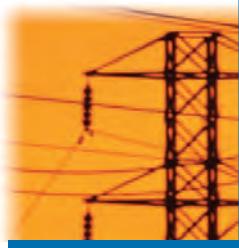


REAL TIME DIGITAL SIMULATION FOR THE POWER INDUSTRY





# Power System Simulation

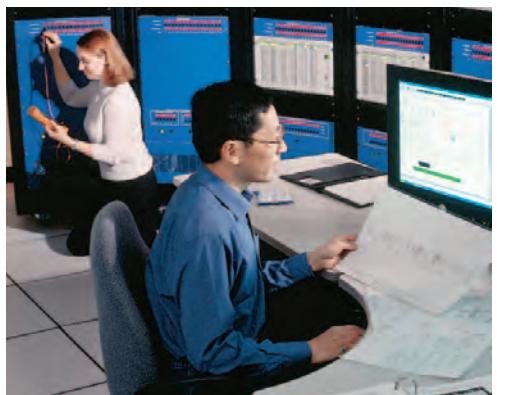
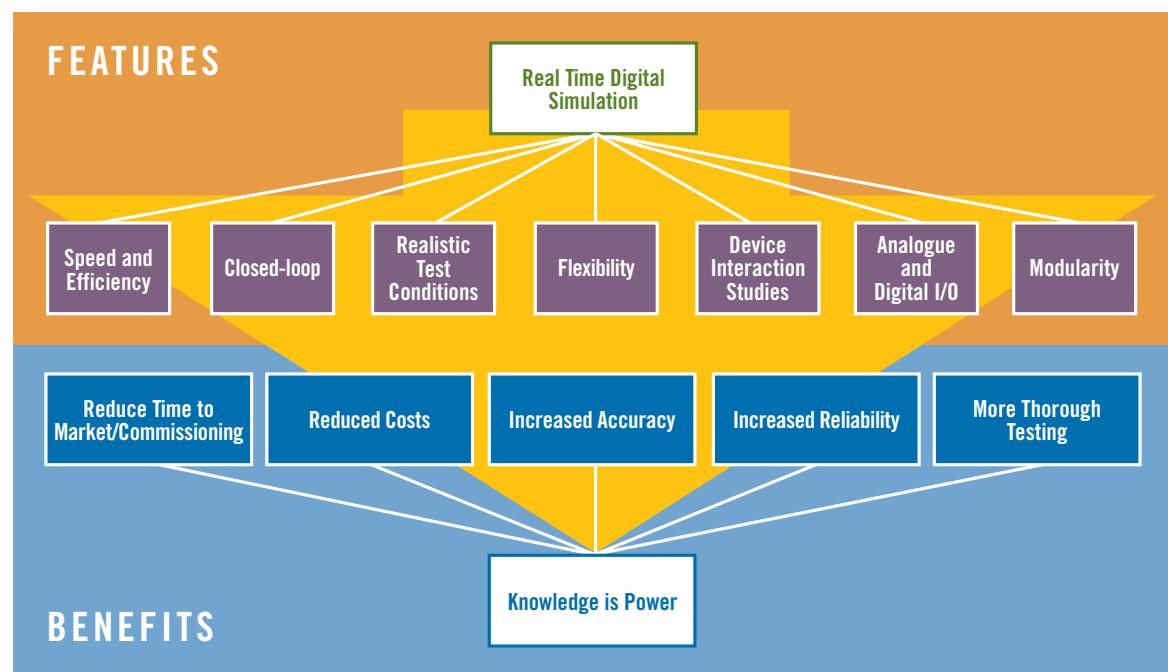
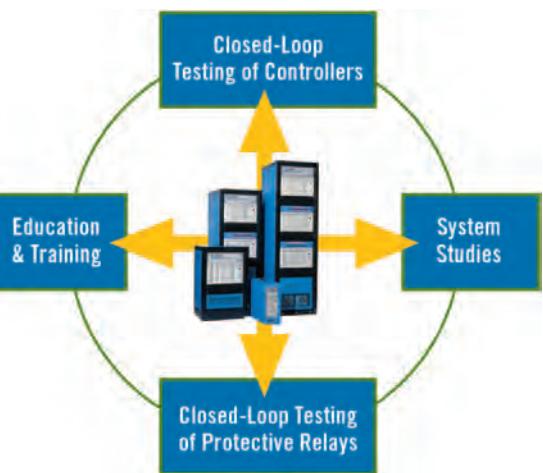
... because power system apparatus must function properly from the first day of operation, under the most extreme conditions.

## Real Time Digital Simulator RTDS®

Since worst case power system conditions are rare and dangerous to induce in the real world, the Real Time Digital Simulator – RTDS® – is used to provide them in a realistic and safe environment.

- overall system performance can be optimized;
- new power system network designs or upgrades can be evaluated and accurately tested;
- equipment can be test-driven and customized;
- problems are discovered faster – solutions are designed and tested immediately;
- contingencies can be planned for and modeled;
- component interactions can be better analyzed and understood; and
- productivity and reliability can be improved,

all in real time as if operating under actual network conditions.

