

## Overvoltage protected AC switch (ACS™)

Datasheet - production data



### 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.

### Features

- Blocking voltage:  $V_{DRM} / V_{RRM} = \pm 700 \text{ V}$
- Avalanche controlled:  $V_{CL} \text{ typ.} = 1100 \text{ V}$
- Nominal conducting current:  $I_{T(RMS)} = 2 \text{ A}$
- Gate triggering current:  $I_{GT} < 10 \text{ mA}$
- High noise immunity: static  $dV/dt > 500 \text{ V}/\mu\text{s}$

### Benefits

- 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

**Figure 1. Functional diagram**



# 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<br>50 to 60 Hz  | DPAK                  | $T_C = 119\text{ °C}$  | 2    | A                |
|                   |   | TO-220FPAB            | $T_C = 117\text{ °C}$  |      |                  |
|                   |   | TO-220AB              | $T_C = 119\text{ °C}$  |      |                  |
| $I_{TSM}$         | Non repetitive surge peak on-state current<br>$T_J$ initial = 25 °C, full cycle sine wave           |                       | $t_P = 20\text{ ms}$   | 20   | A                |
|                   |   |                       | $t_P = 16.7\text{ ms}$ | 21   | A                |
| $I^2t$            | Fusing capability   |                       | $t_P = 10\text{ ms}$   | 2.6  | A <sup>2</sup> s |
| $di/dt$           | Repetitive on-state current critical rate of rise<br>$I_G = 10\text{ mA}$ ( $t_r < 100\text{ ns}$ ) | $T_J = 125\text{ °C}$ | $f = 120\text{ Hz}$    | 50   | A/ $\mu$ s       |
| $V_{PP}$          | Non repetitive line peak pulse voltage <sup>(1)</sup>   |                       | 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 ( $t_P = 20\text{ }\mu$ s)       | 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 | $S = 0.5\text{ cm}^2$ <sup>(1)</sup> 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

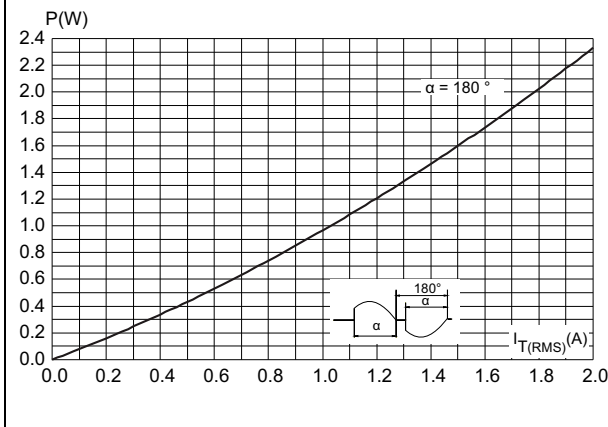
Table 4. Parameter description

| 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) <sub>c</sub> | Critical rate of rise of commutating off-state voltage    |
| (dI/dt) <sub>c</sub> | Critical rate of decrease of commutating on-state current |
| $V_{CL}$             | Clamping voltage  |
| $I_{CL}$             | Clamping current  |

