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DISEÑO Y DESARROLLO DE PROTOTIPO PARA AHORRO DE ENERGÍA ELÉCTRICA EN LAS AULAS DEL TECNOLÓGICO NACIONAL DE MÉXICO CAMPUS CONKAL

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Abstract: Design and development of a prototype that works by means of an on-off control with hysteresis, by means of an access key chain, the lighting, fans and projector are controlled on and off in a classroom. The objective is to make efficient use of electricity by reducing CO2 emissions at the Tecnológico Nacional de México Campus Conkal. In the methodology, a description of the devices used is made, the electrical diagram of connection to the prototype with the electrical network in the classroom and the flowchart is explained to carry out the Arduino programming of the central device that controls the ignition and off. As a result, the prototype of a low-cost device was obtained, with minimum dimensions and adequate management for its maintenance, managing to improve energy performance by reducing the inappropriate use of energy and consequently the reduction of the greenhouse effect, which leads to another benefit in the economic part and prolongs the useful life of the devices found in a classroom.
Keywords: Prototype, Design, Energy.

INTRODUCTION

We are experiencing the consequences of global warming of 1°C, with more extreme weather conditions, rising sea levels and shrinking Arctic sea ice, among other changes (United Nations, 2018). Organizations of all kinds contribute significantly to international greenhouse gas emissions (Robinson, Tewkesbury, Kemp, & Williams, 2018).

Higher Education Institutions (HEIs) generate very high socio-environmental impacts (Chiappetta Jabbour, Sarkis, López de Sousa Jabbour, & Govindan, 2013); They have very serious commitments to society. Depending on the size of the HEIs, the number of employees, students and vehicles, the amount of goods consumed and other complex activities, they are considered "small cities" with direct and indirect impacts (Tauchen & Londero Brandli, 2006).

HEIs seek to communicate sustainability in institutional terms through their mission, vision and values, plans and strategic objectives, as well as through sustainability activities and their concern for ethical issues (Aleixo, Azeiteiro, & Leal, 2018).

The performance and good environmental practices of HEIs may vary depending on their geographical location, size, local environmental conditions, ability to take advantage of opportunities, inter-institutional cooperation, ability to materialize associations with very different entities and other aspects (Veiga Ávila, Da Rosa Gama Madruga, & Beuron, 2016). Similarly, energy efficiency intervention studies have enormous benefits for society and the different energy sectors of the economy (Altan, 2010).

The 2030 agenda, among the seventeen objectives is affordable and non-polluting energy (objective 7), Mexico as a country signed said program promoted by the UN. The Tecnológico Nacional de México (TecNM) to be aligned with national policies, implements among its goals the certification of the Energy Management System (SGEn) under the ISO 50001: 2011 standard in 2017 in conjunction with CONUEE; sixteen campuses were certified in the multi-site modality, Conkal is one of them. And in January 2020 nine campuses are incorporated and an expansion certification is made under the ISO 50001:2018 standard, the objective of the EnMS is: "***To improve energy efficiency in all activities, through the uses and energy consumption of the TecNM, through a culture of saving and efficient use of energy, promoting awareness among staff, students and interested parties.***"

On the Conkal Campus, electrical energy is one of its significant energies, which is used in lighting, ventilation, computer equipment, etc. In the classrooms, laboratories, and workshops where the classes are held, the

lights, fans, and projector are generally left on when no one is using them, doors open with the air conditioning running, this results in an inefficient use of electrical energy, although there are signs and talks where everyone is invited to become aware of the importance of caring for and using electricity correctly, it is observed that it is in the classrooms where a lot of electrical energy is wasted. It is decided to design a device that controls the electrical energy in the classrooms, the organization obtains, among other benefits, better control of the electrical resource; academically, the students in collaboration with the ICT academy develop the prototype, this allows optimizing the financial resources of the campus.

During the last years, prototypes and applications have been developed to save electrical energy, either at home or in the industry, alternative energies are currently used, the most common being solar panels, wind energy. Some of the prototypes that have been implemented with renewable energies in [1] present a work aimed at reducing the consumption of electrical energy delivered by the conventional electrical network, through the use of photovoltaic solar energy. in [Rodríguez Igor 2011] they developed a power strip prototype that helped reduce the consumption of electrical energy caused by the equipment called electric vampires, for this purpose, the characteristics and consumption of these devices were studied once they enter the state of sleep mode. low consumption managing to detect when the equipment is in the standby state, to disconnect it from the electrical network automatically.

This paper presents the design of a prototype that will serve to save energy in the classrooms of the Tecnológico de México Conkal campus, ensuring that it is low cost, as well as easy to install and that the design is scalable to be able to build enough for all classrooms in the institute.

DESCRIPTION OF THE METHOD

The system to be developed must meet some characteristics such as having an interface, a protection module and an ON-OFF controller.

Speaking of the ON-OFF, or two-position controller, it can only switch between two values just like two states of a switch. The controller does not have the ability to produce an exact value in the controlled variable for a given reference value as the controller produces a continuous deviation from the reference value.

The action of the two-position controller has a simple construction mechanism, for this reason this type of controller is one of the most widely used, and commonly used in different control systems.

Hysteresis is defined as the difference between the controller turn-off and turn-on times. Using a two position action controller results in a simplification in circuit design.

One of the main devices in our system is a 13.56 MHz RFID key fob.

