INDUSTRIAL FIELD INSTRUMENT PROGRESSION TO SMART DIGITISATION ENABLING IIOT

1.0 Synopsis

Consistent technology maturity over centuries in industrial automation domain firing off from field instrumentation to control system(s) enables more plant productivity, more automation enabling stress free life for plant operators, remote monitoring and operation of plants including but not limited to critical data availability on mobile phones empowering supervision and expert advice/controls from anywhere across the globe with internet access.

Automation is motivated by the fact that machines are more proficient when compared with human beings at measurement, indication, monitoring, communication of data; controlling plant data with accuracy, reliability and consistency. Further, revolution in digital technology has led to the development of multiple innovative methodologies easing adaptive and preventive plant maintenance, plant inventory and asset management, plant administration and people management. Latest data consolidation and analysis tools benefit industrial organizations by assisting in determination and resolution of problems quickly reducing plant down time saving cost. Consequently, advanced innovative analysis tools reduce overall plant operating and maintenance expenditure, thus promoting intelligent automation initiatives of the company.

With the increase in pace of technological changes, plant operators can no longer maintain a “cold shoulder” attitude toward modernization. Today’s smart field instrumentation are state of the art IIOT ready breakthrough developments in comparison with pneumatic field instrumentation conceived few decades ago. Even the mobile phones we bought just one year back is already obsolete. As legacy field instrumentation and control systems age and OEM (Original equipment manufacturer) support for older equipment ceases, it would be increasingly challenging to maintain existing plant facilities.

This article presents a brief outlook regarding the historical and latest development, trends in industrial plant automation in coalescence with industrial internet. It further highlights progression of field instrument devices and advanced control systems towards smart digitization and trends in measurement and controls technology applications, IIoT(Industrial internet of things) benchmarks a major significance with potential in industrial automation where in there is an increasing thrust on cost reduction, maintainability, operability, sustainability, green environment and quality control.

2.0 Field instrumentation- an introduction

Field instrumentation is a standard term used for measuring instruments utilised for indication, recording and transmission of measured physical quantities of parameters like flow, pressure, temperature, level, differential pressure, etc.

Industrial field instrument measurements have evolved from traditional measurement techniques based on manual measurement, pneumatic instruments, electronic instruments with 4 to 20 mA output, electronic instruments with HART protocol superimposed 4 to 20 ma output, Field bus/Profibus compatible transmitters to wireless transmitters. However, plant operators are inching towards smart digitization of plants although they have not been primary adopters

despite quantum surge in multiple directions in state of art technology which has left them mystified and reluctant.

3.0 Field instrument evolution

3.1. Pneumatic instruments work on instrument air or instrument gas supply generally at a pressure of 3.5 to 4 bars with signal output of 0.2 to 1 bar based on force balance principle for indication, recording and control applications. These instruments were robust, required more space, and could be fitted with a local indicator for viewing process value. Data was usually recorded by a technician manually on a record sheet. However, local chart recorders were later developed for automatic saving of data for recording and analytical purpose. Challenges faced with pneumatic instruments were uninterrupted instrument air/gas requirement, huge space, Noise levels and manual recording in case of chart recorder non availability.

3.2. Pneumatic instruments are superseded by electronic instrumentation which gained more popularity and are in current use considering the ease of availability of electric power supply for their operation, reliability, cost, ease of maintenance. Electronic transmitters for measurement of pressure, level, temperature, flow were developed to ensure better characteristics of measurement systems with the introduction of loop powered transmitters; generally 4 wired {2 wires for power supply, 2 wires for measured variable signal output). Sensors used for measurement in electronic transmitters include Strain gauge , capacitance, potentiometric, piezoelectric, magnetic, inductive and optical transducers for pressure measurement; thermistors, resistance temperature detectors, thermocouples, etc. for temperature measurement; capacitance and radio frequency, conductivity, diaphragm, float, displacer, laser and radar (electromagnetic waves) for level measurement; orifice plates, pitot tubes for flow measurement. Laminar flow meters, magnetic flow meters, positive displacement meters, mass flow meters, ultrasonic flow meters, V cone flow meters, multiphase flow meters, etc. widely used for flow measurement based on application requirement.

