



# STGW39NC60VD

N-channel 40A - 600V - TO-247  
Very fast switching PowerMESH™ IGBT

## Features

| Type         | V <sub>CES</sub> | V <sub>CE(sat)</sub><br>(Max) @ 25°C | I <sub>C</sub><br>@ 100°C |
|--------------|------------------|--------------------------------------|---------------------------|
| STGW39NC60VD | 600V             | <2.5V                                | 40A                       |

- Low C<sub>RES</sub> / C<sub>IES</sub> ratio (no cross conduction susceptibility)
- High frequency operation
- Very soft ultra fast recovery anti parallel diode

## Applications

- High frequency inverters
- UPS
- Motor drivers

Induction heating

## Description

Using the latest high voltage technology based on a patented strip layout, STMicroelectronics has designed an advanced family of IGBTs, the PowerMESH™ IGBTs, with outstanding performances. The suffix "V" identifies a family optimized for high frequency.

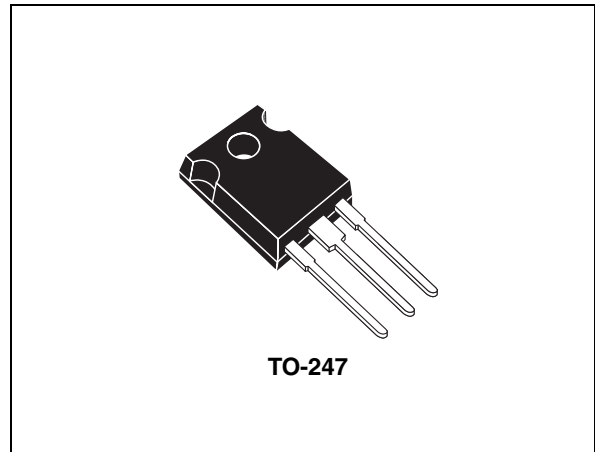


Figure 1. Internal schematic diagram

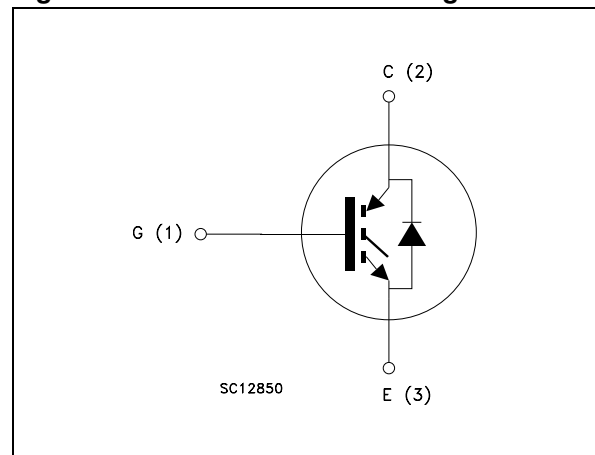


Table 1. Device summary

| Order code   | Marking    | Package | Packaging |
|--------------|------------|---------|-----------|
| STGW39NC60VD | GW39NC60VD | TO-247  | Tube      |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter   | Value       | Unit |
|----------------|---|-------------|------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GS} = 0$ )            | 600         | V    |
| $I_C^{(1)}$    | Collector current (continuous) at 25°C                | 70          | A    |
| $I_C^{(1)}$    | Collector current (continuous) at 100°C               | 40          | A    |
| $I_{CL}^{(2)}$ | Turn-off SOA minimum current                          | 220         | A    |
| $V_{GE}$       | Gate-emitter voltage                                  | ± 20        | V    |
| $I_F$          | Diode RMS forward current at $T_C = 25^\circ\text{C}$ | 30          | A    |
| $P_{TOT}$      | Total dissipation at $T_C = 25^\circ\text{C}$         | 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.  $V_{clamp} = 480\text{V}$ ,  $T_j = 150^\circ\text{C}$ ,  $R_G = 10\Omega$ ,  $V_{GE} = 15\text{V}$

