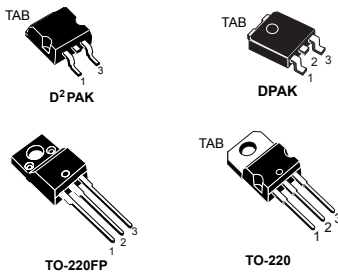


## Trench gate field-stop 600 V, 5 A high speed H series IGBT

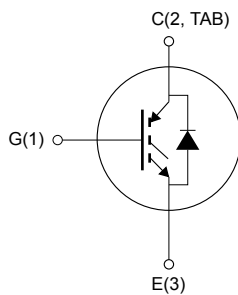


### Features

- High-speed switching
- Tight parameter distribution
- Safe paralleling
- Low thermal resistance
- Short-circuit rated
- Ultrafast soft recovery antiparallel diode

### Applications

- Motor control
- UPS
- PFC



NG1E3C2T

### Description

These devices are IGBTs developed using an advanced proprietary trench gate field-stop structure. These devices are part of the H series of IGBTs, which represents an optimum compromise between conduction and switching losses to maximize the efficiency of high switching frequency converters. Furthermore, a slightly positive  $V_{CE(sat)}$  temperature coefficient and very tight parameter distribution result in safer paralleling operation.



#### Product status link

[STGB5H60DF](#)

[STGD5H60DF](#)

[STGF5H60DF](#)

[STGP5H60DF](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK, TO-220	DPAK	TO-220FP	
V <sub>CES</sub>	Collector-emitter voltage (V <sub>GE</sub> = 0)	600			V
I <sub>C</sub>	Continuous collector current at T <sub>C</sub> = 25 °C	10		10 <sup>(1)</sup>	A
	Continuous collector current at T <sub>C</sub> = 100 °C	5		5 <sup>(1)</sup>	
I <sub>CP</sub> <sup>(2)</sup>	Pulsed collector current	20		20 <sup>(1)</sup>	A
V <sub>GE</sub>	Gate-emitter voltage	±20			V
I <sub>F</sub>	Continuous forward current T <sub>C</sub> = 25 °C	10		10 <sup>(1)</sup>	A
	Continuous forward current at T <sub>C</sub> = 100 °C	5		5 <sup>(1)</sup>	
I <sub>FP</sub> <sup>(2)</sup>	Pulsed forward current	20		20 <sup>(1)</sup>	A
V <sub>ISO</sub>	Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; T <sub>C</sub> = 25 °C)			2500	V
P <sub>TOT</sub>	Total power dissipation at T <sub>C</sub> = 25 °C	88	83	24	W
T <sub>STG</sub>	Storage temperature range	-55 to 150			°C
T <sub>J</sub>	Operating junction temperature range	-55 to 175			

1. Limited by maximum junction temperature.
2. Pulse width limited by maximum junction temperature.

**Table 2. Thermal data**

Symbol	Parameter	Value			Unit
		D <sup>2</sup> PAK, TO-220	DPAK	TO-220FP	
R <sub>thJC</sub>	Thermal resistance junction-case IGBT	1.7	1.8	6.2	°C/W
R <sub>thJC</sub>	Thermal resistance junction-case diode	4	4.5	7	°C/W
R <sub>thJA</sub>	Thermal resistance junction-ambient	62.5	100	62.5	°C/W

## 2 Electrical characteristics

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

**Table 3. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage	$V_{GE} = 0\text{ V}$ , $I_C = 2\text{ mA}$	600			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}$ , $I_C = 5\text{ A}$		1.5	1.95	V
		$V_{GE} = 15\text{ V}$ , $I_C = 5\text{ A}$ , $T_J = 125\text{ °C}$		1.6		
		$V_{GE} = 15\text{ V}$ , $I_C = 5\text{ A}$ , $T_J = 175\text{ °C}$		1.7		
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}$ , $I_C = 250\text{ }\mu\text{A}$	4.8	6.2	6.9	V
$I_{CES}$	Collector cut-off current	$V_{CE} = 600\text{ V}$ , $V_{GE} = 0\text{ V}$			25	$\mu\text{A}$
$I_{GES}$	Gate-emitter leakage current	$V_{GE} = \pm 20\text{ V}$ , $V_{CE} = 0\text{ V}$			$\pm 250$	nA

**Table 4. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$	-	855	-	$\mu\text{F}$
$C_{oes}$	Output capacitance			34		
$C_{res}$	Reverse transfer capacitance			19		
$Q_g$	Total gate charge	$V_{CC} = 480\text{ V}$ , $I_C = 5\text{ A}$ , $V_{GE} = 0\text{ to }15\text{ V}$ (see Figure 35. Gate charge test circuit)	-	38	-	nC
$Q_{ge}$	Gate-emitter charge			6.5		
$Q_{gc}$	Gate-collector charge			17.5		

**Table 5. Switching characteristics (inductive load)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ ,	-	30	-	ns
$t_r$	Current rise time	$R_G = 47\ \Omega$ , $V_{GE} = 15\text{ V}$		10.8		
$(di/dt)_{on}$	Turn-on current slope	(see Figure 34. Test circuit for inductive load switching and Figure 36. Switching waveform)		370		
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ ,	-	28	-	ns
$t_r$	Current rise time	$R_G = 47\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_J = 175\text{ }^\circ\text{C}$		11		
$(di/dt)_{on}$	Turn-on current slope	(see Figure 34. Test circuit for inductive load switching and Figure 36. Switching waveform)		363		
$t_{r(voff)}$	Off voltage rise time	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ , $R_G = 47\ \Omega$ , $V_{GE} = 15\text{ V}$	-	29	-	ns
$t_{d(off)}$	Turn-off delay time			140		
$t_f$	Current fall time			95		
$t_{r(voff)}$	Off voltage rise time	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ , $R_G = 47\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_J = 175\text{ }^\circ\text{C}$	-	44	-	ns
$t_{d(off)}$	Turn-off delay time			146		
$t_f$	Current fall time			134		
$t_{sc}$	Short-circuit withstand time	$V_{CC} \leq 360\text{ V}$ , $V_{GE} = 15\text{ V}$ , $R_G = 47\ \Omega$	-	5	-	$\mu$ s

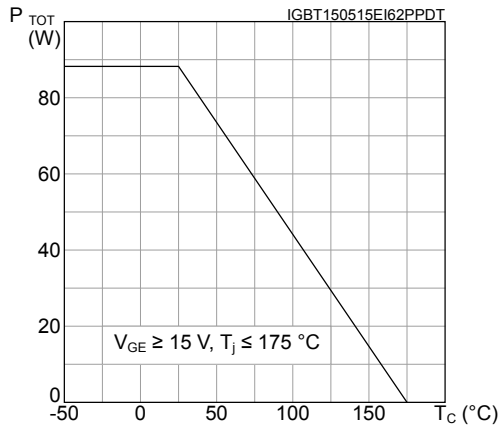
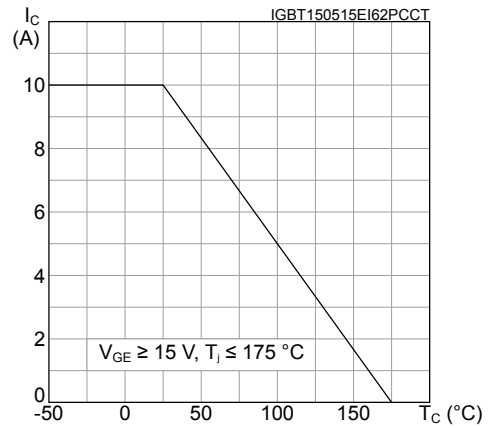
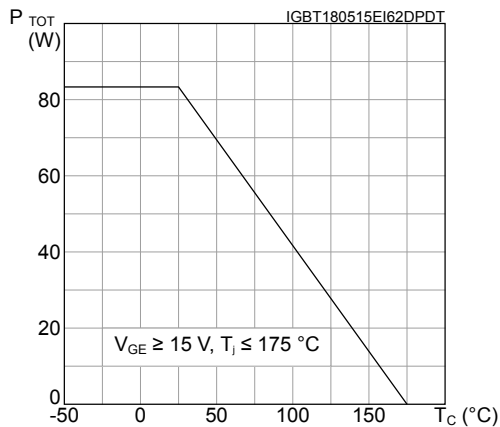
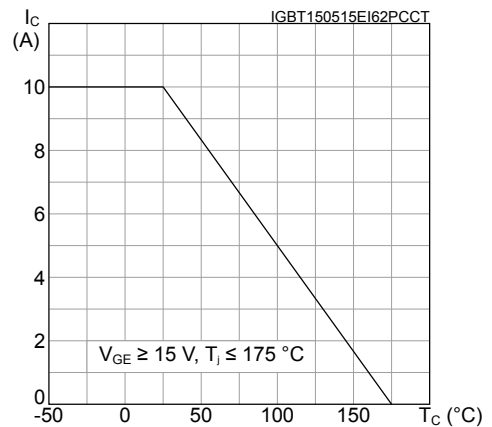
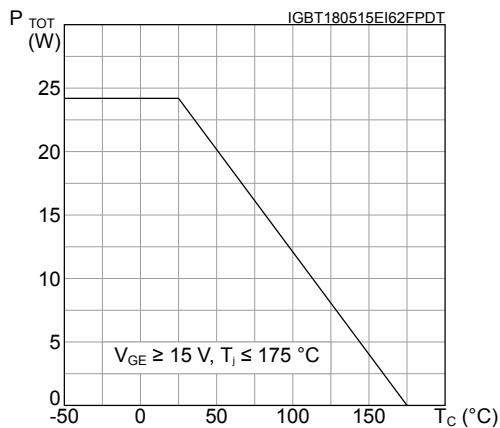
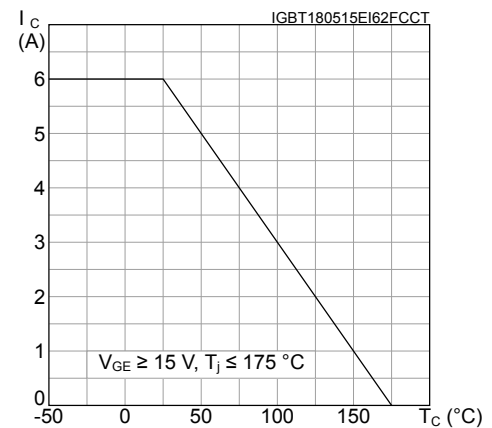
**Table 6. Switching energy (inductive load)**

