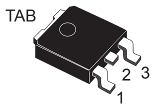
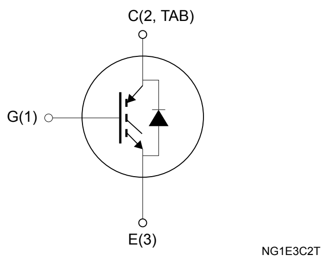
Trench gate field-stop, 650 V, 6 A, low-loss M series IGBT in a DPAK package



DPAK



Features

- Maximum junction temperature: T_J = 175 °C
- 6 µs of minimum short-circuit withstand time
- $V_{CE(sat)}$ = 1.55 V (typ.) @ I_C = 6 A
- Tight parameter distribution
- Safer paralleling
- Positive $V_{CE(sat)}$ temperature coefficient
- Low thermal resistance
- Soft and very fast-recovery antiparallel diode

Applications

- Industrial motor control
- Uninterruptable power supplies (UPS)
- PFC converters

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 link
STGD6M65DF2

Product summary	
Order code	STGD6M65DF2
Marking	G6M65DF2
Package	DPAK
Packing	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	12	A
	Continuous collector current at T_C = 100 °C	6	
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	
I_{FP} (1)	Pulsed forward current	24	A
P_{TOT}	Total power 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

1. *Pulse width is limited by maximum junction temperature.*

Table 2. Thermal data

Symbol	Parameter	Value	Unit
R_{thJC}	Thermal resistance, junction-to-case IGBT	1.7	°C/W
	Thermal resistance, junction-to-case diode	5	
R_{thJA}	Thermal resistance, junction-to-ambient	100	°C/W

2 Electrical characteristics

T_J = 25 °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 V, I_C = 250 µA	650			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_{GE} = 15 V, I_C = 6 A		1.55	2.0	V
		V_{GE} = 15 V, I_C = 6 A, T_J = 125 °C		1.9		
		V_{GE} = 15 V, I_C = 6 A, T_J = 175 °C		2.1		
V_F	Forward on-voltage	I_F = 6 A		2.2	2.6	V
		I_F = 6 A, T_J = 125 °C		2.0		
		I_F = 6 A, T_J = 175 °C		1.9		
$V_{GE(th)}$	Gate threshold voltage	V_{CE} = V_{GE}, I_C = 250 µA	5	6	7	V
I_{CES}	Collector cut-off current	V_{GE} = 0 V, V_{CE} = 650 V			25	µA
I_{GES}	Gate-emitter leakage current	V_{CE} = 0 V, V_{GE} = ±20 V			±250	nA

Table 4. Dynamic characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{ies}	Input capacitance	V_{CE} = 25 V, f = 1 MHz, V_{GE} = 0 V	-	530	-	nF
C_{oes}	Output capacitance		-	31	-	nF
C_{res}	Reverse transfer capacitance		-	11	-	nF
Q_g	Total gate charge	V_{CC} = 520 V, I_C = 6 A, V_{GE} = 0 to 15 V (see Figure 29. Gate charge test circuit)	-	21.2	-	nC
Q_{ge}	Gate-emitter charge		-	5.2	-	nC
Q_{gc}	Gate-collector charge		-	8.8	-	nC

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 V, I_C = 6 A, V_{GE} = 15 V, R_G = 22 Ω (see Figure 28. 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/μs
$t_{d(off)}$	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 V, I_C = 6 A, V_{GE} = 15 V, R_G = 22 Ω, T_J = 175 °C (see Figure 28. Test circuit for inductive load switching)		17	-	ns
t_r	Current rise time			7	-	ns
$(di/dt)_{on}$	Turn-on current slope			685	-	A/μs
$t_{d(off)}$	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} ≤ 400 V, V_{GE} = 15 V, T_{Jstart} ≤ 150 °C	6		-	μs
		V_{CC} ≤ 400 V, V_{GE} = 13 V, T_{Jstart} ≤ 150 °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 = 6 A, V_R = 400 V, V_{GE} = 15 V, di/dt = 1000 A/μs (see Figure 28. Test circuit for inductive load switching)	-	140	-	ns
Q_{rr}	Reverse recovery charge		-	210	-	nC
I_{rrm}	Reverse recovery current		-	6.6	-	A
dI_{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 A, V_R = 400 V, V_{GE} = 15 V, di/dt = 1000 A/μs, T_J = 175 °C (see Figure 28. Test circuit for inductive load switching)	-	200	-	ns
Q_{rr}	Reverse recovery charge		-	473	-	nC
I_{rrm}	Reverse recovery current		-	9.6	-	A
dI_{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 1. Power dissipation vs. case temperature

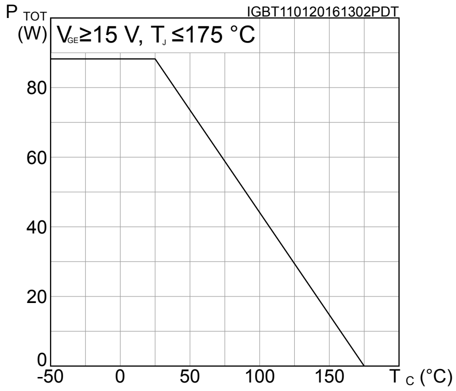


Figure 2. Collector current vs. case temperature

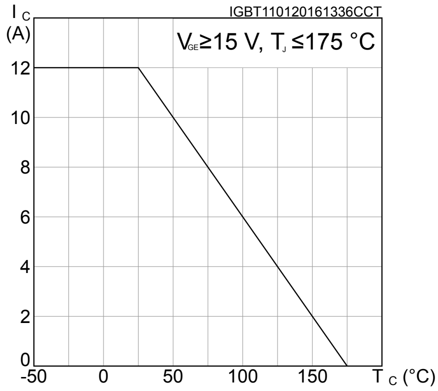


Figure 3. Output characteristics (T_J = 25 °C)

