Smart High-Side Power Switch
RM77020T4S Datasheet

1.Basic Features

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

2.Description

RM77020T4S 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.

RM77020T4S 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
- All types of resistive, inductive and capacitive loads
- Replaces electromechanical relays, fuses and discrete circuits

4.Product Summary

Overvoltage protection	$V_{Z(IN)}$	73	V
Operating voltage	$V_{bb(ON)}$	5...62	V
On-state resistance	R_{ON}	15	mΩ
Nominal load current	$I_{L(NOM)}$	6.5	A
Short circuit current limitation	$I_{L(SC)}$	40	A
Current sense ratio	I_L:I_{IS}	9600	

5.Ordering Code

Part number	Package Type	Marking	Materials	Package			Package Qty
RM77020T4S	TO-252-4L	RM77020T4S	Halogen free	Tape&reel	10 reels /box	25k/ box	2500/reel

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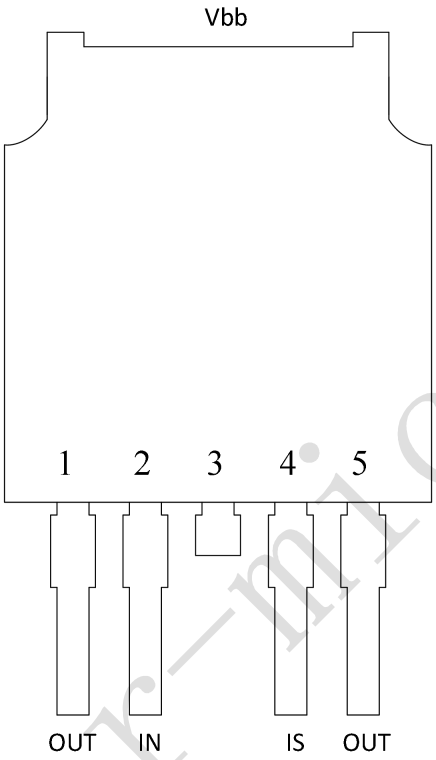
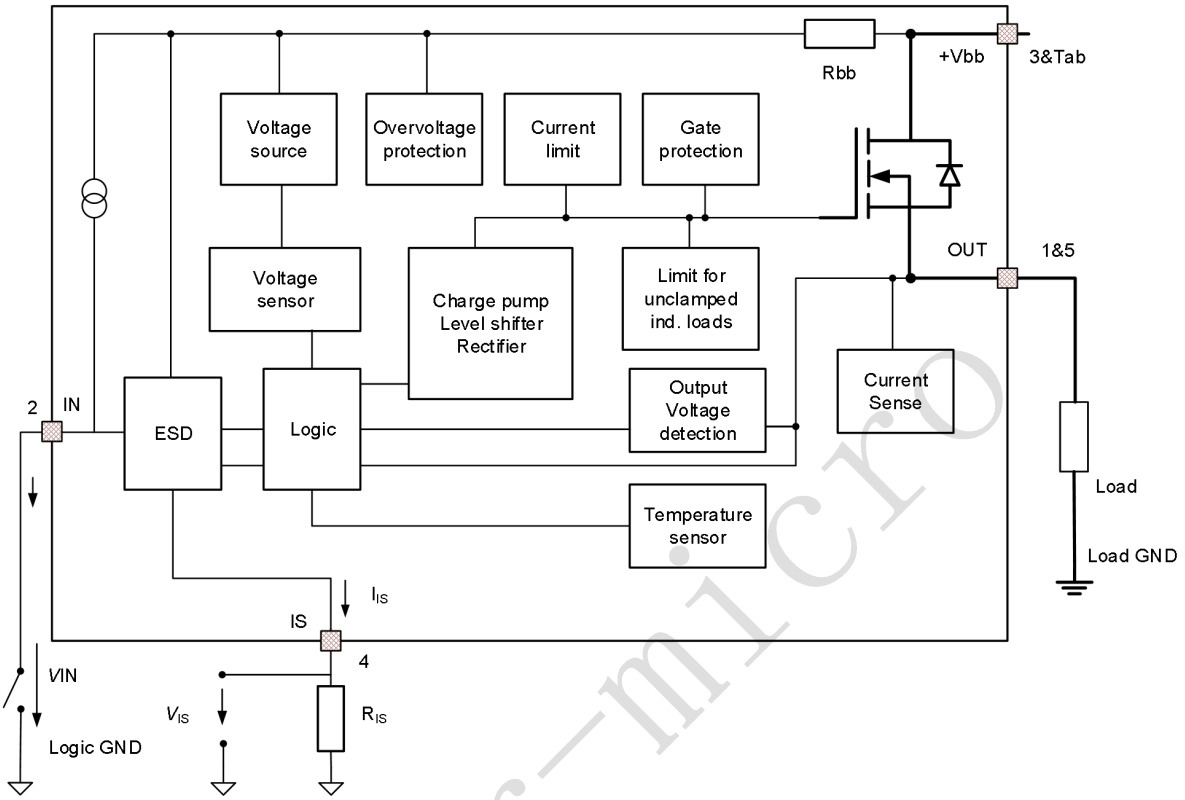
6. Pin Configuration

RM77020T4S (TO-252-4L)



Pin	Symbol	Function
1/5	OUT	Output; output to the load; pin 1 and 5 must be externally shorted.
2	IN	Input; activates the power switch if shorted to ground.
3/Tab	V_{bb}	Supply Voltage; positive power supply voltage; tab and pin3 are internally shorted.
4	IS	Sense Output; Diagnostic feedback; provides at normal operation a sense current proportional to the load current; in case of overload, overtemperature and/or short circuit a defined current is provided.

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_S	62	V	
Load dump protection	$V_{Loaddump}$	70	V	$V_{LoadDump}=U_A+V_S$, U_A=24V, R_I=2Ω, R_L=4.4Ω, t_d=400ms, IN=low or high
Current through INPUT pins	I_{IN}	-120 to 15	mA	
Current through IS pin	I_{IS}	-120 to 15	mA	
Power dissipation(DC)	P_{tot}	49.2	W	
Junction temperature	T_J	-40 to 150	℃	
Ambient temperature	T_A	-40 to 125	℃	
Storage temperature	T_{STG}	-55 to 150	℃	
Thermal resistance junction - ambient (free air)	R_{thJA}	77	K/W	
Thermal resistance junction -case	R_{thJC}	1.32	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	V_{IN}=0V, V_{bb}=5V, I_L=7.5A, T_J=25℃	-	17	25	mΩ
		V_{IN}=0V, V_{bb}=12V~24V, I_L=7.5A, T_J=25℃		15	23	
		V_{IN}=0V, V_{bb}=12V~24V, I_L=7.5A, T_J=150℃		30	46	
$V_{ON(NL)}$	Output voltage drop limitation at small load currents		-	40	65	mV
$I_{L(NOM)}$	Nominal load current	V_{ON}≤0.5V, T_A=85℃	5.5	6.5	-	A
$I_{L(ISO)}$[1)]	Nominal load current(ISO)	V_{ON}=0.5V, T_C=85℃	17	22.5	-	A
t_{ON}	Turn-ON time	R_L=3.9Ω, I_{IN} Turn-ON time to 90% V_{OUT}	50	140	300	us
t_{OFF}	Turn-OFF time	R_L=3.9Ω, I_{IN} Turn-OFF time to 10% V_{OUT}	50	100	550	us
dV/d_{tON}	Turn-ON Slew rate	R_L=3.9Ω, From 10% to 30% V_{OUT}	0.2	0.6	1.0	V/us
$-dV/d_{tOFF}$	Turn-OFF Slew rate	R_L=3.9Ω, From 70% to 40% V_{OUT}	0.2	0.9	1.2	V/us
$V_{bb(ON)}$	Operating voltage		5	-	62	V
$V_{bb(u)}$	Undervoltage shutdown		-	2.6	3.5	V
$V_{bb(ucp)}$	Undervoltage restart of charge pump		-	4.5	5.5	V
$I_{bb(off)}$	Standby current	I_{IN}=0, V_{bb}=35V, T_J=25℃	-	0.1	1	uA
$I_{L(SC)}$	Short circuit current limit	V_{ON}=12V, T_J=25℃	30	-	100	A
$I_{L(SC)}$	Short circuit current limit	V_{ON}=24V, t_m=170us, T_J=25℃	25	-	60	A
$V_{ON(SC)}$	Short circuit shutdown detection voltage		2.5	3.5	4.5	V
$t_{d(SC1)}$	Short circuit shutdown delay	V_{ON}>$V_{ON(SC)}$	350	-	1200	us
$t_{d(SC2)}$	Short circuit shutdown delay	During on condition, V_{ON}>$V_{ON(SC)}$	-	2	-	us
$V_{ON(CL)}$	Output clamp (inductive load switch off)	V_{OUT}=V_{bb}-$V_{ON(CL)}$, I_L=40mA	63	67	-	V
T_{Jt}	Thermal overload trip temperature	T_A=25℃	150	-	-	℃
ΔT_{Jt}	Thermal hysteresis	T_A=25℃	-	10	-	℃
$I_{IN(ON)}$	Required current capability of input switch	V_{IN}=0V	-	0.5	2.4	mA
$I_{IN(OFF)}$	Input current for turn-off		-	22	30	uA

