Smart High-Side Power Switch
RM76003TS Datasheet

1.Basic Features

- Very low standby current
- Overload protection
- Current limitation
- Short circuit protection
- Over temperature protection
- Over voltage protection
- Clamp of inductive loads
- Fast demagnetization of inductive loads
- Load current reverse conduction
- Diagnostic feedback with load current sense
- Electrostatic discharge (ESD) protection
- Green Product (RoHS compliant)
- AEC-Q100 qualified

2.Description

RM76003TS 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.

RM76003TS 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

- 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

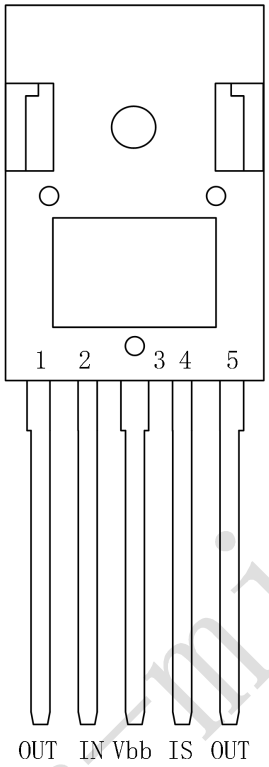
Overvoltage protection	$V_{bb(AZ)}$	62	V
Operating voltage	$V_{bb(ON)}$	5...34	V
On-state resistance	R_{ON}	2.8	mΩ
Nominal load current	$I_{L(NOM)}$	20	A
Current limitation	$I_{L(SC)}$	220	A
Current sense ratio	I_L:I_{IS}	29000	

5.Ordering Code

Device	Package Type	Marking	Materials	Package			Package Qty
RM76003TS	TO-247-5L	RM76003TS	Halogen free	tube	60 tubes/box	1800/box	30/tube

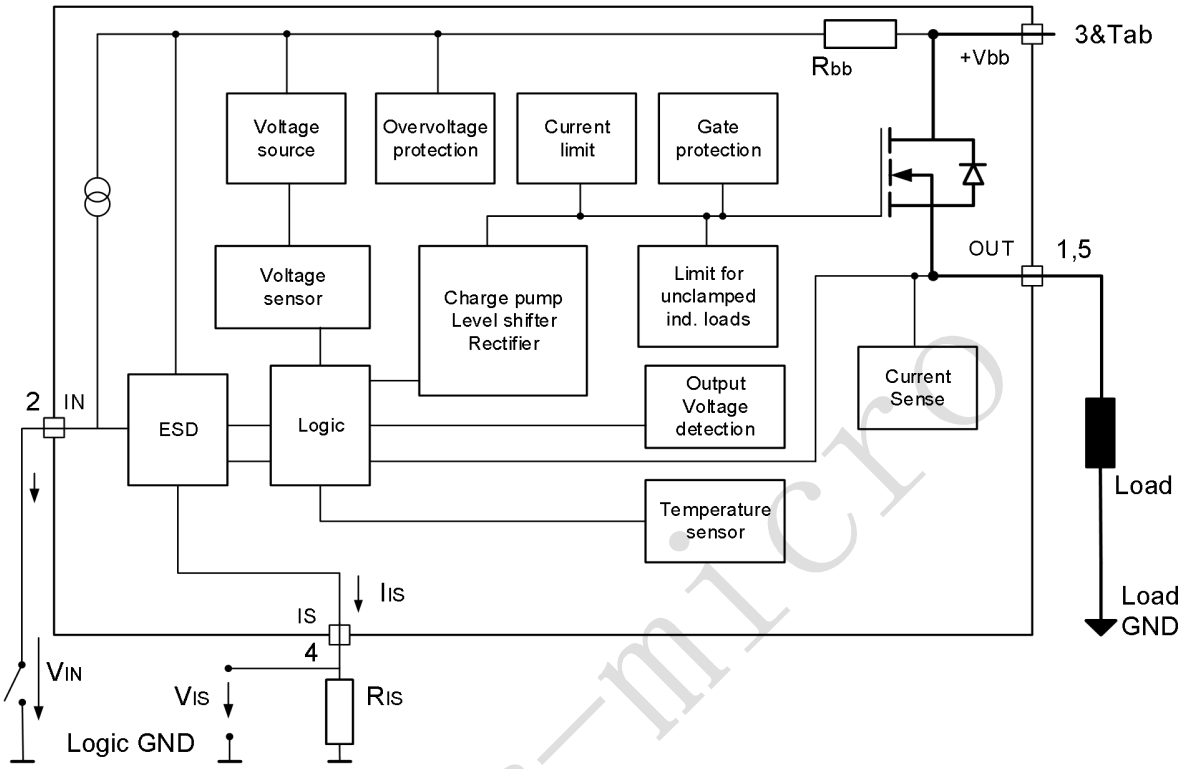
Table of Contents

6. Pin Configuration



Pin	Symbol	Function
1	OUT	Output to the load; The pins 1 and 5 must be shorted with each other especially in high current applications
2	IN	Input; activates the power switch in case of short to ground
3	V_{bb}	Positive power supply voltage; the tab is electrically connected to this pin; In high current applications the tab should be used for the Vbb connection instead of this pin
4	IS	Diagnostic feedback providing a sense current proportional to the load current; zero current on failure
5	OUT	Output to the load; The pins 1 and 5 must be shorted with each other especially in high current applications

