EU153-1 Smart Water Leakage Sensor

Hardware User's Guide

Contents

1. Overview

This is Renesas EU153-1 Water Leakage Sensor solution kit.

It demonstrates detection of inappropriately high moisture level or water spilling to allow quick evaluation of Renesas relative humidity using temperature sensors using Renesas WiFi/BLE device and third-party visualization tools.

2. Purpose of this document

This Hardware user manual provides you in-depth details on the hardware of this solution kit.

2.1 EU153-1 Solution Kit Features

- Sensors
  - Temperature and humidity sensor
  - Water Leakage Sensor
- Connectivity
  - Bluetooth® 5.1 LE
    - Operating frequency range: 2402÷2480 MHz
    - Power level: +4 dBm
  - WiFi IEEE 802.11b/g/n, 1×1, 20 MHz channel, bandwidth, 2.4 GHz
  - Debug/programming connector with JTAG SWD Interface for the DA16200 MCU.
  - 1x 3.3V UART trace port: connected to the DA16200 MCU.
- Power supply:
  - Micro USB connector for wired charging of Li-Ion battery (5 V / 400 mA)
  - 3.7V rechargeable Li-Ion battery
  - Solar cell or external DC power supply (1V-5V)
- Push buttons
  - 2x general-purpose button connected to DA16600MOD
- 5x LEDs
- 1x ON/OFF switch

2.2 Features of integrated Renesas components

The EU153-1 solution kit features

- HS3001– high performance relative humidity and temperature sensor
- ISL9301 - Li-Ion Charger with power path management
- ISL9122A - Ultra-Low Iq DCDC Buck/Boost regulator
- ISL9111A – High Efficiency Synchronous Boost Converter
- SLG59H1401C – GreenFET Load Switch for OR'ing Power MUX
- SLG59M1557V – GreenFET Single P-Channel Load Switch
- ISL90727 – Digitally Controlled Potentiometer
- DA16600MOD - Ultra-Low Power Wi-Fi + Bluetooth® Low Energy Combo Module

2.3 Components layout

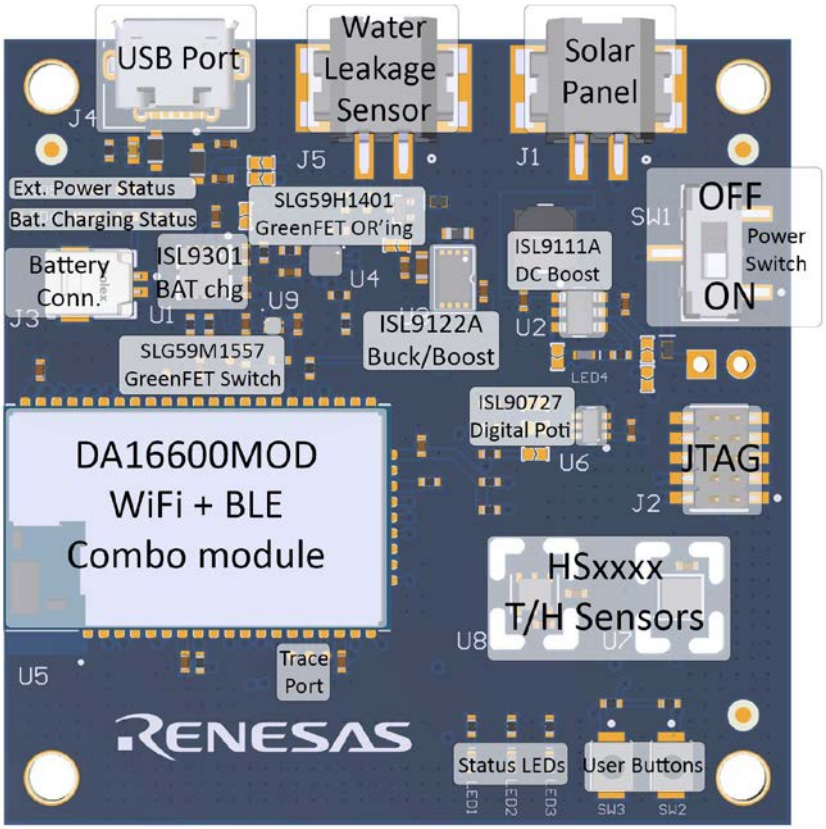

Figure 1: EU153-1 board top side.

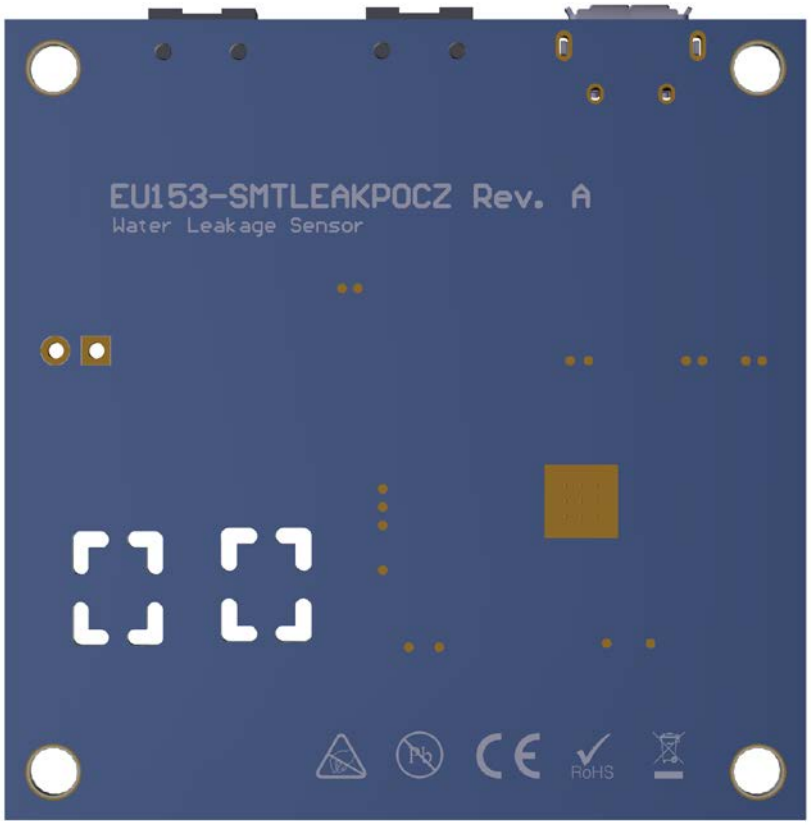

Figure 2: EU153-1 board bottom side.

2.4 Mechanical view and connections

Figure 3 shows the EU153-1 device PCB from top and bottom sides and in Figure 4 you can see the whole setup – battery and water leakage sensor cable connected to the board.

