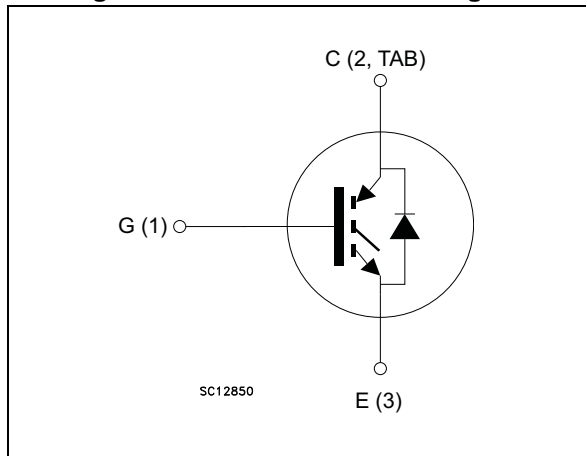


Figure 1. Internal schematic diagram



### Features

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

### Applications

- Motor control
- UPS, PFC

### Description

This device is an IGBT developed using an advanced proprietary trench gate and field stop structure. This IGBT series offers the optimum compromise between conduction and switching losses, maximizing the efficiency of very high frequency converters. Furthermore, a positive  $V_{CE(sat)}$  temperature coefficient and very tight parameter distribution result in easier paralleling operation.

Table 1. Device summary

Order codes	Marking	Packages	Packaging
STGB10H60DF	GB10H60DF	D <sup>2</sup> PAK	Tape and reel
STGF10H60DF	GF10H60DF	TO-220FP	Tube
STGP10H60DF	GP10H60DF	TO-220	Tube

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	TO-220 D <sup>2</sup> PAK	TO-220FP	Unit
$V_{CES}$	Collector-emitter voltage ( $V_{GE} = 0$ )	600		V
$I_C$	Continuous collector current at $T_C = 25\text{ °C}$	20	20 <sup>(1)</sup>	A
	Continuous collector current at $T_C = 100\text{ °C}$	10	10 <sup>(1)</sup>	A
$I_{CP}^{(2)}$	Pulsed collector current	40	40 <sup>(1)</sup>	A
$V_{GE}$	Gate-emitter voltage	±20		V
$I_F$	Continuous forward current $T_C = 25\text{ °C}$	20	20 <sup>(1)</sup>	A
	Continuous forward current at $T_C = 100\text{ °C}$	10	10 <sup>(1)</sup>	
$I_{FP}^{(2)}$	Pulsed forward current	40	40 <sup>(1)</sup>	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ °C}$	115	30	W
$T_{STG}$	Storage temperature range	- 55 to 150		°C
$T_J$	Operating junction temperature	- 55 to 175		

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

**Table 3. Thermal data**

Symbol	Parameter	TO-220 D <sup>2</sup> PAK	TO-220FP	Unit
$R_{thJC}$	Thermal resistance junction-case IGBT	1.3	5	°C/W
$R_{thJC}$	Thermal resistance junction-case diode	2.78	6.25	°C/W
$R_{thJA}$	Thermal resistance junction-ambient	62.5		°C/W

## 2 Electrical characteristics

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

**Table 4. Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage ( $V_{GE} = 0$ )	$I_C = 2\text{ mA}$	600			V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15\text{ V}, I_C = 10\text{ A}$		1.5	1.95	V
		$V_{GE} = 15\text{ V}, I_C = 10\text{ A}$ $T_J = 125\text{ °C}$		1.65		
		$V_{GE} = 15\text{ V}, I_C = 10\text{ A}$ $T_J = 175\text{ °C}$		1.7		
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}, I_C = 1\text{ mA}$	5.0	6.0	7.0	V
$I_{CES}$	Collector cut-off current ( $V_{GE} = 0$ )	$V_{CE} = 600\text{ V}$			25	$\mu\text{A}$
$I_{GES}$	Gate-emitter leakage current ( $V_{CE} = 0$ )	$V_{GE} = \pm 20\text{ V}$			250	nA

**Table 5. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{ies}$	Input capacitance	$V_{CE} = 25\text{ V}, f = 1\text{ MHz},$ $V_{GE} = 0$	-	1300	-	pF
$C_{oes}$	Output capacitance		-	60	-	pF
$C_{res}$	Reverse transfer capacitance		-	30	-	pF
$Q_g$	Total gate charge	$V_{CC} = 480\text{ V}, I_C = 10\text{ A},$ $V_{GE} = 15\text{ V}$	-	57	-	nC
$Q_{ge}$	Gate-emitter charge		-	8	-	nC
$Q_{gc}$	Gate-collector charge		-	27	-	nC

Table 6. Switching characteristics (inductive load)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 10\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$		19.5		ns
$t_r$	Current rise time			6.9		ns
$(di/dt)_{on}$	Turn-on current slope				1170	
$t_{d(on)}$	Turn-on delay time	$V_{CE} = 400\text{ V}$ , $I_C = 10\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ $T_J = 175\text{ }^\circ\text{C}$		20		ns
$t_r$	Current rise time			6.8		ns
$(di/dt)_{on}$	Turn-on current slope				1176	
$t_{r(Voff)}$	Off voltage rise time	$V_{CE} = 400\text{ V}$ , $I_C = 10\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$		19.6		ns
$t_{d(off)}$	Turn-off delay time			103		ns
$t_f$	Current fall time			73		ns
$t_{r(Voff)}$	Off voltage rise time	$V_{CE} = 400\text{ V}$ , $I_C = 10\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ $T_J = 175\text{ }^\circ\text{C}$		28		ns
$t_{d(off)}$	Turn-off delay time			104		ns
$t_f$	Current fall time			110		ns
$t_{sc}$	Short-circuit withstand time	$V_{CC} \leq 360\text{ V}$ , $V_{GE} = 15\text{ V}$ , $R_G = 10\ \Omega$	3	5		$\mu$ s

Table 7. Switching energy (inductive load)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit	
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CE} = 400\text{ V}$ , $I_C = 10\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$	-	83	-	$\mu$ J	
$E_{off}^{(2)}$	Turn-off switching losses			-	140	-	$\mu$ J
$E_{ts}$	Total switching losses			-	223	-	$\mu$ J
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CE} = 400\text{ V}$ , $I_C = 10\text{ A}$ , $R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ $T_J = 175\text{ }^\circ\text{C}$	-	148	-	$\mu$ J	
$E_{off}^{(2)}$	Turn-off switching losses			-	214	-	$\mu$ J
$E_{ts}$	Total switching losses			-	362	-	$\mu$ J

1. Energy losses include reverse recovery of the diode.
2. 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	$I_F = 10\text{ A}$ $I_F = 10\text{ A}, T_J = 175\text{ °C}$	-	1.7	2.2	V	
				1.3		V	
$t_{rr}$	Reverse recovery time	$V_r = 60\text{ V}; I_F = 10\text{ A};$ $di_F/dt = 100\text{ A} / \mu\text{s}$	-	107		ns	
$Q_{rr}$	Reverse recovery charge		-	120		nC	
$I_{rrm}$	Reverse recovery current		-	2.24		A	
$t_{rr}$	Reverse recovery time	$V_r = 60\text{ V}; I_F = 10\text{ A};$ $di_F/dt = 100\text{ A} / \mu\text{s}$ $T_J = 175\text{ °C}$	-	161		ns	
	$Q_{rr}$		Reverse recovery charge	-	362		nC
	$I_{rrm}$		Reverse recovery current	-	4.5		A

