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Welcome

This document presents the proceedings of the 2nd Symposium of Applied Science for Young Researchers - SASYR. This scientific event welcomed works by junior researchers on any research topic covered by the following three research centres: ADiT-lab (from IPVC, Instituto Politécnico de Viana do Castelo), 2Ai (from IPCA, Instituto Politécnico do Cávado e do Ave) and CeDRI (from IPB, Instituto Politécnico de Bragança). The main objective of SASYR is to provide a friendly and relaxed environment for young researchers to present their work, discuss recent results and develop new ideas. In this way, this event offered an opportunity for the ADiT-lab, 2Ai, and CeDRI research communities to gather synergies and promote collaborations, thus improving the quality of their research. The SASYR 2022 took place in a hybrid environment at Escola Superior de Tecnologia e Gestão of Instituto Politécnico de Viana do Castelo on the 22nd of June, 2022.

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Building of Smart Plugs to Energy Efficiency in the Residence Load Management

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Abstract. It is known that electrical energy consumption is higher during the day than at night.This is a challenge to balance the consumption levels because when the consumption is high at night, it does not have energy production to supply and the tariff usage is cheaper. Aspiring to avoid the users consuming too much electrical energy and work on this usage control during the night, the present work aims to develop smart plug modules that could self-manage power in residence utilizing the minimum of grid energy. In this sense, the modules may use the overproduction of energy coming from generator systems (such as photovoltaic panels), eliminating the necessity of battery usage. Sometimes, the power supply could provide different values of current, consequently, the use of this electric energy needs to adapt according to the production. Therefore, the final objective is to build an intelligent electrical management system that works on energy efficiency.

Keywords: Smart Plugs · Energy Efficiency · Renewable Sources.

1 Introduction

With the population growth and the technological development that has been seen in the last years [4, 10], turns increasingly intense and necessary electrical energy usage. However, many sources used for electricity generation own limitations in nature or/and are big carbon gas emitters. Furthermore, in 2015 a work made by the Brazilian Association of Energy Conservation Service Companies (ABESCO), a non-profit company focused to promote actions and projects aiming the development of the energetic industry, demonstrated that companies also are affected by energy waste. The report shows that approximately 10% of the energy generated in Brazil, a country predominantly supplied by hydroelectric, is wasted. This percentage represents 12.64 billion reais which 2.79 billion are from the commercials end-users, 5.51 billion residential end-users, and others from industries and less impactful end-users.

In case of Portugal, one of the biggest issues related in the last years is the energy poverty that has been verified through the high percentage of people exposed to the cold weather at their homes: 18,9% of the population meanwhile the European average is 7,5% related to the European Union Statistics on Income and Living Conditions (EU-SILC) [2] turning the cold weather one of the most critical living conditions. Another research about this topic has been realized by OpenEXP, a global network of independent experts that aims the implementation of the sustainable development goals [7],

that 24,9% of the deaths in the winter was because of the bad home conditions and puts Portugal in the 25th place of the poorest countries energetically with 36,7% in the scale of the European Energy Poverty Index Tool (EDEPI) [6].

Furthermore, with the increase of the Internet of Things (IoT) in so many applications aiming smart and efficient systems, is introduced in the industry the smart plugs, that are plugged with a supervisory and control of energy supply apparatus set by the user through an app or via Web.

2 Related Works

The smart plugs present in the industry cannot disconnect a load automatically, for example, [9]. They have only an on-off control and don't have a sophisticated supervisory system away as the user could determine the priorities of each load and a custom supervisory system.

Some research about smart plugs can be found in IEEE Xplore, for example, like [8], that proposes the elaboration of a smart plug that communicates through Wi-Fi connection, uses of ESP32 microcontroller as an information center, a relay as an actuator, voltage and current sensor to get the measures and all the control and supervision are made by a WebApp. This system can measure the instantaneous voltage, current, power, energy consumption, and electricity bills. It had a virtual button to turn on or turn off the plug via the app as an action.

In [1], a similar proposal has been applied, which is used the wireless protocol Zigbee. This work has developed smart plugs and a condition monitoring circuity, with the function of a group of all the information and communication with the plugs. This circuit is composed of sensors that aim to control the temperature of a refrigerator and the illuminance through two temperature sensors, one for the room and another for the fridge, and a luminosity sensor. Therefore, through an algorithm flowchart defined by the code, the system can handle the load actuation automatically.

From the point of view of self-consumption, the energy oversupply from photovoltaic panels usually comes back to the grid, and, in some countries, does not have a regulation of this energy aiming to utilize the maximum of the generated power. Concessionaires can apply taxes that could vary depending on the company [5] or, in the case of self-generation, which is disconnected from the grid, it is necessary high invest in batteries.

