

TOPFET high side switch  
SMD version of BUK223-50Y

BUK224-50Y

DESCRIPTION

Monolithic single channel high side protected power switch in **TOPFET2** technology assembled in a 5 pin plastic surface mount package.

APPLICATIONS

General controller for driving lamps, motors, solenoids, heaters.

QUICK REFERENCE DATA

| SYMBOL   | PARAMETER                                      | MIN. | UNIT |
|----------|------------------------------------------------|------|------|
| $I_L$    | Nominal load current (ISO)                     | 12   | A    |
| SYMBOL   | PARAMETER                                      | MAX. | UNIT |
| $V_{BG}$ | Continuous off-state supply voltage            | 50   | V    |
| $I_L$    | Continuous load current                        | 25   | A    |
| $T_J$    | Continuous junction temperature                | 150  | °C   |
| $R_{ON}$ | On-state resistance $T_J = 25^{\circ}\text{C}$ | 30   | mΩ   |

FEATURES

- Vertical power TrenchMOS
- Low on-state resistance
- CMOS logic compatible
- Very low quiescent current
- Overtemperature protection
- Load current limiting
- Latched overload and short circuit protection
- Overvoltage and undervoltage shutdown with hysteresis
- On-state open circuit load detection
- Diagnostic status indication
- Voltage clamping for turn off of inductive loads
- ESD protection on all pins
- Reverse battery, overvoltage and transient protection

FUNCTIONAL BLOCK DIAGRAM

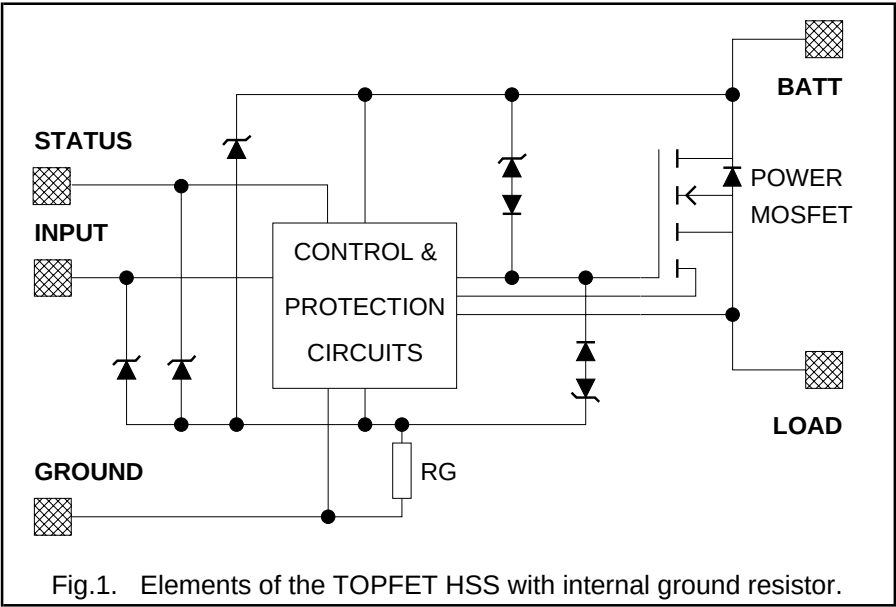
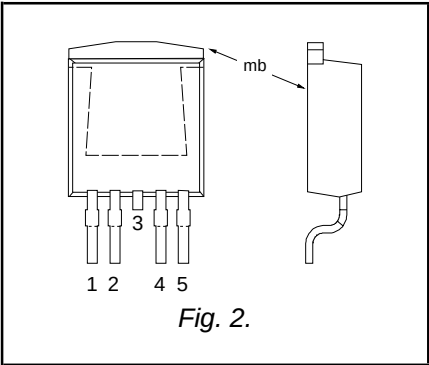


Fig.1. Elements of the TOPFET HSS with internal ground resistor.

