Aspects of moisture ingress in polymer housed surge arresters

Polymers have been extensively applied in the industry, especially in energy system e.g. due to their good processability and insulation properties. However, all polymers are permeable in different extent, which requires a good knowledge about the process of permeation through these materials. In this study the moisture dynamics of four different surge arresters were studied in several ways,—at first by analysing the moisture diffusion properties of the housing polymers and finally by testing the full arrester structures against moisture ingress. Housing polymer composites were evaluated using thermogravimetric analysis and differential scanning calorimetry while the polymers’ ability to withstand moisture diffusion was studied by water vapor transmission rate measurements. Moisture ingress behavior of the full surge arresters was examined by daily measurements of internal resistive leakage current along 30 days immersion test. Although correlations were found between the material composition and the diffusivity through the polymer, the moisture dynamic is deemed to be much more complex in the full surge arrester. Moisture permeation through separate housing material samples was typically high compared to internal leakage current formed in real arresters which highlights the main conclusion drawn,—internal structures and long term quality of interfaces are the key issues in preventing moisture induced degradation in metal oxide surge arresters.
Utilization Possibilities of Electrical Energy Storages in Households' Energy Management in Finland

Electrical energy storage is one option for making the environmental impact of households' energy usage smaller. A storage could improve the profitability of household level electricity production and could also decrease the load in the electricity networks. So far, poor profitability has been the greatest barrier to the use of storages. The battery systems prices have been high and the benefits difficult to predict. The benefit of the use of storage and the factors affecting to the benefits are studied in this paper. For this purpose, a simulator has been designed for modelling the energy storage as part of the household’s electricity grid. The control of the storage significantly affects to the amount of benefits. The developed control method of the simulator aims to maximize the benefits. The simulations took into account the variables that are not accurately known when the storage is controlled. For these variables, such as e.g. future consumption, various forecasts were formed.

A comparative study between surge arrester monitoring through capacitive/resistive measurement bridge and digital decomposition

In order to improve the reliability of the energy system, a variety of techniques to access the condition monitoring of important equipment connected to the network have been developed in the past decades. However, it is important to choose the adequate method when evaluating the behavior of these devices. In this way, the current work aims to compare three techniques used to evaluate the condition of metal oxide surge arrester based on the decomposition of leakage current into its capacitive and resistive components. Each method was described in detail and their results compared.
Implementing of Activating Learning Strategy for a Course on Electric Drives

Effective teaching of electric drives is highly important for the electrical engineers, because almost half of the global produced electrical energy is consumed by electric motor drives. Electric drives are a key technology for reducing energy consumption of industrial processes, for wind power generation and for electric transportation. The pedagogical premise is to improve the educational methods of an Electrical Drives course by activating students to work on their own. The paper describes the educational strategy and course objectives. Student feedback was collected at the end of the course and the results of the evaluation are summarized.

Modeling of Hysteresis Losses in Ferromagnetic Laminations under Mechanical Stress

A novel approach for predicting magnetic hysteresis loops and losses in ferromagnetic laminations under mechanical stress is presented. The model is based on combining a Helmholtz free energy-based anhysteretic magnetoelastic constitutive law to a vector Jiles-Atherton hysteresis model. This paper focuses only on unidirectional and parallel magnetic fields and stresses, albeit the model is developed in full 3-D configuration in order to account also for strains perpendicular to the loading direction. The model parameters are fitted to magnetization curve measurements under compressive and tensile stresses. Both the hysteresis loops and losses are modeled accurately for stresses ranging from -50 to 80 MPa.
Coil Winding Losses: Decomposition Strategy

Precise modeling of the magnetic field in the coil wire of an electric machine often becomes a major challenge: with the high number of turns and small penetration depth, the number of degrees of freedom exceeds reasonable limits in any standard approximation method. Precise approximation, however, is critical, e.g., to reliable coil loss estimation. Hence, there is a call for specialized approximative methods. This paper presents a method for time-harmonic coil wire field computations in 2-D problems. We replace the coil by a lattice of polygonal plane fillers and span a low-dimensional function space on the polygon boundaries. The reliability of loss estimates requires accurate computations of the responses to the interface excitations of this space. The responses constitute a Dirichlet-to-Neumann map to efficiently couple plane fillers together and to a standard finite-element method (FEM) outside the coil regions. The outcome is significantly faster than the standard FEM alone. The results are still in good agreement.

General information
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Authors: Lehti, L., Keränen, J., Suuriniemi, S., Kettunen, L.
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Web of Science (2015): 1.277 1.328 8.5 0.139 0.02867 0.358
Publication Forum (2015): 1
Scopus rating (2014): 0.715 1.491
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Publication Forum (2014): 1
Scopus rating (2013): 0.608 1.424
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Scopus rating (2012): 0.788 1.574
Publication Forum (2012): 1
Scopus rating (2011): 0.829 1.445
Scopus rating (2010): 0.698 1.134
Scopus rating (2009): 0.644 1.098
Scopus rating (2008): 0.788 1.165
Scopus rating (2007): 0.71 1.152
Scopus rating (2006): 0.913 1.232
Scopus rating (2005): 1.024 1.258
Scopus rating (2004): 0.813 1.129
Scopus rating (2003): 1.056 1.094
Scopus rating (2002): 1.078 1.027
Scopus rating (2001): 0.707 1.007
Scopus rating (2000): 0.831 1.022
Scopus rating (1999): 0.918 1.249
Original language: English
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Coupled Magneto-Mechanical Analysis of Iron Sheets Under Biaxial Stress
A novel single sheet tester design is proposed and a directly coupled magneto-mechanical model is used to numerically analyze the behavior of iron sheets under biaxial magneto-mechanical loading applied by the tester device. Magneto-mechanically coupled constitutive equations of the material derived using an energy based approach are integrated into a finite element model of the single sheet tester device and simulations are performed to solve for the displacement field and the magnetic vector potential in the sample. The obtained numerical results of magnetostriction evolution due to uniaxial stress and stress induced anisotropies due to permeability variation under different magneto-mechanical loadings are presented. The simulation results are compared to the results published in the literature for the purpose of validation.
Model of Magnetic Anisotropy of Non-Oriented Steel Sheets for Finite Element Method

Even non-oriented steel sheets present a magnetic anisotropic behavior. From rotational flux density measurements at 5 Hz, the model of magnetic anisotropy is derived from two surface Basis-cubic splines with the boundary conditions matching with ferromagnetic theory. Furthermore, the investigation of the magnetic anisotropy shows that the H(B) characteristic is not strictly monotonous due to the angle difference between the field and the flux density. Hence, standard non-linear solvers would either diverge or converge towards the closest local minimum. Thus, we propose two different specific solvers: a combined Particle Swarm Optimization with a relaxed Newton-Raphson and a Modified Newton Method.

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Organisations: Department of Electrical Engineering, Aalto University
Authors: Martin, F., Singh, D., Rasilo, P., Belahcen, A., Arkkio, A.
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Publication Forum (2015): 1
Scopus rating (2014): 0.715 1.491
Web of Science (2014): 1.386 1.395 8.4 0.169 0.03242 0.403
Publication Forum (2014): 1
Scopus rating (2013): 0.608 1.424
Publication Forum (2013): 1
Scopus rating (2012): 0.788 1.574
Publication Forum (2012): 1
Scopus rating (2011): 0.829 1.445
Scopus rating (2010): 0.698 1.134
Scopus rating (2009): 0.644 1.098
Scopus rating (2008): 0.788 1.165
Scopus rating (2007): 0.71 1.152
Scopus rating (2006): 0.913 1.232
Scopus rating (2005): 1.024 1.258
Scopus rating (2004): 0.813 1.129
Scopus rating (2003): 1.056 1.094
Scopus rating (2002): 1.078 1.027
Scopus rating (2001): 0.707 1.007
Scopus rating (2000): 0.831 1.022
Scopus rating (1999): 0.918 1.249
Original language: English
Electronic versions:
Numerical Analysis of the Power Balance of an Electrical Machine with Rotor Eccentricity

The power balance in the numerical simulation of a cage induction machine with eccentric rotor has been studied. The asymmetrical air gap flux density distribution caused by the non-uniform air gap due to eccentricity produces forces that play an important role in the rotordynamic stability. These forces act both in the radial and the tangential directions. The tangential force together with the whirling motion produces additional power in the shaft. If the power balance of the simulation satisfies, the power due to the whirling can be calculated from the power balance. This could also give a new approach to compute the forces due to eccentricity or verify the existing force computation methods. The error in the power balance of an eccentric machine has been calculated and the sources of the errors have been illustrated and discussed.

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Organisations: Department of Electrical Engineering, Aalto University
Authors: Silwal, B., Rasilo, P., Perkkiö, L., Hannukainen, A., Eirola, T., Arkkio, A.
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Publication Forum (2015): 1
Scopus rating (2014): 0.715 1.491
Web of Science (2014): 1.386 1.395 8.4 0.169 0.03242 0.403
Publication Forum (2014): 1
Scopus rating (2013): 0.608 1.424
Publication Forum (2013): 1
Scopus rating (2012): 0.788 1.574
Publication Forum (2012): 1
Scopus rating (2011): 0.829 1.445
Scopus rating (2010): 0.698 1.134
Scopus rating (2009): 0.644 1.098
Scopus rating (2008): 0.788 1.165
Scopus rating (2007): 0.71 1.152
Scopus rating (2006): 0.913 1.232
Scopus rating (2005): 1.024 1.258
Scopus rating (2004): 0.813 1.129
Scopus rating (2003): 1.056 1.094
Scopus rating (2002): 1.078 1.027
Scopus rating (2001): 0.707 1.007
Scopus rating (2000): 0.831 1.022
Performance of a Polymer-Based Sensor Package at Extreme Temperature

There is an increasing need for inexpensive packaging structures for demanding industrial electronics applications. This paper studies the usability of a polymer-based sensor package at very high temperatures. Resistance-based temperature sensors were attached with polymer-based electrically conductive adhesives (ECAs) onto flexible polyimide (PI) printed circuit boards (PCB). The materials used in the structure were not specifically designed for high temperature use. However, they were all commercial materials, easily available and typically reliable under normal use conditions of consumer electronics. The samples were aged at 240°C and electrically monitored during the test. Electrically, the sensor samples were observed to fail after 100 h of aging. However, material characterisation revealed that the materials started to degrade much earlier. The adhesive layer in the PI PCB and the ECA materials started to degrade after just 30 h of aging at 240°C, and mechanically the materials were observed to become brittle, making them prone to cracking and delamination. The results showed that such a polymer package is usable at 240°C for relatively short exposure times, but under longer exposure times the mechanical reliability of the package deteriorates and this needs to be taken into account.
Scopus rating (2006): 1.041 1.241
Scopus rating (2005): 1.12 1.236
Scopus rating (2004): 1.093 1.232
Scopus rating (2003): 1.174 1.161
Scopus rating (2001): 1.253 1.183
Scopus rating (2000): 1.316 0.971
Scopus rating (1999): 1.422 0.968
Original language: English
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ORG=dee,0.8
ORG=mol,0.2
Research output: Scientific - peer-review › Article

Pohjoismaiden energiapoliittika 2030: Hiilineutraalimpaan energiajärjestelmään osin yhdessä, osin eri polkuja pitkin

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Organisations: Department of Civil Engineering, Department of Electrical Engineering, Department of Chemistry and Bioengineering, Department of Physics, Research group: Construction Processes, University of Tampere, VTT
Keywords: (Energy policy, Energy system, Carbon footprint)
Number of pages: 23
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Electrically Conductive Adhesives for Demanding Temperature Cycling Environment with Water Immersions
Electrically conductive adhesives are versatile attachment materials offering benefits for many applications in industrial electronics. However, the stability of these materials is typically less than that of metals and ceramics, thus their suitability for demanding environments must be carefully studied. In this paper the performance of anisotropically conductive adhesive (ACA) attachments was studied in a demanding environment combining both high temperature cycling and water immersions. Real-time measurements were conducted during testing. Significant differences between the ACA materials were seen. Promising results were obtained with some of the ACA materials studied, emphasising the importance of material choice. Cracking in the ACA interconnections could be seen in some of the samples studied for failure analysis. However, it remained unclear whether the cracks were the reason for the failures during testing.

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Authors: Lahokallio, S., Kilunen, J., Frisk, L.
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Thermal Cycling Reliability Analysis of an Anisotropic Conductive Adhesive Attached Large-Area Chip with Area Array Configuration

The reliability of adhesive flip chip attachments was studied. A large-area chip with a great number of contacts was attached onto a flexible polyimide substrate using anisotropic conductive adhesive film (ACF). The test samples were manufactured using various bonding forces and the reliability of the assemblies was examined using a thermal cycling test. Two temperature change rates were used in the cycling test to study the effect of the change rate on the observed failure times and modes. The results show that the ACF flip chip attachment of large-area chips with matrix array interconnections is an applicable technique. Furthermore, a significant increase in the reliability of the assemblies was obtained by increasing the bonding force. However, early failures were observed in all the samples, especially in the outermost adhesive interconnections. Failure analysis performed on the samples exhibiting early failures showed signs of adhesive delamination and silicon chip cracking. No clear differences in the results between the two temperature cycling tests used were observed. However, the faster temperature change rate seemed to cause a higher number of early failures.

Temperature Cycling of Low Voltage Motor Drives

Motor drives are used in a wide range of industrial applications, many of which impose high reliability demands on the electronics used in them. Moreover, the environmental conditions in industrial applications may vary a lot and therefore reliability studies for the motor drives are essential. In this study the reliability of a low voltage motor drive was studied with two different temperature cycling profiles. The results of the study showed that temperature cycling triggered some reversible device faults during testing, but catastrophic IGBT failures, common for power electronics, were less seen. More detailed analysis suggests that the reason for the device faults may have been cracks in the solder joints of the pinheader connector between two PCBs of the device, or fretting corrosion on the connector contact materials.

