DESIGN AND CONSTRUCTION OF AN AGROMETEOROLOGICAL MONITORING SYSTEM USING APRS

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Abstract: This paper describes the design and the construction of a measurement and transmission system of the variables air temperature, relative humidity, soil moisture and precipitation, using APRS. It is described: the conditioning of sensors LM335 and HIH-3610, the instrumentation used to measure the humidity of the ground and the quantity precipitation; in addition, the operation of the control unit and processing, the module for codification AX.25/APRS and transmission AFSK/FM using the format of telemetry and position of the Automatic Position Reporting System (APRS). The module constructed allows the surveillance, local and remote of the agrometeorologic characteristics in situ, necessary to make decisions and to do actions focused to: to protect the cultivated zone of the abrupt changes of the climate, to experience new processes of farming development and to obtain a representative data base of microclimates of the monitored agrarian zone.

Keywords: Agrometeorology, APRS, Geolocation, Sensors, telemetry.

1. INTRODUCTION

The system that appears is a tool that improves the level of automation of the farming sector in Boyacá. It is a development that allows the constant remote observation of temperature (T), relative humidity (H.R.), soil moisture (H.S.), and the quantity precipitation (PCP), so that it is possible to be visualized in a virtual map the position of the station and the value of the measured magnitudes. In this way, the user of the system can know the agrometeorologic state of his agrarian zone, without having to move to the monitored zone and to establish together with a professional the implications, being generated the possibility of an immediate action.

It is important to stand out that the development of present agriculture and the animal production need the detailed and continuous knowledge of the elements of the climate, to obtain better results.

2. METHODS AND MATERIALS

The design of this module began for establishing the ranks of T, H.R. and PCP normally registered in the industrial runner of Boyacá. From data provided by the IDEAM it was established that the T oscillates, in this zone, between -8.8 °C and 28.6 °C, the H.R. between 41 % and 87 % and the total value monthly maximum of PCP is of 287.4 mm. The H.S. is measured normally of 0 % (totally dry) to 100 %.

Considered the nature variable of the climate it was defined to extend, reasonably, the rank of measurement of the sensors of the module, since it is possible appears greater or smaller magnitudes to the registered until december of 2003. Thus it was delimited to measure magnitudes in the following ranks: T from -15 to 35 °C, H.R. and H.S. from 0 to 99 % and PCP until 99 mm.

Some commercial alternatives of sensors for this type of applications were investigated, in companies like Davis Instruments, Met One Instruments, Campbell Scientific, Spectrum Technologies, etc. The cost was obtained and technical characteristics, the acquisition facility was analyzed, and it was decided to acquire and to arrange sensors LM335 and HIH-3610, this last one of the Honeywell Company.

Due to the high cost of the sensors for these applications experiment in the construction and instrumentation of a conductive-capacitive sensor with electrodes to measure H.S. and a rain collector sensor of balance - reed switch magnetic.

2.1. Construction of Sensors

H.S. Conductive-Capacitive Sensor. Is used the system soil-water like dielectric and a pair of stainless steel electrodes of 30 cm in length, separated equal distance using a similar structure to the employed by the humidity sensors of Dr. Calderón Laboratorios Ltda.

Rain Collector Sensor. The sensor consists of a rain collector structure formed by a canalized/filter funnel, located within a tank of 16.5 cm of diameter and 20.5 cm of high. Underneath the collector structure a bascule of two arms was located, each one with a bucket that accumulates 0.2 mm of rain. The base of the tank was perforated to generate the trickle that fills the bucket located in the superior part, which when filling turns upside down positioning under the trickle the other bucket.

2.2. Temperature Sensor LM335 Instrumentation

It was used the circuit of calibration proposed by the manufacturer, this circuit provides out 2.982V to 25 ºC, therefore the out signal is calibrated with a sensibility of 10 mV/°K. With the conditioning it was obtained a voltage output between 0 and 5V. Thus, zero volts indicate -15 °C, 1.5V indicate 0 °C and 5V represents 35 °C. As the sensibility of the sensor is 10 mV/°K, it makes sure that the voltage to -15 °C is of 2.58V and that 3.08V °C indicates a temperature of 35 ºC. The previous thing shows a span of 500 mV in the voltage output of the sensor, for the delimited rank of temperature.

A potentiometer was utilized to obtain a voltage of reference of 2.58V, with which to realize the difference of tension with respect to the tension output of the sensor. In order to condition the tension of 0 to 5V, it was used an instrumentation amplifier (A.I.) with gain of 10 in the differential amplifier basic of exit.
At the exit of the A.I. it was utilized an active low pass filter with slope of -20 dB/dec. and fc of 0,5 Hertz.