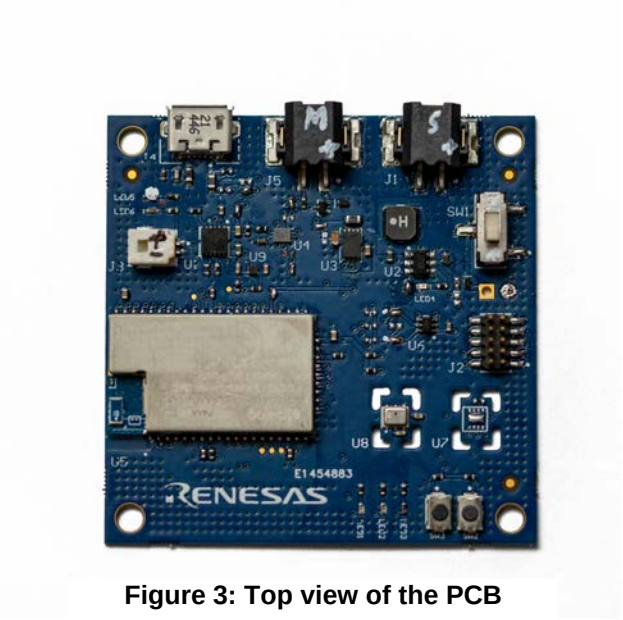

Figure 3: Top view of the PCB

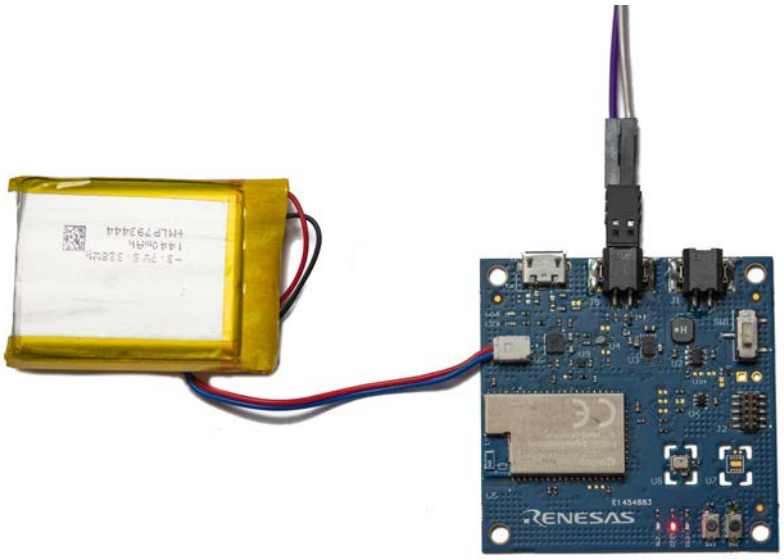

Figure 4: EU153-1 with battery and water leakage sensor

2.5 Default Jumper Settings

There are jumpers/ solder bridges for the default power setup with placed 0Ω resistors.

Jumper	Section	Default state	Function
SB1	Power supply	CLOSED	Possibility to measure battery charger performance
SB2	Power supply	OPEN	Possibility to bypass U2 boost converter ISL9111A. In this case SB3 and SB4 should be kept open.
SB3	Power supply	CLOSED	Connects Solar connector J1 with 5V U2 boost converter ISL9111A.
SB4			
SB5	Power supply	CLOSED	Possibility to measure system current without power supplies
SB7	Sensors	OPEN	If digital potentiometer is not used it is possible to use fixed resistors. In this case SB7 should be closed and SB8 and SB9 – open
SB8	Sensors	CLOSED	Option to bypass digital potentiometer
SB9			
SB10	Connectors and Interfaces	OPEN	Direct connection to Solar Cell input
SB17	Connectors and Interfaces	CLOSED	Connection to U4 GreenFET OR'ing.

More detailed power supply block diagram can be found in Figure 7.

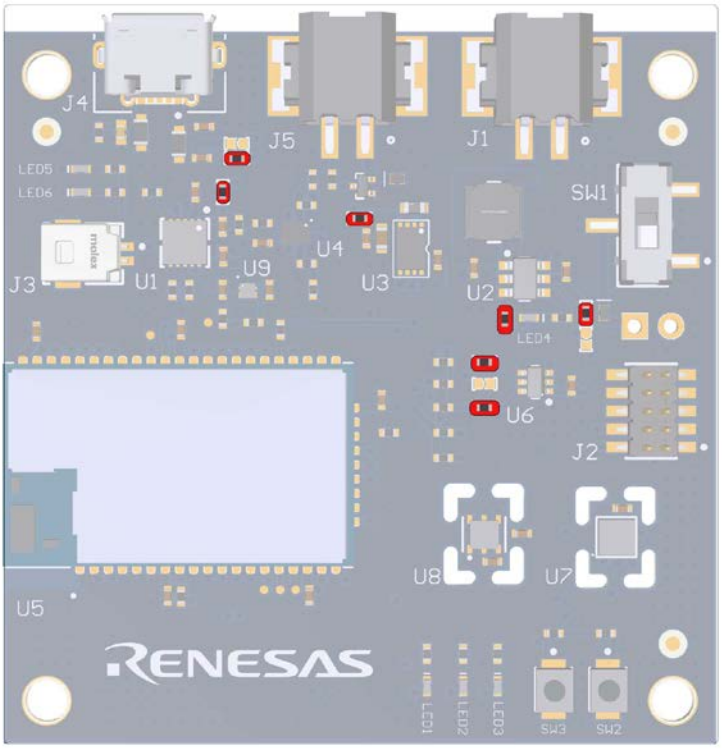

Figure 5: Default jumper settings, red color indicates a closed jumper.

3. EU153-1 Solution Kit Components

Figure 6 shows the EU153-1 block diagram.

