

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

Datasheet - production data

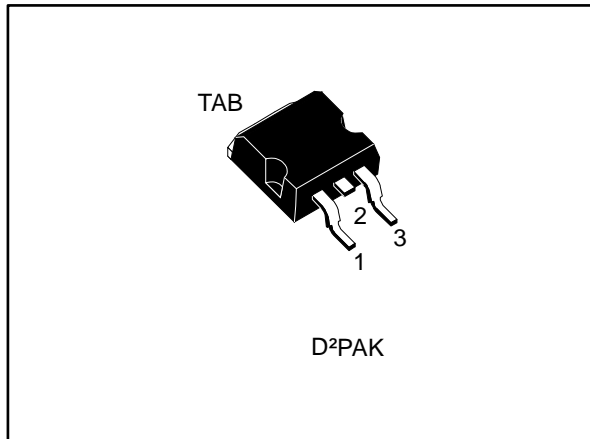
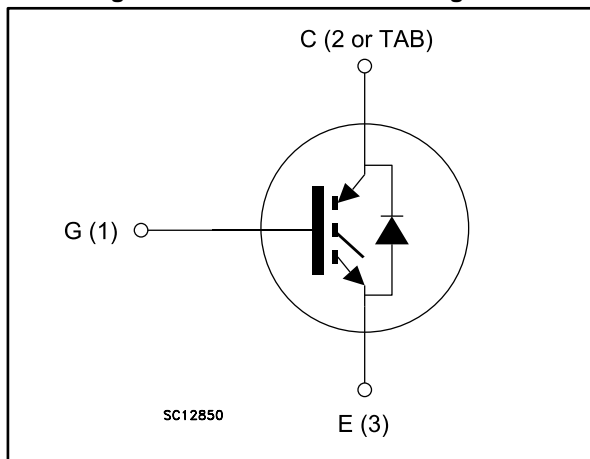


Figure 1: Internal schematic diagram



### Features

- 6  $\mu$ 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
STGB4M65DF2	G4M65DF2	D <sup>2</sup> PAK	Tape and reel

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## Contents

<b>1</b>	<b>Electrical ratings .....</b>	<b>3</b>
<b>2</b>	<b>Electrical characteristics .....</b>	<b>4</b>
	2.1 Electrical characteristics (curves).....	6
<b>3</b>	<b>Test circuits .....</b>	<b>11</b>
<b>4</b>	<b>Package information .....</b>	<b>12</b>
	4.1 D <sup>2</sup> PAK (TO-263) type A package information .....	12
	4.2 Packing information.....	15
<b>5</b>	<b>Revision history .....</b>	<b>17</b>

# 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	8	A
	Continuous collector current at $T_C = 100$ °C	4	A
$I_{CP}^{(1)}$	Pulsed collector current	16	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$I_F$	Continuous forward current at $T_C = 25$ °C	8	A
	Continuous forward current at $T_C = 100$ °C	4	A
$I_{FP}^{(1)}$	Pulsed forward current	16	A
$P_{TOT}$	Total dissipation at $T_C = 25$ °C	68	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	2.2	°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	$V_{GE} = 15\text{ V}$ , $I_C = 4\text{ A}$		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	$\mu\text{A}$
$I_{GES}$	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	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$	-	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 <a href="#">Figure 30: "Gate charge test circuit"</a> )	-	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 <a href="#">Figure 29: "Test circuit for inductive load switching"</a> )		12	-	ns
$t_r$	Current rise time			6.9	-	ns
$(di/dt)_{on}$	Turn-on current slope			480	-	A/ $\mu$ 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 <a href="#">Figure 29: "Test circuit for inductive load switching"</a> )		11.6	-	ns
$t_r$	Current rise time			8	-	ns
$(di/dt)_{on}$	Turn-on current slope			410	-	A/ $\mu$ 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		-	$\mu$ s
		$V_{CC} \leq 400\text{ V}$ , $V_{GE} = 13\text{ V}$ , $T_{Jstart} = 150\text{ }^\circ\text{C}$	10		-	$\mu$ s

