Smart High-Side Power Switch
RM77020TXS 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

RM77020TXS 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.

RM77020TXS 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	$V_{bb(AZ)}$	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

Device	Package Type	Marking	Materials	Package			Package Qty
RM77020T4S	TO-252-4L	RM77020T4S	Halogen free	Tape&reel	10 reels /box	25k/ box	2500/reel
RM77020T5S	TO-263-5L	RM77020T5S	Halogen free	Tape&reel	5 reels /box	4k/ box	800/reel

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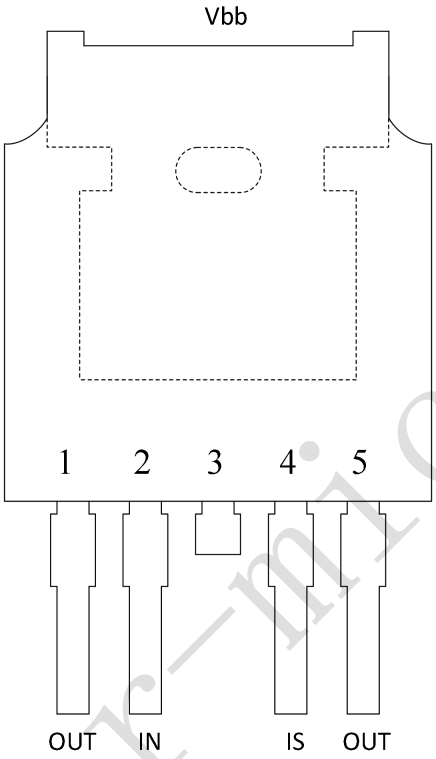
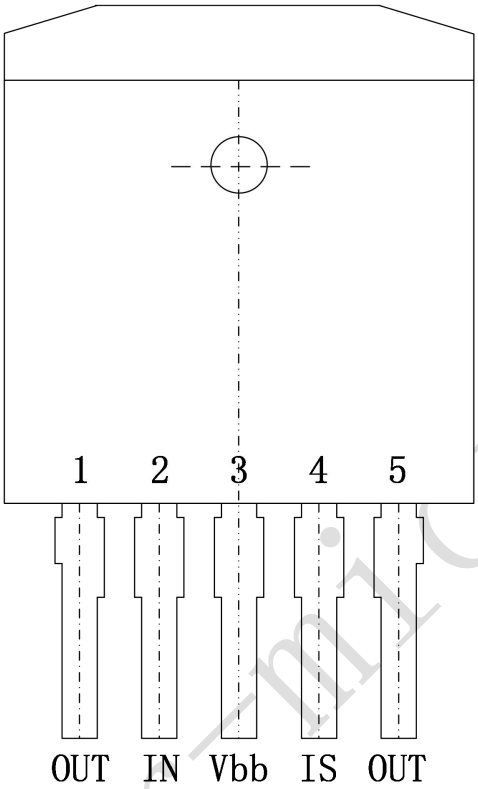
6. Pin Configuration

RM77020T4S (TO-252-4L)



Pin	Symbol	Function
1	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	Vbb	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.
5	OUT	Output; output to the load; pin 1 and 5 must be externally shorted .

RM77020T5S (TO-263-5L)



Pin	Symbol	Function
1	OUT	Output; output to the load; pin 1 and 5 must be externally shorted.
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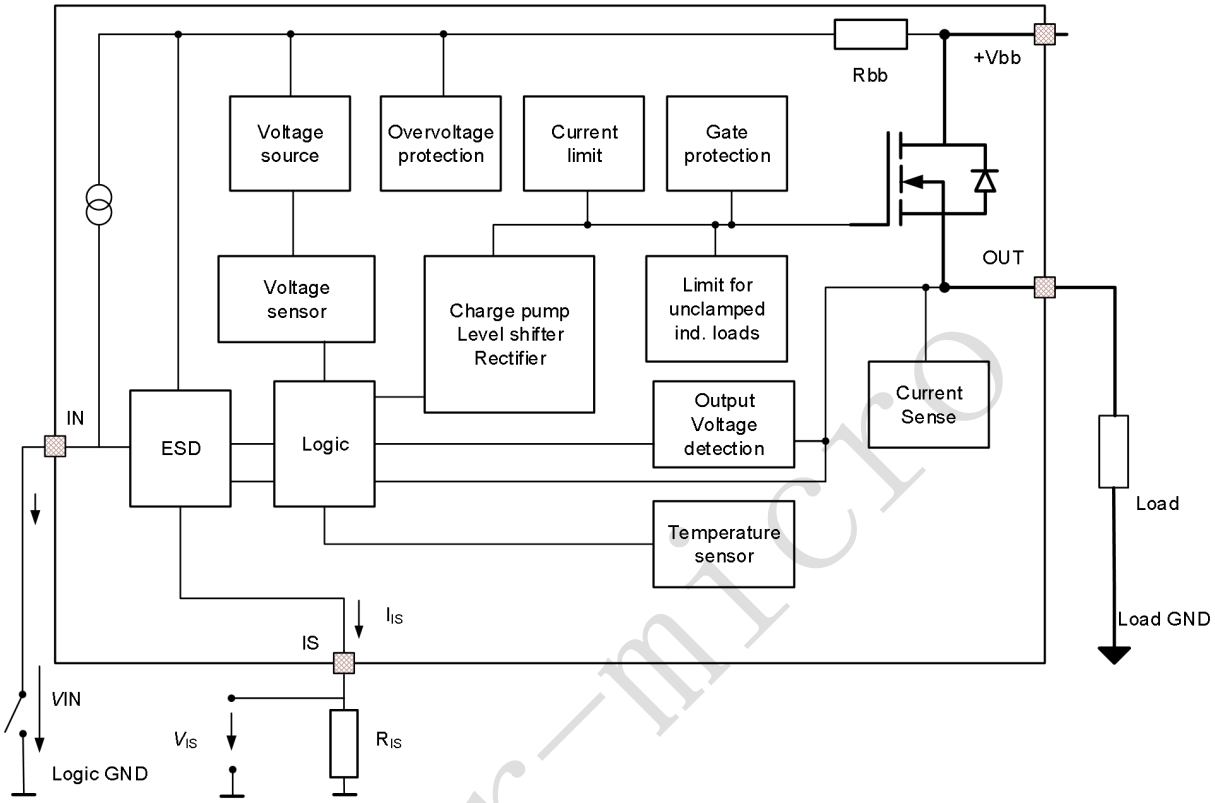
5	OUT	Output; output to the load; pin 1 and 5 must be externally shorted.

