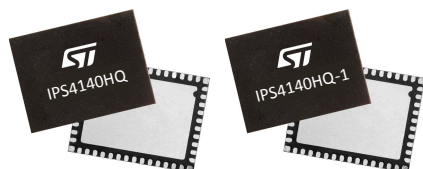


## Quad high-side smart power solid-state relay in QFN48L 8x6 mm package



### Product status link

[IPS4140HQ](#)

[IPS4140HQ-1](#)

### Product label



## Features

- Operating output current: 0.6 A (IPS4140HQ) or 1.0 A (IPS4140HQ-1) per channel
- Per channel short-circuit protection
- Per channel overtemperature protection
- Thermal case protection
- Not simultaneous channel reactivation at thermal case reset
- All type of loads (resistive, capacitive, inductive load) are driven
- Loss of GND protection
- Undervoltage shutdown with hysteresis
- Overvoltage protection ( $V_{CC}$  clamping)
- Very low supply current
- Per channel open drain thermal fault pins
- 5 V and 3.3 V compatible I/Os
- Fast demagnetization of inductive loads
- Designed to drive DC-13 loads according to EN 60947-5-1
- Designed to meet IEC61131-2, IEC61000-4-4, and IEC61000-4-5
- ESD according to IEC 61000-4-2 up to  $\pm 25$  kV

## Applications

- Programmable logic control
- Industrial PC peripheral input/output
- Numerical control machines

## Description

The **IPS4140HQ** (for loads up to 0.6 A) and **IPS4140HQ-1** (for loads up to 1.0 A) are monolithic 4-channel drivers featuring very low  $R_{DS(on)}$  and per-channel diagnostic. The ICs, realized in STMicroelectronics™ VIPower™ technology, are intended to drive any kind of load with one side connected to ground.

Active channel current limitation combined with thermal shutdown, independent for each channel, and automatic restart, protect the device against overload.

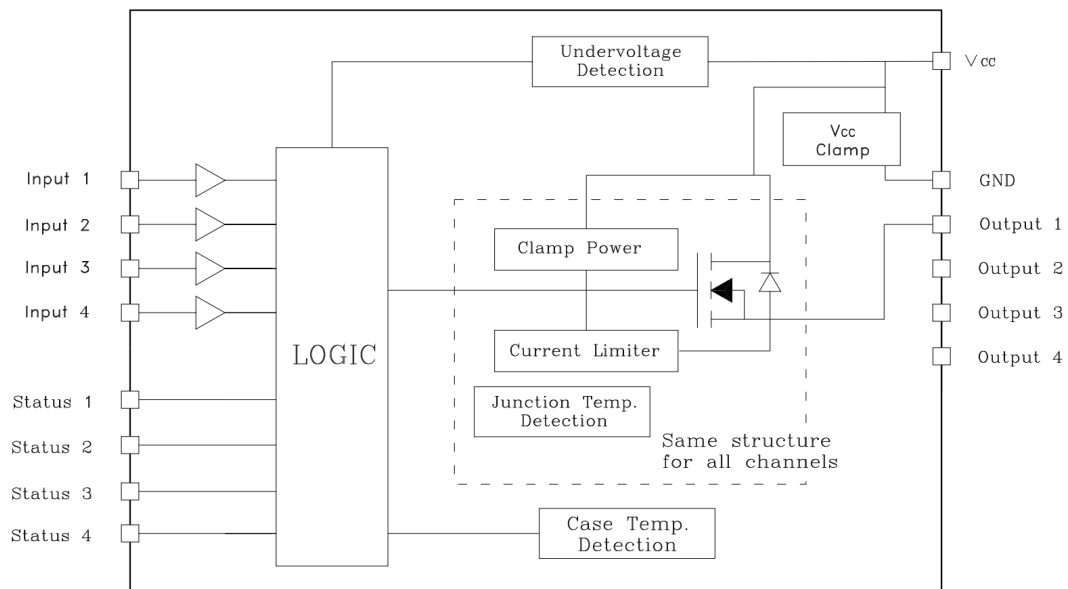
A channel in an overload condition overheats and turns OFF and back ON automatically in order to maintain its junction temperature between  $T_{TSD}$  and  $T_R$ . If this condition makes case temperature reach  $T_{CSD}$ , the overloaded channel is turned OFF and restarts only when case temperature has decreased down to  $T_{CR}$ .

In case of more than one channel in overload, restart of the overloaded channels is not simultaneous, in order to avoid high peak current from the supply. Non-overloaded (non-overheated) channels continue operating normally.

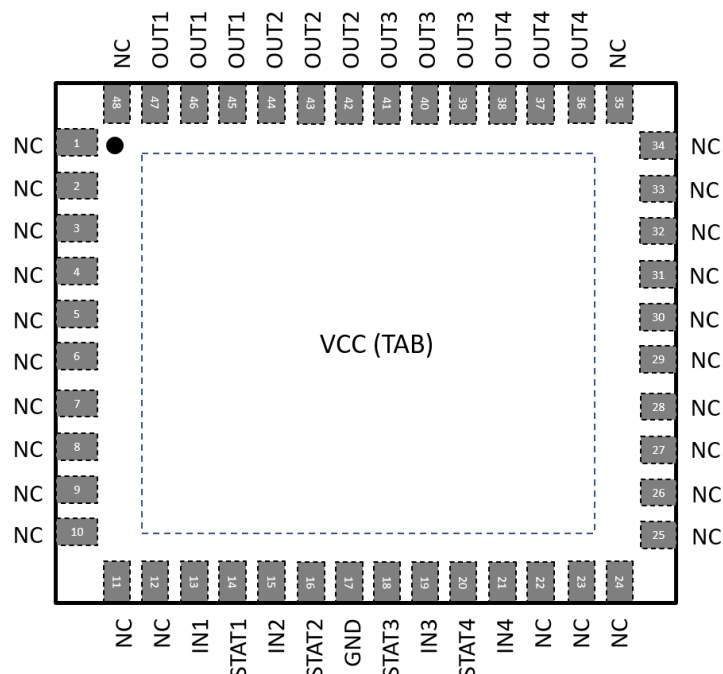
The four open drain STATUS<sub>X</sub> output pins indicate per-channel overtemperature conditions.

