



STGB7NC60HD, STGF7NC60HD, STGP7NC60HD

N-channel 14 A, 600 V, very fast IGBT with Ultrafast diode

Datasheet – production data

Features

- Low on-voltage drop ($V_{CE(sat)}$)
- Off losses include tail current
- Losses include diode recovery energy
- High frequency operation up to 70 kHz
- Very soft ultra fast recovery anti parallel diode

Applications

- High frequency inverters
- SMPS and PFC in both hard switch and resonant topologies
- Motor drivers

Description

These devices are very fast IGBT developed using advanced PowerMESH™ technology. This process guarantees an excellent trade-off between switching performance and low on-state behavior. These devices are well-suited for resonant or soft-switching applications.

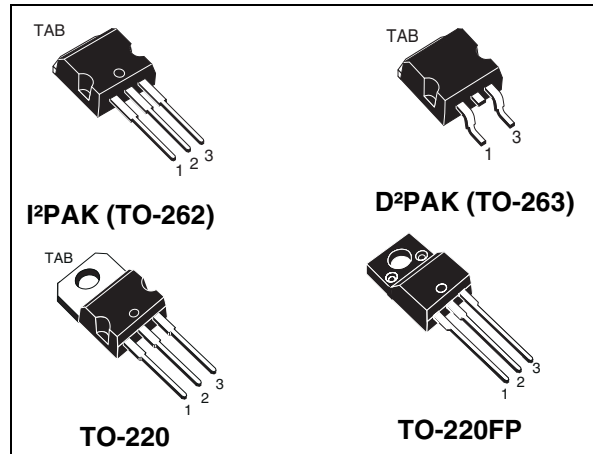


Figure 1. Internal schematic diagram

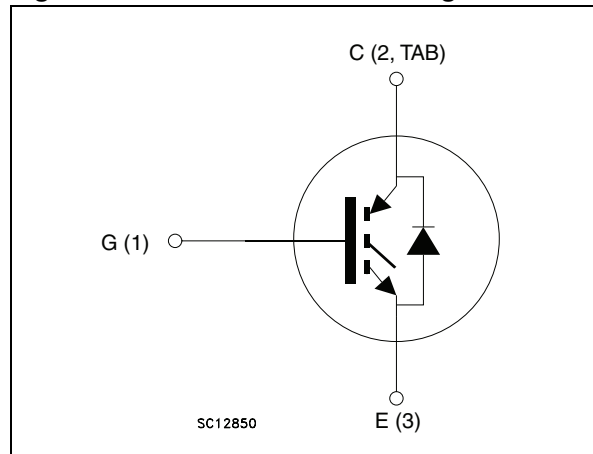


Table 1. Device summary

Order codes	Markings	Packages	Packaging
STGB7NC60HD-1	GB7NC60HD	I ² PAK (TO-262)	Tube
STGB7NC60HDT4		D ² PAK (TO-263)	Tape and reel
STGF7NC60HD	GF7NC60HD	TO-220FP	Tube
STGP7NC60HD	GP7NC60HD	TO-220	Tube

Contents

1	Electrical ratings	3
2	Electrical characteristics	4
2.1	Electrical characteristics (curves)	6
2.2	Operating frequency	9
3	Test circuits	10
4	Package mechanical data	11
5	Packaging mechanical data	19
6	Revision history	21

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		I ² PAK, D ² PAK, TO-220	TO-220FP	
V _{CES}	Collector-emitter voltage (V _{GS} = 0)	600		V
V _{ECR}	Emitter-collector voltage	20		V
V _{GE}	Gate-emitter voltage	±20		V
I _C	Collector current (continuous) at T _C = 25 °C ⁽¹⁾	25	10	A
I _C	Collector current (continuous) at T _C = 100 °C ⁽¹⁾	14	6	A
I _{CM} ⁽²⁾	Collector current (pulsed)	50		A
I _F	Diode RMS forward current at T _C = 25 °C	20		A
P _{TOT}	Total dissipation at T _C = 25 °C	80	25	W
	Derating factor	0.64	0.20	W/°C
V _{ISO}	Insulation withstand voltage A.C. (t = 1 sec; T _C = 25 °C)	--	2500	V
T _{stg}	Storage temperature	– 55 to 150		°C
T _j	Operating junction temperature			

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. Pulse width limited by maximum junction temperature and turn-off within RBSOA.

Table 3. Thermal data

Symbol	Parameter	Value		Unit
		I ² PAK, D ² PAK, TO-220	TO-220FP	
R _{thJC}	Thermal resistance junction-case	1.56	5.0	°C/W
R _{thJA}	Thermal resistance junction-ambient	62.5		°C/W

2 Electrical characteristics

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

Table 4. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-emitter breakdown voltage	$I_C = 1 \text{ mA}, V_{GE} = 0$	600			V
I_{CES}	Collector cut-off current ($V_{GE} = 0$)	$V_{CE} = 600 \text{ V}$ $V_{CE} = 600 \text{ V}, T_C = 125^{\circ}\text{C}$			10 1	μA mA
I_{GES}	Gate-emitter leakage current ($V_{CE} = 0$)	$V_{GE} = \pm 20 \text{ V}$			± 100	nA
$V_{GE(th)}$	Gate threshold voltage	$V_{CE} = V_{GE}, I_C = 250 \mu\text{A}$	3.75		5.75	V
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{GE} = 15 \text{ V}, I_C = 7 \text{ A}$ $V_{GE} = 15 \text{ V}, I_C = 7 \text{ A}, T_C = 125^{\circ}\text{C}$		1.85 1.7	2.5	V V

Table 5. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{CE} = 15 \text{ V}, I_C = 7 \text{ A}$		4.30		S
C_{ies}	Input capacitance	$V_{CE} = 25 \text{ V}, f = 1 \text{ MHz},$ $V_{GE} = 0$		720		pF
C_{oes}	Output capacitance			81		pF
C_{res}	Reverse transfer capacitance			17		pF
Q_g	Total gate charge	$V_{CE} = 390 \text{ V}, I_C = 7 \text{ A},$ $V_{GE} = 15 \text{ V}$		35	48	nC
Q_{ge}	Gate-emitter charge			7		nC
Q_{gc}	Gate-collector charge			16		nC
I_{CL}	Turn-off SOA minimum current	$V_{clamp} = 480 \text{ V}, T_j = 150^{\circ}\text{C}$ $R_G = 10 \Omega, V_{GE} = 15 \text{ V}$	50			A

1. Pulsed: Pulse duration= 300 μs , duty cycle 1.5%

Table 6. Switching on

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 390 \text{ V}, I_C = 7 \text{ A}$ $R_G = 10 \Omega, V_{GE} = 15 \text{ V}$ (see Figure 21)		18.5		ns
t_r	Current rise time			8.5		ns
$(di/dt)_{on}$	Turn-on current slope			1060		A/ μs
$t_{d(on)}$	Turn-on delay time	$V_{CC} = 390 \text{ V}, I_C = 7 \text{ A}$ $R_G = 10 \Omega, V_{GE} = 15 \text{ V},$ $T_j = 125^{\circ}\text{C}$ (see Figure 21)		18.5		ns
t_r	Current rise time			7		ns
$(di/dt)_{on}$	Turn-on current slope			1000		A/ μs

