



# STGW39NC60VD

40 A - 600 V - very fast IGBT

## Features

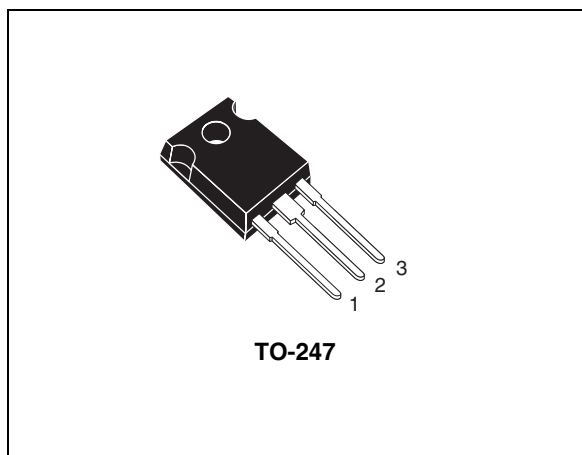
- Low  $C_{RES} / C_{IES}$  ratio (no cross conduction susceptibility)
- IGBT co-packaged with ultra fast free-wheeling diode

## Applications

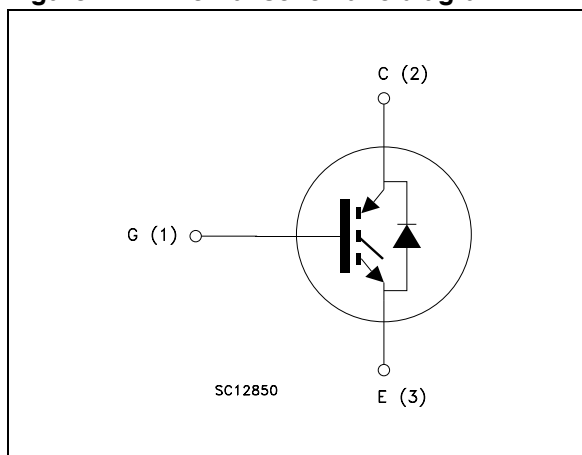
- High frequency inverters
- UPS
- Motor drivers
- Induction heating

## 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 code	Marking	Package	Packaging
STGW39NC60VD	GW39NC60VD	TO-247	Tube

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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 25 °C	80	A
$I_C^{(1)}$	Collector current (continuous) at 100 °C	40	A
$I_{CL}^{(2)}$	Turn-off latching current	220	A
$I_{CP}^{(3)}$	Pulsed collector current	220	A
$V_{GE}$	Gate-emitter voltage	± 20	V
$I_F$	Diode RMS forward current at $T_C = 25$ °C	30	A
$I_{FSM}$	Surge non repetitive forward current (tp=10 ms sinusoidal)	120	A
$P_{TOT}$	Total dissipation at $T_C = 25$ °C	250	W
$T_j$	Operating junction temperature	– 55 to 150	°C

1. Calculated according to the iterative formula:

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

2.  $V_{clamp} = 80\%(V_{CES})$ ,  $T_j = 150$  °C,  $R_G = 10$  Ω,  $V_{GE} = 15$  V

3. Pulse width limited by max. junction temperature allowed

**Table 3. Thermal resistance**

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case (IGBT) max	0.5	°C/W
$R_{thj-case}$	Thermal resistance junction-case (diode) max	1.5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max	50	°C/W

## 2 Electrical characteristics

( $T_{CASE}=25\text{ }^{\circ}\text{C}$  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	$V_{GE} = 15\text{ V}$ , $I_C = 30\text{ A}$ $V_{GE} = 15\text{ V}$ , $I_C = 30\text{ A}$ , $T_C = 125\text{ }^{\circ}\text{C}$		1.8 1.7	2.4	V V
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$	3.75		5.75	V
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 600\text{ V}$ $V_{CE} = 600\text{ V}$ , $T_C = 125\text{ }^{\circ}\text{C}$			500 5	$\mu\text{A}$ mA
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$			$\pm 100$	nA
$g_{fs}^{(1)}$	Forward transconductance	$V_{CE} = 15\text{ V}$ , $I_C = 30\text{ A}$		20		S

