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Digital power

Power plant sees green with new digital bus system

By John Blaney, Jim Murray, and Gary Tingley

Portland General Electric, an integrated electric utility headquartered in Portland, Ore., serves more than 755,000 residential, commercial, and industrial customers. Seeing advantages in design and construction savings, the utility wanted to incorporate digital bus technology in as many areas as possible at Port Westward last April. Both Foundation fieldbus and PROFIBUS are used significantly throughout the balance of plant systems. Another reason behind the decision was simply the opportunity to try new technology on a new plant since the technology has been proven in many other industries, just not in the power industry.

While smart devices have existed for over 15 years, fieldbus standards, such as Foundation fieldbus, have allowed communication in digital format and the availability of direct fieldbus interfaces in control systems, allowing users to readily access all the data. Asset management software packages use this wealth of data and provide detailed diagnostic information and predictive maintenance analysis functions. Control accuracy also improves since the signals are not converted to 4-20mA for transmission to the DCS I/O module then converted into a digital value for use in the control scheme.

FAST FORWARD

- Oregon power plant gives digital bus a try for design, construction savings.
- Plant personnel hopeful for detailed, actionable diagnostics.
- Asset management software key to better communication.
- Tips, benefits of installing smart instrumentation.

Smart instrumentation and actuators, besides providing primary sensed values, are a rich source of other data. Actuators can provide travel deviation, cycle counts, a valve signature, and a step response. Others self-diagnose plugged impulse lines, reverse, and no-flow alerts. Most provide sensor, drift, calibration, configuration, and electronics failure alerts.

The Port Westward Power Plant is a 407-megawatt, natural-gas fired, 1x1 combined-cycle plant—the most efficient of its kind in the Pacific Northwest. Located on the Columbia River, the plant uses a MHI 254 MW M501G combustion turbine with a heat recovery steam generator with duct burning to provide steam to a MHI 153 MW reheat steam turbine.

The ability of the digital bus architecture to provide specific, detailed, and actionable diagnostics to the correct personnel was key. The plant staff is set at 17 including the plant manager. Therefore, one of the design goals was to automate as much equipment as possible. Providing digital bus technologies offers a significant amount of operations and diagnostic data to plant personnel on a real-time basis.

Most utility personnel are only now becoming familiar with this fieldbus technology. It is new to Portland General Electric as well as the plant design engineers. It was their first digital bus startup. In order to offset this risk, the control system vendor provided expert technical resources: a project manager experienced with digital fieldbus architectures; field engineering personnel with Foundation fieldbus and PROFIBUS expertise; and periodic involvement of a fieldbus expert to review the design through startup requirements.

The heat recovery steam generator (HRSG) vendor approached the project with a willingness to use digital bus technologies to implement the instrumentation and control portions of the HRSG and balance of plant. Among the key loops implemented on Foundation fieldbus are the drum level for the HRSG, the feedwater flow valve, most of the analog instrumentation, and all temperature signals. This plant used a total of 29 Foundation fieldbus segments with nearly 185 devices installed and located throughout the plant.

Factory testing

Long held practice in DCS factory acceptance testing has included a set of processes and procedures to simulate the presence of 4-20mA devices. It is impractical to have all field devices available. Only when you install the DCS in the plant can you connect the actual devices and individually test and calibrate them during the commissioning process. This is a manpower-intensive and time-consuming process. Yet it is necessary to confirm correct connectivity between the control system and the device.

While it is equally impracticable to have all the smart devices available for DCS factory testing, a proven process is to test using a representative device of each type in the plant. This provides the designer with proof of concept; it allows the control system supplier to confirm operation with the control logic; and it reassures the owner the connectivity is viable throughout the chain.

On the other side is the need to test a packaged system that uses smart devices and fieldbus technology. In the case of a motor control center (MCC) or lineup, you should conduct this test using the devices and configurations that will ship to the plant. The MCC's segment trunk cable should interface with a PC-based system running the fieldbus host software package. Tests should confirm functionality as required.

The approach that these two combined tests represent is from one end to the other with some overlap in the middle. Neither test by itself proves the complete communications chain but in combination assures the significant elements can communicate successfully, easily, and quickly when all the parts reach the field.

Asset management software

Asset management software provides a single location for device configuration, calibration management, diagnostics, and the documentation of smart devices in the plant.

The commissioning process allows you to configure through a graphics onscreen interface with the devices. The need for additional personnel in the field is limited to making sure the correct process device is being read or manipulated and the valve stroke and feedback mechanism is correctly adjusted on actuators. Documentation of the calibrations and an audit trail of adjustments are preserved for future reference. We were able to commission six valve devices in one morning.

You should supply a control system using Foundation fieldbus with management and diagnostic software. With a package defined for a specific number of device tags you could apply it to, you can include all capable devices or some important but more critical subset of them. It is important to understand how many tags are supplied and to make a decision if this is sufficient for the project under consideration. There may also be optional add-on packages available that extend and broaden the package's capability and diagnostic analysis functions associated with each vendor's devices.

The real value of the asset management software is its operations and maintenance savings ability. Foundation fieldbus devices have three levels of internal diagnostic alerts denoted by Failed, Advisory, and Information categories. Each type can have multiple contributor items. You should integrate these alerts into the control system to provide predictive notice of a device issue with filtering based on device criticality to the process. In addition, maintenance personnel can also have full and detailed access to the predictive diagnostic data to observe, plan, and schedule any repairs or parts necessary to remove the alert. The changes to maintenance work practices mean personnel only service those devices that need service with parts and repairs they have previously identified.

