STD11NM60ND, STF/I11NM60ND STP11NM60ND, STU11NM60ND

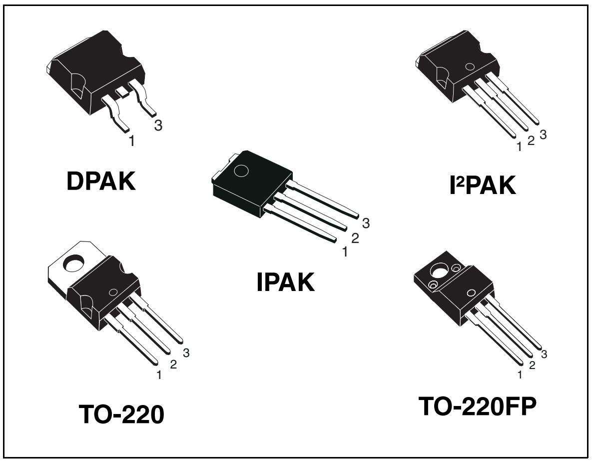
N-channel 600 V, 0.37 Ω, 10 A, FDmesh™ II Power MOSFET I^2PAK, TO-220, TO-220FP, IPAK, DPAK

Features

Order codes	V_{DSS} (@T_{jmax})	$R_{DS(on)}$ max	I_D
STD11NM60ND	650 V	< 0.45 Ω	10 A
STF11NM60ND			10 A(1)
STI11NM60ND			10 A
STP11NM60ND			10 A
STU11NM60ND			10 A

1. Limited only by maximum temperature allowed

- The worldwide best $R_{DS(on)}$* area amongst the fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities



Application

Switching applications

Description

The device is an N-channel FDmesh™ II Power MOSFET that belongs to the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout and associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode.It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

Figure 1. Internal schematic diagram

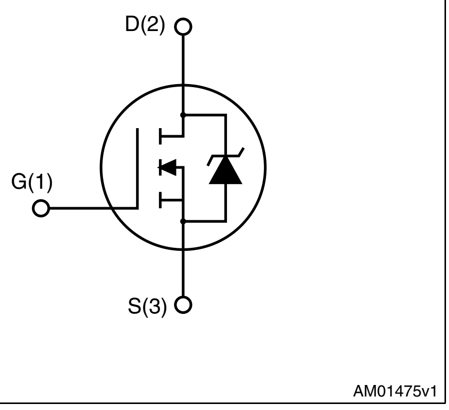


Table 1. Device summary

Order codes	Marking	Package	Packaging
STD11NM60ND	11NM60ND	DPAK	Tape and reel
STF11NM60ND		TO-220FP	Tube
STI11NM60ND		I^2PAK	Tube
STP11NM60ND		TO-220	Tube
STU11NM60ND		IPAK	Tube

Contents

1 Electrical ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		DPAK/I²PAK, TO-220/IPAK	TO-220FP	
V_{DS}	Drain-source voltage (V_{GS}=0)	600		V
V_{GS}	Gate-source voltage	± 25		V
I_D	Drain current (continuous) at T_C = 25°C	10	10 (1)	A
I_D	Drain current (continuous) at T_C = 100°C	6.3	6.3(1)	A
I_{DM} (2)	Drain current (pulsed)	40	40 (1)	A
P_{TOT}	Total dissipation at T_C = 25°C	90	25	W
dv/dt (3)	Peak diode recovery voltage slope	40		V/ns
V_{ISO}	Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1s;T_C=25°C)		2500	V
T_{stg}	Storage temperature	-55 to 150		°C
T_j	Max. operating junction temperature	150		°C

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I_{SD} $\leq$ 10 A, di/dt $\leq$ 400 A/µs, V_{DD} = 80% $V_{(BR)DSS}$, peak VDS $\leq$ $V_{(BR)DSS}$

Table 3. Thermal data

Symbol	Parameter	Value					Unit
		TO-220	I²PAK	DPAK	IPAK	TO-220FP	
$R_{thj-case}$	Thermal resistance junction-case max	1.38				5	°C/W
$R_{thj-amb}$	Thermal resistance junction-amb max	62.5			100	62.5	°C/W
$R_{thj-pcb}$ (1)	Thermal resistance junction-pcb max			50			°C/W
T_l	Maximum lead temperature for soldering purposes	300			300		°C

1. When mounted on 1inch² FR-4 board, 2 oz Cu

Table 4. Avalanche characteristics

Symbol	Parameter	Max value	Unit
I_{AS}	Avalanche current, repetitive or not-repetitive[(1)]	3.5	A
E_{AS}	Single pulse avalanche energy [(2)]	200	mJ

1. Pulse width limited by Tj max
2. starting Tj= 25 °C, I_D=I_{AS}, V_{DD}= 50 V

2 Electrical characteristics

(T_{CASE} = 25 °C unless otherwise specified)

Table 5. On/off states

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	I_D = 1 mA, V_{GS}= 0	600			V
dv/dt(1)	Drain-source voltage slope	V_{DD} = 480 V,I_D = 10 A, V_{GS} = 10 V		45		V/ns
I_{DSS}	Zero gate voltage drain current (V_{GS} = 0)	V_{DS} = max rating, V_{DS} = max rating, @125 °C			1 100	µA µA
I_{GSS}	Gate body leakage current (V_{DS} = 0)	V_{GS} = ±20 V			100	nA
$V_{GS(th)}$	Gate threshold voltage	V_{DS}= V_{GS}, I_D = 250 µA	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	V_{GS}= 10 V, I_D= 5 A		0.37	0.45	Ω