**Notes:**

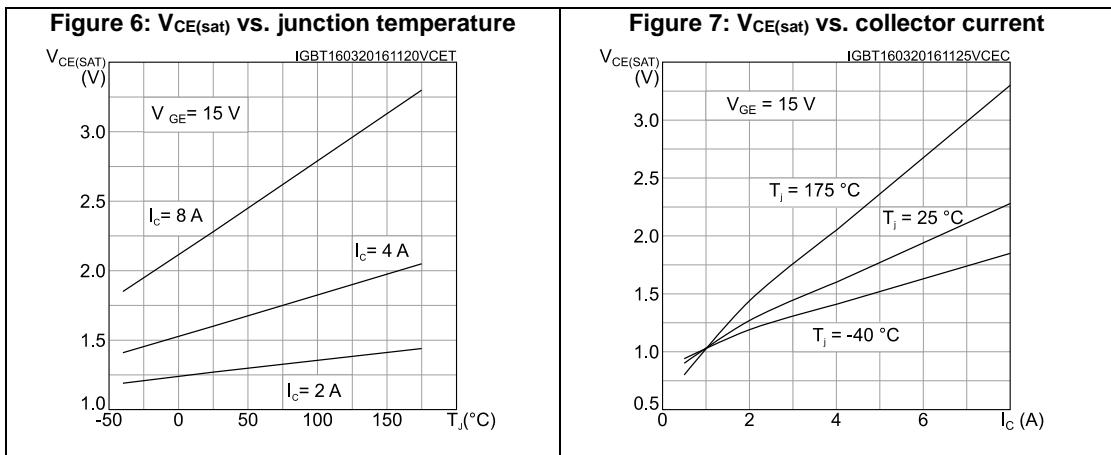
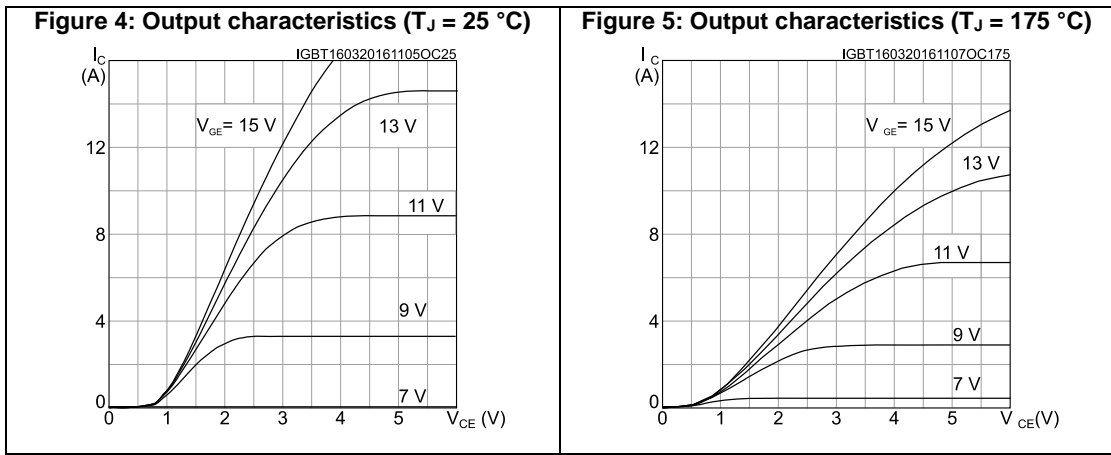
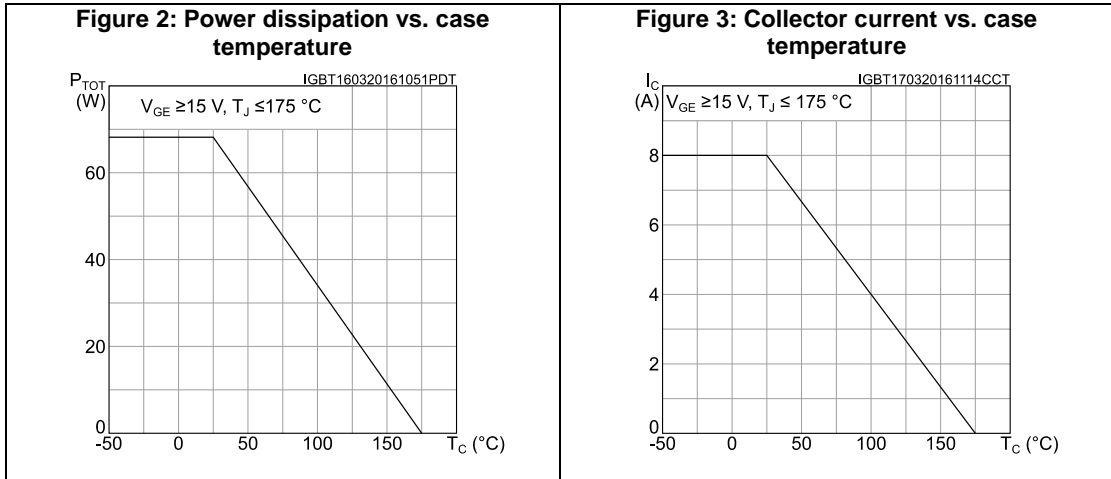
(1)Including the reverse recovery of the diode.

(2)Including the tail of the collector current.

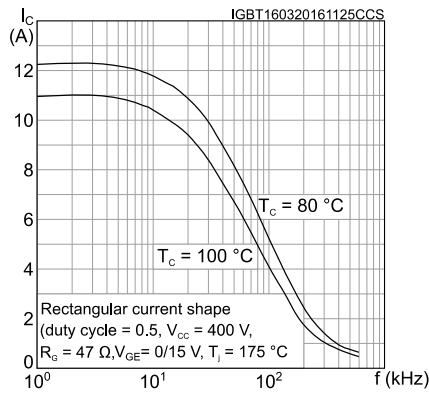
Table 7: Diode switching characteristics (inductive load)

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 <a href="#">Figure 29: "Test circuit for inductive load switching"</a> )	-	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/ $\mu$ s
$E_{rr}$	Reverse recovery energy		-	15	-	$\mu$ 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 <a href="#">Figure 29: "Test circuit for inductive load switching"</a> )	-	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/ $\mu$ s
$E_{rr}$	Reverse recovery energy		-	32	-	$\mu$ J

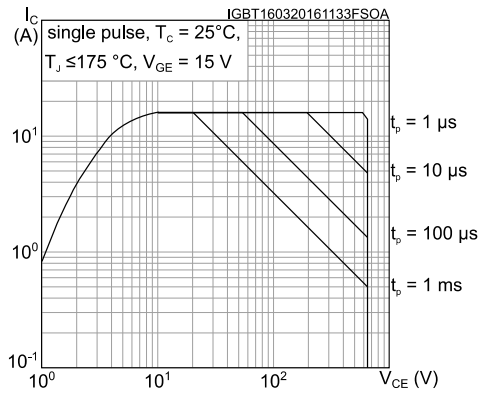
## 2.1 Electrical characteristics (curves)