**Table 3. Thermal resistance**

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

## 2 Electrical characteristics

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

**Table 4. Static**

| Symbol        | Parameter  | Test conditions   | Min. | Typ.       | Max.      | Unit                |
|---------------|--|---|------|------------|-----------|---------------------|
| $V_{BR(CES)}$ | Collector-emitter breakdown voltage                | $I_C = 1\text{mA}, V_{GE} = 0$  | 600  |            |           | V                   |
| $V_{CE(SAT)}$ | Collector-emitter saturation voltage               | $V_{GE}=15\text{V}, I_C=30\text{A}, T_j=25^{\circ}\text{C}$<br>$V_{GE}=15\text{V}, I_C=30\text{A}, T_j=125^{\circ}\text{C}$ |      | 1.8<br>1.7 | 2.5       | V<br>V              |
| $V_{GE(th)}$  | Gate threshold voltage                             | $V_{CE}= V_{GE}, I_C= 250\mu\text{A}$   | 3.75 |            | 5.75      | V                   |
| $I_{CES}$     | Collector-emitter leakage current ( $V_{GE} = 0$ ) | $V_{CE} = \text{Max rating}, T_c=25^{\circ}\text{C}$<br>$V_{CE}= \text{Max rating}, T_c=125^{\circ}\text{C}$                |      |            | 500<br>5  | $\mu\text{A}$<br>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                           | $V_{CE} = 15\text{V}, I_C = 30\text{A}$   |      | 20         |           | S                   |

**Table 5. Dynamic**

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

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

| Symbol          | Parameter             | Test conditions                         | Min. | Typ. | Max. | Unit             |
|-----------------|-----------------------|---|------|------|------|------------------|
| $t_{d(on)}$     | Turn-on delay time    | $V_{CC}=390\text{ V}, I_C=30\text{ A},$ |      | 33   |      | ns               |
| $t_r$           | Current rise time     | $R_G=10\Omega, V_{GE}=15\text{ V}$      |      | 13   |      | ns               |
| $(di/dt)_{onf}$ | Turn-on current slope | $T_j=25^\circ\text{C}$ (see Figure 18)  |      | 2500 |      | A/ $\mu\text{s}$ |
| $t_{d(on)}$     | Turn-on delay time    | $V_{CC}=390\text{ V}, I_C=30\text{ A},$ |      | 32   |      | ns               |
| $t_r$           | Current rise time     | $R_G=10\Omega, V_{GE}=15\text{ V}$      |      | 14   |      | ns               |
| $(di/dt)_{on}$  | Turn-on current slope | $T_j=125^\circ\text{C}$ (see Figure 18) |      | 2280 |      | A/ $\mu\text{s}$ |
| $t_{r(Voff)}$   | Off voltage rise time | $V_{CC}=390\text{ V}, I_C=30\text{ A},$ |      | 33   |      | ns               |
| $t_{d(off)}$    | Turn-off delay time   | $R_G=10\Omega, V_{GE}=15\text{ V}$      |      | 178  |      | ns               |
| $t_f$           | Current fall time     | $T_j=25^\circ\text{C}$ (see Figure 18)  |      | 65   |      | ns               |
| $t_{r(Voff)}$   | Off voltage rise time | $V_{CC}=390\text{ V}, I_C=30\text{ A},$ |      | 68   |      | ns               |
| $t_{d(off)}$    | Turn-off delay time   | $R_G=10\Omega, V_{GE}=15\text{ V}$      |      | 238  |      | ns               |
| $t_f$           | Current fall time     | $T_j=125^\circ\text{C}$ (see Figure 18) |      | 128  |      | ns               |

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

| Symbol          | Parameter                 | Test conditions                            | Min | Typ. | Max | Unit          |
|-----------------|---------------------------|--|-----|------|-----|---------------|
| $E_{on}^{(1)}$  | Turn-on switching losses  | $V_{CC} = 390\text{ V}, I_C = 30\text{ A}$ |     | 333  |     | $\mu\text{J}$ |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 10\Omega, V_{GE} = 15\text{ V},$    |     | 537  |     | $\mu\text{J}$ |
| $E_{ts}$        | Total switching losses    | $T_j = 25^\circ\text{C}$ (see Figure 20)   |     | 870  |     | $\mu\text{J}$ |
| $E_{on}^{(1)}$  | Turn-on switching losses  | $V_{CC} = 390\text{ V}, I_C = 30\text{ A}$ |     | 618  |     | $\mu\text{J}$ |
| $E_{off}^{(2)}$ | Turn-off switching losses | $R_G = 10\Omega, V_{GE} = 15\text{ V},$    |     | 1125 |     | $\mu\text{J}$ |
| $E_{ts}$        | Total switching losses    | $T_j = 125^\circ\text{C}$ (see Figure 20)  |     | 1743 |     | $\mu\text{J}$ |

