Indonesian Journal of Electrical Engineering and Computer Science
Vol. 21, No. 3, March 2021, pp. 1485~1492
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v21.i3.pp1485-1492

An automatic system for detecting voltage leaks in houses to save people's lives

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Article Info

Article history:

Received Sep 23, 2020
Revised Dec 7, 2020
Accepted Dec 23, 2020

Keywords:

Arduino
Electrical leakage
House water network
Leak detection
Voltage sensor

ABSTRACT

Many people are exposed to many dangers, such as electrical leakage into parts of the home that lead to death, injury, or loss of material resources. With the great developments that happen daily in the field of technology, one of the most important examples of these developments is the Arduino. The Arduino is a company that produces a software and electronic parts that are open source for companies and students in order to design and build digital devices, design and implement projects and systems that can be linked together or linked with the Internet to facilitate their use to serve society and humanity. It became easier to deploy this technology to solve problems that put people at risk. Many systems that detect leakage of gas, liquids and fires were built using these modern technologies to protect the lives of people and their resources, but no one has actually used these technologies to detect unexpected electrical voltage leaks into the home's water network or walls that resulting from damage in some parts of electrical devices. Therefore, in this paper, we have proposed and designed a system that can detect an unexpected voltage leak from some electric devices to the water network or walls in houses, alarm of house owners by sound, and cut off the electrical current to the house in order to save people's lives and resources.

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1. INTRODUCTION

Many victims fall annually in the world for many reasons, including natural disasters such as earthquakes, floods, volcanoes and hurricanes, from wars, due to multiple accidents such as traffic accidents and fires, or from electrical shocks resulting from electrical current leakage from household appliances to the home water network or the walls and floor of the house. In recent years in the United States alone, fire departments have recorded more than 44,880 house fires due to electrical leakage, which led to the death of more than 490 people and more than 1250 injuries. In addition to all that, the material damage to property, which was more than 1.3 billion dollars annually [1].

Faults in electrical appliances such as water heaters, cooking, heating equipment, fans, water pumps, clothes dryers, air conditioners, etc. lead to fires or voltage leaks in water networks or walls that cause people to die. Most of the fires occurred after midnight and 8 am in the months when the weather was cold and people were asleep. Voltage leaks that cause fires in these periods were responsible for 60% of people's deaths [2]. One of the important examples of voltage leaks on cold days is heaters, water pumps, and electric heaters [3]. There is a lot of work in developing systems to alert people of fires or floods and dangers in order to save their lives. But there are still many accidents that happen and kill people. Many causes lead to such accidents, such as the

poor quality of electrical products (wires, water pumps, heats, main circuit breakers, switches, etc.) [4]. In addition to that, misuse of electrical appliances, resulting from negligence and lack of awareness.

In the shadow of this great development in the field of technology, where technology has been introduced into most aspects of human life and has become one of the main pillars in providing security and safety for humans due to the great capabilities it provides and the ease of use of electronic for most people. Therefore, to save people's lives from unexpected leakage of electrical voltage, in this paper, we have designed a system that detects the electrical voltage leaked into water networks or in walls using the Internet of Things and Arduino to alert people at any time and to save their lives.

2. RESEARCH METHOD

A lot of works have been accomplished in the past few years to design many types of systems that work to discover the leakage of liquids [5], gas [6-8], or electricity in buildings [9], cars [10], streets [11], or swimming pools [12], and so on. All these systems are designed to save people's lives from the dangers resulting from such an unexpected leak. Many of these systems have been designed using modern technologies such as the Internet of Things and Arduino [13]. We will review some previous works that have designed systems that detect such unexpected leaks. Arpitha, et al. [14] have designed and built a system called FBGA to detect gas leaks in buildings and vehicles and made an automatic warning call by GSM. The results obtained from the system were satisfactory through its speed in detecting the leakage occurring in less than a minute.

In [15] a method and system for detecting water leaks in building structures and roofs were invented. Mahalakshmi, et al. [16] have proposed and designed a system using the Arduino model to detect the unexpected leakage of gas in public buildings and homes, the results from this system were perfect according to the researchers' expectations. Singh, et al. [17] have designed a system that detects unexpected gas leaks in buildings using sensors and Arduino Uno microcontroller and alerts the user through phone calls and SMS by exploiting the GSM network. Abdul Hannan, et al. [18] also they have built a system using the internet of things and the Arduino controller to early detection of unexpected gas leaks and notify the homeowner through warning messages via e-mail.

