STEVAL-IFP034V1 evaluation board for the IPS161H single high side driver

Introduction

The STEVAL-IFP034V1 evaluation board is designed to analyze the IPS161H device functionality.

It provides galvanic isolation between the user interface and the power interface through optical isolation implemented with optocouplers OPTO1 for forward signals to the device and OPT2 for diagnostic feedback signals.

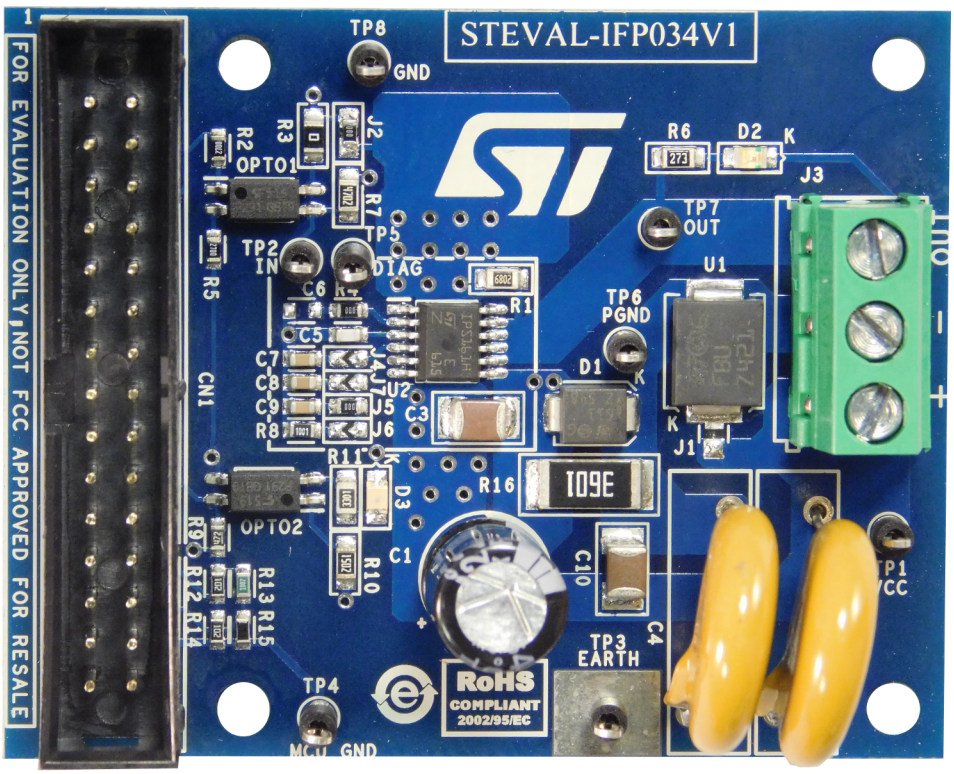
IEC 61000-4-2, IEC61000-4-4 and IEC 61000-4-5 compliance is achieved by the IPS161H itself and the U1 component (the external TVS between V_{CC} supply rail and power ground).

A dedicated GUI interface helps you test IPS161H functionality. To use it, ensure the STEVAL-IFP034V1 is connected via a 30-way flat cable to a STEVAL-PCC009V2, which is connected via USB to the PC running the GUI.

The GUI allows driving the STEVAL-IFP034V1 and monitoring the power output status with fault information from the IPS161H DIAG pin.

The STEVAL-IFP034V1 also optimizes thermal performance, thanks to a dedicated copper area which connects the PSSO12 package exposed pad and acts as a heat sink.

Figure 1. STEVAL-IFP034V1 evaluation board



1 Board description

1.1 STEVAL-IFP034V1 features

- Operating voltage range: 8 to 60 V
- Operating current: 0.5 A max
- Programmable cut-off delay time
- Reverse polarity protection
- Galvanic isolation on PCB
- Input pins compatible with V_{CC} rails
- Green LED for channel ON/OFF status
- Red LED for Common Diagnostics on:
  - open load in OFF state
  - cut-off
  - thermal protection
- Microcontroller interface
- Compliant with IEC 61000-4-2, IEC61000-4-4 and IEC 61000-4-5
- RoHS compliant

Important: *Red LED functionality on the DIAG pin is guaranteed from V_{cc}=12 V.*

For a supply voltage higher than 40 V, J1 must be open, otherwise U1 will be permanently damaged.

