VN540SP-E

Single high-side smart power solid state relay

Datasheet - production data

PowerSO-10™

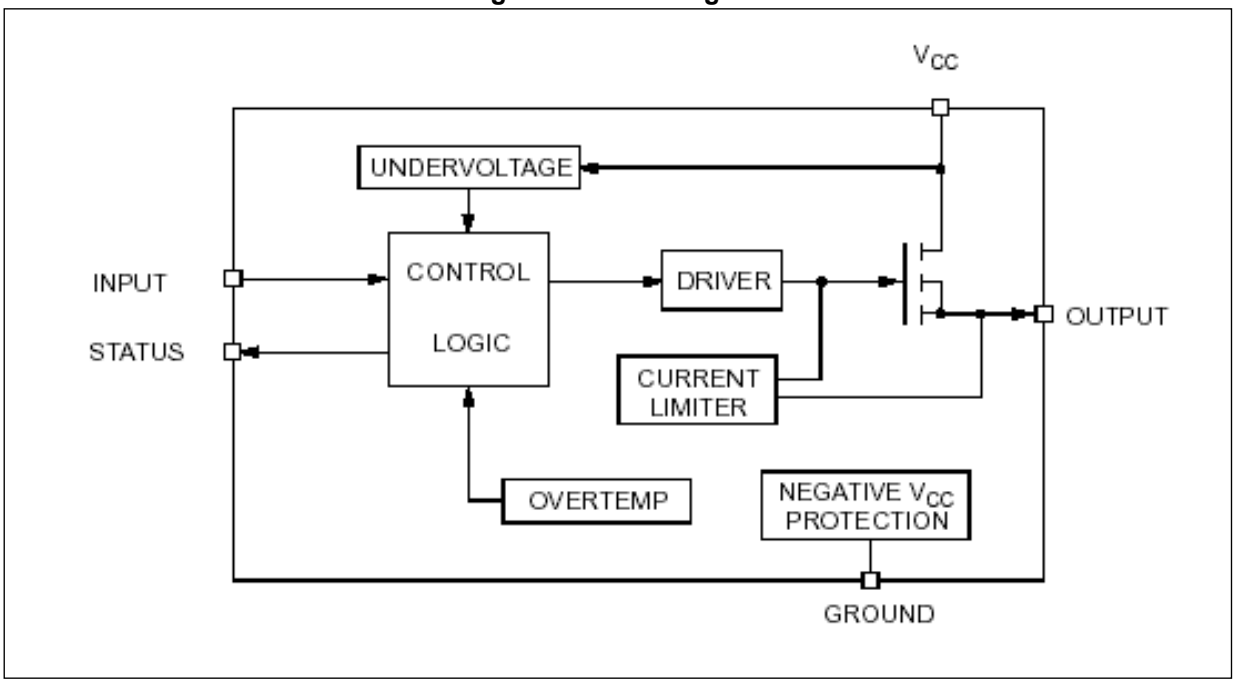
Features

- 10 V to 36 V supply voltage range
- Up to I_{OUT} = 2.8 A operating current
- $R_{DS(on)}$ = 50 mΩ
- V_{demag} = V_{CC} - 55 V
- Digital input clamped at 32 V
- Protection against:
  - Loss of ground
  - Shorted load and overtemperature
- Built-in current limiter
- Undervoltage shutdown
- Open drain diagnostic output
- Fast demagnetization of inductive loads

Description

The VN540SP-E is a monolithic devices designed in STMicroelectronics VIPower technology, intended for driving resistive or inductive loads with one side connected to ground. Active current limitation avoids the system power supply dropping in case of shorted load. Built-in thermal shutdown protects the chip from overtemperature. The open drain diagnostic output indicates overtemperature conditions.

