A NEW RADIO MODULE FOR AN ANCIENT WEATHER STATION

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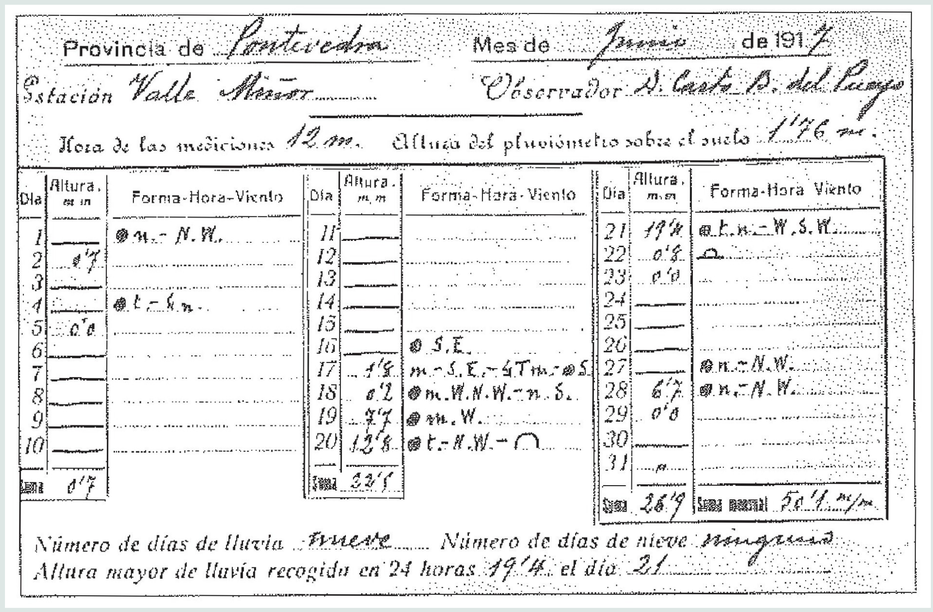
INTRODUCTION

This paper presents the process of updating of the automatic weather station at Escolas Proval High School (Nigrán, Spain). The weather station, that was created as early as 1917, was automated in 2005 with a radio module powered by solar energy that transmitted data to a remote server. Currently we are designing new electronic modules with better sensors and radio modules that will greatly improve the performance and transmission distance, opening the door to the acquisition of remote variables like sea water temperature or tidal range.

The meteorological history of Val Miñor (a region to the south-west of Galicia) starts in 1917 with the first measurements made at the school created and maintained by the Unión Hispano-Americana Valle Miñor (UHAVM), an association of galician emigrants to Argentina. The data were collected and sent by mail to the Spanish National Institute of Meteorology (INM). Many cards with the manuscript data are still conserved (Fig. 1).


Provincia de Pontevedra Mes de Junio de 1917
Estación Valle Miñor Observador D. Carlos D. del Campo
Hora de las mediciones 12 m. Altura del pluviómetro sobre el suelo 1'76 m.

Día	Altura m/m	Forma-Hora-Viento	Día	Altura m/m	Forma-Hora-Viento	Día	Altura m/m	Forma-Hora-Viento
1		@ n.-N.W.	11			21	19'4	@ t.-n.-W.S.W.
2	0'7		12			22	0'8	
3			13			23	0'0	
4		@ t.-l.-n.	14			24		
5	0'0		15			25		
6			16		@ S.E.	26		
7			17	1'5	m.-S.E.-4Tm.-@ S.	27		@ n.-N.W.
8			18	0'2	@ m.W.N.W.-n.-S.	28	6'7	@ n.-N.W.
9			19	7'7	@ m.W.	29	0'0	
10			20	12'8	@ t.-N.W.-∩	30		
						31		
Lms	0'7		Lms	33'1		Lms	26'9	Lms mensal 50'1 m/m

Número de días de lluvia Trece Número de días de nieve ninguno
Altura mayor de lluvia recogida en 24 horas 19'4 el día 21

Fig. 1: Card with meteorological data (1917)

Many years later, in 1980, the old building was reopened as a modern high school and Prof. Salvador Rodríguez Muñoz started a new meteorological project that sent also data to the INM. As the new school was mainly dedicated to vocational training (electronics and administration) it was a logical step to automate the measurements, a didactic project that started in 2005 and continues today. This project received an innovation award granted by the Instituto Enerxético de Galicia (INEGA) in 2007.

The elements of this first automation project (microcontroller, sensors, radio module) have been efficiently working for almost 20 years, but now they are a bit outdated and should be replaced. Several factors have been considered: the wide use of Arduino in programming education, the development of new digital sensors used in our teaching activities and the appearance of new communications modules, together with the development of the Internet of Things (IoT), that has greatly facilitated the transmission of information from remote acquisition systems, reaching distances of tens of kilometers with the most efficient modulations such as LoRa.

HARDWARE DESIGN

We have started the design of a new module (Fig. 2) compatible with the equipments used by the students in the practices of microcontrollers and programming subjects. This has allowed to create a compact, portable and multipurpose module that can be reused for teaching purposes.

For the definition of the hardware, we have taken as a starting point the requirements of the Cansat Challenge [8], an educational activity of the European Space Agency (ESA) in which we have participated during the course 2022-23.

MICROCONTROLLER

The new electronic scheme consists of an Arduino-compatible microcontroller such as the Atmega328P. The board has a connector that allows the code transfer from a computer via an usb cable. The use of this microcontroller grants access to a wide range of libraries, code examples and information from the Arduino ecosystem that will ease the development of the system.

