Special Report - Session 3
OPERATION, CONTROL AND PROTECTION

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Introduction

The interest in Session 3 –like the interest in CIRED at all– is still and constantly growing. The –once again– record number of 468 abstracts received for Session 3 underlines this growing interest impressively. Due to the extreme high number of abstracts received for Session 3, the Chairman and Rapporteurs had to be –once again– quite strict in rejecting papers. Since the quality of abstracts and full papers is constantly increasing during the last years, even well written abstracts had to be rejected in order to keep a manageable number of papers during the conference

Therefore 150 abstracts were accepted by National Committees and the Technical Committee (TC); and the authors were called to submit a full paper, which means, that nearly two-third of the proposed abstracts had to be rejected. Finally 141 full papers have been accepted for Session 3. Fig. 1 gives an overview of the review process.

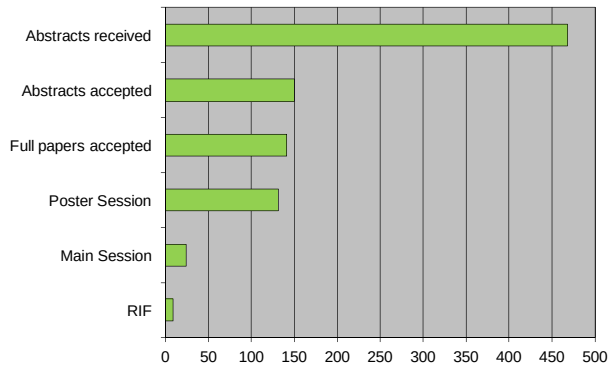


Fig. 1: Overview of the review process

All authors are asked for a poster presentation during CIRED 2015, 24 of them will additionally present their paper in the Main Session and ten papers are allocated to the Research and Innovation Forums (RIF).

Traditionally and according to the topics of the papers submitted, Session 3 is structured into three blocks. Each of these blocks is divided into sub blocks to have a better overview:

Block 1 Operation

- Maintenance and Condition Assessment
- Distribution Management
- Blackout Prevention / Crisis Management

Block 2 Control

- Low-Voltage Automation
- Medium-Voltage Automation
- High-Voltage Automation / Phasor Measurement Units (PMU)
- SCADA / Distribution Management Systems
- Communication
- Islanding

Block 3 Protection

- Fault Location / Earth Fault
- Applications
- Algorithms and Simulations
- Fault Ride Through

In the area of grid **operation** the subject maintenance condition assessment has been established. Once again a lot of papers have been submitted for this topic since it is not solved sufficiently, yet. Nevertheless it is a major problem because most maintenance and renewal strategies are fundamentally based on a correct assessment of the component condition.

The major number of papers is related to the sub block Distribution Management. One focus in the block is the reduction of losses.

In the meantime the topic "blackout prevention" and "the management of crisis" is an established part in this block, due to the increasing responsibility of distribution network operators in case of emergence.

In the area of grid **control** two trends can still and clearly be observed: As a first trend more and more automation of Medium Voltage (MV)-grids or even of Low Voltage (LV)-grids can be considered – these voltage levels are getting smarter and smarter. Roughly 50 % of all papers about Control can be related to these two sub blocks. This comes along with a higher demand on communication and corresponding techniques and infrastructure. Several papers discuss the islanding of networks. This topic becomes more important and highlight two issues: (i) the detection of islanded grid and (ii) the operation of islanded grids.

The **protection** block covers new applications of established protection concepts, several types of fault locations (e.g. earth faults, high impedance faults), new algorithms and simulations and the new sub block fault ride through. For a long time the topic "fault location" is a wide field of developments, simulations and practical experiments. New protection algorithms and strategies are developed and shown in simulations as well as in applications. Applications and practical tests are very interesting and most important to support new protection devices and systems. An upcoming topic is titled with "Fault Ride Through". According to the European standards different strategies are discussed to keep the distribution grid stabile.

An overview of the number of papers related to the different blocks and sub blocks is given in **Erreur ! Source du renvoi introuvable.**.

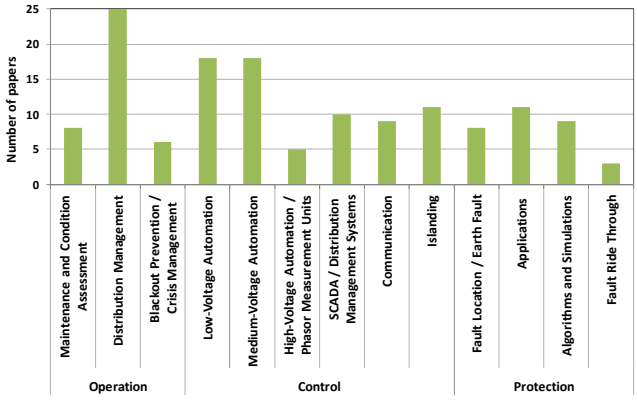


Fig. 2: Paper overview of blocks and sub blocks

Block 1: "Operation"

In this block 39 papers were received, covering several issues in the area of grid operation. For giving a better overview, this block is divided into three sub blocks:

- Maintenance and Condition Assessment
- Distribution Management
- Blackout Prevention / Crisis Management

Sub block "Maintenance and Condition Assessment"
The main topics in this sub block are Preventive Maintenance, Monitoring on Operating Resources and Strategies of Condition Assessments.

Two papers are describing monitoring applications. An "Integrated Monitoring System for Distribution Substations" is discussed in paper 0282, coming from Portugal. The monitoring system includes three independent parts, Thermal Monitoring, Corona Discharge Detection and Intrusion Detection, sharing some hardware and computing capabilities. This system provides both alarm and warning messages to staff in charge, corresponding to instant detection of appliance failures, as single events, as much as early warning of probable future malfunctions, from trend analysis of slow varying analogue data. Thus, allowing faster and more reliable condition diagnosis of Distribution HV/MV Substations and, therefore, accurate and timely responses whenever required, the present solution is part of a broader sophisticated framework of asset management, which provides gains in operation efficiency, power availability and overall quality of service.

Paper 0664 is coming from Spain and describes practical experience of a "Partial Discharge (PD) Monitoring Application" on a private medium voltage (MV) distribution and experimentation grid. Important for the future is continuous expanding the database of typical PD sources that can be found on networks in different "real life" situations. This database is being used to continually improve upon algorithms designed for the early identification and localization of possible faults.

Preventive maintenance is discussed in paper 0648 from Egypt. Power transformers are the most expensive and strategically important components on any power system. Their proper and continuous function is important for the reliability of the system at all. Their failures can impose extraordinary high costs on plants, factories and utilities.
The preventive maintenance technologies adopted by Alexandria Electricity Distribution Company (AEDC) for power transformers are shown in this paper. These technologies can be divided into two categories. The first category is the infrared thermography which has been used for detecting temperature abnormalities on external

surfaces of the transformer (see Fig. 3). The second one is the partial discharge testing which monitors the insulation breakdown of power transformer through the electromagnetic waves or the sound waves production.

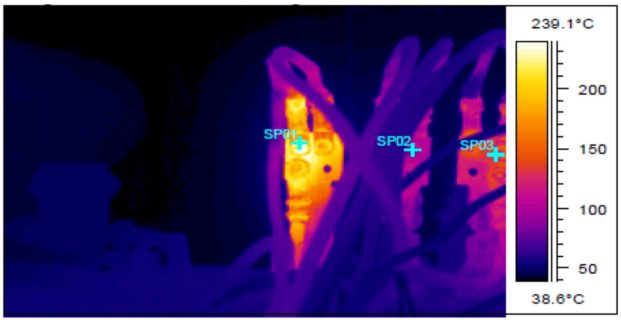


Fig. 3: Transformer bushing, increasing temperature in all three phases

A thermography measurement on transformers is also the main topic of paper 0810 from Brazil. External tank temperature rises are an important indicative that the distribution transformer is in excessive overhead. Fig. 4 presents the daily loss of life estimated and measured in the laboratory for balanced and unbalanced loads with a fitted curve indicating the daily loss of life as function of average load during the peak load cycle, with a statistic confidence interval of 95%.

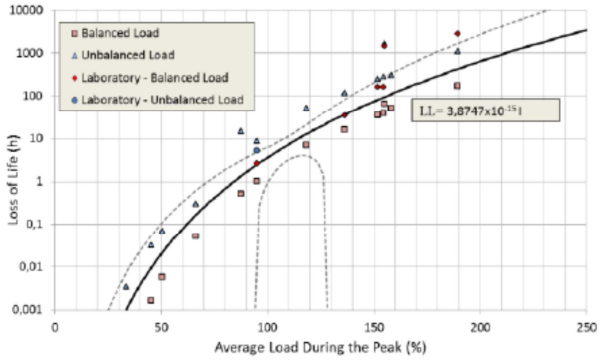


Fig. 4: Daily loss of life depending on the maximum loading at the peak load (18-23h)

Paper 0815, coming from Brazil too, proposed a method to model the cost-benefit of preventive maintenance investments on electric distribution systems. The main advantages of the proposed method are described in this paper. The application of the methodology using real data from a Brazilian utility shows that the method can successfully forecast the frequency of interruptions using maintenance investments as inputs. This can be a powerful tool to be integrated with traditional maintenance strategies in utilities, using data from their own feeders.

A new approach in the area of asset maintenance management is moving from standard time based and break-through maintenance to more sophisticated methods like condition based and predictive maintenance. Paper 1030 from Slovenia explains how asset management strategy corrects the behaviour of maintenance decision intelligence while determining when to maintain and replace assets.

Power line inspection involves examining the pylons, connectors, loose bolts and nuts and their high voltage insulators. This process is increasingly performed by helicopters. Paper 1276 form Portugal describes a new method, doing this inspection by "Unmanned Aerial Vehicles (UAV's)". Visual and thermal inspections, corridor mapping, LIDAR and GIS data services and other features are shown in this paper.

Paper 1626, coming from China, is presenting the comprehensive assessment of the reliability and economy of a 10 kV XLPE cable. Referring to the IEC and other international standards, combined with the product standards of the manufacturers, the ampacity improvement has been developed. By measuring the core temperature of wires, the actual load flow in different cables and laying conditions, provides the basis for analysis to improve asset utilization, the efficiency and the safety of cables.

Sub block "Distribution Management"

The sub block "Distribution Management" contains 25 papers coming from the UK, Brazil, Canada, India, the Netherlands, Germany, Portugal, Norway, Italy, Finland, Belgium, Poland, France, China, Spain and Austria.

Three of these papers (706, 822 and 1486) are about smart grids. Paper 706 from Italy describes the evolution of a defence plan for an electrical system towards the smart grid. The dramatic increase of distributed generation (DG) connected both at MV and LV levels, driven by incentive policies mainly to wind and photovoltaic (PV), the Italian system operator elaborated a new annex of grid code. All solutions described are hypothesis finalizing for reaching a smart management of a defence plan in compliance with requirements of grid code (European and Italian in specific case).
In paper 822 from Poland the results of a pilot smart grid project are discussed. The paper focuses on an analysis and the results of the Smart Grid project, especially on new possibilities to reduce technical losses the in MV and LV networks.
A data repository for automated evaluation of smart grid solutions is presented in paper 1486 from Greece. This paper describes the design of a data repository that is used to store scenarios from six successful smart grids demonstration projects that are analysed within the EC IGREENGrid project. The data repository is flexible and scalable and can be used to automatically calculate Key Performance Indicators (KPIs) and facilitate the comparison between technical solutions. The repository architecture is shown in Fig. 5.

