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Development and Regulation of Dual-Lane Traffic Signal Utilising Programmable Logic Controller

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ABSTRACT

Traffic is a major challenge in many cities in the world today dictated by devices such as traffic lights. Traffic lights have become an integral part of human day-to-day life. Problems associated with such traffic light usage includes lateness of workers to work, fatigue of traffic warders and vehicle owners, accidents due to collisions, bribery and corruption by traffic warders, bad health conditions The basic fixed -time method for traffic light is not always effective which leads to traffic congestion during peak hours as well as threat to emergency situation. This work provides a simple model for the design of a PLC based traffic light control system during congestion and emergency. The PLC controller was design using a ladder programming approach. The components used here are the PLSES software, TPS 3071 PLC control Trainer, Resistors, LEDs (Blue, Red, Yellow). The display unit of each stand consists of LED, the first is RED in colour, the second is YELLOW in colour and the last is GREEN in colour.

Keywords: Programmable Logic Controller, Traffic Signal.

INTRODUCTION

The traffic on our roads, especially intra-city traffic due to increasing number of cars grow by the day and unless adequate steps are taken to control the situation, we shall soon meet with circumstances we do not bargain for. That the innumerable traffic junctions in the country by far out-number the staff strength of the traffic wardens available and that the traffic wardens even where they are enough to control all the junctions cannot do so throughout the day is not in doubt. Traffic control at junctions or elsewhere ensures orderliness of movements of vehicles, goods and pedestrians while its absence strongly indicates chaos and most at times leads to accidents. In the light of the above, it is imperative to recognize the need to compliment the physical exhausting efforts of the traffic wardens. In doing so, steps to be taken should assume permanence in nature rather than any ad -hoc exercise. Such is the role expected to be played by an installed operational road junction traffic controller.

This is such a device that will play significant role in controlling traffic at junctions to ease the expected increased rush at such junctions and reduce to minimum such disorderliness that may arise as well as allowing the 2 pedestrians a right of the way at intervals rather than being struck down when in a hurry to cross the roads. Such an electrical system with a touch of electronics that controls the flow of traffic in a pre-determine sequential pattern at a junction has its diagram below with blocks representing distinct units.

AIM AND OBJECTIVES OF THE PROJECT
The main Aim of this project is to construct a 2-lane traffic light control using programmable logical controller (PLC) for practical demonstration to Student of Electrical and Mechatronics Engineering.

The Objectives of the project includes:
1. To construct the Two-lane traffic light
2. To implement the PLC program for traffic light
3. To design voltage amplifier circuit
4. To test the working program on the PLC trainer

METHODOLOGY

To implement the PLC program using PLSES software, which provide window for developing a computer program using a ladder method.

Power units supply 3V DC and the output voltage of the PLC was tested as 0.6v which is not sufficient to light the LED display, therefore amplifier circuit was design and constructed to boost the output voltage of the PLC.

A well-constructed Traffic light model will be constructed using a plastic material and a wooden base. The testing of the complete project was done using a TPS 3071 PLC control trainer

PROGRAMMABLE LOGIC CONTROLLER (PLC)

A programmable logic controller (PLC) is a special form of microprocessor-based controller that uses programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic to control machine and processes (Bolton, 2010). PLC is a programmable device developed to replace mechanical relays, timers and counters. PLCs are used successfully to execute complicated control operations in a plant. The PLCs helped reduce the changeover time from a month to a matter of just few days. Complete system setup for PLC consists of an input/output (I/O) unit, central processing unit (CPU) and memory (figure 1.1). The I/O unit acts as the interface between PLC and real time systems. All logic and control operations, data transfer and manipulation work is done by CPU. PLCs provide the advantages of high reliability in operation, flexibility in control techniques, small space and computing requirements, expandability, high power handling, reduced human efforts and complete programming and reprogramming in a plant. The PLC is designed to operate in the industrial environment with wide ranges of ambient temperature, vibration, and humidity and is not usually affected by the electrical noise that is inherent in most industrial locations. It also provides the cost-effective solution for controlling complex systems (Ahmad Ullah Abu Saeed, June, 2012), (Hemant Ahuja, 2014).
Before you start using PLC, it is convenient to know and understand its architecture.

