

Smart Low-Side Power Switch

1. Overview

SL3405S is a two channel low - side power switch in SOP8 package providing embedded protective functions. The device consists of two separate monolithic IC. Each with one N-channel power MOS and additional protection circuitry.

SL3405W in SOT23-3L package with a separate IC is available for the case of single-channel applications.

2. Features

- Low input current
- Short circuit and overload protection
- Current limiting function
- Input protection (ESD)
- Thermal protection function that can be automatically Restarted
- Compatible with standard Power MOSFET
- Driven in analog mode
- Dual channel design reduces PCB pin
- RoHS compliant

Protective function

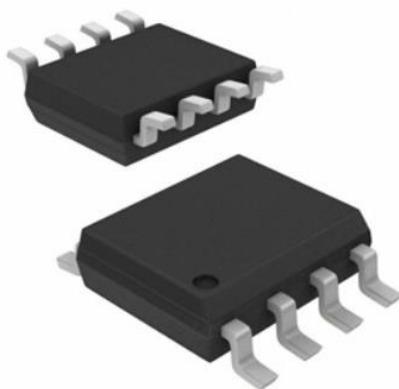
- Electrostatic discharge protection (ESD)
- Active clamp over voltage protection
- Thermal shutdown with auto restart
- Short circuit protection

Fault information

- Thermal shutdown
- Short circuit or overload of power supply

Application

- Designed for Relays driving in Automotive Applications
- All types of resistive, inductive and capacitive loads
- Suitable for loads with peak currents
- Replaces discrete circuits



SOP8

Detailed Description :

The device is able to switch all kind of resistive, inductive and capacitive loads, limited by E_{AS} and maximum current capabilities.

The SL3405 offers ESD protection of each IN Pin in relation to the corresponding Source Pin.

The overtemperature protection is in order to prevent the device from overheating due to overload and/or bad cooling conditions. The temperature information is given by a temperature sensor in each of the two power MOSFET. During thermal shutdown the device tries to sink an increased input current at the corresponding IN pin to feedback the fault condition on this channel.

The SL3405 has a thermal-auto-restart function, the regarding channel will turn on again after the measured temperature has dropped for the thermal hysteresis. The over voltage protection is active during load-dump or inductive turn off conditions. The power MOSFET is turned on if the Drain-source voltage gets too high. This function is available without supply, means without voltage on the IN pins.

Table1 Product Summary

Drain voltage	VD(max)	42V ¹⁾
Input voltage	VIN(max)	7V
Typical on-resistance(Tj=25°C , Vin=5V)	RDS(ON,amb typ)	0.7Ω
Maximum on resistance(Tj=150°C , Vin=5V)	RDS(ON,hot max)	1.9Ω
Load current	IDnom(min)	350mA
Drain current	ID	600mA ²⁾
Single clamp power	EAS	65mJ

