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 370 abstracts received for Session 3 underlines this growing interest impressively. Due to the extreme high number of abstracts received for Session 3 Chairman and Rapporteurs had to be –once again– quite strict in rejecting papers in order to keep quality and a manageable number of papers during the conference.

Therefore 244 abstracts were accepted by National Committees and Technical Committee (TC) and the authors were called to submit a full paper. Finally the record number of 230 full papers has been accepted for Session 3. Fig. 1 gives an overview of the review process.

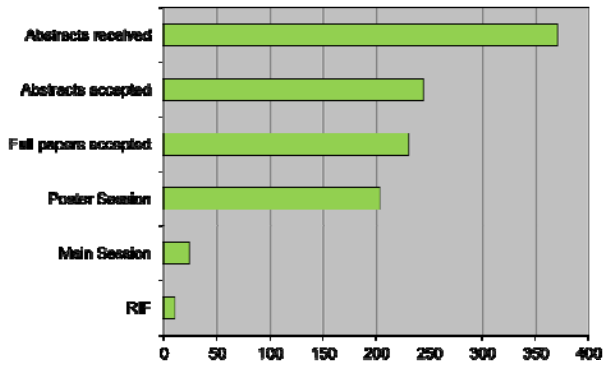

Fig. 1: Overview of the review process

All authors are asked for a poster presentation, 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:

Block 1 Operation

- Thermal Rating of Overhead Lines
- Maintenance and Condition Assessment
- Distribution Management
- Blackout Prevention / Crisis Management

Block 2 Control

- Communication / IEC61850
- Scada-Systems/DM-Systems
- Cyber Security
- Distribution Automation
- Phasor Measurement Units
- LV Automation

Block 3 Protection

- Fault Location
- Neutral Grounding
- Distributed Generation
- Applications
- Algorithms, Simulations

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. A new topic is the prevention of blackout and the management of crisis due to the increasing responsibility of distribution network operator in case of emergence. The main number of paper is related to the sub block Distribution Management. One focus in the block is the use of different data source and the interface between databases.

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. This comes along with a higher demand on communication and corresponding techniques and infrastructure. The number of papers related to communication is decreasing but the content of these papers show that communication protocols are already implemented into demo projects and now lead to question regarding cyber security. Several papers discuss the protection of communication networks and also they offer first approaches for test routines.

In the **protection** block we have several types of fault locations (e.g. earth faults, high impedance faults). Islanding and stability losses caused by Distributed Generation are still a challenge for protection technology and new functions. 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 overview of the number of papers related to the different blocks and sub blocks is given in Fig. 2.

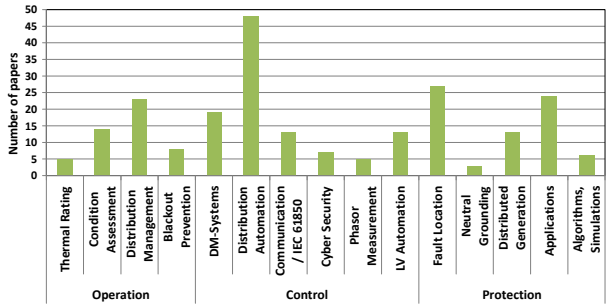

Fig. 2: Overview of the accepted papers

The majority of papers is prepared by groups of authors. In some cases these groups are composed of authors from different countries and even continents. The authors are from grid operating companies, vendors, universities and other research associations. Therefore, Session 3 of Cired 2013 truly reflects the 'state of art' of the grid operation community in case of Operation, Control and Protection.

Operation

In total 50 papers have been received covering the topic grid operation and can be divided into several different themes and tasks. The Block has been divided into:

- Thermal Rating of Overhead Lines
- Maintenance and Condition Assessment
- Distribution Management
- Blackout Prevention / Crisis Management

Thermal Rating of Overhead Lines

Five papers from United Kingdom, Sweden and Belgium are dealing with the thermal rating of overhead lines. One major aspect of monitoring the temperature of overhead lines is to increase the utilization.

The British paper 0242 shows an evaluation of extra thermal capacity available in the critical network components, overhead lines, transformers and cables when the thermal limits are varied many times a day according to the prevailing environmental conditions.

In paper 0299 from UK it will be expected that 100% redundancy will no longer be adequate. Use of real time thermal ratings (RTTR) can increase the static rating of a critical circuit to a generally higher dynamic rating.

For the implementation of real-time thermal rating it is necessary to manage and reduce the risks and uncertainties. Paper 1106 discusses the lessons learned from development of a management system and its implementation across a 132kV network.

The results of dynamic line rating from EU-funded project TWENTIES is presented in paper 0946 from Belgium. Sensors are use to monitor the impact of overhead line utilization and free capacities. The paper focuses on the use of forecasts to give trend of overhead line ampacity for the following days.

Fig. 3: Installation of smart grid sensor Ampacimon on a 150kV line

Main aspect of the possibility for higher overhead line loading is wind cooling of lines. In paper 0631 from Sweden shows the impact of wind cooling for dynamic

capacity rating. Hundreds of measures have been used to analyse impacts of wind speed and temperature.

Maintenance and Condition Assessment

The sub-block maintenance and condition assessment contains 14 papers from Iran, Poland, Spain, Finland, Germany, United Kingdom, Sweden, Korea and USA.

Two papers describe the asset management process in industrial plants. Paper 1105 from Germany describes the evaluation of an asset management process of a large industrial plant using probabilistic reliability analysis whereas paper 0395 analysis condition based management assessment. Similar to the German paper the Iranian authors of Paper 0371 use information about importance and risk for the

Two papers (paper 0820 and paper 1194) show the use photographic information for inspection of overhead line distribution systems. Both papers use GPS information to identify the location and combine the picture with additional information stored in maintenance databases.

Three Iranian papers dealing with maintenance strategies Papers 0185 and 1108 show maintenance strategies of two Iranian utilities. It is describe how decision making is done in these companies.

Similar to the German paper1105 the Iranian authors of Paper 0371 use information about importance and risk for the decision about maintenance priorities for transformers. Paper 0357 gives a detailed view on dissolved gas analysis of load tap changers. The information is used for condition assessment and fault diagnostics.

Measures on cables and overhead lines are used to identify the technical conditions in Paper 0383 and paper 1471. In this context paper 1477 and paper 1103 describes techniques to control / monitor cable insulations.

The Swedish paper 1233 introduces some thoughts on methods of planning what kind of grounding system one should use for best economic and technical result.

