EXPLORING THE APPLICATION OF RADIO FREQUENCY SENSOR AT SIGNALIZED INTERSECTIONS FOR EMERGENCY VEHICLES

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I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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ABSTRAK

Masalah kesesakan lalu lintas merupakan satu fenomena yang memberi kesan besar kepada sistem pengangkutan Malaysia. Ini menimbulkan pelbagai masalah, terutamanya apabila berlaku kecemasan di persimpangan lampu isyarat yang sesak. Sistem kawalan lampu isyarat direka untuk menangani isu ini. Pengawal mikro litar bersepadu boleh atur cara (PIC) 16F877A digunakan untuk menukar jujukan kembali kepada normal sebelum mengaktifkan mod kecemasan apabila sistem menerima isyarat daripada kenderaan kecemasan melalui penghantaran frekuensi radio (RF). Memandangkan kenderaan tambahan mesti dipasang untuk membolehkan kenderaan kecemasan mendapatkan laluan unik, strategi ini akan mengurangkan kemalangan yang kerap berlaku di persimpangan lampu isyarat. Oleh itu, kajian ini secara berkesan menyelidik dan melaksanakan komunikasi tanpa wayar, juga dikenali sebagai penghantaran frekuensi radio (RF), dalam sistem pengurusan lampu isyarat kenderaan kecemasan. Prototaip yang dihasilkan dalam kajian ini beroperasi pada 315MHz dan menggunakan mod jujukan lampu isyarat apabila kenderaan kecemasan melalui persimpangan, mengembalikan jujukan kepada normal sebelum mencetuskan mod kecemasan. Sistem prototaip boleh dipertingkatkan pada masa hadapan dengan mengawal keadaan trafik dunia sebenar, dengan berkesan meningkatkan teknologi sistem isyarat trafik semasa. Pada masa hadapan, prototaip dalam kajian ini boleh dipertingkatkan dengan menguruskan keadaan trafik sebenar, seterusnya meningkatkan teknologi kejuruteraan sistem isyarat trafik semasa.

ABSTRACT

The problem of traffic congestion is a phenomenon that has a major impact on Malaysia's transportation system. This creates a slew of problems, especially when emergency situations arise at congested traffic light junctions.The main controller, control circuit, counter, timer, decoder, clock signal generator, decoder drive circuit, and digital display decoder drive circuit are all necessary components of the traffic light control system to complete the entire process of operating the traffic light. A traffic light controller system was developed to overcome these concerns. The PIC 16F877A microcontroller was used to shift the sequence back to the normal sequence before the emergency mode was activated by pressing the button on the remote. The radio signal receiver is fixed in the traffic lights and the transmitter is fixed in the remote. Because other vehicles must assemble in order for an emergency vehicle to be granted a unique route, this strategy will reduce accidents that occur regularly at traffic light crossings. As a result, this study was effective in studying and implementing wireless communication, also known as radio frequency (RF) transmission, in the emergency vehicle traffic light management system. The prototype developed in this study operates on the frequency of 315MHz and works with the cycle mode of traffic lights when an emergency vehicle passes through a junction, altering the sequence back to normal before the emergency mode is triggered. This prototype system can be enhanced in the future by controlling real-world traffic conditions, effectively upgrading current traffic signal system technology. In the future, this prototype system can be enhanced by managing the actual traffic condition, thereby enhancing the technology of the current traffic signal system.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Overview

The issue at traffic signal crossing points that results in accidents between emergency vehicles and other open vehicles is one that many countries throughout the world are dealing with. Particularly in Malaysia, the structure for traffic control at signalised intersection is not set up with an appropriate plan for when a crisis occurs. This will make it difficult for emergency vehicles like ambulances to arrive at their destination on time because delay caused by the traffic control at signalised intersection. Furthermore, when emergency vehicles undergoes delay waiting for other vehicles to move forward at intersection with red lights, the delay is getting worse. This causes delay of time and might influence the traffic flow at signalised intersection and late arrival of ambulance. Based on study, from 505 cases, 75% found to be delayed case meanwhile 25% is non delayed case and the mean response is 12.42 minutes (Zulaili Asri et al., 2021). Other than that, the accidents with other vehicles from another course might happen at convergences when emergency vehicle such as ambulance had to supersede the red traffic lights. Using this radio frequency-based traffic light control system will allow emergency vehicles to keep a safe distance from all of these obstacles. Vehicle tracking system is one of the easy ways to control traffic conditions in addition to its implementation that can arrange a good time distribution for all branches of road junctions involved. A traffic light controller acting as the main role