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-pack diode, the co-pack 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       | $I_f = 15\text{ A}$   |     | 1.3  | 2.9 | V    |
|           |                          | $I_f = 15\text{ A}, T_j = 125^\circ\text{C}$                |     | 1.1  |     | V    |
|           |                          | $I_f = 30\text{ A}, T_j = 125^\circ\text{C}$                |     | 1.2  |     | V    |
| $t_{rr}$  | Reverse recovery time    | $I_f = 30\text{ A}, V_R = 50\text{ V},$                     |     | 45   |     | ns   |
| $Q_{rr}$  | Reverse recovery charge  | $T_j = 25^\circ\text{C}, di/dt = 100\text{ A}/\mu\text{s}$  |     | 56   |     | nC   |
| $I_{rrm}$ | Reverse recovery current | (see Figure 21)   |     | 2.55 |     | A    |
| $t_{rr}$  | Reverse recovery time    | $I_f = 30\text{ A}, V_R = 50\text{ V},$                     |     | 100  |     | ns   |
| $Q_{rr}$  | Reverse recovery charge  | $T_j = 125^\circ\text{C}, di/dt = 100\text{ A}/\mu\text{s}$ |     | 290  |     | nC   |
| $I_{rrm}$ | Reverse recovery current | (see Figure 21)   |     | 5.8  |     | A    |

