SOLUTION TO DETECT, WARN AND PREVENT PEOPLE FROM CLIMBING HIGH-VOLTAGE POWER POLES, DISTRIBUTION TRANSFORMERS

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Abstract. Currently, in Vietnam, the management and operation of the power system face challenges and difficulties due to complex terrain conditions, natural disasters, floods, and typhoons. In addition to the power grid failures caused by natural disasters that damage the power system. The power grid failures caused by humans are serious and directly affect human life. Power outages that disrupt the supply of electricity have had an enormous impact on the economy, politics, and energy security. The cause of fatal power grid failures is a lack of understanding and subjectivity. With the continuous development of electronic devices, wireless communication technology will serve as the basis for the construction of applications that protect electrical systems and human life at a cheap and effective cost. In this paper, the authors built a device that can detect, warn, and prevent climbers from climbing high-voltage towers using Arduino UNO, the HC SR04 distance sensor. When the device detects an intruder, the system will ring an alarm, activate the anti-intrusion mechanism, and send SMS via GSM SIM 800I to the operator of the grid to promptly have a suitable treatment solution.

Keywords. GSM SIM800I; Arduino UNO; HC-SR04 sensor; power grid.

1. INTRODUCTION

Fatal accidents caused by electrocution when climbing on high-voltage power transmission poles, and outdoor distribution transformers in recent years in Vietnam occur much. These accidents are caused by many people climbing on electric poles to commit suicide, children climbing up to get bird nests, and kites. On the other hand, another problem is climbing on the power pole to steal equipment on the grid. stolen electrical equipment may be bars, pieces of iron, or bolts of low value, but the consequences can be huge for the safety of human life and the power grid. Although the electricity industry has carried out propaganda, disseminating acts dangerous to life and the consequences of the safety of the grid affecting energy security, production, and business, the results are limited because the grid must be managed too large. On the other hand, along with the requirement to increase labor productivity, each power worker must do many different things, so it is difficult to cover all the power poles, and transformers assigned to manage.

Communication technology related to mobile devices and machinery is developing rapidly in both the industrialized and globalized worlds [1, 2]. In particular, the application of GSM wireless communication protocol is also widely used in various fields such as GSM and Arduino module control models.

In [3], the authors presented a solution to build IoT applications to control home appliances and sensors based on ESP8266 and Raspberry Pi chips. The home appliances are connected to the ESP8266 module so that they can be linked to the indoor Wi-Fi network, through which mobile devices can remotely control the smart home via the internet. In [4], the authors built an IoT application based on Arduino and GSM modules to collect and send information about the electrical system for efficient energy use in households. We see that these monitoring applications are being used in households and civil households, especially some applications that require a connection to the internet system through the Wi-Fi module to be able to transmit data to the data collector remotely. These network modules are not suitable for applying to power transmission poles placed outdoors with difficult terrain or areas without Wi-Fi networks to connect to the internet.

In [5], the authors built IoT-based anti-theft systems to enhance public area safety in smart cities. The system works based on Bluetooth Low Energy (BLE) and combines with GPS-enabled smartphones to report the location of the device that was stolen. We found that IoT applications based on BLE technology

are very suitable and effective in cities because this is a densely populated area, the devices are connected at close distances and can connect through network topologies such as Mesh, Stars, and trees to form a network. However, the BLE-based information and data transmission system is not suitable for the linear network structure of the long power transmission line and the distance at the two adjacent poles is up to 800m.

The authors in [6] have implemented the development of a power transmission line monitoring system based on unmanned aerial vehicles. This system will automatically identify threats that are likely to adversely affect the line based on computer vision. UAV line monitoring using computer vision is highly effective in automatically detecting problems on the line, but these systems require someone to control the flying device while the grid is very wide, and the battery capacity of the device is limited. Therefore, monitoring the line with a continuous time of 24/7 is not feasible.

