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1 Block diagram and pin description

Figure 1. Block diagram

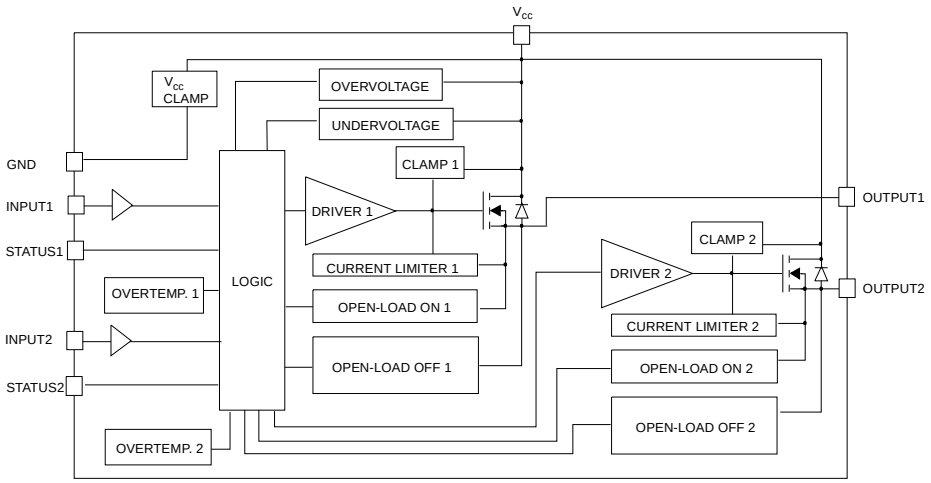
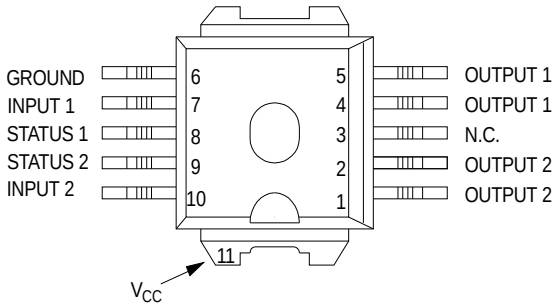


Figure 2. Configuration diagram (top view)



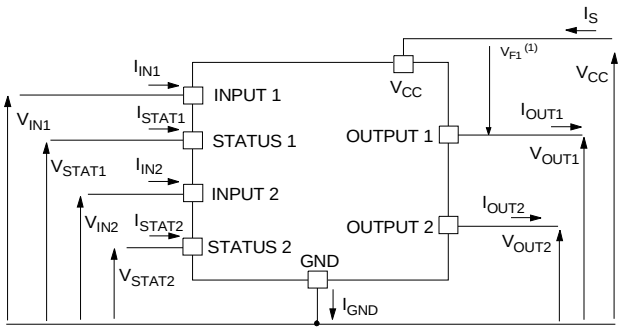
PowerSO-10

Table 2. Suggested connections for unused and not connected pins

Connection / pin	Status	N.C.	Output	Input
Floating	X	X	X	X
To ground		X		Through 10 KΩ resistor

2 Electrical specifications

Figure 3. Current and voltage conventions



1) $V_{Fn} = V_{CCn} - V_{OUTn}$ during reverse battery condition.

2.1 Absolute maximum ratings

Stressing the device above the rating listed in *Table 3* may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics sure program and other relevant quality document.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	DC supply voltage	41	V
- V_{CC}	Reverse DC supply voltage	-0.3	V
- I_{GND}	DC reverse ground pin current	-200	mA
I_{OUT}	DC output current	Internally Limited	A
- I_{OUT}	Reverse DC output current	-6	A
I_{IN}	DC input current	+/- 10	mA
I_{stat}	DC status current	+/- 10	mA
V_{ESD}	Electrostatic discharge (Human Body Model: R = 1.5 KΩ; C = 100 pF) – INPUT – STATUS – OUTPUT – V_{CC}	 4000 4000 5000 5000	 V V V V

Table 3. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
E_{MAX}	Maximum switching energy (L = 1.4 mH; R_L = 0 Ω; V_{bat} = 13.5 V; T_{jstart} = 150 °C; I_L = 5 A)	24	mJ
P_{tot}	Power dissipation T_C = 25 °C	52	W
T_j	Junction operating temperature	Internally Limited	°C
T_c	Case operating temperature	-40 to 150	°C
T_{stg}	Storage temperature	-55 to 150	°C

2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Value		Unit
$R_{thj\text{-}case}$	Thermal resistance junction-case	2.4		°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient	52.4 (1)	37 (2)	°C/W

1. When mounted on a standard single-sided FR-4 board with 0.5 cm^2 of Cu (at least 35 µm thick). Horizontal mounting and no artificial air flow.
2. When mounted on a standard single-sided FR-4 board with 6 cm^2 of Cu (at least 35 µm thick). Horizontal mounting and no artificial air flow

2.3 Electrical characteristics

Values specified in this section are for 8 V < V_{CC} < 36 V; -40 °C < T_j < 150 °C, unless otherwise stated.

(Per each channel)

Table 5. Power output

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}(1)	Operating supply voltage		5.5	13	36	V
V_{USD}(1)	Undervoltage shutdown		3	4	5.5	V
V_{OV}(1)	Overvoltage shutdown		36			V
R_{ON}	On-state resistance	I_{OUT} = 1 A; T_j = 25 °C I_{OUT} = 1 A; V_{CC} > 8 V			160 320	mΩ mΩ
I_S(1)	Supply current	Off-state; V_{CC} = 13 V; V_{IN} = V_{OUT} = 0 V Off-state; V_{CC} = 13 V; V_{IN} = V_{OUT} = 0 V; T_j = 25 °C On-state; V_{CC} = 13 V; V_{IN} = 5 V; I_{OUT} = 0 A		12 12 5	40 25 7	µA µA mA
$I_{L(off1)}$	Off-state output current	V_{IN} = V_{OUT} = 0 V	0		50	µA

Table 5. Power output (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{L(off2)}$	Off-state output current	V_{IN} = 0 V; V_{OUT} = 3.5 V	-75		0	µA
$I_{L(off3)}$	Off-state output current	V_{IN} = V_{OUT} = 0 V; V_{CC} = 13 V; T_j =125 °C			5	µA
$I_{L(off4)}$	Off-state output current	V_{IN} = V_{OUT} = 0 V; V_{CC} = 13 V; T_j = 25 °C			3	µA

1. Per device.

Table 6. Protection(1)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature		135			°C
T_{hyst}	Thermal hysteresis		7	15		°C
t_{sdl}	Status delay in overload conditions	T_j>T_{TSD}			20	µs
I_{lim}	Current limitation	V_{CC} = 13 V 5.5 V < V_{CC} < 36 V	3.5	5	7.5 7.5	A A
V_{demag}	Turn-off output clamp voltage	I_{OUT} = 1 A; L = 6 mH	V_{CC}-41	V_{CC}-48	V_{CC}-55	V

1. To ensure long term reliability under heavy overload or short circuit conditions, protection and related diagnostic signals must be used together with a proper software strategy. If the device is subjected to abnormal conditions, this software must limit the duration and number of activation cycles

Table 7. V_{CC} output diode

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V_F	Forward on voltage	-I_{OUT} = 0.5 A; T_j = 150 °C	-	-	0.6	V

Table 8. Status pin

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V_{STAT}	Status low output voltage	I_{STAT} = 1.6 mA			0.5	V
I_{LSTAT}	Status leakage current	Normal operation; V_{STAT} = 5 V			10	µA
C_{STAT}	Status pin input capacitance	Normal operation; V_{STAT} = 5 V			100	pF
V_{SCL}	Status clamp voltage	I_{STAT} = 1 mA I_{STAT} = -1 mA	6	6.8 -0.7	8	V V

