

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

Datasheet - production data

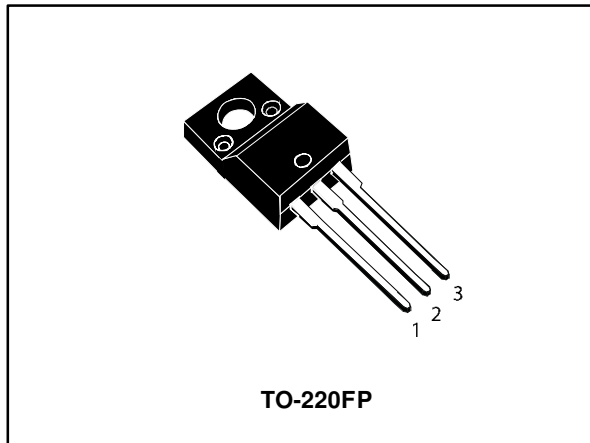
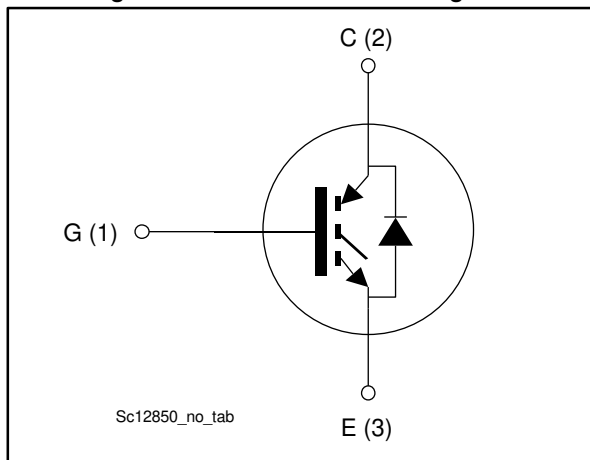


Figure 1: Internal schematic diagram



### 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
STGF6M65DF2	G6M65DF2	TO-220FP	Tube

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# 1 Electrical ratings

**Table 2: Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>CES</sub>	Collector-emitter voltage (V <sub>GE</sub> = 0 V)	650	V
I <sub>C</sub> <sup>(1)</sup>	Continuous collector current at T <sub>C</sub> = 25 °C	12	A
	Continuous collector current at T <sub>C</sub> = 100 °C	6	A
I <sub>CP</sub> <sup>(2)</sup>	Pulsed collector current	24	A
V <sub>GE</sub>	Gate-emitter voltage	±20	V
I <sub>F</sub> <sup>(1)</sup>	Continuous forward current at T <sub>C</sub> = 25 °C	12	A
	Continuous forward current at T <sub>C</sub> = 100 °C	6	A
I <sub>FP</sub> <sup>(2)</sup>	Pulsed forward current	24	A
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)	2.5	kV
P <sub>TOT</sub>	Total dissipation at T <sub>C</sub> = 25 °C	24.2	W
T <sub>STG</sub>	Storage temperature range	- 55 to 150	°C
T <sub>J</sub>	Operating junction temperature range	- 55 to 175	°C

**Notes:**

(1)Limited by maximum junction temperature.

(2)Pulse width limited by maximum junction temperature.

**Table 3: Thermal data**

Symbol	Parameter	Value	Unit
R <sub>thJC</sub>	Thermal resistance junction-case IGBT	6.2	°C/W
R <sub>thJC</sub>	Thermal resistance junction-case diode	7	°C/W
R <sub>thJA</sub>	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</a> : "Gate charge test circuit")	-	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	$V_{CE} = 400\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 25\ \Omega$ , $T_J = 175\text{ }^\circ\text{C}$ (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		-	

