

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

Datasheet - production data

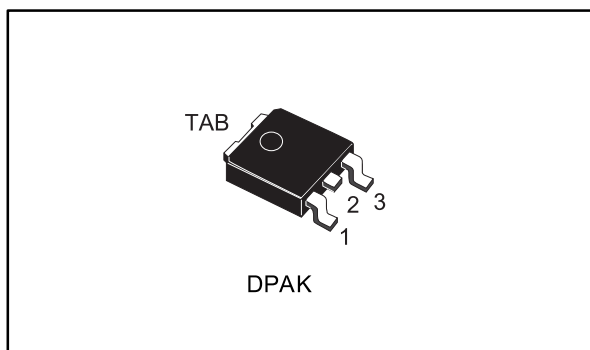
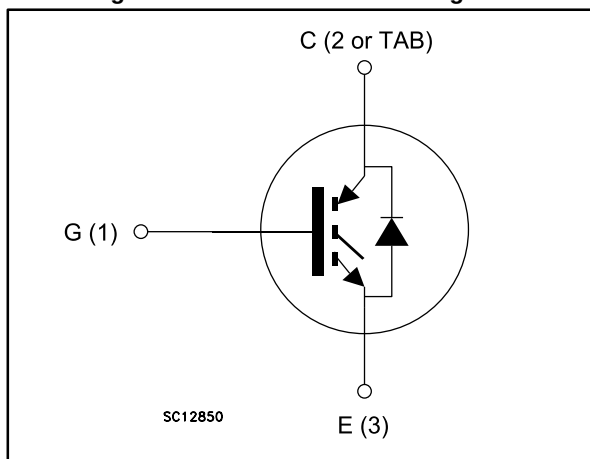


Figure 1: Internal schematic diagram



Features

- 6 μ 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
STGD6M65DF2	G6M65DF2	DPAK	Tape and reel

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	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	± 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:

⁽¹⁾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	100	°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	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	$V_{CE} = 25\text{ V}$, $f = 1\text{ MHz}$, $V_{GE} = 0\text{ V}$	-	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 Figure 30: "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 Figure 29: "Test circuit for inductive load switching")		15	-	ns
t_r	Current rise time			5.8	-	ns
$(di/dt)_{on}$	Turn-on current slope			828	-	A/ μ 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 Figure 29: "Test circuit for inductive load switching")		17	-	ns
t_r	Current rise time			7	-	ns
$(di/dt)_{on}$	Turn-on current slope			685	-	A/ μ 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		-	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) 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 Figure 29: "Test circuit for inductive load switching") $di/dt = 1000\text{ A}/\mu\text{s}$	-	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/ μs
E_{rr}	Reverse recovery energy		-	16	-	μJ
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 Figure 29: "Test circuit for inductive load switching") $di/dt = 1000\text{ A}/\mu\text{s}$	-	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/ μs
E_{rr}	Reverse recovery energy		-	32	-	μJ

2.1 Electrical characteristics (curves)

Figure 2: Power dissipation vs. case temperature

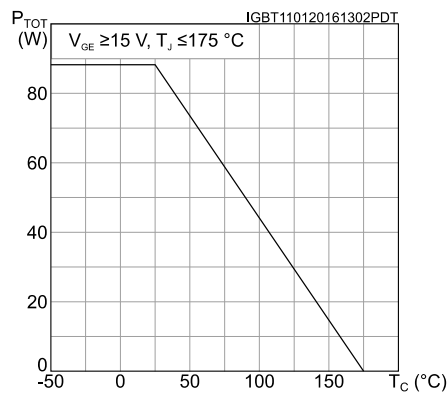


Figure 3: Collector current vs. case temperature

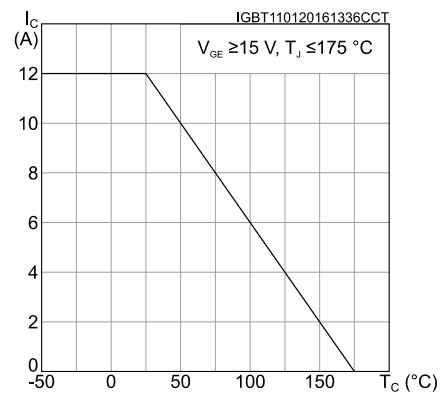


Figure 4: Output characteristics (T_J = 25 °C)