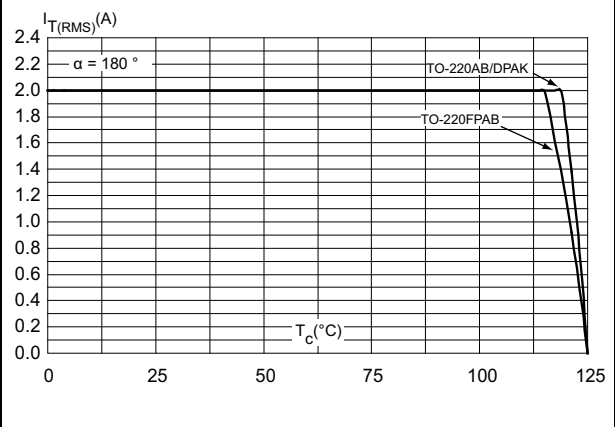
Table 5. Electrical characteristics

| Symbol               | Test conditions                           |           |                     | Values | Unit           |
|----------------------|---|-----------|---------------------|--------|----------------|
| $I_{GT}$             | $V_{OUT} = 12V$ (DC), $R_L = 140 \Omega$  | QII -QIII | $T_J = 25^\circ C$  | Max    | 10 mA          |
| $V_{GT}$             | $V_{OUT} = 12V$ (DC), $R_L = 140 \Omega$  | QII -QIII | $T_J = 25^\circ C$  | Max    | 1 V            |
| $V_{GD}$             | $V_{OUT} = V_{DRM}$ , $R_L = 3.3 k\Omega$ |           | $T_J = 125^\circ C$ | Min    | 0.15 V         |
| $I_H$                | $I_{OUT} = 100$ mA gate open              |           | $T_J = 25^\circ C$  | Max    | 45 mA          |
| $I_L$                | $I_G = 20$ mA                             |           | $T_J = 25^\circ C$  | Max    | 65 mA          |
| $V_{TM}$             | $I_{OUT} = 2.8$ A, $t_p = 380 \mu s$      |           | $T_J = 25^\circ C$  | Max    | 1.3 V          |
| $V_{TO}$             |   |           | $T_J = 125^\circ C$ | Max    | 0.85 V         |
| $R_d$                |   |           | $T_J = 125^\circ C$ | Max    | 200 m $\Omega$ |
| $I_{DRM} / I_{RRM}$  | $V_{OUT} = 700$ V                         |           | $T_J = 25^\circ C$  | Max    | 2 $\mu A$      |
|                      |   |           | $T_J = 125^\circ C$ | Max    | 200            |
| dV/dt                | $V_{OUT} = 460$ V gate open               |           | $T_J = 110^\circ C$ | Min    | 500 V/ $\mu s$ |
| (dI/dt) <sub>c</sub> | (dV/dt) <sub>c</sub> = 20 V/ $\mu s$      |           | $T_J = 125^\circ C$ | Min    | 1 A/ms         |
| $V_{CL}$             | $I_{CL} = 1$ mA, $t_p = 1$ ms             |           | $T_J = 25^\circ C$  | Typ    | 1100 V         |

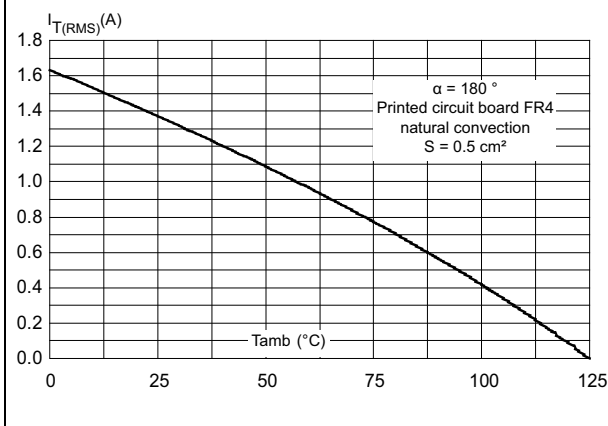
**Figure 2. Maximum power dissipation versus RMS on-state current**



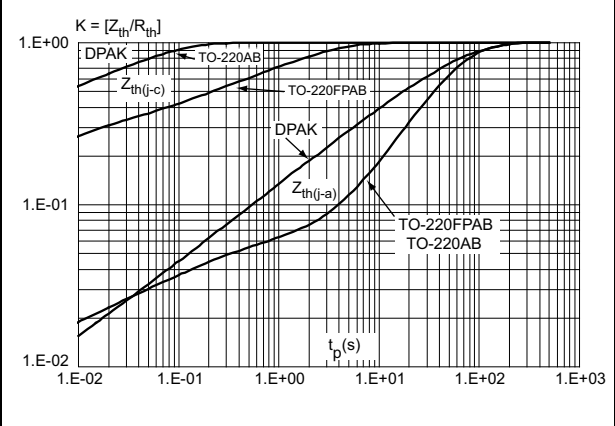
**Figure 3. On-state RMS current versus case temperature**



