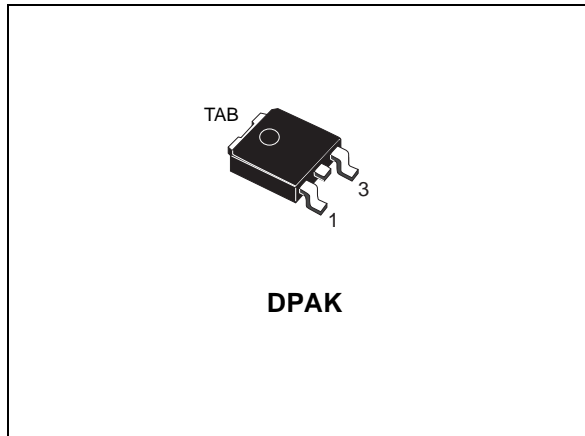
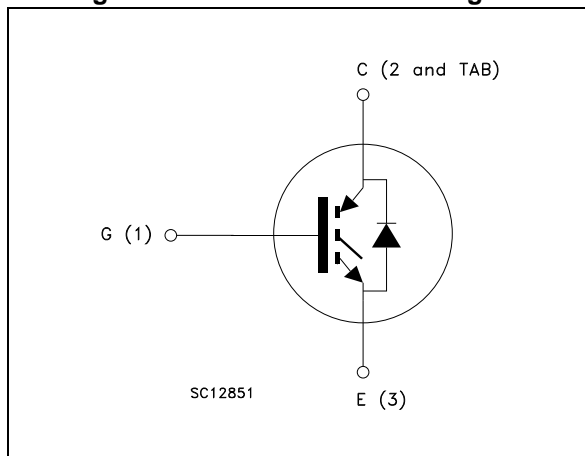


## Automotive-grade 10 A, 600 V, short-circuit rugged IGBT with Ultrafast diode

Datasheet - production data



**Figure 1. Internal schematic diagram**



### Features

- Designed for automotive applications and AEC-Q101 qualified
- Low on-voltage drop ( $V_{CE(sat)}$ )
- Low  $C_{res} / C_{ies}$  ratio (no cross conduction susceptibility)
- Switching losses include diode recovery energy
- Short-circuit rated
- Very soft Ultrafast recovery anti-parallel diode

### Applications

- High frequency inverters
- SMPS and PFC in both hard switch and resonant topologies
- Motor drives
- Injection systems

### Description

This device utilizes the advanced PowerMESH™ process for the IGBT and the Turbo 2 Ultrafast high voltage technology for the diode. The combination results in a very good trade-off between conduction losses and switching behavior rendering the product ideal for diverse high voltage applications operating at high frequencies.

**Table 1. Device summary**

Order code	Marking	Package	Packaging
STGD10HF60KD	GD10HF60KD	DPAK	Tape and reel

# Contents

<b>1</b>	<b>Electrical ratings</b> .....	<b>3</b>
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# 1 Electrical ratings

$T_{CASE} = 25\text{ °C}$  unless otherwise specified.

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	600	V
$I_C^{(1)}$	Collector current (continuous) at $T_C = 25\text{ °C}$	18	A
$I_C^{(1)}$	Collector current (continuous) at $T_C = 100\text{ °C}$	10	A
$I_{CL}^{(2)}$	Turn-off latching current	30	A
$I_{CP}^{(3)}$	Pulsed collector current	30	A
$V_{GE}$	Gate-emitter voltage	$\pm 20$	V
$V_{GEM}$	Gate-emitter voltage pulsed ( $t_p \leq 1\text{ ms}$ )	$\pm 30$	V
$I_F$	Diode RMS forward current	7	A
$I_{FSM}$	Surge non repetitive forward current $t_p = 10\text{ ms}$ sinusoidal	20	A
$P_{TOT}$	Total dissipation	62.5	W
$t_{scw}$	Short circuit withstand time ( $V_{CE} = 50\text{ V}$ , $V_{GE} = 15\text{ V}$ , $T_C = 150\text{ °C}$ )	10	$\mu\text{s}$
$T_j$	IGBT operating junction temperature	- 55 to 150	$^{\circ}\text{C}$
	Diode operating junction temperature	- 55 to 175	$^{\circ}\text{C}$
$T_{stg}$	Storage temperature	- 65 to 150	$^{\circ}\text{C}$

1. Calculated according to the iterative formula:

$$I_C(T_C) = \frac{T_{j(max)} - T_C}{R_{thj-c} \times V_{CE(sat)(max)}(T_{j(max)}, I_C(T_C))}$$

2.  $V_{clamp} = 80\%$  of  $V_{CES}$ ,  $T_j = 150\text{ °C}$ ,  $R_G = 10\ \Omega$ ,  $V_{GE} = 15\text{ V}$
3. Pulse width limited by max. junction temperature allowed

**Table 3. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case IGBT	2	$^{\circ}\text{C/W}$
$R_{thj-case}$	Thermal resistance junction-case diode	5.8	$^{\circ}\text{C/W}$
$R_{thj-amb}$	Thermal resistance junction-ambient	100	$^{\circ}\text{C/W}$

## 2 Electrical characteristics

$T_{CASE}=25\text{ °C}$  unless otherwise specified.

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage ( $V_{GE}=0$ )	$I_C = 1\text{ mA}$ , $T_C = -40\text{ °C}$ <sup>(1)</sup>		610		V
		$I_C = 1\text{ mA}$	600	650		V
		$I_C = 1\text{ mA}$ , $T_C = 150\text{ °C}$		700		V
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$ $V_{GE} = \pm 20\text{ V}$ , $T_C = 150\text{ °C}$			$\pm 100$ $\pm 1$	nA $\mu\text{A}$
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 600\text{ V}$ $V_{CE} = 600\text{ V}$ , $T_C = 150\text{ °C}$			150 1	$\mu\text{A}$ mA
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 250\text{ }\mu\text{A}$	4.5		6.5	V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 5\text{ A}$	1.4		2.5	V

1. Value guaranteed by design

**Table 5. Dynamic <sup>(1)</sup>**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0$	-	430	-	pF
$C_{oes}$	Output capacitance		-	45	-	pF
$C_{res}$	Reverse transfer capacitance		-	10	-	pF
$Q_g$	Total gate charge	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ , $V_{GE} = 15\text{ V}$	-	23	-	nC
$Q_{ge}$	Gate-emitter charge		-	4	-	nC
$Q_{gc}$	Gate-collector charge		-	11	-	nC

1. Values guaranteed by design

Table 6. Switching on/off (inductive load) <sup>(1)</sup>

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 400\text{ V}, I_C = 5\text{ A}$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$	-	9.5	-	ns
$t_r$	Current rise time		-	4.4	-	ns
$(di/dt)_{on}$	Turn-on current slope				930	
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 400\text{ V}, I_C = 5\text{ A}$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_C = 150\text{ }^\circ\text{C}$	-	11	-	ns
$t_r$	Current rise time		-	4.8	-	ns
$(di/dt)_{on}$	Turn-on current slope		-	904	-	A/ $\mu$ s
$t_{r(Voff)}$	Off voltage rise time	$V_{CC} = 400\text{ V}, I_C = 5\text{ A},$ $R_{GE} = 10\ \Omega, V_{GE} = 15\text{ V}$	-	34	-	ns
$t_{d(off)}$	Turn-off delay time		-	87	-	ns
$t_f$	Current fall time		-	100	-	ns
$t_{r(Voff)}$	Off voltage rise time	$V_{CC} = 400\text{ V}, I_C = 5\text{ A},$ $R_{GE} = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_C = 150\text{ }^\circ\text{C}$	-	83	-	ns
$t_{d(off)}$	Turn-off delay time		-	93	-	ns
$t_f$	Current fall time		-	224	-	ns