7.Block Diagram



8.Absolute Maximum Ratings

T_J = 25°C; (unless otherwise specified)

Parameter	Symbol	Values	Unit
Supply voltage	V_{bb}	40V	V
Supply voltage for Load dump protection $V_{LoadDump}=U_A+V_S$, U_A=13.5VR_I=2Ω, R_L=0.54Ω, t_d=200ms, IN, IS=open or grounded	$V_{Loaddump}$	80V	V
Power dissipation(DC)	P_{tot}	360W	W
Ambient temperature	T_a	-40 to 125	℃
Junction temperature	T_j	-40 to 150	℃
Storage temperature	T_{stg}	-55 to 150	℃
Thermal resistance junction - ambient (free air)	R_{thJA}	33.43	K/W
Thermal resistance chip - case	R_{thJC}	0.35	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℃ to +150°C, Vbb=24V; (unless otherwise specified)

Symbol	Parameter	Test Condition	Values			Unit
			Min	Typ	Max	
Load Switching Capabilities and Characteristics						
R_{ON}	On-state resistance	I_L=20A, T_j=25℃ I_L=20A, T_j=150℃	-	2.8 5	3.6 6.5	mΩ
$I_{L(nom)}$	Nominal load current		20	-	-	A
$I_{L(ISO)}$	Nominal load current(ISO)		90	100	-	A
t_{on}	Turn-ON time	I_{IN} Turn-ON to 90%V_{OUT} V_{bb}=12V, R_L=2Ω	50	-	200	μs
t_{off}	Turn-OFF time	I_{IN} Turn-OFF to 10% V_{OUT} V_{bb}=12V, R_L=2Ω	10	-	100	μs
dV/dt_{on}	Turn-ON Slew rate	From 10% to 30% V_{OUT} V_{bb}=12V, R_L=2Ω	0.2	-	1.5	V/μs
dV/dt_{off}	Turn-OFF Slew rate	From 70% to 40% V_{OUT} Vbb=12V, RL=2Ω	0.5	-	2.0	V/μs
$V_{bb(on)}$	Operating voltage	R_{load}=100Ω	5		34	V
$V_{bIN(u)}$	Undervoltage shutdown	V_{OUT}<0.5V, R_L=100Ω	1.5	3.3	4.5	V
$V_{bIN(ucp)}$	Undervoltage restart of charge pump	V_{OUT}>0.5V, R_L=100Ω	3.0	4.9	6.0	V
$I_{bb(off)}$	Standby current	I_{IN}=0, T_j=25℃	-	0.1	1	μA
$I_{L(SC)}$	Short circuit current limit	V_{bb}=12V, T_j=-40℃ V_{bb}=12V, T_j=25℃ V_{bb}=12V, T_j=150℃	- - -	230 220 210	- - -	A
$t_{d(SC)}$	Short circuit shutdown delay	V_{ON}>$V_{ON(SC)}$	80	-	350	μs
$V_{ON(CL)}$	Short circuit shutdown detection voltage	V_{OUT}=V_{bb}-$V_{ON(CL)}$, L_{out}=1H	38	42	47	V
$-V_{OUT(CL)}$	Short circuit shutdown detection voltage	L_{out}=1H	14	18	20	V
T_{jt}	Thermal overload trip temperature	V_{bb}=12V, R_{load}=1.2Ω, T_A=25℃	150	-	-	℃
ΔT_{jt}	Thermal hysteresis	V_{bb}=12V, R_{load}=1.2Ω, T_A=25℃	-	10	-	K
$I_{IN(ON)}$	Input and operating current	V_{bb}=24V, R_{load} floating	-	0.8	1.5	mA

$I_{IN(OFF)}$	Input current for turn-off	V_{OUT}<0.5V, R_{load} floating	-	-	100	μA
$V_{bb(az)}$	overvoltage protection	T_j=-40℃ T_j=25℃...150℃	62 62	- 66	- -	V
Inverse Load Current Operation						
$R_{ON(inv)}$	On-state resistance	V_{bin}=24V, I_L=-20A, T_j=25℃ V_{bin}=24V, I_L=-20A, T_j=150℃	- -	2.8 5	4.3 6.5	mΩ
$I_{L(inv)}$	Nominal inverse load current	V_{ON}=-0.5V, T_j=85℃	90	100	-	A
$-V_{ON}$	Drain-source diode voltage	I_L=-20A, I_{IN}=0, T_j=25℃ (V_{out}>V_{bb})	-	-	0.85	V
Diagnostic Characteristics						
K_{ilis}	Current sense ratio	K_{ilis}=I_L:I_S, V_{ON}<1.5V I_L=20A	23000	-	34000	
		K_{ilis}=I_L:I_S, V_{ON}<1.5V IL=50A	25000	-	33000	
I_{IS_lim}	Sense current saturation	I_{OUT}=70A	3.5	-	-	mA
$I_{IS(LL)}$ $I_{IS(LH)}$	Current sense leakage current	I_{IN}=0 V_{IN}=0, I_L=0	- -	- 2	0.5 100	μA
V_{Z_IS}	Current sense over voltage protection	T_j=-40℃ T_j=25℃...150℃	62 62	- 66	- -	V
$t_{S(IS)}$	Current sense settling time	V_{OUT} from 90% V_{bb} to 90% V_{IS}, R_{load}=2Ω	-	-	500	μs

