An Intelligent PLC based traffic control system for a busy single lane junction

SYNOPSIS

This project is about a demonstration of sensor integrated PLC based traffic control system to ensure the efficiency of traffic in and out flow at any congested lane of an intersection.

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An Intelligent PLC based traffic control system for a busy single lane junction

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ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my project supervisor Dr. Md. Aziz Ul Huq of Electrical and Electronics Engineering Department at International University of Business, Agriculture & Technology for his inexhaustible guidance, motivation and insightful advices throughout this project work. He always encouraged me to do research and analyze each and every components of this work. His door was always open for me whenever I needed his counsel.

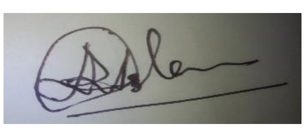
I also want to thank Engr. Md. Abul Bashar, Departmental Coordinator, EEE and laboratory staffs of International University of Business, Agriculture & Technology for their co-operation and support.

ABSTRACT

Traffic congestion, now-a-day, is one of the most frequent struggles of city dwellers around the world. The difficult situations that they are encountering can be ameliorated by utilizing state-of-art technology like- a new type of sensor integrated PLC based traffic control system. A PLC controller, Siemens S7 200 and Transceiver sensors are used to demonstrate an intelligent system in this project. The key objective of this project is to illustrate an example to improve the efficacy of current control method and the efficiency of traffic flow by sensing the presence or absence of automotive within certain range. The other objectives are to reduce mean delay time of drivers, to create a logical order for road traffic in rush hour, to minimize environmental pollution due to fuel burn inside vehicles. The controller of this system analyzes the queue and recognizes the blockade of the streets in a junction with the help of Transceiver sensors deployed in queue at each side of the street. It then sends a signal prior to the current junction. This advanced detection of congestion at previous junction is to manage the inflow of traffic to that intersection of road where the PLC based intelligent traffic control system is installed. Meanwhile, the PLC system allocates some more time for high congested section. LLD program is also developed to manipulate the time counter to adjust with real time traffic flow. PLC controller checks sensors, logical operations and turns ON or OFF the red, yellow or green light to indicate which lane to serve first. It prefers to resolve main street traffic congestion over sub-street gridlock as our system does high occupancy vehicle (HOV) priority treatment. When flow of traffic or traffic density becomes lower at each lane of an intersection, this traffic controller operates sequentially like a time constant traffic controller and the traffic system prior to that junction allows to pass vehicles in a typical manner.

SELF-DECLARATION

I hereby declare that “An Intelligent PLC based traffic control system for a busy single lane junction” project and paper work are solely done by me under the supervision of Dr. Md. Aziz Ul Huq, Associate Professor of Electrical and Electronics Engineering Department, IUBAT-International University of Business, Agriculture and Technology. The test, analysis and result of this project have not submitted to any other institution or university. I also declare that all the source of information are specifically acknowledged and it is done purely of academic interest.



(Rifatul Islam Himel)

SUPERVISOR-DECLARATION

This is to certify that the project entitled “An Intelligent PLC based traffic control system for a busy single lane junction” submitted by Rifatul Islam Himel is done for academic purpose under my supervision. To best of my knowledge, this type of sensor integrated PLC based traffic control system project work has not performed yet by any other students or institutions.

I examined the project work and paper and found it acceptable to publish electronically or by any other means.

(Dr. Md. Aziz Ul Huq)

1. INTRODUCTION

The sheer advancement of modern communication is one of the greatest achievement of human civilization. The results of the developments of this sector bring sophistication, comfort and efficient transportation system into our life. But the management and control of traffic movements within the existing modern city infrastructure are also getting harder than ever before because of higher rate of increase in vehicle use and unpredictability of traffic load at certain point of our day to day journey. Thus, we have to mobilize ourselves into jam-packed, bustling, poorly managed city street which causes a significant waste of time, increases environmental vulnerability to global warming and leads to financial losses to a lots of members of our community. Therefore, we need to implement an effective and smart control system to overcome all those inconveniences. Researches are continuously working to improve traffic control and management system. Some of the research have been done to detect the congestion or management of traffic or addressing both by implementing different kind of technologies, like- inductive loop system, infrared spectrum study, visual camera implementation, image processing technique, RFID and GSM technology etc. But neither of them used sensor integrated PLC based intelligent system to analyze the queue of a gridlock to do priority treatment, manage and control the traffic flow. In this project we will show how we can develop a smart system in PLC platform to get rid of traffic snarl-up in a single junction.

2. TRAFFIC CONTROL SYSTEM

Traffic control system or road traffic control is a method of directing and controlling traffic movements in an intersection to ensure the reduction of right-angle collisions, safety of pedestrian and to warn, command or prohibit drivers from certain actions. It can be operated manually or by TSR (Traffic sign recognition) method or by adopting modern automation technology. Generally, traffic controller uses the concept of phases and stage to manage any cross-section. Phase means directions of traffic movement grouped together and stage is group of phases which is operated at the same time. However, the traffic controller has to make sure that phases of stage do not get into any kind of collision with one another.

However, traffic control system can also be classified as saturated and unsaturated type. The aim of saturated category is to serve as many drivers as possible whereas in an unsaturated network, it is desirable to reduce average delay time in a junction. When the control system serves the highest possible drivers at any side of a network, it actually maximizes traffic capacity, thus minimizes queue of that portion of the intersection.

2.1 CONTROL OF TRAFFIC ACCORDING TO LAW OF BANGLADESH

According to the reference 14, the following traffic control laws have to be obeyed by the citizens of Bangladesh while they are on the road of the people's republic of Bangladesh:

1. **Speed limit**: No vehicle can surpass fixed maximum speed limit assigned by under any law in public place. The authority authorized by Government can restrict speed of motor vehicle for one month by notification in official Gazette if it is necessary for public safety or nature of thoroughfare.

2. **Weight and usage limitation:** Transport committee may assign some condition to permit heavy motor vehicle on road except those which is not fitted with pneumatic tires and if unladen, laden and axle weight exceed respective maximum weight specified in the registration certificate.

3. **Power to have vehicle weighted:** If any authorized person feels that a goods vehicle weight is more than maximum fixed weight, the vehicle has to be on weighting device for evaluation. When excessive goods are found, those have to be removed from goods vehicle to the nearest specified place for a limited time. The authority may sell unperishable goods on auction if those are not taken away from that place within the time limit. The owner will only receive the amount curtailed due to storage charge and cost incidental.

4. **Power to restrict the use of vehicle:** The authorized person by government may restrict or prohibit certain types of motor vehicle by notifying in the official Gazette if it is necessary for public safety.

5. Power to erect traffic signs: The authorized person by government has the right to place or erect traffic sign in any public place for the purpose of bringing it into public notice that illustrates any restricted speed limit for regulating motor vehicle traffic. Government also have the authority to add any sign that is fit, provided that the transcriptions shall be similar size and color to the words, figures and letters set forth in Ninth Schedule. If any advertisement or sign is found to make traffic signal obscure, the authority may remove those. None can willfully place, erect or damage any traffic sign and if someone does accidently, he has to report the circumstance of occurrence at nearest police station. Additionally, the set forth size, color and letter of traffic signal in Ninth Schedule can be deemed for bringing any sign in conformity with any international convention

6. **Parking places and halting station:** The government authorized person can determine the parking place of vehicle for limited or indefinite time. He may also can affix a place for public transportation.

7. **Main Road:** The government can designate certain road as main road, by notification in official Gazette or by the erection at suitable places of the appropriate traffic sign.

8. **Duty to obey traffic signs:** Every driver should have to follow the traffic rules and have to stop near the liner lines marked for pedestrian crossing when any pedestrian is in the middle of the crossing.

9. **Signals and signaling device:** Right and left hand steering controlled vehicle have to follow the prescribed signal provided by an affixed nature of electrical or mechanical device. If any failure in the device occurs, the signal will be given with left hand.

10. **Vehicle with left hand control:** A left hand steering control motor vehicle is not allowed to drive in public place unless it has a prescribe nature of mechanical or electrical signaling device. But government may exempt from punishment due to rule violation by considering some facts and conditions, by notifying in official Gazette.

11. **Leaving Vehicle in dangerous position:** No person is allowed to leave a car in a position where the car can create inconvenience, obstruction and likely to cause danger.

12. **Riding on running board:** The person in charge of a motor vehicle cannot take any person on board while he is running to climb up. They are not allowed to take passenger on roof or outer surface of the body of vehicle.

13. **Restrictions on boarding public service motor vehicle:** No public transport is allowed to board excessive people, greater than its capacity. A sub-inspector of police in uniform can stop the

vehicle unless extra passengers do not get down from that vehicle. If those extra passengers who have to climb down at the middle of their fare pay for the ride, they are entitled to the refund.

14. **Obstruction of driver:** No driver can allow a person to hamper his control over vehicle by letting that person sitting or standing next to him or by letting him placing anything distracting or inconvenient for driving.

15. **Stationary vehicle:** The person in charge of a vehicle cannot allow the vehicle to remain stationary in a public place unless he has a proper license to do it or it happens due to some kind of mechanical problem. In absence of driver, a brake should be applied to the vehicular system to stop it from rolling further on road.

16. **Pillion riding:** Two wheel motor cycle drivers cannot take more than one person addition to himself. Both of them have to wear a helmet during bike ride.

17**. Duty of obtain license and certification of registration etc.:** The person in charge of vehicle has to produce his license, certificate of registration and certificate of fitness, if government authorized officer wants to examine these documents.

18. **Duty of driver to stop in certain cases:** The driver of a vehicle should make his vehicle stationary if government authorized officer wants it to or it may cause some particular animal and human life in danger. If any vehicle involves with accident, the driver has to provide the name and address of him and the vehicle owner to the affected person who demands it, provided that such person also furnish his name and address.

19. **Duty of motor vehicle owner to provide information:** The owner, the driver or conductor have to give all the information regarding the name and address, the license of driver or conductor if any of them is accused of any offense.

20. **Duty of driver in case of accident and injury to a person:** When a motor vehicle is involved with an accident that may cause property damage or injury to any person, the person in charge of vehicle has to take the injured person to nearby hospital for medical attention and has to report this incident at nearest police station within 24 hour of occurrence.

21. **Inspection of vehicle involved in accident:** A technically qualified officer who is authorized by authority can inspect a vehicle in prescribe manner and if required, can take the vehicle for

examination when the vehicle is involved in accident. But the place of examination should be familiar to owner and the vehicle has to be returned back to owner within 48 hours in metropolitan areas and within 72 hours for other areas.

