STEVAL-ISV021V1 energy harvesting system based on the SPV1050

Introduction

The STEVAL-ISV021V1 is an evaluation kit, which features a complete energy harvesting module based on the SPV1050 ultra-low-power energy harvester and battery charger. It shows the electrical performance of the power converter and other fundamental electrical quantities related to the overall system.

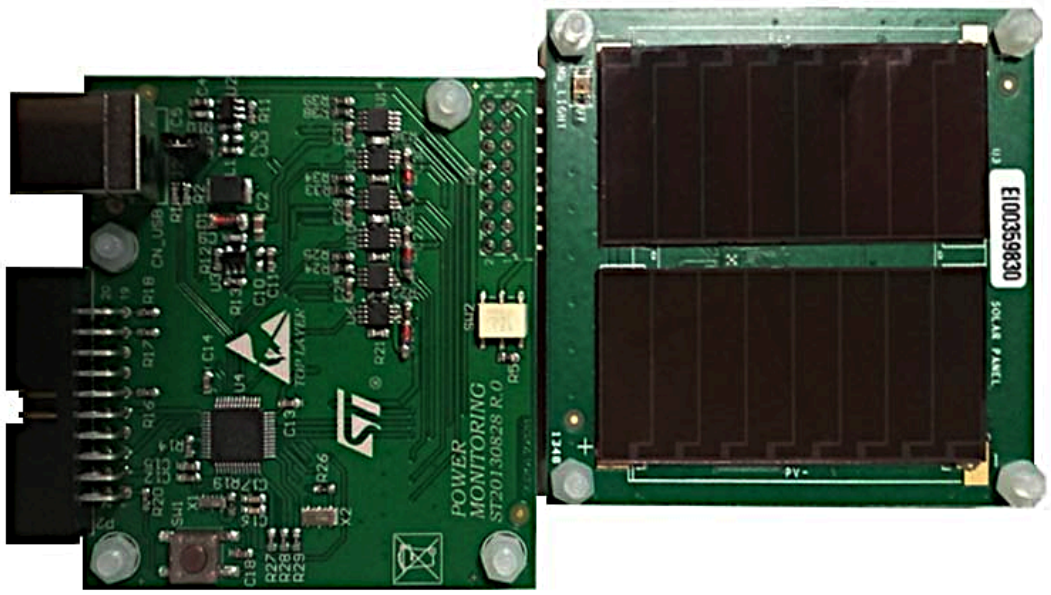
The SPV1050 power manager is configured as a buck-boost converter, which fits the electrical characteristics of the mounted PV panel and battery.

A power monitoring board and a GUI allow monitoring and building graphs of the PV panel, the battery voltage, the current, and the system performance, such as the MPPT accuracy and conversion efficiency.

The STEVAL-ISV021V1 represents a standalone harvesting module that can be interfaced with a wireless sensor node to provide the microcontroller, transmitter, and sensors with the energy scavenged and stored into the battery.

Moreover, the STEVAL-ISV021V1 harvesting module embeds an extension connector to interface and monitor some of the SPV1050 input and output signals through a microcontroller-based board.

Figure 1. Power monitoring board (left) and harvesting module (right) - top view



1 Harvesting module layout

The figures below show the component placement and the layout (top and bottom views) of the harvesting module.

Figure 2. Harvesting module layout - top view

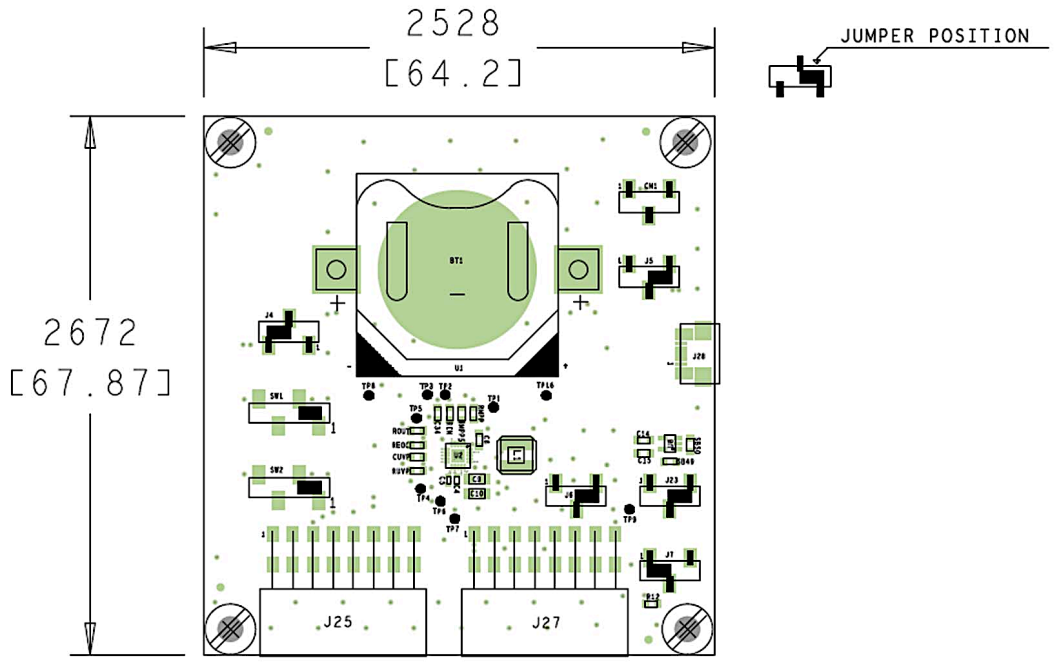
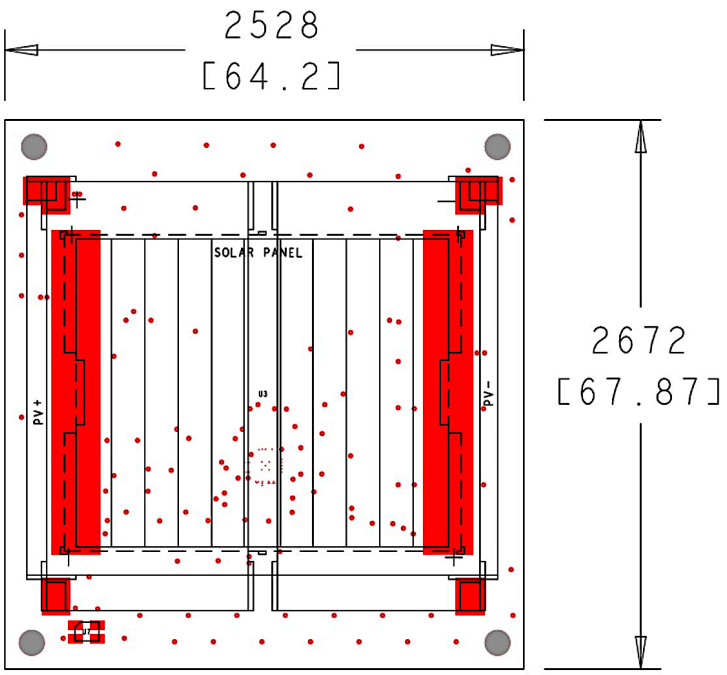


