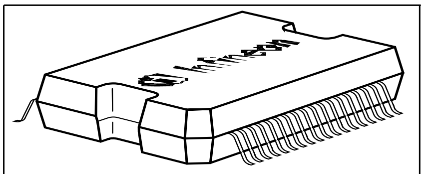
Smart Power High-Side-Switch
Eight Channels: 8 x 200 mΩ

Features

- Output current 0,625 A per channel
- Short circuit protection
- Maximum current internally limited
- Overload protection
- Input protection
- Overvoltage protection (including load dump)
- Undervoltage shutdown with auto-restart and hysteresis
- Switching inductive loads
- Thermal shutdown with restart
- Thermal independence of separate channels
- ESD - Protection
- Loss of GND and loss of V_{bb} protection
- Very low standby current
- Reverse battery protection
- Programmable input for CMOS or $V_{bb}/2$
- Common diagnostic output for overtemperature

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	47	V
Operating voltage	$V_{bb(on)}$	tbd...45	V
On-state resistance	R_{ON}	200	mΩ



P-DSO-36-12; -10

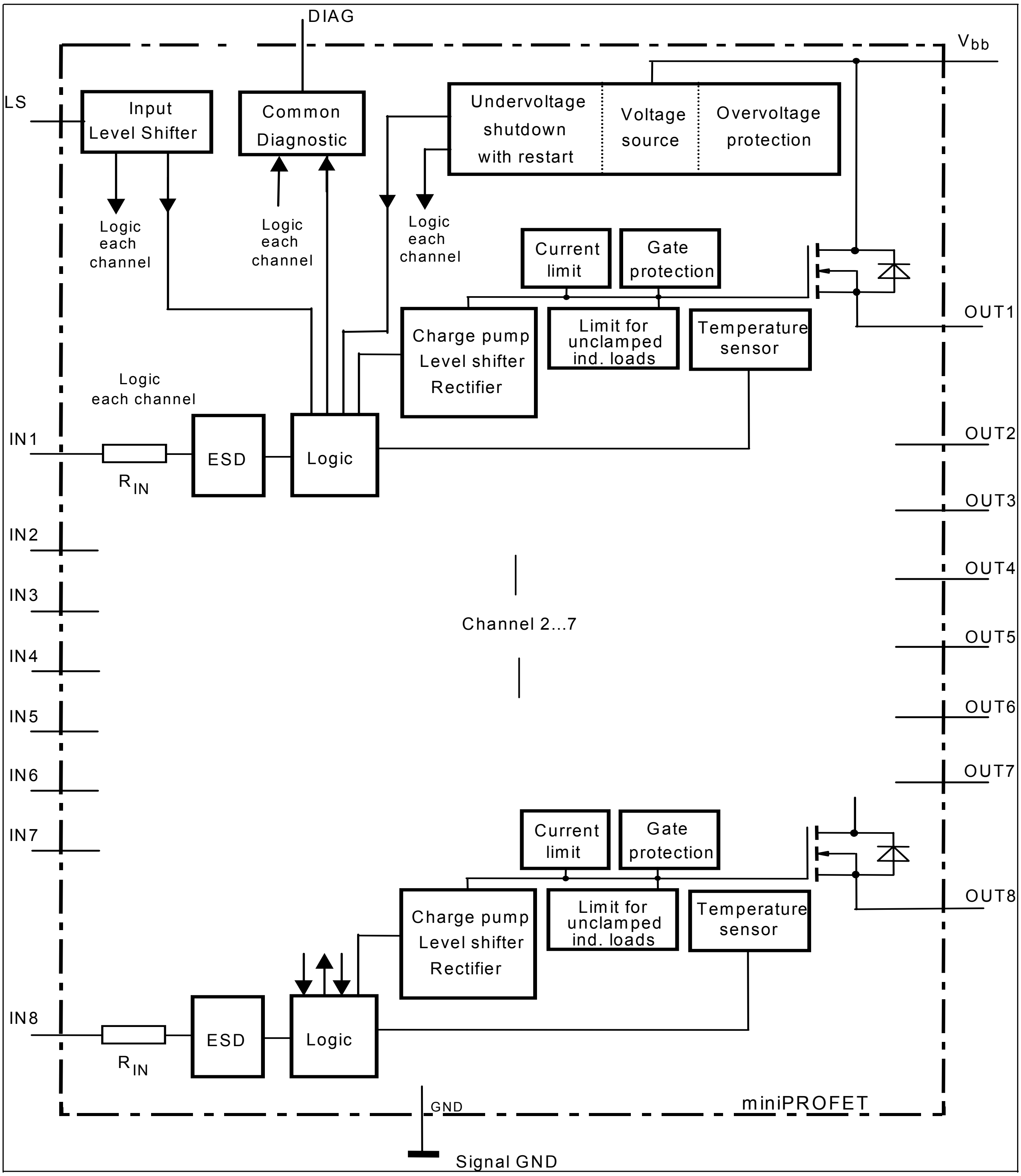
Application

- All types of resistive, inductive and capacitive loads
- µC compatible power switch for 12 V and 24 V DC applications
- Replaces electromechanical relays and discrete circuits

General Description

N channel vertical power FET with charge pump, ground referenced CMOS or $V_{bb}/2$ compatible input and common diagnostic feedback, monolithically integrated in Smart SIPMOS® technology. Fully protected by embedded protection functions.

Block Diagram



Pin	Symbol	Function
1,2,4,5	NC	not connected
3	LS	Enable pin for switching the input-levels to $V_{bb}/2$
6	IN1	Input, activates channel 1 in case of logic high signal
7	IN2	Input, activates channel 2 in case of logic high signal
8	IN3	Input, activates channel 3 in case of logic high signal
9	IN4	Input, activates channel 4 in case of logic high signal
10	IN5	Input, activates channel 5 in case of logic high signal
11	IN6	Input, activates channel 6 in case of logic high signal
12	IN7	Input, activates channel 7 in case of logic high signal
13	IN8	Input, activates channel 8 in case of logic high signal
14-18	NC	not connected