Table 9. Switching (V_{CC} = 13 V)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	R_L = 13 Ω from V_{IN} rising edge to V_{OUT} = 1.3 V	-	30	-	µs
$t_{d(off)}$	Turn-off delay time	R_L = 13 Ω from V_{IN} falling edge to V_{OUT} = 11.7 V	-	30	-	µs
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	R_L = 13 Ω from V_{OUT} = 1.3 V to V_{OUT} = 10.4 V	-	See *Table 21*	-	V/µs
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	R_L = 13 Ω from V_{OUT} = 11.7 V to V_{OUT} = 1.3 V	-	See *Table 22*	-	V/µs

Table 10. Open-load detection

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I_{OL}	Open-load on-state detection threshold	V_{IN} = 5V	20	40	80	mA
$t_{DOL(on)}$	Open-load on-state detection delay	I_{OUT} = 0 A			200	µs
V_{OL}	Open-load off-state voltage detection threshold	V_{IN} = 0 V	1.5	2.5	3.5	V
$t_{DOL(off)}$	Open-load detection delay at turn-off				1000	µs

Table 11. Logic input

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V_{IL}	Input low level				1.25	V
I_{IL}	Low level input current	V_{IN} = 1.25 V	1			µA
V_{IH}	Input high level		3.25			V
I_{IH}	High level input current	V_{IN} = 3.25 V			10	µA
V_{hyst}	Input hysteresis voltage		0.5			V
V_{ICL}	Input clamp voltage	I_{IN} = 1 mA I_{IN} = -1 mA	6	6.8 -0.7	8	V V

Figure 4. Status timing

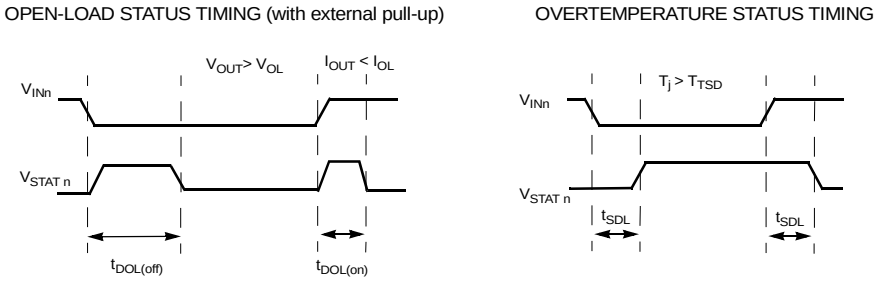


Figure 5. Switching time waveforms

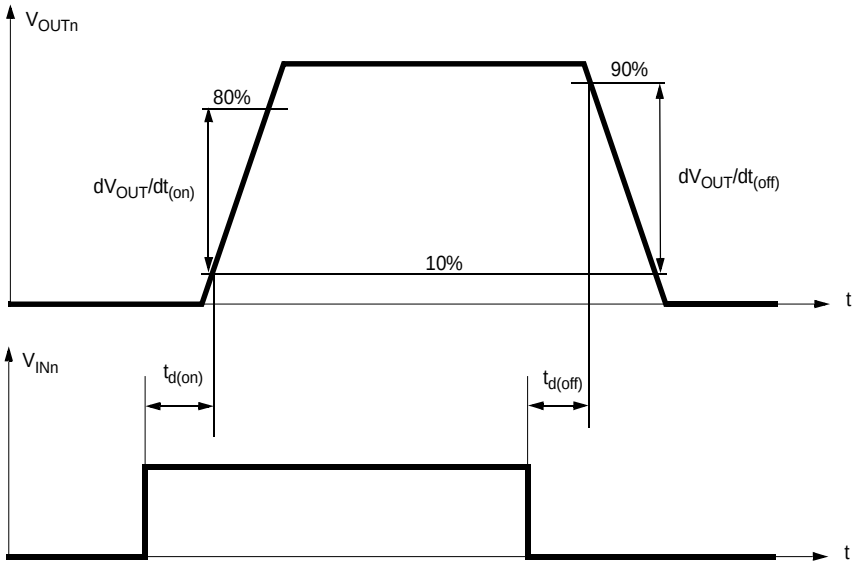


Table 12. Truth table

Conditions	Input	Output	Status
Normal operation	L H	L H	H H
Current limitation	L H H	L X X	H ($T_j < T_{TSD}$) H ($T_j > T_{TSD}$) L
Overtemperature	L H	L L	H L
Undervoltage	L H	L L	X X
Overvoltage	L H	L L	H H
Output voltage > V_{OL}	L H	H H	L H
Output current < I_{OL}	L H	L H	H L

Table 13. Electrical transient requirements on V_{CC} pin (part 1)

ISO T/R 7637/1 Test pulse	Test levels				
	I	II	III	IV	Delays and impedance
1	-25 V	-50 V	-75 V	-100 V	2 ms, 10 Ω
2	+25 V	+50 V	+75 V	+100 V	0.2 ms, 10 Ω
3a	-25 V	-50 V	-100 V	-150 V	0.1 µs, 50 Ω
3b	+25 V	+50 V	+75 V	+100 V	0.1 µs, 50 Ω
4	-4 V	-5 V	-6 V	-7 V	100 ms, 0.01 Ω
5	+26.5 V	+46.5 V	+66.5 V	+86.5 V	400 ms, 2 Ω

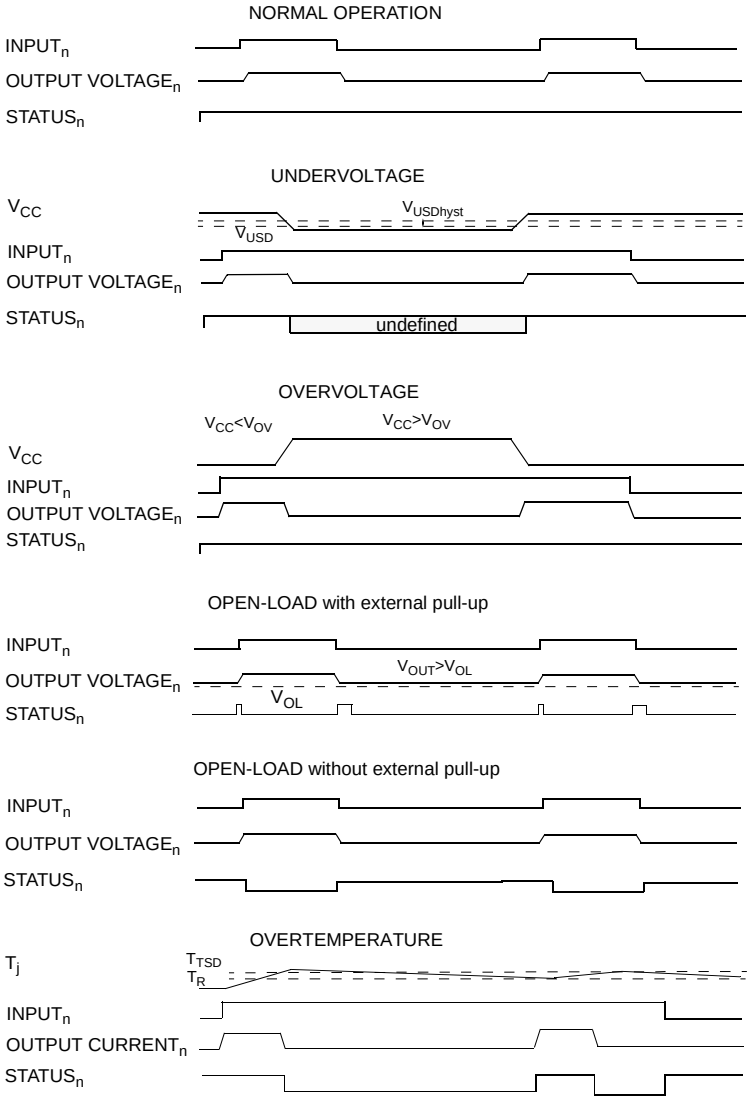
Table 14. Electrical transient requirements on V_{CC} pin (part 2)

ISO T/R 7637/1 Test pulse	Test levels			
	I	II	III	IV
1	C	C	C	C
2	C	C	C	C
3a	C	C	C	C
3b	C	C	C	C
4	C	C	C	C
5	C	E	E	E

Table 15. Electrical transient requirements on V_{CC} pin (part 3)

Class	Contents
C	All functions of the device are performed as designed after exposure to disturbance.
E	One or more functions of the device is not performed as designed after exposure and cannot be returned to proper operation without replacing the device.

