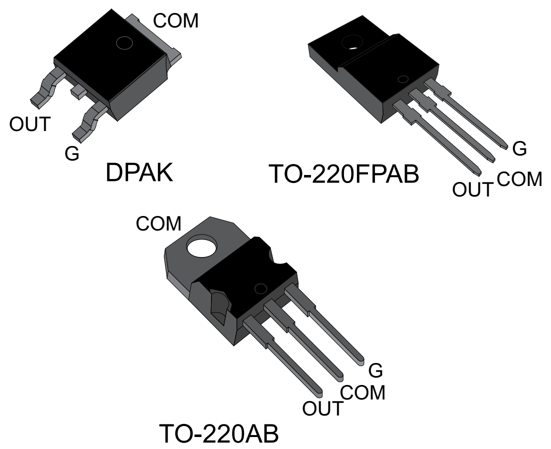
ACS120

Overvoltage protected AC switch (ACS)

Datasheet - production data



Features

- Blocking voltage: V_{DRM} / V_{RRM} = +/- 700 V
- Avalanche controlled: V_{CL} typ. = 1100 V
- Nominal conducting current: $I_{T(RMS)}$ = 2 A
- Gate triggering current: I_{GT} < 10 mA
- High noise immunity: static dV/dt > 500 V/µs
  - Needs no more external protection snubber or varistor
  - Enables equipment to meet IEC 61000-4-5
  - Reduces component count up to 80%
  - Interfaces directly with the micro controller
  - Eliminates any gate kick back on the micro-controller
  - Allows straightforward connection of several AC switches on same cooling pad

Applications

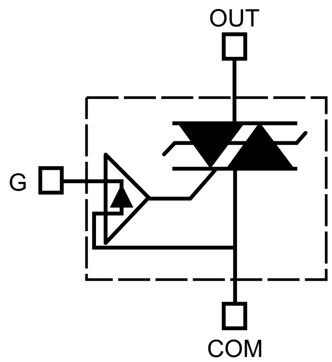
- AC static switching in appliance control systems
- Drive of low power high inductive or resistive loads like:
  - Relay, valve, solenoid, dispenser
  - Pump, fan, micro-motor
  - Defrost heater

Description

The ACS120 belongs to the AC line switch family. This high-performance switch circuit is able to control a load of up to 2 A.

The ACS switch embeds a high-voltage clamping structure to absorb the inductive turn-off energy and a gate level shifter driver to separate the digital controller from the main switch. It is triggered with a negative gate current flowing out of the gate pin.

Figure 1. Functional diagram



COM	Common drive reference to connect to the mains
OUT	Output to connect to the load.
G	Gate input to connect to the controller through gate resistor

1 Characteristics

Table 1. Absolute ratings (limiting values)
for either positive or negative polarity of pin OUT voltage in respect to pin COM voltage

Symbol	Parameter			Value	Unit
V_{DRM}/V_{RRM}	Repetitive peak off-state voltage			700	V
$I_{T(RMS)}$	On-state RMS current full cycle sine wave 50 to 60 Hz	DPAK	T_C = 119 °C	2	A
		TO-220FPAB	T_C = 117 °C		
		TO-220AB	T_C = 119 °C		
I_{TSM}	Non repetitive surge peak on-state current T_J initial = 25 °C, full cycle sine wave		t_P = 20 ms	20	A
			t_P = 16.7 ms	21	A
I^2t	Fusing capability		t_P = 10 ms	2.6	A^2s
dI/dt	Repetitive on-state current critical rate of rise I_G = 10 mA (t_r < 100 ns)	T_j = 125 °C	f = 120 Hz	50	A/µs
V_{PP}	Non repetitive line peak pulse voltage(1)			2	kV
T_{stg}	Storage temperature range			- 40 to + 150	°C
T_J	Operating junction temperature range			- 30 to + 125	°C
T_L	Maximum lead soldering temperature during 10 s			260	°C

1. According to test described by IEC 61000-4-5 standard and *Figure 17*.

Table 2. Switch Gate characteristics (maximum values)

Symbol	Parameter	Value	Unit
$P_{G(AV)}$	Average gate power dissipation	0.1	W
I_{GM}	Peak gate current (t_P = 20 µs)	1	A
V_{GM}	Peak positive gate voltage (in respect to pin COM)	5	V

Table 3. Thermal resistances

Symbol	Parameter			Value	Unit
$R_{th\ (j-a)}$	Junction to ambient	S = 0.5 cm^2(1)	DPAK	70	°C/W
		TO-220FPAB		60	°C/W
		TO-220AB		60	°C/W
$R_{th\ (j-c)}$	Junction to case	DPAK		2.6	°C/W
		TO-220FPAB		3.5	°C/W
		TO-220AB		2.6	°C/W

1. S = Copper surface under tab

Table 4. Parameter description

Symbol	Parameter description
I_{GT}	Triggering gate current
V_{GT}	Triggering gate voltage
V_{GD}	Non-triggering gate voltage
I_H	Holding current
I_L	Latching current
V_{TM}	Peak on-state voltage drop
V_{TO}	On-state threshold voltage
R_d	On-state dynamic resistance
I_{DRM} / I_{RRM}	Maximum forward or reverse leakage current
dV/dt	Critical rate of rise of off-state voltage
(dV/dt)c	Critical rate of rise of commutating off-state voltage
(dI/dt)c	Critical rate of decrease of commutating on-state current
V_{CL}	Clamping voltage
I_{CL}	Clamping current