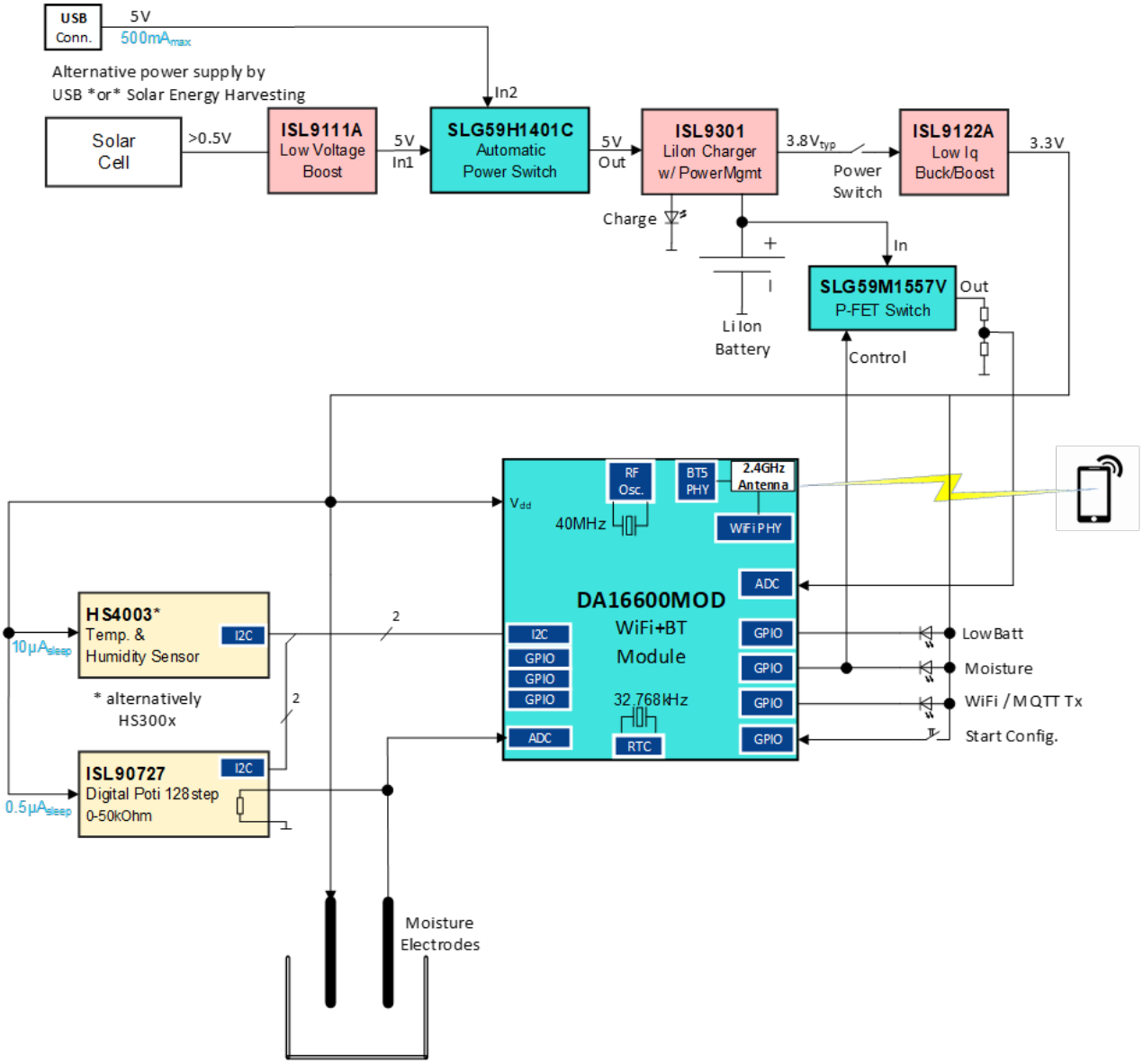

Figure 6: Smart Water Leakage Sensor Block Diagram.

EU153-1 firmware is running on DA16200 Cortex M3 MCU together with WiFi and communication stacks. BLE is used only for WiFi provisioning and initial system setup. It is running on DA14531. Both devices are integrated into one DA16600MOD module.

Trace output is made only for DA16200 and it is routed to test points (TP_P16 and TP_P15) on the top side of the PCB.

Humidity sensor HS3001 and digital potentiometer ISL90727 are connected using i2c.

The EU153-1 solution kit user interface includes two buttons, SW2 + SW3, and 6 LEDs.

3.1 Power Supply

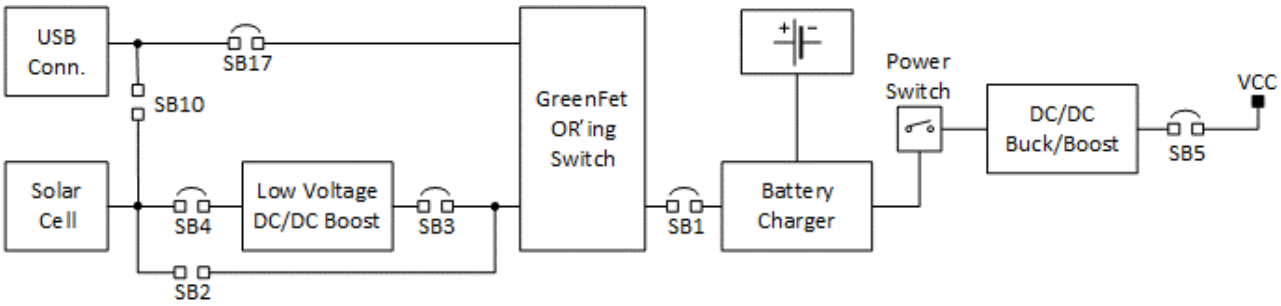

Figure 7: Power supply block diagram.

The EU153-1 solution kit has two external power supply options. First is USB and second option – Solar cell. Both can be used for battery charging and powering the system. In case of solar cell there is added boost converter to boost up the voltage up to 5V. SLG59H1401 GreenFET OR'ing switch automatically selects power supply. Both external power supplies (USB and solar cell) can be used at the same time. Priority is set to USB and the management is done by GreenFET.

This solution kit features a 1400mAh rechargeable Li-Ion battery, which can be charged using USB device port or solar panel connector.

SLG59H1401 output is connected to ISL9301 battery charger with a solder bridge in between delivering possibility to measure charge performance.

The ISL9301 battery charger has been configured to perform the following charging profile:

Parameter	Value	Function
I_{REF}	410 mA	Charging current level.
I_{MIN}	40 mA	End Of Charge (EOC) current threshold. CHG pin will toggle when timeout is reached.
$t_{TIMEOUT}$	4 h	Total charging period, after this period the charger is terminated.

The ISL9122A DC/DC buck-boost regulator is connected to the output of the battery charger to generate the 3.3 V main power supply with ultra-low quiescent current. Buck/Boost function is needed to allow battery voltages above and below 3.3V, i.e. to get everything out of the battery with best efficiency.

The DA16600MOD, humidity sensor and water leakage measurement part are directly connected to the 3.3V VCC power rail through SB5 solder bridge allowing to measure its power consumption.

The power supply chain is depicted in Figure 7.

3.2 DA16600MOD – WiFi + BLE Module

The whole firmware is running on DA16200 Cortex M3 MCU that which is embedded into DA16600MOD module together with DA14531 BLE device.

DA16200 and DA14531 are sharing the same antenna on the module. Priority is set using 1-wire coexistence interface – BT_ACT.

I2C pullups (R18 and R19) are placed next to the module.

Wake up pin is not used and device can be waken only by RTC.

