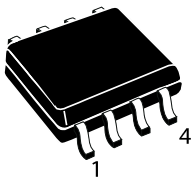
L6375S

0.5 A high-side driver intelligent power switch

Datasheet - production data



SO - 8

Features

- 0.5 A output current
- 8 to 35 V supply voltage range
- Internal current limit
- Non-dissipative short-circuit protection
- Thermal shutdown
- Undervoltage lockout with hysteresis
- Internal negative voltage clamping for fast demagnetization
- Differential inputs with large common mode range and threshold hysteresis
- Open load detection
- Two diagnostic outputs
- Open ground protection
- Output status LED driver
- Immunity against burst transient (IEC 61000-4-4)
- ESD protection (human body model ±2 kV)

Description

The L6375S is a monolithic intelligent power switch in multipower BCD technology to drive inductive, capacitive or resistive loads with controlled output voltage slew rate and short-circuit protection. An internal clamping diode enables the fast demagnetization of inductive loads. Diagnostic for CPU feedback and extensive use of electrical protections make this device robust and suitable for industrial automation applications.

Table 1: Device summary

Order code	Temperature range	Package	Packing
L6375S	-25 to +125 °C	SO-8	Tube
L6375STR			Tape and reel

This is information on a product in full production.

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1 Pin connections

Figure 1: Pin connections (top view)

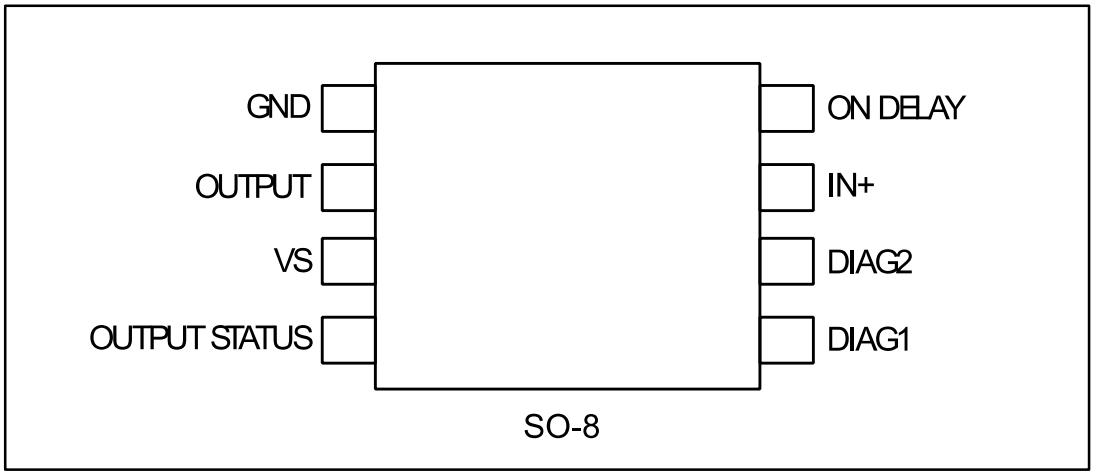

Table 2: Pin description

Pin	Pin name	Function
1	GND	Ground
2	OUTPUT	High-side output with built-in current limitation
3	VS	Supply voltage range with undervoltage monitoring
4	Output status	This current source output can drive a LED to signal the status of the output pin. The pin is active (source current) when the output pin is high
5	DIAG1	Diagnostic1 output. This open drain reports the IC working conditions
6	DIAG2	Diagnostic2 output. This open drain reports the IC working conditions
7	IN+	Comparator inverting input
8	ON DELAY	Programmable ON time interval duration during short-circuit operation

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2 Maximum ratings

Table 3: Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_s	Supply voltage (tw ≤ 10 ms)	50	V
	Supply voltage (DC)	40	V
V_S- V_{OUT}	Supply to output differential voltage	Internally limited	V
V_{od}	ON DELAY pin voltage	-0.3 to 7	V
I_{od}	ON DELAY pin current	± 1	mA
I_{out}	Output current	Internally limited	A
V_{out}	Output voltage	Internally limited	V
E_I	Energy inductive load: T_J = 85 °C	200	mJ
P_{tot}	Power dissipation	Internally limited	W
V_{diag}	DIAGx pin voltage	-0.3 to 40	V
I_{diag}	DIAGx pin current	-10 to 10	mA
I_i	IN+ pin current	20	mA
V_i	IN+ pin voltage	-10 to V_s+0.3	V
T_{op}	Ambient temperature, operating range	-25 to 85	°C
T_J	Junction tmperature, operating range	-25 to 125	°C
T_{stg}	Storage temperature	-55 to 150	°C

Table 4: Thermal data

Symbol	Parameter	Value	Unit
$R_{th(JA)}$	Thermal resistance junction-ambient	100 max.(1)	°C/W
$R_{th(JP)}$	Thermal resistance junction-pins	15 max.	

