

# FDDS100H06\_F085 Smart High Side Switch

## Features

- Short circuit protection
- Current limitation
- Thermal shutdown with restart.
- Overvoltage protection(including load dump)
- Very low standby current
- Under voltage and over voltage shutdown with auto-restart and hysteresis.
- Fast demagnetization of inductive loads
- Open load detection in ON-state
- CMOS compatible input
- ESD protection
- Optimized static electromagnetic compatibility
- Open drain fault output
- Qualified to AEC Q100

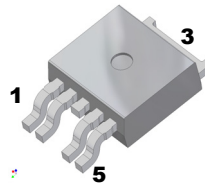
## Typical Applications

- Power switch with diagnostic feedback for DC ground loads
- All types of resistive, inductive, and capacitive loads
- Replace electromechanical relays, fuses and discrete circuits

## Description

N channel power FET with charge pump, ground referenced CMOS compatible input and diagnostic output with integrated protective functions.

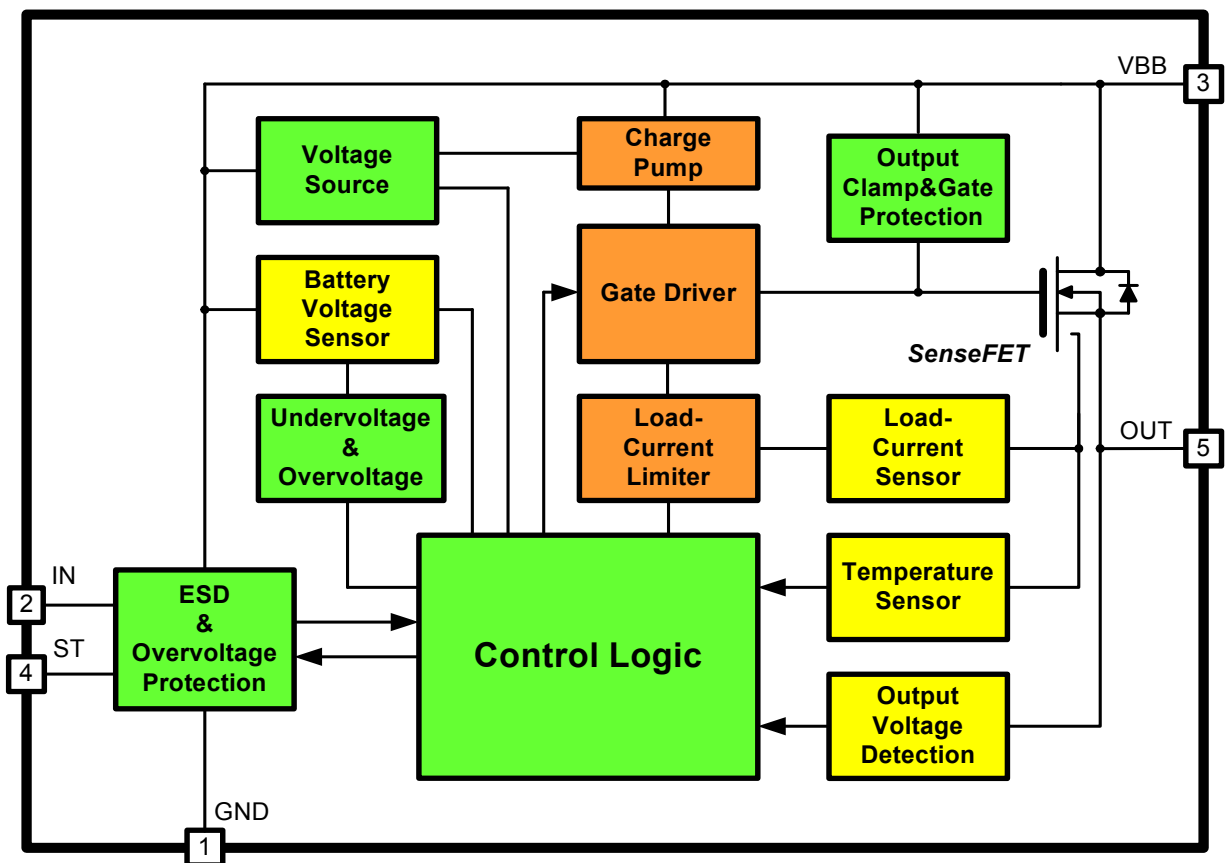
**TO252-5L**



## Ordering Information

| Device          | Package   | Operating Temp. |
|-----------------|-----------|-----------------|
| FDDS100H06_F085 | TO252- 5L | -40 °C ~ 150 °C |

## Block Diagrams



## Pin Definitions

| Pin Number | Pin Name | I/O | Pin Function Description                                |
|------------|----------|-----|---|
| 1          | GND      | P   | Ground  |
| 2          | IN       | A   | Input, activates the power switch in case of logic high |
| 3          | Vbb      | P   | Supply voltage; Pin3 and TAB are internally shorted     |
| 4          | ST       | A   | Fault signal feedback; low on failure                   |
| 5          | OUT      | A   | Output to loads   |

## Absolute Maximum Ratings

At Tj=25°C unless otherwise specified.