19	GND	Logic ground
20	DIAG	Common diagnostic output for overtemperature
21	OUT8	High-side output of channel 8
22	OUT8	High-side output of channel 8
23	OUT7	High-side output of channel 7
24	OUT7	High-side output of channel 7
25	OUT6	High-side output of channel 6
26	OUT6	High-side output of channel 6
27	OUT5	High-side output of channel 5
28	OUT5	High-side output of channel 5
29	OUT4	High-side output of channel 4
30	OUT4	High-side output of channel 4
31	OUT3	High-side output of channel 3
32	OUT3	High-side output of channel 3
33	OUT2	High-side output of channel 2
34	OUT2	High-side output of channel 2
35	OUT1	High-side output of channel 1
36	OUT1	High-side output of channel 1
TAB	Vbb	Positive power supply voltage

Maximum Ratings

Parameter at T_j = 25 °C, unless otherwise specified	Symbol	Value	Unit
Supply voltage	V_{bb}	-1[1]...45	V
Supply voltage for full short circuit protection	$V_{bb(SC)}$	tbd	
Continuous input voltage[2]	V_{IN}	-10...V_{bb}	
Continuous voltage at LS-pin	V_{LS}	-1...V_{bb}	
Load current (Short - circuit current, see page 6)	I_L	self limited	A
Current through input pin (DC), each channel	I_{IN}	±5	mA
Reverse current through GND-pin[1]	$-I_{GND}$	1.6	A
Operating temperature	T_j	internal limited	°C
Storage temperature	T_{stg}	-55 ... +150	
Power dissipation [3]	P_{tot}	3.3	W
Inductive load switch-off energy dissipation[3][4] single pulse, T_j = 125 °C, I_L = 0.625 A each channel all channels simultaneously active	E_{AS}	 10 1	J
Load dump protection[4] $V_{LoadDump}$[5]= V_A + V_S V_{IN}= low or high t_d = 400 ms, R_I = 2 Ω, R_L = 27 Ω, V_A = 13.5 V t_d = 350 ms, R_I = 2 Ω, R_L = 47 Ω, V_A = 27 V	$V_{Loaddump}$	 90 117	V
Electro**s**tatic **d**ischarge voltage (Human Body Model) according to ANSI EOS/ESD - S5.1 - 1993 ESD STM5.1 - 1998 Input pin, LS pin, Common diagnostic pin all other pins	V_{ESD}	 ±1 ±5	kV

[1]defined by P_{tot}

[2]At V_{IN} > Vbb, the input current is not allowed to exceed ±5 mA.

