

# PORTABLE WIRELESS TRAFFIC LIGHT SYSTEM (PWTLTS)

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## Abstract

A Portable Wireless Traffic Light System using a microcontroller and wireless ZigBee is the best system to control the traffic flow during the road construction or maintenance. This traffic light is designed to solve the various type of hazard which may happen to the worker, flagman and also road users during the road construction. The communication between these two traffic lights is via wireless. Due to this it can be deployed anywhere because no wire is used. This system is equipped with the safety purpose where it is equipped with motion and infrared sensor to detect and count the number of vehicles to avoid any collision. This automated system can be used 24-hours in various weather conditions. This eliminate the limited working hours when using the flagman. This system is a low cost system where it uses microcontroller to control the system.

**Keywords**—Portable Wireless Traffic Light, PIC Microcontroller, flagman.

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## 1. INTRODUCTION

The process of developing the safety and comfort road for user involved a road construction. Currently, the flagman who acts as a traffic controller is a must to ensure the traffic went smooth during the road construction besides optimized the safety.

Road construction might happen everywhere either at highway, two-way road, and hilly road. Due to this the traffic need to be monitored and controlled. This flagman is used to control and monitored the flow of traffic. The cost needed for man power utilization is high. Because of this, most of the flagman hired is not well trained due to the high cost of training session. Various type of hazard can happen to the flagman, workers and also road users during the construction road. Besides, the possibilities of flagman, workers and also road users involve in an accident are high during the road construction.

Road construction may happen for overnight or sometime 24-hours in different weather condition. So, it is not applicable to use flagman especially at night or on rainy day. This portable traffic light system is more effective to be used for two way road where one way is under construction or maintenance and the other ways is use for vehicles traffic.



**Fig 1:** One person was injured when a pickup truck collide a sweeper in a construction zone



**Fig 2:** Road user not follow the flagman instruction and accident occur during road construction

## 2. CURRENT SYSTEM DURING ROAD CONSTRUCTION

Until now, during road construction the flagman is used to monitor and control the flow of traffic until the session of construction or maintenance is finished. Usually the flagman is highly visible in their bright orange vests, as they stood up with their “Stop” and “Go” signs. Sometimes they will use flag red and green color. As an alternative, some contractors practice the usage of flaggers with a custom flags to alerts and direct the drivers when bypass the road to a single line [1].



**Fig 3:** Flagman with sign and flag when control the traffic.

There are some regulations contained of legal requirement created by The Department of Occupational Safety and Health (DOSH), which needed to be followed by the contractor in order to ensure the safety of the workers at work zone. During the road construction there should be a minimum of 10 safety alert sign boards which must be placed on specific locations at the construction area. In most cases the contractors may overlook the safety regulations and rules appointed by Ministry of Works. This irresponsible attitude may also causes problem to numerous parties. Also, the flagman who is appointed by the contractors might not be well trained by their employment. These untrained flagmen could be harmful for the road users and themselves. At times the flagman's concentration on controlling the traffic flow also can result in various miseries not only to his life but also to the public. For an example, when the flagman works under the hot sun, they get tired easily and lose their concentration on work [2].



**Fig 4:** Several safety alert sign that will use during road construction

During the road construction, the driver must follow the instruction given by flagman to avoid an accident involved of flagman, worker and also road user [2]. However, some drivers do not follow the instructions from the flagman and drive with reckless and this may cause an accidents.



**Fig 5:** Flagman controlled the traffic during road construction

## 3. PWTLs SYSTEM

Portable Wireless Traffic Light System (PWTLs) is design to develop a smart system that can be used during the road construction in order to reduce the amount of flagman use and also to smooth the flow of traffic.

The system proposed used two traffic lights. The communication between these two traffic lights is via wireless. Due to this, the traffic light is portable since there is no wire used. Besides, this may eliminate the limit usage of the traffic light and it can be deployed anywhere. The system of the traffic lights is fully automated and will operate without human control at all times. Usually, the flow of traffic especially on a two-way road is difficult to be monitored and controlled during a rainy day and also extremely hot weather. So, with this proposed system, the traffic problem can be solved. Besides,

the system is designed to help in the effort to control the traffic and decrease the number of accident without having a flagman during the road construction.

