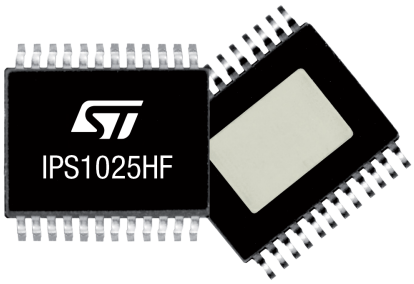
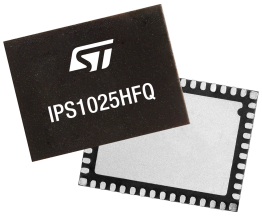
IPS1025HF, IPS1025HFQ

Datasheet

High efficiency, high-side switch with extended diagnostics, smart driving for capacitive loads and short propagation delay at power-on





Features

- 8.65 V to 60 V operating supply voltage range
- 2.4 A operating output current
- Smart driving of capacitive load
- Fast demagnetization of inductive loads
- Under-voltage lock-out
- V_{CC} over-voltage protection
- Output overload and over-temperature protection
- Case over-temperature protection
- Ground disconnection protection
- Overload and over-temperature event diagnostic pins
- Designed to meet IEC 61000-4-2, IEC 61000-4-4, IEC 61000-4-5
- Packages: PowerSSO-24 and QFN48L 8x6x0.9 mm

Applications

- Programmable logic control
- Vending machines
- Industrial PC peripheral input/output
- Numerical control machines
- General high-side switch applications

Product status link
IPS1025HF
IPS1025HFQ

Product label
SUSTAINABLE TECHNOLOGY

Description

The IPS1025HF and IPS1025HFQ are single high-side switch ICs able to drive capacitive, resistive or inductive loads with one side connected to ground.

The 60 V operating range and $R_{DS\text{-}ON}$ = 12 mΩ (typ.), combined with the extended diagnostic (Over Load, Over-temperature) and the < 60 us propagation delay time at startup (enabling Class 3 for interface types C and D), make the IC suitable for applications implementing the proper architectures to address higher SIL levels.

The very low $R_{DS\text{-}ON}$ (≤ 25 mΩ up to T_J = 125 °C) makes the IC suitable for the applications with up to 2.4 A steady state operating current.

The output channel is protected against junction over-temperature events by a junction temperature sensor, and a further temperature sensor is included to monitor case temperature, so the overheated output channel can only be turned back ON when the case temperature returns below the reset temperature.

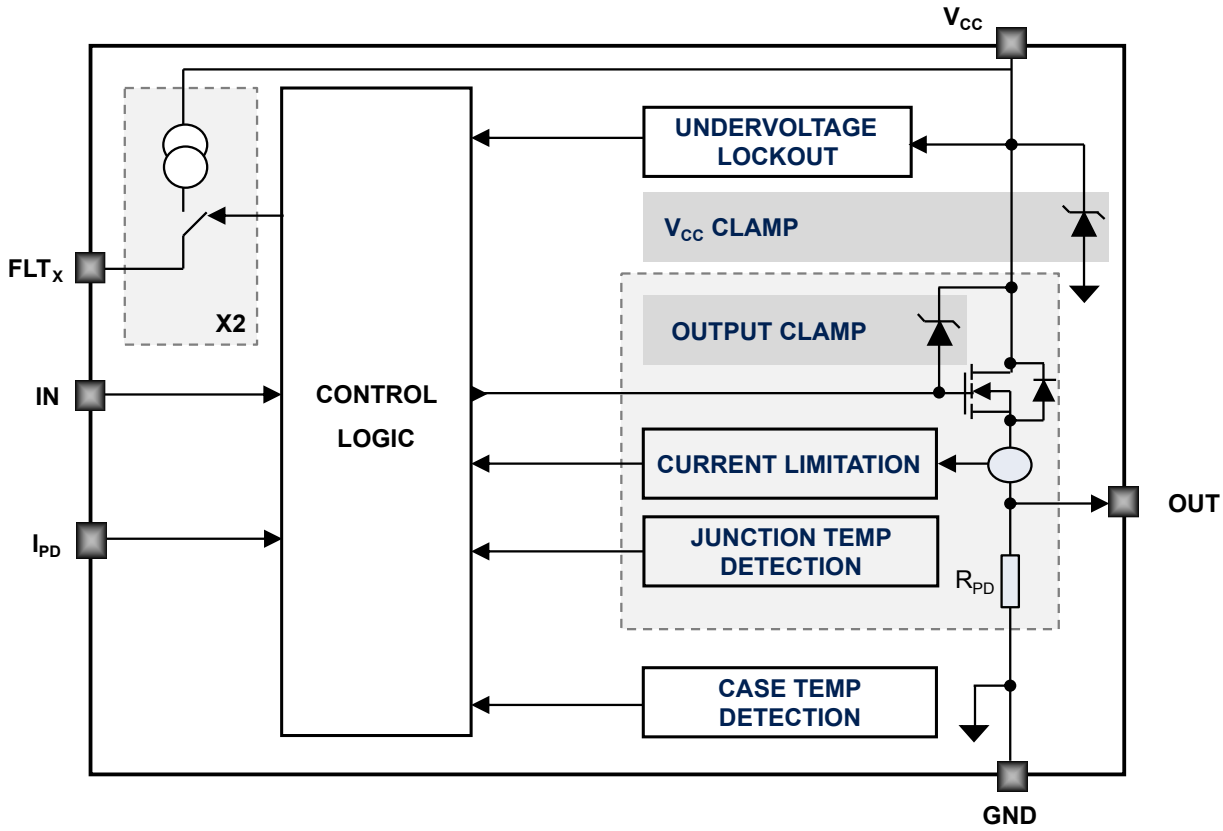
The embedded overload protection circuit monitors the output current and, on triggering of the activation threshold (I_{PK}), starts modulating the impedance of the output switch to limit the output current to I_{LIM}, for both IC and load protection.

The IC offers two different sets of activation threshold and limitation levels (I_{PKH}, I_{LIMH} and I_{PKL}, I_{LIML}) for smart driving of capacitive loads (such as bulb lamps) and loads with initial peak current requirements.

The IC diagnostics is based on FLT_1 and FLT_2 pins (both current source); activated by respective overload or overtemperature events on the output channel.

1 Block diagram

Figure 1. **IPS1025HF/IPS1025HFQ block diagram**



2 Pin connection

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

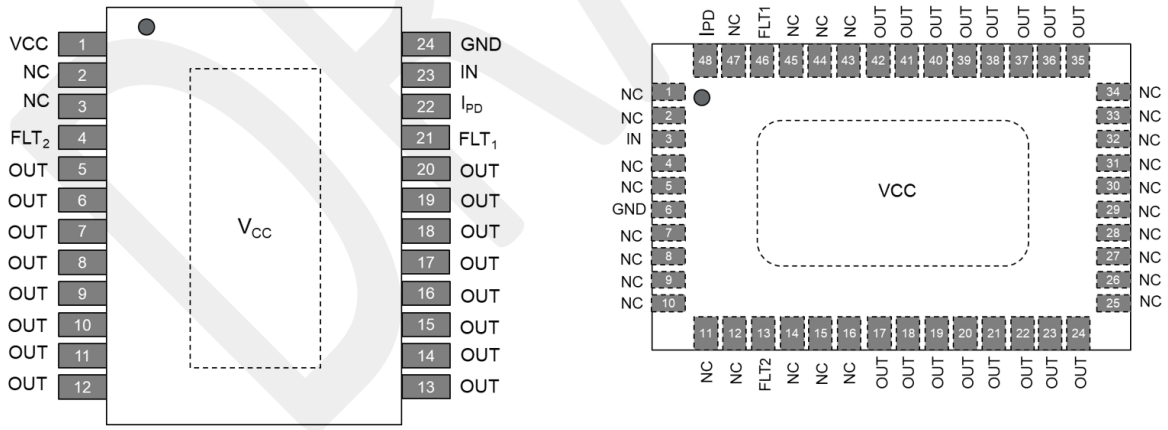


Table 1. **Pin descriptions**

Pin no.			
PSSO24	**QFN48L**	**Name**	**Description**
1, exposed pad	exposed pad	VCC	Supply voltage
2,3	1,2,4,5,7,8,9,10,11,12,14,16,25,26,27,28,29,30,31,32,33,34,43,45,47	N.C.	Not connected
4	13	FLT2	Overload event diagnostic pin
5 to 20	17 to 24, 35 to 42	OUT	Power stage output channel
21	46	FLT1	Over-temperature event diagnostic pin
22	48	IPD	Initial current duration / level selector. Connect to GND by a capacitor to set duration of I_{PKH} (see Section 7.3 and Table 9). Connect to IN pin by a 220 kΩ resistor to disable initial I_{PKH} threshold (the over-current limit is only I_{PKL}). Connect to GND by a 10 kΩ resistor to disable I_{PKL} (the over-current threshold is only I_{PKH}). *Note: Leaving I_{PD} floating is equivalent to a 1 µs duration for I_{PKH}.*
23	3	IN	Input
24	6	GND	Device ground

3 Absolute maximum ratings

Absolute maximum ratings are the values beyond which damage to the device may occur. Functional operation under these conditions is not implied. All voltages are referenced to GND.