Table 7. Switching off

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_r(V_{off})$	Off voltage rise time	$V_{CC} = 390\text{ V}, I_C = 7\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$	-	27	-	ns
$t_{d(off)}$	Turn-off delay time			72		ns
t_f	Current fall time			60		ns
$t_r(V_{off})$	Off voltage rise time	$V_{CC} = 390\text{ V}, I_C = 7\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V}$ $T_j = 125\text{ }^\circ\text{C}$	-	56	-	ns
$t_{d(off)}$	Turn-off delay time			116		ns
t_f	Current fall time			105		ns

Table 8. Switching energy

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 390\text{ V}, I_C = 7\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V},$	-	95	125	μJ
$E_{off}^{(2)}$	Turn-off switching loss			115	150	μJ
E_{ts}	Total switching loss			210	275	μJ
$E_{on}^{(1)}$	Turn-on switching losses	$V_{CC} = 390\text{ V}, I_C = 7\text{ A},$ $R_G = 10\ \Omega, V_{GE} = 15\text{ V},$ $T_j = 125\text{ }^\circ\text{C}$	-	140		μJ
$E_{off}^{(2)}$	Turn-off switching loss			215		μJ
E_{ts}	Total switching loss			355		μJ

1. E_{on} is the turn-on losses when a typical diode is used in the test circuit. If the IGBT is offered in a package with a co-pack diode, the co-pack diode is used as external diode. IGBTs and diode are at the same temperature (25°C and 125°C).
2. Turn-off losses include also the tail of the collector current.

Table 9. Collector-emitter diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_f	Forward on-voltage	$I_f = 3.5\text{ A}$	-	1.3	1.9	V
		$I_f = 3.5\text{ A}, T_j = 125\text{ }^\circ\text{C}$		1.1		V
t_{rr}	Reverse recovery time	$I_f = 7\text{ A}, V_R = 40\text{ V},$ $di/dt = 100\text{ A}/\mu\text{s}$	-	37		ns
t_a				22		ns
Q_{rr}	Reverse recovery charge			40		nC
I_{rrm}	Reverse recovery current			2.1		A
S	Softness factor of the diode			0.68		
t_{rr}	Reverse recovery time	$I_f = 7\text{ A}, V_R = 40\text{ V},$ $T_j = 125\text{ }^\circ\text{C}, di/dt = 100\text{ A}/\mu\text{s}$	-	61		ns
t_a				34		ns
Q_{rr}	Reverse recovery charge			98		nC
I_{rrm}	Reverse recovery current			3.2		A
S	Softness factor of the diode			0.79		

