Model and Simulation of Automaton Control Using Microcontroller and LDR to Monitor the City's Public Lighting System

Modelo e Simulação do Controle Autômato Usando Microcontrolador e LDR para Monitorar o Sistema de Iluminação Pública das Cidades

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RESUMO

O presente trabalho tem como objetivo apresentar uma aplicação em Lógica Fuzzy para avaliar informações de métodos de Reconhecimento e Classificação de Padrões aplicados a medidas de Qualidade de Energia Elétrica em centros de medição inteligentes. A Lógica Fuzzy é responsável por gerenciar o resumo dos resultados apresentados por diversos métodos de Padrões de Reconhecimento e Classificação e, assim, pode sintetizar e integrar os desempenhos das técnicas, melhorando o desempenho do sistema. Desta forma, um sistema de Lógica Fuzzy pode inferir uma classificação potencializando os pontos fortes individuais de cada técnica para suprir as deficiências específicas em algum erro de classificação obtido por uma dada técnica é apresentada. Para validação, a arquitetura do sistema foi aplicada a um problema de qualidade de energia de transformadores de distribuição.

Palavras-chave: Lógica Fuzzy, Reconhecimento e Classificação de Padrões, Distorções Harmônicas de Tensão.

ABSTRACT
The present work aims to present a Fuzzy Logic application to evaluate information from methods of Pattern Recognition and Classification applied to Power Quality measurements from smart metering center. Fuzzy Logic is responsible for managing the summary of results presented by several methods of Recognition and Classification Patterns and thus can synthesize and integrate the performances of techniques, improving system performance. This way, a system of Fuzzy Logic can infer a classification leveraging the individual strengths of each technique to meet the specific deficiencies in some misclassification obtained by a given technique is presented. For validation, the architecture of the system was applied to a problem of power quality of distribution transformers.

Keyword: Fuzzy Logic, Pattern Recognition and Classification, Voltage Harmonic Distortion.

1 INTRODUCTION

Electricity is an input that impacts the costs of municipalities and varies depending on how it is used and how it is purchased from the supplier. The management of public lighting with the improvement of technologies aiming at efficiency and quality can result in savings, because the public sector represents a significant portion of the final consumption of electricity in Brazil. (ERC, 2014).

Public lighting can be defined as a service that aims to provide light, at night or during occasional daytime darkening, public places, including those that require permanent lighting during the day. (RESOLUTION OF THE NATIONAL ELECTRICITY AGENCY - ANEEL Nº. 456/2000).

In Brazil, public lighting, based on a survey carried out by the National Electricity Conservation Program (NECP) of Brazilian Power Plants S. A. (ELETROBRÁS) with electricity concessionaires, in 2008, has approximately 15 million public lighting points, a demand of 2.2 GW (4.5% of national demand) and a consumption of 9.7 billion kWh/ year (3% of the country's total electricity consumption) (NECP, 2010).

In view of the panoramas, this work suggests a model to save electricity consumption. In countries where load reduction is a major problem due to the short fall in electricity and less in the resources to generate electricity. In these countries, the load reduction problem can be solved to some extent, saving as much as possible. Using the automatic control of streetlights, the maximum amount of energy that is useful and beneficial to the population can be saved.

2 THEORETICAL FOUNDATION

The light sensor is used to detect the amount of light. There are many light sensors available on the market, but the light dependent resistor (LDR) is used as a light sensor. Because it is cheap in price, easily available on the market and can be easily connected to the microcontroller to detect the intensity

of light. LDR has the property of changing its resistance according to the intensity of the light. If the light is high, the LDR will have low resistance and if the light is low, the LDR will have high resistance. Therefore, the microcontroller can easily read this resistance in the form of voltage and it can be converted into a proportional value of light using a formula available in the data sheet.

Relay interface with microcontroller is used to analyze the light intensity and to generate the control signal that turns the transistor on or off, which in turn energizes the relay to turn the streetlight on or off. The NPN transistor is used as a switch and the resistor at the base of the transistor is used as the current limiting resistor. The diode is used to avoid the emf voltage that can produce sparks in the relay.

