Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

Smart High-Side Power Switch

Smart High-Side Power Switch

PROFET BTS712N1

Data Sheet

Rev 1.3, 2010-03-16

Automotive Power

Smart Four Channel Highside Power Switch

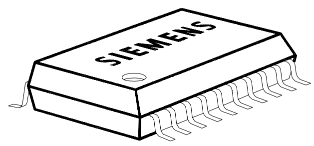
Product Summary

Overvoltage Protection	$V_{bb(AZ)}$			43	V
Operating voltage	$V_{bb(on)}$			5.0 ... 34	V
active channels:	one	two parallel	four parallel		
On-state resistance R_{ON}	200	100	50		mΩ
Nominal load current $I_{L(NOM)}$	1.9	2.8	4.4		A
Current limitation $I_{L(SCr)}$	4	4	4		A

Features

- Overload protection
- Current limitation
- Short-circuit protection
- Thermal shutdown
- Overvoltage protection (including load dump)
- Fast demagnetization of inductive loads
- Reverse battery protection[1)]
- Undervoltage and overvoltage shutdown with auto-restart and hysteresis
- Open drain diagnostic output
- Open load detection in OFF-state
- CMOS compatible input
- Loss of ground and loss of V_{bb} protection
- **E**lectro**st**atic **d**ischarge (**ESD**) protection

PG-DSO20



Application

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

General Description

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

Pin Definitions and Functions

Pin	Symbol	Function
1,10, 11,12, 15,16, 19,20	V_{bb}	**Positive power supply voltage**. Design the wiring for the simultaneous max. short circuit currents from channel 1 to 4 and also for low thermal resistance
3	IN1	**Input 1 .. 4**, activates channel 1 .. 4 in case of logic high signal
5	IN2	
7	IN3	
9	IN4	
18	OUT1	**Output 1 .. 4**, protected high-side power output of channel 1 .. 4. Design the wiring for the max. short circuit current
17	OUT2	
14	OUT3	
13	OUT4	
4	ST1/2	**Diagnostic feedback 1/2** of channel 1 and channel 2, open drain, low on failure
8	ST3/4	**Diagnostic feedback 3/4** of channel 3 and channel 4, open drain, low on failure
2	GND1/2	**Ground 1/2** of chip 1 (channel 1 and channel 2)
6	GND3/4	**Ground 3/4** of chip 2 (channel 3 and channel 4)

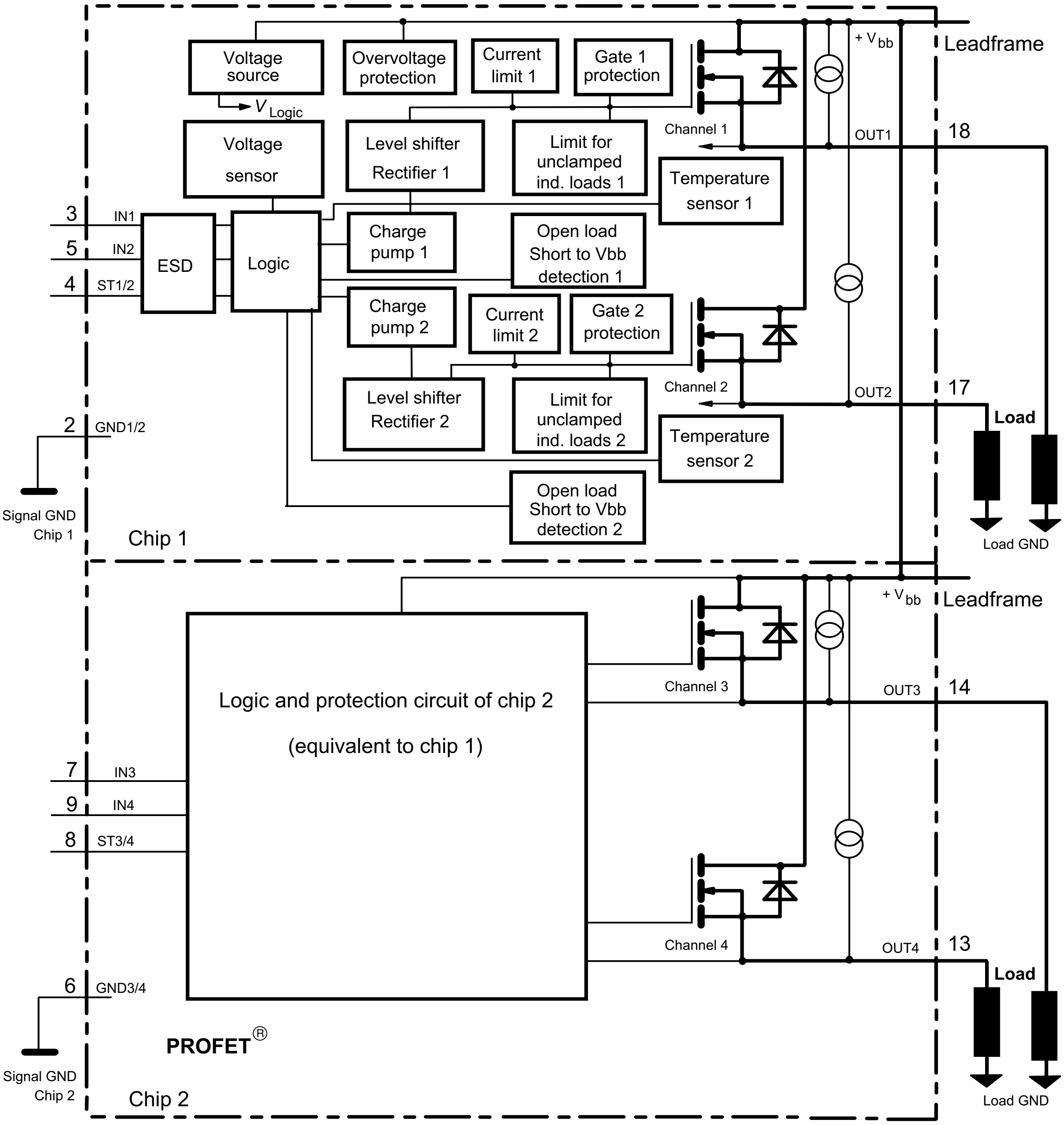
Pin configuration (top view)

V_{bb}	1	20	V_{bb}
GND1/2	2	19	V_{bb}
IN1	3	18	OUT1
ST1/2	4	17	OUT2
IN2	5	16	V_{bb}
GND3/4	6	15	V_{bb}
IN3	7	14	OUT3
ST3/4	8	13	OUT4
IN4	9	12	V_{bb}
V_{bb}	10	11	V_{bb}

1) With external current limit (e.g. resistor R_{GND}=150 Ω) in GND connection, resistor in series with ST connection, reverse load current limited by connected load.