$V_{Z(IN)}$	Overvoltage protection	I_{bb}=15mA	68	73	-	V
Inverse Operation:						
$-V_{ON(INV)}$	Output voltage drop	I_L=-7.5A, R_{Is}=1K, T_J=25℃,	-	0.7	-	V
$-V_{ON(INV)}$	Output voltage drop	I_L=-7.5A, R_{Is}=1K, T_J=150℃,	-	0.3	-	V
$t_{d(INV)}$	Turn-on delay after inverse operation	$V_{IN(INV)}$=$V_{IN(fwd)}$=0V	-	1	-	ms
Diagnostic Characteristics:						
K_{ILIS}	Current sense ratio	I_L=7.5A, T_J=25℃	6000	9600	15000	
$I_{IS(Fault)}$	Sense current under fault conditions		4.0	-	7.5	mA
$I_{IS(lim)}$	Sense current saturation	V_{ON}<1V	4.0	6.0	7.5	mA
$I_{IS(LL)}$	Current sense leakage current	I_{IN}=0	-	0.1	0.5	uA
$I_{IS(LH)}$		V_{IN}=0, I_L=0	-	10	100	
$V_{Z(IS)}$	Current sense over voltage protection	I_{bb}=15mA	68	73	-	V
$t_{SON(IS)}$	Current sense settling time	I_L=0A to 6A	-	-	500	us
NOTE:1) not subject to production test, specified by design						

10.Timing diagrams

Figure 1: Switching a Resistive Load Timing

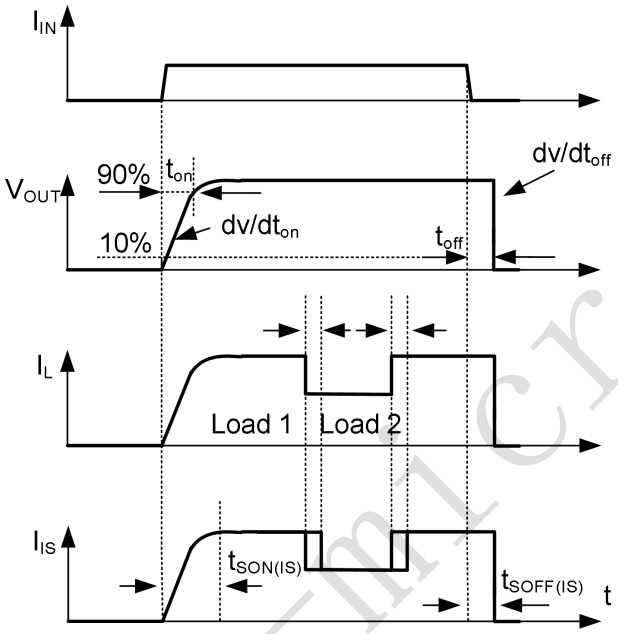


Figure 2a: Switching motors and lamps

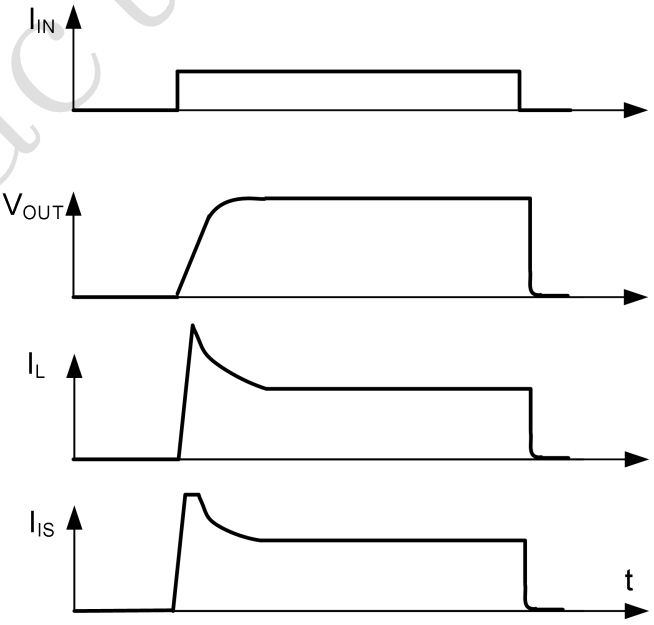


Figure 2b: Switching an inductive load

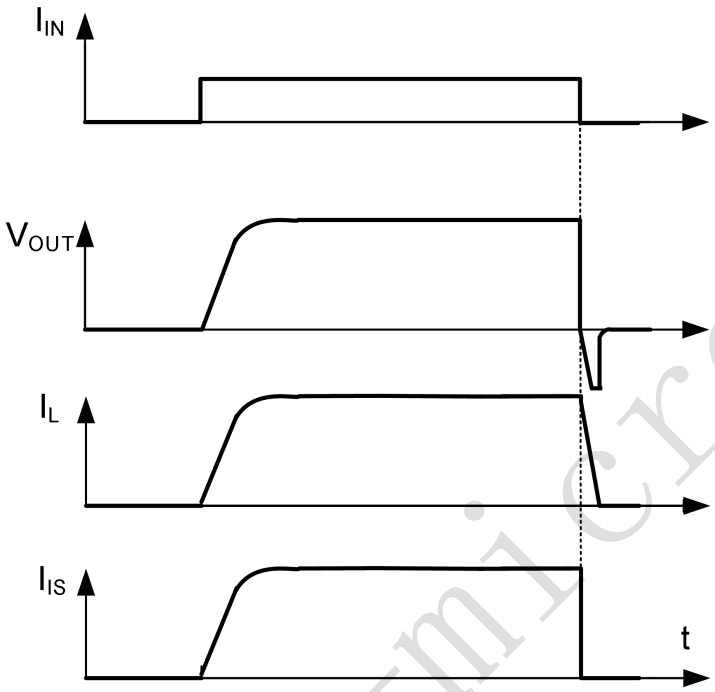
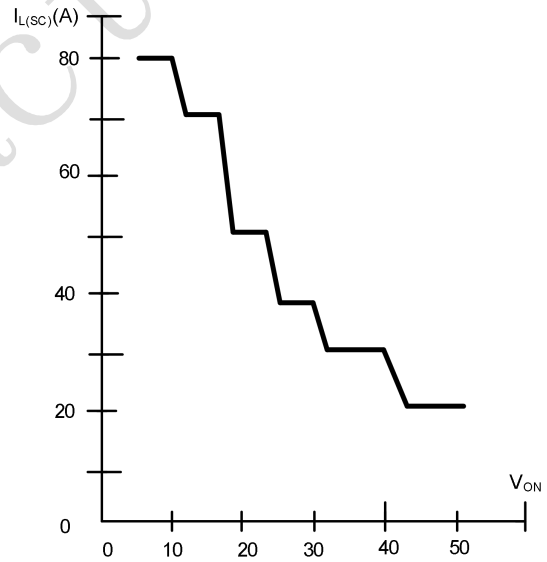


Figure 3a: current limitation characteristic



In case of $V_{ON} > V_{ON(SC)}$ (typ. 3.5 V) the device will be switched off by internal short circuit detection

