

## Smart Low-Side Switch

### Features

- Power limitation
- Thermal shutdown
- Overload protection
- Short circuit protection
- Diagnostic feedback
- Overvoltage protection
- Reverse polarity protection
- $\mu\text{C}$  compatible input
- Electrostatic discharge (ESD) protection

### Application

- All kinds of resistive and inductive loads (relays, electromagnetic valves)
- $\mu\text{C}$  compatible power switch for 12 and 24 V applications
- Solenoid control switch in automotive and industrial control systems

### General description

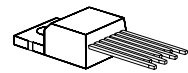
Single channel Low-Side Switch in Smart Power Technology (SPT) with  $\mu\text{C}$  compatible input and an open drain DMOS output stage. The TLE 4224-2 is fully protected by embedded protection functions and designed for automotive and industrial applications.

### Product Summary

Supply voltage	$V_S$	6.5 - 45	V
Drain source voltage	$V_{DS(AZ)max}$	65	V
On resistance	$R_{ON(typ)}$	0.25	$\Omega$
Output current	$I_D$	4	A

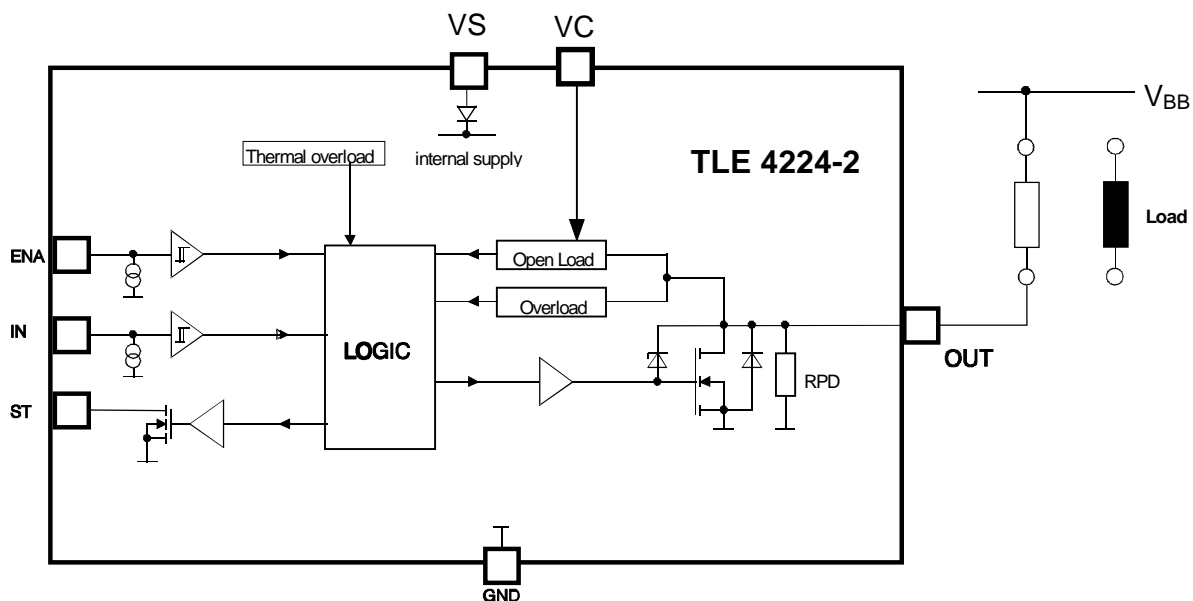


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### Block Diagram

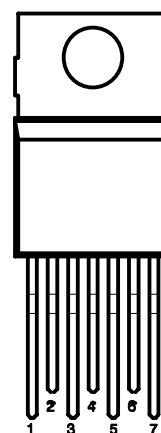


**Maximum Ratings for  $T_j = -40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$** 

Parameter	Symbol	Values	Unit	
Supply voltage	$V_S$	- 15 ... + 60	V	
Supply voltage operational range	$V_S$	+ 5.5 ... + 45	V	
Compare voltage	$V_C$	- 0.3 ... 65	V	
Continuous drain source voltage (OUT)	$V_{DS}$	45	V	
Input voltage (IN)	$V_{IN}$	- 0.3 ... + 6	V	
Status output voltage (ST)	$V_{ST}$	- 0.3 ... + 32	V	
Operating temperature range	$T_j$	- 40 ... + 150	$^{\circ}\text{C}$	
Storage temperature range	$T_{stg}$	- 55 ... + 150		
Output current	$I_{D(lim)}$	self limited	A	
Status output current	$I_{ST}$	- 5 ... + 5	mA	
Inductive load switch off dissipation energy	$T_{case} = 125^{\circ}\text{C}$ $T_{case} = 75^{\circ}\text{C}$	$E_{AS}$	100	mJ
			200	
Thermal resistance	junction - case	$R_{thJC}$	3	K/W
	junction - ambient	$R_{thJA}$	65	

**Pin Definitions and Functions**

Pin	Symbol	Function
1	ST	Status Output (open drain) for error monitoring