1.2 Connectors and jumpers

Table 1. STEVAL-IFP034V1 connectors and jumpers

Name	Type	Function	Notes
J1	Jumper	OPEN (default): disconnects U1 CLOSED: connects U1	J1 must be open for tests with V_{CC} > V_{BR} of U1. External TVS is necessary to improve surge test requirements on V_{CC} pin.
J2	Jumper	OPEN: disables the on-board optocouplers CLOSED (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: CUT-OFF enabled with t_{COFF} = 5 ms ±35%	If J4 is closed, J5, J6 and J7 must be left OPEN
J5	Jumper	OPEN: see J4, J6, J7 CLOSED (default): CUT-OFF enabled with t_{COFF} = 500 µs ±35%	If J5 is closed, J4, J6 and J7 must be left OPEN
J6	Jumper	OPEN (default): see J4, J5, J7 CLOSED: CUT-OFF disabled	If J6 is closed, J4, J5 and J7 must be left OPEN

Name	Type	Function	Notes
J7	Jumper	OPEN (default): see J4, J5, J6 CLOSE: CUT-OFF enabled with t_{COFF} = 2.5 ms ±35%	If J7 is closed, J4, J5 and J6 must be left OPEN
TP1	Test point	V_{CC} (U2 supply voltage)	
TP2	Test point	OPTO1 output (U2 driving signal)	
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	U2 diagnostic pin	
TP6	Test point	Ground of power interface	
CN1	30 way connector	Connection for digital interface and GUI	See Table 2. STEVAL-IFP034V1 30-way signal connector

Table 2. STEVAL-IFP034V1 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_V_{DD}
15, 16, 17, 18, 19	NC
20	DIAF_FAULT (common fault for open load in OFF state, cut-off and thermal events)
21, 22, 23	NC
24, 25	Digital acknowledge (proprietary)
26, 27	NC
28	MCU_GND
29, 30	NC

1.3 Supply voltage

The STEVAL-IFP034V1 is supplied by the J3 connector via pin 1, which is directly connected to the IPS161H V_{CC} supply (operating between 8 and 60 V).

If jumper J1 is closed, the TVS U1 is active and the board supply range is limited to 40 V by the U1 breakdown voltage. When enabled (J1 closed), U1 allows improving the immunity surge pulses of IPS161H V_{CC} pin.

A red LED is connected to the IPS161H DIAG (common diagnostic) pin; when V_{CC} = 12 V, representing open load (off state), the LED switches on. For different operating ranges, you can use R1 and/or R6 (see Open load).

1.4 Communication

Outputs can be driven by connecting the PC to the STEVAL-PCC009V2 through the CN1 connector on the STEVAL-IFP034V1, allowing the use of a dedicated GUI interface. The galvanic isolation between process and control side is implemented through optocouplers OPTO1 and OPTO2.

The input signal can also be provided through CN1 pins 2 (MCU_GND) and 7 (OPTO1 input).

Once the STEVAL-IFP034V1 and STEVAL-PCC009V2 are connected, the communication starts performing the board recognition: the ADC integrated in the STEVAL-PCC009V2 reads the voltage on the resistor network (R1, R13, R14 and R15) and, if the reading is ok, the graphical interface starts.

Afterwards, it is possible to select one of the following modes:

1. Steady driving
2. PWM driving

In the first configuration it is possible to drive the output always ON or OFF, whereas in the second one, it is possible to configure frequency and duty cycle and drive the output in PWM mode.

1.5 Operating current

The IPS161H mounted on the STEVAL-IFP034V1 is designed to supply all kinds of loads (resistive, inductive and capacitive) connected between output and process ground and requiring up to 0.5 A.

