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1 Block diagram and pin description

Figure 1. Block diagram

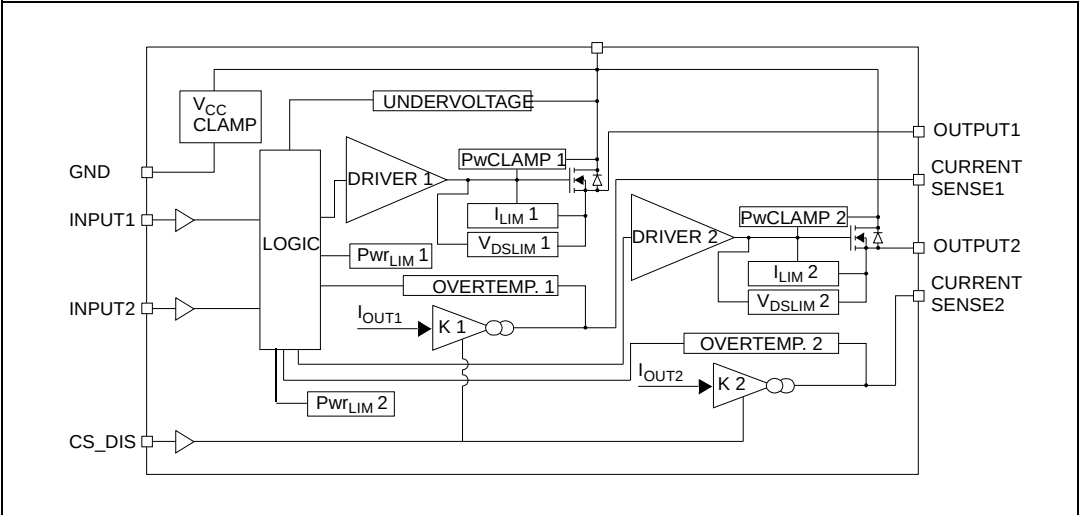


Table 2. Pin functions

Name	Function
V _{CC}	Battery connection
OUTPUT _{1,2}	Power output
GND	Ground connection; must be reverse battery protected by an external diode/resistor network
INPUT _{1,2}	Voltage controlled input pin with hysteresis, CMOS compatible; controls output switch state
CURRENT SENSE _{1,2}	Analog current sense pin; delivers a current proportional to the load current
CS_DIS	Active high CMOS compatible pin to disable the current sense pin

Figure 2. Configuration diagram (top view)

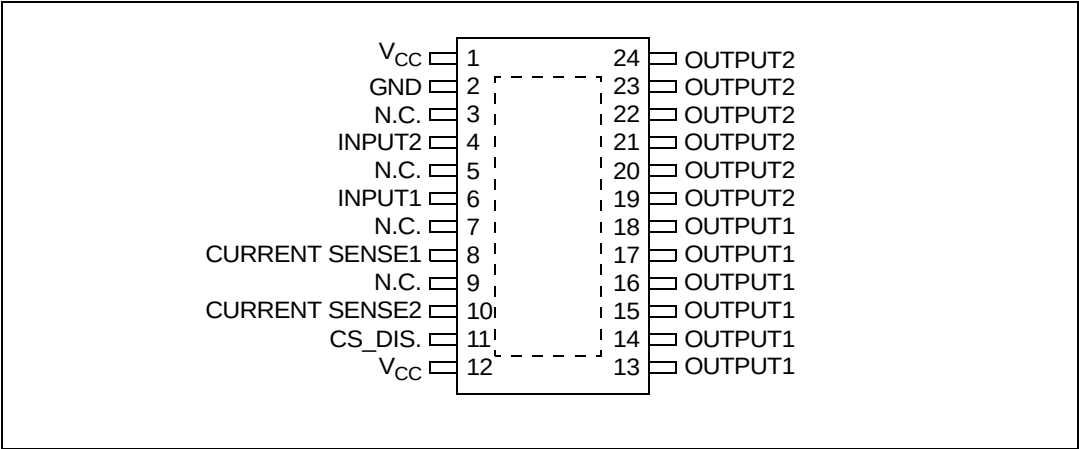


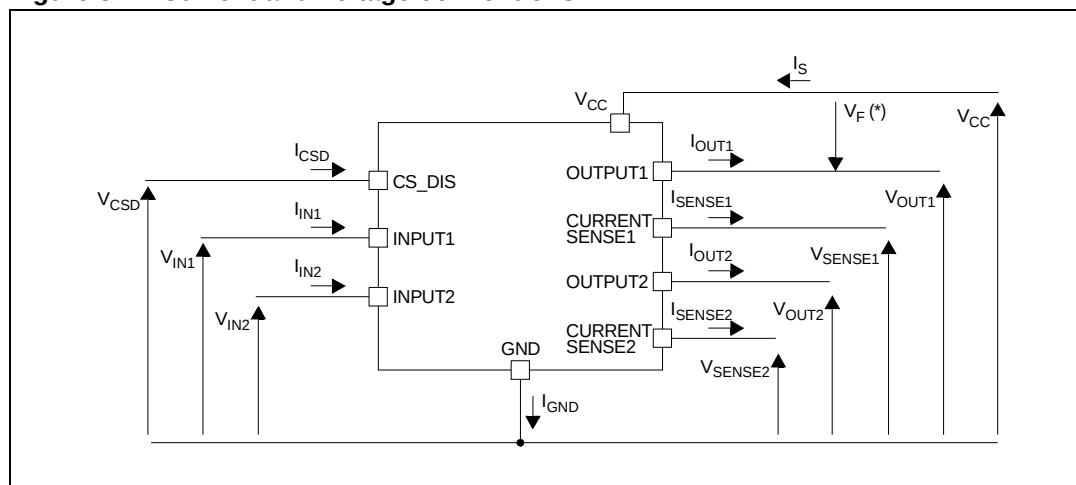
Table 3. Suggested connections for unused and not connected pins

Connection / Pin	Current Sense	N.C.	Output	Input	CS_DIS
Floating	N.R. ⁽¹⁾	X	X	X	X
To ground	Through 1kΩ resistor	X	N.R.	Through 10kΩ resistor	Through 10kΩ resistor

1. Not recommended

2 Electrical characteristics

Figure 3. Current and voltage conventions



Note: $V_{Fn} = V_{OUTn} - V_{CC}$ during reverse battery condition

2.1 Absolute maximum ratings

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	DC supply voltage	41	V
$-V_{CC}$	Reverse DC supply voltage	0.3	
$-I_{GND}$	DC reverse ground pin current	200	mA
I_{OUT}	DC output current	Internally limited	A
$-I_{OUT}$	Reverse DC output current	24	
I_{IN}	DC input current	-1 to 10	mA
I_{CSD}	DC current sense disable input current		
$-I_{CSENSE}$	DC reverse CS pin current		
V_{CSENSE}	Current sense maximum voltage	$V_{CC} - 41$ to $+V_{CC}$	V
$E_{MAX}^{(1)}$	Maximum switching energy (single pulse) ($L = 0.3mH$; $R_L = 0\Omega$; $V_{bat} = 13.5V$; $T_{jstart} = 150^\circ C$; $I_{OUT} = I_{limL}(Typ.)$)	109	mJ
V_{ESD}	Electrostatic Discharge (Human Body Model: $R = 1.5k\Omega$; $C = 100pF$)		
	- Input	4000	V
	- Current sense	2000	V
	- CS_DIS	4000	V
	- Output	5000	V
	- V_{CC}	5000	V

Table 4. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
V_{ESD}	Charge device model (CDM-AEC-Q100-011)	750	V
T_j	Junction operating temperature	-40 to 150	°C
T_{stg}	Storage temperature	-55 to 150	

1. See [Section 3.4](#) for details.

2.2 Thermal data

Table 5. Thermal data

Symbol	Parameter	Max Value	Unit
$R_{thj-case}$	Thermal resistance junction-case (MAX) (with one channel ON)	1.35	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient (MAX)	See Figure 29	

2.3 Electrical characteristics

8V < V_{CC} < 36V; -40°C < T_j < 150°C, unless otherwise specified

Table 6. Power section

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V_{CC}	Operating supply voltage		4.5	13	36	V
V_{USD}	Undervoltage shutdown			3.5	4.5	
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.5		
R_{ON}	On-state resistance ⁽¹⁾	$I_{OUT} = 3A$; $T_j = 25^\circ C$			25	mΩ
		$I_{OUT} = 3A$; $T_j = 150^\circ C$			50	
		$I_{OUT} = 3A$; $V_{CC} = 5V$; $T_j = 25^\circ C$			35	
V_{clamp}	Clamp voltage	$I_S = 20\text{ mA}$	41	46	52	V
I_S	Supply current	Off-state; $V_{CC} = 13V$; $T_j = 25^\circ C$; $V_{IN} = V_{OUT} = V_{SENSE} = V_{CSD} = 0V$		2 ⁽²⁾	5 ⁽²⁾	μA
		On-state; $V_{CC} = 13V$; $V_{IN} = 5V$; $I_{OUT} = 0A$		3	6	mA
$I_{L(off)}$	Off-state output current ⁽¹⁾	$V_{IN} = V_{OUT} = 0V$; $V_{CC} = 13V$; $T_j = 25^\circ C$	0	0.01	3	μA
		$V_{IN} = V_{OUT} = 0V$; $V_{CC} = 13V$; $T_j = 125^\circ C$	0		5	
V_F	Output - V_{CC} diode voltage ⁽¹⁾	$-I_{OUT} = 3A$; $T_j = 150^\circ C$			0.7	V

1. For each channel

2. PowerMOS leakage included

Table 7. Switching ($V_{CC} = 13V$; $T_j = 25^\circ C$)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	$R_L = 4.3\Omega$ (see Figure 8)	-	35	-	μs
$t_{d(off)}$	Turn-off delay time		-	50	-	
$(dV_{OUT}/dt)_{on}$	Turn-on voltage slope	$R_L = 4.3\Omega$	-	(see Figure 21)	-	$V/\mu s$
$(dV_{OUT}/dt)_{off}$	Turn-off voltage slope		-	(see Figure 10)	-	
W_{ON}	Switching energy losses during tW_{ON}	$R_L = 4.3\Omega$ (see Figure 8)	-	0.45	-	mJ
W_{OFF}	Switching energy losses during tW_{OFF}		-	0.35	-	