| Parameter  | Symbol                              | Values           | Unit |    |
|--|-------------------------------------|------------------|------|----|
| Supply voltage <sup>1)</sup>   | V <sub>bb</sub>                     | 37               | V    |    |
| Supply voltage for full short circuit protection   | V <sub>bb</sub>                     | 34               | V    |    |
| Load dump protection V <sub>LoadDump</sub> = UA + VS, UA=13.5V<br>Ri=2Ω, RL=12Ω, td=400ms, IN=Low or High                      | V <sub>LoadDump</sub> <sup>2)</sup> | 60               | V    |    |
| Load current (Short-circuit current) <sup>3)</sup>   | IL                                  | Self-limited     | V    |    |
| Operating temperature range  | T <sub>j</sub>                      | -40 ~ 150        | °C   |    |
| Storage temperature range  | T <sub>stg</sub>                    | -55 ~ 150        | °C   |    |
| Power Dissipation(DC) TC ≤ 25 °C   | P <sub>tot</sub>                    | 41.6             | W    |    |
| Inductive load switch-off energy dissipation <sup>4)</sup><br>Single pulse, IL= 2.67A, L=100mH, V <sub>bb</sub> =12V, Tj=150°C | EAS                                 | 0.425            | J    |    |
| Electrostatic discharge capability (ESD)   | HBM (Human Body Model)              | V <sub>ESD</sub> | 4    | KV |
|  | CDM (Charged Device Model)          |                  | 2    | KV |
| Input Voltage (DC)   | V <sub>IN</sub>                     | -0.5 ... + 5.4   | V    |    |
| Current through input pin(DC)  | I <sub>IN</sub>                     | +/-2             | mA   |    |
| Current through status pin(DC)   | I <sub>ST</sub>                     | +/-5             | mA   |    |

Note:

- 1) See also on page 04.
- 2) V<sub>Load dump</sub> is setup without the DUT connected to the generator.
- 3) See also diagram on page 05.
- 4) not subject to production test, specified by design. See also on page 10.

## Electrical Characteristics

At T<sub>j</sub>=25°C, V<sub>bb</sub>=12V unless otherwise specified.

| Parameter  | Symbol                  | Conditions  | Min. | Typ.      | Max.       | Unit |
|--|-------------------------|---|------|-----------|------------|------|
| <b>Thermal Characteristics</b>                       |                         |   |      |           |            |      |
| Thermal resistance                                   | R <sub>thJC</sub>       | (junction to case)  | -    | -         | 3          | K/W  |
|  | R <sub>thJA</sub>       | Mini. footprint (junction to ambient)   | -    | 99        | -          | -    |
|  |                         | 1 Inch <sup>2</sup> device on PCB <sup>1)</sup>   | -    | 35        | 45         | -    |
| <b>Load Switching Capability and Characteristics</b> |                         |   |      |           |            |      |
| On-state resistance(Pin3 to pin 5)                   | R <sub>ON</sub>         | V <sub>IN</sub> =5V, V <sub>bb</sub> =12V, I <sub>L</sub> =2.5A T <sub>j</sub> =25°C<br>V <sub>IN</sub> =5V, V <sub>bb</sub> =12V, I <sub>L</sub> =2.5A T <sub>j</sub> =150°C | -    | 80<br>160 | 100<br>200 | mΩ   |
| Nominal load current( tab to pin5)                   | I <sub>L(NOM)</sub>     | SMD <sup>1)</sup> V <sub>ON</sub> ≤ 0.5V, T <sub>a</sub> =85°C, T <sub>j</sub> ≤150°C   | 2.8  | 3.0       | -          | A    |
| Turn-on time ( to 90% V <sub>OUT</sub> )             | t <sub>on</sub>         | RL=12Ω, T <sub>j</sub> = -40~ 150°C   | 24   | 70        | 170        | us   |
| Turn-off time ( to 10% V <sub>OUT</sub> )            | t <sub>off</sub>        | RL=12Ω, T <sub>j</sub> = -40~ 150°C   | 10   | 66        | 170        | us   |
| Slew rate on (10% to 30% V <sub>OUT</sub> )          | dV / dt <sub>on</sub>   | RL=12Ω, T <sub>j</sub> = -40~ 150°C   | 0.2  | 0.8       | 1.5        | V/us |
| Slew rate off (70% to 40% V <sub>OUT</sub> )         | -dV / dt <sub>off</sub> | RL=12Ω, T <sub>j</sub> = -40~ 150°C   | 0.2  | 0.8       | 3          | V/us |
| <b>Operating Parameters</b>                          |                         |   |      |           |            |      |
| Operating Voltage                                    | V <sub>bb(ON)</sub>     | T <sub>j</sub> = -40~ 150°C   | 5.5  | -         | 37         | V    |
| Over voltage shutdown                                | V <sub>bb(SD)</sub>     | T <sub>j</sub> = -40~ 150°C   | 38   | 43.5      | 48         | V    |
| Over voltage restart                                 | V <sub>bb(RE)</sub>     | T <sub>j</sub> = -40~ 150°C   | 37.5 | -         | -          | V    |
| Over voltage hysteresis                              | V <sub>bb(HYS)</sub>    | T <sub>j</sub> = -40~ 150°C   | -    | 0.5       | -          | V    |
| Under voltage shutdown <sup>2)</sup>                 | V <sub>bb(u)</sub>      | T <sub>j</sub> = -40~ 150°C   | 2.5  | 3.5       | -          | V    |
| Under voltage restart                                | V <sub>bb(u rst)</sub>  | T <sub>j</sub> = -40~ 150°C   | -    | 4.2       | 5.2        | V    |
| Under voltage restart of charge pump                 | V <sub>bb(ucp)</sub>    | T <sub>j</sub> = -40~ 150°C   | -    | 5         | 5.5        | V    |
| Overvoltage protection <sup>3)</sup>                 | V <sub>bb(AZ)</sub>     | I <sub>bb</sub> =40mA, T <sub>j</sub> =-40 ~ 150°C  | 49   | 54        | 62         | V    |
| Standby current                                      | I <sub>bb(off)</sub>    | V <sub>IN</sub> =0, T <sub>j</sub> = -40~ 150°C   | -    | 4.8       | 15         | uA   |
| Leakage output current                               | I <sub>L(off)</sub>     | V <sub>IN</sub> =0, T <sub>j</sub> = -40~ 150°C   | -    | -         | 15         | uA   |
| Operating current <sup>4)</sup>                      | I <sub>bb(GND)</sub>    | V <sub>IN</sub> =5V, T <sub>j</sub> = -40~ 150°C  | -    | 0.5       | 2.0        | mA   |

Note:

1) Device on 76.2mm \* 114mm \* 1.57mm glass epoxy PCB FR4 with 1inch<sup>2</sup>(one layer 70um) copper area. still air condition.