## 2.1 Electrical characteristics (curves)

Figure 2. Power dissipation vs. case temperature for D<sup>2</sup>PAK and TO-220

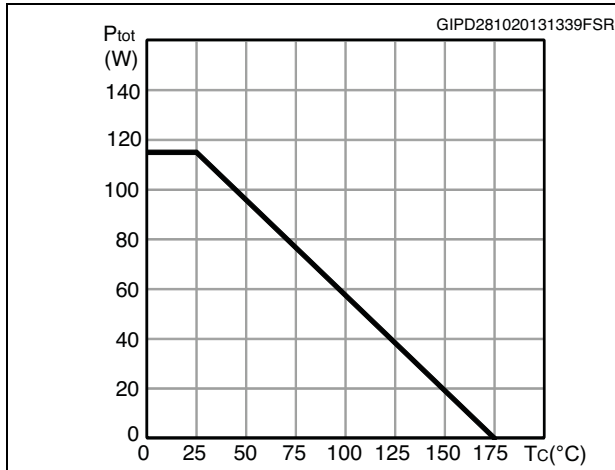


Figure 3. Collector current vs. case temperature for D<sup>2</sup>PAK and TO-220

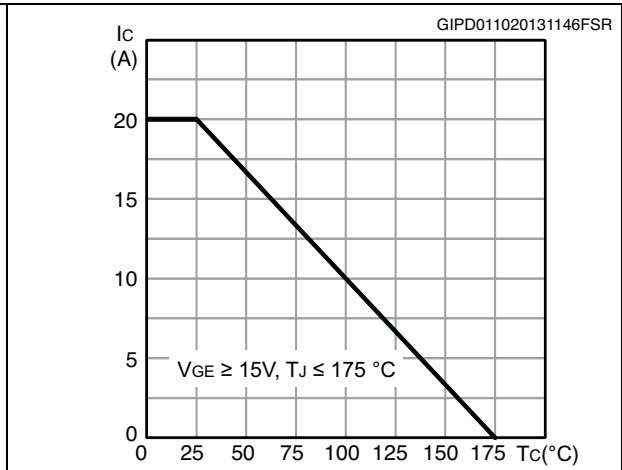


Figure 4. Power dissipation vs. case temperature for TO-220FP

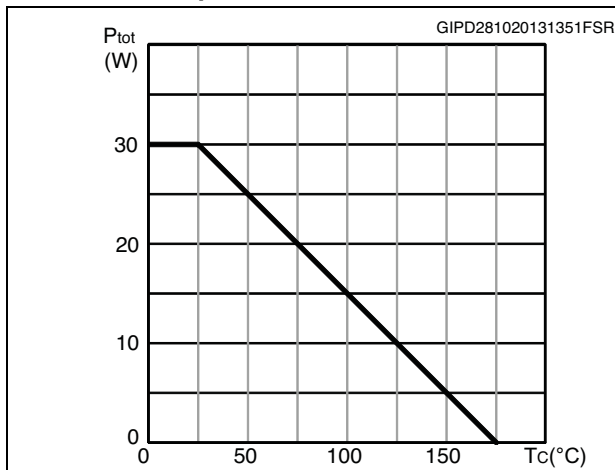


Figure 5. Collector current vs. case temperature for TO-220FP

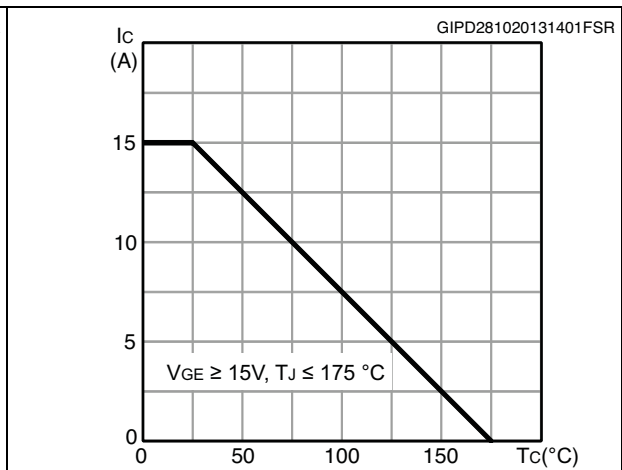


Figure 6. Output characteristics ( $T_J = 25\text{ °C}$ )

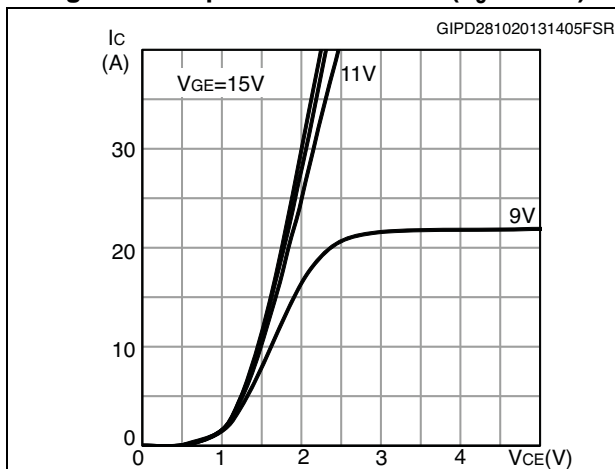


Figure 7. Output characteristics ( $T_J = 175\text{ °C}$ )

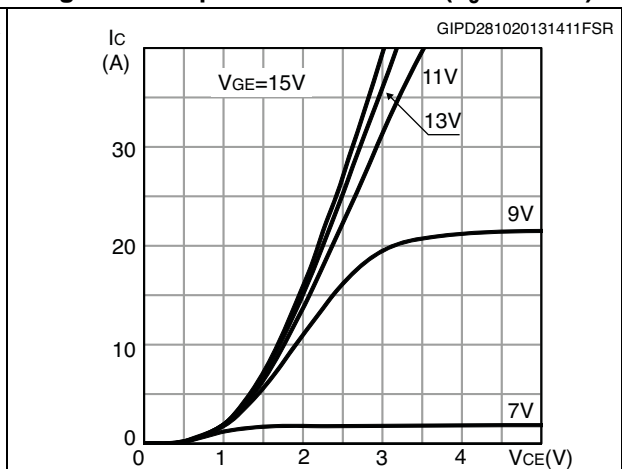


Figure 8.  $V_{CE(sat)}$  vs. junction temperature

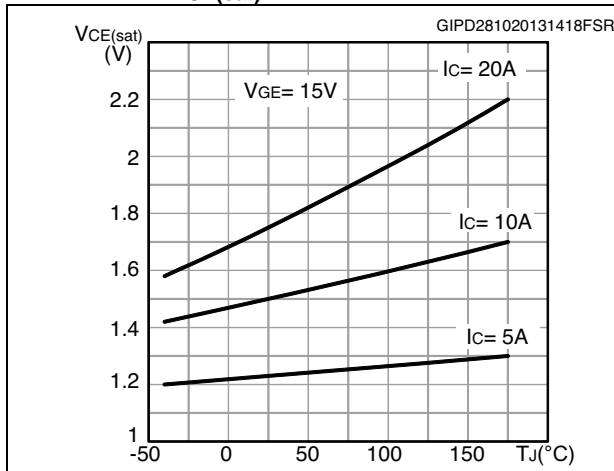


Figure 9.  $V_{CE(sat)}$  vs. collector current

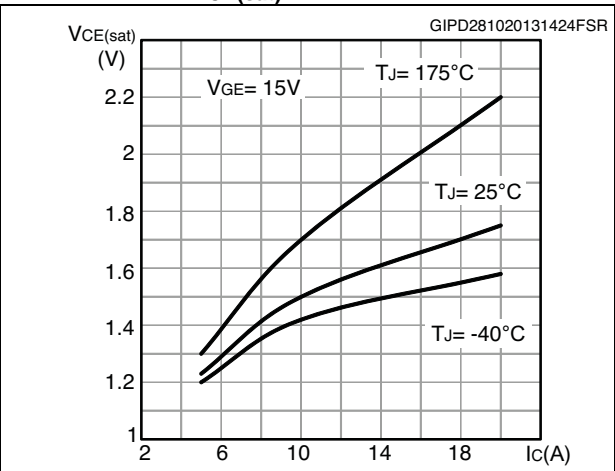


Figure 10. Collector current vs. switching frequency for D<sup>2</sup>PAK and TO-220