1. Pulsed: 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	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0$		2900		pF
$C_{oes}$	Output capacitance			298		pF
$C_{res}$	Reverse transfer capacitance			59		pF
$Q_g$	Total gate charge	$V_{CE} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $V_{GE} = 15\text{ V}$ (see Figure 19)		126		nC
$Q_{ge}$	Gate-emitter charge			16		nC
$Q_{gc}$	Gate-collector charge			46		nC

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ (see Figure 18)		33		ns
$t_r$	Current rise time			13		ns
$(di/dt)_{onf}$	Turn-on current slope			2500		A/ $\mu$ s
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_C = 125\text{ }^\circ\text{C}$ (see Figure 18)		32		ns
$t_r$	Current rise time			14		ns
$(di/dt)_{on}$	Turn-on current slope			2280		A/ $\mu$ s
$t_{r(Voff)}$	Off voltage rise time	$V_{CC} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ (see Figure 18)		33		ns
$t_{d(off)}$	Turn-off delay time			178		ns
$t_f$	Current fall time			65		ns
$t_{r(Voff)}$	Off voltage rise time	$V_{CC} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_C = 125\text{ }^\circ\text{C}$ (see Figure 18)		68		ns
$t_{d(off)}$	Turn-off delay time			238		ns
$t_f$	Current fall time			128		ns

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , (see Figure 20)		333		$\mu$ J
$E_{off}^{(2)}$	Turn-off switching losses			537		$\mu$ J
$E_{ts}$	Total switching losses			870		$\mu$ J
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 390\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_C = 125\text{ }^\circ\text{C}$ (see Figure 20)		618		$\mu$ J
$E_{off}^{(2)}$	Turn-off switching losses			1125		$\mu$ J
$E_{ts}$	Total switching losses			1743		$\mu$ J

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in figure 2  $E_{on}$  include diode recovery energy. 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	$I_F = 30\text{ A}$ $I_F = 30\text{ A}, T_C = 125\text{ °C}$		2.4 1.8		V V
$t_{rr}$ $Q_{rr}$ $I_{rrm}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_F = 30\text{ A}, V_R = 50\text{ V},$ $di/dt = 100\text{ A/}\mu\text{s}$ (see Figure 21)		45 56 2.55		ns nC A
$t_{rr}$ $Q_{rr}$ $I_{rrm}$	Reverse recovery time Reverse recovery charge Reverse recovery current	$I_F = 30\text{ A}, V_R = 50\text{ V},$ $T_C = 125\text{ °C},$ $di/dt = 100\text{ A/}\mu\text{s}$ (see Figure 21)		100 290 5.8		ns nC A