[3] Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm2 (one layer, 70µm thick) copper area for drain connection. PCB is vertical without blown air.

[4]not tested, specified by design

[5]$V_{Loaddump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839 .

Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND pin, e.g. with a 150Ω resistor in GND connection. A resistor for the protection of the input is integrated.

Electrical Characteristics

Parameter at T_j = -40...150°C, V_{bb}=9...40V, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Thermal Characteristics					
Thermal resistance junction - case	R_{thJC}	-	-	1.5	K/W
Thermal resistance @ min. footprint	$R_{th(JA)}$	-	-	50	
Thermal resistance @ 6 cm^2 cooling area [1)]	$R_{th(JA)}$	-	-	38	

Load Switching Capabilities and Characteristics

On-state resistance T_j = 25 °C, I_L = 0.5 A T_j = 150 °C	R_{ON}	 - -	 150 tbd	 200 400	mΩ
Turn-on time to 90% V_{OUT} V_{IN} = 0 to 10 V	t_{on}	-	50	tbd	µs
Turn-off time to 10% V_{OUT} V_{IN} = 10 to 0 V	t_{off}	-	75	tbd	
Slew rate on 10 to 30% V_{OUT},	dV/dt_{on}	-	1	tbd	V/µs
Slew rate off 70 to 40% V_{OUT},	$-dV/dt_{off}$	-	1	tbd	

1 Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm2 (one layer, 70µm thick) copper area for drain connection. PCB is vertical without blown air.

Electrical Characteristics

Parameter at T_j = -40...150°C, V_{bb}=9...40V, unless otherwise specified	**Symbol**	**Values** min.	typ.	max.	**Unit**
Operating Parameters					
Operating voltage	$V_{bb(on)}$	tbd	-	45	V
Undervoltage shutdown	$V_{bb(under)}$	7	-	tbd	
Undervoltage restart of charge pump	$V_{bb(u\,cp)}$	-	-	tbd	
Standby current	$I_{bb(off)}$	-	50	tbd	µA
Operating current[1)]	I_{GND}	-	5	tbd	mA
Leakage output current (included in $I_{bb(off)}$) V_{IN} = low , each channel	$I_{L(off)}$	-	-	10	µA

Protection Functions

Initial peak short circuit current limit	$I_{L(SCp)}$				A
T_j = -40 °C		-	-	tbd	
T_j = 25 °C		-	1.4	-	
T_j = 150 °C		tbd	-	-	
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams)	$I_{L(SCr)}$	-	1.1	-	
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$,	$V_{ON(CL)}$	47	53	60	V
Overvoltage protection [2)]	$V_{bb(AZ)}$	47	-	-	
Thermal overload trip temperature[3)]	T_{jt}	150	-	-	°C
Thermal hysteresis	ΔT_{jt}	-	10	-	K

[1]contains all input currents

[2] see also $V_{ON(CL)}$ in circuit diagram on page 10

[3] higher operating temperature at normal function for each channel available

Electrical Characteristics

Parameter at T_j = -40...150°C, V_{bb}=9...40V, unless otherwise specified	**Symbol**	**Values**			**Unit**
		min.	**typ.**	**max.**	
Input					
Continuous input voltage[1)]	V_{IN}	-10	-	V_{bb}	V
Input turn-on threshold voltage CMOS[2)]	$V_{IN(T+)}$	-	-	2.2	
Input turn-off threshold voltage CMOS[2)]	$V_{IN(T-)}$	0.8	-	-	
Input turn-on threshold voltage $V_{bb}/2$ [2)]	$V_{IN(T+)}$	-	-	$V_{bb}/2+1$	
Input turn-off threshold voltage $V_{bb}/2$[2)]	$V_{IN(T-)}$	$V_{bb}/2-1$	-	-	
Input threshold hysteresis	$\Delta V_{IN(T)}$	-	0.3	-	
Off state input current CMOS (each channel)	$I_{IN(off)}$	8	-	-	µA
On state input current CMOS (each channel)	$I_{IN(on)}$	-	-	70	
Off state input current $V_{bb}/2$ (each channel)	$I_{IN(off)}$	80	-	-	
On state input current $V_{bb}/2$ (each channel)	$I_{IN(on)}$	-	-	260	
Input delay time at switch on V_{bb}	$t_{d(Vbbon)}$	tbd	340	-	µs
Input resistance (see page 10)	R_I	2	3	4	kΩ
Internal pull down resistor at LS-pin[3)]	R_{LS}	tbd	800	-	

Diagnostic Characteristics

Common diagnostic output current (overtemperature of any channel) T_j = 150 °C	I_{diag}	2	3	tbd	mA
Common diagnostic output leakage current	$I_{diag(high)}$	-	-	2	µA

[1]At V_{IN} > Vbb, the input current is not allowed to exceed ±5 mA.

