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RESEARCH ARTICLE

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Study of Distributed Control System for Gas Processing Plant

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ABSTRACT
Control systems have taken over most of the industrial scale processes that were performed manually before. The overall control actions and monitoring of the entire process can be performed from a central control station or control room. This concept of centralized control and monitoring is realized using a Distributed Control System or DCS. The excellent control features and reliability of the DCS makes it suitable for implementation in the process industry, especially for critical area plants such as Oil/gas plants, refineries, power plants, nuclear plants and also for normal plants such as Food processing, Textile industry, water treatment plants etc.
Keywords: Distributed Control system, DCS, Process control, Industrial process control, Gas plant control, ESD.

I. INTRODUCTION

Designing and commissioning of large scale process plants are a reality due to the advancements made in the field of process control and Automation. [3]For the design of process plants in the Oil & Gas industry sector there are different design constraints, safety is the primary design constraint while designing processing plants for the Oil & Gas industry, hence all the different international safety standards and norms should be satisfied.

The main control action is performed by the Distributed Control System (DCS), in case of any emergencies during the process the Emergency Shutdown (ESD) system comes into action and shuts down the plant in a controlled manner. If the ESD system fails or there is an outbreak of explosions and fire the F&G or Fire & Gas system takes over the plant control and initiates action to reduce the damage caused and prevents the further spreading of the fire. In this case the software used for the Distributed Control System is Centum VP (Vigilant Plant), the Logic designer tool present in the software is used for implementing the control logics for the Distributed Control System (DCS), Emergency Shutdown system (ESD) and Fire & Gas (F&G) system.

II. METHODOLOGY

The overall design of the plant is done based on the logics for the functioning of all the different field instruments present such as Transmitters, Actuators, Valves etc., along with the Piping & Instrumentation Diagrams (P&ID)available. [6]The total number and type of Input – Output is assessed based on this document. Predefined function blocks are used for compiling the logic programs. The Field Controller Station (FCS) is loaded with these developed function blocks to perform the overall control scheme. The design and implementation of the ESD and F&G systems are on the basis of the Cause & Effect matrix.

All the hardware systems are redundant in nature this approach of redundancy is to prevent the failure of the complete control system in case of a single module failure [2]. By default the communication protocols and the overall control logics used will be largely proprietary depending on the supplier of the control system.

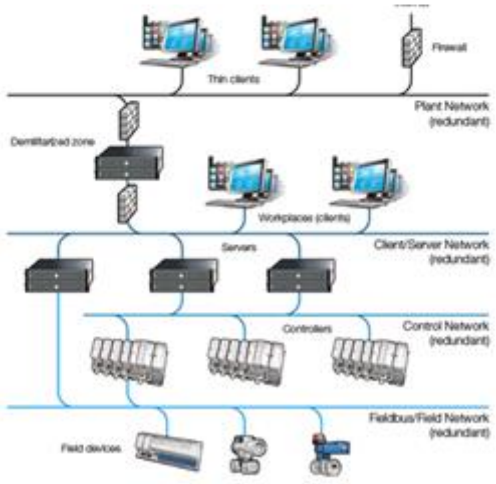

Figure 1.1 Block Diagram of Distributed Control System

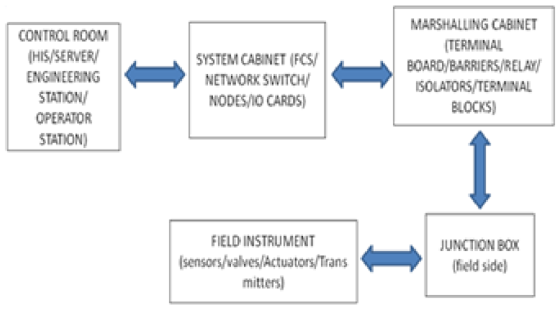

Figure 2. Block Diagram of Signal flow in Distributed Control System

The Output signal from the DCS is generated at the Human Machine Interface (HIS) by the engineering operator, this goes to the System cabinet which houses the Field control station node, Network switches, the power supply and IO module cards. The FCS is essentially the DCS controller. The signal after processing passes to the Marshalling cabinet which consists of different components such as Terminal boards, intrinsic safety barriers, relays, Terminal blocks, Isolators etc. from here the signal travels to the Junction boxes wherein the signals are paired and sent to the appropriate sections in the field area.

A. Hardware Design Criteria: The power distribution of the system is a major design criteria. The power is taken from UPS and Non – UPS power supply. There are mainly 3 types of cabinets System cabinet, PDB cabinet and the Marshalling cabinet.

1) Field Control Station & Input-Output Module Design Criteria: The field control station acts as the controller of the Distributed Control System (DCS). It is connected to the Human Interface System (HIS) via Ethernet cables through the network switches. There are 2 quantity of FCS present together to make the system redundant in nature.