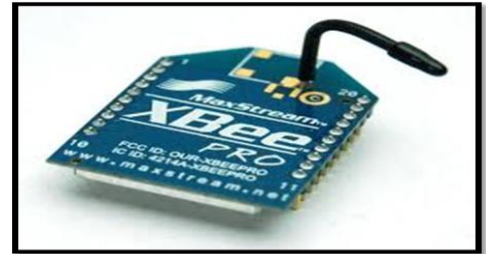
PWTLs consist of hardware and software part. For hardware part, the PIC (Programmable Interface Controllers) microcontroller, IEEE 802.15.4 device, light emitting diode (LED), infrared sensor and motion sensor are used. PIC microcontrollers can be programmed to be timers or to control a production line and much more. Most of the traffic light which has been proposed is using the PLC (Programmable Logic Circuit) instead of microcontroller. In this project the PIC Microcontrollers is used since it is cheaper compare to the PLC and also can be as pre-built circuits. The entire program has been created and downloads to the PIC microcontroller circuit. The advantage of the PIC is its fast performance since it uses RISC architecture and the power conception is also less compare to other microcontroller [6]. Besides, the PIC microcontroller is used in this project to reduce the cost of traffic light. It also uses low power which is only at 5 volts. Due to this, the PIC may use the battery to function. Figure 6 shows an overview of PIC microcontroller.



**Fig 6:** Pic microcontroller

The IEEE 802.15.4 device, Zigbee is used in this project for communication purpose. Zigbee is a communications standard that provides a short range cost effective networking capability. It has been developed with the emphasis on low-cost battery powered applications. X-bee is also under the Zigbee wireless network [6]. This Zigbee defines mesh, star and cluster tree network topologies with data security features and interoperable application profiles [3]. It requires longer battery life, lower data rates and less complexity than those from existing standards. The Zigbee network node is designed for battery powered or high energy savings, searches for available networks, transfers data from its application as necessary, determines whether data is pending, requests data from the network coordinator, can sleep for extended periods [4]. Besides, this type of device is used in this project because it has a wide range of radio communication where the outdoor range can be up to 750m. The Zigbee is controlled by the PIC microcontroller. Most of the implementation of wireless traffic

light use RF module where the radio range is only 100m. However, is not applicable to be used at a road construction. This is because the maximum range according to the United States Department Of Labor (Occupational Safety & Health Administration) the maximum length for the road construction for one-way road is 400 feet or around 122 m [10]. Due to this, the Zigbee module is used in this project since the maximum radio range is up to 750m as mentioned before. Figure 7 shows the overview of the Zigbee device.



**Fig 7:** Zigbee (Xbee)

Infrared sensor is used in PWTLs system. This sensor is implementing at both traffic lights and is control by the PIC microcontroller. This sensor is used to detect vehicles that passed through each of the traffic light. When this sensor detects vehicles, it will be count by the PIC microcontroller. The number of vehicles passed at the first traffic light will be transmitted to the second traffic light and it will be compared with the number of vehicles passed at the second traffic light. If the number of vehicles are equal at both traffic lights, then only the second traffic light turn green and vice versa. This is to ensure the safety and to avoid any collision especially at hilly road.