¹⁾Active clamp

²⁾ Internal current limit

3.Block Diagram

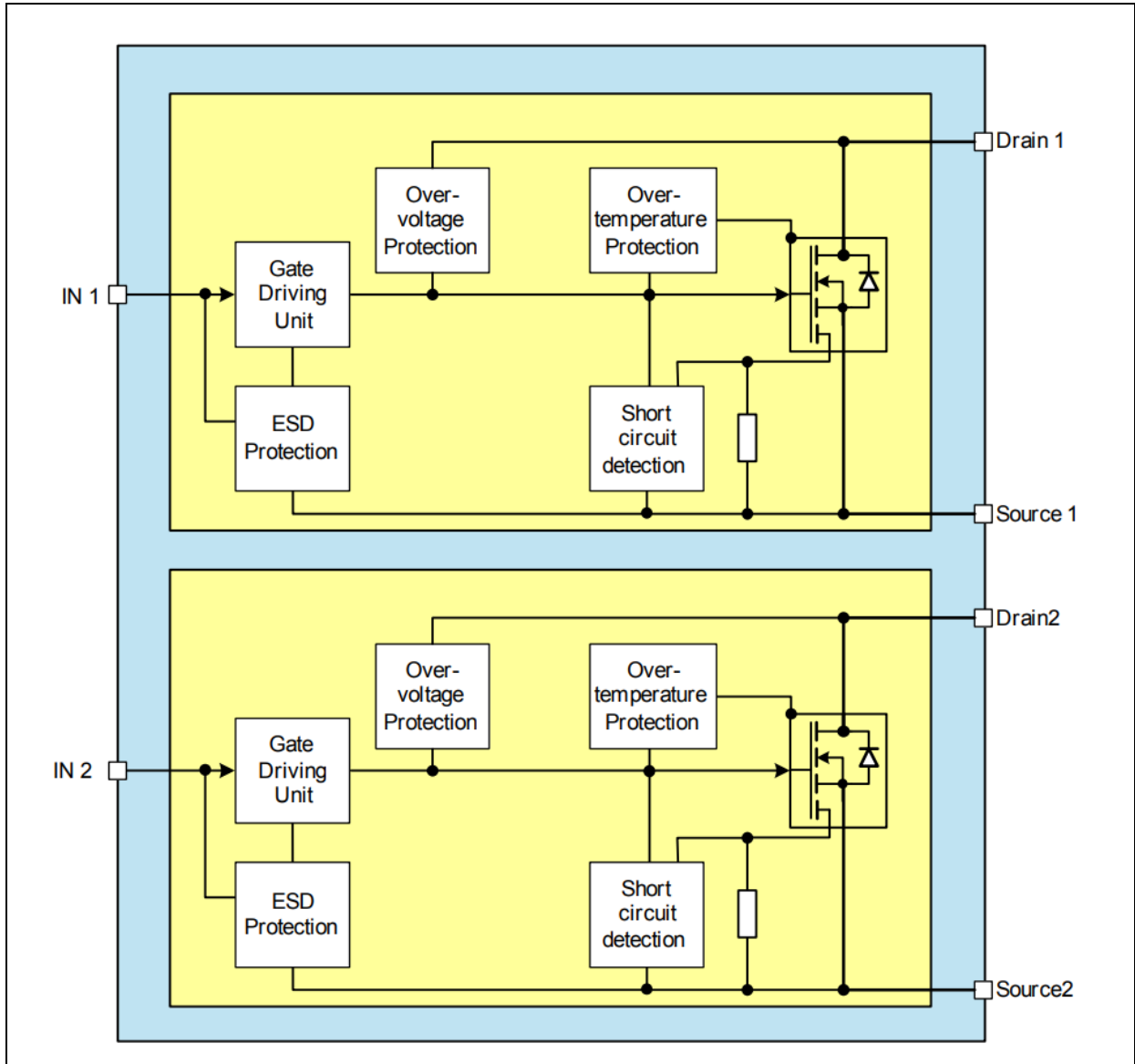


Figure 3-1 Block Diagram

Typical application circuit:

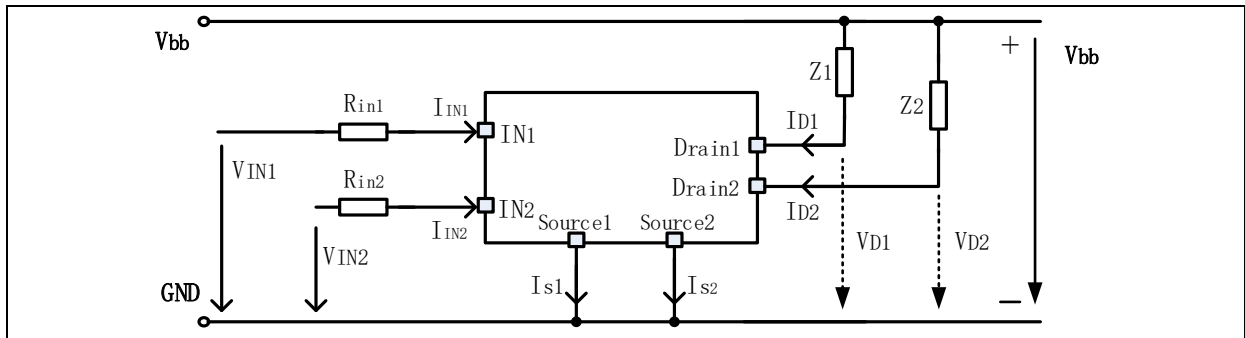


Figure 3-2 Application circuit

4. Pin Configuration

4.1 Pin Assignment SL3405S

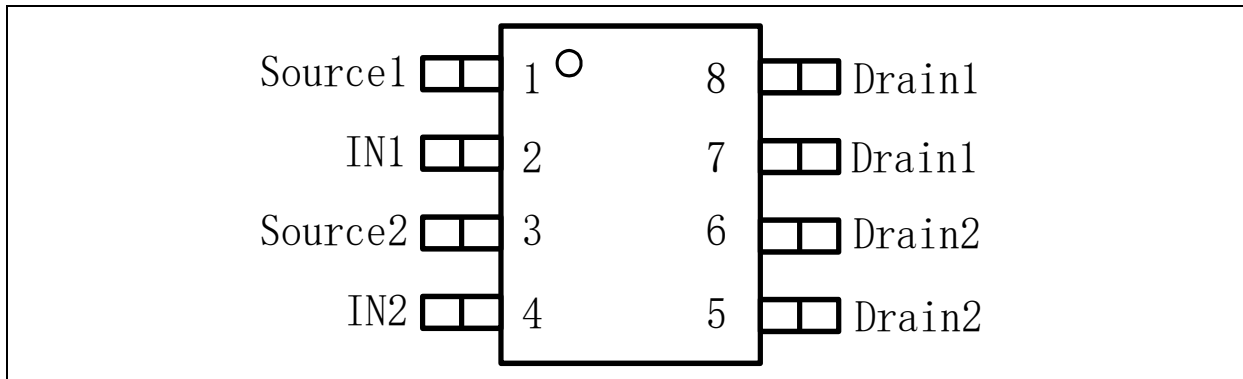


Figure4-1 Pin Configuration SOP8

Pin Definition and Function

PIN	Mark	Function
1	Source1	Ground connection for channel 1
2	IN1	Input / Fault feedback for channel 1
3	Source2	Ground connection for channel 2
4	IN2	Input / Fault feedback for channel 2
5,6	Drain2	Load connection channel 2
7,8	Drain1	Load connection channel 1