2) Refer to page 13. Should reset I<sub>N</sub> to restart in case battery voltage comes back to normal operating range after undervoltage shutdown.

3) See also V<sub>ON(CL)</sub> in table of protection functions and circuit diagram on page 14.

4) Add I<sub>ST</sub>, if I<sub>ST</sub>>0, and add I<sub>IN</sub>, if V<sub>IN</sub> > 5.5V

## Electrical Characteristics

At Tj=25°C, Vbb=12V unless otherwise specified

| Parameter  | Symbol     | Conditions  | Min.        | Typ.          | Max.           | Unit |
|--|------------|---|-------------|---------------|----------------|------|
| <b>Protection Functions</b> <sup>1)</sup>  |            |   |             |               |                |      |
| Short circuit current limit (pin3 to pin 5)<br>VON > VON(SC)                               | IL(SCP)    | Tj=-40°C<br>Tj=25°C<br>Tj=150°C                   | 9<br>7<br>4 | 15<br>12<br>7 | 24<br>19<br>10 | A    |
| Short Circuit detection voltage  | VON(SC)    |   | -           | 4             | -              | V    |
| Short Circuit shutdown delay time  | td(SC)     | Tj=-40°C ~ 150°C<br>Minimum Input low time : 60us | 80          | 250           | 530            | us   |
| Output clamp(inductive load switch off)<br>at VOUT= Vbb-VON(CL)(overvoltage) <sup>2)</sup> | VON(CL)    | IL=40mA<br>Tj=-40°C ~ 150°C                       | 50          | 56.5          | 63             | V    |
| Thermal overload trip temperature  | Tjt        |   | 150         | 170           | -              | °C   |
| Thermal hysteresis   | ΔTjt       | VIN =5V   | -           | 10            | -              | K    |
| Reverse battery voltage <sup>3)</sup>  | -Vbb       |   | -           | -             | 32             | V    |
| <b>Diagnostic Characteristics</b>  |            |   |             |               |                |      |
| Open load detection current  | IL(OL)     | VIN =5V, Tj=-40 ~ 150°C                           | 12          | -             | 480            | mA   |
| <b>Input &amp; Status Feedback</b> <sup>4)</sup>   |            |   |             |               |                |      |
| Input Resistance   | RI         | Tj=-40 ~ 150°C                                    | 2.4         | 3.0           | 3.6            | KΩ   |
| Input turn-on threshold voltage  | VINH       | Tj=-40 ~ 150°C                                    | -           | 2.2           | 2.9            | V    |
| Input turn-off threshold voltage   | VINL       | Tj=-40 ~ 150°C                                    | 1.2         | -             | -              | V    |
| Off state input current  | IIN(OFF)   | VIN=0V, Tj=-40 ~ 150°C                            | -           | -             | 1              | uA   |
| On state input current   | IIN(ON)    | VIN=3.5V, Tj=-40 ~ 150°C                          | 20          | 45            | 70             | uA   |
| Initial open load delay time   | td(ST)     | Tj=-40 ~ 150°C                                    | -           | 380           | 750            | us   |
| Delay time for status with open load<br>while ON <sup>5)</sup>                             | td(ON_OL)  | Normal --> Open load, Tj=-40 ~ 150°C              | 10          | 30            | 90             | us   |
| Delay time for status with open load<br>while ON   | td(ON_Nor) | Open load --> Normal, Tj=-40 ~ 150°C              | 10          | 30            | 90             | us   |
| Status output(open drain) for high level   | VSTH       | IST=1.6mA, Tj=-40 ~ 150°C                         | 5.4         | 6.3           | -              | V    |
| Status output(open drain) for low level  | VSTL       | IST=1.6mA, Tj=-40 ~ 150°C                         |             |               | 0.6            | V    |

notes:

- 1) 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.
- 2) See the page12
- 3) Required 150Ω resistor in GND PIN. Note that the power dissipation is higher compared to normal operation condition due to the voltage drop across the intrinsic drain-source diode. The temperature protection is not active during reverssrse current operation. IN and ST currents have to be limited by max rating.
- 4) If a ground resistor RGND is used, add the voltage drop across this resistor.
- 5) Guaranteed by design.