2	IN	Control Input, active high
3	ENA	Enable Input, active high
4	GND	Ground, connected internally to cooling lug
5	VC	Compare voltage for open load detection
6	OUT	Power Output (open drain)
7	VS	Supply Voltage

**Pin Configuration**

## Electrical Characteristics

Parameter and Conditions $V_S = 6.5$ to $45$ V ; $T_j = -40$ °C to $+150$ °C (unless otherwise specified)	Symbol	Values			Unit
		min	typ	max	

### 1. Power Supply ( $V_S$ )

Supply current (Output ON)	$I_S$			5	mA
Supply current (Output OFF)	$I_S$	$V_S \leq 18$ V		1.5	mA
Operation voltage	$V_S$		5.5	45	V

### 2. Power Outputs

ON state resistance; $I_D = 4$ A	$R_{DS(ON)}$	$T_j = 25$ °C $T_j = 150$ °C		0.25 0.5	$\Omega$	
Z-Diode clamping voltage (OUT)	$V_{DS(AZ)}$		45	65	V	
Pull down resistor	$R_{PD}$	$T_j = 25$ °C	14	20	26	k $\Omega$
Output on delay time <sup>1</sup>	$t_{on}$	$I_D = 0.2$ A	10	25	40	$\mu$ s
Output off delay time <sup>1</sup>	$t_{off}$	$I_D = 2$ A		50		
Output on fall time <sup>1</sup>	$t_{fall}$	$I_D = 0.2$ A		20		
Output off rise time <sup>1</sup>	$t_{rise}$	$I_D = 2$ A		25		
Output off status delay time <sup>1</sup>	$t_4$	$I_D = 2$ A	20	40	60	
Output on status delay time <sup>1,2</sup>	$t_5$				50	
Overload switch-off delay time <sup>3</sup>	$t_{DSO}$		50		150	

### 3. Digital Inputs (IN, ENA)

Input low voltage	$V_{INL}$		- 0.3		1.0	V
Input high voltage	$V_{INH}$		2.0		6.0	V
Input voltage hysteresis	$V_{INHys}$		0.2		0.6	V
Input pull down current	$I_{IN}$	$V_S \geq 9$ V ; $V_{IN} = 5$ V	50	100	140	$\mu$ A
Enable pull down current	$I_{ENA}$	$V_S \geq 9$ V ; $V_{ENA} = 5$ V	5	15	22	$\mu$ A

### 4. Digital Status Outputs (ST) open Drain

Output voltage low	$V_{STL}$	$I_{ST} = 2$ mA			0.5	V
Leakage current high	$I_{STH}$				10	$\mu$ A

<sup>1</sup> See timing diagram, resistive load condition;  $V_S \geq 9$  V

<sup>2</sup> Time till status valid after switching on or error detection

<sup>3</sup> This parameter will not be tested but assured by design

## Electrical Characteristics

Parameter and Conditions $V_S = 6.5$ to $45$ V ; $T_j = -40$ °C to $+150$ °C (unless otherwise specified)	Symbol	Values			Unit
		min	typ	max	