4.2 Pin Assignment SL3405W

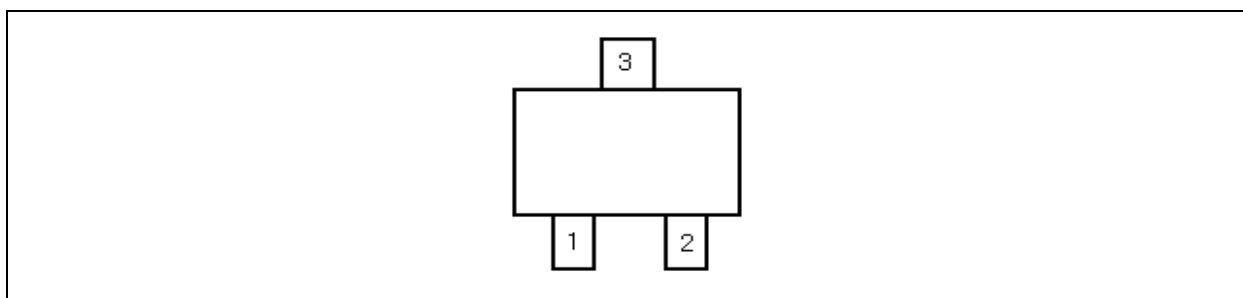


Figure 4-2 SOT23-3L Pin arrangement diagram

Pin Definition and Function

Pin	Mark	Function
1	Drain	The Drain Of Power MOS
2	IN	Input voltage
3	Source	Ground

5. General Product Characteristics

Absolute Maximum Ratings $T_j = -40\text{ °C}$ to $+150\text{ °C}$; all voltages with respect to ground, positive current flowing into pin (unless otherwise specified), all values valid for both channels

Table 5.1 Maximum rating ¹⁾: All parameters apply to both channels

Pos.	Parameter	Symbol	Limit values		Unit	Test Conditions
			Min.	Max.		
Voltage						
5.1.1	Drain voltage	VD	-	42	V	²⁾ VIN =0V, ID=10mA
5.1.2	Input voltage	VIN	-0.2	7	V	-
5.1.3	Input Current	IIN	Self limited		mA	-0.2V<VIN<5V
5.1.4			-2	2	mA	VIN<-0.2V或VIN>5V
5.1.5	Drain current	ID	-	600	mA	³⁾ Tj=25°C
Energies						
5.1.6	Total Power Dissipation	Ptot	-	0.78	W	⁴⁾ Ta = 85°C
Temperature						
5.1.7	Operating temperature	Tj	-40	+125	°C	-
5.1.8	Storage temperature	Tstg	-55	+150	°C	-
ESD Susceptibility						
5.1.9	Electrostatic discharge voltage ⁵⁾	VESD	-4	4	kV	R = 1.5k; C = 100pF Tj = 25°C

- 1) Not subject to production test, specified by design.
- 2) Active clamped.
- 3) Internally limited.
- 4) Device mounted on PCB according EIA/JEDEC standard JESD51-7(4-layer FR4, 76.2 mm x 114.3 mm with buried planes). PCB is mounted vertical without blown air.
- 5) ESD susceptibility HBM according to EIA/JESD 22-A 114B, section 4.

Table 5.2 Thermal Resistance

Pos.	Parameter	Symbol	Limit value			Unit	Conditions
			Min.	Type.	Max.		
5.2.1	Junction to Soldering Point	R _{thJC}	-	-	38	K/W	^{1) 2)}
5.2.2	Junction to Ambient all channel ON	R _{thJA}	-	80	-	K/W	^{1) 2)}

- 1) Not subject to production test, specified by design.
- 2) Device mounted on PCB according EIA/JEDEC standard JESD51-7 (4-layer FR4, 76.2 mm x 114.3 mm with buried planes). PCB is mounted vertical without blown air with 0.78W power dissipation generated in each channel on the DMOS.

Note: 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.

Note: Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as “outside” normal operating range. Protection functions are not designed for continuous repetitive operation.

6. Block Description and Characteristics

6.1 Input Circuit

Figure 6-1 shows the input circuit of the SL3405. The zener Diode protects the input circuit against ESD pulses. The internal circuitry is supplied by the input PIN. During normal operation the Input is connected to the Gate of the power MOSFET. During fault condition the device tries to sink the current I_{INlim} in order to give the fault information back to the driving circuit.

