**PIP3211-R** 

## **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.

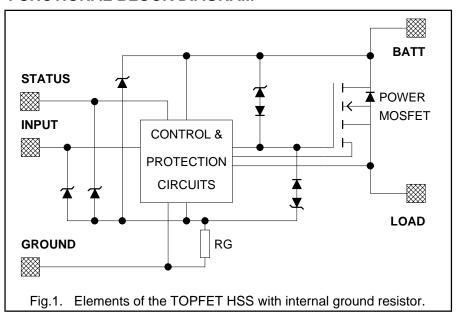
### **FEATURES**

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

## **QUICK REFERENCE DATA**

SYMBOL	PARAMETER	MIN.	UNIT
I <sub>L</sub>	Nominal load current (ISO)	9	А
SYMBOL	PARAMETER	MAX.	UNIT
V <sub>BG</sub> I <sub>L</sub> T <sub>j</sub> R <sub>ON</sub>	Continuous off-state supply voltage Continuous load current Continuous junction temperature On-state resistance $T_j = 25^{\circ}C$	50 20 150 38	> A ° C mΩ

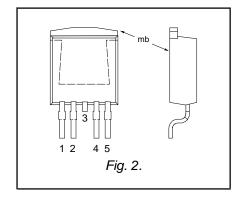
### **FUNCTIONAL BLOCK DIAGRAM**



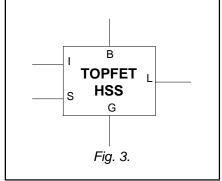
#### **PINNING - SOT426**

PIN	DESCRIPTION
1	Ground
2	Input
3	(connected to mb)
4	<b>S</b> tatus
5	Load
mb	Battery

## **PIN CONFIGURATION**



### **SYMBOL**



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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 <sub>L</sub>	Continuous load current	T <sub>mb</sub> ≤95°C	-	20	Α
P <sub>D</sub>	Total power dissipation	$T_{mb} \le 25^{\circ}C$	-	67	W
T <sub>stg</sub>	Storage temperature		-55	175	°C
T <sub>j</sub>	Continuous junction temperature <sup>1</sup>		-	150	°C
T <sub>sold</sub>	Mounting base temperature	during soldering	-	260	°C
	Reverse battery voltages²				
-V <sub>BG</sub>	Continuous reverse voltage		-	16	V
-V <sub>BG</sub>	Peak reverse voltage		-	32	V
	Application information				
R <sub>I</sub> , R <sub>S</sub>	External resistors <sup>3</sup>	to limit input, status currents	3.2	-	kΩ
	Input and status				
I <sub>I</sub> , I <sub>S</sub>	Continuous currents		-5	5	mA
I <sub>I</sub> , I <sub>S</sub>	Repetitive peak currents	$\delta \le 0.1$ , tp = 300 μs	-50	50	mA
	Inductive load clamping	I <sub>L</sub> = 10 A, V <sub>BG</sub> = 16 V			
E <sub>BL</sub>	Non-repetitive clamping energy	$T_j \le 150^{\circ}$ C prior to turn-off	-	150	mJ

## **ESD LIMITING VALUE**

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V <sub>C</sub>	Electrostatic discharge capacitor voltage	Human body model; C = 250 pF; R = 1.5 kΩ	-	2	kV

## THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Thermal resistance⁴					
R <sub>th j-mb</sub>	Junction to mounting base	-	-	1.52	1.86	K/W

<sup>1</sup> 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.

<sup>2</sup> 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<sub>j</sub> rating must be observed.

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

<sup>4</sup> Of the output power MOS transistor.

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## STATIC CHARACTERISTICS

Limits are at -40  $^{\circ}$ C  $\leq$  T<sub>mb</sub>  $\leq$  150  $^{\circ}$ C and typicals at T<sub>mb</sub> = 25  $^{\circ}$ C unless otherwise stated.

