

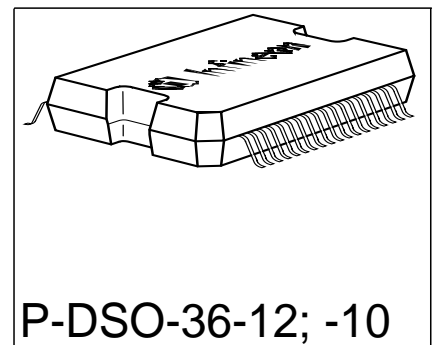
Smart Power High-Side-Switch Eight Channels: 8 x 200 mΩ

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 |



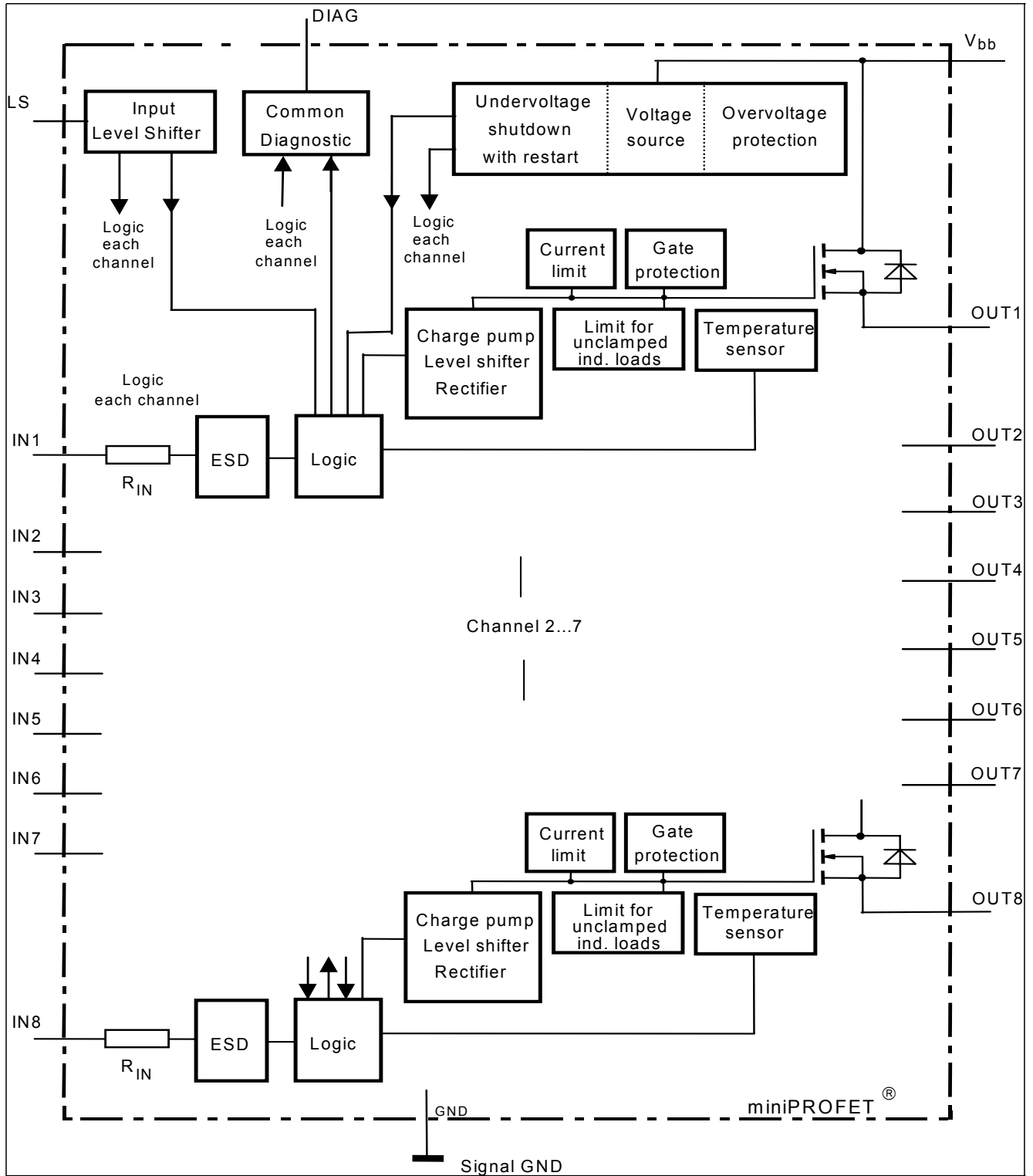
Application

- Output driver for industrial applications (PLC)
- All types of resistive, inductive and capacitive loads
- μ C 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 | Symbol | Value | Unit |
|---|----------------|------------------------|------|
| at $T_j = -40...135\text{ °C}$, unless otherwise specified | | | |
| 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, $T_j = 125\text{ °C}$, $I_L = 0.625\text{ A}$ one channel active all channels simultaneously active (each channel) | E_{AS} | | J |
| | | 10 | |
| | | 1 | |
| Load dump protection ⁴⁾ $V_{LoadDump}^{5)} = V_A + V_S$ $V_{IN} = \text{low or high}$ $t_d = 400\text{ ms}$, $R_I = 2\ \Omega$, $R_L = 27\ \Omega$, $V_A = 13.5\text{ V}$ $t_d = 350\text{ ms}$, $R_I = 2\ \Omega$, $R_L = 47\ \Omega$, $V_A = 27\text{ V}$ | $V_{Loaddump}$ | | V |
| | | 90 | |
| | | 117 | |
| Electrostatic discharge 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} | | kV |
| | | ± 1 | |
| | | ± 5 | |
| Continuous reverse drain current ¹⁾⁴⁾ , each channel | I_S | 4 | A |

¹⁾ defined by P_{tot}

²⁾ At $V_{IN} > V_{bb}$, the input current is not allowed to exceed $\pm 5\text{ mA}$.

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 | Symbol | Values | | | Unit |
|--|--------|--------|------|------|------|
| | | min. | typ. | max. | |
| at $T_j = -25...125^\circ\text{C}$, $V_{bb} = 15...30\text{V}$, unless otherwise specified | | | | | |

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 $T_j = 25^\circ\text{C}$, $I_L = 0.5\text{ A}$ $T_j = 125^\circ\text{C}$ | R_{ON} | - | 150 270 | 200 320 | m Ω |
| Turn-on time to 90% V_{OUT} $R_L = 47\ \Omega$, $V_{IN} = 0$ to 10 V | t_{on} | - | 50 | 100 | μs |
| Turn-off time to 10% V_{OUT} $R_L = 47\ \Omega$, $V_{IN} = 10$ to 0 V | t_{off} | - | 75 | 150 | |
| Slew rate on 10 to 30% V_{OUT} , $R_L = 47\ \Omega$, $V_{bb} = 15\text{ V}$ | dV/dt_{on} | - | 1 | 2 | V/ μs |
| Slew rate off 70 to 40% V_{OUT} , $R_L = 47\ \Omega$, $V_{bb} = 15\text{ V}$ | $-dV/dt_{off}$ | - | 1 | 2 | |

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

Electrical Characteristics

| Parameter | Symbol | Values | | | Unit |
|--|--------|--------|------|------|------|
| | | min. | typ. | max. | |
| at $T_j = -25...125^\circ\text{C}$, $V_{bb}=15...30\text{V}$, unless otherwise specified | | | | | |

Operating Parameters

| | | | | | |
|---|-------------------------------|----|-----|------|---------------|
| Operating voltage | $V_{bb(\text{on})}$ | 11 | - | 45 | V |
| Undervoltage shutdown | $V_{bb(\text{under})}$ | 7 | - | 10.5 | |
| Undervoltage restart | $V_{bb(\text{u rst})}$ | - | - | 11 | |
| Undervoltage hysteresis $\Delta V_{bb(\text{under})} = V_{bb(\text{u rst})} - V_{bb(\text{under})}$ | $\Delta V_{bb(\text{under})}$ | - | 0.5 | - | |
| Standby current | $I_{bb(\text{off})}$ | - | 50 | 150 | μA |
| Operating current ¹⁾ | I_{GND} | - | 5 | 12 | mA |
| Leakage output current (included in $I_{bb(\text{off})}$) $V_{\text{IN}} = \text{low}$, each channel | $I_{\text{L}(\text{off})}$ | - | 5 | 10 | μA |

