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# LUBRICATOR FOR SECTIONAL SWITCHES AND FUSES WITH AUTOMATIC ACTIVATION IN SUBSTATIONS UP TO 138 KV

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**Abstract:** Currently, the procedure for using the remote lubricator for cleaning and lubricating disconnect switches and fuse switches in operation up to 138 kV, is done with a manual applicator, which inserts a spray can containing micro oil and is manually activated through a activation lever which, in turn, can be fixed on a Telescopic Maneuver Pole, known as a stick, and activated by another performer carrying a second stick. In order to improve the technique currently used, a Lubricating Device was developed for Disconnecting Switches and Fuses with Automatic Remote Activation for Substations up to 138 kV, in which only one operator is necessary, in the case of a de-energized circuit, and ensures the activation of the micro lubricating oil in sufficient quantity for use, avoiding waste and acting only at the desired point. The device is composed of an electronic triggering mechanism causing greater sensitivity and precision at the time of application, which will occur automatically.
**Keywords**: Automatic Trigger. Switches. Remote Activation. Automatic lubricator.

## INTRODUCTION

Industrial automation is an area of research that has been gradually expanding its activities in recent years. The use of devices and the application of developed solutions have great repercussions, especially in the industrial sector. The applications are not limited to replacing human work with exhausting, monotonous and dangerous tasks, but also improve the quality of processes, optimize spaces, reduce production time and costs. There are several ways of controlling and automating small, medium and large industrial machines and processes (PAREDE; GOMES, 2011).

One of the main advantages of automation is also the safety of the professionals involved. The interconnected electronic components form the most important part of a circuit, through them an infinite universe of applications becomes possible and can vary according to the creativity and needs of each user.

An automated system requires a survey of the characteristics of the components and their applications, based on this idea, among the other components, a common electromechanical relay was used, which works as a switch or electromechanical switch that is activated when current is established. electricity through its coil. Relays are used in various types of applications, in consumer equipment such as electronics and even in automotive use, they can be easily found (BRAGA, 2001).

For better operation, together with the relay, a distance sensor was added that reads the surface and sends activation commands to the relay. A type of sensor widely used in industrial applications and which makes use of ultrasound.

Ultrasonic sensors can be used to detect the presence of people or substances in various states. They are characterized by operating with a type of radiation that does not suffer electromagnetic interference and is totally clean, which makes it extremely important for the application of this project, which was subjected to different values and high voltage levels, reaching 138 kV (BRAGA, 2016).

In addition to the ultrasonic sensor, there was a need for a regulation and control component, so that it is possible to insert parameters for use. These components are the microcontrollers. A microcontroller is a complete computer system, which includes a CPU (Central Processing Unit), data and program memory, a clock system, I/O (Input/Output) ports, as well as other possible peripherals integrated into the same component (DENARDIN, 2016).

Among the microcontrollers surveyed, the Atmel™ family was chosen for its ease of programming in C language. A medium-level language allows the manipulation of basic elements with which the computer works. Another advantage of C is that it allows code written to assume portability and this means that it is possible to adapt software written for one type of computer to another.

The C language was created, influenced and field tested by professional programmers. The result is that C gives the programmer what he wants: few restrictions, few claims, block structures, isolated functions, and a compact set of keywords (SCHILDT, 1996).

In order to use the components mentioned above, it was decided to use a software widely used for editing, drawing and solid modeling, SolidWorks™, which is one of the most efficient systems for 3D modeling whose purpose is to enable designers and engineers to transform their ideas in complete projects, through an easy-to-learn tool (SOLIDWORKS, 2016).

Finally, a 3D printer will play an important role in the production of designs created using SolidWorks™. 3D printing or rapid prototyping is a form of manufacturing technology where a three-dimensional model is created by successive layers of material, usually thermoplastics.

ABS (Acrinolitrile Butadiene Styrene) was the material used in this project, which is a petroleum-derived plastic, requires a higher temperature compared to others, but is a rigid and light material, which offers a balance between strength and flexibility that will contribute significantly for a satisfactory result.

When examining the mechanism used for remote lubrication of disconnect switches and fuse switches in substations of up to 138 kV, there was a need for equipment that promotes greater ergonomics to the performer, facilitating use with a view, in the first place, to safety. worker who acts directly on exposure to the SEP (Electric Power System) and greater precision during its application. As a result, this project aims to better use the technique used for this particular task in order to automate part of the process ensuring quality, or even higher (CEMIG, 2011).