## 1 Block diagram

Figure 1. Block diagram



## 2 Pin connection

**Figure 2. Pin connection (top through view)**

**Table 1. Pin description**

Pin	Name	Type	Description
TAB	V <sub>CC</sub>	Supply	IC supply voltage.
1 to 12, 22 to 35, 48	NC	-	Internally not connected (these pins can be routed at pcb level).
13	IN1	Logic input	Channel 1 input, 3.3 V CMOS/TTL compatible.
14	STAT1	Output/Open drain	Channel 1 overtemperature status (active low).
15	IN2	Logic input	Channel 2 input, 3.3 V CMOS/TTL compatible.
16	STAT2	Output/Open drain	Channel 2 overtemperature status (active low).
17	GND	Ground	Device ground connection.
18	STAT3	Output/Open drain	Channel 3 overtemperature status (active low).
19	IN3	Logic input	Channel 3 input, 3.3 V CMOS/TTL compatible.
20	STAT4	Output/Open drain	Channel 4 overtemperature status (active low).
21	IN4	Logic input	Channel 4 input, 3.3 V CMOS/TTL compatible.
36,37,38	OUT4	Output	Channel 4 power stage output, internally protected. These three pins must be shorted on the application.
39,40,41	OUT3	Output	Channel 3 power stage output, internally protected. These three pins must be shorted on the application.
42,43,44	OUT2	Output	Channel 2 power stage output, internally protected. These three pins must be shorted on the application.
45,46,47	OUT1	Output	Channel 1 power stage output, internally protected. These three pins must be shorted on the application.

### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Power supply voltage	-0.3 to 41	V
I <sub>GND</sub>	DC ground reverse current	-250	mA
I <sub>OUT</sub>	DC output current	Internally limited <sup>(1)</sup>	A
I <sub>R</sub>	DC reverse output current (per channel)	-15 <sup>(2)</sup>	A
I <sub>IN</sub>	Input pin current (per channel)	+/-10	mA
V <sub>IN</sub>	Input pin voltage	+V <sub>CC</sub>	V
V <sub>STAT</sub>	Status pin voltage	+V <sub>CC</sub>	V
I <sub>STAT</sub>	Status pin current (per pin)	+/-10	mA
V <sub>ESD</sub>	Electrostatic discharge (R = 1.5 kΩ; C = 100 pF)	2000	V
E <sub>AS</sub> <sup>(3)</sup>	Single channel/single pulse avalanche energy @T <sub>amb</sub> = 125 °C, I <sub>OUT</sub> = 0.5 A	2.5	J
P <sub>TOT</sub>	Power dissipation at T <sub>C</sub> = 25 °C	Internally limited <sup>(1)</sup>	W
T <sub>J</sub>	Junction operating temperature	Internally limited <sup>(1)</sup>	°C
T <sub>STG</sub>	Storage temperature	-55 to 150	°C

1. Protection functions are intended to avoid IC damage in fault conditions and are not intended for continuous operation. Continuous and repetitive operation of protection functions may reduce the IC lifetime.
2. Intended with the 3 pins of each OUTX connected together in the application board.
3. Single pulse, not repetitive

**Table 3. Thermal data**

Symbol	Parameter	Value	Unit
R <sub>th(JC)</sub>	Thermal resistance junction-case <sup>(1)</sup>	1.5	°C/W
R <sub>th(JA)</sub>	Thermal resistance junction-ambient <sup>(2)</sup>	27	°C/W

1. R<sub>th</sub> between the die and the bottom case surface measured by cold plate as per JESD51-12
2. JESD51-7

## 4 Recommended operating conditions

**Table 4.** Input switching limits

Symbol	Parameter	Value	Unit
$f_{VIN(MAX)}$	Maximum input switching frequency	10	kHz

## 5 Electrical characteristics

10.5 V < V<sub>CC</sub> < 36 V; -40 °C < T<sub>J</sub> < 125 °C; unless otherwise specified

### 5.1 Power section

**Table 5. Power section**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>CC</sub>	Supply voltage		10.5		36	V
R <sub>DS(on)</sub>	ON-state resistance	IPS4140HQ, I <sub>OUT</sub> = 0.5 A @T <sub>J</sub> = 25 °C			0.08	Ω
		IPS4140HQ, I <sub>OUT</sub> = 0.5 A			0.14	
		IPS4140HQ-1, I <sub>OUT</sub> = 0.7 A @T <sub>J</sub> = 25 °C			0.08	
		IPS4140HQ-1, I <sub>OUT</sub> = 0.7 A			0.14	
I <sub>S</sub>	V <sub>CC</sub> supply current	All channels in OFF-state		0.25		mA
		All channels in ON-state, V <sub>IN1..4</sub> = 5 V		2.4	4	mA
V <sub>CC</sub> clamp	Clamp on V <sub>CC</sub>	I <sub>S</sub> = 20 mA	41	45	52	V
V <sub>OUT(OFF)</sub>	OFF-state output voltage	V <sub>IN</sub> = 0 V, I <sub>OUT</sub> = 0 A, V <sub>CC</sub> = 24V			1	V
I <sub>OUT(OFF)</sub>	OFF-state output current	V <sub>IN</sub> = V <sub>OUT</sub> = 0 V, V <sub>CC</sub> = 24V	0		5	μA
I <sub>LGND</sub>	IPS4140HQ output current at GND disconnection	V <sub>CC</sub> = V <sub>IN</sub> = V <sub>STAT</sub> = V <sub>GND</sub> = 24 V; V <sub>OUT</sub> = 0 V			1.0	mA
	IPS4140HQ-1 output current at GND disconnection				0.5	mA
f <sub>CP</sub>	Charge pump frequency	Channel in ON-state <sup>(1)</sup>		1.45		MHz

