AN4395
Application note

Autonomous wireless multi-sensor node powered by PV cells and based on SPV1050 (SPIDEr™)

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Introduction

The STEVAL-IDS002V1 is a complete and fully configurable reference design of a wireless sensor node powered by the energy harvested from a photovoltaic module soldered on the top. It is composed by a fully integrated transmitter board which contains a temperature sensor, an air pressure sensor and a 3-axis accelerometer MEMS sensor powered by the SPV1050 device. Moreover a microcontroller and an RF Sub-Giga transmitter, all by ST, are mounted on the board.

The system has a receiver companion powered through a USB cable by the PC. For further details on the SPV1050 device, please refer to the related datasheet.

The reference design kit is supported by a software user-friendly GUI able to show PV module and battery electrical characteristics, conversion efficiency, MPPT accuracy and sensors readings.

The transmitter module is based on an STM32L151 low power microcontroller which controls sensors configuration and data communication. A digital temperature sensor (STTS751), a pressure sensor (LPS331AP) and a 3-axis accelerometer (LIS3DH) are connected to the microcontroller through the I^2C bus.

Figure 1. STEVAL-IDS002V1 reference design kit (SPIDEr™)

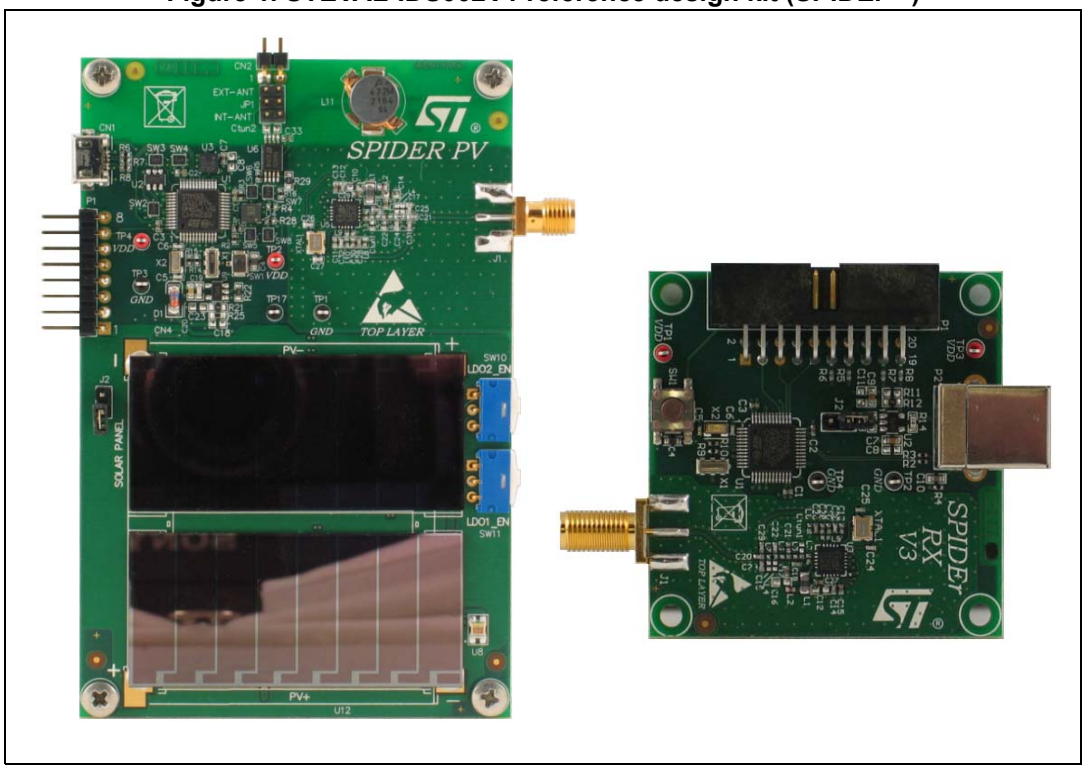

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Figure 2. Board schematic - transmitter/receiver

