Case Study: RDI Controls

Turbine control experts execute fast, cost-effective retrofit of failing control system

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THE CHALLENGE

When you're designing critical control systems for the power and energy industry, it's completely reasonable to be frustrated when expensive components don't perform as expected.

In regional power generation systems, combustion turbines have become a mainstay in recent years. These powerful, complex machines are used in two ways:

- In combined cycle configurations for base load generation
- In simple cycle arrangements for peaking plants, which handle mid- to high-demand power fluctuations.

Pennsylvania-based engineering services company RDI Controls provides fully engineered retrofit packages for industrial and aeroderivative turbine control systems, including demolition, installation, control valve and field device integration, water injection, nitrous oxide (NOx) emission mitigation, generator protection, and auxiliary/balance of plant (BOP) controls.

One of RDI's customers invited them to bid on a project to retrofit three turbine peaking plants, each equipped with Westinghouse W301 and GE Frame 5LA combustion turbines in a simple cycle configuration with each operating in the 20-30 MW range.

The previous iteration of the control system was designed with a pair of Allen-Bradley ControlLogix PLCs for each of the six turbines, but due to repeated control and maintenance issues, the customer needed a better engineered solution that was easier to troubleshoot and more reliable.

OBJECTIVES

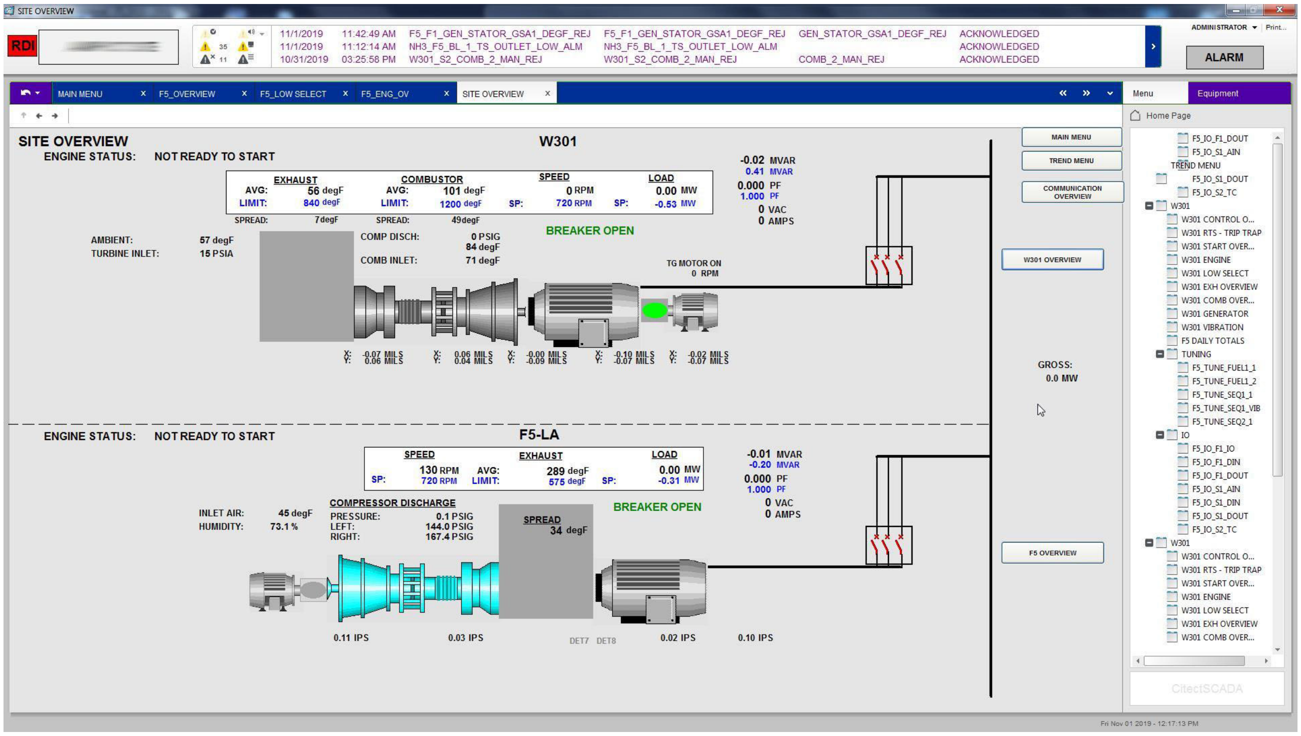
Peaking plants trade off efficiency for responsiveness, generating significant waste heat and losing work to the operation of the turbine rather than power generation. To minimize these losses and reduce stress on the system as a whole, it is critical to keep the turbine running within tight tolerances during startup and operation.