Table 5. Electrical characteristics

Symbol	Test conditions				Values	Unit
I_{GT}	V_{OUT} = 12V (DC), R_L = 140 Ω	QII -QIII	T_J = 25 °C	Max.	10	mA
V_{GT}	V_{OUT} = 12V (DC), R_L = 140 Ω	QII -QIII	T_J = 25 °C	Max.	1	V
V_{GD}	V_{OUT} = V_{DRM}, R_L = 3.3 kΩ		T_J = 125 °C	Min.	0.15	V
I_H	I_{OUT} = 100 mA gate open		T_J = 25 °C	Max.	45	mA
I_L	I_G = 20 mA		T_J = 25 °C	Max.	65	mA
V_{TM}	I_{OUT} = 2.8 A, t_p = 380 µs		T_J = 25 °C	Max.	1.3	V
V_{TO}			T_J = 125 °C	Max.	0.85	V
R_d			T_J = 125 °C	Max.	200	mΩ
I_{DRM} /I_{RRM}	V_{OUT} = 700 V		T_J= 25 °C	Max.	2	µA
			T_J = 125 °C	Max.	200	
dV/dt	V_{OUT} = 460 V gate open		T_J = 110 °C	Min.	500	V/µs
(dI/dt)c	(dV/dt)c = 20 V/µs		T_J = 125 °C	Min.	1	A/ms
V_{CL}	I_{CL} = 1 mA, t_p = 1 ms		T_J = 25 °C	Typ.	1100	V

Figure 2. Maximum power dissipation versus RMS on-state current

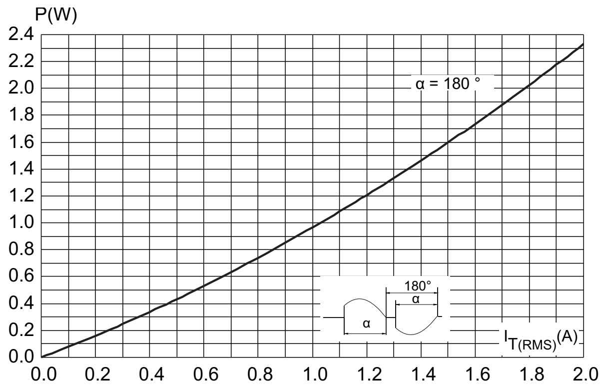


Figure 3. On-state RMS current versus case temperature

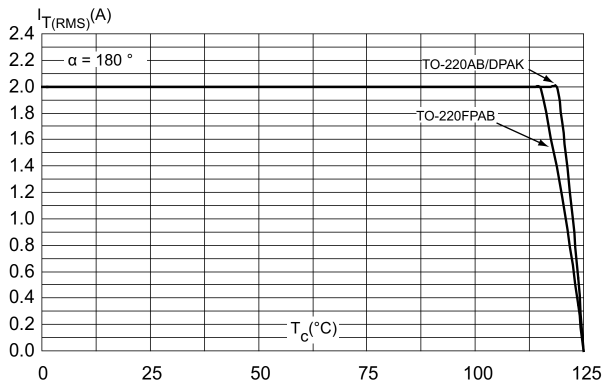


Figure 4. On-state RMS current versus ambient temperature

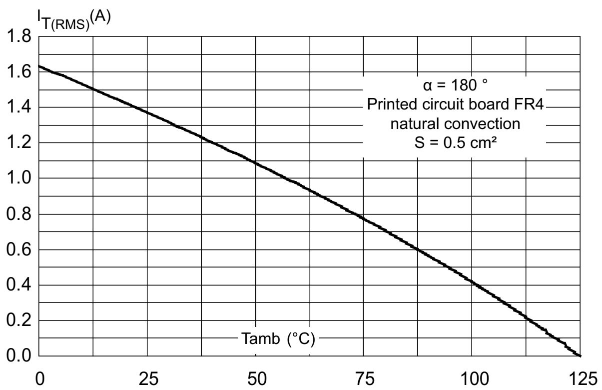


Figure 5. Relative variation of thermal impedance versus pulse duration

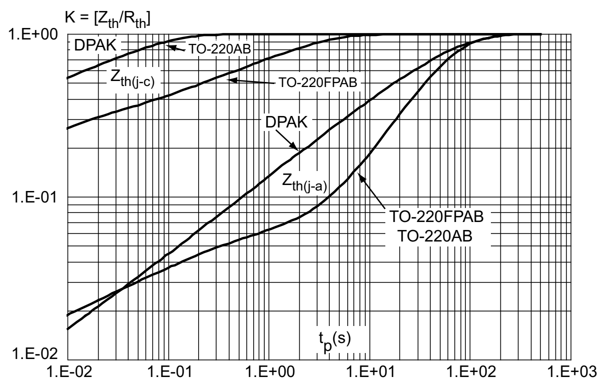


Figure 6. Relative variation of gate trigger, holding and latching current versus junction temperature

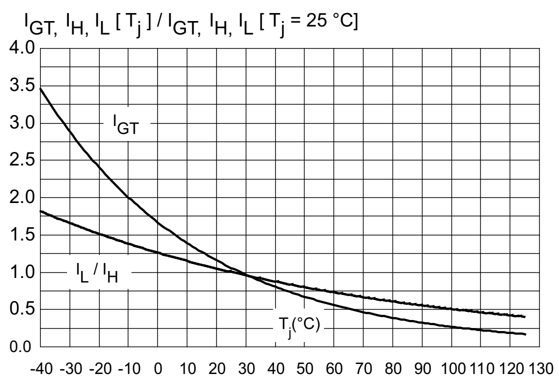


Figure 7. Relative variation of static dV/dt versus junction temperature

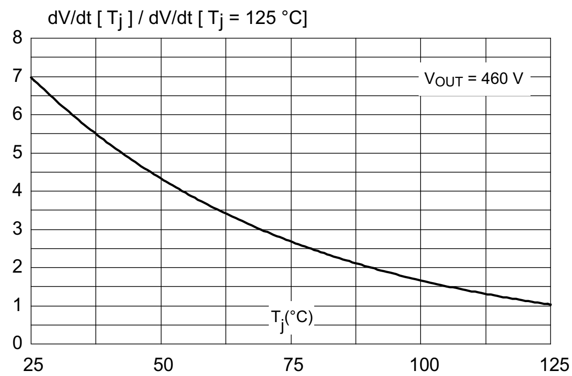


Figure 8. Relative variation of critical rate of decrease of main current versus reapplied dV/dt (typical values)