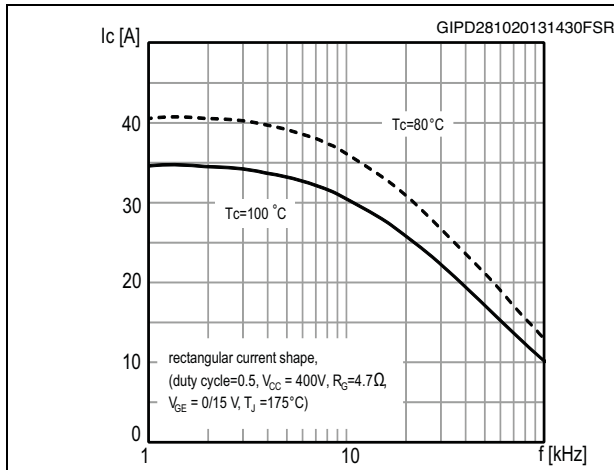


Figure 11. Collector current vs. switching frequency for TO-220FP

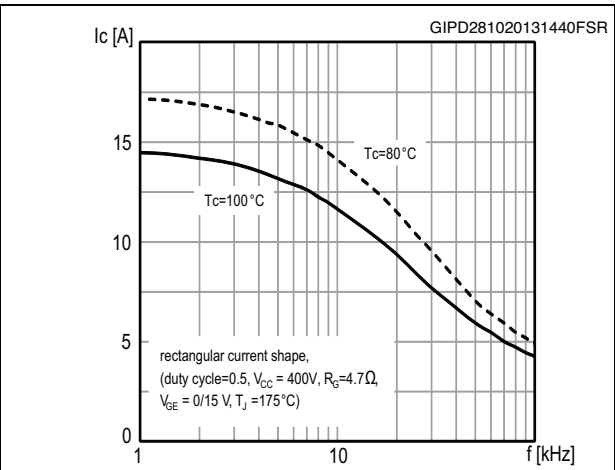


Figure 12. Forward bias safe operating area for D<sup>2</sup>PAK and TO-220

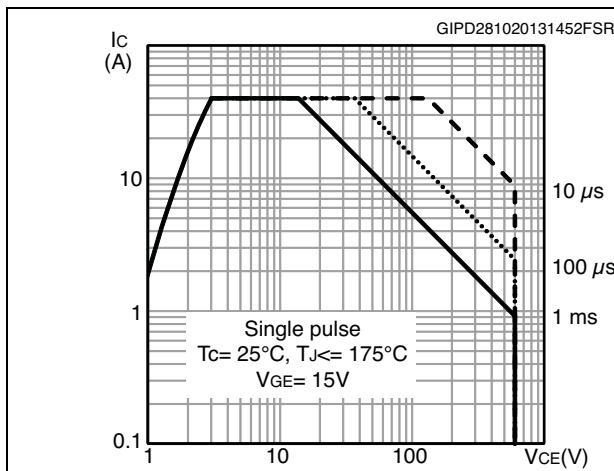


Figure 13. Forward bias safe operating area for TO-220FP

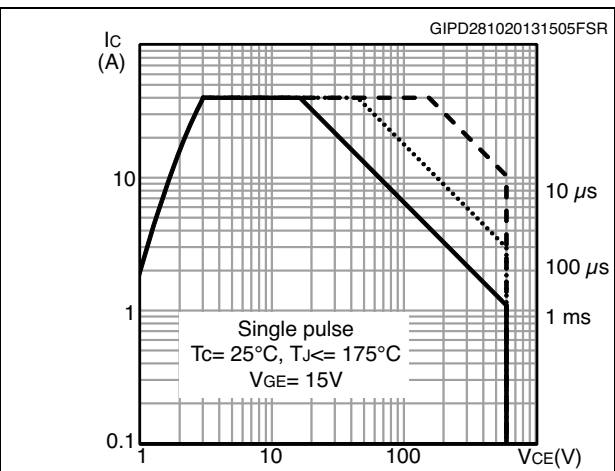




Figure 14. Transfer characteristics

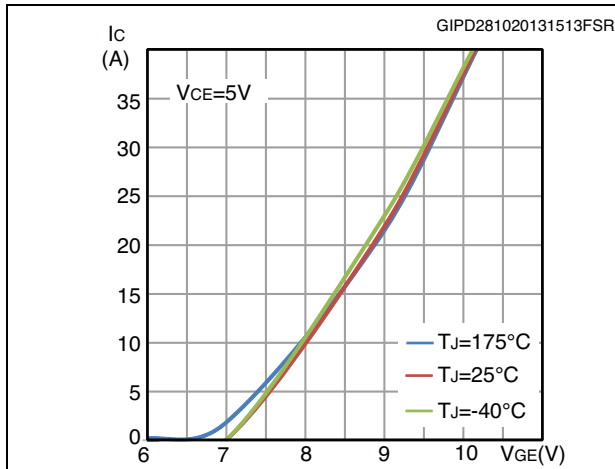


Figure 15. Diode  $V_F$  vs. forward current

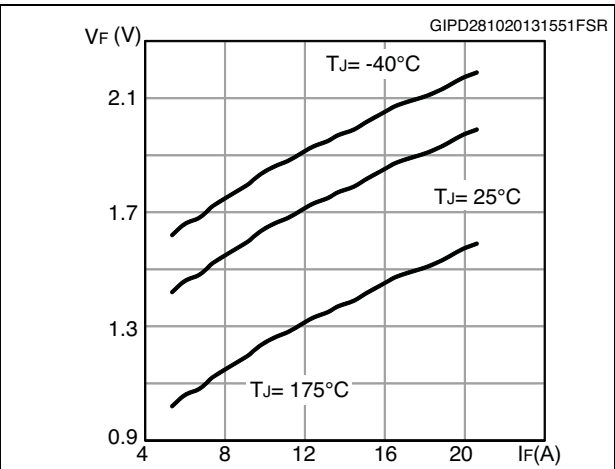


Figure 16. Normalized  $V_{GE(th)}$  vs junction temperature

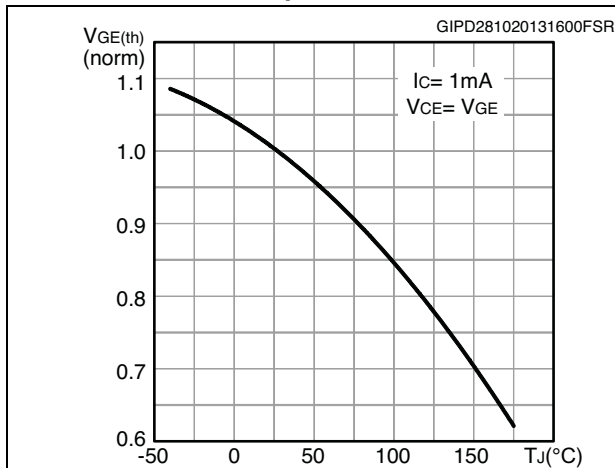


Figure 17. Normalized  $V_{(BR)CES}$  vs. junction temperature

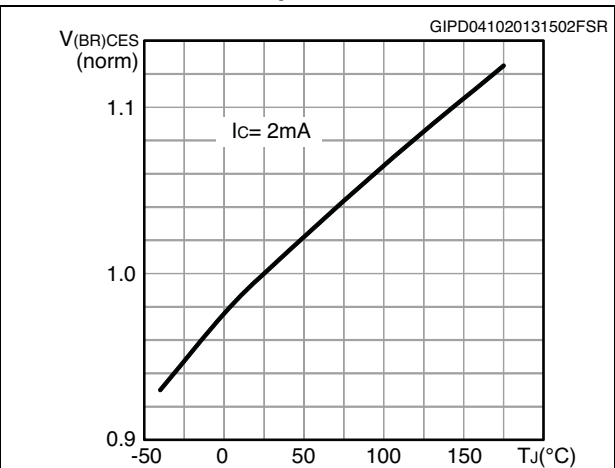


Figure 18. Capacitance variation

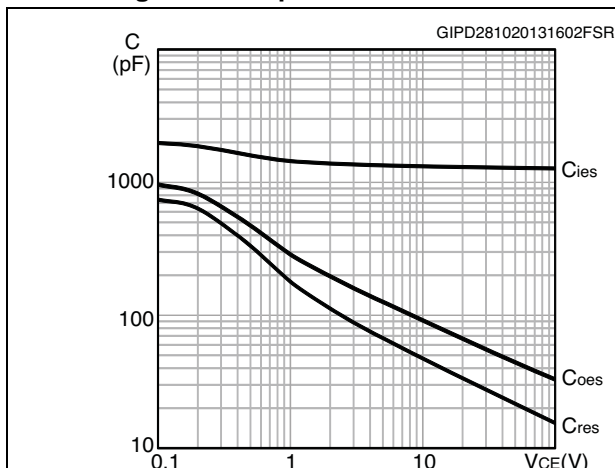