In case of overload, the IPS161H regulates its internal impedance limiting the output current to I_{LIM}. In case of inductive load, the maximum demagnetization energy ($E_{DEMAG(MAX)}$) that can be managed by the IPS161H is limited by its internal thermal dissipation capability (for further details, refer to the IPS161H datasheet).

1.6 Cut-off

In case the overcurrent threshold (I_{LIM}) is triggered and the IPS161H cut-off protection feature is activated (J4, J5 or J7 closed and J6 open), the output is driven on at least for time t_{COFF} (set by the selected capacitance on pin 4). The output is then enabled to turn on again only after the cut-off restart time (t_{RES}) has elapsed.

In case of overheating (see Section 1.7 Overheating and thermal protection), t_{COFF} is overridden.

1.7 Overheating and thermal protection

When the working condition causes overheating, the whole application is protected by the thermal protection integrated in IPS161H: once its junction temperature triggers the T_{JSD} threshold (170°C, typical value), the output is forced off until the temperature decreases back to T_{JSD}-T_{HYST} (155°C, typical value).

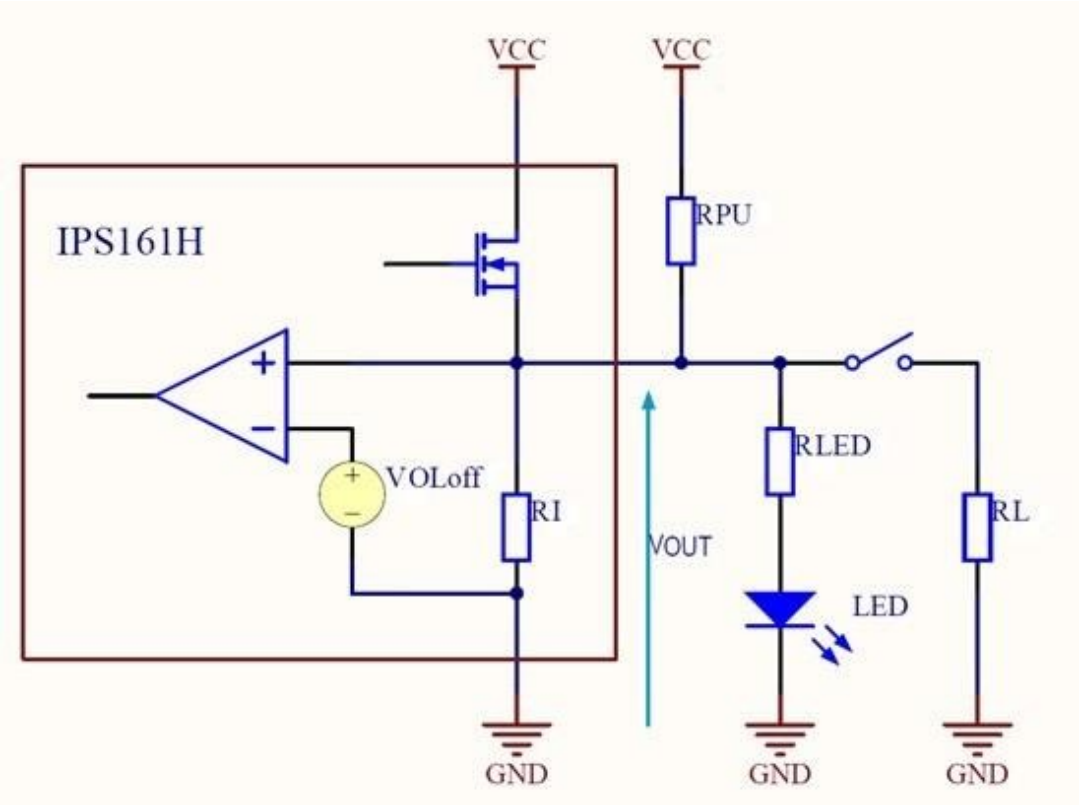
1.8 Open load

The IPS161H integrates the open load detection (in off state) feature activated on the STEVAL-IFP034V1 by R1, the pull-up resistor between IPS161H V_{CC} rail and output pin. When the input is forced low, and if the load is disconnected, the voltage on the output pin is pulled up by R1, the open load detection threshold (V_{OLoff}) is triggered and the diagnostic pin is consequently forced low, switching the red LED on.