Figure 3. Harvesting module layout - bottom view



To ensure a proper noise rejection that could impact the SPV1050 device performance, follow the indications below related to the PCB routing:

- connect the exposed pad and the PGND and GND pins to the same ground plane;
- place the capacitor on the STORE pin as close as possible to the related pin;
- place the capacitors on the LDO1 and LDO2 pins as close as possible to the related pins.

2 Harvesting module connectors

The STEVAL-ISV021V1 provides a set of connectors for the input sources.

CN1 (2-pin connector) supplies the SPV1050 through an alternative supply source in place of the on-board PV panel.

Table 1. CN1 connector

Pin number	Signal
1	SOURCE+
2	SOURCE-

J4 must be open before an external source is connected to CN1. To select the external source properly, refer to the SPV1050 datasheet.

J25 (16-pin extension connector) connects the harvesting module to an external load such as a wireless sensor node.

Table 2. J25 connector

Pin number	SPV1050 pin signal	Pin description
1-2	LDO1_EN CONTROL (input)	It provides the connection to an external signal that controls the LDO1_EN pin. In this case, SW1 must be left open. If the LDO1 is not used, the LDO1_EN pin has to be connected to the ground.
3-4	LDO2_EN CONTROL (input)	It provides the connection to an external signal that controls the LDO2_EN pin. In this case, the SW2 must be left open. If the LDO2 is not used, the LDO2_EN pin has to be connected to the ground.
5-6	$\overline{\text{BATT\_CHG}}$ (output)	It is the battery charge status pin. This is an open drain pin that has to be pulled up by a resistor (10 MΩ typical) to the VSTORE voltage rail.
7-8	$\overline{\text{BATT\_CONN}}$ (output)	It is the battery connection status pin. This is an open drain pin that has to be pulled up by a resistor (10 MΩ typical) to the VSTORE voltage rail.
9-10	LDO2	LDO2 (3.3 V) output voltage pin.
11-12	LDO1	LDO1 (1.8 V) output voltage pin.
13-16	GND	Ground pin of the extension board.

J27 (16-pin monitoring connector) provides the connection to the power monitoring board.

Table 3. J27 connector

Pin number	Signal	Description
1-2	SOURCE	It is the harvesting source current sensing pin. If the power monitoring board is used, the J5 jumper must be left open; otherwise, J5 pins 1 and 2 must be shorted.
3-4	PV+	It is the harvesting source current sensing pin. If the power monitoring board is used, the J5 jumper must be left open; otherwise, J5 pins 1 and 2 must be shorted.
5-6	VBATT+	It is the battery current sensing pin. If the power monitoring board is used, the J6 jumper must be left open; otherwise, J6 pins 1 and 2 must be shorted.
7-8	VBATT_OUT	It is the battery current sensing pin. If the power monitoring board is used, the J6 jumper must be left open; otherwise, J6 pins 1 and 2 must be shorted.
9-10	SUPPLY_SFH5711	It is the power supply of the ambient light sensor pin (placed on the board top side).
11-12	AMBIENT_LIGHT_PIN	It is the ambient light current sensing pin. If the power monitoring board is used, the J7 jumper must be left open.
13-14	AMBIENT_LIGHT	It is the ambient light current sensing pin. If the power monitoring board is used, the J7 jumper must be left open.
15-16	GND	It is the ground pin.

