

# Smart High-Side Power Switch for Industrial Applications Two Channels: $2 \times 90 \text{m}\Omega$

Status Feedback

#### **Product Summary**

Operating Voltage	$V_{bb}$	5.540V		
	Active channels	one	two parallel	
On-state Resistance	R <sub>oN</sub>	$90 m\Omega$	$45 \text{m}\Omega$	
Nominal load current	I <sub>L(NOM)</sub>	3.7A	7.4A	
Current limitation	I <sub>L(SCr)</sub>	12A	12A	
Operating Temperatur	e T <sub>a</sub>	-30	+85°C	

# RoHS

#### **Package**



Green Product (RoHS compliant)

#### **General Description**

- N channel vertical power MOSFET with charge pump, ground referenced CMOS compatible input and diagnostic feedback, monolithically integrated in Smart SIPMOS<sup>®</sup> technology.
- Providing embedded protective functions

#### **Applications**

- µC compatible high-side power switch with diagnostic feedback for 12V and 24V grounded loads in industrial applications
- All types of resistive, inductive and capacitve loads
- Most suitable for loads with high inrush currents, so as lamps
- · Replaces electromechanical relays, fuses and discrete circuits

#### **Basic Functions**

- Very low standby current
- CMOS compatible input
- Improved electromagnetic compatibility (EMC)
- Fast demagnetization of inductive loads
- Stable behaviour at undervoltage
- Wide operating voltage range
- Logic ground independent from load ground

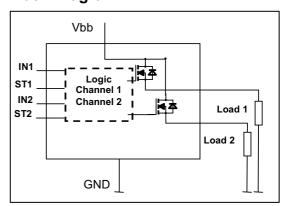
#### **Protection Functions**

- Short circuit protection
- Overload protection
- Current limitation
- Thermal shutdown
- Overvoltage protection (including load dump) with external resistor
- Reverse battery protection with external resistor
- Loss of ground and loss of V<sub>bb</sub> protection
- Electrostatic discharge protection (ESD)

#### **Diagnostic Function**

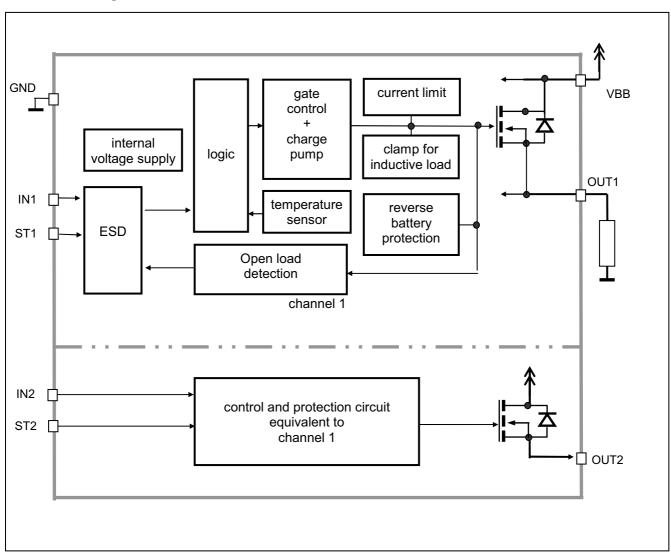
- · Diagnostic feedback with open drain output
- Open load detection in OFF-state
- Feedback of thermal shutdown in ON-state

#### **Block Diagram**





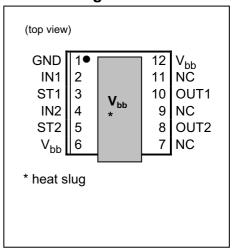
#### **Functional diagram**



#### **Pin Definitions and Functions**

Pin	Symbol	Function
1	GND	Ground of chip
2	IN1	Input 1,2 activates channel 1,2 in case of logic
4	IN2	high signal
3	ST1	Diagnostic feedback 1 & 2 of channel 1,2
5	ST2	open drain, low on failure
6,12, heat slug	V <sub>bb</sub>	Positive power supply voltage. Design the wiring for the simultaneous max. short circuit currents from channel 1 to 2 and also for low thermal resistance
7,9,11	NC	Not Connected
8	OUT2	Output 1,2 protected high-side power output
10	OUT1	of channel 1 and 2. Design the wiring for the max. short circuit current

