AN4781
Application note

STEVAL-IFP028V1 evaluation board for single high-side driver IPS160H

Introduction

The STEVAL-IFP028V1 is an evaluation board designed to analyze all IPS160H functionality.

It is designed to meet the application requirements in terms of:

- Galvanic isolation between user interface and power interface. This requirement is satisfied by an optical isolation implemented through optocouplers OPTO1 for signal forward to the device and OPTO2 for the feedback diagnostic signal.
- Compliant with IEC 61000-4-2, IEC61000-4-4, IEC 61000-4-5 requirements. These requirements are satisfied by IPS160H itself and by the component U1 (the external TVS between V_{CC} supply rail and power ground).

To provide a user friendly interface to test IPS160H functionality, a dedicated GUI interface has been developed. In order to use the GUI, the STEVAL-IFP028V1 is connected to the STEVAL-PCC009V2 through a 30-way flat cable and then the STEVAL-PCC009V2 is connected through an USB cable to the PC with the GUI.

The GUI lets you drive the STEVAL-IFP028V1 and monitor the status of the output on the power side, receiving fault information from the IPS160H DIAG pin.

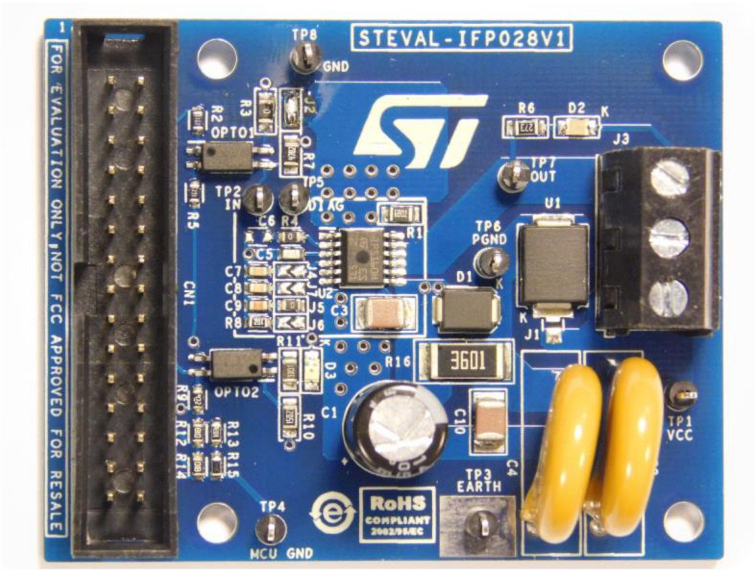
Finally, the STEVAL-IFP028V1 optimizes thermal performance through a careful layout with a dedicated copper area connecting the exposed pad of the PSSO12 package and acting as a heat-sink.

Contents

1 Features

- Operating voltage from 8 to 60 V
- Operating current up to 2.5 A
- Programmable cutoff delay time
- Reverse polarity protection
- Galvanic isolation
- Input pins compatible with V_{CC} rails
- Green LED for channel ON/OFF status
- Red LED for common diagnostic on:
  - Open load in OFF state
  - Cutoff
  - Thermal protection
  - Red LED functionality on DIAG pin guaranteed from V_{CC} = 12 V
- Microcontroller interface
- IEC 61000-4-2, IEC61000-4-4 and IEC 61000-4-5 compliant
- RoHS compliant

