PID CONTROL OF FIELD DEVICES AND SCADA INTEGRATION WITH IIOT

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Abstract - *Industrial communication systems represent one of the most important innovations of the last decades in the context of factory and process automation systems. They are networks specifically designed to cope with the tight requirements of these challenging application fields such as real time, determinism, and reliability. Moreover, industrial networks are often deployed in environments characterized by strong electromagnetic interference, mechanical stress, critical temperature, and humidity. Over the last three decades, different classes of industrial networks have been developed according to changing requirements and available communication and information technologies. In this project we control the mainline pump in a crude oil pipeline using a PID controller. The logics for mainline pump is done using the FBD logic in RTU. We then gather field data to RTU to which the field devices are connected by hardwiring. Then the data is viewed in SCADA using DNP3 and/or MODBUS communication protocols. Here we use MODBUS protocol when DNP3 communication fails. For MODBUS communication we use a GPRS modem through which we get the data to SCADA. The data observed in SCADA system can also be monitored by other authorized users in different locations who have access to a SCADA system in the same network. If both fails, the data is sent through MQTT protocol. And the Data/Alarms can also be monitored in the mobile device using dedicated application. We use python scripting for the IIoT applications. In the next part, we address the future perspectives focusing on new methods, standards, and fields of application for monitoring the data. In particular, we consider MODBUS, DNP3, Message Queuing Telemetry Transport (MQTT), Python, Industrial Internet-of-Things (IIoT), and high-performance LANs, and Ethernet networks for communication.[1]*

***Key Words*: IIoT, MODBUS, DNP3, MQTT, SCADA, RTU, FBD LOGIC, PLC.**

1. INTRODUCTION

The term "Industrial Communication Systems" refers to networks typically adopted in factory automation, manufacturing and process control to implement data exchange between controllers, sensors, actuators, input/output devices, any industrial equipment in general. Industrial networks were first introduced in the early 1980s and, since then, their growth has been impressive in terms of performance and market share. Initially, conceived as mere replacements of point-to-point connections between controllers and sensors/actuators, characterized by limited performance, network size, and spatial extension, these networks rapidly became the backbones of factory automation and process control systems. Over the years, new protocols were designed taking into account novel concepts from the IT world, and performance was improved thanks to the technological progresses.[2]

The Internet of Things (IoT) concept allows objects to share data through wired or wireless connections for communication purposes. The Industrial Internet of Things (IIoT) is an extended concept of IoT that refers to an integration of Data Acquisition, Communication, and Processing of a real time networks. As the operating of systems is extremely time crucial, low-latency lightweight messaging protocol communications need to be considered for most control and monitoring applications. Real-time capability of IoT is considered as a key feature for monitoring and control applications of industrial systems. Therefore, system operators can use the real-time monitoring system to provide better decisions.

The SCADA system adheres to Client/Server architecture and provides the real-time scanning of RTUs. In this project, there are two stations Main Master Control Station (MMCS) and the Backup Master Control Station (BMCS). The SCADA servers at MMCS & BMCS are configured in Quad hot-standby redundancy mode for ensuring maximum availability of SCADA system in various failure scenarios.

It provides all facilities such as multi-tasking, multithreading, multiprogramming, pre-emptive scheduling, asynchronous I/O operations, task synchronization mechanism etc. The RDBMS (Remote Data-Base Management System) software ensures open connectivity by making the information available in a standard, known manner.

For MQTT there is a dedicated library for accessing the data for remote monitoring of the data. Python language is used for scripting. The MQTT design principles are to minimize network bandwidth and device resource requirements whilst also attempting to ensure reliability for mobile applications where bandwidth and battery power are at a premium with some degree of assurance of delivery.[3]

The devices cannot be controlled from the remote android devices because of security concerns. It can only be controlled from the SCADA servers or by the SCADA HMIs which are in the network.

This project mainly aims to provide a practical application that can be implemented in a real industrial system.

1.1 SCADA

SCADA stands for Supervisory Control and Data Acquisition. It is a complicated complex of high-tech hardware and software designed to automate the management of industry, transport and technological operations and equipment in the production as a whole and on separate areas. SCADA applications are diverse and could affect all large-scale (Multi-threaded, multi-stage, continuous, etc.), critical or hazardous industrial production cycles. SCADA constitutes a critically important infrastructure whose components are objects of national economic complex maintaining spheres of life activity, the failure of which can affect the national security, even might cause emergency situations in government level and scale. Specificity of SCADA security is due to its technical features: the distribution of components and the heterogeneity of the information and the software component, the geographical remoteness of segments and objects of information and control. The advantages of SCADA are incompatible compared with traditional approaches, especially in the field of ensuring the reliability and security.[4]

1.2 SCADA System

The SCADA system developed provides fault isolation operation, monitoring and controlling functions for the operators and data collection for future analysis. RTU will initiate the transaction with the digital input and output modules. Two proprietary software systems are used are to develop algorithm for the controller and to develop HMI for monitoring and controlling functions for the operator. [1]

Control systems designed to monitor processes are referred to as data acquisition systems. If the system allows also remote control to function based upon the acquired data, it is referred to as a SCADA system. Modern SCADA provides proper monitoring of equipment to maintain operations at an optimal level by identifying and correcting problems before they turn into significant system failures. A SCADA system gathers information, such as where a leak on a pipeline has occurred, transfers the information back to a central site, alerting the home station that the leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. It uses other peripheral devices such as Programmable Logic Controller (PLC) and discrete Proportional Integral Differentiator (PID) controllers to interface with the process plant. [2]

2. METHODOLOGY

In this project we are considering a mainline pump as a field device. We are controlling the mainline pump using PID controller. The complete logic part is done in Logic Designer which the RTU supports.