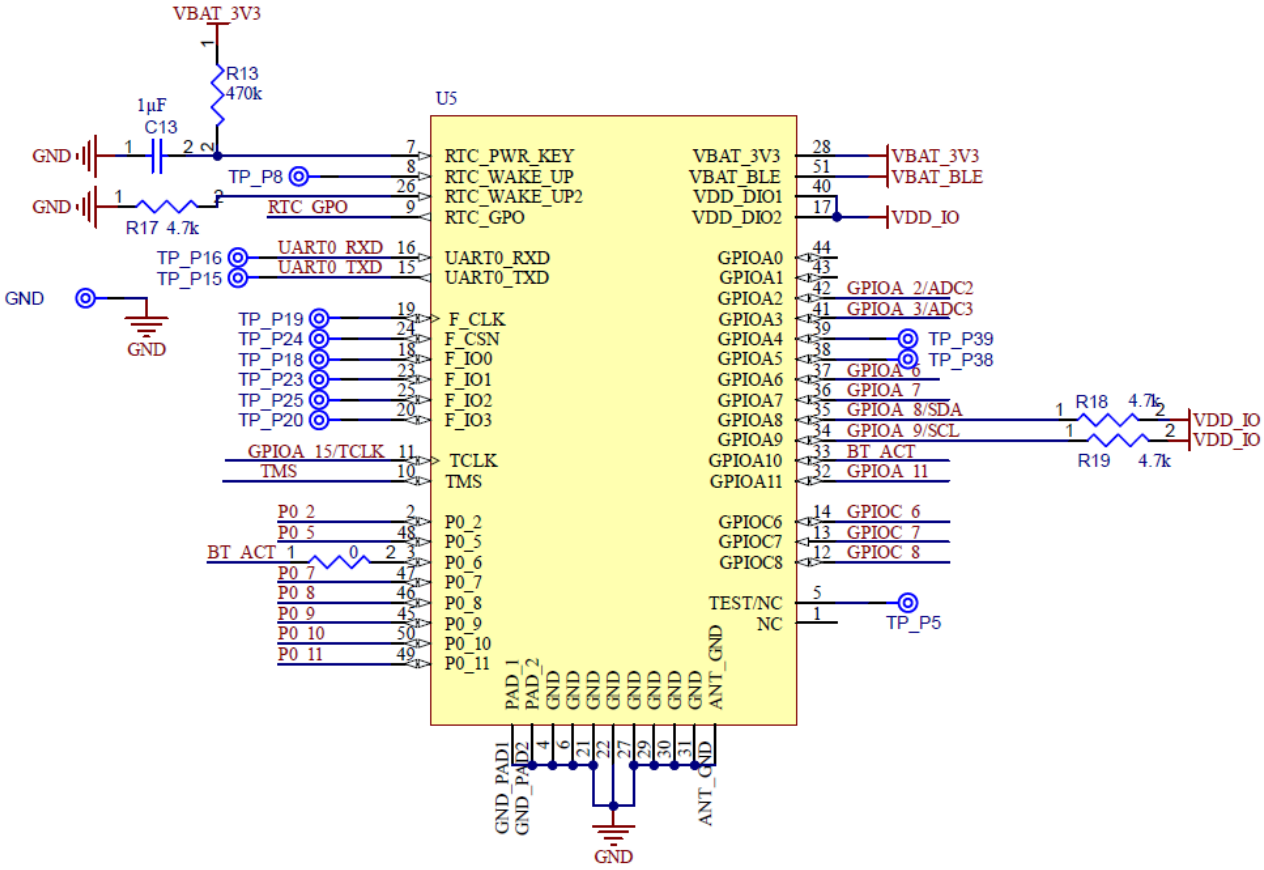

Figure 8. DA16600MOD Module

DA16200 MCU can be programmed using standard 10 pin and 1.27mm pitch pin header J2 (**Figure 13**). No additional adapter is required.

There are 1.27mm pitch test points for Trace purposes with possibility to access MCU directly via Terminal. More detailed interface description can be found in section 3.5 UART Debug Port.

3.3 Battery Voltage Measurement

Battery voltage is measured using simple voltage divider. To save the power while measurement is not going on there is added GreenFET switch Figure 9. The switch is controlled by DA16200 GPIOA_6 and measurement is processed on ADC3 channel.

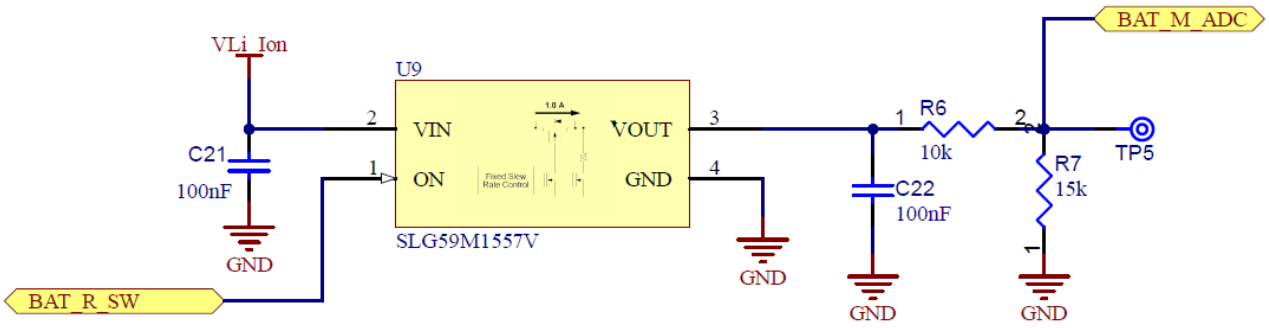

Figure 9. Battery Voltage Measurement

3.4 HS3001 - Temperature and Humidity Sensor

For reference and comparison purposes there can be used - HS3001 and HS400x series relative humidity and temperature sensors. By default, HS3001 is assembled and U7 HS4003 is not populated.

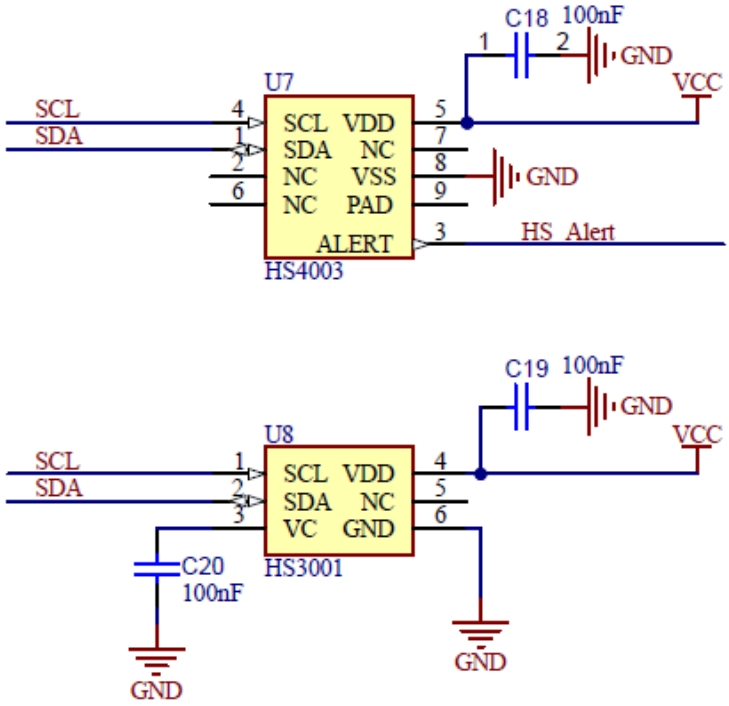

Figure 10. Humidity and Temperature Sensors

3.5 Sensing Water Leakage

For water leakage detection, resistive measurement method is used. On the same PCB there can be tested two options – one with digital potentiometer as variable resistor divider and fixed resistors divider (Figure 10). Each measurement method can be chosen by removing and place solder bridges SB7, SB8, SB9.

