# Smart High-Side Power Switch
# RM77007TSP1 Datasheet

## 1.Basic Features

- Very low standby current
- Overload protection
- Current limitation
- Short circuit protection
- Over temperature protection
- Over voltage protection
- Clamp of negative voltage at output
- Fast deenergizing of inductive loads
- Open load detection via current sense
- Diagnostic feedback with load current sense
- Electrostatic discharge (ESD) protection
- Green Product (RoHS compliant)
- AEC-Q100 qualified

## 2.Description

RM77007TSP1 is a Smart High-side Power Switch, Reverse battery protection by self turn on of power MOSFET, current controlled input and diagnostic feedback with load current sense.It can connect to various loads such as inductive loads, resistive loads, capacitive loads, etc.

RM77007TSP1 integrates multiple protection functions. Overload protection, Current limitation, Short circuit protection, Over temperature protection, Over voltage protection, Clamp of negative voltage at output, Fast deenergizing of inductive loads, Electrostatic discharge (ESD) protection.

## 3.Application

- Suitable for 12 V and 24 V Trucks and Transportation System
- Most suitable for loads with high inrush current like lamps and motors; all types of resistive and inductive loads
- Replaces electromechanical relays, fuses and discrete circuits

## 4.Product Summary

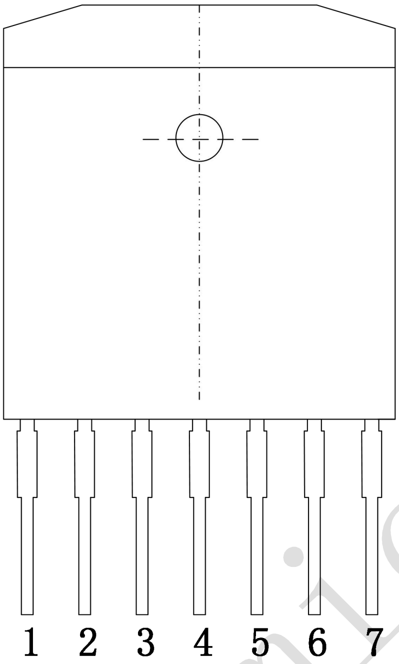
| | | | |
|---|---|---|---|
| Overvoltage protection | $V_{Z,IN}$ | 72 | V |
| Operating voltage | $V_{bb(on)}$ | 5...58 | V |
| On-state resistance | $R_{ON}$ | 7.2 | mΩ |
| Nominal Load current | $I_{L(NOM)}$ | 11.1 | A |
| Short circuit current limitation | $I_{L(SC)}$ | 90 | A |
| Current sense ratio | $I_L:I_{IS}$ | 14000 | |

## 5.Ordering Code

| Part number | Package Type | Marking | Materials | Package | | | Package Qty |
|---|---|---|---|---|---|---|---|
| RM77007TSP1 | TO-263-7L | RM77007TSP1 | Halogen free | Tape&reel | 5 reels/box | 4k/box | 800 /reel |

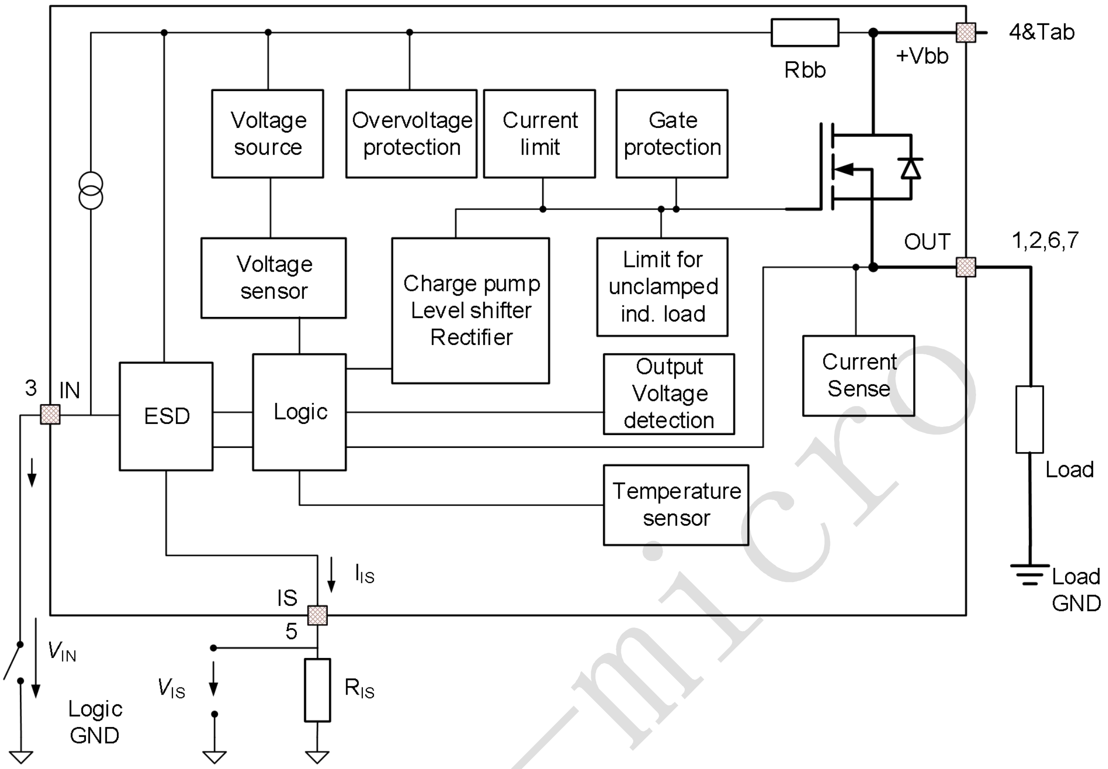
## Table of Contents

## 6.Pin Configuration



| Pin | Symbol | Function |
|---|---|---|
| 1/2/6/7 | OUT | Output; Output to the load. The pins 1, 2, 6 and 7 must be shorted with each other especially in high current applications. |
| 3 | IN | Input; has an internal pull up; activates the power switch in case of short to ground. |
| 4/Tab | $V_{bb}$ | Supply voltage; Positive power supply voltage, tab and pin 4 are internally shorted. |
| 5 | IS | Sense Output; Diagnostic feedback providing a sense current proportional to the load current; zero current on failure. |

## 7.Block Diagram



## 8.Absolute Maximum Ratings[1)]

(Maximum Ratings at $T_J$=25 °C unless otherwise specified)

| Parameter | Symbol | Values | Unit | Note or Test Condition |
|---|---|---|---|---|
| Supply voltage | $V_{bb}$ | 62 | V | |
| Supply voltage for full short circuit protection | $V_{bb}$ | 58 | V | |
| Load dump protection | $V_{Load\ dump}$ | 80 | V | $V_{LoadDump}=U_A+Vs$,<br>$U_A$=13.5V, $R_I$=2Ω,<br>$R_L$=0.23Ω, $t_d$=200ms,<br>IN, IS=open or grounded |
| Power dissipation (DC), $T_C \leq 25$ °C | $P_{tot}$ | 139 | W | |
| Inductive load switch-off energy dissipation, single pulse | $E_{AS}$ | 1.2 | J | $V_{bb}$=12V, $T_{J,start}$=150°C,<br>$T_C$=150°C const.,<br>$I_L$=20 A, $Z_L$=6mH, 0Ω, |
| Current through input pin (DC) | $I_{IN}$ | -250 to +15 | mA | |
| Current through current sense status pin (DC) | $I_{IS}$ | -250 to +15 | mA | |
| Junction temperature | $T_J$ | -40 to 150 | ℃ | |
| Ambient temperature | $T_A$ | -40 to 125 | ℃ | |
| Storage temperature | $T_{STG}$ | -55 to 150 | ℃ | |
| Thermal resistance Junction to ambient (free air) | $R_{thJA}$ | 66.21 | K/W | |
| Thermal resistance Junction to case | $R_{thJC}$ | 0.9 | K/W | |