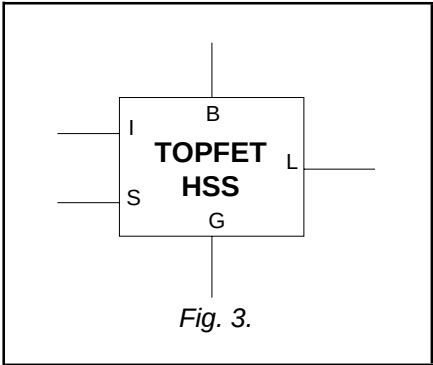
PINNING - SOT426

| PIN | DESCRIPTION       |
|-----|-------------------|
| 1   | Ground            |
| 2   | Input             |
| 3   | (connected to mb) |
| 4   | Status            |
| 5   | Load              |
| mb  | Battery           |

PIN CONFIGURATION



SYMBOL



# TOPFET high side switch SMD version of BUK223-50Y

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## LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134)

| SYMBOL     | PARAMETER                                    | CONDITIONS                                                                                    | MIN. | MAX. | UNIT             |
|------------|----------------------------------------------|-----------------------------------------------------------------------------------------------|------|------|------------------|
| $V_{BG}$   | Continuous supply voltage                    |                                                                                               | 0    | 50   | V                |
| $I_L$      | Continuous load current                      | $T_{mb} \leq 100^\circ\text{C}$                                                               | -    | 25   | A                |
| $P_D$      | Total power dissipation                      | $T_{mb} \leq 25^\circ\text{C}$                                                                | -    | 80   | W                |
| $T_{stg}$  | Storage temperature                          |                                                                                               | -55  | 175  | $^\circ\text{C}$ |
| $T_j$      | Continuous junction temperature <sup>1</sup> |                                                                                               | -    | 150  | $^\circ\text{C}$ |
| $T_{sold}$ | Mounting base temperature                    | during soldering                                                                              | -    | 260  | $^\circ\text{C}$ |
|            | <b>Reverse battery voltages<sup>2</sup></b>  |                                                                                               |      |      |                  |
| $-V_{BG}$  | Continuous reverse voltage                   |                                                                                               | -    | 16   | V                |
| $-V_{BG}$  | Peak reverse voltage                         |                                                                                               | -    | 32   | V                |
|            | <b>Application information</b>               |                                                                                               |      |      |                  |
| $R_I, R_S$ | External resistors <sup>3</sup>              | to limit input, status currents                                                               | 3.2  | -    | k $\Omega$       |
|            | <b>Input and status</b>                      |                                                                                               |      |      |                  |
| $I_I, I_S$ | Continuous currents                          |                                                                                               | -5   | 5    | mA               |
| $I_I, I_S$ | Repetitive peak currents                     | $\delta \leq 0.1$ , $t_p = 300 \mu\text{s}$                                                   | -50  | 50   | mA               |
|            | <b>Inductive load clamping</b>               |                                                                                               |      |      |                  |
| $E_{BL}$   | Non-repetitive clamping energy               | $I_L = 10 \text{ A}$ , $V_{BG} = 16 \text{ V}$<br>$T_j = 150^\circ\text{C}$ prior to turn-off | -    | 270  | mJ               |

## ESD LIMITING VALUE

| SYMBOL | PARAMETER                                 | CONDITIONS                                                            | MIN. | MAX. | UNIT |
|--------|-------------------------------------------|-----------------------------------------------------------------------|------|------|------|
| $V_C$  | Electrostatic discharge capacitor voltage | Human body model;<br>$C = 250 \text{ pF}$ ; $R = 1.5 \text{ k}\Omega$ | -    | 2    | kV   |

## THERMAL CHARACTERISTICS

| SYMBOL        | PARAMETER                             | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------|---------------------------------------|------------|------|------|------|------|
|               | <b>Thermal resistance<sup>4</sup></b> |            |      |      |      |      |
| $R_{th j-mb}$ | Junction to mounting base             | -          | -    | 1.25 | 1.56 | K/W  |

1 For normal continuous operation. A higher  $T_j$  is allowed as an overload condition but at the threshold  $T_{j(TO)}$  the over temperature trip operates to protect the switch.

2 Reverse battery voltage is allowed only with external resistors to limit the input and status currents to a safe value. The connected load must limit the reverse load current. The internal ground resistor limits the reverse battery ground current. Power is dissipated and the  $T_j$  rating must be observed.