2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

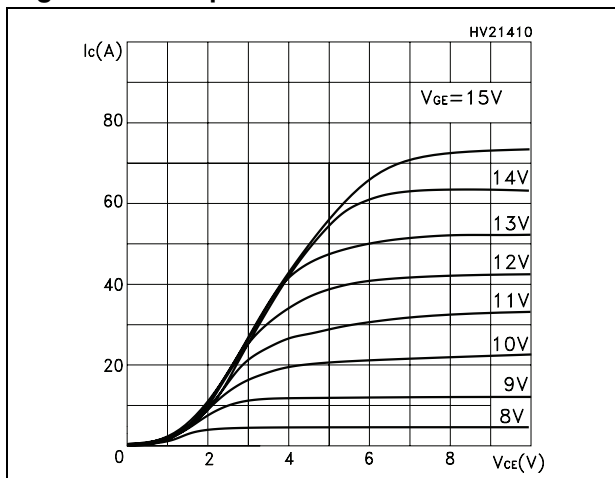


Figure 3. Transfer characteristics

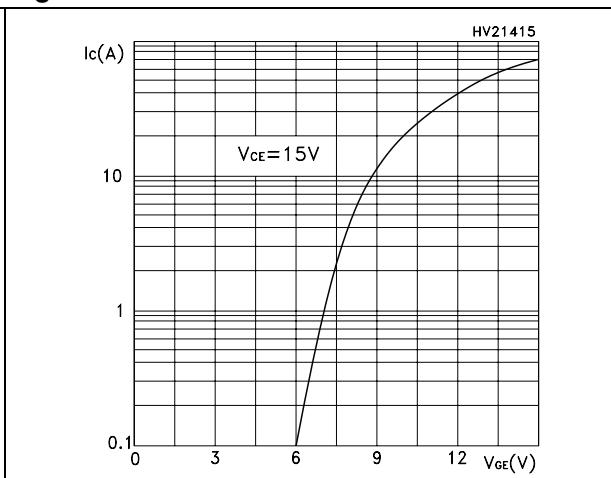


Figure 4. Transconductance

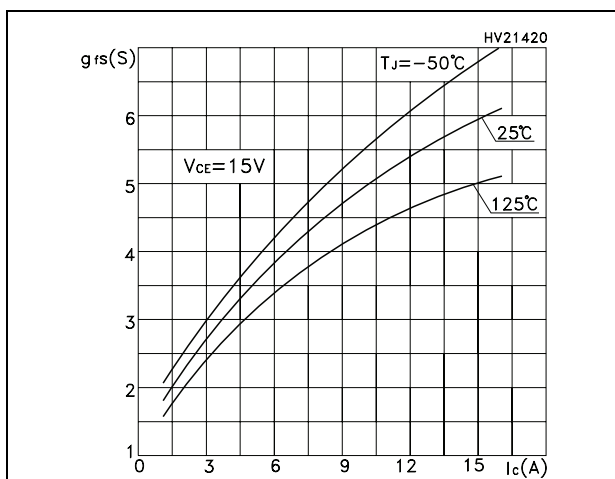


Figure 5. Collector-emitter on voltage vs. temperature

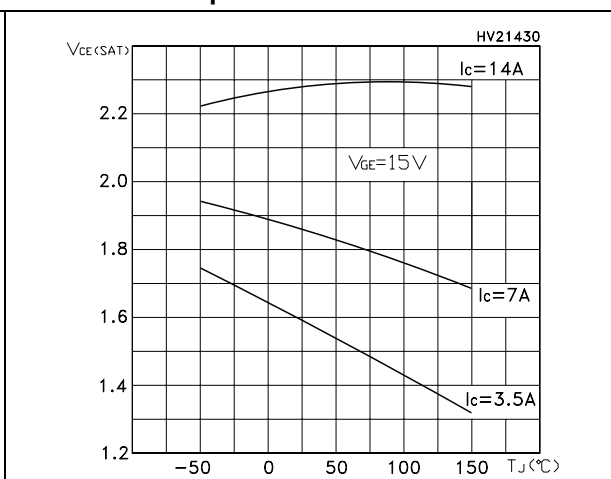


Figure 6. Collector-emitter on voltage vs. collector current

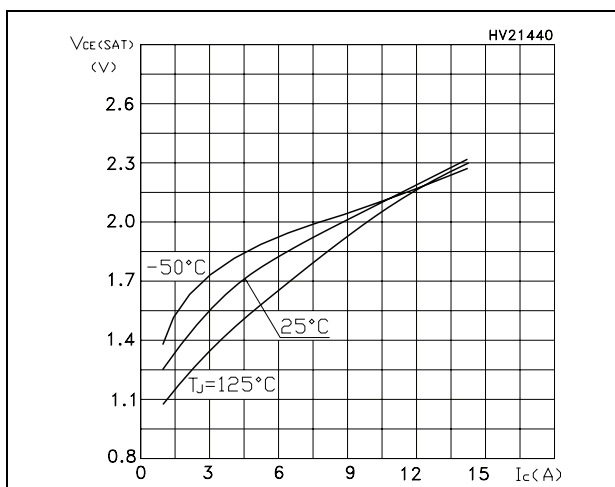


Figure 7. Normalized gate threshold vs. temperature

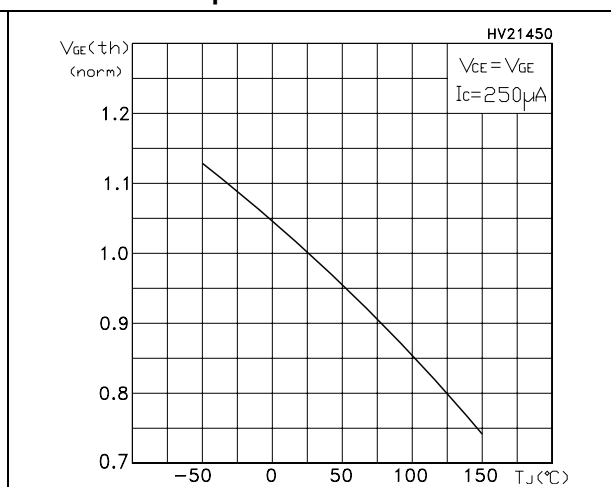


Figure 8. Normalized breakdown voltage vs temperature

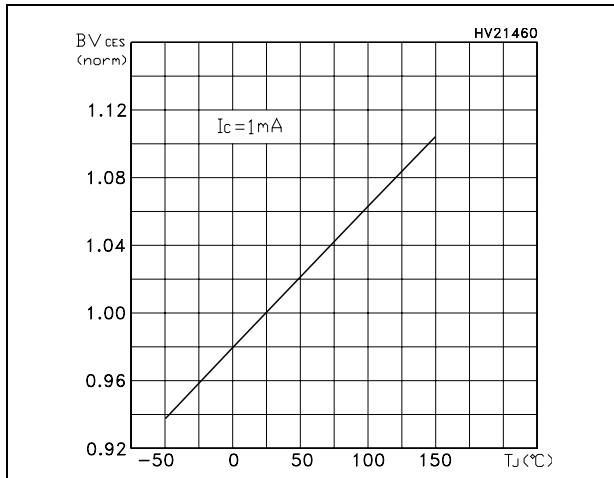


Figure 9. Gate charge vs. gate-emitter voltage

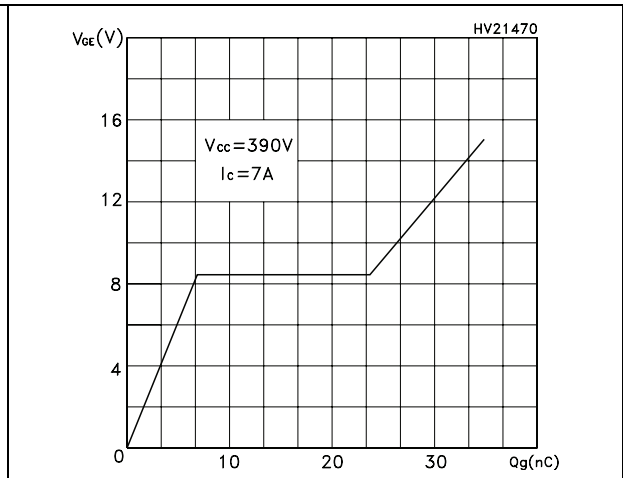


Figure 10. Capacitance variations

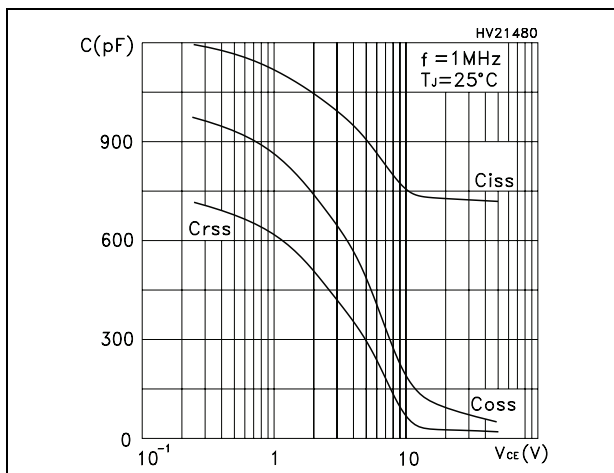


Figure 11. Total switching losses vs. temperature

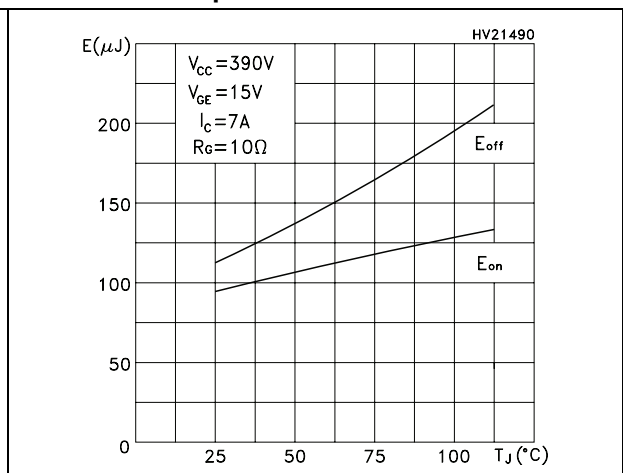


Figure 12. Total switching losses vs. gate resistance

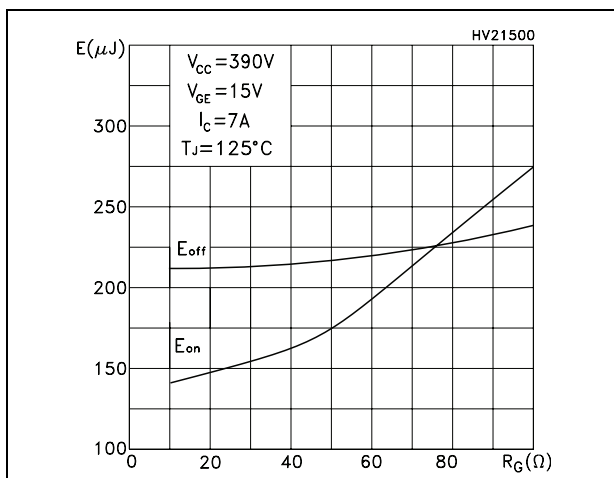


Figure 13. Total switching losses vs collector current

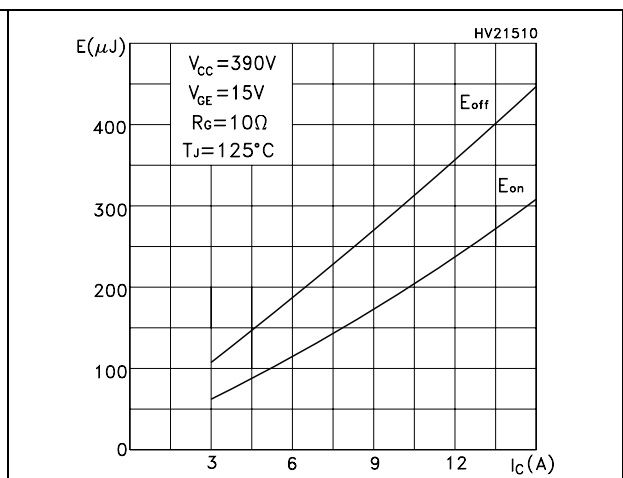