Figure 1. Block diagram



Contents

1 Absolute maximum rating

Table 1. Absolute maximum rating

Symbol	Parameter	Value	Unit
V_{CC}	Power supply voltage	45	V
$-V_{CC}$	Reverse supply voltage	-4.0	V
I_{OUT}	Maximum DC load current	Internally limited	A
I_R	Reverse output current	-10	A
I_{IN}	Input current	± 10	mA
I_{STAT}	Status pin current	± 10	mA
V_{ESD}	Electrostatic discharge (R = 1.5 KW; C = 100 pF)	2000	V
P_{TOT}	Power dissipation (see thermal thresholds in *Table 6 on page 7*)	Internally limited	W
T_J	Junction operating temperature	Internally limited	°C
T_{STG}	Storage temperature	-55 to 150	°C
E_{AS}	Single pulse avalanche energy (T_{amb} = 125 °C, V_{CC} = 24 V, I_{load} = 2.5 A)	17	J

2 Pin connections

Figure 2. Connection diagram (top view)

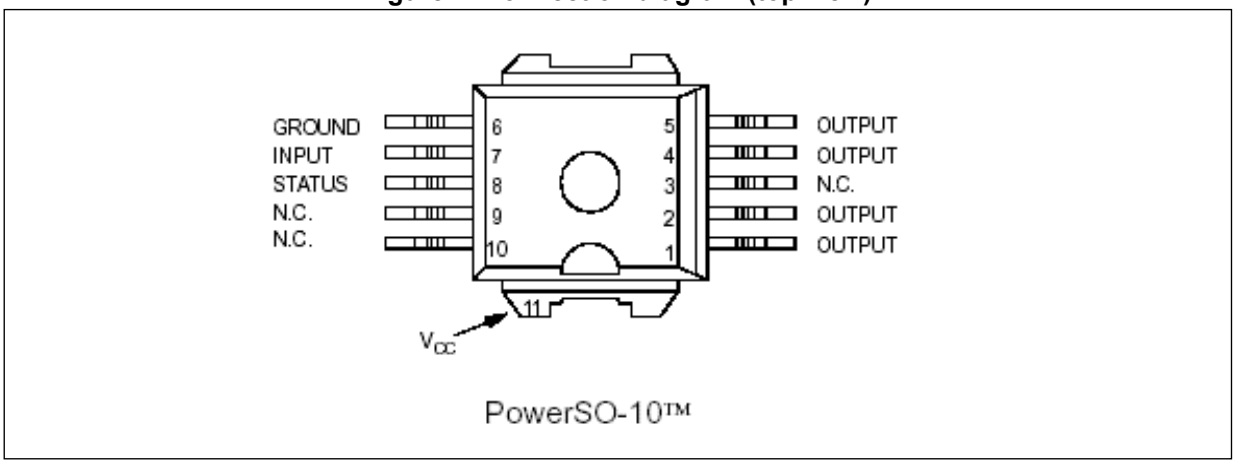
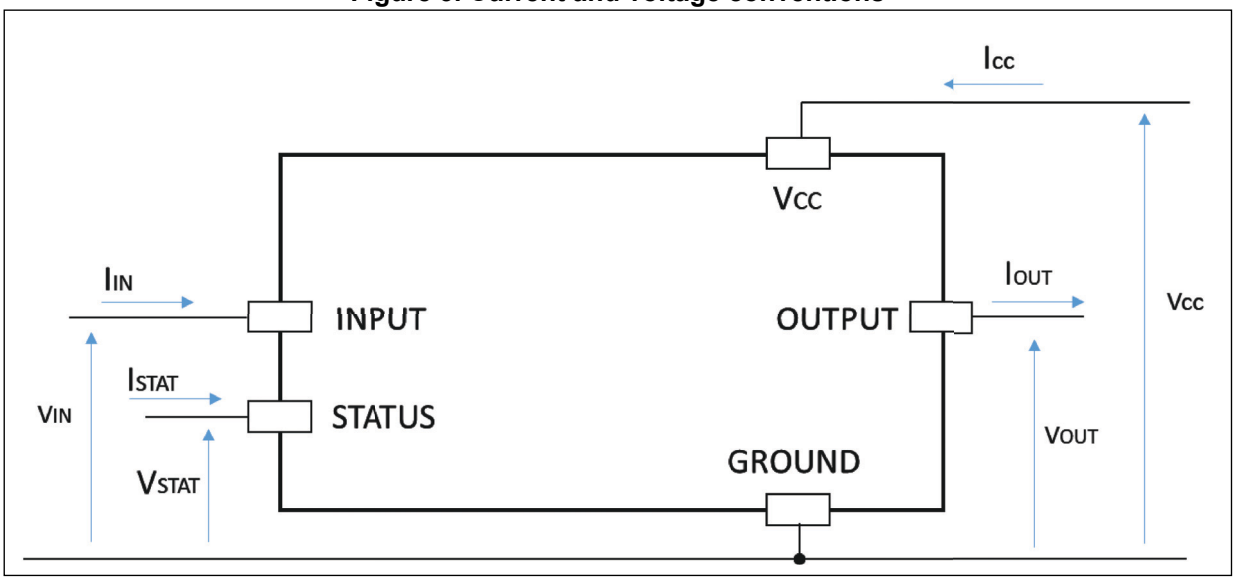