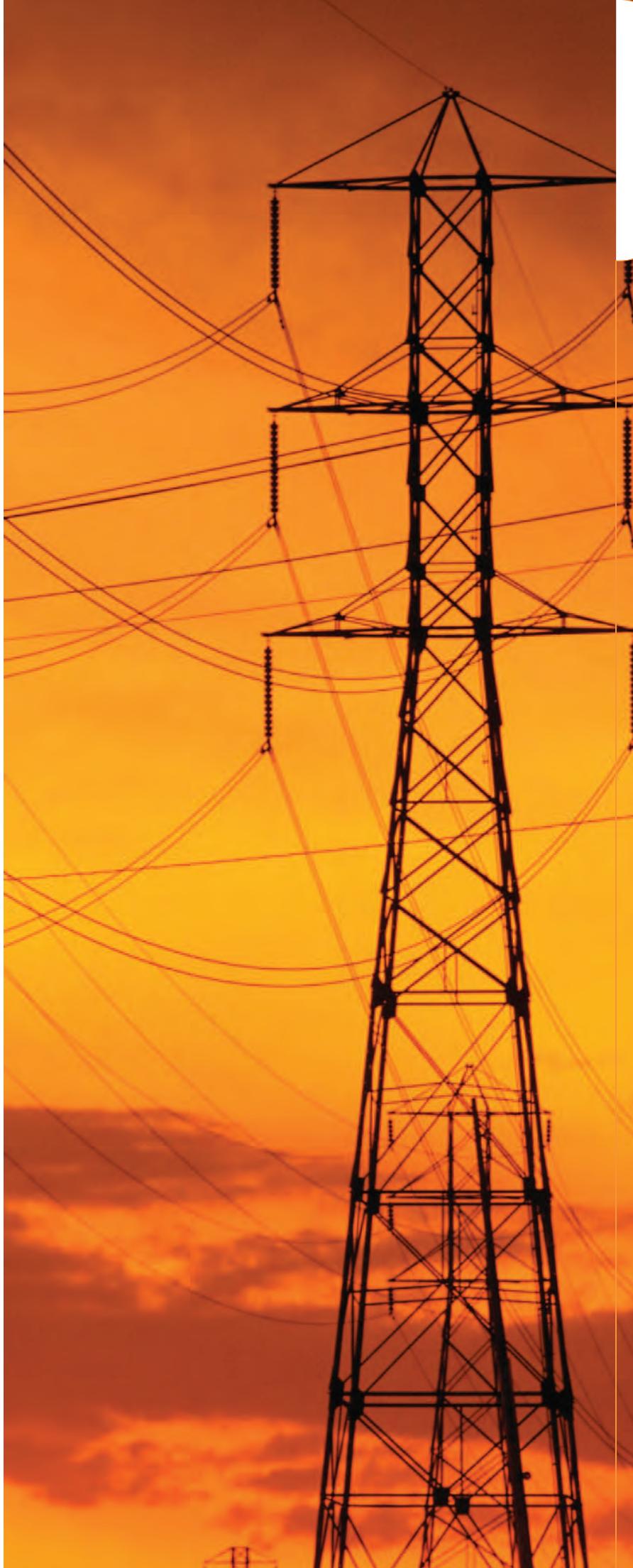


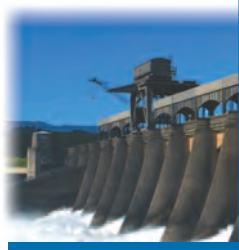
The RTDS Simulator performs simulations for the study and analysis of small or very large and complex electrical power networks. To date some applications include:

- closed-loop testing of protective relays, and integrated protection and control schemes;
- closed-loop testing of control systems for HVDC, SVC, TCSC, and synchronous machines, including AVR and PSS;
- studying general AC system operation including behaviour of generation and transmission systems;
- investigating power system equipment interaction;
- studying interaction between integrated AC/DC systems;
- developing FACTS devices and associated controls; and
- educating and training of power system personnel.

The RTDS Simulator was the first of its kind and is the world's **benchmark** for performing real time simulations.

Utilizing custom computing hardware and software, simulations performed by the RTDS Simulator encompass results from DC up to electromagnetic transients. Inherently, these results include information regarding the system load flow and transient stability, as well as that of faster disturbances. The proprietary operating system used by the RTDS Simulator guarantees "*hard real time*" during simulations, therefore, ensuring a true replica of the real power system signals.





# Real Time Digital Simulator – RTDS

... depended on by many of the world's key manufacturers of protective relays, controllers, and power electronic systems, as well as, the world's most progressive utilities and universities.

## PROVEN AND VALIDATED TECHNOLOGY FOR CLOSED-LOOP CONTROL AND PROTECTION TESTING

SIEMENS started in 1996 with RTDS simulators for closed loop testing of HVDC and FACTS controls and for protective relays. Initially using RTDS for the digital ac system simulation as part of hybrid simulators we ended up at fully digital applications first for SVC and TCSC and recently also for line-commutated HVDC systems.

Impressed and encouraged by the positive results, the wide range of applications and the excellent support RTDS today is our main tool for off-site Functional and Dynamic Performance Tests. These tests are an essential part of SIEMENS study and testing schedule for HVDC and FACTS and make therefore great demands on the simulator models.

Type testing and training on protective relays is also handled with RTDS, which allows a fast and flexible adaptation to various power system topologies and configurations. It provides also in this field a high standard and an efficient solution to our requirements on real-time simulation.

Siemens AG, Power Transmission and Distribution, System Technology Department EVNP4 – Germany

## IMPROVING EFFICIENCY, PRODUCTIVITY, AND RESULTS OF TESTING

Since 1996, we have performed Control System tests such as HVDC, TCSC, and Switching controllers and also several Protection tests. In addition, FURNAS has been hired by other companies to perform Protection System tests using the RTDS. The number of tests performed and complexity of them have increased continuously, demanding upgrades of our RTDS. Using the RTDS Simulator, Protection tests improved - the quality of the tests increased; the number of tests increased; the number of cases in each test increased; and the complexity of the tests increased. With the help of the batch mode, the RTDS performs almost everything unsupervised, including analysis. It's a very powerful tool!

