Цифровое моделирование в реальном времени для энергетики
ТЕХНИЧЕСКИЕ ПУБЛИКАЦИИ

Для получения текста и более подробной информации по любой из этих публикаций обращайтесь в ЗАО "ЭнЛАБ" по адресу support@ennlab.ru.

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РЕЛЕЙНАЯ ЗАЩИТА

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
1.	**Utilizing RTDS Simulation Scenarios for PHASOR System Performance Testing at Southern California Edison** Joshua Park, David Martinez, Anthony Johnson, and Rudi Wierckx. 2013	Southern California Edison (SCE) is deploying the first phase of its new synchrophasor data management and exchange system, which is referred to as the PHASOR System, as part of its smart grid development program. The PHASOR System is comprised of General Electric's (GE) XA/21 1 system as the core, Electric Power Group's (EPG) Enhanced Phasor Data Concentrator (ePDC™) and ISG synchrophasor applications for data synchronization and external data transfer, and Instep's eDNA data historian for long-term data archival. SCE's PHASOR System is designed to support a maximum of 2,000 phasor data quantities sourced from up to 100 unique phasor measurement units (PMUs).	**Использование сценариев моделирования на RTDS при функциональных испытаниях системы ВЕКТОР в компании SCE**
2.	**RTDS Simulation and Testing of a Remedial Action Scheme at Southern California Edison** Allison Auld, Joshua Park, Anthony Johnson, Marc Desjardine and Rudi Wierckx. 2013.	The goal of this effort is to determine how a real-time digital simulator (RTDS) can be used to simulate the behavior of a remedial action scheme (RAS) in a controlled laboratory environment at the Southern California Edison (SCE) Power Systems Laboratory. The RAS functions with two redundant pairs: System A and System B. The lab test setup includes all actual RAS System A relays and all simulated System B relays. The RTDS scripting capability automates more than 9,000 tests that span various contingencies, arming levels, load flows, and A/B system availability. The simulator demonstrated the ability to re-create an existing RAS in the laboratory environment, which will be a valuable tool in preparing for future RAS applications.	**Моделирование и испытания на RTDS схем деления энергосистемы при авариях в компании SCE**
3.	**Using a New Faulted Synchronous Machine Model for Hardware-In-Loop Testing of a Generator Protection Relay** Presented at Southern African Power Systems Protection Conference, Johannesburg, South	This paper presents the results of a study into the use of a new faulted synchronous generator model for testing generator protection schemes using a real-time simulator. The paper presents results of tests on stator differential, loss of excitation and 100% stator ground fault protection schemes.	**Новая модель КЗ синхронной машины для проверки реле защиты генератора при исследованиях по замкнутой схеме**

	Africa, 14-16 November 2012		
4.	**Certification of Protection Relay Models for Eskom Using Real Time Digital Simulation** Presented at Southern African Power Systems Protection Conference, Johannesburg, South Africa, 14-16 November 2012	This paper describes methods that have been developed to validate relay models within the EMT simulation program used by Eskom. The paper describes how, with a combination of carefully-designed study-system models, and real-time simulator testing, the models used day-to-day by protection engineers in the utility can be validated against actual relay performance under controlled, but representative conditions, and any shortcomings in these models rectified accordingly. Confidence established in these models is essential for system operation investigations, where a key part of the process is injecting these relay models with fault recordings of incidents being investigated by protection engineers on 24-hour standby for the utility's National Control Centre.	**Сертификация моделей релейной защиты используемых на RTDS компании Eskom**
5.	**Experiences with Detailed Hardware-In-Loop Testing of Protection Relays and Settings Within ESKOM** Presented at Southern African Power Systems Protection Conference, Johannesburg, South Africa, 14-16 November 2012	This paper presents a review of how hardware-in-loop testing of protection relays on a real-time simulator has been put to use in a range of applications by Eskom. In some of these applications, models of relatively large parts of the transmission network have been used on a real-time simulator, either to study the performance of a relay already in service and improve its settings in response to changes in system conditions, or to test new protection settings and relay hardware prior to commissioning. In other cases, models of small-scale but representative study systems have been used to allow careful comparative evaluation of the suitability of different relay technologies for practical field conditions	**Наработки Eskom по углубленному исследованию по замкнутой схеме релейной защиты и уставок**
6.	**A Dynamic Modelling Environment for the Evaluation of Wide Area Protection Systems** Presented at 43rd International Universities Power Engineering Conference (UPEC '08), Padova Italy, September 2008	This paper introduces the concept of dynamic modelling for wide area and adaptive power system protection. Although not limited to these types of protection schemes, these were chosen due to their potential role in solving a multitude of protection challenges facing future power systems. The dynamic modelling will be implemented using a bespoke simulation environment. This tool allows for a fully integrated testing methodology which enables the validation of protection solutions prior to their operational deployment. Furthermore the paper suggests a distributed protection architecture, which when applied to existing and future protection schemes, has the potential to enhance their functionality and avoid mal-operation given that safety and reliability of power systems are paramount. This architecture also provides a means to better understand the underlying dynamics of the aforementioned protection schemes and will be rigorously validated using the modelling environment.	**Динамическое моделирование окружающих условий при анализе территориально-распределённой системы релейной защиты**
7.	**Real Time Power System Simulation using RTDS and NI PXI** North American Power Symposium (NAPS), Calgary, Canada, September 28th to 30th, 2008	Real time simulation is becoming an essential simulation environment for engineering design, especially in power systems. This paper discusses two real time simulators applied to power system simulation: Real Time Digital Simulator (RTDS) and National Instruments-PXI (PCI eXtensions for Instrumentation). RTDS is an efficient tool for the design, development, and testing of power system and its components. NI-PXI is a high-performance and low-cost PC-based platform, used for simulating wide variety of systems. Virtual testing of power systems on the NI-PXI and its potential power system simulating capabilities has been discussed here. The performances of both the simulators are studied and compared by running an eight-bus power system under different fault conditions in real time. A Schweitzer Engineering Laboratories (SEL)-351S directional over-current relay is used to test these power system simulators. The SEL reports obtained by simulating the power system on these simulators are compared as a part of verification process.	**Оценка моделирования энергосистемы в реальном времени на RTDS и NI PXI**

8.	**Secondary Arc Extinction and Detection Real and Simulated** IET 9th International Conference on Developments in Power System Protection, 2008. DPSP 2008	Removal of a single line to ground fault by isolating only the faulted phase frequently leads to the creation of a secondary fault arc. Auto reclose protection schemes depend upon the absence of a secondary arc prior to reclosing. Consequently, there is great benefit from a technology to determine Secondary Arc Extinction Detection. The testing of SAED can be difficult and require the expense and complexity of staged system faults. A great deal of planning is necessary to do this however, and many fault scenarios cannot be fully studied. Accurate simulation of the phenomenon can alleviate many of these difficulties	**Определение повторного зажигания дуги- реальное и моделируемое**
9.	**Using a Multi-Threaded Time-Step to Model a Multi-Function Relay in a Real Time Digital Simulator** IET 9th International Conference on Developments in Power System Protection, 2008. DPSP 2008	By default, a real time digital simulator will execute a simulation case and provide the solution for the controls and power system every time-step (typically 50 µsec). The length of the time step is decided by the time taken to execute the longest component algorithm. The component in question may be that for a protective relay which takes in new data only every 1 or 2 milliseconds. The idea behind a multithreaded component is that a protection algorithm does not need to be executed every time-step. A component algorithm can be separated into individual blocks of code processed independently of each other to create a multi-threaded component running within the main simulation. Details are given of this process and how it is applied to several relay models.	**Использование многопоточного квантования по времени для моделирования многофункциональных реле защиты в цифровом симуляторе реального времени**
10.	**Impact of Waveform Distorting Fault Current Limiters on Previously Installed Overcurrent Relays** IEEE Transactions on Power Delivery, Volume 23, Issue 3, July 2008, pp. 1310-1318.	This paper investigates in detail the impacts of distorted current waveforms, produced by certain types of fault current limiters on time-overcurrent protection relays. A thyristor based solid-state fault current limiter is chosen as representative of such a device for a case study which investigates its effects on two coordinated protection relays. A detailed software model of the current limiter has been developed and implemented on the real-time digital simulator platform, modeling a typical distribution system. Relay models are used to obtain initial results, which are later validated by an actual protective relay connected in a hardware-in-the-loop simulation setup. The results illustrate the increase of relay tripping times due to severe current limitation caused by the fixed firing angle control of the current limiter. It is revealed that different current measurement principles employed by the relays, such as fundamental, peak, or true RMS, can lead to miscoordination due to the distorted fault current waveform. It is demonstrated that these undesirable effects can be mitigated by employing appropriate control strategies for the firing angle in the current limiter.	**Влияние искажений сигналов, вызванных действиями ограничителей тока КЗ на уже установленные реле максимального тока**
11.	**Comparative Assessment of Differential Relay Model Performance with Hardware Equipment** Grand Challenges in Modeling & Simulation, Summer Simulation Conference (SummerSim), June 16-19, 2008 Edinburgh, Scotland	The stability and security of the power system has to be maintained under different fault conditions. Modeling and simulation of different fault conditions are needed for a better design of future Shipboard Power Systems (SPS). The protective relay plays a major role in the protection of the power system. The real time digital simulator (RTDS) is an effective tool for modeling and simulation of a power system, protective relay and the controls needed to simulate different fault conditions in real time. The Hardware in the Loop Testing (HIL) provides the opportunity to understand the behavior and validate the model of a physical device. This paper addresses the HIL tests of the Schweitzer Engineering Laboratories SEL-487B bus differential relay and the software differential relay model development. The software relay model is designed by using the RSCAD software suite and is validated using the results from the HIL testing. The Hardware in the Loop (HIL) tests and the software relay model tests has been implemented using an 8-bus terrestrial power system test case. The consistency and performance of the software differential relay model has been analyzed.	**Сравнительная оценка модели устройства дифференциальной защиты с реальным реле**

12.	**Designing and Testing Protective Overcurrent Relay Using Real Time Digital Simulation** Grand Challenges in Modeling & Simulation, Summer Simulation Conference (SummerSim), June 16-19, 2008 Edinburgh, Scotland	The Real Time Digital Simulator (RTDS) is a tool for the design, development, and testing of power system protection and control schemes. RTDS can be used for the investigation, development, and integration of new and complex power system components. The user is able to study both the device itself and the response of the existing power system to its operation (or misoperation). The Hardware in the Loop (HIL) test provides an opportunity for understanding the behavior and validating the model of physical device. In the HIL simulation, parts or components of the virtual power system are replaced with physical devices. In the Software in the Loop (SIL) simulation, the software model replaces the physical protective device. This paper presents the modeling and testing of a Schweitzer Engineering Laboratories (SEL) 351S protective overcurrent relay using RTDS. The first part of the paper discusses HIL tests conducted with the physical SEL 351S overcurrent relay for an eight-bus power system. The second part discusses the development of a software relay model in RSCAD and real time SIL simulation. The results obtained by conducting the real time HIL are presented and procedure to conduct the SIL tests is proposed.	**Использование RTDS при проектировании и испытаниях реле максимального тока**
13.	**Modeling and Validation of an Overcurrent Relay Using LabVIEW and RTDS** Grand Challenges in Modeling & Simulation, Summer Simulation Conference (SummerSim), June 16-19, 2008 Edinburgh, Scotland	Instability in a power system can be manifested during fault conditions in different ways. To ensure system stability, satisfactory performance of protection systems such as a protective relay is of great importance. Development of more reliable digital protection devices is possible with modeling, simulation and testing. This paper describes a detailed software model of an overcurrent relay developed in the Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) graphical programming language. The performance of the relay model is tested under different fault scenarios with both the relay model and power system model running in real time. The results obtained are validated against hardware in the loop (HIL) tests conducted with a Schweitzer Engineering Laboratories (SEL)-351S overcurrent relay and power system model in Real Time Digital Simulator (RTDS) to modify the software model to best represent the hardware functionality.	**Моделирование и проверка реле максимального тока с использованием LabVIEW и RTDS**
14.	**Impact of Fault Current Limiters on Existing Protection Schemes** CIGRE WG A3.16, Electra, No 236, Fenruary 2008, pp. 31-41.	The deregulation of the power market causes a strong tendency towards separating generation from transmission. The utilities responsible for operation the networks are losing control over the placement and scheduling of generation. A consequence of this development is that in certain parts of power networks the short circuit currents approach, or even exceed, the allowable values based on equipment rating, primarily circuit breaker interrupting capability. There are clear indications for a growing interest in fault current limiting devices rated for applications in the high voltage system. The answers of a survey among worldwide utilities, conducted by CIGRE WG A3.16, show an increase in the need for fault current limitation in medium voltage (MV) systems (below 72 kV) and especially at the high voltage (HV) level between 110 kV and 145 kV.	**Влияние искажений сигналов, вызванных действиями ограничителей тока КЗ на уже действующие схемы защит**
15.	**In System Emulation of a New Current Differential Back-up Protection Relay** DPSP 2008. IET 9th International Conference on Developments in Power System Protection, 2008. Publication Year: 2008 , Page(s): 400 – 405	The philosophy, design, and evaluation of a wide area back-up differential protection scheme are described in this paper. In the absence of a commercially available relay capable of servicing the back-up function the back-up relay is “emulated” on a DSP in a real time digital simulator and coordinates with commercially available primary protection relays interfaced to the power system simulation running on the simulator. The scheme is evaluated on a small closely coupled power distribution system.	**Моделирование энергосистемы с новым реле резервной дифференциальной защитой**

16.	**Large Scale Power System Simulation and PMU testing using a Real Time Digital Simulator** Presented at IPEC 2007, Singapore, December 2007	In recent times the use of PMU's is being investigated as part of wide area power system control. Real time simulation and closed-loop testing is essential to the development of these controllers. This paper introduces the methods used to create large scale power system models on the RTDS Simulator for the testing of PMU's. Data conversion and load flow programs are two tools that are very effective when creating large scale electromagnetic transient simulations. The paper explains the key aspects of these tools. For some applications, high precision pulses are used by PMU's to measure generator rotor angles. A pulse must be given for each revolution of the generator with an accuracy of 3-5 microseconds. This is a challenge for a discrete time simulation operating with a typical timestep of 50-70 microseconds. A technique to provide the pulse with an accuracy of 1 microsecond is introduced. Finally an example is presented to demonstrate the entire process of creating large scale power system models on the RTDS Simulator for PMU testing.	**Применение RTDS для моделирования крупномасштабной энергосистемы и испытания синхрофазоров (PMU)**
17.	**Performance Comparison of Distance Protection Schemes for Shunt-FACTS Compensated Transmission Lines** IEEE Transactions on Power Delivery,Issue Date: Oct. 2007, Volume: 22 Issue:4, On page(s): 2116 – 2125	This paper presents a comparative study of the performance of distance relays for transmission lines compensated by shunt connected flexible ac transmission system (FACTS) controllers/ devices. The objective of this study is to evaluate the performance of various distance protection schemes on transmission lines with shunt-FACTS devices applied for midpoint voltage control. The impact of two types of shunt FACTS devices, static var compensator (SVC) and static synchronous compensator (STATCOM) on the transmission line distance protection schemes is studied for different fault types, fault locations and system conditions. The power system elements and the shunt-FACTS devices with their associated controllers are modeled using RSCAD/RTDS software. The results are based on the performance of commercial distance relays using a real time digital simulator (RTDS).	**Оценка различных схем дистанционной защиты линий электропередачи с поперечной компенсацией FACTS**
18.	**Backup Transmission Line Protection for Ground Faults and Power Swing Detection Using Synchrophasors** Armando Guzmán, Venkat Mynam, Greg Zweigle, Schweitzer Engineering Laboratories, Inc.	This paper proposes the use of synchrophasors for backup transmission line protection for ground faults and power swing detection. The proposed protection approach complements protective distance elements and is suitable for single-pole and three-pole tripping applications. The paper presents the synchrophasor- based protective element performance for challenging fault conditions such as cross-country faults with high fault resistance. The power swing detection algorithm this paper proposes uses angle difference measurements and does not require setting traditional impedance-based out-of-step (OOS) characteristics.	**Использование синхрофазоров (PMU) для резервной защита ЛЭП при замыканиях на землю и выявления качания мощности**
19.	**Hardware-in-the-Loop Simulation of Distance Relay Using RTDS** 2007 Summer Simulation Multiconference (SummerSim'07), Jul 14, 2007 - Jul 19, 2007, San Diego, CA United States	Modeling and simulation of different conditions are needed for a better design of future Shipboard Power Systems (SPS). Research work at Mississippi State University (MSU) related to SPS protection aims to develop an adaptive protective controller, which can adapt to different protection schemes depending upon requirements. The first step in this research work is to develop the relay models. The developed relay model will be validated against a commercial relay using hardware-in-the-loop (HIL) simulation. HIL provides an opportunity for understanding the behavior and validating model of the physical device. This paper discusses HIL simulation for Schweitzer Engineering Laboratories (SEL) distance relay using the Real Time Digital Simulator (RTDS).	**Программно-аппаратное моделирование реле дистанционной защиты на RTDS**
20.	**Real Time Simulation Testing Using IEC61850** Presented at IPST 2007, Lyon France, June 2007, Session 26 Paper No. 177	As IEC 61850 becomes more widely accepted in the electrical engineering community, it is important that the testing tools keep pace with this development. IEC 61850 presents new challenges to real time simulation and closed-loop testing of protective relays. Electrical interfaces used for binary signaling and voltage/current amplifiers must be replaced by an Ethernet connection and an IEC 61850 protocol stack. The electrical interfaces of a real time	**Моделирование в реальном времени с использованием протокола МЭК61850**

		simulator are engineered to provide low latency and deterministic performance appropriate for a real time simulation. Similar attention must be given to IEC 61850 interfaces. Latency must be minimized so that the IEC 61850 interface does not add unacceptable delays to the operation of the simulator. Also, protocol processing must be deterministic to allow real time simulations to be repeatable and dependable. In addition, IEC 61850 specifies new configuration parameters and a new method for configuration called the Substation Configuration Language (SCL). These must be implemented in such a way that they fit within the typical modes of operation of the simulator. The paper presents a successful hardware implementation for IEC 61850 messaging on a real time simulator and discusses the key design criteria. The software required to configure the IEC 61850 will also be addressed along with the advantages in using the IEC 61850 protocol. One of the biggest advantages is brought about by the realization of the IEC 61850-9-2 sampled values, removing the need for amplifiers as the standard interface to protection devices. Sampled values of the voltage and current signals can be sent via Ethernet, making it even more practical to perform testing on a protective relaying scheme rather than just individual devices.	
21.	**Real Time Simulation of Internal Faults in Synchronous Machines** Presented at IPST 2007, Lyon France, June 2007, Session 24 Paper No. 90	This paper presents the development of a real-time digital simulator model for the simulation of arbitrary internal faults in synchronous machines. The model is an extension of the embedded phase-domain model of the synchronous machine [1]. To represent a fault, the winding or windings involved in the fault are considered as a set of split windings[2,3,4,5] with their terminal nodes connected by a suitable fault impedance (or short circuit), which is switched in when the fault is applied. From the machine and winding geometry, values are calculated for the resulting set of mutually coupled inductances for this new winding arrangement. The proposed method takes into account the actual geometry of the slots and the number of turns in each coil and uses an offline procedure to obtain the magneto-motive force (MMF) distribution due to each winding for a unit injection of current. This MMF along with the air-gap geometry information is used to calculate the flux linkages, and hence the self and mutual inductances of the windings. Thus in contrast with earlier approaches, it is able to calculate the inductances of the machine when the windings are arbitrary distributed. Since this model is developed for real-time digital simulator, it has the unique feature of being a tool to test the relays designed to protect the synchronous machines from internal faults.	**Моделирование в реальном времени внутренних КЗ в синхронной машине**
22.	**Performance Analysis of the ROCOF and Vector Shift Methods Using a Dynamic Protection Modelling Approach** Proc. 15th International Conference on Power System Protection, Bled Slovenia, September 2006, pp. 139-144	Due to the continually increasing levels of penetration of distributed generation the correct operation of Loss-Of-Mains protection is of prime importance. Many UK utilities report persistent problems relating to incorrect operation of the Rate of Change of Frequency (ROCOF) and Vector Shift methods which are currently the most commonly applied methods for Loss-Of-Mains (LOM) detection. The main focus of this paper is to demonstrate the problems associated with these methods through detailed dynamic modelling of existing available relays. The ability to investigate the transient response of the LOM protection to various system events highlights the main weaknesses of the existing methods, and more importantly, provides the means of quantitative analysis and better understanding of these weaknesses. Consequently, the dynamic analysis of the protective algorithms supports the identification of best compromise settings and gives insight to the future areas requiring improvement.	**Анализ защит по скорости изменения частоты и по сдвигу вектора напряжения, используя возможности динамического моделирования.**