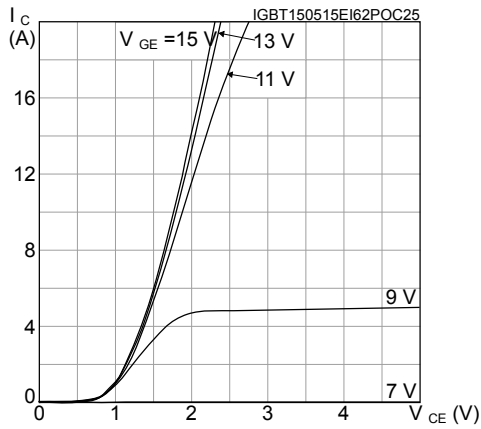
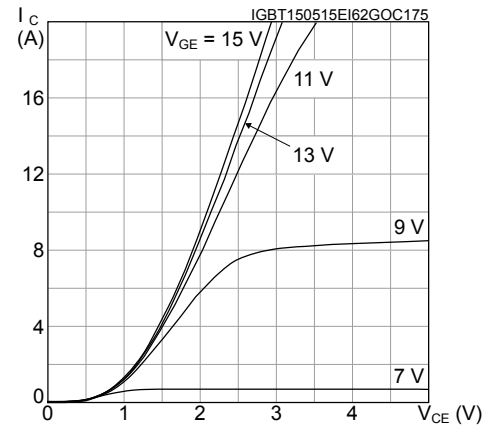
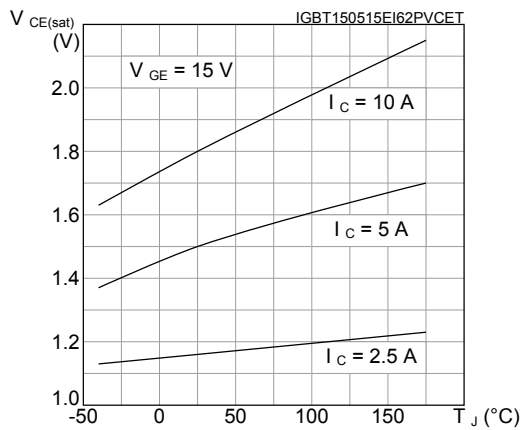
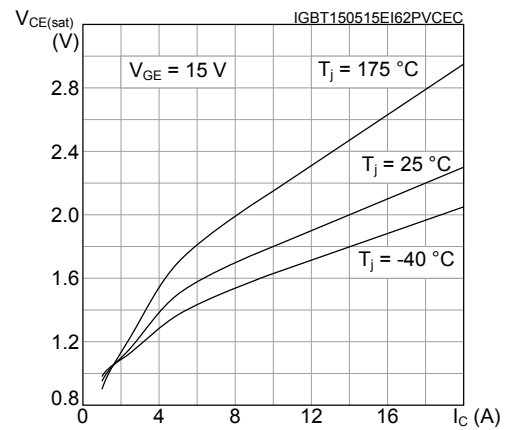
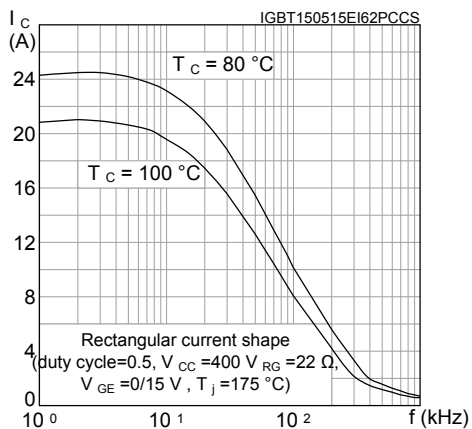
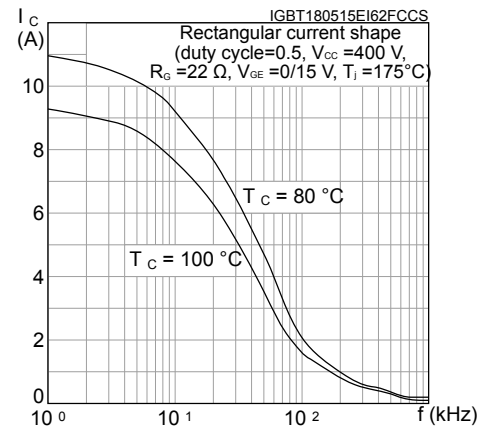
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$	Turn-on switching energy	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ , $R_G = 47\ \Omega$ , $V_{GE} = 15\text{ V}$	-	56	-	$\mu$ J
$E_{off}^{(2)}$	Turn-off switching energy			78.5		
$E_{ts}$	Total switching energy			134.5		
$E_{on}^{(1)}$	Turn-on switching energy	$V_{CE} = 400\text{ V}$ , $I_C = 5\text{ A}$ , $R_G = 47\ \Omega$ , $V_{GE} = 15\text{ V}$ , $T_J = 175\text{ }^\circ\text{C}$	-	87	-	$\mu$ J
$E_{off}^{(2)}$	Turn-off switching energy			134		
$E_{ts}$	Total switching energy			221		

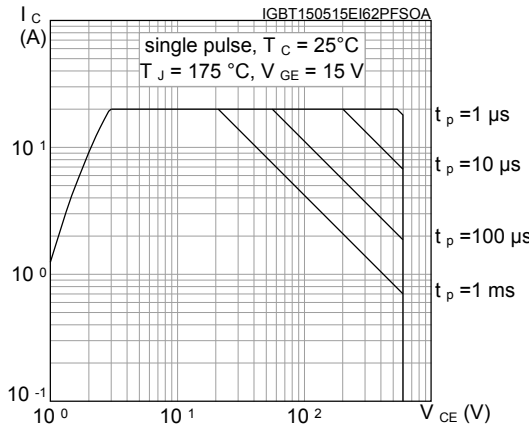
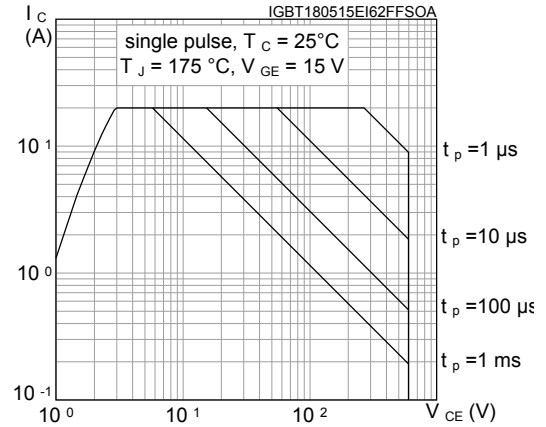
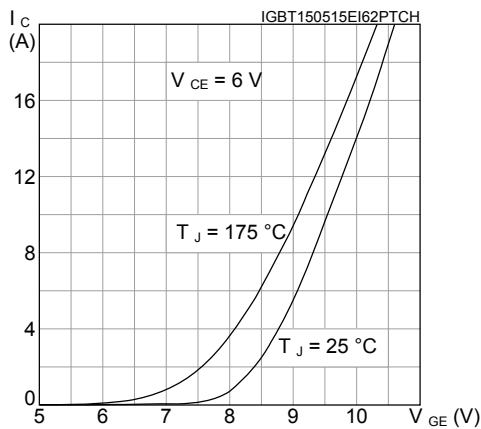
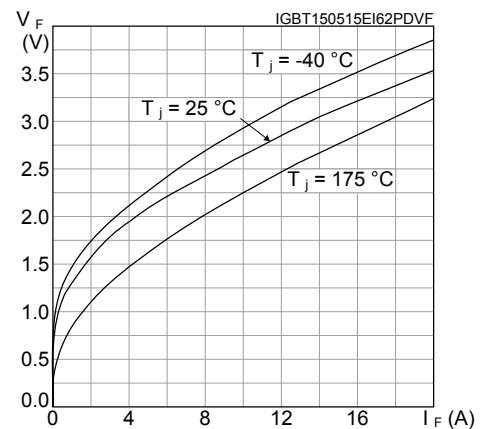
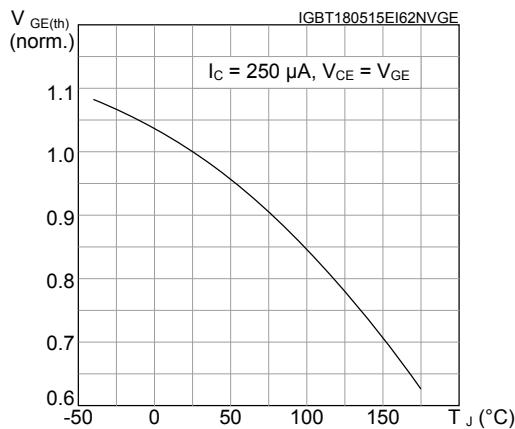
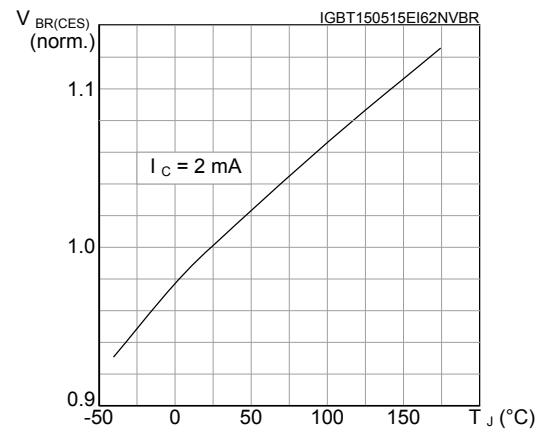
1. Including the reverse recovery of the diode.
2. Including the tail of the collector current.

