SSRG International Journal of Electronics and Communication Engineering
ISSN: 2348 – 8549 / https://doi.org/10.14445/23488549/IJECE-V8I5P102

Volume 8 Issue 5, 6-10, May, 2021

Original Article

Designing and Supervising Equipment for Urban Lighting Schemes, as well as Warning the Theft of Power Supply Lines

Nguyen Thi Hai Ninh[1], Nguyen Quang Hai[2], Bach Van Nam [3]

[1,3] *Faculty of Electronic Engineering, Thai Nguyen University of Technology, Viet Nam*
[2] *Faculty of Physics, Thai Nguyen University of Education, Viet Nam*

Received: 03 April 2021 Revised: 10 May 2021 Accepted: 13 May 2021 Published: 18 May 2021

Abstract *- This paper presents a design solution for equipment monitoring and warning the power supply line for city lighting systems. The hardware and software are implemented based on the solution concept. The warning signals are sent to the lighting system manager, who can also use text messages and voice calls to set up working parameters for the lighting cabinet. The test results proved that the proposed system meets the problem's requirements and can be integrated into the lighting control cabinet. The system has also been applied at two industrial zones, Diem Thuy and Yen Binh, Thái Nguyên, Việt Nam, to verify the applicability of the design solution*

Keywords **-** *Monitoring the power supply line, Power supply line, The lighting control cabinet, Urban lighting schemes, Warning against the theft of Power supply lines.*

1. Introduction

In Vietnam, in recent years, the urbanization process has developed rapidly. According to the World Bank, the average urbanization rate of Vietnam in the 1999-2009 period was 3. 4% / year. By the end of 2013, the rate of urbanization nationwide reached 33. 47%, equal to 29.72 million people, increased by about 1% compared to 2012 (similar to 1.35 million people).[1]. The public lighting or urban lighting system is rapidly evolving in tandem with the urbanization process. Urban lighting ensures the safety of vehicles and people on the road and brings a safe life to residential areas and public spaces by reducing traffic incidents and maintaining protection. In addition, it creates life attractive and magnificent for nighttime cities, contributing to the quality improvement of life for urban residents and promoting commercial and tourism development.

An urban lighting system consists of lighting control cabinets, power supply lines, lamp posts, and lights. Depending on demand and cost, the lighting system cabinets are divided into three basic types: The lighting cabinet using a timer with low cost, allowing control of the lights on and off based on the pre-installed time; PLC lighting cabinets for the installation of an automated system; and Communication lighting cabinets with the highest cost, automatically controlling the system operation, also performing the system monitoring. In addition, power supply lines are an essential and expensive component of the lighting system, which endangers people, and requires maintenance and anti-theft marking costs.

There has been a lot of research that focuses on urban lighting systems. Some of them proposed a new method to increase energy efficiency [2], [3], [4]. Some others aimed to develop new designs of smart lighting systems [5], [5], [6], [7], [8], [9]. However, with an unsynchronized telecommunications infrastructure, especially in urban areas under construction, it is difficult to apply smart lighting systems; also, the lighting system cost will significantly increase.

In this article, we propose a design of a lighting control cabinet with integrated monitoring equipment and a power supply line theft-warning system without the requirement of complicated telecommunications infrastructure.

The remainder of the paper is organized as follows. (1) Introduction; (2) Power supply line theft warning and monitoring equipment design solution; (3) Hardware and software design; (4) Experiments and results; (5) Conclusion.

2. Equipment Design Solution Monitoring and Warning of Theft of Power supply Lines

2.1. Design Solutions

It can be realized that the lighting system was not supplied with electricity but in the night mode. So the wiring conducting electricity is very vulnerable to theft at dusk. So the power supply monitoring and warning systems must ensure daytime and nighttime monitoring, even during a power outage situation.

2.1.1. To monitor the line system in the daytime mode (power off)

A method of measuring and reading resistance on the line is implemented by adding a power resistor (or an incandescent light bulb) at the end of the power supply system, as shown in Fig. 1.

