

## Trench gate field-stop IGBT, M series 650 V, 6 A low loss

Datasheet - production data

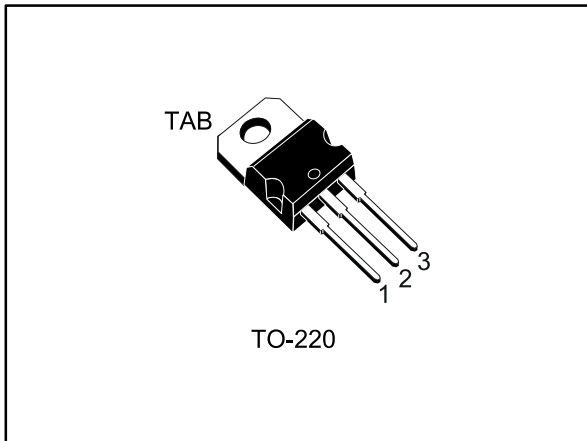
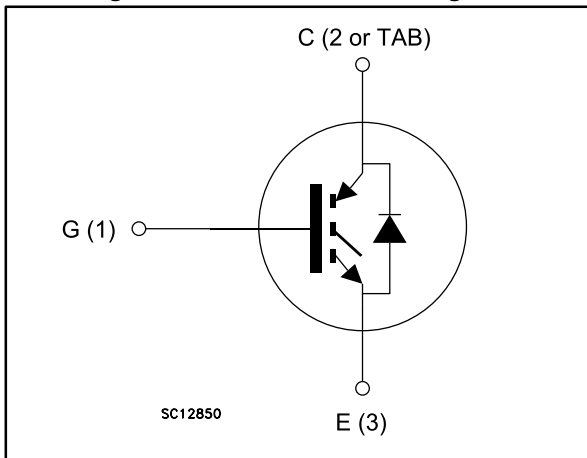


Figure 1: Internal schematic diagram



### Features

- 6  $\mu$ s of short-circuit withstand time
- $V_{CE(sat)} = 1.55$  V (typ.) @  $I_c = 6$  A
- Tight parameter distribution
- Safer paralleling
- Low thermal resistance
- Soft and very fast recovery antiparallel diode

### Applications

- Motor control
- UPS
- PFC

### Description

This device is an IGBT developed using an advanced proprietary trench gate field-stop structure. The device is part of the M series IGBTs, which represent an optimal balance between inverter system performance and efficiency where low-loss and short-circuit functionality are essential. Furthermore, the positive  $V_{CE(sat)}$  temperature coefficient and tight parameter distribution result in safer paralleling operation.

Table 1: Device summary

Order code	Marking	Package	Packing
STGP6M65DF2	G6M65DF2	TO-220	Tube

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# 1 Electrical ratings

**Table 2: Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ V)	650	V
$I_C$	Continuous collector current at $T_C = 25$ °C	12	A
	Continuous collector current at $T_C = 100$ °C	6	A
$I_{CP}^{(1)}$	Pulsed collector current	24	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$I_F$	Continuous forward current at $T_C = 25$ °C	12	A
	Continuous forward current at $T_C = 100$ °C	6	A
$I_{FP}^{(1)}$	Pulsed forward current	24	A
$P_{TOT}$	Total dissipation at $T_C = 25$ °C	88	W
$T_{STG}$	Storage temperature range	- 55 to 150	°C
$T_J$	Operating junction temperature range	- 55 to 175	°C

**Notes:**

<sup>(1)</sup>Pulse width limited by maximum junction temperature.

**Table 3: Thermal data**

Symbol	Parameter	Value	Unit
$R_{thJC}$	Thermal resistance junction-case IGBT	1.7	°C/W
$R_{thJC}$	Thermal resistance junction-case diode	5	°C/W
$R_{thJA}$	Thermal resistance junction-ambient	62.5	°C/W

## 2 Electrical characteristics

$T_C = 25\text{ °C}$  unless otherwise specified

**Table 4: Static characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage	$V_{GE} = 0\text{ V}$ , $I_C = 250\text{ }\mu\text{A}$	650			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 6\text{ A}$		1.55	2.0	V
		$V_{GE} = 15\text{ V}$ , $I_C = 6\text{ A}$ , $T_J = 125\text{ °C}$		1.9		
		$V_{GE} = 15\text{ V}$ , $I_C = 6\text{ A}$ , $T_J = 175\text{ °C}$		2.1		
$V_F$	Forward on-voltage	$I_F = 6\text{ A}$		2.2		V
		$I_F = 6\text{ A}$ , $T_J = 125\text{ °C}$		2.0		
		$I_F = 6\text{ A}$ , $T_J = 175\text{ °C}$		1.9		
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 250\text{ }\mu\text{A}$	5	6	7	V
$I_{CES}$	Collector cut-off current	$V_{GE} = 0\text{ V}$ , $V_{CE} = 650\text{ V}$			25	$\mu\text{A}$
$I_{GES}$	Gate-emitter leakage current	$V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$			$\pm 250$	$\mu\text{A}$