Another of the materials used for the construction of this prototype is shown in table 1, additionally a cabinet and the support to insert the card shown in figure 3 were needed.

arduino nano
relay module
SD card module
Limit switch
RC522 RFID module
RTC Module and Memory
Contactor 220V 50[a]

Table 1. List of main materials.

In this system, and in order to save energy, several options were analyzed, including locking the classroom after the end of the

class, but it was not viable because staff would be needed to attend to it. This way it was considered to use this electronic device which the teacher when using the classroom inserts this key ring and removes it when finished, this key ring together with the reader allows to supply electrical energy.

To understand the logic that was used to program the device, a flow diagram is presented in figure 1 where you can see the steps that are carried out to program the Arduino nano with the RFID key fob. As can be seen, everything leads to the control module, since this is the one that processes all the information that is in the input ports (RFID keyring), and directs them to the output ports (disconnection from the electrical network).

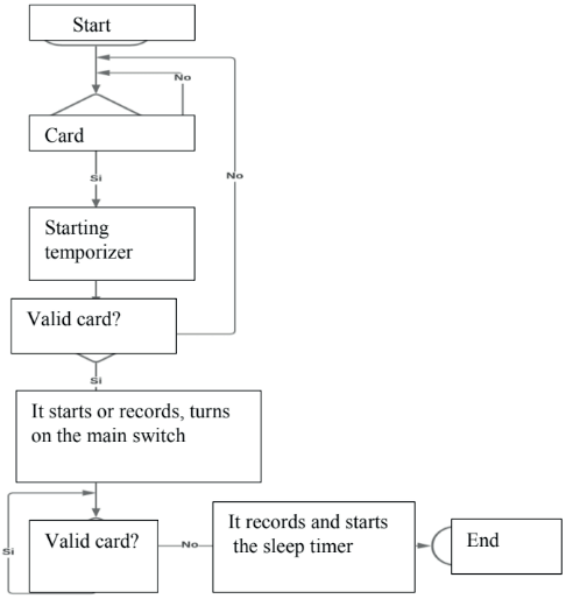

Figure 1. Flowchart of energy control using RFID card or key fob.

SUMMARY OF RESULTS

This system, see figure 2, works as an activated switch, the user inserts the key ring into the reader and the reader enables the switch, providing electricity to the classroom.

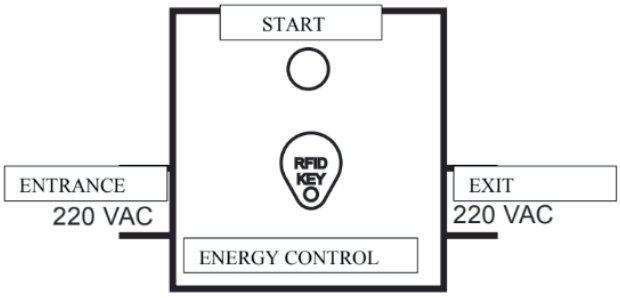

Figure 2. Energy control block.

When power is turned on through key fob validation, the date, time, and key fob ID are recorded. When the key fob is removed, the control stays on for 1 minute and then turns off, removing power to the classroom. When the power control is at rest, it does not consume electrical energy, this is because it cuts off the electrical energy itself, to use it you must press the start button, at that time the control remains on for 15 seconds waiting After inserting the key fob, inserting the key fob and being validated activates a power switch (contactor) inside, and keeps the starter relay energized that provides power to the power control. When the use is finished and the key ring is removed, the power control waits for the key ring for a minute. If that time elapses and it does not detect a valid key ring, it turns off completely, cutting off the electrical power in the classroom and the controller, thus This way it also saves electrical energy by not being turned on in standby mode.

Figure 3. Physical appearance of energy control with its RFID key fob.

In the case of the output interface, it is intended to download the data stored in an SD memory through an Arduino nano and it will be sent to a computer through bluetooth. These data can be used for statistics, such as classroom use and user identification. Being built with Arduino it has many possibilities for future expansion of features.

CONCLUSIONS

This document presents the design and development of an energy saving prototype where the main devices were an Arduino nano and an RFID key fob. It was possible to make a low-cost device, with minimal dimensions and adequate handling for its maintenance. The design was made so that its operation is simple and scalable, with the purpose of replicating the prototype in more classrooms, as well as its use in other types of scenarios for statistical purposes.

This device is currently in operation and the pertinent tests are being carried out to find out how much energy would be saved in the classrooms where it is installed. Finally, another benefit that is intended to be achieved with this prototype in the environmental ecological aspect, to ensure that energy is not wasted, managing to reduce the demand for its production and consequently the reduction of the greenhouse effect, this leads to another benefit in the part economical, since there is no waste of energy, it pays for lower consumption and prolongs the useful life of the devices found in a classroom.

Class	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
S1	07-14 = 7	07-15 = 8	12-18 = 6	07-15 = 8	07-15 = 8	08-14 = 6
S2	07-14 = 7	07-15 = 8	07-15 = 8	11-18 = 7	07-15 = 8	08-14 = 6
S3	09-14 = 5	07-15 = 8	07-14 = 7	07-15 = 8	12-17 = 5	08-14 = 6
S4	07-18 = 11	07-17 = 10	07-19 = 12	07-17 = 10	07-18 = 11	08-14 = 6
S5	07-15 = 8	07-14 = 7	07-14 = 7	07-15 = 8	07-11 = 4	08-14 = 6
Total of hours	38	41	40	41	36	30

Table 2. Relationship of class assignment versus group in classrooms with installed prototypes

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