1. Value guaranteed by design

Table 7. Switching energy (inductive load) <sup>(1)</sup>

Symbol	Parameter	Test conditions	Min	Typ.	Max	Unit
$E_{on}^{(2)}$	Turn-on switching losses	$V_{CC} = 400\text{ V}, I_C = 5\text{ A}$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$	-	45	-	$\mu$ J
$E_{off}^{(3)}$	Turn-off switching losses		-	105	-	$\mu$ J
$E_{ts}$	Total switching losses		-	150	-	$\mu$ J
$E_{on}^{(2)}$	Turn-on switching losses	$V_{CC} = 400\text{ V}, I_C = 5\text{ A}$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_C = 150\text{ }^\circ\text{C}$	-	84	-	$\mu$ J
$E_{off}^{(3)}$	Turn-off switching losses		-	286	-	$\mu$ J
$E_{ts}$	Total switching losses		-	370	-	$\mu$ J

- Value guaranteed by design
- IGBT and diode are at the same temperature
- Turn-off losses include also the tail of the collector current

Table 8. Collector-emitter diode

Symbol	Parameter	Test conditions	Min	Typ.	Max	Unit
$V_F$	Forward on-voltage	$I_F = 3\text{ A}$	-	1.75	2.5	V
		$I_F = 3\text{ A}, T_C = 150\text{ °C}$	-	1.45		V
$t_{rr}^{(1)}$	Reverse recovery time	$I_F = 3\text{ A}, V_R = 400\text{ V},$ $di/dt = 100\text{ A}/\mu\text{s}$	-	50		ns
$Q_{rr}^{(1)}$	Reverse recovery charge		-	45		nC
$I_{rm}^{(1)}$	Reverse recovery current		-	1.7		A
$t_{rr}^{(1)}$	Reverse recovery time	$I_F = 3\text{ A}, V_R = 400\text{ V},$ $T_C = 150\text{ °C},$ $di/dt = 100\text{ A}/\mu\text{s}$	-	100		ns
$Q_{rr}^{(1)}$	Reverse recovery charge		-	150		nC
$I_{rm}^{(1)}$	Reverse recovery current		-	3.1		A

1. Value guaranteed by design

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics ( $T_C = -50^\circ\text{C}$ )

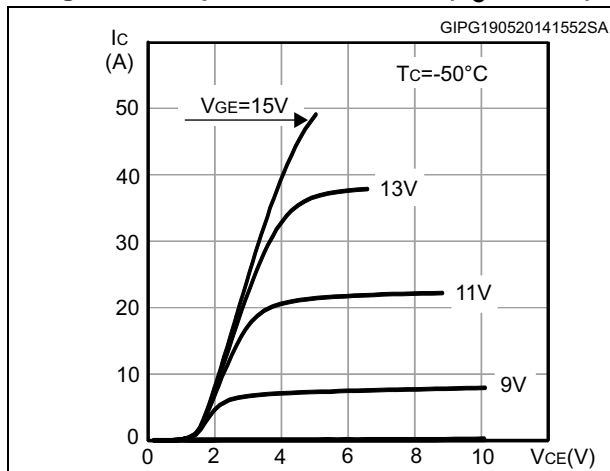


Figure 3. Output characteristics ( $T_C = 25^\circ\text{C}$ )

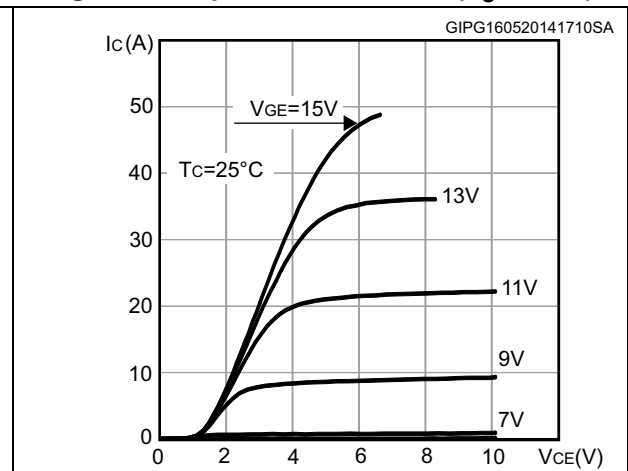


Figure 4. Output characteristics ( $T_C = 150^\circ\text{C}$ )