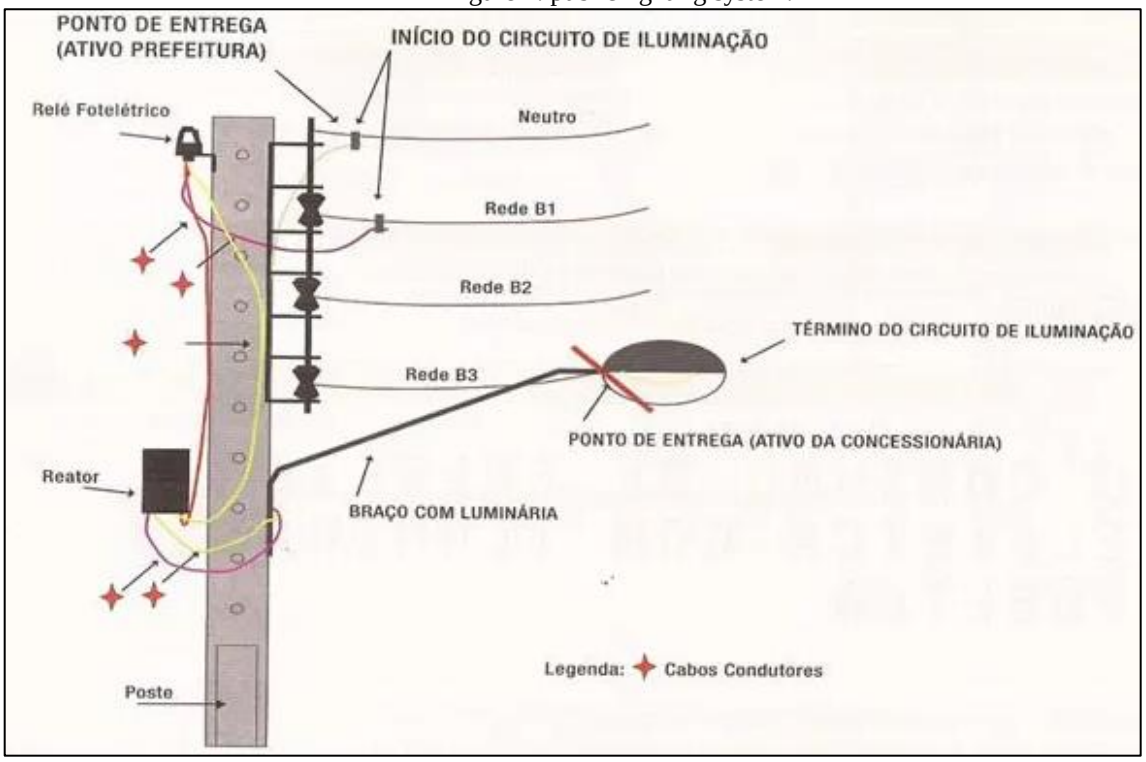
2.1 MODELING ITEMS OF THE PUBLIC LIGHTING SYSTEM

The public lighting system can be divided into several items that expose the shape of the degree of the system, below are the most important items:

- Supply networks: the networks must be adjusted and measured for the loads involved. In the event of a change in power, it will be necessary to analyze the impacts on the supply networks of public lighting systems;
- Supports: in public lighting systems in Brazil in general they use their own electricity distribution posts as supports; in many cases the assemblies end up being inadequate;
- Control keys: at the beginning of the development of public lighting systems, the activation of the circuits was done by a person designated for this purpose. Today, due to the huge amount of lighting points, this practice is unimaginable. So, over the years, several pieces of equipment have been developed and perfected to carry out this task automatically;
- Reactors: electronic ballasts are high frequency switching sources, of the order of kilohertz, which control the lamp supply current. This equipment, unlike magnetic ballasts, does not require the use of ignitors and large external capacitors to correct the power factor. They also make it possible to control other electrical parameters of the lamp, giving it a longer life and greater efficiency throughout the whole set;
- Luminaires: initially the luminaries had the function of only serving as a support and connection interface between the lamps and the electrical network;
- Lamps: a lamp is a device that supports one or more artificial lights and serves to illuminate. It may be an object hanging or supported on a base or a foot.

  (Source: the authors with data from Eletrobrás, 2004c).

Figure 1: public lighting system.



(Source: National Confederation of Municipalities (NCM), 2016).

Figure 1 shows the public lighting system in the city of Matão - São Paulo as an example, where the city government focused on saving electricity in order to help the environment and manage the Brazilian hydrological cycle. It was thought to avoid excessive and unnecessary expenditure of the energy consumed by the city.