3 Jumpers and switches

Table 4. Jumper function description

J4	J5	J6	J7	J23
Close 1-2: the on-board PV panel supplies the harvesting board	Close 1-2: it bypasses the power monitoring sense and supply directly the SPV1050	Close 1-2: it bypasses the power monitoring sense and connects the battery to the BATT pin	Close 1-2: not used	Close 1-2: the USB cable supplies the STORE pin
Open 1-2: it enables an alternative source from CN1	Open 1-2: the power monitoring board enables the power monitoring	Open 1-2: it enables the sensing from the monitoring board	Open 1-2: it enables the ambient light sensing from the monitoring board	Open 1-2: the energy harvesting source supplies the STORE pin

Table 5. Switch function description

SW1	SW2
Close 1-3: LDO1 disabled	Close 1-3: LDO2 disabled
Close 2-3: LDO1 enabled	Close 2-3: LDO2 enabled
Floating: external control by J25	Floating: external control by J25

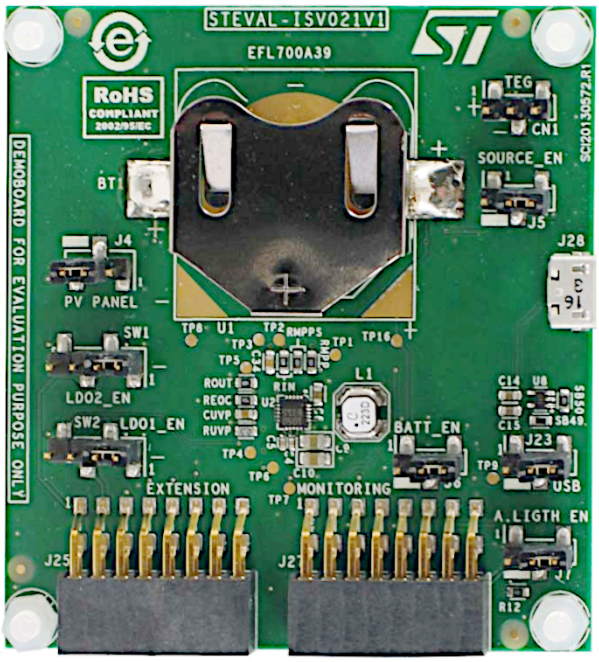
4 Harvesting module and power monitoring board

The harvesting module can be used as a standalone device or with the power monitoring board.

In the standalone mode, leave the CN1 open and connect the jumpers as described below:

- close the J4 pins 2-3 and close the J5 pins 1-2 to supply the SPV1050 device via the on-board PV panel;
- close the J6 pins 1-3 to connect the on-board battery.

Figure 4. Jumper configuration for the harvester module in the standalone mode



You can monitor the system behavior and efficiency by:

- placing a voltmeter between the CN1 pins 1-2 (VIN);
- replacing the short on the J5 with an ammeter (IIN);
- placing a voltmeter between TP16 and TP8 (VBATT);
- replacing the short on the J6 with an ammeter (IBATT).

The STEVAL-ISV021V1 includes the power monitoring board and the related GUI, which runs on Windows XP and Windows 7.

The power monitoring board and the related GUI allow monitoring the system performance in a quick and intuitive way.

Before connecting the harvester module to the power monitoring board, set the jumpers as follows:

- close the J4 pins 2-3 to supply the SPV1050 device via the on-board PV panel;
- close the J5 pins 2-3 to allow the power monitoring to sense the input voltage and current;
- close the J6 pins 2-3 to allow the power monitoring to sense the battery voltage and current;
- close the J7 pins 2-3 to allow the power monitoring to sense the ambient light on the PV panel.

Figure 5. **Jumper configuration for harvester module connected to power monitoring board**