Decomposition of Electric Motor Torque According to Electromagnetic Field Sources

This paper proposes a systematic approach to isolate and quantify electromagnetic forces and torques between any two distinct parts of an electric motor. The approach is based on a decomposition of the magnetic field into components that are generated by different magnetized or current-carrying motor parts. Forces and torques exerted by the field components can be computed using the conventional force and torque formulas. The proposed decomposition is applied to a squirrel-cage induction motor and to a permanent magnet synchronous motor. In these examples, the magnetic fields
are decomposed according to current-carrying conductors, magnetized iron, and permanent magnets. Thereafter, the torques exerted by these fields are specified. The results predict which part-pairs of the motor produce the desired and undesired behavior, for example, torque and torque ripple, respectively.

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Web of Science (2015): 2.596 3.46 8.4 0.192 0.01076 1.215
Publication Forum (2015): 2
Scopus rating (2014): 1.633 2.876
Web of Science (2014): 2.326 3.392 8.1 0.24 0.01055 1.126
Publication Forum (2014): 3
Scopus rating (2013): 2.077 3.285
Publication Forum (2013): 3
Scopus rating (2012): 1.719 3.218
Publication Forum (2012): 3
Scopus rating (2011): 1.709 3.075
Scopus rating (2010): 2.152 3.056
Scopus rating (2009): 2.157 2.916
Scopus rating (2008): 2.43 2.919
Scopus rating (2007): 1.459 2.793
Scopus rating (2006): 1.284 2.529
Scopus rating (2005): 1.405 2.194
Scopus rating (2004): 1.478 2.263
Scopus rating (2003): 1.395 1.954
Scopus rating (2002): 1.517 1.31
Scopus rating (2001): 0.78 1.097
Scopus rating (2000): 0.391 0.809
Scopus rating (1999): 0.36 2.576
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DOIs: 10.1109/TEC.2015.2490801
Links: http://youtu.be/NLxNuauUPeI (Animation of forces exerted on a permanent magnet by stator magnetization and phase currents, respectively.)
Research output: Scientific - peer-review › Article

Towards washable electro-textile UHF RFID tags: reliability study of epoxy-coated copper fabric antennas

**General information**
State: Published
Aspects of Electric Vehicles and Demand Response in Electricity Grids

The growing global energy demand combined with limited resources of fossil energy (especially crude oil), climate change and other environmental issues, the energy system has faced significant challenges. There is significant pressure to diversify the energy sources towards more sustainable choices and to increase energy efficiency. Shifting gradually from the use of fossil fuels to use of renewable energy sources is a long way to go, and to make it economically feasible requires a significant amount of will, effort and innovation.

This thesis deals with two parts of the energy system: the electrical energy system and the energy system of road transportation. A “smart” electrical energy system of the future includes the flexibility of electricity demand, i.e. demand response (DR), enabled by different types of incentives and offering many potential advantages. A road transportation system of the future can include significant amount of electric vehicles (full electric vehicles – full EVs and plug-in hybrid electric vehicles – PHEVs) as part of the vehicle fleet. These vehicles could also participate in the operation of an electrical power system. This thesis discusses electric vehicles and demand response in smart grid context.

The most important results and findings of the thesis are the following. In Finland, PHEVs could offer a significant proportion or even most of the benefits of EVs even with a quite modest charging infrastructure, and simultaneously the most severe obstacles of full EVs could be avoided or at least mitigated. In this thesis, a flexible methodology for modeling PHEV charging load using National Travel Survey data has been developed. Statistical PHEV charging load models, taking into account modeled statistical distributions of the loads, have been used by two different real DNOs in their network information systems to assess the impacts of EVs on distribution network planning in urban networks. It seems that high amounts of EVs fit well into Finnish distribution networks, but in certain cases demand response of electric vehicles would be reasonable. Electric vehicles, some DR actions and other changes in electricity use can increase peak powers in distribution networks. New distribution tariffs have been developed and simulated in a real distribution network with the purpose of encouraging small electricity customers towards peak load restriction. It seems that these kinds of tariffs would be efficient in restricting the increase of peak powers of spot price based DR, although it seems to be hard to decrease the present peak powers very much in the distribution networks. Different general DR and smart charging concepts have been sketched, and a practical local customer-site peak load control management algorithm of an EV charging station group has been developed as a tool to realize demand response of a group of electric vehicles.
Preparation of Supercapacitors on Flexible Substrates with Electrodeposited PEDOT/Graphene Composites

Composite films consisting of poly(3,4-ethylenedioxythiophene) (PEDOT) and graphene oxide (GO) were electrochemically polymerized by electrooxidation of EDOT in ionic liquid (BMIMBF₄) onto flexible electrode substrates. Two polymerization approaches were compared, and the cyclic voltammetry (CV) method was found to be superior to potentiostatic polymerization for the growth of PEDOT/GO films. After deposition, incorporated GO was reduced to rGO by a rapid electrochemical method of repetitive cathodic potential cycling, without using any reducing reagents. The films were characterized in 3-electrode configuration in BMIMBF₄. Symmetric supercapacitors with aqueous electrolyte were assembled from the composite films and characterized through cyclic voltammetry and galvanostatic discharge tests. It was shown that PEDOT/rGO composites have better capacitive properties than pure PEDOT or the unreduced composite film. The cycling stability of the supercapacitors was also tested, and the results indicate that the specific capacitance still retains well over 90% of the initial value after 2000 consecutive charging/discharging cycles. The supercapacitors were demonstrated as energy storages in a room light energy harvester with a printed organic solar cell and printed electrochromic display. The results are promising for the development of energy-autonomous, low-power, and disposable electronics.
Methodology for Dynamic Stability and Robustness Analysis of Commercial-Power-Module-Based DC-Distributed Systems

The purpose of this thesis is to present dynamic small-signal stability and performance analysis methodology for dc-distributed systems consisting of commercial power modules. Furthermore, the objective is to introduce a simple method to state the least conservative margins for robust stability as a single number. In addition, an index characterizing the overall system stability is obtained, based on which different dc-distributed systems can be compared in terms of robustness.

The interconnected systems are prone to impedance-based interactions which might lead to transient-performance degradation or even instability. These systems typically are constructed using commercial converters with unknown internal structure. Therefore, the analysis presented throughout this thesis is based on frequency responses measurable from the input and output terminals. The stability margins are stated utilizing a concept of maximum peak criteria, derived from the behavior of impedance-based sensitivity function that provides a single number to state robust stability. Using this concept, the stability information at every system interface is combined to a meaningful number to state the average robustness of the system. In addition, theoretical formulas are extracted to assess source and load side interactions in order to describe detailed couplings within the system. The presented theoretical analysis methodologies are experimentally validated throughout the thesis.

In this thesis, according to the presented analysis, the least conservative stability margins are provided as a single number guaranteeing robustness. It is also shown that within the interconnected system the robust stability is ensured only if the impedance-based minor-loop gain is determined at the very input or output of each subsystem. Moreover, a complete set of impedance-type internal parameters as well as the formulas according to which the interaction sensitivity can be fully explained and analyzed, is provided. The given formulation can be utilized equally either based on measured frequency responses, time-domain identified internal parameters or extracted analytic transfer functions.

Based on the analysis methodologies presented in this thesis, the stability and performance of interconnected systems consisting of converters with unknown internal structure, can be predicted. Moreover, the provided concept to assess the least conservative stability margins enables to obtain an index to state the overall robust stability of distributed power architecture and thus to compare different systems in terms of stability.

General information
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Towards deeper comprehension in higher engineering education: rethinking "in theory yes, but not in practice"

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Organisations: Department of Electrical Engineering, Research area: Electromagnetics, Department of Electrical Engineering, Tampere University of Applied Sciences, Tampere, Finland
Authors: Korpela, A., Tarhasaari, T., Kettunen, L., Mikkonen, R., Kinnari-Korpela, H.
Number of pages: 12
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Publication Forum (2015): 1
Original language: English
Links:
http://scimath.net/articles/34/348.pdf
Research output: Scientific - peer-review › Article

Decomposition analysis of Cuban energy production and use: Analysis of energy transformation for sustainability
The aim of the article to analyse the changes in Cuban energy system. It uses decomposition analysis to reveal the impacts of the changes in key drivers of energy consumption and CO2 emissions. The Cuban Energy Revolution, which was started in 2006, was the policy response to the local energy crisis; oil imports caused serious balance of payment problems, the old centralised electricity production system was inefficient and hurricanes caused wide damage to the transmission and distribution system resulting large black outs. The Energy Revolution has been quite successful in changing the energy use patterns in Cuban households. Switch from kerosene to electricity in cooking and using energy saving pressure cookers have had an effect on energy efficiency. In addition, the decentralisation of electricity production has increased the reliability of supply and improved the efficiency when new smaller scale power plants have replaced
older technology. The energy revolution has, so far not had much impact on energy use in industry, transport and agriculture, which are the areas where the future policies should be directed.

**General information**

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Organisations: Department of Automation Science and Engineering, Research area: Measurement Technology and Process Control
Authors: Vazquez, L., Luukkanen, J., Kaisti, H., Käkönen, M., Majanne, Y.
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Peer-reviewed: Yes

**Publication information**

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- Scopus rating (2016): 3.051 3.454
- Publication Forum (2016): 1
- Scopus rating (2015): 2.999 3.387
- Web of Science (2015): 6.798 7.896 3.8 1.421 0.07471 1.715
- Publication Forum (2015): 1
- Web of Science (2014): 5.901 7.445 3.7 1.176 0.05856 1.606
- Publication Forum (2014): 2
- Scopus rating (2013): 3.072 3.889
- Publication Forum (2013): 2
- Scopus rating (2012): 2.814 3.915
- Publication Forum (2012): 2
- Scopus rating (2011): 2.787 3.901
- Scopus rating (2010): 2.374 3.112
- Scopus rating (2009): 2.494 3.6
- Scopus rating (2006): 0.889 1.758
- Scopus rating (2005): 0.956 2.649
- Scopus rating (2004): 1.152 2.268
- Scopus rating (2003): 0.813 2.492
- Scopus rating (2002): 0.72 2.152
- Scopus rating (2001): 0.201 1.035
- Scopus rating (2000): 0.267 1.112
- Scopus rating (1999): 0.219 1.351
Original language: English
DOIs: 10.1016/j.rser.2015.04.156
Source: RIS
Source-ID: urn:A652723212A5CDBB8B16C0AB41DE5F232
Research output: Scientific - peer-review › Article

**Optimization of Quench Protection Heater Performance in High-Field Accelerator Magnets through Computational and Experimental Analysis**

Superconducting accelerator magnets with increasingly high magnetic fields are being designed to improve the performance of the Large Hadron Collider (LHC) at CERN. One of the technical challenges is the magnet quench protection, i.e., preventing damage in the case of an unexpected loss of superconductivity and the heat generation related
to that. Traditionally this is done by disconnecting the magnet current supply and using so-called protection heaters. The
heaters suppress the superconducting state across a large fraction of the winding thus leading to a uniform dissipation of
the stored energy. Preliminary studies suggested that the high-field Nb3Sn magnets under development for the LHC
luminosity upgrade (HiLumi) could not be reliably protected using the existing heaters. In this thesis work I analyzed in
detail the present state-of-the-art protection heater technology, aiming to optimize its performance and evaluate the
prospects in high-field magnet protection. The heater efficiency analyses focused on the time delays from heater activation
to normal zone initiation in the coils. I developed a numerical simulation tool CoHDA (Code for Heater Delay Analysis) to
model the heat transfer from the heater to the cables and estimate the delay based on the superconductor critical surface.
All the important parameters relative to the heater, the cable, and the magnet operation conditions were included. The
simulation results were validated experimentally using measured data from several R&D Nb3Sn quadrupoles and dipoles.
Then, a method based on parametric sweeps was utilized to optimize the heater layouts. The goal was to minimize the
delay to quench the entire coil, taking into account the different field regions. New heater designs were proposed for the
Nb3Sn R&D prototype LHQ and the HiLumi quadrupole QXF. Finally, I simulated the heaters in high temperature
superconductor magnets, which are being considered for the LHC energy upgrade. Consequently, I proposed technology
improvements to increase the heater energy in order to meet the requirements also in these very high-field magnets.