Protection Functions²⁾

| | | | | | |
|---|----------------------------|---------------|---------------|---------------|------------------|
| Initial peak short circuit current limit $T_j = -25^\circ\text{C}$, $V_{bb} = 30\text{V}$, $t_m = 700\ \mu\text{s}$ $T_j = 25^\circ\text{C}$ $T_j = 125^\circ\text{C}$ | $I_{\text{L}(\text{SCp})}$ | - - 0.7 | - 1.4 - | 1.9 - - | A |
| Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams) | $I_{\text{L}(\text{SCr})}$ | - | 1.1 | - | |
| Output clamp (inductive load switch off) at $V_{\text{OUT}} = V_{bb} - V_{\text{ON}(\text{CL})}$, | $V_{\text{ON}(\text{CL})}$ | 47 | 53 | 60 | V |
| Overvoltage protection ³⁾ | $V_{bb(\text{AZ})}$ | 47 | - | - | |
| Thermal overload trip temperature ⁴⁾ | T_{jt} | 135 | - | - | $^\circ\text{C}$ |
| 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 $V_{\text{ON}(\text{CL})}$ in circuit diagram on page 10

⁴⁾ higher operating temperature at normal function for each channel available

Electrical Characteristics

| Parameter at $T_j = -25...125^\circ\text{C}$, $V_{bb}=15...30\text{V}$, 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} | $t_{d(V_{bb}on)}$ | 150 | 340 | - | μs |
| Input resistance (see page 10) | R_I | 2 | 3 | 4 | $\text{k}\Omega$ |
| Internal pull down resistor at LS-pin ³⁾ | R_{LS} | 300 | 800 | - | |

Diagnostic Characteristics

| | | | | | |
|---|------------------|---|---|---|---------------|
| Common diagnostic output current ⁴⁾ (overtemperature of any channel) $T_j = 135^\circ\text{C}$ | I_{diag} | 2 | 3 | 4 | mA |
| Common diagnostic output leakage current | $I_{diag(high)}$ | - | - | 2 | μA |

¹⁾At $V_{IN} > V_{bb}$, the input current is not allowed to exceed $\pm 5\text{ mA}$.

²⁾see page 9

³⁾LS-pin is connected to V_{bb}

⁴⁾see page 10

Electrical Characteristics

| Parameter at $T_j = -25...125^\circ\text{C}$, $V_{bb}=15...30\text{V}$, unless otherwise specified | Symbol | Values | | | Unit |
|---|--------|--------|------|------|------|
| | | min. | typ. | max. | |

Reverse Battery

| | | | | | |
|---|------------------|---|---|---------|---|
| Reverse battery voltage ¹⁾ $R_{\text{GND}} = 0 \Omega$ $R_{\text{GND}} = 150 \Omega$ | $-V_{\text{bb}}$ | - | - | 1 45 | V |
| Diode forward on voltage $I_F = 1.25 \text{ A}$, $V_{\text{IN}} = \text{low}$, each channel | $-V_{\text{ON}}$ | - | - | 1.2 | |

¹defined by P_{tot}

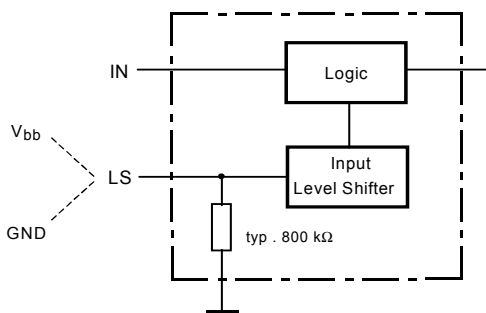
Truth table for common diagnostic pin (LED-driver):

| | Input level | Output level | Diagnostic |
|----------------------|-------------|--------------|-----------------|
| Normal operation | L | L | L |
| | H | H | L |
| Short circuit to GND | L | L | L |
| | H | L | L |
| Undervoltage | L | L | L |
| | H | L | L |
| Overtemperature | L | L | L |
| | H | 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

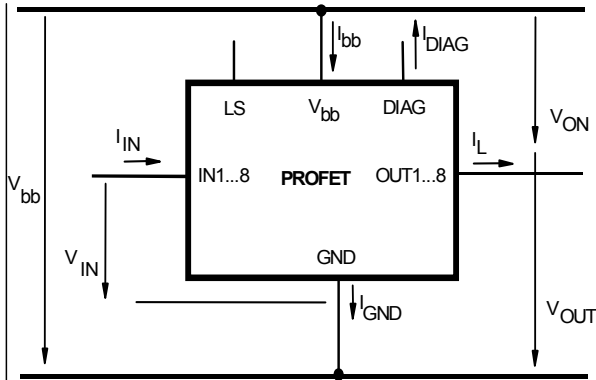
CMOS - Input level

State 2: LS-Pin to supply voltage

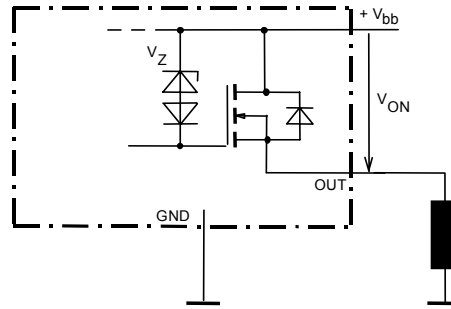
$V_{bb}/2$ - Input level

¹toggeling with restart

Terms
each channel

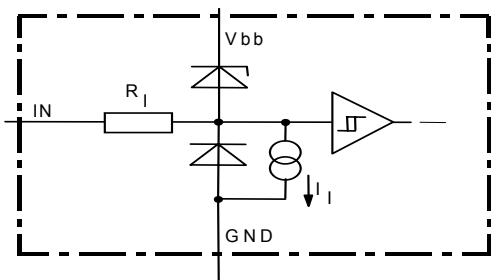


Inductive and overvoltage output clamp
each channel



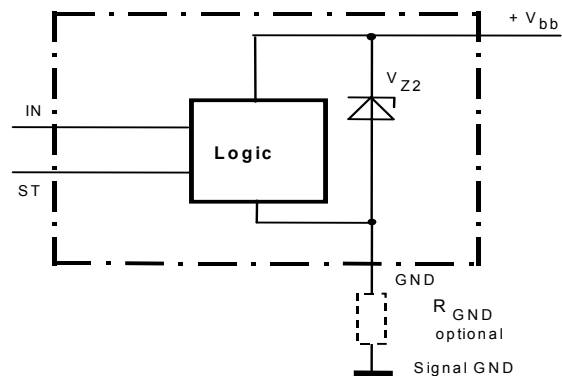
V_{ON} clamped to 47 V min.

Input circuit (ESD protection)
each channel



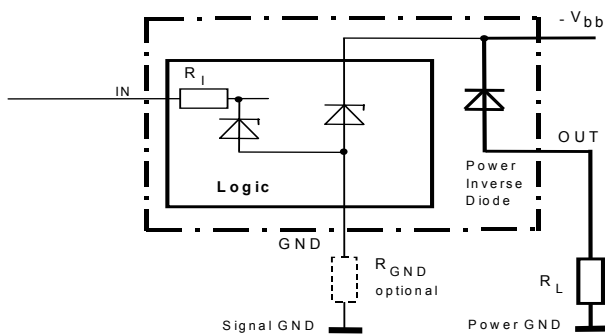
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



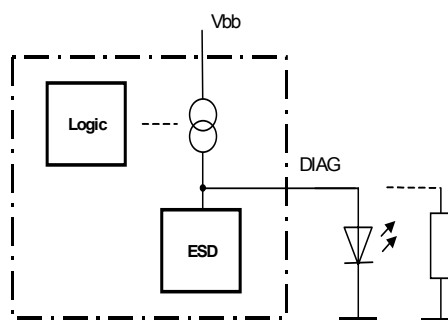
$V_{Z2} = V_{bb(AZ)} = 47 \text{ V min.}$,
 $R_I = 3 \text{ k}\Omega \text{ typ.}$, $R_{GND} = 150 \Omega$

Reverse battery protection
each channel



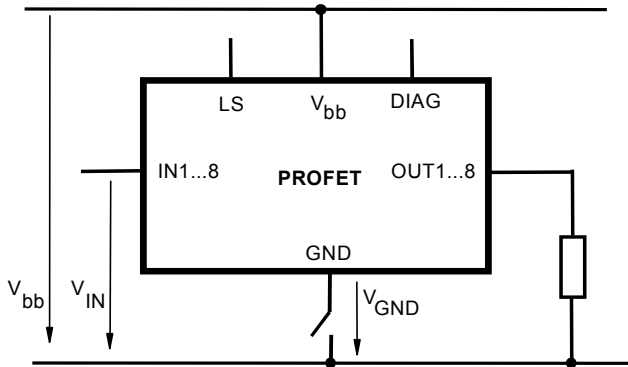
$R_{GND} = 150 \Omega$, $R_I = 3 \text{ k}\Omega \text{ typ.}$,
Temperature protection is not active during inverse current