**Notes:**

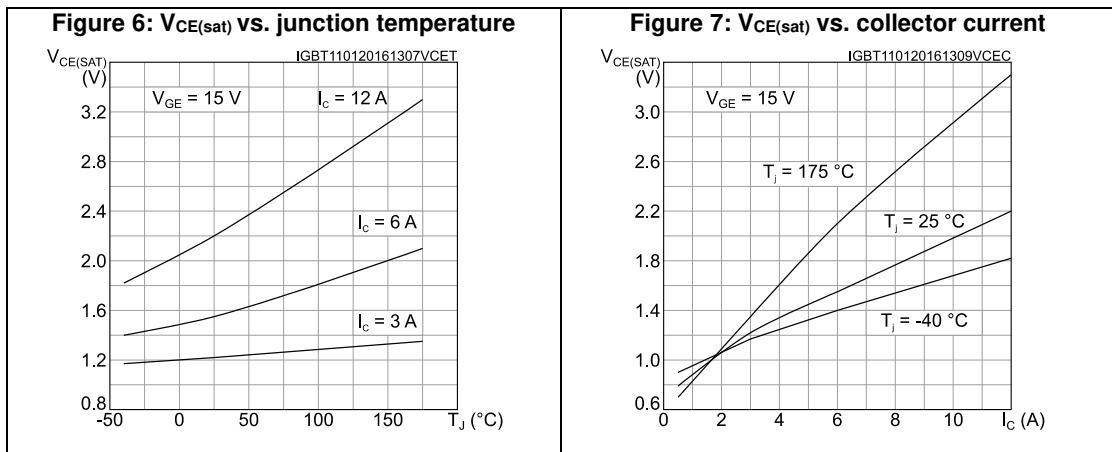
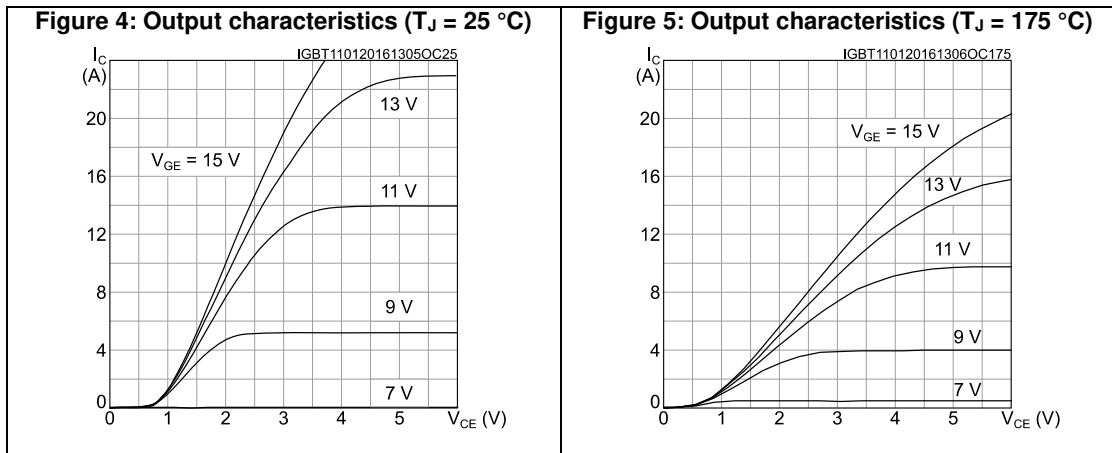
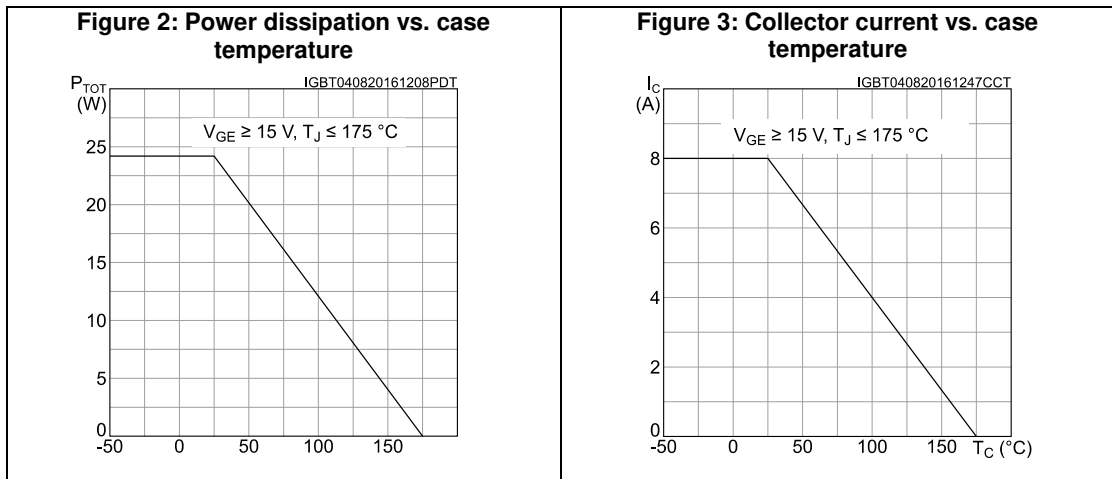
(1) Turn-on switching energy includes reverse recovery of the diode.

