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PLC-CONTROLLED INTELLIGENT TRAFFIC MANAGEMENT SYSTEM DESIGN AND SIMULATION

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1. ABSTRACT

The evolution of urban infrastructure necessitates increasingly sophisticated control mechanisms to manage the dense flow of modern traffic. This project presents a high-level automated solution for a three-phase traffic light system using a robust PLC (Programmable Logic Controller) architecture. The study integrates the Rockwell Automation software suite specifically Studio 5000 Logix Designer and FactoryTalk View Studio to create a synchronized environment where control logic and user monitoring coexist. By leveraging Studio 5000 Logix Emulate, the system provides a risk-free testing ground that mirrors physical industrial hardware. This paper details the systematic approach to configuring the 50-second signal cycle, the mapping of I/O addresses, and the development of a SCADA interface that offers real-time visualization of the intersection's status.

Keywords: Programmable Logic Controller (PLC), Intelligent Traffic Management System, SCADA Interface, Studio 5000 Logix Designer, FactoryTalk View Studio, Ladder Logic, Studio 5000 Logix Emulate, RS Linx Classic, Virtual Commissioning, Smart City Infrastructure, and Traffic Signal Automation

2. INTRODUCTION

Traffic management is one of the most critical aspects of civil engineering and public safety. In the past, simple relay-based systems or fixed-timing circuits were sufficient; however, these lacked the scalability and diagnostic capabilities required for modern smart cities. The shift toward PLCs has revolutionized this field. A PLC offers a modular, high-speed, and reliable platform that can be reprogrammed on the fly without changing physical wiring.

In this project, we utilize the Logix 5000 architecture. The core of the system is a 1756-L71/Emulator controller, which allows us to simulate the logic within a virtual 1756-A10 backplane. This simulation-first approach is standard in industrial automation, ensuring that every rung of code is validated for safety and timing accuracy before it is deployed to a live intersection.

3. OBJECTIVE

The primary objective of this project is to design a fail-safe, automated traffic signal controller that operates autonomously while providing a human-readable interface. The specific goals include:

- Logical Synchronization: Developing a precise timing sequence where the transition from Green to Yellow and then to Red is managed by a single master timer to prevent overlapping signals.
- Hardware Emulation: Configuring a virtual backplane with specific I/O modules, including the 1756-IB32/B for inputs and the 1756-OB32 for outputs, to simulate real-world hardware interaction.
- SCADA Development: Creating a high-fidelity visual representation of the traffic signal using the FactoryTalk View Studio environment, ensuring the SCADA interface is directly linked to the PLC's internal tags.
- System Integrity: Ensuring the system can be started manually via the SCADA interface and will loop indefinitely until halted.

4. SOFTWARE DESCRIPTION

The project relies on a multi-layered software stack that facilitates communication, logic execution, and visualization:

- RS Linx Classic: This is the backbone of the communication layer. It handles the "Who" of the network, identifying the emulated PLC in the virtual chassis and making it accessible to the programming software and the SCADA interface.
- Studio 5000 Logix Emulate: This software creates a virtual environment for the 1756-L71 controller. As seen in the project configuration, the controller is located in Slot 2 of the virtual backplane, allowing for

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real-time execution of the ladder logic as if physical hardware were present.

- Studio 5000 Logix Designer: Used as the primary IDE (Integrated Development Environment). The software organizes the project into a Main Task, which contains the Main Program and the Main Routine where the ladder logic is stored. It also manages the Controller Tags and I/O Configuration, such as the 1756-OB32 output module in Slot 4.
- FactoryTalk View Studio (Site Edition): This is the SCADA design environment. It allows us to draw graphical objects like the "START" button and the traffic signal ellipses and link them to "SCADA Tags" that mirror the PLC's output data.

5. SYSTEM WORKING

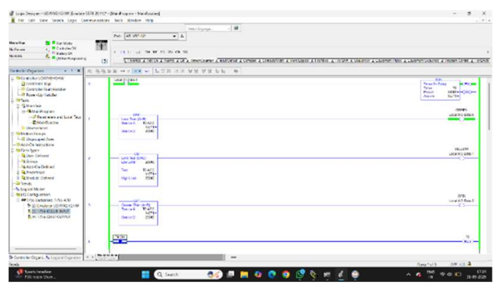
The system is designed around a 50-second continuous loop. The "brain" of the operation is the Timer On Delay (TON) instruction, which is given the tag name T0.

- Initialisation: When the "START" button on the SCADA interface is pressed, it energizes the PLC logic.
- Timing Cycle: The timer T0 begins accumulating time with a Preset value of 50,000 milliseconds.
- Sequence Execution:
  - Phase 1 (Green): For the first 20,000 ms (20 seconds), the system evaluates that the timer's current value is "Less Than" the limit, keeping the Green light on.
  - Phase 2 (Yellow): Between 20,000 ms and 25,000 ms (a 5-second window), a "Limit Test" instruction activates the Yellow light.
  - Phase 3 (Red): Once the timer exceeds 25,000 ms (25 seconds), a "Greater Than" instruction triggers the Red light, which remains active for the remaining 25 seconds of the cycle.
- Auto-Reset: At 50,000 ms, the timer's "Done" bit (T0.DN) is set to true, triggering a Reset (RES) instruction to restart the cycle.

6. DETAILEDLADDER LOGIC CONFIGURATION

The ladder logic is the core of the system, consisting of five critical rungs:

- Rung 0 (Master Control): Features the T0 TON instruction to manage the 50,000 ms cycle.
- Rung 1 (Green Output): Uses a LES (Less Than) instruction comparing T0.ACC to 20,000, mapped to Local:4:O.Data.0 on the 1756-OB32 module.
- Rung 2 (Yellow Output): Uses a LIM (Limit Test) instruction (Low: 20,000, High: 25,000) mapped to Local:4:O.Data.1.
- Rung 3 (Red Output): Uses a GRT (Greater Than) instruction (Source B: 25,000) mapped to Local:4:O.Data.2.
- Rung 4 (Looping): Uses a normally open contact for T0.DN to activate the RES instruction for T0, ensuring the process is perpetual.



7. SCADA INTERFACE

The SCADA display was built in FactoryTalk View Studio to provide a user-friendly way to interact with the PLC logic.

- The Canvas: The display, titled "TRAFFIC SIGNAL," features a vertical black rectangle with rounded edges to simulate a physical traffic signal housing.
- The Lamps: Three Ellipse objects represent the lights, configured with "Color Animation" linked to the Red, Yellow, and Green output tags (e.g., Local:4:O.Data.2 for Red).
- Operator Controls: A standard Rectangle object with the text "START" functions as a pushbutton, mapped to an internal tag or a point on the 1756-IB32/B module to initiate the timer.

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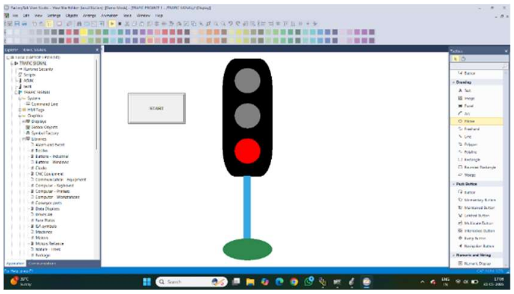

8. CONCLUSION

The integration of Studio 5000 and FactoryTalk View provides a comprehensive platform for managing urban infrastructure. This project proves that through careful timing and comparison instructions, a reliable traffic system can be established. The use of Logix Emulate ensures the logic is foolproof before physical deployment. This model can be expanded by adding sensor-based inputs via the 1756-IB32 module to create a "smart" system responding to real-time road conditions.

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