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	-0.3 to 65	V
I_{CC}	Maximum DC reverse current (from GND to V_{CC})	-250	mA
I_{OUT}	Output stage current	Internally limited	A
$-I_{OUT}$	Reverse current (from OUT to V_{CC})	5	A
V_{IN}	IN pin voltage	-0.3 to V_{CC}	V
I_{IN}	IN pin current	-10/+10	mA
V_{PD}	I_{PD} pin voltage	-0.3 to 5.5	V
I_{PD}	I_{PD} pin current	-1/+10	mA
V_{FAULT}	FLT pins voltage	-0.3 to 5.5	V
I_{FAULT}	FLT pins current	-1[1]/+10	mA
E_{AS}	Single pulse avalanche energy (T_{AMB} = 125 °C, V_{CC} = 24 V, I_{OUT} = 2 A)	14[2]	J
		5.8[3]	J
P_{TOT}	Power Dissipation at T_C = 25 °C	Internally limited	W
T_{STG}	Storage Temperature Range	-55 to 150	°C
T_J	Junction Operating Temperature	Internally limited	°C
T_C	Case Operating Temperature	-40 to 150	°C

1. *intended as worst case when IC is in normal operation (no fault)*
2. *IPS1025HF*
3. *IPS1025HFQ*

4 Thermal data

Table 3. Thermal data

Symbol	Parameter	PSSO24	QFN48L	Unit
$R_{th(JC)}$ (1)	Thermal resistance junction-case	0.7	1	°C/W
$R_{th(JA)}$ (2)	Thermal resistance junction-ambient	22	26	°C/W

1. *Rth between the die and the bottom case surface measured by cold plate as per JESD51.*
2. *JESD51-7.*

5 Electrical characteristics

(8.65 V < V_{CC} < 60 V; -40 °C < T_J < 125 °C, unless otherwise specified)

Table 4. Supply

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{UVON}	Under-voltage ON threshold	-	7.4	-	8.65	V
V_{UVOFF}	Under-voltage OFF threshold	-	6.5	-	7.8	V
V_{UVH}	Under-voltage hysteresis	-	0.7	0.95	-	V
I_{SOFF}	Supply current in OFF state	V_{CC} = 24 V, IN = GND, OUT = open load	0.28	-	0.64	mA
		V_{CC} = 36 V, IN = GND, OUT = open load	0.28	-	0.64	mA
		V_{CC} = 60 V, IN = GND, OUT = open load	0.29	-	0.685	mA
I_{SON}	Supply current in ON state	V_{CC} = 24 V, IN = 5 V, OUT = open load	1.05	-	2.25	mA
		V_{CC} = 36 V, IN = 5 V, OUT = open load	1.15	-	2.35	mA
		V_{CC} = 60 V, IN = 5 V, OUT = open load	1.35	-	2.55	mA

Table 5. Output stage

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
R_{DSON}	On-state resistance	V_{CC} = 24 V, R_{LOAD} = 12 Ω, @ T_J = 25 °C	-	12	15	mΩ
		V_{CC} = 24 V, R_{LOAD} = 12 Ω, @ T_J = 125 °C	-	-	25	mΩ
$V_{OUT(OFF)}$	OFF state output voltage	V_{IN} = 0 V and I_{OUT} = 0 A	-	-	2	V
$I_{OUT(OFF)}$	OFF state output current	V_{IN} = 0 V, V_{OUT} = 0 V	-	-	10	µA

Table 6. Switching

(V_{CC} = 24 V; -40 °C < T_J < 125 °C, R_{LOAD} = 12 Ω, input rise time < 0.1 µs)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_r	Rise time		-	30	60	µs
t_f	Fall time		-	25	60	µs
$t_{PD(L-H)}$	Propagation delay time IN to OUT, low to high		-	13	25	µs
$t_{PD(H-L)}$	Propagation delay time IN to OUT, high to low		-	60	100	µs
td(Vccon)	Propagation delay time IN to OUT at power-on	V_{IN} = V_{CC} and rising from 0 to 24 V	5	-	60	µs

Figure 3. **Timing**

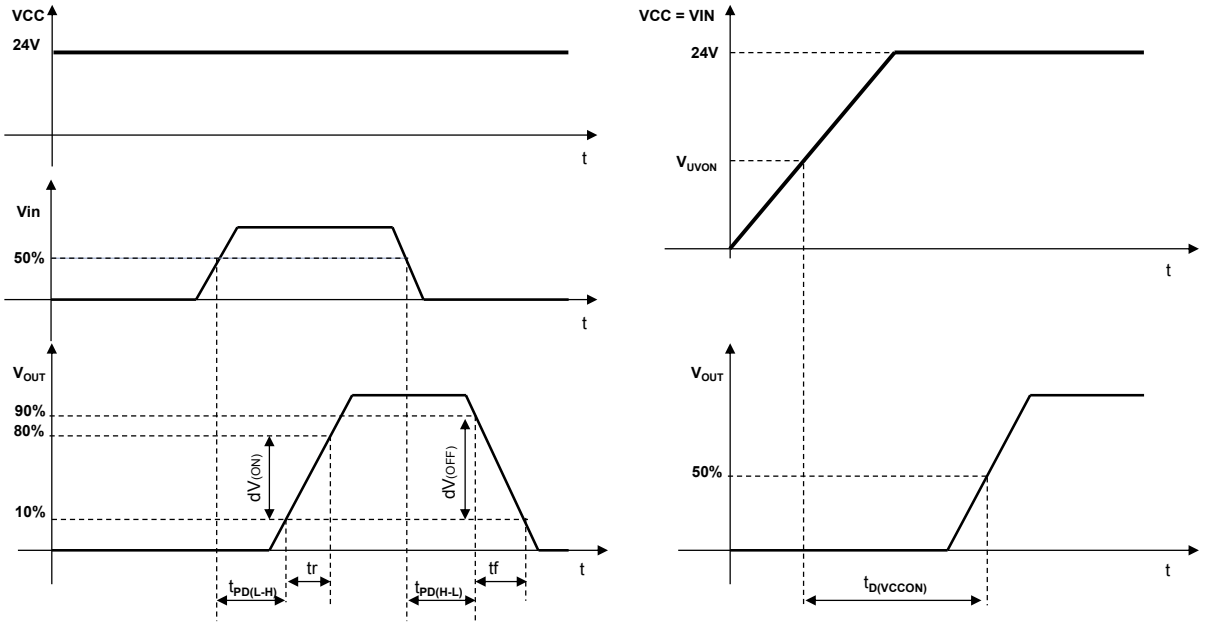


Table 7. **Input pin (IN)**

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{IL}	Input pin low level voltage	-	-	-	0.8	V
V_{IH}	Input pin high level voltage	-	2.2	-	-	V
$V_{I(HYST)}$	Input pin hysteresis voltage	-	-	0.4	-	V
I_{IN}	Input pin current	$V_{IN} = V_{CC}$ = 36 V	-	-	200	µA
		$V_{IN} = V_{CC}$ = 60 V	-	-	600	

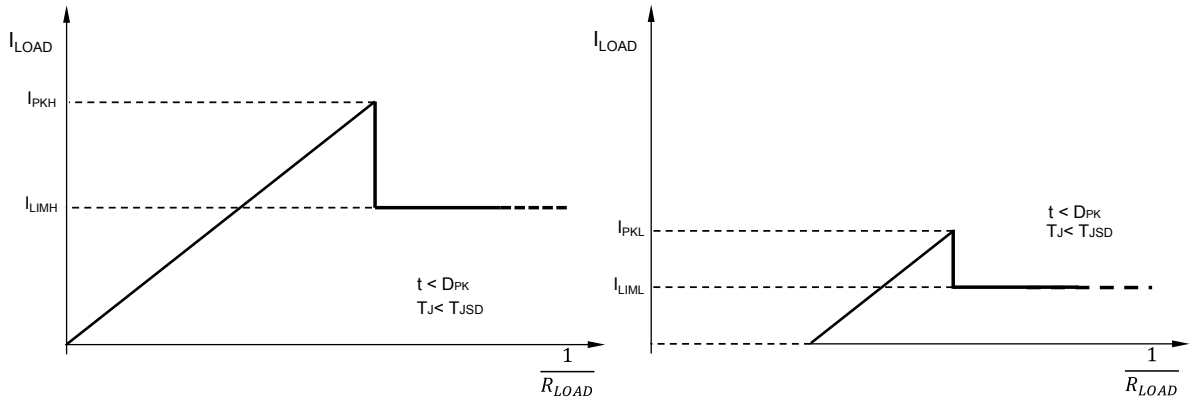
Table 8. **Diagnostic pins (FLT_1, FLT_2)**

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
IH_{FLT}	Diagnostic pins source current in fault condition.	V_{FLT} = 1 V (fault condition active)	-2.0	-	-4.0	mA
		V_{FLT} = 5 V (fault condition active)	-0.4	-	-1.0	
IL_{FLT}	Diagnostic pins leakage current	Normal operation V_{CC} = 60 V	0	-	-25	µA
BT_{FLT}	Diagnostic pins blanking time	-	60	-	400	µs
VCL_{FLT}	Diagnostic pins clamp voltage	I_{FLT} = +1 mA	6	6.8	8	V
		I_{FLT} = -1 mA	-	-	0.7	