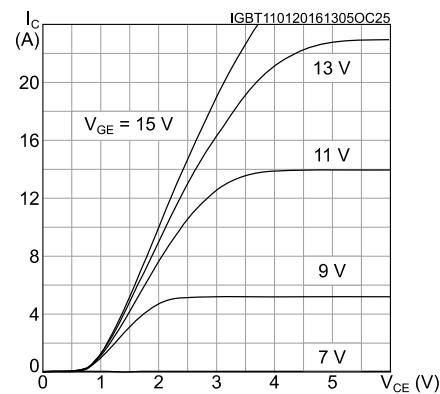


Figure 5: Output characteristics (T_J = 175 °C)

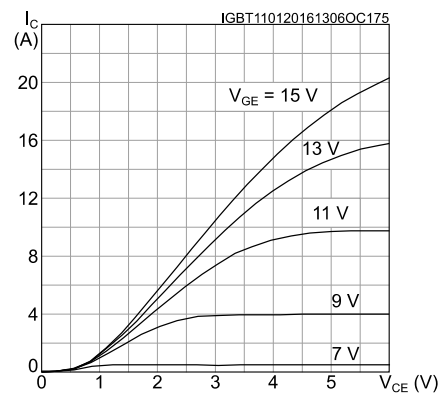


Figure 6: V_{CE(sat)} vs. junction temperature

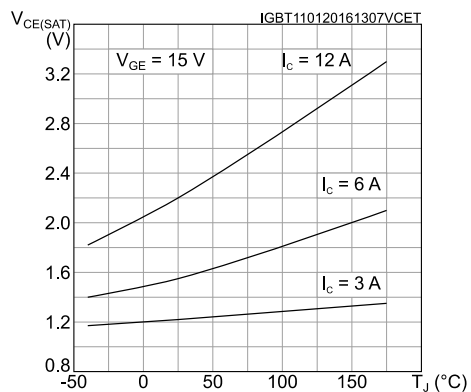


Figure 7: V_{CE(sat)} vs. collector current

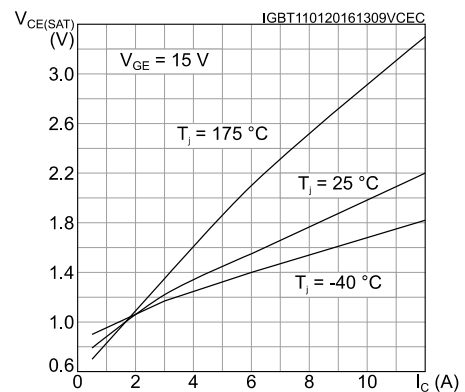


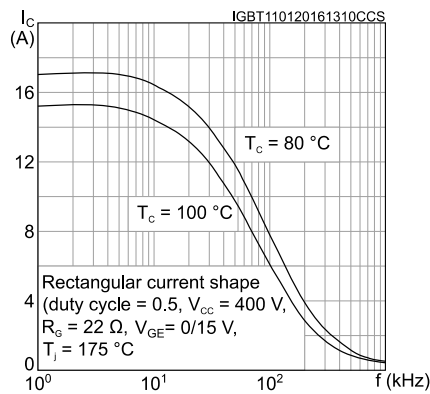
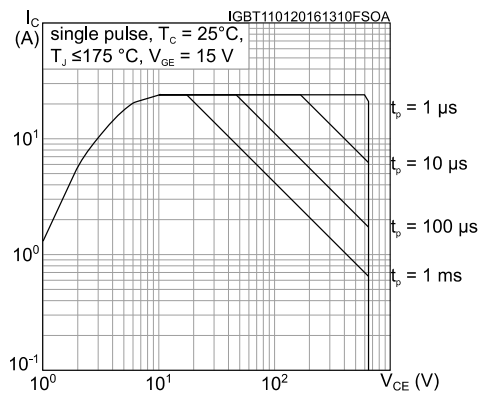
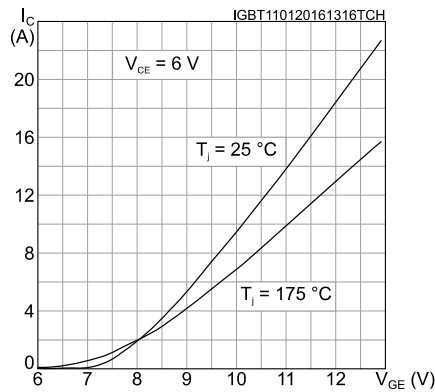
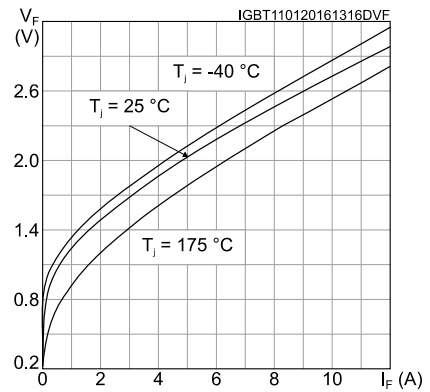
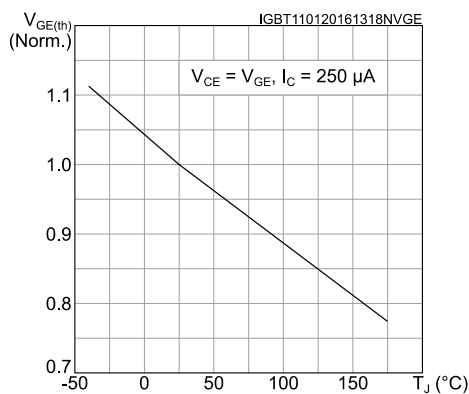
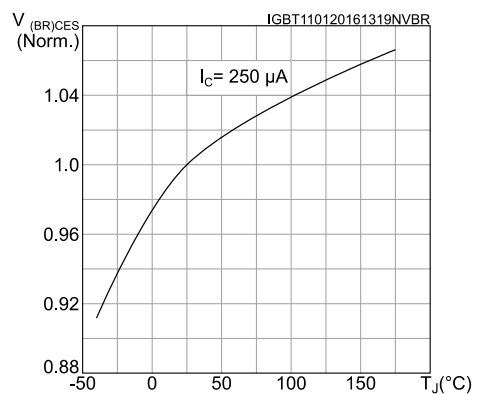
Figure 8: Collector current vs. switching frequency**Figure 9: Forward bias safe operating area****Figure 10: Transfer characteristics****Figure 11: Diode V_F vs. forward current****Figure 12: Normalized V_{GE(th)} vs. junction temperature****Figure 13: Normalized V_{(BR)CES} vs. junction temperature**