Common diagnostic output

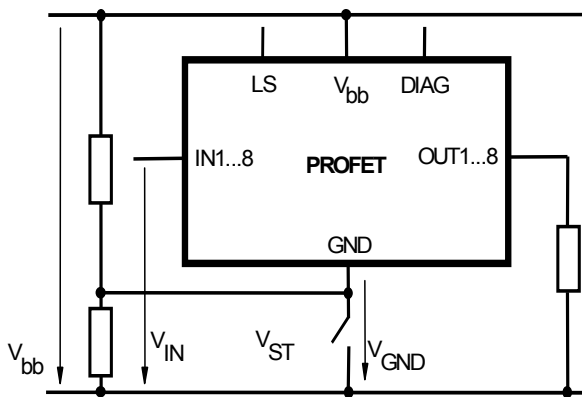


Output current typ. 2 mA

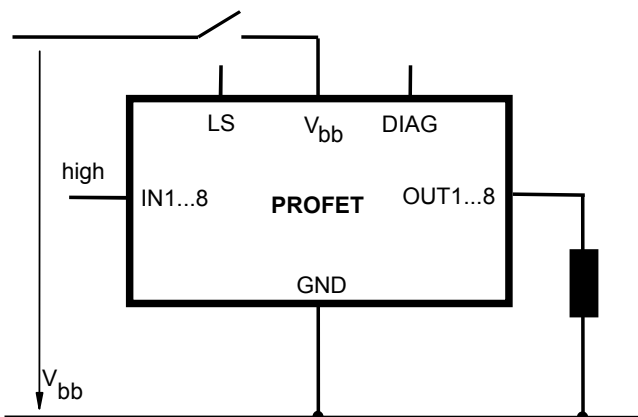
GND disconnect



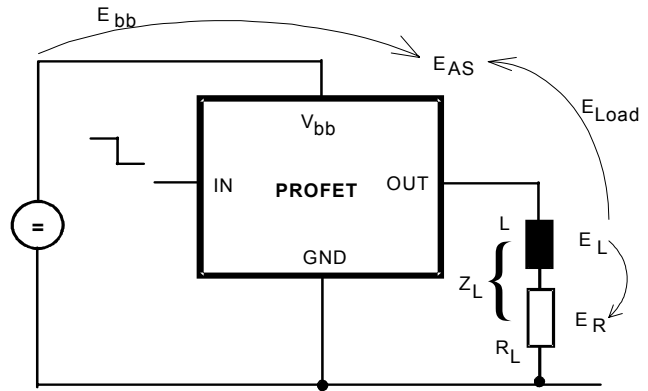
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation, each channel



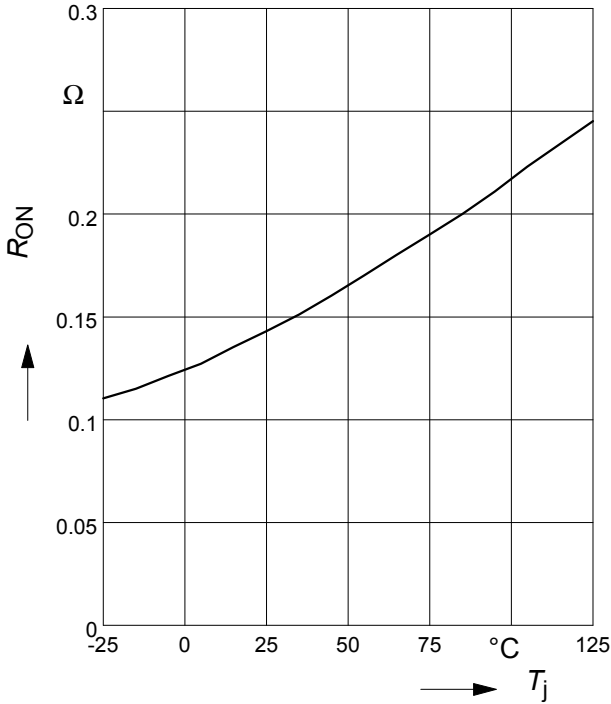
Energy stored in load inductance: $E_L = \frac{1}{2} * L * I_L^2$

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

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

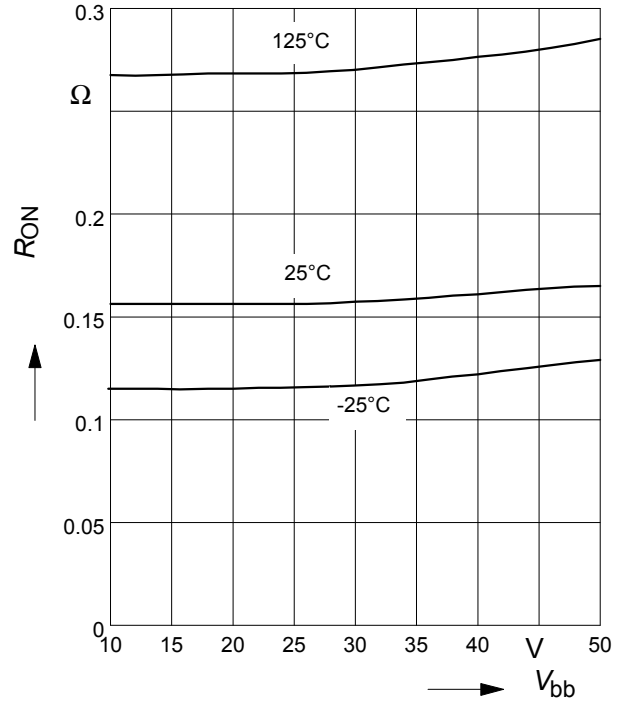
Typ. on-state resistance

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



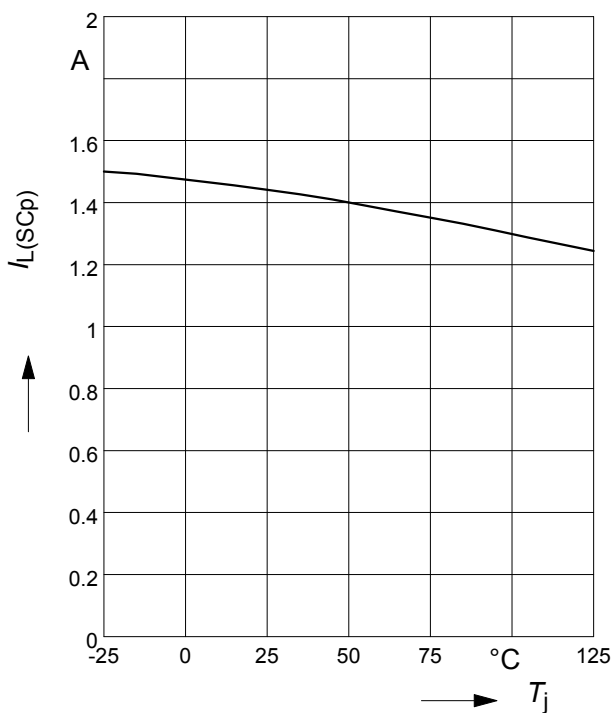
Typ. on-state resistance

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



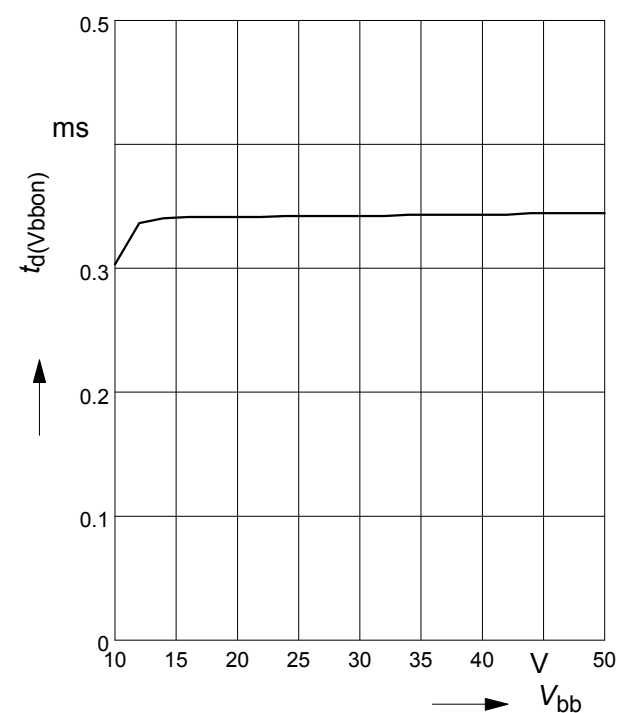
Typ. initial peak short circuit current limit

