

## Implementation of T-Junction Traffic Light Control System Using Simatic S7-200 PLC

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### ABSTRACT

A conventional traffic light control system is designed by using devices such as timers, relays and contactors etc. The critical timing operation is required to be carried out under the existence of heavy traffic situations. This conventional practice leads to many problems that need additional maintenance cost and subsequent delay for a long time. With the help of a PLC, the requirement of fast automation and effective optimization of traffic light control system can be achieved. Use of PLC helps us to develop this process not only for traffic signal on the roads, but also on the movement of trains and the transfer of containers in ports in maritime works. In order to provide a solution to the above problem, this paper introduces an execution and implementation of T-junction traffic control system using SEIMENS S7-200 PLC. Programming in PLC is written in ladder logic with the help of STEP7 MICROWIN software.

**Keywords:** Programmable Logic Controller (PLC), T-junction Traffic light control.

### 1. Introduction

A programmable logic controller (PLC) is a special purpose controller aimed at implementing control solutions. It is originally intended as relay replacement equipment for the automotive industry. A PLC is normally a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog input/output modules, various types of machines or processes. Programmable controllers were originally designed for General Motors Corporation in 1968 to eliminate costly scrapping of assembly-line relays during model changeover. Today there are at least two recognized PLC sizes to select.

They are the small programmable logic controller which is primarily a relay replacement unit that provides a few additional functions. This is an extremely basic controller in a single mounted hardened case. It is intended to provide reliable control to a stand-alone section of process. The modern medium-sized PLCs, they perform all the relay replacement functions expected of it but also add many other function-including counting, timing and complex mathematical applications. Most medium sized PLCs can perform PID, fed forward and other control functions as well.

### 2. Functional Description of PLC

A programmable logic controller (PLC) manufactured by any company has several common functional parts.

#### 2.1 Block diagram of PLC

The block diagram of a PLC consists of several parts like, power supply, central processing unit, memory unit and programming and peripheral device subsections etc. The major components of PLC are:-

1. Power Supply
2. Input Modules
3. Output Modules
4. Central Processing Unit (Cup)
5. Memory Unit
6. Programming Unit

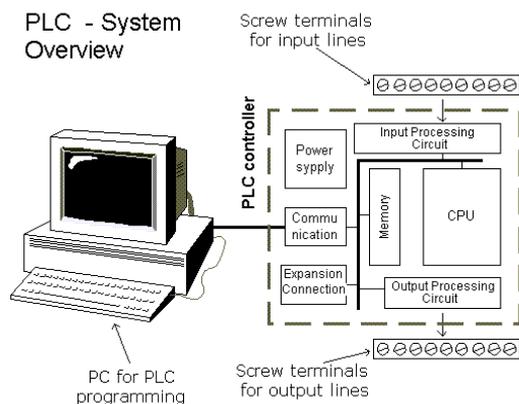


Figure 1 PLC-System Overview.

### 2.1.1 Power Supply

The power system supply may be integral or separately mounted. It always provides the isolation necessary to protect solid state components from most high voltage line spikes. The power supply converts power line voltages to those required by the solid state components. All PLC manufactures provide the option to specify line voltage condition. In addition the power supply is rated to heat dissipation requirements for plant floor operation. The dissipation capability allows PLCs to have high ambient temperature specification and represents an important difference between programmable controllers and personal computer for industrial application.

### 2.1.2 Input Modules

Inputs are defined as real world signals giving the controller relative status of process variable. These signals can be analog or digital, low or high frequency, maintained or momentary typically. They are presented to the programmable controller as varying voltage, current or resistance values. Signals from thermocouple (TCs) and resistance temperature detectors are common examples of analog signals. Some flow meters and strain gauges provide frequency signals, while push button, limit switch, or even electromechanical relay contacts are familiar examples of digital, contact closure type signals.