### 5. Diagnostic Functions

Open load detection voltage (Output OFF)	$V_C = 0$ V ; $8 \leq V_S \leq 18$ V $6.5 \leq V_S \leq 45$ V	$V_{DS(OL)}$	$0.5 \cdot V_S$		$0.6 \cdot V_S$	V
			$0.45 \cdot V_S$		$0.65 \cdot V_S$	
Open load compare detection	$6.5 \leq V_C \leq 18$ V	$V_{DS(OL)C}$	$V_C - 1.6$		$V_C - 0.9$	V
Open load detection current (Output ON)		$I_{D(OL)}$	100		500	mA
Overload threshold current $V_S \geq 9.5$ V	$T_j = 25$ °C	$I_{D(lim)}$	5.25			A
	$T_j = 150$ °C		4			A
Overtemperature shutdown threshold <sup>4</sup>		$T_{th}$	155		185	°C
Hysteresis		$T_{hys}$		10		K
$V_C$ -Input current	$V_C \leq 18$ V	$I_{VC}$			0.25	mA

## Application Description

This IC is specially designed to drive inductive loads (relays, electromagnetic valves). An integrated clamp-diode limits the output voltage when inductive loads are discharged.

For the detection of errors there is a open-drain status output, which monitors the following errors by logic level:

- overloading of output (also shorted load to supply) in active mode
- open and shorted load to ground in active and inactive mode
- thermal overload.

## Circuit Description

### Input Circuits

The control and enable inputs, all active high, consist of schmitt triggers with hysteresis. All inputs are connected with pull-down current sources. Not connected inputs are interpreted as LOW.

### Switching Stages

The power output consists of a DMOS-power transistor with open drain. The output stage is shorted load protected throughout the operating range. The integrated clamp-diode limit voltage spikes produced when inductive loads are discharged.

<sup>4</sup> This parameter will not be tested but assured by design

**Protective Circuits**

An integrated diode protects the device against reverse polarity of the operating voltage. The load circuit withstands reverse poling within the limits of the maximum ratings (no shorted load permissible at the same time).

The outputs are protected against current overload and thermal overload.

**Error Detection**

The status output signals the switching state at normal operating conditions (LOW = off; HIGH = on) and in case of errors. The outputs are set according to the diagnostic table below.

If current overload occurs, the error condition is stored into an internal register and the output is shut-down. To reset the register, the control input of the corresponding channel has to be switched off and then on again.

Open load is detected in on- and off-modus: In on-modus the load current is monitored , in the off-modus the ouput voltage is monitored.