FURNAS Centrais Eletrica – Brazil

## ACCOMPLISH MORE WITH AUTOMATED TESTING

We have relied heavily on our RTDS Simulator since 1997 for closed-loop testing of protective relays. Our RTDS runs nearly 24 hours/day, often running 5000 cases in an 8 hour period. The design flexibility of the RTDS Simulator as well as support from staff at RTDS Technologies enables the system to grow with our needs. Several new complex models have been developed jointly between our companies.



Alstom T&D Protection and Control – England

## LARGE SCALE REAL TIME SIMULATIONS OPEN UP NEW APPLICATIONS

In early 2001, KEPRI installed a large scale RTDS simulator at our research centre, KEPRI. Our RTDS is used together with other study and analysis tools for a wide range of research, development and testing projects relating to South Korea's power system.

KEPRI's RTDS is the largest and most powerful real time simulator in the world and consequently, many challenges were met during its design and testing. RTDS Technologies provided KEPRI engineers with in depth training... allowing KEPRI to contribute to the successful and timely completion of the simulator project.

Since installation, our simulator has been successfully used for:

- Busbar Protection Testing,
- PSS design and testing for real in-service generator units,
- Unbalance fault studies and their affect on power transformers, and
- Pre-commissioning studies for the first 765 kV twin circuit transmission lines in Korea. The studies utilized a network model with 90 full generator units and over 200 buses.



KEPCO/KEPRI – South Korea

## PROVIDING FLEXIBLE, EASY, AND SAFE ACCESS TO A POWER SYSTEM FOR TESTING DEVICES

Our RTDS is mainly used for testing protective relays. RTDS is also used to test safety and stability control instruments for power systems. We use RTDS to simulate many types of complex faults that may occur in the power system...RTDS has become an important tool for Sifang to research and develop control systems.

Hathway Sifang Protection and Control Co., Ltd.  
– Peoples Republic of China

## WORKING WITH OUR USERS TO BETTER SERVICE THEIR NEEDS

Our RTDS Simulator has become an essential tool in the development and testing of our relays. We have undertaken work together with RTDS Technologies to develop new components for relay modeling. In addition to our internal use of the RTDS, it has also been used for performing numerous studies for clients and subsequently we have purchased a second RTDS Simulator for that purpose. Our clients demand high quality products tailored to their needs – our RTDS plays an integral part in meeting those expectations.

SEL – Schweitzer Engineering Laboratories – USA



## PROVIDING THE SUPPORT AND SERVICES EXPECTED BY CLIENTS

The RTDS Simulator is an innovative tool for power system education, research and development. We value it particularly as an intermediate step between software simulation and field trials. The similarity of the user interface with EMTDC is very helpful to the students. We have always found the RTDS staff extremely helpful and very much appreciate their enthusiastic support.