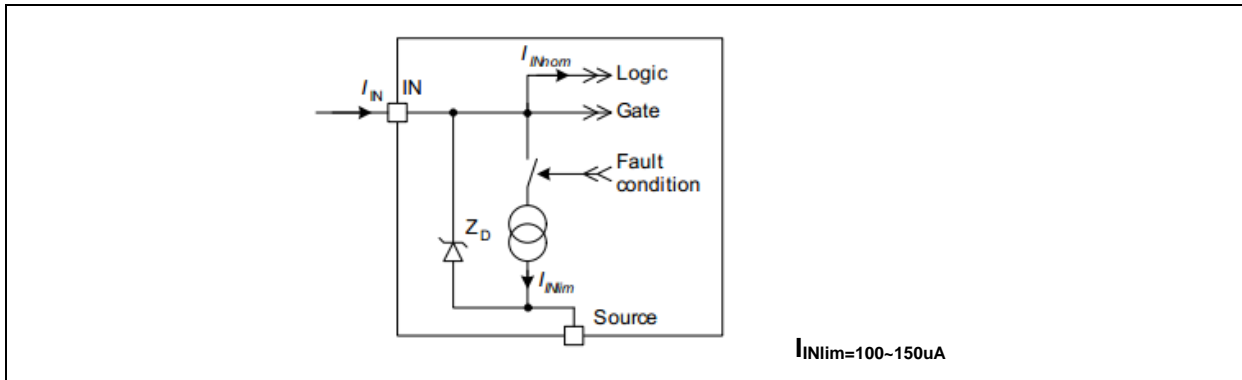


Figure 6-1 Input circuit

6.2 Transmission Characteristics

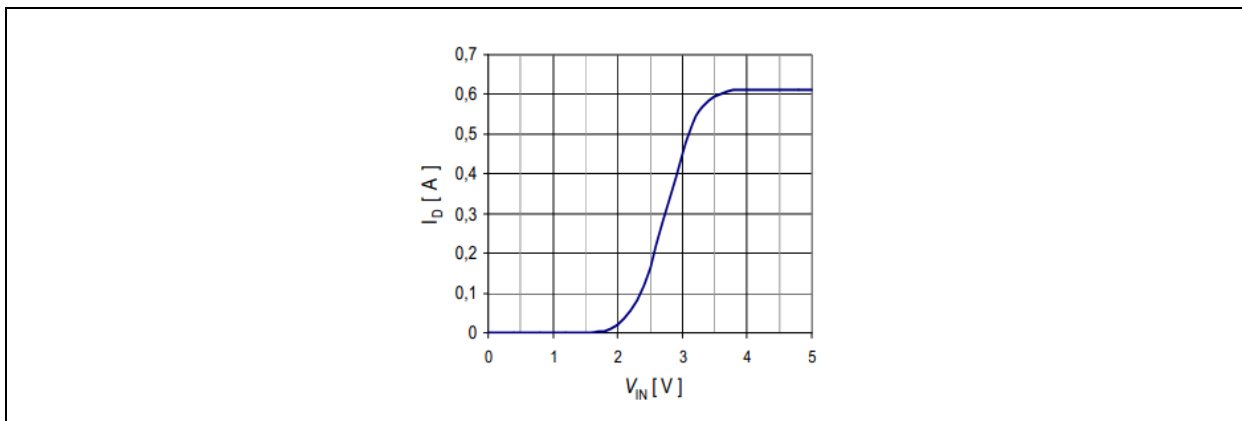


Figure 6-2 typical transmission characteristics $I_D = f(V_{IN})$; $V_D = 12\text{ V}$, $T_{Jstart} = 25\text{ }^\circ\text{C}$

6.3 Failure Feedback

During failure condition the SL3405 tries to receive a increased input current I_{INlim} .

6.4 Output On-State Resistance

The on-state resistance depends on the junction temperature T_J . Figure 6-3 shows this dependency for the typical on-state resistance $R_{DS(on)}$.

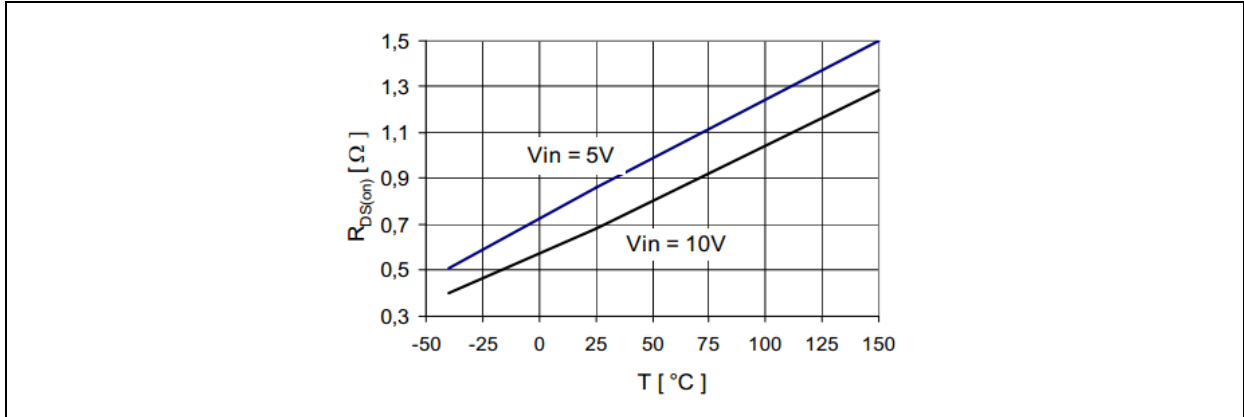


Figure 6-3 Typical On-State Resistance, $R_{DS(on)}$ f(T_J)

6.5 Power Dissipation

The maximum allowed power dissipation in Figure 6-4 is calculated by R_{thJC} and R_{thJA} .

