UM3539

User manual

Getting started with STEVAL-HARVEST1 energy harvesting board for NUCLEO-WL55

Introduction

STEVAL-HARVEST1 is a hardware board based on energy harvesting. It has storage capacitors, a solar panel, and sensors on it. The solar panel charges the storage capacitors (Tantalum capacitor and super-capacitor). Since the board operates on the voltage built up by the storage capacitors, which are charged by solar panel, the STEVAL-HARVEST1 installed over NUCLEO-WL55JC1 functions as a battery-less system. STEVAL-HARVEST1 must be used with NUCLEO-WL55JC1. The sensors used in the STEVAL-HARVEST1 board are the following:

- Temperature sensor: STTS22H.
- Accelerometer: LIS2DU12.
- IR motion sensor: STHS34PF80.
- Humidity and temperature sensor: SHT40.

When this board is mounted on NUCLEO-WL55JC1, the NUCLEO board transmits the LoRa Packet by using the energy stored in the capacitors, which are charged by solar panel, without using any external battery. This board works with both outdoor and indoor light.

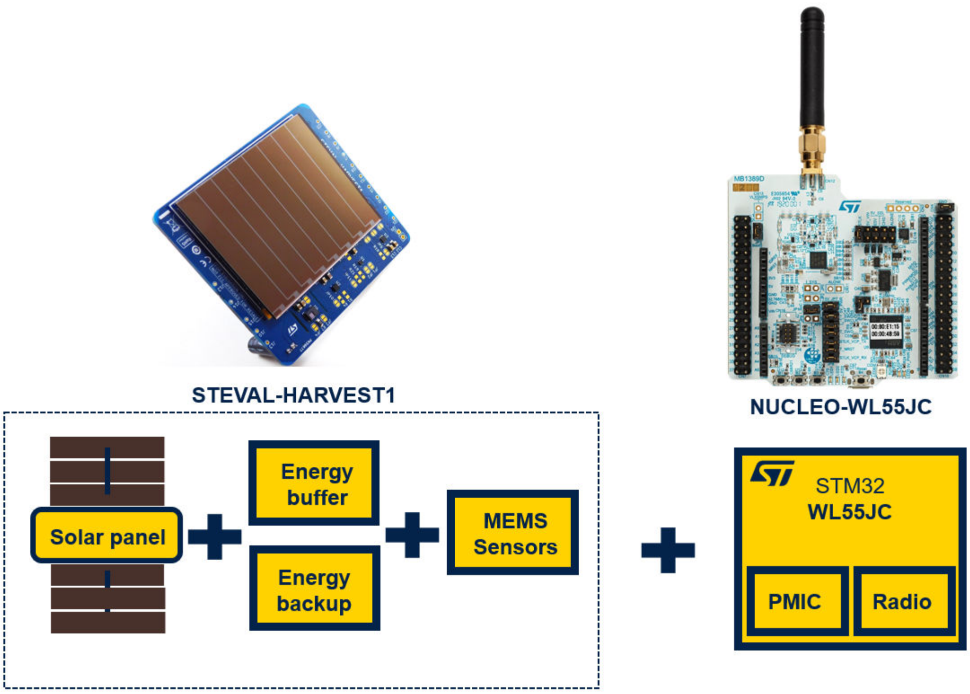
The LoRa packet consists of data taken from the sensors mounted on the board.

The STM32WL55/54xx is a long-range wireless and ultra-low-power device that embeds a powerful and ultra-low-power LPWAN-compliant radio solution, enabling the following modulations:

1. LoRa.
2. (G)FSK.
3. (G)MSK.
4. BPSK.

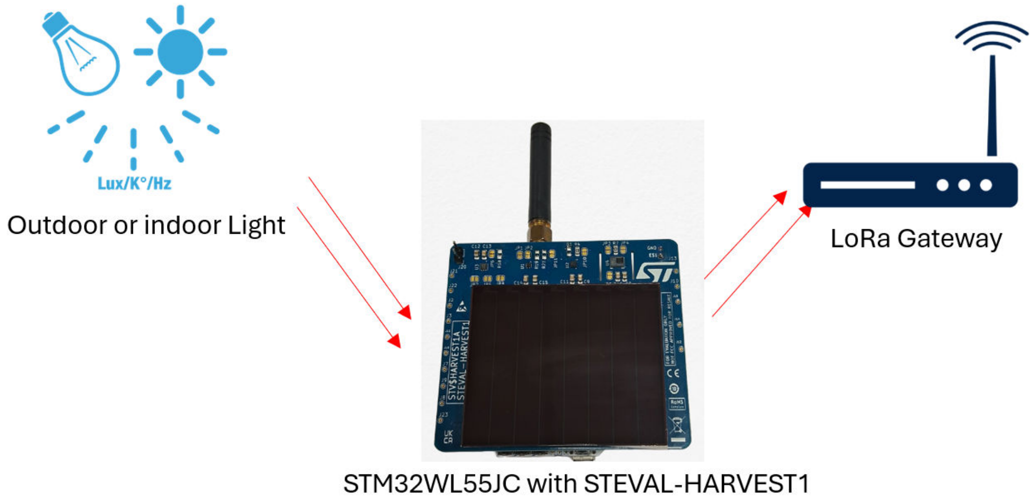
The device embeds high-speed memories (256 Kbyte flash memory, 64 Kbyte SRAM) and an extensive range of enhanced I/Os and peripherals. The operating temperature and voltage ranges are –40°C to +105°C (+85°C with radio) from a 1.8 V to 3.6 V power supply. A comprehensive set of power-saving modes allows the design of low-power applications.

Figure 1. STEVAL-HARVEST1 configuration with NUCLEOWL55



Below is the typical application.

Figure 2. Application scenario



*Notice: For dedicated assistance, submit a request through our online support portal at **www.st.com/support**.*

1 References

1. Databrief of NUCLEO-WL55JC1 board: DB3933
2. Datasheet of STHS34PF80: DS13916
3. Datasheet of STTS22H: DS12606
4. Datasheet of LIS2DU12TR: DS12422

2 Acronyms and abbreviations

Acronym	Description
(G)FSK	Gaussian Frequency-Shift Keying
(G)MSK	Gaussian Minimum-Shift Keying
BPSK	Binary Phase Shift Keying
MCU	Microcontroller Unit
GPIO	General Purpose Input Output
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
LPWAN	Low Power Wide Area Network
LoRa	Long Range

3 Sensors

3.1 STTS22H

The STTS22H is a digital temperature sensor, which communicates via a 2-wire I²C/SMBus 3.0 serial interface. Thanks to its factory calibration, the STTS22H offers high-end accuracy performance over the entire operating temperature application level. The sensor operating mode is user-configurable and it allows to select between different ODRs (down to 1 Hz) and the one-shot mode for battery saving. In one-shot mode, the sensor current consumption falls to 1.75 µA.

The STTS22H comes in a 6-pin device that supports user-configurable slave addresses. By connecting the Addr pin to either GND or VDD, two different addresses can be specified, allowing to have up to two STTS22H sharing the same I²C/SMBus bus line. An interrupt pin is also available to signal the application whenever the user-selectable high and low threshold are exceeded.

3.2 LIS2DU12

The LIS2DU12 is a linear 3-axis accelerometer with advanced digital functions, whose MEMS and ASIC have been designed to build an outstanding ultra-low-power architecture in which the anti-aliasing filter operates with a current consumption that is among the lowest in the market. The LIS2DU12 has user-selectable full scales of ±2g, ±4 g, ±8 g, and ±16 g, and it is capable of measuring accelerations with output data rates from 1.6 Hz to 800 Hz. The LIS2DU12 has an integrated 128-level FIFO buffer, which allows to store a wide range of data and to reduce system power consumption. The embedded self-test capability allows the user to check that the sensor works in the final application. The LIS2DU12 has a dedicated internal engine to process motion and acceleration detection, including free-fall, wake-up, single/double-tap recognition, activity/inactivity, and 6D/4D orientation. The LIS2DU12 is available in a small 2.0 x 2.0 mm plastic land grid array package (LGA) only 0.74 mm thin, which places it among the smallest solutions available in the market. It is guaranteed to operate over an extended temperature range, from -40°C to +85°C.