22. **Power to make rules:** The government may make rules for mechanical or electrical signaling devices, removing and safety of vehicle custody including their loads, installation and use of weighting device, maintenance or management of storage goods removed from vehicle, parking place, stands and fees, exemption from provisions of this traffic control chapter of special class of vehicle according to prescribed condition, prohibiting the use of footpath, the taking hold of or mounting of vehicle in motion, the driving downhill of motor vehicle with sear disengaged and doing something that prevents damage, injury and annoyance of public and obstruction of road.

2.2 CURRENT TRAFFIC CONTROL METHOD

In our country at many intersections, most of the traffic control and congestion management are being manually done by either our vigilant traffic police or by the traffic controllers. They normally use their hand for traffic control service to direct vehicles to different direction. They have to be very cautious. They always have to be conscious of several other stuffs as well, like- monitoring bottlenecks & pedestrians, allocating times for different section according to traffic density and priority, emergency management, maintaining traffic rules and regulations, penalizing for rule violation etc. If our intelligent traffic control system (ITCS) can be implemented in those manually controlled zones, the whole mechanism of traffic management would step into next level. This control method will surely make current technique of traffic control much more efficient and orderly.

Fig 1: Manual current traffic control method by traffic police

3. SMART TRAFFIC CONTROL SYSTEM

Smart traffic control system has the ability to sense the presence or absence of the vehicle in the street by receiving detectors inputs & processing status data and can compute timing accordingly to switch on correct signal for a particular lane in an intersection. By implementing certain mathematical and logical operation and by utilizing cutting age electronic technology, traffic movement can be manipulated for gaining optimum service and efficient support. Generally, an electronically interconnected smart traffic control system depends on (1) cycle length and signal phases in a track, (2) the system's response to interruption, (3) HOV priority treatment. If we can design our system by analyzing those conditions and can address each point successfully, we will be able to build one for ourselves. Besides, the control system variables, like- flow rate, occupancy and density, vehicular presence, speed, queue length and headway have also to be taken into consideration to design an efficient smart traffic control system unit.

Smart traffic control system works in four modes: Peak time, Off time, Normal flow and Manual operation. Peak time and Off time modes normally are relied on output feed by an electronic system which is then integrated into conventional traffic control lighting system. Thus, the system with the help of valid coding can decide for itself how and whom to serve in chronological order.

In our sensor integrated intelligent traffic control system project, we will set feasible cycle length and signal phase by LLD. The system's response to interrupt and HOV priority are done by series of sensors, PLC hardware and traffic light control unit. Although our system will be suitable for every modes of traffic control system, it will be very effective on peak hours and normal flow.

3.1 ADVANTAGES

There are several advantages of smart traffic control system or ITCS over conventional manually controlled system. Such as-

1. ITCS reduces congestion, average delay time of vehicles and improves traffic handling capacity in a junction.

2. It provides advanced notification to its prior junction to inform drivers to aware of road situation and encourages them to take alternative pathway or necessary measures to become efficient in road usage.

3. It minimizes driver's frustration, road rage and collisions.

4. It ensures traffic's orderly movement and fine-tunes journey time.

5. It cuts down time wastage of pedestrian when they try to cross roads at intersections

6. It implies bringing down different kinds of environmental pollution caused by traffic.

7. It reduces fuel consumption.

8. It eradicates flaws of manual control and assigns proper amount of time for over-crowded side.

9. It is a helpful system for traffic police as they will be able to more focused on other responsibilities,

10. Overall, it introduces more secured crossing system for pedestrian and vehicle.

4. PLC

Programmable logic controller or PLC is microprocessor based controller which is highly reliable in automation of electromechanical process, such as- control of machinery on factory assembly lines. It stores instructions in programmable memory unit. The functions like- sequencing, timing, counting, arithmetic etc. are also implemented in the memory in order to control machines and various type of industrial processes. Most of the time it replaces timers, counters and necessary sequential relays circuits to make rugged automation operations smoother and sound. It executes logics and performs switching according to the program that the operator sets, e.g.- if M or N occurs, then turn on A, if M and N happens together, switch on B. Different kind of sensors, detectors, switch, push button can be used as ‘Input’ and motors, valves, buzzer, relay circuits etc can be acted as output. PLC is now one of the most popular technologies in the field of factory control applications because of its cost effective control, flexibility, reusability, computational ability, analytical power and decision making. There are several models of PLC in the market now-a-days, like- PLC S-7 200, 300, 400, 1200, ET 200, TI 545, 555, SLC 500, Modicon 984 PLC, MicroLogix, PLC 5 etc.

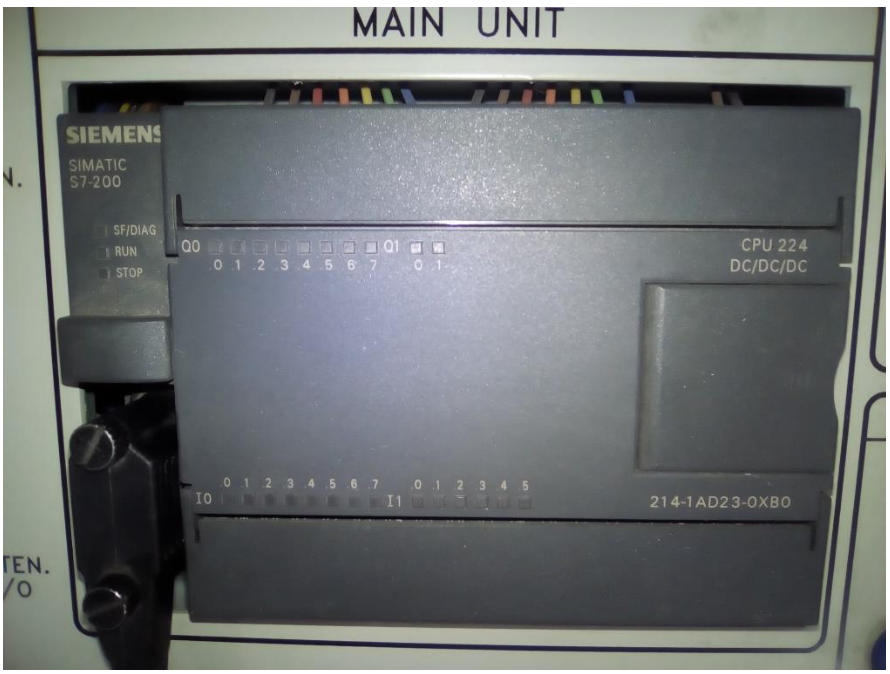


Fig 2: SIEMENS SIMATIC S7-200 PLC unit

In 1968, Richard Morley along with Mike Greenberg, Jonas Landau and Tom Boissevain worked on designing of 084 which was later known to us as PLC. Richard Morley considers himself to be the father of PLC as he believes that its creation is a group effort.

4.1 INTRODUCTION TO PLC 200 TRAINER

Siemens PLC 200 trainer is a complete set of lab equipment which contains a variety of I/O module and PLC main unit. It helps the operators to develop and to program a control system by familiar ladder logic diagram. The main unit, SIMATIC S7 200 is a micro programmable logic controller (Micro PLCs) is fast, reliable, and highly productive in real time operation and has capability of controlling wide variety of device. It models CPU 221-224, 226 and CPU 224XP to include new CPU hardware support and it also gets new memory cartridge support. It is very consistent and compact in design. It has a rich and power instruction sets. It monitors inputs and changes output accordingly. It can execute Boolean logics, complex mathematical operations, LLD and can also communicate with other devices. Its feature allows it to be both as a stand-alone Micro PLC solution and in concomitance with other controllers in the industry.

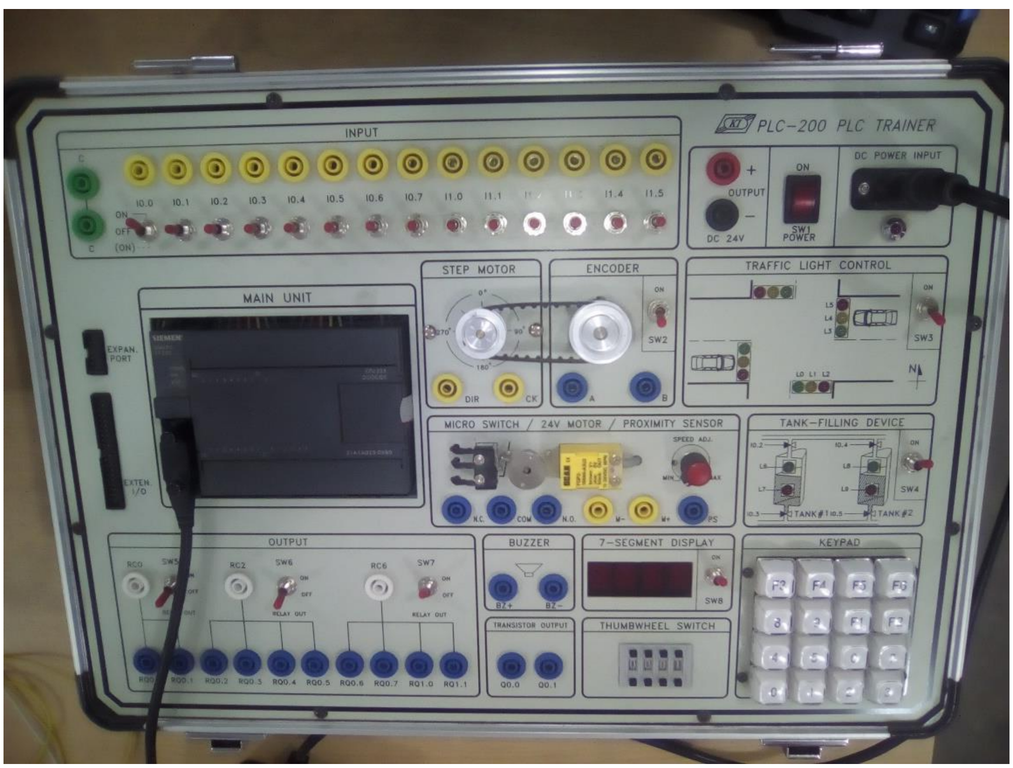


Fig 3: PLC 200 trainer

4.2 PLC 200 TRAINER HARDWARE CONFIGURATION

The followings are the main specification of Siemens S7 200 hardware [reference no: 3]-

1. AC Power Supply: 100V-240V AC 50/60 Hz

2. PLC main unit: SIEMENS SIMATIC S7-200 CPU 224 DC/DC/DC transistor output type

3. 14 points digital input

4. 10 points digital output:

5. 6 high speed counter support

6. Four 1-ms, 16 10-ms and 236 100-ms timers support

7. Communication Port: RS-485

8. Display: One 4-digit 7-segment

9. Switch: One 4-digit thumbwheel

10. One encoder

11. One proximity sensor

12. One 24V DC motor

13. One step motor

14. One buzzer

15. One 24-VDC expansion power

16. One 4*4 Keypad

17. One Micro switch

18. I/O module expansion port and DIO extension port

4.3 SOFTWARE COMPONENT

K&H MFG. Co. LTD provides a windows OS based IDE (Integrated Development Environment) software STEP 7-Micro/Win (V4.0) along with PLC 200 trainer. This software is very user friendly and any LLD program can be created and modified according to the user requirements. It also has functions of project managing, LLD printing, report producing and PLC status checking. The flexibility of editing and fundamental copy, paste & delete operations ease the complex program developments. The subsections of a program can also be used to test its functionality or other categorical methodology independently without effecting succeeding or preceding logics. Hence, the maintenance of the whole application is very much trouble-free. It has a build in simulator engine which provides facility to simulate our LLD program without any PLC device so that we can test our logics, make program error-free and ensure the feasibility of the system.