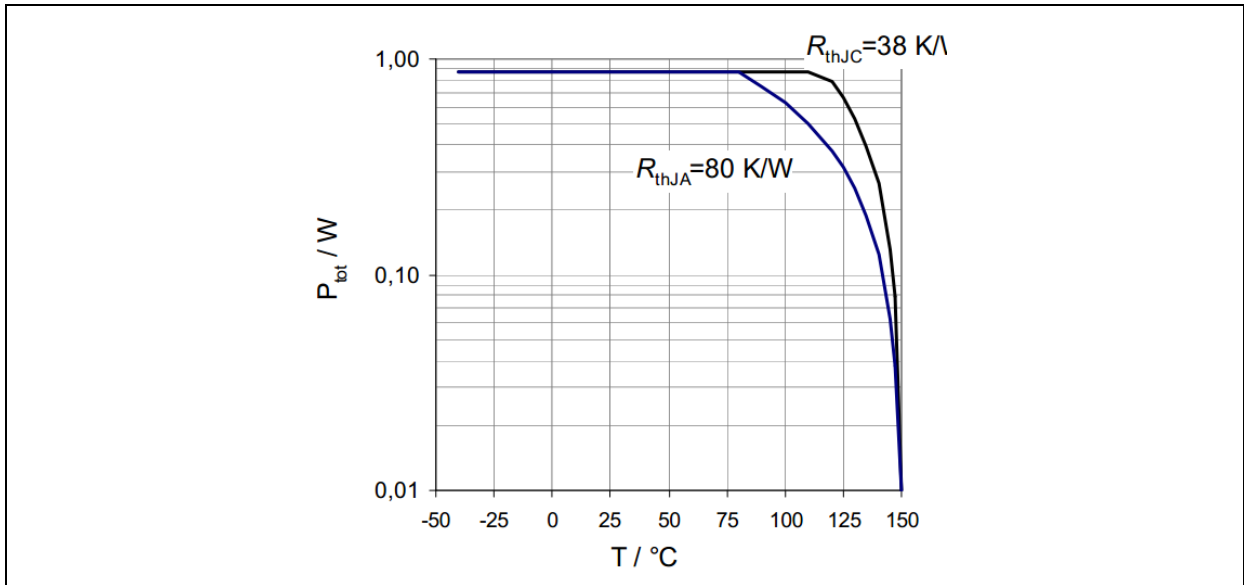
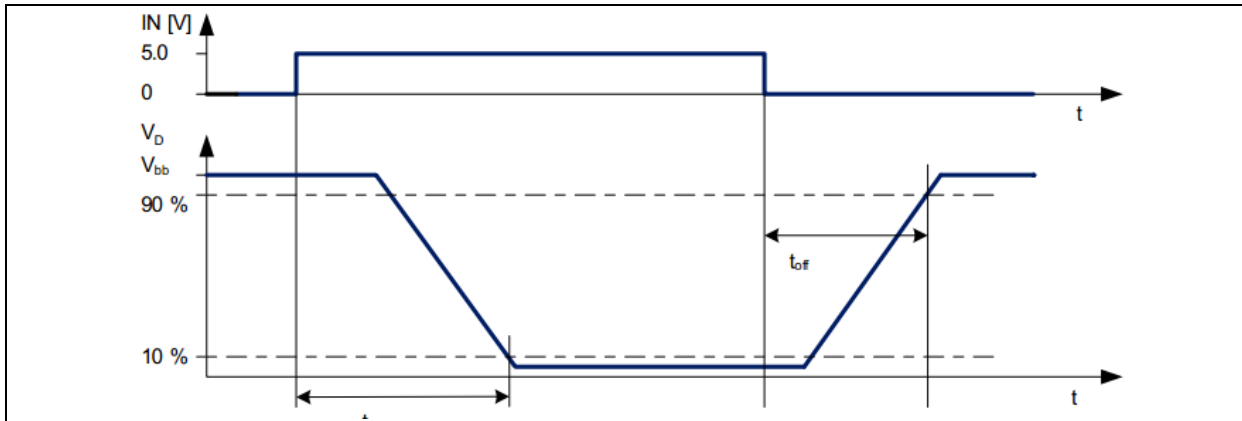


Figure 6-4 Maximal Allowable Power Dissipation

6.6 Output Timing

A voltage signal at the input pin above the threshold voltage causes the power MOSFET to switch on with a dedicated slope which is optimized for low EMC emission. Figure 6-5 shows the timing definition.


Figure 6-5 Definition of Power Output Timing for Resistive Load

6.7 Characteristics

Note: Characteristics show the deviation of parameter at given input voltage and junction temperature.

Typical values show the typical parameters expected from manufacturing.