Block diagram

Four Channels; Open Load detection in off state;



Leadframe connected to pin 1, 10, 11, 12, 15, 16, 19, 20

Maximum Ratings at T_j = 25°C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 4)	V_{bb}	43	V
Supply voltage for full short circuit protection $T_{j,start}$ = -40 ...+150°C	V_{bb}	34	V
Load current (Short-circuit current, see page 5)	I_L	self-limited	A
Load dump protection[2] $V_{LoadDump} = U_A + V_s$, U_A = 13.5 V R_I[3] = 2 Ω, t_d = 200 ms; IN = low or high, each channel loaded with R_L = 7.1 Ω,	$V_{Load\ dump}$[4]	60	V
Operating temperature range Storage temperature range	T_j T_{stg}	-40 ...+150 -55 ...+150	°C
Power dissipation (DC)[5] T_a = 25°C: (all channels active) T_a = 85°C:	P_{tot}	3.6 1.9	W
Inductive load switch-off energy dissipation, single pulse V_{bb} = 12V, $T_{j,start}$ = 150°C[5], I_L = 1.9 A, Z_L = 66 mH, 0 Ω one channel: I_L = 2.8 A, Z_L = 66 mH, 0 Ω two parallel channels: I_L = 4.4 A, Z_L = 66 mH, 0 Ω four parallel channels: see diagrams on page 9	E_{AS}	150 320 800	mJ
Electrostatic discharge capability (ESD) (Human Body Model)	V_{ESD}	1.0	kV
Input voltage (DC) Current through input pin (DC) Current through status pin (DC) see internal circuit diagram page 8	V_{IN} I_{IN} I_{ST}	-10 ... +16 ±2.0 ±5.0	V mA
Thermal resistance junction - soldering point[5),6)] each channel: junction - ambient[5] one channel active: all channels active:	R_{thjs} R_{thja}	16 44 35	K/W

2) Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND and status pins, e.g. with a 150 Ω resistor in the GND connection and a 15 kΩ resistor in series with the status pin. A resistor for input protection is integrated.

3) R_I = internal resistance of the load dump test pulse generator

4) $V_{Load\ dump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

5) Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air. See page 14

Electrical Characteristics

Parameter and Conditions, each of the four channels at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	**Symbol**	**Values**			**Unit**
		min	typ	max	
Load Switching Capabilities and Characteristics					
On-state resistance (V_{bb} to OUT) I_L = 1.8 A each channel, T_j = 25°C:	R_{ON}	--	165	200	mΩ
T_j = 150°C:			320	400	
two parallel channels, T_j = 25°C:			83	100	
four parallel channels, T_j = 25°C:			42	50	
Nominal load current one channel active:	$I_{L(NOM)}$	1.7	1.9	--	A
two parallel channels active:		2.6	2.8		
four parallel channels active: Device on PCB[5]), T_a = 85°C, $T_j \leq$ 150°C		4.1	4.4		
Output current while GND disconnected or pulled up; V_{bb} = 30 V, V_{IN} = 0, see diagram page 9	$I_{L(GNDhigh)}$	--	--	10	mA
Turn-on time to 90% V_{OUT}:	t_{on}	80	200	400	µs
Turn-off time to 10% V_{OUT}: R_L = 12 Ω, T_j =-40...+150°C	t_{off}	80	200	400	
Slew rate on 10 to 30% V_{OUT}, R_L = 12 Ω, T_j =-40...+150°C:	dV/dt_{on}	0.1	--	1	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 12 Ω, T_j =-40...+150°C:	$-dV/dt_{off}$	0.1	--	1	V/µs
Operating Parameters					
Operating voltage[7]) T_j =-40...+150°C:	$V_{bb(on)}$	5.0	--	34	V
Undervoltage shutdown T_j =-40...+150°C:	$V_{bb(under)}$	3.5	--	5.0	V
Undervoltage restart T_j =-40...+25°C:	$V_{bb(u\ rst)}$	--	--	5.0	V
T_j =+150°C:				7.0	
Undervoltage restart of charge pump see diagram page 14 T_j =-40...+150°C:	$V_{bb(ucp)}$	--	5.6	7.0	V
Undervoltage hysteresis $\Delta V_{bb(under)} = V_{bb(u\ rst)} - V_{bb(under)}$	$\Delta V_{bb(under)}$	--	0.2	--	V
Overvoltage shutdown T_j =-40...+150°C:	$V_{bb(over)}$	34	--	43	V
Overvoltage restart T_j =-40...+150°C:	$V_{bb(o\ rst)}$	33	--	--	V
Overvoltage hysteresis T_j =-40...+150°C:	$\Delta V_{bb(over)}$	--	0.5	--	V
Overvoltage protection[8]) T_j =-40...+150°C: I_{bb} = 40 mA	$V_{bb(AZ)}$	42	47	--	V

7) At supply voltage increase up to V_{bb} = 5.6 V typ without charge pump, $V_{OUT} \approx V_{bb}$ - 2 V
8) see also $V_{ON(CL)}$ in circuit diagram on page 8.

