TRAFFIC SIGNAL CONTROL USING PROGRAMMABLE LOGIC CONTROLLER (PLC)

OUSMAN BADJIE

STUDENT NO. 143419, BSc TE

OSAMA KHALID

STUDENT NO. 153428, BSc TE

OMAIR MOHAMMAD ALI

STUDENT NO. 143420, BSc TE

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT) THE ORGANISATION OF THE ISLAMIC COOPERATION (OIC)

BOARD BAZAR, GAZIPUR, DHAKA BANGLADESH

NOVEMBER, 2016

TRAFFIC SIGNAL CONTROL USING PROGRAMMABLE LOGIC CONTROLLER (PLC)

BY

OUSMAN BADJIE

STUDENT NO. 143419, BSc TE

OSAMA KHALID

STUDENT NO. 153428, BSc TE

OMAIR MOHAMMAD ALI

STUDENT NO. 143420, BSc TE

Submitted in partial fulfilment of the requirements for the

Degree of Bachelor of Science in Technical Education in Electrical and Electronics Engineering at the

Department of Technical and Vocational Education (TVE)

Islamic University of Technology (IUT)

Dhaka Bangladesh November, 2016

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

DEPARTMENT OF TECHNICAL AND VOCATIONAL EDUCATION (TVE)

We hereby recommend that this thesis prepared by Ousman Badjie, Osama Khalid and Omair Mohammad Ali, entitled "**Traffic Signal Control Using Programmable Logic Controller (PLC)"** has been accepted as fulfilling the part of the requirement for the degree of Bachelor of Science in Technical Education in Electrical and Electronics Engineering (BSc TE).

……………………….. Supervisor

Prof. Dr. Kazi Khairul Islam

Professor, Dept. of EEE, IUT

DECLARATION

This is to certify that the work presented in this thesis is the outcome of the investigation carried out by **Ousman Badjie, Osama Khalid** and **Omair Mohammad Ali** under the supervision of **Prof. Dr. Kazi Khairul Islam,** Professor, Department of Electrical and Electronics Engineering (EEE), Islamic University of Technology (IUT). The organisation of the Islamic Cooperation (OIC), Dhaka, Bangladesh.

………………………

Ousman Badjie

Student No. 143419

BSc TE

……………………..

Osama Khalid

Student No. 153428

BSc TE

……………………….

Omair Mohammad Ali

Student No. 143420

BSc TE

ACKNOLEDGEMENT

First and foremost, we must feel grateful to and wish to acknowledge my profound indebtedness to **Prof. Dr. Kazi Khairul Islam**, Professor, Department of Electrical and Electronics Engineering (EEE), Islamic University of Technology (IUT). His deep knowledge in the field of research influenced us to carry out this project up to this point. His endless patience, scholarly guidance, continuous encouragement constant supervision, constructive criticism, valuable advice and responding to our request at all circumstances have made it possible to come to this stage.

We would like to convey our deep gratitude and appreciation to the electronic lab technicians for their guidance and valuable suggestions regarding this study.

Finally, we like to appreciate and thank our family members for their patience and continuous encouragement for completion of this project

ABSTRACT

TRAFFIC SIGNAL CONTROL USING PROGRAMMABLE LOGIC CONTROLLER (PLC)

The scope of this project is to present a proposal in the implementation of a traffic light control system based on Programmable Logic Controller (PLC) technology. In this method, the traffic density will be measured by counting the number of vehicles in each lane and which lane first detects the presents of a vehicle. In practical situations sensors are used to detect presence of vehicles in a lane and calculate the density and sends an interrupt signal to the control unit. In PLC the status of the sensors is checked and certain logical operations are performed to decide which lane is to be serviced first. Under low density condition it would operate sequentially. A Ladder diagram will be developing for the implementation of this in the PLC.

As it is also difficult for a traffic police to monitor the whole scenario around the clock. So, this system can be implemented on highways, city traffic and intersection roads like 4-way 6 lanes etc.

Table of Contents

CHAPTER I

INTRODUCTION TO TRAFFIC SIGNAL CONTROL

1.1 Introduction

Traffic light which is one of the vital public facilities plays an important role to the road users. It will help to curb from accidents and gridlocks. This research exposed the operational of traffic light such as understanding the flow of the traffic system and the program itself. Traffic signal light is used to control the movement of vehicles and passengers, so that traffic can flow smoothly and safely. Traffic signal lights have been around for years and are used to efficiently control traffic through intersections. Although traffic signal lights are relatively simple and commonplace, they are critical for ensuring the safety of the driving area. The growing use of traffic lights attests to their effectiveness in directing traffic flow, reducing the number of accidents, and the most recently to their utility in controlling the flow of traffic through metropolitan areas when have been used together with computer systems.

Traffic signal lights will improve the road safety and reduce congestion by providing the signals orderly through junctions. Traffic control lights are provided for traffic control on streets and highways, especially at junctions. The traffic signals are cyclically displayed through a suitable timing and control mechanism.

A traffic light has three colours which are red, yellow and green. Every colour carries a certain sign. The red light means the road user has to stop driving and not crossing or pursuing the ride while the yellow light show that the road user has to ready to stop their ride. However, if the user is too close to the line that is not safe for a stop they have to continue the ride. The green light shows the road user can continue their journey only with the absence of any hindrance. Driving through a red light without justification may be a citation able traffic offense.

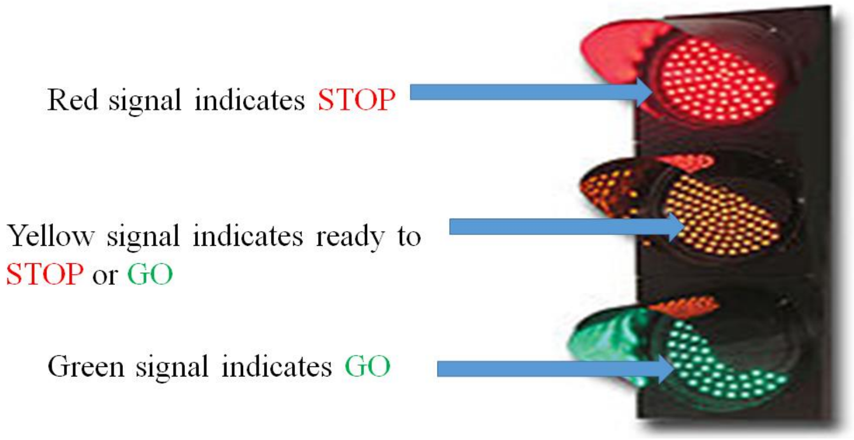


Figure 1: Traffic light model

The transition of the light is controlled by PLC to help the traffic movement run smooth from one direction to the other. PLC reduces traffic congestion especially in the morning and evening. Besides, it also helps to reduce the accident rate especially in town.

1.2 Objectives of the project

- ✓ To reduce the heavy traffic and congestion on the road by using PLC based traffic diversion system.
- ✓ To get a real life application in the implementation of programmable logic controllers PLC
- ✓ To save energy in the use of traffic signal control.

1.3 Problem statement

The monitoring and control of city traffic light is becoming a major problem in many countries. The increasing number of vehicles and the lower phase of highways developments have led to traffic congestion problem especially in major cities. Travel time, environment quality, life quality, and road safety are all adversely affected as a result of traffic congestions. In addition, delays due to traffic congestions also indirectly affect productivity, efficiency, and energy losses.

There are many factors that lead to traffic congestion such as the density of vehicles on the roads, human habits, social behaviour, and traffic light system. One major factor is due to the traffic lights system that controls the traffic at junctions. Traffic policeman are deployed at traffic intersection every day in order to overcome these congestion during peak hour, thus one of the roots of the problem is due to ineffective traffic lights controllers. With effective control the intersection, it is believed that the overall capacity and performance of urban traffic network could be resolve.

There are several types of conventional methods of traffic light control; however, they fail to deal effectively with complex and time varying traffic conditions. Currently, one type of traffic light control is commonly installed in many parts of the world: the pre-set cycle time (PCT). Due to the deployment of a large number of traffic police in the city during peak hours, it is evident that these types of traffic lights controllers are inadequate. There is a need to research on new types of highly effective practical traffic light controllers.

In this project, the proposed of a new development of a traffic light control system controlled by PLC. This system will decrease the traffic congestion at traffic light by extend the time for the green signal if traffic density at that lane are high and give the priority to who first arrive at the junction to get a green signal.

CHAPTER II

INTRODUCTION TO PROGRAMMABLE LOGIC CONTROLLERS (PLC)

2.1 Introduction and a brief history of a PLC

In 1968 the automatic transmission division of General Motors sought to replace hard wired relay systems and control panels with a software based control system. GM was using thousands of relays, cam timers, drum sequencers and dedicated closed loop controllers. Whenever engineers wanted to update the manufacturing process, usually once a year, they had to rewire the relays and components consuming a lot of time and money. GM sought a system that could change the logic rather than rewiring relays.

Dick Morley of Bedford Associates, Bedford, Massachusetts, now known as the "father of the PLC", designed the Modular Digital Controller or "Modicon" which used "ladder logic" and replaced relay logic with schematic diagrams, in the process reducing wiring by 80 percent.

As they were originally designed as a replacement for hard-wired relay and timer logic control systems. PLCs have the great advantage that it is possible to modify a control system without having to rewrite the connections to the input and output devices, the only requirement being that an operator has key in a different set of instruction. The result is a flexible system which can be used to control systems which vary quite widely in their nature and complexity.

2.2 What is PLC (Programmable Logic Controller)?

2.2.1 Definition of PLC: - A digitally operating electronic apparatus which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analogue modules, various types of machines or process.

2.3 Types of PLC

General definitions of PLC size are given in terms of program memory size and the maximum number of input/output points the system can support.

PLC Size Defined	Max I/O points	User memory size (No. of instructions)
Small (mini)	**40/40**	**1K**
Medium (micro)	**128/128**	**4K**
Large (modular)	**>128/>128**	**>4K**

Figure 2: Table of PLC specification

However, to evaluate properly any programmable logic controller we must consider many additional features such as its processor, cycle time, language facilities, functions, expansion capability, etc.

2.3.1 Small (mini) PLC: In general, small and mini PLCs are designed as robust, compact units which can be mounted on or beside the equipment to be controlled. They are mainly used to replace hardwired logic relays, timers, counters, etc. that control individual items of plant or machinery, but can also be used to coordinate several machines working in conjunction with each other.

Small PLCs can normally have their total I/O expanded by adding one or two I/O modules. However, if any further development is required, it will often mean replacement of the complete unit.

2.3.2 Medium (micro)-sized PLC: In this range modular construction predominates with plug-in modules on rack mounting system or Back Plane system. This construction allows the simple upgrading or expansion of the system by fitting additional I/O cards into the racks, since most rack systems have space for several extra function cards. Boards are usually ruggedized to allow reliable operation over a range of environments.