Figure 14. Emitter-collector diode characteristics

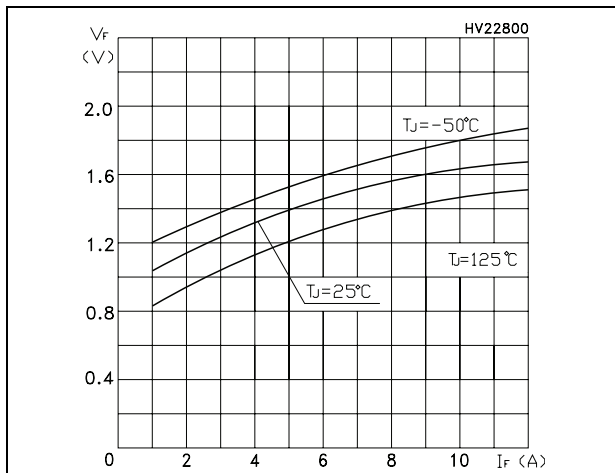


Figure 15. Turn-off SOA

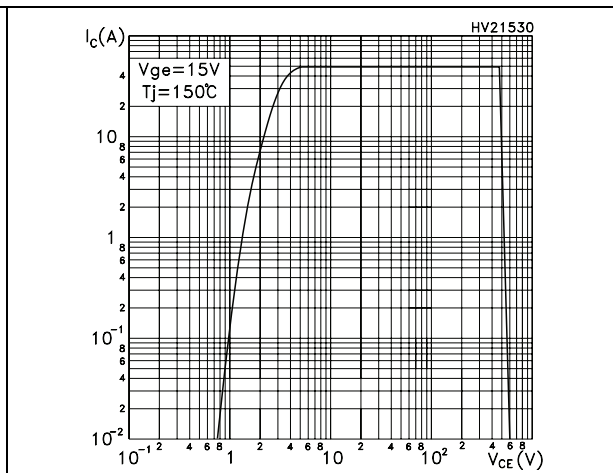


Figure 16. Thermal impedance for I²PAK, D²PAK and TO-220

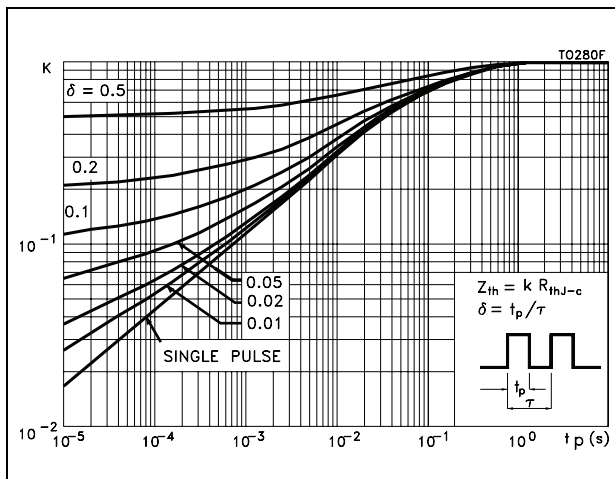
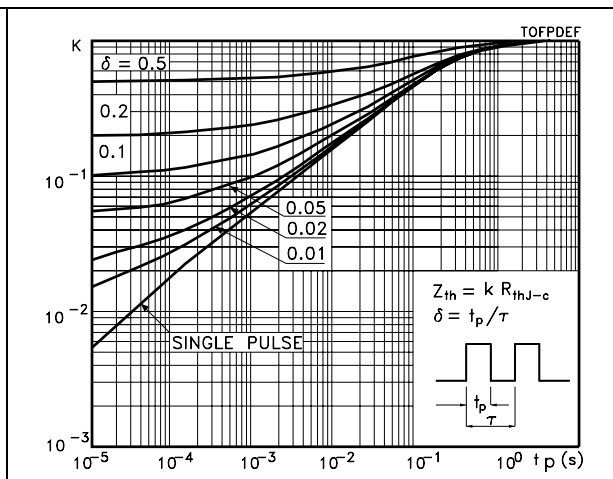
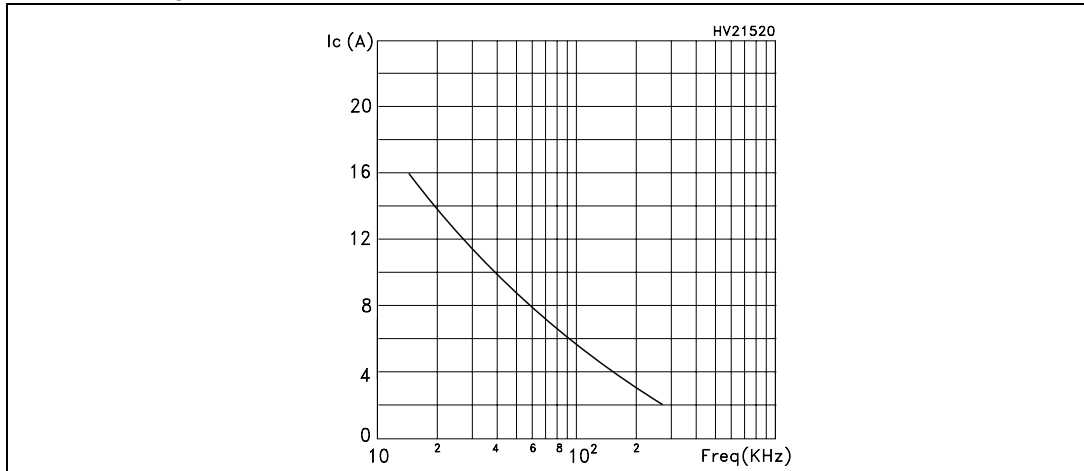


Figure 17. Thermal impedance for TO-220FP



2.2 Operating frequency

Figure 18. I_C vs. frequency



For a fast IGBT suitable for high frequency applications, the typical collector current vs. maximum operating frequency curve is reported. That frequency is defined as follows:

Equation 1

$$f_{MAX} = (P_D - P_C) / (E_{ON} + E_{OFF})$$

The maximum power dissipation is limited by maximum junction to case thermal resistance:

Equation 2

$$P_D = \Delta T / R_{THJ-C}$$

considering $\Delta T = T_J - T_C = 125\text{ }^\circ\text{C} - 75\text{ }^\circ\text{C} = 50\text{ }^\circ\text{C}$

The conduction losses are:

Equation 3

$$P_C = I_C * V_{CE(SAT)} * \delta$$

with 50% of duty cycle, $V_{CE(sat)}$ typical value $T_C = 125\text{ }^\circ\text{C}$.