The objective of this work is to present some of the means used, highlighting the main functions and characteristics of its components in order to promote the necessary efficiency for the process, taking as its main objective the physical safety of the performer, reduction of damage to the environment in which it will be carried out., the integrity of the equipment to be maintained, as well as the cost-benefit ratio that will be provided to the process unit.

## MATERIALS AND METHODS

The present work is a case study of deductive character, where it was observed the need to improve the maintenance process in Switching Switches in Substations up to 138KV. To this end, a qualitative approach is characterized with an exploratory objective, because during some interventions to carry out maintenance, it was found that it was difficult to carry out the same, where a purely manual process is used. Through a basic research consulting bibliographic literature and internal manuals of the company, it made possible a case study, where a prototype was built for field testing.

In this chapter, the development of the project will be presented, presenting components and the system used. Thus, the most relevant components used in the work and the methods that were performed to obtain the final result are cited and explained.

### EMBEDDED SYSTEM

With the components in hand, work began with the programming of the Atmel™ family microcontroller using the C programming language as a resource and code edition, with minor modifications.

The programming meets the requirements and requests of the drives efficiently and accurately, as a result, some details were verified in the use of the lubricator currently used to insert in the adjustments in the programming. It was observed that the jet that is expelled by the spray can must not be activated far from the desired point so that it can ionize the air through the energized points, as a result, the microcontroller was configured to activate the trigger if and only if, the distance between the desired object and the spray nozzle was less than 23 centimeters, which guarantees maximum approximation of the jet directing straw that is connected to the nozzle at an approximate distance of 4 centimeters, considering the sensor installed on the can.

Because the microcontroller has its digital output ports with voltage values regulated at 5V, it was necessary to use a simple relay for direct drive of the traction, which is done by a motor that can operate at voltages from 9 to 12V. The relay consists of a coil, which when an electric current passes through it, creates a magnetic field, which in turn attracts the internal contact responsible for changing the state of the NO (Normally Open) or NC (Normally Closed) contacts.

The microcontroller must also interpret and calculate the information received by the ultrasonic distance sensor through its analog ports in order to maintain coherence between the current state and the triggering condition. The ultrasonic sensor has the main objective of measuring the distance between the object and the sensors through the emission of a sound wave that, when encountering an obstacle, will bounce back towards the module. After receiving the wave return, the calculation shown in equation (1) will be performed

$$Distance = \frac{Return\ time\ x\ speed\ of\ sound}{2} \quad (1)$$

```
void loop()
{
float distancia,inMsec;
long microsec = ultrasonic.timing();
distancia = ultrasonic.convert(microsec,Ultrasonic::CM);
Serial.print("cm:");
Serial.println(distancia);
if (distancia<23)
{
digitalWrite(rele,LOW);
delay(100);
digitalWrite(buzzer,HIGH);
delay(50);
digitalWrite(buzzer,LOW);
delay(50);
}
```

Figure 1:Basic structure of the algorithm used.



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The speed of sound can be considered equal to 340m/s and the result obtained will be in meters if time is considered in seconds. The wave travels the distance 'd' once to reach the obstacle and a second time to return to the receiver, the total distance is equal to '2d'.

## POWER SYSTEM

Two common 9V batteries were used, one of which powers the microcontroller and its logic system and the other is responsible for driving a 9V motor together with the relay that drives the spray directly. It was decided to use two different power supplies to avoid possible interference in the logic system due to a possible and sudden voltage drop caused by the motor starting, which could result in the partial loss of the readings and calculations of the logic system or a shutdown. unexpected by suddenly shutting down the entire system.

The motor used makes the mechanism pull a lever directed to the jet in its upper part, moving it only to pull it, the lever return will occur naturally by the spring of the spray nozzle jet itself, avoiding the need to reverse the direction of rotation of the motor. LEDs, voltage regulators, on/off buttons, phenolite board, among other components were used.

## MECHANICAL STRUCTURE

The mechanical structure of the device was printed on a 3D printer. 3D printers are equipment that allow you to print different shapes using three- dimensional technology. The materials used in the printing were plastic resin and laser modeling. With them it is possible to create the most diverse types of objects and it is with this equipment that we will create a modeling with the desired dimensions in order to meet the set of accessories that constitute this project.

SolidWorks™ was used to create 3D images and models, making it possible to create and produce all the necessary accessories for the development of this project. It was selected among others because it is easy to learn and use (SOLIDWORKS, 2016).