In general, this type of PLC is applied to logic control tasks that cannot be met by small controllers due to insufficient I/O provision, or because the control task is likely to be extended in the future. This might require the replacement of a small PLC, whereas a modular system can be expanded to a much greater extent, allowing for growth. A medium-sized PLC may therefore be financially more attractive in the long term.

Communications facilities are likely to be provided, enabling the PLC to be included in a distributed control system.

Combinations of single and multi-bit processors are likely within the CPU. For programming, standard instructions or ladder and logic diagrams are available. Programming is normally carried out via a small keypad or a VDU terminal.

2.3.3 Large (modular) PLC: Where control of very large numbers of input and output points is necessary or complex control functions are required, a large programmable controller is the obvious choice. Large PLC are designed for use in large plants or large machines requiring continuous control. They are also employed as supervisory controllers to monitor and control several other PLCs or intelligent machines, e.g. CNC tools.

2.4 Advantages of PLC

More flexible: Original equipment manufacturers (OEMs) can provide system updates for a process by simply sending out a new program. It is easier to create and change a program in a PLC than to wire and rewire a circuit. End-users can modify the program in the field.

Increased Reliability: Once a program has been written and tested it can be downloaded to other PLCs. Since all the logic is contained in the PLC's memory, there is no chance of making a logic wiring error.

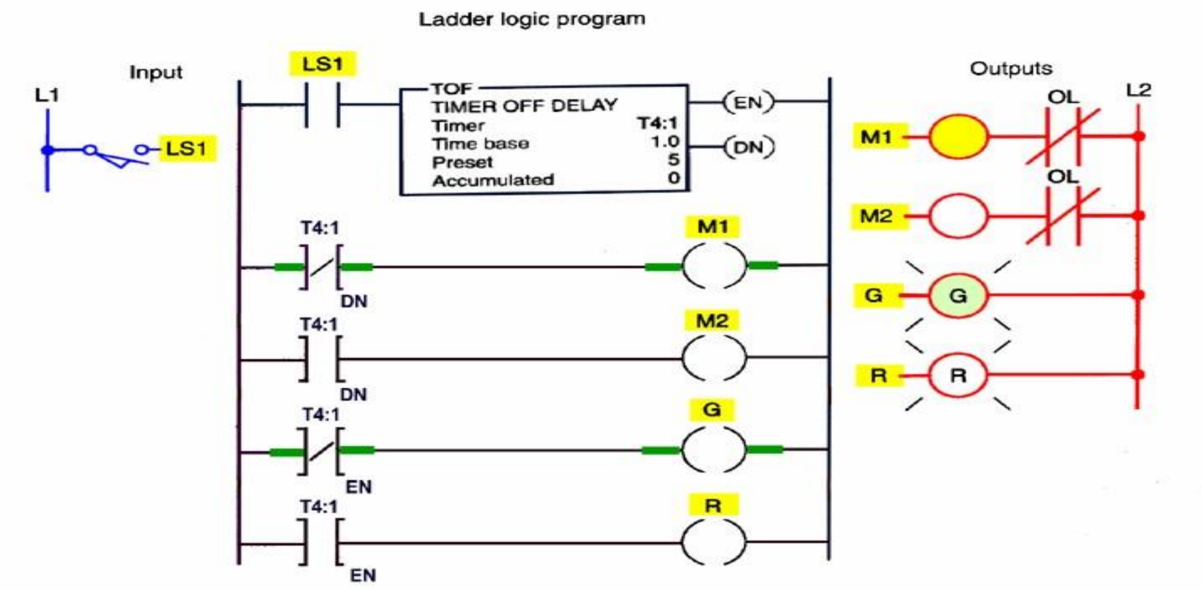


Figure 3: Ladder diagram model

Lower Costs: Originally PLCs were designed to replace relay control logic. The cost savings using PLCs have been so significant that relay control is becoming obsolete, except for power applications. Generally, if an application requires more than about 6 control relays, it will usually be less expensive to install a PLC.

Communications Capability: A PLC can communicate with other controllers or computer equipment. They can be networked to perform such functions as: supervisory control, data gathering, monitoring devices and process parameters, and downloading and uploading of programs.

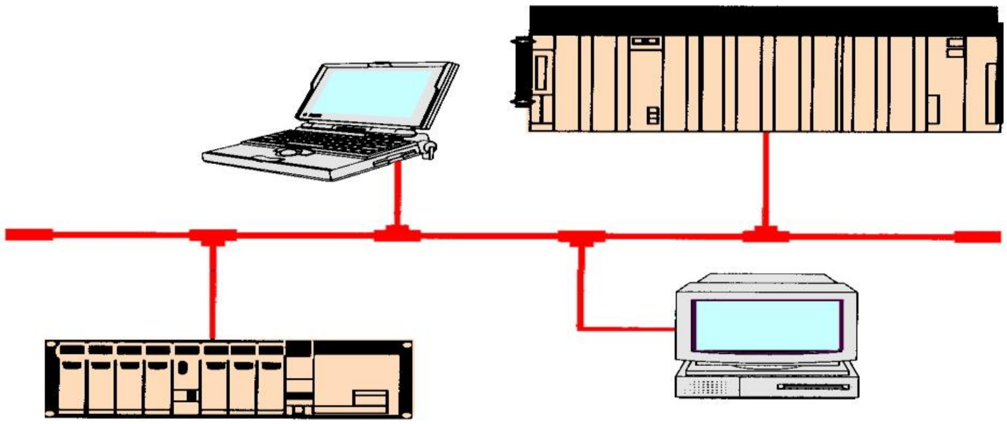


Figure 4: PLC network topology

Faster Response Time: PLCs operate in real-time which means that an event taking place in the field will result in an operation or output taking place. Machines that process thousands of items per second and objects that spend only a fraction of a second in front of a sensor require the PLC's quick response capability.

Easier to Troubleshoot*:* PLCs have resident diagnostic and override functions allowing users to easily trace and correct software and hardware problems. The control program can be watched in real-time as it executes to find and fix problems.

2.5 PLC Hardware System

The structure of a PLC can be divided into four parts. They are input/output modules, central processing unit (CPU), power supply.

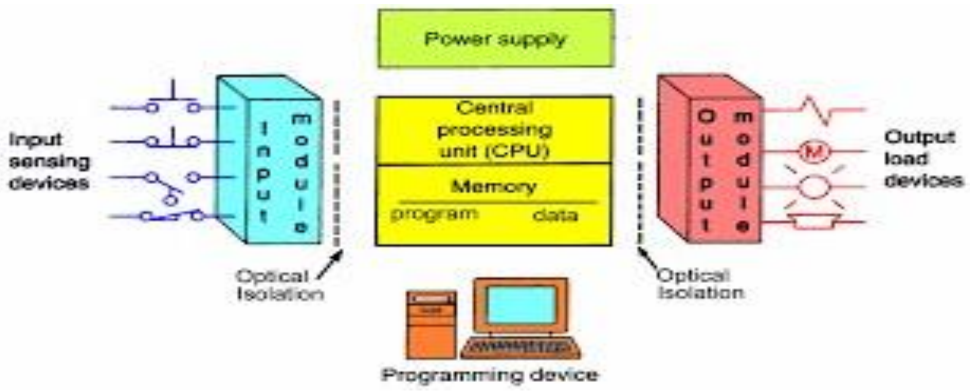


Figure 5: PLC Block diagram

Programmable logic controllers are purpose-built computers consisting of three functional areas: *processing*, *memory* and *input/output*. Input conditions to the PLC are sensed and then stored in memory, where the PLC performs the programmed logic instructions on these input states. Output conditions are then generated to drive associated equipment. The action taken depends totally on the control program held in memory.

2.5.1 Central Processing Unit(CPU)

The CPU controls and supervises all operations within the PLC, carrying out programmed instructions stored in the memory. An internal communications highway, or *bus system,* carries information to and from the CPU, memory and I/O units, under control of the CPU.

Virtually all modern PLCs are *microprocessor-based,* using a 'micro' as the system CPU. Some larger PLCs also employ additional microprocessors to control complex, time consuming functions such as mathematical processing, three-term PID control, etc.

2.5.2 Input/output Module Units

The input/output unit of PLCs can handle the job of interfacing high power industrial devices to the low-power electronic circuitry that stores and executes the control program.

Most PLCs operate internally at between 5 and 15V dc (common TTL and CMOS voltages), whilst signal from input devices can be much greater, typically 24V dc to 240V ac at several amperes.

The I/O module units form the *interface* between the microelectronics of the programmable controller and the real world outside, and must therefore provide all necessary signal conditioning and isolation functions. This often allows a PLC to be *directly connected* to process actuators and input devices without the need for intermediate circuitry or relays.

To provide this signal conversion, programmable controllers are available with a choice of input/output units to suit different requirements. For example:

Input	**Output**
5 V (TTL level)	24 V 100 mA dc
24 V dc/ac	110 V 1 A ac
110 V ac	240 V 1 A ac (triac)

240 V ac	240 V 1 A ac (relay)

It is standard practice for all I/O channels to be electrically isolated from the controlled process, using opto-isolator circuits on the I/O modules. An opto-isolator allows small signal to pass through, but will clamp any high-voltage spikes or surges down to the same small level. This provides protection against switching transients and power-supply surges, normally up to 1500v.

In small self-contained PLCs in which all I/O points are physically located on one casing, all inputs will be of one type (e.g. 24V) and the same for outputs (e.g. 240V triac). This is because manufacturers supply only standard function boards for economic reasons. On the other hand, modular PLCs have greater flexibility of I/O, since the user can select from several different types and combinations of input and output modules.