The authors implemented a GPRS mobile network-based remote power line monitoring solution to connect to the internet and send the data to the screen monitoring [7]. The authors in [8, 9] proposed a wireless power transmission power pole body monitoring system consisting of accelerometers and several environmental sensors. The system tracks real-time the status of the power transmission pole through a combination of ZigBee and GSM. Although there has been a lot of research in the world applying wireless sensor networks, and computer vision to automatically evaluate, however, the power grid in Vietnam has not had much research and similar applications carried out.

Application of Arduino, the GSM communication protocol has been widely applied in civil, and academic applications. However, currently, the protection of high-voltage transmission power lines and distribution transformers in Vietnam is still mainly carried out by manual monitoring, most cases of people climbing are not detected to prevent in time. In this paper, the authors built a cheap intruder detection device using the HC-SR04 ultrasonic sensor, the Arduino UNO module. After detection, the system activates the siren with a loud sound to attract attention, and the rotating arm structure will prevent the person from continuing to climb, and through the location of the intrusion will be sent to the respective power grid management team via SMS from the SIM800L module. The product of this research has been applied to practice and brought high efficiency with extremely low investment costs, this product can be widely applied to the power grid in many areas in Vietnam to contribute to protecting human life and ensuring the safe operation power grid.

2. DEVICE AND METHOD

2.1. Devices and their function

In this research, we have built a system to detect and warn that people are entering the power pole with low-cost electronic devices. However, the efficiency of the equipment has met the requirements of the research and can be applied to the grid in a wide range.

In this research, we used the Arduino UNO module [10] to collect signals from the HC-SR04 Ultrasonic distance sensor [11] and make control decisions such as playing a warning speaker for attention, controlling the rotating structure to prevent people from climbing onto the power pole, and sending a warning message to the team to manage the grid via SMS using the SIM800L module [12]. Voltage Reduction Circuit DC-DC Buck LM2596 [13] in this research was used to adjust the voltage of the solar power source from 12VDC to 5VDC to provide power for the whole system can work. The system can operate at night due to the solar power being stored by a 12VDC battery with a capacity of 12Ah. The main devices and their functions in this paper are presented in table 1.

Table 1: Devices and their functions

Devices	specific parameters	Functions
Arduino UNO R3	Input voltage: 7-12VDC Digital I/O pins: 14 Analog inputs: 6	Read the signal from the HC-SR04 sensor to make the decision to activate the alert and send the message. Communicate with the SIM800L module to send a warning message to the grid management team

HC-SR04 Ultrasonic sensor	Distance: 2cm to 400cm Operating voltage: 5VDC Measurement Angle: 15º	Determine the distance of the object to the sensor location and send a signal to Arduino
GSM SIM800L	Operating voltage: 3.7-4.2 VDC frequency band: GSM850MHz, EGSM900MHz, DSC1800Mhz, PCS1900MHz Interface via TTL	Take orders from Arduino and send SMS to the mobile phone number.
DC Buck LM2596	Input Voltage: 3.2-40VDC Output Voltage: 1.25-35VDC	Reduce power voltage from the solar system to supply Arduino and Sim800L Module to work

2.2. Prototype Design

In this research, the authors using the GSM SIM800L module will be connected to the Rx/Tx pin of ATmega328. The GSM SIM800L module is used to send text messages including warning information and the location of power poles to mobile devices. Arduino also sends the commands allowing the alarm and the motor to turn the arm to stop the person from climbing. Both alarm bell and motor use a 12VDC supply, thus using a 2-channel relay module that receives a forward signal from Arduino to control the 12VDC power supply for the bell and motor to operate. An overview of the wiring diagram of the devices is presented in Figure 1.