### 2.1.3 Output Modules

There are three common categories of output modules, discrete, register, and analog. Discrete outputs can be pilot lights, solenoid valves. Register outputs can drive signals to variable drives and then to control valves.

### 2.1.4 Central Processing Unit (CPU)

The central process unit (CPU) or central control unit (CCU) performs the tasks necessary to fulfill the PLC functions. Amongst these tasks is scanning, I/O bus traffic control, program execution, peripheral and external device communication, special function or data handling execution (enhancement) and self-diagnostics.

### 2.1.5 Memory Unit

The memory unit of the PLC serves several functions. It is the library where the application program is stored. It is also where the PLCs execution program is stored. An execution program functions as the operating system of the PLC. It is the program that interprets, manages and executes the users application program finally the memory unit is the part of the programmable controller where process data from the input modules are temporarily

stored as data tables. Memory can be volatile or non-volatile. Volatile memory is erased if power is removed.

### 2.1.6 Programming Unit

The programming unit provides an interface between the PLC and the user during program development, start-up and troubleshooting. The instruction to be performed during each scan are coded and inserted in to memory with the programming unit. In PLC, there are different types of programming languages.

Most common languages encountered in PLC programming are:

- 1) Ladder Logic (LAD)
- 2) Statement List (STL)
- 3) Functional Block Diagram (FBD)

## 2.2 Ladder Logic

Ladder logic is a graphic representation of program. Its syntax for the instructions is similar to a relay ladder logic diagram: Ladder allows you to track the power flow between power rails as it passes through various contacts, complex elements, and output coils. Ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. Ladder logic is used to develop software for programmable logic controllers (PLCs) used in industrial control applications. Ladder logic is useful for simple but critical control systems or for reworking old hardwired relay circuits. As programmable logic controllers became more sophisticated it has also been used in very complex automation systems. Often the ladder logic program is used in conjunction with an HMI program operating on a computer workstation.

The main symbols in ladder logic are:-

- —( )— A regular coil, energized whenever its rung is closed. It generally referred as output.
- —( \ )— A "not" coil, energized whenever its rung is open.
- —[ ]— A regular contact, closed whenever its corresponding coil or an input which controls it is energized. It is generally referred as input.
- —[ \ ]— A "not" contact, closed whenever its corresponding coil or an input which controls it is not energized.

## 2.3 Simatic S7-200 PLC

SIMATIC S7-200 is a programmable logic controller designed by SEIMENS Company. It consists of six outputs and eight inputs. The overview of the SIMATIC S7-200 PLC is shown in the figure below.



**Figure 2 Simatic S7-200 Plc.**

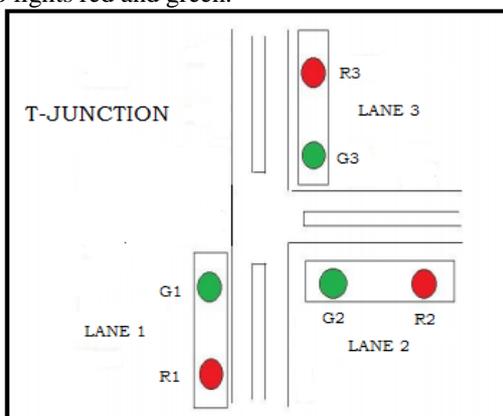
SIMATIC S7-200 requires software called STEP7 MICROWIN in order to write the logic or program and download it to the PLC. A T-junction traffic control system which requires one input switch and six outputs is implemented using this PLC.

### 2.4 Programming In Step7

STEP 7 is the software used for configuring and programming SIMATIC S7-200/S7-300/S7-400 and M7-300/M7-400 programmable logic controllers (PLCs) and SIMATIC C7 automation computers. STEP 7 comprises the standard software and optional software packages which run under Windows 95 or Windows NT. The STEP 7 standard software supports you in all phases of the creation process of an automation task, such as setting up and managing projects, configuring and assigning parameters to hardware and communications, downloading programs to programmable logic controllers, testing the automation system and diagnosing plant failures. STEP 7 programming language permits Ladder Logic, Statement List, and Function Block Diagram. Here, for implementing T-junction traffic control system ladder logic is used in step7.

