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FLOW CALIBRATION USING PLC AND SCADA

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ABSTRACT

This paper focuses on a new step in calibration of flow sensors in industries. Manual calibration requires a lot of labour and human resource. This also requires a lot of hard work and patience as the person has to note each and every value at different times by taking readings manually. The person has to take in account the values being given by the sensors and that of the pump or dry block calibrator. In case the reading goes critical suitable corrections have to be made to save the equipment from any damage. Managing all these equipment and taking care of them if they are damaged is a tough task. This paper uses the technology to increase the efficiency and decrease the labour required for the process by introducing automated calibration of sensors.

The proposed system provides calibration of Flow instruments, Data Logging and Printing of Calibration reports by the help of Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA). The proposed model can effectively supervise flow parameters in multiple sections. The PLC controls the process of calibration by taking inputs and producing outputs. A Proportional Integral Derivative (PID) controller is provided for manually overriding the automatic system. The M340 PLC is used as the main decision making module. The system is implemented in SCADA to create the required Human Machine Interface (HMI).

One standard sensor is placed in the system along with one or more test sensors. PLC system receives the input from the test sensors and standard sensors and compares the two readings to determine if the test sensor is working acceptably or not.

1. INTRODUCTION

I. PLC

A **PROGRAMMABLE LOGIC CONTROLLER** (PLC) is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices or PLC for short, is simply a special computer device used for industrial control systems Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

Almost any production line, machine function, or process can be greatly enhanced using this type of control system. However, the biggest benefit in using a PLC is the ability to change and replicate the operation or process while collecting and communicating vital information.

II.SCADA

SCADA (**supervisory control and data acquisition**) is a system for remote monitoring and control that operates with coded signals over communication channels (using typically one communication channel per remote station). The control system may be combined with a data acquisition system by adding the use of coded signals over communication channels to acquire information about the status of the remote equipment for display or for recording functions.[1] It is a type ofindustrial control system (ICS). Industrial control systems are computer-based systems that monitor and control industrial processes that exist in the physical world. SCADA systems historically distinguish themselves from other ICS systems by being large-scale processes that can include multiple sites, and large distances.[2]These processes include industrial, infrastructure, and facility-based processes.

2. BRIEF REVIEW OF PLC AND SCADA

2.1 ARCHITECTURE OF PLC

A Programmable Logic Controller is a specialized computer since it is a computer, it has all the basic component parts that any other computer has; a Central Processing Unit, Memory, Input Interfacing and Output Interfacing. A typical programmable controller block diagram is shown below

The Central Processing Unit

The central processing unit is the control portion of the PLC. It interprets the program commands retrieved from memory and acts on those commands. In present day PLC's this unit is a microprocessor based system. The CPU is housed in the processor module of modularized systems.

Memory

Memory in the system is generally of two types; ROM and RAM. The ROM memory contains the program information that allows the CPU to interpret and act on the Ladder Logic program stored in the RAM memory. RAM memory is generally kept alive with an on-board battery so that ladder programming is not lost when the system power is removed. This battery can be a standard dry cell or rechargeable nickel-cadmium type. Newer PLC units are now available with Electrically Erasable Programmable Read Only Memory (EEPROM) which does not require a battery. Memory is also housed in the processor module in modular systems.

Input Unit

Input unit can be any of several different types depending on input signals expected as described above. The input section can accept discrete or analog signals of various voltage and current levels. Present day controllers offer discrete signal inputs of both AC and DC voltages from TTL to 250 VDC and from 5 to 250 VAC. Analog input units can accept input levels such as ±10 VDC, ±5 VDC and 4-20 ma. Current loop values. Discrete input units present each input to the CPU as a single 1 or 0 while analog input units contain analog to digital conversion circuitry and present the input voltage to the CPU as binary number normalized to the maximum count available from the unit. The number of bits representing the input voltage or current depends upon the resolution of the unit. This number generally contains a defined number of magnitude bits and a sign bit. Register input units present the word input to the CPU as it is received (Binary or BCD).

