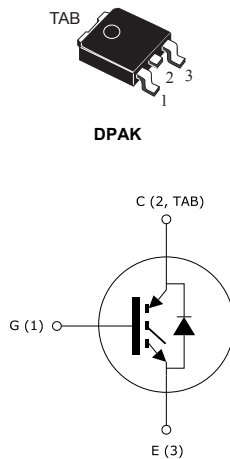


## Trench gate field-stop, 650 V, 4 A, M series low-loss IGBT



## 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 the low-loss and the short-circuit functionality is essential. Furthermore, the positive  $V_{CE(sat)}$  temperature coefficient and the tight parameter distribution result in safer paralleling operation.

## Product status

STGD4M65DF2

## Product summary

<b>Order code</b>	STGD4M65DF2
<b>Marking</b>	G4M65DF2
<b>Package</b>	DPAK
<b>Packing</b>	Tape and reel

# 1 Electrical ratings

**Table 1. 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 power 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

1. Pulse width limited by maximum junction temperature.

**Table 2. 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	100	°C/W

## 2 Electrical characteristics

$T_C = 25\text{ °C}$  unless otherwise specified

**Table 3. 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 4. 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	-	$\mu\text{F}$
$C_{oes}$	Output capacitance		-	24.8	-	
$C_{res}$	Reverse transfer capacitance		-	8	-	
$Q_g$	Total gate charge	$V_{CC} = 520\text{ V}, I_C = 4\text{ A}, V_{GE} = 0\text{ to }15\text{ V}$ (see <a href="#">Figure 29. Gate charge test circuit</a> )	-	15.2	-	nC
$Q_{ge}$	Gate-emitter charge		-	3	-	
$Q_{gc}$	Gate-collector charge		-	7	-	

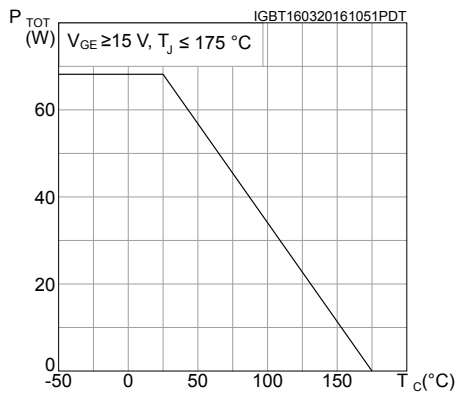
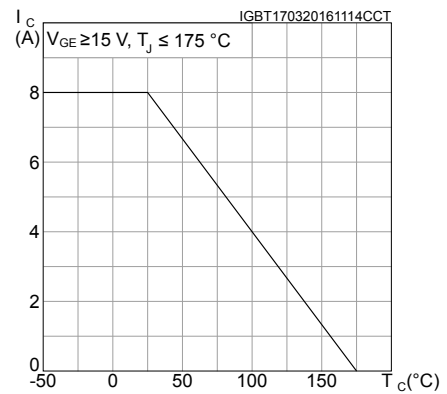
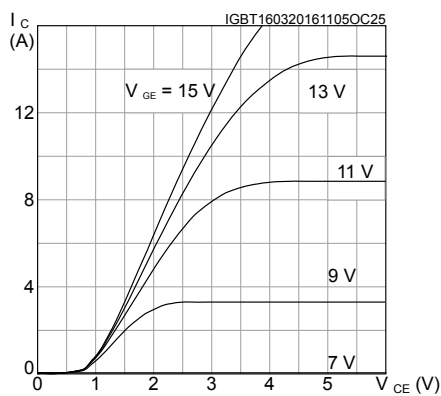
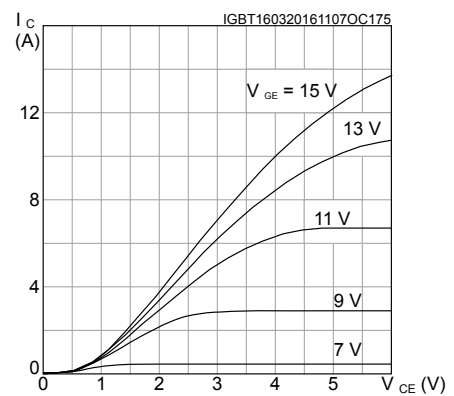
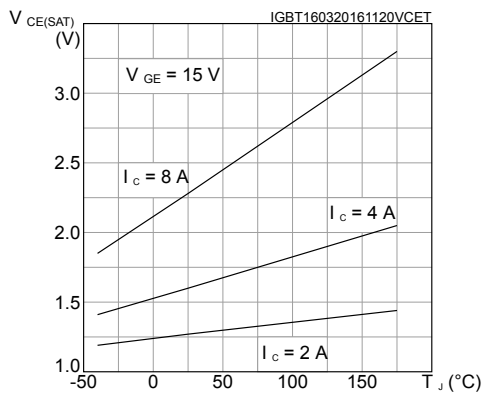
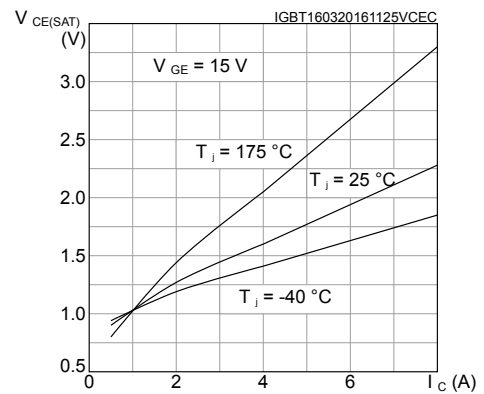
**Table 5. IGBT switching characteristics (inductive load)**