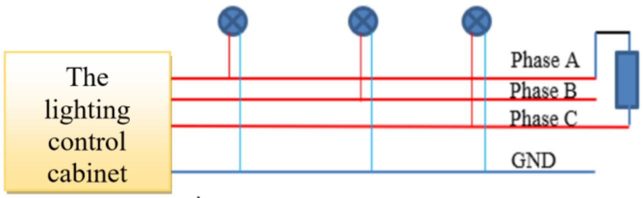

Fig. 1 Monitor the line system in the daytime mode diagram

In this diagram, the power resistor is applied between any two phases. Control and center monitoring read the resistance between these two phases (like using a resistances meter) and compare it to the default value. In normal conditions (when no line is lost), the resistance value is small in reading, and not no warning actions are performed. If one line is broken, it behaves as an open circuit, and the measured resistance is increased (very large value); after comparing it to the default value, the circuit gives in-place warnings by using a bell and sends a warning message to the manager.

Table 1. The working regimes to determine the status of the line

CBDP	CBDL	Mode
0	0	Witching to resistance measurement mode.
1	0	Send warning of a power outage of load and witching to resistance measurement mode.
1	1	Don't send the warning.

2.1.2. To monitor the line system in the night mode (when there is power)

In night mode, when there is a power outage, two situations occur: power loss because of a supply or power loss on the transmission line, so the current block consisting of a current supply-side sensor (CBDP) the load line sensor (CBDL) is used to determine the situation. When there is electricity, both 2 current sensors send logic level 1 to the central controller, corresponding to normal operation. Suppose there is a sudden power failure (either by theft of the line or an active power outage). In that case, the program automatically turns to read the resistance mode to determine the line's condition. State table 1 describes the working regimes to assess the line's status in the case of a Timer at night work mode.

2.2. Block Diagram of the Monitor and Warning of the Power Supply Line Outage

From the design solution for the problem, we construct the block diagram of the console and monitoring system, as shown in fig. 2.

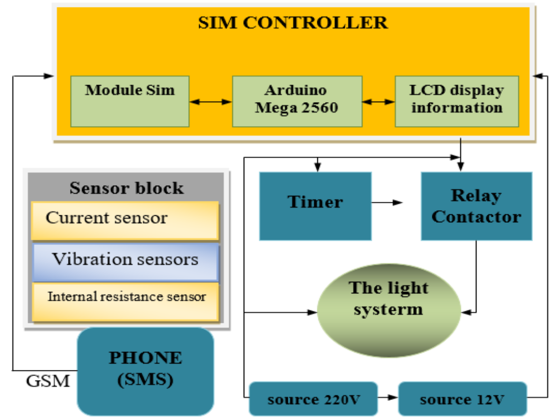

Fig. 2 The diagram of the equipment

2.2.1. The function of the blocks

- source block 220v/12v: source of the control cabinet and a lighting system. power for the sim controller.
- timer: to turn on or turn off the lights when switching to manual control.
- relay/ contactor: to switch on or switch off the power circuit and the lights when there is a sim controller signal.
- current sensors: an internal resistance measurement circuit used to determine the line condition. the nature of a measurement circuit is to measure the voltage over the bias circuit, which gives the "0" or "1" logical level to the middle processor that signals the line's status.
- internal resistance sensor: to measure internal resistance whether it is broken in the daytime mode (when there is no electricity)
- the arduino mega 2560 is used to process information, provide control signals, and report to the module sim lcd.
- modul sim 800l (sim controller): receives and sends signals to the central microcontroller; sends messages.
- lcd (sim controller): displays some information, such as checks system status, sms command feedback, and install specifications.

3. Designing Hardware And Software

3.1. Designing Hardware

The sim controller is integrated into the illumination control cabinet as the primary device for monitoring and monitoring the power supply lines. It consists of three main parts: (1) The central processor uses the Arduino Mega 2560 board, (2) the Sim 800L Module, (3) a block that detects the condition of power supply lines, (4) a closed circuit/cut circuit measurement, and (5) on /off light bulb circuit.