Distribution Management

23 papers have been received that contribute to the sub-block Distribution Management. These papers have been submitted by authors from Iran, Denmark, Sweden, Chine, Switzerland, Portugal, Brazil, United Kingdom, Malaysia, Austria, USA and France.

A very special paper in the context is paper 1485 from France. This paper presents a game to train 8000 electricity technicians of ERDF. The simulator is based on a video game and allows the players to discuss the action which have to me taken. Each player can chose its own character in the virtual company. Due to advanced technologies which can be used for training this might be a future possibility to address the behaviour of young professionals. Fig. 4 gives an impression of the game.

Fig. 4: "Serious Game" – Virtual training of technicians

As important as the training of a team to operate a network a training models for substations. The Chinese paper 0293 introduces a 3D model of a substation for training aspects.

Paper 0542 also addresses a very special topic which becomes more and more important. The Portuguese authors present mechanical and electronic components against the theft of power equipments.

Two papers discuss the use of GIS information in management and operation. Paper 0108 from Iran uses the GIS data in combination with a power system calculation tool to optimize the network, whereas paper 1010 describes how to use GIS information for optimal locating of faults. In Paper 0566 GIS information are used to display device information on a city maps. The measurement devices are equipped with GPRS.

In any case it is necessary to integrate data of several data source. The description of an interface based on IEC 61970 CIM is presented in paper 0516.

Paper 0798 propose to use British Standard PAS55 an ideal tool and model for asset cooperate governance of distribution network operators.

Information and Communication Technology (ICT) for asset management at city power in Johannesburg (South Africa) is presented in paper 1028. ICT is also used for medium voltage reinforcement techniques discussed in paper 1359. The Flexible Approaches to Low Carbon Networks (FALCON) project is a UK Government funded initiative to look at ways of improving understanding of the UK infrastructure needs in a low carbon future. This is focused on the provision of networks to support energy demand for the future.

Smart technologies lead to new methods for distribution management. Paper 0286 and Paper 0526 describes the use of smart grid in LV networks. Both papers show the use of smart meter information in control centres with main goals in identification of power interruptions and power quality aspect. Based on smart grid technologies the paper 0936

and 0938 demonstrate two different methods for the analysis of distribution network by the control centre.

Paper 0261 describes the provision of service associated with large scale deployment of distributed energy resource (DER). For that purpose, different services utilizing the DER in a future system are identified as well as potentially conflicting interests between services.

For integrating DER paper 0502 presents an advanced measurement method for power flow in MV grids. The authors have investigated the problems of congestion during the parallel coupling of multiple substations using special equipment.

Five papers describe the identification of faults in power distribution networks. The Iranian paper 0954 shows the monitoring of street lighting systems to identify malfunctions. Paper 1326 shows a fault location methodology for cable failures. Paper 0934 presents the implementation of new technologies and methodologies implemented to reduce the number of repeat faults on networks. Papers 0977 and 0877 are dealing with overhead line faults. Paper 0977 from Malaysia shows measures to reduce the interruptions coming from lightning. Paper 0877 discuss the use of a power flow methodology based on Gauss Elimination Method to evaluate the performance of the distribution network.

This paper 0626 aims to present a multicriteria model used to perform the correct sizing of the emergency service teams, defining them in quantitative terms, their geographical distribution and coverage of service

Blackout Prevention / Crisis Management

One sub-topic of papers with operational aspects is focusing the question of blackout strategies. How a blackout does occur? This question a well as consequences and crisis management shows paper 0658 based on the example of the outage caused by storm Dagmar.

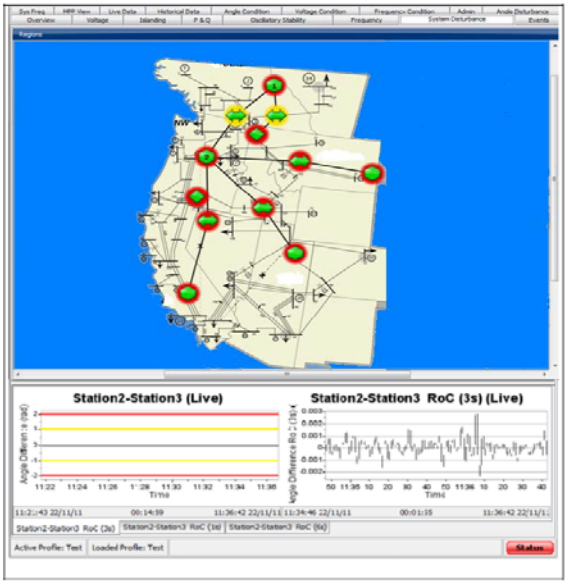

Fig. 5: System disturbance view of Indian power system

Several papers explain the role of DSO during the restoration phase. The Austrian Paper 0002 explains the key aspects for grid restoration also in the context of DSO and TSO role in case of a blackout. The paper shows a broad overview about responsibilities, coordination aspect and finally a 3-step approach for network restoration. Also the papers 0603, 1198 and 1508 describe the DSO requirements and tools during blackout. A very important aspect in case of an emergency is the stable communication as described in paper 1473. Paper 1180 shows “Smart Emergency” and how ICT can be used to stabilize the system during recovery phase. The Indian paper 682 looks at how the current situation may be mitigated by implementing a Wide area critical care desk. The target is to analyse the corridor power flow influencing the mode and generators crossing the step, contributors of the oscillations present in the network would be identified.