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

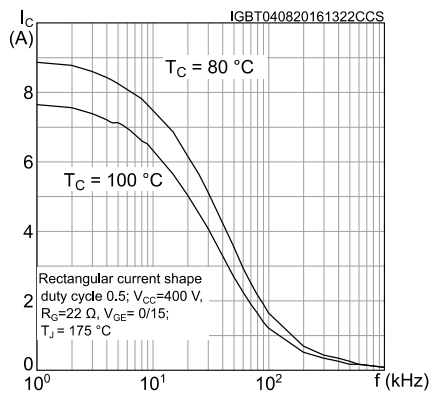
Table 7: Diode switching characteristics (inductive load)

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		$\mu\text{J}$

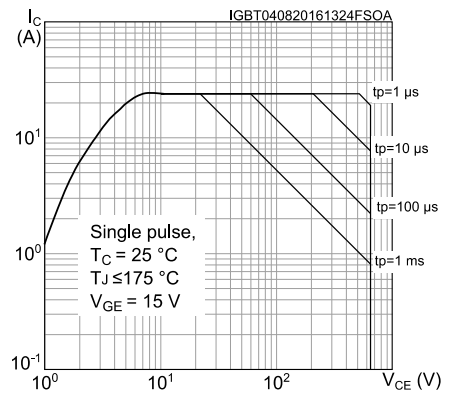
## 2.1 STGF6M65DF2 electrical characteristics curves



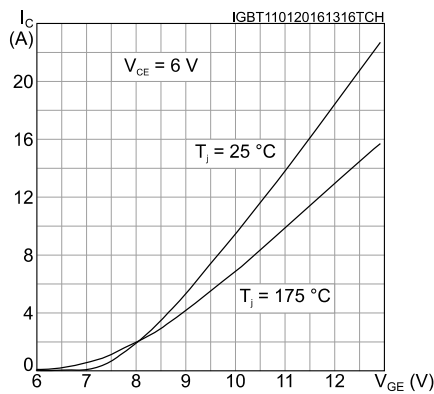
**Figure 8: Collector current vs. switching frequency**



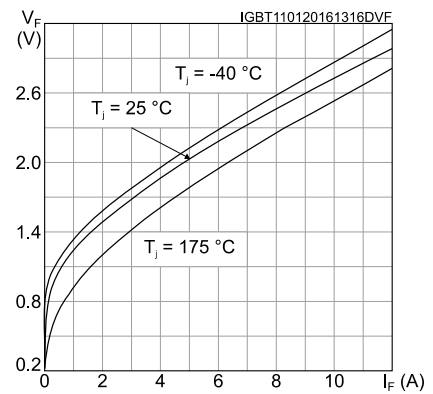
**Figure 9: Forward bias safe operating area**