1. Value measured at turn off under inductive load

Table 6. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
g_{fs}(1)	Forward transconductance	V_{DS} =15 V, I_D= 5 A	-	7.5	-	S
C_{iss} C_{oss} C_{rss}	Input capacitance Output capacitance Reverse transfer capacitance	V_{DS} = 50 V, f =1 MHz, V_{GS} = 0	-	850 44 5	-	pF pF pF
$C_{oss\ eq.}$(2)	Equivalent output capacitance	V_{GS} = 0, V_{DS} = 0V to 480 V	-	130	-	pF
Rg	Gate input resistance	f=1 MHz Gate DC Bias=0 Test signal level=20 mV open drain	-	3.7	-	Ω
Q_g Q_{gs} Q_{gd}	Total gate charge Gate-source charge Gate-drain charge	V_{DD} = 480 V, I_D = 10 A V_{GS} = 10 V (see *Figure 19*)	-	30 4 16	-	nC nC nC

1. Pulsed: pulse duration = 300µs, duty cycle 1.5%
2. $C_{oss\ eq.}$ is defined as a constant equivalent capacitance giving the same charging time as C_{oss} when V_{DS} increases from 0 to 80% V_{DSS}

Table 7. Switching times

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on delay time Rise time Turn-off delay time Fall time	V_{DD} = 300 V, I_D = 5 A, R_G = 4.7 Ω, V_{GS} = 10 V (see *Figure 18*)	-	16 7 50 9	-	ns ns ns ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I_{SD} I_{SDM} (1)	Source-drain current Source-drain current (pulsed)		-		10 40	A A
V_{SD}(2)	Forward on voltage	I_{SD} = 10 A, V_{GS}=0	-		1.3	V
t_{rr} Q_{rr} I_{RRM}	Reverse recovery time Reverse recovery charge Reverse recovery current	I_{SD} =10 A, di/dt =100 A/µs, V_{DD} = 100 V (see *Figure 20*)	-	130 0.69 11		ns µC A
t_{rr} Q_{rr} I_{RRM}	Reverse recovery time Reverse recovery charge Reverse recovery current	V_{DD} = 100 V di/dt =100 A/µs, I_{SD} = 10 A Tj = 150 °C (see *Figure 20*)	-	200 1.2 12		ns µC A