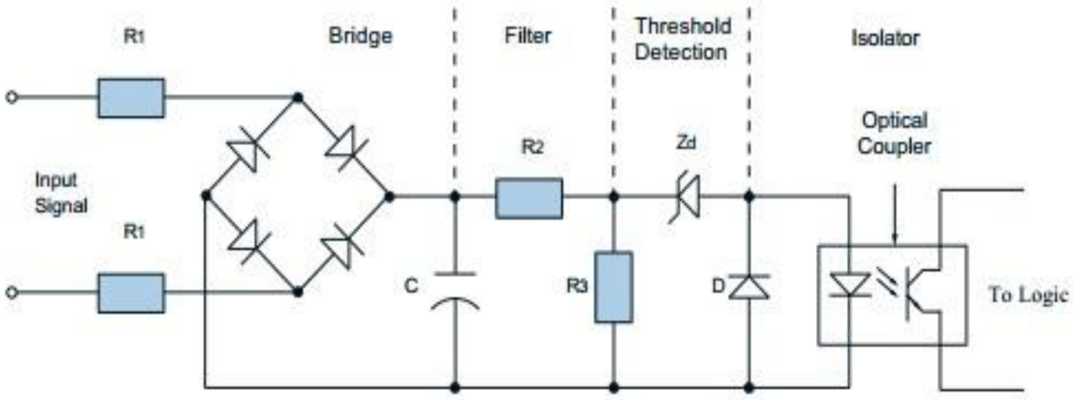


Figure 6: PLC input circuit

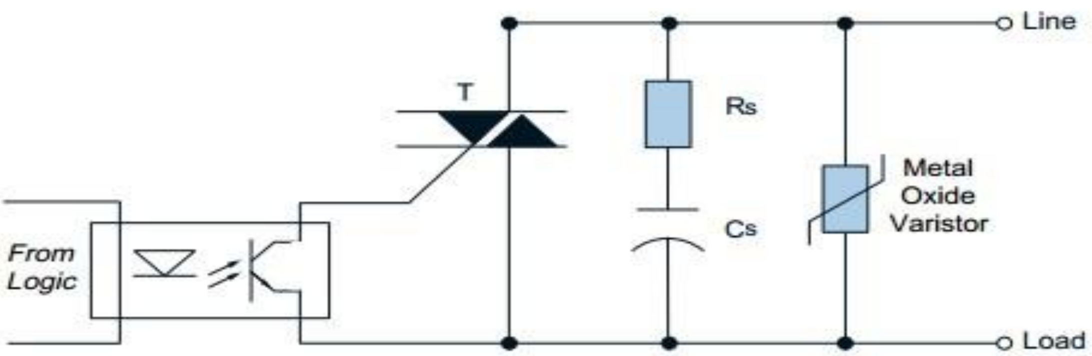


Figure 7: PLC output circuit

In all cases the input/output module units are designed with the aim of simplifying the connection of input devices and actuators to the PLC. For this purpose, all PLCs are equipped with standard screw terminals or plugs on every I/O point, allowing the rapid and simple removal and replacement of a faulty I/O card. Every input/output module point has a unique address or channel number which is used during program development to specify the monitoring of an input or the activating of a particular output within the program. Indication of the status of input/output channels is provided by light-emitting diodes (LEDs) on the PLC or I/O unit, making it simple to check the operation of processed inputs and outputs from the PLC itself.

2.6 How does a PLC work?

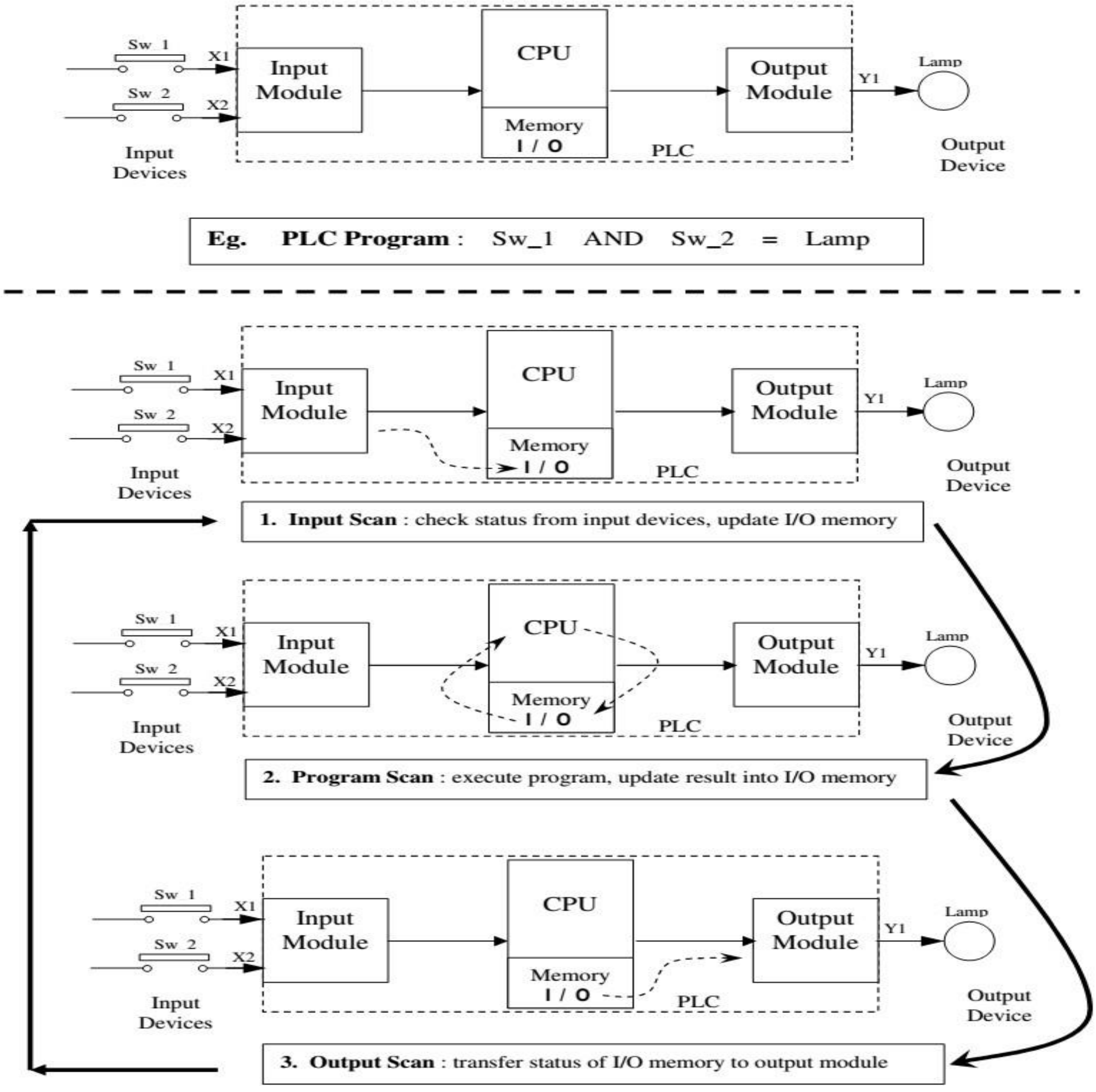


Figure 8:PLC sequence of operation

2.6.1 Internal Operation and Signal Processing

The CPU of the PLC executes the user-program over and over again when it is in the RUN mode. Figure 9 shows the entire repetitive series of events.

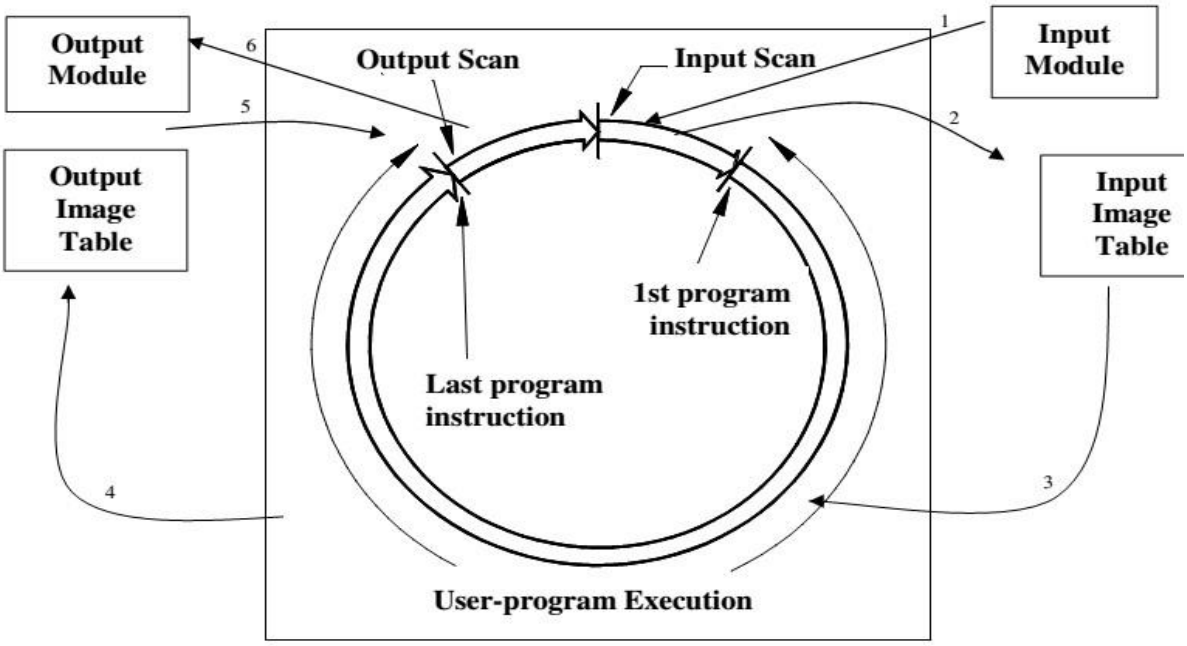


Figure 9: CPU Operation

(a) Input scan

During the input scan, the current status of every input module is stored in the input image (memory) table, bringing it up-to-date. Thus all the status of the input devices (which in turn is connected to the input module) are updated in the input memory table.

(b) Program scan

Following the input scan, the CPU enters its user program execution, or program scan. The execution involves starting at the program's first instruction, then moving on to the second instruction and carrying out its execution sequence. This continues to the last program instruction. Throughout the user-program execution, the CPU continually keeps its output image (memory) table up-to-date.

(c) Output scan

During program scan, the output modules themselves are not kept continually up to date. Instead, the entire output image table is transferred to the output modules during the output scan which comes after the program execution. Thus the output devices are activated accordingly during the output scan.

Note that by virtue of the cyclic nature of the program I/O scan, the status of the inputs and outputs cannot be changed within the same scan cycle. If an input signal changes state after the input scan, it will not be recognized until the next input scan occurs.

The time to update all inputs and outputs depends on the total number to be copied, but is typically a few milliseconds in length. The total program execution time (or cycle time) depends on the length of the control program. Each instruction takes 1-10 µs to execute depending on the particular programmable controller employed. So a 1K (1024) instruction program typically has a cycle time of 1-10 ms. However, programmable controller programs are often much shorter than 1000 instructions, namely 500 steps or less.

Input Listing	**Address**	**Output Listing**	**Address**
Inductive Sensor	**I0**	Pilot Light	**Q0**
Reed Sensor	**I1**	Small DC Motor	**Q1**
Capacitive Sensor	**I2**	Solenoid Valve	**Q2**
Pushbutton	**I3**		**Q3**

Figure 10: PLC Input Output addressing

2.7 PLC Software System

Types of programming languages.

