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Batch Process Control using AB1400 Programmable Logic Controller

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ABSTRACT

Industrial control system (ICS) is a general term that encompasses several types of control systems, including Supervisory Control and Data Acquisition (SCADA) systems, Distributed Control Systems (DCS), and other control system configurations such as Programmable Logic Controllers (PLC) often found in the industrial sectors and critical infrastructures. The objective of this paper is to control an industrial mixer and by doing this work can develop a program that can be used for the actual implementation of such a model. This mixer is controlled using a programmable logic controller and programmed using ladder logic language.

Keywords : Industrial Control System, Programmable Logic Controllers, Batch Process

I. INTODUCTION

A Programmable Logic Controller (PLC) is a specialized computer used to control machines and processes. It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic, and data handling.

Initially the PLC was used to replace relay logic, but it's ever increasing range of functions means that it is found in many and more complex applications. Because the structure of a PLC is based on the same principles as those employed in computer architecture, it is capable not only of performing relay switching tasks but also of performing other applica-tions such as counting, calculating, comparing, and the processing of analog signals (Positite 2003).

Programmable controllers offer several advantages over a conventional relay type of control. Relays have to be hardwired to perform a specific function. When the system requirements change, the relay wiring has to be changed or modified. In extreme cases, such as in the auto industry, complete control panels had to be replaced since it was not economically feasible to rewire the old panels with each model changeover. The programmable controller has eliminated much of the hardwiring associated with conventional relay control circuits. It is small and inexpensive compared to equivalent relay-based process control systems (Bryan 1997).

I. BATCH PROCESS CONTROL

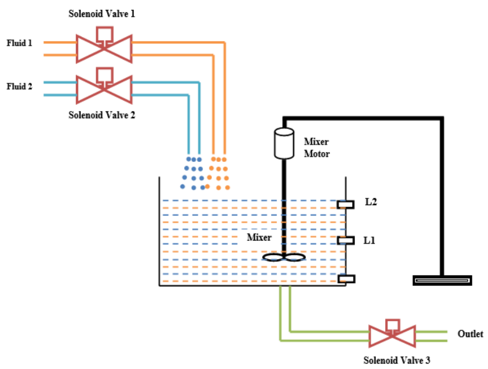


Figure 1 Process Diagram for PLC based Batch Process Control

Application of PLC where two liquids are mixed in required proportion to form a batch .Rate of the flow is already fixed. We only control the time of the flow. Level of the liquids in the tank are sensed by the level sensor switches (www.foodtechcompare.com, www.wikipedia.com/industrial mixer).

II. OBJECTIVE

This work try a simple blending of two colour fluids in a container where we only have three level sensors (L1,L2, and L3) and two liquids flowing in through two solenoid valves, solenoid a(water control) and solenoid b(acid control)and draining out through solenoid c(blend outflow).The batch is to be controlled by timer. After required level of blend is sensed (by L3) the mixer runs for 3 mins. By the motor. They are mixed in ratio of 3:2. The process initiates with the drain valve open, water and acid valves closed, mixer motor is off, and the tank is empty.

III. OBSERVATION

When start button is pressed water is filled upto L2 and it ends as L2 is closed. First of all as start is pressed output O:0/15 turns ON and remains ON until tank is emptied. Rung 2 closes normally open drain valve, before timer T:4 activates. Rung 3 energises solenoid 1 until L2 doesn't signal, once it signals solenoid 1 gets de-energised. Then motor is turned ON and mix it for 3 mins.

Similarly acid is filled upto L3 by solenoid 2 as level gets detected by L3 solenoid b de-energises .And then mixer gets started and it runs for 3 minutes. After time delay of 3 mins solenoid 3 opens and the blend gets drained out. Once the blend gets out completely, the process cycle restarts. The ladder diagram was successfully checked in the PLC simulator and all the prescribed conditions were observed completely.