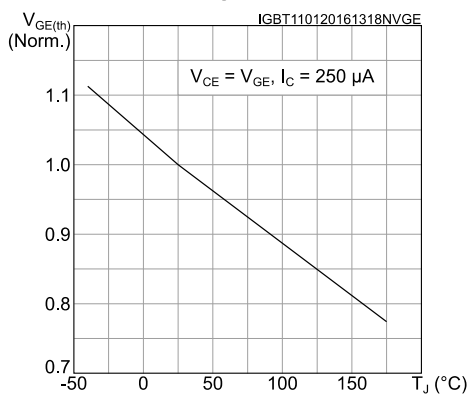
**Figure 10: Transfer characteristics**



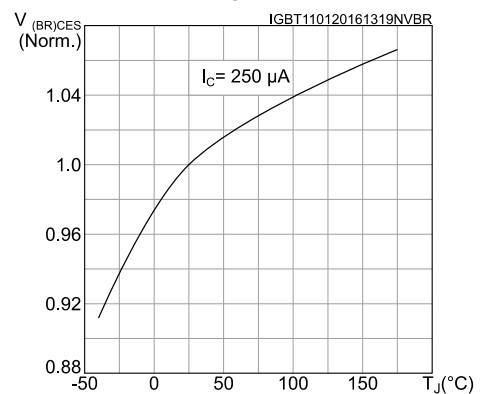
**Figure 11: Diode V\_F vs. forward current**



