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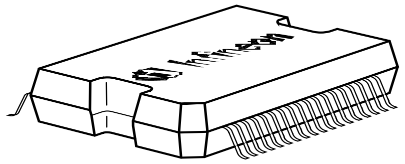
Smart Power High-Side-Switch
Eight Channels: 8 x 200 mΩ

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 (current output) for overtemperature

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	47	V
Operating voltage	$V_{bb(on)}$	11...45	V
On-state resistance	R_{ON}	200	mΩ



P-DSO-36-12; -10

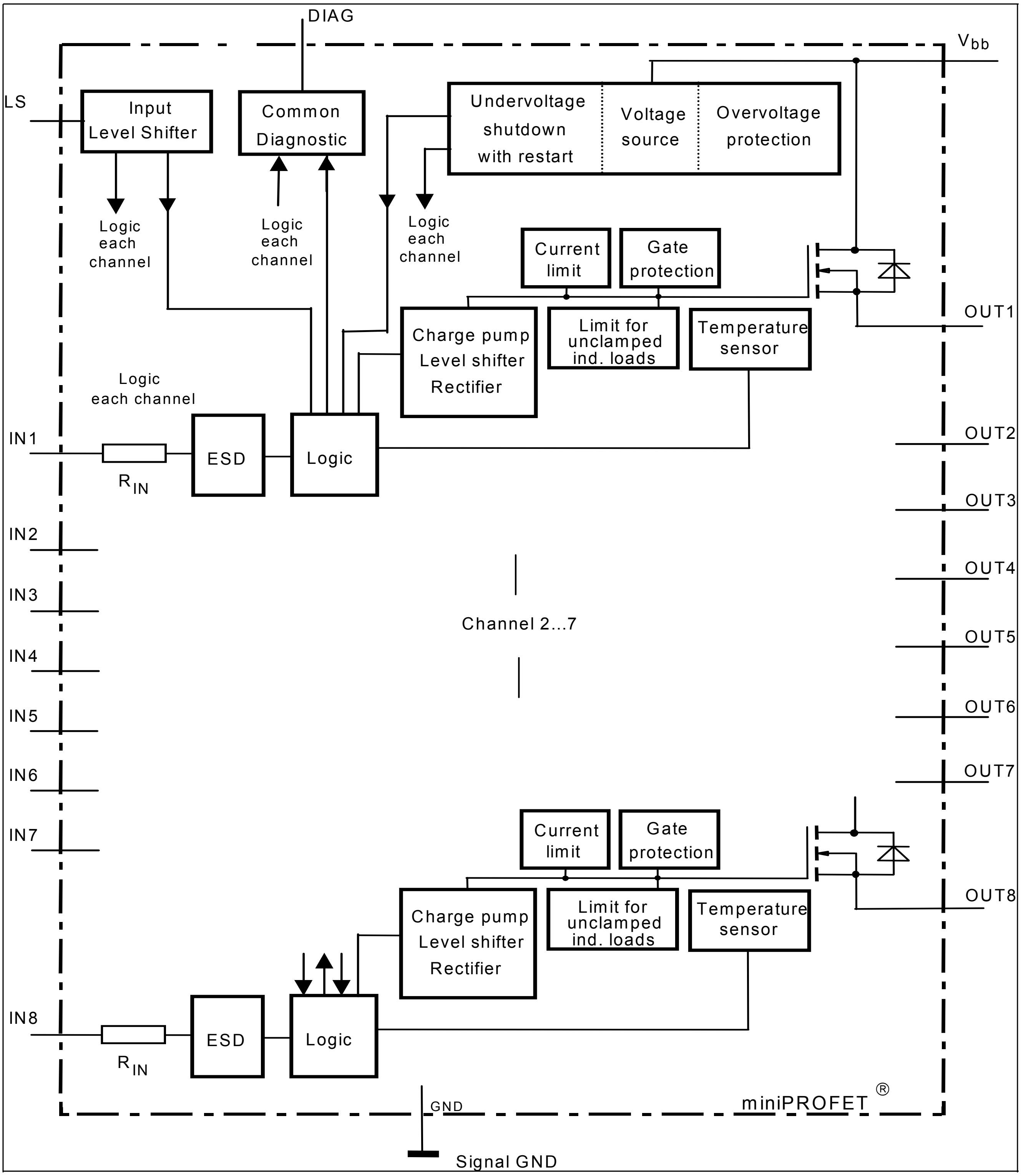
Application

- Output driver for industrial applications (PLC)
- All types of resistive, inductive and capacitive loads
- µC or optocoupler compatible power switch for 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. Providing embedded protective 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 = -40...135 °C, unless otherwise specified	**Symbol**	**Value**	**Unit**
Supply voltage	V_{bb}	-1[1]...45	V
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[4] single pulse, T_j = 125 °C, I_L = 0.625 A one channel active all channels simultaneously active (each channel)	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
Continuous reverse drain current[1][4], each channel	I_S	4	A

[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 subject to production test, 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 = -25...125°C, V_{bb}=15...30V, unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
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

Parameter	Symbol	min.	typ.	max.	Unit
On-state resistance T_j = 25 °C, I_L = 0.5 A T_j = 125 °C	R_{ON}	 - -	 150 270	 200 320	mΩ
Turn-on time to 90% V_{OUT} R_L = 47 Ω, V_{IN} = 0 to 10 V	t_{on}	-	50	100	µs
Turn-off time to 10% V_{OUT} R_L = 47 Ω, V_{IN} = 10 to 0 V	t_{off}	-	75	150	
Slew rate on 10 to 30% V_{OUT}, R_L = 47 Ω, V_{bb} = 15 V	dV/dt_{on}	-	1	2	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 47 Ω, V_{bb} = 15 V	$-dV/dt_{off}$	-	1	2	

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 = -25...125°C, V_{bb}=15...30V, unless otherwise specified	**Symbol**	**Values** min.	typ.	max.	**Unit**
Operating Parameters					
Operating voltage	$V_{bb(on)}$	11	-	45	V
Undervoltage shutdown	$V_{bb(under)}$	7	-	10.5	
Undervoltage restart	$V_{bb(u\ rst)}$	-	-	11	
Undervoltage hysteresis $\Delta V_{bb(under)} = V_{bb(u\ rst)} - V_{bb(under)}$	$\Delta V_{bb(under)}$	-	0.5	-	
Standby current	$I_{bb(off)}$	-	50	150	µA
Operating current[1)]	I_{GND}	-	5	12	mA
Leakage output current (included in $I_{bb(off)}$) V_{IN} = low , each channel	$I_{L(off)}$	-	5	10	µA

Protection Functions[2)]

Initial peak short circuit current limit	$I_{L(SCp)}$				A
T_j = -25 °C, V_{bb} = 30 V, t_m = 700 µs		-	-	1.9	
T_j = 25 °C		-	1.4	-	
T_j = 125 °C		0.7	-	-	
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 [3)]	$V_{bb(AZ)}$	47	-	-	
Thermal overload trip temperature[4)]	T_{jt}	135	-	-	°C
Thermal hysteresis	ΔT_{jt}	-	10	-	K

[1]contains all input currents

[2]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.