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Organisations: Department of Electrical Engineering, Research area: Electromagnetics
Authors: Salmi, T.
Number of pages: 146
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Determination of asymmetry of currents and voltages in high voltage power transmission with a long transmission line

General information
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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical and Communications Engineering, Research group: Environmental Health,
Department of Electrical Energy National Technical University, Kharkiv Polytechnic Institute, LLC Soyuzenergoproekt,
Kharkiv
Authors: Okun, O., Ivanov, Y., Korpinen, L.
Number of pages: 5
Publication date: 23 Aug 2015

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Article number: 229
ASJC Scopus subject areas: Electrical and Electronic Engineering
Links:
Analysis of uncertainties in protection heater delay time measurements and simulations in Nb3Sn high-field accelerator magnets

The quench protection of superconducting high-field accelerator magnets is presently based on protection heaters, which are activated upon quench detection to accelerate the quench propagation within the winding. Estimations of the heater delay to initiate a normal zone in the coil are essential for the protection design. During the development of Nb<sub>3</sub>Sn magnets for the LHC luminosity upgrade, protection heater delays have been measured in several experiments, and a new computational tool CoHDA (Code for Heater Delay Analysis) has been developed for heater design. Several computational quench analyses suggest that the efficiency of the present heater technology is on the borderline of protecting the magnets. Quantifying the inevitable uncertainties related to the measured and simulated delays is therefore of pivotal importance. In this paper, we analyze the uncertainties in the heater delay measurements and simulations using data from five impregnated high-field Nb<sub>3</sub>Sn magnets with different heater geometries. The results suggest that a minimum variation of 3 ms or 20% should be accounted in the heater design for coil outer surfaces and at least 10 ms or 40% in the inner surfaces due to more uncertain heater contact. We also propose a simulation criterion that gives an upper bound enclosing 90% of the measured delays for heaters on the coil outer surface.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Research area: Electromagnetics, CERN, Conseil Europeen pour la Recherche Nucleaire, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory
Authors: Salmi, T., Chlachidze, G., Marchevsky, M., Bajas, H., Felice, H., Stenvall, A.
Keywords: (Nb<sub>3</sub>Sn accelerator magnets, Protection heaters, Quench protection, Thermal modelling)
Publication date: 1 Aug 2015
Peer-reviewed: Yes
ASJC Scopus subject areas: Electrical and Electronic Engineering, Condensed Matter Physics, Electronic, Optical and Magnetic Materials

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Scopus rating (2016): 0.395 1.031
Publication Forum (2016): 1
Scopus rating (2015): 0.35 0.935
Web of Science (2015): 1.092 0.903 5.3 0.629 0.01158 0.229
Publication Forum (2015): 1
Scopus rating (2014): 0.47 1.113
Web of Science (2014): 1.235 1.001 5.3 0.371 0.01307 0.229
Publication Forum (2014): 1
Scopus rating (2013): 0.431 1.171
Publication Forum (2013): 1
Scopus rating (2012): 0.575 1.27
Publication Forum (2012): 1
Scopus rating (2011): 0.364 1.063
Scopus rating (2010): 0.468 1.073
Scopus rating (2009): 0.452 1.033
Scopus rating (2008): 0.878 0.987
Scopus rating (2007): 0.611 1.104
Scopus rating (2006): 0.731 0.935
Scopus rating (2005): 0.645 0.996
Scopus rating (2004): 0.867 0.9
Scopus rating (2003): 0.494 1.045
Cardiac pacemakers in magnetic fields of a shunt reactor at a 400 kV substation

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Environmental Health, Fingrid Oyj, The Heart Center, Tampere University Hospital
Authors: Korpinen, L., Kuisti, H., Tarao, H., Elovaara, J., Virtanen, V.
Number of pages: 4
Pages: 229-232
Publication date: Aug 2015
Peer-reviewed: Yes
ASJC Scopus subject areas: Electrical and Electronic Engineering

Publication information
Journal: International Journal of Occupational Safety and Ergonomics
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Issue number: 2
ISSN (Print): 1080-3548
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Publication Forum (2017): 1
Scopus rating (2016): 0.259 0.673
Publication Forum (2016): 1
Scopus rating (2015): 0.284 0.729
Web of Science (2015): 0.381 0.711 7.0 0.043 7.4E-4 0.193
Publication Forum (2015): 1
Scopus rating (2014): 0.23 0.62
Web of Science (2014): 0.312 0.615 6.8 0.069 6.3E-4 0.169
Publication Forum (2014): 1
Scopus rating (2013): 0.232 0.853
Publication Forum (2013): 1
Scopus rating (2012): 0.344 0.732
Publication Forum (2012): 1
Scopus rating (2011): 0.286 0.578
Scopus rating (2010): 0.221 0.341
Scopus rating (2009): 0.272 0.673
Scopus rating (2008): 0.369 0.488
Scopus rating (2007): 0.431 0.618
Scopus rating (2006): 0.205 0.427
Scopus rating (2005): 0.216 0.257
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Scopus rating (2003): 0.19 0.344
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Scopus rating (2001): 0.141 0.333
Scopus rating (2000): 0.136 0.264
Scopus rating (1999): 0.197 0.372
Accelerator-quality HTS dipole magnet demonstrator designs for the EuCARD-2 5-T 40-mm clear aperture magnet

Future high-energy accelerators will need very high magnetic fields in the range of 20 T. The Enhanced European Coordination for Accelerator Research and Development (EuCARD-2) Work Package 10 is a collaborative push to take high-temperature superconductor (HTS) materials into an accelerator-quality demonstrator magnet. The demonstrator will produce 5 T stand alone and between 17 and 20 T when inserted into the 100-mm aperture of a Fresca-2 high-field outsert magnet. The HTS magnet will demonstrate the field strength and the field quality that can be achieved. An effective quench detection and protection system will have to be developed to operate with the HTS superconducting materials. This paper presents a ReBCO magnet design using a multistrand Roebel cable that develops a stand-alone field of 5 T in a 40-mm clear aperture and discusses the challenges associated with a good field quality using this type of material. A selection of magnet designs is presented as the result of the first phase of development.
Managing cascade transformers equipped with on-load tap changers in bidirectional power flow environment

Existing voltage control schemes of cascade on-load tap changers (OLTCs) have been developed considering unidirectional power flow. However, in recent years, integration of distributed generation such as solar and wind power to the grid has created possibility for bidirectional power flow resulting in inefficiency of previous voltage control methods of cascade OLTCs. In this paper, an effective method for managing cascade OLTCs in bidirectional power flow environment is presented. Tracking the active and reactive power changes in both MV and LV networks, the developed method is able to detect the cause of voltage variation i.e. MV or LV network. Accordingly, it enables the system operator to order tap actions at accurate voltage level which decreases unnecessary tap actions and improves the voltage quality at customer points. The proposed voltage control method is tested in different network scenarios.
In response to the EU Mandate M/490, two crucial tools were developed for supporting the standardization of the Smart Grid: the Smart Architecture Model (SGAM) framework and the Use Case Methodology. This paper shows and exemplifies the use of these tools to incrementally develop the automation architecture for future active distribution power systems, by leveraging on existing automation architectures from literature and existing standards. This method for architecture development has been formalized and used in EU Project IDE4L, but it is generally applicable.

Systematic method for the development of future active distribution network automation architectures

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, Smart Energy Systems (SES)
Authors: Riccobono, A., Angioni, A., Ponci, F., Monti, A., Della Giustina, D., Dede, A., Repo, S.
Test results of the LARP HQ02b magnet at 1.9 K

The HQ magnet is a 120-mm aperture, 1-m-long Nb$_3$Sn quadrupole developed by the LARP collaboration in the framework of the High-Luminosity LHC project. A first series of coils was assembled and tested in five assemblies of the HQ01 series. The HQ01e model achieved a maximum gradient of 170 T/m at 4.5 K at LBNL in 2010-2011 and reached 184 T/m at 1.9 K at CERN in 2012. A new series of coils incorporating major design changes was fabricated for the HQ02 series. The first model, HQ02a, was tested at Fermilab where it reached 98% of the short sample limit at 4.5 K with a gradient of 162 T/m in 2013. However, the full training of the coils at 1.9 K could not be performed due to a current limit of 15 kA. Following this test, the azimuthal coil pre-load was increased by about 30 MPa and an additional current lead was installed at the electrical center of the magnet for quench protection studies. The test name of this magnet changed to HQ02b. In 2014, HQ02b was then shipped to CERN as the first opportunity for full training at 1.9 K. In this paper, we present a comprehensive summary of the HQ02 test results including: magnet training at 1.9 K with increased preload; quench origin and propagation; and ramp rate dependence. A series of powering tests was also performed to assess changes in magnet performance with a gradual increase of the MIITs. We also present the results of quench protection studies using different setting for detection, heater coverage, energy extraction and the coupling-loss induced quench (CLIQ) system.

General information
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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, European Organization for Nuclear Research, CERN, Conseil Européen pour la Recherche Nucléaire, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Brookhaven National Laboratory, University of Twente
Keywords: (Niobium-tin, quadrupole magnet, Superconducting coils)
Publication date: 1 Jun 2015
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ASJC Scopus subject areas: Electrical and Electronic Engineering, Condensed Matter Physics, Electronic, Optical and Magnetic Materials

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Scopus rating (2015): 0.35 0.935
Web of Science (2015): 1.092 0.903 5.3 0.629 0.01158 0.229
Publication Forum (2015): 1
Scopus rating (2014): 0.47 1.113
The EuCARD-2 future magnets European collaboration for accelerator-quality HTS magnets

EuCARD-2 is a project supported by FP7-European Commission that includes, inter alia, a work-package (WP10) called "Future Magnets." This project is part of the long term development that CERN is launching to explore magnet technology at 16 T to 20 T dipole operating field, within the scope of a study on Future Circular Colliders. The EuCARD2 collaboration is closely liaising with similar programs for high field accelerator magnets in the USA and Japan. The main focus of EuCARD2 WP10 is the development of a 10 kA-class superconducting, high current density cable suitable for accelerator magnets. The cable will be used to wind a stand-alone magnet 500 mm long and with an aperture of 40 mm. This magnet should yield 5 T, when stand-alone, and will enable to reach a 15 to 18 T dipole field by placing it in a large bore background dipole of 12-15 T. REBCO based Roebel cables is the baseline. Various magnet configurations with HTS tapes are under investigation and also use of Bi-2212 round wire based cables is considered. The paper presents the structure of the collaboration and describes the main choices made in the first year of the program, which has a breadth of five to six years of which four are covered by the FP7 frame.
Utilizing triangular mesh with MMEV to study hysteresis losses of round superconductors obeying critical state model

Nature's minimum energy principle formulated in minimum magnetic energy variation (MMEV) and coupled with the Bean's critical state model (CSM) has resulted in feasible tools to model hysteresis losses in superconductors. These tools have been applied for single wires as well as for multi-turn coils in two-dimensional modelling domains. However, so far the discretization of the modelling domain has always relied on regular rectangular meshes. Therefore, the mesh representation of round filaments suffers from large discretization error if the mesh is not refined considerably more than triangular meshing would need. In this paper, we study the utilisation of triangular mesh in such a hysteresis loss modelling tool. We present the required extension to the already available knowledge that is needed to implement such a modelling tool. With our home-brewed tool, we study the convergence of the simulated transport current losses in the cross-section of a round wire represented with triangular and rectangular meshes of different types and of different densities. According to the results, triangular meshing is considerably more efficient than rectangular meshing for simulating transport current losses in the investigated situation.
DC Dielectric Breakdown Behavior of Thermally Sprayed Ceramic Coatings

Previous studies of dielectric properties of thermally sprayed insulating ceramic coatings are focused on linearly ramped dielectric breakdown strength as well as DC resistivity, relative permittivity and dielectric loss characterizations. However, reports of the effects of ramp rate or of any kind of long term stressing on the breakdown strength cannot be found in literature. The aim of this paper was to study the DC breakdown behavior of one type of HVOF sprayed alumina coating under different stresses. It can be concluded that the ramp rate of DC breakdown measurement has no remarkably influence on the breakdown strength. The
breakdown behavior was also studied using step-by-step tests with two constant step voltages and step durations. The DC resistivity of the alumina coating showed strong dependence on the applied electric field. The resistivity behaved ohmically below the field strength of ~0.5 V/µm and above ~8...12 V/µm, however, the resistivity decreased approximately three decades in the non-ohmic region (0.5 V/µm). At electric field strengths above ~25 V/µm, the degradation started in the material leading to breakdown. However, when the step duration was longer (60 min), the degradation process started already slightly below the applied field of 25 V/µm.

**General information**

State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, VTT Technical Research Centre of Finland
Authors: Niittymäki, M., Suhonen, T., Metsäjoki, J., Lahti, K.
Number of pages: 6
Pages: 80-85
Publication date: Jun 2015

**Host publication information**

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Place of publication: Copenhagen, Denmark
ISBN (Print): 978-82-321-0274-7
Research output: Scientific - peer-review » Conference contribution

**Electromagnetic Design of Ultrafast Electromechanical Switches**

To open electromechanical switches within the range of tens of microseconds, we exploit repulsive electromagnetic forces between current-carrying conductor loops. For this we study the power conversion efficiency from electromagnetic to kinetic form. These studies suggest connecting moving coils in series rather than employing inductive coupling. These techniques are put into practice in two prototype switches: the first one is based on induction and the other on series connected coils. Measurements with a high-speed camera verify that both switches achieve accelerations in the magnitude of 140000 g and breaking distances of 1 mm within 50 μs. The switch with series connected coils obtains 44% greater force than the one based on induction.

**General information**

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Research area: Electromagnetics
Authors: Puumala, V., Kettunen, L.
Number of pages: 6
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Publication date: Jun 2015
Peer-reviewed: Yes

**Publication information**

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ISSN (Print): 0885-8977
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Scopus rating (2016): 1.791 2.408
Publication Forum (2016): 2
Scopus rating (2015): 1.967 2.66
Web of Science (2015): 2.032 2.464 8.9 0.235 0.02085 0.872
Publication Forum (2015): 2
Scopus rating (2014): 1.726 2.693
Web of Science (2014): 1.733 2.178 9.0 0.208 0.01621 0.655
Publication Forum (2014): 2
We show by modelling that the quench propagation velocity is not constant in HTS coils but it changes during the quench. Due to the large temperature margin between the operation and the current sharing temperatures, the normal zone does not propagate with the temperature front. This means that the temperature will rise in a considerably larger volume when compared to the quenched volume. Thus, the evolution of the temperature distribution below current sharing temperature $T_{(c\,s)}$ after the quench onset affects the normal zone propagation velocity in HTS more than in LTS coils. This can be seen as an acceleration of the quench propagation velocities while the quench evolves when margin to $T_{(c\,s)}$ is high. In this paper, we scrutinize quench propagation in a stack of YBCO cables with an in-house finite element method software which solves the heat diffusion equation. We compute the longitudinal and transverse normal zone propagation velocities at various distances from the hot spot to demonstrate the distance-variation of these velocities. According to the results in our particular simulation case, the longitudinal normal zone propagation velocity is 30% higher far away from the quench origin compared to its immediate vicinity when $T_{(op)}$=4.2 K and $T_{(c\,s)}$=15 K.

**Variation of Quench Propagation Velocities in YBCO Cables**

**General information**

State: Published

Ministry of Education publication type: A1 Journal article-refereed

Organisations: Department of Electrical Engineering, Research area: Electromagnetics

Authors: Härö, E., Järvelä, J., Stenvall, A.

