

# Implementation of Automatic Color Mixing and Filling Using PLC & SCADA

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**Abstract:** *The objective of this paper is to design, develop and monitor “Automatic Color Mixing and Filling Using PLC and SCADA”. A modern programmable logic controller deliver a wide range of functionality, including basic relay control, motion control, process control, and complex networking, as well as being used in Distributed Control Systems. There are several different types of interfaces that are used when people need to interact with the programmable logic controller to configure it or work with it.*

*In this application, going to mix the color in different proportion and fill in a bottle using PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition). Here Allen Bradley Micrologix 1400x PLC is used, which acts as the heart of the system. The system sequence of operation is designed by ladder diagram. Several electronics and electric devices that usually be controlled and operated by the PLC such as a submersible motor pump, conveyor belt, solenoid valve, relays etc. This system is applicable in color mixing plant, milk industries, chemicals, foods, mineral water and many more manufacturing, processing and packaging industries. A prototype has been developed to illustrate the application.*

**Keywords:** Allen Bradley, Automation, Ladder Logic, PLC, SCADA.

## 1. INTRODUCTION

Automation is used to reduce the human work and helps in increasing the production. PLC plays an important role in the world of automation industry. It acts as major function in the automation field which tends to reduce the complexity, increases safety and cost efficient. It requires continuous monitoring and inspection at frequent intervals. There are possibilities of errors in parameter measuring, human intervention at various stages and also the lack of advance features. Thus this paper takes a sincere attempt to explain the benefits to the companies by making process automated. In order to automate a plant and minimize human intervention, there is a need to develop a system that monitors the plant and helps to reduce the errors caused by humans.

PLC is the main part of the system which makes the whole process simple, flexible and accurate. A color mixing and filling system with PLC allows the user to mix

the colors in different proportion and fill the bottle till a desired level without wastage of the liquid. Ladder logic is used to perform the sequence of operation. The system is controlled by a Allen Bradley Micrologix 1400 Series-B PLC which operates on 24V DC and is a compact PLC which has a fixed number of inputs and outputs i.e., 32 number of digital input/output ports and 6 number of analog input/output ports. In addition to this, the use of SCADA has also been implemented for the monitoring of the entire system.

## 2. METHODOLOGY

There are three containers, first container contains color 1 liquid, second container contains color 2 liquid with the respective solenoid valve connected on it, and middle container is mixing and filling container. Mixing container connected with a solenoid valve and a level sensor to sense the water level in it.

When the level sensor moves from NO contact to NC contact the conveyor belt (i.e. DC Motor) starts rotating. Afterwards the bottle is placed on the conveyor then proximity sensor 1 senses the bottle and conveyor belt stops below the solenoid valve 3. Then there will be delay of 5 seconds, after this solenoid valve open and starts filling the bottle for 15 seconds, after 2 second of delay filled bottle will move forward on conveyor system till the proximity sensor 2 senses the bottle. After this the process continues till the stop switch is not pressed.

## 3. PROPOSED MODEL

The whole system is divided in two important parts hardware and software

### 3.1 Hardware Description

Number equations consecutively with equation numbers in Allen Bradley Micrologix 1400 Series-B used for controlling the inputs and outputs. The model number of PLC is 1766-L32BXBA. The PLC controls the input and output according to the program. Input supply to the PLC is given through a SMPS as this is the compact type of PLC. The rating of the SMPS is 24V DC, 5Amp. Various proximity sensors have been used for the positioning of the bottle. A DC motor is used for the conveyor system. The rating of the DC motor is 24V for high torque. Toggle switch and push buttons are used which acts as the input to the PLC. Solenoid valve is used for the filling process of

the bottle.

### 3.2 Software Description

There are five important languages which are used for the programming of the PLC. The lists of the methods are as follows:

- Functional Block Diagram (FBD)
- Structure Text
- Instruction list
- Sequential Flow chart (SFC)
- Ladder diagram

Out of these five languages, ladder diagram is the most widely used language and is simple as compared to other languages. Ladder logic is the main programming method used in PLC. Ladder logic is based on mimic relay logic.

### 3.3 PLC Working

Basics of a PLC function are continuous scanning of a program. The scanning process involves three basic steps.[8]

Step 1: Read input status

First the PLC checks whether inputs like switches, sensors etc., is on or off state. The information is stored in memory in order to use in the following steps.