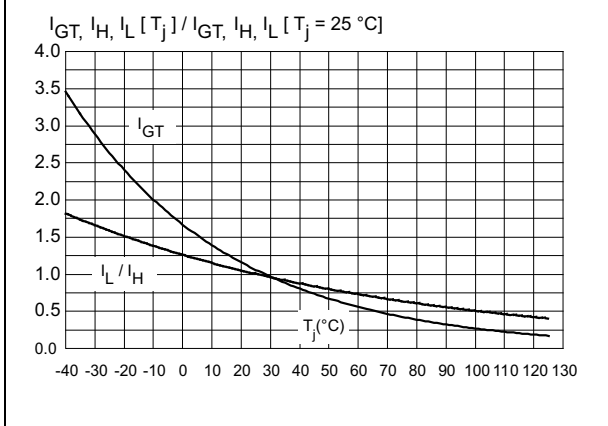
**Figure 4. On-state RMS current versus ambient temperature**



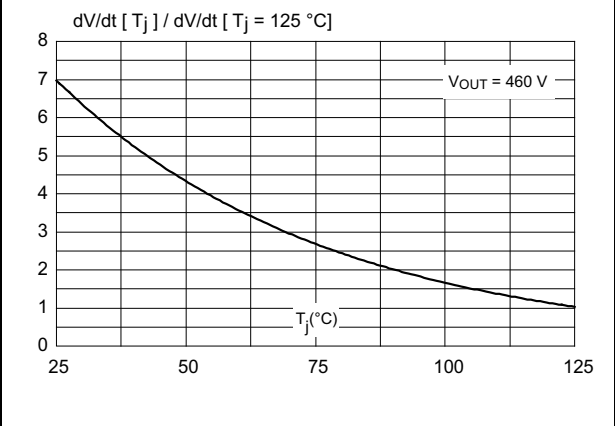
**Figure 5. Relative variation of thermal impedance versus pulse duration**



**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 reappplied 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 tp < 10 ms**



**Figure 12. On-state characteristics (maximum values)**



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



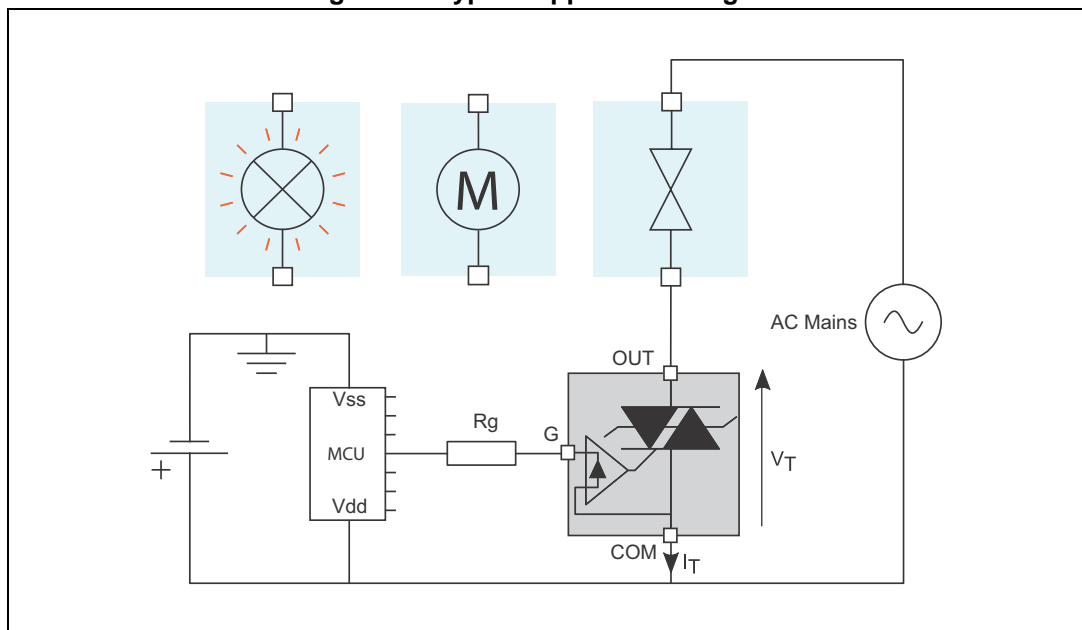
## 2 AC line switch basic application

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).



