

High efficiency, high-side switch with extended diagnostics and smart driving for capacitive loads



Features

- 8 V to 60 V operating supply voltage range
- Smart driving of capacitive load
- Under-voltage lock-out
- V_{CC} over-voltage protection
- Fast demagnetization of inductive loads
- Per-channel overload and over-temperature protection
- Case over-temperature protection
- Per channel overload/over-temperature event diagnostic pins
- Ground disconnection protection
- Designed to meet IEC 61000-4-2, IEC 61000-4-4, IEC 61000-4-5
- Package PowerSSO-24

Applications

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

Product status link

[IPS2050H](#)
[IPS2050H-32](#)

Product label



Description

The IPS2050H and IPS2050H-32 are dual high-side switch ICs able to drive capacitive, resistive or inductive loads with one side connected to ground.

The very low R_{DS-ON} (≤ 50 mΩ up to T_J = 125 °C) makes the IC suitable for applications with up to 2.4 A / 5.6 A steady state operating current.

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

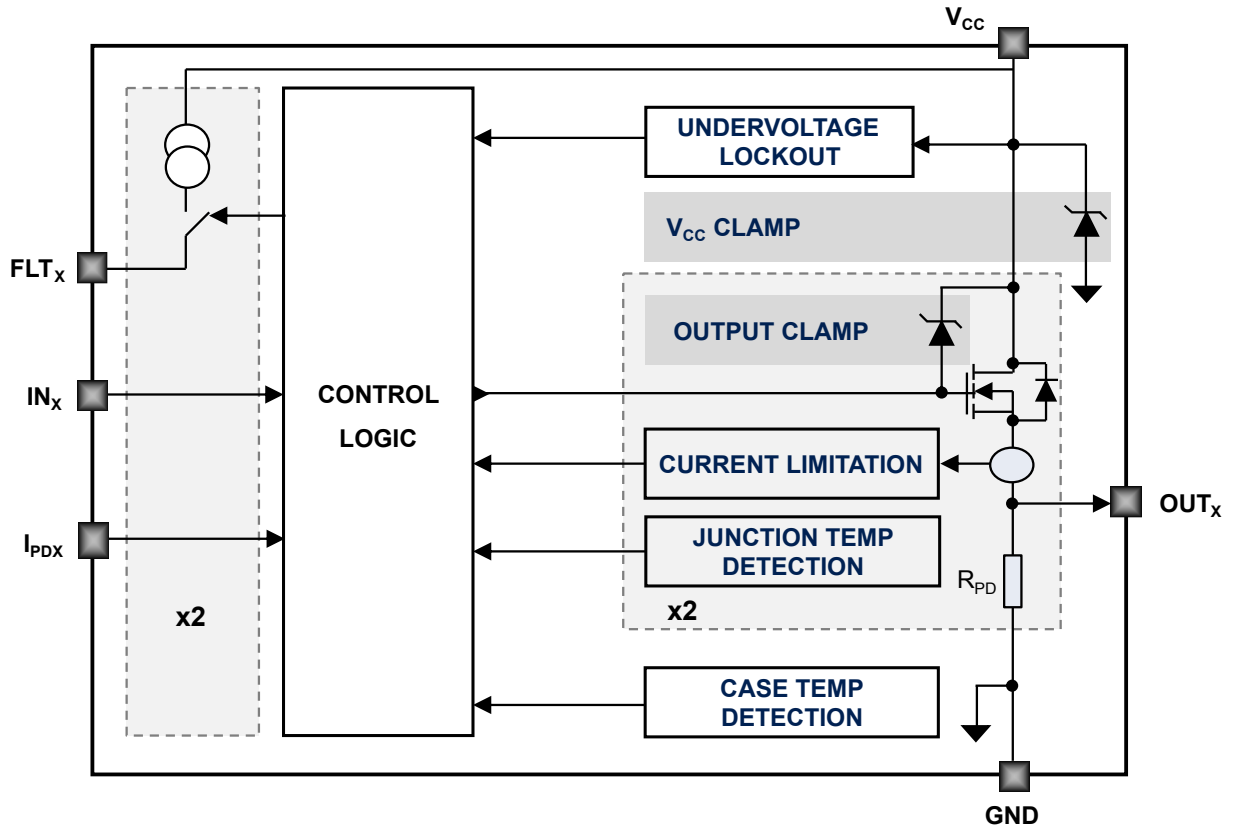
The embedded per-channel overload protection circuit monitors the output current and, on triggering of the activation threshold (I_{PK-X}), starts modulating the impedance of the output switch to limit the output current to I_{LIM-X}, for both IC and load protection.

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

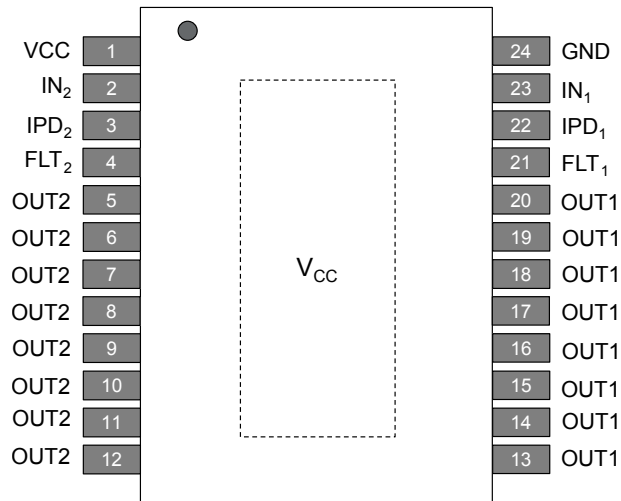
The IC diagnostics is based on two FAULT pins (current source), one for each channel. Each FAULT pin is activated by an overload or an over-temperature event on the related channel.

1 Block diagram

Figure 1. IPS2050H, IPS2050H-32 block diagram



2 Pin connection

Figure 2. Pin connections (top through view)

Table 1. Pin descriptions

Pin no.	Pin name	Type
1, exposed pad	VCC	Supply voltage
2	IN ₂	Channel 2 input
3	IPD ₂	Channel 2 initial current duration / level selector. Connect to GND by a capacitor to set duration of I _{PKH-2} (see Section 7.3 and Table 9). Connect to IN ₂ by a 220 kΩ resistor to disable initial I _{PKH-2} threshold on channel 2 (the over-current limit for channel 2 is only I _{PKL-2}). Connect to GND by a 10 kΩ resistor to disable I _{PKL-2} on channel 2 (the over-current threshold for channel 2 is only I _{PKH-2}).
4	FLT ₂	Fault (Overload or Over-temperature) diagnostic pin for channel 2
5 to 12	OUT ₂	Channel 2 power stage output
13 to 20	OUT ₁	Channel 1 power stage output
21	FLT ₁	Fault (Overload or Over-temperature) diagnostic pin for channel 1
22	IPD ₁	Channel 1 initial current duration / level selector. Connect to GND by a capacitor to set duration of I _{PKH-1} (see Section 7.3 and Table 9). Connect to IN ₁ by a 220 kΩ resistor to disable initial I _{PKH-1} threshold on channel 1 (the over-current limit for channel 1 is only I _{PKL-1}). Connect to GND by a 10 kΩ resistor to disable I _{PKL-1} on channel 1 (the over-current threshold for channel 1 is only I _{PKH-1}).
23	IN ₁	Channel 1 input
24	GND	Device ground

Note: Leaving IPD_X floating is equivalent to a 1 μs duration for I_{PKH-X}.