Figure 3b: Short circuit type one

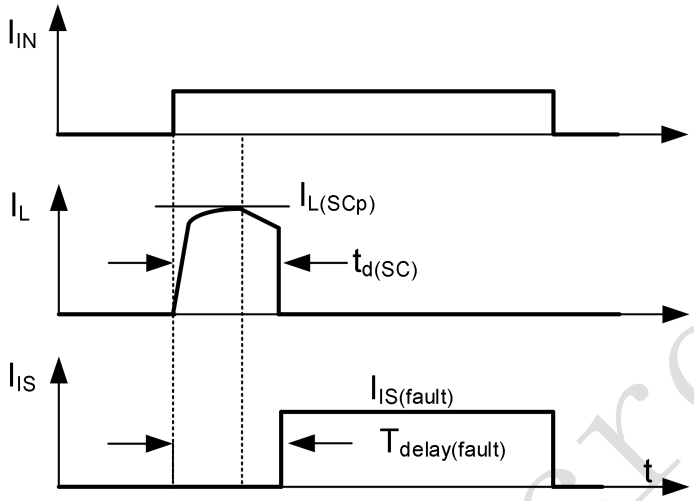


Figure 3c: Short circuit type two

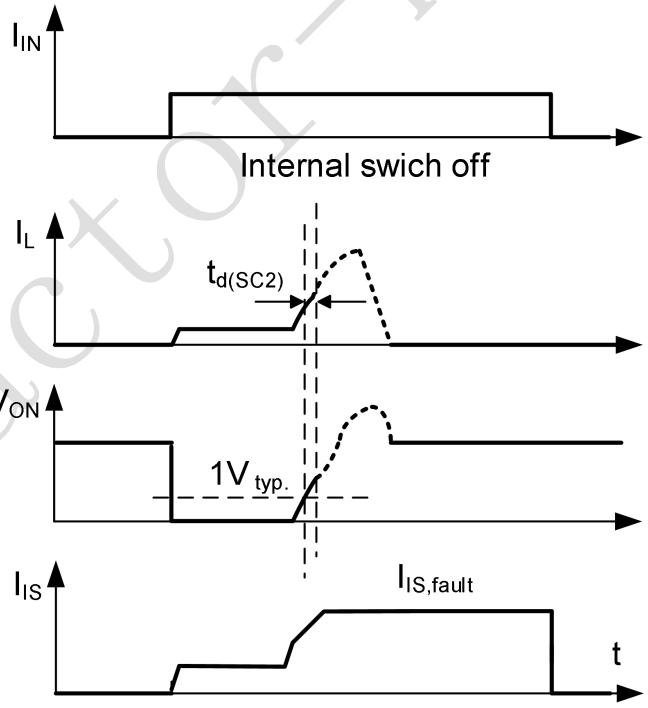
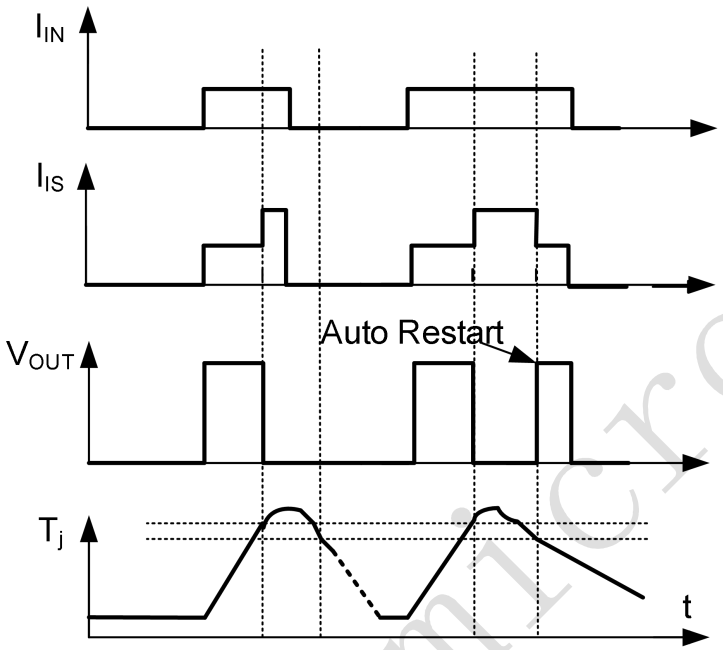


Figure 4a: Overtemperature



Reset if T_J<T_{JT}.