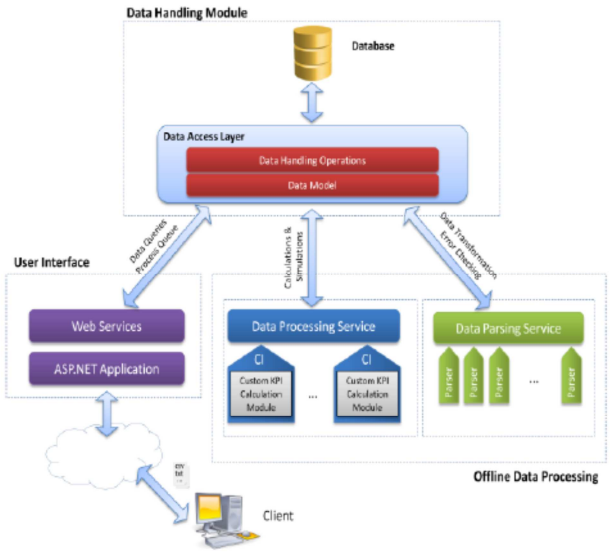
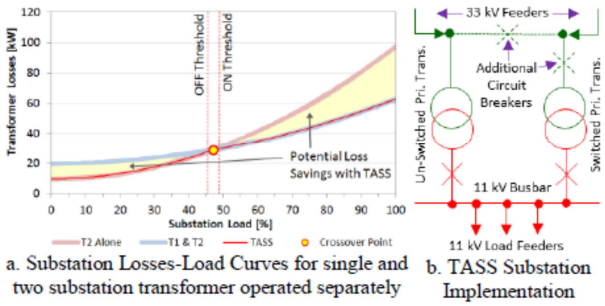


Fig. 5: Repository architecture

Different kinds of losses are covered in the papers 0070, 0225 and 0613.

Paper 0070 coming from the UK presents a novel method called Transformer Auto Stop-Start (TASS) that will automatically energise and de-energise one of a pair of transformers at a HV/MV substation, therefore reducing overall substation electrical losses and related carbon emissions. The paper also presents the TASS performance benefits (assessed against a variety of substation which are existing and future load and generation scenarios) and associated challenges in its implementation in 'real world' distribution networks.



a. Substation Losses-Load Curves for single and two substation transformer operated separately

b. TASS Substation Implementation

Fig. 6: Substation Arrangement, Switching Logic, and Loss Savings

The behaviour of the losses of two transformers in a substation and the so called "Crossover Point" is illustrated in Fig. 6a. A high level hardware implementation of TASS scheme at a 33/11 kV substation is outlined in Fig. 6b.

The purpose of paper 0225 from Canada is to develop models for the evaluation of distribution substation CVR (Conservation Voltage Reduction), using electrical and meteorological quantities obtained from the measurements. The paper will first expose the theory of polynomial approximations for a function of n variables, using relative uncertainties to develop models for the evaluation of global and individual CVRs later, respectively for distribution substations and loads.

In paper 0613 from France a day-ahead optimization algorithm based on dynamic programming logic was proposed. The goal of the algorithm is to ensure minimum operating expenditures for DSOs, based on the valorization of network actions for the utilization of flexibilities and also penalties for network problems. The proposed algorithm was tested on a reduced-scale test network at the University of Grenoble-Alps under different conditions. The results show a significant improvement in network operating conditions, and a very good overall decrease in DSO expenditures.

Work Force Management (WFM) is one common topic of the papers 0232, 0354, 0357 and 1277.

Paper 0232, coming from India, describes how Tata Power (India's largest integrated power company) has enhanced consumer services through the auto generation of service tickets on the basis of SMS received from Modem and in house development of a GIS tool that enables a call centre executive to respond to consumer complaints proactively.

Paper 0354, coming from Portugal, shows a new mobility solution to give access to field teams to the HV and MV network schematics that are stored in the GIS that holds all network data base. By using an image of the GIS schematics, one guarantees that the information that is provided to the teams is accurate and in sync with what the dispatch operators use. By doing so, the necessity of updating the single-line diagrams is eliminated.

Fig. 7: Geospatial position of a damaged MV overhead line support with additional notes

In order to record further information from the field, this application provides basic sketching tools. This functionality allows the field teams to insert notes directly on the photo or emphasize small details like a specific damaged insulator of an isolator string or the damaged supports of an overhead line. This additional information is very useful in identifying problems and brings significant operational improvement to the process.

In paper 0357, also coming from Portugal, the dematerialisation of the information processes, regarding activities that are carried out in the field, maintenance, outage and commercial tasks, are only possible with the technological implementation of the WFM (Work Force Management) and MGIS (Mobility Geographic Information System) platform. All the activity characterization sheets are eliminated and the information is loaded directly into the mobility tool. On the other hand, the information collected in the field is directly registered through a specific workflow sorted by activity type and without data handling by other contributors. Thus, there is a significant increase in the quality of the information that will support the company's activity. This fact will improve the knowledge of the assets' condition and all the work related, which allows a better planning management decision.

In paper 1277 from Italy another method of paperless planning and dynamic scheduling is described. The so called ADL System (ADL is the acronym for Assegnazione Dinamica Lavori: the Italian translation is OTA - Optimal Task Assignment) is a homemade ENEL solution developed for scheduling and dispatching tasks for the crews. After five years of the project start the evolution of the ADL System is shown.

The challenge of implementing a new underground line in a crowded city is presented in paper 0088 from Brazil. This paper aims to show the experience acquired and the results achieved during the implementation of the design of the RSE Juscelino Kubitscheck 138 kV underground distribution line in the city of São Paulo. It shows the main data of the executive engineering project, the difficulties and solutions found during the construction and the methodology applied to the project management.

Paper 0254 from the Netherlands shows advantages of a closed-ring operation in medium voltage distribution grids. As power flows are able to naturally balance out between feeders of a ring shaped distribution grid, it is expected that peak loading will be reduced, and with that, grid losses. As such, investment costs can be postponed or avoided and operational costs can be reduced due to lower grid losses. This paper presents the results found in a field test, performed within a live distribution grid, which was operated in closed-ring configuration.

Paper 0309 from Germany proposes a novel dynamic design for control reserve dimensioning. In contrast to the current statistical analytic design a data driven approach with methods of computational intelligence is presented. A new methodology for predicting the amount of balancing power with methods of machine learning, namely with a two-step k-Nearest Neighbor regression is discussed.

Paper 0413 from Portugal provides a description of the OCR3 (Recloser for MV overhead lines) pilot project, presenting an overview on the implementation, the pilot network and its architecture. In order to mitigate the risk associated with the introduction of this new device in the grid, EDP carried out a pilot project in order to evaluate its behavior as a key component of the smart grid.

Paper 0677, coming from Norway, addresses the need for standardized reliability data management and systems for documentation. Failure frequencies and repair times are presented for the main components in the Norwegian power system for the periods 2004-2013 and 2009-2013, respectively, as well as failure causes. These data are collected and documented through the FASIT standard.

Paper 0710 from Finland researches how managing situation awareness (SA) can be developed in power distribution grid outages. Managing SA enables a fast recovery from the disturbance, minimizing the unwanted impacts of major disturbances, efficient management of the disturbance and delivering information to the stakeholders. SA is required for decision-making in a dynamic environment. Forming SA requires a system that combines, analyzes and shares the situation related information from different sources. In this paper the managing SA is divided into managing DSO's internal SA and stakeholders' SA.

Paper 0791 from Belgium proposes individual and aggregated EV (Electric Vehicles) charging models for different types of controlled and uncontrolled charging scenarios. These models represent EVs either as inflexible loads, or as flexible resources described by sets of constraints. The output of these EV aggregation models can be integrated in distribution grid optimization problems.

Paper 0911 gives an overall presentation of TC57 and an overview of TC57 production, with a focus on the field of Power Distribution, with a description of its objectives, and how it fits into the existing series. Furthermore, a description of the projects undertaken for the revision of the reference architecture for power system information exchange is presented.

Paper 1087 from Italy deals with the innovative SHAPE Web software platform for Data Analytics applied to the load patterns sourced from the Italian Enel network's smart meters. A previous contribution reported on the customer classification and segmentation modules implemented in the SHAPE platform. This work describes the Load prediction and Non-technical losses modules. The SHAPE Data Warehouse (DW) currently stores four years of progressively updated customer's load patterns.

Based on the concept of electricity demand elasticity and adjustable load, a design of hierarchical demand-side integration (HDSI) is discussed in paper 1233, coming from China.

Paper 1329 from Spain and paper 1357 from Italy both summarize the control mechanisms for operation of the future network (2030 and beyond) proposed by the ongoing EU-funded ELECTRA Integrated Research

Programme (IRP) on Smart Grids. After describing a future grid scenario in compliance with the European Energy Strategy, the new ELECTRA control scheme is introduced to outline a high-level functional architecture for frequency and voltage control. The future role of resources connected to the distribution network for the provision of ancillary services is formulated and the requirements necessary for the integration of all stakeholders is drafted.

The high penetration of DER into the European power system requires a radical new approach to the real time grid operation. The ELECTRA IRP is active in the definition of the new system requirements, deploying flexibility resources to be triggered in response to proper grid observable inputs. ELECTRA proposes to organize the power grid as a web-of-cells (see Fig. 8), where a cell is defined as "a group of interconnected loads, distributed energy resources and storage units within well-defined grid boundaries corresponding to a physical portion of the grid and to a confined geographical area".

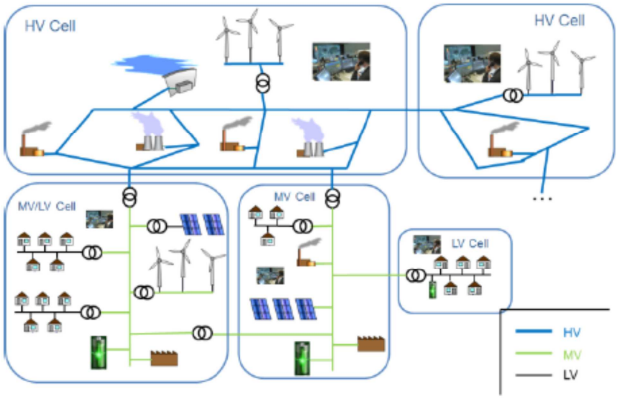


Fig. 8: Schematic example of proposed "Web of Cells" architecture

Cells are connected to their neighbors via inter-cell physical tie lines.

Paper 1374 from Brazil presents a multi-objective mathematical model for optimal allocation of automated devices with protection and switching capabilities in distribution networks. A contingency simulation-based technique is used to model distribution reliability considering the protection system response to faults and the post-fault restoration, thus incorporating the most important actions that have impact on the performance of distribution systems. In addition to reliability criteria, the investment costs are also taken into account in determining number and locations of automated devices. In this paper, restoration constraints are addressed by a linear power flow whose nodal-current equations are formulated as functions of geographical locations of the automated switches in a feeder.

The implementation of Advanced Distribution Automation (ADA) functions in a way that it allows students to be aware of developments in the control and the management of the distribution network. In paper 1439 from France, many aspects are discussed: implementation of ADA functions such as Sequential Opening of Branches' (SOB) and Voltage Control' (VC) algorithms. The communication tools of PREDIS µnetwork were also discussed.

In Paper 1467 from Austria, the authors show the influence of grounded conductive structures connected to the earthing system during a ground fault in the station and of the fault current distribution. As a result, touch and step voltages and potential transfers during an earth-fault and other fault cases can be identified, for example in a transformer station or a cable to overhead line pylon. To round the paper off, some statistical approaches for the evaluation of grounding systems are shown. As Fig. 9 shows that inside of the global earthing system (village with about 40 single-family homes and foundation earthing electrodes) no high touch voltages have to be expected. The same applies to the area of the substation.

