Getting started with the STM32Cube function pack for IoT sensor node with cellular connectivity enabling IOTA Distributed Ledger Technology (DLT) functions

Introduction

FP-SNS-IOTA1 is an STM32Cube function pack which lets you enable IOTA DLT functions on an IoT sensor node with cellular connectivity.

The function pack implements and demonstrates IOTA DLT use cases for the STM32 MCUs.

The IOTA DLT is a transaction settlement and data transfer layer for the Internet of Things (IoT) IOTA for money and/or data transfer without any transaction fees in a trustless, permissionless and decentralized environment.

The featured use cases acquire sensor data and send them to the IOTA Ledger (also called Tangle) via LTE cellular connectivity.

RELATED LINKS

Visit the STM32Cube ecosystem web page on www.st.com for further information

1 FP-SNS-IOTA1 software expansion for STM32Cube

1.1 Overview

FP-SNS-IOTA1 is an STM32 ODE function pack and expands STM32Cube functionality.

The software package shows how to enable IOTA DLT functions on an IoT sensor node with cellular connectivity.

The key package features are:

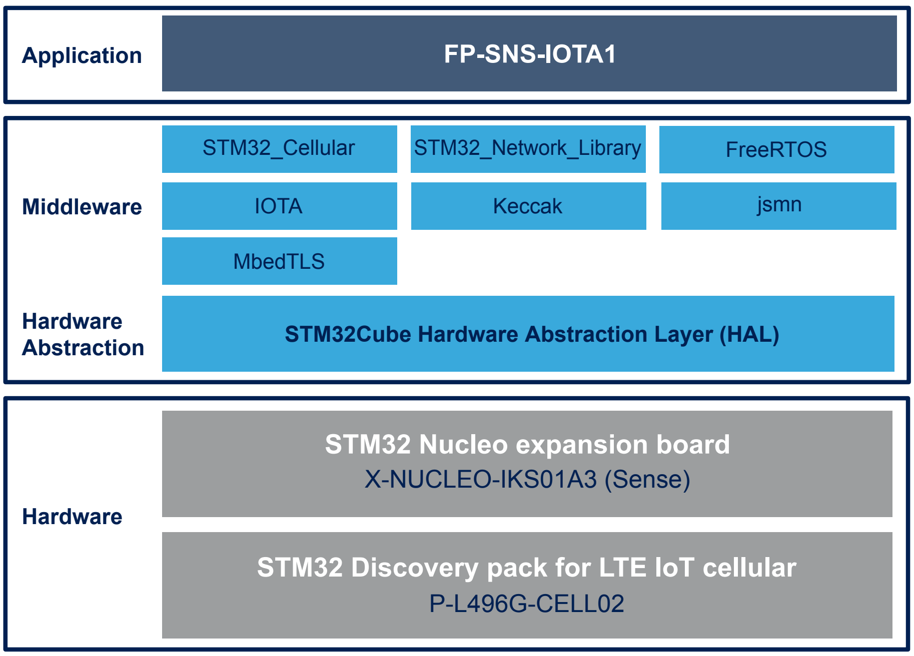
- Complete firmware to build IOTA DLT applications for STM32-based boards
- Middleware libraries featuring cellular management, transport-level security (MbedTLS) and IOTA cryptography management
- Ready-to-use binary to build IOTA transactions including sensor data and to send them to the Tangle via LTE connectivity
- Sample implementation available for 32L496GDISCOVERY Discovery board equipped with the P-L496G-CELL02 STMod+ cellular expansion board with antenna and the X-NUCLEO-IKS01A3 sensor expansion board
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

1.2 Architecture

The application software accesses the X-NUCLEO-IKS01A3 and cellular expansion boards through the following software layers:

- the **STM32Cube HAL layer**, which provides a simple, generic, multi-instance set of application programming interfaces (APIs) to interact with the upper application, library and stack layers. It has generic and extension APIs and is directly built around a generic architecture and allows successive layers like the middleware layer to implement functions without requiring specific hardware configurations for a given microcontroller unit (MCU). This structure improves library code reusability and guarantees an easy portability on other devices.
- the **board support package** (BSP) layer, which supports all the peripherals on the STM32 Nucleo except the MCU. This limited set of APIs provides a programming interface for certain board-specific peripherals like the LED, the user button, etc. This interface also helps in identifying the specific board version.