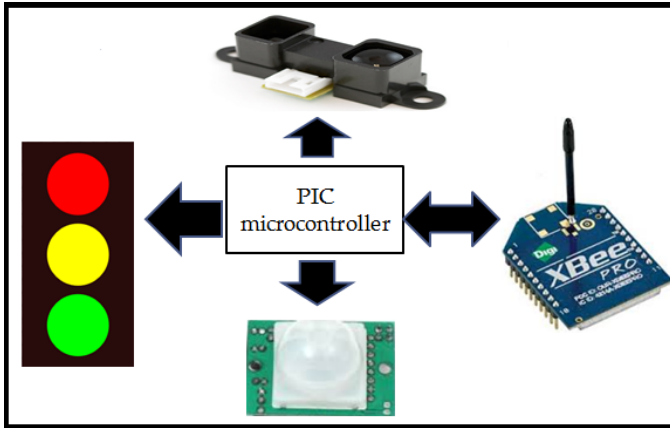
The motion sensor is used in this system for the safety purpose. This sensor will be put at a maximum height of the traffic light. This sensor is also implementing at both traffic light. This sensor is used to sense the vehicles along the single lane used. The sensor will sense the vehicles when both of the traffic lights are red. Even if the numbers of vehicles are equal at both side, but there are still vehicles detection on that single lane road, the system will not let any of the traffic light turns green. Figure 8 shows an overview of motion sensor used in this system.



**Fig 8:** Motion Sensor



For the software part, C programming using the MPLAB software is developed for the system of the traffic light. The software is then embedded in the PIC Microcontroller. This PIC microcontroller will control the system as programmed. Figure 9 shows the system design of the PWTLS which consists of PIC microcontroller, Zigbee module, infrared and motion sensor.



**Fig 9: System Design of PWTLS**

### 3.1 Advantages of PWTLS

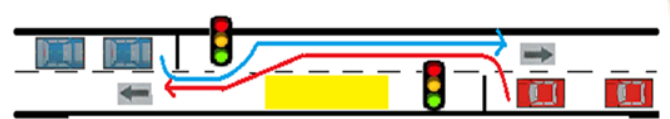
The advantages of this system are it can be one of the effective practices in road construction traffic control systems. The main factor of developing this system is to reduce the amount of accident which mostly involved the flagman. So, this system is suitable to be used at the road construction where the risk and limitation of a flagman can be reduced. Moreover, it can be used overnight or 24-hours operation at any environmental and weather factors since it uses low power to operate. Besides, by using this system the working hours are unlimited compared to flagman.

The system in PWTLS is equipped with a safety purpose where the green light at both side will only turn on when the road is clear. This is by having the IR sensor which can be used for counting purpose and motion sensor which is used for vehicles detection along the single lane road.

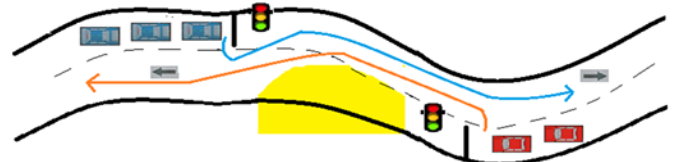
Most of the traffic lights are using the programmable logic circuit which is much more expensive compared to PIC microcontroller. So, this system is not only good in term of safety but also low in cost. Besides, these systems also use low power and this makes the system operate by only using batteries instead of having generator.

### 3.2 Operation of PWTLS during road construction

The PWTLS system is proposed to be used at a two-way road which is on construction. Figure 10 and Figure 11 shows the critical zone in a two-way road at a construction site.



**Fig 10: A straight two-way road**



**Fig 11: A curve two-way road**

Figure 10 shows the overview of a straight two-way road where the road construction is held and block one of the roads. In this situation, only one road is available for both ways. As mentioned before, usually the road will be control by a flagman. But this can be replaced by having the traffic light to control the traffic. One traffic light will acts as the master and the other traffic light will acts as a slave.

Figure 11 shows an overview of a curve or hilly two-way road. The road construction is held on one of the road. So, as explained in Figure 10, only one of the roads can be used for both ways. In this situation, the traffic is hard to be controlled. Usually at this situation, at least two flagman need to be place at each of the side. The communication between the flagman must be strong so that there will be no collision to avoid accidents to happen. This situation can be replaced with the portable wireless traffic light system. Since the communication range for the Zigbee is up to 750m, then the signal transmit and receive at both side will faced no problem.