Mehta and Misra in [19] have designed a system that monitors and detects theft or illegal water leakage from the city's main water pipeline. They have used to design that system: flow sensors and solenoid valves, and connect them to the GSM network via the Arduino board. If there is an unnormal difference in the water flow rate between the two ends of the pipeline, the control unit will be alerted by text message about the flow rates recorded in the system. Sarhan in [20] has worked on designing and implementing a home warning system using many sensors and cameras connected to the Arduino controller, it is also connected to the GSM network. The goal of this system to control the home remotely and to prevent human and material losses that may occur due to unexpected accidents. In cases of unexpected accidents such as fires or gas leak, the system works to alert the owner of the house by SMS and e-mail messages, this system can also help by taking some smart measures to stop fires and gas leaks.

From reviewing some previous related works that have used IoT technology with the Arduino, we have noted that most of them have designed monitoring systems to detect gas or water leaks, but we haven't noticed that one of them has used these important techniques (IoT technology with the Arduino) to design a monitoring system that can help to control on the electrical current sources in the case of an unexpected leak in electric to the house that usually leads to loss of human life and resources. Therefore, in this paper, we have proposed and designed a system that can detect an unexpected voltage leak from some electric devices to water network or walls in houses, alarm of house owners by sound, and it works to cut off the electrical current to the house in order to save people's lives and resources.

3. PROPOSED SYSTEM

The proposed system works to protect people from the risk of voltage leakage. The voltage leakage usually is to the home water network or walls from one of the electrical devices or their wires such as water heaters and water pumps. The dropout voltage happens without the knowledge of people and it is invisible. Therefore, it is very dangerous because it causes great human and material losses. Death occurs as a result of people touching to parts that have been subjected to an unexpected electrical leakage beforehand. Figure 1 is an example of an electrical voltage leakage into the water network from Heaters without the knowledge of people, most of these problems are caused by damage in the internal parts of electrical devices as shown in Figure 2. It has become very important to design and build a system that alerts and protects people when an unexpected electrical leak occurs. This system is designed in an excellent way to detect the leakage voltage and give an audible alarm to alert when an electrical leak occurs and works to cut off the main source of electrical current for the house. Figure 3 a diagram showing the mechanism of the proposed system. The

system works periodically to sense the voltage every 1 second in the water network and the walls of the house. When the system detects a high voltage in the water network or walls, it instructs to operate a sound alarm and works to cut off the main electricity of the house. The house's electricity continues to be cut off for 10 minutes, and after this period ends, the electrical current will be restored and the check is done again. This process continues until the risk of electrical leakage is removed.

Figure 1. Electrical current leakage through the water heater

Figure 2. Damage in the water heater causing electrical leakage in the water network