will process the signal received from the detector which the detector is placed in the ambulance and the traffic light will receive a signal to convert from red to green. These detectors will detect the presence of an ambulance in an emergency situation as it heads towards the intersection and this will automatically make it easier for the ambulance to cross the intersection quickly, easily and safely (Follow, 2015).

1.2 Problem Statement

Ambulances carrying critically ill patients often face problems when trying to get past intersections especially during peak hours, which can endanger the patient's life. This is because the vehicles in front of them do not dare to break the traffic lights on the basis of maintaining their safety. Road safety is not guaranteed for road users and pedestrians. The second problem is the traffic light green time and red time is fixed thus whenever the ambulance need to pass through the junction it only have one option which is requesting for way. In that situation if the red time is high then it takes more time for the ambulance to pass through. Due to that problem, Few modifications were made to the existing road junction by using RF (radio frequency) to facilitate the ambulance to pass the junction (traffic) safely and quickly.According to the study, it says that 20% of emergency patients death caused by traffic congestion (The Nation, 2017). According to studies an ambulance should reach the scene within 8 minutes, while waiting for an ambulance (Zulaili Asri et al., 2021). Observations made on the ground indicate that traffic at Hospital Pantai Puteri, Jalan Tambun, may impede other users, particularly ambulances, during emergencies and cause delays in saving the patients' lives and conditions. Emergency patients might not survive because of the traffic gridlock, which preventing the ambulances from getting to the hospital quickly. Additionally, road congestion and delays frequently result in issues and slow down the

delivery of emergency medical services. The two sides of the road are frequently used by motorists to park their cars. It's not unusual to see double parking as far as the eye can see. Because of the resulting traffic congestion, especially during rush hours, it is hazardous for pedestrians to cross the roads (Mei Kuan, 2015).

1.3 Objective

1. To understand the road users perception on traffic congestion and intersection condition due to emergency vehicles.
2. To develop a computer programmed system that can be used to set the signal timing of the traffic light at an intersection for emergency vehicles.
3. To build a prototype of the radio frequency sensor using the Programmable Integrated Circuit (PIC)

1.4 Study scope

This study needs to create a device to control the traffic lights especially the timing from red to green and from green to red in any junction. This study will also cause changes in traffic signal design and traffic flows.This study uses 3 types of circuits, namely traffic light circuits, transmitter circuits and also receiver circuits. The traffic light circuit serves as an existing traffic light, while the transmitter circuit is used to send a signal to the receiver to be ready to give way to an ambulance in an emergency, finally a receiver circuit that serves as a frequency receiver when the button is pressed in the ambulance.

The project prototype developed in this study used 315 MHz type radio which works for a 100m range and it has 4 fixed buttons in a remote in the ambulance for the driver access the traffic light which namely button number 1 for traffic light number 1; button number 2 for traffic light number 2, button number 3 for traffic light number 3 and last button i.e. button number 4 for traffic light number 4. Each of these buttons is fixed in controller that placed in the ambulance to make it easier for the ambulance driver to press to cross the intersection safely and quickly. This study uses 2 9v battery power, one battery is placed in the ambulance for the transmitter circuit to operate and another battery to run the traffic light.

This study need to find out the changes and benefit in traffic signal design and level of service of each lane in junction during application of radio frequency traffic light. The initial setup used in this study is for 15 seconds of green time and 3 seconds of yellow time. Finally, when the ambulance presses the button on the ambulance to pass the junction, the traffic light will automatically be interrupted to make it easier for the ambulance to pass the junction. From the direction of ambulance approaching the junction, all four signalised traffic light will change from red to yellow for 4 seconds where it shows an emergency sign, then the signal will change from yellow to green for 15 seconds while the other three traffic light will turn to yellow for 4 seconds and then change to red.