Figure 1: STEVAL-IFP028V1 evaluation board



2 Board description

Table 1: STEVAL-IFP028V1 connectors and jumpers

Name	Type	Function	Notes
J1	JUMPER	OPEN (default): disconnect U1 CLOSE: connect U1	J1 must be open in case of tests with V_{CC} > V_{BR} of U1. External TVS is necessary to improve surge test requirements on V_{CC} pin.
J2	JUMPER	Open: disable the on board optocouplers CLOSE (default): enables the on-board optocouplers	
J3	3-way screw connector	PIN1: V_{CC} PIN2: LOAD PIN3: GND	Power section connector
J4	JUMPER	OPEN (default): see J5, J6, J7 CLOSE: cutoff enabled with t_{COFF} = 5 ms ± 35%	If J4 is closed then J5, J6 and J7 must be left OPEN.
J5	JUMPER	OPEN: see J4, J6, J7 CLOSE (default): CUTOFF enabled with t_{COFF} = 500 µs ±35%	If J5 is closed then J4, J6 and J7 must be left OPEN.
J6	JUMPER	OPEN (default): see J4, J5, J7 CLOSE: CUTOFF disabled	If J6 is closed then J4, J5 and J7 must be left OPEN.
J7	JUMPER	OPEN (default): see J4, J5, J6 CLOSE: cutoff enabled with t_{COFF} = 2.5 ms ± 35%	If J7 is closed then J4, J5 and J6 must be left OPEN.
TP1	Test point	V_{CC} (Supply voltage of U2)	
TP2	Test Point	OUTPUT of OPTO1 (driving signal of U2)	
TP3	Test Point	EARTH connection (common node) between C2 and C4	C2 and C4 are used for surge test in common mode configuration
TP4	Test Point	Ground of user interface	
TP5	Test Point	Diagnostic pin of U2	
TP6	Test Point	Ground of power interface	
CN1	30-way	Connection for digital interface and GUI	See *Table 2: "STEVAL-IFP028V1 30-way signal connector"*

Table 2: STEVAL-IFP028V1 30-way signal connector

Pin number	Description
1	NC
2	MCU_GND
3, 4, 5, 6	NC
7	Digital Input IN1/PWM1
8	NC
9, 10, 11, 12	NC
13	MCU_GND
14	MCU_Vdd
15, 16, 17, 18, 19	NC
20	DIAG_FAULT (common fault for open load in OFF state, cutoff and thermal events)
21, 22, 23	NC
24, 25	Digital acknowledge (proprietary)
26, 27	NC
28	MCU_GND
29, 30	NC

