Smart High-Side Power Switch
RM77010DS Datasheet

1.Basic Features

- Very low stand-by current
- 3.3 V and 5 V compatible logic inputs
- Electrostatic discharge protection (ESD)
- Optimized electromagnetic compatibility
- Logic ground independent from load ground
- Very low power DMOS leakage current in OFF state
- Green Product (RoHS compliant)
- AEC-Q100 qualified

2.Description

The RM77010DS is a 10mΩ single channel Smart High Side Power Switch, embedded in a DFN9*6-14L, providing protective functions and diagnosis. The power transistor is built by an N-channel MOSFET with charge pump.

3.Application

- Suitable for resistive, inductive and capacitive loads
- Replaces electromechanical relays, fuses and discrete circuits
- Most suitable for loads with high inrush current, such as lamps
- Suitable for 12 V and 24 V truck and transportation system

4.Product Summary

Over voltage protection	$V_{S(AZ)}$	70	V
Operating voltage	$V_{S(OP)}$	5...48	V
On state resistance	$R_{DS(ON)}$	10	mΩ
Nominal load current	$I_{L(NOM)}$	9	A
Short circuit current limitation	$I_{L(SC)}$	50	A
Typical current sense ratio	I_L:I_{IS}	3910	

5.Ordering Code

Device	Package Type	Marking	Materials	Package			Package Qty
RM77010DS	DFN9*6-14L	RM77010DS	Halogen free	Tape&reel	10 reels/box	30k/box	3000/reel

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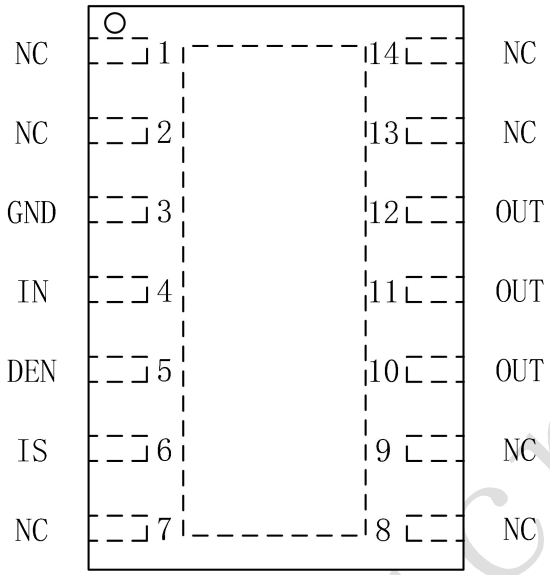
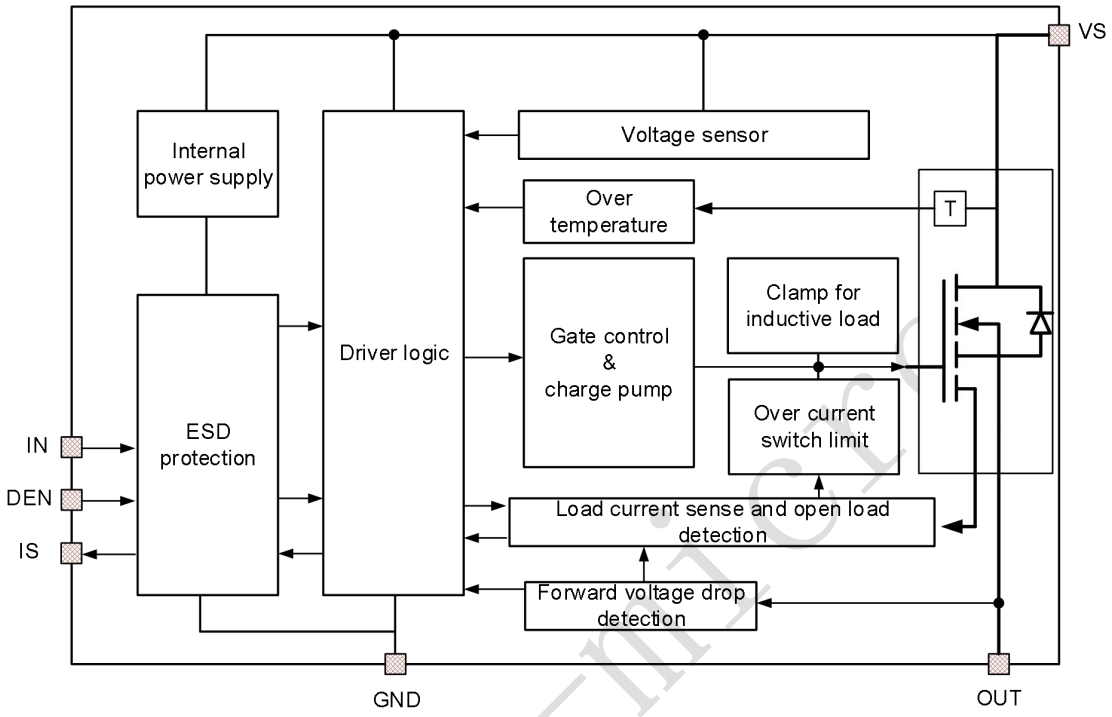
6.Pin Configuration



Pin	Symbol	Function
1/2/7/8/9/13/14	NC	Not Connected; No internal connection to the chip
3	GND	GND Ground; Ground connection
4	IN	Input channel; Input signal for channel activation
5	DEN	DEN Diagnostic enable; Digital signal to enable/disable the diagnosis of the device
6	IS	Sense; Sense current of the selected channel
10/11/12	OUT	Output; Protected high side power output channel
PAD	VS	Voltage Supply; Battery voltage

7.Block Diagram



8.Absolute Maximum Ratings

T_J = -40°C to +150°C; (unless otherwise specified)

Parameter	Symbol	Values	Unit
Supply voltage	V_S	48	V
Supply voltage for short circuit protection	V_{bb}	30	V
Supply voltage for Loaddump protection	$V_{Loaddump}$	65	V
Power dissipation (DC), TC ≤ 25 °C	P_{tot}	1.6	W
Junction temperature	T_j	-40 ... 150	℃
Ambient temperature	T_a	-40 ... 125	℃
Storage temperature	T_{stg}	-55 ... 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_S=28V; (unless otherwise specified)

