Traffic Light

Prepare by:

Rebaz Mustafa Mohammed

Electrical Engineer

٢٠٢١

ABSTRACT

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. The PLC used is from Siemens company, S٧-١٢٠٠ CPU ١٢١٤c. Many researches in same area discussed and reviewed to take the benefit from it. In this method, the traffic density will be measured by timer. 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 ٤-way ٦ lanes etc. Those features were the project aims and objectives, and all of them were achieved. The used hardware is mentioned clearly, and the program developed is illustrated and explained. The limitations faced are mentioned and improvement are for future work discussed.

CHAPTER ١

INTRODUCTION

١,١ INTRODUCTION

With the development of urbanization, the problem of urban traffic congestion has attracted more rapidly. Also, more attention, and the traffic congestion has become a major problem restricting urban development (M. Groover, ٢٠١٤).

Cities have built high-speed road, main road, the subway to play its expected role, and the same sections in different periods of the traffic condition, how to adopt the suitable control method, the maximum advantage of one city road, reduce traffic congestion in peak road, has become a problem to be solved in the traffic control Traffic load is highly dependent on parameters such as time, day, season, weather and unpredictable situations such as accidents, special events or construction activities. (J. H. Karl & T. Micheal, ٢٠٠٩)

A traffic control system that solves these problems by continuously sensing and monitoring traffic conditions and adjusting the timing of traffic lights according to the actual traffic load is called an intelligent traffic control system. Traffic signals have strengths and weaknesses that must be considered when deciding whether to install them. Signal intersections can reduce delay for side road traffic and reduce the occurrence of collisions by turning traffic and cross traffic. But they may also cause delay for traffic on the main road, and often increase rear-end collisions by up to ٥٠٪. Since right-angled and turn-against-traffic collisions are more likely to result in injuries, this is often an acceptable trade-off.

A variety of different control systems are used to accomplish this, ranging from simple clockwork mechanisms to sophisticated computerized control and coordination systems that self-adjust to minimize delay to people using the road. We need to understand the function of traffic signals so that we can improve driving habits by controlling the speed in order to reduce the number of associated traffic accidents. The more number of drivers who know about the operation of traffic signals, the less frustrated they are going to be while waiting for the lights to change. The main aim in designing and developing of the Intelligent Traffic Signal Simulator is to reduce the waiting time of each lane of the cars and also to maximize the total number of cars that can cross an intersection given the mathematical function to calculate the waiting time. The Intelligent Traffic signal control System consists of three important parts. The first part is the PLC controller and second part is hardware. These usually comprise of red, yellow, and green lights. (E. Mueller, ١٩٧٠)

١,٢ PROBLEM OF STATEMENT

The intersection traffic signal control problem (ITSCP) has become even more important as traffic congestion has been more intractable.

The ITSCP seeks an efficient schedule for traffic signal settings at intersections with the goal of maximizing traffic flow while considering various factors such as real-time strategies, signal timing constraints, rapid developments in traffic systems, and practical implementation. Since the factors constituting the ITSCP exhibit stochastically complicated interactions, it is essential to identify these factors to propose solution methods that can address this complexity and still be practically implemented.

١,٣ OBJECTIVE

The objective behind the proposal is to limit the stoppage time and also regulate the traffic flow by means of the introduction of the sensors at all major traffic signals.

The proposal aims at reducing the traffic jams in order to reduce traffic congestion, optimize traffic flow and help pro-actively manage traffic conditions.

The proposed multi-objective function includes

weighted summed reward functions that:

– To reduce time waiting of drivers.

– To be safe and exact in change of ways

– To be more helpful for emergency and health services

١,٤ PROJECT OUTLINES

This project comprises four chapters to deal with the controlling traffic light system. In chapter one highlighted the necessity of traffic light controlling system or organizing. This includes the introduction of the subject, problem statements to be solved, main objectives of this study, and the outlines. Later, in Chapter Two the main hardware utilized in this work explained; such as the module, PLC hardware, and connecting cables. Moreover, in chapter three, the proposed language; which is ladder discussed and programing networks are introduced. Finally, in chapter four, the discussion of the program and the main suggestions for future works are revealed.

CHAPTER ٢

HARDWARE OF PLC

٢,١ SYSTEM DESCRIPTION

The designed system is, PLC controlling a four-ways traffic junction with pedestrian signal. The inputs are, one switch from star the operations and stop the operations and pedestrian request, and three of them represent a vehicles density on each side of the four-ways junction, and the other one switches represent the priority case for each side of the four-ways junction. So, the system has in total ١ inputs and ١٢ outputs. The outputs are, ٤ yellow lights and four red light and ٤ green lights. Each side of the junction has a signal contain one yellow and one green and one red light, the pedestrian signal used, contain one green and one red light, only one signal for pedestrian used because of the physical limitations of the system, but in reality, there should be pedestrian signal for each side.

The designed system is working symmetrically, this mean each signal will perform independently, only ١ signal will be green lighting at a time, and since its symmetric junction.

when green light opens for any direction, the vehicles from that direction are allowed to turn right or go straight or turn left or take a U-turn, because of that reason, when pedestrian signal is green, all other vehicles signals must be red. Figure ٢.١ below, shows the designed traffic junction.

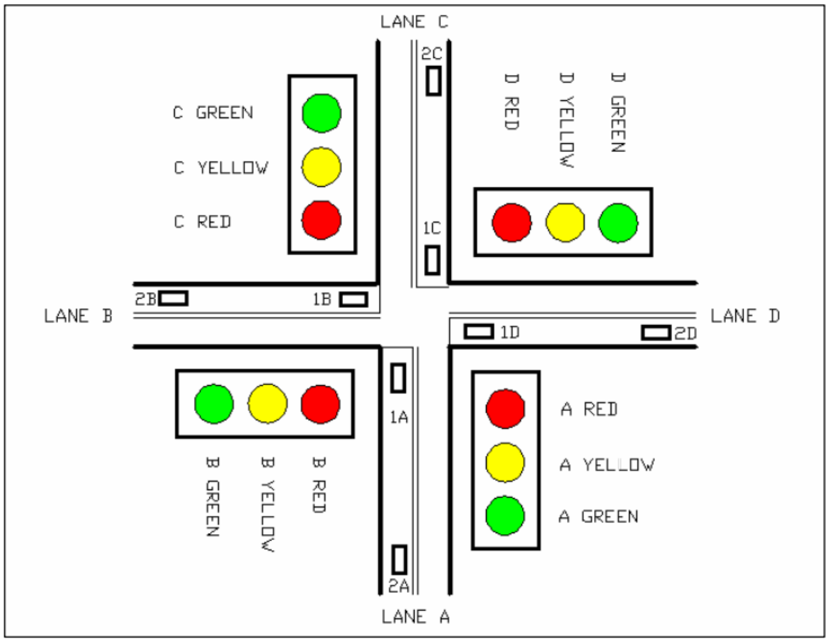


Figure2.1: show the system

It’s clear in figure ١ above, the designed system has ١٢ outputs. But, because of the physical limitations, and since the pedestrian signals are working at the same time and triggered at the same time, only ١ pedestrian signal is used and only ١ switches for the pedestrian is used. By another way, in reality there should be four pedestrian signals as shown in figure ٢.٢, and four push buttons for the pedestrians,