3.3 STHS34PF80

The STHS34PF80 is an infrared sensor that can be used to detect the presence of stationary and moving objects, as well as overtemperature conditions. It measures the object's IR radiation with unique TMOS technology, to detect the presence or motion when an object is inside the field of view.

The sensor is split into two parts: one is exposed to IR radiation and the other one is shielded. Differential reading between the two parts is implemented to remove the effect of sensor self-heating. An optical band-pass filter is placed over the sensor, limiting its operating range within the wavelengths of 5 µm and 20 µm, making it insensitive to visible light and other bands.

The STHS34PF80 embeds a high-accuracy temperature sensor to measure the ambient temperature and to compensate for heating of the device and/or application. The ASIC also implements dedicated smart processing to detect and discriminate between stationary and moving objects, which can assert dedicated interrupts. Different ODRs from 0.25 Hz to 30 Hz and a one-shot mode are available.

3.4 SHT40

SHT40 is a digital sensor from Sensirion that measures relative humidity and temperature at different accuracy classes. Its I^2C interface provides several preconfigured I^2C addresses and maintains an ultra-low power budget. The power-trimmed internal heater can be used at three heating levels, thus enabling sensor operation in demanding environments. The four-pin dual-flat-no-leads package is suitable for surface mount technology (SMT) processing, and it comprises an optional on-package patented PTFE membrane or a removable protection cap. It possesses the following features.

- Relative humidity accuracy: up to ±1.0% RH.
- Operating range: 0% ~ 100% RH, from -40°C to 125°C.
- Temperature accuracy: up to ±0.1°C.
- Average current: 0.4 µA (at meas. rate 1 Hz).
- Variable power heater.
- I^2C FM+, CRC checksum, multiple I^2C addresses.
- NIST traceability.
- JEDEC JESD47 qualification.

4 Energy harvesting board package description

4.1 Overview

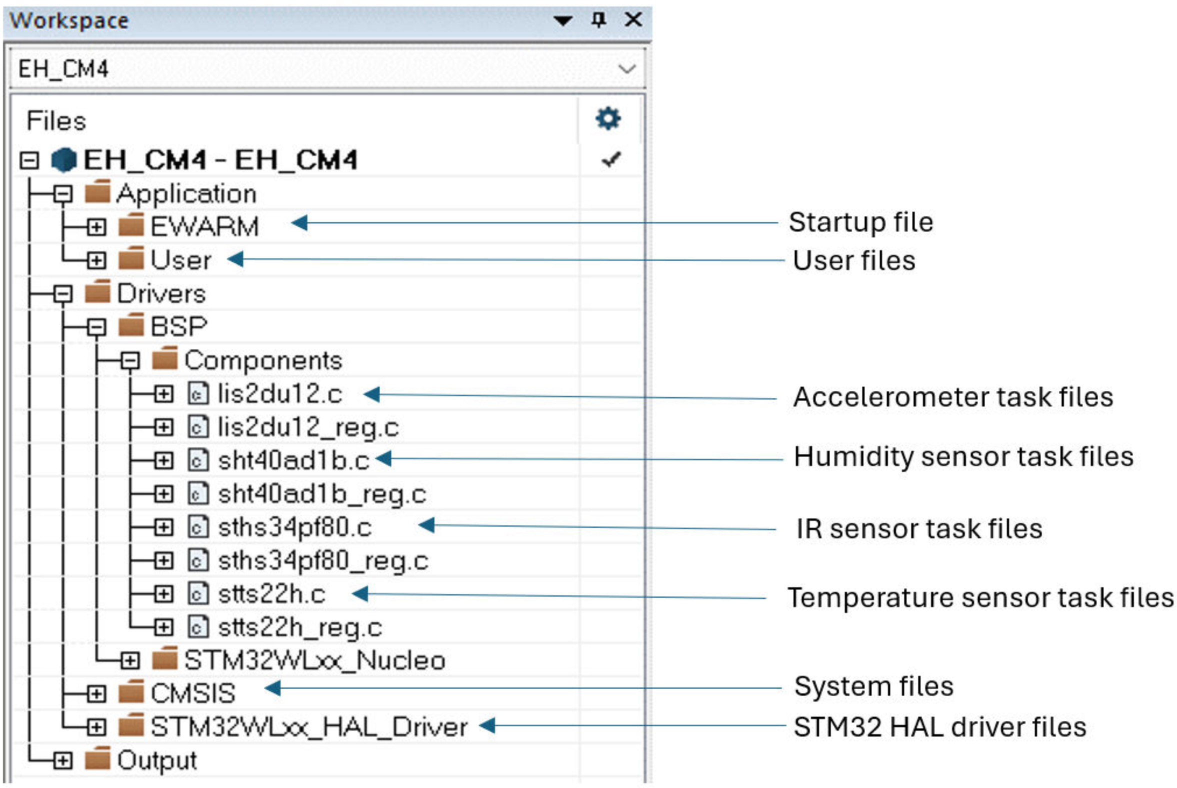
The software package includes the following documentation:

- STEVAL-HARVEST1 User Manual.
- STM32WL55_Driver.
- Application files.
- Html resources.

4.2 Folder structure for continues mode operation

This section provides an overview of the package folders structure, including the files to select ST devices.

