A Proposal of an Energetic Monitoring and Automation System for the School of Science and Technology Building of UFRN

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***Abstract*—The purpose of this work is to create a centralized interface to allow the monitoring and managing of an educational building's cooling system. The intent is to reduce the energy consumption making the building more energy efficient. The graphical interface was designed using a prototyping software and the communication is done from the operation center to the classroom terminal via Ethernet protocol. A microcontroller system transmits the commands to the air conditioner units via infrared as a normal remote control, requiring no modification of the equipment itself, widely facilitating the implementation of this system.**

***Index Terms*—Energy efficiency, automation building, temperature control.**

I. Introduction

The growth of a country is directly related to the expansion of activities in primary, secondary and tertiary sectors, resulting in increased power consumption [1]. To meet this growing demand, there is a need for increased production and improved electrical system infrastructure, all of which run into large financial investment and environmental and structural constraints [2][3]. Then, the search for greater efficiency in energy consumption is becoming increasingly important as a way to allow the country's sustainable growth.

It is known that users tend to be more economical in the use of electricity when they have access to more detailed data on power consumption [4]. Furthermore, projects performed previously show that through the cooling system control is possible to obtain a reduction of up to 36% in the consumption of electric power [5]. Moreover, previous studies indicate that savings of up to 15% spent on electricity through demand analysis process are possible [6].

This paper aims to present the energy efficiency project of the School of Science and Technology (ECT) of Federal University of Rio Grande do Norte (UFRN), which seeks to obtain a reduction in electricity consumption by more detailed data collection on consumption and cooling system control of the ECT's auditoriums.

II. The School of Science and Technology of UFRN

The School of Science and Technology of the UFRN offers the Bachelor degree of Science and Technology (BC&T), which is the course with more students in the campus.

In 2014, the Natal city Campus offered through SISU (Unified Selection System) 5826 places to undergraduates, from which, 1120 only to BC&T. It means that in 2014 this particular degree was responsible for 19% of all the students of the university.

Fig. 1. ECT building outside view.

The school structure benefits students, professors and staff with laboratories, auditoriums, rooms, etc. Due to the size of that building, there is a considerable number of air conditioner units and actions in the direction of improving the energy efficiency are welcomed.

A 1000kVA power capacity sheltered substation supplies the school and indicates the need to study and implement solutions that lead to an optimization in the energy consumption and then a decrease in the electric bill.

III. The Monitoring System

The proposal is to implement a system capable to monitor the auditoriums of the ECT in order to identify whether these places are occupied or not and what is the current temperature inside them. From this data, as well as the information obtained through the three-phase power meters to be installed in the ECT, the system should be able to control the air conditioner units so that to obtain the best relation 'Thermal Comfort x Power Consumption'.

The air conditioner units present in the ECT auditorium will be configured in the options ON/OFF, temperature, mode and speed by a communication system described in Section IV. The control of these units will be performed through the interfaces showed in Fig. 2 and Fig. 3.

Fig. 2. Interface for monitoring and controlling of ECT's cooling system – general view.

Fig. 3. Interface for monitoring and controlling the Auditorium 1's cooling system.

Through these interfaces, it is possible to configure the system for each of the auditoriums operates autonomously, situation in which algorithms through will set the air conditioner units' parameters to get the best 'Thermal Comfort x Power Consumption' relationship, or manually, where the system operator will be able to change settings freely. In addition, by the interface the operator may also look the auditorium's cameras to notice if these places are occupied or not.

IV. The Communication System

The communication of the entire system will be possible through three different technologies. The Operation Center communicates with the terminal in each auditorium through Ethernet protocol. This terminal will be able to communicate with the microcontroller responsible for each of the air conditioner units at auditorium via Bluetooth. It was used an Arduino to meet microcontroller's role. The communication between Arduino and air conditioner unit will be given by commands via infrared.

In Fig. 4 is possible to observe the block diagram showing the system described in the previous paragraph.

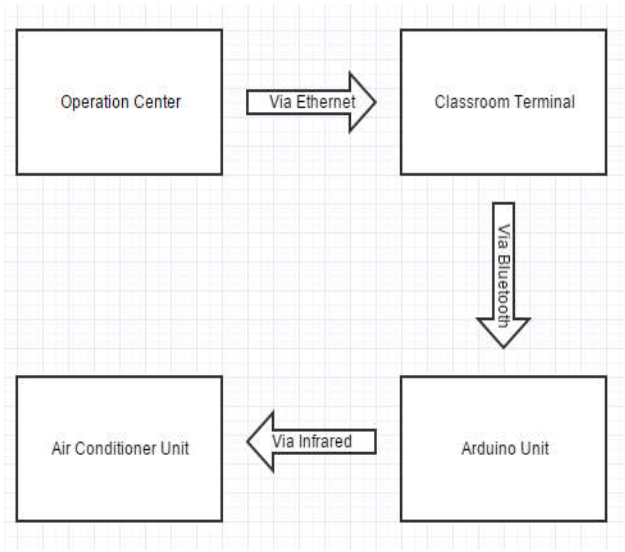

Fig. 4. Communication system's block diagram.