1.5 Outline of Dissertation

The thesis is divided into five chapters. Chapter 1 covers the overview and background of this study. It gives a brief introduction about the emergency traffic light and its relation to the traffic signal design and transportation. This chapter also

describes the problem statement, research objective, and scope of study. Chapter 2 discusses the literature review on what is radio frequency traffic light and other type of traffic light that practices in Malaysia and around the world. Moreover, this chapter also provides comparison and explanations of this study and existing studies. Plus, this chapter discusses about the advantages and disadvantages of each literature review. Subsequently, Chapter 3 provides the methodology used to conduct this study. This chapter explains briefly about the questionnaire survey that was used to conduct this research and the content of the questionnaire. This is followed by Chapter 4 which covers the outcome of the results and discussion part of this research. The questionnaire results obtained are elaborated further and analysed. Lastly, Chapter 5 concludes the study by summarising the findings obtained in this study and highlights several recommendations which can be adopted for future studies.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

In this chapter, the differences in the literature with advantages and disadvantages between this study and the existing projects has explained and shown clearly.

In the growing technological era, the traffic in every city has increased due to increased number of population and number of vehicles. This condition has a definite effect over the daily life and other activities of the society. When it is the matter of safety over the roads and the emergency situations like fire and health, congestion cause a danger to the people (Sanjay, 2019).

The frequency band at which wireless telecommunications signals are sent and broadcast is referred to as the radio frequency in the field of information and communications technology. Different parts of the frequency range are split and allotted to different technology industries. The radio spectrum is what we call it. For example, the VHF (very high frequency) band, which spans 30-300 MHz, is utilised for FM radio, TV broadcasts, and amateur radio. The ultra-high frequency (UHF) band is used by a large number of electronic communication equipment. Mobile phones, wireless LAN, Bluetooth, television, and terrestrial radio all occupy this space.

Creators use RF modules to transmit and receive data in many studies since they have a larger number of applications than IR. To send and receive data, an RF transceiver module must always work in tandem with a transmitter and receiver. Because a transmitter can only send information and a receiver can only receive it, data can only be sent from one end to the other. In this chapter, it is shown that radio frequency system better than other systems.

2.2 Existing projects of emergency traffic lights

Levi L. Rose (1997) created a traffic signal system that was solely utilised for emergency vehicles. A sensor is used to convey a signal from an emergency vehicle to a receiver stationed at each traffic light intersection. When an emergency vehicle arrives at a traffic light intersection, the signal code and frequency modulation information will be delivered to the receiver. The received code is extracted by the receiver, and the red traffic light is activated at all intersections. As a result, emergency vehicles will take a different path to their destination than ordinary vehicles (Rose ,1997).

M. R. Smith (1998) devised a traffic signal system that offered early warning of incoming emergency vehicles, allowing them to find a way out of traffic and direct them to their destination. An emergency vehicle may also take control of a traffic light at a crosswalk. When an emergency vehicle is in emergency mode, a transmitter on the vehicle broadcasts a signal to receivers at traffic lights. The received signal is subsequently evaluated by a master controller, who then pre-empts the traffic light sequence to regulate traffic flow at the intersection where the emergency vehicle is travelling. The master controller also has an output that shows signs to other road users

coming from the other way at the traffic light intersection that there is an emergency vehicle present. The display system also shows whether or not the emergency vehicle has passed through the intersection (Michael R. Smith, Paul J. Davidson and Henry L. Pfister, 1998).

Mitchell (1994) created a traffic light management system that solved the traffic congestion problem while also providing an emergency way for the emergency vehicle, which was equipped with a radio transmitter and antenna. The signal will be broadcast over the radio to any adjacent vehicles. The radio receivers installed at four intersection traffic lights will receive an emergency signal from an emergency vehicle passing through the intersection. The first signal code contains an emergency vehicle frequency, whereas the second signal code comprises a vehicle frequency. In regular or emergency conditions, the transmitted signals supply miscellaneous traffic light poles. The traffic light system for emergency vehicles will turn on when the receiver receives the signal from the emergency vehicle transmitter (Mitchell ,1994).