The R1 (68 kΩ) is suitable for correctly signalling an open load in the off state in the supply range from V_{CC} = 12 V and I_{LOAD} ≥ 10 mA (for applications without a LED on the output pin, the design rules for R1 are reported in the IPS161H datasheet).

A LED connected through a polarization resistor between output and ground affects the output voltage in the off state and, consequently impacts the functionality of the open load in off state signalization.

Figure 2. **IPS161H electrical schematic for a typical application case**



If the load is not connected

$$V_{OUT} = V_{CC} - R_{PU} \times I_{PU} = V_{CC} - R_{PU} \times (I_{RI} + I_{LED} + I_{RL}) \quad (1)$$

In order to guarantee correct open load signalization, it must result in:

$$V_{OUT} > V_{OLoff(\max)} \quad (2)$$

Consequently:

$$R_{PU} < \frac{V_{CC(min)} - V_{OLoff(max)}}{\left(\frac{V_{OLoff(\max)}}{R_1} + \frac{V_{OLoff(\max)} - V_{LED}}{R_{LED}}\right)} \quad (3)$$

If the load is connected:

$$V_{OUT} = V_{CC} - R_{PU} \times I_{PU} = V_{CC} - R_{PU} \times \left(\frac{V_{OUT}}{R_1} + \frac{V_{OUT} - V_{LED}}{R_{LED}} + \frac{V_{OUT}}{R_L}\right) \quad (4)$$

In order to avoid any false signalization of the open load on the diagnostic pin, it must result in:

$$V_{OUT} < V_{OLff(min)} \quad (5)$$

$$R_{PU} > \frac{V_{CC(\max)} - V_{OLoff(\min)}}{\left(\frac{V_{OLoff(\min)}}{R_1} + \frac{V_{OLoff(\min)} - V_{LED}}{R_{LED}} + \frac{V_{OLoff(\min)}}{R_L}\right)} \quad (6)$$

1.9 Reverse polarity protection

If the V_{CC} and process GND cables are wrongly swapped, the D1 diode blocks any current flow and consequently protects the IPS161H and all the other application components.

1.10 Board layout

During normal operation, the IPS161H could be subjected to particular conditions that cause performance degradation of the device:

1. wrong supply cable connection
2. overheating
3. EMC phenomena from atmospheric events

The STEVAL-IFP034V1 layout has been designed to avoid that the above conditions could limit the device performance.

Figure 3. STEVAL-IFP034V1 layout (top view)