Figure 6. Waveforms



2.4 Electrical characteristics curves

Figure 7. Off-state output current

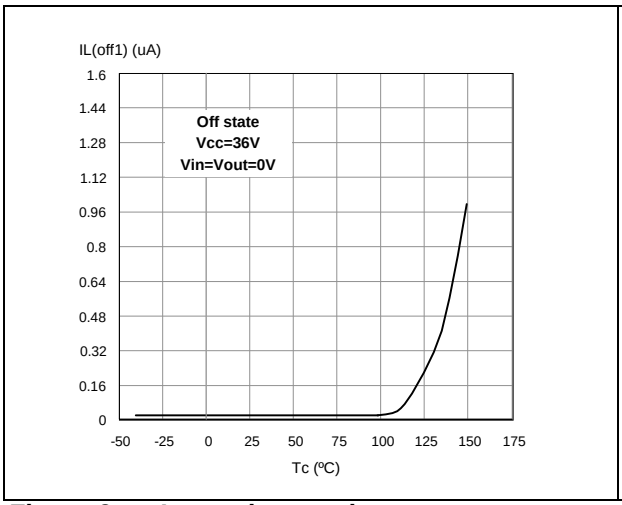


Figure 8. High level input current

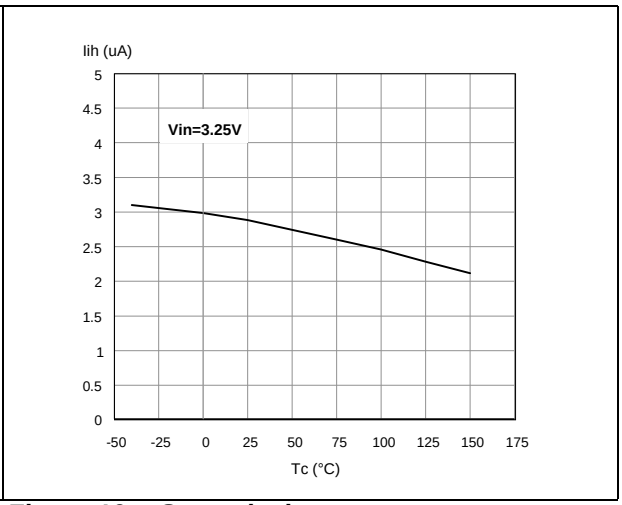


Figure 9. Input clamp voltage

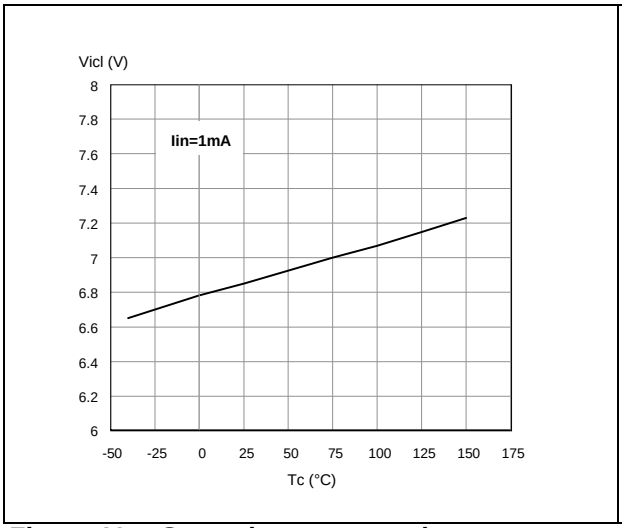


Figure 10. Status leakage current

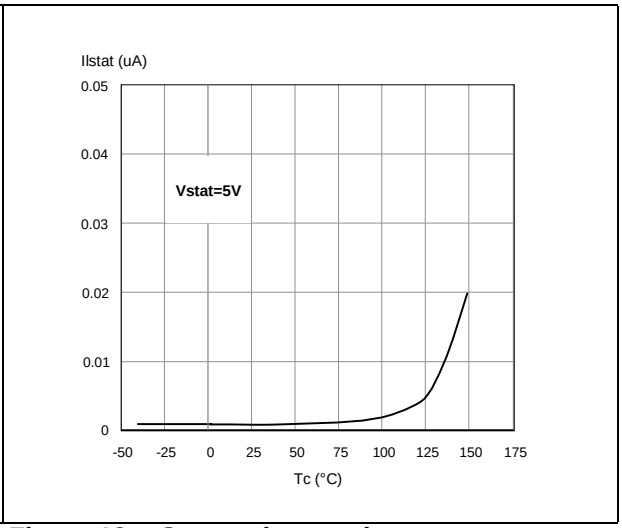


Figure 11. Status low output voltage

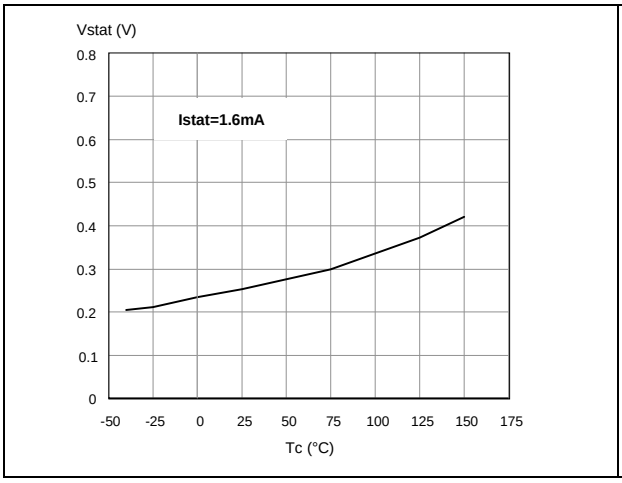


Figure 12. Status clamp voltage

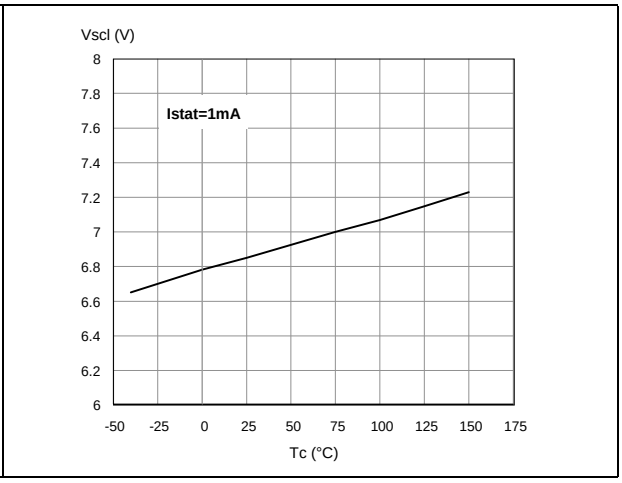


Figure 13. On-state resistance vs T_{case}

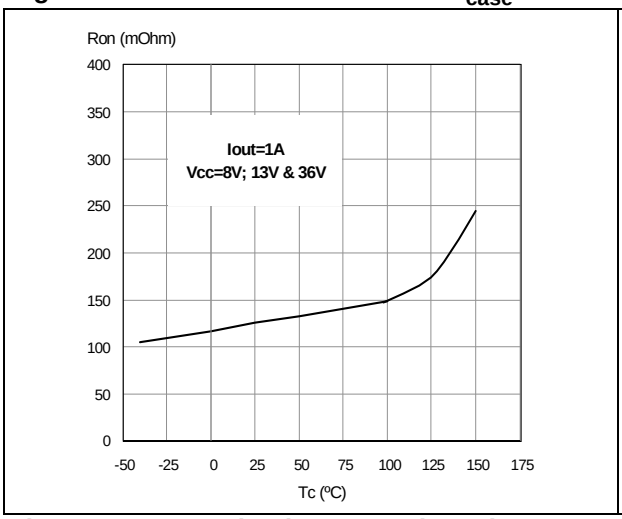


Figure 14. On-state resistance vs V_{CC}

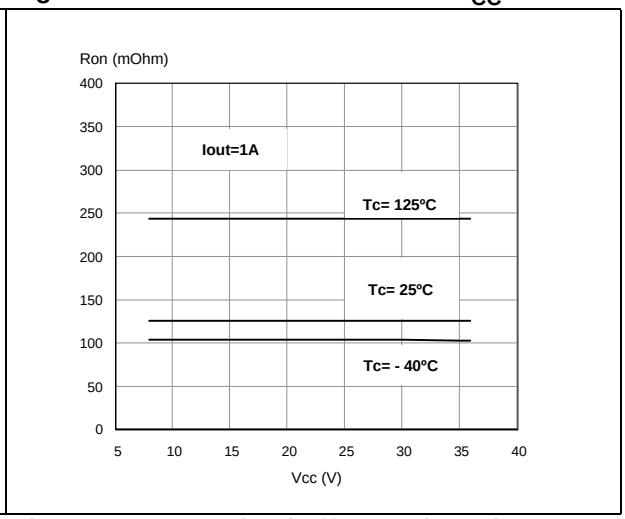


Figure 15. Open-load on-state detection threshold

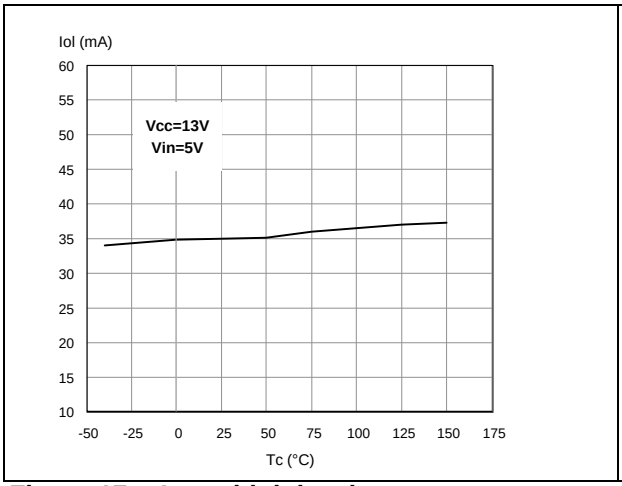


Figure 16. Open-load off-state detection threshold

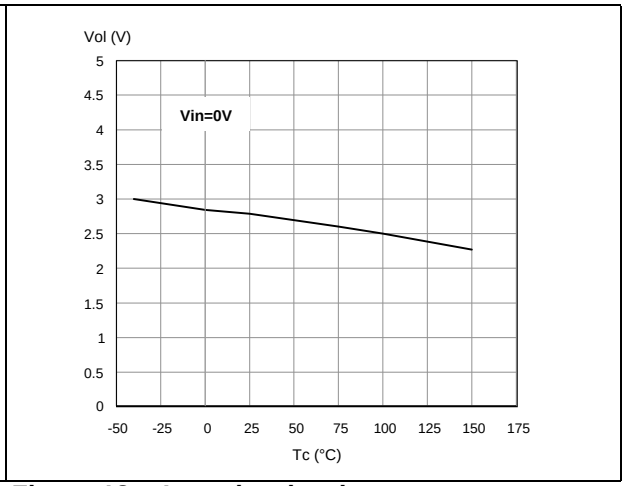


Figure 17. Input high level

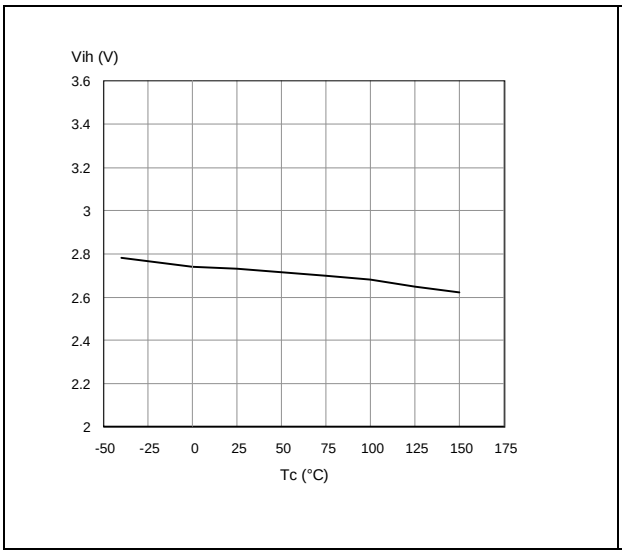


Figure 18. Input low level

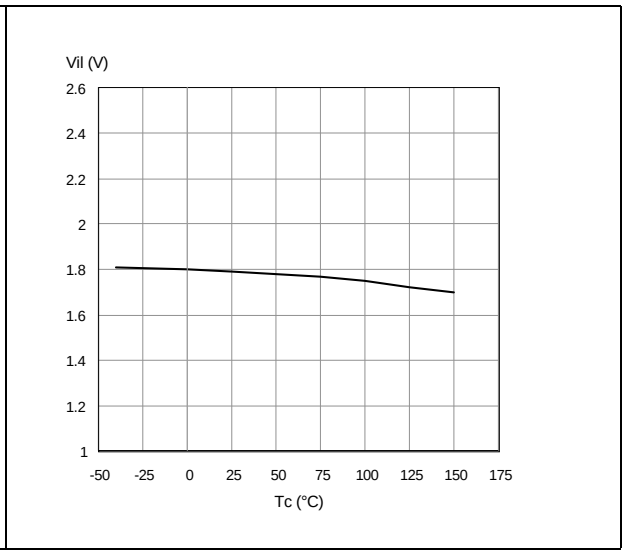


Figure 19. Input hysteresis voltage

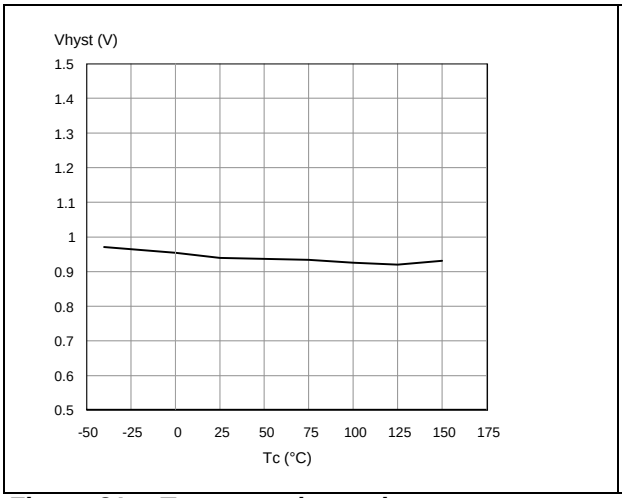


Figure 20. Overvoltage shutdown

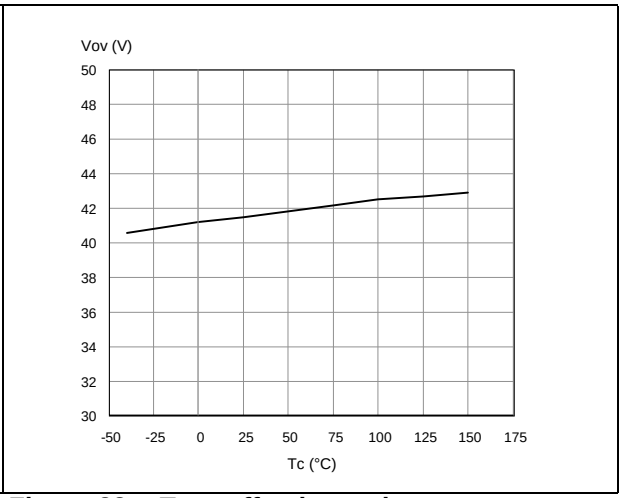


Figure 21. Turn-on voltage slope

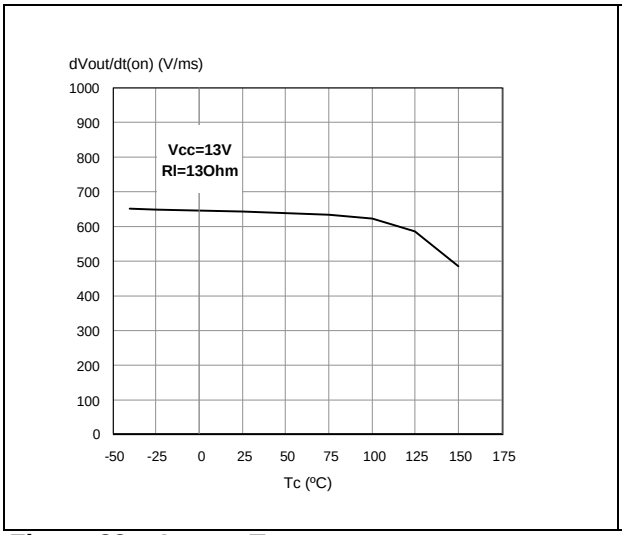


Figure 22. Turn-off voltage slope

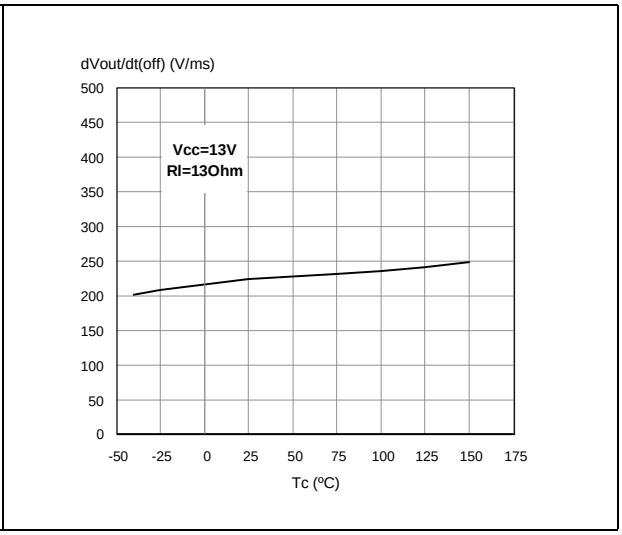
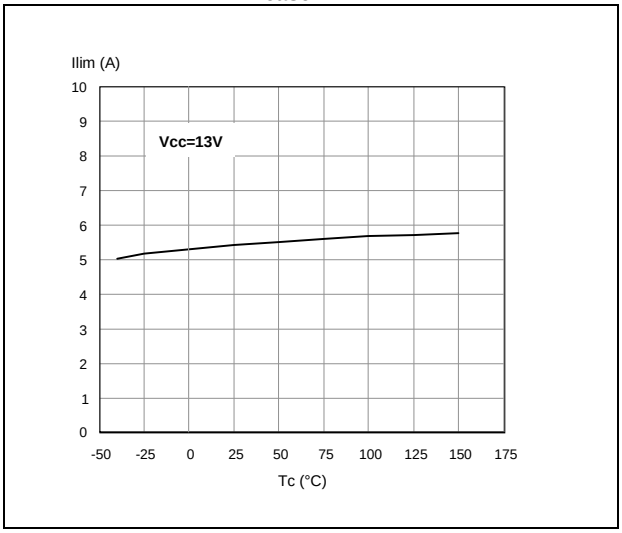
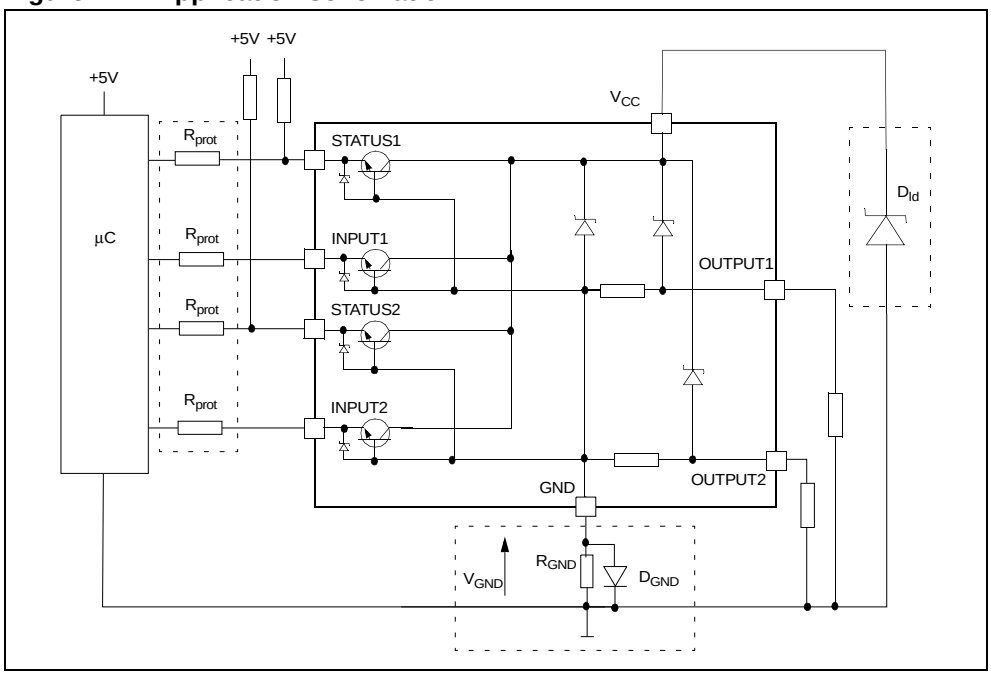


Figure 23. I_{LIM} vs T_{case}



3 Application information

Figure 24. Application schematic



3.1 GND protection network against reverse battery