3 To limit currents during reverse battery and transient overvoltages (positive or negative).

4 Of the output power MOS transistor.

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## STATIC CHARACTERISTICS

Limits are at  $-40^{\circ}\text{C} \leq T_{\text{mb}} \leq 150^{\circ}\text{C}$  and typicals at  $T_{\text{mb}} = 25^{\circ}\text{C}$  unless otherwise stated.

| SYMBOL           | PARAMETER                           | CONDITIONS                                                                      |                |                |                 | MIN. | TYP. | MAX. | UNIT |
|------------------|-------------------------------------|---------------------------------------------------------------------------------|----------------|----------------|-----------------|------|------|------|------|
|                  | <b>Clamping voltages</b>            |                                                                                 |                |                |                 |      |      |      |      |
| V <sub>BG</sub>  | Battery to ground                   | I <sub>G</sub> = 1 mA                                                           |                |                |                 | 50   | 55   | 65   | V    |
| V <sub>BL</sub>  | Battery to load                     | I <sub>L</sub> = I <sub>G</sub> = 1 mA                                          |                |                |                 | 50   | 55   | 65   | V    |
| -V <sub>LG</sub> | Negative load to ground             | I <sub>L</sub> = 10 mA                                                          |                |                |                 | 18   | 23   | 28   | V    |
| -V <sub>LG</sub> | Negative load voltage <sup>1</sup>  | I <sub>L</sub> = 10 A; t <sub>p</sub> = 300 μs                                  |                |                |                 | 20   | 25   | 30   | V    |
|                  | <b>Supply voltage</b>               | battery to ground                                                               |                |                |                 |      |      |      |      |
| V <sub>BG</sub>  | Operating range <sup>2</sup>        | -                                                                               |                |                |                 | 5.5  | -    | 35   | V    |
|                  | <b>Currents</b>                     |                                                                                 |                |                |                 |      |      |      |      |
| I <sub>B</sub>   | Quiescent current <sup>3</sup>      | 9 V ≤ V <sub>BG</sub> ≤ 16 V<br>V <sub>LG</sub> = 0 V<br>T <sub>mb</sub> = 25°C |                |                |                 | -    | -    | 20   | μA   |
| I <sub>L</sub>   | Off-state load current <sup>4</sup> | V <sub>BL</sub> = V <sub>BG</sub><br>T <sub>mb</sub> = 25°C                     |                |                |                 | -    | 0.1  | 2    | μA   |
| I <sub>G</sub>   | Operating current <sup>5</sup>      | I <sub>L</sub> = 0 A                                                            |                |                |                 | -    | 0.1  | 20   | μA   |
| I <sub>L</sub>   | Nominal load current <sup>6</sup>   | V <sub>BL</sub> = 0.5 V                                                         |                |                |                 | -    | 2    | 4    | mA   |
|                  |                                     |                                                                                 |                |                |                 | 12   | -    | -    | A    |
|                  | <b>Resistances</b>                  |                                                                                 |                |                |                 |      |      |      |      |
|                  |                                     | V <sub>BG</sub>                                                                 | I <sub>L</sub> | t <sub>p</sub> | T <sub>mb</sub> |      |      |      |      |
| R <sub>ON</sub>  | On-state resistance <sup>7</sup>    | 9 to 35 V                                                                       | 10 A           | 300 μs         | 25°C            | -    | 22   | 30   | mΩ   |
|                  |                                     |                                                                                 |                |                | 150°C           | -    | -    | 55   | mΩ   |
| R <sub>ON</sub>  | On-state resistance                 | 6 V                                                                             | 10 A           | 300 μs         | 25°C            | -    | 28   | 38   | mΩ   |
|                  |                                     |                                                                                 |                |                | 150°C           | -    | -    | 70   | mΩ   |
| R <sub>G</sub>   | Internal ground resistance          | I <sub>G</sub> = 10 mA                                                          |                |                |                 | 95   | 150  | 190  | Ω    |

1 For a high side switch, the load pin voltage goes negative with respect to ground during the turn-off of an inductive load.

2 On-state resistance is increased if the supply voltage is less than 9 V. Refer to figure 8.

3 This is the continuous current drawn from the supply when the input is low and includes leakage current to the load.

4 The measured current is in the load pin only.

5 This is the continuous current drawn from the supply with no load connected, but with the input high.

6 Defined as in ISO 10483-1. For comparison purposes only. This parameter will not be characterised for automotive PPAP.

7 The supply and input voltage for the  $R_{\text{ON}}$  tests are continuous. The specified pulse duration  $t_{\text{p}}$  refers only to the applied load current.

