

Trench gate field-stop IGBT, M series 650 V, 4 A low loss

Datasheet - production data

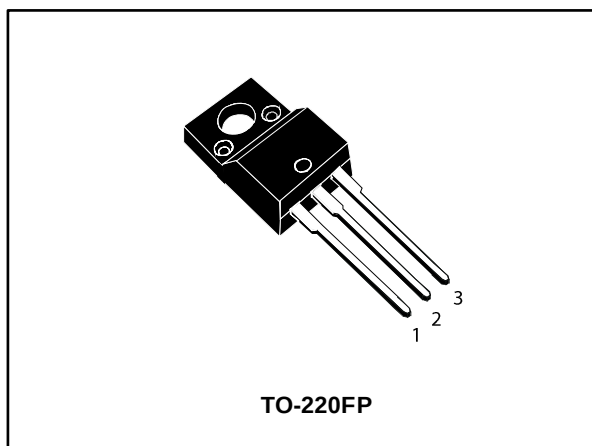
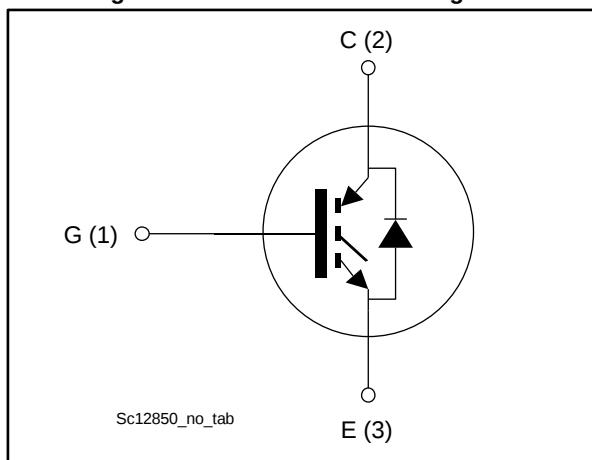


Figure 1: Internal schematic diagram



Features

- 6 μ s of short-circuit withstand time
- $V_{CE(sat)} = 1.6$ V (typ.) @ $I_C = 4$ 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
STGF4M65DF2	G4M65DF2	TO-220FP	Tube

Contents

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1 Electrical ratings

Table 2: Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CES}	Collector-emitter voltage ($V_{GE} = 0$ V)	650	V
$I_C^{(1)}$	Continuous collector current at $T_C = 25$ °C	8	A
	Continuous collector current at $T_C = 100$ °C	4	A
$I_{CP}^{(2)}$	Pulsed collector current	16	A
V_{GE}	Gate-emitter voltage	± 20	V
$I_F^{(1)}$	Continuous forward current at $T_C = 25$ °C	8	A
	Continuous forward current at $T_C = 100$ °C	4	A
$I_{FP}^{(2)}$	Pulsed forward current	16	A
V_{ISO}	Insulation withstand voltage (RMS) from all three leads to external heat sink ($t=1s$, $T_C = 25$ °C)	2.5	kV
P_{TOT}	Total dissipation at $T_C = 25$ °C	23	W
T_{STG}	Storage temperature range	- 55 to 150	°C
T_J	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_{thJC}	Thermal resistance junction-case IGBT	6.5	°C/W
R_{thJC}	Thermal resistance junction-case diode	7	°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	$V_{GE} = 15\text{ V}$, $I_C = 4\text{ A}$		1.6	2.1	V
		$V_{GE} = 15\text{ V}$, $I_C = 4\text{ A}$, $T_J = 125\text{ °C}$		1.9		
		$V_{GE} = 15\text{ V}$, $I_C = 4\text{ A}$, $T_J = 175\text{ °C}$		2.1		
V_F	Forward on-voltage	$I_F = 4\text{ A}$		1.9		V
		$I_F = 4\text{ A}$, $T_J = 125\text{ °C}$		1.7		
		$I_F = 4\text{ A}$, $T_J = 175\text{ °C}$		1.6		
$V_{GE(th)}$	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	μA
I_{GES}	Gate-emitter leakage current	$V_{CE} = 0\text{ V}$, $V_{GE} = \pm 20\text{ V}$			± 250	μA