This section provides two solutions for implementing a ground protection network against reverse battery.

3.1.1 Solution 1: a resistor in the ground line (R_{GND} only)

This can be used with any type of load.

The following shows how to dimension the R_{GND} resistor:

1. $R_{GND} \leq 600\ mV / I_{S(on)max}$.
2. $R_{GND} \geq (-V_{CC}) / (-I_{GND})$

where $-I_{GND}$ is the DC reverse ground pin current and can be found in the absolute maximum rating section of the device's datasheet.

Power dissipation in R_{GND} (when $V_{CC} < 0$ during reverse battery situations) is:
$P_D = (-V_{CC})^2 / R_{GND}$

This resistor can be shared amongst several different HSD. Please note that the value of this resistor should be calculated with formula (1) where $I_{S(on)max}$ becomes the sum of the maximum on-state currents of the different devices.

Please note that, if the microprocessor ground is not common with the device ground, then the R_{GND} produces a shift ($I_{S(on)max} * R_{GND}$) in the input thresholds and the status output values. This shift varies depending on how many devices are ON in the case of several high side drivers sharing the same R_{GND}.

If the calculated power dissipation requires the use of a large resistor, or several devices have to share the same resistor, then ST suggests using *Section 3.1.2* described below.

3.1.2 Solution 2: a diode (D_{GND}) in the ground line