**Table 5: Dynamic characteristics**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$	-	530	-	pF
$C_{oes}$	Output capacitance		-	31	-	
$C_{res}$	Reverse transfer capacitance		-	11	-	
$Q_g$	Total gate charge	$V_{CC} = 520\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 15\text{ V}$ (see <a href="#">Figure 30: "Gate charge test circuit"</a> )	-	21.2	-	nC
$Q_{ge}$	Gate-emitter charge		-	5.2	-	
$Q_{gc}$	Gate-collector charge		-	8.8	-	

Table 6: IGBT switching characteristics (inductive load)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 22\ \Omega$ (see <a href="#">Figure 29: "Test circuit for inductive load switching"</a> )		15	-	ns
$t_r$	Current rise time			5.8	-	ns
$(di/dt)_{on}$	Turn-on current slope			828	-	A/ $\mu$ s
$t_{d(off)}$	Turn-off-delay time			90	-	ns
$t_f$	Current fall time			130	-	ns
$E_{on(1)}$	Turn-on switching energy			0.036	-	mJ
$E_{off(2)}$	Turn-off switching energy			0.200	-	mJ
$E_{ts}$	Total switching energy			0.236	-	mJ
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 22\ \Omega$ , $T_J = 175\text{ }^\circ\text{C}$ (see <a href="#">Figure 29: "Test circuit for inductive load switching"</a> )		17	-	ns
$t_r$	Current rise time			7	-	ns
$(di/dt)_{on}$	Turn-on current slope			685	-	A/ $\mu$ s
$t_{d(off)}$	Turn-off-delay time			86	-	ns
$t_f$	Current fall time			205	-	ns
$E_{on(1)}$	Turn-on switching energy			0.064	-	mJ
$E_{off(2)}$	Turn-off switching energy			0.290	-	mJ
$E_{ts}$	Total switching energy			0.354	-	mJ
$t_{sc}$	Short-circuit withstand time	$V_{CC} \leq 400\text{ V}$ , $V_{GE} = 15\text{ V}$ , $T_{Jstart} = 150\text{ }^\circ\text{C}$	6		-	$\mu$ s
		$V_{CC} \leq 400\text{ V}$ , $V_{GE} = 13\text{ V}$ , $T_{Jstart} = 150\text{ }^\circ\text{C}$	10		-	$\mu$ s