**Table 7. Collector-emitter diode**

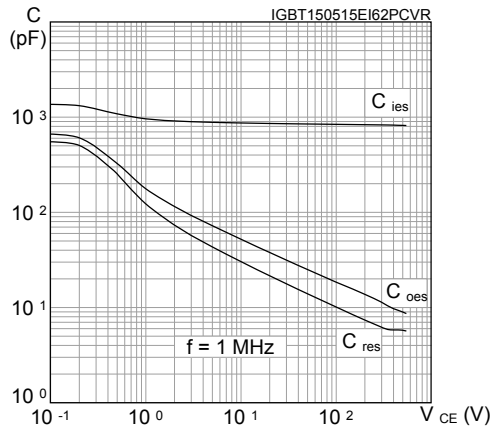
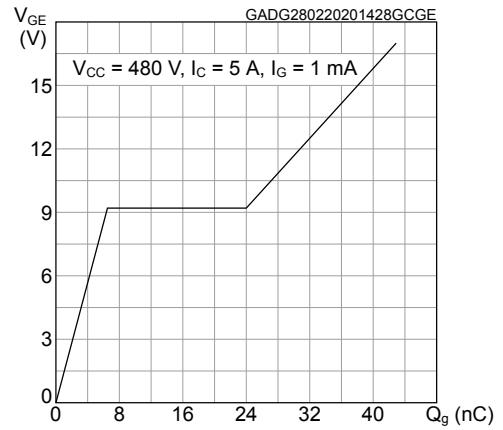
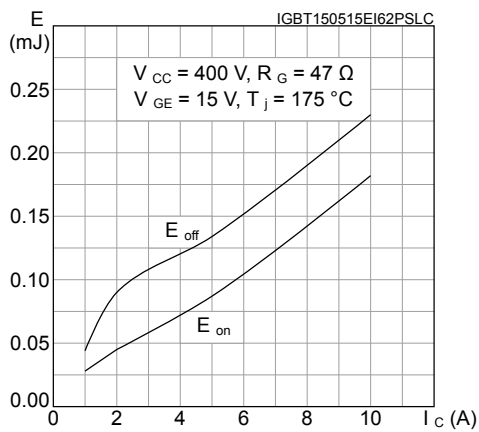
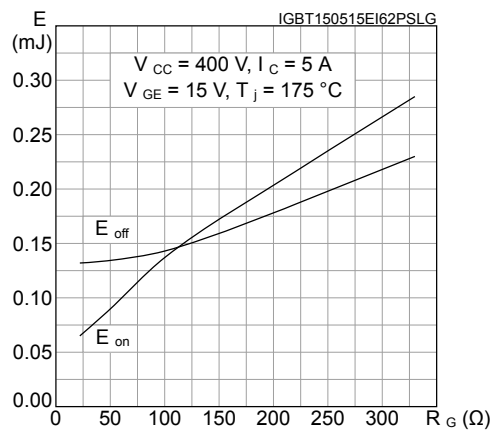
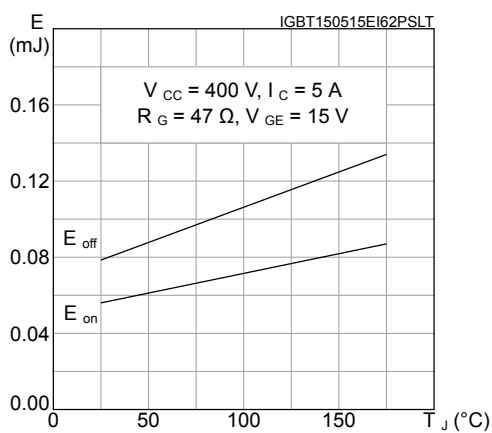
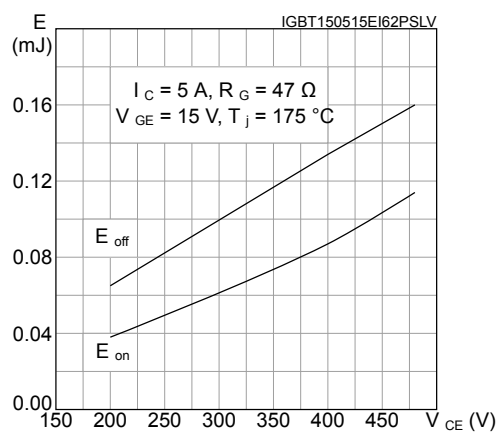
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit		
$V_F$	Forward on-voltage	$I_F = 5 \text{ A}$	-	2.1	-	V		
		$I_F = 5 \text{ A}, T_J = 175 \text{ }^\circ\text{C}$		1.65				
$t_{rr}$	Reverse recovery time	$V_{CC} = 400 \text{ V}; I_F = 5 \text{ A};$ $di_F/dt = 100 \text{ A} / \mu\text{s}$	-	134.5	-	ns		
$Q_{rr}$	Reverse recovery charge			48		nC		
$I_{rrm}$	Reverse recovery current			1.38		A		
$t_{rr}$	Reverse recovery time	$V_{CC} = 400 \text{ V}; I_F = 5 \text{ A};$ $di_F/dt = 100 \text{ A} / \mu\text{s}, T_J = 175 \text{ }^\circ\text{C}$	-	157	-	ns		
				$Q_{rr}$		Reverse recovery charge	165	nC
				$I_{rrm}$		Reverse recovery current	2.4	A