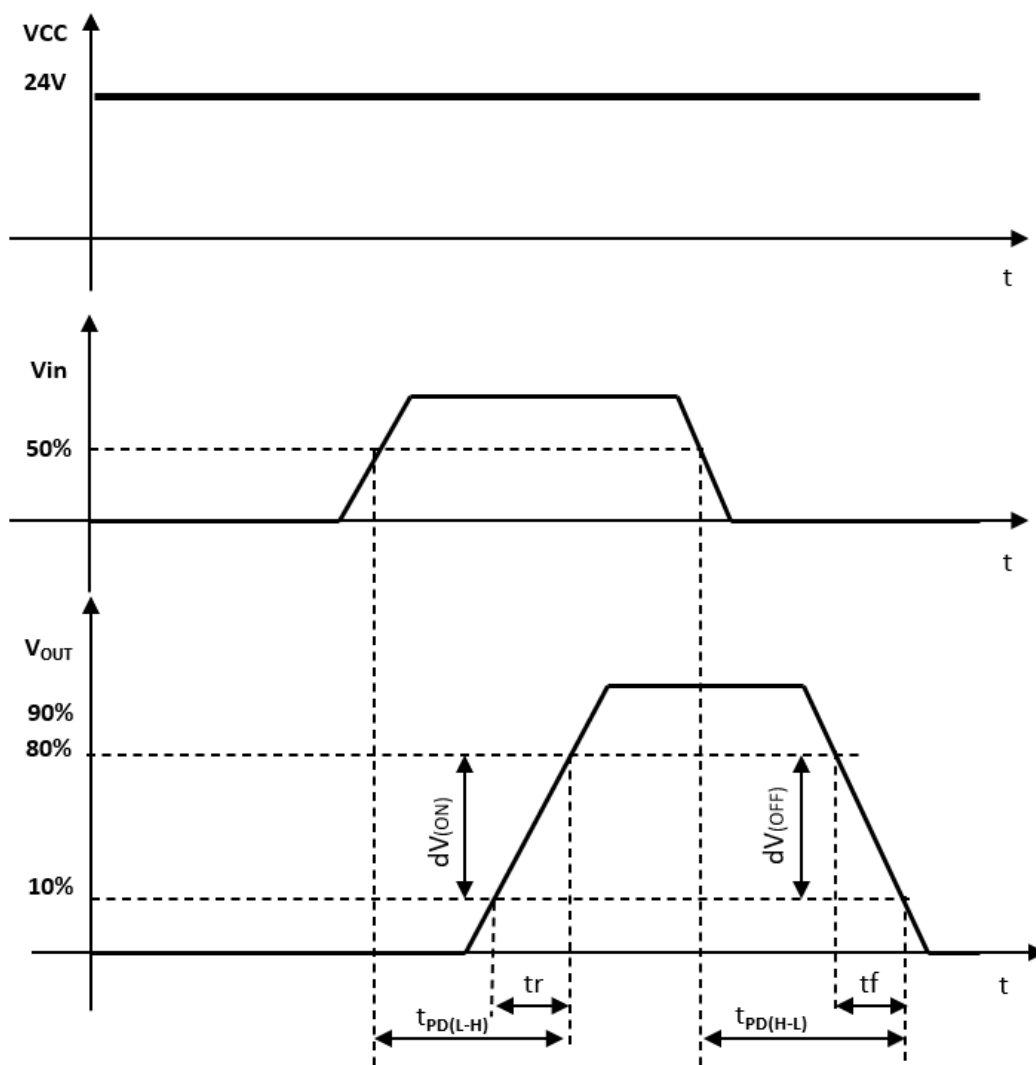
1. To cover EN55022 class A and class B normative.

### 5.2 Switching

**Table 6. Switching**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t <sub>PD(L-H)</sub>	Turn-on delay time	V <sub>CC</sub> = 24 V, R <sub>L</sub> = 48 Ω, input rise time < 0.1 μs, see Figure 3		16	35	μs
t <sub>r</sub>	Rise time			8	25	μs
t <sub>PD(H-L)</sub>	Turn-off delay time			21	36	μs
t <sub>f</sub>	Fall time			4	12	μs
dV <sub>(ON)</sub> /dt <sub>r</sub>	Turn-on voltage slope			2		V/μs
dV <sub>(OFF)</sub> /dt <sub>f</sub>	Turn-off voltage slope			4		V/μs

Figure 3. Timing in normal operation



### 5.3 Logic inputs

Table 7. Logic inputs

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{IL}$	Input low level voltage				0.8	V
$V_{IH}$	Input high level voltage		2.20			V
$V_{I(HYST)}$	Input hysteresis voltage			0.15		V
$I_{IN}$	Input current	$V_{IN} = 15\text{ V}$			10	$\mu\text{A}$
		$V_{IN} = 36\text{ V}$			210	

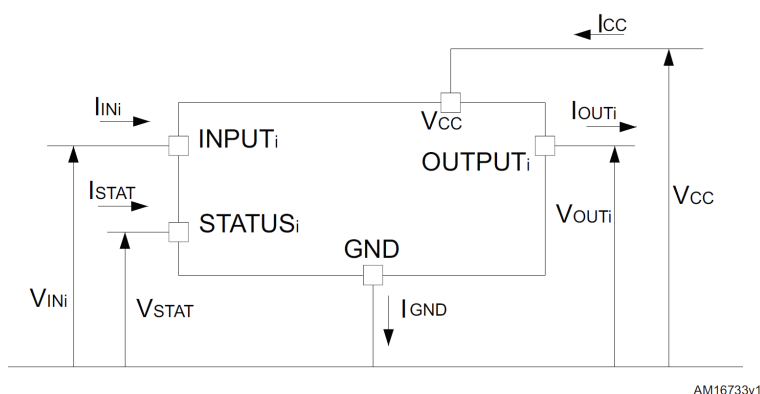
## 5.4 Protection and diagnostic

Table 8. Protection and diagnostic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{STAT}$	Status voltage output low	$I_{STAT} = 1.6 \text{ mA}$			0.6	V
$V_{USD}$	Undervoltage protection		7		10.5	V
$V_{USDHYS}$	Undervoltage hysteresis		0.4	0.5		V
$I_{PEAK}$	IPS4140HQ maximum DC output current	Dynamic load		1.3		A
	IPS4140HQ-1 maximum DC output current			1.6		
$I_{LIM}$	IPS4140HQ, DC short-circuit current	$V_{CC} = 24 \text{ V}$ , $R_{LOAD} \leq 10 \text{ m}\Omega$	0.7	1.0	1.7	A
	IPS4140HQ-1, DC short-circuit current		1.1	1.5	2.6	
$I_{LSTAT}$	Status leakage current	$V_{CC} = V_{STAT} = 36 \text{ V}$		30		$\mu\text{A}$
$T_{TSD}$	Junction shutdown temperature		150	170	190	$^{\circ}\text{C}$
$T_R$	Junction reset temperature		135			$^{\circ}\text{C}$
$T_{HYST}$	Junction thermal hysteresis		7	15		$^{\circ}\text{C}$
$T_{CSD}$	Case shutdown temperature		125	130	135	$^{\circ}\text{C}$
$T_{CR}$	Case reset temperature		110			$^{\circ}\text{C}$
$T_{CHYST}$	Case thermal hysteresis		7	15		$^{\circ}\text{C}$
$V_{DEMAG}$	Output voltage at turn-OFF	$I_{OUT} = 0.5 \text{ A}$ ; $L_{LOAD} \geq 1 \text{ mH}$	$V_{CC} - 41$	$V_{CC} - 45$	$V_{CC} - 52$	V