Figure 1. **FP-SNS-IOTA1 software architecture**



1.3 Folder structure

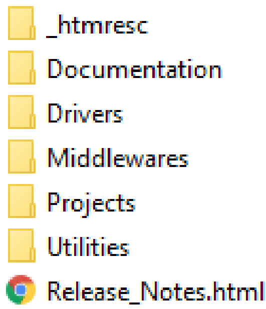


Figure 2. **FP-SNS-IOTA1 package folder structure**

The following folders are included in the software package:

- **Documentation**: contains a compiled HTML file generated from the source code detailing the software components and APIs (one for each project).
- **Drivers**: contains the HAL drivers and the board-specific drivers for each supported board or hardware platform, including those for the on-board components, and the CMSIS vendor-independent hardware abstraction layer for the ARM Cortex-M processor series.
- **Middlewares**: libraries and protocols featuring FreeRTOS, cellular management, transport-level security (MbedTLS) and IOTA cryptography management.
- **Projects**: contains a sample application implementing an IOTA Sensor Node. This application is provided for the P-L496G-CELL02 platform with three development environments: IAR Embedded Workbench for ARM, RealView Microcontroller Development Kit (MDK-ARM-STR) and STM32CubeIDE.
- **Utilities**: contains some complementary project files.

1.4 APIs

Detailed technical information with full user API function and parameter description are in a compiled HTML file in the “Documentation” folder.

1.5 Sample application description

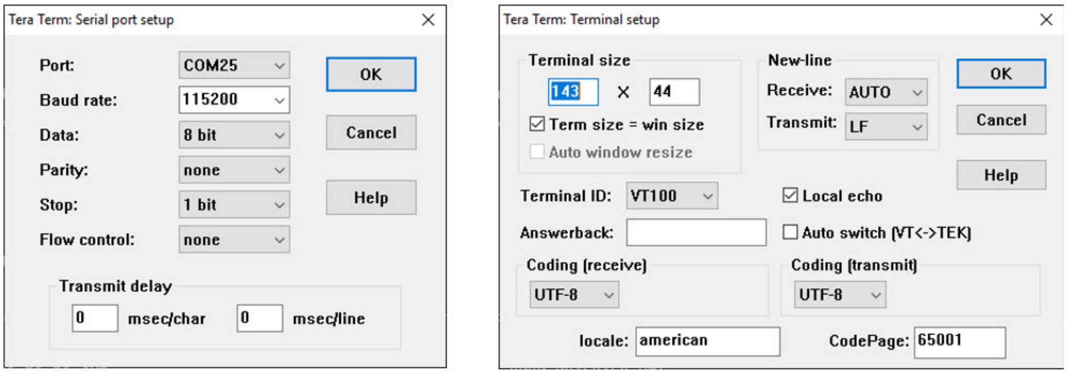
A sample application is provided in the Projects folder, using the X-NUCLEO-IKS01A3 and LTE IoT cellular expansion boards with P-L496G-CELL02.

Ready-to-build projects are available for multiple IDEs.

Before flashing the FP-SNS-IOTA1 firmware, it is necessary to register the P-L496G-CELL02 SIM card as described in UM2567 (freely available at www.st.com). Alternatively, you can use an external SIM and insert it into the micro SIM card socket. The software automatically detects your SIM and connect it to your local telecom service provider.

The user interface is provided via serial port and must be configured with the following settings.

Figure 3. **Terminal settings**



To run the FP-SNS-IOTA1 firmware, follow the procedure below.

Step 1. Open a serial terminal to visualize the log of messages.

Step 2. Enter your C2C network configuration (SIM operator access point code, username and password). with Emnify SIM, access point = "EM", username = "", password = ""