each button related to only one of the pedestrian signals, and in case of redesigning the traffic junction, only the PLC program has to be modified while the physical wiring won’t be changed, this is the most significant benefit for the PLC over the old relay wiring control, the flexibility. Because of what mentioned, the physical system built in the lab, shown below in figure ٢.٢

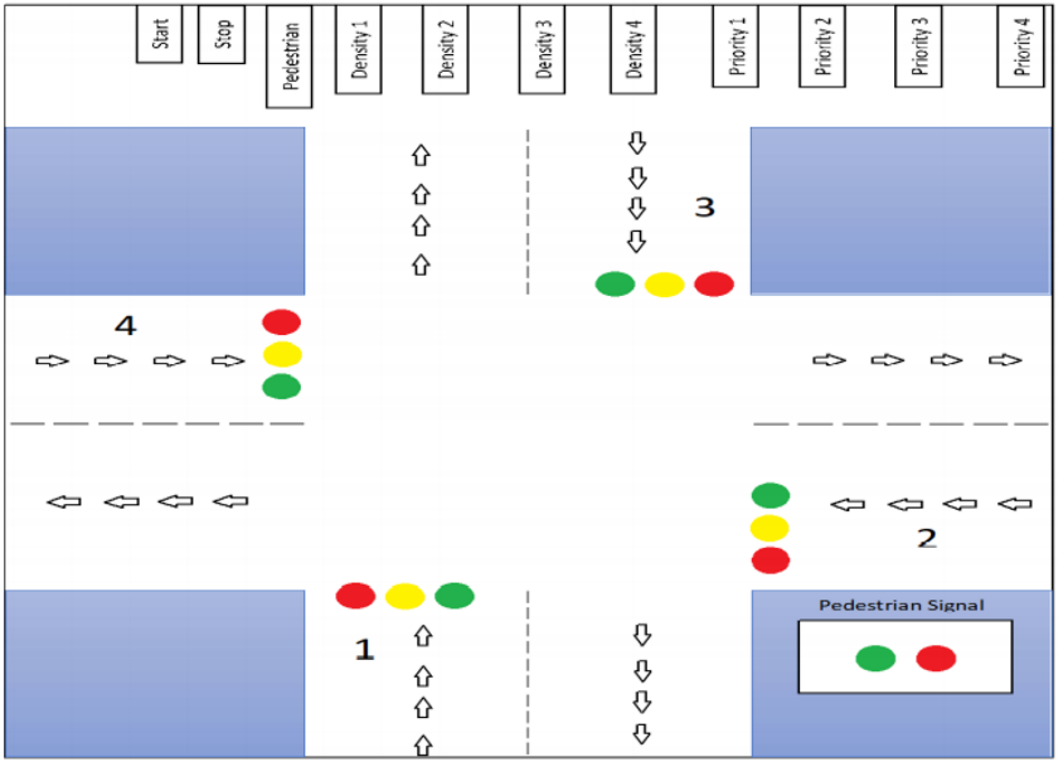


Figure 1.2: The physical system built in the lab

As shown in figure ٢.٢ above, only one pedestrian signal is used and only one pedestrian push button is used. But they represent the four pedestrian signals and four pedestrian push buttons. If same system used in reality, the four push buttons will be connected in parallel and the four pedestrian lights will be connected in parallel also, this helps in using only one input for the pedestrian request and two outputs for the pedestrian signal,

but if the junction design might be change in the future, four different outputs will be used to trigger the pedestrian signal and eight outputs for the pedestrian lights signal. This should be considered as a strategic plan for the junction design. The junction built in the lab.

٢,٢ HARDWARE OF COMPONENTS

This section is about the hardware used to build the prototype, the PLC, LEDs (light emitting diode), resistors and braid board used. showing a photo for the designed system. The PLC used is S٧-١٢٠٠ CPU ١٢١٤c DC/DC/DC from Siemens, Figure ٢.٣ below, shows the PLC used.

Figure 2.2: Siemens PLC S7-1200 CPU 1214 DC/DC/DC

The power input for this PLC is ٢٤ DC voltage and the switch input voltage is ٢٤ DC voltage and the output is ٢٤ DC voltage, so this what DC/DC/DC stand for. This PLC has ١ digital input and ١٢ digital outputs, also without analog input and analog output. Since there are only ١٢ digital outputs and the designed system required ١٢ digital outputs,

a signal module is added to the system, SM ١٢٢٣ DC/DC add extra ٨ digital inputs and ٨ digital outputs. Figure ٢.٤ below

Figure 2.3: Signal module 1223 DC/DC

This signal module is compatible with the PLC S٧-١٢٠٠. A photo for PLC and signal module.

The PLC with the signal module represents the controller used, the LEDs red, green and yellow represent the actuators. Figure ٢.٥ below show the LEDs green, yellow and red.

Figure 2.4 LEDs green, red and yellow

These basic LEDs ٥mm size, work on ٢-volt DC and ٢٠mA, but the PLC output is ٢٤ volts, so it can't be connected directly to the PLC. In real case, the traffic light operates on ٢٤٠ AC volt. So, using a PLC with ٢٤٠ AC input/output is recommended, no need for conversion, the controller can control the light directly. But, in the prototype case, the ٢-volt LEDs can be controller directly using ٢٤-volt PLC, the use of converter or resistors is mandatory. In the designed system, a ٢,٢K Ω resistors with ٠,٢٥-watt capability is used to dissipate the rest of the power. Figure ٢.٦ below, show the resistor used with color code red-red-red.