Table 9. Protections

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Overload with Dual Threshold Protection: I_{PD} pin to GND by C_{PD} (470 pF ≤ C_{PD} ≤ 470 nF); see Section 7.3.1						
I_{PKH}	Initial over-current activation threshold	V_{CC} = 24 V	-	15.4	-	A
I_{LIMH}	Initial over-current limitation level		6.25	9.0	11.75	A
D_{PK}	Time limit of Initial over-current		-	215*C_{PD} [nF]	-	µs
I_{PKL}	Steady state over-current activation threshold		-	8.0	-	A
I_{LIML}	Steady state over-current limitation level		2.5	3.5	4.5	A
I_{HYS}	Steady state output Current limitation hysteresis		-	0.3	-	A
$I_{LIML-OFF}$	Steady state over-current limitation deactivation threshold		-	I_{LIML} - I_{HYS}	-	A
Overload with Single Level (Lowest) Protection: I_{PD} pin connected to IN by 10 kΩ resistor; see Section 7.3.2						
I_{PKL}	Steady state over-current activation threshold	V_{CC}= 24 V	-	8.0	-	A
I_{LIML}	Steady state over-current limitation level		2.5	3.5	4.5	A
I_{HYS}	Steady state output Current limitation hysteresis		-	0.3	-	A
$I_{LIML-OFF}$	Steady state over-current limitation deactivation threshold		-	I_{LIML}-I_{HYS}	-	A
Overload with Single Level (Highest) Protection: I_{PD} pin connected to GND by 10 kΩ resistor; see Section 7.3.3						
I_{PKH}	Initial over-current activation threshold	V_{CC}= 24 V	-	15.4	-	A
I_{LIMH}	Initial over-current limitation level		6.25	9.0	11.75	A
Over-temperature protections						
T_{JSD}	Junction temperature shutdown	-	150	170	190	°C
T_{JR}	Junction temperature reset	-	-	150	-	°C
T_{JHYS}	Junction temperature hysteresis	-	-	20	-	°C
T_{CSD}	Case temperature shutdown	-	-	130	-	°C
T_{CR}	Case temperature reset	-	-	110	-	°C
T_{CHYS}	Case temperature hysteresis	-	-	20	-	°C
Ground disconnection/Wire break						
I_{LGND}	GND disconnection output current	V_{INX} = 24 V, V_{CC} = 24 V, V_{OUT} = 0 V	-	-	0.5	mA
V_{CC} over-voltage						
V_{CLAMP}	V_{CC} Clamp Voltage	I_{CC} ≤ 10 mA	65.5	70.0	73.5	V
Demagnetization of inductive load						
V_{DEMAG}	Demagnetization Voltage	I_{OUT} = 0.5 A, Load ≥ 10 mH	Vcc-76	Vcc-72.5	Vcc-68	V

Figure 4. High (left) and Low (right) I_{LOAD} control activation thresholds (I_{PK}) and limitation levels (I_{LIM})



6 Output Logic

Table 10. Output stage truth table

(L = pin voltage Low, H = pin voltage High, X = not determined)

Condition	IN	OUT	FLT1	FLT2
Normal Operation	L H	L H	L L	L L
Overload protection	L H	L X(1)	L L	L H
Junction over-temperature protection (see Section 7.2 Over-temperature)	L H	L L	L H	L L
Case over-temperature protection (see Section 7.2 Over-temperature)	L H	L L	L H	L L
UVLO	L H	L L	X X	X X

1. *Pin voltage = I_{OUT} * R_{LOAD}*

Figure 5. Typical application diagram with opto-couplers

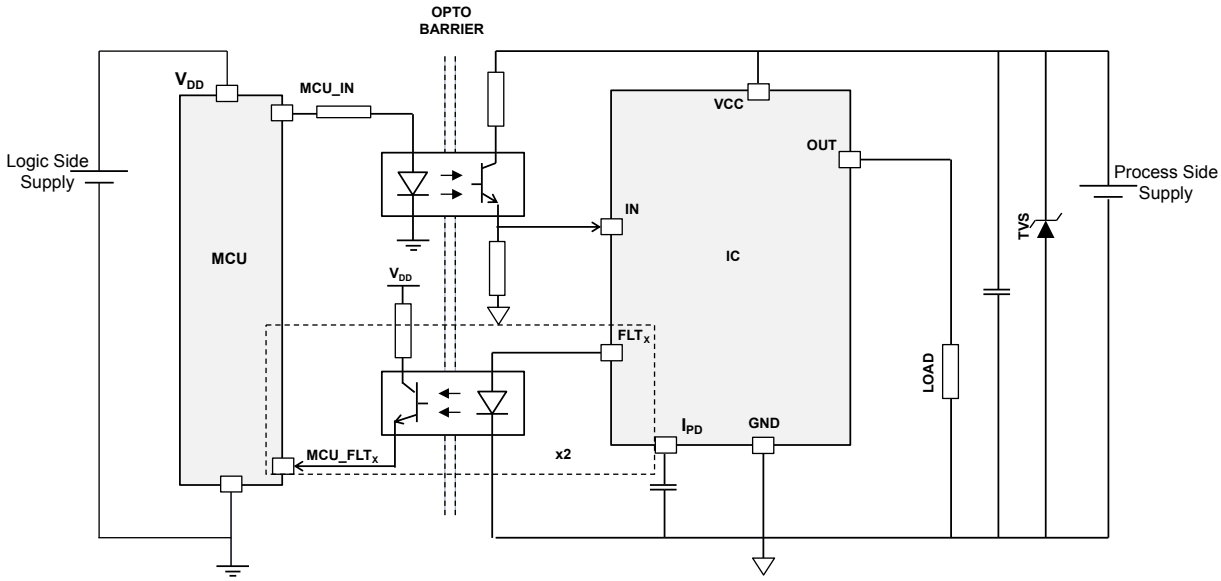
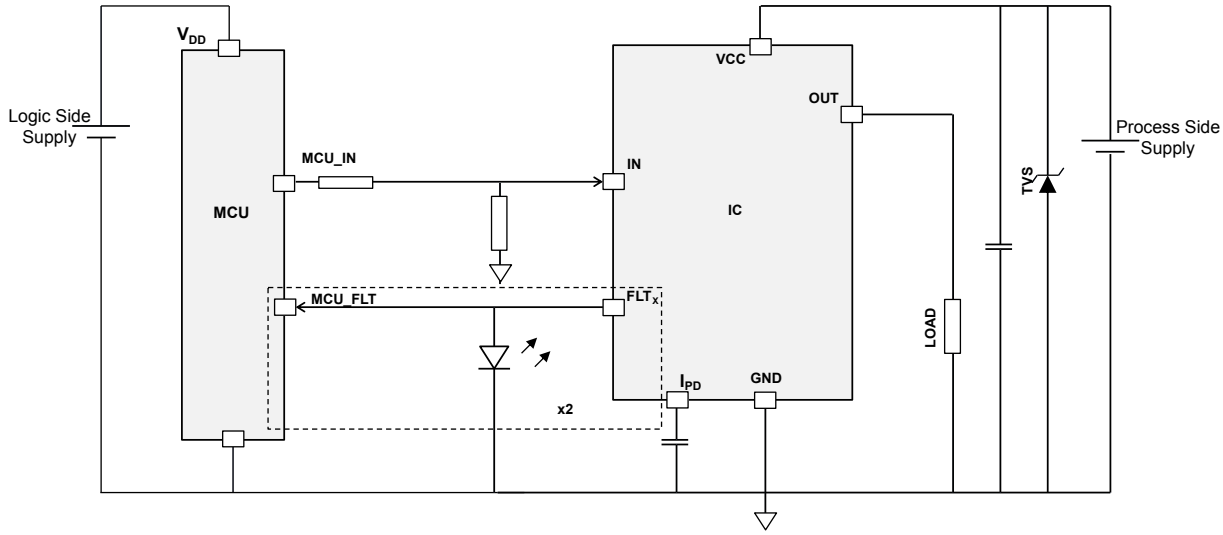


Figure 6. **Typical application diagram without opto-couplers**



7 Protections and diagnostic

The IC integrates several protections to help the design of robust applications.

7.1 Under-voltage lock-out

The IC is turned off if the voltage on V_{CC} pin falls below the turn-off threshold (V_{UVOFF}). Normal operation restarts after V_{CC} exceeds the turn-on threshold (V_{UVON}). Turn-on and turn-off thresholds are defined in Table 4 .

7.2 Over-temperature

The device is protected against overheating in case of overload conditions. During the driving period (when the MCU is forcing the IN pin high), if the output is overloaded, the device suffers two different thermal stresses: one related to the junction temperature of each output channel, and the other related to the whole case temperature.

The two thermal faults (Thermal Junction and Thermal Case) have different trigger thresholds: T_{JSD} and T_{CSD}, respectively.

Usually, in thermal stress conditions due to overload, the junction thermal shutdown is the first protection that is activated: the output channel (OUT) is turned off when its junction temperature (T_J) is higher than the activation threshold (T_{JSD}) and turned back on when it falls below the reset threshold (T_{JR}). This behavior continues while overload on the output persists. When the thermal protection is active, the FLT_1 (current source) becomes active accordingly.

If the thermal protection is active and the temperature of the case (T_C) increases over the case protection threshold (T_{CSD}), then the thermal case protection is activated and the output is switched off until the junction temperature and case temperature fall below their respective reset thresholds (T_{CR} and T_{JR}). The FLT_1 pin is active even when thermal case events occur.

Figure 7 shows the thermal protection behavior, while Figure 8 shows typical temperature trends and output vs. input state.