### 3. T-Junction Traffic Control System

The model view of a T-junction traffic control system is shown below. It consists of three lanes lane 1, lane2 and lane 3. Each lane consists of two lights red and green.



**Figure 3 Top View Of A T-Junction With Traffic Lights.**

Totally it requires one input switch(S) and six outputs namely G1&R1, G2&R2 and G3&R3. The total operation of this system takes place in sequence of operation of states which are explained below.

### 3.1 Sequence Of Operation

The operation of the T-junction traffic control system takes place in sequence of operation of states. There are three states in the operation of this system. They are:-

#### State 1:

In this state the traffic of lane 1 is allowed and the traffic of lane 2&3 are stopped. Here in this state, green light of lane 1(G1) glows and red lights of lane 2&3 (R2) and (R3) glows. This period is continued for fifteen seconds of duration.

#### State 2:

In this state the traffic of lane 2 is allowed and the traffic of lane 1&3 are stopped. Here in this state, green light of lane 2(G2) glows and red lights of lane 1&3 (R1) and (R3) glows. This period is continued for fifteen seconds of duration.

#### State 3:

In this state the traffic of lane 3 is allowed and the traffic of lane 1&2 are stopped. Here in this state, green light of lane 3(G3) glows and red lights of lane 1&2 (R1) and (R2) glows. This period is continued for fifteen seconds of duration.

Between each state a gap of two seconds is left in order to prevent any collisions. After the execution of three stages is completed, the timer resets and the sequence of operation again start and it repeats continuously.

### 3.2 Flow Chart

The figure below represents a flowchart which shows the sequence of operation of T-junction traffic light control system.

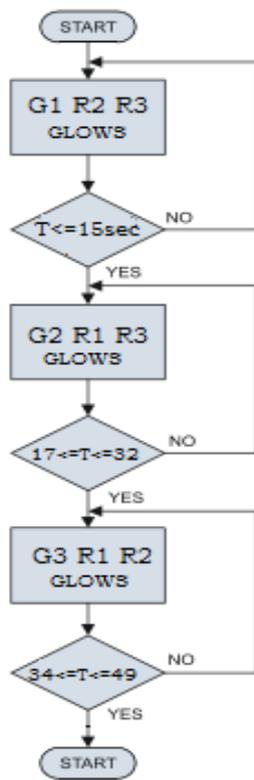


Figure 4 Flow Chart

3.3 State Table

STATE	G1	R1	G2	R2	G3	R3
1	1	0	0	1	0	1
2	0	1	1	0	0	1
3	0	1	0	1	1	0

Table 1 State Table

3.4 Ladder Logic Diagram

The program which is required to implement a T-junction traffic light control system is written in ladder logic as show below.