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 VCC)	-250	mA
I _{OUT}	Output stage current	Internally limited	A
-I _{OUT}	Reverse current (from single OUT pin to VCC)	5	A
V _{IN}	IN pins voltage	-0.3 to VCC	V
I _{IN}	IN pins current	-10/+10	mA
V _{PD}	I _{PD} pins voltage	-0.3 to 5.5	V
I _{PD}	I _{PD} pins 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 per channel, all channels driven simultaneously (T _{AMB} = 125 °C, V _{CC} = 24 V, I _{OUTX} = 2 A)	1.3	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)

4 Thermal data

Table 3. Thermal data

Symbol	Parameter	Value	Unit
$R_{th(JC)}^{(1)}$	Thermal resistance junction-case per channel	0.7	°C/W
$R_{th(JA)}^{(2)}$	Thermal resistance junction-ambient	22	°C/W

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

5 Electrical characteristics

(8 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	-	6.9	-	8	V
V _{UVOFF}	Under-voltage OFF threshold	-	6.5	-	7.8	V
V _{UVH}	Under-voltage hysteresis	-	0.15	0.5	-	V
I _{SOFF}	Supply current in OFF state	I _{NX} = GND, O _{UTX} = open load	-	0.5	0.95	mA
I _{SON}	Supply current in ON state	V _{CC} = 24V	1.95	2.6	3.2	mA
		V _{CC} = 36V	2.05	2.7	3.3	mA
		V _{CC} = 60V	2.25	2.9	3.5	mA

Table 5. Output stage

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
R _{DS(ON)}	On-state resistance	V _{CC} = 24 V, R _{LOAD} = 12 Ω, @ T _J = 25 °C	-	25	30	mΩ
		V _{CC} = 24 V, R _{LOAD} = 12 Ω, @ T _J = 125 °C	-	-	50	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		-	25	50	μs
t _f	Fall time		-	15	30	μs
t _{PD(L-H)}	Propagation delay time IN to OUT, low to high			14	25	μs
t _{PD(H-L)}	Propagation delay time IN to OUT, high to low		-	33	60	μs
t _{D(VCCON)}	Propagation delay time IN to OUT at power-on	V _{IN} = V _{CC} and rising from 0 to 24 V	150	500	1600	μs

Figure 3. Timing

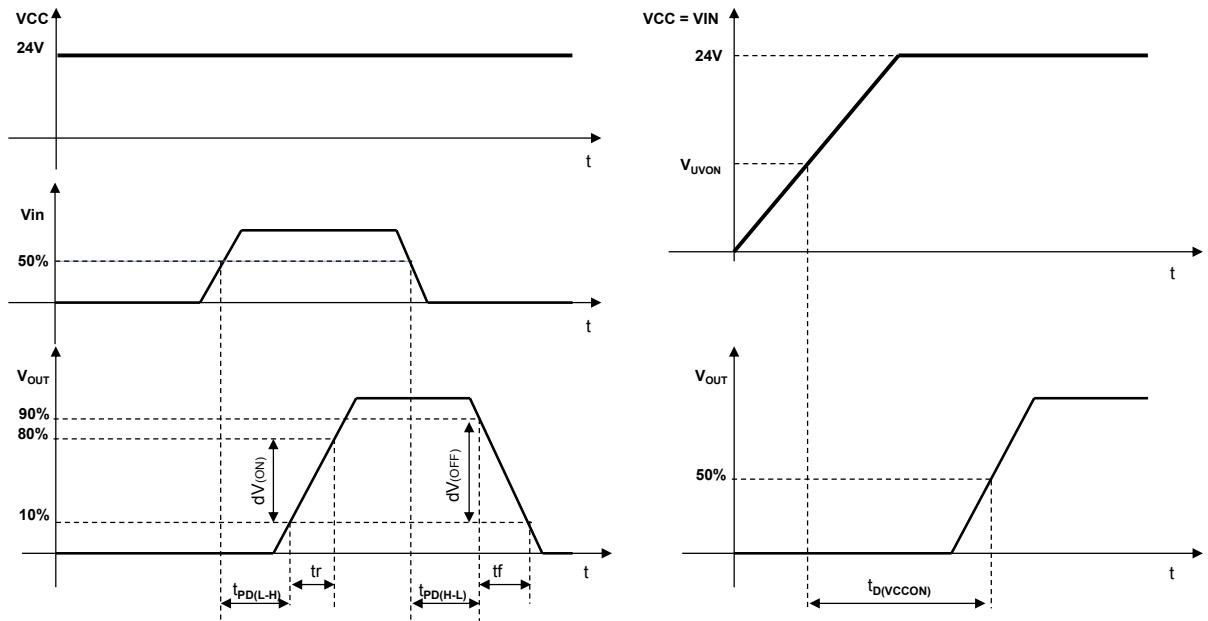


Table 7. Input pin (IN1 or IN2)

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	$V_{IN} = V_{CC} = 36V$	-	-	200	μA
		$V_{IN} = V_{CC} = 60V$	-	-	600	

Table 8. Diagnostic pins (FLT₁, FLT₂)

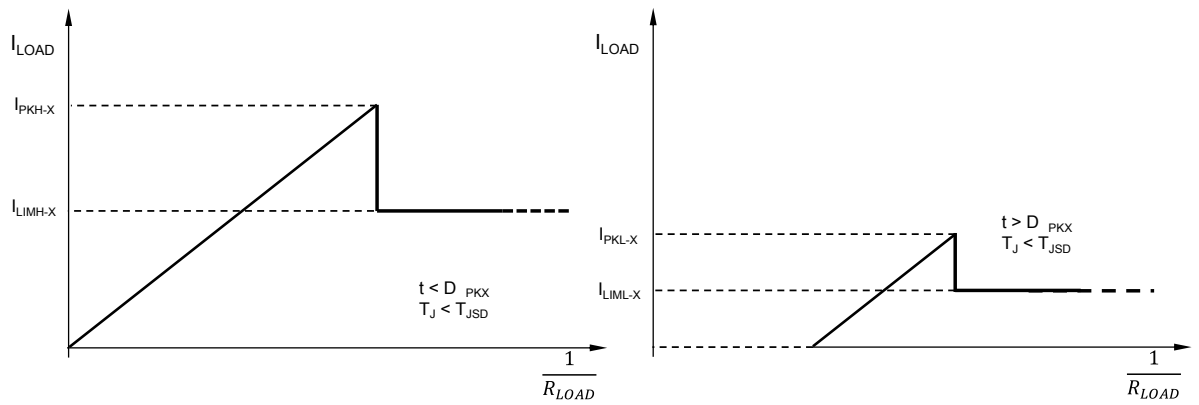
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
I_{HFLT}	Diagnostic pins source current in fault condition.	$V_{FLT} = 1 V$ (fault condition active)	-2	-3	-4	mA
		$V_{FLT} = 5 V$ (fault condition active)	-0.4	-0.7	-1.0	
I_{LFLT}	Diagnostic pins leakage current	Normal operation $V_{CC} = 60 V$	-	-	-25	μA
BT_{FLT}	Diagnostic pins blanking time	-	60	-	400	μs
V_{CLFLT}	Diagnostic pins clamp voltage	$I_{FLT} = +1 mA$	6	6.8	8	V
		$I_{FLT} = -1 mA$	-	-	0.7	