Table 8. Logic input

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V_{IL}	Input low level voltage				0.9	V
I_{IL}	Low level input current	$V_{IN} = 0.9V$	1			μA
V_{IH}	Input high level voltage		2.1			V
I_{IH}	High level input current	$V_{IN} = 2.1V$			10	μA
$V_{I(hyst)}$	Input hysteresis voltage		0.25			V
V_{ICL}	Input clamp voltage	$I_{IN} = 1mA$	5.5		7	
		$I_{IN} = -1mA$		-0.7		
V_{CSDL}	CS_DIS low level voltage				0.9	
I_{CSDL}	Low level CS_DIS current	$V_{CSD} = 0.9V$	1			μA
V_{CSDH}	CS_DIS high level voltage		2.1			V
I_{CSDH}	High level CS_DIS current	$V_{CSD} = 2.1V$			10	μA
$V_{CSD(hyst)}$	CS_DIS hysteresis voltage		0.25			V
V_{CSCL}	CS_DIS clamp voltage	$I_{CSD} = 1mA$	5.5		7	
		$I_{CSD} = -1mA$		-0.7		

Table 9. Protections and diagnostics⁽¹⁾

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I_{LIMH}	DC short circuit current	$V_{CC} = 13V$				A
		$5V < V_{CC} < 36V$				
I_{LIML}	Short circuit current during thermal cycling	$V_{CC} = 13V$; $T_R < T_j < T_{TSD}$				

Table 9. Protections and diagnostics⁽¹⁾ (continued)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature		$T_{RS} + 1$	$T_{RS} + 5$		
T_{RS}	Thermal reset of STATUS		135			
T_{HYST}	Thermal hysteresis ($T_{TSD} - T_R$)			7		
V_{DEMAG}	Turn-off output voltage clamp	$I_{OUT} = 2A$; $V_{IN} = 0$; $L = 6mH$	$V_{CC} - 41$	$V_{CC} - 46$	$V_{CC} - 52$	V
V_{ON}	Output voltage drop limitation	$I_{OUT} = 0.2A$; $T_j = -40^{\circ}C$ to $150^{\circ}C$ (see Figure 9)				mV

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 10. Current sense ($8V < V_{CC} < 16V$)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
K_{LED}	I_{OUT}/I_{SENSE}	$I_{OUT} = 0.05A$; $V_{SENSE} = 0.5V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ to $150^{\circ}C$	1450	3300	5180	
K_0	I_{OUT}/I_{SENSE}	$I_{OUT} = 0.5A$; $V_{SENSE} = 0.5V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ to $150^{\circ}C$		3020	4360	
K_1	I_{OUT}/I_{SENSE}	$I_{OUT} = 2A$; $V_{SENSE} = 4V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ $T_j = 25^{\circ}C$ to $150^{\circ}C$	1940 2230	2810 2810	3740 3390	
$dK_1/K_1^{(1)}$	Current sense ratio drift	$I_{OUT} = 2A$; $V_{SENSE} = 4V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ to $150^{\circ}C$	-10		+10	%
K_2	I_{OUT}/I_{SENSE}	$I_{OUT} = 3A$; $V_{SENSE} = 4V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ $T_j = 25^{\circ}C$ to $150^{\circ}C$	2250 2400	2790 2790	3450 3180	
$dK_2/K_2^{(1)}$	Current sense ratio drift	$I_{OUT} = 3A$; $V_{SENSE} = 4V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ to $150^{\circ}C$	-7		+7	%
K_3	I_{OUT}/I_{SENSE}	$I_{OUT} = 10A$; $V_{SENSE} = 4V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ $T_j = 25^{\circ}C$ to $150^{\circ}C$	2610 2650	2760 2760	2970 2870	
$dK_3/K_3^{(1)}$	Current sense ratio drift	$I_{OUT} = 10A$; $V_{SENSE} = 4V$; $V_{CSD} = 0V$; $T_j = -40^{\circ}C$ to $150^{\circ}C$	-3		+3	%

Table 10. Current sense (8V < V_{CC} < 16V) (continued)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I _{SENSE0}	Analog sense leakage current	I _{OUT} = 0A; V _{SENSE} = 0V; V _{CSD} = 5V; V _{IN} = 0V; T _j = -40°C to 150°C	0		1	μA
		V _{CSD} = 0V; V _{IN} = 5V; T _j = -40°C to 150°C	0		2	μA
		I _{OUT} = 2A; V _{SENSE} = 0V; V _{CSD} = 5V; V _{IN} = 5V; T _j = -40°C to 150°C	0		1	μA
V _{SENSE}	Max analog sense output voltage	I _{OUT} = 3A; V _{CSD} = 0V	5			V
V _{SENSEH}	Analog sense output voltage in overtemperature condition	V _{CC} = 13V; R _{SENSE} = 3.9kΩ		9		
I _{SENSEH}	Analog sense output current in overtemperature condition	V _{CC} = 13V; V _{SENSE} = 5V		8		mA
t _{DSENSE1H}	Delay response time from falling edge of CS_DIS pin	V _{SENSE} < 4V, 0.5 < I _{OUT} < 10A I _{SENSE} = 90% of I _{SENSEMAX} (see Figure 4)		50	100	μs
t _{DSENSE1L}	Delay response time from rising edge of CS_DIS pin	V _{SENSE} < 4V, 0.5 < I _{OUT} < 10A I _{SENSE} = 10% of I _{SENSEMAX} (see Figure 4)		5	20	
t _{DSENSE2H}	Delay response time from rising edge of INPUT pin	V _{SENSE} < 4V, 0.5 < I _{OUT} < 10A I _{SENSE} = 90% of I _{SENSEMAX} (see Figure 4)		70	300	
Δt _{DSENSE2H}	Delay response time between rising edge of output current and rising edge of current sense	V _{SENSE} < 4V, I _{SENSE} = 90% of I _{SENSEMAX} , I _{OUT} = 90% of I _{OUTMAX} , I _{OUTMAX} = 3A (see Figure 5)			110	
t _{DSENSE2L}	Delay response time from falling edge of INPUT pin	V _{SENSE} < 4V, 0.5 < I _{OUT} < 10A I _{SENSE} = 10% of I _{SENSEMAX} (see Figure 4)		100	250	

1. Parameter guaranteed by design; it is not tested.

Figure 4. Current sense delay characteristics

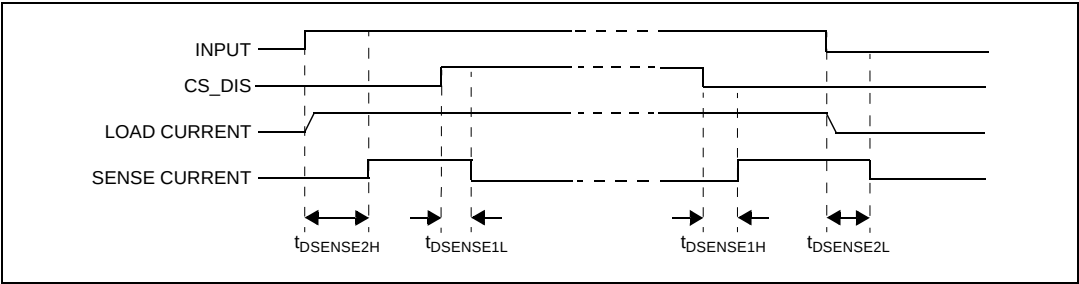


Figure 5. Delay response time between rising edge of output current and rising edge of current sense (CS enabled)