## Application Information

### 1. Truth Table

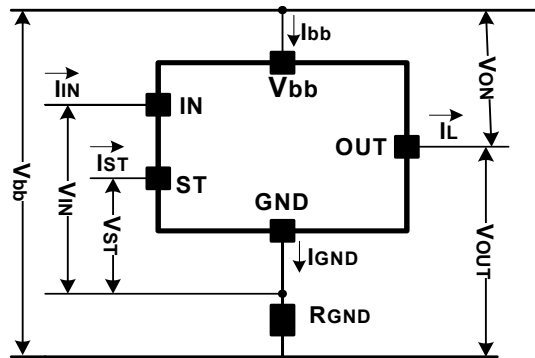
| Sense current under fault conditions | Input Level | Output Level    | Status               |
|--------------------------------------|-------------|-----------------|----------------------|
| Normal operation                     | L           | L               | H                    |
|                                      | H           | H               | H                    |
| Open load                            | L           | X <sup>1)</sup> | H                    |
|                                      | H           | H               | L                    |
| Short circuit to Vbb                 | L           | H               | L <sup>2)</sup>      |
|                                      | H           | H               | H (L <sup>3)</sup> ) |
| Short circuit to GND                 | L           | L               | H                    |
|                                      | H           | L               | L <sup>4)</sup>      |
| Overtemperature                      | L           | L               | L                    |
|                                      | H           | L               | L                    |
| Undervoltage                         | L           | L               | H                    |
|                                      | H           | L               | H (L <sup>5)</sup> ) |
| Overvoltage shutdown                 | L           | L               | H                    |
|                                      | H           | L               | H                    |

L = "LOW" Level, Z = High impedance, potential depends on external circuit, H = "HIGH" Level

Notes:

- 1) Power TR off, high impedance.
- 2) An short of output to Vbb ,in the off state, causes an internal current from output to ground. If RGND is used, an offset voltage at the GND and ST pins will occur and VSTL signal may be errorious.
- 3) Low resistance to Vbb may be detected in ON-state by the no-load-detection.
- 4) Latched and reset by input. Low resistance to Vbb may be detected in ON-state by the no-load-detection.
- 5) Should reset IN to restart in case battery voltage comes back to normal operating range after undervoltage shutdown and status = "Low" level.

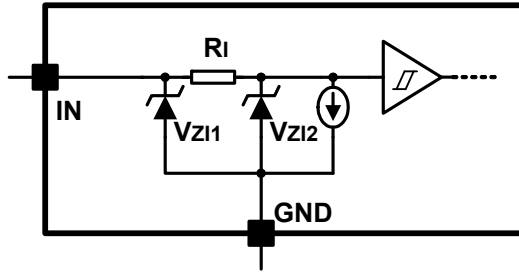
### 2. Terms



Notes:

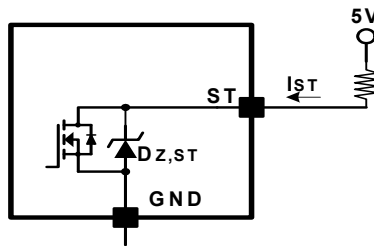
### 3. Detailed Function Blocks

#### 3.1 Input circuit (ESD protection)



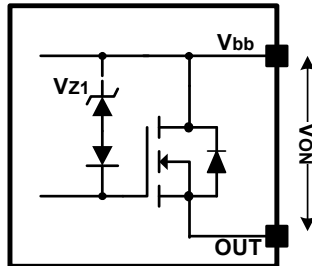
$V_{Z11} = 16V$  (typ.),  $V_{Z12} = 6.1V$  (typ.).  $R_i = 3K$ .

#### 3.2 Status output



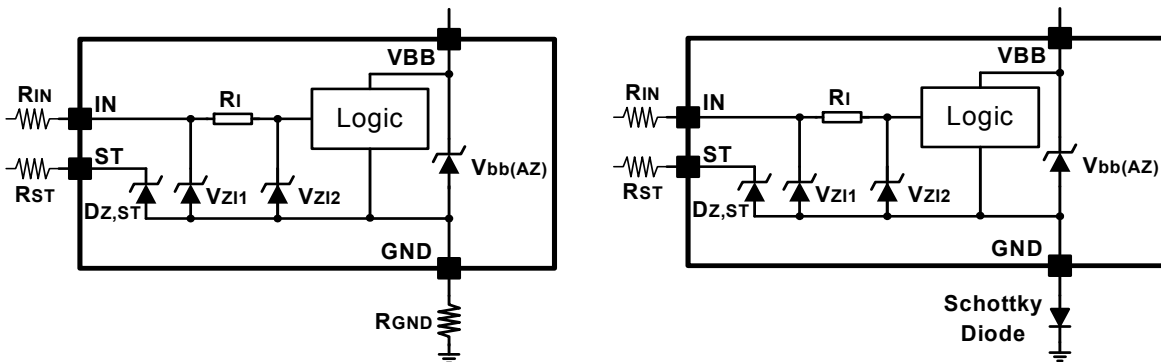
$V_{Dz,ST} = 6.1V$  (typ.), Max 5mA. with  $I_{ST} = 1.6mA$ . Low level of ST is 0.6(Max).

#### 3.3 Inductive and overvoltage output clamp



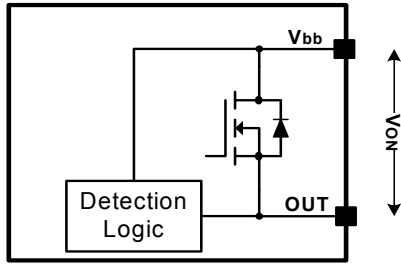
$V_{ON}$  is clamped to  $V_{ON(CL)} = 59V$  (Typ).

#### 3.4 Overvoltage and reverse battery protection



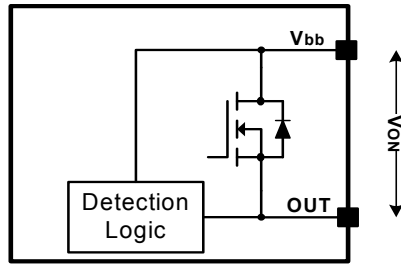
$V_{Dz,ST} = 6.1V$  (Typ),  $V_{Z11} = 16V$  (typ.),  $V_{Z12} = 6.1V$  (Typ).  $R_{GND} = 150\Omega$  typ.  $V_{bb(AZ)} = 54V$  (typ).