Table 9. Protections and diagnostics

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-X}	Initial overcurrent activation threshold for channel x	V _{CC} = 24 V	IPS2050H	-	11.5	-	A
			IPS2050H-32		19.8		
I _{LIMH-X}	Initial overcurrent limitation level for channel x	V _{CC} = 24 V	IPS2050H	6.1	8.8	11.5	A
			IPS2050H-32	12.5	17.9	23.2	
D _{PKX}	Time limit of Initial overcurrent for channel x	V _{CC} = 24 V	-	215*C _{PD} [nF]	-	μs	
I _{PKL-X}	Steady state overcurrent activation threshold for channel x	V _{CC} = 24 V	IPS2050H	-	5.2	-	A
			IPS2050H-32		10.5		
I _{LIML-X}	Steady state overcurrent limitation level for channel x	V _{CC} = 24 V	IPS2050H	2.5	3.5	4.5	A
			IPS2050H-32	5.7	8.0	10.4	
I _{HYS}	Steady state output Current limitation hysteresis	V _{CC} = 24 V	-	0.3	-	A	
I _{LIML-OFF}	Steady state overcurrent limitation deactivation threshold		-	I _{LIML} - I _{HYS}	-	A	
Overload with Single Level (Lowest) Protection: I_{PD} pin connected to IN by 10kΩ resistor; see Section 7.3.2							
I _{PKL-X}	Steady state overcurrent activation threshold for channel x	V _{CC} = 24 V	IPS2050H	-	5.2	-	A
			IPS2050H-32		10.5		
I _{LIML-X}	Steady state overcurrent limitation level for channel x	V _{CC} = 24 V	IPS2050H	2.5	3.5	4.5	A
			IPS2050H-32	5.7	8.0	10.4	
I _{HYS}	Steady state output Current limitation hysteresis	V _{CC} = 24 V	-	0.3	-	A	
I _{LIML-OFF}	Steady state overcurrent limitation deactivation threshold		-	I _{LIML} - I _{HYS}	-	A	
Overload with Single Level (Highest) Protection: I_{PD} pin connected to GND by 10kΩ resistor; see Section 7.3.3 .							
I _{PKH-X}	Initial overcurrent activation threshold for channel x	V _{CC} = 24 V	IPS2050H	-	11.5	-	A
			IPS2050H-32		19.8		
I _{LIMH-X}	Initial overcurrent limitation level for channel x	V _{CC} = 24 V	IPS2050H	6.1	8.8	11.5	A
			IPS2050H-32	12.5	17.9	23.2	
Overtemperature protections							
T _{JSD}	Junction temperature shutdown	-	150	170	190	°C	
T _{JR}	Junction temperature reset	-	-	150	-	°C	
T _{JHYS}	Junction temperature hysteresis	-	7	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} = V _{CC} = 24 V, V _{OUT} = 0 V	-	-	0.5	mA	
VCC overvoltage							
V _{CLAMP}	V _{CC} Clamp Voltage	I _{CC} ≤ 10 mA	65.5	70.0	73.5	V	

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Demagnetization of inductive load						
V_{DEMAG}	Demagnetization Voltage	$I_{OUT} = 0.5\text{ A}$, Load $\geq 10\text{ mH}$	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)

	IN	OUT	FLT
Normal Operation	L	L	L
	H	H	L
Overload	L	L	L
	H	X ⁽¹⁾	H
Junction over-temperature	L	L	L
	H	L	H
Case over-temperature	L	L	L
	H	L ⁽²⁾	L ⁽²⁾
UVLO	L	L	X
	H	L	X

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

 2. Channels with $T_J > T_{JSD}$ are forced off and the related FLT are activated

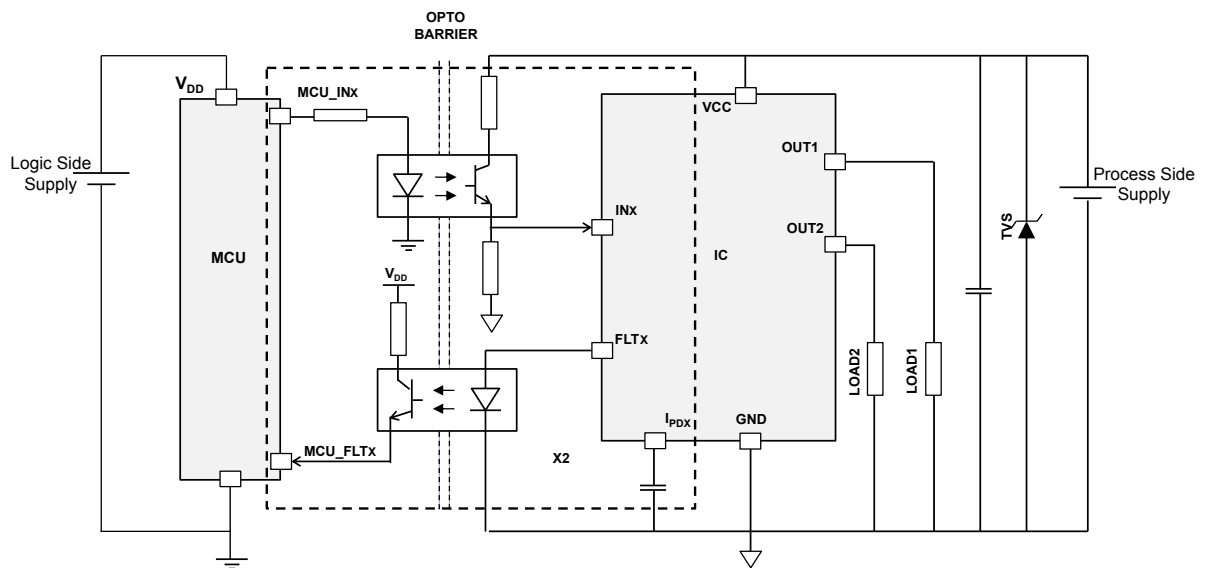
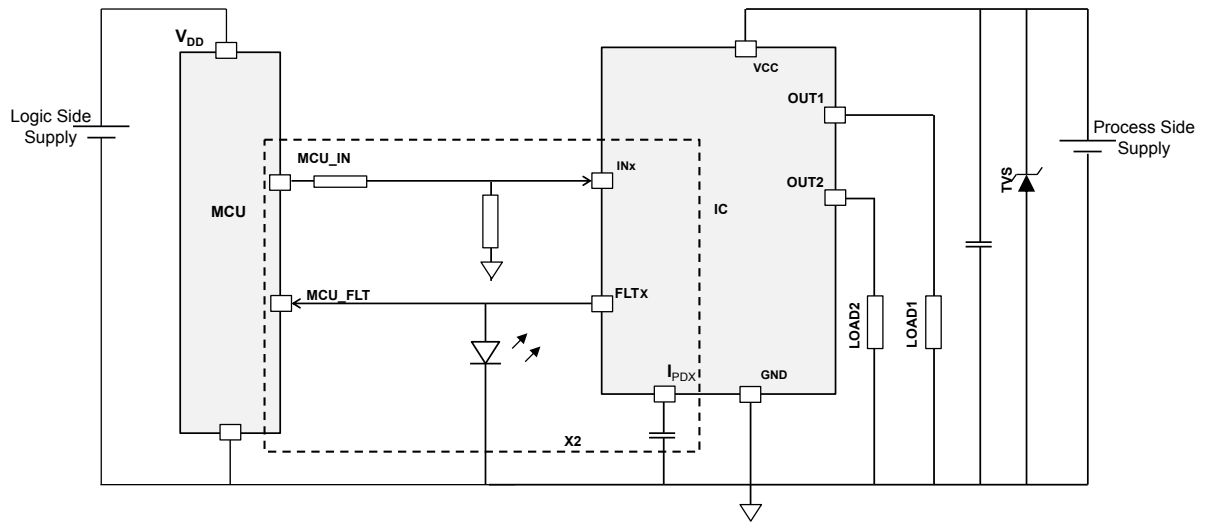
Figure 5. Typical application diagram with opto-couplers