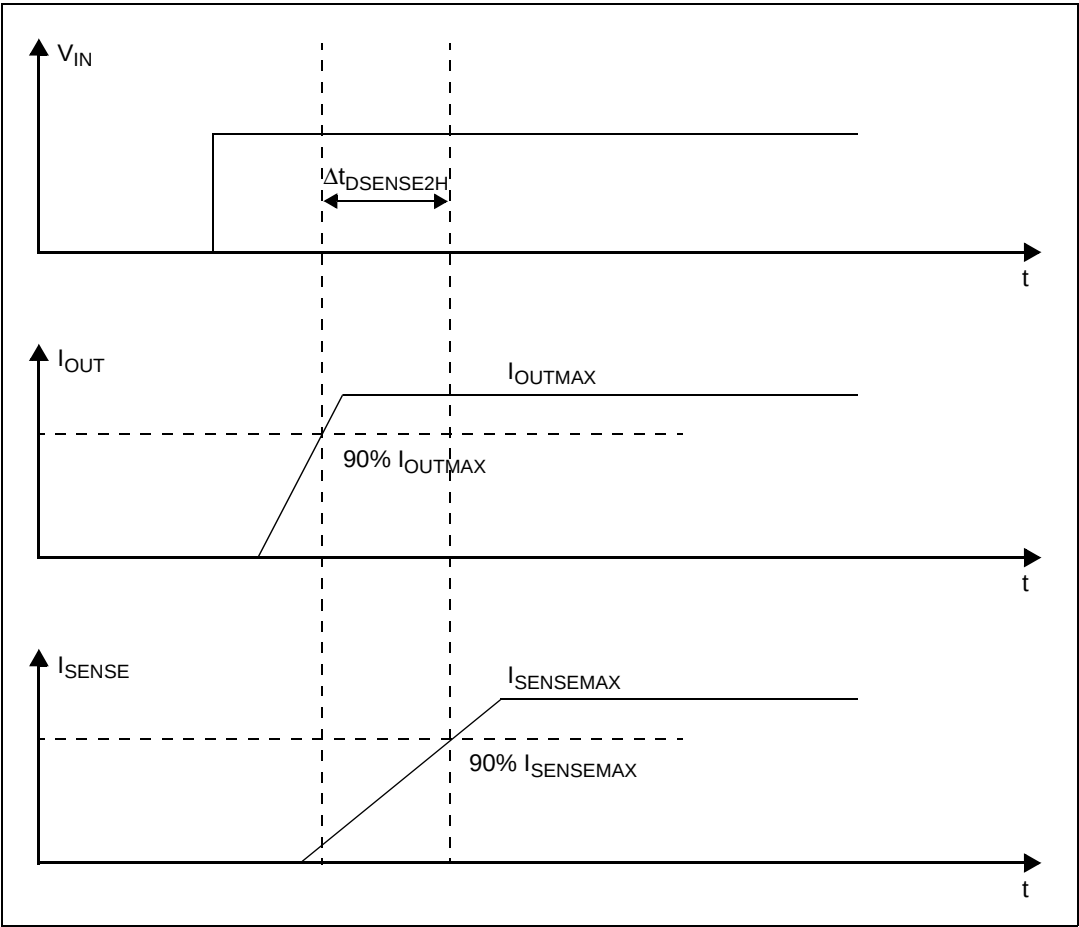
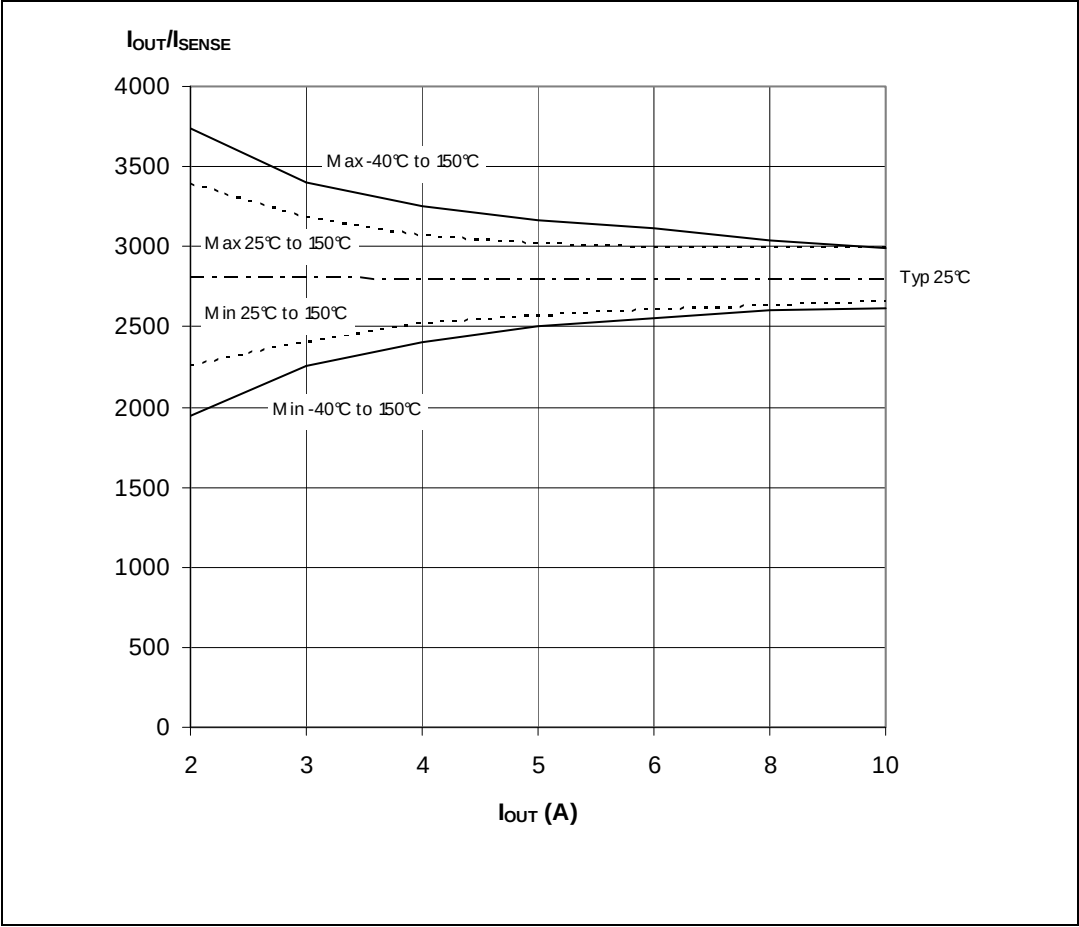


Figure 6. I_{OUT}/I_{SENSE} vs $I_{OUT}^{(1)}$



1. See [Table 9](#) for details.

Figure 7. Maximum current sense ratio drift vs load current

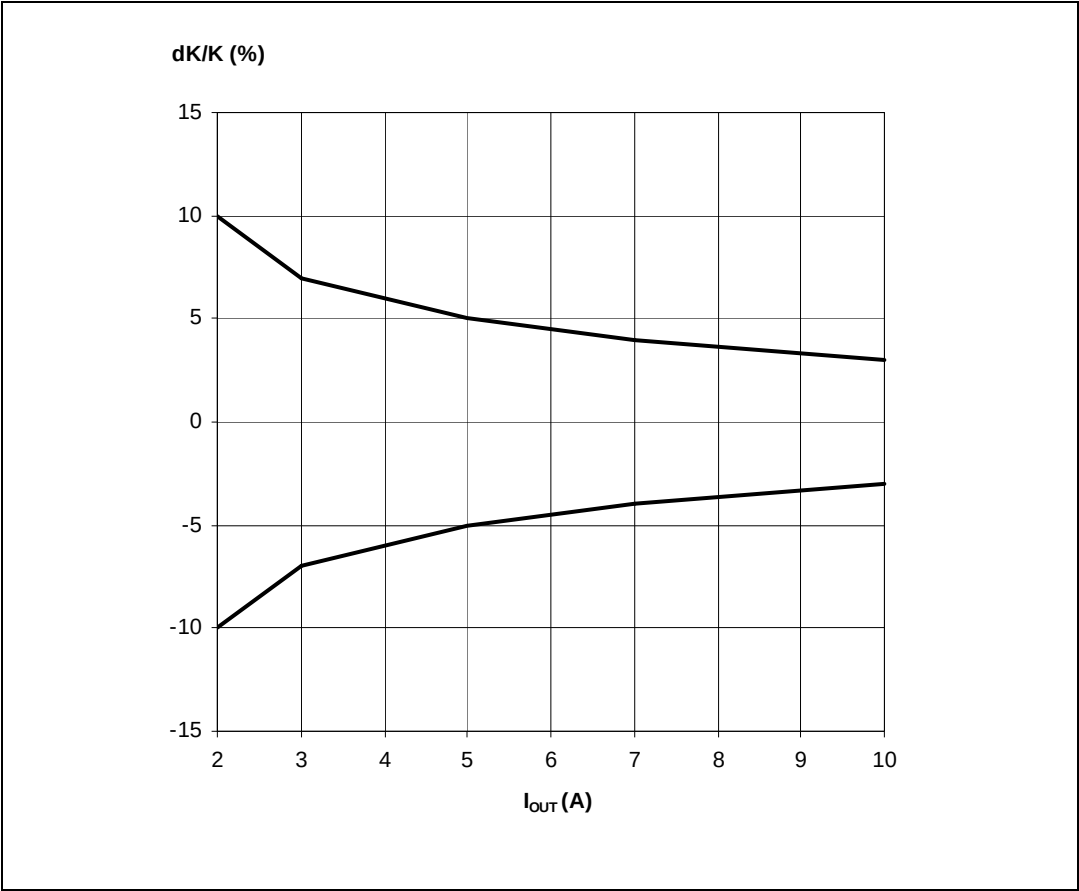


Table 11. Truth table

Conditions	Input	Output	Sense ($V_{CSD} = 0V$) ⁽¹⁾
Normal operation	L	L	0
	H	H	Nominal
Overtemperature	L	L	0
	H		V_{SENSEH}
Undervoltage	L	L	0
	H		
Short circuit to GND ($R_{SC} \leq 10m\Omega$)	L	L	0
	H		0 if $T_j < T_{TSD}$
			V_{SENSEH} if $T_j > T_{TSD}$
Short circuit to V_{CC}	L	H	0
	H		< Nominal
Negative output voltage clamp	L	L	0

1. If the V_{CSD} is high, the SENSE output is at a high impedance; its potential depends on leakage currents and external circuit.