#### Pin configuration





#### **Maximum Ratings** at $T_i = 25$ °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 5)	$V_{ m bb}$	43	V
Supply voltage for full short circuit protection $T_{j,\text{start}} = -40 \dots +150^{\circ}\text{C}$	V <sub>bb</sub>	36	V
Load current (Short-circuit current, see page 6)	<b>I</b> ∟	self-limited	Α
Load dump protection <sup>1)</sup> $V_{\text{LoadDump}} = V_{\text{A}} + V_{\text{S}}$ , $V_{\text{A}} = 13.5 \text{ V}$ $R_{\text{I}}^{2)} = 2 \Omega$ , $t_{\text{d}} = 400 \text{ ms}$ ; IN = low or high, each channel loaded with $R_{\text{L}} = 13.5 \Omega$ ,	V <sub>Load dump</sub> <sup>3)</sup>	60	V
Junction temperature	$\mid T_{j} \mid$	+150	°C
Operating temperature range	T <sub>a</sub>	-30+85	
Storage temperature range	$T_{ m stg}$	-40 +105	
Power dissipation (DC) <sup>4)</sup> $T_a = 25^{\circ}\text{C}$ :	P <sub>tot</sub>	3.1	W
(all channels active) $T_a = 85$ °C:		1.6	
Maximal switchable inductance, single pulse $V_{bb} = 12V$ , $T_{j,start} = 150^{\circ}C^{4}$ , see diagrams on page 9			
$I_L = 3.5 \text{ A}, E_{AS} = 178 \text{ mJ}, 0\Omega$ one channel:	$ z_{L} $	21.3	mH
$I_L = 7.0 \text{ A}$ , $E_{AS} = 337 \text{ mJ}$ , $0 \Omega$ two parallel channels:		10	
Electrostatic discharge capability (ESD) IN: (Human Body Model) ST: out to all other pins shorted: acc. MIL-STD883D, method 3015.7 and ESD assn. std. S5.1-1993 R=1.5kΩ; C=100pF	V <sub>ESD</sub>	1.0 4.0 8.0	kV
Input voltage (DC) see internal circuit diagram page 8	V <sub>IN</sub>	-10 +16	V
Current through input pin (DC)	I <sub>IN</sub>	±0.3	mA
Pulsed current through input pin <sup>5</sup> )	I <sub>INp</sub>	±5.0	
Current through status pin (DC)	I <sub>ST</sub>	±5.0	

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<sup>1)</sup> Supply voltages higher than  $V_{bb(AZ)}$  require an external current limit for the GND and status pins (a 150 $\Omega$  resistor for the GND connection is recommended.

 $<sup>^{2)}</sup>$   $R_{\rm I}$  = internal resistance of the load dump test pulse generator

<sup>3)</sup> V<sub>Load dump</sub> is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

<sup>4)</sup> Device on 50mm\*50mm\*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70μm thick) copper area for V<sub>bb</sub> connection. PCB is vertical without blown air. See page 13

<sup>5)</sup> only for testing



#### **Thermal Characteristics**

Parameter and Conditions		Symbol	Values			Unit
			min	typ	max	
Thermal resistance junction - Case <sup>6)</sup> junction – ambient <sup>6)</sup>	each channel:	R <sub>thjC</sub> R <sub>thja</sub>		1	5 	K/W
@ 6 cm <sup>2</sup> cooling area	one channel active: all channels active:	,		45 40		