Keywords: (High temperature superconductors, Normal zone propagation, Quench simulation, Stability analysis, superconducting magnets, STABILITY CONSIDERATIONS, HTS MAGNETS, SUPERCONDUCTORS, CONDUCTORS, 1D)

Number of pages: 6

Pages: 1705-1710

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Peer-reviewed: Yes

**Publication information**

Journal: Journal of Superconductivity and Novel Magnetism

Volume: 28

Issue number: 6

ISSN (Print): 1557-1939

Ratings:

Publication Forum (2017): 1
Feasibility of electric buses in public transport

This study examines the economic feasibility of electric buses in a mid-sized city, where public transport is currently organized with buses only. The difference in lifetime cost of electric buses and diesel buses was calculated with the chosen parameters that were selected after careful background analysis. A viable business case can be created when the battery and the charging infrastructure are selected shrewdly. The electricity is much cheaper fuel than diesel but with the current battery technologies and battery prices the significant cost from operating an e-bus comes from the wear of the battery. Two types of Li-ion batteries were compared, LFP (Lithium Iron Phosphate) and LTO (Lithium Titanate). Also different conductive opportunity charging strategies were examined: 1. Charging at the depot. 2. Charging at the end stop(s). 3. Charging at the line stops.

The round trip line length assessed was 20 km. Calculations show that the LTO buses and a fast charger at the end stop complemented with low power overnight chargers at the depot is the best investment combination based on the given assumptions. The 200 kW charging power is sufficient to ensure the charging in the normal end stop breaks. Due to a longer cycle life the wear cost per km was lower for LTO than for LFP. LTO is also better adapted for fast charging. The battery size has to be sufficient compared to the required driving range during peak consumption, to the charging current and to the performance requirements of the e-bus. Oversizing the battery has some positive effects (improved cycle life, less heating and better flexibility) but the negative effects were estimated to be more significant (higher investment cost, increased weight and space requirement).

General information
State: Published
Ministry of Education publication type: D3 Professional conference proceedings
Organisations: Department of Electrical Engineering, Research area: Power engineering
Authors: Vilppo, O., Markkula, J.
Number of pages: 9
Publication date: 3 May 2015
Motor drives utilizing power semiconductors play an important role in modern day electric motor control. Although the reliability of power semiconductors is widely studied, the product level reliability of motor drives has been studied markedly less even though their more complex control and measuring electronics often make them more vulnerable to environmental stresses. In order to advance product level accelerated reliability testing, customized test methods with multiple simultaneous or sequential stresses can be used. However, the knowledge of combined effects of different stresses is still largely unknown. In this research the reliability of a commercial motor drive was studied. Environmental conditions used included an 85 °C constant temperature test and an 85 °C test with 85% relative humidity. Additionally, input power interruptions were included to study the effect of sudden shortages of electricity. The results of the study showed that the mean time to failure for the devices tested with the input power interruptions was notably shorter than that for the test series without them. An especially clear effect of the input power interruptions was seen on the power MOSFETs of the motor drives. Moreover, the humidity was found to play an important role in the reliability of the motor drives.
Hot spot temperature in an HTS Coil: Simulations with MIITs and finite element method

MIITs, a zero-dimensional concept to study hot spot temperature, has been previously used to estimate hot spot temperatures and quench heater delays in NbTi and Nb$_3$Sn magnets. However, quench behavior is completely different in high-temperature superconducting (HTS) magnets due to the slow normal zone propagation velocity and the high temperature margin. Because the MIITs concept does not take into account thermal diffusion in the magnet, opposite to the finite-element method (FEM) analysis, the difference of these concepts is studied in this paper. Here, we have taken the approach to compute the hot spot temperatures for a future HTS magnet, designed to be built from REBCO Roebel cable, with MIITs and FEM simulations. The magnet protection is accomplished with a dump resistor, and the effect of quench detection threshold voltage on the hot spot temperature has been studied. Furthermore, the inductance of the magnet increases with the magnet length. Thus, there exists a maximum inductance of the magnet, which should not be exceeded to be able to protect the magnet only with a dump resistor. The hot spot temperatures with different values of inductance are also studied in this paper. Our simulations show that the hot spot temperatures computed with MIITs are from 60 to 150 K higher than those of FEM analysis. Thus, the MIITs concept seems unreliable when considering hot spot temperatures in HTS magnets protected with only dump resistors. However, the MIITs concept might be a usable tool when comparing different magnet designs. If 400 K is the upper limit for the hot spot temperature and the protection scheme includes only a dump resistor, the length of the investigated magnet can be increased to only such value that the magnet inductance is at most 50 mH.

General information

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Research area: Electromagnetics, European Organization for Nuclear Research
Authors: Härö, E., Stenvall, A., Van Nugteren, J., Kirby, G.
Keywords: (Finite element method (FEM), high-temperature superconductors (HTSs), quench simulation, stability analysis, superconducting magnets)
Publication date: 1 Apr 2015
Peer-reviewed: Yes
ASJC Scopus subject areas: Electrical and Electronic Engineering, Condensed Matter Physics, Electronic, Optical and Magnetic Materials

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ISSN (Print): 1051-8223
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Scopus rating (2016): 0.395 1.031
Publication Forum (2016): 1
Scopus rating (2015): 0.35 0.935
Web of Science (2015): 1.092 0.903 5.3 0.629 0.01158 0.229
Publication Forum (2015): 1
Scopus rating (2014): 0.47 1.113
Web of Science (2014): 1.235 1.001 5.3 0.371 0.01307 0.229
Publication Forum (2014): 1
Scopus rating (2013): 0.431 1.171
Publication Forum (2013): 1
On improvement of transient stage of composite nonlinear feedback control using arbitrary order set point filters

This paper studies the generalization of composite nonlinear feedback (CNF) control using arbitrary order set point filters, which focus on the initial stage of the transient response. The set point filters can be used to provide more performance by shortening the rise and settling times of the control system. Furthermore, the filters operate outside the feedback loop, and hence, they do not sacrifice loop robustness. The new method is illustrated by a benchmark problem found in an open literature. The simulation results show that the proposed method improves the set point response more than 10% in terms of settling time.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Pyrhönen, V., Koivisto, H.
Keywords: (Composite nonlinear feedback, actuator saturation, high performance, robust control, set point filter, control system synthesis, feedback, nonlinear control systems, transient response)
Number of pages: 6
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Title of host publication: 2014 IEEE International Conference on Control System, Computing and Engineering (ICCSCE)
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10.1109/ICCSCE.2014.7072705
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http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7072705
Research output: Scientific - peer-review › Conference contribution

Systematic approach to secure automation – coordinated voltage control use-case

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Salmenperä, M., Seppälä, J., Koivisto, H., Lu, S., Repo, S.
Towards automation security research and training environment

An automation system is a networked software product in hardware intensive environment and requires more than normal IT security skills. Building an automation security research and training environment for automation requires knowledge on the internal workings of an automation system as well as creative approach on how to keep the system secure where needed, and broken when required for development and teaching purposes. The main challenges are to combine the amount of automation specific hardware and to create good practices which keep the need for maintenance, versatility and pedagogical aspects in balance. This paper presents a project called TUTCyberLabs, the learned lessons and the design decisions. The main focus is on Department of Automation Science and Engineering environment ASECyberLab.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Seppälä, J., Salmenperä, M., Koivisto, H., Harju, J., Repo, S., Holmström, J., Ahonen, P.
Publication date: 18 Mar 2015

Air Gap Fields in Electrical Machines: Harmonics and Modeling of Movement

The aim of this thesis is to develop mathematical tools for the efficient electromagnetic analysis of electromechanical devices. In the analysis of rotating electrical machines, the air gap fields play an important role. It is particularly useful to write the magnetic flux density in the air gap as a Fourier series expansion with respect to mechanical angle and/or time. Different terms in the series expansions are then called space and time harmonics and almost all relevant phenomena can be understood from the behaviour of the harmonics. The main topic of this thesis is the application of spectral Dirichlet-to-Neumann mappings to model rotating electrical machines in terms of air gap harmonics. A spectral Dirichlet-to-Neumann mapping for a rotor or stator subproblem in a time or frequency domain boundary value problem (BVP) completely characterizes the electromagnetic behaviour of the subproblem from the viewpoint of the remaining problem and can be used to replace the subproblem with an implicit Neumann boundary condition. This allows the development of new...
efficient numerical and analytical methods for analysis of electrical machines. We discuss several analytical and numerical methods, where reformulation of one or both subproblems with Dirichlet-to-Neumann maps is used to speed up the solution or to obtain more accurate solutions. Moreover, properties of the spectral Dirichlet-to-Neumann maps yield information, which can be used to predict and understand the air gap field harmonics. The second topic of the thesis is the application of Riemannian geometry to construct BVPs for electromechanical devices in coordinate systems fixed to the moving bodies. Then, change of distances of the material points corresponds to change in the coordinate expression of the metric tensor in the air gap. In FE implementations, this allows modeling of movement without changes to the finite element mesh. We discuss the application of the approach to linear and rotating movement.

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Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Department of Electrical Engineering
Authors: Räisänen, V.
Number of pages: 78
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Original language: English

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main.pdf: 1260988 bytes, checksum: e71585df8f6c692bb8a67b02c5cc2254 (MD5)<br/>
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main.pdf: 1260988 bytes, checksum: e71585df8f6c692bb8a67b02c5cc2254 (MD5)<br/>
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No. of bitstreams: 1
main.pdf: 1260988 bytes, checksum: e71585df8f6c692bb8a67b02c5cc2254 (MD5)
Source: researchoutputwizard
Source-ID: 123456789/22703
Research output: Collection of articles › Doctoral Thesis

Design, fabrication, and testing of a low AC-loss conduction-cooled cryostat for magnetization loss measurement apparatus
Conduction cooling has become a viable alternative for cooling superconducting devices. However, the thermal pathways of a conduction-cooled cryostat can be problematic for applications where time-varying magnetic fields are present. Such alternating magnetic fields are present, e.g., in a magnetization ac-loss measurement system. The losses in the thermal pathways are unwanted as they increase the heat load into the cryostat and interfere with the measurement. To solve this challenge, a conduction-cooled cryostat with special attention in limiting eddy-current losses in the cryostat structures was constructed. The design process is illustrated in detail starting from the specifications and proceeding through the fabrication of individual components. The loss dissipated in the cryostat is experimentally examined, and the finished conduction-cooled magnetization loss measurement system is demonstrated by characterizing a multifilamentary MgB$_2$ conductor.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Research area: Electromagnetics, Lappeenranta University of Technology, LUT Energy, Slovak Academy of Sciences
Authors: Järvelä, J., Lyly, M., Stenvall, A., Juntunen, R., Souc, J., Mikkonen, R.
Publication date: 1 Feb 2015
Recognition and modelling of irradiance transitions caused by moving clouds

Fast irradiance transitions caused by the edges of shadows of moving clouds have various effects on the operation of photovoltaic (PV) systems. They can lead to situations where the grid inverter is not able to follow the global maximum power point causing extra losses. Fast fluctuations of the power fed to the electric grid can also cause energy balance and power quality problems. Further, partial shading of PV generators causes mismatch losses.

In this paper, a method to recognize irradiance transitions caused by moving clouds from the measured extensive irradiance data is presented. A total of around 40,000 irradiance transitions were recognized from a measured data of 13 months around midsummer in 2011-2013 and their shading strength, duration, time of occurrence etc. have been analysed. It has been found that the duration of irradiance transitions varies a lot from a few seconds up to several minutes. The average duration of irradiance rises is clearly longer than that of falls. Shading strengths of transitions varies quite evenly from very thin shadings up to 90% shading strength and the highest transition rates take place around noon. Furthermore, a mathematical model of the irradiance transitions has been developed and validated with the extensive set of experimental data. (C) 2014 Elsevier Ltd. All rights reserved.
**Modeling deformations in magnetic systems - a finite element implementation**

**General information**
- **State:** Published
- **Ministry of Education publication type:** A1 Journal article-refereed
- **Organisations:** Department of Electrical Engineering, Electromagnetics
- **Authors:** Kovanen, T., Tarhasaari, T., Kettunen, L.

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- **Contribution:** organisation=dee,FACT1=1<br/>
- **DOIs:** 10.1016/j.solener.2014.11.018
- **Publisher name:** Elsevier Ltd
- **Source:** researchoutputwizard
- **Source-ID:** 888
- **Research output:** Scientific - peer-review › Article
Combined Electricity and Mobile Network Situation Awareness System for Disturbance Management

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, Department of Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning
Authors: Krohns-Välimäki, H., Haapanen, J., Verho, P., Säe, J., Lempläinen, J.
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia)
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Electronic): 978-1-5090-1237-4
DOI: 10.1109/ISGT-Asia.2015.7387099

Bibliographical note
ORG=dee,0.7
ORG=elt,0.3
Research output: Scientific - peer-review › Conference contribution
DC ramp rate effect on the breakdown response of SiO2-BOPP nanocomposites
The effect of voltage ramp rate on the short-term dielectric breakdown strength of polymer nanocomposites is not well-documented. In this paper, the effect of DC field ramp rate on the large-area breakdown performance of melt-extruded bi-axially oriented polypropylene (BOPP) films incorporating 4.5 wt-% of nano-silica is studied. By utilizing a self-healing multi-breakdown measurement method with a variable DC voltage ramp rate, a statistically large amount of breakdown data was obtained from a large total sample film area as a function of DC field ramp rate (0.1–50 Vs−1µm−1)). With a decreasing ramp rate, Weibull statistical analysis of the breakdown data suggests a systematically decreasing trend in the breakdown strength (Weibull α) and an increase in the Weibull shape parameter of time (>1) for the nanocomposite. The observed behavior is speculated to be attributable to highly altered internal charge dynamics of the silica-BOPP nanocomposite. The results exemplify the importance of careful breakdown strength assessment when dielectric films of more complex internal structure are studied.