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

Figure 3. Transfer characteristics

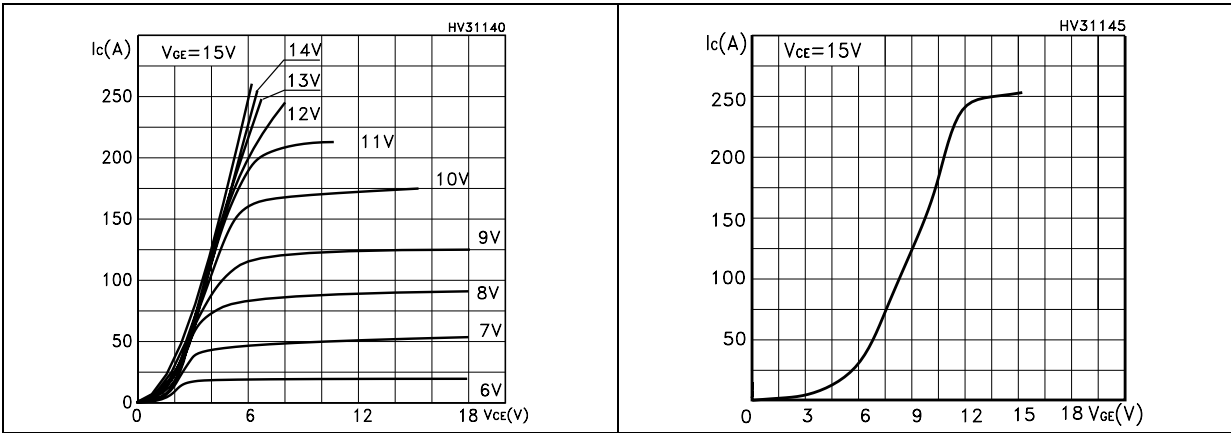


Figure 4. Transconductance

Figure 5. Collector-emitter on voltage vs temperature

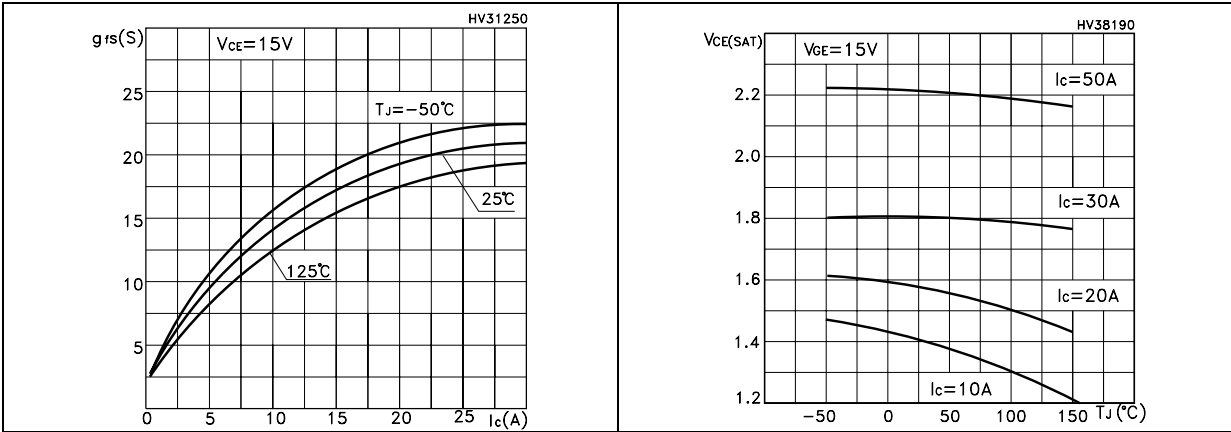


Figure 6. Collector-emitter on voltage vs collector current

Figure 7. Normalized gate threshold vs temperature

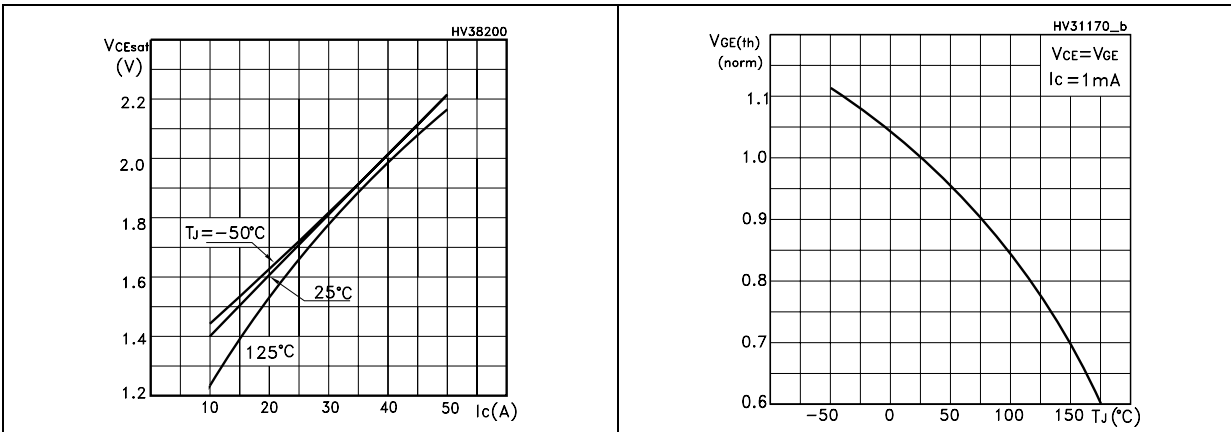