[2]see page 9

[3]LS-pin is connected to V_{bb}

Electrical Characteristics

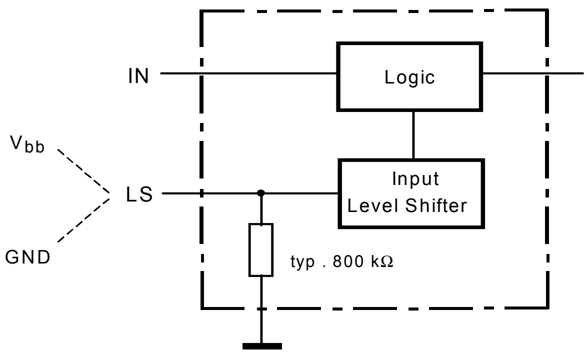
Parameter at T_j = -40...150°C, V_{bb}=9...40V, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Reverse Battery					
Reverse battery voltage[1)] R_{GND} = 0 Ω R_{GND} = 150 Ω	$-V_{bb}$	 - -	 - -	 1 45	V
Diode forward on voltage I_F = 1.25 A, V_{IN} = low , each channel	$-V_{ON}$	-	-	1.2	

[1]defined by P_{tot}

Truth table for common diagnostic pin:

	Input level	Output level	Diagnostic
Normal operation	L H	L H	L L
Short circuit to GND	L H	L L	L L
Undervoltage	L H	L L	L L
Overtemperature	L H	L L	L H[1)]

Programmable input:



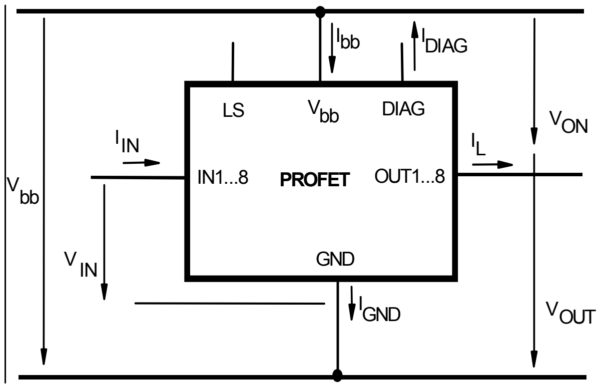
Functional description LS-Pin:

With using the LS-pin it is possible to change the input turn-on and -off threshold voltage between CMOS and half supply voltage level.
Therefore you have either to connect the LS-pin to GND (state 1) or to supply voltage (state 2).
If the LS-pin is not connected the input threshold voltages are automatically at CMOS level, caused by an internal pull down to GND with typ. 800kΩ (see circuit).

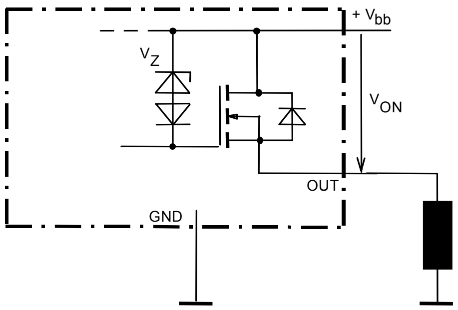
State 1: LS-Pin to GND CMOS - Input level
State 2: LS-Pin to supply voltage V_{bb}/2 - Input level