Most widely used electronic transmitters are 2 wire transmitters with 4 to 20 ma output wired to central control system located in remote plant control rooms for plant monitoring and control applications. Electronic transmitters available today are generally 2 wire, 24 V DC powered from control system to which they are connected with 4 to 20 mA HART (Highway addressable remote transducer) superimposed output.

4.0 Developments and trend

4.1. HART enabled transmitters could be connected to HART management system/ Smart transmitter management system in a remote control room wherein it is possible to configure transmitter range and also, monitor transmitter diagnostics based on the huge data collected in Hart management system. Development of HART enabled transmitters lead to a new era of remote configuration and monitoring system diagnostics. Few HART management systems by OEM's are empowered with advanced diagnostic capabilities including but not limited to process monitoring statistics which provides capability to help plant operation and maintenance personnel to focus on devices and equipment that need maintenance, identify devices and equipment that could be underperforming, identify impulse pipe/tube blockages, fluid

composition detection and hence, reduce process downtime by elimination of predictive errors. In today's world, most of the industrial plants like Chemical, Oil and gas, Power are equipped with HART/ Smart transmitter management system enabling operating and maintenance personnel to sit in the comfort of centrally air conditioned control room and configure, review diagnose, adopt predictive and preventive maintenance of field instruments.

4.2 Microprocessor based digital controllers provide output of 4 to 20 milli ampere signal. In addition, digital controllers with HART communication protocol give access to digital information critical to operating process application. Information regarding sensor, instrument and process could be obtained from these field mounted digital controllers in associated control system enabling remote monitoring on a single loop basis.

These instruments could be queried digitally for information as required, or configured in Burst mode to regularly transmit all information digitally. However, in multi drop mode - output current of these controllers is fixed at 4 mA, and only digital data is transmitted to control system. These are generally utilised for remote inaccessible parts of industrial plant with limited number of local control loops.

4.3 Parallel innovative developments in industry include:

i. Dual input transmitters like temperature transmitters wherein redundant inputs from duplex RTD's or duplex thermocouple could be connected increasing sensor availability for important applications

ii. Transmitters with dual relay output alarms. Applications wherein minimum measuring instruments are to be utilised for multiple functions (Transmit, switch and alarm) warranted this technological development.

iii. Non-contact type sensors like RF, Radar type for level measurement.

iv. Heat flux sensors for temperature measurement with comparable accuracy wherein the sensor is surface mounted preventing process intrusion.

v. 3D mapping level scanners for measuring level and/or volume of solid material provide continuous online volume measurement in addition to display graphics of contours – Zenith and valleys within the container enabling visualisation of material formation which plays an important role in monitoring and preventive maintenance as asymmetrical sidewall loads caused by irregular filling and evacuation can cause containers to collapse followed by devastating consequences.

vi. Enclosure protection for transmitters for protection against dust, water and hazardous area. Depending on the plant location and plant owner's requirement, instruments complying with applicable codes and standards like IEC, DIN, NEC, ATEX could be selected

vii. Safety integrity level (SIL) certified electronic transmitters and valves to meet the safety requirements of plant to ensure personnel and equipment safety. SIL certification is generally

specified in Oil and Gas, Chemical industries wherein plant equipment are located in Hazardous area.

viii. Recent advancement includes foundation field bus, profibus compatible transmitters which are installed in few plants. Plant owners initially implemented the same for few simple loops like temperature loops for monitoring applications. Field bus and profibus based transmitters could reduce installation and maintenance cost in comparison to traditional wiring practices. However, due to compatibility issues with control systems, lack of distinguished applications and plant operator familiarity - referred technology is yet to be utilised to its fullest potential.