7.Block Diagram



8.Absolute Maximum Ratings[1)]

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

Parameter	Symbol	Values	Unit
Supply voltage	V_S	62	V
Load dump protection $V_{LoadDump}=U_A+V_S$, U_A=24VR_I=2Ω, R_L=4.4Ω, t_d=400ms, IN=low or high	$V_{Loaddump}$	70	V
Power dissipation(DC)	P_{tot}	59	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, Vbb=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℃	-	15	23	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	
$V_{ON(NL)}$	Open load detection		-	40	65	mV
$I_{L(NOM)}$	Nominal load current	V_{on}=0.5V;T_j=25℃	5.5	6.5	-	A
$I_{L(ISO)}$	Nominal load current(ISO)	V_{on}=0.5V;T_j=25℃	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/dt_{ON}	Turn-ON Slew rate	R_L=3.9Ω, From 10% to 30% V_{OUT}	0.2	0.6	1.0	V/us
$-dV/dt_{OFF}$	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
$V_{bIN(u)}$	Undervoltage shutdown		-	2.6	3.5	V
$V_{bIN(ucp)}$	Undervoltage restart of charge pump		-	4.5	5.5	V
$V_{bb(off)}$	Standby current	I_{in}=0;V_{bb}=24V;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	
$I_{IS(lim)}$	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

10.Timing diagrams

Figure 1: Switching a Resistive Load Timing

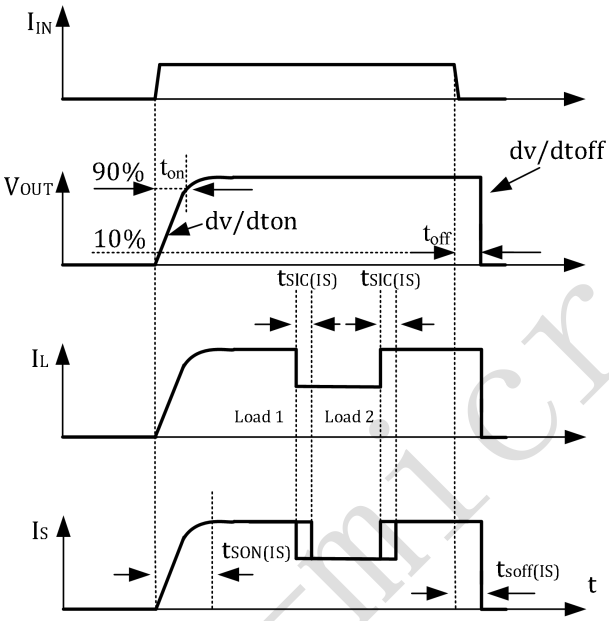
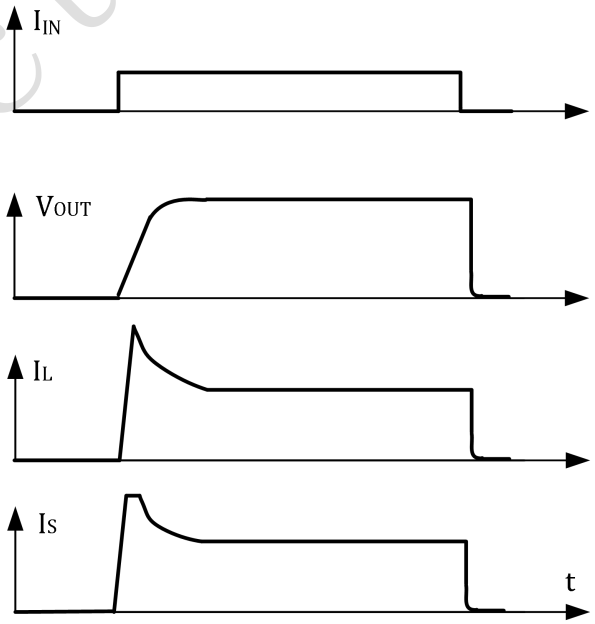


Figure 2a: Switching motors and lamps



As long as VbIS < VZ,IS the sense current will never exceed IIS,fault and/or IIS,lim

Figure 2b: Switching an inductive load

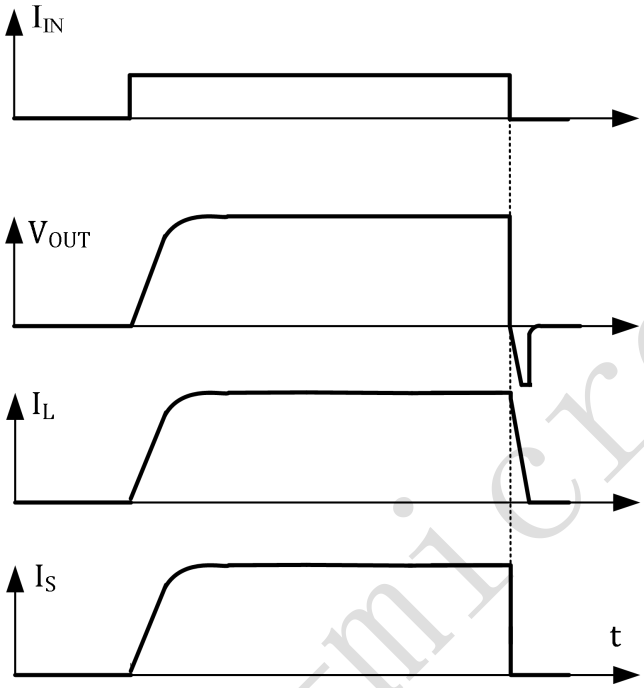
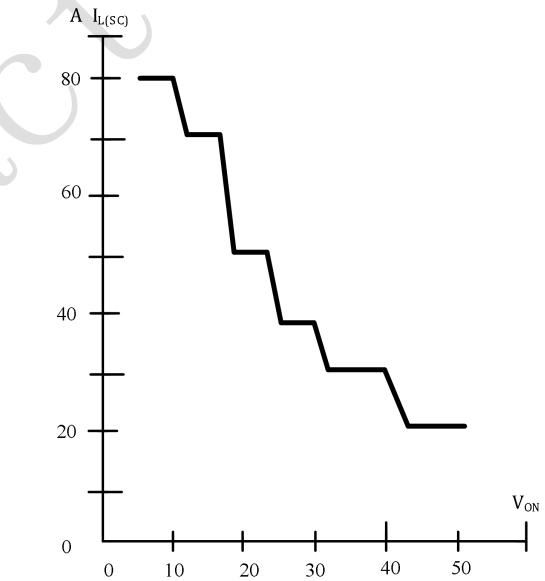


Figure 3a: current limitation characteristic



In case of VON > VON(SC) (typ. 3.5 V) the device will be switched off by internal short circuit detection