Symbol	Parameter	Test Condition	Values			Unit
			Min	Typ	Max	
$R_{DS(ON)\_150}$	ON-state resistance	I_L=10A, V_{IN}=4.5V, T_j=150℃	-	17	22	mΩ
$R_{DS(ON)\_25}$	ON-state resistance	T_j=25℃	-	10	-	
Supply Voltages:						
V_S	Supply Voltages	V_{IN}=4.5V, R_L=4Ω, V_{DS}<0.5V	5	-	48	V
$V_{S(AZ)}$	Overvoltage protection	I_{SOV}=5mA	66	70	75	V
$V_{S(UV)}$	Undervoltage shutdown	V_{IN}=4.5V, R_L=4Ω, From V_{DS}<1V to I_{OUT}=0A	3	3.6	4.1	V
$V_{S(OP)\_MIN}$	Minimum functional supply voltage	V_{IN}=4.5V, R_L=4Ω, From I_{OUT}=0A to V_{DS}<0.5V	3.8	4.5	5	V
$I_{S(OFF)}$	Standby current	V_S=36V, V_{OUT}=0V, T_j≤85℃, V_{IN}, V_{DEN} floating	-	0.1	0.5	uA
$I_{S(OFF)\_150}$	Maximum standby current for whole device with load	V_S=36V, V_{OUT}=0V, T_j=150℃, V_{IN}, V_{DEN} floating	-	-	15	uA
$I_{L(NOM)}$	Nominal load current	T_A=85℃, T_j<150℃	-	9	-	A
$V_{DS(AZ)}$	Drain to source clamping voltage	I_{DS}=20mA, $V_{DS(AZ)}$ = V_S - V_{OUT}	66	70	75	V
$I_{OUT(GND)}$	Output leakage current while GND disconnected	V_S=36V	-	0.2	5	uA
I_{GND}	Operating current channel active	V_S=36V, V_{IN}=V_{DEN}=5.5V	-	0.6	2	mA
Input Pin Voltage:						
$V_{IN(H)}$	High level input voltage range		1.4	1.7	2.3	V
$V_{IN(L)}$	Low level input voltage range		0.9	1.3	1.9	V
$V_{IN(HYS)}$	Input voltage hysteresis		-	0.4	-	V
$I_{IN(H)}$	High level input current	V_{IN}=5.5V	1	10	25	uA
$I_{IN(L)}$	Low level input current	V_{IN}=0.8V	1	5	25	uA
$V_{DEN(H)}$	DEN High level input voltage range		1.4	1.7	2.3	V
$V_{DEN(L)}$	DEN Low level input voltage range		0.9	1.3	1.9	V
$V_{DEN(HYS)}$	DEN Input voltage hysteresis		-	0.4	-	V
$I_{DEN(H)}$	DEN High level input current	V_{DEN}=5.5V	1	10	25	uA
$I_{DEN(L)}$	DEN Low level input current	V_{DEN}=0.8V	1	5	25	uA
d_V/d_{tON}	Turn-ON Slew rate	R_L=4Ω, V_S=28V, From 30% to 70%V_S	0.7	1.4	2.1	V/us
$-d_V/d_{tOFF}$	Turn-OFF Slew rate	R_L=4Ω, V_S=28V, From 70% to 30%V_S	1.1	1.8	2.5	
t_{ON}	Turn-ON time	R_L=4Ω, V_S=28V From V_{IN}=V_{IN_H} to V_{OUT}=90%Vs,	-	50	150	us
t_{OFF}	Turn-OFF time	R_L=4Ω, V_S=28V From V_{IN}=V_{IN_L} to	-	50	150	us

		V_{OUT}=10%V_S,				
t_{ON_delay}	Turn-ON delay time	R_L=4Ω, V_S=28V From V_{IN}=V_{IN_H} to V_{OUT}=10%V_S,	-	20	70	us
t_{OFF_delay}	Turn-OFF delay time	R_L=4Ω, V_S=28V From V_{IN}=V_{IN_L} to V_{OUT}=90%V_S,	-	35	150	us
Diagnostic Characteristics:						
$t_{SIS(ON)}$	Current sense settling time to k_{ILIS} function stable after positive input slope on both INput and DEN	V_{DEN}=V_{IN}= 0 to 4.5V, V_S=28VR_{IS}=1.2kΩ, C_{SENSE}<100pF, I_L=4A	-	-	150	us
$t_{SIS(ON\_DEN)}$	Current sense settling time with load current stable and transition of the DEN	V_{IN}=4.5V, V_{DEN}=0 to 4.5V, R_{IS}=1.2kΩ, C_{SENSE}<100pF, I_L=4A	-	-	65	us
$I_{IS\_(DIS)}$	IS pin leakage current when sense is disabled	V_{IN}=4.5V, V_{DEN}=0V, I_L=10A	-	-	1	uA
$I_{IS(FAULT)}$	Sense signal maximum current in fault condition	V_{IS}=V_{IN}=V_{DSEL}=0V, V_{OUT}=V_S>10V, V_{DEN}=4.5V	-	7	40	mA
Protection Functions:						
$I_{L(SC)}$	Short circuit current limitation	V_{DS} = 28V	-	50	90	A
$t_{d(sc)}$	Short circuit protection delay		-	-	200	us
$T_{J(SC)}$	Thermal shutdown temperature		-	150	-	℃
V_S-$V_{OL(OFF)}$	Open load detection threshold in OFF state	V_{IN} = 0V, V_{DEN} = 4.5V	3	-	5	V
$V_{IS(AZ)}$	Sense pin maximum voltage	I_{IS}=5mA	66	70	75	V
K_{ILIS1}		I_{L1} = 0.5A	3090	3860	4630	
K_{ILIS2}		I_{L2} = 2A	3490	3830	4170	
K_{ILIS3}		I_{L3} = 4A	3700	3890	4080	
K_{ILIS4}		I_{L4} = 10A	3720	3910	4080	
E_{AS}	Maximum energy dissipation Single pulse	I_L=9A, T_j=150℃, V_S=28V	-	-	219	mJ
$V_{DS(REV)}$	Drain source diode voltage during reverse polarity	I_L=-4A, T_j=25℃	200	700	750	mV