SYMBOL	PARAMETER	CONDITIO	NS			MIN.	TYP.	MAX.	UNIT
	Clamping voltages								
$V_{BG}$	Battery to ground	$I_G = 1 \text{ mA}$	I <sub>G</sub> = 1 mA				55	65	V
$V_{BL}$	Battery to load	$I_L = I_G = 1 \text{ m}$	nΑ			50	55	65	V
-V <sub>LG</sub>	Negative load to ground	$I_L = 10 \text{ mA}$				18	23	28	V
-V <sub>LG</sub>	Negative load voltage <sup>1</sup>	$I_{L} = 10 \text{ A}; t_{p}$	$= 300 \mu$	เร		20	25	30	V
	Supply voltage	battery to g	round						
$V_{BG}$	Operating range <sup>2</sup>					5.5	-	35	V
	Currents	9 V ≤ V <sub>BG</sub> ≤	16 V						
I <sub>B</sub>	Quiescent current <sup>3</sup>	$V_{LG} = 0 V$				-	-	20	μΑ
				$T_{mb} =$	= 25°C	-	0.1	2	μΑ
I <sub>L</sub>	Off-state load current <sup>4</sup>	$V_{BL} = V_{BG}$				-	-	20	μΑ
				$T_{mb} =$	= 25°C	-	0.1	1	μΑ
$I_{G}$	Operating current <sup>5</sup>	$I_L = 0 A$				-	2	4	mΑ
I <sub>L</sub>	Nominal load current <sup>6</sup>	$V_{BL} = 0.5 \text{ V}$		T <sub>mb</sub> =	= 85°C	9	-	-	Α
	Resistances	$V_{BG}$	Ι <sub>L</sub>	t <sub>p</sub> <sup>7</sup>	$T_{mb}$				
R <sub>on</sub>	On-state resistance	9 to 35 V	10 A	300 μs	25°C	-	28	38	$m\Omega$
					150°C	-	-	70	mΩ
R <sub>on</sub>	On-state resistance	6 V	10 A	300 μs	25°C	-	36	48	$m\Omega$
					150°C	-	-	88	mΩ
$R_{G}$	Internal ground resistance	I <sub>G</sub> = 10 mA				95	150	190	Ω

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

 $<sup>{\</sup>bf 2}$  On-state resistance is increased if the supply voltage is less than 9 V.

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

<sup>4</sup> The measured current is in the load pin only.

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

<sup>6</sup> Defined as in ISO 10483-1. For comparison purposes only.

<sup>7</sup> The supply and input voltage for the R<sub>oN</sub> tests are continuous. The specified pulse duration t₀ refers only to the applied load current.

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## INPUT CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I <sub>1</sub>	Input current	$V_{IG} = 5 V$	20	90	160	μΑ
V <sub>IG</sub>	Input clamping voltage	Ι <sub>ι</sub> = 200 μΑ	5.5	7	8.5	V
$V_{IG(ON)}$	Input turn-on threshold voltage		-	2.4	3	V
$V_{IG(OFF)}$	Input turn-off threshold voltage		1.5	2.1	-	V
$\Delta V_{IG}$	Input turn-on hysteresis		-	0.3	-	V
I <sub>I(ON)</sub>	Input turn-on current	$V_{IG} = 3 V$	-	-	100	μΑ
I <sub>I(OFF)</sub>	Input turn-off current	V <sub>IG</sub> = 1.5 V	10	-	-	μΑ

## 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  $^{\circ}$ C  $\leq$  T<sub>mb</sub>  $\leq$  150  $^{\circ}$ C and typicals at T<sub>mb</sub> = 25  $^{\circ}$ C unless otherwise stated. Refer to TRUTH TABLE.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{SG}$	Status clamping voltage	I <sub>S</sub> = 100 μA	5.5	7	8.5	V
$V_{SG}$	Status low voltage	I <sub>S</sub> = 100 μA	-	-	1	V
		$T_{mb} = 25^{\circ}C$	-	0.7	0.8	V
Is	Status leakage current	$V_{SG} = 5 V$	-	-	15	μΑ
		$T_{mb} = 25^{\circ}C$	-	0.1	1	μΑ
Is	Status saturation current <sup>1</sup>	$V_{SG} = 5 \text{ V}$	2	7	12	mA
	Application information					
R <sub>s</sub>	External pull-up resistor		-	47	-	kΩ

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<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  $^{\circ}$ C  $\leq$  T<sub>mb</sub>  $\leq$  150  $^{\circ}$ C and typicals at T<sub>mb</sub> = 25  $^{\circ}$ C. Refer to TRUTH TABLE.