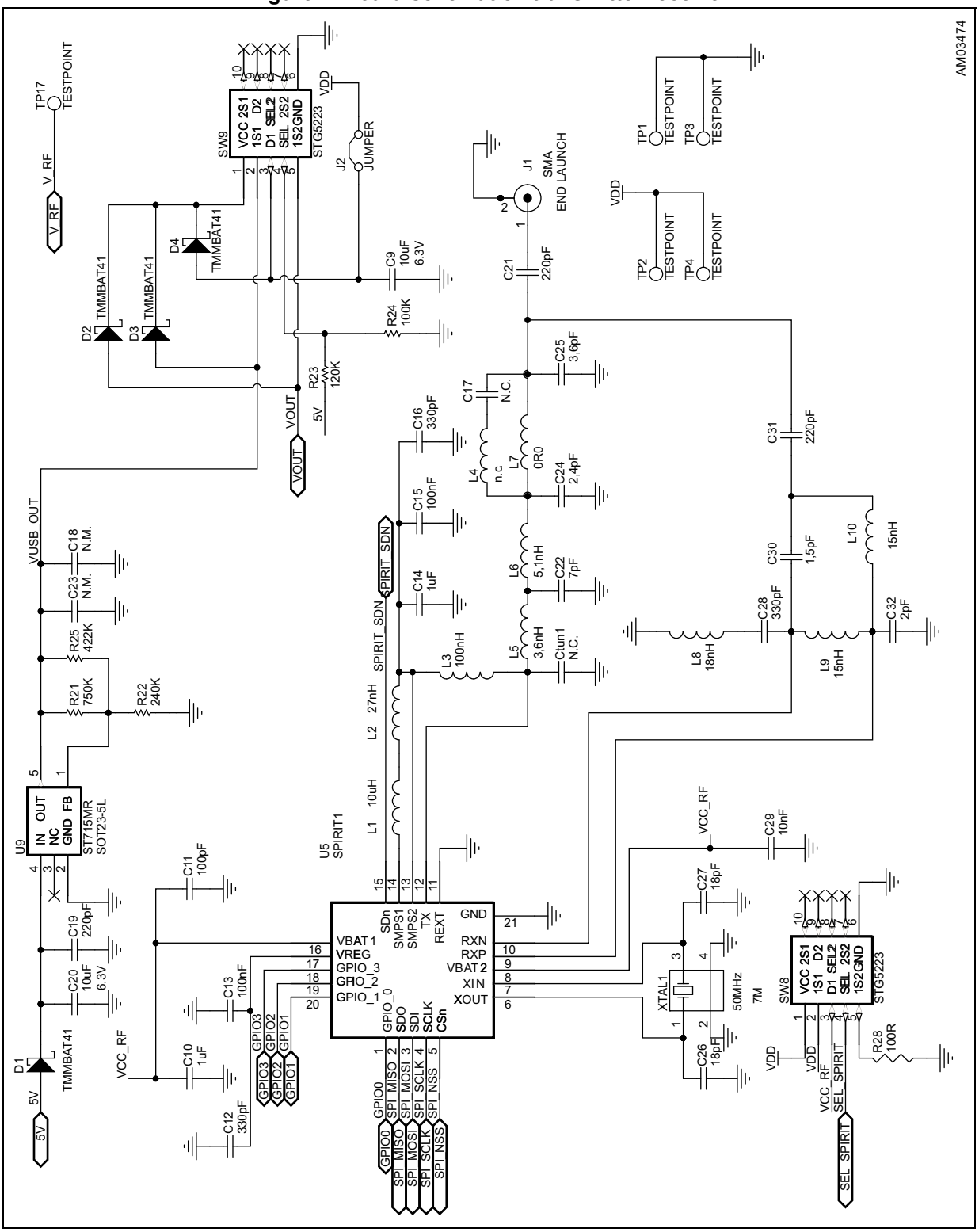


Figure 3. Board schematic - antenna

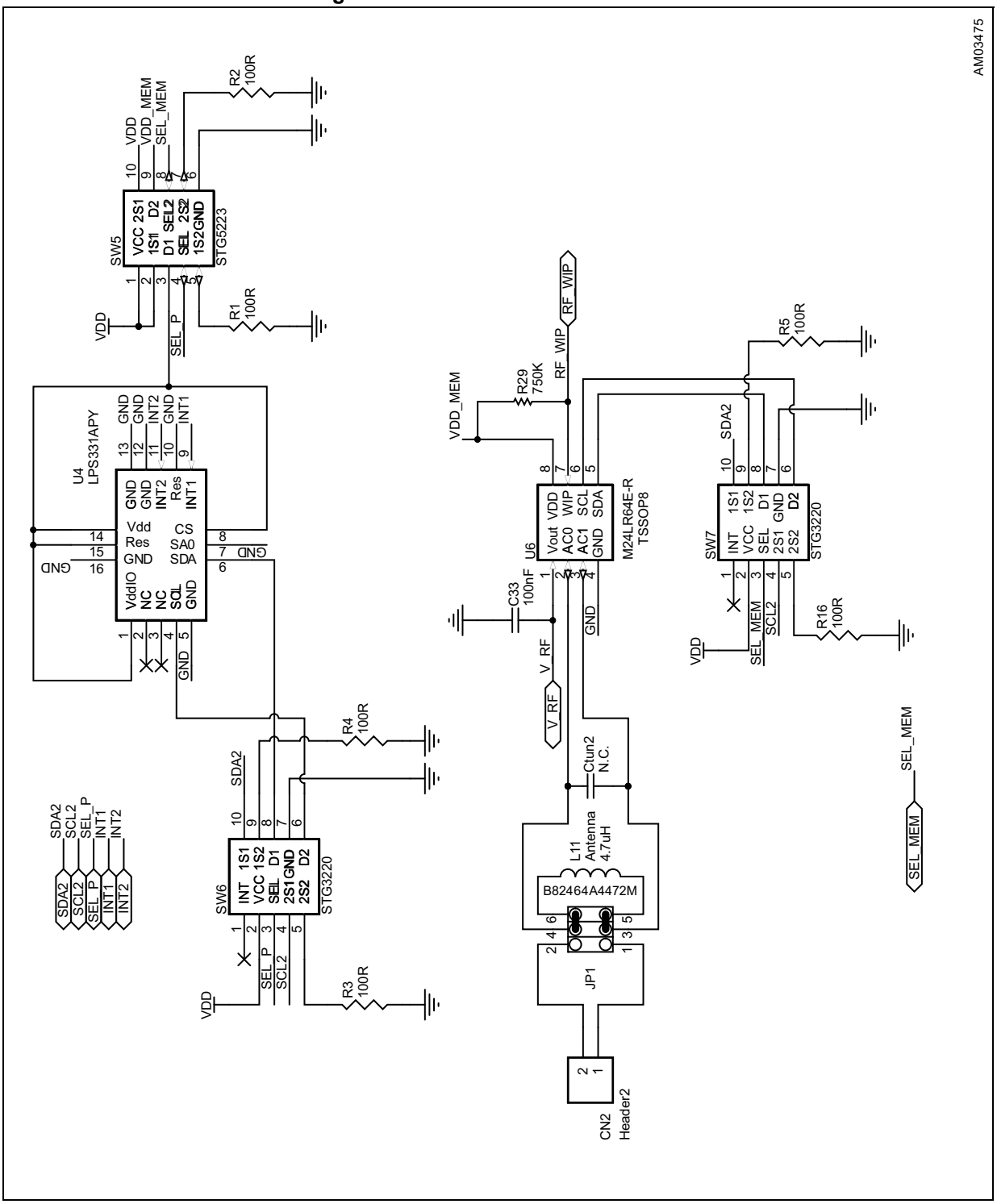


Figure 4. Board schematic - microcontroller

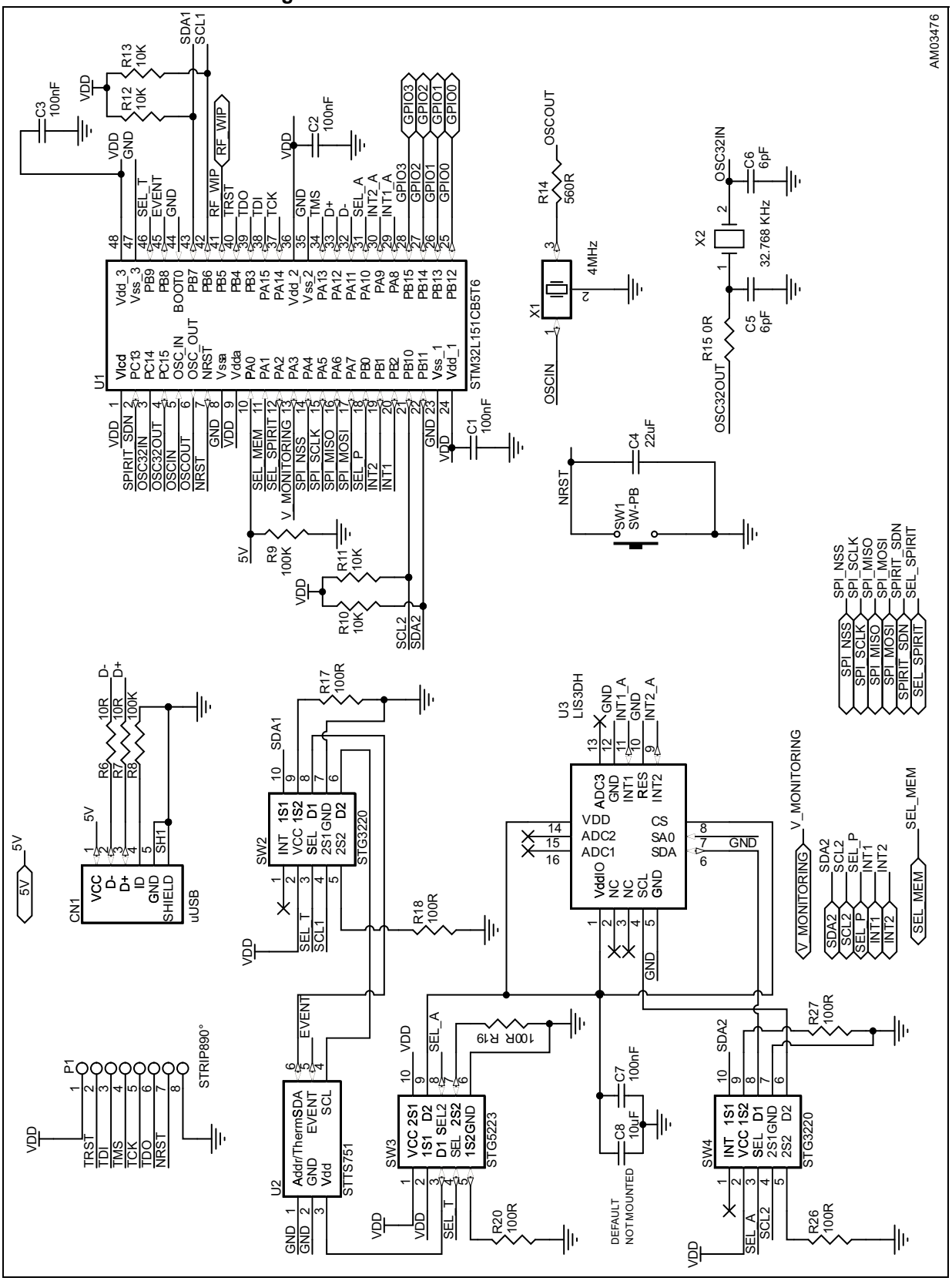


Figure 5. Board schematic - photovoltaic harvester

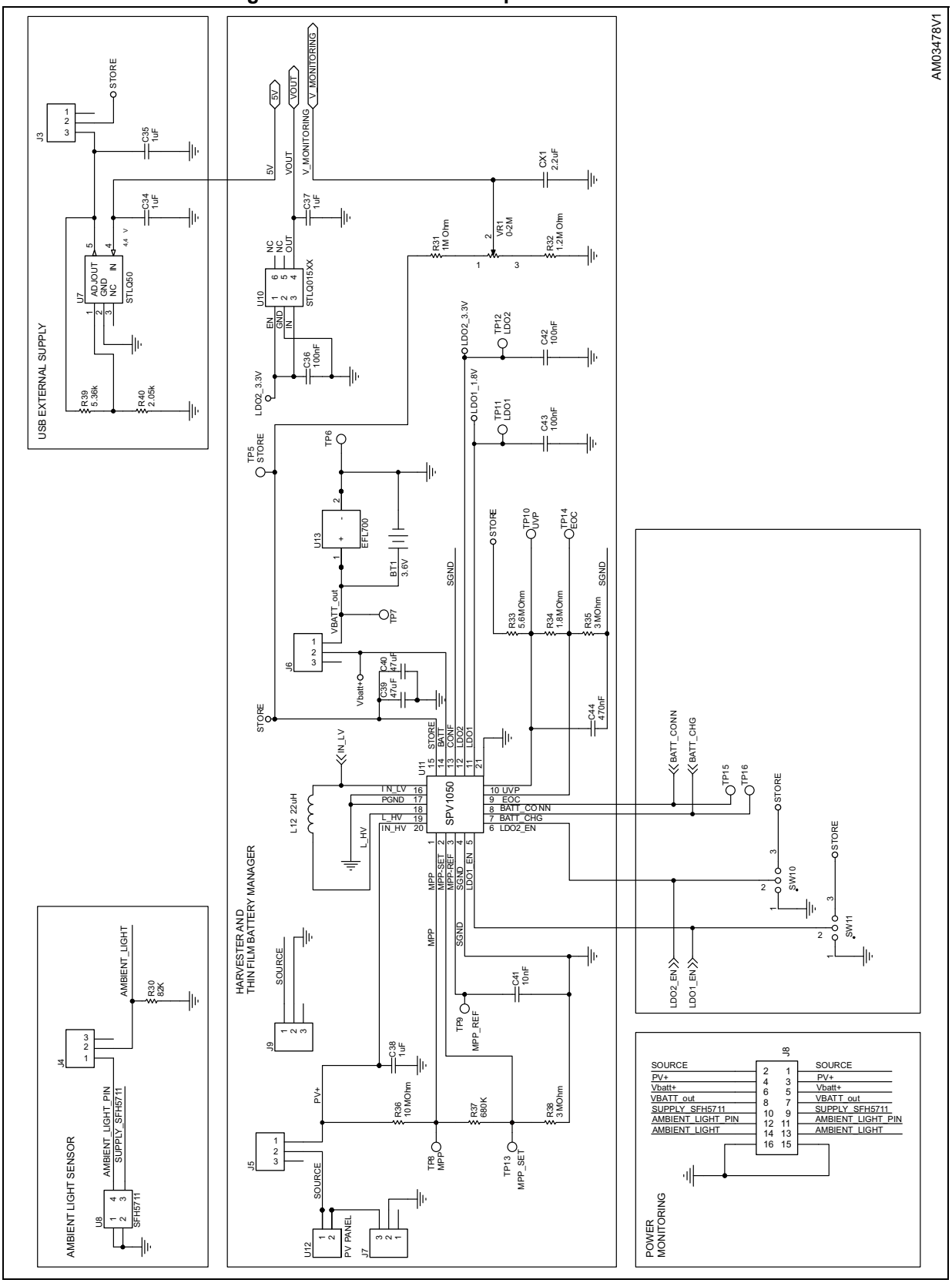


Table 1. Transmitter board - bill of material

Item	Qty.	Designator	SCI part number	Value
1	1	BT1	BATT-CR2450-3V6	3.6 V
2	9	C1, C2, C3, C7, C13, C15, C33, C42, C43	CCERSMD104-0402M	100 nF
3	1	C4	CCERSMD226-0603V	22 µF
4	2	C5, C6	CCERSMD060-0402	6 pF
5	1	C8		10 µF - DNM
6	2	C9, C20	CCERSMD106-0603R	10 µF
7	1	C10	CCERSMD105-0603T	1 µF
8	1	C11	CCERSMD101-0402M	100 pF
9	3	C12, C16, C28	CCERSMD331-0402	330 pF
10	1	C14	CCERSMD105-0603T	1 µF
11	2	C17, Ctun1		DNM
12	2	C18, C23		DNM
13	1	C19	CCERSMD221-0603	220 pF
14	2	C21, C31	CCERSMD221-0402	220 pF
15	1	C22	CCERSMD070-0402	7 pF
16	1	C24	CCERSMD024-0402	2.4 pF
17	1	C25	CCERSMD036-0402	3.6 pF
18	2	C26, C27	CCERSMD180-0402	18 pF
19	1	C29	CCERSMD103-0402M	10 nF
20	1	C30	CCERSMD015-0402	1.5 pF
21	1	C32	CCERSMD020-0402	2 pF
22	2	C34, C35	CCERSMD105-0603T	1 µF
23	1	C36	CCERSMD104-0603T	100 nF
24	2	C37, C38	CCERSMD105-0603T	1 µF
25	2	C39, C40	CCERSMD476-0805K	47 µF
26	1	C41	CCERSMD103-0603R	10 nF
27	1	C44	CCERSMD474-0603P	470 nF