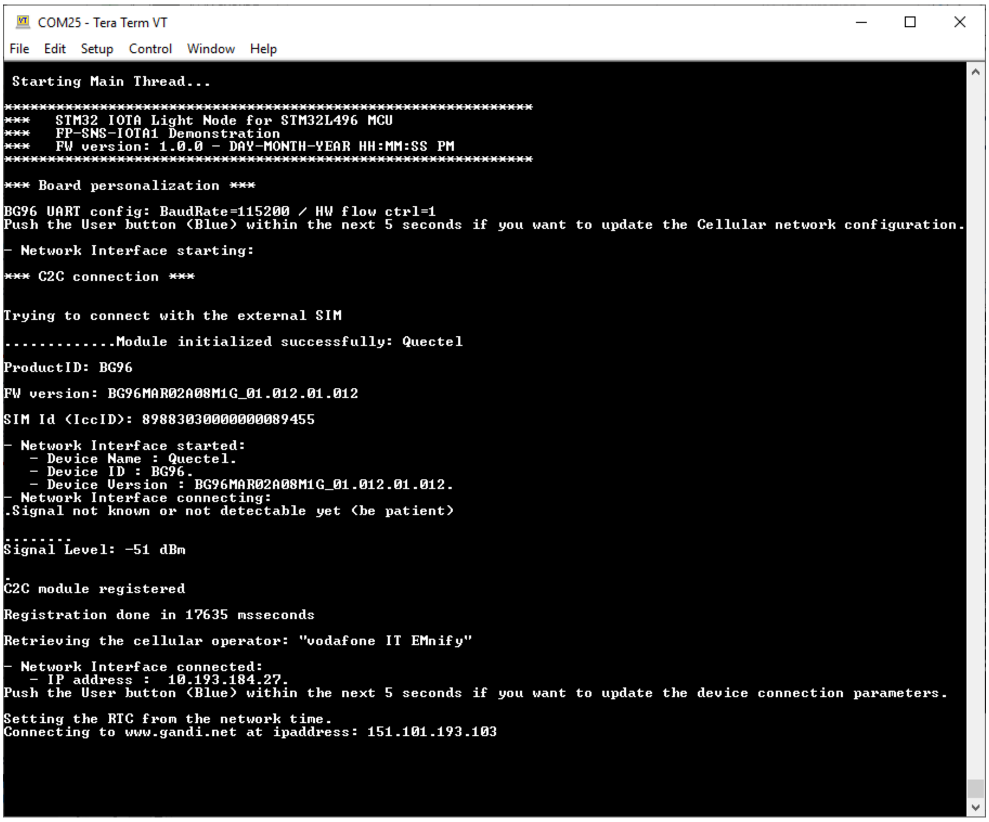
Step 3. Set the TLS root CA certificates.
The device uses them to authenticate the remote hosts through TLS.

Step 4. Copy and paste the contents of Projects\ST32L496G_Discovery\Applications\DLT\IOTA-SensorNode\usertrust_thetangle.pem.

Note: *After the parameters are configured, it is possible to change them by restarting the board and pushing the User button (blue button) within 5 seconds. This data will be saved in the flash memory.*

Step 5. Wait for the modem to be successfully initialized and in active state.

Figure 4. C2C parameter settings



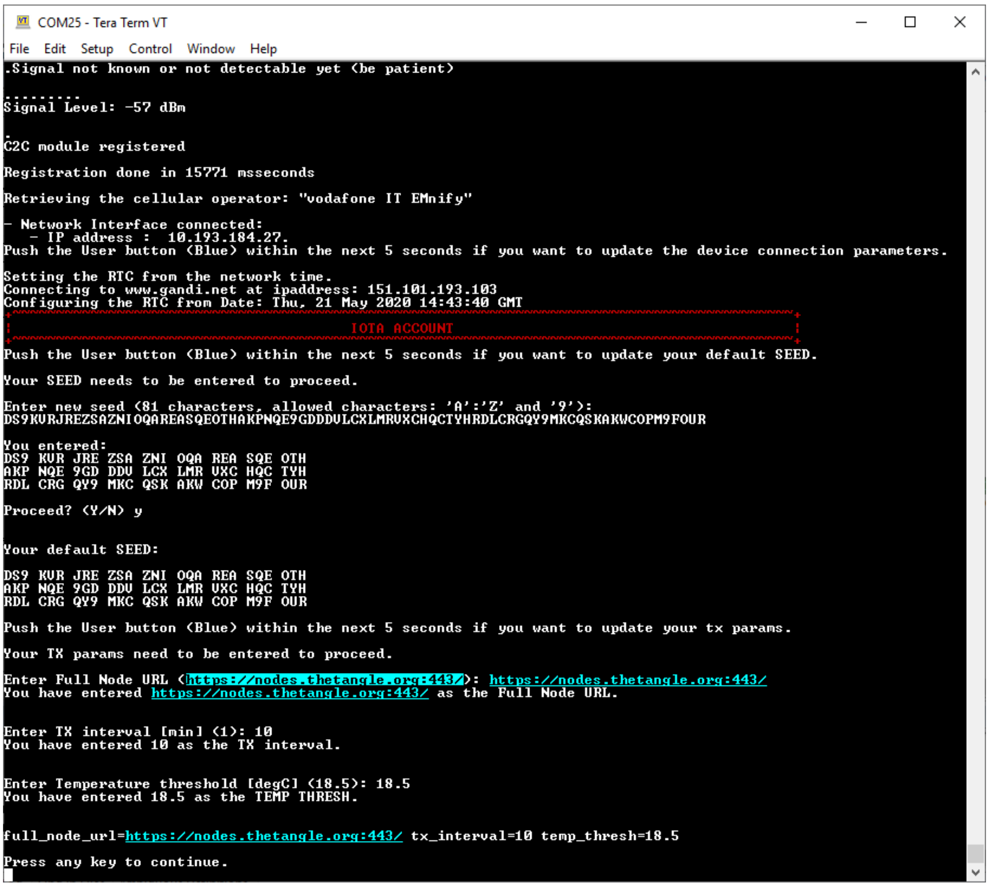
Step 6. Enter a seed (a character string, 81-character long, composed of only capital letters from 'A' to 'Z' and number 9) representing the IOTA account.

