Best Practices in Nuclear Digital Controls

NUCLEAR REACTOR COMPLETES CONTROLS AND INSTRUMENTATION UPGRADE PROJECT

The power plant has seen improved reliability and availability with its new digital controls, partly due to the extensive redundancy engineered into the wiring, instrumentation, computers, switches, sensors, power supplies, I/O cards, and other electronics.

Organization: A PWR nuclear power plant located in the Eastern US. It produces over 2,000 megawatts of electricity which is enough to power approximately 1.5 million homes.

Challenge: After receiving a plant life extension, the nuclear power station needed to update their plant's digital control system. The new digital control system needed to be a form, fit, and function replacement for the original hardware while also seamlessly integrating with existing systems.

Solution: The plant turned to Curtiss-Wright's Instrumentation and Controls team for their industry expertise. They installed a new reactor controls and instrumentation system and human machine interface system.

Results: The upgraded digital control systems offer greater reliability, stability, and precision. The components are also easier to replace which will better support the plant's increased lifespan.

When instrumentation and controls (I&C) engineers at this Eastern US nuclear power plant needed to upgrade their digital control systems to support a 20-year plant extension, they selected Curtiss-Wright to implement a new reactor controls and instrumentation (RCI) system and a new human machine interface (HMI) system. The I&C team chose Curtiss-Wright for this project based on their proven track record with I&C implementations that improve the reliability, stability, and longevity of critical plant components, while also increasing the precision of operational controls.

Today, this modern digital infrastructure delivers real-time data for controlling every facet of the nuclear power plant's operation—as well as more precise methods for adjusting configuration parameters. The new RCI system augments a plant process computer (PPC) system and control room annunciator system, which Curtiss-Wright installed previously. Curtiss-Wright served as the primary systems integrator for all three projects.

OUT WITH THE OLD, IN WITH THE NEW

The original reactor control system employed stand-alone hardware components that were no longer supported by their respective original equipment manufacturers (OEMs). These systems needed to be retired due to difficulty procuring replacement parts for critical components of these systems. The I&C team's goals were to maximize plant efficiency, reduce the cost of system maintenance, and extend the viability and stability of one of the plant's key systems, while adopting and embracing current technology.

Best Practices in Nuclear Digital Controls

As a system integrator and OEM for numerous process control product lines, Curtiss-Wright collaborated with the plant's I&C team to bring critical insight and understanding to the upgrade project. The Curtiss-Wright project team used their extensive knowledge of digital technology to design equipment that will last for the life of the plant. They replaced aged analog and digital controls with state-of-the-art digital components including power supplies, servers, network switches, and input/output (I/O) devices. The Curtiss-Wright team selected, configured, and integrated new hardware components, and spearheaded all software development tasks. The nuclear power plant selected an A/E firm to assist with the modification design packages for the 12 instrumentation racks (cabinets) with redundant power feeds.

Overall, the project implementation necessitated a significant number of operating loops and components, with 18,000 wiring terminations. Curtiss-Wright worked closely with the plant's I&C engineers to replace obsolescent technologies with digital control systems, including a best-in-class nuclear-grade RTP 3000 I/O platform to optimize operations.

SUMMING UP THE BENEFITS

The main objective of the RCI project was to replace the existing reactor controls systems' control processing modules, associated displays, and supporting components with a fault-tolerant distributed control platform that increased system availability and provided reliable and event-free operation.

The nuclear power plant has obtained long-lasting benefits from this successful implementation, including the following:

Reliability: On many levels, they have seen improved reliability and availability with its new digital controls, partly due to the extensive redundancy engineered into the wiring, instrumentation, computers, switches, sensors, power supplies, I/O cards, and other electronics.

Stability: As part of this plant-wide digital upgrade, Curtiss-Wright's engineers eliminated more than 30 points of special interest to the operators.

Longevity: The upgraded system offers significant performance improvements such as easier to replace parts and a triple-redundant operating system.

Precision: The modern RCI infrastructure delivers real-time data for controlling every facet of plant operations, including more precise methods for adjusting configuration parameters with greater granularity.