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

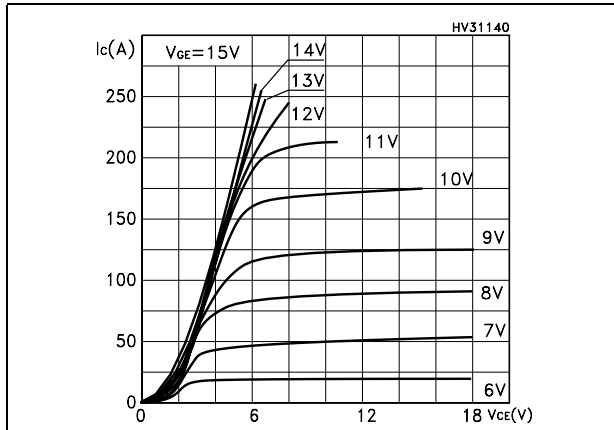


Figure 3. Transfer characteristics

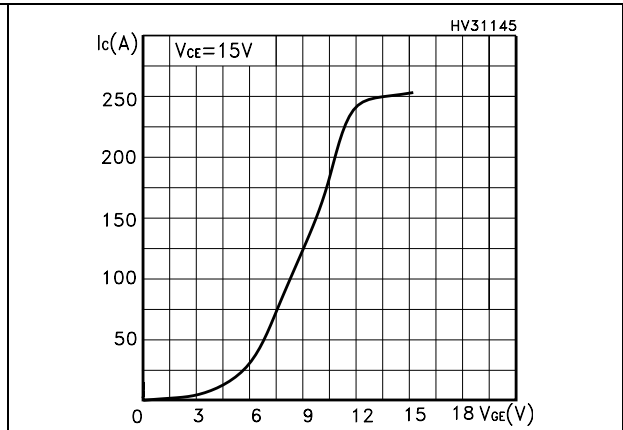


Figure 4. Transconductance

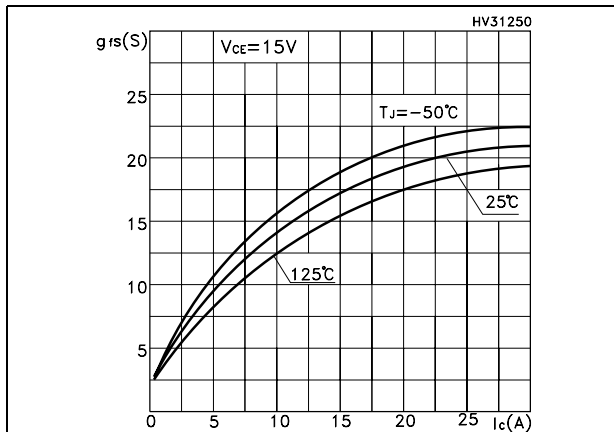


Figure 5. Collector-emitter on voltage vs temperature

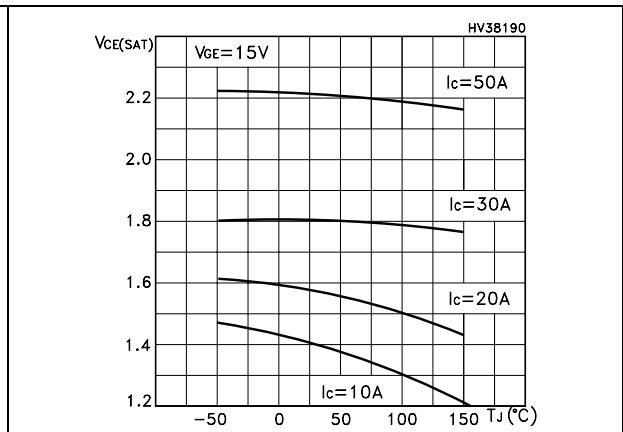


Figure 6. Collector-emitter on voltage vs collector current

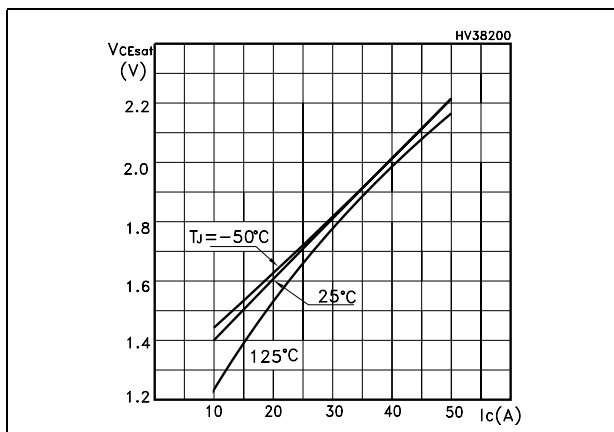


Figure 7. Normalized gate threshold vs temperature

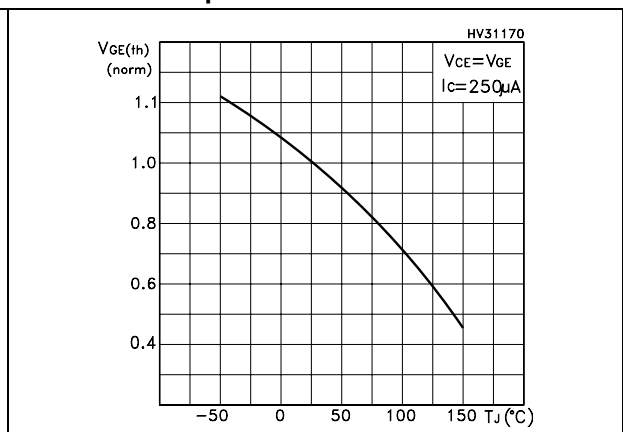