[1]toggeling with restart

Terms
each channel

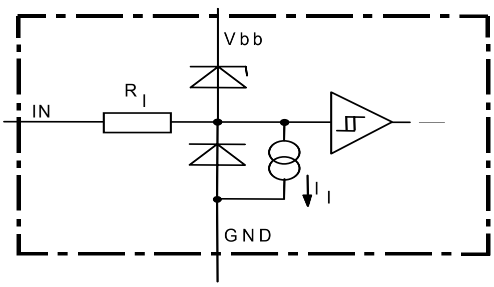


Inductive and overvoltage output clamp
each channel



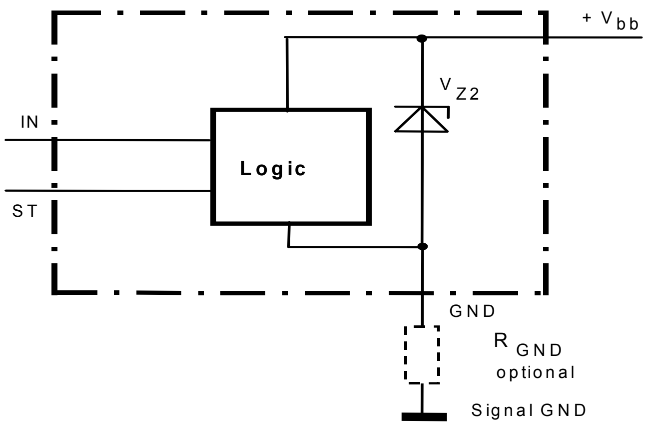
V_{ON} clamped to 47 V min.

Input circuit (ESD protection)
each channel



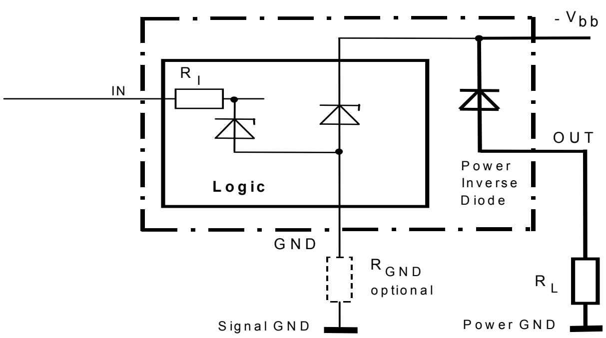
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



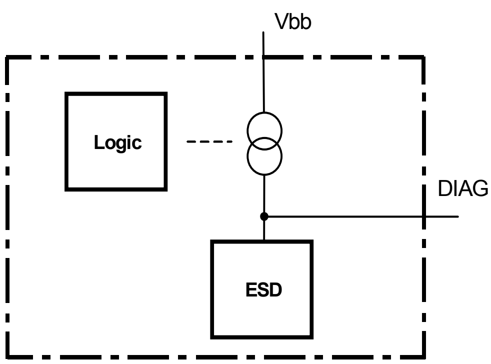
V_{Z2}=$V_{bb(AZ)}$=47 V min.,
R_I=3 kΩ typ., R_{GND}=150Ω

Reverse battery protection
each channel

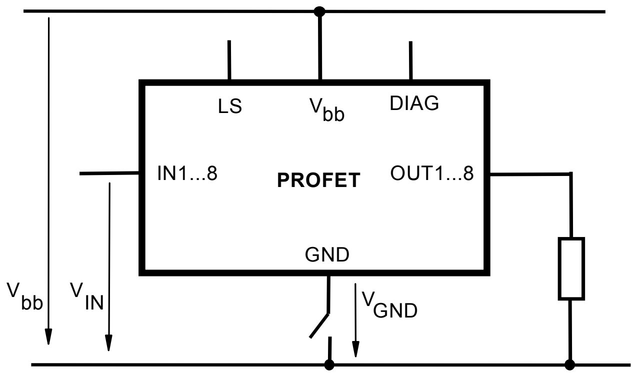


R_{GND}=150Ω, R_I=3kΩ typ.,
Temperature protection is not active during inverse current