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## INPUT CHARACTERISTICS

9 V ≤ V<sub>BG</sub> ≤ 16 V. Limits are at -40°C ≤ T<sub>mb</sub> ≤ 150°C and typicals at T<sub>mb</sub> = 25 °C unless otherwise stated.

| SYMBOL               | PARAMETER                        | CONDITIONS              | MIN. | TYP. | MAX. | UNIT |
|----------------------|----------------------------------|-------------------------|------|------|------|------|
| I <sub>I</sub>       | Input current                    | V <sub>IG</sub> = 5 V   | 20   | 90   | 160  | μA   |
| V <sub>IG</sub>      | Input clamping voltage           | I <sub>I</sub> = 200 μA | 5.5  | 7    | 8.5  | V    |
| V <sub>IG(ON)</sub>  | Input turn-on threshold voltage  |                         | -    | 2.4  | 3    | V    |
| V <sub>IG(OFF)</sub> | Input turn-off threshold voltage |                         | 1.5  | 2.1  | -    | V    |
| ΔV <sub>IG</sub>     | Input turn-on hysteresis         |                         | -    | 0.3  | -    | V    |
| I <sub>I(ON)</sub>   | Input turn-on current            | V <sub>IG</sub> = 3 V   | -    | -    | 100  | μA   |
| I <sub>I(OFF)</sub>  | Input turn-off current           | V <sub>IG</sub> = 1.5 V | 10   | -    | -    | μA   |

## STATUS CHARACTERISTICS

The status output is an open drain transistor, and requires an external pull-up circuit to indicate a logic high. Limits are at -40°C ≤ T<sub>mb</sub> ≤ 150°C and typicals at T<sub>mb</sub> = 25 °C unless otherwise stated. Refer to TRUTH TABLE.

| SYMBOL          | PARAMETER                                                   | CONDITIONS              | MIN. | TYP. | MAX. | UNIT |
|-----------------|-------------------------------------------------------------|-------------------------|------|------|------|------|
| V <sub>SG</sub> | Status clamping voltage                                     | I <sub>S</sub> = 100 μA | 5.5  | 7    | 8.5  | V    |
| V <sub>SG</sub> | Status low voltage                                          | I <sub>S</sub> = 100 μA | -    | -    | 1    | V    |
|                 |                                                             | T <sub>mb</sub> = 25°C  | -    | 0.7  | 0.8  | V    |
| I <sub>S</sub>  | Status leakage current                                      | V <sub>SG</sub> = 5 V   | -    | -    | 15   | μA   |
|                 |                                                             | T <sub>mb</sub> = 25°C  | -    | 0.1  | 1    | μA   |
| I <sub>S</sub>  | Status saturation current <sup>1</sup>                      | V <sub>SG</sub> = 5 V   | 2    | 7    | 12   | mA   |
| R <sub>S</sub>  | <b>Application information</b><br>External pull-up resistor |                         | -    | 47   | -    | kΩ   |

## OPEN CIRCUIT DETECTION CHARACTERISTICS

An open circuit load can be detected in the on-state. Refer to TRUTH TABLE.

Limits are at -40°C ≤ T<sub>mb</sub> ≤ 150°C and typical is at T<sub>mb</sub> = 25 °C.

| SYMBOL              | PARAMETER                     | CONDITIONS                   | MIN. | TYP. | MAX. | UNIT |
|---------------------|-------------------------------|------------------------------|------|------|------|------|
|                     | <b>Open circuit detection</b> | 9 V ≤ V <sub>BG</sub> ≤ 35 V |      |      |      |      |
| I <sub>L(TO)</sub>  | Low current detect threshold  |                              | 0.3  | -    | 2    | A    |
|                     |                               | T <sub>J</sub> = 25°C        | 0.5  | 1    | 1.5  | A    |
| ΔI <sub>L(TO)</sub> | Hysteresis                    |                              | -    | 0.2  | -    | A    |

<sup>1</sup> In a fault condition with the pull-up resistor short circuited while the status transistor is conducting. This condition should be avoided in order to prevent possible interference with normal operation of the device.

