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PLC-SCADA Based Industrial Process Monitoring Using GSM Technology

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***Abstract*: In process industries, field buses have dominated the connection establishment between sensors, actuators and controllers. In large scale industries the number of sensors and actuators are greater in number where wiring of such components to the controller involves higher installation cost. Ageing of cables also pose as a great disadvantage as the quality of the cable erodes day by day. In order to overcome this problem a wireless communication can be chosen as an alternative. In this project the Global System for Mobile Communications is chosen for the wireless communication. SCADA stands for Supervisory Control and Data Acquisition, this software provides the necessary details about the process information with animations wherever needed. Continuous monitoring of the process can be done through the SCADA software by interfacing it with an industrial modem which could update us continuously about the process parameters. Upon interfacing, messages will be sent to the corresponding registered mobile number through short message service. The time delay between the instant at which the parameter is actually read and the instant at which the message regarding the parameters reaches the mobile is studied.**

***Keywords*: Cascade, PID, Controller, SCADA**

1. Introduction

Wireless communications, considering many factors, are the rapidly growing segment in the communications field. Due to such reasons media has been strongly attracted and diverted all the eyes towards it. Cell phones have been gaining tremendous popularity since the last decade. At present, there an approximately more than two billion users all over the world. In fact, cell phones are shaping themselves as a business tool and an essential segment of daily routine life in most developed countries. They are uprooting the old conventional cable systems in more number of developing countries. Supporting to that, wireless local area networks (LANs) currently either supplement or substitute wired networks in many homes, industries and institutions. Innovative applications, like networks containing wireless sensors, highway automation, industrial applications, home applications and appliances are developing as high value subjects from simple test subjects. The exponential growth of wireless devices coupled with the spreading popularity of laptops and palmtops clearly visualize a bright future for wireless networks, both as independent systems and as a division of a larger networking facility. Despite so many advantages of wireless networks, many technical hurdles remain in building a reliable wireless networks that delivers the requisite performance to support developing applications.

2. GSM technology

GSM is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in December 1991. As of 2014 it has become the de facto global standard for mobile communications-with over 90% market share, operating in over 219 countries and territories.

2G networks developed as a replacement for first generation (1G) analog cellular networks, and the GSM standard originally described as a digital, circuit-switched network optimized for full duplex voice telephony. This expanded over time to include data communications, first by circuit-switched transport, then by packet data transport via GPRS and EDGE.1900 MHz bands were used instead. In rare cases the 400 and 450 MHz frequency bands are assigned in some countries because they were previously used for first-generation systems. For comparison, most 3G networks in Europe operate in the 2100 MHz frequency band. Regardless of the frequency selected by an operator, it is divided into timeslots for individual phones. This allows eight full-rate or sixteen half-rate speech channels per radio frequency. These eight radio timeslots are grouped into a TDMA frame. Half-rate channels use alternate frames in the same timeslot. The channel data rate for all 8 channels is 270.833 Kbit/s, and the frame duration is 4.615ms.The GSM standard has given birth to wireless services like General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE). Its end users were the first to take advantage of an inexpensive implementation of SMS. The GSM system is the most widely used cellular technology in use in the world today. It has been a particularly successful cellular phone technology for a variety of reasons including the ability to roam worldwide with the certainty of being able to be able to operate on GSM networks in exactly the same way.

3. Block diagram

The overall block diagram of Process Monitoring system is shown in Fig. 1. The essential components involved has been listed below:

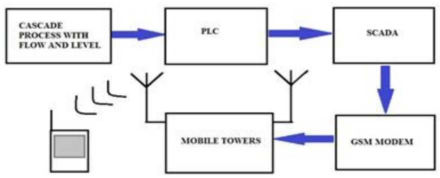

Fig. 1. Block diagram of proposed methodology

This project is mainly focused on the control and monitoring of the cascade control process through PLC and SCADA. The experimental setup is designed to implement the advanced computer control methods which are used in complex processes in the process industries. Various experiments for example, cascade control, level and flow can be configured accordingly and tested with the setup. Basically, a cascade control scheme consists of two loops namely primary and secondary loop. Here the primary controller of the primary loop will be responsible for the level control and secondary controller of the secondary loop will be responsible for the flow control. The primary and secondary controllers will be working based on the PID algorithm. For any cascade controller the secondary loop or the inner loop must be contained with lower delay period to help primary control loop or outer loop to produce necessary control action. Thus the requisite care has been taken to design the PID algorithm for the cascade controller. The type of PLC chosen here is 1762 Micro Logix 1200 Controllers. It contains isolated RS-232/RS-485 combo port for serial and networked communication. Provides four latching or pulse-catch inputs and four interrupt inputs and also includes built-in independent 20 kHz high-speed counter. Offers Programmable Limit Switch function, provides program data security and supports floating point data files. The PID algorithm for both primary and secondary controller is programmed into the programmable logic controller using ladder logic programming. Necessary inputs will be obtained from level transmitter and flow transmitter. The input leads are connected at the input section of the PLC which bears specific address for each and every input terminal and so is the case with output too. These addresses are noted down for sake of ladder logic programming. The ladder logic program can be designed according to the specific necessary cascade control scheme. To monitor the industrial process on a computer screen a graphical representation of the process is needed, which could possibly provide control facility too. One such tool is Supervisory Control and Data Acquisition (SCADA) software, which we are using, is designed by Rockwell Automation. Each and every object which is being created in SCADA screen can be tagged using a tag name which is created in the tag database. Tag Database maintains a list of tags which are configured with an address, which could be either input address or output address from the PLC. These addresses are continuously monitored by the SCADA to provide a continuous real time representation of the process.

A. *Cascade process*

Cascade process is any process that takes place in a number of steps, usually because the single step is too inefficient to produce the desired result. For example, in some uranium-enrichment processes the separation of the desired isotope is only poorly achieved in a single stage; to achieve better separation the process has to be repeated a number of times, in a series, with the enriched fraction of one stage being fed to the succeeding stage for further enrichment. Another example of cascade process is that operating in a cascade process.

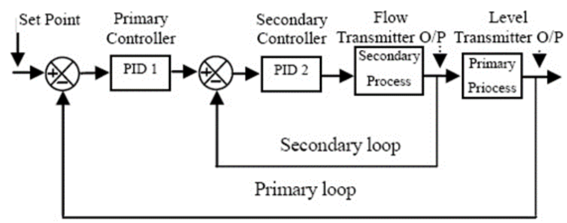

Fig. 2. Cascade control process

When multiple sensors are available for measuring conditions in a controlled process, a cascade control system can often perform better than a traditional single measurement controller. A cascade control system could solve both the transmitter problems. The second controller has taken over responsibility for manipulating the valve opening based on measurements from a second sensor monitoring the steam flow rate. Compensate for inner loop disturbances before they can affect the primary process. The inner loop disturbances are less severe than the outer loop disturbances. Otherwise, the secondary controller will be constantly correcting for disturbances to the secondary process and unable to apply consistent corrective efforts to the primary process. When more than one element can affect a single process variable, treating each separately can make the process easier to control. One process variable that depends on more than one measurement might need more than one controller. Cascade control can also have its drawbacks. Most notably, the extra sensor and controller tend to increase the overall equipment costs. Cascade control systems are also more complex than single measurement controllers, requiring twice as much tuning. Then again, the tuning procedure is fairly straight forward tune the secondary controller first, then the primary controller using the same tuning tools applicable to single measurement controllers.

B. *Level transmitter*

Fig. 3. Level transmitter

Level Sensors detect the level of liquids and other fluids and

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fluidized solids, including slurries, granular materials, and powders that exhibit an upper free surface. Substances that flow become essentially horizontal in their containers because of gravity whereas most bulk solids pile at an angle of repose to a peak.