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



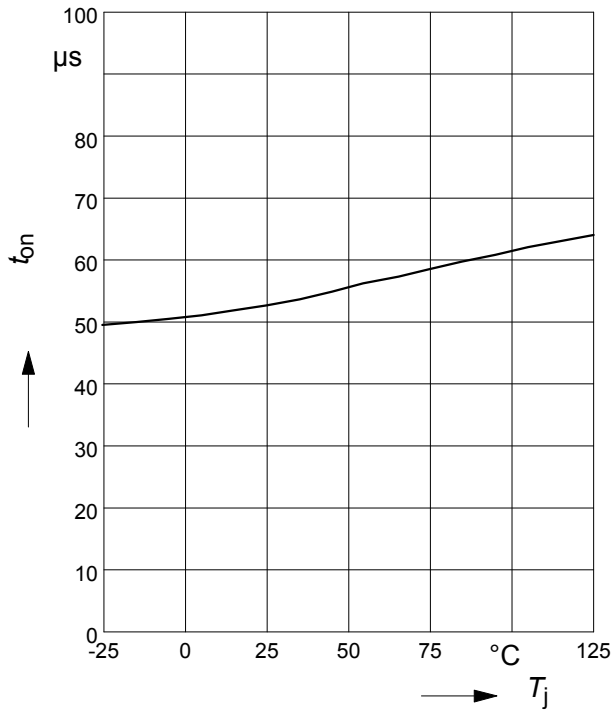
Typ. input delay time at switch on V_{bb}