- **Statement list**
- **Ladder diagram**
- **Functional Block diagram**
- **Function flow chart**

2.7.1 Ladder diagram

The ladder diagram has and continues to be the traditional way of representing electrical sequences of operations. These diagrams represent the interconnection of field devices in such a way that the activation, or turning ON, of one device will turn ON another device according to a predetermined sequence of events. Figure 11 illustrates a simple electrical a ladder diagram.

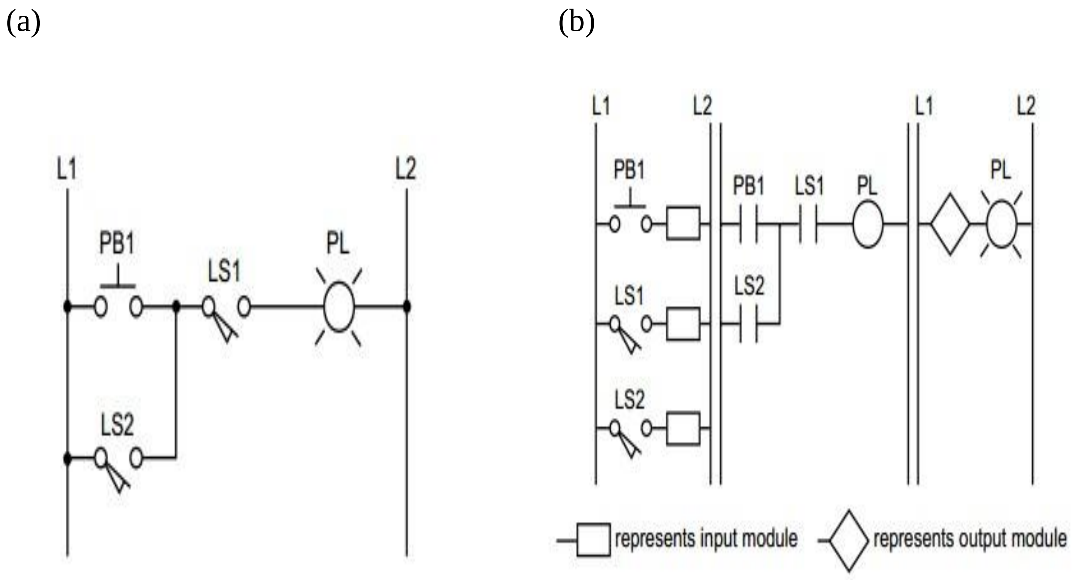


Figure 11: Ladder diagram

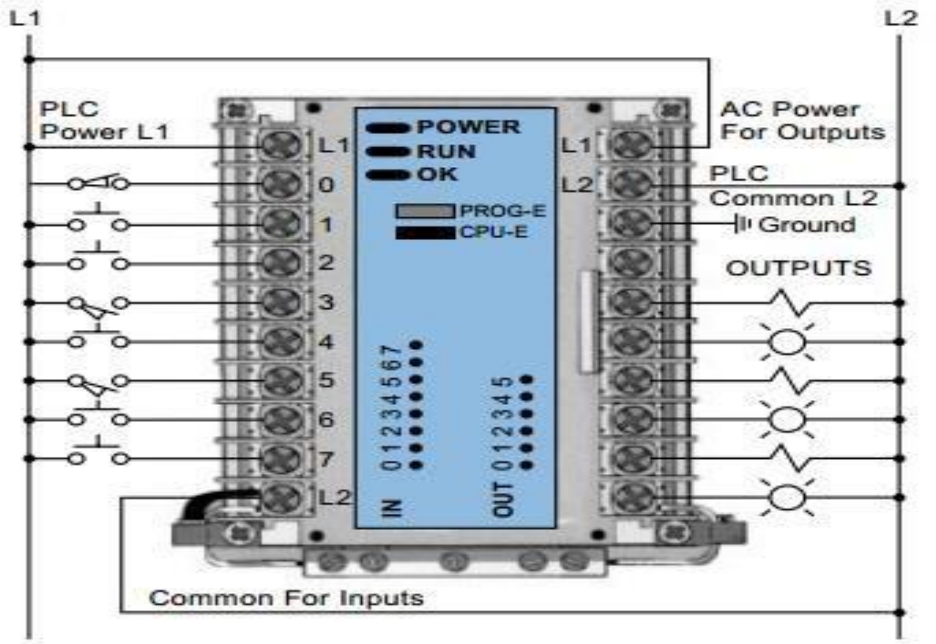
The original ladder diagrams were established to represent hardwired logic circuits used to control machines or equipment. Due to wide industry use, they became a standard way of communicating control information from the designers to the users of equipment. As programmable controllers were introduced, this type of circuit representation was also desirable because it was easy to use and interpret and was widely accepted in industry.

Programmable controllers can implement all of the “old” ladder diagram conditions and much more. Their purpose is to perform these control operations in a more reliable manner at a lower cost. A PLC implements, in its CPU, all of the old hardwired interconnections using its software instructions. This is accomplished using familiar ladder diagrams in a manner that is transparent to the engineer or programmer. As you will see throughout this book, a knowledge of PLC operation, scanning, and instruction programming is vital to the proper implementation of a control system.

Figure 11(b) illustrates the PLC transformation of the simple diagram shown in Figure 11(a) to a PLC format. Note that the “real” I/O field devices are connected to input and output interfaces, while the ladder program is implemented in a manner, similar to hardwiring, inside the programmable controller (i.e., *soft wired* inside the PLC’s CPU instead of *hardwired* in a panel). As previously mentioned, the CPU reads the status of inputs, energizes the corresponding circuit element according to the program, and controls a real output device via the output interfaces.

As you will see later, each instruction is represented inside the PLC by a reference **address**, an alphanumeric value by which each device is known in the PLC program. For example, the push button PB1 is represented inside the PLC by the name PB1 (indicated on top of the instruction symbol) and likewise for the other devices shown in Figure 119(b). These instructions are represented here, for simplicity, with the same device and instruction names.

The figure 12 shows an example on how the input and output elements are connected to the PLC.



. Programmable controller I/O connection diagram showing no physical connections between the inputs and outputs.

Figure 12: PLC I/O Connection diagram

CHAPTER III

LITERATURE REVIEW

As the control of traffic congestion and time delay is becoming an issue of focus in developing and underdeveloped countries. Several works are going on in order to resolve these issues. From our literature review it came to our knowledge that there are only two (2) universal jurisdiction in traffic system namely. Left-deriving jurisdiction and Right–deriving jurisdiction.

As far as this project is concern, the proceeding analysis will be based on the left-driving jurisdiction.

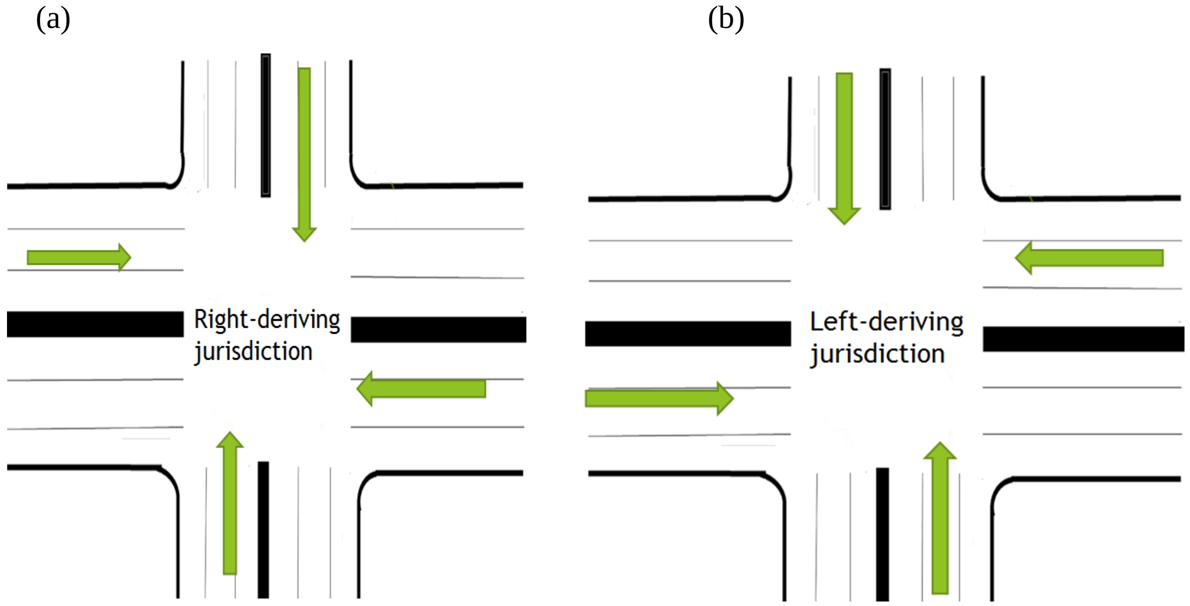


Figure 13: Traffic jurisdiction

It also came to our knowledge that the main traffic signal controlling system in the world are namely.

- Static signal control
- Coordinated signal control
- Continuous flow intersection (CFI)
- Actuated signal control

3.1 Static signal control

In static signal control the toggling sequence of the signal are in fixed time and preferences is not given to any lane due to its traffic volume. This result in time delay in the traffic sequence. In static signal control there is high possibility of waste of energy. As one of the main objectives in this project is to solve the above problems, which from the conclusion can be done by using actuated signal controlling method.

3.2 Coordinated signal control

3.2.1 Complications that Impact Signal Coordination Plans

Traffic signal coordination plans are strongly influenced by dynamic conditions such as corridor speeds, traffic signal spacing, congestion, traffic volumes on major streets, pedestrian volumes, traffic signal cycle lengths, additional phasing, and safety considerations. Each factor can significantly complicate good coordination schemes. Below are descriptions of these influencing factors, and the resulting conditions that may be undesirable for our driving public.

Corridor Speeds: Signal coordination plans are established by using prevailing travel speeds. Motorists traveling at these speeds will achieve optimal travel times; however, those traveling above or below the prevailing speed may have significantly greater stops and delays as they are traveling outside the progression band.

Traffic Signal Spacing: Well-coordinated timings are established when signals are uniformly spaced along busy streets. For most busy corridors, spacing would be approximately ½ mile. However, while newly developed arterial corridors provide signal spacing in accordance with access management policies, the older developed corridors do not have proper signal spacing which can result in more stops and delays.