Figure 3b: Short circuit type one

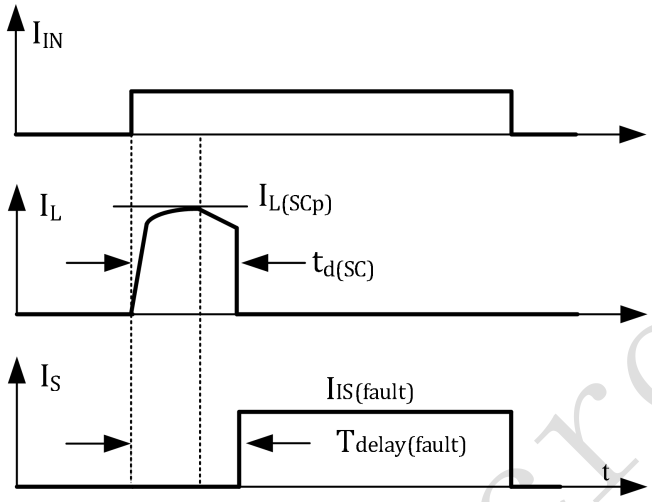


Figure 3c: Short circuit type two

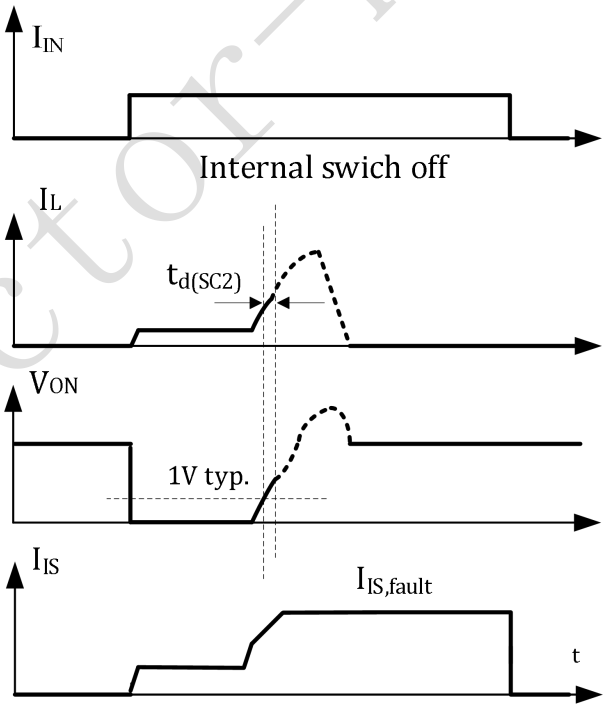


Figure 4a: Overtemperature

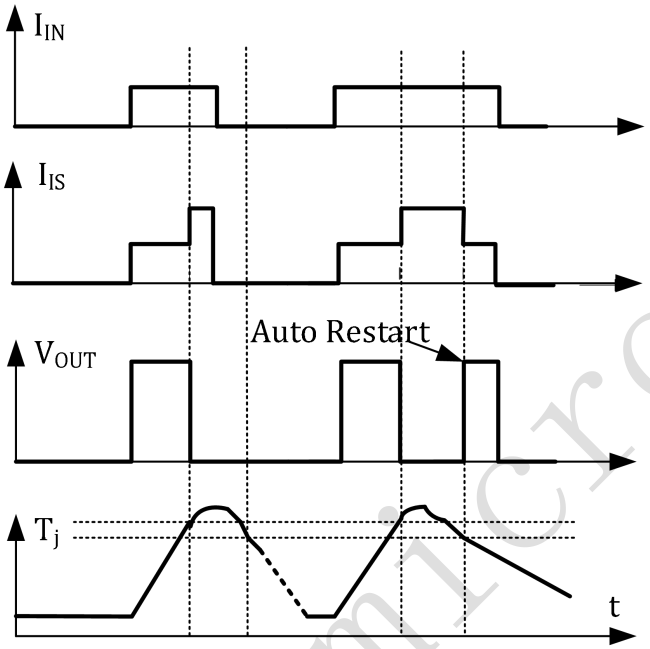


Figure 4b: Overload

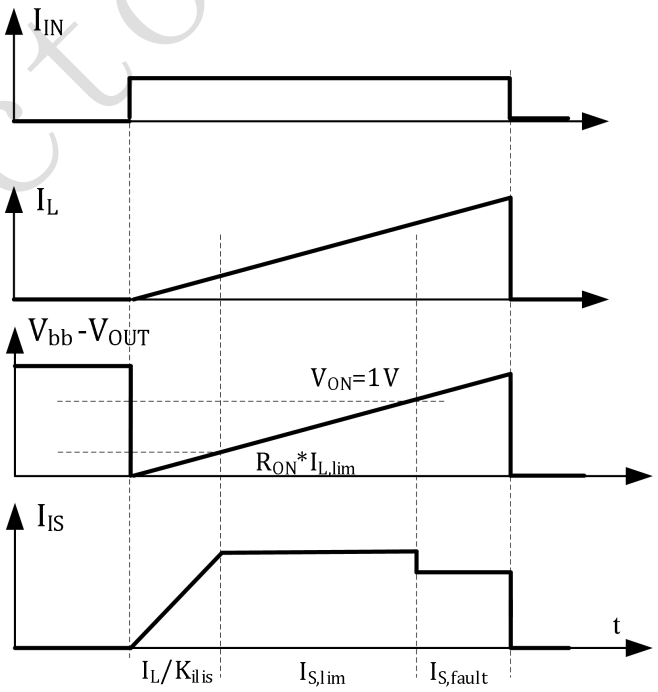


Figure 5:Undervoltage restart of charge pump, overvoltage clamp

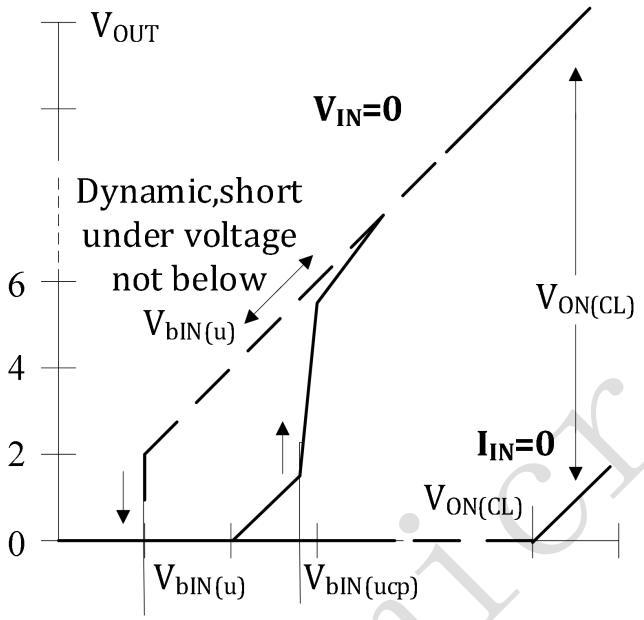


Figure 6a: Current sense versus load current

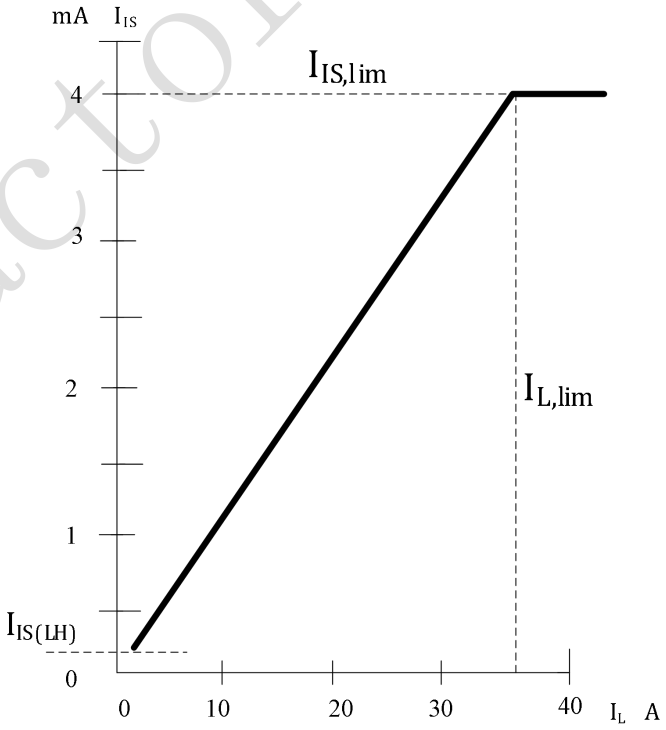


Figure 6b: Current sense ratio