A sound signal-producing device is mounted on an emergency vehicle, a sound signal detection device is mounted on a non-emergency vehicle, and a device is remotely mounted on the non-emergency vehicle. W. E. Brill (2002) developed an emergency vehicle detection system for warning a vehicle of an impending emergency vehicle. A sound generator is used to create and transmit a sound signal in the sound signal-producing unit. In conjunction with a siren, a switch is utilised to control the operation of the sound generator.At least one sound transducer is included in the sound signal detection unit for detecting sound signals and creating an electric current when a signal is detected. A signal compactor, which is attached to the sound transducers, compares the currents coming from the transducers to pre-programmed patterns. If a matching pattern is found, a signal output encoder attached to the signal comparator

creates an encoded signal, which is then transmitted to a remote display unit through a transmitter. The display unit has a receiver that receives the encoded signal and sends it to a signal comparator, which compares the encoded signal to known patterns and activates at least one illumination device if a matched pattern is detected (William E. Brill,March 26th,2002).

Carl J. Obeck (1998) created a traffic light control system that involves two-way communication between emergency vehicles approaching a busy intersection with one or more traffic lights. The system diverts regular traffic while temporarily overriding the traffic light sequence to direct the car through the intersection as efficiently as possible. As part of the idea, the traffic light control system will inform the emergency vehicle that it has received the sent signal. In one illustration, the preset traffic patterns may respond to manual intervention from a dispatching centre or to the time of day. The standard two voice communications system of the emergency vehicle can broadcast data or voice to a central control station for the traffic light control apparatus. (Carl J. Obeck, May 7th, 1998).

2.3 Traffic light with timer

Time timer lights can usually be seen in areas with congested traffic lanes, these traffic lights are usually located on the main road of road users. This traffic light timer is determined and scheduled by traffic control engineers, however this timer is regularly updated depending on traffic flow.This timer traffic light is very common in most of countries but it has it’s own advantages and disadvantages. At peak hours, this system causes huge traffic congestion.

The reason for this is that drivers pay more attention to the countdown timer than to their surroundings, which makes them more prepared to move when it is time to. As a result, there is a greater flow of traffic on the street with traffic signals (at crossings or intersections). It is important to note that the longer it takes for individual vehicles to turn on their lights, the more congestion there is, and the more localised environmental pollution there is.(Małecki, 2019).

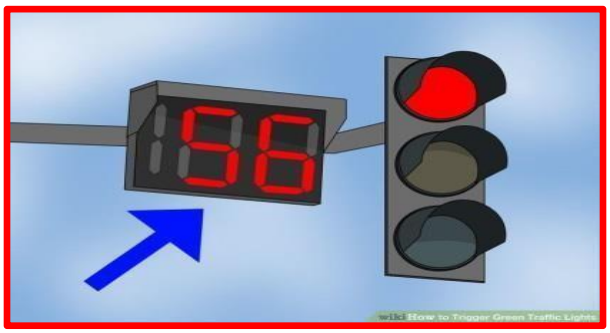

Figure 2. 1 Traffic light with timer (Source : wikiHow, 2008)

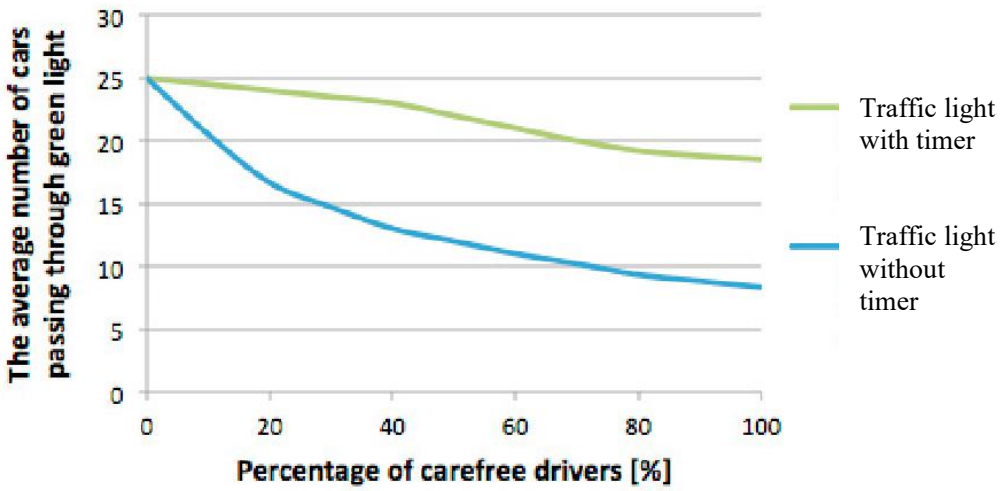

Figure 2. 2 Percentages of carefree drivers (source : Krzysztof Małecki, 2019)