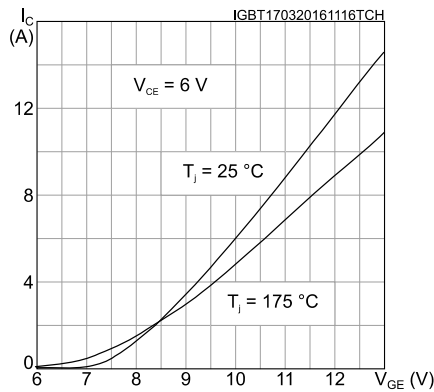
**Figure 8: Collector current vs. switching frequency**



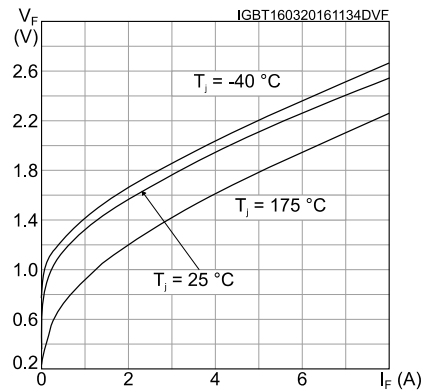
**Figure 9: Forward bias safe operating area**



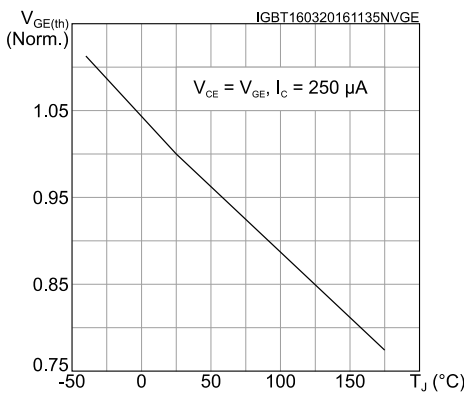
**Figure 10: Transfer characteristics**



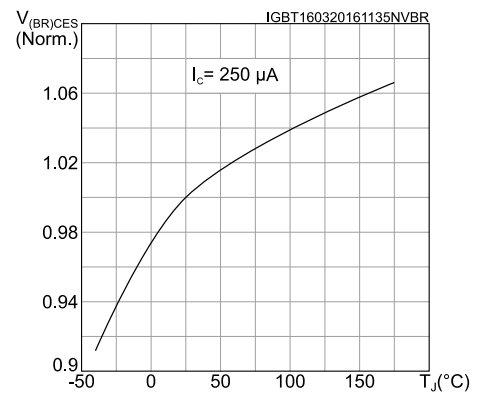
**Figure 11: Diode VF vs. forward current**