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Blackout					
0002	Blackout - Key Aspects for Grid Restoration	X			X
0603	How does a dno anticipate a blackout?				X
0658	Major storms - main causes, consequences and crisis management	X			X
0682	Advanced wide area monitoring system to secure transmission corridors during phases of high dynamic activity.	X			X
1180	Smart Emergency – New Issues of Emergency Supply Systems for Critical Infrastructure				X
1198	Improving the shared situation awareness in disturbance management				X
1473	The new approach of emergency management - automatized outage communication to rescue organisations and municipal authorities				X
1508	NEW TOOLS TO ASSESS CRISIS IMPACTS				X
Thermal Rating of Overhead Lines					
0242	Real-time thermal rating for improved network utilisation				X
0299	Use of real time thermal ratings to support customers under faulted network conditions				X
0631	Dynamic capacity rating for wind cooled overhead lines	X			X
0946	Dynamic Line Rating and ampacity forecasting as the keys to optimise power line assets with the integration of RES. The European project TWENTIES demonstration inside Central Western Europe.	X			X
1106	De-risking the implementation of real-time thermal ratings				X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Maintenance and Condition Monitoring					
0185	Investigation of the Current Maintenance Experiences in Power Distribution Utilities of Iran				
0357	Condition assessment and fault diagnosis of two load tap changers using dissolved gas analysis				
0371	Maintenance Priorities in Distribution Transformers Based on Importance and Risk				
0383	Partial discharge measurements as a source of information about the technical condition of PILC insulated MV cables				X
0395	Condition based maintenance assessment in the petro-chemical industry				X
0820	Distribution network aerial photographing benefits in practice				X
1103	Control of Insulation Condition of Smart Grids by Means of Continuous PD Monitoring				X
1105	Initial assessment of the asset management process of a large industrial plant including probabilistic reliability analysis				X
1108	Design and implementation a new model for preventive maintenance of Medium voltage electrical distribution networks				
1194	The application of handheld photogrammetry to deliver quick return on investment on pole audit projects.				X
1233	Grounding system - knowledge of soil resistivity				X
1471	Field experience of diagnosis techniques for detecting damaged insulators in overhead distribution line				X
1477	A Transient Fault Location System in Low Voltage Underground Distribution Networks				X
1509	Transformer Condition and Loading Evaluation				X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Distribution Management					
108	Management and Operation of Electricity Distribution Networks on Geographic Information System Platform				
261	Coordination of system needs and provision of services	X			X
286	Smart meters in operation centre				X
293	Research and implementation of 3d training system for substation simulation				X
502	An advanced measurement method for power flow in MV-grids			X	X
516	DMS, GIS and Planning data integration in a distribution utility using IEC 61970 CIM				X
526	SmartGrids arrives at the low voltage dispatch centers				X
542	EDP Distribuição: Smart solutions against the theft of power equipments				X
566	Gprs based distribution transformers monitoring system				
626	Multicriteria model for sizing the workforce of electricians in a power utility				X
798	A path towards PAS-55 in the Portuguese DSO: A working example in the Protection and Control Systems				X
844	Monitoring approach for detection compromise attacks in the smart meter				
877	Development of a genetic algorithm for evaluating the performance of overhead power distribution lines and proposing solutions to improve distribution line safety				X
934	A new approach to intermittent fault management in low voltage networks to reduce the number of repeat interruptions				X
936	Artificial Neural Network Hourly Load Forecasting Of a Small Area				
938	Programmatic smart grid trial design, development and analysis methodology				X
954	Monitoring and remote sensing of the street lighting system using computer vision and image processing techniques for the purpose of mechanized blackouts				
977	Use of Combined Approaches Towards Mitigating Faults Caused by Lightning on TNB Distribution Overhead Lines				X
1010	Using geographical information system to develop a tool for optimal locating of fault indicators				
1028	Asset management at city power johannesburg enabled by ict				X
1326	New enhancements for cable fault location in complex medium voltage distribution networks				X
1359	Medium voltage reinforcement techniques and role of the communication network				X
1485	"Serious Games" serving electricity technicians professional development				X

Control

In total 106 papers have been received covering the topic grid operation and can be divided into several different themes and tasks. The block has been divided into:

- Communication / IEC61850
- Scada-Systems/DM-Systems
- Cyber Security
- Distribution Automation
- Phasor Measurement Units
- LV Automation

Communication / IEC61850

13 papers are related to this sub block. Main aspects of the papers are the use of IEC61850, the performance of communication, security and communication technology.

One important aspect of selecting communication in distribution grids is the performance. Paper 0218 highlights this aspect and demonstrated this with a triangle of performance. This triangle depends upon the required speed of communication, the expected dependability of the command, and the security of receipt (see Fig. 6). These three aspects are interlinked, and the correct balance of each is required in order to offer the traditional functionality such as permissive signalling, blocking and intertripping schemes.

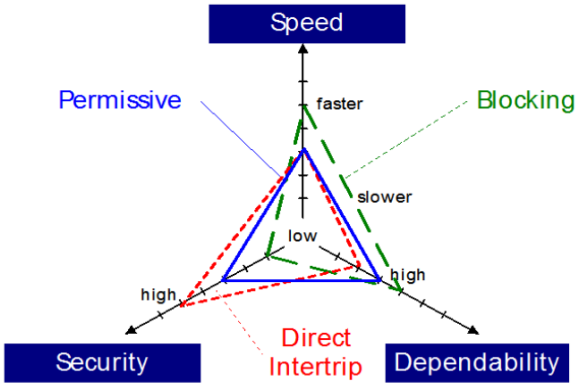

Fig. 6: Performance triangle

Also the authors of paper 0730 discuss the performance of ICT which have been analysed in the HiPerDNO project. Due to the increasing number of DER new DMS functions are need to be developed.

Paper 0439 from Colombia describes the experience gained while implementing a MetroLAN Ethernet network. The Slovenian and Croatian authors of paper 0453 describe the usage of GPRS for communication in distribution network.

Quantum Key Distribution (QKD) guarantees secure communication. It allows two partners to produce secret key known only to them to secure data transmission. Paper 0154 from China gives an overview about QKD shows use cases within a smart grid.

Paper 0894 discuss the safety of data transmission and it describes the methodology of throughput tests and the deployment in the telecommunication networks. The authors considered the different requirements regarding telecommunication parameters of each subsystem (e.g. SCADA, AMI). The safety is also discussed in the two Iranian papers 0803 and 0174. Paper 0803 discusses the quality of communication infrastructure whereas paper 0174 describes the fault analysis in communication systems. It has been shown that nearly 70% of all faults are in the field. This will lead to additional workflow of the service teams.

Paper 0225 and paper 1189 presents IEC61850 in substations. Paper 0225 describes the utilization of the non-conventional measurements and advanced features of IEC 61850 standard for substation automation systems. Vattenfall Distribution Nordic initiated a project to define and prepare the implementation of internal processes for deploying IEC 61850 as the primary enabler for smart substations, and to compile a strategy for substation projects (Paper 1189) The benefits and value of using IEC 61850 is created by efficient processes, less manual work during import and export of data, specifications and documentation using tools that support most phases of the lifecycle of the substation automation system.

The Portuguese paper 0398 follows the vision of a unified modelling language built upon IEC 61850. The authors show a detailed language overview and discuss the advantages of model-driven engineering.

Paper 0739 presents the associated work carried out to design and deploy a modern communications infrastructure: the IP communications platform that is capable of carrying the open standard protocol defined by IEC 61850 as used in the “Felxible Plug and Play Low Carbon Network” (FPP) project.