UMIST – England



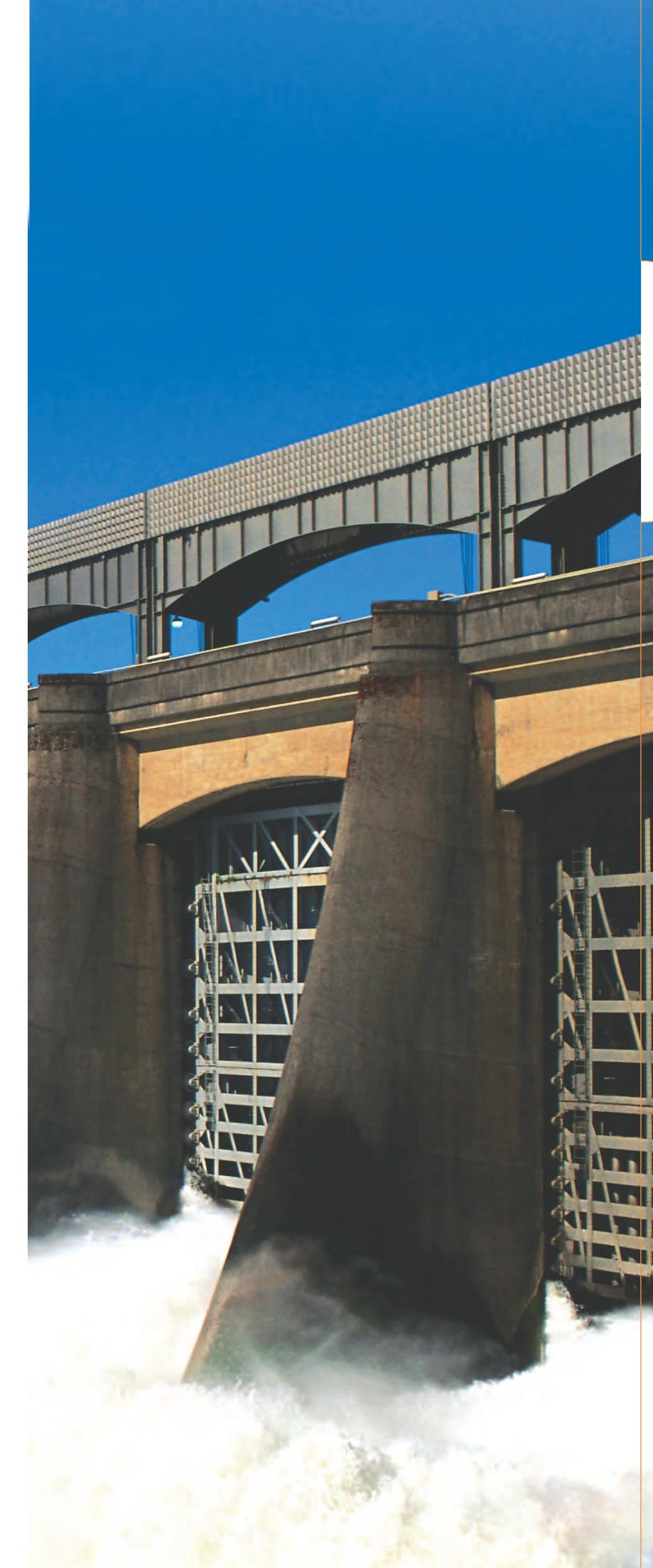
## RTDS TECHNOLOGIES ALSO PROVIDES TESTING AND SIMULATION SERVICES

Nokian Capacitors Ltd. from Finland has verified the operation of their SVC system for a utility SVC installation they are supplying to Furnas Eletricas in Brazil by carrying out a comprehensive test program utilizing the simulator laboratory and personnel of RTDS Technologies.

Nokian Capacitor Ltd. – Finland



The RTDS Simulator is more widely used than any other simulator in the world. RTDS Technologies has the experience, expertise, and proven technology for fast, reliable, accurate, and cost effective study of power systems. We pioneered real time digital simulation and remain focused on the support and continued development of the RTDS Simulator.





## RTDS Simulator Hardware and Software

...built specifically to address power simulation needs, the RTDS Simulator provides accuracy, speed, and flexibility through sophisticated and user-friendly hardware and software.

### HARDWARE

The RTDS's parallel processing architecture is designed specifically for power system simulation. Some key features are:

#### Real Time

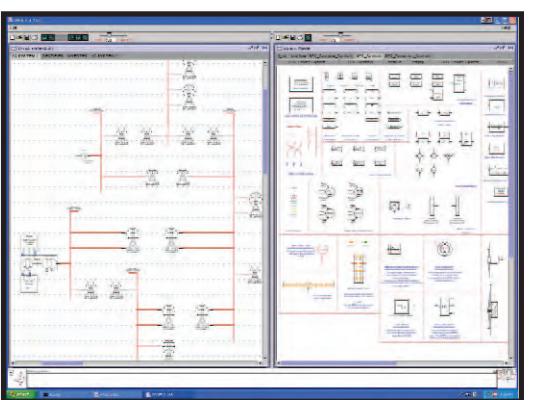
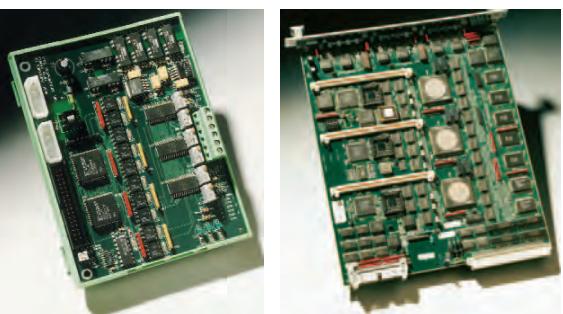
The custom design ensures continuous hard real time operation. For each increment in time, all of the equations representing the power system are computed (and all I/O updated) in a measured time exactly equal to the timestep.

#### Modularity

The RTDS Simulator is modular in many aspects of its design ensuring that clients receive the hardware required for their specific needs - best utilizing their investment and yet allowing for future expansion.

#### Input and Output (I/O)

The simulator provides the most direct data path possible from the processor to the I/O. This structure allows the use of hundreds of I/O channels at minimum cost, without significantly impacting the timestep or creating communication bottlenecks. The I/O is modular, customizable and easily expanded as required.



### SOFTWARE

The RTDS software is the user's link to the simulator hardware. The main elements of the software are the graphical user interface, RSCAD, and the libraries of power and control system component models.

#### RSCAD Graphical User Interface

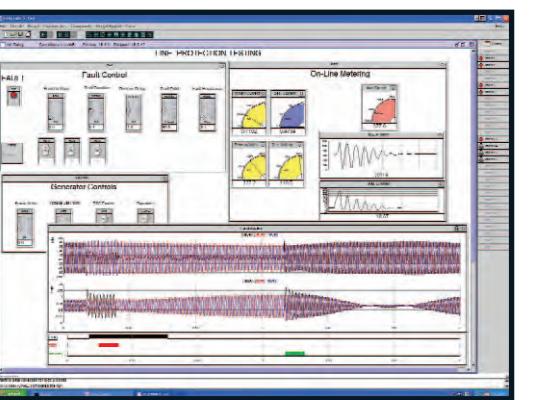
RSCAD represents a family of software tools consisting of individual modules that accomplish the different tasks involved in operating the simulator. Through RSCAD, the user has the ability to organize and share simulation projects and cases; assemble circuit diagrams using predefined or user-defined power and control system component models; automate or interact with simulator operation; and analyze and post-process simulation results.

#### Component Model Libraries

Extensive libraries of power and control system component models have been designed and tested by RTDS Technologies and subsequently validated by users. Much care has been given to ensuring that the library components operate efficiently since the length of their code directly impacts the minimum achievable simulation timestep. User Defined Component (UDC) models enable new components to be created and integrated with the predefined components already available.