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_X 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: each output channel (OUT_X) is turned off when its junction temperature (T_{JX}) is higher than the activation threshold (T_{JSD}) and turned back on when it goes below the reset threshold (T_{JR}). This behavior continues while overload on the output persists. When the thermal protection is active for OUT_X , the related FLT_X (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 of each channel in fault and case temperature fall below the respective reset thresholds (T_{CR} and T_{JR}). The FLT_X pins are active even when thermal case events occur.

[Figure 7](#) shows the thermal protection behavior, while [Figure 8](#) and [Figure 9](#) show typical temperature trends and output vs. input state.

Figure 7. Thermal protection flowchart

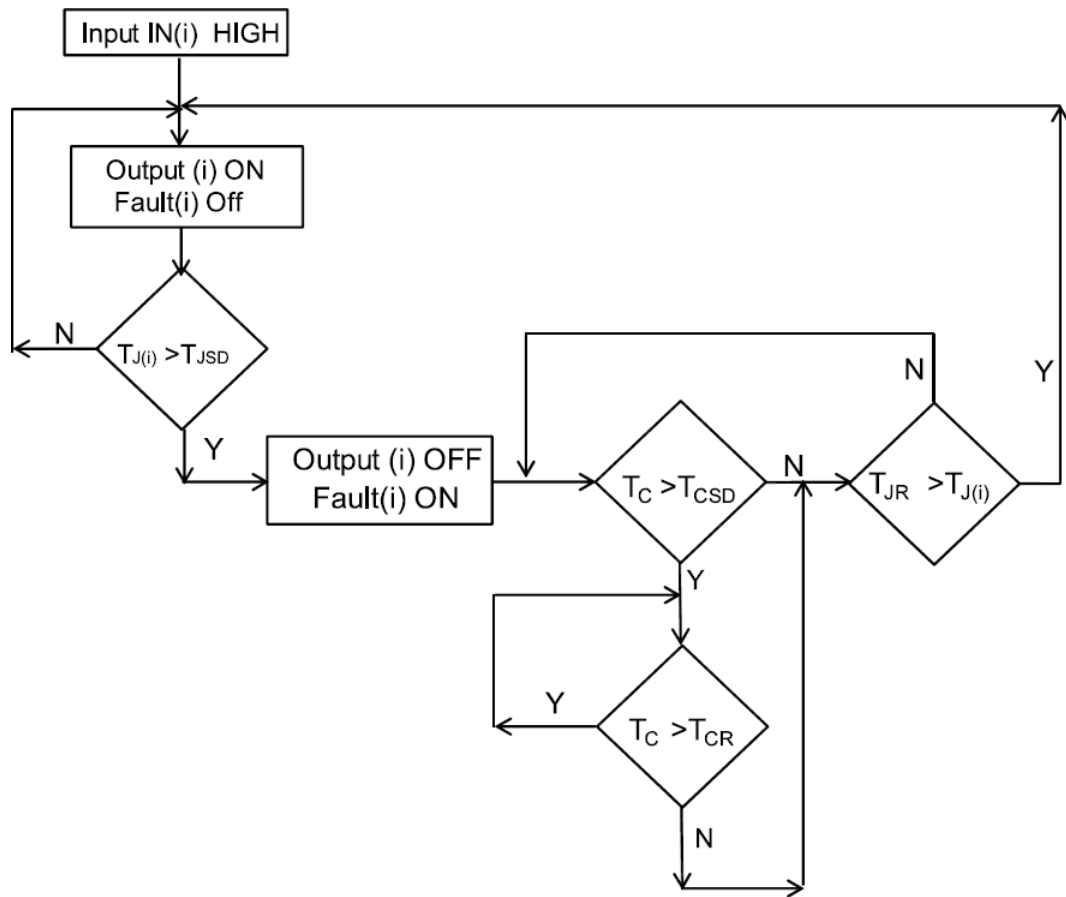


Figure 8. Thermal protection plot, $T_J > T_{JSD}$

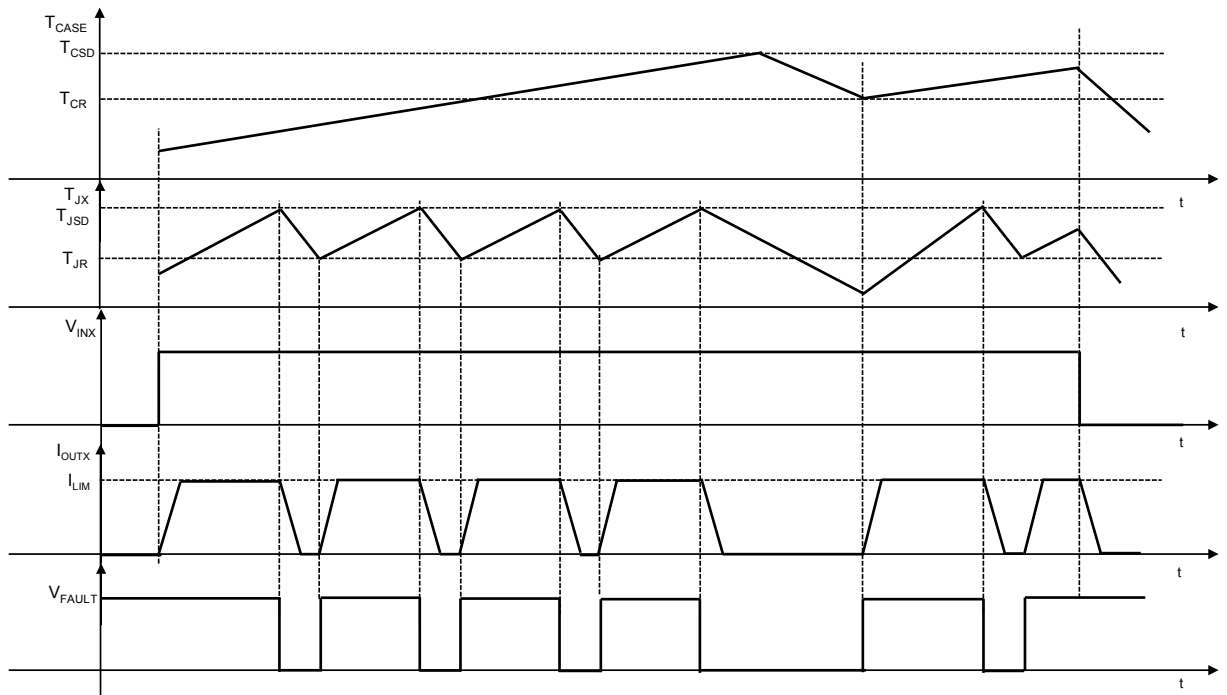
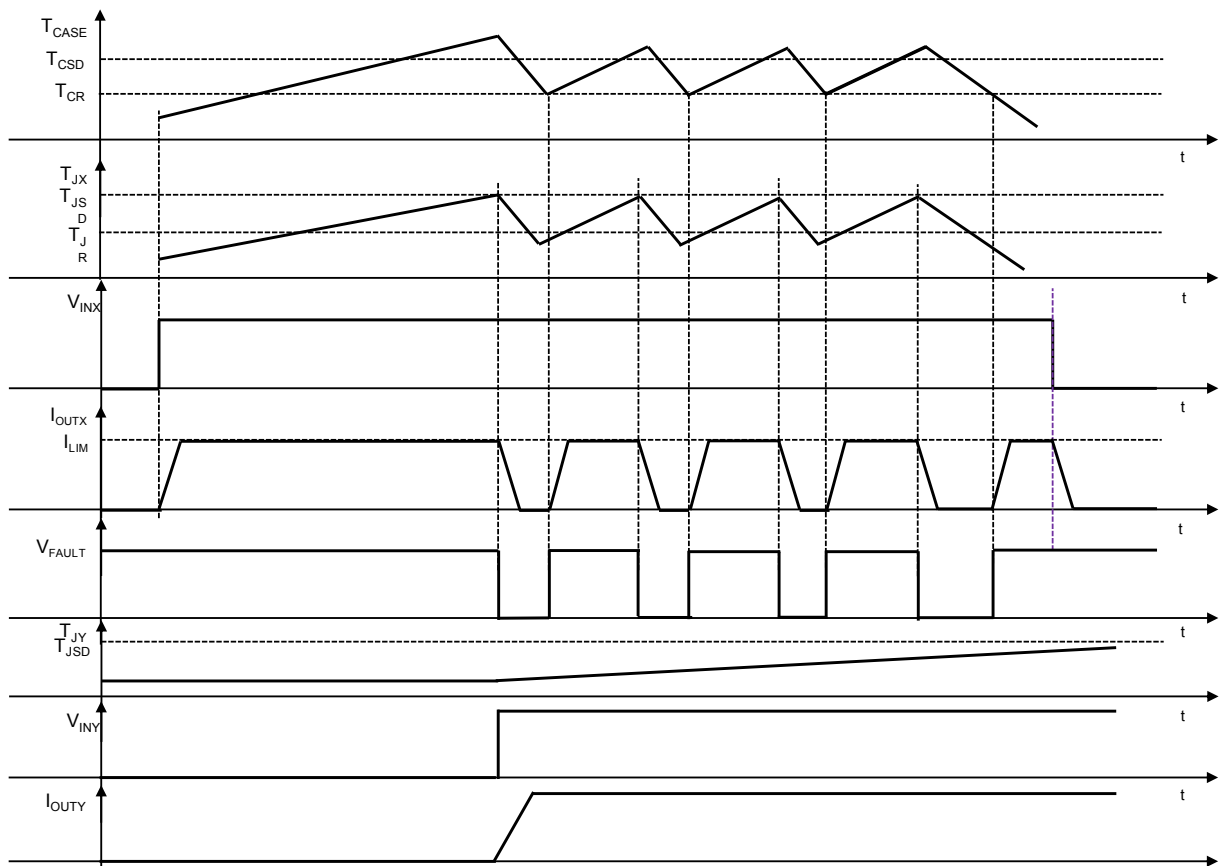


Figure 9. Thermal protection plot, $T_C > T_{CSD}$


7.3 Overload

The IC integrates two independent overload protection circuits (one for each output channel) 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-X}) is triggered, then the current limitation control circuitry is activated to limit output current to the current limitation level (I_{LIM-X}) and FLT_X pin is activated until the overload condition is removed.

The IC allows the user to set both single and dual activation thresholds for each channel. See the following sections for details and [Table 9. Protections and diagnostics](#) for specific activation thresholds and limitation levels. Note that while an 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 $V_{DS} * I_{LIM-X}$, where V_{DS} is the voltage drop between OUT_X and V_{CC} pins of the IC. In order to protect the IC against thermal stress, the overtemperature 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-X} is connected to GND by a capacitor (C_{PD}) and the IC works with two activation thresholds I_{PKH-X} and I_{PKL-X} .