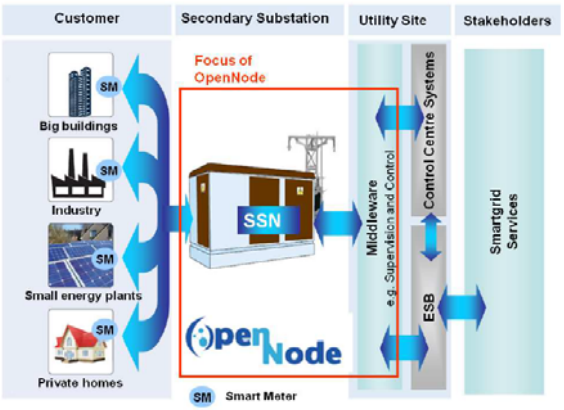

Fig. 7: Open Node architecture

Open Node is EU-funded project with partners from six European countries (see Fig. 7). The target is that every

stakeholder and customer can use the platform to exchange information. The projects address the future requirements to guarantee the access to only those data, which is needed for the individual operation functions in a smart grid.

Scada-Systems/DM-Systems

This sub block contains 19 papers from Egypt, Iran, Austria, Serbia, Indonesia, USA, Brazil, Portugal, Finland, Korea, Netherlands and Italy. The papers demonstrate that is become more important to handle the mass of data and ensure the security and correct operation of control centre especially when different data source have to be used.

Electrical networks are critical infrastructures and the proper operation and control of these networks is important for DNOs. One major question is: How can security and Reliability can be guaranteed whenever complexity will increase. This topic is discussed in the Austrian paper 0272. The author demonstrates the risks as well as the methodology for risk assessment (see Fig. 8) and certification.

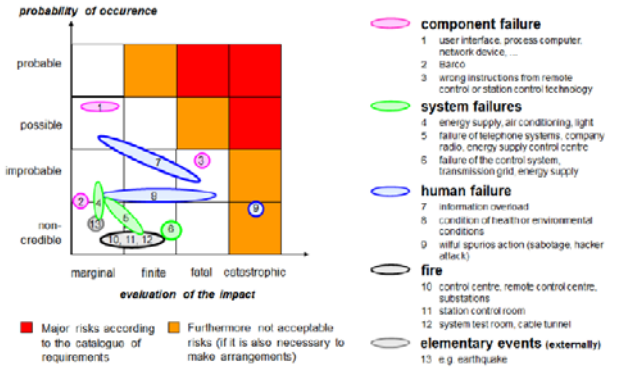

Fig. 8: Risk analysis for control centers

For proper operation a lot of data and functions are needed. Paper 91 from Egypt shows how the Alexandria Electricity Distribution Company integrated GIS information into the SCADA system as well as SCADA information in the GIS system. Paper 0927 from Portugal shows how model can be generated automatically to replace manual drawing.

In distribution network the number of information are much more limited than in transmission networks. The Serbian paper 0335 explains the work of a Distribution State Estimator in a field test. In comparison to the state estimation Paper 0201 form Iran shows how the information from outgoing feeders can be used to identify abnormal patterns. The problem will be identified when defined limits are overexcited. In paper 1134 a chronological analysis is presented for simulation of optima performance of dispatch centres.

One major aspect of control centre application is to identify faults and to have restoration strategy. The Papers 0649, 1012 and 0879 are showing failure localization, failure isolation and network restoration from Portuguese, Finish and Brazilian experience. Paper 0858 discusses how the dispatcher can handle the large number of alarms by presenting a single composite alarm. Paper 0870 faces the increasing number of reclosers in electrical network by presenting an intelligent system for management of reclosers.

Paper 426 describes a management system to enhance customer satisfaction which has been proven in Netherlands. With the system it is possible to reduce the customer minutes lost in a smart grid. Paper 1459 summarizes the development and test for the Korean Smart Distribution Management system.

The Indonesian paper 0353 describes the experience of the development of a disaster recovery system in SCADA. In case of a disaster system operation will be handled by neighbouring SCADA system in the region so that any outage of a control centre can be handled.

Parallel operation of control centres in distribution network is also discussed in Paper 0630. The authors explain how to handle 16 distributed operation centres.

A very detailed view about the optimization of control centre organisation is presented in paper 0480. The authors show the impact energy market requirements and cost efficiency to a high performance operation model and demonstrate the impact to the organisation scheme.

The paper 1493 presents some significant results of an extensive modelling activity being carried out within ATLANTIDE, an on-going Italian Research Project. The attention is focused on the DMS and its integration into urban distribution networks.

Paper 0222 shows a dispatcher training system for substation. This system is based on 3D technology and allows simulating scenarios close to realty.

Cyber Security

Seven papers discuss cyber security in SCADA and communication systems as well as in substations.

Modernisation of electrical systems starts in the substations. The implementation of intelligent Electronic devices (IED) and the use of WLAN and GPRS offer the possibility for cyber attacks. Paper 0645 and paper 0818 discuss how to protect substations. The approach bases on already available standards for security. The Columbian authors paper 0030 present recommendation for communication systems in substations based on IEC and NERC standards which have not yet fully implemented in Colombia.

Testing of security is discussed in two papers. Paper 1300 presents a way of analysing and testing information security of a demonstration environment for smart grids. The authors presented a checklist for security analysis to eliminate the

weak points. Paper 1109 presents a tool for cyber security analysis and describes the architecture of the cyber security modelling language.

Paper 1250 shows different hierarchies of layers to defend cyber attacks. Each layer should have its own security level started from the physical device (outer layer). The strategy of the approach is the any attack will not be able to get from one layer to another layer so that the inner layer is highly protected.

There is still a risk for cyber security and this is discussed in paper 1155. This Iranian paper shows a case study of Shiraz Power distribution Company and presents risk management approaches for smart grids.

Phasor Measurement Units

Five papers discussing fields of application for phasor measurement units have been received from Switzerland, Czech Republic Germany and Iran.

Paper 1325 shows a workplace for testing the dynamic properties of PMU. It has been found out that the behaviour of PMU for dynamic changes in power systems will not be correctly determined by PMU of all manufacturers.

Paper 0050 shows an algorithm for optimal placement of PMU. The target is to reduce the number of device with full availability of information to make a network observable. Probabilistic events have to be considered o identify the PMU locations.

Paper 0190 expects that the increase of DER in LV networks lead to the need of PMU in these networks. Due to the high number of equipment units new low cost devices have to be implemented. The author presents the test of a low cost PMU in a LV network. These PMU communicate with a smart RTU in the ring main unit.