2.2 PROBLEM FORMULATION

- Difficulty performing controller programming and project simulation;
- Problems arise when executing the circuit assembly.
- Goals:
- The focus of this project is to make a mechanism that controls the action of turning the streetlights on and off;
- Reducing human labor and helping to manage work.
- Results:
- Reduction of waste of electricity in the metropolises;
- Process control for turning streetlights on and off.

3 METHODOLOGY

Necessary hardware components:

LDR: the LDR, a light-dependent resistor, is an electronic semiconductor device that has two terminals and has the characteristic of having resistance according to the amount of light incident on it almost linearly, in addition to being a non-polarized element, making it that the chain can circulate in both directions. (MENDES JUNIOR, J. J. A.; STEVAN JUNIOR, S. L., 2013).

Transistor: the transistor came about as a result of studies where it was desired to use germanium and silicon crystals as radar detectors, and perhaps that explains why in the beginning its inventors had not given due importance to the new device. (MEHL, E. L. M., 2009).

Resistor: resistors are basic components used in electrical and electronic circuits to control the intensity of current flowing through the various components as well as to control the voltage applied to each part of the circuit. (DIAS, I. A., 2012).

LED: lighting systems have undergone profound advances in the last two decades, especially those related to the use of electronics in the processes of ignition, activation and promotion of energy efficiency. Over the past ten years, a new concept in lighting has been established progressively unmistakably. It is the use of light emitting diodes, or LEDs (light emitting diodes), to constitute lighting systems for the domestic, commercial, industrial or external (public) environment. (CAMPOS, L. D.; SANTOS, G. C.; ROBERTO, J. T. S., 2013).

Battery: is a set of batteries grouped in series or parallel, depending on the demand for greater potential or current. (BOCCHI, N.; FERRACIN, L. C.; BIAGGIO, S. R., 2000).

Power supply: a power supply is a device or device made up of four building blocks of electrical components and are: voltage transformer, rectifier circuit, filter and voltage regulator. (REIS, A. L. E.; VIANNA, J. T. A.; MELO, L. M. F.; 2011).

Diode: Semiconductor diode is a component that can behave as a conductor or electrical insulator, depending on how the voltage is applied to its terminals. This characteristic allows the semiconductor diode to be used in several applications, such as, for example, in the transformation of alternating current into direct current. (WENDLING, M., 2011).

PCB: currently, printed circuit boards (PCBs) are widely used in all types of electronic equipment, especially when integrated circuits are used in their construction. The material initially used for the manufacture of printed circuit boards (PCBs) was a plate known as phenolite. (MEHL, E. L. M., 2005).

Microcontroller: the microcontroller is defined as a small electronic component, with programmable intelligence, used in the control of logical processes. Its further states that "in a single encapsulated silicon wafer, there are all the components necessary to control a process". Thus, the

microcontroller is internally provided with program memory, data memory, input ports, parallel output, timers, counters, serial communication, PWM, analog-to-digital converters, among others. (SOUZA, 2005).

Crystal: one of the characteristic properties of minerals is the crystalline structure. Unlike amorphous substances, such as wood, plastics and glass, crystalline substances have an orderly arrangement of the atoms, ions or molecules that constitute them. This regular stacking of atoms explains the flat faces of the crystals. (BRANCO, P. M., 2014). Relay: the IEEE (INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS) defines the relay as "an electrical device designed to respond to prescribed input conditions and which, after the occurrence of specific conditions, causes electrical contact operations or abrupt change in the associated electrical circuits ". There is also a complementary note stating that "generally the inputs are electrical, but they can be mechanical, thermal, or other physical quantities or a combination of them.

Capacitor: a system of two metallic conductors of any shape and isolated, usually called plates, constitutes a capacitor. Charging a capacitor means removing a certain amount of charge Q from one of the plates and depositing it on the other, and this is achieved by applying a potential difference (DDP) between them. (REDONDO, D. M.; LIBERO, V. L., 1996).

Regulator: the conventional control for adjusting taps of voltage regulators, equipment widely used in electrical energy distribution systems for the adjustment and correction of long-term voltage variations, keeps the position of the equipment's taps fixed when the voltage in its input is null, that is, when power interruptions occur. (SANTOS, S. L. F., 2013).