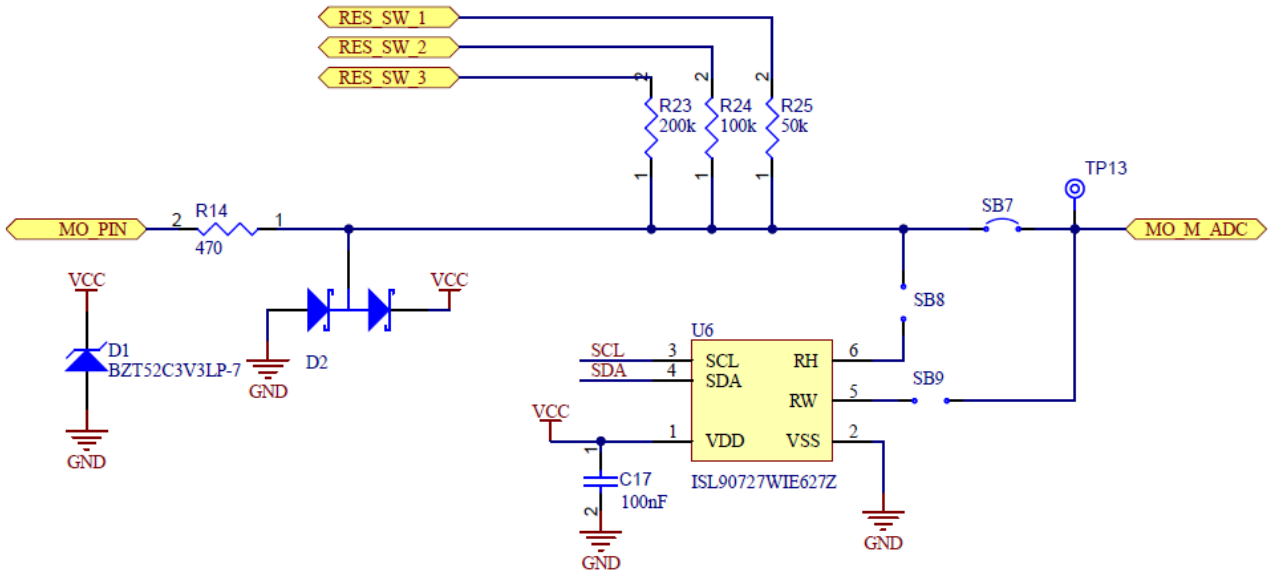

Figure 11. Water Leakage Sensing

3.5.1 Digital potentiometer as variable resistor divider

The advantage of this method is that it is possible to sense wide range of moisture on electrodes using adaptive potentiometer wiper position depending on input voltage.

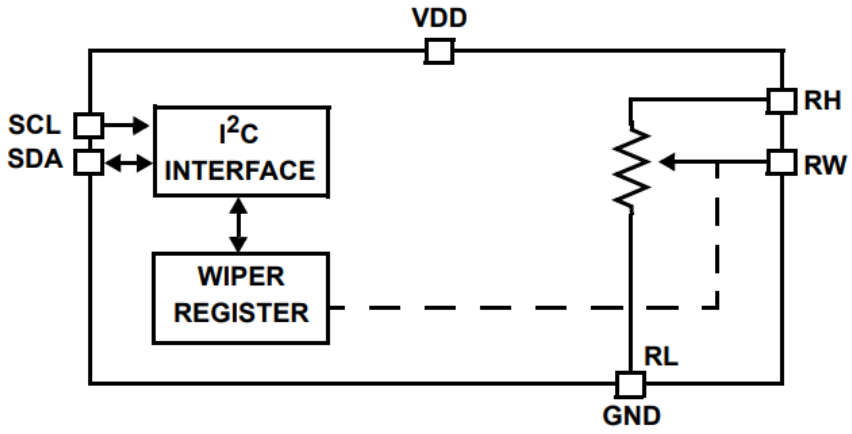

Figure 12. Digital Potentiometer Block Diagram

In our schematics potentiometer High Terminal RH is connecter do the sensor signal and Wiper Terminal goes to ADC input forming variable resistors divider that is controlled via I2C (Figure 11).

3.5.2 Fixed resistors

Resistor divider is formed from three resistors R23, R24, R25 where one lead is connected to ADC and sensor input and others to DA16200 GPIOs. By driving GPIO pins low or keeping in HiZ it is possible to have different pull-down values what allows several resistors divider options.

3.6 UART Debug Port

The UART0 module (available on TP_P16 and TP_P15 test points, see Figure 12) is used for debugging purposes (3.3V level). Test points are on top side with 1.27mm pitch so standard 1.27 needle adapter could be used.

