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Developing Monitoring System of Traffic Signal Using Microcontroller Device by SMS of GSM Network

Aleksander Purba[1, *], Rahayu Sulistyorini[1], Ageng Sadnowo Repelianto[2], and Agung Ilhami[2]
[1]*Civil Engineering Department, the University of Lampung, Jalan Sumantri Brojonegoro 1 Bandar Lampung 35145 Indonesia;* [2]*Electrical Engineering Department, the University of Lampung, Jalan Sumantri Brojonegoro 1 Bandar Lampung 35145 Indonesia*
* Corresponding e-mail: aleksander.purba@eng.unila.ac.id

Abstract. *This research aims to design a traffic light system within the ability to diagnose itself (self-diagnose) include the series of electronic work function. Even as traffic lights are being disrupted and can detect suspicious operation activity and troubleshoot and report directly by using short message service (SMS) to a monitoring unit which can be placed anywhere as far as covering by wireless communications services through Global System for Mobile communications (GSM). To detect any malfunction of traffic light operations, a microcontroller device as the system's main controller need to be installed. The expected output obtained from this research is an appropriate system for monitoring of traffic lights which enable to inform the types of malfunctions regarding the operation of traffic lights: it sends a message to the microcontroller and the controller responds immediately. Benefits of using a self-diagnose traffic control system include provide efficient traffic flow, reduce travel time, reduce fuel costs, reducing vehicle emissions, reducing rear end collisions as long as some actions are performed to enable the traffic light system to control and report directly the traffic light operation based on the current traffic light condition.*
Keywords*: self-diagnose, GSM, traffic light, benefits*

INTRODUCTION

Traffic signal infrastructure is responsible for assigning the right of way to vehicular and pedestrian traffic at intersections. Traffic signal management and operations ensure the proper design, location, operation and maintenance of this infrastructure to provide safe and efficient movement of pedestrians and traffic through signalized intersections. There is a lot of mystery surrounding how traffic signals work, however they are relatively simple. In a nutshell, a traffic signal installation is comprised of a controller, traffic light heads and detection. The controller is the 'brains' behind the installation and contains the information required to force the lights through various sequences. Traffic signals run under a variety of different modes which can be dependent on location and time of day. Under fixed time operation the traffic signals will display green to each approach for the same time every cycle regardless of the traffic conditions. This may be adequate in heavily congested areas but where a lightly trafficked side road is included within the sequence it is very wasteful if in some cycles there are no vehicles waiting as the time could be better allocated to a busier approach. Vehicle actuation is one of the most common modes of operation for traffic signals and as the name suggests it takes into account the vehicle demands on all approaches and adjusts the green time accordingly. The traffic demands are registered through the detection installed either in the carriageway or above the signal heads. The controller then processes these demands and allocates the green time in the most appropriate way. Minimum and maximum green times are specified in the controller and cannot be violated. A vehicle passing a detector will demand a certain phase and once that phase is green any additional vehicles passing the detector will cause the phase to extend. Traffic continues extending the green until either the traffic demand ceases or another approach gains green, or a conflicting demand causes the maximum green timer to count down. Whilst vehicle actuation mode is more responsive than fixed time it can still be inefficient if there are long queues building up on conflicting approaches. The setting of maximum timers can be difficult due to changes in traffic patterns through junctions over time therefore to maintain effective operation the maximum timings should be regularly updated. This is a labour intensive task for a local transportation authority and is often not undertaken thus leading to the signals becoming less and less effective over time.

Traffic signals, like all electronic equipment, are subject to breakdowns, malfunctions, and power outages. When this happens, otherwise safe intersections can become dangerously congested and confusing, resulting in needless accidents. One study by the city of Boston calculated that simply reconfiguring the timings of 60 intersections in one district of the city could save US$1.2 million per year in person-hours, safety, emissions, and energy costs [1]. When it comes to malfunctioning traffic signals, the entity responsible for maintaining the signal may also be held accountable. Regions and municipalities have a statutorily imposed duty to ensure roads are safe for users. The Province of Ontario has set out certain minimum requirements for the maintenance of roadways including standards related to traffic signals.