**3.5 Open load detection.**



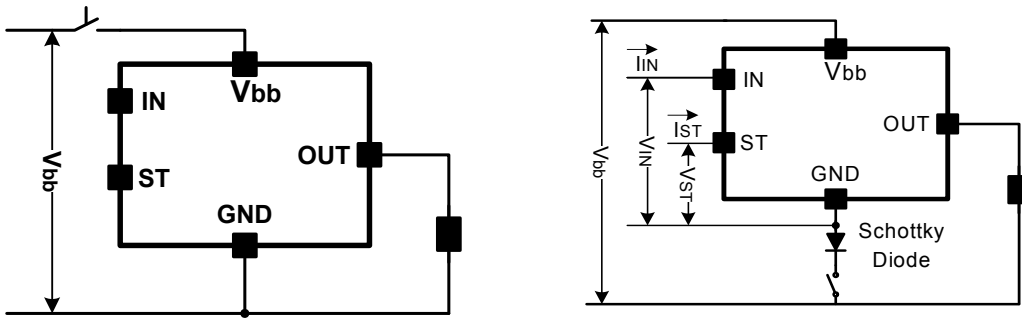
Open load is detected when  $IN=H$  and  $V_{ON} < R_{on} * I_{L(OL)}$ .

**3.6 Short circuit detection.**



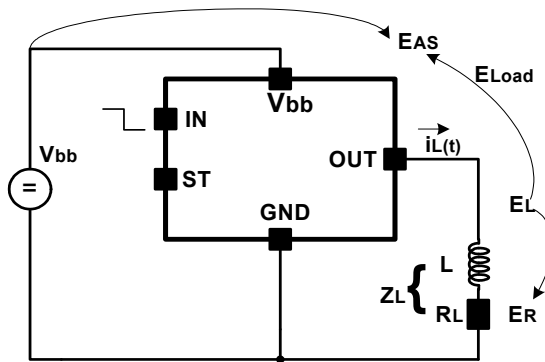
Short circuit is detected when  $V_{ON} > 4V$ .(Typ) and  $t > t_{(asc)}$ , typically 250us.

**3.7 Vbb disconnect with energized inductive load and GND disconnect**



Nominal load current can be handled by the device itself.

**3.8 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 MOSFET is

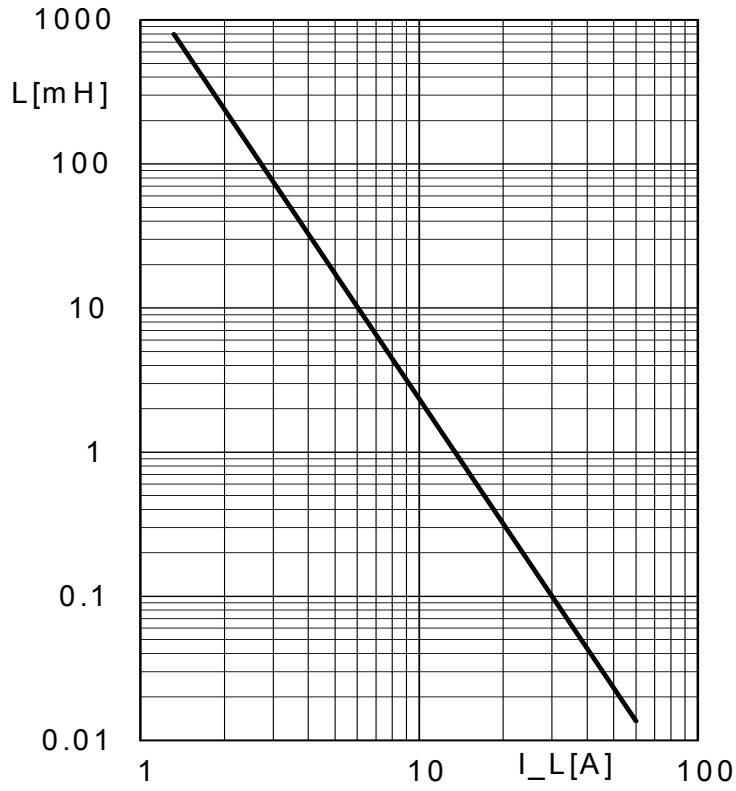
$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} \cdot i_L(t) dt$$

with an approximate solution for  $RL > 0$  :