A. *Ethernet communication*

The choice of the Ethernet to perform communication between Operation Center and terminals of each of auditoriums occurred because it is a robust technology considering the distance between the communication points. The ECT's local area network will be used to realize this part of the project.

B. *Bluetooth communication*

Bluetooth communication was considered ideal to connect the auditorium terminal and the Arduinos that will set the air conditioner units because it is a wireless technology and is characterized by low power consumption. To make this possible an Ethernet/Bluetooth converter will be used at terminal of each auditorium as well as Bluetooth/Serial converters will be used at Arduinos.

C. *Infrared communication*

The communication between the air conditioner units and the controller is possible by the use of an infrared transmitter that sends the commands which specify temperature, speed and mode, working like a normal remote control.

It was used the same commands like in the original remote control. The Arduino libraries record the instructions sent by the remote original codes and later decode them.

To implement the interface it is necessary to understand the way in which communication between air conditioner unit and remote control works. When a button of the remote is pressed it sends a signal that consists in a string of bits represented by a PWM (Pulse Width Modulation) waveform, where each large space represents a bit 1 and each short space represents a bit 0. The pulses in the wave have all the same duration and are used to separate the bits. Instead of transmitting only the command assigned to the button that is pressed, like TVs remote controls, the air conditioner unit remote control sends a signal that contains all the important information to control the air, resulting in a long string of bits. The waveform can be seen at the Fig. 5, where we can notice the difference between 1's and 0's.

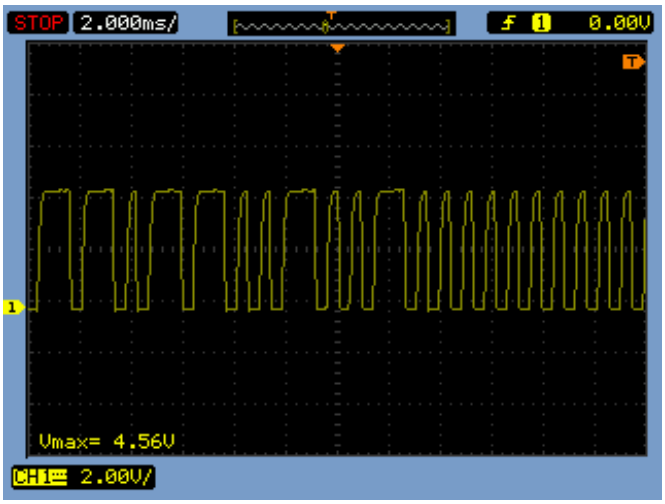

Fig. 5. Partial waveform of the transmitted signal.

To learn how the commands are coded by the remote control, it was used an infrared receiver to record several signals changing only one setting every time. With many signals recorded in binary form it was possible to identify which group of bits was responsible for each instruction. All signals have 112 bits, or 14 bytes. To ease the analysis, the string of bits was represented in a hexadecimal word. For example, the set of instructions that determines the operation mode "AUTO", a temperature of 22º C and a level 3 fan speed is represented by:

"C4D3648000241090A00000010053"

If is desirable to change to "FAN" mode, it is just send the following code:

"C4D364800024E090A00000010053"

It is possible to note that only the seventh byte changed (from 10 to E0). After repeating this process several times, it was mapped the following:

TABLE I. MAPPING BYTES

Parameter	Bytes responsible for
Turn On and Off	6
Mode	7
Temperature	8 and 14
Fan Speed	9

Knowing the procedure, it was built a simple transmitter using an infrared LED emitter and an Arduino board, the logic could be latter ported to a PLC or a cheaper circuitry, and there is also plans to integrate it into the larger system of monitoring.

V. PARTIAL RESULTS AND FUTURE PROJECTS

In this stage of the project, was developed the infrared interface for the communication between the air conditioner unit and an Arduino board, as well as an early version of the software interface that will be used to centralize all the information and control. Together, both software and hardware, it becomes capable of controlling an air conditioner unit automatically based in a set of rules accordingly to the room's temperature.

For future work, the goal is to expand the current proposal. In [5] there is an implementation of air conditioner control in order to maintain the thermal comfort of the environment and in [6] there is a demand control motion using fuzzy logic. Thus, a future proposal for this work is, based on data such as temperature, humidity, time, number of students and external temperature, using fuzzy logic in the temperature control of each auditorium, to ensure thermal comfort from more efficient use of energy.

Another future proposal for this work would be to make the building demand control using fuzzy logic. Consumer measurement data of electric energy of the building, carried out by a power meter, would be sent to a central Arduino. This Arduino would be responsible for controlling air conditioner units, turning off them or lowering its power consumption and, moreover, would communicate itself to a programmable logic controller (PLC) so there would be disconnections of other non-essential loads such as lighting sections.

Also would be possible, as a future project, the use of images from the cameras so there is automatic shutdown of air conditioners when the auditoriums are unoccupied. The ECT cameras are already adapted to record only when motion is detected in the environment, therefore, it is possible to adapt the shutdown of air conditioners to motion perception in the environment, ensuring that when the auditoriums are empty, there will be no waste of energy.

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