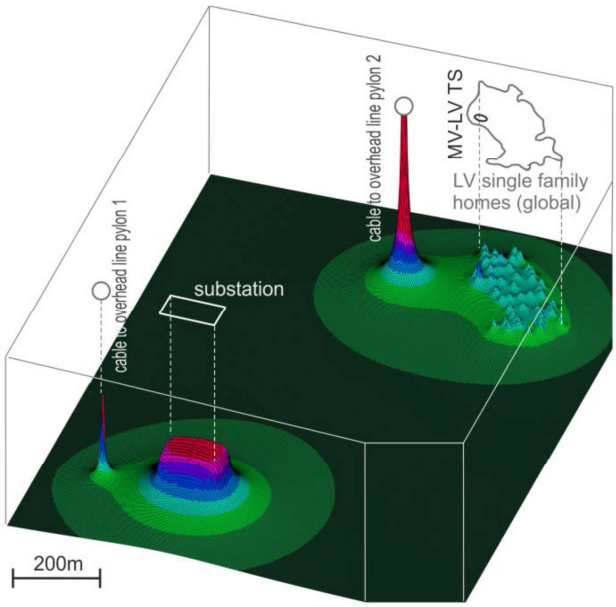


Fig. 9: Earth surface potential

Sub block "Blackout Prevention / Crisis Management"

In this sub block papers from Pakistan, the Netherlands, Portugal, Germany, Slovenia and Finland will be discussed.

Paper 0265 from Pakistan presents the design of an intelligent blackout management system augmented by a load shedding system. The blackout management becomes more effective, ensuring proper shutdown of plants for safety of equipment and personnel. In addition to it, a restart of plant has become much easier considering the availability of power on different buses throughout the site.

Reduction of outage time is one of the major goals of network operators. One way to reduce the outage time is to train outage crews in fast and efficient outage restoration. Paper 0308 from The Netherlands describes a training program for outage crews set up by Enexis, one of the major distribution network operators in The Netherlands. The most important part of this training is done with two simulators, both a hardware version and a software version. This paper describes the whole training that has been set up, with special attention to the application of the software simulator.

Paper 0346 from Portugal describes how extreme scenarios like thunderstorms, strong winds, snow or extreme heat require organizational flexibility to improve operational effectiveness and recovery time in the electrical network. For higher effectiveness several extreme scenarios occurred, after 2009; they are compared in performance to get benchmarks with other electrical utilities.

Paper 0603, coming from Germany, shows that the behavior of the 110-kV-grid is important for the calculation of the active power flows and the reactive power demand of the transmission grid. To cope with this challenge and to account for all controllability within the 110-kV-grid, the authors propose an extended system equivalent to integrate the sub transmission grid into the SSA. Within this model all controllable nodes are represented. The grid structure itself is modelled with the help of the ward reduction algorithm. It is shown that the model is highly accurate for the contingency analysis within the System Security Assessment (SSA).

Severe icing has caused a big disturbance in Slovenia in February 2014 (see Fig. 10). Paper 0923 from Slovenia outlines the circumstances which lead to severe icing, main problems which were caused by severe damage over the big territory and the extreme duration of disturbances. The conclusions and possible solutions for disturbances to mitigate in future are presented in this paper.

Fig. 10: Ice caused damage on an overhead line

Paper 1123 from Finland presents a demonstration of the inter-organizational situation awareness system developed in this research. The demonstration consists of an internet service which combines information about disturbances in the electricity supply from DSOs' information systems and information from other actors. The demonstration illustrates how the exchange of information between actors can be executed by using a situation awareness system. It extends the integration of DMS (Distribution Management System) in an unusual direction by taking the other actors into account.

Table 1: Papers of Block 1 "Operation" assigned to the Session 3

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Maintenance and Condition Assessment					
0282	Integrated Monitoring System for Distribution Substations				
0648	Preventive Maintenance Technologies for Power Transformers in Alexandria Electricity Distribution Company				
0664	Practical Experience of a Partial Discharge Monitoring Application on an Experimentation MV Distribution Network				
0810	Methodology for preventive replacement of overload distribution transformers based on external tank thermography measurements				
0815	Robust method to evaluate cost-benefit from preventive maintenance actions using historical data and an optimization algorithm				
1030	Asset Management Decision Intelligence based on the Condition (Risk) Importance Method with Dynamic Weighing Factors				
1276	Inspection of high voltage overhead power lines with UAV's				
1626	10kV XLPE cable ampacity improvement research in Guangzhou area	X			
Distribution Management					
0070	Transformer Loss Reduction with Varying Substation Load-Generation Profiles				
0088	The Challenge of Implementing a New Underground Line in a crowded city				
0225	Models of CVR Evaluation for the Hydro-Quebec Distribution Networks				
0232	"Proactive" Handling of Power Failure Complaints by Call Center				
0254	Closed-Ring Operation of Medium Voltage Distribution Grids - Theory meets Practice	X			
0309	Dynamic Dimensioning of Balancing Power with Flexible Feature Selection				
0354	Dispatch Web Application for Field Operation Support				
0357	Asset Management and Process Dematerialization in EDP, the Contribution of the Workforce Mobility System (WFM) Integrated with the Geographic Information System (GIS) Mobility Solution				
0413	Last Generation Reclosers for MV Overhead Lines at EDP Distribuição - Results and Conclusions				
0613	A Dynamic Programming Based Approach to Day-Ahead Operational Cost Reduction for DSOs			X	
0677	Reliability data management by means of the standardised FASIT system for data collection and reporting				
0706	Evolution of defence plan for electrical system to towards the smart grids				
0710	Managing Situation Awareness in Power Distribution Grid Disturbances				
0791	EV aggregation models for different charging scenarios				
0822	The increase in the power network observability as a data source to improve the efficiency of power network - results of the pilot Smart Grid project				
0911	Advanced standardization in distribution system management and associated information exchange				
1087	SHAPE: the non-technical losses detection and load prediction modules				
1233	Preliminary Study on the Hierarchical Demand-Side Integration in China Power Grids				

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Distribution Management					
1277	ADL - Scheduling and Assignment Optimisation: the Dynamic Version				
1329	Scenarios and requirements for the operation of the 2050 electricity network				
1357	ELECTRA IRP approach to Voltage and Frequency control for future power systems with high DER penetration	X			
1374	Methodology for Optimal Allocation of Protection and Switching Devices in MV Distribution Networks				
1439	Development of Advanced Distribution Automation functions on an analogical micro distribution network for training				
1467	High Current Earth Fault in Resonant Grounded Networks under Aspects of a Global Earthing System	X			
1486	A Data Repository for Automated Evaluation of Smart Grid Solutions				
Blackout Prevention / Crisis Management					
0265	Managing Blackout for a Large Industrial Distribution Network				
0308	Simulator for training of outage crews	X			
0346	Organizational flexibility for extreme scenarios effectiveness				
0603	An advanced model of distribution grids with renewable generation for transmission system security assessment				
0923	A big disturbance in Slovenia in February 2014 caused by severe icing	X			
1123	Demonstration of the Inter-Organizational Situation Awareness System to Major Disturbances				

Block 2: „Control“

Block 2 „Control“ contains 80 papers within six categories:

- Low-Voltage Automation
- Medium-Voltage Automation
- High-Voltage Automation / Phasor Measurement Units (PMU)
- SCADA / Distribution Management Systems
- Communication
- Islanding

About 50 % of the selected papers discuss the Low and Medium Voltage Automation as shown in the fig. 11. An increasing portion of papers also discuss the effects of islanding of electrical power systems.

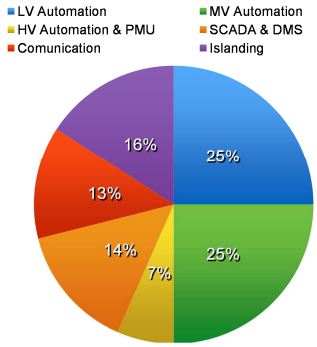


Fig. 11: Distribution of papers to the six sub blocks

Sub block „Low Voltage Automation“
18 Papers discuss the Low Voltage Automation of electrical power systems. One major aspect of low voltage automation papers are voltage control functions in LV power systems. Especially the use of on-load tap changers have analysed in most of the papers.

Paper 0053 of Maschinenfabrik Rheinhausen shows the operation of a MV/LV transformer with On-Load Tap Changer (OLTC) in LV grid with high penetration of PV generation. The paper describes four different voltage control algorithms which were tested on a real German LV grid. The paper compares these control options regarding costs and effectiveness.

Paper 0111 from RWTH Aachen, Germany, has investigated synchronization under current limitation for grid, inverter and load variations within reasonable boundaries. The behavior of inverters in case of load steps has been analyzed. As current limitation is obligatory, a severe impact would threaten the operation of inverter only islanded grids.

Paper 0301 (see also the similar paper 1102) addresses the modeling of unknown power values, so-called pseudo-measurements, for the use in distribution grid state estimation. Historical load data from smart metering devices in private households and photovoltaic systems is analyzed regarding phase distribution, reactive power and correlation between different generators. As one result the paper shows that use of indirect measurements, meta information, e.g. time, and probabilistic estimation methods of active power are essential for real time application and might further reduce the estimation errors.

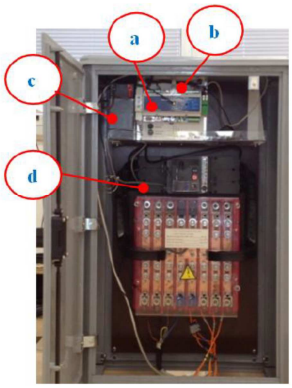


Fig. 12: Photo of the junction box with S-RTU: a) µUP, b) power supply, c) battery, d) motorized switch.

Paper 0694 from Enel, Italy, presents the design and the development of a Smart Infrastructure based on Remote Terminal Unit and on a Remote Control System for several applications in LV grid. The concept of Smart Grid has led Enel to design a new infrastructure for the LV grid management based on: Low Voltage Remote Control Center, Multi carrier communication system and Smart Remote Terminal Unit (see Fig. 12).

Paper 0755 is looking after distributed intelligence on LV networks. The system has been implemented into a rural network of rural community in Oxfordshire with around 2,500 residents and 800 properties. The paper describes Distributed Intelligence concept on the LV network including hardware, solution and platform concept. An Open Platform is an initiative to allow 3rd party applications to execute their software on the system in a secure manner.

The Chinese paper 0823 is presenting the use of FACTS (flexible alternative current transmission systems) in distribution networks. Generally switched capacitors and controlled reactors encounter the inherent disadvantages such as low accuracy, slow response speed, complicated calculation of capacitor currents, etc. To solve this problem, a device based on the flexible grounding technique to suppress the three- phase unbalanced voltage is proposed. Flexible grounding technique is developed from the flexible alternative current transmission system (FACTS).

The German Paper 0930 proposes an algorithm for linear LV state estimation based on smart meter data and photovoltaic feed-in predictions. The results gathered from simulations and field tests are promising, especially due to a special approach resulting in a relatively high measurement redundancy which is not common for state

estimation in LV grids. The project with 6 partners started in 2013 and includes a smart meter rollout in a semi-urban LV grid and the development of LV state estimation algorithms based on smart meter data and PV-feed-in-forecasts. The increased measurement redundancy leads to the fact that bad data analysis works great for voltage measurements even in asymmetrical cases provided that the accuracy of pseudo measurements is sufficient.

Paper 1029 reviews the state of the art of distribution state estimation (DSE), focusing on the requirements for smart distribution grid applications, the effects of distribution network characteristics and bad data detection capability. The performance of DSE methods is evaluated by using Taiwan Power Company (TPC) 3-phase unbalance 39 bus test system. The paper presents a comparison between three existing weighted least square based DSE formulations.

Optimization of power flow in distribution grids is the focus of paper 1045 from France.The paper introduces a concept for optimal power flow management in distribution grids, using DER flexibility. With the concept LV4MV the authors show how low voltage DER management can successfully be used to manage the medium voltage network. The economical and technical optimization will take into account the OLTC position of the HV/MV transformer as well as the cost and performance of activation of MV and LV flexibilities, determined by a method based on the voltage sensitivity analysis of local flexibilities.

Another method for monitoring and control of LV grids called GridBox is presented by paper 1070 from Switzerland. GridBox is an open platform for monitoring and active control of distribution grids. It is based on an innovative concept that comprehensively addresses the challenges DSOs will be exposed to in the context of increasing amounts of decentralized and often fluctuating generation as well as the electrification of the heat and transportation sector .