4.4 LADDER LOGIC DIAGRAM

Ladder logic diagram, in short LLD, is a form of rule based programming language or graphical documentation which is based on circuit diagrams of sequential relay logic hardware. The term ‘Ladder logic’ comes from its structural appearance as ladder on pc screen. It has two vertical power rails and series of horizontal rungs or rule fixtures between them. This language is often used by factory Engineers and technocrats in conjugation with HMI program controlling its function on a computer workstation to develop software for machinery control and operation without any additional training on FORTRAN or any general purpose computer language.

When LLD is applied to PLC, the software executes the program sequentially and in a continuous loop. So, it may seem a simultaneous and immediate system if the software starts to execute loop very quickly. That is why programmer should properly develop a program that has to be suitable for electromagnetic nature of the device. Otherwise, they device can omit some instructions which will hamper total operation. Therefore, proper understanding of correct use of programmable controller is required to work on PLC based automation system.

Because of its simplicity and convenience, LLD is widely used in PLCs for manufacturing and control process. The following symbols are the most basic symbols in LLD (SIMATIC S7 200 model):

Rung inputs: Checkers

— [ ] — Normally open

— [\] — Normally closed

Rung outputs: Actuators

— ( ) — Normally inactive

— (\) — Normally active

Series connection of contacts= And

Parallel connection of contacts= Or

There are also timers, clocks, counters, transitions available to build a program according to the necessity of industry.

4.5 TIME CONSTANT TRAFFIC CONTROL SYSTEM

Constant time traffic control system is a method where Siemens S7 200 PLC system assigns a particular amount of time for each line. This system does not acknowledge traffic jam and cannot involve into real time operation. It just provide directions to the traffic when and where to move by changing its Green, Yellow and Red light of system hardware when an assigned time interval is provided in the program of Windows based IDE software. We have STEP 7-Micro/Win (V4.0) software installed in our PC for LLD program development.

The system consists of PLC main unit, I/O module, relay circuit, pc for program development and traffic control lighting system. The LLD program is developed in PC. LLD program mainly consists of On-Delay Timer (TON), UP counter (CTU), Positive transition (EU), memory and switching logics.

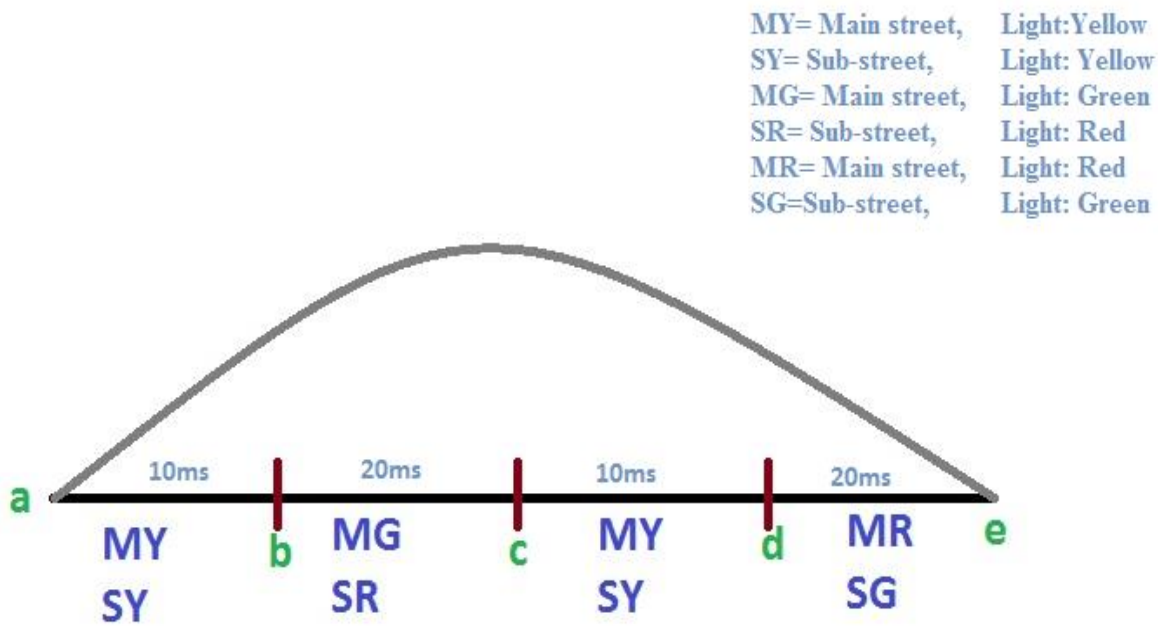
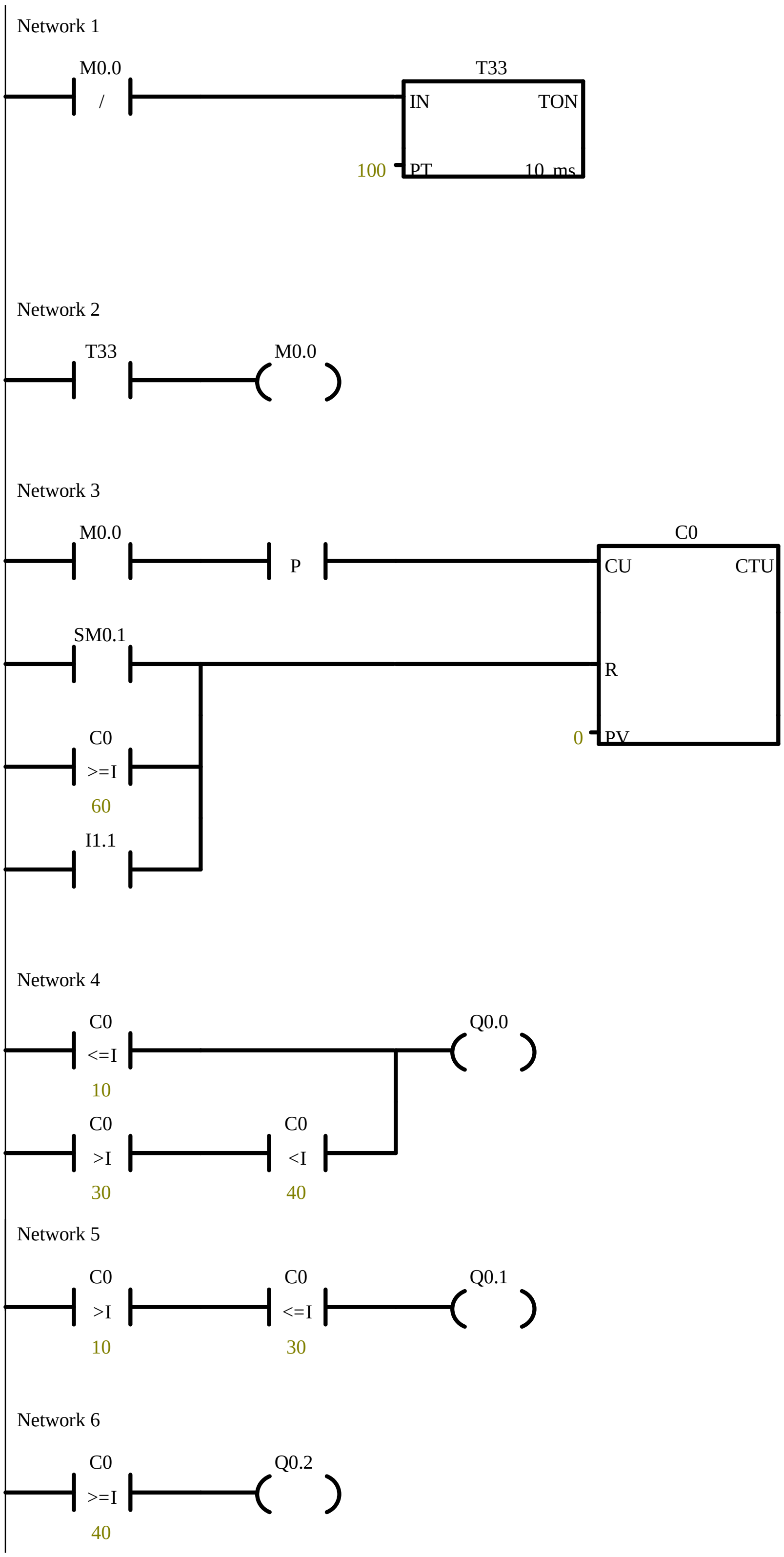


Fig 4: Design of time constant traffic control system operation

The following page illustrates a simple time constant traffic control system in PLC platform. We use Siemens PLC 200 trainer along with traffic control lighting system and STEP 7-Micro/Win (V4.0) software for development of time constant traffic control system:


Network 1
M0.0
/
T33
IN
TON
100
PT
10 ms
Network 2
T33
M0.0
Network 3
M0.0
P
C0
CU
CTU
SM0.1
R
0
PV
C0
>=I
60
I1.1
Network 4
C0
<=I
10
Q0.0
C0
>I
30
C0
<I
40
Network 5
C0
>I
10
C0
<=I
30
Q0.1
Network 6
C0
>=I
40
Q0.2

Here, M0.0 is normally closed input. When M0.0 bit is closed, T33 on-delay timer starts working. It counts time up to PT. In the meantime, output of T33 is off. When T33 ≥ PT (Present time), then the timer resets itself and TON of T33 triggers next circuit to ON state. This circuit makes M0.0 bit ON and again this process continues after completion of execution of the whole program. This is how a clock is created in our PLC module.
The diagram above counts 100*10ms= 1s before any transition.