10.Timing diagrams

Figure 1: Switching a Resistive Load Timing

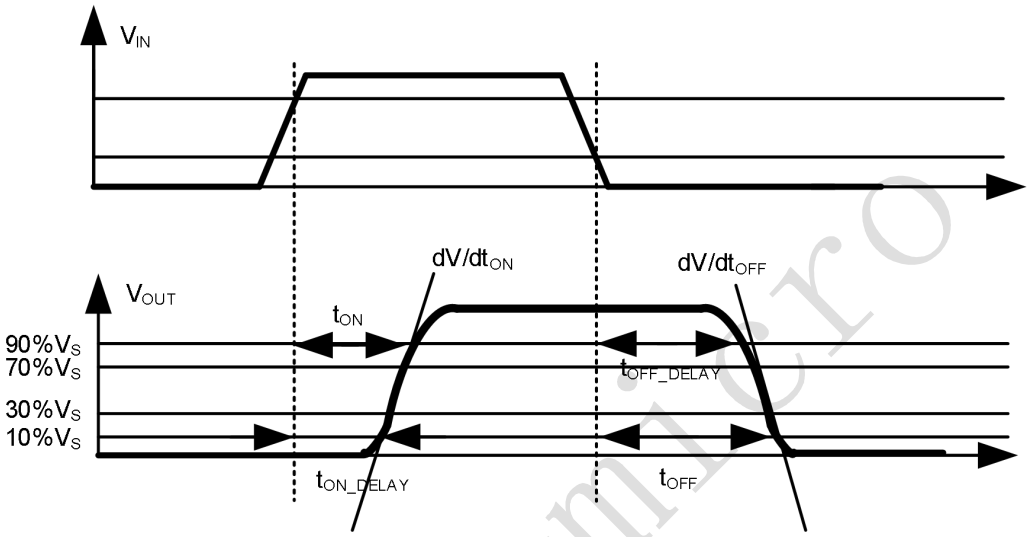


Figure 2: Switching an Inductive Load Timing

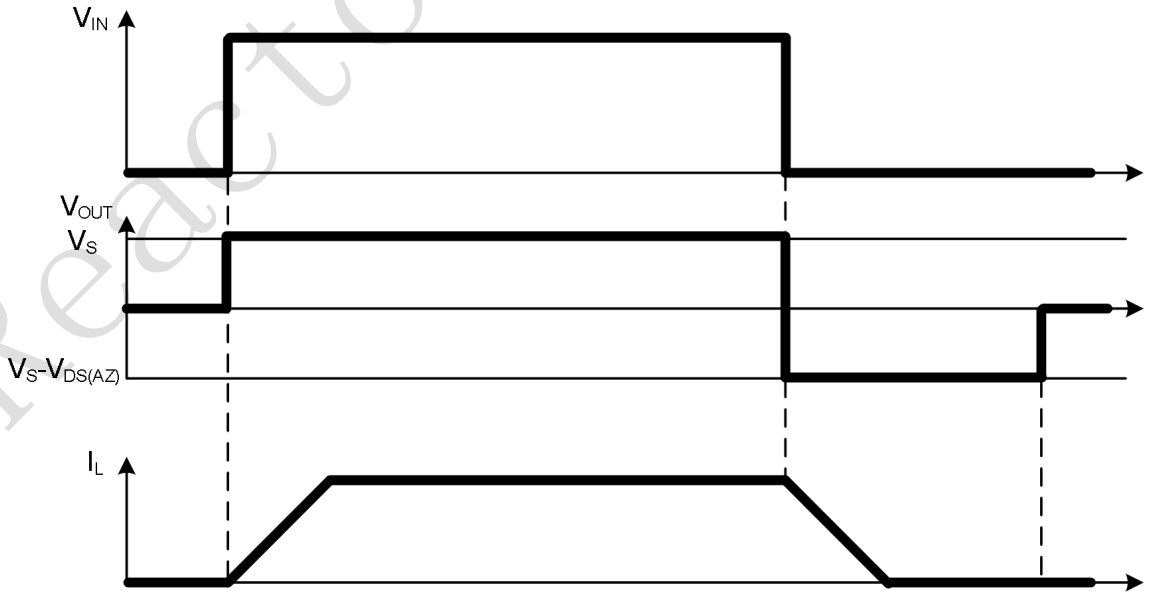


Figure 3: Current Sense Settling / Disabling Timing

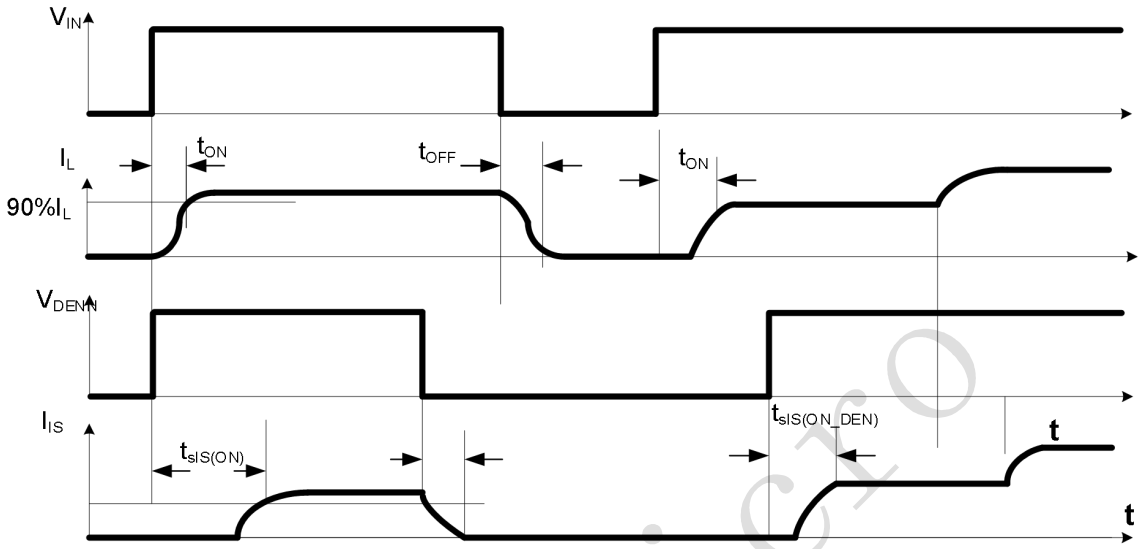


Figure 4: Sense Signal in Open Load Timing

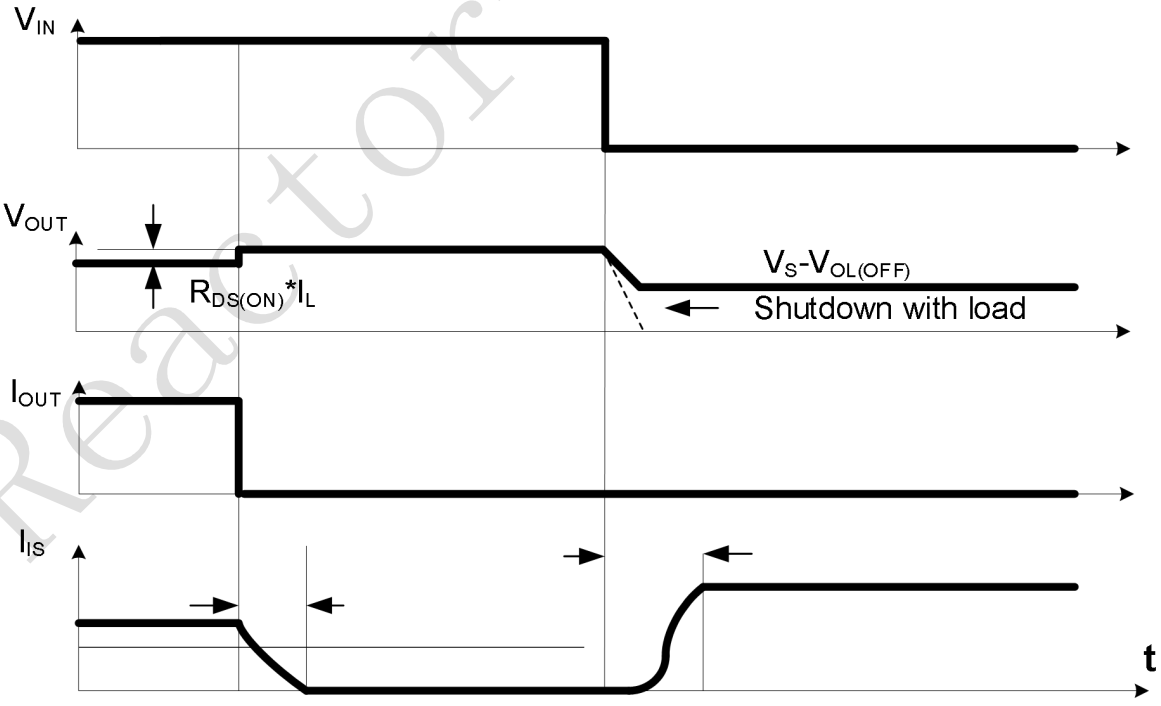


Figure 5: Over temperature

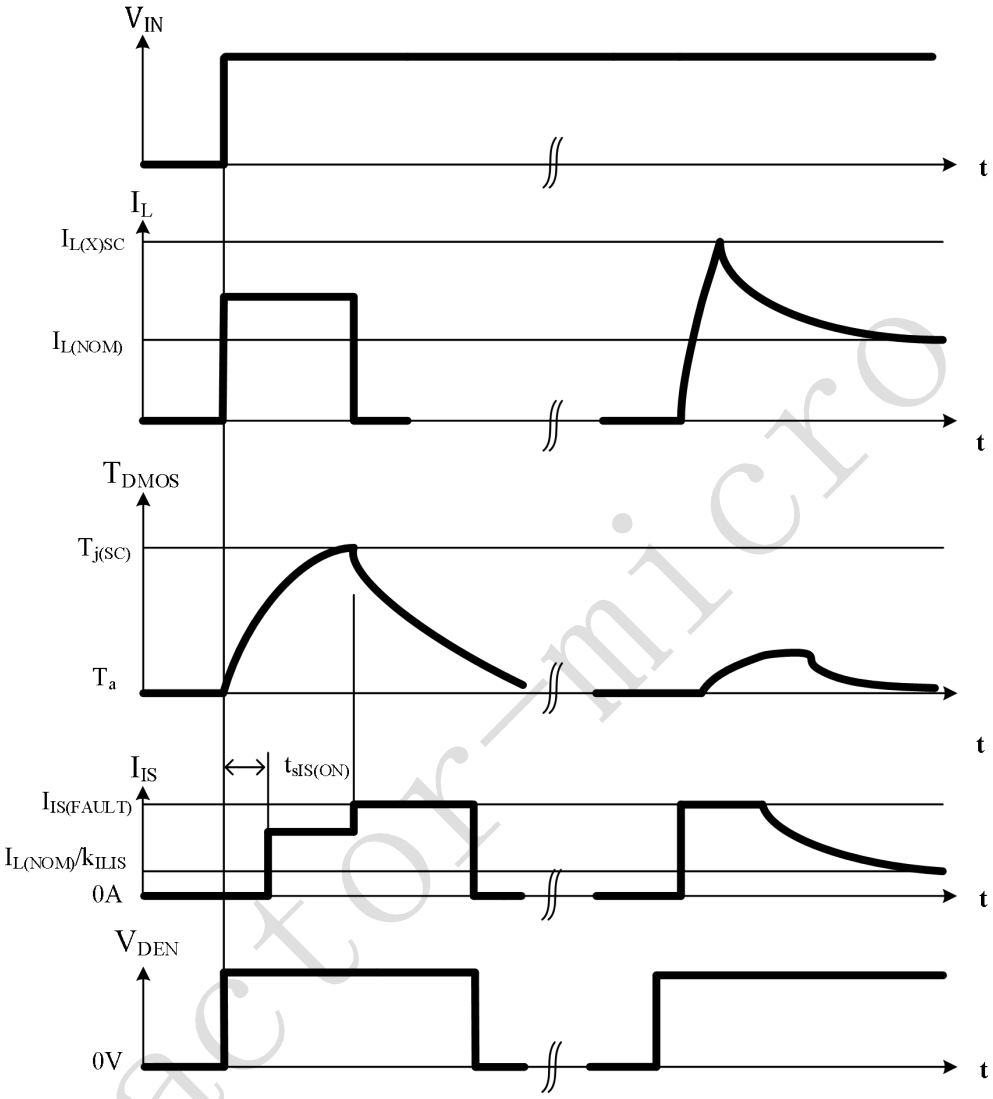


Figure 6: Undervoltage Behavior

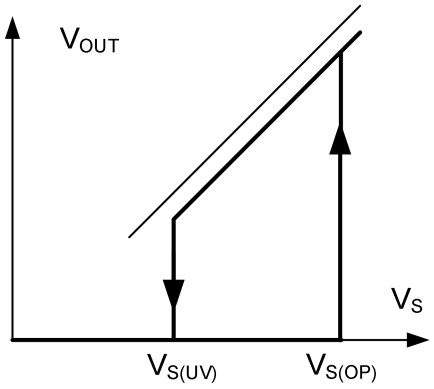
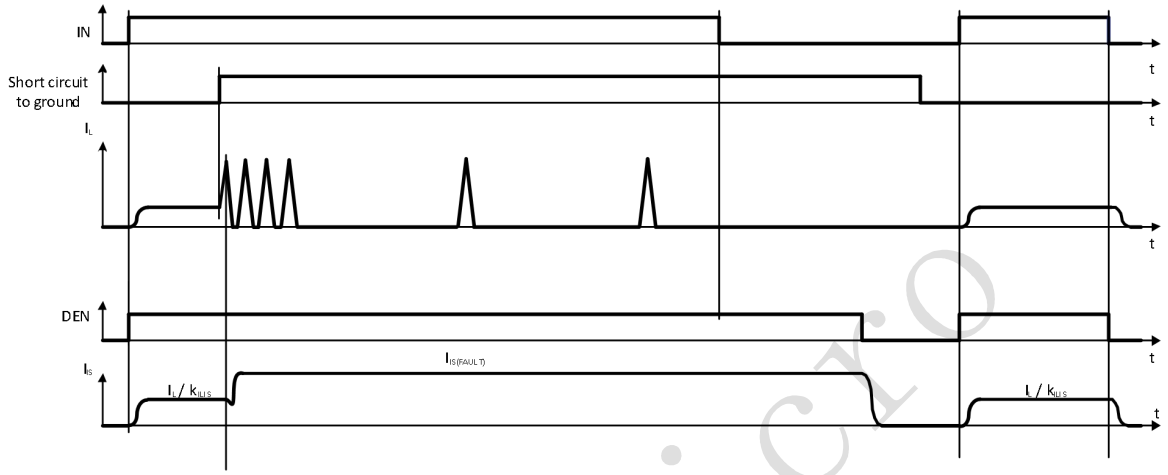


Figure 7:Retry Strategy Timing Diagram