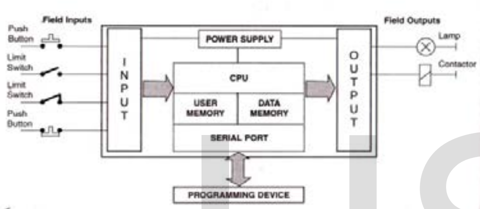

Fig 2.1 Architecture of PLC

Extending PLC:

- Every PLC controller has a limited number of input/output lines.
- If needed this number can be increased through certain additional modules by system extension through extension lines.
- Each module can contain extension both of input and output lines.
- Also, extension modules can have inputs and outputs of a different nature from those on the PLC controller (ex. in case relay outputs are on a controller, transistor outputs can be on an extension module).

2.2 FEATURES OF PLC

- **Flexibility**: One single Programmable Logic Controller can easily run many machines.
- **Correcting Errors**: In old days, with wired relay-type panels, any program alterations required time for rewiring of panels and devices. With PLC control any change in circuit design or sequence is as simple as retyping the logic. Correcting errors in PLC is extremely short and cost effective.
- **Space Efficient:** Today's Programmable Logic Control memory is getting bigger and bigger this means that we can generate more and more contacts, coils, timers, sequencers, counters and so on. We can have thousands of contact timers and counters in a single PLC. Imagine what it would be like to have so many things in one panel.
- **Low Cost:** Prices of Programmable Logic Controllers vary from few hundreds to few thousands. This is nothing compared to the prices of the contact and coils and timers that you would pay to match the same things. Add to that the installation cost, the shipping cost and so on.
- **Testing:** A Programmable Logic Control program can be tested and evaluated in a lab. The program can be tested, validated and corrected saving very valuable time.
- **Visual observation:** When running a PLC program a visual operation can be seen on the screen. Hence troubleshooting a circuit is really quick, easy and simple.

2.3 SCADA AECHITECTURE

a) **Monolithic** (Uses a single PC)
b) **Distributed** (Uses a LAN of PCs with different responsibilities)
c) **Networked** (Capable of connecting multiple LANs)
d) **Internet of Things** (Can report state in near real-time and use the horizontal scale available in cloud environments to implement more complex control algorithms than are practically feasible to implement on traditional PLCs)

2.4 FEATURES OF SCADA

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- **Advance Polling Management:** Replaces expensive master PLC device to poll remote sites. Group and schedule polling cycles for increased efficiency
- **Full Redundancy:** Easily configure automatic failover to back-up server, internet server and I/O links.
- **Historical Data Viewer:** Generate graphs or tablets of historical data that you can annotate and export.
- **Alarms:** Sort or filter current, unacknowledged and historical alarms.
- **Rich Graphic Capabilities:** Photo-realistic meters, switches, animations, grouping, colour and transparent adjustment and over 3,500 images.
- **Display Creations Tools:** Drag & drop tool set and object-oriented scripting language allow simple display creation and limitless customization.
- **Auto-Generated SCADA Display:** VT SCADA creates a display (with I/O and alarms) for each RTU.
- **Security:** Privilege-based user account control access to pages, workstation, internet clients, WAP client and alarm notification system.
- **Report Generation:** Create custom or scheduled report for the screen, printer, file, database or email, Excel or excel templates.
- **Water/Wastewater Report:** Daily total and derived flow, pump run-time discrepancy, communication error summaries.
- **High Efficiency Tag Development:** Special analog and digital tag types features built-in-alarms, logging and report.