The comprehensive component libraries, built up through years of experience, as well as, the user-defined capability ensure the ability to meet study requirements now and in the future.

The Real Time Network Solution, Embedded Valve Groups, and Improved Firing are just a few of the advanced algorithms developed and implemented specifically for the RTDS Simulator. These algorithms provide the accuracy and efficiency needed to realistically simulate complex power system networks and devices in real time.



# Application – Closed-loop Testing of Protective Relays

... ensuring that protection devices operate reliably and securely.

The RTDS Simulator is an ideal tool for thoroughly designing, studying, and testing protection schemes; initially simulating the protection, if desired, and later interfacing the physical equipment for final verification.

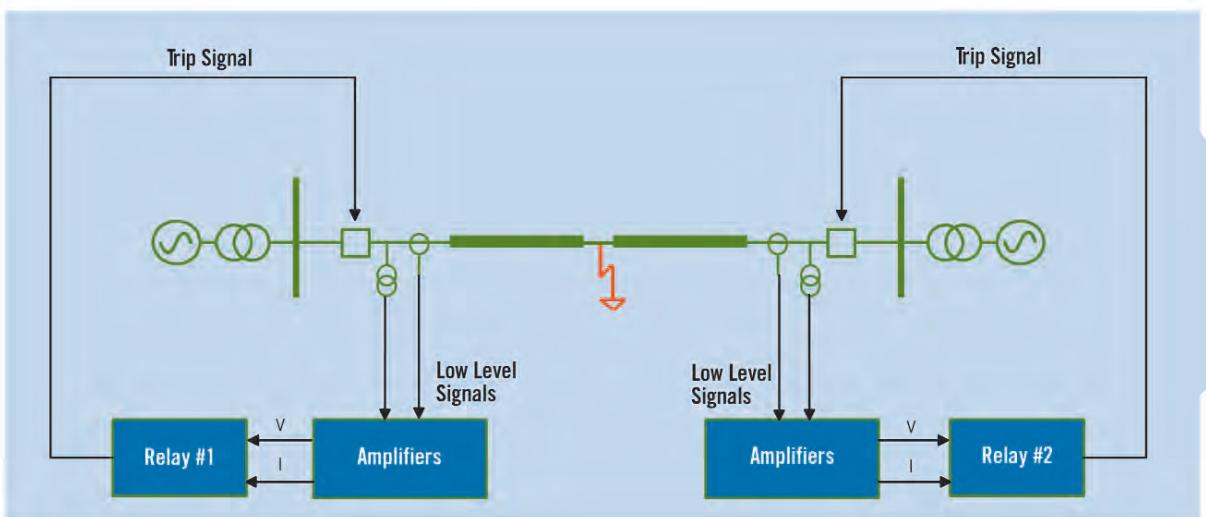
As relays have become more sophisticated, more sophisticated testing methods are required. The RTDS Simulator provides the most advanced and comprehensive testing available.

Closed-loop testing on the RTDS Simulator is the only method capable of:

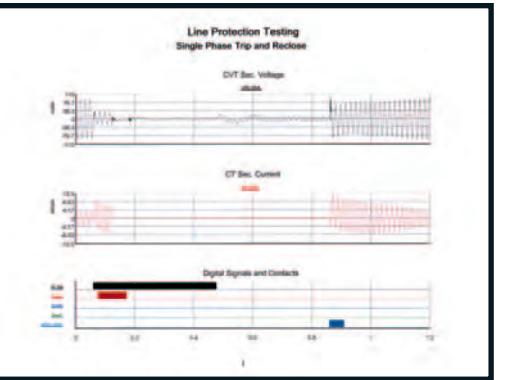
- fully evaluating the interaction of more than one protection device;
- studying the true interaction of the protection system with the power system; and
- providing maximum testing efficiency (i.e. more contingencies can be investigated in less time).