Since the system is made as portable, there will be no usage of wire. So the workers can place the traffic light at anywhere with range limited to 750m. The system is supplied with a power voltage of 12 Volt. Once the system is on, the master traffic light will be turning green while the slave traffic light will turn red. There will be three type of condition that is considered in this design which is normal condition, unequal condition and equal condition after time limited. These conditions are different in terms of time delay in turning the light sequence. There will be two types of signal which will be sending and received at both side of traffic lights. The first signal is used to inform the other traffic light that it has turned red. This is also to give the other traffic light permission to turn into green. The second signal is the number of vehicles passed through it. These two signals are important in order to let the other traffic light to turn into green. The delay time is set in programming and is controlled by the PIC Microcontroller. The delay time is important for safety purpose in controlling the turning of green signal at both sides. A motion sensor is also added at both traffic lights to sense if there are any vehicles still using the single lane road.

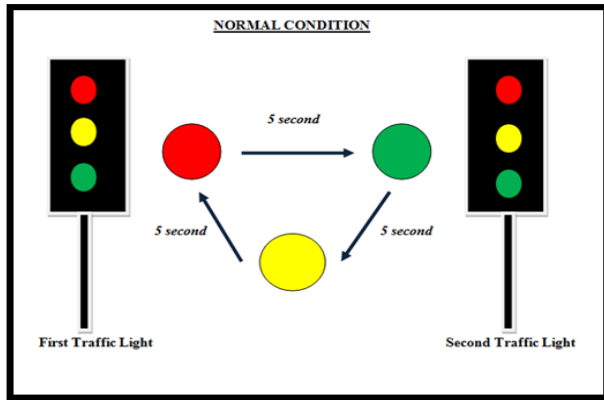


Fig 12: Normal Condition

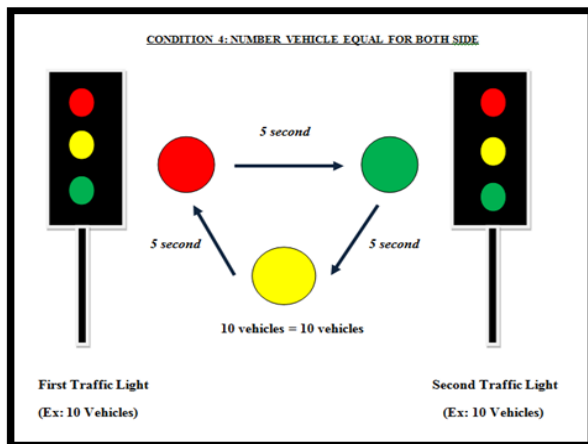


Fig 13: Normal Condition 2

Figure 12 and Figure 13 shows the overview of normal condition of the system. In this system, the time for each sequence of light is setting at 5 seconds. This condition is where the number of vehicles passed at both traffic lights is equal. When the first traffic light is green and yellow, the number of vehicles passed through it will be counted using infrared sensor. When it turn red, the microcontroller will stop counting and send a signal to the second traffic light to inform that the first traffic light has turn red. Then it will also send the second signal to inform the number of vehicle counted. At second traffic light, before receiving the signal it will also count the number of vehicle passed through it. When it received the first signal, it will wait for the second signal. At the same time, it will still count the number of vehicles passed through it. Once received the number of vehicles from the first traffic light, it will compared with the number of vehicles passed through it. At the same time the motion sensor will also sense the vehicles on the single road. When the number is equal and there is no vehicles using that single road, it will automatically turn into green. This is continuous for the first and second traffic light in sending signal, receiving signal also change the state of light color. This is also happened when there is no vehicle passed through both traffic lights.

