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	$V_{bb(AZ)}$	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

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

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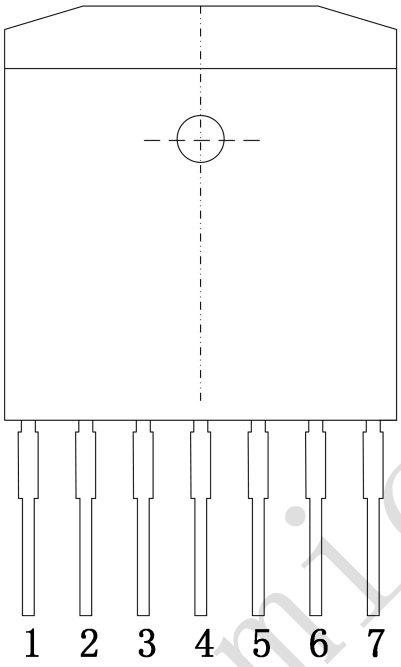
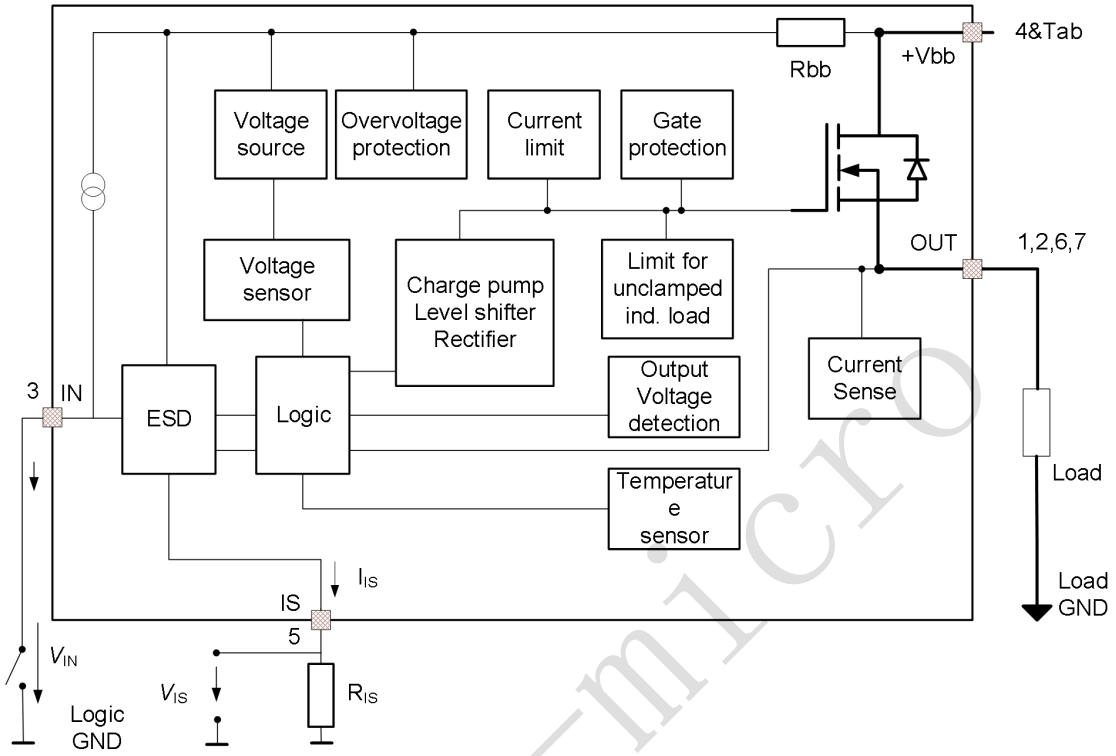
6. Pin Configuration



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	Vbb	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 Tj = 25 °C unless otherwise specified)

Parameter	Symbol	Values	Unit
Supply voltage	V_{bb}	62	V
Supply voltage for full short circuit protection	V_{bb}	58	V
Load dump protection $V_{LoadDump}=U_A+Vs$, U_A=13.5V, R_i=2Ω,R_L=0.23Ω, t_d=200ms, IN, IS=open or grounded	$V_{Load\ dump}$	80	V
Power dissipation (DC), $T_C \leq 25$ °C	P_{tot}	170	W
Junction temperature	T_j	-40 to 150	℃
Ambient temperature	T_a	-40 to 125	℃
Storage temperature	T_{stg}	-55 to 150	℃

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}=12V; (unless otherwise specified)