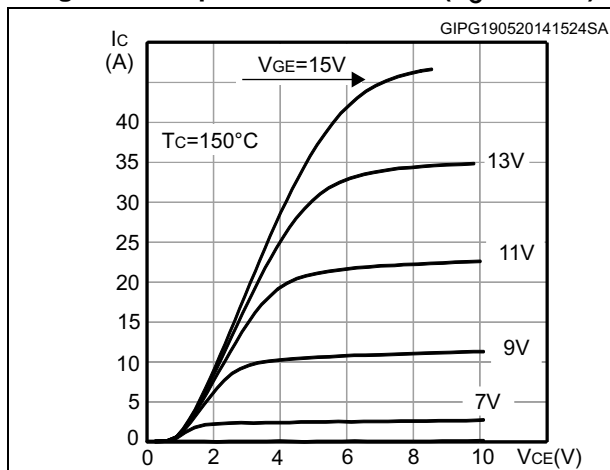


Figure 5. Transfer characteristics

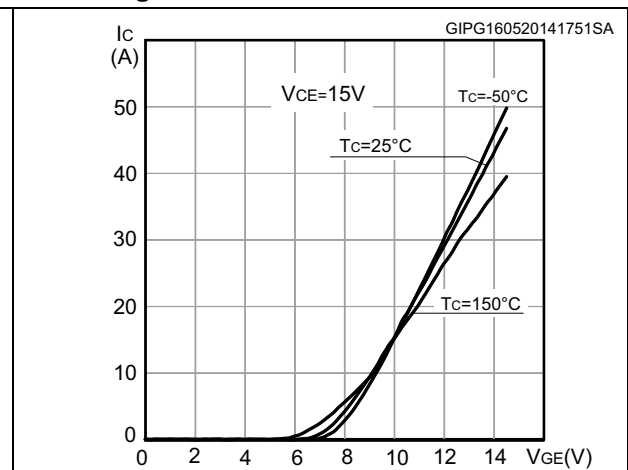


Figure 6. Collector-emitter on voltage vs. collector current

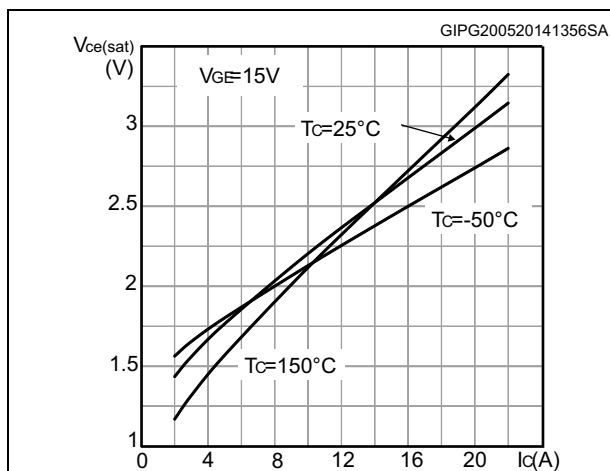


Figure 7. Collector-emitter on voltage vs. temperature

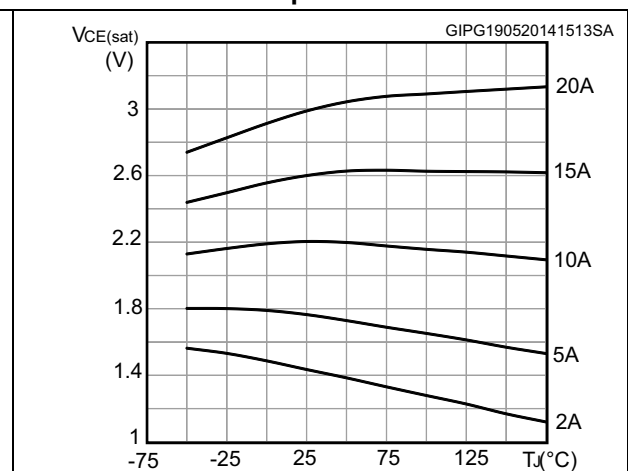


Figure 8. Normalized  $V_{(BR)CES}$  vs. temperature

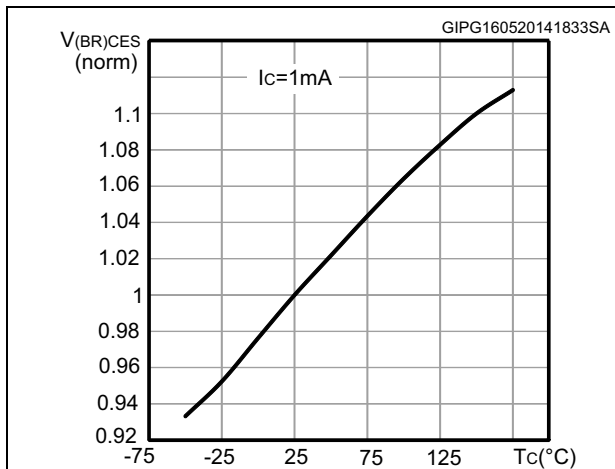


Figure 9. Normalized gate threshold vs. temperature

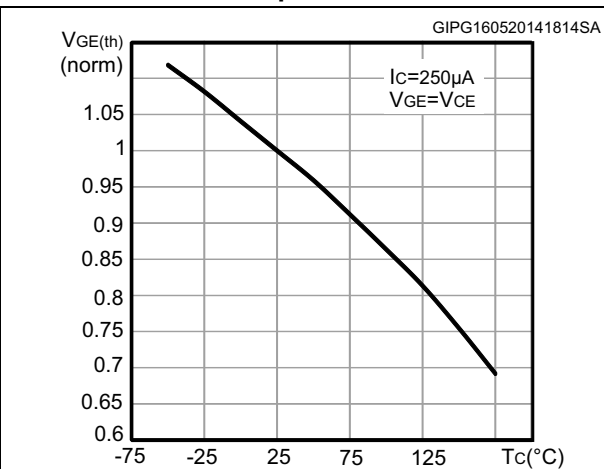


Figure 10. Gate charge vs. gate-emitter voltage

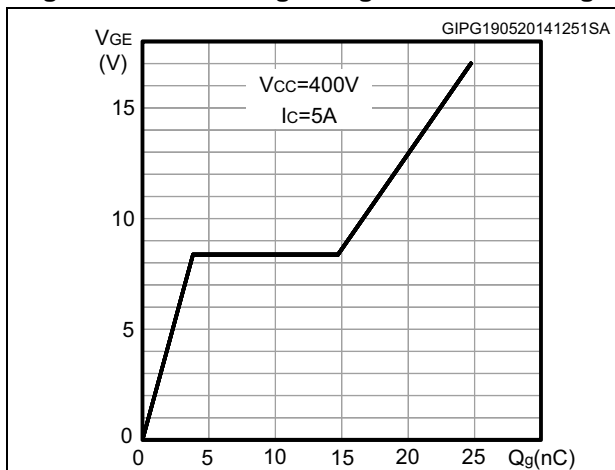


Figure 11. Capacitance variations

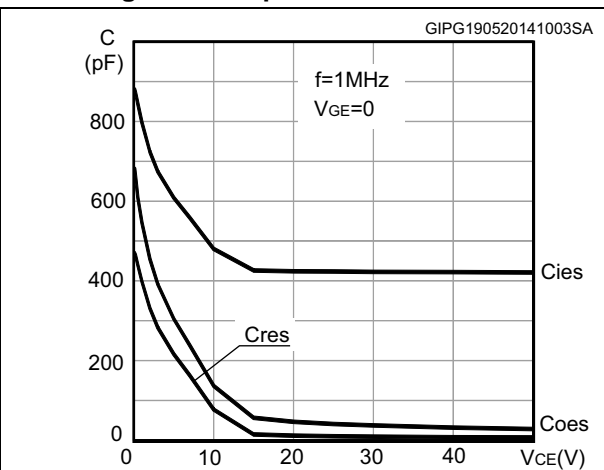


Figure 12. Switching losses vs. temperature

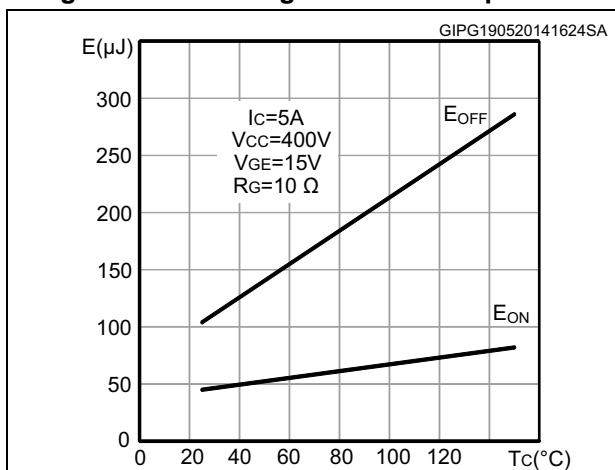


Figure 13. Switching losses vs. gate resistance

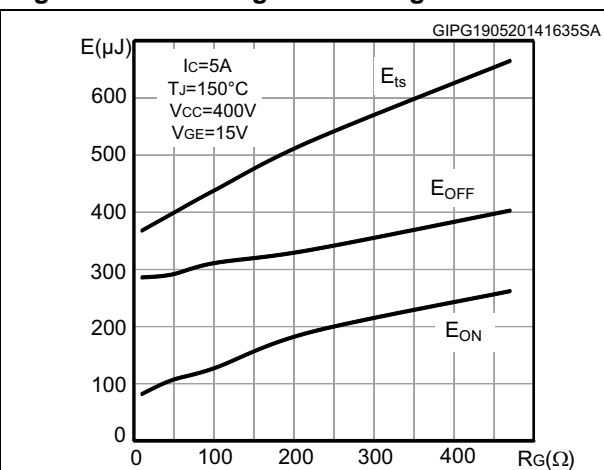