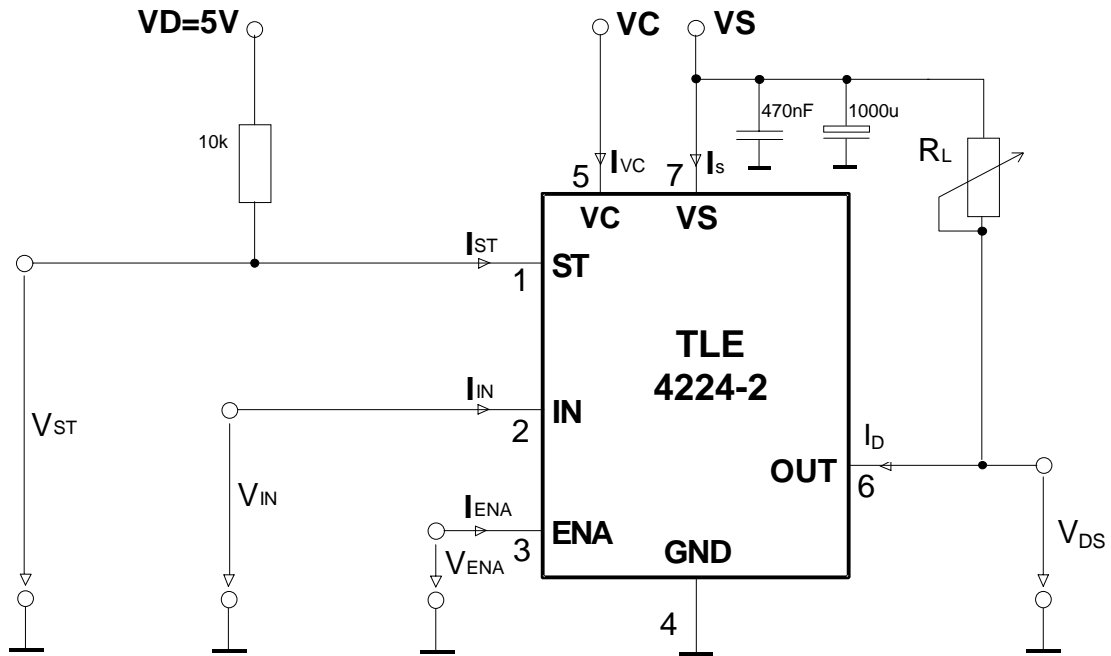
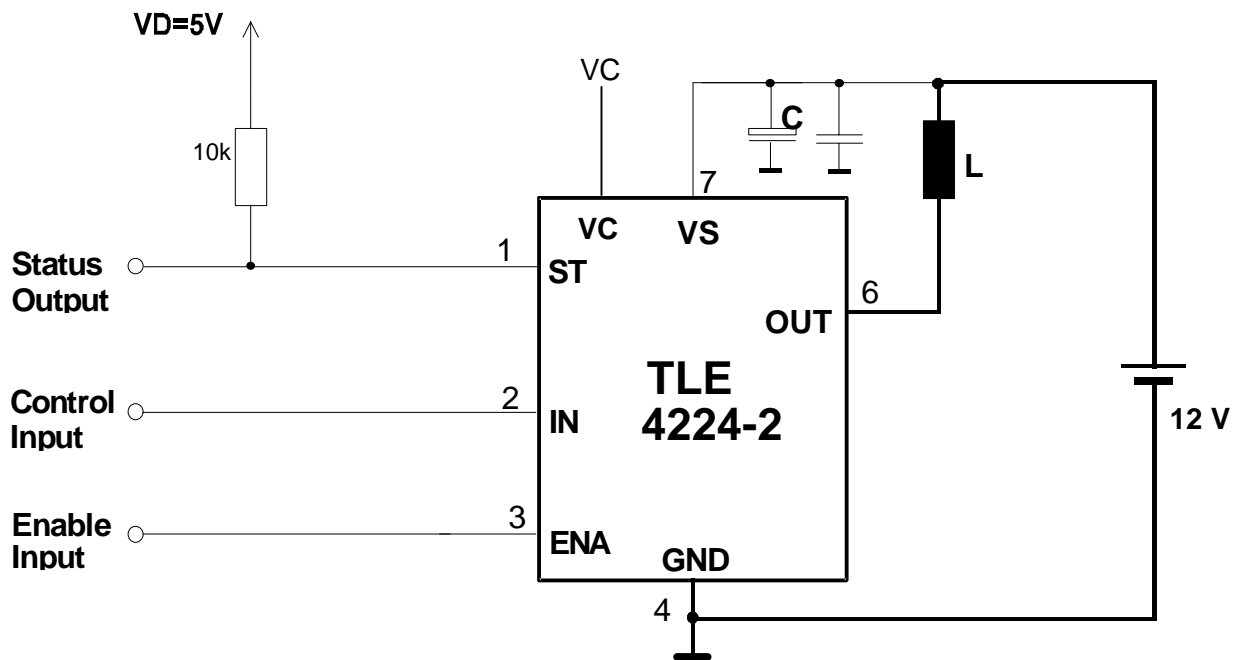
The open load voltage threshold is programmable via the voltage supplied to the VC.

The state of the error detection circuit is directly dependent on the input status.