Symbol	Parameter	Test Condition	Values			Unit
			Min	Typ	Max	
R_{TH}	Thermal resistance	chip to case	-	-	1.0	K/W
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_j=25℃	9.9	11.1	-	A
$I_{L(ISO)}$	Load current	V_{on}=0.5V; T_j=25℃	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
$V_{bIN(u)}$	Under voltage shutdown		1.5	3.0	4.5	V
$V_{bIN(ucp)}$	Under voltage start of charge pump		3.0	4.5	6.0	V
$I_{bb(off)}$	Standby current	I_{IN}=0; V_{bb}=24V; 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		-	6	-	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	-	-	℃
ΔT_{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_{bIN}=12V; I_L=-20A; T_j=25℃	-	7.2	15.0	mΩ
		V_{bIN}=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

10. Timing diagrams

Figure 1: Switching a Resistive Load Timing

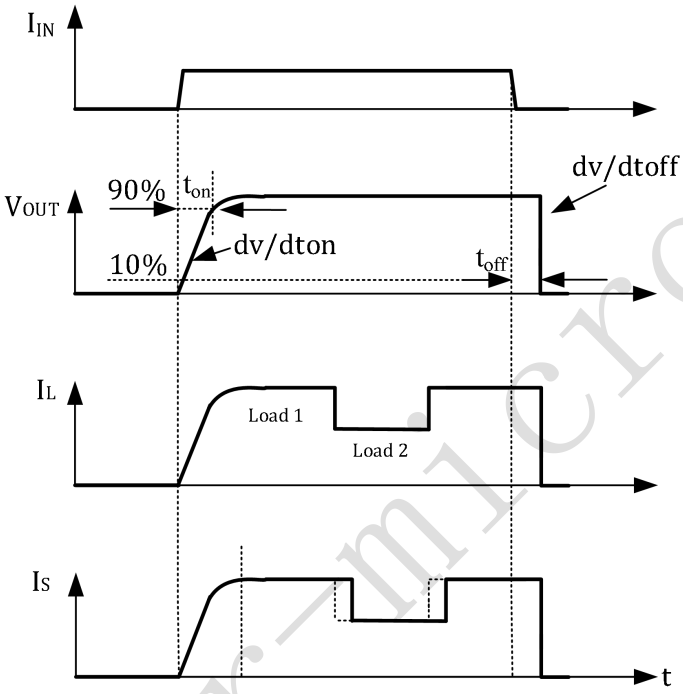
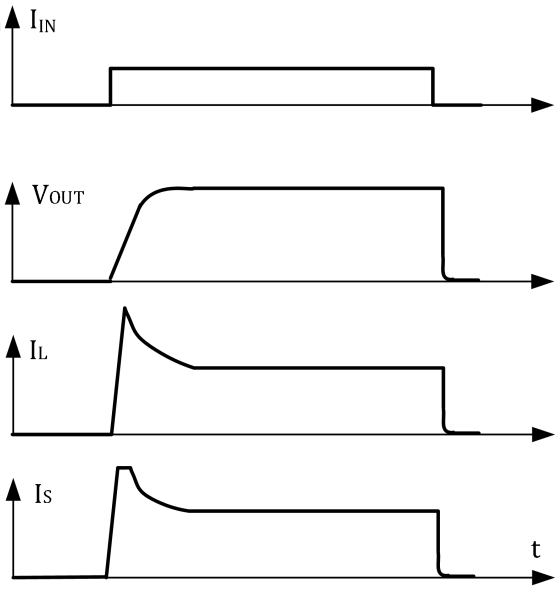