## RESULTS AND DISCUSSION

When routine inspections are carried out at the substations that make up the group

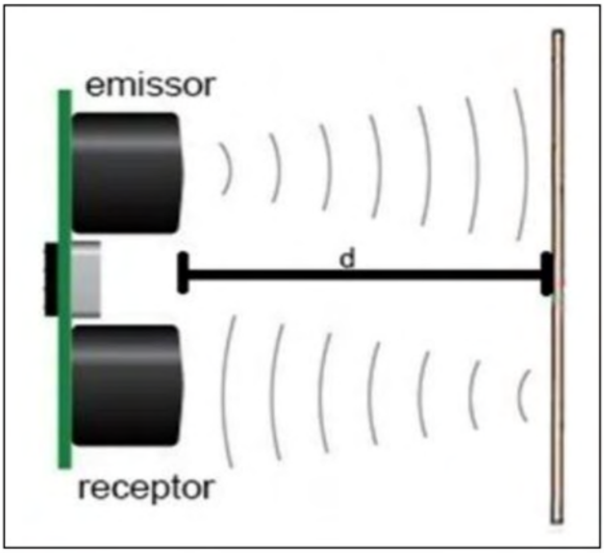


Figure 2: ultrasonic distance sensor.


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of companies of Companhia Energética de Minas Gerias, according to the specific procedure of each installation, technical reports are prepared with relevant information on the current state of all equipment according to the characteristics of each one and are informed and registered with the maintenance engineering management areas so that normalization measures are taken, prioritizing the continuous condition of the electrical system, protection and control of equipment (CEMIG, 2013).

In the inspection process, a thermographic camera is used in order to visualize a possible electrical connection with bad contact, causing the difficulty of the electric current to pass and generating excessive heat in that place, which in most cases, ends up being imperceptible to the human eye.

If a thermal anomaly is found at the time of a routine inspection or during an operation in the circuit of a disconnector switch or fuse switch and it is in a state of operational difficulty caused by the binding of its moving or fixed parts, due to its exposure to the weather, a Lubricator can be used for Disconnecting Switches and Fuses with Automatic Activation in Substations up to 138 kV, in order to fully repair or mitigate the risk of emergency shutdown, being prepared for future interventions.

The spray can is wrapped in a heat-shrinkable blanket made of modified cross-linked polyolefins to protect against short circuits caused by accidental touches to energized equipment. The lubricating device can be installed on a telescopic hot stick using at least 3 elements as determined by the specific instructions for use (CEMIG, 2011).

Once the device is fixed to the telescopic rod so that it remains positioned vertically or in another way that facilitates the application of micro oil, the on/off key on the body of the device must be activated, which will emit a sound through an electrolytic buzzer that will indicate to the user its operating status. Then, the spray nozzle must be approached smoothly and gradually so that the sensor perceives this approach.

After pressing the on/off key, the sensor will immediately enter into full working condition and start emitting sound waves that will repel each other on objects and return in the form of an echo which, in turn, will calculate the sending and return time. allowing the calculation of the distance of objects.

When a distance between the spray nozzle and the object with a value smaller than 23 cm is detected, according to the programming that meets the conditions of use, the microcontroller will send a signal with a voltage equal to 5V through a digital output that will energize the relay coil that, in turn, will promote the action of the NA and NF contacts, immediately changing their positioning.

During the elaboration and operation tests, some difficulties were encountered that at first referred to some error in the programming or failure in the microcontroller. The relay operating condition was not consistent with the desired action, because the microcontroller emitted a 5V signal (high logic level = 1) causing the relay to change the state of the contacts, however, the relay only switched between the contacts when the off condition (low logic level=0) was issued interrupting the digital output power continuity. It was discovered then that the model of relay used has a power supply and control circuit that made the inversion of the logic, turning the contacts on with the action of low logic level and off with the action of high logic level. The problem was solved by correcting the algorithm inserted in the microcontroller in order to compensate for this inversion, making the relay able to

Figure 3: Automatic lubricator.

Figure 4: Installing the automatic lubricator.



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perform its functions in the desired way.

Activating the relay, through a previously programmed digital output, will energize a direct current motor that is exclusively connected to a 9V battery, as a result, the motor will be activated and will exert a traction force on a lever that is connected to the top of the spray can nozzle where the micro oil will be expelled. For the purpose of testing, a motor with a capacity of 1kgf was mounted on the set of accessories, which was not able to activate the spray nozzle, causing some reduction gears to break, making their use inefficient for this purpose. Therefore, it was replaced by a larger and more robust model, given that the intention would be a lighter and more compact model, which enabled the continuity of the project and performed its function satisfactorily when requested.