- Programmable logic controllers serve as the main form of control for manufacturing today.
- The use of Programmable logic controllers for Industrial mixing will enable flexibility thereby allowing the manufacturer to meet a customer's specific demand much quicker.
- A programmable logic controller which has been programmed using ladder logic can be applied to highly customized systems so that the cost of a packaged PLC is low compared to the cost of a specific custom-built controller design.
- The programmable logic controller which has been programmed using ladder logic can employ different techniques to perform a task which could lead to increased efficiency where some techniques are not economically viable.
- A programmable logic controller which has been programmed using ladder logic can be used to monitor the output at each stage in the production process and to make adjustments in a timely fashion.

IV. PUSHBUTTON SWITCHES

A. Terms for Configuration and Structure

A Pushbutton Switch is a switch designed so that its contacts are opened and closed by depressing and releasing a pushbutton on the Switch in the direction of its axis. Pushbutton Switches come in two categories: lighted and non-lighted. The structure of a typical Lighted Pushbutton Switch is shown below. Broadly speaking.

B. Level Sensor

Level sensors detect the level of substances that flow, including liquids, slurries, granular materials, and powders. Fluids and fluidized solids flow to become essentially level in their containers (or other physical boundaries) because of gravity whereas most bulk solids pile at an angle of repose to a peak. The substance to be measured can be inside a container or can be in its natural form (e.g., a river or a lake). The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally the latter detect levels that are excessively high or low.

There are many physical and application variables that affect the selection of the optimal level monitoring method for industrial and commercial processes. The selection criteria include the physical: phase (liquid, solid or slurry), temperature, pressure or vacuum, chemistry, dielectric constant of medium, density (specific gravity) of medium, agitation (action), acoustical or electrical noise, vibration, mechanical shock, tank or bin size and shape. Also important are the application constraints: price, accuracy, appearance, response rate, ease of calibration or programming, physical size and mounting of the instrument, monitoring or control of continuous or discrete (point) levels.

V. ALLEN BRADLEY PLC

Programmable Logic Controller or PLC is an intelligent system of modules, which was introduced in the control, & instrumentation industry for replacing relay based logic. Over a period of time, better I/O handling capabilities and more programming elements have been added along with improvement in communication (Rockwell Automation 1998, Knight 1989).

A. Features of Allen Bradley PLC

Using Allen Bradley 1000/1400 PLC Micrologix 1000/1400 PLC has 20 digital outputs. The relationship with bit address to input and output devices is shown in the figure below.

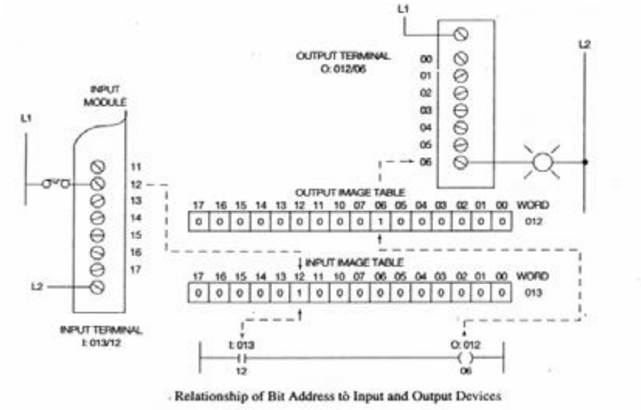


Figure 2 I/O Pin Configuration of AB PLC

The left side of the screen shows that eh project tree while the right side of the screen is the programming area. Either area can be increased in size, minimized, or closed by left clicking the mouse on the appropriate symbol.