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

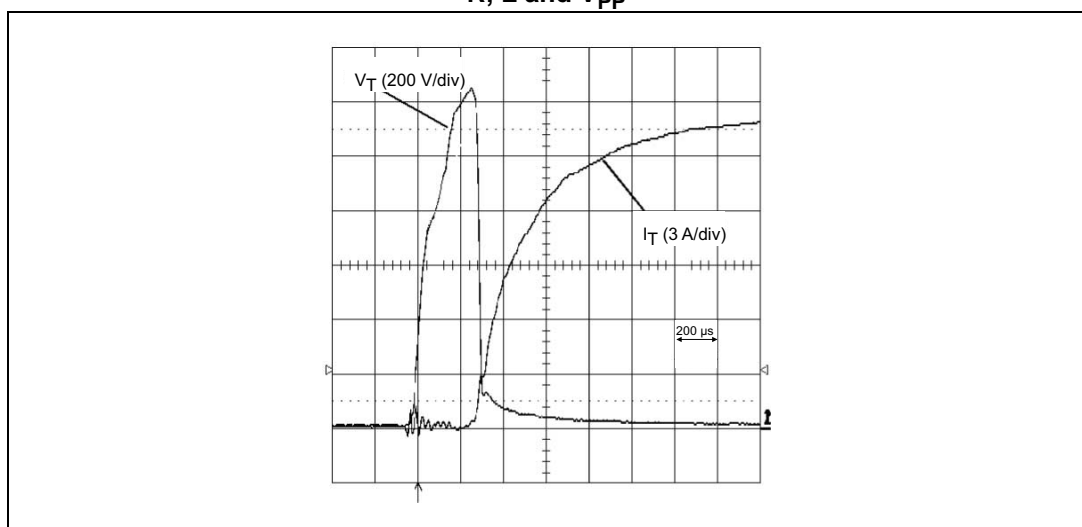
### 2.3 Alternating current mains transient voltage ruggedness

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<sub>pp</sub>**





### 3 Package information

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

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#### 3.1 TO-220FPAB package information