## 5.5 Current and voltage conventions

Figure 4. Current and voltage conventions



## 6 Truth table

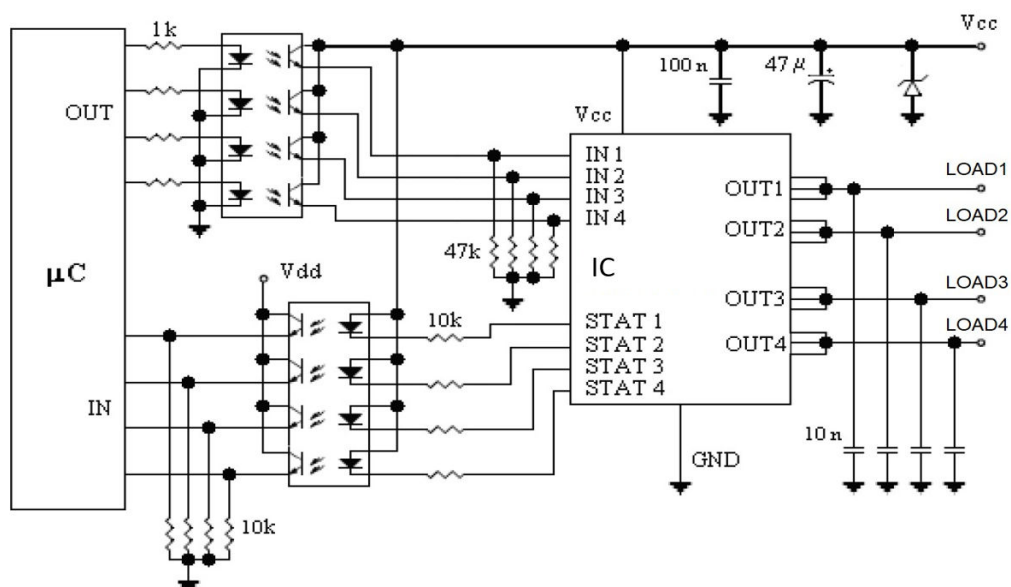
**Table 9. Truth table**

Condition	Input <sub>n</sub>	Output <sub>n</sub>	Status <sub>n</sub>
Normal operation	L	L	H
	H	H	H
Overtemperature	L	L	H
	H	L	L
Undervoltage	L	L	X
	H	L	X
Output overload (current limitation before overtemperature)	L	L	H
	H	X	H

*Note:* X = don't care

## 7 Typical application circuit

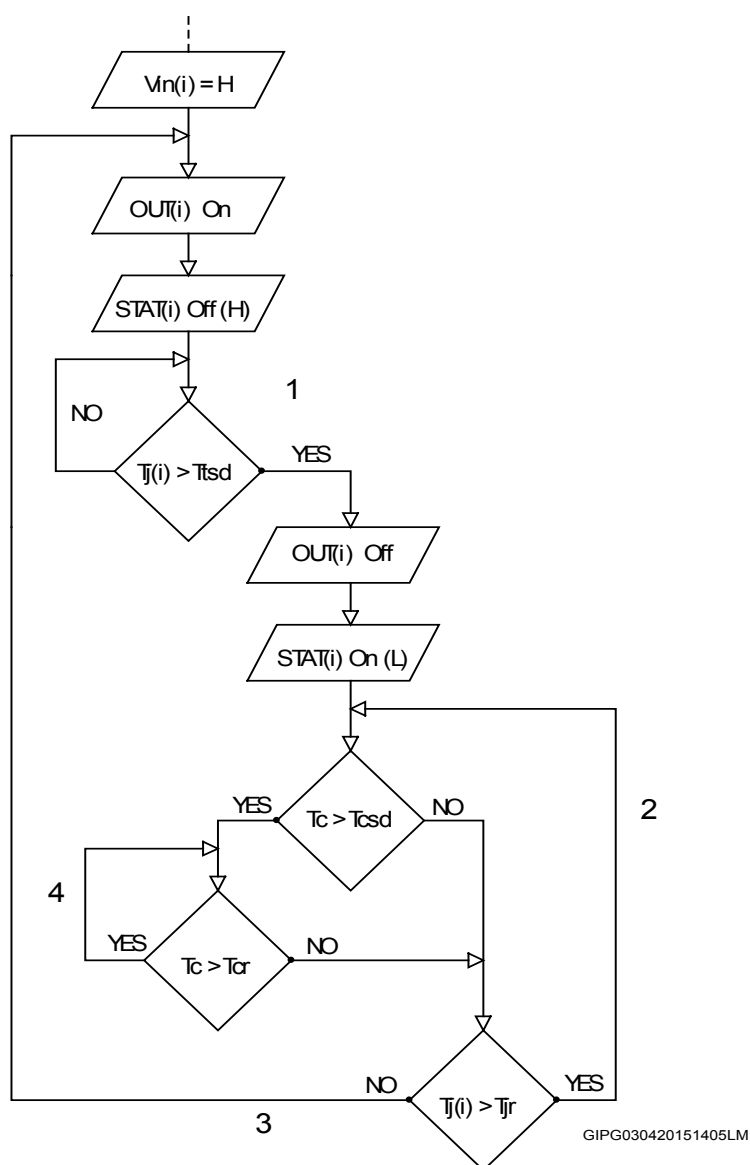
Figure 5. Typical application circuit



## 8 Thermal management

The power dissipation in the IC is the main factor that sets the safe operating condition of the device in the application. Therefore, it must be considered very carefully. Furthermore, the available space on the PCB should be chosen considering the power dissipation. Heat sinking can be achieved using copper on the PCB with proper area and thickness. Two different protections have been implemented to guarantee safety of the device if it overheats due to an overloaded condition or high environment temperature. The following flowchart explains in detail this protection functionality.