Figure 4b: Overload

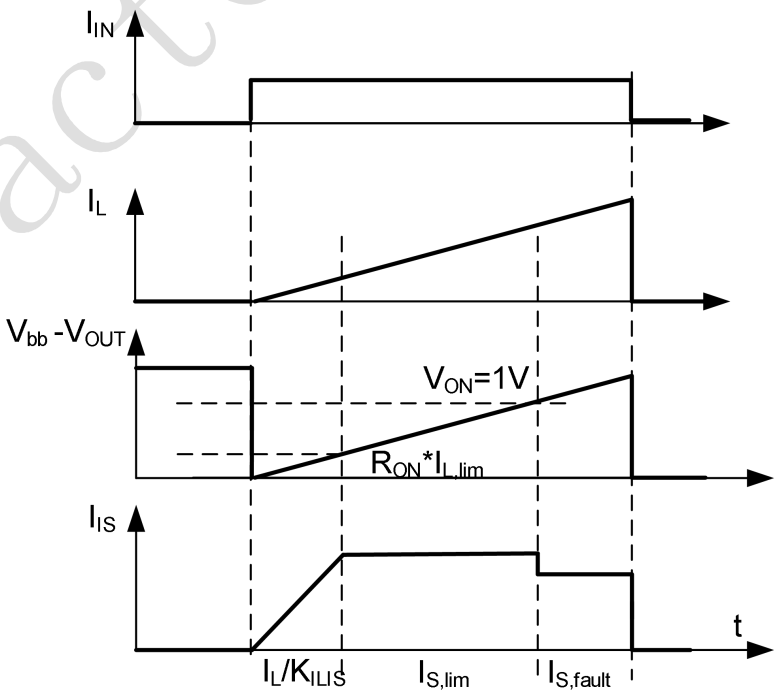


Figure 5:Undervoltage restart of charge pump, overvoltage clamp

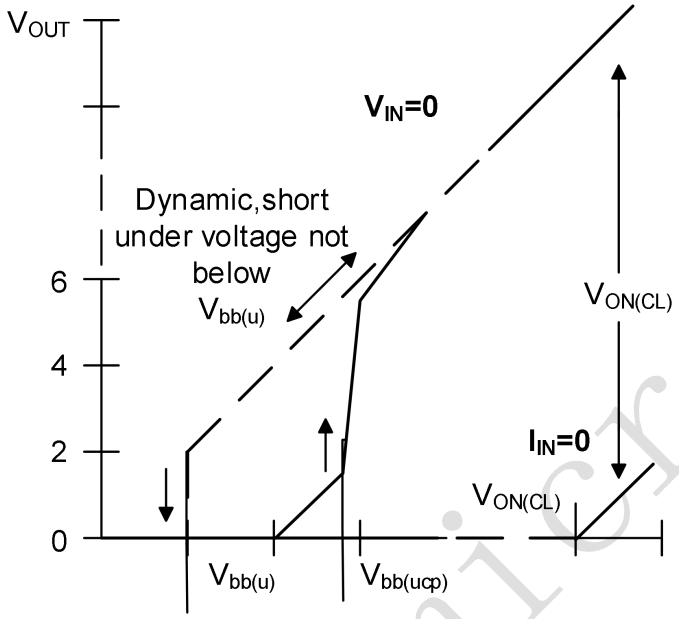


Figure 6a: Current sense versus load current

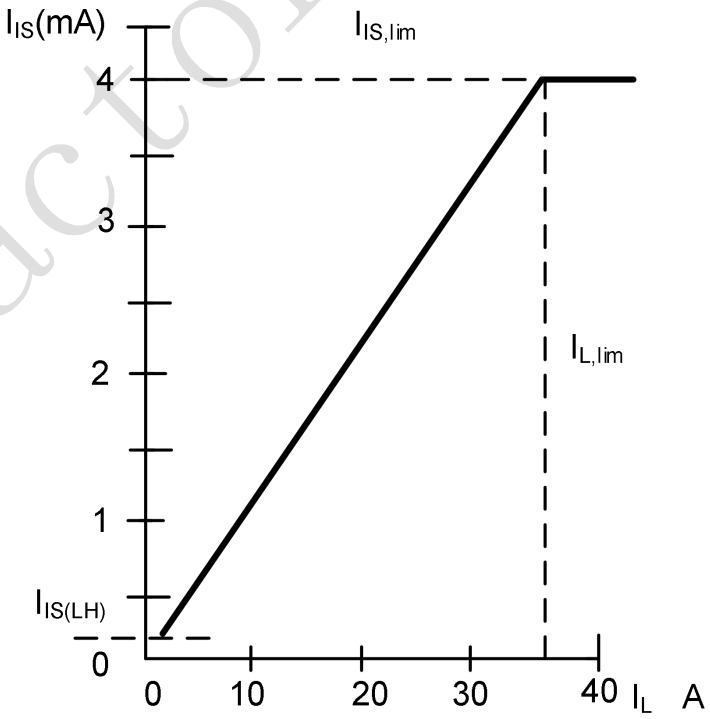


Figure 6b: Current sense ratio

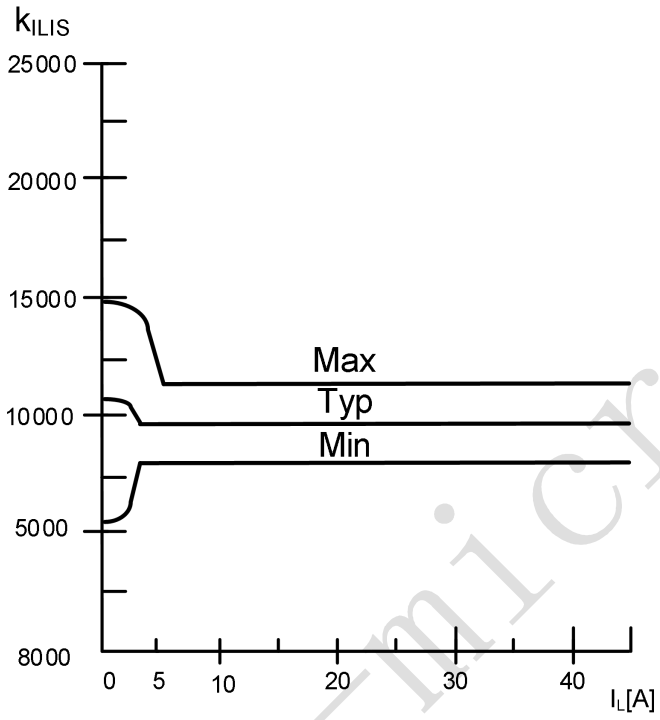
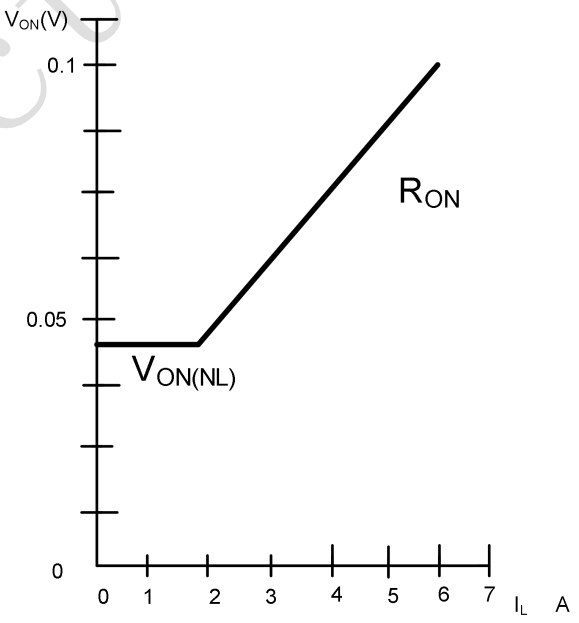
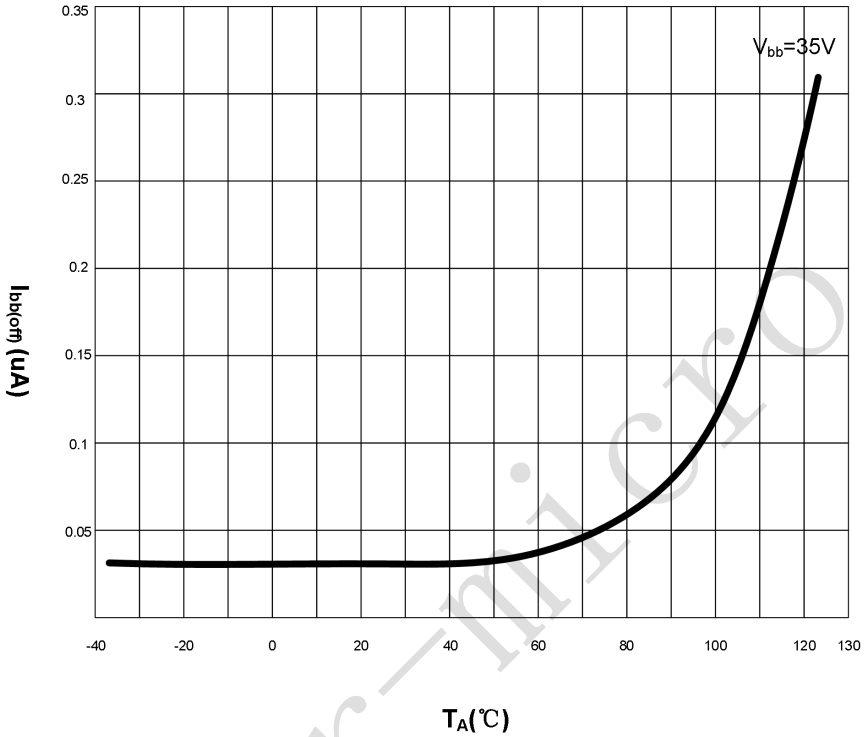