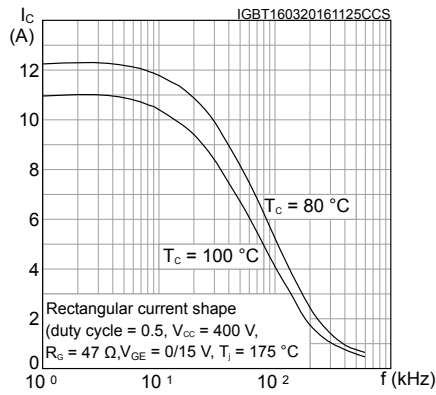
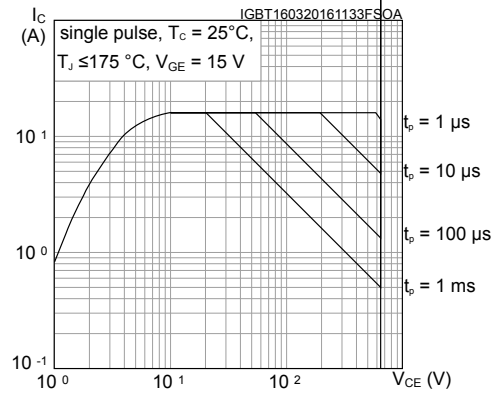
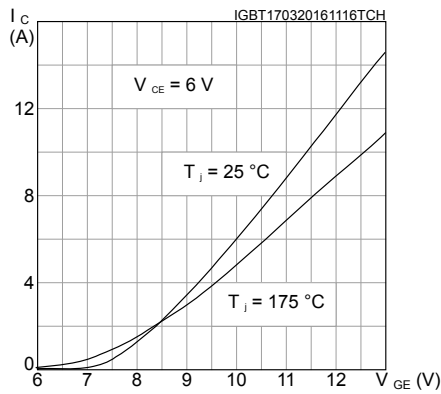
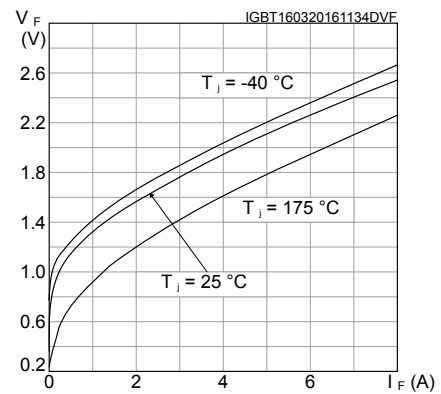
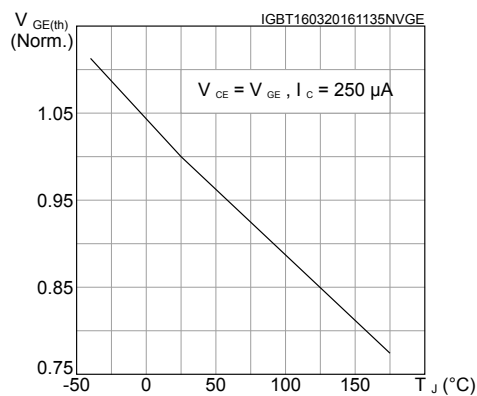
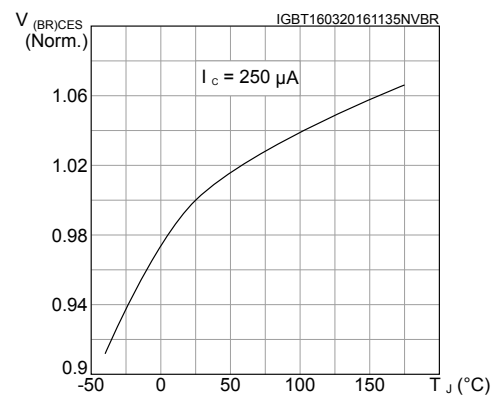
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 4\text{ A}$ , $V_{GE} = 15\text{ V}$ , $R_G = 47\ \Omega$ (see Figure 28. Test circuit for inductive load switching )		12	-	ns
$t_r$	Current rise time			6.9	-	ns
$(di/dt)_{on}$	Turn-on current slope			480	-	A/ $\mu$ 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 Figure 28. 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/ $\mu$ 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		-	