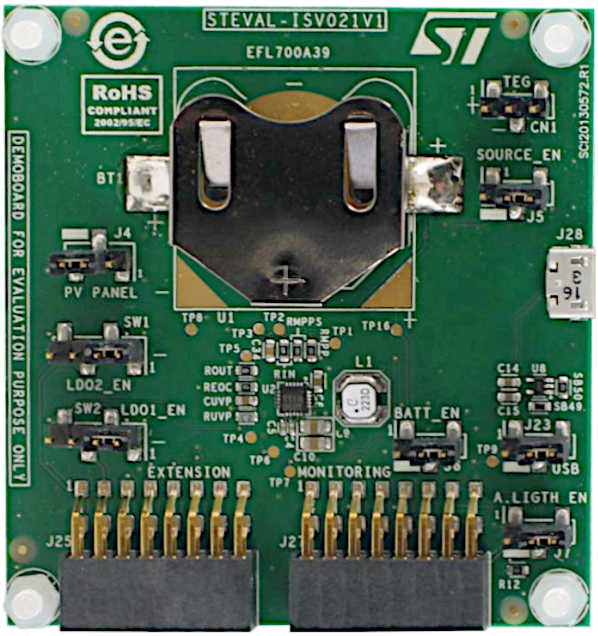
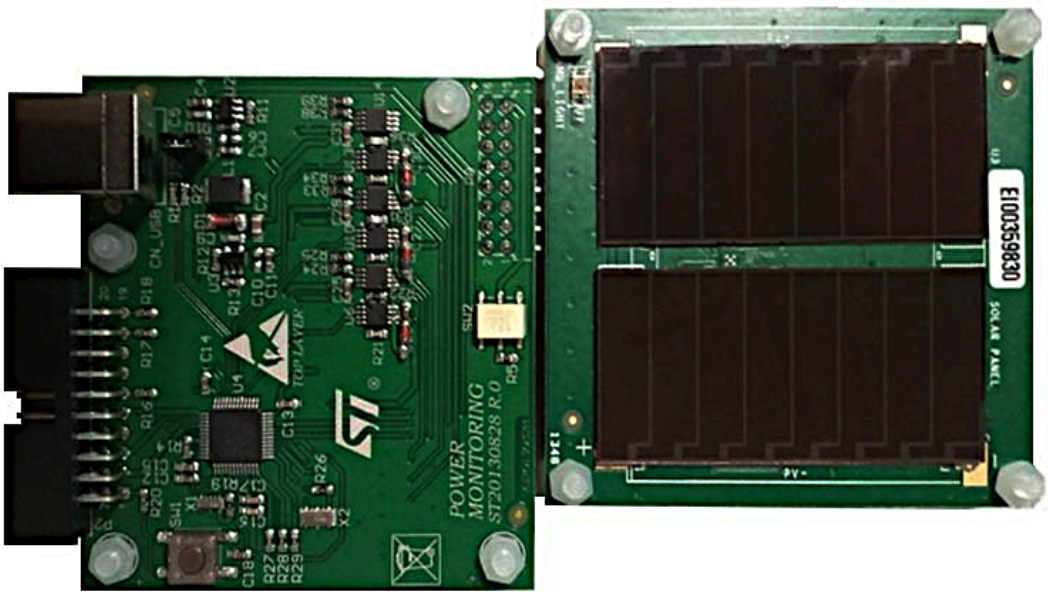


Figure 6. **Power monitoring board (left) and harvesting module (right)**



The power monitoring board allows measuring up to three voltage-current pairs when connected to a generic DUT. The board can acquire up to 12800 samples per second when a single channel is active. For multichannel acquisitions, the available bandwidth is split among the three channels. Two channels can acquire currents in the range 1 µA - 15 mA, whereas the third one works in the range 1 µA - 1 mA.

The power monitoring board can be also used as a general-purpose measurement board. In this case, it is a part of the STEVAL-ISV021V1 kit.

The ambient light irradiation, the input supply operating points (the input voltage and current of the harvested source), and the output stage operating points (the battery voltage and current) are sampled. The GUI can display these sampled parameters once the monitoring board is connected to a PC or laptop through the dedicated USB cable.

Caution: Connecting the harvesting module to the power monitoring board, while the latter is not powered through the USB cable, causes current draining from the battery, leading to a potential damage.

The GUI is arranged in four selectable tabs:

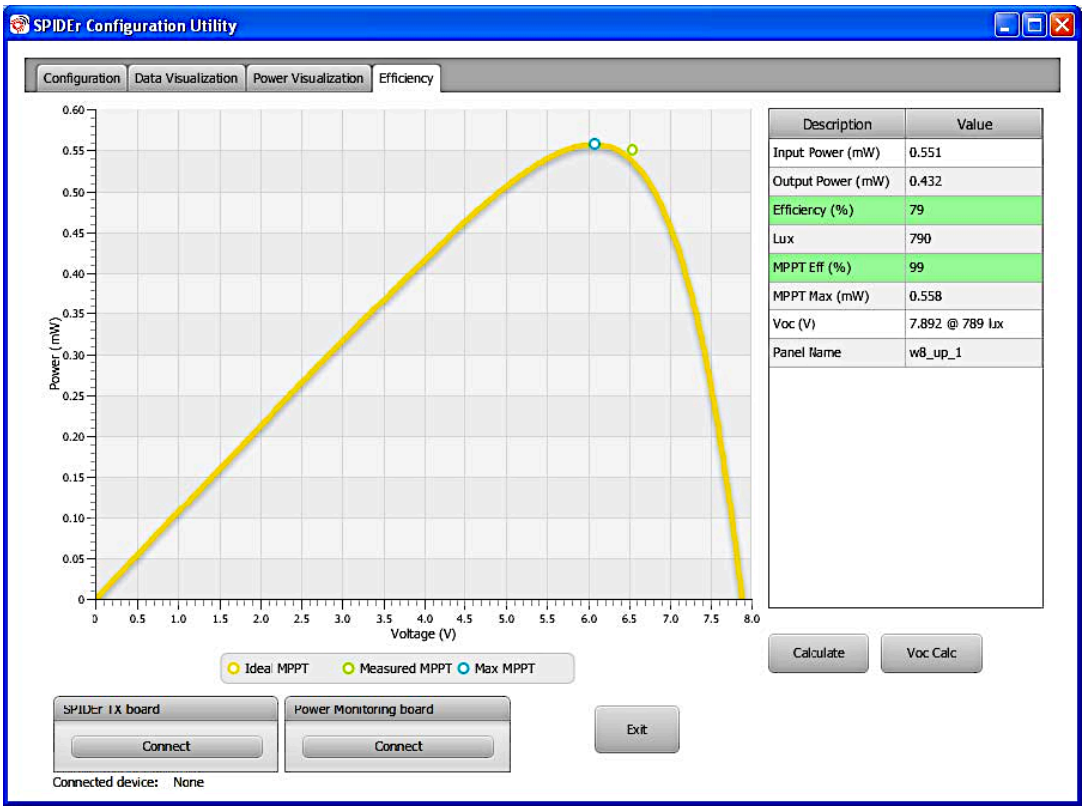
- configuration: to set up the power monitoring board;
- data visualization: not used with the STEVAL-ISV021V1;
- power visualization: to display the power sink by the load eventually connected to the J25 extension connector;
- efficiency: to display the system performance in terms of MPPT accuracy and power efficiency.