28	1	CN1	USB-MICROB-SMD	µUSB
29	1	CN2	SAM-TSW10208GSRA	Header 2
30	1	Ctun2		DNM
31	4	D1, D2, D3, D4	DBAT41M-SMD	Schottky
32	1	J1	BNC-SMA-9EL-SMD	BNC
33	1	No reference: antenna to be screwed on J1	LPRS - WR868	868 MHz to 915 MHz, SMA antenna
34	1	J2	STRIP2PM	JUMPER

Table 1. Transmitter board - bill of material (continued)

Item	Qty.	Designator	SCI part number	Value
35	6	J3, J4, J5, J6, J7, J9	STRIP1X3-M-SMD	ST_19_STRIP3_100M_V_
36	1	J8	SAM-SMH10802GD	Header 8X2
37	1	JP1	SAM-TMM10302GD	STRIP2X3
38	1	L1	INDLQM21FN100M70	10 µH
39	1	L2	IND0402CS-27N	27 nH
40	1	L3	INDLQG15HSR10J02	100 nH
41	1	L4		DNM
42	1	L5	INDLQG15HN3N6S02	3.6 nH
43	1	L6	INDLQG15HN5N1S02	5.1 nH
44	1	L7	RESMD000-0402	0 Ω
45	1	L8	INDLQG15HN18NJ02	18 nH
46	2	L9, L10	INDLQG15HN15NJ02	15 nH
47	1	L11	INDSMD4,7UH82464	Antenna
48	1	L12	IND-LPS4018223ML	22 µH
49	1	P1	STRIP40PMD90	STRIP 8 POLI
50	13	R1, R2, R3, R4, R5, R16, R17, R18, R19, R20, R26, R27, R28	RESMD101-0402	100 Ω
51	2	R6, R7	RESMD100-0402	10 Ω
52	2	R8, R9	RESMD104-0402	100 KΩ
53	4	R10, R11, R12, R13	RESMD103-0402	10 KΩ
54	1	R14	RESMD561-0402	560 Ω
55	1	R15	RESMD000-0402	0 Ω
56	2	R21, R29	RESMD754-0603	750 KΩ
57	1	R22	RESMD244-0603	240 KΩ
58	1	R23	RESMD124-0603	120 KΩ
59	1	R24	RESMD104-0603	100 KΩ
60	1	R25	RESMD4223-0603	422 KΩ