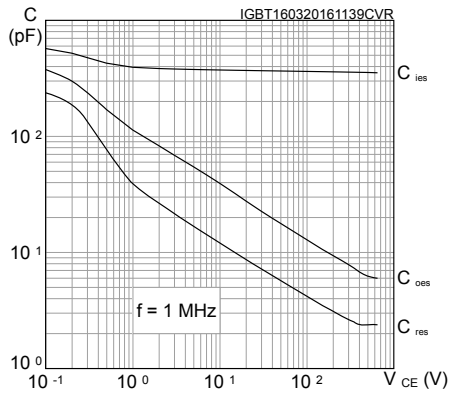
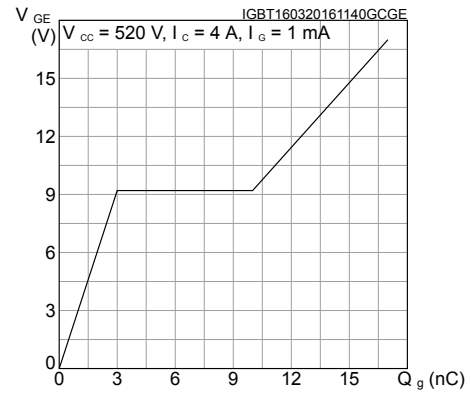
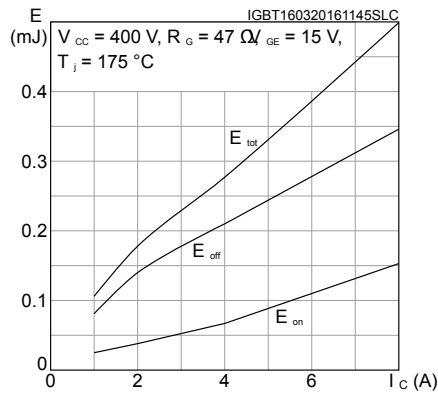
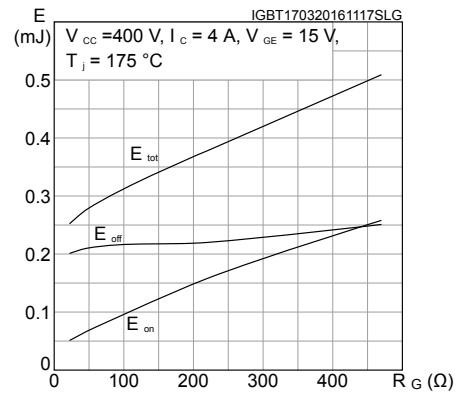
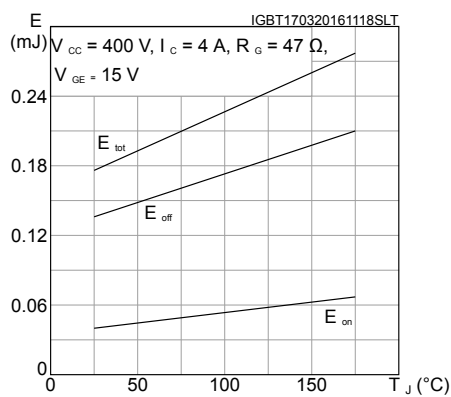
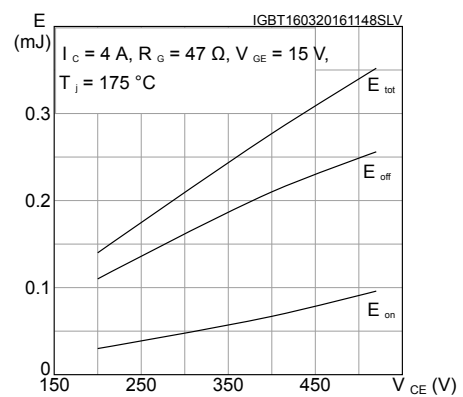
1. Including the reverse recovery of the diode.
2. Including the tail of the collector current.

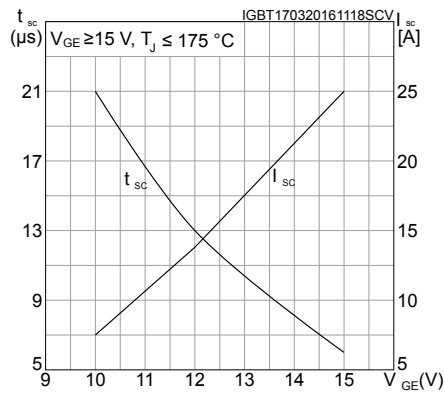
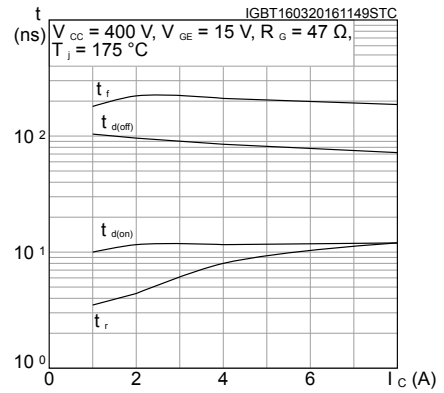
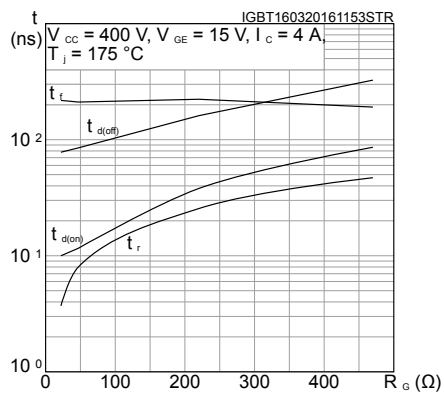
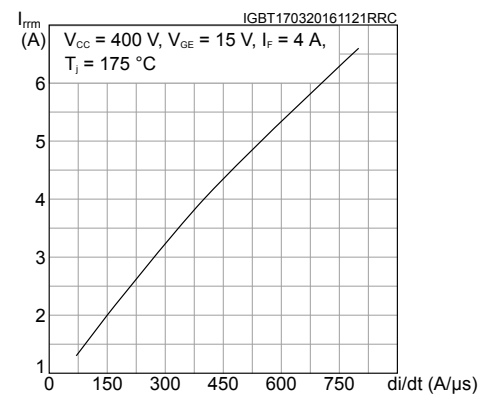
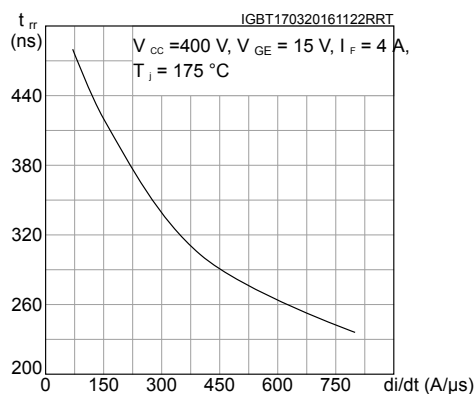
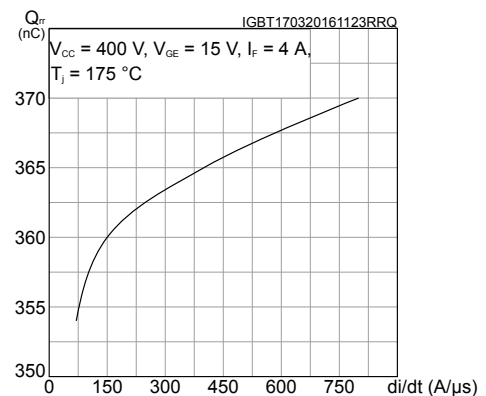
**Table 6. Diode switching characteristics (inductive load)**