A resistor (R_{GND} = 1 kΩ) should be inserted in parallel to D_{GND} if the device is driving an inductive load. This small signal diode can be safely shared amongst several different HSD. Also in this case, the presence of the ground network produce a shift (~600 mV) in the input threshold and the status output values if the microprocessor ground is not common with the device ground. This shift does not vary if more than one HSD shares the same diode/resistor network. Series resistor in INPUT and STATUS lines are also required to prevent that, during battery voltage transient, the current exceeds the absolute maximum rating. Safest configuration for unused INPUT and STATUS pin is to leave them unconnected.

3.1.3 Load dump protection

D_{ld} is necessary (Voltage Transient Suppressor) if the load dump peak voltage exceeds V_{CC} max DC rating. The same applies if the device is subjected to transients on the V_{CC} line that are greater than the ones shown in *Table 13*.

3.2 MCU I/O protection

If a ground protection network is used and negative transients are present on the V_{CC} line, the control pins is pulled negative. ST suggests to insert a resistor (R_{prot}) in line to prevent the microcontroller I/O pins from latching up.

The value of these resistors is a compromise between the leakage current of microcontroller and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of microcontroller I/Os:

$$-V_{CCpeak} / I_{latchup} \leq R_{prot} \leq (V_{OH\mu C} - V_{IH} - V_{GND}) / I_{IHmax}$$

Example

For the following conditions:

V_{CCpeak} = -100 V

$I_{latchup} \geq$ 20 mA

$V_{OH\mu C} \geq$ 4.5 V

5 kΩ ≤ R_{prot} ≤ 65 kΩ.