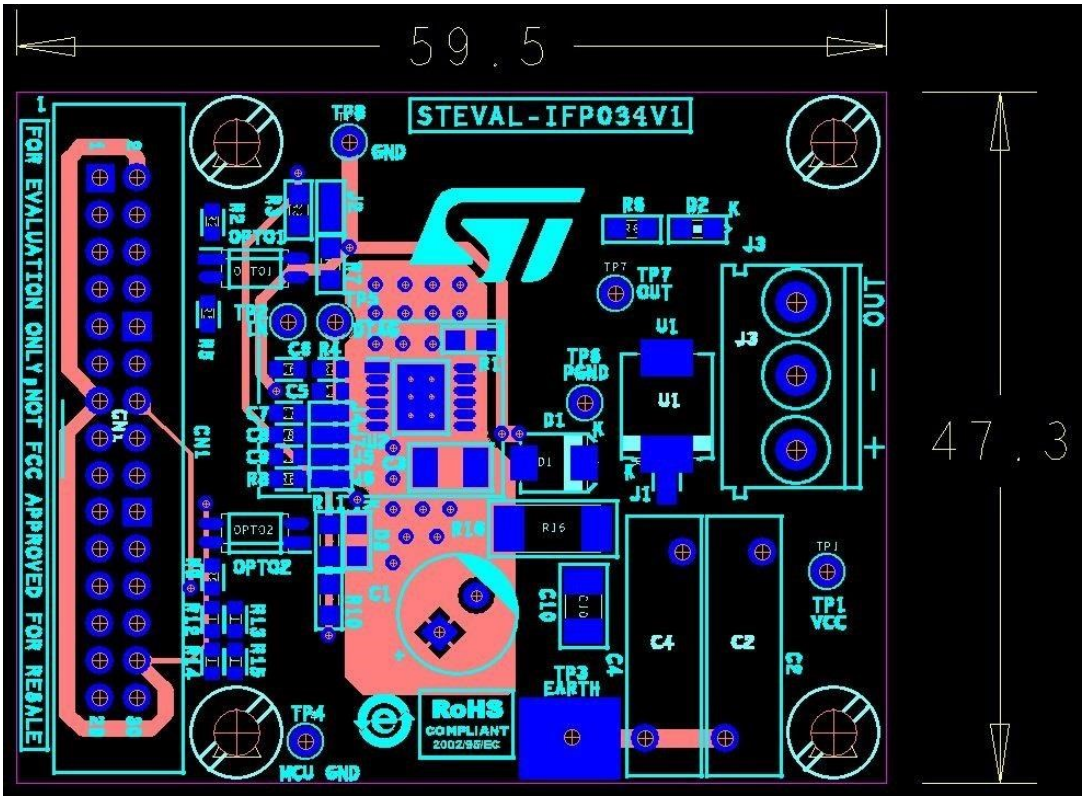
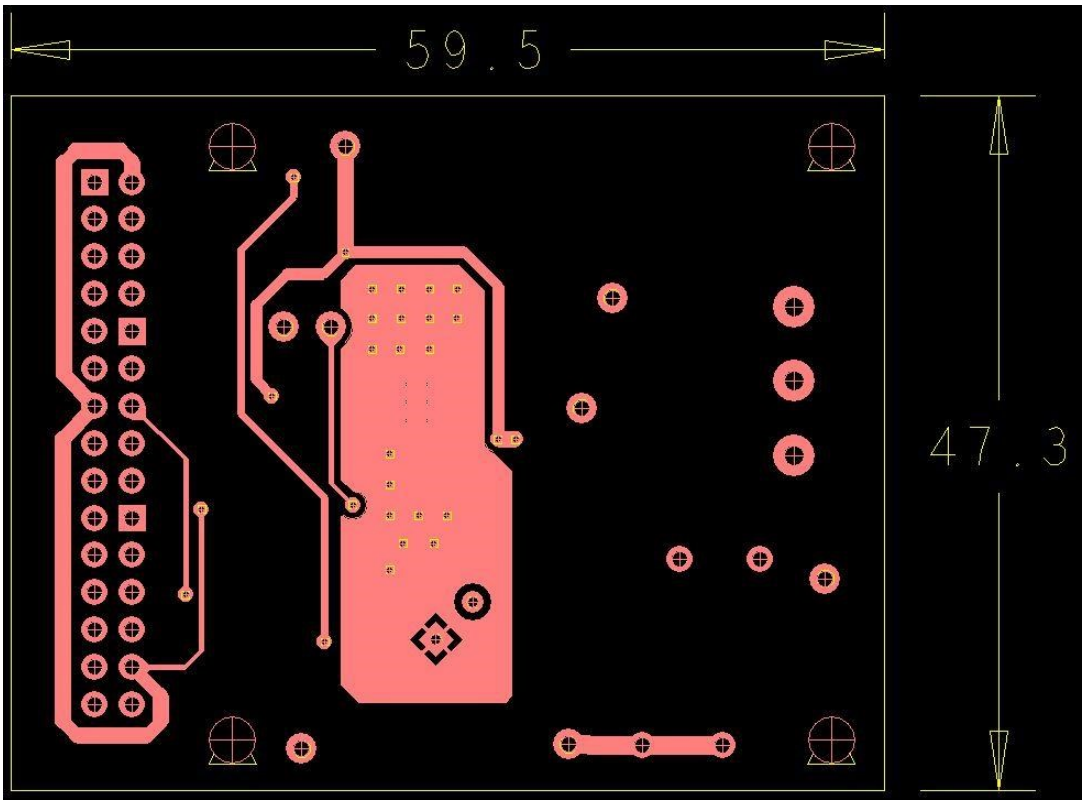