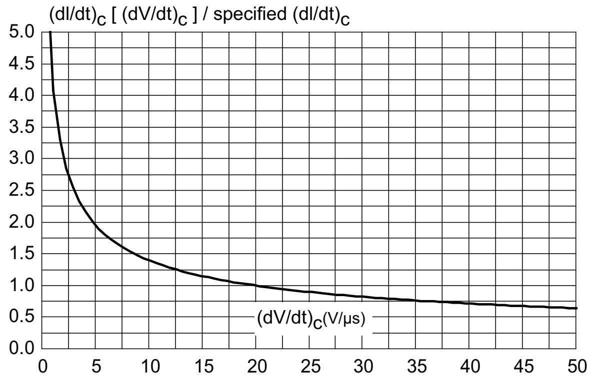


Figure 9. Relative variation of critical rate of decrease of main current versus junction temperature

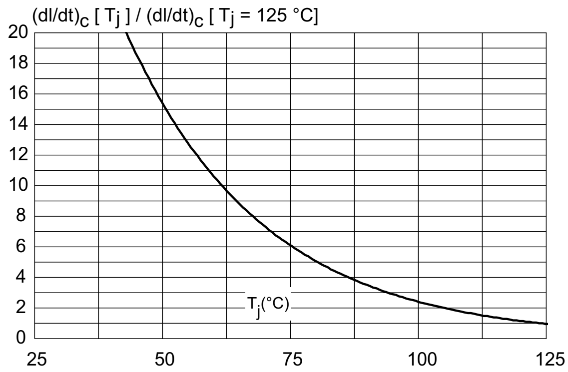


Figure 10. Surge peak on-state current versus number of cycles

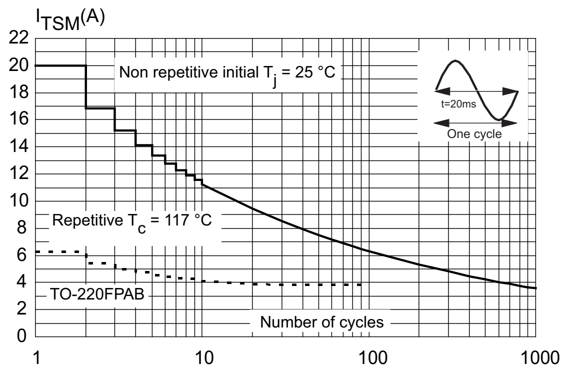


Figure 11. Non repetitive surge peak on-state current for a sinusoidal pulse with width t_p < 10 ms

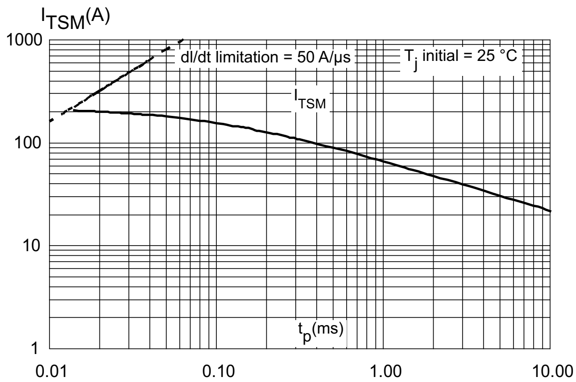


Figure 12. On-state characteristics (maximum values)

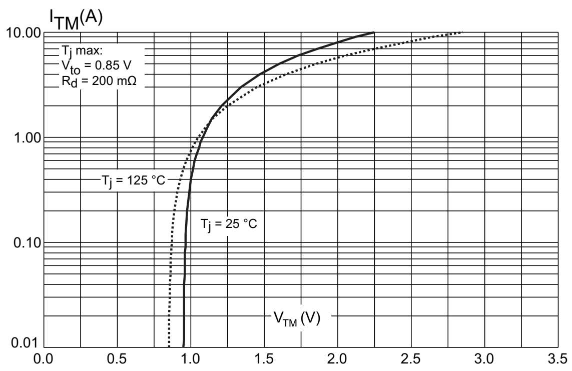
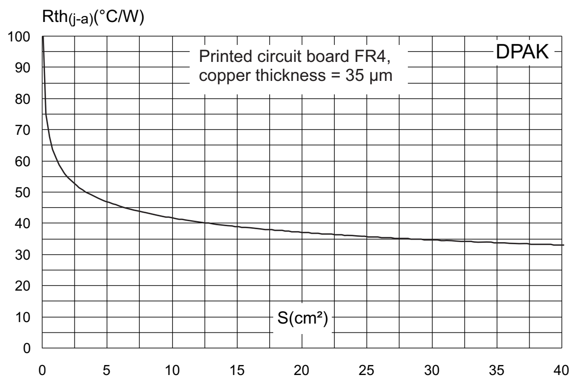


Figure 13. Thermal resistance junction to ambient versus copper surface under tab