RTP Hardware

SIL-3 hardware:

- 9–Dual redundant nodes
- 16–Remote nodes, consists of 2–CP's, 13–I/O slots, 2–120 VAC/DC P.S.
- 50–8 channel current input cards
- 21–12 channel isolated relay output cards (24V AC/DC)
- 71–12 channel isolated relay output cards (120V AC)

SIL-2 hardware:

- 1–Single node
- 137–8-channel isolated differential high level analog input cards
- 30–32-channel isolated analog/digital input cards

Cards:

- 11–16-channel 16-bit analog output cards (-10 to +10 or 0-10 volts
- 22–8-channel differential RTD cards, 16-bit A/D, 1KHz scan rate
- 1–32-channel digital input card, 125VDC sinking
- 4–NI 8-channel differential RTD card, 16-bit A/D, 1KHz scan rate
- 18–8-channel RTD card, 16-bit A/D, measures up to 800 Ohms
- 70–16-channel analog 16-bit analog output card 10-50 mA
- 23–16-channel 16-bit analog output cards (-20 to +20 or 0 to 20 volts or 4 to 20 mA)

Best Practices in Nuclear Digital Controls

IMPLEMENTATION DETAILS

The RCI upgrade involved four separate control groups, reflecting the plant's four-loop plant design. Common indication, control, and alarming functions are distributed across these four control groups, with dozens of control functions and alarming functions.

Overall project goals included the following:

- Replace obsolete equipment
- Improve system redundancy
- Improve plant reliability
- Maintain separation among control groups
- Minimize the effect on safety analysis and perform the work under 10 CFR § 50.59

The major components that were replaced or upgraded are summarized below.

Human Machine Interface (HMI)

Digital control systems monitor a plant as it operates, helping nuclear power plants move away from traditional scheduled maintenance and towards a more optimized schedule based on condition-based monitoring. To facilitate this proactive mindset, Curtiss-Wright eliminated older Main Control Board (MCB) display monitors and installed new remote display screen computers for indicators, recorders, and alarming functions.

I/O System

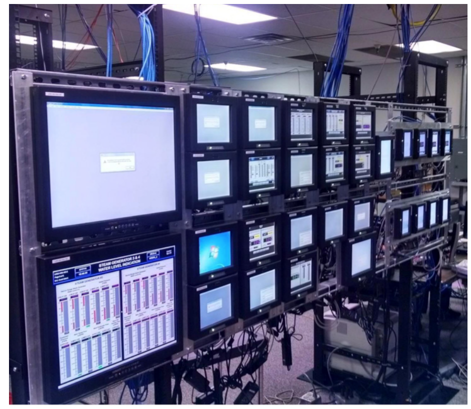
Leveraging RTP 3000 I/O equipment, the new RCI system captures more than 700 inputs and outputs per unit and includes advanced features for HMI, data trending, and real-time diagnostics. Curtiss-Wright worked closely with RTP to develop or modify the following equipment to meet the power plant's specific requirements:

- Dual Redundant Node Processors
- Dual Redundant Chassis Processors
- Dual Redundant Power Supplies
- Dual Redundant I/O Cards
- Termination modules for all inputs and outputs
- Average of 4 I/O chassis per control group
- Node Processors directly connected to server computers to separate RTP I/O equipment by control group

Servers

Curtiss-Wright's advanced digital control systems connect to sensors throughout the plant to collect real-time data and store it in a database that is modeled to reflect each unique installation. Engineers, plant operators, and maintenance personnel gain immediate access to current and historical data to monitor processes, identify patterns, detect anomalies, and troubleshoot issues.

Curtiss-Wright installed a redundant pair of servers for each control group. The servers are configured with automatic failover



Touch-screen panels on the new control board mimic the former analog displays.

Example of RTP 3000 I/O equipment.

technology to maintain uptime in the event of a server outage. Each server maintains a direct connection to the RTP I/O equipment, along with access to a shared network the spans all four control groups and the HMI workstations. For example, if the main control board controller fails, operators can interface with critical plant processes from two other workstations in the control room.

