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Monitoring the Discharge Voltage of Li-Ion Batteries in the UAV Component Through the Thingspeak IoT Cloud Platform Using LoRa

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Abstract
Along with the development of the concept of the Internet of Things (IoT), the number of devices that send data from sensors to the cloud of IoT platforms has also increased. In some areas or in rural areas the internet connection is non-existent or very weak. In this paper, the authors carry out a case study in which they use LoRa technology to transmit data from a sensor module that monitors the discharge voltage of a Li-ion battery from an Unnamed Aerial Vehicle (UAV) to ThingSpeak IoT platform cloud.

Keywords: *IoT, LoRa, ThingSpeak, Raspberry Pi, Li-ion battery monitoring.*

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I. INTRODUCTION

The Internet of Things (IoT) comes with the interconnection of things with each other for a collaborative purpose. IoT devices often collect environmental information from sensors, then transmit this data to the cloud to be stored, analyzed and then displayed. Along with the development of IoT, a series of cloud platforms have appeared that offer data storage, processing and visualization services. The most used platforms include: ThingSpeak, IBM Bluemix, Azure IoT, ThingWorx, Google Cloud Platform and AWS IoT. The main advantage of using IoT cloud platforms to analyze data sent from devices is data availability. The data can be accessed from any location on the globe where there is Internet access [1].

ThingSpeak is an open-source cloud platform that can be used to store, pre-process, analyze and visualize data from IoT devices [2]. The data stored in the cloud of the ThingSpeak platform can be analyzed with the help of the code written in the MATLAB language [2], [3]. The ThingSpeak platform can display real-time data through graphs. Among the possible applications of the platform suggested by the platform developer we can specify: air quality monitoring, energy monitoring and smart farms. In these applications, monitoring via sensors is sometimes required. Thus, objects are equipped with sensors and transmit data to the cloud to be stored, analyzed and visualized [4]. The devices are designed to have a reduced complexity so that they have a reduced energy consumption [5].

In hard-to-reach areas or in rural areas, the Internet connection is weak or non-existent. To facilitate IoT connections in these areas, Low-Power Wide-Area Network (LPWAN) technologies are used that facilitate communications over distances of 10 [km] to 20 [km]. Due to its immunity to interference and long communication distance, LoRa is one of the most widespread LPWAN technologies [5]. LoRa is a radio modulation technology owned by Semtech Corporation. For Europe the allocated frequency is 863-870 [MHz] and for the other countries the allocated frequencies are between 470 [MHz] - 925 [MHz]] [6], [7]. It uses the Chirp Spread Spectrum (CSS) radio modulation method to transmit data over long distances [6]. LoRa modulation defines the physical layer in the network stack while LoRaWAN is the protocol that defines the data-link layer and network layer in the network stack [6]. LoRaWAN has made new contributions to the field of IoT by favoring long-distance transmission with low power [7], [8]. The main advantage of this technology would be that LoRa allows bidirectional data transmission over long distances with low energy consumption. LoRa is one of the most used data transmission techniques in the field of IoT [8]. Due to the low bandwidth of about 5.5 [Kbps] a real-time voice or audio signal cannot be sent via LoRa. Making a comparison with other data transmission technologies we can say that technologies such as WiFi and Bluetooth are suitable for transmitting a large volume of data over short distances while LoRa allows the transmission of a very small volume of data over long distances [9]. There are three classes of LoRa devices, such as class A, B and C. The first two classes have low power consumption, they are battery powered and class C is mains powered [10].

In this paper the authors present a case study on the transmission of data from a sensor module that can be located in areas without internet coverage in the cloud of the ThingSpeak platform using LoRa technology.

The created system allows the transmission of data from the device that monitors the voltage at the terminals of the Li-ion battery within the Unmanned Aerial Vehicle (UAV), which can be in areas without internet coverage to the area with internet coverage in order to facilitate the transmission data in the ThingSpeak platform cloud.

II. REALIZATION OF LONG-DISTANCE CLOUD DATA TRANSMISSION SYSTEM

The electrical wiring diagrams used to transmit data from the module used to minorize the voltage at the terminals of the Li-ion battery in the UAV component to the ThingSpeak platform through LoRa transmission is shown in Figure 1.