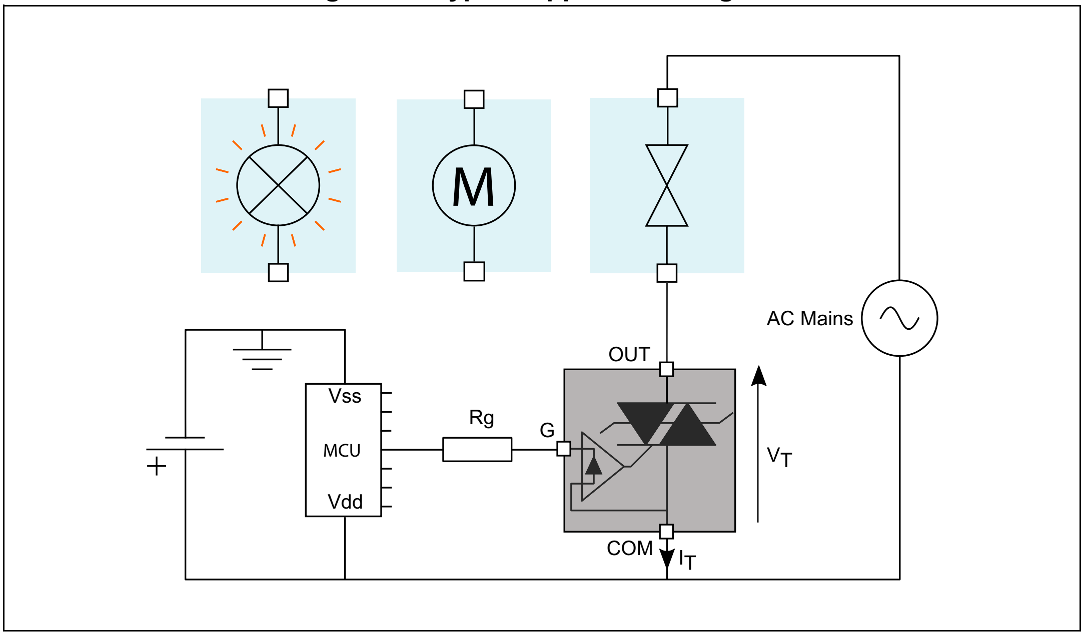
2 AC line switch basic application

The ACS120 device is well adapted to washing machine, dishwasher, tumble drier, refrigerator, air-conditioning systems, and cookware. It has been designed especially to switch on and off low power loads such as solenoid, valve, relay, dispenser, micro-motor, pump, fan and defrost heaters.

This AC switch is triggered by a negative gate current flowing out of the gate pin G. It can be driven directly by the digital MCU through a resistor as shown on the typical application diagram.

Thanks to its thermal and turn-off commutation performance, the ACS120 switch can drive, with no additional turn-off snubber, an inductive load up to 2 A.

Figure 14. Typical application diagram



2.1 Protection against overvoltage: the best choice is ACS

In comparison with standard Triacs the ACS120 is over-voltage self-protected, as specified by the new parameter V_{CL}. This feature is useful in two operating conditions: in case of turn-off of very inductive load, and in case of surge voltage that can occur on the electrical network.

2.2 High inductive load switch-off: turn-off overvoltage clamping

With high inductive and low RMS current loads the rate of decrease of the current is very low. An overvoltage can occur when the gate current is removed and the OUT current is lower than I_H.

As shown in *Figure 15 and Figure 16*, at the end of the last conduction half-cycle, the load current decreases (1). The load current reaches the holding current level I_H (2), and the ACS turns off (3). The water valve, as an inductive load (up to 15 H), reacts as a current generator and an overvoltage is created, which is clamped by the ACS (4). The current flows through the ACS avalanche and decreases linearly to zero. During this time, the voltage across the switch is limited to the clamping voltage V_{CL}. The energy stored in the inductance of the load is dissipated in the clamping section that is designed for this purpose. When the energy has been dissipated, the ACS voltage falls back to the mains voltage value (230 V rms, 50 Hz) (5).

Figure 15. Turn-off operation of the ACS120 switch with an electro-valve

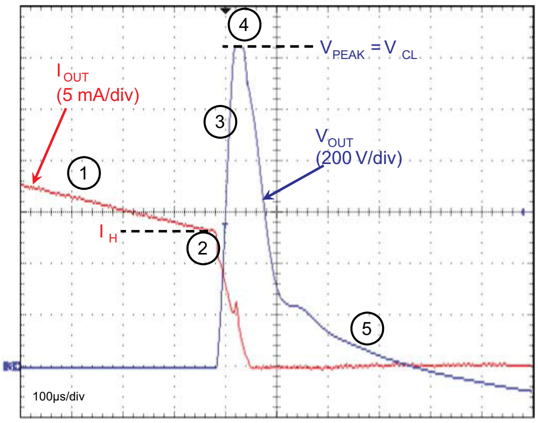
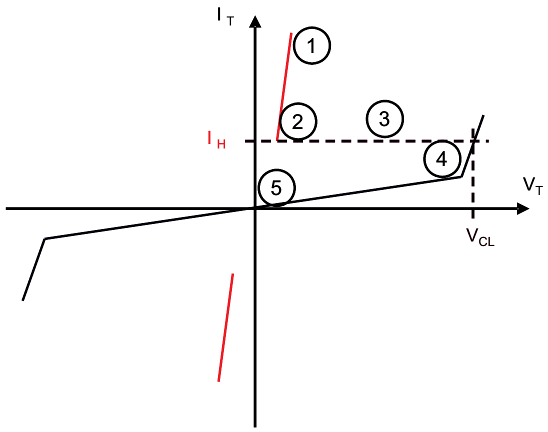


Figure 16. ACS120 switch static characteristic



Note: Same working principle described in item 2.2 is valid for both current directions.

2.3 Alternating current mains transient voltage ruggedness

The ACS120 switch is able to withstand safely the AC mains transients either by clamping the low energy spikes or by breaking-over when subjected to high energy shocks, even with high turn-on current rises. The test circuit shown in *Figure 17* is representative of the final ACS120 application, and is also used to test the AC switch according to the IEC 61000-4-5 standard conditions. Thanks to the load limiting the current, the ACS120 switch withstands the voltage spikes up to 2 kV above the peak mains voltage. The protection is based on an overvoltage crowbar technology. Actually, the ACS120 breaks over safely as shown in *Figure 18*. The ACS120 recovers its blocking voltage capability after the surge (switch-off back at the next zero crossing of the current). Such non-repetitive tests can be done 10 times on each AC mains voltage polarity.