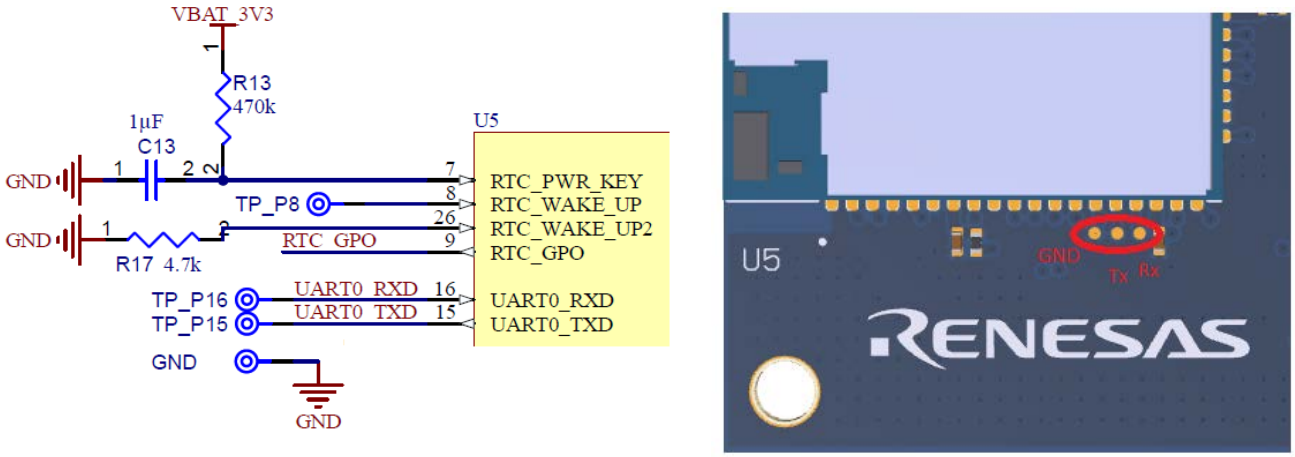

Figure 13. DA16200 UART Debug/Trace Port

Table 1. Debug/Trace Test Points

Test Point	Function
TP_P15	UART0 TXD
TP_P16	UART0 RXD
GND	GND

3.7 SWD – Serial Wire Debug Interface

The Renesas DA16200 MCU can be programmed using the 10-pin SWD connector J2, directly connected to the MCU, Figure 13 by using Segger® J-Link.

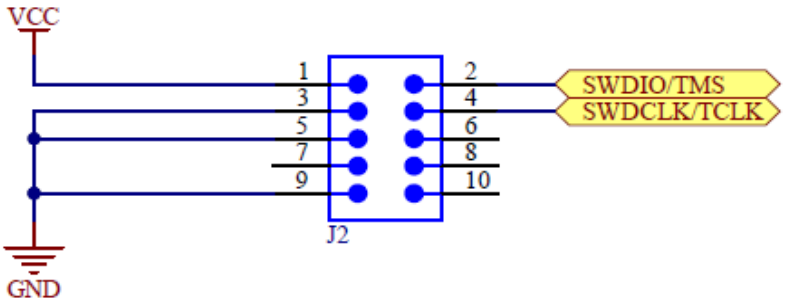

Figure 14. DA16200 MCU Debug/Programming SWD Connector

3.8 USB Device Port

The USB Device port J4 is used only for powering the board and charging the battery. There is also left an option to use solar panels with USB connector without voltage regulation. In this case it is needed to shorten correct solder bridge. By default, there is mounted 0Ω resistor on SB17 and SB10 is left open.

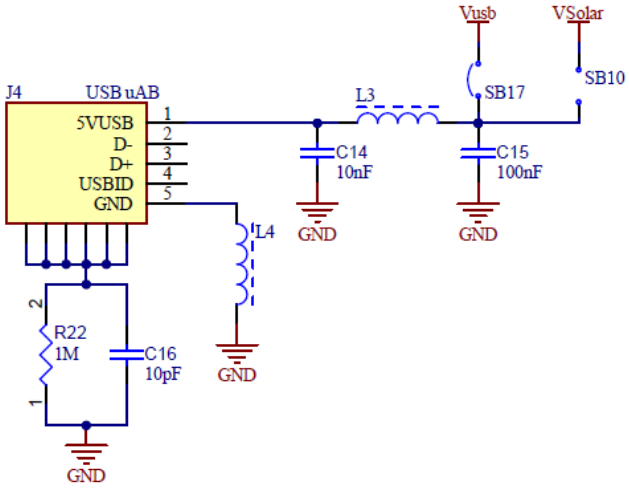

Figure 15. USB Connector

3.9 LEDs and Buttons

There are six LEDs on the board displaying hardware and software status. First three LEDs in Figure 15 are used to display state of the system and are connected to DA16600MOD GPIO pins.

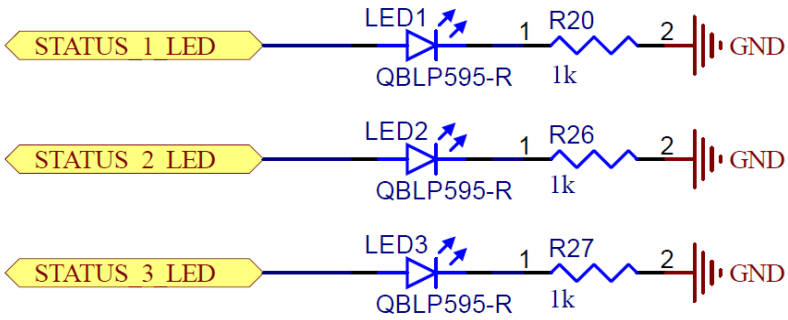

Figure 16. Status LEDs

LED4 is connected to ISL9111A DC/DC Boost converter (Figure 16) and it is lit in case of fault.

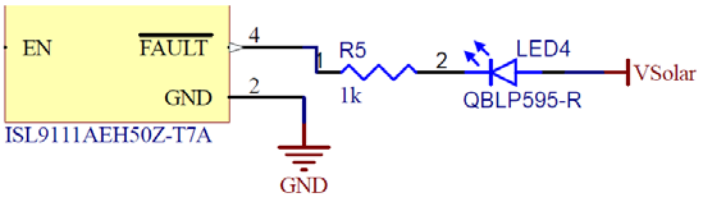

Figure 17. DC/DC Boost Converter Status LED

LED5 is connected to ISL9301 PPR pin and is showing status of external power supply. LED6 displays charging status. If battery is being charged LED6 is ON. If external power supply is on (LED5 ON) and LED6 is off – battery is fully charged.

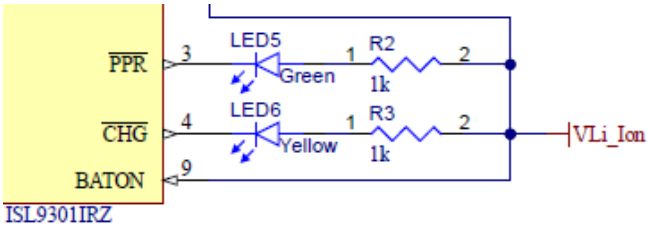

Figure 18. Power and Charging State LEDs

As it is shown in Figure 18, there are also two push buttons:

- SW2: used as a general-purpose button, connected to DA16600MOD GPIOC_8
- SW3: used as a general-purpose button, connected to DA16600MOD GPIOA_15 (It is sharing the same ping with SWDCLK).