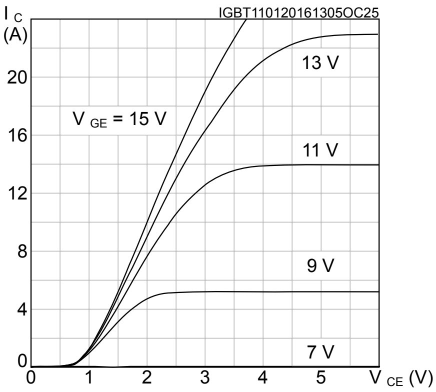


Figure 4. Output characteristics (T_J = 175 °C)

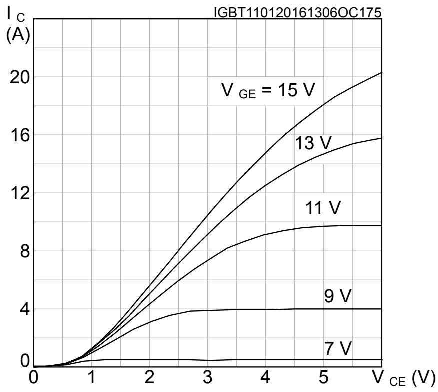


Figure 5. V_{CE}(sat) vs. junction temperature

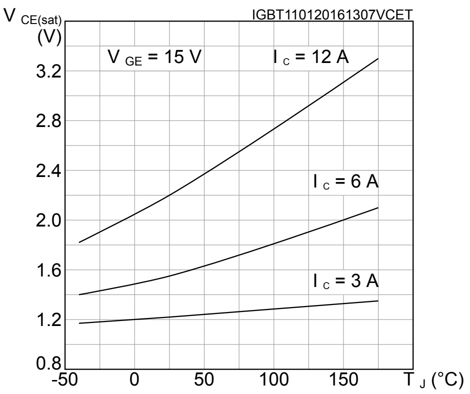


Figure 6. V_{CE}(sat) vs. collector current

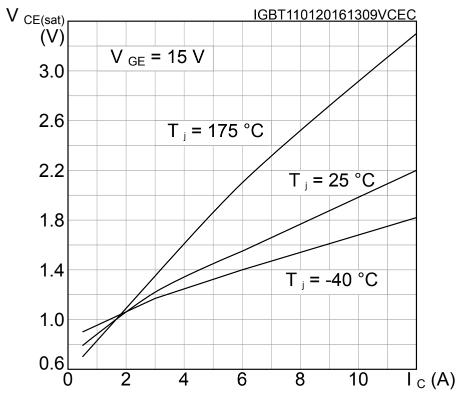


Figure 7. **Collector current vs. switching frequency**

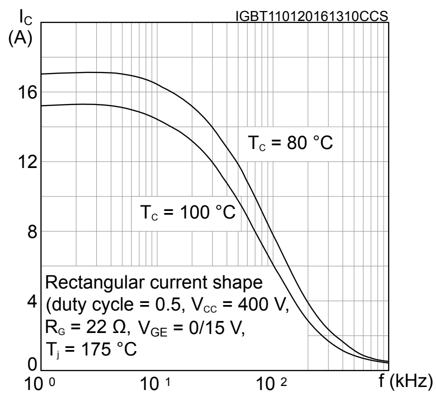


Figure 8. **Forward bias safe operating area**

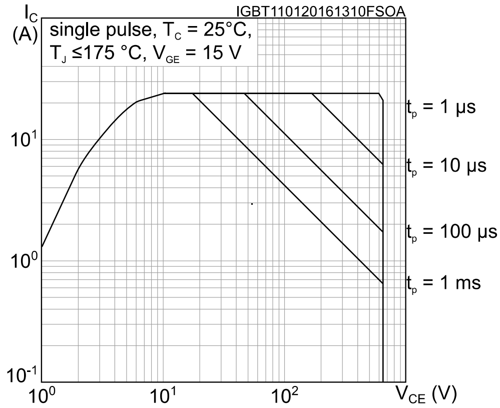


Figure 9. **Transfer characteristics**

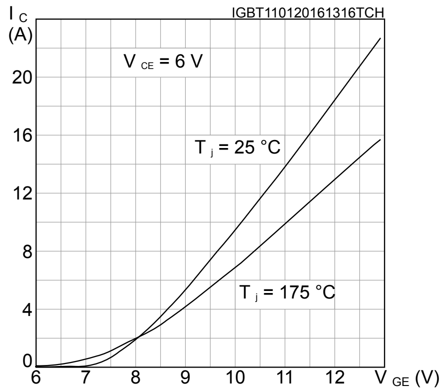


Figure 10. **Diode V_F vs. forward current**

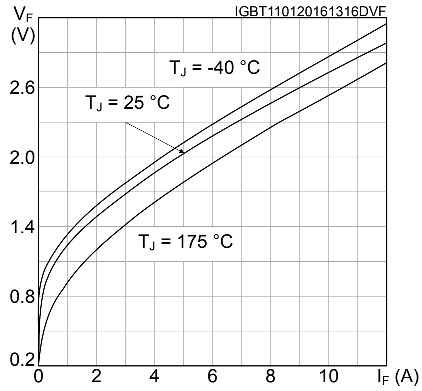


Figure 11. **Normalized $V_{GE(th)}$ vs. junction temperature**