23.	**Validation of Out-of-Step Protection With a Real Time Digital Simulator** Frank Plumptre, BC Hydro, Stephan Brettschneider, Cegertec, Allen Hiebert, BC Transmission Corporation Michael Thompson and Mangapathirao “Venkat” Mynam, Schweitzer Engineering Laboratories, Inc.	This paper describes the use of a real time digital simulator with dynamic machine models to validate out-of-step tripping and blocking elements in a new protective relaying system being installed on the BC Hydro 500 kV power system. The technique has also been used to study and validate a generation shedding remedial action scheme. This unique approach has many advantages over traditional methods of studying the effect of power swings on protection systems. Traditional methods for studying power swings are limited in their ability to predict the response of protective elements due to the fact that they model the power system in the positive-sequence network only. A real time digital simulator can represent the power system under more realistic conditions so that the response of the protective system can be tested under conditions that nearly match actual field conditions. Case studies are discussed in the paper showing the importance of this new approach.	**Валидация устройства защиты от асинхронного хода с помощью RTDS**
24.	**Impact of Shunt- FACTS on Distance Protection of Transmission Lines** Power Systems Conference: Advanced Metering, Protection, Control, Communication, and Distributed Resources, 2006. PS '06	This paper presents the performance of distance protection of transmission lines when compensated with shunt Flexible AC Transmission System (FACTS) Controllers/Devices. The performance of distance protection is evaluated for shunt- FACTS Controllers applied for mid-point voltage control. The impact of two types of shunt FACTS Controllers, Static Var Compensators (SVC) and Static Synchronous Compensators (STATCOM) on the transmission line distance protection are studied for different fault types, fault locations and system conditions. The dynamics of the shunt-FACTS Controllers with their associated control systems are considered and simulated using RSCAD/RTDS testing environment. The performance of both the basic/non-pilot distance scheme and a Directional Comparison Blocking (DCB) scheme are evaluated in this paper. The results of the commercial relay testing show the adverse effects of mid-point shunt-FACTS compensation of transmission protection line on both non-pilot and DCB distance protection schemes.	**Влияние поперечных компенсаторов FACTS на дистанционную защиту линий электропередачи**
25.	**Protective Relay Synchrophasor Measurements During Fault Conditions** Presented at Power Systems Conference: Advanced Metering, Protection, Control, Communication, and Distributed Resources, Clemson USA, March 2006, pp. 83 – 95	Abstract— This paper describes details of the signal processing techniques that a protective relay uses to provide both synchronized phasor measurements and line distance protection. The paper also presents a comprehensive system model of nor-mal and faulted power system operating conditions. Finally, the paper provides power system model test results that demonstrate the ability of the described protective relay to provide synchrophasor measurements during both normal and faulted conditions.	**Синфазные измерения устройствами защиты в течение аварийных процессов**
26.	**Hardware Implementation of a Ship-Wide Area Differential Protection Scheme** Presented at WMSCI 2005, Orlando USA, July 2005, Paper No. S762HI	The philosophy, design, implementation and evaluation of a ship wide area differential protection scheme is described in this paper.	**Аппаратная реализация схемы общесудовой дифференциальной защиты**
27.	**Performance of Distance Relays on Shunt-FACTS Compensated Transmission Lines** IEEE Transactions on Power Delivery, Volume: 20, Issue: 3, Publication Year: 2005, Page(s):	This paper presents a study of the performance of distance protection relays when applied to protect shunt Flexible AC Transmission System (FACTS) compensated transmission lines. The objective of this study is to evaluate the performance of distance relays on transmission lines with FACTS devices applied for midpoint voltage control. Effect of two types of shunt FACTS devices, Static Var Compensators (SVC) and Static Synchronous Compensators (STATCOM) are studied. The study is conducted in three stages. First the situation is studied analytically,	**Надежность дистанционной защиты ЛЭП с поперечной компенсацией на базе FACTS**

	1837 – 1845	where the errors introduced in the impedance measurement due to the presence of shunt FACTS devices on the line are analyzed. In the second stage, the situation is simulated using transient simulation software, EMTDC. In this method, the response of FACTS devices for different fault conditions and system conditions is also modeled. This method brings out some unique problems that would be experienced by the distance relays due to some specific characteristics of the FACTS devices. Finally, the findings are confirmed by testing a commercial distance relay using a Real Time Digital Simulator (RTDS). The results obtained by testing the commercial relay validate the analytical and simulation studies.	
28.	**A Generic Real-Time Computer Simulation Model for Superconducting Fault Current Limiters and its Application in System Protection Studies** Applied Superconductivity, IEEE Transactions on, Volume: 15, Issue: 2 , Part: 2 Publication Year: 2005 , Page(s): 2090 - 2093	A model for the SCFCL suitable for use in real time computer simulation is presented. The model accounts for the highly non-linear quench behavior of BSCCO and includes the thermal aspects of the transient phenomena when the SCFCL is activated. Implemented in the RTDSTM real-time simulation tool the model has been validated against published BSCCO characteristics. As an example for an application in protection system studies, the effect of an SCFCL on a utility type impedance relay has been investigated using a real time hardware-in-the-loop (RT-HIL) experiment. The test setup is described and initial results are presented. They illustrate the effect of how the relay misinterprets the dynamically changing SCFCL impedance as an apparently more distant fault location. It is expected that the new real-time SCFCL model will provide a valuable tool not only for further protection system studies but for a wide range of RT-HIL experiments of power systems.	**Основная модель для RTDS сверхпроводникового ограничителя тока КЗ и его применение при исследовании защит.**
29.	**Real Time Digital Simulation for Control and Protection System Testing** In Proc. PESC 2004, Aachen Germany, June 2004, pp. 329-335	Today's power system environment is becoming more and more complex. Electrical power networks are being pushed closer to their limits, while at the same time higher reliability and efficiency are demanded. As a result, electrical equipment manufacturers are developing advanced equipment and installations to meet these requirements. Part of the challenge in designing such apparatus is the need to accurately simulate (prove) and test these devices before they are installed in an actual power system. The Real Time Digital Simulator (RTDS®) allows developers to accurately and efficiently simulate electrical power systems and their ideas to improve them. The RTDS Simulator operates in real time, therefore not only allowing the simulation of the power system, but also making it possible to test physical protection and control equipment. This gives developers the means to prove their ideas, prototypes and final products in a realistic environment. This paper will summarize the fundamental design of the RTDS® Simulator, with particular emphasis on recent developments and enhancements. It will also describe practical applications of the simulator in the various stages of power system design, testing and implementation. A brief description of ongoing development for the real time simulation of Voltage Source Converter (VSC) converters is included.	**Симулятор реального времени RTDS для проверки систем автоматического регулирования и релейной защиты**
30.	**Protective Relay Testing for Relays installed in the Vicinity of Active Power System Components** Presented at the Power System Protection and Automation Conference, New Delhi India, November 2004	The paper describes the testing of transmission line protection which is to operate in the vicinity of active power system components such as HVDC, SVC and protected series capacitors. The relay's performance under highly nonlinear conditions is tested using a real–time digital simulator. Details of the power system model and the relay testing are described.	**Проверка реле защиты, устанавливаемых в непосредственной близости с активными системами электроэнергетики.**

31.	**Modelling an Impedance Relay using a Real Time Digital Simulator** In Proc. 8th Annual Conference on Developments in Power System Protection DPSP 2004, Amsterdam Netherlands, pp. 665-668	The Real Time Digital Simulator (RTDS®) was used to develop and verify protective relay algorithms by modeling the actual protective relay as well as the power system in one simulation. The real time operation of the simulator provides a time and personnel efficient environment for the work. This allows the models to be subjected to exhaustive test case scenarios before final implementation of the protective relay algorithm in the development platform. Since the developmental and final hardware implementations of the relay will be tested with the real time simulator, the use of the RTDS during early design stages also allows one simulation tool to be used throughout the process. Regression testing can be automated using the script features of RSCAD. The scripted cases can be run during non-work hours to minimize personnel requirements and maximize the simulator usage. This paper describes the technique used to model an impedance relay using the RTDS software and hardware. The relay model included a mho characteristic polarized with positive sequence memory voltage Andrichuk and Alexander (1), Roberts and Schweitzer (2). Phase selector logic, loss of potential logic and direction control logic, all of which are essential in a commercial relay (2), were not implemented here to limit the modeling complexity to the basic requirements.	**Моделирование реле сопротивления с использованием RTDS**
32.	**Simulation Studies of OLTC Transformer AVC Relays Operating in Series using a RTDS, Real Time Digital Simulator** In Proc. 8th Annual Conference on Developments in Power System Protection DPSP 2004, Amsterdam Netherlands, pp. 619-622	The most effective method for demonstrating the performance of protection relay schemes is to test them using a power supply network. If this is not possible, the operation of real protection relays can be demonstrated using a specialist real time power system simulator. This paper describes a series of tests conducted to demonstrate the operation of new tap changer control strategies using a commercial real time digital simulator (RTDS) and commercially available automatic voltage control (AVC) relays. The demonstration tests used AVC relays operating at different voltage levels in the network. Each relay was provided with the required voltage and current outputs from the RTDS as derived from the appropriate locations on the power system network. Different scenarios were then simulated and the performance of the different AVC voltage regulation strategies was investigated. Since the relays were effectively connected in series, the operation of any one of the relays influenced the other AVC relays in the network. The response of the AVC relays with a selection of control strategies to different power system scenarios was demonstrated. The use of the RTDS enabled the real time adaptive features of the different control strategies to be investigated. This was achieved by interfacing the relay inputs and outputs through the RTDS system with control logic developed in PSCAD. These techniques and the results of the tests are described in this paper.	**Исследование на RTDS работы реле напряжения для управления РПН силовых трансформаторов при каскадном включении.**
33.	**Testing a Protection System using the RTDS Batch Mode Facility** In Proc. IPST 2001, Rio de Janeiro Brazil, June 2001, pp. 447-452	The demonstration tests used AVC relays operating at different voltage levels in the network. Each relay was provided with the required voltage and current outputs from the RTDS as derived from the appropriate locations on the power system network. Different scenarios were then simulated and the performance of the different AVC voltage regulation strategies was investigated. Since the relays were effectively connected in series, the operation of any one of the relays influenced the other AVC relays in the network. The response of the AVC relays with a selection of control strategies to different power system scenarios was demonstrated. The use of the RTDS enabled the real time adaptive features of the different control strategies to be investigated. This was achieved by interfacing the relay inputs and outputs through the RTDS system with control logic developed in PSCAD. These techniques and the results of the tests are described in this paper.	**Система пакетной проверки устройств релейной защиты на RTDS**

34.	**Testing Line Current Differential Relays using Real-Time Digital Simulators** In Proc. IEEE T&D Conference & Exposition 2001, Atlanta USA, November 2001, Vol. 1 pp. 516-521	Abstract—Real-time digital simulators in conjunction with current and voltage amplifiers offer an opportunity for detailed testing of modern microprocessor based relays in conditions as close to realistic as possible. Testing a digital line current differential protection system creates challenging problems as a number of communications–related test scenarios should be examined in combination with power system disturbances. This paper presents a methodology for testing 2- and 3-terminal line current differential systems. Sample test results and a number of recommendations for testing digital relays have been included. The Real-Time Digital Simulator (RTDS) and Communications Data Link Simulator (CDLS) were the testing tools used.	**Проверка реле дифференциальной защиты линии с использованием RTDS**
35.	**Dynamic Simulations challenge Protection Performance** In Proc. WPRC 2003, Spokane USA, October 2003, Paper No. 8	This paper describes some experiences with and the impact of the addition of power system dynamic models to application testing of EHV transmission line protection systems. These models provide useful information, especially in highly stressed systems, during frequency excursions, or where there are applications of synchronizing or synchronism-check functions. This paper reviews the various forms of test signals that may be applied to relays. It also discusses factors to consider when reducing complex power systems to lumped components. The reduced system should retain features that impose significant challenges to the protection system, while keeping the system simple enough to be modeled by reasonably sized test facilities. The value of application testing for protection systems is well recognized, especially for complex protection systems. The degree of complexity of test simulations should be balanced with the possible benefit of discovering limitations or challenges that may affect specific applications in a significant manner.	**Проблемы моделирования защит в динамическом режиме**
36.	**HVDC Control and Protection Testing using the RTDS Simulator** In Proc. 4th International HVDC Transmission Operating Conference, Yichang PRC, September 2001, Paper No. 17 pp. 101-106	Many advantages can be gained by integrating High Voltage Direct Current (HVDC) technology with conventional AC power systems. The widespread acceptance of HVDC technology is for a large part due to its fast and effective controllability. Fundamental control of an HVDC system is achieved through well coordinated, interdependent adjustment of valve firing instants at the respective converter terminals. Unlike AC systems, where a combination of relays and circuit breakers provide protection, the HVDC scheme relies on the quick and coordinated response of its controllers.	**Проверка систем управления и защиты HVDC с использованием RTDS**
37.	**A New Algorithm for Digital Low-Impedance Protection of Busbars** In Proc. IEE/PES Summer Meeting 2001, Vancouver Canada, July 2001, Vol. 1 pp. 97-102	The paper presents a new algorithm its implementation, and results of extensive testing, for a microprocessor-based lowimpedance busbar relay. For increased security, the presented technique combines percent differential and current directional protection principles. The directional (phase comparison) principle does not require a voltage signal as it responds to relative directions of the currents. For fast operation, the outlined approach uses an adaptive trip logic that shifts between the 2-of-of-2 operating mode and the differential principle alone depending on a detection of CT saturation. The saturation detector responds to a differential-restraint current trajectory and is capable of detecting saturation occurring as fast as approximately 2 msec into a fault. The presented solution is implemented as a centralized type microprocessor-based relay with a sub-cycle tripping time and exceptional immunity to CT saturation.	**Новый алгоритм цифровой низкоомной защиты шин**
38.	**Implementation of Dynamic Distance Relay Scheme Evaluation Testing Guidelines using Analogue and Real Time Digital Simulators**	This paper discusses an implementation of Cigre dynamic scheme test guidelines for 'Evaluation of Characteristics and Performance of Power System Protection Relays and Protective Systems'. Practical issues of obtaining data and the extent of modelling are considered. Implementation is achieved using a Real Time Digital Simulator (RTDS) and analogue test system. Examples of simulation results are discussed. The examples highlight some of the im-	**Оценка работы схемы дистанционной защиты с использованием аналогового и цифро-**