61	1	R30	RESMD823-0603	82 KΩ
62	1	R31	RESMD105-0603	1 MΩ
63	1	R32	RESMD125-0603	1.2 MΩ
64	1	R33	RESMD562-0603	5.6 MΩ
65	1	R34	RESMD185-0603	1.8 MΩ
66	2	R35, R38	RESMD305-0603	3 MΩ
67	1	R36	RESMD106-0603	10 MΩ
68	1	R37	RESMD684-0603	680 KΩ

Table 1. Transmitter board - bill of material (continued)

Item	Qty.	Designator	SCI part number	Value
69	1	R39	RESMD5361-603-01	5.36 kΩ
70	1	R40	RESMD2051-0603	2.05 kΩ
71	1	SW1	PULS-B3U1100-SMD	SW-PB
72	4	SW2, SW4, SW6, SW7	STG3220QTR-SMD	STG3220
73	4	SW3, SW5, SW8, SW9	STG5223QTR-SMD	STG5223
74	2	SW10, SW11	RS 712-2558	SW SLIDE-SPST
75	3	TP1, TP3, TP17	TEST2	TEST2
76	2	TP2, TP4	TEST2-R	TEST2
77	12	TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16		DNM
78	1	U1	STM32L151-SMD	STM32L151CB5T6
79	1	U2	STTS7510WB3-SMD	STTS751
80	1	U3	LIS3DH-SMD	LIS3DH
81	1	U4	LPS331AP-SMD	LPS331APY
82	1	U5	SPIRIT1QTR-SMD	SPIRIT1
83	1	U6	M24LR64ER-SMD	M24LR64E-R
84	1	U7	STLQ50C-R-SMD	STLQ50
85	1	U8	PTR-SFH5711-SMD	SFH5711
86	1	U9	ST715MR-SMD	ST715MR
87	1	U10	STLQ015XG25R-SMD	STLQ015XX
88	1	U11	KIT-EXT	SPV1050
89	2	U12	PANN-AM-1801	PV PANEL
90	1	U13	BATT-HOLD-2450	BATT-HOLD-2450
91	1	VR1	RTR-3312-2M-SMD	0 - 2 MΩ
92	1	X1	Q4MHZ-SMD-RISZ	4 MHz
93	1	X2	Q32,768-ABS07SMD	XT-2PIN
94	1	XTAL1	Q50MHZ-TXC7M-SMD	50 MHz
95	1	CX1	CCERSMD225-0805X	2.2 µF