1. Pulse width limited by safe operating area
2. Pulsed: pulse duration = 300µs, duty cycle 1.5%

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220, I²PAK

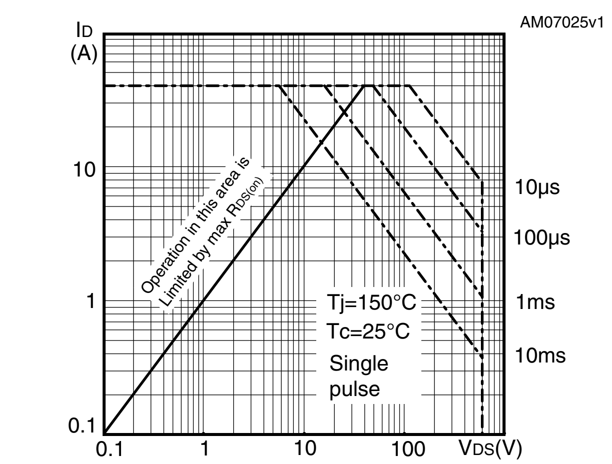


Figure 3. Thermal impedance for TO-220, I²PAK

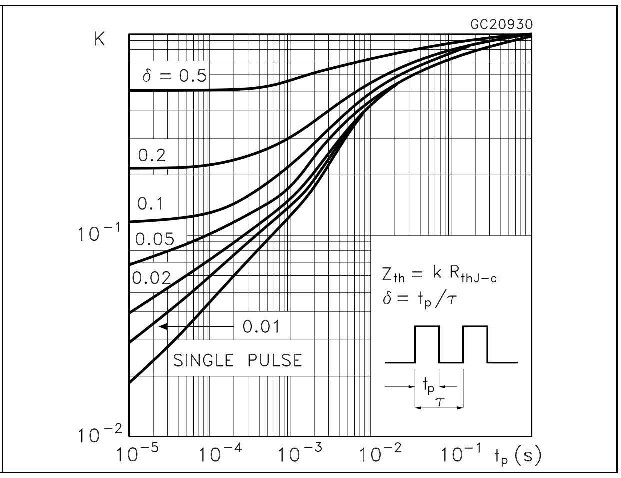


Figure 4. Safe operating area for TO-220FP

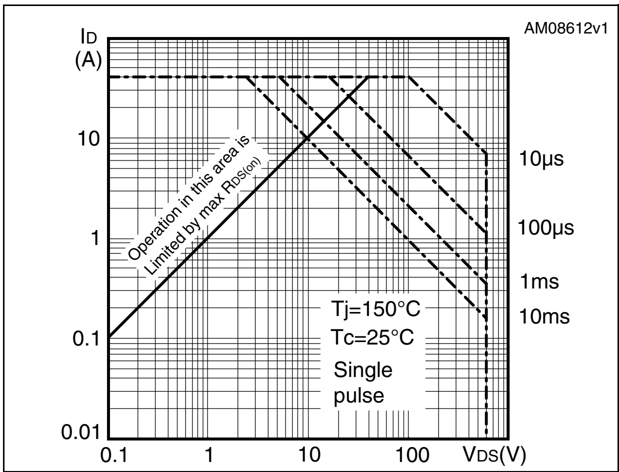


Figure 5. Thermal impedance for TO-220FP

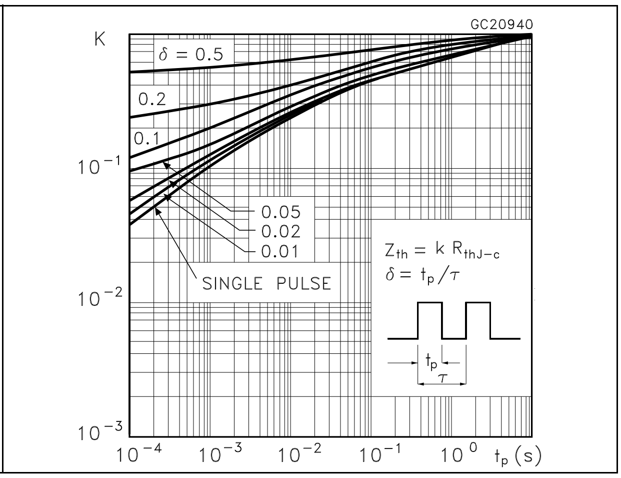