**Closed-loop Testing of Protective Relays**  
The RTDS Simulator is the power system.



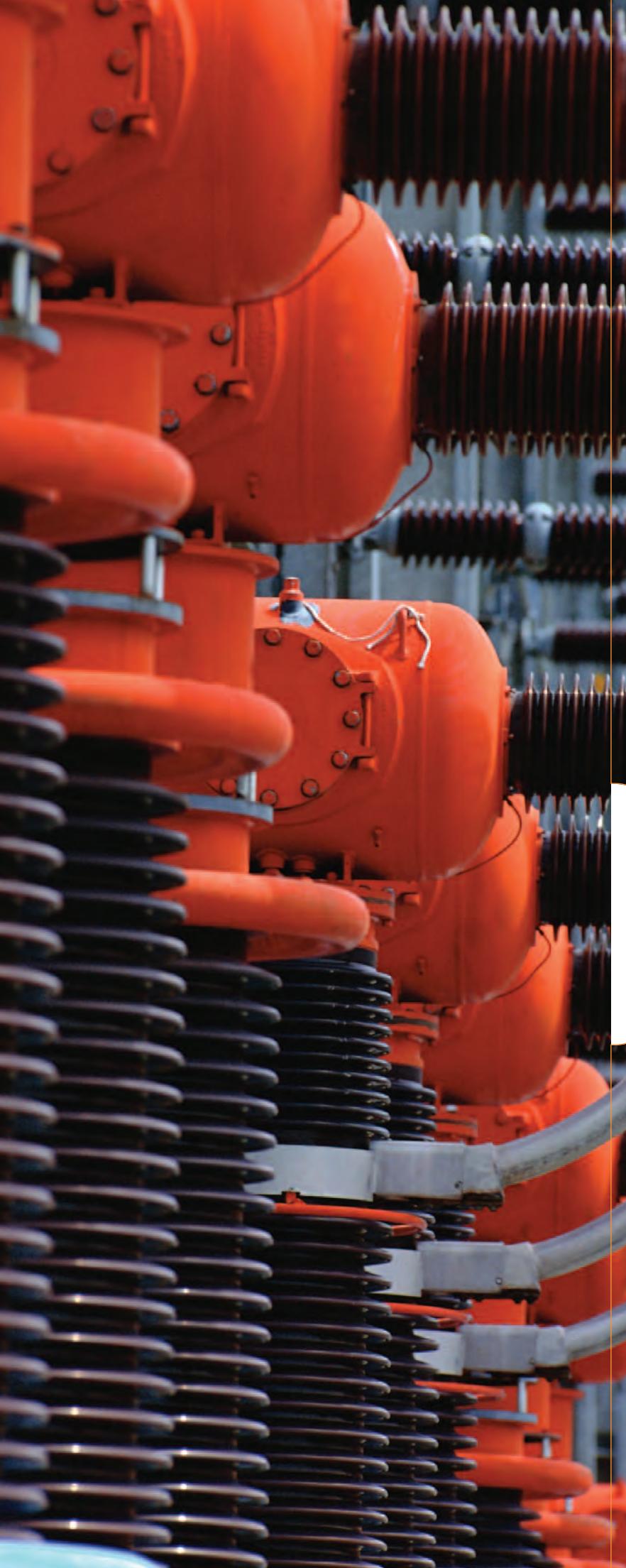
The RTDS Simulator is capable of testing single and multiple protective relay schemes either at low levels (i.e. +/- 10 Vpk) or at standard secondary levels (e.g. In=5 A, Vn=67 V). To provide secondary level voltages and currents, amplifiers are connected in the test loop between the RTDS Simulator and the protective relay.



It provides a proven power system representation including advanced models for components such as instrument transformers, critical for relay testing.

The RTDS Simulator has been used to protect power system apparatus, as well as for testing all types of relay devices used in transmission systems apparatus (e.g. lines, generators, and transformers). It has been used for relay algorithm simulation, prototype testing, validation, type testing, relay selection, and pre-commissioning.

Various RTDS hardware configurations have been used to test single relays and more complex multi-terminal systems with relay interaction. The modular structure of the RTDS hardware enables the appropriate configuration to be allocated. I/O peripherals, such as high precision output and optical isolation, are designed to make interfacing and testing easy.





# Application – Closed-loop Testing of Control Equipment

... providing a realistic closed-loop environment to test the operation of controls.

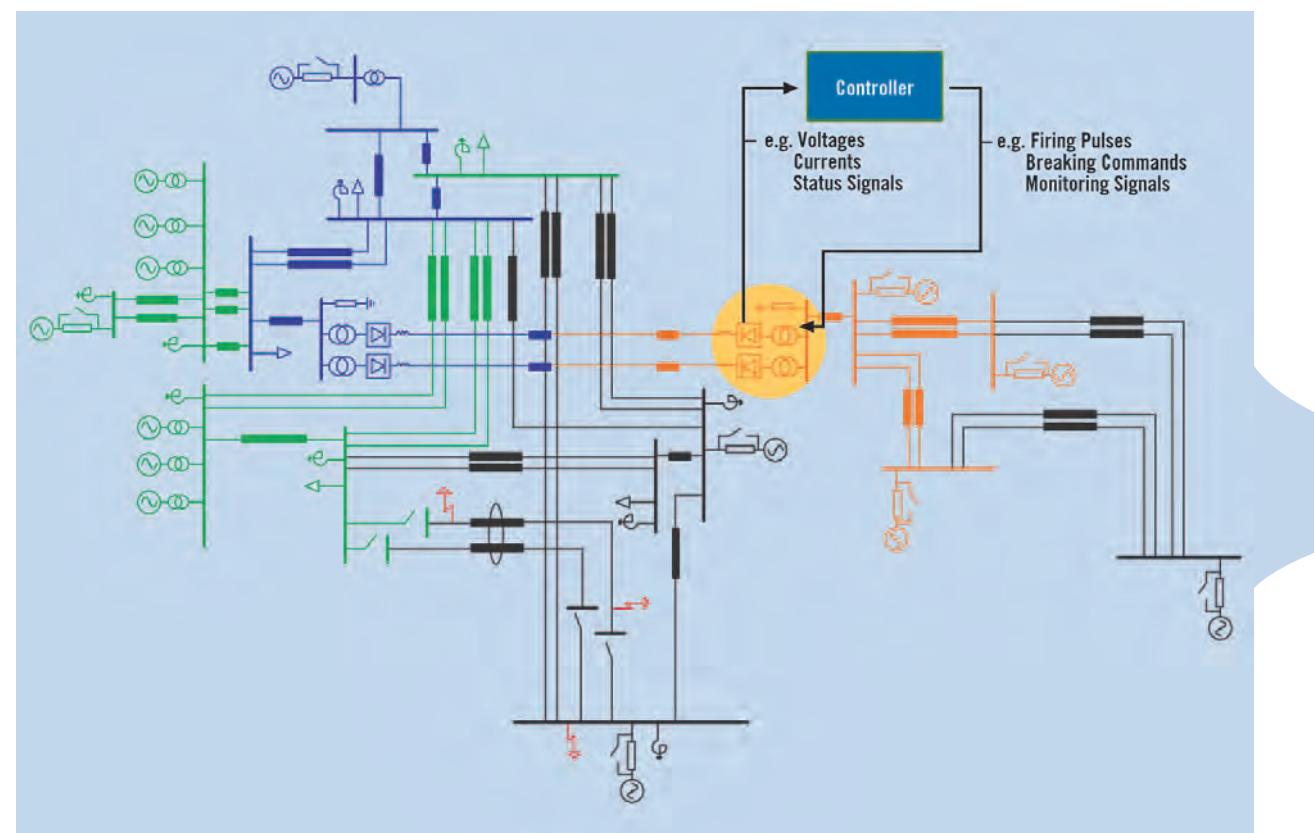
Control system research, development, and testing can be easily performed using the RTDS Simulator. Control systems can be either internally represented using individual control blocks or the physical controller can be interfaced to the simulator through analogue and digital I/O for closed-loop operation.