10.Timing diagrams

Figure 1a: Switching a Resistive Load Timing

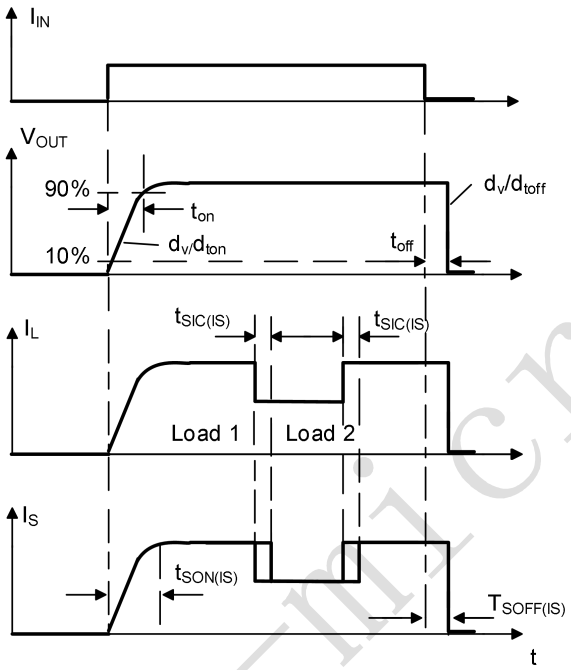
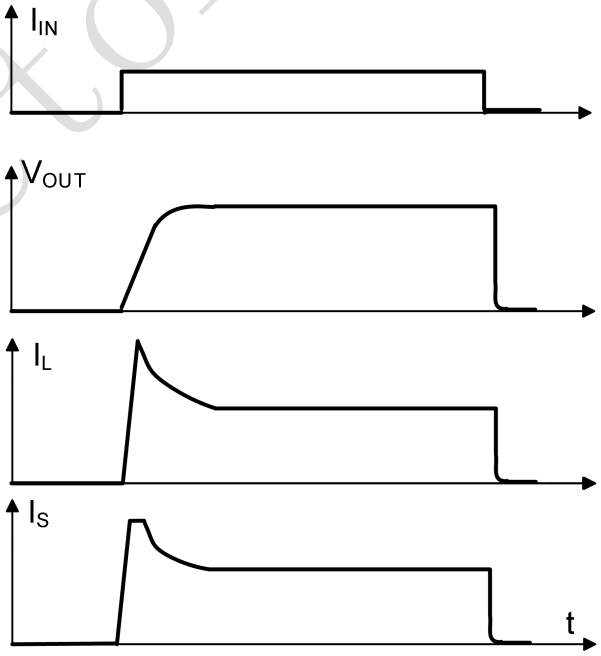