Figure 4. **STEVAL-IFP034V1 layout (bottom view)**

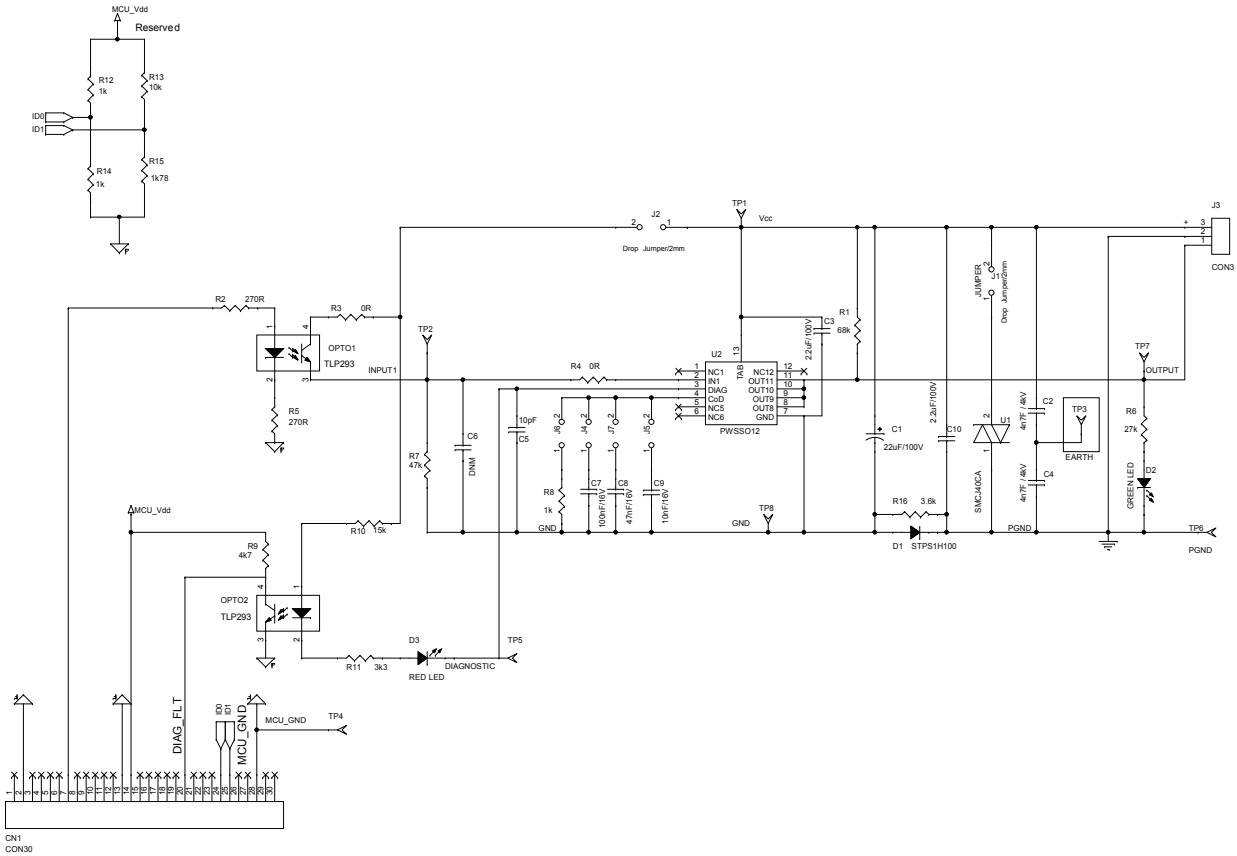


2 References

1. IPS161H datasheet on www.st.com
2. International standard IEC-61131-2

3 Schematic diagram

Figure 5. **STEVAL-IFP034V1 circuit schematic**



4 Bill of materials

Table 3. **STEVAL-IFP034V1 bill of materials**

Item	Quantity	Reference	Part/Value	Description	Manufacturer	Order code
1	1	CN1	CON30 2.54 mm	Connector	FCI	52601-S30-4LF
2	1	C1	100 V,22 µF, ±20%	Electrolytic capacitor	Rubycon	100YXF22MEFC8X11.5
3	2	C2, C4 (DNM)	4.7 nF, 4kV	Single layer capacitors	Vishay	VY1472M63Y5UG63V0
4	1	C3	1 µF,100 V, X7R±10%	Ceramic capacitor	Kemet	C1210C105K1R1CTU
5	1	C5	1 pF, 100 V ±5%	Capacitor	Vishay	VJ0603A100JXBT
6	1	C6	DNM	Capacitor	Any	Any
7	1	C9	10 nF, 16 V ±5%	Ceramic capacitor	Murata	GRM188R71C103KA01D
8	1	C8	47 nF, 16 V ±10%	Ceramic capacitor	AVX	0603YC473KAT2A
9	1	C7	100 nF, 16 V±10%	Ceramic capacitor	Murata	GRM188R71C104KA01D
10	1	C10	2.2 µF, 100 V, X7R ±10%	Capacitor	TDK	C3225X7R2A225K230AB
11	1	D1	100 V, 1 A	100 V, 1 A SMA(flat), SMB power Schottky rectifier	ST	STPS1H100U
12	1	D2	2.2 V	Green LED	OSRAM Wurth	LG R971
13	1	D3	1.8 V	Red LED	OSRAM Wurth	LH R974
14	1	J1		Jumper	Any	Any
15	1	J2		Jumper	Any	Any
16	3	J4, J6, J7		Jumpers	Any	Any
17	1	J5	0 Ω, 100 mW±1%	Jumper	Vishay	CRCW06030000Z0EB
18	1	R10	15 K, 125 mW±1%	Resistor	Te Connectivity	CRG0805F15K
