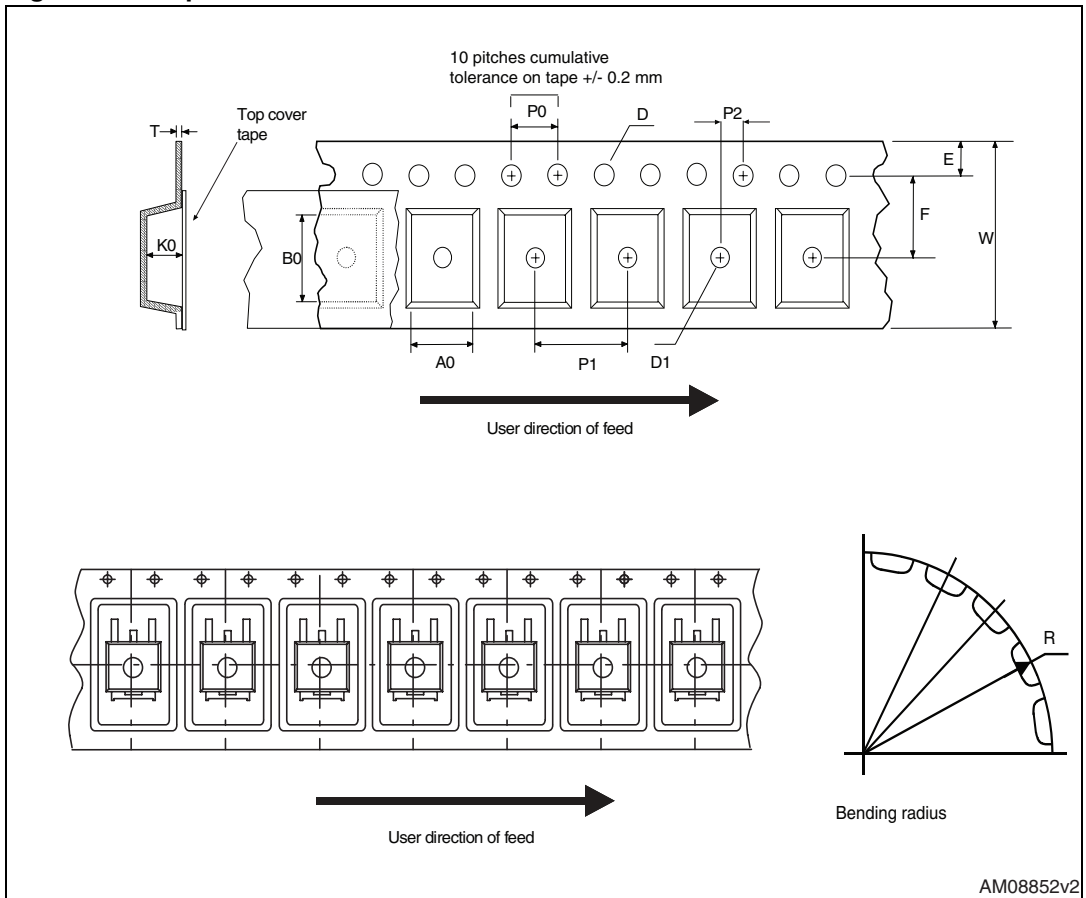
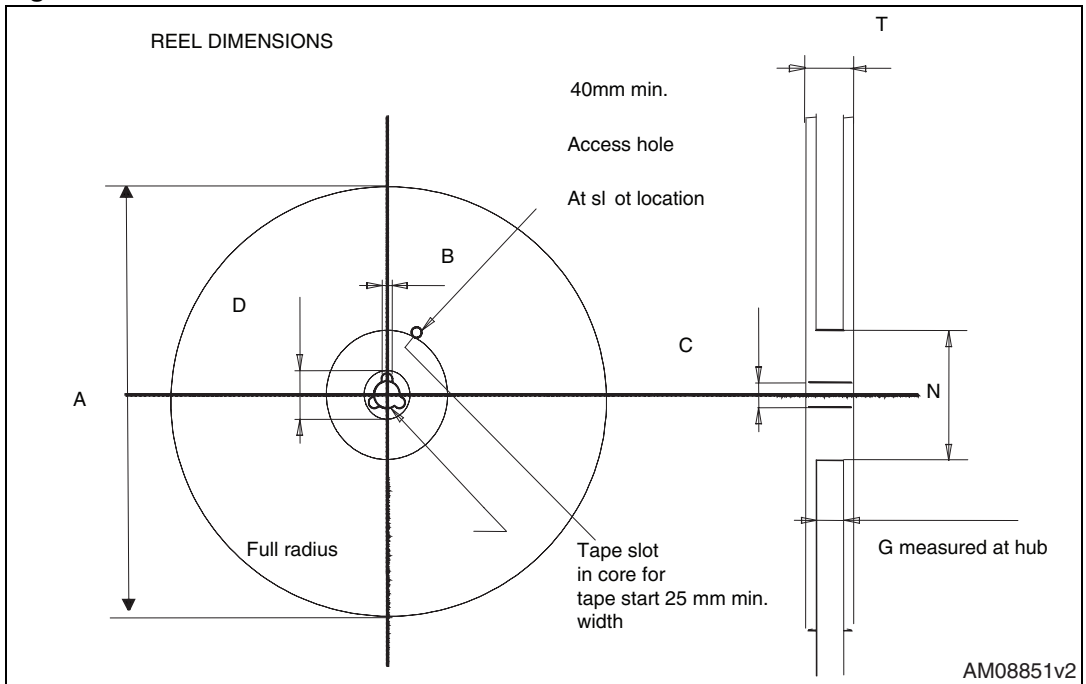


Figure 24. Reel



## 6 Revision history

**Table 13. Document 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.
21-Nov-2008	3	Updated <a href="#">Table 9</a> and <a href="#">Figure 15</a>
20-Sep-2012	4	Minor text changes in the Description. Updated: <a href="#">Section 4: Package mechanical data on page 10</a> and <a href="#">Section 5: Packaging mechanical data on page 14</a> .



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