[1]Features of FCS are**,**

- Processor card : VR5432 at a frequency of 133 MHz
- Main Memory : 32 MB Random Access Memory (RAM)
- Battery Backup : Max of 72 hours
- Node Units : 14 no's-Input
- Output Signals : total upto 5000

The I/O modules are assigned based on the type of signal being considered. There are many different types of communication modules such as Analog input module, Analog output module, Digital input module, Digital output module, Analog Input-Output module.[8] These modules can be for current reading (4-20 mA) or for reading voltage. Analog I/O modules are either 8 – channel or 16 – channel. The digital I/O modules are 16, 32 or 64 channel; they are further classified on the basis of voltages as 24V, 110V or 220V DC. There are also modules dedicated for relay output.

*2) Design criteria of Cabinets:*Cabinet dimensions are standard and are designed to house all hardware components neatly and efficiently. Heat dissipation is an important constraint while designing cabinets; hence fans are provided for proper ventilation along with air filters to prevent dust and other particle entry into the cabinet.

Fuse ratings, wire sizing and number of hardware components such as MCB's, Terminal blocks, relays, Terminal boards, and safety barriers are quantified for perfectly fitting inside the cabinet.

3) Power Consumption & Heat Dissipation: The flow of current through the hardware components with respect to the overall Heat dissipation is calculated using the formulae,

Case 1: 240V AC power supply

$$I = \frac{Power}{Voltage * Power\ factor}$$

Case 2: 24V DC

$$I = \frac{Power}{Voltage}$$

Heat Dissipation at full load in case of AC voltage,

$$KCal\ per\ Hr = VA * Cos\ Q * 0.86$$

Cos Q=0.8 unless specified otherwise.

[5]Failure of the power supply can be due to a number of reasons such as,

- Hardware components defect.
- Voltage and Current Transients.
- Overheating &Overloading of the system.
- System failure caused by wear & tear.

4) Types of signals: There are mainly 2 types of signals,

Intrinsically Safe (IS) signals are those which are used in Hazardous areas, since they are well below the voltage level needed to produce sparks for ignition in an explosive area.

Non- Intrinsically safe (NIS) signals are used in Non- Hazardous areas.

The signals from the DCS to the field instruments are considered as Output signals by default and the signals from the field instruments to the DCS are considered as Input signals.

All the Analog signals coming from the field instruments are in the form of 4-20 mA signals. The Digital signals from and to the field are in the form of Voltage.

Different types of wiring connections are also present such as 2-wire, 3-wire and 4-wire connections. [7]The signal is through the positive and negative is grounded in the case of 2-wire, 3-wire connections are mainly for usage with RTD's and are for voltage, signal and ground. 4-wire connections have the supply voltage of the field instruments also sent along with the normal signal wires.

5) Cabinet Grounding scheme: Different types of cables such as Prefabricated (Pre-Fab) cables, power cables, CAT5E cable, and RJ45 connector cables are used for interconnectivity between the cabinets.

3 types of grounding schemes are followed,

- Panel Earthing
- Shield Earthing
- System Earthing

Intrinsic safety barriers, Terminal Blocks, Terminal Boards, I/O cards

Figure 3. Sample picture, FCS of Distributed Control System with IO cards, Power supply and Controller

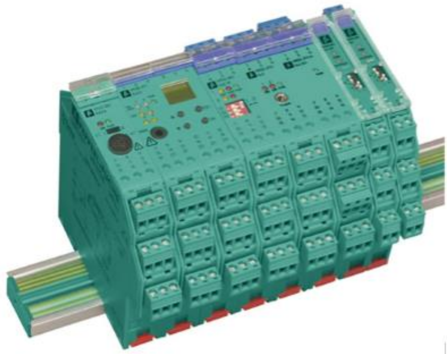

Figure 4. Sample picture of Intrinsic Safety Barriers

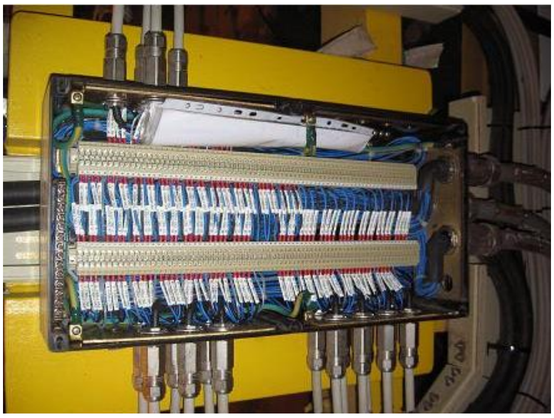

Figure 5. Sample picture of Junction box with field wirings

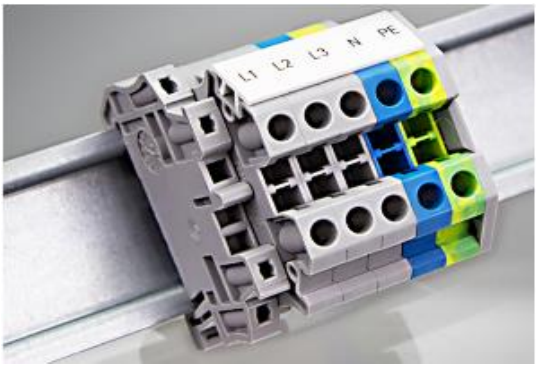

Figure 6. Sample picture of Terminal Blocks

B. Software Design: The software of the Distributed Control System considered for this study is Centum

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VP (Vigilant Plant). There is pre-defined function blocks available in the software which can be used to create the required logic action.