We use this PID controller to vary the speed of the mainline pump according to the requirement. It can be manual or automatic depending on the necessity. The operator sets the "set value" so the PID controller adjusts the speed of the pump. Then the data is fetched to SCADA system from RTU via DNP3 protocol.

It is primarily used for communications between a master station and RTUs. It makes use of cyclic redundancy check codes to detect errors.

The RTU is initially interrogated with what DNP3 terms an "Integrity Poll". This causes the RTU to send all buffered events and all static point data to the Master station. Following this, the Master polls for the event data. The protocol is robust, efficient, and compatible with a wide range of equipment.

In the SCADA system the data is acquired and monitored by the operator for further control decisions. The field values are seen in the HMI as a graphical representation in order to enhance the understandability of the process and carefully monitor the major parts of the system. Each user has a separate login for the system which has different authorization levels in-order to prevent errors.

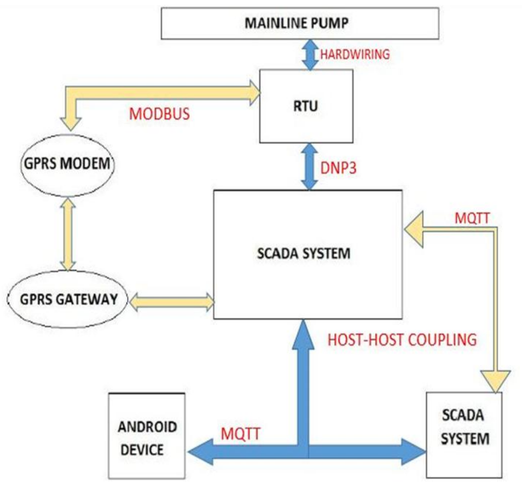


Fig -1: Block diagram of the system.

In case the DNP3 communication fails, the data is acquired through MODBUS TCP/IP communication protocol. The operator at the station can read/write values to field devices from the HMI.

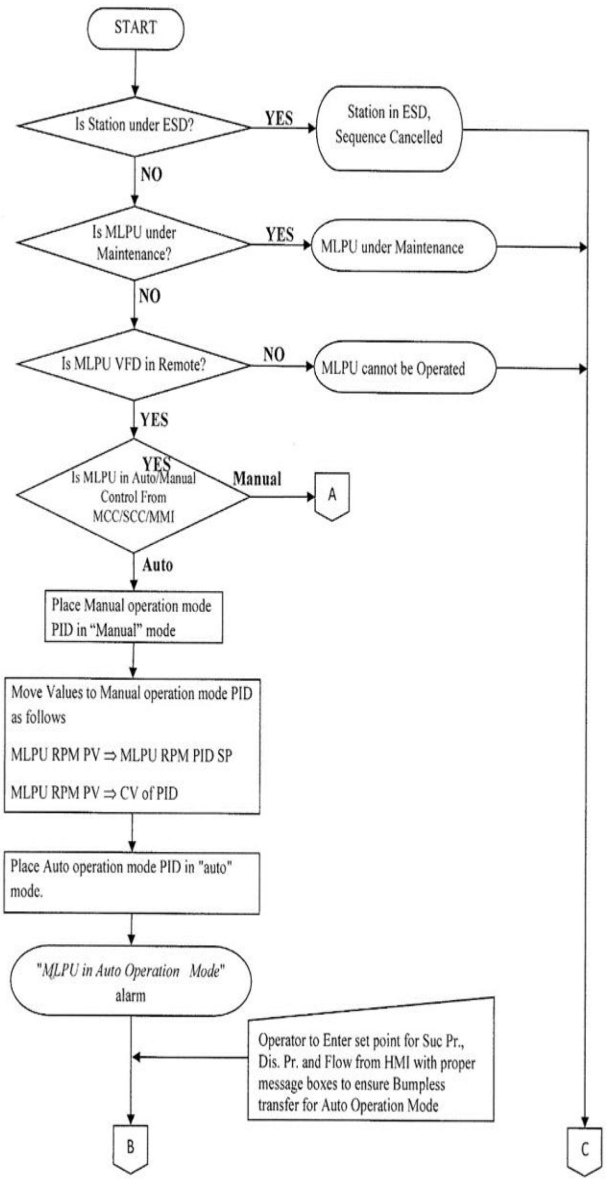
In MODBUS communication the data is sent to GPRS modem (client) to GPRS gateway then to SCADA system. Cat-6 Ethernet cables are used. The data from SCADA system is then transferred to SCADA system in different geographical locations via HOST-TO-HOST native FAST/TOOLS communication protocol. This is done within the SCADA software by creating a setup-file as per requirement. If there is some hardware failure, then the data is sent through MQTT using python. Using a dedicated library FAST/TOOLS data is fetched and published to a broker. We use MOSQUITTO as a broker. The SCADA system which needs the data subscribes to the publisher through the broker.