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, temperature, pressure and etc. The level sensor used for this project is Holykell-HPT600. It is fully sealed submersible level transducer/transmitter. It is made by building in high stable and reliable OEM piezo-resistive pressure sensor and high accurate circuit board in to the stainless steel housing. Integrated construction and standard signal provide the user easy and convenient application in the local working place. The special cable connects with housing, can be immerged into the media for a long time.HPT600 level transducer/transmitter has compact size, light weight and good stability; it can be used for water or liquid measure and control of medicine; metallurgy, electricity, mine, city water supply and drainage and hydrology.

C. Flow transmitter

Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area.

Fig. 4. Flow transmitter

D. Temperature sensor

Fig. 5. Pressure sensor

A thermocouple is an electrical device consisting of two dissimilar conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor.

E. Programmable logic controller (PLC)

A Programmable Logic Controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes such as assembly lines or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis. PLC's can range from small "building brick" devices with tens of I/O in a housing integral with the processor, to large rack-mounted modular devices with a count of thousands of I/O, and which are often networked to other PLC and SCADA systems. They can be designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. More recently, PLCs are programmed using application software on personal computers, which now represent the logic in graphic form instead of character symbols. The computer is connected to the PLC through USB, Ethernet, RS-232, RS-485 or RS-422 cabling. The programming software allows entry and editing of the ladder-style logic. In some software packages, it is also possible to view and edit the program in function block diagrams, sequence flow charts and structured text. Generally the software provides functions for debugging and troubleshooting the PLC software. The software will upload and download the PLC program, for backup and restoration purposes. In some methods of programmable controller, the program is transferred from a personal computer to the PLC through a programming board which writes the program into a removable chip such as an EPROM. Most modern PLCs can communicate over a network to some other system, such as a computer running a SCADA system or Web browser. Under the IEC 61131-3 standard, PLCs can be programmed using standards-based programming languages.

Fig. 6. Programmable Logic Controller

The 1769 compact Logix controllers have one built-in RS-232 port. By default, that port is channel 0 on these controllers. The 1769 compact Logix controller has two RS-232 ports. One port only allow DFI protocol only. The second port accepts DFI and ASCII protocol.

F. Supervisory control and data acquisition system

SCADA is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management, but uses other peripheral devices such as programmable logic controllers and discrete PID controllers to interface to the process plant or machinery. The operator interfaces which enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system. However, the real-time control logic or controller calculations are performed by networked modules which connect to the field sensors and actuators. The SCADA concept was developed as a universal means of remote access to a variety of local control modules, which could be from different manufacturers allowing access through standard automation protocols.

G. Pyhton

Python is an easy to learn, powerful programming language. It has efficient high level data structures and a simple but effective approach to object-oriented programming. Python's elegant syntax and dynamic typing, together with its interpreted nature, make it an ideal language for scripting and rapid application development in many areas on most platforms. Python is a widely used high-level programming language for general-purpose programming, created by Guido van Rossum and first released in 1991. An interpreted language, Python has a design philosophy which emphasizes code readability and a syntax which allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large scale.

4. Results and discussion

Thus the SCADA and PLC system gives us the detailed output obtained from the plant during the period in which we require. The output of the Level, Flow, Temperature and Pressure sensor are obtained from the plant and according to those variables obtained the monitoring of the plant is executed. The Ubidots software is used here to send us the data that we acquire from those sensors and the controlling or monitoring is simplified.