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

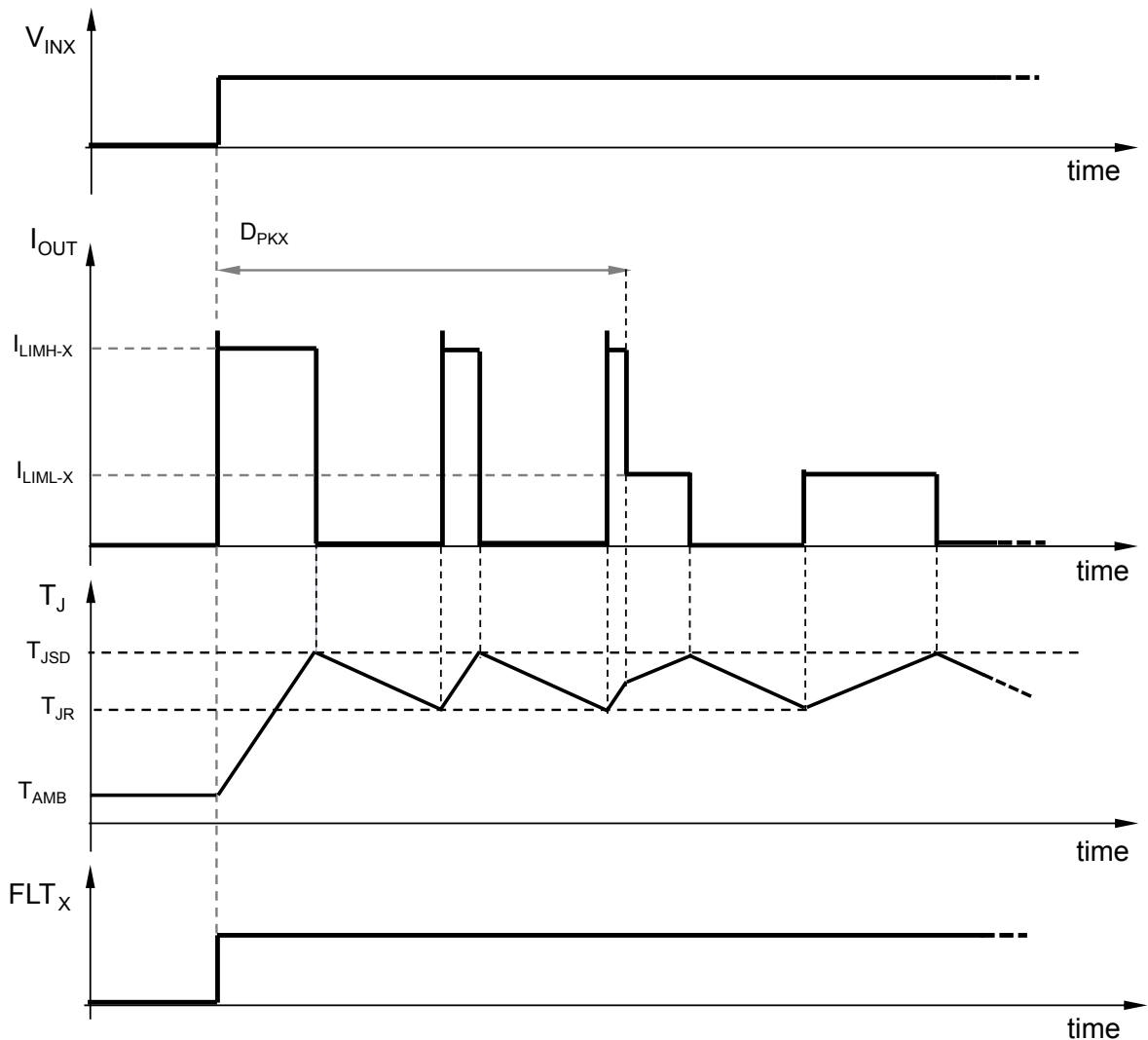
$$D_{PKX} [\mu s] = 215 \times C_{PD} [nF]$$

The above design rule is valid in the range $470 \text{ pF} \leq C_{PD} \leq 470 \text{ nF}$ (see [Table 9. Protections and diagnostics](#)).

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

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

Figure 10. 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-X} and the limitation level to I_{LIML-X} by connecting the I_{PDX} pin to the related IN_X pin with a 220 K Ω resistor.

This condition is equivalent to setting $D_{PKX} = 0 \mu s$.

Note: Leaving I_{PDX} 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-X} and the limitation level to I_{LIMH-X} by connecting the I_{PDX} pin to GND with a 10 K Ω resistor.

7.4 VCC disconnection protection

VCC 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 VCC pin remains higher than the UVLO threshold. In case of inductive load, if the VCC 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.

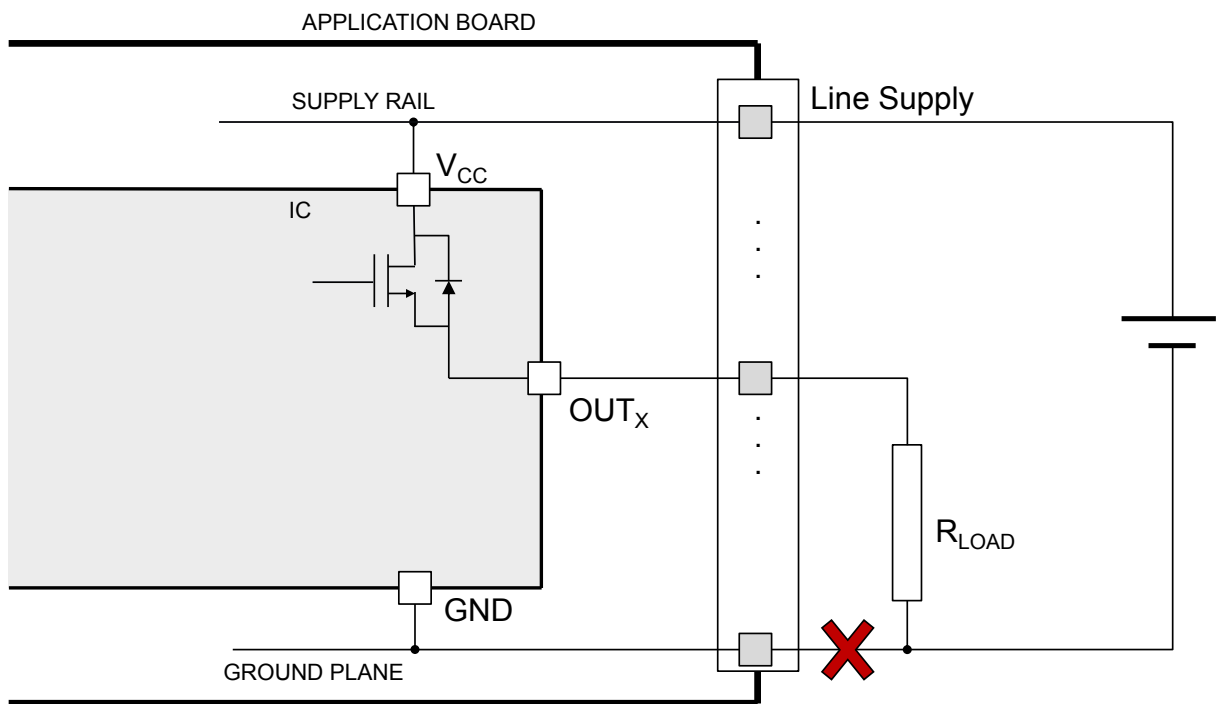
7.5 GND disconnection protection

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 VCC and GND pins of the IC results $\geq V_{UV\text{OFF}}$. 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 ($I_{L\text{GND}}$) 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 11. 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 $\sim V_{DEMAG}$ until the load energy has been dissipated. The energy is dissipated in both IC internal switch and load resistance.