#### **Electrical Characteristics**

Parameter and Conditions, each of the four channels	Symbol		Values	;	Unit
at T <sub>j</sub> = -40+150°C, $V_{bb}$ = 12 V unless otherwise specified		min	typ	max	
Load Switching Capabilities and Characteristics		.,			
On-state resistance ( $V_{bb}$ to OUT); $I_L = 2 A$					
each channel, $T_j = 25$ °C: $T_j = 150$ °C:	R <sub>ON</sub>		70 140	90 180	mΩ
two parallel channels, $T_j = 25$ °C: see diagram, page 10			35	45	
Nominal load current one channel active: two parallel channels active:	I <sub>L(NOM)</sub>	3.7 7.4	4.7 9.5		А
Device on PCB <sup>6</sup> ), $T_a = 85$ °C, $T_j \le 150$ °C					
Output current while GND disconnected or pulled up <sup>7</sup> ); Vbb = 32 V, V <sub>IN</sub> = 0, see diagram page 8	I <sub>L(GNDhigh)</sub>			2	mA
Turn-on time <sup>8)</sup> IN to 90% V <sub>OUT</sub> :	$t_{\sf on}$		100	250	μs
Turn-off time IN $\square$ to 10% $V_{OUT}$ :	$t_{ m off}$		100	270	
$R_{L} = 12 \Omega$					
Slew rate on 8) 10 to 30% $V_{OUT}$ , $R_L = 12 \Omega$ :	dV/dt <sub>on</sub>	0.2		1.0	V/μs
Slew rate off <sup>8</sup> ) 70 to 40% $V_{OUT}$ , $R_L = 12 \Omega$ :	-dV/dt <sub>off</sub>	0.2		1.1	V/μs

<sup>6)</sup> Device on 50mm\*50mm\*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70μm thick) copper area for V<sub>bb</sub> connection. PCB is vertical without blown air. See page 13

not subject to production test, specified by design



Parameter and Conditions, each of the four channels	Symbol	Values			Unit
at $T_j$ = -40+150°C, $V_{bb}$ = 12 V unless otherwise specified		min	typ	max	
Operating Parameters					
Operating voltage	$V_{ m bb(on)}$	5.5		40	V
Undervoltage switch off <sup>9</sup> ) $T_j = -40^{\circ}\text{C}25^{\circ}\text{C}$				4.5	V
<i>T</i> <sub>j</sub> =125°C				4.510)	
Overvoltage protection <sup>11)</sup>	$V_{\mathrm{bb}(AZ)}$	41	47	52	V
$I_{\rm bb} = 40 \text{ mA}$					
Standby current <sup>12</sup> ) $T_j = -40^{\circ}\text{C}25^{\circ}\text{C}$	: I <sub>bb(off)</sub>		4.5	10	μΑ
$V_{IN} = 0$ ; see diagram page 11 $T_j = 150$ °C				15	
<i>T</i> <sub>j</sub> =125°C	:			10 <sup>10)</sup>	
Off-State output current (included in $I_{bb(off)}$ ) $V_{IN} = 0$ ; each channel	I <sub>L(off)</sub>		1	5	μΑ
Operating current <sup>13)</sup> , $V_{IN} = 5V$ ,					
one channel on all channels on			0.6 1.2	1.2 2.4	mA
Protection Functions <sup>14)</sup>					
Current limit, V <sub>out</sub> = 0V, (see timing diagrams, page 11)					
	: / <sub>L(lim)</sub>			23	Α
Τ <sub>j</sub> =-40°C Τ <sub>j</sub> =25°C Τ <sub>j</sub> =+150°C			15		
/j =+150 C		9			
Repetitive short circuit current limit,					
$T_{\rm j}$ = $T_{\rm jt}$ each channel two channels			12 12		Α
(see timing diagrams, page 11)					
Initial short circuit shutdown time $T_{j,start} = 25^{\circ}C$	$t_{\rm off(SC)}$		2		ms
V <sub>out</sub> = 0V (see timing diagrams on page 11	)				
Output clamp (inductive load switch off) <sup>15)</sup> at VON(CL) = Vbb - VOUT, IL= 40 mA	V <sub>ON(CL)</sub>	41	47	52	V
Thermal overload trip temperature	$T_{\rm jt}$	150			°C
Thermal hysteresis	$\Delta T_{\rm jt}$		10		K

<sup>&</sup>lt;sup>9)</sup> is the voltage, where the device doesn't change it's switching condition for 15ms after the supply voltage falling below the lower limit of Vbb(on)

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<sup>10)</sup> not subject to production test, specified by design

Supply voltages higher than V<sub>bb(AZ)</sub> require an external current limit for the GND and status pins (a 150Ω resistor for the GND connection is recommended). See also V<sub>ON(CL)</sub> in table of protection functions and circuit diagram on page 8.