Figure 2: STEVAL-IFP028V1 schematic diagram

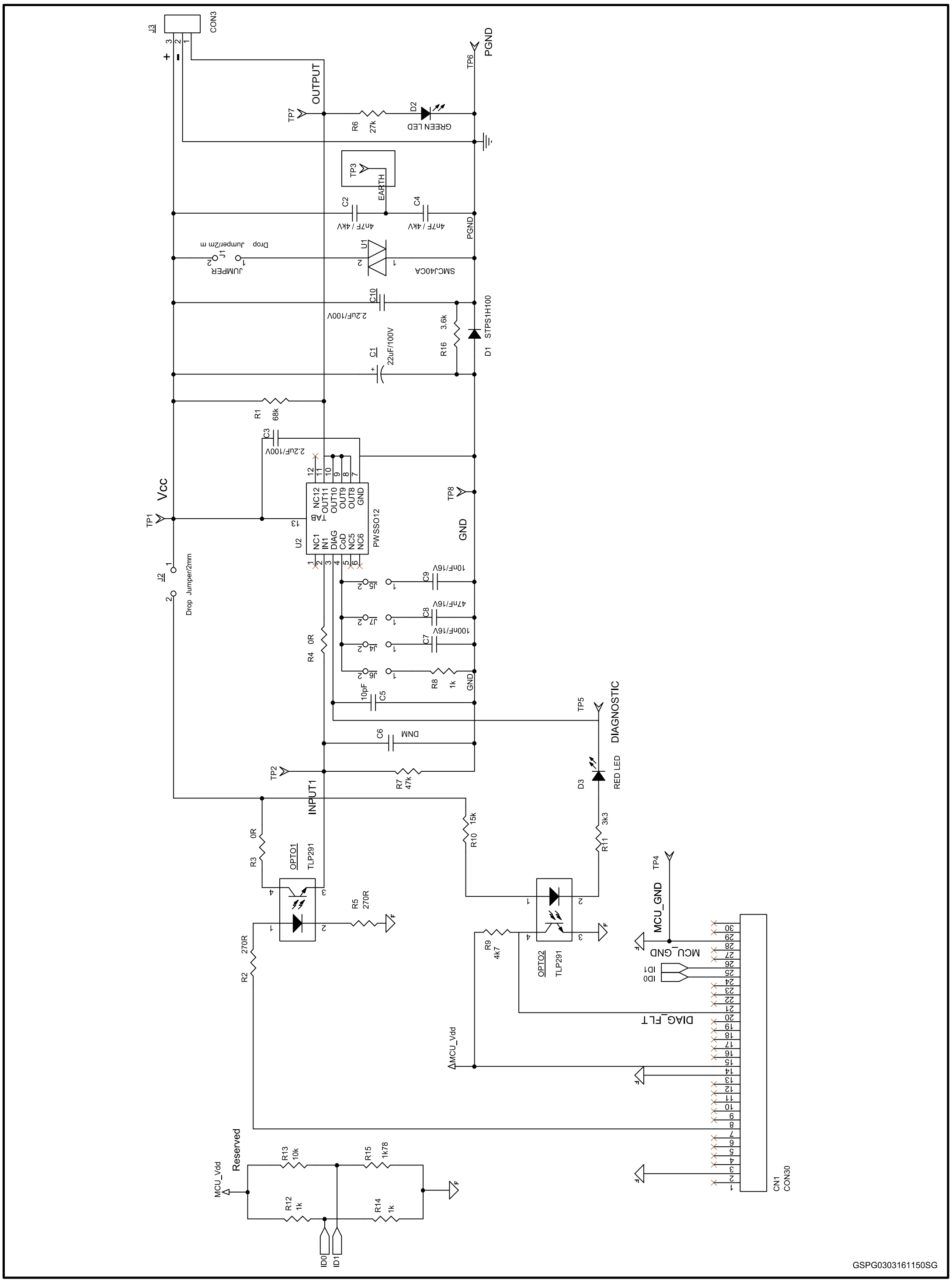


Table 3: STEVAL-IFP032V1 30-pin signal connector description

Item	Q.ty	Reference	Part/Value	Volt. / W / Amp.	Type	Tol.	Package	Manuf.
1	1	CN1	CON30		2.54 mm 30 pins (15x2rows)		TH	FCI
2	1	C1	22 µF	100 V	Electrolytic	+/-20%	TH	Rubycon
3	2	C2,C4 (DNM)	4.7 nF	4 kV	Single layer capacitor		TH	VISHAY
5	1	C3	1 µF	100 V	CERAMIC, X7R	+/-10%	1210	KEMET
6	1	C5	10 pF	100 V	CERAMIC	+/-5%	0603	VISHAY
7	0	C6	DNM				0603	
8	1	C9	10 nF	16 V	Ceramic	+/-5%	0603	MURATA
9	1	C8	47 nF	16 V	Ceramic	+/-10%	0603	AVX
10	1	C7	100 nF	16 V	Ceramic	+/-10%	0603	MURATA
11	1	C10	2.2 µF	100 V	X7R	+/-10%	1210	TDK
12	1	D1	STPS1H100U	100 V, 1 A			SMB	STM
13	1	D2	GREEN LED	2.2 V	GaP		0805	OSRAM WURTH
14	1	D3	RED LED	1.8 V	GaAlAs		0805	OSRAM WURTH
15	1	J1	Drop Jumper				0603	
	1	J2	Drop Jumper				0603	
16	3	J4, J6, J7	Drop Jumper				0603	
19	1	J5	0 Ω	100 mW		1%	0603	VISHAY
20	1	R10	15 k	125 mW		1%	0805	TE Connectivity
21	1	R1	68 k	125 mW		1%	0805	BOURNS
22	1	R7	47 k	125 mW		1%	0805	BOURNS
23	2	R2, R5	270R	100 mW		5%	0603	Panasonic
25	1	R9	4k7	125 mW		1%	0805	BOURNS
26	1	R3	0 Ω	125 mW		5%	0805	BOURNS
27	1	R4	0 Ω	100 mW		1%	0603	VISHAY
28	2	OPTO1, OPTO2	OPTO COUPLER	80 V			TLP291-SO4	Toshiba
30	1	R6	27 k	125 mW		0.5%	0805	Panasonic
31	2	R12, R14	1 k	100 mW		0.1%	0603	Panasonic
33	1	R8	1 k	100 mW		1%	0603	TE Connectivity
34	1	R11	3k3	125 mW		1%	0805	Bourns
35	1	R13	10 k	100 mW		0.1%	0603	Panasonic
36	1	R15	1k78	100 mW		0.1%	SMD 0603	Panasonic
37	6	TP1, TP2, TP3, TP4, TP5, TP6, TP7	TEST POINT				Ring test point 1 mm	