Table 5: Dynamic characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{ies}	Input capacitance	$V_{CE} = 25\text{ V}$, $f = 1\text{ MHz}$, $V_{GE} = 0\text{ V}$	-	369	-	pF
C_{oes}	Output capacitance		-	24.8	-	
C_{res}	Reverse transfer capacitance		-	8	-	
Q_g	Total gate charge	$V_{CC} = 520\text{ V}$, $I_C = 4\text{ A}$, $V_{GE} = 15\text{ V}$ (see Figure 30: "Gate charge test circuit")	-	15.2	-	nC
Q_{ge}	Gate-emitter charge		-	3	-	
Q_{gc}	Gate-collector charge		-	7	-	

Table 6: IGBT switching characteristics (inductive load)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$, $I_C = 4\text{ A}$, $V_{GE} = 15\text{ V}$, $R_G = 47\ \Omega$ (see Figure 29: "Test circuit for inductive load switching")		12	-	ns
t_r	Current rise time			6.9	-	ns
$(di/dt)_{on}$	Turn-on current slope			480	-	A/ μ s
$t_{d(off)}$	Turn-off-delay time			86	-	ns
t_f	Current fall time			120	-	ns
$E_{on(1)}$	Turn-on switching energy			0.040	-	mJ
$E_{off(2)}$	Turn-off switching energy			0.136	-	mJ
E_{ts}	Total switching energy			0.176	-	mJ
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$, $I_C = 4\text{ A}$, $V_{GE} = 15\text{ V}$, $R_G = 47\ \Omega$, $T_J = 175\text{ }^\circ\text{C}$ (see Figure 29: "Test circuit for inductive load switching")		11.6	-	ns
t_r	Current rise time			8	-	ns
$(di/dt)_{on}$	Turn-on current slope			410	-	A/ μ s
$t_{d(off)}$	Turn-off-delay time			85	-	ns
t_f	Current fall time			211	-	ns
$E_{on(1)}$	Turn-on switching energy			0.067	-	mJ
$E_{off(2)}$	Turn-off switching energy			0.210	-	mJ
E_{ts}	Total switching energy			0.277	-	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		-	μ s
		$V_{CC} \leq 400\text{ V}$, $V_{GE} = 13\text{ V}$, $T_{Jstart} = 150\text{ }^\circ\text{C}$	10		-	μ s

Notes:

(1)Including the reverse recovery of the diode.

(2)Including 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	$I_F = 4\text{ A}$, $V_R = 400\text{ V}$, $V_{GE} = 15\text{ V}$, $di/dt = 800\text{ A}/\mu\text{s}$ (see Figure 29: "Test circuit for inductive load switching")	-	133	-	ns
Q_{rr}	Reverse recovery charge		-	140	-	nC
I_{rrm}	Reverse recovery current		-	5	-	A
dl_{rr}/dt	Peak rate of fall of reverse recovery current during t_b		-	520	-	A/ μ s
E_{rr}	Reverse recovery energy		-	15	-	μ J
t_{rr}	Reverse recovery time	$I_F = 4\text{ A}$, $V_R = 400\text{ V}$, $V_{GE} = 15\text{ V}$, $T_J = 175\text{ }^\circ\text{C}$, $di/dt = 800\text{ A}/\mu\text{s}$ (see Figure 29: "Test circuit for inductive load switching")	-	236	-	ns
Q_{rr}	Reverse recovery charge		-	370	-	nC
I_{rrm}	Reverse recovery current		-	6.6	-	A
dl_{rr}/dt	Peak rate of fall of reverse recovery current during t_b		-	378	-	A/ μ s
E_{rr}	Reverse recovery energy		-	32	-	μ J