- Real time simulation is the only means for testing control equipment, and the digital simulator represents the most flexible and efficient method of performing such tests.
- The flexible I/O structure used by the RTDS Simulator facilitates the high volume of signal exchange required when testing complex controllers. The modular design allows additional I/O to be added if interfacing requirements expand.



## Closed-loop Testing of Control Equipment

The RTDS Simulator is the power system.



Closed-loop controller testing often requires interfacing numerous analogue and digital signals. The RTDS Simulator's modular I/O design enables efficient and straightforward connection, and provides optical isolation when necessary.

- Components such as the Embedded Valve Group with Improved Firing, the Real Time Network Solution, and the Switched Filter component provide the necessary features to fully and efficiently utilize the simulator for control system testing.

The RTDS Simulator has been used extensively to test various types of controllers:

- Generator AVRs and PSSs,
- HVDC controls,
- SVC controls,
- TCSC controls, and
- Other specialized control equipment.

The simulator has been used for control system development, verification, prototype testing, validation, type testing, and pre-commissioning.



photo courtesy of Manitoba Hydro



## Application – Power System Studies and Education

... using the RTDS Simulator provides the link between theory and practical operation of the power system.



Whether studying a specific power system or providing education and training, the RTDS Simulator provides access to a convenient, safe and realistic power system model.

Power system simulation studies can involve nearly any network configuration, including models that represent the fundamental dynamics of an entire utility's network. Regardless of the size of the power system, the RTDS Simulator provides an interactive learning environment where the user plays an active part in the simulation. Simulation studies and training can be performed with off-line simulation programs, but they are generally slower – leaving the user to wait. With a real time tool, the same results are available immediately and no time is wasted. Users are able to follow their engineering intuition and in turn increase their understanding of the system under study.

The RTDS Simulator is an ideal tool to illustrate simulation techniques, as well as, power system dynamics and operation. It represents the system

performance over a large frequency range (DC to approximately 3 kHz). This depth of analysis provides long term system dynamic and stability information that may not be seen using off-line electromagnetic transient simulation tools.



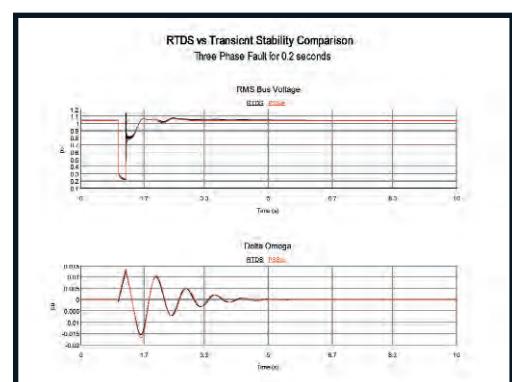
**Simulation services, from setting up cases and creating new models through to performing complete simulation studies and tests, are available from RTDS Technologies.**

The comprehensive power and control system libraries provided with the simulator make it possible to conduct meaningful power system studies. The model representations have been validated and benchmarked against various well-known and well-accepted methods. Benchmark cases have been run on the RTDS Simulator to validate its response over the following range of simulation classes:

- Electromagnetic Transient
- Electromechanical Transient
- Transient Stability
- Load Flow / Steady State