The recommended values are:

R_{prot} = 10 kΩ

3.2.1 Open-load detection in off-state

Off-state open-load detection requires an external pull-up resistor (R_{PU}) connected between OUTPUT pin and a positive supply voltage (V_{PU}) like the +5 V line used to supply the microprocessor.

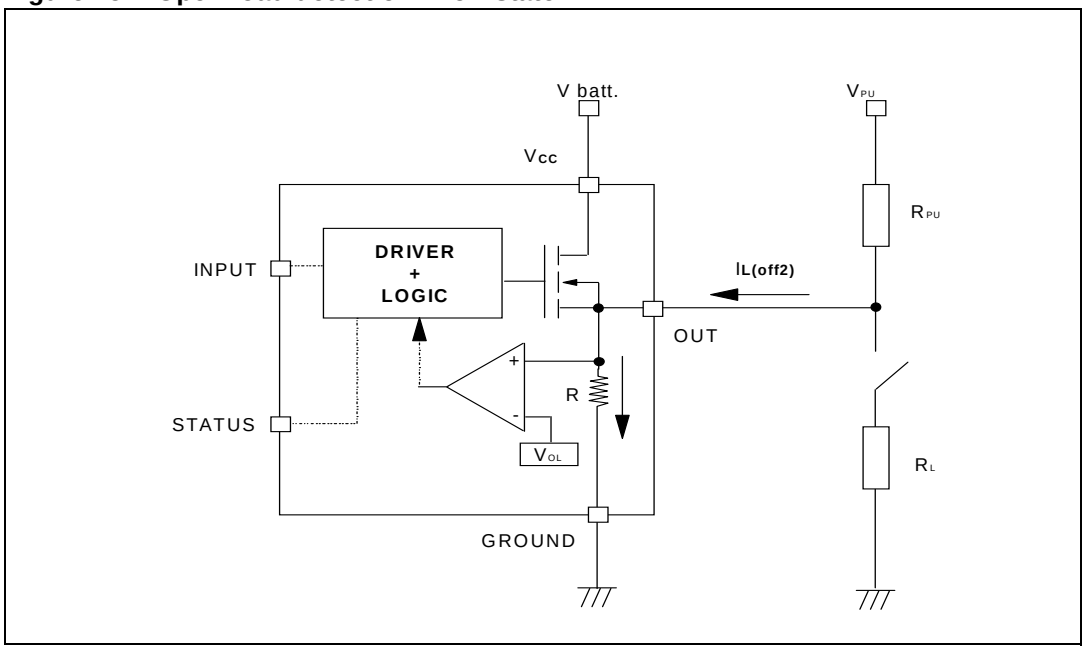
The external resistor has to be selected according to the following requirements:

1. No false open-load indication when load is connected: in this case it needs to avoid V_{OUT} to be higher than V_{Olmin}; this results in the following condition:
   $V_{OUT} = (V_{PU}/ (R_L + R_{PU}))R_L < V_{Olmin}$.
2. No misdetection when load is disconnected: in this case the V_{OUT} has to be higher than V_{OLmax}; this results in the following condition $R_{PU} < (V_{PU} – V_{OLmax})/ I_{L(off2)}$.

Because $I_{s(OFF)}$ may significantly increase if V_{out} is pulled high (up to several mA), the pull-up resistor R_{PU} should be connected to a supply that is switched OFF when the module is in standby.

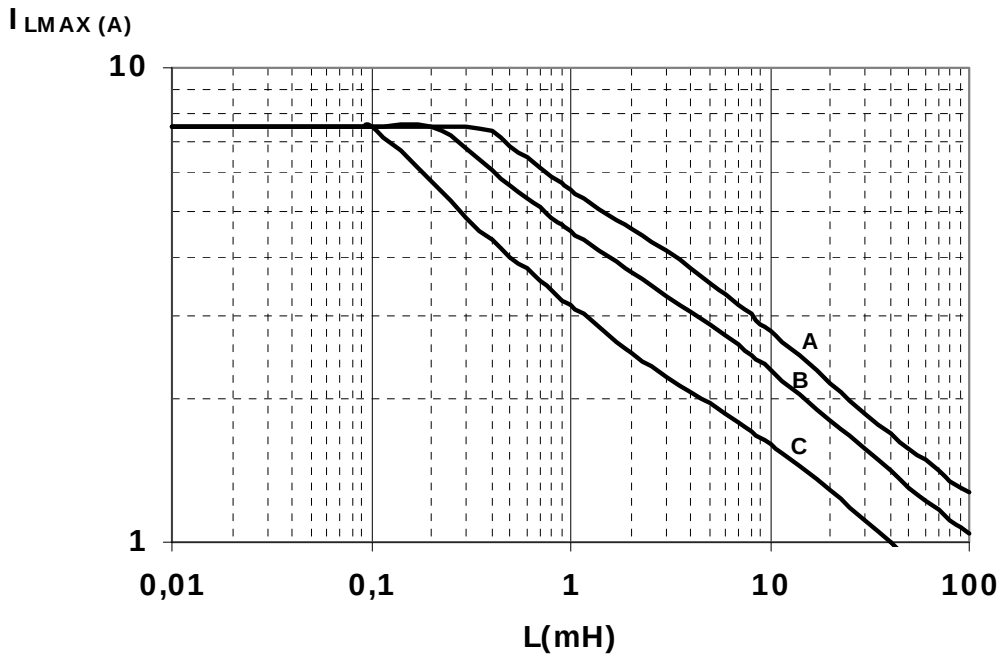
The values of V_{OLmin}, V_{OLmax} and $I_{L(off2)}$ are available in *Section 2.3*.

Figure 25. Open-load detection in off-state



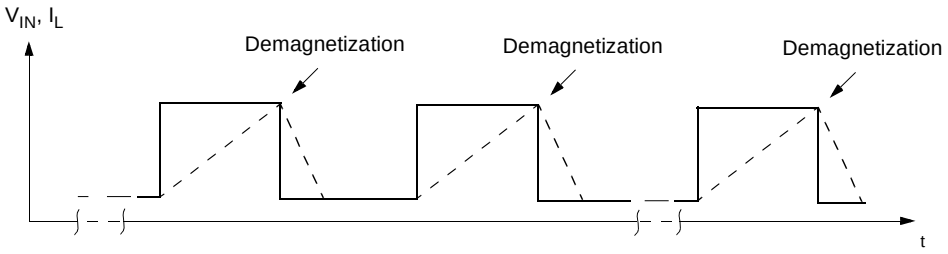
3.3 Maximum demagnetization energy

Figure 26. Maximum turn-off current versus load inductance



A = Single pulse at T_{Jstart} = 150 °C
B = Repetitive pulse at T_{Jstart} = 100 °C
C = Repetitive pulse at T_{Jstart} = 125 °C

Conditions:
V_{CC} = 13.5 V

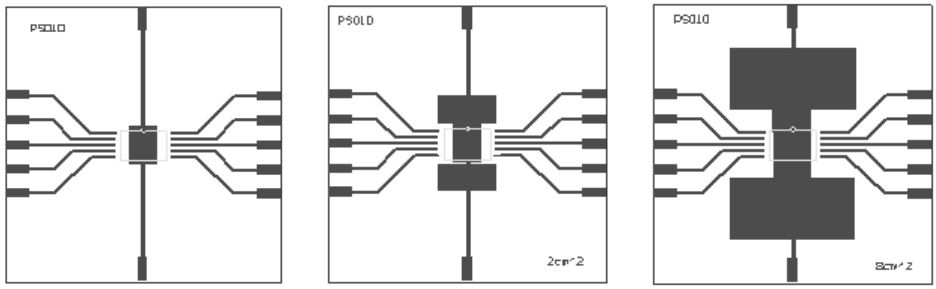


1. Values are generated with R_L=0 Ω
In case of repetitive pulses, T_{jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

4 Package and PCB thermal data

4.1 PowerSO-10 thermal data

Figure 27. PowerSO-10 PC board



1. Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area= 58 mm x 58 mm, PCB thickness = 2 mm, Cu thickness = 35 μm, Copper areas: from minimum pad lay-out to 8 cm^2).