Figure 3. Current and voltage conventions



3 Thermal data

Table 2. Thermal data

Symbol	Parameter		Value	Unit
R_{thJC}	Thermal resistance junction-case	Max.	1.5	°C/W
R_{thJA}	Thermal resistance junction-ambient	Max.	50	°C/W

4 Electrical characteristics

Electrical characteristics (10 V < V_{CC} < 36 V; -25 °C < T_J < 85 °C; unless otherwise specified).

Table 3. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Supply voltage		10	-	36	V
R_{ON}	On state resistance	I_{OUT} = 2.8 A; T_J = 25 °C I_{OUT} = 2.8 A	- -	- -	50 90	mΩ mΩ
I_S	Supply current	OFF state ON state; T_J = 125 °C I_{OUT} = 0 A	- -	- -	1 3	mA mA
I_{LS}	Output leakage current	Channel OFF V_{CC} = 45 V	-	-	100	µA
I_{LGND}	Output current at turn-off	V_{CC} = V_{IN} = V_{GND} = V_{STAT} = 24 V T_J = - 25 °C < T_J < 100 °C	-	-	2	mA
V_{OL}	Low state output voltage	V_{IN} = V_{IL}; R_{LOAD} ≥ 10 MΩ	-	-	1.5	V
V_{demag}	Output voltage at turn-off	I_{OUT} = 2.8 A; L_{LOAD} ≥ 1 mH	V_{CC} - 65	V_{CC} - 55	V_{CC} - 45	V

Table 4. Switching

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(ON)}$	Turn-on delay on output current	I_{OUT} = 2.8 A, resistive load input rise time < 0.1 s, V_{CC} = 24 V; T_J = 25 °C	-	40	-	µs
t_r	Rise time of output current	I_{OUT} = 2.8 A, resistive load input rise time < 0.1 s, V_{CC} = 24 V; T_J = 25 °C	-	60	-	µs
$t_{d(OFF)}$	Turn-off delay time of output current	I_{OUT} = 2.8 A, resistive load input rise time < 0.1 s, V_{CC} = 24 V; T_J = 25 °C	-	60	-	µs
t_f	Fall time of output current	I_{OUT} = 2.8 A, resistive load input rise time < 0.1 s, V_{CC} = 24 V; T_J = 25 °C	-	25	-	µs
$dI/dt_{(on)}$	Turn-on current average slope	I_{OUT} = 2.8 A, I_{OUT} = I_{LIM}; 25 °C < T_J < 140 °C	-	-	0.5 2	A/µs
$dI/dt_{(off)}$	Turn-off current average slope	I_{OUT} = 2.8 A, I_{OUT} = I_{LIM}; 25 °C < T_J < 140 °C	-	-	2 4	A/µs

Table 5. Logical input

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input low level voltage	-	-	-	2.0	V
V_{IH}	Input high level voltage	-	3.5	-	-	V
$V_{I(HYST)}$	Input hysteresis voltage	-	-	0.5	-	V
I_{IN}	Input current	V_{IN} = 30 V V_{IN} = 2.0 V	- 25	- -	300 -	µA µA
V_{ICL}	I/O input clamp voltage(1)	I_{IN} = 1 mA I_{IN} = -1 mA	32 -	36 -0.7	- -	V V

1. The input voltage is internally clamped at 32 V minimum, it is possible to connect the input pins to a higher voltage via an external resistor calculate to not exceed 10 mA.