Figure 14. Switching losses vs. collector current

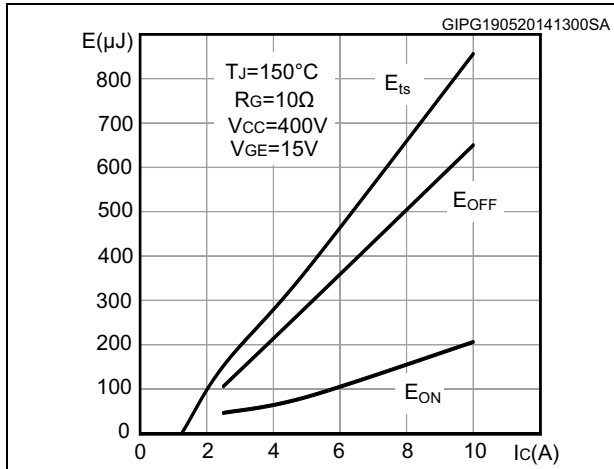


Figure 15. Short-circuit withstand time and current vs. gate-emitter voltage

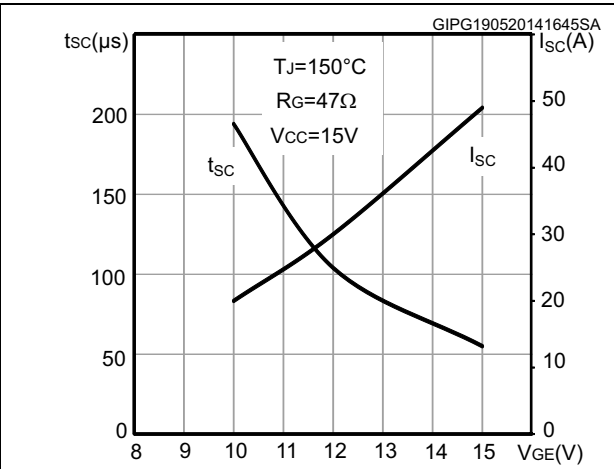


Figure 16. RBSOA

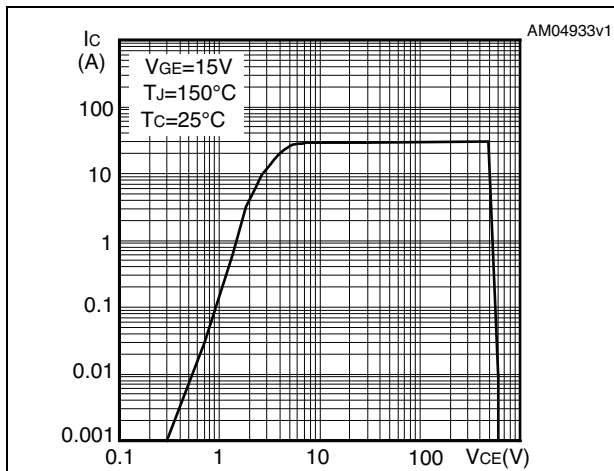


Figure 17. Switching times vs. gate resistance at  $T_J=25^\circ\text{C}$

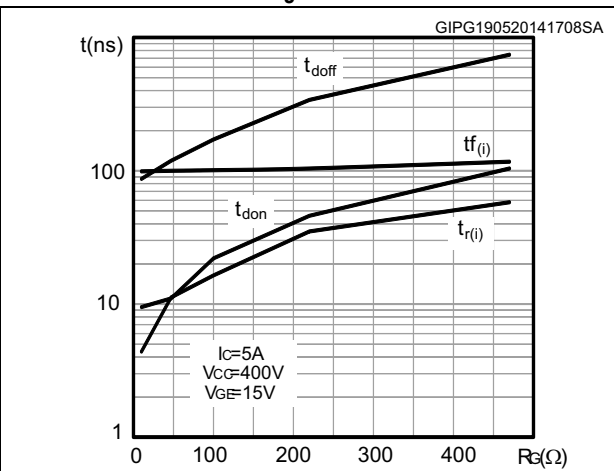


Figure 18. Switching times vs. gate resistance at  $T_J=150^\circ\text{C}$

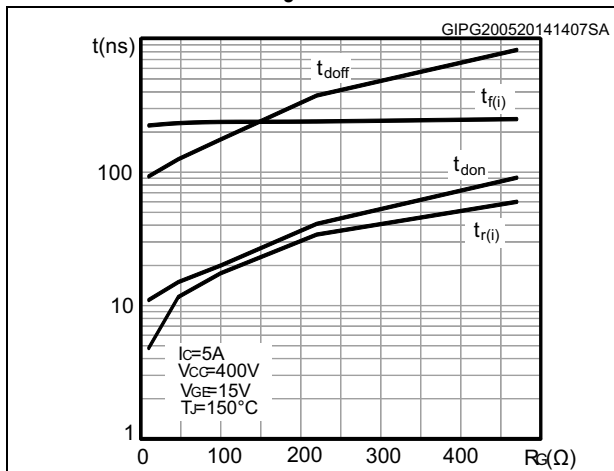


Figure 19. Switching times vs. collector current

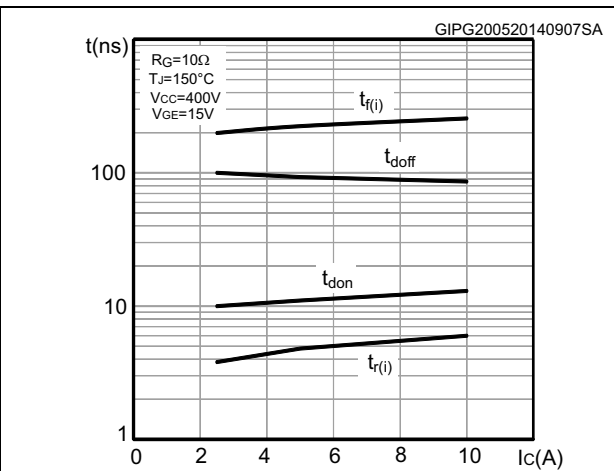


Figure 20. Diode forward voltage drop vs. forward current

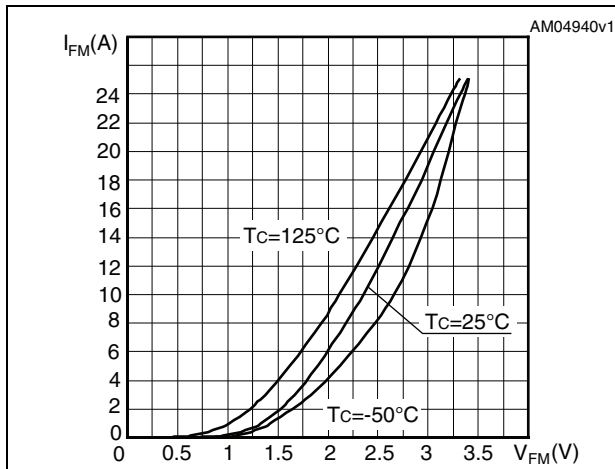


Figure 21. Peak reverse recovery current vs. di/dt

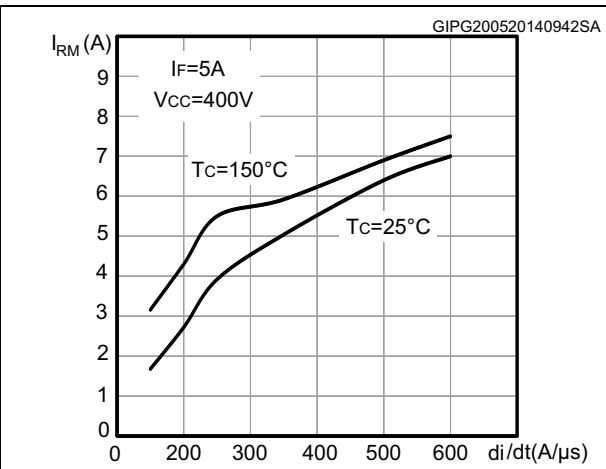


Figure 22. Reverse recovery time vs. di/dt

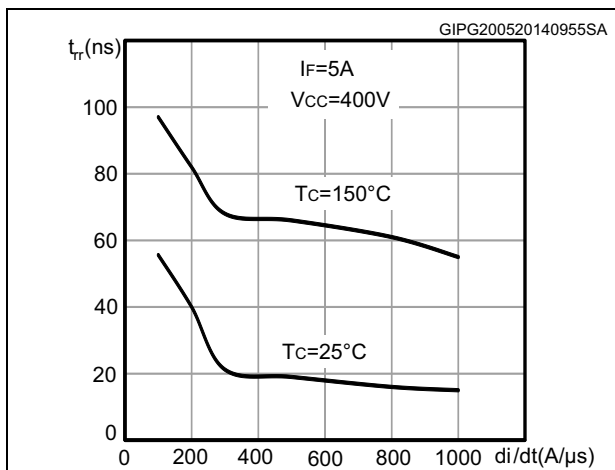