Power dissipation during ON & OFF commutations is due to the switching frequency:

Equation 4

$$P_{SW} = (E_{ON} + E_{OFF}) * \text{freq.}$$

Typical values $T_C = 125\text{ }^\circ\text{C}$ for switching losses are used (test conditions: $V_{CE} = 390\text{ V}$, $V_{GE} = 15\text{ V}$, $R_G = 3.3\text{ }\Omega$). Furthermore, diode recovery energy is included in the E_{ON} , while the tail of the collector current is included in the E_{OFF} measurements.

3 Test circuits

Figure 19. Test circuit for inductive load switching

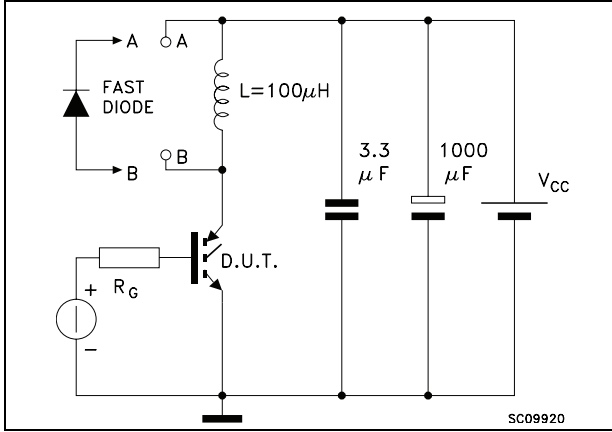


Figure 20. Gate charge test circuit

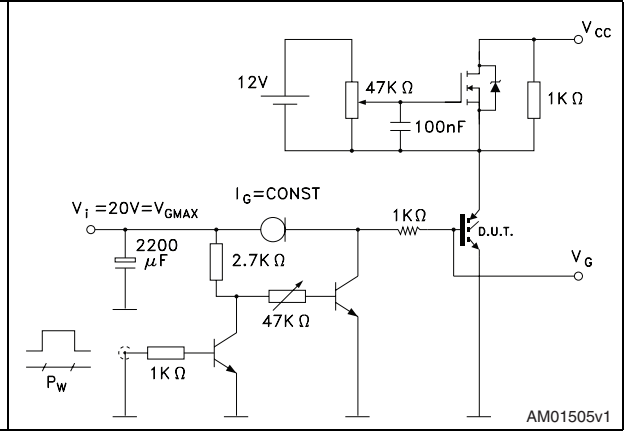


Figure 21. Switching waveform

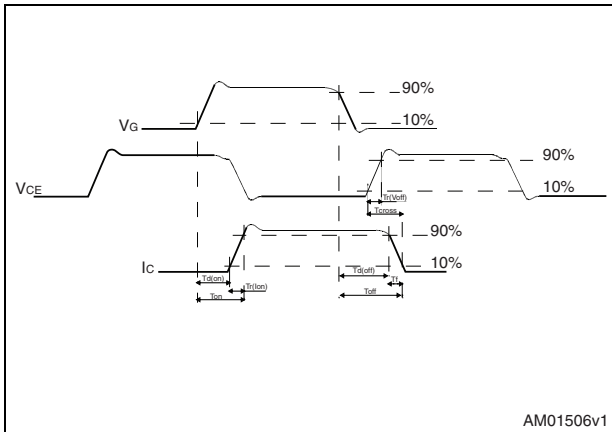
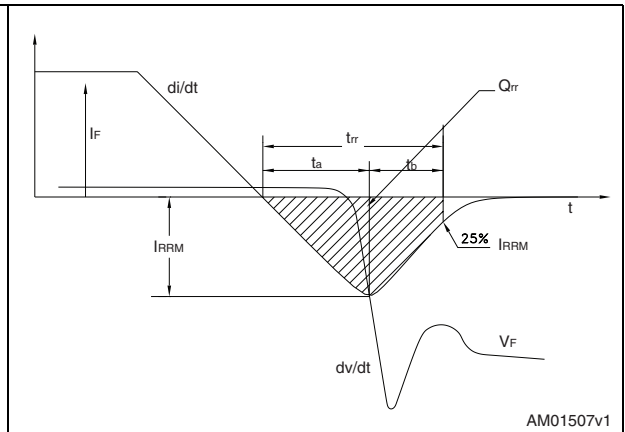


Figure 22. Diode recovery time waveform



4 Package mechanical data

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.

Table 10. I²PAK (TO-262) mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A	4.40		4.60
A1	2.40		2.72
b	0.61		0.88
b1	1.14		1.70
c	0.49		0.70
c2	1.23		1.32
D	8.95		9.35
e	2.40		2.70
e1	4.95		5.15
E	10		10.40
L	13		14
L1	3.50		3.93
L2	1.27		1.40