The following figure shows the efficiency tab, where:

- the GUI shows the actual PV panel curve according to the current ambient light conditions;
- on the PV panel curve, the green dot indicates the real working point, whereas the blue dot indicates the maximum power point;
- the table on the top-right side of the screen shows the main system parameters and performance.

For a detailed description of the GUI, refer to UM1752.

Figure 7. Efficiency tab



5 Schematic diagrams

Figure 8. **STEVAL-ISV021V1 circuit schematic (1 of 4)**

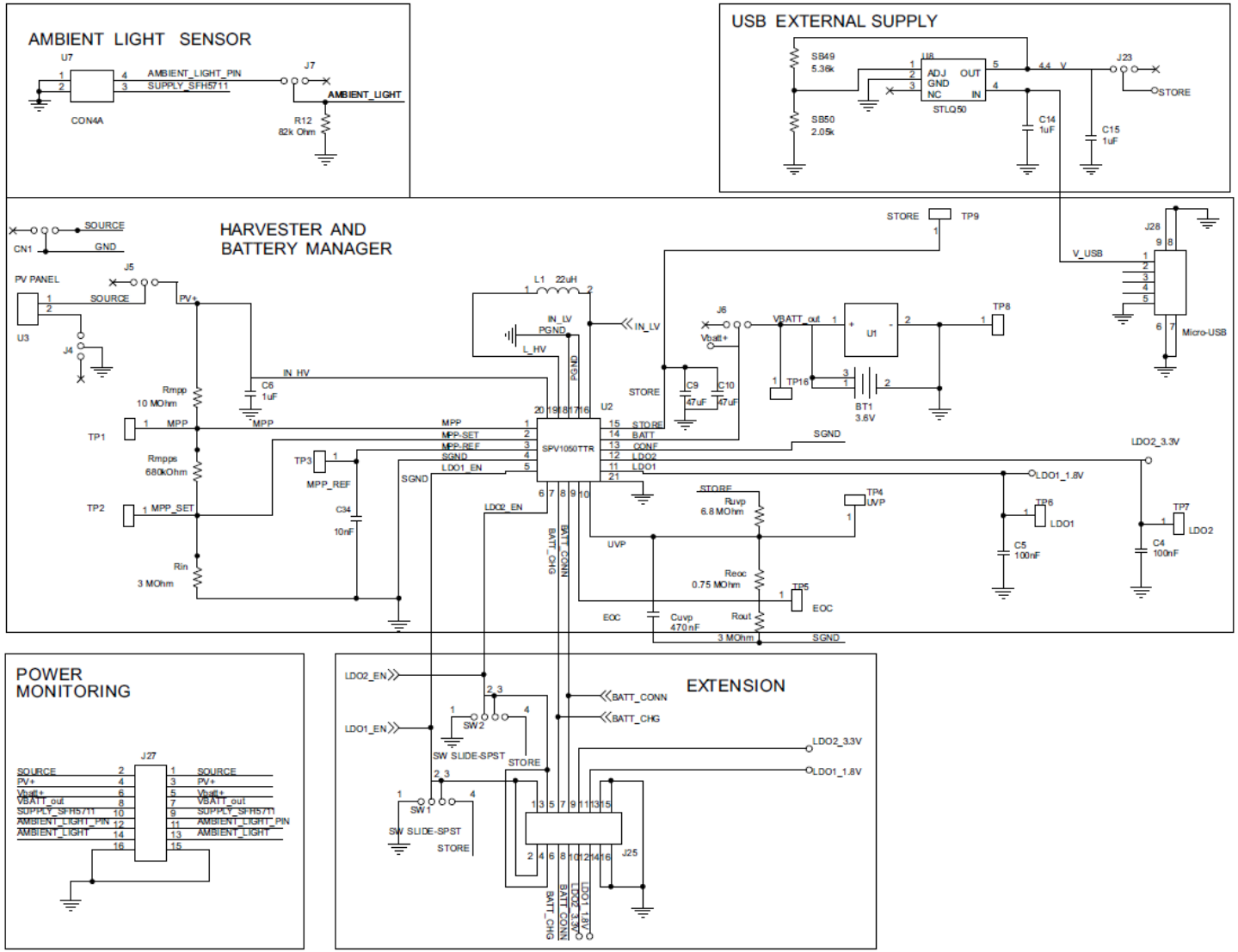


Figure 9. STEVAL-ISV021V1 circuit schematic (2 of 4)