Paper 0498 explains the reasons for Wide Area Monitoring (WAM) and PMU and it shows applications. The main application (island state detection, power swing recognition and voltage stability monitoring) are described.

Paper 1121 shows practical experience with WAM. The paper presents the results from the observation of a 110kV distribution network. Within one year the PMU have been installed and 2 years experience is available. Main aspect of the usage of PMU is the observation of equipment parameters under consideration of weather conditions.

LV Automation

The sub block contains 13 papers from Czech Republic, United Kingdom, Belgium, South Africa, Austria, Brazil, Germany, Sweden and Japan.

50 % of the paper discussing the voltage regulation in LV network explicitly.

Due to increasing share of DER, especially PV, the regulation of voltage becomes the major challenge in future LV grid operation. One possibility is the limitation of power infeed as discussed in Paper 0062, 0391 and 0532.

Paper 0469 shows how to protect power system with PV generation against overvoltages. The target is to reduce the PV infeed but not to loose all PV infeeds at the same time. In case of an overvoltage PV strings on the ´DC will be disconnected until the Voltage is under a defined level.

The papers 0508 and 1273 discuss the use onload tap changers due reduce voltage in LV network during time of high PV infeed. Paper 0508 show that the control of the HV/MS transformer. The interesting aspect of this paper is that two controllers will be used. One is responsible for the voltage set value of the transformer and other for the reactive power set value of the dispersed generators. Both are combined in a central voltage control unit. Paper 1273 shows the simulation of PV infeed and effect of voltage regulation to keep the voltage in the limits.

Paper 0246 presents a transformer to balance the LV power system. Due to unsymmetrical infeed of smaller PV units the challenge network balancing increase. This transformer is original used to link two-phase and three-phase networks and has been tested in the laboratory to balance three phase networks with unsymmetrical load.

The use of smart meter information is also one important topic in this sub-block. Paper 0640 describes the meter placement to ensure accurate and reliable sate estimation. This method reduces the uncertainty of the estimated state variable where no measurement is available and demonstrates the result in a case study. Paper 1290 and 1239 show the use of meter information in LV grids. PBoth paper discussing what kind of data and what kind of use cases are relevant for LV grid operation. They also presenting that the large number of information has to be reduced to an observable level especially when end customer information (e.g. smart building) will be collected.

Autonomous, active, intelligent grids and Grid management are the topics of three German papers. Paper 0717 discusses the need to operate an autonomous grid. Monitoring of the network does include the measurement of electrical parameters, as well as the information about topology. Based on this information the control process (e.g. voltage control) will be started. Before sending the control command the control algorithm calculates the effect of the command to ensure proper operation. Paper 0702 presents a smart grid control strategy for real-time LV grid management applications based on an online-learning algorithm. It enables for the derivation of a schedule-forecast for installed assets. Next to coordinated voltage and line utilization control the approach optimally exploits the potential benefits of innovative grid assets for grid operation. Paper 0819 focuses on voltage control strategies applied in active, intelligent low voltage (LV) networks. Newly developed components (a MV/LV transformer with

OLTC, adjustable PV-inverters and an intelligent control unit of the LV network) required for this active, intelligent LV network are described and they are integrated in a rural LV network with an already high penetration of PV. Different system concepts and operating modes will be tested within this setup.