Notes:

1:Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## 9.Electrical Characteristics

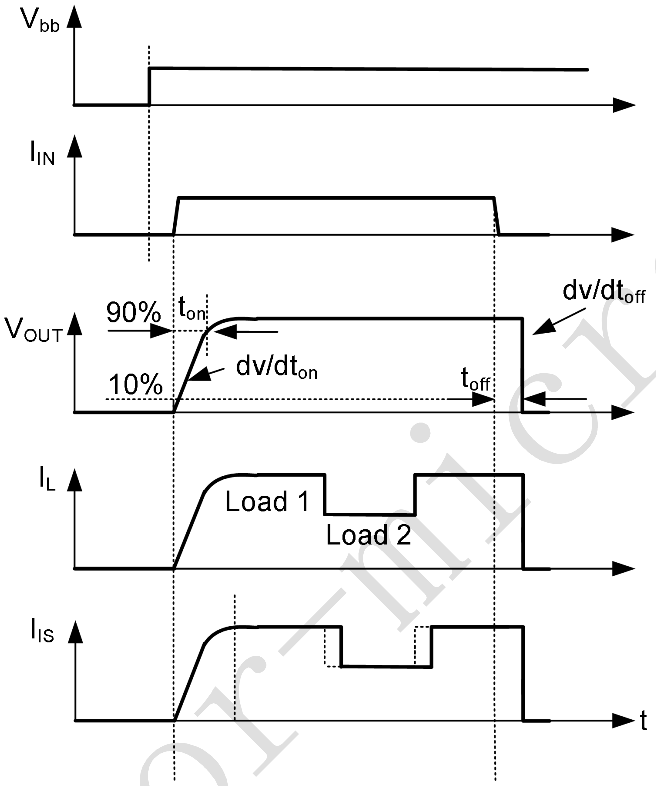
$T_J$=-40°C to +150°C, $V_{bb}$=24V, (unless otherwise specified)

| Symbol | Parameter | Test Condition | Values | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| $R_{on}$ | On-state resistance | $I_L$=20A, $T_J$=25℃ | - | 7.2 | 9.0 | mΩ |
| | | $V_{IN}$=0V, $I_L$=20A, $T_J$=150℃ | | 12.0 | 20.0 | |
| $I_{L(NOM)}$ | Nominal load current | $V_{ON}$⩽0.5V, $T_A$=85℃ | 9.9 | 11.1 | - | A |
| $I_{L(ISO)}$$^{1)}$ | Nominal Load current (ISO) | $V_{ON}$=0.5V, $T_C$=85℃ | 38 | 44 | - | A |
| $t_{on}$ | Turn-ON time | $R_L$=1Ω, $I_{IN}$ Turn-ON time to 90% $V_{OUT}$ | 50 | - | 200 | us |
| $t_{off}$ | Turn-OFF time | $R_L$=1Ω, $I_{IN}$ Turn-OFF time to 10% $V_{OUT}$ | 10 | - | 110 | us |
| $dV/dt_{on}$ | Turn-ON Slew rate | $R_L$=1Ω, From 10% to 30%$V_{OUT}$ | 1.0 | 1.7 | 3.2 | V/us |
| $-dV/dt_{off}$ | Turn-OFF Slew rate | $R_L$=1Ω, From 70% to 40%$V_{OUT}$ | 1.0 | 1.5 | 2.6 | V/us |
| $V_{bb(on)}$ | Operating voltage | | 5 | - | 58 | V |
| $V_{bb(u)}$ | Under voltage shutdown | | 1.5 | 3.0 | 4.5 | V |
| $V_{bb(ucp)}$ | Under voltage start of charge pump | | 3.0 | 4.5 | 6.0 | V |
| $I_{bb(off)}$ | Standby current | $I_{IN}$=0, $V_{bb}$=35V, $T_J$≤25℃ | - | 0.1 | 1.0 | uA |
| $I_{L(SC)}$ | Short circuit current limit | $T_J$=-40℃ | - | - | 180 | A |
| | | $T_J$=25℃ | - | 90 | - | |
| | | $T_J$=150℃ | 50 | 80 | - | |
| $V_{ON(SC)}$ | Short circuit shutdown detection voltage | | - | 5.8 | - | V |
| $t_{d(SC)}$ | Short circuit shutdown delay after input current positive slope | $V_{ON}$>$V_{ON(SC)}$ | 80 | - | 350 | us |
| $V_{ON(CL)}$ | Output clamp (inductive load switch off) | $V_{OUT}$=$V_{bb}$-$V_{ON(CL)}$, $I_L$=40mA | 62 | 65 | 72 | V |
| $T_{JT}$ | Thermal overload trip temperature | | 150 | - | - | ℃ |
| $\Delta T_{JT}$ | Thermal hysteresis | | - | 10 | - | K |
| $I_{IN(ON)}$ | Input and operating current | $V_{IN}$=0V | - | 0.8 | 1.5 | mA |
| $I_{IN(OFF)}$ | Input current for turn-off | | - | - | 100 | uA |
| $V_{Z,IN}$ | Overvoltage protection | $I_{bb}$=15mA, $T_J$=25℃ | 70 | 72 | - | V |
| **Inverse Load Current Operation:** | | | | | | |
| $R_{ON(INV)}$ | On-state resistance | $V_{bb}$=12V, $I_L$=-20A, $T_J$=25℃ | - | 7.2 | 15.0 | mΩ |
| | | $V_{bb}$=12V, $I_L$=-20A, $T_J$=150℃ | - | 12.0 | 25.0 | mΩ |

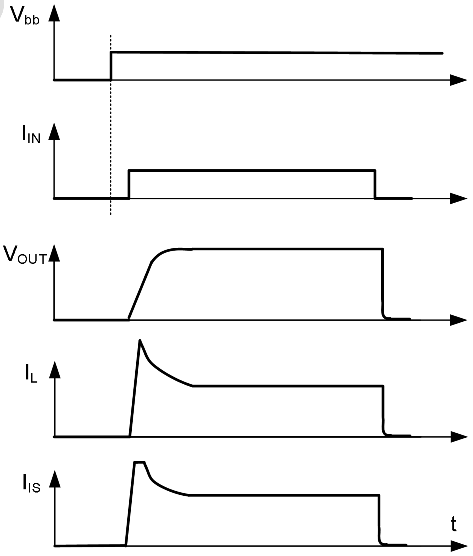
| | | | | | | |
|---|---|---|---|---|---|---|
| $I_{L(INV)}$ | Nominal inverse load current | $V_{ON}$=-0.5V, $T_A$=85℃ | 40 | 50 | - | A |
| $-V_{ON}$ | Drain-source diode voltage | $I_L$=-20A, $I_{IN}$=0, $T_J$=25℃, ($V_{out}$>$V_{bb}$) | - | - | 0.85 | V |
| | | $I_L$=-20A, $I_{IN}$=0, $T_J$=150℃, ($V_{out}$>$V_{bb}$) | - | - | 0.7 | V |
| **Diagnostic Characteristics :** | | | | | | |
| $K_{ILIS}$ | Current sense ratio | $I_L$=10A, $T_J$=25℃ | 10500 | 14000 | 16500 | |
| $I_{IS.lim}$ | Sense current saturation | | 5.0 | - | - | mA |
| $I_{IS(LL)}$ | Current sense leakage current | $I_{IN}$=0 | - | - | 0.5 | uA |
| $I_{IS(LH)}$ | | $V_{IN}$=0, $I_L$=0 | - | 2 | 65 | |
| $V_{Z,IS}$ | Current sense over voltage protection | $I_{bb}$=15mA, $T_J$=25℃ | 70 | 72 | - | V |
| $t_{S,IS}$ | Current sense settling time | | - | - | 500 | us |
| NOTE:1) not subject to production test, specified by design | | | | | | |