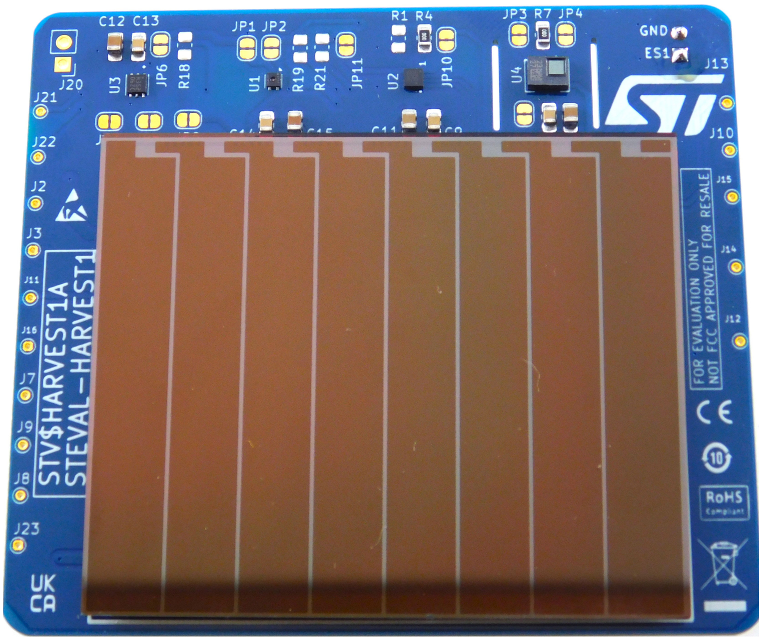
Figure 3. Firmware folder structure



4.3 Getting started with STEVAL-HARVEST1

4.3.1 PCB

Figure 4. Hardware board

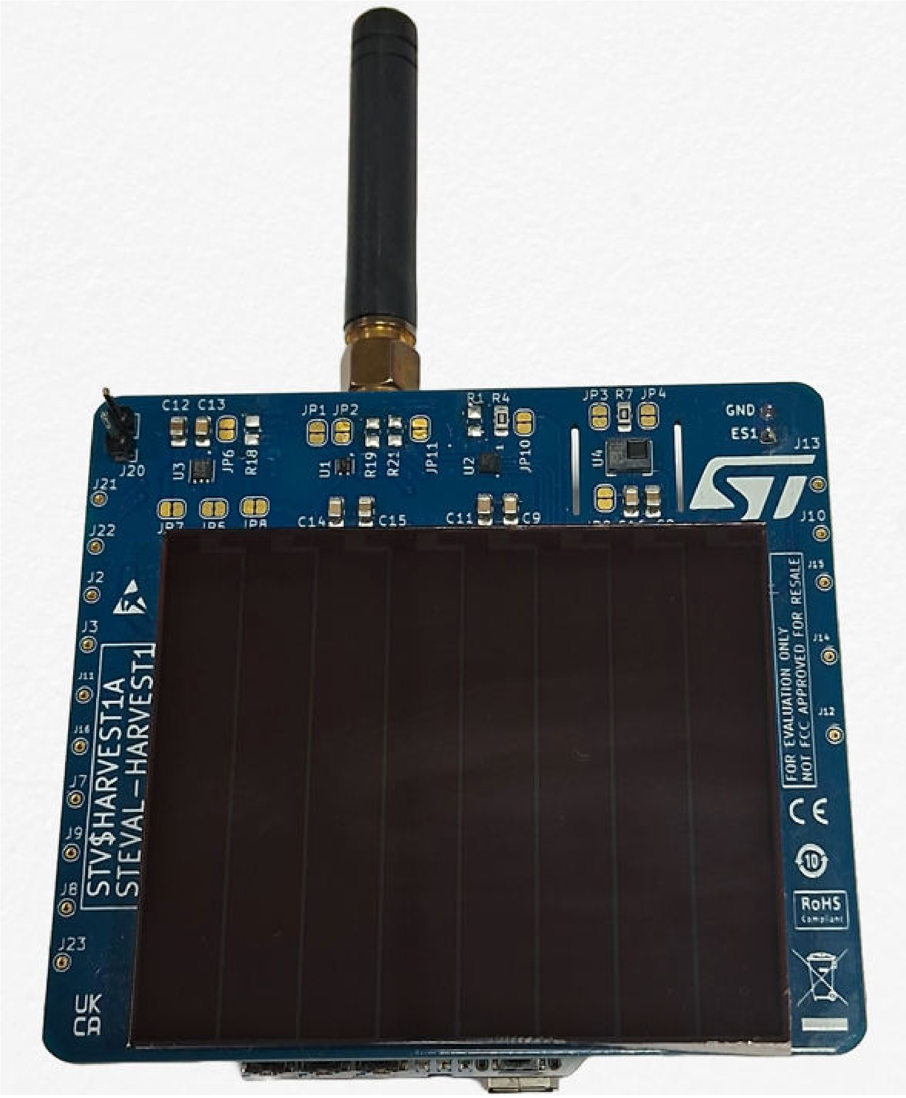


4.3.2 NUCLEO-WL55JC with STEVAL-HARVEST1

NUCLEO-WL55JC is interfaced with a STEVAL-HARVEST1 board, which has the following sensors:

- SHT40: humidity sensor.
- LIS2DU12: accelerometer.
- STTS22H: temperature sensor.
- STHS34PF80: infrared sensor.

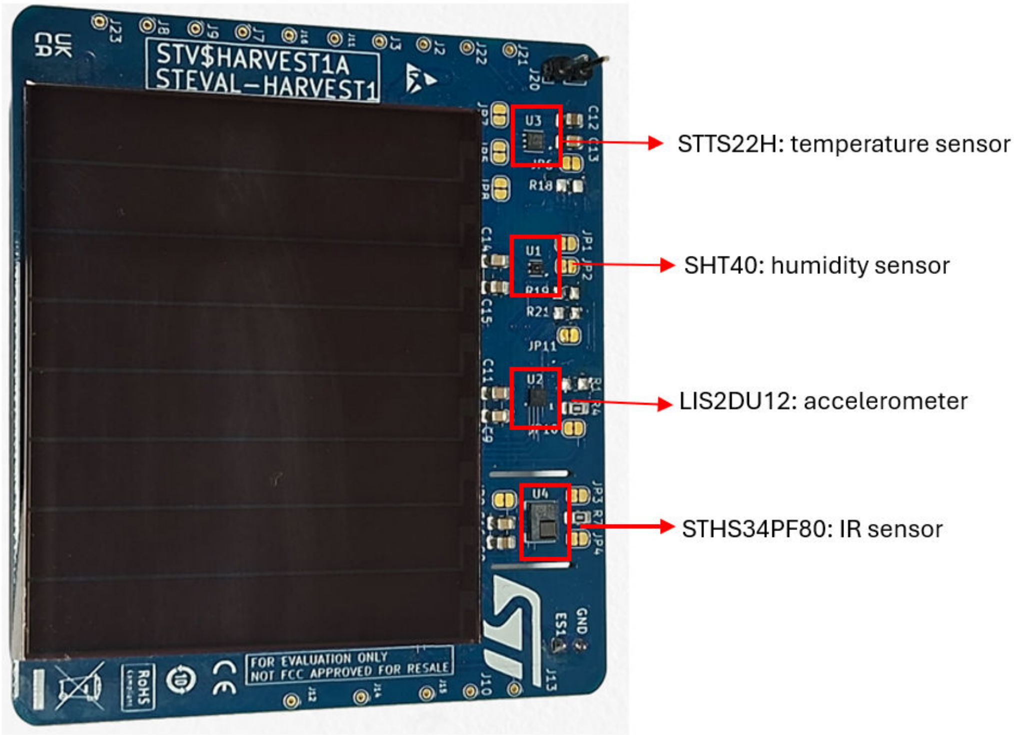
Figure 5. **STEVAL-HARVEST1 interfaced with NUCLEO-WL55JC**



The STEVAL-HARVEST1 energy harvesting board based on LoRa consists of different IC’s, which perform the desired sensor operations:

- U1: SHT40.
- U2: LIS2DU12.
- U3: STTS22H.
- U4: STHS34PF80.

Figure 6. STEVAL-HARVEST1 board with sensors



4.4 Modes of operation

4.4.1 Continuous mode through USB power

In this mode, the STEVAL-HARVEST1 board is powered by the NUCLEO board, which is connected via USB power cable. Once it is powered up, it transmits the sensor's data to the terminal via UART.

Before programming the board, CLOSE the highlighted jumpers and SB32 resistor to get power from USB.