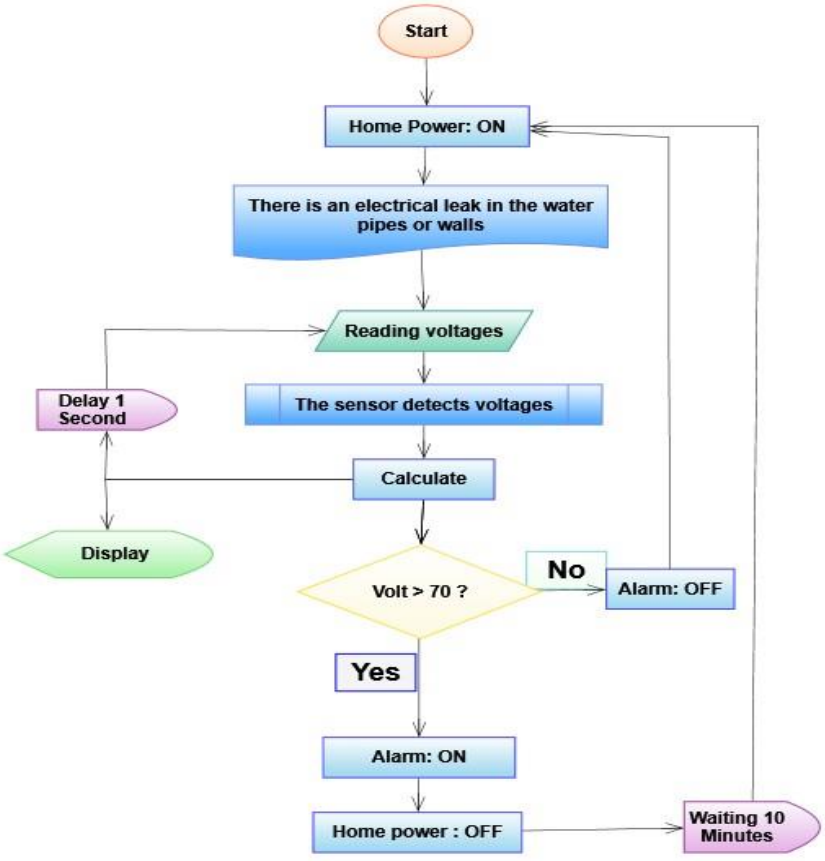

Figure 3. How the proposed system works

4. COMPONENTS OF THE PROPOSED SYSTEM

The basic physical components that were used to build the proposed system are Arduino Board Uno, ZMPT 101b AC Voltage Sensor, OLED Display, Buzzer, Power Supply 5V, and 1 Relay Module. In down, we will briefly explain each of them.

4.1. Arduino board uno

It is a controller board that can be considered the mind that controls all the other connected parts in any system, as it relies on ATmega328 that can be programmed to do many actions such as converting the input values from analog to digital and vice versa. This board includes many ports: (14 digital input and output ports, some of them are intended to supply the board with power and some are considered as input ports, and others are considered as output ports), and it also includes a USB connection, 6 analog inputs, ICSP header, 16 MHz crystal oscillator, a Power jack, and restart button. It is powered by a DC to an AC adapter or battery. It is easily possible to connect it to a computer via a USB cable when needed to be programmed and assigned as a controller in order to design and build a system [21].

4.2. ZMPT 101b AC voltage sensor

It is a sensor used for voltage sense, the main part in its manufacture is ZMPT101B. One of the advantages of this sensor is the high accuracy and excellent regularity in measuring the electric current and voltage, as it can measure up to 250 volts AC. Its use is very easy and the output voltage value can be changed with a multi-role voltmeter [22].

4.3. OLED display

It is a digital screen used to display some of the results from the system. This screen can be easily connected to the Arduino board and programmed to display the system results. It is supplied with power from the Arduino board through some ports. Dedicating some analog ports as outputs on the Arduino board to transfer the results from the Arduino board to the OLED screen and display them [23].

4.4. Buzzer

The bell in the Arduino is an electronic bell that is similar to a regular bell, as it consists of an electrical coil connected to a diaphragm. It contains two N and L ports, the N port is usually connected continuously, while the L port works only when an error or danger occurs, and in this case, the electrical circuit completes inside the bell and gives an alarm sound. When the poles N and L are connected, the cycle completes inside the coil and it becomes an electromagnet starts vibrating that pulls the diaphragm back and forth and starts making a sound as a result of the generated air movement [24].

4.5. Power supply 5V

Power Supply 5V contains two input ports and two output ports that receive electricity from 100-240 volts via input ports and convert it to 5 volts. Its function is to supply power with 5V to the system circuit [25].

4.6. 1 relay module

Relay is a switch that works on 5V and above consists of two phases. The first phase consists of a magnetic coil that is controlled through another circuit via the IN1 port and it is called the control signal. The second phase consists of contact points that depend on their operation on the control signal coming from the first phase. When there is a control signal, the magnetic coil will work, and thus the contact points will connect to each other, the power is connected to a device or the main breaker for a house through the ON mode, and when the control signal stops, the power is cut off from the device through the off mode [26]. Physical system components as shown in Figure 4.