$t_d(V_{bbon}) = f(V_{bb})$; $T_j = -25...125$ °C



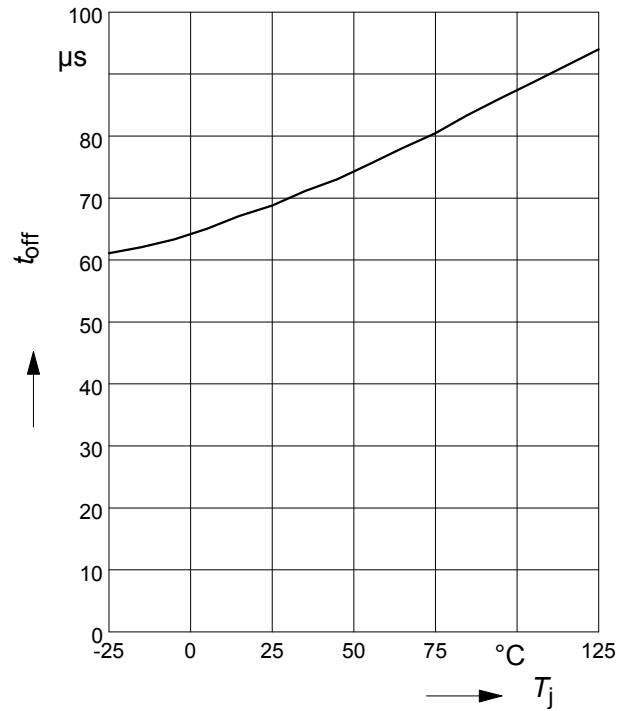
Typ. turn on time

$t_{on} = f(T_j); R_L = 47\Omega$



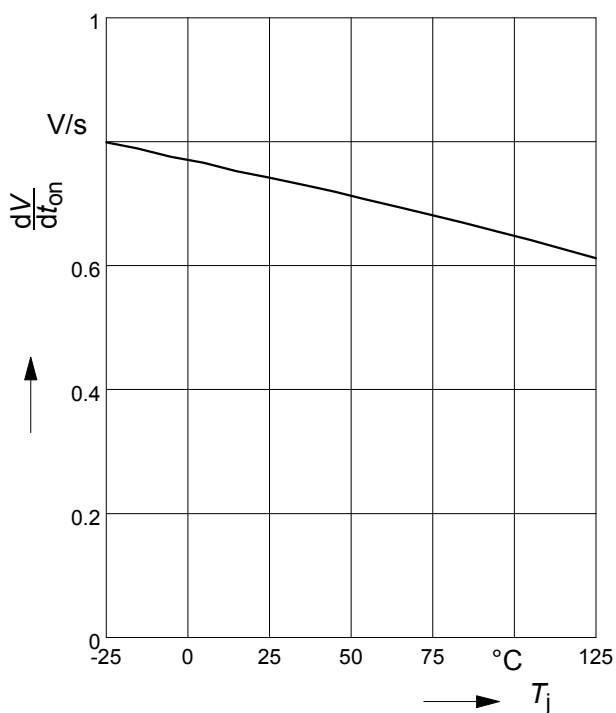
Typ. turn off time

$t_{off} = f(T_j); R_L = 47\Omega$



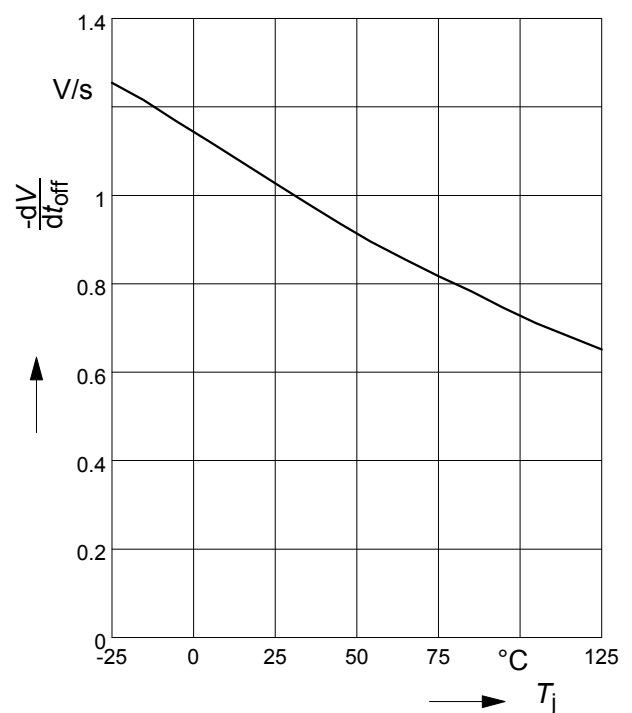
Typ. slew rate on

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



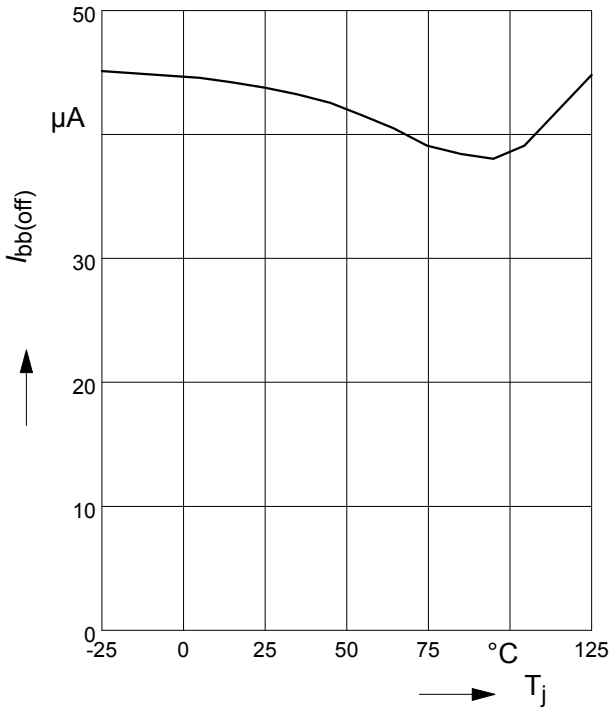
Typ. slew rate off

$-dV/dt_{off} = f(T_j); R_L = 47\Omega, V_{bb} = 15V$



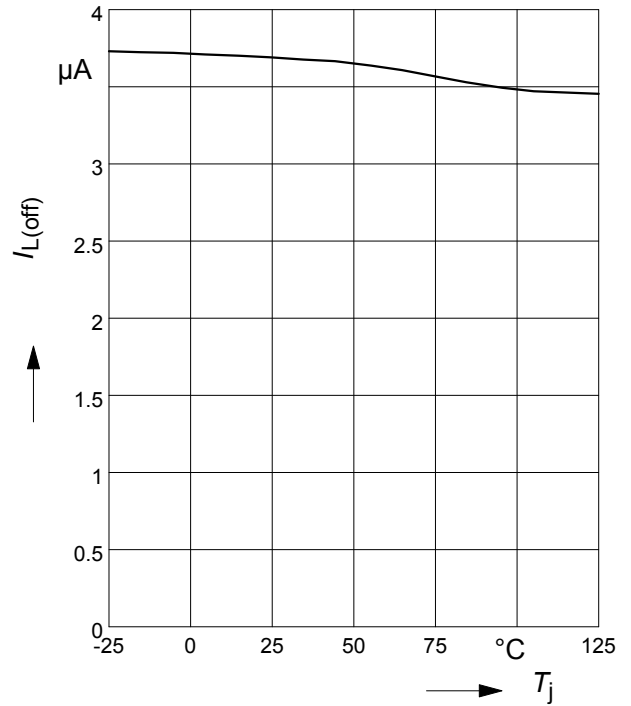
Typ. standby current

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



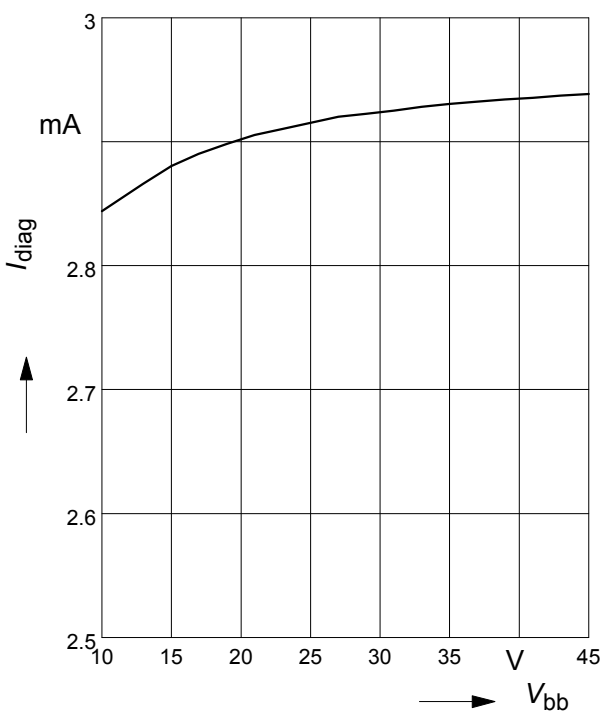
Typ. leakage current

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



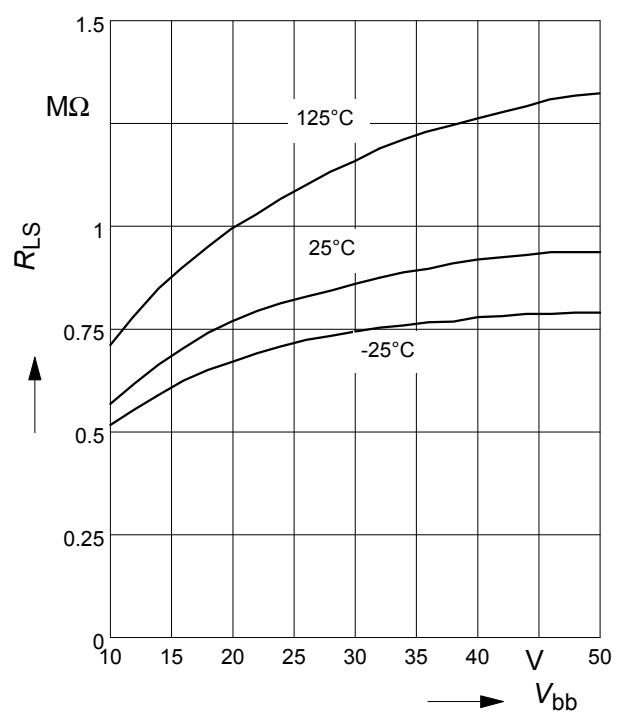
Typ. common diagnostic output current

$I_{diag} = f(V_{bb}) ; T_j = 135^{\circ}C$



Typ. internal pull down resistor at LS-pin

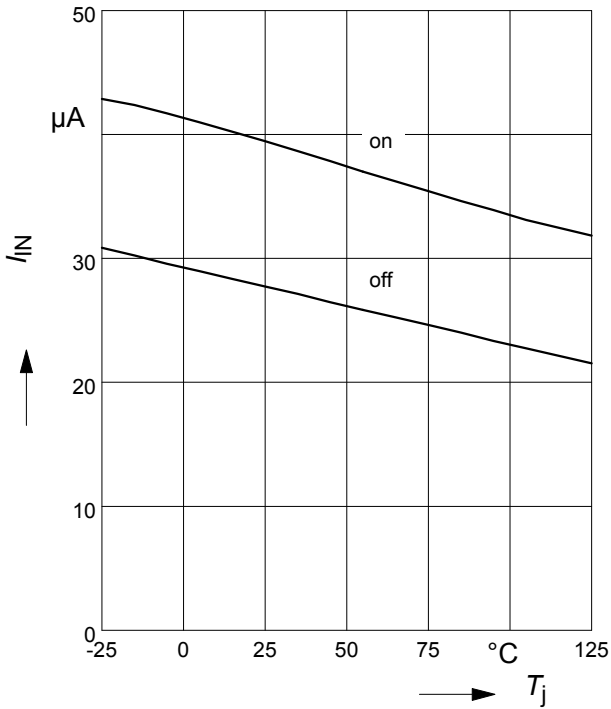
$R_{LS} = f(V_{bb}) ; V_{LS} = V_{bb}$



Typ. input current @ CMOS level

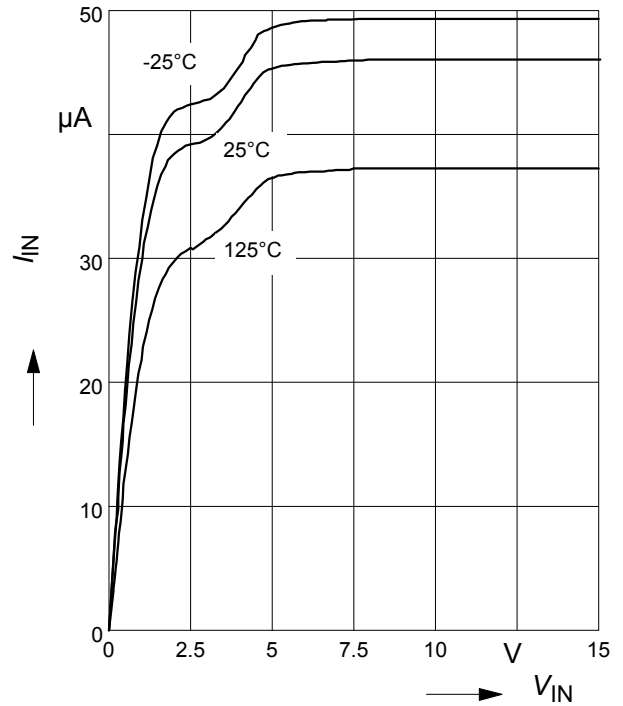
$I_{IN(on/off)} = f(T_j)$; $V_{bb} = 15V$; $V_{IN} = \text{low/high}$