Figure 7. Jumper and resistor settings for continuous mode

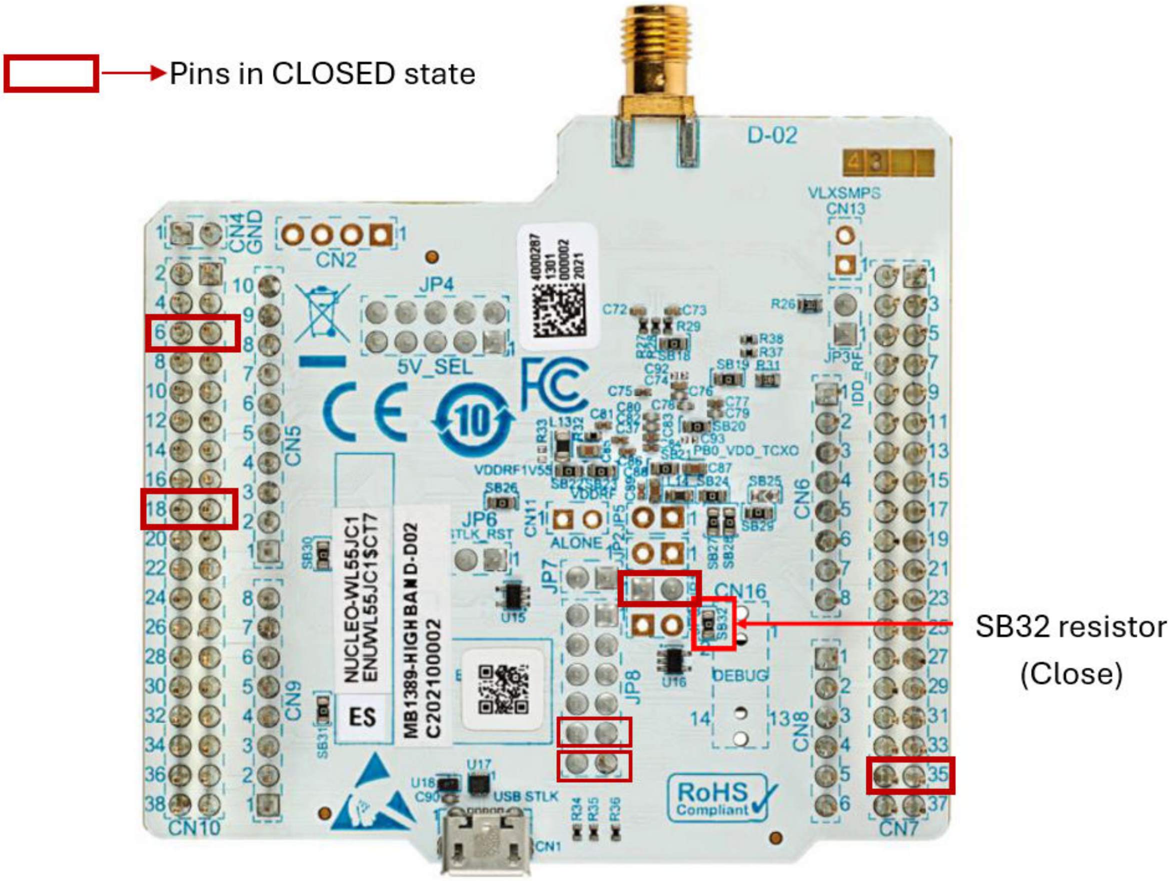


Figure 8. Sensor data logging in continuous mode

```
LIS2DU12 X-Acc: 901 <LF>
LIS2DU12 Y-Acc: -12 <LF>
LIS2DU12 Z-Acc: 423 <LF>
SHT40 TEMP: 25.590141 <LF>
SHT40 HUMIDITY: 42.237583 <LF>
STTS22H TEMP: 26.120001 <LF>
STHS34PF80 MOTION: 7980 <LF>
STHS34PF80 PRESENCE: 8835 <LF>
STHS34PF80 TEMP: 1.000000 <LF>
```

4.4.2 Energy harvesting mode

This mode works based on the power voltage detector (PVD) feature. STM32WL55 wakes up using this feature, it harvests the energy through the solar panel and, once there is voltage buildup across the storage capacitor, it reaches the threshold voltage, the MCU wakes up and it initializes all the ICs (STTS22H, LIS2DU12, STHS34PF80, SHT40) and takes its readings. Then, the LoRA packet consisting of these sensors data is sent by STM32WL55 to NUCLEO-WL55JC1. After sending the LoRA Packet, the MCU enters STOP mode. Due to this, the voltage decreases. The storage capacitors are then charged again by the solar panel. This full process continues repeatedly.

Once the board is programmed (see Figure 7) follow these steps:

- Change the jumper settings as instructed in Figure 9.
- All the highlighted jumpers must be in CLOSED state.
- Switch SB32 resistor to OPEN state.
- The LoRa packet is visible on the Gateway after ambient light is harvested through the solar panel and there is voltage buildup across the storage capacitor.

Figure 9. Jumper and resistor settings for energy harvesting mode (1/3)

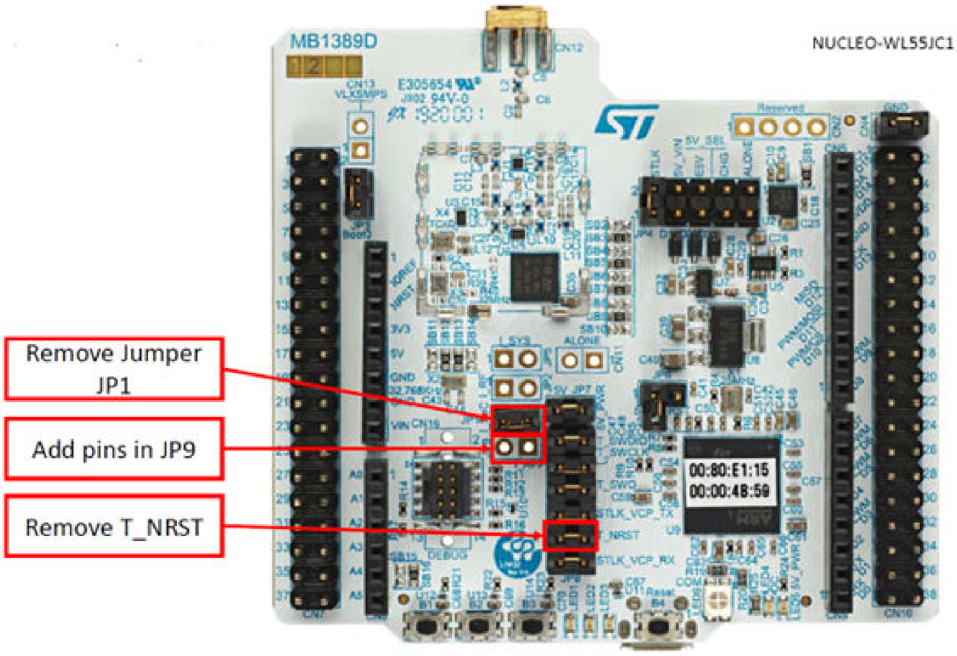


Figure 10. Jumper and resistor settings for energy harvesting mode (2/3)

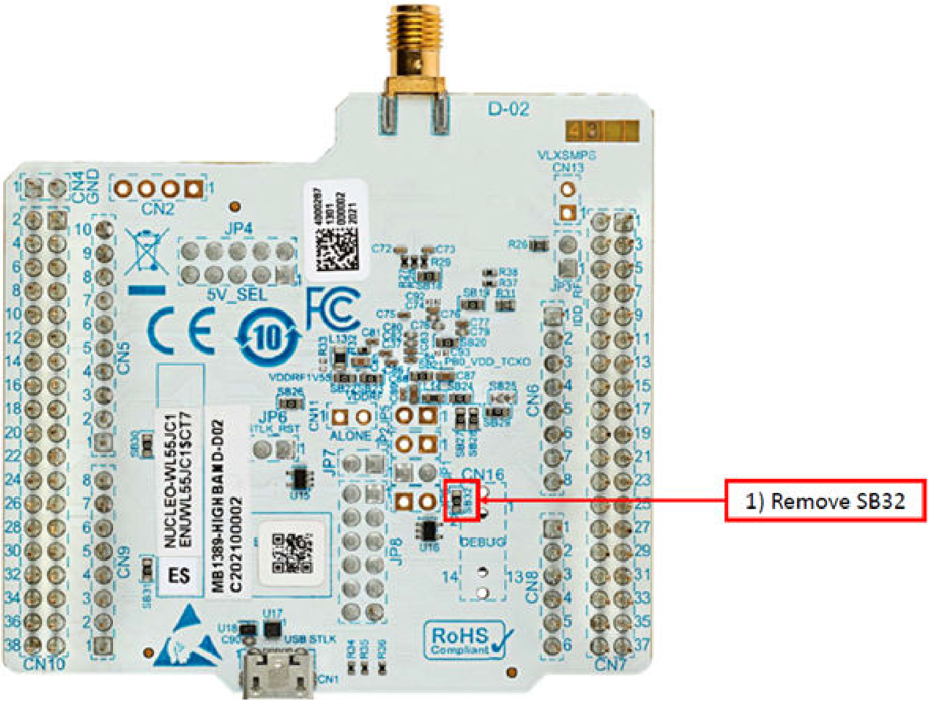
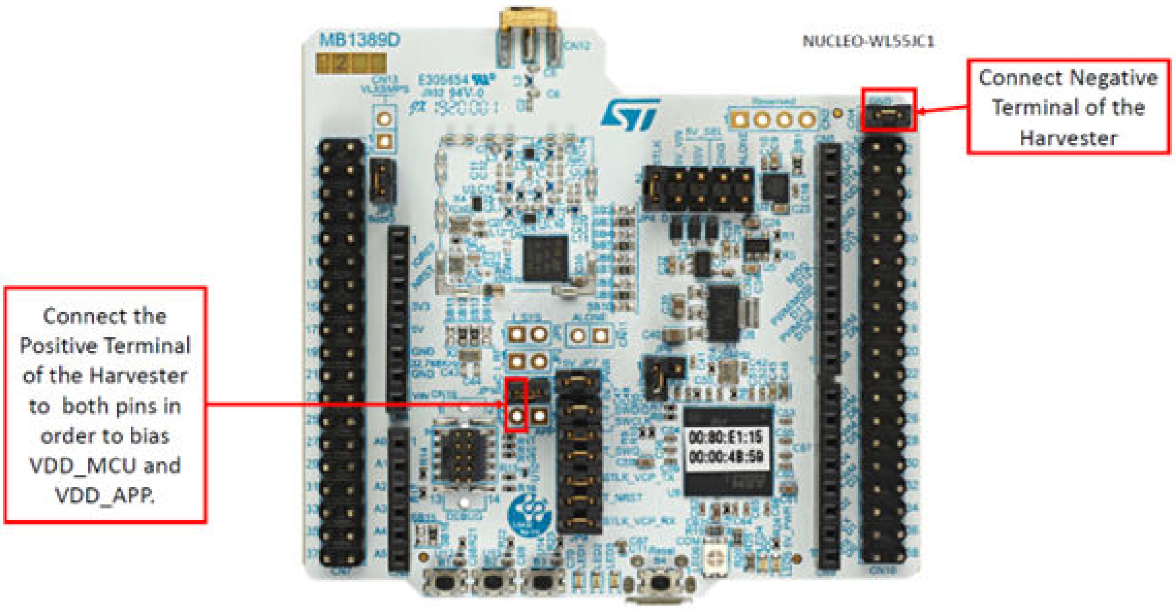