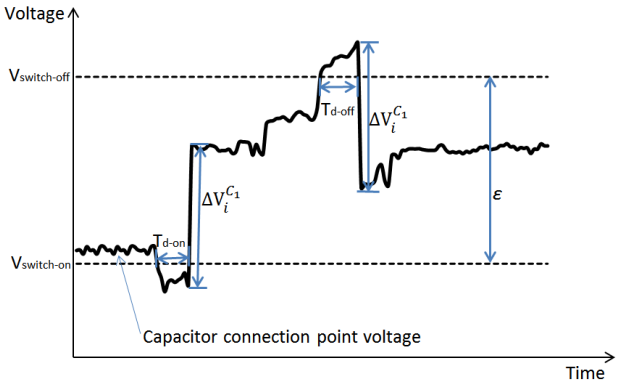


Fig. 13: Voltage-based control of the capacitor banks

Paper 1210 is using capacitor banks for voltage control in distribution grids.The capacitors are placed in the more loaded LV feeders and are operated in a decentralized voltage-based control mode. Results demonstrate that it is possible to effectively manage voltages by adopting the highest off-load tap position (lowest busbar voltage) and the coordinated control of capacitor banks (see Fig. 13).

„NO SMART MV/LV STATION WITHOUT A SMART APPROACH“ is the headline of paper 1259. The paper describes the pilot project KRIS in the Netherlands where pilot systems for automated substations were installed. The complete project and it requirements form specification phase up to the installation is shown.

Paper 1300 from USA and Canda serves as a practical guide to estimating the benefits associated with Smart Distribution (SD) technologies. The methodology defined will assist utilities in making proactive capital expenditure (CAPEX), operational expenditure (OPEX) investments and justify these expenditures during rate hearings. Also, the methodology will assess, estimate and calculate numerical values of benefits.

The French paper 1319 shows the Volt VAr control at the LV distribution level in the GreenLys pilot project. The area is in Lyon and also includes the conference location of this CIRED 2015. The solution presented uses the experience of Volt VAr control from MV grid in the LV networks. The voltage measurements are sent to the voltage regulation box with a wireless communication system. The regulation box algorithm manages the booster transformer and the reactive electronic device in order to deliver the most adapted voltage to the LV grid (see Fig. 14).

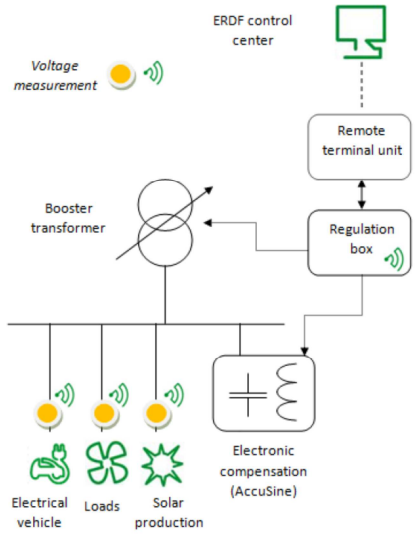


Fig. 14: Volt VAr control solution developed in GreenLys

Paper 1325 discusses how to select a smart grid / smart metering architecture that is able to adapt to change. The presentation provides guidelines, criteria about how to select for the short term and limit risk for the long term.

The focus is on selecting solutions that create an open architecture and do not lock you into a specific standard.

Also paper 1328 is looking to voltage regulation. This paper outlines the process and steps ERDF intends to follow to assess which Smart Grid solutions tested in ongoing French demonstrators. The objectives of this screening process are to assess from a technical, economic, social, and organizational perspective if some solutions should be industrialized and elaborate recommendations for the roll-out. The paper also details two examples of smart solutions related to voltage regulation within the VENTEEA demonstrator.

The Swiss paper 1546 introduces the concept of synchronized control of many inverters distributed on a low voltage network. It is shown in this paper that intelligence and communicating capability added to Active In feed converter could reduce risk and even represent an advantage for the grid operability. The concepts developed during the project have been simulated but also implemented on industrial components in the new GridLab laboratory (see fig. 15) at the University of applied science of western Switzerland HES-SO Valais.

Fig. 15: Principle scheme and view of components used to emulate prosumers and feeders in the Gridlab units.

Sub block „Medium Voltage Automation“

18 Papers discuss the Medium Voltage Automation of electrical power systems. Also the discussion of medium voltage automation is mainly focusing the voltage control. Two papers (0924 and 1071) are discussing the testing of smart systems.

Paper 0029 from Serbia considers the possibility for determining On-Load Tap Changer (OLTC) position using primary and secondary (tertiary) currents and voltages of transformers equipped with OLTC. Different influences on algorithm accuracy like analog inputs errors of Intelligent Electronic Devices, transformer turn ratio errors, instrument transformers accuracy errors, errors due to magnetizing (no load) currents and voltage drop were considered. Results of practical check are given in order to prove applicability with aim to improve reliability in particular segments of electricity distribution: automation, protection and control.

The German large scale demonstration project of the FP7 funded European project GRID4EU is described in paper 0184. The paper addresses the development, implementation and field test of an autonomous grid control system in the Medium Voltage (MV) level. The German Demo of the European project GRID4EU is focused on the basic idea of an autonomously acting and switching grid control system in the medium voltage level. The approach enables an autonomous interaction between the installed modules and their responsibility for a defined part of the MV network. Figure 16 shows the basic communication structure of the system:

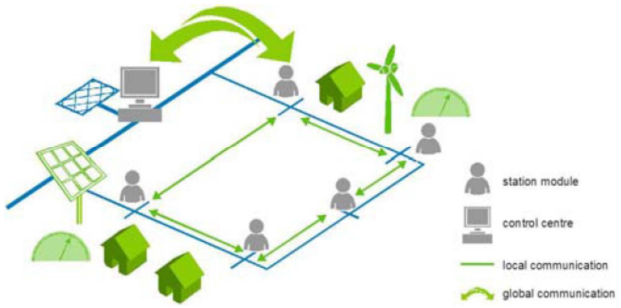


Fig. 16: Basic communication structure

The central issue of paper 0512 from Austria is the analysis of the reactive power behavior in the presence of distributed generation and the outline of a method to control and dynamically optimize the reactive power flow. The coordination and the control of the Volt/var in medium and high voltage grid is proposed to be realized by two secondary control loop types for the MV grids and HV grids respectively. Results show that the local control of decentralized reactive power produces an uncontrolled reactive power flow in the high voltage grid and changes the static behavior of the load seen from it. Under these conditions, the coordinated operation of medium and high voltage grids is essential to maintain efficient and safe operation of the power system and to facilitate further DG integration.

Paper 0560 from South Korea presents the effectiveness of local voltage regulation scheme in MV feeder with 3MW wind turbines. Due to the reverse power flow of distributed generations (DG), the conventional step voltage regulator (SVR) is unable to regulate voltages properly in the distribution network with DGs and thus the network may be subjected to over- and under-voltage circumstances easily. In order to solve these voltage problems, an active voltage manager for SVR has been developed and tested at the realistic Korea electric power corporation (KEPCO) distribution network.

Paper 0712 analyzes an automatic control mechanism that frees the system operator of to evaluate all control actions that optimize the process in real time. This paper proposes to apply a control strategy based in static voltage maintenance by injecting or absorbing reactive power inherent in each of the network components as well taps changers of the HV/HV and HV/MV transformers.

Paper 0924 from USA discusses in detail the requirements for functional testing of devices and distributed functions used in distribution automation systems. The methods for testing of both types of systems are proposed.

Paper 0936 describes the experiences gained from two practical implementations of automated distribution feeder self-healing pilot projects. The first project, located in the Isle of Wight in UK, was implemented for Scottish and Southern Energy plc (SSE) The primary objectives of the SSE pilot program were to evaluate the benefits of PulseClosing technology and an automated feeder self- healing solution using distributed intelligence. The second project was implemented for State Grid Corporation of China (SGCC) and is located in Ningxia, China. The primary objectives of the SGCC pilot program were to investigate the potential of an automated feeder self-healing solution to improve reliability.

The second paper dealing with the testing of smart devices is paper 1071 from Portugal. This paper provides the results of an implementation of a commissioning test system for smart devices used on SmartGrid national rollout. The paper provides experience and architectures of the system as also challenges for ICT. The project provides an invaluable tool for field commissioners/testers and back office operators that manage the system integration (SCADA, AMI, etc.), ensuring an adequate, reliable and faster installation process for smart meters and switchgear/transformer controllers/RTUs.

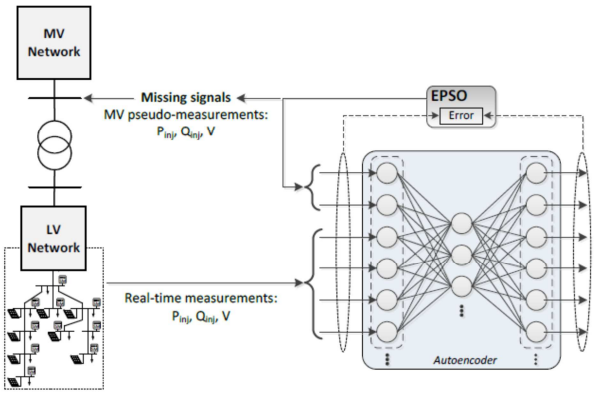


Fig. 17: Illustration of the methodology proposed for pseudo-measurements generation.

Paper 1102 see also the similar paper 0301) presents a new method to generate pseudo- measurements of different electrical quantities for distribution secondary substations. The idea is to take advantage of the stronger correlation that exists between electrical variables in a given MV/LV substation and the correspondent downstream network. Autoencoders trained with historical data are integrated on an optimization algorithm, together with real-time metering information of the LV network, for accurately estimate pseudo-measurements at the correspondent MV/LV substation (see Fig. 17).

The next paper is from Germany. The authors of paper 1126 are developing a decentralized automation concept for monitoring and control of MV-grids (see Fig. 18). The paper gives a comprehensive analysis of the impact of LV-interconnections on the grid state identification for a decentralized MV automation concept. The superordinate scope of the research work is to develop an integrated automation system for LV and MV grids, which enables an integrated smart distribution solution.

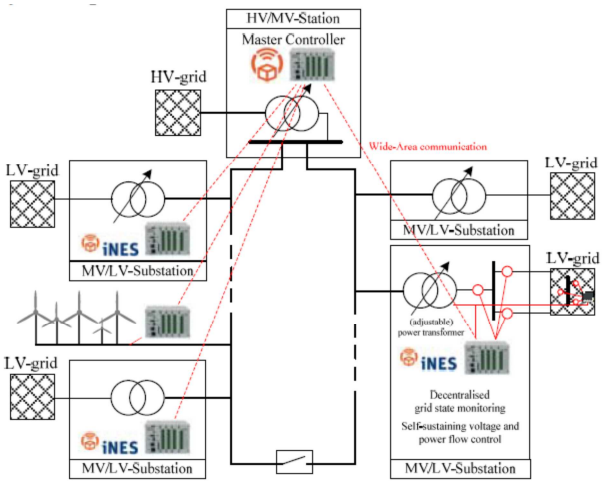


Fig. 18: Integrated automation system for LV- and MV-grids

Paper 1323 presents an overview of the activities of the CIGRE/CIRED C6.25/B5 Joint Working Group (JWG), focusing on the control and automation systems for the future electric networks. This JWG is mainly focus to evaluate the level of automation and control necessary to better manage distribution networks with large penetrations of DER, as seen from the both the TSO and DSO perspectives, and to provide services and information about the two level of management (i.e at TSO and DSO level). The C6.25/B5 JWG aims at addressing the following issues: (i) Survey on the state of the art on planning for active distribution systems; (ii) Requirements of planning methodologies; (iii) Identification of short, medium and long term models for active distribution system planning; (iv) reliability models of active distribution systems; and (v) algorithms for active distribution system expansion and upgrade

planning, including demand-side integration and storage.