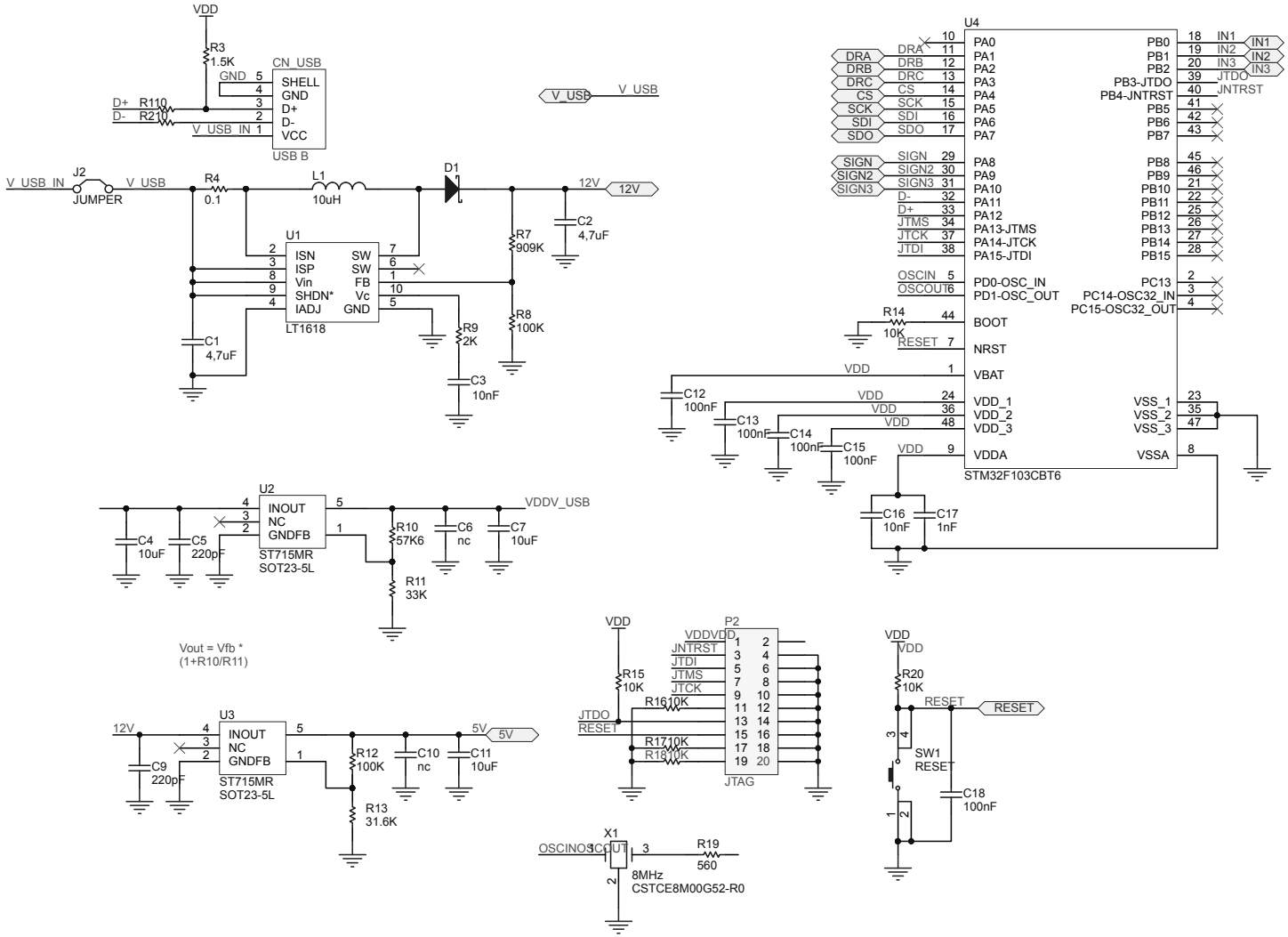


Figure 10. STEVAL-ISV021V1 circuit schematic (3 of 4)