<sup>12)</sup> Measured with load; for the whole device; all channels off

<sup>13)</sup> Add  $I_{ST}$ , if  $I_{ST} > 0$ 

<sup>&</sup>lt;sup>14)</sup> Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal operating range. Protection functions are not designed for continuous repetitive operation.

<sup>15)</sup> If channels are connected in parallel, output clamp is usually accomplished by the channel with the lowest VON(CL)



Parameter and Conditions, each of the four channels	Symbol	Values			Unit
at T <sub>j</sub> = -40+150°C, $V_{bb}$ = 12 V unless otherwise specified		min	typ	max	
Reverse Battery					
Reverse battery voltage <sup>16</sup> )	-V <sub>bb</sub>			32	V
Drain-source diode voltage ( $V_{out} > V_{bb}$ ) $I_L = -2.0 \text{ A}, T_j = +150^{\circ}\text{C}$	-V <sub>ON</sub>		600		mV
Diagnostic Characteristics					
Open load detection voltage	V <sub>OUT(OL)</sub>	1.7	2.8	4.0	V
Input and Status Feedback <sup>17)</sup>					
Input resistance (see circuit page 8)	$R_{l}$	2.5	4.0	6.0	kΩ
Input turn-on threshold voltage	$V_{IN(T+)}$			2.5	V
Input turn-off threshold voltage	$V_{IN(T-)}$	1.0			V
Input threshold hysteresis	$\Delta V_{\text{IN(T)}}$		0.2		V
Status change after positive input slope <sup>18)</sup> with open load	$t_{\sf d(STon)}$		10	20	μS
Status change after positive input slope <sup>18)</sup> with overload	$t_{\sf d(STon)}$	30			μS
Status change after negative input slope with open load	$t_{d(SToff)}$			500	μS
Status change after negative input slope <sup>18)</sup> with overtemperature	$t_{\sf d(SToff)}$			20	μS
Off state input current $V_{IN} = 0.4 \text{ V}$ :	I <sub>IN(off)</sub>	5		20	μΑ
On state input current $V_{IN} = 5 \text{ V}$ :	I <sub>IN(on)</sub>	10	35	60	μΑ
Status output (open drain)					
Zener limit voltage $I_{ST} = +1.6 \text{ mA}$ :	V <sub>ST(high)</sub>	5.4			V
ST low voltage $I_{ST} = +1.6 \text{ mA}$ :	$V_{\rm ST(low)}$			0.6	

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Requires a 150 Ω resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection is not active during reverse current operation! Input and Status currents have to be limited (see max. ratings page 3 and circuit page 8).

 $<sup>^{\</sup>rm 17)}$  If ground resistors  $\rm R_{\rm GND}$  are used, add the voltage drop across these resistors.

<sup>18)</sup> not subject to production test, specified by design



#### **Truth Table**

(each channel)

	IN	OUT	ST
Normal operation	L	L	Н
	Н	Н	Н
Open load	L	Z	լ19)
	Н	Н	Н
Overtemperature	L	L	Н
	Н	L	L

L = "Low" Level

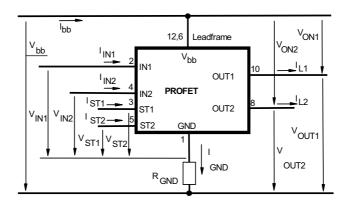
X = don't care

Z = high impedance, potential depends on external circuit

H = "High" Level Status signal valid after the time delay shown in the timing diagrams

Parallel switching of channel 1 and 2 is easily possible by connecting the inputs and outputs in parallel (see truth table). If switching channel 1 to 2 in parallel, the status outputs ST1 and ST2 have to be configured as a 'Wired OR' function with a single pull-up resistor.