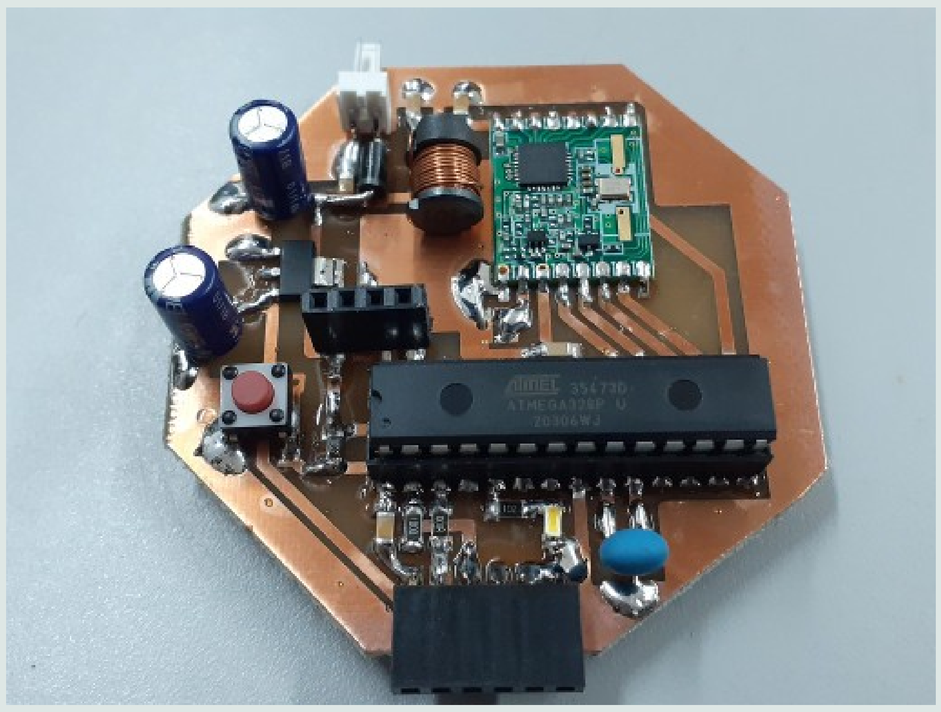


Fig. 2: New prototype of the system

TEMPERATURE AND BAROMETRIC PRESSURE SENSORS

The temperature and relative humidity sensors are an important part of any weather station. In the previous design we used the Sensirion SHT15, a sensor that provides both measurements with a good range of precision and error. For the new board we are planning to use new sensors like the SHT3x family, specifically the SHT35 that has a very low temperature and relative humidity error (± 0.2ºC in the range 0-100ºC and ± 1.5% RH).

For the barometric pressure measurement, the old board had a MPXA6115A analog sensor. This type of sensor had the problem of a high variability due to small changes in supply voltage, temperature or other factors. For the new design we have chosen a digital sensor like the Bosch BMP180/280.

RADIO MODULE

A wide variety of digital radio modules is available on the market for the free ISM frequency bands 433/868 Mhz (Europe) or 915 Mhz (USA). We would like to use FSK modulation but also LoRa modulation for long distance transmission. LoRa boards use Semtech circuits, so our new board will be based in one of this circuits like the SX1272 or SX1276.

We have chose the RFM95W module, because it allows to implement OOK, FSK, GFSK, MSK and LoRa modulations by simply changing the communication parameters. By these reasons we have chosen these modules for our system.

We have already made the first version of the boards for testing purposes, with all the components on one side of the board and the antenna and ground plane on the other side.

FIRST TESTS AND RESULTS

During the courses 2022-23 and 2023-24 we had made several tests, first with the FSK modules and last with the RFM95 LoRa modules. We used different types of antennas (like monopoles, patch antennas and commercial Yagi-Uda) and ground planes of different sizes to study their influence in the quality of communication and distance achieved.

The tests were made in FSK mode. The maximum distance achieved under these conditions was more than 2 km with continuous data reception. The typical distances for commercial modules are in the range of a few hundreds of meters (without directional antennas), so this data confirms the validity of our design. Fig. 3 shows the location of the transmitter and receiver for one of the tests and the measurement of the distance achieved. The tests have been made at Praia América in Nigrán, a coastal area with no obstacles and direct visibility between the emitter and the receiver.

Fig. 3: Distance test in Praia América (Nigrán, Spain)

The results of these tests show that the new elements of hardware can be used to improve the performance of the weather station, increase its working range and allow for a new distributed configuration with both local and remote sensors. In particular, we will continue the design to include new sensors and achieve the distance needed for the measurement of sea water temperature and tidal range with a GNSS (GPS-Galileo) receiver.

During the development of this system, we have made many activities with the students. They have collaborated in the design and assembly of the first boards and also in the antenna adjust and measurements (made with a RigExpert AA-600 meter) that have served to completely define the current configuration. Moreover, the centre has participated in the ESA CanSat 2023 Challenge [8], for which this system worked as a backup prototype.

In the next courses it is planned to carry out a program of activities with the students of subjects related to microcontrollers and communications, such as "Microprogrammable Equipment" or "Maintenance of Radio Communication Equipment", in which the students will make development of applications with microcontrollers, programming, handling of technical documentation and maintenance and repair of failures in microprogrammable and communications systems.