Step 7. Enter the IOTA transaction parameters (Full Node URL, tx-interval, and temperature threshold).

Note: After the parameters are configured, it is possible to change them by restarting the board and pushing the User button (blue button) within 5 seconds. This data will be saved in the flash memory.

Step 8. Wait for the message “Press any key to continue.” to appear.

Figure 5. IOTA parameter settings

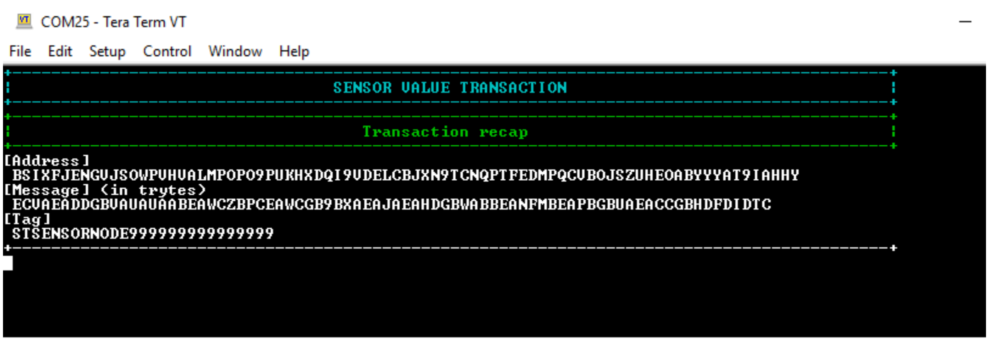


A new 0-value transaction will be automatically generated and sent to the Tangle every `tx_interval` minutes.

The transaction data include information about:

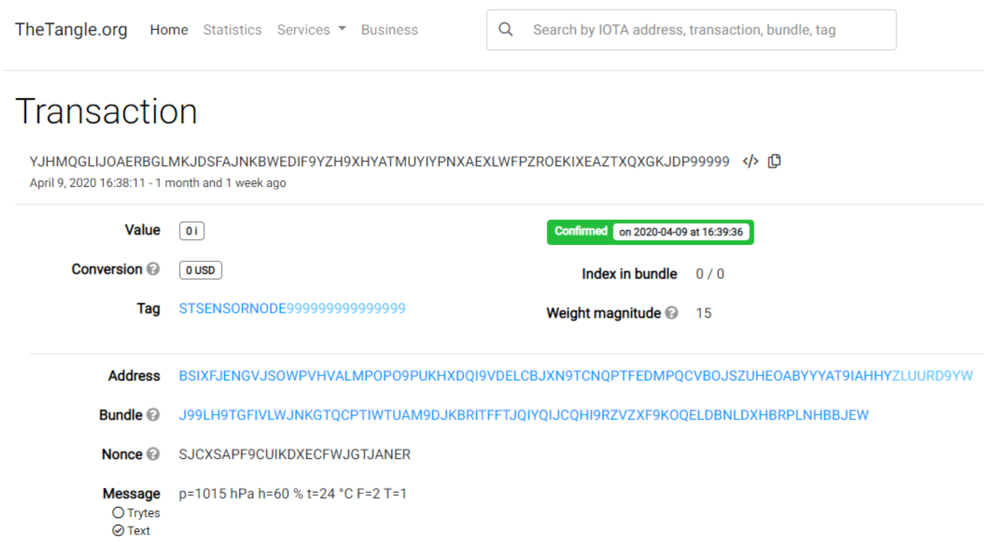
– pressure
– humidity
– temperature
– FreeFall counter - number of FreeFall events occurred during a `tx_interval`
– Temperature event - true if the measured temperature has overcome the configurable threshold during a `tx_interval`; false otherwise