Notes:

(1)When mounted on a standard single-sided FR-4 board with 0.5 cm^2 of Cu (at least 35 µm thick) connected to all VCC pins. Horizontal mounting and no artificial air flow.

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3 Electrical characteristics

V_S = 24 V; T_J = -25 to 125 °C, unless otherwise specified.

Table 5: Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{smin}	Supply voltage for valid diagnostic	I_{diag} ≥ 0.5 mA; V_{diag} = 1.5 V	4		35	V
V_S	Operative supply voltage		8	24	35	V
V_{sth1}	Undervoltage threshold 1		7	7.5	8	V
V_{sth2}	Undervoltage threshold 2		6.5	7	7.5	V
V_{shys}	Undervoltage hysteresis		300	500	700	mV
I_q	Quiescent current	Output open		800		µA
I_{qo}		Output on		1.6		mA
V_{ith}	IN+ pin threshold voltage		0.8	1.3	2	V
V_{iths}	IN+ pin threshold hysteresis		50		400	mV
V_{il}	IN+ pin low level voltage		-7		0.8	V
V_{ih}	IN+ pin high level voltage	V_S < 18 V	2		V_S-3	V
		V_S >18 V	2		15	
I_{ib}	IN+ pin bias current	V_i = -7 to 15 V	-250		250	µA
I_{dch}	Delay capacitor charging current	ON DELAY pin shorted-to-ground		2.5		µA
V_{don}	Output voltage drop	I_{out} = 500 mA; T_J = 25 °C		200	280	mV
		T_J = 125 °C		320	440	
		I_{out} = 625 mA; T_J = 25 °C		250	350	
		T_J = 125 °C		400	550	
I_{olk}	Output leakage current	V_i = low; V_{out} = 0			100	µA
V_{ol}	Output low-state voltage	V_i= high; pin floating		0.8	1.5	V
V_{cl}	Internal voltage clamp (V_s- V_{out})	I_o = 200 mA single Pulsed = 300 ms	48	53	58	V
I_{SC}	Short-circuit output current	V_S = 8 to 35 V; R_l = 2 Ω	0.75	1.1	1.5	A
I_{old}	Open load detection current	V_i = V_{ih}; T_A = 0 to +85 °C	1	3	6	mA
V_{oth1}	Output status threshold 1 voltage		4.5	5	5.5	V

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Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{oth2}	Output status threshold 2 voltage		4	4.5	5	V
V_{ohys}	Output status threshold hysteresis		300	500	700	mV
I_{osd}	Output status source current	$V_{out} > V_{oth1}$; V_{OS} = 2.5 V	2		4	mA
V_{osd}	Active output status driver drop voltage	$V_S - V_{OS}$; I_{OS} = 2 mA; T_A = 0 to +85 °C		1.5	3	V
I_{oslk}	Output status driver leakage current	$V_{out} < V_{oth2}$; V_{OS} = 0 V; V_S = 18 to 35 V			25	µA
V_{dgl}	Diagnostic drop voltage	D1 / D2 = L; I_{diag} = 0.5 mA		40		mV
		D1 / D2 = L; I_{diag} = 3 mA		250		
I_{dglk}	Diagnostic leakage current	D1 / D2 = H; 0 < V_{dg} < V_S V_S = 15.6 to 35 V			5	µA
$T_{max.}$	Overtemperature upper threshold			150		°C
T_{hys}	Overtemperature hysteresis			20		°C
AC operation						
t_r- t_f	Rise or fall time	V_s = 24 V; R_l = 70 Ω; R_l to ground		20		µs
t_d	Delay time			5		
dV/dt	Slew rate (rising and falling edge)		0.7	1	1.5	V/µs
t_{ON}	On-time during short-circuit condition	50 pF < C_{DON} < 2 nF		1.28		µs/pF
t_{OFF}	Off-time during short-circuit condition			64		t_{ON}
$f_{max.}$	Maximum operating frequency			25		kHz
Source drain NDMOS diode						
V_{fsd}	Forward on voltage	I_{fsd} = 625 mA		1	1.5	V
I_{fp}	Forward peak current	t_p = 10 ms; duty cycle = 20%			2	A
t_{rr}	Reverse recovery time	I_{fsd} = 625 mA; dI_{fsd}/dt = 25 A/µs		200		ns
t_{fr}	Forward recovery time			50		ns