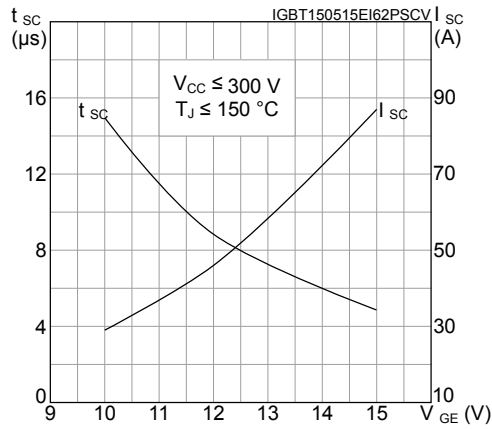
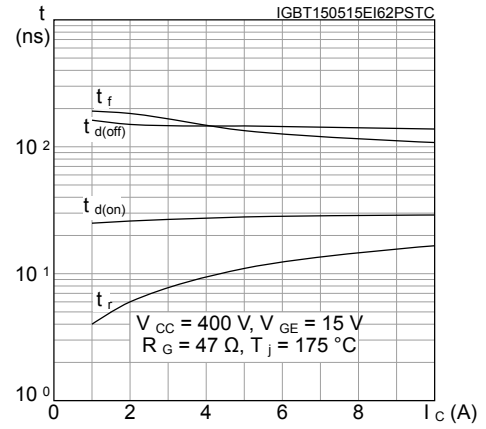
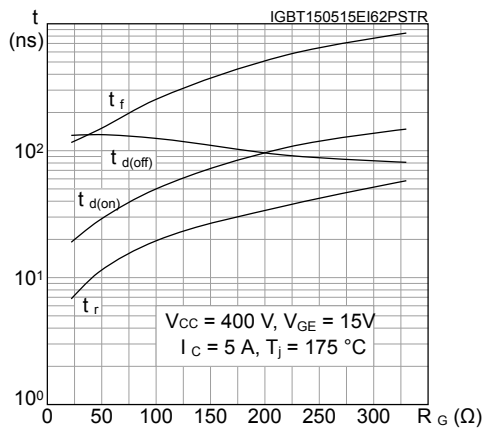
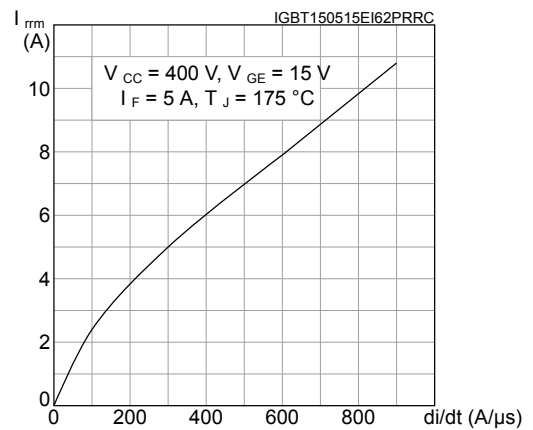
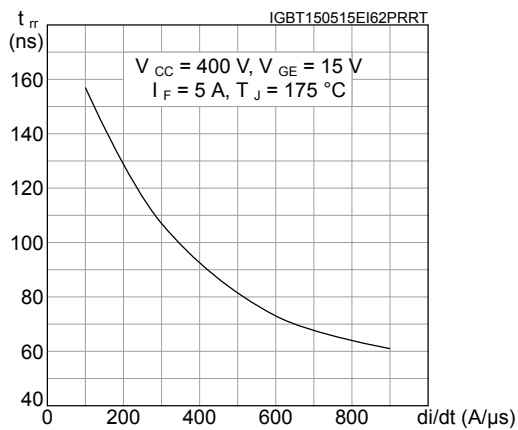
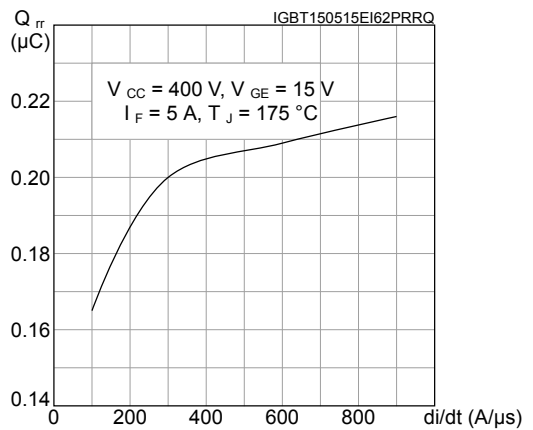
**2.1 Electrical characteristics (curves)**
**Figure 1. Power dissipation vs case temperature for D<sup>2</sup>PAK and TO-220**

**Figure 2. Collector current vs case temperature for D<sup>2</sup>PAK, DPAK and TO-220**

**Figure 3. Power dissipation vs case temperature for DPAK**

**Figure 4. Collector current vs case temperature for DPAK**

**Figure 5. Power dissipation vs case temperature for TO-220FP**

**Figure 6. Collector current vs case temperature for TO-220FP**


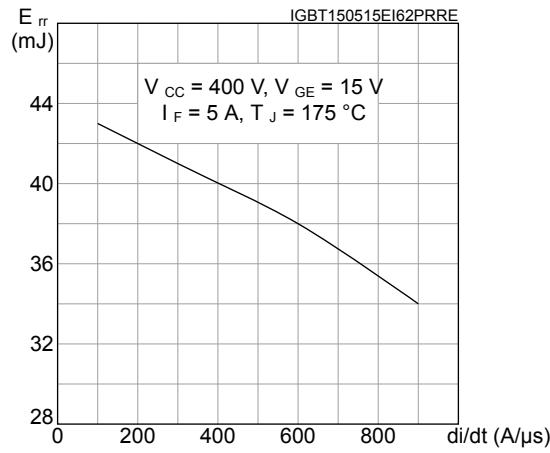
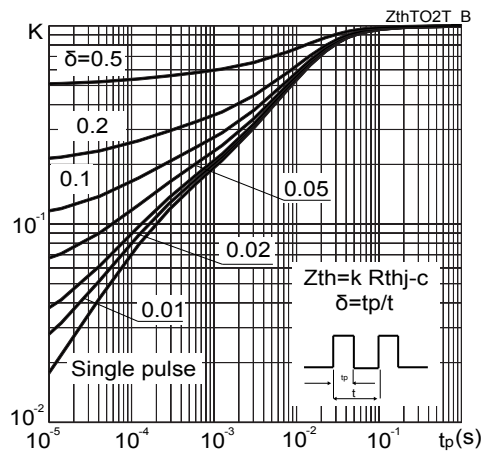
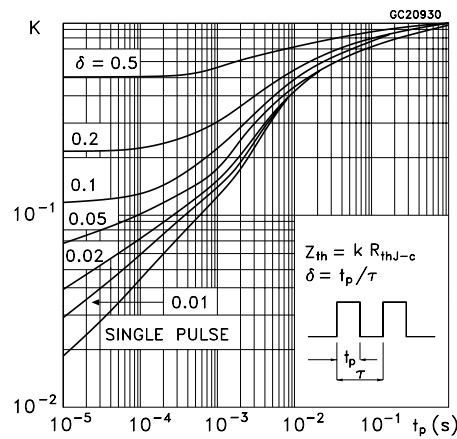
**Figure 7. Output characteristics ( $T_J = 25^\circ\text{C}$ )**

**Figure 8. Output characteristics ( $T_J = 175^\circ\text{C}$ )**

**Figure 9.  $V_{CE(sat)}$  vs junction temperature**

**Figure 10.  $V_{CE(sat)}$  vs collector current**

**Figure 11. Collector current vs switching frequency for D<sup>2</sup>PAK, DPAK and TO-220**

**Figure 12. Collector current vs switching frequency for TO-220FP**


**Figure 13. Forward bias safe operating area for D<sup>2</sup>PAK, DPAK and TO-220**

**Figure 14. Forward bias safe operating area for TO-220FP**

**Figure 15. Transfer characteristics**

**Figure 16. Diode V\_F vs forward current**

**Figure 17. Normalized V\_GE(th) vs junction temperature**

**Figure 18. Normalized V\_BR(CES) vs junction temperature**




**Figure 19. Capacitance variation**

**Figure 20. Gate charge vs. gate-emitter voltage**

**Figure 21. Switching energy vs collector current**

**Figure 22. Switching energy vs gate resistance**

**Figure 23. Switching energy vs temperature**

**Figure 24. Switching energy vs collector-emitter voltage**


**Figure 25. Short circuit time and current vs  $V_{GE}$** 

**Figure 26. Switching times vs collector current**

**Figure 27. Switching times vs gate resistance**

**Figure 28. Reverse recovery current vs diode current slope**

**Figure 29. Reverse recovery time vs diode current slope**

**Figure 30. Reverse recovery charge vs diode current slope**


**Figure 31. Reverse recovery energy vs diode current slope**

**Figure 32. Thermal impedance for D<sup>2</sup>PAK, DPAK and TO-220 IGBT**

**Figure 33. Thermal impedance for D<sup>2</sup>PAK, DPAK and TO-220 diode**


### 3 Test circuits

Figure 34. Test circuit for inductive load switching

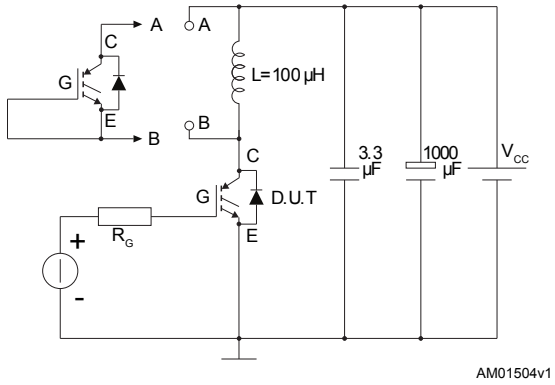


Figure 35. Gate charge test circuit

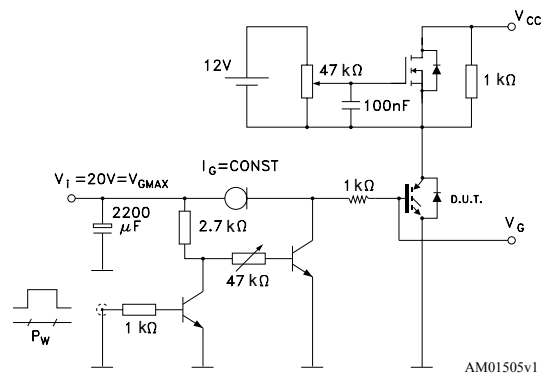


Figure 36. Switching waveform

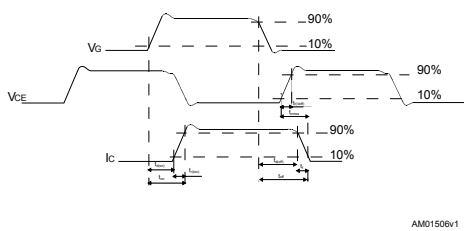
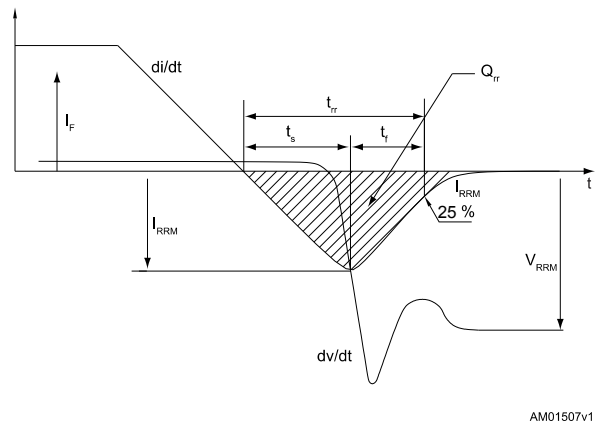