Figure 19. Gate charge vs. gate-emitter voltage

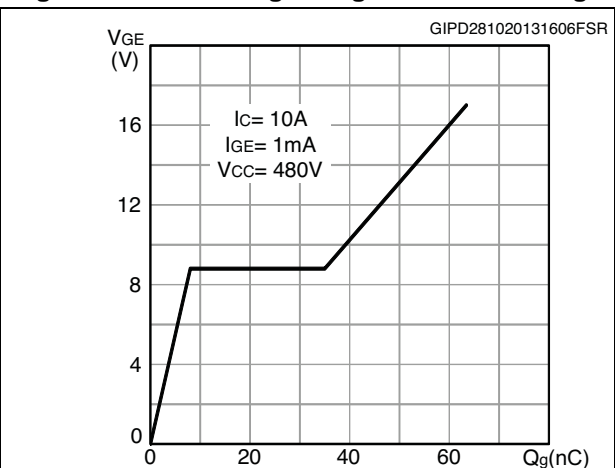


Figure 20. Switching loss vs collector current

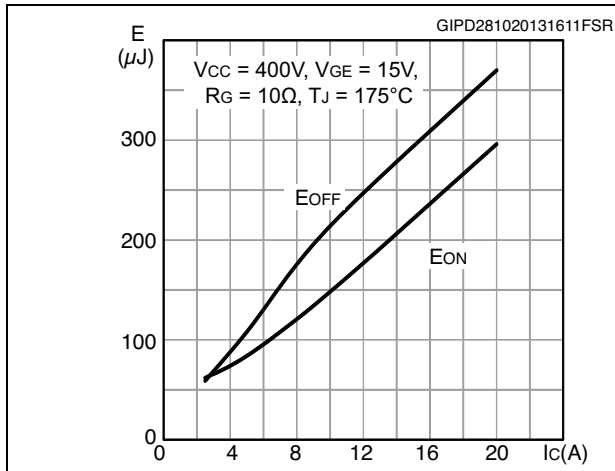


Figure 21. Switching loss vs gate resistance

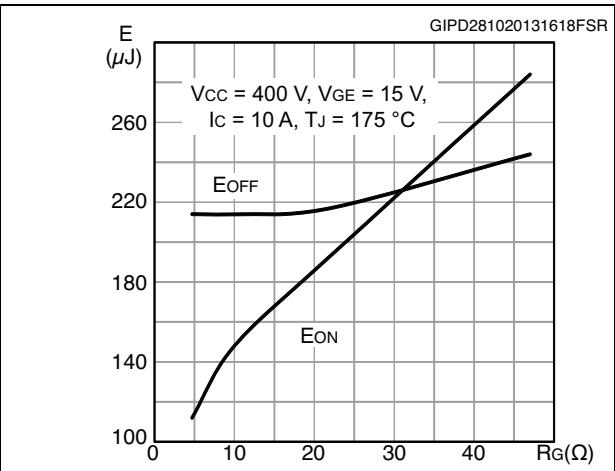


Figure 22. Switching loss vs temperature

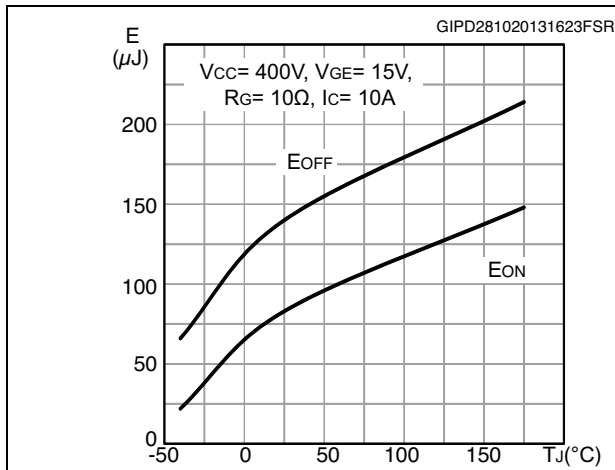


Figure 23. Switching loss vs collector-emitter voltage

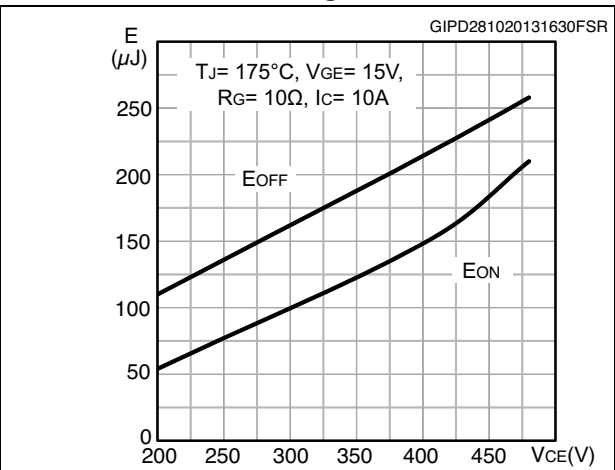


Figure 24. Short circuit time and current vs  $V_{GE}$  Figure 25. Switching times vs. collector current

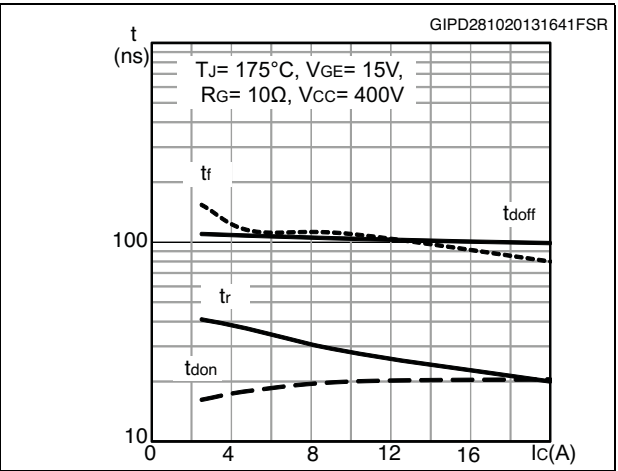
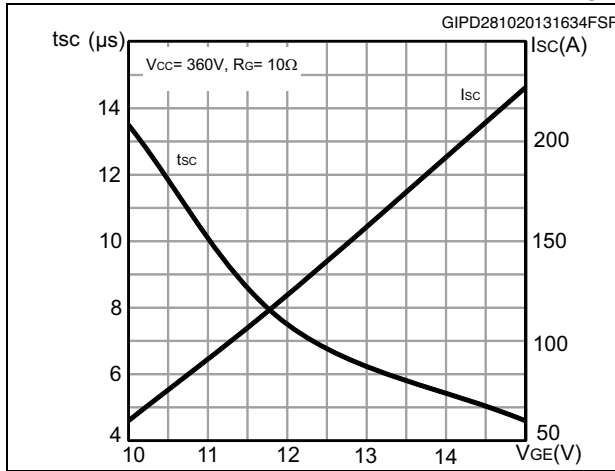


Figure 26. Switching times vs. gate resistance

Figure 27. Reverse recovery current vs. diode current slope

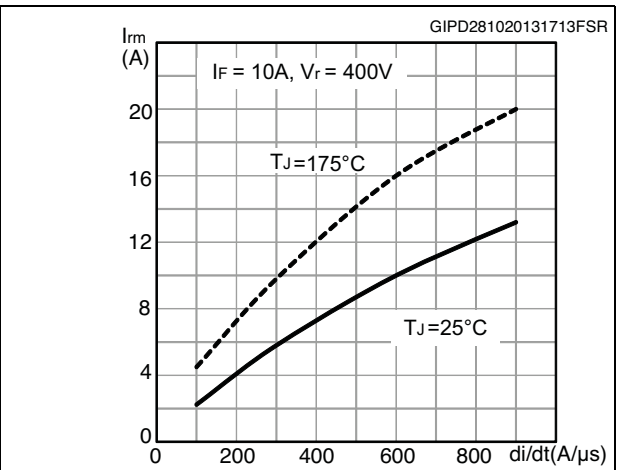
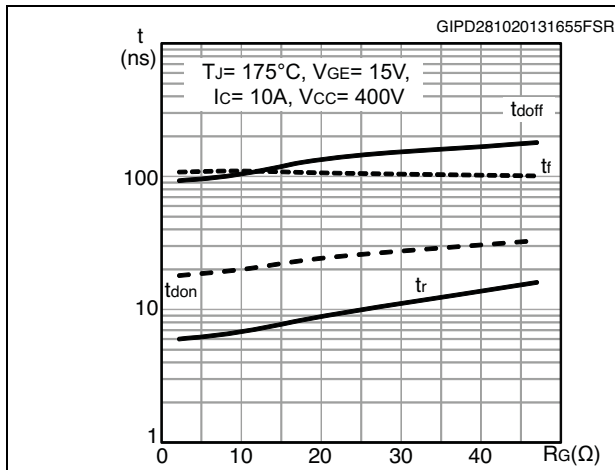