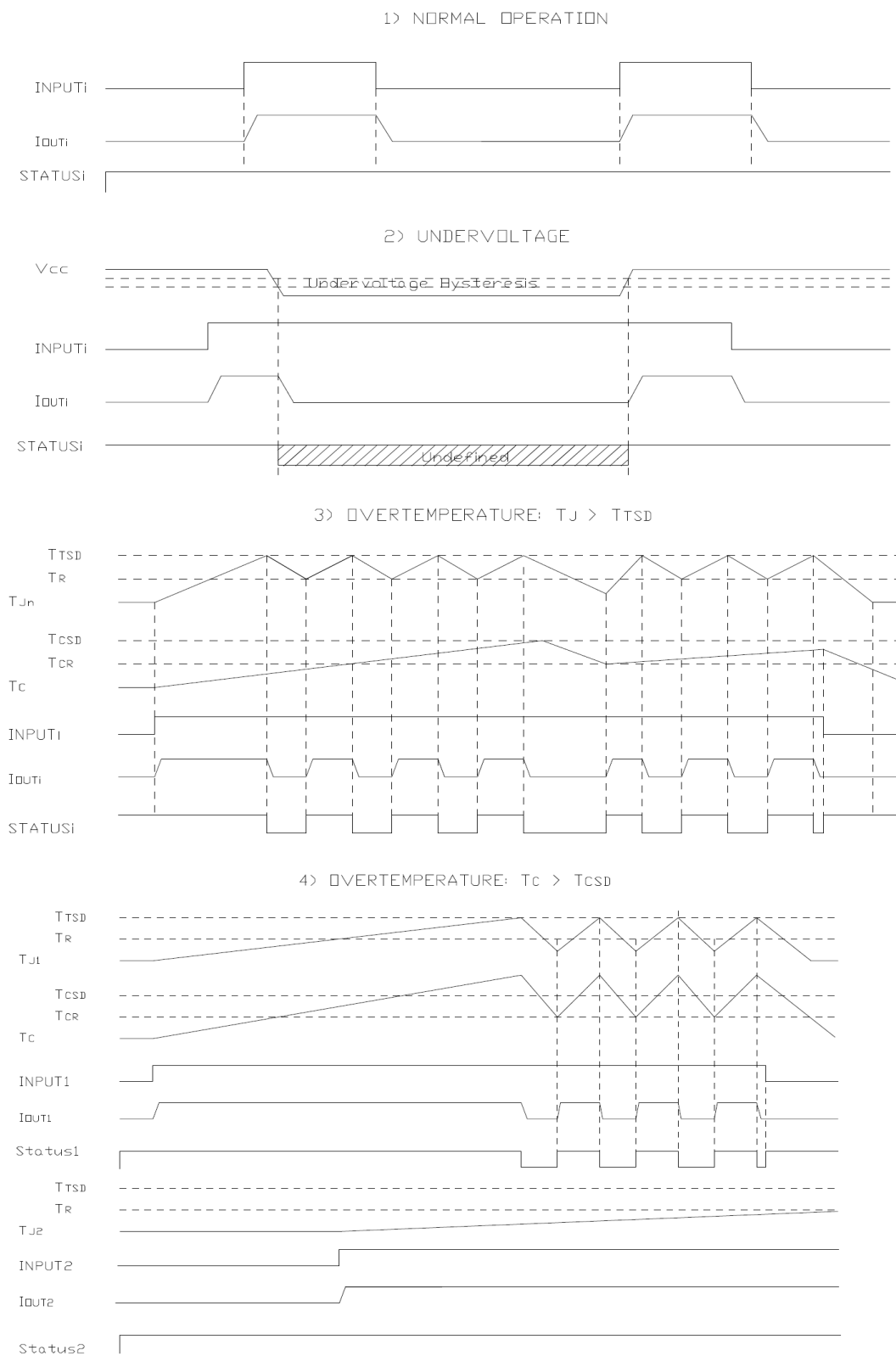
Figure 6. Thermal behavior



- Note:
- 1 Thermal shutdown
  - 2 Junction hysteresis
  - 3 Restore to idle condition
  - 4 Case hysteresis