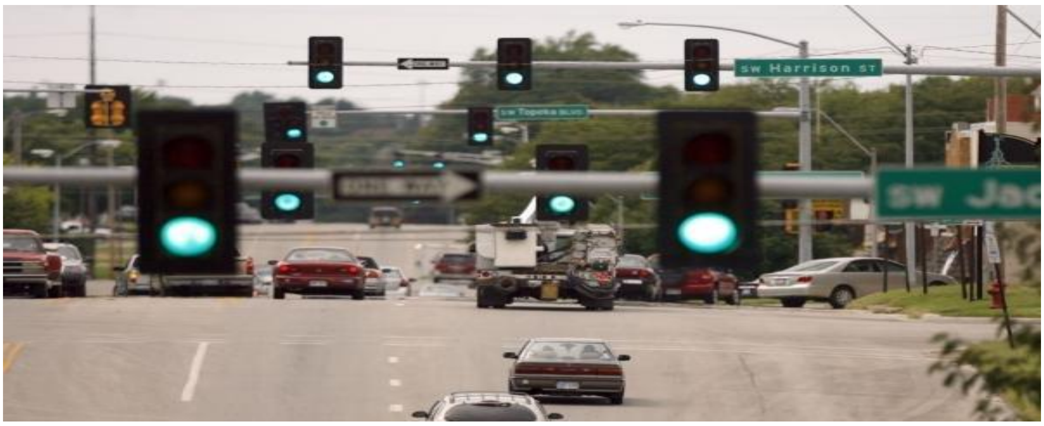


Figure 14: Coordinated signal control

Traffic signal coordination plans are limited when it comes to signal spacing. Signals are typically spaced no more than ¾ miles apart, as distance can cause the breakup of platoons due to access movements, lane changes, truck traffic, varying travel speeds, geometric conditions and other elements. Without regulation, motorists may have more stops and delays than expected.

Congestion: Our plans are detrimentally impacted when capacities at our busiest intersections are exceeded. Under such conditions, traffic signal operations cannot fully serve the demand, resulting in limited progression. In such cases, strategies may include serving only the heaviest directional flows.

Traffic Flow Characteristics Our signal coordination plans are strongly influenced by the volume of total traffic, the directionality of the traffic, and the amount of traffic entering, exiting or crossing from a side street. In most cases, our traffic signal coordination is designed to favour the heavier traffic flow. This may cause frustrations for motorists driving in less travelled directions as they may experience more stops and delays than desired.

Pedestrian Volumes: We are very sensitive to the needs of pedestrians and bicyclists. To serve them safely, we have pedestrian signal phases at nearly all crossing locations. Though good for pedestrians, these phases reduce our proportional green time for thru-traffic on major streets. Reducing green "thru" bands affect coordination since it narrows the window when motorists can travel through the intersection without stopping.

Traffic Signal Cycle Lengths: Traffic signals must operate under the same cycle length along a coordinated network to produce consistent results. These cycle lengths are typically set to serve the needs of the busiest intersection as well as provide the optimal coordination along the corridor.

As volumes grow on our major streets, cycle lengths increase. This is due primarily to the extended green phase times needed to serve the approach traffic demands. This may cause some delay at minor signalized approaches. In some situations, motorists traveling on side streets may experience longer delays than expected.

Additional Left Turn Signal Phases: We are careful when adding left-turn phases along our busiest corridors due to their effect on green phase bands. Because our cycle lengths are fixed, each additional left-turn phase can reduce "thru" green times by as much as 25% to 40%. As a result, the reduced green “thru” bands can narrow the window allowing motorists to travel through the intersection without stopping.

3.3 Continuous flow intersection (CFI)

3.3.1 CFI Concept

The CFI design centres on the concept of removing the left-turn conflict from the main intersection. This is accomplished by crossing the left-turn traffic and oncoming through traffic at a signalized bay placed several hundred feet before the intersection. Traffic from the left-turn bay crosses the opposing traffic and continues down the CFI leg unit it reaches the main intersection. This allow through traffic and left-turn traffic to move simultaneously. The net result is that the opposing traffic no longer has to be stopped to accommodate left-turning vehicles, eliminating a single phase and increasing through traffic movement at the main intersection**.**

The implementation this traffic control system need a huge amount of space which might be a disadvantage affecting its implementation.

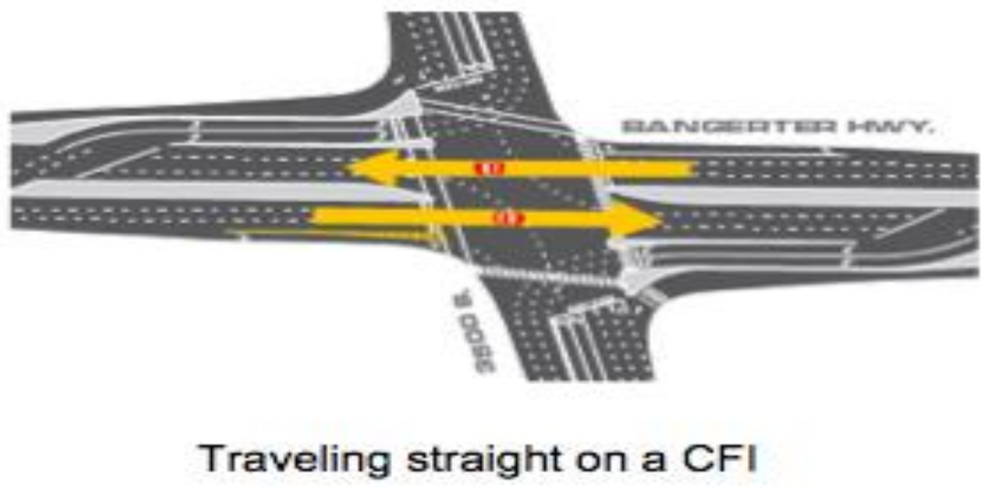


Figure 15: Travelling Straight on a CFI signal control system

3.4 Actuated signal control

3.4.1 Introduction

Now-a-days, controlling traffic congestion relies on having an efficient and well-managed traffic signal control policy. Traffic signals operate in either pre-timed or actuated mode or some combination of the two. Pre-timed control consists of a series of intervals that are fixed in duration. They repeat a pre-set constant cycle. In contrast to pre-timed signals, actuated signals have the capability to respond to the presence of vehicles or pedestrians at the intersection. Actuated control consists of intervals that are called and extended in response to vehicle detectors. The controllers are capable of not only varying the cycle length & green times in response to detector actuation, but of altering the order and sequence of phases. Adaptive or area traffic control systems (ATCS) belong to the latest generation of signalized intersection control. ATCS continuously detect vehicular traffic volume, compute optimal signal timings based on this detected volume and simultaneously implement them. Reacting to these volume variations generally results in reduced delays, shorter queues and decreased travel times. Coordinating traffic signals along a single route so that vehicles get progressive green signal at each junction is another important aspect of ATCS. In the subsequent pages, the operating principles and features of Vehicle-Actuated Signals & Area Traffic Control Systems will be briefly discussed.

3.4.2 Basic Principles

As stated earlier, Vehicle-Actuated Signals require actuation by a vehicle on one or more approaches in order for certain phases or traffic movements to be serviced. They are equipped with detectors and the necessary control logic to respond to the demands placed on them. Vehicle-actuated control uses information on current demands and operations, obtained from detectors within the intersection, to alter one or more aspects of the signal timing on a cycle-by-cycle basis. Timing of the signals is controlled by traffic demand. Actuated controllers may be programmed to accommodate:

- Variable phase sequences (e.g., optional protected LT phases)
- Variable green times for each phase
- Variable cycle length, caused by variable green times

Such variability allows the signal to allocate green time based on current demands and operations. A proper clearance interval between the green & the red phases is also ensured.

3.4.3 Advantages of Actuated Signals

The various advantages of actuated signals are stated below:

- They can reduce delay (if properly timed).
- They are adaptable to short-term fluctuations in traffic flow.
- Usually increase capacity (by continually reapportioning green time).
- Provide continuous operation under low volume conditions.
- Especially effective at multiple phase intersections.

3.4.4 Disadvantages of Actuated Signals

The main disadvantages are as following:

- If traffic demand pattern is very regular, the extra benefit of adding local actuation is minimal, perhaps non-existent.
- Installation cost is two to three times the cost of a pre-timed signal installation.
- Actuated controllers are much more complicated than pre-timed controllers, increasing maintenance costs.
- They require careful inspection & maintenance to ensure proper operation.

The above disadvantages are not given too much consideration because, every advanced and sophisticated technology which needs to be implemented without any other alternative the above factors must be accepted.

3.5 Types of Actuated Control

There are three basic types of actuated control, each using signal controllers that are somewhat different in their design:

1. Semi-Actuated Control
2. Full-Actuated Control
3. Volume-Density Control

3.5.1 Semi-Actuated Control

This type of controller is used at intersections where a major street having relatively uniform flow is crossed by a minor street with low volumes. Detectors are placed only on the minor street. The green is on the major street at all times unless a call on the side street is noted. The number and duration of side-street green is limited by the signal timing and can be restricted to times that do not interfere with progressive signal-timing patterns along the major street.

Concept of Semi-Actuated Controller

Principles

- Detectors on minor approaches only.
- Major phase receives a minimum green interval.
- The green remains on the main street until a call for service on the side street is registered.

- If the main street has had enough green, the side street is given the green for just enough time to guarantee that its vehicles are processed.
- Usually Point Detectors are used.
- Detectors can be placed at either stop line or upstream location.

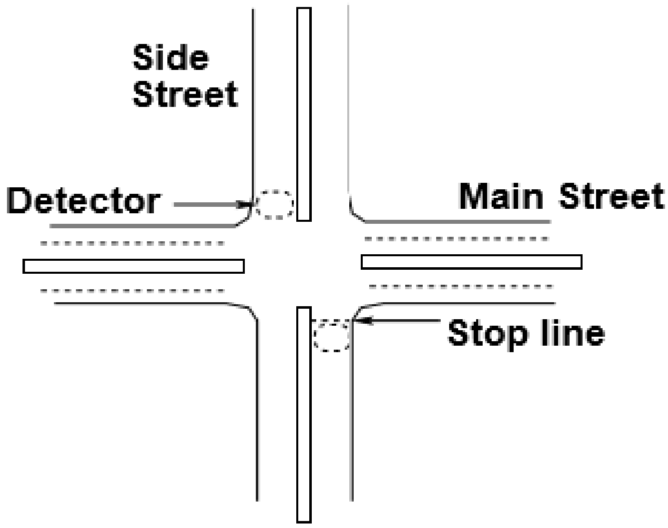


Figure 16: Semi actuated control

Advantages

- It can be used effectively in a coordinated signal system.
- Relative to pre-timed control, it reduces the delay incurred by the major-road through movements during periods of light traffic.
- It does not require detectors for the major-road through movement phases and hence, its operation is not compromised by the failure of these detectors.
- Generally, the main street indeed has the green whenever possible.

Disadvantages

- Continuous demand on the phases associated with one or more minor movements can cause excessive delay to the major road through movements if the maximum green and passage time parameters are not appropriately set.
- Detectors must be used on the minor approaches, thus requiring installation and ongoing maintenance.
- It also requires more training than that needed for pre-timed control.