Figure 2a: Switching motors and lamps



Sense current saturation can occur at very high inrush currents

Figure 2b: Switching an inductive load

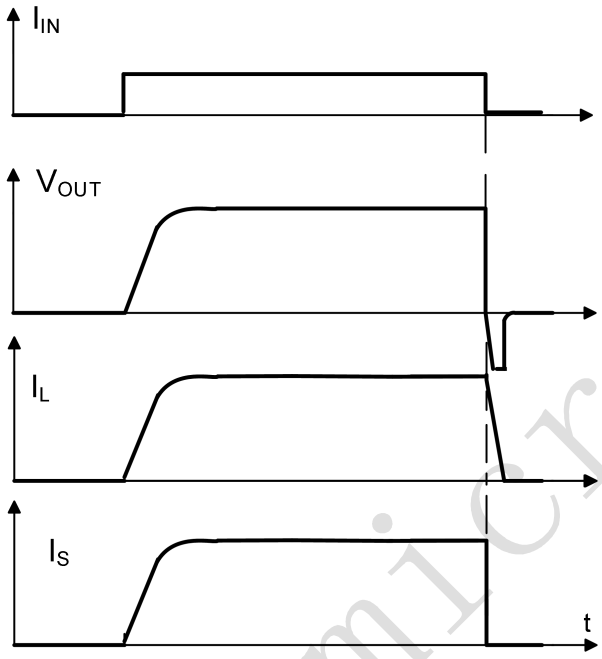


Figure 3a: Short circuit

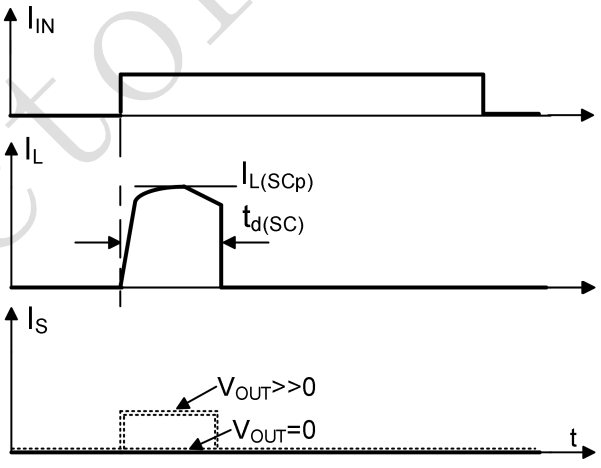
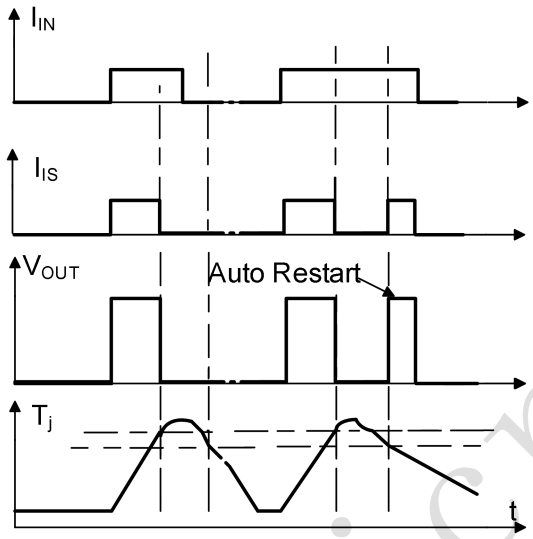
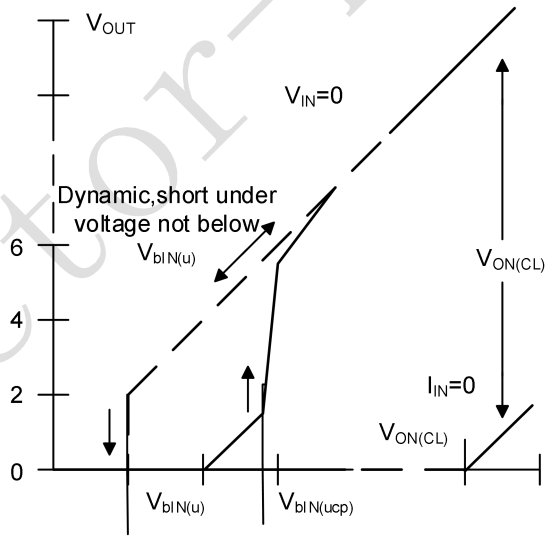


Figure 4a: Overtemperature



Reset if $T_j<T_{jt}$

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



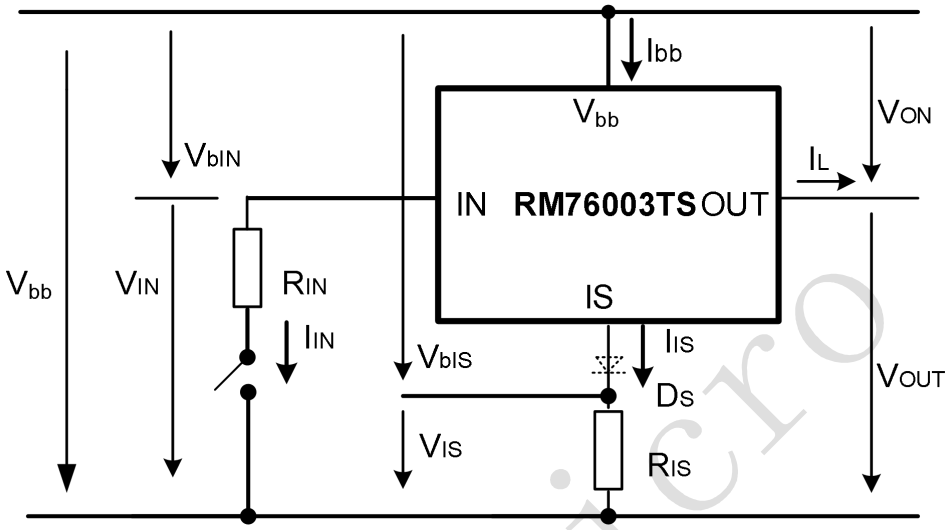
11.Truth Table

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	if $V_{ON}>V$, 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	
Open load	L H	Z 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