The Ontario Regulation 239/02: Minimums Maintenance Standards for Municipal Highways, under the Municipal Act, outlines the standards related to traffic signals. Section 13 of the Ontario Regulation 239/02 stipulates that when a traffic control signal system is not working properly the minimum standard is to "deploy resources as soon as practicable after becoming aware of the defect to repair the defect or replace the defective component" [2]. However, more regions and municipalities have no statutory regarding minimum requirements for maintenance traffic signals as Ontario performed and since most of traffic signals categorized as isolated intersections, therefore surveillance

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system is highly dependent on road users report. Response time needed will be longer in terms of traffic signals malfunction occurring during out of work hours. The aim of this research is to design a traffic light system within the ability to diagnose itself (self-diagnose) include the series of electronic work function. Even as traffic lights are being disrupted and can detect suspicious operation activity and troubleshoot and report directly by using short message service (SMS) to a monitoring unit which can be placed anywhere as far as covering by wireless communications services through Global System for Mobile communications (GSM).

RESEARCH METHODOLOGY

In the second year (2018), research focuses on tools creation. At this stage, the product's realization is made using the circuit design. Initially, creating the circuit tools uses a project board. If the circuit works in line with the desired function, it is then made into a PCB (Printed Circuit Board) form. Also, if there are occurrences of several failed functions, a review process is carried out. The review process is carried out either in the review of the selection of the component type, the pattern of relationships between the components or the program algorithm on the controller. The realization of the application program made is conducted by creating a program with the algorithm that has been made. The Visual Basic 6 is the programming language used in this study. The end product is a software with a GUI display (graphic user interface). This software carries out its operation by retrieving data from Mobile, displaying the results of monitoring traffic light conditions and documenting these data into a database.

The testing and analysis stages of the circuit are then carried out. In this stage, several tools tests are carried out, which includes:

1. Test on the response of the tool to various conditions provided by the simulator.
2. Test on the time of sending data by the transmitter with the arrival time of data on the receiver, with various variations of distance between station and server.
3. Test on the time of sending data by the transmitter with the time the data arrives at the receiver, with a variety of delivery times.

Evaluation will be carried out on the three testing processes above to test the working reliability of the system, this evaluation process involves the following questions:

1. Is the system able to respond to all activities produced by the simulator? Can the system cope with an average delay of delivery times of one minute at various distances tested between the station and server?
2. Is the system able to work with an average delay of delivery times under one minute in various time variations when sending data, to the development of data storage applications?

The overall research design and flowchart of this study is shown in Figure 1 below.

RESULTS AND DISCUSSION

Generally, this system has two main parts. The first part is a station which could be a simulator, a microcontroller (Arduino UNO) or a GSM SIM800L module. It functions as an information provider. While the second part is called a server, which comprises a cell phone or smartphone and a set of computers. This section performs the role of information reception. The traffic monitoring system device is basically designed to quickly inform the traffic light conditions in the event of damage. To speed up information arrival, a wireless communication service is chosen, by using a GSM SIM800L module. The microcontroller will diagnose the traffic lights conditions that are in operation. Some damages have the tendencies of occurrence when the traffic lights operate. Hence they will be programmed on this microcontroller. If there is a corresponding damage scenario, the microcontroller will order the GSM SIM800L module to send information in the form of an SMS about the damage that occurred to the server.

In the early stages of tool design, it is not yet possible to make the equipment ready for use as a whole. This is due to the need to perform simulations in advance and test tools to find the specifications to be achieved. The desired initial stage of achievement in the prototype of the self-diagnosis system of traffic lights is as follows:

1. normally at a specified time to the server. for example, every 10 minutes the station continuously sends an SMS to the server that the traffic lights are operating normally.
2. The station section can provide information in the form of SMS news immediately to the section in the server in cases of malfunctions in the condition of the traffic lights that are in operation. At this initial stage, an abnormality scenario will be performed with the aid of the simulator section.

Designing Simulation System (Simulator)

The principle behind this is that this simulator system is designed to replace the functions of real traffic lights. The reason for replacing the overall traffic light with a simulator is to simplify the overall system testing process. The role of the simulator is to prevent a variety of possible damage that may occur at any traffic lights on the highway. At the initial stages of this design, there are two possible abnormalities that can occur at any traffic light.

1. Abnormalities as a result of the break-up of one or more lights, also the occurrence of more than one light at the same time. The state of the light is illustrated by the high logic condition (1), while the condition of the off lights is represented by the low logic condition (0).

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2. Abnormalities that occur in the timer system at the traffic light. For example, the red light is simulated for 10 seconds, after which a yellow light is followed for 5 seconds and the green light lasts for 15 seconds. This kind of scenario will be programmed inside the microcontroller. If the traffic lights operation is not in accordance with this scenario, the microcontroller will regard it as an abnormality. Furthermore, the microcontroller will instruct the SIM800L module to send SMS messages to the server that there has been an abnormality in the traffic light timer system.