11.Truth Table

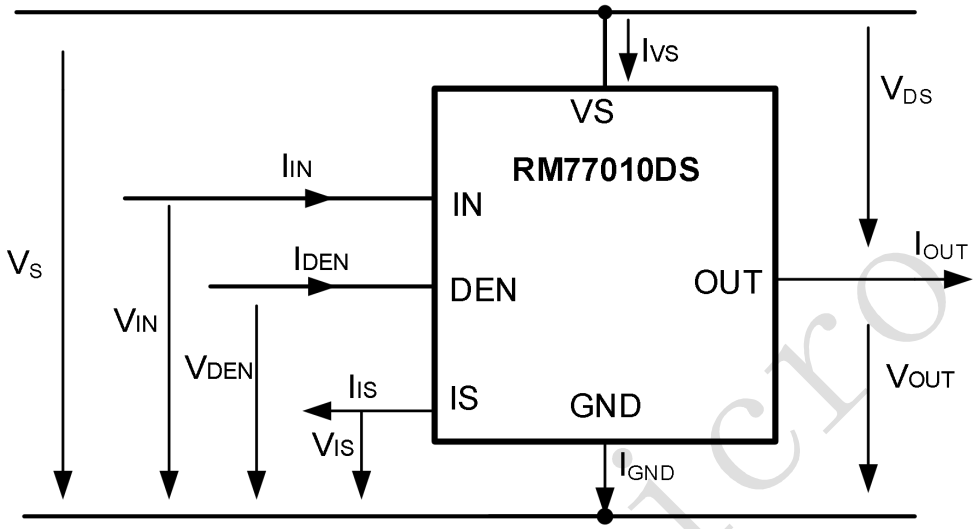
Operation Mode	Input level Channel	DEN	Output Level	Diagnostic Output
Normal operation	L H	H	L ~V_S	L $I_{IS}=I_L/K_{ilis}$
Short circuit to GND	L H	H	~GND ~GND	L $I_{IS(FAULT)}$
Overtemperature	L H	H	L L	L $I_{IS(FAULT)}$
Short circuit to VS	L H	H	V_S V_S	$I_{IS(FAULT)}$ $I_{IS}<I_L/K_{ilis}$
Open Load	L L H	H	<$V_{OL(OFF)}$ >$V_{OL(OFF)}$ 1) ~V_S 2)	L $I_{IS(FAULT)}$ $I_{IS}<I_{IS(OL)}$
Inverse current	L H	H	~V_{INV} ~V_{INV}	$I_{IS(FAULT)}$ $I_{IS}<I_{IS(OL)}$ 3)
Current limitation	H	H	<V_S	$I_{IS(FAULT)}$
Underload	H	H	~V_S 4)	$I_{IS(OL)}<I_{IS}<I_{L/Kilis}$