Large, rotating machinery operating at high speeds and temperatures also requires many safety considerations. Should the system fail to limit the speed of the turbine, for example, it might break apart, so RDI's solution needed to include appropriate failsafes to protect against overspeed events and react to load rejections.

And, although each turbine would have its own control system, every pair utilized common site subsystems, which would need to be integrated into the primary controls. These included ammonia control systems, which RDI had previously retrofitted using Opto 22 SNAP PAC programmable automation controllers, and electric starter motor controls that still ran on Allen-Bradley PLCs.

Finally, for the sake of speed, cost, and error-reduction, RDI aimed to leave as much of the existing field wiring in place as possible.

One of the retrofitted peaking plants



Site overview screen showing Westinghouse W301 and GE Frame 5LA status

SOLUTION

To satisfy these objectives, RDI designed a distributed control system at each site using a combination of Opto 22's *groov* EPIC and SNAP PAC controllers. Lou Bertha, principal engineer at RDI Controls, says it was this same kind of experience that first led him to try Opto 22.

"At the time, Allen-Bradley was the biggest contender in industrial turbine control, but it was expensive and kludgey.... From a flexibility standpoint, for my money, Opto 22 gave me more bang for my buck. ...I was able to do just about anything you could do with A-B at a fraction of the cost."

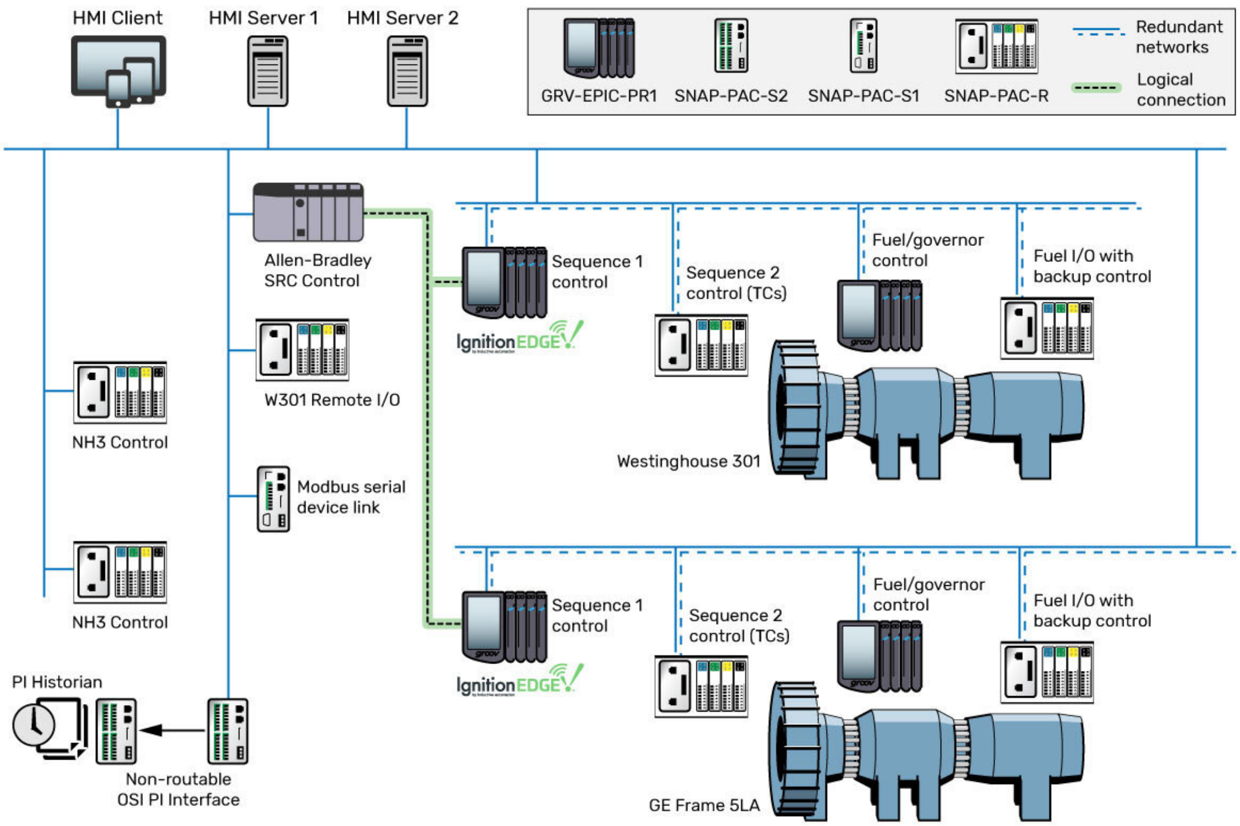
More than twenty years later, RDI Controls has carried out over 160 retrofit and design projects on a variety of turbines from brands like GE, Westinghouse, Pratt-Whitney, and Rolls Royce using control systems from Allen-Bradley, ABB/Bailey, and Westinghouse/Emerson. But Opto 22 continues to be Lou's supplier of choice, and his ability to deliver affordable, high-performing systems continues to win him business.