Figure 7. **Thermal protection flowchart**

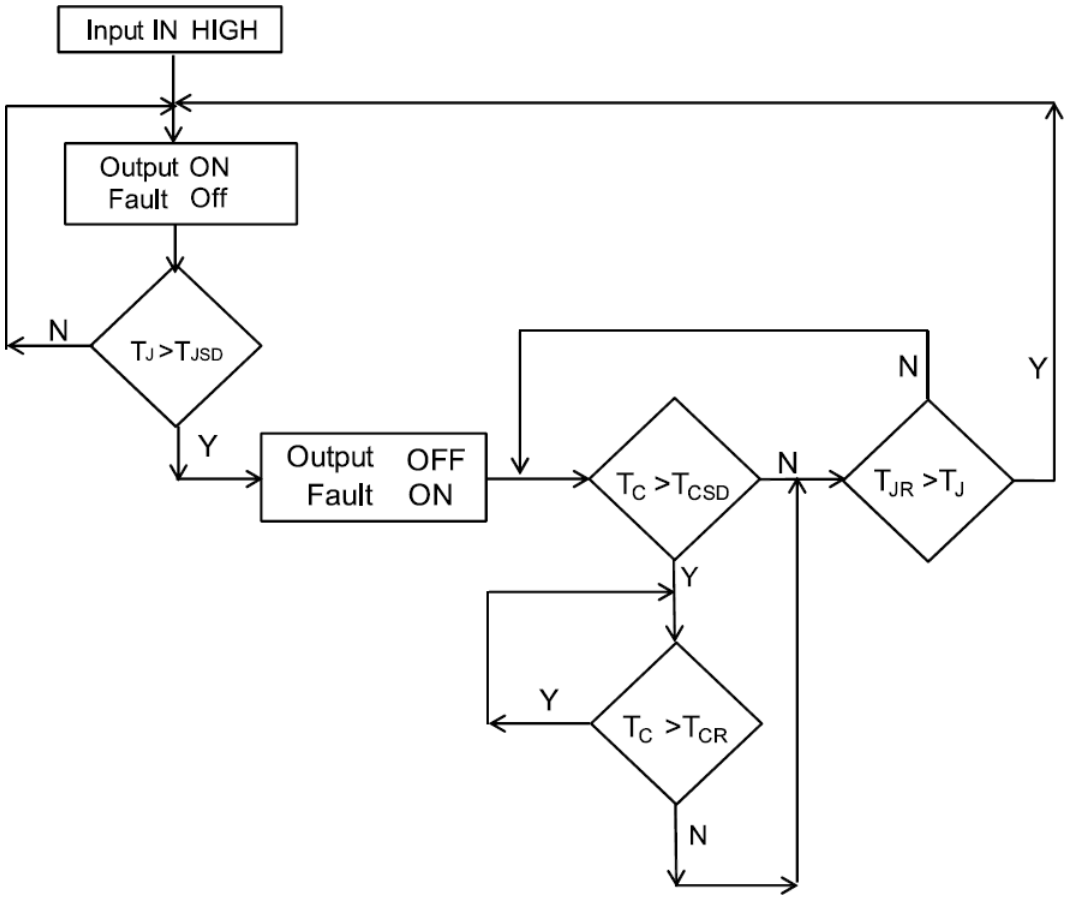
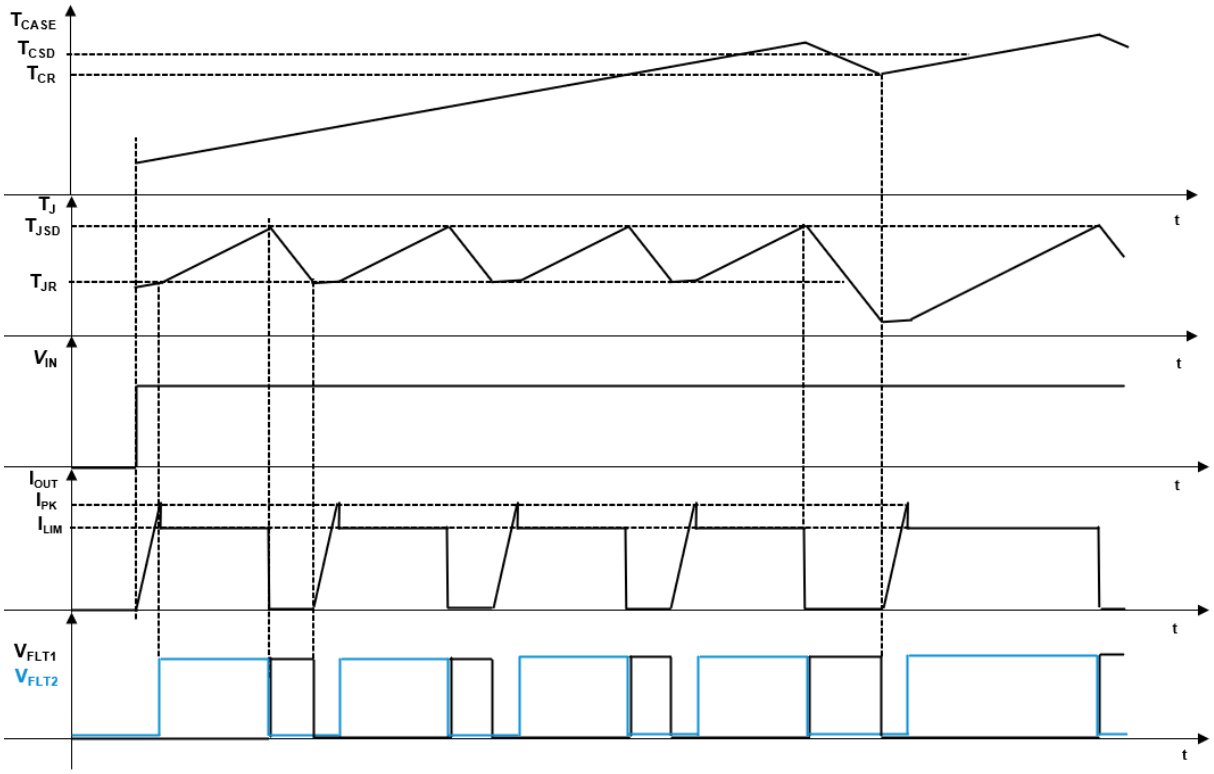


Figure 8. **Thermal protection plot**



7.3 Overload

The IC integrates an overload protection circuit consisting of an output current sensing section and an output current limitation section.

When the output channel is ON, the sensing circuitry monitors the current supplied to the load: if the activation threshold (I_{PK}) is triggered, then the current limitation control circuitry is activated to limit output current to the current limitation level (I_{LIM}) and FLT_2 pin is activated until the overload condition is removed.

See the following sections for details and Table 9 for specific activation thresholds and limitation levels.

Note that while the output channel operates below its activation threshold, the power dissipation can be calculated by $R_{ON} * I_{OUT}{}^2$, but when the current limitation circuit is activated, power dissipation increases and can be calculated by $V_{DS} * I_{OUT}$, where V_{DS} is the voltage drop between the OUT and V_{CC} pins of the IC. In order to protect the IC against thermal stress, the over-temperature protection is always active and retains the highest priority.

7.3.1 Overload protection with dual threshold

This case is activated when the pin I_{PD} is connected to GND by a capacitor (C_{PD}) and the IC works with two activation thresholds I_{PKH} and I_{PKL}.

The I_{PKH} is active only in the limited time frame between the L-H transition of the IN signal and the D_{PK} delay defined by the following design rule:

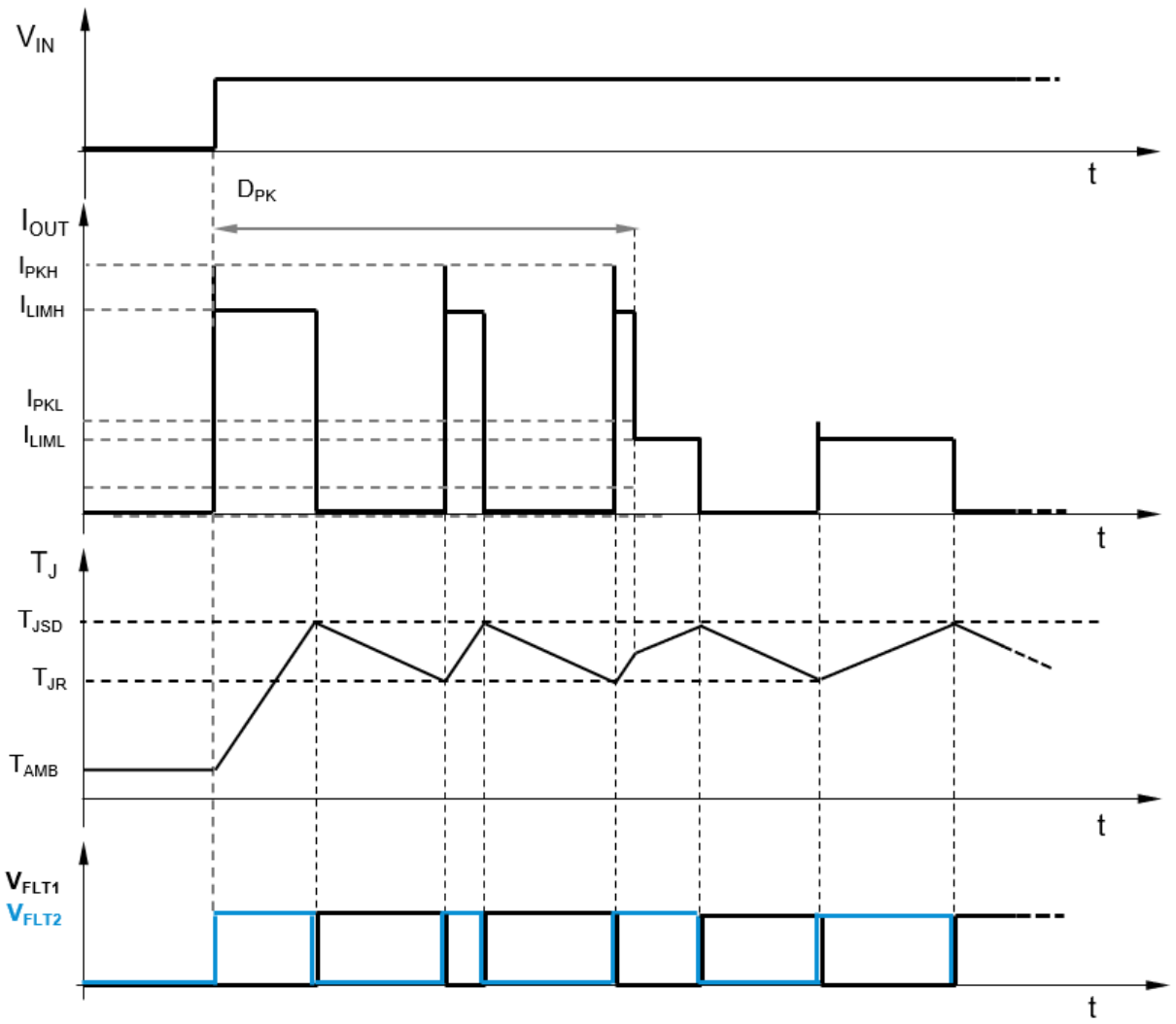
$$D_{PK}\,[\mu s] = 215 \times CPD\,[nF]$$

The above design rule is valid in the range 470 pF ≤ C_{PD} ≤ 470 nF (see Table 9).