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3.1 Schematic diagram

Figure 2: Block diagram

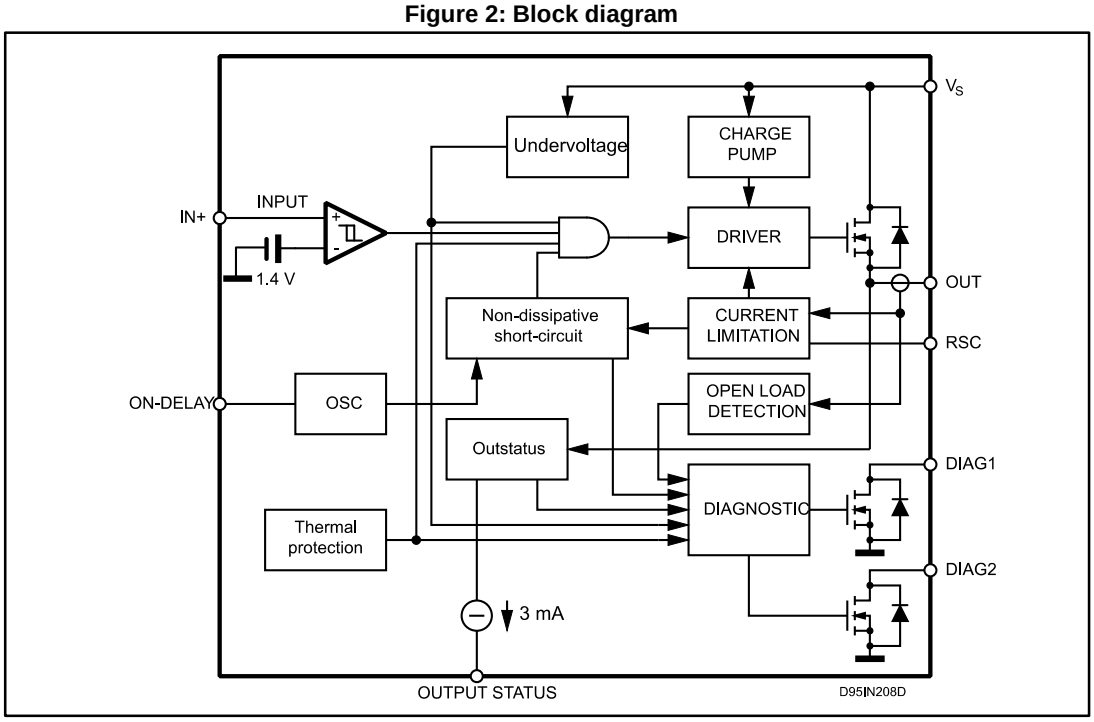
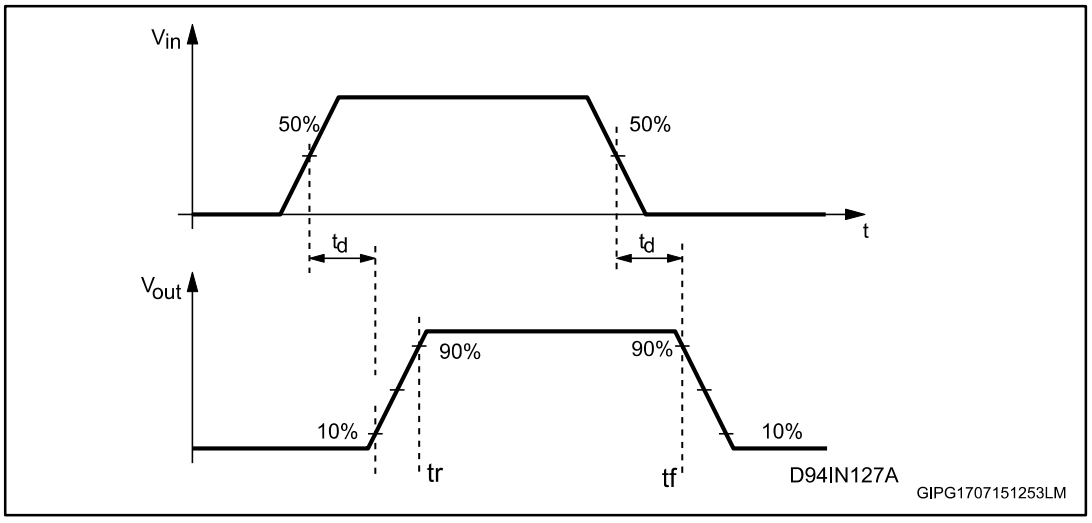


Figure 3: Switching waveforms



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3.2 Input section

A single ended input TTL/CMOS compatible with a wide voltage range and high noise immunity (thanks to a built-in hysteresis) is available.

3.3 Overtemperature protection

On-chip overtemperature protection provides an excellent protection of the device in extreme conditions. Whenever the temperature, measured on a central portion of the chip, exceeds $T_{max.}$ = 150 °C (typical value) the device shuts down, and the DIAG2 output goes low. Normal operation is resumed as the chip temperature (normally after few seconds) falls below $T_{max.}$-T_{hys} = 130 °C (typical value). The hysteresis avoids that an intermittent behavior occurs.