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

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

Electrical Characteristics

Parameter at T_j = -25...125°C, V_{bb}=15...30V, 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}	$t_{d(Vbbon)}$	150	340	-	µs
Input resistance (see page 10)	R_I	2	3	4	kΩ
Internal pull down resistor at LS-pin[3]	R_{LS}	300	800	-	

Diagnostic Characteristics

Common diagnostic output current[4] (overtemperature of any channel) T_j = 135 °C	I_{diag}	2	3	4	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}

[4] see page 10

Electrical Characteristics

Parameter at T_j = -25...125°C, V_{bb}=15...30V, unless otherwise specified	**Symbol**	**Values** min.	typ.	max.	**Unit**
Reverse Battery					
Reverse battery voltage[1)]	$-V_{bb}$				V
R_{GND} = 0 Ω		-	-	1	
R_{GND} = 150 Ω		-	-	45	
Diode forward on voltage I_F = 1.25 A, V_{IN} = low , each channel	$-V_{ON}$	-	-	1.2	

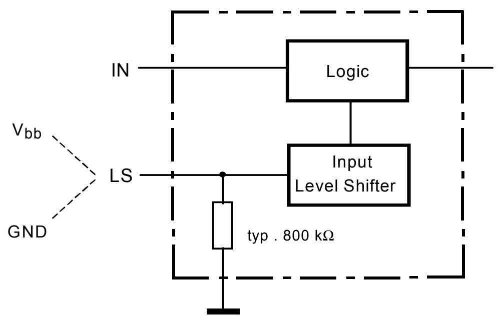
[1]defined by P_{tot}

Truth table for common diagnostic pin (LED-driver):

	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)]

L = no diagnostic output current
H = diagnostic output current typ. 2 mA (see page 7)

Programmable input:



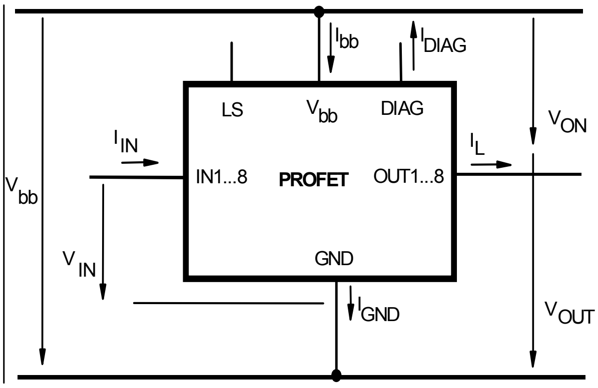
Functional description LS-Pin:

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).

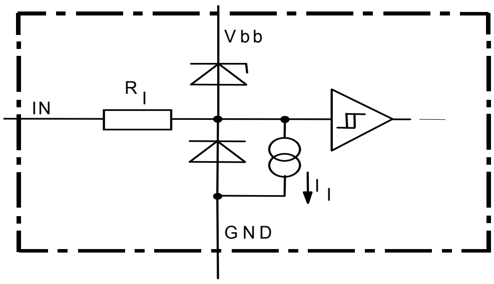
State 1: LS-Pin to GND	CMOS - Input level
State 2: LS-Pin to supply voltage	$V_{bb}/2$ - Input level

[1] toggeling with restart

Terms
each channel

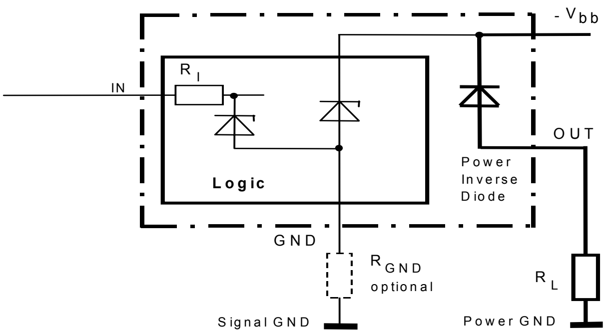


Input circuit (ESD protection)
each channel



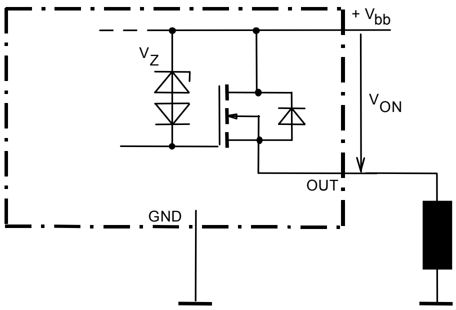
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Reverse battery protection
each channel



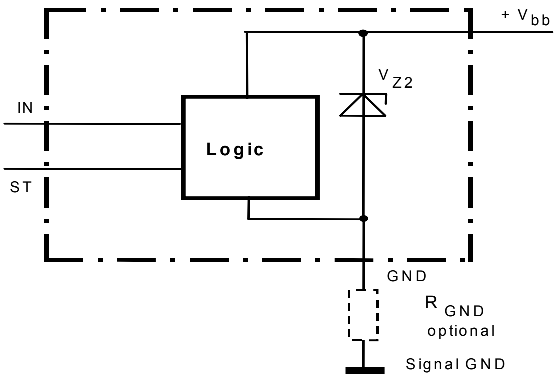
R_{GND}=150Ω, R_I=3kΩ typ.,
Temperature protection is not active during inverse current

Inductive and overvoltage output clamp
each channel



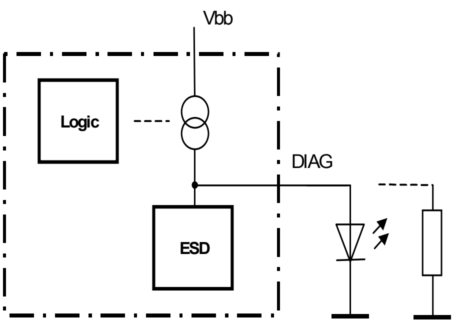
V_{ON} clamped to 47 V min.

Overvoltage protection of logic part



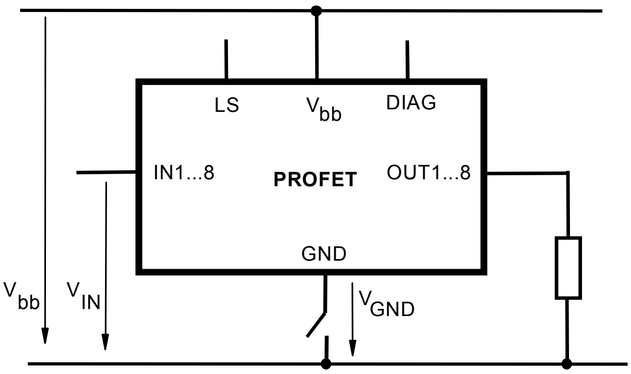
V_{Z2}=$V_{bb(AZ)}$=47 V min.,
R_I=3 kΩ typ., R_{GND}=150Ω

Common diagnostic output

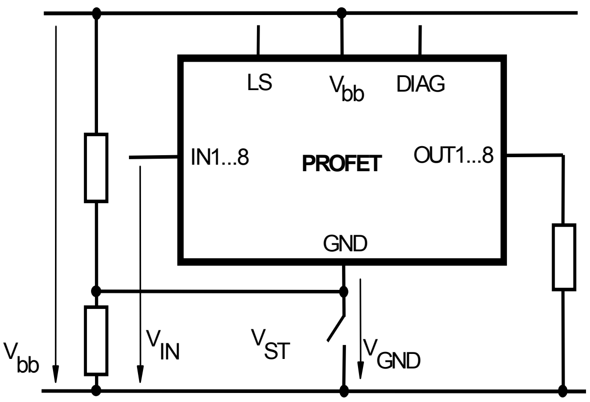


Output current typ. 2 mA

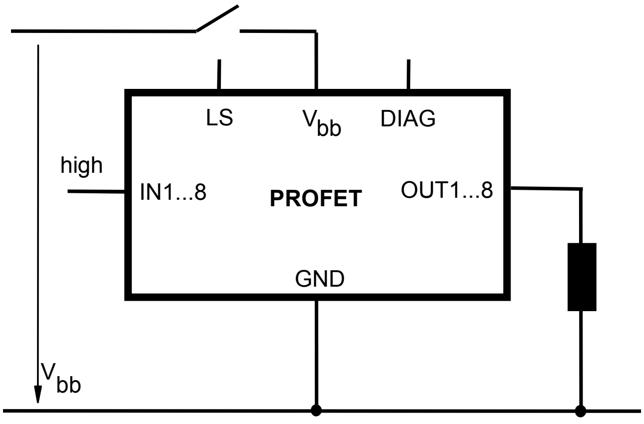
GND disconnect



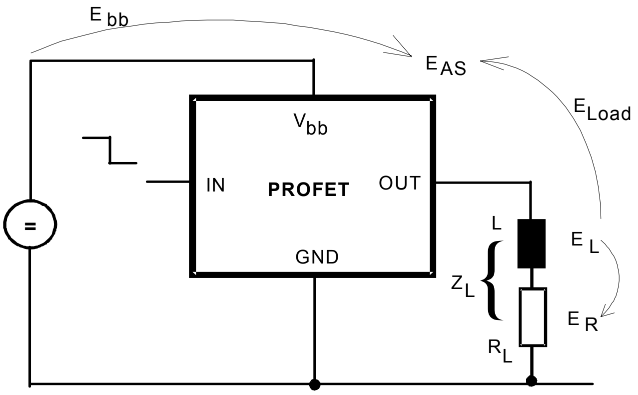
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation, each channel