If the I_{PKH} is triggered within the D_{PK} time frame, then the output current is limited to I_{LIMH}.

After D_{PK} has elapsed, the IC operates with I_{PKL} activation threshold and I_{LIML} limitation level, respectively.

Figure 9. **Short-circuit behavior with dual threshold ($T_{CASE} < T_{CSD}$)**



7.3.2 Overload protection with single (low) threshold

The user can set the activation threshold to I_{PKL} and the limitation level to I_{LIML} by connecting the I_{PD} pin to the IN pin with a 220 KΩ resistor.

This condition is equivalent to setting D_{PK} = 0 µs.

Note: Leaving I_{PD} floating is equivalent to having an initial peak duration of 1 µs.

7.3.3 Overload protection with single (high) threshold

The user can set the activation threshold to I_{PKH} and the limitation level to I_{LIMH} by connecting the I_{PD} pin to GND with a 10 KΩ resistor.

7.4 V_{CC} disconnection protection

V_{CC} disconnection involves the disconnection of the module from the supply line. When this condition is detected, the output channel can be driven normally until the voltage on V_{CC} pin remains higher than the UVLO threshold.

In case of inductive load, if the V_{CC} is disconnected while the channel is active, the energy stored in the inductance is discharged through the power switch thanks to the integrated demagnetization circuit.

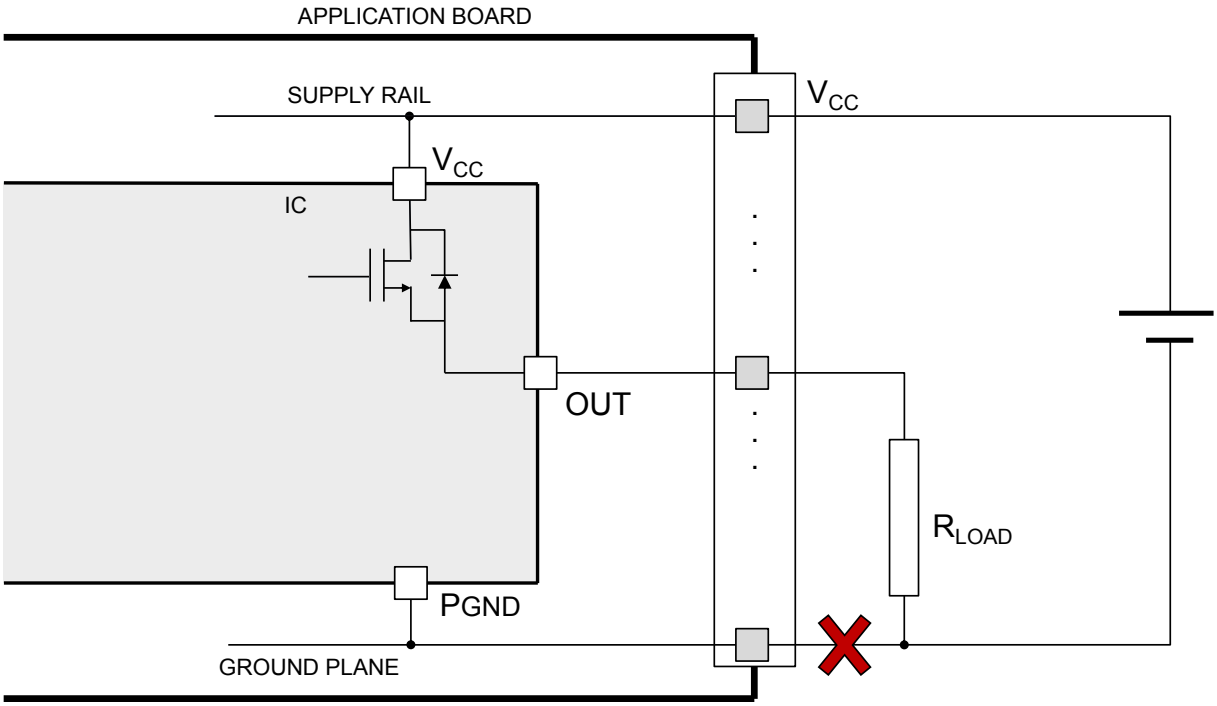
7.5 GND disconnection protection

GND disconnection is the disconnection of the module from the reference line. When this condition occurs, the output channel is turned off regardless of the input status.

When this event occurs, the IC continues working normally until the voltage between V_{CC} and GND pins of the IC results ≥ V_{UVOFF}. The voltage on the GND pin of the IC rises up to the supply rail voltage level. In case of a GND disconnection event, a current (I_{LGND}) flows through OUT pin.

For an inductive load, if the GND is disconnected while the output channel is active, the current flows through the power, which is activated by an active clamp as if the input had been deactivated.

Figure 10. Ground disconnection



8 Active clamp

Active clamp is also known as Fast Demagnetization of inductive loads or Fast Current Decay. When a high-side driver turns off an inductance, an under-voltage on output is detected.

The OUT pin is pulled-down to V_{CC}-V_{DEMAG}. The conduction state is modulated by an internal circuitry in order to keep the OUT pin voltage at ~V_{DEMAG} until the load energy has been dissipated. The energy is dissipated in both IC internal switch and load resistance.

Figure 11. Active clamp equivalent principle schematic

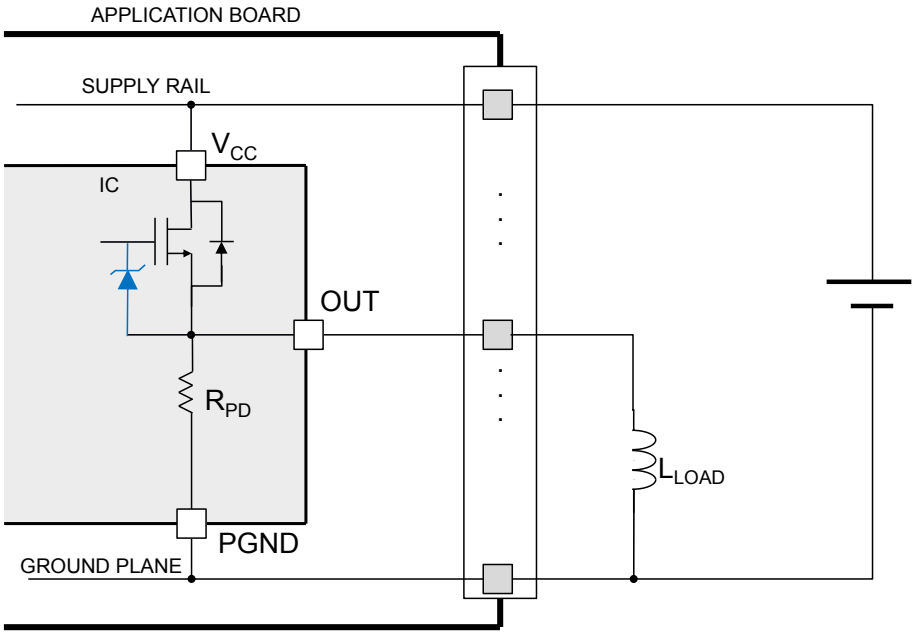
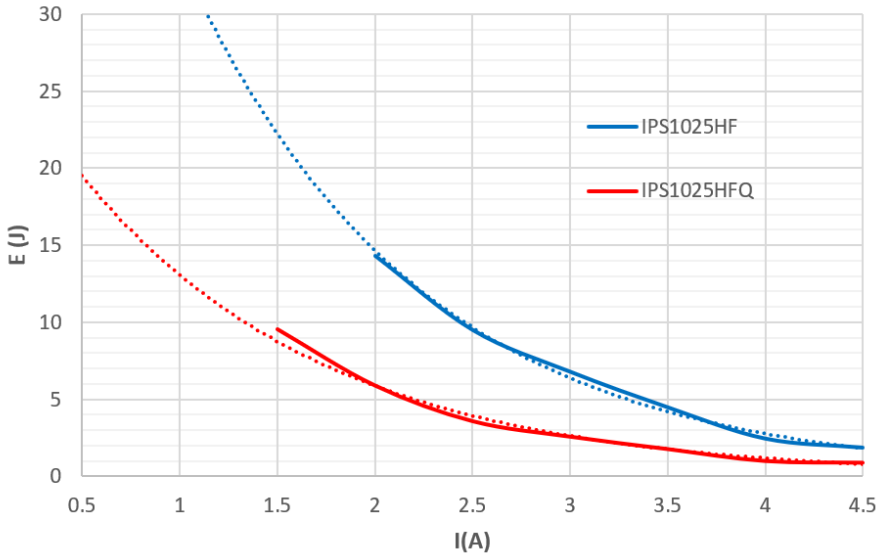