Figure 11. Jumper and resistor settings for energy harvesting mode (3/3)



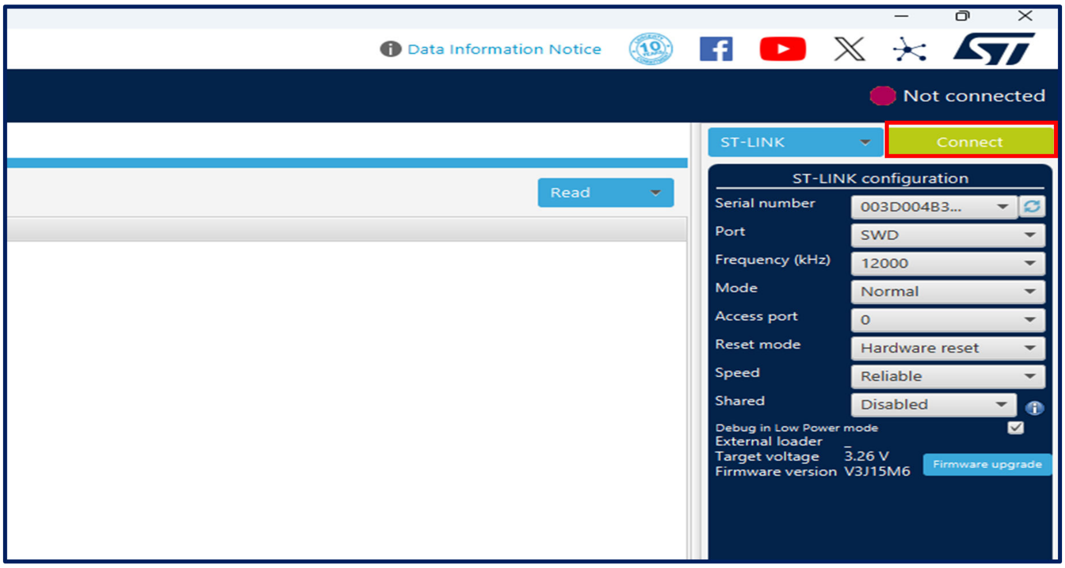
4.5 Integration of LoRaWAN end node with things network

4.5.1 Programming the end node (STEVAL-HARVEST1+NUCLEO-WL55) through STM32CubeProgrammer

To start with program the given elf file (i.e.) **STSW-HARVEST1.elf** on the NUCLEO board with jumper settings on “Continuous mode” (see Section 4.4.1) through STM32CubeProgrammer.

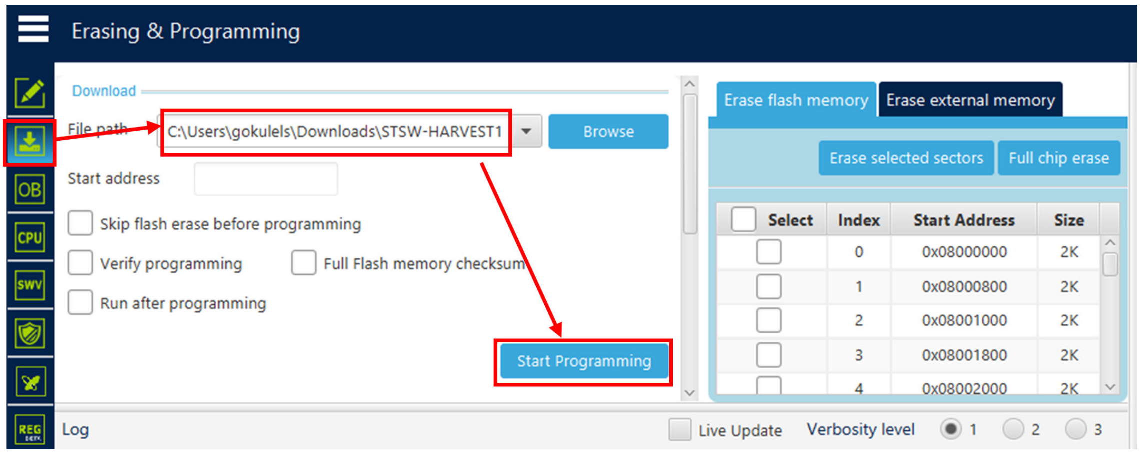
“Continuous mode” is needed for programming the board.

Figure 12. **Programming the end node**



Once the board is connected, paste the file path of elf file (i.e.) STSW-HARVEST1.elf and click on “Start Programming” option. The default start address (0x08000000) for programming.

Figure 13. **Erasing & Programming**



4.5.2 Interface of LoRaWAN end node with things network

Once the respective End Node is programmed, change the jumper settings to Energy Harvesting mode (see Section 4.4.2) and interface the respective node with **Things Network** console.

The steps involved in the interface are.

4.5.2.1 For gateway addition

- Click on the “Add” option and select “Add new gateway”.