Figure 7: Output voltage drop versus load current

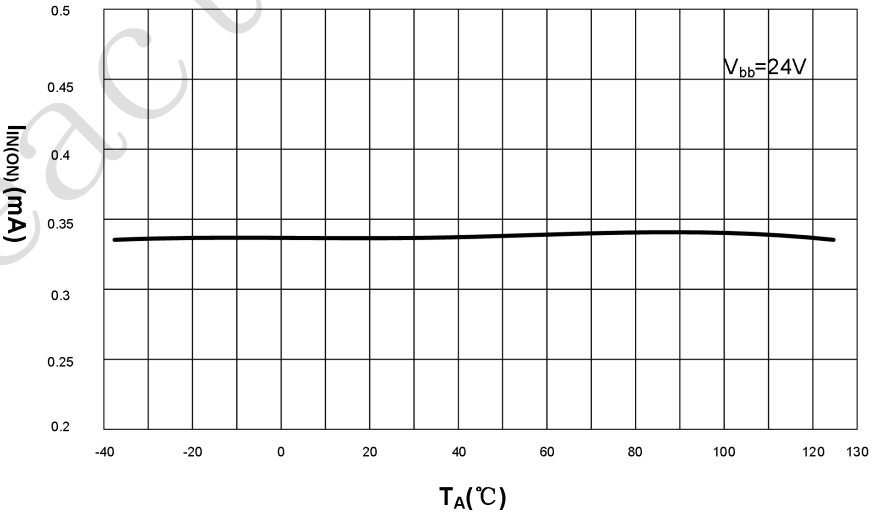


11.General Product Characteristics

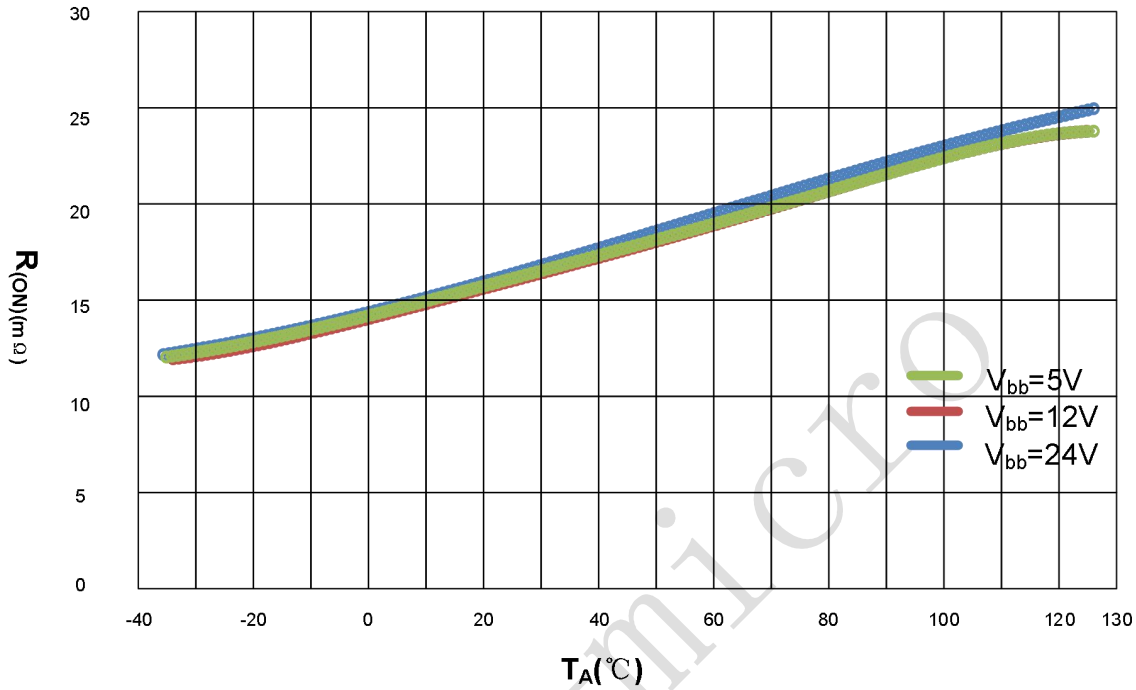
11.1 Standby Current



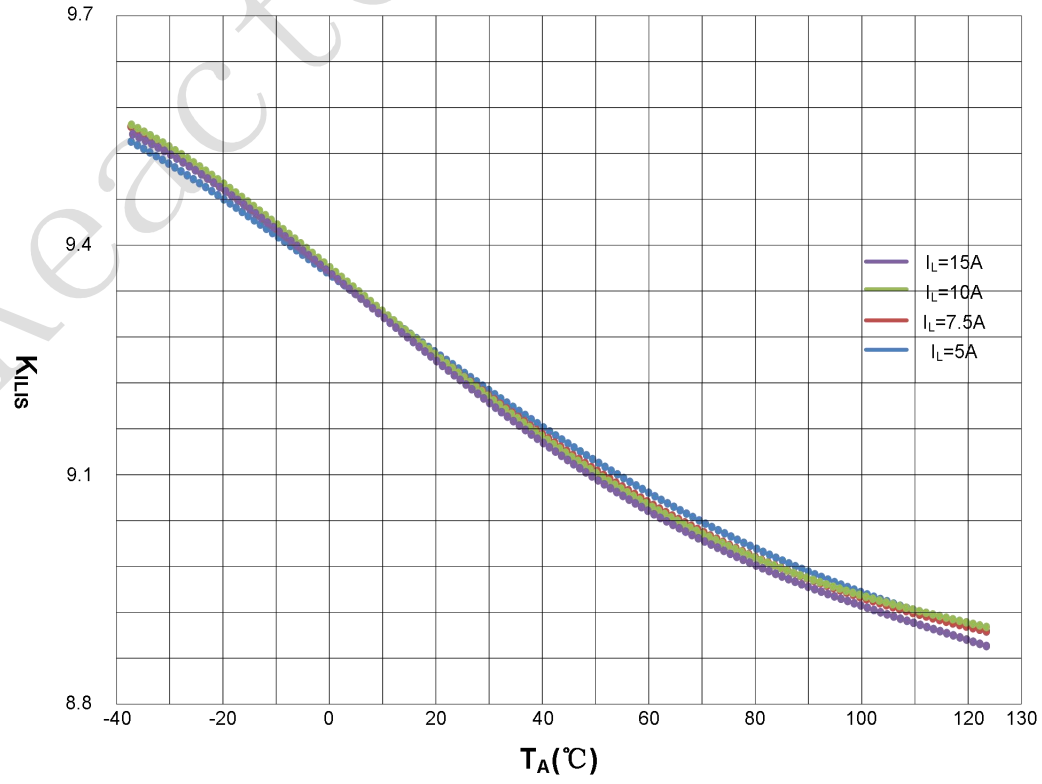
11.2 Required current capability of input switch



11.3 Typical ON-State Resistance



11.4 Current Sense



12.Truth Table

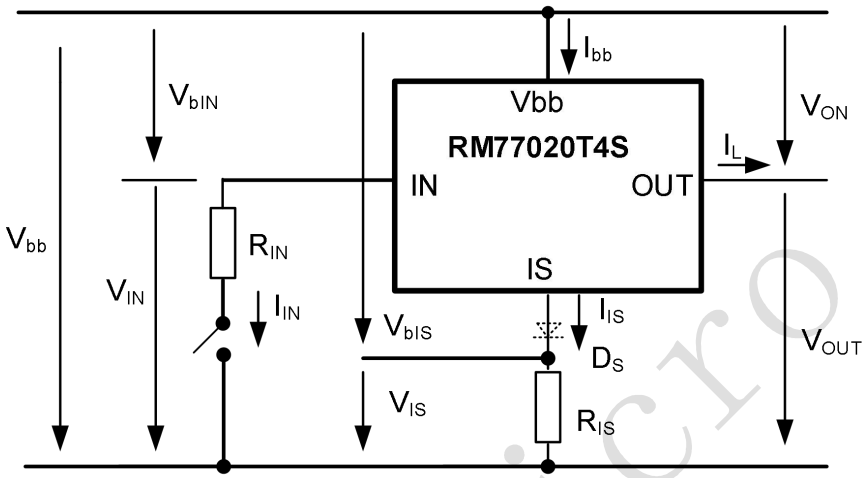
Operation Mode	Input Current level	Output level	Current Sense I_{IS}	Remark
Normal operation	L[1)] H[1)]	L H	0 Nominal	
Overload	L H	L H	0 $I_{IS,fault}$	
Short circuit to GND	L H	L L	0 $I_{IS,fault}$	
Over temperature	L H	L L	0 $I_{IS,fault}$	
Short circuit to V_{bb}	L H	H H	0 Nominal	
Open load	L H	Z[2)] H	0 0	