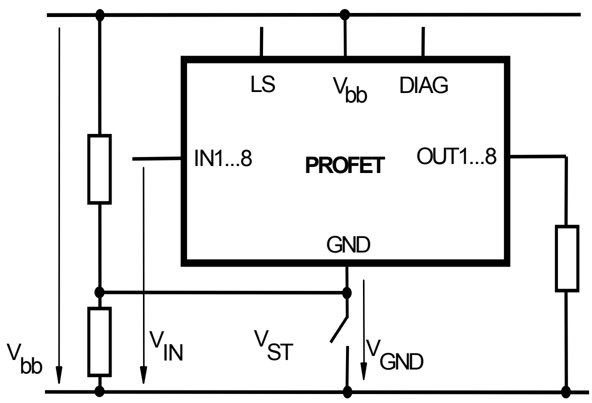
Common diagnostic output



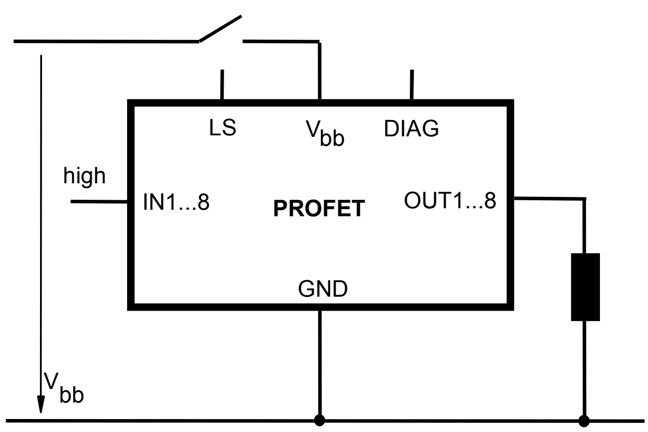
GND disconnect



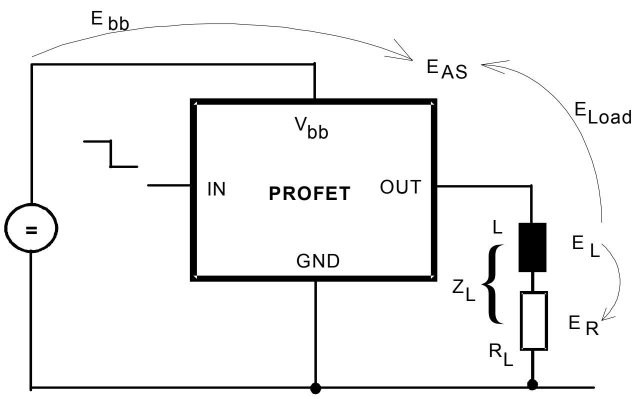
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation, each channel



Energy stored in load inductance: $E_L = ½ * L * I_L^2$
While demagnetizing load inductance,
the enérgy dissipated in PROFET is
$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t)\, dt$,
with an approximate solution for $R_L > 0\Omega$:

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

Timing diagrams

Figure 1a: Vbb turn on:

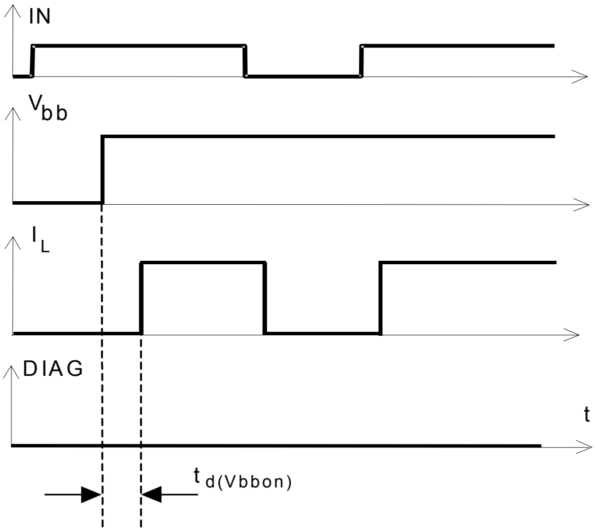


Figure 2b: Switching a lamp

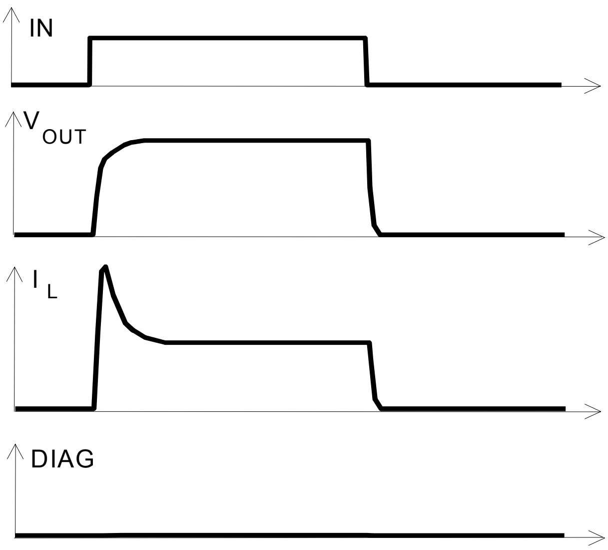


Figure 2a: Switching a resistive load, turn-on/off time and slew rate definition

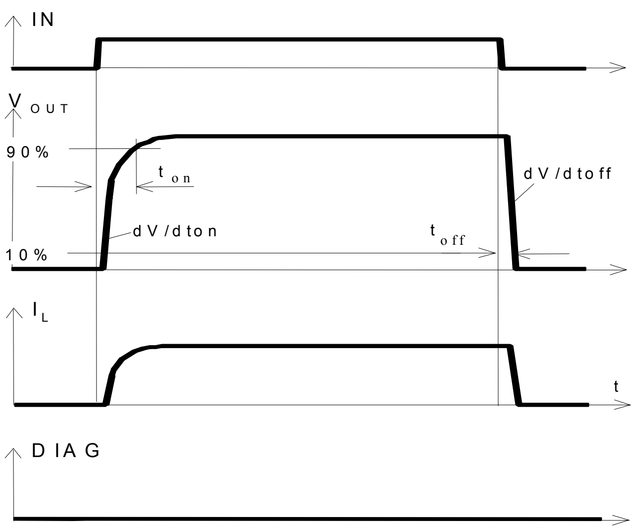


Figure 2c: Switching an inductive load

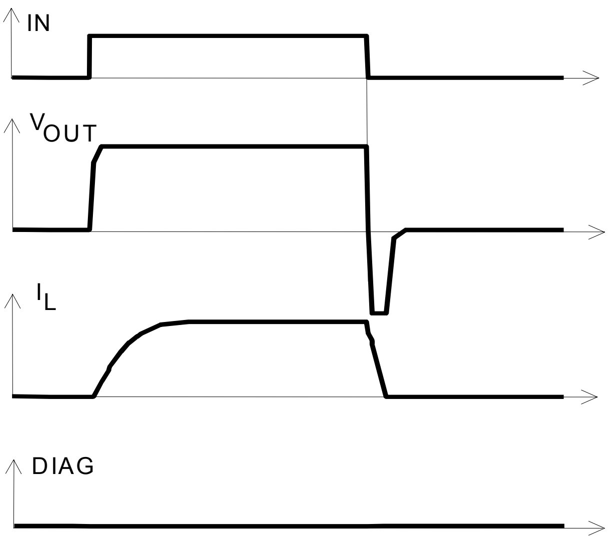
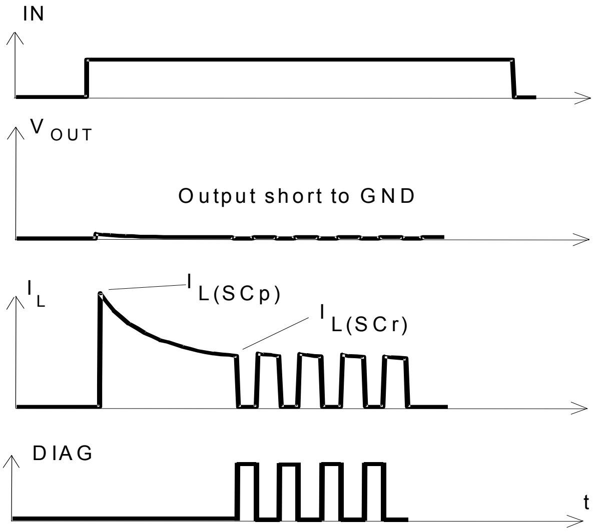


Figure 3a: Turn on into short circuit, shut down by overtemperature, restart by cooling



Heating up of the chip may require several milliseconds, depending on external conditions.