Figure 8. Normalized breakdown voltage vs temperature

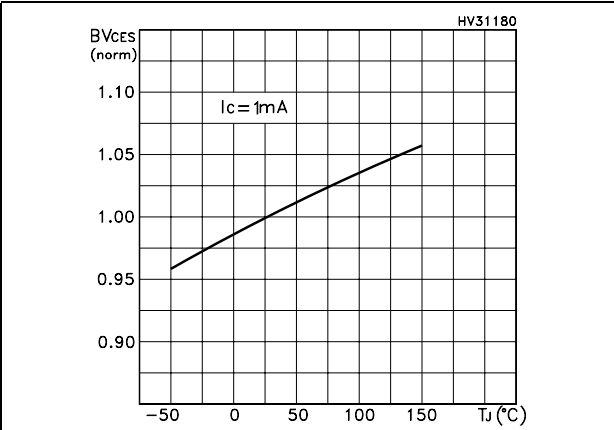


Figure 9. Gate charge vs gate-emitter voltage

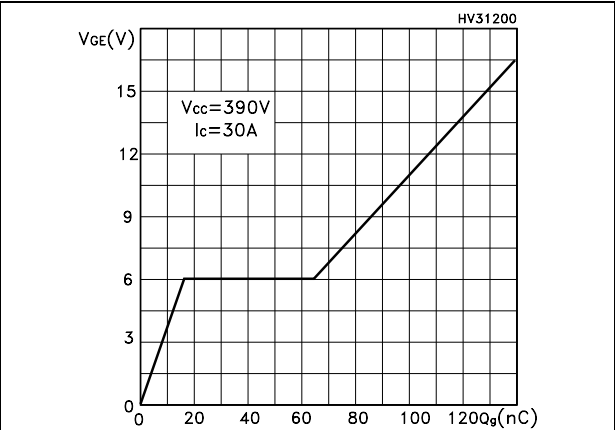


Figure 10. Capacitance variations

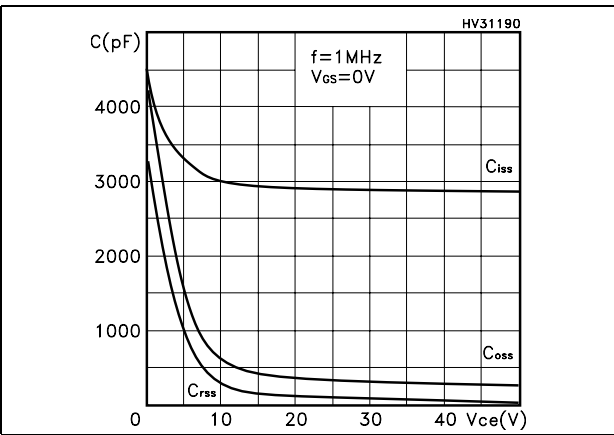


Figure 11. Switching losses vs temperature

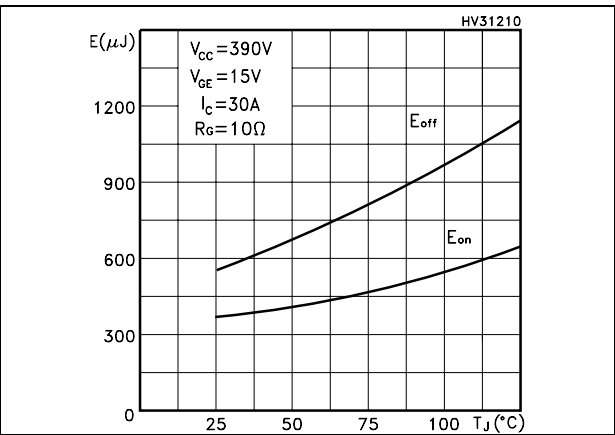


Figure 12. Switching losses vs gate resistance