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 28. 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/ $\mu$ 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 Figure 28. 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/ $\mu$ s
$E_{rr}$	Reverse recovery energy		-	32	-	$\mu$ J

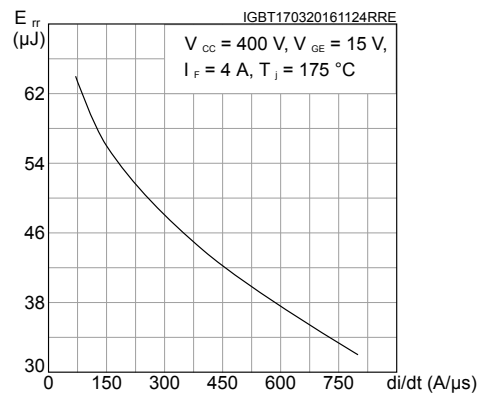
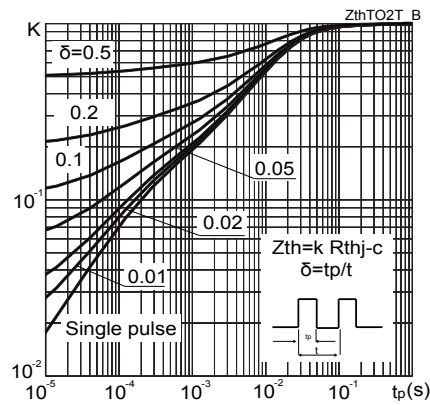
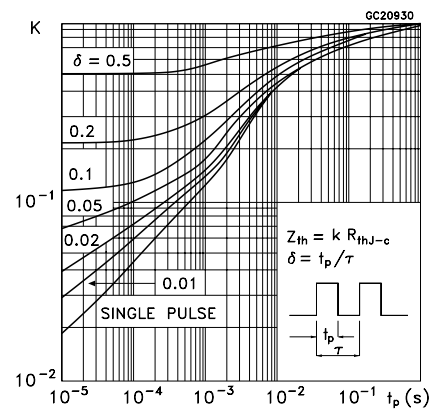
**2.1 STGD4M65DF2 electrical characteristics (curves)**
**Figure 1. Power dissipation vs. case temperature**