The Brazilian paper 1343 aims to describe a substation-based self- healing solution with advanced features for monitoring and control of the electric grid, developed as part of the utility's Smart Grid Project. The solution will be implemented in one of AES Eletropaulo's substations, "Tambore", which has 14 feeders and 25 reclosers. The solution presents a substation-based architecture with advanced features to control and monitor the electric system. The self-healing solution performs advanced analyses as the ones performed by centralized solutions, without requiring the same communication infrastructure.

Paper 1411, coming from Portugal, describes the work done in the 3PHASE project, regarding the development of a state estimator for distribution networks handling substantial integration of DER, AMI (Advanced Metering Infrastructure) data and unbalanced and asymmetrical configurations. The load and DER power allocation presented here, as part of a DMS system, constitutes a first estimation of the network, assuming an extreme importance for other studies as it helps solve the lack of measurements problem.

Paper 1506 from China also highlights voltage control strategies. The paper illustrates the impact of distributed generation to the voltage profile and control strategies of distribution networks.

The application of distribution system state estimation on engineering instrumentation zones of low carbon London is the topic of paper 1510. The authors discuss the performance and presents potential benefits of the application of State Estimation on real distribution network. The application is tested using real network measurements and demonstrates that the deployed distribution system state estimation, through a limited number of optimally placed sensors with adequate accuracy, can robustly estimate voltage and power flows in high voltage distribution networks.

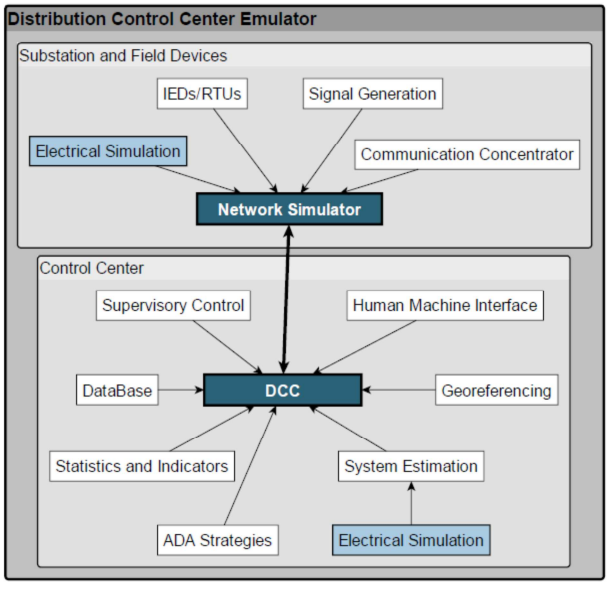


Fig. 19: Functional Blocks in the emulator.

Also paper 1529 from Brazil is dealing with state estimation and presents a fuzzy state estimation approach applied to medium voltage distribution networks. The algorithm implemented merge concepts of fuzzy regression, load allocation and robust state estimation.

In paper 1565 the Columbian authors describe one methodological approach to design and implement control center emulators with distributed real-time hardware and algorithms founded in the Common Information Model. The proposed model, based on actor framework, for CIM on control center emulation has the ability to integrate new components and applications without information loss (see Fig 19).

Sub block „High Voltage Automation & PMU"

5 Papers discuss the High Voltage Automation and the use of PMU within electrical distribution systems.

First paper within this block is Paper 0185 from Czech Republic. The authors report about 10 years experience since the first experiments with VVC function deployment in the CEZ Distribuce, a.s. 110 kV network.

The Belgium authors of paper 0576 show how a distribution grid state estimator combined with the deployment of a limited number of PMU's in the medium voltage grid can help to increase observability, and highlights what is needed to attain sufficient accuracy. A real-time demo platform was setup in an urban area on three different MV-grids to evaluate the concepts in a real-life situation.

Paper 0773 proposes a frequency-adaptive weighted least squares-based algorithm for accurate identification and estimation of synchronized measurements over wide frequency range. A new mathematical formulation is performed to estimate all synchronized components of a single-phase voltage or current input signal when spurious frequency such as harmonics and off-nominal frequency, within the range of ±5 Hz around the fundamental frequency, are presented.

Paper 0812 from Austria presents the implementation of a wide area measurement system (WAMS) in a 110kV grid. The theoretical considerations is supported by practical experiences during non-disturbed grid operation and islanded grid restoration tests within the grid of the KNG-Kärnten Netz GmbH (KNG), an Austrian DSO. Furthermore, off-line analyses of PMU data are used to gain a better understanding of the dynamic behavior of the grid. Due to the new challenges in distribution systems, PMU applications can be used to support the grid operation in the sub-transmission voltage levels. The PMU data are visualized online, as shown in Fig. 20, in the control centre of the KNG to support the operating staff.

Fig. 20: Online visualization of the PMU data

Also paper 1046 shows the use of PMU in distribution grids. In a joint effort of the Delta Network Group (DNWG) and VSL, the national metrol- ogy institute of the Netherlands, a project is started for monitoring a heavily loaded 50 kV ring of the DNWG network with phasor measurement units (PMUs). A set of six PMUs is installed in five substations of the ring with the aim to gain more insight in the grid behaviour, especially in dynamic events caused by the large amount of RES connected to the 50 kV ring.

Sub block „SCADA and Distribution Management Systems“

11 papers discuss the High Voltage Automation and the use of PMU within electrical distribution systems.

The first paper 0004 is from Austria and addresses the support of the grid operators in a centralized operational control room with real-time correlation of data from a lightning detection system with information from SCADA, from a distribution management system (DMS) and from an outage management system (OMS). The requirements of the grid operators are met with a new application within network control-systems. The resulting information enables the operators to reclose tripped circuit breakers or to dispatch the maintenance crew more accurately and hence to obtain quicker restoration times.

Paper 0150 from Italy shows that a precise evaluation of the distribution network technical losses is crucial to plan efficiency actions on the network. For this reason, Enel Distribuzione, the main Italian distribution system operator, customized its Distributed Management System and integrated it to other Corporate Systems in order to get accurate and reliable results on losses calculation.

The Portuguese paper 0351 from EDP Distribuição shows the rusts of an OMS project. One of the major objectives of the OMS upgrade Project is to address the issue to generate more real-time information for regulator and customers, by having simultaneous and complementary approaches.

Paper 0387 shows the use of fault information from protection devices to locate the failure even if not all of the relays can provide the necessary information. The solution was to install an off-the-shelf communications gateway with special software for fault location calculation from disturbance recordings. The proposed algorithm was then tested against the outputs of vendor’s protection unit’s.

Paper 0406 demonstrates how effective visualization strategies and intuitive workflow guidance can support distribution grid operators in coping with tomorrow’s challenges. Firstly, it will describe a methodology for understanding the requirements for Advanced Distribution Management Systems (ADMS) from an end-user perspective and illustrate an example outcome which has been evaluated with users. Secondly, it will introduce two new strategies for enhancing situational awareness.

The paper 0482 addresses techniques to improve operation efficiency and data management and it shows the benefits of system integration for utilities. The advanced approach has been put in place by Romande Energie for the integration of IT and OT systems and for sharing data efficiently between the SCADA DMS, the Geographical Information System and the Enterprise Systems.

Another big issue of future network operation and control is big data which addressed by paper 0556. In this research, the authors tease out three rules of the big data for the electricity sector and induce a systematic criteria framework for building and evaluating data models for supporting the electricity-system big data.

Paper 1334 describes the main developments of the LV SCADA project and addresses the technical challenges to be tackled when managing LV grids. The project entails the development of technological solutions that contribute for an effective Smart Grid implementation, creating flexible solutions allowing the anticipation of future trends, supporting the introduction of new technical, commercial and regulatory solutions to improve operation efficiency. It includes a description of the architecture, main functionalities and control capabilities associated to a new advanced LV SCADA.

Paper 1550 describes E.ON’s Smart Grid Control Center vision, deployment experience and discusses integrated Demand Response Management System, Distributed Energy Resource management and Volt VAr Optimization to deploy the Virtual Power Plant.

The last paper in this sub block is paper 1570 from Brazil. This paper introduces an alarm processing without using any connectivity information of the substation electrical network. In order to do so, timestamp and location readily defines specific alarm patterns. In this sense, the proposed algorithm resembles the typical procedure that operators do.

Sub block „Communication“
Communication technologies are getting more important due to increasing need of automation. 9 papers discuss communication technologies.

Paper 0224 builds on the in-service advantages realized using IEC 61850-8-1 for the digital control system, including the full protection and control scheme, extending the implementation to include the process bus too. Correct application of the standards has allowed a lot more of the substation engineering and construction activity to be undertook in the controlled environment of the factory, rather than on the substation site – where outage times and site labour are at a premium.

Paper 0459 from Iran present a new synchronization method of fractional chaotic system based on unscented Kalman filter (UKF) which is applicable in a secure protocol for WSN to overcome the drawbacks of small key space and weak security in the used integer order systems.

The Slovenian paper 0541 describes an innovative approach in management of SLA parameters inside the ICT networks, which should support different Smart Grids applications, for communication data flows between broad range of end devices in DSO's ICT networks and furthermore also other subsystems needed by DSO to provide business and operational services to the users inside the organization. DSO's ICT networks tend towards converged networks, based on Ethernet/IP protocols, where the management of SLA parameters became important task.

Paper 0557 from Finland is focusing the issue of Cyber security. This paper presents an approach taken to handle these cyber security vulnerabilities by way of careful assessment of vulnerability reports and its applicability to IEDs/devices. Also described are careful analysis of cyber security updates, integration of these updates into the IED software architecture and making the IED's cyber security architecture remain relevant and able to handle the cyber security vulnerabilities effectively.

Back to the communication protocols traditionally used for communication is paper 0596 looking to IEC 61850. The paper covers some substation automation experiences based on the IEC 61850 GOOSE messages for an specific automation function applied to a substation topology commonly known as 'H' and the use of the GOOSE messages in the communication between control and protection relays and remote I/O modules (RIO).

Paper 0925 from USA describes an engineering approach based on standard protection and control schemes developed by utilities and implemented using multifunctional intelligent electronic devices supporting the IEC 61850 standard. The use of substation configuration language files in the engineering process is also described in the paper.

The paper 1049 from Portugal defines the concept of medium voltage feeder automation systems (DAS) based on distributed intelligence within control areas, supported by the IEC 61850 family of standards. Open distributed feeder automation systems based on the IEC 61850 family of international standards will enable utilities to attain a very high level of Quality of Supply and optimized use of resources.

Paper 1291 is focusing on broadband power line pilot project in Belgium. Goal is to test if the BPL network could be used as an extension of the fiber network. Measurements between adjacent substations have been executed to understand the influence of different parameters like line length, line section, frequency mode, coupling devices.

Last paper in the sub block looks to reliability of communication systems. The Brazilian paper 1431 presents a methodology to evaluate the process bus reliability based on the reliability model for various network topologies. Considering the MTBF of the elements of the protection system, the reliability level of the whole system was determined and the results were analyzed.

Sub block „Islanding“
The last sub block islanding shows the need for more solutions to operate electrical grid in islanded mode 11 papers discuss islanding of grids.

The first paper 0294 from Japan focuses on the stand-alone power supply for a smart house that avoids inconvenience to residents when a blackout occurs. In the smart house, different types of power generation equipment (photovoltaic (PV), battery energy storage system (BESS), electric vehicle (EV), fuel cell (FC) systems etc.), which have different output power, capacity, and response time characteristics are used.

Paper 0480 is dealing with detection of islander grids. In order to improve the reliability of vector shift based islanding detection an advanced vector shift algorithm has been developed. This algorithm can use all three phase voltages or a positive sequence voltage for vector shift detection and will not cause nuisance tripping of DG units due to other network disturbances.

Paper 0507 from France shows that though the escalating frequency shift is potentially an efficient anti-islanding method (with possible restriction for industrial loads), its massive use may impair the stability of the power system. This islanding detection is authorized in some European countries and a question that may be raised is how much of it is actually implemented in Europe.