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



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



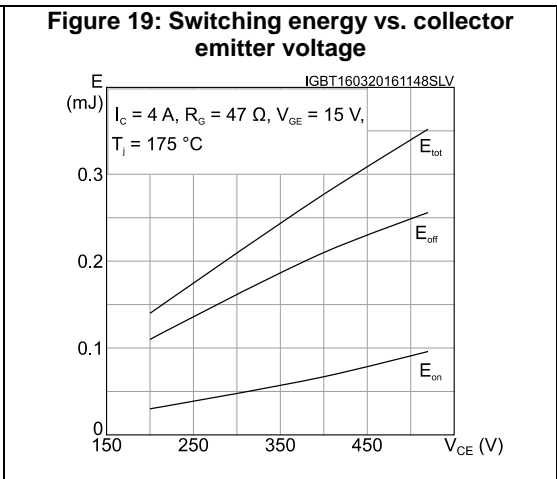
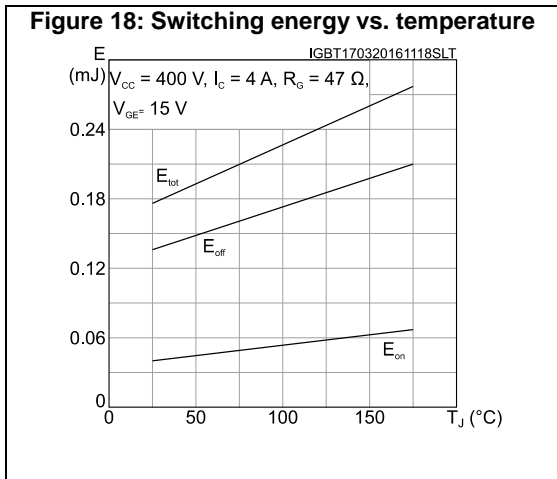
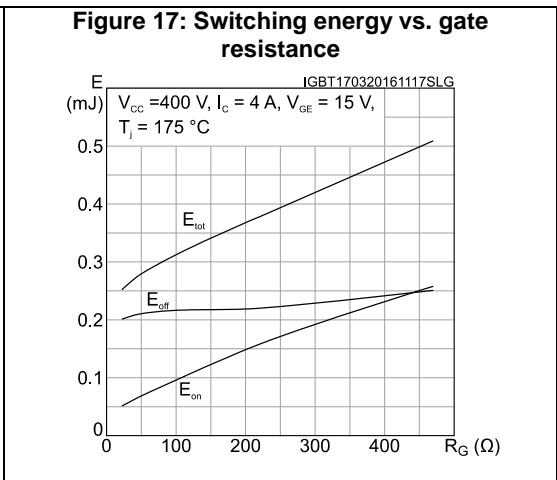
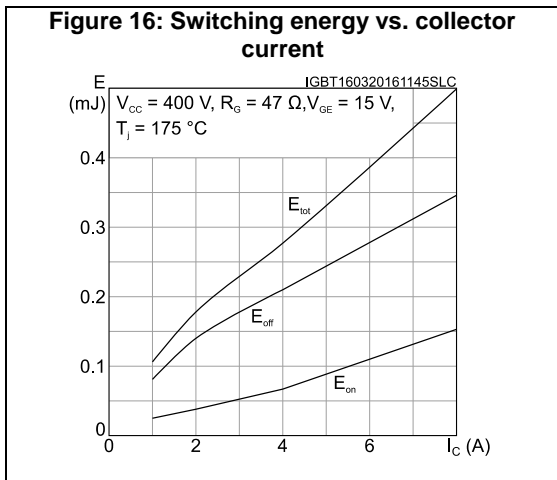
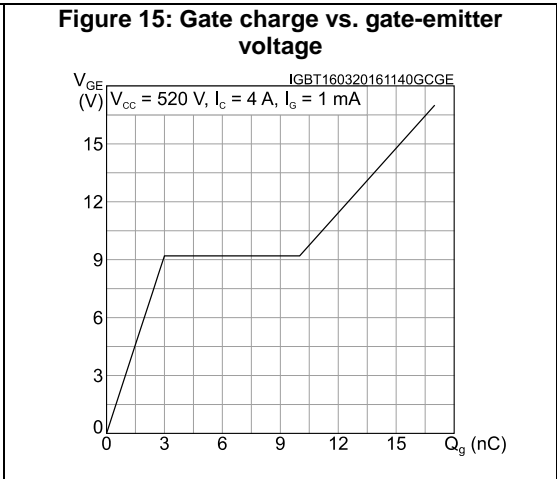
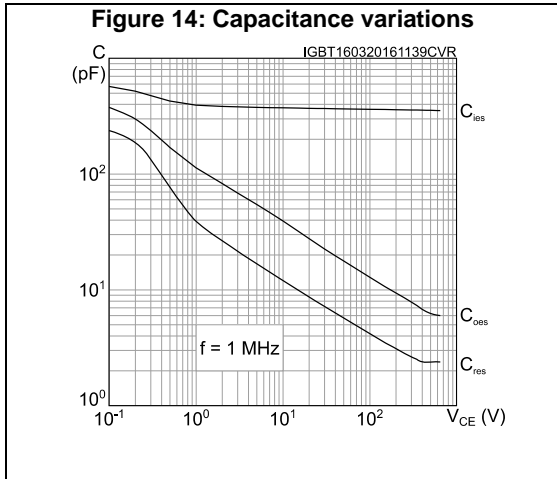