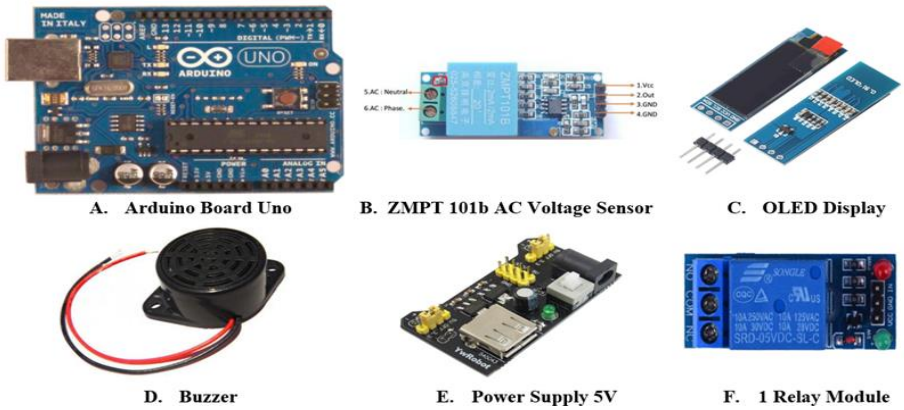

Figure 4. Physical system components

5. DESIGN AND BUILD THE PROPOSED SYSTEM

The proposed system was designed and built using several Arduino parts as physical parts and connecting them to the water network that may be exposed to leakage in the electrical current from some devices such as heaters and water pumps. The language used is IDE Arduino for programming the system [27, 28]. The arduino board uno acts as a controller of the system that connects many physical pieces and makes appropriate decisions. The breadboard was used to expand the number of L and N ports in order to supply all parts of the system with power. The system works continuously and it's power from outside the main circuit breaker for home electricity via power supply 5V. The analog port (A0) on the Arduino Board Uno is designated to receive voltages from the ZMPT 101b AC Voltage Sensor, which is looking for voltages in the water grid every 1 second. Two analog ports (A4 and A5) for transmitting voltage and displaying it on an OLED screen. On the opposite side of the Arduino Board Uno, the digital port 4 is designated to supply (relay 5V) power. Relay 5V is responsible for the operation and shutdown of the main breaker for home electricity. Digital port 2 was programmed to operate against Port No. 4, Which has been designated to power the bell. If an electrical voltage is detected by the voltage sensor in the water network, the controller makes several decisions: The first decision is to turn on the digital port 2 to operate the bell and to give a sound alarm about the presence of electrical leakage. The second decision is to turn off the digital port 4 responsible for feeding (relay 5V) with power, thus cutting off the electrical source for the house. The third decision is to display the voltage on the display (OLCD). The fourth decision, wait 10 minutes before returning the power supply. After 10 minutes, if an electrical leak is discovered again, the same previous decisions are repeated. In the event that the electrical leakage is removed, turn on port 4 to supply (relay 5V) and return the electrical current to the house. Turn off port 2 to stop the sound of the bell. Figure 5 shows the method of interconnecting the physical parts of the system circuit. Figure 6 shows a piece of code that was used to program the system.