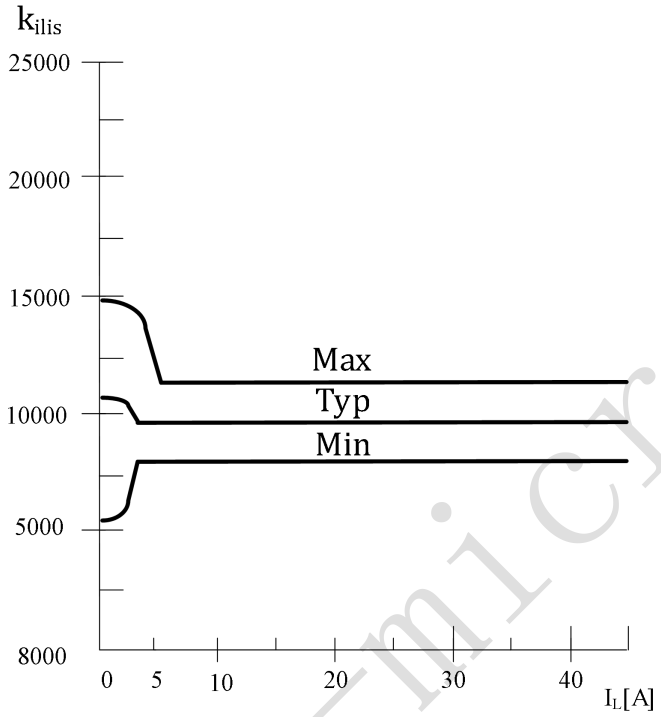
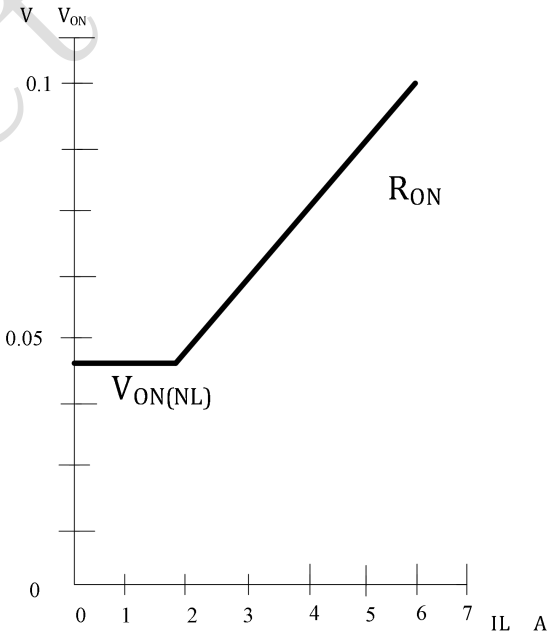


Figure 7: Output voltage drop versus load current



11.Truth Table

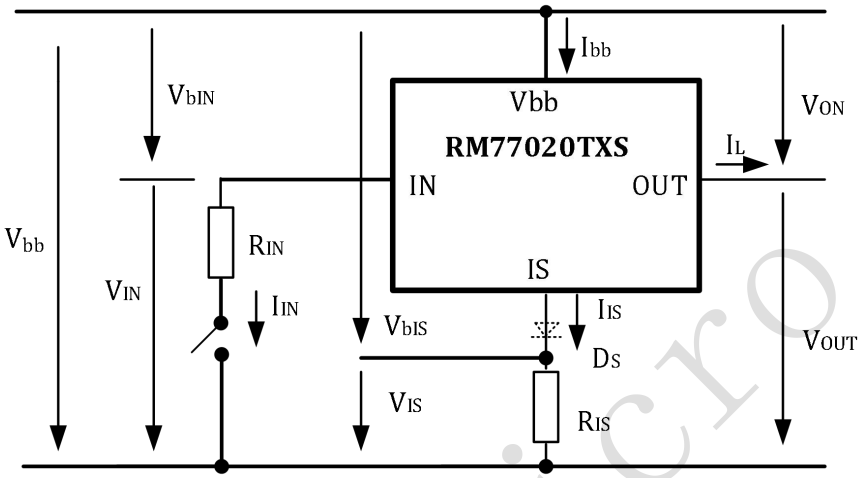
Operation Mode	Input Current level	Output level	Current Sense I_{IS}	Remark
Normal operation	L[1)] H[1)]	L H	0 Nominal	
Overload	L H	L H	0 $I_{IS,\ fault}$	
Short circuit to GND	L H	L L	0 $I_{IS,\ fault}$	
Over temperature	L H	L L	0 $I_{IS,\ fault}$	
Short circuit to Vbb	L H	H H	0 Nominal	
Open load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