Figure 12. Typical demagnetization energy (single pulse) at V_{CC} = 24 V and T_{AMB} = 125 °C



9 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. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

9.1 Package mechanical data

Figure 13. **PowerSSO-24 package dimensions [mm]**

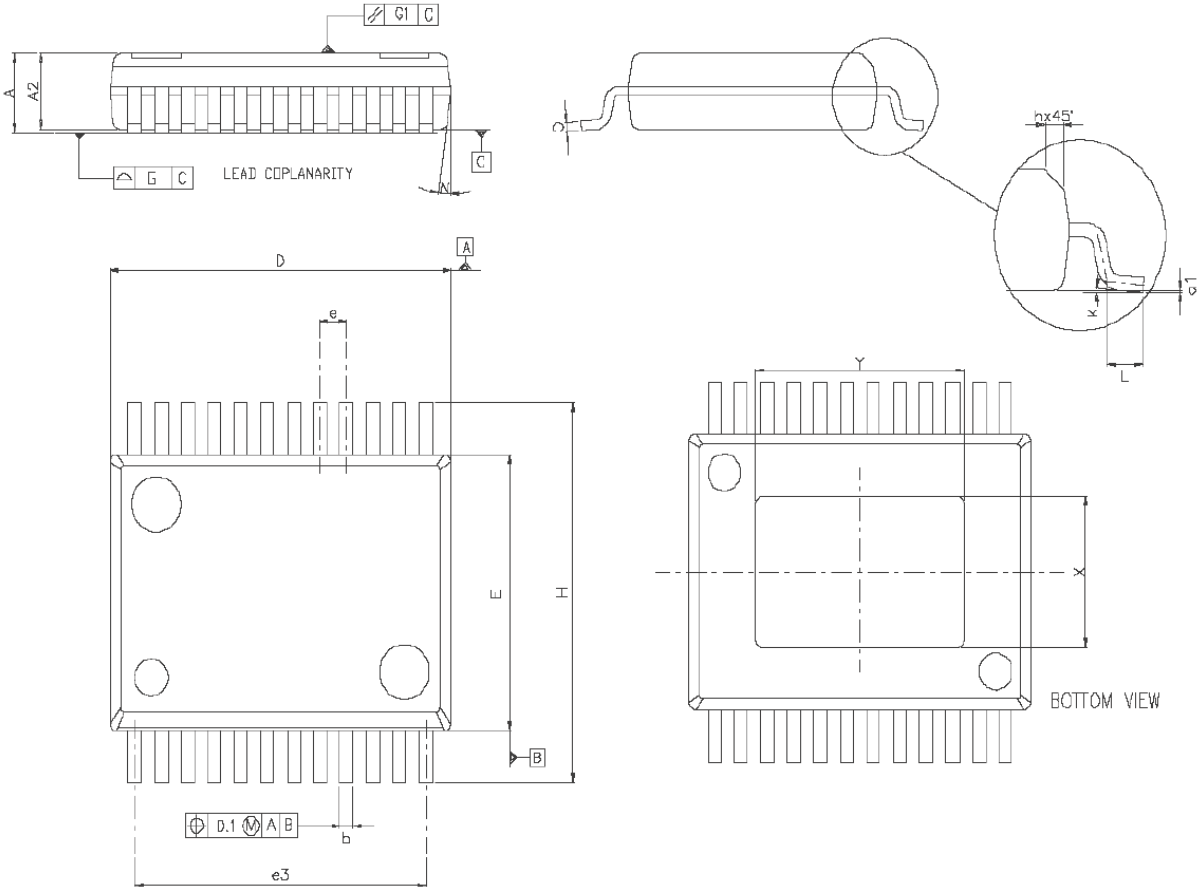
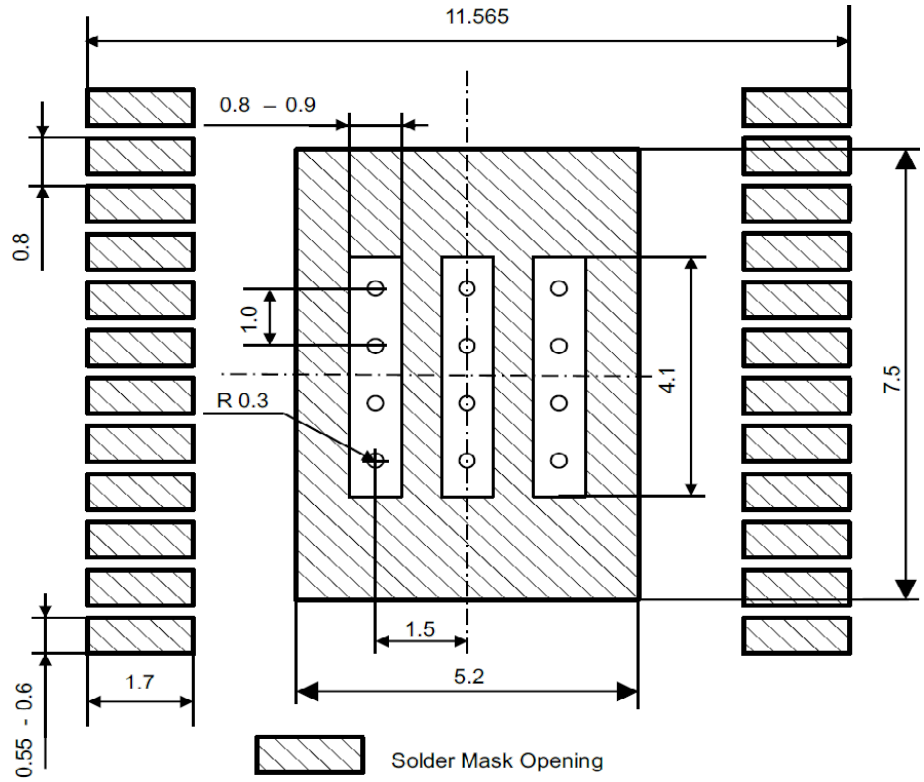


Table 11. **PowerSSO-24 mechanical data**

Dim.	[mm]		
	Min.	Nom.	Max.
A	2.15	-	2.47
A2	2.15	-	2.40
a1	0	-	0.075
b	0.33	-	0.51
c	0.23	-	0.32
D	10.10	-	10.50
E	7.4	-	7.6

Dim.	[mm]		
	Min.	Nom.	Max.
e	-	0.8	-
e3	-	8.8	-
G	-	-	0.1
G1	-	-	0.06
H	10.1		10.5
h	-	-	0.4
L	0.55	-	0.85
N	-	-	10 deg
X	4.1	-	4.7
Y	6.5	-	7.1

Figure 14. PowerSSO-24 suggested footprint [mm]



STMicroelectronics is not responsible for PCB-related issues. The footprint shown in the above figure is a suggestion which may differ from the customer PCB supplier design rules.