2.1 Electrical characteristics (curves)

Figure 2: Power dissipation vs. case temperature

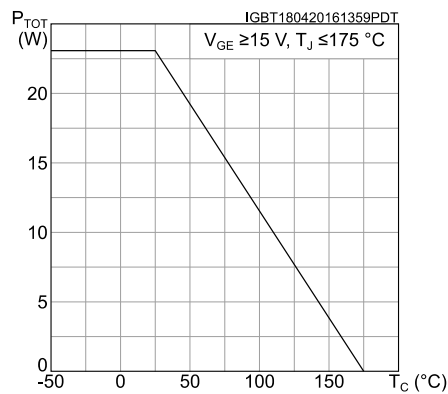


Figure 3: Collector current vs. case temperature

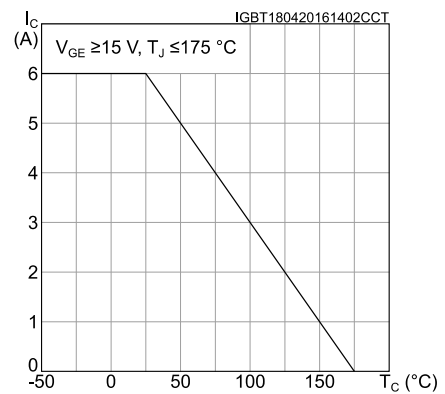


Figure 4: Output characteristics (T_J = 25 °C)

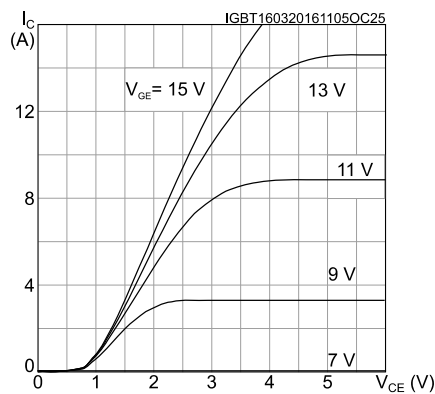


Figure 5: Output characteristics (T_J = 175 °C)