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

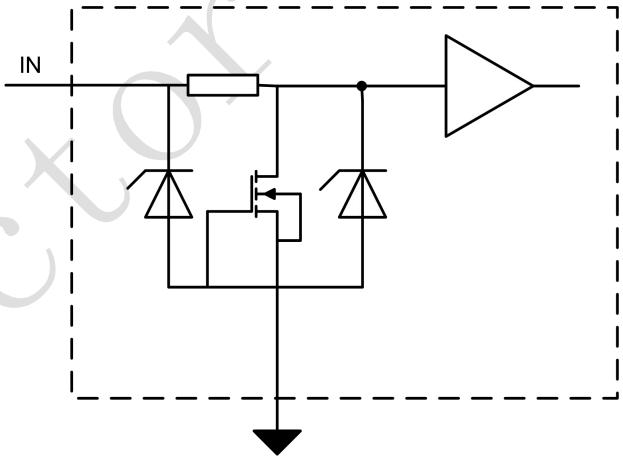
1) Stable with additional pull-up resistor.
2) The output current has to be smaller than $I_{L(OL)}$.
3) After maximum t_{INV} .
4) The output current has to be higher than $I_{L(OL)}$

12.Functions

12.1 Terms



12.2 Input circuit (ESD protection)

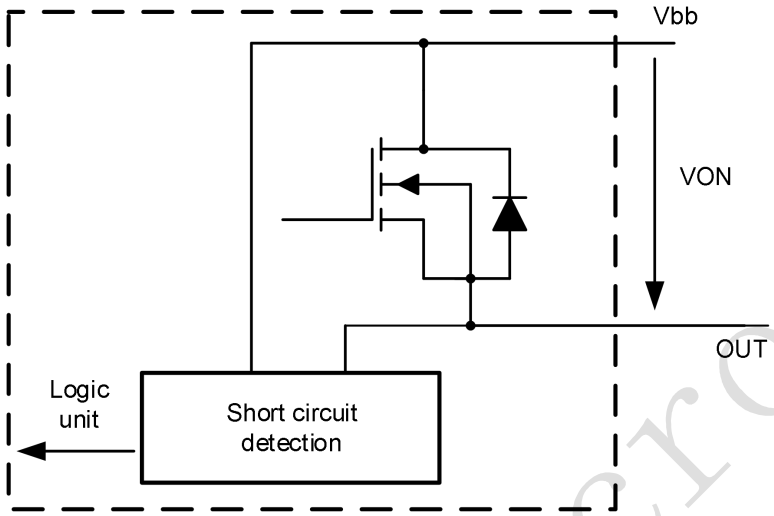


The input circuitry is compatible with 3.3 and 5 V microcontrollers.An implemented Schmitt trigger avoids any undefined state if the voltage on the input pinis slowly increasing or decreasing.