The Italian paper 0600 focuses on the validation of an innovative islanding detector, named SmartID, to be included into anti-islanding protection systems for LV distribution networks. The SmartID is designed to guarantee a reliable islanding detection when the classical voltage and frequency relays at the distributed generation

premises fail, due to their limited sensitivity.

Also an Italian paper 0699 focusses the issue of detecting islanded grids. The above mentioned short-term countermeasures will allow to detect uncontrolled islanding phenomena at MV feeder, portion of MV feeder, MV/LV substation or LV line level. Any uncontrolled operation of a network's portion has to be adequately managed in order to avoid mainly the risks for apparatus (DSOs and Users).

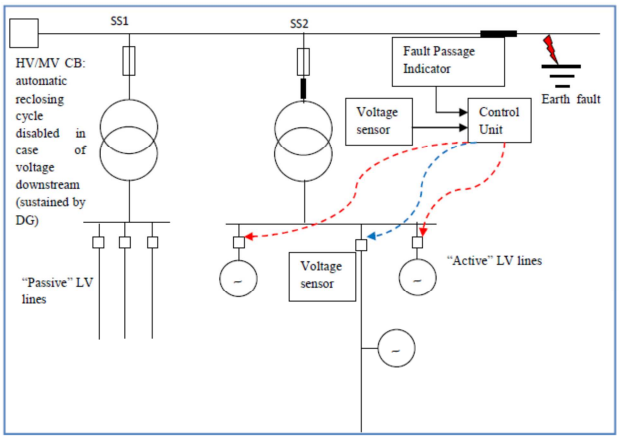


Fig. 21: Representative scheme of all equipment to manage the islanding phenomena.

Paper 0705 from France is discussing anti-islanding requirements. This paper deals with one of the main issues that such generators may cause, namely, unintentional islanding. The aim of the paper is thus to study how the non-detection zones of a standard test case (parallel RLC oscillating circuit) will be modified when these new requirements are implemented.

In paper0841 from Iran a new hybrid islanding detection method, using Sandia Frequency shift and Rate of Change of Frequency relay, to eliminate non detection zones has been proposed for islanding detection in hybrid AC/DC microgrid. Furthermore, the islanding detection method of the interlinking converter has been modified and coordinated with converters of DC subgrid to improve its operation.

In paper 0913 from Iran droop control based islanding microgrid will be evaluated in different fault conditions and the main causes of the grid instability will be discussed. In autonomous mode of operation, maintaining the service to the local loads when a fault or disturbance is occurred has the major importance. Therefore, evaluation of microgrid operation in standalone mode due to its large flexibility and limited power source of distributed generators (DGs) should be investigated. During fault condition, microgrid controllers should have the capability of maintaining system stability. In this paper droop control based islanding microgrid will be evaluated in different fault conditions and the main causes of the grid instability will be discussed.

The study of paper 0972 presents the challenges met by a distribution operator in unbalanced conditions, i.e. when the energy produced within a contour area by Distributed Generation units is greater than the load in the considered area. Analyse of two islanding events shows that new technologies must be implemented taking into consideration all particularities at a certain connection point in order to avoid harmful effects.

Paper 1011 is from Croatia. In this paper two experiences with plants will be presented, especially their influence on control and protection of distribution system. In Croatia feasibility study of distributed power plants (DPP) is one of steps during the process of accession DPP to distribution grid. Feasibility studies show the need for active protection methods or some other solutions (adaptive protection or inter-tripping).

The last paper 1449 of sub block islanding presents a charging control strategy of plug-in electric vehicles (PEVs) in a smart grid including network communication and information systems. The proposed strategy aims at reducing impact of Micro Grid (MG) stability problem during islanding mode, no power support from the main grid. MG model in this simulation study imitates the 22 kV 50 Hz electric power distribution system of Provincial Electricity Authority (PEA).

Table 2: Papers of Block 2 "Control" assigned to the Session 3

Paper No	Title	MS a.m.	MS p.m.	RIF	PS
Low Voltage Automation					
53	Apparent power dependent voltage control in the LV grids with distributed generation using on-load tap-changer transformers				
111	Influence of Virtual Impedance Design and Current Limitation on the Synchronization of Droop Controlled Inverters in Low Voltage Distribution System Islands with High R/X Ratio				
301	Impact of three-phase pseudo-measurement generation from Smart Meter Data on Distribution Grid State Estimation				
694	Enel Smart infrastructure for the Remote Control and Automation of LV Grid		X		
755	Distributed Intelligence on LV Networks - Proof of Concept Project				
823	FACTS Based Suppressing Techniques & Device of Three-phase Unbalanced Overvoltage for Distribution Networks				
930	State Estimation in Low Voltage Grids based on Smart Meter Data and Photovoltaic-Feed-In-Forecast				
1007	Flexible LV Grid for Dynamic Power Flow and Voltage Control				
1029	Requirements of State Estimation in Smart Distribution Grid				
1045	LV4MV: a concept for Optimal Power Flow management in distribution grids, using DER flexibility				
1070	GridBox - An open platform for monitoring and active control of distribution grids		X		
1210	Adoption of capacitors to mitigate voltage issues in low voltage networks with photovoltaic systems			X	
1259	NO SMART MV/LV STATION WITHOUT SMART THINKING				
1300	Guide to Estimate Benefits from Smart Grid Applications - FLISR and VVO				
1319	Volt VAr control at the LV distribution level in the GreenLys project		X		
1325	A Future proof architecture for Smart Grid and Smart Metering				
1328	A step beyond French demonstrators : first approach in terms of Smart Grid solutions industrial development. The example of voltage regulation solutions tested in Venteea demonstrator				
1546	Inverter to Grid: Voltage control strategies for the grid integration of Distributed Energy Resources				

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Medium Voltage Automation					
29	Tap changer position determination using new algorithm and possibilities of intelligent electronic devices				
184	The German large scale demonstration project inside GRID4EU:Challenges of an autonomous Medium Voltage control system		X		
410	Automatic Grid Recovery (AGR/ARA), the virtual Operator				
512	Uncontrolled Reactive Power Flow Due to Local Control of Distributed Generators				
560	Field test results of SVR operations based on measurement data for local voltage regulation on MV feeder with wind turbine		X		
712	Voltage Control Strategy in weak distribution networks with Hybrids Systems Generation.				
924	Ensuring the Correct Operation of Distribution Automation Systems				
936	EXPERIENCE WITH SELF-HEALING GRIDS				
1071	Safe, simple and fast commissioning of smart devices for MV and LV networks using new support tools				
1102	Using LV Real-Time Data for Pseudo-Measurements Generation in MV Distribution Networks			X	
1126	State identification methods for MV-grid automation with special regard to LV-interconnections		X		
1323	Control and Automation Systems for Electricity Distribution Networks of the Future – An Update on the activities of Joint Working Group CIGRE C6.25/ B5 /CIRED				
1343	Substation-Based Self-Healing Solution with Advanced Features for Control and Monitoring of Distribution Systems				
1411	DER and load allocation for an unbalanced distribution networks state estimator				
1509	Research on Coordinate Voltage Control Strategy of Active Distribution Network				
1510	Application of Distribution System State Estimation on Engineering Instrumentation Zones of Low Carbon London				
1529	Fuzzy State Estimation Applied to Smart Distribution Network Automation Functions				
1565	Distribution Control Center Emulator for Advanced Distributed Automation Tests				

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
High Voltage Automation and PMU					
185	ONLINE CLOSED-LOOP OPTIMIZATION OF DISTRIBUTION NETWORKSWITHOUT VERIFICATION OF DISPATCHER				
576	Benefits of phasor measurement units for distribution grid state estimation : practical results from an urban demonstrator				
773	Adaptive Weighted Least Squares-Based Algorithm to Estimate Synchronized Measurements over Wide Frequency Range				
812	Implementation of Phasor Measurement Units in Distribution Systems				
1046	Application of PMUs for monitoring a 50 kV distribution grid	X			
SCADA and Distribution Management systems					
4	Integration of Lightning Stroke Information into SCADA and OMS to indicate or verify Faults on Overhead Lines				
150	Network technical losses precise evaluation using distribution management system and accurate network data				
351	Adapting OMS System to deal with storms data in real time				
387	Getting real-time fault location information from multi-vendor legacy protection systems				
406	2D and 3D Visualization Strategies for Distribution Management	X			
482	Integration of IT and OT systems: an efficient data sharing between SCADA_DMS, GIS and Enterprise Applications				
556	Research of Smart Distribution Network Big Data Model				
1334	LV SCADA - How to effectively manage LV networks with limited topology and electrical characteristics data				
1550	Control Center Transformation to Enable Virtual Power Plant in Sweden				
1570	Fast alarm processing without connectivity information				

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Communication					
224	Feedback on Installed Experience with Fully-Digital Substations				
459	WSN-based smart grid security using chaotic synchronization				
541	Management of SLA parameters in ICT networks for smart grids				
557	Handling Cyber security updates for protection and control IEDs in substation during product's life cycle				
596	Substation automation experiences based on the IEC 61850 GOOSE messages				
925	Standards Based Engineering of Distribution Protection, Automation and Control Systems				
1049	Towards Open Distributed Feeder Automation Systems				
1291	BPL pilot: measurements and analysis	X			
1431	Framework for Process Bus Reliability Analysis				
Islanding					
294	Islanding operation technology integurated with multi power supplies	X			
480	Advanced Vector Shift Algorithm for Islanding Detection	X			
507	Potential risk for power system stability of massive use of escalating frequency shift islanding detection method			X	
600	Field tests of a new Smart Islanding Detector (SmartID)	X			
699	Risk of uncontrolled islanding on active distribution networks: short-term countermeasures taken by Enel Distribuzione				
705	Impact of new European grid codes requirements on anti-islanding protections: a case study			X	
841	A Modified Islanding Detection Method for Hybrid AC/DC Microgrids with Reduced Detection Time				
913	Analysis of islanding microgrid stability during fault condition				
972	ISLANDING OF DISTRIBUTION NETWORKS - CASE STUDY				
1011	Prevention of islanding in distribution network with distributed sources				
1449	Stabilization of Islanding PEA Micro Grid by PEVs Charging Control				

Block 3: "Protection"

In the "Protection" block 31 papers are discussed covering contemporary issues. There are unresolved problems in fault location and new algorithms and applications with practical experience.

Sub block "Fault Location / Earth Fault"

The first paper in this sub block (0044 from Ireland) outlines the assessment of the present logic functions in the faulted phase earthing (FPE) relays on the 10 kV network in Ireland. It also outlines the process used to determine if a newly proposed logic algorithm will be sufficient to increase the sensitivity of the relay to pick up high resistance faults without increasing spurious operations.

The results of the study showed that the altered algorithm would increase the detection limit of the existing relays presently installed on the Irish 10 kV network. Resulting from this work, the ESB (international energy company) has decided to adopt the altered algorithm settings. The new FPE relay still must be field-tested to verify the benefits found in the results of the study.

The next paper, 0415 from Germany, describes a new digital sensitive method for the directional detection of ground faults in resonant-grounded or isolated networks. The method evaluates the transient response which occurs due to the state change after the ground fault ignition. The methodology, whereby algorithms are developed in MATHLAB and the target system in parallel, as well as prototype testing in the field, has proven itself worthwhile. The new measuring method has proven to be very dependable. The method is simple and robust and shows significantly improved characteristics during high resistance ground faults.

Paper 0676, coming from Germany, presents the joined research results of an intelligent secondary substation design including improved methods for voltage control, fault detection and localization. Thereby the work's focus is on the novel secondary substation's characteristic function and its impact on the fault clearance process in medium voltage level. Simulation results emphasize its benefits for modern grid operation.

Paper 0785 from Brazil proposes a new approach for high impedance faults detection. The approach is based on the DQ-transformation with an adaptive filtering technique for detection signal generation. Transient signals detection is made by means of two thresholds, which are self-adaptive with the noise level present on the detection signal. The thresholds definition is made with an algorithm designed to confirm true transients from false ones. The proposed approach is evaluated through simulated test scenarios of high impedance faults on a modelled real distribution network. An evaluation of the proposal with additive noise confirms the robustness in detection of transients induced by high impedance faults.