Figure 14: Capacitance variations

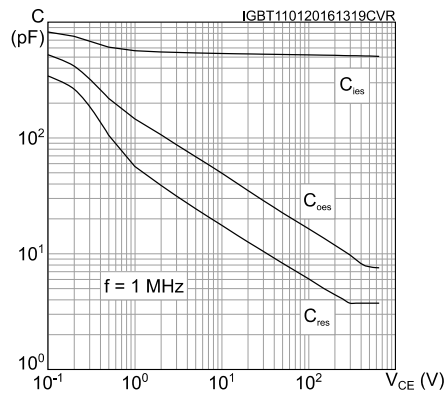


Figure 15: Gate charge vs. gate-emitter voltage

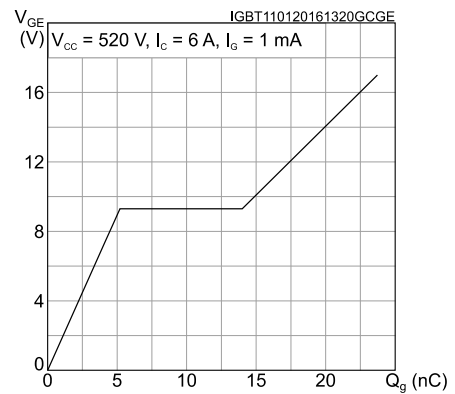


Figure 16: Switching energy vs. collector current

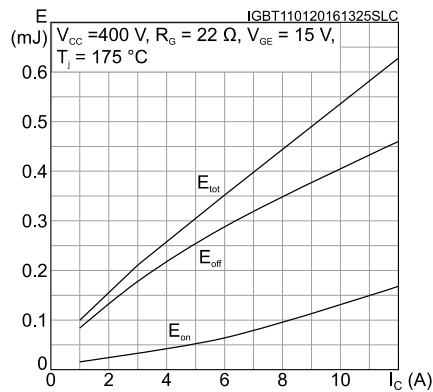


Figure 17: Switching energy vs. gate resistance

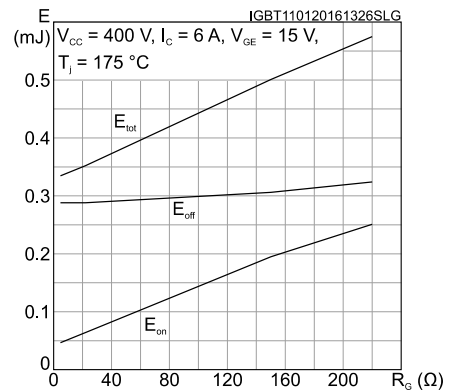


Figure 18: Switching energy vs. temperature

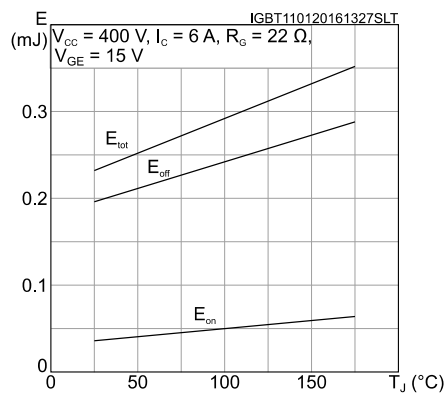


Figure 19: Switching energy vs. collector emitter voltage

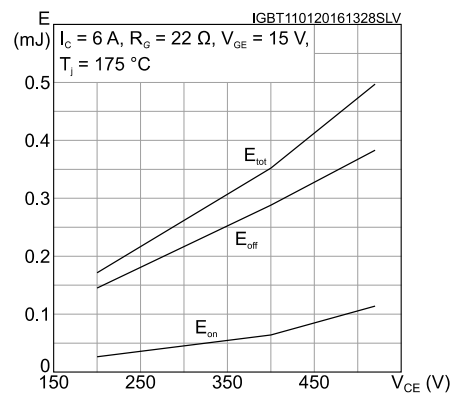


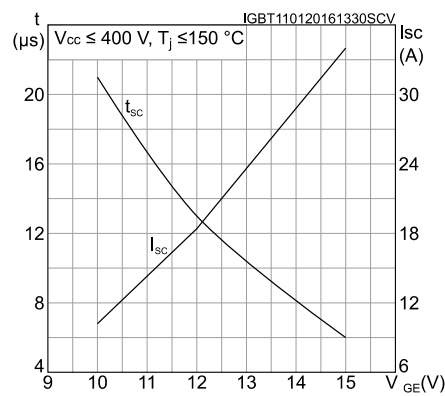