2 Transmitter board layout

Figure 6. Transmitter board - top layer view

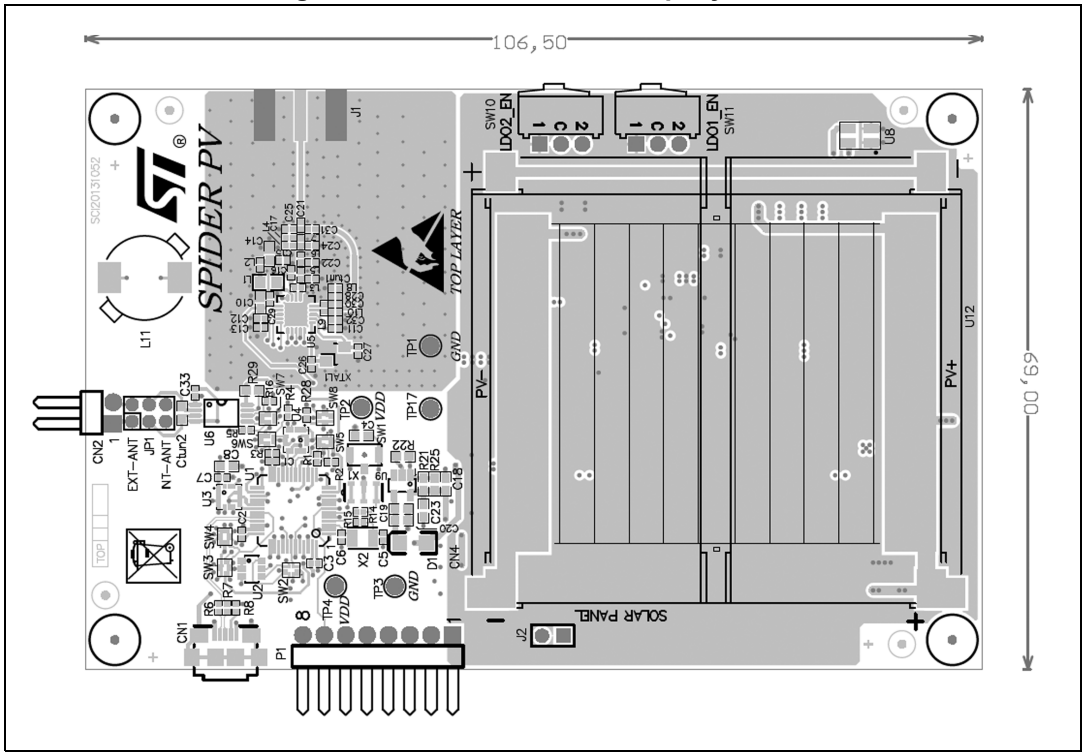


Figure 7. Transmitter board - inner layer 1 view

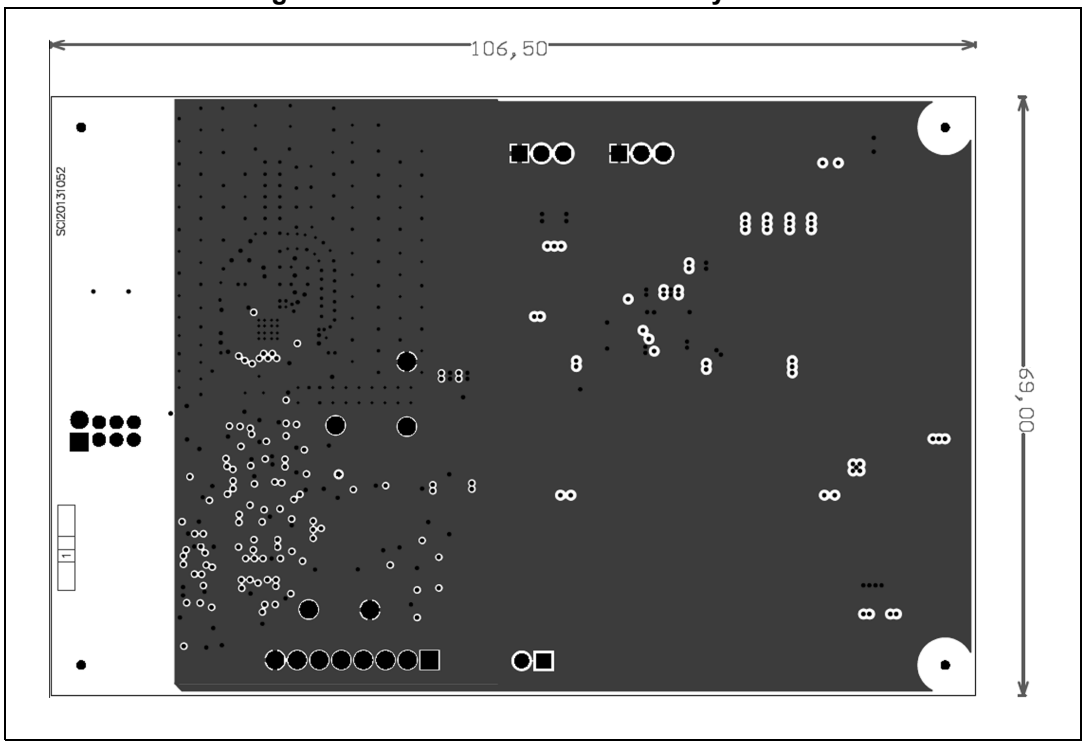


Figure 8. Transmitter board - inner layer 2 view

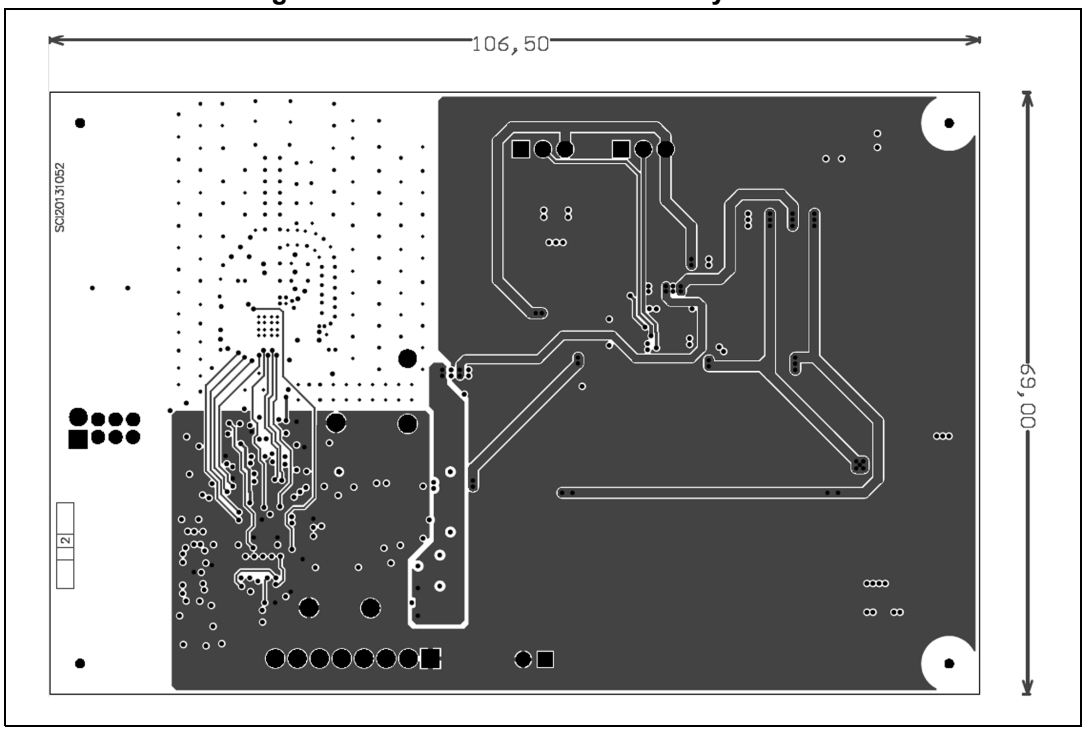
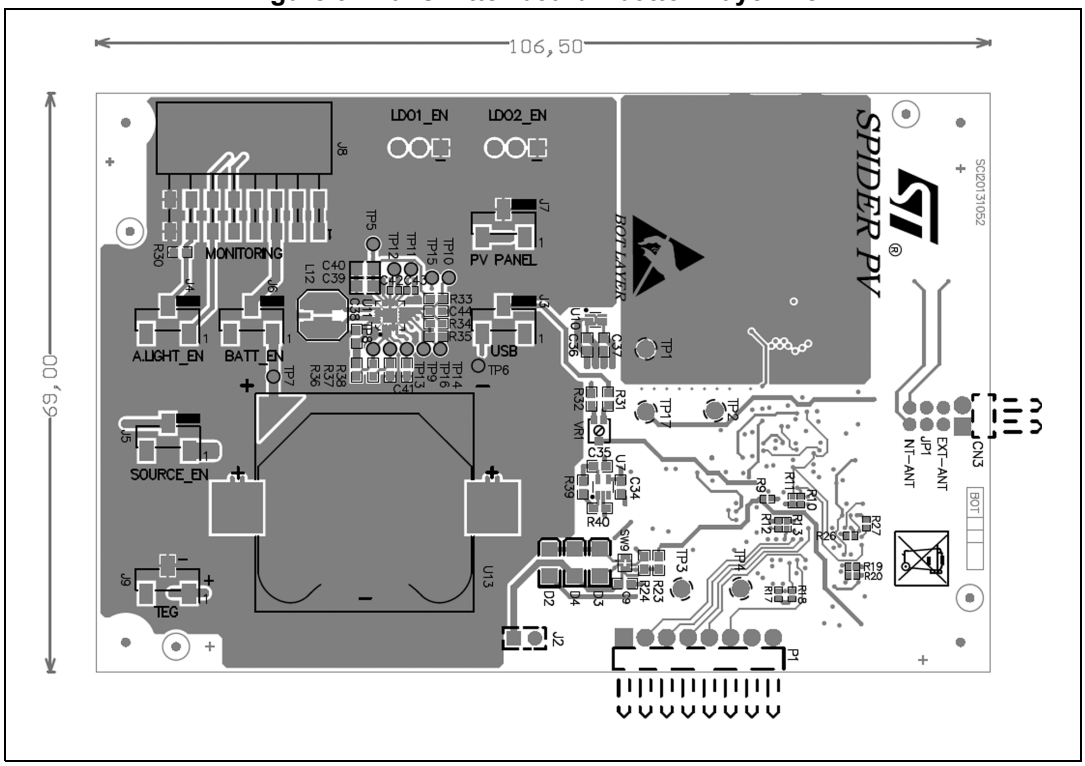