Figure 28. Reverse recovery time vs. diode current slope

Figure 29. Reverse recovery charge vs. diode current slope

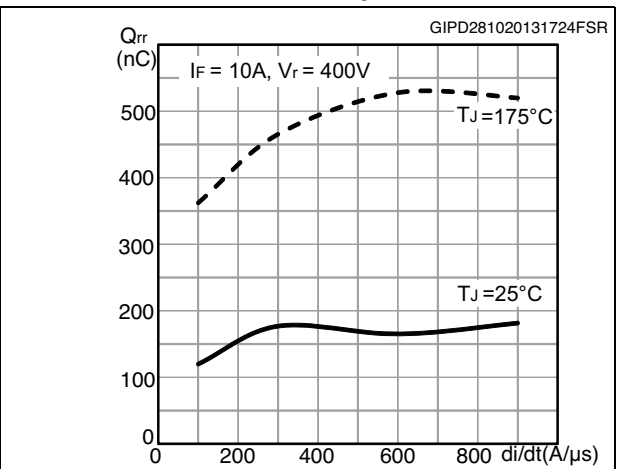
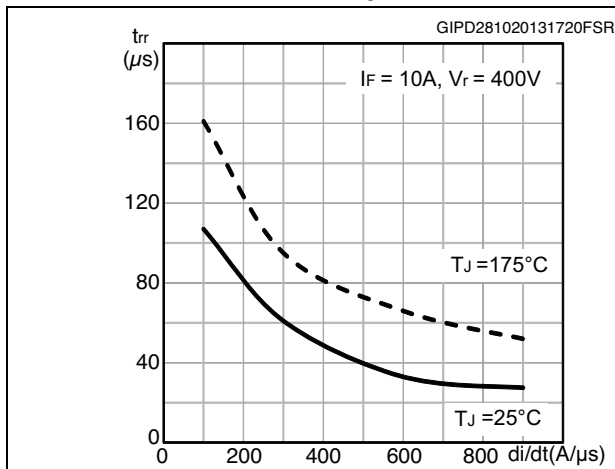


Figure 30. Reverse recovery energy vs. diode current slope

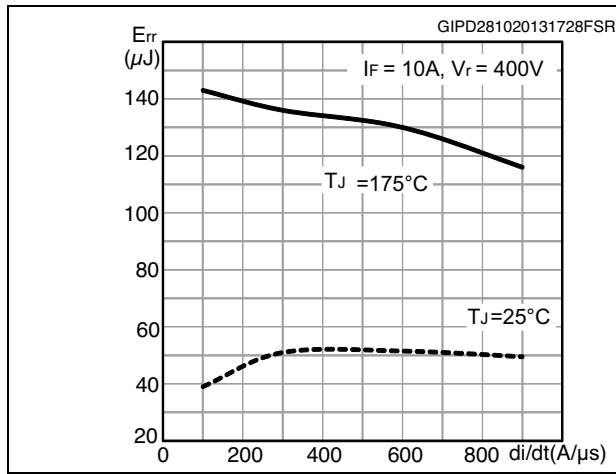


Figure 31. Thermal impedance for IGBT

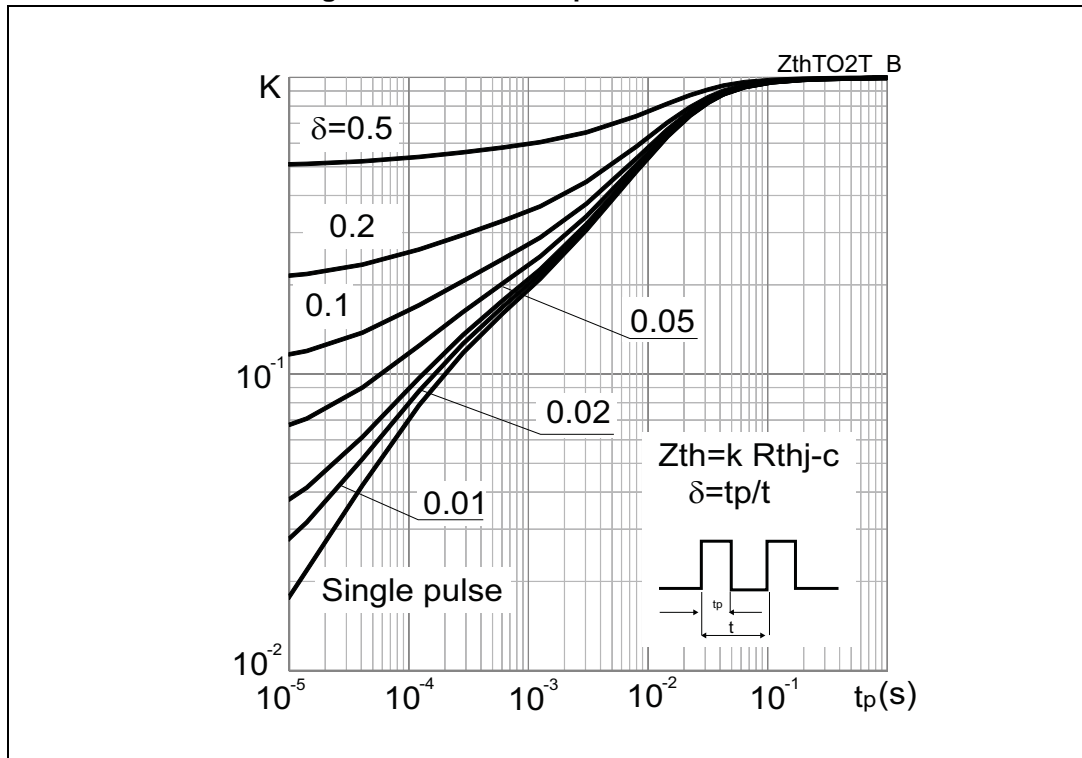
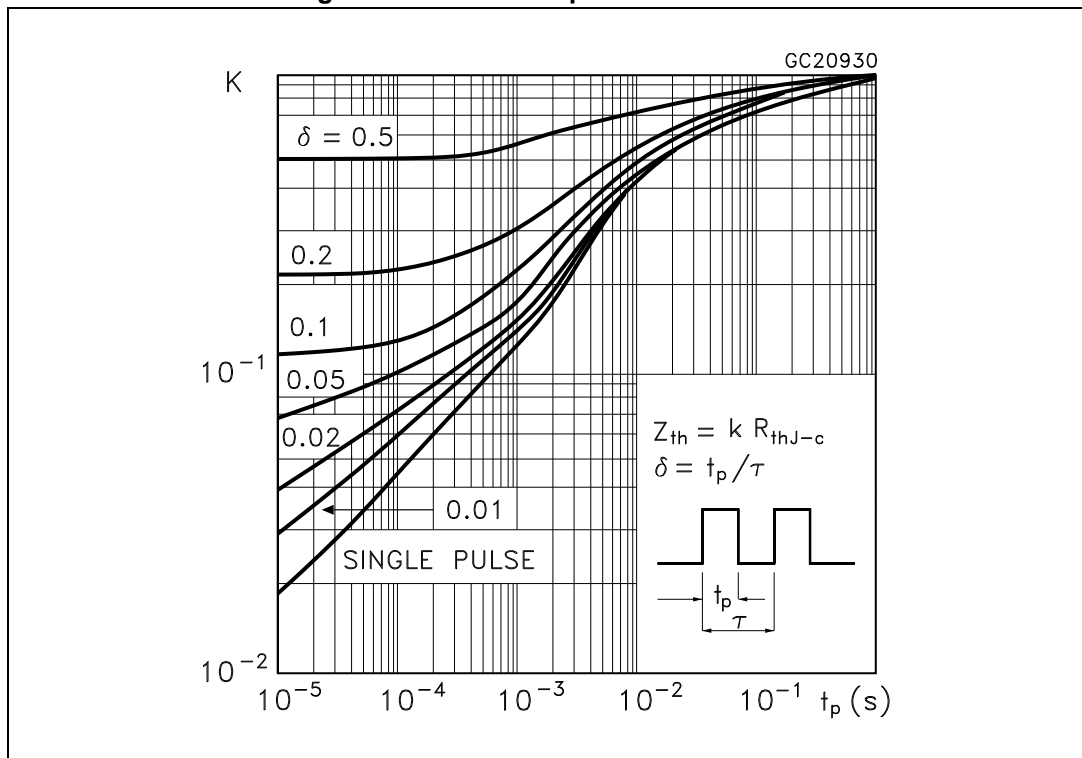
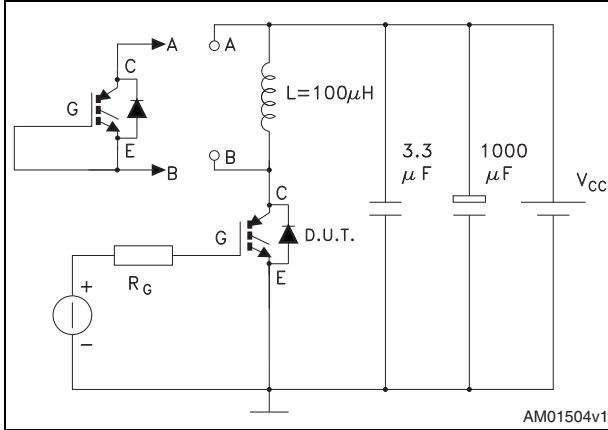


