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\textsubscript{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.
1 Features

- Operating voltage from 8 to 60 V
- Operating current up to 2.5 A
- Programmable cut-off 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
  - Cut-off
  - 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
### Board description

**Table 1. STEVAL-IFP028V1 connectors and jumpers**

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

**Table 2. STEVAL-IFP028V1 30-way signal connector**

<table>
<thead>
<tr>
<th>Pin number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NC</td>
</tr>
<tr>
<td>2</td>
<td>MCU_GND</td>
</tr>
<tr>
<td>3, 4, 5, 6</td>
<td>NC</td>
</tr>
<tr>
<td>7</td>
<td>Digital Input IN1/PWM1</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
</tr>
</tbody>
</table>
### Table 3. STEVAL-IFP028V1 Bill of material

<table>
<thead>
<tr>
<th>Item</th>
<th>Q.ty</th>
<th>Reference</th>
<th>Part/Value</th>
<th>Volt. / W / Amp.</th>
<th>Type</th>
<th>Tol.</th>
<th>Package</th>
<th>Manuf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>CN1</td>
<td>CON30</td>
<td>2.54 mm 30 pins (15x2rows)</td>
<td>TH</td>
<td>FCI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>C1</td>
<td>22 µF</td>
<td>100 V</td>
<td>Electrolytic</td>
<td>+/-20%</td>
<td>TH</td>
<td>Rubycon</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>C2, C4 (DNM)</td>
<td>4.7 nF</td>
<td>4 kV</td>
<td>Single layer capacitor</td>
<td>TH</td>
<td>VISHAY</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>C3</td>
<td>1 µF</td>
<td>100 V</td>
<td>CERAMIC, X7R</td>
<td>+/-10%</td>
<td>1210</td>
<td>KEMET</td>
</tr>
</tbody>
</table>
### 2.1 Supply voltage section

The STEVAL-IFP028V1 is supplied from pin 1 of connector J3, which is directly connected to the V\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{LIM} (see the IPS160H datasheet of for details). For an inductive load, the maximum demagnetization energy (E\textsubscript{DEMAG(MAX)}) manageable by the IPS160H is limited by its internal thermal dissipation capacity. Please refer to the datasheet of IPS160H for E\textsubscript{DEMAG(MAX)} vs. I\textsubscript{LOAD}.

### 2.4 Cutoff

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

In case of overheating (see Section 2.5 Overheating and thermal protection), the t\textsubscript{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\textsubscript{JSD} threshold (170 °C, typical) the OUTPUT is forced OFF until the temperature drops back to T\textsubscript{JSD} - T\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{CC} = 12 V and I\textsubscript{LOAD} > 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:

\[ V_{\text{OUT}} = V_C - R_P \times I_P = V_C - R_P \times (I_{R_1} + I_{\text{LED}} + I_{R_L}) \]

To ensure correct open load signaling, the following must be true:
\[ V_{\text{OUT}} > V_{\text{OL}_\text{off}}(\text{max}) \]
Consequently:

\[ V_{\text{OUT}} = V_C - R_P \times I_P = V_C - R_P \times \left( \frac{V_{\text{OUT}} - V_{\text{LED}}}{R_{\text{LED}}} + \frac{V_{\text{OUT}}}{R_{\text{L}}} \right) \]

If the load is connected:

\[ R_P < \frac{V_{\text{CC}(m \alpha n)} - V_{\text{OL}_{\text{off}}(m \alpha x)}}{V_{\text{OL}_{\text{off}}(m \alpha x)^2} + V_{\text{OL}_{\text{off}}(m \alpha x) - V_{\text{LED}}}} \]

To avoid any false signaling of the open load in the diagnostic pin, the following must be true:
\[ V_{\text{OUT}} < V_{\text{OL}_{\text{off}}(\text{min})} \]

\[ R_P > \left( \frac{V_{\text{OL}_{\text{off}}(m \alpha n)}}{R_{\text{L}}} + \frac{V_{\text{OL}_{\text{off}}(m \alpha n) - V_{\text{LED}}}{R_{\text{LED}}} + \frac{V_{\text{OL}_{\text{off}}(m \alpha n)}}{R_{\text{L}}} \right) V_{\text{OUT}} \]
2.7 Reverse polarity protection

The STEVAL-IFP028V1 implements reverse polarity protection on the process side through diode D1. In fact, if the VCC 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. STEVAL-IFP028V1 bottom layout view
4 Reference documents

- IPS160H datasheet
- STEVAL-IFP028V1 data brief
- IEC-61131-2
## Revision history

Table 4. Document revision history

<table>
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<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-May-2016</td>
<td>1</td>
<td>Initial release.</td>
</tr>
<tr>
<td>16-May-2019</td>
<td>2</td>
<td>Updated Figure 2. STEVAL-IFP028V1 schematic diagram</td>
</tr>
</tbody>
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