Figure 2.5 : 2.2k ohm and 0.25-watt capability, color code Red-Red-Red

Since the PLC output voltage is ٢٤-volt and the LEDs operate on ٢-volt, if they are connected on series the voltage across the resistor will be ٢٤-٢=٢٢-volt. From the basic ohm's-law $I = V\ R$ and the power $P = I \times$ (no reference used since this law is a common knowledge) where I is the current and V is the voltage and R is the resistance and P is the power. Since the power capability for the resistor is ٠,٢٥-watt,

the current chose to be limited to ١٠,٩mA, so the power across the resistor is P = ٢٢ × ٠.٠١٠٩ = ٠,٢٤ *watt* which within the power capability, so the current across the LED will be also ١٠,٩mA since they are connected in series, while the maximum operating current for the LED is ٢٠mA, ١٠,٩mA used, it was enough emitting to serve the purpose of the LEDs, showing a photo for the system with the LEDs working on ١٠,٩mA current. Limiting the current on ١٠,٩mA was by using ٢,٢k Ω resistor depending on R = ٢٤$volt$ ٠,٠١٠٩A = ٢,٢$K\Omega$. shows a photo for the resistors connected is series to the LEDs. Another hardware used is the braid board,

which is a standard board help with the wiring instated of using PCB (printed circuit board), the reason of not using PCB is to save the cost of designing a PCB and the ease of getting a braid board. The braid board used is shown in appeared in Lab. next section of this report is about the software used to program the PLC and the programming itself. Last hardware used is the switches

٢,٣ HARDWARE OF BOARD

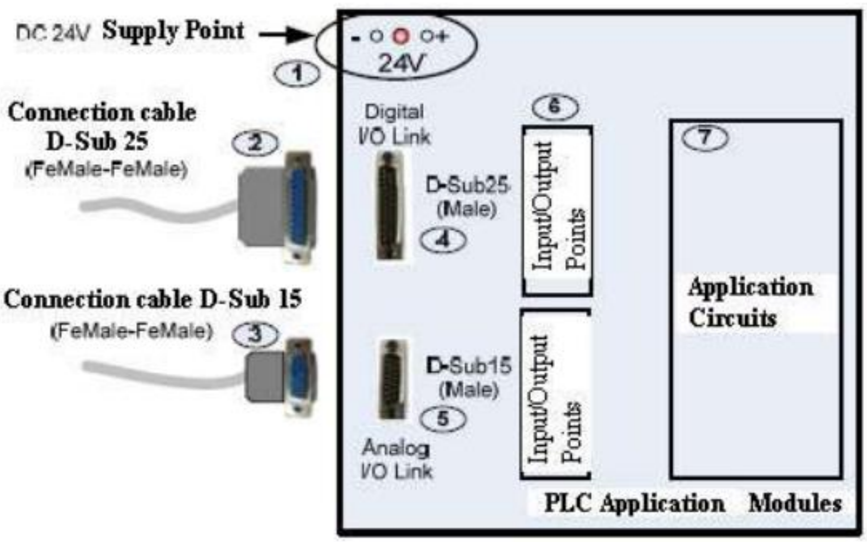


Figure 2.6: Module connection point with PLC I/O link cable

General structure of Y-٠٠٣٠A application modules is composed of components above. These components can show changes according to the type of the application module. Components and their usages are listed below.

١. DC ٢٤V power input. DC ٢٤V power that is required for application circuits is applied with the external power supply. Pay attention to the polarity (+, -polar) when applying DC ٢٤V power. If the application modules are to be used with D-sub٢٥ connecting cable, there is no need to apply energy to the power input.

٢. Connecting cable provides the connection between ٨-bit digital input/output points of PLC and the module. How inputs/outputs between the application and digital inputs/outputs from this cable are used is shown in input/output tables of the application. On the connecting cable, ٢٤V DC supply voltage that is required for the module is available.

. Connecting cable provides the connection between ٨-bit digital input/output points of PLC and the module. There are conductors for ٢ analog input and ١ analog output in the cable. How inputs/outputs between the application and digital inputs/outputs from this cable are used is shown in input/output tables of the application.٤

٤. Digital inputs/outputs of the application are transferred to D-Sub٢٥ Male connector in each application module. İnput/output points on this socket and inputs and outputs that are used in the application are specified in application input/output table.

٥. Analog inputs/outputs of the application are transferred to D-Sub٢٥ Male connector in application modules where analog input/output connections are used. Input/output connections that are used in the application are shown in application input/output table. In some application modules, there is no need of analog inputs/outputs so these connection sockets are not included in the module.

٦. When D-Sub٢٥ and D-Sub١٥ connection cables are not used for input/output connections of the applications, connections can be made with the help of ٢ mm sockets. For inputs and outputs that are used in the applications, ٢ mm sockets on the board can be used.

٧. It is the part where application circuits are present. All input/output points of the application can be externally connected to the PLC through ٢ mm sockets.

They can make individual connections between PLC and input/output points of the applications. Besides, D-Sub connection cables and all inputs/outputs can be connected directly at a time over Digital I/O link (Y-٠٠٣٠-M٠٤) and/or Analog I/O link (Y-٠٠٣٠-M٠٦) module cards on modular PLC platform (Yıldırım Electronic Product Y-٠٠٣٠M).

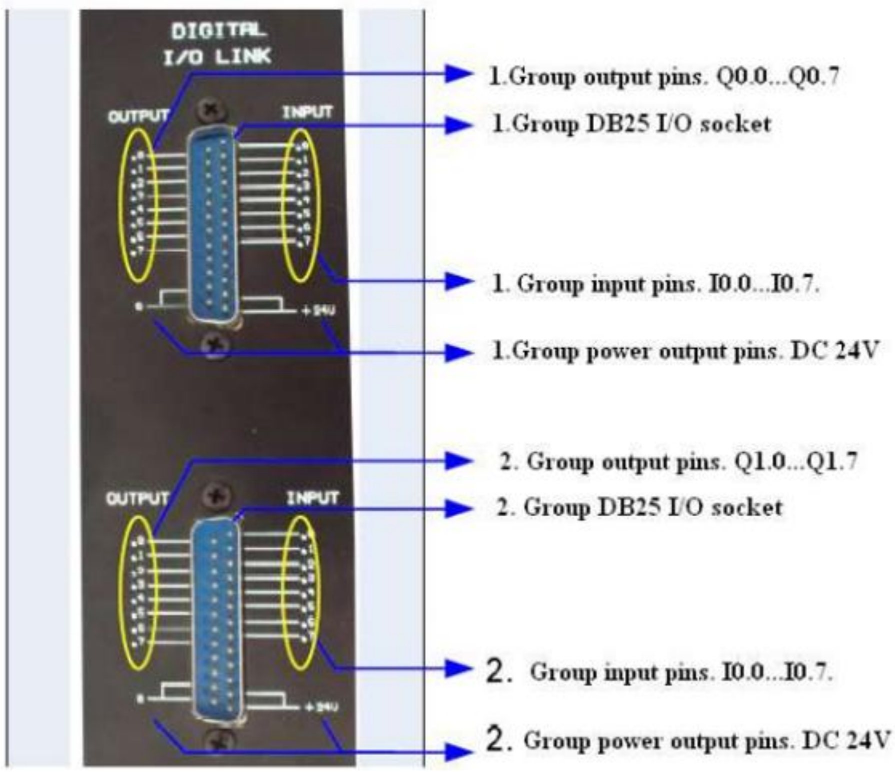


Figure 2.7: Modular PLC digital

In Figure ٢.٩, connection parts of D-sub-٢٥/D-sub ١٥ male and female connectors that are used in PLC applications can be seen. In Figure ٢.٧, connection principles between application modules and I/O link modules can be seen.