Figure 32. Thermal impedance for diode



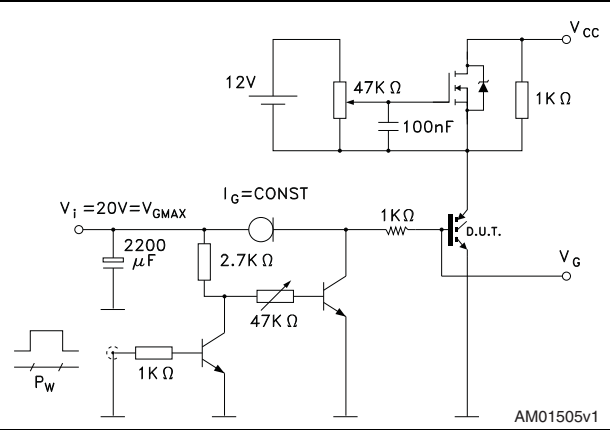
### 3 Test circuits

Figure 33. Test circuit for inductive load switching



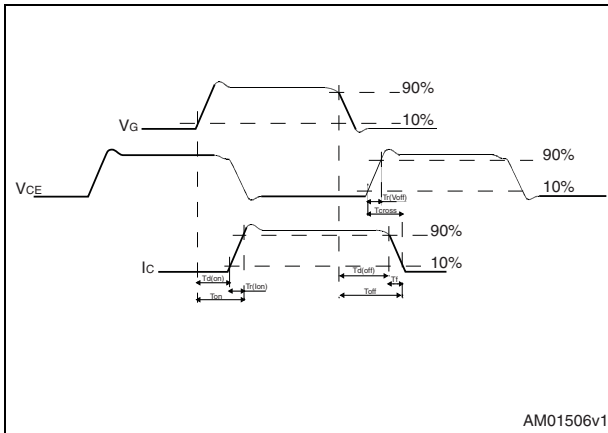
AM01504v1

Figure 34. Gate charge test circuit



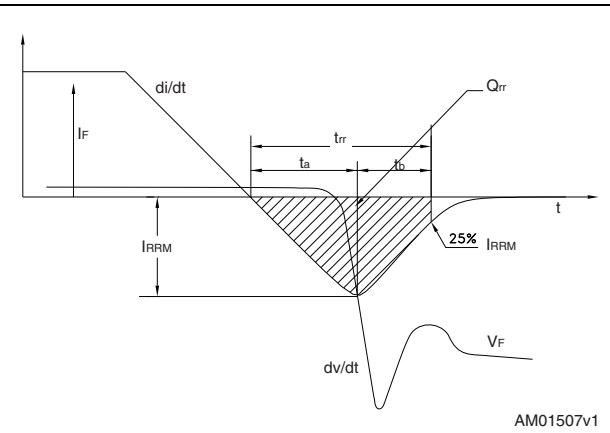
AM01505v1

Figure 35. Switching waveform



AM01506v1

Figure 36. Diode recovery time waveform



AM01507v1

## 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 is an ST trademark.

**Table 9. D<sup>2</sup>PAK 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		
E	10		10.40
E1	8.50		
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 37. D<sup>2</sup>PAK drawing

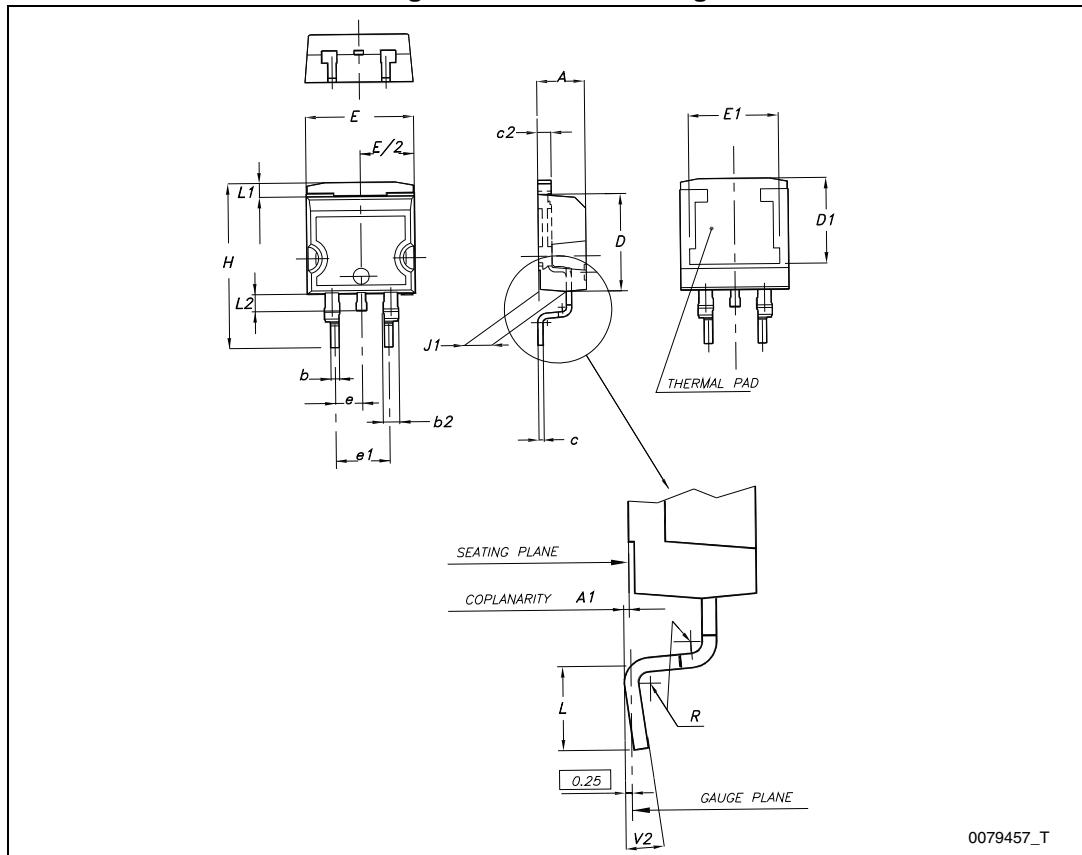
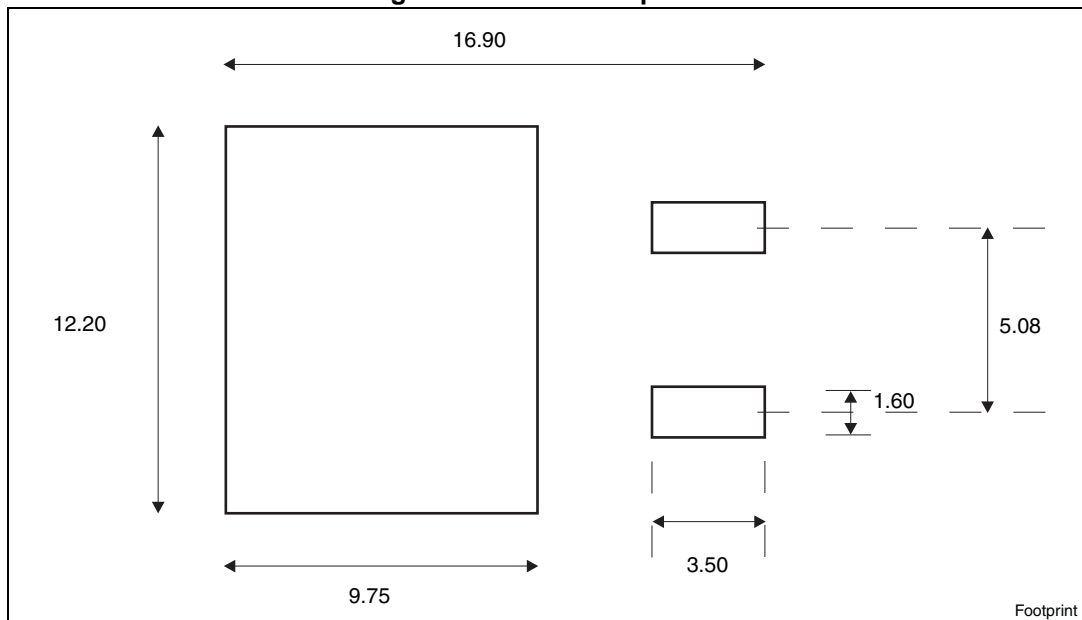