	In Proc. DPSP 2001, Amsterdam Netherlands, April 2001, pp. 213-217	portant features that can have an impact on the relay response to the simulation.	**вого моделирования в реальном времени.**
39.	**Simulation of a differential current protection scheme involving multiple Current Transformers** In Proc. ICDS '99, Vasteras Sweden, May 1999, Poster Session	Differential protection schemes for busbar, generators or transformers connect multiple current transformers in parallel across a common burden. This paper describes the techniques used to simulate such an arrangement.	**Моделирование схемы дифференциальной защиты включающей несколько ТТ.**
40.	**Improved Current Transformer Model Based on the Jiles/Atherton Theory of Ferromagnetic Materials** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session III	The hysteresis loop of the core material in a test CT is simulated using the Jiles/Atherton theory. Comparisons are made between recorder and simulated waveform and it is found necessary to replace the modified Langevin function used by Jiles and Atherton. Using an alternative function described in the paper, good agreement is achieved between test and simulated waveform	**Улучшенная модель трансформатора тока на базе теории ферримагнитных материалов Джилса - Аттертона**
41.	**A Novel Series Capacitor Bank Protection Scheme Validity Tests** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session I	Recent developments in hybrid optical current measuring techniques revolutionize the design of protection schemes of fixed and thyristor controlled series capacitor banks. The scheme, described in this paper, is completely independent of the line current, as an auxiliary power source for the current sensors, as well as for the gap trigger electronics on the platform. Extensive tests using RTDS were performed to establish the performance of protection. An essential feature of the real-time simulation is the fairly accurate representation of the non linear characteristics of the MOV elements. The functions tested included: a) Capacitance overload and unbalance b) Line current supervision supplemented by subharmonic current detection c) Gap and Platform Faults d) MOV overload protection. The tests encompass simulation of different fault conditions including external and internal faults to confirm the design of MOV energy requirements. Results and detailed discussions of these RTDS - tests are presented in this paper. One section of the paper highlights the different simulation techniques used, to enable the testing of all protection functions. The reaction of protection on the control strategy of the TCSC scheme is also established during the RTDS tests.	**Тестирование новой схемы для защиты батареи конденсаторов последовательной компенсации**
42.	**Using a Real-Time Digital Simulator to Test a Circuit Breaker Synchronizer Device** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session I	This paper presents a real-time study analyzing a large capacitor bank energization using a real controlled switching device. The study was performed at FURNAS Simulation Centre using the RTDS™ - Real Time Digital Simulator. The capacitor bank is located at Tijuco Preto substation. The main purpose of this study was to verify the reliability and accuracy of the real equipment acting together with the RTDS™ Simulator. The statistical nature of this study required improvements, developed by FURNAS on standard RTDS™ circuit breaker model. The results were compared with those obtained using traditional methods to control the	**Использование RTDS для проверки устройства синхронного включения выключателя**

		switching transients, like pre-insertion resistors and metallic oxide arresters. The breaker closing was commanded by the real synchronizer and delayed by software, simulating the breaker closing time.	
43.	**Batch Mode Operating Software for Relay Test Applications of the RTDS™ Simulator** In Proc. EMPD '98, Singapore, March 1998, pp. 356-361	Digital simulation studies are becoming increasingly common in the power system industry. The introduction of real time digital simulation techniques has further broadened the applicability of such studies over the last several years. This paper presents details of new operating software for the Real Time Digital Simulator (RTDS™) designed to facilitate the investigation and evaluation of protective relays and integrated protection and control systems.	**Программное обеспечение для пакетной проверки реле защиты на RTDS**
44.	**Evaluation and Testing of Line Protection for Series-Compensated Transmission Lines** In Proc. the 1997 Sixth International Conference on Developments in Power System Protection, Nottingham UK, March 1997, pp. 155-158	Fundamental-frequency models of protective relays can play an important role in the testing and evaluation of the relays' suitability in complex applications. This paper describes a process for evaluation of distance protections for application in series-compensated and adjacent lines. The process consists of the use of fundamental-frequency phasor models of relays to reduce the scope of necessary testing for a particular application. The application is a major North-South power corridor in the Ontario Hydro system, where it was proposed to install series capacitors in two parallel 500-кV lines at approximately midpoint of the 176 km lines. (Subsequent to these studies, the plan has been cancelled) The proposed compensation was to be either 40% or 60%. Investigation of the effect of 60% compensation on the line protection on the compensated and adjacent lines is reported in this paper. Included in this investigation were studies to evaluate the suitability of existing protections and the selection of new protection equipment where deemed necessary.	**Оценка и проверка защиты линий с последовательной компенсацией**
45.	**Comparisons of Relay Transient Test Results Using Various Testing Technologies** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 57-62	This paper compares relay test results for a number of different testing methods ranging from full secondary level testing with an RTDS to off-line tests with a relay model.	**Сравнение результатов проверки защиты в переходных режимах при различных методиках испытаний**
46.	**Testing of Integrated Multifunction Protection Systems on the Real-Time Digital Simulator** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 177-182	The paper describes the testing of multifunction protection systems in simulated in-situ conditions on the Real-Time Digital Simulator (RTDS). The significance of this type of testing is described in relation to tests on a multifunction generator protection, an integrated protection and control system for substations, and distance relays for application in series-compensated transmission lines.	**Испытание комплектного многофункционального устройства защиты на RTDS**
47.	**Using a Real Time Digital Simulator to Develop an Accurate Model of a Digital Relay** In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 173-178	A software model of a digital relay is added to an off-line emtp (EMTDC) and is then subjected to the same waveforms as the actual relay. Its performance is measured against the performance of the actual relay and the accuracy of the model is assessed.	**Использование RTDS для создания точной модели поведения реле защиты**
48.	**Testing of the Beckwith Electric M-0430 Multifunction Protection using Relay Real Time Digital Simulator (RTDS)**	This paper reports on tests performed on the Beckwith M-0430 Multifunction Protective Relay using a Real Time Digital Simulator (RTDS ™). The tests were performed between March and May of 1992 at the Manitoba HVDC Research Centre in Winnipeg, Canada.	**Проверка многофункционального реле защиты Beckwith Electric M-0430 на RTDS**

	In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 49-54		
49.	**On Site Relay Testing for a Series Compensation Upgrade** Presented at IEEE-PES Summer Meeting, Vancouver British Columbia, Canada, July 1993	This paper reports on the results of on site relay tests carried out at the Dorsey substation in Manitoba. The purpose of the tests was to investigate the behaviour of the presently installed relays on the 500kV ac line from Dorsey to the Forbes and Chisago substations in Minnesota. The need for investigation arose as a result of the intention to upgrade the line in 1993 by the inclusion of series compensation. The line has two sections: the north line section from Dorsey to Forbes and the south line section from Forbes to Chisago. The north line compensation will be approximately at the centre of the section and the south line compensation will be at the Chisago substation. The amount of compensation will be approximately 50% in both cases. The major concern was with the distance relays being used on the two line sections since it is well known that distance relays have directional and reach problems depending where the potential measurement is made.[l] The tests were carried out at the end of 1991 in order to allow sufficient lead time to commission new relays should this prove necessary.	**Испытания на месте устройства защиты для модернизируемой последовательной компенсации**
50.	**A Real Time Digital Simulator for Testing Relays** IEEE Transactions on Power Delivery, Jan. 1992, Vol. 7, No.1, pp. 207 - 213 ** IEEE PSRC 1993 PRIZE PAPER **	The paper details the design, architectural features and application of a fully digital electromagnetic transients simulator capable of real-time operation. The custom hardware and software developed to implement the Real-Time Digital Simulator (RTDS) is described with special emphasis given to the high level graphical user interface written especially for use with the RTDS.	**Цифровое устройство моделирования в реальном времени (RTDS) для проверок реле.**

СИСТЕМЫ УПРАВЛЕНИЯ

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
51.	**Utilizing RTDS Simulation Scenarios for PHASOR System Performance Testing at Southern California Edison** Joshua Park, David Martinez, Anthony Johnson, and Rudi Wierckx. 2013.	Southern California Edison (SCE) is deploying the first phase of its new synchrophasor data management and exchange system, which is referred to as the PHASOR System, as part of its smart grid development program. The PHASOR System is comprised of General Electric's (GE) XA/21 1 system as the core, Electric Power Group's (EPG) Enhanced Phasor Data Concentrator (ePDC™) and ISG synchrophasor applications for data synchronization and external data transfer, and Instep's eDNA data historian for long-term data archival. SCE's PHASOR System is designed to support a maximum of 2,000 phasor data quantities sourced from up to 100 unique phasor measurement units (PMUs).	**Использование сценариев моделирования на RTDS при функциональных испытаниях системы ВЕКТОР в компании SCE**
52.	**RTDS Simulation and Testing of a Remedial Action Scheme at Southern California Edison** Allison Auld, Joshua Park, Anthony Johnson,	The goal of this effort is to determine how a real-time digital simulator (RTDS) can be used to simulate the behavior of a remedial action scheme (RAS) in a controlled laboratory environment at the Southern California Edison (SCE) Power Systems Laboratory. The RAS functions with two redundant pairs: System A and System B. The lab test setup includes all actual RAS System A relays and all simulated System B relays. The RTDS scripting capability automates	**Моделирование и испытания на RTDS схем деления энергосистемы при авариях в компании SCE**

	Marc Desjardine and Rudi Wierckx. 2013.	more than 9,000 tests that span various contingencies, arming levels, load flows, and A/B system availability. The simulator demonstrated the ability to re-create an existing RAS in the laboratory environment, which will be a valuable tool in preparing for future RAS applications.	
53.	**Co-simulation of an FPGA-based Electromagnetic Transient Model and a Small Time-Step Model in the RTDS Real-Time Digital Simulator** GCMS 2012 at SummerSim '12, Genoa, Italy, July 2012	This paper describes work in electromagnetic transient co-simulation of a field-programmable gate array (FPGA)- based model with an RTDS Real-Time Digital Simulator. Results are presented toward achieving the goal of simulating high-frequency power electronic converters in real-time co-simulation with a rest-of-system transient model. Power system converter models using the RTDS were previously implemented at rates up to approximately 6 kHz switching frequency using voltage source converter models in a small time-step of ~1.5-2 µsecs. In this work, the FPGA-based transient simulation models of a static and switched RL load are interfaced to the RTDS small timestep model through a traveling wave model. The highfrequency switching models suggest the feasibility of FPGA-based simulation of a high-frequency switching converter.	**Симулирование на ПЛИС электромагнитных переходных процессов и процессов с малым шагом расчета на RTDS**
54.	**Design and Development of a Static VAR Compensator for Load Compensation Using Real-Time Digital Simulator and Hardware Simulation** 2007 Large Engineering Systems Conference on Power Engineering	A Static Var Compensator (SVC) is designed for compensation of a midsized three-phase unbalanced industrial load. The control system is programmed in the National Instruments LabView programming environment and implemented in an Intel based platform using National Instruments digital to analog conversion and timing hardware. The hardware design is done for a Fixed Capacitor – Thyristor Controlled Reactor (FC-TCR) configuration of a Static Var Compensator (SVC). The SVC controller is tested on both a Real-Time Digital Simulator (RTDS) and a physical hardware model.	**Разработка с помощью RTDS и аппаратного моделирования статического компенсатора реактивной мощности для коррекции колебаний нагрузки**
55.	**Real Time Digital Simulation for Control and Protection System Testing** In Proc. PESC 2004, Aachen Germany, June 2004, pp. 329-335	Today's power system environment is becoming more and more complex. Electrical power networks are being pushed closer to their limits, while at the same time higher reliability and efficiency are demanded. As a result, electrical equipment manufacturers are developing advanced equipment and installations to meet these requirements. Part of the challenge in designing such apparatus is the need to accurately simulate (prove) and test these devices before they are installed in an actual power system. The Real Time Digital Simulator (RTDS®) allows developers to accurately and efficiently simulate electrical power systems and their ideas to improve them. The RTDS Simulator operates in real time, therefore not only allowing the simulation of the power system, but also making it possible to test physical protection and control equipment. This gives developers the means to prove their ideas, prototypes and final products in a realistic environment. This paper will summarize the fundamental design of the RTDS® Simulator, with particular emphasis on recent developments and enhancements. It will also describe practical applications of the simulator in the various stages of power system design, testing and implementation. A brief description of ongoing development for the real time simulation of Voltage Source Converter (VSC) converters is included.	**Симулятор реального времени RTDS для проверки систем автоматического регулирования и релейной защиты**
56.	**FURNAS Strategy Regarding Real-Time Tests: A Practical Case – Campos Static VAr Compensator** In Proc. WMSCI 2005, Orlando USA, July 2005,	The use of power electronic devices has been improving the performance of the electrical power systems. In spite of the fact that the use of these types of equipment's optimizes the performance of the system, it increases the complexity of the power system. Therefore a special attention for the power system representation is required, as well as the correct modeling of the transfer function of the controllers is fundamental to achieve correct results on simulations and permit reliable and accurate analyses. Actual real-time simulators allow a	**Принципы компании ФУРНАС в области проверок на цифровой модели реального времени - компенсатор реактивной мощности в**

	Paper No. S300VW	detailed representation of the network and its components, even for very large and complex power systems. Those improvements have helped the real-time tests to become more realistic and easier to be performed. In Brazil, additionally, due to the fact that the deregulation of the energy market, with more strict rules and severe penalties associated, real-time power system tests have been widely used to ensure that the controllers and protections are working in an efficient way. The main purpose of this article is to present the FURNAS' reasons for including real time tests in the specification of new equipment's that include power electronics devices and protective relays. The paper will focus in the recent purchase of a Static VAr Compensator installed at Campos substation, which was tested in two different real-time laboratories during commissioning process and then reevaluated in a different power system configuration in FURNAS' laboratory.	**г. Кампус (Бразилия)**
57.	**Control System Improvement and Behaviour Assessment** In Proc. SEPOPE 2002, Brasilia Brazil, May 2002	**Two Thyristor Controlled Series Capacitors [TCSC's], one at Serra da Mesa Substation in the Furnas' System and the other at Imperatriz Substation in the Eletronorte's System, both part of North-South Interconnection, make it possible to damp out the oscillation mode of the two interconnected systems, reducing the risk of instability. This paper presents Serra da Mesa TCSC control testing history, and a description of the monitoring system developed by Furnas operation engineers to follow-up the control performance at head office, in Rio de Janeiro.**	**Совершенствование системы управления и оценка ее поведения**
58.	**HVDC Control and Protection Testing using the RTDS Simulator** In Proc. 4th International HVDC Transmission Operating Conference, Yichang PRC, September 2001, Paper No. 17 pp. 101-106	Many advantages can be gained by integrating High Voltage Direct Current (HVDC) technology with conventional AC power systems. The widespread acceptance of HVDC technology is for a large part due to its fast and effective controllability. Fundamental control of an HVDC system is achieved through well coordinated, interdependent adjustment of valve firing instants at the respective converter terminals. Unlike AC systems, where a combination of relays and circuit breakers provide protection, the HVDC scheme relies on the quick and coordinated response of its controllers.	**Проверка систем управления и защиты HVDC с использованием RTDS**
59.	**Using an External Controller with the Real-Time Digital Simulator** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session IV	The paper describes the utility of an external Sequence Controller in testing protection and control equipment on the Real-Time Digital Simulator (RTDS). The controller facilitates the execution of test programs requiring numerous test cases with variation in the incidence angle of the fault, and the fault type. The Sequence Controller also facilitates testing with multiple faults requiring variation in the time between sequential faults m different parts of the modelled system. The significance is described in relation to tests on a transmission line protection and an integrated protection and control system for substations.	**Использование внешней системы управления совместно с RTDS**
60.	**Cahora Bassa GMPC Testing using a Real Time Digital Simulator** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 251-256	This paper presents the use of an RTDS simulator for the testing of a Grid Master Power Controller (GMPC) implemented in a commercial project for the Cahora Bassa HVDC upgrade. Three AC systems are connected by the 1500 km bipolar HVDC and a relatively weak 330 / 400 kV AC link. The GMPC uses coordinated HVDC and braking resistor control technologies for the stabilization of the system during and after transients. A GPS (Global positioning system) satellite signal provides long distance angle measurement facilities. The real-time simulation requires detailed models of the complex HVAC and HVDC systems. The verification of the simulator setup is done by comparison with site recordings, EMTDC, PSS/E™ and NETOMAC study results. The GMPC performance is verified by different types of AC and DC faults. Results of the tests are presented.	**Тестирование контроллера сети от ГЭС Кабора-Басса с использованием RTDS**

61.	**Application of Real Time Digital Simulation for Commissioning Automatic Voltage Regulators for Synchronous Condensers** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 211-216	This paper describes the use of a Real Time Digital Simulator (RTDS) for commissioning and optimization of the excitation system of a synchronous machine. Manitoba Hydro is replacing the excitation system on three synchronous condensers at Dorsey HVOC Converter Station. A discussion is included on RTDS models for the synchronous machine, 6-pulse exciter bridge, three winding converter transformer, 278 MW valve group and 230 KV System equivalent developed on RTDS. RTDS features available for model development are also addressed. The tests performed on the AVR are described and the results are presented.	**Применение RTDS при вводе в эксплуатацию автоматического регулятора напряжение для синхронных компенсаторов**
62.	**Model Development of an Actual HVdc Control for the RTDS Simulator** Late Submissions to ICDS '97, Montreal Canada, May 1997; not included in Conference Proceedings (contact RTDS Technologies for copies)	The development of detailed models of the Manitoba Hydro HVdc Bipole I and Bipole II controls has been undertaken to allow rapid evaluation of contemplated changes to the controls and to allow evaluation of potential adverse interaction with physical controls on remote power system components. Ideally, a duplicate set of HVdc controls would be connected to a real time simulator to study these problems. In this case however, duplicate controls were not a practical possibility and detailed software models for the RTDS™ have been developed instead.	**Разработка модели действующего контроллера HVDC для симулятора RTDS**
63.	**Control System Modelling using the Real Time Digital Simulator** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 197-202	This paper discusses software that has been developed for the Real-Time Digital Simulator (RTDS) which permits users to assemble control and protection systems by graphically interconnecting basic function blocks. Operation of the new software with the existing power system simulation capabilities of the RTDS are discussed.	**Моделирование системы управления с помощью RTDS**
64.	**HVDC Simulation and Control Testing using a Real Time Digital Simulator (RTDS)** In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 213-218	This paper reports on a recently completed evaluation study in which physical High Voltage Direct Current (HVDC) controls were interconnected to the Real- Time Digital Simulator (RTDS). The study was performed jointly by RTDS Technologies Inc. of Winnipeg, Canada and ABB Power Systems AB of Ludvika, Sweden. In the past such a study could only have been performed using an analogue HVDC simulator. The recent introduction of an accurate and flexible real-time digital simulator has however made it possible to perform this study, and many others like it, in a new, more efficient manner.	**Моделирование HVDC и тестирование ее системы управления на RTDS**
65.	**Validation of a Fully Digital Real-Time Electromagnetic Transients Simulator for HVDC System & Controls Studies** In Proc. Athens Powertech (APT'93), Athens Greece, September 1993, Vol. 2, pp. 751-759	A fully digital, electromagnetic transients class of power systems simulator capable of continuous real-time operation has been developed at the Manitoba HVDC Research Centre. A detailed model of the Nelson River HVDC System's Bipole 1 controls was prepared for use with the RTDS (Real-Time digital Simulator). Operation of the RTDS using the modelled HVDC controls, as well as using physical controls interfaced to the simulator is presented herein.	**Валидация цифрового симулятора реального времени электромагнитных переходных процессов при исследованиях HVDC и системы управления.**
66.	**Closed Loop Testing of a Joint VAR Controller Using a Digital Real-Time Simulator** IEEE Transactions on Power Systems, Aug 91, Vol. 6, No. 3, pp. 1140-1146	The paper describes a new Joint VAR Controller which was designed for use at Manitoba Hydro's Dorsey Converter Station. The controller was tested in closed loop mode using a fully digital real-time simulator. By performing a broad range of simulated system disturbances the controller's operation could be verified before its installation at site.	**Программно-аппаратная проверка системы управления регулятором реактивной мощности с использованием RTDS**

ИССЛЕДОВАНИЕ ВЫСОКОВОЛЬТНЫХ ЛИНИЙ И ВСТАВОК ПОСТОЯННОГО ТОКА (HVDC)