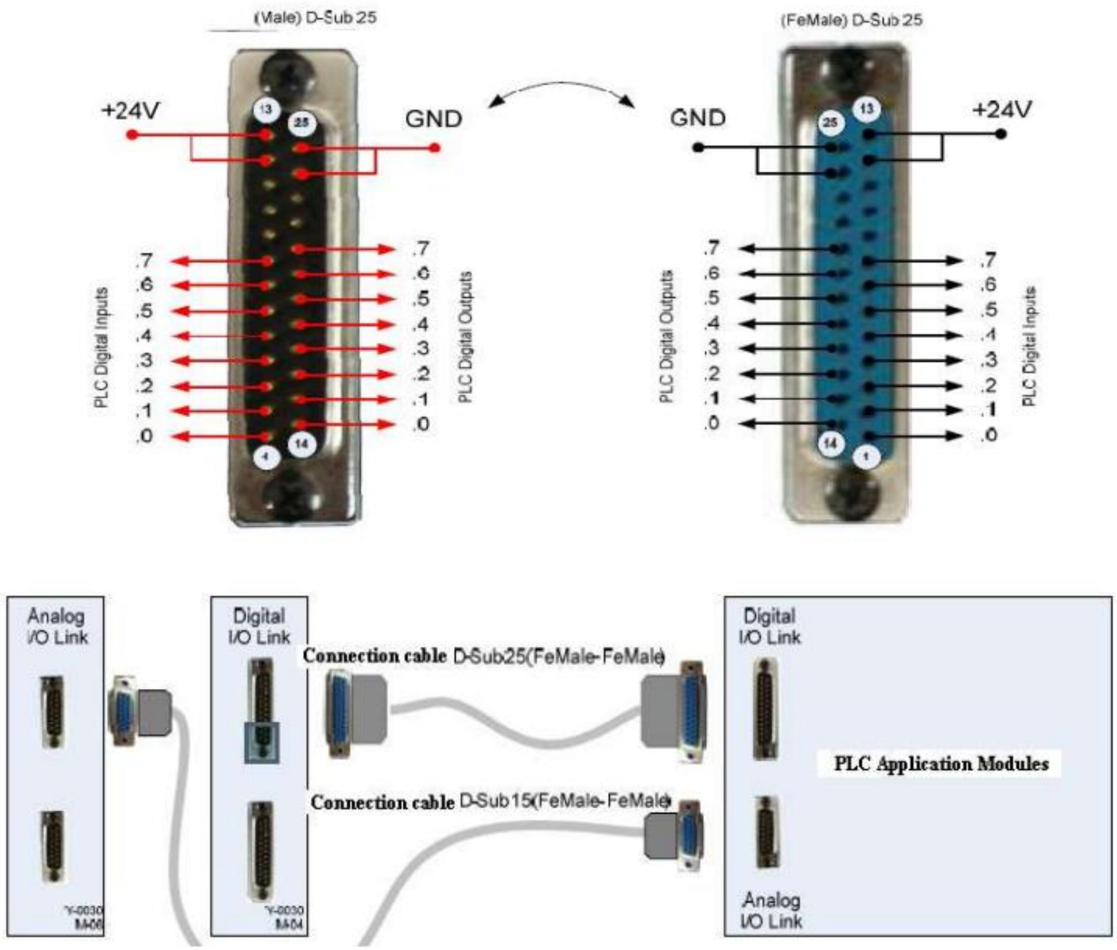


Figure 2.8: Connection between I/O link module and application nodules

٤ mm sockets are used for connections in asynchronous application modules. Y-٠٠٣٠- A٠١/٠٦ PLC I/O LINK module should be used in order to make the connection between PLC and asynchronous application modules via ٤ mm sockets.

CHAPTER ٣

METHODOLOGY

٣,١ SOFTWARE OF PLC

The software used to program the PLC, is TIA portal v١٥,١, TIA stands for totally integrated automation. This software developed by Siemens company to program it is own PLCs and HMIs. This software support three programming languages, ladder logic, function block diagram and structured control language (SCL) which is like structured text language. figure ٣,١ below, shows the software interface.