**Notes:**

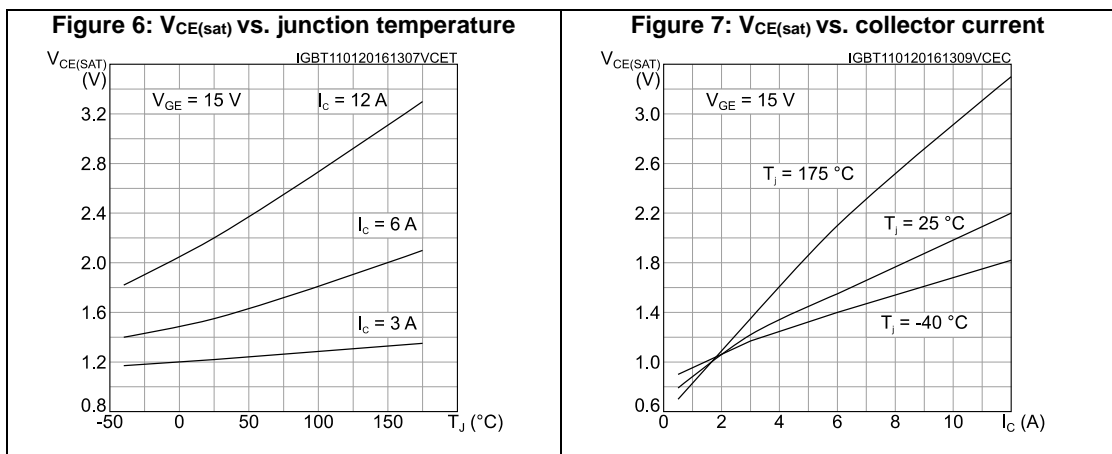
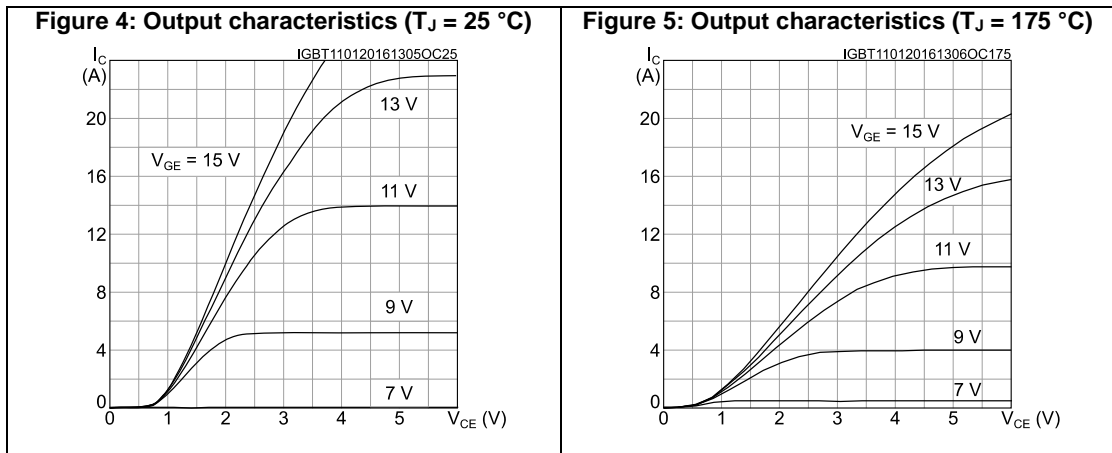
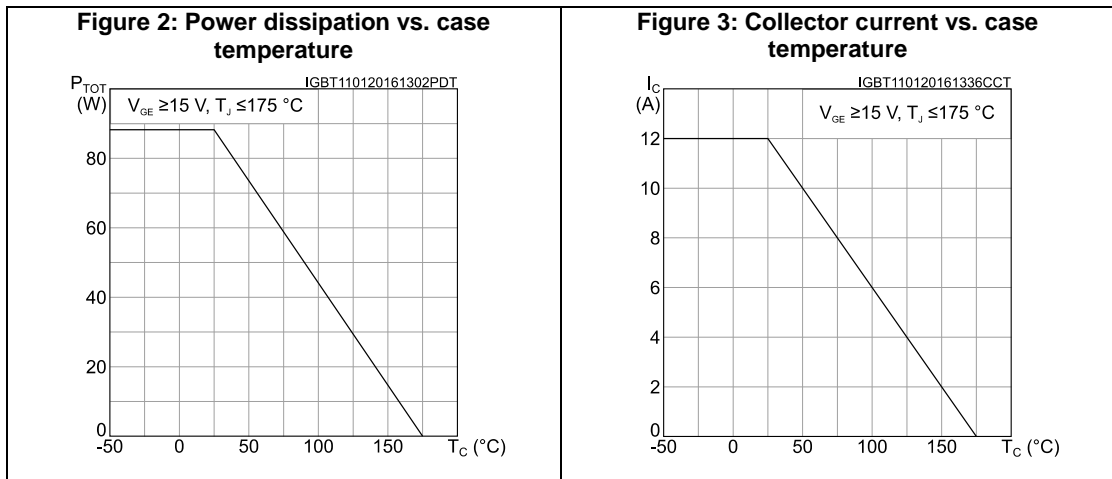
(1) Turn-on switching energy includes reverse recovery of the diode.

(2) Turn-off switching energy also includes the tail of the collector current.

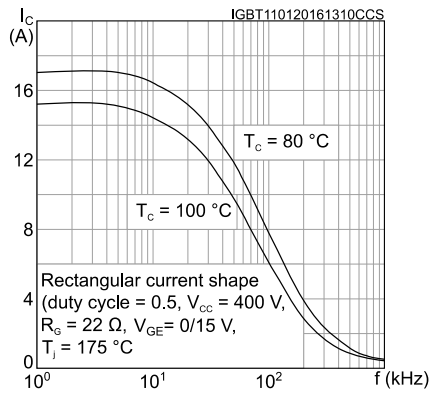
Table 7: Diode switching characteristics (inductive load)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{rr}$	Reverse recovery time	$I_F = 6\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ (see <a href="#">Figure 29: "Test circuit for inductive load switching"</a> ) $di/dt = 1000\text{ A}/\mu\text{s}$	-	140		ns
$Q_{rr}$	Reverse recovery charge		-	210		nC
$I_{rrm}$	Reverse recovery current		-	6.6		A
$dl_{rr}/dt$	Peak rate of fall of reverse recovery current during $t_b$		-	430		A/ $\mu\text{s}$
$E_{rr}$	Reverse recovery energy		-	16		$\mu\text{J}$
$t_{rr}$	Reverse recovery time	$I_F = 6\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ $T_J = 175\text{ }^\circ\text{C}$ (see <a href="#">Figure 29: "Test circuit for inductive load switching"</a> ) $di/dt = 1000\text{ A}/\mu\text{s}$	-	200		ns
$Q_{rr}$	Reverse recovery charge		-	473		nC
$I_{rrm}$	Reverse recovery current		-	9.6		A
$dl_{rr}/dt$	Peak rate of fall of reverse recovery current during $t_b$		-	428		A/ $\mu\text{s}$
$E_{rr}$	Reverse recovery energy		-	32		$\mu\text{J}$