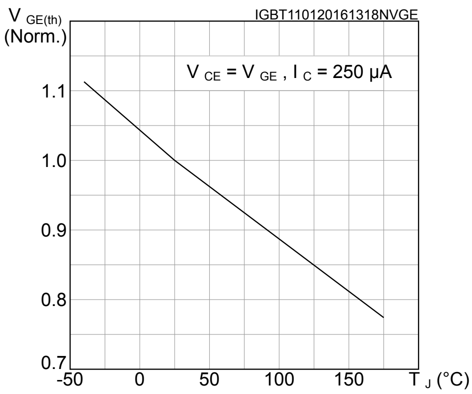


Figure 12. **Normalized $V_{(BR)CES}$ vs. junction temperature**

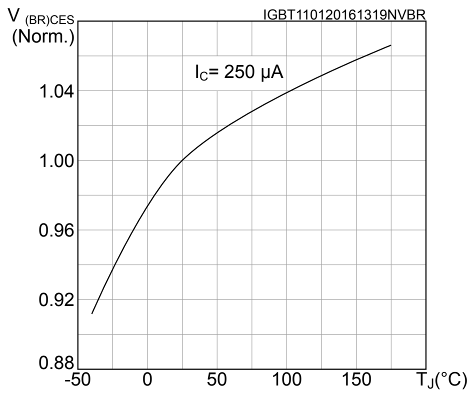


Figure 13. Capacitance variations

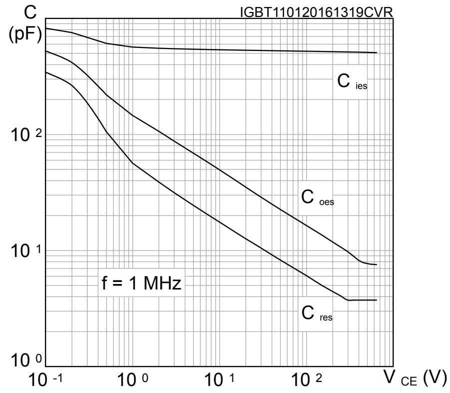


Figure 14. Gate charge vs. gate-emitter voltage

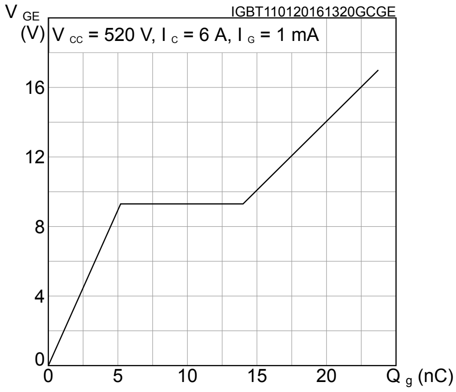


Figure 15. Switching energy vs. collector current

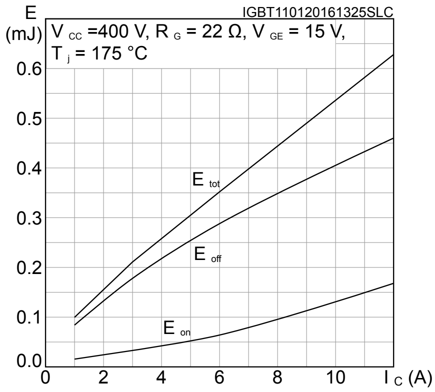


Figure 16. Switching energy vs. gate resistance

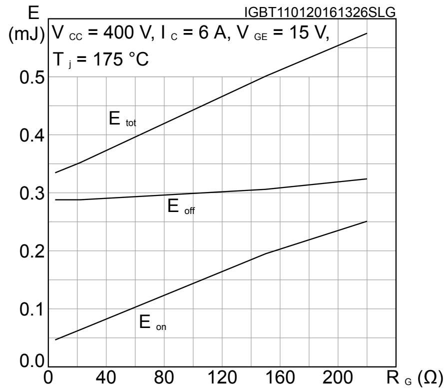


Figure 17. Switching energy vs. temperature

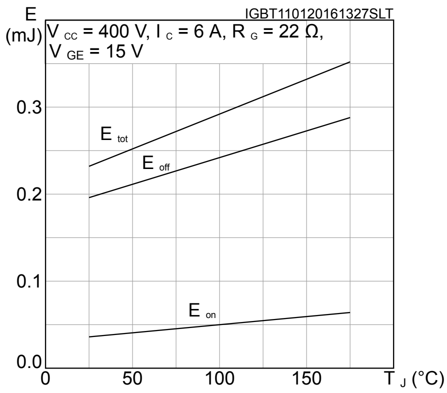


Figure 18. Switching energy vs. collector emitter voltage

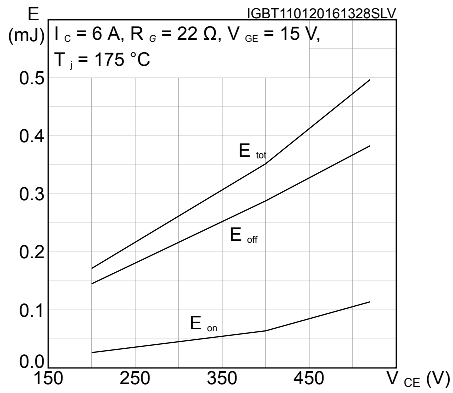


Figure 19. Short-circuit time and current vs. V_{GE}