3. PROPOSED FLOW CALIBRATION SYSTEM

3.1 BLOCK DIAGRAM

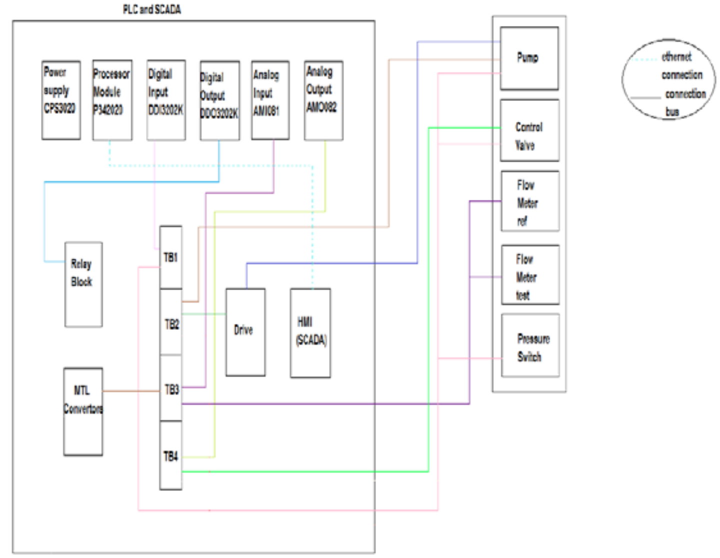

Fig 3.1 Block Diagram of Flow

This system receives readings from various parts of the whole system and takes logical decisions based on it. Different blocks of this system and functionalities are discussed below.

Power Supply

The Power Supply of the PLC is an essential component to running the PLC. The Power supply for a Programmable Logic Controller converts the input source power into voltages required for internal circuitry. In some cases, it also provides an isolated VDC supply to power DC input circuits, switches and other indicators. System uses a CPS 3020 block for supplying power to both racks and is capable of generating 24V to 48V DC supply with the power output of 15W to 31.2W.

Processor Module

The processor, or the brain of the PLC system, is a solid-state device designed to perform a wide variety of production, machine tool, and process-control functions. Conventional electromechanical devices, relays and their associated wiring formerly performed these functions. Processors provide these same functions, in a wider scope and variety of control functions, with minimal effort, making the PLC a much more popular choice. The processor operates on DC power (± 5V), that is supplied by the power supply. Internal DC power is also routed through the processor and operates a portion of the I/O and devices connected to the service port of the PLC. Once the ladder-diagram program is entered into the processor, it remains until changed by the user with one of the programming devices. The program is unaltered through power failure or power off conditions. We are using M340 for this purpose. It has the capability of managing single or multiple racks on which slots can be equipped with:

- Discrete I/O Module
- Analog I/O Module
- Application Specific Module (counter, motion control, Ethernet modbus communication).

Digital Input

Digital input include push-buttons, limit switches, relay contacts, proximity switches, photo sensors (On/Off), pressure switches and more. Digital inputs devices are available in both DC as well as AC and some are voltage independent such as a switch contact. This system uses DDI3202K module for the digital input module. It has 32 isolated channels that mean it can read that many digital at a time. It has a 40 way connector slot for parallel ATA interface.

Digital Output

Digital Output they are transistor, relay etc... This system uses DDO3202K module for the digital output module. It has 32 protected channels. It has a 40 way connector slot for parallel ATA interface.

Analog Input

Analog Input includes temperature sensors/transmitters, current sensors, voltage sensors and others that can convert a physical quantity to a electrical signal. These electrical signals used for PLC input are typically 4-20ma or 1-5vdc. We are using an AMI0810 for this purpose.

Analog Output

This module produces analog output to the modules that need a set point to start continue their function properly, for example, it gives the operating frequency to the pump and it gives set points to the drive block calibrators. We are using AMO0802 module to serve this purpose.

Relay

A relay is an electrical switch that uses an electromagnet to move the switch from the off to on position instead of a person moving the switch. It takes a relatively small amount of power to turn on a relay but the relay can control something that draws much more power. This is a pass through block which take input from DO block and produces switching actions accordingly. It takes digital input from DO block and produces or cuts off AC supply to switch on the equipment that needs to be switched ON/OFF respectively.

Terminal Block

A terminal block is used to fasten or terminate wires. It is often used to connect wiring to a ground or electrical switches and outlets to the mains supply. These act as safety device for the circuits and equipment in the system. Their job is to take the input from one block and forward it to another. A simple design has several single terminals positioned in a long strip, with an insulating frame and a clamping part to prevent the equipment from damaging.

MTL Converters

This block receives outputs of thermocouples and converts it in accordance to be read by AI block. Thermocouples generate output in terms of millivolts but AO block needs a current signal in order to properly read it. This is done by MTL convertors. They convert the voltage signal from thermocouples into current signals of the range 4 to 20 milliamps which readable by the AO block. We are using MTL5575 convertors in this project.