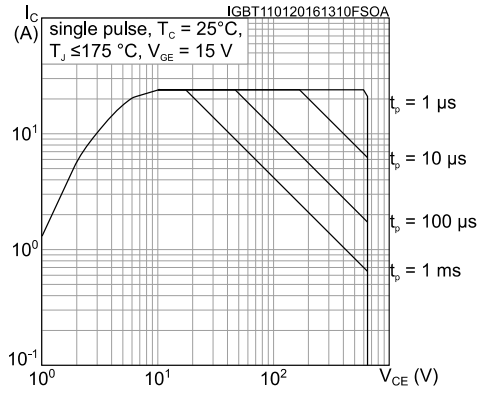
2.1 Electrical characteristics (curves)



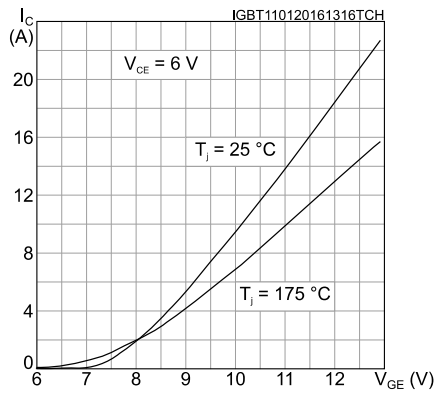
**Figure 8: Collector current vs. switching frequency**



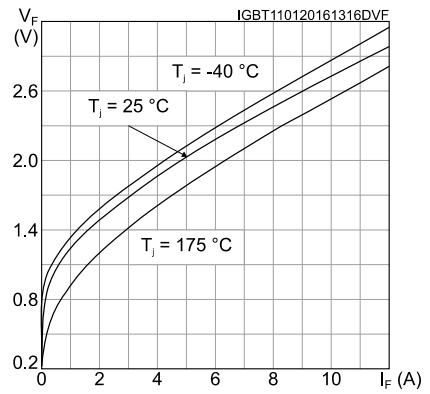
**Figure 9: Forward bias safe operating area**



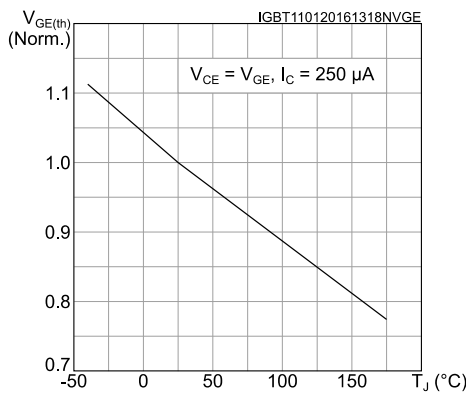
**Figure 10: Transfer characteristics**



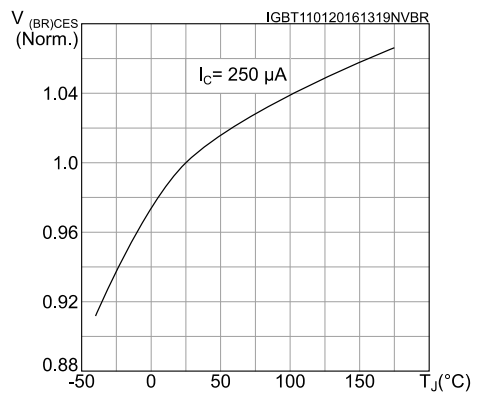
**Figure 11: Diode V\_F vs. forward current**