2.4 Traffic light with remote button

Traffic light with remote button, works the same as the television remote for example the remote works to control the television from a distance to make it easier for the user to watch television. While the user presses the green button to turn on the television, the television can be turned on remotely and this can save time and makes it easier for users to watch television.When press the button marked Red, the red light goes on and the green one goes off. when press the button marked green, the green light goes on and the red one goes off. Since it should be used manually,the chances to affect traffic signal design and level of service is very high.

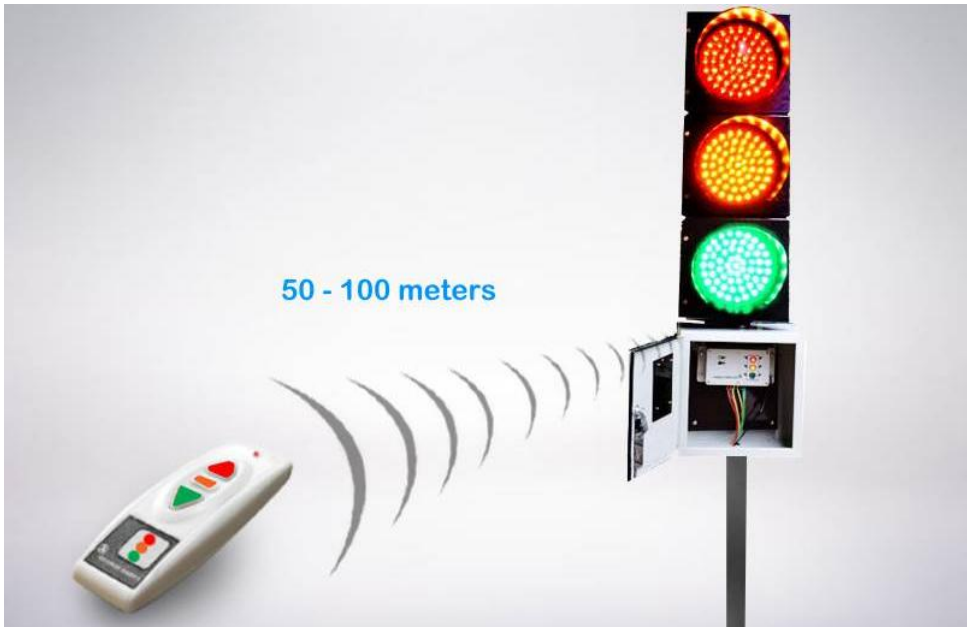

Figure 2. 3 Traffic light with remote button (Source : admin, 2009)

2.5 Emergency traffic light with sensor

In the implementation of this sensor, four TC-QT50 counter vehicle sensors have been installed in TLC per SJ and pointing towards each lane, this is to detect the

vehicle from that view up to the set distance. Then the sensor is wired to connect to the ES, which is placed in the TLC of each SJ so that it can receive count information for each lane and each specific intersection.On the other hand, in the suburbs and on county roads, traffic signal sensors (detectors) are usually preferred because they not only manage the inconsistent traffic flow effectively, but, also detect when cars arrive at intersections, when several cars are stacked at an intersection, and, when cars have entered turn lanes.

Another sort of sensor commonly utilised in traffic signals is infrared sensors. These sensors are positioned overhead rather than implanted in the pavement to detect the presence of cars in an intersection. Active infrared sensors and passive infrared sensors are the two types of infrared traffic sensors.To identify automobiles, active infrared sensors release low-level infrared light into a specified zone. When that energy is disrupted by a car, the sensor sends a pulse to the traffic signal, which causes the light to change. Passive infrared sensors don't produce any energy of their own; instead, they detect energy emitted by adjacent automobiles and other things. When a vehicle enters the field of a passive sensor, the sensor detects a change in energy and alerts the traffic signal, allowing the light to be adjusted.