**Figure 12: Normalized V\_{GE(th)} vs. junction temperature**



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





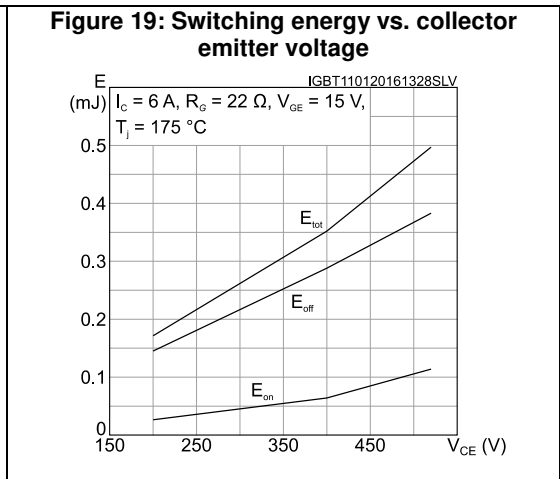
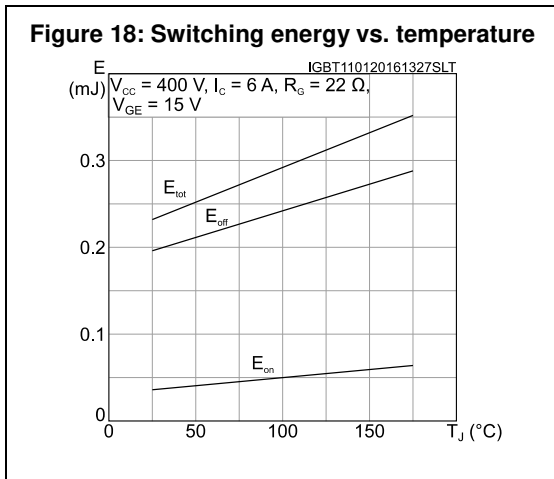
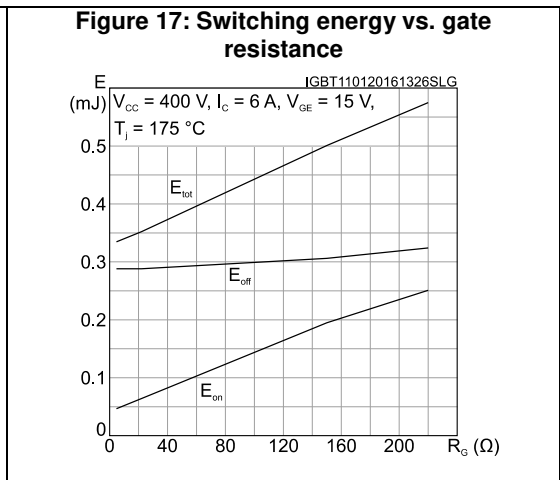
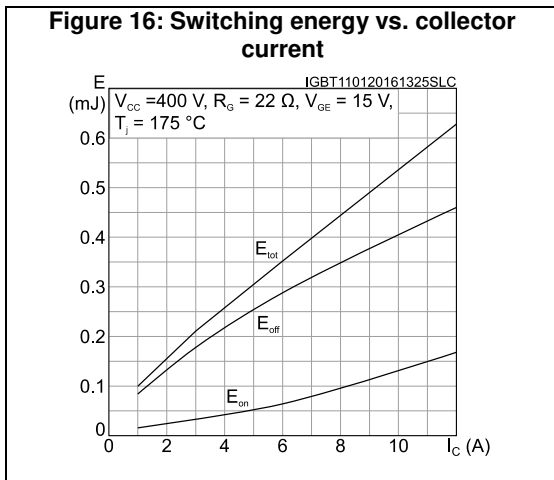
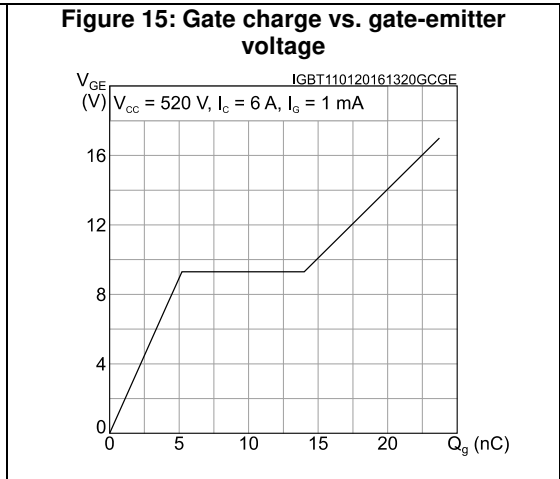
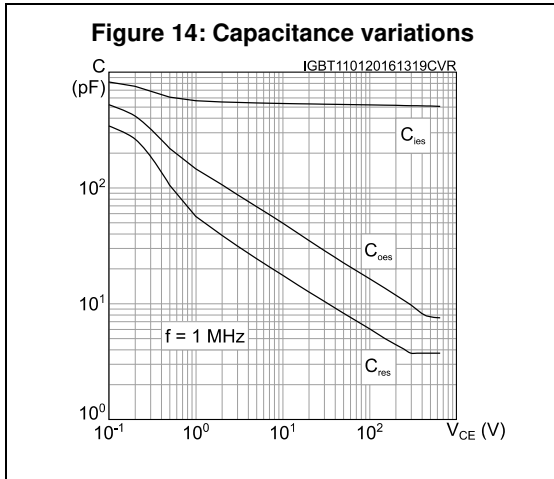