## 10.Timing diagrams

### Figure 1: Switching a Resistive Load Timing



### Figure 2a: Switching motors and lamps



Sense current saturation can occur at very high inrush currents

**Figure 2b: Switching an inductive load**

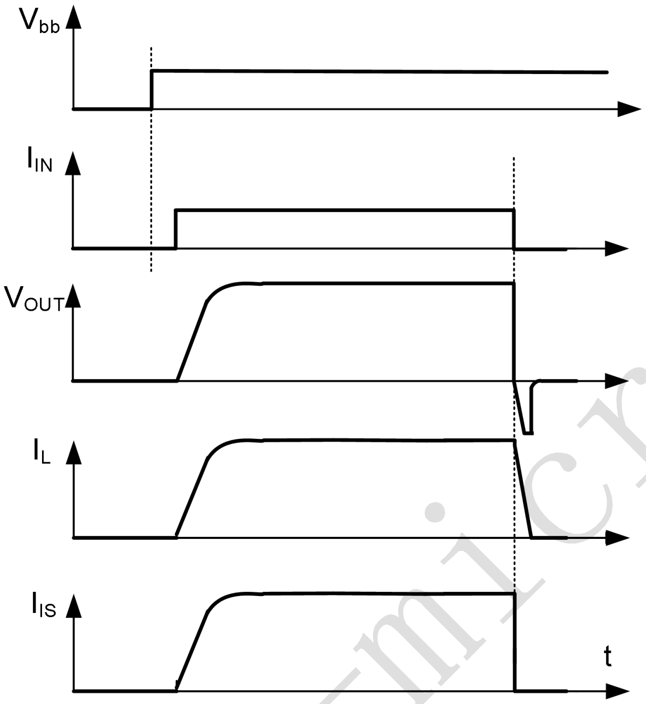


**Figure 3: Short circuit**

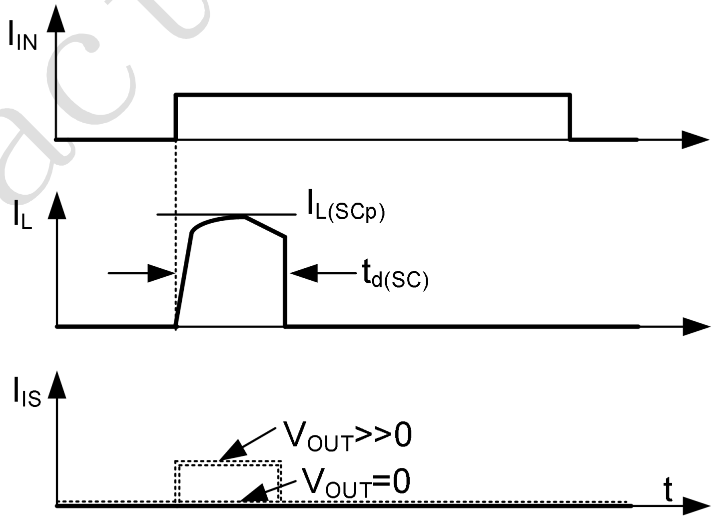
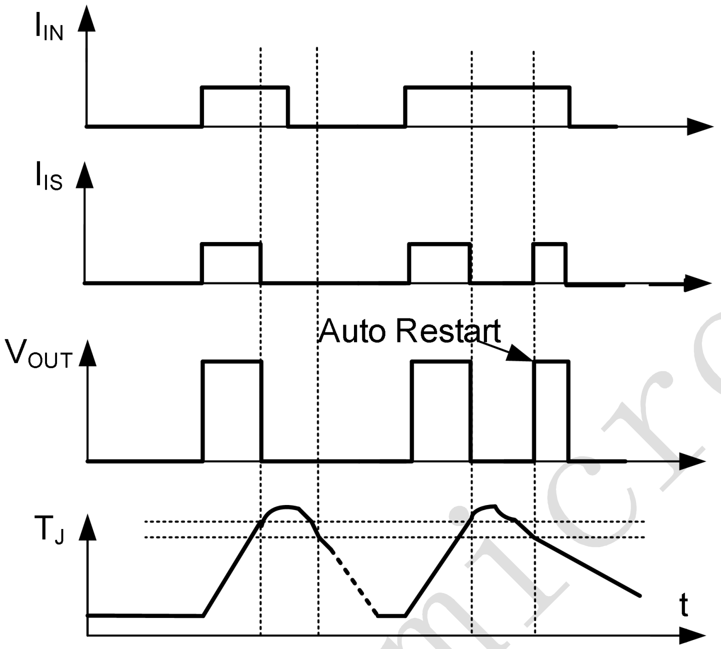
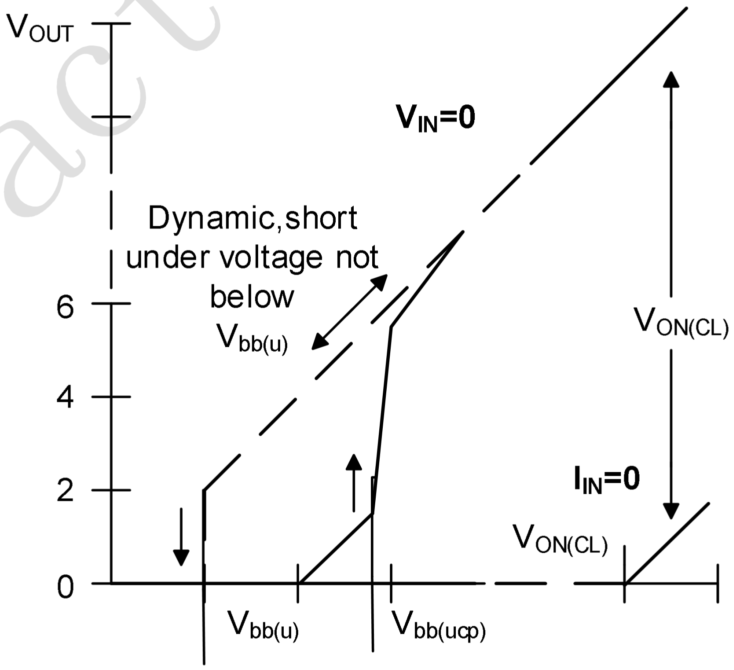