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
67.	**RTDS Environment Development of Ultra-High-Voltage Power System** IEEE Power Engineering Society General Meeting, 2007	The increased interest in using Ultra-High-Voltage (UHV) transmissions has stimulated research in UHV operation characteristic and correlative relay protections. Operational experience in UHV is limited and hence there is a need to model UHV transmission systems and test the operational performance of traditional protection devices already in use on High-Voltage (HV) and Extra-High-Voltage (EHV) systems. This paper pre-sents the development of a test environment based on a Real-Time Digital Simulator (RTDS) of a UHV power system model and the results of testing a distance relay using the model. It reveals that the protective zone will be enlarged in the UHV system with shunt reactor compensation and reduced without the compensation. To resolve these issues further investigation is needed and ways of resolving them, including the development of new algorithms, should be examined.	**RTDS как средство разработки энергосистем ультравысокого напряжения**
68.	**HVDC Control and Protection Testing using the RTDS Simulator** In Proc. 4th International HVDC Transmission Operating Conference, Yichang PRC, September 2001, Paper No. 17 pp. 101-106	Many advantages can be gained by integrating High Voltage Direct Current (HVDC) technology with conventional AC power systems. The widespread acceptance of HVDC technology is for a large part due to its fast and effective controllability. Fundamental control of an HVDC system is achieved through well coordinated, interdependent adjustment of valve firing instants at the respective converter terminals. Unlike AC systems, where a combination of relays and circuit breakers provide protection, the HVDC scheme relies on the quick and coordinated response of its controllers.	**Проверка систем управления и защиты HVDC с использованием RTDS**
69.	**Chandrapur – Padghe HVDC Schemes Coordination Study** In Proc. ICDS ’99, Vasteras Sweden, May 1999, Session I	This paper presents the Chandrapur - Padghe Coordination Simulator Study performed as part of the Chandrapur 2 x 500MW HVDC Back-to-Back (BtB) and the Chandrapur-Padghe 2 x 750MW HVDC Transmission (CTP) Projects. The BtB project [ALSTOM] has been in service since 1998 for the Power Grid Corporation of India Limited (POWERGRID) and the CTP Project [ABB] is presently being completed for the Maharashtra State Electricity Board (MSEB). This study was performed to investigate interaction between the two HVDC schemes.	**Исследование взаимосвязей HVDC линии Чандрапур - Падж**
70.	**Validating the Real Time Digital Simulator for HVDC Dynamic Performance Studies** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 245-250	This paper describes and presents results from a validation study in which the Real Time Digital Simulator (RTDS™) was compared with a conventional analogue simulator. The particular phase of the validation work being presented here relates to Dynamic Performance Studies (DPS) of HVDC systems and their associated controls.	**Валидация с помощью RTDS исследований по пропускной способности HVDC систем**
71.	**Model Development of an Actual HVdc Control for the RTDS Simulator** Late Submissions to ICDS '97, Montreal Canada, May 1997; not included in Conference Proceedings (contact RTDS Technologies for copies)	The development of detailed models of the Manitoba Hydro HVdc Bipole I and Bipole II controls has been undertaken to allow rapid evaluation of contemplated changes to the controls and to allow evaluation of potential adverse interaction with physical controls on remote power system components. Ideally, a duplicate set of HVdc controls would be connected to a real time simulator to study these problems. In this case however, duplicate controls were not a practical possibility and detailed software models for the RTDS™ have been developed instead.	**Разработка модели действующего контроллера HVDC для симулятора RTDS**

72.	**Expanding an Analogue HVDC Simulator's Modelling Capability using a Real Time Digital Simulator (RTDS)** In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 199-204	This paper reports on a study which investigated expanding and enhancing the capabilities of a traditional analogue simulator using a Real-Time Digital Simulator (RTDS). The main thrust of the investigation focused on methods of interfacing the two simulators. The solution algorithm of the RTDS, a multi-processor device employing parallel processing techniques, proved to be a very important consideration. Of the three methods considered, the one based on a traveling wave transmission line models was found to be the best suited for the task. This method was satisfactorily tested in an integrated ac/dc system.	**Увеличение возможностей моделирования HVDC с использованием RTDS в сравнении с аналоговым симулятором**
73.	**HVDC Simulation and Control Testing using a Real Time Digital Simulator (RTDS)** In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 213-218	This paper reports on a recently completed evaluation study in which physical High Voltage Direct Current (HVDC) controls were interconnected to the Real- Time Digital Simulator (RTDS). The study was performed jointly by RTDS Technologies Inc. of Winnipeg, Canada and ABB Power Systems AB of Ludvika, Sweden. In the past such a study could only have been performed using an analogue HVDC simulator. The recent introduction of an accurate and flexible real-time digital simulator has however made it possible to perform this study, and many others like it, in a new, more efficient manner.	**Моделирование HVDC и тестирование ее системы управления на RTDS**
74.	**Validation of a Fully Digital Real-Time Electromagnetic Transients Simulator for HVDC System & Controls Studies** In Proc. Athens Powertech (APT'93), Athens Greece, September 1993, Vol. 2, pp. 751-759	A fully digital, electromagnetic transients class of power systems simulator capable of continuous real-time operation has been developed at the Manitoba HVDC Research Centre. A detailed model of the Nelson River HVDC System's Bipole 1 controls was prepared for use with the RTDS (Real-Time digital Simulator). Operation of the RTDS using the modelled HVDC controls, as well as using physical controls interfaced to the simulator is presented herein.	**Валидация цифрового симулятора реального времени электромагнитных переходных процессов при исследованиях HVDC и системы управления.**
75.	**Enhanced Performance of a Conventional HVDC analogue Simulator with a Real-Time Digital Simulator** In Proc. Power Systems Computation Conference (PSCC11), Avignon France, August 1993. Vol. 1pp. 663-669	The real time digital simulator (RTDS) developed by the Manitoba HVDC Research Centre is interfaced to a fully analogue HVdc simulator to greatly enhance its capability and performance. This paper describes the principle of the interface and features of the digital simulator. A test system based on an actual HVdc scheme is simulated with the combined real time digital and analogue simulators and compared with the analogue system alone to verify the interface technique.	**Улучшение мощности классического аналогового симулятора HVDC за счет RTDS**

ИССЛЕДОВАНИЕ ГИБКИХ СИСТЕМ ПЕРЕДАЧИ ЭЛЕКТРОЭНЕРГИИ ПЕРЕМЕННЫМ ТОКОМ (FACTS)

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
76.	**RTDS Implementation of STATCOM for Power System Stability Improvement** Presented at Saudi Arabia Smart Grid Confer-	In this paper, analysis and implementation of STATCOM based stabilizers to enhance damping of low frequency oscillations is studied and demonstrated. The effectiveness of STATCOM gain and phase modulation channels to enhance the damping characteristics is investigated. The coordination among the internal AC and DC voltage controllers and the proposed damping controllers on each channel is designed. Differential Evolution as an intelligent optimization technique is considered to design the STATCOM supplementary damping controllers. The	**Использование RTDS для повышения устойчивости энергосистемы на базе STATCOM**

	ence, Jeddah, Saudi Arabia, December 2012	implementation of STATCOM based stabilizers on Real Time Digital Simulator (RTDS) is carried out. The RTDS experimental setup of a power system with STATCOM is verified. The power system considered is tested through nonlinear time domain simulations to examine the validity of the proposed approach to damp low frequency oscillations. Comparisons with similar results reported in literature are demonstrated.	
77.	**Performance Comparison of Distance Protection Schemes for Shunt-FACTS Compensated Transmission Lines** IEEE Transactions on Power Delivery,Issue Date: Oct. 2007, Volume: 22 Issue:4, On page(s): 2116 – 2125	This paper presents a comparative study of the performance of distance relays for transmission lines compensated by shunt connected flexible ac transmission system (FACTS) controllers/ devices. The objective of this study is to evaluate the performance of various distance protection schemes on transmission lines with shunt-FACTS devices applied for midpoint voltage control. The impact of two types of shunt FACTS devices, static var compensator (SVC) and static synchronous compensator (STATCOM) on the transmission line distance protection schemes is studied for different fault types, fault locations and system conditions. The power system elements and the shunt-FACTS devices with their associated controllers are modeled using RSCAD/RTDS software. The results are based on the performance of commercial distance relays using a real time digital simulator (RTDS).	**Оценка различных схем дистанционной защи-ты линий электропередач с поперечной компенсацией FACTS**
78.	**Design and Development of a Static VAR Compensator for Load Compensation Using Real-Time Digital Simulator and Hardware Simulation** 2007 Large Engineering Systems Conference on Power Engineering	A Static Var Compensator (SVC) is designed for compensation of a midsized three-phase unbalanced industrial load. The control system is programmed in the National Instruments LabView programming environment and implemented in an Intel based platform using National Instruments digital to analog conversion and timing hardware. The hardware design is done for a Fixed Capacitor – Thyristor Controlled Reactor (FC-TCR) configuration of a Static Var Compensator (SVC). The SVC controller is tested on both a Real-Time Digital Simulator (RTDS) and a physical hardware model.	**Разработка с помощью RTDS и аппаратного моделирования статического компенсатора реактивной мощности для коррекции колебаний нагрузки**
79.	**Impact of Shunt- FACTS on Distance Protection of Transmission Lines** Power Systems Conference: Advanced Metering, Protection, Control, Communication, and Distributed Resources, 2006. PS '06	This paper presents the performance of distance protection of transmission lines when compensated with shunt Flexible AC Transmission System (FACTS) Controllers/Devices. The performance of distance protection is evaluated for shunt- FACTS Controllers applied for midpoint voltage control. The impact of two types of shunt FACTS Controllers, Static Var Compensators (SVC) and Static Synchronous Compensators (STATCOM) on the transmission line distance protection are studied for different fault types, fault locations and system conditions. The dynamics of the shunt-FACTS Controllers with their associated control systems are considered and simulated using RSCAD/RTDS testing environment. The performance of both the basic/non-pilot distance scheme and a Directional Comparison Blocking (DCB) scheme are evaluated in this paper. The results of the commercial relay testing show the adverse effects of mid-point shunt-FACTS compensation of transmission protection line on both non-pilot and DCB distance protection schemes.	**Влияние поперечных компенсаторов FACTS на дистанционную защиту линий электропередачи**
80.	**Performance of Distance Relays on Shunt-FACTS Compensated Transmission Lines** IEEE Transactions on Power Delivery, Volume: 20, Issue: 3, Publication Year: 2005, Page(s): 1837 - 1845	This paper presents a study of the performance of distance protection relays when applied to protect shunt Flexible AC Transmission System (FACTS) compensated transmission lines. The objective of this study is to evaluate the performance of distance relays on transmission lines with FACTS devices applied for midpoint voltage control. Effect of two types of shunt FACTS devices, Static Var Compensators (SVC) and Static Synchronous Compensators (STATCOM) are studied. The study is conducted in three stages. First the situation is studied analytically, where the errors introduced in the impedance measurement due to the presence of shunt FACTS devices on the line are analyzed. In the second stage, the situation is simulated using transient simulation software, EMTDC. In this method, the response of FACTS devices for	**Надежность дистанционной защиты ЛЭП с поперечной компенсацией на базе FACTS**

		different fault conditions and system conditions is also modeled. This method brings out some unique problems that would be experienced by the distance relays due to some specific characteristics of the FACTS devices. Finally, the findings are confirmed by testing a commercial distance relay using a Real Time Digital Simulator (RTDS). The results obtained by testing the commercial relay validate the analytical and simulation studies.	
81.	**FURNAS Strategy Regarding Real-Time Tests: A Practical Case – Campos Static VAr Compensator** In Proc. WMSCI 2005, Orlando USA, July 2005, Paper No. S300VW	The use of power electronic devices has been improving the performance of the electrical power systems. In spite of the fact that the use of these types of equipment's optimizes the performance of the system, it increases the complexity of the power system. Therefore a special attention for the power system representation is required, as well as the correct modeling of the transfer function of the controllers is fundamental to achieve correct results on simulations and permit reliable and accurate analyses. Actual real-time simulators allow a detailed representation of the network and its components, even for very large and complex power systems. Those improvements have helped the real-time tests to become more realistic and easier to be performed. In Brazil, additionally, due to the fact that the deregulation of the energy market, with more strict rules and severe penalties associated, real-time power system tests have been widely used to ensure that the controllers and protections are working in an efficient way. The main purpose of this article is to present the FURNAS' reasons for including real time tests in the specification of new equipment's that include power electronics devices and protective relays. The paper will focus in the recent purchase of a Static VAr Compensator installed at Campos substation, which was tested in two different real-time laboratories during commissioning process and then reevaluated in a different power system configuration in FURNAS' laboratory.	**Принципы компании ФУРНАС в области проверок на цифровой модели реального времени - компенсатор реактивной мощности в г. Кампус (Бразилия)**
82.	**FURNAS TCSC – An Example Using Different Simulation Tools for Performance Analysis** In Proc. IPST 2001, Rio de Janeiro Brazil, June 2001, pp. 675-680	This paper presents the conclusion of extensive work aimed to verify the satisfactory performance of new equipment, the TCSC (Thyristor Controlled Series Compensation). From factory tests to commissioning tests and from real time simulations to digital program simulations with a validated model, two years of studies were spent to assure that the system control of this new equipment provides enough damping for the inter-area oscillation mode of the interconnected North/Northeast and South/Southeast system. Such experience pointed out the importance of having good tools to represent the real behavior of any important equipment, especially when new knowledge is involved.	**Тиристорно- управляемая продольная компенсация ФУРНАС - Пример использования различных инструментов моделирования для анализа производительности**
83.	**SVC for Resonance Control in NamPower Electrical Power System** In Proc. IEE/PES Summer Meeting 2001, Vancouver Canada, July 2001, Vol. 1 pp. 860-865	The new 400 kV interconnection between Namibia and South Africa was successfully commissioned in the last quarter of 2000. The 890 km single circuit 400 kV AC transmission line interconnects the two systems, ESKOM and NamPower, at Aries substation near Kenhardt in South Africa and Auas substation near Windhoek in Namibia. With the new interconnection, the NamPower system is strengthened but the new 400 kV line is also very long with a large charging capacitance which aggravates the inherent problems in the NamPower system; namely voltage stability and near 50 Hz resonance. The charging capacitance shifts the existing parallel resonance very close to 50 Hz and makes the network more voltage sensitive during system transients such as 400 kV line energisation or recovery after clearing of line faults.	**Система тиристорной компенсации для подавления резонансов в энергосистеме NamPower (Намибия)**
84.	**Advanced Fully Digital TCSC Real-Time Simulation** In Proc. CEPSI 2000, Manila Philippines, October	This paper presents the use of a new fully digital RTDS™ (Real Time Digital Simulator) simulator model for the dynamic testing of Thyristor Controlled Series Compensation (TCSC). RTDS uses fast DSP technology (digital signal processors) with standard models on TPC (NEC Tandem processor card) in combination with the new 3PC (SHARC 3 processor cards) for ad-	**Усовершенствованное полностью цифровое моделирование в реальном времени тиристорно-управляемой продольной компенса-**

	2000	vanced modelling requirements like the fully digital TCSC This TCSC model has been developed and verified for the Serra da Mesa project in Brazil. It is suitable for connecting to physical plant control and protection equipment Highlights of the TCSC control tests in the simulator are presented and compared with site-recordings. For study purposes, a digital model of the main TCSC control functions has been developed and verified versus test results with the real control. With this digital control model, additional studies can be carried out independent from the availability of physical control equipment	**ции**
85.	**Advanced Fully Digital TCSC Real-Time Simulation in Comparison with Computer Studies and On-Site Testing** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session VIII	TCSC (Thyristor Controlled Series Compensation) are FACTS devices which contribute substantially to the improvement of the dynamic stability of power systems. The series compensation technology uses TCR (Thyristor Controlled Reactor), very similar to the classical shunt compensation by means of an SVC. However, the TCSC´s control can only be applied effectively if the TCSC scheme and its rating as well as the control and protection circuits are well matched to the specific network parameters and the specification requirements. Hence, design verification by real-time simulation is imperative to successful TCSC operational performance. In this paper, the use of a new fully digital RTDS TM (Real Time Digital Simulator) model for the dynamic testing of TCSC control and protection functions is presented. RTDS uses fast DSP (digital signal processors) technology with standard models on TPC (NEC Tandem processor card) in combination with the new 3PC (SHARC 3 processor cards) for advanced modelling requirements like the fully digital TCSC. This TCSC model has been developed and verified for the Serra da Mesa project in Brazil. It is suitable for combining with physical plant control and protection equipment. In the development of the TCSC model, special attention was given to the specific requirements for testing the latest developments of the series compensation including the hybrid optical current measuring techniques. These measurements are likely to revolutionise the design of the protection schemes for TCSC. Highlights of the control and protection tests for the scheme hard - and software equipment in the simulator are presented and compared with site-recordings.	**Усовершенствованное моделирование на RTDS тиристорно-управляемой продольной компенсации в сравнении с компьютерными исследованиями и проверка на месте.**
86.	**A Novel Series Capacitor Bank Protection Scheme Validity Tests** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session I	Recent developments in hybrid optical current measuring techniques revolutionize the design of protection schemes of fixed and thyristor controlled series capacitor banks. The scheme, described in this paper, is completely independent of the line current, as an auxiliary power source for the current sensors, as well as for the gap trigger electronics on the platform. Extensive tests using RTDS were performed to establish the performance of protection. An essential feature of the real-time simulation is the fairly accurate representation of the non linear characteristics of the MOV elements. The functions tested included: a) Capacitance overload and unbalance b) Line current supervision supplemented by subharmonic current detection c) Gap and Platform Faults d) MOV overload protection. The tests encompass simulation of different fault conditions including external and internal faults to confirm the design of MOV energy requirements. Results and detailed discussions of these RTDS - tests are presented in this paper. One section of the paper highlights the different simulation techniques used, to enable the testing of all protection functions. The reaction of protection on the control strategy of the TCSC scheme is also established during the RTDS tests.	**Тестирование новой схемы для защиты батареи конденсаторов последовательной компенсации**

87.	**Evaluation and Testing of Line Protection for Series-Compensated Transmission Lines** In Proc. the 1997 Sixth International Conference on Developments in Power System Protection, Nottingham UK, March 1997, pp. 155-158	Fundamental-frequency models of protective relays can play an important role in the testing and evaluation of the relays' suitability in complex applications. This paper describes a process for evaluation of distance protections for application in series-compensated and adjacent lines. The process consists of the use of fundamental-frequency phasor models of relays to reduce the scope of necessary testing for a particular application. The application is a major North-South power corridor in the Ontario Hydro system, where it was proposed to install series capacitors in two parallel 500-кV lines at approximately mid-point of the 176 km lines. (Subsequent to these studies, the plan has been cancelled) The proposed compensation was to be either 40% or 60%. Investigation of the effect of 60% compensation on the line protection on the compensated and adjacent lines is reported in this paper. Included in this investigation were studies to evaluate the suitability of existing protections and the selection of new protection equipment where deemed necessary.	**Оценка и проверка защиты линий с последовательной компенсацией**
88.	**Advanced SVC Testing using a Real Time Digital Simulator** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 265-270	This paper presents the use of an RTDS™ simulator for real-time testing of Static Var Compensators (SVC). SVCs are the fastest devices within the family of FACTS (Flexible AC Transmission Systems), which contribute substantially to improved voltage quality in power systems. In principle, they are shunt compensation devices which employ powerful thyristor valves for controllability. However, the SVC's high speed control can only be applied effectively if the type and size of the power components as well as the control and protection schemes are well matched to the specific network parameters and requirements. Hence, design verification by computer and real-time simulation is imperative to successful commissioning.	**Усовершенствованная проверка системы тиристорной компенсации на RTDS**
89.	**Advanced Hybrid Testing in FACTS Environment using a Real Time Digital Simulator** Late Submissions to ICDS '97, Montreal Canada, May 1997; not included in Conference Proceedings (contact RTDS Technologies for copies)	This paper presents the use of an RTDS™ simulator for the testing of HVDC schemes in FACTS environment. Results of computer, analogue and digital real-time simulator type tests are compared with regard to the different model capabilities and their limitations. On the basis of these results, a new approach for an Advanced Hybrid HVDC Real-Time Simulator using classical physical models for the converter section in combination with a complex fully digital AC and DC power system simulator implemented on RTDS is developed.	**Усовершенствованная гибридная проверка в условиях работы с FACTS на RTDS**
90.	**Application of Real Time Digital Simulation for Commissioning Automatic Voltage Regulators for Synchronous Condensers** In Proc. ICDS '97, Montreal Canada, May 1997, pp. 211-216	This paper describes the use of a Real Time Digital Simulator (RTDS) for commissioning and optimization of the excitation system of a synchronous machine. Manitoba Hydro is replacing the excitation system on three synchronous condensers at Dorsey HVOC Converter Station. A discussion is included on RTDS models for the synchronous machine, 6-pulse exciter bridge, three winding converter transformer, 278 MW valve group and 230 KV System equivalent developed on RTDS. RTDS features available for model development are also addressed. The tests performed on the AVR are described and the results are presented.	**Применение RTDS при вводе в эксплуатацию автоматического регулятора напряжение для синхронных компенсаторов**
91.	**On-Site Transient Testing for a Series Compensation Upgrade** In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 335-340	This paper describes the preparation for tests on the relays on a long 500k V ac line carried out on site using the Real Time Digital Simulator developed by the Manitoba HVDC Research Centre. The purpose of the tests was to examine the relay behavior prior to the insertion of series compensation in 1993. Off-line simulations were used to check the validity of the equivalents used for the real time simulations and the simulator waveforms were compared to staged fault test recordings. Some test waveforms are shown.	**Испытания на месте переходных режимов при модернизации последовательной компенсации**
92.	**On Site Relay Testing for a Series Compensation Upgrade**	This paper reports on the results of on site relay tests carried out at the Dorsey substation in Manitoba. The purpose of the tests was to investigate the behaviour of the presently installed relays on the 500kV ac line from Dorsey to the Forbes and Chisago substations in Minnesota.	**Испытания на месте устройства защиты для модернизируемой последовательной ком-**