Figure 23. Reverse recovery softness factor vs. di/dt

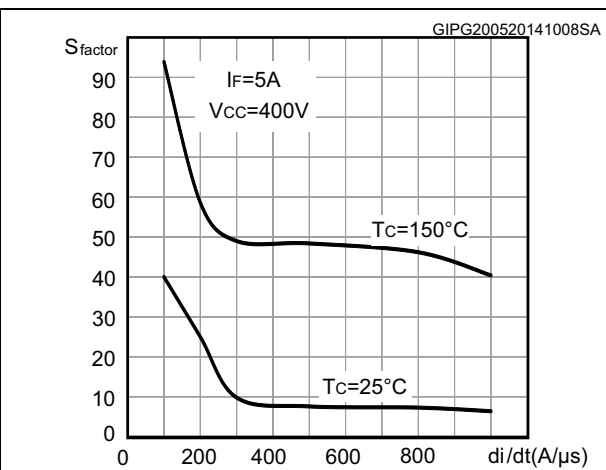


Figure 24. Reverse recovery charges vs. di/dt

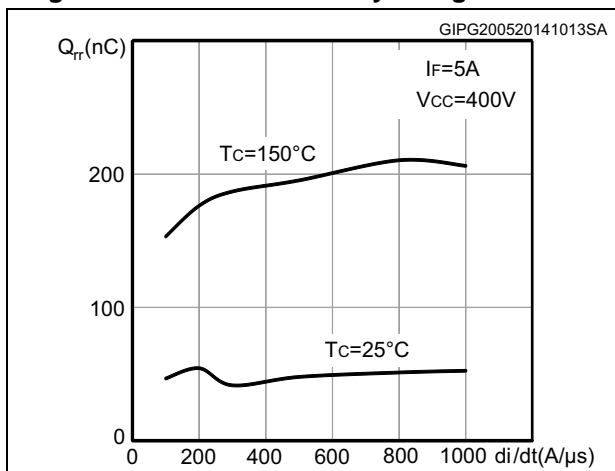


Figure 25. IGBT thermal impedance

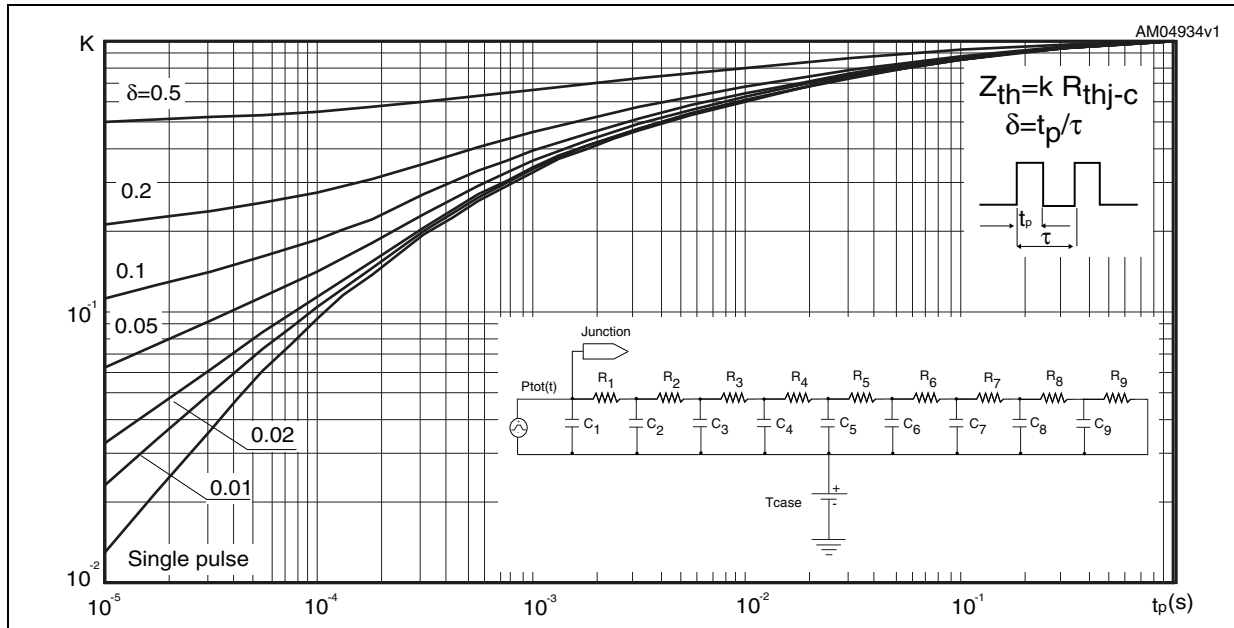


Table 9. IGBT RC-Cauer thermal network

Symbol	Value	Unit	Symbol	Value	Unit
R <sub>1</sub>	0.344	°C/W	C <sub>1</sub>	0.4E-3	W*s/°C
R <sub>2</sub>	0.0686	°C/W	C <sub>2</sub>	0.162E-4	W*s/°C
R <sub>3</sub>	0.0958	°C/W	C <sub>3</sub>	0.684E-3	W*s/°C
R <sub>4</sub>	0.177	°C/W	C <sub>4</sub>	0.923E-4	W*s/°C
R <sub>5</sub>	0.250	°C/W	C <sub>5</sub>	0.3E-2	W*s/°C
R <sub>6</sub>	0.245	°C/W	C <sub>6</sub>	0.9E-2	W*s/°C
R <sub>7</sub>	0.152	°C/W	C <sub>7</sub>	0.678E-3	W*s/°C
R <sub>8</sub>	0.135	°C/W	C <sub>8</sub>	0.807E-3	W*s/°C
R <sub>9</sub>	0.530	°C/W	C <sub>9</sub>	0.248	W*s/°C