**Figure 2. Collector current vs. case temperature**

**Figure 3. Output characteristics (T<sub>J</sub> = 25 °C)**

**Figure 4. Output characteristics (T<sub>J</sub> = 175 °C)**

**Figure 5. V<sub>CE(sat)</sub> vs. junction temperature**

**Figure 6. V<sub>CE(sat)</sub> vs. collector current**


**Figure 7. Collector current vs. switching frequency**

**Figure 8. Forward bias safe operating area**

**Figure 9. Transfer characteristics**

**Figure 10. Diode V\_F vs. forward current**

**Figure 11. Normalized V\_GE(th) vs. junction temperature**

**Figure 12. Normalized V\_BR(CES) vs. junction temperature**


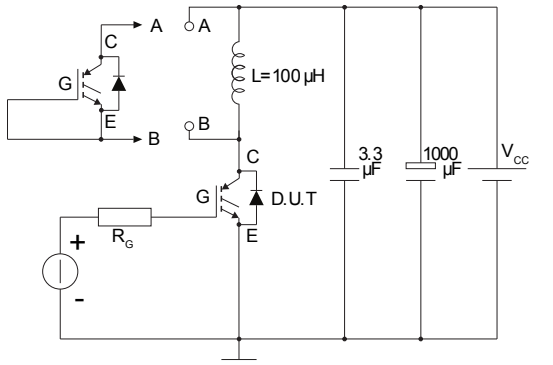
**Figure 13. Capacitance variations**

**Figure 14. Gate charge vs. gate-emitter voltage**

**Figure 15. Switching energy vs. collector current**

**Figure 16. Switching energy vs. gate resistance**

**Figure 17. Switching energy vs. temperature**

**Figure 18. Switching energy vs. collector emitter voltage**


**Figure 19. Short-circuit time and current vs.  $V_{GE}$** 

**Figure 20. Switching times vs. collector current**

**Figure 21. Switching times vs. gate resistance**

**Figure 22. Reverse recovery current vs. diode current slope**

**Figure 23. Reverse recovery time vs. diode current slope**

**Figure 24. Reverse recovery charge vs. diode current slope**


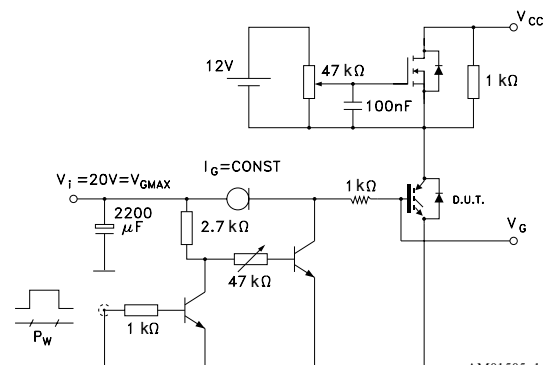


**Figure 25. Reverse recovery energy vs. diode current slope**

**Figure 26. Thermal impedance for IGBT**

**Figure 27. Thermal impedance for diode**


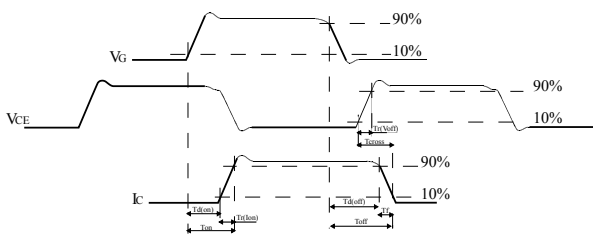
### 3 Test circuits

**Figure 28. Test circuit for inductive load switching**


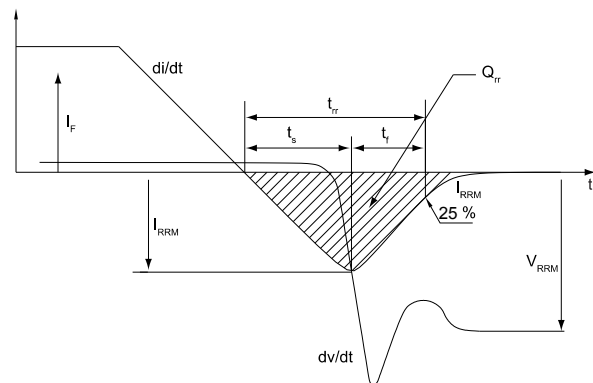
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**Figure 29. Gate charge test circuit**


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**Figure 30. Switching waveform**


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**Figure 31. Diode reverse recovery waveform**