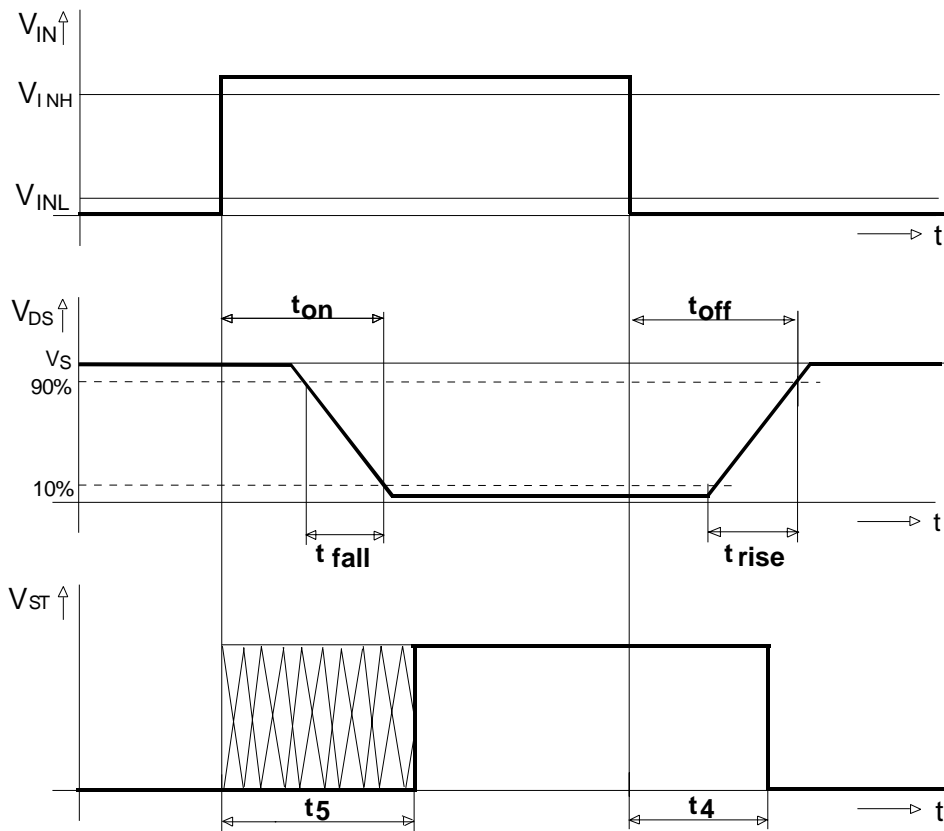
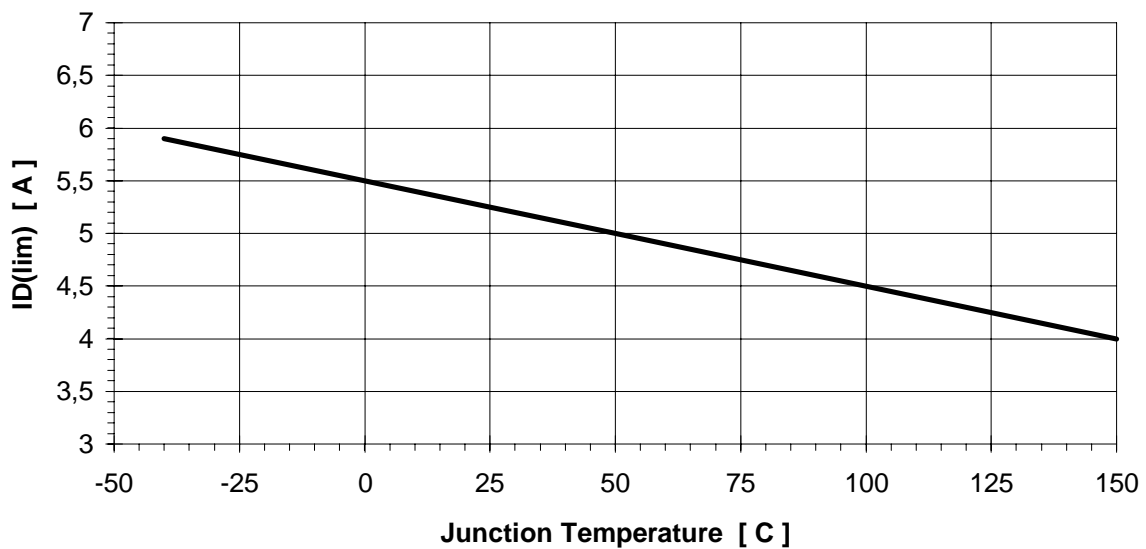
**Diagnostic Table**