Effect of Inductor Saturation on the Harmonic Currents of Grid-Connected Three-Phase VSI in PV Application
The optimal design of a VSI based photovoltaic (PV) inverter has been studied extensively during the last years. The focus in these studies has been in the selection of the reactive components of the LCL-filter, leaving the inductor design out from the discussion. However, the inductor design plays important role when the design target is to minimize the size and the cost of the filter. Unfortunately, the minimization of the filter size might yield saturating inductors. In this paper, the effect of inductor saturation on the harmonic currents of grid-connected three-phase PV inverter is studied by simulations and measurements on a prototype inverter. The results indicate that application of saturating inductors increases the fifth and seventh harmonics in the output current of the inverter when it is operating at open-loop. However, these harmonics are effectively attenuated when the inverter is operated at closed-loop.

Electric field dependency of dielectric behavior of thermally sprayed ceramic coatings
High temperature applications e.g. fuel cells require ceramic based insulation solutions instead of polymers. The aim of this paper was to characterize the dielectric properties of thermally sprayed ceramic coatings; especially the electric field dependency of AC and DC behavior of thermally sprayed ceramic coatings. One of the spinel samples and one of the
alumina samples have quite similar lamellar microstructure which may partly explain their similar type of behavior in DC resistivity as well as in AC loss indexes at low frequencies. These two samples had smaller lamellar size than the other alumina and spinel samples which also had quite similar behavior of AC losses at low frequencies, respectively. In addition to the lamellar size and structure, also micro cracks in the coating microstructure are proposed to have an effect on the dielectric behavior and its electric field dependency.

Flexible fast-convolution implementation of single-carrier waveform processing for 5G
This paper proposes and analyzes the use of effective and flexible fast-convolution (FC) implementation for single-carrier (SC) waveforms with very small roll-offs to reach high spectrum efficiency and significantly lower peak-to-average power ratio (PAPR) than corresponding multicarrier schemes. The generated waveforms are spectrally well-contained, with very small power leakage to adjacent frequencies, and are thus good candidates for opportunistic and heterogeneous spectrum use scenarios. The SC-waveforms are found to exhibit similar PAPR characteristics as the OFDM based SC-FDMA scheme. On the receiver side, fast-convolution filter bank (FC-FB) approach supports effective frequency-domain equalization with low complexity. It can be used for simultaneous processing of multiple SC channels with individually tunable bandwidths, center frequencies and timing offsets. This solution enables different terminals to operate with different roll-offs and hence with different PAPR. The approach supports well asynchronous multi-user operation, which is considered as an important element in 5G networks.

Generalized multivariable small-signal model of three-phase grid-connected inverter in DQ-domain

General information
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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, Smart Energy Systems (SES), VTT Technical Research Centre of Finland
Authors: Niittymäki, M., Metsäjoki, J., Suhonen, T., Lahti, K.
Number of pages: 4
Pages: 500-503
Publication date: 2015
High-Temperature Storage Testing of ACF Attached Sensor Structures

General information
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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Research area: Reliability, Department of Materials Science, Research group: Plastics and Elastomer Technology, Engineering materials science and solutions (EMASS)
Authors: Lahokallio, S., Hoikkanen, M., Vuorinen, J., Frisk, L.
Pages: 8641-8660
Publication date: 2015
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Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.834 1.497
Publication Forum (2016): 1
Scopus rating (2015): 0.852 1.495
Web of Science (2015): 2.728 3.3 3.3 0.356 0.01592 0.77
Publication Forum (2015): 1
Scopus rating (2014): 0.777 1.256
Web of Science (2014): 2.651 3.35 3.6 0.353 0.01273 0.796
Publication Forum (2014): 1
Scopus rating (2013): 0.998 1.673
Publication Forum (2013): 1
Scopus rating (2012): 0.838 1.471
Publication Forum (2012): 1
Scopus rating (2011): 0.65 1.239
Scopus rating (2010): 0.394 0.99
Original language: English
DOIs:
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ORG=dee,0.8
ORG=mol,0.2
Research output: Scientific - peer-review › Article

Kanavamittaus moderneja laajakaistaisia HF-järjestelmää varten: Tilivistelmäraportti

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Kyyne1 Oy, Oulun Yliopisto/CWC
Authors: Saarnisaari, H., Hovinen, V., Tuomivaara, H., Yli-Kaakinen, J., Renfors, M.
Number of pages: 10
Publication date: 2015

Publication information
Modeling of Minimum Energy Required to Quench an HTS Magnet with a Strip Heater

Due to the wide spectrum of current sharing temperatures in an HTS magnet, estimating the energy required to quench the magnet is a complicated task. On the other hand, quenching an LTS magnet for quench characterization purposes with a heater is straightforward due to the small temperature margin, and correspondingly low minimum quench energy (MQE). To estimate the required energy for LTS magnet, the analytic concept of MQE can be utilized. In this paper we propose that only numerical simulations can give adequate estimates to the MQE of an HTS magnet for measurement purposes. Further, due to the high enthalpy margin, the utilization of spot heaters with short energy pulses becomes questionable. We present in detail the effect of heater’s pulse length to the MQE when a strip heater is utilized for quenching. In addition, the effect of the heater area on MQE is studied. We consider the model of a REBCO coil to be constructed and tested in a European project EuCARD-2. According to the results: 1) MQE increases almost linearly for pulse lengths between 100 ms and 500 ms. 2) When the heater area is enlarged, the required energy per area saturates to a certain value related to the coil’s enthalpy margin. 3) MQE obtained with a traditional analytic approach based on a minimum propagating zone (MPZ) underestimates considerably the numerically obtained MQE.
Modeling quench protection heater delays in an HTS coil

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Authors: Salmi, T., Stenvall, A.
Number of pages: 5
Pages: 1-5
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Volume: 25
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ISSN (Print): 1051-8223
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Scopus rating (2016): 0.395 1.031
Publication Forum (2016): 1
Scopus rating (2015): 0.35 0.935
Web of Science (2015): 1.092 0.903 5.3 0.629 0.01158 0.229
Publication Forum (2015): 1
Scopus rating (2014): 0.47 1.113
Web of Science (2014): 1.235 1.001 5.3 0.371 0.01307 0.229
Publication Forum (2014): 1
Scopus rating (2013): 0.431 1.171
OPC UA security for protecting substation and control center data communication in the distribution domain of the smart grid

The distribution domain of the smart grid incorporates advantages of the newest substation automation standards in order to enhance distribution network automation. State-of-the-art distribution automation solutions use the public Internet for exchanging data between substation and control center. This presents challenges for cybersecurity, particularly for critical data determining distribution network operation. Therefore, Internet communication between substation and control center should be carried out via a secure communication protocol. OPC Unified Architecture (UA) is an interoperable communication standard supports Internet protocols from one hand and obtains benefits from mature built-in security mechanisms from other hand. This paper describes a solution for secure data transmission between modern substation and control center over the Internet. In this approach, circuit breaker position data is chosen as the data example that is defined in respect to the IEC 61850 data model and securely transmitted to OPC UA client application at remote control center by employing the OPC UA security architecture functions.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Jafary, P., Repo, S., Salmenperä, M., Koivisto, H.
Number of pages: 7
Pages: 645-651
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DOIs: 10.1109/INDIN.2015.7281811

Bibliographical note
ORG=dee,0.6
ORG=ase,0.4
Principles of designing for situation awareness

High level of situation awareness is a key factor in many domains to ensure correct decision making and actions. Situation awareness has been studied extensively in the aviation and military domains but the research also applies to other domains e.g. power grid operations and managing disturbances of electricity supply. Based on the research design principles have been created in order to help system designers to create better user interfaces for systems used in operational activities. These principles have been applied when designing the situation awareness system concept for managing disturbances of electricity supply.

Secure communication of smart metering data in the smart grid secondary substation

Simulointi nopeuttaa käyttöiän määrittelyä
Subdomain Reduction by Dirichlet-to-Neumann Mappings in Time-Domain Electrical Machine Modeling

General information
State: Published
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Organisations: Department of Electrical Engineering
Authors: Räisänen, V., Suuriniemi, S., Kurz, S., Kettunen, L.
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Peer-reviewed: Yes

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Volume: 30
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Publication Forum (2016): 2
Scopus rating (2015): 1.601 2.624
Web of Science (2015): 2.596 3.46 8.4 0.192 0.01076 1.215
Publication Forum (2015): 2
Scopus rating (2014): 1.633 2.876
Web of Science (2014): 2.326 3.392 8.1 0.24 0.01055 1.126
Publication Forum (2014): 3
Scopus rating (2013): 2.077 3.285
Publication Forum (2013): 3
Scopus rating (2012): 1.719 3.218
Publication Forum (2012): 3
Scopus rating (2011): 1.709 3.075
Scopus rating (2010): 2.152 3.056
Scopus rating (2009): 2.157 2.916
Scopus rating (2008): 2.43 2.919
Scopus rating (2007): 1.459 2.793
Scopus rating (2006): 1.284 2.529
Scopus rating (2005): 1.405 2.194
Scopus rating (2004): 1.478 2.263
Scopus rating (2003): 1.395 1.954
Temperature Effect on Breakdown Performance of Insulating Polymer Thin Films

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering
Authors: Ritamäki, M., Rytöluoto, I., Lahti, K.
Number of pages: 4
Pages: 75-79
Publication date: 2015

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ISBN (Print): 978-82-321-0274-7
Research output: Scientific - peer-review › Conference contribution

The role of film processing in the large-area dielectric breakdown performance of nano-silica-BOPP films
This paper summarizes the effects of various compositional, structural and film processing factors on the breakdown behavior of laboratory- and pilot-scale melt-compounded bi-axially oriented polypropylene (BOPP) nanocomposite films with silica fillers. A self-healing multi-breakdown measurement approach has been extensively utilized for large-area breakdown characterization of a large number of material variants from different processing trials. The results suggest that although the optimum level of silica presumably resides at the low fill-fraction range (~1 wt-%), the silica content itself is not the only determining factor, as compounds with equal silica content were found to exhibit large differences in the breakdown properties depending on the compounding and film processing steps. Dispersion quality and filler agglomeration (in both the nm- and µm-scale) appear to be of great importance. Indications of possible interaction between nano-silica and co-stabilizer Irgafos 168 are also presented. Overall, the laboratory- and pilot-scale film processing trials suggest that up-scaling of the polymer nanocomposite production is sensible with traditional melt-blending technology, although further development and optimization of nanocomposite formulations and processing is necessary.

Characterization of MgB2 Superconductors in Conduction-Cooled Systems
Superconductivity as a phenomenon was discovered over 100 years ago and the first commercially viable materials have been in use for over 50 years. Today, the truly commercial applications in medical imaging and scientific research are
limited to operating temperatures near 4.2 K. However, the discovery of high temperature superconductivity in 1986, and
the discovery of superconductivity in magnesium diboride, MgB2, in 2001, have the potential for changing this. The high
temperature superconductors have proven to be useful in many applications including electric machinery and power
transfer. However, their wide spread application is in part limited by their steep price. This is not the case with MgB2. The
cheap and easy-to-manufacture material has been shown to be competitive at applications with low to medium strength
magnetic fields at an elevated operation temperature of 20 K. The most important commercial application, the magnetic
resonance imaging falls within this range. These elevated operation temperatures are cost-effectively reachable with
conduction-cooling and mechanical cryorefrigerators, i.e. cryocoolers. Designing and engineering of such dry system
requires different approaches than their liquid cooled predecessors. To support these activities, accurate and relevant
measurement data on the superconductor properties under the proper operating conditions, is required. In this thesis, I
present the approaches, challenges and solutions for obtaining valid measurement data in a conduction-cooled
measurement system, focusing on the measurements of the properties used in characterizing the superconductor
performance. I show how measurements in conduction-cooled system differs from ones cooled with liquid or gaseous
cryogens. I discuss the importance of a proper sample holder and present considerations on how to make one. While the
physical components of the measurement system are important, acquiring valid results requires proper measurement
procedures. I analyze the voltage-current characteristic measurement and show how the results are easily effected by
improper procedures. I consider, how the quench initiation and propagation experiments are performed, and how the
quench dynamics MgB2 and high temperature superconductors differ from low temperature ones. To demonstrate the
applicability of conduction-cooling, I present the design, construction and benchmarking a measurement system for
determining the magnetization AC-losses in a superconductor.

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Organisations: Department of Electrical Engineering
Authors: Järvelä, J.
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Issues in Discontinuous Space-Vector Modulation and Grid-Current Control of Three-Wire Three-Level Static
Synchronous Compensator
In modern power systems, the quality of electric power should be maintained within statutory limits and tolerances to
enable normal and uninterrupted operation of the load equipment in their electrical environment. However, the severity of
power quality problems, as well as the frequency of their occurrence, has been in continuous increase because of growing
energy consumption, proliferation of non-linear loads, and the sensitivity of modern loads to electromagnetic disturbances
in the networks. Therefore, more efficient and faster-acting power quality conditioners are needed. Currently the broadest
operating range and the fastest dynamics are provided by solid-state power quality conditioners based on pulse-width
modulated power converters. Considering high power and medium to high voltage applications, the multilevel converter
topologies have gained special interest because they can generate low-harmonic voltage and current waveforms by using
lower switching frequencies and with no need for complex transformer circuits. This thesis studies the digital control of a
STATCOM (static synchronous compensator) based on the three-wire three-level neutral-point-clamped rectifier. The
focus is on the control system functions that primarily determine the dynamic behavior and the performance of the
compensator. The main addressed research issues are the pulse-width modulation strategy and the grid current control,
using a suitable combination of fundamental theory, computer-aided modelling and simulations, and laboratory experiments. A discontinuous space-vector modulation algorithm is implemented for a three-level STATCOM. Space-vector theory is used to analyse the effect of switching sequence arrangement on the switching ripple current. It is revealed that the sequences should be arranged according to a specific method to maintain sinusoidal grid currents when an LCL grid interface filter is used. Furthermore, the output voltage distortion caused by the blanking times and the semiconductor voltage losses is studied and a compensation algorithm is developed. After that, two grid current control strategies are analysed by means of dynamic modelling and simulations. The main problems observed are poor capability to reject low-order grid voltage harmonics and the sensitivity to parametric uncertainties. The presented theoretical considerations are validated with laboratory tests of a 10 kVA three-wire three-level STATCOM prototype.