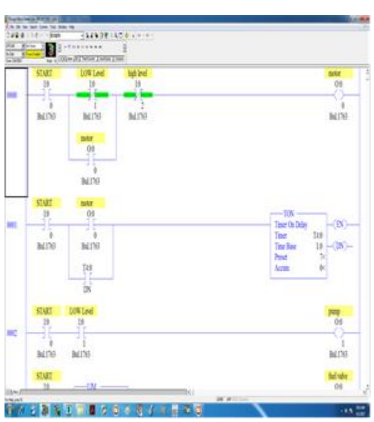


Fig. 7. PLC-rung program

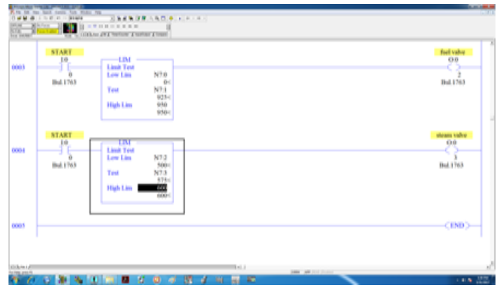


Fig. 8. PLC-rung program

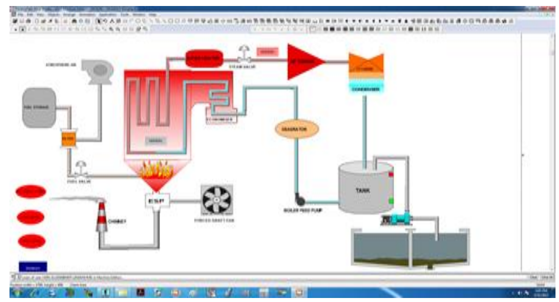
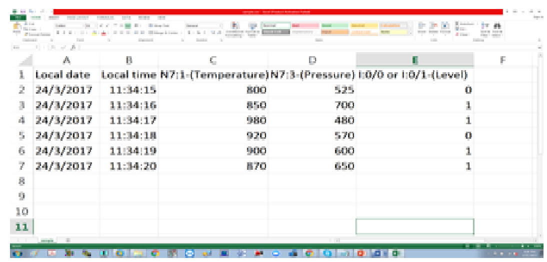


Fig. 9. SCADA design



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24/3/2017	11:34:16	850	700	1
24/3/2017	11:34:17	980	480	1
24/3/2017	11:34:18	920	570	0
24/3/2017	11:34:19	900	600	1
24/3/2017	11:34:20	870	650	1

Fig. 10. Excel output

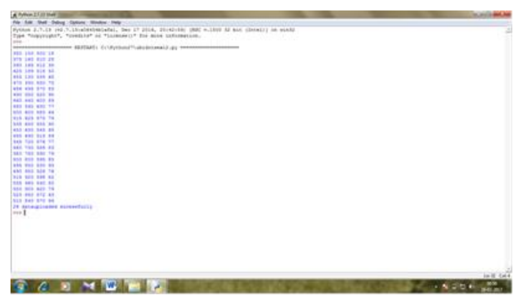

Fig. 11. Python output

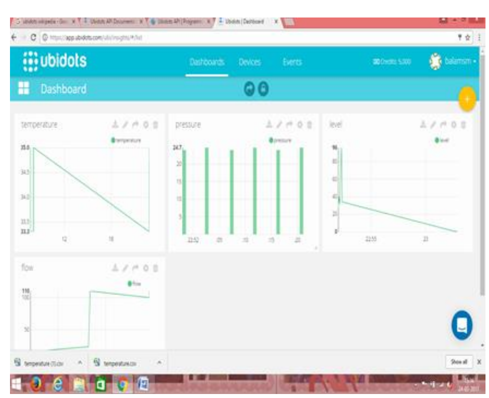

Fig. 12. Ubidots output

Fig. 13. GSM output

5. Conclusion

Remote controlling of process can be enabled in future. Plant Startup and Shut down can be made from mobile. The processes could also be viewed in LabVIEW by making necessary interfacing works with the SCADA. It is also possible to view the process graphs and desired specific parameters on an android device by developing an application dedicated for the process. This project effectively promotes high portability and provides a simple way to monitor the process on the go. The proposed project is completely safe from unauthorized personnel as security username and password are provided to ensure processes' safety. Practically there would be time delay in message services which could be not more than two to three seconds. The main factor holding the project up straight is the modification and development which could be made possibly with available resources

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