Figure 6. IOTA transaction



Step 9. Check the status of the transaction on the Tangle Explorer website searching by IOTA address, transaction, bundle, and tag.

Figure 7. Tangle Explorer



2 System setup guide

The following systems are compatible with the FP-CLD-AWS1 function pack software for IoT nodes:
1. P-L496G-CELL02 Discovery Kit plus X-NUCLEO-IKS01A3 sensor expansion board.
2. B-L475E-IOT01A STM32L4 Discovery Kit for IoT nodes.

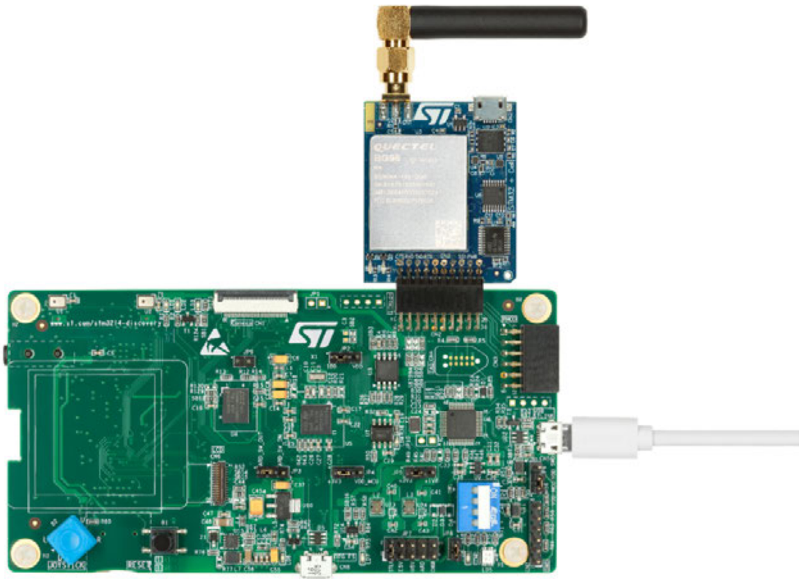
2.1 Hardware description

2.1.1 P-L496G-CELL02 discovery pack

The P-L496G-CELL02 STM32 discovery pack for LTE IoT cellular to cloud (STM32-C2C/LTE IoT) is a turnkey development platform for cellular and cloud technology-based solutions.

The discovery pack consists of the following boards:
1. An STM32L496AGI6-based low-power discovery motherboard with preloaded firmware (32L496GDISCOVERY). The microcontroller has 1 Mbyte of Flash memory and 320 Kbytes of RAM in a UFBGA169 package.
2. An STMod+ cellular expansion board with antenna. The expansion board features a Quectel BG96 worldwide cellular modem LTE Cat M1/Cat NB1/EGPRS module 300 kbps downlink, 375 kbps uplink.

