2019 International Symposium on Lightning Protection (XV SIPDA), São Paulo, Brazil, 30th September – 4th October 2019.

AKUNU Status and Outlook

Gabriela Nicora
UNIDEF (MINDEF - CONICET)
UMI-IFAECI-CNRS 3351
Buenos Aires, Argentina

Marc Labie
IICT
University of Applied Sciences,
Western Switzerland
Yverdon-les-Bains, Switzerland

Juanita Fernández Ortega
Dept. of Electrical and Electronics Engineering
Universidad Nacional de Colombia
Bogota, Colombia

Marcos Rubinstein
IICT
University of Applied Sciences,
Western Switzerland
Yverdon-les-Bains, Switzerland

Félix Vega
Dept. of Electrical and Electronics Engineering
Universidad Nacional de Colombia
Bogota, Colombia

Farhad Rachidi
EMC Laboratory
Swiss Federal Institute of Technology (EPFL)
Lausanne, Switzerland

Vernon Cooray
University of Uppsala
Uppsala, Sweden

***Abstract*—The AKUNU project is an international effort to design an inexpensive sensor network for the measurement of atmospheric parameters including lightning. The current AKUNU platform can record temperature, light, humidity and wind speed. In this paper, the AKUNU devices, both in their previous version and in their current state of development are presented and the current extension to the measurement of return stroke fields, as well as the deployment of the sensor network in Argentina for test purposes are described.**

Keywords—weather; electromagnetic field measurements; lightning location

I. Introduction

Atmospheric data are important for climate research, weather nowcasting and weather forecasting. These data are collected nowadays using radar, satellite imaging or at ground-based weather stations. Although the latter are by far the least expensive (as long as atmospheric electricity data are not included), the cost of weather data collection systems for research purposes remains high and some countries struggle to find public or private funding to acquire them and operate them. If high quality lightning detection and location are included, the cost increases to prohibitive levels for many developing countries. It is these realizations that led to the initiation of the AKUNU project.

The main objective of the project is the development of a system to record atmospheric data including atmospheric electricity quantities at low cost. The development of a first version of the AKUNU platform was described in [1]. In this update, we report on the progress made as well as the first planned experimental deployment of the system in Argentina.

The paper is structured as follows: In Section II, we present a brief historical overview of the project. Section III is devoted to the current extension of the platform to include fast electric field measurements for lightning detection. Section IV describes the planned deployment in an area in Buenos Aires, Argentina. Finally, in Section V, general conclusions and the outlook of the AKUNU project are given.

II. Historical Overview

A. Original Idea During the XII Edition of SIPDA

In 2013, at the SIPDA Symposium in Belo Horizonte, Brazil, the idea of the development of an open system for the measurement of atmospheric physical quantities including lightning was floated by several researchers from developing countries or having ties to developing countries. The system to be developed would be used for scientific research, applied research and to aide in teaching and any other academic purposes. AKUNU means “lightning” in Singhalese.

The project members are members of the research and academic communities of Argentina, Colombia, Sri Lanka, Malaysia, Switzerland and Sweden.

B. Development of a first version of the AKUNU platform

A first version of the AKUNU platform was the result of a Bachelor’s diploma project.

The architecture of the system is shown in Fig. 1.

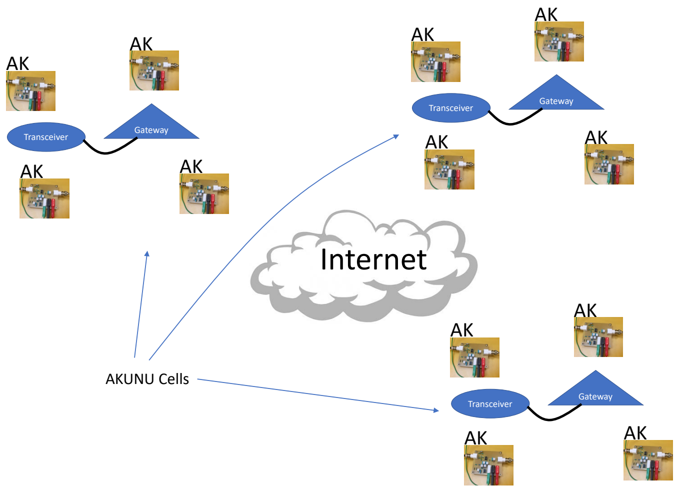

Fig. 1. AKUNU architecture (adapted from [1].

Several communication technologies were considered for the data transfer from AKUNU devices.

One of the candidate technologies is LPWAN (Low-Power Wide-Area Network technologies), which is actually a family of technologies operating in the unlicensed frequency bands, typically under 1 GHz [2]. They can transmit and receive messages over very long distances, up to 40 km. The data rates are of the order of a hundred bits per second and the transmissions occur only a few tens of times a day to conserve energy. LoRa, SigFox and Thread belong to LPWAN technologies. This option has been scratched from the current iteration of AKUNU due to the low effective throughput.

Several other technologies were contemplated and, for simplicity, the very first prototype used IEEE 802.11 protocol for its high bit rate, hardware availability setup simplicity, although the maximum distance was limited to a couple hundred meters.

Temperature, humidity and barometric sensors were used in the first AKUNU prototype, all of them available on the Adafruit's BME280 three-in-one board [3]. The sensor board is shown in Fig. 2.

An anemometer was also used to measure wind speed (see Fig. 3).