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## UNDERVOLTAGE & OVERVOLTAGE CHARACTERISTICS

Limits are at  $-40^{\circ}\text{C} \leq T_{\text{mb}} \leq 150^{\circ}\text{C}$  and typicals at  $T_{\text{mb}} = 25^{\circ}\text{C}$ . Refer to TRUTH TABLE.

| SYMBOL                     | PARAMETER                                                        | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------------------|------------------------------------------------------------------|------------|------|------|------|------|
| $V_{\text{BG(UV)}}$        | <b>Undervoltage</b><br>Low supply threshold voltage <sup>1</sup> |            | 2    | 4.2  | 5.5  | V    |
| $\Delta V_{\text{BG(UV)}}$ | Hysteresis                                                       |            | -    | 0.5  | -    | V    |
| $V_{\text{BG(OV)}}$        | <b>Overvoltage</b><br>High supply threshold voltage <sup>2</sup> |            | 40   | 45   | 50   | V    |
| $\Delta V_{\text{BG(OV)}}$ | Hysteresis                                                       |            | -    | 1    | -    | V    |

## TRUTH TABLE

| INPUT | ABNORMAL CONDITIONS DETECTED |    |      |    |    | LOAD OUTPUT | STATUS | DESCRIPTION                 |
|-------|------------------------------|----|------|----|----|-------------|--------|-----------------------------|
|       | SUPPLY                       |    | LOAD |    |    |             |        |                             |
|       | UV                           | OV | LC   | SC | OT |             |        |                             |
| L     | X                            | X  | X    | X  | X  | OFF         | H      | off                         |
| H     | 0                            | 0  | 0    | 0  | 0  | ON          | H      | on & normal                 |
| H     | 0                            | 0  | 1    | 0  | 0  | ON          | L      | on & low current detect     |
| H     | 1                            | 0  | X    | X  | X  | OFF         | H      | supply undervoltage lockout |
| H     | 0                            | 1  | X    | 0  | 0  | OFF         | H      | supply overvoltage shutdown |
| H     | 0                            | 0  | 0    | 1  | X  | OFF         | L      | SC tripped                  |
| H     | 0                            | 0  | 0    | 0  | 1  | OFF         | L      | OT shutdown <sup>3</sup>    |

## KEY TO ABBREVIATIONS

|   |                       |    |                                  |
|---|-----------------------|----|----------------------------------|
| L | logic low             | UV | undervoltage                     |
| H | logic high            | OV | overvoltage                      |
| X | don't care            | LC | low current or open circuit load |
| 0 | condition not present | SC | short circuit                    |
| 1 | condition present     | OT | overtemperature                  |

<sup>1</sup> Undervoltage sensor causes the device to switch off and reset.

<sup>2</sup> Overvoltage sensor causes the device to switch off to protect its load.

<sup>3</sup> The status will continue to indicate OT (even if the input goes low) until the device cools below the reset threshold. Refer to OVERLOAD PROTECTION CHARACTERISTICS.

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## OVERLOAD PROTECTION CHARACTERISTICS

5.5 V ≤ V<sub>BG</sub> ≤ 35 V, limits are at -40°C ≤ T<sub>mb</sub> ≤ 150°C and typicals at T<sub>mb</sub> = 25 °C unless otherwise stated.

Refer to TRUTH TABLE.

| SYMBOL              | PARAMETER                                                                           | CONDITIONS                                                 | MIN.    | TYP.     | MAX.     | UNIT   |
|---------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------|---------|----------|----------|--------|
| I <sub>L(lim)</sub> | <b>Overload protection</b><br>Load current limiting                                 | V <sub>BL</sub> = V <sub>BG</sub><br>V <sub>BG</sub> ≥ 9 V | 38      | 55       | 72       | A      |
| V <sub>BL(TO)</sub> | <b>Short circuit load protection</b><br>Battery load threshold voltage <sup>1</sup> | V <sub>BG</sub> = 16 V<br>V <sub>BG</sub> = 35 V           | 8<br>15 | 10<br>20 | 12<br>25 | V<br>V |
| t <sub>d sc</sub>   | Response time <sup>2</sup>                                                          | V <sub>BL</sub> > V <sub>BL(TO)</sub>                      | -       | 180      | 250      | μs     |
| T <sub>J(TO)</sub>  | <b>Overtemperature protection</b><br>Threshold junction temperature <sup>3</sup>    |                                                            | 150     | 170      | 190      | °C     |
| ΔT <sub>J(TO)</sub> | Hysteresis                                                                          |                                                            | -       | 10       | -        | °C     |