RDI easily outbid the competition with a distributed system that incorporated high-speed PID control, secondary control and networking, and embedded third-party communication.

At the peaking plants, the *groov* EPIC and SNAP PAC controllers integrate all functions of the W301, F5LA, and shared subsystems. Subsystems are integrated using native peer-to-peer communication and through embedded OPC UA communication using Inductive Automation's Ignition Edge. Additionally, each site reports to an external historian through a secure PAC gateway and integrates with a Citect SCADA HMI network, which RDI also designed.

Distributed control architecture

For each turbine, one EPIC provides primary governor control, managing fuel mix, combustion, and shaft speed, with one PAC providing backup control and overspeed protection. A second EPIC handles sequencer control, including startup of auxiliary systems, process monitoring and coordination, and alarming, with a second PAC integrating high-density thermocouple sensing for temperature limiting and ramping. Finally, RDI uses the dual Ethernet ports on each controller to set up redundant network connections.



RDI's site-level control network architecture

Distributed control provides RDI with inherent failsafes. Since all four controllers are peers on the network, not remote I/O, each has the ability to interlock the system in the event of a partial loss of control or network connectivity.

"Network redundancy is critical," explains Lou Bertha. "We can't let the system fail for the sake of a bad switch…. But in the event of network issues, each controller has the ability to trip the system as needed while maintaining their own control functionality, for example, lube oil operation, fan control, monitoring, etc."

"I can say that [full controller redundancy] doesn't matter since the control is at the I/O level. If we are isolated from the network, we can continue running, and if we lose the I/O, redundancy won't matter anyway."

However, as with remote I/O, distributing control and I/O across multiple controllers also allowed RDI to reduce costs and minimize rewiring. High-density and specialty I/O was placed on lower-cost PACs and then located close to the equipment, rather than requiring long runs back to the primary controllers.

In Lou's assessment, "The existing hardware was susceptible to damage if moved and the drawings were out of date, so we avoided rewiring altogether by dropping controllers into existing panels" instead of building new panels or attempting to marshall field wiring to a smaller number of controllers.