## 9 Switching waveforms

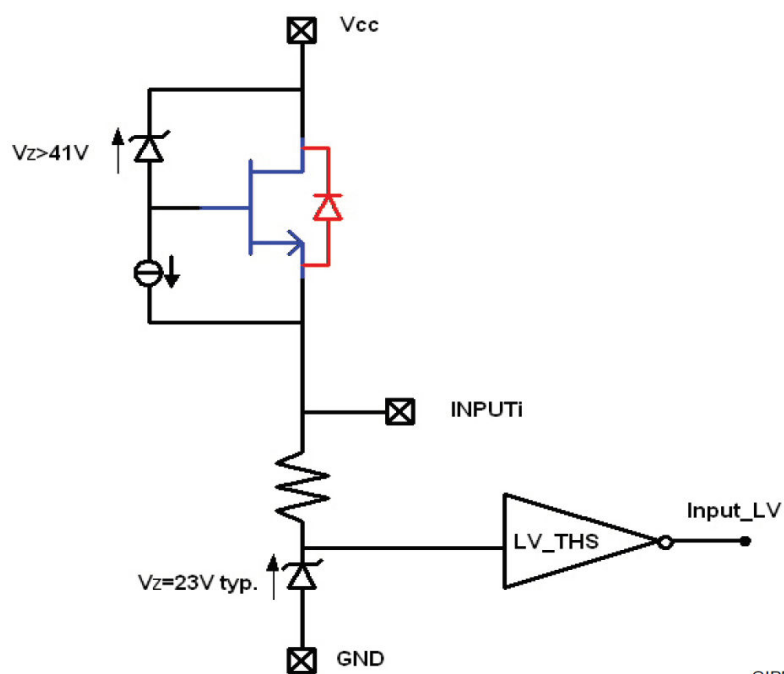
Figure 7. Switching waveforms



GIPD0611131025LM

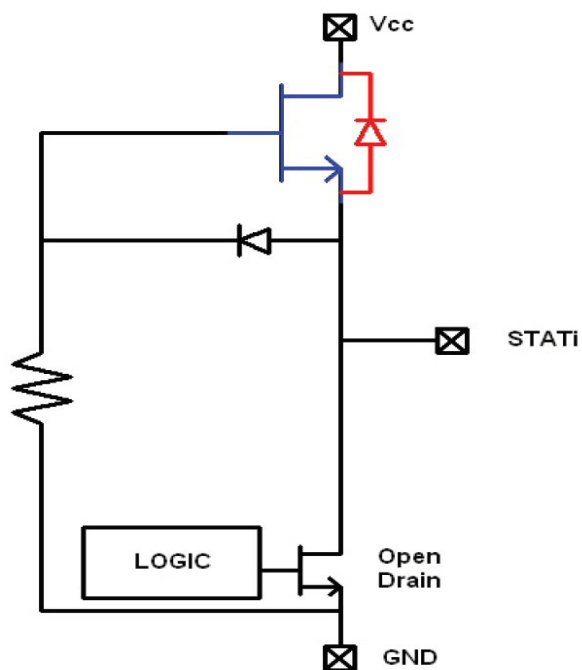
## 10 Pin function description

Figure 8. Input circuit



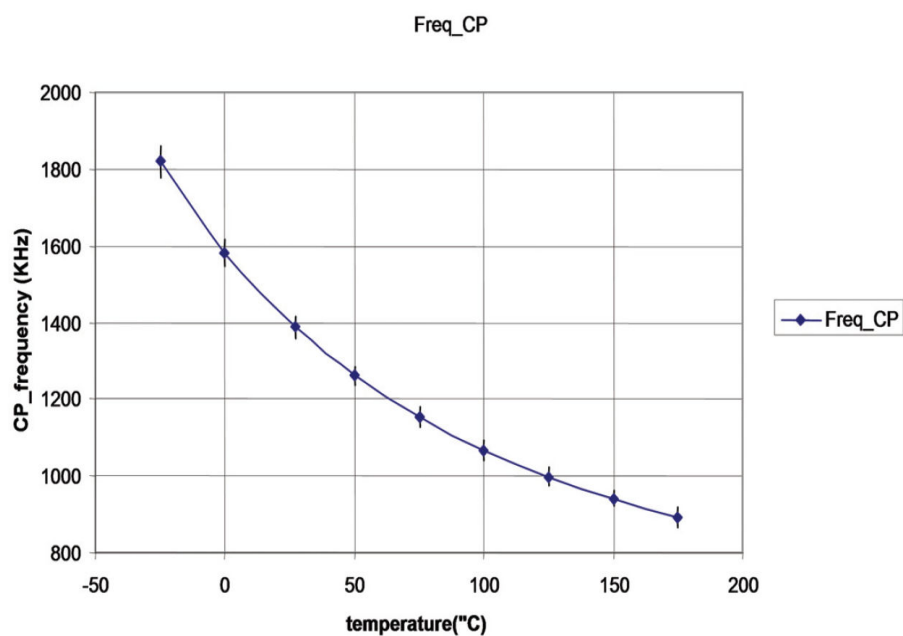
GIPD0611131030LM

Figure 9. Status circuit



GIPD0611131035LM

Figure 10. Charge pump switching frequency (typical) vs. temperature



GIPD0611131040LM

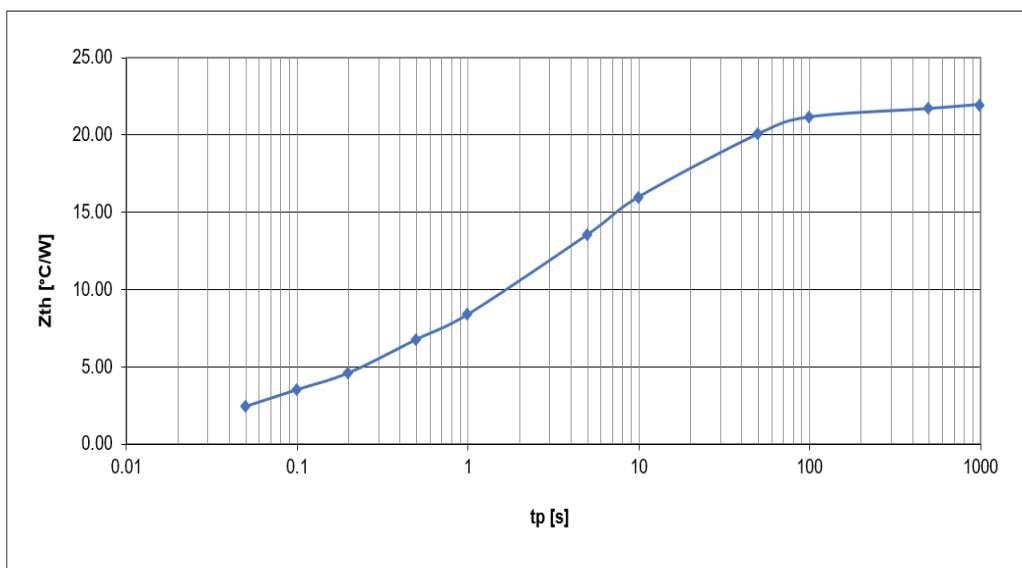
## 11 Thermal data

The power dissipation in the IC is the main factor that sets the safe operating condition of the device in the application. Therefore, it must be taken into account very carefully.

Heatsinking can be achieved using copper on the PCB with proper area and thickness.

The following image shows the junction-to-ambient thermal impedance values for the QFN48L 8x6 mm package referred to JEDEC conditions with 2s2p layers and thermal vias below the exposed pad.

**Figure 11. QFN48L 8x6 mm, thermal impedance**



## 12 Reverse polarity protection

Reverse polarity protection can be implemented on-board using two different solutions:

1. Placing a resistor ( $R_{GND}$ ) between IC GND pin and load GND
2. Placing a diode between IC GND pin and load GND

If option 1 is selected, the minimum resistance value has to be selected according to the following equation:

$$R_{GND} \geq V_{CC} / I_{GND}$$

where  $I_{GND}$  is the DC reverse ground pin current and can be found in [Section 3](#) of this datasheet.

Power dissipated by  $R_{GND}$  (when  $V_{CC} < 0$ : during reverse polarity situations) is:

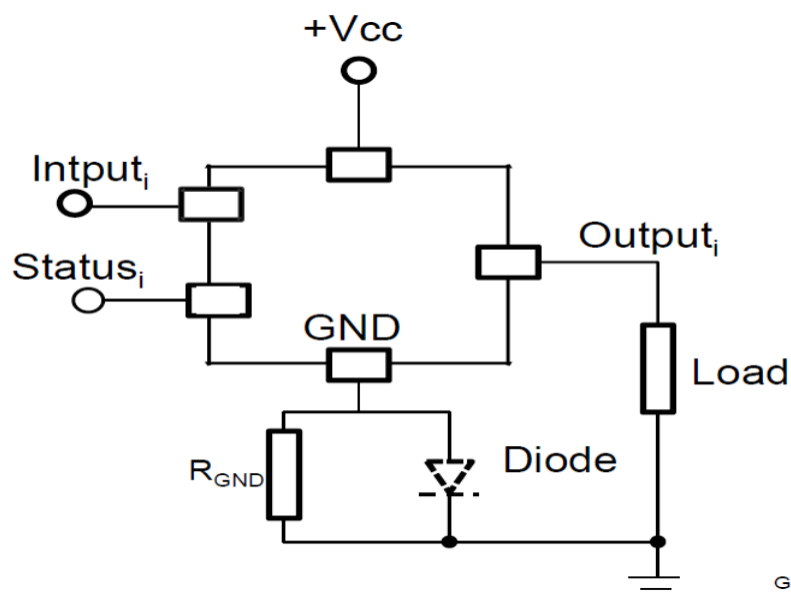
$$P_D = (V_{CC})^2 / R_{GND}$$

If option 2 is selected, the diode has to be chosen by taking into account  $V_{RRM} > |V_{CC}|$  and its power dissipation capability:

$$P_D \geq I_S \cdot V_F$$

**Note:** *In normal conditions (no reverse polarity), due to the diode, there is a voltage drop between GND of the device and GND of the system.*