Figure 9. Transmitter board - bottom layer view



3 Receiver board schematics and bill of material

Figure 10. Receiver board schematic - RF transmitter/receiver

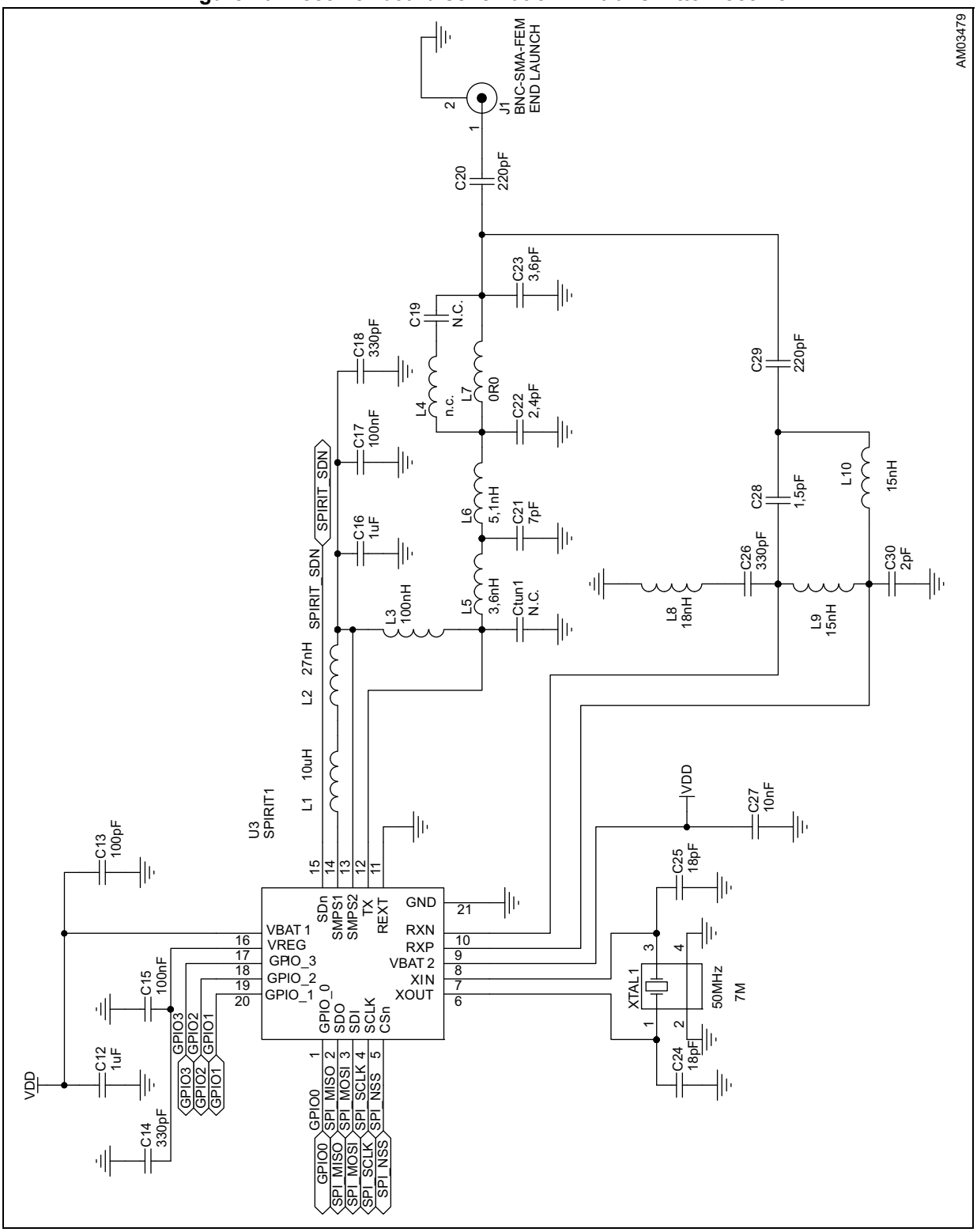


Figure 11. Receiver board schematic - microcontroller

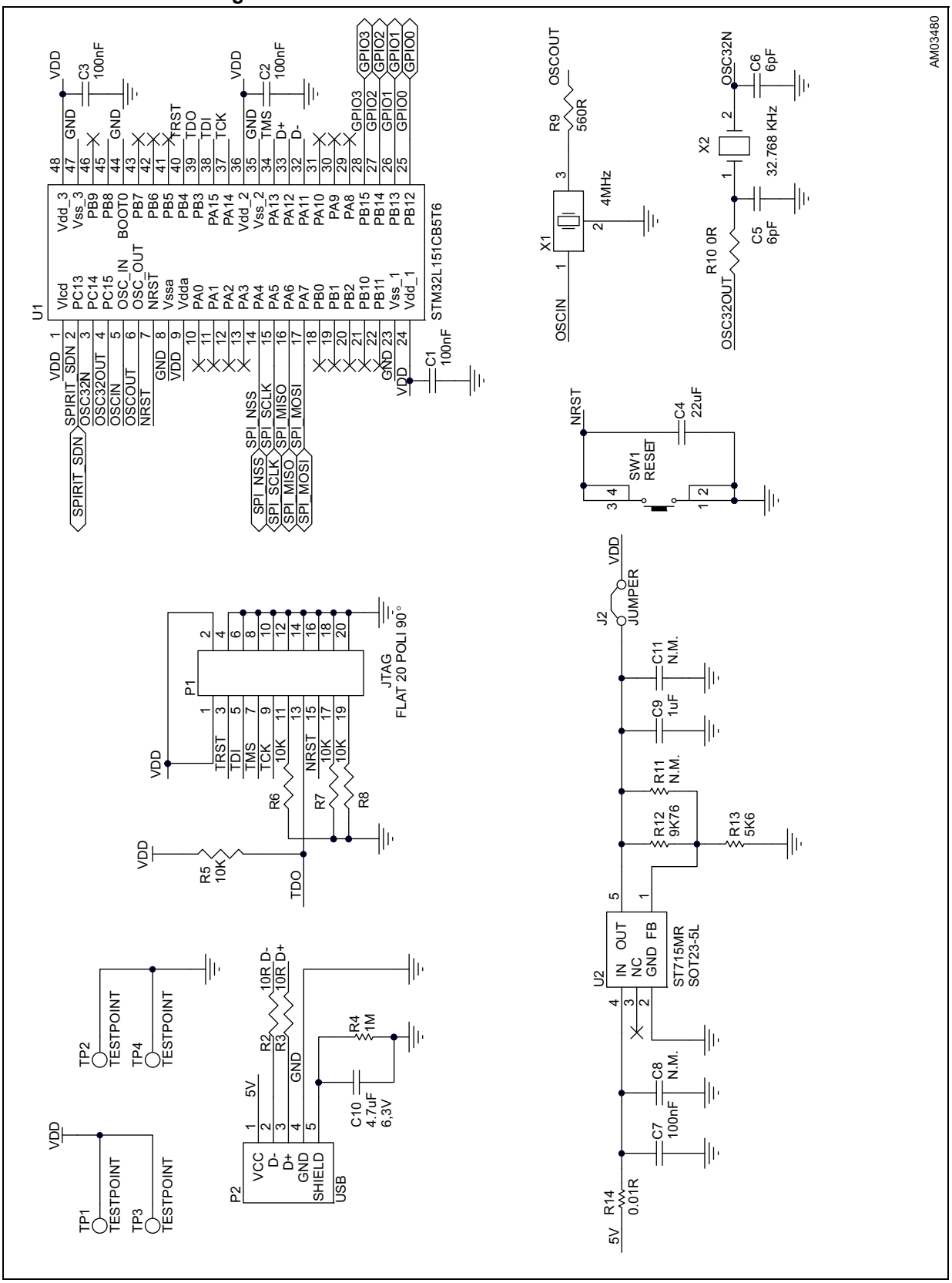


Table 2. Receiver board - bill of material

Qty.	Designator	Part number SCI	Comment	Part description
5	C1, C2, C3, C15, C17	CCERSMD104-0402M	100 nF	Mult. cer. cap. 16 V SMD 0402
1	C4	CCERSMD226-0603V	22 µF	Mult. cer. cap. 6.3 V SMD 0603
2	C5, C6	CCERSMD060-0402	6 pF	Mult. cer. cap. 50 V SMD 0402
1	C7	CCERSMD104-0603V	100 nF	Mult. cer. cap. 50 V SMD 0603
2	C8, C11		N. M.	Mult. cer. cap. 6.3 V SMD 0603
1	C9	CCERSMD105-0603M	1 µF	Mult. cer. cap. 25 V SMD 0603
1	C10	CCERSMD475-0603	4.7 µF	Mult. cer. cap. 6.3 V SMD 0603
1	C13	CCERSMD101-0402M	100 pF	Mult. cer. cap. 50 V SMD 0402
3	C14, C18, C26	CCERSMD331-0402	330 pF	Mult. cer. cap. 50 V SMD 0402
2	C19, Ctun1		N. C.	Mult. cer. cap. SMD 0402
2	C20, C29	CCERSMD221-0402	220 pF	Mult. cer. cap. 50 V SMD 0402
1	C21	CCERSMD070-0402	7 pF	Mult. cer. cap. 50 V SMD 0402
1	C22	CCERSMD024-0402	2.4 pF	Mult. cer. cap. 50 V SMD 0402
1	C23	CCERSMD036-0402	3.6 pF	Mult. cer. cap. 50 V SMD 0402
2	C24, C25	CCERSMD180-0402	18 pF	Mult. cer. cap. 50 V SMD 0402
1	C27	CCERSMD103-0402M	10 nF	Mult. cer. cap. 50 V SMD 0402
1	C28	CCERSMD015-0402	1.5 pF	Mult. cer. cap. 50 V SMD 0402
1	C30	CCERSMD020-0402	2pF	Mult. cer. cap. 50 V SMD 0402
1	J1	BNC-SMA-9EL-SMD	BNC	Female SMA end launch jack
1	No reference: antenna to be screwed on J1	LPRS - WR868	Antenna	868 MHz to 915 MHz, SMA antenna
1	J2	STRIP2PM	Jumper	Male strip 2 poles
1	L1	INDLQM21FN100M70	10 µH	SMPS out inductor - Murata LQM21 series
1	L2	IND0402CS-27N	27 nH	SMPS out inductor - Coilcraft
1	L3	INDLQG15HSR10J02	100 nH	TX PA choke
1	L4		N. C.	SMD inductor 0402
1	L5	INDLQG15HN3N6S02	3.6 nH	TX LPF 1st series
1	L6	INDLQG15HN5N1S02	5.1 nH	TX LPF 2nd series
1	L7	RESMD000-0402	0 Ω	Resistor 1/16 W 1% SMD 0402
1	L8	INDLQG15HN18NJ02	18 nH	TX LPF 2nd series
2	L9, L10	INDLQG15HN15NJ02	15 nH	TX LPF 2nd series
1	P1	M.20.90 LP	20 Flat	20-way flat connector (horizontal)
1	P2	SAMTECUSBB	USB	SAMTEC USB B connector, right angle
2	R2, R3	RESMD100-0402	10 Ω	Resistor 1/16 W 1% SMD 0402
1	R4	RESMD105-0402	1 MΩ	Resistor 1/16 W 1% SMD 0402

Table 2. Receiver board - bill of material (continued)

Qty.	Designator	Part number SCI	Comment	Part description
4	R5, R6, R7, R8	RESMD103-0402	10 KΩ	Resistor 1/16 W 1% SMD 0402
1	R9	RESMD561-0402	560 Ω	Resistor 1/16 W 1% SMD 0402
1	R10	RESMD000-0402	0 Ω	Resistor 1/16 W 1% SMD 0402
1	R11		N. M.	Resistor 1/10 W 1% SMD 0603
1	R12	RESMD9761-0603	9.76 KΩ	Resistor 1/10 W 1% SMD 0603
1	R13	RESMD562-0603	5.6 KΩ	Resistor 1/10 W 1% SMD 0603
1	R14	RESMD0R01-0603	0.01 Ω	Resistor 1/10 W 1% SMD 0603
1	SW1	PULS-DTSM61-SMD	Reset	Pushbutton_SMD
2	TP1, TP3	TEST2-R	TEST2	PCB test point - raised loops
2	TP2, TP4	TEST2	TEST2	PCB test point - raised loops
1	U1	STM32L151-SMD	STM32L151CB5T6	Microprocessor - SMD LQFP48
1	U2	ST715MR-SMD	ST715MR	High input voltage - 85 mA LDO linear regulator - SOT23-5L
1	U3	KIT-EXT	SPIRIT1	ST
1	X1	Q4MHZ-SMD-RISZ	4 MHz	4 MHz SMD RESONATOR
1	X2	Q32,768-ABS07SMD	XT-2PIN	QUARTZ ABRACON SMD ABS07
1	XTAL1	Q50MHZ-TXC7M-SMD	50 MHz	QUARTZ 50 MHz SMD TXC 7M series