Figure 2a: Switching motors and lamps



Sense current saturation can occur at very high inrush currents

Figure 2b: Switching an inductive load

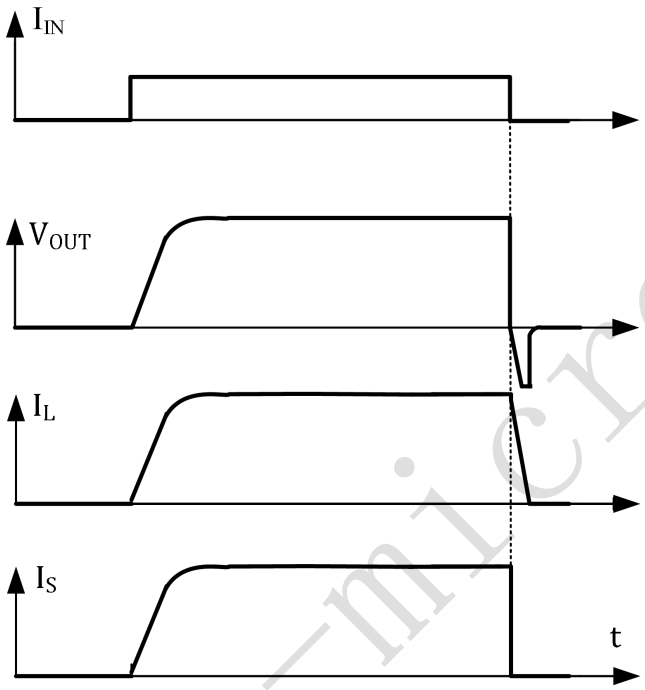


Figure 3: Short circuit

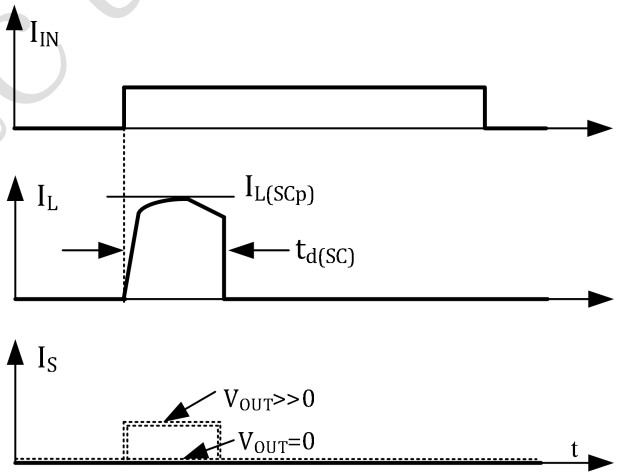
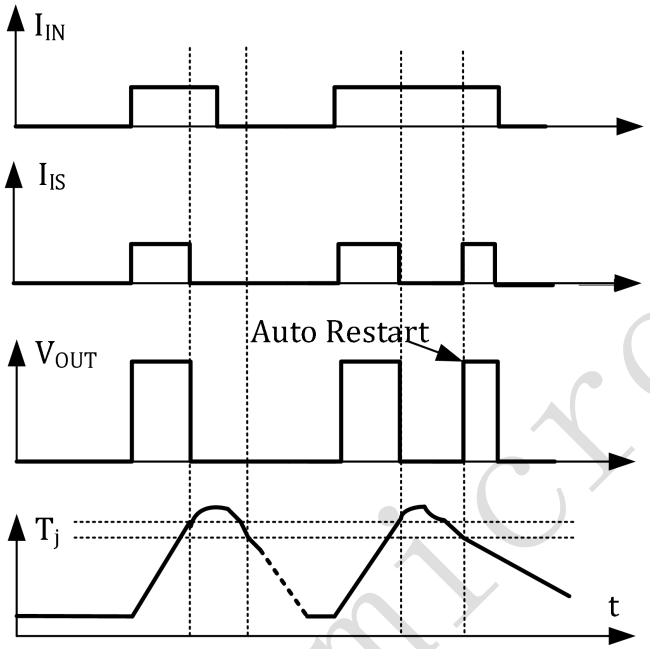
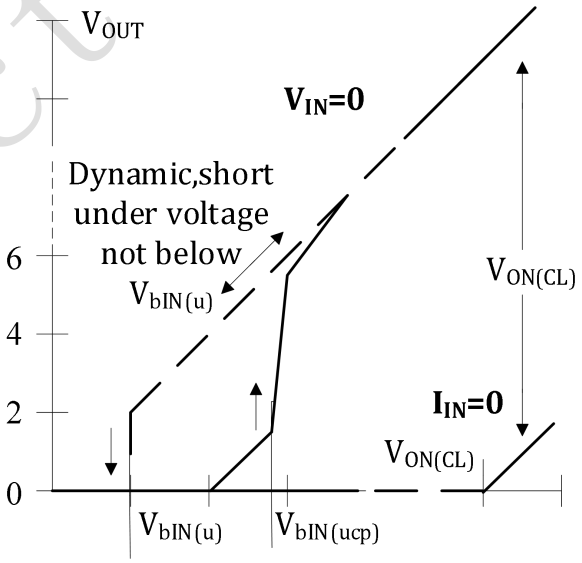


Figure 4: Over temperature



Shut down remains latched until next reset via input

Figure 5: Undervoltage restart of charge pump, overvoltage clamp



11. Truth Table

Operation Mode	Input Current level	Output level	Current Sense I_{IS}	Remark
Normal operation	L H	L H	0 Nominal	$=I_L/K_{ilis,}$ 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 H	L L	0 0	
Over temperature	L H	L L	0 0	
Short circuit to Vbb	L H	H H	0 Nominal(1)	
Open load	L H	Z(2) H	0 0	
Negative output voltage clamp	L	L	0	
Inverse load current	L H	H H	0 0	