	Presented at IEEE-PES Summer Meeting, Vancouver British Columbia, Canada, July 1993	The need for investigation arose as a result of the intention to upgrade the line in 1993 by the inclusion of series compensation. The line has two sections: the north line section from Dorsey to Forbes and the south line section from Forbes to Chisago. The north line compensation will be approximately at the centre of the section and the south line compensation will be at the Chisago substation. The amount of compensation will be approximately 50% in both cases. The major concern was with the distance relays being used on the two line sections since it is well known that distance relays have directional and reach problems depending where the potential measurement is made.[l] The tests were carried out at the end of 1991 in order to allow sufficient lead time to commission new relays should this prove necessary.	**пенсации**

МОДЕЛИРОВАНИЕ ЕДИНОЙ ЭНЕРГОСИСТЕМЫ

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
93.	**Power Hardware-in-the-Loop Testing of a YBCO Coated Conductor Fault Current Limiting Module** IEEE Trans. on Applied Superconductivity, Special Issue from the Applied Superconductivity Conference, Chicago, August 17-22, 2008.	In recent years, good progress has been made in improving the quality and quantity afforded by the manufacturing process for YBCO coated conductors. As a result, several programs have started to develop electrical power applications like motors, transformers, and fault current limiters (SCFCL) with these conductors. High voltage resistive type SCFCLs may typically be assembled from modules connected in series and parallel to accommodate the required voltage and current levels. The limited length of such a SCFCL module simplifies the configuration, manufacturing, and maintenance. It also allows testing of these modules under laboratory conditions at reduced power levels. In order to test SCFCL modules under conditions they will experience in high voltage electrical networks, advanced test methods such as power hardware-in-the-loop (PHIL) can offer significant advantages. This method allows studying conditions such as voltage stability and severe system perturbations with the actual SCFCL module in the loop. Hence, the quench and recovery behaviour of the SCFCL module can be investigated under conditions characteristic of real electrical power networks without elaborate experimental setups. This paper presents results from PHIL experiments with a SCFCL module consisting of an approx. 10 m coated conductor.	**Силовое программно-аппаратное моделирование (PHIL) ограничителя тока КЗ с покрытием проводников из оксида иттрий-барий-медь (YBCO)**
94.	**Wide Band Equivalent For Real Time Digital Simulators** Presented at WMSCI 2007, Orlando USA, July 2008, Paper No. S013BM	As a real-time implementation of Electromagnetic Transient (EMT) simulation, the Real Time Digital Simulator (RTDS) can be connected directly to real physical control devices for testing and studying purposes. RTDS simulations cover events lasting from microseconds to hours. The capability of RTDS to correctly reproduce the dynamic and transient behaviors of large system is often limited by the burdens of extra hardware. In many RTDS studies, a certain part of the network, labeled the 'internal' network is of direct interest and the network external to it is only required to provide a response which results in the accurate responses within the internal network. The paper proposes a wideband equivalent for this external network, which can preserve the essential electromagnetic transient characteristics as well as the essential electromechanical dynamic characteristics of the external network. Thus the proposed equivalent permits the simulation of a large power system in real-time with reduced hardware cost.	**Широкополосная эквивалентная модель для RTDS**

95.	**Voltage Sensitivity to Capacitor Switching on an Existing Fixed Speed Induction Generator Wind Farm** Presented at IEEE Power Engineering Society General Meeting, June 24-28, 2007. pp. 1-4.	Switched capacitors at wind farms employing fixed speed induction generators are intended to provide reactive power support to control and maintain the voltage at the point of common coupling (PCC) within acceptable operational values. Malfunction of the capacitor switching control may lead to voltage depression and, subsequently, to tripping of turbines which could create additional transient power quality disturbances. This paper presents results of simulations of voltage regulation problems of an existing wind farm on the Bonneville Power Administration (BPA) system where voltage regulation problems have led to the study of possible dynamic voltage compensation schemes to minimize the problem. SCADA data for real and reactive powers and voltage have been analyzed against results from simulation models to verify the behavior and confirm the mechanisms associated with the voltage regulation problems. Other aspects associated with the high fidelity modeling of the wind farm and issues about the sizing of a possible dynamic voltage controller are investigated.	**Восприимчивость выходного напряжения ветропарка на базе асинхронных генераторов с фиксированной частотой вращения к коммутациям конденсаторов**
96.	**Real-Time Digital Time-Varying Harmonic Modeling and Simulation Techniques: IEEE Task Force on Harmonics Modeling and Simulation** IEEE Trans. on Power Delivery, Volume 22, Issue 2, April 2007, pp. 1218-1227.	With the growing importance of power quality problems to electric utilities and customers, there is an increased focus on the search for new tools and techniques for accurate analysis and resolution of such problems. This paper reviews currently available techniques for the modeling and simulation of time- varying harmonics in real-time. Following a brief summary of the currently used off-line harmonics modeling and simulation methods, the principles and sys- tem element representations using Wave Digital Filter (WDF) and Discrete Wavelet Transform (DWT) methods are discussed. Hardware and software architectures of Real-Time Network Simulator (RTNS), HYPER- SIM, and PC-Cluster based Real-Time Simulator are presented. Towards the end, two case studies are given to demonstrate the real-time analysis of time-varying harmonics generated by a three-phase arc furnace using the PC-Cluster based Real-Time Simulator, and a real- time hardware-in-the-loop (HIL) equipment testing using the Real-Time Digital Simulator (RTDS).	**Методы моделирования и симуляции в режиме реального времени нестационарных гармоник: Рабочая группа IEEE по моделированию и симуляции гармоник.**
97.	**Development of a Training Simulator for Power System Operation** Presented at WMSCI 2006, Orlando USA, Paper No. S154GT	A new type of simulation training system for power system operation is presented in this paper. It is based on transmission mimic board, double screen PC, mimic control panel, and real-time digital simulator, KEPS. The operating simulation includes the simulations of the control panel interface and the simulator. The mimic board displays transmission network summary information using a software view of the hardware based mimic board. The symbols, numbers and colors layout exactly match those of the KEPS draft case to provide operators a familiar and effective starting point. This paper describes the development of an innovative training system, utilizing the benefits of 3 dimension visualization s/w and communication-control s/w to create the appropriate operational environment and allow simulation of various power system operations without the restrictions of other training methods. Experiences gained in developing concepts and meeting considerable s/w challenges are outlined, and the potential of the simulator for future operations training discussed.	**Разработка тренажера действующей энергосистемы**
98.	**UMEC Transformer Model for the Real Time Digital Simulator** In Proc. IPST 2005, Montreal Canada, June 2005, Paper No. IPST05-077-25a	This paper introduces the UMEC (Unified Magnetic Equivalent Circuit) transformer model recently implemented for the RTDS® Simulator. The UMEC transformer algorithm was reorganized to meet the requirement of real time simulation. The detailed implementation and optimization of the algorithm are described. Validation of the model is also presented. The validation was conducted by comparing the real time output with that of analytical calculations and off-line simulation results from EMTDC™.	**Модель трансформатора с унифицированной магнитной эквивалентной схемой (UMEC) для RTDS**
99.	**A Real-time Platform for Teaching Power System Control Design**	This paper describes the development of a real-time digital simulation platform that can be used for the teaching of design principles for power system controls. In the developed ap-	**Платформа реального времени для преподавания проектирования систем управления**

	International Conference on Power Systems Transients, IPST 2005	proach, a rapid controller-prototyping platform (dSPACE) is interfaced to a real-time power system simulator (RTDS). The real-time platform is very successful when used in a post-graduate University course; but should also prove equally beneficial to the training of practicing engineers. The approach permits developers to physically prototype their designs and via the simulator, have them tested as if in the field. In contrast to offline simulation, this approach extends the design to the next logical step, and exposes engineers to the important issues of implementation and real-time testing. The use of this platform is demonstrated through the design of a power system stabilizer (PSS) for a One-Machine Infinite Bus (OMIB) system.	**для энергетики**
100.	**Recent Developments in Digital Real Time Simulation for Power Systems** In Proc. WMSCI 2005, Orlando USA, July 2005, Paper No. S762HI	This paper introduces important new developments in digital real time simulation of electrical power systems and their complex components. Particular emphasis is placed on two recent developments, the voltage source converter (VSC) model and the phase domain frequency dependent transmission line model. Various issues such as background, algorithms, implementations, applications and validation have been described and included in the paper. The paper also provides insight into the specific challenges faced when real time digital simulation is considered. Approaches commonly used in non real time simulation programs are not always possible when real time operation is required. For this reason accurate and efficient alternative methods must often be developed, implemented and validated.	**Последние события в области цифрового моделирования энергосистем в реальном времени**
101.	**Real Time Simulation for Advanced Time-Varying Harmonic Analysis** In Proc. IEEE Power Engineering Society General Meeting, 12-16 June 2005, pages 2250-2252, volume 3	Time varying harmonics are becoming an increasing issue in power quality analysis. Especially for future all-electric Navy ships which will feature closely coupled and complex electrical power systems with a large number of power electronic converter systems. In this paper, Real-Time Hardware in- the-Loop (RT-HIL) simulation is discussed as one of the tools to help analyzing the time varying power quality problems. First, recent additions to extensive RT-HIL capabilities of the Center for Advanced Power System (CAPS) at Florida State University are presented. Subsequently, results form RT-HIL experiments with commercial grade power electronics controllers are discussed.	**Моделирование в режиме реального времени как средство углубленного анализа нестационарных гармоник**
102.	**A Generic Real-Time Computer Simulation Model for Superconducting Fault Current Limiters and Its Application in System Protection Studies** IEEE Trans. Applied Superconductivity, Volume 15, Issue 2, Part 2, June 2005, pages 2090-2093.	A model for the SCFCL suitable for use in real time computer simulation is presented. The model accounts for the highly nonlinear quench behavior of BSCCO and includes the thermal aspects of the transient phenomena when the SCFCL is activated. Implemented in the RTDS real-time simulation tool the model has been validated against published BSCCO characteristics. As an example for an application in protection system studies, the effect of an SCFCL on a utility type impedance relay has been investigated using a real time hardware-in-the-loop (RT-HIL) experiment. The test setup is described and initial results are presented. They illustrate the effect of how the relay misinterprets the dynamically changing SCFCL impedance as an apparently more distant fault location. It is expected that the new real-time SCFCL model will provide a valuable tool not only for further protection system studies but for a wide range of RT-HIL experiments of power systems.	**Основная модель для RTDS сверхпроводникового ограничителя тока КЗ и его применение при исследовании защит.**
103.	**The FURNAS' Experience on Real Time Simulation** Presented at IX SEPOPE, Rio de Janeiro Brazil, May 2004	FURNAS' Real Time Power System Simulator has been working with real time power system simulation in order to help the operation planning and the system operation itself. During the years, the Laboratory has passed through Analog to Digital technology. This paper presents FURNAS' knowledge and experience in this area.	**Опыт FURANS в моделировании в режиме реального времени**

104.	**Complexity in Power Systems and Consequences for Real-Time Computing** In Proc. PSCE 2004, New York USA, October 2004, Paper No. PSCE2004-000711	The scale of the computational problem involved in correctly analyzing present-day and future power systems is shown to be significantly greater than in the past. Concepts for characterizing the nature and scale of the new systems and for creating new approaches to simulating them quickly enough for real-time operations are discussed.	**Сложность энергосистем и требования к расчетам в реальном времени**
105.	**An Efficient Saturation Algorithm for Real Time Synchronous Machine Models using Flux Linkages as State Variables** In Proc. Electrimacs 2002, Montreal Canada, June 2002	This paper presents an efficient method of calculation concerning D-axis saturation in a synchronous machine model when winding flux linkages are the state variables. A method is presented for calculation of a saturation indicator S based on a linear combination of the flux linkages in the D-axis windings. A method is then presented for developing a look-up curve F(S) which is dependent on the saturation indicator. The product of S times F(S) produces ψmd, the main mutual magnetizing flux linkage for the D-axis. The component of flux linkage due to leakage in each winding on the D-axis can be obtained by subtracting ψmd from the flux linkage of the particular winding. D-axis winding currents are subsequently obtained by multiplying the components of winding flux linkages due to leakage by the precalculated inverse of the leakage inductance matrix.	**Эффективный алгоритм насыщения для модели синхронной машины с заданием потокосцепления как переменных состояния**
106.	**New Simulation Tools for Power Systems** In Proc. IEEE T&D Conference & Exposition 2001, Atlanta USA, November 2001, Vol. 1 pp. 91-96	A brief history of analog simulators is given leading up to the development of the new types of digital simulator. Examples of the older analog simulators is followed by examples of their digital counterparts. Typical output waveforms from the new simulators are shown both in playback and interactive mode. Specific examples are given of the increase in testing efficiency using the new real time digital simulators with a batch testing feature.	**Новые инструменты моделирования для электроэнергетики**
107.	**Comparison of Transient Stability Analysis and Large-Scale Real Time Digital Simulation** In Proc. IEEE Porto PowerTech '2001, Porto Portugal, Sept. 2001, EMT-175	The KEPS Real Time Digital Simulator (RTDS®) is the largest real time power system simulator ever built. A power system which includes 320 (3-phase) buses and 90 generators has been modeled and run in real time. Since such large-scale systems were involved, it was not practical to validate them using non-real time electromagnetic transient programs such as EMTDC™ or EMTP. Instead, the results of the real time electromagnetic transient simulation were validated by comparing to transient stability simulations run using PTI's PSS/E™ program. The comparison of results from the two programs were in almost all cases very good. However, as expected, some differences did exist and were investigated. The differences in the results were primarily traced to the fact that the electromagnetic transient solution algorithm provides more detail and therefore greater accuracy than the transient stability algorithm. After finding very good comparison of results between the RTDS Simulator and PSS/E, and after investigating the discrepancies found, KEPCO gained the necessary confidence to use the large-scale real time simulator to analyze and develop their power system.	**Сравнение результатов исследований динамической устойчивости на крупномасштабной модели реального времени**
108.	**Development and Testing of a Large Scale Digital Power System Simulator at KEPCO** In Proc. IPST2001, Rio de Janeiro Brazil, June 2001, pp. 704-709	Abstract: This paper deals with the development and testing of a large scale, real time digital power system simulator for the Korean Electric Power Corporation. The so-called KEPS Simulation Center is to be located at KEPCO's research center (KEPRI) in Teajon, South Korea and is expected to be in full operation by September 2001. The KEPS Simulation Center includes a wide range of off line power system simulation and analysis tools, as well as an advanced real time digital simulator for the study of large scale AC and DC system performance. Because the application scope of the KEPS real time simulator is broad, and because the network models being considered are significantly larger and more complex than in traditional	**Разработка и испытания на крупномасштабном симуляторе RTDS, установленного в компании KEPCO**

		real time simulator applications, many developments and tests have been required during the course of the project. In this paper, the authors will describe some of these developments and will present results from various benchmark tests that have been performed.	
109.	**Computer and Real-Time Simulation of Large Power Systems** In Proc. CEPSI 2000, Manila Philippines, October 2000	Successful operation of a power system depends largely on the engineer's ability to provide safe, reliable and economic service to the customer. Advanced simulation technologies provide useful means to the engineer for the design and analysis of the power system, and assisting them in making reasonable decisions. Due to powerful software and advanced real-time simulators, it became possible to simulate the dynamic behavior of very large power systems including HVDC and FACTS, and to verify the performance of these complex systems with the original control and protection equipment in a fast and accurate manner. The simulation covers all stages of development and operation of a power system, such as planning, design, test and also during operation. In this paper advanced software and real-time power system simulation technologies are presented. With practical examples benefits of the simulation for large power systems are demonstrated.	**Моделирование больших энергосистем на компьютере и в режиме реального времени.**
110.	**Power System Analysis Using the Real Time Digital Simulator** In Proc. ICEE2K, Kitakyushu Japan, July 2000	This paper will describe the findings and developments associated with an ongoing R&D project at the Korean Electric Power Corporation's research institute, KEPRI, in which a power system simulation center is being designed and installed. The so-called KEPCO Enhanced Power System Simulator (KEPS) will include both off line (i.e. non-real time) and on line (real time) simulation capabilities and will be used by KEPRI to study various aspects of the growing power network in Korea. A Real Time Digital simulator based on the well known RTDSTM hardware and software architecture will form the core of the KEPS system. A number of developments and enhancements have been made to the fundamental simulation technology in order to meet some of the special requirements defined in the KEPS project. The authors will also provide a brief summary of various simulation and analysis tools including those used for steady state simulation, dynamic simulation, transient simulation, electromagnetic transients simulation and real time simulation. A comparison of simulation results from the KEPS real time digital simulator with other well accepted programs will be given in order to illustrate the accuracy and the application scope of KEPS	**Анализ энергосистем с помощью RTDS**
111.	**Overview & Comparison of Power System Analysis and Study Tools** In Proc. IERE Workshop, Taejon Korea, September 1999, pp. 63-69	Over the past several decades a number of important analytical tools have been developed for the power system industry. In this paper the authors will present an overview of several commonly used simulation and analysis tools including those used for steady state simulation, dynamic simulation, transient simulation, electromagnetic transients simulation and real time simulation. Special emphasis will be placed to real time digital simulation (the most recent development in power system simulation) and how it compares with other widely used non-real time software.	**Обзор и сравнение средств анализа энергосистем и установившихся режимов**
112.	**Comparison of IEEE Benchmark for Computer Simulation of Subsynchronous Resonance** In Proc. ICDS '99, Vasteras Sweden, May 1999, Poster Session	The IEEE First Benchmark Model was created by the IEEE Working Group on Subsynchronous Resonance in 1977 for use in computer program comparisons and development |1|. This small system is described in realistic parameters and provides an useful test bed for SSR analytical methods. The purpose of the Benchmark Model is to prepare standard test cases to facilitate the comparison of calculations and the debugging of computers programs in order to meet the needs of the electric power industry. One of the main objectives of SSR analysis is to predict the amount of fatigue damage that might occur on turbine-generator rotors. Transient disturbances on either an uncompensated or series capacitor compensated transmission network (the case discussed here) can result in fatigue of turbine-generator shafts. Justification for expenditure on countermeasures is de-	**Сравнение результатов тестов IEEE цифрового моделирования подсинхронного резонанса**