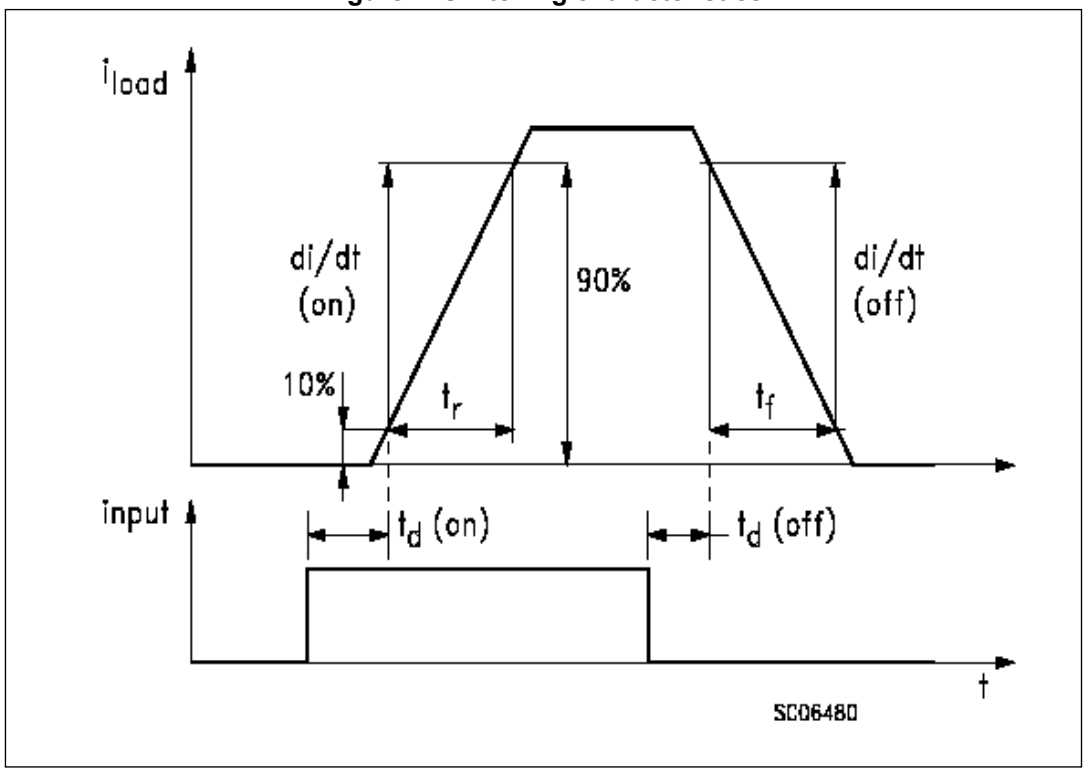
Table 6. Protection and diagnostic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{STAT}	Status output voltage	I_{STAT} = 5 mA (fault condition)	-	-	1	V
V_{SCL} (1)	Status clamp voltage	I_{STAT} = 1 mA I_{STAT} = -1 mA	32	36 -0.7	- -	V V
I_{STAT}	Leakage on diagnostic pin in high state	V_{STAT} = 5 V	-	-	-	µA
V_{USD}	Undervoltage shutdown	-	5.0	-	8.0	V
I_{LIM}	DC short-circuit current	V_{CC} = 24 V; R_{LOAD} < 10 mΩ	2.8	5.0	8.0	A
I_{OVPK}	Peak short-circuit current	V_{CC} = 24 V; V_{IN} = 30; R_{LOAD} < 10 mΩ	-	-	4	A
t_{SC}	Delay time of current limiter	-	-	-	100	µs
T_{TSD}	Thermal shutdown temperature	-	150	170	-	°C
T_R	Thermal reset temperature	-	135	155	-	°C

1. Status determination > 100 ms after the switching edge.

5 Switching characteristics

Figure 4. Switching characteristics



6 Truth table

Table 7. Truth table

Conditions	INPUT	OUTPUT	STATUS
Normal operation	L H	L H	H H
Overtemperature	L H	L L	H L
Undervoltage	L H	L L	H H
Shorted load (current limitation)	L H	L H	H H