**Figure 12: Normalized V\_GE(th) vs. junction temperature**



**Figure 13: Normalized V\_(BR)CES vs. junction temperature**





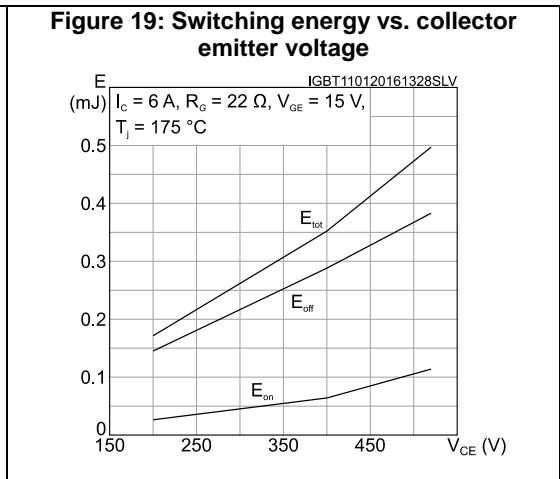
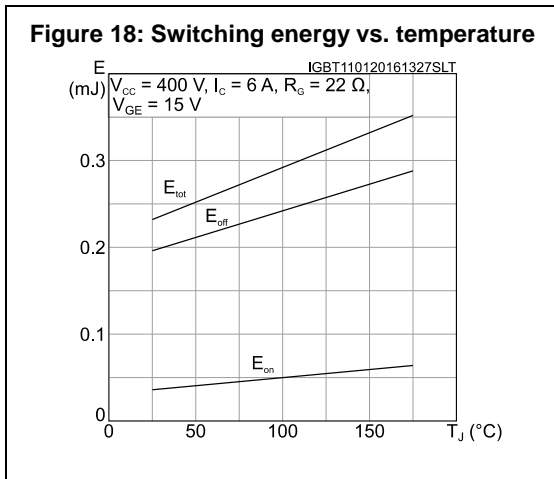
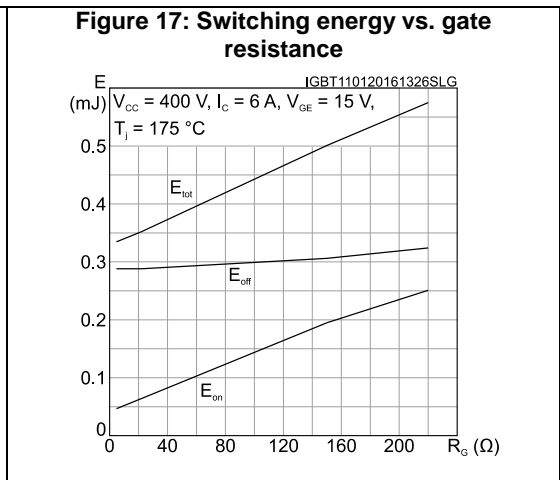
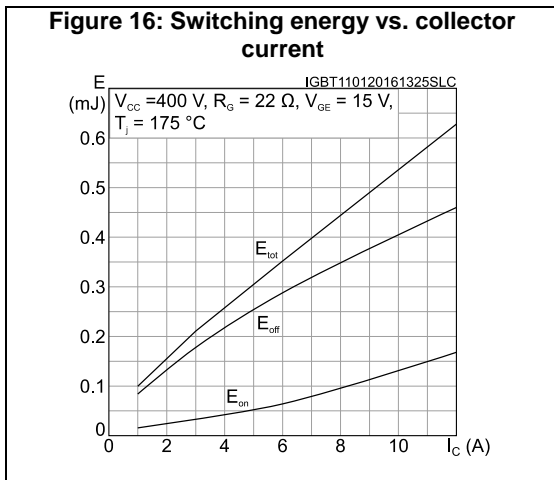
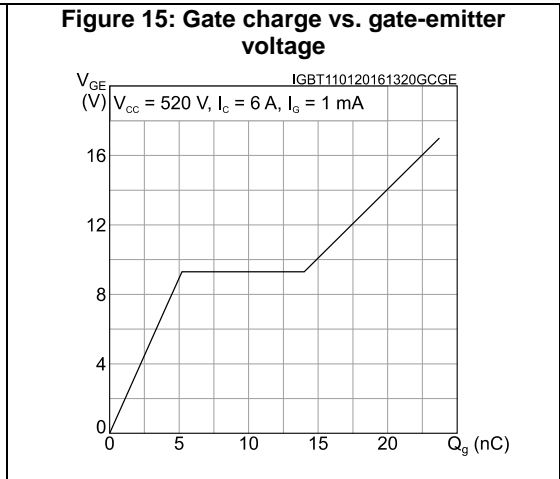
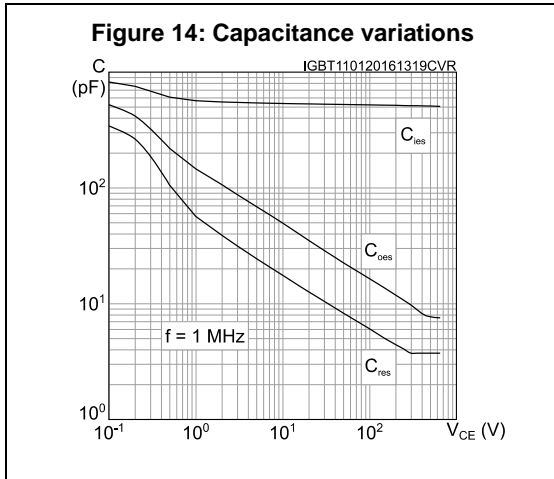