Paper 0890 from Colombia presents the methodology to perform sensitivity analysis for impedance-based fault location methods, considering power distribution systems and the presence of a distributed generation. The proposed methodology helps to determine the power distribution system model parameters, which significantly affect the fault locator performance. Having identified such parameters, the next step is to perform analysis and compensations aimed to develop more robust locators. As result of the proposed methodology, a set of critical parameters of the power system model is identified here.

This paper described the post-fault oscillation phenomenon, which may lead to transient overcompensation of the protected feeder with distributed compensation coils. The same phenomenon deteriorates the accuracy of phasor calculation during intermittent earth faults, which may lead to unwanted starting or even operation of the basic protection in the healthy feeders. Understanding the theory of this oscillation and its effect on earth-fault protection helps to ensure correct relay operation. Furthermore, the protection algorithm design should consider this phenomenon e.g. by means of proper filtering or frequency adaptation.

Paper 1290 from Spain proposes a new fault location method based on travelling wave theory and electric system behavior in time domain. Furthermore, the development of a new protection device and where it was implemented is presented. The performance of the proposed method has been evaluated in a 20 kV distribution network modelled in PSCAD/EMTDC. Also, laboratory and field tests in a 15 kV distribution line have been carried out. Results from simulations are presented, varying ground resistivity, fault resistance, fault type and the location of the fault; furthermore, harmonic distortion has been considered in the distribution network model.

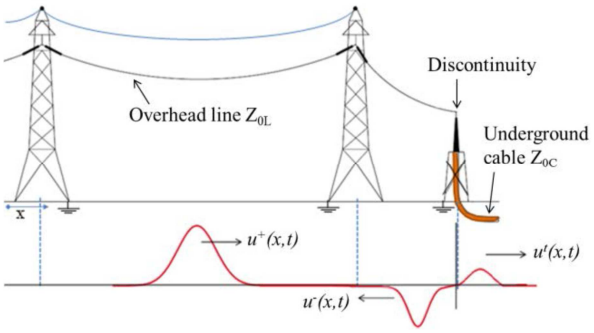


Fig. 22: Incident, reflected and transmitted waves

Fig. 22 shows the incident u+(x,t), reflected u-(x,t) and transmitted ut(x,t) waves in a discontinuity due to a change from overhead line to underground cable.

Paper 1450, coming from Austria, discusses that the behaviour of the restriking earthfault in a cable is completely different in isolated and compensated networks. Due to the different behaviour, there are new possibilities to reduce the current via the fault location. Furthermore, the influence of travelling waves to limit

the maximum current via fault location and on the self-distinguishing of arcs in case of restriking faults in well-tuned compensated networks is shown. Using new methods and devices, this behaviour leads to reducing the current at the fault location dramatically. The implementation of the faulty phase earthing enables a correct tuning of the Petersen-Coil, even during the earthfault. This paper proves that the new combination of Petersen-Coil and Faulty-Phase-Earthing (see Fig. 23) is an ideal combination for linear impedances (stationary earthfaults) and nonlinear impedances (restriking earthfault) at the fault location.

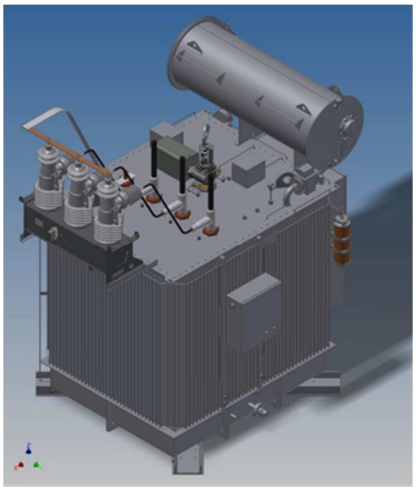


Fig. 23: Combination of Petersen-Coil with ZN-Transformer and Faulty-Phase-Earthing

Sub block "Applications"

A new possible protection scheme has been proposed in paper 0009 from Egypt. The proposed solution manipulates the feeder radial form for a strict time of 0.02 sec in order to transfer the DG from the faulty feeder to a near synchronized healthy one. Both insertion points should be chosen wisely and then the transfer connection switchgear will be installed in order to achieve the procedures of the proposed scheme. The proposed scheme has been tested on various test cases and its effectiveness has been proven. A practical radial feeder from South Delta for Electricity Distribution SDEDC was digitally simulated with PSCAD/EMTDC® showing the suitability of the proposed scheme for the distribution networks in Egypt. For simulations, a TC relay model was developed.

Paper 0245 from Brazil presents the main results about the development of a new single-phase recloser for medium voltage (see Fig. 24) based on a technique that allows using the same mountings used for fuse link and to aggregate characteristics as reclosing capacity, trip level adjusting and mechanical disconnection. Some short-circuits results obtained from laboratory and filed tests are presented, along with equipment details. Its reclosing capacity is limited to 6 kA and nominal current up to 200 A.

Fig. 24: Recloser prototype before installation

The connection of distributed generation (DG) to the feeders of the distribution network can cause the power flow to be bi-directional instead of unidirectional affecting the network performance and stability in a number of ways. A new protection scheme for finding out the optimal placement of protective devices in distribution grids considering DG is proposed in paper 0291 from Egypt. Risk analysis is used to optimize the number and the locations of circuit breakers on the distribution feeders. As the number of the feeders increase in the network, the locations of the circuit breakers increase enormously so that the finding of the optimal solution becomes much harder. This pushes us to the need of applying metaheuristic algorithms as efficient tools to find the optimal solution. In this paper, the Genetic Algorithm (GA) was implemented on a typical Egyptian real distribution network. Results are being presented and analyzed.

Paper 0316 from Germany describes a new assessment methodology and summarizes the findings from a systematic network protection performance project carried out for a complete municipal 10kV distribution system of a 300,000 resident city. The project showed that the applied protection security assessment methodology and software enables systematic protection performance assessment for large municipal distribution systems. It provides deep insight into the protection system behavior and helps to optimize the protection system performance.

The Under-Frequency Load Shedding (UFLS) as its main purpose contributing to the balance between production and consumption in case of lack of generation, thus avoiding the collapse of the system. The objective is to develop a new methodology with focus on clear and transversal criteria not forgetting the restraints and needs to cope with the operational implementation. Paper 0389, coming from Portugal, presents the approach taken by EDP Distribuição, as a DSO, in assessing and reviewing the actual UFLS, aiding the DSO in the transition to the new guidelines in order to respond positively to the

requirements, both by ENTSO-E (Policy 5) and by the Portuguese Regulator.

The next paper, 0708 from Italy, summarizes the first results obtained by Enel Distribuzione regarding the experimentation of a new and innovative scheme of operation of a medium voltage distribution network: closed-loop scheme. A different scheme of operation required a deep reorganization of the grid operation methods adopted until now; in particular it is need to foresee the installation of new and innovative protection devices, the adoption of new automation logics for the network protection components, to have the coordination between various protection devices installed on the loop, upgrade the remote control system to manage this new scheme of grid and, at the end, define new operation rules in terms of setting up of a protection system, management and control in case of typical circumstances occurring on the network (f.i. faults, maintenance and so on).

Paper 0723 from Argentina illustrates the importance of personal protection against electrical arc flash in distribution systems by selecting the right high breaking capacity fuse. The personnel risk due to electric arc flash is very important today, due to the high number of accidents with consequences suffered by utilities´ personnel. The personnel protection is based on control of the arc released energy, and of the incident energy on the personnel by means of protective clothing. The coordination procedure is presented, considering the arc energy control given by high breaking capacity fuses and circuit breakers. Protective clothing can be selected based on the let-through energy and the personnel' body incident energy. It is concluded that to carry out an appropriate coordination study among arc control elements it is justifiable due to the substantial personnel risk reduction.

Paper 906 from Finland presents a communication based protection automation system which is designed for solving DG related protection problems. The system is able to tackle problems related to protection blinding, nuisance tripping of feeders and generators and problems related to unintentional islanding. Moreover, the system can be configured to allow low voltage ride-through without compromising loss of mains protection. However, the system also has the potential of enhancing the reliability of electricity distribution service to DG units by automatically switching an alternative feeding path if the original feeding route is faulted.

Paper 1242 from the UK focuses on the role of directional overcurrent (DOC) protection and provides an overview of options for alternative solutions to replace this scheme. This includes an analysis of their suitability and impact from a technical perspective. The paper will share the UK Power Networks experience, decisions and trial results to manage with the reverse power flow issues in an area of Cambridgeshire, UK, as part of the Flexible Plug and Play project.

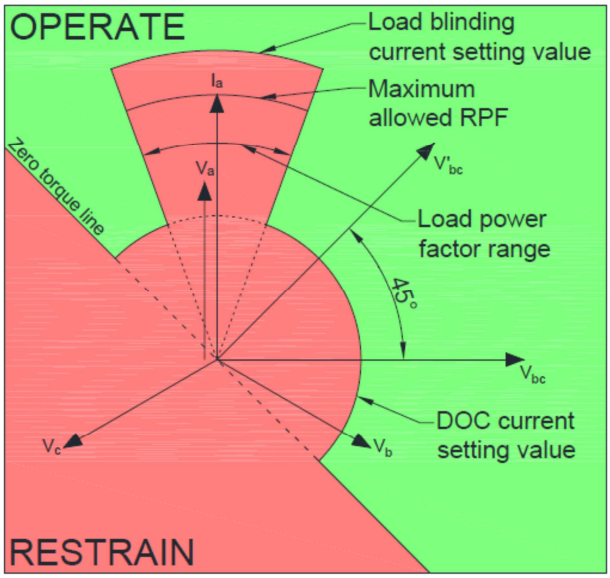


Fig. 25: Vector diagram for response of a DOC relay with a load blinding function

For a number of years, distance protection relays and schemes have had load blinder (or load encroachment detection) functions available. This fact utilized that the load and fault angles were significantly different which allowed for the necessary discrimination. If the load blinder principle is combined with the basic DOC function, the DOC relay will be blind to reverse load but will still be operated as normal for normal faults, as illustrated in Fig. 21.

Paper 1494 from Brazil proposes a novel method for the design and implementation of digital protection relays. In such an approach, some functionalities of the relay, including protection functions, are implemented in reconfigurable hardware and executed in parallel using FPGAs (Field-Programmable Gate Array). A protection relay was fully developed employing this technology. The parallel characteristics of this relay allow it to have a deterministic trip time that is unaffected by the number of enabled protection functions and secondary processes. The applied FPGA technology allows the parallel execution of protections functions with a deterministic trip time. Using this technology it is possible to design digital protection relays that have deterministic trip time of the protection functions and are immune to secondary processes. This work presents the principles of a common digital relay. The FPGA technology and a digital relay based on it are exposed next. Finally, the paper presents a comparison between the FPGA based relay and two regular commercial ones.

Paper 1523 from Hungary describes experimental issues of overvoltage-coordination of a grid. Many failures are commonly marked as lightning or overvoltage-related, but many of them have a root cause different than these kinds of phenomena. Different principles are available to analyze a grid from the aspect of overvoltage-coordination; statistical ways can be used effectively to

inspect a given grid as a whole. Special network components have to be taken into consideration separately in each case. With Probability Modulated Attractive Space Method an improved way of risk analysis is possible.

Sub block "Algorithms and Simulations"

In paper 0156 from Iran, it is shown that there is a requirement to investigate the contribution of Electric Vehicles (EVs) on the fault current, as the high penetration of EVs necessitates a change in the historical view that inverter-based sources do not have any significant effect on the fault level. Different modeling aspects of vehicle-to-grid (V2G) are discussed and evaluated by simulation results. It is shown that the models of the battery along with the inverter are crucial in calculating the contribution of the fault current by EVs. The simulation results show that the EVs could inject currents during faults if there is minimum impedance in the fault loop.