Figure 23. I²PAK (TO-262) drawing

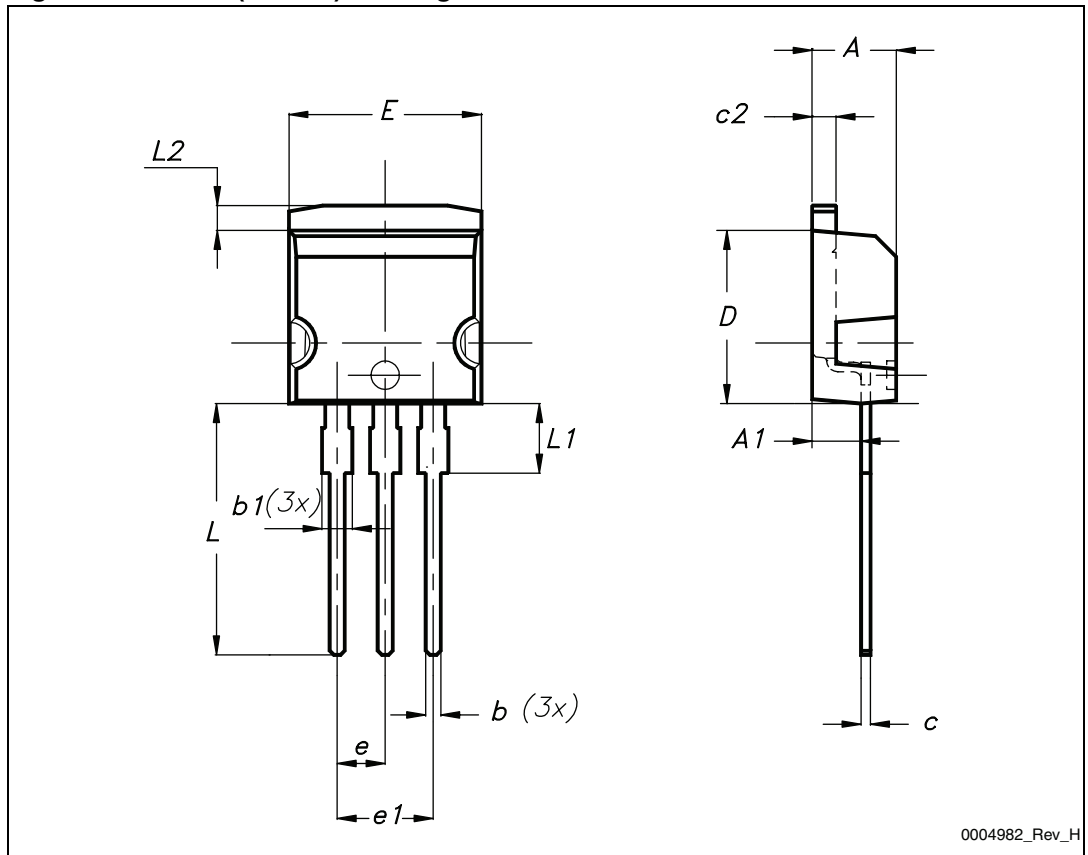


Table 11. D²PAK (TO-263) mechanical data

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 24. D²PAK (TO-263) drawing

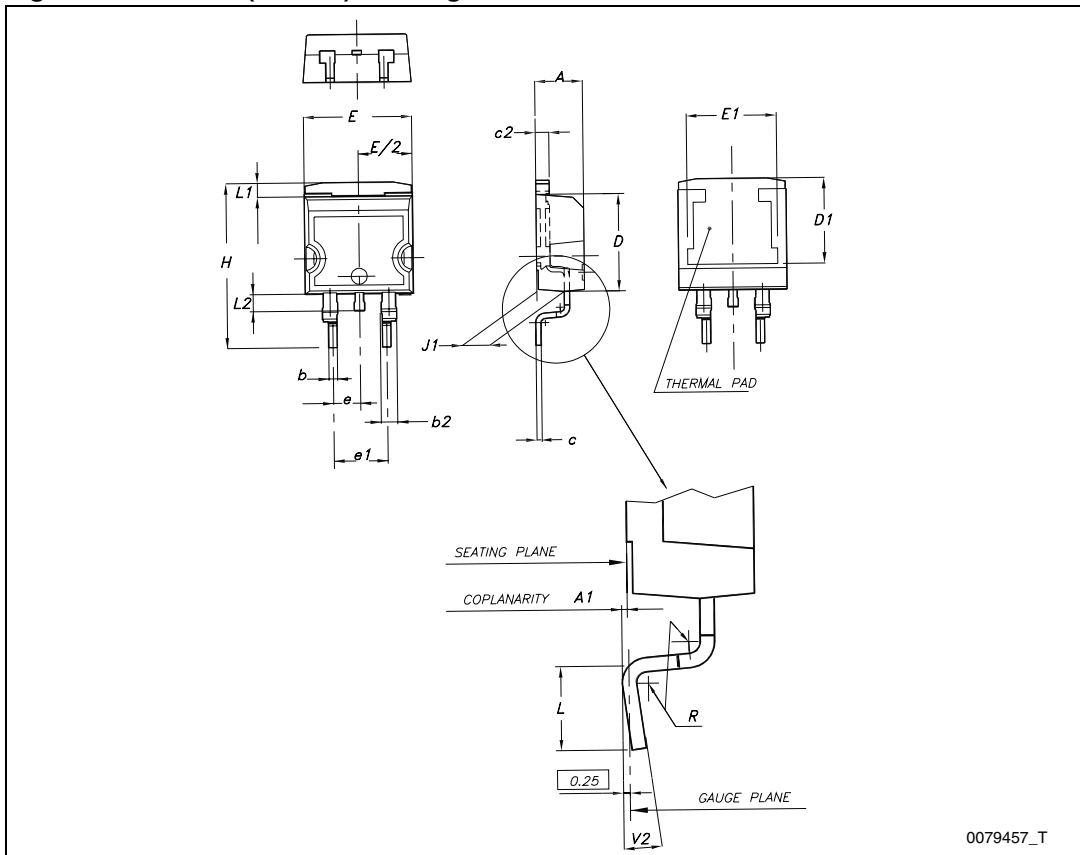
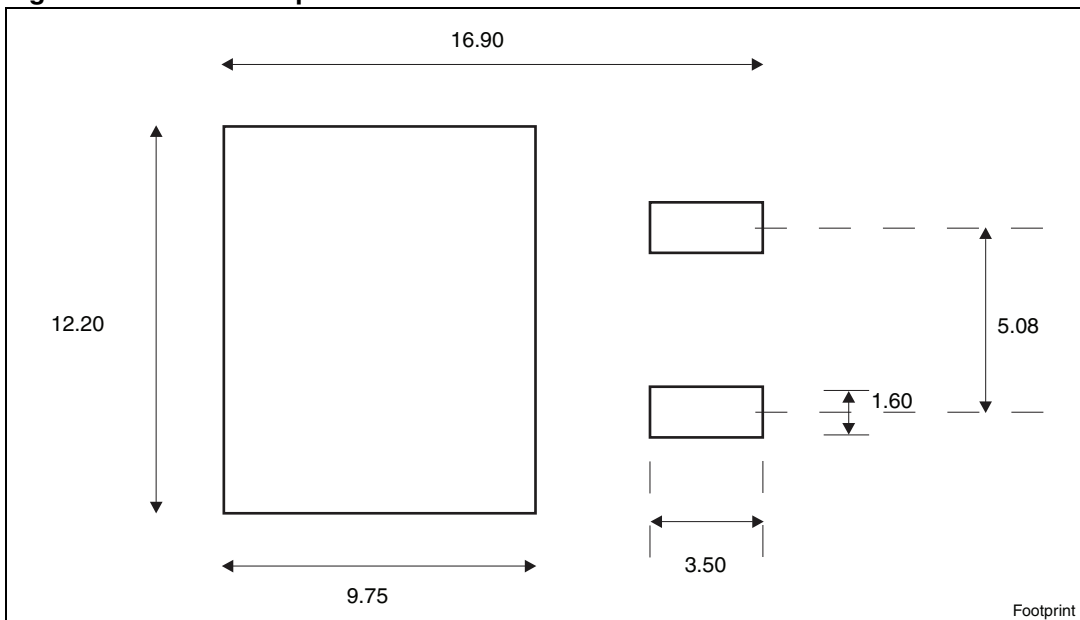