Figure 8. Switching characteristics

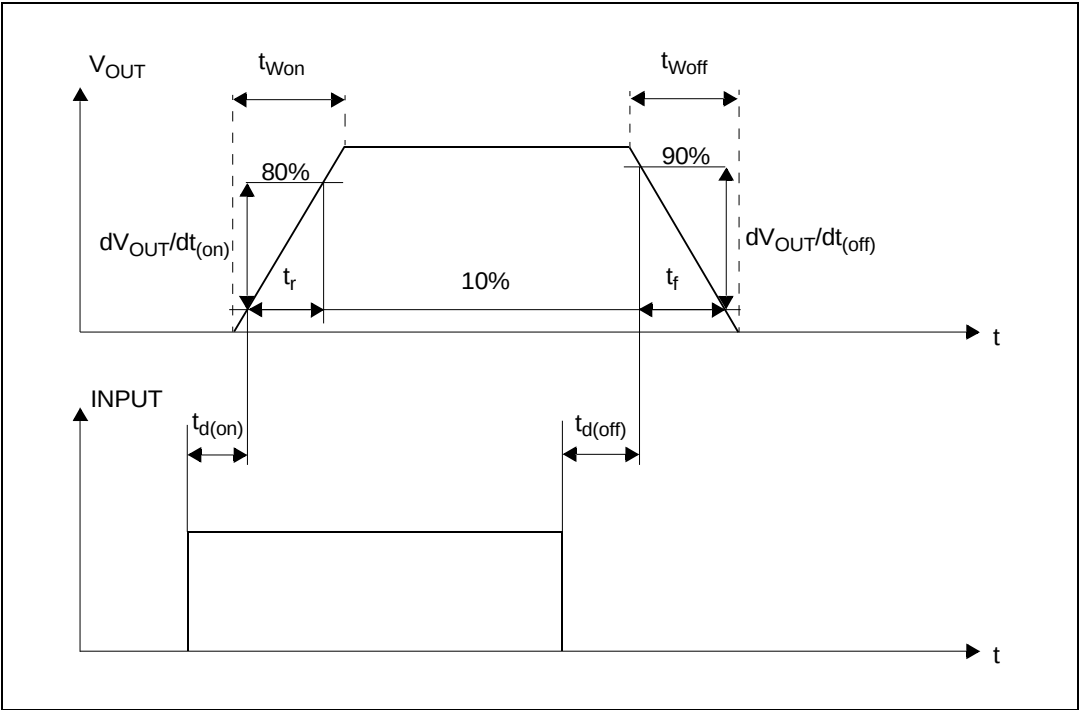


Figure 9. Output voltage drop limitation

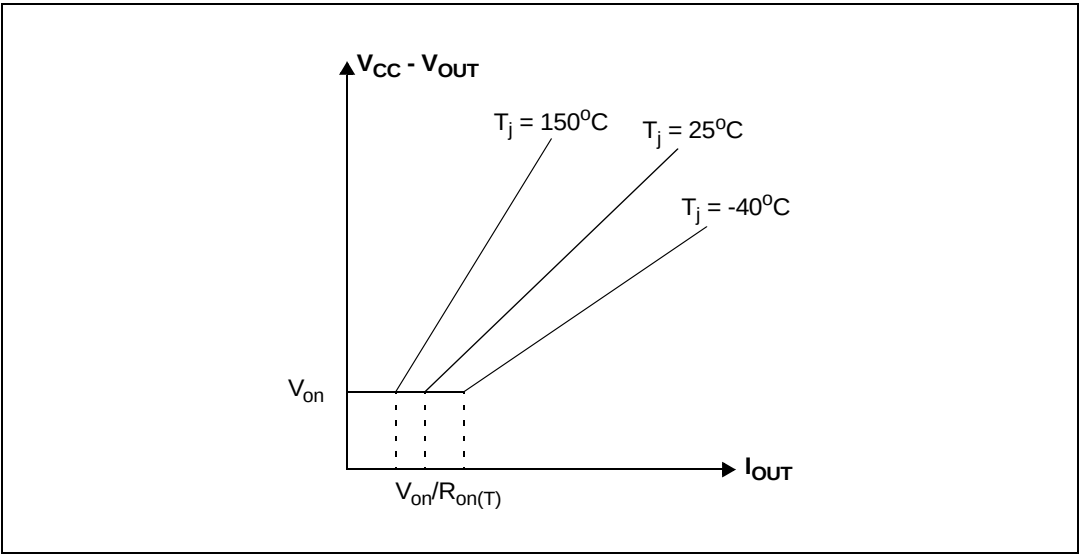


Table 12. Electrical transient requirements (part 1/3)

ISO 7637-2: 2004(E) Test pulse	Test levels ⁽¹⁾		Number of pulses or test times	Burst cycle/pulse repetition time		Delays and Impedance
	III	IV		Min	Max	
1	-75V	-100V	5000 pulses	0.5s	5s	2ms, 10Ω
2a	+37V	+50V	5000 pulses	0.2s	5s	50μs, 2Ω
3a	-100V	-150V	1h	90ms	100ms	0.1μs, 50Ω
3b	+75V	+100V	1h	90ms	100ms	0.1μs, 50Ω
4	-6V	-7V	1 pulse			100ms, 0.01Ω
5b ⁽²⁾	+65V	+87V	1 pulse			400ms, 2Ω

1. The above test levels must be considered referred to $V_{CC} = 13.5V$ except for pulse 5b.

2. Valid in case of external load dump clamp: 40V maximum referred to ground.

Table 13. Electrical transient requirements (part 2/3)

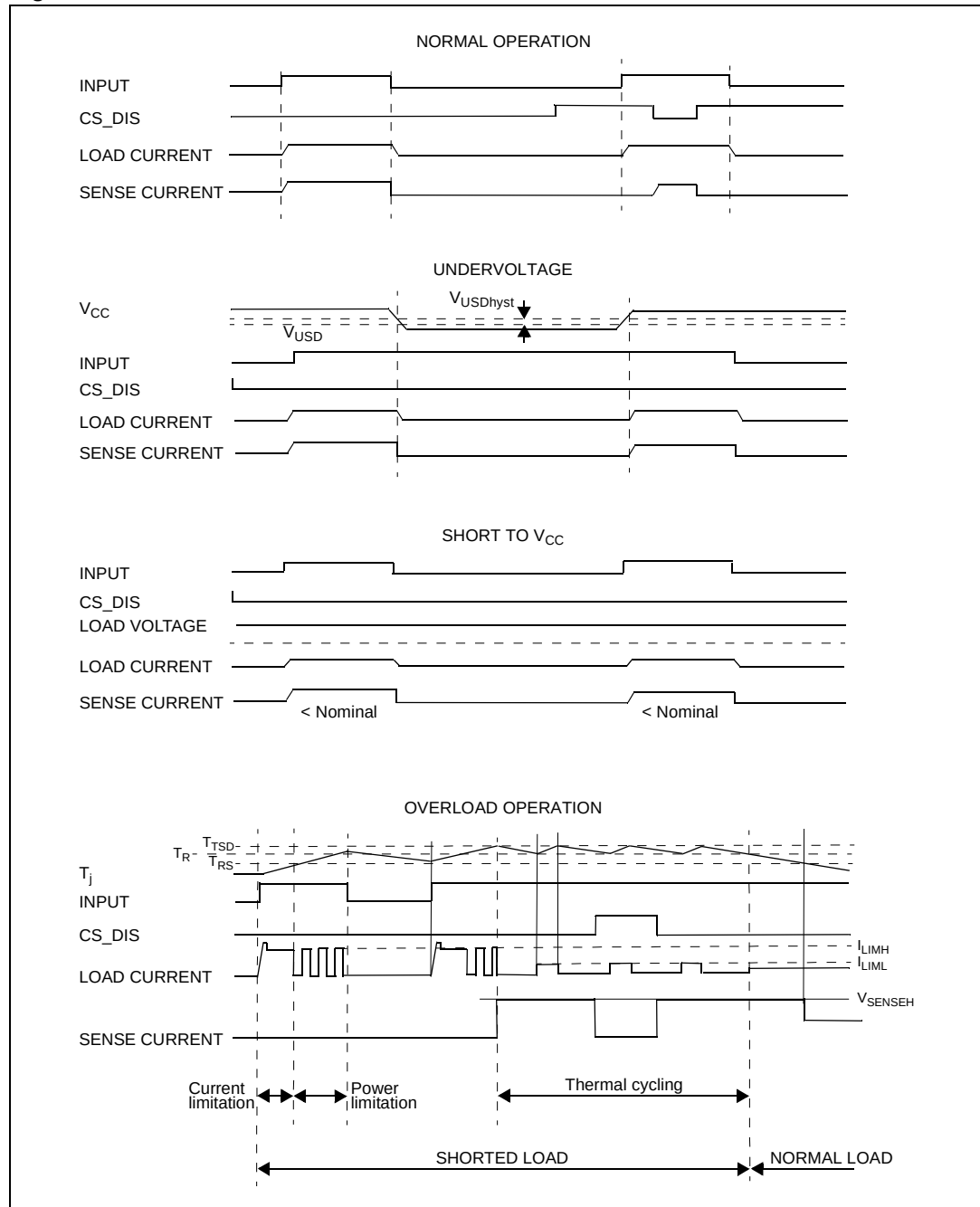
ISO 7637-2: 2004E Test pulse	Test level results	
	III	VI
1	C	C
2a	C	C
3a	C	C
3b	C	C
4	C	C
5b ⁽¹⁾	C	C

1. Valid in case of external load dump clamp: 40V maximum referred to ground.

Table 14. Electrical transient requirements (part 3/3)