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

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

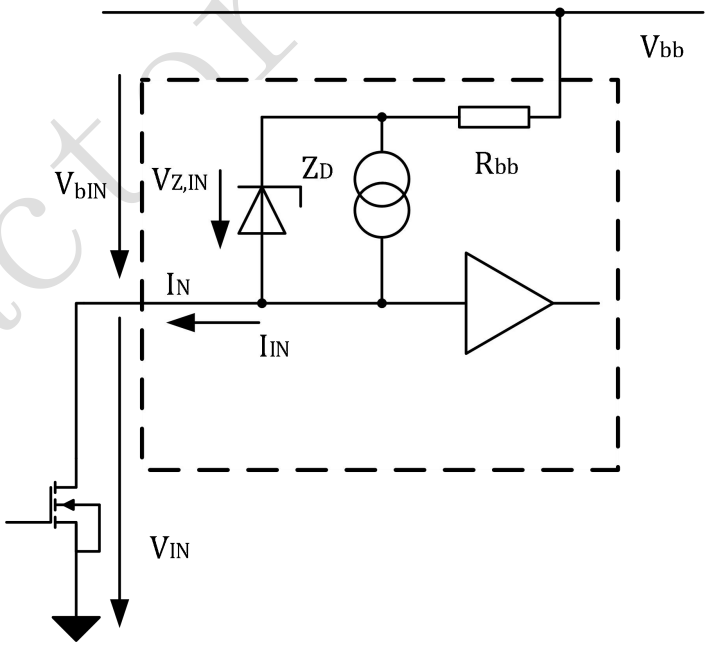
12.Functions

12.1 Terms



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

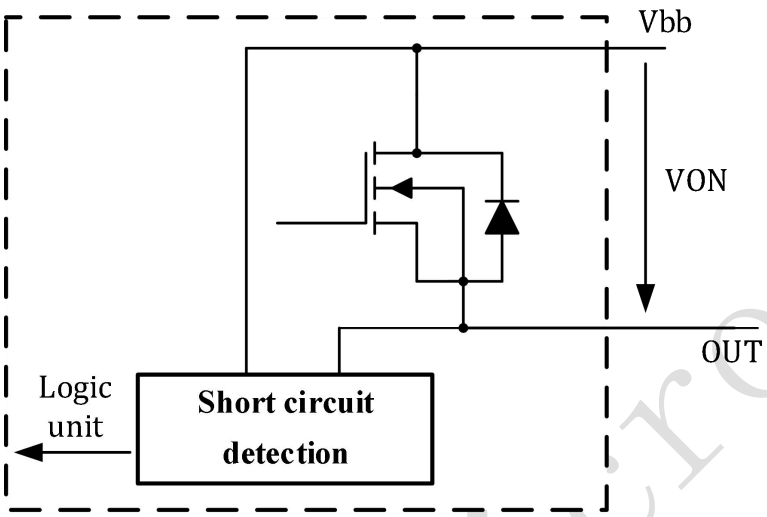
12.2 Input circuit (ESD protection)



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.

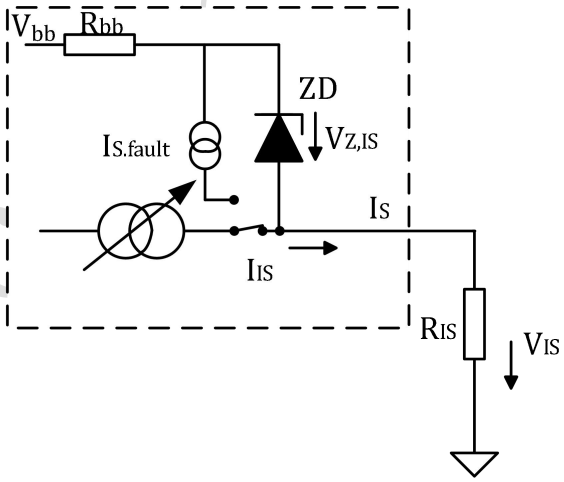
ESD-Zener diode: 73 V typ, max 15 mA;

12.3 Short circuit detection



Fault Condition: VON > 2.5V

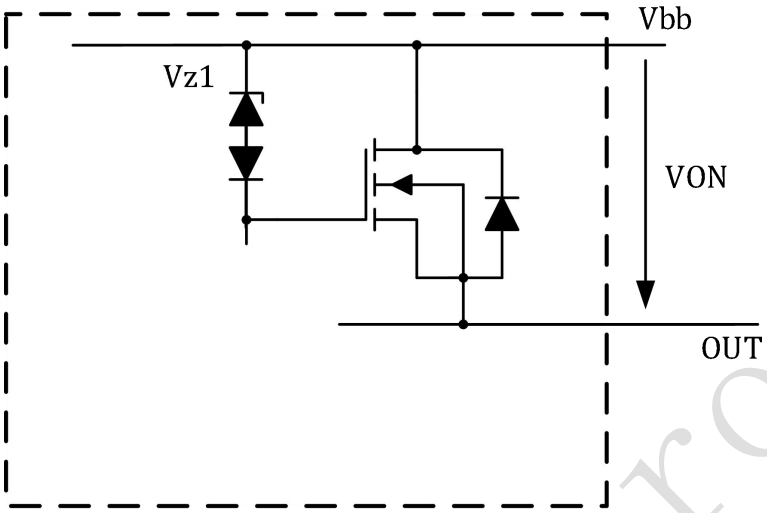
12.4 Current sense output



VZ, IS = 73V (typ.), RIS =1 kΩ nominal (or 1 kΩ /n, if n devices are connected in parallel). $I_S = I_L / kilis$ can be only driven by the internal circuit as long as Vout - V_{IS} > 5V. Therefore R_{IS} should be less than $\frac{V_{bb} - 5V}{7.5\,mA}$.