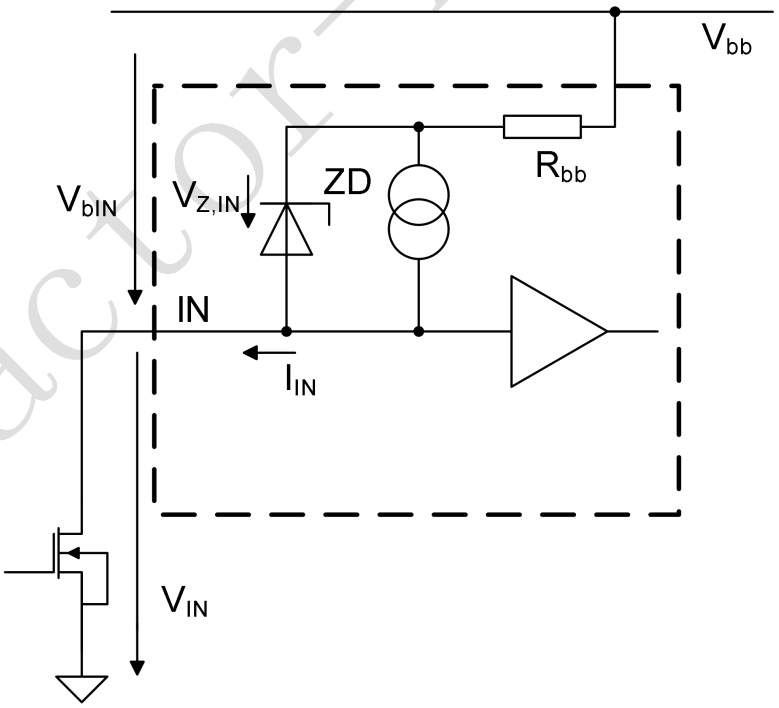
12.Functions

12.1 Terms



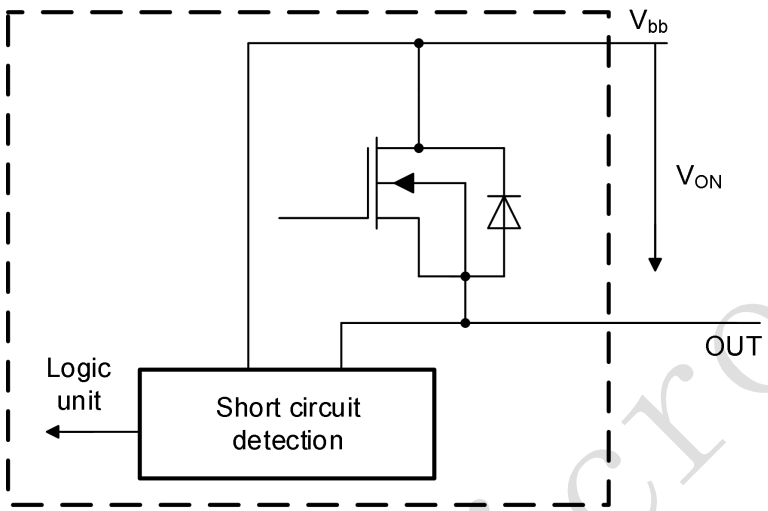
Two or more devices can easily be connected in parallel to increase load current capability.

12.2 Input circuit (ESD protection)



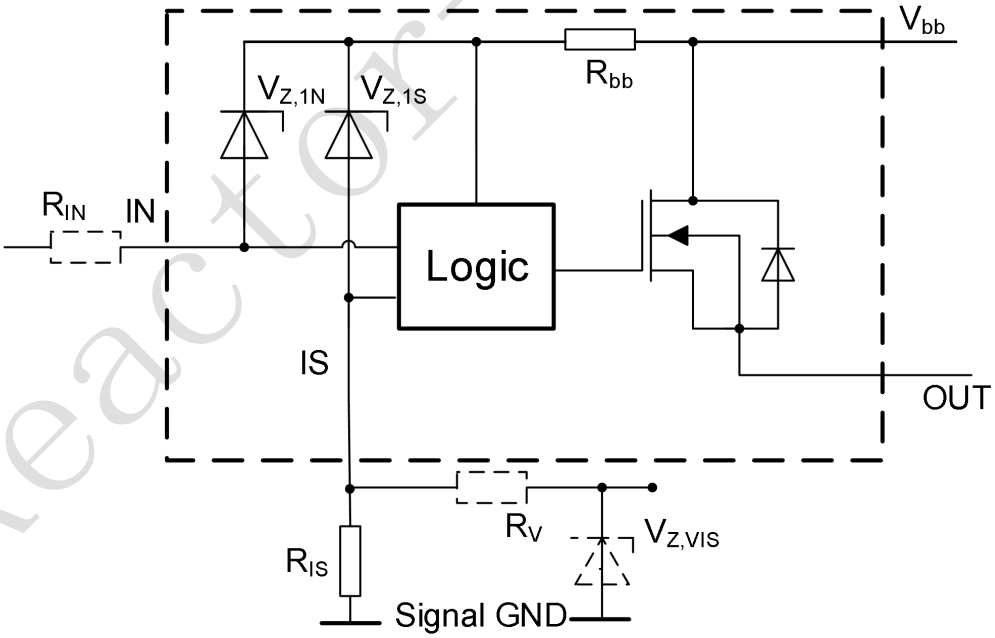
When the device is switched off (I_{IN} =0) the voltage between IN and GND reaches almost V_{bb}. Use a mechanical switch, a bipolar or MOS transistor with appropriate breakdown voltage as driver. $V_{Z,\,IN}$ = 66V (typ).

