Testing Smart Grid Equipment and Systems

Smart Grid Testing determines if and how well the automatic and control systems will function correctly and fully every time and how well given all the circumstances they will encounter in the field these systems will perform. In some ways it bears a resemblance to software testing, in that it must assess in detail and completely the functions of a complicated serially-programmed sequence (the smart grid functions) within a larger framework of a system interconnected to and running in parallel and around it. Individual units of the smart grid system are can be tested in simulations that replicate the conditions, equipment, signals and control inputs, and sensory readings they will receive in the field.

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Real Time Digital Simulation Testing

RTDS is a real-time power system simulation platform for precise modeling and analysis of transient phenomena, utilizing simulation time close to the time frame of actual events. RTDS is primarily developed and utilized for hardware-in-the-loop (HIL) testing of protective relays, digital controllers and process control devices for performance evaluation and pre-commissioning testing under close to real world conditions. RTDS testing is also commonly used for prototype development and/or finalizing a new application design involving several digital control, protection and measurement devices.
An RTDS (Real Time Digital Simulation) system has facilities to produce digital and analog readings and signals like the equipment would see in actual operation, and coordinate those sequences and combinations to replicate the full range of situations that equipment will see in the field.

**Smart Grid Testing Procedures**

RTDS testing normally involves a sequence of event analysis by developing realistic test scenarios under which the application performance needs to be evaluated. In an RTDS test, simulated power system quantities (e.g. voltages and currents at secondary levels), status signals and control commands (e.g. circuit breaker on/off positions and tap-changers status) are exchanged with the control or protection devices in real time through several analog and digital interface cards with high precision. Simultaneously, the processed signals and/or control commands (e.g. trip signals from protective relays and gating control signals for power electronic apparatus), representing the reaction of the devices under the test to the simulated phenomena are fed back to the real time simulator. The feedback signals and control commands from the devices are used to adjust the power system topology and change any applicable set points as typically performed by system operators or dispatch centers.

The precise representation of complex power system transient phenomena (faults, frequency oscillations, voltage collapse) and real-time interactions with the actual control and protective devices (rather than modeling them) are the salient features of RTDS testing. Practically, an unlimited number of test cases and study scenarios can be generated and used to evaluate device performance and operation under
system normal and contingency (N-1/N-2) conditions.

**Smart Grid Testing Using the RTDS Lab at Quanta Technology**

Quanta Technology maintains and manages the Real Time Digital Simulation Laboratory located on the Centennial Campus of NC State University as part of the FREEDM lab initiative. The laboratory consists of all equipment needed to test a wide range of modern commercial equipment as well as equipment in the research and development phase. Simulations of specific events or sets of events for forensic analysis or contingency study can be set up as well.

**Quanta Technology’s RTDS Specifications**

- Two RTDS racks (representing up to 44 bus power systems)
- Input & Output analog and digital cards for precise monitoring and command signal exchange
- Comprehensive library of detailed component models for closed-loop real-time simulation subsystems and isolated parts of systems as well as entire systems
- Actual power system transient phenomena
- Interfacing digital/analog protective relays, FACTS device controllers and automation apparatuses
- Communication network cards supporting protocols such as DNP, IEC 61850 (sampled values)

A complete range of services for testing equipment, evaluating sufficiency and suitability, or specifying systems and equipment needed, are available, along with experienced staff and experts in all field of power systems and Smart Grid systems and applications. Services offered include:

- Test Plan and Model Development
- End-to-end Relay Application Testing
- System Design and Integration Testing
- Interoperability Testing and Conformance Evaluation
- Power System Transient Studies and Model Verifications
- Industry renowned power system and protection experts for consulting services

**Examples of Applications of RTDS Testing**

*Hardware-in-the-loop testing* of automatic and automation devices (e.g: voltage regulator and capacitor bank controllers, protective relays, measurement equipment).

*Protective relay applications and pre-commissioning testing* of protective communications systems and equipment to verify adequacy of all aspects of capability.

*Power System Transient Studies* are precise modelings of transient phenomena and fast
interactions among switching devices and power electronic devices (FACTS, Renewable Energy Sources, etc.). Model verification using simulation calibrated to replication field data and event records.

*Prototype development and product conformance testing* of measurement & automation devices (IEDs, IEC 61850 based devices, Smart Grid apparatuses).

*Verification of partial functions of modules* under development as part of R&D programs for new equipment and systems.

**Quanta Technology Experts in Smart Grid and Smart Grid Testing**

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