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

## **TRUTH TABLE**

	AE	BNORMA DE	AL CON		S	LOAD		
INPUT	SUPPLY		LOAD		OUTPUT	STATUS	DESCRIPTION	
	UV	ov	LC	SC	ОТ			
L	Х	Х	Х	Х	Х	OFF	Н	off
Н	0	0	Х	0	0	ON	Н	on & normal (LC not detected!)
Н	1	0	Х	Х	Х	OFF	Н	supply undervoltage lockout
Н	0	1	Х	0	0	OFF	Н	supply overvoltage shutdown
Н	0	0	0	1	0	OFF	L	SC protection
Н	0	0	Х	Х	1	OFF	L	OT shutdown

## **KEY TO ABBREVIATIONS**

logic low logic high don't care

condition not present

condition present

UV undervoltage
OV overvoltage
LC low current or open circuit load LC low current or ope SC short circuit OT overtemperature

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<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.

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### **OVERLOAD PROTECTION CHARACTERISTICS**

 $5.5~V \le V_{BG} \le 35~V$ , limits are at -40°C  $\le T_{mb} \le 150$ °C and typicals at  $T_{mb} = 25~$ °C unless otherwise stated. Refer to TRUTH TABLE.

SYMBOL	PARAMETER	CONDITIONS		MIN.	TYP.	MAX.	UNIT
	Overload protection	$V_{BL} = V_{BG}$					
$I_{L(lim)}$	Load current limiting	$V_{BG} \ge 9 \text{ V}$		34	45	64	Α
	Short circuit load protection						
$V_{\text{BL(TO)}}$	Battery load threshold voltage <sup>1</sup>		$V_{BG} = 16 \text{ V}$	8	10	12	V
			$V_{BG} = 35 \text{ V}$	15	20	25	V
$t_{\rm dsc}$	Response time <sup>2</sup>	$V_{BL} > V_{BL(TO)}$		-	180	250	μs
	Overtemperature protection						
$T_{j(TO)}$	Threshold junction temperature <sup>3</sup>			150	170	190	°C

### **SWITCHING CHARACTERISTICS**

 $T_{mb}$  = 25 °C,  $V_{BG}$  = 13 V, for resistive load  $R_L$  = 13  $\Omega$ .

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	During turn-on	from input going high				
$t_{d on}$	Delay time	to 10% V <sub>L</sub>	-	40	60	μs
$dV/dt_{on}$	Rate of rise of load voltage	30% to 70% V <sub>L</sub>	-	0.35	1	V/μs
t on	Total switching time	to 90% V <sub>L</sub>	-	140	200	μs
	During turn-off	from input going low				
t <sub>d off</sub>	Delay time	to 90% V <sub>L</sub>	-	55	80	μs
dV/dt <sub>off</sub>	Rate of fall of load voltage	70% to 30% V <sub>L</sub>	-	0.6	1	V/μs
t off	Total switching time	to 10% V <sub>L</sub>	-	85	120	μs

## **CAPACITANCES**

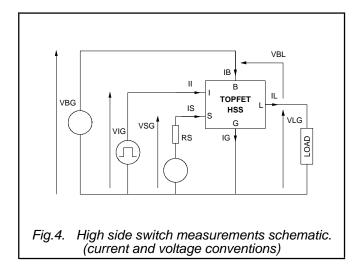
 $T_{mh}$  = 25 °C; f = 1 MHz;  $V_{IG}$  = 0 V. designed in parameters.