Figure 37. Diode reverse recovery waveform

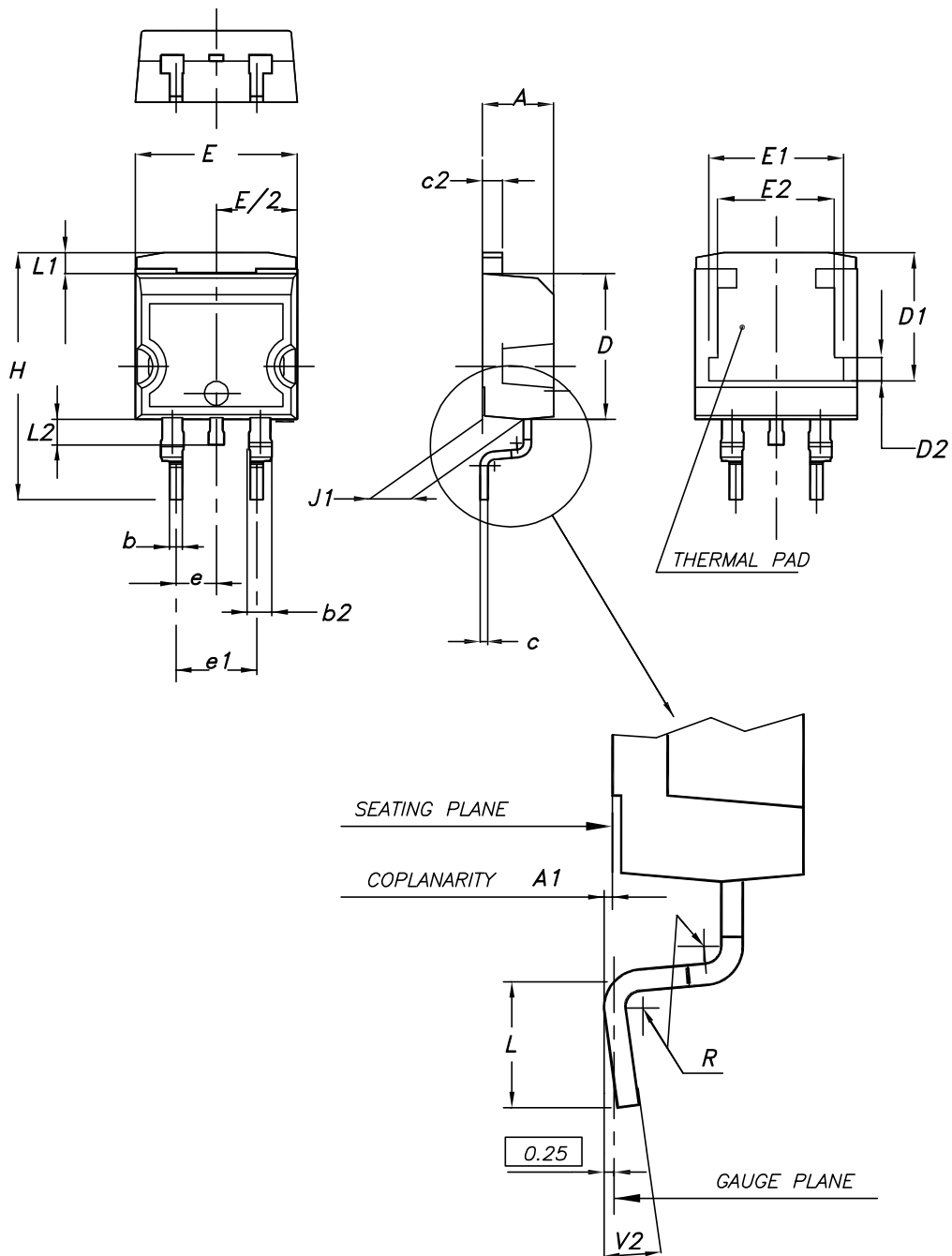


## 4 Package information

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](http://www.st.com). ECOPACK is an ST trademark.

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

Figure 38. D<sup>2</sup>PAK (TO-263) type A package outline

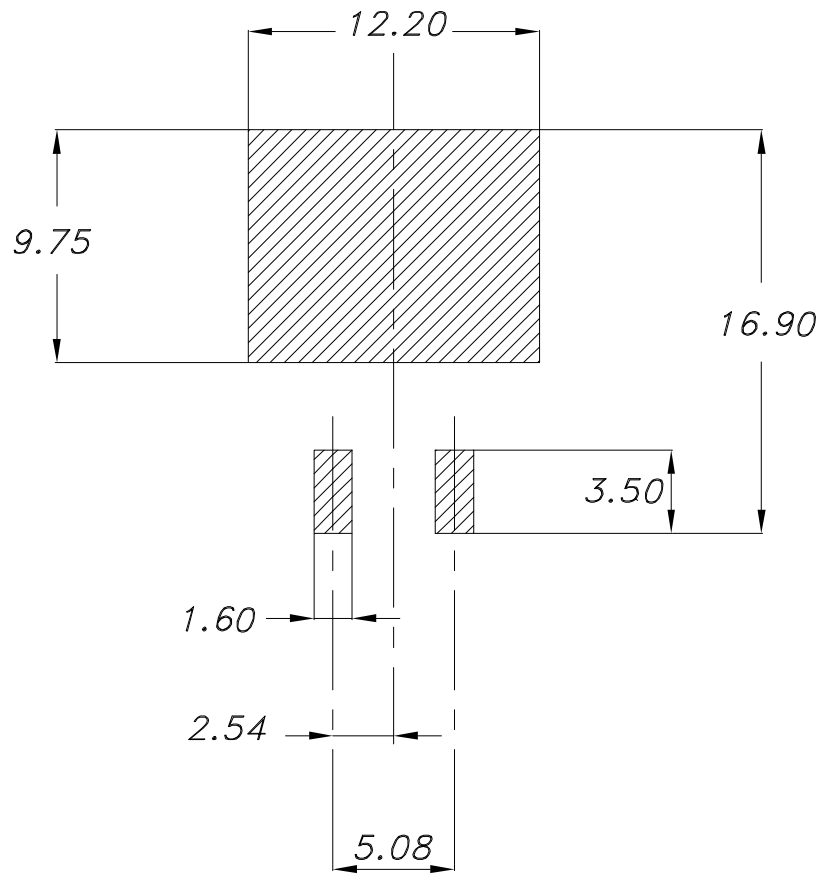


0079457\_26

**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	10.00		10.40
E1	8.30	8.50	8.70
E2	6.85	7.05	7.25
e		2.54	
e1	4.88		5.28
H	15.00		15.85
J1	2.49		2.69
L	2.29		2.79
L1	1.27		1.40
L2	1.30		1.75
R		0.40	
V2	0°		8°