B. AB 1400 PLC

User Memory

User memory is the amount of controller storage available to store data such as ladder logic, data table files, and I/O configuration. User data files consist of the system status file, I/O image files, and all other user-creatable data files (bit, timer, counter, control, integer, string, long word, MSG, and PID). A word is defined as a unit of memory in the controller. The amount of memory available to the user for data files and program files is measured in user words. Memory consumption is allocated as follows:

• For *data files*, a word is the equivalent of 16 bits of memory. For example,

- 1 integer data file element = 1 user word
- 1 long word file element = 2 user words
- 1 timer data file element = 3 user words

• For *program files*, a word is the equivalent of a ladder instruction with one operand. For example (1),

- 1 XIC instruction, which has 1 operand, consumes 1 user word
- 1 EQU instruction, which has 2 operands,

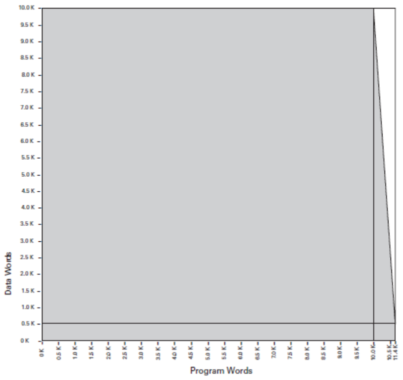
consumes 2 user words

- 1 ADD instruction, which has 3 operands, consumes 3 user words

• *Function files* do not consume user memory.

C. MicroLogix 1400 User Memory

The MicroLogix 1400 controller supports 20K of memory. Memory can be used for program files and data files. The maximum data memory usage is 10K words as shown.



D. Function Files

Function Files are one of the three primary file structures within the MicroLogix 1400 controller (Program Files and Data Files are the others). Function Files provide an efficient and logical interface to controller resources. Controller resources are resident (permanent) features such as the Real-Time Clock and High-Speed Counter. The features are available to the control program through either instructions that are dedicated to a specific function file, or via standard instructions such as MOV and ADD.

E. Timer and Counter Instructions

Timers and counters are output instructions that let you control operations based on time or a number of events. Timers in a controller reside in a timer file. A timer file can be assigned as any unused data file. When a data file is used as a timer file, each timer element within the file has three sub-elements. These sub-elements are:

• Timer Control and Status

• Preset - This is the value that the timer must reach before the timer times out. When the accumulator reaches this value, the DN status bit is set (TON and RTO only). The preset data range is from 0…32767. The minimum required update interval is 2.55 seconds regardless of the time base.

• Accumulator - The accumulator counts the time base intervals. It represents elapsed time. The accumulator data range is from 0…32767.

VI. INSTRUCTION OPERATION

This instruction executes on a true rung. When the rung is true, this instruction moves the current value of the 10 μs free running clock into the Destination.

If the Destination is an integer address type, only 16 bits are moved into the address. If the Destination is floating point address, the long integer value is converted into a float and is moved the relative address.

After the free running clock reaches 0xFFFFFFFF (42949.67295 seconds) value, it wraps around to 0 and continues incrementing. The RESET signal or Power Cycle sets the free running clock to 0.

VII. COMMUNICATIONS INSTRUCTIONS

The communication architecture is comprised of three primary components:

• Ladder Scan

• Communications Buffers

• Communication Queue

These three components determine when a message is transmitted by the controller. For a message to transmit, it must be scanned on a true rung of logic.

When scanned, the message and the data defined within the message (if it is a write message) are placed in a communication buffer. The controller continues to scan the remaining user program. The message is processed and sent out of the controller via the communications port after the ladder logic completes, during the Service Communications part of the operating cycle, unless an SVC is executed. If a second message instruction is processed before the first message completes, the second message and its data are placed in one of the three remaining communication buffers. This process repeats whenever a message instruction is processed, until all four buffers are in use. When a buffer is available, the message and its associated data are placed in the buffer immediately. If all four buffers for the channel are full when the next (fifth) message is processed, the message request, not the data, is placed in the channel's communications queue. The queue is a message storage area that keeps track of messages that have not been allocated a buffer. The queue operates as a first-in first-out (FIFO) storage area. The first message request stored in the queue is the message that is allocated a buffer as soon as a buffer becomes available. The queue can accommodate all MSG instructions in a ladder program. When a message request in a buffer is completed, the buffer is released back to the system. If a message is in the queue, that message is then allocated a buffer. At that time, the data associated with the message is read from within the controller.