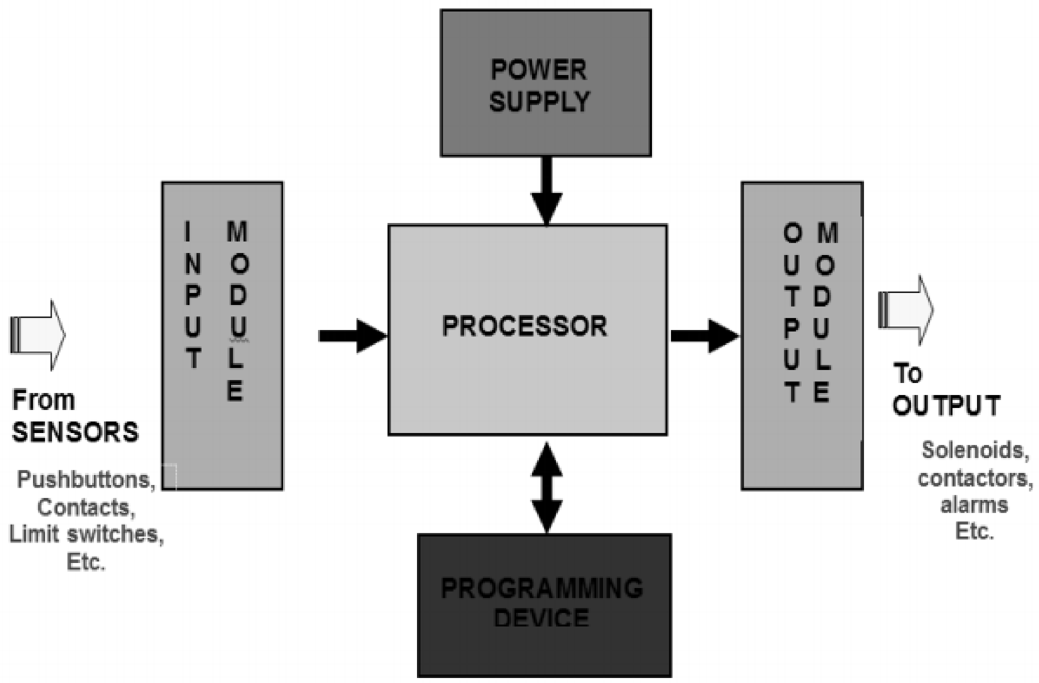

Figure 3.1: PLC architecture

As shown in figure 1, PLC consists of the following parts:
1. POWER SUPPLY: Provides the voltage needed to run the primary PLC components.
2. I/O MODULES: Provides signal conversion and isolation between the internal logic-level signals inside the PLC and the field's high-level signal.
3. PROCESSOR SYSTEM: Provides intelligence to command and govern the activities of the entire PLC systems.
4. PROGRAMMING DEVICE: Used to enter the desired program that will determine the sequence of operation.