Parameter and Conditions, each of the four channels at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values min	Values typ	Values max	Unit
Standby current, all channels off T_j =25°C: / V_{IN} = 0 T_j =150°C:	$I_{bb(off)}$	-- --	180 160	300 300	µA
Operating current [9], V_{IN} = 5V, T_j =-40...+150°C $I_{GND} = I_{GND1/2} + I_{GND3/4}$, one channel on: / four channels on:	I_{GND}	-- --	0.35 1.2	0.8 2.8	mA
Protection Functions[10]					
Initial peak short circuit current limit, (see timing diagrams, page 12) each channel, T_j =-40°C: / T_j =25°C: / T_j =+150°C:	$I_{L(SCp)}$	5.5 4.5 2.5	9.5 7.5 4.5	13 11 7	A
two parallel channels		twice the current of one channel			
four parallel channels		four times the current of one channel			
Repetitive short circuit current limit, $T_j = T_{jt}$ each channel / two parallel channels / four parallel channels (see timing diagrams, page 12)	$I_{L(SCr)}$	-- -- --	4 4 4	-- -- --	A
Initial short circuit shutdown time $T_{j,start}$ =-40°C: / $T_{j,start}$ = 25°C: (see page 10 and timing diagrams on page 12)	$t_{off(SC)}$	-- --	48 29	-- --	ms
Output clamp (inductive load switch off)[11] at $V_{ON(CL)} = V_{bb} - V_{OUT}$	$V_{ON(CL)}$	--	47	--	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Reverse Battery					
Reverse battery voltage [12]	$-V_{bb}$	--	--	32	V
Drain-source diode voltage ($V_{out} > V_{bb}$) I_L = - 1.9 A, T_j = +150°C	$-V_{ON}$	--	610	--	mV
Diagnostic Characteristics					
Open load detection current	$I_{L(off)}$	--	30	--	µA
Open load detection voltage T_j =-40..+150°C:	$V_{OUT(OL)}$	2	3	4	V

9) Add I_{ST}, if $I_{ST} > 0$

10) 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.

11) If channels are connected in parallel, output clamp is usually accomplished by the channel with the lowest $V_{ON(CL)}$

12) 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. Note that the power dissipation is higher compared to normal operating conditions due to the voltage drop across the intrinsic 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).

Parameter and Conditions, each of the four channels at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Input and Status Feedback[13]					
Input resistance (see circuit page 8) T_j =-40..+150°C:	R_I	2.5	3.5	6	kΩ
Input turn-on threshold voltage T_j =-40..+150°C:	$V_{IN(T+)}$	1.7	--	3.5	V
Input turn-off threshold voltage T_j =-40..+150°C:	$V_{IN(T-)}$	1.5	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.5	--	V
Off state input current V_{IN} = 0.4 V: T_j =-40..+150°C:	$I_{IN(off)}$	1	--	50	µA
On state input current V_{IN} = 5 V: T_j =-40..+150°C:	$I_{IN(on)}$	20	50	90	µA
Delay time for status with open load (see timing diagrams, page 12)	$t_{d(ST\ OL3)}$	--	220	--	µs
Status output (open drain)					
Zener limit voltage T_j =-40...+150°C, I_{ST} = +1.6 mA:	$V_{ST(high)}$	5.4	6.1	--	V
ST low voltage T_j =-40...+25°C, I_{ST} = +1.6 mA:	$V_{ST(low)}$	--	--	0.4	
T_j = +150°C, I_{ST} = +1.6 mA:		--	--	0.6	

13) If ground resistors R_{GND} are used, add the voltage drop across these resistors.

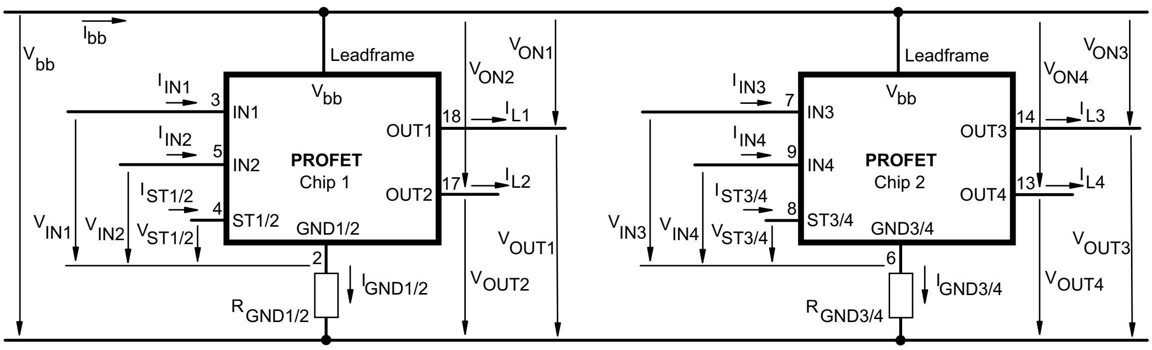
Truth Table

Channel 1 and 2	Chip 1	IN1	IN2	OUT1	OUT2	ST1/2	ST1/2
Channel 3 and 4 (equivalent to channel 1 and 2)	Chip 2	IN3	IN4	OUT3	OUT4	ST3/4 BTS 711L1	ST3/4 BTS 712N1
Normal operation		L	L	L	L	H	H
		L	H	L	H	H	H
		H	L	H	L	H	H
		H	H	H	H	H	H
Open load	Channel 1 (3)	L	L	Z	L	H(L[14])	L
		L	H	Z	H	H	H
		H	X	H	X	L	H
	Channel 2 (4)	L	L	L	Z	H(L[14])	L
		H	L	H	Z	H	H
		X	H	X	H	L	H
Short circuit to V_{bb}	Channel 1 (3)	L	L	H	L	L[15]	L[15]
		L	H	H	H	H	H
		H	X	H	X	H(L[16])	H
	Channel 2 (4)	L	L	L	H	L[15]	L[15]
		H	L	H	H	H	H
		X	H	X	H	H(L[16])	H
Overtemperature	both channel	L	L	L	L	H	H
		X	H	L	L	L	L
		H	X	L	L	L	L
	Channel 1 (3)	L	X	L	X	H	H
		H	X	L	X	L	L
	Channel 2 (4)	X	L	X	L	H	H
		X	H	X	L	L	L
Undervoltage/ Overvoltage		X	X	L	L	H	H

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 (also channel 3 and 4) is easily possible by connecting the inputs and outputs in parallel (see truth table). If switching channel 1 to 4 in parallel, the status outputs ST1/2 and ST3/4 have to be configured as a 'Wired OR' function with a single pull-up resistor.

Terms



Leadframe (V_{bb}) is connected to pin 1,10,11,12,15,16,19,20
External R_{GND} optional; two resistors $R_{GND1/2}$,$R_{GND3/4}$ = 150 Ω or a single resistor R_{GND} = 75 Ω for reverse battery protection up to the max. operating voltage.