The data is also sent to android mobile device through MQTT. No graphic displays can be seen. We can only read/write data to a field device in case of an emergency.

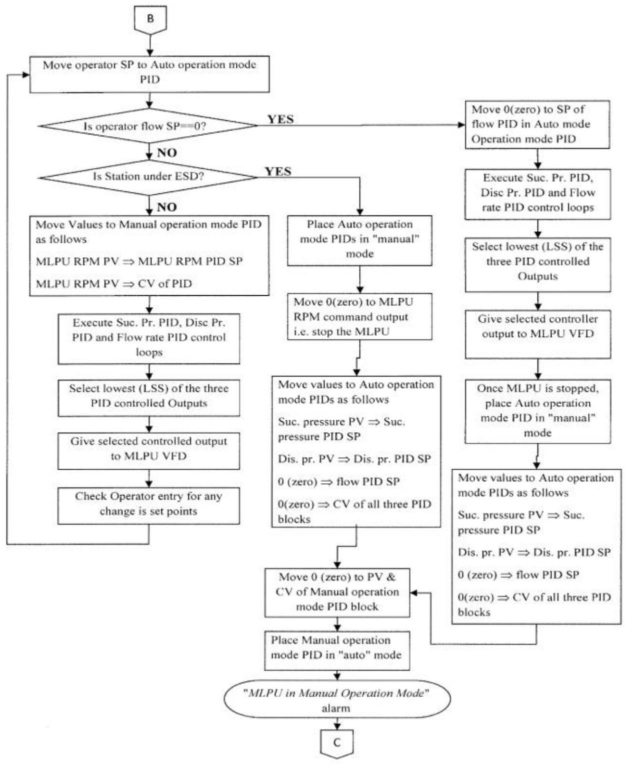
2.1 Flow Chart

The following flow chart shows the actual speed controlling of the mainline pump in a crude oil pipeline using PID controller.

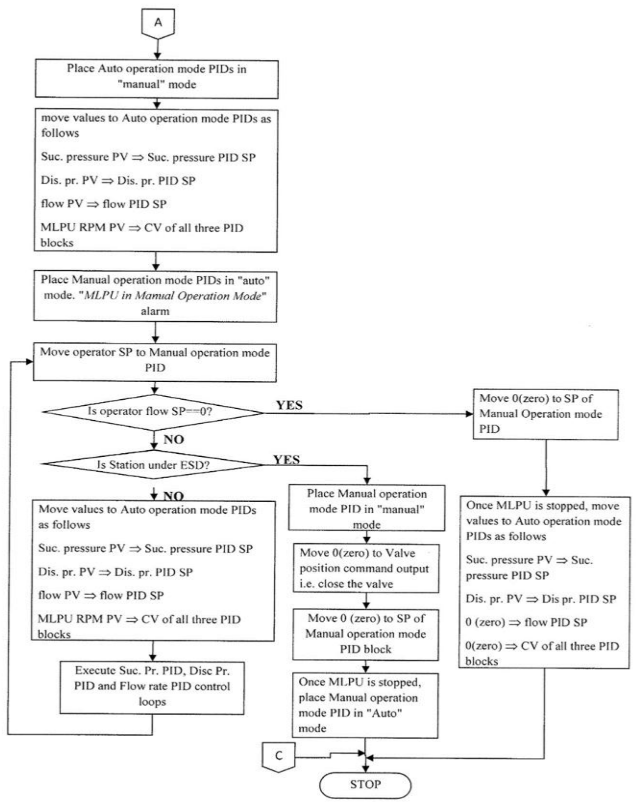
MP PID Logic for Speed Control (Page-1)



MP PID Logic for Speed Control(Page-2)



MP PID Logic for Speed Control(Page-3)



MLPU - Mainline Pump, PV – Process Value, SV – Set Value, CV – Corrected Value, ESD – Emergency Shutdown, VFD – Variable Frequency Drive.

Logics are done in Functional Block Diagram (FBD) language according to the flow chart. Each and every value and status of the field instrument value are monitored in SCADA system. If any of the values exceed the threshold limit then alarms are generated and if required necessary actions are taken automatically which is programmed beforehand. The alarms generated can also be stored for future purposes.

3. CONCLUSIONS

The speed of mainline pump is controlled according to the requirement by operator in control station.

Data is successfully and precisely acquired by SCADA system The necessary alarms and data is monitored and can be controlled by SCADA system in different location via MODBUS/DNP3 communication protocol.

The data is sent and can be controlled by a mobile device by MQTT.

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