Figure 6. Safe operating area for DPAK, IPAK

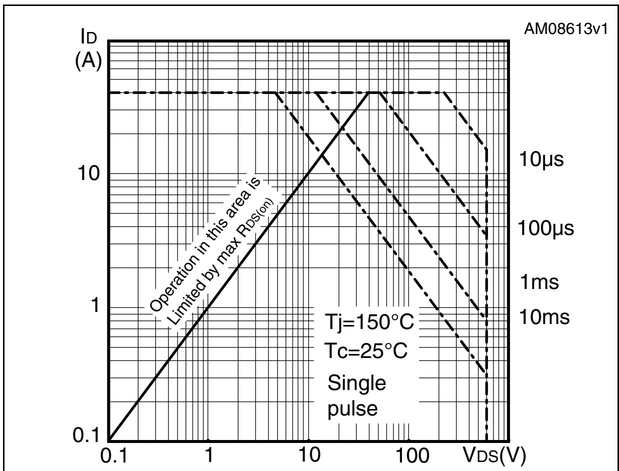


Figure 7. Thermal impedance for DPAK, IPAK

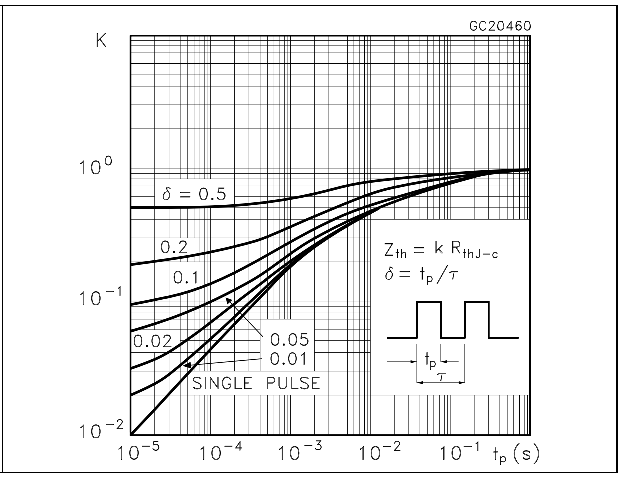


Figure 8. Output characteristics

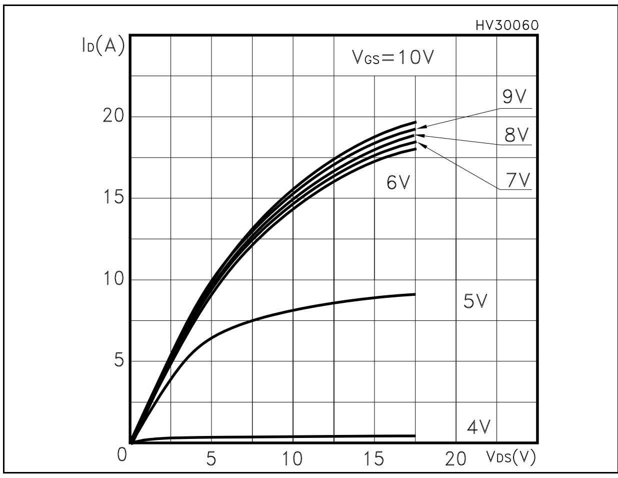


Figure 9. Transfer characteristics

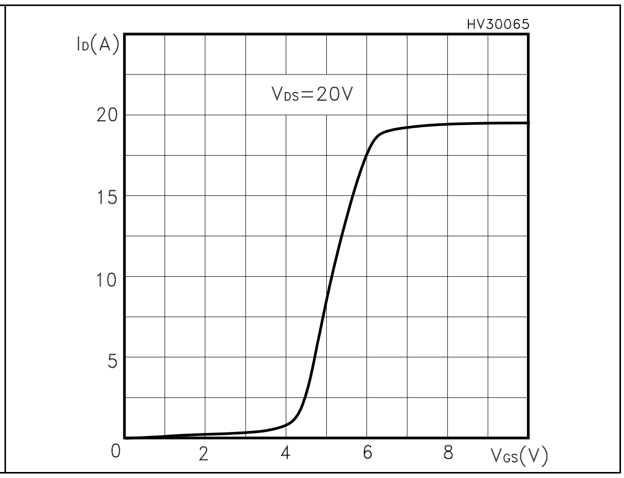


Figure 10. Transconductance

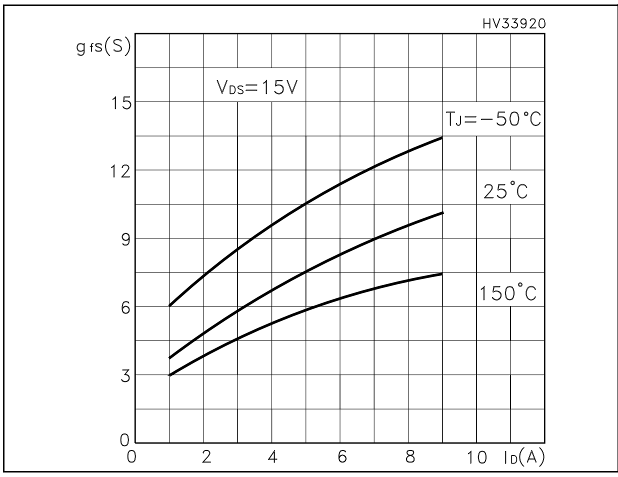


Figure 11. Static drain-source on resistance

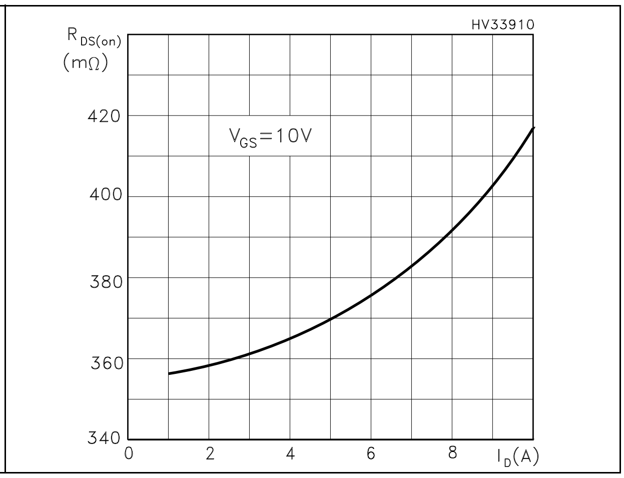