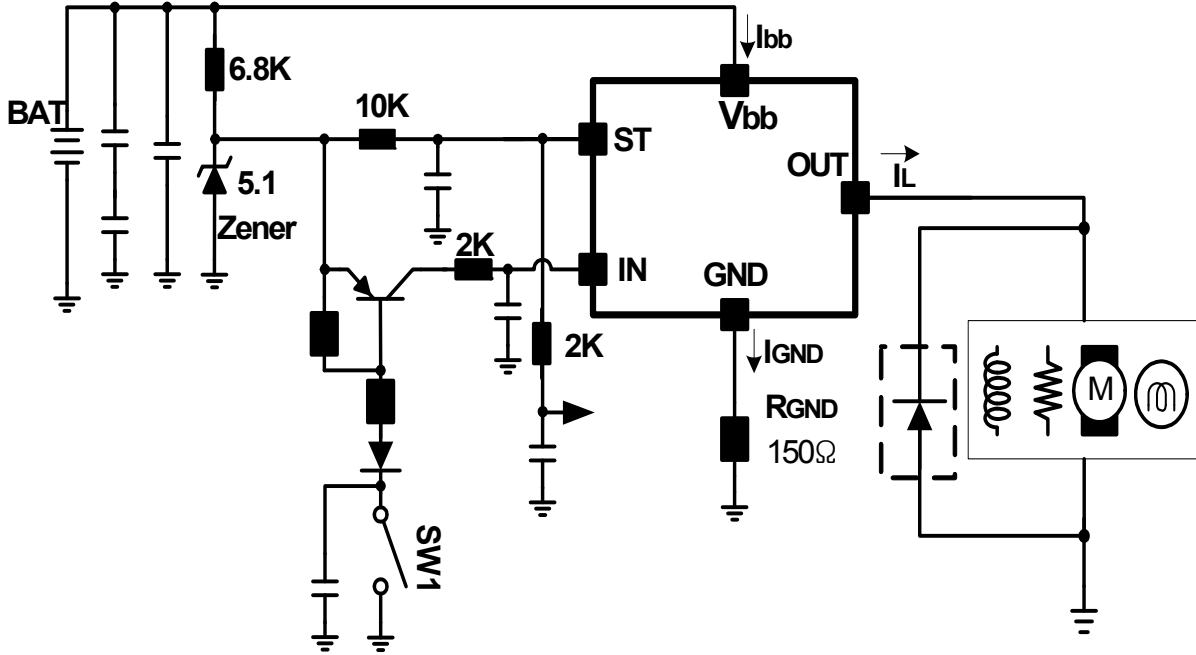
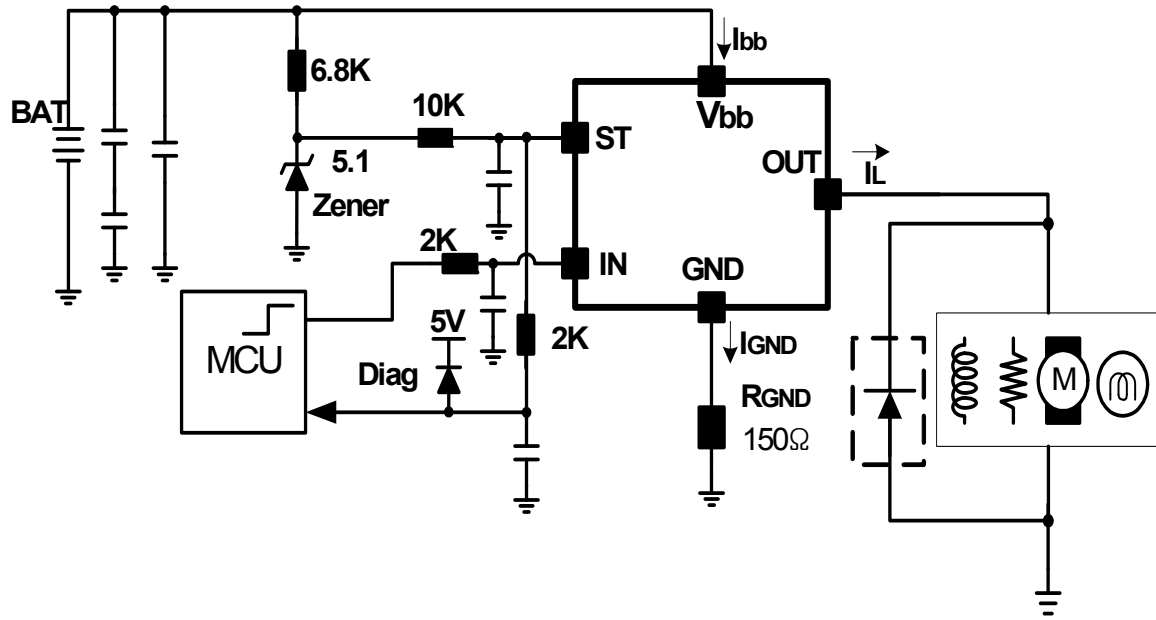
$$E_{AS} = \frac{I_L \cdot L}{2 \cdot R_L} (V_{ON(CL)}) \ln \left( 1 + \frac{I_L \cdot R_L}{|V_{OUT(CL)}|} \right)$$