7 Test circuits and waveforms

Figure 5. Peak short test circuit

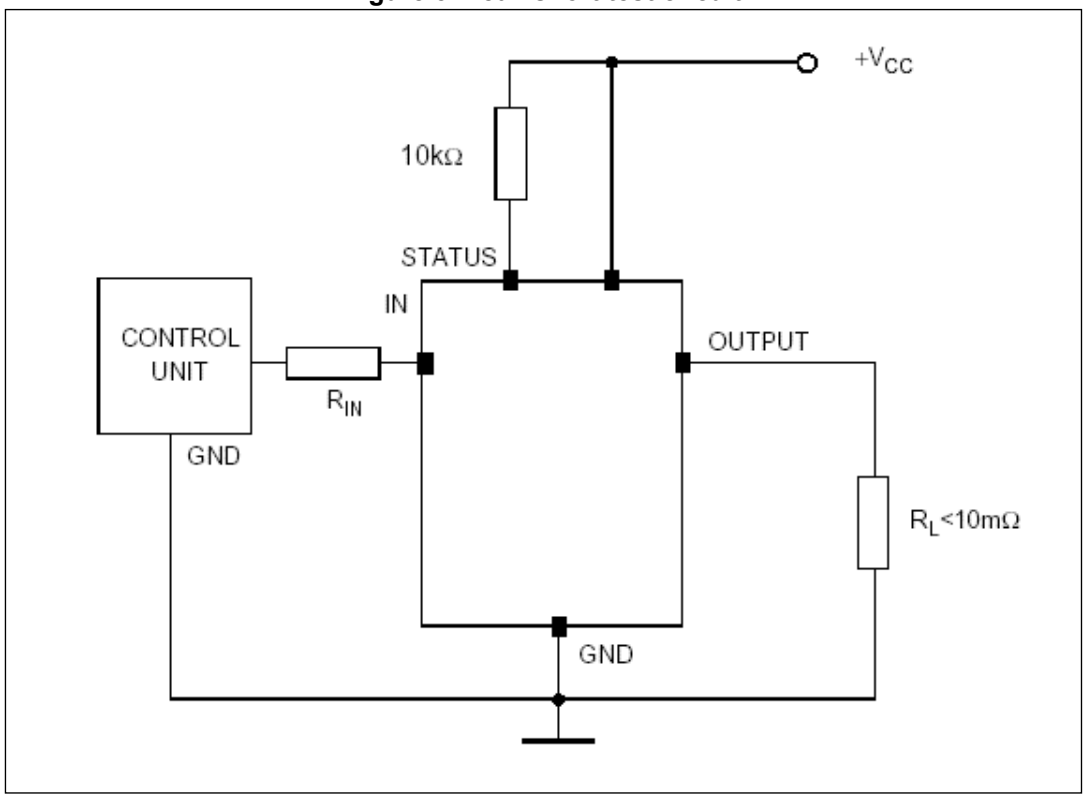