3.1.1. The Central Processor

In this central processor, the Arduino Mega 2560 is a microcontroller board built on the Atmega 2560 chip. It has 54 pins for I/O digital signal (of which 15 pins can be used for pulse-width modulation), 16 for the analog signal, and a

16MHz quartz frequency oscillator, which has a USB connector, source leg, an ICSP header, a reset button. It contains everything needed to support microcontrollers, and the Arduino supply can be from a computer via a USB port or an adapter that is converted from AC to DC or from a battery. Arduino Mega is compatible with most shield designs for Arduino Duemilanove or Diecimila. Arduino Mega 2560 is an update from Arduino Mega [11]. Thus, the Arduino Mega 2560 responds to processing speed requirements and is resistant to noise. Large numbers of interrupted resources and high stability ensure reliable transmission of data. Images of the Arduino Mega 2560 board are shown in Fig. 3.

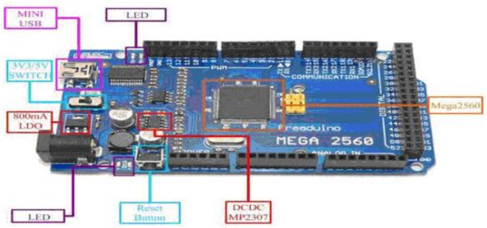

Fig. 3 Arduino Mega 2560 board

The Sim 800L Module inherited functions from previous generations of Sim modules. The sim800L module can transmit SMS, listen, call, GPRS, etc., like a phone but is the smallest of the SIM modules (25mm x 22mm)[11]. The module controls use an AT instruction set easily, and the connecting leg uses a standard male header of 100mil. Images of the sim800L Module are shown in Fig. 4.

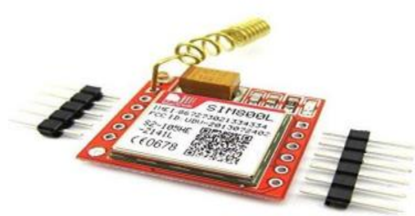
Fig. 4 Module sim 800L

3.1.2. The detected Block the Status of the Power Line

Internal resistance measurement circuits (b) and current sensor circuits (b). Internal resistance measurement circuits are used to monitor the line system in daytime mode (when there is no power), and current sensors are used to monitor the line system in night mode (when power is on), as shown in Section 2 of the article.

Internal Resistance Measurement Circuits

Without line theft, RCS power resistors are connected in parallel to VR2 resistors. The measured voltage at note A0 is:

$$V_{A0} = \frac{12}{R5 + (VR2//RCS)}(VR2//RCS) = 8V \qquad (1)$$

When there is a breach of the line, the RCS power resistor circuit is opened when the measured voltage at note A0 is:

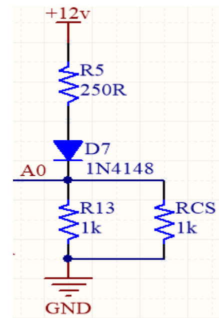

Fig. 5 Internal resistance measurement circuits

$$V_{A0} = \frac{12}{R5 + R13}R13 = 9{,}6V \qquad (2)$$

Then $V_{A0} > V_{ng}$, the central control circuit sends a wire-theft warning message to the manager.

The Current Sensor Circuit

Fig. 6 is the Current sensor circuit. When there is power, the current sensor measures current, and the output voltage of the Sensor is sent to the diode bridge circuit to rectify and pass through the voltage divider formed by VR2 and R5 to generate the "1" logic level corresponding to the 5VDC output, denoted by the CBDP and CBDL.