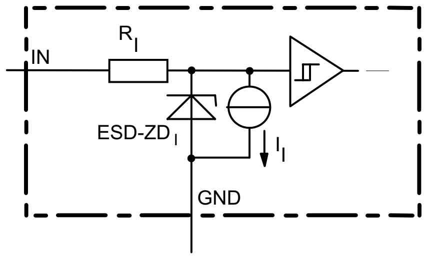
---

14) With additional external pull up resistor

15) An external short of output to V_{bb} in the off state causes an internal current from output to ground. If R_{GND} is used, an offset voltage at the GND and ST pins will occur and the $V_{ST\ low}$ signal may be errorious.

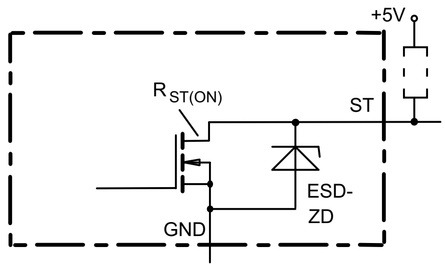
16) Low resistance to V_{bb} may be detected by no-load-detection

Input circuit (ESD protection), IN1...4



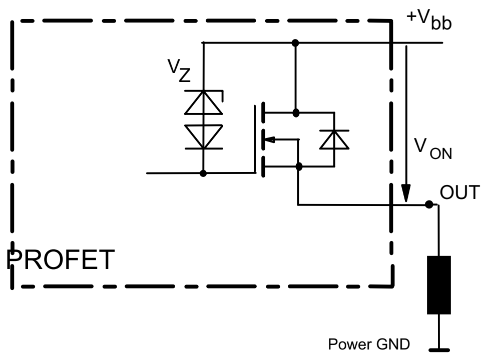
ESD zener diodes are not to be used as voltage clamp at DC conditions. Operation in this mode may result in a drift of the zener voltage (increase of up to 1 V).

Status output, ST1/2 or ST3/4



ESD-Zener diode: 6.1 V typ., max 5.0 mA; $R_{ST(ON)}$ < 380 Ω at 1.6 mA, ESD zener diodes are not to be used as voltage clamp at DC conditions. Operation in this mode may result in a drift of the zener voltage (increase of up to 1 V).

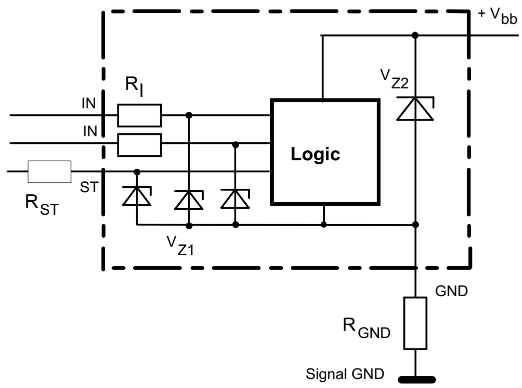
Inductive and overvoltage output clamp, OUT1...4



V_{ON} clamped to $V_{ON(CL)}$ = 47 V typ.

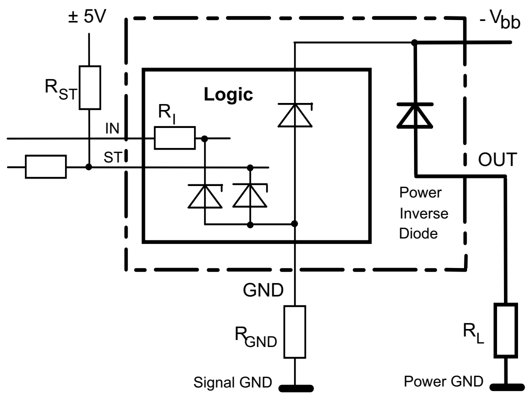
Overvoltage protection of logic part

GND1/2 or GND3/4



V_{Z1} = 6.1 V typ., V_{Z2} = 47 V typ., R_I = 3.5 kΩ typ., R_{GND} = 150 Ω

Reverse battery protection



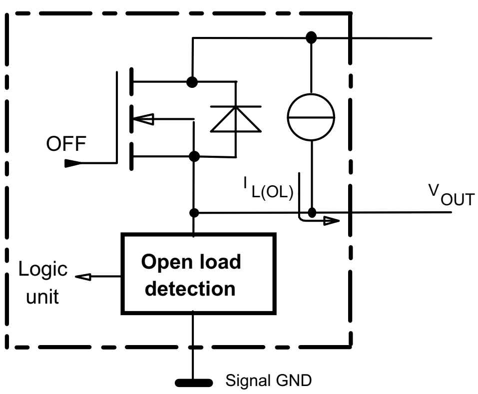
R_{GND} = 150 Ω, R_I = 3.5 kΩ typ,

Temperature protection is not active during inverse current operation.

Open-load detection, OUT1...4

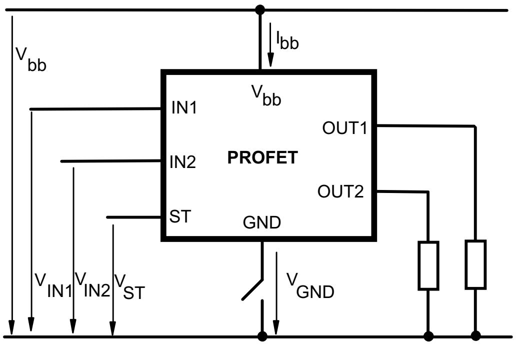
OFF-state diagnostic condition:

V_{OUT} > 3 V typ.; IN low



GND disconnect

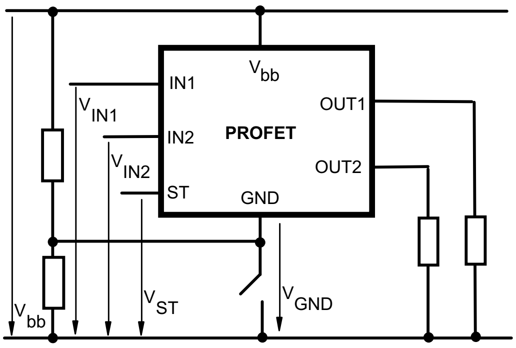
(channel 1/2 or 3/4)



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.

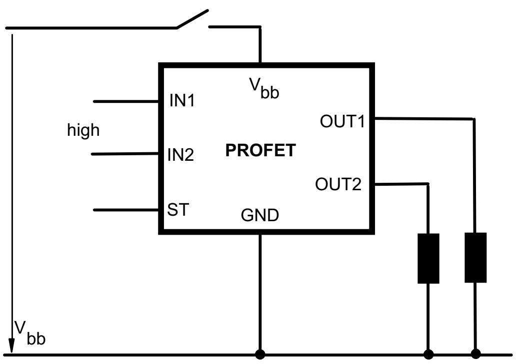
GND disconnect with GND pull up

(channel 1/2 or 3/4)



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.