All voltages with respect to Source Pin unless otherwise stated.

Table 6.1 Electrical Characteristics: Input and Power Stage

T_j = -40 °C to +150 °C , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified).

Pos.	Parameter	Symbol	Limit value			Unit	Test Conditions
			Min.	Type.	Max.		
INput							
6.7.1	Nominal Input current	IINnom	-	40	55	uA	V _D =0V; V _{IN} =5V
6.7.2	Input current protection mode	IINlim	-	100	150	uA	V _{IN} =5V; T _J =150°C
6.7.3	Input threshold voltage	VINTH	1.3	1.7	2.2	V	V _D =V _{IN} ; I _D =50uA; T _J =25°C
6.7.4			0.8	-	-	V	V _D =V _{IN} ; I _D =50uA; T _J =150°C
Power Stage							
6.7.5	On-State Resistance	RDS(on)	-	0.7	-	Ω	T _J =25°C ; V _{IN} =5V; I _D =200mA
6.7.6			-	1.9	2.4	Ω	T _J =150°C ; V _{IN} =5V; I _D =200mA
6.7.7	Nominal load current for both channels ON	IDnom	350	400		mA	T _J <150°C T _A =105°C ²⁾ V _{IN} =5V

6.7.8	Zero input voltage drain current	IDSS	-	-	5	uA	VDS=13.5V; VIN =0V; TJ=150°C
			-	2.5	6	uA	VDS=32V; VIN=0V; TJ=-40~85°C
			-	4	7	uA	VDS=32V; VIN =0V; TJ=150°C

Switching: Vbb=12V, RL=82Ω

6.7.9	Turn-on time	t _{on}	-	16	38	us	V _{IN} =5Vto90%I _D
6.7.10	Turn-off time	t _{off}	-	15	45	us	V _{IN} = 0Vto10%I _D
6.7.11	Slew rate on	dVds/dton	-	2.5	9.3	V/us	50%-30%Vbb; RL=82Ω VIN=0V到5V; Vbb=12V
6.7.12	Slew rate off	dVds/dtoff	-	6.0	18.2	V/us	30%-50%Vbb; RL=82Ω VIN=5V到0V; Vbb=12V

Inverse Diode

6.7.13	Inverse Diode forward voltage	V _D	-	-1.0	-1.5	V	ID = -1A; VIN = 0V
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- 1) Not subject to production test, calculated by RthJA and RDS(on).
- 2) Device mounted on PCB according EIA/JEDEC standard JESD51-7 (4-layer FR4, 76.2 mm × 114.3 mm with buried planes). PCB is mounted vertical without blown air.

7. Protection Functions

The device provides embedded protection functions. Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as “outside” normal operation.

7.1 Thermal Protection

The device is protected against over temperature due to overload and / or bad cooling conditions. To ensure this a temperature sensor located in the Power MOSFET is used.

The SL3405 has a thermal auto-restart function. After the device has cooled down it will switch on again see Figure 7-1 ;

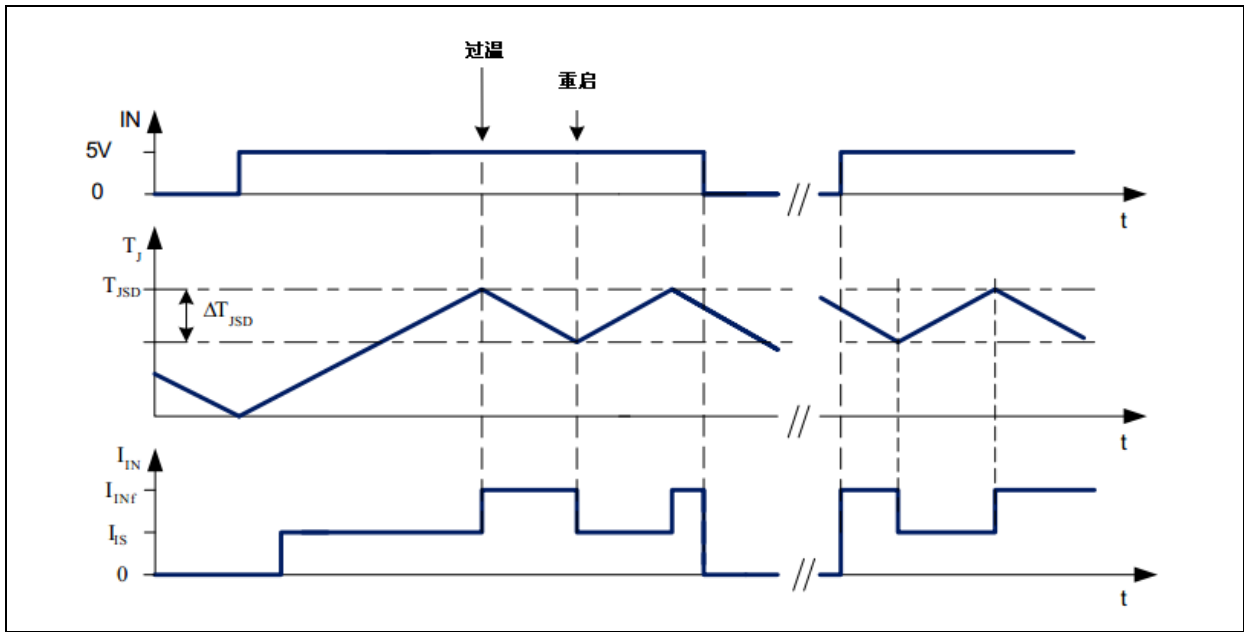


Figure 7-1 Error Signal via Input Current at Thermal Shutdown

7.2 Overvoltage Protection

When switching off inductive loads with low-side switches, the Drain-Source voltage V_D rises above battery potential, because the inductance intends to continue driving the current.