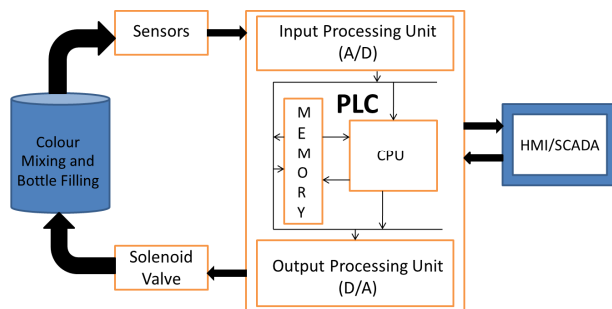
Step 2: Program execution

Here a PLC executes a program rung by rung from top to bottom and left to right. According to input status output status modifies and store in memory.

Step 3: Update output

PLC update the output signals according to change in input.

Here figure-1 indicates the block diagram of the system.



**Figure-1** Block Diagram of System

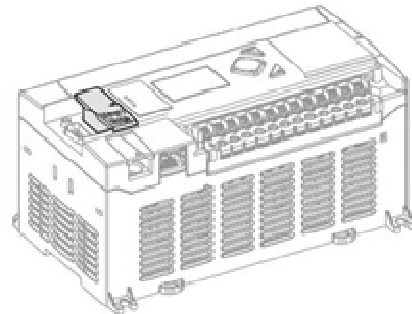
## 4. SELECTION OF PLC

While selecting a PLC, various factors should be considered as per the application.[7] The important factors that affect this criteria are :

- Number of Inputs and Outputs.
- Scan Time
- Communication Protocol
- Memory Size
- Software

Different PLC's have different configuration of input and output module. Normally, compact type PLC has fixed inputs and outputs.[1] Modular type of PLC's having flexibility to increase the I/O but they are compactible only with the high-end models, provision to save the

programs in flash clips/memory module and also has the communication support. Figure-2 shows the basic model of Micrologix 1400 Series-B PLC.



**Figure-2** Micrologix 1400 Series-B PLC

### 4.1 Allen Bradley PLC

PLC has 20 digital inputs and 12 digital outputs. The entire bottling process is automated by applying the necessary conditions into the PLC using ladder logic. The input/output unit of the PLC acts as an interface to the real world. Inputs from real world are given to the input unit which is manipulated based on the system requirement, and outputs are given to the real world through the output unit of the PLC.

The Table-1 below shows the Input/output Configuration of the PLC for color mixing plant.

**Table-1** PLC Input/output Configuration for the Plant

Sr. No.	Address	Description
1	I:0/0	Start Switch
2	I:0/1	Level Sensor
3	I:0/2	Proximity Sensor 1
4	I:0/3	Proximity Sensor 2
5	I:0/4	Stop Switch
6	O:0/0	Solenoid Valve 1
7	O:0/1	Solenoid Valve 2
8	O:0/2	Conveyor Belt (Motor)
9	O:0/3	Solenoid Valve 3

### 4.1 Input Module

The input module connected to proximity sensors and level sensors. Proximity sensors are used to detect the bottle position. There are three level sensors used. One level sensor is used in tank 1 to indicate low level and similarly one sensor are used in tank 2. One level sensor is used in the process tank to indicate the low level.

### 4.2 Signal Conditioning

The input-output device cannot connect directly to the PLC CPU as voltage level of input-output device and PLC CPU is different. Hence signal conditioning circuit is required.

Output devices such as motors and pump require different voltages for their operation. Hence the output signals from the PLC are given through a relay drive unit which drives the output devices [6].

### 4.3 Output Module

The various output devices used in the process are motors, pumps, solenoid valve. These are connected to the output module. The motor is used to rotate the conveyor belt in forward direction. Two pumps used for the filling process of Tank3 (Mixing tank). Pumps are connected to the Tank 1 and Tank 2 respectively. Solenoid valve is for filling the liquid into the bottle.

Figure-3 shows the connection diagram of PLC (1766-L32BXBA).