Figure 12. Reverse polarity protection

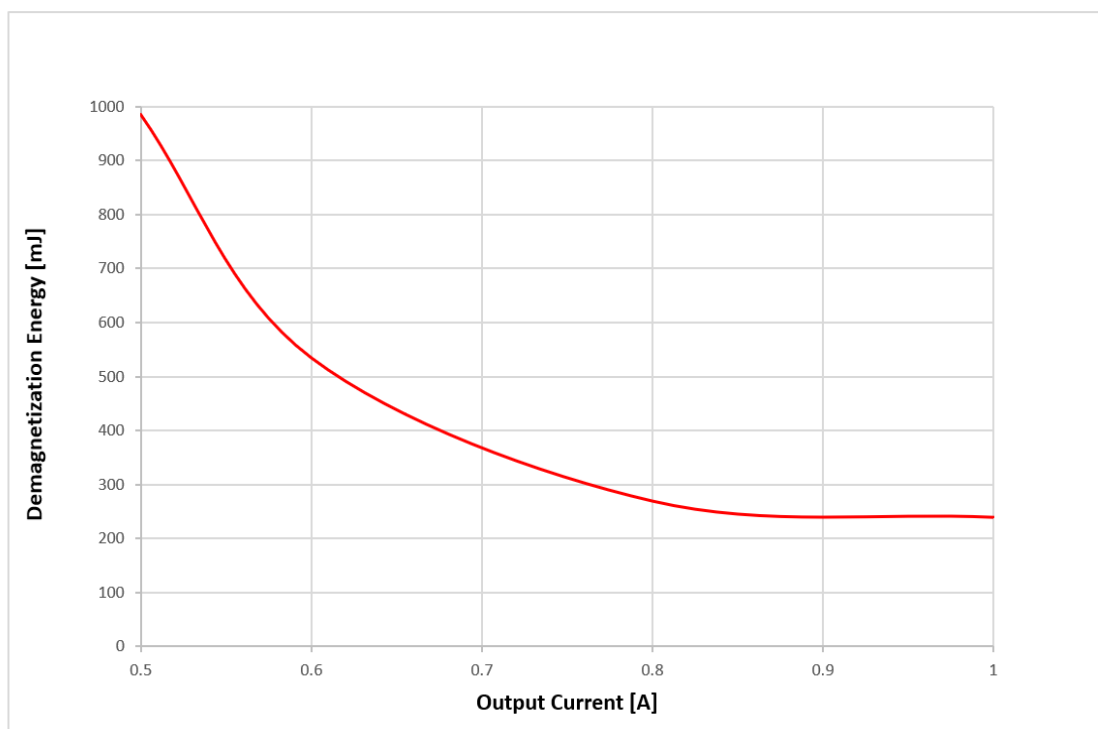


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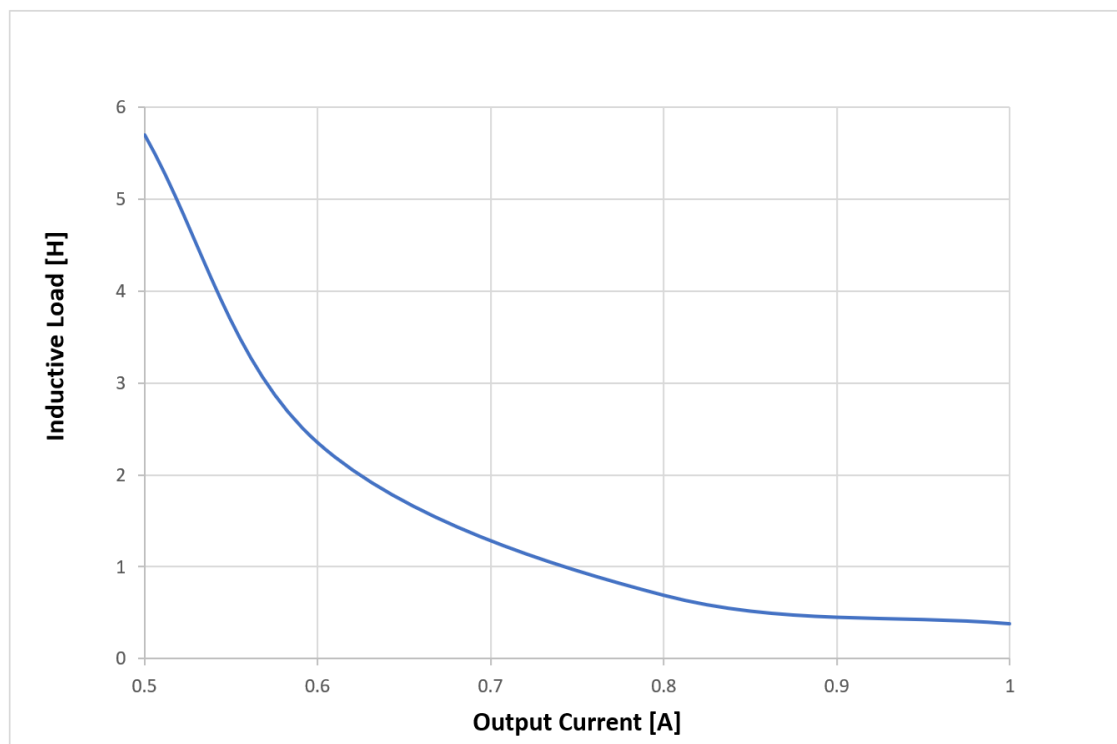
This schematic can be used with any type of load.

## 13 Demagnetization energy

**Figure 13.** Typical single pulse (not repetitive) demagnetization:  $E_{OFF}$  vs  $I_{OUT}$  ( $V_{CC} = 24\text{ V}$ ,  $T_{AMB} = 125\text{ °C}$ , all channels simultaneously demagnetized)



**Figure 14.** Typical single pulse (not repetitive) demagnetization:  $L_{LOAD}$  vs  $I_{OUT}$  ( $V_{CC} = 24\text{ V}$ ,  $T_{AMB} = 125\text{ °C}$ , all channels simultaneously demagnetized)



## 14 Maximum capacitive load

Following table shows the value of maximum capacitive load.

The value is calculated using a dedicated evaluation board (X-Nucleo-OUT20A1 or X-Nucleo-OUT21A1) with an RC load on one channel and leaving the other three channels in open load state.

**Table 10. Maximum capacitive load**

Symbol	Parameter	Value	Unit
C <sub>LOAD(MAX)</sub>	Maximum capacitive load @ VCC=24 V, Tamb=125 °C	300	μF

## 15 Package information

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](http://www.st.com). ECOPACK is an ST trademark.