Lamp: the fluorescent lamp has a different working principle than incandescent lamps. It is classified among the discharge lamps. In discharge lamps, light is produced by the passage of electric current in a gas or mixture of gases contained in a tube. This happens when a high voltage is applied to its electrodes, overcoming the dielectric strength of the gaseous medium, this process is known as ignition of the lamp. (KALACHE, N.; MOREIRA, S. G.; ARAUJO, R. M., 2013).

IC: the concept of integrated circuit was proposed in 1958 by Jack Kilby, when he developed the first device in this way, coming to receive the Nobel Prize later in the year 2000. The main reason for the great evolution of the electronics industry is the advance in the performance of integrated circuits, while manufacturing costs remain fixed or sometimes decreases. In addition to the fact that these devices become smaller and smaller, occupying less space and allowing greater portability in their applications, which allows the circuits that use them to become smaller, more reliable and dissipate less power. (CHEAH, 2008).

Electronic components are all the elements that make up the structure of an electronic or electrical circuit and are always linked together, forming a sequence of functions, interconnecting all

components and providing a joint work where one interferes in the functioning of the other. Table nº 1 specifies all the components of the model used in the project and others to improve it in the future, showing the amount of equipment, evaluation and specifications.

Table 1: specification of components.

N°.	Quantity/Equipments:	Evaluation/Specification:
1.	1/LDR	-
2.	1/Transistor	NPN-DC548B
3.	3/Resistors	$10k$
4.	5/LEDs	$12V$
5.	1/Battery	$9V$
6.	1/Power supply	$12V$
7.	1/Diode	IN-4007
8.	1/PCI	-
9.	1/Microcontroller	PIC16F877A
10.	1/Crystal	$2MHz$
11.	1/Relay	$12V$
12.	2/Capacitors (ceramic type)	$33\mu F$
13.	2/Regulators	7805,7812
14.	5/Lamps	$12V$, $2Hz$
15.	IC	-
16.	1/Step-Down transformer	$12V$

(Source: the authors, 2020)

3.1 EXPLANATION OF THE PROBLEM AND PURPOSES

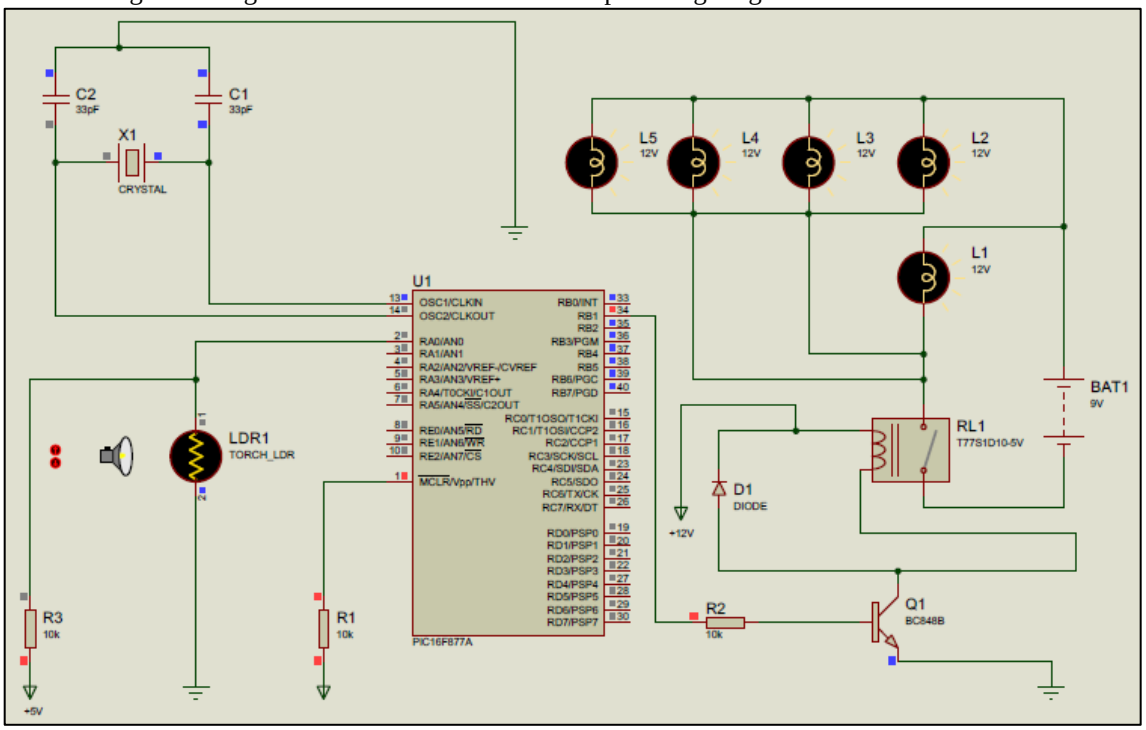
Automated public lighting control must turn streetlights on and off automatically. This project investigates the amount of light. If the light is 80% accessible, it should automatically turn off. If the accumulation of light is less than 80% this project will automatically activate the streetlights. The model can be adjusted according to the needs of each city.