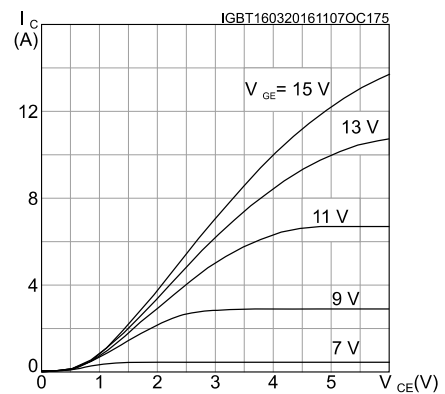


Figure 6: V_CE(sat) vs. junction temperature

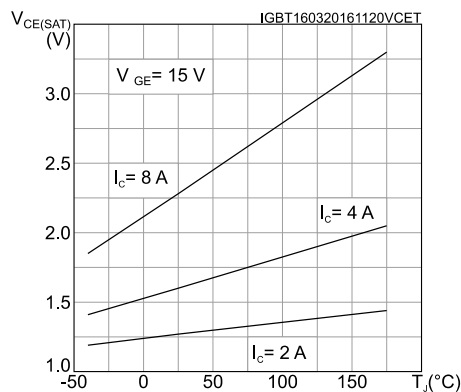


Figure 7: V_CE(sat) vs. collector current

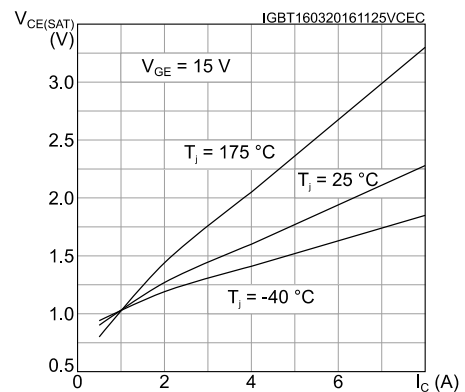


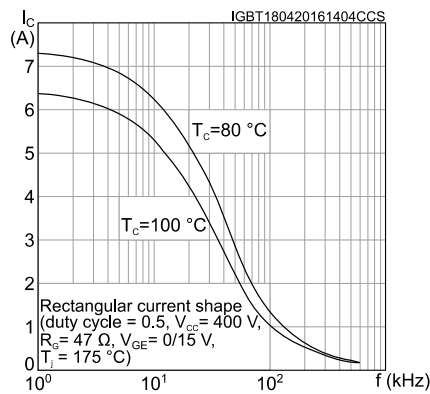
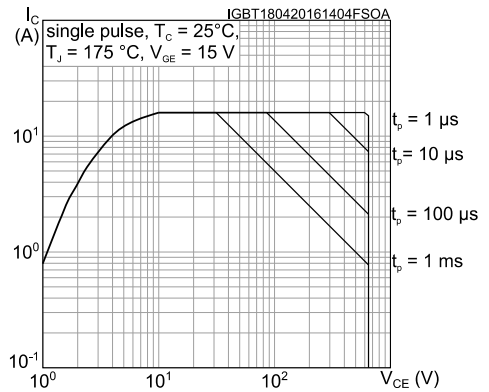
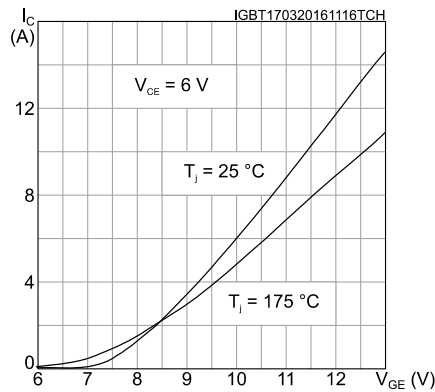
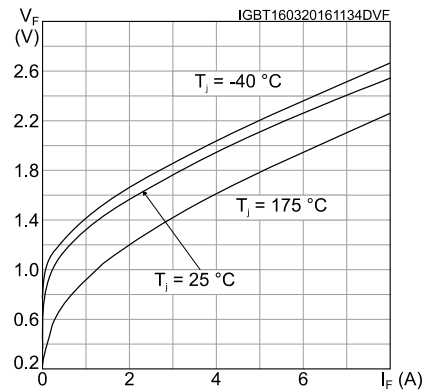
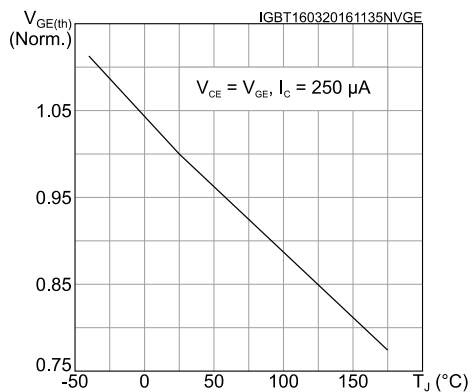
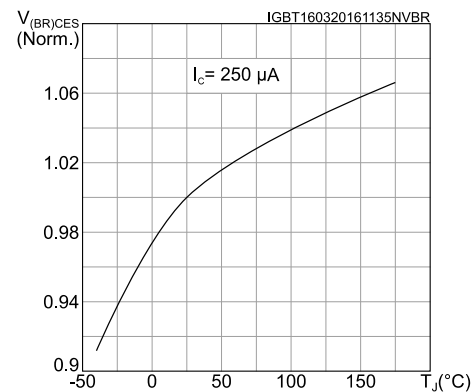
Figure 8: Collector current vs. switching frequency**Figure 9: Forward bias safe operating area****Figure 10: Transfer characteristics****Figure 11: Diode V_F vs. forward current****Figure 12: Normalized $V_{GE(th)}$ vs. junction temperature****Figure 13: Normalized $V_{(BR)CES}$ vs. junction temperature**