### 15.1 Package mechanical data

Figure 15. QFN48L 8x6 mm package dimensions

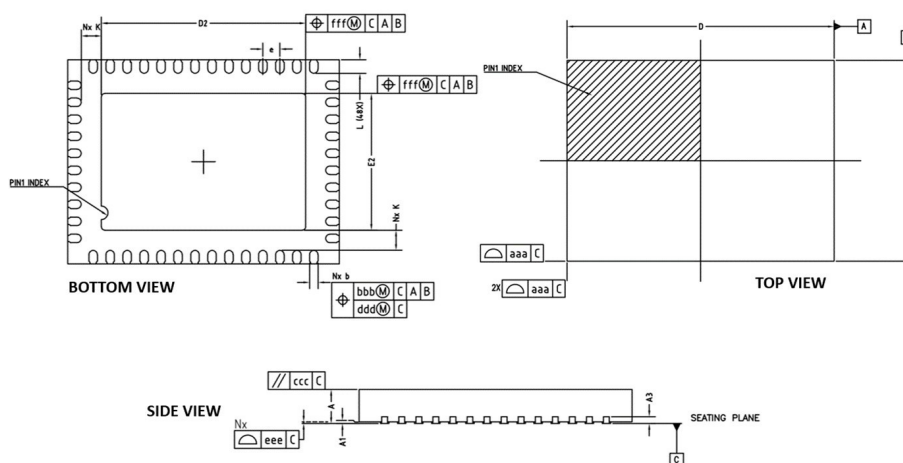
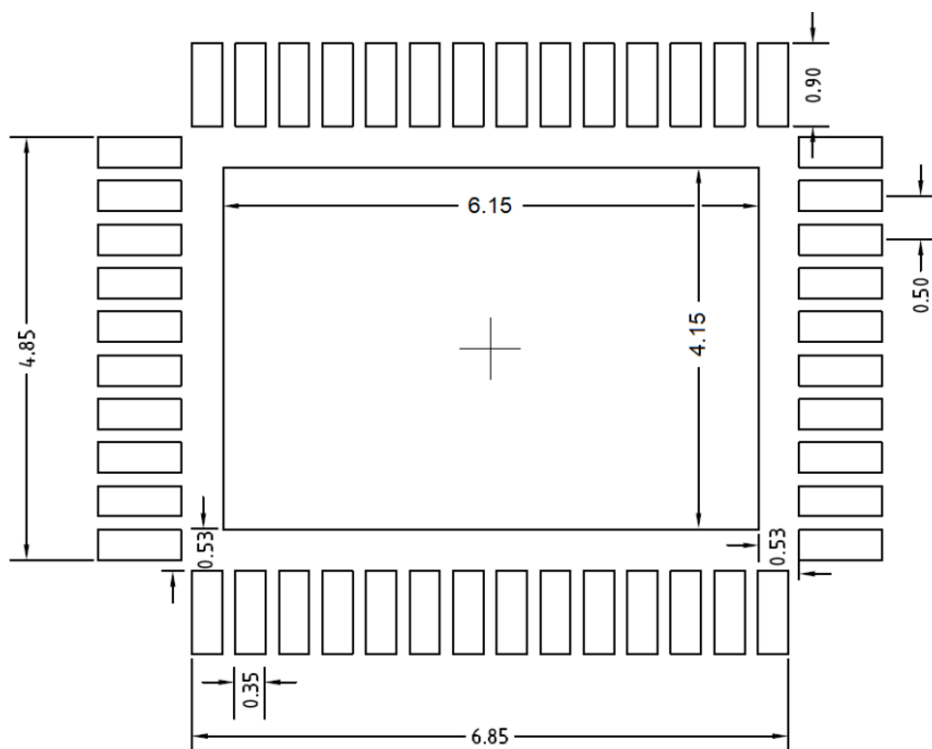


Table 11. QFN48L, mechanical data

Dim.	(mm)		
	Min.	Typ.	Max.
A	0.80	0.85	0.90
A1	0.00	-	0.05
A3	0.20 REF.		
b	0.20	0.25	0.30
D	8.00 BSC		
e	0.50 BSD		
E	6.00 BSC		
D2	5.97	6.02	4.07
E2	3.97	4.02	4.07
L	0.365	0.40	0.435
k	0.53	-	-
N	Tolerance of forms and positions		
aaa	0.10		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.05		
fff	0.10		

Figure 16. QFN48L 8x6 mm suggested footprint [mm]



**Note:** STMicroelectronics is not responsible for any PCB related issues. The footprint shown in the above figure is a suggestion which might not be in line with the customer PCB supplier design rules.

## 16 QFN48L, packing information

Figure 17. QFN48L reel shipment reference

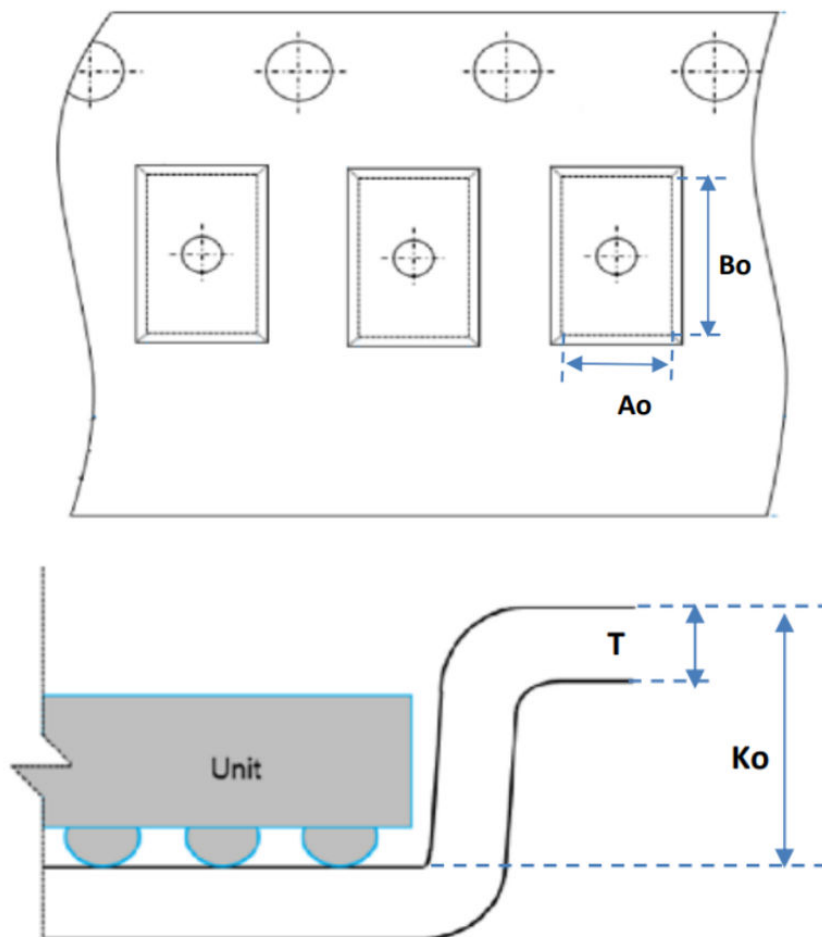


Table 12. Standard SPC parameters

Description	Value
Ao	Pocket Length
Bo	Pocket Width
Ko	Pocket Depth
T	Tape Thickness

2.00±0.05 SEE NOTE 2

4.00 SEE NOTE 1

8.00

$\phi 1.50^{+0.1}_{0.0}$

$\phi 1.50^{+0.1}_{0.0}$

B

1.75±0.1

5.50±0.05 SEE NOTE 2

12.00±0.3

A

A

0.25

R0.25

T±0.05

Bø

R0.30 MAX

Kø

SECTION B-B

Aø

SECTION A-A

Diagram illustrating the layout of a feed system. It shows six circular feeders arranged in a horizontal row at the top. Below them are two rectangular feeders, each containing a smaller rectangular area with a circular symbol in the top right corner. An arrow at the bottom points to the right, labeled "User Direction of Feed".

## 17 Ordering information

Table 13. Order codes

Order code	Package	Package marking	Packaging
IPS4140HQ	QFN48L 8x6 mm	IPS4140HQ	Tape and reel
IPS4140HQ-1		IPS4140HQ-1	

## Revision history

**Table 14. Document revision history**

Date	Version	Changes
06-Dec-2024	1	Initial release.
10-Jul-2025	2	Corrected typo in <a href="#">Table 13</a> ; some minor changes.
13-Oct-2025	3	Added "Designed to drive DC-13 loads according to EN 60947-5-1" in <a href="#">Section Features</a> ; added <a href="#">Section 14</a> .

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