Item	Q.ty	Reference	Part/Value	Volt. / W / Amp.	Type	Tol.	Package	Manuf.
43	3	J3	3-way screw connector		5_08 mm		TH, 5.08 mm	Phoenix Contact
46	1	U2	IPS160H				PWSSO12	ST
47	1	U1	TVS	V_{BR}= 2 V			SMCJ40CA	ST

2.1 Supply voltage section

The STEVAL_IFP028V1 is supplied from pin 1 of connector J3, which is directly connected to the V_{CC} supply of IPS160H (operating between 8 V and 60 V).

If jumper J1 is closed, the TVS U1 is active and the supply range of the board is limited to 40 V by the breakdown voltage of U1. When enabled (J1 closed), U1 improves the immunity to surge pulses from the V_{CC} pin of the IPS160H.

A red LED is connected on the DIAG (common diagnostics) pin of the IPS160H; the red LED signaling of open load (off state) is guaranteed from V_{CC} = 12 V. For different operating ranges the user may act on R1 and/or R6 (see *Section 2.6: "Open load"*).

2.2 Communication

As already discussed, outputs can be driven by connecting the PC to the STEVAL-IFP028V1 board via the STEVAL-PCC009V2 communication board. The galvanic isolation between process side and control side is implemented through optocouplers OPTO1 and OPTO2.

The evaluation board STEVAL-IFP028V1 CN1 30-way connector provides the interface for the STEVAL-PCC009V2, thus allowing the use of the dedicated GUI interface. Instead of the STEVAL-PCC009V2, the input signal can be provided through the pins 2 (MCU_GND) and 7 (input of OPTO1) of CN1.

Once the STEVAL-IFP028V1 and STEVAL-PCC009V2 boards are connected, communication begins with board recognition: the ADC integrated in the STEVAL-PCC009V2 reads the voltage on the resistor network R1, R13, R14 and R15 and, if recognition is successful, the graphical interface is started.

Following acknowledgment, it is possible to select from the modalities:

- Steady driving
- PWM driving

In the first configuration, you can drive the output always ON or always OFF, whereas in the second, you can drive the output in PWM mode after configuring the frequency and duty cycle.

2.3 Operating current

The IPS160H mounted on the STEVAL-IFP028V1 is designed to supply all kinds of loads (resistive, inductive and capacitive) connected between OUTPUT and process ground and requiring up to 2.5 A. In case of overload, the IPS160H regulates its internal impedance, limiting the output current to I_{LIM} (see the IPS160H datasheet of for details). For an inductive load, the maximum demagnetization energy ($E_{DEMAG(MAX)}$) manageable by the IPS1060 is limited by its internal thermal dissipation capacity. Please refer to the datasheet of IPS160H for $E_{DEMAG(MAX)}$ vs. I_{LOAD}.

2.4 Cutoff

Whenever the overcurrent threshold (I_{LIM}) is triggered and the IPS160H cutoff protection feature is activated (J4, J5 or J7 closed and J6 open), the OUTPUT is driven ON for at least time t_{COFF} (set by the selected capacitance on pin 4). The output is only allowed to turn on again after the cutoff restart time (t_{RES}).

In case of overheating (see *Section 2.5: "Overheating and thermal protection"*), the t_{COFF} is overridden.

2.5 Overheating and thermal protection

In case of overheating during operation, the whole application is protected by the thermal protection integrated by the IPS160H: once its junction temperature triggers the T_{JSD} threshold (170 °C, typical) the OUTPUT is forced OFF until the temperature drops back to T_{JSD} - T_{HYST} (155 °C, typical).