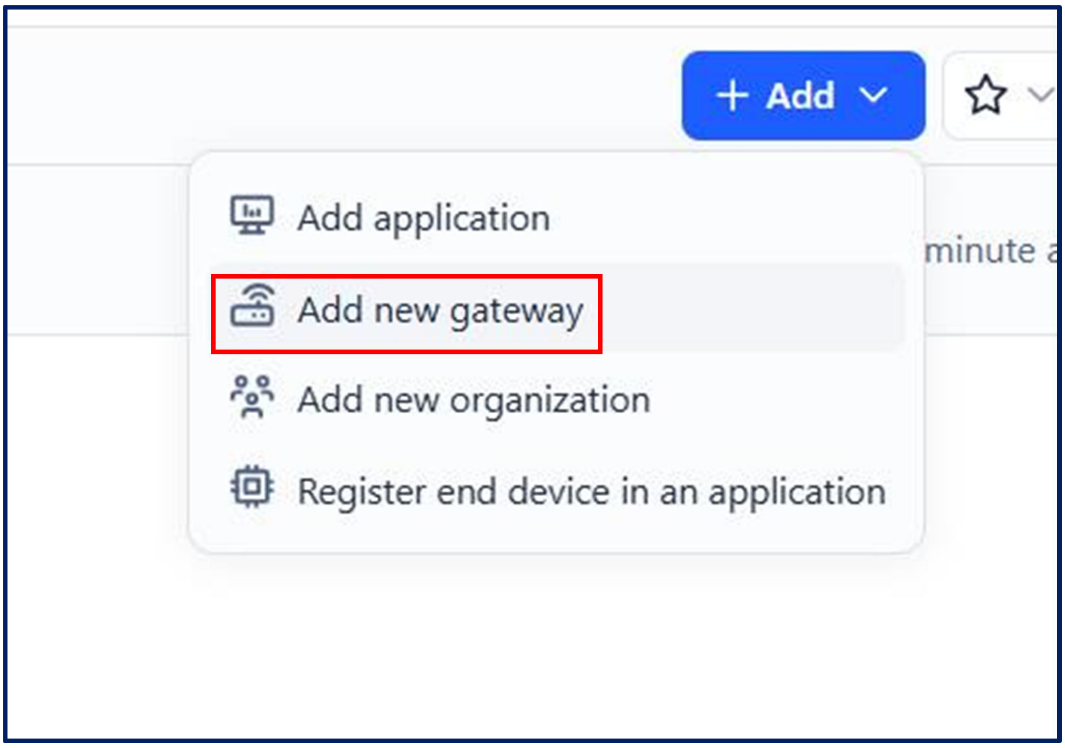
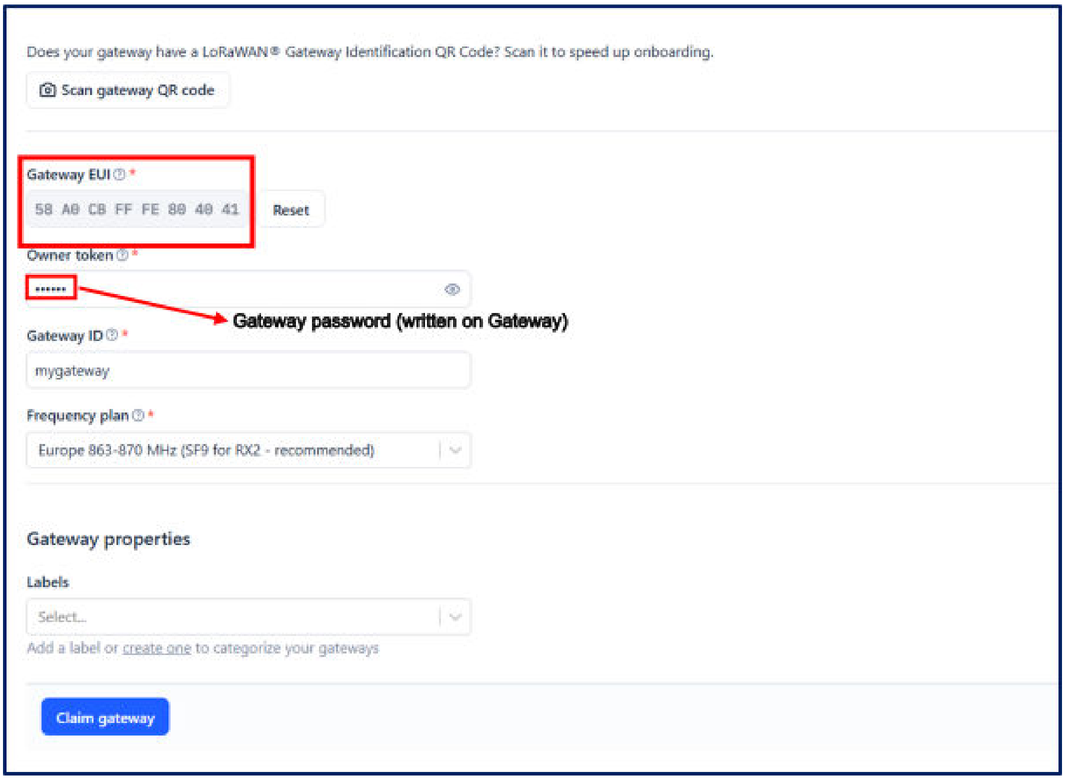


Figure 14. Add new gateway

- Enter the required Gateway EUI, Owner token, Gateway ID and Frequency plan as given below and click on the “Claim gateway” option.

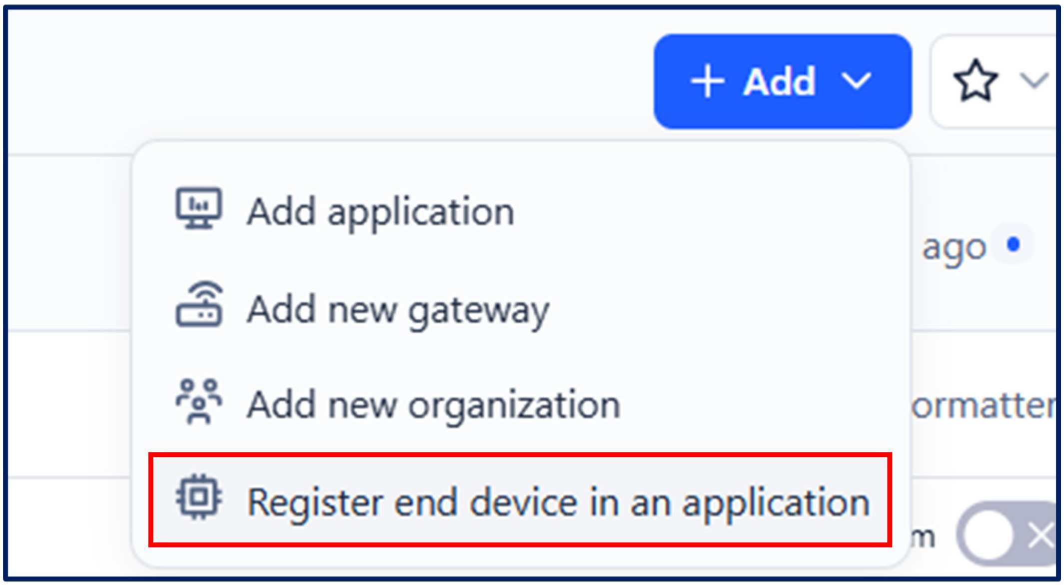
Figure 15. Gateway EUI



4.5.2.2 *For end node device addition*

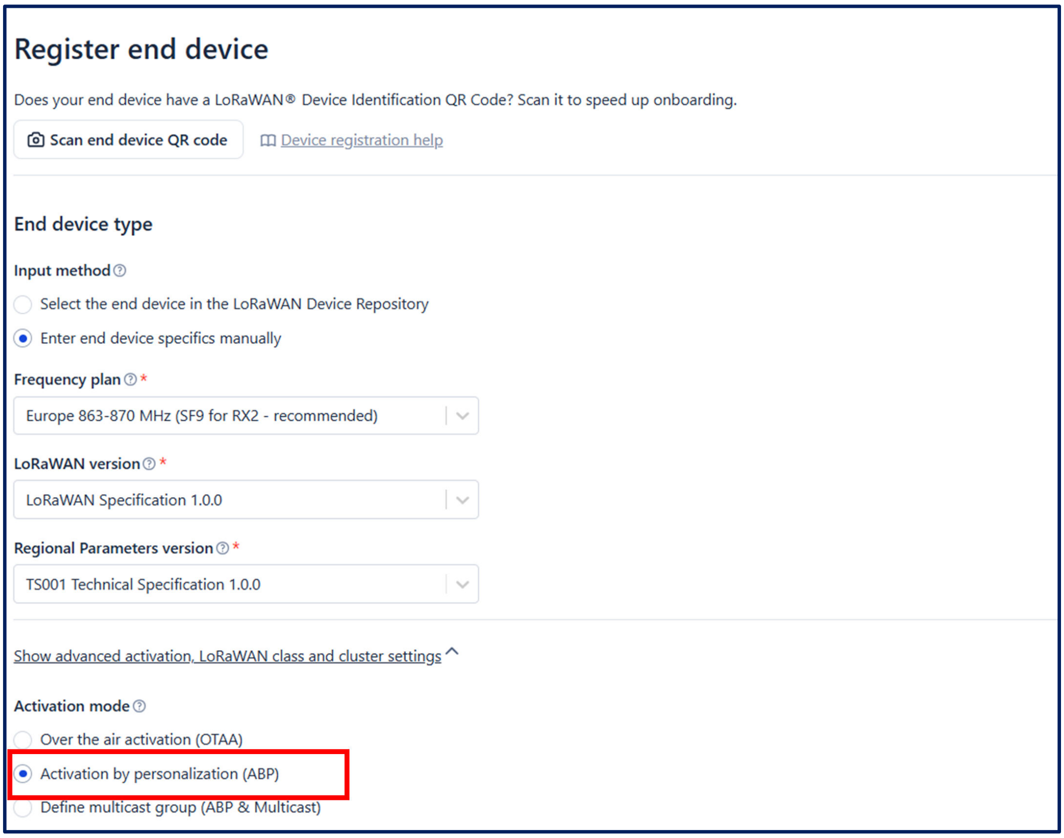
1. Click on the "Add" option and select "Register end device in an application".