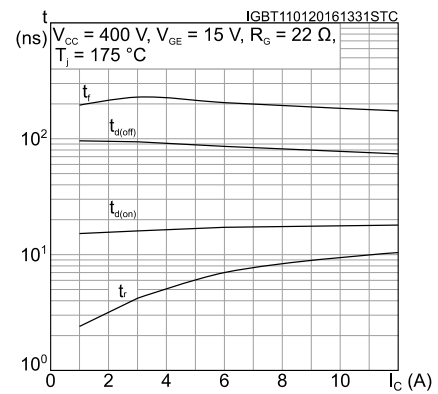
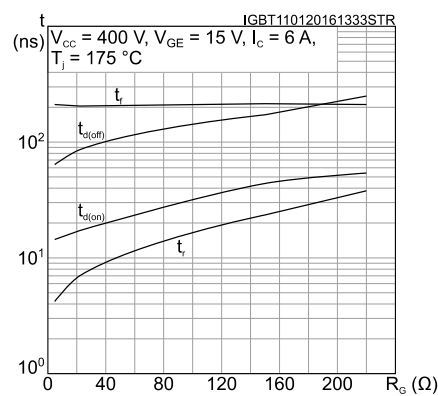
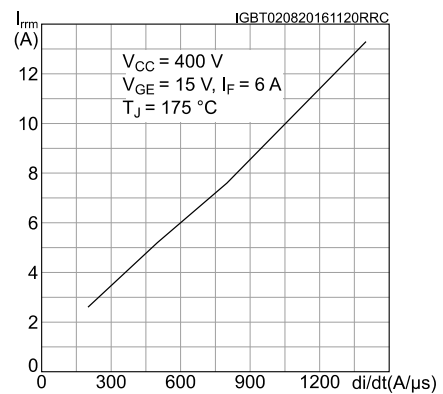
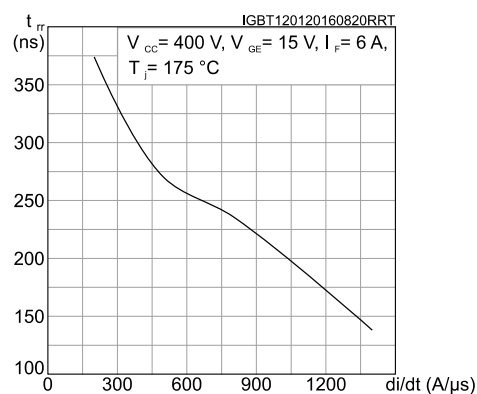
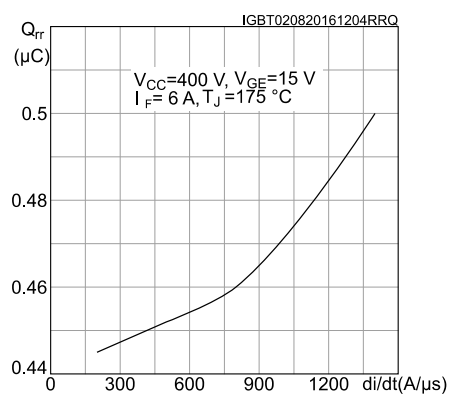
Figure 20: Short-circuit time and current vs. V_{GE} **Figure 21: Switching times vs. collector current****Figure 22: Switching times vs. gate resistance****Figure 23: Reverse recovery current vs. diode current slope****Figure 24: Reverse recovery time vs. diode current slope****Figure 25: Reverse recovery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