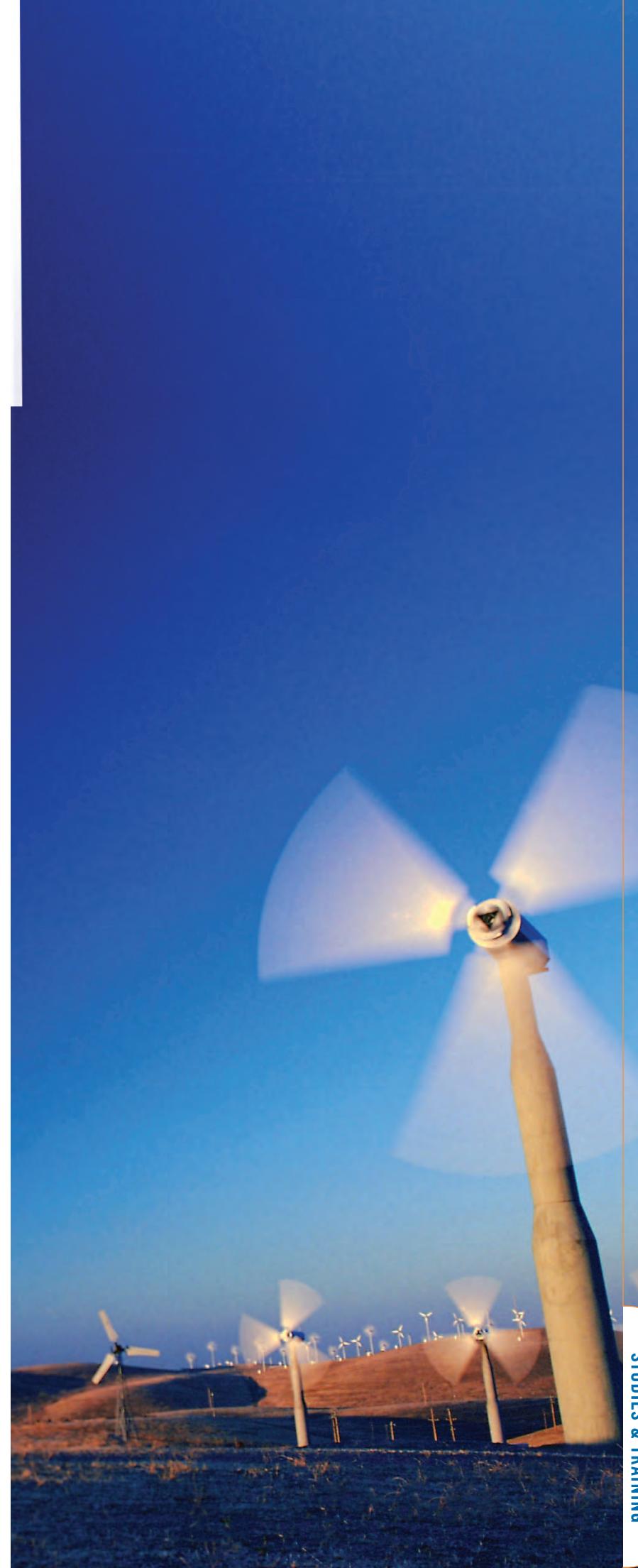
The validation process includes comparisons between the RTDS Simulator and various references including:

- EMTDC®, EMTP® and NETOMAC®
- PSS/E®, Y-Method and BPA Transient Stability
- PSS/E® and BPA Load Flow
- CIGRE® and IEEE® benchmark cases
- Actual power system measurements



Examples of the studies which have been performed using the RTDS Simulator include:

- Power system and equipment interaction investigation
- Breaker reclose and fault recovery strategies
- Transformer inrush and saturation studies
- Subsynchronous Resonance studies
- Power swing damping strategies





## RTDS Technologies

... providing superior expertise, equipment, support and services – expected and relied on by our clients.

**Knowledge is power and the RTDS Simulator helps provide the knowledge needed for reliable and efficient operation of power systems and power system equipment.**

RTDS Technologies has an innovative team of world class electrical engineers – experts in the design and implementation of computer hardware and software for power system simulation. Our close relationship with our clients and a clear understanding of their unique requirements enables us to focus on their individual needs and incorporate requests into further product development.

Fast, knowledgeable technical support and one-on-one training is provided around the globe by our developers, application experts and technicians, as well as our network of local representatives. Together, we provide insightful direction and expertise.

RTDS Technologies offers a comprehensive Warranty and Extended Warranty and Maintenance program that includes:

- continual upgrades of software and documentation
- hardware and software trouble-shooting
- simulation study support
- extended hardware warranty

**You can depend on RTDS Technologies for your current and future simulation requirements.**

RTDS Technologies has demonstrated a commitment to continued research and development in the area of real time power system simulation. New and innovative hardware and software has been provided to customers as a part of a continuous upgrade path furthering the capabilities of the RTDS Simulator.

**RTDS Technologies has shaped the power system simulation industry.  
Choose with confidence – trust in our many years of experience in real time simulation.**



RTDS Technologies accomplishments during the past decade include:

- Developed and introduced the world's first fully digital real time simulator
- Provided affordable fully digital technology which enabled a wider group of users to access real time simulation
- Changed the way protective relay testing is performed, adding more complex thorough testing as well as a fast batch test facility
- Changed the way real time studies and controls testing are performed, providing larger systems and improved accuracy
- Introduced the world's first portable real time simulator
- Installed the world's largest real time simulator for power system studies

... growing out of research and development conducted at the Manitoba HVDC Research Centre.

RTDS Technologies Inc. was established and incorporated in Manitoba, Canada in February, 1994. The company, privately owned and operated, is primarily engaged in manufacturing, marketing, servicing and continuing development of the Real Time Digital Simulator (RTDS®).

The simulator was originally developed at the Manitoba HVDC Research Centre following several years of hardware and software design. Research on the fundamental RTDS Simulator technology began in the mid 1980s, with the first commercial simulator installation following in 1993. After completing the development phase, the Research Centre granted RTDS Technologies an exclusive license to manufacture, market, service and further develop both the hardware and software related to the RTDS Simulator. Since that time, RTDS Technologies Inc. has continued to advance this exciting new technology.

The RTDS Simulator's transition from research project to commercial product was overseen by former employees of the Manitoba HVDC Research Centre who were key to the simulator's development and who subsequently founded RTDS Technologies.

RTDS is a registered trademark of the Manitoba HVDC Research Centre.



photo courtesy of Manitoba Hydro



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