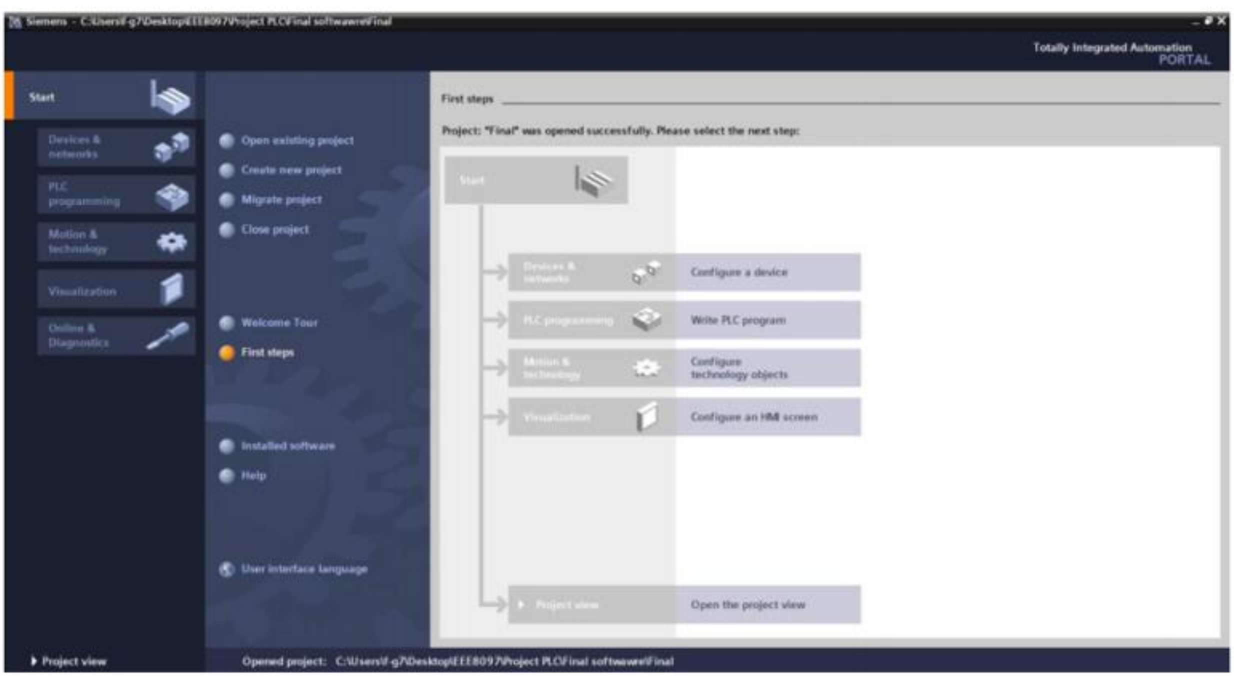


Figure 3.1: TIA Portal interface

Since there are four functions for the junction design, the programming description will be divided into four sections.

And the overall program shown in below

Normal cycle program First is to latch the start button, figure ٣.١ below, shows how latching is made with ladder logic, its noticeable that, pressing the stop button will stop the latch star, so everything will start by pressing START push button and will stop by pressing STOP Push button.

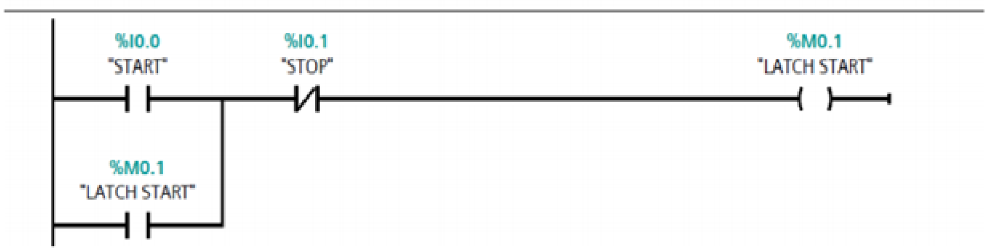


Figure3.2: Latching the start button in ladder language

The main feature of the normal cycle is that, it is a sequence of outputs, the end of one output will be the start of the next output, as illustrated in system description section. Because of that feature, TP timer has been used to control the all operations, TP timer is, a timer will change it is output from ١ to ٠ after the input time.

٣,٢ MAIN PROGRAMM

On the system, load the initialization data, the remote start switches, the system starts to work normally, the relay closes the acquisition system time, and the time is used to check the module in real time.

Also, in figure ٣.٢ shown all tags so used to program, and in figure ٣.٣ shown all times

PLC tags

	Name	Tag table	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
1	Red1	Default tag table	Bool	%Q0.0	☐	☑	☑	☑	
2	Red2	Default tag table	Bool	%Q0.1	☐	☑	☑	☑	
3	Red3	Default tag table	Bool	%Q0.2	☐	☑	☑	☑	
4	Red4	Default tag table	Bool	%Q0.3	☐	☑	☑	☑	
5	Green1	Default tag table	Bool	%Q0.4	☐	☑	☑	☑	
6	Green2	Default tag table	Bool	%Q0.5	☐	☑	☑	☑	
7	Green3	Default tag table	Bool	%Q0.6	☐	☑	☑	☑	
8	Green4	Default tag table	Bool	%Q0.7	☐	☑	☑	☑	
9	Yallow1	Default tag table	Bool	%Q1.0	☐	☑	☑	☑	
10	Yallow2	Default tag table	Bool	%Q1.1	☐	☑	☑	☑	
11	Yallow3	Default tag table	Bool	%Q8.2	☐	☑	☑	☑	
12	Yallow4	Default tag table	Bool	%Q8.3	☐	☑	☑	☑	
13	switch	Default tag table	Bool	%I0.0	☐	☑	☑	☑	
14	Tag_1	Default tag table	Bool	%M5.0	☐	☑	☑	☑	
15	Tag_2	Default tag table	Bool	%M5.1	☐	☑	☑	☑	
16	Tag_3	Default tag table	Bool	%M5.2	☐	☑	☑	☑	
17	Tag_4	Default tag table	Bool	%M5.3	☐	☑	☑	☑	
18	Tag_5	Default tag table	Bool	%M5.4	☐	☑	☑	☑	
19	Tag_6	Default tag table	Bool	%M5.5	☐	☑	☑	☑	
20	Tag_7	Default tag table	Bool	%M5.6	☐	☑	☑	☑	
21	Tag_8	Default tag table	Bool	%M5.7	☐	☑	☑	☑	
22	Tag_9	Default tag table	Bool	%M6.0	☐	☑	☑	☑	
23	<Add new>				☐	☑	☑	☑	