## SWITCHING CHARACTERISTICS

T<sub>mb</sub> = 25 °C, V<sub>BG</sub> = 13 V, for resistive load R<sub>L</sub> = 13 Ω.

| SYMBOL               | PARAMETER                            | CONDITIONS                                         | MIN. | TYP. | MAX. | UNIT |
|----------------------|--------------------------------------|----------------------------------------------------|------|------|------|------|
| t <sub>d on</sub>    | <b>During turn-on</b><br>Delay time  | to V <sub>IG</sub> = 5 V                           | -    | 50   | 70   | μs   |
| dV/dt <sub>on</sub>  | Rate of rise of load voltage         | to 10% V <sub>L</sub><br>30% to 70% V <sub>L</sub> | -    | 0.4  | 1    | V/μs |
| t <sub>on</sub>      | Total switching time                 | to 90% V <sub>L</sub>                              | -    | 140  | 200  | μs   |
| t <sub>d off</sub>   | <b>During turn-off</b><br>Delay time | to V <sub>IG</sub> = 0 V                           | -    | 70   | 95   | μs   |
| dV/dt <sub>off</sub> | Rate of fall of load voltage         | to 90% V <sub>L</sub><br>70% to 30% V <sub>L</sub> | -    | 0.6  | 1    | V/μs |
| t <sub>off</sub>     | Total switching time                 | to 10% V <sub>L</sub>                              | -    | 105  | 140  | μs   |

## CAPACITANCES

T<sub>mb</sub> = 25 °C; f = 1 MHz; V<sub>IG</sub> = 0 V. *designed in parameters.*

| SYMBOL          | PARAMETER          | CONDITIONS             | MIN. | TYP. | MAX. | UNIT |
|-----------------|--------------------|------------------------|------|------|------|------|
| C <sub>ig</sub> | Input capacitance  | V <sub>BG</sub> = 13 V | -    | 15   | 20   | pF   |
| C <sub>bl</sub> | Output capacitance | V <sub>BL</sub> = 13 V | -    | 320  | 450  | pF   |
| C <sub>sg</sub> | Status capacitance | V <sub>SG</sub> = 5 V  | -    | 11   | 15   | pF   |

1 The battery to load threshold voltage for short circuit protection is proportional to the battery supply voltage. A graph showing V<sub>BL(TO)</sub> versus V<sub>BG</sub> will be provided in the product specification. After short circuit protection has operated, the input voltage must be toggled low for the switch to resume normal operation.