Figure 19. TO-220FPAB package outline

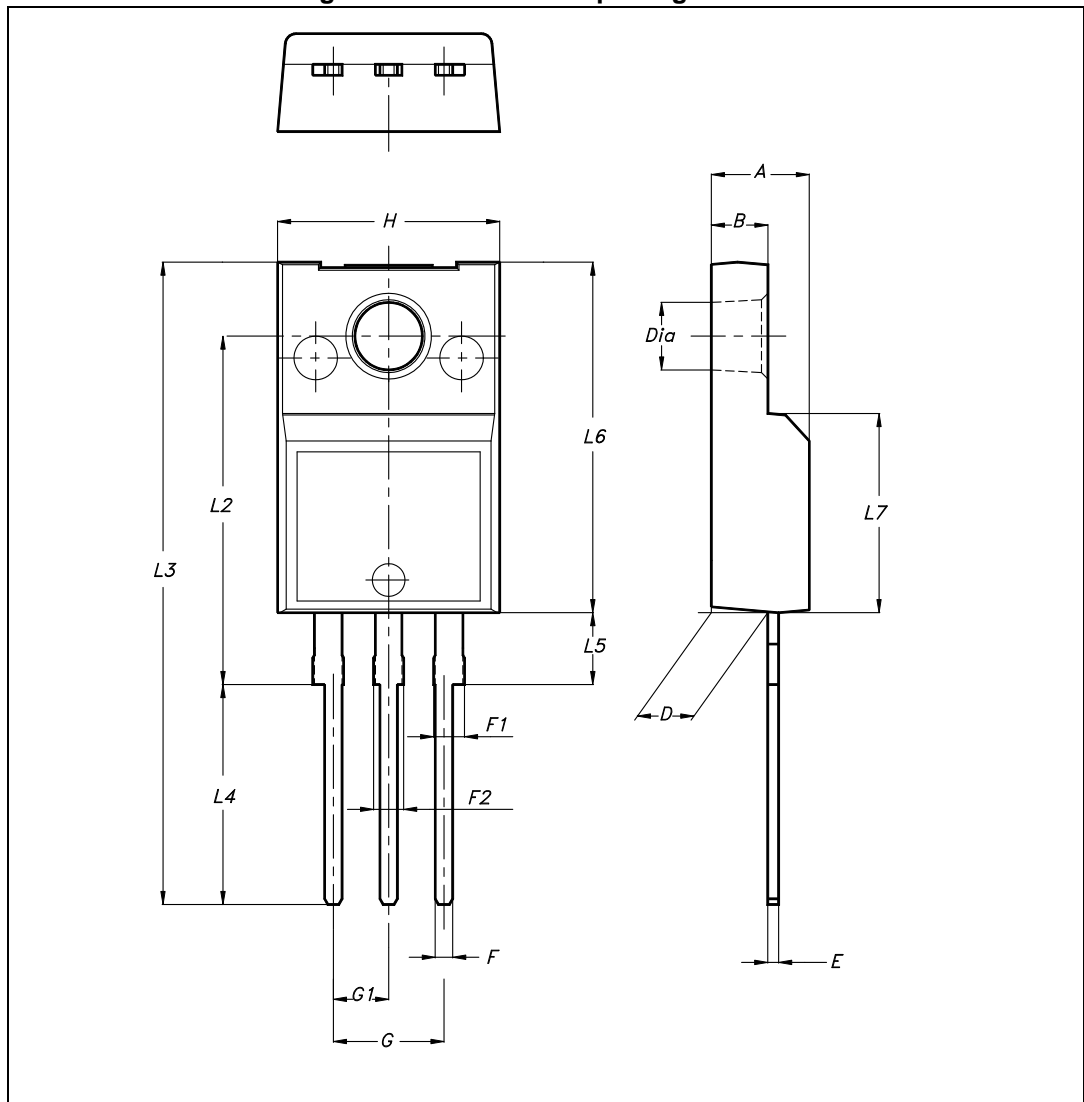


Table 6. TO-220FPAB package mechanical data

| Ref. | Dimensions  |       |                       |        |
|------|-------------|-------|-----------------------|--------|
|      | Millimeters |       | Inches <sup>(1)</sup> |        |
|      | 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 <sup>(1)</sup> |        |        |
|      | 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°    |

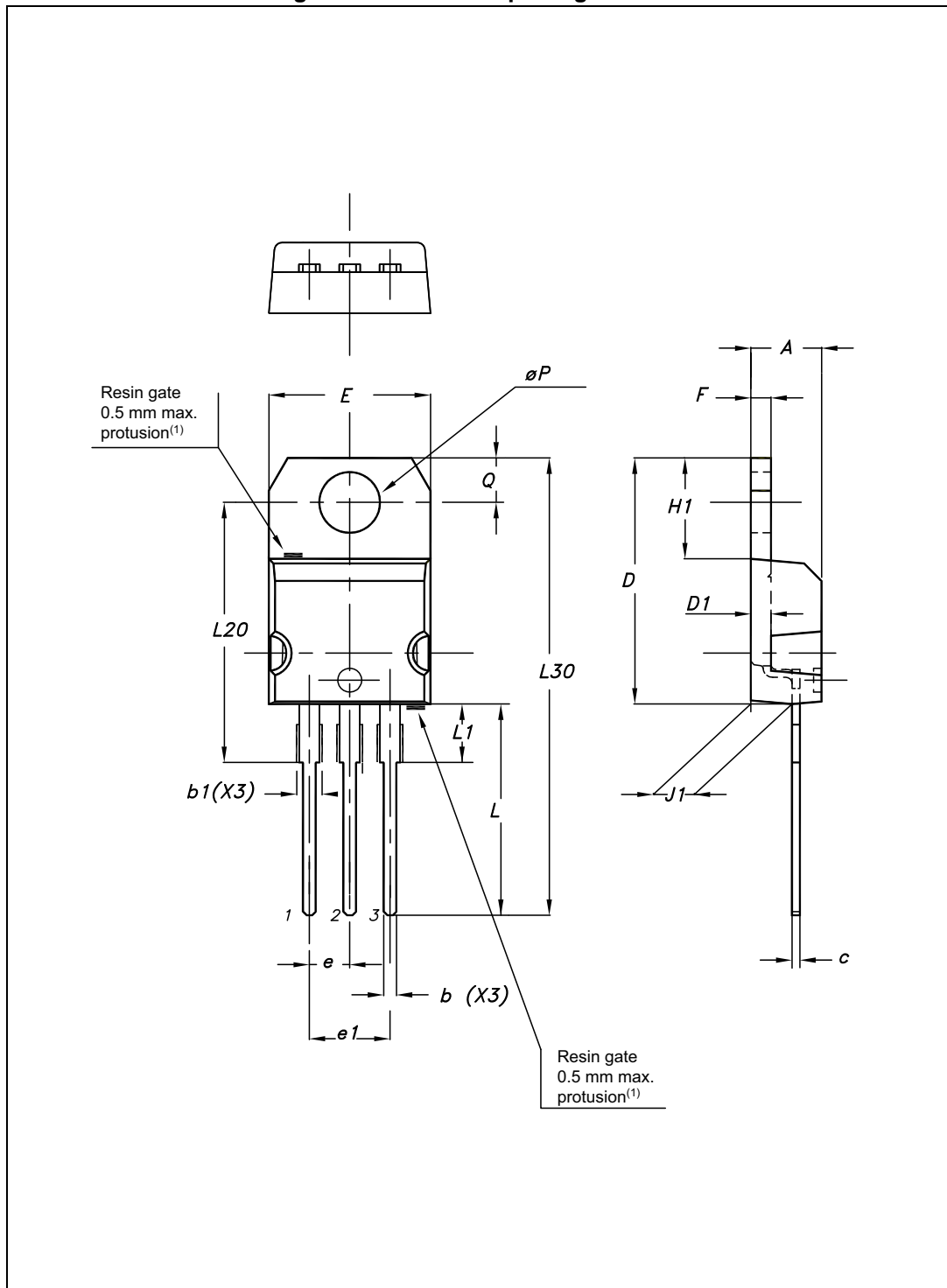
1. Inches only for reference.