Figure 8. Normalized breakdown voltage vs temperature

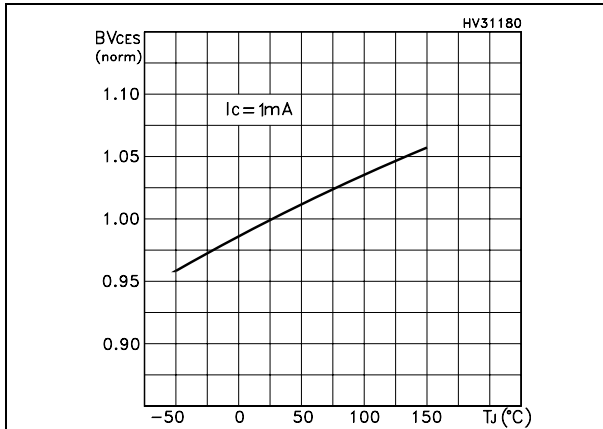


Figure 9. Gate charge vs gate-emitter voltage

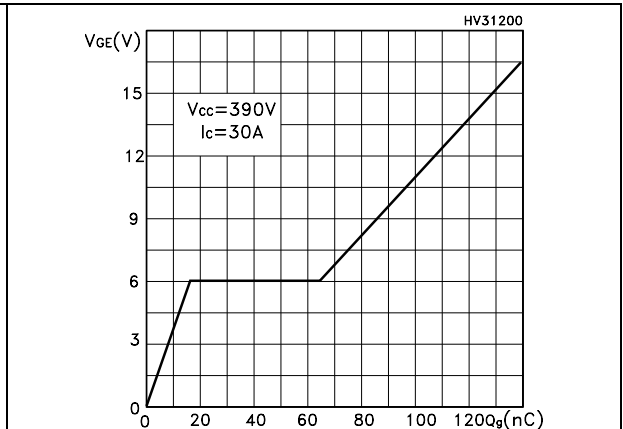


Figure 10. Capacitance variations

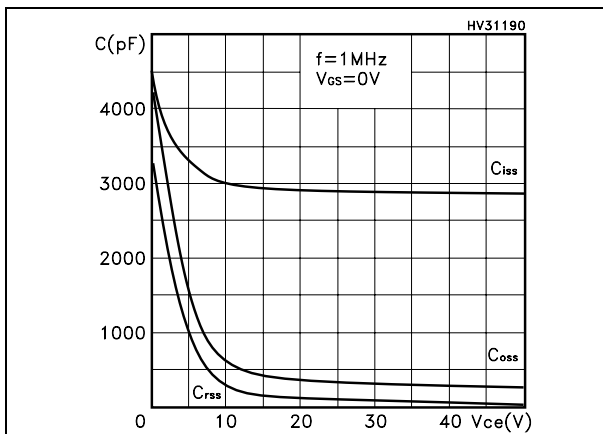


Figure 11. Switching losses vs temperature

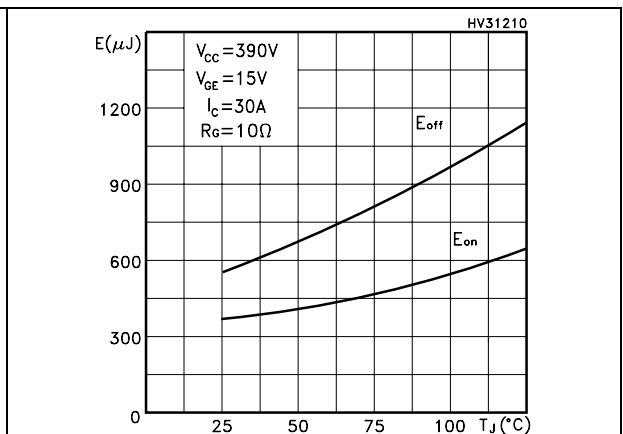


Figure 12. Switching losses vs gate resistance Figure 13. Switching losses vs collector current

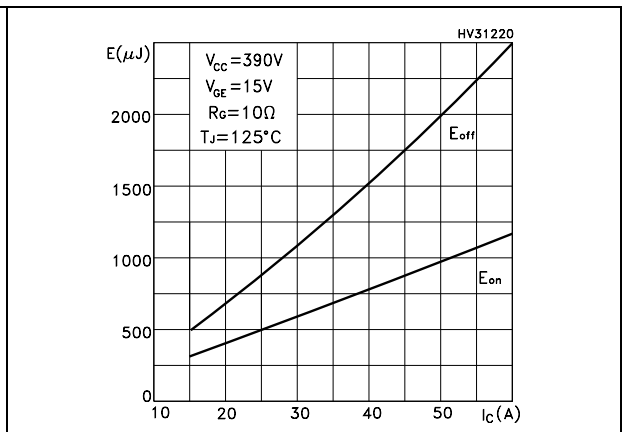
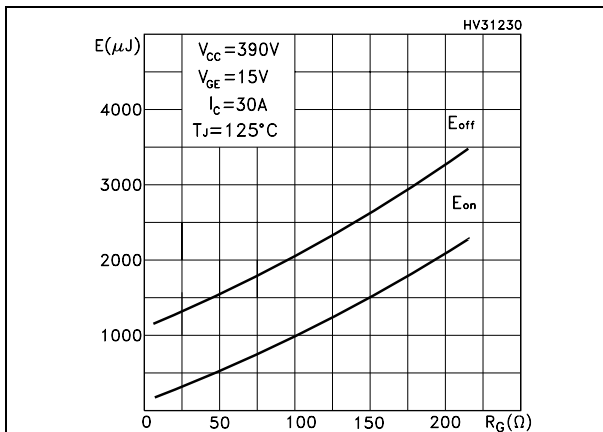