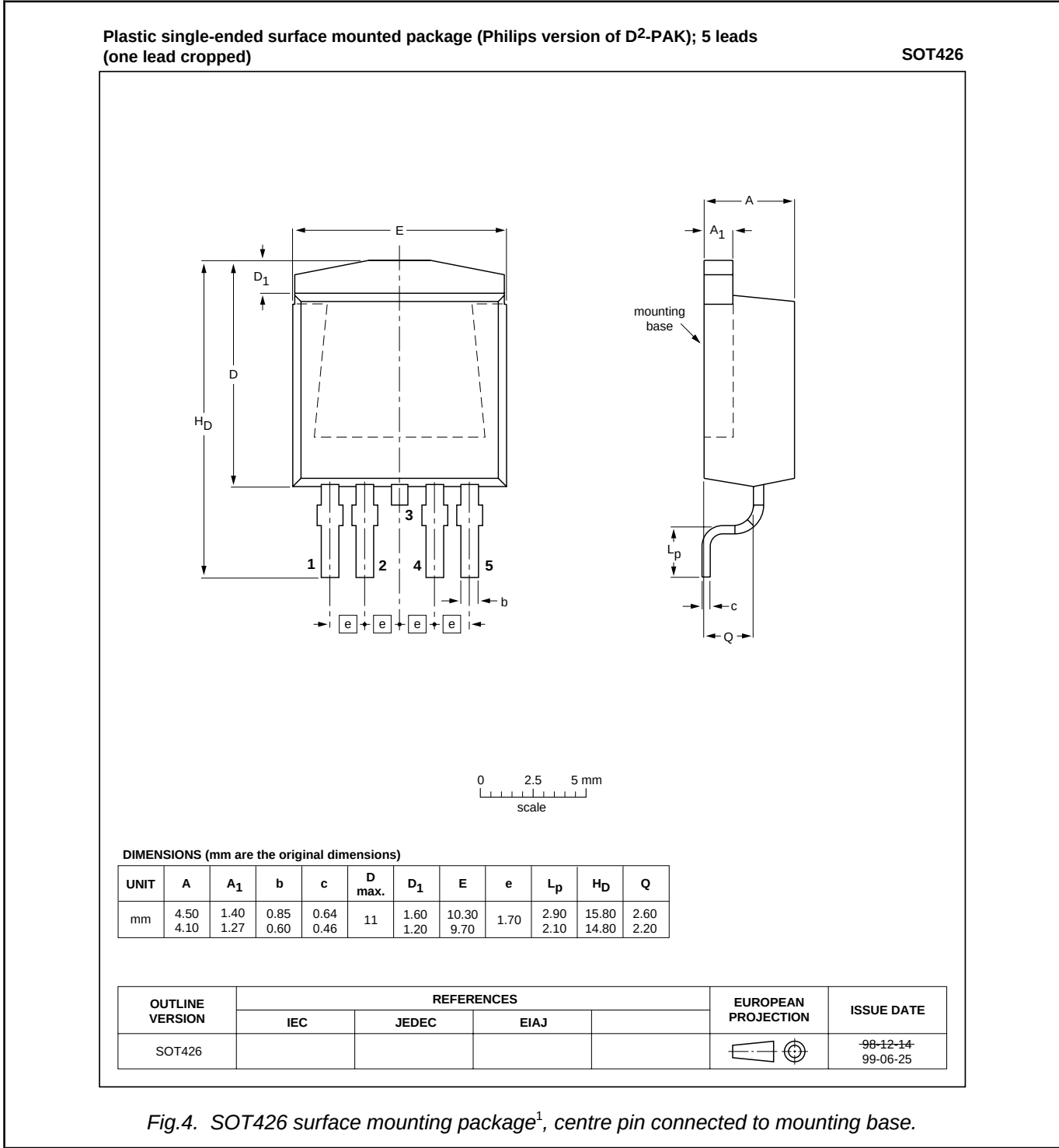
2 Measured from when the input goes high.

3 After cooling below the reset temperature the switch will resume normal operation.

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MECHANICAL DATA



<sup>1</sup> Epoxy meets UL94 V0 at 1/8". Net mass: 1.5 g.  
For soldering guidelines and SMD footprint design, please refer to Data Handbook SC18.

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## DEFINITIONS

| DATA SHEET STATUS                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DATA SHEET STATUS <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                             | PRODUCT STATUS <sup>2</sup> | DEFINITIONS                                                                                                                                                                                                                                                                                                           |
| Objective data                                                                                                                                                                                                                                                                                                                                                                                                                                             | Development                 | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice                                                                                                                            |
| Preliminary data                                                                                                                                                                                                                                                                                                                                                                                                                                           | Qualification               | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product                                     |
| Product data                                                                                                                                                                                                                                                                                                                                                                                                                                               | Production                  | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Changes will be communicated according to the Customer Product/Process Change Notification (CPCN) procedure SNW-SQ-650A |
| <b>Limiting values</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     |                             |                                                                                                                                                                                                                                                                                                                       |
| Limiting values are given in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of this specification is not implied. Exposure to limiting values for extended periods may affect device reliability. |                             |                                                                                                                                                                                                                                                                                                                       |
| <b>Application information</b>                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |                                                                                                                                                                                                                                                                                                                       |
| Where application information is given, it is advisory and does not form part of the specification.                                                                                                                                                                                                                                                                                                                                                        |                             |                                                                                                                                                                                                                                                                                                                       |
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