Figure 26: Reverse recovery energy vs. diode current slope

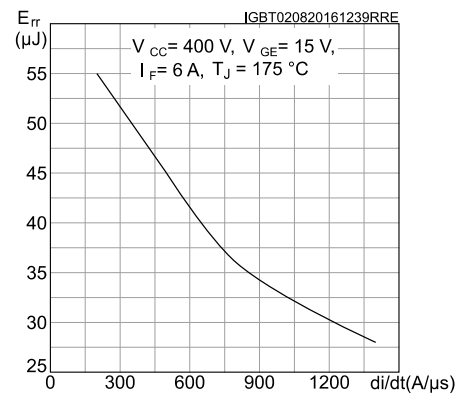


Figure 27: Thermal impedance for IGBT

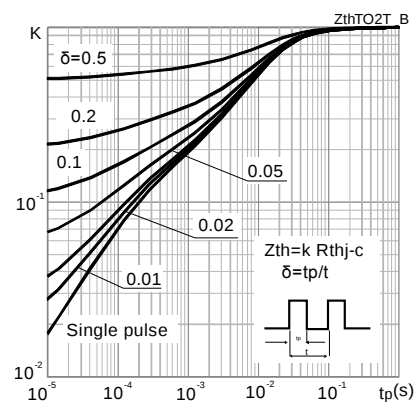
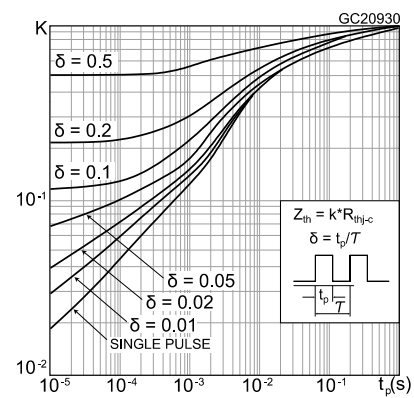


Figure 28: Thermal impedance for diode



3 Test circuits

Figure 29: Test circuit for inductive load switching

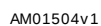


Figure 30: Gate charge test circuit



Figure 31: Switching waveform



Figure 32: Diode reverse recovery waveform



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 DPAK (TO-252) type A2 package information