		termined essentially by the accuracy of transient case simulations and therefore validation of simulation tools is always necessary. This report compares the results of the SSR transient case as set out in the paper [1] with those obtained by means of RTDS simulation. Three alternative transformer models are used to refine the proposed electrical network. Good correspondence of the results confirms the validity of RTDS simulation for SSR studies.	
113.	**Overview of the Development and Installation of KEPCO Enhanced Power System Simulator** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session VII	This paper will describe design, development and implementation details of a large scale power system simulator being installed at the Korea Electric Power Research Institute. The so-called Korea Enhanced Power System Simulator (KEPS) will include both off line (i.e. non-real time) and on line (real time) simulation capabilities and will be used by KEPRI to study various aspects of the growing power network in Korea. A Real Time Digital simulator based on the well known RTDS™ hardware and software architecture will form the core of the KEPS system. A number of developments and enhancements will made to the fundamental simulation technology in order to meet some of the special requirements defined in the KEPS project	**Обзор развития и наладки расширенного симулятора RTDS в KEPCO**
114.	**The Implementation of the Cholesky Factorization Routine in the RTDS Real Time Network Solution** In Proc. ICDS '99, Vasteras Sweden, May 1999, Session III	This paper presents the development of modern real-time simulation technologies suitable for FACTS and HVDC control and protection testing. For verification of the new technologies, comparison is made with analogue simulators and computer simulation. The advanced real-time simulators in either a purely digital or hybrid analogue-digital form provide substantial benefits to the testing of modern power electronic equipment under extended system conditions. Scenarios, that were previously difficult, if not impossible, are now made relatively simple. The requirements for control and protection testing are discussed, simulation highlights of large project studies are presented and strategies of solving specific simulation problems are outlined.	**Реализация процедуры разложения методом Холецкого в RTDS для сетевых вычислений в реальном времени**
115.	**Development of Real-Time Simulation Technology - Summary of Experiences and Results** In Proc. ICDS '99, Vasteras Sweden, May 1999	This paper presents the development of modern real-time simulation technologies suitable for FACTS and HVDC control and protection testing. For verification of the new technologies, comparison is made with analogue simulators and computer simulation. The advanced real-time simulators in either a purely digital or hybrid analogue-digital form provide substantial benefits to the testing of modern power electronic equipment under extended system conditions. Scenarios, that were previously difficult, if not impossible, are now made relatively simple. The requirements for control and protection testing are discussed, simulation highlights of large project studies are presented and strategies of solving specific simulation problems are outlined.	**Развитие технологии моделирования в реальном времени - обзор наработок и результатов**
116.	**RTDS - A Fully Digital Power System Simulator Operating in Real Time** In Proc. ICDS '95, College Station Texas USA, April 1995, pp. 19-24	This paper presents details on the design, architectural features and applications of a real-time digital simulator (RTDS™) developed at the Manitoba HVDC Research Centre (Winnipeg, Canada). Custom hardware and software have been developed and collectively applied to the simulation and study of electromagnetic transients phenomenon in power systems in real-time. The combination of real-time operation, flexible I/O, graphical user interface and an extensive library of accurate power system component models make the RTDS an ideal simulation tool with a wide range of applications.	**RTDS - Полностью цифровой симулятор энергосистем, работающий в режиме реального времени**
117.	**Fully Digital Real-Time Electromagnetic Transients Simulator**	The paper details the design, architectural features and application of a fully digital electromagnetic transients simulator capable of real-time operation. The custom hardware and software developed to implement the Real-Time Digital Simulator (RTDS) is described with	**Полностью цифровой симулятор реального времени для электромагнитных переходных**

	In Proc. IERE International Electric Research Exchange, Workshop on New Issues in Power System Simulation, Caen France, March 1992, pp. 218-228	special emphasis given to the high level graphical user interface written especially for use with the RTDS.	**процессов**

ИНТЕЛЛЕКТУАЛЬНЫЕ СЕТИ И РАСПРЕДЕЛЕННАЯ ГЕНЕРАЦИЯ

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
118.	**Automatic Distributed Voltage Control Algorithm in Smart Grids Applications** Published in IEEE Transactions on Smart Grid. Volume 4, Issue 2, June 2013.	The widespread use of distributed generation (DG), which is installed in medium-voltage distribution networks, impacts the future development of modern electrical systems that must evolve towards smart grids. A fundamental topic for smart grids is automatic distributed voltage control (ADVC). The voltage is now regulated at the MV busbar acting on the on-load tap changer of the HV/MV transformer. This method does not guarantee the correct voltage value in the network nodes when the distributed generators deliver their power. In contrast, the ADVC allows control of the voltage acting on a single generator; therefore, a better voltage profile can be obtained. In this paper, an approach based on sensitivity theory is shown to control the node voltages regulating the reactive power injected by the generators. After the theoretical analysis, a numerical example is presented to validate the theory. The proposed voltage regulation method has been developed in collaboration with Enel Distribuzione S.p.A. (the major Italian DSO), and it will be applied in the Smart Grids POI-P3 pilot project, which is financed by the Italian Economic DevelopmentMinistry. Before the real field application in the pilot project, a real-time digital simulation has been used to validate the algorithm presented. Moving in this direction, Enel Distribuzione S.p.A. built a new test center in Milan equipped with a real-time digital simulator (from RTDS Technologies).	**Алгоритм автоматического управления напряжением распределительной сети в "умной сети" Smart Grid**
119.	**Power System Stability Enhancement Through Wide Area Measurements** Presented at Saudi Arabia Smart Grid Conference, Jeddah, Saudi Arabia, December 2012	Low frequency inter-area oscillations is one of the main concerns for power system operation and control therefore damping of inter-area oscillations is necessary for secure and reliable system operation. However, to enhance damping of the inter-area modes remote signal need to be measured and feedback to the power system stabilizers. This can be done by wide area measurements, through phasor measurement units (PMUs). The power system stabilizers in conjunction with PMUs provide adequate stability. Remote signals through PMUs are of great interest to damp out inter area oscillations. In this paper enhancing the damping of the inter-area modes using wide area measurements has been addressed. The power system stabilizers has been be designed, tested and validated on real time digital simulator (RTDS). The experimental results show the effectiveness of the proposed approach to damp out the low frequency inter-area oscillations	**Повышение устойчивости энергосистемы посредством территориально-распределённых измерений**
120.	**Laboratory Experiences with Power-Hardware-in-the-Loop Simulation for Distributed Energy Resources**	Презентация. Аннотация отсутствует.	**Лабораторные работы по силовому программно-аппаратному моделированию рас-**

	Presented at 3rd IEEE PES Innovative Smart Grid Technologies (ISGT) Conference. Berlin, Germany, October 17, 2012.		**пределенных энергоресурсов**
121.	**A Dynamic Modelling Environment for the Evaluation of Wide Area Protection Systems** Presented at 43rd International Universities Power Engineering Conference (UPEC '08), Padova Italy, September 2008	This paper introduces the concept of dynamic modelling for wide area and adaptive power system protection. Although not limited to these types of protection schemes, these were chosen due to their potential role in solving a multitude of protection challenges facing future power systems. The dynamic modelling will be implemented using a bespoke simulation environment. This tool allows for a fully integrated testing methodology which enables the validation of protection solutions prior to their operational deployment. Furthermore the paper suggests a distributed protection architecture, which when applied to existing and future protection schemes, has the potential to enhance their functionality and avoid maloperation given that safety and reliability of power systems are paramount. This architecture also provides a means to better understand the underlying dynamics of the aforementioned protection schemes and will be rigorously validated using the modelling environment.	**Динамическое моделирование окружающих условий при анализе глобальной системы релейной защиты**
122.	**A Study on Stability Enhancement of Distributed Generators** Presented at 2008 IEEE Power Engineering Society General Meeting, Pittsburgh USA, July 2008	Large number of 400V distributed generators (DGs) connected to existing electric systems may have a great impact on their dynamic behaviour when external disturbances occur, such as a three-phase short circuit fault. This paper presents an investigation about the transient stability and the capacity of DG to withstand disturbances in the distribution network. Three proposed solutions to avoid the loss of generation are presented. The RTDS (real time digital simulator) platform is used for analysis of system performance.	**Исследование вопросов повышения устойчивости для распределенной генерации**
123.	**Performance of Induction Generator Protection During Distributed Network Disturbances** Proc. IET 9th International Conference on Developments in Power System Protection, Glasgow UK, March 2008, Vol. 1, pp. 529-534	Distributed generators (DGs) that are rated between several kVA and 250kVA in size are increasingly being connected at the 400V electrical distribution level. Therefore, new requirements for the traditional network protection schemes and the co-ordination between network protection and intertie protection are needed. Actual problems have been experienced relating to DG transient behaviour, thereby, more accurate analysis is required. This paper presents studies using a real time simulation platform to investigate the transient behaviour of the distributed generators' protection under external disturbances. Furthermore, an optimized DG protection setting for keeping most of the DG stable under such disturbances is proposed.	**Поведение защиты асинхронного генератора при возмущениях в сети распределенной генерации**
124.	**Large Scale Power System Simulation and PMU testing using a Real Time Digital Simulator** Presented at IPEC 2007, Singapore, December 2007	In recent times the use of PMU's is being investigated as part of wide area power system control. Real time simulation and closed-loop testing is essential to the development of these controllers. This paper introduces the methods used to create large scale power system models on the RTDS Simulator for the testing of PMU's. Data conversion and load flow programs are two tools that are very effective when creating large scale electromagnetic transient simulations. The paper explains the key aspects of these tools. For some applications, high precision pulses are used by PMU's to measure generator rotor angles. A pulse must be given for each revolution of the generator with an accuracy of 3-5 microseconds. This is a challenge for a discrete time simulation operating with a typical timestep of 50-70 microseconds. A technique to provide the pulse with an accuracy of 1 microsecond is introduced. Finally an example is presented to demonstrate the entire process of creating large scale	**Применение RTDS для моделирования крупномасштабной энергосистемы и испытания синхрофазоров (PMU)**

		power system models on the RTDS Simulator for PMU testing.	
125.	**Voltage Source Converter Modeled in RTDS – Experiences and Comparison with Field Results** Presented at IPST 2007, Lyon France, June 2007, Session 24 Paper No. 76	Abstract—For the first time it has been possible to model a three-level Voltage Source Converter (VSC) and test the physical firing pulse controls using a Real Time Digital Simulator (RTDS®). The new RTDS model is more flexible and comprehensive than both earlier digital versions and analogue TNA models. This allows more tests to be conducted in a shorter time and provides a more detailed power system representation for the tests. Using the new system to test the controls also simplifies the recording of results since all signals can now be gathered by the RTDS Simulator. For the case of Electric Arc Furnace (EAF) compensation, the new real time digital simulation has made it convenient and easy to demonstrate the flicker improvement factor provided by the actual VSC controls under realistic system conditions. The paper compares results from off-line and real time RTDS simulations, as well as from field measurements taken at a full scale ABB SVC Light® installation. The good correlation between simulation results and field measurements give confidence to the digital modeling.	**Моделирование на RTDS преобразователя напряжения (VSC) - накопленный опыт и сопоставление с опытными данными**
126.	**Real Time Simulation Testing Using IEC61850** Presented at IPST 2007, Lyon France, June 2007, Session 26 Paper No. 177	As IEC 61850 becomes more widely accepted in the electrical engineering community, it is important that the testing tools keep pace with this development. IEC 61850 presents new challenges to real time simulation and closed-loop testing of protective relays. Electrical interfaces used for binary signaling and voltage/current amplifiers must be replaced by an Ethernet connection and an IEC 61850 protocol stack. The electrical interfaces of a real time simulator are engineered to provide low latency and deterministic performance appropriate for a real time simulation. Similar attention must be given to IEC 61850 interfaces. Latency must be minimized so that the IEC 61850 interface does not add unacceptable delays to the operation of the simulator. Also, protocol processing must be deterministic to allow real time simulations to be repeatable and dependable. In addition, IEC 61850 specifies new configuration parameters and a new method for configuration called the Substation Configuration Language (SCL). These must be implemented in such a way that they fit within the typical modes of operation of the simulator. The paper presents a successful hardware implementation for IEC 61850 messaging on a real time simulator and discusses the key design criteria. The software required to configure the IEC 61850 will also be addressed along with the advantages in using the IEC 61850 protocol. One of the biggest advantages is brought about by the realization of the IEC 61850-9-2 sampled values, removing the need for amplifiers as the standard interface to protection devices. Sampled values of the voltage and current signals can be sent via Ethernet, making it even more practical to perform testing on a protective relaying scheme rather than just individual devices.	**Проведение испытаний в реальном времени по интерфейсу МЭК61850**
127.	**The CAPS-SNL Power System Security Testbed** Presented at Third International Conference on Critical Infrastructures, Alexandria USA, Sept 2006	Securing cyberspace is a vital element of critical infrastructure protection efforts currently underway in the United States and other industrialized nations. As pointed out in U.S. Department of Homeland Security Testimony to Congress, interdependency of cyber and physical infrastructure is particularly “acute” in the case of control systems [1]. The automation and communication networks being used today to control electrical power systems are a particular concern, and, until now, methods to explore the effects on the physical power system due to control system compromise have been very limited. “Successful” hackers could gain access to vital control and protection settings and commands and cause significant problems for the operators and the system. In order to understand the consequences of hacker attacks and to find ways to harden the system against such attacks, Sandia National Laborato-	**Испытательный стенд изучения кибербезопасности энергосистем созданный CAPS и SNL**

		ries (SNL) and the Center for Advanced Power Systems (CAPS) at FSU have combined forces to create a “virtual” electrical grid system linked to an actual control, communication and protection system.	
128.	**Development of a Unified Design Test and Research Platform for Wind Energy Systems Based on Hardware-in-the-Loop Real-Time Simulation** IEEE 35th Annual Power Electronics Specialists Conference, 2004. PESC 04	Traditionally, offline modeling and simulation has been the tool of choice for improving wind energy system control strategies and their utility system integration. This paper exploits how a newly established real-time hardware-in-the-loop (HIL) test facility, which is designed for testing all-electric ship propulsion systems, can be utilized for wind energy research. The test site uses two 2.5-MW/220-rpm dynamometers and a 5-MW variable voltage and frequency converter to emulate a realistic dynamic environment, both mechanically and electrically. The facility is controlled by a digital real-time electric power system simulator that is capable of simulating electrical networks and control systems of substantial complexity, typically with a 50-µs time step. Substantial input/output allows the feedback of measured quantities into the simulation. A 15-kW mock-upmotor–generator set is used to demonstrate some critical aspects of the concept including the implementation of a proposed neural-network-based sensorless maximum wind energy capture control. From the dynamic test results presented, it is concluded that the proposed system shows great potential for the development of a unified wind energy design, test, and research platform.	**Разработка унифицированной научно-исследовательской платформы для программно-аппаратного моделирования ветроэнергетических систем в реальном времени**
129.	**A Real-Time Controller Concept Demonstration for Distributed Generation Interconnection** In Proc. IEEE Power Engineering Society General Meeting, Montreal, QC, Canada, June 2006.	In this paper, the set up and demonstration of a real-time controller based on the IEEE Std. 1547 for interconnection of distributed generation (DG) sources to the electric utility grid is presented. The case studies described are based on the philosophy of real-time (RT) hardware in the loop (HIL) simulation. The RT-HIL technique is capable of providing insight into the performance of both the system with the DG as well as the external hardware controller. The results of a real-time controller concept demonstration may be useful in understanding the recommendations of the IEEE Std. 1547 and analyzing the system impact of the interconnection of DGs.	**Демонстрация идеи контроллера реального времени для управления внутренними подключениями в сети распределенной генерации.**
130.	**Protective Relay Synchrophasor Measurements During Fault Conditions** Presented at Power Systems Conference: Advanced Metering, Protection, Control, Communication, and Distributed Resources, Clemson USA, March 2006, pp. 83 – 95	This paper describes details of the signal processing techniques that a protective relay uses to provide both synchronized phasor measurements and line distance protection. The paper also presents a comprehensive system model of normal and faulted power system operating conditions. Finally, the paper provides power system model test results that demonstrate the ability of the described protective relay to provide synchrophasor measurements during both normal and faulted conditions.	**Синфазные измерения устройствами защиты в течение аварийных процессов**
131.	**Development of a Unified Design Test and Research Platform for Wind Energy Systems Based on Hardware-in-the-Loop Real-Time Simulation** IEEE 35th Annual Power Electronics Specialists Conference, 2004. PESC 04	Traditionally, offline modeling and simulation has been the tool of choice for improving wind energy system control strategies and their utility system integration. This paper exploits how a newly established real-time hardware-in-the-loop (HIL) test facility, which is designed for testing all-electric ship propulsion systems, can be utilized for wind energy research. The test site uses two 2.5-MW/220-rpm dynamometers and a 5-MW variable voltage and frequency converter to emulate a realistic dynamic environment, both mechanically and electrically. The facility is controlled by a digital real-time electric power system simulator that is capable of simulating electrical networks and control systems of substantial complexity, typically with a 50-µs time step. Substantial input/output allows the feedback of measured quantities into the simulation. A 15-kW mock-upmotor–generator set is used to demonstrate some critical aspects of the concept including the implementation of a proposed neural-network-based	**Разработка унифицированной научно-исследовательской платформы для программно-аппаратного моделирования ветроэнергетических систем в реальном времени**

		sensorless maximum wind energy capture control. From the dynamic test results presented, it is concluded that the proposed system shows great potential for the development of a unified wind energy design, test, and research platform.	
132.	**PV-Wind-Fuel Cell-Electrolyzer Micro-grid Modeling and Control in Real Time Digital Simulator** Presented at ICCEP 2009, Capri, Italy, June 2009	Micro-grid consisting of Photovoltaic (PV) arrays, Wind Turbine Generator (WTG), Fuel Cell, Supercapacitor and Electrolyzer (EL) serving a village load is modeled and implemented in Real Time Digital Simulator (RTDS). Operating scenarios under fluctuating load conditions using an appropriate control strategy are simulated and analyzed. The advantages of using RTDS for micro-grid studies are presented.	**Моделирование и управление микросетями солнечных, ветровых установок и топливных элементов на RTDS**