3.4 Undervoltage protection

The supply voltage operates correctly in a range from 8 to 35 V. Below 8 V the overall system has to be considered not reliable. To avoid any malfunctioning, the supply voltage is continuously monitored to provide an undervoltage protection. As V_s falls below V_{sth}-V_{shys} (typically 7.5 V) the output power MOSFET switches off and DIAG1 and DIAG2 output go low. Normal operation is resumed as soon as V_s exceeds V_{sth}. The hysteretic behavior prevents intermittent operation at low supply voltage.

3.5 Overcurrent operation

In order to implement a short-circuit protection, the output power MOSFET is driven to linear mode to limit the output current to the I_{SC} value (1.1 A typical value).

This condition (current limited to the I_{SC} value) lasts for a T_{ON} time interval that can be set by a capacitor (C_{DON}) connected to the ON DELAY pin according to the following formula:

Equation 1:

t_{ON} = 1.28 µs/pF for 50 pF < C_{DON} < 2 nF

After the t_{ON} interval has expired the output power MOSFET switches off for the t_{OFF} time interval:

Equation 2:

$t_{OFF} = 64 \cdot t_{ON}$

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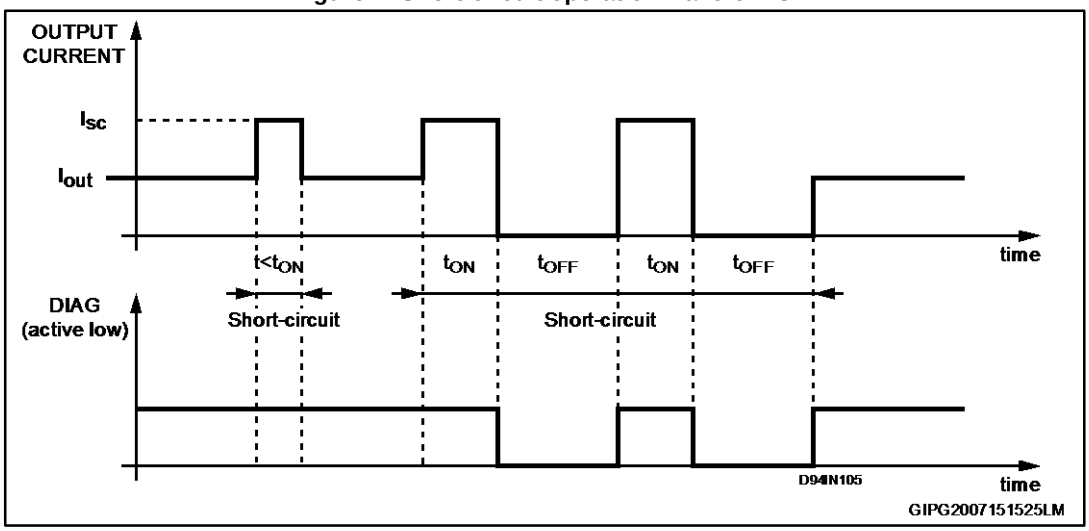
Figure 4: Short-circuit operation waveforms



When the t_{OFF} interval has expired, the output power MOSFET switches on. In this manner two conditions may occur:

- the overload is still present. In this case, the output power MOSFET is again driven to linear mode (limiting the output current to I_{SC}) for another t_{ON}, starting a new cycle
- the overload condition is removed, and the output power MOSFET is no longer driven to linear mode

Please, see the DIAG pin (see *Figure 4: "Short-circuit operation waveforms"*). This unique feature is called no-dissipative short-circuit protection and it ensures a very safe operation even in permanent overload conditions. The choice of the most appropriate value for the t_{ON} interval (the value of the C_{DON} capacitor) is very important, a delay (the t_{ON} itself) prevents the misleading short-circuit information is presented on the DIAG output, when capacitive loads are driven or incandescent lamp, a cold filament, has a very low resistive value. The non-dissipative short-circuit protection can be disabled (keeping t_{ON} = 0 but with the output current still limited to I_{SC}, and diagnostic disabled) by shorting to ground the ON DELAY pin.

3.6 Diagnostic logic

The operating conditions of the device are permanently monitored and the following occurrences are indicated by DIAG1/DIAG2 open drain output pins.

- Short-circuit vs. ground
- Short-circuit vs. VS
- Undervoltage (UV)
- Overtemperature (OVT)
- Open load, if the output current is less than 3 mA (typical value)

3.7 Demagnetization of inductive loads

An internal Zener diode, limiting the voltage across the power MOSFET between 50 and 60 V (V_{cl}), provides safe and fast demagnetization of inductive loads without the external clamping devices. The maximum energy absorbed by an inductive load is specified as 200 mJ (at T_J = 85 °C).