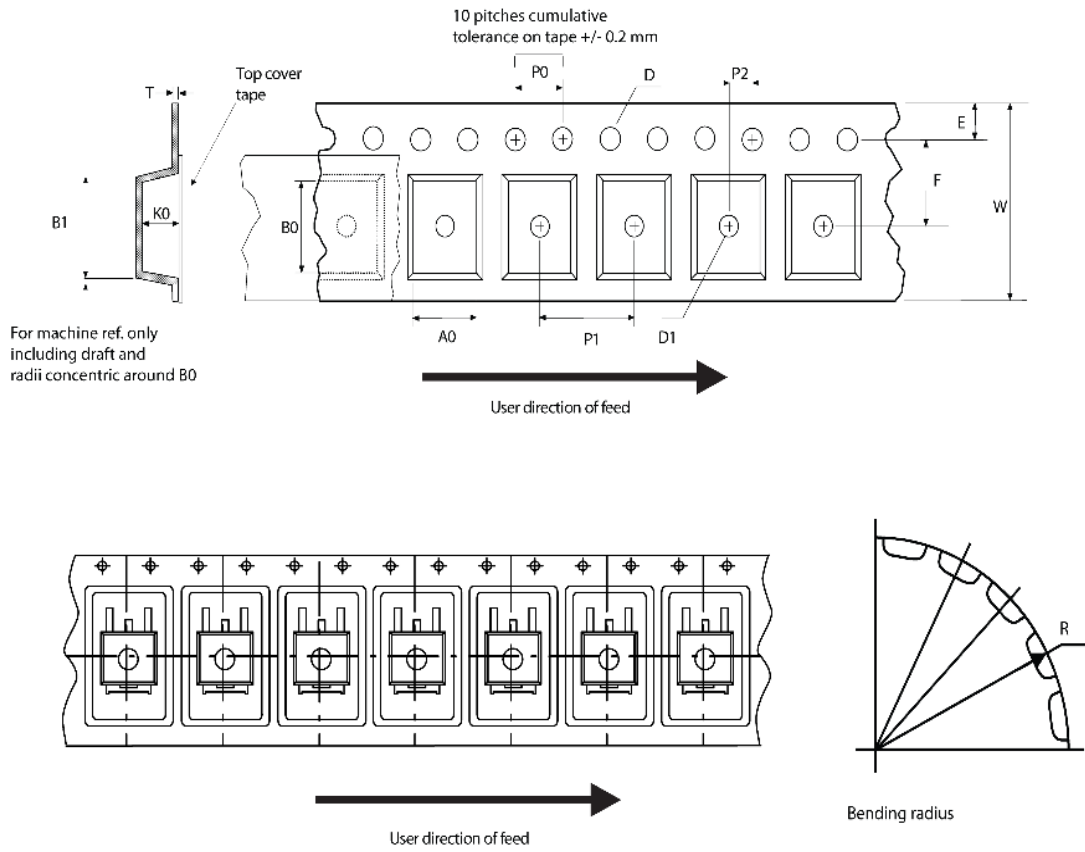
Figure 39. D<sup>2</sup>PAK (TO-263) recommended footprint (dimensions are in mm)



Footprint\_26

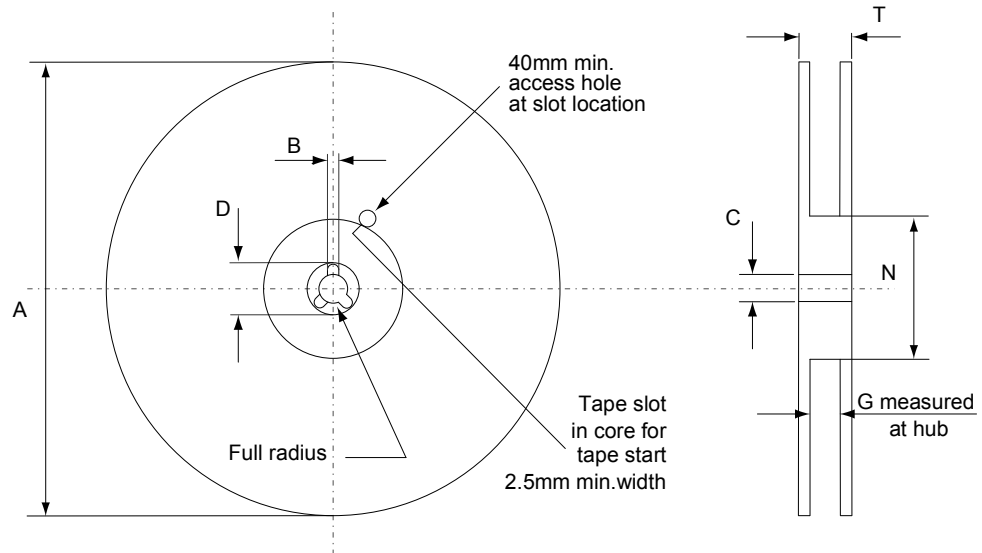
## 4.2 D<sup>2</sup>PAK packing information

Figure 40. D<sup>2</sup>PAK tape outline



AM08852v1



**Figure 41. D<sup>2</sup>PAK reel outline**


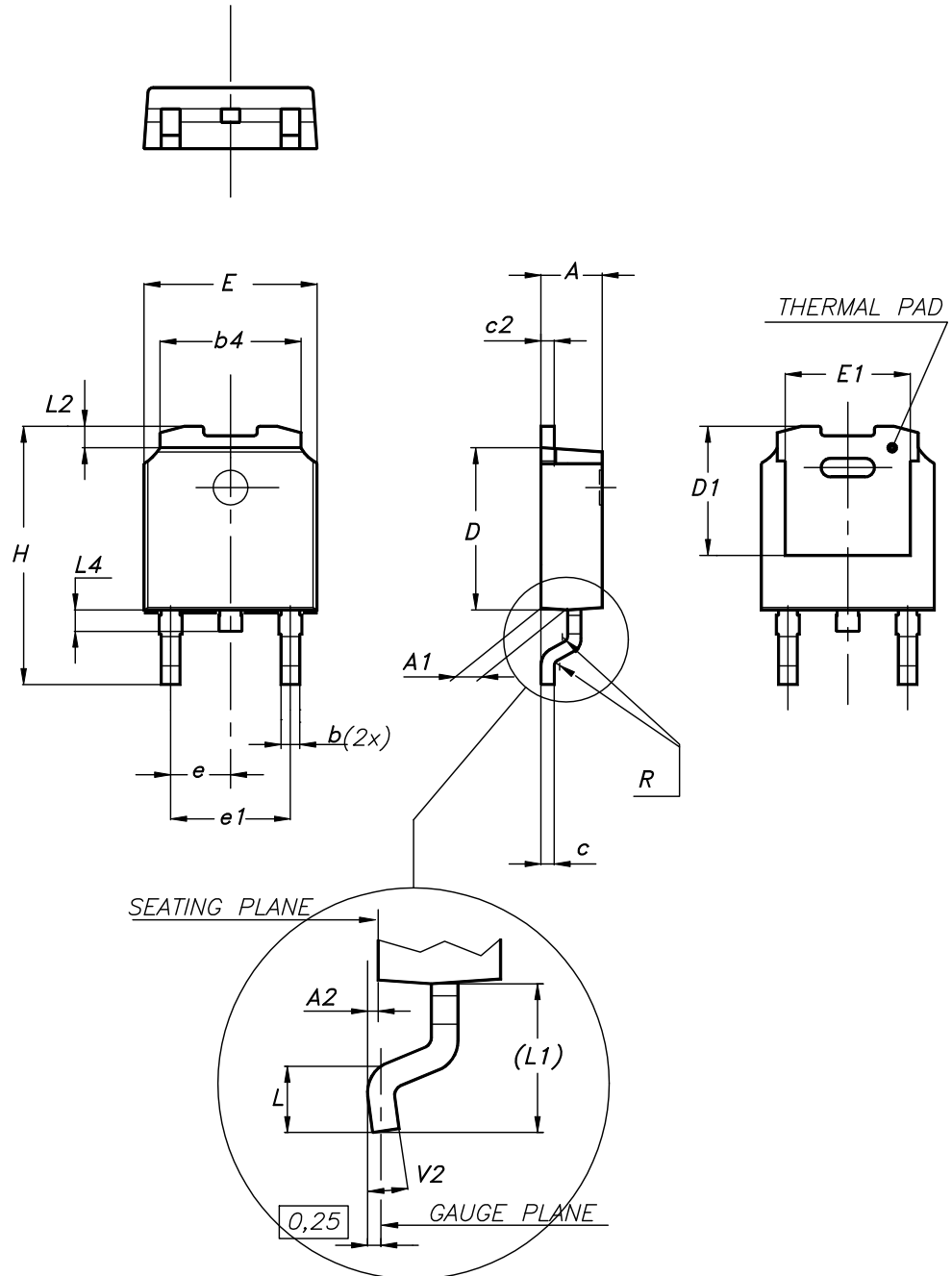
AM06038v1

**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	Base quantity Bulk quantity			
P1	11.9	12.1				1000
P2	1.9	2.1				1000
R	50					
T	0.25	0.35				
W	23.7	24.3				

### 4.3 DPAK (TO-252) type A2 package information

Figure 42. DPAK (TO-252) type A2 package outline



0068772\_type-A2\_rev27

Table 10. DPAK (TO-252) type A2 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10