4 Receiver board layout

Figure 12. Receiver board - top layer view

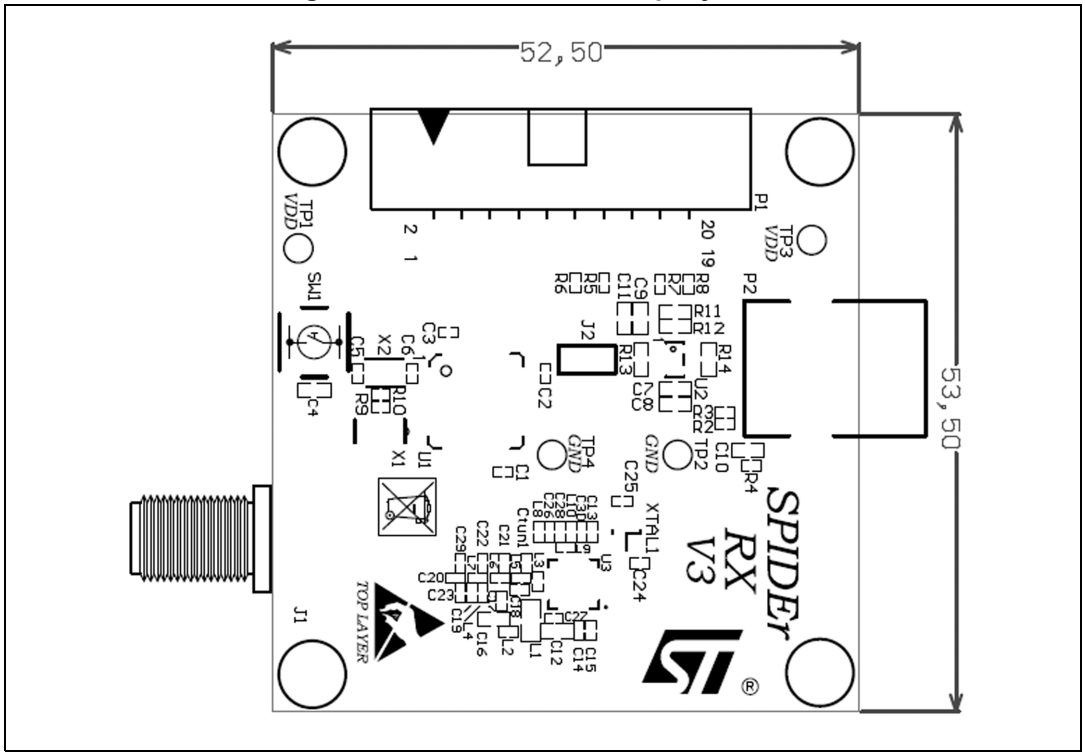
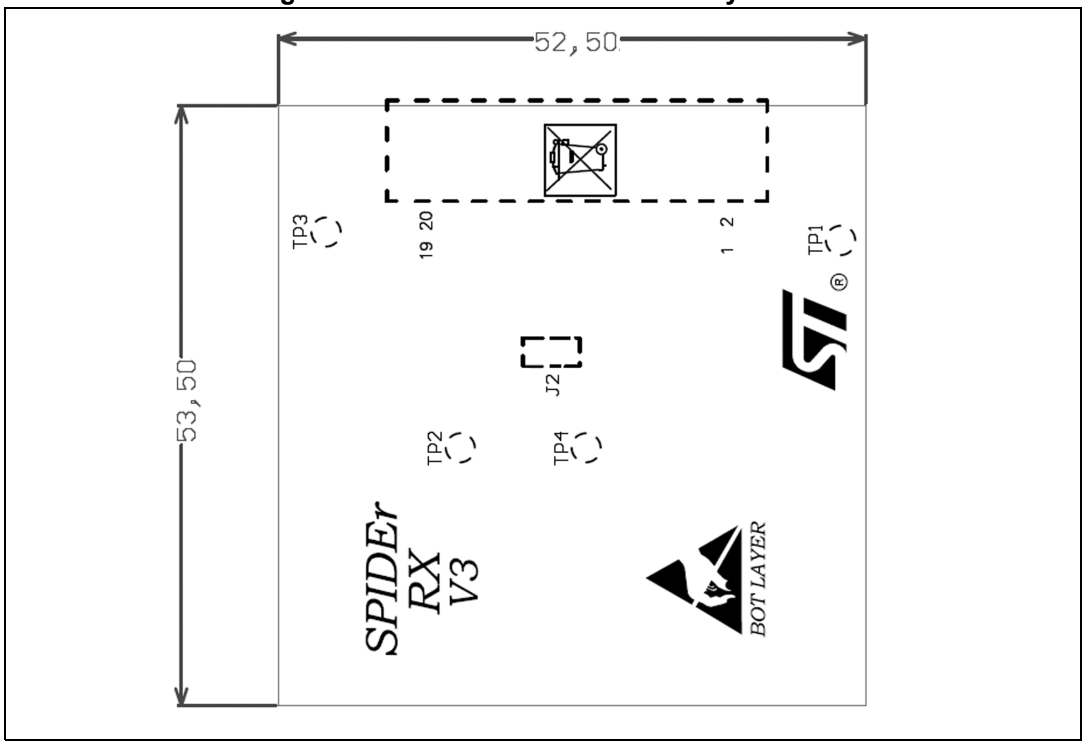


Figure 13. Receiver board - bottom layer view



5 STEVAL-IDS002V1 reference kit description (SPIDEr™)

The STEVAL-IDS002V1 kit includes two different boards:

- The TX board integrating both the harvesting module and the sensor/transmitting module.
- The RX board that only receives data and lets them available to the PC GUI.

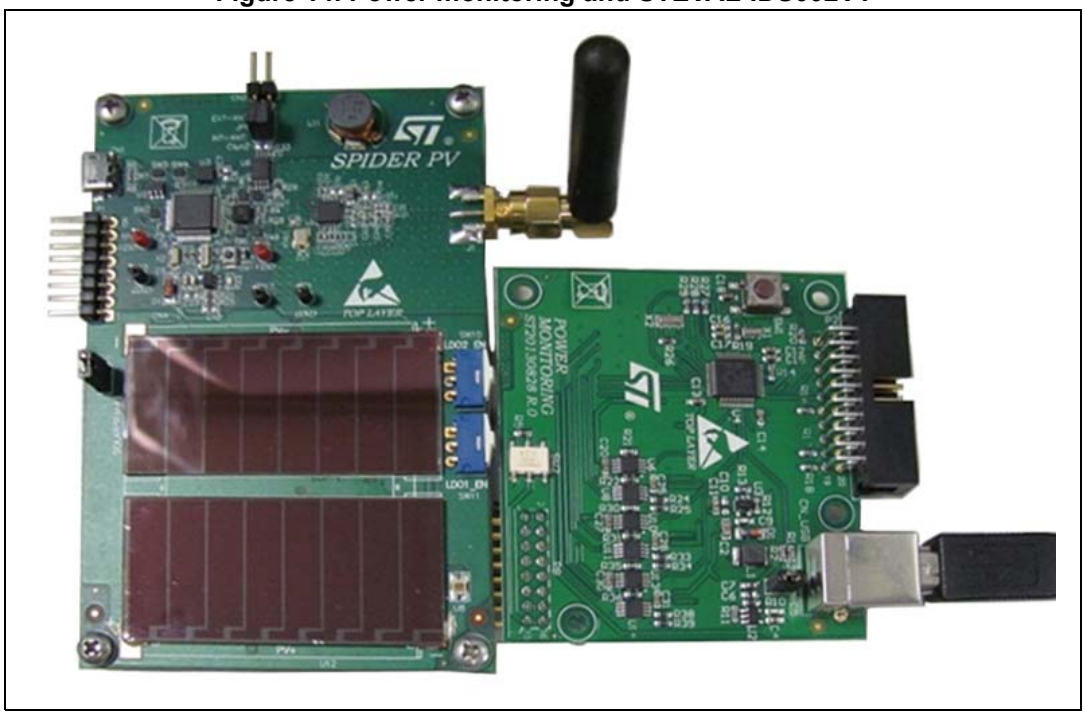
The harvesting module on the TX board is based on the SPV1050 ULP energy harvester, battery charger and power manager IC.

Purposes of the harvesting module are extracting the maximum power allowable from the on-board PV panel, controlling the battery charging and supplying the sensor/transmitting module.

For an exhaustive description of the SPV1050 device, please refer to the related datasheet.

The power efficiency and MPPT accuracy of the harvesting module can be monitored by connecting the power monitoring board on J8 and lunching the provided software. *Figure 14* shows the transmitter board connected to the power monitoring board.