Figure 17. Overvoltage ruggedness test circuit for resistive and inductive loads

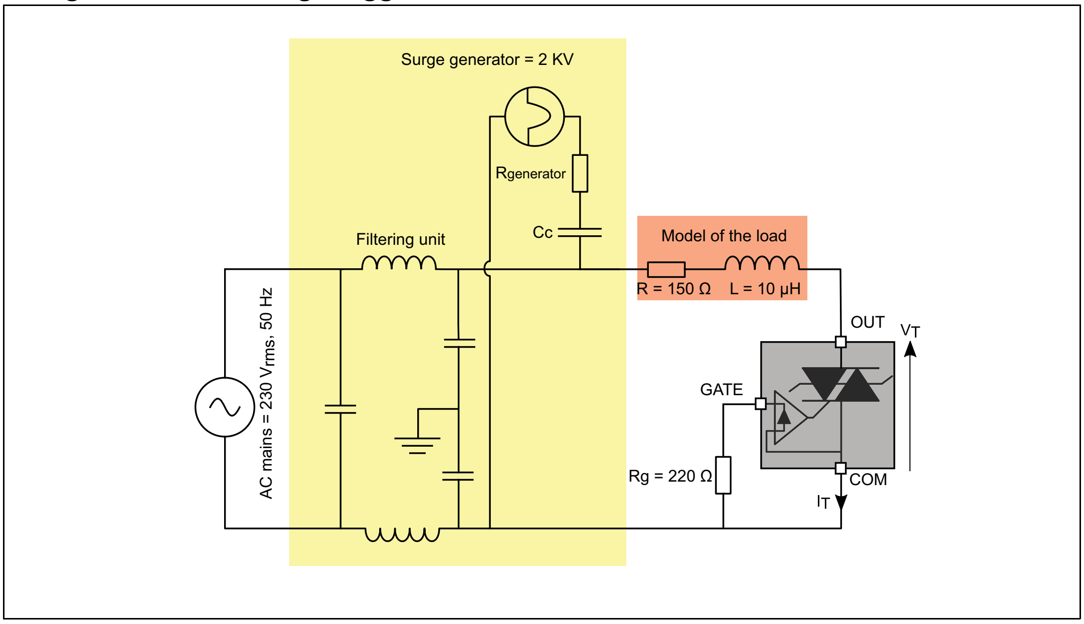
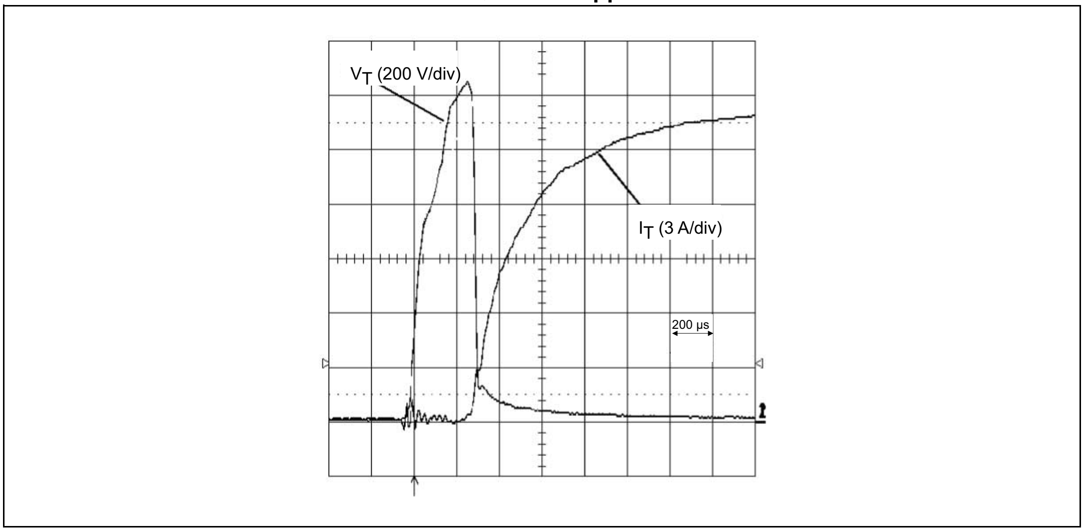


Figure 18. Current and voltage of the ACS120 during IEC 61000-4-5 standard test with R, L and V_{PP}



3 Package information

- Epoxy meets UL94-V0
- Lead-free package
- Recommended torque: 0.4 to 0.6 N·m (TO-220AB, TO-220FPAB)

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.