Figure 6. Switching waveforms

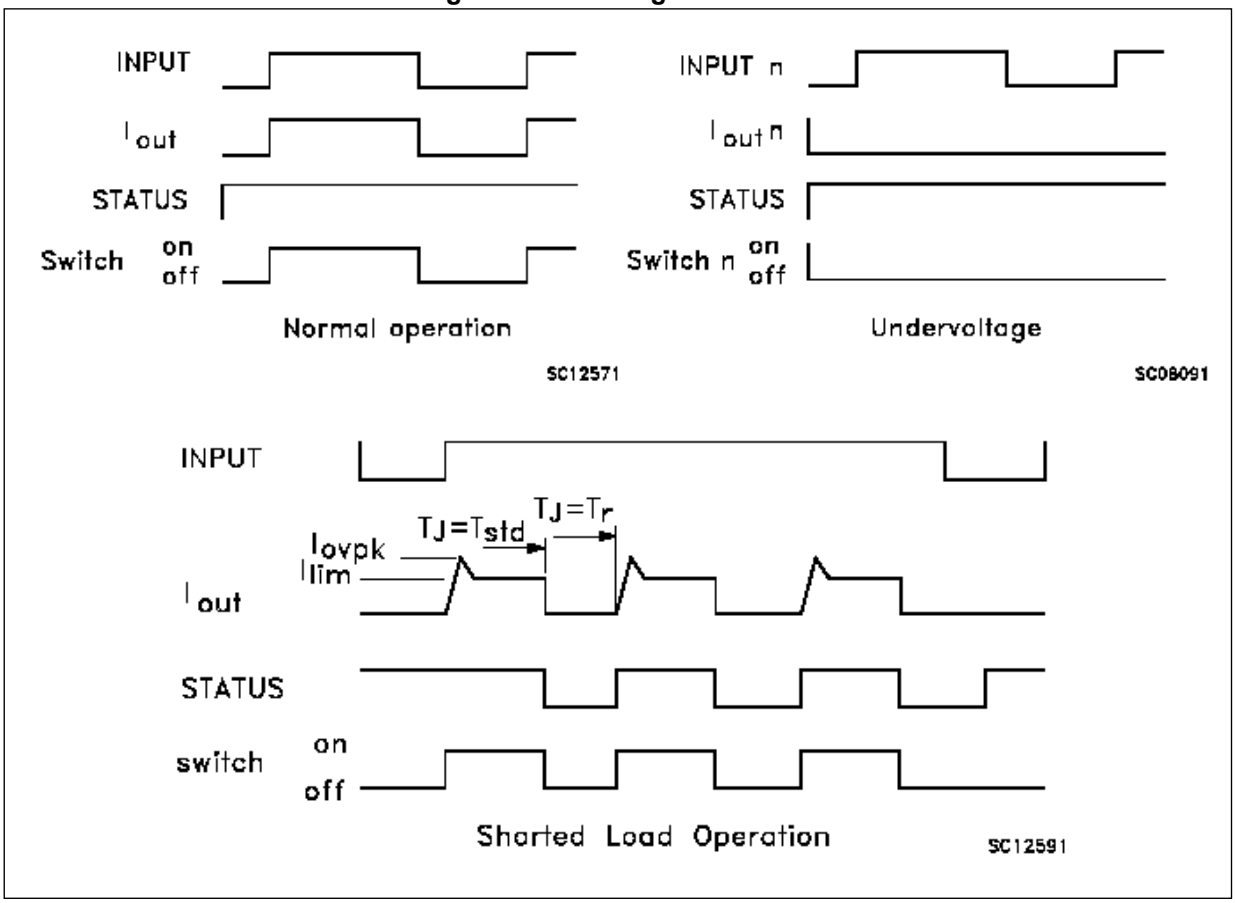


Figure 7. I_{LGND} test