СИЛОВАЯ ЭЛЕКТРОНИКА

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
133.	**FPGA model of a High-frequency Power Electronic Converter in an RTDS Power System Co-simulation** R. Meka, M. Sloderbeck, Md. O. Faruque, J. Langston, M. Steurer, L. S. DeBruner Proceedings of the IEEE Electric Ship Technologies Symposium (ESTS 13), Arlington, VA 22-24, 2013	This paper presents the work being done in developing Field Programmable Gate Array (FPGA) based high-frequency power electronic models in co-simulation with Real Time Digital Simulator (RTDS) small time step models. With the inclusion of FPGAs in the Electromagnetic Transient simulations, higher frequencies for power electronic models, which were not previously possible using only RTDS, can be achieved. A two port buck converter is modeled on an FPGA using Dommel's algorithm and interfaced with the small time-step environment in RTDS using a travelling wave model. The RTDS small time-step size is 2 µs, whereas the time-step for the FPGA is 300 ns. This paper presents the results and challenges faced in developing this system.	**Моделирование на ПЛИС высокочастотных силовых электронных преобразователей совместно с моделированием энергосистемы на RTDS**
134.	**RTDS Implementation of STATCOM for Power System Stability Improvement** Presented at Saudi Arabia Smart Grid Conference, Jeddah, Saudi Arabia, December 2012	In this paper, analysis and implementation of STATCOM based stabilizers to enhance damping of low frequency oscillations is studied and demonstrated. The effectiveness of STATCOM gain and phase modulation channels to enhance the damping characteristics is investigated. The coordination among the internal AC and DC voltage controllers and the proposed damping controllers on each channel is designed. Differential Evolution as an intelligent optimization technique is considered to design the STATCOM supplementary damping controllers. The implementation of STATCOM based stabilizers on Real Time Digital Simulator (RTDS) is carried out. The RTDS experimental setup of a power system with STATCOM is verified. The power system considered is tested through nonlinear time domain simulations to examine the validity of the proposed approach to damp low frequency oscillations. Comparisons with similar results reported in literature are demonstrated.	**Использование RTDS для повышения устойчивости энергосистемы на базе STATCOM**
135.	**Co-simulation of an FPGA-based Electromagnetic Transient Model and a Small Time-Step Model in the RTDS Real-Time Digital Simulator** GCMS 2012 at SummerSim '12, Genoa, Italy,	This paper describes work in electromagnetic transient co-simulation of a field-programmable gate array (FPGA)- based model with an RTDS Real-Time Digital Simulator. Results are presented toward achieving the goal of simulating high-frequency power electronic converters in real-time co-simulation with a rest-of-system transient model. Power system converter models using the RTDS were previously implemented at rates up to approximately 6 kHz switching frequency using voltage source converter models in a small time-step of ~1.5-2 µsecs. In this work, the FPGA-based transient simulation models of a static and switched RL load are inter-	**Симулирование на ПЛИС электромагнитных переходных процессов и процессов с малым шагом расчета на RTDS**

	July 2012	faced to the RTDS small timestep model through a traveling wave model. The highfrequency switching models suggest the feasibility of FPGA-based simulation of a high-frequency switching converter.	
136.	**Backup Transmission Line Protection for Ground Faults and Power Swing Detection Using Synchrophasors** Armando Guzmán, Venkat Mynam, Greg Zweigle, Schweitzer Engineering Laboratories, Inc.	This paper proposes the use of synchrophasors for backup transmission line protection for ground faults and power swing detection. The proposed protection approach complements protective distance elements and is suitable for single-pole and three-pole tripping applications. The paper presents the synchrophasor- based protective element performance for challenging fault conditions such as cross-country faults with high fault resistance. The power swing detection algorithm this paper proposes uses angle difference measurements and does not require setting traditional impedance-based out-of-step (OOS) characteristics.	**Использование синхрофазоров (PMU) для резервной защита ЛЭП при замыканиях на землю и выявления качания мощности**
137.	**Study of Power Loss of Small Time-Step VSC Model in RTDS** In Proc. Of the IEEE PES General Meeting, June 24-28, 2007 in Tampa, Florida, USA (submission no. 07GM1261)	In this paper, the power loss of power electronic switches modeled as RTDS small time-step Voltage Source Converter (VSC) is studied. The reduction of time step size and resistance at OFF state can decrease the artificial switching loss in the RTDS small time-step VSC models. Higher noise levels in the RTDS simulations indicate more power loss in the RTDS simulations than in equivalent PSIM simulations. The sensitivity of the power loss and the Total Harmonic Distortion (THD) to parameters, including switch model parameters and interface transformer model parameters are studied. With appropriately selected component model parameters, the power loss of the modeled switches can be reduced.	**Исследование потери мощности на модели преобразователя напряжения VSC с малым шагом расчета на RTDS**
138.	**Voltage Source Converter Modeled in RTDS – Experiences and Comparison with Field Results** Presented at IPST 2007, Lyon France, June 2007, Session 24 Paper No. 76	Abstract—For the first time it has been possible to model a three-level Voltage Source Converter (VSC) and test the physical firing pulse controls using a Real Time Digital Simulator (RTDS®). The new RTDS model is more flexible and comprehensive than both earlier digital versions and analogue TNA models. This allows more tests to be conducted in a shorter time and provides a more detailed power system representation for the tests. Using the new system to test the controls also simplifies the recording of results since all signals can now be gathered by the RTDS Simulator. For the case of Electric Arc Furnace (EAF) compensation, the new real time digital simulation has made it convenient and easy to demonstrate the flicker improvement factor provided by the actual VSC controls under realistic system conditions. The paper compares results from off-line and real time RTDS simulations, as well as from field measurements taken at a full scale ABB SVC Light® installation. The good correlation between simulation results and field measurements give confidence to the digital modeling.	**Моделирование на RTDS преобразователя напряжения (VSC) - накопленный опыт и сопоставление с опытными данными**
139.	**PEBB based High-Power Hardware-In-Loop Simulation Facility for Electric Power Systems** In Proc. IEEE Power Engineering Society General Meeting, Montreal, QC, Canada, June 2006	Hardware-in-the-loop (HIL) simulation has been used in the past primarily for testing system interactions of control systems. Extending the concept of HIL into the realm of real power equipment, such as motors and power electronic converters, results in the so-called power hardware-in-loop (PHIL) simulations. The Center for Advanced Power Systems (CAPS) at Florida State University is currently in the process of commissioning a dedicated 5 MW PEBB based variable voltage source (VVS) power converter system as part of its existing 5 MW (6.25 MVA) PHIL experimental facility. This system consists of a large-scale commercial digital power system simulator which can provide speed and torque signal references to variable speed drives of dynamometers as well as instantaneous voltage references to the VVS while receiving the appropriate feedbacks in real time for PHIL simulation. This setup will allow for the first time to connect MW class electric power apparatus to an experimental bus which can represent any desired characteristic by means of real-time simulations. In order to get familiar with the vendor specific controller architecture and possibly develop adequate compensation	**Блочная установка силового программно-аппаратного моделирования для электроэнергетических систем**

		remedies (i.e. using the RTDS) CAPS has also installed a low power version of the VVS. Preliminary test results from a closed loop PHIL experiment with this low power VVS are presented.	
140.	**Use of RTDS Real-Time Simulator for Dynamometer Control in Electrical Machine Testing**. In Proc. SCI 2004, Orlando USA, July 2004, Paper No. S874EP	The use of a real-time simulator for the control of a dynamometer for testing electrical machines is described. The simulator computes the torque to be applied to the test machine using a dynamic load model appropriate to the application and computes the required control signals to get that torque by means of a feedback control algorithm. The simulator also controls the test, manages data acquisition and monitors the progress of the test for safety and institutes a shut-down procedure if a dangerous or unexpected condition develops.	**Использование RTDS для динамометрического контроля при испытаниях вращающихся электрических машин.**
141.	**Small Time-Step (<2µSec) VSC Machine Drives for the Real Time Digital Simulator** In Proc. Electrimacs 2005, Hammamet Tunisia, April 2005, Paper No. 210	This paper describes a recently developed approach for representing Voltage Source Converter (VSC) bridges using real time electromagnetic transient (EMT) simulators. The fact that such simulators must provide continuous real time response introduces numerous challenges normally not faced in typical offline EMT simulations. The method presented in this paper utilizes a multiple time step approach in which time critical components are simulated with a small time step (< 2 µsec) while the remainder of the circuit is simulated with more typical time step (~ 50 µsec). The VSC bridge, which can include many valves within a single lumped circuit is interfaced to the time-domain simulation of the main network. In an EMT simulation program, the representation of a valve is achieved by the combination of a conductance in parallel with a controlled current source. For the method described in this paper the ON and OFF states of any valve are achieved by modification of the current injection coming from the controlled source rather than changing the conductance value.	**Малый шаг расчетов в RTDS (< 2 мкс) для электропривода с преобразованием напряжения VSC**
142.	**Small Time-Step (<2µSec) VSC Model for the Real Time Digital Simulator** In Proc. IPST 2005, Montreal Canada, June 2005, Paper No. IPST05-168-25c	This paper describes a method for time-domain electromagnetic transients modeling of Voltage Source Converter (VSC) bridges in a real time digital simulator using a short time-step (< 2 µsec). The method supports the modeling of many valves in one lumped connected network. The model of the VSC bridge is interfaced into the time-domain simulation of a main network that uses a larger time-step (~ 50 µsec). The representation of each valve in the EMT type program is provided by a fixed conductance in parallel with a current source. The calculation of the parallel current source is modified to facilitate the representation of the ON and OFF states of the valve.	**Малый шаг расчетов в RTDS (< 2 мкс) для преобразователя напряжения VSC**
143.	**The Real Time Digital Simulation of a Single Phase Voltage Source Converter and its Application** In Proc. IPST 2003, New Orleans USA, October 2003, Paper No. 13-2	Voltage Source Converters (VSCs) use Gate Turn-Off (GTO) devices and Pulse Width Modulation (PWM) technology to control the operation of the converter bridge. This paper presents a new fully digital model of a single phase VSC. The unique improved firing algorithm (a numerical algorithm for compensating discrete time step firing error) allows the simulation time step to be in the range of 50 S while maintaining the high firing accuracy required by PWM. The real time network solution algorithm of the RTDS simulator makes it possible to inter-connect the VSC models with any other models in the RTDS power systems library. As a result, complex schemes of inter-connected single phase VSCs can be studied in real time. Physical controllers can also be tested using the model.	**Моделирование на RTDS однофазного преобразователя напряжения и его применение**

КОРАБЕЛЬНЫЕ СИСТЕМЫ

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
144.	**FPGA model of a High-frequency Power Electronic Converter in an RTDS Power System Co-simulation** R. Meka, M. Sloderbeck, Md. O. Faruque, J.	This paper presents the work being done in developing Field Programmable Gate Array (FPGA) based high-frequency power electronic models in co-simulation with Real Time Digital Simulator (RTDS) small time step models. With the inclusion of FPGAs in the Electromagnetic Transient simulations, higher frequencies for power electronic models, which were not previously possible using only RTDS, can be achieved. A two port buck converter is modeled on an	**Моделирование на ПЛИС высокочастотных силовых электронных преобразователей совместно с моделированием энергосисте-**

	Langston, M. Steurer, L. S. DeBrunner Proceedings of the IEEE Electric Ship Technologies Symposium (ESTS 13), Arlington, VA 22-24, 2013	FPGA using Dommel's algorithm and interfaced with the small time-step environment in RTDS using a travelling wave model. The RTDS small time-step size is 2 µs, whereas the time-step for the FPGA is 300 ns. This paper presents the results and challenges faced in developing this system.	**мы на RTDS**
145.	**Adaptive Transfer Function Estimation of a Notional High-Temperature Superconducting Propulsion Motor** Accepted for publication in IEEE Transactions on Industrial Applications, accepted January 2008.	In this paper, the application of a novel time frequency analysis tool for online estimation of the transfer functions of a notional high-temperature superconducting (HTS) marine propulsion motor is demonstrated. Detailed simulation model of the notional HTS motor, with realistic load modeling of sea-states to produce torque oscillations are utilized for the analysis. A method is presented for online near real-time estimation of transfer functions between the torque oscillations and the concomitant variations in field current and mechanical speed of the HTS motor. The transfer functions, obtained using the novel method, are compared with the results from a traditional offline transfer function estimation technique.	**Определение адаптивной передаточной функции для условного ходового электродвигателя на высокотемпературных сверхпроводниках**
146.	**Controls for Minimizing Ship Power System Frequency Fluctuations** In Proc. ASNE Controls & Automation Symposium, Biloxi, MS, December 10-11, 2007	The application of large load steps to the power system of an all-electric ship raises power quality issues since sudden changes in electrical loading on synchronous generators can cause their output frequency to fluctuate widely as the prime mover adjusts to meet the demand. This paper explores three control strategies for minimizing the fluctuations of generator frequency during load-step disturbances. These strategies include reducing propulsion motor power demand, accessing propulsion motor regenerative power, and applying regenerative power from a dedicated capacitor energy storage device to the generator bus. The performance of each control strategy was examined using a large-scale, real-time digital simulation model of a notional ship system. The simulation results demonstrate the control strategies' effectiveness in eliminating load-step frequency disturbances as well as limiting their magnitude to the level of military standards for shipboard systems.	**Управление с целью минимизации отклонений частоты судовой энергоустановки**
147.	**A Co-Simulation Approach for Real-Time Transient Analysis of Electro-Thermal System Interactions on Board of Future All-Electric Ships** In Proc. Of the 2007 Summer Computer Simulation Conference, July 15-18 2007, San Diego, CA	This paper presents an approach to performing real-time co-simulation of electro-thermal coupled power systems for aiding the design of future all-electric Navy ships. The goal is to study the transient interactions between the electrical and the thermal sub-systems. The approach utilizes the existing large scale real-time simulation capabilities of electrical systems established at Florida State University on the Real Time Digital Simulator (RTDS) platform in conjunction with real-time simulation models of thermal systems from the University of South Carolina implemented on the Virtual Test Bed (VTB) platform. The paper first briefly discusses methods for linking the RTDS and the VTB models. It then describes the different modes of interactions between the electrical and the thermal subsystems and illustrates them on realistic example cases. A simplified application scenario is analyzed. Initial results clearly illustrate the thermal runaway phenomena as long term system instability typically not revealed by snapshot type off-line simulations. The paper concludes with an outlook on future steps to improve this approach towards higher system fidelity and level of detail represented in the thermal system.	**Методика моделирование переходных процессов в реальном времени при электротепловом взаимодействии судовых систем полностью электрического корабля будущего.**
148.	**Characterization of the Transient Behaviour of an AC/DC Conversion System for a Notional All-Electric Ship Simulation Using Sequential Experimental Design Methodology**	Experimental design methodology is applied to the characterization of a transient simulation of the AC/DC conversion system of a notional all-electric ship in terms of parameters of the simulation. The process of constructing the surrogate models describing the behavior of the system during a load rejection transient scenario is presented and selected results from predictions from the surrogate models are presented.	**Определение характеристик в переходных режимах AC/DC преобразователя для условного электрохода при опытно-**

	In Proc. Of the 2007 Summer Computer Simulation Conference, July 15-18 2007, San Diego, CA		**конструкторском проектировании**
149.	**Applying Controller and Power Hardware-in-the-Loop Simulation in Designing and Prototyping Apparatuses for Future All Electric Ship** Electric Ship Technologies Symposium, 2007. ESTS '07. IEEE, Publication Year: 2007, Page(s): 443 - 448	Power Hardware-in-the-Loop (PHIL) simulation is not plug-and-play. Stability and accuracy issues must be well investigated before concluding anything from the simulation result. This paper describes a simulation based pre-evaluation sequence which has been followed in performing a PHIL simulation for a notional electric ship study. In the pre-evaluation, it is found that the interface time delay causes large error in the ship bus power. A compensation method is then proposed and applied to the final PHIL simulation to improve the accuracy.	**Силовое программно-аппаратное моделирование систем управления и силовых установок при проектировании и разработке опытных образцов аппаратуры для будущих полностью электрифицированных кораблей**
150.	**Investigating the Impact of Pulsed Power Charging Demands on Shipboard Power Quality** Proc. Of 2007 IEEE Electric Ship Technologies Symposium, May 22-23, Arlington, USA	The impact of pulsed power loads on shipboard power systems need to be properly determined to prevent pulsed loads from causing unacceptable power quality deviations, interference with other loads and degradation of overall system performance. This paper uses a high fidelity modeling and simulation approach to investigate the impact of real and reactive power, pulse ramp rate, pulse duration and frequency of occurrence of the pulsed power load. For this purpose, a notional shipboard power system, modeled in a real-time digital simulator, is used. Most pulsed loads on shipboard systems are not fed directly from the prime power system but via an energy storage system. This energy storage system in turn is interfaced with the shipboard prime power system typically through an electronic front-end charging circuit. In order to evaluate the impact of pulsed loads, existing power quality standards (related to voltage transients, harmonic distortions, and frequency variations) are applied.	**Исследование воздействий от импульсных ударных нагрузок на качество электроэнергии судовой энергосистемы**
151.	**Sequential Experimental Design Based Modeling of a Notional All-Electric Ship AC/DC Conversion System for Sensitivity and Uncertainty Analysis** Proc. Of 2007 IEEE Electric Ship Technologies Symposium, May 22-23, Arlington, USA.	The construction of surrogate models for a large-scale transient simulation of the AC/DC conversion system of a notional all-electric warship is described. A sequential experimental design approach is used to progressively glean information about the simulation model, while increasing the number of runs executed and the complexity of the surrogate model as needed. The surrogate models are utilized for sensitivity and uncertainty analysis of the simulation model.	**Поэтапное опытно-конструкторское моделирование AC/DC преобразователя условного электрохода для анализа неопределенностей и восприимчивости**
152.	**Crashback Simulations of a Notional Destroyer-Class All-Electric Ship** Presented at the ASNE Advanced Naval Propulsion Symposium 2006, Arlington, VA, October 30-31, 2006.	Crashback is one of the most dramatic maneuvers a naval combatant can perform. Propulsion power can go from full ahead to full astern in minutes and the rate of change of power itself changes dramatically during this period. The integrated power system of an all-electric ship can experience unfortunate electrical disturbances and even system-wide instability. This paper investigates the dynamics of crashback maneuvers on IPS performance. A detailed description of the crashback maneuver is given with emphasis on the problems posed for motor control during each phase of the maneuver. A discussion of the possibilities for drive controller optimization are then presented. A notional destroyer-class all-electric ship simulation capability developed on the Real Time Digital Simulator (RTDS) is described. Finally, simulation results for crashback simulations performed under varying conditions are given with the propulsion motor drives operating under speed control and then power control.	**Моделирование аварийного реверса на условном электроходе класса эсминец**