The overall process industry accuracy of field bus compatible instrumentation results in less wastage, capacity utilization and improved product quality. These installations have an edge for retrofit jobs subject to compatibility with existing control system; mainly due to interoperability, wiring cost saving, flexibility in control implementation and increased field information for better predictive maintenance.

ix. Supplementary development in field instrumentation includes the introduction of wireless transmitters. These are being utilised for few remote applications wherein clear line of sight is available and it was not feasible to run cables over long distances due to difficult topography and long distances. Use of wireless technology also reduces installation and maintenance cost. Current applications include transmission of data from remote sea water or river intake pump house or remote oil tanks to Main plant control system for remote monitoring applications in power plants.

Wireless field instrumentation with wireless gateway is seamlessly integrated with plant control systems. Generally, less time critical sensor data like tank level, PH, Conductivity, vibration, etc. for monitoring and predictive maintenance are transmitted over wireless communication.

Wireless solutions are implemented for specific applications in process industry, which improves productivity, energy efficiency with less investment and time.

The main distinction among HART, foundation field bus, profibus and wireless systems are their functional competency and related intricacies. HART enabled field instruments generally deliver a single output signal – Eg: 4 to 20 mA with limited diagnostics and installation is simpler being the conventional wiring practice being followed for decades. However- profibus, foundation fieldbus and wireless HART instruments provide multiple signals and diagnostic messages from originating field instrument to remote monitoring and configuring system or control system which could impose exhaustive, methodical and meticulous design considerations and execution to ensure unperturbed maintenance.

5.0 Conclusion:

Advanced technology has driven many plant operators to modernise existing plant facilities. Also, as legendary field instrumentation phases out and original equipment manufacturer (OEM) support for prior field instrument versions decline, plant operators would find it increasingly challenging to keep plant facilities operational. In few instances, removal and replacement of

older field instruments could be grueling in view of availability of same product considering OEM's quest to maintain their product's competitive superiority.

With introduction and phenomenal growth of Industry 4.0, IIoT, cloud technology, data analytics driving transformation; cutting edge IIoT ready field instruments have revolutionised process automation with ability to communicate digital process and diagnostic information incessantly, thus augmenting data transfer capabilities between field instruments and rest of world systems like distributed control system/ programmable logic controller/ local control panels.

Current day field instrumentation has a variety of advanced features ranging from non-contact type sensors, HART, Profibus, Fieldbus, POE (Power over Ethernet) enabled wireless transmitters, etc. to 3D visualization providing efficient and transparent means of collecting process as well as field instrument diagnostics and hence could be coined "IIoT ready" devices. Collective data hence compiled in the field instrument connected control system is utilised for visualization, analysis and optimum control enabling appropriate asset management.

Smart sensors and wireless sensors are considered as nodes with content awareness and huge potential for enabling IIoT depending on application. IIoT connects intelligent physical entities (sensors, devices, machines, assets, and products) to each other, to internet services, and to relevant applications. Further, Smart sensor/ control systems connected to the internet allow greater business efficiency by enabling remote process monitoring, predictive system maintenance, process control and production data analysis of multiple plants from a single remote location. Digitally networked architecture of industrial controls powered by field intelligence improves plant performance, diagnostics and monitoring.

Thus, field instrument digitisation is an enabling technology providing end users with the freedom to choose & integrate the best in class automation solutions. Development and use of controls in field devices could give new dimension to the control strategy by taking remote control blocks to field instruments for faster response, reduced data transmission errors, reduction in load on remote control system(s), cost reduction due to decrease in hardwired interfaces / components. This technology is maturing and evolving with superior reliability of digital networks in comparison with hardwired analog systems.

From industrial system's architectural viewpoint, it is significant that plant field instruments and control system are flexible to interface over any of the standard bus (Field bus, Profibus) or wireless protocols, allowing ultimate autonomy to plant operator based on their business, technical and comfort requirements. Also, there is tremendous thrust to integrate all intelligent field devices that have not been traditionally interfaced directly with process automation systems, notably intelligent electrical devices like numerical relays which are generally integrated over IEC61850 communication protocol standard enabling advanced electrical system automation ensuring integrated comprehensive power management.