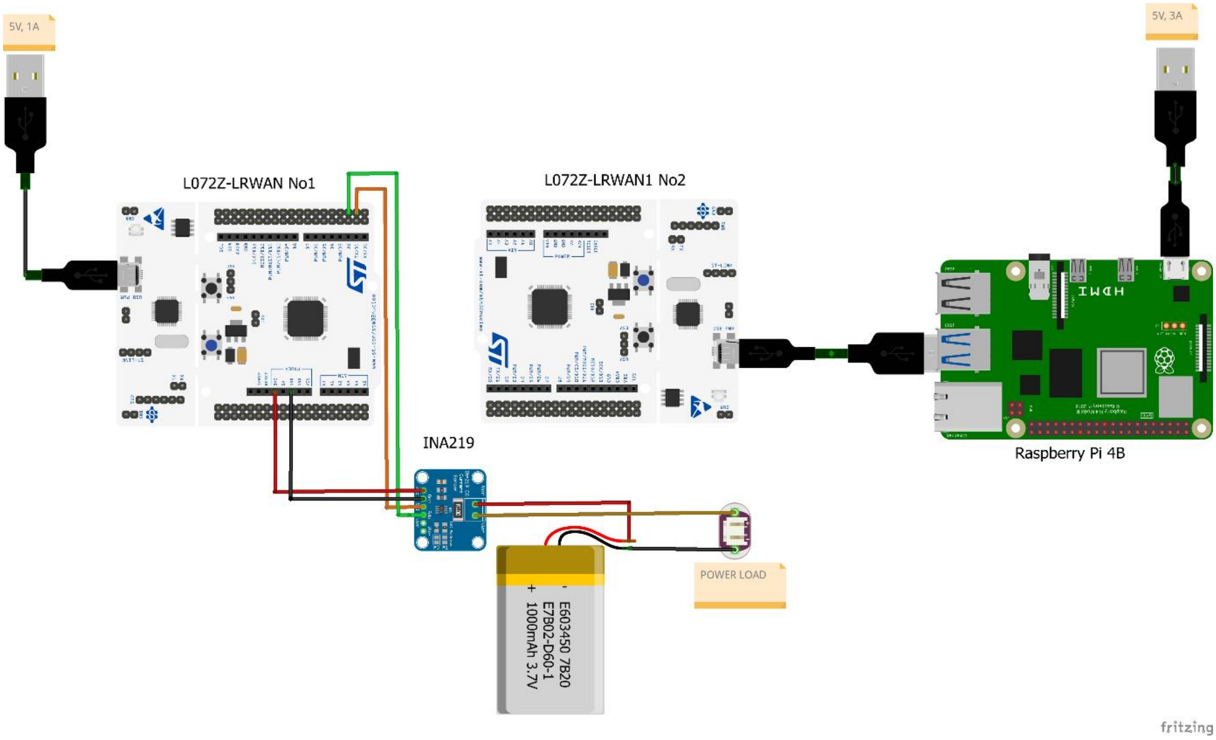

Figure 1: Electrical wiring diagrams used to monitor the voltage at the terminals of the Li-ion battery.

Within the electrical wiring diagram in Figure 1., the sensor module INA2019 measures the voltage at the terminals of the Li-ion battery and transmits it via the I2C protocol to the LoRa module L072Z-LRWAN1 no. 1. L072Z-LRWAN1 development board No. 1 sends the measured voltage value via LoRa transmission to L072Z-LRWAN1 development board No. 2. L072Z-LRWAN1 development board no. 2 receives the data and transmits it through the serial protocol of the Raspberry Pi 4. The Raspberry Pi 4 having a high storage capacity and processing power, pre-processes the data (removes outliers, fills in missing values, etc.) and stores it as a backup. Raspberry Pi 4 also has a role as a Gateway, through it the data is transmitted to the cloud of the ThingSpeak platform, using the WiFi module.

The INA2019 sensor module can measure a current in the range of ±3.2[A] and a voltage in the range of 0 [V] – 26 [V], its resolution is ±0.8[mA] and the maximum error is 1%.

The L072Z-LRWAN1 is a development board containing an STM32L072CZ microcontroller and an SX1276 LoRa transceiver module. The LoRaWAN™ stack supports the three classes A, B and C and the Sigfox™ stack is compatible with RC1, RC2, RC3 and RC4. It also has ADC, DAC, LP-UART, I2C and SPI [11]. The programming of the microcontrollers in the composition of the two L072Z-LRWAN1 development boards was done using the Arduino IDE.

Raspberry Pi 4 is a SBC. It has a Broadcom BCM2711 Quad core Cortex-A72 (ARM v8) 64-bit processor at 1.5 [GHz]; the amount of RAM depends on the 1GB, 2GB, 4GB or 8GB version; connectivity WiFi 2.4 [GHz] and 5.0 [GHz], Bluetooth 5.0, BLE; has peripherals such as: GPIO (40 pins), USB 2.0, USB 3.0, HDMI, MIPI DSI, MIPI CSI. The preferred languages of programmers to program this platform are Python and C++ [11], [12]. The program running on Raspberry Pi 4 was created in the Python 3.6 language and performs the reception, preprocessing, local storage and transmission of data in the cloud of the ThingSpeak platform.