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

Figure 10. Waveforms



2.4 Electrical characteristics curves

Figure 11. Off-state output current

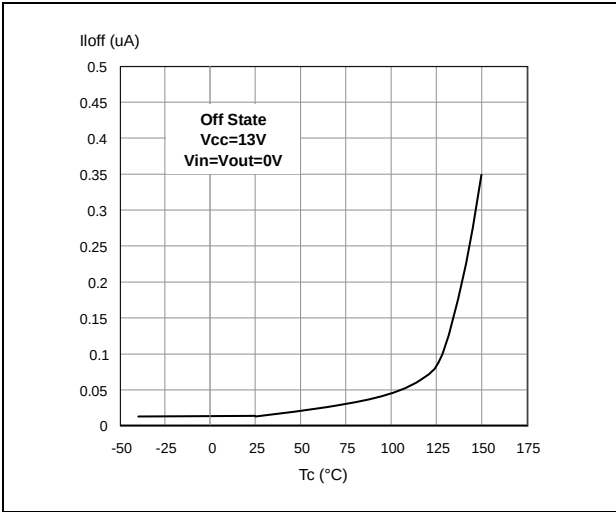


Figure 12. High level input current

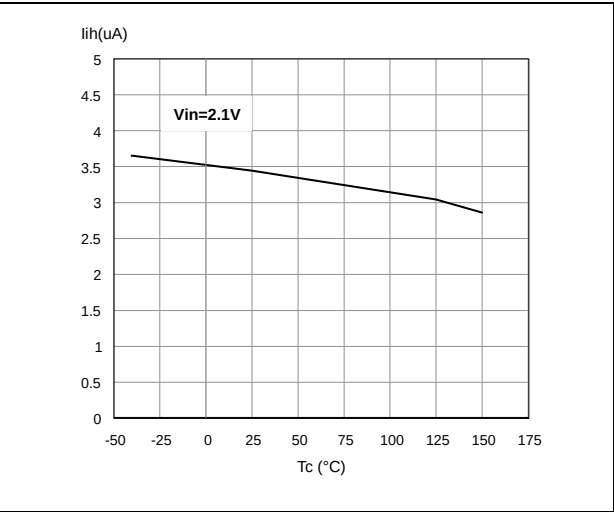


Figure 13. Input clamp voltage

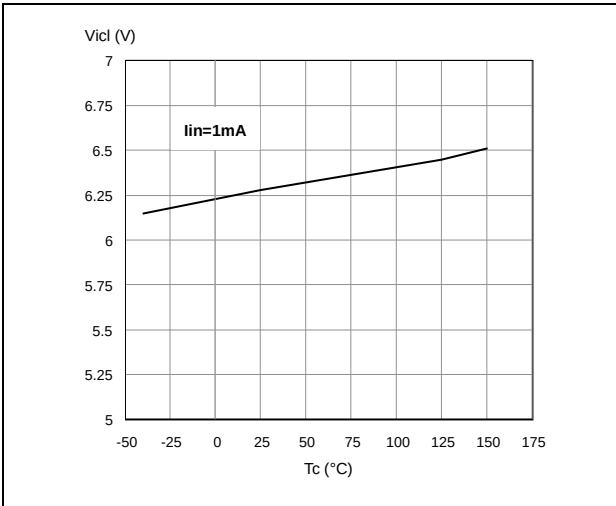


Figure 14. Input high level

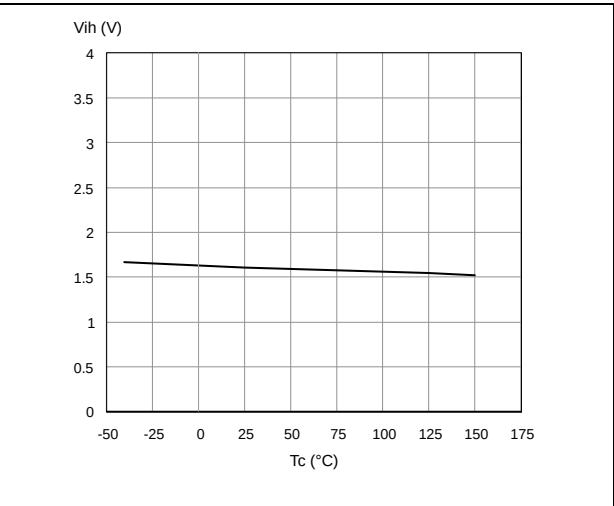


Figure 15. Input low level

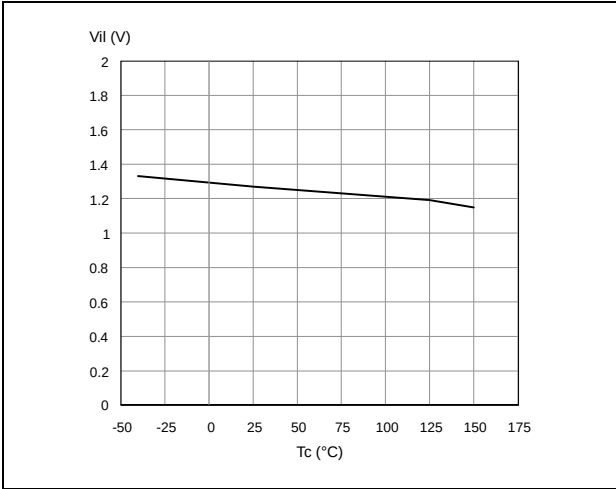


Figure 16. Input hysteresis voltage

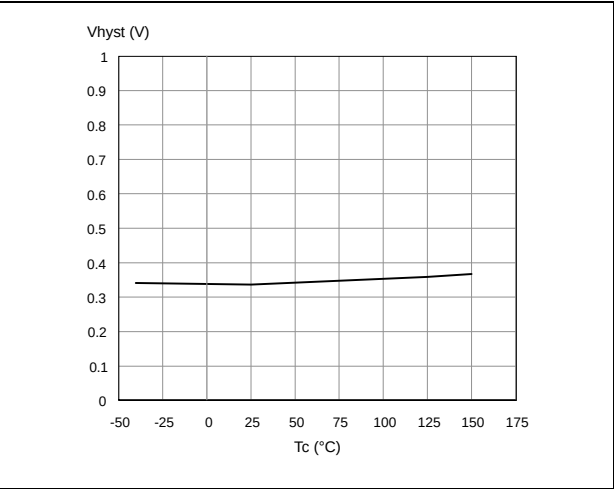


Figure 17. On-state resistance vs T_{case}

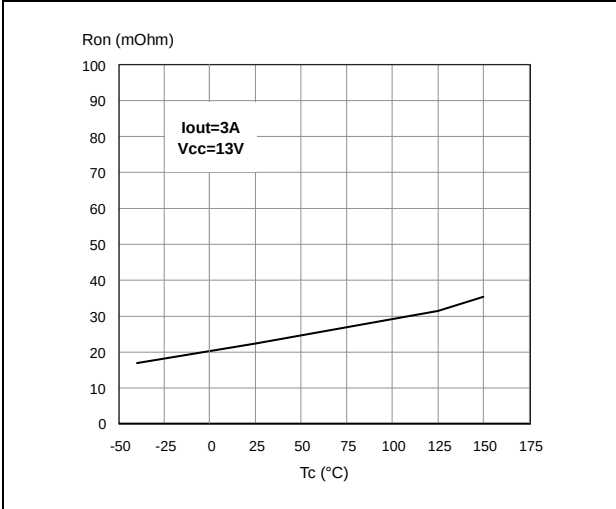


Figure 18. On-state resistance vs V_{CC}

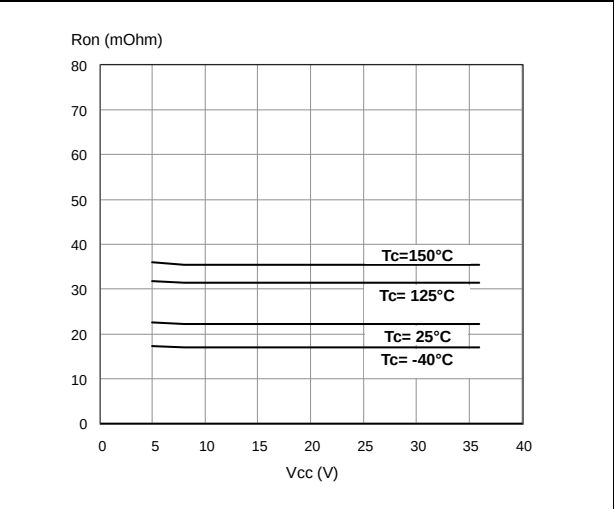


Figure 19. Undervoltage shutdown

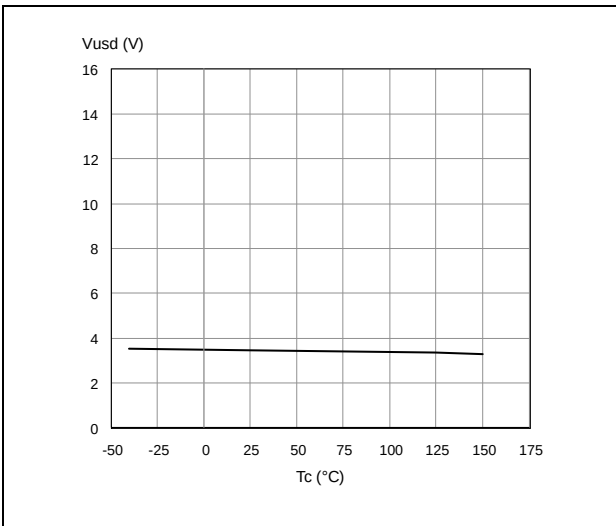


Figure 20. I_{LIMH} vs T_{case}

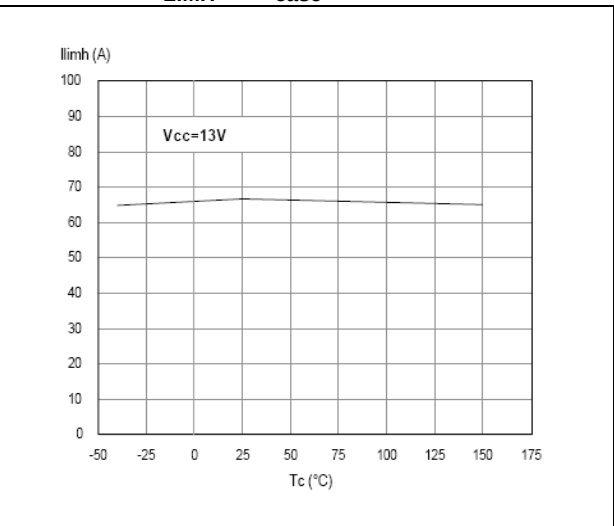


Figure 21. Turn-on voltage slope

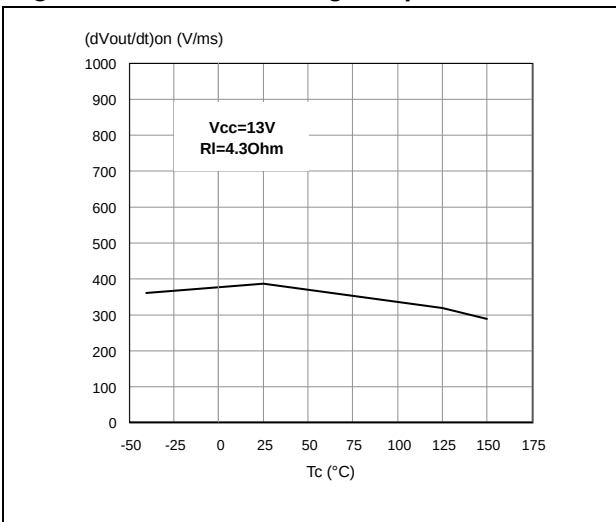


Figure 22. Turn-off voltage slope

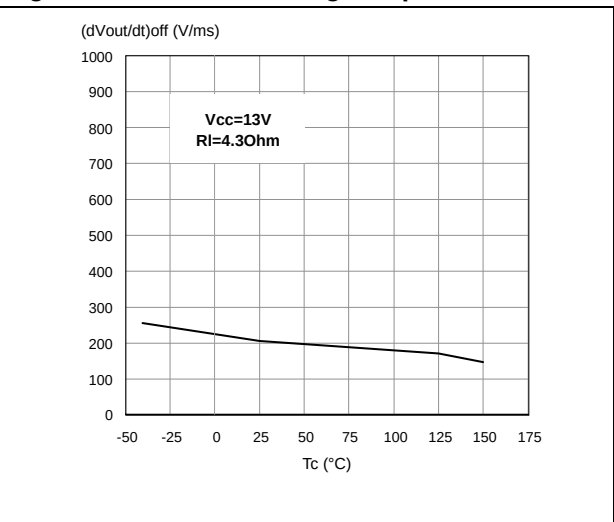


Figure 23. CS_DIS high level voltage

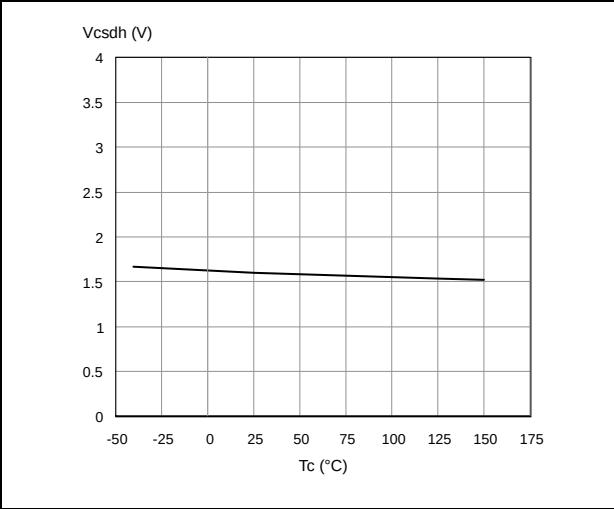


Figure 24. CS_DIS low level voltage

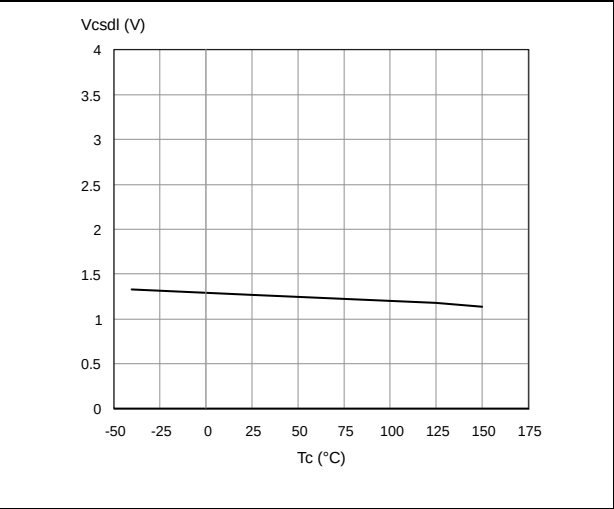
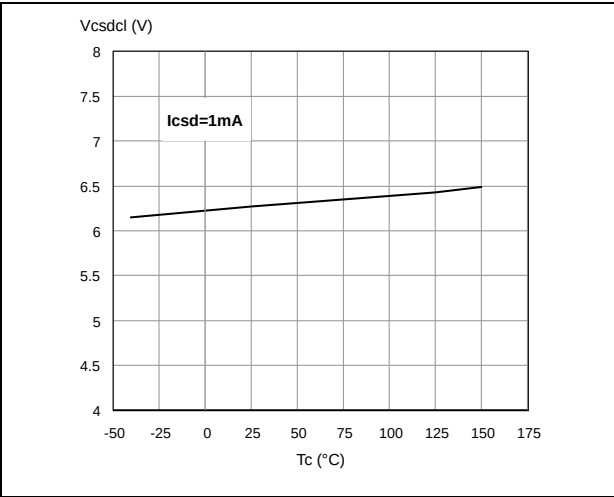
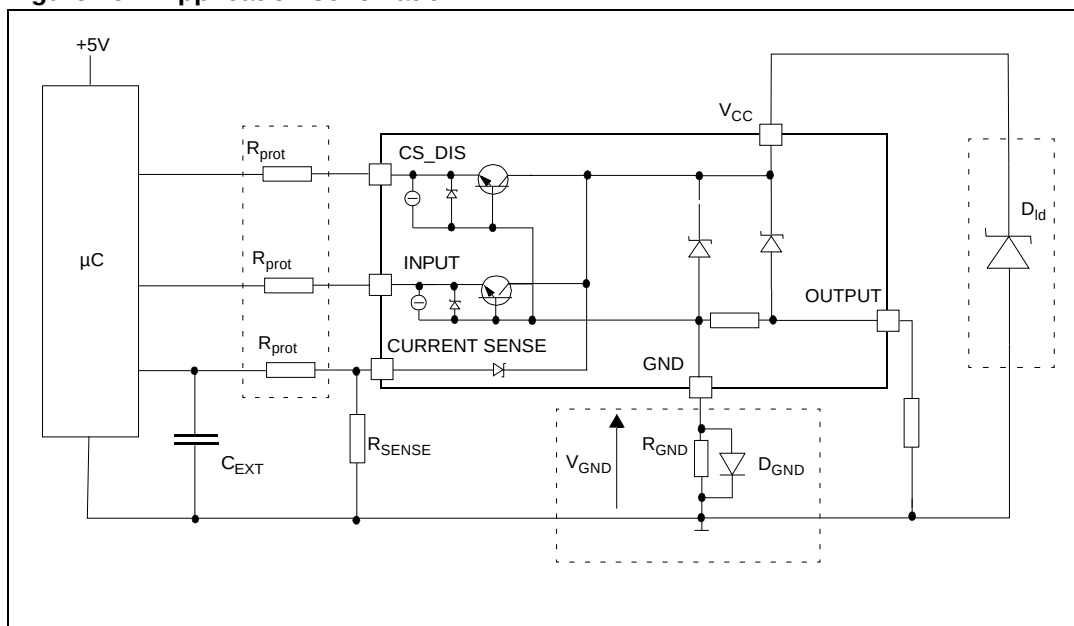


Figure 25. CS_DIS clamp voltage



3 Application information

Figure 26. Application schematic⁽¹⁾



1. Channel 2 has the same internal circuit as channel 1

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: Resistor in the ground line (R_{GND} only)

This first solution can be used with any type of load.

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