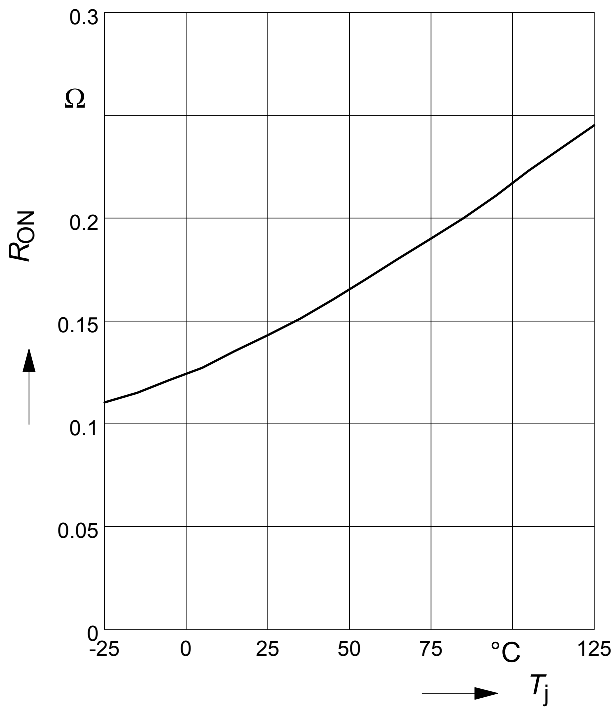


Energy stored in load inductance: E_L = ½ * L * I_L^2
While demagnetizing load inductance,
the enérgy dissipated in PROFET is
$E_{AS} = E_{bb} + E_L - E_R = V_{ON(CL)} * i_L(t)\, dt$,
with an approximate solution for $R_L > 0\Omega$:

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

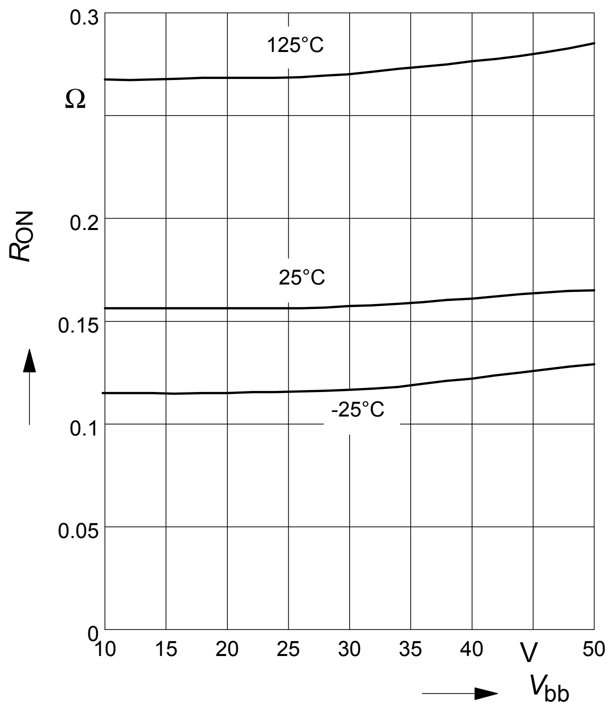
Typ. on-state resistance

R_{ON} **= f(** T_j **)** ; V_{bb} = 15V ; V_{in} = high



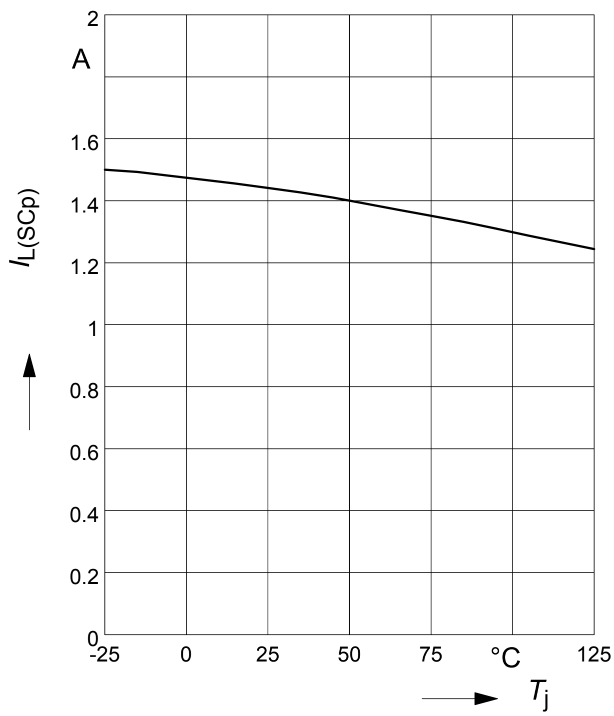
Typ. on-state resistance

R_{ON} **= f(** V_{bb} **)**; I_L = 0.5A ; V_{in} = high



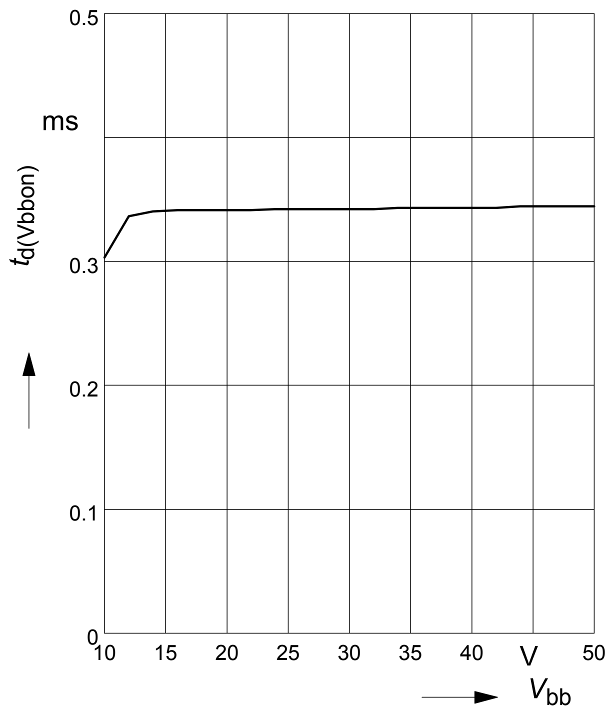
Typ. initial peak short circuit current limit

$I_{L(SCp)}$ **= f(** T_j **)** ; V_{bb} = 24V



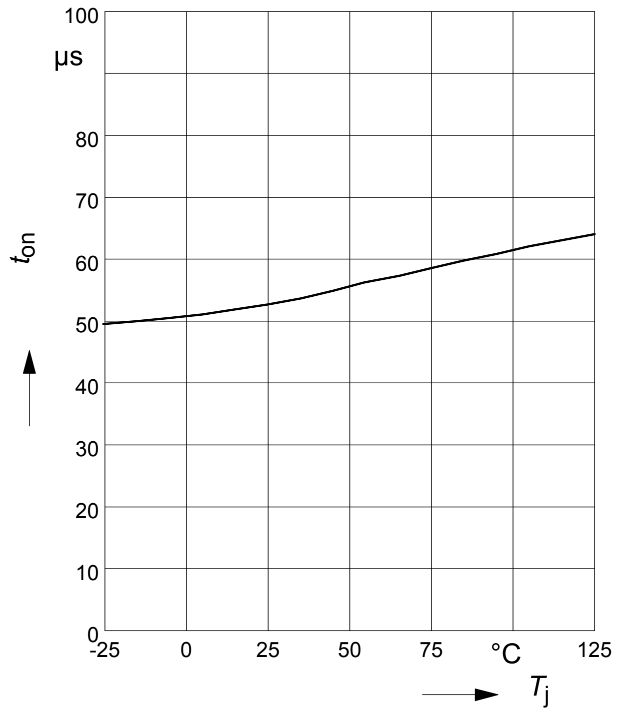
Typ. input delay time at switch on V_{bb}