Operating Condition	Enable Input	Control Input	Power Output	Status Output
	<b>ENA</b>	<b>IN</b>	<b>OUT</b>	<b>ST</b>
Normal Operation	L	L	OFF	L
	L	H	OFF	L
	H	L	OFF	L
	H	H	ON	H
Thermal Overload	X	L	OFF	H
	X	H	OFF	L
Open Load or shorted load to ground	L	L	OFF	H
	L	H	OFF	H
	H	L	OFF	H
	H	H	ON	L
Overload or shorted load to supply	L	L	OFF	L
	L	H	OFF	L
	H	L	OFF	L
	H	H	OFF	L

L = LOW      H = HIGH      X = RANDOM

Test CircuitApplication Circuit

The blocking capacitor C is recommended to avoid critical negative voltage spikes on Vs in case of battery interruption during OFF-commutating.

**Timing Diagram****Overload Current versus temperature**

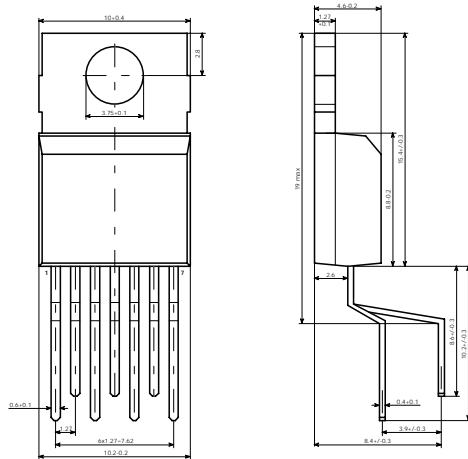
**Package and ordering code**

all dimensions in mm

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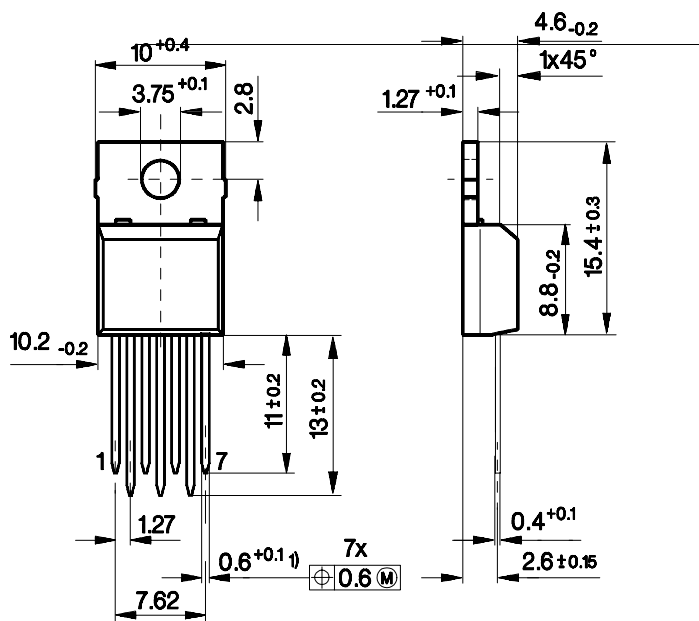
Ordering code

	Q67000-A9062
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Ordering code

	Q67000-A9279
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- 1)  $0.75_{-0.15}$  at dam bar (max. 1.8 from body)  
 1)  $0.75_{-0.15}$  im Dichtstegbereich (max. 1.8 vom Körper)