Figure 25. D²PAK footprint^(a)

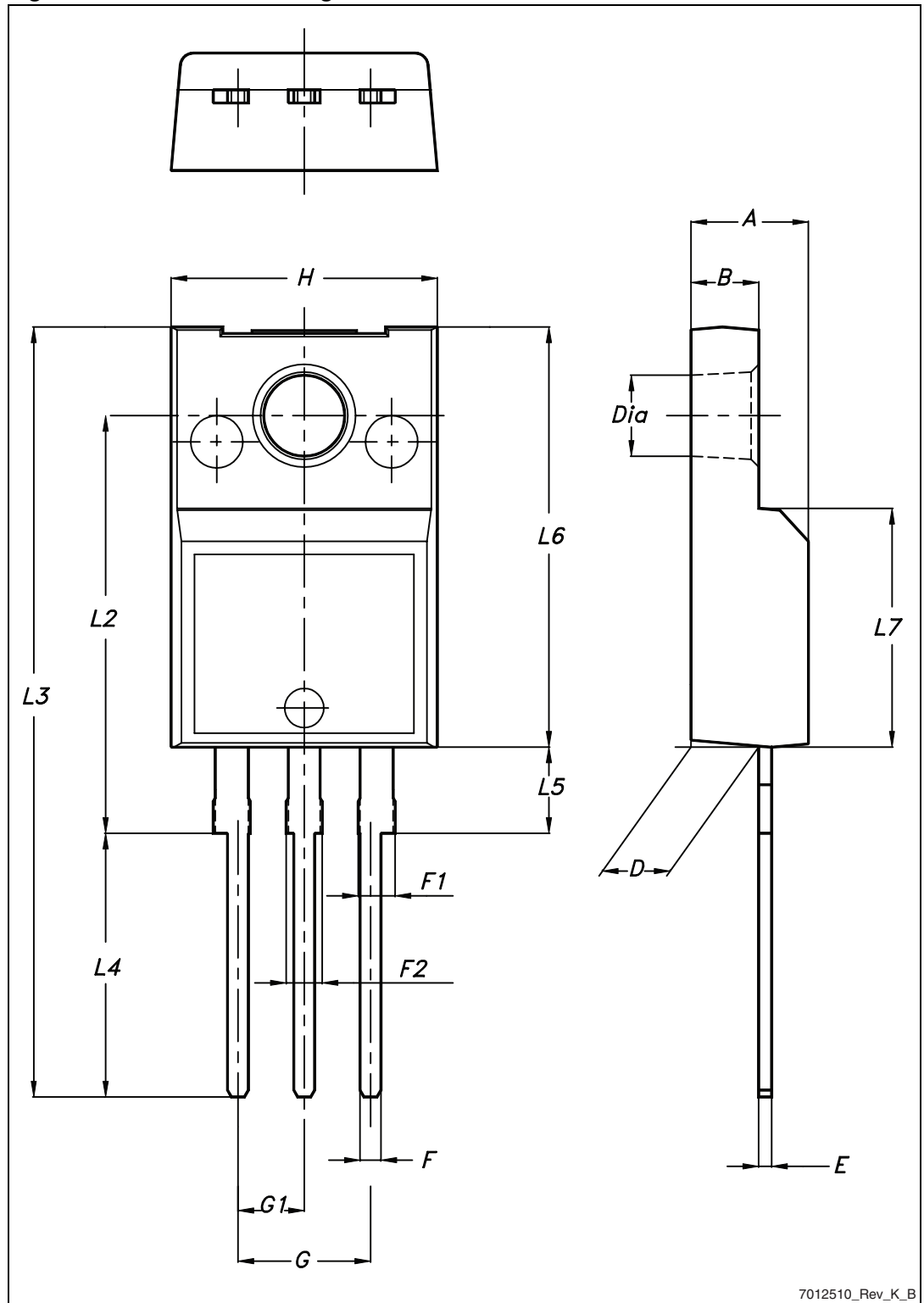


a. All dimensions are in millimeters

Table 12. 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 26. TO-220FP drawing

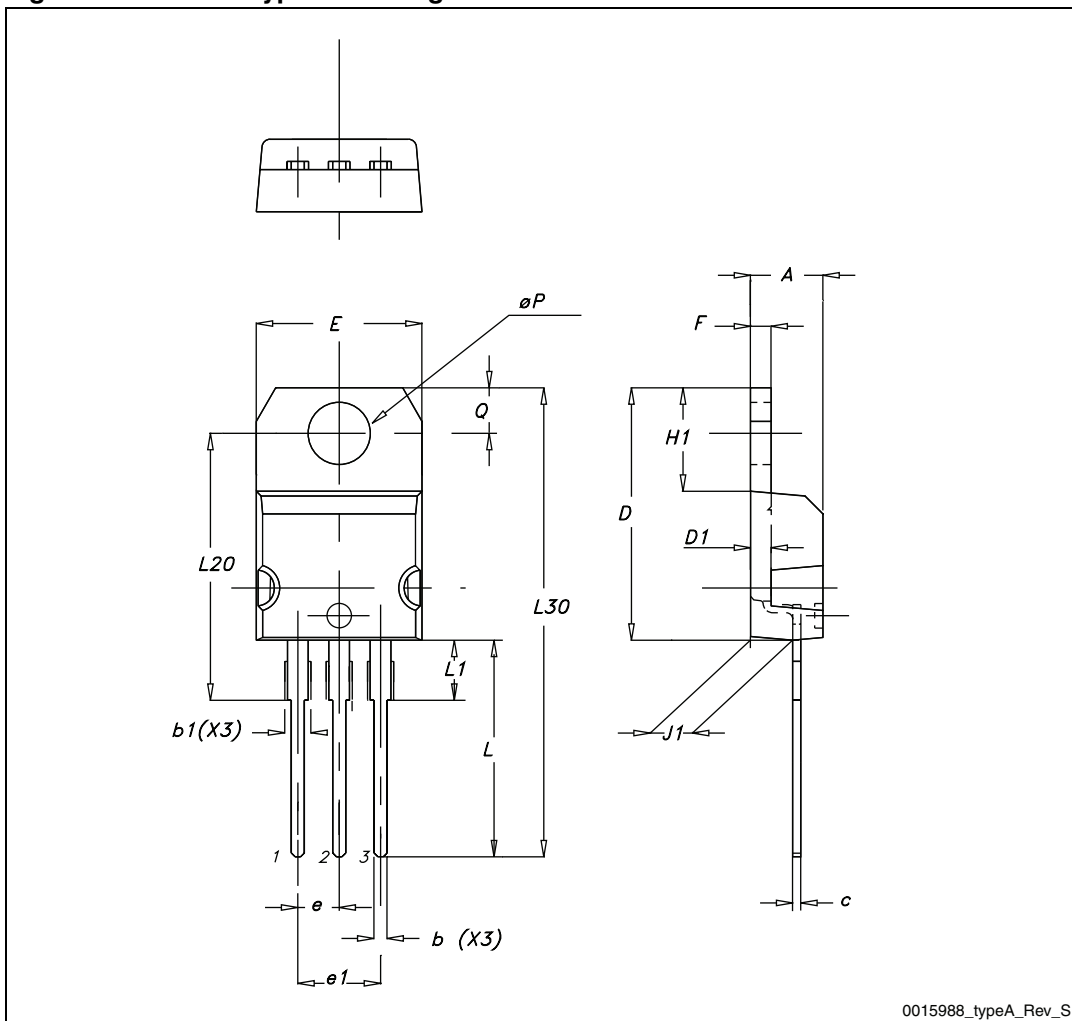


7012510_Rev_K_B

Table 13. 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	
∅P	3.75		3.85
Q	2.65		2.95