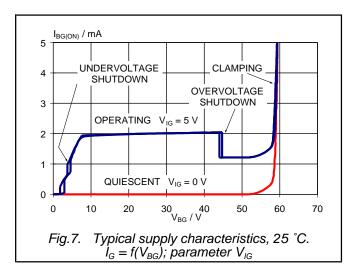
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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
C <sub>ig</sub>	Input capacitance	$V_{BG} = 13 \text{ V}$	-	15	20	рF
C <sub>bl</sub>	Output capacitance	V <sub>BL</sub> = 13 V	-	250	350	рF
C <sub>sg</sub>	Status capacitance	$V_{SG} = 5 \text{ V}$	-	11	15	рF

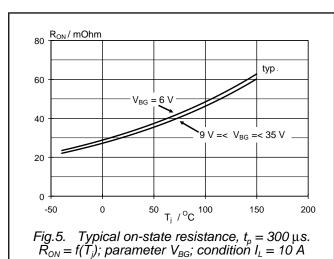
<sup>1</sup> The battery to load threshold voltage for short circuit protection is proportional to the battery supply voltage. After short circuit protection has operated, the input voltage must be toggled low for the switch to resume normal operation.

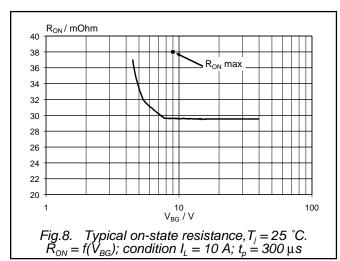
<sup>2</sup> Measured from when the input goes high.

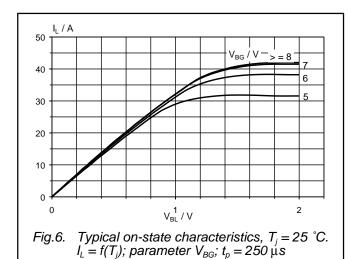
<sup>3</sup> Latched protection. After cooling below the threshold temperature the switch will resume normal operation only after the input has been toggled low.

