

New Tool for Generator Dynamics Validation Reduces Costs and Downtime

The Western Electricity Coordinating Council (WECC) requires periodic validation of the computer simulation models used to represent power plant equipment to ensure that the models reasonably represent a plant's actual dynamic performance. To perform such model validation, dynamic fluctuations are "staged" during scheduled maintenance outages as part of a series of predefined tests, including small (~10% of the unit's rating) megawatt and megavar rejection tests and off-line and on-line voltage reference step tests. The recorded test data are used to validate models of the plant's generator and control systems to ensure that the models adequately capture the plant's expected response to system events.

Because generating units are required to be out of commercial service during these procedures, utilities may lose revenue for the 4 to 6 hours typically required for a large unit. Consultants needed for the testing can add to costs. And although experience has demonstrated a low risk of damage to equipment during testing, some utilities believe that tests such as megawatt load rejection can cumulatively reduce the service life of the turbine-generator shaft and potentially expose the unit to other damage.

EPRI has developed a computer simulation program that eliminates the need for such staged testing. The software tool uses real-time data captured from the plant during an actual grid disturbance to validate the model of the plant and its controls.

Setting Up for Real-Time Data

In 2009, Tri-State Generation and Transmission Association successfully applied the Power Plant Parameter Derivation software tool on its system. With EPRI's help, Tri-State configured digital fault recorders at its Craig Station to provide data on multiple system disturbance events. Tri-State already had digital fault recorders installed at the plant, and modifications involved the addition of a few more recorder signals for the model validation process. It took only a few weeks to collect baseline data and prepare the tool for data processing. This one-time setup process is likely to be streamlined in future applications as experience is gained at more plants.

Over 17 months, the demonstration project captured data from seven disturbances, including grid faults and loss of large generating units elsewhere on the interconnected power system. The software was used to process these data and validate the models for the electrical generator, the excitation system (including the power system stabilizer), and the turbine governor.

The validation work was submitted to WECC, which has



Tri-State Generation and Transmission Association's Craig Station

confirmed that the information meets certification requirements and that it will certify Tri-State's validation testing for these units. This will be among the first certifications of large thermal generating units based on analysis of data from on-line disturbance monitoring rather than from staged physical testing.

A Timely Innovation

Acceptance of EPRI's validation method is particularly valuable and timely, considering that the North American Electric Reliability Corporation is expected in the near future to institute nationwide requirements similar to WECC's regional mandate. Staged testing will still be prudent and necessary for determining baseline data when commissioning a generating unit or retrofitting the unit with new equipment or controls. For routine model revalidation, however, the Power Plant Parameter Derivation software significantly reduces the cost and introduces no additional risk, since users are simply monitoring the unit during normal operation and recording machine response during disturbances.

According to Chris Pink, senior power systems planning engineer at Tri-State, "Validation of generator dynamic models using real-world disturbance data will enable us to provide accurate and timely model validation, reduce costs and downtime on our generating units, and maintain system reliability according to WECC and NERC requirements."

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Simpler Circuits May Benefit Nuclear I&C Systems

As utilities replace aging instrumentation and control (I&C) systems in nuclear plants, they are considering an electronic alternative to microprocessors in such systems, particularly for safety-related applications. Called field programmable gate arrays (FPGAs), these comparatively simple integrated circuits can be configured to perform specific functions very rapidly, without overhead functionality not needed for the specific application.

I&C systems for most of today's nuclear plants originally relied on conventional relay and analog electronics technologies, and many of these systems are now being replaced with microprocessor-based equipment. But microprocessors tend to become obsolete much more quickly than the analog systems, and replacing them can be complicated and costly. Also, gaining regulatory approval can be difficult and expensive.

In contrast, an FPGA system operates more like the hardwired electronics previously used in analog systems, with multiple data streams processed independently and in parallel. Relying on FPGAs for I&C upgrades allows for discrete functions to be separated at the circuit level, enhancing reliability and testability, and can mean that only specific components need be replaced. This approach can keep costs lower—by up to an order of magnitude—than upgrades involving microprocessors.

While an FPGA application chip is created using complex software development and verification tools—and will be treated much like software-based applications by regulatory reviewers—the unit operates as hardware, with no external software interface. By avoiding the complexity of microprocessor-based systems and processing individual signal paths using only hardware, FPGAs are expected to reduce the cost of upgrading nuclear I&C systems and ease the process of gaining regulatory approval.

Guidance on Application

Although FPGAs have been used extensively in military and aerospace applications, many utilities are not familiar with the technology and its potential benefits. To provide an information resource, EPRI recently published *Guidelines on the Use of Field Programmable Gate Arrays in Nuclear Power Plant I&C Systems* (1019181). The report begins with a primer on FPGA technology, followed by a discussion of potential advantages and limita-



tions, including insights culled from experience in previous applications. Examples of these applications include the Wolf Creek main steam and feedwater isolation system and the Advanced Boiling Water Reactor power range neutron monitoring system.

The report also provides specific guidance on specifying and selecting FPGA-based systems, while taking into account the full life cycle: requirements, design, verification, and validation. Two primary resources are also described regarding safety justification and gaining regulatory approval—the recent U.S.

Nuclear Regulatory Commission

approval of an FPGA-based safety system application and an upcoming international standard specifically directed at FPGAs and related devices.

Benefits and Limitations

FPGA technology also may offer some advantages over conventional microprocessor-based systems for cyber security, increasing the level of difficulty that would be faced by a would-be attacker. For example, FPGA-based systems that directly implement I&C functions do not contain higher-level, general-purpose components that could be diverted more easily for malicious purposes. Some FPGA technologies currently used for safety applications can also be implemented in ways that would require physical access to I&C equipment in order to alter their programming.

FPGA systems do, however, have important limitations that need to be taken into account when utilities update their control rooms. In particular, FPGAs are not well suited for systems involving complicated human-system interfaces, such as those used by control room operators. For these applications, software-based menus and multiple-window interfaces provide broader functionality and greater ease in selecting ways to display information and manage complex systems.

“FPGA technology offers many potential benefits for nuclear I&C systems, and I believe its use will increase rapidly as more products become available,” said technical executive Joseph Naser. “EPRI’s guidelines can help utilities become more familiar with FPGA-based systems and learn how to implement them so as to maximize their advantages.”

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