3.1 TO-220FPAB package information

Figure 19. TO-220FPAB package outline

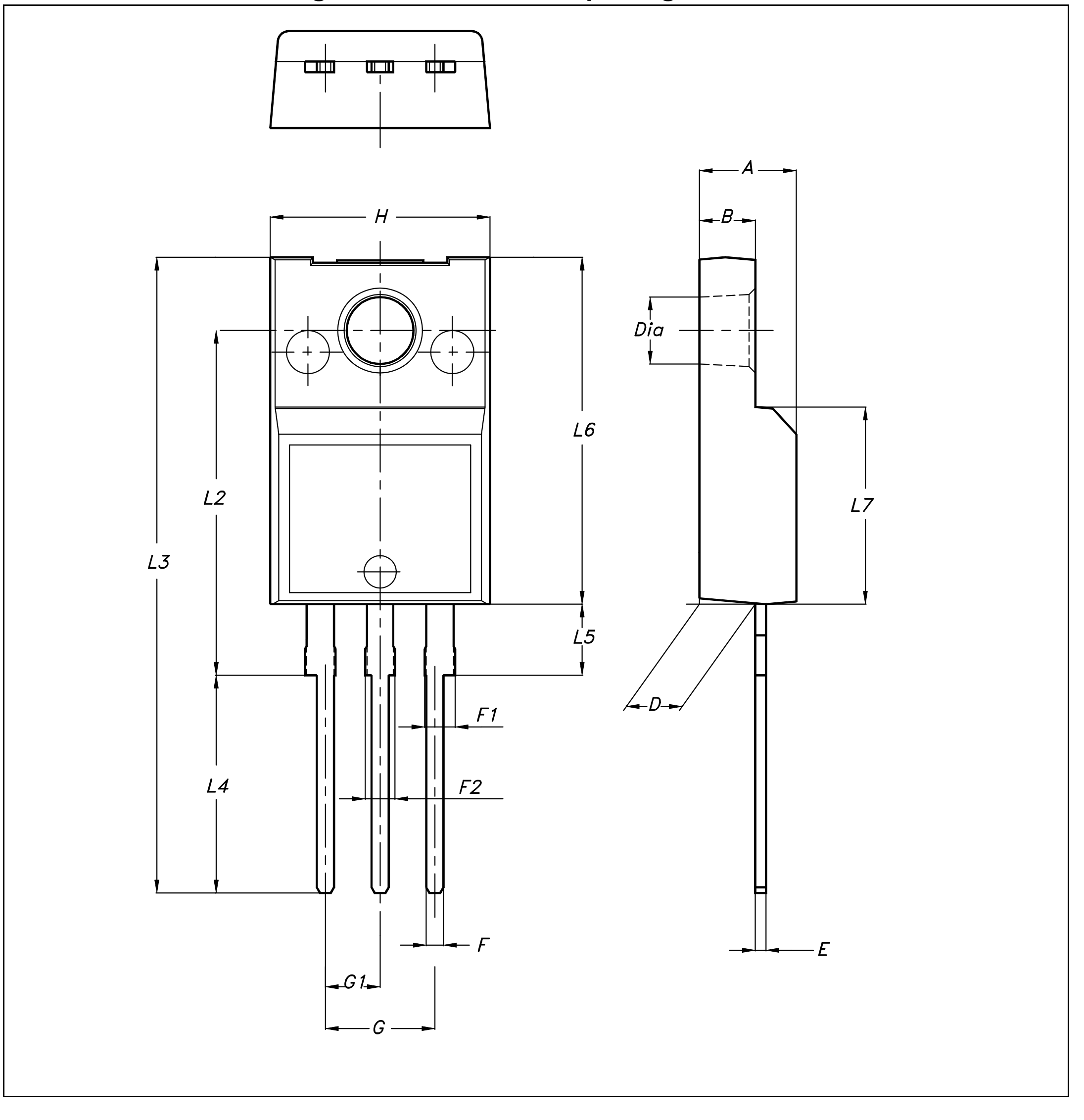


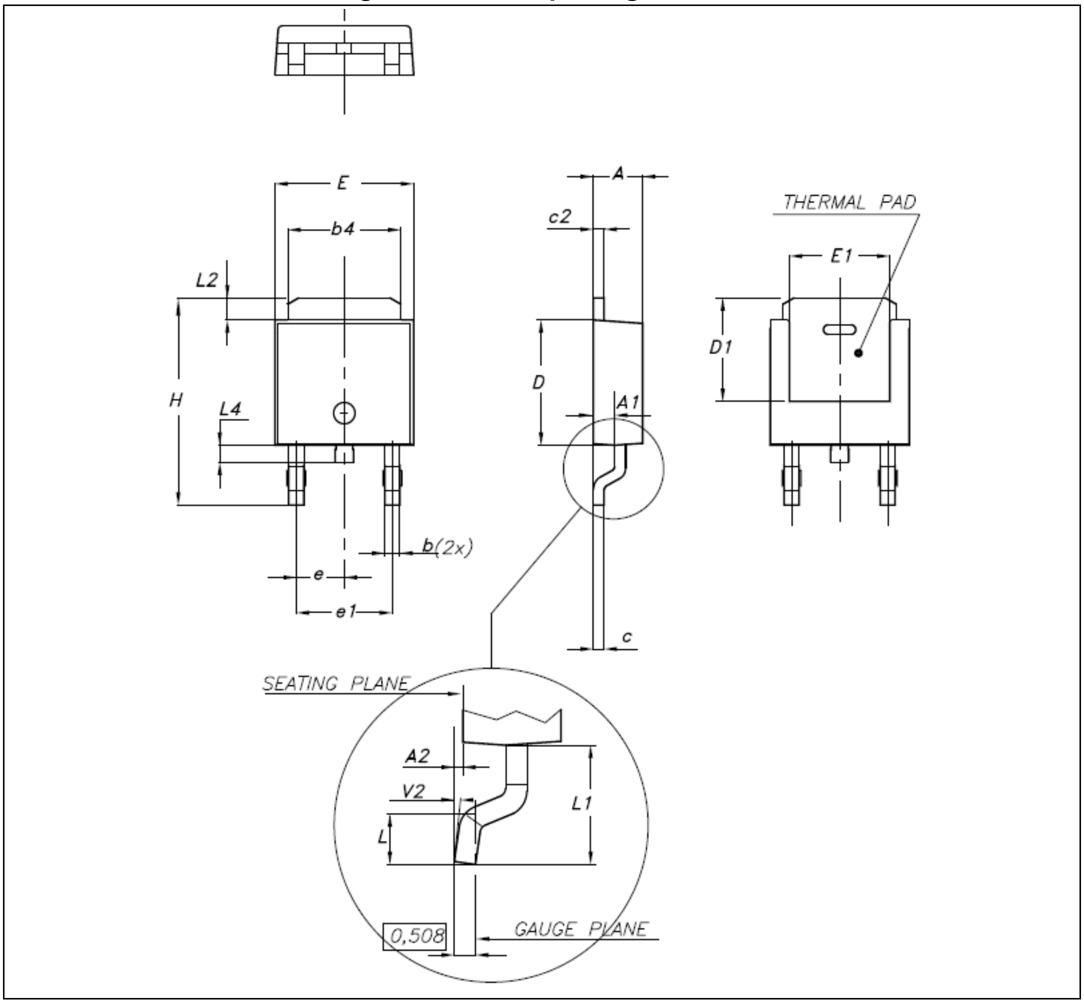
Table 6. TO-220FPAB package mechanical data