Fortunately, with the EPICs as primary controllers, performance is not an issue. Powered by quad-core ARM processors, Lou says "the horsepower is amazing." PID control functionality is utilized for speed, load, startup, and temperature control with the speed control loop executing at 50 ms or less. With that speed, RDI was easily able to maintain the turbine/generator speed at 3600 RPM to within +/- 1 RPM.

Opto 22's EPICs and PACs are both fully compatible with the latest versions of the PAC Project development environment, so RDI could manage each control strategy with the same toolset.

Subsystem integration

To interface with the shared subsystems at each of the three power generation sites, RDI leverages a mix of hardware and software communication options included in Opto 22's EPIC and PAC controllers.

With *groov* EPIC, there's no need to have a separate communication server. The EPIC sequence controllers coordinate data passing between the starting resistor controller (SRC), ammonia system, the other turbine controllers, and remote I/O.

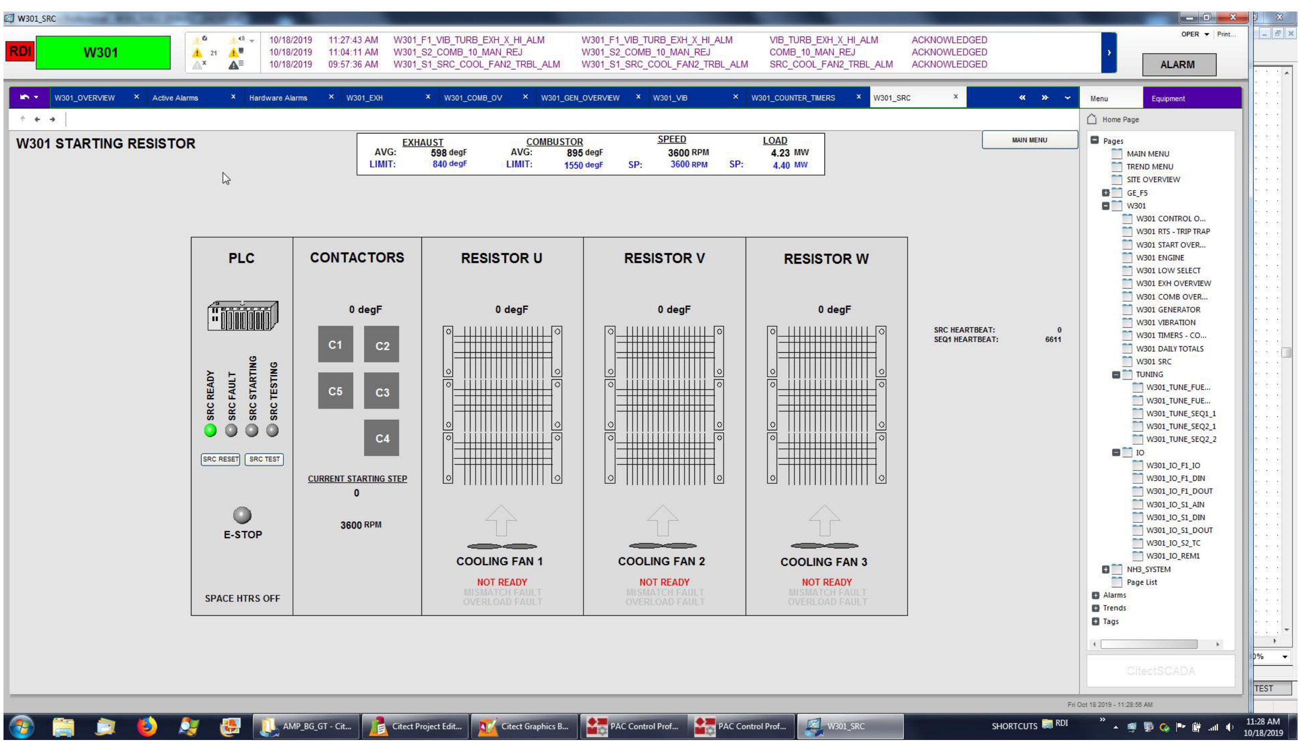
The SRC, a kind of electric starting motor, is controlled by an Allen-Bradley PLC, which adjusts its output in response to the speed of the turbine. RDI uses the Ignition Edge platform built into *groov* EPIC, which provides a suite of native protocol drivers for common industrial devices, like PLCs.