Figure 26. Diode thermal impedance

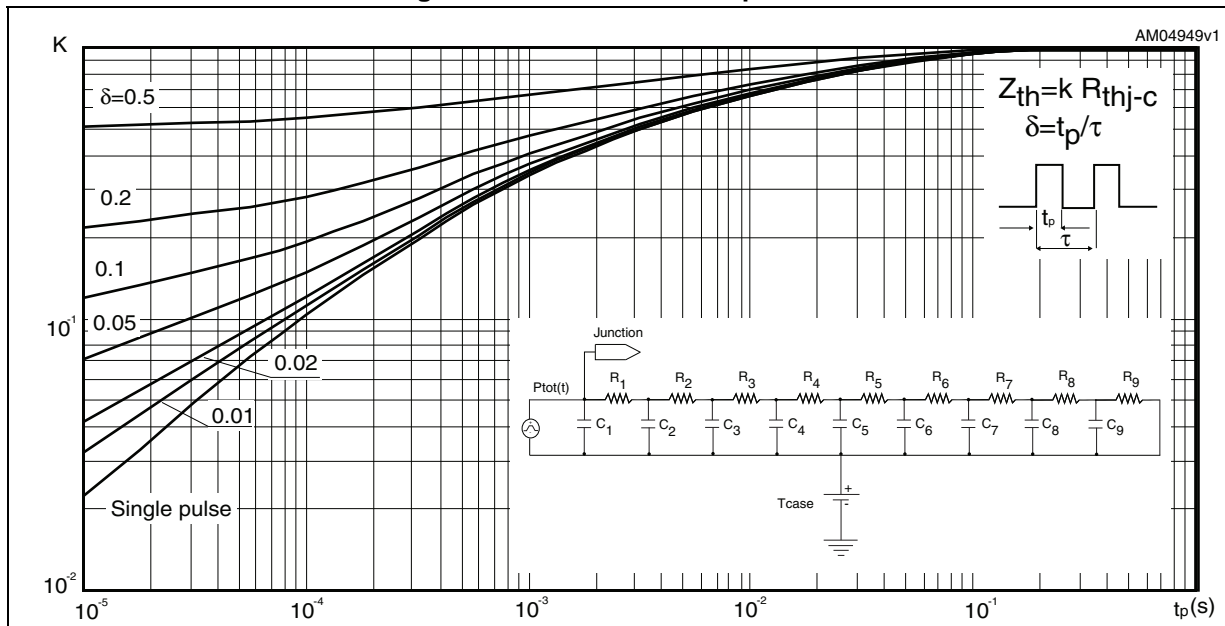
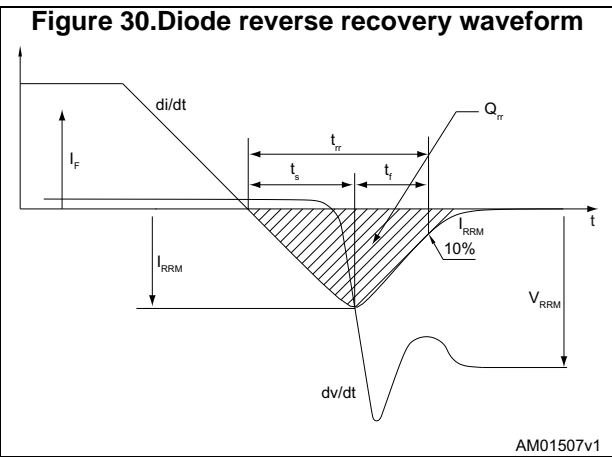
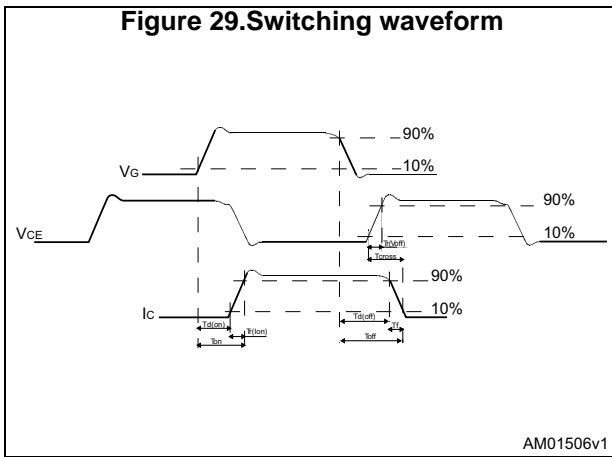
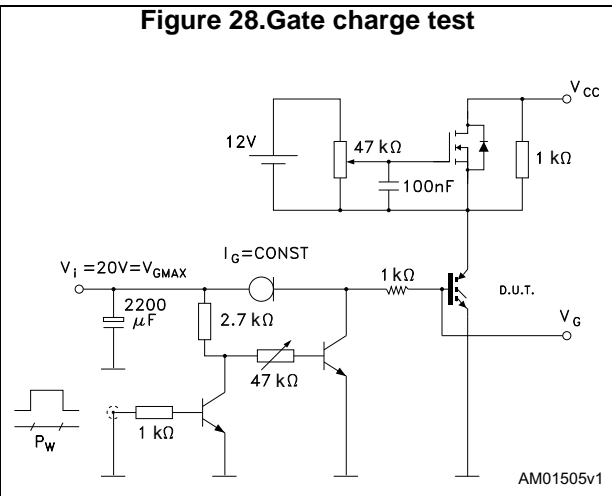
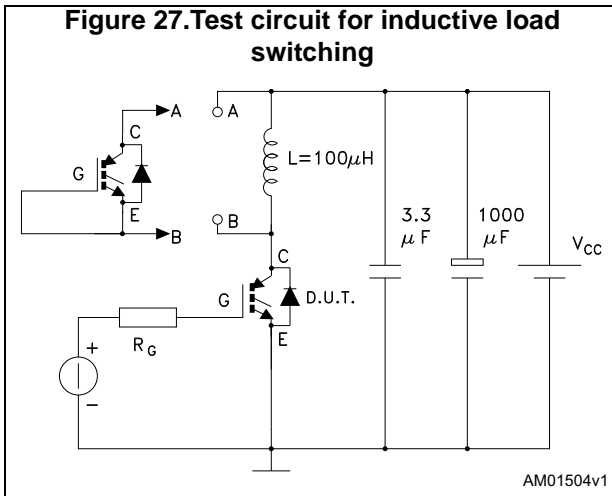