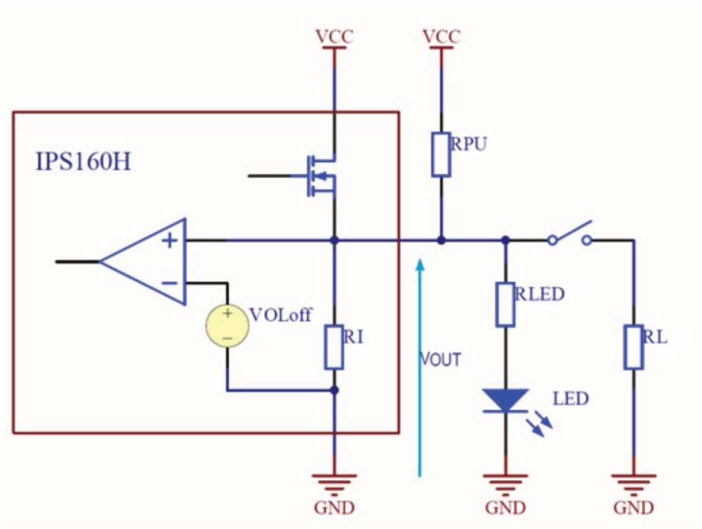
2.6 Open load

The IPS160H integrates the open load detection (in OFF state) feature that is activated on the STEVAL-IFP028V1 board by the R1 pull-up resistor between V_{CC} rail and the OUTPUT pin of IPS160H. When the input is forced low and the load is disconnected, the voltage on OUTPUT pin is pulled up by R1, the open load detection threshold (V_{OLoff}) is triggered and the diagnostic pin is consequently forced low, causing the red LED to turn on.

The STEVAL-IFP028V1 pull-up resistor R1 (68 kΩ) is suitable for signaling open load in the OFF state in the supply range from V_{CC} = 12 V and I_{LOAD} ³ 10 mA. For applications without a LED on the output pin, the design rules for R1 are provided in the IPS160H datasheet.

A LED connected through a polarization resistor between output and ground affects the output voltage in the OFF state and therefore impacts the functionality of the open load in OFF state signaling.

Figure 3: Circuit schematic for typical application case



If the load is not connected:

$$V_{OUT} = V_{CC} - R_{PU} \times I_{PU} = V_{CC} - R_{PU} \times (I_{RI} + I_{LED} + I_{RL})$$

To ensure correct open load signaling, the following must be true:

$V_{OUT} > V_{OLoff(max)}$

Consequently:

$$V_{OUT} = V_{CC} - R_{PU} \times I_{PU} = V_{CC} - R_{PU} \times \left(\frac{V_{OUT}}{R_I} + \frac{V_{OUT} - V_{LED}}{R_{LED}} + \frac{V_{OUT}}{R_L} \right)$$

If the load is connected:

$$R_{PU} < \frac{V_{CC(min)} - V_{OLoff(max)}}{\left(\frac{V_{OLoff(max)}}{R_I} + \frac{V_{OLoff(max)} - V_{LED}}{R_{LED}} \right)}$$

To avoid any false signaling of the open load in the diagnostic pin, the following must be true:

$V_{OUT} < V_{OLoff(min)}$

$$R_{PU} > \frac{V_{CC(max)} - V_{OLoff(min)}}{\left(\frac{V_{OLoff(min)}}{R_I} + \frac{V_{OLoff(min)} - V_{LED}}{R_{LED}} + \frac{V_{OLoff(min)}}{R_L} \right)} VOUT$$

2.7 Reverse polarity protection

The STEVAL-IFP028V1 implements reverse polarity protection on the process side through diode D1. In fact, if the V_{CC} and process GND are swapped, diode D1 blocks any current flow and consequently protects the IPS160H and the rest of the application components.

3 Board layout

The PCB is designed with varying device operating conditions in mind.

During normal operation, the IPS160H may be subject to conditions that have an adverse impact on device performance, such as:

- wrong supply cable connection
- overheating
- EMC phenomena associated with atmospheric events

The STEVAL-IFP028V1 layout is designed to avoid any such conditions that may hamper device operation.