AM01507v1

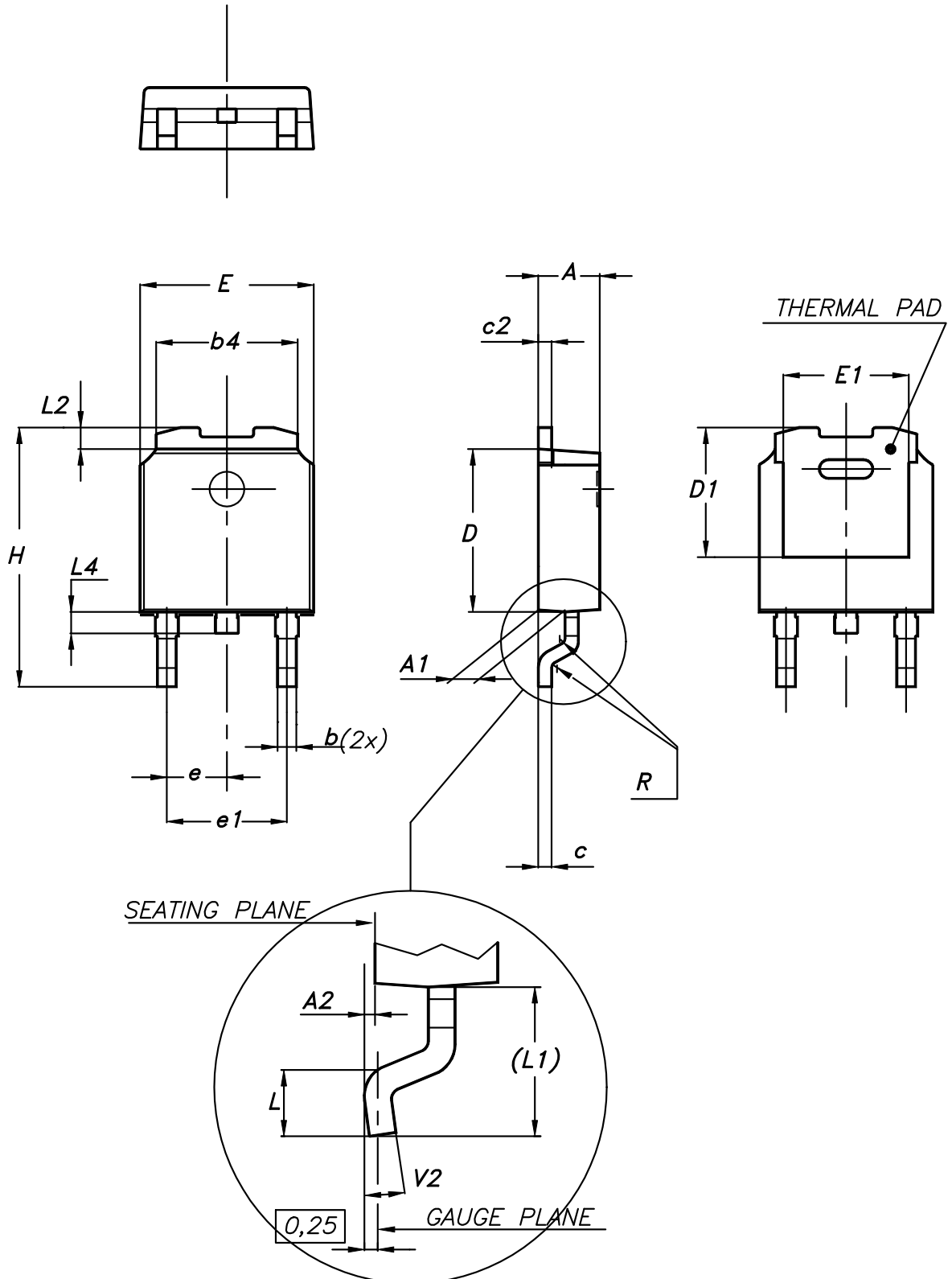
## 4 Package information

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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 DPAK (TO-252) type A2 package information

Figure 32. DPAK (TO-252) type A2 package outline



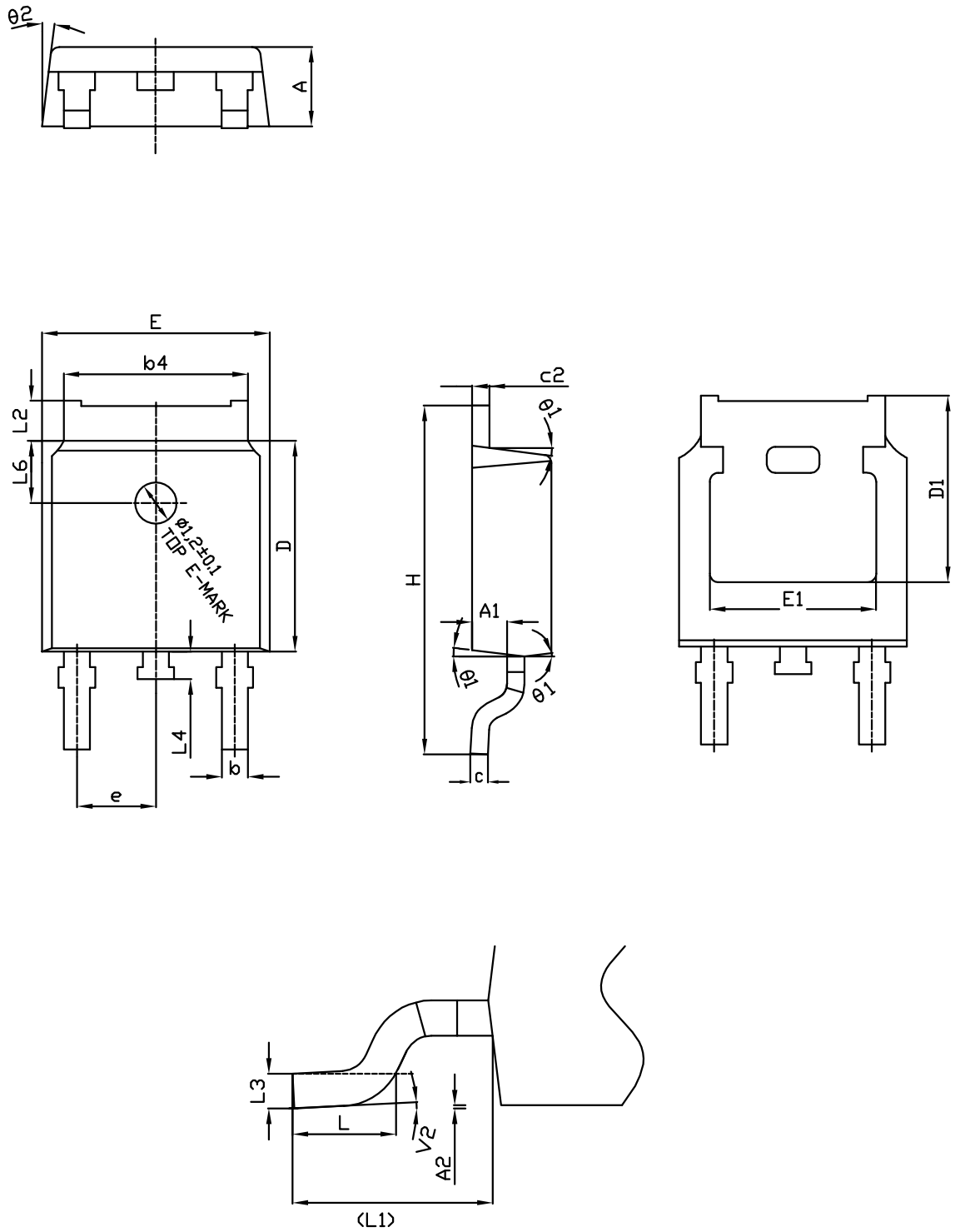
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**Table 7. DPAK (TO-252) type A2 mechanical data**