#### **Terms**



Leadframe (V<sub>bb</sub>) is connected to pin 6,12

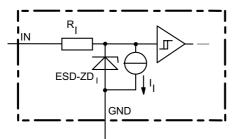
External R<sub>GND</sub> optional; single resistor R<sub>GND</sub> = 150  $\Omega$  for reverse battery protection up to the max. operating voltage.

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<sup>&</sup>lt;sup>19)</sup> L, if potential at the Output exceeds the OpenLoad detection voltage

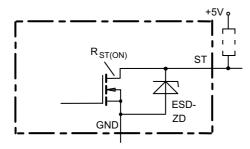


#### Input circuit (ESD protection), IN1 or IN2



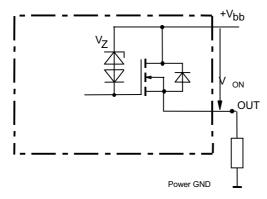
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended.

#### Status output, ST1 or ST2



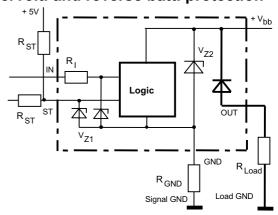
ESD-Zener diode: 6.1 V typ., max 0.3 mA;  $R_{ST(ON)}$  < 375  $\Omega$  at 1.6 mA. The use of ESD zener diodes as voltage clamp at DC conditions is not recommended.

# **Inductive and overvoltage output clamp,** OUT1 or OUT2



VON clamped to VON(CL) = 47 V typ.

#### Overvolt. and reverse batt. protection



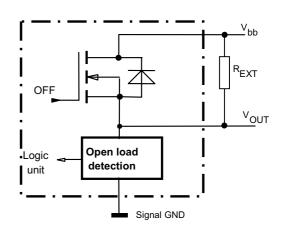
 $V_{Z1}$  = 6.1 V typ.,  $V_{Z2}$  = 47 V typ.,  $R_{GND}$  = 150 Ω,  $R_{ST}$ = 15 kΩ,  $R_{I}$ = 3.5 kΩ typ.

In case of reverse battery the load current has to be limited by the load. Temperature protection is not active

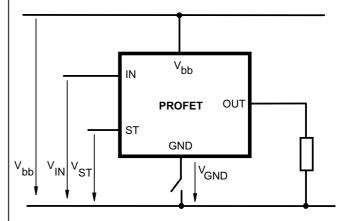
#### Open-load detection, OUT1 or OUT2

OFF-state diagnostic condition:

Open Load, if  $V_{OUT} > 3 \text{ V typ.}$ ; IN low



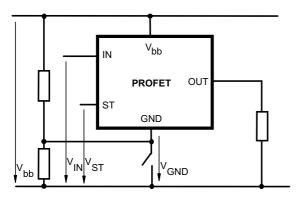
#### **GND** disconnect



Any kind of load. In case of IN = high is  $V_{OUT} \approx V_{IN} - V_{IN}(T+)$ . Due to  $V_{GND} > 0$ , no  $V_{ST} = low$  signal available.

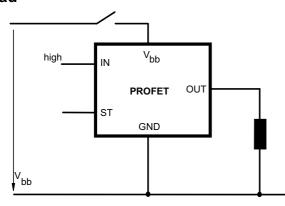


#### GND disconnect with GND pull up



Any kind of load. If  $V_{GND} > V_{IN} - V_{IN(T+)}$  device stays off Due to  $V_{GND} > 0$ , no  $V_{ST} = low$  signal available.

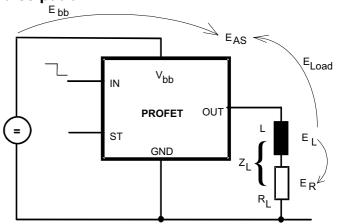
# V<sub>bb</sub> disconnect with energized inductive load



For inductive load currents up to the limits defined by  $Z_L$  (max. ratings and diagram on page 9) each switch is protected against loss of  $V_{\mbox{bb}}$ .

Consider at your PCB layout that in the case of Vbb disconnection with energized inductive load all the load current flows through the GND connection.