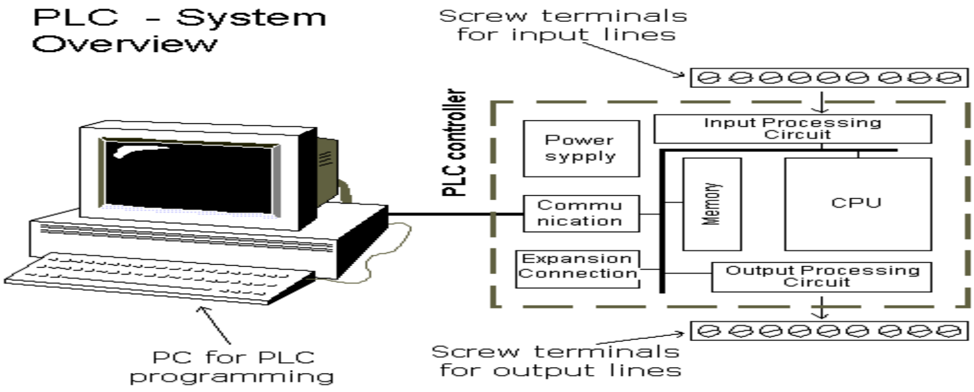

Figure 3.2: PLC System Overview

3.2 TRAFFIC LIGHT

Traffic-signal control systems coordinate individual traffic signals to achieve network-wide traffic operations objectives. These systems consist of intersection traffic signals, a communications network to tie them together, and a central computer or network of computers to manage the system. Coordination can be implemented through several techniques including time-base and hardwired interconnection methods. Coordination of traffic signals across agencies requires the development of data sharing and traffic signal control agreements. Therefore, a critical institutional component of Traffic Signal Control is the establishment of formal or informal arrangements to share traffic control information as well as actual control of traffic signal operation across jurisdictions. Signal coordination systems are installed to provide access. A traffic-signal system has no other purpose than to deliver favorable signal timings to motorists. The system provides features that improve the traffic engineer's ability to achieve this goal. These are primarily access features. They provide access to the intersection signal controller for maintenance and operations. The completer and more convenient the access, the more efficient the operator will be and the more effective the system. In addition to control of traffic signals, modern systems also provide wide -ranging surveillance capabilities, including various kinds of traffic detection and video surveillance. They also provide more powerful traffic-control algorithms, including the potential for adaptive control and predictive surveillance [10].

Figure 3.3: A simple Road Traffic light controller

4. SOFTWARE IMPLEMENTATION

LADDER LOGIC PROGRAMMING

Figure 3.1 shows electrical continuity, when SW1 is closed, the current will flow from L-1 to L-2 and energize the load.

Figure 3.1: Hardwire switch-lamp circuit

Even though PLC ladder logic was modelled after the conventional relay ladder, there is no electrical continuity in PLC ladder logic. PLC ladder rungs should have logical continuity for the output to be energized. PLC ladder program uses familiar terms like “rungs”, “normally open” and “normally closed” contacts, as illustrated in table 1.

Table 4.1: Fundamental contacts and coils instructions of PLC ladder logic programming

Symble	Name	Description
—| |—	*Examine if closed*	*It works as normally open switch in a ladder program. If it is ON, the contact will close and allow power (logic) to flow from left to right. If the status is OFF (logical 0), the contact is Open, power (logic) will NOT flow from left to right.*
—|/|—	*Examine if open*	*It works as normally closed switch in a ladder program, and it works exactly opposite to that of the examine if closed.*
—( )—	*Normally open coil*	*This can be used to represent any discrete output from the control logic. When "solved" if the logic to the left of the coil is TRUE, the referenced output is ON (logical 1).*

In a ladder logic program, there is no physical conductor that carries the input signal through to the output. Each rung in the ladder diagram is a program statement. This program statement consists of a condition or sometimes conditions, along with some type of action. Inputs are the conditions, and the action, or output, is the result of the conditions. As in case of physical wiring hardware devices connected in series or parallel, PLC also combines ladder program instructions in series or parallel. However, rather than working in series or parallel, the PLC combines instructions logically using logic operators like: AND, OR, and NOT. These operators are used to combine the instructions on a PLC rung to make the outcome of each rung either true or false.

Description: --(S)-- (Set Coil) is executed only if the RLO of the preceding instructions is "1" (power flows to the coil). If the RLO is "1" the specified <address> of the element is set to "1". An RLO = 0 has no effect and the current state of the element’s specified address remains unchanged. The following example illustrates the operation of set coil instruction, see figure 4.2:

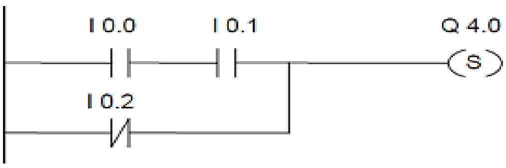

Figure 3.2: Set coil instruction example

The signal state of output Q4.0 is "1" if one of the following conditions exists:
- The signal state is "1" at inputs I0.0 and I0.1
- Or the signal state is "0" at input I0.2.

If the RLO is "0", the signal state of output Q4.0 remains unchanged.

4.1 TIMERS

Timers are used to provide logic when a circuit turns on or off. Traditional pneumatic timers were provided as either on-delay timers or off-delay timers. Contacts were provided both normally open and normally closed for each type of timer. The timer head was chosen as either the on-delay type or off-delay type. PLCs allow for a quick change from one type to the other with a few keystrokes on the programming panel. Symbols for Timers:

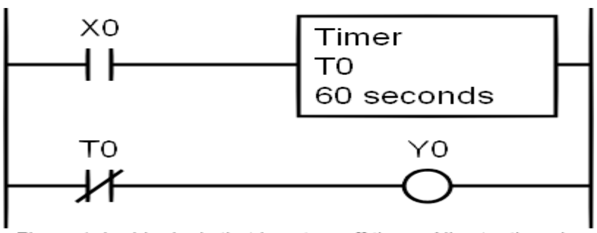

Figure 1: Ladder logic that is not an off timer. Nice try though.