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	2.159	2.286	2.413
e1	4.445	4.572	4.699
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°

## 4.2 DPAK (TO-252) type C2 package information

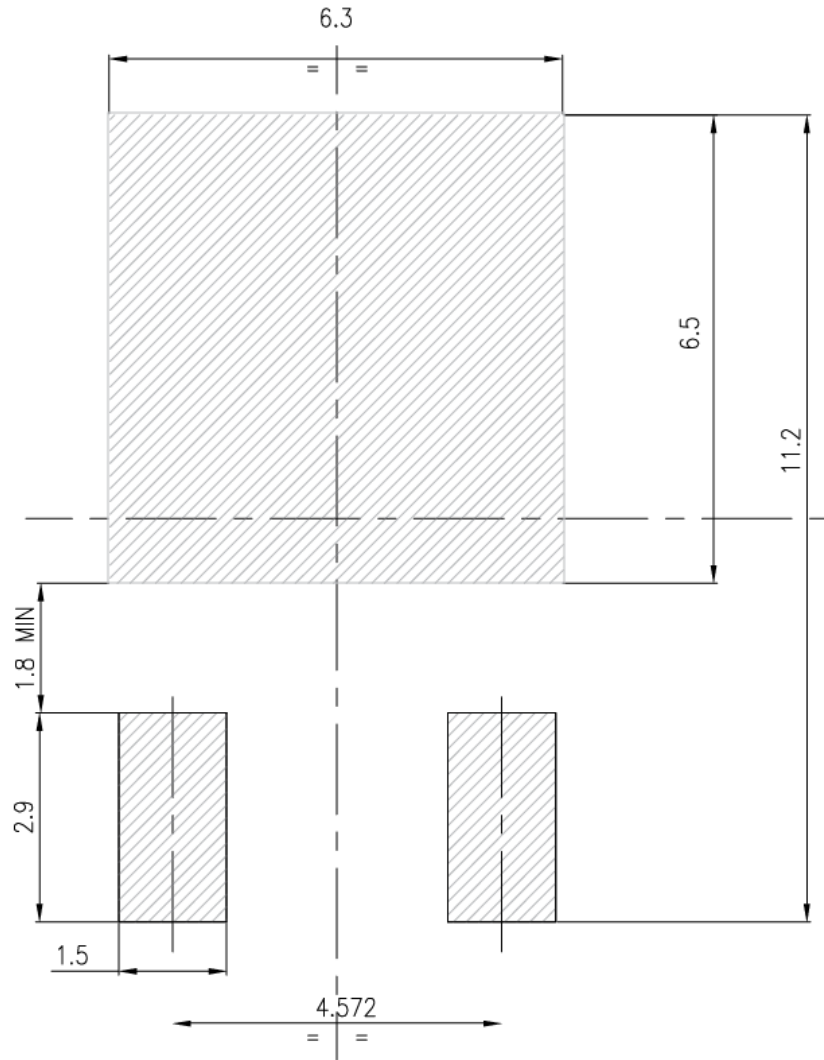
Figure 33. DPAK (TO-252) type C2 package outline



**Table 8. DPAK (TO-252) type C2 mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	2.20	2.30	2.38
A1	0.90	1.01	1.10
A2	0.00		0.10
b	0.72		0.85
b4	5.13	5.33	5.46
c	0.47		0.60
c2	0.47		0.60
D	6.00	6.10	6.20
D1	5.10		5.60
E	6.50	6.60	6.70
E1	5.20		5.50
e	2.186	2.286	2.386
H	9.80	10.10	10.40
L	1.40	1.50	1.70
L1	2.90 REF		
L2	0.90		1.25
L3	0.51 BSC		
L4	0.60	0.80	1.00
L6	1.80 BSC		
θ1	5°	7°	9°
θ2	5°	7°	9°
V2	0°		8°