Due to the temperature requirements, Curtiss-Wright deployed industrial models from Crystal Rugged, a company specializing in hardened servers and workstations. These models were comparable to commercial grade servers from other vendors.

Best Practices in Nuclear Digital Controls

HMI Workstations

Each operator desk has redundant pairs of Advantech Alarm Log PCs (ALPCs)—one for the Reactor Operator (RO) and one for the Balance of Plant (BOP). These workstations have touchscreen monitors that can directly access all four control groups via the HMI network.

Curtiss-Wright provided one commercial-grade Dell engineering workstation (EWS) for I&C engineering and maintenance functions. While this system is connected to the HMI network, it can only communicate with the servers and cannot be used for RTP functions.

Curtiss-Wright also installed 57 MCB MOD 30 HMI Units—29 for Unit 1 and 28 for Unit 2—to handle supervisory control functions.

HMI units with their touchscreen counterparts.

Example of HMI workstation.

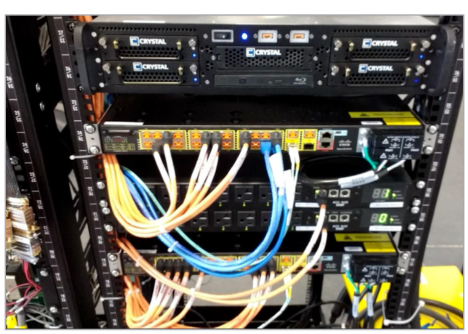
Network

The network configuration includes triple-redundancy using industrial-grade equipment from Cisco Systems with a connection to the plant's Layer 4 Centralized Cyber Security Network (CCSN). These communication networks provide a secure channel for the flow of data between the supervisory control system, the data acquisition units, and any controller that is connected to the system. Interfaces to various programmable logic controllers (PLC) bring in data to monitor thermal performance and other operational metrics.

Power Supplies

Redundant cabinet power feeds ensure protected power from multiple independent sources, including:

- An 80 VDC power supply for loop powered devices and RTP powered devices
- A 24 VDC power supply for whetting voltage and current loop outputs



HMI units with their touchscreen counterparts.