Installation benefits

Some benefits of digital bus technology include reductions in cable tray, cable, and conduit. This less-is-more approach simplifies the design of the associated field installation work. The reduction in I/O modules reduces their cost and the associated cabinet cost. It also results in a significant reduction in the number of field terminations you will need to make. You can see other cabling benefits by using prefabricated cables and segment junction blocks with trunk cabling and short-circuit protected spur connections. These can also provide spare device connection points and allow you to remove devices without affecting the complete segment. There are some added instrumentation costs, but costs are also included for the analog control segments, data acquisition system segments for resistance temperature detectors and thermocouples, and the inclusion of MCC/switchgear and their DeviceNet or Profibus segments.

Adopting fieldbus technology blurs the lines between what was the traditional DCS and what the smart instrumentation can do, since both of them are now capable of executing control strategies.

Work practices

Selecting a digital bus technology does not force owners to adopt it for all applications since they can readily mix it as necessary with conventional I/O. However adopting fieldbus technology blurs the lines between what was the traditional DCS and what the smart instrumentation can do, since both of them are now capable of executing control strategies. This may not be a major issue since the control design remains as before but with the final determination necessary if control needs to be located in the devices. However the requirements for segmentation of functions, loops, and processes remains in order to ensure the process works and works safely without disruption caused by process, instrumentation, and other failures.

Using conventional I/O means you can determine the numbers of each type based on reviewing the plant design process and instrumentation diagrams (P&IDs). The good news when using fieldbus technology, from the control strategy design point of view, is they require the same basic I/O types and quantity of information to run it as before. There may be some additional permissives required in the control strategy that allow for remote operation via the fieldbus.

Smart instrumentation

Smart instrumentation requires careful selection of devices from the respective foundation's approved vendor lists. Smart devices also have variable I/O data transmission capabilities and even include onboard process control and logic processing capability. You need to understand the impact of these capabilities and use them in the control strategy design by making sure the function block capabilities required are available with the device. Does the device execute a select function block between two transmitters and provide one input to the proportional integral derivative (PID) function block? Is the device capable of providing a backup link active scheduler function to run the loop in the event of a controller or fieldbus interface module failure? You should reflect all these in the instrumentation data sheets for the devices used.

However there may be different I/O configurations the devices provide. You need to make a decision as to which, based on one of three perspectives: What I/O is really needed for control of the device? What I/O can be made available if needed for process and device diagnostics and alerts? What other data is available to an analysis function that provides the advanced diagnostic capabilities? This prioritizes the data and the required access to it. You should clearly identify and standardize this for each device type to maintain some repeatability of configuration and control scheme interface. Once you have defined the standard in the design process, all vendors need to maintain it.

Foundation fieldbus devices have capabilities for executing control functions in the field through the use of flexible function blocks and so have the necessary control status data exchanges built in. Some Profibus and DeviceNet devices have device-specific internal logic capabilities, some based on 61131-3 programming. You should design any control you consider for implementation on the device within the overall control scheme early on so all parties understand the interfacing, status, and I/O update requirements this imposes between the control capabilities.

The designers described reviewing where some of the additional information is best documented. They placed more emphasis on some, such as data sheets, and left others essentially unchanged, such as P&IDs and loop/segment drawings. Device data sheets can reflect the increased capabilities by including calibration data, available software functionality, descriptor files, revision levels, and certification information. You could replace loop drawings that document electrical, grounding, powering, terminal, and wire information for a single device with segment drawings.

The difference is a single segment drawing includes all the same information but for all instruments on those segments. This increases their complexity slightly but significantly reduces the number of drawings required. The approach to P&IDs was to leave them as is since they document the instrumentation and control functionality, not where it is located. That function is left to the self-documentation features of the control builder (provided with the control system) along with the asset management software that documents device configurations.

Checking the segment wiring is important since a single pair of wires connects a number of devices and, in the case of Foundation fieldbus, can also provide device powering. Checks on each segment are pertinent, including the wiring polarity, the voltage at the device, the actual signal waveform, and device communication.

The design of segment layouts is important so as not to exceed parameters of the bus with distance and voltage at the devices being important to the operation of the fieldbus. Some designers keep the layout of the segment and the segment drawings simple by including only terminal electrical connections in the devices and junction boxes and at the interface to the control system.

Actual segment wiring is sometimes left to the discretion of the contractor with only placement of devices and some junction boxes specified. In one case this resulted in segment wiring which exceeded the distance limits although calculated not to. Upon review, they realized they had routed the wiring up and down the HRSG and exceeded the distance limits rather than the out and back design used for the distance calculation. A number of vendors supply segment design tools which provide a graphical means to select components such as interfaces, power conditioners, connection blocks, cables, and devices from a library, which includes their power usage and other relevant parameters. The results tend to be conservative, which works to the designer's advantage to prevent overruns. However segment loading should also allow for future spare requirements and should not attempt to maximize the segments loading Fieldbus. Experience to date has shown the technology is a solid performer, and with correct wiring and connections can shorten commissioning cycles. We recommend junction blocks with additional capabilities, such as identified trunk and spur connections, short circuit protection on the spurs, and switchable terminators. All Fieldbus technologies require terminating both ends of the trunk cabling to eliminate reflections and ensure communications. Spur short circuit protection prevents an incorrectly wired device from affecting the other devices and interrupting the segment communications.

Since this is an early project, we need to identify further data supporting field commissioning devices on a segment as the correct device on the process and at the junction block.

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