4 RESULTS AND DISCUSSIONS

The algorithm implemented in the project was in the C programming language, using the mikroC PRO for PIC compiler. mikroC PRO for PIC is a complete ANSI C compiler for Microchip PIC devices. It is the best solution for developing code for PIC devices. It has an intuitive IDE, a powerful compiler with advanced optimizations, many hardware and software libraries and additional tools that will help you in your work. The compiler comes with a comprehensive help file and many ready-to-use examples, designed to be used immediately. (MIKROC, 2015).

The project circuit was designed using Proteus software. The Proteus VSM software is an ideal tool for students and professionals who want to develop analog and digital applications. It allows complete development of projects through schematics, simulations and layouts (PCB). The great advantage of Proteus in relation to other software is the ability to simulate electrical circuits and microcontroller circuits, because in addition to providing animated components, it also has the necessary tools to debug the software developed for the microcontroller, following its behavior in the simulation of the hardware. (ANACOM ELECTRONICS LTDA, 2010).

Figure 2: diagram of the simulation circuit for public lighting of the automaton control.



(Source: the authors, 2020).

The light sensor serves to capture its strength. The microcontroller PIC16F877A has the function of being used as an interaction with the sensor light to verify the abundance of available light. The control signal is triggered with the protection of the PIC16F877A microcontroller after the amount of light is explored. The command signal generated by the microcontroller PIC is used to turn on the transistor, which in turn energizes the relay coil and it turns on the streetlights. The model used in practice can be used by n lamps, the whole process will be controlled by the automatic control of streetlights. Figure 2 shows the simulation scheme of the automatic street lighting circuit for streetlights.

Implemented algorithms:

```
int light; // Declaring the variable as an integer.
void read_ldr() // Return type of the function header.
{
  unsigned int adc_value=0; // Unsigned integer. Value will receive nothing (0).
  adc_value=ADC_Read(0); // Compulsory library.
  light = 100 - adc_value/10.24; // Conversion of light intensity in percentage.
  if(light>=80) // If the light shows 80%, it will automatically turn off.
   {
    PORTB.F1=0; // These registers contain the current status of the I/O ports.
   }
     else // Change the program's execution flow.
        {
          PORTB.F1=1; // We have 8 I/O pins on the PORTB.
        }
}
void main() // Functions that return nothing and functions that have no parameters.
{
  TRISB=0X00; // TRISB configures “PORTB” / 0X01 = 1 in the unit box.
  PORTB=0X00; // Has the PORTB, PINB and DDRB registers.
  Adc_Init(); // Compulsory library.

    while (1) // While.
        {
          read_ldr(); // Read the LDR.
        }
}
```

5 CONCLUSIONS

After the development of the project, the performance of the automaton control of public lighting is noted, it is of paramount importance in helping to save electricity from city lights. This project had the conception, relation and advancement of the automaton control system of the public streetlights and was subjected to the best configuration of the software and hardware with an

architecture that is combined for interaction purposes. The system uses the use of technology to verify the intensity of streetlights.

With the results achieved and the difficulties noted at work, it is expected that he can help studies and research on simulation of public lighting and can contribute to the job market, together to help current systems and find a better use of the benefit provided, causing positive points for the population.

For future work, the proposed model will be of great benefit to cities, as it will save electricity from power plants that is unused in lighting streetlights while traditional energy sources are depleted each year, so other possibilities should be suggested. to avoid any waste of electrical energy.

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