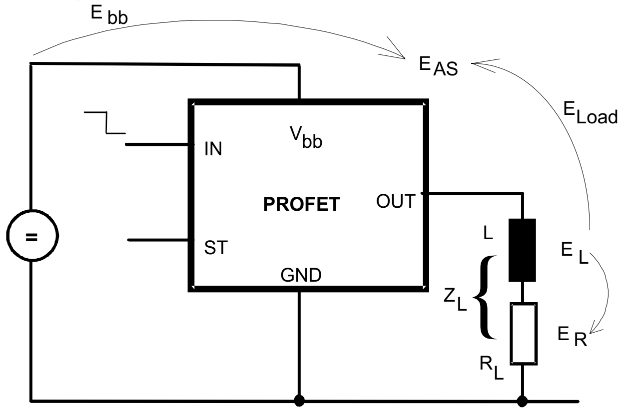
V_{bb} disconnect with energized inductive load



For an inductive load current up to the limit defined by E_{AS} (max. ratings see page 3 and diagram on page 9) each switch is protected against loss of V_{bb}.

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

Inductive load switch-off energy dissipation



Energy stored in load inductance:

$$E_L = {}^1/_2 \cdot L \cdot I_L^2$$

While demagnetizing load inductance, the energy dissipated in PROFET is

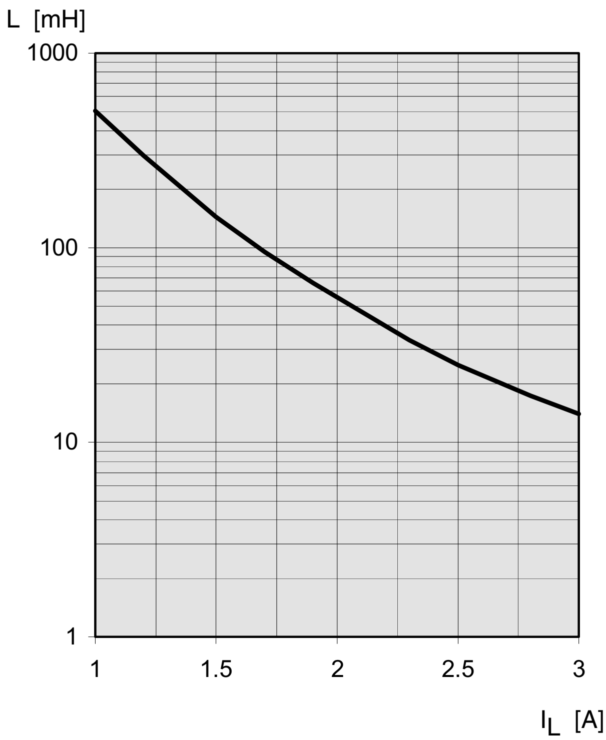
$$E_{AS} = E_{bb} + E_L - E_R = V_{ON(CL)} \cdot i_L(t)\, dt,$$

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

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

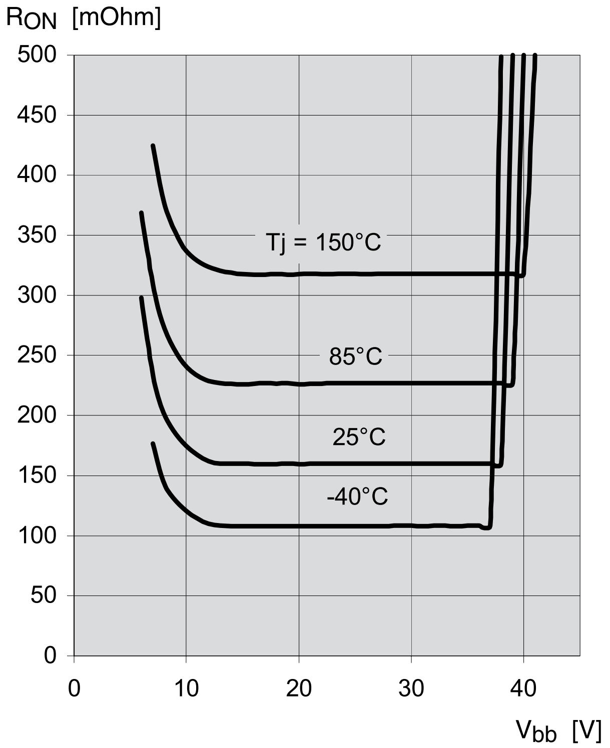
Maximum allowable load inductance for a single switch off (one channel)[5)]