Figure 28. PowerSO-10 $R_{thj\text{-}amb}$ vs PCB copper area in open box free air condition

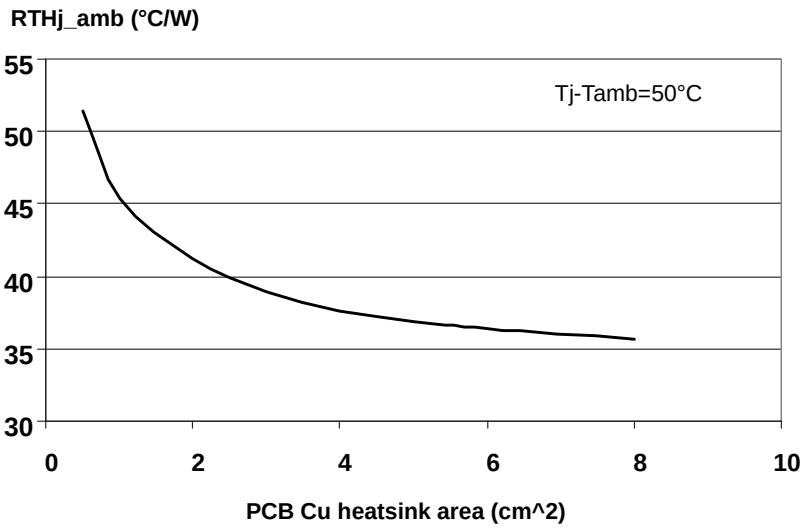


Figure 29. PowerSO-10 thermal impedance junction ambient single pulse

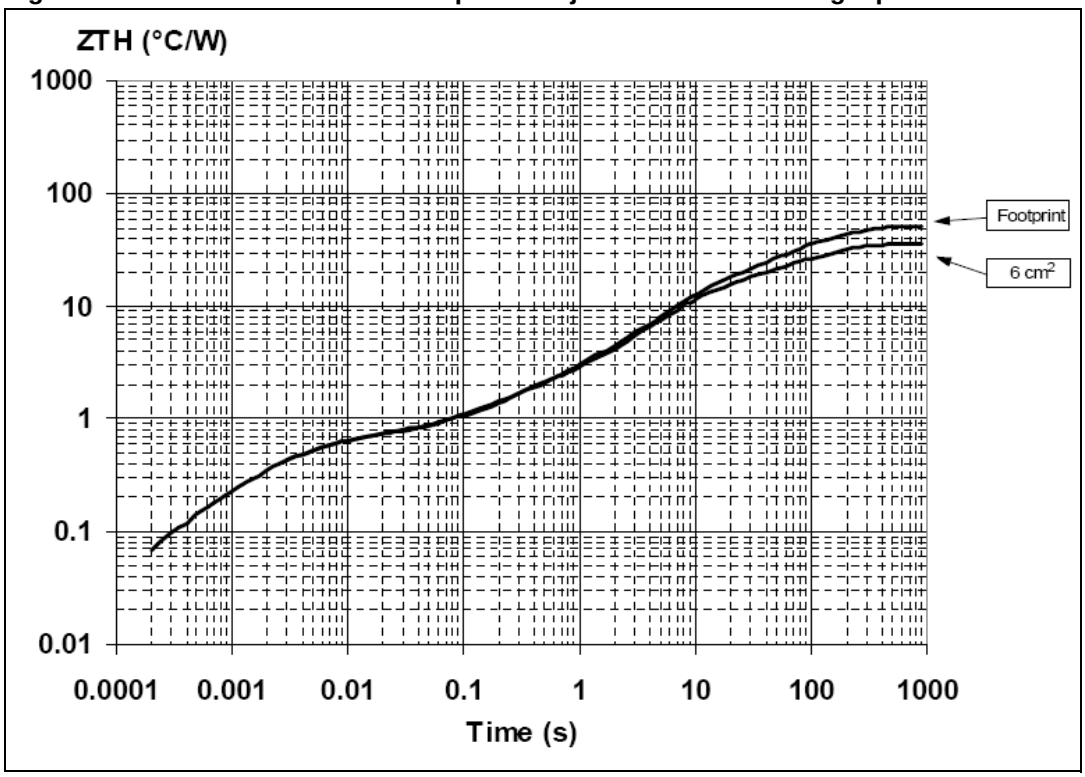
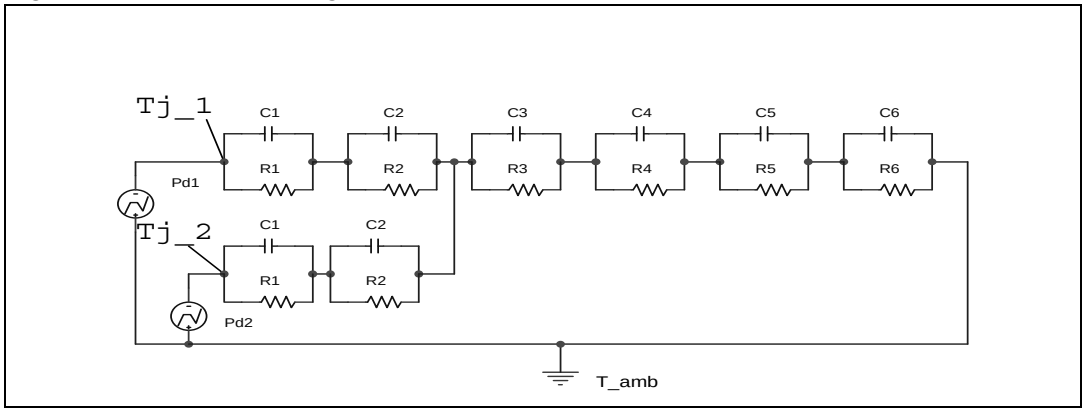


Figure 30. Thermal fitting model of a double channel HSD in PowerSO-10



Equation 1: pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1-\delta)$$

where $\delta = t_p/T$

Table 16. Thermal parameter

Area/island (cm^2)	Footprint	6
R1 (°C/W)	0.35	
R2 (°C/W)	1.8	
R3(°C/W)	1.1	
R4 (°C/W)	0.8	
R5 (°C/W)	12	
R6 (°C/W)	37	22
C1 (W.s/°C)	0.0001	
C2 (W.s/°C)	7E-04	
C3 (W.s/°C)	0.008	
C4 (W.s/°C)	0.3	
C5 (W.s/°C)	0.75	
C6 (W.s/°C)	3	5

5 Package and packing information

5.1 ECOPACK® packages

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.