Figure 15. **QFN48L package dimensions [mm]**

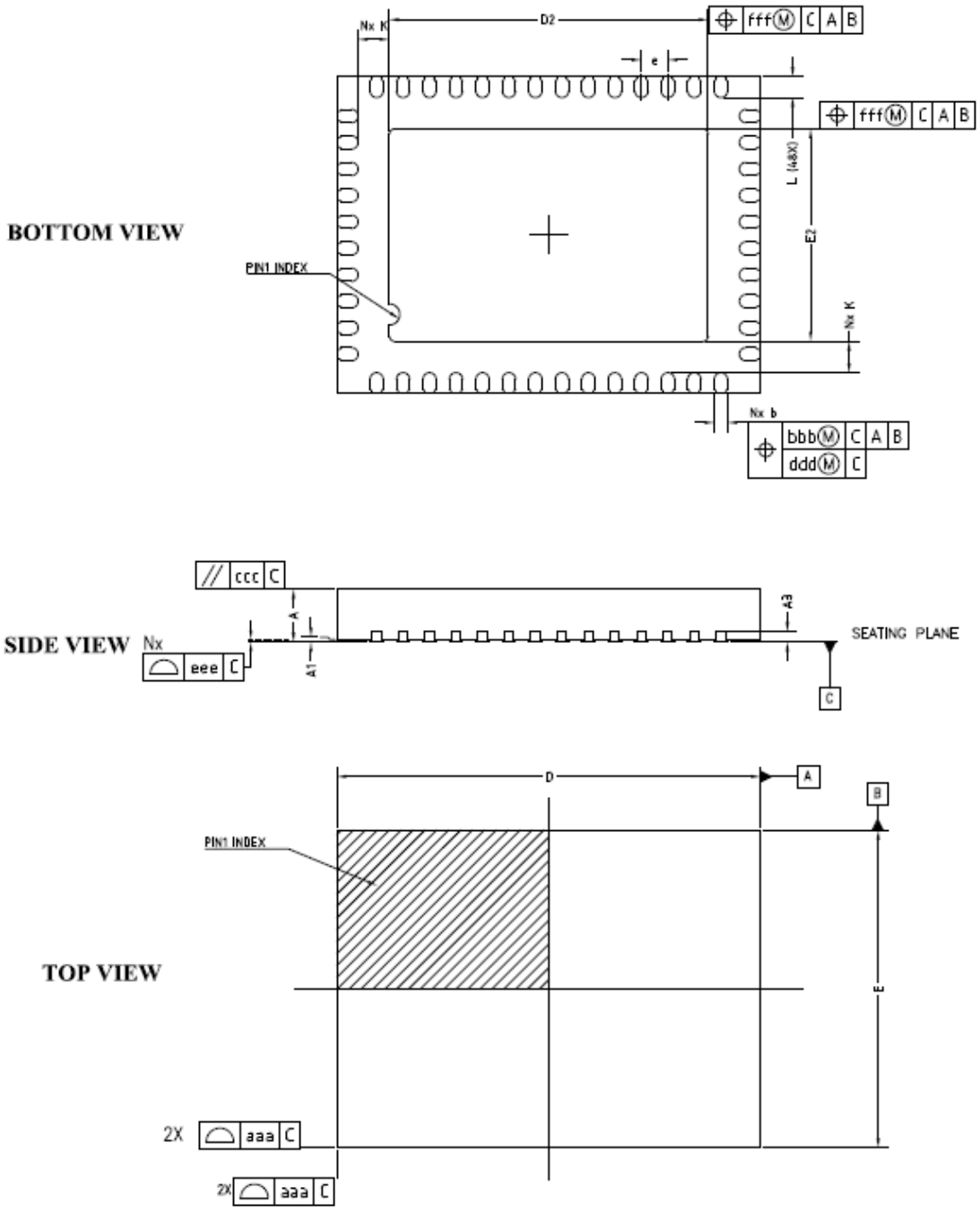


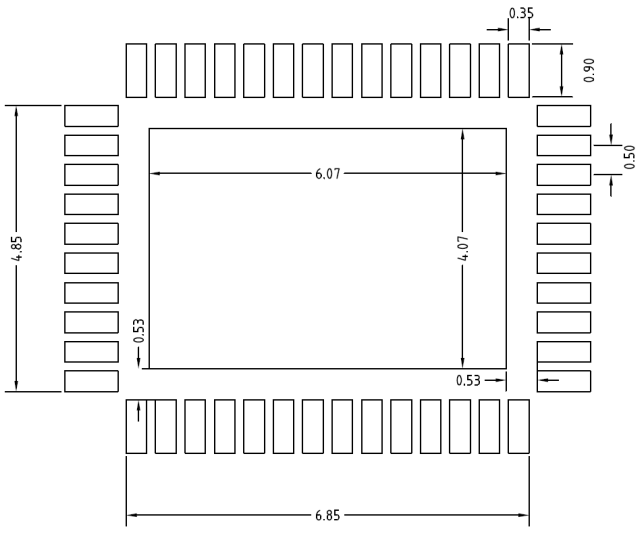
Table 12. **QFN48L mechanical data**

Dim.	[mm]		
	Min.	Nom.	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 BSC	
E		6.00 BSC	
D2	5.97	6.02	6.07
E2	3.97	4.02	4.07
L	0.365	0.40	0.435
k	0.53	-	-
N		48	

Table 13. **Tolerance of forms and positions**

Dim.	Tolerance of forms and positions
aaa	0.10
bbb	0.10
ccc	0.10
ddd	0.05
eee	0.08
fff	0.10

Figure 16. **QFN48L suggested footprint [mm]**



10 Packing information

10.1 Packing mechanical data

Figure 17. **PowerSSO-24 tube shipment (no suffix)**

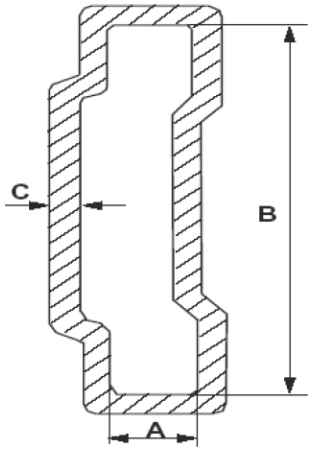


Table 14. **PowerSSO-24 tube shipment information**

All dimensions are in mm

Description	Value
Base quantity	49
Bulk quantity	1225
Tube length (±0.5)	532
A	3.5
B	13.8
C (±0.1)	0.6

Figure 18. **PowerSSO-24 reel shipment**

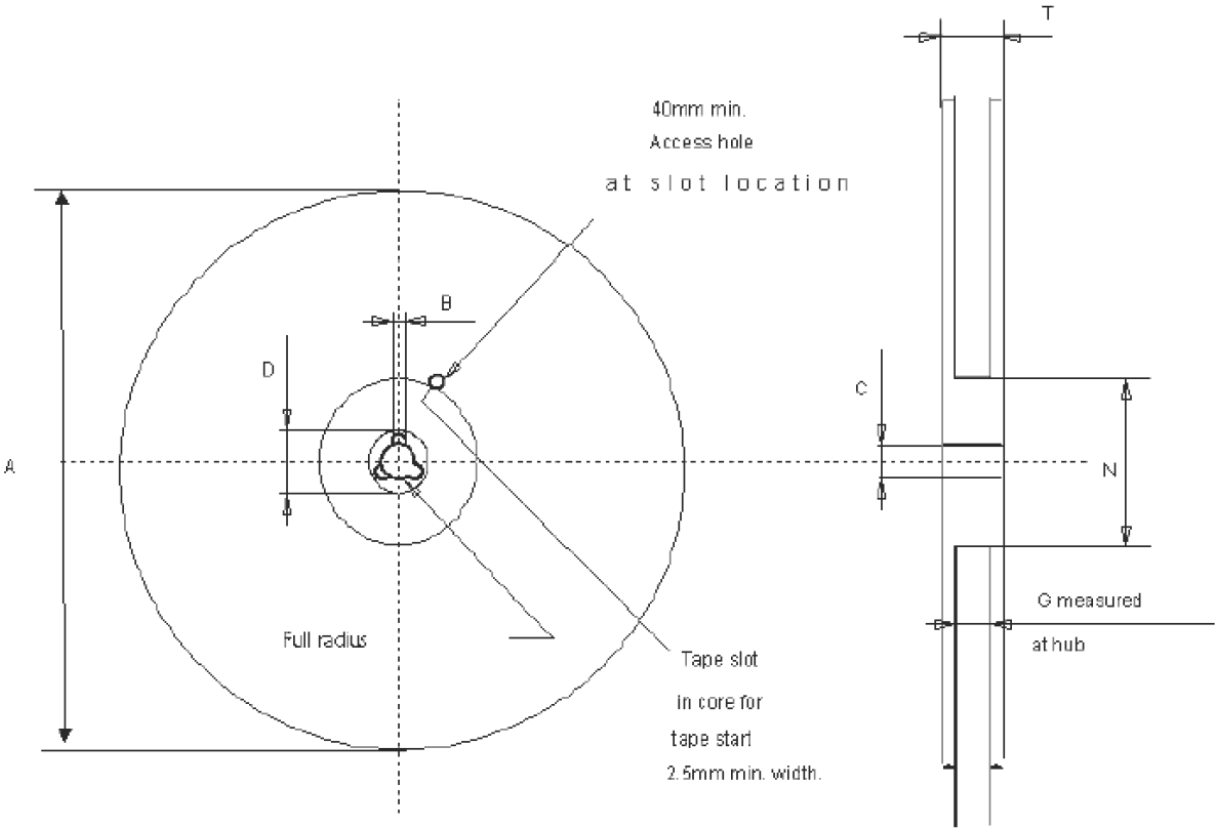


Table 15. **PowerSSO-24 reel information**

All dimensions are in mm

Description	Value
Base quantity	1000
Bulk quantity	1000
A (max.)	330
B (min.)	1.5
C (±0.2)	13
F	20.2
G (2 ±0)	24.4
N (min.)	100
T (max.)	30.4

Figure 19. **PowerSSO-24 tape drawings**

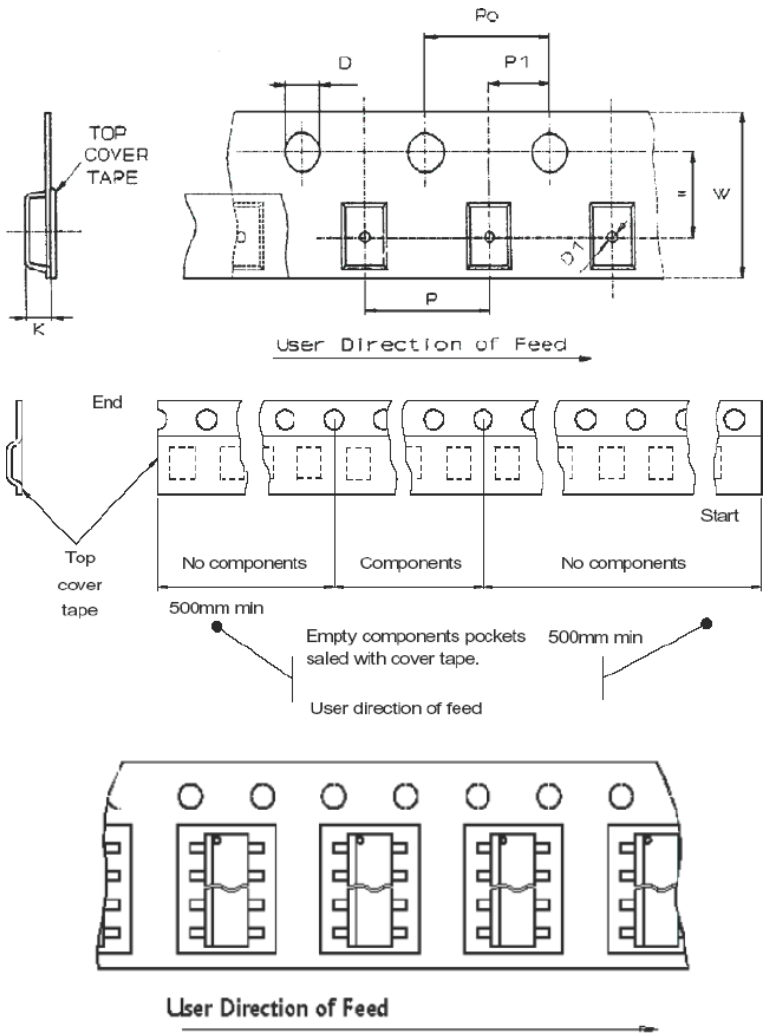


Table 16. **PowerSSO-24 tape dimension**

All dimensions are in mm

Description	Symbol	Value
Tape width	W	24
Tape hole spacing	P0 (± 0.1)	4
Component spacing	P	12
Hole diameter	D (± 0.05)	1.55
Hole diameter	D1 (min.)	1.5
Hole position	F (± 0.1)	11.5
Compartment depth	K (max.)	2.85
Hole spacing	P1 (± 0.1)	2