# Inductive load switch-off energy dissipation



Energy stored in load inductance:

$$E_L = \frac{1}{2} \cdot L \cdot I_1^2$$

While demagnetizing load inductance, the energy dissipated in PROFET is

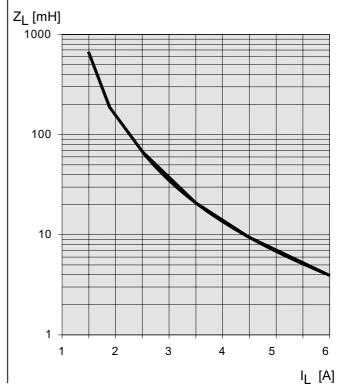
$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} \cdot i_L(t) dt$$

with an approximate solution for  $R_L > 0 \Omega$ :

$$E_{AS} = \frac{I_L \cdot L}{2 \cdot R_L} \left( V_{bb} + |V_{OUT(CL)}| \right) ln \left( 1 + \frac{I_L \cdot R_L}{|V_{OUT(CL)}|} \right)$$

# Maximum allowable load inductance for a single switch off (one channel)<sup>4)</sup>

$$L = f(I_L)$$
; T<sub>j,start</sub> = 150°C, V<sub>bb</sub> = 12 V, R<sub>L</sub> = 0  $\Omega$ 

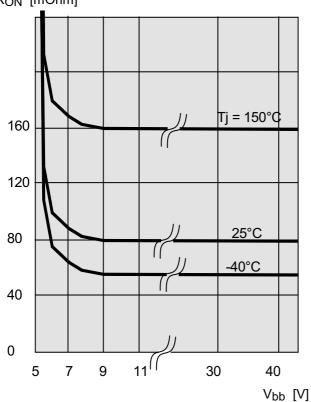




#### Typ. on-state resistance

 $R_{ON} = f(V_{bb}, T_j); I_L = 2 A, IN = high$ 

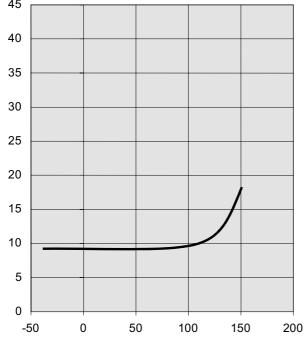




#### Typ. standby current

 $I_{bb(off)} = f(T_j); V_{bb} = 9...34 \text{ V, IN1,2} = \text{low}$ 

# I<sub>bb(off)</sub> [μΑ]





#### **Timing diagrams**

Both channels are symmetric and consequently the diagrams are valid for channel 1 and channel 2

Figure 1a: V<sub>bb</sub> turn on:

IN1

IN2

V bb

V OUT1

ST1 open drain

ST2 open drain

t

**Figure 2a:** Switching a resistive load, turn-on/off time and slew rate definition:

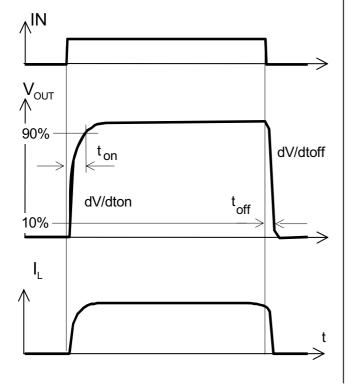
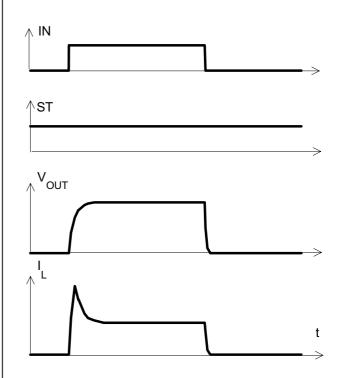
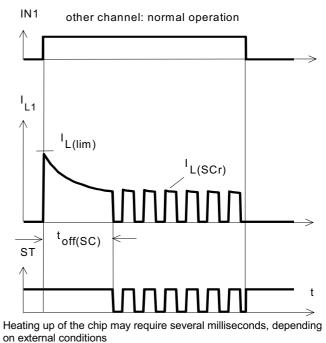