In case the pin is not needed, it must be left opened, or must be connected to device ground (and not module ground) via an 4.7 kΩ input resistor.

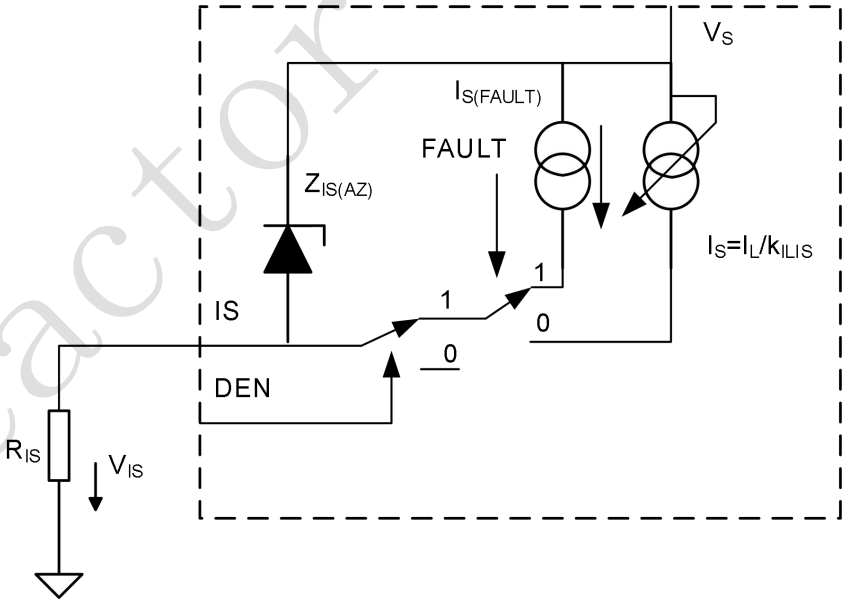
The DEN pins enable and disable the diagnostic functionality of the device. This pin has the same structure as the input pin.

12.3 Short circuit detection



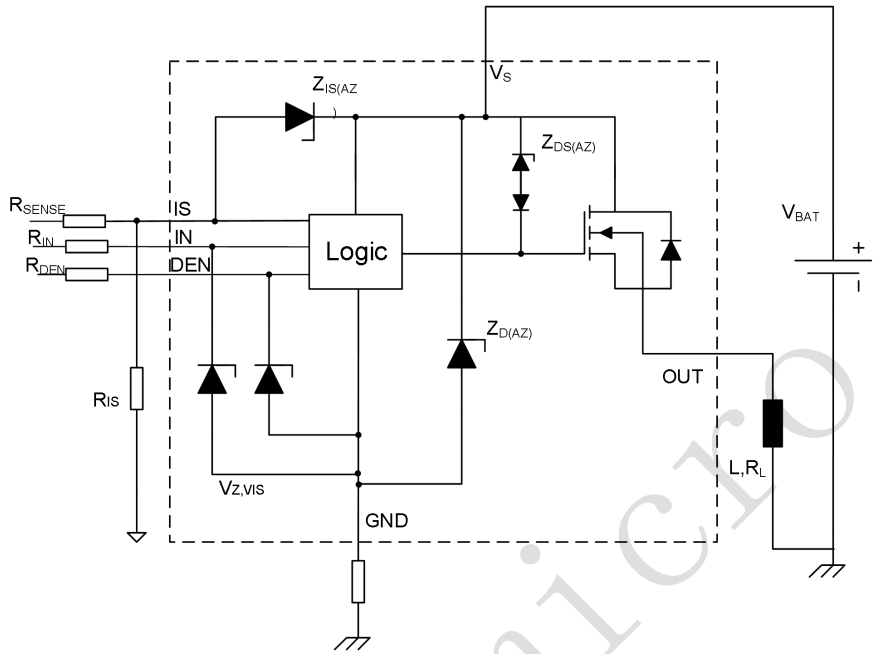
Fault Condition: $V_{ON} > V_{ON(SC)}$ (6 V typ.).

12.4 Current sense status output



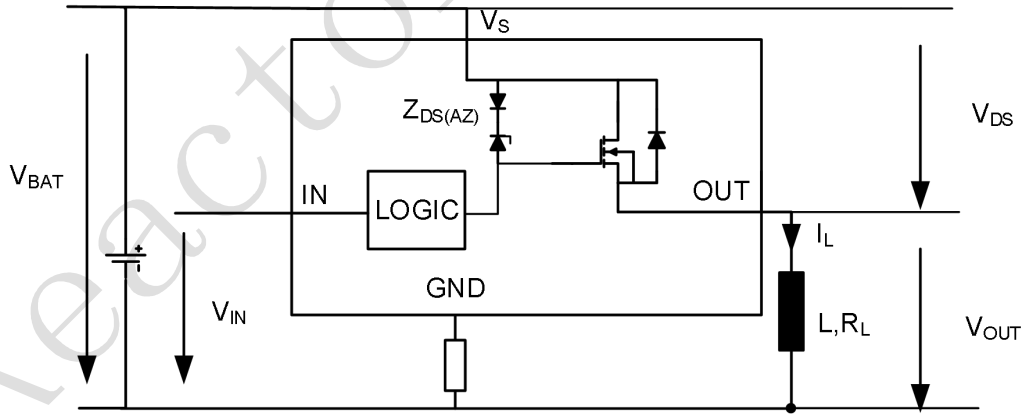
As long as no “hard” failure mode occurs a proportional signal to the load current (ratio $k_{ILIS} = I_L / I_{IS}$) is provided;The accuracy of the sense current depends on temperature and load current.