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3.8 Diagnostic truth table

Table 6: Diagnostic truth table

Diagnostic conditions	Input	Output	DIAG1	DIAG2
Normal operation	L	L	H	H
	H	H	H	H
Open load condition (I_o< I_{old})	L	L	H	H
	H	H	L	H
Short to V_S	L	H	L	H
	H	H	L	H
Short-circuit to ground (I_O = I_{sc})[a] (ON DELAY pin grounded)	H	X	H	H
	L	L	H	H
Output DMOS open	L	L	H	H
	H	L	L	H
Overtemperature	L	L	H	L
	H	L	H	L
Supply undervoltage (V_S< V_{sth2})	L	L	L	L
	H	L	L	L

[a] A cold lamp filament or a capacitive load activates the current limiting circuit of the IPS, when the IPS is initially turned on.

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4 Application circuits

Figure 5: Input comparator hysteresis

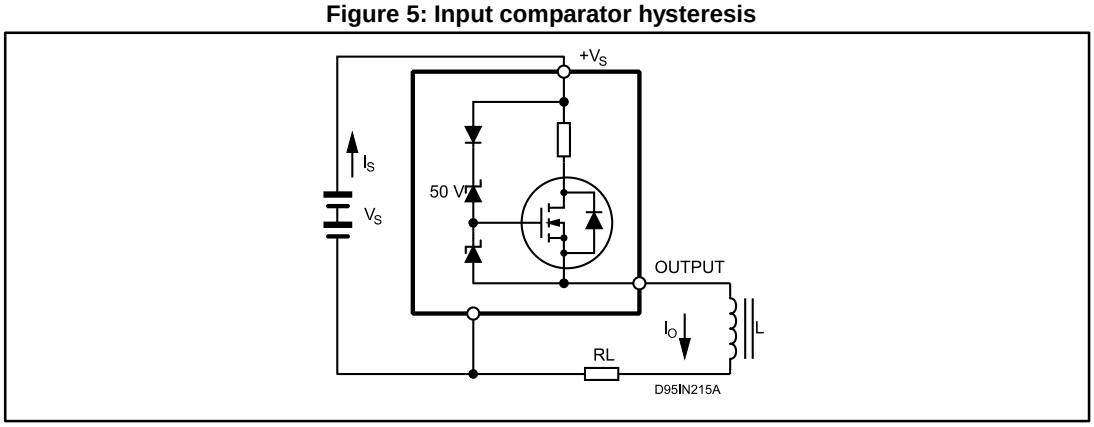

Figure 6: External demagnetization circuit (versus ground)

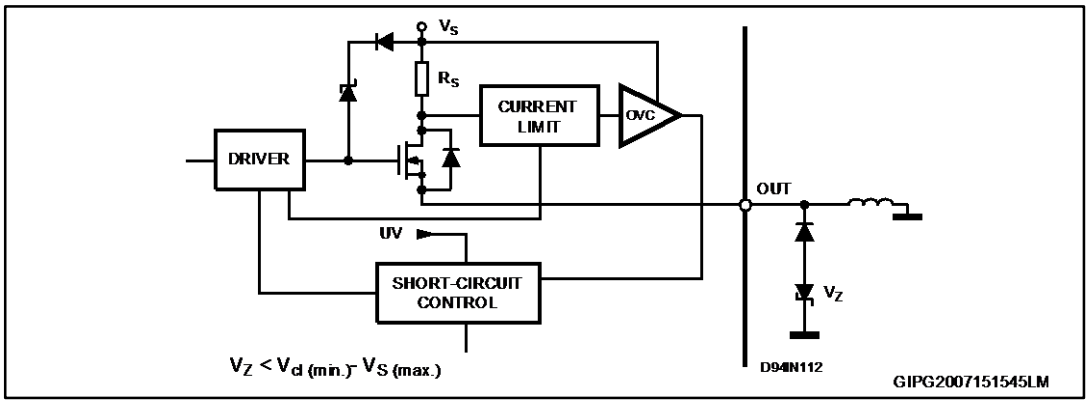

Figure 7: External demagnetization circuit (versus VS)