$t_{d(Vbbon)}$ **= f(** V_{bb} **);** Tj = -25...125 °C



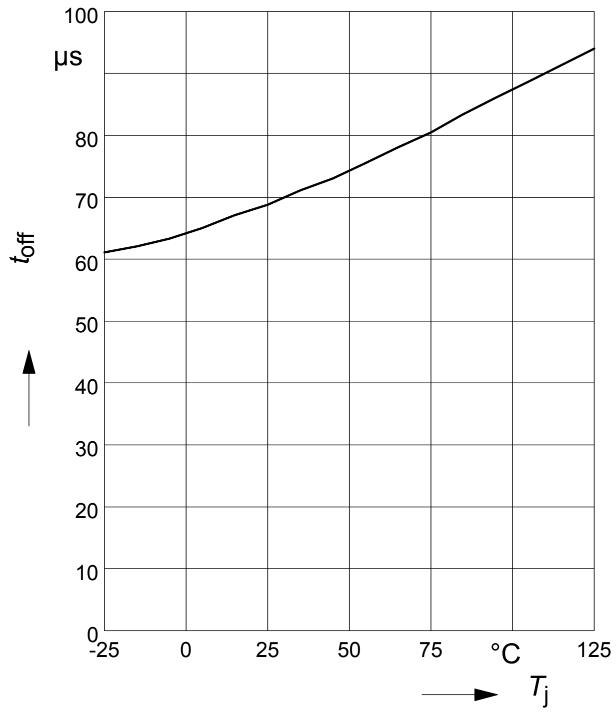
Typ. turn on time

t_{on} = f(T_j); R_L = 47Ω



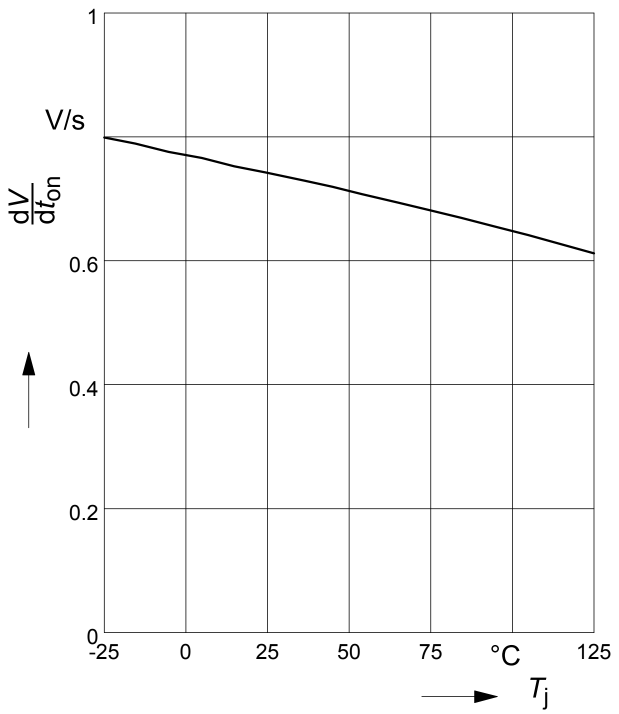
Typ. turn off time

t_{off} = f(T_j); R_L = 47Ω



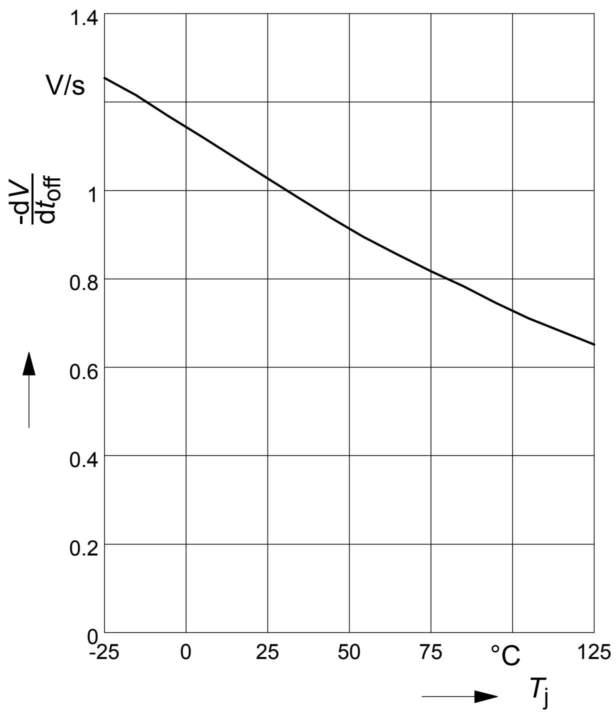
Typ. slew rate on

dV/dt_{on} = f(T_j) ; R_L = 47 Ω, V_{bb} = 15 V



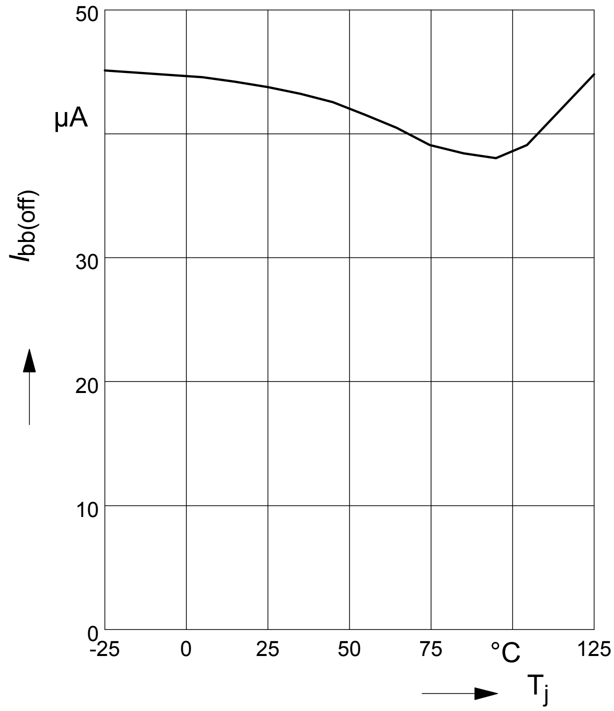
Typ. slew rate off

dV/dt_{off} = f(T_j); R_L = 47 Ω, V_{bb} = 15 V



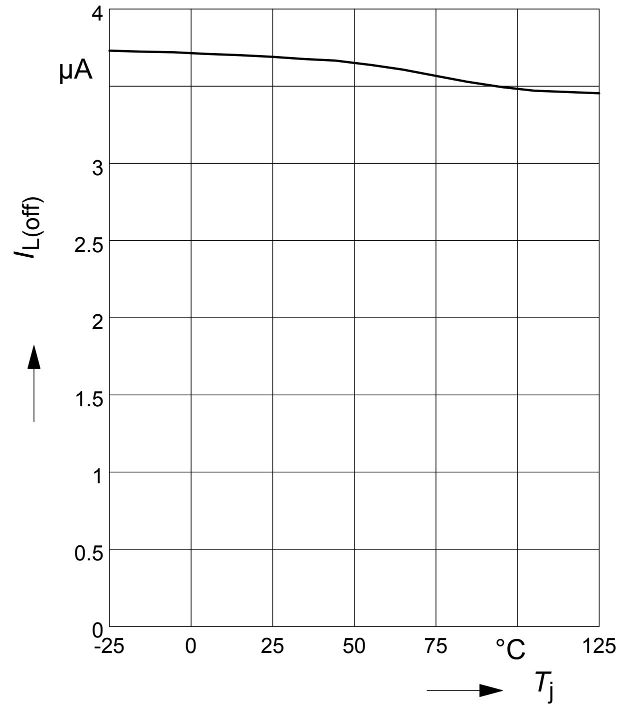
Typ. standby current