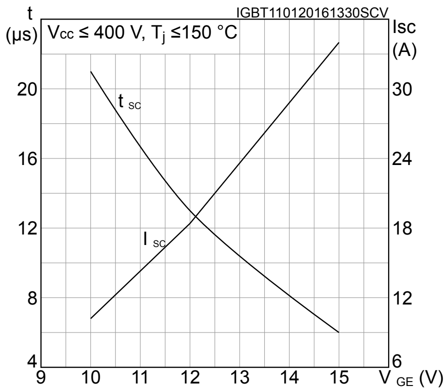


Figure 20. Switching times vs. collector current

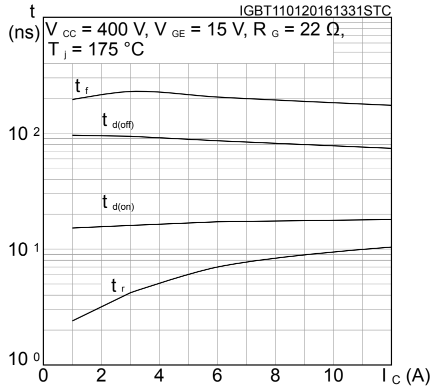


Figure 21. Switching times vs. gate resistance

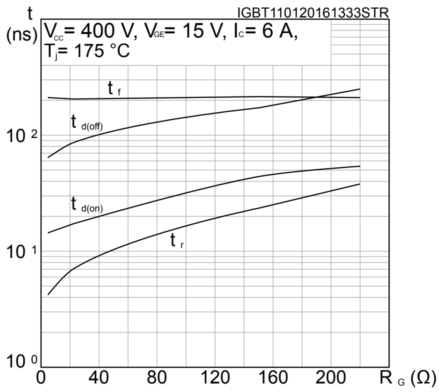


Figure 22. Reverse recovery current vs. diode current slope

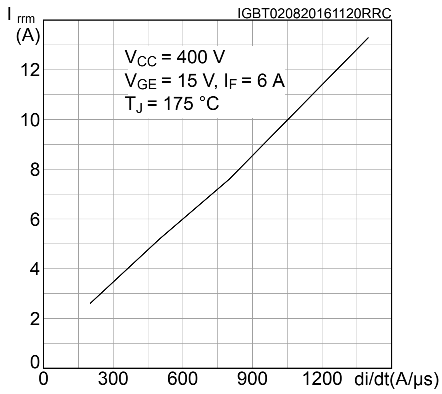


Figure 23. Reverse recovery time vs. diode current slope

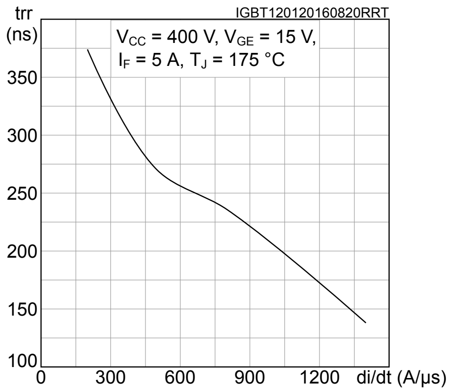


Figure 24. Reverse recovery charge vs. diode current slope

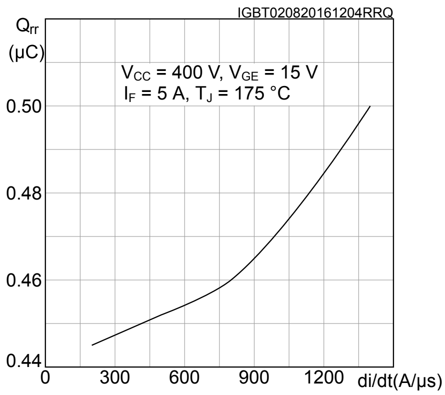


Figure 25. Reverse recovery energy vs. diode current slope

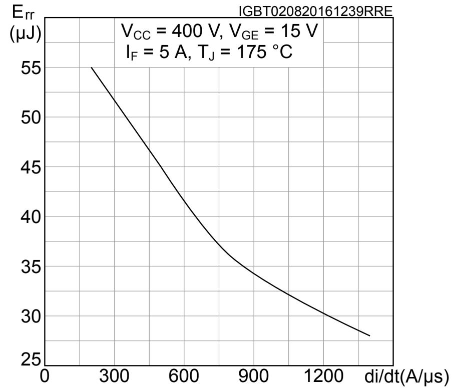


Figure 26. Thermal impedance for IGBT

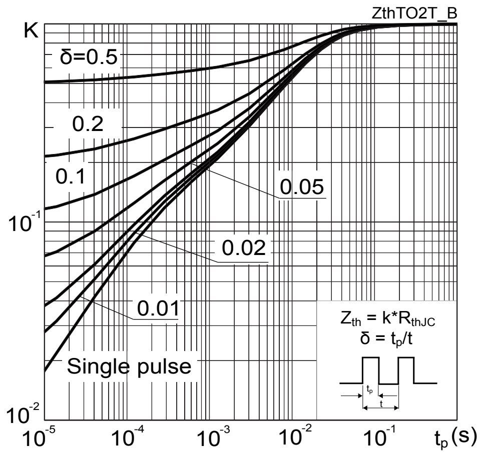
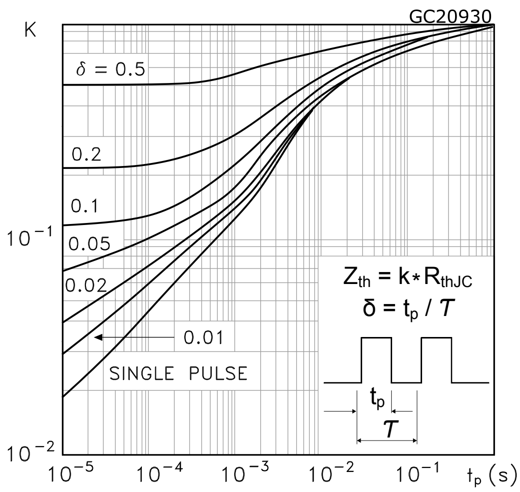