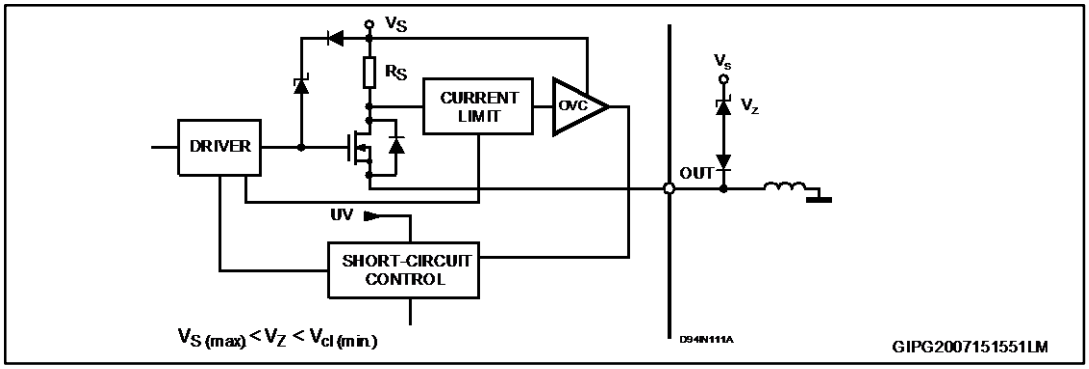

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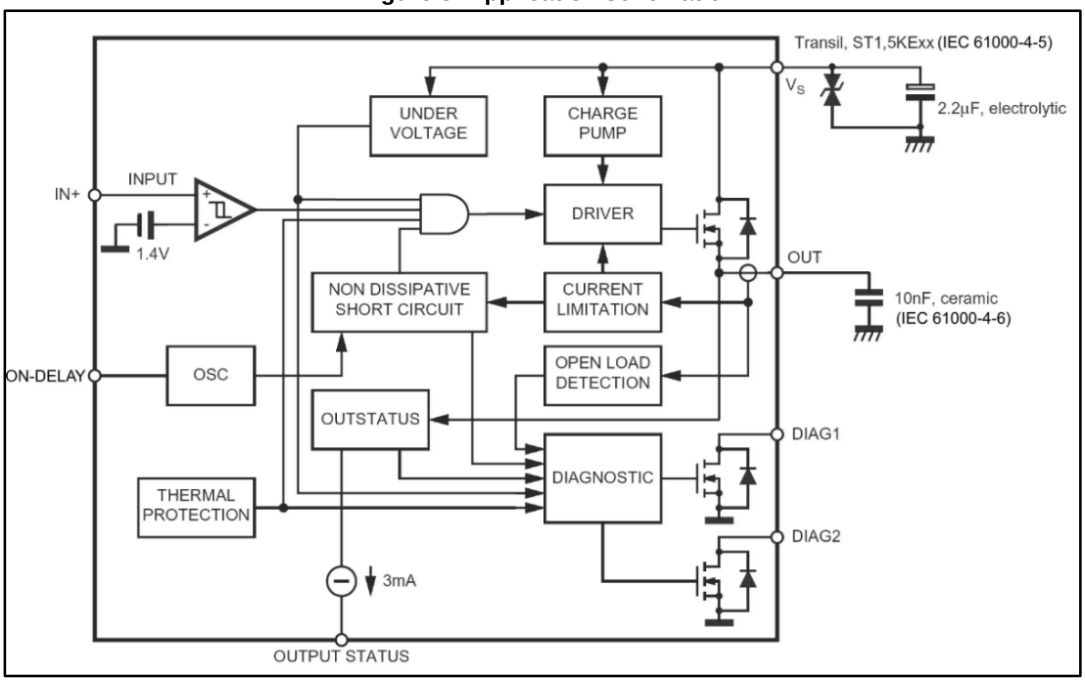
Figure 8: Application schematic



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5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: ***www.st.com***. ECOPACK® is an ST trademark.

5.1 SO-8 package information

Figure 9: SO-8 package outline

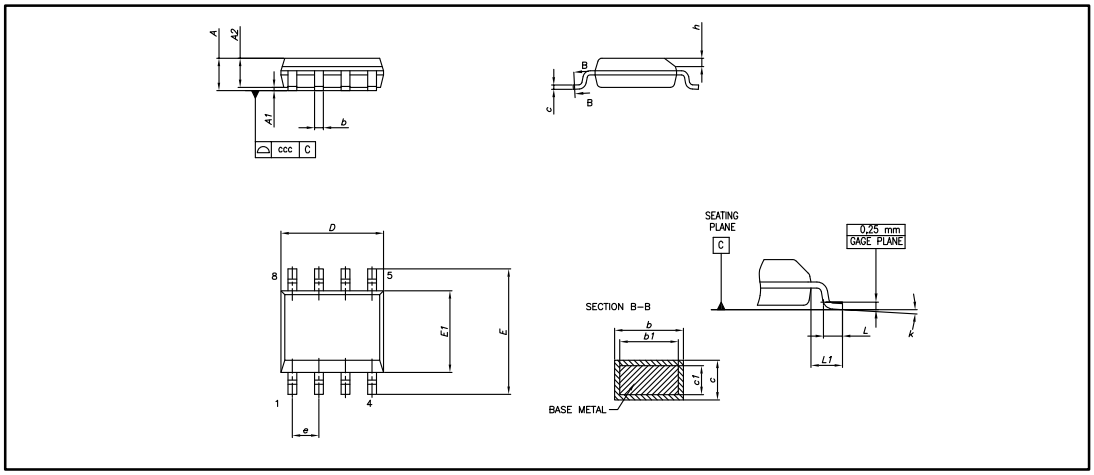

Table 7: SO-8 package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0°		8°
ccc			0.10