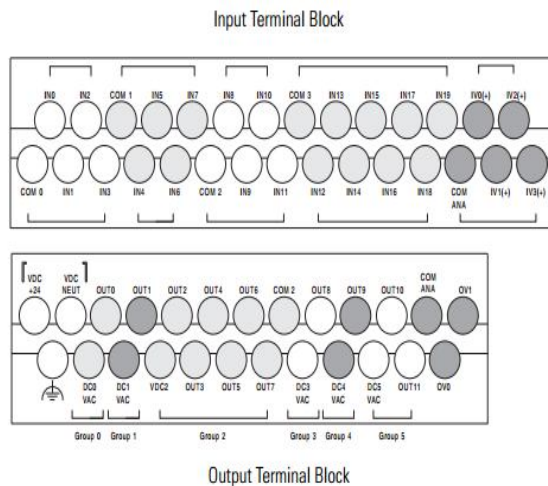


Figure-3 Wiring Diagram of PLC (1766-L32BXBA)

#### 4.4 Proximity Sensor

Rated Operational Voltage	24 VDC
Supply Voltage	10 to 30 VDC
Voltage drop	≤ 2.0 V
Rated insulation voltage	≥ 20 MΩ
Load current capacity(DC/AC)	200 mA
Off-state current(NPN/PNP)	≤ 15 mA
Leak current	≤ 20 μA
No. of wires x gauge	12 x 0.16mm

Table-2 Specification of Proximity Sensor

PNP Normally Open: provides voltage to BR & BL, the resistor such as 1K can be used as a load. BK will provide a positive voltage if the metal object presence [9]. Therefore, you can use BK & BL to power a motor or a light when the metal part is presence. PNP Normally Closed: provides voltage to BR & BL, the resistor such as 1K can be used as a load. BK will not provide a positive voltage if the metal object presence. Therefore, you can use BK & BL to turn off a motor or a light when the metal part is presence. NPN Normally Open: provides voltage to BR & BL, the resistor such as 1K can be used as a load. BK will provide a negative voltage if the metal object presence. Therefore, you can use BK & BR to power a motor or a light when the metal part is presence. NPN Normally Closed: provides voltage to BR & BL, the resistor such as 1K can be used as a load. BK will not

provide a negative voltage if the metal object presence. Therefore, you can use BK & BR to turn off a motor or a light when the metal part is presence. Figure-4 shows the proximity sensor.



Figure-4 PNP type Proximity Sensor

These amplified D.C. sensors contain an output amplifier. They are supplied as 3 wire with function N.O. or NC in the types NPN and PNP. Standard version include protected against short circuit, protected against polarity and peaks created by the disconnection of inductive loads. They are compatible with P.L.C. Units. Type of wiring of proximity Sensor is shown in Figure-5.

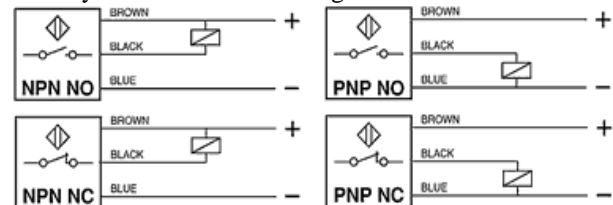


Figure-5 Three wire function of Proximity Sensor

#### 5 ALGORITHM OF THE PROCESS

- STEP I : Press the “START” Push Button.
- STEP II : Both pumps start and liquid from Tank1 and Tank2 fill in the Tank 3 (Mixing Tank)
- STEP III : Tank 3 will fill till high level sensor detect the Liquid level then both the valves (valve 1 and Valve 2) will close.
- STEP IV : After the water level sensor senses the high level, the conveyor belt starts moving and bottle moves on the conveyor belt.
- STEP V : Bottle is sensed by the sensor1 (Proximity Sensor) then conveyor belt motor will stop.
- STEP VI : Solenoid valve 3 is open and bottle will fill for the set time duration.
- STEP VII : The bottle is filled, solenoid valve will be closed and motor starts again after the delay of 2 sec.
- STEP VIII : The bottle is moving towards the sensor 2

and if sensor 2 senses the bottle, conveyor belt motor stops again until the bottle is removed.

STEP IX : The process will be continued until the stop switch is pressed.

## 6 LADDER DIAGRAM

Ladder diagrams are specialized schematics commonly used to document industrial control logic systems. They are called “ladder” diagrams because they resemble a ladder, with two vertical rails (supply power) and as many “rungs” (horizontal lines) as there are control circuits to represent.