$L = f(I_L)$; $T_{j,start} = 150°C$, $V_{bb} = 12\,V$, $R_L = 0\,\Omega$



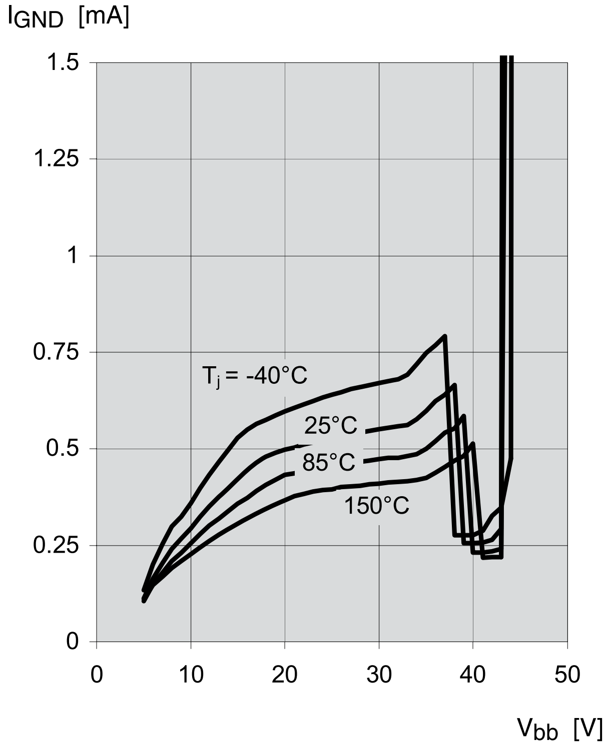
Typ. on-state resistance

$R_{ON} = f(V_{bb}, T_j)$; I_L = 1.8 A, IN = high



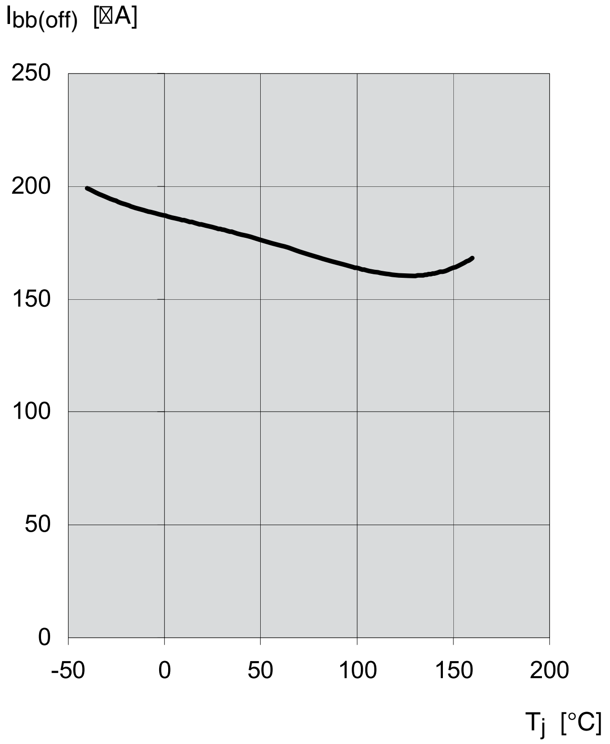
Typ. ground pin operating current

$I_{GND} = f(V_{bb}, T_j)$; V_{IN} = high (one channel on)



Typ. standby current

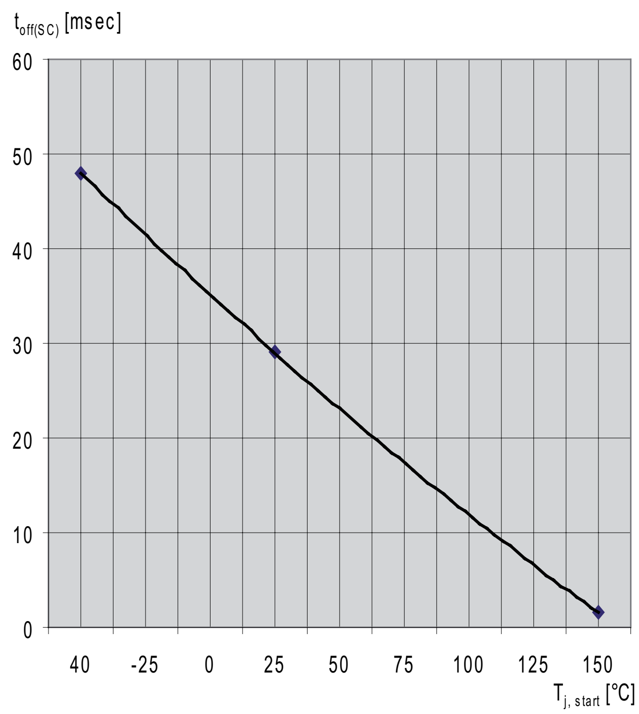
$I_{bb(off)} = f(T_j)$; V_{bb} = 9...34 V, IN1...4 = low



$I_{bb(off)}$ includes four times the current $I_{L(off)}$ of the open load detection current sources.

Typ. initial short circuit shutdown time

$t_{off(SC)} = f(T_{j,start})$; V_{bb} =12 V



Timing diagrams

Timing diagrams are shown for chip 1 (channel 1/2). For chip 2 (channel 3/4) the diagrams are valid too. The channels 1 and 2, respectively 3 and 4, are symmetric and consequently the diagrams are valid for each channel as well as for permuted channels

Figure 1a: V_{bb} turn on:

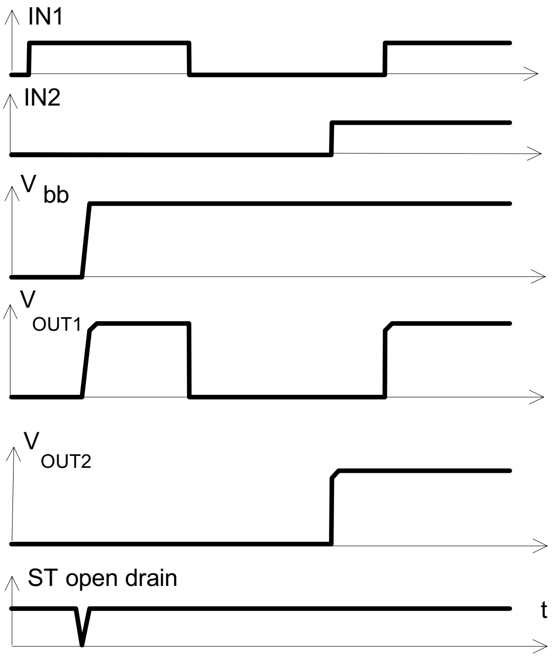
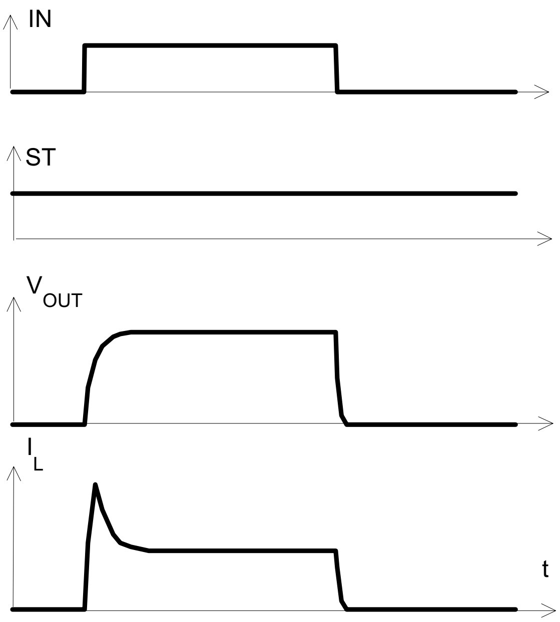


Figure 2a: Switching a lamp:



The initial peak current should be limited by the lamp and not by the initial short circuit current $I_{L(SCp)}$ = 7.5 A typ. of the device.