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Source: researchoutputwizard
Source-ID: 902
Research output: Monograph › Doctoral Thesis

**Differentiation of multiple maximum power points of partially shaded photovoltaic power generators**
Partial shading conditions have a major effect on the electrical characteristics of photovoltaic (PV) power generators. In this paper, the effects of partial shading on maximum power points (MPPs) of a PV power generator have been systematically studied by using Simulink simulation model of a PV power generator composed of 18 series-connected PV modules. It is shown that the local MPPs can be classified into MPPs at low and high voltages based on the MPP operating point of the PV generator. The results also show that based on the MPP current and voltage it is possible to directly know if the MPP at high voltages is a local or a global MPP. The differentiation between local and global MPPs at high voltages is based on the voltage difference between the actual MPP voltage at high voltages and the theoretical MPP voltage under corresponding uniform conditions. This differentiation method was also tested to work correctly by utilizing experimental measurements of the Tampere University of Technology Solar PV Power Station Research Plant. By using this method, it can be identified if the system is operating at a local or a global MPP. This method can further be utilized to develop global MPP tracking algorithms. (C) 2014 Elsevier Ltd. All rights reserved.

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Research area: Power engineering, Smart Energy Systems (SES)
Authors: Mäki, A., Valkealahti, S.
Keywords: (Global maximum power point, Maximum power point, Maximum power point tracking, Partial shading, Photovoltaic power generator, CURRENT-VOLTAGE CHARACTERISTICS, PARTIAL SHADING CONDITIONS, SOLAR-CELLS, THERMAL-MODEL, PV MODULE, ARRAYS, SIMULATION, TRACKING, SYSTEMS, MISMATCH)
Number of pages: 11
Pages: 89-99
Publication date: Nov 2014
Photovoltaic (PV) technology permits us to harness and transform solar radiation into electricity. However, PV power generators are still a minor share in the global power generation capacity. One of the main reasons for it is that PV systems are greatly dependent on the atmospheric conditions affecting their operation. Furthermore, series connection of PV cells is prone to power losses when the electrical characteristics of the cells are dissimilar or the cells operate under non-uniform operating conditions. Especially during changing atmospheric conditions, the operation and control of PV generators is complicated and there is a demand for improvement since today's inverters do not reach their best performance. In this thesis, a state of the art inclusive thermal and electric simulation model of PV generators is proposed and validated with data measured at the Tampere University of Technology (TUT) solar PV power station research plant. The dynamic thermal and electric behaviors of the PV modules are first modelled separately theoretically based on previous authors' work. Subsequently, these models are further improved by analyzing module temperature measurements and the electric behavior of the PV modules operating under varying meteorological conditions. All the relevant climatic and site specific parameters, heat transfer mechanisms and parasitic resistive effects are considered without major simplifications to obtain the highest possible accuracy. Finally, the separate thermal and electric models are integrated and the result is a comprehensive simulation model that predicts the thermal and electric performance of PV generators operating under varying atmospheric conditions. This simulation model is intended, among other things, to assist in the inverter design and development of maximum power point (MPP) tracking algorithms, especially to improve...
their efficiency and operation under non-ideal and fast changing environmental conditions. Partial shading affects the electrical characteristics of PV generators, causing them to operate away from their MPP and thus complicating the task to reach the maximum power production. This task is normally carried out by the power electronic converters interfacing the PV generators. Furthermore, partial shading conditions generally cause mismatch losses too. In this thesis, a method to generate a spatial irradiance map from a set of irradiance measurements is proposed and utilized to analyze the effect of moving clouds on the mismatch losses on several PV generator configurations and layouts. The mismatch losses are studied for several sizes of generators in which both series and parallel connection of PV modules are considered. The results indicate that the mismatch power losses caused by non-uniform operating conditions due to moving clouds can be reduced by locating PV modules of the generator as close to each other as possible. Furthermore, parallel connection of PV modules should be favored with respect to series connection.

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Authors: Torres Lobera, D.
Number of pages: 113
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Source: researchoutputwizard
Source-ID: 1640
Research output: Monograph › Doctoral Thesis

Development and Evaluation of Accelerated Environmental Test Methods for Products with High Reliability Requirements
Reliability testing of electronics is performed to ensure that products function as planned in specific conditions for a specified amount of time. This is usually both time-consuming and expensive and therefore test time acceleration is often required. The acceleration may be realized by using more severe stress levels or higher use cycle frequencies, but at the same time the risk increases of inducing failure mechanisms not relevant to the use conditions. As a consequence, the accelerated reliability testing of products with markedly long lifetimes and high reliability is frequently challenging. In this thesis different methods for test time acceleration for products with high reliability requirements and long service lives were studied. Both standard tests and modifications of these were used. The effect of the accelerated tests used on the failure modes and mechanisms observed was examined and the limitations of the test methods discussed. The research in this work was conducted at both interconnection level and at device level. The interconnection level testing focused on anisotropically conductive adhesive (ACA) flex-on-board (FOB) attachments. In addition to the effect of the curing process on the mechanical strength of ACA FOB attachments, their applicability and long-term performance in industrial applications was studied. According to the real-time resistance measurement the assembly tested was observed to be extremely resilient in thermal cycling and hygrothermal aging. However, a significant decrease in the mechanical strength of the FOB attachment was also seen. Hydrolysis and embrittlement of the flex material was also observed to limit the applicability of harsher hygrothermal aging conditions. Clear ACA joint failures were only observed with moisture condensation testing, but this may not be a suitable test method for applications that are not susceptible to such a stressor. The device level testing comprised reliability analysis of two frequency converter models. The older generation device and its field failure data were used as the starting point in the development of a test method that could be used to minimize testing time and to induce comparable failure modes to those occurring in the use conditions of the devices. The tests showed that only with the simultaneous use of stresses could a significant reduction in the testing time be achieved. However, the application of the same test method to the newer generation device proved challenging because of differences in materials, components and layouts. Although similar failure modes were observed in both devices, the combined effect of the stresses used on the failure mechanisms requires further study. In addition, knowledge of the
Factors Affecting Stable Operation of Grid-Connected Three-Phase Photovoltaic Inverters

The amount of grid-connected photovoltaic energy generation has grown enormously since the beginning of the 21st century. Photovoltaic power plants are interfaced with the utility grid by using three or single-phase inverters which convert the direct current generated by the photovoltaic modules into three or single-phase alternating current. The photovoltaic inverters have been observed to degrade power quality in the grid and to suffer from reliability problems related to their control software. Therefore, the design of these inverters has become a significant research topic in academia and in the power electronic industry. Control design of a photovoltaic inverter is often based on the small-signal models characterizing its dynamic behavior. In this thesis, the existing small-signal models are upgraded to include the effect of an upstream DC-DC converter and its control mode. In addition, the models are upgraded to include the effect of a phase-locked-loop which is often used as a synchronization method and the effect of the grid-voltage feedforward which is often used to improve the transient performance. The control mode of the upstream DC-DC converter is shown to have a significant effect on the minimum DC-link capacitance which is required for stable operation due to a RHP-pole in the inverter control dynamics. However, operating the DC-DC converter under input-voltage control is shown to remove the RHP-pole and, consequently, the constraint imposed on the size of the minimum DC-link capacitance. The phase-locked-loop (PLL) is shown to make the q-component of the inverter’s output impedance resemble a negative resistor. Based on the small-signal models, the negative resistance is shown to appear at the frequencies below the crossover frequency of the PLL. Therefore, a wide-bandwidth PLL causes easily instability due to the negative-resistance behavior when the grid inductance is large. The grid-voltage feedforward is shown to increase the magnitude of both the d and q-components of the inverter’s output impedance. The PV inverter with grid-voltage feedforward is shown to be more resistant against impedance-based interactions than an inverter without the feedforward.
Alternating current (AC) or magnetic field leads to heat generation in otherwise lossless superconducting materials. Such heat generation is called AC loss. AC loss of special type that occurs in the superconducting material itself, and not in the normal-conducting parts of the superconducting wire is called hysteresis loss. Hysteresis loss is a restricting factor for the feasibility of many superconducting applications, and hence, having reliable and efficient models for predicting hysteresis losses in devices is crucial for the design process. In this thesis, we first introduce the readers to the mathematical structures that are essential for simulating AC losses. The level of abstraction deviates from what is typical in this field, but it allows us to present the models and formulations we use in a structured manner and naturally program simulation tools, which are independent of the dimension of the modelling domain. We also discuss the background of the research by presenting important aspects of our research philosophy and the framework inside which the research in this field is conducted. Then, we briefly present two formulations implemented in our AC loss simulation tool, the so called H-formulation and the so called T-Phi-Psi-formulation, and compare their properties through simulations. The latter of the formulations exploits the topology of the modelling domain to reduce the number of required equations, and it is superior to the former in terms of running times of the simulations. Furthermore, we discuss the properties of two widely used models, the critical state model and the eddy current model, through particular case studies of superconductors under direct current bias and an alternating magnetic field. Neither one of the models is fully able to reflect the intrinsic properties of high-temperature superconductors. Finally, the possibilities of our simulation tool are investigated: we study the potential of the tool in question to yield predictions of multifilamentary twisted superconductors with partially coupled filaments in external magnetic field in two dimensions. We present a simple algorithm for this, and the obtained simulation results show good agreement with results of three-dimensional simulations.
Design of boost-power-stage converter for PV generator interfacing

This paper investigates the benefits which can be obtained if the maximum output current of a photovoltaic (PV) generator is taken into account in the design of a boost-power-stage converter. The investigations clearly show that the benefits are smaller inductor core size and more uniform temperature distribution among the power electronic components compared to the conventional design method. It will also be shown how to make the design with small input capacitor and how to take the power decoupling into account in the design process.

Physical Insight into the factors affecting the load-transient response of a buck converter

This paper investigates the physical issues affecting the load transient response both from the power-stage-component-selection and control-design point of views. A conventional buck converter under three different control schemes - direct-duty-ratio control, peak-current control and peak-current-control with load-current-feedforward control - is used as an example. The outcomes of the investigation are validated by simulations and experimental tests.
This paper presents an integrated thermal and electric simulation model for the operation of photovoltaic (PV) modules and strings. The dynamic thermal model is based on the total energy balance in the module in which all essential heat transfer mechanisms between the module and the environment are modeled theoretical. The electric model is based on the well-known one-diode model and a method is introduced to derive the unknown parameters from the manufacturer's information datasheet. The complete model has been implemented in Matlab Simulink software for a PV module and a PV string of six series-connected modules and validated using environmental and electric measurements of the TUT solar PV power station research plant during 20 days of the summer and autumn in 2013. The input parameters used by the integrated simulation model are the received solar radiation on the tilted plane of the PV modules, the global and diffuse solar radiations received on the horizontal plane, the wind speed and direction and the ambient temperature. The accuracy of the predicted module temperatures and the complete power voltage (P-V) curves has been evaluated by means of the root mean square error (RMSET) and the normalized root mean square error (NRMSEP), respectively. The results show a good agreement between the predicted and measured module temperatures and P V curves. The average RMSET and NRMSEP values during the measurement period were 1.34 degrees C and 1.98%, respectively. (C) 2014 Elsevier Ltd. All rights reserved.
Active Voltage Control in Distribution Networks Including Distributed Energy Resources

The structure and control methods of existing distribution networks are planned assuming unidirectional power flows. The amount of generation connected to distribution networks is, however, constantly increasing which changes the operational and planning principles of distribution networks radically. Distributed generation (DG) affects power flows and fault currents in the distribution network and its effect on network operation can be positive or negative depending on the size, type, location and time variation of the generator. In weak distribution networks, voltage rise is usually the factor that limits the network’s hosting capacity for DG. At present, voltage rise is usually mitigated either by increasing the conductor size or by connecting the generator to a dedicated feeder. These passive approaches maintain the current network operational principles but can lead to high DG connection costs. The voltage rise can be mitigated also using active voltage control methods that change the operational principles of the network radically but can, in many cases, lead to significantly smaller total costs of the distribution network than the passive approach. The active voltage control methods can utilize active resources such as DG in their control and also the control principles of existing voltage control equipment such as the main transformer tap changer can be altered. Although active voltage control can often decrease the distribution network total costs and its effect on voltage quality can also be positive, the number of real distribution network implementations is still very low and the distribution network operators (DNOs) do not consider active voltage control as a real option in distribution network planning. Some work is, hence, still needed to enable widespread utilization of active voltage control. This thesis aims at overcoming some of the barriers that are, at present, preventing active voltage control from becoming business as usual for the DNOs. In this thesis, active voltage control methods that can be easily implemented to real distribution networks are developed. The developed methods are, at first, tested using time domain simulations. Operation of one coordinated voltage control (CVC) method is tested also using real time simulations and finally a real distribution network demonstration is conducted. The conducted simulations and demonstrations verify that the developed voltage control methods can be implemented relatively easily and that they are able to keep all network voltages between acceptable limits as long as an adequate amount of controllable resources is available. The developed methods control the substation voltage based on voltages in the whole distribution network and also reactive and real powers of distributed energy resources (DERs) are utilized in some of the developed CVC methods. All types of DERs capable of reactive or real power control can be utilized in the control. The distribution network planning tools and procedures used currently are not capable of taking active voltage control into account. DG interconnection planning is based only on two extreme loading conditions (maximum generation/minimum load and minimum generation-maximum load) and network effects and costs of alternative voltage control methods cannot be compared. In this thesis, the distribution network planning procedure is developed to enable comparison of different voltage control strategies. The statistical distribution network planning method is introduced and its usage is demonstrated in example cases. In statistical distribution network planning, load flow is calculated for every hour of the year using statistical-based hourly load and production curves. When the outputs of hourly load flows (e.g. annual losses, transmission charges and curtailed generation) are combined with investment costs the total costs of alternative voltage control strategies can be compared and the most cost-effective approach can be selected. The example calculations show that the most suitable voltage control strategy varies depending on the network and DG characteristics. The studies of this thesis aim at making the introduction of active voltage control as easy as possible to the DNOs. The developed CVC methods are such that they can be implemented as a part of the existing distribution management systems and they can utilize the already existing data transfer infrastructure of SCADA. The developed planning procedure can be implemented as a part of the existing network information systems. Hence, the currently used network planning and operational tools do not need to be replaced but only enhanced.
Aktiivinen jännitteensäätö pienentää hajautetun sähköntuotannon liittämiskustannuksia