Figure 14: Capacitance variations

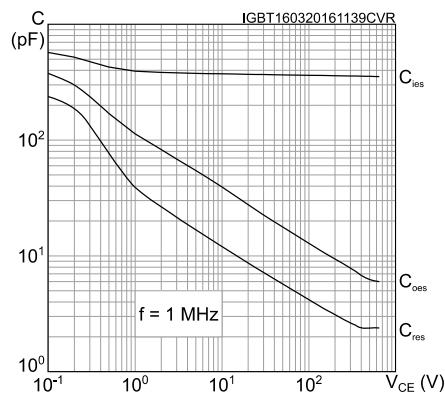


Figure 15: Gate charge vs. gate-emitter voltage

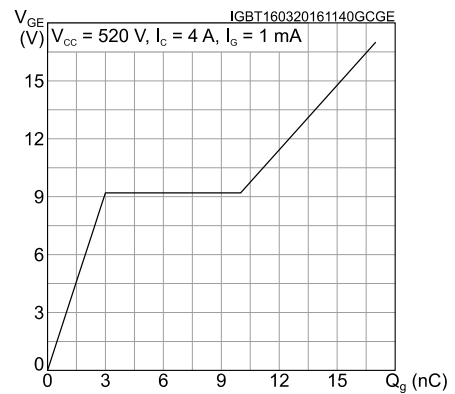


Figure 16: Switching energy vs. collector current

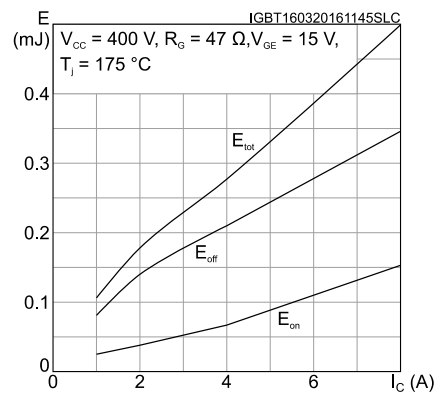


Figure 17: Switching energy vs. gate resistance

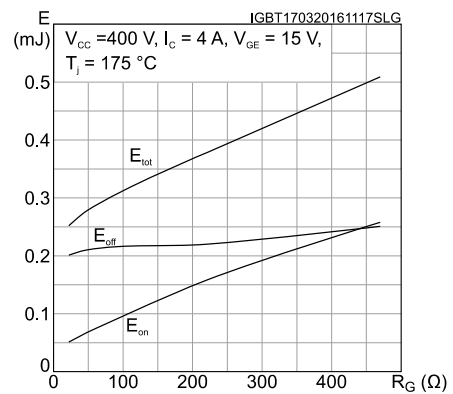


Figure 18: Switching energy vs. temperature

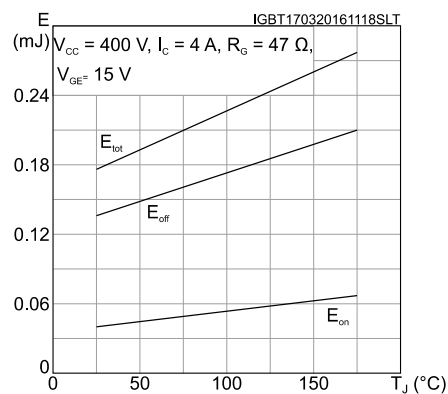


Figure 19: Switching energy vs. collector emitter voltage

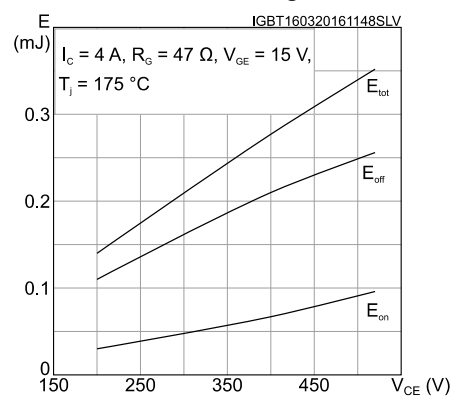


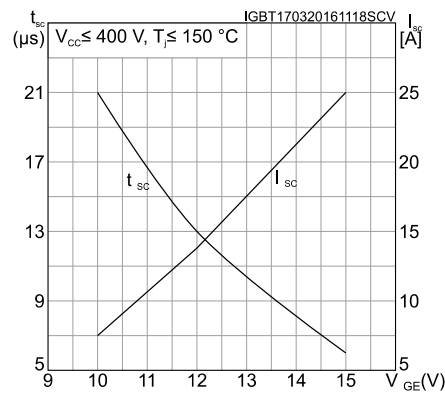