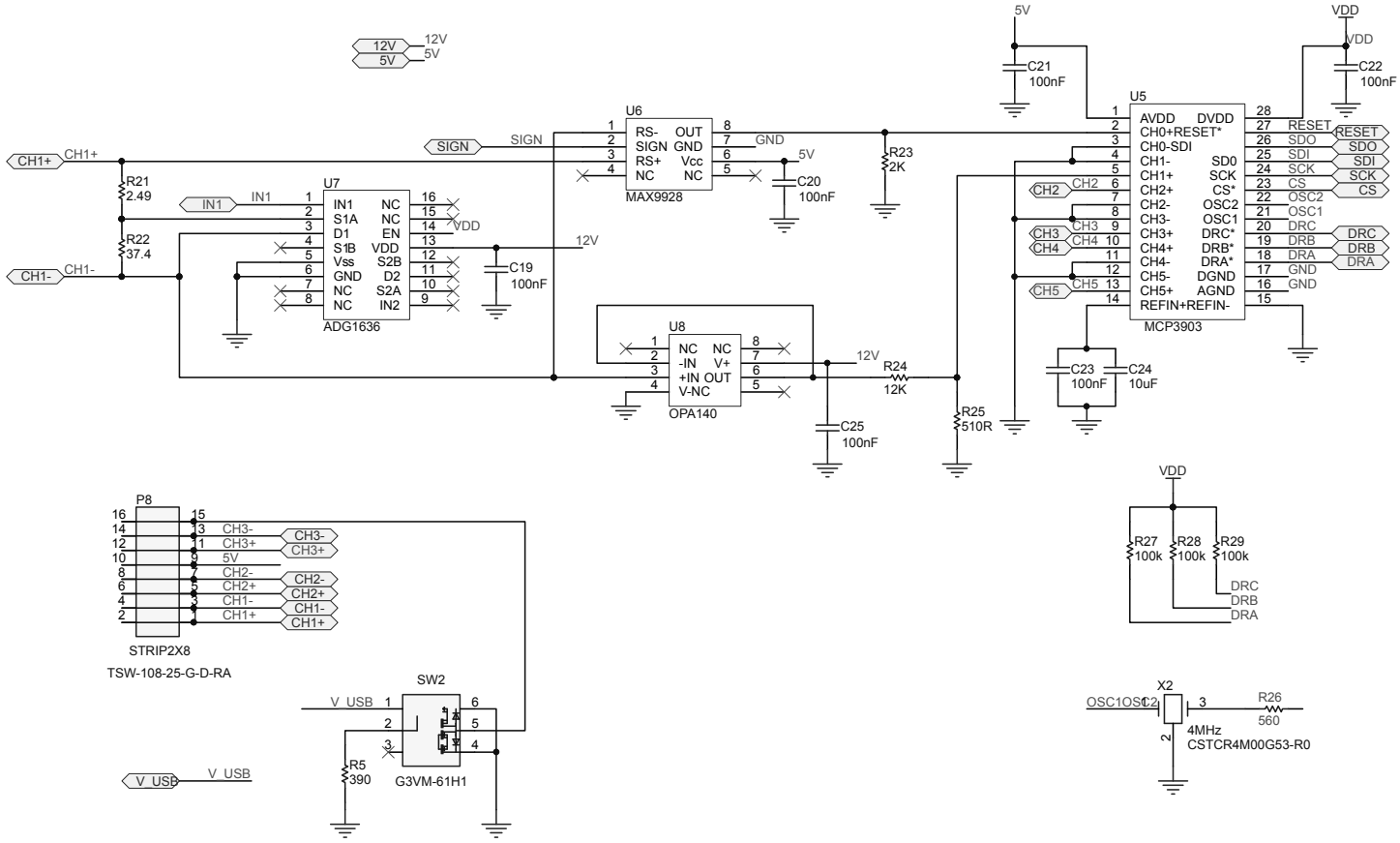
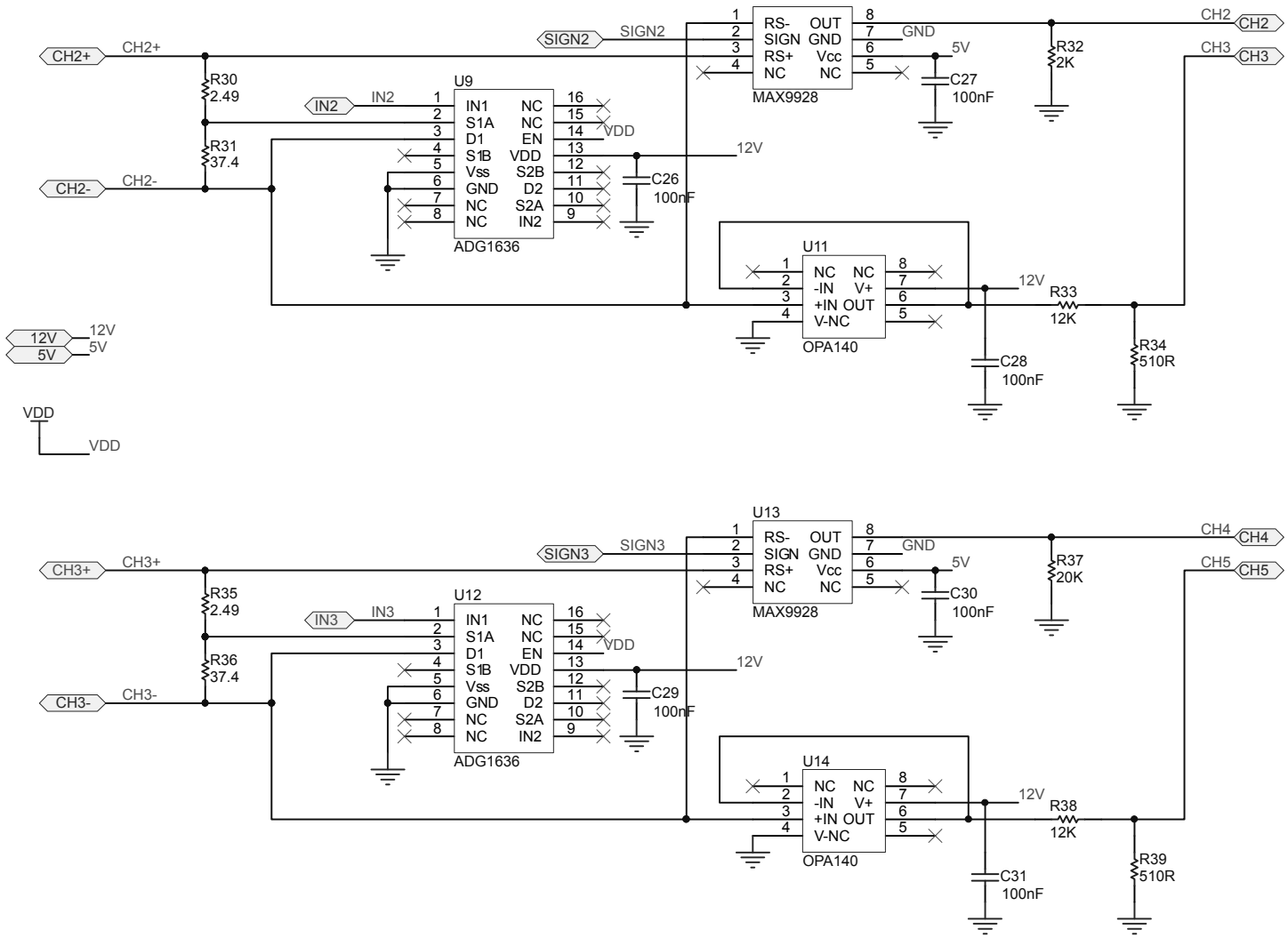