Figure 8. P-L496G-CELL02 LTE cellular to cloud pack



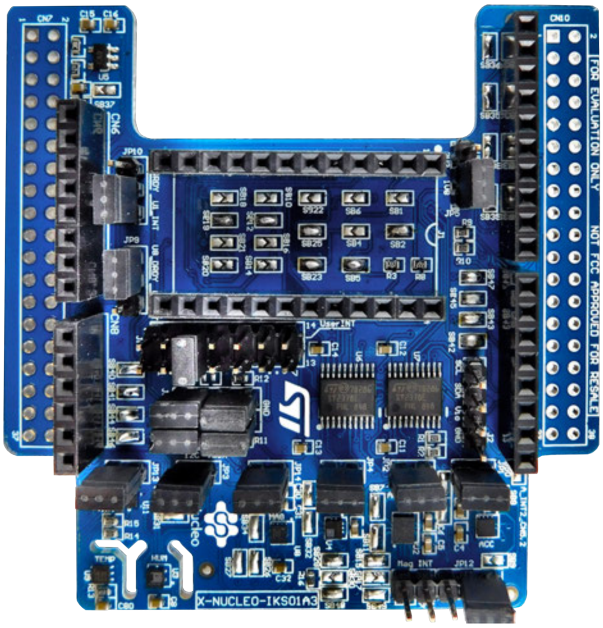
2.1.2 X-NUCLEO-IKS01A3 expansion board

The X-NUCLEO-IKS01A3 is a motion MEMS and environmental sensor evaluation board system.

It is compatible with the Arduino UNO R3 connector layout and features the LSM6DSO 3-axis accelerometer + 3-axis gyroscope, the LIS2MDL 3-axis magnetometer, the LIS2DW12 3-axis accelerometer, the HTS221 humidity and temperature sensor, the LPS22HH pressure sensor, and the STTS751 temperature sensor.

The X-NUCLEO-IKS01A3 interfaces with the STM32 microcontroller via the I²C pin, and it is possible to change the default I²C port.

Figure 9. X-NUCLEO-IKS01A3 MEMS and environmental sensor expansion board



2.2 Hardware setup

The following hardware components are needed:

1. One STM32 discovery pack for LTE IoT cellular to cloud (STM32-C2C/LTE IoT) (order code: P-L496G-CELL02)
2. One motion MEMS and environmental sensor expansion board (order code: X-NUCLEO-IKS01A3)
3. A USB type A to Mini-B USB Type B cable to connect the STM32 discovery board to the PC

2.3 Software setup

The following software components are needed to set up a suitable development environment to create applications for the 32L496GDISCOVERY board stacked to the X-NUCLEO-IKS01A3 and the LTE IoT cellular expansion board:

- FP-SNS-IOTA1 firmware and related documentation available on www.st.com/stm32cube
- One of the following development tool-chain and compilers:
  - IAR Embedded Workbench for ARM® toolchain + ST-LINK/V2
  - RealView Microcontroller Development Kit toolchain (MDK-ARM-STR) + ST-LINK/V2
  - STM32CubeIDE + ST-LINK/V2