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Communication / IEC61850					
0154	Prospects of fiber quantum key distribution technology for power systems				X
0174	Distribution Communication Substructure Fault Analysis by Data mining				
0218	The performance triangle in digital substation architectures		X		X
0225	Switchgear optimization using IEC 61850-9-2				X
0398	Empowering the systems engineer - IEC 61850 and visual languages				X
0439	A Tele-protection Implementation Experience at Power Substations using Metro-Ethernet Networks				X
0453	Automation of distribution network based on GPRS communication				X
0730	High Performance Computing and Communications Technology Solutions for Future Smart Distribution Network Operation				X
0733	Assessment and outlook of the OpenNode architecture		X		X
0739	Flexible Plug and Play Low Carbon Networks: Modern Communications Infrastructure that will enable Flexible Management of Network Constraints and Increased Levels of Renewable Generation				X
0803	Quality of service guarantee in smart grid communication infrastructure using traffic classification				
0894	Methodology of throughput tests in telecommunication networks for MV/LV substations				X
1189	Deployment of smart substation standard IEC 61850				X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
SCADA-Systems/DM-Systems					
0091	Integrated GIS and SCADA system model for Alexandria Electricity Distribution Company				X
0201	Finding assignable cause in medium voltage network by statistical process control				
0222	Multifunctional dispatcher training system for substation				X
0272	Ensuring Security and Reliability of Supply by Certification of Control Centres and Network Operation				X
0335	Field Testing of Distribution State Estimator				X
0353	DISASTER RECOVERY OF PLN EAST JAVA DISTRIBUTION CONTROL CENTRE				X
0365	Smart metering for the distribution control room				X
0426	Enhancing customer satisfaction and operational excellence by deploying an Integrated Distribution Management System (IDMS) at Stedin				X
0480	A Queue Theory Approach to optimise Control Center Organisation			X	X
0630	Challenges of implementation a distribution automation project in a model of decentralized operation centers				X
0649	Integration of fault location in a smart grid operating system				X
0858	Smart alarm processing		X		X
0870	Intelligent System for Management of Reclosers and Maneuver Proposition to Support Operations Teams				X
0879	Optimized switching using heuristic algorithm to support the restoration of distribution systems				X
0927	Model driven and pattern diagrams generation				X
1012	Control-center-based automatic fault isolation and restoration system for rural medium voltage networks				X
1134	Dispatch center operational performance improvement by chronological analysis and simulation				X
1459	Development and Test of Smart Distribution Management System				X
1493	Applications of DMS in the ATLANTIDE Project: models and tools			X	X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Cyber Security					
0030	CYBERSECURITY RECOMMENDATIONS FOR COMMUNICATION SYSTEMS IN THE COLOMBIAN ELECTRICAL SECTOR				X
0645	How can CyberSecurity be enhanced in existing substations minimizing impact on the automation and control system.		X		X
0818	Cyber security in smart grid stations				X
0995	The SINARI project : Security analysis and risk assessment applied to the electrical distribution network				X
1109	A tool for cyber security analysis of enterprises				X
1155	Smart Power Grid Security Services: Risk Management Approach Considering Both OT and IT DomainsCase Study: Shiraz Power Distribution Company				
1250	Security for critical infrastructure scada systems				X
1300	Analysing security issues for a smart grid demonstration environment				X
Phasor measurement units					
0050	Optimal Placement of PMUs for Reliable Observability of Network under Probabilistic Events Using BABC Algorithm				
0190	Field experience of phasors measurement in a distribution network with increased level of LV-connected PV				X
0498	APPLICATION of phasor measurement units in distribution networks				X
1121	Advanced applications of WAMS		X		X
1325	Modular PMU tester				X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
LV Automation					
0062	Problems of voltage stabilization in MV and LV distribution grids due to the operation of renewable energy sources				X
0246	Voltage balancing in low voltage distribution networks using Scott transformers			X	X
0391	Constrained PV penetration level in LV distribution networks based on the voltage operational margin	X			X
0469	Controlled switching scheme for photovoltaic generation for reducing overvoltage				X
0508	DGDemoNet: Impact of Volt/Var control on increasing the voltage band reserve - Results from field trial validations	X			X
0532	Blocking Reactive power Generation as a Voltage Control Measure				X
0640	Meter placement for low voltage system state estimation				X
0702	An online learning algorithm approach for low voltage grid management				X
0717	Experience with first smart, autonomous LV-grids in Germany	X			X
0819	Active, intelligent low voltage networks - Results and experiences of the field test	X			X
1239	Smart grid using 1th generation AMR meters - an operational view				X
1273	Development of voltage regulation method considering mutual smoothing e ect of PV in power distribution system				X
1290	Pilot System "Intelligent Low Voltage Grid"				X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Distribution Automation					
0115	Improving reliability in MV distribution networks case study				X
0127	New functionalities and features of IEDs to realize active control and protection of smart grids				X
0160	Optimal Automation Level in Microgrids				
0196	Self Healing distribution networks using Smart controllers	X			X
0197	Application of pulse closing technology for automatic loop restoration				
0200	Improving the Operational Efficiency of Fault Repairing with Partnership Management				X
0243	Experience with accumulated phase angle drift measurement for islanding detection			X	X
0259	Super decentralized control for distribution voltage regulation robust against imperfect power flow data collection				X
0263	Limits of the MV/LV grid supplied by renewable energy				X
0275	Telecommunication independent "Self-healing" M.T. Cable Distribution Network				X
0303	Use of System Integrity Protection Schemes To Improve Supply Continuity				X
0310	Movement to the full digital substation for primary distribution				X
0328	Model-driven software design for smart grid data analytics				
0342	Hierarchical operation and control for microgrids				X
0385	Distribution network reconfiguration to reduce losses and enhance reliability using binary gravitational search algorithm				
0396	The Smart Peninsula" pilot project of smart grid deployment at ENERGA-OPERATOR SA				X
0436	The Study of the Reliability Indices of Distribution Networks with VIT Switches on the MV Feeders Automation				
0443	Implementation of an active demand management procedure through of automatic load control and management of prosumers developed under the concept of smart grids				X
0496	Improvement of on-load tap changer performance in voltage regulation of MV distribution system with DG units using STATCOM				X
0514	Smart distribution through layered intelligence for next generation self-healing distribution networks	X			X
0528	Evaluating the robustness of an active network management function in an operational environment.				X
0550	Super decentralized control on the basis of centrally optimized control model for distribution voltage regulation				X
0571	ScheMa Project–Innovative criteria for management and operation of a closed ring MV network				X
0590	Wireless Remote Control in Ring Main Units: Experiences in Intelligent Grids				X

Paper No.	Title	MS a.m.	MS p.m.	RIF	PS
Distribution Automation					
0617	Impact of Savica hydro power plant operation on voltage quality and practical experience in implementing new VOLT/VAR control system architecture				X
0627	Meter placement impact on distribution system state estimation				X
0647	The enel smart grid test system: a real-time digital simulator-based infrastructure				X
0657	Real Time Volt/Var Control Using Advance Metering Infrastructure System in FAHAM Project				
0670	Automatic network reconfiguration - Split Airport (Croatia)				X
0693	Improving open-loop medium-voltage feeder self-healing				X
0722	A novel fault diagnosis approach of smart transmission grid based on knowledge grid technology				X
0727	Detection of measurements errors with a distribution network state estimation function				X
0801	Diagnosis of Advanced Distribution Automation in Brazil				X
0835	Design of an economical and technical distribution automation system				
0850	The Technologies of the self healing grid				X
0860	Autonomic control algorithm selection in decentralised power systems: a voltage control case study			X	X
0863	Universal IED for Distribution Smart Grids				X
0874	Flexible Plug and Play project : An open and scalable Active Network Management solution for a faster and cheaper DG connection		X		X
0949	Development of comprehensive analysis tool for distribution system with distributed generations and customer system				X
1021	Coordinated voltage control of distribution networks hosting dispersed generation				X
1137	Green Campus – Energy Management System				X
1142	Voltage quality and reactive power flow solution in distribution networks with a high share of renewable energy sources				X
1313	A Long Term Platform for Operation and Control of a Regulated Smart Grid				X
1358	A flexible control strategy for active distribution networks in a fast-changing scenario				X
1378	Active distribution system management				X
1424	Towards Distribution Energy Management Systems: Maximising Renewable DG				X
1425	A case study of systems architecture for decentralised topology inference of distribution networks				X
1433	Deterministic versus probabilistic approaches to self-healing in smart grid				X

Protection

Fault Location

Single phase earth fault detections and high impedance fault locations are prioritised in this sub block. 27 papers are in this sub block, most of them dealing with the problems of earth-faults.

Beginning with Paper 119, coming from UK, a new technique to detect the fault direction of single-phase-to-earth fault for Petersen's Coil compensated earthed power system is presented. The proposed technique does not special hardware with higher sampling rates or higher accuracy measurements.

In Paper 122, coming from Czech Republic, low-power stand-alone sensors based on nonconventional principles are discussed. The benefits of MV sensors (accuracy and dynamic range) utilised in earth-fault protection based on residual current detection are described in particular tests.

In Paper 202 from Egypt, a discrete-wavelet-transform (DWT) is used to simulate algorithms to detect high-impedance faults (HIF). The modelling and the results of the simulation are discussed. The algorithms should be capable to determine the phase and the feeder where the HIF occurs.

The Paper 368 from China shows a new approach to locate low-resistance grounding faults in a railway DC power supply system. A method to transform the DC traction power supply circuit into the Bergeron-equivalent-circuit is proposed and fault location methods are simulated.