A. Address

A character string that uniquely identifies a memory location. For example, I:1/0 is the memory address for data located in Input file word 1, bit 0.

B. AIC+ Advanced Interface Converter

A device that provides RS-232 isolation to an RS-485 Half-Duplex communication link. (Catalog Number 1761-NET-AIC.)

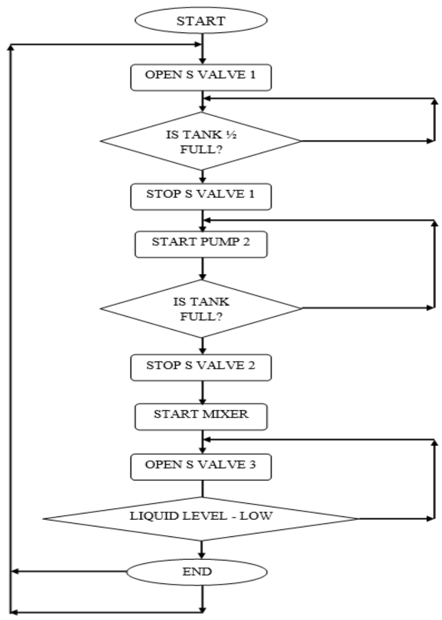


Figure 3 Flowchart for Batch control Process

VIII. SOFTWARE DESCRIPTION

PLC's programming is based on the logic demands of input devices and the programs implemented are predominantly logical rather than numerical computational algorithms. Most of the programmed operations work on a straightforward two-state "on or off" basis and these alternate possibilities correspond to "true or false" (logical form) and "1 or 0" (binary form), respectively. Thus, PLCs offer a flexible programmable alternative to electrical circuit relay-based control systems built using analog devices (www.xtronics.com).

The programming method used is the ladder diagram method.

The PLC program uses a cyclic scan in the main program loop such that periodic checks are made to the input variables .The program loop starts by scanning the inputs to the system and storing their states in fixed memory locations (input image memory I). The ladder program is then executed rung-by-rung. Scanning the program and solving the logic of the various ladder rungs determine the output states. The updated output states are stored in fixed memory locations (output image memory Q). The output values held in memory are then used to set and reset the physical outputs of the PLC simultaneously at the end of the program scan.

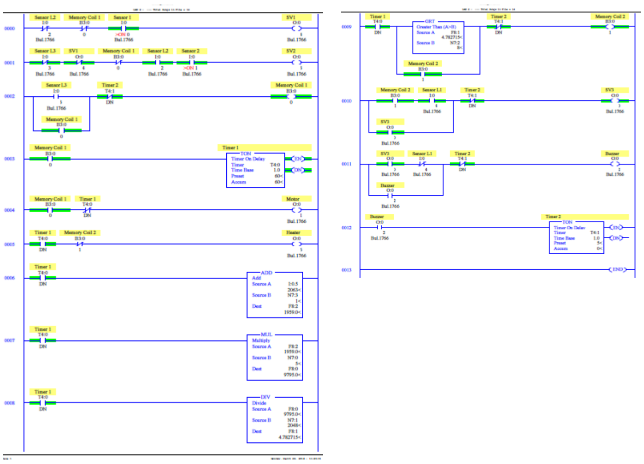


Figure 4 Ladder Network for batch process control

IX. CONCLUSION

In the proposed batch process has shown how programmable logic controllers are a flexible and easily adaptable to typical industrial equipment such as the industrial mixer. These controllers are programmed by using a programming language called Ladder logic language. This language is easy to understand and is used by engineers and technicians thus can be changed to suit any particular need. The Industrial mixer is one of the several applications of the programmable logic controller to the control of an industrial process.

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