Figure 4: STEVAL-IFP028V1 top and component placement layout view

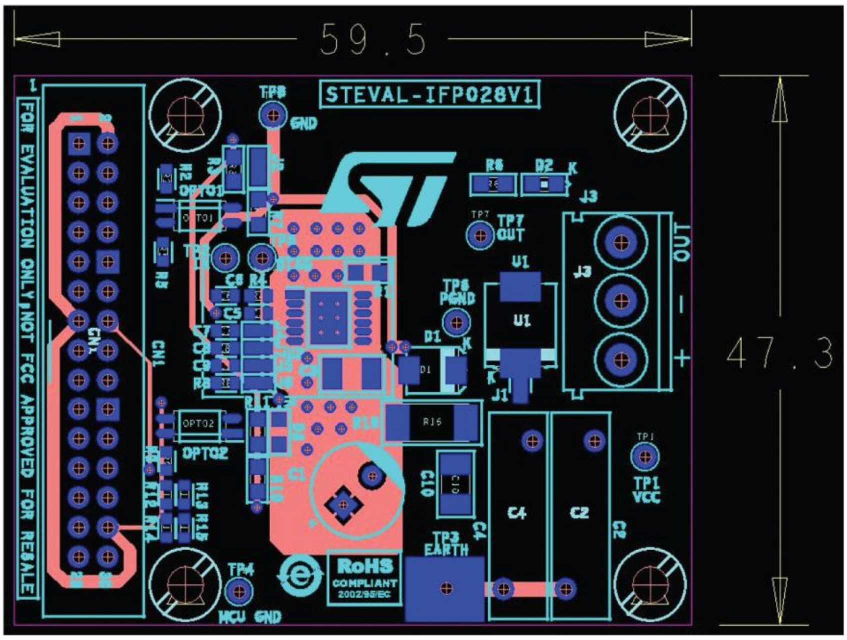
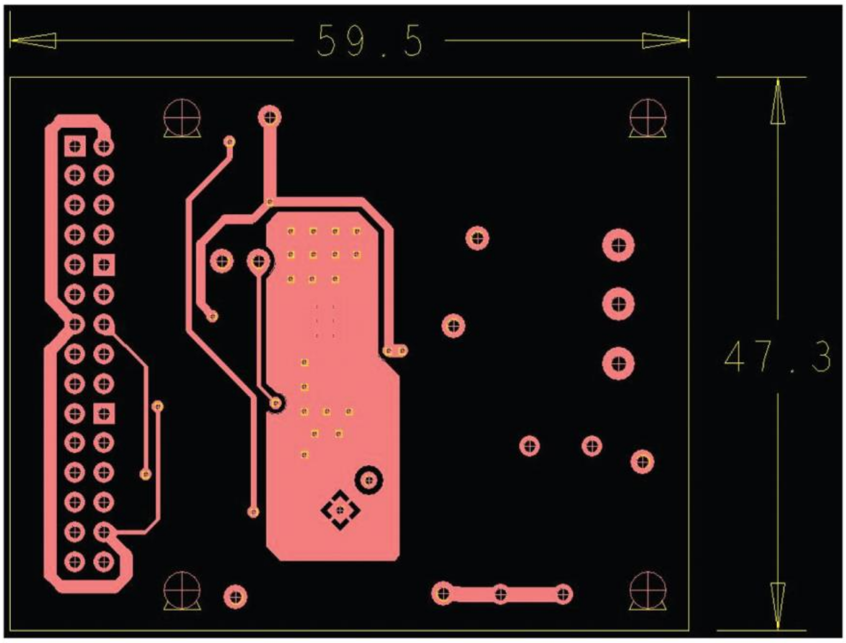


Figure 5: STEVALIFP028V1 bottom layout view



4 Reference documents

- IPS160H datasheet
- IEC-61131-2

5 Revision history

Table 4: Document revision history

Date	Revision	Changes
05-May-2016	1	Initial release.

IMPORTANT NOTICE – PLEASE READ CAREFULLY