5.2 PowerSO-10 mechanical data

Figure 31. PowerSO-10 package dimensions

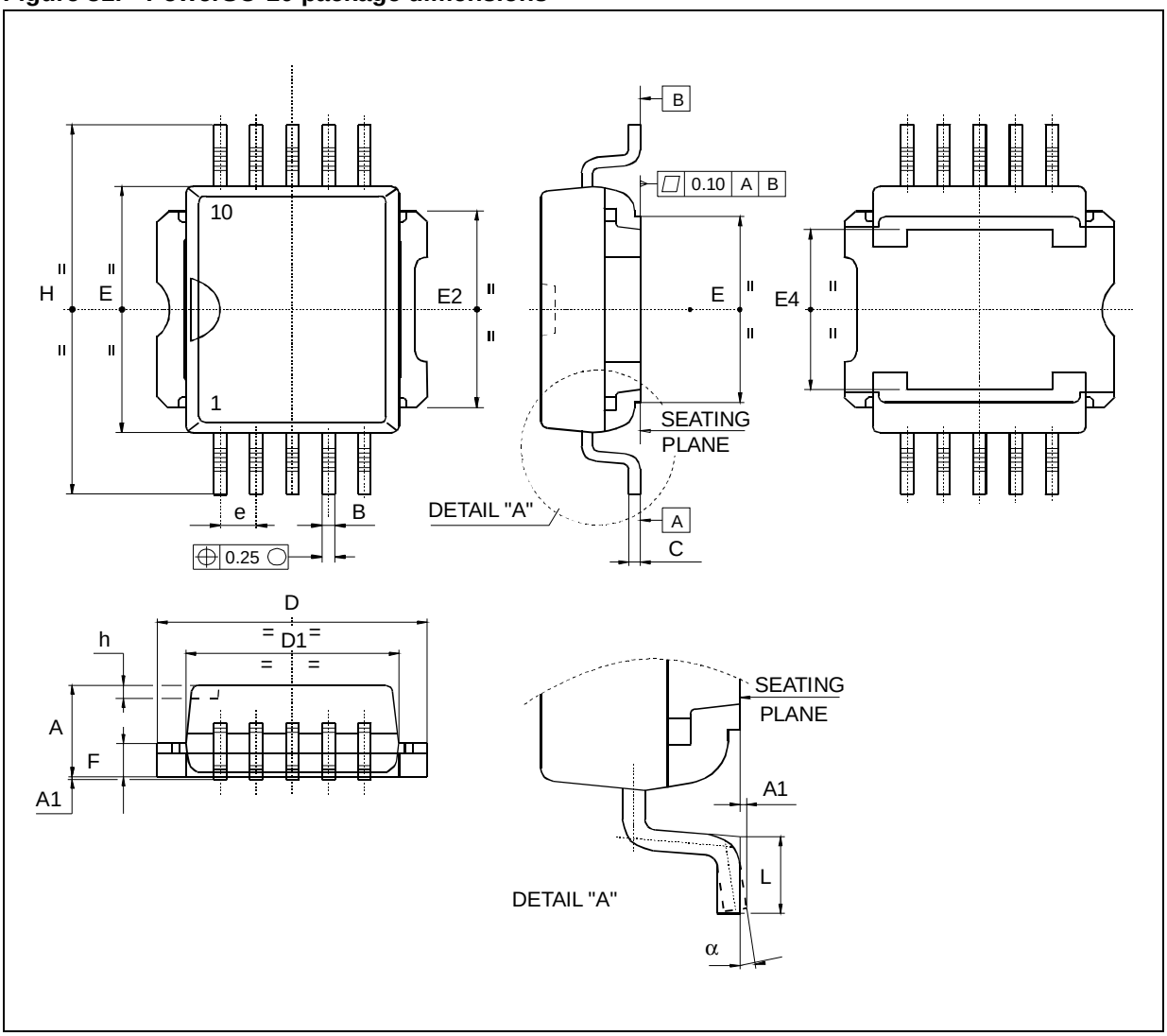


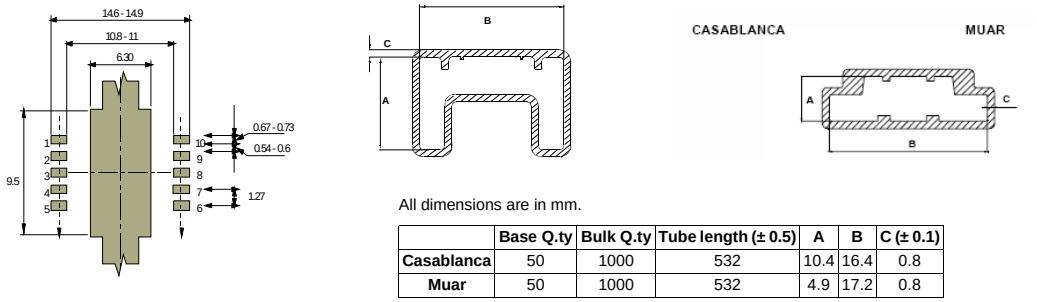
Table 17. PowerSO-10 mechanical data

Symbol	Millimeters		
	Min	Typ	Max
A	3.35		3.65
A(1)	3.4		3.6
A1	0.00		0.10
B	0.40		0.60
B(1)	0.37		0.53
C	0.35		0.55
C(1)	0.23		0.32
D	9.40		9.60
D1	7.40		7.60
E	9.30		9.50
E2	7.20		7.60
E2(1)	7.30		7.50
E4	5.90		6.10
E4(1)	5.90		6.30
e	1.27		
F	1.25		1.35
F(1)	1.20		1.40
H	13.80		14.40
H(1)	13.85		14.35
h	0.50		
L	1.20		1.80
L(1)	0.80		1.10
a	0°		8°
α(1)	2°		8°

1. Muar only POA P013P

5.3 PowerSO-10 packing information

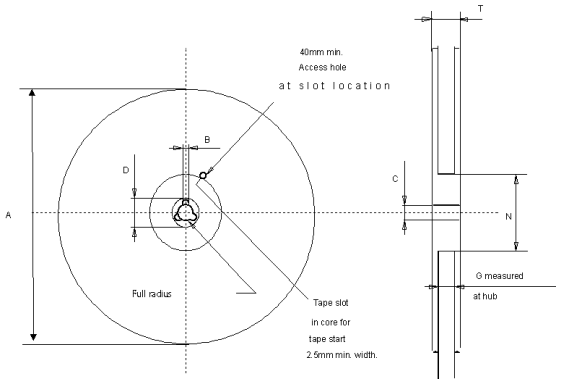
Figure 32. PowerSO-10 suggested pad layout and tube shipment (no suffix)



All dimensions are in mm.

	Base Q.ty	Bulk Q.ty	Tube length (± 0.5)	A	B	C (± 0.1)
Casablanca	50	1000	532	10.4	16.4	0.8
Muar	50	1000	532	4.9	17.2	0.8

Figure 33. Tape and reel shipment (suffix “TR”)



REEL DIMENSIONS

Base Q.ty	600
Bulk Q.ty	600
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	24.4
N (min)	60
T (max)	30.4

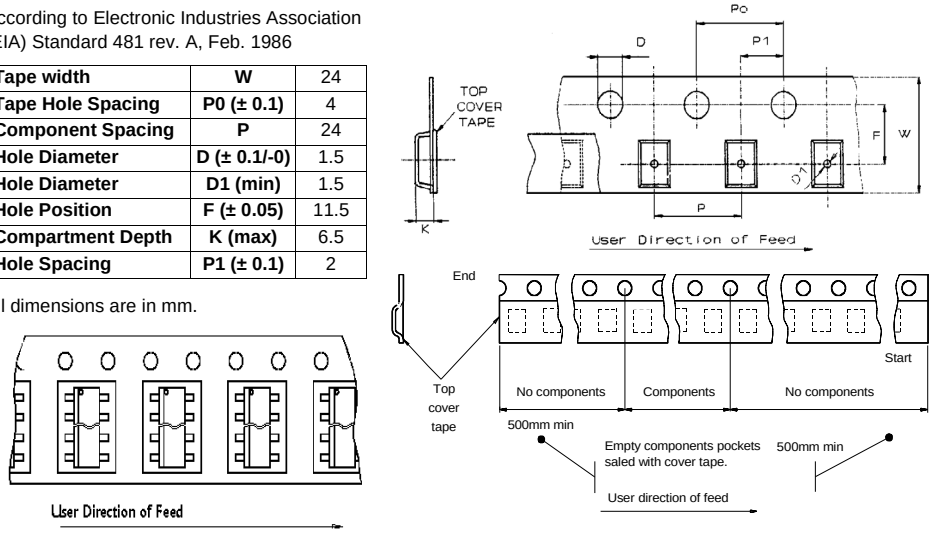
All dimensions are in mm.

TAPE DIMENSIONS

According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

Tape width	**W**	24
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	24
Hole Diameter	**D (± 0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	11.5
Compartment Depth	**K (max)**	6.5
Hole Spacing	**P1 (± 0.1)**	2

All dimensions are in mm.



6 Revision history

Table 18. Document revision history

Date	Revision	Changes
01-Oct-2004	1	Initial release.
25-May-2010	2	Changed document template. Reformatted entire document. Changed *Features* list.
08-Oct-2010	3	Updated following tables: – *Table 6: Protection* – *Table 12: Truth table* – *Table 17: PowerSO-10 mechanical data* Updated *Figure 26: Maximum turn-off current versus load inductance*
19-Sep-2013	4	Updated Disclaimer.

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