Now as we know from definition that for one scan, the positive transition (EU) contact permits power to flow to C0 or Up counter (CTU) for each off to on transition. So, when positive transition in clock occurs, it sets M0.0 in to ON state which makes C0 ON. C0 has SM0.1, C0 (up to 60) and I1.1 input connected to its reset button. SM0.1 bit ON means first scan according to PLC-200 experimental manual. C0 (up to 60) means the Up counter, C0 will reset itself after counting 60 and I1.1 is for manual reset operation. When positive transition allows power to flow in to C0, SM0.1 starts checking whether there is any input or counting operation remains in C0 memory. As SM0.1 is connected with R, it automatically resets C0 at first scan.

After C0 is cleared, C0 starts counting time. There are Q0.0, Q0.1 and Q0.2 bit available which is actually are attached with output unit. In this case, these are with relay circuit which operates traffic light. When C0 value remains within 0 to 10 and 30 to 40, Q0.0 is ON, hence the yellow light in traffic lighting is ON. When C0 counts from 10 to 30 and 40 to 60, it energizes Q0.1 and Q0.2 respectively. Q0.1 is for Red light and Q0.2 is for green light. When C0 finish counting 60, it resets itself and starts counting when T33 provides positive transition to C0. This process continues until we stops the program or manually stop the circuit. Thus how a time constant traffic control system can be built by PLC 200 and other utilities. This is the basis of our smart traffic control system. In this project we modifies and upgrades this control system version to produce a smart traffic control system.

5. SENSOR

Sensor is a module or an electronic component which has the ability to detect any change of in its ambient or environmental condition and alters its output accordingly. It can convert any physical quantity into signal which can be used to control, monitor or store. Generally, sensors detects rate of change of data, process the input signals into its system and provides output to other system to facilitate the provision other electronic system offer. It is an integral part of any smart system. A good sensor must have the following qualities:

1. High sensitivity
2. Linearity
3. Capability of less power consumption
4. Immunity to disturbance and noise
5. Process of identifying smallest change in a closed system

Now-a-days, sensors and sensor systems are vastly applied to almost every smart system. It is highly used in industrial processing and controlling unit, laboratory tests, different electronic devices and systems, security system etc. There are many types of sensor available in the market to meet the demands of customers' requirements, like- chemical sensors, automotive sensors, proximity sensors, sound sensors, optical, thermal or mechanical sensors etc. The following picture illustrates one of the common type of sensors which has already been used in many electric appliances.

Fig 5: Proximity sensor

5.1 TRANSCEIVER SENSOR

Transceiver sensor is a kind of electronic sensing system which uses interruption of light to detect any change of a system. It has one transmitter which sends light beam to its receiver. As this sensor unit does both transmission and reception, it is known as transceiver sensor. Normally, when the sensor is 'ON', sender continuously sends light beam to its receiver. But when something comes in between sender and receiver, it blocks the transmission path of light. As receiver cannot detect the light, the system sends interruption signal to the sensing module. The signal of sensing module can be placed as input to build any smart system. In this project, we use this sensor's interruption signal as an input to PLC modular. We used the transceiver sensor device illustrated below for our experiment. To implement this system on the road and highway, some enduring, insensitive to noise and highly responsive to light path disruption type transceiver sensors have to be deployed for better performance.

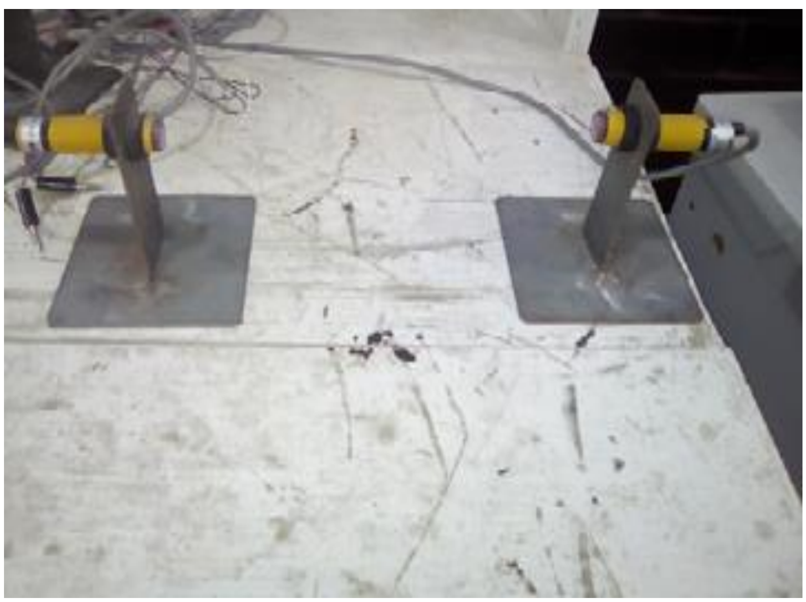


Fig 6: Transceiver sensor

6. TRAFFIC CONTROL LIGHTING SYSTEM

In 1868 J. P. Knight created traffic signal for the first time. He developed it in London, England. After that New York installed modern traffic light- the three color system in 1918 for the first time to control traffic which was operated from a tower in the middle of a street. Later in 1923, Garrett Morgan produced an electric traffic system where he used pole with cross-section. In his design STOP and GO words were added and they were illuminated according to the condition of traffic in road. Three years later, in London first automatic signals were lodged. New system of that time depended on the timers to activate them. The researchers of ITCS introduced a lot of method to make the traffic control system smart afterward. The major goal of traffic control lighting system is to ensure smooth and safe traffic and pedestrian movement in a road or cross-section. It contains three LED commonly- red, yellow and green. Red is to stop traffic flow, yellow is for warning for changes of commands and green is for allowance of traffic movement on street. There are STOP and GO signals available with the lighting system to supervise the persons on foot in any cross-section.

Fig 7: Traffic control lighting system

7. PROJECT DESIGN AND ANALYSIS

In this project, we plan to design a smart traffic control system for single lane where the vehicles will move towards AC or BD (fig: 8). We are not considering any CA and DB flow of traffic here. We want to implement our system to improve the efficiency AC and BD traffic movement and their inflow. We will also do HOV priority treatment for AC traffic flow, because AC is considered to be Main Street and BD is sub-street in this project. As Main Street contains more vehicles in peak hour and most of the cars, trucks, van etc. belong to important business dealings, it is necessary to put priority to major road than the sub roads. We use transducer sensors S1-S4 in series at main street and S5-S8 sensors at sub-street to identify any blockage and to do queue analysis. We also program the PLC system to put priority for S1-S4 sensors. Red, yellow and green light will be illuminated according to the timing set in program. For each interruption of light path between transmitter and receiver of sensors, the time length of three kind of light's illumination in traffic control lighting cycle set in program will be extended. Hence, AC or BD will have an opportunity to clear its own gridlock according to the density of the traffic. The inflow rate of the traffic at AC or BD can also be controlled when the traffic snarl-up signal at AC or BD will be conveyed to its prior intersection.

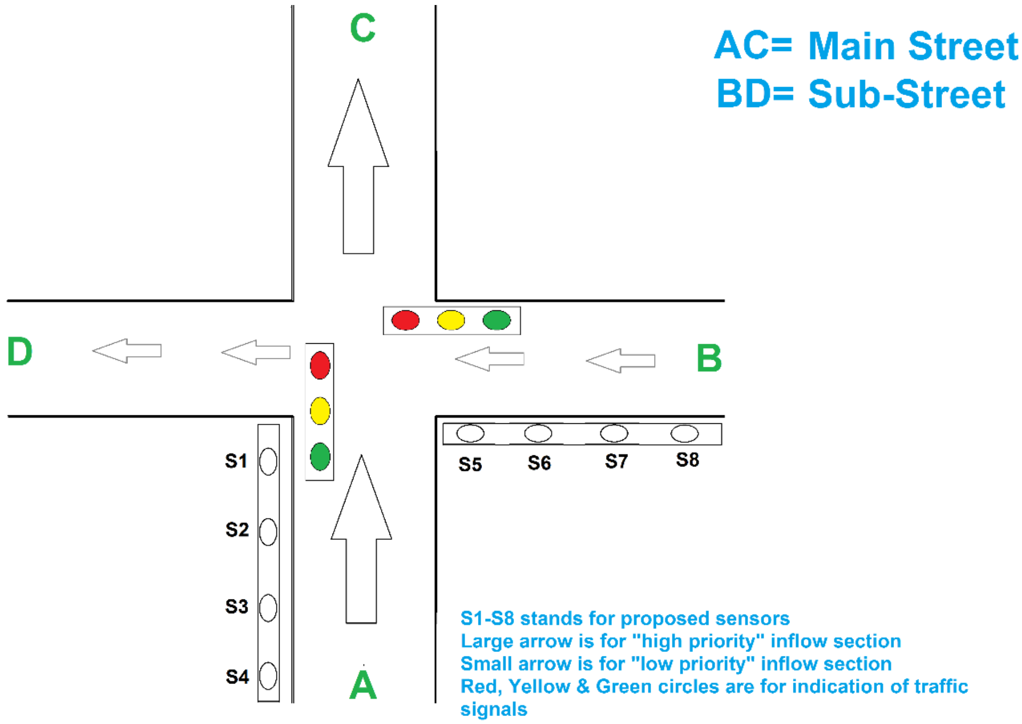


Fig 8: Proposed plan diagram for single lane system

7.1 COMPONENTS OF PROPOSED SMART TRAFFIC CONTROL SYSTEM

We have to use the following components to create our proposed smart traffic control unit:

1. PLC-200 trainer- 1 Unit

2. Transceiver sensors- 8 Unit

3. STEP 7-Micro/Win Software

4. PC- 1 unit

5. AC adapter-1 unit

6. USB cable- 1 unit

7. AC Power source

8. Traffic light control module- 1 unit

7.2 WORKING PRINCIPLE:

Sensor integrated PLC based smart traffic control system takes sensor input in PLC and allows more time for blocked area. It has three integral parts, e.g. - (1) PLC controller, (2) Hardware or traffic lighting system and (3) sensors. PLC controller controls the whole unit, the hardware acts according to the output provided by PLC and the sensors provide inputs to main controller.

The PLC controller can be further divided into two parts. One is it hardware and another is software. The logical commands from software are integrated into hardware to make PLC controller a fully functioning system.