Software

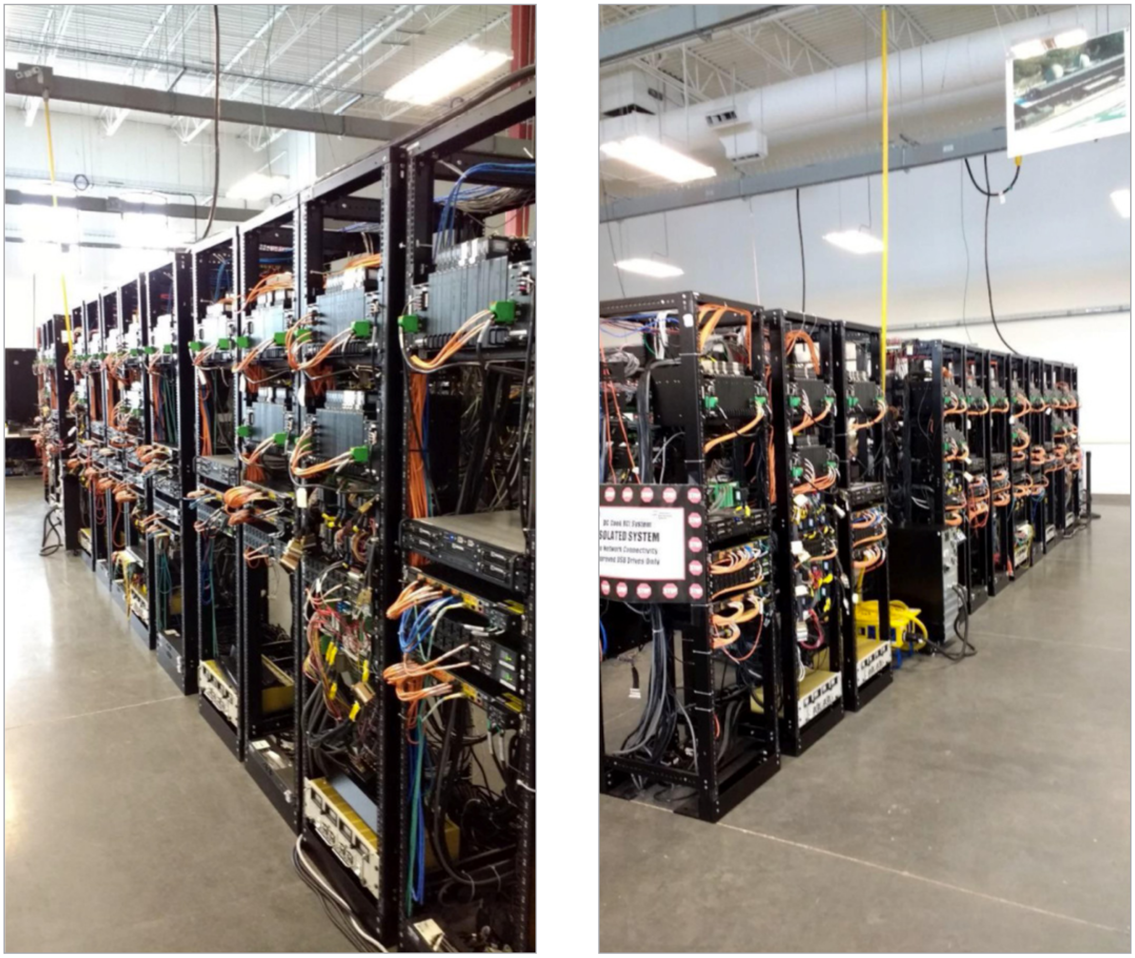
Curtiss-Wright worked with RTP to create a custom PLC that allows existing plant sensors, indicators, and actuators to work with 4-to-20 milli amp current loops, avoiding expensive upgrades to equipment originally designed for 10-to-50 milli amps.

In addition, the Curtiss-Wright implementation team integrated the PPC software with an RTP NetSuite I/O system.

Curtiss-Wright deployed its R*TIME software platform to acquire data from plant sensors and other computer systems. R*TIME includes functions for data acquisition, data display, and data processing. A data historian maintains a complete history of all data inputs and outputs.

FACTORY ACCEPTANCE TESTING

Each component and each system was subjected to rigorous factory, site, and operational tests to ensure that it meets or exceeds the plant's availability requirement. Curtiss-Wright's integration team configured the hardware and software development in a secure area on isolated systems. Once the initial configuration was completed, they shipped the equipment to the nuclear power station, where the on-site team made the final connections and conducted factory acceptance testing to verify that everything was properly configured, tested, and documented, as well as train the team in its use.



Unit 1 and Unit 2 Systems staged for FAT testing at Curtiss-Wright's Idaho Falls facility.

To streamline this process, the plant's team built a Digital Control Staging Area (DCSA) on the turbine deck, not far from the control rooms. The DCSA was large enough to simultaneously stage both the Unit 1 and Unit 2 RCI systems in a protected work environment. This allowed Curtiss-Wright to verify plant procedure changes for I&C, maintenance, engineering, and operations prior to final installation.

The Curtiss-Wright team performed 14 factory acceptance tests (FATs) for each unit. Each test comprised about 19,000 pages of data.

SUMMARY AND FUTURE APPLICATIONS

All in all, the new RCI and HMI systems will allow the nuclear power plant to operate more efficiently and cost effectively for its expected long system life cycle. As other plants approach their own license renewal period, innovative digital solutions like this can serve as a lifeline for plant life extensions.

The Curtiss-Wright project team used their extensive knowledge of digital technology to design equipment that will last for the life of the plant. They replaced aged analog and digital controls with state-of-the-art digital components including power supplies, servers, network switches, and input/output (I/O) devices.