3 Research proposal

Trying to use the supply energy coming from the photovoltaic panels, it is interesting develop an smart plug capable to redirect this surplus energy to a load that needs to work constantly during this period and, when this surplus energy over, it can switch automatically to the conventional one. The plugs also could make decisions based on the tariffs during the day turning the bills more cheaper.

The main idea of this work for now is to develop the hardware part of the plugs whose power can be controlled remotely using IoT technologies by decision-making made by the user in a supervisory system. Then, considering the voltage is constant, the current

intensity is the variable to be controlled using a TRIAC (Triode of Alternating Current). Arduino UNO R3 could control this component, that is, the microcontroller could set the values of current that an electrical device can use. The measures will be sent to the microcontroller for each plug connected with an ESP32 node, grouping many plugs, which will send, via Wi-Fi, to a monitoring center made with another ESP32 to receive the data and manipulate it to show on a screen to the user all the status of the system and customize the levels of power. The focus now is on the development of the hardware of the plug and the software using the Arduino board that controls each plug as marked in the red square in Figure 1.

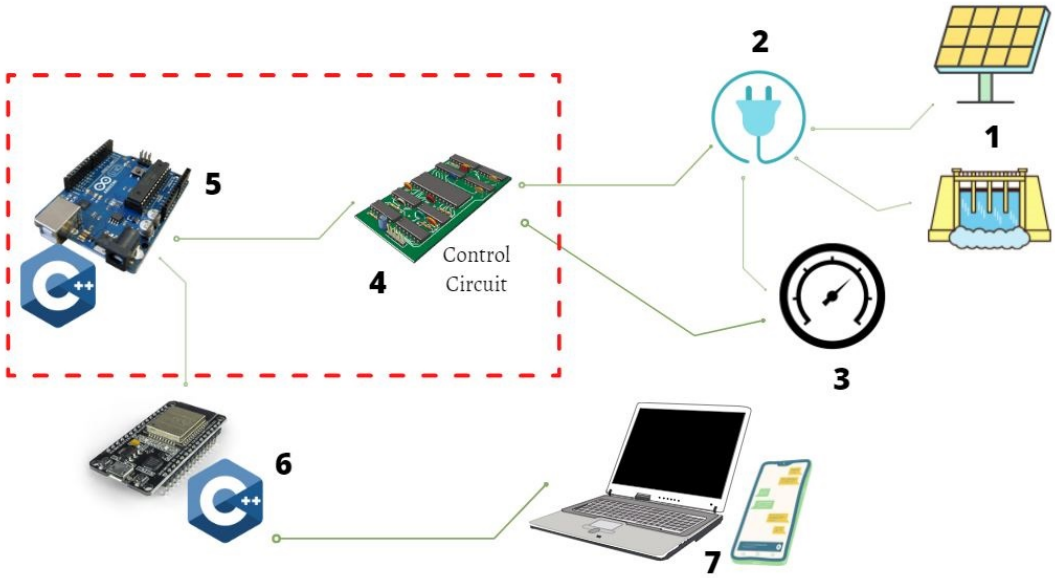

Fig. 1: Schema of the components that compose the smart plug operation.

The part ① is the generation coming from the renewable source or from the conventional power grid. The part ② represents the alternate energy available to be used or manipulated by the control circuit represented by ④. It will be necessary collect all the measures represented by ③ to build a complete supervisory system. The parts ④ and ⑤ will be inserted in a same protoboard which is the start step of the work. The supervising system that will be increase later is represented by the ESP32 of ⑥ and all the data and server represented in ⑦ that could be shown on a smartphone or laptop screen.

The control circuit was started with a basic dimmer lamp based on [3] replacing the control of TRIAC with the digital output of Arduino, increasing with an optocoupler that offers better isolation. After that, was growing an LDR (Light Dependent Resistor) to get information about the luminosity and control a load according to this data feeding with the 5V DC voltage and getting by the analog input of Arduino the luminosity.

Hereupon, it was designed as a circuit that only turns on or off the load through a relay. Last, it developed a circuit that works like a fading switch and is helpful in some applications like a chicken coop greenhouse. For example, a smooth luminosity control is necessary to offer comfort to the animals. These circuits grouped on an only board offer the user multiple possibilities of application in the same device.

One of the principal challenges of this work is dealing with the processing time and avoiding undesirable delays as long as it has an interaction between an analog variable and a digital one, causing an improper operation. As a solution for this issue, an appropriate way to get a fast response is the use of interruptions in the Arduino code.

4 Conclusion and future works

This work shows a purpose to control the power offering security for the user and an economical way to use the electrical energy through the joining of electronic components, offering different ways to control the power depending on the kind of load and programmatic skills to activate the TRIAC and, in the meantime, solving delaying problems that a digital converter can face interacting with an analog system.

For future works, it could be increased a machine learning system to get a considerable volume of data like the weather conditions and the user lifestyle to control some load getting more smarter management as a similar application that can be related in [9].

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