Ignition creates a bridge between the EPICs and the PLC, consuming A-B tags and exposing their data through its embedded OPC UA server. OPC UA tags can be linked directly to the control engine and other applications running on the EPIC.

Compared to passing data via an HMI/PC interface, this approach provides a fully independent link between the systems to ensure it maintains operation in the event of an HMI/PC failure. Lou adds, "If you haven't used this on a project, it's fantastic. I could shut down the HMI and it will keep running. If I were using the HMI to pass tags around, as is common, I would have been in trouble."

RDI uses the native OptoMMP protocol to communicate with the other subsystems. Turbine flow rate and temperature are passed to the ammonia system PACs to control the amount that is injected into turbine exhaust gas. Another PAC interfaces with Modbus serial devices to communicate voltage and protective relay statuses. And a pair of PACs create a non-routable interface for the external OSI PI historian. One PAC is linked to the control network, gathers data, and passes it to another PAC on the historian's network.

The dual independent Ethernet ports on each PAC allow RDI to segment the networks so that data only flows out, not in.



RDI integrated Allen-Bradley PLCs into its *groov* EPIC control strategy using Ignition Edge

RESULTS

"We definitely had a competitive advantage price-wise," says Lou Bertha. "We redid everything, including demo and install, and still came in 30-40% cheaper than competing bids." With Opto 22, RDI won the peaking plant contract and then completed the project in only two weeks.

Besides lower material costs, Lou attributes his advantage to three factors:

- **Control at the I/O level:** Opto 22 automation systems leverage intelligent I/O networks to distribute functions that, in a traditional remote I/O system, would typically be handled by a central controller. This architecture ensures that systems can continue to run even with partial impairment.
- **Flexibility:** *groov* EPIC and SNAP PAC are designed with embedded hardware and software tools—multiple networking options, communication servers, data processing functions—that provide engineers with many options for designing and scaling systems.
- **Openness:** Opto 22 products are built on open standards and technologies, making it easy to integrate with 3rd-party devices and external systems.

By leveraging these capabilities, RDI was able to meet the project's objectives for performance and reliability. With no external dependencies or expensive server licensing, the system was also straightforward to design and simple to maintain.

"With Opto 22," Lou adds, "we can do more and my customers are happy. It's easy. It's clean. The system just runs. If people don't have to think about it, they are happy."

For more information on RDI Controls, visit rdicontrols.com.

ABOUT OPTO 22

Opto 22 was started in 1974 by a co-inventor of the solid-state relay (SSR), who discovered a way to make SSRs more reliable.

"We redid everything, including demo and install, and still came in 30-40% cheaper than competing bids."

- Lou Bertha, RDI Controls

Opto 22 has consistently built products on open standards rather than on proprietary technologies. The company developed the red-white-yellow-black color-coding system for input/output (I/O) modules and the open Optomux® protocol, and pioneered Ethernet-based I/O.

Famous worldwide for its reliable industrial I/O, the company in 2018 introduced *groov* EPIC® (edge programmable industrial controller). EPIC has an open-source Linux® OS and provides connectivity to PLCs, software, and online services, plus data handling and visualization, in addition to real-time control.

groov RIO Ethernet-based edge I/O modules, introduced in 2020, include I/O and IIoT software in a compact industrial package that goes anywhere.

All Opto 22 products are manufactured and supported in the U.S.A. Most solid-state SSRs and I/O modules are guaranteed for life.

MADE IN THE USA

The company is especially trusted for its continuing policy of providing free product support, free training, and free pre-sales engineering assistance.

For more information, visit opto22.com or contact **Opto 22 Pre-Sales Engineering**:

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