An H-formulation-based three-dimensional hysteresis loss modelling tool in a simulation including time varying applied field and transport current: the fundamental problem and its solution
A Novel Anti-islanding Protection Method Based on the Combination of a Q-f Droop and RPV

**General information**

State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Raipala, O., Mäkinen, A., Repo, S., Järventausa, P.
Number of pages: 6
Pages: 1-6
Publication date: 2014

**Host publication information**

Assessment of Some Methods for Short-Term Load Forecasting

General information
State: Published
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Organisations: Department of Electrical Engineering
Authors: Koponen, P., Mutanen, A., Niska, H.
Number of pages: 6
Publication date: 2014

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
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DOIs: 10.1109/ISGTEurope.2014.7028901
Links: http://www.ieee-isgt-eu.org/

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-30
Source: researchoutputwizard
Source-ID: 756
Research output: Scientific - peer-review › Conference contribution

Comparison of the Low Voltage Distribution Network Voltage Control Schemes

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Tuominen, J., Repo, S., Kulmala, A.
Number of pages: 6
Pages: 1-6
Publication date: 2014

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7720-8
DOIs: 10.1109/ISGTEurope.2014.7028928
Links: http://www.ieee-isgt-eu.org/

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-30
Source: researchoutputwizard
Source-ID: 756
Research output: Scientific - peer-review › Conference contribution
Control Strategies of Network Connected Electricity Storage Elements - Case Simulations

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Electrical Engineering
Authors: Supponen, A., Repo, S.
Number of pages: 10
Pages: 1-10
Publication date: 2014

Host publication information
Title of host publication: NORDAC 2014, The 11th Nordic Electricity Distribution and Management Conference, 8-9 September 2014, Stockholm, Sweden

Publication series
Name: Elforsk rapport 14:32

Bibliographical note

Coordinated Voltage Control Algorithms Tested in Real Time Digital Simulator

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Tuominen, J., Repo, S., Kulmala, A.
Number of pages: 7
Pages: 1-7
Publication date: 2014

Host publication information
Links:

Bibliographical note

Coordinated Voltage Control in Distribution Networks Including Several Distributed Energy Resources

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Kulmala, A., Repo, S., Järventusta, P.
Number of pages: 11
Pages: 2010-2020
Publication date: 2014
Peer-reviewed: Yes
Demand Response in Finland - Potential Obstacles in Practical Implementation

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Electrical Engineering
Authors: Honkapuro, S., Tuunanen, J., Valtonen, P., Partanen, J., Järventausta, P., Harsia, P.
Number of pages: 8
Pages: 1-8
Publication date: 2014

Host publication information
Title of host publication: NORDAC 2014, The 11th Nordic Electricity Distribution and Management Conference, 8-9 September 2014, Stockholm, Sweden

Publication series
Name: Elforsk rapport 14:32

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-11-30<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 500
Research output: Scientific › Conference contribution

Design of a Control Scheme for Distribution Static Synchronous Compensators with Power-Quality Improvement Capability

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
**Dynamic Characterization of Power Electronic Interfaces**

**General information**

State: Published  
Ministry of Education publication type: A1 Journal article-refereed  
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)  
Authors: Suntio, T., Viinamäki, J., Jokipii, J., Messo, T., Kuperman, A.  
Number of pages: 13  
Pages: 949-961  
Publication date: 2014  
Peer-reviewed: Yes  

**Publication information**

Journal: IEEE Journal of Emerging and Selected Topics in Power Electronics  
Volume: 2  
Issue number: 4  
ISSN (Print): 2168-6777  
Ratings:  

*Publication Forum (2017):* 1  
*Scopus rating (2016):* 2.194 2.298  
*Publication Forum (2016):* 1  
*Scopus rating (2015):* 2.259 2.811  
*Web of Science (2015):* 3.129 3.129 2.0 0.339 0.00305 1.449  
*Publication Forum (2015):* 1  
*Scopus rating (2014):* 0.879 2.375  
*Publication Forum (2014):* 1  
*Publication Forum (2013):* 1  
Original language: English  
DOIs:  

10.1109/JESTPE.2014.2313704

**Bibliographical note**

Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-11-30<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE  
Source: researchoutputwizard  
Source-ID: 1565  
Research output: Scientific - peer-review › Article

**Effect of conventional grid-voltage feedforward on the output impedance of a three-phase photovoltaic inverter**

**General information**

State: Published  
Ministry of Education publication type: A4 Article in a conference publication  
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)  
Authors: Messo, T., Jokipii, J., Suntio, T.  
Number of pages: 8  
Pages: 514-521  
Publication date: 2014  

**Host publication information**

Title of host publication: International Power Electronics Conference, ECCE ASIA, IPEC-Hiroshima, May 18-21, 2014, Hiroshima, Japan  
Place of publication: Piscataway, NJ  
Publisher: Institute of Electrical and Electronics Engineers IEEE  
ISBN (Print): 978-1-4799-2705-0  
DOIs:  

10.1109/IPEC.2014.6869632
Effect of input and output terminal sources on dynamic behavior of switched-mode converters

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Suntio, T., Viinamäki, J., Jokipii, J., Messo, T., Sitbon, M., Kuperman, A.
Number of pages: 7
Pages: 2240-2246
Publication date: 2014

Host publication information
Title of host publication: International Power Electronics Conference, ECCE ASIA, IPEC-Hiroshima, May 18-21, 2014, Hiroshima, Japan
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-2705-0
DOIs:
10.1109/IPEC.2014.6869901

Effect of network configuration and load profile on efficiency of LVDC distribution network

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Rekola, J., Jokipii, J., Suntio, T.
Number of pages: 10
Pages: 1-10
Publication date: 2014

Host publication information
Title of host publication: EPE 14-ECCE Europe, the 16th European Conference on Power Electronics and Applications, 26-28 August 2014, Lappeenranta, Finland
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/EPE.2014.6910919

Effects of demand response on load profiling of small-scale customers

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Efficiency of Converters and Amorphous Core AC-Filters in an LVDC Distribution

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Rekola, J., Tuusa, H.
Number of pages: 8
Pages: 1827-1834
Publication date: 2014

Host publication information
Title of host publication: 29th Annual IEEE Applied Power Electronics Conference and Exposition (APEC 2014), March 16-20, 2014, Forth Worth, Texas, USA
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-2325-0
DOIs: 10.1109/APEC.2014.6803554

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Source: researchoutputwizard
Source-ID: 1372
Research output: Scientific › peer-review › Conference contribution

Electricity Distribution Pricing Methodology In Finnish Regulation Framework - A Case Study of Matching Principle

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Electrical Engineering
Authors: Lummi, K., Mákinen, A., Mutanen, A., Järventausta, P.
Number of pages: 12
Pages: 1-12
Publication date: 2014

Host publication information
Title of host publication: NORDAC 2014, The 11th Nordic Electricity Distribution and Management Conference, 8-9 September 2014, Stockholm, Sweden

Publication series
Name: Elforsk rapport 14:32

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-11-30
Frequency Domain Methods for Transmission Network Planning to Assess Subsynchronous Torsional Interaction due to High Voltage Direct Current Transmission System

General information
State: Published
Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Department of Electrical Engineering
Authors: Rauhala, T.
Number of pages: 87
Publication date: 2014

Publication information
Place of publication: Tampere
Publisher: Tampere University of Technology
Original language: English

Publication series
Name: Tampere University of Technology. Publication
Publisher: Tampere University of Technology
Volume: 1272
ISSN (Print): 1459-2045

Bibliographical note
Awarding institution: Tampere University of Technology

Holistic View of Active Distribution Network and Evolution of Distribution Automation

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Repo, S., Ponci, F., Della Giustina, D.
Number of pages: 6
Pages: 1-6
Publication date: 2014

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7799-8
DOI:
10.1109/ISGTEurope.2014.7028980
Links:
http://www.ieee-isgt-eu.org/

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-30

Impact Evaluation of PV Generation on LV Networks

General information
Influence of humidity and temperature on the dielectric properties of thermally sprayed ceramic MgAl2O4 coatings

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Niittymäki, M., Lahti, K., Suhonen, T., Kanerva, U., Metsäjoki, J.
Number of pages: 4
Pages: 94-97
Publication date: 2014

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7523-5
DOIs: 10.1109/CEIDP.2014.6995894

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-30
Source: researchoutputwizard
Source-ID: 1140
Research output: Scientific - peer-review › Conference contribution

Influence of Low Amounts of Nanostructured Silica and Calcium Carbonate Fillers on the Large-Area Dielectric Breakdown Performance of Bi-axially Oriented Polypropylene

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Rytöluoto, I., Lahti, K., Karttunen, M., Koponen, M., Virtanen, S., Pettersson, M.
Number of pages: 4
Pages: 655-658
Publication date: 2014

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7523-5
DOIs:
Influence of Major Disturbances in Electricity Supply on the Operating Environment of Distribution System Operators: a Case Study

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Stranden, J., Krohns-Välimäki, H., Verho, P., Sarsama, J., Hälvä, V.
Number of pages: 10
Pages: 363-372
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: International Review of Electrical Engineering: IREE
Volume: 9
Issue number: 2
ISSN (Print): 1827-6660
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.556 0.556
Publication Forum (2016): 1
Scopus rating (2015): 0.384 0.387
Publication Forum (2015): 1
Scopus rating (2014): 0.469 0.503
Publication Forum (2014): 1
Scopus rating (2013): 0.373 0.711
Publication Forum (2013): 1
Scopus rating (2012): 0.32 0.529
Publication Forum (2012): 1
Scopus rating (2011): 0.306 0.975
Scopus rating (2010): 0.261 0.269
Scopus rating (2009): 0.15 0.252
Original language: English

Bibliographical note
Contribution: organisation=dee,FAC1=1
Portfolio EDEND: 2014-12-30
Publisher name: Praise Worthy Prize
Source: researchoutputwizard
Source-ID: 1415
Research output: Scientific - peer-review > Conference contribution

Load Control System of an EV Charging Station Group

General information
State: Published
Ministry of Education publication type: B3 Non-refereed article in conference proceedings
Organisations: Department of Electrical Engineering
Authors: Rautiainen, A., Järventausta, P.
Number of pages: 11
Pages: 1-11
Publication date: 2014

Host publication information
Losses of Converters with Iron and Amorphous Core AC-Filter Inductors in an LVDC Distribution

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, Smart Energy Systems (SES)
Authors: Rekola, J., Jokipii, J., Suntio, T.
Number of pages: 7
Pages: 1-7
Publication date: 2014

Host publication information
Title of host publication: 40th Annual Conference of the IEEE Industrial Electronics Society, October 29 - November 1, 2014, Dallas, TX, USA
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ISBN (Print): 97814799940325
DOI:
10.1109/IECON.2014.7048714

Modeling Rotation in Electrical Machines

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Authors: Kettunen, L., Kurz, S., Tarhasaari, T., Räisänen, V., Stenvall, A., Suuriniemi, S.
Number of pages: 10
Pages: 1-10
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Magnetics
Volume: 50
Issue number: 4
ISSN (Print): 0018-9464
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.48 0.915
Publication Forum (2016): 1
Scopus rating (2015): 0.565 1.207
Web of Science (2015): 1.277 1.328 8.5 0.139 0.02867 0.358
Publication Forum (2015): 1
Scopus rating (2014): 0.715 1.491
Web of Science (2014): 1.386 1.395 8.4 0.169 0.03242 0.403
Net environmental impacts of low-share wood pellet co-combustion in an existing coal-fired CHP (combined heat and power) production in Helsinki, Finland

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Automation Science and Engineering
Authors: Judl, J., Koskela, S., Korpela, T., Karvosenoja, N., Häyrinen, A., Rantsi, J.
Number of pages: 8
Pages: 844-851
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Energy
Volume: 77
ISSN (Print): 0360-5442
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.999 1.798
Publication Forum (2016): 3
Scopus rating (2015): 2.276 2.046
Web of Science (2015): 4.292 4.81 4.2 0.636 0.06258 0.984
Scopus rating (2014): 2.647 2.63
Web of Science (2014): 4.844 5.153 3.9 0.819 0.04667 0.923
Publication Forum (2014): 2
Scopus rating (2013): 2.54 2.593
Publication Forum (2013): 2

Scopus rating (2012): 0.788 1.574
Publication Forum (2012): 1
Scopus rating (2011): 0.829 1.445
Scopus rating (2010): 0.698 1.134
Scopus rating (2009): 0.644 1.098
Scopus rating (2008): 0.788 1.165
Scopus rating (2007): 0.71 1.152
Scopus rating (2006): 0.913 1.232
Scopus rating (2005): 1.024 1.258
Scopus rating (2004): 0.813 1.129
Scopus rating (2003): 1.056 1.094
Scopus rating (2002): 1.078 1.027
Scopus rating (2001): 0.707 1.007
Scopus rating (2000): 0.831 1.022
Scopus rating (1999): 0.918 1.249
Original language: English
DOIs:
10.1109/TMAG.2013.2290101

Bibliographical note
Contribution: organisation=dee_FACT1=1<br/>Portfolio EDEND: 2014-06-18<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 707
Research output: Scientific - peer-review › Article
Observers and splitting structures in relativistic electrodynamics