(1)L="Low" Level, H="High" Level

(2)Z=high impedance, potential depends on external circuit

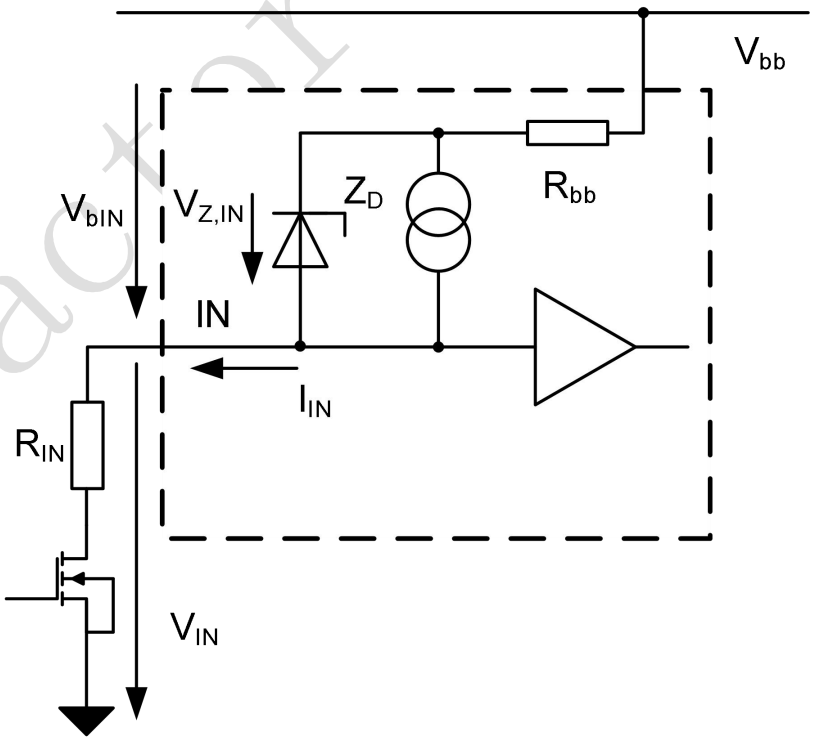
13.Functions

13.1 Terms



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

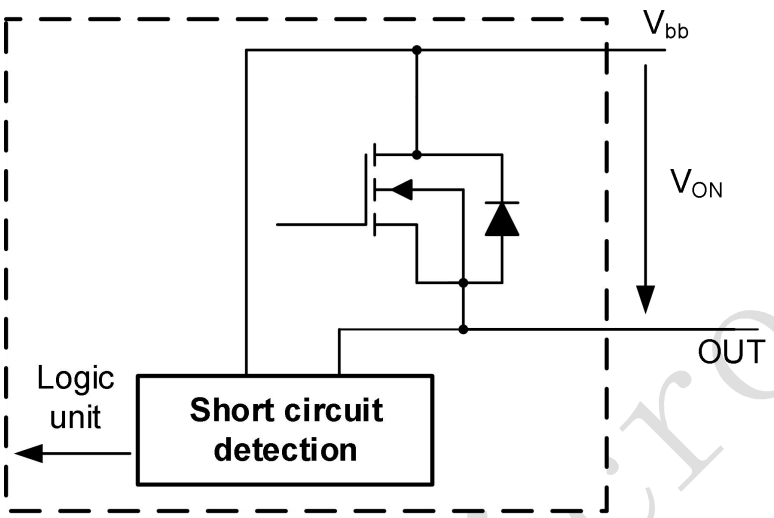
13.2 Input circuit (ESD protection)



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.

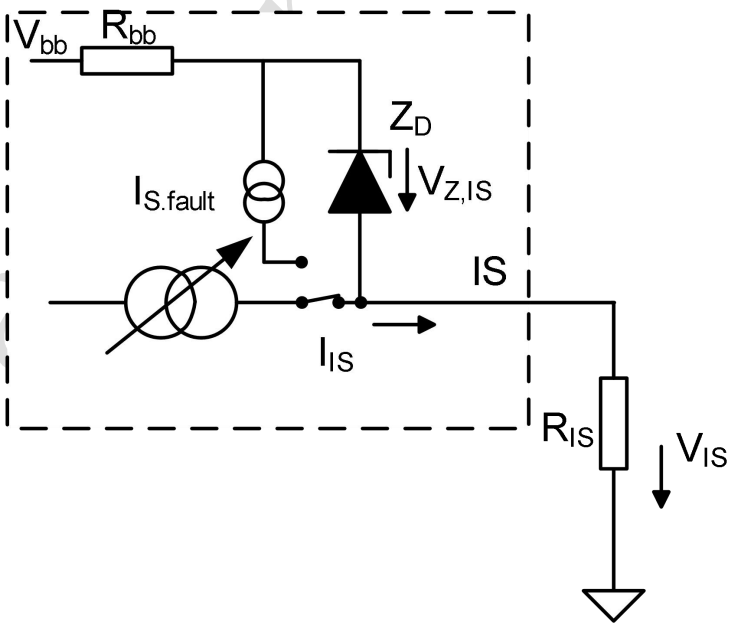
ESD-Zener diode: 73 V typ, max 15 mA;

13.3 Short circuit detection



Fault Condition: V_{ON}>2.5V

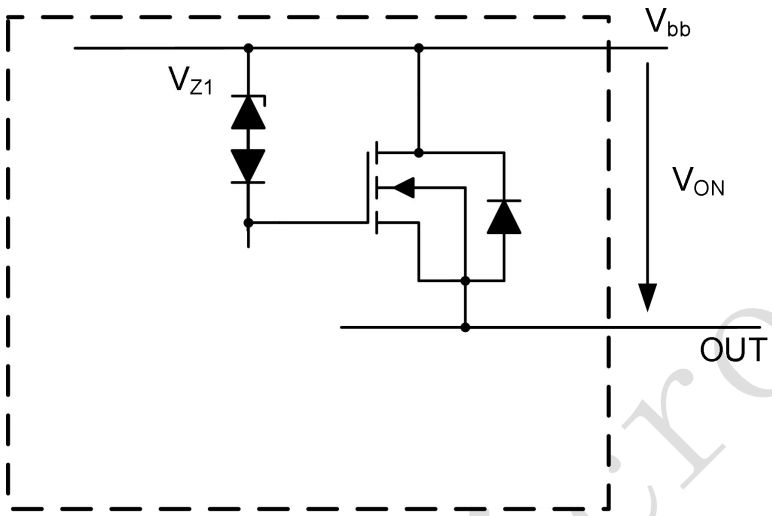
13.4 Current sense output



$V_{Z(IS)}$=73V (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 only driven by the internal circuit as long as V_{out}-V_{IS}>5V. Therefore R_{IS} should be less than $\frac{V_{bb} - 5V}{7.5\,mA}$.

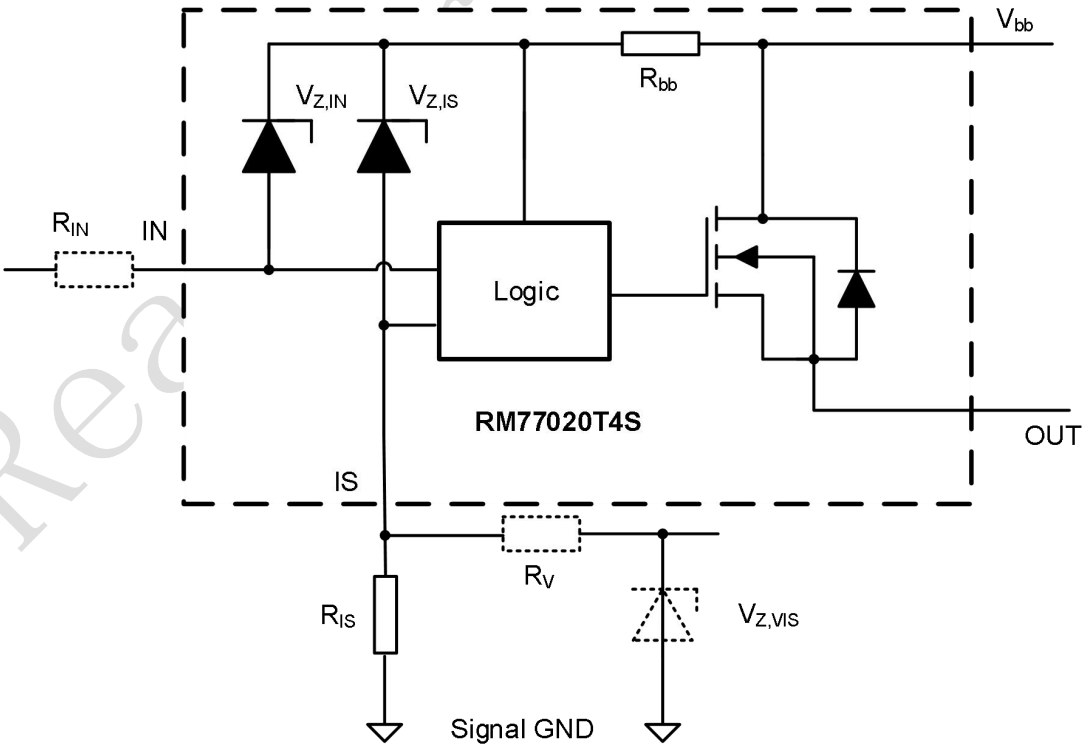
Note: For large values of R_{IS} the voltage V_{IS} can reach almost V_{bb}. See also overvoltage protection. If you don't use the current sense output in your application, you can leave it open.