7.3 Short Circuit Protection

The condition short circuit is an overload condition of the device. If the current reaches the value of I_{lim} the device starts to limit the current. In the condition of current limitation the device heats up. If the thermal shutdown temperature is reached the device turns off. Figure 7-2 shows this behavior. During the current limitation the input current is above I_{INnom} . During the time period t_{dim} , the current can be above I_{lim} .

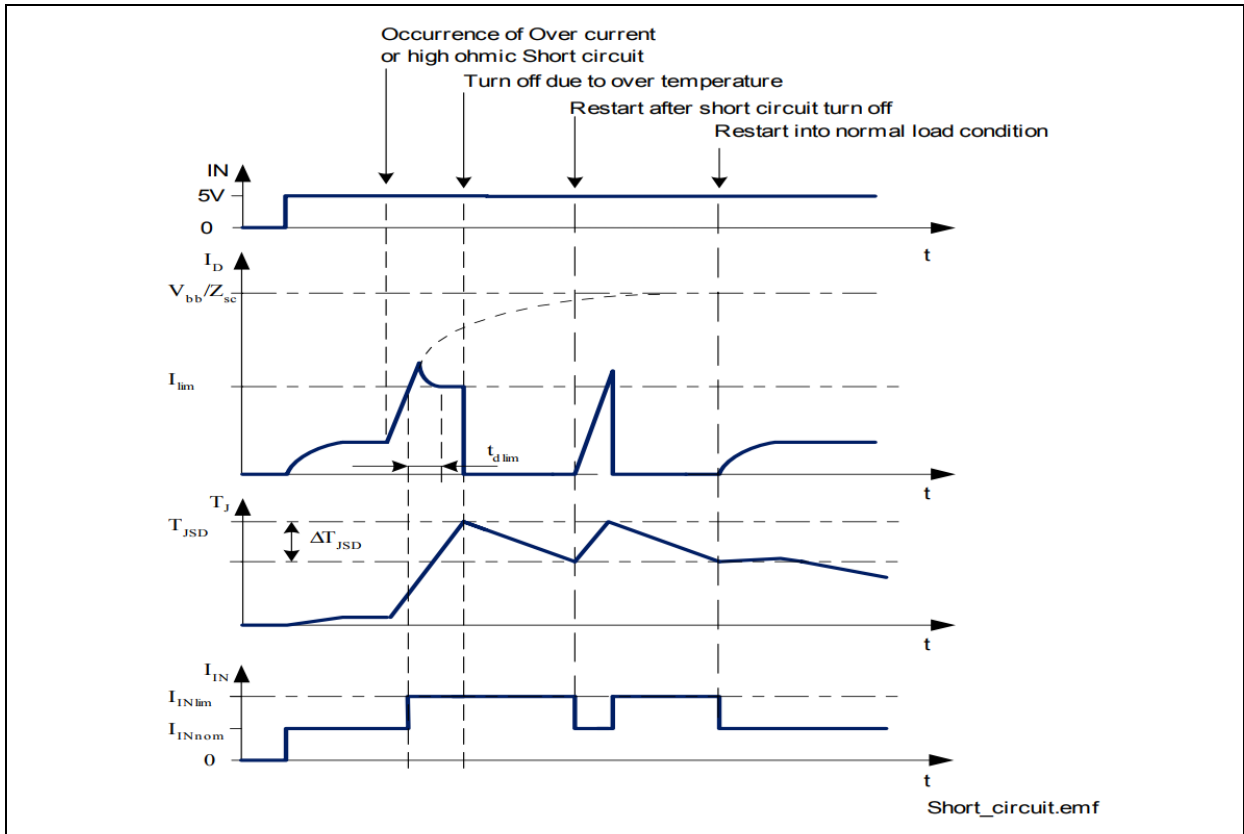


Figure 7-2 Short Circuit Behavior of SL3405

As the device is a low side switch it can be assumed that the Source to Ground path has a neglectable low impedance and resistance.

7.4 Characteristics

Note: Characteristics show the deviation of parameter at given input voltage and junction temperature.
 Typical values show the typical parameters expected from manufacturing.