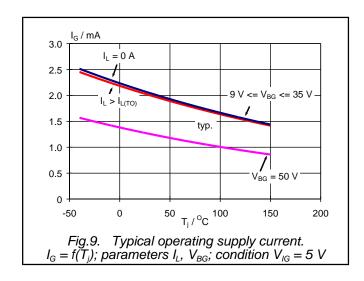


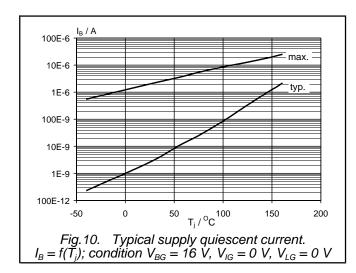


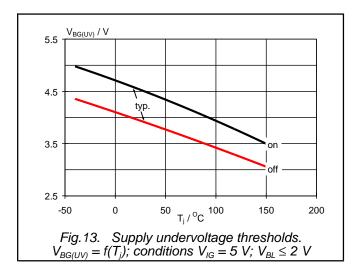


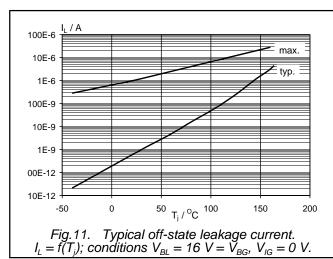


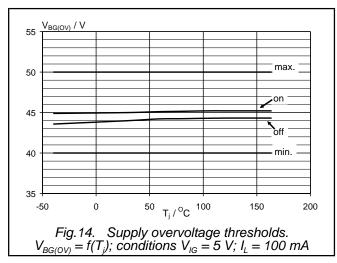


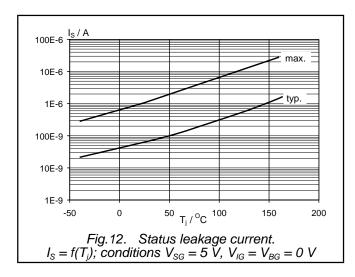


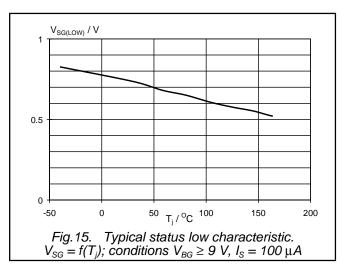


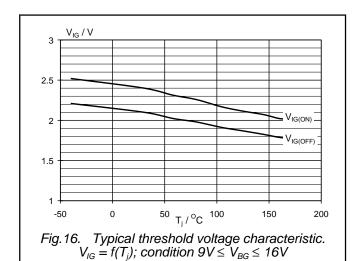


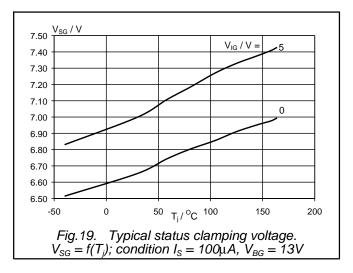


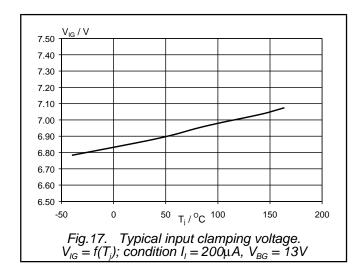


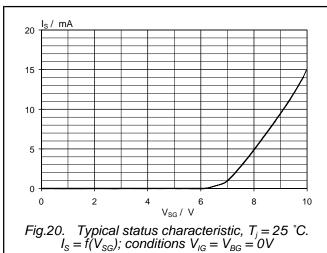


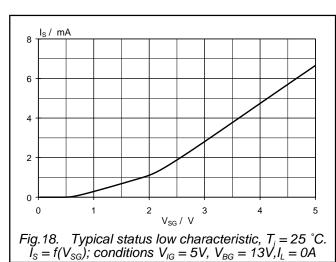












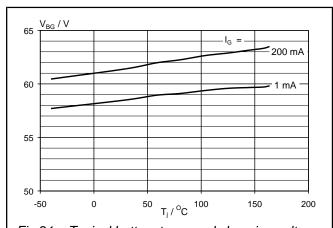


Fig.21. Typical battery to ground clamping voltage.  $V_{BG} = f(T_j)$ ; parameter  $I_G$ 

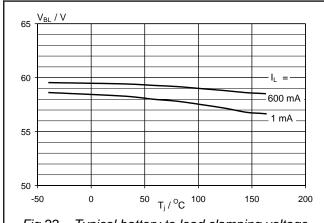
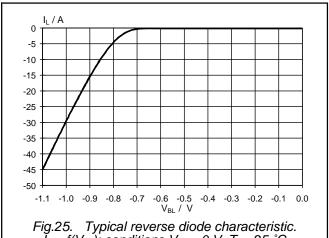


Fig.22. Typical battery to load clamping voltage.  $V_{BL} = f(T_j)$ ; parameter  $I_L$ ; condition  $I_G = 10 \text{mA}$ 



 $I_L = f(V_{BL})$ ; conditions  $V_{IG} = 0$  V,  $T_i = 25$  °C

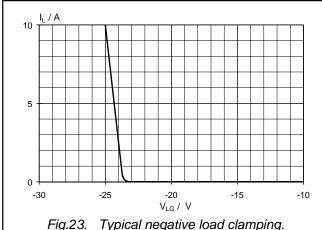


Fig.23. Typical negative load clamping.  $I_L = f(V_{LG})$ ; conditions  $V_{IG} = 0V$ ,  $T_j = 25$ °C

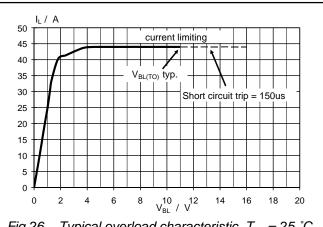


Fig.26. Typical overload characteristic,  $T_{mb} = 25$  °C.  $I_L = f(V_{BL})$ ; condition  $V_{BG} = 16$  V; parameter  $t_p$ 

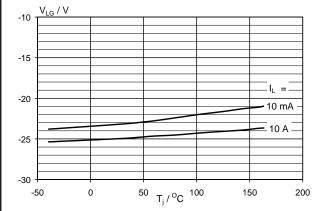
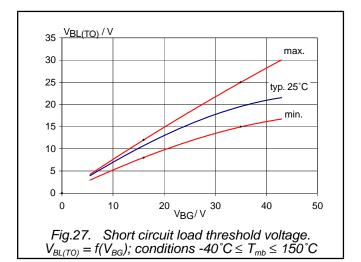