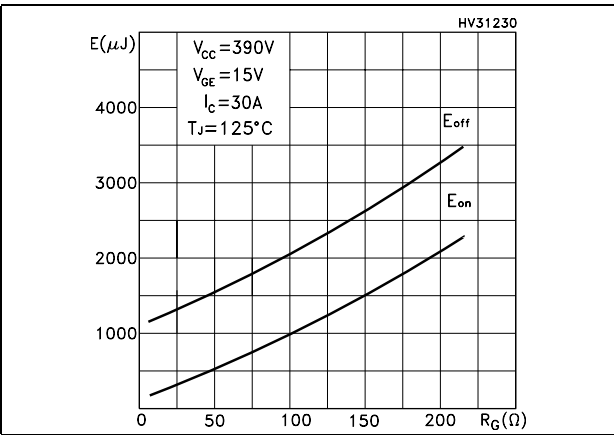


Figure 13. Switching losses vs collector current

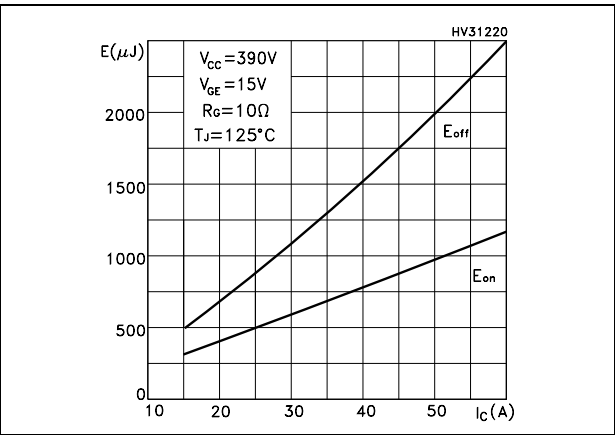




Figure 14. Thermal impedance

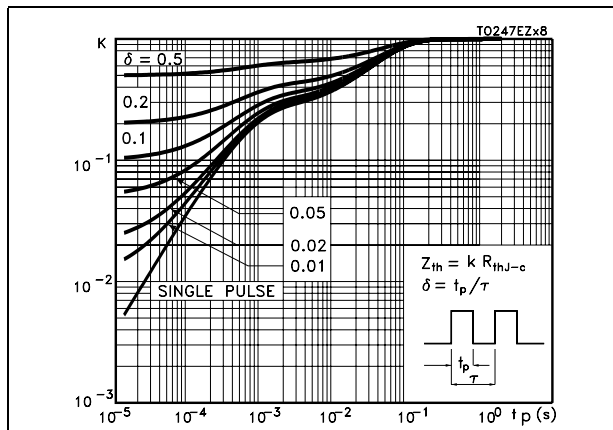


Figure 15. Turn-off SOA

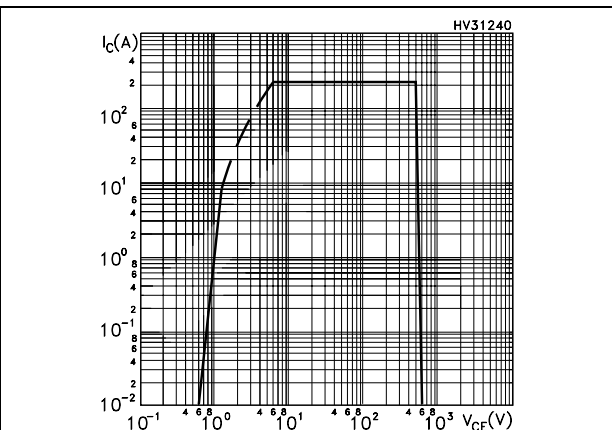


Figure 16. Emitter-collector diode characteristics

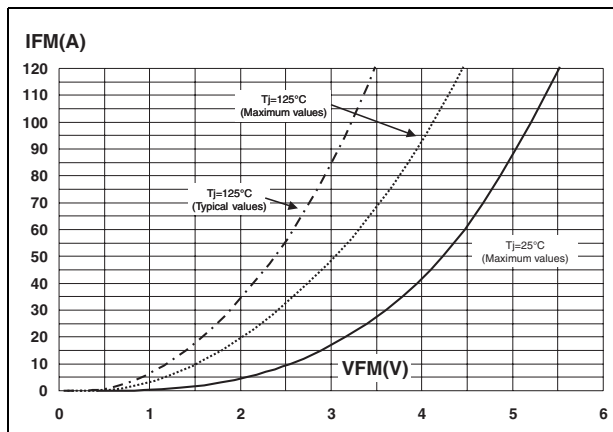
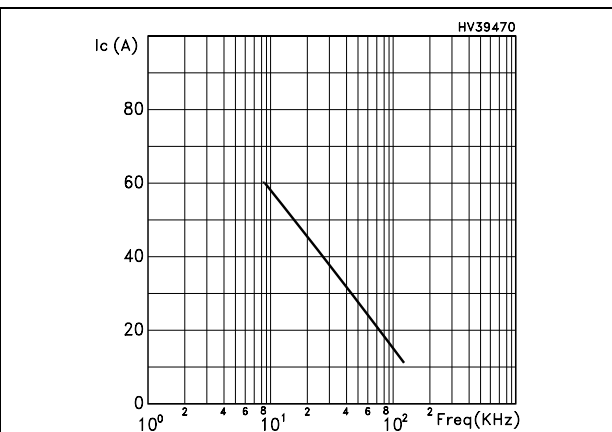