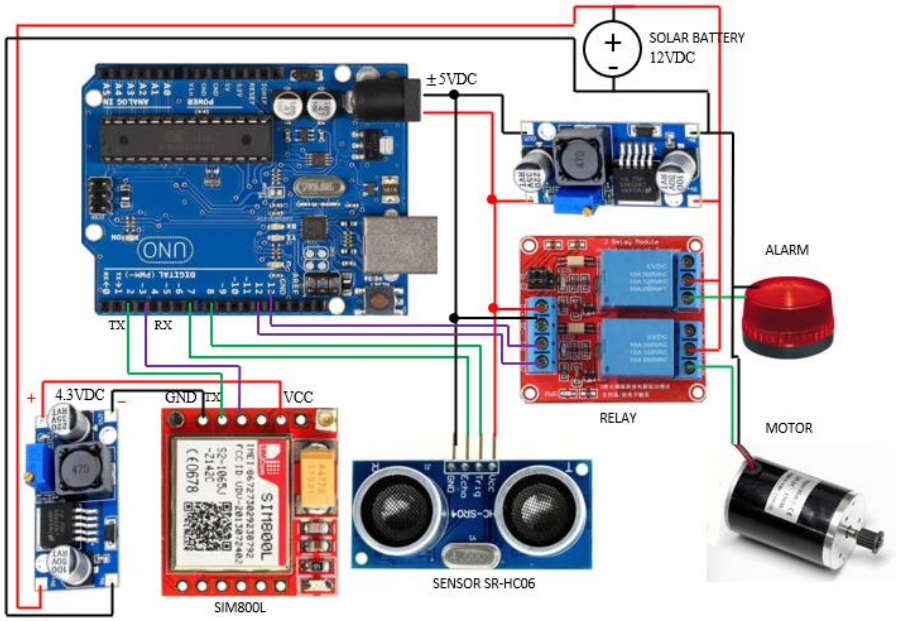


Figure 1: Diagram of connection of devices (Sensor Network Node)

To avoid sending false warnings to the grid management team when non-human objects fly past sensors such as birds and butterflies, we created a delay that activated the system to send an alert. The system will check if there is an object in the detection area of the sensor for greater than 5 seconds, it will ring the alarm and send a text message, in cases where objects move fleetingly through the sensors with a time of fewer than 5 seconds will be considered non-human and will not trigger warnings. The working flow chart of the system is shown in Figure 2.