Figure3.3: PLC tags

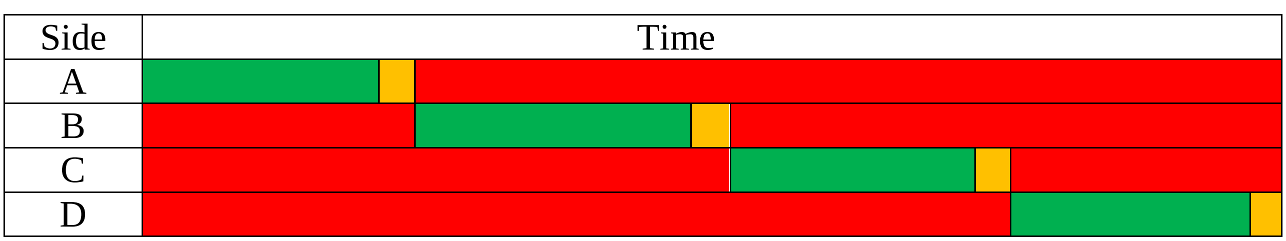
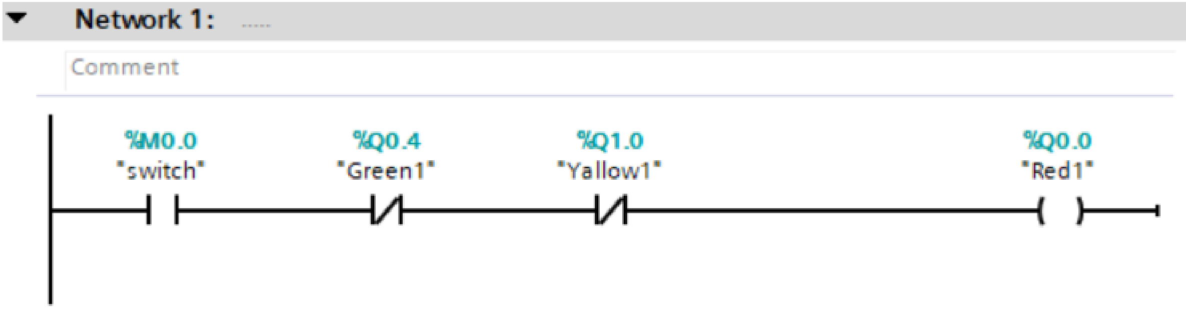
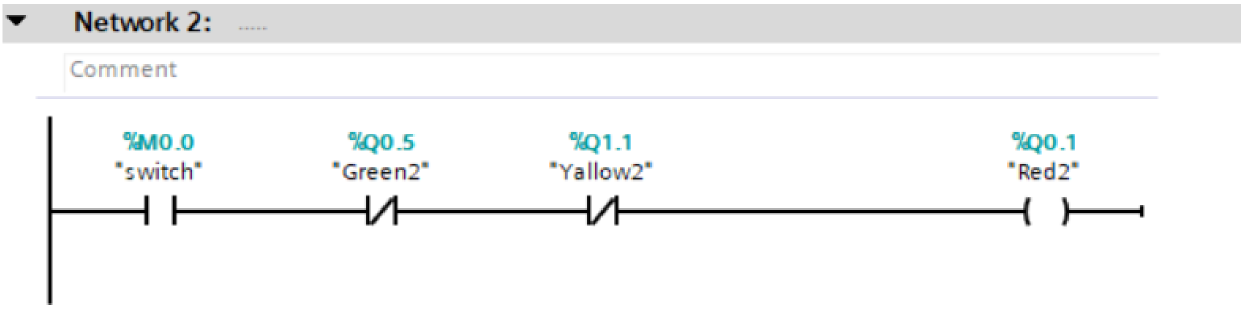


Figure3.4: Timing of traffic light

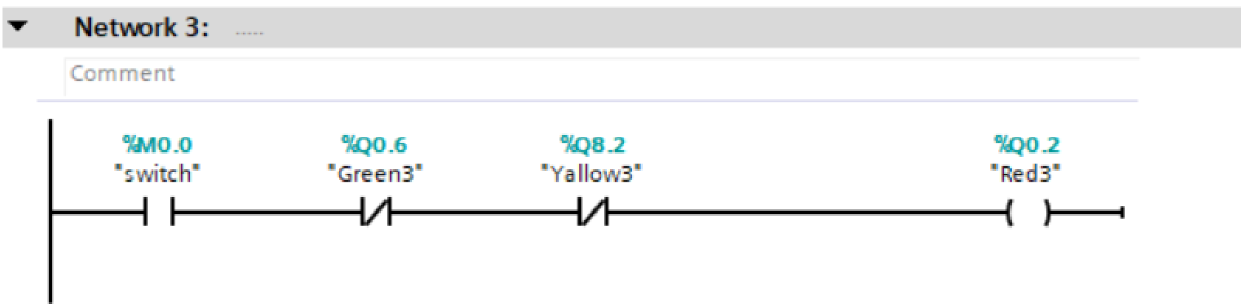
When the switch turns on and the green ١ with yallow ١ turn off then red ١ is glowing.



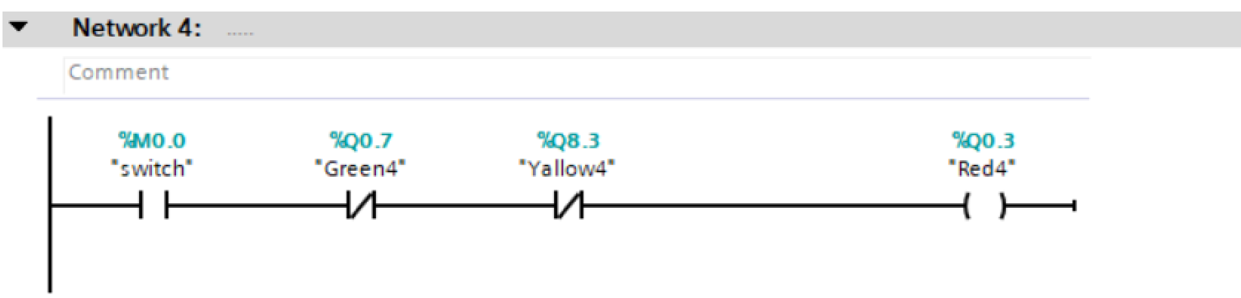
When the switch turns on and the green ٢ with yallow ٢ turn off then red ٢ is glowing.



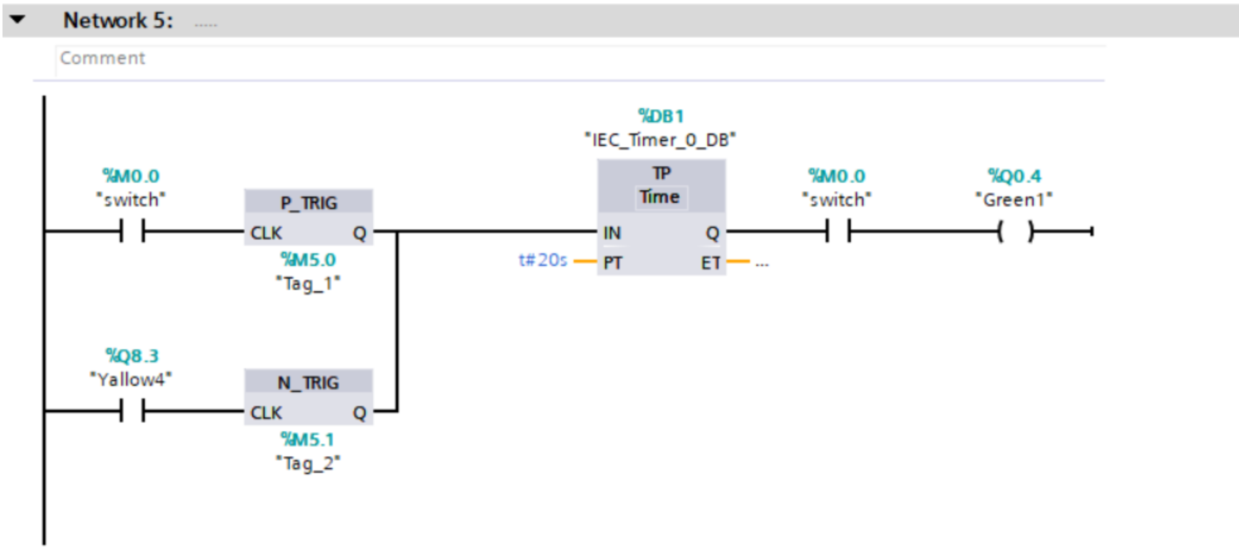
When the switch turns on and the green ٣ with yallow ٣ turn off then red ٣ is glowing.