Ref.	Dimensions			
	Millimeters		Inches[1]	
	Min.	Max.	Min.	Max.
A	4.40	4.60	0.1732	0.1811
B	2.50	2.70	0.0984	0.1063
D	2.50	2.75	0.0984	0.1083
E	0.45	0.70	0.0177	0.0276
F	0.75	1.00	0.0295	0.0394
F1	1.15	1.70	0.0453	0.0669
F2	1.15	1.70	0.0453	0.0669
G	4.95	5.20	0.1949	0.2047
G1	2.40	2.70	0.0945	0.1063
H	10.00	10.40	0.3937	0.4094
L2	16.00 Typ.		0.6299 Typ.	
L3	28.60	30.60	1.1260	1.2047
L4	9.80	10.60	0.3858	0.4173
L5	2.90	3.60	0.1142	0.1417
L6	15.90	16.40	0.6260	0.6457
L7	9.00	9.30	0.3543	0.3661
Dia.	3.00	3.20	0.1181	0.1260

1. Inches only for reference.

3.2 DPAK package information

Figure 20. DPAK package outline



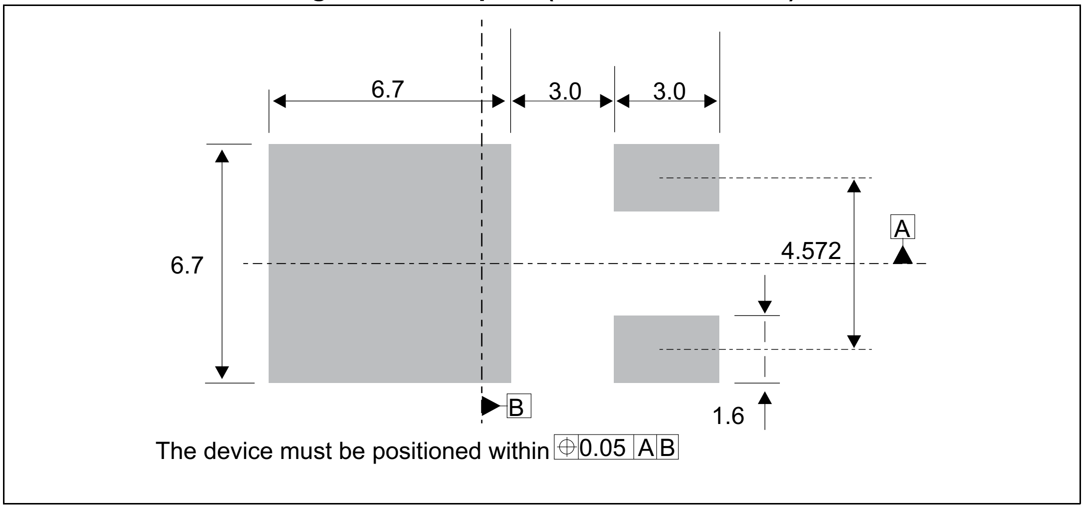
Note: This package drawing may slightly differ from the physical package. However, all the specified dimensions are guaranteed.

Table 7. DPAK package mechanical data

Ref.	Dimensions					
	Millimeters			Inches[1]		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.18		2.40	0.0858		0.0945
A1	0.9		1.10	0.0354		0.0433
A2	0.03		0.23	0.0012		0.0091
b	0.64		0.90	0.0252		0.0354
b4	4.95		5.46	0.1949		0.2150
c	0.46		0.61	0.0181		0.0236
c2	0.46		0.60	0.0181		0.0236
D	5.97		6.22	0.2350		0.2449
D1	4.95		5.60	0.1949		0.2205
E	6.35		6.73	0.2500		0.2650
E1	4.32		5.50	0.1701		0.2165
e		2.286			0.0900	
e1	4.40		4.70	0.1732		0.1850
H	9.35		10.40	0.3681		0.4094
L	1.0		1.78	0.0394		0.0701
L2			1.27			0.0500
L4	0.6		1.02	0.0236		0.0402
V2	-8°		+8°	-8°		+8°

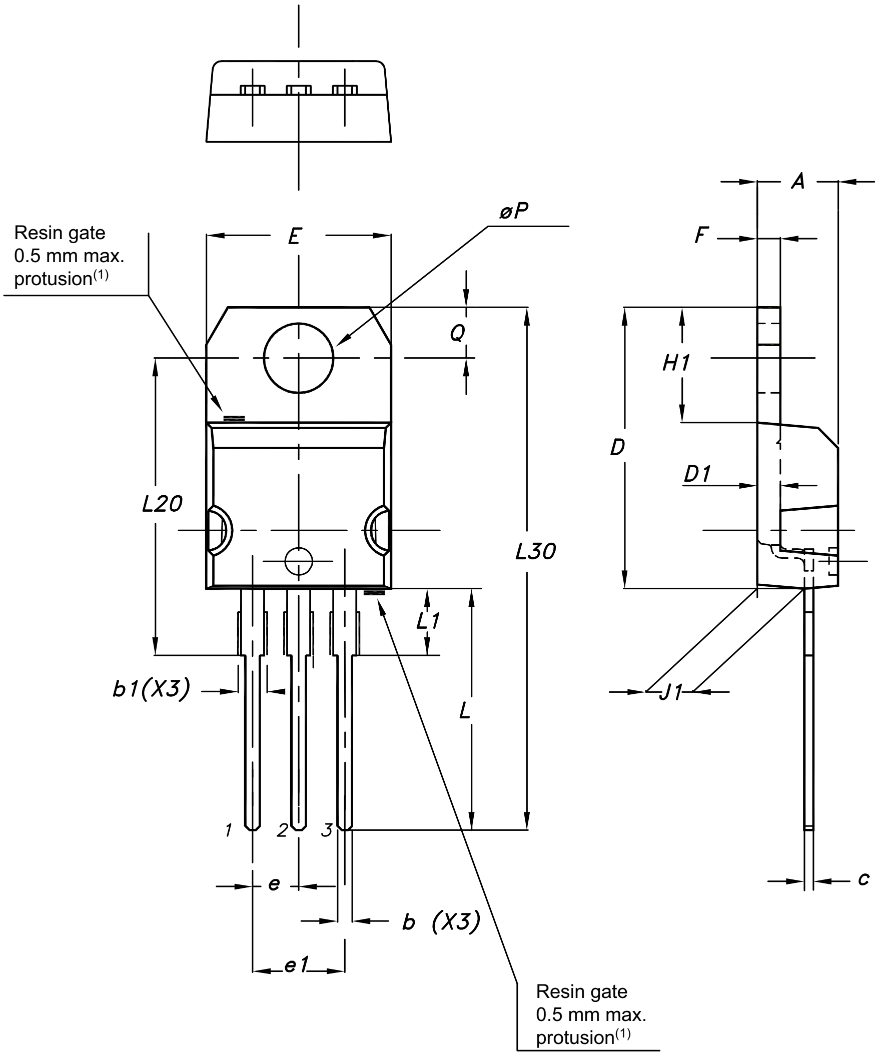
1. Inches only for reference.