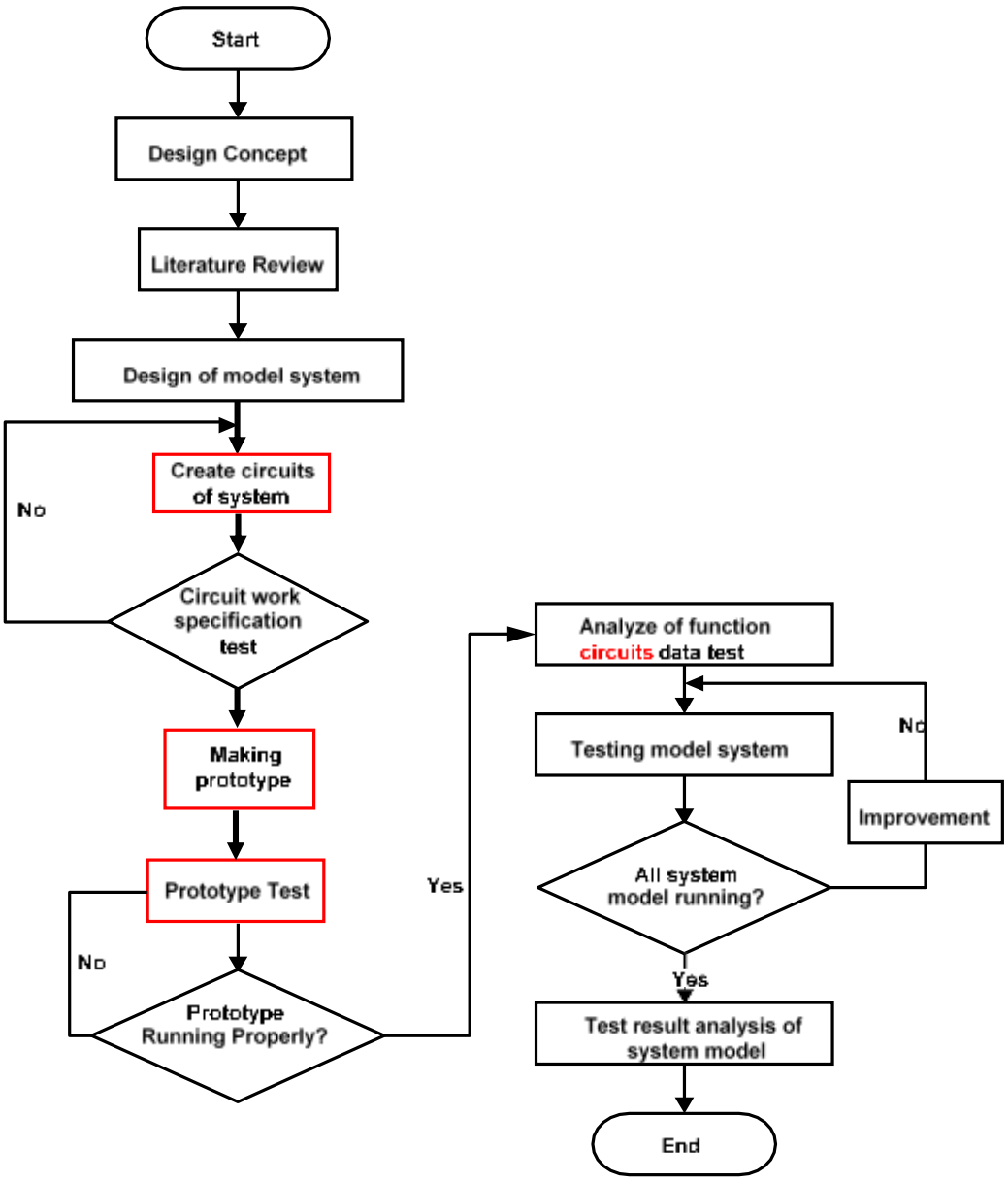

Figure 1. Flowchart of research

The station section can provide information on its own condition (auto-update) as long as the traffic lights operate The simulator section is made up of various parts, namely:

1. 4 channel solid state relay SSR module.
2. Arduino UNO, a microcontroller which serves as a diagnostic data processor. It is a storage place for several scenario rules and at the same time giving orders whether or not the GSM module sends news.
3. SIM800L GSM module performs the roles of sending news in the form of SMS results from diagnosis and microcontroller commands to the server. The communication service used is GSM. In this module, you must insert a SIM card that has been topped up and activated the SMS service. This SIM800L module is ordered using AT Command. Library AT Command can be easily downloaded from the official Arduino site. It is an open

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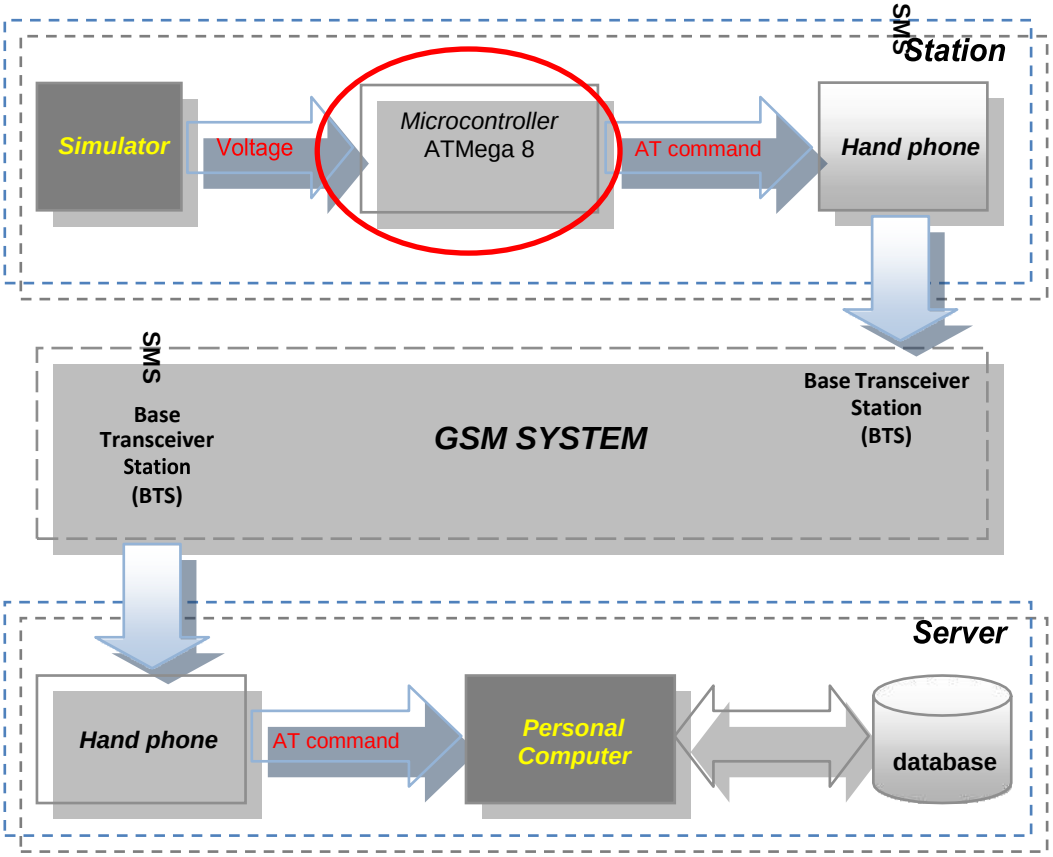
source, hence anybody can download it freely and may be used for the development of a programming electronics based on Arduino.

4. The 3-color lamp module, as a miniature of the real traffic lights
5. SMPS (Switching Mode Power Supply), as a 12-volt DC power source and 5 volts to turn on the four previous modules.



CONCLUSION

Fundamentally, the traffic light monitoring system program is designed to function quickly in information delivery to the traffic light conditions in case of interference. To accelerate information and not limited by wiring communication services, wireless services are chosen. This is achieved with the aid of two cell phones with GSM communication services. In the microcontroller, a program is stored to detect abnormal conditions at traffic lights. Automatically the microcontroller will drive the hand phone to send an SMS containing information that there has been a traffic light abnormality. A personal computer (PC) with the aid of Visual Basic 6 inbuilt software, retrieves the SMS data from the mobile phone and displays the contents of the SMS on the screen of the monitor. The software system is built to carry out auto-response. This means that the computer will automatically update when there are the latest information updates. It displays information received by the mobile on the screen of the monitor. Furthermore, the information received will be stored in a database.

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