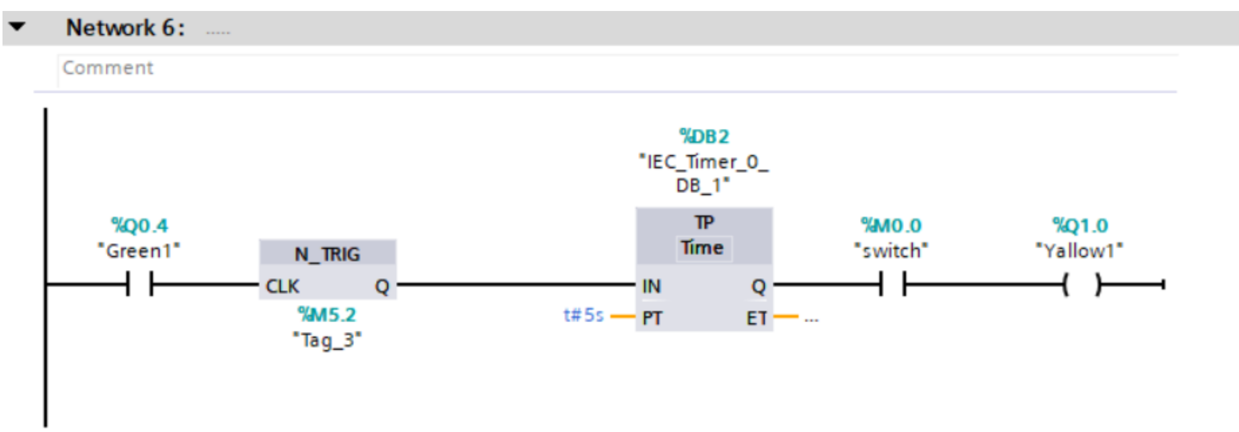
When the switch turns on and the green ٤ with yallow ٤ turn off then red ٤ is glowing.



When the switch closes P-TRIG block sends a pulse to the timer and activates the timer and turns on for ٢٠s, during this delay the green light is glowing, and after process finishes returns to Network ٥.

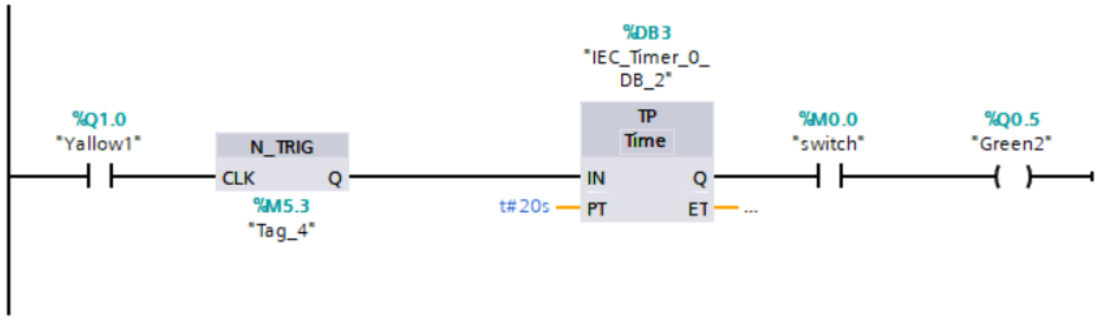


When green ١ turns off, N-TRIG block emmit a pulse to the timer and the timer block turns on by the time delay, the yellow led is on will the timer block is active and then this process is working continously as alike till Network ١٢ and then returns back to the Network ٥ .



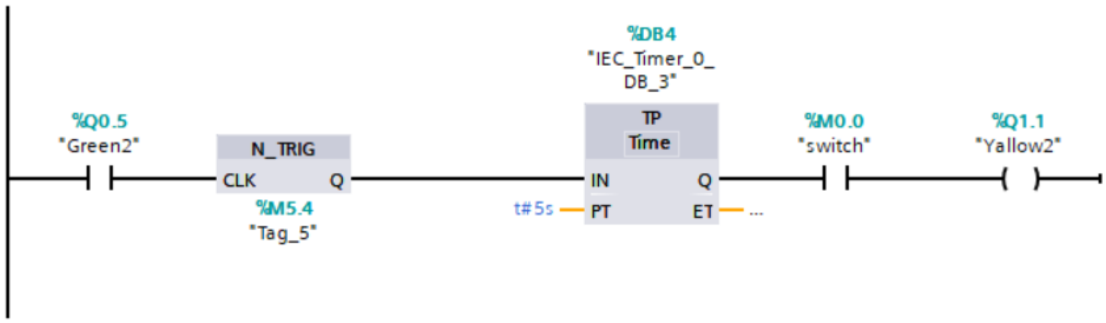
Network 7: .....

Comment



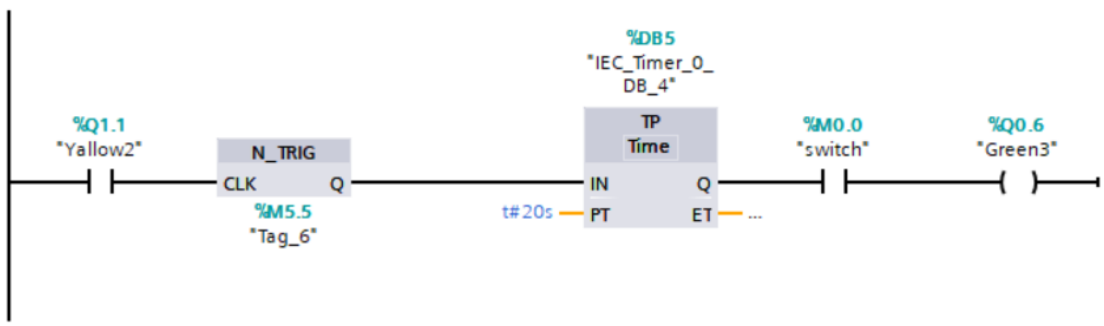
Network 8: .....