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

where $-I_{\text{GND}}$ is the DC reverse ground pin current and can be found in the absolute maximum rating section of the device 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 among several different HSDs. Please note that the value of this resistor is 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 shared by the device ground, 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 leads to a large resistor or several devices have to share the same resistor, then ST suggests to utilize the following Solution 2.

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

If the device drives an inductive load, insert a resistor ($R_{GND} = 1k\Omega$) in parallel to D_{GND} .

This small signal diode can be safely shared among several different HSDs. Also in this case, the presence of the ground network produces a shift ($\approx 600mV$) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift does not vary if more than one HSD shares the same diode/resistor network.

3.2 Load dump protection

D_{ld} is necessary (Voltage Transient Suppressor) if the load dump peak voltage exceeds the V_{CC} maximum DC rating. The same applies if the device is subject to transients on the V_{CC} line that are greater than the ones shown in the ISO 7637-2:2004E table.

3.3 Microcontroller I/Os protection

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

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

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

Calculation example:

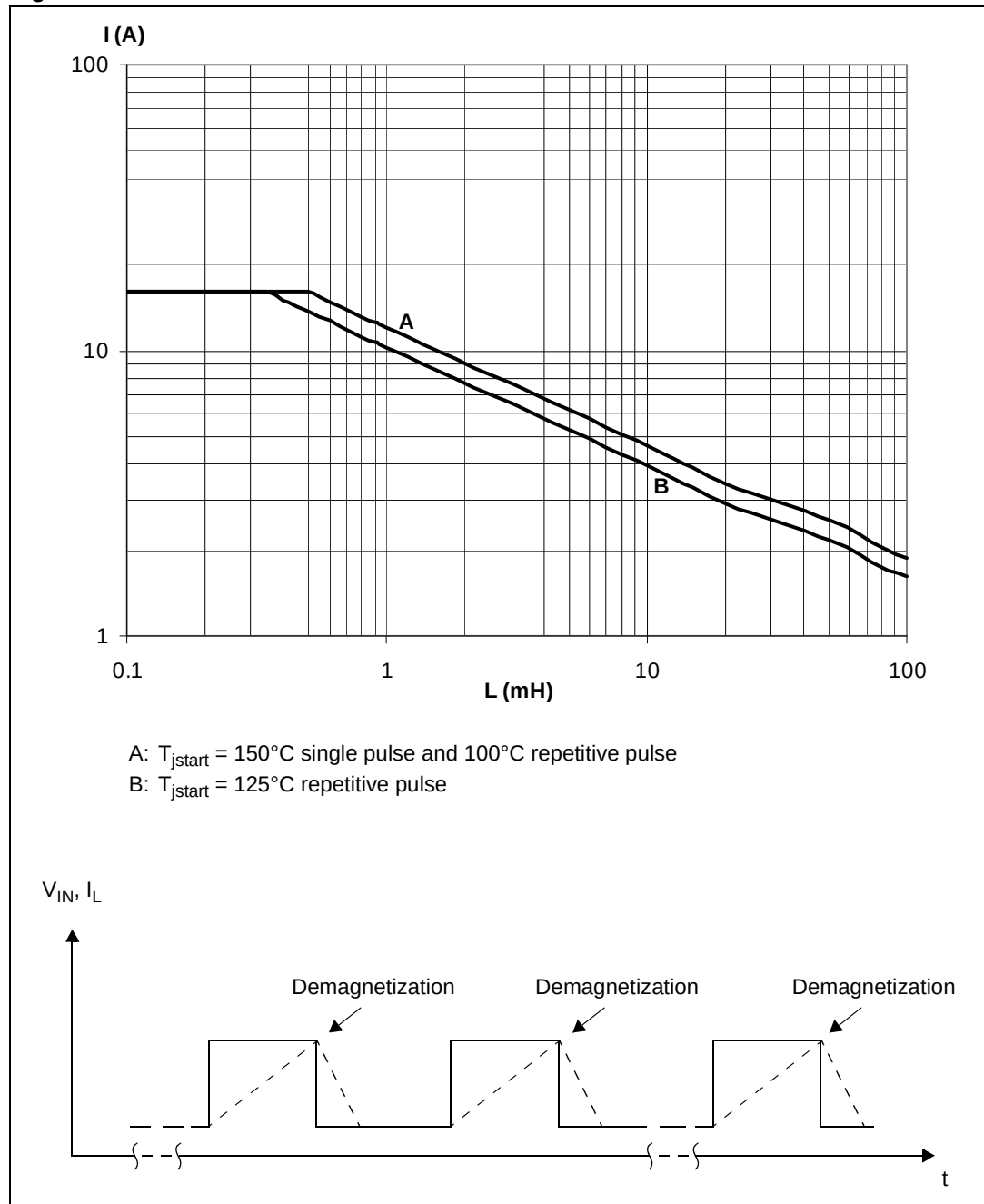
For $V_{CCpeak} = -100V$ and $I_{latchup} \geq 20mA$; $V_{OH\mu C} \geq 4.5V$