Figure 17. I\_C vs. frequency



## 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  $\Delta T = T_J - T_C = 125^\circ\text{C} - 75^\circ\text{C} = 50^\circ\text{C}$

- 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:  $V_{CE} = 390 \text{ V}$ ,  $V_{GE} = 15 \text{ V}$ ,  $R_G = 10 \text{ }\Omega$ ). Furthermore, diode recovery energy is included in the  $E_{ON}$  (see note 2), while the tail of the collector current is included in the  $E_{OFF}$  measurements (see note 3).

3 Test circuit

Figure 18. Test circuit for inductive load switching

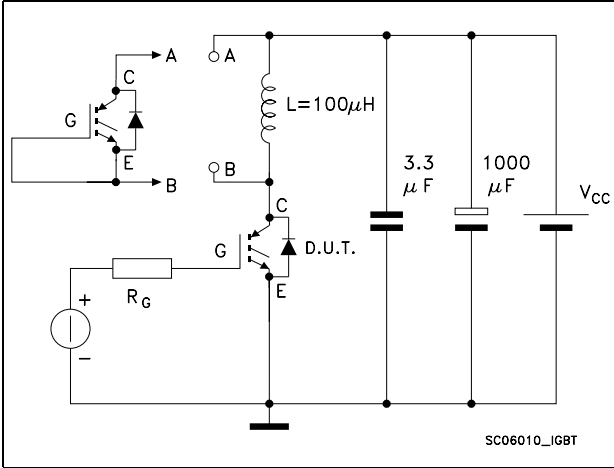


Figure 19. Gate charge test circuit

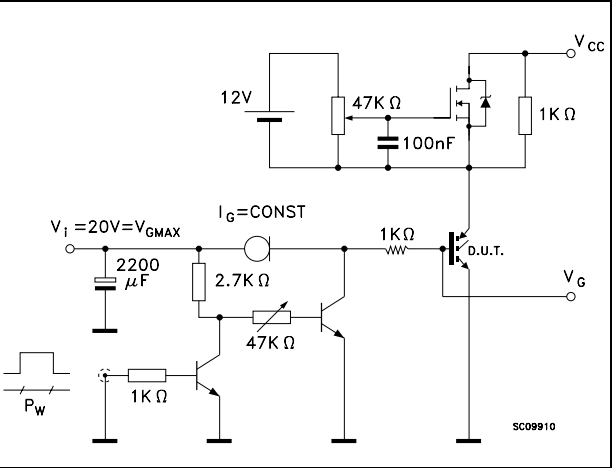


Figure 20. Switching waveforms

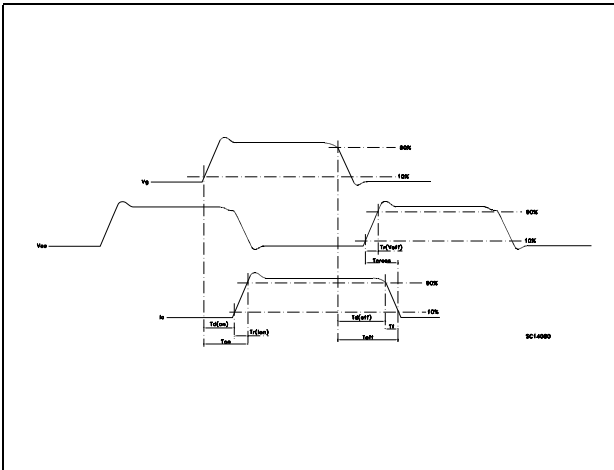
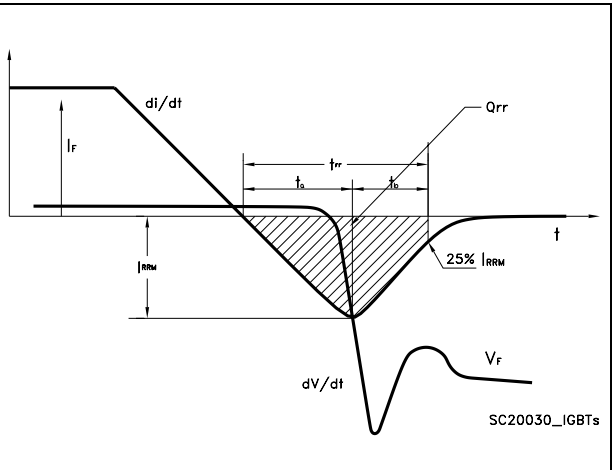