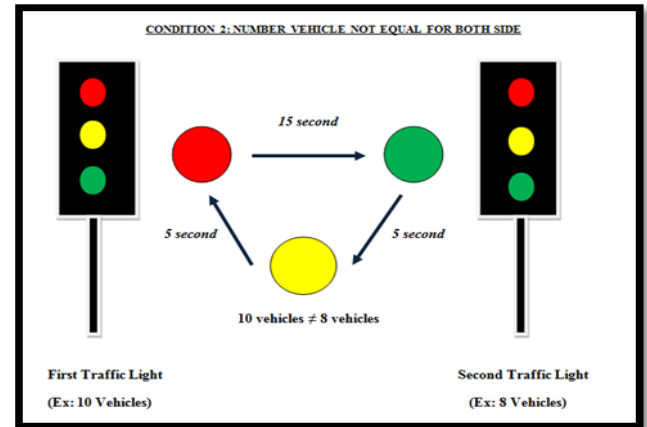


Fig 14: Unequal Condition

Figure 14 show the condition where the number vehicles passed through both traffic lights is not equal. At this condition, there are still two types of signal will be send and received. For example, there are 10 vehicles passed through the first traffic light before it turns into red. At the second traffic light, there are only 8 vehicles passed through it until it received the second signal which contain the number of vehicles at the first traffic light. In this situation, the second traffic light will not automatically turn into green but there will be delayed. In this system, the maximum delay is set to 15 second. After 15 seconds and there is no vehicle detection on that road, then only the second traffic light will turns green even the number of vehicles is not equal. This is for the safety purpose.

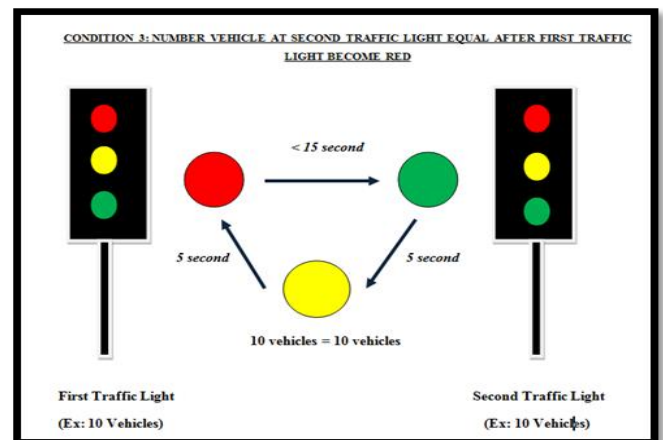


Fig 15: Equal Condition

Figure 15 shows the condition where the numbers of vehicles passed at both traffic lights are equal after both traffic lights are turning into red. As mentioned before, the second traffic lights will still counting the number of vehicles passed through it even it received the second signal from the first traffic light. This is also vice versa. For example, if there are 10 vehicles passed through the first traffic light before it turns red, the first traffic light will send the second signal with the number of vehicles is 10 to the second traffic light. When the second traffic light

received the signal, it will then compare with the number of vehicles passed through it. If it is not equal, then it will wait for another 15 seconds and still counting. In between 15 second if the number of vehicles is equal and there is no vehicle detection on that road, then it will automatically turn into green. The system of the second traffic light will not wait until the maximum delay.

#### 4. CONCLUSIONS

Road construction process will happen every day on hilly road, straight road or highway. These processes are needed in order to repair the damaged or upgrading the existing road or highway. Road construction process will involve many people, including road users, workers and the flagman.

Individuals involved are often faced with the risk of an accident while they were working especially flagman. During the process of road construction, the traffic will be controlled by a flagman manually by using the flag (red and green) or signals (stop and go). They will control traffic throughout the day regardless of time and weather to avoid traffic congestion. Many ways is use to prevent the occurrence of safety accidents. The safety features are done by wearing protective clothing to facilitate the road users to see the flagman and putting the warning signs before the construction of roads and so on. However, accidents are still occurs during the road construction.

The usage of flagman is important and until now, Malaysia still uses the flagman to control the flow of traffic during road construction. Nowadays technologies have become more and more advanced and sophisticated. With the skills and knowledge available, various methods are created to facilitate many type of work.

With the existing technologies, a Portable Wireless Traffic Light System was created. This system was implemented to replace the work done by a flagman. This system was created based on the safety and it is use to minimize the number of accident happen which involved flagman, worker and also the road user. Moreover, this is a low cost system compares to the others traffic since it use microcontroller to controlled the system. Besides, it is portable and can it be deployed anywhere. This traffic light is the best solution to replace the flagman in order to control the flow of traffic during the road construction.

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