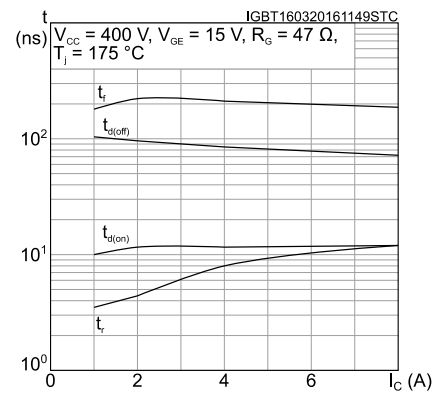
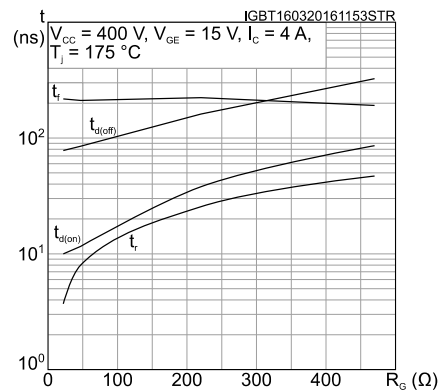
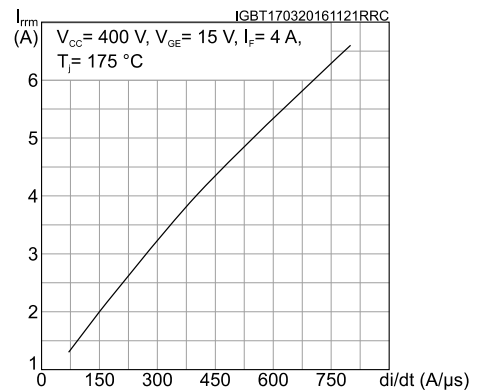
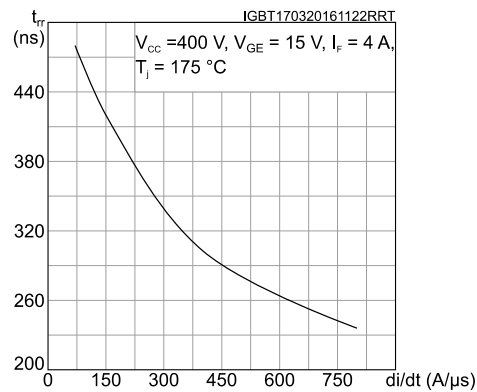
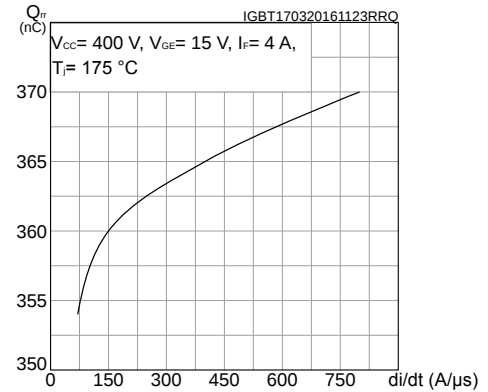
Figure 20: Short-circuit time and current vs. V_{GE} **Figure 21: Switching times vs. collector current****Figure 22: Switching times vs. gate resistance****Figure 23: Reverse recovery current vs. diode current slope****Figure 24: Reverse recovery time vs. diode current slope****Figure 25: Reverse recovery charge vs. diode current slope**