Paper 0307 from Germany addresses the field of analysis and evaluation of electrical models with high-dimensional parameter spaces. Two case studies within the context of stability and protection of distribution grids demonstrate the usability of sensitivity analysis (SA) as an efficient assessment tool for practical applications whilst comparing the different methods with respect to the resulting computational time and accuracy. An analysis identifies the SA method that can be used best for different modelling purposes.

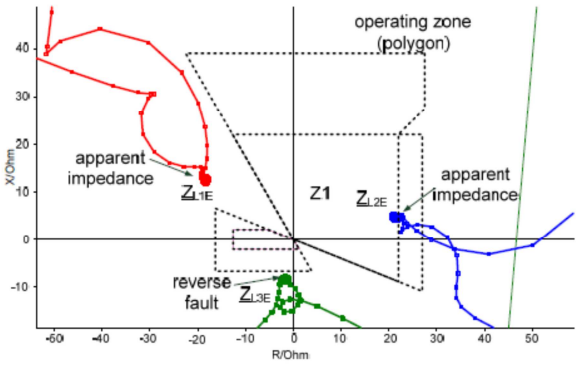


Fig. 26: Impedance trajectories during single phase-to-earth fault with Bauch's paradox

False tripping is frequently blamed on incorrect settings or poor system models. However in many cases, it may be attributed to not uncommon phenomena, such as the so called "Bauch's paradox". In paper 0448, coming from Germany, the physical background of the Bauch's paradox phenomena will be explained. Based on this, a method for the correct response of distance protection under these extreme conditions is presented. Amongst others, this method consists of: the detection of the Bauch's paradox phenomena, optimised loop selection logic and a modified directional element. Chosen events recorded during distance protection tests are used to illustrate the effectiveness of this method.

Historically in Italy the MV distribution network has been normally operated in radial mode and, accordingly the fault selectivity has been chronometric. The main objective of the "Smart Grid" project POI P4 of Enel Distribuzione is to test the operation of the network in loop mode with a logical selectivity during faults. The selectivity is performed using optical fiber communication via IEC-61850 standard. The paper 0649 from Italy analyzes all preliminary tests made by Enel in simulation mode using a Real-Time Digital Simulator (RTDS) in order to set the protections relays correctly and to avoid unwanted protections tripping.

The differential phase angle of incremental currents can indicate internal/external fault rapidly and reliably. This feature can be employed to change the characteristic dynamically. By this means, adaptive differential characteristic is achieved, which improves the speed and sensitivity for internal faults and improves the security for external faults even with heavy CT saturation. Some general mathematical equations of the new idea are described in the paper 0688 from Sweden. Finally, simulation tests demonstrate that the principle has not only very good dependability for internal faults but also high security for external faults.

A new enhanced technique to detect the earth fault in a compensated network (Peterson coil) is presented in the paper 0963 from France. The proposed innovative protection algorithm has been developed to comply with the French NF C13-100 norm. The NF C13-100 norm requires the application of PWH2 function (wattmetric directional earth fault protection function for ERDF). The algorithm performance and selectivity allows operation to be precisely deterministic for any kind of fault. This innovative algorithm did not require additional sophisticated hardware and software, and it has been implemented into the compact intelligent electronic device.

The main aim of the paper 0973 from Czech Republic is the verification of designed principle for earth fault location in real distribution network which is based on the evaluation of voltage sags recorded on secondary side of distribution transformers MV/LV. For this purpose, series of experimental measurement in real compensated MV distribution network were carried out. During the experiments, different types of earth fault (solid, arcing and impedance earth fault) were artificially ignited and all important waveforms (secondary voltages of distribution transformer, fault currents, voltages and currents at supply substation) were recorded for further analyses. These fault records were used for verification of the described method. The result of the analyses is an answer to the question, if it is possible to use the idea of earth fault localization method in real conditions of compensated distribution network operation.

Directional relays may be a good solution for the protection of MV distribution networks with distributed generators (DG). In a more advanced protection scheme, with some protections distributed along the feeders, the directional algorithms without voltage sensors would be more interesting because of investment cost reduction. These algorithms use only sequence current ratios (i.e. ΔI -/ΔI0 and ΔI -/ΔI+) coupled with a SVM classifier to determine the fault direction. In paper 1305 from France, the algorithms will be analysed in the case of double-line-to-ground faults: theoretical base is explained; offline simulations are performed with Simulink / SimPowerSystems. The simulation results are subsequently used for training SVM (support vector machine) classifiers.

Paper 1409 from Croatia describes a methodology for power system and relay modelling. A distribution system, instrument transformers and relay models with different protection algorithms are developed using Matlab/Simulink environment. Developed comprehensive relay models process voltage and current transient waveforms obtained from electromagnetic transients simulations, actual fault waveforms captured by numerical relays, or from digital fault recorders. In this way a user can observe their response to these transients and reaffirm the protection behavior during network disturbances.

Sub block "Fault Ride Through"

Medium-voltage (MV) network short-circuit protection operation time delays have traditionally been dependent on fault-current magnitude or measured impedance with fixed time delays or inverse time curves. However, MV feeder protection selectivity issues with low-voltage-ride-through (LVRT) curves of distributed generation (DG) units and the possibility of intended island operation will be increasingly important in the future and must be taken into consideration as a part of the protection scheme. Therefore, the paper 0214 from Finland presents a grid code compatible, future-proof, directional short-circuit protection scheme for Smart Grids. The proposed scheme enables the definition of protection operation time delays during normal, grid connected operation for IEDs in MV distribution network having multiple protection zones without the need for high-speed communication between IEDs.

Decentralized power plants have to stay connected to the grid during grid disturbances. Only under certain conditions they are allowed to trip. The capability of power generation units (PGU) to withstand a defined voltage-against-time-profile, the so called "low voltage ride through (LVRT)" capability, has to be proven by type testing or unit testing before they are allowed to be connected to the grid. The most common way to test PGUs is using a test container, which is emulating a fault event in the grid with reduced short circuit power. Simulations with different setups with and without LVRT test container and variation of the fault location, but always keeping the same short circuit ratio and remaining voltage at the PGU's connection point, reveal different transient behavior of the device under test. In paper 1133 from Austria the influence of the LVRT test equipment is analyzed in detail and recommendations for modifications of the test procedure are given.

Withstanding voltage dips without disconnection for certain time durations is state-of-the-art among manufacturers of wind turbine generators. Meanwhile, new challenges evolved along with the sustained connection of dispersed power generators to medium and high voltage systems. Not only the resistance against voltage dips but also the fault-ride-through-capability in terms of overvoltage gets increasingly important. Temporary overvoltage may occur in the system because of load shedding, phase-to-earth faults or generation losses combined with dynamic variations in loadings and huge transmission line capacitances. Since this feature is only addressed in very few technical guidelines yet, the paper 1391 from Germany therefore emphasizes the technical relevance of such HVRT requirement within grid codes on one hand and the configuration of the testing setup and used procedure on the other hand. Insights and experiences are demonstrated based on successful pilot project testing of a wind turbine. From the results, recommendations for HVRT testing procedures can be provided for guideline proposals as well as for drafting of the requirement within the codes.

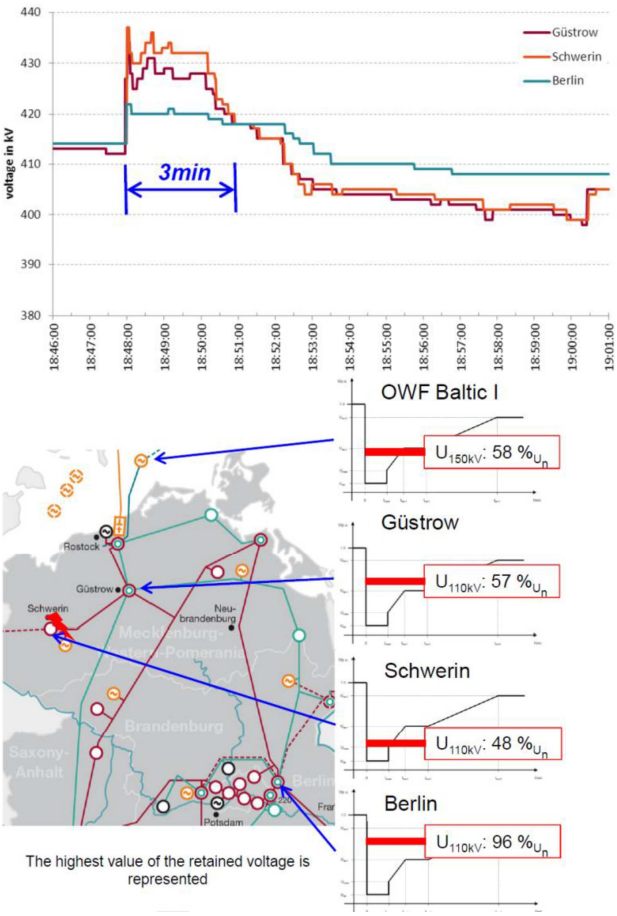


Fig. 27: Short-circuit and subsequent overvoltage

Table 3: Papers of Block 3 "Protection" assigned to the Session 3

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Fault Location / Earth Fault					
0044	Assessment of Logic Algorithms for Faulted Phase Earthing Protection Relays on 10kV Networks				
0415	New Digital Method for the Directional Detection of Transient Ground Faults		X		
0676	Design & Analysis of an Improved Fault Localization Scheme for Secondary Substation Automation				
0785	High Impedance Fault Detection in Distributions Systems: Adaptive Approach Considering Noising Environment				
0890	Sensitivity Analysis of Fault Locators in Power Distribution Systems Considering Distributed Generation				
1042	Post-fault oscillation phenomenon in compensated MV-networks challenges earth-fault protection				
1290	New fault location method for up-to-date and upcoming distribution networks		X		
1450	Advantages of the New Combination: Petersen-Coil and Faulty-Phase-Earthing		X		
Application					
0009	DG Transfer Connection as A Solution for the Protection of Active Distribution Networks				
0245	Development of single-phase recloser for medium voltage protection				
0291	Protective Devices Optimal Placement in Distribution Networks Considering DGs				
0316	Protection Performance Assessment of a Municipal Medium-Voltage Distribution System				
0389	The Portuguese Grid under-frequency load shedding (UFLS) plan - The DSO role.		X		
0708	Implementation and first operation results of the MV loop scheme				
0723	Personal protection against electric arc flash in distribution systems, by selecting the right high breaking capacity fuse				
0906	A communication based protection system for solving DG related protection challenges				
1242	A Trial of Alternatives to Directional Overcurrent Protection on Grid Transformers to Improve the Network Capacity to Accommodate Reverse Power Flow				
1494	Protection Functions Implemented in Configurable Hardware: A Paradigm Shift				
1523	Experimental issues of overvoltage coordination		X		
Algorithms and Simulations					
0156	Protection Needs for Grids with High Penetration of DG, Storage and EV				
0307	Application of Variance-Based Sensitivity Analysis to Issues of Stability and Protection in Distribution Grids - Two Case Studies			X	
0448	A method for the correct protection response during power system faults subjected to the Bauch's paradox phenomenon				
0649	Fault Test in MV network operated in "Loop Mode". Comparison between Simulated Results (obtained by RTDS) and several Real Field Results.				
0688	Line Differential Protection Enhanced by the Use of Incremental Currents				
0963	Wattmetric Earth Fault Protection – Innovation for Compensated Distribution Networks				

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Algorithms and Simulations					
0973	Verification of the Earth Fault Location Method Based on Evaluation of Voltage Sag in Real Distribution Network			X	
1305	Performance of directional relays using SVM classification with Double-Line-to-Ground faults				
1409	Distribution protection relay software models in interaction with power system simulators				
Fault Ride Through					
0214	Grid Code Compatible Protection Scheme for Smart Grids		X		
1133	Influence of LVRT Test Equipment Characteristics on the Dynamic Performance of a Power Generation Unit			X	
1391	Relevance of HVRT Capability and Corresponding Testing			X	