In Paper 375, coming from Iran, a new fault location method using artificial neural network (ANN) is proposed. For the input of ANN the currents and active power of the feeder are measured, to estimate the distance of faults to the substation.

The recognition and location of self-extinguishing faults in MV cable networks is discussed in Paper 431 from The Netherlands. Statistic tools and observed historical measurement records are used to recognize self-extinguishing single phase faults. This algorithm is implemented in the fault location system of the Dutch DSO Alliander. In many cases it takes several weeks before such a fault develops into a persistent single- or multi-phase fault. Therefore, if a self-extinguishing fault is known in time, it might be possible to repair the cable in advance.

In Paper 458, coming from China, a method to indicate a transient equivalent circuit of single phase earth-faults on isolated neutral system is proposed. The results of the simulation shows, that the precision of the transient method is higher than the traditional equivalent circuit model.

In Paper 495, coming from Poland, a new solution of identification of high-impedance earth-fault in compensated MV network is discussed. The method is based on additional signal injection in the neutral point of the MV network. Theoretical studies, simulations and practical test in the laboratory demonstrate the benefits of this solution.

Paper 557 from China, presents a new principle to avoid mal-operation of the restricted earth-fault protection (REF), using the pearson-correlation-coefficient. Records of real mal-operation events are used to show in simulations and RTDS dynamic tests the function of this algorithm.
Paper 582 and 953, both coming from China, are presenting single phase fault location methods. The algorithms are based on the zero mode current correlation and the transient power direction. The simulations and field tests shows the function of this new method to detect small-current grounding faults.

In Paper 606, coming from Finland, a novel earth-fault location algorithm is presented, which enables the estimation of the earth-fault distance in compensated MV-networks. The performance of the novel algorithm is tested using data from comprehensive field tests, conducted in a typical rural 20 kV overhead line network with central compensation.
Another novel algorithm for feeder earth-fault protection in compensated MV-networks is presented in Paper 607, from Finland. The novel function is based on the patented concept of Cumulative Phasor Summing (CPS) in combination with the multi-frequency neutral admittance measurement.

Paper 903 from Brazil presents a new methodology for locating faults on primary feeders which is based on the concept of calculating short-circuit considering uncertainties in the assessment of some of the influential parameters. In order to validate the developed methodology some cases were simulated in a real network and the results are compared with actual fault-locations. The possible values of short-circuits at a specific point of the electric network and their probabilities of occurrence can be an interesting tool for protection engineers.

In Paper 994, coming from Slovenia, show field-tests in a resonant earthed MV system. The newly developed equipment and procedures, required to perform the tests, are presented together with the obtained results. The schematic experimental setup is shown in Fig. 9.

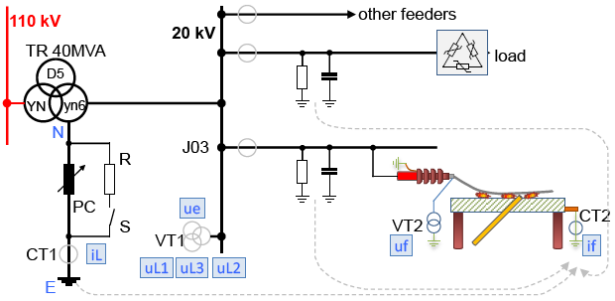

Fig. 9: Schematic experimental setup

Paper 1003 from Croatia presents a system to detect faults in MV-networks using GPRS communication. This paper describes the technical implementation of the GPRS communication solution for connecting Fault Circuit Indicators (FCI), which are installed in the MV-network, to the supervisory control system at Elektra Zagreb.

In Paper 1063 from Germany, new low-power sensors combined with units for fault detection and condition monitoring are presented. The advantages by using this technology are cost efficient measuring, very low influence by temperature and aging, easy installation and no adjustment to the primary signal.

The Paper 1081, coming from Finland, presents PSCAD simulations to verify how some factors such as the density of compensation coils, the share of decentralized compensation, the background network and the parallel resistance affect the earth fault current and how the earth fault current can be minimized during a fault condition. The simulation results show that there is an essential difference between the centralized and decentralized compensation method. The results also indicate that there is no problem in detecting the faulted feeder correctly when the decentralized compensation is applied.

The Paper 1092, coming from Germany, describes a fast selective earth fault localization, using the new fast pulse detection method. In contrast to the traditional pulse detection, this method is based on a thyristor-controlled High-Power-Current-Injection (HPCI) with a lot of advantages.

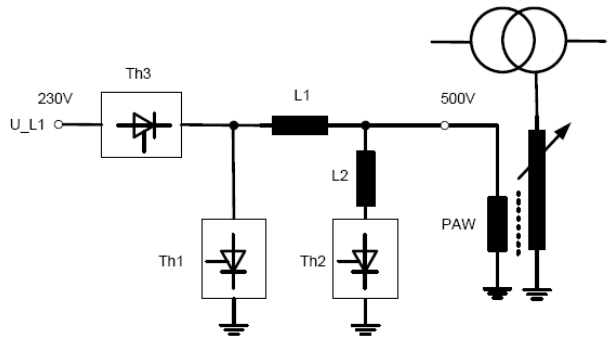

Fig. 10: Cost-optimized High-Power-Current-Injection

Fig. 11: Realized thyristor-controlled HPCI

Field tests are shown in Paper 1317.

The Paper 1206, coming from Spain, illustrates the function of a device to improve the earth of a secondary substation by connecting both neutral and protection earth in a very short time to drain an overvoltage before disturbing the domestic differential protections.
The device is also capable o detecting permanent phase to earth faults in the low voltage grid and it can also send a signal to a remote control centre.

Paper 1210, coming from Belgium, presents a novel method to detect earth fault with a strong sensitivity regarding the fault impedance. The algorithm builds a model of the sound feeder behaviour using the zero sequence voltage and current. The algorithm takes into account the historic of five periods which brings quite lot of information to differentiate the sound and faulty feeder.
In Paper 1214 from Finland, examples of existing AMR (Automatic Meter Reading) systems and IT integration solutions are described. By using present smart energy meters neutral faults can be detected rather comprehensively. It is also shown that voltage level alarms can indicate further possible faults than only the actual neutral fault alarms when set limits are adequate.