Figure 20: Short-circuit time and current vs.  $V_{GE}$

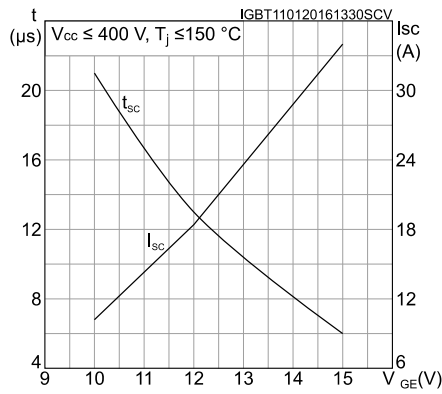


Figure 21: Switching times vs. collector current

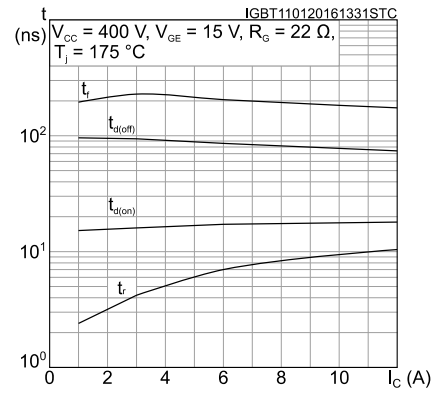


Figure 22: Switching times vs. gate resistance

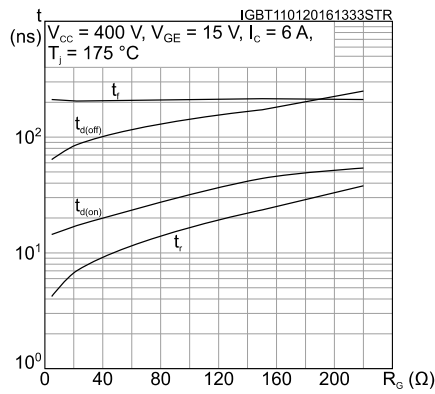


Figure 23: Reverse recovery current vs. diode current slope

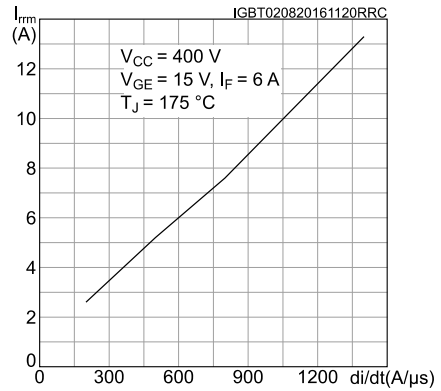


Figure 24: Reverse recovery time vs. diode current slope

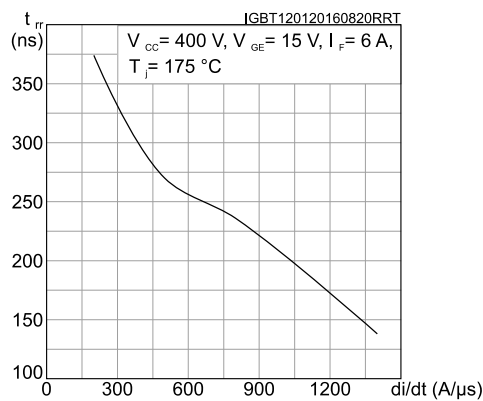


Figure 25: Reverse recovery charge vs. diode current slope

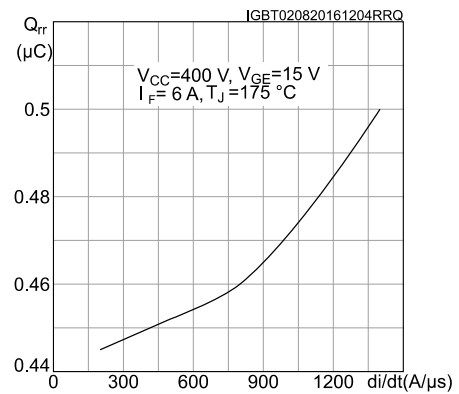


Figure 26: Reverse recovery energy vs. diode current slope