When power is lost, the CBD output of the current sensor circuit is at a "0" logical level

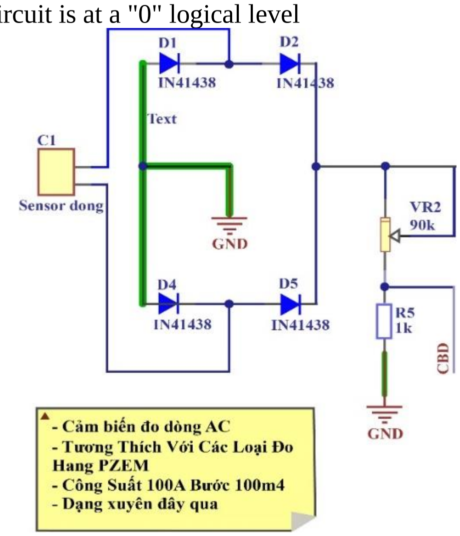

Fig. 6 Current sensor circuit

3.1.3. The on/off Circuit for Measurement Circuit

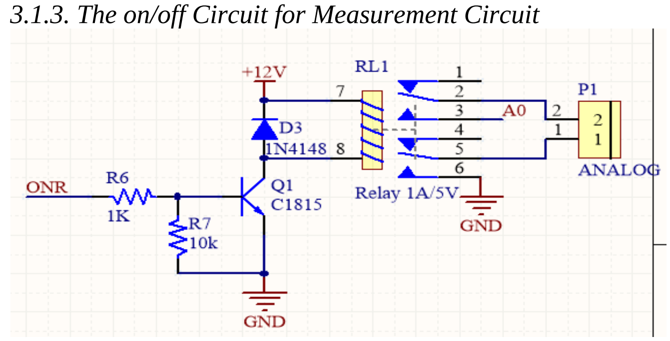

Fig. 7 The on/off circuit for the measurement circuit

In the night mode

The line AC voltage puts on two terminals of the resistor; if the measurement circuit is not removed from the A0, the control circuit will be damaged. Therefore, before the beginning of the night mode, the ONR signal is set to 1, and the relay will disconnect the measurement circuit from the controller.

3.1.4. The on/off Lights Circuit

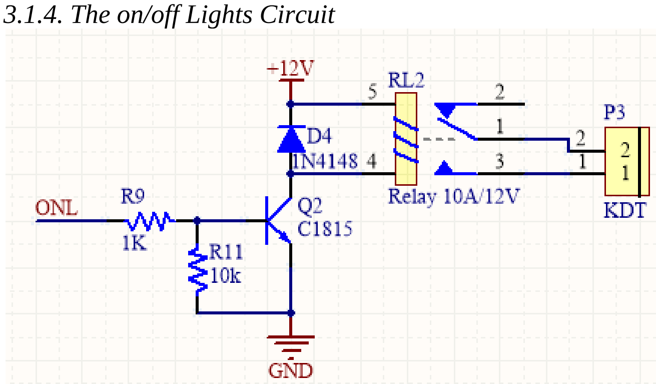

Fig. 8 The on/off lights circuit

At Night Mode

When the measurement circuit is completely disconnected from the controller, the ONL signal is set to 1, and the contactor is turned on, connecting the lighting system to the power.

3.2. Designing the Software

Fig. 9 is the system flowchart. The program is implemented on Arduino Mega 2560 microcontroller (The Central Controller).

4. Experiment and Result

Fig. 10 shows the circuit drawing of each system unit. Besides the main units mentioned in Section 3, the circuit also has a source, collision sensing, and a display unit.

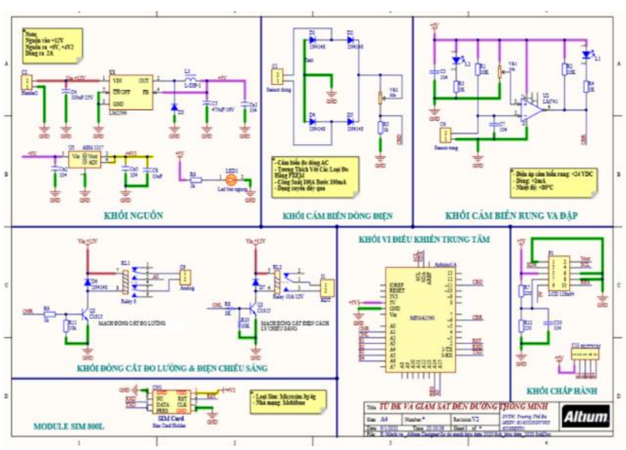

Fig. 10 The general principle diagram of equipment

Figure 11 (a) shows the printed circuit board, and the final system in the package is depicted in Figure 11(b).