12.5 Over voltage protection of logic part



There is an integrated clamp mechanism for overvoltage protection ($Z_{D(AZ)}$). To guarantee this mechanism operates properly in the application, the current in the Zener diode has to be limited by a ground resistor.

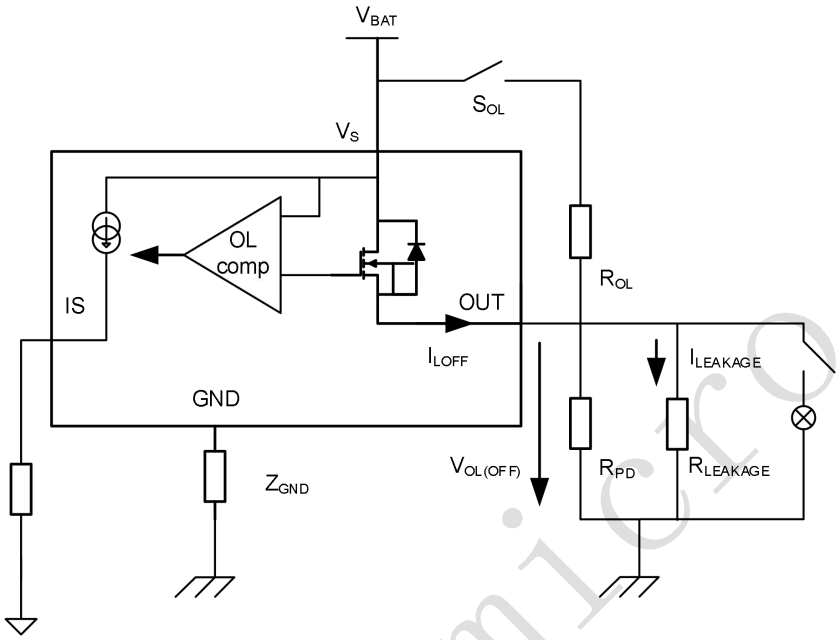
12.6 Output Clamping



When switching OFF inductive loads with high side switches, the voltage V_{OUT} drops below ground potential, because the inductance intends to continue driving the current. To prevent the destruction of the device by avalanche due to high voltages, there is a voltage clamp mechanism $Z_{DS(AZ)}$ implemented that limits negative output voltage to a certain level (V_S - $V_{DS(AZ)}$).

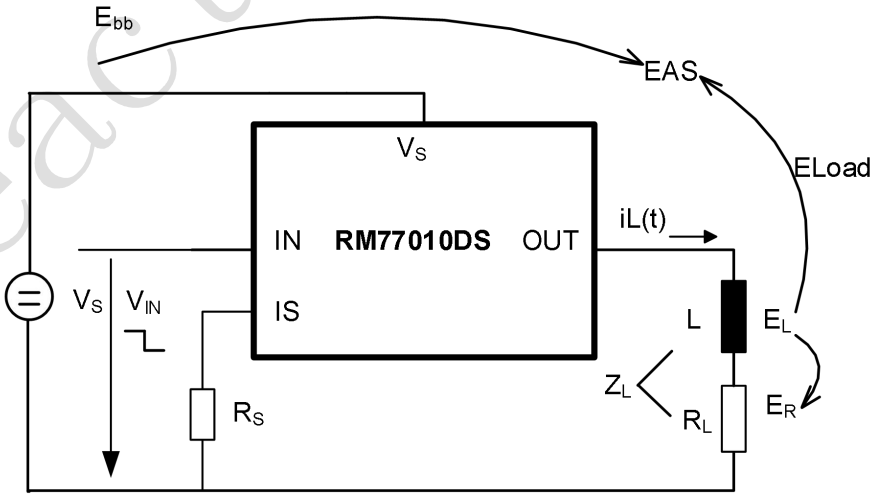
The maximum allowed load inductance is limited.

12.7 Open Load Detection in OFF Electrical Equivalent Circuit



For open load diagnosis in OFF-state, an external output pull-up resistor (R_{OL}) is recommended. For the calculation of pull-up resistor value, the leakage currents and the open load threshold voltage $V_{OL(OFF)}$ have to be taken into account.

12.8 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 RM77010DS is:

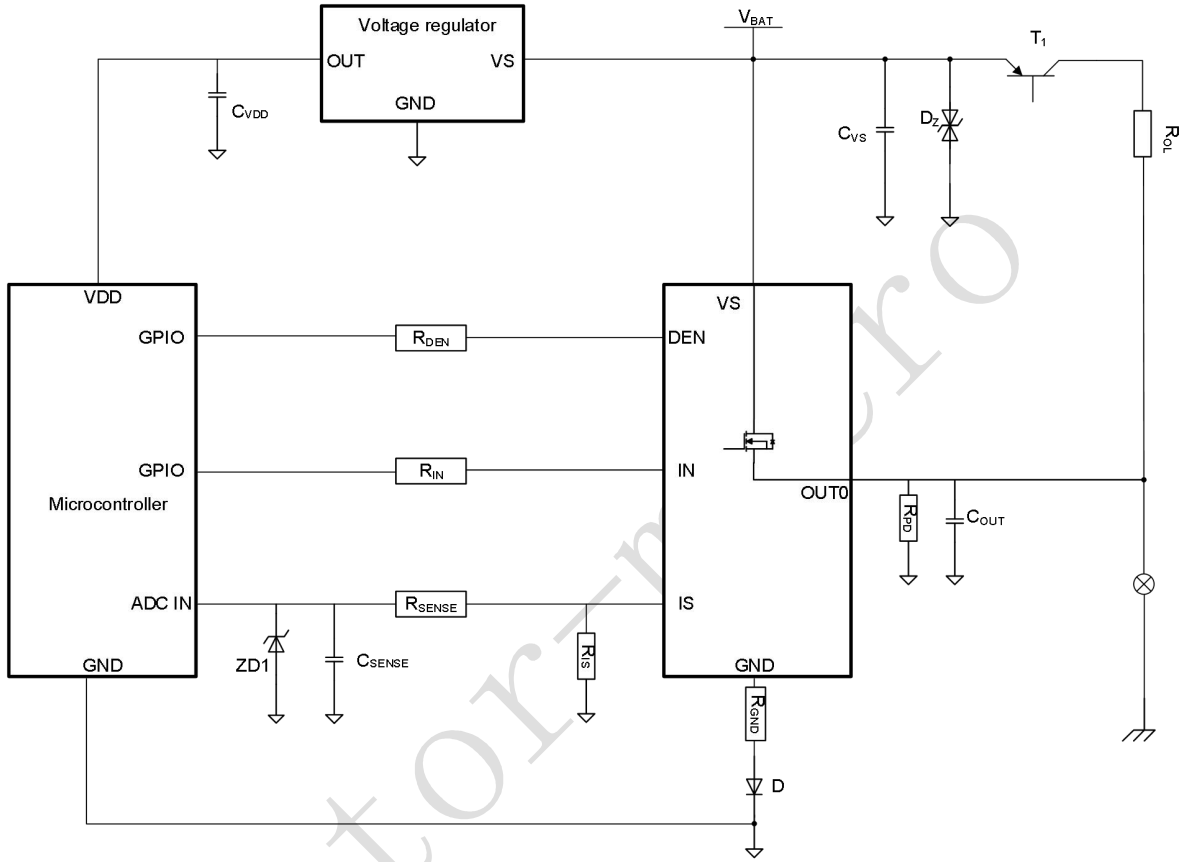
$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t) dt$$

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

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

13.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.