Figure 2b: Switching a lamp:



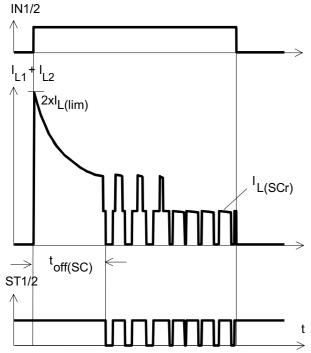
**Figure 3a:** Turn on into short circuit: shut down by overtemperature, restart by cooling



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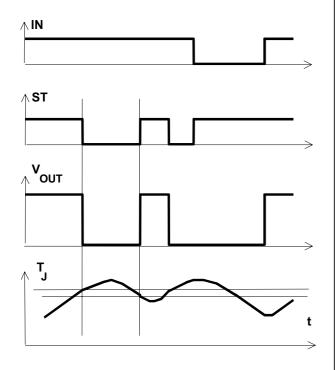


**Figure 3b:** Turn on into short circuit: shut down by overtemperature, restart by cooling (two parallel switched channels 1 and 2)



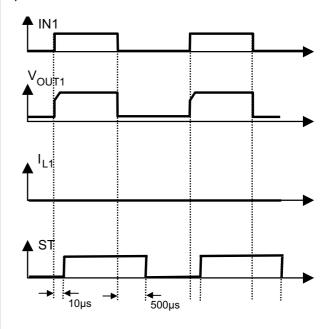
ST1 and ST2 have to be configured as a 'Wired OR' function ST1/2 with a single pull-up resistor.

**Figure 4a:** Overtemperature: Reset if  $T_i < T_{it}$ 



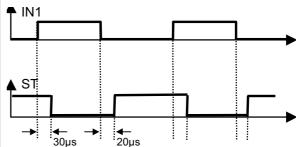
**Figure 5a:** Open load: detection in OFF-state, turn on/off to open load

Open load of channel 1; other channels normal operation



**Figure 6a:** Status change after, turn on/off to overtemperature

Overtemperature of channel 1; other channels normal operation





**Package Outlines** 

#### 1 Package Outlines

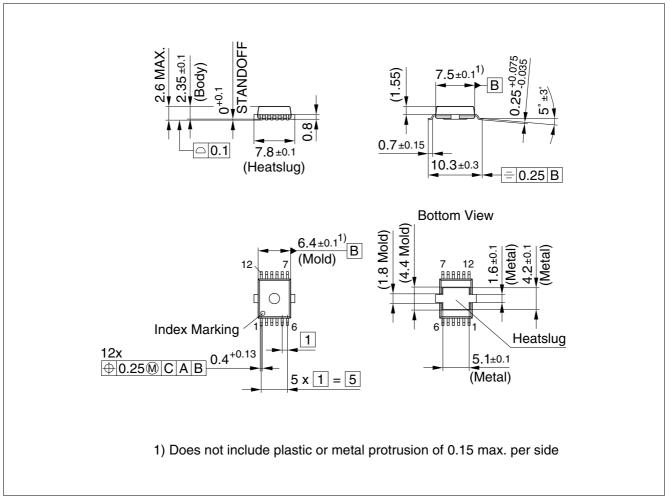


Figure 1 PG-DSO-12-9

#### **Green Product (RoHS compliant)**

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).



**Revision History** 

### 2 Revision History

Revision	Date	Changes
1.1 2008-10-07	2008-10-07	RoHS-compliant DSO package version of the ITS724G
		All pages: Infineon logo updated
		Page 1: Added "RoHS" logo, added "Green Product (RoHS compliant)" statement
		to feature list, package names changed to RoHS compliant versions.
		Page 14: Package names changed to RoHS compliant versions, added "Green
		Product" description
		page 15: added Revision History
		page 16: added Legal Disclaimer

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Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

#### Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



**«JONHON»** (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«**FORSTAR**» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: ocean@oceanchips.ru

Web: http://oceanchips.ru/

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А