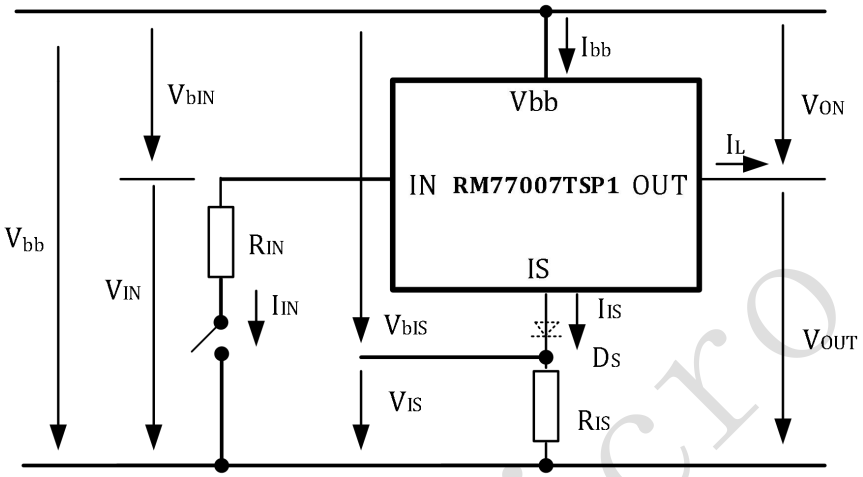
L = "Low" Level, H = "High" Level

1) Low ohmic short to Vbb may reduce the output current I L and can thus be detected via the sense current I IS.

2) Power Transistor "OFF", potential defined by external impedance.

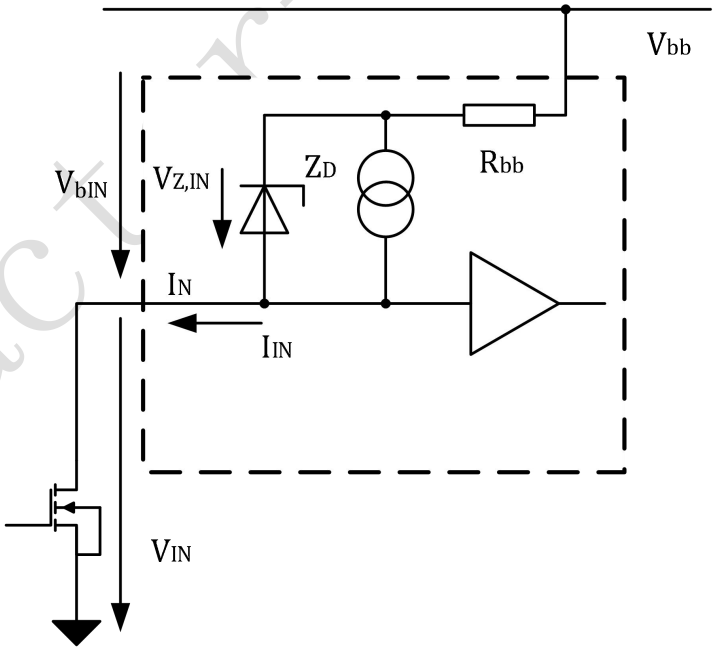
12. Functions

12.1 Terms



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

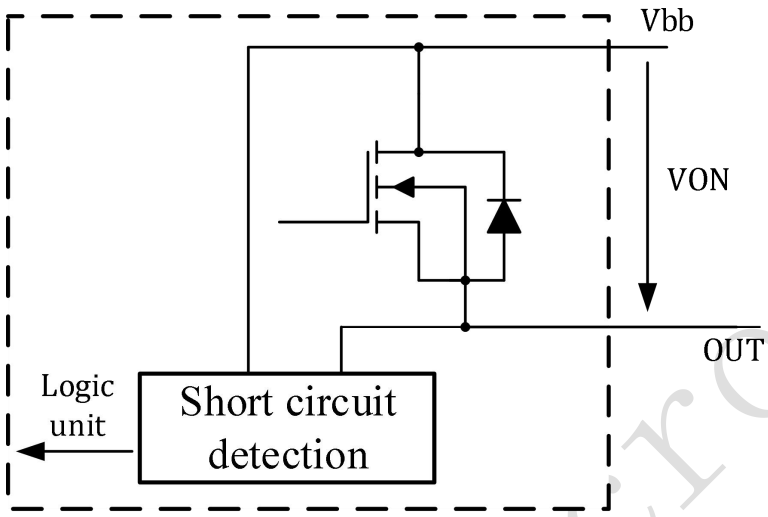
12.2 Input circuit (ESD protection)



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.