Figure 38. D<sup>2</sup>PAK footprint<sup>(a)</sup>



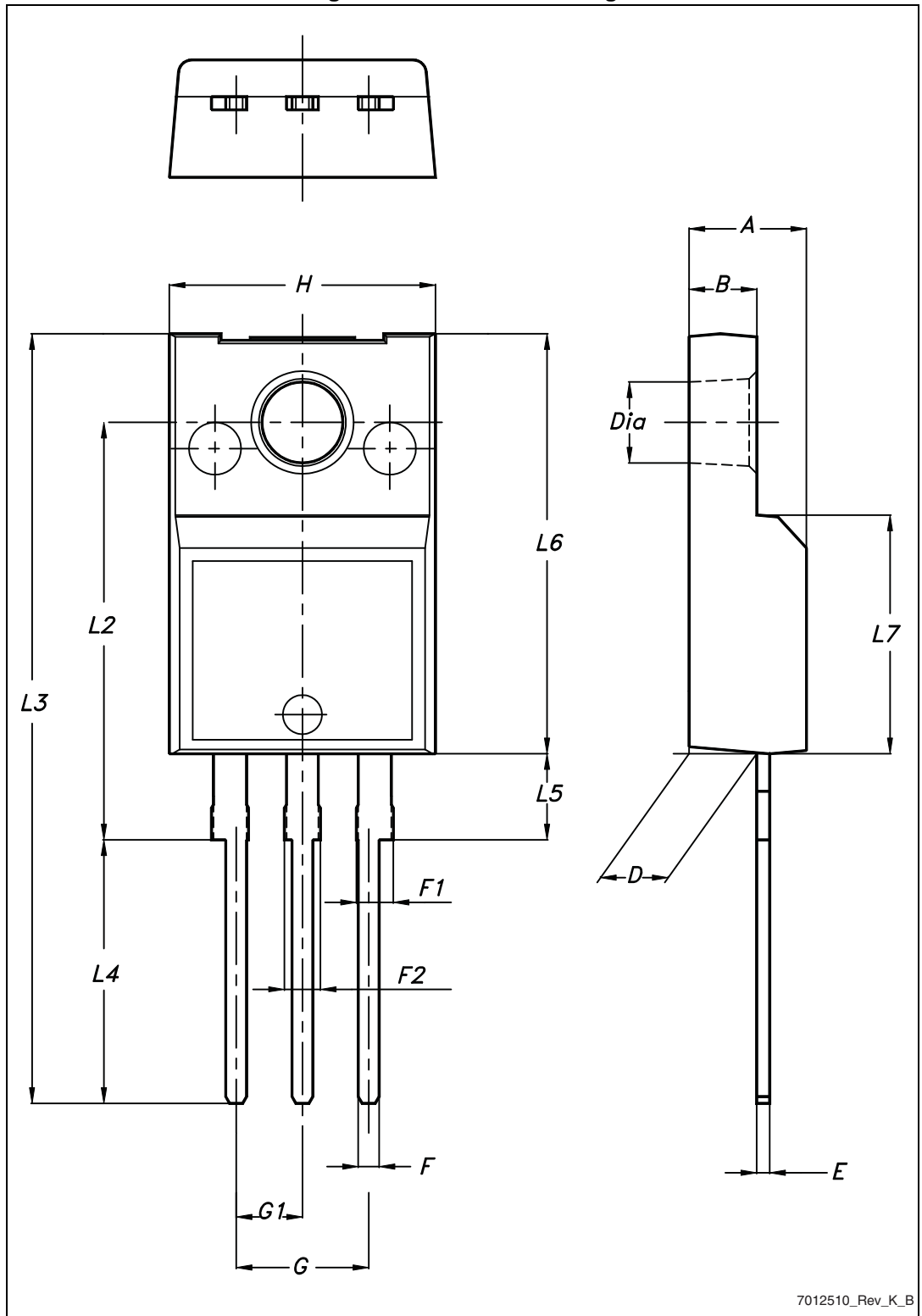
a. All dimension are in millimeters



Table 10. TO-220FP mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

Figure 39. TO-220FP drawing

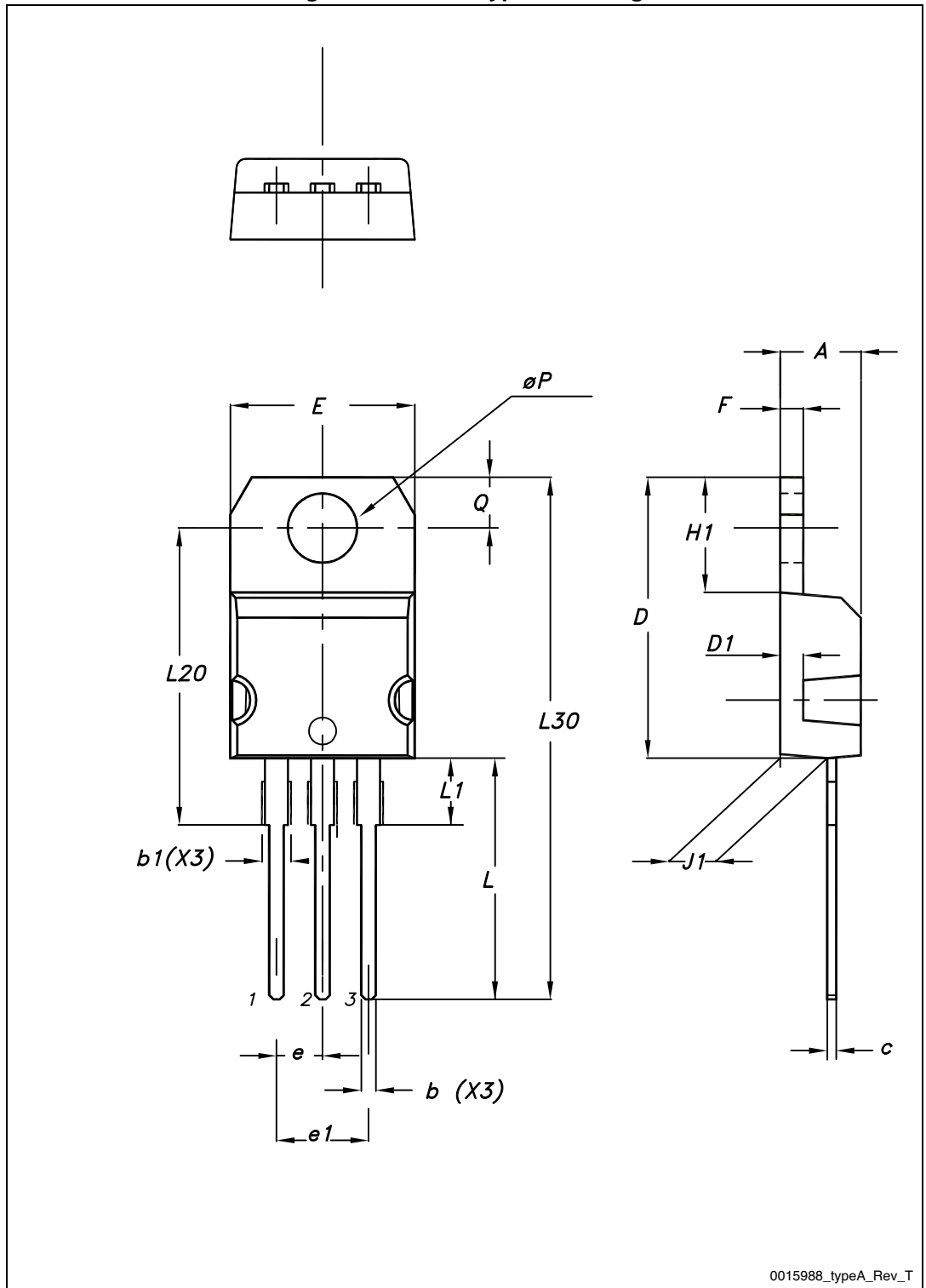


7012510\_Rev\_K\_B

Table 11. TO-220 type A mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.70
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10		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		14
L1	3.50		3.93
L20		16.40	
L30		28.90	
ØP	3.75		3.85
Q	2.65		2.95

Figure 40. TO-220 type A drawing



0015988\_typeA\_Rev\_T