$I_{bb(off)}$ = f(T_j) ; V_{bb} = 30V ; V_{IN} = low



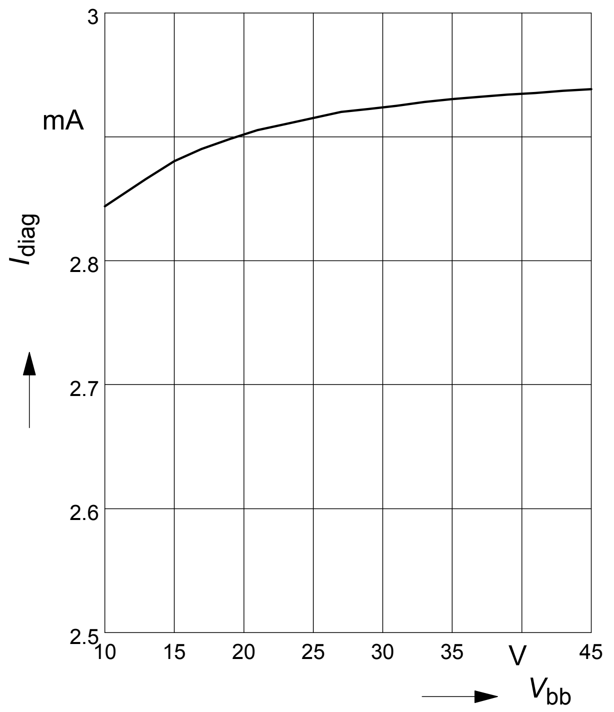
Typ. leakage current

$I_{L(off)}$ = f(T_j) ; V_{bb} = 30V ; V_{IN} = low



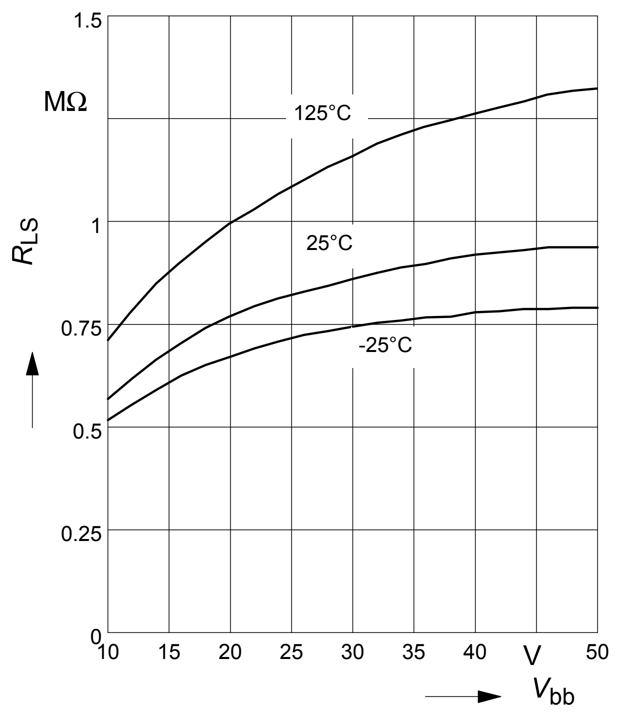
Typ. common diagnostic output current

I_{diag} = f(V_{bb}) ; T_j = 135°C



Typ. internal pull down resistor at LS-pin

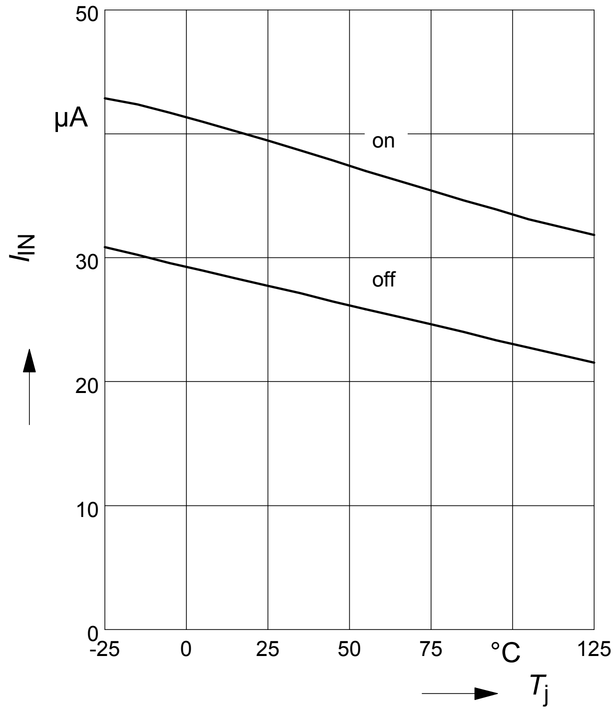
R_{LS} = f(V_{bb}); V_{LS} = V_{bb}



Typ. input current @ CMOS level

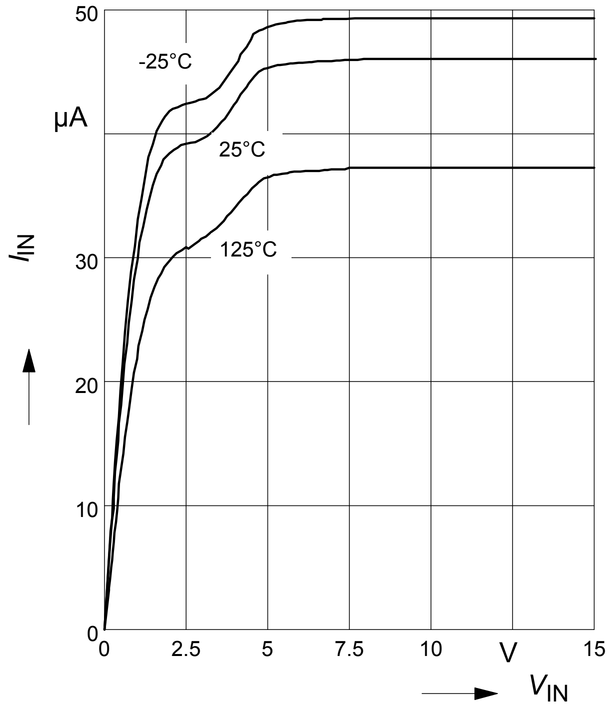
$I_{IN(on/off)} = f(T_j)$; V_{bb} = 15V; V_{IN} = low/high