### 3.9 Maximum allowable load inductance for a single switch off

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



Typical Application Circuit



### Timing Diagram

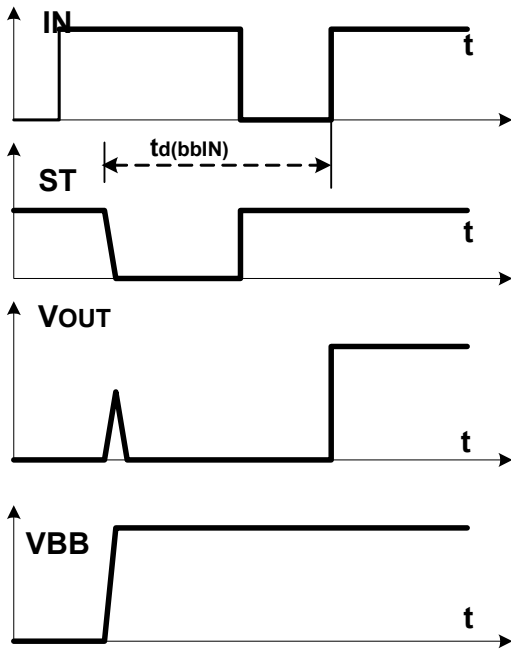


Figure 1. Vbb turn-on Switching a lamp

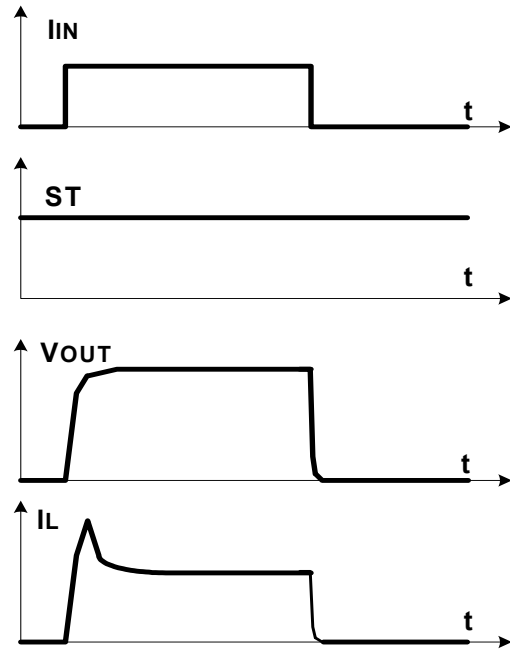


Figure 2a. Switching motors and lamps

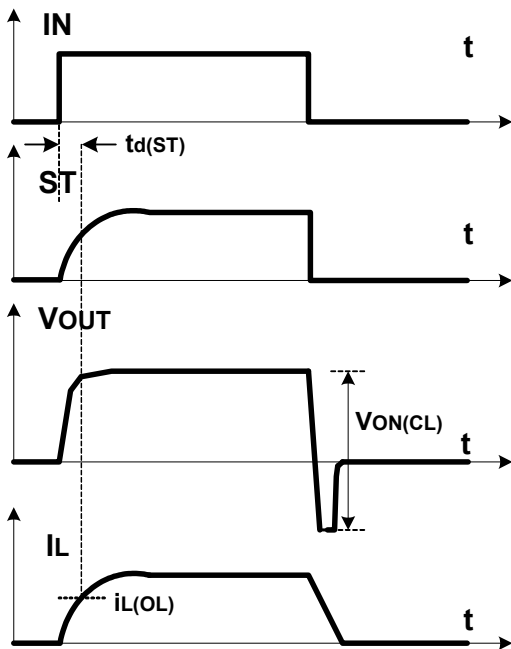


Figure 2b. Switching an inductive load

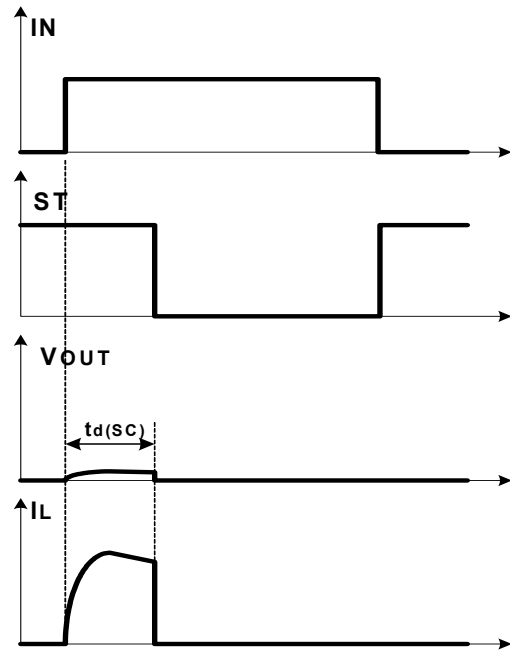


Figure 3. Turn-on into short circuit

In case of  $V_{ON} > V_{ON(SC)}$  (typ. 4V) the device will be switched off by internal short circuit detection