Figure 12. Gate charge vs gate-source voltage

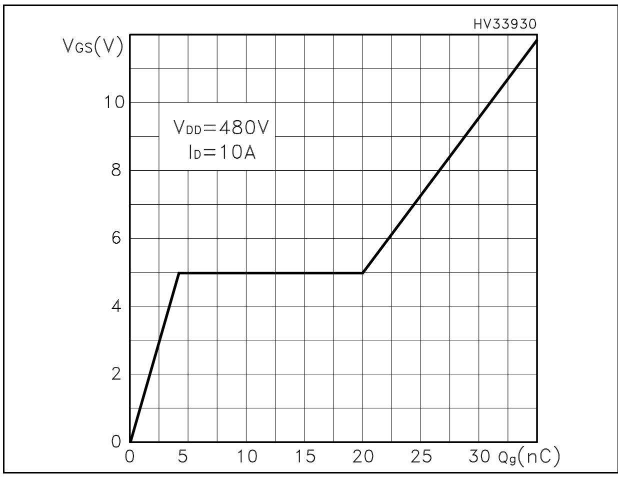


Figure 13. Capacitance variations

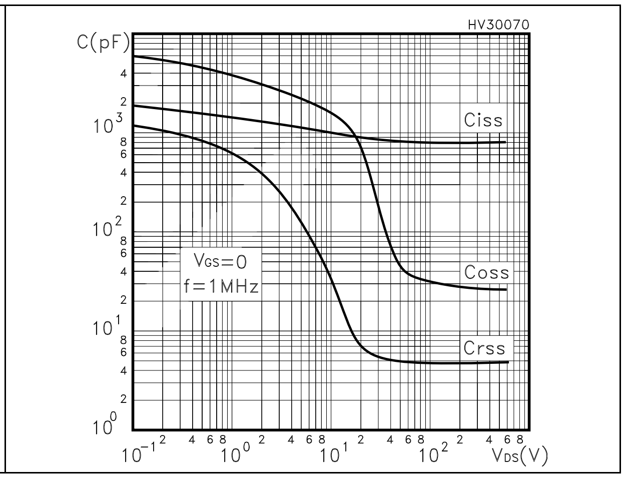


Figure 14. Normalized gate threshold voltage vs temperature

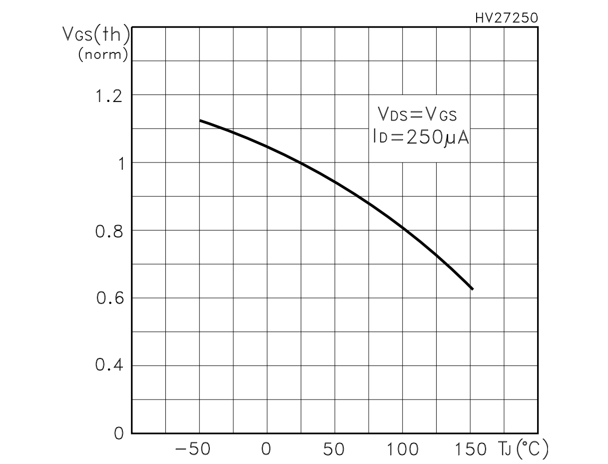


Figure 15. Normalized on resistance vs temperature

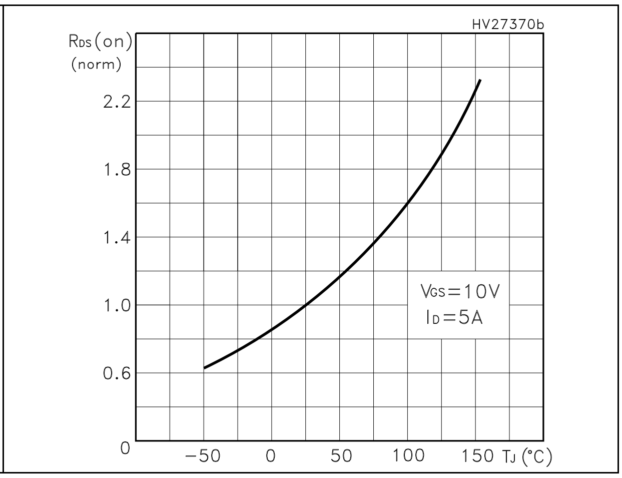


Figure 16. Source-drain diode forward characteristics

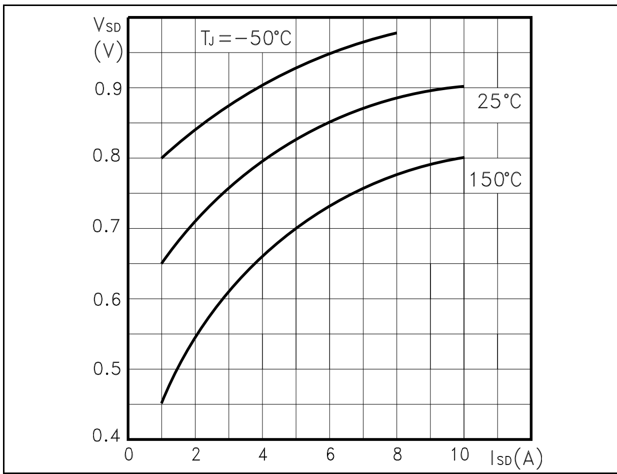
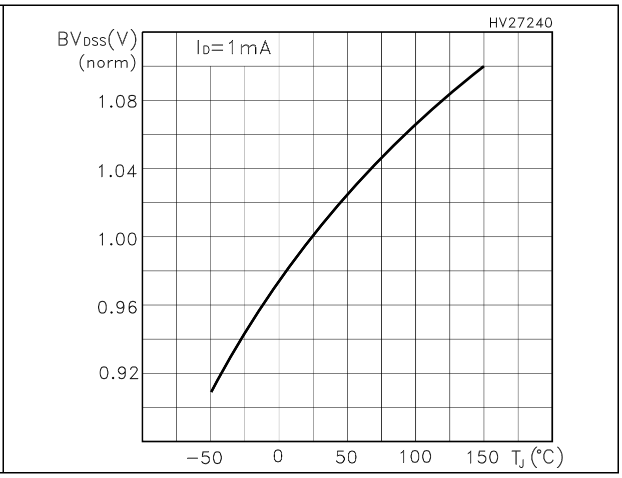