Figure 21. Diode recovery times waveform

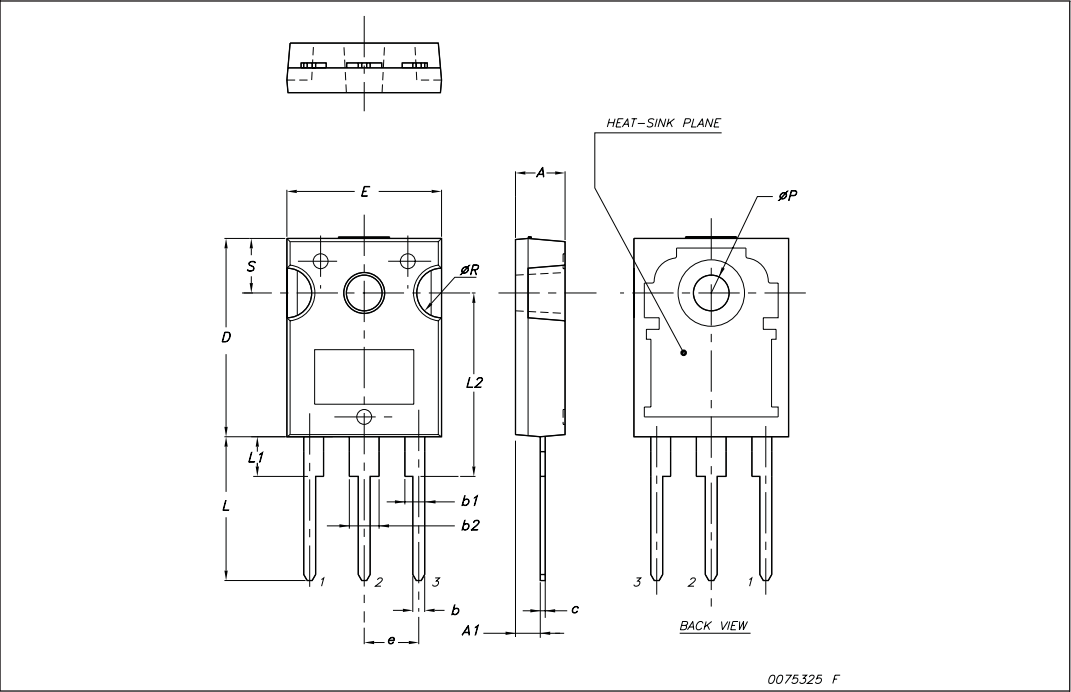


## 4 Package mechanical data

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-247 mechanical data

Dim.	mm.		
	Min.	Typ	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e		5.45	
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
øP	3.55		3.65
øR	4.50		5.50
S		5.50	



## 5 Revision history

**Table 9. Document revision history**

Date	Revision	Changes
17-Nov-2005	1	First release
05-May-2006	2	Inserted curves
10-Jul-2006	3	Modified value on <i>Absolute maximum ratings</i>
01-Dec-2006	4	Modified value on <i>Dynamic</i>
16-May-2007	5	New curves updated: <i>Figure 5</i> and <i>Figure 6</i>
22-Aug-2007	6	Added new <i>Figure 17</i> and new section <i>2.2: Frequency applications</i>
31-Jan-2008	7	Modified: <i>Table 8: Collector-emitter diode</i>
29-Jul-2008	8	Updated $V_{CE(sat)}$ on <i>Table 4</i>

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