**Figure 4: Over temperature**



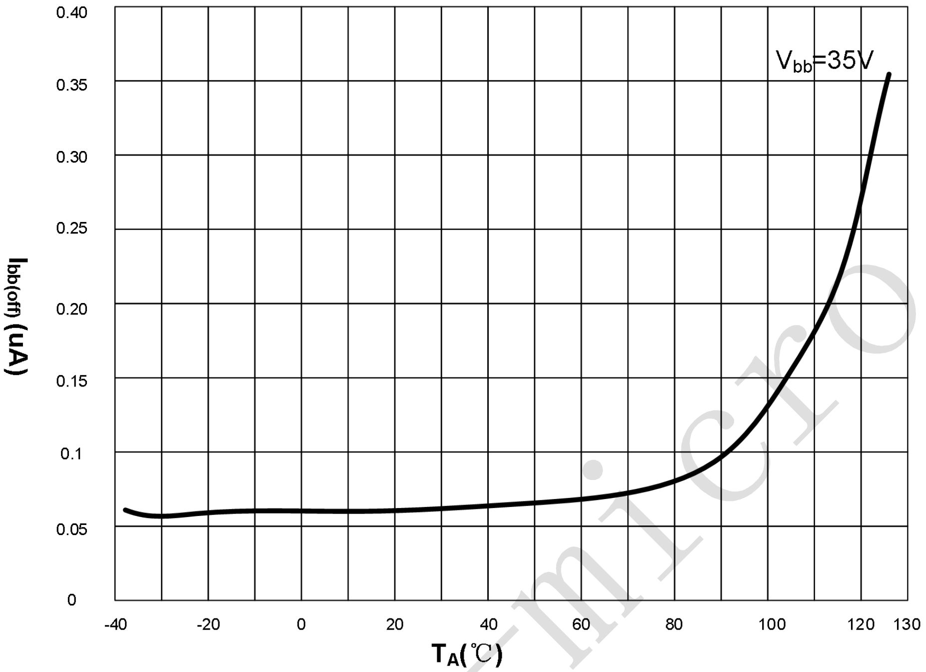
Reset if $T_J<T_{JT}$.