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Authors: Auchmann, B., Kurz, S.
Number of pages: 72
Pages: 1-72
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Journal of Physics A: Mathematical and Theoretical
Volume: 47
Issue number: 43
ISSN (Print): 1751-8113
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.879 0.868
Publication Forum (2016): 1
Scopus rating (2015): 0.921 0.963
Web of Science (2015): 1.933 1.591 9.7 0.625 0.04241 0.711
Publication Forum (2015): 1
Scopus rating (2014): 0.92 0.918
Web of Science (2014): 1.583 1.476 9.3 0.615 0.05048 0.714
Publication Forum (2014): 2
Scopus rating (2013): 0.926 1.002
Publication Forum (2013): 2
Scopus rating (2012): 1.016 1.05
Publication Forum (2012): 2
Scopus rating (2011): 0.934 0.946
Scopus rating (2010): 1.056 1.037
Optimizing the accuracy of electrical models of PV systems operating under non-ideal conditions

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Torres-Lobera, D., Valkealahti, S.
Number of pages: 8
Pages: 1-8
Publication date: 2014

Host publication information
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Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs: 10.1109/EPE.2014.6910873

Bibliographical note
Contribution: organisation=dee,FACT1=1
Portfolio EDEND: 2014-11-30
Publisher name: Institute of Physics Publishing Ltd.
Source: researchoutputwizard
Source-ID: 124
Research output: Scientific - peer-review › Article

Possibilities to protect pole-mounted distribution transformers by means of externally gapped MO arresters

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, Smart Energy Systems (SES)
Authors: Lahti, K., da Silva, D.
Number of pages: 4
Pages: 1-4
Publication date: 2014

Host publication information
Title of host publication: 2014 International Conference on High Voltage Engineering and Application, ICHVE 2014, September 8-11, 2014, Poznan, Poland

Bibliographical note
Contribution: organisation=dee,FACT1=1
Portfolio EDEND: 2014-10-31
Publisher name: Institute of Physics Publishing Ltd.
Source: researchoutputwizard
Source-ID: 1642
Research output: Scientific - peer-review › Conference contribution
Power hardware in-the-loop laboratory test environment for small scale wind turbine prototype

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Mäkinen, A., Messo, T., Tuusa, H.
Number of pages: 10
Pages: 1-10
Publication date: 2014

Host publication information
Title of host publication: EPE 14-ECCE Europe, the 16th European Conference on Power Electronics and Applications, 26-28 August 2014, Lappeenranta, Finland
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/EPE.2014.6910804

Bibliographical note
Contribution: organisation=dee,FAC1=1
Portfolio EDEND: 2014-12-22
Source: researchoutputwizard
Source-ID: 1002
Research output: Scientific - peer-review › Conference contribution

Protection Heater Delay Time Optimization for High-Field Nb3Sn Accelerator Magnets

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Authors: Salmi, T., Ambrosio, G., Caspi, S., Chlachidze, G., Felice, H., Marchevsky, M., Prestemon, S., ten Kate, H.
Number of pages: 5
Pages: 1-5
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Applied Superconductivity
Volume: 24
Issue number: 3
ISSN (Print): 1051-8223
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.395 1.031
Publication Forum (2016): 1
Scopus rating (2015): 0.35 0.935
Web of Science (2015): 1.092 0.903 5.3 0.629 0.01158 0.229
Recognition of irradiance transitions caused by moving clouds harmful to the operation of PV systems

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering
Authors: Lappalainen, K., Valkealahti, S.
Number of pages: 4
Pages: 2650-2653
Publication date: 2014

Host publication information
Place of publication: Munich, Germany
Publisher: WIP
Editors: Bokhoven, T., Jäger-Waldau, A., Helm, P.
ISBN (Print): 3-936338-34-5
DOI:
10.4229/EUPVSEC20142014-5BV.1.23
Links:
http://www.eupvsec-proceedings.com/

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-31<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1439
Research output: Scientific - peer-review → Article
Reliability analysis of an ACA attached flex-on-board assembly for industrial application

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Authors: Kiilunen, J., Frisk, L.
Number of pages: 9
Pages: 62-70
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Soldering and Surface Mount Technology
Volume: 26
Issue number: 2
ISSN (Print): 0954-0911
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.311 0.863
Publication Forum (2016): 1
Scopus rating (2015): 0.244 0.608
Web of Science (2015): 0.913 0.842 6.3 0.038 3.5E-4 0.19
Publication Forum (2015): 1
Scopus rating (2014): 0.228 0.859
Web of Science (2014): 0.872 0.727 5.7 0.167 3.2E-4 0.166
Publication Forum (2014): 1
Scopus rating (2013): 0.196 0.523
Publication Forum (2013): 1
Scopus rating (2012): 0.277 0.67
Publication Forum (2012): 1
Scopus rating (2011): 0.158 0.651
Scopus rating (2010): 0.181 0.511
Scopus rating (2009): 0.287 1.006
Scopus rating (2008): 0.207 0.604
Scopus rating (2007): 0.321 0.865
Scopus rating (2006): 0.259 0.743
Scopus rating (2005): 0.411 1.056
Scopus rating (2004): 0.419 0.893
Scopus rating (2003): 0.206 0.798
Scopus rating (2002): 0.197 0.856
Scopus rating (2001): 0.188 0.831
Scopus rating (2000): 0.195 0.261
Scopus rating (1999): 0.263 0.549
Original language: English
DOIs:
10.1108/SSMT-03-2013-0007

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-11-30<br/>Publisher name: Emerald Group Publishing Ltd.
Source: researchoutputwizard
Source-ID: 721
Research output: Scientific - peer-review › Article

Ripple field losses in direct current biased superconductors: Simulations and comparison with measurements
Secure integration of the Home Energy Management System to the battery management system in the customer domain of the smart grid
Organisations: Department of Electrical Engineering, Department of Automation Science and Engineering, Smart Energy Systems (SES)
Authors: Jafary, P., Repo, S., Koivisto, H.
Number of pages: 5
Pages: 1-5
Publication date: 2014

**Host publication information**
Title of host publication: IEEE Power & Energy Society General Meeting, 27-31 July, 2014, National Harbor, MD, United States
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOI: 10.1109/PESGM.2014.6938986

**Bibliographical note**
Contribution: organisation=dee,FACT1=0.7<br/>Contribution: organisation=ase,FACT2=0.3<br/>Portfolio EDEND: 2014-11-30
Source: researchoutputwizard
Source-ID: 567
Research output: Scientific - peer-review › Conference contribution

**Shear Strength of Eutectic Sn-Bi Lead-Free Solders After Corrosion Testing and Thermal Aging**

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Authors: Mostofizadeh, M., Pippola, J., Frisk, L.
Number of pages: 12
Pages: 1335-1346
Publication date: 2014
Peer-reviewed: Yes

**Publication information**
Journal: Journal of Electronic Materials
Volume: 43
Issue number: 5
ISSN (Print): 0361-5235
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.487 0.76
Publication Forum (2016): 1
Scopus rating (2015): 0.586 0.844
Web of Science (2015): 1.491 1.566 5.8 0.23 0.01317 0.363
Publication Forum (2015): 1
Scopus rating (2014): 0.69 1.083
Web of Science (2014): 1.798 1.77 5.6 0.254 0.01513 0.441
Publication Forum (2014): 1
Scopus rating (2013): 0.713 1.109
Publication Forum (2013): 1
Scopus rating (2012): 0.866 1.318
Publication Forum (2012): 1
Scopus rating (2011): 0.841 1.157
Scopus rating (2010): 0.777 1.049
Scopus rating (2009): 0.927 1.148
Scopus rating (2008): 0.875 0.961
Scopus rating (2007): 0.897 1.067
Scopus rating (2006): 1.041 1.241
Scopus rating (2005): 1.12 1.236
Simple method for measuring output impedance of a three-phase inverter in dq-domain

Sizing energy storage to be used in parallel with grid connected PV inverters to balance the output power fluctuations due to varying insolation
Standard-based Secondary Substation Automation Unit - the ICT Perspective

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Lu, S., Repo, S., Della Giustina, D.
Number of pages: 6
Pages: 1-6
Publication date: 2014

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7720-8
DOIs: 10.1109/ISGTEurope.2014.7028792
Links:
http://www.ieee-isgt-eu.org/

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-30
Source: researchoutputwizard
Source-ID: 968
Research output: Scientific - peer-review › Conference contribution

Test of the High-Field Nb3Sn Dipole Magnet HD3b

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering
Number of pages: 6
Pages: 1-6
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Applied Superconductivity
Volume: 24
Issue number: 3
ISSN (Print): 1051-8223
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.395 1.031
Publication Forum (2016): 1
Scopus rating (2015): 0.35 0.935
Web of Science (2015): 1.092 0.903 5.3 0.629 0.01158 0.229
Publication Forum (2015): 1
Time and frequency-domain evidence on power quality issues caused by grid-connected three-phase photovoltaic inverters

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Messo, T., Jokipii, J., Aapro, A., Suntio, T.
Number of pages: 9
Pages: 1-9
Publication date: 2014

Host publication information
Title of host publication: EPE 14-ECCE Europe, the 16th European Conference on Power Electronics and Applications, 26-28 August 2014, Lappeenranta, Finland
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/EPE.2014.6910808

Bibliographical note
Contribution: organisation=dee,FACT1=1
Portfolio EDEND: 2014-12-31
Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1029
Research output: Scientific - peer-review → Article
Validation of an Inclusive Dynamic-Thermal and Electric Simulation Model for PV Systems with Measurements from a Commercial Grid-Connected PV Inverter

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering
Authors: Torres-Lobera, D., Valkealahti, S.
Number of pages: 5
Pages: 2794-2798
Publication date: 2014

Host publication information
Place of publication: Munich, Germany
Publisher: WIP
Editors: Bokhoven, T., Jäger-Waldau, A., Helm, P.
ISBN (Print): 3-936338-34-5
DOI: 10.4229/EUPVSEC20142014-5BV.2.2
Links:
http://www.eupvsec-proceedings.com/

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2014-12-10
Source: researchoutputwizard
Source-ID: 1643
Research output: Scientific - peer-review › Conference contribution

MO Surge Arresters Stresses and Test Procedures: CIGRE Technical Brochure, WG A3.17

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Electrical Engineering, Research area: Power engineering
Number of pages: 146
Publication date: Aug 2013

Publication information
Publisher: International Council on Large Electric Systems CIGRE
Volume: 544
Original language: English
Research output: Professional › Commissioned report

A comparision of measures to reduce the intensity of magnetic field outside high voltage power substations

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering
Authors: Okun, O., Shevchenko, S., Korpinen, L.
Number of pages: 5
Pages: 108-112
Publication date: 2013

Host publication information
Title of host publication: 18th International Symposium on High Voltage Engineering, ISH 2013, in Hanyang University in Seoul, Republic of Korea from August 25 to 30, 2013
Article number: PA-11

Publication series
An Advanced STATCOM Model for Optimal Power Flows Using Newton's Method

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Kazemtabrizi, B., Acha, E.
Number of pages: 12
Pages: 1-12
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Power Systems
ISSN (Print): 0885-8950
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 3.757 3.624
Publication Forum (2016): 3
Web of Science (2015): 3.342 4.234 8.5 0.363 0.0357 1.469
Scopus rating (2014): 2.831 3.577
Web of Science (2014): 2.814 3.899 8.7 0.359 0.02492 1.061
Publication Forum (2014): 3
Scopus rating (2013): 2.939 4.35
Publication Forum (2013): 3
Scopus rating (2012): 2.177 3.516
Publication Forum (2012): 3
Scopus rating (2011): 1.725 3.254
Scopus rating (2010): 1.949 2.826
Scopus rating (2009): 1.94 2.723
Scopus rating (2008): 1.537 2.448
Scopus rating (2007): 1.24 2.521
Scopus rating (2006): 1.233 2.316
Scopus rating (2005): 1.582 2.547
Scopus rating (2004): 1.036 2.843
Scopus rating (2003): 2.669 2.652
Scopus rating (2002): 2.271 2.337
Scopus rating (2001): 1.708 1.837
Scopus rating (2000): 1.169 3.37
Scopus rating (1999): 0.418 1.408
Original language: English
DOIs: 10.1109/TPWRS.2013.2287914

Bibliographical note
Contribution: organisation=dee,FACT1=1<br/>Portfolio EDEND: 2013-11-29<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 2537
A Theoretical Investigation of the Influence of Underground Power Cable Parameters on Magnetic Field Levels

Examples of spark discharge under a 400 kV power line

Examples of UV Measurements under 400 kV Powerlines in Finland
Input voltage control of a three-phase Z-source inverter in photovoltaic applications

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Jokipii, J., Messo, T., Suntio, T.
Number of pages: 8
Pages: 1-8
Publication date: 2013

Host publication information
Title of host publication: Conference Proceedings of the 2013 4th IEEE International Symposium on Power Electronics for Distributed Generation Systems, (PEDG), July 8-11, 2013, Rogers, Arkansas, USA
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/PEDG.2013.6785600

Modeling the Grid Synchronization Induced Negative-Resistor-Like Behavior in the Output Impedance of a Three-Phase Photovoltaic Inverter

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Smart Energy Systems (SES)
Authors: Messo, T., Jokipii, J., Mäkinen, A., Suntio, T.
Number of pages: 7
Pages: 1-7
Publication date: 2013

Host publication information
Place of publication: Piscataway, NJ
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/PEDG.2013.6785602
Possible Methods for Limiting Magnetic Fields outside a High Voltage Power Substation by Changing the Phase Sequence of Busbar Wires

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering
Authors: Okun, O., Shevchenko, S., Korpinen, L.
Number of pages: 4
Pages: 1109 - 1112
Publication date: 2013

Host publication information
Links:
http://piers.org/piersproceedings/download.php?file=cGlIcnMyMDEzU3RvY2totb2xtfDJQX0tfMTEwOS5wZGZ8MTMwMzE5MDc1MjIz
http://www.piers.org/piersproceedings/

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2013-09-29
Source: researchoutputwizard
Source-ID: 3054
Research output: Scientific - peer-review » Conference contribution