$$5k\Omega \leq R_{prot} \leq 65k\Omega$$

Recommended values: $R_{prot} = 10k\Omega$, $C_{EXT} = 10nF$

3.4 Maximum demagnetization energy ($V_{CC} = 13.5V$)

Figure 27. Maximum turn-off current versus inductance⁽¹⁾

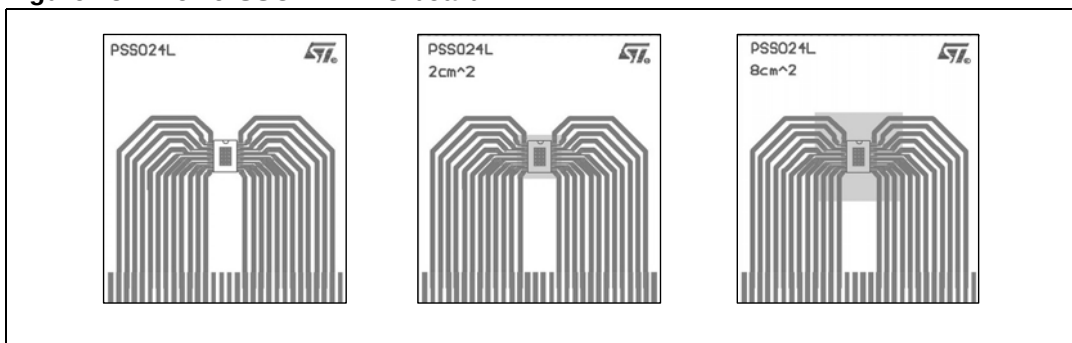


1. Values are generated with $R_L = 0\Omega$. In case of repetitive pulses, T_{jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

4 Package and thermal data

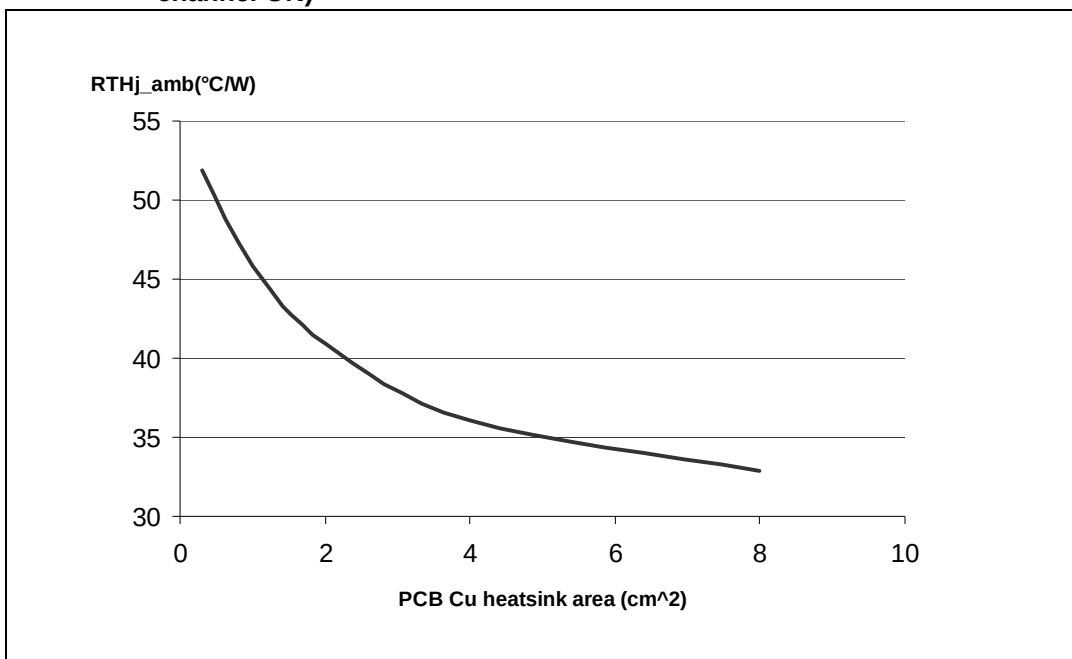
4.1 PowerSSO-24™ thermal data

Figure 28. PowerSSO-24™ PC board⁽¹⁾



1. Layout condition of R_{th} and Z_{th} measurements (PCB: Double layer, Thermal Vias, FR4 area = 77mm x 86mm, PCB thickness = 1.6mm, Cu thickness = 70μm (front and back side), Copper areas: from minimum pad layout to 8cm²).

Figure 29. $R_{thj-amb}$ vs PCB copper area in open box free air condition (with one channel ON)



Equation 1: pulse calculation formula

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

where $\delta = t_p/T$

Figure 30. PowerSSO-24™ thermal impedance junction to ambient single pulse (with one channel ON)

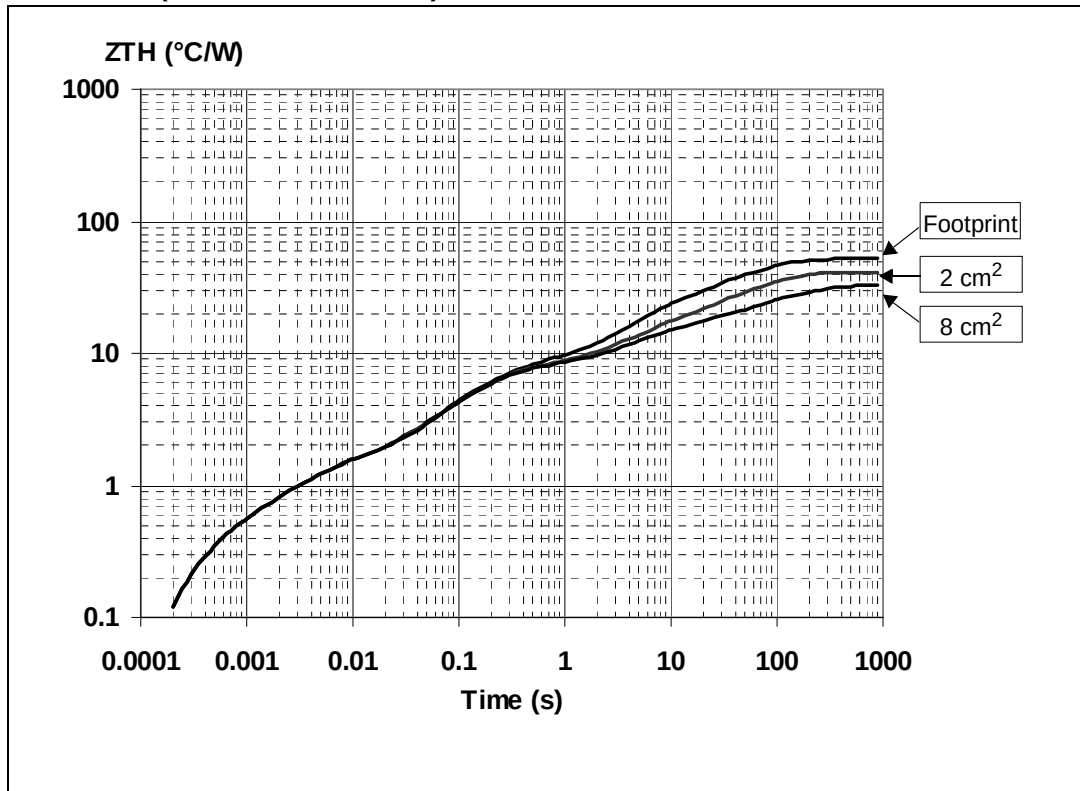
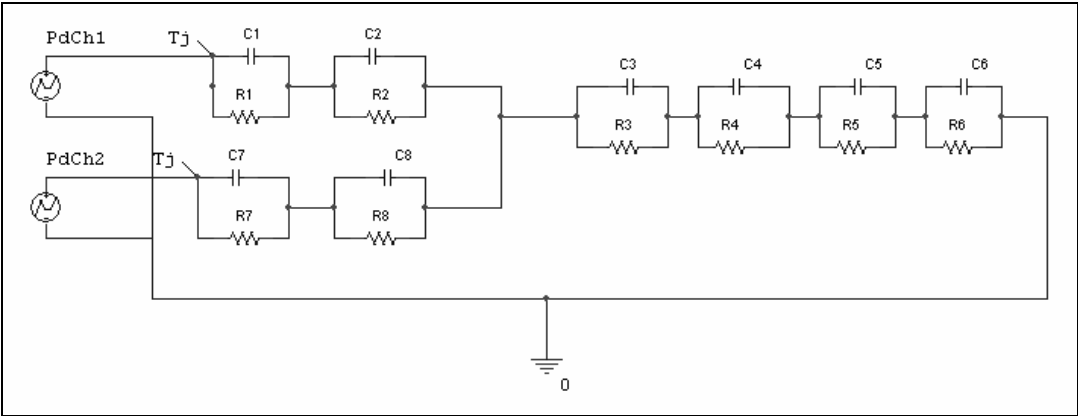