12.3 Short circuit detection



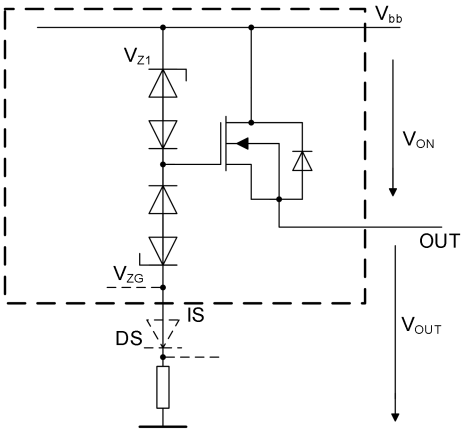
Fault Condition: $V_{ON} > V_{ON(SC)}$ (6V typ.) and $t > t_{d(SC)}$ (80μs~350 μs).

12.4 Overvoltage protection of logic part



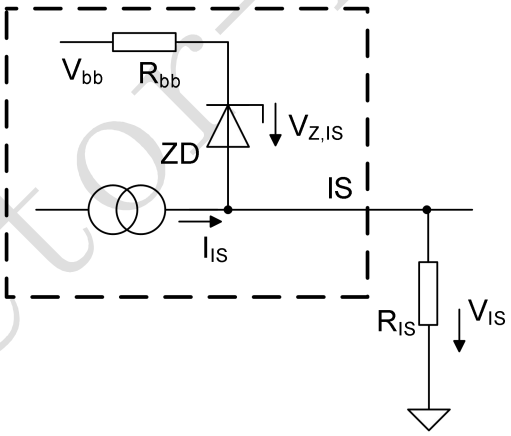
R_{bb} =120Ω typ., $V_{Z,\,IN} = V_{Z,\,IS}$ = 66V typ., R_{IS} =1kΩ nominal. Note that when overvoltage exceeds 66V typ. a voltage above 5V can occur between IS and GND, if R_V, $V_{Z,\,VIS}$ are not used.

12.5 Inductive and overvoltage output clamp



V_{ON} is clamped to $V_{ON(CL)}$ =42V typ. At inductive load switch-off without D_S, V_{OUT} is clamped to $V_{OUT(CL)}$ = -18V typ. via V_{ZG}. With D_S, V_{OUT} is clamped to V_{bb} - $V_{ON(CL)}$ via V_{Z1}. Using DS gives faster deenergizing of the inductive load, but higher peak power dissipation in the RM76003TS. In case of a floating ground with a potential higher than 19V referring to the OUT – potential the device will switch on, if diode DS is not used.

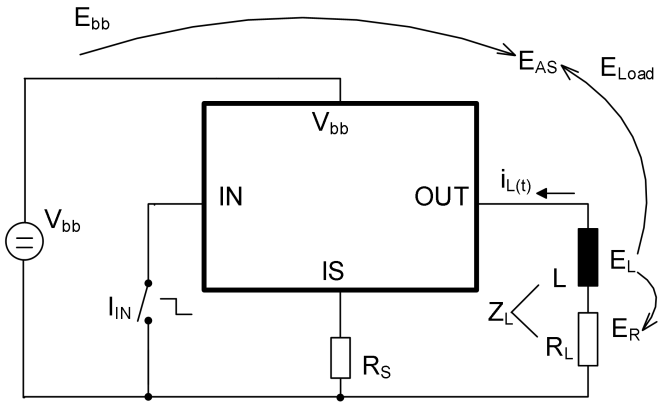
12.6 Current sense status output



$V_{Z,IS}$ = 66V (typ.), R_{IS} =1 kΩ nominal (or 1 kΩ /n, if n devices are connected in parallel). $I_S = I_L / k_{ilis}$ can be driven only by the internal circuit as long as Vout - V_{IS} > 5 V. If you want to measure load currents up to $I_{L(M)}$, R_{IS} should be less than $\dfrac{V_{bb} - 5V}{I_{L(M)} / k_{ilis}}$

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

12.7 Inductive load switch-off energy dissipation



Energy stored in load inductance:

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

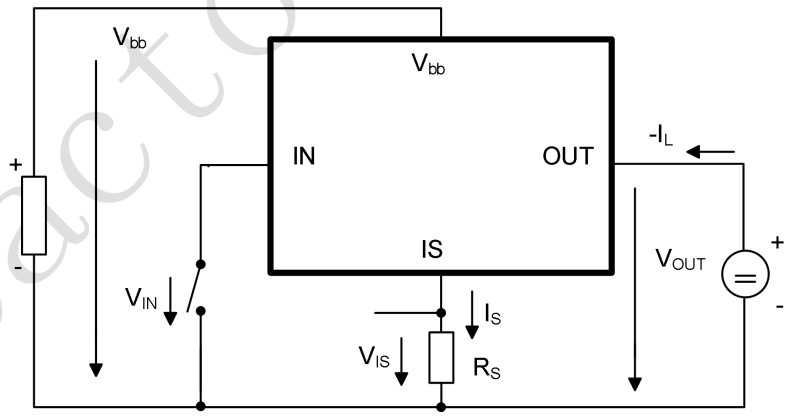
While demagnetizing load inductance, the energy dissipated in RM76003TS is