Figure 33: DPAK (TO-252) type A2 package outline

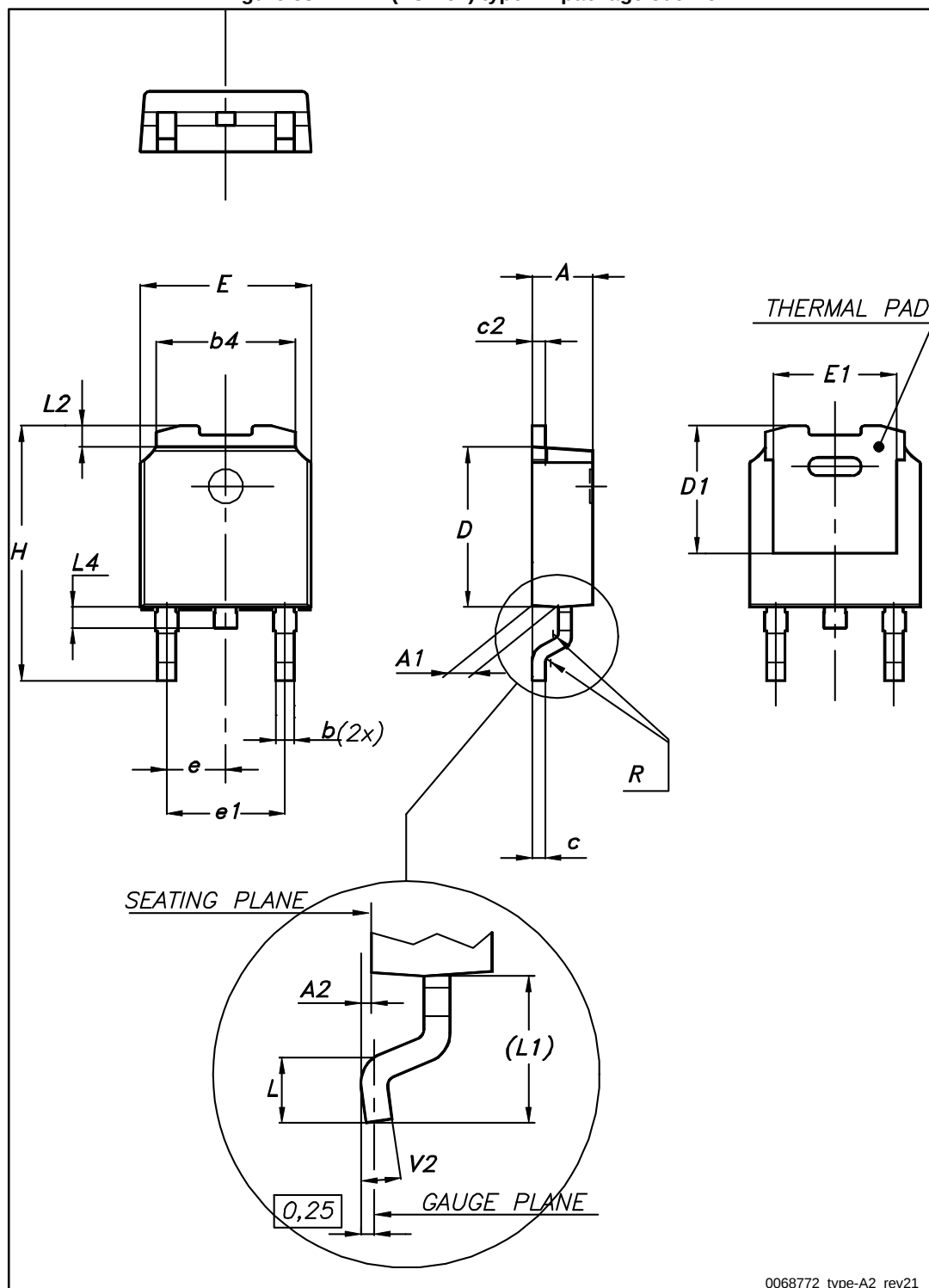
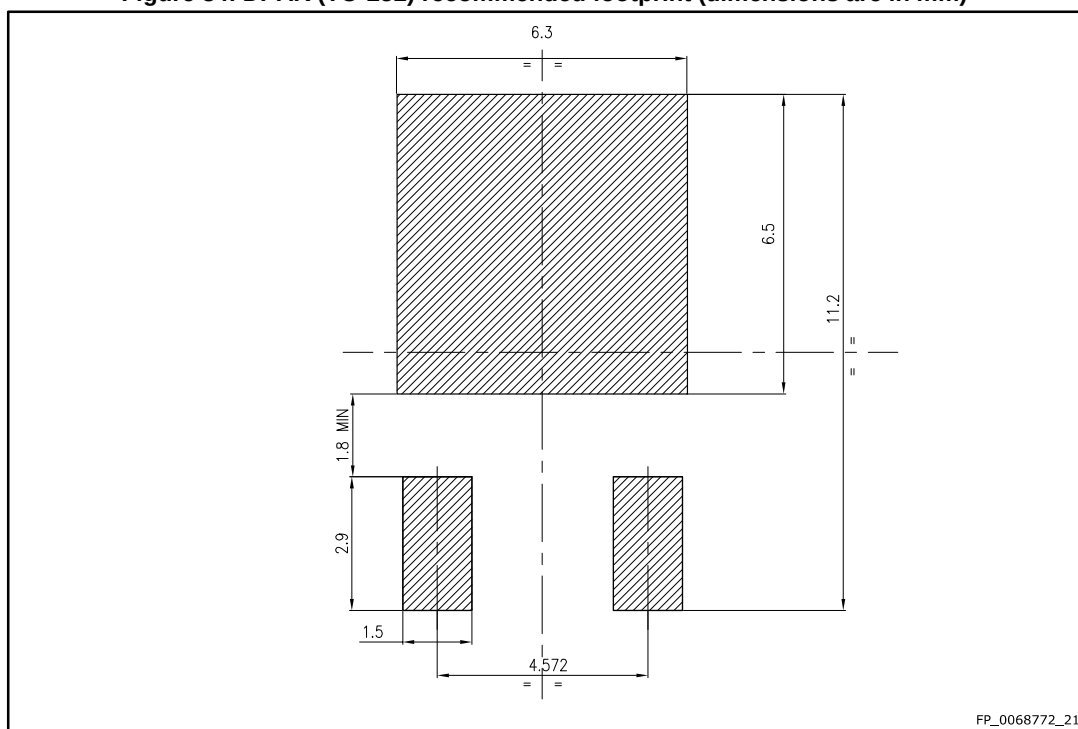