## 5 Packaging mechanical data

Table 12. 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 qty	1000
P2	1.9	2.1		Bulk qty	1000
R	50				
T	0.25	0.35			
W	23.7	24.3			

Figure 41. Tape

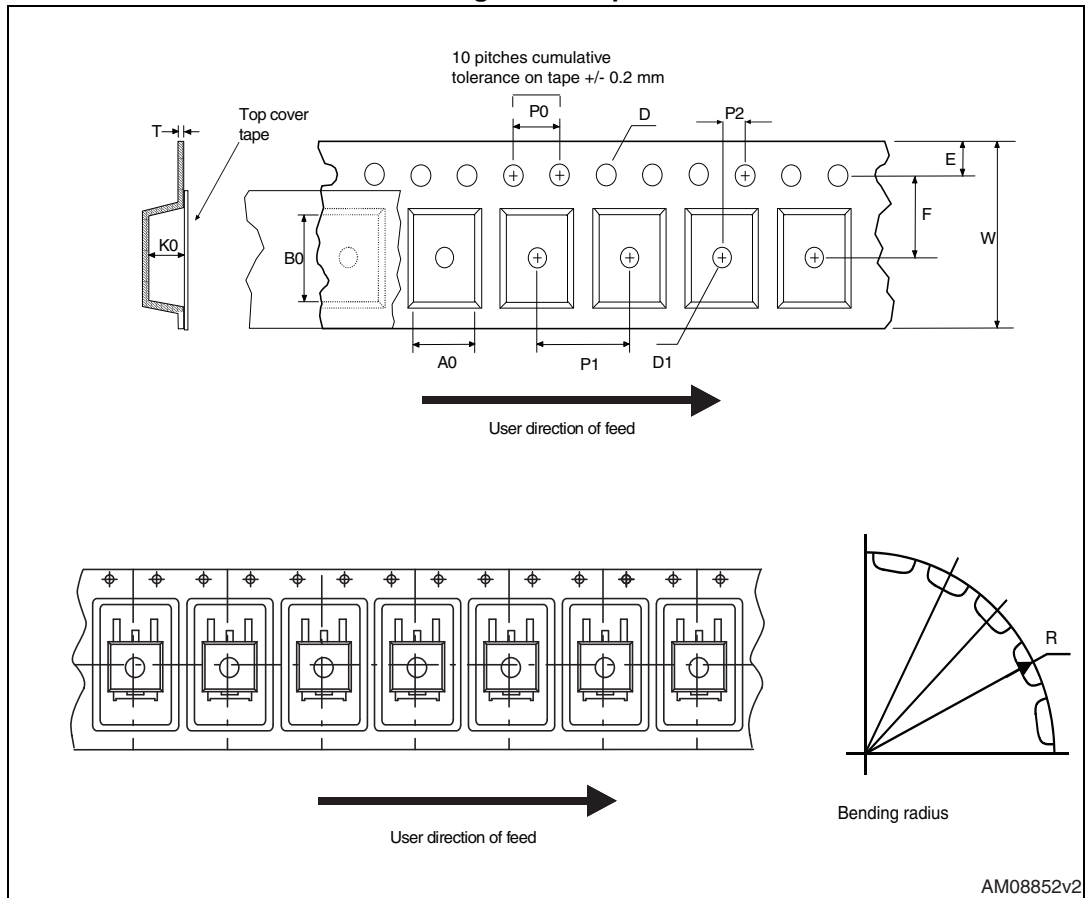
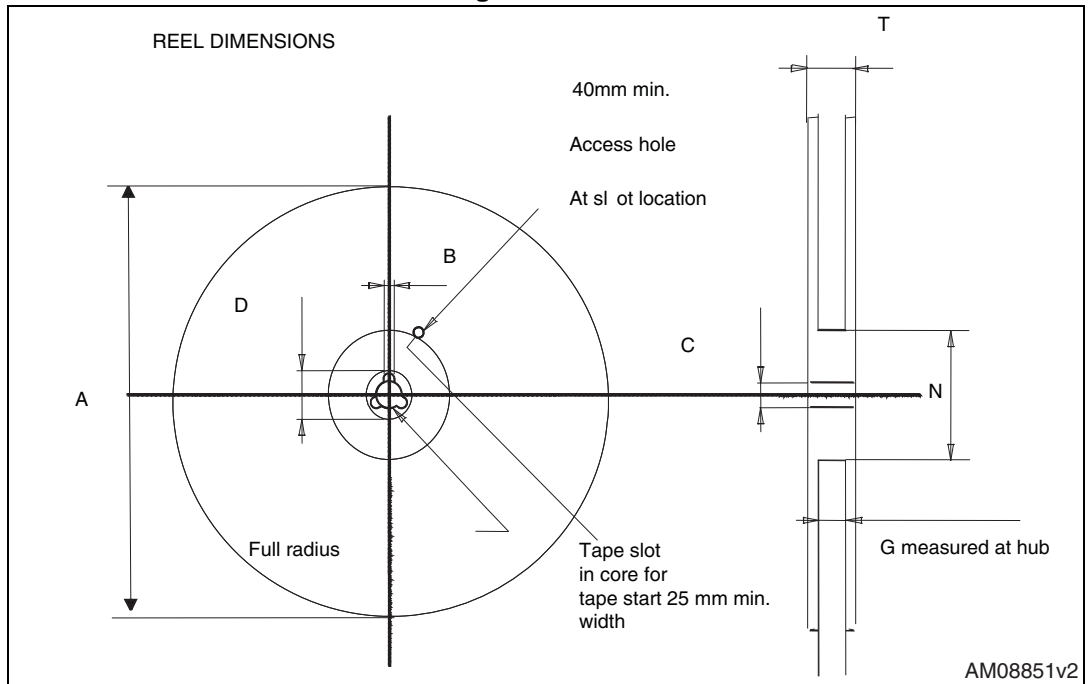


Figure 42. Reel



## 6 Revision history

Table 13. Document revision history

Date	Revision	Changes
12-Aug-2013	1	Initial release.
31-Oct-2013	2	Document status promoted from preliminary to production data. Inserted <a href="#">Section 2.1: Electrical characteristics (curves)</a> . Minor text changes.

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