Figure 16. Register end device in an application



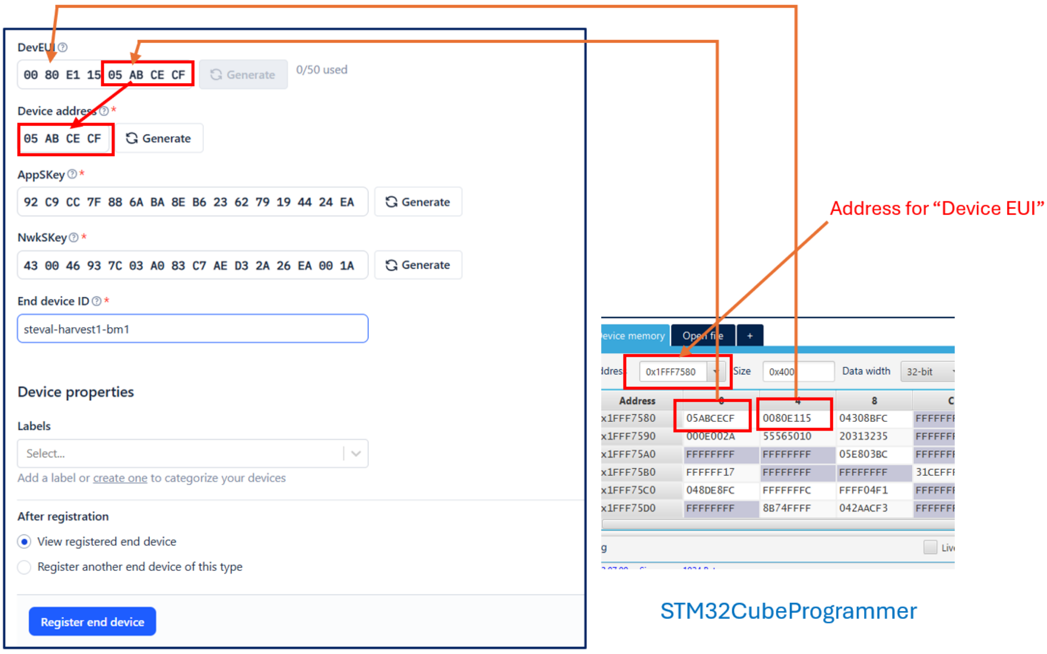
2. Within the end device section, select the given Input method, Frequency plan, LoRaWAN version, Regional Parameters version and Advanced mode options as given below.

Figure 17. Register end device (1/2)



3. Enter the required:
   - DevEUI.
   - Device address, that is, last eight hex digits of DevEUI .
   - AppSKey.
   - NwkSKey as given below, name the End device ID as per your need, and click on the “Register End Device” option at the last.

Figure 18. Register end device (2/2)



Notice:

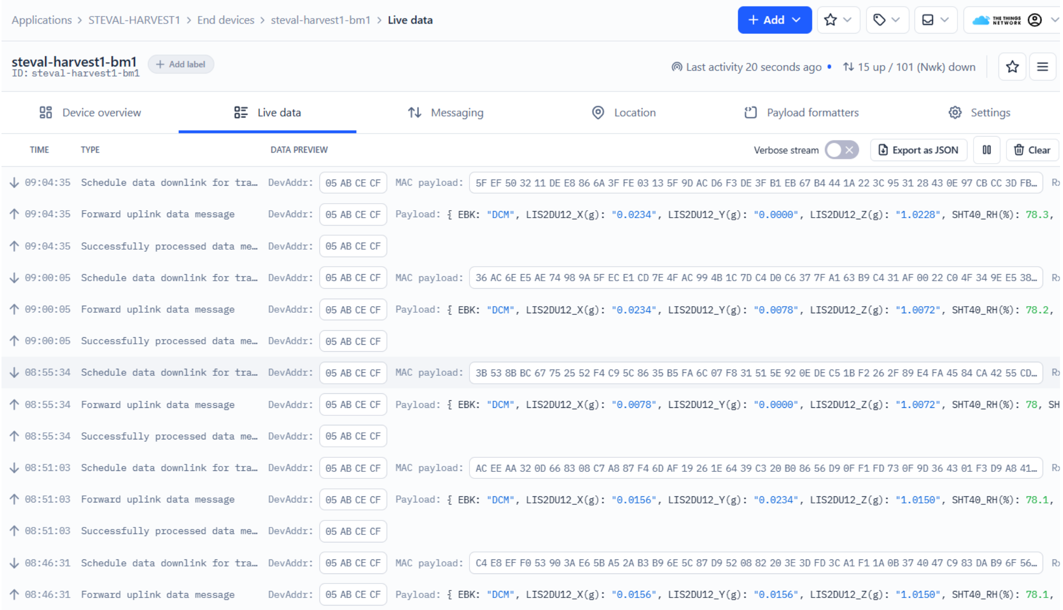
a. Device EUI starts with 0x00, 0x80, 0xE1, 0x15.

b. Device address corresponds to the last 4 bytes of Device EUI.

c. This information is generally also included in the NUCLEO-WL55JC board (UID64 sticker).

4. Once the End device is registered, we get the readings of all sensors of STEVAL-HARVEST1 that has been placed on the given End device in the “Live data” section.

Figure 19. Live data



4.6 Conclusion

1. **Continuous Mode:**
   – Mount the STEVAL-HARVEST1 energy harvesting board on NUCLEO-WL55JC.
   – Program the NUCLEO board with the firmware given.
   – Connect any terminal utility @ Baud rate 115200.