153.	**Demonstrating the Power Hardware-in-the-Loop through Simulations of a Notional Destroyer-Class All-Electric Ship System during Crashback** Presented at the ASNE Advanced Naval Propulsion Symposium 2006, Arlington, VA, October 30-31, 2006	In this paper, a notional destroyer-class all electric ship system, particularly its dynamic behavior during the crashback maneuver, is studied via real time Power Hardware-in-the- Loop (PHIL) experiments. By replacing one of the two propulsion systems of the ship with a downscaled hardware motor-dynamometer set, the PHIL simulations are performed at two different power levels (first at 16 kW and then at 2.5 MW). It is shown through the simulation results that although the two propulsion systems are implemented in substantially different ways (i.e., one in hardware and the other in simulation) their dynamic responses during the crashback match very well. This also demonstrates the feasibility and reliability of using the PHIL simulation as an effective tool for testing the prototypes of novel apparatuses under the most realistic scenarios.	**Демонстрация возможностей силового программно-аппаратного моделирования аварийного реверса на условном электроходе класса эсминец**
154.	**Augmenting E-Ship Power System Evaluation and Converter Controller Design by Means of Real-Time Hardware-in-Loop Simulation** Proc. Of 2005 IEEE Electric Ship Technologies Symposium, July 25-27, Philadelphia, USA, pp.171-175.	This paper evaluates the performance of an industrial power electronic building block (PEBB) controller in a large scale all electric ship power system by means of real-time hardware in the loop (RT-HIL) simulation. As an example relevant to future all electric navy ships, transients originating from the charging circuit of a puls power load integrated with the prolusion motor drive and its impact on the system are studied. Different solutions to mitigate the impact by coordinating the power sharing between the pulse load's energy storage system and the ship propulsion motor drive are proposed and evaluated. The second part of the paper discusses how the RT-HIL tool can be used for system-wide performance optimization. Experimental results show the effectiveness of this method in finding the optimal parameter setting for the voltage loop control. It is concluded that due to distinct advantages of the RT-HIL method over conventional (off-line) simulations for system response analysis as well as for performance optimization, RT-HIL shall be employed more rigorously for electric ship system designs in the future.	**Уточнение расчетов энергосистемы электрохода и проектирование системы управления преобразователем с использованием программно-аппаратного моделирования**
155.	**Hardware Implementation of a Ship-Wide Area Differential Protection Scheme** Presented at WMSCI 2005, Orlando USA, July 2005, Paper No. S762HI	The philosophy, design, implementation and evaluation of a ship wide area differential protection scheme is described in this paper	**Аппаратная реализация схемы судовой дифференциальной защиты**
156.	**Progress and Challenges in Real Time Hardware-in-the-Loop Simulations of Integrated Ship Power Systems** In Proc. IEEE Power Engineering Society General Meeting, 12-16 June 2005, pages 534-537, vol. 1.	Future all-electric Navy ships will feature closely coupled, complex integrated power systems for propulsion, ship services, navigation, and, especially, pulse loads, all with an extensive usage of power electronic converter systems. In order to simulate the dynamics of these systems as accurately as possible, the Center of Advanced Power System (CAPS) at Florida State University has established an extensive Real-Time Hardware-inthe- Loop (RT-HIL) simulation capability. In this paper, the CAPS platform is utilized for the first time to perform RT-HIL experiments with an industrial-grade power electronics controller that operates a simulated pulse power compensator on a notional all-electric ship system. The system configuration, both in software and hardware, are presented. The results illustrate the reduction of bus frequency deviations caused by pulse power loads due to the active power compensation. Challenges unique to the RT-HIL environment are discussed and remedies are suggested for future studies.	**Проблемы и достижения программно-аппаратного моделирования встроенных судовых энергосистем**
157.	**Large-Scale Simulation of Naval Power Systems for Design Optimization**	This paper introduces important new developments in digital real time simulation of electrical power systems and their complex components. Particular emphasis is placed on two recent developments, the voltage source converter (VSC) model and the phase domain frequency	**Широкомасштабное моделирование военно-морских энергосистем для оптимизации**

	Electric Machine Technology Symposium 2004, Philadelphia USA, January 2004	dependent transmission line model. Various issues such as background, algorithms, implementations, applications and validation have been described and included in the paper. The paper also provides insight into the specific challenges faced when real time digital simulation is considered. Approaches commonly used in non real time simulation programs are not always possible when real time operation is required. For this reason accurate and efficient alternative methods must often be developed, implemented and validated.	**конструкции**

СИЛОВОЕ ПРОГРАММНО-АППАРАТНОЕ МОДЕЛИРОВАНИЕ POWER-HARDWARE-IN-THE-LOOP (PHIL)

№	Название публикации и выходные данные	Аннотация	Название публикации на русском
158.	**Laboratory Experiences with Power-Hardware-in-the-Loop Simulation for Distributed Energy Resources** Presented at 3rd IEEE PES Innovative Smart Grid Technologies (ISGT) Conference. Berlin, Germany, October 17, 2012.	Презентация. Аннотация отсутствует.	**Лабораторные работы по силовому программно-аппаратному моделированию распределенных энергоресурсов**
159.	**Design, Development and Operation of a PHIL Environment for Distributed Energy Resources** IEEE IECON 2012, Montreal, Canada, October 2012	The challenges in achieving higher integration of Distributed Energy Resources (DER) in electricity grids require advances and novel approaches in simulation and testing. An approach that is increasingly gaining interest is Hardware-inthe- Loop (HIL) simulation and especially Power-Hardware-inthe- Loop (PHIL), where power equipment is connected to a simulated system. This paper firstly discusses interfacing issues of PHIL simulation providing a theoretical basis. A detailed description of the design and development phase of a PHIL environment for DER devices is provided. The development of the Power Interface, stability analysis and design of appropriate protection schemes are presented, aiming at assisting the development of other PHIL environments. As a first experiment, a voltage divider circuit is implemented in the PHIL approach. Subsequently, hardware PV panels and a PV inverter are connected at a simulated simple distribution grid and it is demonstrated that the voltage of the common-node follows the variation of the solar irradiation.	**Конструирование, разработка и эксплуатация в условиях PHIL для распределенных энергетических ресурсов**
160.	**Improve the Stability and the Accuracy of Power Hardware-in-the-Loop Simulation by Selecting Appropriate Interface Algorithms** Industry Applications, IEEE Transactions on, Volume: 44, Issue: 4, Publication Year: 2008,	The closed-loop stability and the simulation accuracy are two paramount issues in power Hardware-In-the-Loop simulation in regard to the operational safety and the experiment reliability. In this paper, the stability issue of the Power HIL simulation is first introduced with a simple example. A stability analysis and accuracy estimation method based on the system's loop transfer function is later given. Five different interface algorithms are described and their respective characteristics with respect to the system stability are compared. Through Matlab simulations and field experiments of two representative Power HIL examples, it is revealed that certain interface algorithms exhibit higher stability and accuracy than the oth-	**Повышения стабильности и точности силового программно-аппаратного моделирования при выборе подходящих граничных алгоритмов**

	Page(s): 1286 – 1294	ers under the given conditions. A recommendation for selecting appropriate interface algorithms is finally proposed at the end of the paper.	
161.	**Accuracy Evaluation in Power Hardware-in-the-Loop (PHIL) Simulation** In Proc. Of the 2007 Summer Computer Simulation Conference, July 15-18, 2007. San Diego, CA	The inherent non-idealities, especially the time delay, in the interface of a PHIL simulation may lead to large simulation errors or even instabilities. Therefore, it is extremely important to have an effective way to evaluate the simulation accuracy in order to justify the reliability of a PHIL experiment. A generalized metric defining the error functions from two types of PHIL interface perturbations is proposed in this paper. Two simulation examples are performed to show the validity of the proposed method.	**Оценка точности силового программно-аппаратного моделирования (PHIL)**
162.	**Hardware-in-the-Loop Investigation of Rotor Heating in a 5 MW HTS Propulsion Motor** IEEE Trans. on Applied Superconductivity, Volume 17, Issue 2, Part 2, June 2007, pp. 1595-1598	Of particular concern to designers of HTS machines are potential heating effects in the superconducting windings due to AC losses caused by load fluctuations encountered in real-life operating conditions. A 5 MW HTS synchronous prototype ship propulsion motor has been tested extensively under steady-state and dynamic load conditions in the Advanced Test Facility of the Center for Advanced Power Systems at Florida State University. This paper presents results from two tests of rotor heating effects, one employing single frequency torque oscillations and the other more realistic load modeling of sea-states by means of Hardware-in-the-Loop (HIL) real-time simulations. Temperature results from 4 different torque oscillation tests and 12 different sea-state tests provide rotor-heating information, obtained from multiple temperature sensor data within the HTS rotor, and are compared with data obtained from steady-state runs.	**Программно-аппаратное исследование нагрева ротора 5 МВт ходового двигателя на высокотемпературных сверхпроводниках (HTS)**
163.	**Applying Controller and Power Hardware-in-the-Loop Simulation in Designing and Prototyping Apparatuses for Future All Electric Ship** Electric Ship Technologies Symposium, 2007. ESTS '07. IEEE, Publication Year: 2007, Page(s): 443 – 448	Power Hardware-in-the-Loop (PHIL) simulation is not plug-and-play. Stability and accuracy issues must be well investigated before concluding anything from the simulation result. This paper describes a simulation based pre-evaluation sequence which has been followed in performing a PHIL simulation for a notional electric ship study. In the pre-evaluation, it is found that the interface time delay causes large error in the ship bus power. A compensation method is then proposed and applied to the final PHIL simulation to improve the accuracy.	**Силовое программно-аппаратное моделирование систем управления и силовых установок при проектировании и разработке опытных образцов аппаратуры для будущих полностью электрифицированных кораблей (электроходов)**
164.	**Demonstrating the Power Hardware-in-the-Loop through Simulations of a Notional Destroyer-Class All-Electric Ship System during Crashback** Presented at the ASNE Advanced Naval Propulsion Symposium 2006, Arlington, VA, October 30 - 31, 2006	In this paper, a notional destroyer-class all electric ship system, particularly its dynamic behavior during the crashback maneuver, is studied via real time Power Hardware-in-the- Loop (PHIL) experiments. By replacing one of the two propulsion systems of the ship with a downscaled hardware motor-dynamometer set, the PHIL simulations are performed at two different power levels (first at 16 kW and then at 2.5 MW). It is shown through the simulation results that although the two propulsion systems are implemented in substantially different ways (i.e., one in hardware and the other in simulation) their dynamic responses during the crashback match very well. This also demonstrates the feasibility and reliability of using the PHIL simulation as an effective tool for testing the prototypes of novel apparatuses under the most realistic scenarios.	**Демонстрация возможностей силового программно-аппаратного моделирования аварийного реверса на условном электроходе класса эсминец**
165.	**Development of a Unified Design, Test, and Research Platform for Wind Energy Systems Based on Hardware-in-the-Loop Real-Time**	Traditionally, offline modeling and simulation has been the tool of choice for improving wind energy system control strategies and their utility system integration. This paper exploits how a newly established real-time hardware-in-the-loop (HIL) test facility, which is designed for testing all-electric ship propulsion systems, can be utilized for wind energy research. The test	**Разработка унифицированной научно-исследовательской платформы для программно-аппаратного моделирования вет-**

	Simulation IEEE Transactions on Industrial Electronics, Volume 53, Issue 4, June 2006, pages 1144-1151.	site uses two 2.5-MW/220-rpm dynamometers and a 5-MW variable voltage and frequency converter to emulate a realistic dynamic environment, both mechanically and electrically. The facility is controlled by a digital real-time electric power system simulator that is capable of simulating electrical networks and control systems of substantial complexity, typically with a 50-µs time step. Substantial input/output allows the feedback of measured quantities into the simulation. A 15-kW mock-upmotor–generator set is used to demonstrate some critical aspects of the concept including the implementation of a proposed neural-network-based sensorless maximum wind energy capture control. From the dynamic test results presented, it is concluded that the proposed system shows great potential for the development of a unified wind energy design, test, and research platform.	**роэнергетических систем в реальном времени**
166.	**Augmenting E-Ship Power System Evaluation and Converter Controller Design by Means of Real-Time Hardware-in-Loop Simulation** Proc. Of 2005 IEEE Electric Ship Technologies Symposium, July 25-27, Philadelphia, USA, pp.171-175.	This paper evaluates the performance of an industrial power electronic building block (PEBB) controller in a large scale all electric ship power system by means of real-time hardware in the loop (RT-HIL) simulation. As an example relevant to future all electric navy ships, transients originating from the charging circuit of a puls power load integrated with the prolusion motor drive and its impact on the system are studied. Different solutions to mitigate the impact by coordinating the power sharing between the pulse load's energy storage system and the ship propulsion motor drive are proposed and evaluated. The second part of the paper discusses how the RT-HIL tool can be used for system-wide performance optimization. Experimental results show the effectiveness of this method in finding the optimal parameter setting for the voltage loop control. It is concluded that due to distinct advantages of the RT-HIL method over conventional (off-line) simulations for system response analysis as well as for performance optimization, RT-HIL shall be employed more rigorously for electric ship system designs in the future.	**Уточнение расчетов энергосистемы электрохода и проектирование системы управления преобразователем с использованием программно-аппаратного моделирования**
167.	**Testing a 5 MW High-Temperature Superconducting Propulsion Motor** Proc. Of 2005 IEEE Electric Ship Technologies Symposium, July 25-27, Philadelphia, USA, pp. 171-175.	A prototype marine propulsion motor manufactured by American Superconductor Corporation has been tested in the Advanced Test Facility at the Center for Advanced Power Systems at Florida State University. The rotor of this 5 MW synchronous machine is constructed of hightemperature superconducting wire; the three-phase stator is of conventional wire. Testing was conducted with a dynamometer consisting of two 2.5 MW induction motors which permitted a wide range of conventional and novel procedures to be carried out for the characterization of the HTS motor. These tests and some of their results are discussed. The HTS motor functioned satisfactorily in all tests.	**Испытание 5 МВт ходового электродвигателя на высокотемпературных сверхпроводниках**
168.	**Progress and Challenges in Real Time Hardware-in-the-Loop Simulations of Integrated Ship Power Systems** In Proc. IEEE Power Engineering Society General Meeting, 12-16 June 2005, pages 534-537, vol. 1.	Future all-electric Navy ships will feature closely coupled, complex integrated power systems for propulsion, ship services, navigation, and, especially, pulse loads, all with an extensive usage of power electronic converter systems. In order to simulate the dynamics of these systems as accurately as possible, the Center of Advanced Power System (CAPS) at Florida State University has established an extensive Real-Time Hardware-inthe- Loop (RT-HIL) simulation capability. In this paper, the CAPS platform is utilized for the first time to perform RT-HIL experiments with an industrial-grade power electronics controller that operates a simulated pulse power compensator on a notional all-electric ship system. The system configuration, both in software and hardware, are presented. The results illustrate the reduction of bus frequency deviations caused by pulse power loads due to the active power compensation. Challenges unique to the RT-HIL environment are discussed and remedies are suggested for future studies.	**Проблемы и достижения программно-аппаратного моделирования встроенных судовых энергосистем**

169.	**Real Time Digital Simulations Augmenting the Development of Functional Reconfiguration of PEBB and Universal Controller** Presented at the 24th American Control Conference (ACC) in Portland, OR, USA, June 8-10, 2005.	In this paper, real-time hardware-in-the-loop (HIL) simulation is adopted to augment the development of functional reconfiguration of power electronic building blocks and universal controllers. The simulation environment employs a commercial real-time digital simulator allowing real time simulations of large power systems. Two case studies regarding functional reconfiguration are discussed. The first case is a marine all-electric-ship application to improve system power quality. A novel control algorithm is proposed for an active filter, which is derived from reconfiguring variable speed motor drive. The second case outlines how the HIL simulator is utilized to a static synchronous compensator application where a commercial controller provides firing pulses to a simulated converter and the connected power system. Details of the control scheme, the HIL setup, and test results are given.	**Наращивание моделирования в реальном времени при разработке компоновки блоков силовой электроники (PEBB) и универсального контроллера**
170.	**Experimental Determination of Dynamic Parameters for a Superconducting Machine** IEEE Transaction on Applied Superconductivity, Vol. 15, No. 2, June 2005. Pages: 2154 – 2157.	Superconducting electrical machines are increasingly of interest for diverse applications such as generators, synchronous condensers and motors. These machines' dynamic behavior differs from that of conventional machines in significant ways due to certain time constants and reactances being very different. These differences can present difficulties when conventional testing procedures are applied. A 5 MW superconducting rotor machine designed and built by American Superconductor Corporation is currently being tested in the Advanced Test Facility of the Center for Advanced Power Systems at Florida State University. A variety of test procedures are being applied to determine the machine's dynamic performance and the effectiveness of these tests when applied to a superconducting machine is being assessed. In this paper, two means of analysing test data and extracting machine parameters are described.	**Экспериментальное определение динамических параметров электрических машины на сверхпроводниках**
171.	**A Novel Approach to Power Quality Assessment: Real Time Hardware-in-the-Loop Test Bed** IEEE Trans. PD, Volume 20, Issue 2, Part 1, April 2005, pp. 1200-1201.	A novel approach to power quality assessment based on real-time (RT) hardware-in-the-loop (HIL) simulation is proposed. The RT-HIL platform is being used for power quality studies of NAVY all-electric ships. The sensitivity for power quality deviations of a variable speed drive controller card was tested in the platform. The successful experiment has contributed to the conceptual design of a universal power quality test bed, which would have the function of testing the immunity of electric components and equipment and the consequent impact on ac distribution systems.	**Новый подход к оценке качества электроэнергии: испытательная лаборатория программно-аппаратного моделирования**
172.	**Development of a Unified Design Test and Research Platform for Wind Energy Systems Based on Hardware-in-the-Loop Real-Time Simulation** IEEE 35th Annual Power Electronics Specialists Conference, 2004. PESC 04	Traditionally, offline modeling and simulation has been the tool of choice for improving wind energy system control strategies and their utility system integration. This paper exploits how a newly established real-time hardware-in-the-loop (HIL) test facility, which is designed for testing all-electric ship propulsion systems, can be utilized for wind energy research. The test site uses two 2.5-MW/220-rpm dynamometers and a 5-MW variable voltage and frequency converter to emulate a realistic dynamic environment, both mechanically and electrically. The facility is controlled by a digital real-time electric power system simulator that is capable of simulating electrical networks and control systems of substantial complexity, typically with a 50-μs time step. Substantial input/output allows the feedback of measured quantities into the simulation. A 15-kW mock-upmotor–generator set is used to demonstrate some critical aspects of the concept including the implementation of a proposed neural-network-based sensorless maximum wind energy capture control. From the dynamic test results presented, it is concluded that the proposed system shows great potential for the development of a unified wind energy design, test, and research platform.	**Разработка унифицированной научно-исследовательской платформы для программно-аппаратного моделирования ветроэнергетических систем в реальном времени**