2.3. HIH-3610 Sensor Instrumentation

The sensor is feed with 5 Vdc, tension for which this calibrated by the manufacturer. The linear voltage output versus % H.R. is one of the most significant advantages that it has the HIH-3610, although with noise; for this reason, first it was conditioned with an active low pass filter, of -20 dB/dec., fc=0.08 Hertz and voltage ripple of 15 mV, followed of a difference amplifier for to condition the tension between 0 and 5 V.

2.4. H.S. Sensor Instrumentation

The soil-electrodes system is excited with sinusoidal signal of 1645 kHz and Vrms of 5.5V. The signal was generated with a Wien Bridge oscillator with amplitude stabilization (Millman, et al., 1993). Immediately, the signal pass by a class B Push-Pull amplifier that provides the necessary current to the system for a good sensibility, to this amplifier is connected like load the soil-electrodes system.

When increase the moisture of the soil decreases the tension and increases the current of the system. The change of tension is measured and amplified with an instrumentation amplifier, followed of an active low pass filter of fc 0.08 Hertz and a difference amplifier to obtain an exit between 0 and 5 V.

2.5. Rain Measure Instrumentation

A reed switch magnetic of glass blister opened normally was used; this closes by the action of a magnet each that turns upside down one bucket.

When is closed the magnetic switch is polarized the base of a NPN transistor that allows the passage of a pulse of 5V of amplitude towards the microcontroller of the control unit.

2.6. Digital Conditioning and Acquisition Control Unit.

This unit was designed and programmed using a PIC 16F877, which offers the resources necessary to perform the following tasks:

- Automatic acquisition of the signals of the transducers of T, H.R., H.S. and PCP each that is finished a period of programmed time or when the user, in field, requires.
- Conversion of the analogical signals of T, H.R. and H.S to digital words with 10 bits of resolution.
- Execution of firmware programmed for the conversion to Celsius degrees and percentage in the ranks delimited.
- Execution of firmware programmed that allows to the visualization of the magnitudes measured on a 2 LCD of x16 characters.
- Execution of firmware programmed for transmission RS232 to 1200bps, towards the AX-25 coder, each that takes samples.

The unit acquires the T, H.R. and H.S. by means of the input channels of A/D conversion AN0, AN1 and AN4 respectively. The A/D Converter of the PIC was fed externally between 0 and 5 V across AN2 and AN3, this to guarantee stability in the resolution of each bit result of the conversion, that is of 4.883 mV/bit.

The user of the equipment can acquire the agrometeorological information, in field, pressing a button, this task is made by means of the detection of interruption by RB0/INT. Additionally, the system automatically acquires the variables each 10 minutes. In order to control this time is used a 555 timer/oscillator chip in astable multivibrator mode to 10 Hertz and TMR1 configured in counter mode. The clock of 10 Hertz it was connected to RC0 of port C and it increases with each ascending flank TIMER 1, when overflowing itself, it is generated an interruption that allows to acquire automatically the measured variables. The clock of 10 Hertz was used along with the TMR0 and a transistor 3904 like switch for the control of the Back light of the LCD, which remains ignited 45 seconds after updating the data.

After made A/D conversion, it was programmed a code block to obtain the units and the tens represented by the 10 bits. At first it was programmed the conversion of the 16 bits contained in registries ADRESH-ADRESL to BCD of five digits. To the justify to the left the result of A/D conversion, it has a decimal rank of 0 to 65472, ampler that when justifying to the right, this allows major facility to assign the value of the measured physical magnitude. The allocation of the magnitude of temperature and percentage was realized establishing in the first place the number of tens of thousands, of zero to six, and soon establishing the number of units of thousands, of zero to nine, equivalent to the measured magnitude.

2.7. APRS Codification Module

Later on the acquisition appropriation and storing of the variables T, H.R, H.S y PCP in the control unity, the design and construction of the transmission module was made. This module is in charge of the information coding under APRS protocol. The APRS system is a technology developed from the Packet Radio; one of data transmission ways to long distances most used by radio-amateurs and radio-experts since 1980. Bob Bruninga, the APRS creator, put it forward as a tactic strategy for emergency actions, moreover, the ability to interpret climatology and telemetry reports on real time accompanied with objects visualization on virtual maps, became the APRS system a technology of high expectations, facing a huge quantity of available applications taking into account the relation profit-cost; because it works with conventional radio systems.