Figure 27. TO-220 type A drawing



5 Packaging mechanical data

Table 14. D²PAK (TO-263) 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 28. Tape

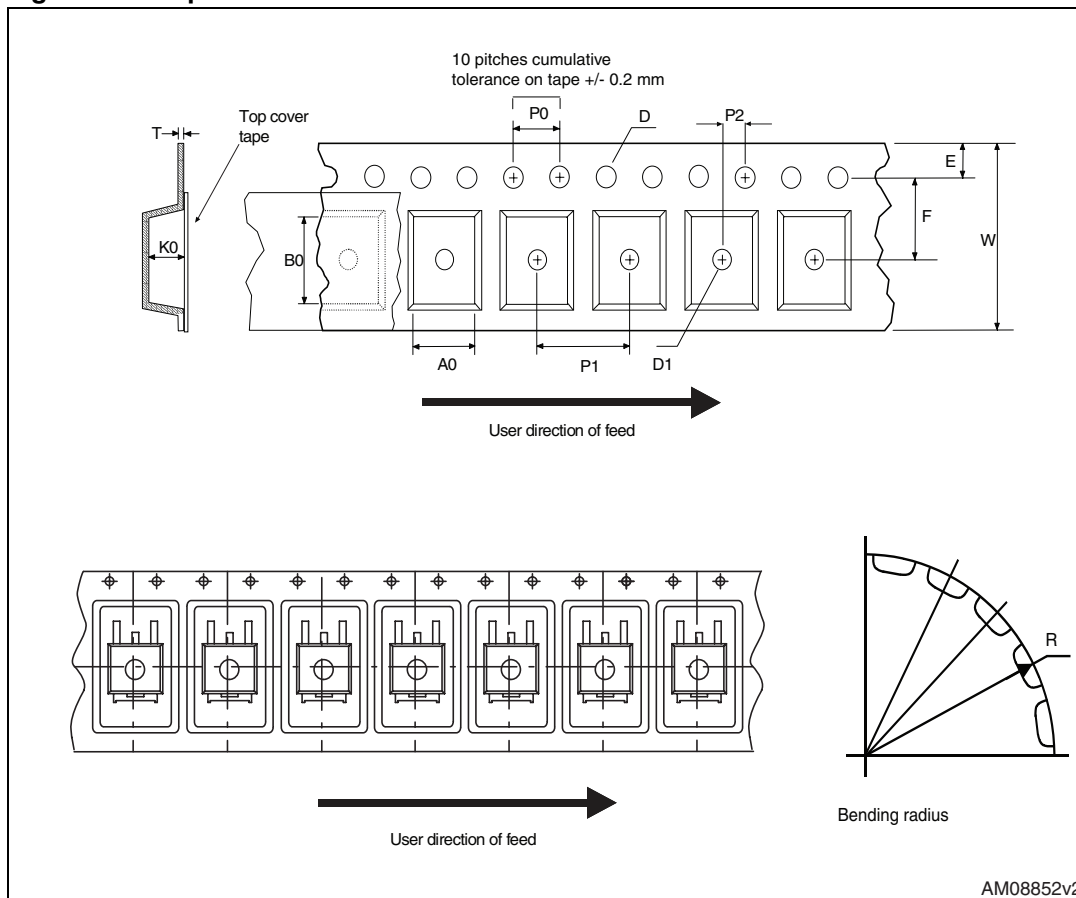
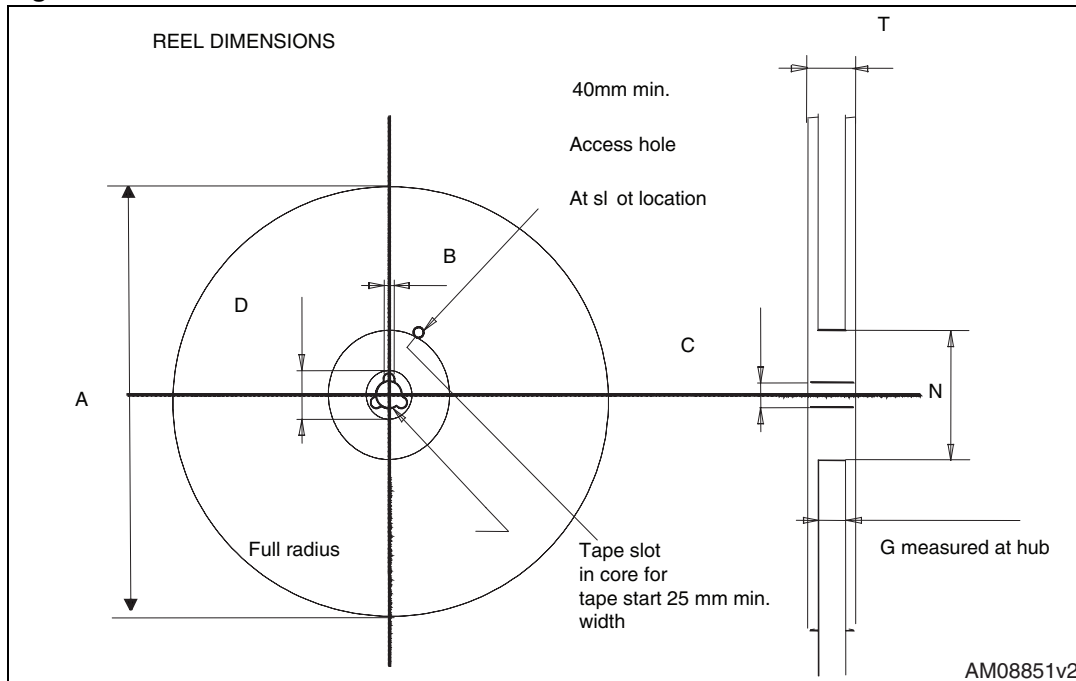


Figure 29. Reel



6 Revision history

Table 15. Document revision history

Date	Revision	Changes
07-Jun-2004	4	Stylesheet update. No content change.
19-Aug-2004	5	Complete version
17-Sep-2004	6	<i>Figure 14</i> has been added
09-Nov-2004	7	Final datasheet
19-Jan-2005	8	Datasheet updated
09-Jun-2005	9	Modified title
27-Jun-2012	10	Inserted commercial type STGB7NC60HD. Minor text changes.

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