Figure 12. Active clamp equivalent principle schematic

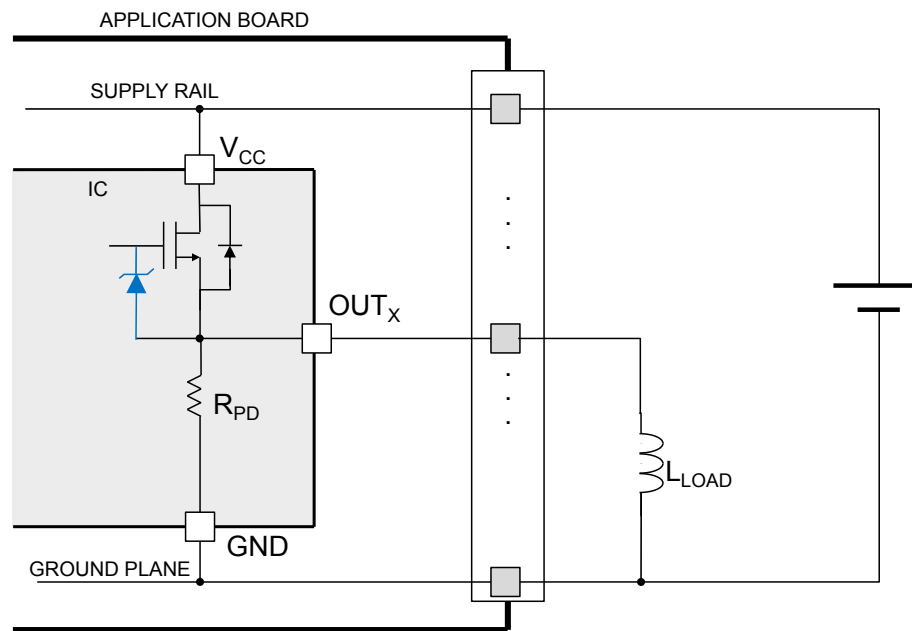
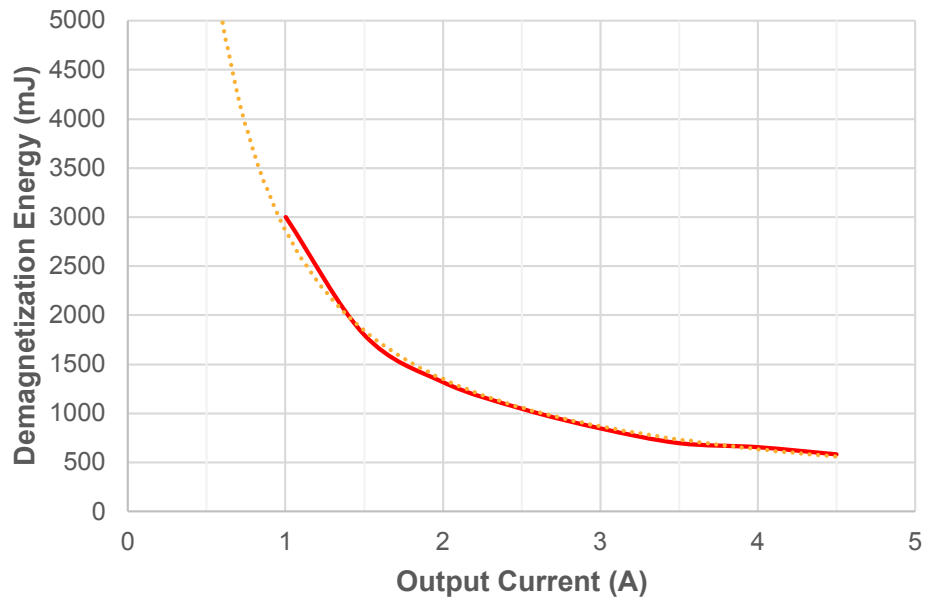


Figure 13. Typical demagnetization energy (single pulse) at $V_{CC} = 24\text{ V}$ and $T_{AMB} = 125\text{ }^{\circ}\text{C}$



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 14. PowerSSO-24 package dimensions [mm]

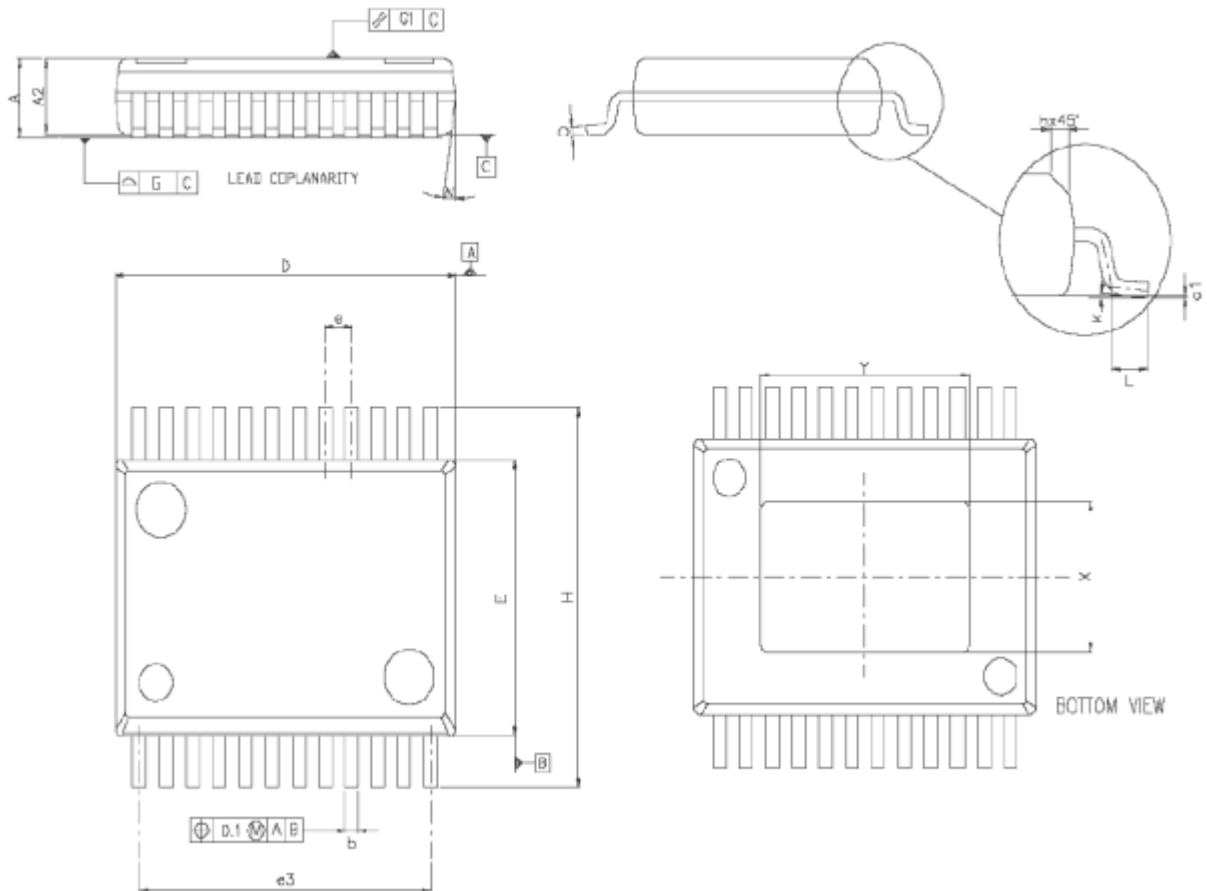


Table 11. PowerSSO-24 mechanical data

Dim.	[mm]		
	Min.	Typ.	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

10 PowerSSO-24 packing information

Figure 16. PowerSSO-24 tube shipment (no suffix)