Figure 4.1: Timer Circuit

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4.2 COUNTER

CTU: UP Counter "The instruction Count up counts up the value at output CV. When the signal state at the CU input changes from 0 to 1 (positive signal edge), the instruction executes and the current count value at the CV output is incremented by one. When the instruction executes for the first time, the current count value at the CV output is set to zero. The count value is incremented each time a positive signal edge is detected, until it reaches the high limit for the data type specified at the CV output. When the high limit is reached, the signal state at the CU input no longer influences the instruction." The following example shows how the instruction works:

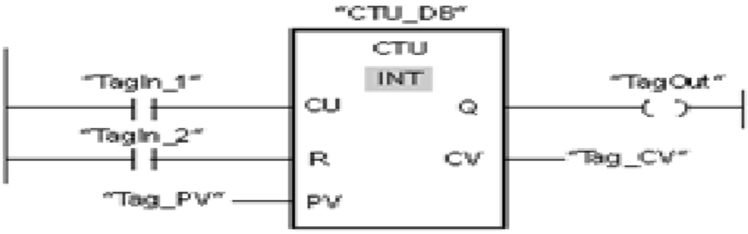

Figure 4.2: Up Counter circuit

CTD: Down Count "You can use the down Counter instruction to decrement the value at output CV. When the signal state at the CD input changes from 0 to 1 (positive signal edge), the instruction executes and the current count value at the CV output is decremented by one. When the instruction executes the first time, the count value of the CV parameter is set to the value of the PV parameter. Each time a positive signal edge is detected, the count value is decremented until it reaches the low limit value of the specified data type. When the low limit is reached, the signal state at the CD input no longer has an effect on the instruction."

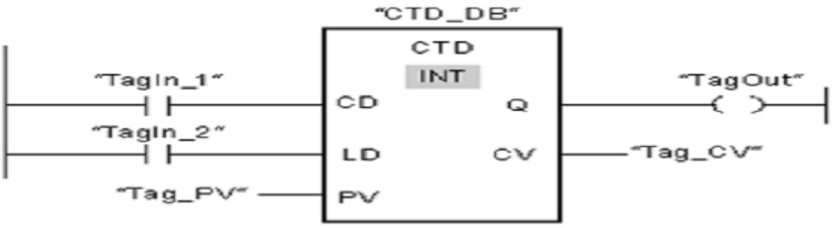

Figure 4.3: Down Counter circuit

5.0 TESTING AND RESULT

This Part explains the Testing and results presentation of the project and the analysis throughout this project. It gives a detailed insight on the analysis and output of the project.

5.2 System Testing

- After the construction and implementation phase, the system built has to be tested for Durability, Efficiency, and Effectiveness.
- All components were properly inserted into the breadboard from whence some tests were carried out at various stages.
- To ensure proper functioning of components' expected data, the components were tested using a digital multi meter (DMM).
- The complete traffic light system was tested using TPS 3071 PLC control trainer and the result was achieved as shown in the setup figure below

Figure 5.1: Complete system setup and tested

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

From the design and construction of a Two lane traffic light controller, carried out in the course of this project, it is obvious that such a system which is used to reduce the human stress of standing under favourable or unfavourable weather conditions and controlling the movement of vehicles at junctions, can be developed by indigenous human resources. This would reduce the spending of huge sums of money that could have been spent on the maintenance of manpower or importation of expatriates to carryout and maintain the installation, since it can be conducted internally. Generally, this research work is aimed at producing a traffic control light system, which can be used by the student in observing the real application of PLC control, as it provide efficient control of a system which can also be manage with ease.

RECOMMENDATIONS

1. Our various governments should establish research and development centers equipped with modern facilities and with effective Internet connectivity to encourage our scientists and engineers to do their research work with ease.
2. Engineering and technology students in our colleges of technology and universities of technology should be encouraged by giving some special allowances to undertake experimental research work such as this. They should also be given scholarship for further studies.
3. Our various governments in alliance with colleges of technology and manufacturers should establish special centers for the design and manufacture technological infrastructures such as this.

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