Table 10. Diode RC-Cauer thermal network

Symbol	Value	Unit	Symbol	Value	Unit
R <sub>1</sub>	0.478	°C/W	C <sub>1</sub>	0.8E-4	W*s/°C
R <sub>2</sub>	0.542	°C/W	C <sub>2</sub>	1E-4	W*s/°C
R <sub>3</sub>	0.600	°C/W	C <sub>3</sub>	2E-4	W*s/°C
R <sub>4</sub>	0.277	°C/W	C <sub>4</sub>	0.5E-5	W*s/°C
R <sub>5</sub>	0.844	°C/W	C <sub>5</sub>	0.145E-2	W*s/°C
R <sub>6</sub>	0.313	°C/W	C <sub>6</sub>	0.499E-4	W*s/°C
R <sub>7</sub>	0.108	°C/W	C <sub>7</sub>	0.727E-3	W*s/°C
R <sub>8</sub>	0.891	°C/W	C <sub>8</sub>	0.393E-4	W*s/°C
R <sub>9</sub>	1.73	°C/W	C <sub>9</sub>	0.0176	W*s/°C

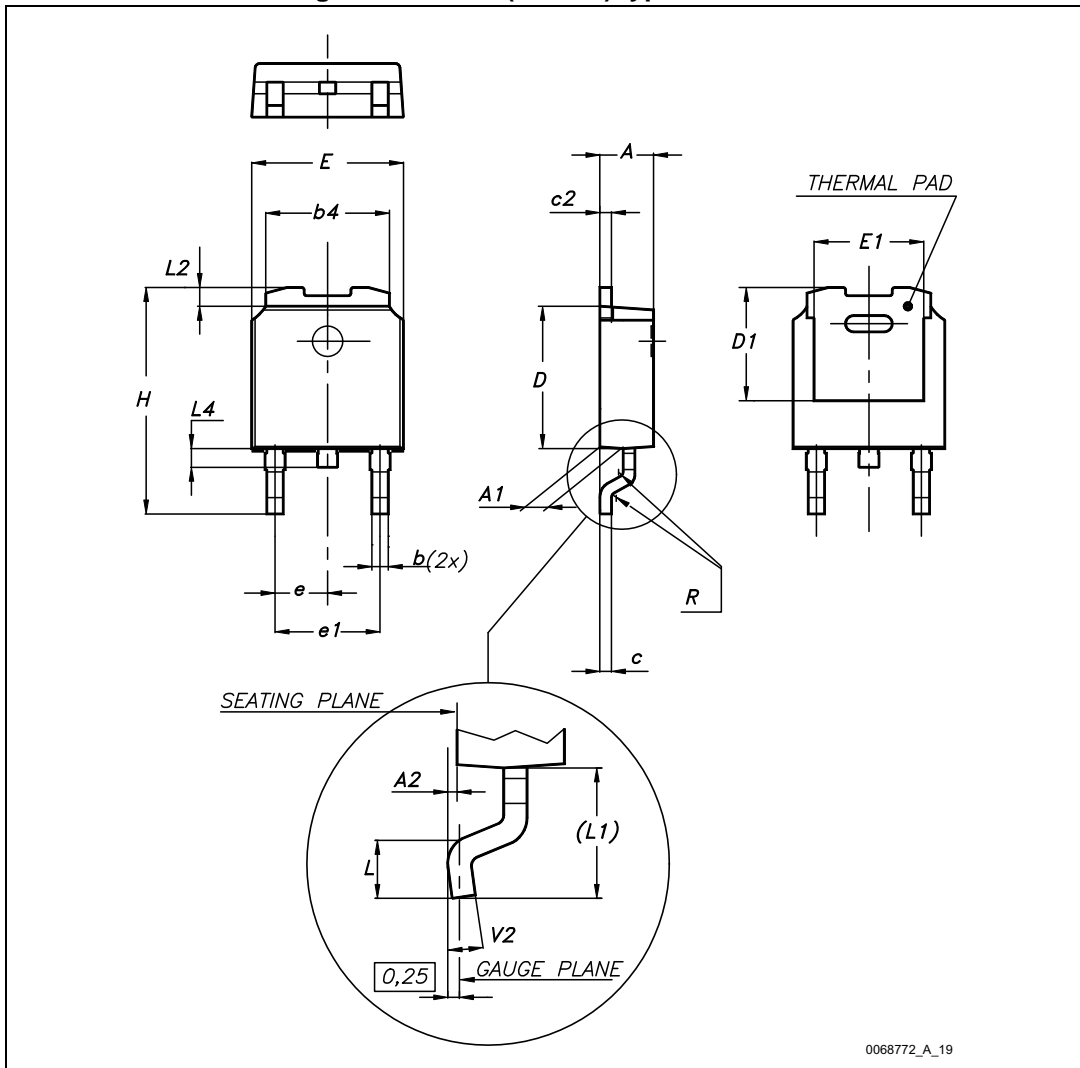
### 3 Test circuits



## 4 Package mechanical data

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

Figure 31. DPAK (TO-252) type A outline



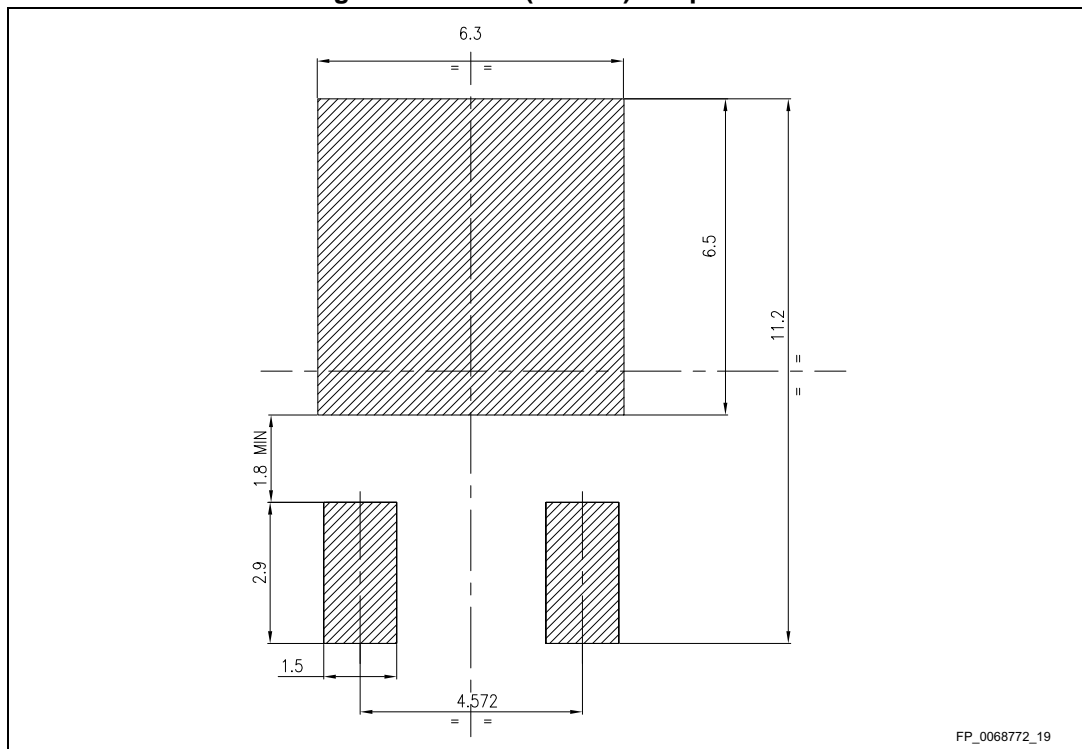
0068772\_A\_19

Table 11. DPAK (TO-252) type A 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	4.60	4.70	4.80
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 32. DPAK (TO-252) footprint (a)



a. All dimensions are in millimeters

# 5 Packaging mechanical data

Figure 33. Tape for DPAK (TO-252)