**Figure 5: Undervoltage restart of charge pump, overvoltage clamp**

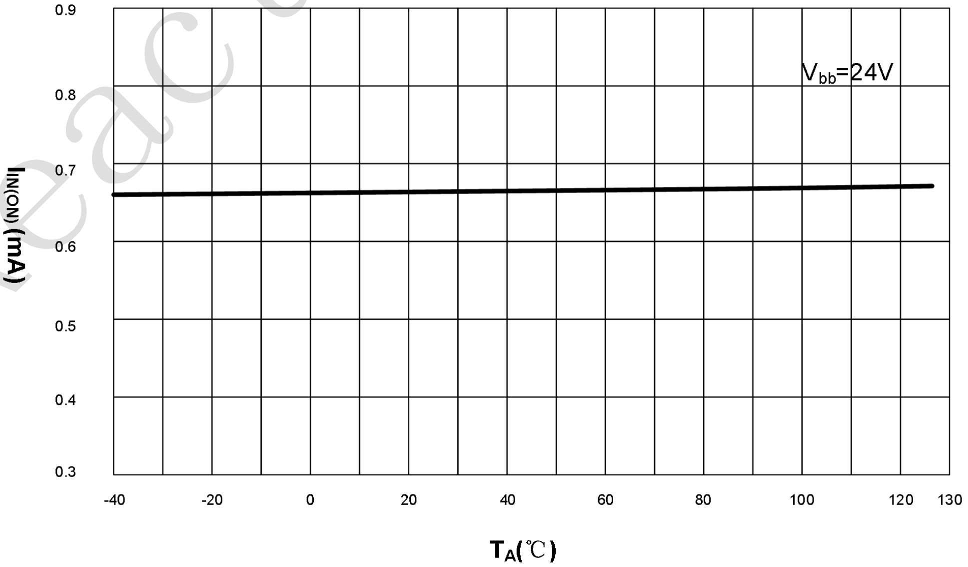


## 11.General Product Characteristics

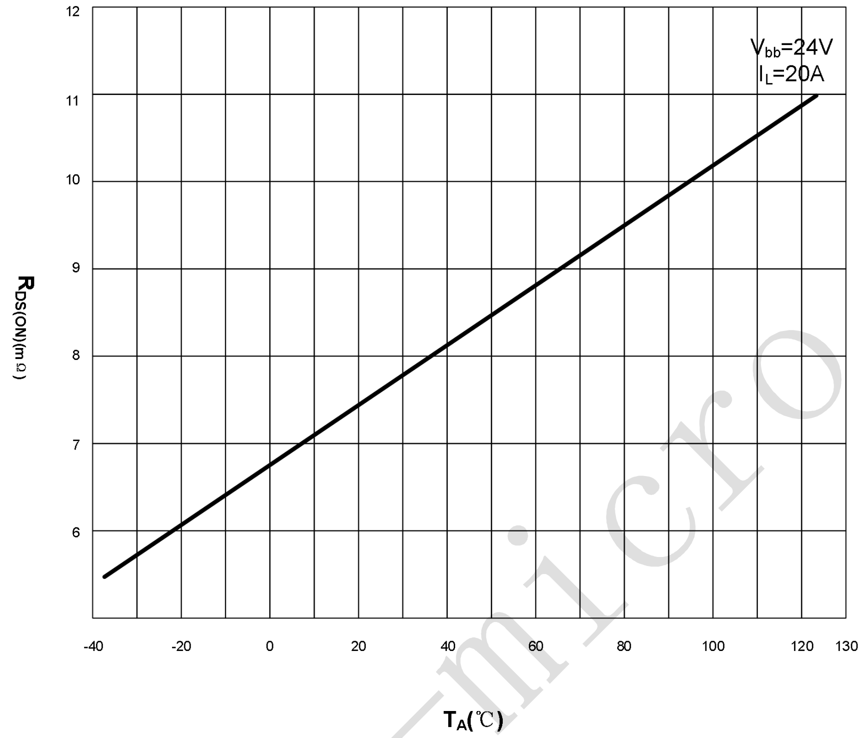
### 11.1 Standby Current



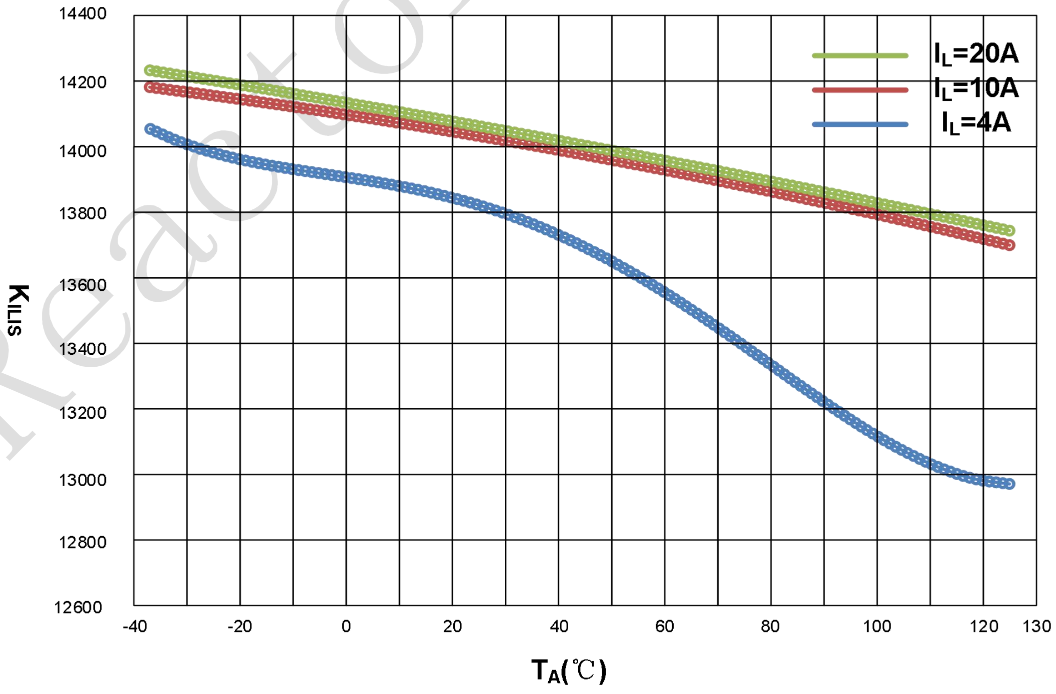
### 11.2 Input and operating current



## 11.3 Typical ON-State Resistance



## 11.4 Current Sense



## 12.Truth Table

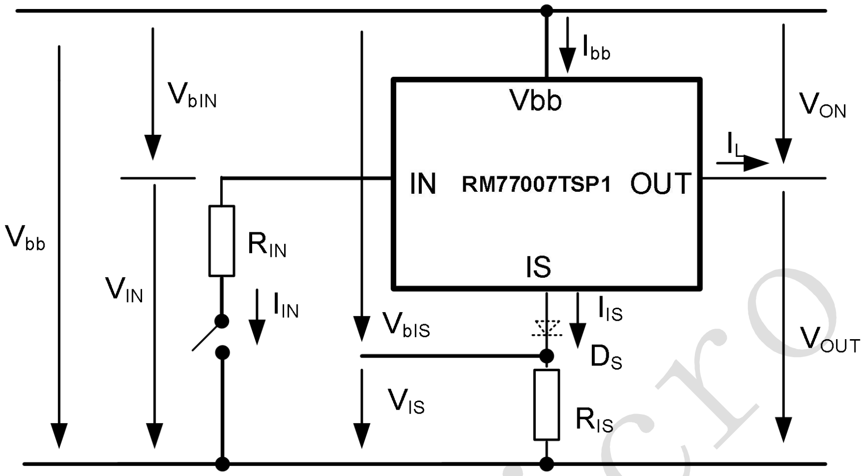
| Operation Mode | Input Current level | Output level | Current Sense $I_{IS}$ | Remark |
|---|---|---|---|---|
| Normal operation | L<br>H | L<br>H | 0<br>Nominal | <br>$=I_L/K_{ILIS}$, up to $I_{IS}=I_{IS,lim}$ |
| Very high load current | H | H | $I_{IS,lim}$ | $I_{IS}$ no longer proportional to $I_L$ |
| Current-limitation | H | H | 0 | $V_{ON}>V_{ON(SC)}$, shutdown will occure |
| Short circuit to GND | L<br>H | L<br>L | 0<br>0 | |
| Over temperature | L<br>H | L<br>L | 0<br>0 | |
| Short circuit to $V_{bb}$ | L<br>H | H<br>H | 0<br>Nominal$^{(1)}$ | |
| Open load | L<br>H | $Z^{(2)}$<br>H | 0<br>0 | |
| Negative output voltage clamp | L | L | 0 | |
| Inverse load current | L<br>H | H<br>H | 0<br>0 | |

L="Low" Level, H="High" Level

1) Low ohmic short to $V_{bb}$ may reduce the output current IL and can thus be detected via the sense current IIS.
2) Power Transistor "OFF", potential defined by external impedance.

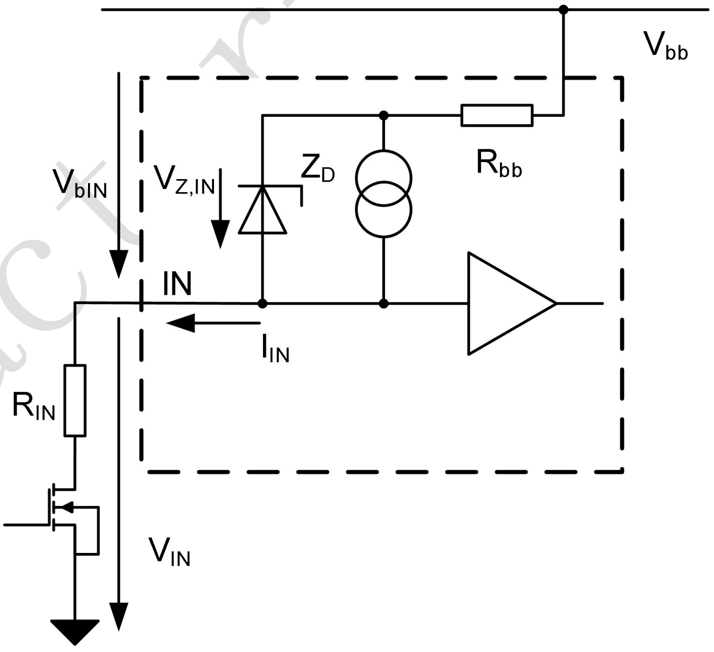
# 13.Functions

## 13.1 Terms



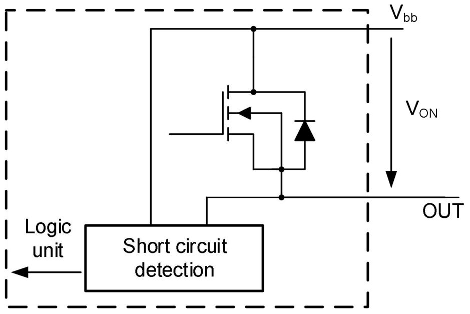
Two or more devices can easily be connected in parallel to increase load current capability.

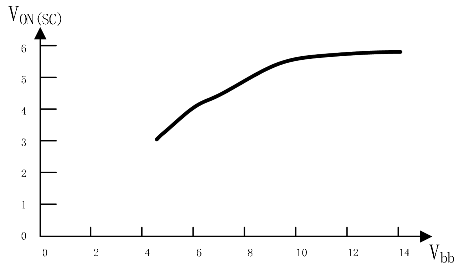
## 13.2 Input circuit (ESD protection)



When the device is switched off ($I_{IN}$=0) the voltage between IN and GND reaches almost $V_{bb}$ . Use a bipolar or MOS transistor with appropriate breakdown voltage as driver.