Figure 14. Thermal impedance

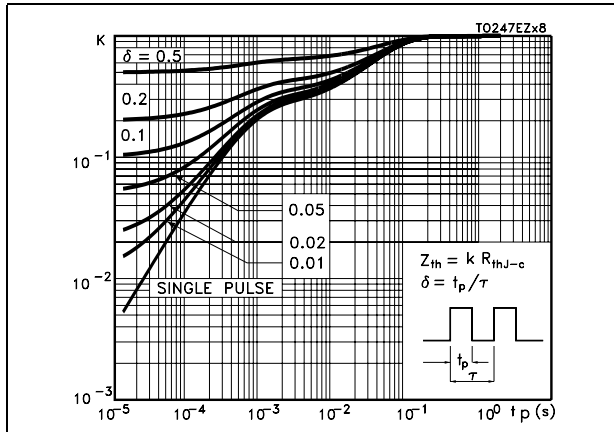


Figure 15. Turn-off SOA

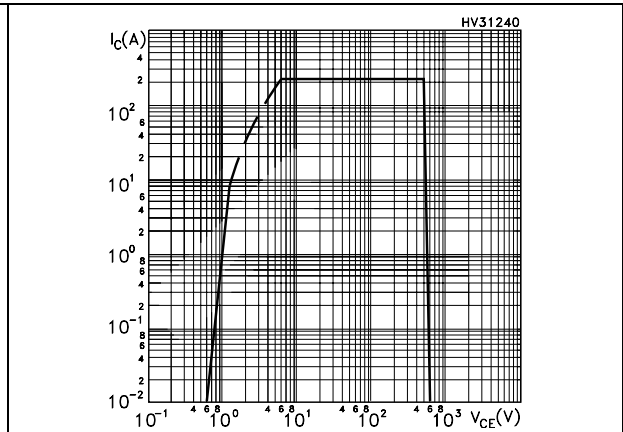


Figure 16. Emitter-collector diode characteristics

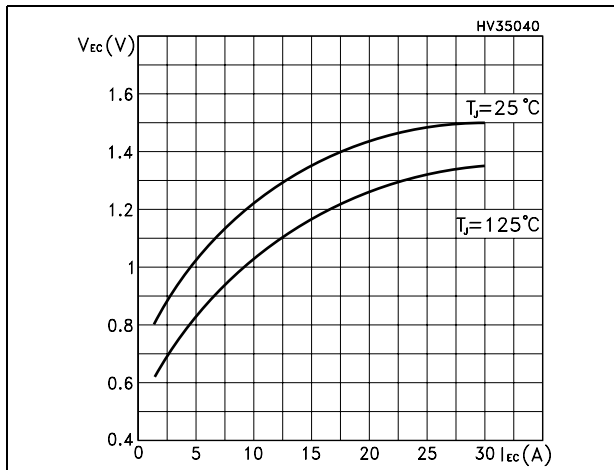
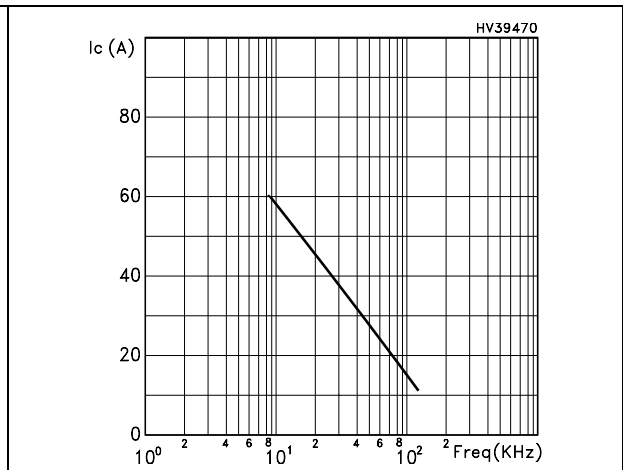