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



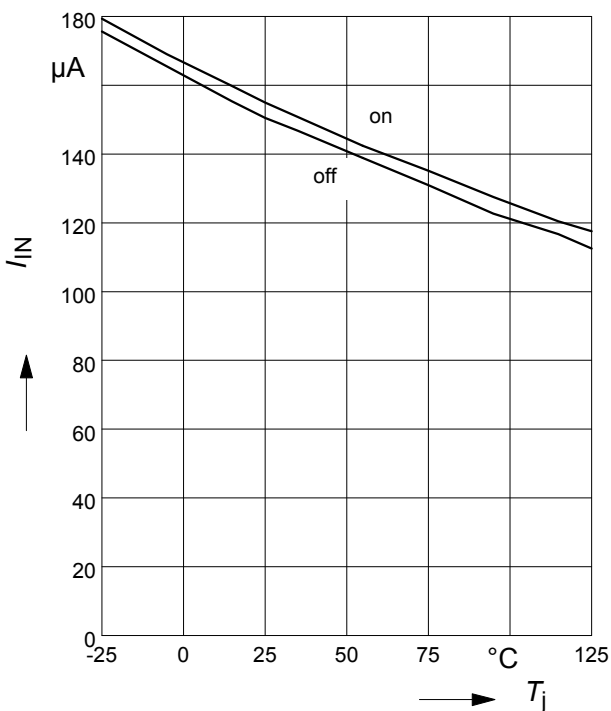
Typ. input current @ CMOS level

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



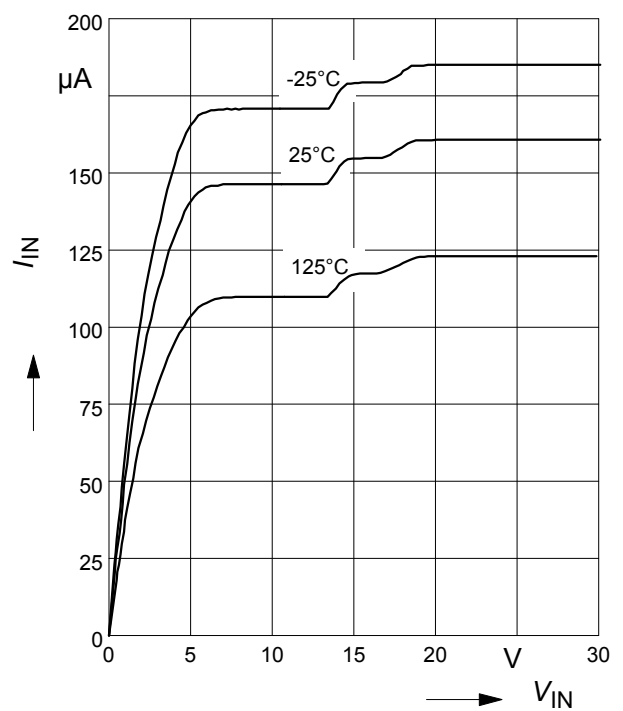
Typ. input current @ V_{bb}/2 level

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



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

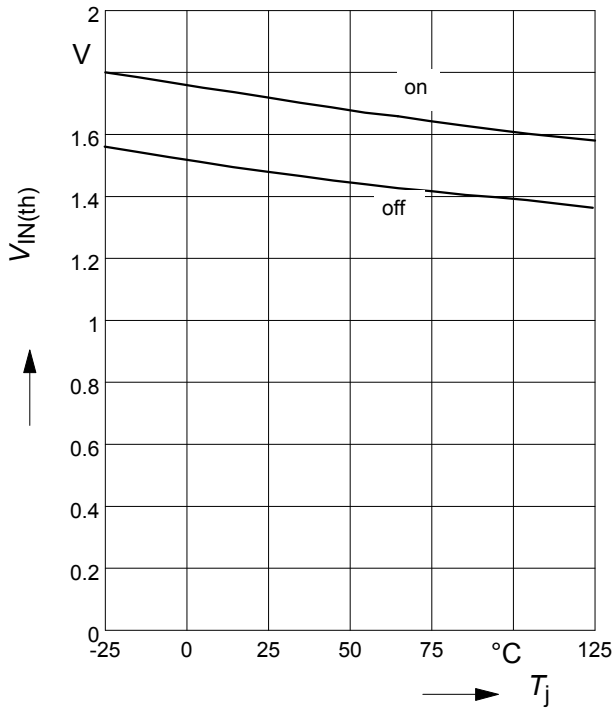
$I_{IN} = f(V_{IN})$; $V_{bb} = 30V$



Typ. input threshold voltage

@ CMOS level

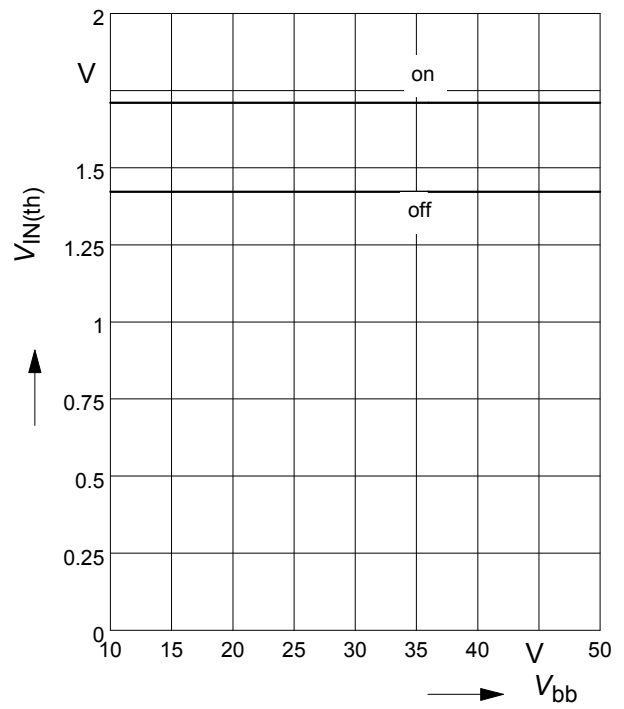
$V_{IN(th)} = f(T_j) ; V_{bb} = 15V$



Typ. input threshold voltage

@ CMOS level

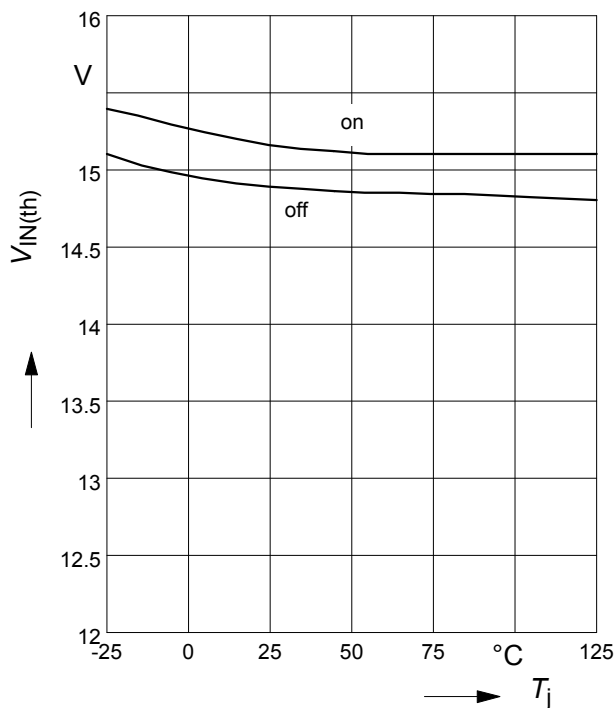
$V_{IN(th)} = f(V_{bb}) ; T_j = 25^{\circ}C$