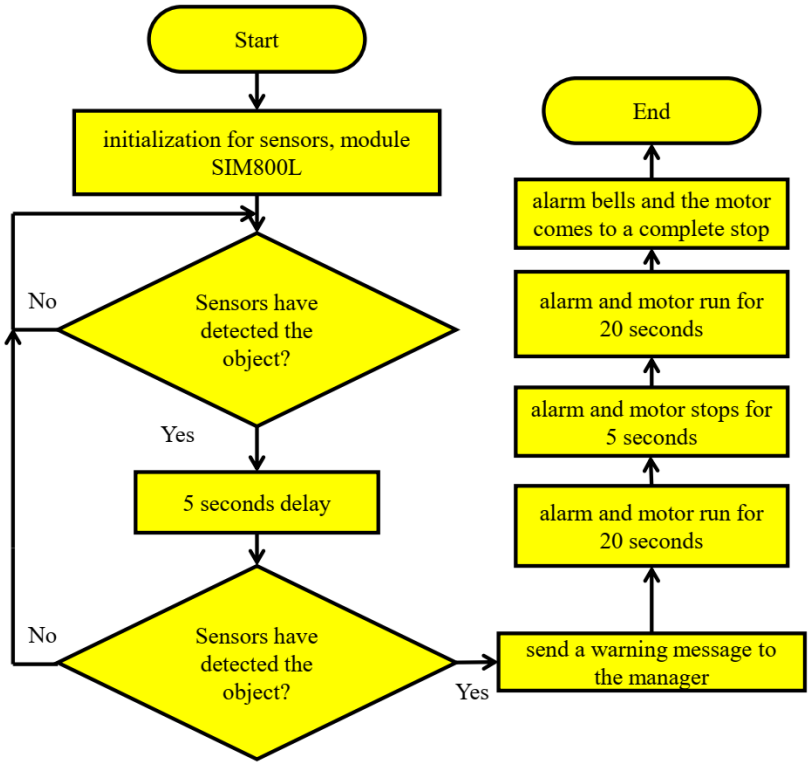


Figure 2: Operation principles of the anti-intrusion system

Algorithm 1: Read the sensors, control the output, and send SMS

```
1.  initialize SIM module
2.  int testbutton = 5, sensor1 = 6, sensor2 = 7;///inputs
3.  int alarm = 12, motor = 13;//output
4.  void setup () {
5.   sim800l.begin(9600);
6.   Serial.begin(9600);
7.   configure pinMode inputs and outputs;}
8.  void loop () {
9.   read all inputs;
10.  if(inputs==1) {
11.  delay (5000);
12.  if(inputs==1) {
13.  Serial.println("detected");
14.  SendSMS ();
15.  digitalWrite outputs==1;}}
16.  if (sim800l.available()) {
17.  Serial.write(sim800l.read());}}
```

To be able to put into operation effectively and extend the life of the system, the authors installed the electrical equipment inside a small electrical cabinet measuring 18x12x10cm. This electrical cabinet has the function of resisting rainwater intrusion and reducing the temperature from the external environment affecting electrical equipment. The results are presented in Figure 3.

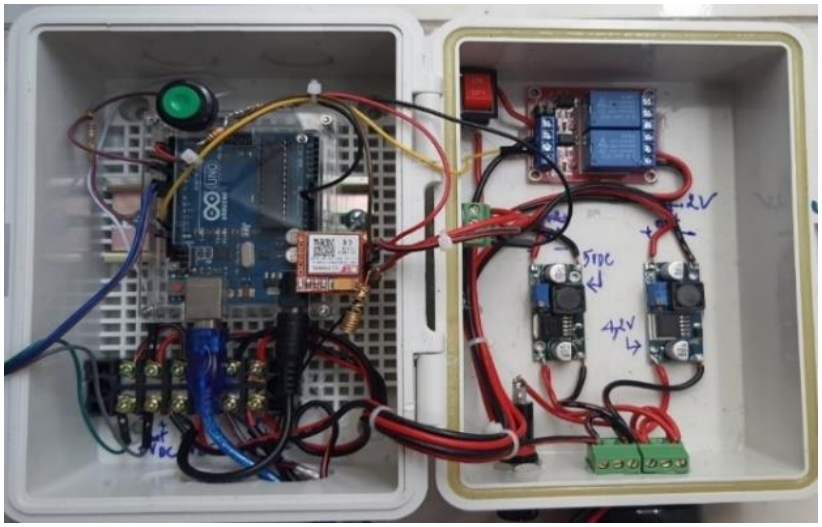


Figure 3: Installation of equipment inside the electrical cabinet measuring 18x12x10cm

3. RESULTS AND DISCUSSION

Currently, in Vietnam, Power Transmission Company 4 of Vietnam National Power Transmission Corporation has also piloted the installation of smart cameras with image processing functions to automatically detect motor vehicles entering power transmission lines, forest fires, or other causes that may cause safety for the line will send a warning to the power grid management team. These cameras are expensive, and this will also be a device at risk of theft if not regularly monitored and checked. Therefore, the protection system in this article can contribute to the security protection of power transmission lines and the protection of assets arranged on power poles.

The equipment has been evaluated at tower 3198 in the line 500kV Dak Nong – Cau Bong under the management of Power Transmission Company 4. The system was installed at an altitude of twenty meters above the ground. The supply for this system to work is derived from the available solar source used to power the previous smart camera.

The distance sensors are installed 6m from the ground, and the detection range of the sensor is from 0cm to 4m. When someone is detected climbing to a high-voltage tower and a transformer, the system activates the alarm, and the pivot motor structure prevents the person from continuing to climb and sends SMS voice messages to the grid management team immediately. The installation of detection, warning, and method of sending notifications to the management team is presented in Figure 4 and Figure 5.