13.5 Inductive and overvoltage output clamp



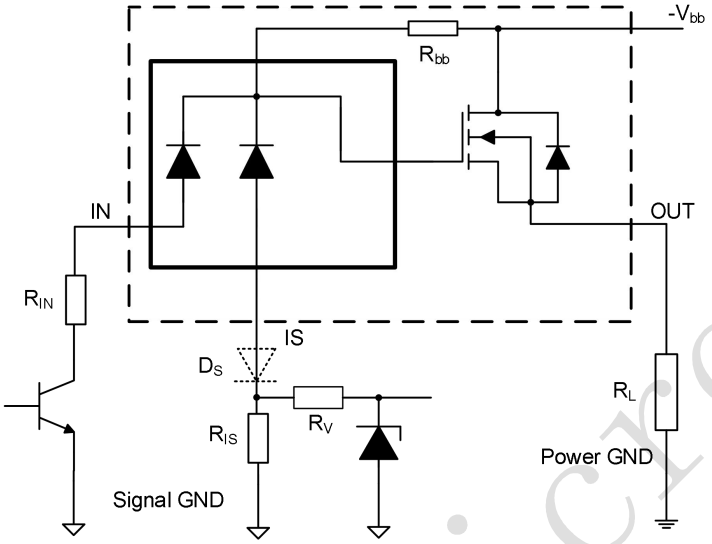
V_{ON} is clamped to $V_{ON(CL)}$=67V typ

13.6 Overvoltage protection of logic part



$V_{Z(IN)}$=$V_{Z(IS)}$=73V typ., R_{IS}=1kΩ nominal. Note that when overvoltage exceeds 78V typ. a voltage above 5V can occur between IS and GND, if R_V, $V_{Z,VIS}$ are not used.

13.7 Reverse battery protection

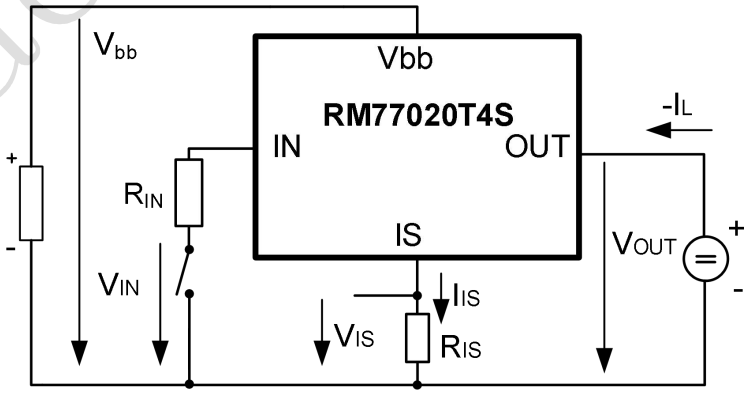


R_{IS}=1 kΩ nominal. Add R_{IN} for reverse battery protection in applications with V_{bb} above 16V;

recommended value: $\frac{1}{R_{IN}}+\frac{1}{R_{IS}}=\frac{0.08A}{|V_{bb}|-12V}$

To minimise power dissipation at reverse battery operation, the overall current into the IN and IS pin should be about 80mA. The current can be provided by using a MOSFET input switch or by proper adjusting the current through R_{IS}. Since the current via R_{bb} generates additional heat in the device, this has to be taken into account in the overall thermal consideration.

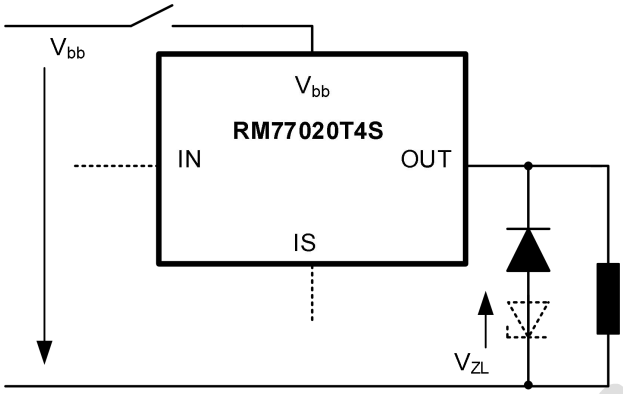
13.8 Inverse load current operation



The device can be operated in inverse load current mode (V_{OUT}>V_{bb}>0V). The current sense feature is not available during this kind of operation (I_{IS}=0). In case of inverse operation the intrinsic drain source diode is eventually conducting resulting in considerably increased power dissipation.

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

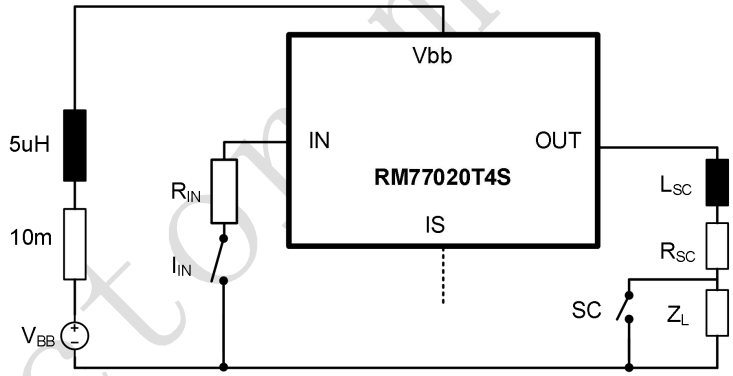
13.9 V_{bb} disconnect with energised inductive load



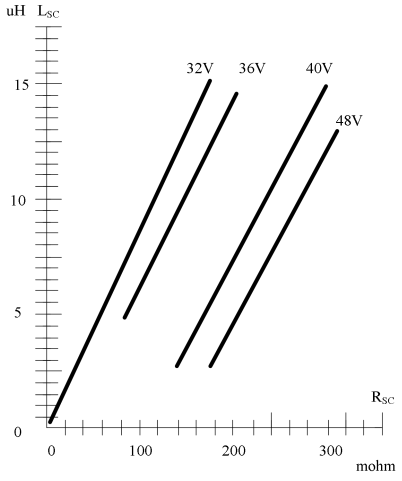
Provide a current path with load current capability by using a diode, a Z-diode, or a varistor.

For higher clamp voltages currents at IN and IS have to be limited to 120 mA.

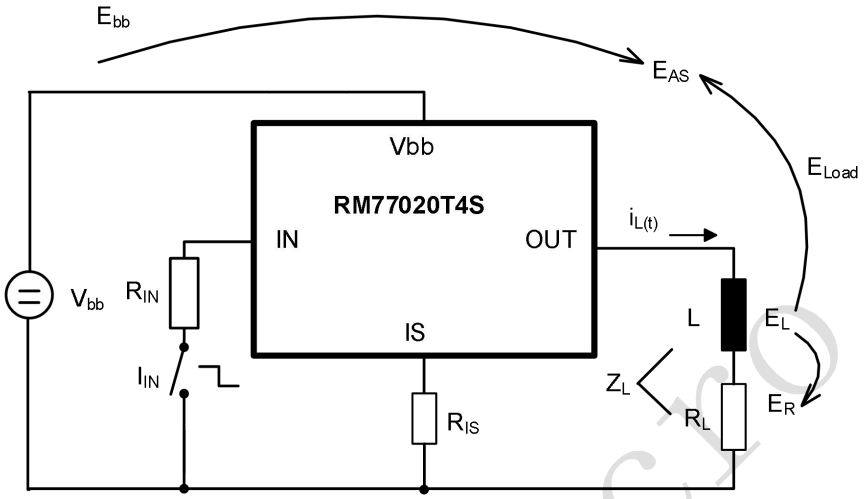
13.10 Short circuit



Short circuit is a combination of primary and secondary impedance's and a resistance's



13.11 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 RM77020T4S is :