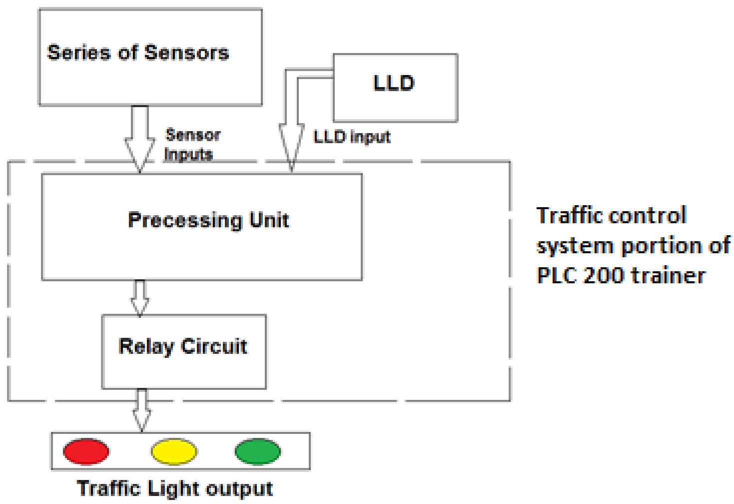


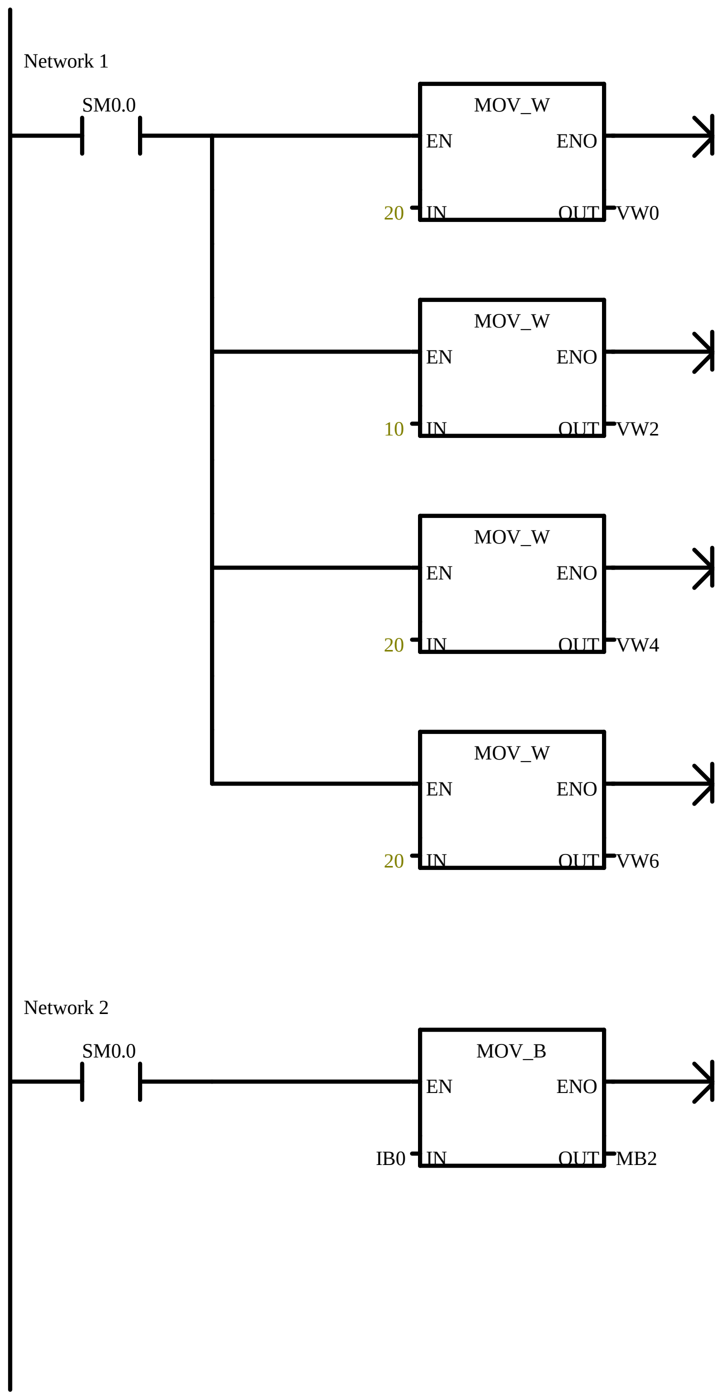
Fig 9: Working principle of smart traffic control system

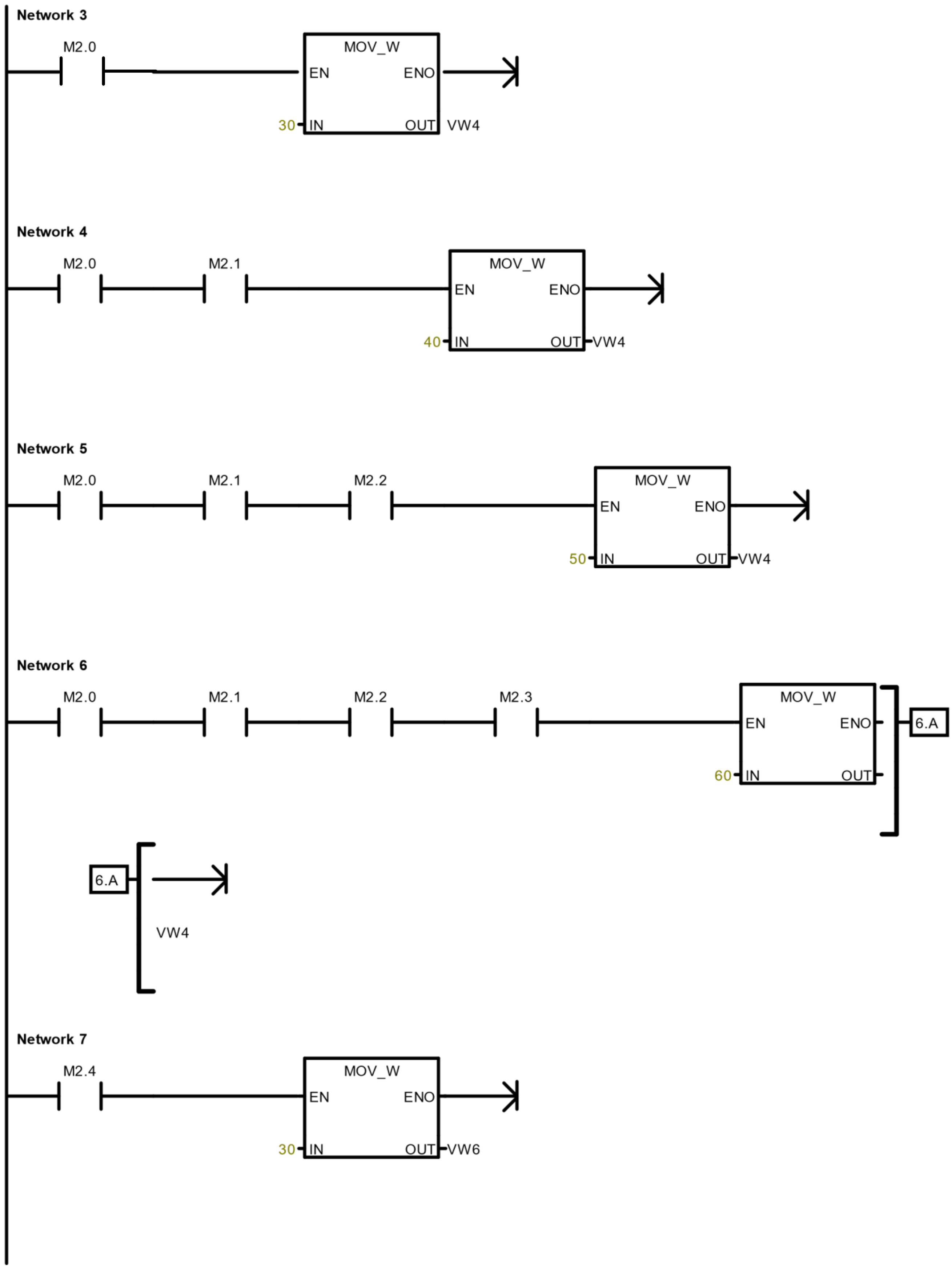
Our PLC 200 trainer has its build in relay circuit to control traffic light output. Traffic light output consists of three kinds of LED signals- Red, Yellow and Green. A serious of sensors work as the input switches of our PLC. When 'Red' light turns on in one side, series vehicles of one side of the road starts to interrupt the light path of transceiver sensors. The series of sensors employed on the street can sense motor vehicle's presence and detect the size of queue in one side of the road. PLC can analyze queue according to the LLD program set into processor by controller. The processor then process the input data and sends a signal according to the logic of the program to the output relay circuit. The relay circuit alters the timing of a signal for a particular lane. Main Street and HOV side get priority in this system.