Note: According to the Electronic Industries Association (EIA) standard 481 rev. A, Feb 1986.

Figure 20. **QFN48L reel shipment reference**

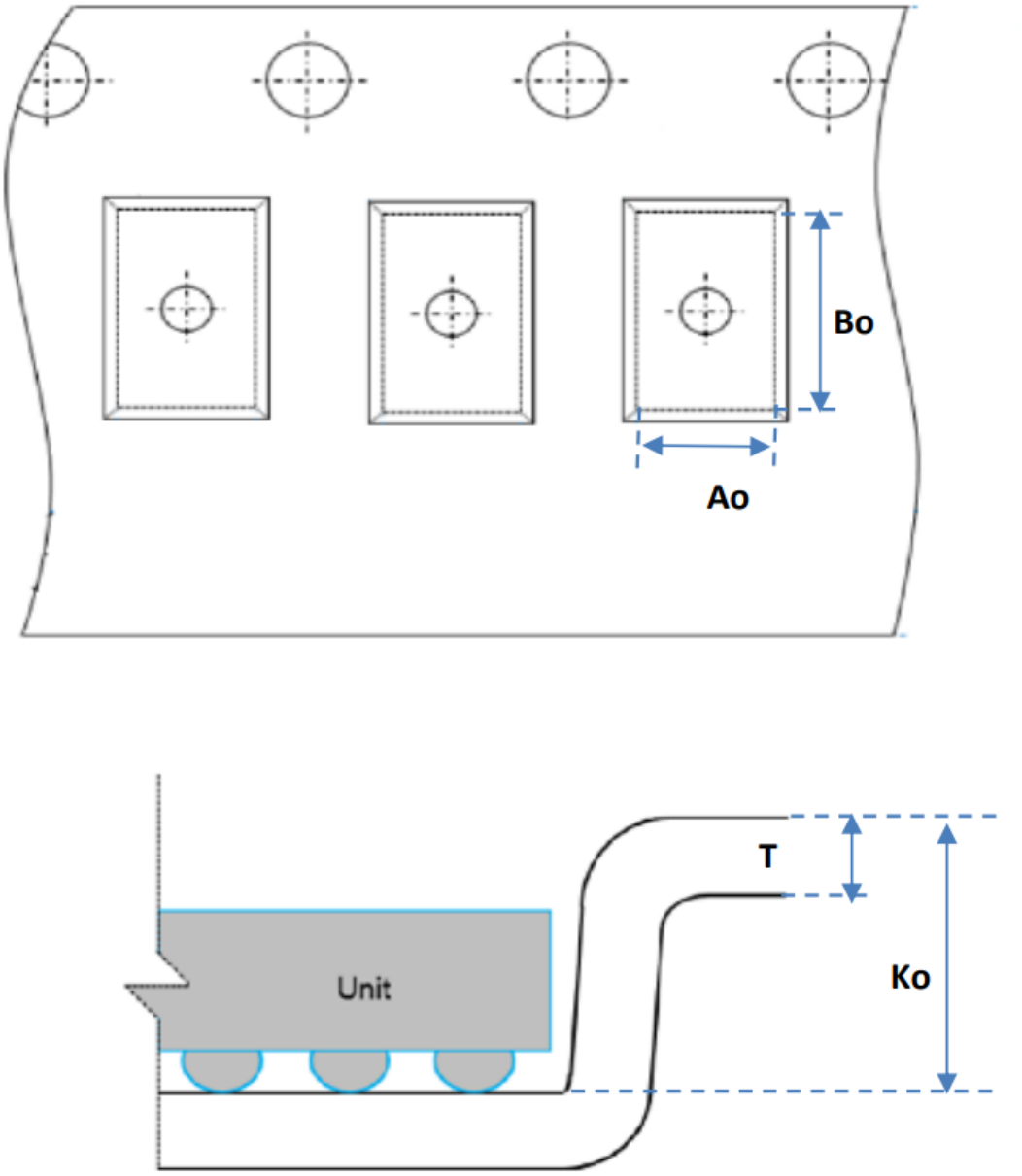
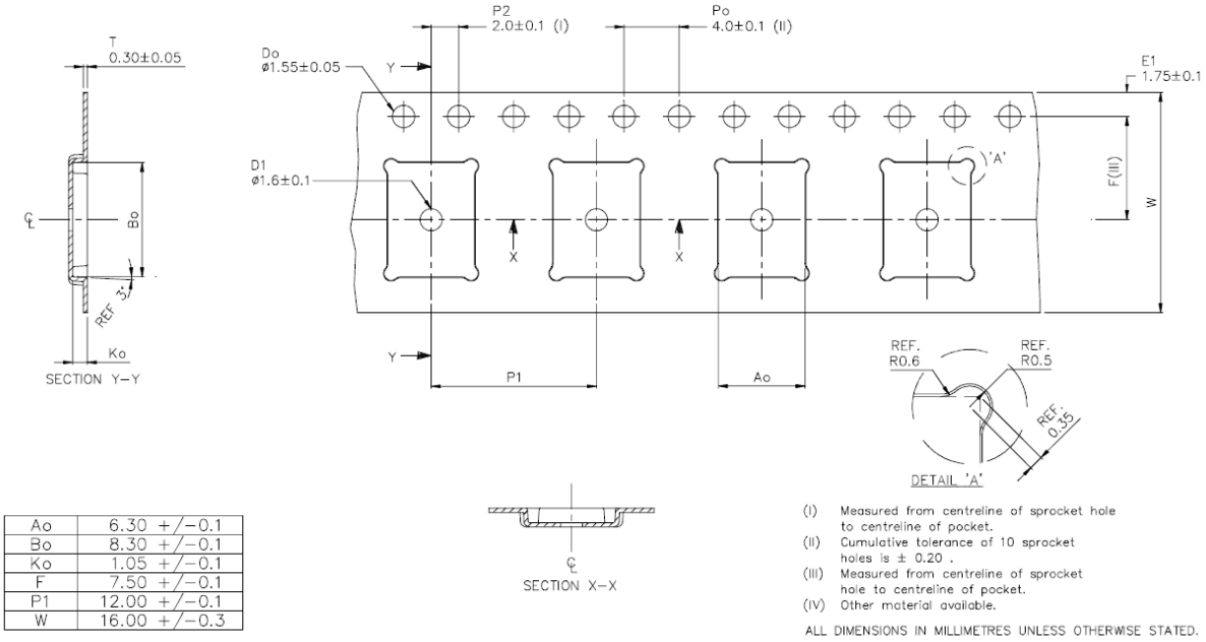


Table 17. **Standard SPC parameters**

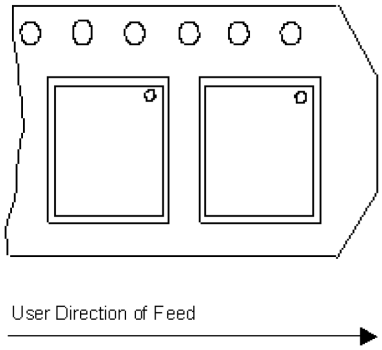
Item	Description
Ao	Pocket Length
Bo	Pocket Width
Ko	Pocket Depth
T	Tape Thickness

Figure 21. **QFN48L carrier tape dimensions**



Ao	6.30 +/−0.1
Bo	8.30 +/−0.1
Ko	1.05 +/−0.1
F	7.50 +/−0.1
P1	12.00 +/−0.1
W	16.00 +/−0.3

Figure 22. **QFN48L carrier tape, Pin 1 indication**



11 Ordering information

Table 18. **Ordering information**

Part number	Package	Packaging
IPS1025HF	PowerSSO-24	Tube
IPS1025HFTR		Tape and reel
IPS1025HFQ	QFN48L 8x6x0.9 mm	Tape and reel

Revision history

Table 19. **Document revision history**

Date	Version	Changes
28-Mar-2022	1	Initial release
28-Jun-2022	2	Corrected typo in "Description" (value of propagation delay time at startup). Table 4 : changed V_{UVON} max value. Some minor changes.
01-Aug-2022	3	Add QFN data: fig.2, 12, 15, 16, 20, 21, 22; tables 1, 2, 3, 12, 13, 17, 18.

Contents

List of tables

List of figures