Figure 20: Short-circuit time and current vs.  $V_{GE}$

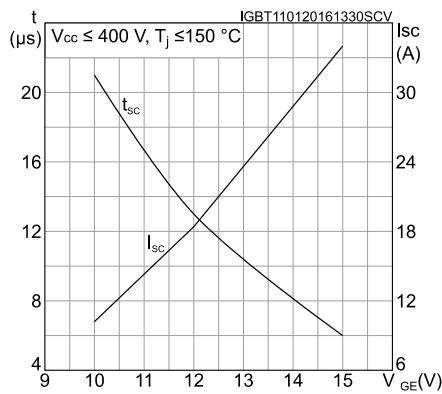


Figure 21: Switching times vs. collector current

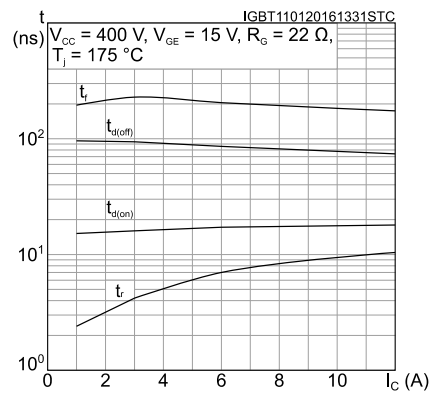


Figure 22: Switching times vs. gate resistance

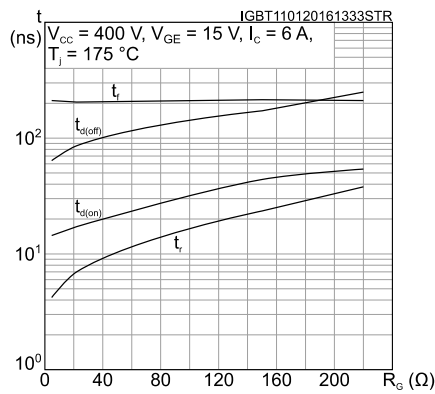


Figure 23: Reverse recovery current vs. diode current slope

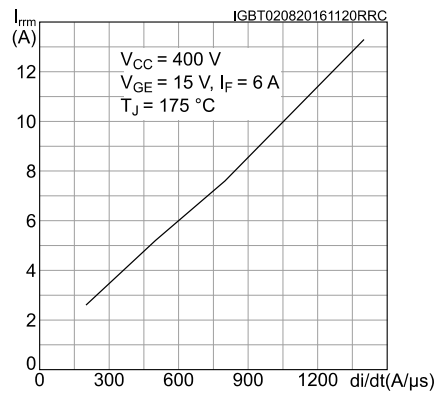


Figure 24: Reverse recovery time vs. diode current slope

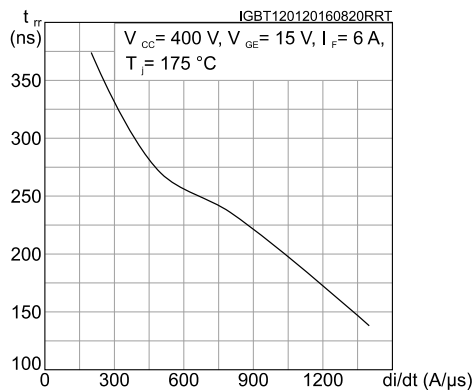


Figure 25: Reverse recovery charge vs. diode current slope

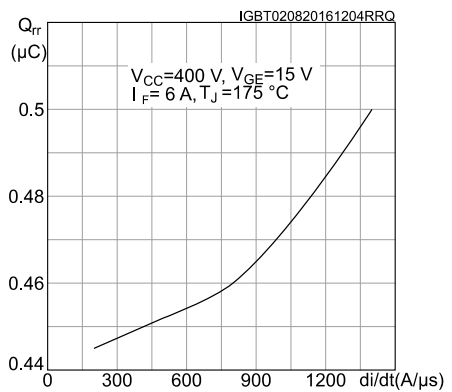


Figure 26: Reverse recovery energy vs. diode current slope

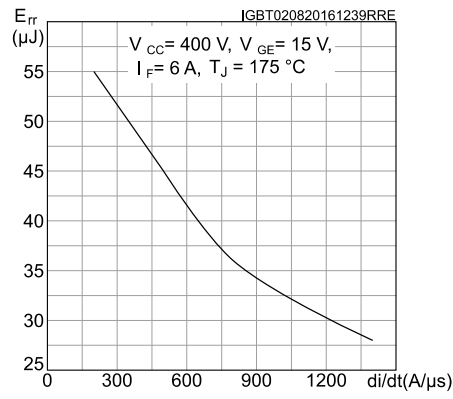


Figure 27: Thermal impedance for IGBT

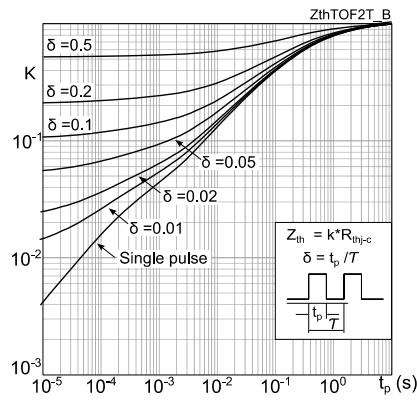
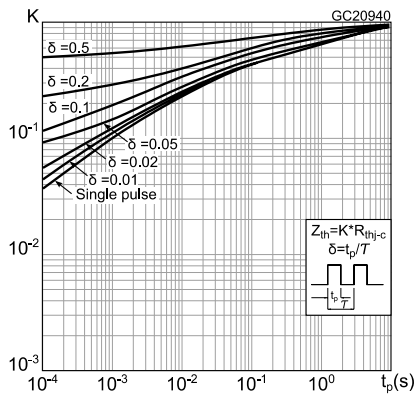
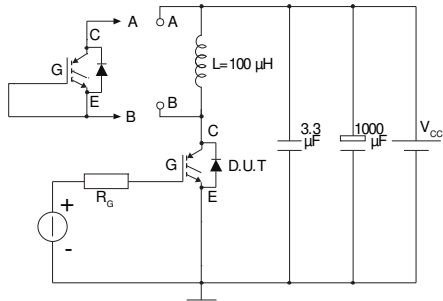


Figure 28: Thermal impedance for diode



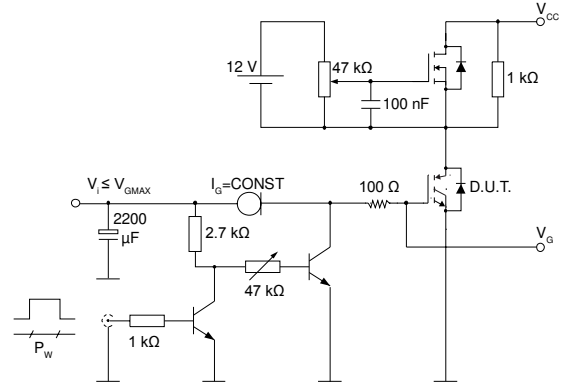