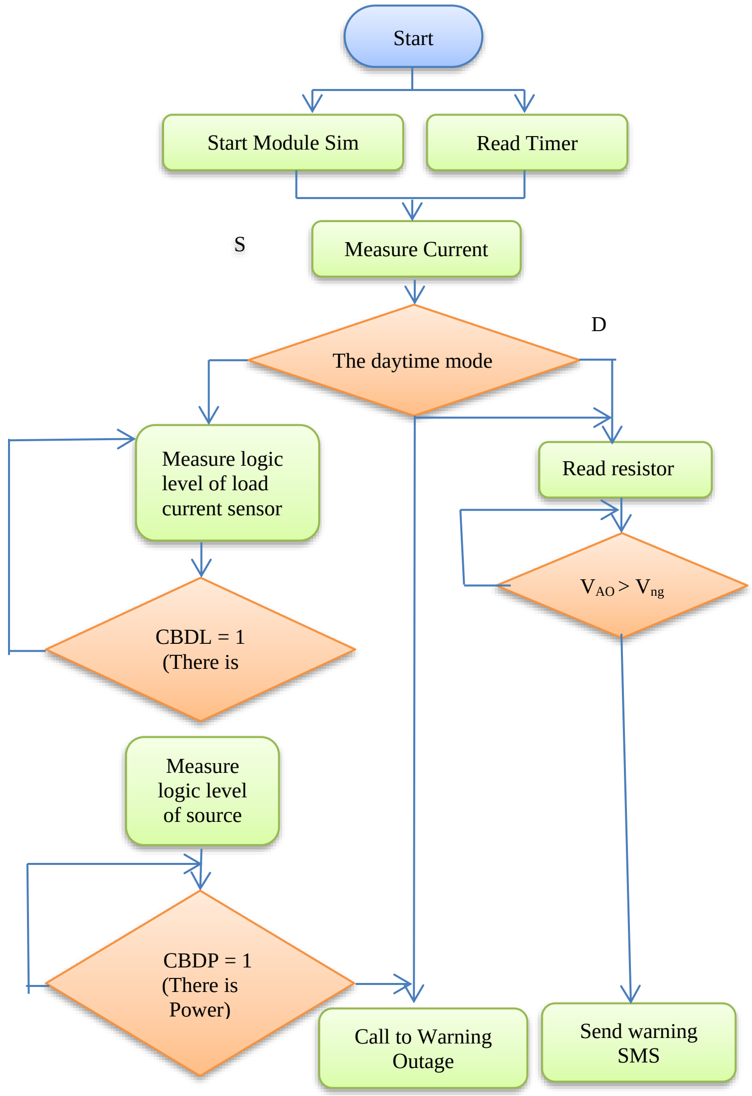

Fig. 9 The system flowchart

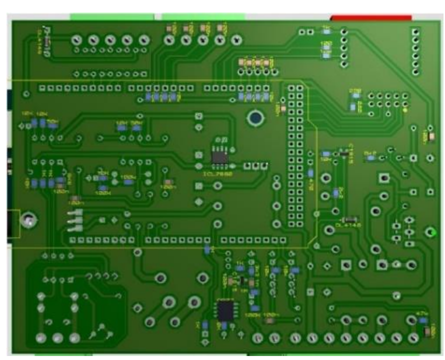

Fig. 11 (a): A printed circuit board

Fig. 11 (b) Package equipment

Fig. 12(a) shows the lighting control cabinet, including the controller and monitor, set up and tested at the lab. The SMS messages and phone calls between the device and the manager are displayed in Fig. 12 (b).

Fig. 12 (a)The controller cabinet and (b) SMS messages and communication calls between the device and the manager.