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 <sup>(1)</sup> |        |
|      | 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

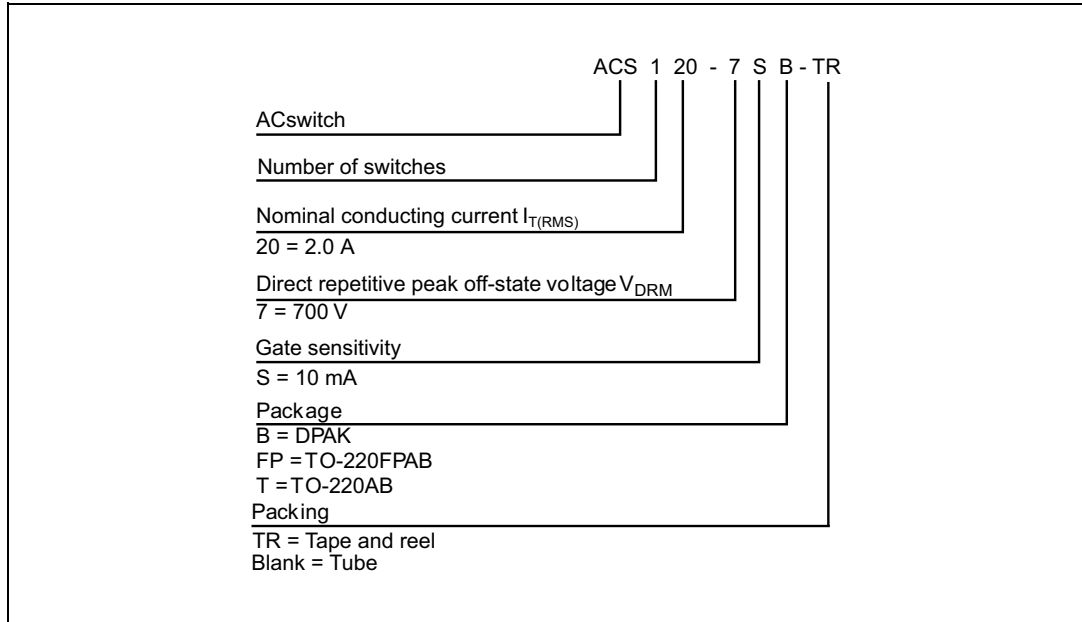


Table 9. Ordering information

| 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**

| <b>Date</b> | <b>Revision</b> | <b>Changes</b>   |
|-------------|-----------------|--|
| 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. |



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### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

Skype отдела продаж:

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