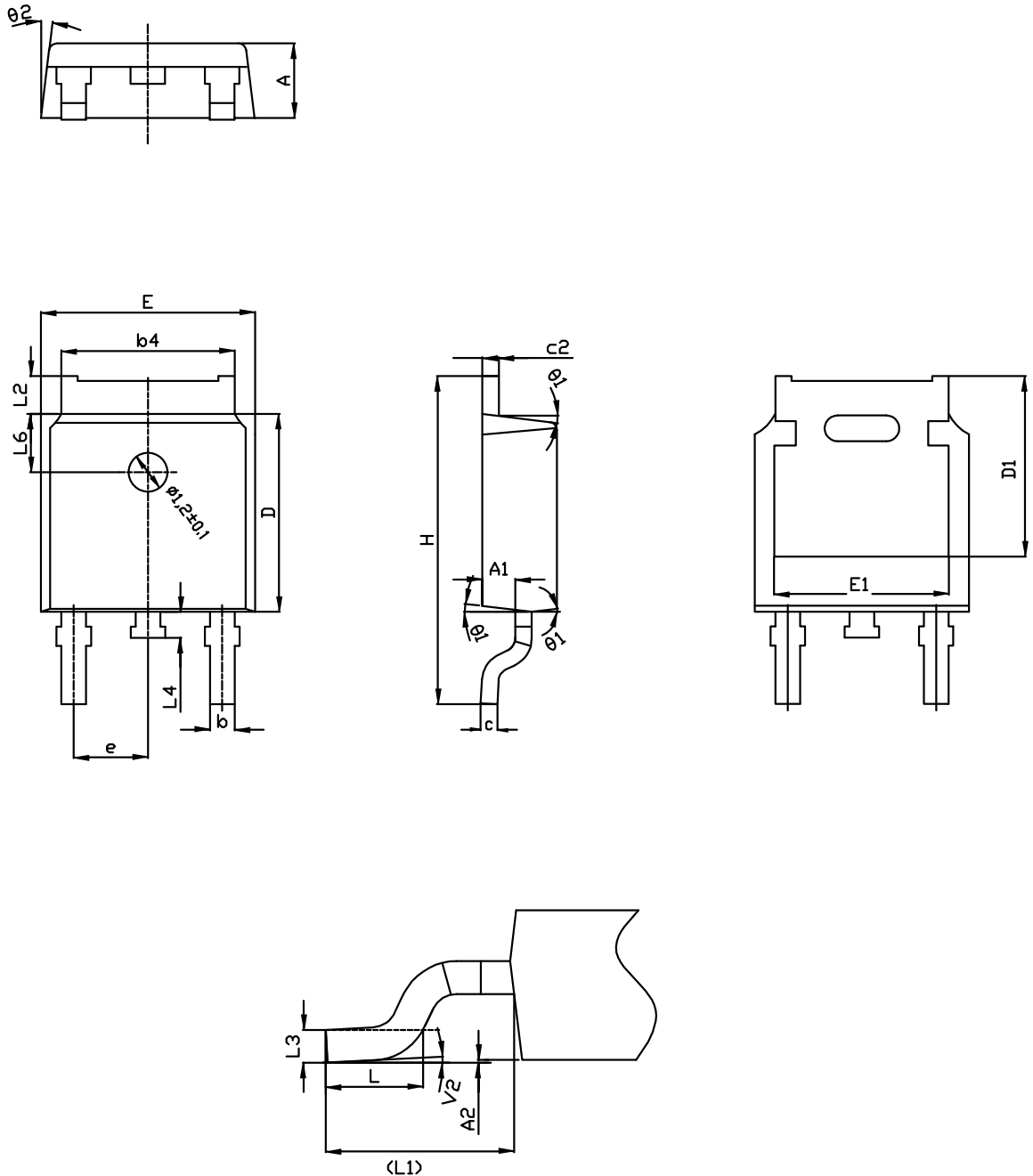
## STGB5H60DF, STGD5H60DF, STGF5H60DF, STGP5H60DF

DPAK (TO-252) type A2 package information

Dim.	mm		
	Min.	Typ.	Max.
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°

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

Figure 43. DPAK (TO-252) type C2 package outline



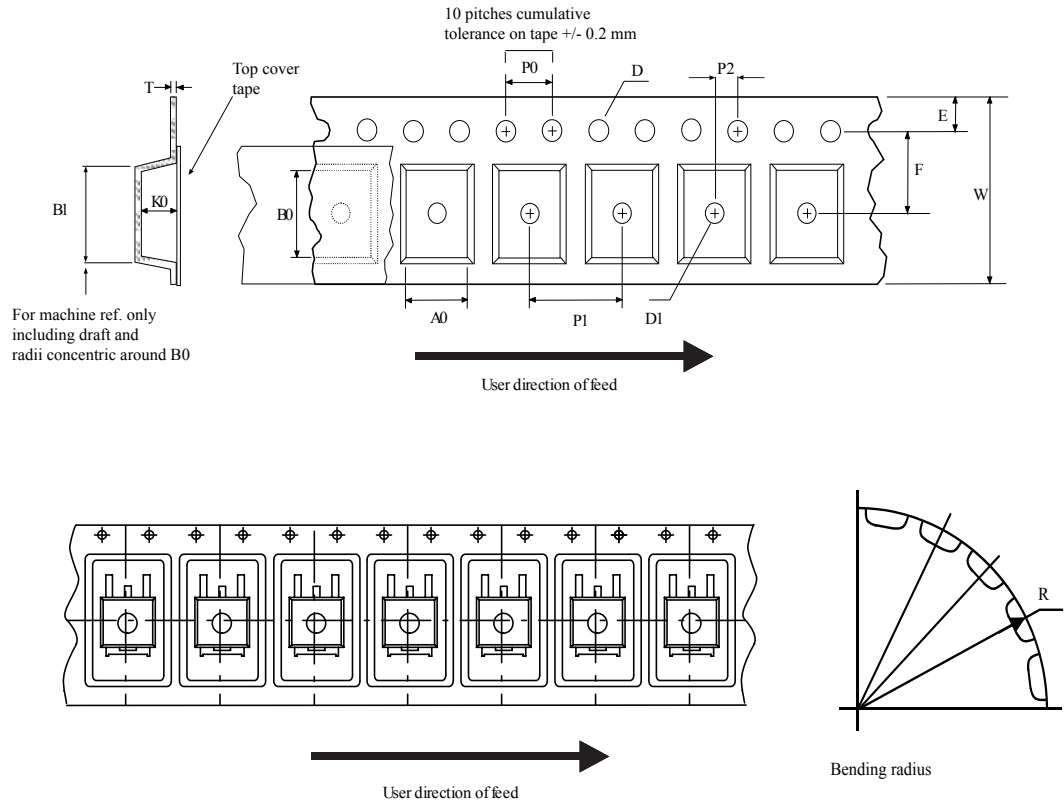
0068772\_C2\_25

**Table 11. 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°

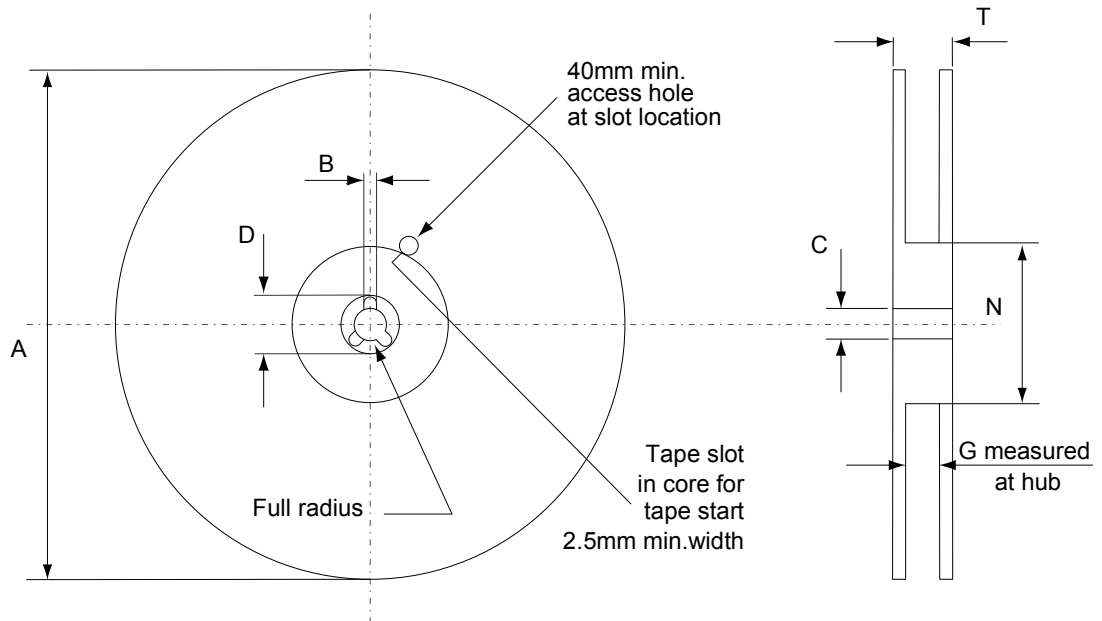
## 4.5 DPAK (TO-252) packing information