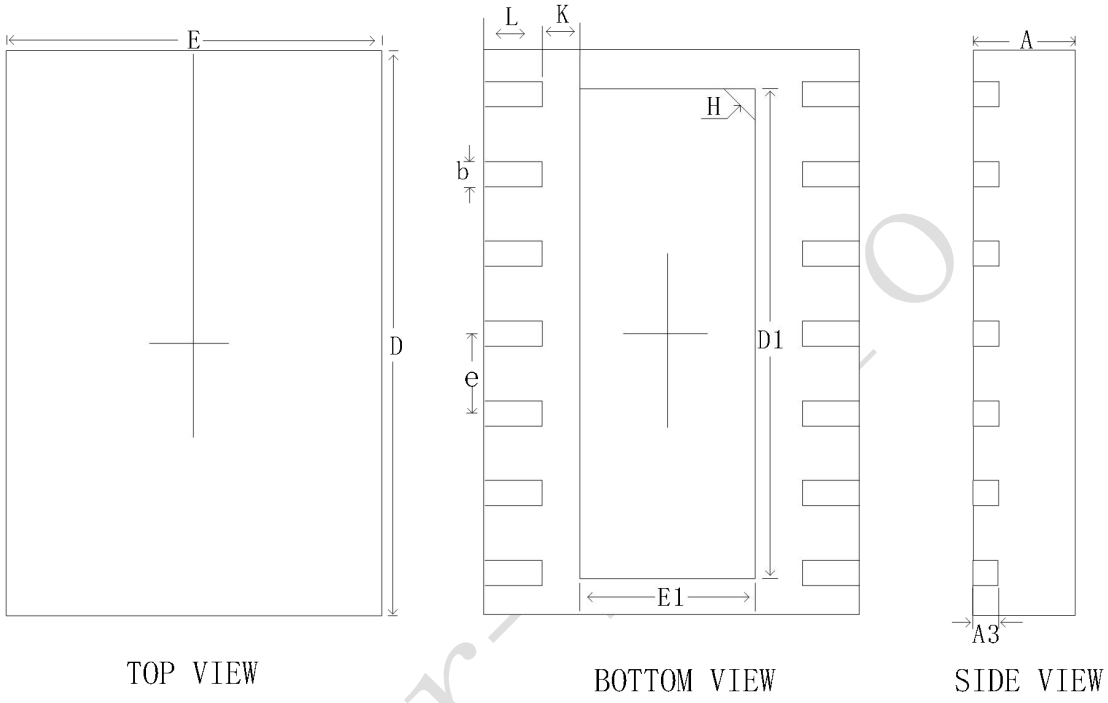
Note: This is a very simplified example of an application circuit.The function must be verified in the real application.

Bill of Material

Reference	Value	Reference	Value
R_{IN}	10KΩ	T_1	Dual NPN/PNP
R_{DEN}	10KΩ	C_{OUT}	10nF
R_{SENSE}	10KΩ	D_Z	58V Zener diode
R_{IS}	1.2KΩ	C_{VS}	100nF
R_{GND}	330Ω	ZD1	6.2V Zener diode
R_{PD}	47KΩ	C_{SENSE}	10nF
R_{OL}	1.5KΩ	D	BAS21

14.Package

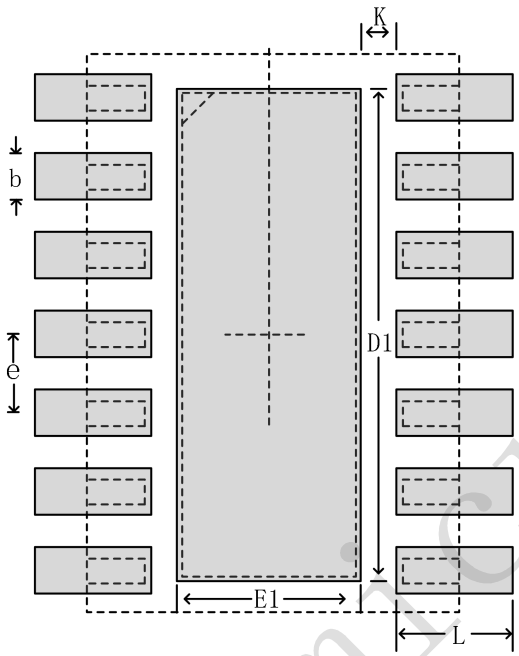
DFN9*6-14L



Unit :mm

Symbol	MIN	NOM	MAX
E	5.80	6.00	6.20
D	8.80	9.00	9.20
E1	2.75	2.80	2.85
D1	7.75	7.80	7.85
K	0.55	0.6	0.65
b	0.35	0.40	0.45
e	-	1.27	-
A	0.90	1.00	1.12
A3	-	0.25	-
L	0.90	1.00	1.10

15.Recommended Soldering Footprint



Unit : mm

Symbol	NOM	Symbol	NOM
E1	2.9	b	0.5
D1	8.0	e	1.27
K	0.5	L	1.3

16.Revision History

Version*	Change Description	Date
REV.A	Initial Version	2024/08/15
REV.B	1) Revised certain parameter in the Electrical Characteristics table.(such as current sense ratio, etc.) 2) Revised Application Information. 3) Revised package dimension tolerances. 4) Added Retry Strategy Timing Diagram	2025/02/17
NOTE*:Datasheets with alphabetic version numbers (e.g., REV.A, REV.B, REV.C) are designated for the sample phase,whereas those with numeric version numbers (e.g., V1.0, V1.1, V1.2) are intended for the mass production phase.		