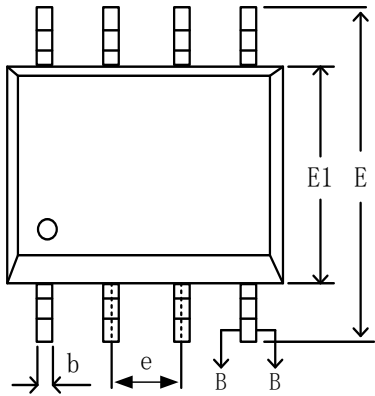
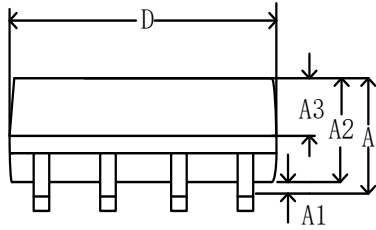
Table 7.1 Electrical Characteristics: Protection Functions

Pos.	Parameter	Symbol	Limit value			Unit	Test Conditions
			Min.	Type	Max.		
Thermal Protection							
7.4.1	Thermal shut down junction temperature	T_{JSD}	150	165 ¹⁾	-	°C	-
7.4.2	Thermal hysteresis	ΔT_{JSD}	-	10	-	K	1)
Overvoltage Protection							
7.4.3	Drain clamp voltage	V_{Clamp}	39	-	42	V	$V_{IN} = 0V$ $I_D = 10mA$
Current Limitation and Short Circuit Protection							
7.4.4	Current limitation	I_{lim}	0.6	0.9	1.2	A	$V_{IN} = 0V$ $V_{DS} = 12V$; $t_{measure} =$ $4 \cdot t_{dlim}$ $T_J = 25^\circ C$ 1)
			0.3	-	-		$T_J = 150^\circ C$
			-	-	1.4		$T_J = -40^\circ C$ 1)
7.4.5	Current limitation delay time	t_{dlim}	-	-	50	us	1)

1) Not subject to production test, specified by design.

8. Package Outlines SL3405S

8.1 Package Outlines SOP8



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.10	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.48
b1	0.38	0.41	0.43
c	0.21	—	0.26
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27 BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05 BSC		
\ominus	0	—	8
L/F载体尺寸 (mil)	80*80	90*90	95*130

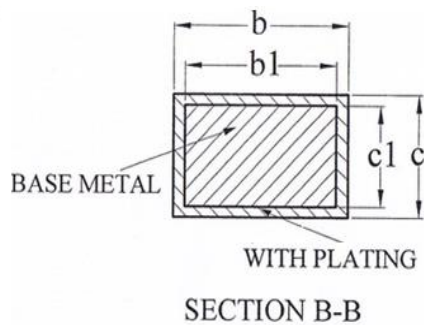
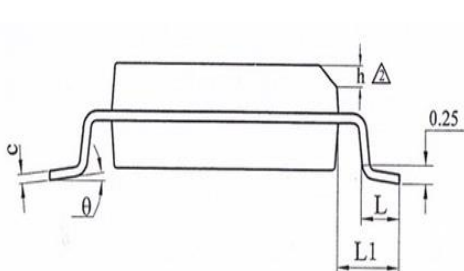
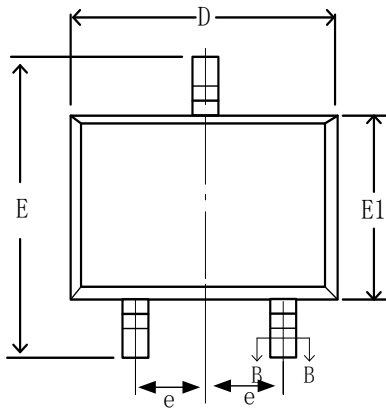
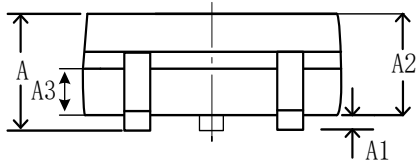
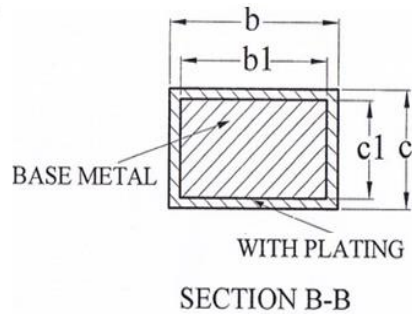
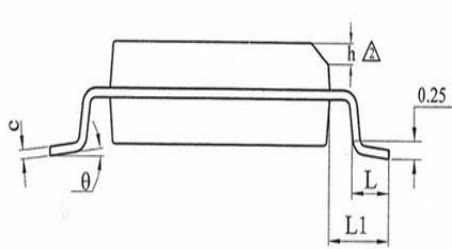


Figure 8-1 SL3405S Package Outlines SOP8

8.2 Package Outline SOT23-3L


SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.35
A1	0.04	0.07	0.15
A2	1.00	1.10	1.20
A3	0.55	0.65	0.75
b	0.38	—	0.48
b1	0.37	0.40	0.43
c	0.11	—	0.21
c1	0.10	0.13	0.16
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95 BSC		
L	0.30	—	0.60
⌀	0	—	8


Figure 8-2 SL3405W Package Outline SOT23-3L