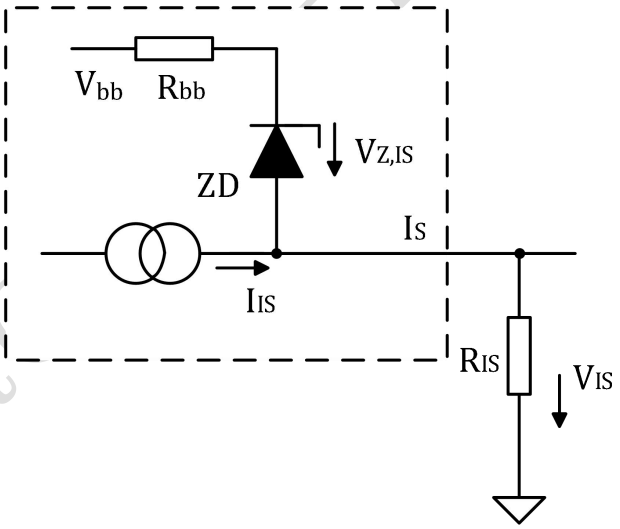
$V_{Z,IN}$ = 66 V (typ).

12.3 Short circuit detection



Fault Condition: $V_{ON} > V_{ON(SC)}$ (6 $V_{typ.}$) and $t>t_{d(SC)}$(80...300 μs)

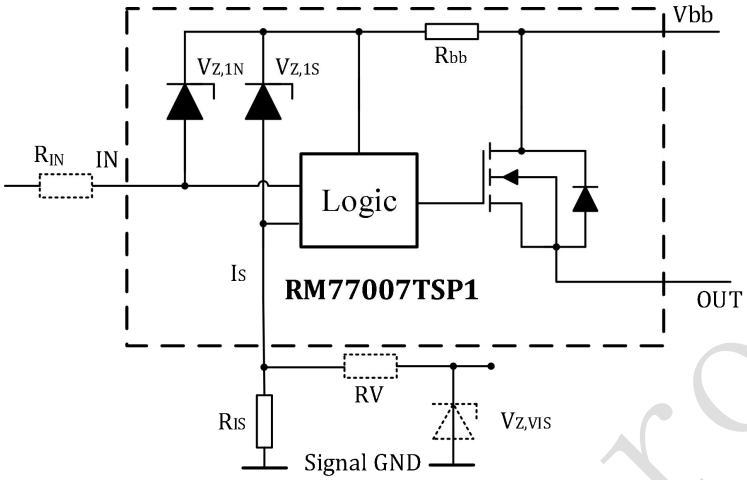
12.4 Current sense status output



$V_{Z,IS}$ = 74 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 Vout - V_{IS} >5 V. If you want measure load currents up to $I_{L(M)}$, R_{IS} should be less than $\frac{V_{bb} - 5V}{I_{L(M)} / k_{ilis}}$.

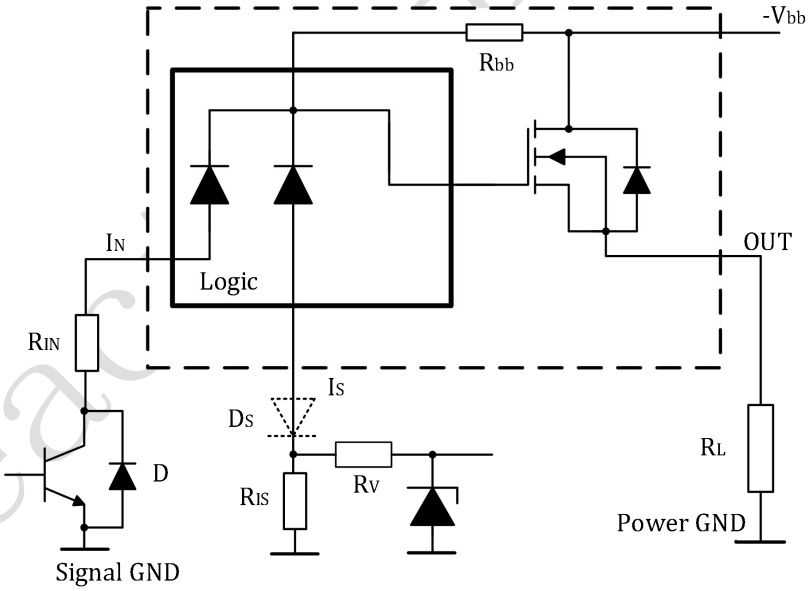
Note: For large values of R_{IS} the voltage V_{IS} can reach almost V_{bb} . See also over voltage protection. If you don't use the current sense output in your application, you can leave it open.