Comment



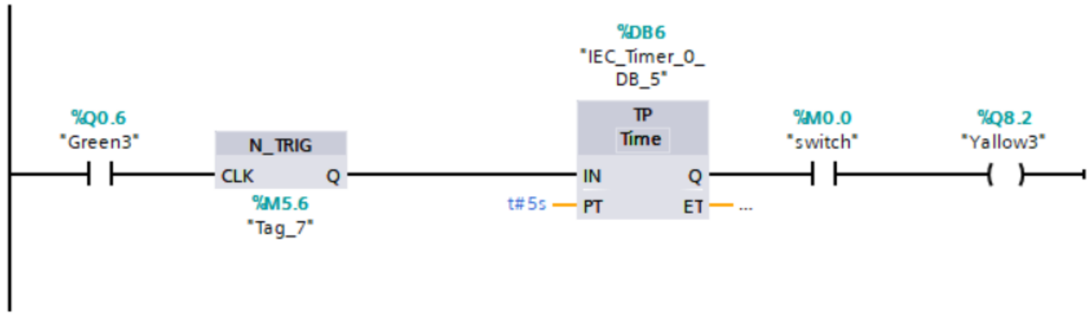
Network 9: .....

Comment



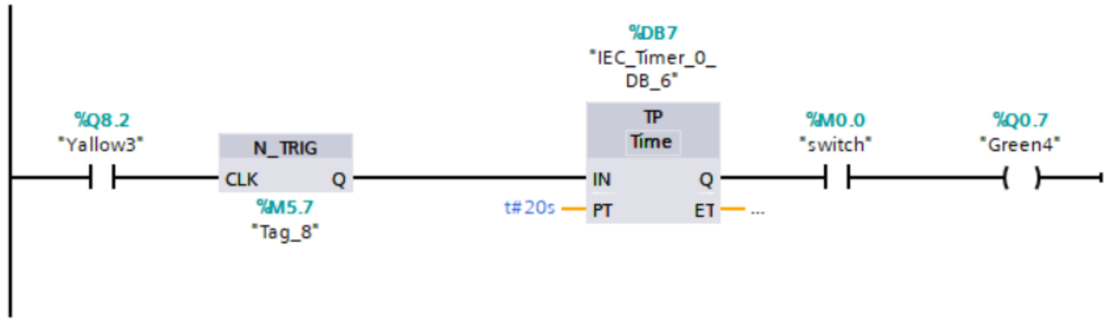
Network 10: ......

Comment



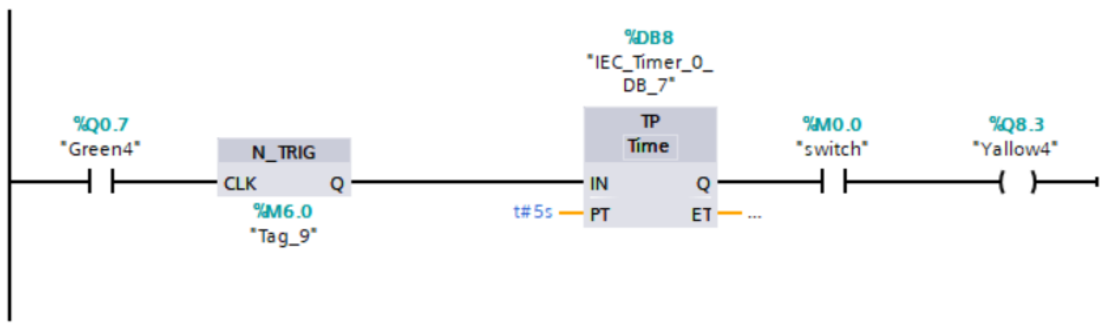
Network 11: ......

Comment



Network 12: ......

Comment



CHAPTER ٤

DISCUSSION AND SUGGESTIONS

٤,١ DISCUSSION

It is a graphical programming language, initially programmed with simple contacts that simulate the opening and closing of relays. Ladder Logic programming has been expanded to include functions such as P_TRIG, Timers, N_TRIG. Ladder logic is a method of drawing electrical logic schematics. It is now a graphical language very popular for programming Programmable Logic Controllers (PLCs). The name is based on the observation that programs in this language resemble ladders, with two vertical "rails" and a series of horizontal "rungs" between them. A program in ladder logic, also called a ladder diagram.

An intelligent traffic light system had successfully been on a Siemens s٧ ١٢٠٠ PLC type ١٢١٤C DC/DC/DC. 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.

٤,٢ 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.

REFERENCE

M. Groover. “Automation, Production systems, and computer-integrated manufacturing”. ٤th edition, Pearson, Aug ٢٠١٤.

J. H. Karl and T. Micheal. “*Programming Industrial Automation system: concepts and Programming Languages, Requirements for Programming Systems, AIDS to Decision making Tools*”. ٢nd edition, Springer Science & Business Media, ٢٠٠٩. IEC ٦١١٣١-٣:

E. Mueller, "Aspects of the history of traffic signals," IEEE Transactions on Vehicular Technology, vol. ١٩, no. ١, pp. ٦-١٧, Feb ١٩٧٠.

M. Dev Srivastava, S. Sachin, S. Sumedha, U. Tyagi and A. Professor, "SMART TRAFFIC CONTROL SYSTEM USING PLC and SCADA," International Journal of Innovative Research in Science, Engineering and Technology, vol. ١, no. ٢, pp. ١٦٩-١٧٢, ٢٠١٢.

B. Ghazal, K. Elkhatib, K. Chahine and M. Kherfan, "Smart traffic light control system," *in ٢٠١٦ ٣rd International Conference on Electrical, Electronics, Computer Engineering and their Applications, EECEA ٢٠١٦*” Beirut, ٢٠١٦.

H. Eren, A. Pakka, A. Alghamdi and Y. Yue, "Instrumentation for safe vehicular flow in intelligent traffic control systems using wireless networks," *in Conference Record - IEEE Instrumentation and Measurement Technology Conference*, Perth, WA, Australia, ٢٠١٣.

D. Latha, K. Sudha and S. Devabhaktuni, "PLC based Smart Street Lighting Control," *International Journal of Intelligent Systems and Applications*, vol. ٦, no. ١, pp. ٦٤-٧٢, ٢٠١٣.

Siemens, "Siemens Industry Online Support," ١٤ ٠٣ ٢٠١٤. [Online]. Available: https://support.industry.siemens.com/tedservices/DatasheetService/DatasheetService?format=p df&mlfbs=٦ES٧٢١٥-١AG٤٠-٠XB٠&language=en&caller=SIOS. [Accessed ١٥ ٠٨ ٢٠١٩].

Contents

Table of Figures