3.5.2 Full-Actuated Control

This type of controller is used at the intersections of streets or roads with relatively equal volumes, but where the traffic distribution is varying. In full actuated operation, all lanes of all approaches are monitored by detectors. The phase sequence, green allocations, and cycle length are all subjected to variation. This form of control is effective for both two-phase and multi-phase operations and can accommodate optional phases.

Concept of Full-Actuated Controller

Principles

- Detectors on all approaches.
- Each phase has a pre-set initial interval.
- Phases are sequenced according to" calls" for service on all approaches.
- Green interval is extended by a pre-set unit extension for each actuation after the initial interval provided a gap greater than the unit extension does not occur.
- Green extension is limited by pre-set maximum limit.
- Generally, Point Detectors are used.
- Detectors can be placed at either stop line or upstream location.

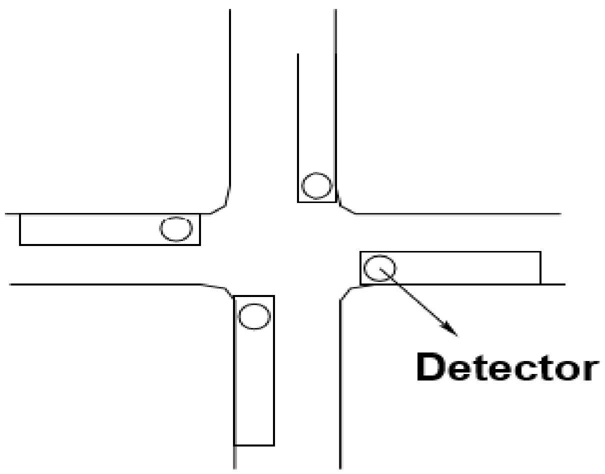


Figure 17: Full actuated control

Advantages

- Reduces delay relative to pre-timed control by being highly responsive to traffic demand and to changes in traffic pattern.

- Detection information allows the cycle time to be efficiently allocated on a cycle-by-cycle basis.
- Allows phases to be skipped if there is no call for service, thereby allowing the controller to reallocate the unused time to a subsequent phase.

Disadvantages

- Initial and maintenance cost is higher than that of other control types due to the amount of detection required.
- It may also result in higher percentage of vehicles stopping because green time is not held for upstream platoons.

3.5.3 Volume-Density Control

Volume-density control is basically the same as full actuated control with additional demand responsive features. It is designed for intersections of major traffic flows having considerable unpredictable fluctuations.

Concept of Volume-Density Controller

Volume-Density Controllers are designed for intersections of major traffic flows having considerable unpredictable fluctuations. They are generally used at intersections with high approach speeds (≥ 45 mi/hr). Here, detectors are placed on all approaches. Generally, this type of controller is used with Area Detectors. To operate efficiently, this type of control needs to receive traffic information early enough to react to existing conditions. So, it is essential that detectors be placed far in advance of the intersection.

3.6 Detection for Actuated Signalization

The various types of detectors used for detection of vehicles are as following:

- **Inductive loop detectors (mostly used sensor).**

  Loop detector technology has become the most widely used sensor in incident detection systems. They are capable of measuring flow and occupancy, and estimating vehicle speed. They can also be used to actuate traffic control devices and detect congestion and incidents.

  An inductive loop detector consists of one or more loops of wire embedded in the pavement and connected to a control box, excited by a signal ranging in frequency from 10 KHz to 200 KHz. When a vehicle passes over or rests on the loop, the inductance of the loop is reduced showing the presence of a vehicle.

The raw data supplied by inductive loop detectors are vehicle passage, presence, count, and occupancy. For incident detection, loop data is usually relayed to a controller for analysis. As shown in figure 19.

Figure 18:Inductive loop sensor on the road

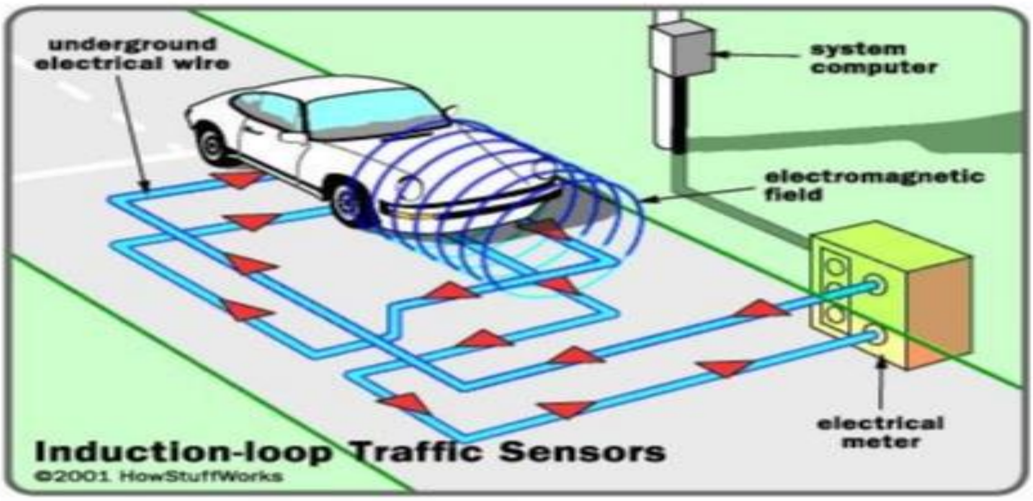


Figure 19: Data transfer between the sensor and the controller

- **Magnetometer detector**
- **Magnetic detectors**
- **Pressure-sensitive detectors**
- **Radar detectors**
- **Sonic detectors**

- **Micro loop detectors etc.**

The vast majority of actuated signal installations use inductive loops for detection purpose. Now, the type of detection is of greater importance than the specific detection device(s) used. There are two types of detection that influence the design and timing of actuated controllers:

1. **Passage or Point Detection: -** In this type of detection, only the fact that the detector has been disturbed is noted. The detector is installed at a point even though the detector unit itself may involve a short length. It is the most common form of detection.
2. **Presence or Area Detection: -** In this type of detection, a significant length (or area) of an approach lane is included in the detection zone. Entries and exits of vehicles into and out of the detection zone are remembered. Thus, the number of vehicles stored in the detection zone is known. It is provided by using a long induction loop, or a series of point detectors. These are generally used in conjunction with volume-density controllers.

3.7 Actuated Control Features

Regardless of the controller type, virtually all actuated controllers offer the same basic functions, although the methodology for implementing them may vary by type and manufacturer. For each actuated phase, the following basic features must be set on the controller:

3.7.1 Minimum Green Time

Each actuated phase has a minimum green time, which serves as the smallest amount of green time that may be allocated to a phase when it is initiated. Minimum green times must be set for each phase in an actuated signalization, including the non-actuated phase of a semi-actuated controller. The minimum green timing on an actuated phase is based on the type and location of detectors.

In case of Area Detectors,

$$G_{m_{in}} = tL + 2n$$

where, tL = start-up lost time (sec) and n = number of vehicles stored in the detection area.

3.7.2 Unit Extension

This time actually serves three different purposes:

1. It represents the maximum gap between actuation at a single detector required to retain the green.

2. It is the amount of time added to the green phase when an additional actuation is received within the unit extension, U.
3. It must be of sufficient length to allow a vehicle to travel from the detector to the STOP line.

In terms of signal operation, it serves as both the minimum allowable gap to retain a green signal and as the amount of green time added when an additional actuation is detected within the minimum allowable gap. The unit extension is selected with two criteria in mind:

- The unit extension should be long enough such that a subsequent vehicle operating in dense traffic at a safe headway will be able to retain a green signal (assuming the maximum green has not yet been reached).
- The unit extension should not be so long that straggling vehicles may retain the green or that excessive time is added to the green (beyond what one vehicle reasonably requires to cross the STOP line on green).

The recommends unit extension of 3.0 s can be used where approach speeds are equal to or less than 30 miles per hour, and that 3.5 s can be used at higher approach speeds. For all types of controllers, however, the unit extension must be equal to or more than the passage time.

3.7.3 Passage Time Interval

It allows a vehicle to travel from the detector to the stop line. It is analogous with 'Unit Extension'. $p = \left[{}^{d}/_{s}\right]$ where, p = passage time, sec, d = distance from detector to stop line, meter and S = approach speed of vehicles, m/s.

3.7.4 Maximum Green Time

Each phase has a maximum green time that limits the length of a green phase, even if there are continued actuation that would normally retain the green. The maximum green time begins when there is a call (or detector actuation) on a competing phase. The estimation can be done by,

$$g_i = [C_{i-L}] \cdot \frac{v_{C_i}}{vC}$$

where g_i= effective green time for Phase i, sec and v_{C_i}= critical lane volume for Phase i, veh/hr. C_i = Initial cycle length, sec, L = Total lost time, sec and vC = Sum of critical lane volumes, veh/hr. The effective green times thus obtained are then multiplied by 1.25 or 1.50 to determine the maximum green time.

CHAPTER IV

METHODOLOGY AND PROCEDURE

The main aim of this project is to attain the above mentioned objectives which can be done through the implementation of actuated signal control. Actuated signal control is proposed due to the analysis done between the various types of traffic signal control. The procedure for the implementation of the proposed project is as follows.

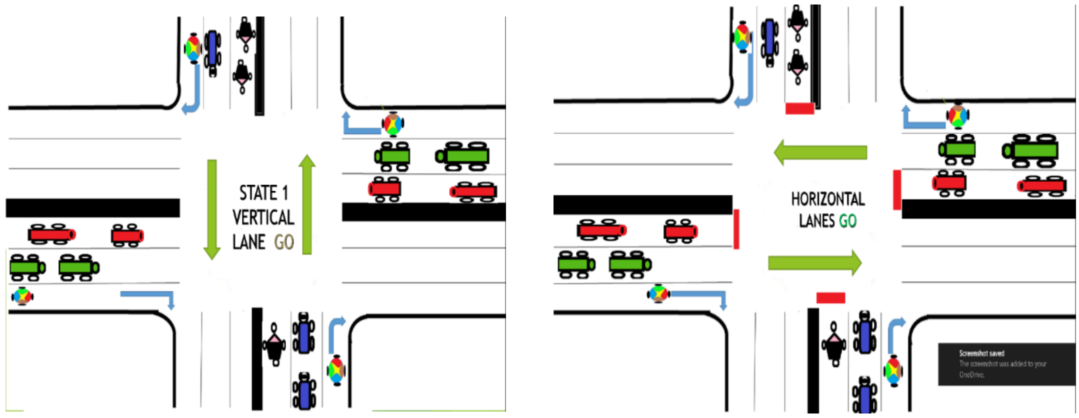
4.1 Hardware materials

- PLC module
- Inductive loop sensor
- Traffic lights (Red, Green, Yellow)
- Power supply

4.2 Traffic sequence

The traffic sequence will be based on the left-drive jurisdiction as shown in the figure 20.