$V_{INlow} \leq$ 0,8V; V_{INhigh} = 2,2V



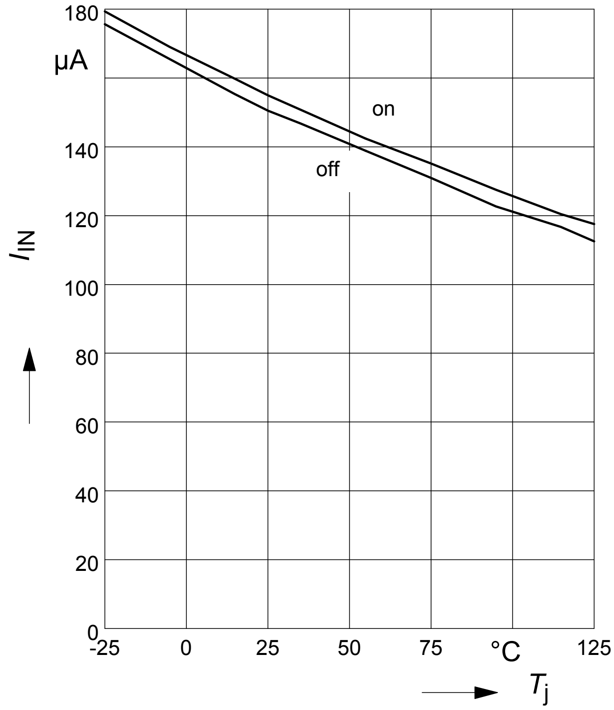
Typ. input current @ CMOS level

$I_{IN} = f(V_{IN})$; V_{bb} = 15V



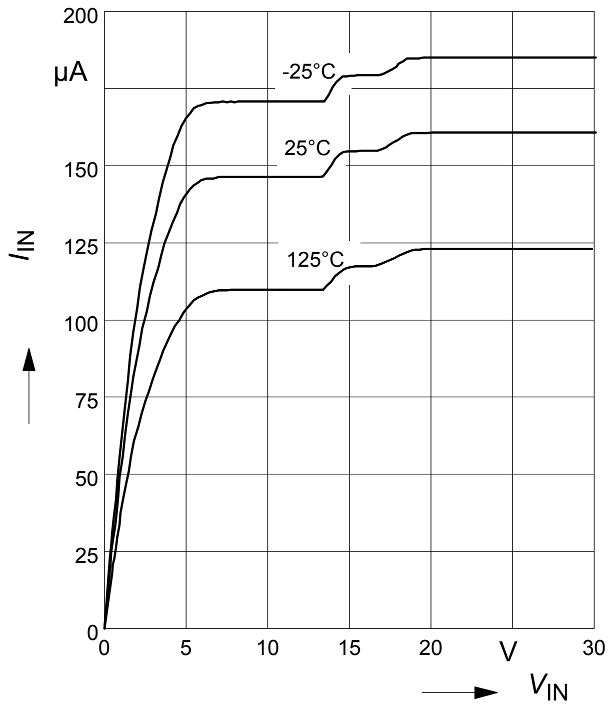
Typ. input current @ V_{bb}/2 level

$I_{IN(on/off)} = f(T_j)$; V_{bb} = 30V; V_{IN} = low/high

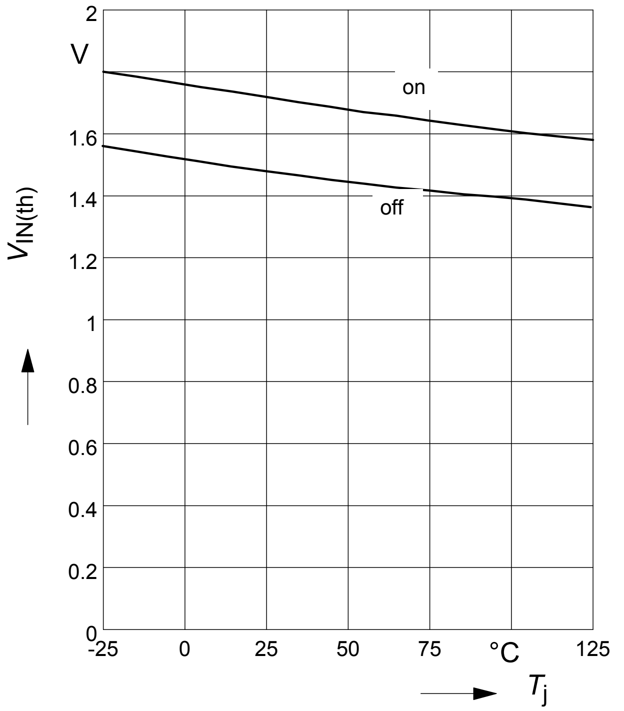


Typ. input current @ V_{bb}/2 level

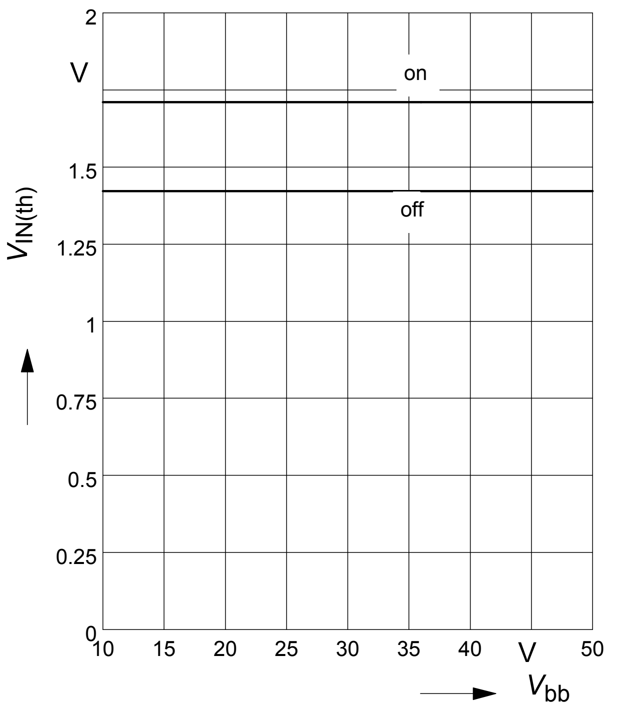
$I_{IN} = f(V_{IN})$; V_{bb} = 30 V



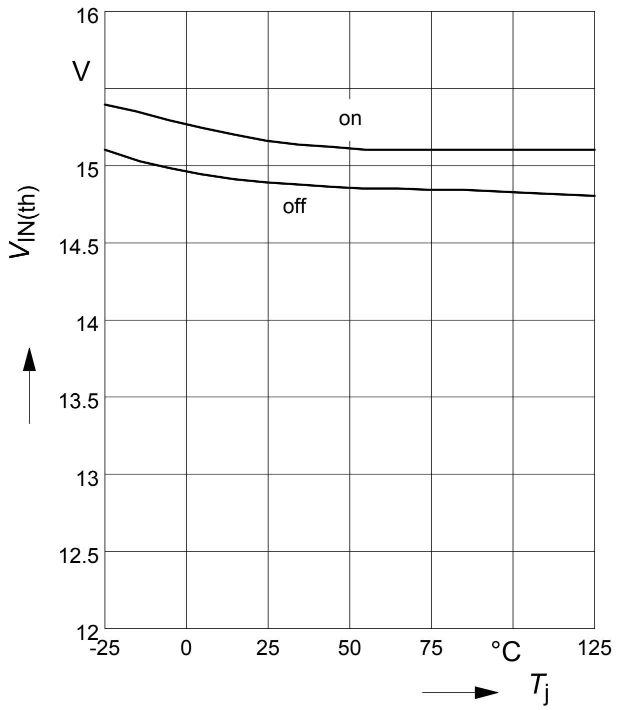
Typ. input threshold voltage
@ CMOS level
$V_{IN(th)}$ = f(T_j) ; V_{bb} = 15V



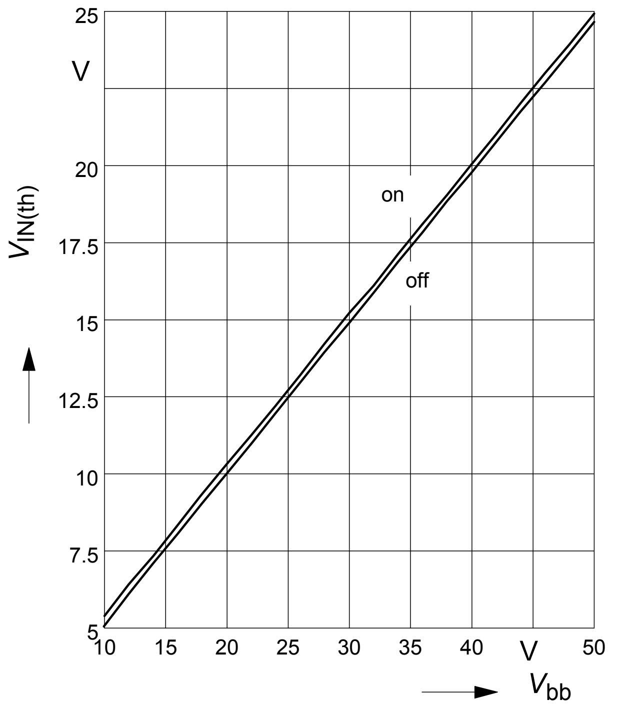
Typ. input threshold voltage
@ CMOS level
$V_{IN(th)}$ = f(V_{bb}) ; T_j = 25°C



Typ. input threshold voltage
@ V_{bb}/2 level
$V_{IN(th)}$ = f(T_j) ; V_{bb} = 30V