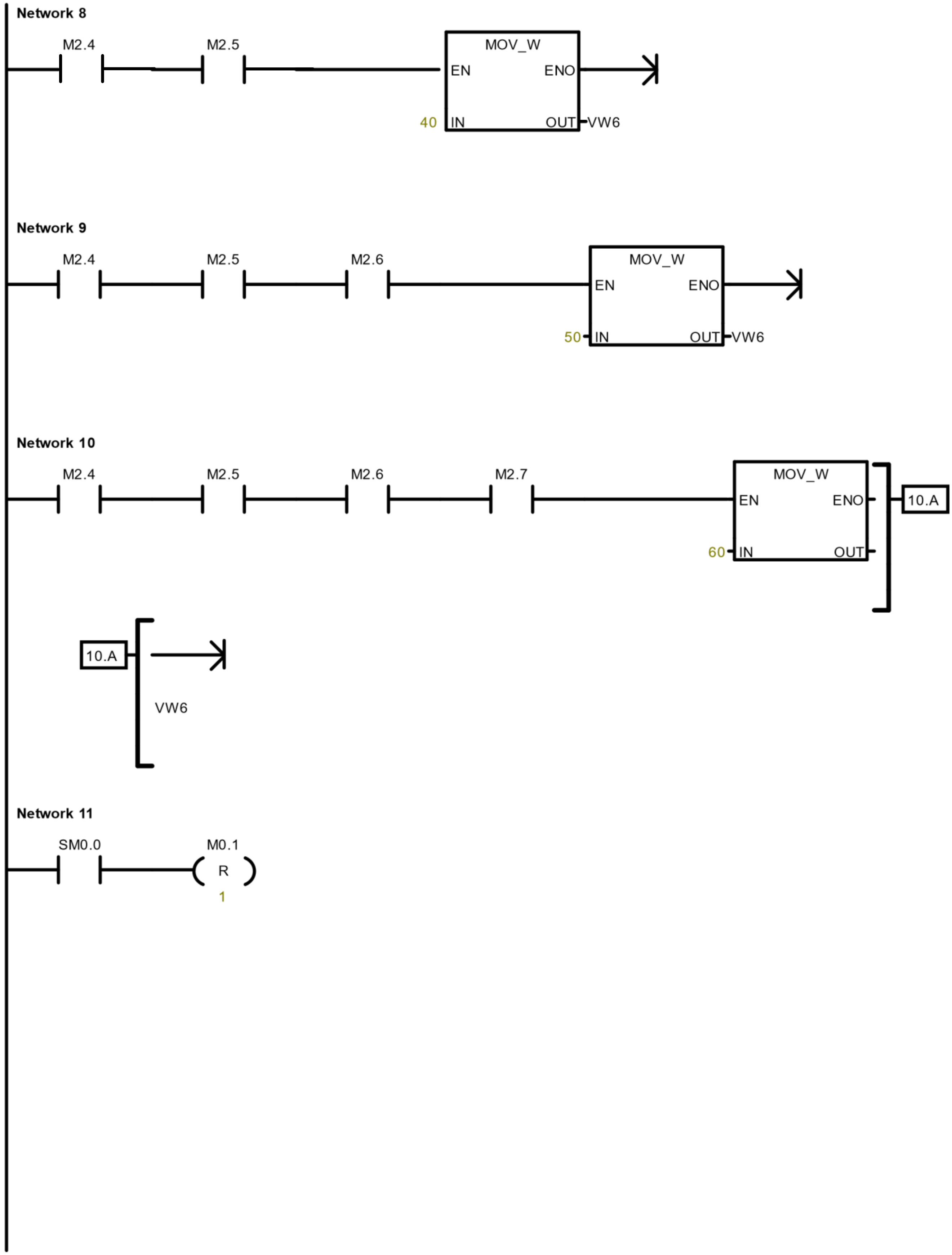
7.3 PLC LLD DESIGN

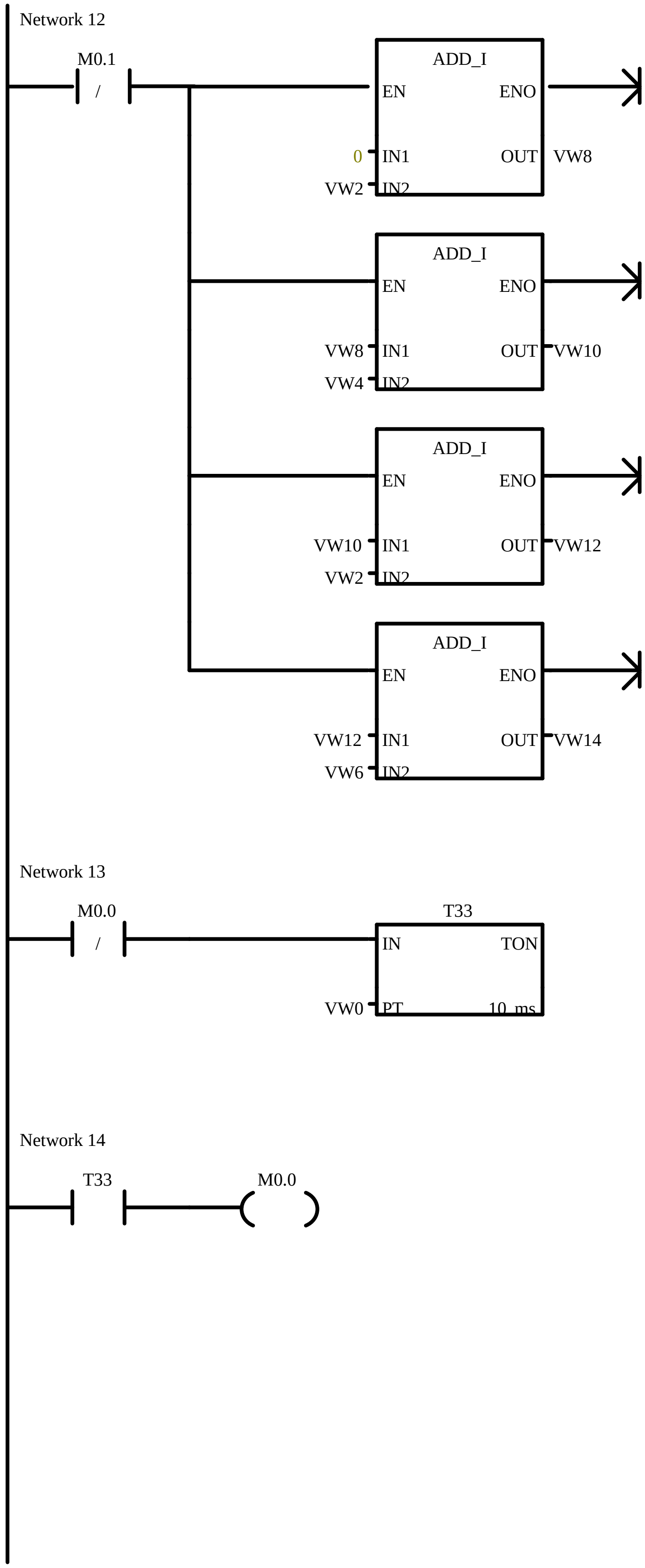
Smart traffic control LLD design consists of move word, move byte, add integer instructions, M2.0 to M2.7 input unit and a simple time constant traffic control system program. Special memory bits like- SM0.0, SM0.1 are a read only component which provide a way of communication between computer's central processing unit and LLD program. According to instruction manual, SM0.0 means that this bit provides always on logic. In this program, we assigned variables for different stages in the counting process and for numbers of the program. VW0, VW2, VW4, VW6, VW8, VW10, VW12 & VW14 are the variables used in the program. Move word (MOV_W) instruction is to shift numerical value from IN memory location to OUT location without changing the value. Here numbers are moved to variables registered in OUT memory. Each variable defines a memory unit which will store the value that we set for the program. Sensor output will be provided in M2.0 to M2.7 memory bit. When any of these memory bit turns on, the variables will add some more time assigned to the program to prolong the duration of traffic light signal shifting to allow more traffic to flow in a particular lane. M0.1 is another bit used here to put logic for add integer instruction set. The command here for M0.1 shows that it is always closed in this program. Add integer (ADD_I) program will get the value from variables and will continue to add the two different variables always. If any of numerical value of a variable changes, the adder will also make the same types of modification to its output variable which allows the total system to adopt with the change of sensor input. A basic time constant traffic system is also included here which is the base of our traffic control system development .It is now programmed with variables. On-delay timer, up counter, positive transition and Q0.0 to Q0.2 bit are for clock, counting time for output signals, power flow to up counter and output respectively. I1.0 memory bits is set to manually control the traffic lighting system unit where SM0.1 is connected with the reset system of the up counter to ensure that first scan service is enabled. With the change of numerical value of VW8, VW10 and VW12, the outputs Q0.0, Q0.1 and Q0.2 starts activating and deactivating.

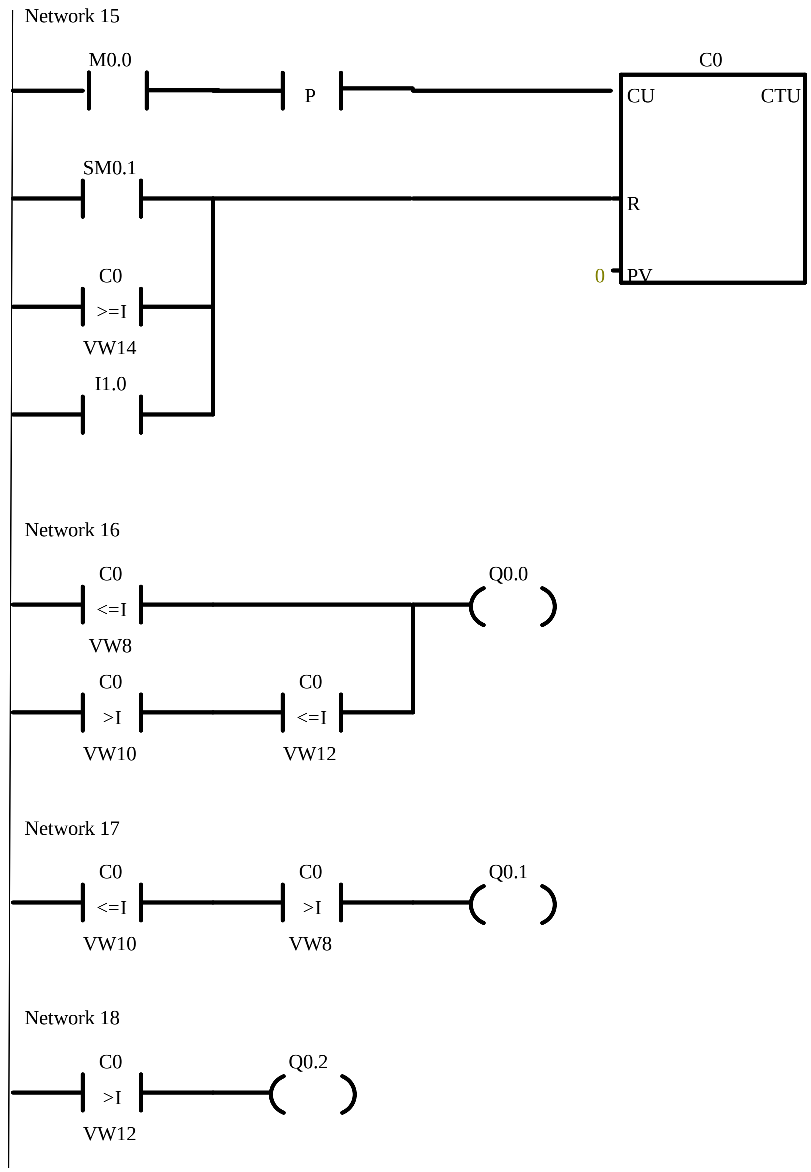
The LLD diagram of our smart traffic control system is illustrated below:




Network 3
M2.0
MOV_W
EN
ENO
30
IN
OUT
VW4
Network 4
M2.0
M2.1
MOV_W
EN
ENO
40
IN
OUT
VW4
Network 5
M2.0
M2.1
M2.2
MOV_W
EN
ENO
50
IN
OUT
VW4
Network 6
M2.0
M2.1
M2.2
M2.3
MOV_W
EN
ENO
6.A
60
IN
OUT
6.A
VW4
Network 7
M2.4
MOV_W
EN
ENO
30
IN
OUT
VW6


Network 8
M2.4
M2.5
MOV_W
EN
ENO
40
IN
OUT
VW6
Network 9
M2.4
M2.5
M2.6
MOV_W
EN
ENO
50
IN
OUT
VW6
Network 10
M2.4
M2.5
M2.6
M2.7
MOV_W
EN
ENO
60
IN
OUT
10.A
10.A
VW6
Network 11
SM0.0
M0.1
R
1


Network 12
M0.1
/
ADD_I
EN
ENO
0
IN1
OUT
VW8
VW2
IN2
ADD_I
EN
ENO
VW8
IN1
OUT
VW10
VW4
IN2
ADD_I
EN
ENO
VW10
IN1
OUT
VW12
VW2
IN2
ADD_I
EN
ENO
VW12
IN1
OUT
VW14
VW6
IN2
Network 13
M0.0
/
T33
IN
TON
VW0
PT
10 ms
Network 14
T33
M0.0



7.4 LOGICAL ANALYSIS OF LLD

First we have to decide the amount of time that we will assign for the cycle of the program, for each of the interruption and for each of the light signal. The following diagram is the actual plan of our system. Here, MY means Main street yellow light is on where SY means sub street yellow light is on. When the signal from Main Street is Red (MR), then the sub-street will send a Green signal (SG) allowing traffic to flow in that portion. Likewise, when sub-street shows Red (SR), then Main Street permits traffic to move forward by providing green signal (MG).