Figure 17. Ic vs. frequency





## 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:  $V_{CE} = 390\text{V}$ ,  $V_{GE} = 15\text{V}$ ,  $R_G = 10\text{ Ohm}$ ). 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

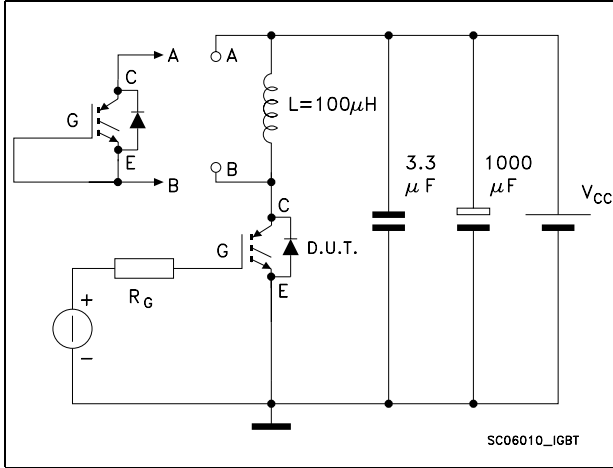


Figure 19. Gate charge test circuit

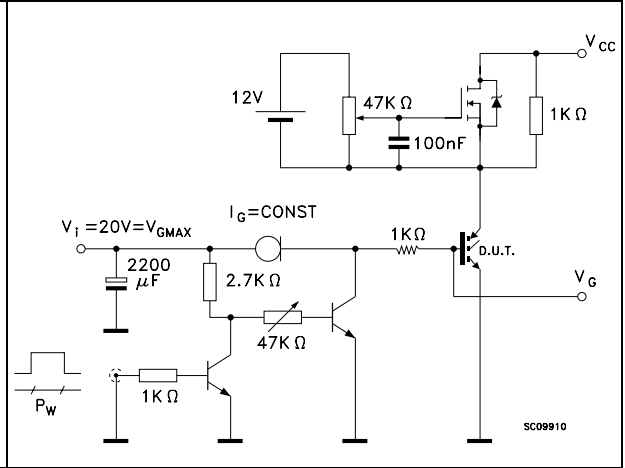


Figure 20. Switching waveforms

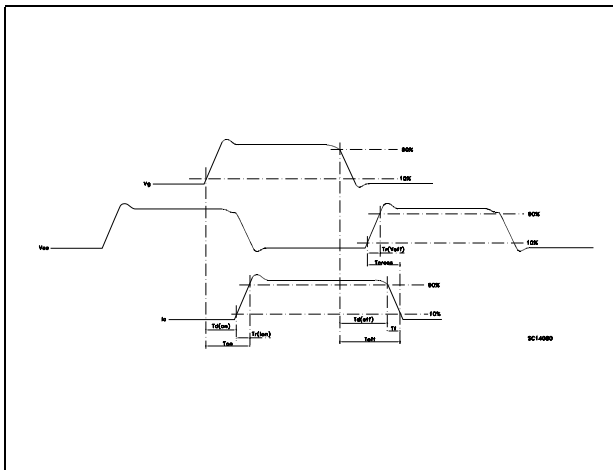
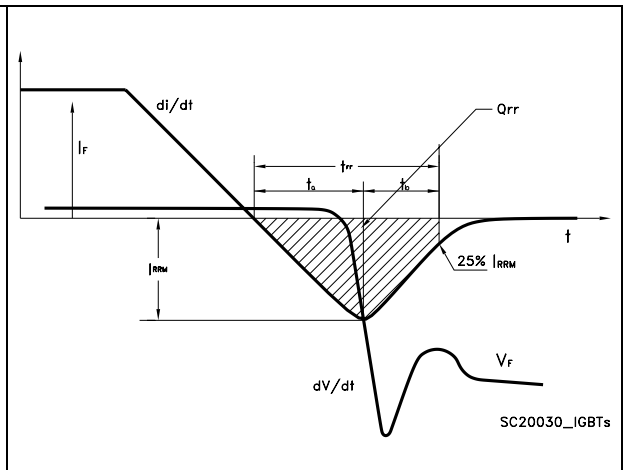