Table 8: DPAK (TO-252) type A2 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.64		0.90
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1	4.95	5.10	5.25
E	6.40		6.60
E1	5.10	5.20	5.30
e	2.16	2.28	2.40
e1	4.40		4.60
H	9.35		10.10
L	1.00		1.50
L1	2.60	2.80	3.00
L2	0.65	0.80	0.95
L4	0.60		1.00
R		0.20	
V2	0°		8°

Figure 34: DPAK (TO-252) recommended footprint (dimensions are in mm)



4.2 DPAK (TO-252) packing information

Figure 35: DPAK (TO-252) tape outline

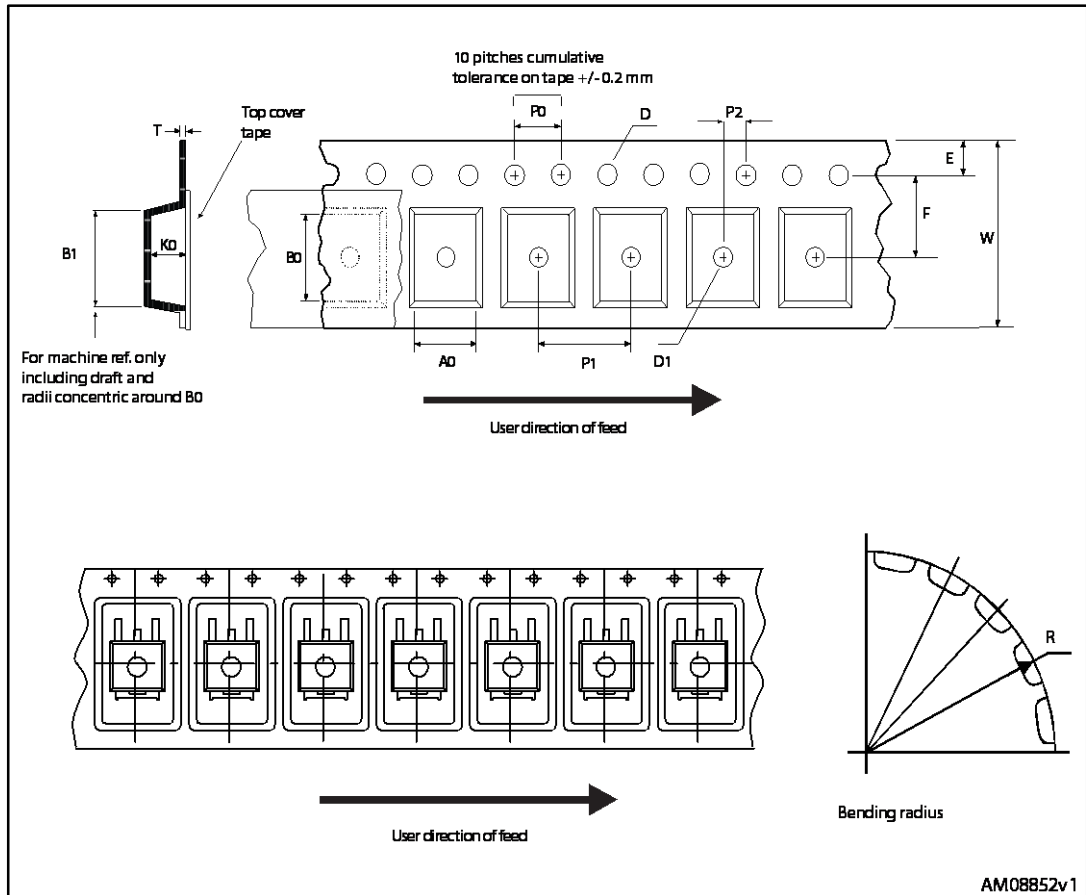


Figure 36: DPAK (TO-252) reel outline