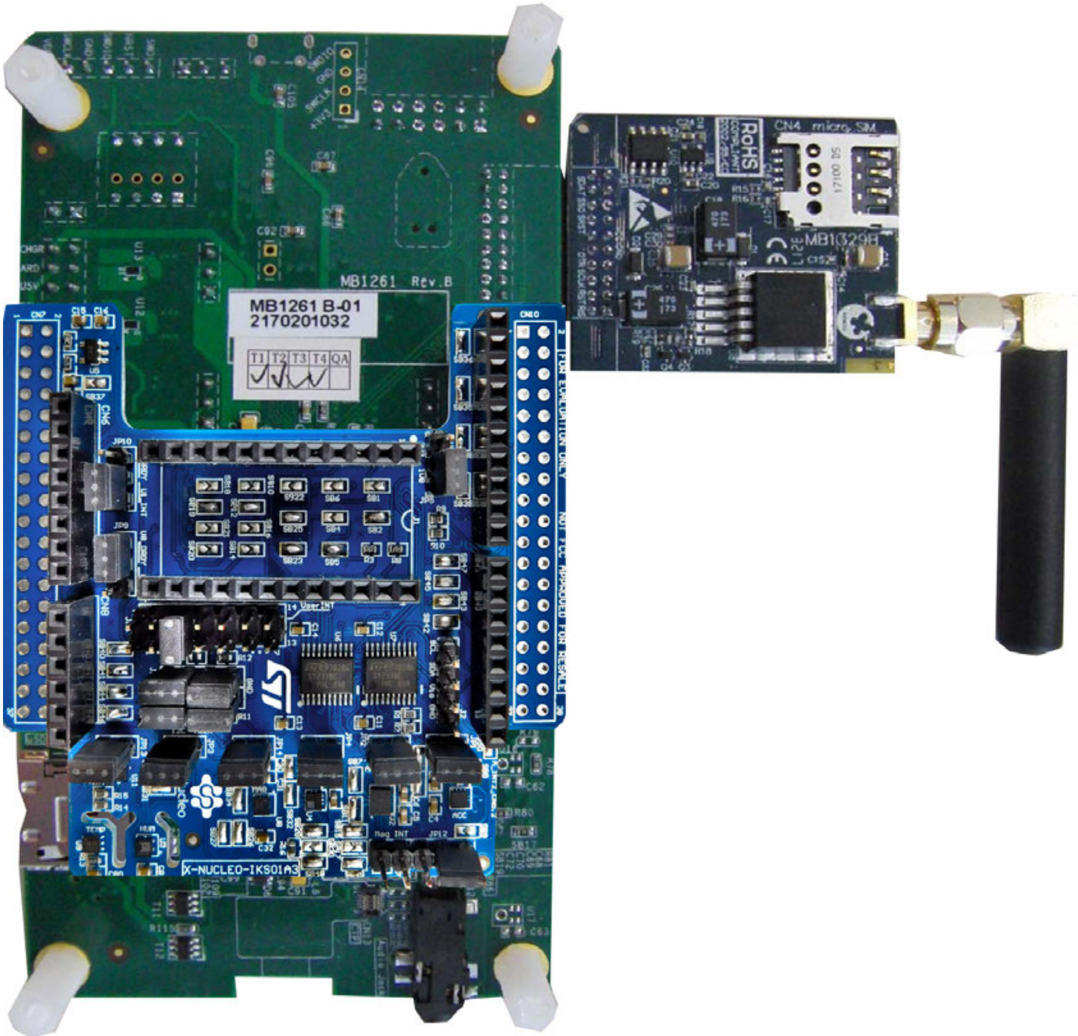
2.4 System setup

The 32L496GDISCOVERY board integrates the ST-LINK/V2-1 debugger/programmer. The developer can download the relevant version of the ST-LINK/V2-1 USB driver by searching STSW-LINK008 or STSW-LINK009 on www.st.com (depending on your Windows version).

The X-NUCLEO-IKS01A3 expansion board can be easily connected to the 32L496GDISCOVERY board through the Arduino UNO R3 extension connector. The board interfaces with the external STM32 microcontroller on the 32L496GDISCOVERY board using inter-integrated circuit (I²C) transport layer.

The Quectel BG96 modem expansion board can be directly connected to the 32L496GDISCOVERY board through the STMod+ port.

Figure 10. X-NUCLEO-IKS01A3 expansion board connected to P-L496G-CELL02 Discovery Kit via Arduino connector



Revision history

Table 1. Document revision history

Date	Version	Changes
25-Jun-2020	1	Initial release.
16-Nov-2020	2	Updated Section 1.2 Architecture, Section 1.3 Folder structure and Section 1.5 Sample application description.

Contents

1 FP-SNS-IOTA1 software expansion for STM32Cube 2

1.1 Overview 2

1.2 Architecture 2

1.3 Folder structure 3

1.4 APIs 3

1.5 Sample application description 3

2 System setup guide. 8

2.1 Hardware description 8

2.1.1 P-L496G-CELL02 discovery pack 8

2.1.2 X-NUCLEO-IKS01A3 expansion board 8

2.2 Hardware setup 9

2.3 Software setup. 9

2.4 System setup 9

Revision history 11

List of figures

Figure 1. FP-SNS-IOTA1 software architecture. 2
Figure 2. FP-SNS-IOTA1 package folder structure 3
Figure 3. Terminal settings. 4
Figure 4. C2C parameter settings 5
Figure 5. IOTA parameter settings 6
Figure 6. IOTA transaction. 6
Figure 7. Tangle Explorer 7
Figure 8. P-L496G-CELL02 LTE cellular to cloud pack 8
Figure 9. X-NUCLEO-IKS01A3 MEMS and environmental sensor expansion board 9
Figure 10. X-NUCLEO-IKS01A3 expansion board connected to P-L496G-CELL02 Discovery Kit via Arduino connector . . 10