12.5 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 72 V typ. a voltage above 5V can occur between IS and GND, if R_V , $V_{Z,}$ V_{IS} are not used.

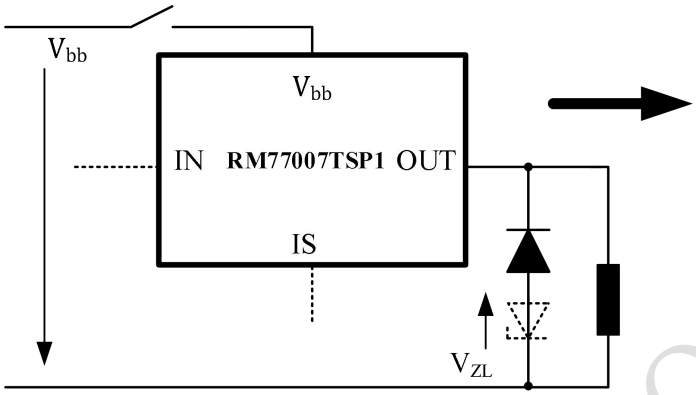
12.6 Reverse battery protection



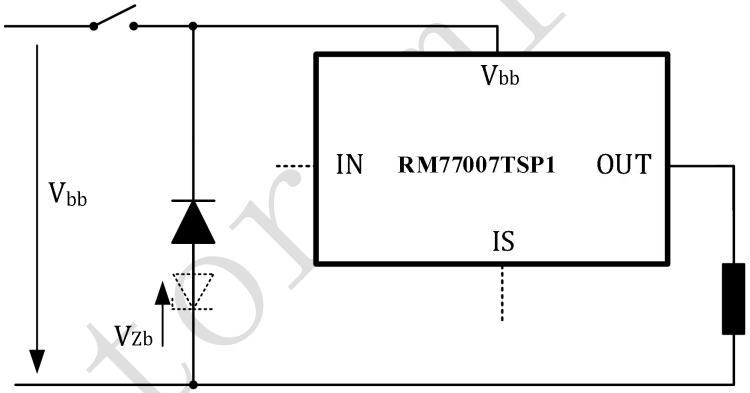
R_V ≥1 kΩ, R_{IS} = 1 kΩ nominal. Add R_{IN} for reverse battery protection; recommended value $\frac{1}{R_V}+\frac{1}{R_{IN}}+\frac{1}{R_{IS}}$; if D_S is used, I_{IN} recommended value: $\frac{1}{R_{IN}}$, R_V > 1KΩ, R_{IS} = 1KΩ.

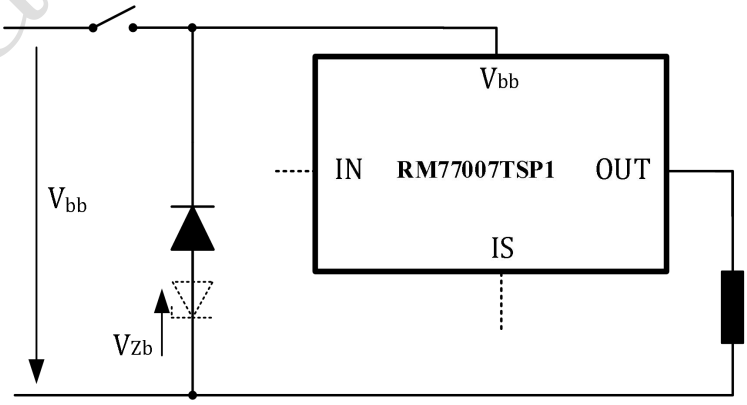
To minimize power dissipation at reverse battery operation, the overall current into the IN and IS pin should be about 120mA. The current can be provided by using a small signal diode D in parallel to the input switch, by using a MOSFET input switch or by proper adjusting the current through R_{IS} and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

12.7 V_{bb} disconnect with energized inductive load



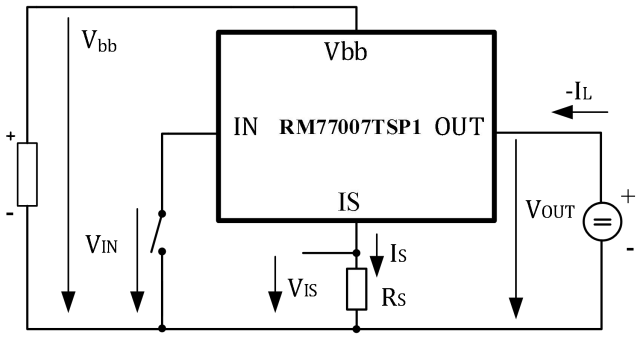
Provide a current path with load current capability by using a diode, a Z-diode, or a varistor. (V_{ZL} < 72 V or V_{Zb} = 42 V if R_{IN} =0).