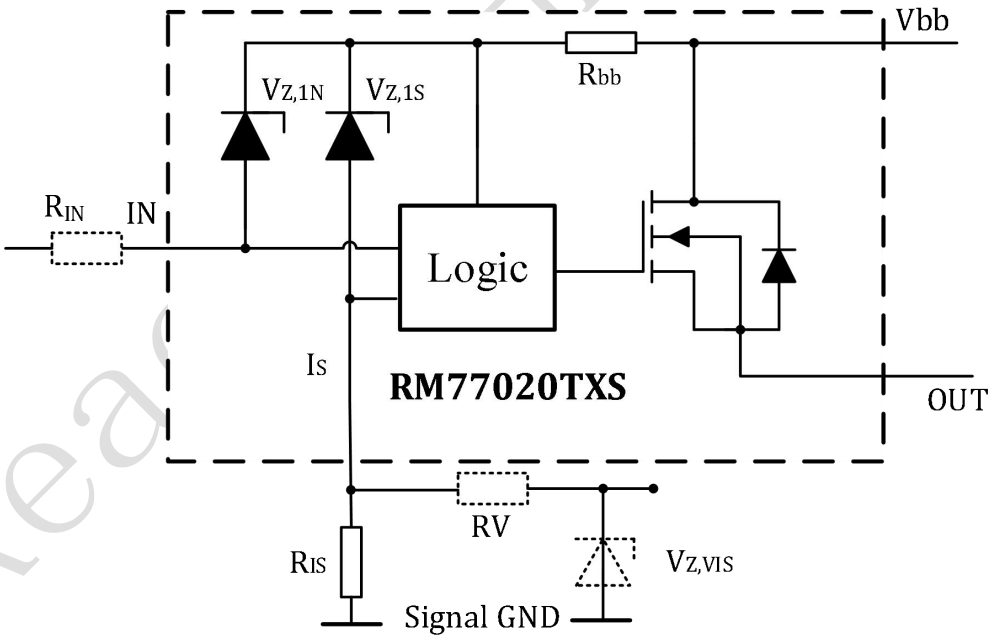
Note: For large values of RIS the voltage VIS can reach almost Vbb. See also overvoltage protection. If you don't use the current sense output in your application, you can leave it open.

12.5 Inductive and overvoltage output clamp



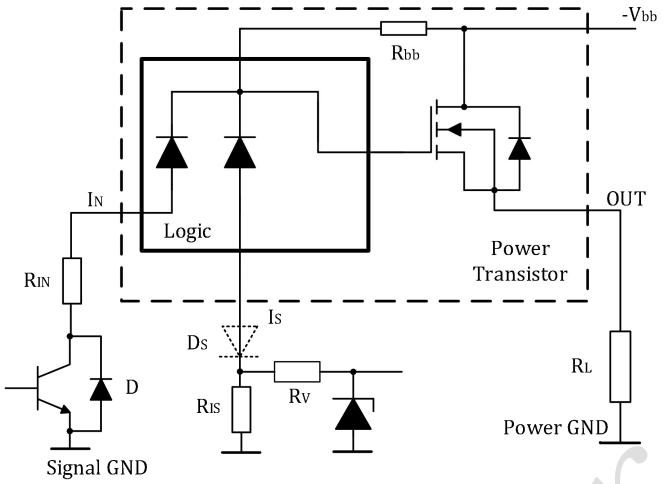
V_{ON} is clamped to $V_{ON(Cl)}$ =67V typ

12.6 Overvoltage protection of logic part



R_{bb} =100Ω typ., $V_{Z,\,IN}$ = $V_{Z,\,IS}$ = 73V typ., R_{IS} =1kΩ nominal. Note that when overvoltage exceeds 73V typ. a voltage above 5V can occur between IS and GND, if RV, VZ, VIS are not used.

12.7 Reverse battery protection

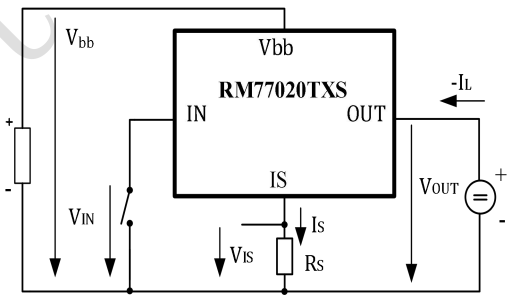


$R_V \geq 1\ k\Omega$, $R_{IS} = 1\ k\Omega$ nominal.Add R_{IN} for reverse battery protection in applications with V_{bb} above 16V; recommended value:

$$\frac{1}{R_{IN}} + \frac{1}{R_{IS}} = \frac{0.08A}{|V_{bb}| - 12V}$$ if D_S is not used (or $$\frac{1}{R_{IN}} = \frac{0.1A}{|V_{bb}| - 12V}$$ if D_S is used)

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 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}.

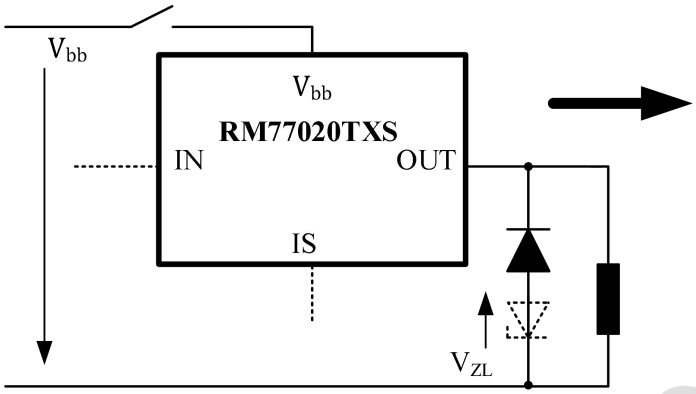
12.8 Inverse load current operation



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.

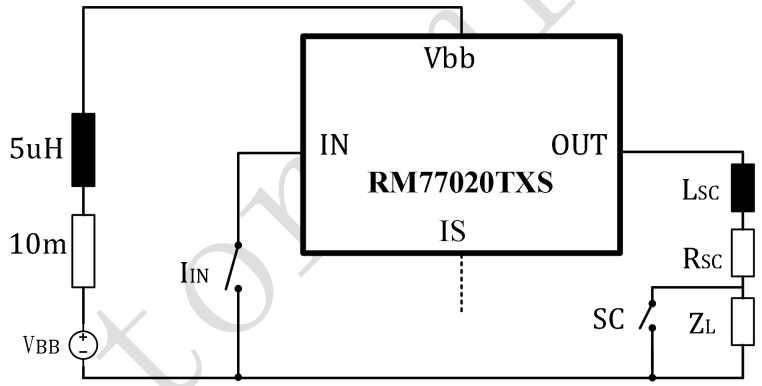
Note: Temperature protection during inverse load current operation is not possible!