Figure 2b: Switching an inductive load,

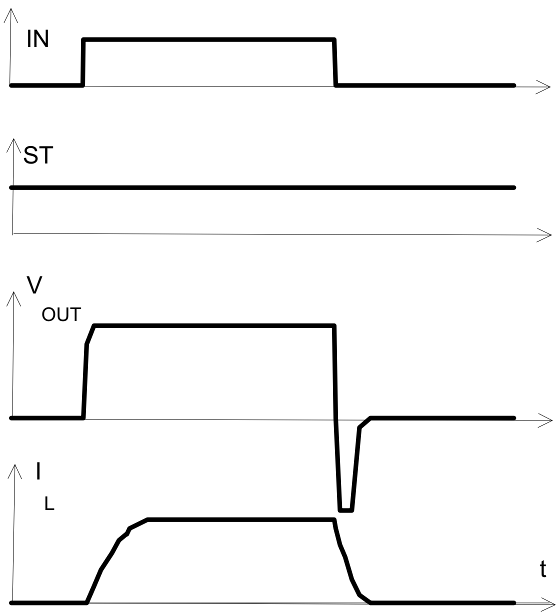
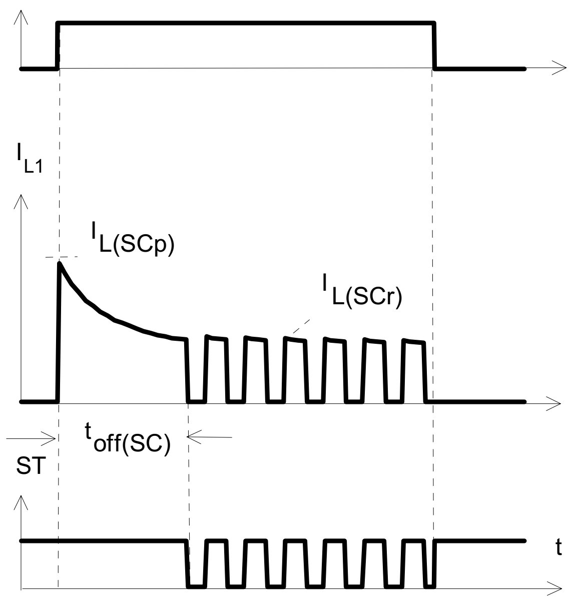


Figure 3a: Turn on into short circuit:
shut down by overtemperature, restart by cooling

IN1 other channel: normal operation



Heating up of the chip may require several milliseconds, depending on external conditions ($t_{off(SC)}$ vs. $T_{j,start}$ see page 11)

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

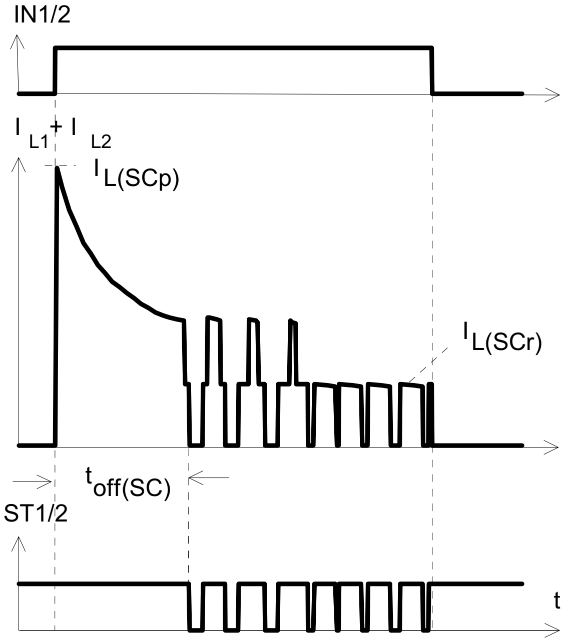


Figure 4a: Overtemperature:
Reset if $T_j < T_{jt}$

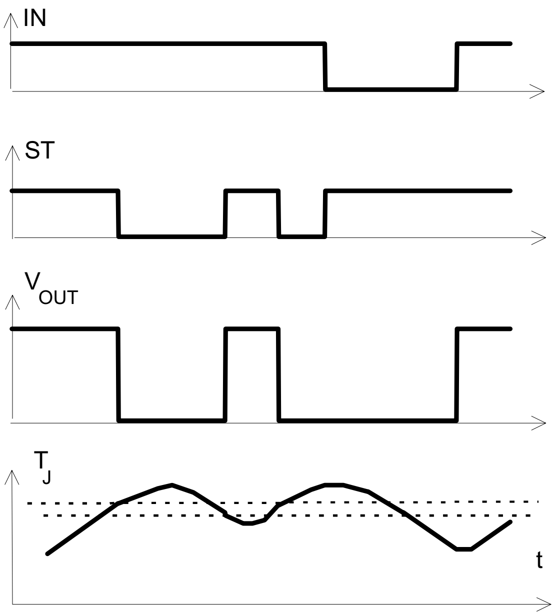
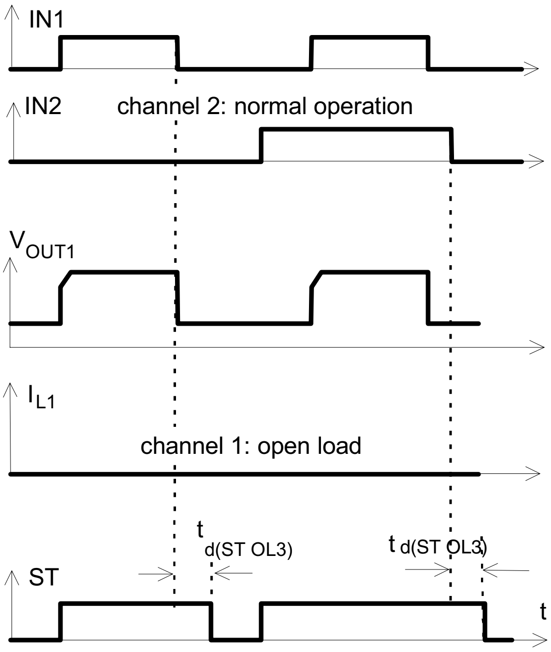