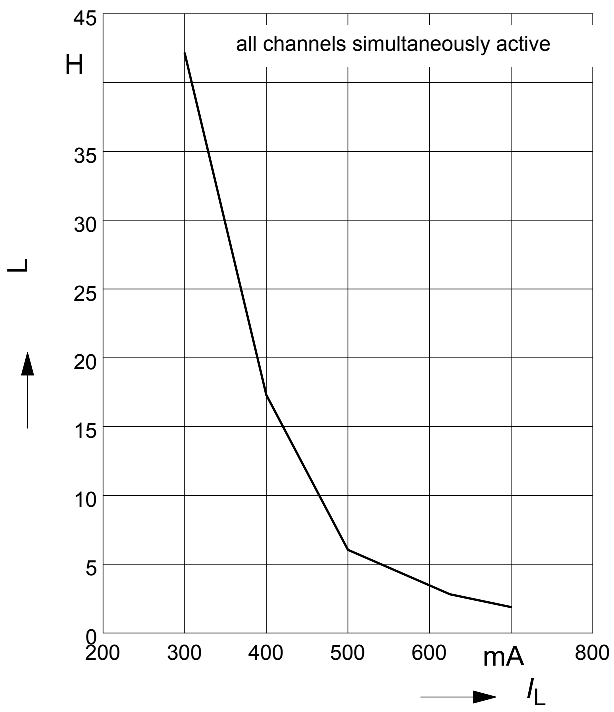


Typ. input threshold voltage
@ V_{bb}/2 level: LS-pin connected to V_{bb}
$V_{IN(th)}$ = f(V_{bb}) ; T_j = 25°C



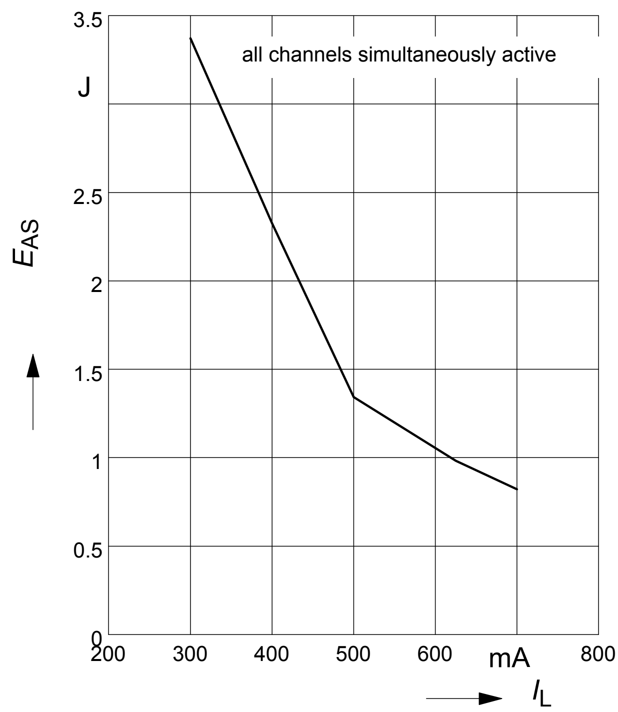
Maximum allowable load inductance for a single switch off, calculated

L **= f(** I_L **)**; T_{jstart}=125°C, V_{bb}=24V, R_L=0Ω



Maximum allowable inductive switch-off energy, single pulse

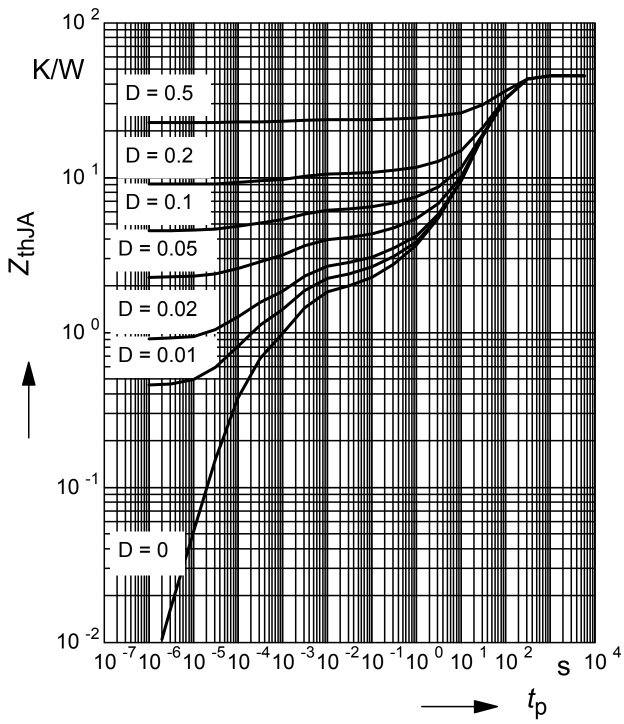
E_{AS} **= f(** I_L **)**; T_{jstart} = 125°C, V_{bb} = 24V



Typ. transient thermal impedance

Z_{thJA}**=f(** t_p **) @ min. footprint**

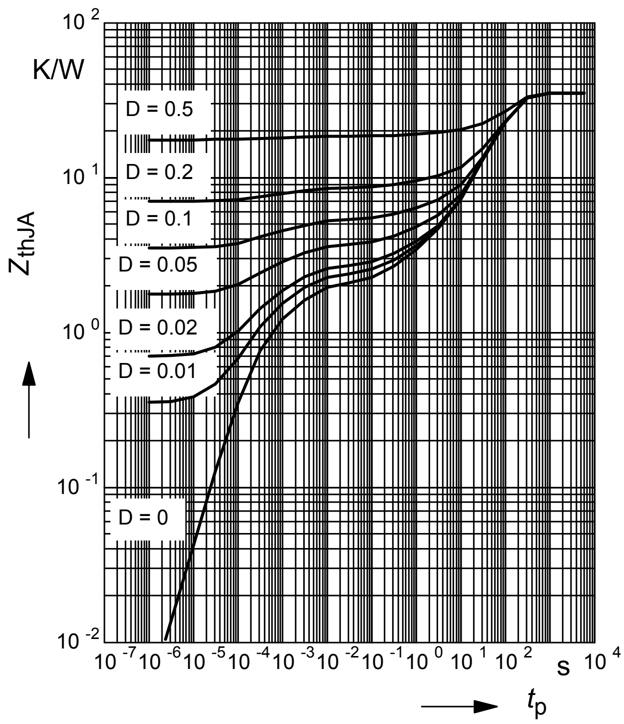
Parameter: D=t_p/T



Typ. transient thermal impedance

Z_{thJA}**=f(** t_p **) @ 6cm² heatsink area**

Parameter: D=t_p/T



Timing diagrams

Figure 1a: Vbb turn on:

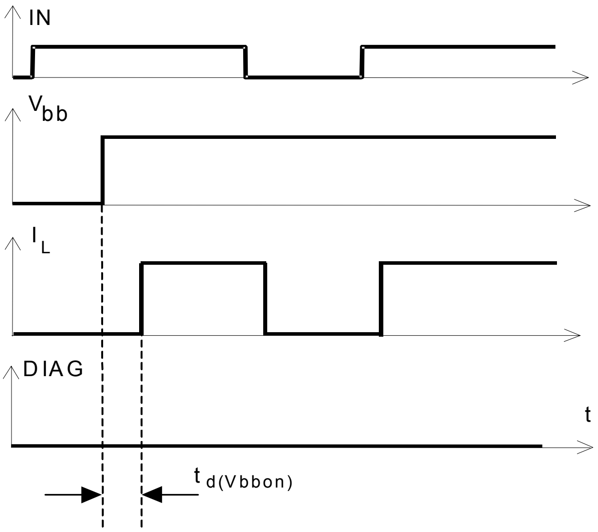


Figure 2b: Switching a lamp

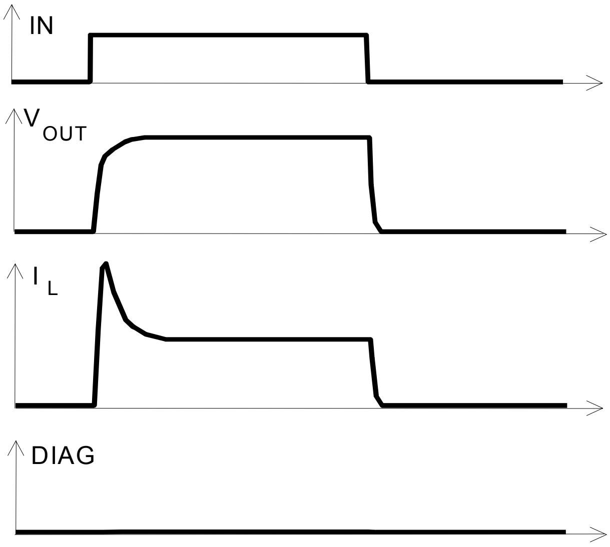


Figure 2a: Switching a resistive load, turn-on/off time and slew rate definition

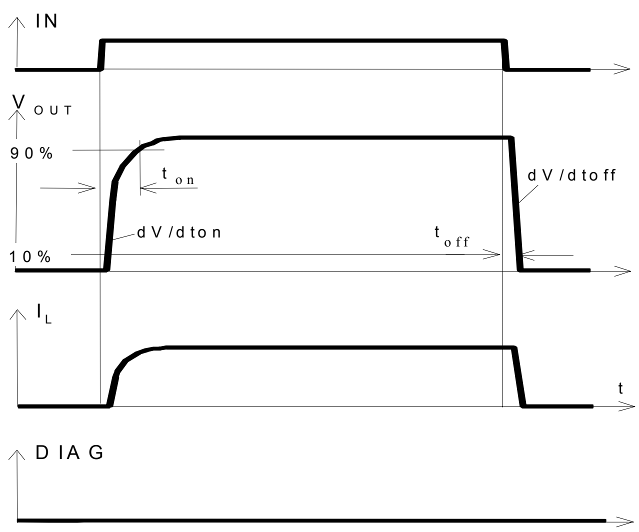


Figure 2c: Switching an inductive load

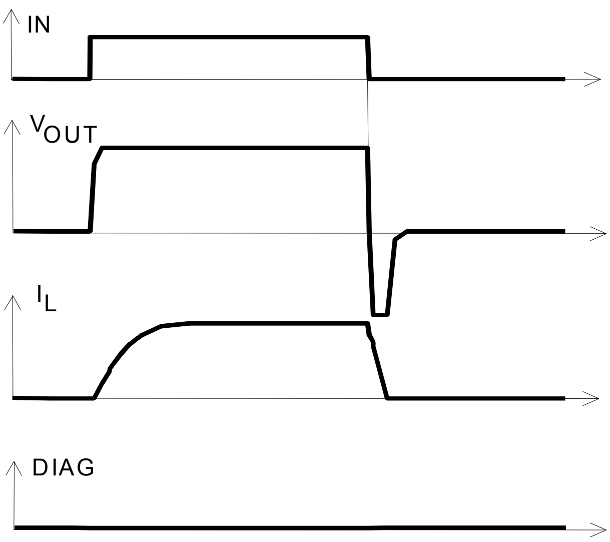
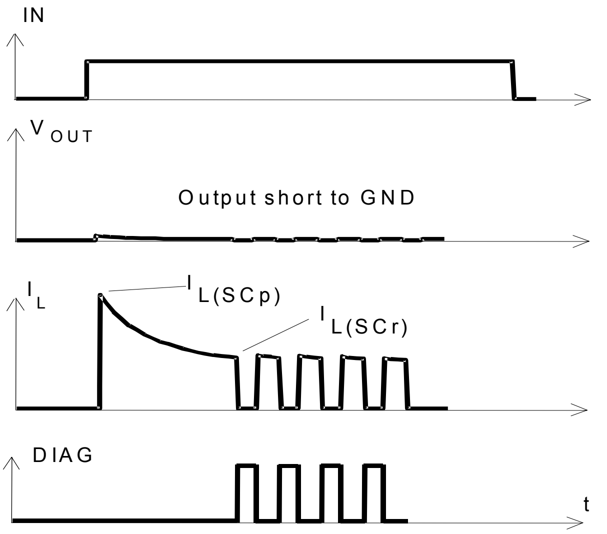


Figure 3a: Turn on into short circuit,
shut down by overtemperature, restart by cooling



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

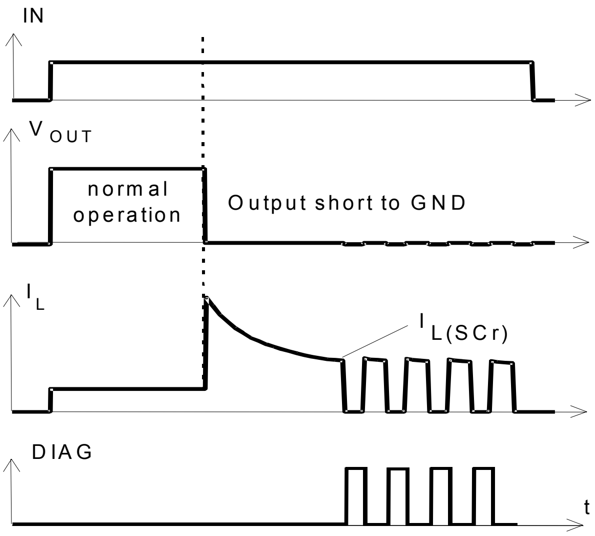


Figure 4: Overtemperature:
Reset if $T_j < T_{jt}$

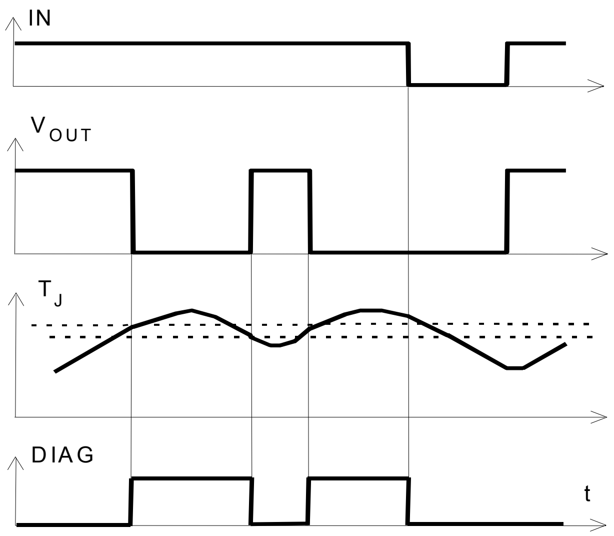
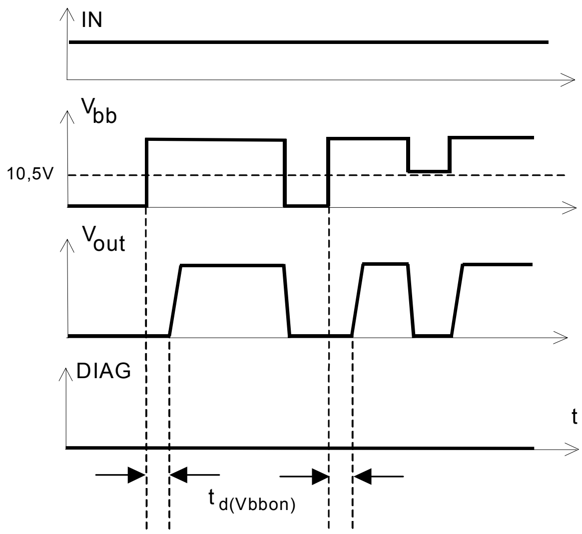


Figure 5: Undervoltage shutdown and restart

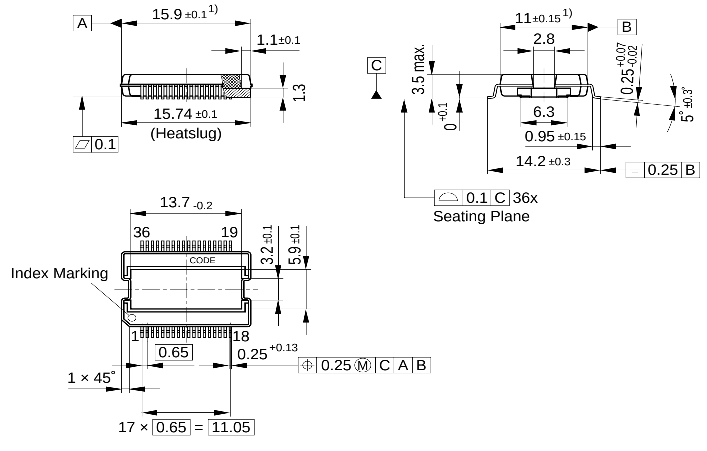


Package and ordering code

all dimensions in mm

Ordering code:

BTS 4880 R	Q67060-S7020



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

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