### 13.3 Short circuit detection





Fault Condition: $V_{ON} > V_{ON(SC)}$ (5.8 $V_{typ}$. ) and $t > t_{d(SC)}$(80...350 μs)

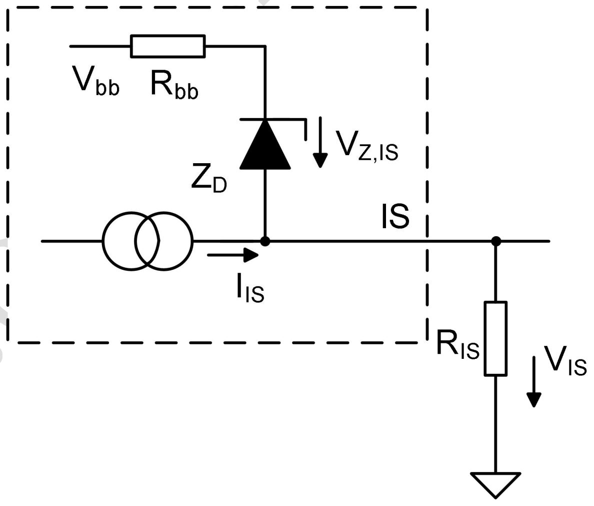
When the $V_{bb}$ supply voltage ramps up gradually and approaches the $V_{bb(ucp)}$, the load may cause a voltage droop on the $V_{bb}$. This droop can reduce the gate drive voltage ($V_{gs}$) of the internal MOSFET, making it unable to enter saturation mode and resulting in an excessive drain-source voltage drop ($V_{ON}$). In such cases, the system may erroneously detect this condition as a short-circuit fault, triggering the protection mechanism.

To prevent false protection triggering, adhere to the following power-up sequence:

First, stabilize the $V_{bb}$ supply voltage to ensure sufficient gate drive for the MOSFET.

Then, activate the IN signal to enable normal operation.

### 13.4 Current sense status output

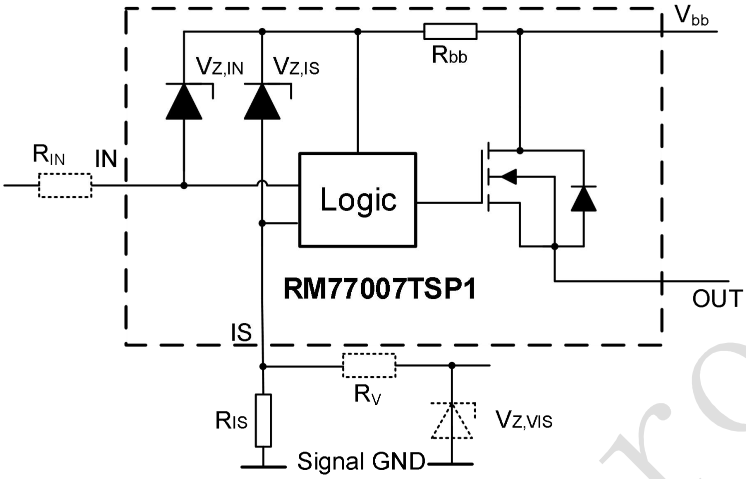


$V_{Z,IS}$=72 V (typ.), $R_{IS}$=1 kΩ nominal (or 1 kΩ /n, if n devices are connected in parallel). $I_S = \frac{I_L}{k_{ilis}}$ can be driven only by the internal circuit as long as $V_{out}$-$V_{IS}$>5 V. If you want measure load currents up to $I_{L(M)}$ , $R_{IS}$ should be less than

$$\frac{V_{bb} - 5V}{I_{L(M)} / k_{ilis}} .$$

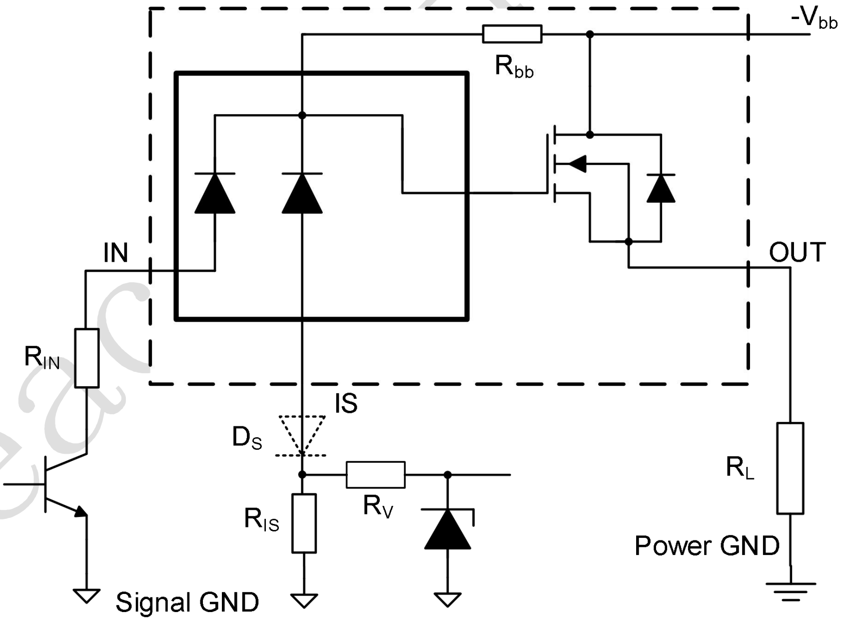
Note: For large values of $R_{IS}$ the voltage $V_{IS}$ can reach almost $V_{bb}$. See also over voltage protection.If you don't use the current sense output in your application, you can connect it to ground through a 1K resistor.

### 13.5 Over voltage protection of logic part



$V_{Z,IN}=V_{Z,IS}=72\ V_{typ.}$, $R_{IS}$=1 kΩ nominal. Note that when over voltage exceeds 77 V typ. a voltage above 5V can occur between IS and GND, if $R_V$ , $V_{Z,VIS}$ are not used.

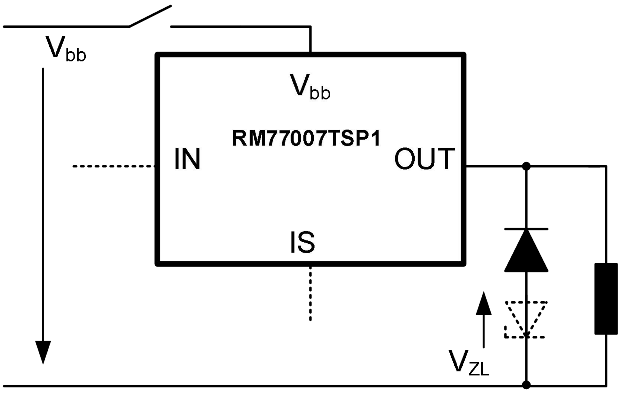
### 13.6 Reverse battery protection



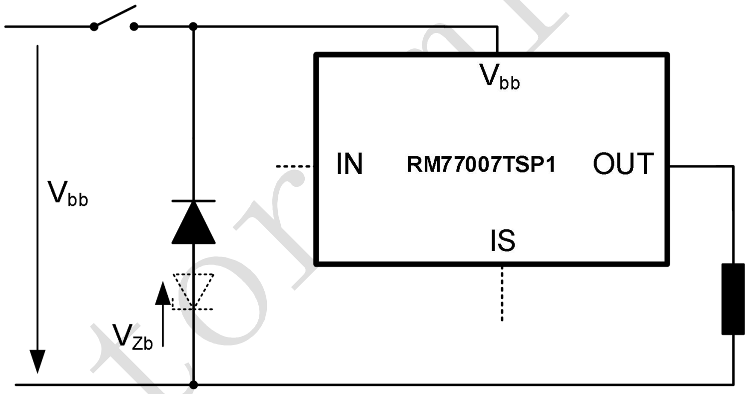
$R_V$≥1 kΩ, $R_{IS}$=1 kΩ nominal. Add $R_{IN}$ for reverse battery protection in applications with $V_{bb}$ above 16V, recommended value: $\frac{1}{R_V}+\frac{1}{R_{IN}}+\frac{1}{R_{IS}}=\frac{0.1A}{|V_{\mathrm{bb}}|-12V}$, if $D_S$ is not used, (or $\frac{1}{R_{IN}}=\frac{0.1A}{|V_{\mathrm{bb}}|-12V}$ if $D_S$ is used).