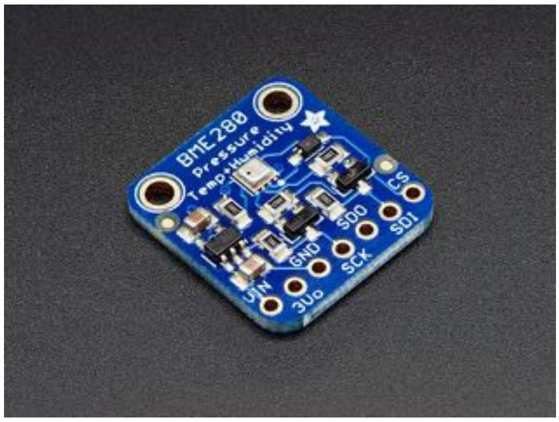

Fig. 2. Adafruit BME 280 sensor board.

Fig. 3. Anemometer.

III. ELECTROMAGNETIC FIELD SENSOR

A first prototype of an electric field sensor for lightning return stroke radiation in the first version of the AKUNU platform used a digitization rate of only 200 kSamples/s. Since the sensor itself had a bandwidth that exceeded the frequency limit set by the Nyquist criterion, aliasing was expected to occur. To solve this problem, a new digitizer that includes an anti-aliasing filter, an adaptation stage, buffering and GPS timing was used. In the following sections, we briefly describe each of these stages.

A. Integrator

The integrator, shown in Fig. 4, is a standard operational amplifier-based circuit with a T resistor network to obtain the desired time constant (of the order of 10 ms in Fig. 4) using standard relatively low resistors. The values of the components shown in the figure are only indicative of the version being simulated and tested at the time of the writing of this paper.

B. Digitizer

The analog-to-digital conversion for the electric field will be carried out using a digitization channel on a dsPIC33CH128MP502 microcontroller with a sampling rate of 2 Msamples/s. To avoid ailiasing, a Butterworth filter will be added before the digitization stage. The filter will be constructed using a standard Operational Amplifier circuit as shown in Fig. 5. The values of the components are not the actual values used.

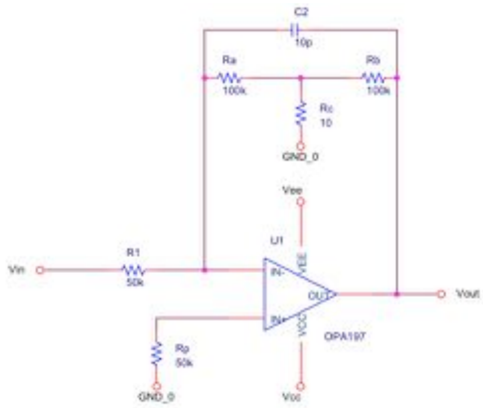

Fig. 4. Integrator used for the E field antenna.

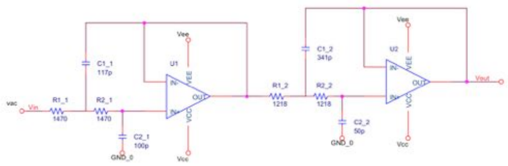

Fig. 5. Schematric diagram of the 4th-order Butterworth anti-aliasing filter.

III. Test Deployment

At the time of the writing of this article, development and planning and preparation are underway for a first in-situ pilot test that will be carried out in Argentina during the months of July and August 2019. The data collection and operations center will be established at the Institute for Scientific and Technical Research (CITEDEF) in the outskirts of the city of Buenos Aires. Three further sites will be equipped in research centers at locations separated by distances of about 10 km. The selected sites are the Dorrego headquarters of the National Meteorological Service (SMN), the School of Natural and Exact Sciences of the University of Buenos Aires (UBA) and one of CITEDEF's researchers' private residence. The locations of the sites are shown in Fig. 6.

The objective of the initial deployment and test is to study the performance from the point of view of resilience, accuracy and functionality with the aim of bringing to light aspects that require improvements related to the usability, accuracy, and reliability which will help define future work. Taking into account this objective, the decision was made to use the CITEDEF as operations center since it already has in its

Fig. 6. Installation sites for field test near Buenos Aires.

Fig. 7. Instruments on the roof of the CITEDEF electronics building.

premises atmospheric monitoring instrumentation (Fig. 7) that can be used to evaluate the performance of the AKUNU prototype. Besides the temperature, humidity and wind sensors, solar radiometers, a Capmbell Scientific electric field sensor and

Fig. 8. Ginkgo field-mill sensor.

a Ginkgo field sensor (Fig. 8) designed by the institute are also available. Although the latter three instruments will not be used in this phase of the AKUNU effort, the physical quantities they measure are being considered for future addition to AKUNU.

IV. Conclusions and Future Outlook

The AKUNU project aims at developing an open, inexpensive atmospheric sensor network for research and academic purposes in countries with limited resources. We described the AKUNU project and platform, including a historical account and the current effort to include a fast electric field sensor for the measurement of return strokes. We also described the upcoming deployment of the prototype in Buenos Aires, Argentina, where it will be tested against existing sensors.

Acknowledgment

The support of Dr. Hannes Pichler from Vienna University of Technology, Maurizio Tognolini, Blaise Grandjean and Steve Maillard of the HEIG-VD in the design and construction of the electronics is acknowledged.

References

[1] G. Nicora *et al.*, “AKUNU: Open Lightning Detection and Atmospheric Data Collection System,” 2018.

[2] P. Raj and A. C. Raman, *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*. CRC Press, 2017.

[3] A. Industries, “Adafruit BME280 I2C or SPI Temperature Humidity Pressure Sensor.” [Online]. Available: https://www.adafruit.com/product/2652. [Accessed: 06-Jun-2018].