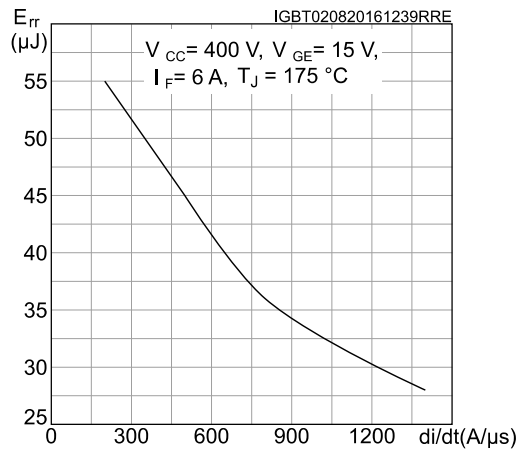


Figure 27: Thermal impedance for IGBT

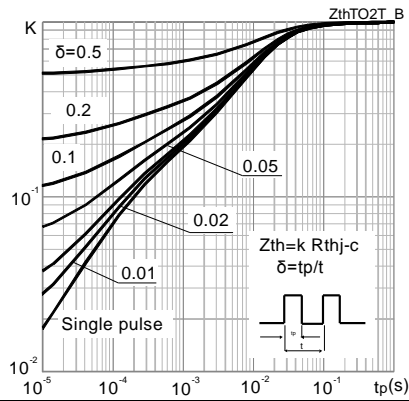
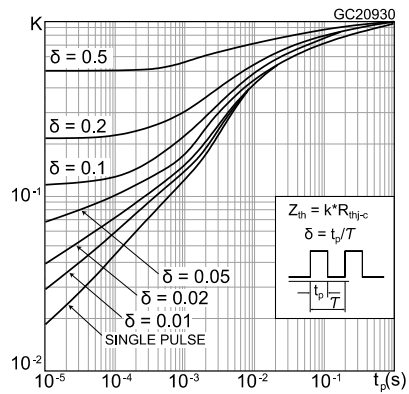
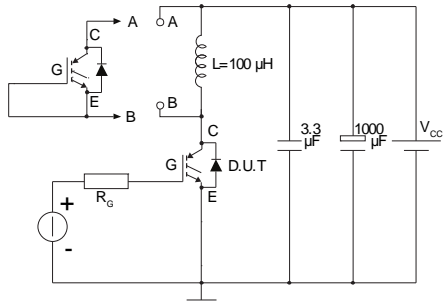


Figure 28: Thermal impedance for diode



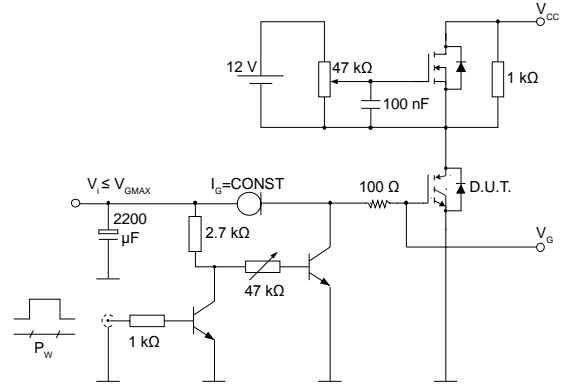
### 3 Test circuits

**Figure 29: Test circuit for inductive load switching**



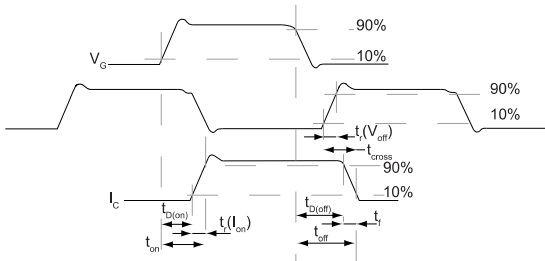
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**Figure 30: Gate charge test circuit**



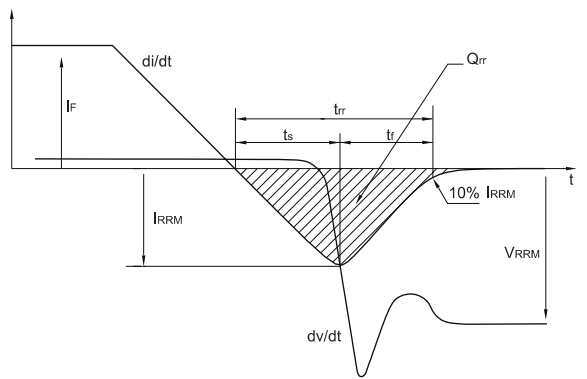
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**Figure 31: Switching waveform**