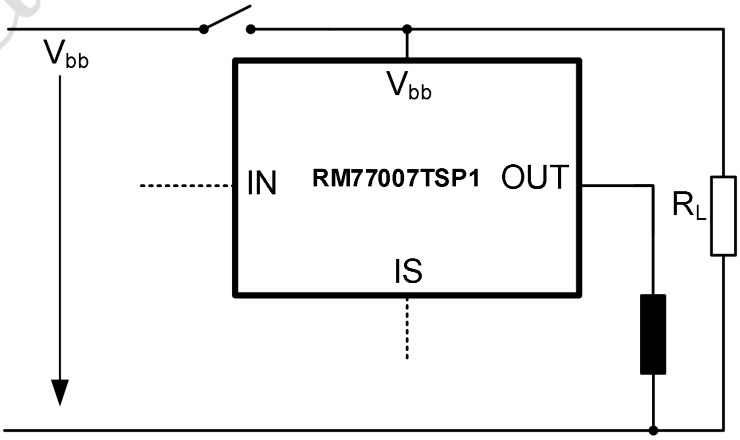
To minimize power dissipation at reverse battery operation, the overall current into the IN and IS pin should be about 120mA. The current can be provided by by using a MOSFET input switch or by proper adjusting the current through $R_{IS}$ and $R_V$.

### 13.7 $V_{bb}$ disconnect with energized inductive load



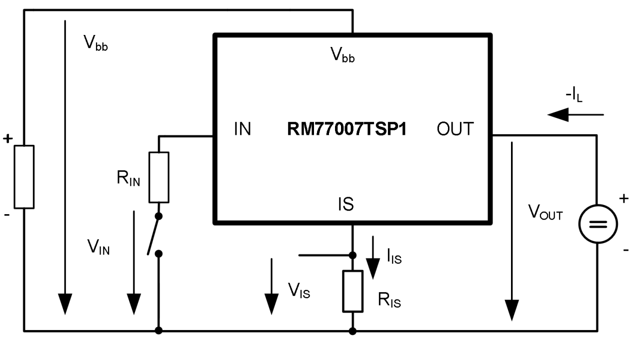
Provide a current path with load current capability by using a diode, a Z-diode, or a varistor.





Note that there is no reverse battery protection when using a diode without additional Z-diode $V_{ZL}$ , $V_{Zb}$.

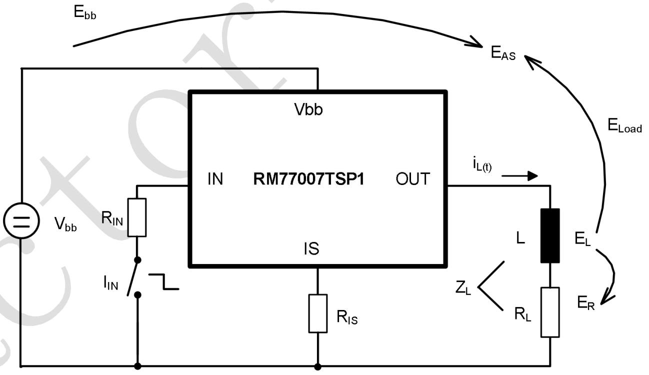
## 13.8 Inverse load current operation



The device is specified for inverse load current operation ($V_{OUT}$>$V_{bb}$>0V). The current sense feature is not available during this kind of operation ($I_{IS}$=0). With $I_{IN}$=0 (e.g. input open) only the intrinsic drain source diode is conducting resulting in considerably increased power dissipation. If the device is switched on ($V_{IN}$=0), this power dissipation is decreased to the much lower value $R_{ON(INV)}*I^2$

Note: Temperature protection during inverse load current operation is not possible!

## 13.9 Inductive load switch-off energy dissipation



Energy stored in load inductance :

$$E = \frac{1}{2} * L * I^2$$

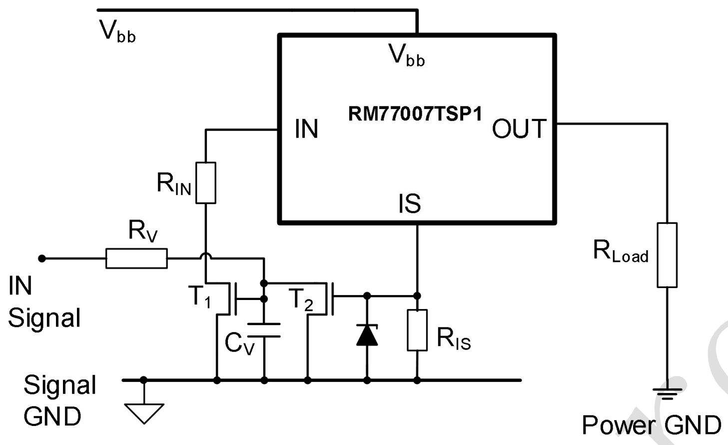
While demagnetizing load inductance, the energy dissipated in RM77007TSP1 is :

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

with an approximate solution for $R_L$>0 Ω:

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

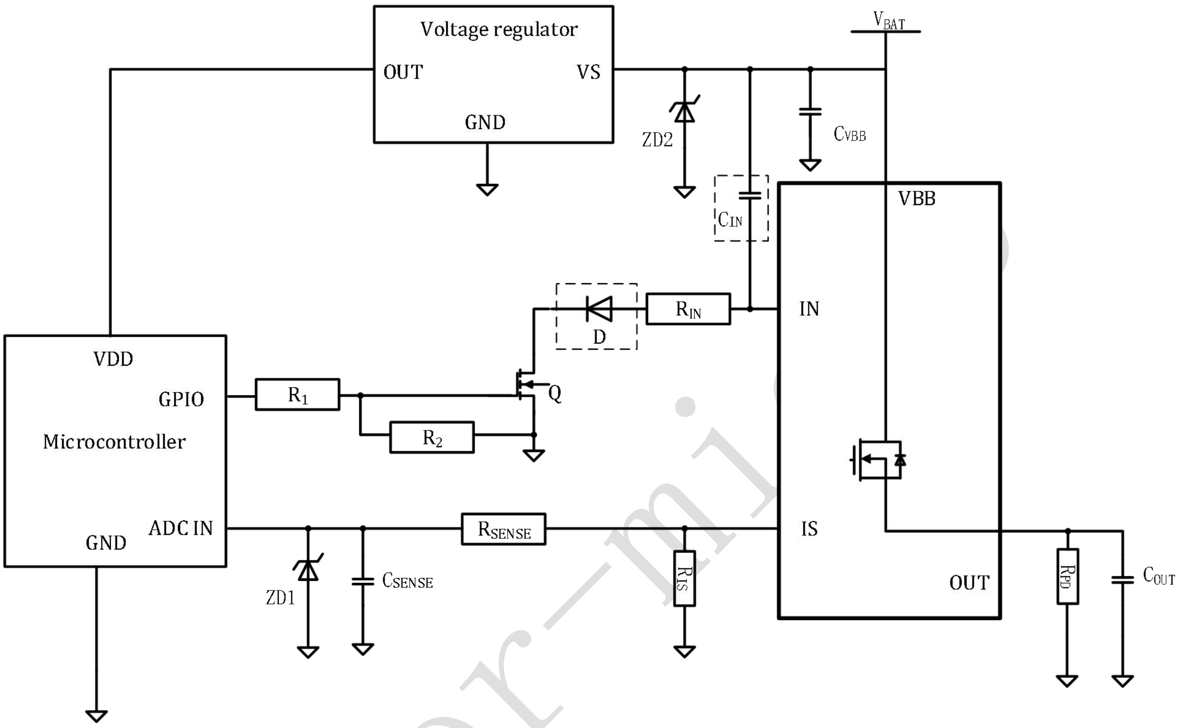
### 13.10 Externally adjustable current limit