12.9 Vbb disconnect with energised inductive load

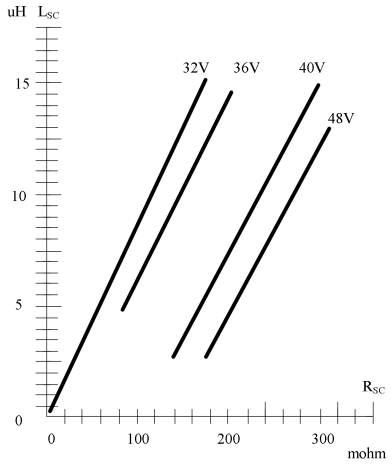


Provide a current path with load current capability by using a diode, a Z-diode, or a varistor. (V_{ZL}+V_D<63 V if R_{IN} =0). For higher clamp voltages currents at IN and IS have to be limited to 120 mA.

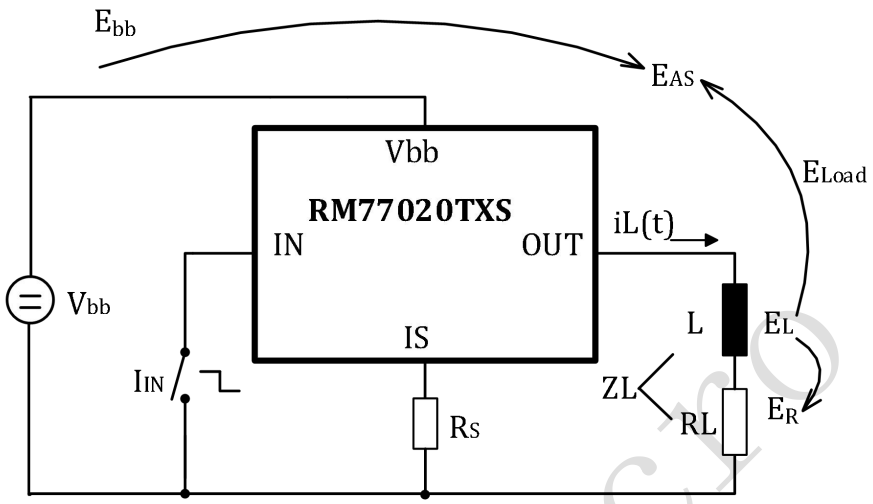
12.10 Short circuit



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



12.11 Inductive load switch-off energy dissipation



Energy stored in load inductance:

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

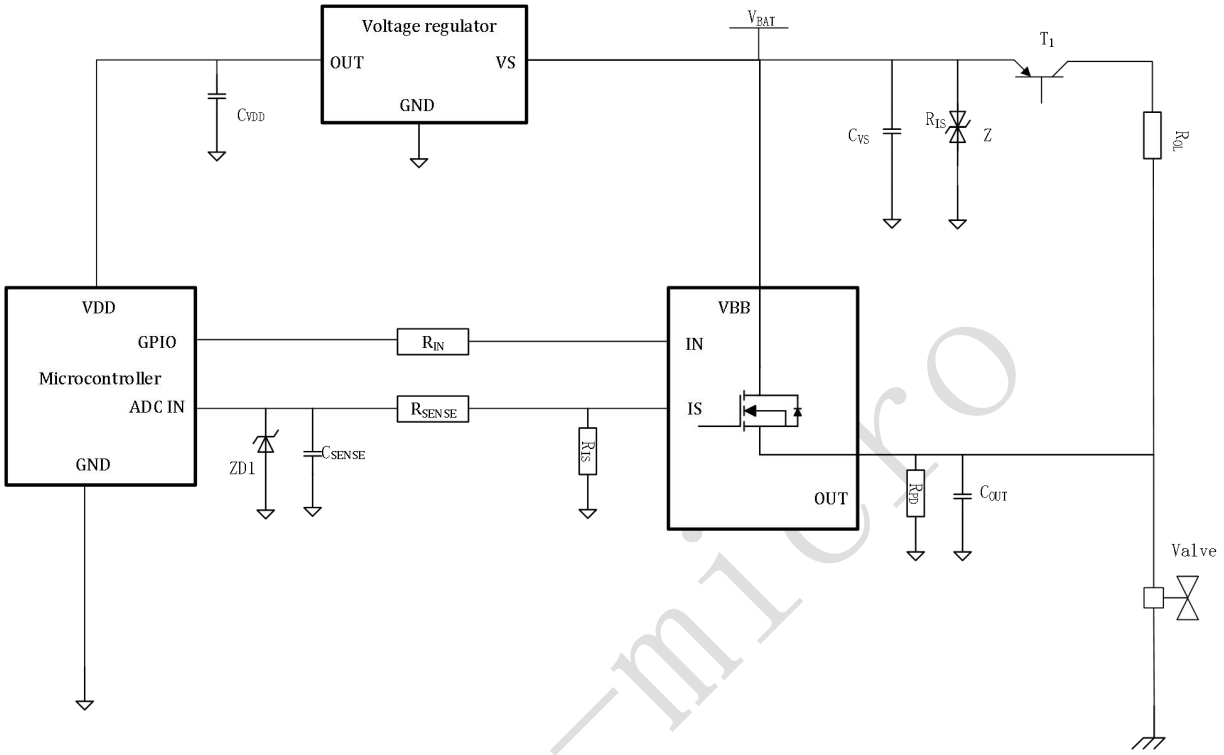
While demagnetizing load inductance, the energy dissipated in RM77020TXS is :

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

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

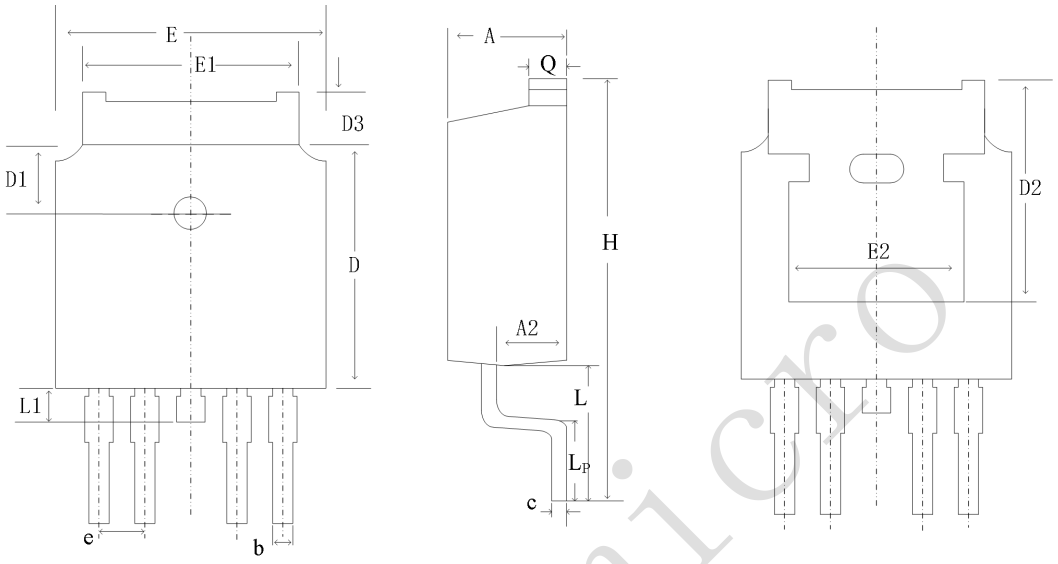
$$E_{AS} = \frac{I_L * L}{2 * R_L} (V_{bb} + |V_{OUT(CL)}|) \ln\left(1 + \frac{I_L * R_L}{|V_{OUT(CL)}|}\right)$$