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

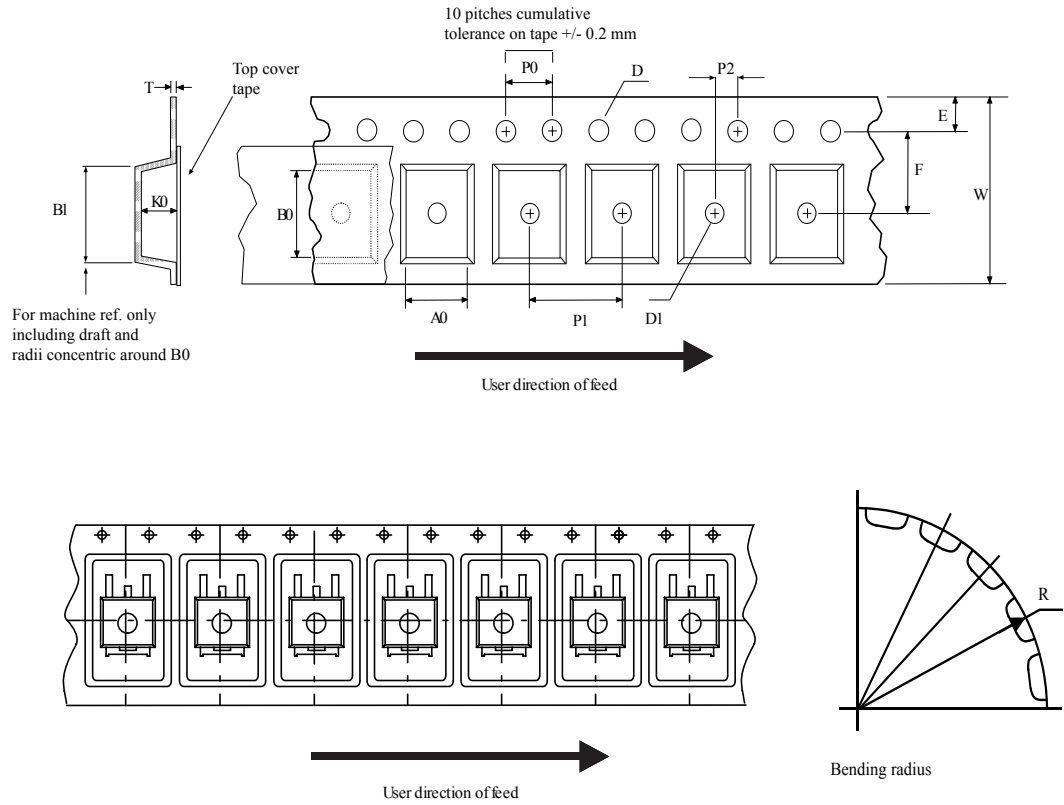


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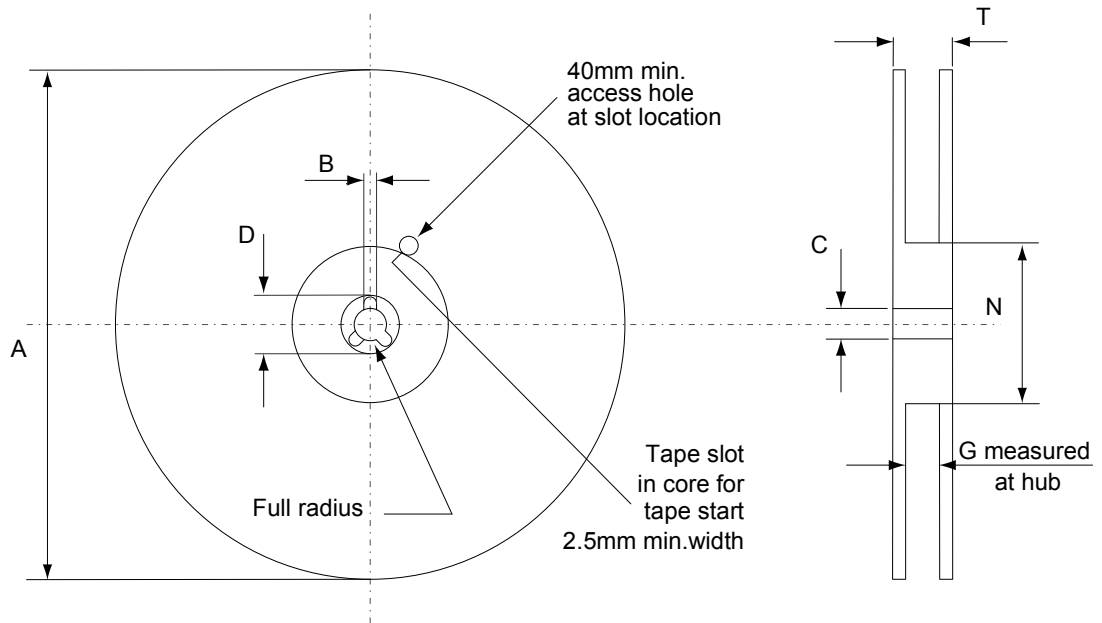
### 4.3 DPAK (TO-252) packing information

Figure 35. DPAK (TO-252) tape outline



AM08852v1

**Figure 36. DPAK (TO-252) reel outline**



AM06038v1

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

Dim.	Tape		Dim.	Reel	
	mm			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			

## Revision history

**Table 10. Document revision history**

Date	Revision	Changes
25-Nov-2015	1	First release.
18-Apr-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 2.1: " <i>Electrical characteristics (curves)</i> " Minor text changes
28-Apr-2016	3	Modified: Table 1: " <i>Device summary</i> " in cover page Minor text changes
21-Nov-2016	4	Updated Table 1. Absolute maximum ratings Updated Figure 24. Reverse recovery charge vs. diode current slope Updated Figure 31. Diode reverse recovery waveform
05-Dec-2018	5	Added Section 4.2 DPAK (TO-252) type C2 package information.

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