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

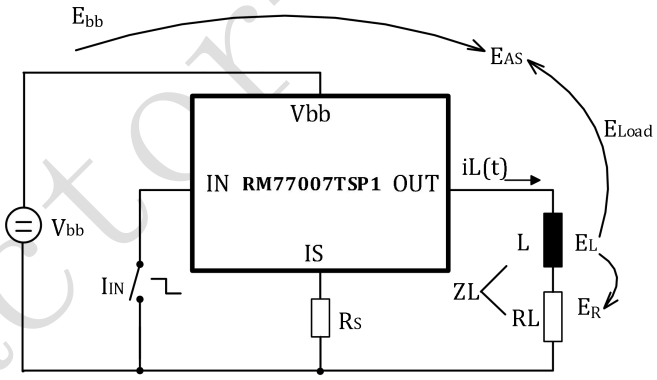
12.8 Inverse load current operation



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!

12.9 Inductive load switch-off energy dissipation



Energy stored in load inductance:

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

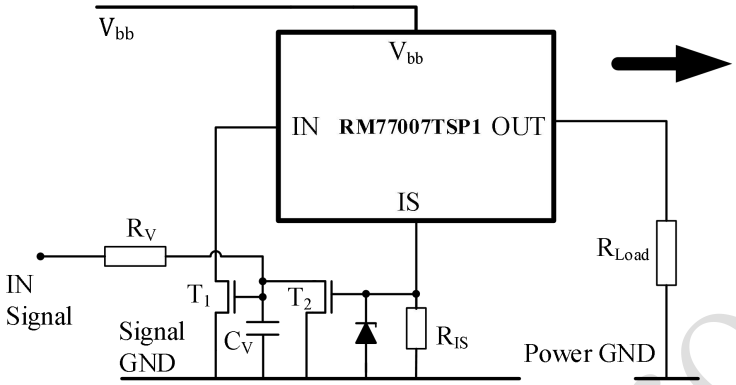
While demagnetizing load inductance, the energy dissipated in RM77007TSP1 is:

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

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

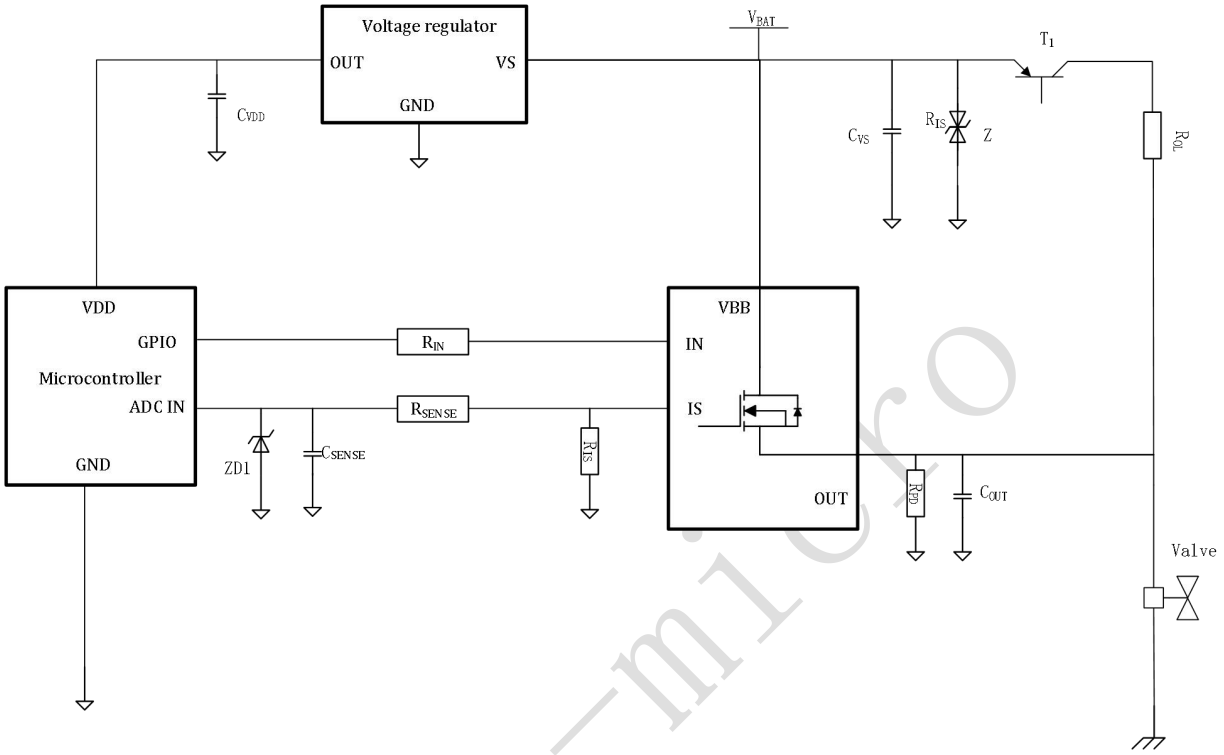
$$E_{AS} = \frac{I_L * L}{2 * R_L} (V_{bb} + |V_{OUT(CL)}|) \ln\left(1 + \frac{I_L * R_L}{|V_{OUT(CL)}|}\right)$$