Figure 20: Short-circuit time and current vs.  $V_{GE}$

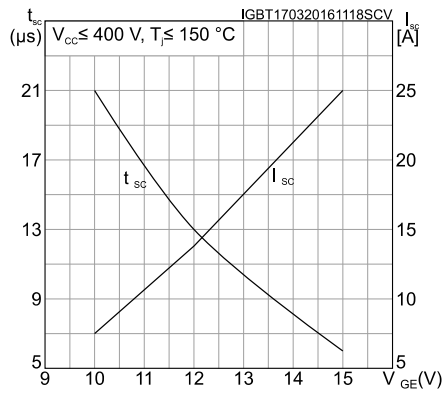


Figure 21: Switching times vs. collector current

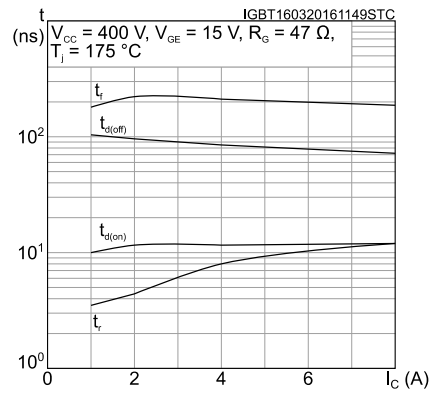


Figure 22: Switching times vs. gate resistance

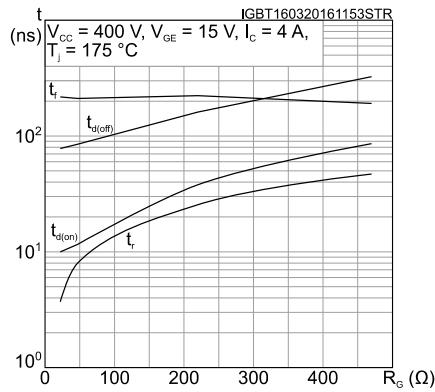


Figure 23: Reverse recovery current vs. diode current slope

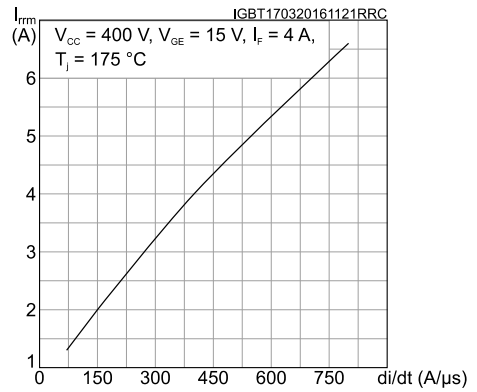


Figure 24: Reverse recovery time vs. diode current slope

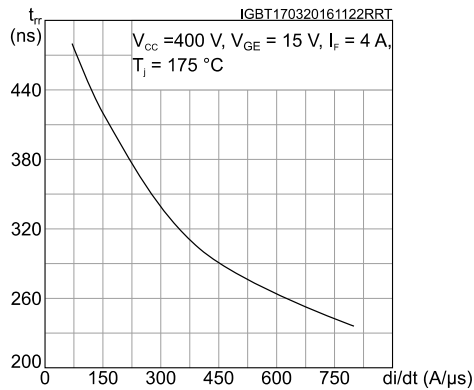


Figure 25: Reverse recovery charge vs. diode current slope

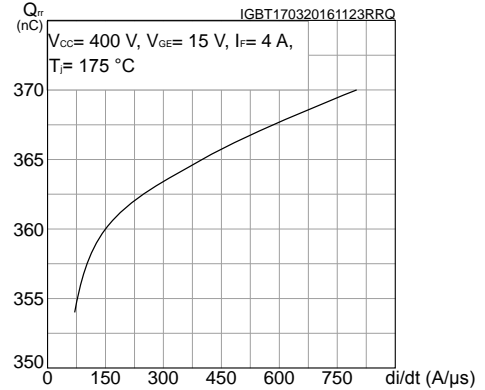


Figure 26: Reverse recovery energy vs. diode current slope

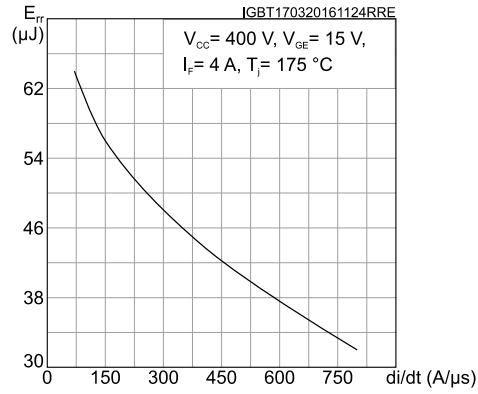


Figure 27: Thermal impedance for IGBT

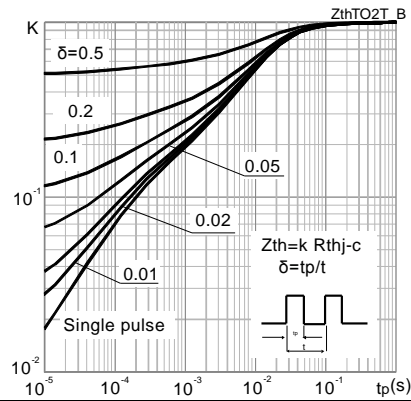
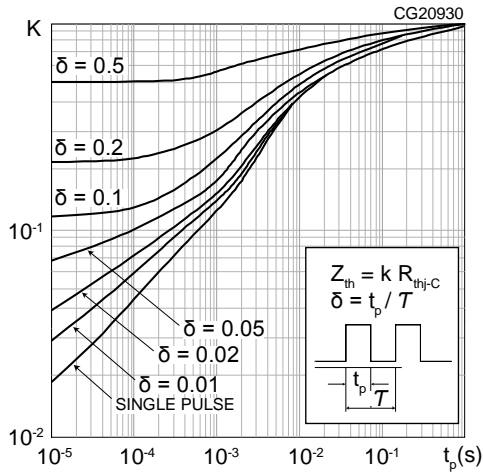
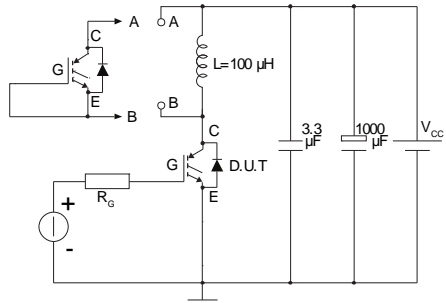


Figure 28: Thermal impedance for diode



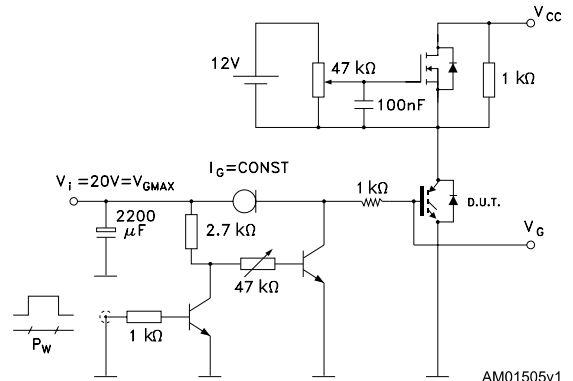
### 3 Test circuits

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



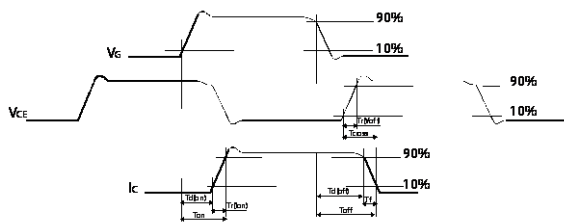
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**Figure 30: Gate charge test circuit**