Figure 26: Reverse recovery energy vs. diode current slope

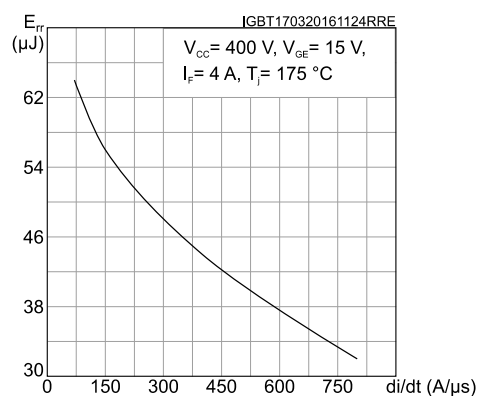


Figure 27: Thermal impedance for IGBT

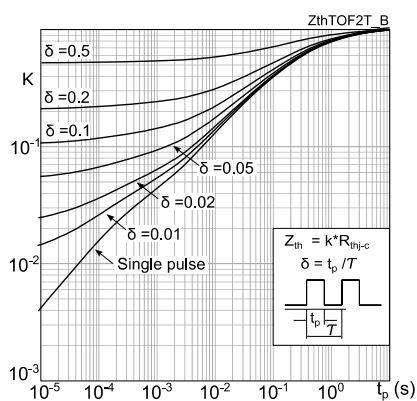
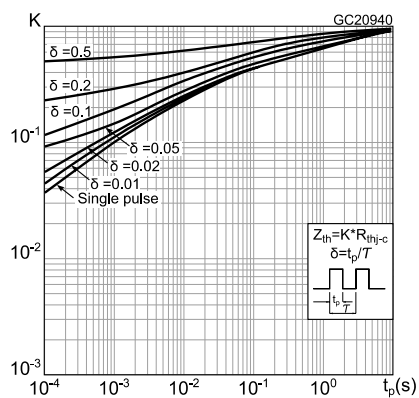
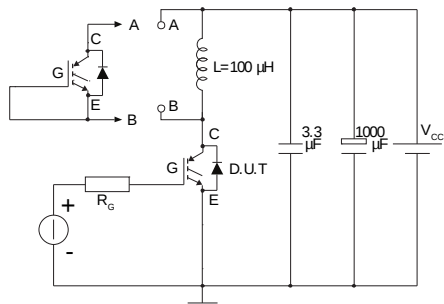


Figure 28: Thermal impedance for diode



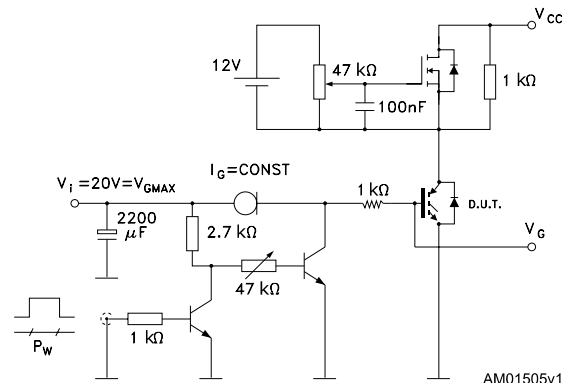
3 Test circuits

Figure 29: Test circuit for inductive load switching



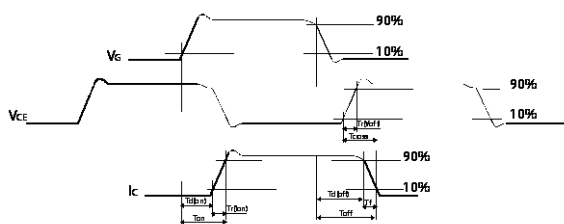
AM01504v1

Figure 30: Gate charge test circuit



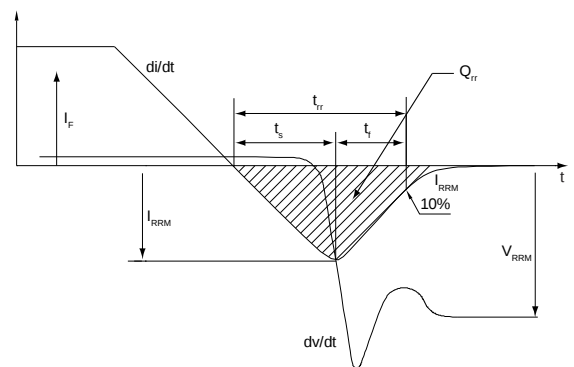
AM01505v1

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**. ECOPACK® is an ST trademark.