In Figure 4, the distance sensors are installed at a position of 8m from the ground, and the detection distance from the object to the sensor position to activate a warning is less than 2m. The grid management team will receive a message warning of the power transmission pole and will move to the pole position to Timely stop the person from climbing. In Figure 5, the distance sensors are installed 4m from the ground, and the distance of detecting objects to the sensor location to activate the warning is less than 2m.

We installed the test, and the signal was received very well. The HC-SR04 ultrasonic sensor has a range that meets the requirements set out in detecting intrusive objects and fewer interference signals are detected because the delay is set in the program to avoid misdetection. The GSM SIM800L module, on the other hand, worked effectively when sending a message to the management team immediately. Figure 6a shows the distance sensor data detected and displayed on the serial port, Figure 6b shows the result of SMS received when intrusion is detected at a preset limit distance. The system meets the desired technical requirements of the author's group.

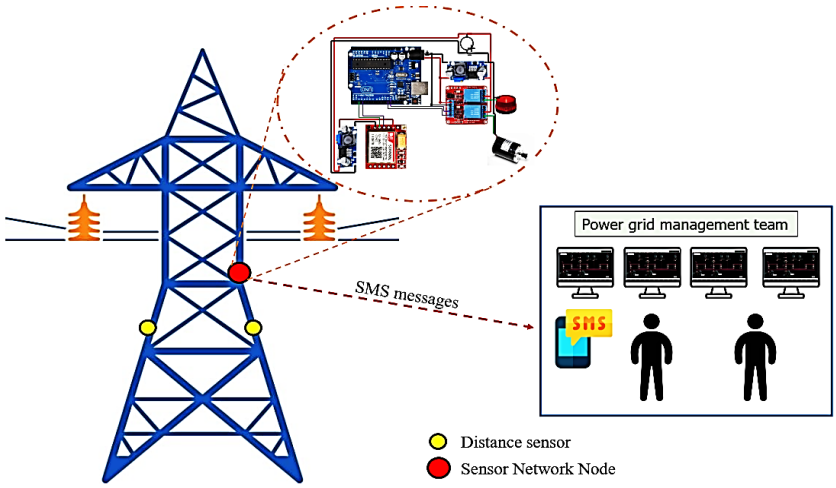


Figure 4: Principles of operation of the system when installed at high-voltage power transmission towers

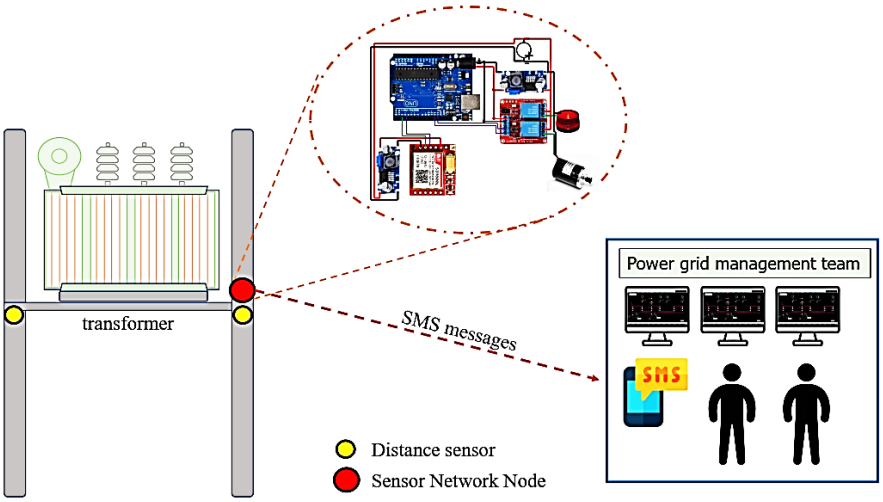
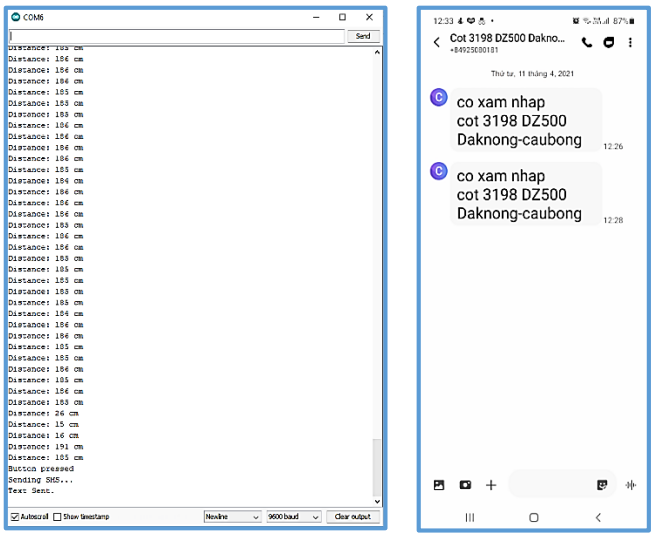