Drive

This is the device that is used to initialize the pump by giving it initial frequency. It may be used to directly give a frequency to the pump. Otherwise AO block communicates with the pump through this block. This is the block that receives a frequency from the AO block and forwards it to the pump.

Human Machine Interface (HMI)

This is the interface that allows a user to keep track of the whole system by standing in front of a screen. This interface is created using supervisory control and data acquisition (SCADA).This allows a user to give set points and pumps from one place without moving about each and every equipment.

3.1.2 Flow blocks

These blocks constitute flow calibration system. This system helps us in finding out if a flow meter is working correctly or not by comparing its output with a standard flow meter. These blocks are described below.

Pump

A pump is a mechanical device that creates suction or pressure to raise or move fluids. Here we are using pump to move water across our calibration system. We are using two pumps, one with a pumping capacity of up to 10,000 litres per hour and another with a capacity of 18,000 litres per hour.

Control Valve

Valve is a device used to control the passage of fluid in one direction through a passage or pipe. Here we are using a control valve that takes input from AO block and opens to allow certain flow of water. If a high pressure is detected inside pipe then the valve has to be opened to prevent any backwards pressure that might be dangerous for the pump. This decision is taken by the PLC system or manually by user.

Standard Flow Transmitter (FT Ref)

This is a standard Coriolis Flow Meter tested and approved by National Accreditation Board for Testing and Calibration Laboratories (NABL). PLC System takes its decision about changing the set points or switching the pump ON or OFF based on the output from this meter.

Test Flow Transmitter (FT Test)

This is the flow transmitter that has to be calibrated using the system. Output from this flow meter is fed to the AI block and it is compared to the output from FT Ref. If it produces acceptable results then it is put to use otherwise it is either discarded or repaired.

Pressure Switch

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. Here it is used to detect the pressure in the flow calibration system. If it rises above a certain point, it sends a signal to DI block which forwards it to processor module and it sends the signal to turn off the pump**.**

3.2 IMPLEMENTATION OF FLOW CALIBRATION SYSTEM

Implementation of flow calibration using PLC AND SCADA involves

3.2.1 Software Description

Unity Pro - IEC Programming Software for Modicon PACs

A unique software platform to increase design productivity and performance of your Modicon M340, M580, Momentum, Premium, Quantum and Quantum Safety applications

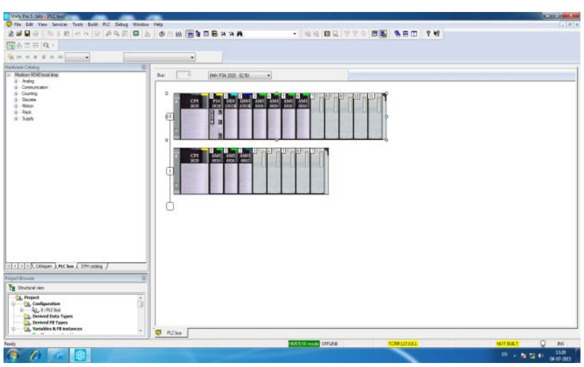

Fig 3.2.1(a) UNITY PRO PLC Bus

SCADA – Vijeo CITECT

Vijeo Citect is a stand-alone control station to redundant supervisor, a solution exists perfectly suited to your specific needs.

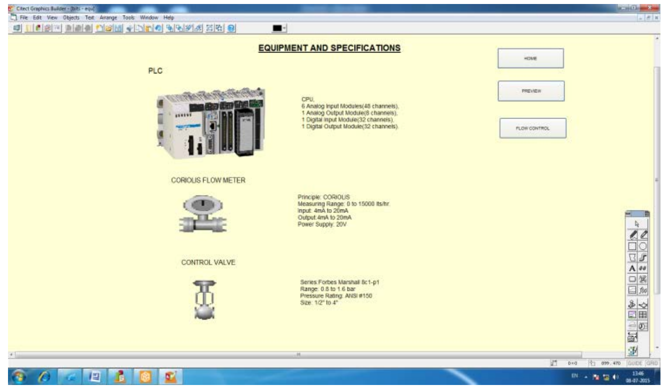

Fig 3.2.1(b) SCADA Equipments

3.2.2 PROGRAMMING:

According to the international standard for programmable controller programming languages, following is a list of programming languages specified:

a) Ladder diagram (LD)
b) Sequential Function Charts (SFC)
c) Function Block Diagram (FBD)
d) Structured Text (ST)
e) Instruction List (IL)