Figure 27. Thermal impedance for diode



3 Test circuits

Figure 28. Test circuit for inductive load switching

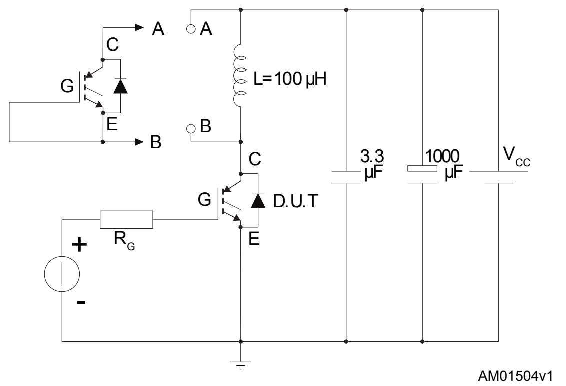


Figure 29. Gate charge test circuit

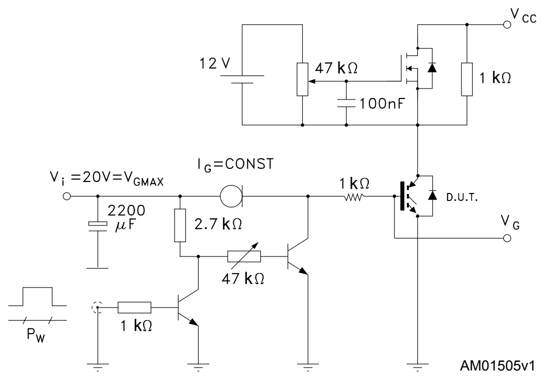


Figure 30. Switching waveform

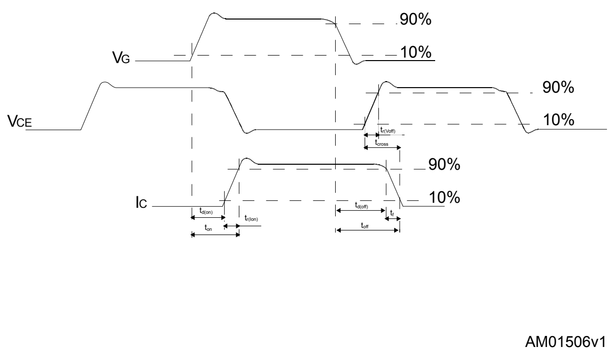
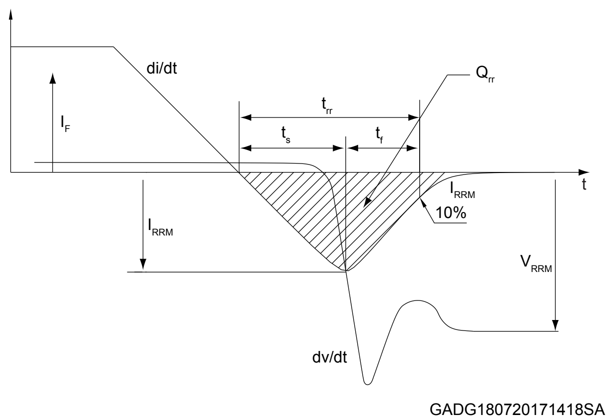