(a) (b)



(c) (d)

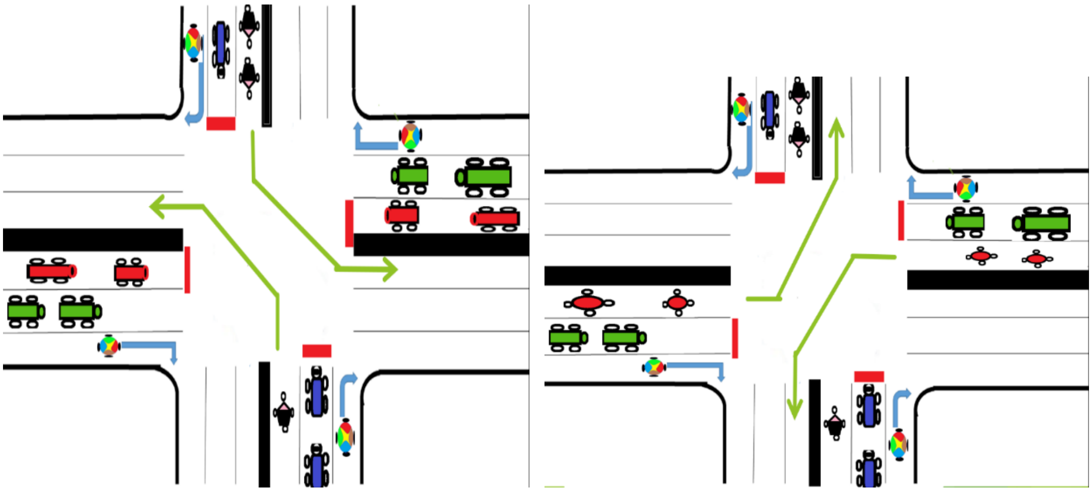


Figure 20: Traffic sequence

4.3 Actuated Control Features

For each actuated phase, the following basic features must be determined and set on the controller:

4.3.1 Calculation of the minimum green time:

$$G_{min} = tL + 2n$$

where, tL = start-up lost time (sec), n = number of vehicles stored in the detection area.

tL = assumed as 4s

n = 10

$$G_{min} = 4 + 2(10) = 24s$$

4.3.2 Calculation of the passage time

$P = \left[{}^{d}/_{S}\right]$ where, P = passage time, sec, d = distance from detector to stop line, meter and S= approach speed of vehicles, m/s.

d = 6m

S = 16.67s

$P = [6/10] = 0.6s$

4.3.3Calculation of the maximum green time:

$$g_i = [C_{i-L}] \cdot \frac{V_{C_i}}{VC}$$

where g_i= effective green time for Phase i, sec and V_{C_i}= critical lane volume for Phase i, veh/hr. C_i = Initial cycle length, sec, L = Total lost time, sec and VC = Sum of critical lane volumes, veh/hr. The effective green times thus obtained are then multiplied by 1.25 or 1.50 to determine the maximum green time.

$C_i = 480s$

L = 16s

$V_{C_i} = 20\ veh/hr$

$VC = 124\ veh/hr$

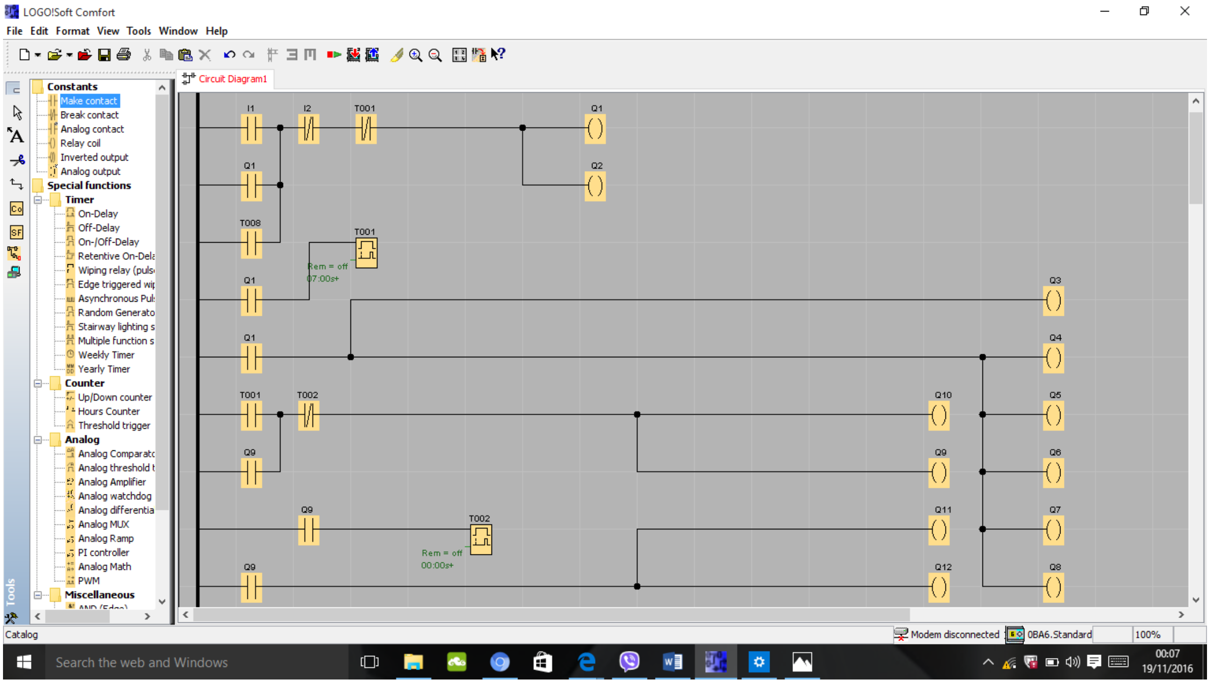
$$g_i = [480 - 16] \cdot \frac{20}{124} = 477.4s$$

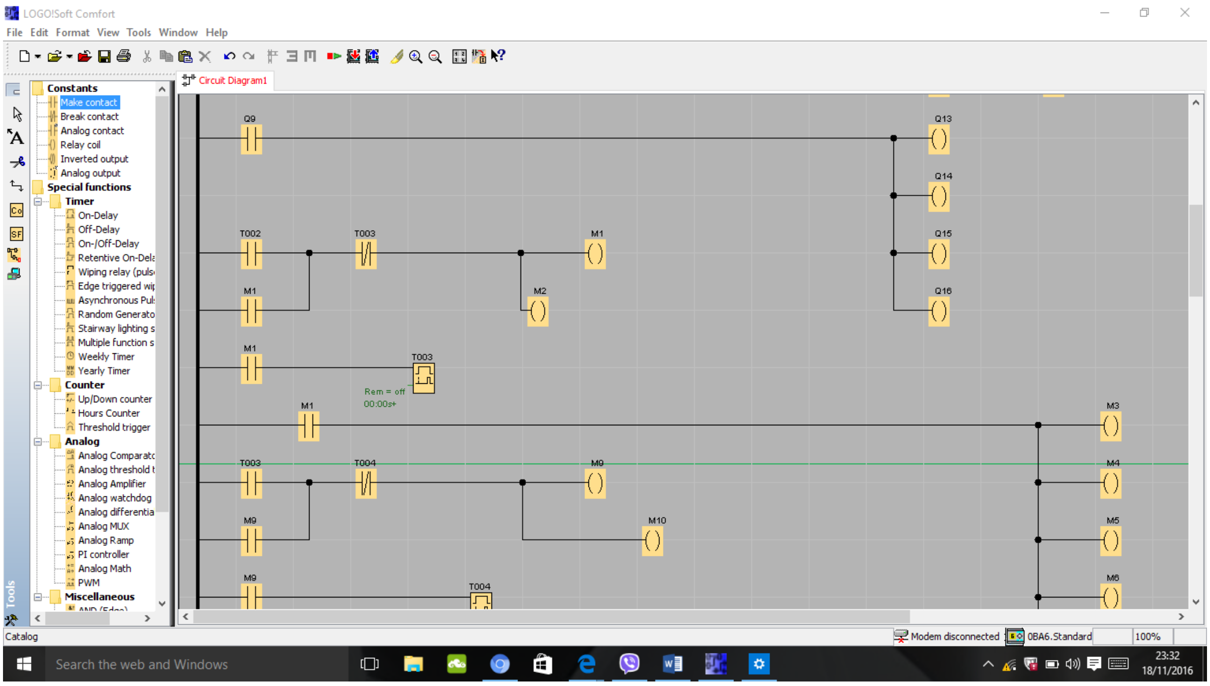
Therefore, maximum green time $Gmax$ is equal to g_i multiplied by 1.25 or 1.50.