Ladder Diagram:

Ladder logic is the main programming method used for PLC's. Ladder logic has been developed to mimic relay logic. The decision to use the relay logic diagrams was a strategic one. By selecting ladder logic as the main programming method, the amount of retraining needed for engineers and trades people was greatly reduced

Sequential Function Charts (SFC)

SFCs have been developed to accommodate the programming of more advanced systems. These are similar to flowcharts, but much more powerful. This method is much different from flowcharts

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because it does not have to follow a single path through the flowchart.

Function Block Diagram (FBD)

FBD is another graphical programming language. The main concept is the data flow that starts from inputs and passes in block(s) and generates the output.

Structured Text (ST)

Programming has been developed as a more modern programming language. It is quite similar to languages such as BASIC and Pascal. Structured Text (ST) is a high level textual language that is a Pascal like language. It is very flexible and intuitive for writing control algorithms.

Ladder logic

Ladder logic is widely used to program PLCs, where sequential control of a process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hardwired relay circuits. The language itself can be seen as a set of connections between logical checkers (contacts) and actuators (coils). If a path can be traced between the left side of the rung and the output, through asserted (true or "closed") contacts, the rung is true and the output coil storage bit is asserted (1) or true. If no path can be traced, then the output is false (0) and the "coil" by analogy to electro-mechanical relays is considered "de-energized".

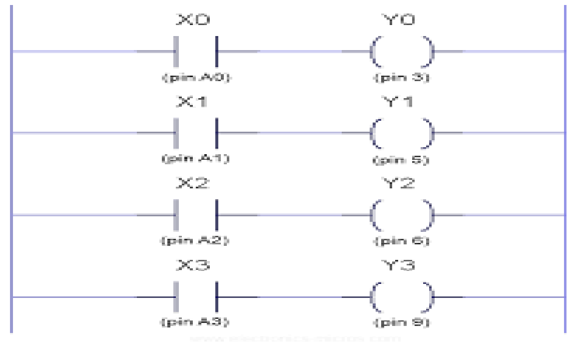
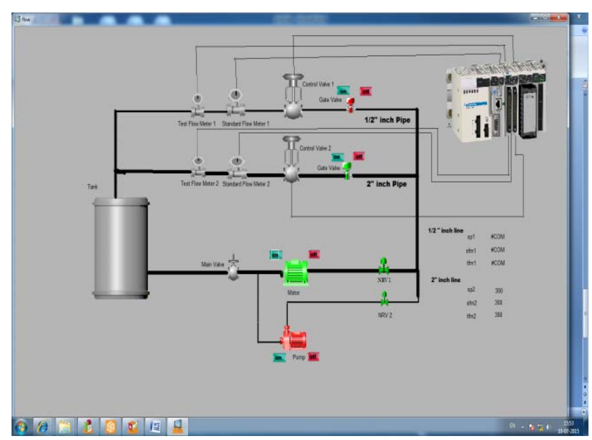


Fig 3.2.2 Ladder Logic

4. RESULT

The Coriolis Sensor is used as Standard flow sensor. The flow sensor values which are sensed by both field and standard sensor is displayed on the HMI. This saves the user from the trouble of manually observing and operating the instruments. Calibration of multiple flow sensors can be done simultaneously, and the report is generated at the HMI by user and stored.



4. SCADA Result

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5. CONCLUSION

This report summarizes all the work we have done on our paper i.e. on "**AUTOMATIC FLOW CONTROL AND CALIBRATION USING PLC AND SCADA**".

It further describes the detailed structure of a PLC, other hardware units and also software used in this paper.

6. FUTURE SCOPE

PLCs are used widely in industries now a days to control many parameters like flow rate, temperature, pressure etc.. PLCs can also be used to mix chemicals in the required quantity automatically. It can also be implemented in educational institutions or domestic applications for filling of water in different blocks from single place through SCADA.

7. REFERENCE

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