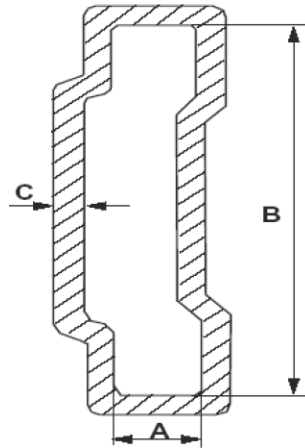


Table 12. PowerSSO-24 tube shipment information

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 17. PowerSSO-24 reel shipment

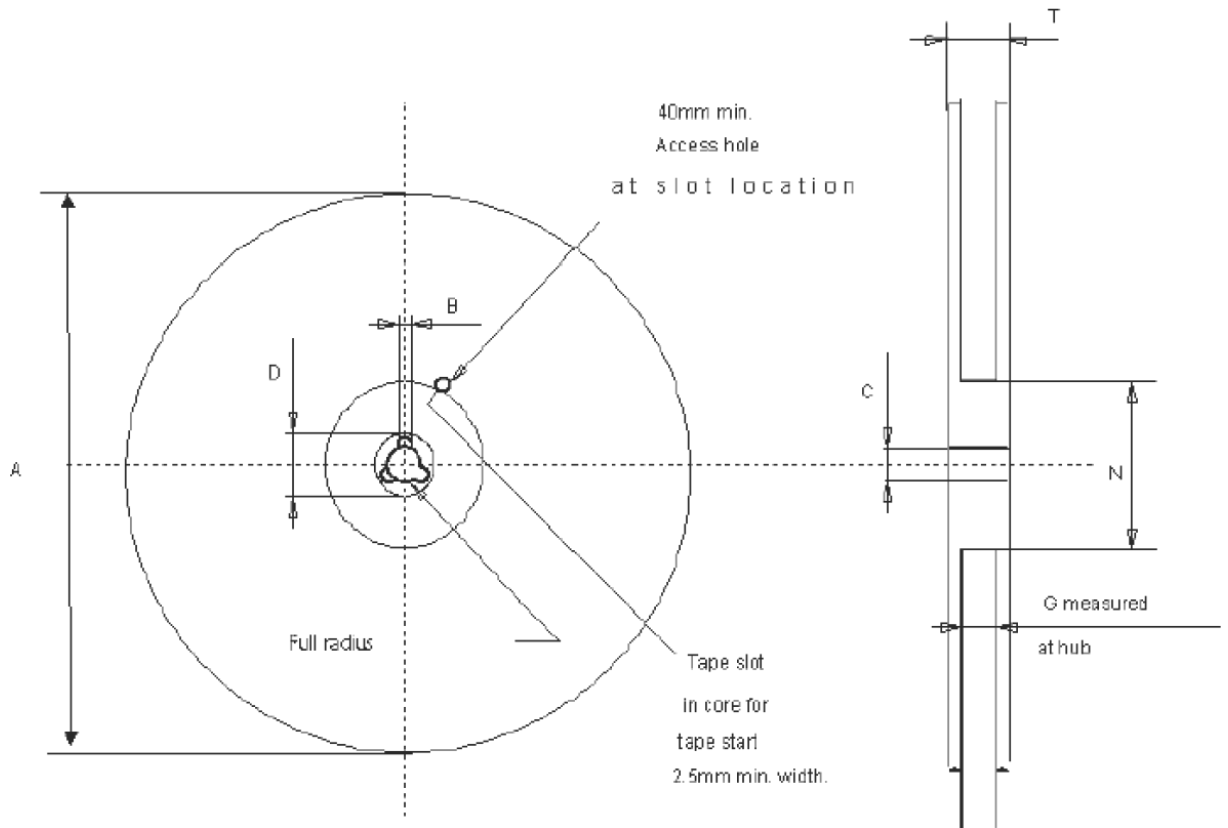


Table 13. PowerSSO-24 reel information

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 18. PowerSSO-24 tape drawings

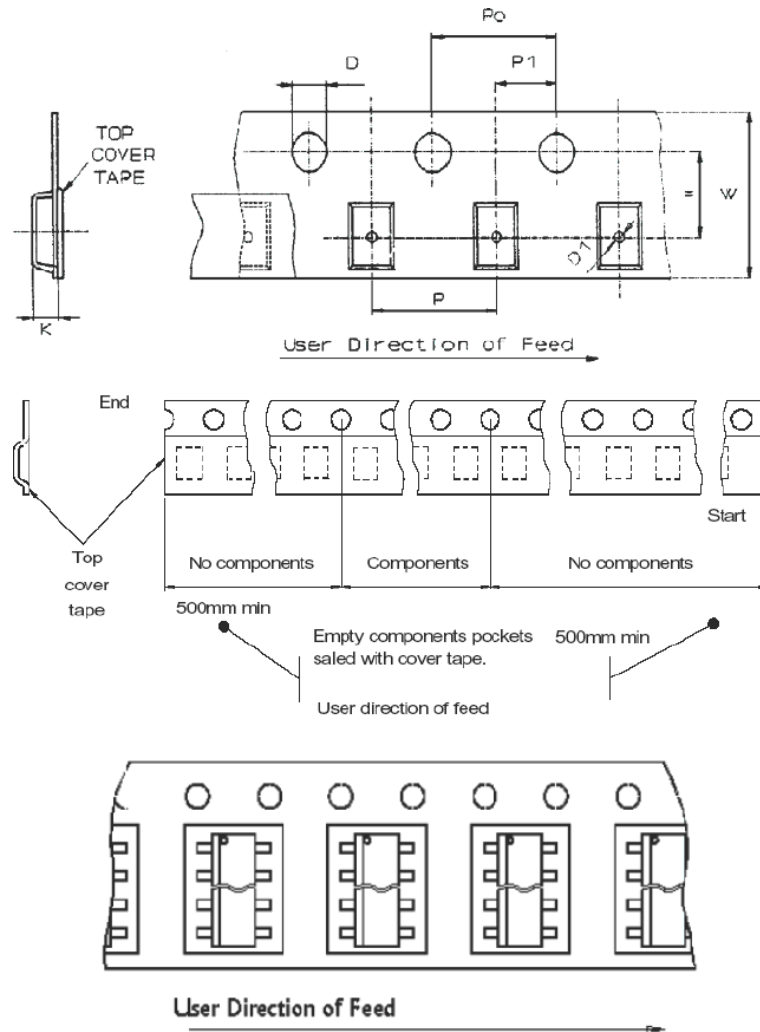


Table 14. PowerSSO-24 tape dimension

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.

11 Ordering information

Table 15. Ordering information

Part number	Package	Packaging
IPS2050H	PowerSSO-24	Tube
IPS2050HTR	PowerSSO-24	Tape and reel
IPS2050H-32	PowerSSO-24	Tube
IPS2050HTR-32	PowerSSO-24	Tape and reel

Revision history

Table 16. Document revision history

Date	Version	Changes
15-Nov-2021	1	Initial release
02-Dec-2021	2	Changed I_{SOFF} max. value in Table 4

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