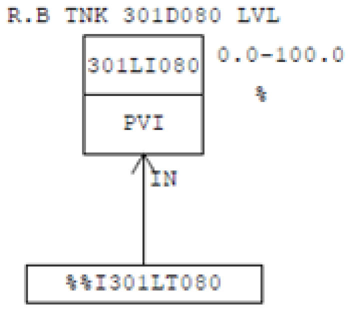

Figure 7. Sample Open loop Function Block

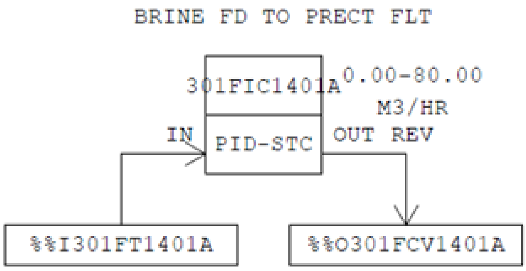

Figure 8. Sample Closed loop Function Block

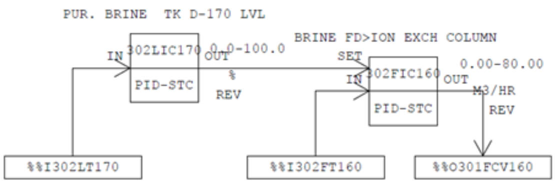

Figure 9. Sample Cascade loop Function Block

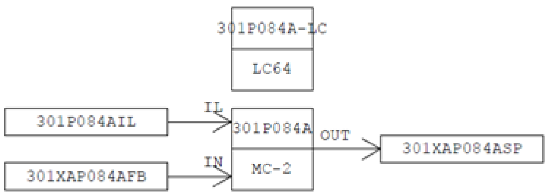

Figure 10. Sample Motor Control Block

III. RESULTS

Once the hardware and software part of the project is completed there are mainly 2 levels of testing that must be done to ensure the performance of the system.

- Factory Acceptance Tests
- Site Acceptance Tests

The factory testing is done by the project engineer in presence of the client, whereas the site testing is done by the Field engineering services at the client's factory/plant after connecting the system to all the field instruments present at location.

During the Factory Acceptance Testing, complete loop checking of all the hardware and software is carried out using a simulation device for simulating analog and digital signals for the system. Along with which all system checks are carried out including for the redundant parts.

Only after the successful completion of the Factory Acceptance Tests will the system be dispatched to the plant for installation, following which the Site Acceptance Tests will be carried out on-site.

IV. DISCUSSION OF RESULTS

In general Distributed Control Systems are very expensive, a typical project containing both hardware and software can cost from Rs.1 Crore to Rs.40 Crores and above depending on,

- The size of the project and its nature of implementation as mentioned in Scope of work document.
- Total number of controllers required.
- Total number of input-output cards and boards.
- The scope of power distribution.
- The control scheme & logics to be implemented.
- Provision of providing Fire & Gas system (FGS) and Emergency Shutdown System (ESD).

The main concern is always the hardware compatibility, since in most plants/process industries/refineries etc. the hardware used will be from different manufacturing companies. This is especially true in the case of up-gradation projects wherein a small section of a functioning plant/industry/refinery is to be upgraded to an a more advanced control system.

V. CONCLUSION

Keeping all the above mentioned criteria and also after extensive study of the Scope of work and other plant layout drawings, Piping & Instrumentation drawing (P&ID) and discussions with consultants (if required) a detailed project plan is conceived and followed.

A general design approach is followed in case of projects wherein only the DCS is to be designed and supplied. If there are any special requirements to be incorporated into the control system, such requirements are taken into consideration after detailed site survey and understanding of any existing hardware in the field that has to be integrated into the Distributed Control System.

To ensure that there are no compatibility issues, international standards are followed during the design phase of all projects. Hence, future up gradation and revamp of the system can be done without much hassle. As far as the software part is concerned, modifications are easier to accommodate.

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Mr ROHIT THOMAS KOSHY completed Bachelor of Engineering degree (B.E) in the field of Electronics & Communication Engg from Anna University, Chennai in 2015. Currently pursuing M.tech degree in Control & Automation at VIT University, Vellore. Worked as a Project Engineer during an internship at Yokogawa India Ltd for 8 months as part of doing the 2nd year M.tech project. The fields of interests are Process Control & Instrumentation and Automation.