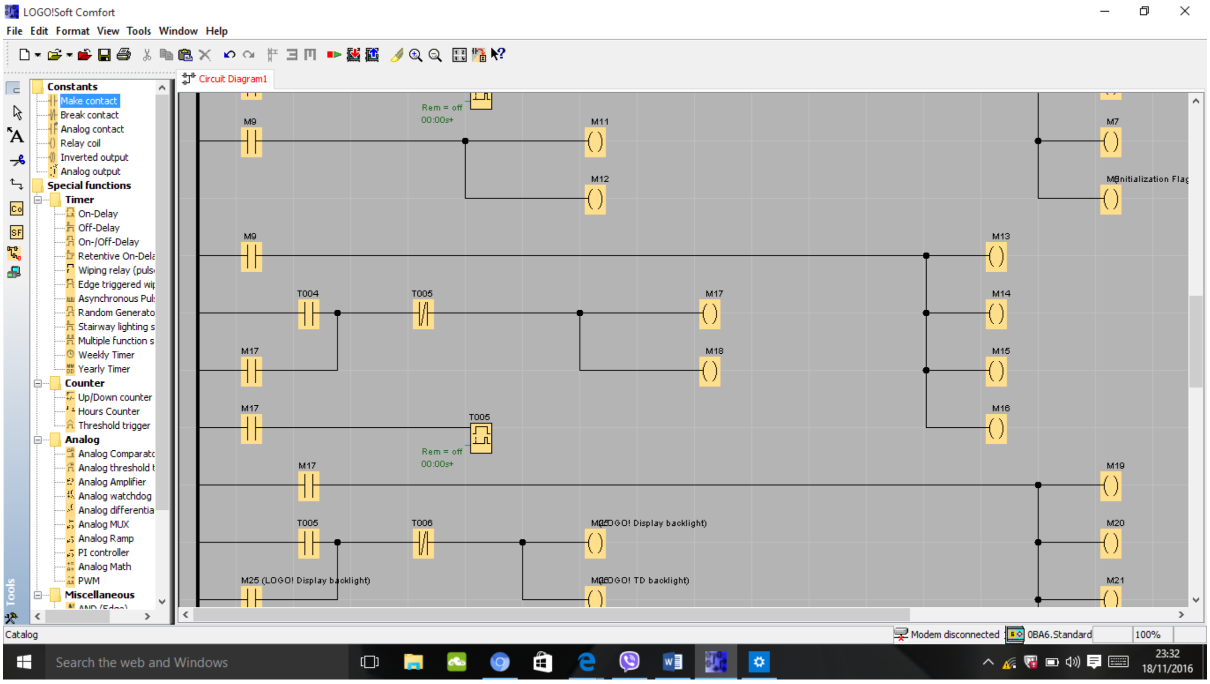
$$Gmax = 477.4 * 1.50 = 7.161s$$

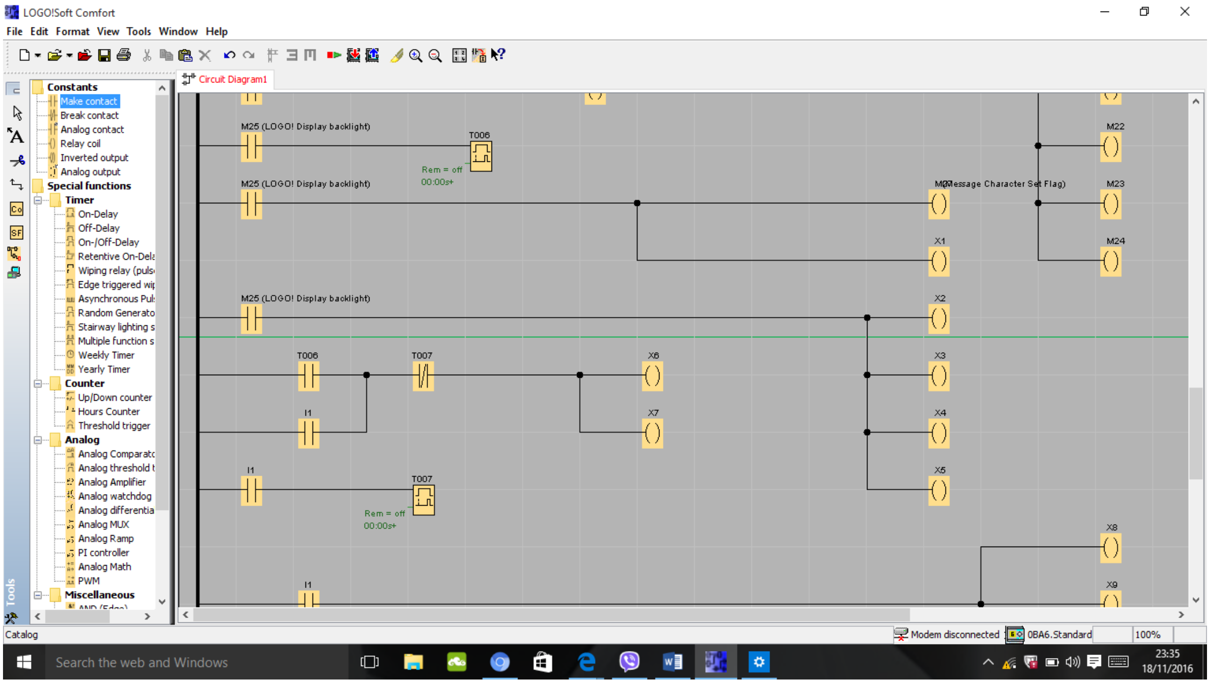
4.3.4 The implementation of ladder diagram

The above calculations are implemented in a ladder diagram shown in figure 21. Logo soft comfort is used to design the ladder diagram due to the unavailability of the actual PLC (Mitsubishi).


LOGO!Soft Comfort
File Edit Format View Tools Window Help
Circuit Diagram1
Constants
Make contact
Break contact
Analog contact
Relay coil
Inverted output
Analog output
Special functions
Timer
On-Delay
Off-Delay
On-/Off-Delay
Counter
Up/Down counter
Hours Counter
Threshold trigger
Analog
Analog MUX
Analog Ramp
PI controller
Analog Math
PWM
Miscellaneous
I1
I2
T001
Q1
Q2
T008
Rem = off
Q3
Q4
T002
Q10
Q5
Q9
Q6
Q11
Q7
Q12
Q8
Catalog
Modem disconnected
0BA6.Standard
100%
Search the web and Windows
00:07
19/11/2016


LOGO!Soft Comfort
File Edit Format View Tools Window Help
Circuit Diagram1
Q9
Q13
Q14
T002
T003
M1
Q15
M2
Q16
Rem = off
00:00s+
M3
T004
M9
M4
M10
M5
M6
Catalog
Modem disconnected
0BA6.Standard
100%
Search the web and Windows
23:32
18/11/2016


LOGO!Soft Comfort
File Edit Format View Tools Window Help
Circuit Diagram1
Constants
Make contact
Break contact
Analog contact
Relay coil
Inverted output
Analog output
Special functions
Timer
On-Delay
Off-Delay
On-/Off-Delay
Weekly Timer
Yearly Timer
Counter
Up/Down counter
Hours Counter
Threshold trigger
Analog
Analog Amplifier
Analog watchdog
Analog MUX
Analog Ramp
PI controller
Analog Math
PWM
Miscellaneous
Rem = off
00:00s+
M9
M11
M12
M7
M8 Initialization Flag
M13
T004
T005
M17
M14
M18
M15
M16
M19
T005
M20
M25 (LOGO! Display backlight)
M26 (LOGO! TD backlight)
M21
Catalog
Modem disconnected
0BA6.Standard
100%
Search the web and Windows
23:32
18/11/2016


LOGO!Soft Comfort
File Edit Format View Tools Window Help
Circuit Diagram1
M25 (LOGO! Display backlight)
T006
Rem = off
00:00s+
M22
M0 Message Character Set Flag)
M23
X1
M24
X2
T006
T007
X6
X3
I1
X7
X4
T007
X5
X8
X9
Catalog
Modem disconnected
0BA6.Standard
100%
Search the web and Windows
23:35
18/11/2016

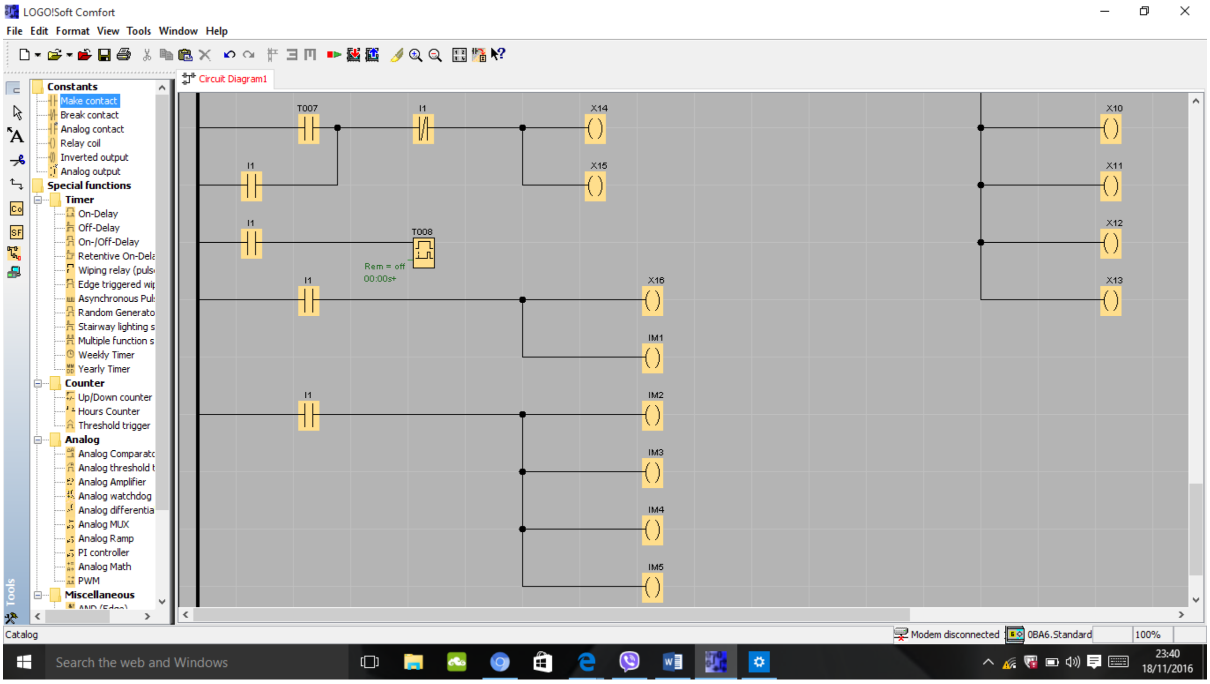


Figure 21 Ladder diagram for the proposed project

CHAPTER V

CONCLUSION

This method will help reduce congestion on roads and would help in coping with accidents. Resultantly, a solution to a much critical problem of traffic congestion and fatal accidents is possible using this system. Thus the proposed system would make our roads a safer place to travel.

An intelligent traffic light system had successfully been designed and developed. The sensors were interfaced with PLC Module. This interface is synchronized with the whole process of the traffic system. This prototype can easily be implemented in real life situations. Increasing the number of sensors to detect the presence of vehicles can further enhance the design of the traffic light system. Another room of improvement is to have the infrared sensors and imaging system/camera system so that it has a wide range of detection capabilities, which can be enhanced and ventured into a perfect traffic system.

References

AHMAD, A. B. (n.d.). *UMP@ INSTITUTIONAL REPOSITORY (UMP IR) Open Access Repository of UMP Resear*. Retrieved from http://umpir.ump.edu.my: http://umpir.ump.edu.my/75/1/cd2636.pdf

Angelfire . (n.d.). Retrieved from http://www.angelfire.com: http://www.angelfire.com/planet/mandy88/Topic_8_PLC.pdf

(April 2005, April). (Traffic Engineering Division Colorado Springs, Colorado) Retrieved from https://permits.springsgov.com: https://permits.springsgov.com/units/traffic/SignalCoordinationPlan.pdf

B, Z. B. (2008, MAY). *uTeM PERPUSTAKAAN*. Retrieved MARCH 2016, from http://library.utem.edu.my/: http://library.utem.edu.my/index2.php?option=com_docman&task=doc_view&gid=5128&Itemid=342

Dr. Tom V. Mathew, I. B. (2014, February 19). (Transportation Systems Engineering) Retrieved march 2016, from http://nptel.ac.in: http://nptel.ac.in/courses/105101008/downloads/cete_39.pdf