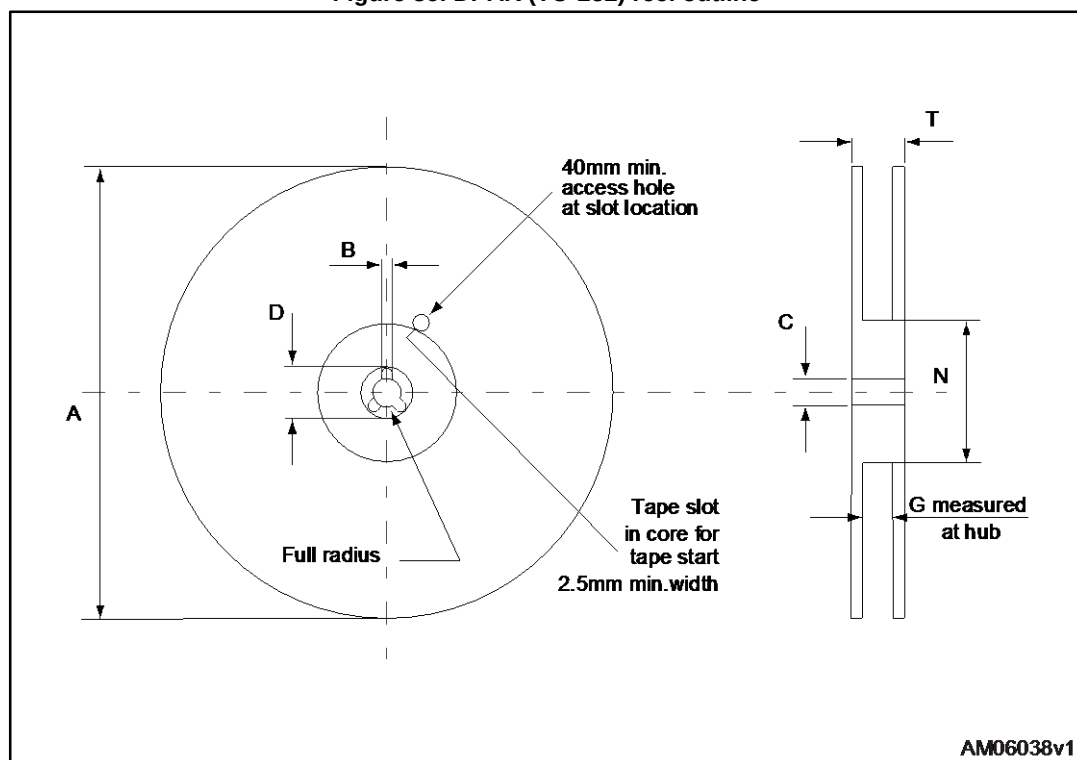


Table 9: DPAK (TO-252) tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	6.8	7	A		330
B0	10.4	10.6	B	1.5	
B1		12.1	C	12.8	13.2
D	1.5	1.6	D	20.2	
D1	1.5		G	16.4	18.4
E	1.65	1.85	N	50	
F	7.4	7.6	T		22.4
K0	2.55	2.75			
P0	3.9	4.1	Base qty.		2500
P1	7.9	8.1	Bulk qty.		2500
P2	1.9	2.1			
R	40				
T	0.25	0.35			
W	15.7	16.3			

5 Revision history

Table 10: Document revision history

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

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