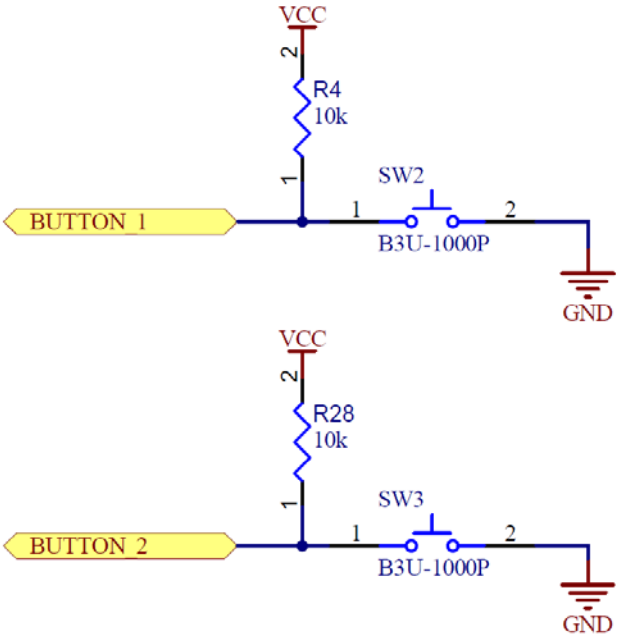

Figure 19. User Buttons

4. BOM

n.	Manufacturer	Manufacturer P/N	Description	Proj. Reference	pcs/ unit	Mount
1	Murata	GRM155R60J106ME15D	Chip Capacitor, 10µF +/-40%, 6.3V, 0402, Thickness 0.6 mm	C1, C6, C11, C12	4	YES
2	Yageo	CC0402MRX5R6BB475	Chip Capacitor, 4.7uF +/-20%, 10V, X5R, 0402 (1005 Metric)	C2, C4, C5	3	YES
3	Samsung	CL05A105KP5NNNC	Chip Capacitor, 1µF +/-20%, 10V, 0402, Thickness 0.6 mm	C3, C9, C10, C13	4	YES
4	Samsung	C1005X7R1H104K	Chip Capacitor, 100nF +/-20%, 50V, 0402, Thickness 0.6 mm	C8, C15, C17, C18, C19, C20, C21, C22	8	YES
5	KEMET	C0402C103K5RAC-TU	Chip Capacitor, 10nF +/-20%, 50V, 0402, Thickness 0.6 mm	C14	1	YES
6	Yageo	CC0402JRNPO9BN100	Chip Capacitor, 10 pF, +/- 5%, 50 V, 0402 (1005 Metric)	C16	1	YES
7	Samsung	CL10A226MP8NUNE	Chip Capacitor, 22µF +/-20%, 10V, 0603, Thickness 0.9 mm	C23	1	YES
8			DNP	D1	0	NO
9	MCC	BAT54ST-TP	Schottky Barrier Diode, 30 V, 0.2 A, -55 to 150 degC, 3-Pin SOT-523, RoHS, Tape and Reel	D2	1	YES
10	Nexperia	RB521CS30L315	Schottky Barrier Rectifier, 30 V, 100 mA, -65 to 125 degC, 2-Pin DFN1006-2, RoHS, Tape and Reel	D3	1	YES
11	Phoenix Contact	1778764	Phoenix Contact Doorvoerbasiselementen PTSM 0, 5/ 2-HH-2, 5-SMD R32 - 1778764	J1, J5	2	YES
12	Wurth Elektronik	62101021021	10 Position, 2 Rows, Header 1.27mm Pitch, SMT	J2	1	YES
13	Molex	501568-0207	Male Header, Pitch 1mm, 1 x 2 Position, Height 3.2mm, Solder RA SMD, RoHS	J3	1	YES
14	Molex	47589-0001	USB Micro AB 2.0 Female 5 Pin Right Angle Molex	J4	1	YES
15	Taiyo Yuden	NRS4012T4R7MDGJ	Inductor Power Shielded Wirewound 4.7uH 20% 100KHz Ferrite 1.5A 0.114Ohm DCR 1515 T/R	L1	1	YES
16	Murata	LQM18PN2R2MGHD	Ind Power Chip Shielded Multi-Layer 2.2uH 20% 1MHz Ferrite 1.15A 0603 Paper T/R	L2	1	YES
17	Murata	BLM18AG121SN1D	Chip Ferrite Bead for General Use, 120 Ohm, 500 mA, -55 to 125 degC, 0603 (1608 Metric), RoHS, Tape and Reel	L3, L4	2	YES
18	QT-Brightek	QBLP595-R	Chip LED 0402, Red, 0.02 A, 2.0 to 2.5 V, -40 to 80 degC, 2-Pin SMD, RoHS, Tape and Reel	LED1, LED2, LED3, LED4	4	YES
19	QT-Brightek	QBLP595-IG	Chip LED 0402, Green, 0.02 A, 3.1 to 3.7 V, -40 to 80 degC, 2-Pin SMD, RoHS, Tape and Reel	LED5	1	YES
20	QT-Brightek	QBLP595-Y	Chip LED 0402, Yellow, 0.02 A, 3.1 to 3.7 V, -40 to 80 degC, 2-Pin SMD, RoHS, Tape and Reel	LED6	1	YES
21	Yageo	RC0402FR-071RL	Chip Resistor, 1R, +/-1 %, 63 mW, -55 to 155 degC, 0402	R1	1	YES
22	Yageo	RC0402FR-074K7L	Chip Resistor, 4.7 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R2, R17, R18, R19	4	YES
23	Yageo	RC0402FR-07510RL	Chip Resistor, 510R, +/-1 %, 63 mW, -55 to 155 degC, 0402	R3, R5, R20, R26, R27	5	YES
24	Yageo	RC0402FR-131KL	Chip Resistor, 1 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R4, R28	2	YES
25	Yageo	RC0402FR-0720KL	Chip Resistor, 20 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R6	1	YES
26	Yageo	RC0402FR-1310KL	Chip Resistor, 10 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R7	1	YES
27			DNP	R8, R10	2	NO
28	Yageo	RC0402FR-070RL	Chip Resistor, 0R jumper, +/-5 %, 63 mW, -55 to 155 degC, 0402	R9, R11, R21, SB1, SB3, SB4, SB5, SB6, SB8, SB9, SB17	11	YES
29	Yageo	RC0402FR-07100KP	Chip Resistor, 100 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R12	1	YES