Figure 5a: Open load: detection in OFF-state, turn on/off to open load



$t_{d(ST,OL3)}$ depends on external circuitry because of high impedance

*) I_L = 30 µA typ

Figure 6a: Undervoltage:

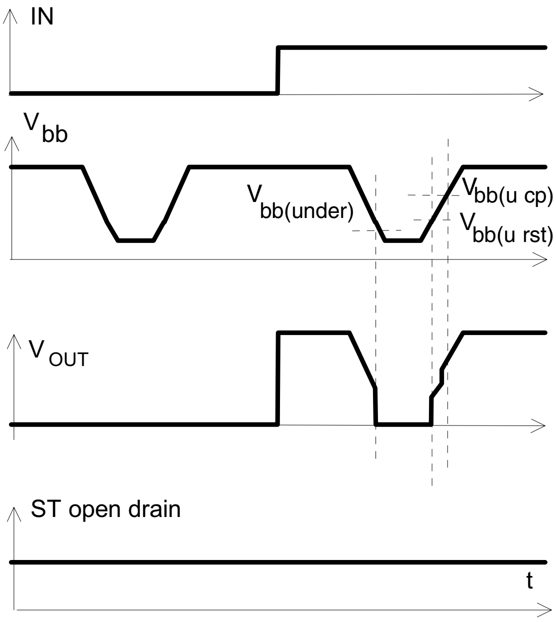
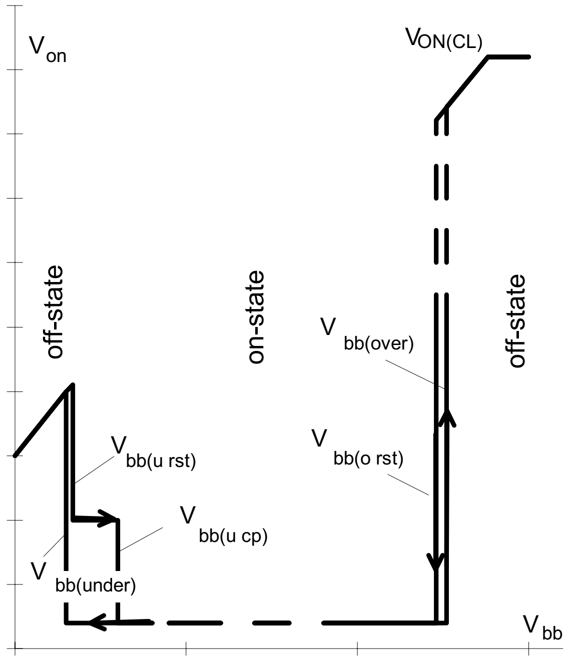
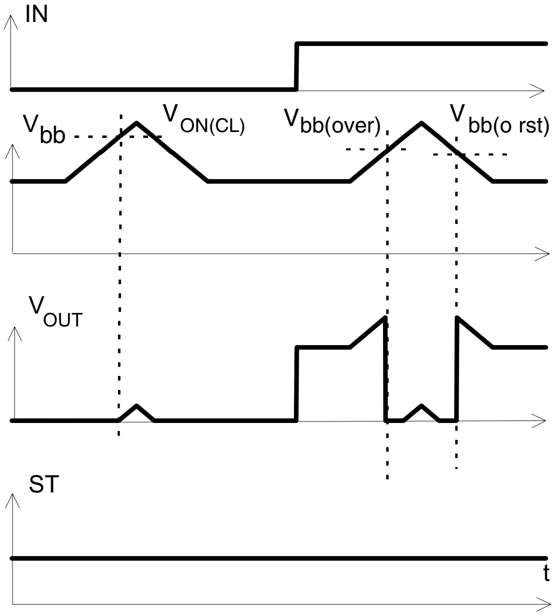


Figure 6b: Undervoltage restart of charge pump



IN = high, normal load conditions.
Charge pump starts at $V_{bb(ucp)}$ = 5.6 V typ.

Figure 7a: Overvoltage:



Package Outlines

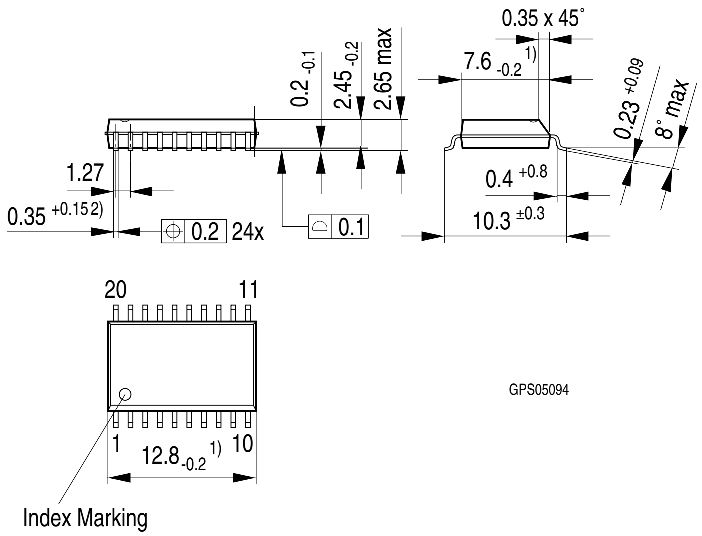


Figure 1 **PG-DSO-20** (Plastic Dual Small Outline Package) (RoHS-compliant)

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).

Please specify the package needed (e.g. green package) when placing an order

You can find all of our packages, sorts of packing and others in our Infineon Internet Page "Products": **http://www.infineon.com/products**.

Dimensions in mm

Revision History

Version	Date	Changes
Rev 1.3	2010-03-16	page 6: changed reference to the timing diagram
Rev 1.2	2009-07-13	page 1: added new coverpage page 6: Initial short circuit shutdown time changed: toff(SC) -40 °C to 48 ms toff(SC) 25 °C to 29 ms page 11: changed graphic
V1.1	2007-08-30	Creation of the green datasheet. First page : Adding the green logo and the AEC qualified Adding the bullet AEC qualified and the RoHS compliant features Package page Modification of the package to be green.

Edition 2010-03-16

Published by
Infineon Technologies AG
81726 Munich, Germany

Legal Disclaimer

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenheitsgarantie"). With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

Information

For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office (**www.infineon.com**).

Warnings

Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office.

Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.