19	1	R1	68 K, 125mW ±1%	Resistor	Bourns	CR0805-FX-6802GLF
20	1	R7	47 K, 125 mW±1%	Resistor	Bourns	CR0805-FX-4702ELF
21	2	R2, R5	270 R, 100 mW±5%	Resistors	Panasonic	ERJ3GEYJ271V
22	1	R9	47 K, 125 mW±1%	Resistor	Bourns	CR0805-FX-4701GLF
23	1	R3	0 Ω, 125 mW±5%	Resistor	Bourns	CR0805-J/-000ELF

Item	Quantity	Reference	Part/Value	Description	Manufacturer	Order code
24	1	R4	0 Ω, 100 mW±1%	Resistor	Vishay	CRCW06030000Z0EB
25	2	OPTO1, OPTO2	80 V	Optocouplers	Toshiba	TLP293 (GRH-TPL,E)
26	1	R6	27 K, 125 mW±0.5%	Resistor	Panasonic	ERJ6RBD2702V
27	2	R12, R14	1 K, 100 mW±0.1%	Resistors	Panasonic	ERA3AEB102V
28	1	R8	1 K, 100 mW±1%	Resistor	Te Connectivity	CRG0603F1K0
29	1	R11	33 K, 125 mW±1%	Resistor	Bourns	CR0805-FX-3301GLF
30	1	R13	10 K, 100 mW±0.1%	Resistor	Panasonic	ERA3APB103V
31	1	R15	178 K, 100 mW±0.1%	Resistor	Panasonic	ERA3AEB1781V
32	6	TP1, TP2, TP3, TP4, TP5, TP6, TP7		Test points	Any	Any
33	1	J3		3 way screw connector	Phoenix contact	MKDSN 1,5/3-5.08
34	1	U2	IPS161H	Single high-side switch for safety integrity level (SIL2 and SIL3) compliant systems	ST	IPS161H
35	1	U1	V_{BR} = 42 V	1500 W TVS	ST	SMCJ40CA-TR

Revision history

Table 4. **Document revision history**

Date	Revision	Changes
06-Feb-2017	1	Initial release.
27-May-2019	2	Updated Section 3 Schematic diagram and Section 4 Bill of materials.