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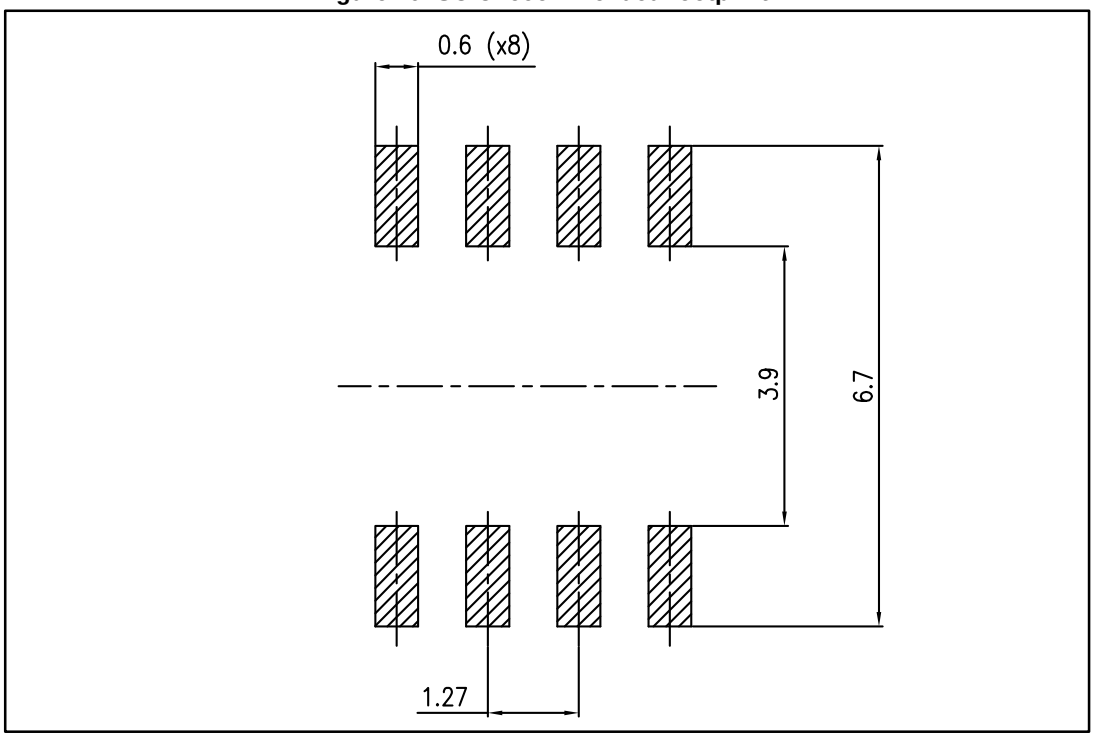
Figure 10: SO-8 recommended footprint



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5.2 SO-8 packing information