6. Conclusion

Design solutions for monitoring equipment and warning of theft of power lines for urban lighting systems are efficient, flexible, affordable, safe, and easy solutions integrated with existing lighting cabinets without requiring complex telecommunications infrastructure. In this article, the author conducted a survey of the practical lighting system in the Diem Thuy industrial zone, Yen Binh industrial zone, the residential areas of the Song Cong - Thai Nguyen, Việt Nam, proposed a design solution, and carried out a test system in the Laboratory of the major of Electronic Engineering, the Faculty of Electronics Engineering, Thai Nguyen university of technology. Experimental results have shown the validity and feasibility of the proposed system. The product was applied at two industrial zones, Diem Thuy and Yen Binh, Thái Nguyên, Việt Nam. The results demonstrate the effectiveness of the practical product. For future work, the fire/fault monitoring feature should be added to the system to support the manager during the repair or maintenance process

Appendix A

Appendices, if present, must be marked A, B, and C, placed before the Acknowledgment section.

Acknowledgment

The author's team thanks for a donation from the Thai Nguyen University of Technology (TNUT) of Vietnam for the team to design and perfect products.

References

[1] Hoang Ba Thinh, and Doan Thi Thanh Huyen, "Urbanization in Vietnam Today," *Vietnam Journal of Social Sciences*, no. 5, 2015.

[2] S. Mohamed, "Smart Street Lighting Control and Monitoring System for Electrical Power Saving by Using VANET," *International Journal of Communications, Network and System Sciences*, vol. 6, no. 8, pp. 351-360, 2013. *Crossref*, https://doi.org/10.4236/ijcns.2013.68038

[3] Chunyu Liu, Quangen Wang, and Fangyuan Zhang, "Design and Development of City Street-Lighting Energy-Saving System," *2010 Second Pacific-Asia Conference on Circuits, Communications and System*, pp. 178-182, 2010. *Crossref*, https://doi.org/10.1109/PACCS.2010.5627060

[4] F. Li et al., "LEDs: A Promising Energy-Saving Light Source for Road Lighting," *2009 Asia-Pacific Power and Energy Engineering Conference*, pp. 1-3, 2009. *Crossref*, https://doi.org/10.1109/APPEEC.2009.4918460

[5] L. Li et al., "The Development of Road Lighting Intelligent Control System Based on Wireless Network Control," *2009 International Conference on Electronic Computer Technology*, pp. 353-357, 2009. *Crossref*, https://doi.org/10.1109/ICECT.2009.15

[6] J. d. Lee et al., "Development of Zigbee Based Street Light Control System," *2006 IEEE PES Power Systems Conference and Exposition*, pp. 2236-2240, 2006. *Crossref*, https://doi.org/10.1109/PSCE.2006.296311

[7] Y. Wu et al., "Design of New Intelligent Street Light Control System," *IEEE ICCA 2010*, pp. 1423-1427, 2010. *Crossref*, https://doi.org/10.1109/ICCA.2010.5524348

[8] E. H. T. Ei-Shirbeeny, and M. E. Bakka, "Experimental Pilot Project for Automating Street Lighting System in Abu Dhabi Using Powerline Communications," *10th IEEE International Conference on Electronics, Circuits and Systems, Proceedings of the 2003*, vol. 2, pp. 743-746, 2003. *Crossref*, https://doi.org/10.1109/ICECS.2003.1301892

[9] H. S. H. Chung et al., "Case Study of a Highly-Reliable Dimmable Road Lighting System with Intelligent Remote Control," *2005 European Conference on Power Electronics and Applications*, pp. 1-10, 2005. *Crossref*, https://doi.org/10.1109/EPE.2005.219632

[10] Ha Manh Dao, and Do Xuan Hung, "IoT Solution to Monitor and Control Urban Public Lighting Systems Using LED Technology on the Basis of Lora Technology," *The 10th National Conference on Basic Research and Application of Information Technology*, pp. 212-217, 2017. *Crossref*, https://doi.org/10.15625/vap.2017.00027

[11] Datasheet pdf, "*Arduino Mega 2560*," 2014.

[12] Datasheet pdf, "*Module Sim 800L*," 2014.