With the nozzle operated by the lever, the distance sensor will continue to make accurate calculations in relation to the nozzle and the object in order to remain with the spray trigger in a triggered condition until the operator distances the device from the object.

During the period in which the device is operating, several beeps will be emitted through the electrolytic buzzer in order to guide the user on the spray actuation, since in most cases it is not possible to visually perceive the spray being expelled depending on the time at which is triggered.

When the sensor notices that the distance has become equal to or greater than 23 cm, that is, when the user wants to stop applying the micro oil, the microcontroller will stop sending the 5V signal through the digital port to which a relay is connected. will have its coil demagnetized and will return with the contacts in their original position, interrupting the motor supply and ceasing the traction force that acts directly on the spray nozzle activation levers. The motor will return to the original position being forced by the force of a spring positioned on the nozzles of the spray cans, making it unnecessary to invert the power supply so that its axis rotates in the opposite direction.

The device must then be retracted, removed from the telescopic hot stick and turned off using the on/off key. If necessary, oil spills must be cleaned and then stored in a place protected from dust and moisture.

The resources used to build the automatic lubricator are described in Table 1.

Using the device carries an annual benefit in the cost of maintenance. For an example of maintenance as shown in figure 6, R$ 10 thousand reais (Brazilian currency) are spent annually, the device reduces this amount by 50%. On a unitary basis, the reduction is greater than 80%.

It is also observed in figure 6 that the cost-benefit ratio of the automatic lubricator is highly satisfactory compared to the current method, cost per hour is reduced by 50%, and it has an even greater amount of lubrication per hour.

## FINAL CONSIDERATIONS

Due to the aspects observed, there was in fact a significant improvement during the performance of the remote lubrication service in cleaning disconnector switches and fuse switches in operation up to 138 kV, taking into account the physical safety of the performer, equipment integrity, ergonomics, practicality, optimization of resources and manpower, reduction in execution time and, consequently, in costs.

The work presented challenging goals and strategies in order to explore the field of action of the components used, in the way in which the plastic parts that make up the mechanical structure would be manufactured and in the way in which an algorithm would be developed that would present coherence in operation and immediately meet the

Figure 5: Device in action.

| **Description** | **Resources** |
|---|---|
| Computer | Author’s own resource |
| Microcontroller Programming/Recording Software | Free<br>R$ 26,99 |
| Electromechanical Relay | R$15,57 |
| 9V Batteries | R$ 20,68 |
| 3D Printer | Author’s own resource |
| Eletronic | Author’s own resource |
| 3D Model | Author’s own resource |
| SolidWorks Software License | USD 99,00/year |
| Ultrasonic Sensor Module | R$ 18,49 |
| Drive motor | R$ 18,99 |

Table 1 – Investments in the manufacture of the automatic lubricator.

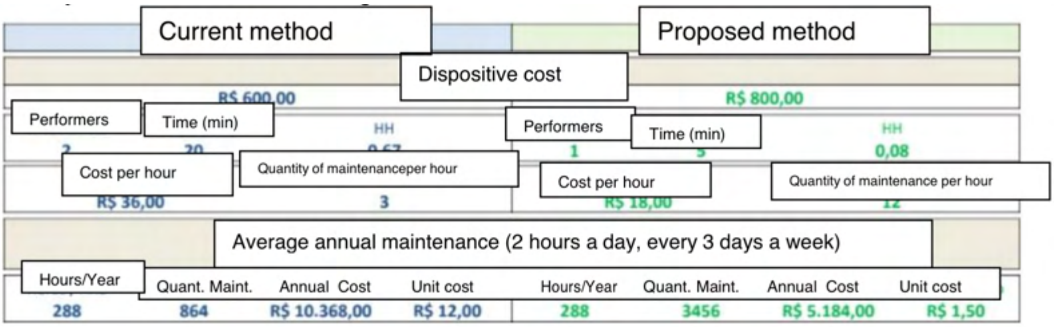


Figure 6: Comparative table of values and costs of the current method of lubrication x automatic lubricator.


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conditions imposed on a device that would be exposed to a high voltage value and that, even under these conditions, would carry out all the required commands, avoiding total or partial interruptions.

Even during the verification of a possible failure in the first installed drive motor and the unexpected condition of the relay acting inversely, the dynamism in the execution of this project, motivated by the perspective of a good result, caused a continuous search for information about the problems witnessed by in order to find strategic solutions that would contribute to the execution of the same, in view of the initial planning and the desired objectives.

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