Typ. input threshold voltage

@ V_{bb}/2 level

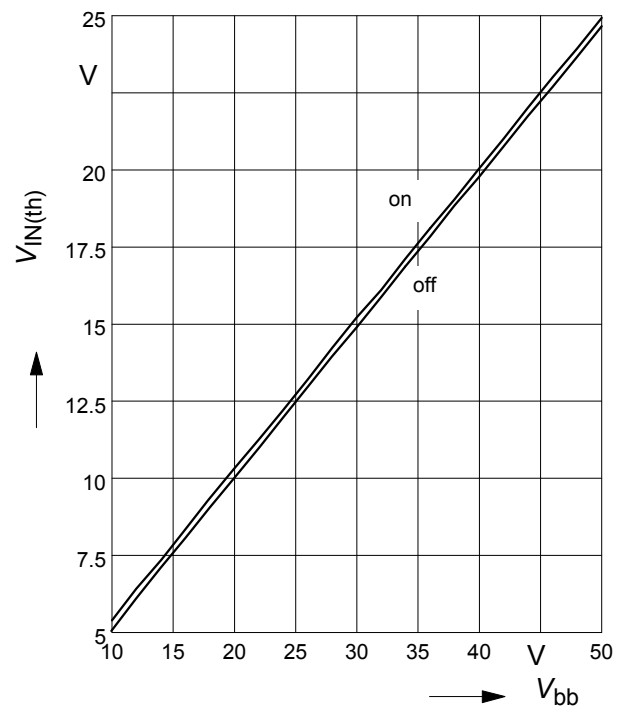
$V_{IN(th)} = f(T_j) ; V_{bb} = 30V$



Typ. input threshold voltage

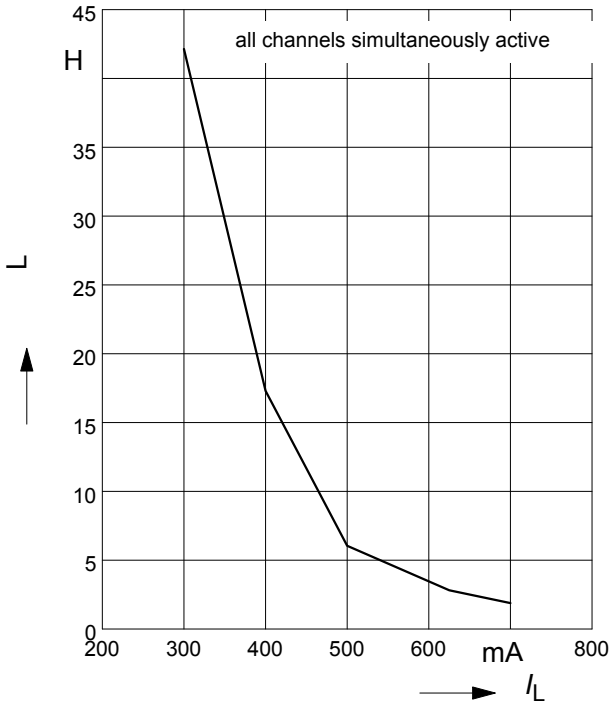
@ V_{bb}/2 level: LS-pin connected to V_{bb}

$V_{IN(th)} = f(V_{bb}) ; T_j = 25^{\circ}C$



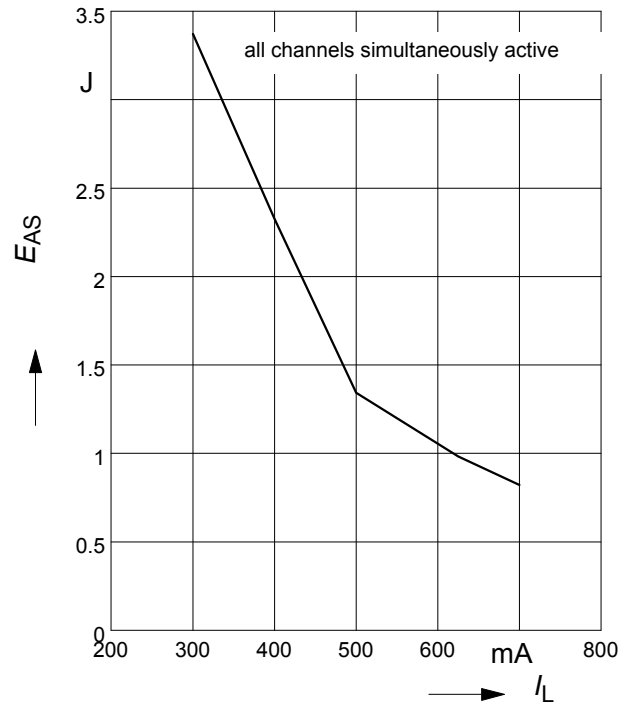
Maximum allowable load inductance for a single switch off, calculated

$L = f(I_L); T_{jstart}=125^{\circ}C, V_{bb}=24V, R_L=0\Omega$



Maximum allowable inductive switch-off energy, single pulse

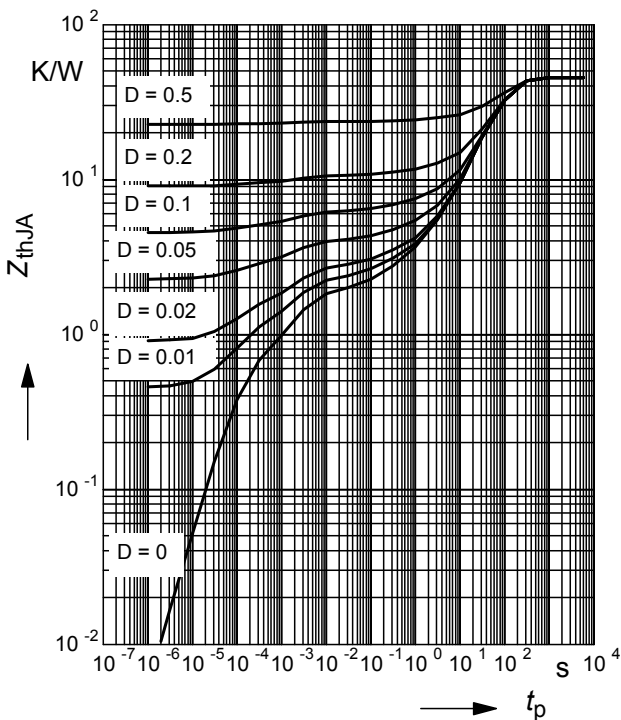
$E_{AS} = f(I_L); T_{jstart} = 125^{\circ}C, V_{bb} = 24V$



Typ. transient thermal impedance

$Z_{thJA}=f(t_p) @ \text{min. footprint}$

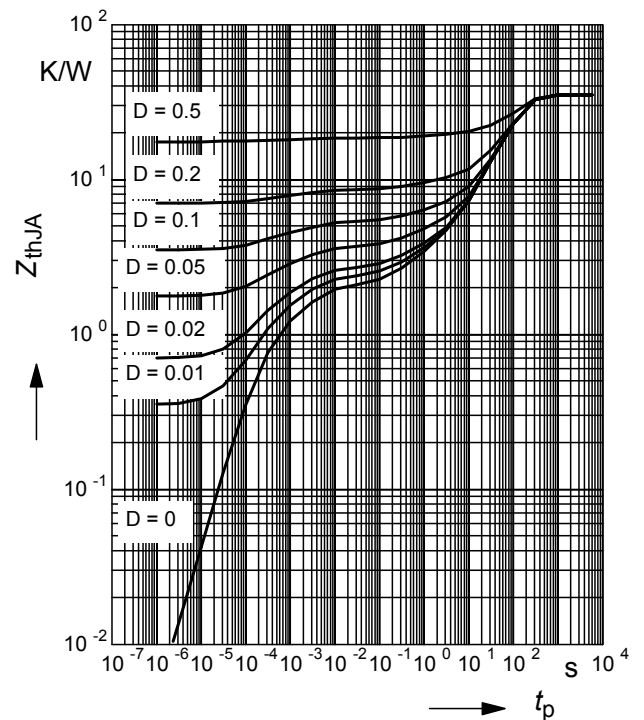
Parameter: $D=t_p/T$



Typ. transient thermal impedance

$Z_{thJA}=f(t_p) @ 6\text{cm}^2 \text{ heatsink area}$

Parameter: $D=t_p/T$



Timing diagrams

Figure 1a: V_{bb} turn on:

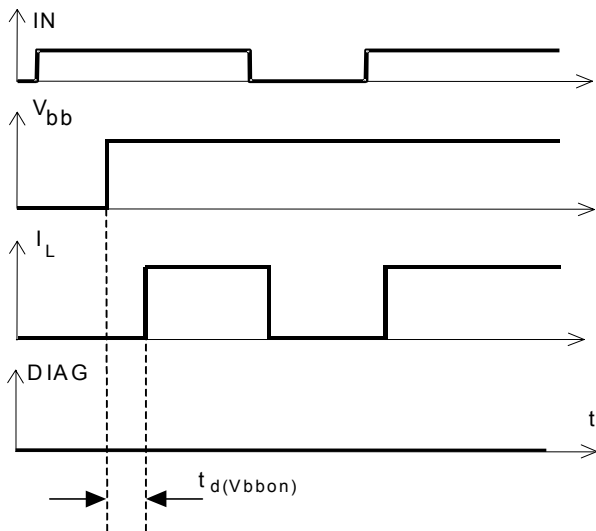


Figure 2b: Switching a lamp

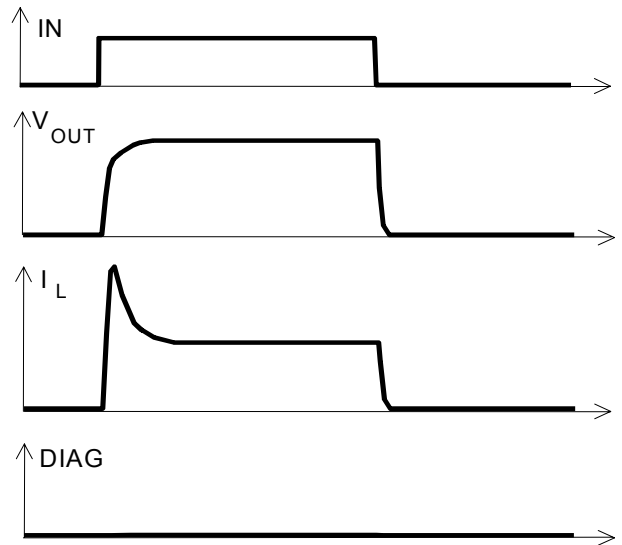


Figure 2a: Switching a resistive load, turn-on/off time and slew rate definition

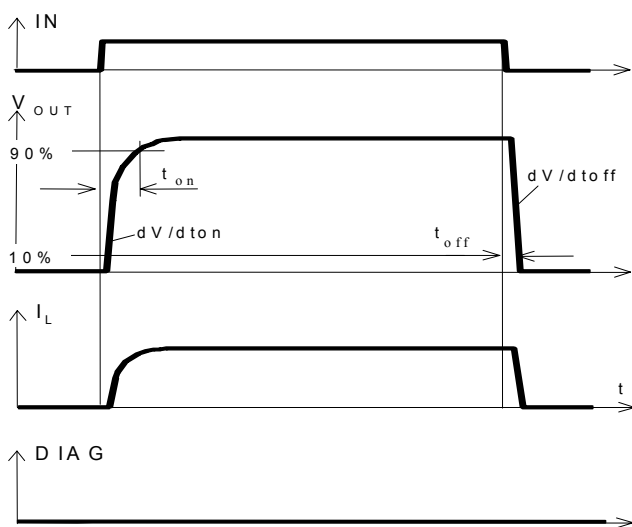


Figure 2c: Switching an inductive load

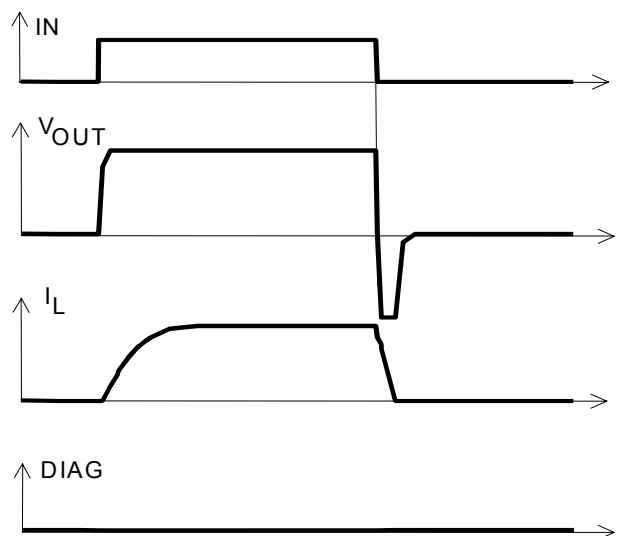
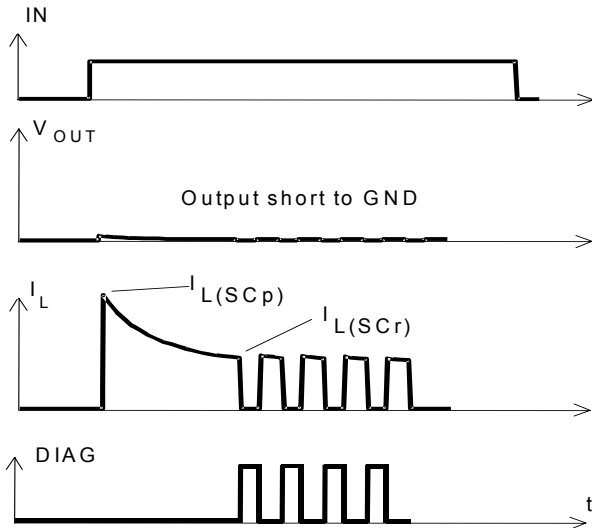


Figure 3a: Turn on into short circuit, shut down by overtemperature, restart by cooling



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

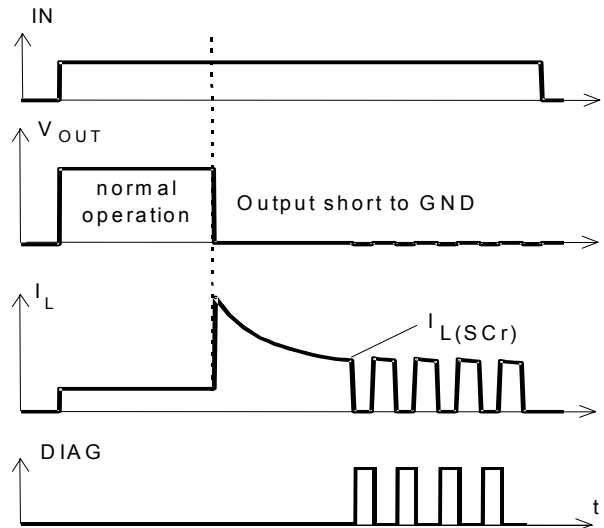


Figure 4: Overtemperature:
Reset if $T_j < T_{jt}$

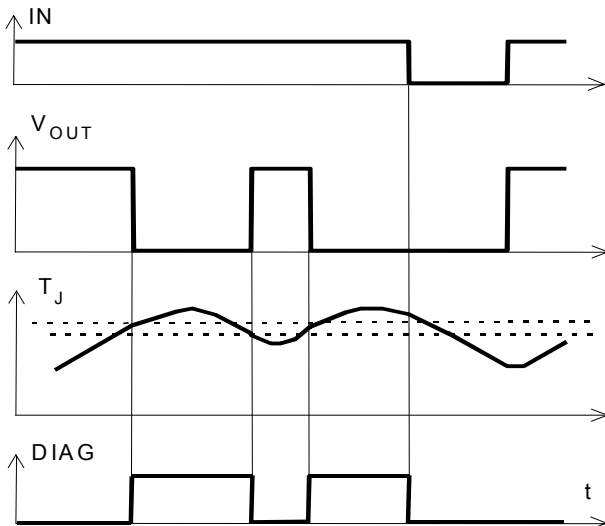
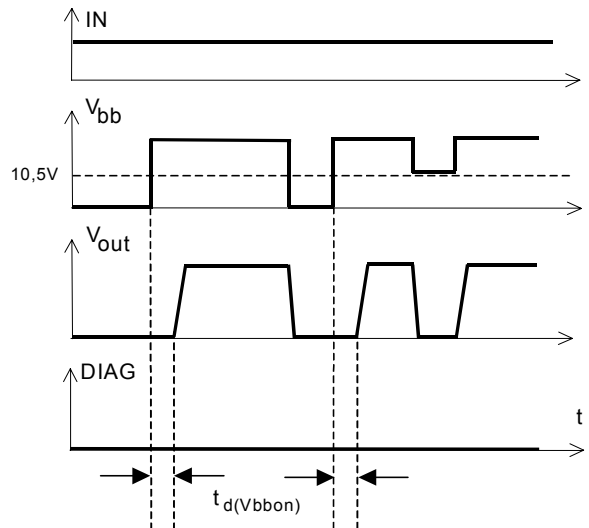


Figure 5: Undervoltage shutdown and restart

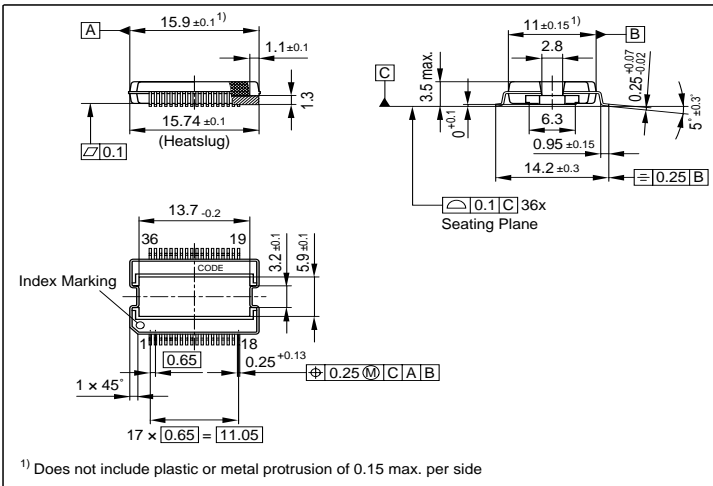


Package and ordering code

all dimensions in mm

Ordering code:

| | |
|------------|--------------|
| BTS 4880 R | Q67060-S7020 |
|------------|--------------|



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