If the device is conducting, the sense current can be used to reduce the short circuit current and allow higher lead inductance (see diagram above). The device will be turned off, if the threshold voltage of T2 is reached by $I_S$*$R_{IS}$ . After a delay time defined by $R_V$*$C_V$ T1 will be reset. The device is turned on again, the short circuit current is defined by $I_{L(SC)}$ and the device is shut down after $t_{d(SC)}$ with latch function.

## 14.Application Information

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality,condition or quality of the device.



Note: This is a very simplified example of an application circuit.The function must be verified in the real application.

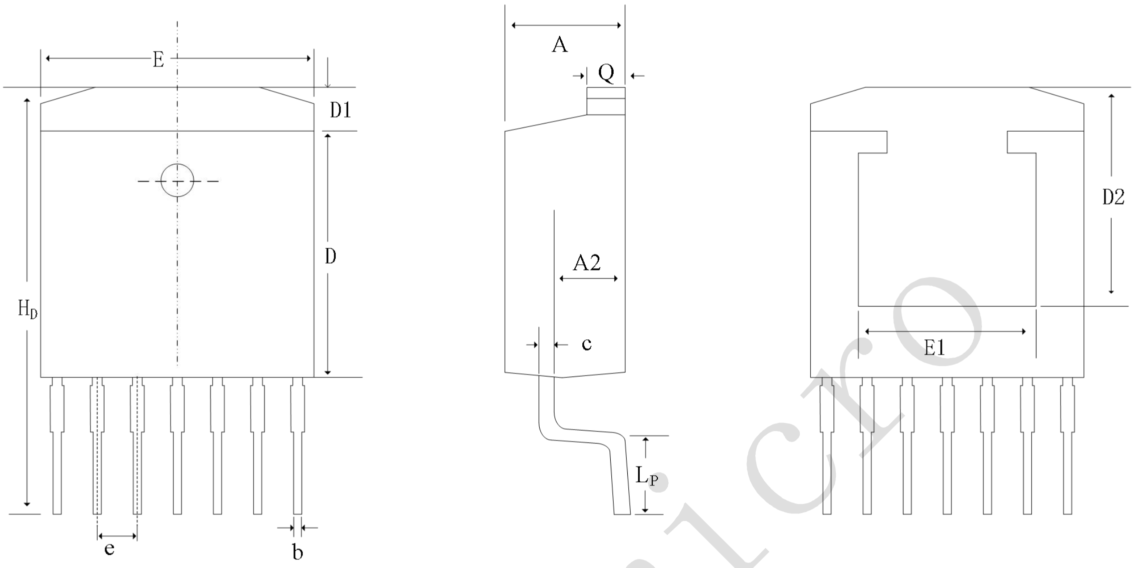
$C_{IN}$ and D are optional depending on application requirements.

### Bill of Material

| Reference | Value | Reference | Value |
|---|---|---|---|
| $R_{IN}$ | 1KΩ | $R_{PD}$ | 47KΩ |
| $R_1$ | 1KΩ | $C_{OUT}$ | 10nF |
| $R_2$ | 10KΩ | $R_{SENSE}$ | 10KΩ |
| Q | 100V MOSFET | $C_{SENSE}$ | 10nF |
| ZD1 | 6.2V Zener diode | $R_{IS}$ | 1KΩ |
| ZD2 | 58V Zener diode | $C_{IN}$ | 47nF |
| $C_{VBB}$ | 100nF | D | |

## 15.Package

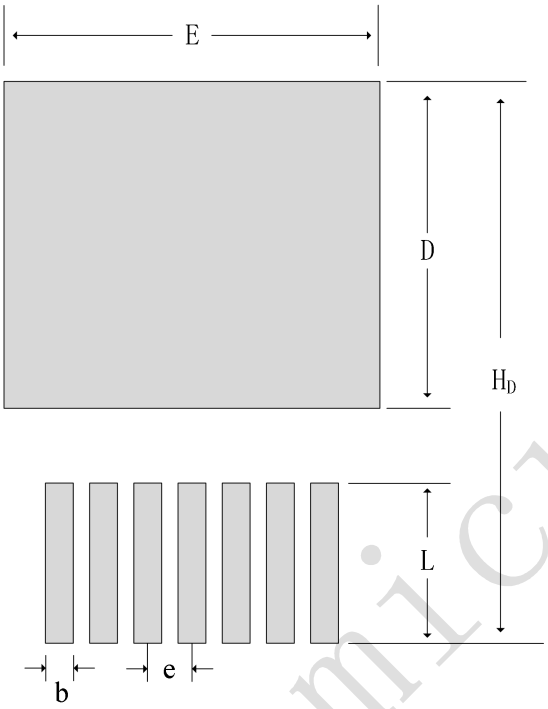
### TO-263-7L



Unit :mm

| Symbol | MIN | NOM | MAX |
|---|---|---|---|
| A | 4.25 | 4.4 | 4.55 |
| Q | 1.2 | 1.3 | 1.4 |
| A2 | 2.25 | 2.4 | 2.55 |
| b | 0.5 | 0.6 | 0.7 |
| c | 0.4 | 0.5 | 0.6 |
| D | 9.05 | 9.25 | 9.45 |
| D1 | 0.7 | 1 | 1.3 |
| D2 | 6.9 | - | - |
| E | 9.8 | 10 | 10.2 |
| e | 1.27BSC | | |
| E1 | 7.25 | - | - |
| $H_D$ | 13.5 | 13.85 | 14.20 |
| L | 3.3 | 3.6 | 3.9 |
| $L_P$ | 1.8 | 2.1 | 2.4 |

## 16.Recommended Soldering Footprint



Unit : mm

| Symbol | NOM | Symbol | NOM |
|---|---|---|---|
| E | 10.2 | $H_D$ | 18 |
| b | 0.8 | e | 1.27 |
| L | 4 | D | 8.9 |

## 17.Revision History

| Version | Change Description | Date |
|---|---|---|
| 1.0 | Initial Version | 2024/08/07 |
| 1.1 | 1) Added certain parameter in the Absolute Maximum Ratings<br>2) Revised and Added certain parameter in the Electrical Characteristics table.<br>3) Added curves showing parameter variations with ambient temperature;<br>4) Revised introductions for circuit functions in the Functions section.<br>5) Revised Recommended Soldering Footprint<br>6) Revised Application Information. | 2025/07/30 |