Figure 21. Footprint (dimensions in mm)



3.3 TO-220AB package information

Figure 22. TO-220AB package outline



1. Resin gate position accepted in each of the two position as well as the symmetrical opposites.

Table 8. TO-220AB package mechanical data

Ref.	Dimensions			
	Millimeters		Inches(1)	
	Min.	Max.	Min.	Max.
A	4.40	4.60	0.1732	0.1811
b	0.61	0.88	0.0240	0.0346
b1	1.14	1.70	0.0449	0.0669
c	0.48	0.70	0.0189	0.0276
D	15.25	15.75	0.6004	0.6201
D1	1.27 typ.		0.05 typ.	
E	10.00	10.40	0.3937	0.4094
e	2.40	2.70	0.0945	0.1063
e1	4.95	5.15	0.1949	0.2028
F	1.23	1.32	0.0484	0.0520
H1	6.20	6.60	0.2441	0.2598
J1	2.40	2.72	0.0945	0.1071
L	13.00	14.00	0.5118	0.5512
L1	3.50	3.93	0.1378	0.1547
L20	16.40 typ.		0.6457 typ.	
L30	28.90 typ.		1.1378 typ.	
∅P	3.75	3.85	0.1476	0.1516
Q	2.65	2.95	0.1043	0.1161

1. Inches only for reference.

4 Ordering information

Figure 23. Ordering information scheme

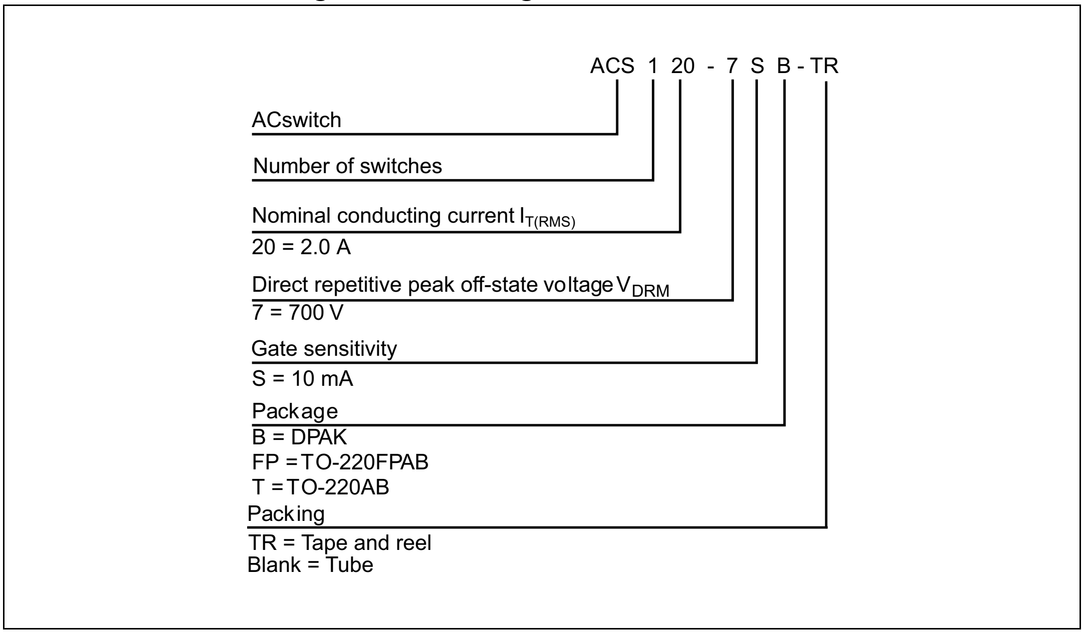


Table 9. Ordering information

Order code	Marking	Package	Weight	Base qty	Packing mode
ACS120-7SB	ACS1207S	DPAK	0.32 g	75	Tube
ACS120-7SB-TR	ACS1207S	DPAK	0.32 g	2500	Tape and reel
ACS120-7SFP	ACS1207S	TO-220FPAB	1.9 g	50	Tube
ACS120-7ST	ACS1207S	TO-220AB	1.9 g	50	Tube

5 Revision history

Table 10. Document revision history

Date	Revision	Changes
Apr-2004	1	Previous release.
28-Jan-2011	2	Added ECOPACK statement. Updated T_C values in Table 1.
28-May-2014	3	Updated DPAK package information and reformatted to current standard.
02-May-2016	4	Added pin name on cover page package view and reformatted to current standard.
24-Mar-2022	5	Updated *Figure 20*.