Fig.24. Typical negative load clamping voltage.  $V_{LG} = f(T_j)$ ; parameter  $I_L$ ; condition  $V_{IG} = 0$ V



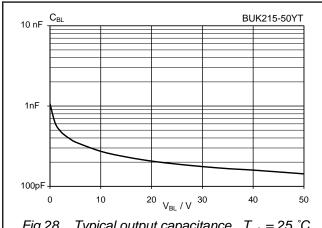


Fig.28. Typical output capacitance.  $T_{mb} = 25$  °C  $C_{bl} = f(V_{BL})$ ; conditions f = 1 MHz,  $V_{lG} = 0$  V

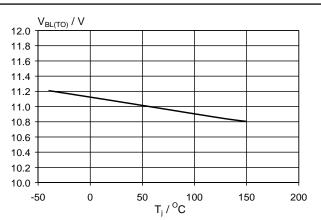


Fig.31. Typical short circuit load threshold voltage.  $V_{BL(TO)} = f(T_j)$ ; condition  $V_{BG} = 16 \text{ V}$ 

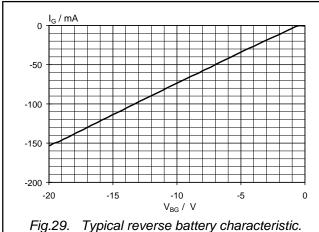
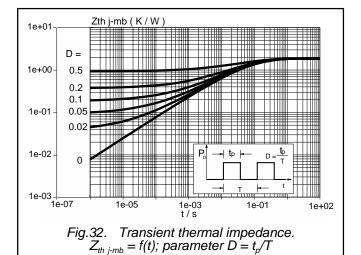
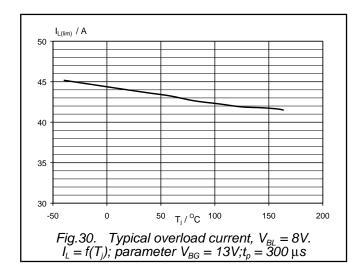


Fig.29. Typical reverse battery characteristic.  $I_{\rm G} = f(V_{\rm BG})$ ; conditions  $I_{\rm L} = 0$  A,  $T_{\rm j} = 25$  °C





## **MECHANICAL DATA**

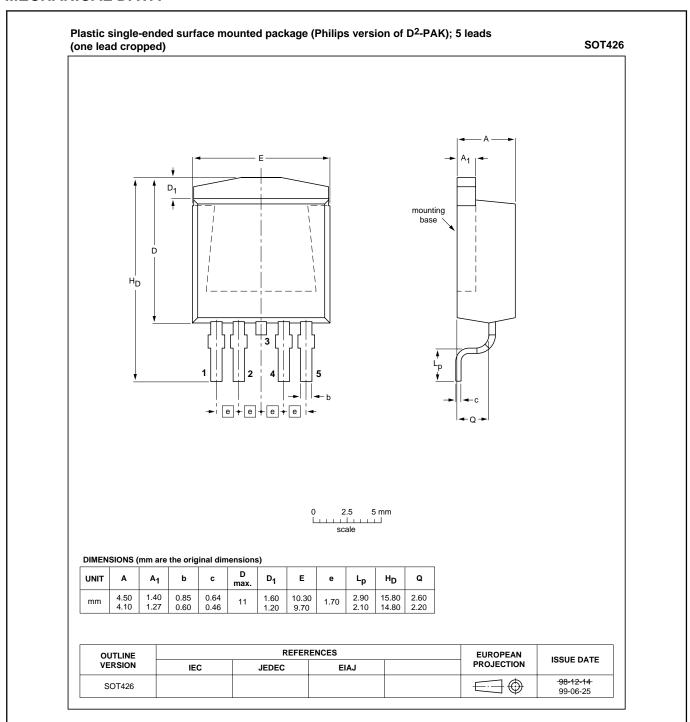


Fig.33. SOT426 surface mounting package<sup>1</sup>, centre pin connected to mounting base.

<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 ordere 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			
Limiting values					

### Limiting values

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.

### **Application information**

Where application information is given, it is advisory and does not form part of the specification.

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