Figure 5: Principles of operation of the system when installed in distribution transformers



(a) (b)

Figure 6: a) Check the data on the serial port; b) receive messages when the system detects an intrusion.

4. CONCLUSIONS

The solution to detect, warn and prevent people from climbing high-voltage power poles, and distribution transformers built by the authors based on the application of inexpensive equipment have brought great efficiency to contribute to improving the management capacity of the power grid of workers and Power companies.

The construction of this anti-intrusion system will contribute to helping the grid management team quickly detect and prevent behaviors that could disrupt the large-scale power supply. Another important issue of this system is contributing to reducing unwanted fatal accidents, especially for rural children in Vietnam who have little understanding of the dangers of high-voltage electrical equipment.

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GIẢI PHÁP PHÁT HIỆN, CẢNH BÁO VÀ NGĂN CHẶN NGƯỜI XÂM NHẬP CÁC TRỤ ĐIỆN CAO ÁP, MÁY BIẾN ÁP PHÂN PHỐI

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Tóm tắt. Hiện nay ở Việt Nam, việc quản lý vận hành hệ thống điện phải đối mặt với những thách thức, khó khăn do điều kiện địa hình phức tạp, thiên tai, lũ lụt, mưa bão. Bên cạnh những sự cố lưới điện do thiên tai gây ra làm hư hỏng hệ thống điện thì những sự cố lưới điện do con người gây ra lại rất nghiêm trọng và ảnh hưởng trực tiếp đến tính mạng của con người. Các sự cố mất điện làm gián đoạn việc cung cấp điện đã ảnh hưởng rất lớn đến nền kinh tế, chính trị và an ninh năng lượng. Nguyên nhân gây ra những sự cố lưới điện làm chết người chủ yếu do thiếu hiểu biết và chủ quan. Với sự phát triển không ngừng của thiết bị điện tử, công nghệ giao tiếp không dây sẽ làm cơ sở cho việc xây dựng các ứng dụng bảo vệ hệ thống điện và tính mạng con người với chi phí rất rẻ và hiệu quả. Trong bài báo này, nhóm tác giả đã xây dựng một thiết bị có thể phát hiện, cảnh báo và ngăn chặn người trèo lên trụ điện cao áp bằng việc sử dụng Arduino UNO, cảm biến khoảng cách HC SR04. Khi thiết bị phát hiện có người xâm nhập thì hệ thống sẽ phát chuông cảnh báo, kích hoạt cơ cấu chống xâm nhập và gửi tin nhắn SMS thông qua GSM SIM 800I đến người quản lý vận hành lưới điện để kịp thời có giải pháp xử lý thích hợp.

Từ khóa. GSM SIM800I; Arduino UNO; cảm biến HC-SR04 sensor; lưới điện

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