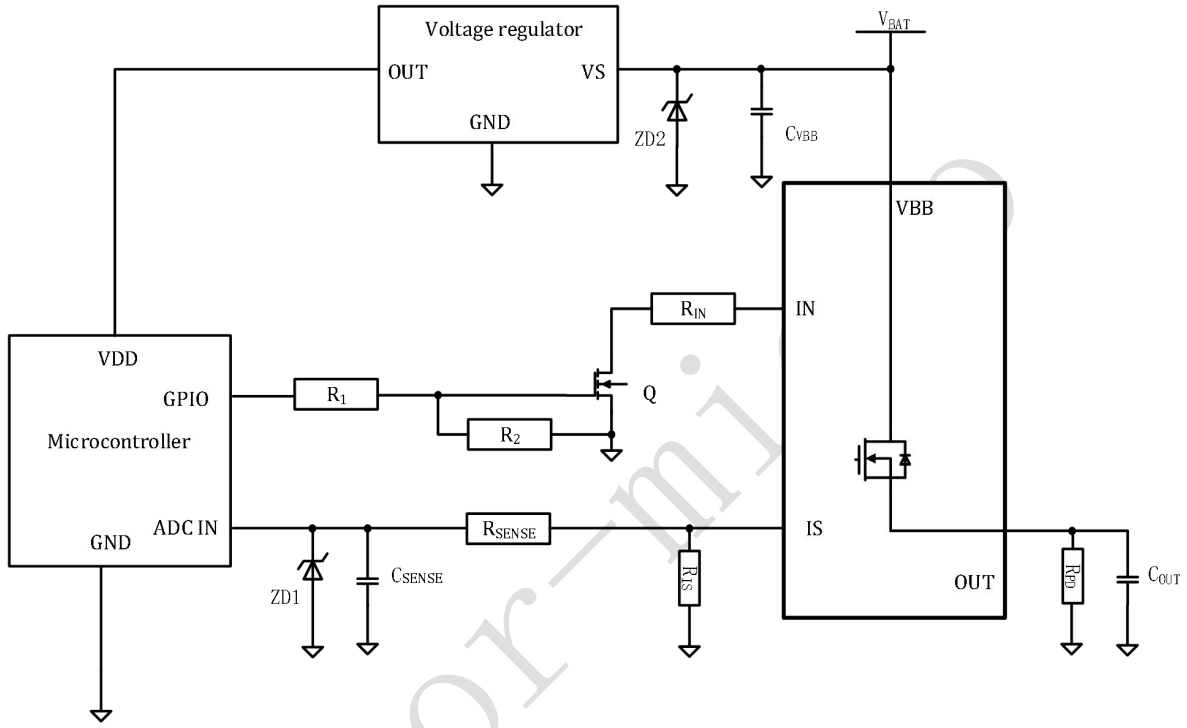
$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t) dt$$

with an approximate solution for R_L>0Ω:

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

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.



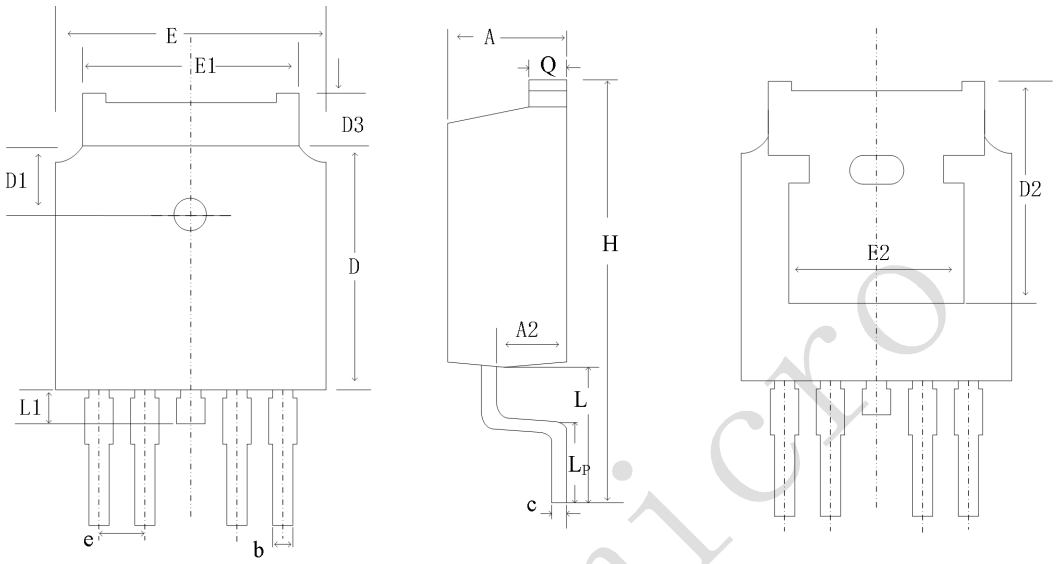
Note: This is a very simplified example of an application circuit.The function must be verified in the real application.

Bill of Material

Reference	Value	Reference	Value
R_{IN}	1KΩ	R_{PD}	47KΩ
R_1	1KΩ	C_{OUT}	10nF
Q	100V MOSFET	R_{SENSE}	10KΩ
R_2	10KΩ	C_{SENSE}	10nF
ZD1	6.2V Zener diode	R_{IS}	1KΩ
C_{VDD}	100nF	ZD2	62V Zener diode

15.Package

TO-252-4L

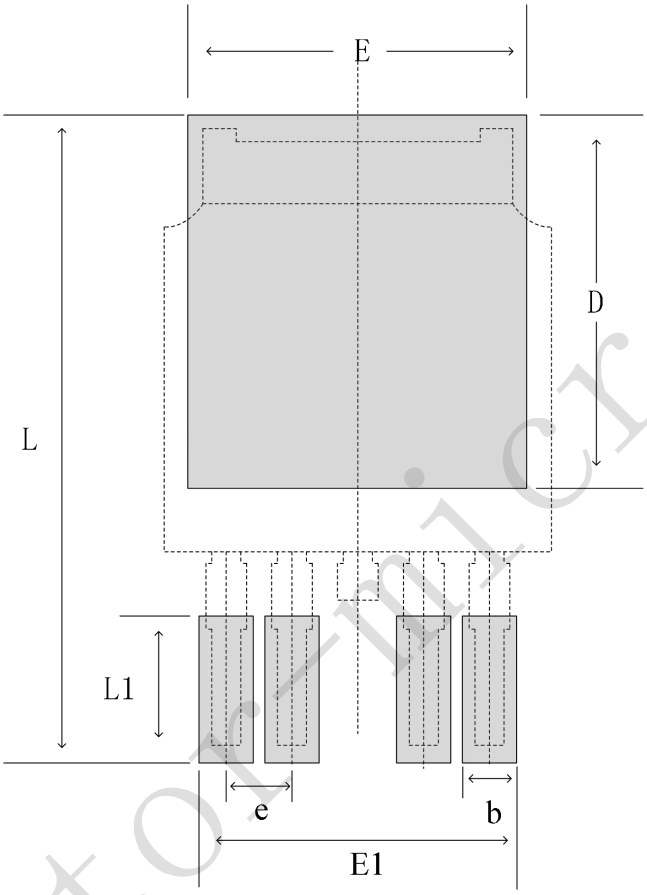


Unit :mm

Symbol	MIN	NOM	MAX
A	2.20	2.30	2.38
A2	0.97	1.07	1.17
b	0.55	0.62	0.70
E1	5.20	5.33	5.46
Q	0.43	0.53	0.61
D	5.98	6.10	6.22
D2		5.30REF	
E	6.4	6.60	6.73
E2	5.10	--	--
e		1.27BSC	
H	9.40	10.10	10.50
L_P	1.38	1.50	1.75
L		2.90REF	
c		0.51BSC	
D1	1.65	1.80	1.95
L1	0.50	-	1.00
D3	0.88	-	1.28

16.Recommended Soldering Footprint

TO-252-4L



Unit : mm

Symbol	NOM	Symbol	NOM
E	5.5	D	7.3
L	13	L1	3
e	1.27	b	0.62
E1	5.7		

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 2) Revised and Added certain parameter in the Electrical Characteristics table. 3) Added curves showing parameter variations with ambient temperature; 4) Revised introductions for circuit functions in the Functions section. 5) Revised Recommended Soldering Footprint 6) Revised Application Information.	2025/7/30