### 3 Test circuits

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



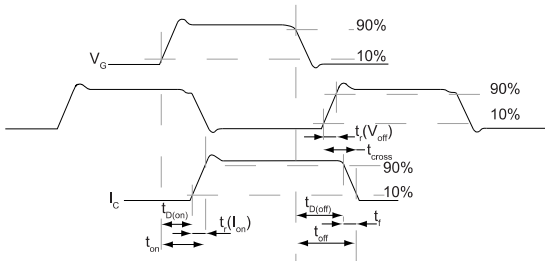
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**Figure 30: Gate charge test circuit**



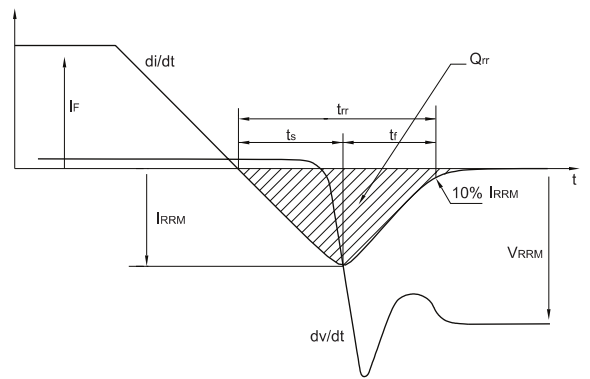
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**Figure 31: Switching waveform**



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.



Table 8: TO-220FP package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

## 5 Revision history

Table 9: Document revision history

Date	Revision	Changes
24-Nov-2015	1	First release.
24-Feb-2016	2	Document status promoted from preliminary to production data.
05-Aug-2016	3	Added <i>Section 2.1: "STGF6M65DF2 electrical characteristics curves"</i> . Updated <i>Section 1: "Electrical ratings"</i> and <i>Section 2: "Electrical characteristics"</i> .



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