configuration

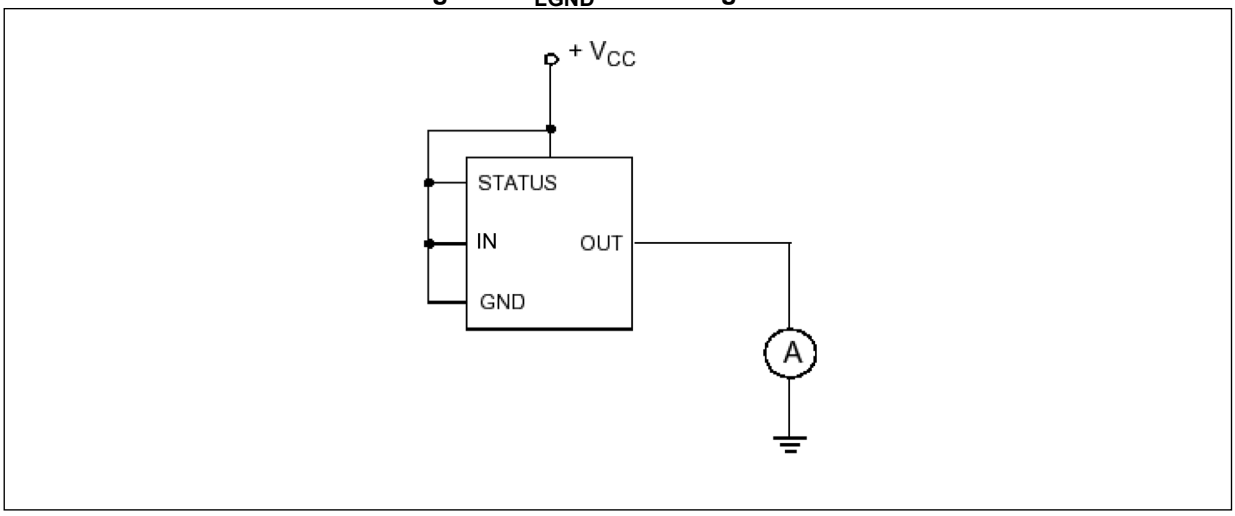
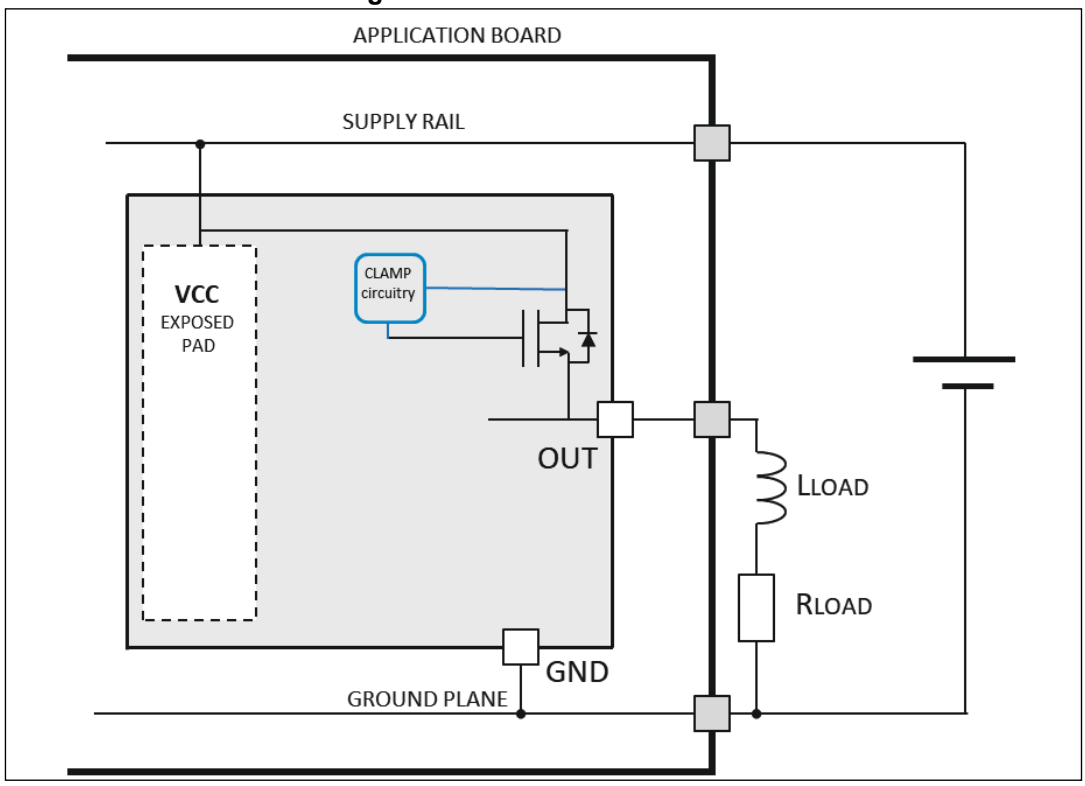