4.1 TO-220FP package information

Figure 33: TO-220FP package outline

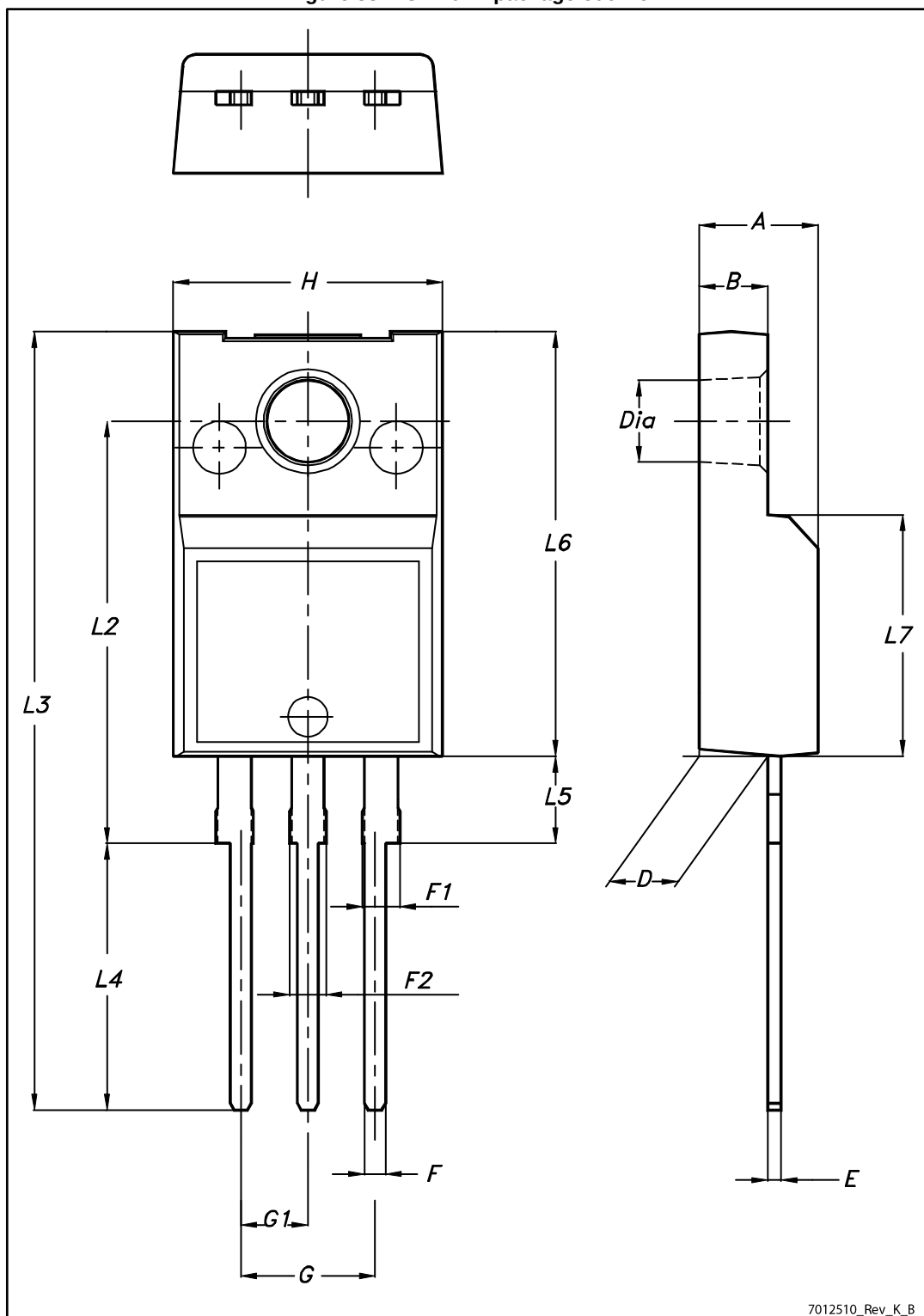


Table 8: TO-220FP package mechanical data

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
25-Nov-2015	1	First release.
18-Apr-2016	2	Modified: features in cover page. Modified: <i>Table 2: "Absolute maximum ratings"</i> , <i>Table 3: "Thermal data"</i> , <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
13-Jul-2016	3	Document status promoted from preliminary to production data.
21-Nov-2016	4	Updated <i>Figure 1: "Internal schematic diagram"</i> Updated <i>Table 2: "Absolute maximum ratings"</i> Updated <i>Figure 25: "Reverse recovery charge vs. diode current slope"</i> Minor text changes

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