Figure 31. Thermal fitting model of a double channel HSD in PowerSSO-24™(1)



1. Values are given in [Table 12](#)

Table 15. Thermal parameters

Area/Island (cm ²)	Footprint	2	8
R1 (°C/W)	0.28		
R2 (°C/W)	0.9		
R3 (°C/W)	6		
R4 (°C/W)	7.7		
R5 (°C/W)	9	9	8
R6 (°C/W)	28	17	10
R7 (°C/W)	0.28		
R8 (°C/W)	0.9		
C1 (W.s/°C)	0.001		
C2 (W.s/°C)	0.003		
C3 (W.s/°C)	0.025		
C4 (W.s/°C)	0.75		
C5 (W.s/°C)	1	4	9
C6 (W.s/°C)	2.2	5	17
C7 (W.s/°C)	0.001		
C8 (W.s/°C)	0.003		

5 Package and packing information

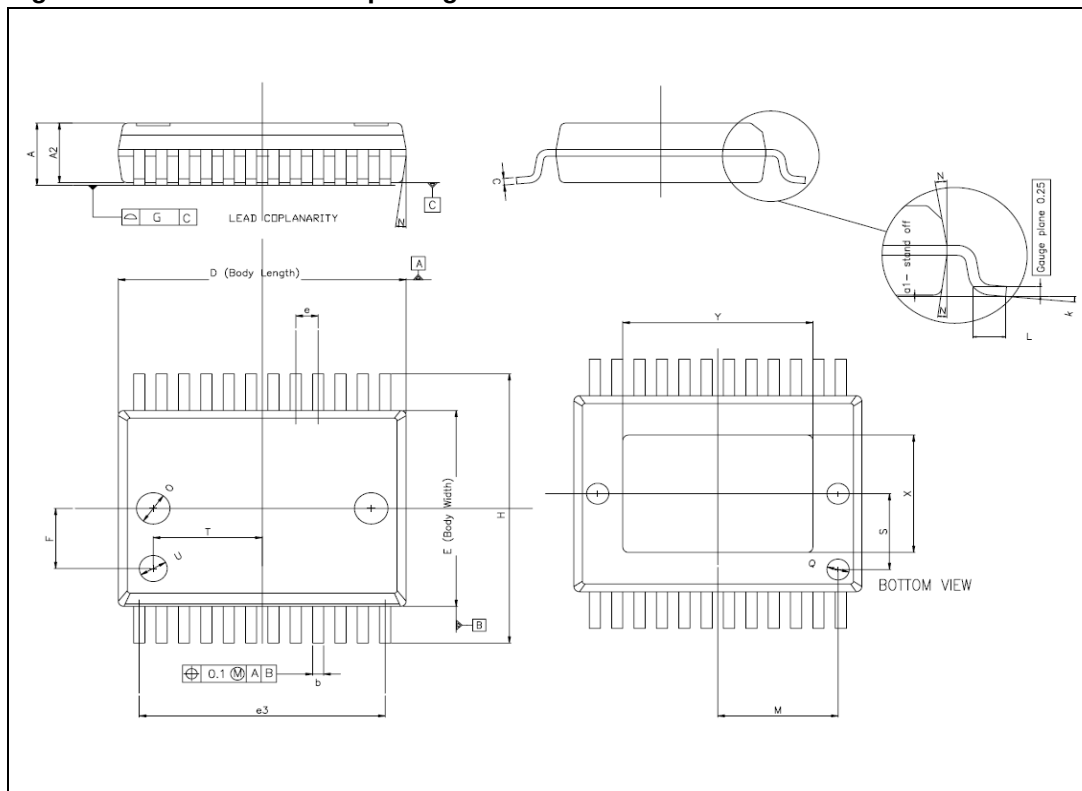
5.1 ECOPACK® packages

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 PowerSSO-24 mechanical data

Figure 32. PowerSSO-24™ package dimensions



5.3 Package mechanical

Table 16. PowerSSO-24™ mechanical data

Symbol	Millimeters		
	Min	Typ	Max
A			2.45
A2	2.15		2.35
a1	0		0.1
b	0.33		0.51
c	0.23		0.32
D	10.10		10.50
E	7.4		7.6
e		0.8	
e3		8.8	
F		2.3	
G			0.1
H	10.1		10.5
h			0.4
k	0°		8°
L	0.55		0.85
O		1.2	
Q		0.8	
S		2.9	
T		3.65	
U		1.0	
N			10°
X	4.1		4.7
Y	6.5		7.1

5.4 Packing information

Figure 33. PowerSSO-24™ tube shipment (no suffix)

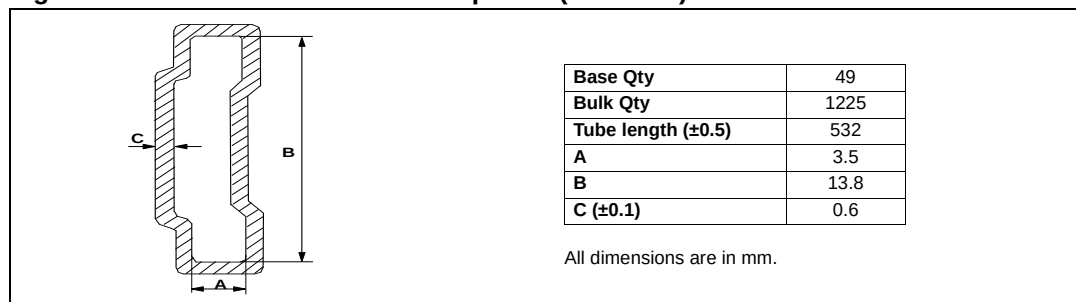
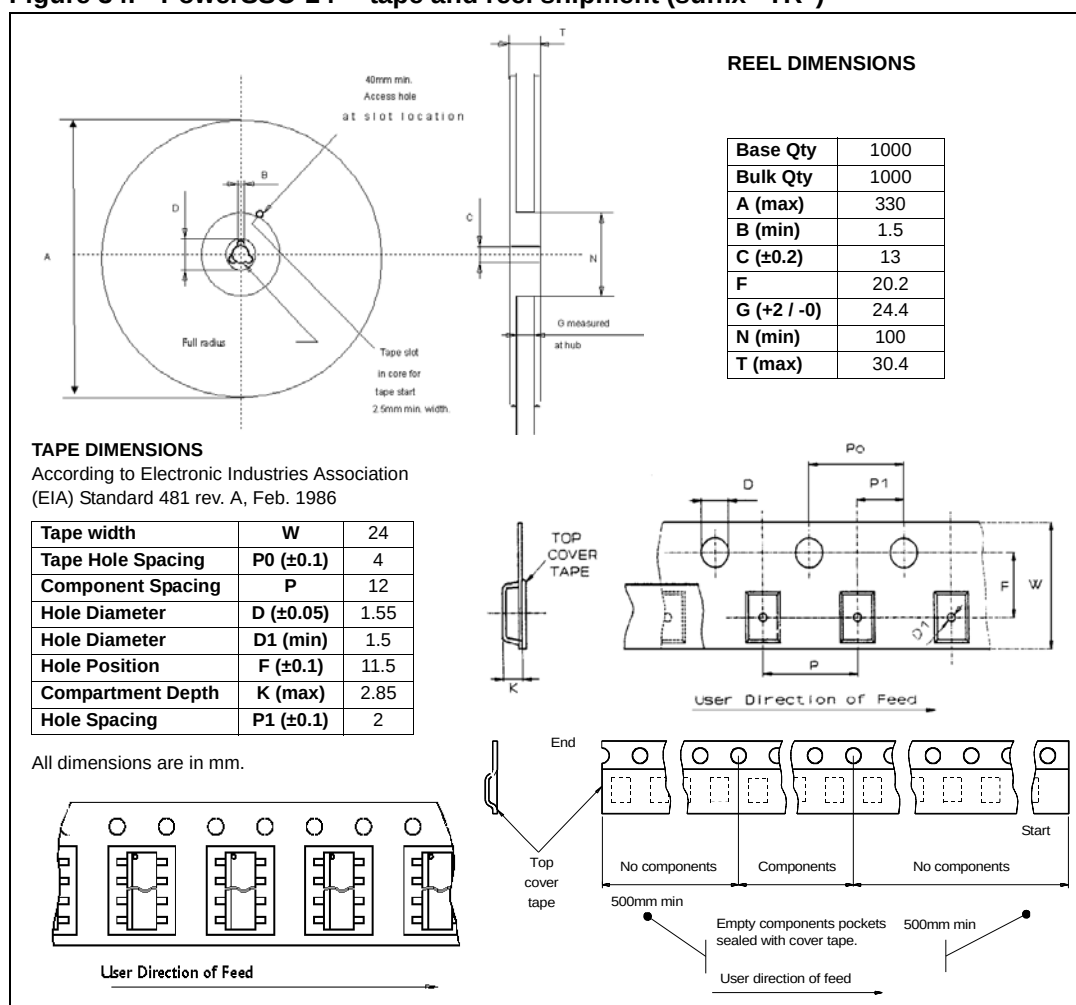


Figure 34. PowerSSO-24™ tape and reel shipment (suffix “TR”)



6 Revision history

Table 17. Document revision history

Date	Revision	Changes
16-Feb-2007	1	Initial release
23-Feb-2007	2	Figure 10: Current sense (8V < VCC < 16V) : error in dK3/K3 current sense ratio drift row corrected.
28-Mar-2007	3	Protection section updated to correct editing error.
02-Jul-2009	4	Updated Table 16: PowerSSO-24™ mechanical data
23-Jul-2009	5	Updated Figure 32: PowerSSO-24™ package dimensions . Updated Table 16: PowerSSO-24™ mechanical data : – Deleted G1 row – Added O, Q, S, T and U rows
20-Sep-2013	6	Updated disclaimer.

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