Figure 11. STEVAL-ISV021V1 circuit schematic (4 of 4)



6 Bill of materials

Table 6. **STEVAL-ISV021V1 bill of materials**

Item	Q.ty	Reference	Part/value	Description	Manufacturer	Order code
1	1	BT1	CR2450 SMD	Support for Li-Ion battery	Keystone	3008
2	1	C34	10 nF X7R ±15% 16 V 0603	Capacitor	Murata	GRM188R71C103KA01D
3	2	C4,C5	100 nF X5R ±10% 10 V 0402	Capacitor	Murata	GRM155R61A104KA01D
4	1	C6	1 µF X5R ±10% 25 V 0603	Capacitor	Murata	GRM188R61E105KA12D
5	2	C14,C15	1 µF X5R ±10% 25 V 0603	Capacitor	Murata	GRM188R61E105KA12D
6	2	C9,C10	47µF X5R ±20% 6.3 V 0805	Capacitor	KEMET	C0805C476M9PAC7800
7	0	Cuvp	470 nF X5R ±15% 10 V 0603	Not mounted	Murata	GRM188R71A474KA61D
8	4		M3x0.5 mm	Nylon nuts	Any	Any
9	4		M3x12.7 mm	Nylon distantiators	Any	Any
10	1	J25	Conn. female 2x8 90° SMD	Connector	Samtec	SMH-108-02-G-D
11	1	J27	Conn. female 2x8 90° SMD	Connector	Samtec	SMH-108-02-G-D
12	1	J28	SMD	Micro-USB type B	Molex	47346-0001
13	1	J4	SMD	SMD jumper	FCI	95293-101-03LF
14	1	J5	SMD	3-way switch	FCI	95293-101-03LF
15	1	J6	SMD	SMD jumper	FCI	95293-101-03LF
16	1	J7	SMD	SMD jumper	FCI	95293-101-03LF
17	1	J23	SMD	SMD jumper	FCI	95293-101-03LF
18	1	CN1	SMD	2-way connector	FCI	95293-101-03LF
19	7	J_4,J_5,J_6,J_7,J_23,SW_1,SW_2		Microshunt jumper	Any	Any
20	1	L1	22 µH 0,305A ±20% SMT	DC-DC inductor	Coilcraft	XFL2006-223ME_
21	1	R12	82 K 80 K ohm ±1% 0603	Resistor	Yageo	RC0603FR-0782KL
22	1	Reoc	750 K ohm ±1% 0603	Resistor	Vishay	CRCW0603750KFKEA
23	1	Rin	3 M ohm ±1% 0603	Resistor	Vishay	CRCW06033M00FKEA
24	1	Rout	3 M ohm ±1% 0603	Resistor	Vishay	CRCW06033M00FKEA

Item	Q.ty	Reference	Part/value	Description	Manufacturer	Order code
25	1	Rmpp	10 M ohm ±1% 0603	Resistor	Vishay	CRCW060310M0FKEA
26	1	Rmpps	680 K ohm ±1% 0603	Resistor	TE Connectivity	CRG0603F680K
27	1	Ruvp	6.8 M ohm ±1% 0603	Resistor	Vishay	CRCW06036M80FKEA
28	1	SB49	5.36 K ohm ±0.1% 0603	Resistor	Panasonic	ERA3AEB5361V
29	1	SB50	2.05 K ohm ±1% 0603	Resistor	Vishay	CRCW06032K05FKEA
30	1	SW1	SMD	3-way switch	FCI	95293-101-04LF
31	1	SW2	SMD	3-way switch	FCI	95293-101-04LF
32	1	U1	120 mAh 3.6 V	Rechargeable lithium battery	Multicomp	LIR2450
33	1	U2	SPV1050TTR VFQFPN 20 3x3	Ultra low power energy harvester and battery charger with embedded MPPT and LDOs	ST	SPV1050TTR
34	2	U3	53 mm x 25 mm PTH	Solar cell	Panasonic - BSG	AM-1801CA
35	1	U7	SFH5711 SMD	Ambient light sensor	OSRAM	SFH 5711
36	1	U8	STLQ50C-R SOT323-5L	50 mA, 3 µA supply current low drop linear regulator	ST	STLQ50C-R

Revision history

Table 7. **Document revision history**

Date	Revision	Changes
19-May-2022	1	Initial release.

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