Figure 11: SO-8 tape and reel outline

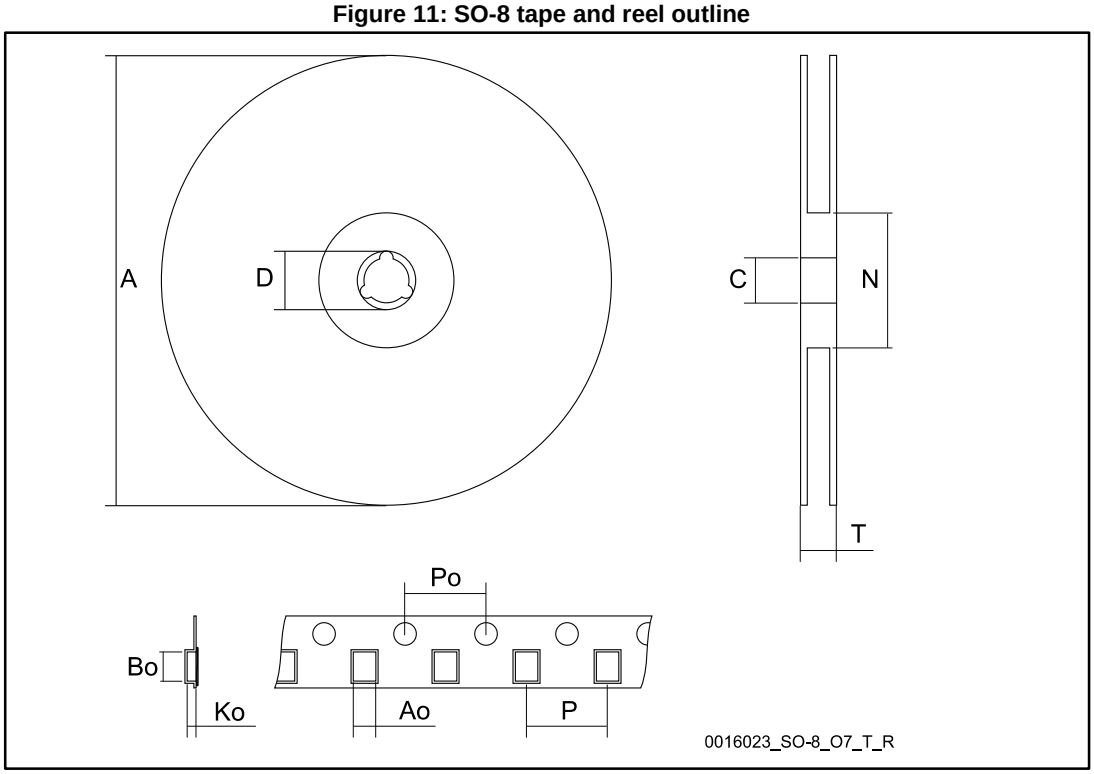

Table 8: SO-8 tape and reel mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			330
C	12.8		13.2
D	20.2		
N	60		
T			22.4
Ao	8.1		8.5
Bo	5.5		5.9
Ko	2.1		2.3
Po	3.9		4.1
P	7.9		8.1

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Figure 12: SO-8 tube outline

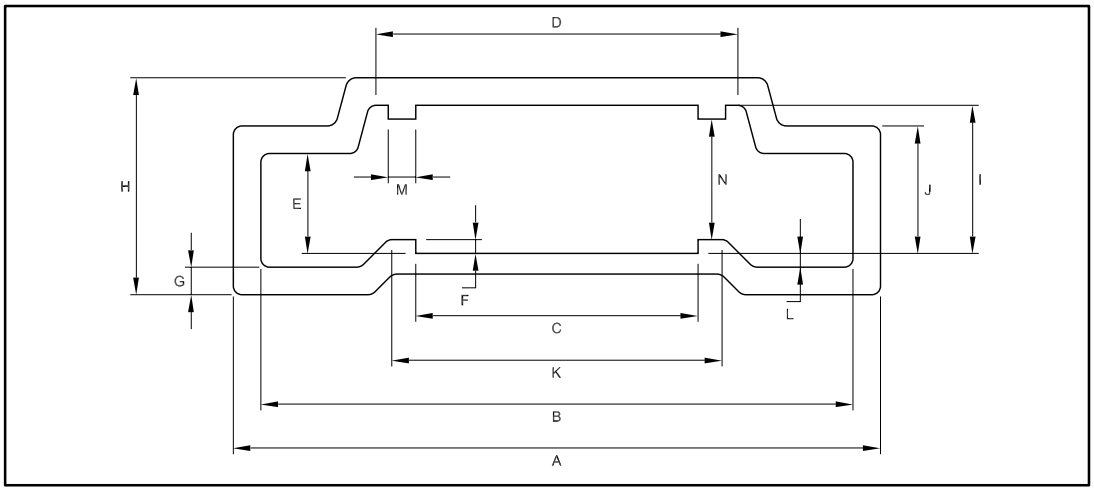

Table 9: SO-8 tube mechanical data

Dim.	mm
A	18.80
B	17.2 ± 0.2
C	8.20 ± 0.2
D	10.90 ± 0.2
E	2.90 ± 0.2
F	0.40
G	0.80
H	6.30
I	4.30 ± 0.2
J	3.7 ± 0.2
K	9.4
L	0.40
M	0.80
N	3.50 ± 0.2

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6 Revision history

Table 10: Document revision history

Date	Revision	Changes
18-Sep-2006	1	Initial release.
19-Jun-2007	2	Truth table updated
05-Jul-2007	3	Typo in Table 5
16-Jul-2007	4	Updated pinout
15-Oct-2007	5	Updated table 4
29-Jun-2009	6	Updated table 5
12-Mar-2010	7	Updated table 5
20-Dec-2011	8	Updated table 5
23-Feb-2016	9	Changed *Figure 1: "Pin connections (top view)"*. Updated *Table 3: "Absolute maximum ratings"* and *Table 5: "Electrical characteristics "*.

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