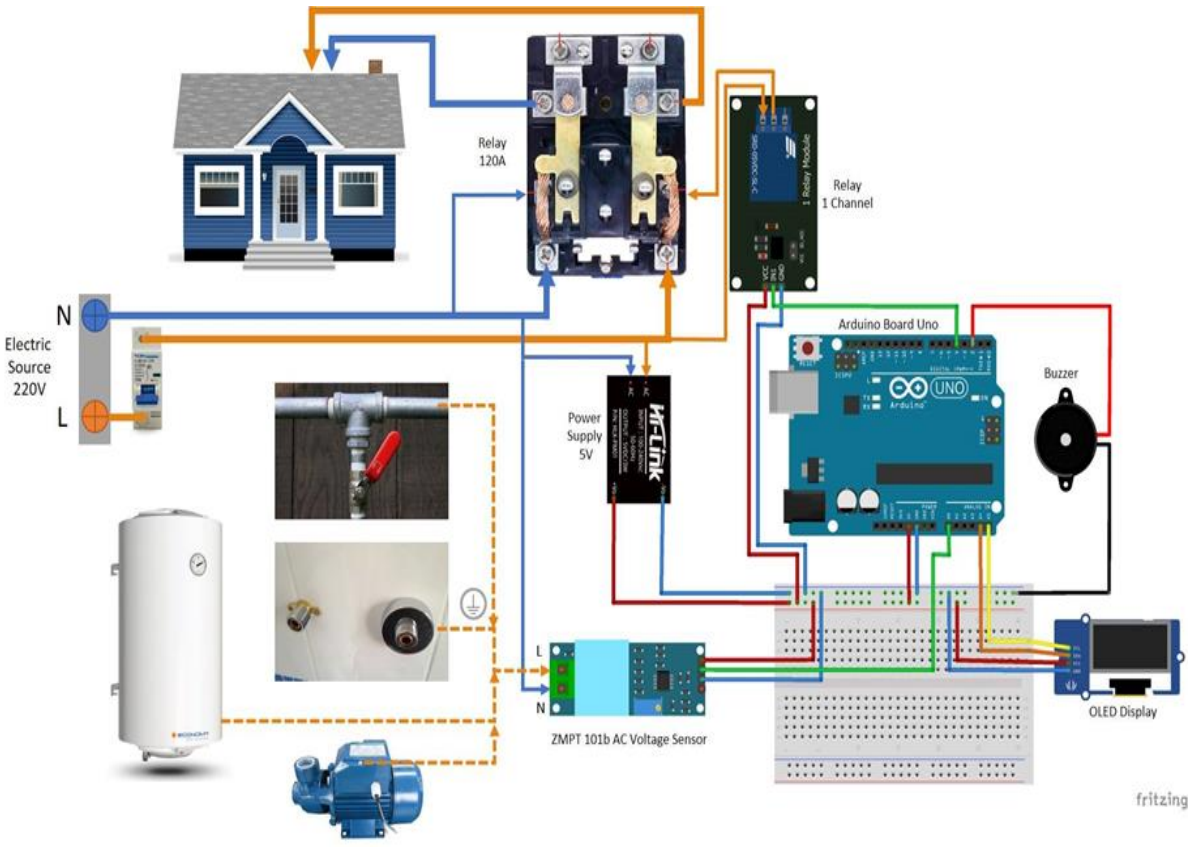

Figure 5. Method of connecting the system circuit

```
if(current_Volts>70)
{
  Serial.print( "\n" );
  Serial.print( "============================" );
  Serial.print( "\n" );
  Serial.print( "Danger !!! electric shock wave   " );
  Serial.print( "\n" );
  Serial.print( "There is a risk !!!   " );
  Serial.print( "\n" );
  Serial.print( "The main electricity source in the house : off" );
  Serial.print( "\n" );
  Serial.print( "Alarm buzzer : on" );
  digitalWrite(buzz,HIGH);
  digitalWrite(homeRelay,LOW);
  Serial.print( "\n" );
  Serial.print( "Waiting 10 Minutes before restart the main electric of house ...." );
  delay(10000);
  Serial.print( "\n" );
  Serial.print( "============================" );
  Serial.print( "\n" );
  Serial.print( "Return the electric to the house ..." );
  Serial.print( "\n" );
  Serial.print( "The main electricity source in the house : on" );
  Serial.print( "\n" );
  Serial.print( "There is no risk..." );
  Serial.print( "\n" );
  Serial.print( "Alarm buzzer : off" );
}
if(current_Volts<=70)
{
  digitalWrite(buzz,LOW);
  digitalWrite(homeRelay,HIGH);
}
```

Figure 6. Part of the code used to program the system

6. SYSTEM RESULTS

The system was actually experimented with by connecting it to the house's water network and applying an intended voltage to the house's water network. The results were very satisfactory and according to expectations. Figure 7 is a picture of the device before the presence of danger and Figure 8 is a picture of the device after a fatal electrical danger was detected. The system detected a high voltage (greater than 70 volts) and gave instructions to operate the alarm bell, cut off the main source of the home electrician, and displayed the leaked voltage on the screen. The process of cutting off the electricity source lasted for 10 minutes, after which the electrical current was restored and the system also performed the same previous steps because there is still an electrical voltage in the water network. But when we removed the voltage applied to the water network, the main electrical current returned to the house normally, with the continuation of the system to search for a leaked voltage every 1 second. Figures 9 and 10 illustrate some of the results that were displayed on the computer screen during the system testing process. Shows some of the results obtained from the system before and after the leak was detected as shown in Table 1.