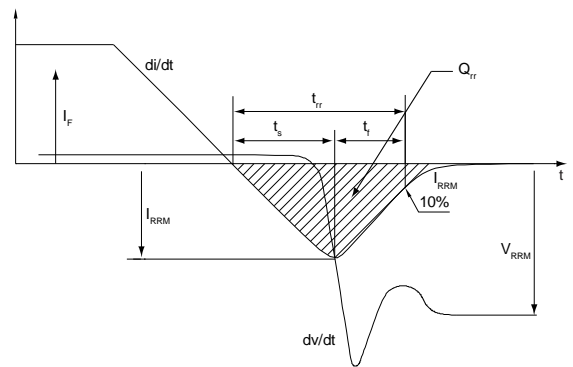
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**Figure 31: Switching waveform**



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 D<sup>2</sup>PAK (TO-263) type A package information

Figure 33: D<sup>2</sup>PAK (TO-263) type A package outline

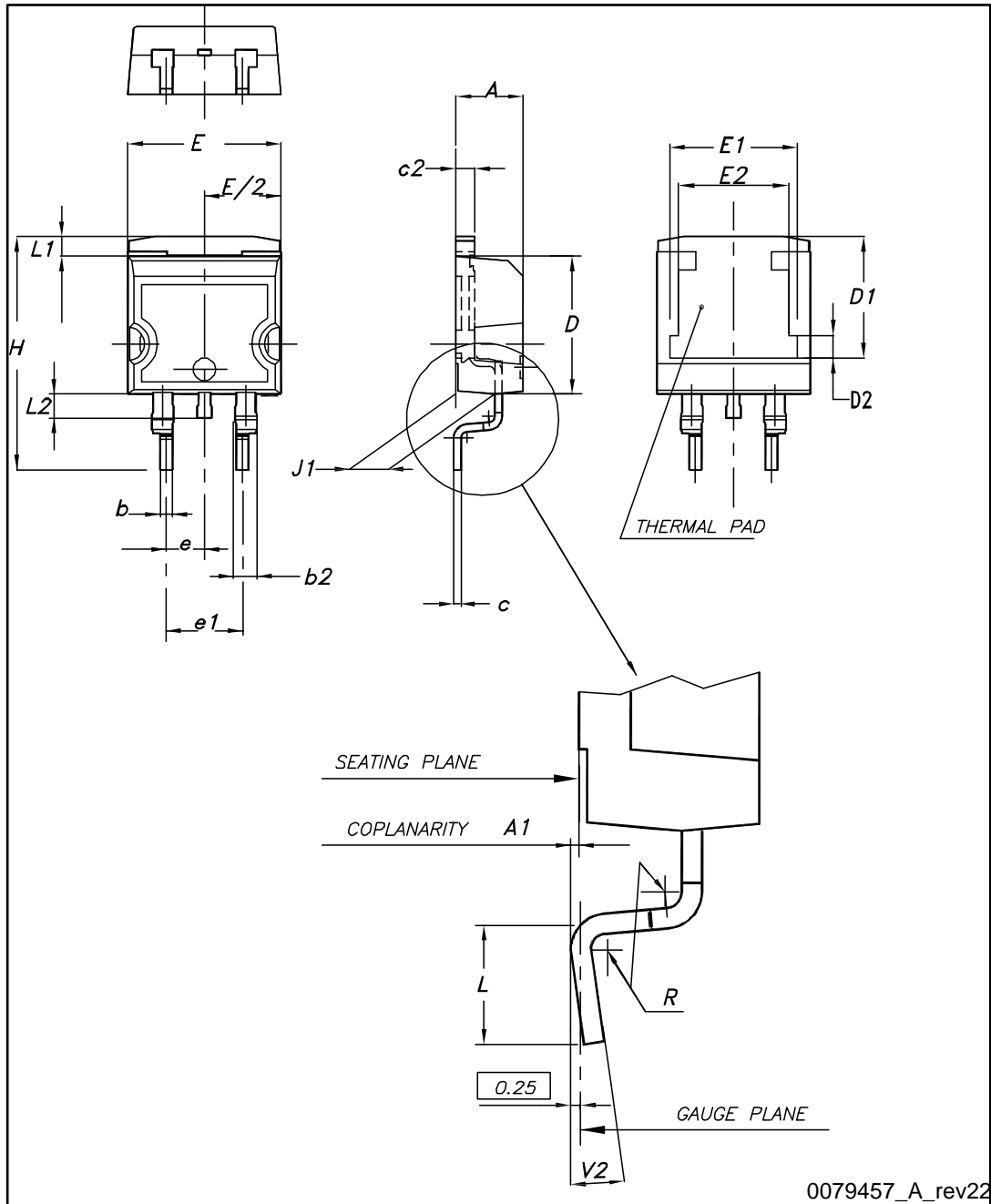
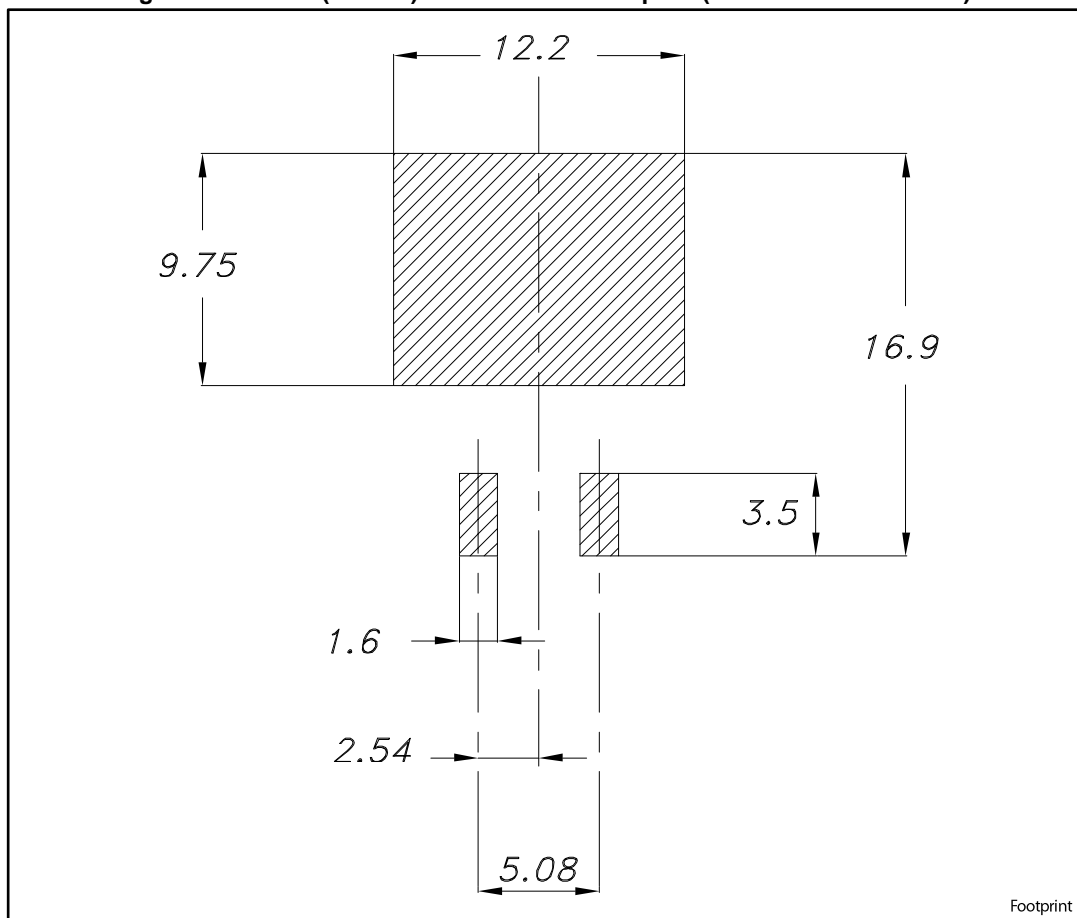