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

with an approximate solution for R_L > 0Ω:

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

12.8 Inverse load current operation



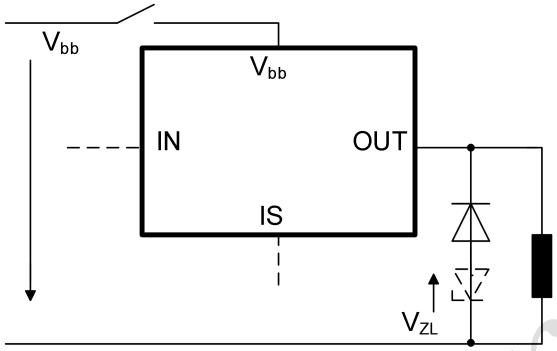
The device is specified for inverse load current operation (V_{OUT} > V_{bb} > 0V). The current sense feature is not available during this kind of operation (I_{IS} = 0). With I_{IN} = 0 (e.g. input open) only the intrinsic drain source diode is conducting resulting in considerably increased power dissipation. 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!

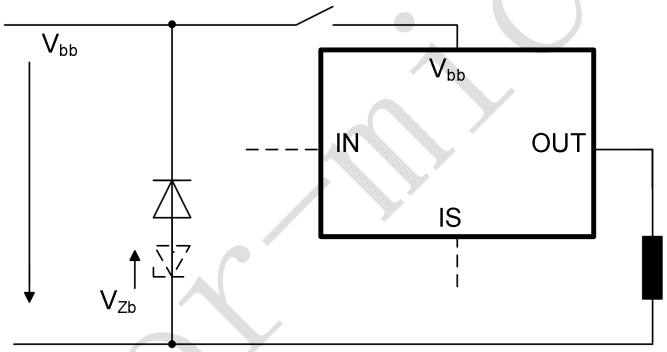
12.9 Vbb disconnect with energized inductive load

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} <30 V if R_{IN}=0). For higher clamp voltages currents at IN and IS have to be limited to 250 mA.

Version A:



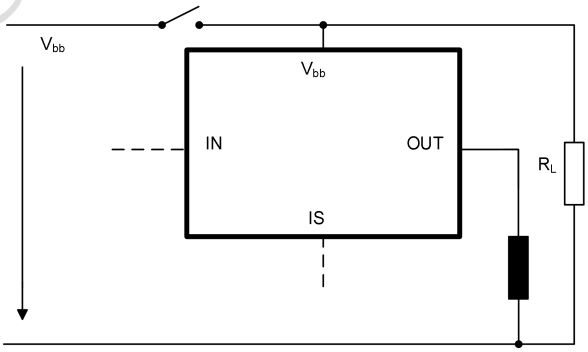
Version B:



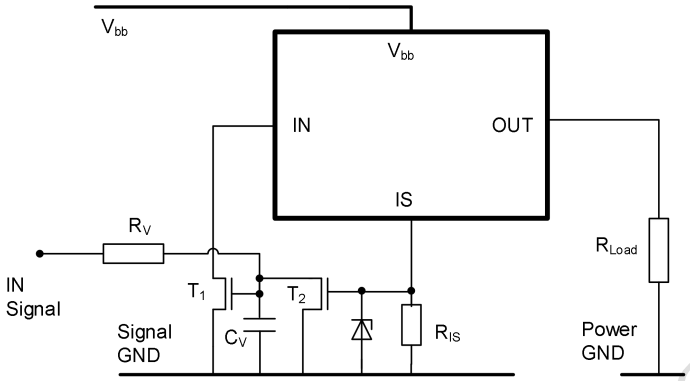
Note that there is no reverse battery protection when using a diode without additional Z-diode V_{ZL}, V_{Zb}.

Version C:

Sometimes a neccessary voltage clamp is given by non inductive loads R_L connected to the same switch and eliminates the need of clamping circuit:

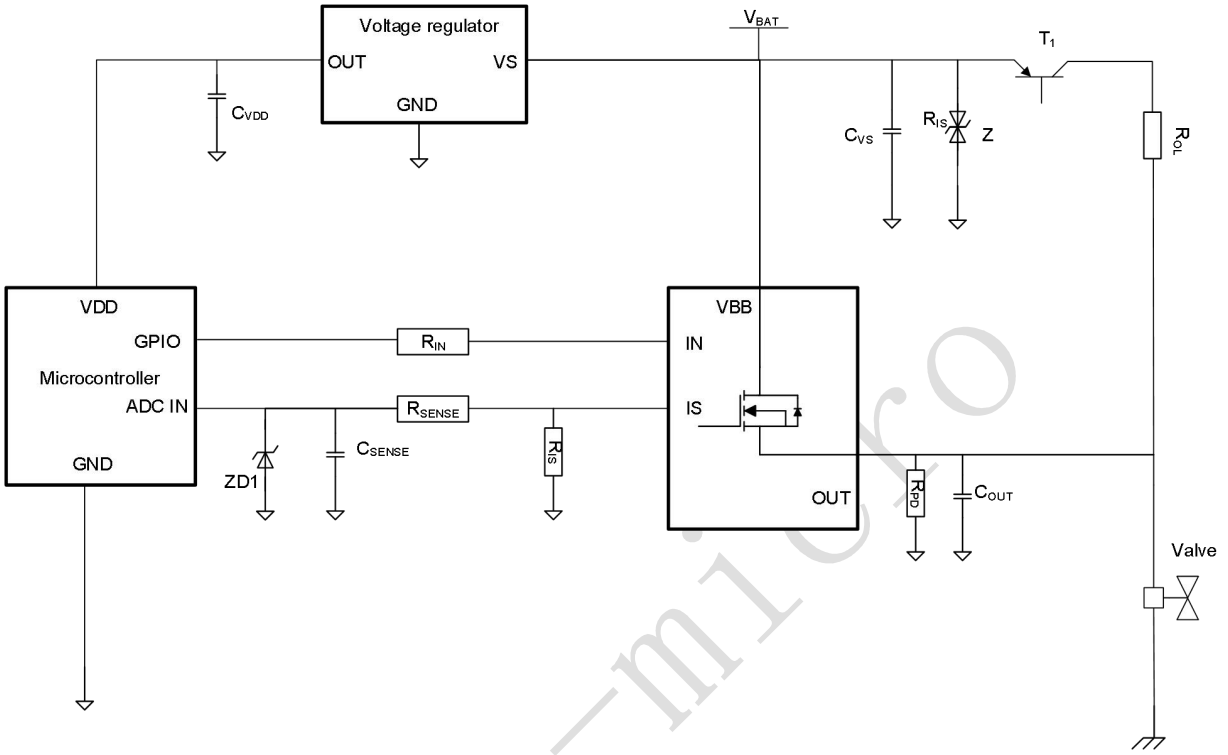


12.10 Externally adjustable current limit



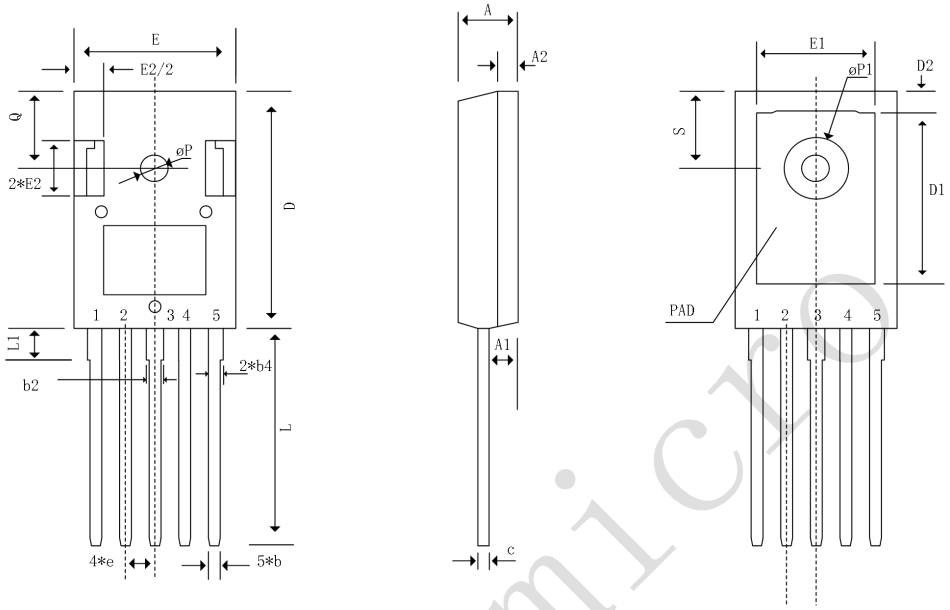
If the device is conducting, the sense current can be used to reduce the short circuit current and allow higher lead inductance (see diagram above). The device will be turned off, if the threshold voltage of T2 is reached by $I_S * R_{IS}$. After a delay time defined by $C_V * R_V$ T1 will be reset. 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-247-5L



Unit :mm

Symbol	MIN	NOM	MAX
A	4.700	4.990	5.280
A1	1.905	2.413	2.921
A2	1.500	1.995	2.490
b	1.020	1.210	1.400
b2	1.854	1.981	2.108
b4	1.372	1.499	1.626
c	0.406	0.596	0.787
D	20.640	20.850	21.060
D1	13.080	-	-
D2	1.160	1.580	2.000
E	15.750	16.000	16.250
E1	13.46	-	-
E2	4.320	4.900	5.480
e	2.54BSC		
L	19.812	20.066	20.320
L1	3.90	4.20	4.50
øP	3.560	3.610	3.660
øP1	-	-	7.39
Q	6.15BSC		
S	6.15BSC		

15.Revision History

Version	Change Description	Date
1.0	Initial Version	2024/08/16