12.10 Externally adjustable current limit



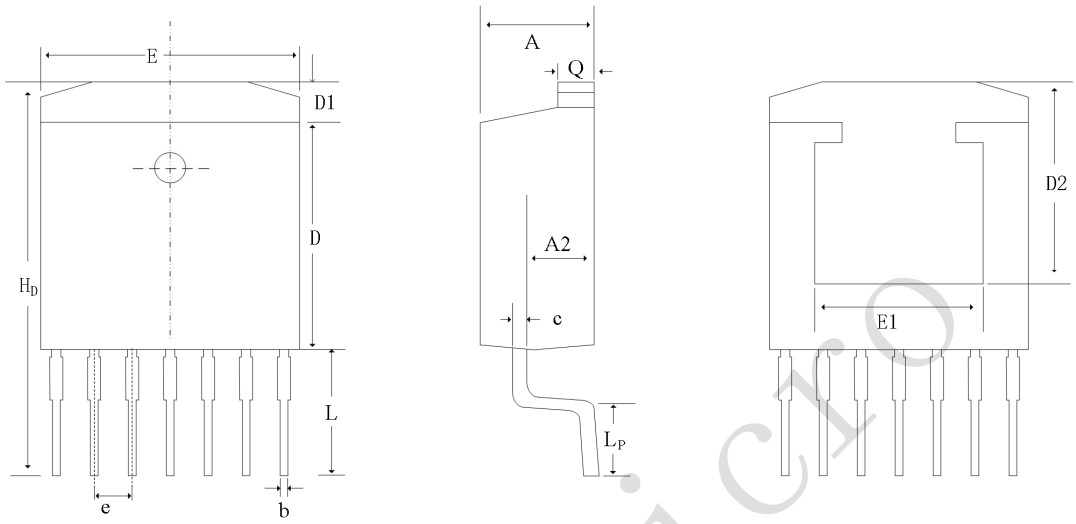
If the device is conducting, the sense current can be used to reduce the short circuit current and allow higher lead inductance (see diagram above). The device will be turned off, if the threshold voltage of T2 is reached by $I_S * R_{IS}$. After a delay time defined by $R_V * C_V$ T1 will be reset.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

13. Application Information



14. Package

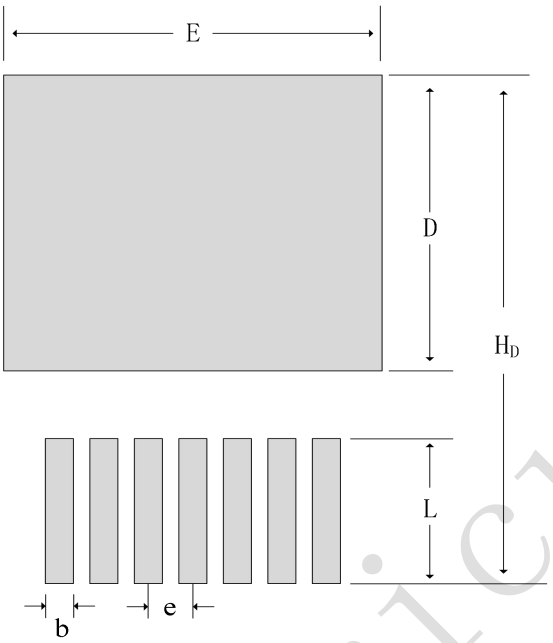
TO-263-7L



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

15. Recommended Soldering Footprint



Unit : mm

Symbol	NOM	Symbol	NOM
E	10.8	H_D	16.15
b	0.8	e	1.27
L	4.6	D	9.4

16. Revision History

Version	Change Description	Date
1.0	Initial Version	2024/08/07