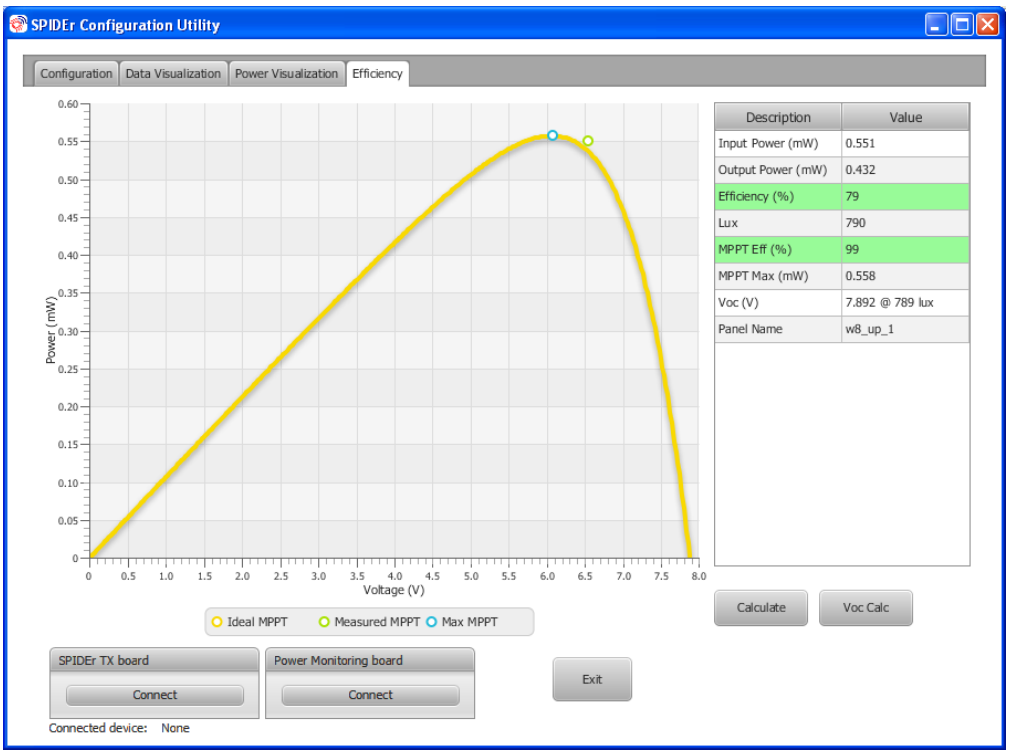
Figure 14. Power monitoring and STEVAL-IDS002V1



A complete description of the software and GUI is reported in the software user manual UM1752. Just as an example, *Figure 15* shows the efficiency tab of the GUI displaying:

- The actual PV panel curve according to the ambient light conditions
- The green dot indicating the real working point
- The blue dot indicating the maximum power point
- The table (on the top right side of the screen) reporting the main system parameters and performances.

Figure 15. Efficiency tab example



The sensor/transmitting module on the TX board is a complete autonomous wireless sensor node, including three different environment sensors based on MEMS technology, a low-power embedded radio, a dual port Flash memory providing a NFC interface and a dedicated microcontroller. Main components are:

- Sensors
  - 1.Temperature sensor STM STTS751
  - 2. Pressure sensor STM LPS331
  - 3. 3-axis accelerometer STM LIS3DH
- Low power radio STM SPIRIT1
- DP memory + NFC interface STM M24LR64E
- Microcontroller STM STM32L151CB5T6

All devices (except the microcontroller) can be physically disconnected via dedicated power switches, which are dynamically configured through the software GUI. All other characteristics of the node are customized by the GUI too, such as the sampling period, transmission delay, and radio configuration.

Moreover the TX board can be used as an extra harvesting source, thanks to the M24LR64E DP memory. As a matter of fact the M24LR64E device works as an RF harvesting module, in the frequency range of NFC communication, so that it is able to provide (through a dedicated pin) a certain energy amount while it is read / written.

5.1 TX board connectors and jumpers

5.1.1 Sensor/transmitting module connectors and jumpers

CN1 (6-pin): micro-USB connector

Table 3. CN1 connector

Pin	1	2	3	4	5	6
Direction/supply	IN	INOUT	INOUT	INOUT	INOUT	INOUT
Signal	VUSB (5 V)	D-	D+	ID	GND	SHIELD

CN2 (2-pin): external antenna connector

Use the pin 1 and pin 2 of CN2 to connect an external antenna, alternative to the one on-board (J1).

Set properly JP1 in case an external antenna is connected on CN2.

P1 (8-pin connector): dedicated JTAG connector

Table 4. P1 connector

Pin	1	2	3	4	5	6	7	8
Direction/supply	OUT	OUT	IN	OUT	OUT	OUT	OUT	INOUT
Signal	VDD	TRST	TDI	TMS	TCK	TDO	NRST	GND

Table 5. JP1 connector

	JP1
Function	CLOSE: 3 - 5 and 4 - 6 to use the on-board antenna CLOSE: 1 - 3 and 2 - 4 to use external antenna on CN2

Table 6. J2 jumper

	J2
Function	CLOSE: sensor/transmitting module supplied by the harvesting module OPEN: sensor/transmitting module supplied by external USB (for test functions)

5.1.2 Harvesting module connectors and jumpers

Table 7. J3 jumper

	J3
Function	CLOSE2 - 3: STORE pin supplied by the USB cable OPEN 1 - 2: STORE pin supplied by the energy harvesting source.

Table 8. J4 jumper

	J4
Function	CLOSE 1 - 2: not used OPEN 1 - 2: enables ambient light sensing from the monitoring board

Table 9. J5 jumper

	J5
Function	CLOSE1 - 2: bypasses power monitoring sense and supplies directly the SPV1050 OPEN 1 - 2: enables input sensing from the power monitoring board

Table 10. J6 jumper

Function	CLOSE 1 - 2: bypasses power monitoring sense and connects the battery to the BATT pin OPEN 1 - 2: enables output sensing from the power monitoring board

Table 11. J7 jumper

	J7
Function	CLOSE 2 - 3: harvesting board supplied by the on-board PV panel OPEN: enables alternative source from J9

J9 (2-pin connector)

This connector is provided to supply the SPV1050 device by supply source alternative to the on-board PV panel. In case a supply source is connected to J9, then J7 must be open.

Table 12. J9 connector

Pin	1	2
Direction/supply	SUPPLY	SUPPLY
Signal	SOURCE +	SOURCE -

J8 (16-pin monitoring connector)

It provides the connection to the power monitoring board.

Table 13. J8 connector

Pin	1 - 2	3 - 4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16
Direction/supply	OUT	OUT	OUT	OUT	SUPPLY	OUT	OUT	SUPPLY
Signal	SOURCE	PV+	Vbatt+	VBATT_ OUT	SUPPLY_ SFH5711	AMBIENT_ LIGHT_PIN	AMBIENT _LIGHT	GND

- **SOURCE, PV+:**
  Harvesting source current sensing pins.
  If the power monitoring board is used, then the jumper J5 must be left open; otherwise (power monitoring board not used) pins 1 - 2 of J5 must be shorted.
- **VBATT+, VBATT_OUT:**
  Battery current sensing pins.
  If the power monitoring board is used, then the jumper J6 must be left open; otherwise (power monitoring board not used) pins 1 - 2 of J6 must be shorted.
- **SUPPLY_SFH5711:**
  Power supply of the ambient light sensor pin (placed on the top side of the board).
  The ambient light sensor is supplied and used only when the power monitoring board is connected.
- **AMBIENT_LIGHT, AMBIENT_LIGHT_PIN:**
  Ambient light current sensing pins.
  If the power monitoring board is used, then the jumper J7 must be left open.
- **GND: Ground pin.**

Table 14. SW1 - SW2

	SW1	SW2
Function	CLOSE 1 - 3: LDO1 DISABLED CLOSE 2 - 3: LDO1 ENABLED	CLOSE 1 - 3: LDO2 DISABLED (sensor/transmitter module **not** supplied) CLOSE 2 - 3: LDO2 ENABLED (sensor/transmitter module supplied)

5.2 RX board connectors and jumpers

P1 (20-pin connector): standard JTAG connector

Table 15. P1- part 1

Pin	1 - 2	3	5	7	9	11	13	15
Direction	OUT	OUT	IN	OUT	OUT	INOUT	OUT	OUT
Signal	VDD	TRST	TDI	TMS	TCK	PD	TDO	NRST

Table 16. P1 - part 2

Pin	17 - 19	2 - 4 - 6 - 8 - 10 - 12 - 14 - 16 - 18 - 20
Direction	INOUT	INOUT
Signal	PD	GND

P2 (5-pin): standard USB connector

Table 17. P2

Pin	1	2	3	4	5
Direction	IN	INOUT	INOUT	INOUT	INOUT
Signal	VUSB (5 V)	D-	D+	GND	SHIELD

Table 18. J2

	J2
Function	CLOSE 1 - 2: USB direct supply OPEN 1 - 2: Alternative supply from P1

6 Revision history

Table 19. Document revision history

Date	Revision	Changes
27-May-2014	1	Initial release.