Considering latest developments, it is imperative that IIOT enabled digitised field transmitter cum controllers are developed and utilised for local process controls and data transmission over wireless / wireless HART technology to remote cloud based control rooms for applications including but not limited to water / fluid conveying pipelines over long distances through difficult terrain. Possibly, we could have common control system for similar multiple plants working on time and load sharing basis which would benefit humankind to a large extent by reducing operation cost and E waste, thus creating a better environment and smarter digital life for future generations. Typical configuration is depicted in Figure 1.

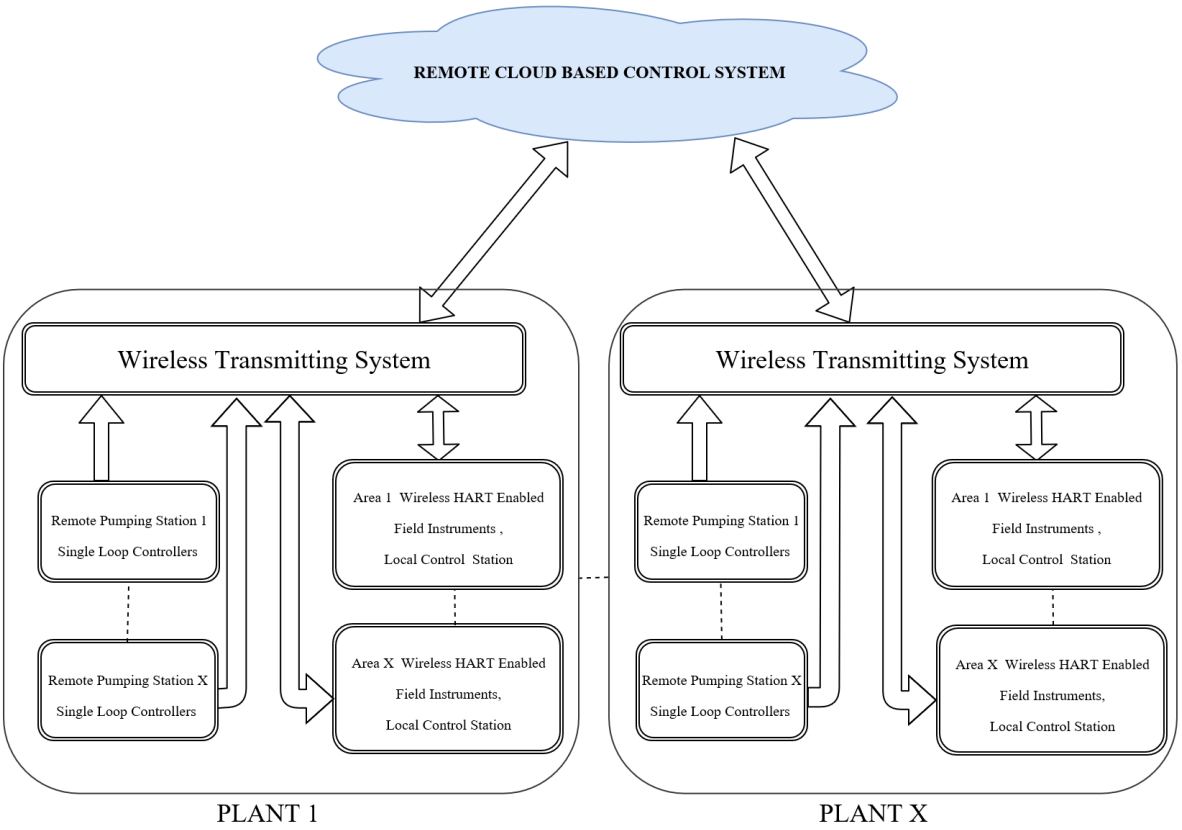

FIGURE 1: Typical configuration

Progressive, revolutionary and quixotic future generation would associate better with companies using latest technologies with smart, well regulated, intuitive and governable systems located in a modern workplace or from the comfort of their home base. Synergy of advanced technological developments improve availability, reliability and efficiency, also promoting reduction in preventive maintenance, calibration, instrument failures and improved plant lifecycle. These readily available advanced features of field instruments and further progressions are to be utilised effectively optimising operational requirements of plants.

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