Figure 31. Diode reverse recovery waveform

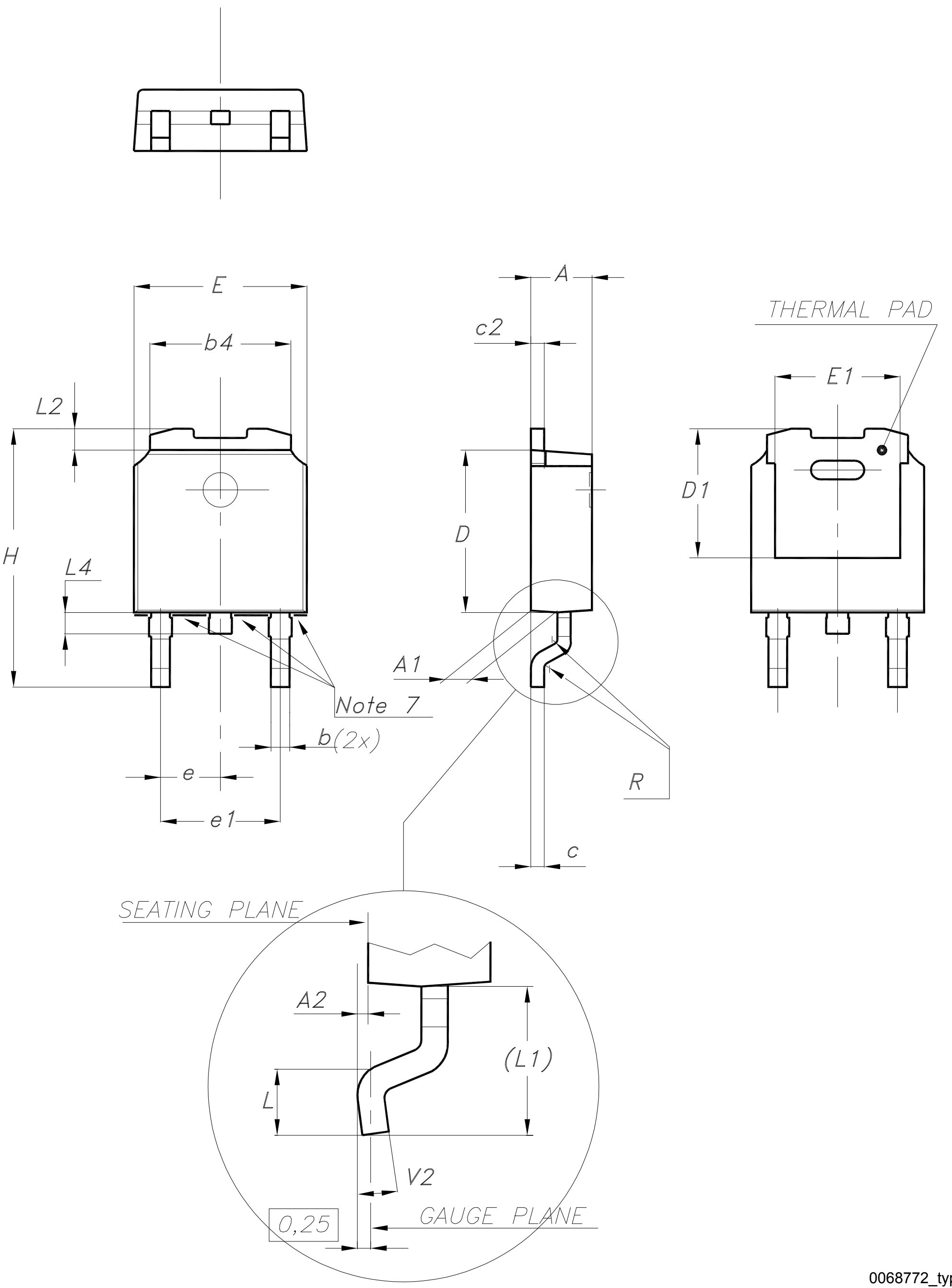


4 Package information

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



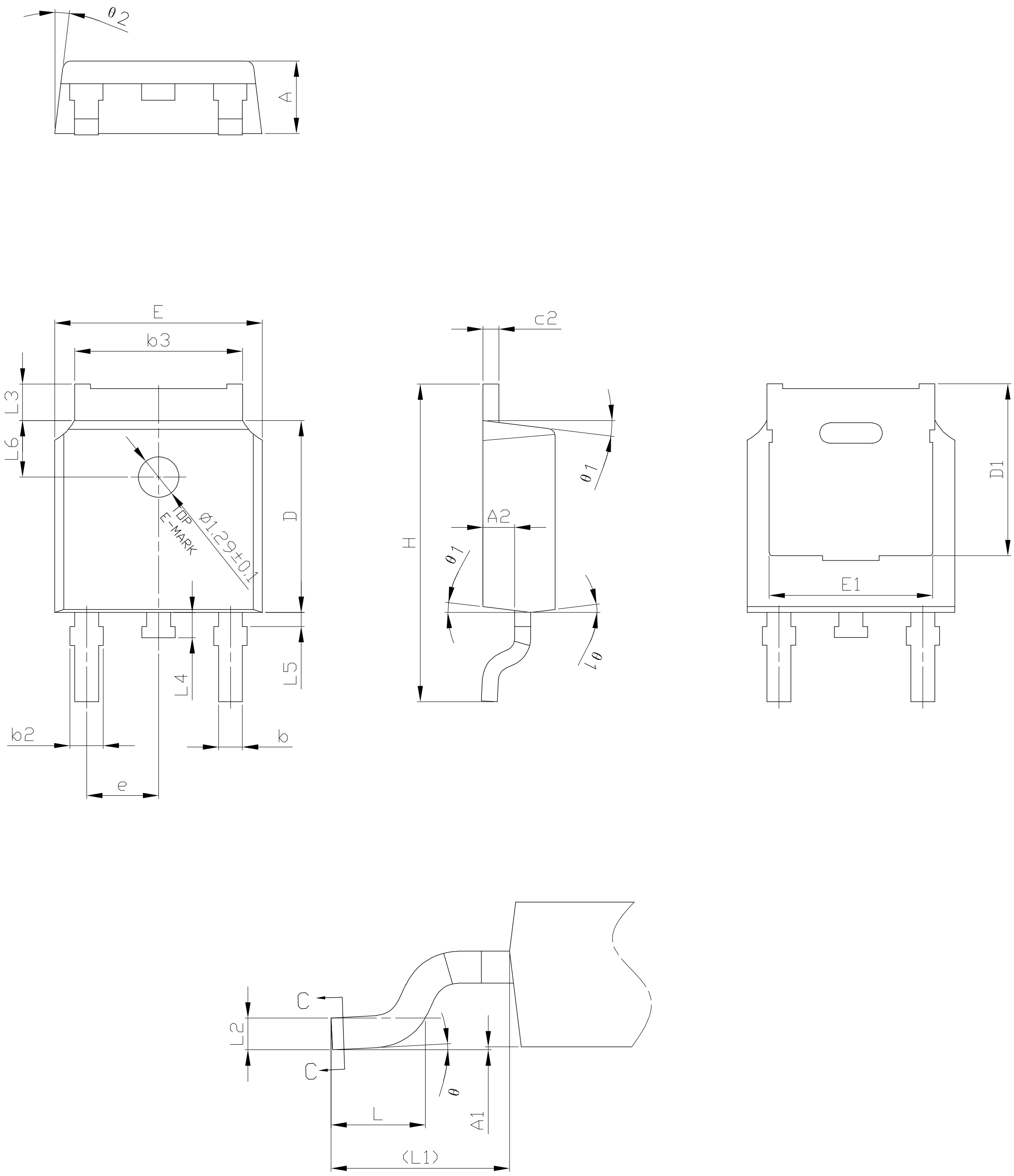
0068772_type-A2_rev34

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 C3 package information

Figure 33. DPAK (TO-252) type C3 package outline

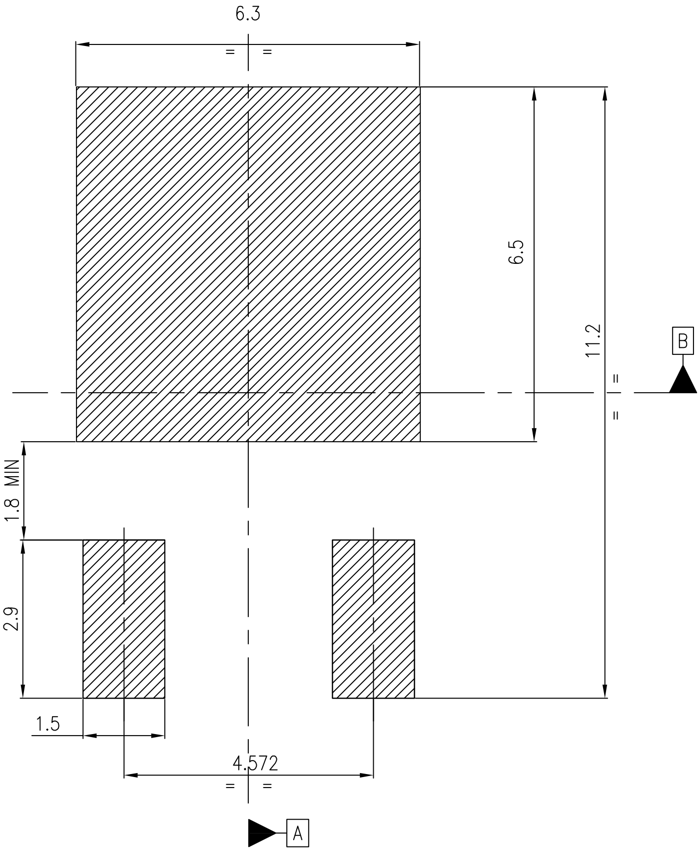


0068772_type-C3_rev34

Table 8. **DPAK (TO-252) type C3 mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	2.20	2.30	2.38
A1	0.00		0.10
A2	0.90	1.01	1.10
b	0.72		0.85
b2	0.72		1.10
b3	5.13	5.33	5.46
c	0.47		0.60
c2	0.47		0.60
D	6.00	6.10	6.20
D1	5.20	5.45	5.70
E	6.50	6.60	6.70
E1	5.00	5.20	5.40
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		0.51 BSC	
L3	0.90		1.25
L4	0.60	0.80	1.00
L5	0.15		0.75
L6		1.80 REF	
θ	0°		8°
θ1	5°	7°	9°
θ2	5°	7°	9°

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



Notes:
1) This footprint is able to ensure insulation up to 630 Vrms (according to CEI IEC 664−1)
2) The device must be positioned within ⌖ 0.05 A B