Figure 17. Normalized B_{VDSS} vs temperature



3 Test circuits

Figure 18. Switching times test circuit for resistive load

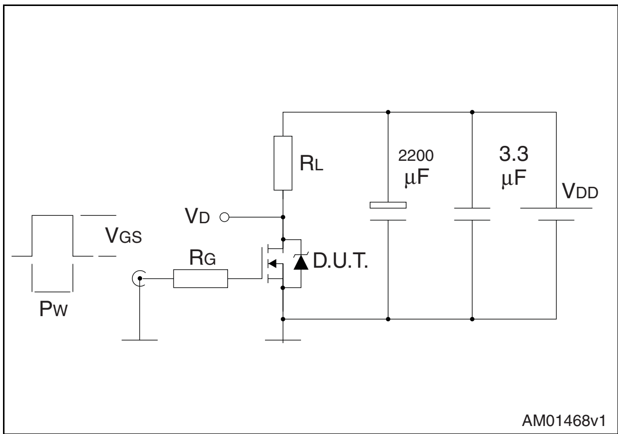


Figure 19. Gate charge test circuit

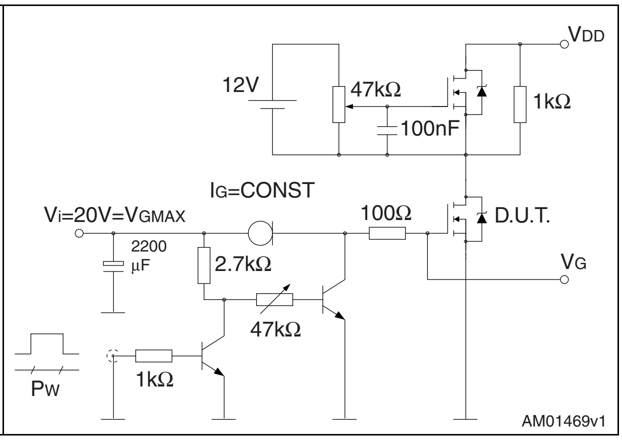


Figure 20. Test circuit for inductive load switching and diode recovery times

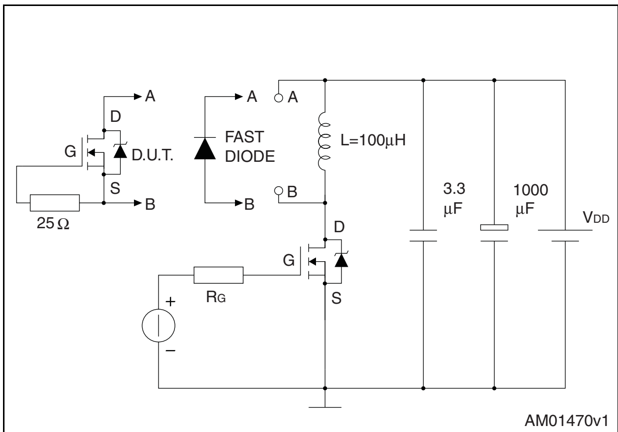


Figure 21. Unclamped inductive load test circuit

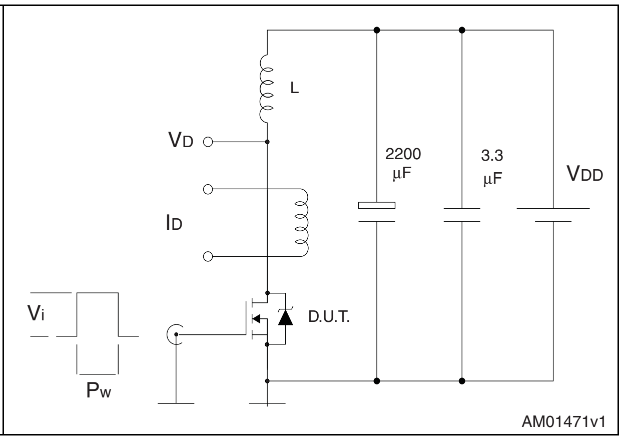


Figure 22. Unclamped inductive waveform

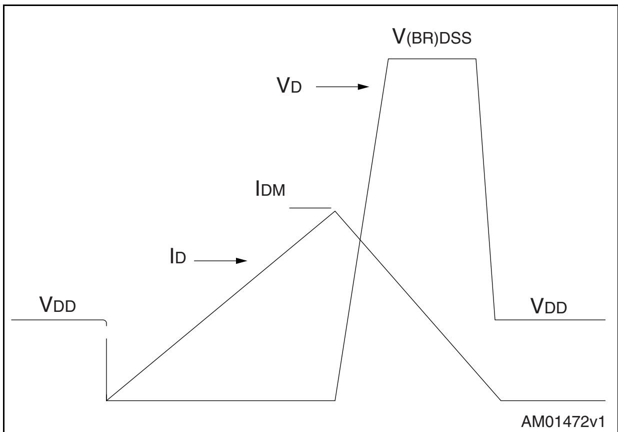
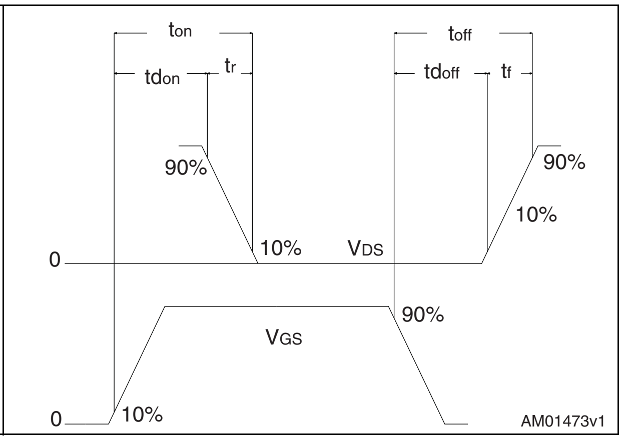


Figure 23. Switching time waveform



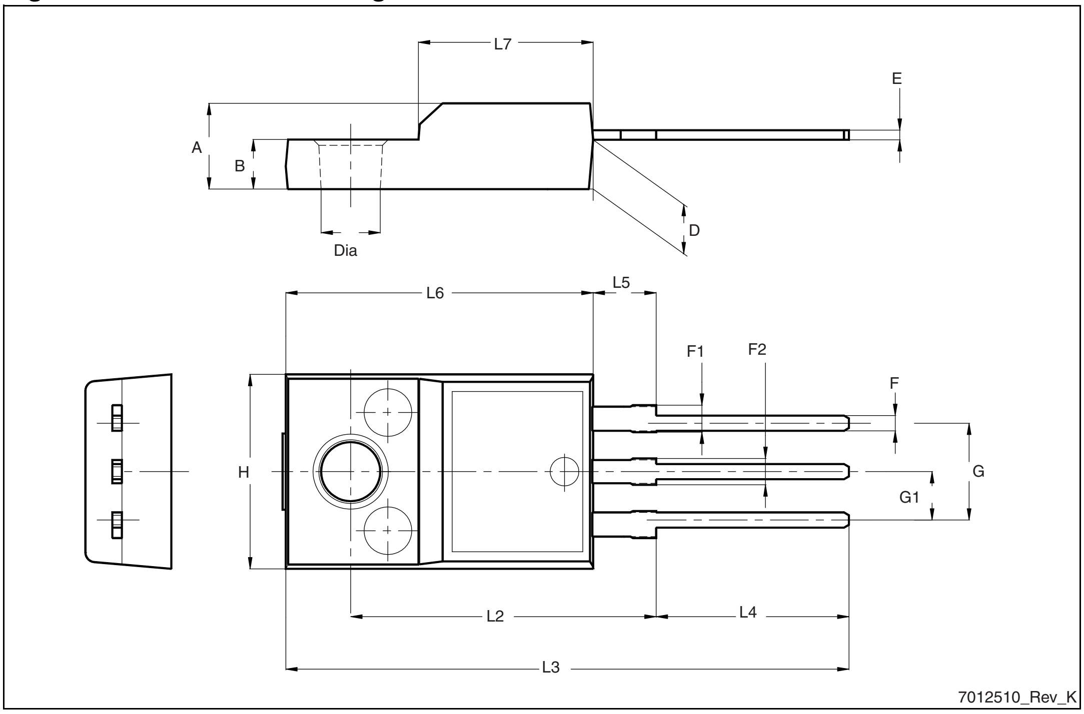
4 Package mechanical data

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 9. TO-220FP mechanical data