AM01506v1

**Figure 32: Diode reverse recovery waveform**



AM01507v1

## 4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 4.1 TO-220 type A package information

Figure 33: TO-220 type A package outline

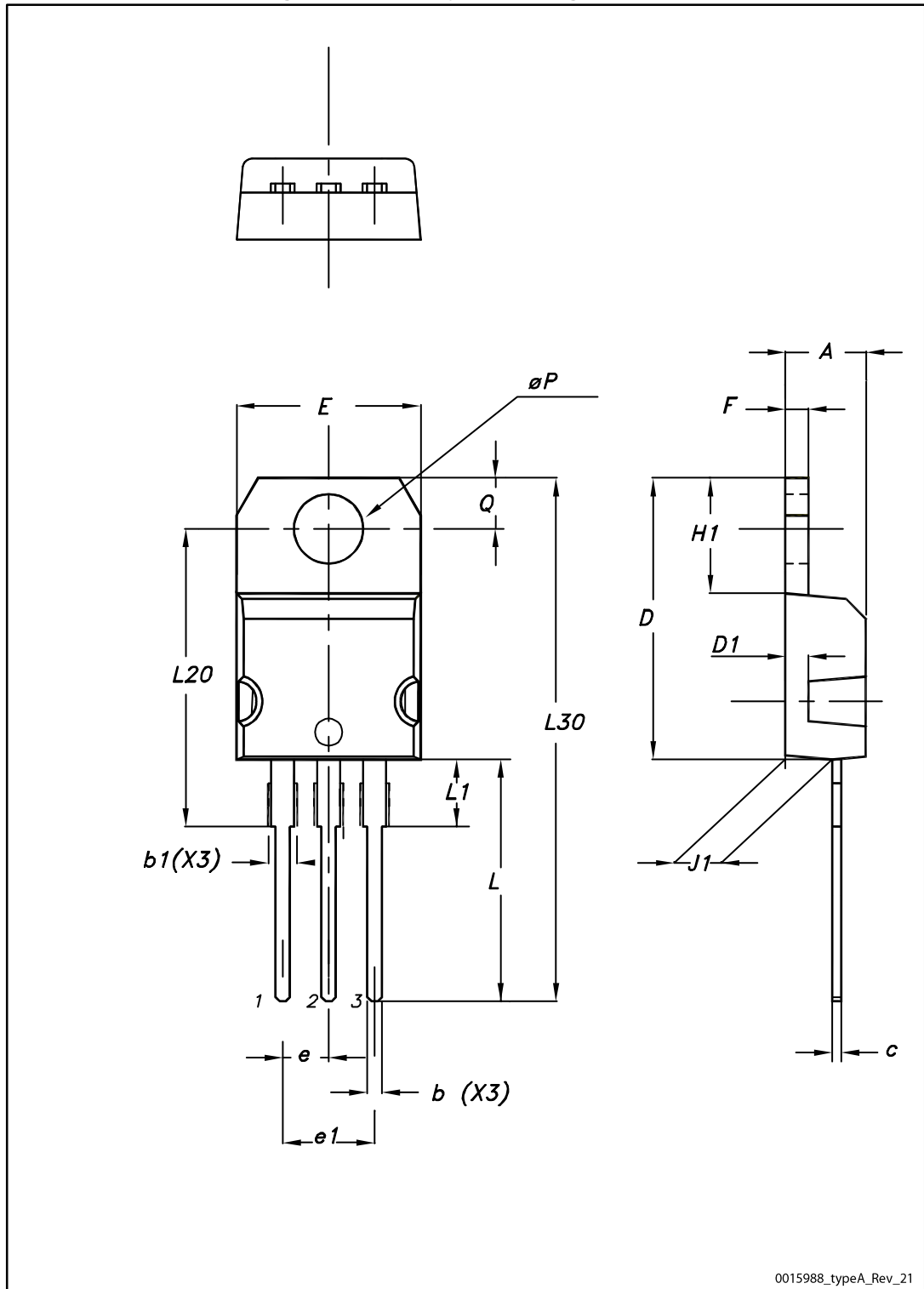


Table 8: TO-220 type A mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.55
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10.00		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	13.00		14.00
L1	3.50		3.93
L20		16.40	
L30		28.90	
øP	3.75		3.85
Q	2.65		2.95

## 5 Revision history

**Table 9: Document revision history**

Date	Revision	Changes
30-Nov-2015	1	First release.
13-Jan-2016	2	Modified: <i>Table 4: "Static characteristics"</i> , <i>Table 5: "Dynamic characteristics"</i> , <i>Table 6: "IGBT switching characteristics (inductive load)"</i> , and <i>Table 7: "Diode switching characteristics (inductive load)"</i> Added: <i>Section 2.1: "Electrical characteristics (curves)"</i> Minor text changes.
03-Aug-2016	3	Updated <i>Table 2: "Absolute maximum ratings"</i> , <i>Table 4: "Static characteristics"</i> , <i>Table 6: "IGBT switching characteristics (inductive load)"</i> , <i>Table 7: "Diode switching characteristics (inductive load)"</i> . Updated <i>Figure 9: "Forward bias safe operating area"</i> , <i>Figure 12: "Normalized VGE(th) vs. junction temperature"</i> , <i>Figure 20: "Short-circuit time and current vs. VGE"</i> , <i>Figure 23: "Reverse recovery current vs. diode current slope"</i> . Changed <i>Figure 25: "Reverse recovery charge vs. diode current slope"</i> and <i>Figure 26: "Reverse recovery energy vs. diode current slope"</i> .



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