FP_0068772_34

4.3 DPAK (TO-252) packing information

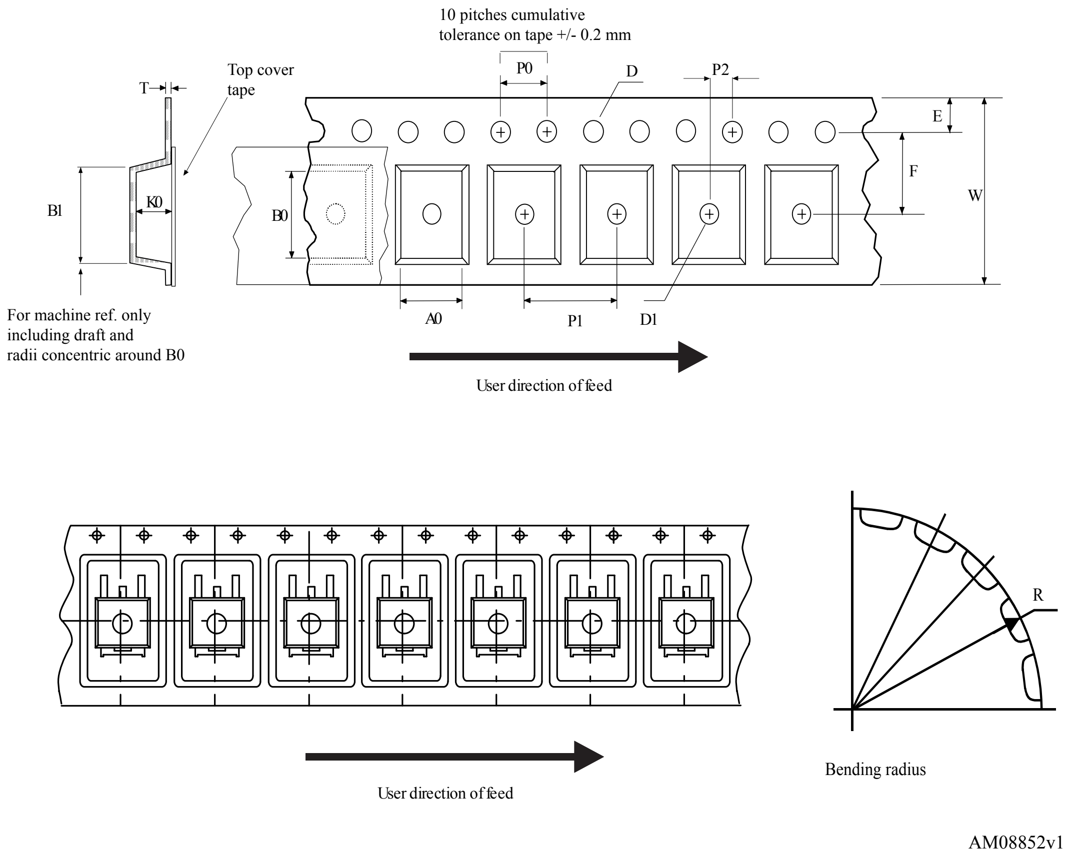


Figure 35. DPAK (TO-252) tape outline

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

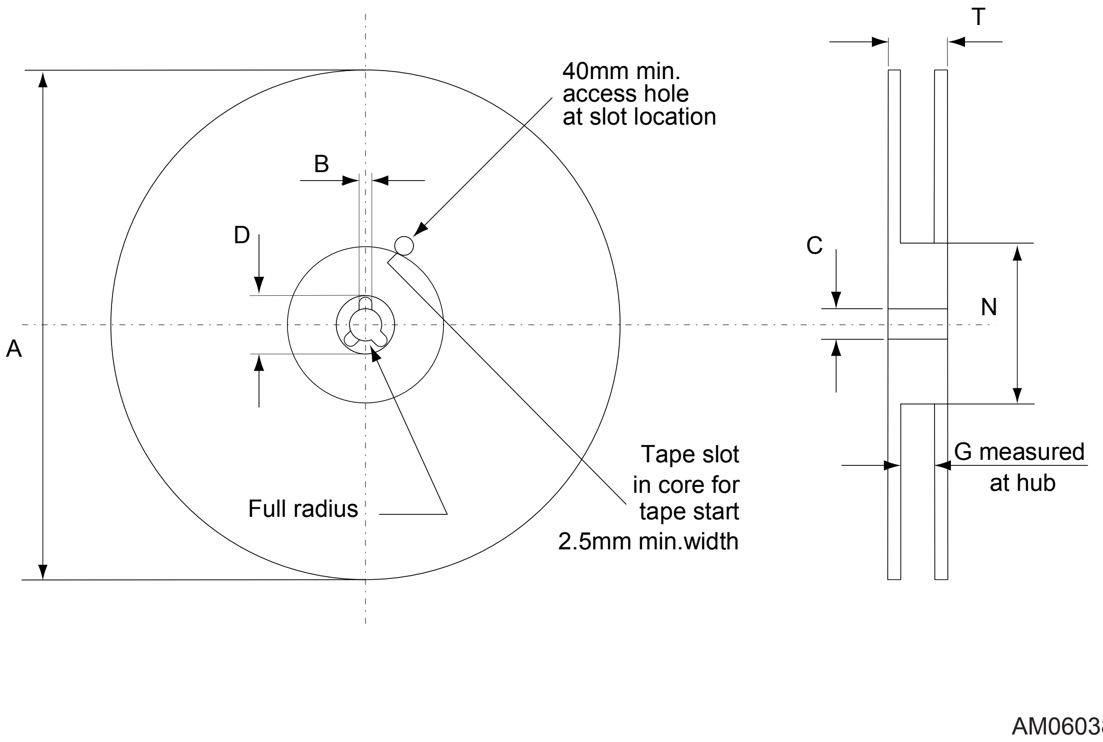


Table 9. **DPAK (TO-252) tape and reel mechanical data**

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			

Revision history

Table 10. Document revision history

Date	Revision	Changes
30-Nov-2015	1	First release.
13-Jan-2016	2	Modified: *Table 4: "Static characteristics"*, *Table 5: "Dynamic characteristics"*, *Table 6: "IGBT switching characteristics (inductive load)"* and *Table 7: "Diode switching characteristics (inductive load)"* Added: *Section 2.1: "Electrical characteristics (curves)"* Minor text changes
04-Aug-2016	3	Updated: *Table 2: "Absolute maximum ratings"*, *Table 4: "Static characteristics"*, *Table 6: "IGBT switching characteristics (inductive load)"*,*Table 7: "Diode switching characteristics (inductive load)"*. Updated *Figure 9: "Forward bias safe operating area"*, *Figure 12: "Normalized VGE(th) vs. junction temperature"*, *Figure 20: "Short-circuit time and current vs.* V_{GE}*"*,*Figure 23: "Reverse recovery current vs. diode current slope"*. Changed:*Figure 25: "Reverse recovery charge vs. diode current slope"*, and *Figure 26: "Reverse recovery energy vs. diode current slope"*. Document status promoted from preliminary to production data.
09-Jun-2023	4	Updated the entire Section 4 Package information. Minor text changes.

Contents