Figure 44. DPAK (TO-252) tape outline



AM08852v1

Figure 45. DPAK (TO-252) reel outline



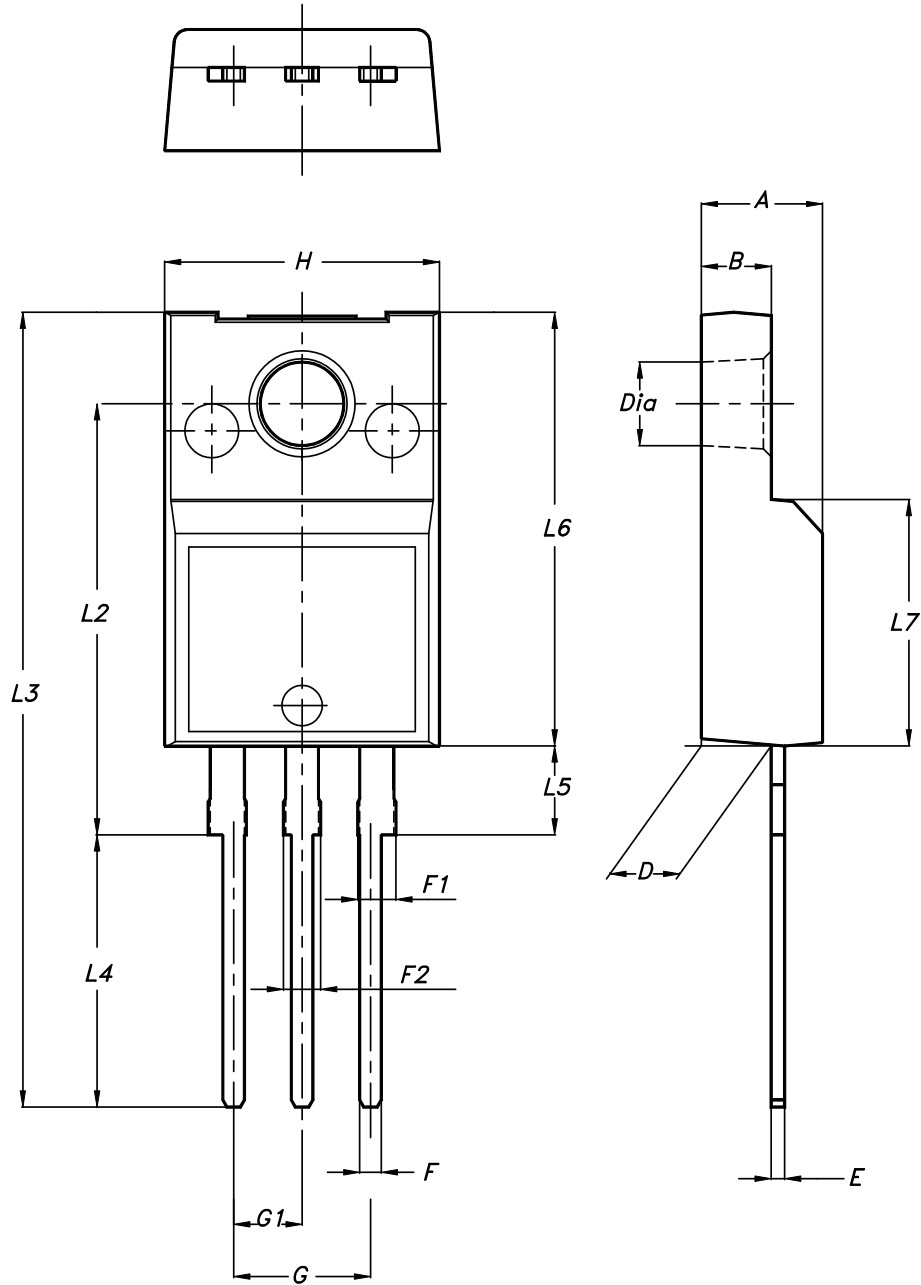
AM06038v1

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			

## 4.6 TO-220FP package information

Figure 46. TO-220FP package outline



7012510\_Rev\_13\_B

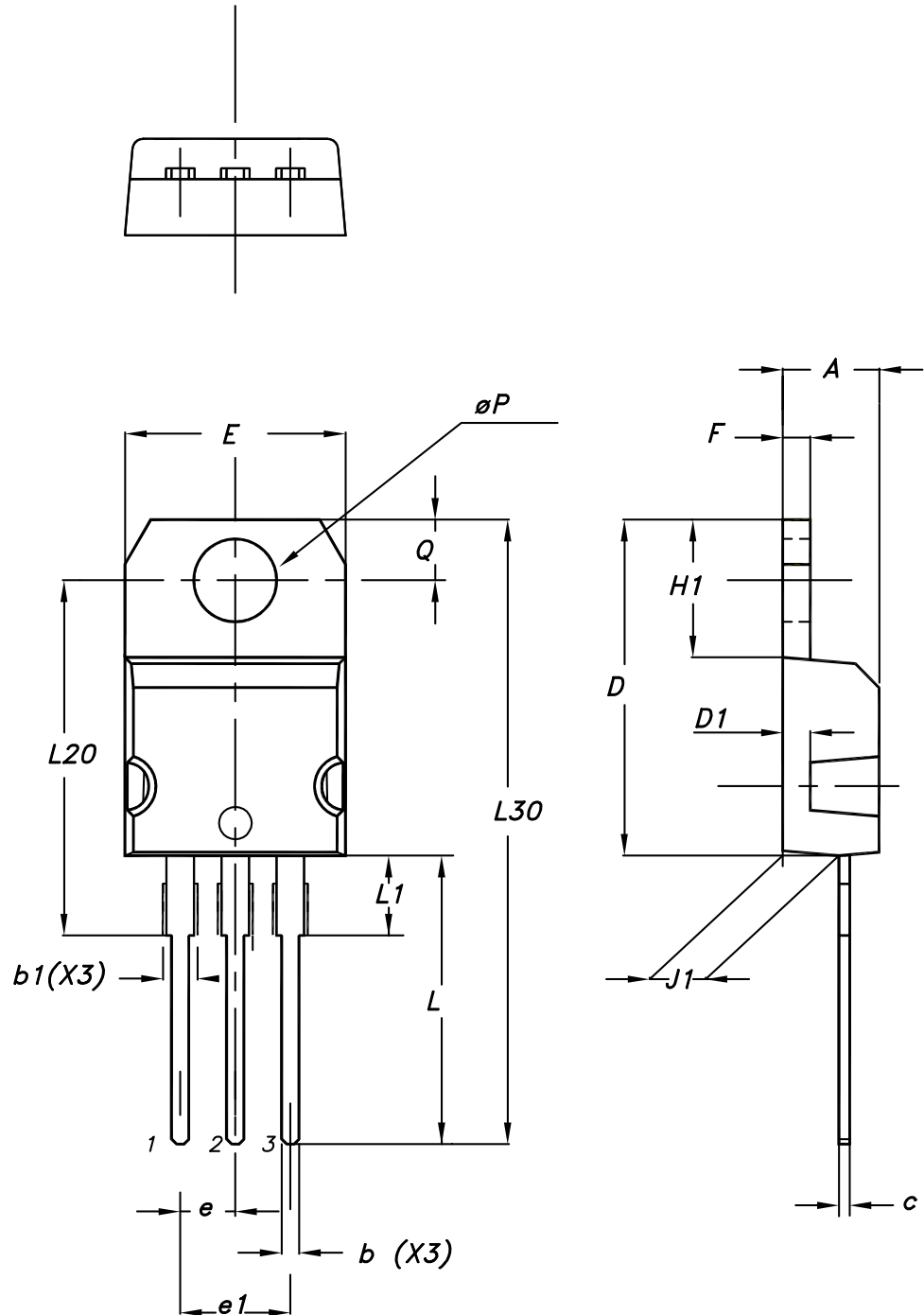


**Table 13. TO-220FP package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
E	0.45		0.70
F	0.75		1.00
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.20
G1	2.40		2.70
H	10.00		10.40
L2		16.00	
L3	28.60		30.60
L4	9.80		10.60
L5	2.90		3.60
L6	15.90		16.40
L7	9.00		9.30
Dia	3.00		3.20

### 4.7 TO-220 type A package information

Figure 47. TO-220 type A package outline



0015988\_typeA\_Rev\_22

**Table 14. TO-220 type A package mechanical data**

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.55
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10.00		10.40
e	2.40		2.70
e1	4.95		5.15
F	1.23		1.32
H1	6.20		6.60
J1	2.40		2.72
L	13.00		14.00
L1	3.50		3.93
L20		16.40	
L30		28.90	
øP	3.75		3.85
Q	2.65		2.95

## 5 Ordering information

**Table 15. Order codes**

Order code	Marking	Package	Packing
STGB5H60DF	GB5H60DF	D <sup>2</sup> PAK	Tape and reel
STGD5H60DF	GD5H60DF	DPAK	
STGF5H60DF	GF5H60DF	TO-220FP	Tube
STGP5H60DF	GP5H60DF	TO-220	

## Revision history

**Table 16. Document revision history**

Date	Version	Changes
28-Nov-2014	1	Initial release.
23-Feb-2015	2	Updated <i>Section 2: Electrical characteristics</i> and <i>Section 4: Package information</i> . Minor text changes.
18-May-2015	3	Text and formatting changes throughout document In <i>Section 1: Electrical ratings</i> : - updated <i>Table 2</i> and <i>Table 3</i> In <i>Section 2: Electrical characteristics</i> : - updated <i>Table 4</i> , <i>Table 5</i> , <i>Table 6</i> , <i>Table 7</i> and <i>Table 8</i> Added <i>Section 2.1: Electrical characteristics (curves)</i> Updated <i>Section 4.2: DPAK package information</i> Document status promoted from "preliminary data" to "production data"
18-Sep-2018	4	Removed maturity status indication from cover page. Updated <i>Section 4 Package information</i> . Minor text changes.
02-Mar-2020	5	Updated <a href="#">Table 4. Dynamic</a> . Updated <a href="#">Figure 20. Gate charge vs. gate-emitter voltage</a> . Minor text changes.

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