HTTP or MQTT protocols can be used to transmit data from IoT devices to the ThingSpeak platform cloud [4]. In this work, the HTTP protocol was used to transmit the voltage value of the Li-ion battery from the Raspberry Pi 4 to the cloud of the ThingSpeak platform. ThingSpeak accepts data transmitted by IoT devices every 15 seconds [13]. ThingSpeak enables the transfer of data to the platform cloud via the data channel. The steps followed to set up a ThingSpeak channel were [4]:

Creating a ThingSpeak account at https://thingspeak.com/.

Create a ThingSpeak channel through the "New Channel" option, then fill in the „Name" field with the name of the ''Li-ion LoRa'' channel and the " Description" field with the channel description. Optionally, you an enter more details about the channel such as location, metadata, etc.

To send data to this channel, a unique key is needed, which can be obtained from the "API Keys" tab, then the "Write API Key"field.

ThingSpeak can support up to 8 data fields. Only one data field was used to transmit the voltage value from the terminals of the Li-ion battery in the UAV. The Python program running on Raspbery Pi 4 that handles data transfer to the cloud uses the urllib and httplib libraries and "Write API Key" to facilitate data transfer from the current sensor to the ThingSpeak platform cloud via the HTTP protocol. To view the graph of the variation of the voltage at the terminals of the Li-ion battery in the UAV composition in relation to time, in real time, it is necessary to access the channel created in the user's account [4].

III. RESULTS AND DISCUSSION

After the realization of the proposed system, the system is able to transmit the voltage from the terminals of the Li-ion battery in the UAV component to the IoT ThingSpeak platform cloud. An icon showing the variation of the voltage at the terminals of the Li-ion battery in the UAV component with respect to time is shown in Figure 2.

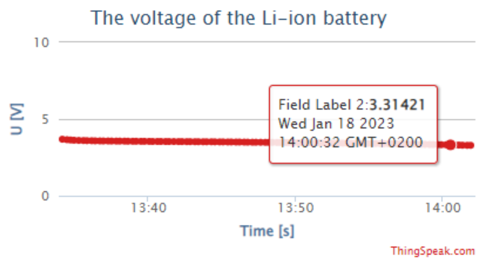

Figure 2: Variation of voltage with respect to time at the terminals of the Li-ion battery in the UAV component, ThingSpeak.

An icon with the interface of the program made in Python language running on Raspbery Pi 4 can be viewed in Figure 3.

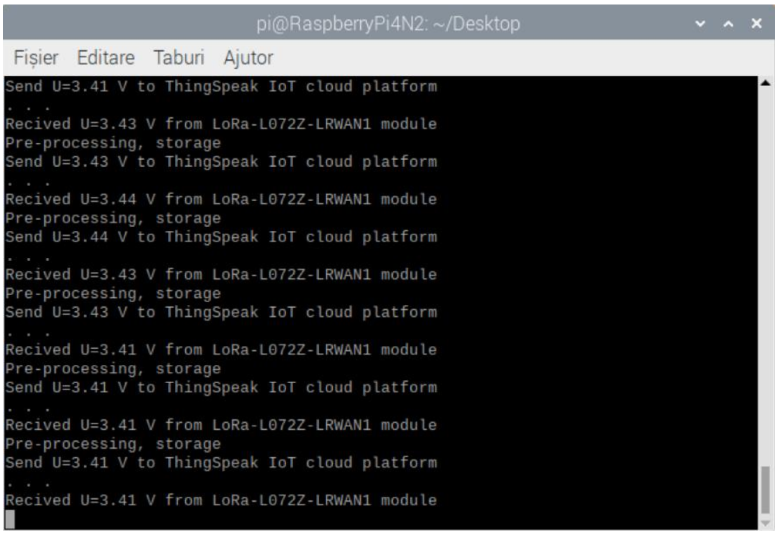

Figure 3: The program interface used by the Raspbery Pi 4 to transmit data to the ThingSpeak IoT cloud platform.

Within the icon in Figure 3. it can be seen how the application made in Python language on the Raspbery Pi device, transmits the voltage value from the Li-ion battery terminals of the UAV component every 20 seconds to the ThingSpeak IoT cloud platform.

IV. CONCLUSION

In this work, the authors propose a system that can be used to monitor the voltage at the terminals of the Li-ion batteries in the UAV by means of the ThingSpeak IoT cloud platform. The created system can transmit data from areas without internet connection. By using this system, operators can view the voltage at the terminals of the Li-ion batteries over several operating cycles. In further developments, the value of the current as well as the discharged capacity per discharge cycle will also be transmitted.

LoRa specifications define a physical layer that can be used for long-distance data transmission while LoRaWAN defines data-link layer and network layer in the network stack. LoRa has a low data rate but which is sufficient for this application, the ThingSpeak platform accepts new data every 15 seconds. LoRa transmission is suitable for use in areas where there is no or limited internet access.

ThingSpeak is an IoT cloud platform that can be used to store, process and visualize data transmitted by devices. Storing and processing data in the cloud is cheap compared to providing these services through local technologies.

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