Figure-6 shows the ladder diagram in RSLogix 500

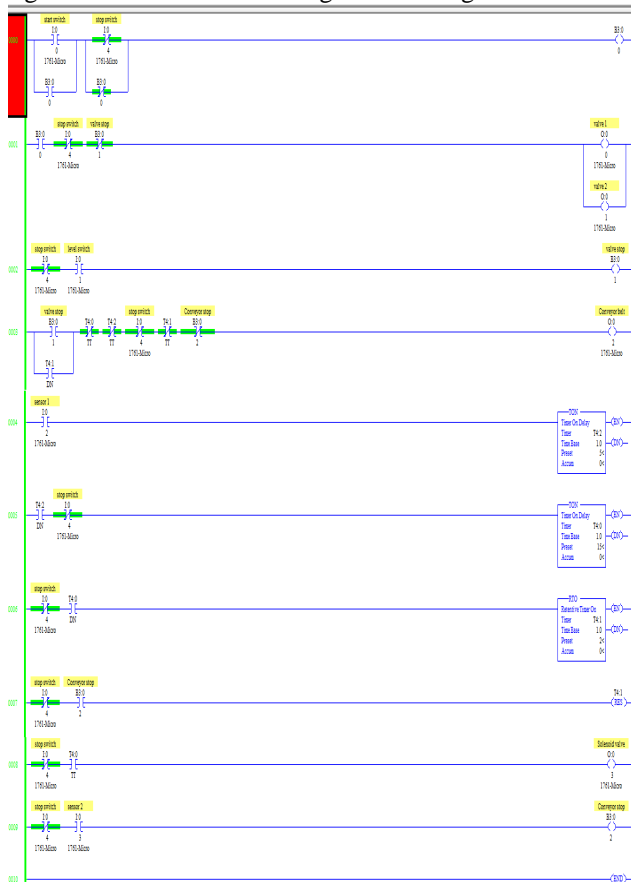


Figure-6 Ladder Diagram

## 7 SCADA

SCADA stands for “Supervisory Control and Data Acquisition. Previously without SCADA an industrial process was entirely controlled by PLC, CNC, PID & micro controllers program. These programs were either written in assembly language or relay logic without any monitoring. Using SCADA we can visualize the graphical view of the entire process and also control from the remote place or control room. [2]

Features of typical SCADA software include,

- Dynamic process graphic
- Real-time and Historical trending

- Alarms
- Recipe Management
- Security
- Device connectivity
- Script for logic development
- Database connectivity
- Networking

Some of the Leading SCADA Software

- Wonderware : InTouch
- Intellution : iFix (Earlier Fix DMACS)
- Allen Bradley : RS View (Earlier Control View)
- Siemens : WinCC (Earlier Coros LS /B )
- GE Fanuc : Cimplicity
- Indusoft : I W S
- Movicon : Progea

From the above software’s, for our application we used Wonderware In Touch software. In this we had use **Application Script** for the SCADA operation.

SCADA used in our research to control and supervise the system remotely. As shown in below figure-7 (before process begins) and figure-8 (during the process).

