Advantages and Safety Features using Foundation Fieldbus-H1 based Instrumentation & Control for Cryo System in Accelerators

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Abstract: Large accelerator programme instrumentation and control for monitoring of large no. of parameters for cryogenic / cooling system. The parameters are Cryo Temperature, Vacuum, He Level and He flow etc. The circumference of the accelerator may vary up to several kilometers. Large size accelerators require huge cabling and hardware. The use of foundation fieldbus based Transmitters for measurement and Control valves field positioners for cryo system shall reduce the cabling, hardware, maintenance and enhance data processing and interoperability.

Safety is an important requirement for efficient, trouble free and safe operation of any process industry such as cryo used in accelerators. Instrumentation and Control systems can be developed using Foundation Field Bus. The safety features in foundation field bus system can be achieved by use of intrinsic safe devices, fail safe configuration, minimize the hazard by distribution of control function blocks, short circuit preventers.

Apart from above features, the significant cable reduction in the fieldbus system reduces the hazard due to electrical cable fire, which is considered one of the major risk in industry. Further the reliability in fieldbus can be improved by hot stand-by redundant power supply, hot stand-by redundant CPU, hot stand-by redundant network capability and use of link active scheduler.

1. About Foundation Fieldbus:

Foundation field bus is the technological evolution to digital communication in instrumentation & process control. It differs from any other communication protocol, because it is designed to resolve process control applications instead of just transfer data in a digital mode. Field bus describes a new digital communications network, which will be used in industry to replace the existing 4-20mA analog signals.

Foundation field bus is an all-digital, serial two-way communication system, which interconnects the “field” equipments such as sensors, actuators, positioners etc. Field bus is a Local Area Network (LAN) for instruments used in both process and manufacturing automation with built-in capability to distribute the control application across the network.
The control strategy is distributed along the field devices. It is possible because besides having functional blocks in their microprocessors, they also have ability to communicate fast & reliably to each other through the bus. Devices can be networked & configured according to user needs, being suitable from small systems to whole plants.

2. Fieldbus Implementation in Cryogenic System:

The cryogenic system is used to cool-down and maintain the required magnet temperature. The helium gas is pumped into the superconducting magnet. The requirement of the control system is always to maintain the magnet in the superconducting phase for the accelerator operation. The parameters monitored are temperature of magnet which is nearly (~ 2 deg K) magnet, vacuum is measured (~ 1200 m bar) and He flow (~ 0-100 gram / sec), level of the He feed tank. The He gas will flow as per the temperature of the magnet. The temperature is the variable to be controlled. A schematic of the cryo system is attached herewith.

The flow is controlled by a throttling valve which is the function of the temperature. This valve has the fieldbus positioner, which houses the PID controller.

All the sensors are fieldbus compatible, and fail safe type. The intrinsic barrier is placed between on H1 bus between fieldbus devices and H1 bridge.

The control strategy is inbuilt with the valve positioners and is distributed in the field.

The fieldbus signal link (H1-Bus) is wired to the two H1 bridges. The H1 bridge has the redundant back-plane power supply, redundant ethernet port. The H1 bridges are connected to engineering station / operating station via redundant ethernet link for data monitoring and control system.

One of the device is made link active scheduler in case if the H1bridge fails.

The comparison of conventional instrumentation system and field bus instrumentation:

| Sl. No. | Conventional Instrumentation System | Fieldbus Instrumentation System |
|---------|-------------------------------------|---------------------------------|
| Cable requirement | Huge | Around 1/10th for analog signals. |
| Hardware (PID Controller) | Depending on no. of loops | Not required. Soft PID Functional Block available. |
| Interoperability | Not there | Available |
| I/P converters | Required for valve controls | Not required |
| Cable tray | The size is more | Small size |
| Configuration | More steps | Easy |

3. Redundancy:

The redundancy in Fieldbus can be implemented as follows:

1. Redundant field-bus transmitters
2. Redundant power supply for H1 Bridge
3. Redundant power supply to fieldbus instruments
4. Back-up LAS in the field devices
5. Redundant ethernet Link
6. Redundant power supply for ethernet switch
7. Multiple operator work stations
8. Redundant NIC in work stations / servers
9. UPS power for servers / workstations
10. Fail safe configuration for devices
4. HMI :

The HMI (Human Machine Interface) can be developed for graphics depicting the process flow sheet, monitoring of parameters, control of parameters, reports, ODBC, history, alarms, current trend etc. The diagnostics screen can be developed to simulate the entire control system. Operations can be initiated from HMI or can be stopped from HMI. The interlocks can be implemented using the foundation fieldbus system.

5. Conclusion :

The implementation of Fieldbus based instrumentation system will minimize the overall cost and maintenance, make the system interoperable and reduce the hazards in accelerators and will make the operators life easy. This will result in better productivity hence will improve the organization profit. The safe operation of facility will not affect environment and general public within and outside the operating facility.

6. Acknowledgement :

This article is based on the experience of the first author when he was on deputation from DAE / BARC to CERN, Geneva, Switzerland.

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