Table 8: D<sup>2</sup>PAK (TO-263) type A package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
A1	0.03		0.23
b	0.70		0.93
b2	1.14		1.70
c	0.45		0.60
c2	1.23		1.36
D	8.95		9.35
D1	7.50	7.75	8.00
D2	1.10	1.30	1.50
E	10		10.40
E1	8.50	8.70	8.90
E2	6.85	7.05	7.25
e		2.54	
e1	4.88		5.28
H	15		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.4	
V2	0°		8°

Figure 34: D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



### 4.2 Packing information

Figure 35: Tape outline

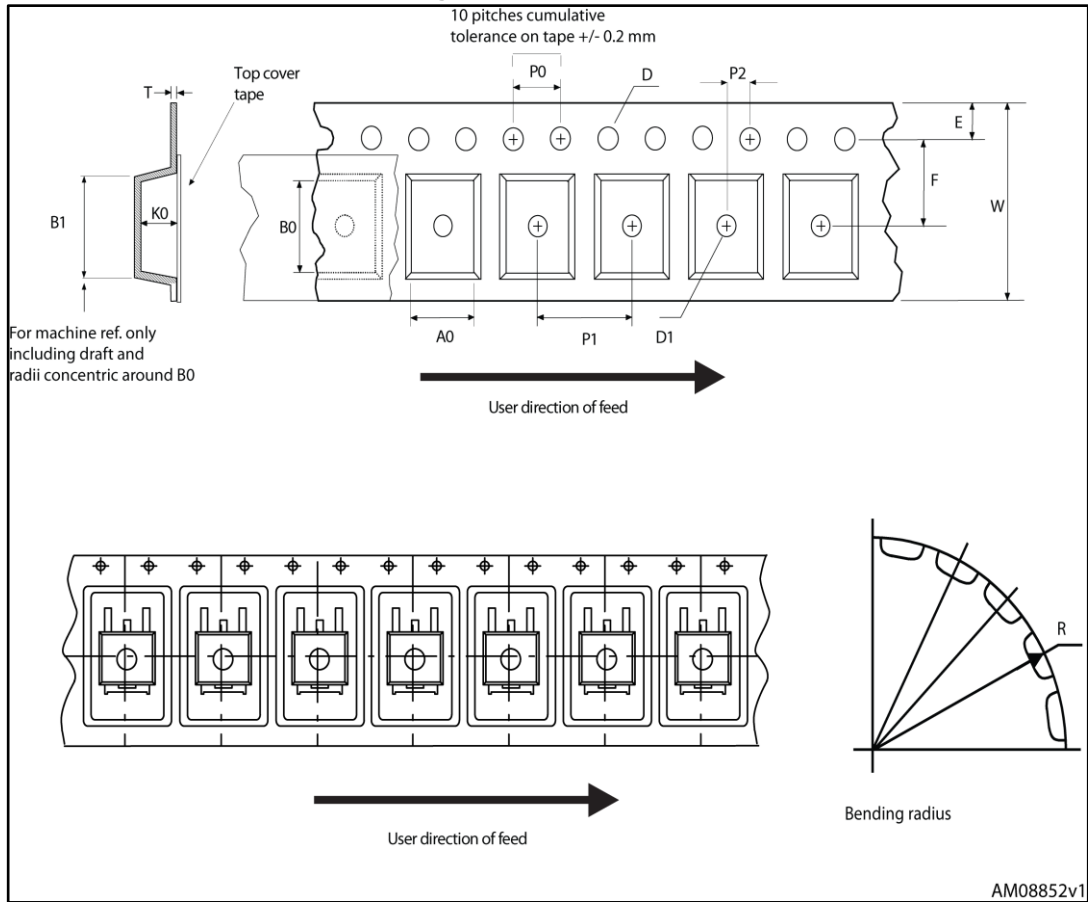
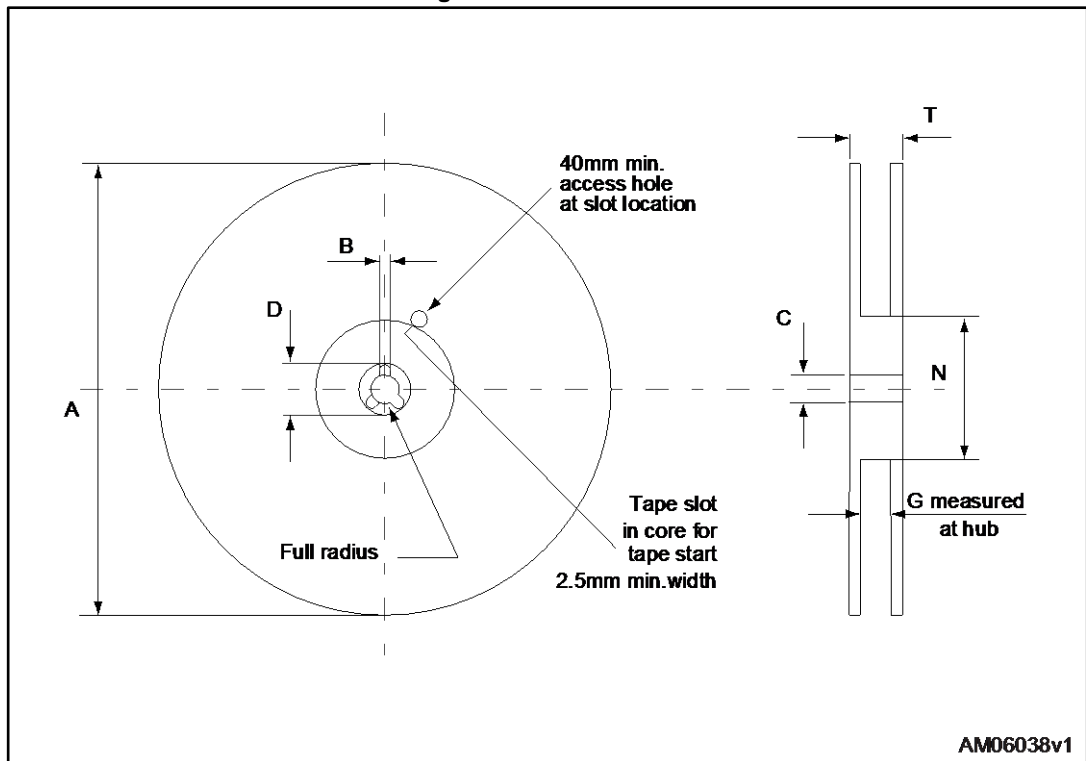


Figure 36: Reel outline



AM06038v1

Table 9: D<sup>2</sup>PAK tape and reel mechanical data

Tape			Reel		
Dim.	mm		Dim.	mm	
	Min.	Max.		Min.	Max.
A0	10.5	10.7	A		330
B0	15.7	15.9	B	1.5	
D	1.5	1.6	C	12.8	13.2
D1	1.59	1.61	D	20.2	
E	1.65	1.85	G	24.4	26.4
F	11.4	11.6	N	100	
K0	4.8	5.0	T		30.4
P0	3.9	4.1			
P1	11.9	12.1	Base quantity		1000
P2	1.9	2.1	Bulk quantity		1000
R	50				
T	0.25	0.35			
W	23.7	24.3			



## 5 Revision history

Table 10: Document revision history

Date	Revision	Changes
23-Nov-2015	1	First release.
17-Mar-2016	2	Modified: features in cover page Modified: Table 2: " <i>Absolute maximum ratings</i> ", Table 4: " <i>Static characteristics</i> ", Table 5: " <i>Dynamic characteristics</i> ", Table 6: " <i>IGBT switching characteristics (inductive load)</i> " and Table 7: " <i>Diode switching characteristics (inductive load)</i> " Added: Section 2: " <i>Electrical characteristics</i> " Minor text changes
21-Mar-2016	3	Modified: schematic in cover page Datasheet promoted from preliminary data to production data Minor text changes
21-Nov-2016	4	Updated <a href="#">Table 2: "Absolute maximum ratings"</a> Updated <a href="#">Figure 25: "Reverse recovery charge vs. diode current slope"</a> Updated <a href="#">Figure 32: "Diode reverse recovery waveform"</a>

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