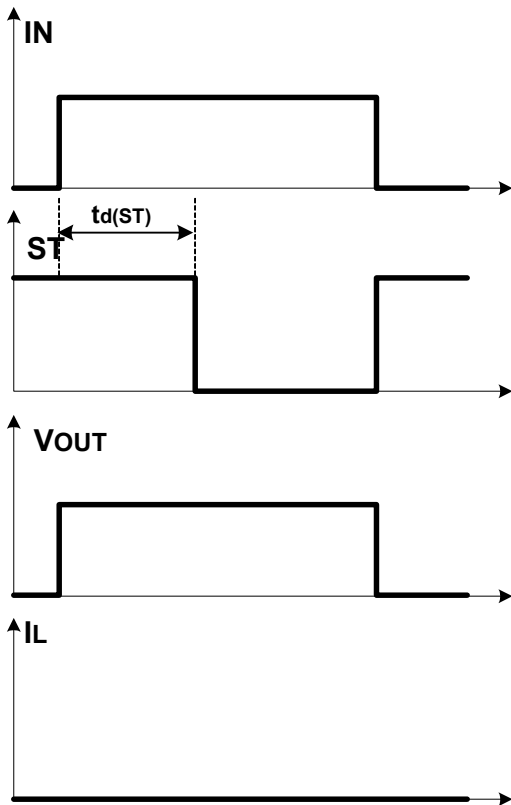


Figure 4a. Open load detection while being open

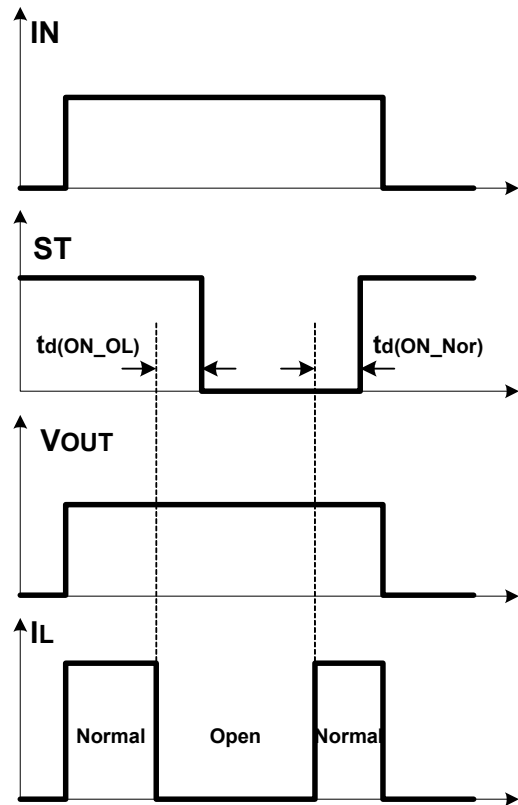


Figure 4b. Open load detection while turning-on

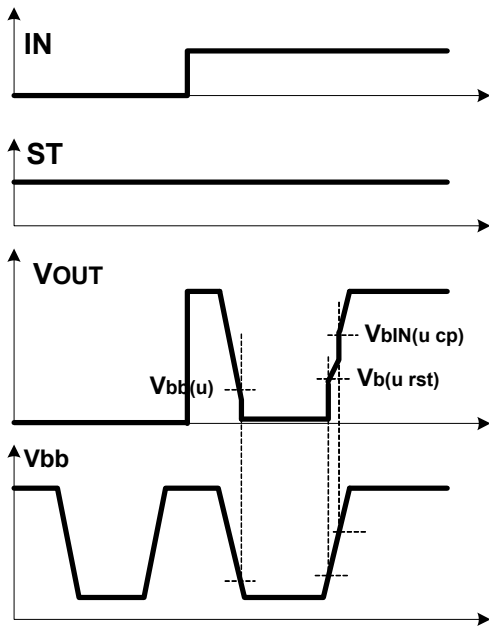


Figure 5a. Undervoltage

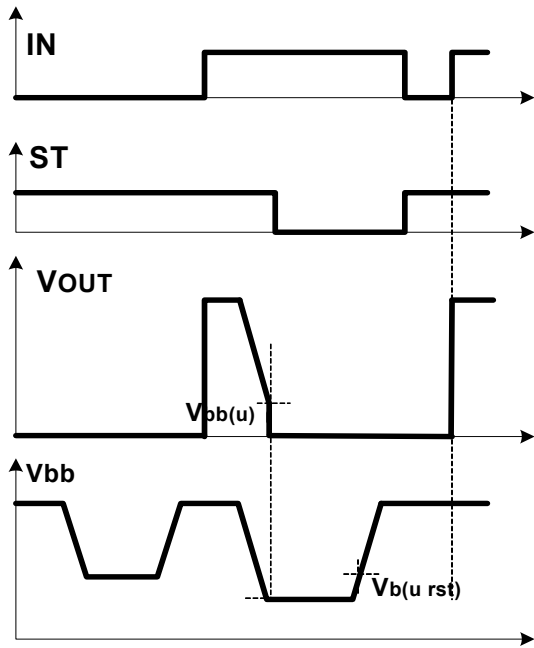


Figure 5b. Undervoltage restart of charge pump

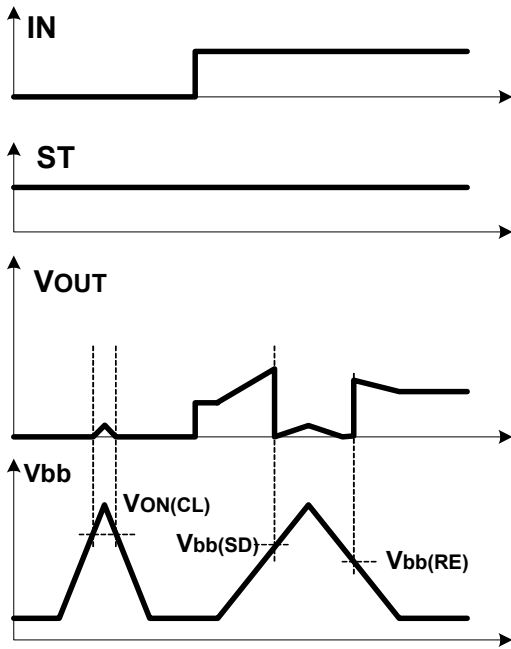


Figure 6. Overvoltage

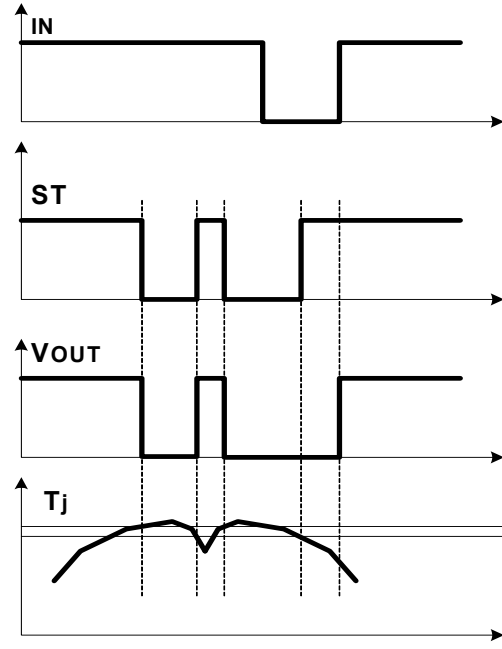


Figure 7. Over temperature

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| Bottomless™                          | FASTr™              | MICROCOUPLER™ | PowerTrench®        | SuperSOT™-6     |
| CoolFET™                             | FPS™                | MicroFET™     | QFET®               | SuperSOT™-8     |
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| FACT™                                | ImpliedDisconnect™  | OCXPro™       | SILENT SWITCHER®    | UltraFET®       |
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