Figure 2. 4 Emergency traffic light with sensor (Source : Dot.gov. 2022)

2.5.1 Traffic Light Sensor

Sensors in traffic control systems are employed at the most basic level to identify the presence of cars at certain spots. Sensors can be used to count and track the number of cars passing at a certain point, as well as the speed at which the vehicles are travelling. Sensors are utilized in a wide range of traffic control and monitoring applications, including traffic signal control, freeway management, ramp metering, toll road monitoring, and more. While some traffic lights are strictly timed, changing the signal only at predetermined intervals, as technology has grown, traffic control systems have gotten more advanced, allowing systems to manage traffic flow more effectively. Different types of traffic sensors have emerged because of technical advancements to regulate traffic in a range of scenarios. There are four main type of sensor which are explained below.

- Induction Loop Sensor
- Infrared Sensor
- Microwave Sensor
- Video Sensor

The ultrasonic Doppler effect is used by these sensors. They use a change in frequency (the Doppler effect) in relation to the speed of the vehicle to detect vehicles moving in a specific direction. They are installed on low-traffic side roads and used for recall control to only turn the side road's traffic light green when a vehicle is spotted (Kyosan.co.jp, 2012).

2.5.2 Inductive Loop sensor

To identify the presence of a vehicle, inductive-loop traffic detectors employ an electrically conducting loop buried in the pavement to transmit a signal to the traffic management system. An inductive loop is made of wire that has been "coiled" into a shape that is typically square, circular, or rectangle and inserted into or beneath the surface of the road (Diamondtraffic.com, 2021). After then, the traffic management system can alter the signal to enable vehicles to proceed through the intersection. If a traffic signal employs an inductive-loop sensor, a triangle, diamond, or square-shaped outline will be seen in the pavement in each lane at a junction that uses this type of sensor. By far the most prevalent form of sensor utilized in traffic control signals is inductive-loop sensors.

2.5.3 Infrared Sensor

Another sort of sensor frequently utilised in traffic signals is infrared sensors. These sensors are positioned overhead to detect the presence of automobiles in an intersection rather than being embedded in the pavement (Elteccorp.com, 2019). Instead of being implanted in the pavement, these sensors are positioned above a junction to detect the presence of cars. Active infrared sensors and passive infrared sensors are the two types of infrared traffic sensors. To identify automobiles, active infrared sensors release low-level infrared light into a specified zone. When that energy is disrupted by the presence of a vehicle, the sensor transmits a pulse to the traffic signal, which causes the light to change. Passive infrared sensors do not generate their own energy, but rather detect energy released by automobiles and other surrounding objects. When a emergency vehicle detected in the field of the passive sensor, the sensor detects the

change of energy in the field and informs the traffic signal to the existence of a vehicle, allowing the light to be adjusted.

2.5.4 Microwave Sensor

Microwave traffic detection sensors, which are also positioned overhead, function in the same way as infrared sensors do. For an example, the Remote Traffic Microwave Sensor (RTMS) is a vehicle detection tool that uses radar technology. In the cross-fire mode, it is currently intended to track vehicle presence simultaneously in up to 12 adjacent lanes (Wang, WHITE and MANOR, 2022). To detect traffic at crossings, both employ electromagnetic radiation. Microwave sensors are often less costly than infrared sensors. Furthermore, microwave technology is less susceptible to disruption by severe temperatures than infrared sensors, although both types provide a number of useful capabilities and are less expensive to install and operate than inductive-loop sensors.

2.5.5 Video Sensor

With developments in video technology and artificial intelligence systems, video traffic sensors may be utilized to regulate traffic patterns in a variety of ways. Video sensors can recognize when a car, bicycle, or even a person enters a certain zone on the camera's detection map using a mix of hardware and software. After that, a signal is transmitted to the traffic light to change the appropriate signal. One disadvantage of video sensors is that their performance might be hampered by inclement weather (How Traffic Lights Sensors Work | Automate Systems, 2022).