Figure 3b: Short circuit in on-state shut down by overtemperature, restart by cooling

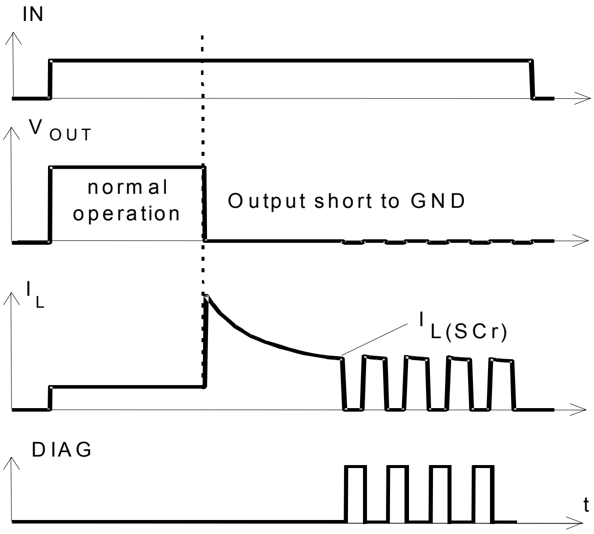


Figure 4: Overtemperature: Reset if $T_j < T_{jt}$

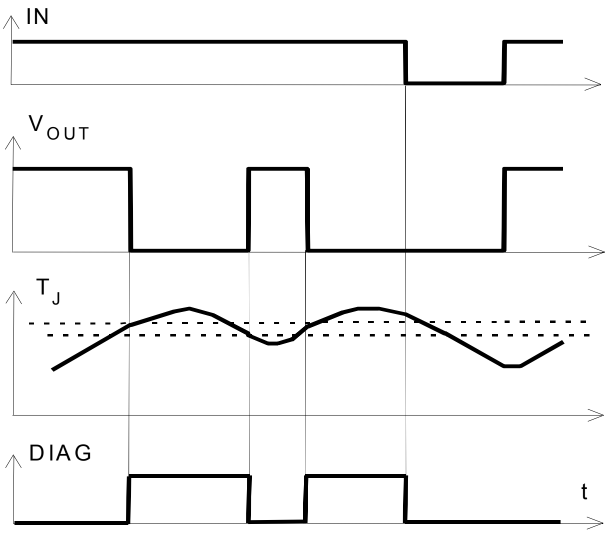
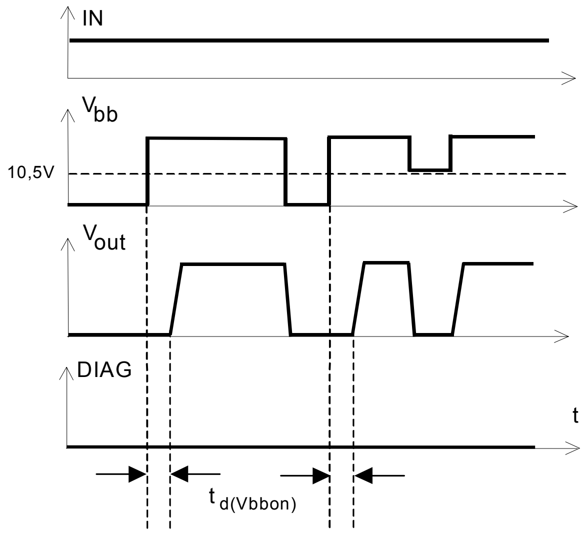


Figure 5: Undervoltage shutdown and restart

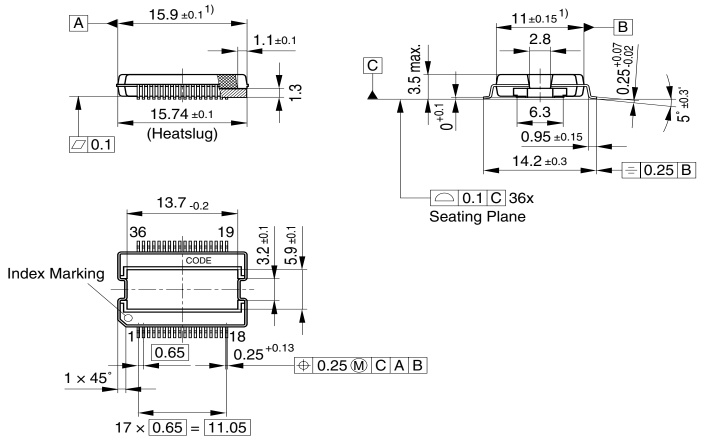


Package and ordering code

all dimensions in mm

Ordering code:

BTS 4881 R	-



1) Does not include plastic or metal protrusion of 0.15 max. per side

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