Figure 7. The device before discovering the danger

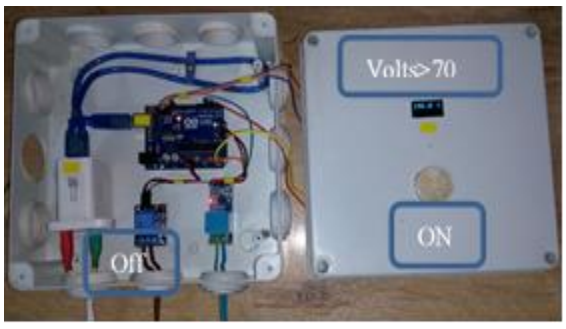

Figure 8. The device after detection of danger

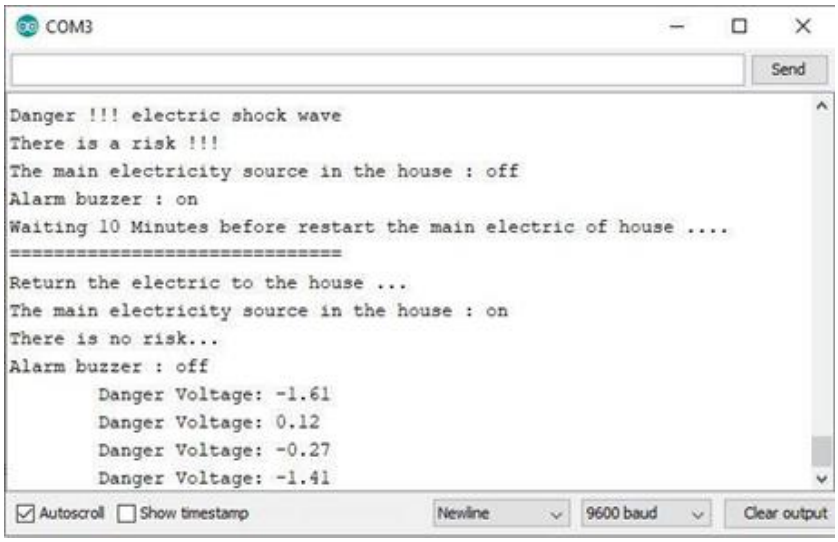

Figure 9. The results before leak detection

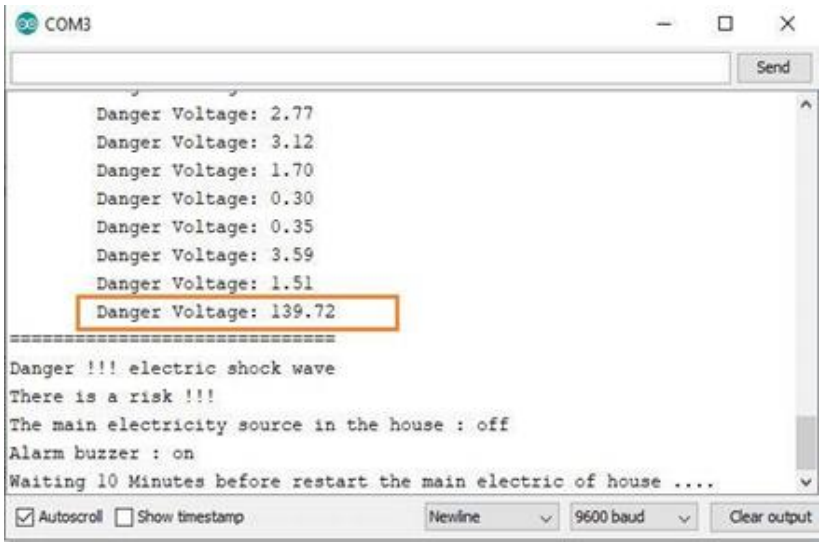

Figure 10. The results after the leak detection

Table 1. Shows some of the results obtained from the system before and after the leak was detected

Existing voltages	Is the voltage>70 volts?	Buzzer	OLED Display	1 Relay Module	Relay 120 A for House	Waiting Time
0.30	No	Off	ON	ON	ON	1 Sec
0.35	No	Off	ON	ON	ON	1 Sec
3.59	No	Off	ON	ON	ON	1 Sec
1.51	No	Off	ON	ON	ON	1 Sec
139.72	Yes	ON	ON	Off	Off	20 m
-1.61	No	Off	ON	ON	ON	1 Sec

7. CONCLUSION

In this paper, a system was proposed that works to protect people from death and resources from the dangers caused by an unexpected electrical leakage into the home's water network or walls by alerting the homeowner to the presence of danger by sound and making smart decisions such as cutting off the electrical current to the house until the danger is gone. The system was designed, implemented, and practically tested on the home water network by applying an intentional electrical voltage to the house's water network, and the results were satisfactory and according to expectations.

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