30	Yageo	RC0402FR-07470KL	Chip Resistor, 470 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R13	1	YES
31	Yageo	RC0402FR-07470RL	Chip Resistor, 470 Ohms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R14	1	YES
32	Yageo	RC0402FR-071ML	Chip Resistor, 1 MOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	R22	1	YES
33	Yageo	RC0402FR-0778K7L	Chip Resistor, 78.7 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	Rimin1	1	YES
34	Yageo	RC0402FR-079K53L	Chip Resistor, 9.53 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	Riref1	1	YES
35	Yageo	RC0402FR-07715KL	Chip Resistor, 715 kOhms, +/-1 %, 63 mW, -55 to 155 degC, 0402	Rtime1	1	YES
36	ITT C&K	JS102011SCQN	Slide Switch SPDT Surface Mount	SW1	1	YES
37	Omron	B3U-1000P	Tactile Switch, SPST-NO, 0.05 A, 12 V, -25 to 70 degC, 2-Pin SMD, RoHS, Tape and Reel	SW2, SW3	2	YES
38	Renesas	ISL9301IRZ-T	Charger IC Lithium Ion/Polymer 10-DFN (3x3)	U1	1	YES
39	Renesas	ISL9111AEH50Z-T7A	Boost Switching Regulator IC Positive Fixed 5V 1 Output 800mA (Switch) SOT-23-6	U2	1	YES
40	Renesas	ISL9122AIRNZ-T7A	3.3V DC/DC, DFN8-B package.	U3	1	YES
41	Renesas	SLG59H1401C	Dual Input Single Output, 3 A Power Multiplexer, 6V Max.	U4	1	YES
42	Renesas	DA16600MOD-AAC4WA32	DA16600MOD, WiFi, 802.11b/g/n, Bluetooth LE, Combo Module	U5	1	YES
43	Renesas	ISL90727WIE627Z-TK	Digital Potentiometer 10k Ohm 1 Circuit 128 Taps I²C SC-70-6	U6	1	YES
44	Renesas	HS4003	Humidity and temperature sensor HS4003 3.5%RH 8-DFN	U7	0	NO
45	Renesas	HS3001	Humidity and temperature sensor HS3001	U8	1	YES
46	Renesas	SLG59M1557VTR	Power Switch/Driver 1:1 P-Channel 1A 4-STDFN (1x1)	U9	1	YES
47	Phoenix Contact	1778832	TERM BLOCK PLUG 2POS STR 2.5MM	J5	2	YES
48			3.7V LiPo battery 1400mAh with 501330-0200 Molex connector on the wires	BAT	1	YES

5. Board Layout

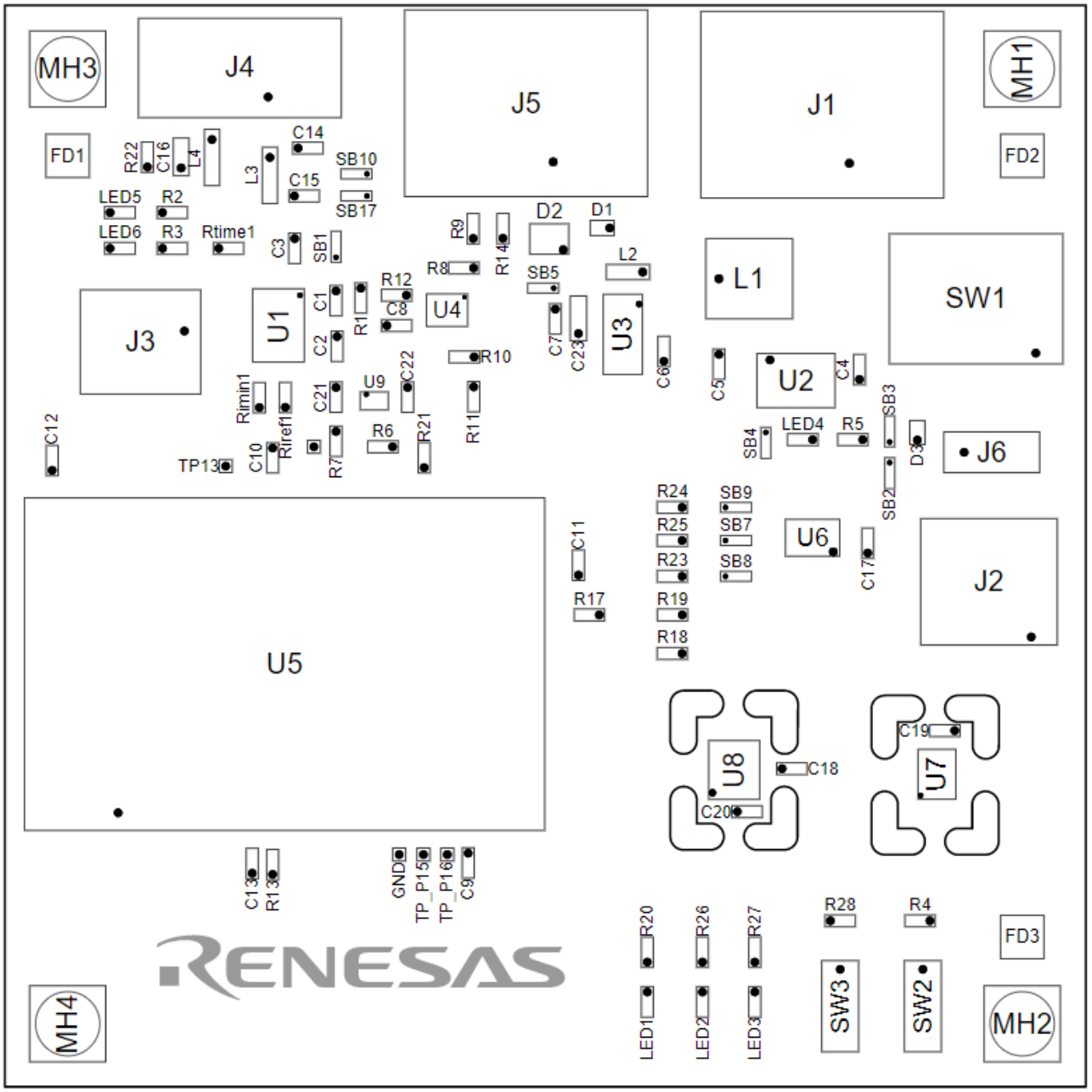

Figure 20. EU153-1 Assembly Drawing

6. Certifications

The EU153-1 Water Leakage Sensor Solution Kit complies with the laws and regulations described below.

6.1 Europe CE

Hereby, Renesas Electronics Europe GmbH, declares that the EU153-1 Water Leakage Sensor Solution Kit (EU153-SMTLEAKPOCZ) is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU.

References

[1] Renesas Electronics, “EU153-1 – Software User’s Guide” – R30AN0417ED0101.

[2] Renesas Electronics, “EU153-1 – Quick Start Guide” – R30QS0009ED0101.

[3] Renesas Electronics, “RA4W1 - User’s Manual: Hardware” Mar. 2020 - R01UH0883.

[4] Renesas Electronics, “RL78/G13 - User’s Manual: Hardware” Jun. 2020 - R01UH0146.

[5] Renesas Electronics (IDT), “HS300x Datasheet - High Performance Relative Humidity and Temperature Sensor”, Aug. 6, 2018.

[6] Renesas Electronics, “ISL29020 Datasheet - A Low Power, High Sensitivity, Light-to Digital Sensor With I2C Interface”, Rev 1.00 Aug. 20, 2009.

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Revision History

Rev.	Date	Description	
		Page	Summary
0.01	1 Feb 2023		Initial version.
1.2	25 Apr 2024		Editorial changes, minor bugfix

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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