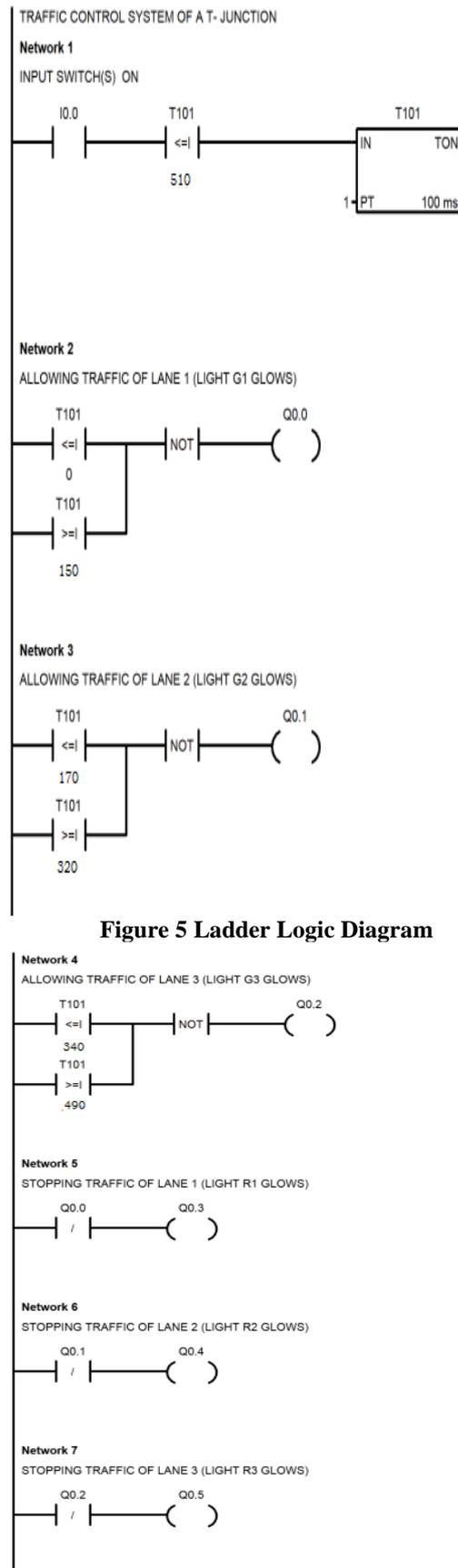


Figure 6 Ladder Logic Diagram contd...

### 3.5 Description Of Ladder Logic

The description of the different symbols used in the ladder logic shown above is described in the following table.

S.NO	SYMBOL	DESCRIPTION
1.	I 0.0	INPUT SWITCH(S)
2.	Q 0.0	GREEN LIGHT OF LANE 1 (G1)
3.	Q 0.1	GREEN LIGHT OF LANE 2 (G2)
4.	Q 0.2	GREEN LIGHT OF LANE 3 (G3)
5.	Q 0.3	RED LIGHT OF LANE 1 (R1)
6.	Q 0.4	RED LIGHT OF LANE 2 (R2)
7.	Q 0.5	RED LIGHT OF LANE 3 (R3)
8.	T 101	ON DELAY TIMER

**Table 2 Description Of Symbols Used In Ladder Logic**

At first when the input switch (I 0.0) is on, the outputs Q0.0, Q0.4 and Q0.5 respond i.e. traffic of lane 1 is allowed. After a time interval of fifteen seconds, this state is changed. Then for an interval of 2 sec all the red lights glow i.e. the outputs Q0.3, Q0.4 and Q0.5 respond. Now, for a time interval of 15 sec the outputs Q0.1, Q0.3 and Q0.5 respond i.e. traffic of lane 2 is allowed. Then again for an interval of 2 sec all the red lights glow i.e. the outputs Q0.3, Q0.4 and Q0.5 respond. For the time interval of 15 sec the outputs Q0.2, Q0.3 and Q0.4 respond i.e. traffic of lane 3 is allowed. After this again for 2 sec all red lights glow. After this instant the timer resets and the sequence of operation again starts. Thus the T-junction traffic control system functions automatically when the switch is on.

### 3.6 Model Of T-Junction Traffic Light Control System Using PLC

The model of a T-junction traffic light control system controlled by SEIMENS S7 PLC is shown in the figure below.



**Figure 7 Model of T-Junction Traffic Control System Using a Plc**

### 4. Conclusion

PLC plays a vital role for automation in any industry and also in many other real time applications. The application of PLC to control devices leads to best productivity, fewer breakdowns, less indenting costs. Thus, high reliability and minimum maintenance costs can be achieved with moderate to low initial investment costs. A program to represent aT-junction traffic light control system using SIMATIC S7-200 PLC is executed with the help of STEP7 MICROWIN software. A model of T-junction traffic control system using PLC is also implemented.

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