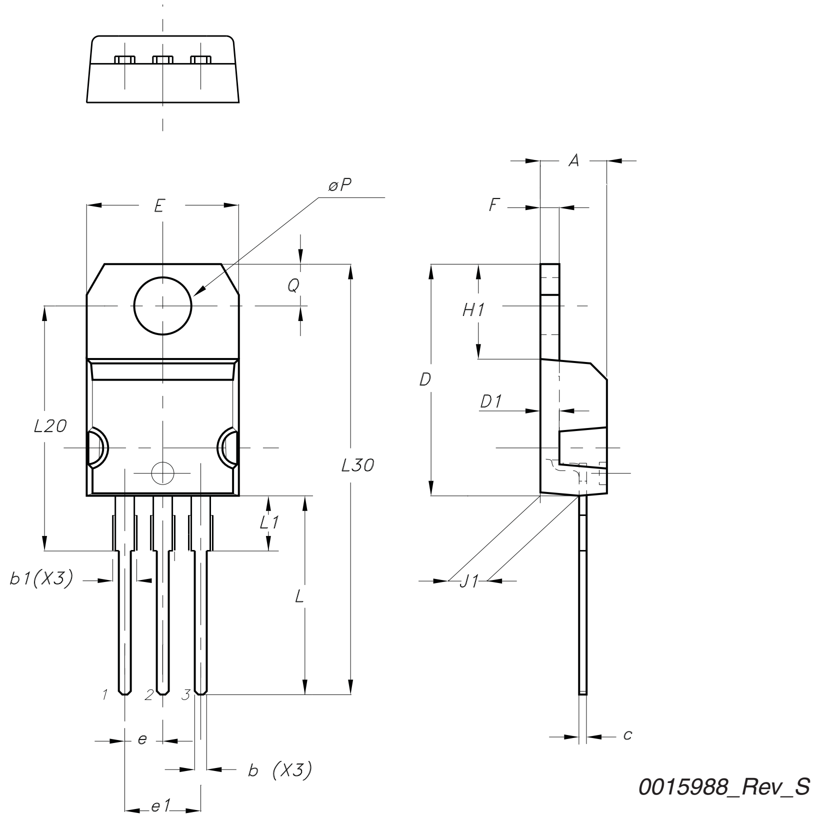
Dim.	mm		
	Min.	Typ.	Max.
A	4.4		4.6
B	2.5		2.7
D	2.5		2.75
E	0.45		0.7
F	0.75		1
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.2
G1	2.4		2.7
H	10		10.4
L2		16	
L3	28.6		30.6
L4	9.8		10.6
L5	2.9		3.6
L6	15.9		16.4
L7	9		9.3
Dia	3		3.2

Figure 24. TO-220FP drawing



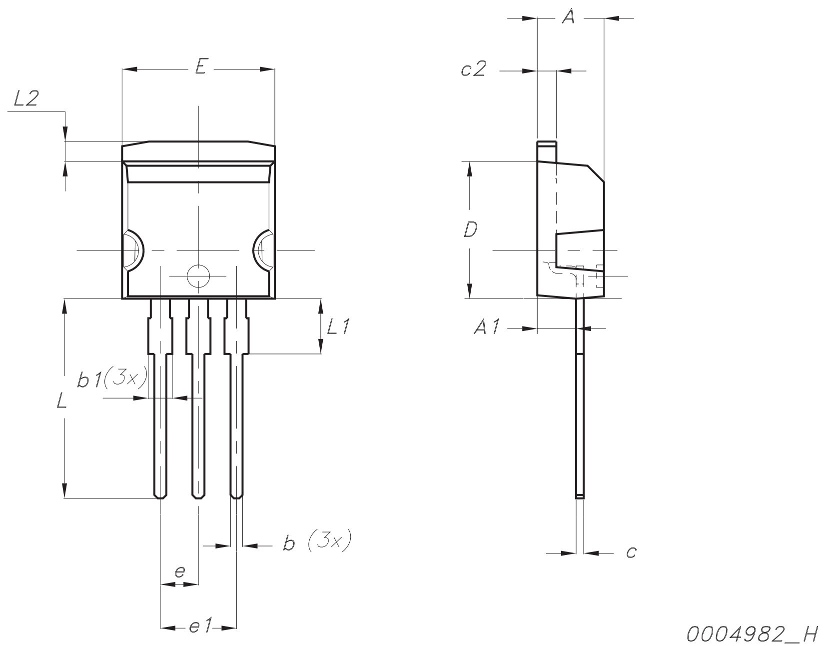
TO-220 type A mechanical data

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



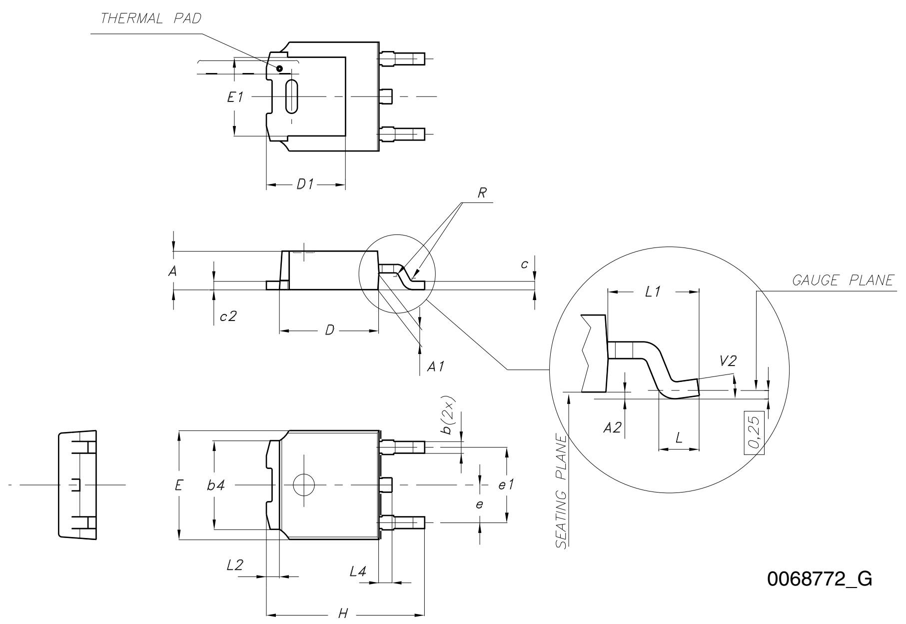
I^2PAK (TO-262) mechanical data

Dim	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A	4.40		4.60	0.173		0.181
A1	2.40		2.72	0.094		0.107
b	0.61		0.88	0.024		0.034
b1	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
c2	1.23		1.32	0.048		0.052
D	8.95		9.35	0.352		0.368
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
E	10		10.40	0.393		0.410
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L2	1.27		1.40	0.050		0.055