Figure 21. Diode recovery times waveform

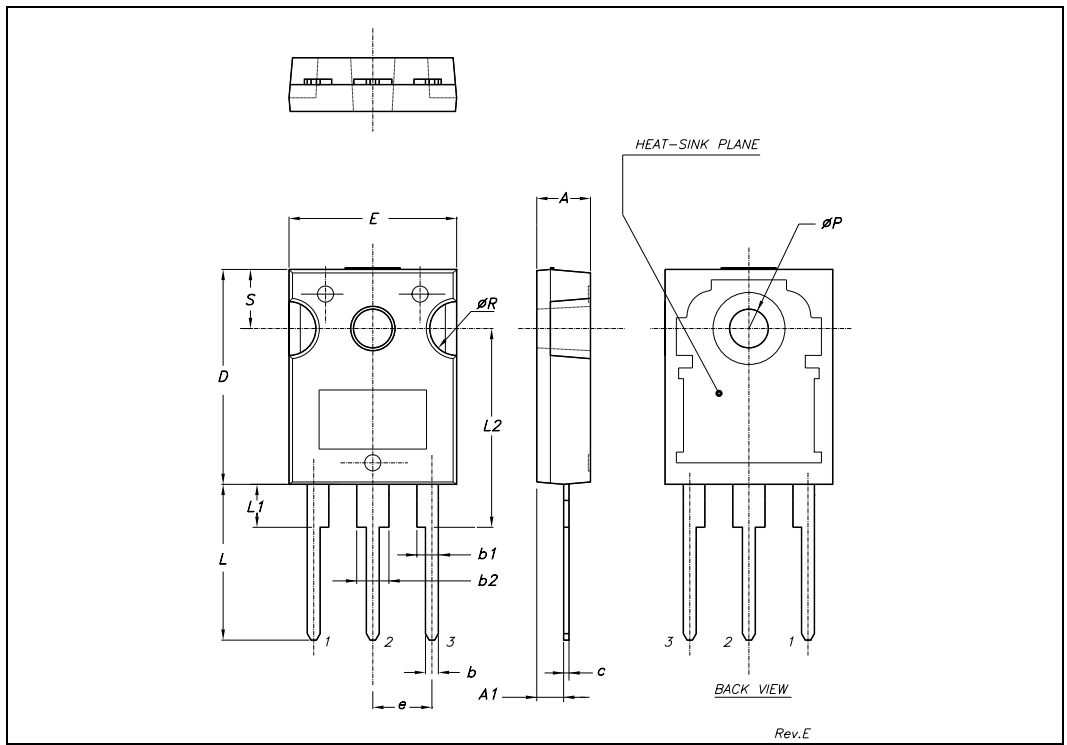


## 4 Package mechanical data

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.   |       |       | inch  |       |       |
|------|-------|-------|-------|-------|-------|-------|
|      | MIN.  | TYP.  | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.85  |       | 5.15  | 0.19  |       | 0.20  |
| A1   | 2.20  |       | 2.60  | 0.086 |       | 0.102 |
| b    | 1.0   |       | 1.40  | 0.039 |       | 0.055 |
| b1   | 2.0   |       | 2.40  | 0.079 |       | 0.094 |
| b2   | 3.0   |       | 3.40  | 0.118 |       | 0.134 |
| c    | 0.40  |       | 0.80  | 0.015 |       | 0.03  |
| D    | 19.85 |       | 20.15 | 0.781 |       | 0.793 |
| E    | 15.45 |       | 15.75 | 0.608 |       | 0.620 |
| e    |       | 5.45  |       |       | 0.214 |       |
| L    | 14.20 |       | 14.80 | 0.560 |       | 0.582 |
| L1   | 3.70  |       | 4.30  | 0.14  |       | 0.17  |
| L2   |       | 18.50 |       |       | 0.728 |       |
| øP   | 3.55  |       | 3.65  | 0.140 |       | 0.143 |
| øR   | 4.50  |       | 5.50  | 0.177 |       | 0.216 |
| S    |       | 5.50  |       |       | 0.216 |       |



## 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> |

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