A micro controller PIC16F84A was used as a APRS code device and the design of its firmware was based, as first, in the established parameters by the acquisition module for quantity and data formating, also for the speed of arriving to the coding module.

The basic structure of a coded frame under the AX.25/APRS protocol consists in: Sign flags, directioning field of origin and destination, control field, information field or user and frame checking sequence. The figure 1 represents the basic structure of a frame.

Flag	Address	Control	Info	FCS	Flag
01111110	112/224 Bits	8/16 Bits	N*8 Bits	16 Bits	01111110

Fig. 1. Basic Frame AX.25/APRS

The information of the directioning field was respectively AGROST as destination and ARGOS1 as origin, the segments of the identification of secondary station or digirepetition were unable to the connection of the meteorological module with the central station was made directly and repetition stations were not needed. The kind of information format APRS effectively used was the report of telemetry data because it has not any restriction of measurement unities for variables and its extension represent a lower scale processing than any other information format.

In general, the frame planning afterwards agrometeorologic data was completely stored in the PIC is the next:

T#X3X2X1,TEMP3TEMP2TEMP1,H.R3H.R2H.R1,H.S3 H.S2H.S1,PCP3PCP2PCP1,000,00000000

Frame Modulation. Mentioned before, the APRS (Briceño, 2005) technology uses conventional radios for voice transmission, then, the frame modulation must be regulated to frequencies inside the human hearing rank, which is from 300Hz to 3300Hz.

The AFSK modulation has been used by the developers of APRS equipment. Normally exist modulation and demodulation devices (MODEMS), specialized in interpretation of AX.25/APRS data, they are also called TNC (Terminal Node Controller), although, their commercialization are very few carrying an expensive importation, for that reason became necessary the use of another component which were easier to get, but also carried out the AFSK modulation of the coded frames. Then MX614 by CML Microcircuits was found, it is able to modulate AFSK in the standard Bell 202, leaving the audio frames ready to be transmitted by the transceivers.

APRS Software. UI-View32 is one of the most known distributions for the Radio packages management, it contains an excellent tool for the interpretation of telemetric data which can be modified or personalized in the variable name, measurement unities and escalization coefficient. This ability joined with the possibility of use a sound card as an interface XMODEM and Geo-localization of objects on virtual maps, are crucial facts for use it in the development of the data reception phase.

The undertaking of monitoring must be accompanied with the ability of making historical reports, based on the permanent observations already done. The APRS system in its philosophy includes the possibility of keep in a safe and automatically way the whole kinds of report formats. That is how all the frames with agrometeorologic information were stored, labeled and dated for later on be analyzed in a file of TXT format, which allows free manipulation. The figure 3 lets see the visualization of agrometeorologic telemetry data and the position of the station on a virtual map.

Owing to the radio localization tools, it was possible to place the station which was agrometeorologic data, transmitted on a Geo-referenced map, in the way that data analysis kept in mind the spatial and temporary variables.

3. RESULTS

The magnitudes of temperature and relative humidity were contrasted and calibrated in Sogamoso town, thanks to the information given by the web page www.espanol.weather.com. In this web site the climatic information gets updated each hour through the information of satellite images so, long prove periods were required for get the right point of the module.

Fig. 2. Agrometeorologic station built

Fig. 3. Data visualization, on a virtual map of the Sugamuxi valley seen since the EARTHSAT satellite of Google Earth

According to the module of acquisition and transmission, the agrometeorologic data transmission was possible to go up to an approximated distance of 4 Km, but usually that distance is not covered by a wireless commercial station. Although some others can go over that distance by using WI-FI technology, rising the transmission cost even doubling it more than necessary whether were used the APRS system.

Looking at the reliability and efficiency of the gotten data in the central station, can be assumed that the system of transmission of agrometeorologic variables is effective in 100 % under line conditions, optimal view and rainless. Figure 2 show a detail of the built structure.

4. CONCLUSIONS

The exhaustive research about several kinds of agrometeorologic stations has certainty concluded that the acquisition and transmission of the module (ARGOS) already built, has been the first implementation of the APRS system applied for monitoring facts in the world. It allows obtaining a representative data base of micro-climates for the monitored zone agrarian.

The main advantages of the built module with regard to the commercial alternatives are: the design characteristics which the ARGOS system was built are based on the typical conditions of the department of Boyacá, then, the fact of being an own tool for specific conditions, gives a local technical support.

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