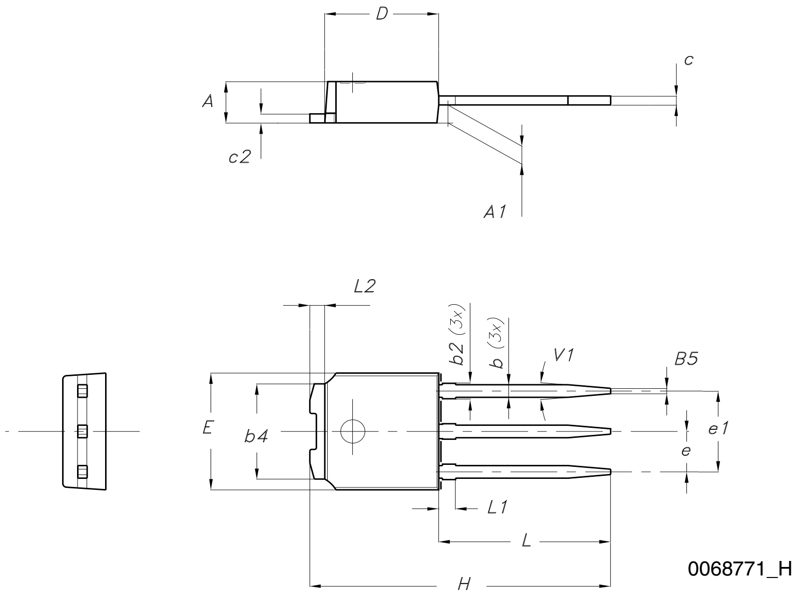
TO-252 (DPAK) mechanical data

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		5.10	
E	6.40		6.60
E1		4.70	
e		2.28	
e1	4.40		4.60
H	9.35		10.10
L	1		
L1		2.80	
L2		0.80	
L4	0.60		1
R		0.20	
V2	0 °		8 °



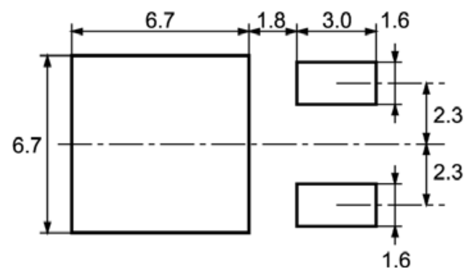
TO-251 (IPAK) mechanical data

DIM.	mm.		
	min.	typ	max.
A	2.20		2.40
A1	0.90		1.10
b	0.64		0.90
b2			0.95
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
E	6.40		6.60
e		2.28	
e1	4.40		4.60
H		16.10	
L	9.00		9.40
(L1)	0.80		1.20
L2		0.80	
V1		10 °	



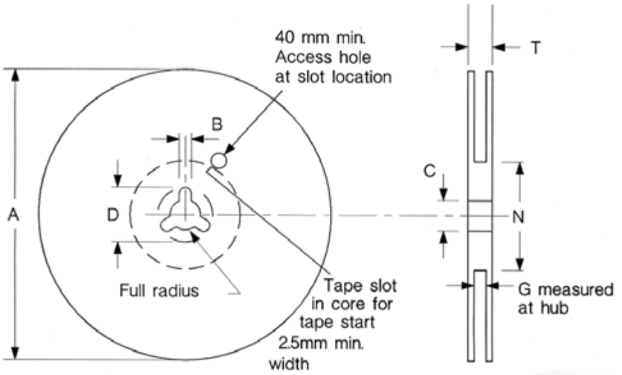
5 Packaging mechanical data

DPAK FOOTPRINT



All dimensions are in millimeters

TAPE AND REEL SHIPMENT



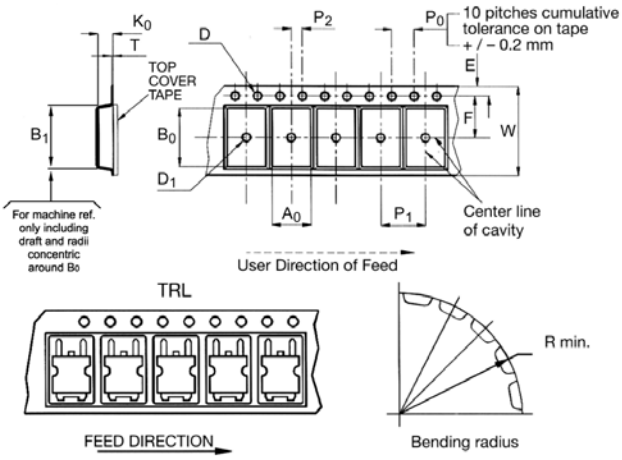
REEL MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A		330		12.992
B	1.5		0.059	
C	12.8	13.2	0.504	0.520
D	20.2		0.795	
G	16.4	18.4	0.645	0.724
N	50		1.968	
T		22.4		0.881

BASE QTY	BULK QTY
2500	2500

TAPE MECHANICAL DATA

DIM.	mm		inch	
	MIN.	MAX.	MIN.	MAX.
A0	6.8	7	0.267	0.275
B0	10.4	10.6	0.409	0.417
B1		12.1		0.476
D	1.5	1.6	0.059	0.063
D1	1.5		0.059	
E	1.65	1.85	0.065	0.073
F	7.4	7.6	0.291	0.299
K0	2.55	2.75	0.100	0.108
P0	3.9	4.1	0.153	0.161
P1	7.9	8.1	0.311	0.319
P2	1.9	2.1	0.075	0.082
R	40		1.574	
W	15.7	16.3	0.618	0.641



6 Revision history

Table 10. Document revision history

Date	Revision	Changes
23-Apr-2008	1	First release
25-Oct-2010	2	– Corrected *Figure 2: Safe operating area for TO-220, I²PAK* – Corrected *Figure 4: Safe operating area for TO-220FP* – Corrected *Figure 6: Safe operating area for DPAK, IPAK*