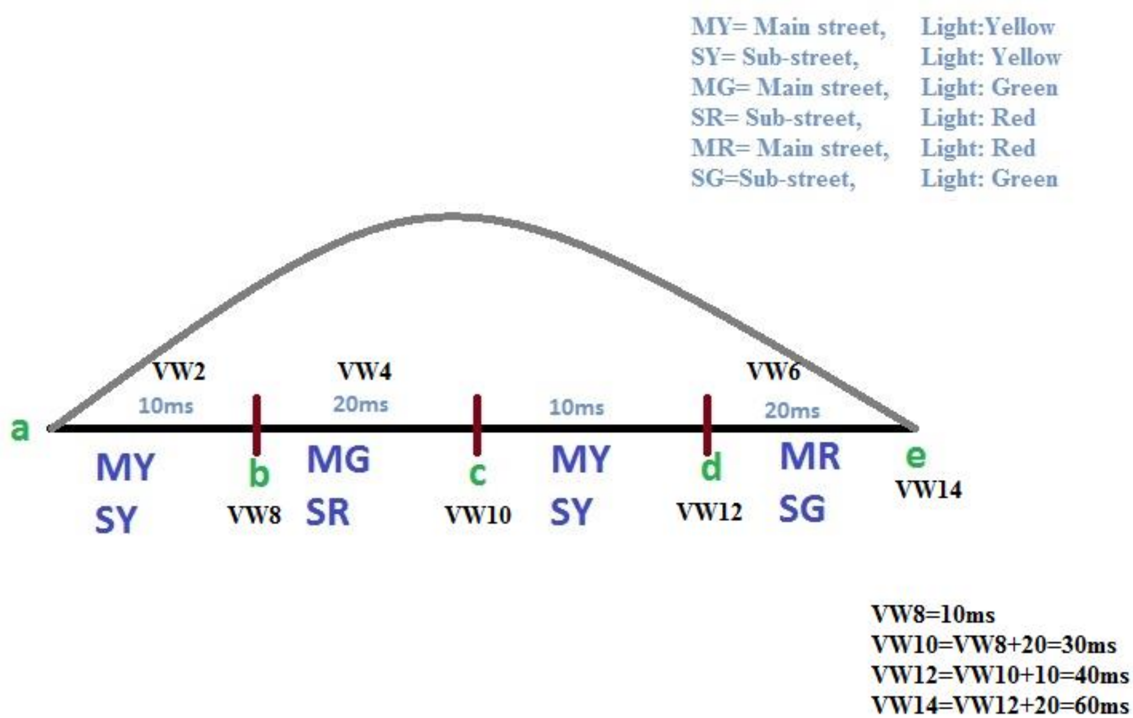


Fig 10: Design of smarts control system operation by using variables

We also have assigned time for each of the interval and for the whole system. The variables VW2 is set for 10ms, VW4 and VW6 are for 20ms but for different logical occurrences. In one case Main Street will indicate to stop traffic by Red light (VW6) and on the other hand, Green signal will appear (VW4). Subsequently, sub- street lighting system will provide signals for outflow.

In network 1, we provide SM0.0 SM bit which is always ON logic. As the circuit is always on, it will do the operations provided in program. Move word (MOV_W) instructions are enabled to move 20 to VW0, VW4 and VW6 memory and 10 to VW2. All the commands will be in parallel which means that Move word (MOV_W) instructions will be executed once at a time as parallel operation suggest OR operation to perform. So, each of the operation will be done separately and independently.

In network 2, SM0.0 always on bit is used to shift all input (IB0) to output (MB2). All the input data will be read and send to another memory bit in this operation. In network 3, 4, 5 and 6, we add M2.0, M2.1, M2.2 and M2.3 memory bits to get input from sensors. For each memory bit we add 10ms more. So, if any of the bit in a row is on, the program will add 10ms to its cycle and for a particular lane signal. The output of these operation will be assigned to VW4 as it will shift or include the time of MG and SR portion. Like the same away, in network 6 to 10, M2.4, M2.5, M2.6 and M2.7 bits are added. These increase 10ms to each of the lane and to the whole cycle. The execution of these operation will move to VW6 unit where time duration of MR and SG will be calculated. Thus, the system will increase the time duration of MR and SG portion for smart controlling.

In network 11 and 12, add integer operations and add cycle are programmed. SM0.0 always ON bit resets M0.1 bit after all operations done in network 12. So, after 1 cycle, it starts adding integers and starts to place the executions of addition operation to different memory bit by assigning different variables for them, like- VW8, VW10, VW12 and VW14. Add integer (ADD_I) integer instruction are in parallel with one another while M0.1 is closed. In this program M0.1 is always closed and is reset when all addition of VW8, VW10, VW12 and VW14 are done once and it continue to do it this operation again. VW8, VW10, VW12 and VW14 variables are assigned to add different variables to the system, like- VW8= VW0+VW2, VW10=VW8+VW4, VW12=VW10+VW2 and VW14= VW12+ VW6.

In network 13-14, we create a clock for C0. This portion of the program is similar to the clock program of time constant traffic control system. Here, PT is equal to VW0. When T33 ≥ PT (Present time)/ VW0, then the timer resets itself and TON of T33 triggers next circuit to ON state. For positive transition, C0 starts working. The length of full cycle is VW14. After the time span of VW14, it automatically resets C0 and the whole program is begun to be executed again. I1.0 memory bit is available to provide a manual control available in case of any failure.

In network 16, 17 and 18, a lighting program has been created by assigning variable times. VW0 to VW8 and VW10 to VW12 time span in circuit make Q0.0 on. Q0.0 is for Yellow light. VW8 to VW10 time period is for MG and SR signal. These are generated when Q0.1 is ON within VW8 to VW10. The total time of VW12 to VW14 is assigned for MR and SG. In this program, it is shown as Q0.2 ON state. Thus, a logic or program is developed to sense the presence and absence of vehicle and to manipulate traffic control system according to the proposed plan, time schedule and condition of traffic congestion in any junction.

7.5 S-7 200 SIMULATOR TEST

S-7 200 simulator is a program which creates a virtual environment for testing any PLC program created in STEP 7-Micro/Win IDE Software. Its LLD program testing arrangement is built such a way that it can replace any laboratory test environment. It executes program with precision like a real PLC modular. It has 10 CPU configurations. It also provides virtual buttons to control input units. We can check program output on KOP screen and from virtual output units. Here, green signal determines the condition of input and output unit according to command and input interruption of the program.

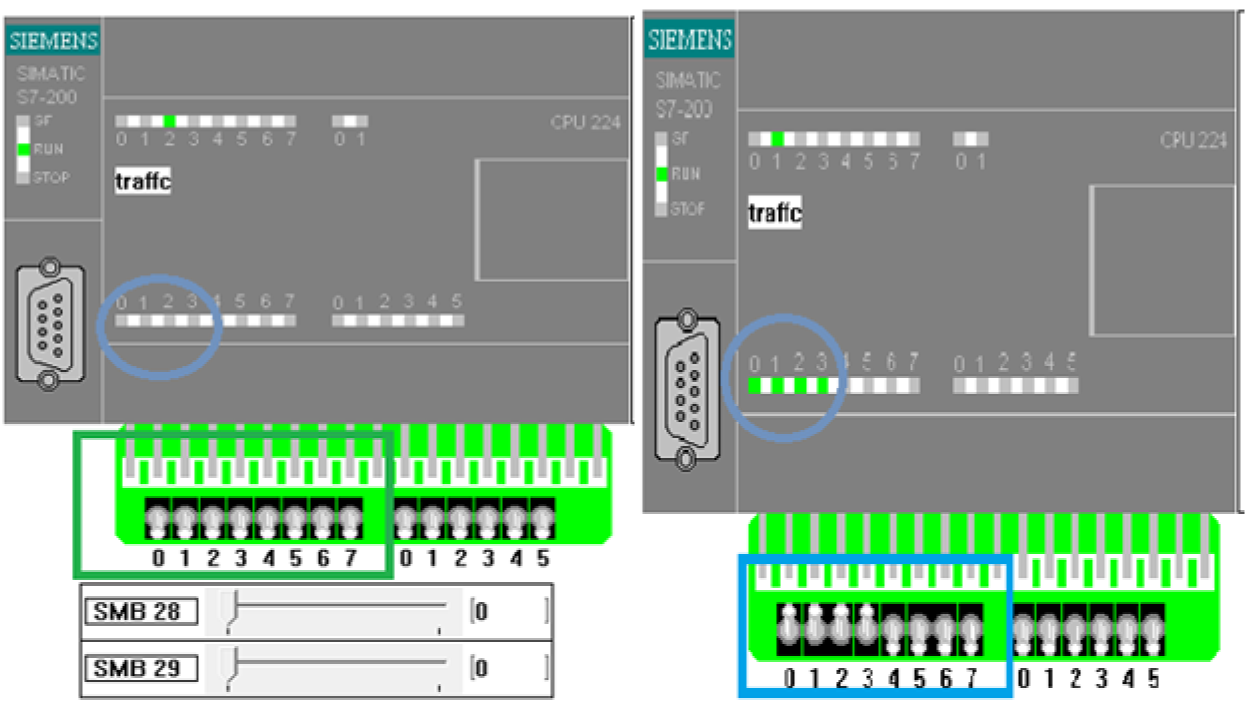


Fig 11: S-7 200 Simulator test- (a) without switching any input, (b) by switching main street side input

Our program is done for CPU 224 system where there are 0-7 inputs and outputs. We need 8 inputs and 3 outputs to examine our program. So, we choose CPU 224 to test this program. When we load our traffic program from load option into this virtual system, it automatically generates KOP and OB1 which are resemble to the actual program's LLD and STL diagram respectively. Now there is Run button in the simulator to start the program and Stop button to hinder the execution. When we run our program without putting any input unit, the program will act like a time constant traffic control system in Fig. 11(a). The time spans for each signal to appear in screen are VW0 to VW8, VW10 to VW12, VW8 to VW10 and VW12 to VW14. In this simulator, output 0 means actual yellow signal of both street ON. Output 1 and 2 are for “MG and SR” and “MR and SG” respectively. From the perspective of LLD program, the output Q0.0, Q0.1 and Q0.2 of this program will be illustrated by output 0, 1 and 2 respectively.