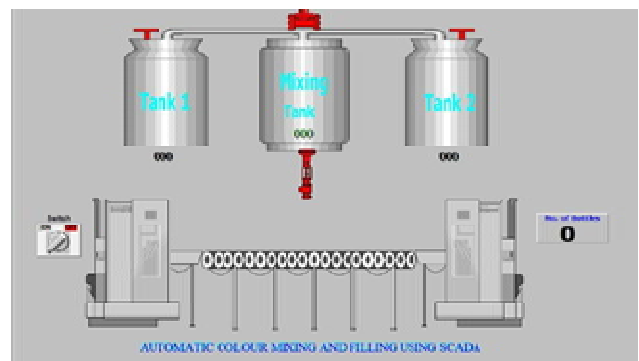


Figure-7 SCADA view of the entire process

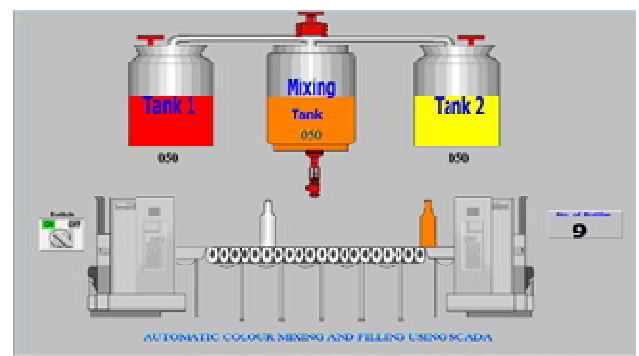


Figure-8 SCADA view during the process

## 8 PROTOTYPE OF AUTOMATIC COLOR MIXING AND FILLING USING PLC & SCADA

Figure-9 shows the prototype of the automatic color mixing and filling using PLC & SCADA.





**Figure-9** Prototype of the Project

## 9 INTERFACING OF PLC & SCADA

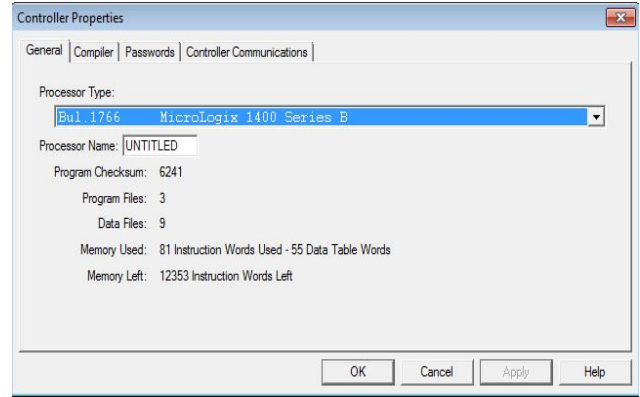
Supervisory control and data acquisition (SCADA) is a system for remote monitoring and control that operates on the principle of unique coded signals over communication channels using typically one communication channel per remote station. [3]. When the control system is combined with a data acquisition system by using the coded signal over communication channel it can be used to retrieve information about the status of the equipment remotely for display or recording functions.

The main purpose of using SCADA is to get a graphical representation, monitoring and control. All the advanced control systems used today are coupled with HMI or SCADA. Here we have implemented RSView32 bit SCADA. Various protocols are used for the interfacing of the PLC and the server. There are so many protocols used for serial communication. Here we have used serial protocol i.e. RS-232 for serial communication. Primary advantage of SCADA is that we can implement limited control options remotely. Figure -10 indicate block diagram of interfacing of PLC and SCADA.[5]

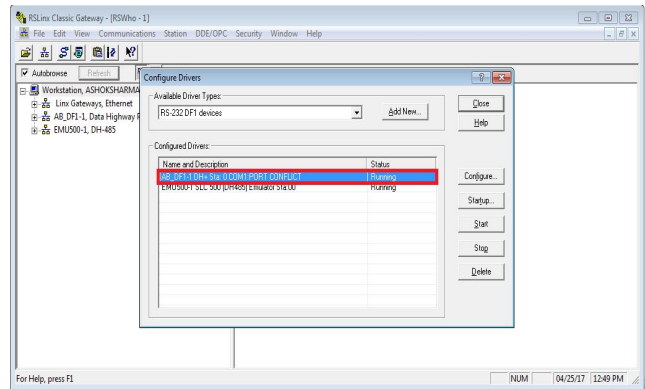


**Figure-10** Interfacing module of PLC and SCADA through RS232[4]

First, we select the processor type (i.e. Selection of PLC) from Controller Properties of RSLogix 500 as shown in figure-11. We connect the RS-232 Cable with the PLC and Computer. Then we Auto configure RS-232 DF1 Devices as shown in Figure-12. In the controller properties we have to select the drivers from the controller communications.



**Figure-11** Controller Properties



**Figure-12** Status of Driver Configuration

## 10 FUTURE WORK

With the help of the hardware of our project we can extend the process for the packing with the help of "Pick and Drop Robot". In this project we can also use the multiple colors to mix the color and fill it in the bottle (i.e.; More than two colors).

## 11 CONCLUSION

The purpose of this project is to develop a PLC based automatic color mixing and filling system plant. We gained more knowledge about various automated processes used in industries. Also know how PLC and SCADA system coordinate with each other and how automation in industries beneficiary compare to conventional method.

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