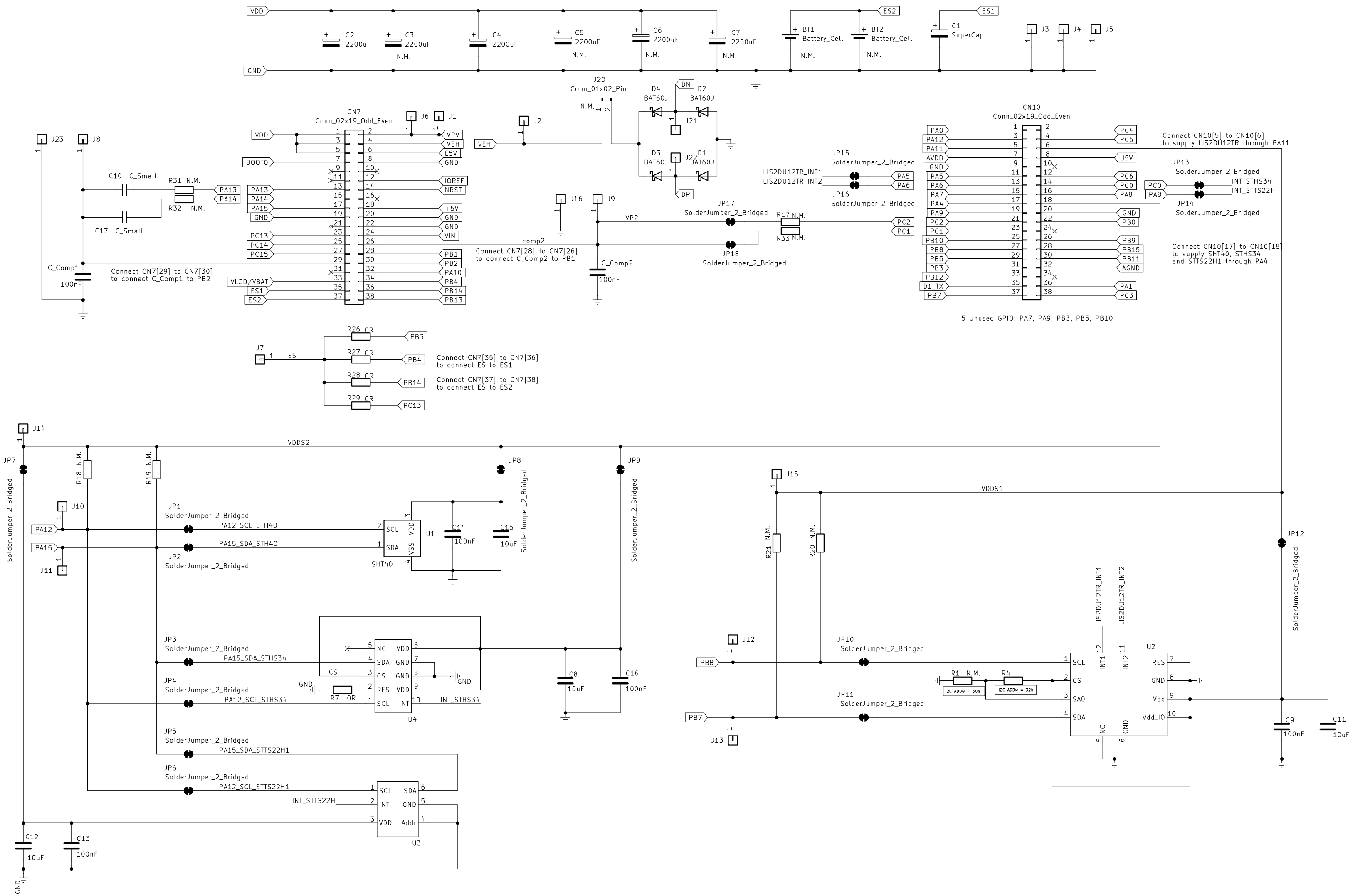
Figure 20. **Output on terminal in continuous mode**

```
SHT40 TEMP: 24.420540 <LF>
SHT40 HUMIDITY: 48.741741 <LF>
STTS22H TEMP: 24.830000 <LF>
STHS34PF80 MOTION: 127 <LF>
STHS34PF80 PRESENCE: 127 <LF>
STHS34PF80 TEMP: 1.000000 <LF>
LIS2DU12 X-Acc: 600 <LF>
LIS2DU12 Y-Acc: -113 <LF>
LIS2DU12 Z-Acc: 791 <LF>
SHT40 TEMP: 24.503319 <LF>
SHT40 HUMIDITY: 51.999542 <LF>
STTS22H TEMP: 24.799999 <LF>
STHS34PF80 MOTION: 5787 <LF>
STHS34PF80 PRESENCE: 6068 <LF>
STHS34PF80 TEMP: 4.000000 <LF>
LIS2DU12 X-Acc: 753 <LF>
LIS2DU12 Y-Acc: -195 <LF>
LIS2DU12 Z-Acc: 483 <LF>
SHT40 TEMP: 28.340584 <LF>
SHT40 HUMIDITY: 59.062561 <LF>
STTS22H TEMP: 28.110001 <LF>
STHS34PF80 MOTION: 12800 <LF>
STHS34PF80 PRESENCE: 14418 <LF>
STHS34PF80 TEMP: 8.000000 <LF>
LIS2DU12 X-Acc: 775 <LF>
LIS2DU12 Y-Acc: -178 <LF>
LIS2DU12 Z-Acc: 497 <LF>
```

2. **Energy harvesting mode:**
   – Program the NUCLEO board with the firmware given.
   – Change the jumper configurations from the default continous mode to energy havesting mode.
   – The packet consiting of sensor data is visible on LoRa Gateway.

5 Schematic diagrams

Figure 21. STEVAL-HARVEST1 circuit schematic



6 Bill of materials

Table 1. STEVAL-HARVEST1 bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	2	BT1, BT2	Battery_Cell	iTen Battery	ITEN	ITX181250B
2	1	C1	SuperCap	Super Capacitor,1.2F, 3V	CORNELL DUBILIER	DSF125M3R0
3	2	C2,C4	C_Storage 3300uF	Storage Capacitor 3300uF	KYOCERA AVX	TLN6338M004R0055
4	4	C3,C5,C6,C7	C_Storage 3300uF	Storage Capacitor 3300uF	KYOCERA AVX	TLN6338M004R0055
5	4	C8,C11,C12, C15	10uF	Capacitor	Würth Elektronik	885012107010
6	4	C9, C14, C_Comp1, C_Comp2	100nF	Capacitor	Würth Elektronik	885012207016
7	4	C10,C13, C16,C17	100nF	Capacitor	Würth Elektronik	885012207016
8	2	CN7, CN10	Conn_02x19_Odd_Even	Morpho Connector	Samtec	SSM-119-L-DV-A
9	17	J2,J3,J4,J6,J7,J8,J9,J10,J11,J12,J13,J14,J15,J16,J21,J22,J23	Conn_01x01	Single Pin, Through Hole	Keystone Electronics	1030
10	1	J20	Conn_01x02_Pin	2 Pin Connector	Würth Elektronik	61300211121
11	9	R1,R17,R18,R19,R20,R21,R31, R32,R33	0R	Resistor	Würth Elektronik	560112120002
12	6	R4,R7,R26,R27 ,R28,R29	0R	Resistor	Würth Elektronik	560112120002
13	1	U1	SHT40	High-Accuracy, Ultra-Low-Power, 16-bit Relative Humidity and Temperature Sensor Platform	Sensirion	SHT40-AD1B-R2
14	1	U4	STHS34PF80, LGA 3.2 x 4.2 x 1.455 mm 10 L 0.5 mm	Low-power, high-sensitivity infrared (IR) sensor for presence and motion detection	ST	STHS34PF80TR
15	1	U3	STTS22H, UDFN 2 x 2 x .55 6 L PITCH0.65	Low-voltage, ultralow-power, 0.5 °C accuracy I²C/SMBus 3.0 temperature sensor	ST	STTS22HTR

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
16	1	U2	LIS2DU12, LGA 12 L 2.0 x 2.0 x 0.74 mm	Ultralow-power accelerometer with antialiasing and motion detection	ST	LIS2DU12TR
17	4	D1,D2,D3,D4	BAT60, SOD323	Small Signal schottkey Diode	ST	BAT60JFILM
18	1	J1,J5	AM-1815CA	Solar Panels & Solar Cells Solar Cells 3 V Glass Indoor	Panasonic	AM-1815CA

7 Board versions

Table 2. **STEVAL-HARVEST1 versions**

Finished good	Schematic diagrams	Bill of materials
STV$HARVEST1A (1)	STV$HARVEST1A schematic diagrams	STV$HARVEST1A bill of materials

1. *This code identifies the STEVAL-HARVEST1 evaluation board first version.*

8 Regulatory compliance information

Notice for US Federal Communication Commission (FCC)

For evaluation only; not FCC approved for resale

FCC NOTICE - This kit is designed to allow:

(1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine

whether to incorporate such items in a finished product and

(2) Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

Notice for Innovation, Science and Economic Development Canada (ISED)

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

Notice for the United Kingdom

This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK S.I. 2012 No. 3032).

Revision history

Table 3. **Document revision history**

Date	Revision	Changes
30-Jul-2025	1	Initial release.

Contents

List of tables

List of figures