In Fig. 11(b) unlike Fig 11(a), inputs have been provided by 0 to 3 input button. Four light indicator on display input unit 0 to 3 ensure that our inputs are ON. This means the sensors of main road get interrupted by vehicles. So, the time of ‘MG and SR’ signal will be lengthened according to the program. In simulator test, after yielding 0 to 3 inputs, output display 1 blinks longer time than other two. Similarly, for 4-7 input, the light flashing period for output display 2 prolonged and it is more for than the normal time constant traffic signal time. So, the display of input and output proves that our system and LLD program are being executed by simulator smoothly and according to the project demand.

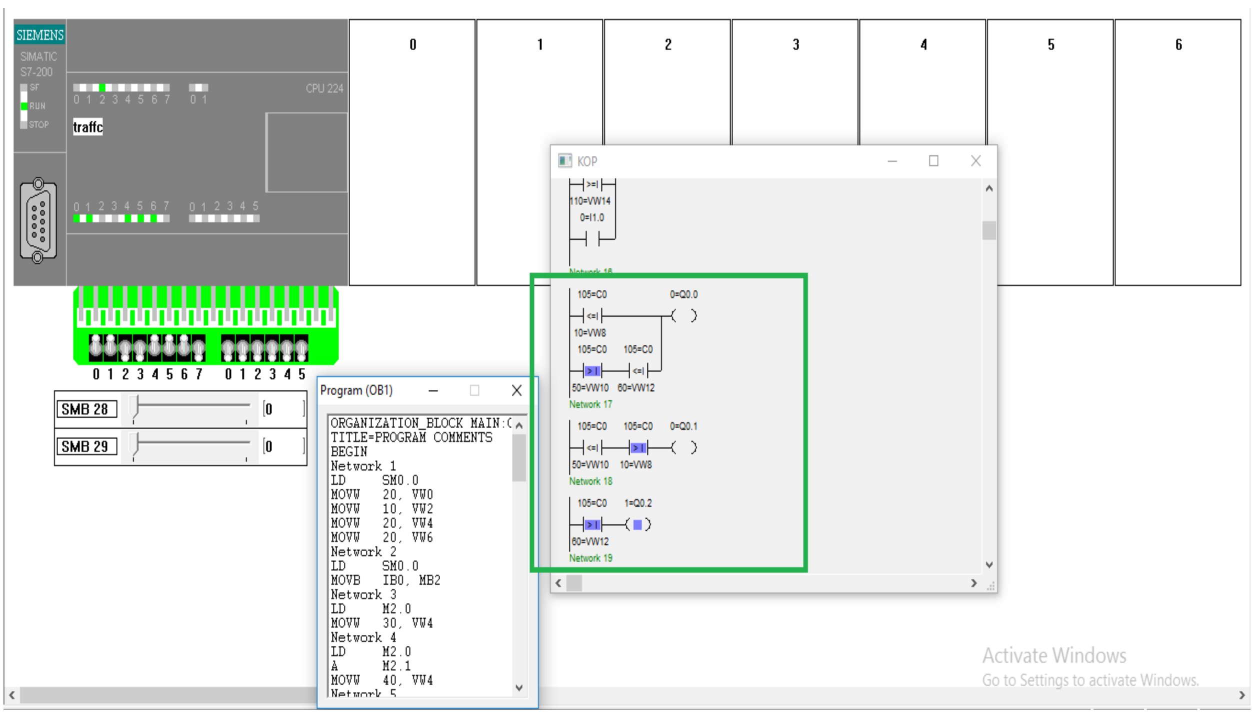


Fig 12: S-7 200 Simulator test by switching some input of both side

In Fig. 12, we have KOP display which facilitates to monitor outputs for each and every second of executed program. It shows the status of time count, output display unit and total time for a cycle. It is very useful tool to check exactly whether the addition of input changes the system or if Q0.0, Q0.1 and Q0.2 are working according to the developed LLD program.

7.6 LABORATORY TEST

From simulator test, we have found that our project is working according to the plan without any interruption. Now, we take our project to real test environment or in laboratory. We have PLC-200 trainer, PC for running program, USB cable to connect modular with PC or program, transceiver sensors for input to PLC modular and traffic control lighting system module to check output.

Fig 13: Laboratory test of smart control traffic system

In this project experiment, PC, sensors, PLC-200 trainer and traffic control lighting module are connected to AC power source. PC USB port is connected with PLC module by USB cable. Now, when we turn on switch of PLC module, our module is ready for operation. With the help of V4.0 STEP 7 MicroWIN SP9, the LLD program of smart traffic control system is loaded into PC. To install LLD into PLC system, we have to use the download option of MicroWIN program. Now traffic control lighting module and transceiver sensors have to be connected with output and input units of module respectively for reexamining our system. When we run the program, the output unit starts to act like a time constant traffic control system. It turns red, green and yellow lights after a certain time period defined by the program. When we use any obstacle to block light transmission and reception of sensors, the module gets input. So, the program elongates time for a particular signal according to the program. We can check the time difference by taking reading before and after placing an obstruction. From our experiment, we can see that our smart traffic control unit is perfectly working in PLC platform according to the system design.

7.7 RESULT

This system is built for single lane system where one is considered to be main road and another is subway road. So, we only take reading of two sides of traffic lighting system. In the first count at first segment, vehicles of both main and Sub Street will get yellow signal which alerts them for next instruction to follow. In the second segment, green light will appear for Main Street as our system follow HOV, so sub street automatically receive red light. The conveyances of main road will start to move and the transport of Sub Street will have to wait until the next green signal. The third segment is for another alert for shifting signal. And in the fourth segment, Sub Street vehicles will have command to move and main street motors will stop. After that the count continues again and the similar operation will be done by the system. Any interruption by vehicles of any sensors will turn input on and that manipulate the mathematical function of the system. Hence, the system will automatically lengthened green light signal time for that side to clear up the queue. If this system can be synchronized with its prior junction, we will be able to notify traffic which lane to follow according to traffic condition so that the drivers will have less frustration to go forward. This will also reduce the collision in the road. As the system automatically recognize queue of vehicle in the road and acts accordingly, this becomes an intelligent system which does not require any human to operate unless there are any hardware and software malfunctioning into the system.

8. DISCUSSION AND FURTHER DEVELOPMENT

In this project, we have developed an intilligent traffic control system where we use PLC tools and sensors. Implementation of this system requires high installation and maintenance charge. But this system will eliminate human errors and other traffic related problems. Our smart system for single lane is much more sophisticated system than manually control system or time constant traffic control system. But like every other scientific system, there will always be some section that need to be improved for more perfection. In this design, we develop a system for a single lane but we did not consider a junction that has double lane (Fig. 14). If we need to consider a double lane system then, we will need more sensor to implement and the program requires to be modified. We have to place more memory unit 3.0 to 3.7 also for other sensors and have to add mathematical functions accordingly. That will take more time and will require more equipments. A theoretical plan has been made for the further development of this project. The plan is illustrated below:

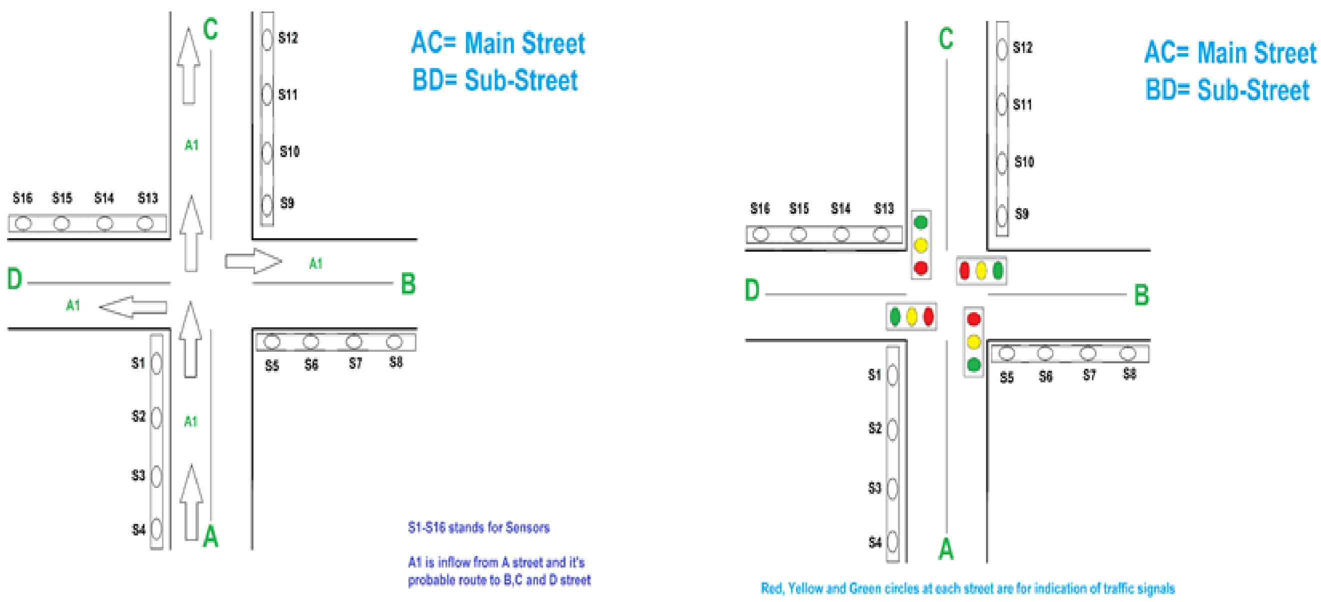


Fig 14: Future plan for multiple lane

In this system, single side of a road will be divided into two segment. For each side of the road A, B, C and D, in flow will be 1 and out flow will be 2. In Fig 14. , A1 is the inflow of the road A and the vehicle of A1 will pass by D2, C2 and B2. A1 is assigned in all of those street to clarify the current traffic movement. We will also do HOV priority here by observing traffic condition. We will assess the requirement from socio-economic perspective. We can also do some research on power source of this smart unit as it requires more power than previous system. We can implement research of renewable energy to make it eco-friendly. In the future, some data acquisition and storage system will be studied for further development to predict traffic condition so that this system can become more effective and efficient.

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