13.Application Information



14.Package

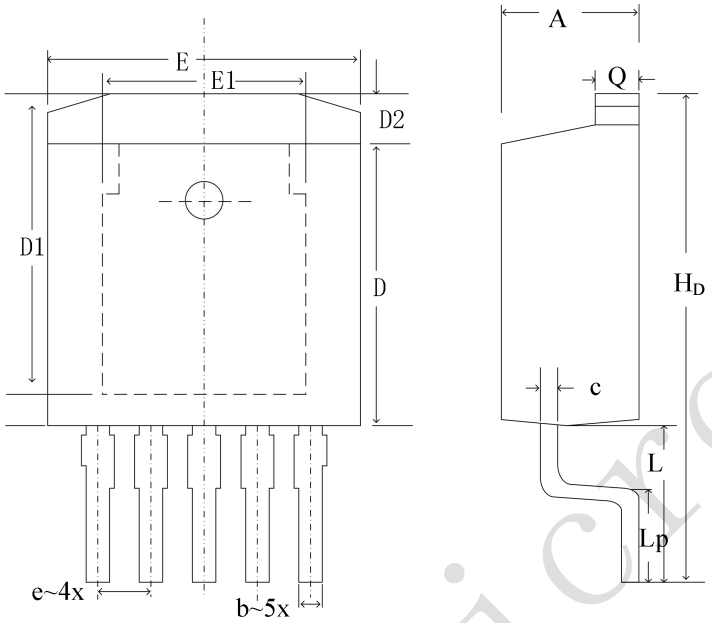
TO-252-4L



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

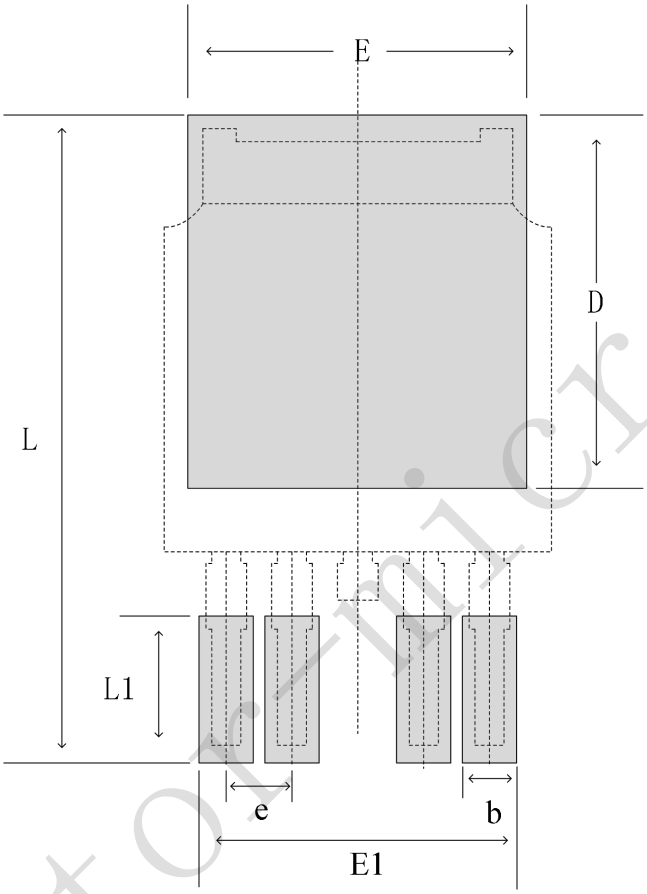
TO-263-5L



Symbol	MIN	NOM	MAX
A	4.064	4.445	4.826
b	0.508	0.750	0.991
c	0.381	0.560	0.737
Q	1.143	1.397	1.651
D	8.382	9.017	9.652
D1	6.858	6.905	7.700
E	9.652	10.160	10.668
E1	6.223	7.112	8.000
e		1.702 BSC	
H_D	14.605	15.240	15.875
Lp	1.778	--	2.794
D2	1.000	--	1.676
L	4.780	--	5.280

15. Recommended Soldering Footprint

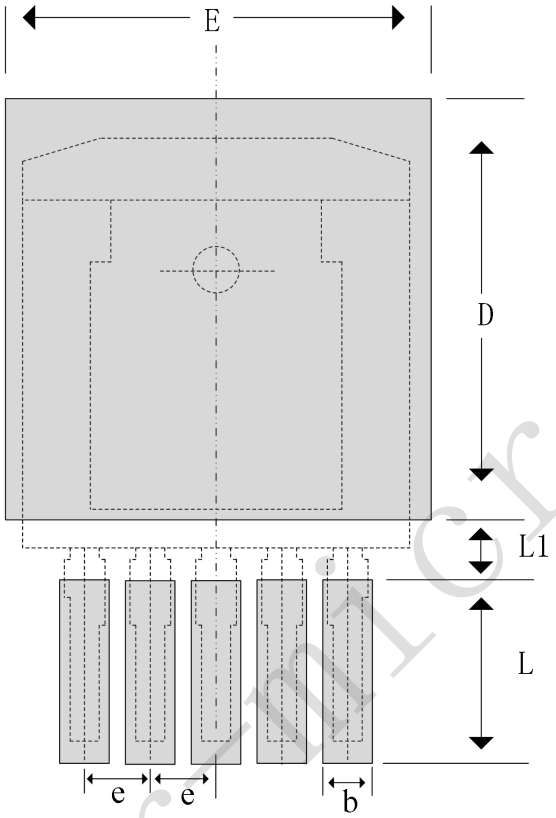
TO-252-4L



Unit : mm

Symbol	NOM	Symbol	NOM
E	5.8	D	6.4
L	10.8	L1	2.5
e	1.27	b	0.8
E1	5.36		

TO-263-5L



Unit : mm

Symbol	NOM	Symbol	NOM
E	10.8	D	9.4
L1	2.2	L	4.6
b	1.1	e	1.702

16.Revision History

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