Figure 8. EAS evaluation circuit



8 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. These packages have a Lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

8.1 PowerSO-10 package information

Figure 9. PowerSO-10 package outline

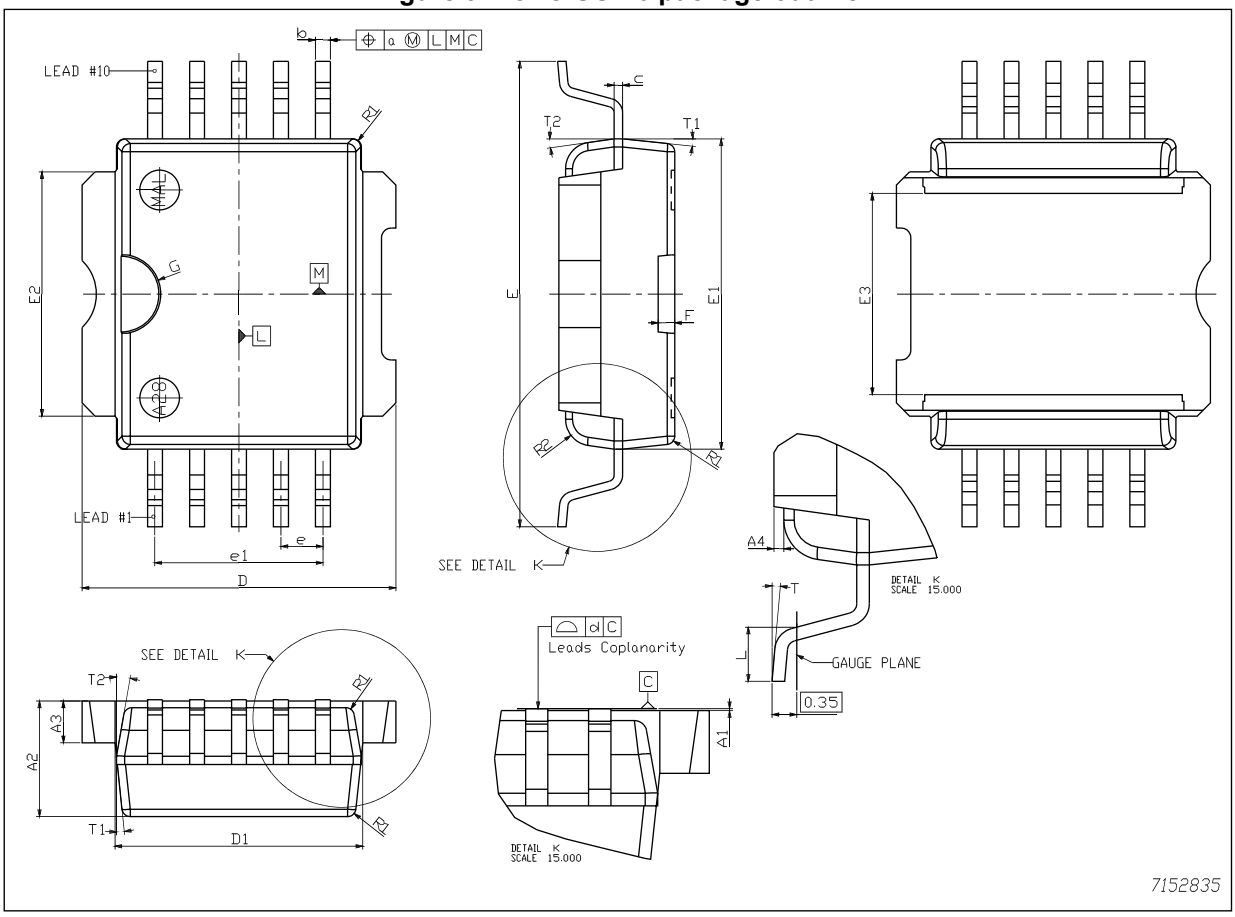


Table 8. PowerSO-10 package mechanical data

Symbol	Dimensions (mm)			Dimensions (inch)			Note
	Typ.	Min.	Max.	Typ.	Min.	Max.	
A1	0.05	0	0.1	0.0019	0.0004	0.003	-
A2	3.5	3.4	3.6	0.137	0.135	0.139	-
A3	1.3	1.2	1.4	0.05	0.048	0.052	-
A4	0.2	0.15	0.25	0.007	0.006	0.01	-
a	0.2	-	-	0.007	-	-	-
b	0.45	0.37	0.53	0.017	0.015	0.019	-
c	0.27	0.23	0.32	0.01	0.009	0.011	-
D	9.5	9.4	9.6	0.374	0.372	0.377	-
D1	7.5	7.4	7.6	0.295	0.292	0.298	-
d	0.05	0	0.1	0.0015	0	0.0035	-
E	14.1	13.85	14.35	0.555	0.547	0.562	-
E1	9.4	9.3	9.5	0.37	0.367	0.372	(1)
E2	7.4	7.3	7.5	0.292	0.291	0.295	-
E3	6.1	5.9	6.3	0.24	0.234	0.246	-
e	1.27	-	-	0.05	0.048	0.051	-
e1	5.08	-	-	0.2	-	-	-
F	0.5	-	-	0.019	-	-	-
G	1.2	-	-	0.047	-	-	-
L	1	0.8	1.1	0.039	0.033	0.043	-
R1	-	-	0.25	-	-	0.01	-
R2	0.8	-	-	0.031	-	-	-
T	5 deg.	2 deg.	8 deg.	5 deg.	3 deg.	7 deg.	-
T1	6 deg.	-	-	6 deg.	-	-	-
T2	10 deg.	-	-	10 deg.	-	-	-

1. Resin protrusions not included (max. value: 0.15 mm per side).

9 Ordering information

Table 9. Order codes

Package	Tube	Tape and reel
PowerSO-10	VN540SP-E	VN540SPTR-E

10 Revision history

Table 10. Document revision history

Date	Revision	Changes
2-Nov-2005	1	Initial release.
09-May-2018	2	Removed VN540-12-E and PENTAWATT(012Y) from the whole document. Updated P_{TOT} and E_{AS} in *Table 1 on page 3*. Added *Figure 8 on page 11*. Updated *Section 8 on page 12*. Minor modifications throughout document.
05-Oct-2020	3	Removed VN540-E and PENTAWATT from the whole document. Updated *Section 8* Updated *Figure 3* and *Figure 8*.

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