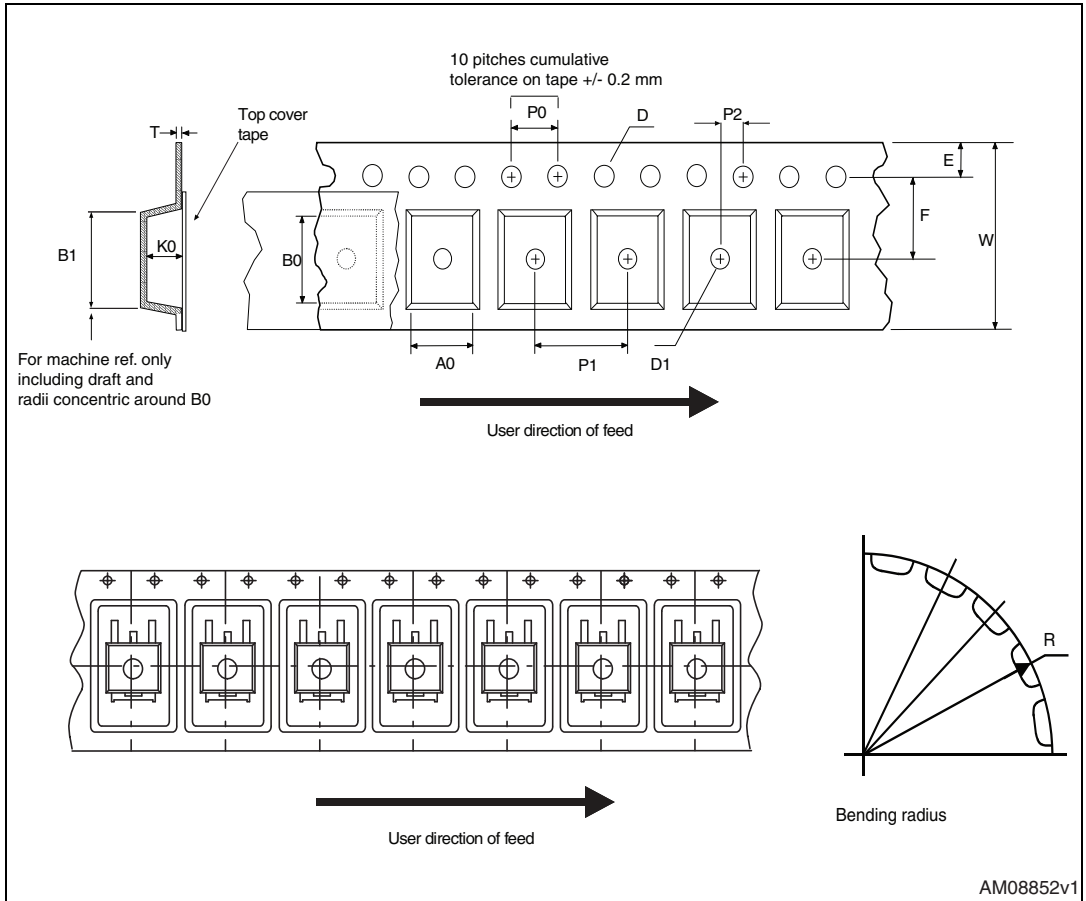


Figure 34. Reel for DPAK (TO-252)

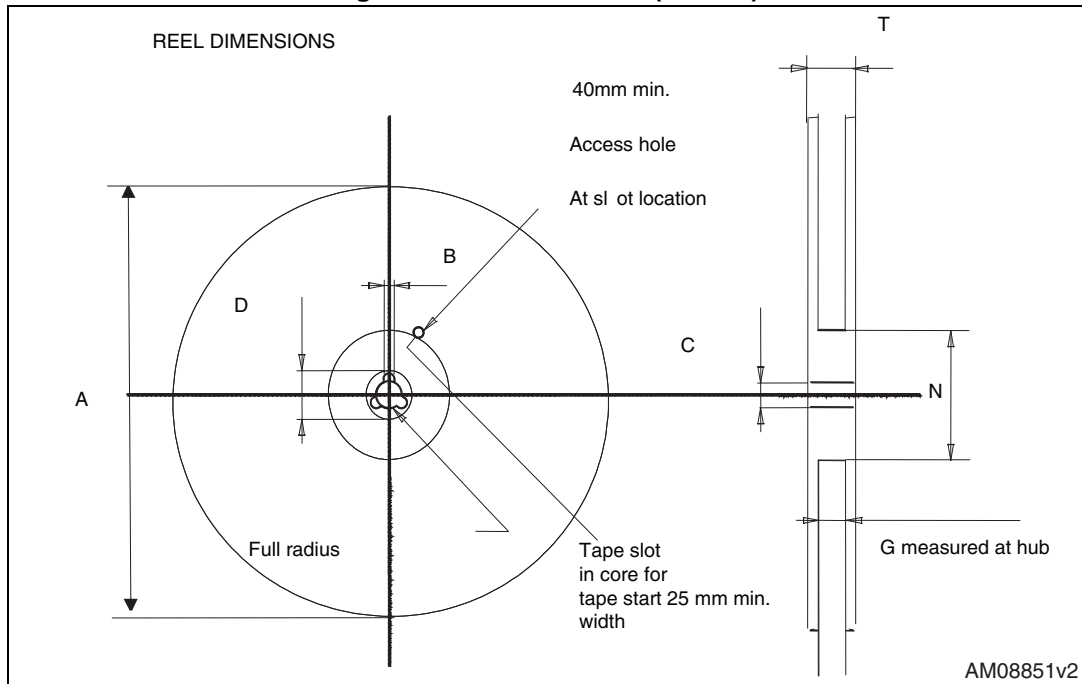


Table 12. DPAK (TO-252) tape and reel mechanical data

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			

## 6 Revision history

**Table 13. Document revision history**

Date	Revision	Changes
28-Feb-2012	1	First release
27-May-2014	2	<ul style="list-style-type: none"><li>– Added: electrical characteristics (curves) section</li><li>– Updated: package mechanical data section</li><li>– Minor text changes</li></ul>
15-Sep-2015	3	<ul style="list-style-type: none"><li>– Modified: <math>V_{CE(sat)}</math> (min and max) values in static table</li><li>– Modified: note 1 relative to collector-emitter diode table</li><li>– Modified: collector-emitter on voltage vs. collector current figure and collector-emitter on voltage vs. temperature</li><li>– Updated: test circuits section</li><li>– Updated: Package mechanical data section</li><li>– Minor text changes</li></ul>

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