The Paper 1228 from Finland presents test results of the indication method for high-resistance phase-to-earth faults. In this study a high-resistance phase-to-earth fault is defined as a fault resistance from 10 kΩ up to some hundreds of kilo-ohms in a MV network with isolated or compensated neutrals. A RTDS environment was developed for testing the indication algorithm. The simulation results show that

the indication algorithm was able to detect and locate faults up to 100 – 200 kΩ. These results are also a good indication of the benefits of centralized protection, not only for real life substations but also for research purposes.

In Paper 1309, coming from Czech Republic, the influence of additional earthing of healthy phase for earth fault location is discussed. The paper deals with analysis of the touch voltage in the point of the fault during fault location and describes the experiment in a real distribution network. There are fast circuit breakers for additional earthing in the substation and the cycle close-open is shorter than 100 ms. The performed experiment confirmed that additional earthing of healthy phase has short-term negative effect on safety in the point of earth fault. In comparison with the permissible touch voltage given in EN 50522 the recorded values of touch voltages are five times lower.
The first results show that this method is acceptable from network safety point of view.

In Paper 1317, coming from Austria, the results of earth-fault field tests in a MV-network are presented. The field test show that within the mentioned grid constellation the transient method, the intermittent method and the fast-pulse-method can all provide stable directional information. Unfortunately, none of the tested methods can provide a stable decision in every fault condition. Only a combination of detection methods can cover all different fault types. To use the fast-pulse-method the installation of a HPCI is required.

A system for detection and disconnection of broken semi-insulated conductors is presented in Paper 1405, coming from Slovenia. It is required that the system includes additional devices (measuring points), measuring asymmetry of the three-phase system.
The technical solution of the electrical protection system LiSa includes new technologies of wireless/mobile telecommunication. Up to now, this system for detection and disconnection of downed conductor has been installed on four overhead lines.

The Paper 1443 from Brazil introduces fault management system architecture in a smart grid environment. The presented methodology allows the automatic solution of the fault identification and location in distribution systems, using multiple information sources. The proposed methodology is being integrated in a self-healing solution under development at CELESC S.A., a distribution utility in south of Brazil.

Neutral Grounding

The Paper 423, coming from Austria, show voltage rise caused by nearby lightning. Simulations were performed to confirm the correlation between lightning and voltage steps on the isolated power high voltage line and for simulations different network types were analysed.

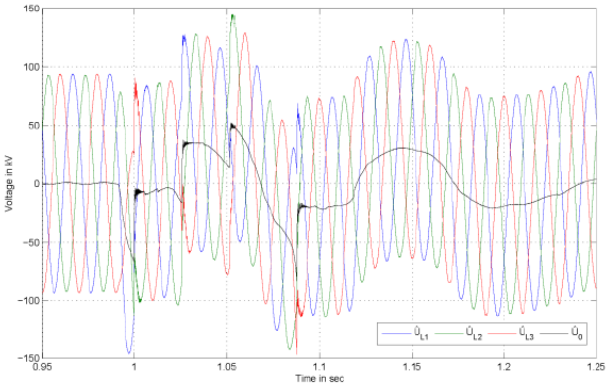

Fig. 12: Measurements of the phenomena

Transient voltage measurements at the isolated network were performed in the first months of operation of a small 110-kV-network. During these measurements unexpected voltage oscillations phenomena were detected as shown in Fig. 12. In low ohmic or resonant grounded grids these problems more or less eliminated.

The aim of Paper 783 from Portugal is to show how EDP Distribuição decided to launch a nationwide program to achieve an uniform MV neutral earthing system. At the end of this project all substations will operate in neutral earthed system. The outcome of those projects confirmed a reduction in the number of outages and a Quality of Service (QoS). One key factor for the success of this project was to establish good communication channels between all stakeholders. An analysis of QoS on 30 substations before and after the neutral earthing changes evaluated a result of 22% reduction on the number of interruptions and 30% in reduction of interruption time.

The Paper 1188 from Slovenia presents neutral-grounding-resistor (NGR) fault detection. During two years operation supervision of implemented detection on several NGR's in distribution company Elektro Primorska d.d. and field testing the proper operation of NGR failure detection is confirmed. With some improfvements of algorithm also verification results are presented in this paper.

Distributed Generation

The Paper 100, coming from Egypt, describes the impact of Distributed Generation (DG) on the behavior of an existing protection system. The main goal of this paper is to find the maximum allowable DG penetration level that maintains the same protection system before DG integration. The simulation includes the over-current, earth fault relays and auto-recloser (AR). The real traditional network of the North Delta Electric Distribution Company (NDEDC) in northern Egypt is studied. The results of this study show that the DG location has an important effect on the maximum level of DG penetration.

Paper 545, coming from Argentine, show the effect of the presence of Distributed Generation (DG) on the overcurrent protection coordination. The study was made in analytic and experimental form using MATLAB and equipment of a teaching laboratory. The overcurrent protection coordination study is carried out more based on the concept of specific energy as time function I^2t (t) rather than based on the time-current characteristics I (t). The method using specific energy is something more laborious but it allows making the coordination study in precise form.

The Paper 654, coming from Italy, presents a study to evaluate the real risk of islanding in a LV grid. In this paper the unwanted island generation and maintaining are analysed for a 4-wire LV grid composed by a mix of generators and loads. Both single-phase and three-phase generators are considered, in order to have an unbalanced grid with realistic topology. Analysis is performed using the Real-Time Digital Simulator (RTDS) installed in the Enel Test Centre of Milan. The study reported in this paper demonstrates that the unwanted (or uncontrolled) islanding is possible (in both LV and MV grid). In Figure 11 the island maintaining possibility is shown. The islanding probability becomes very high when the generators are regulated with drop logics, in terms of active power-frequency (P-f) and reactive power-voltage (Q-V); in fact these logics are designed just for stabilization purposes.

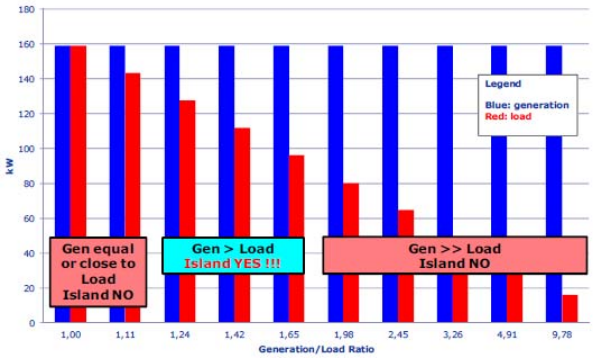

Fig. 13: The island maintaining possibility

Paper 677 from Luxembourg proposes a framework for adaptive feeder protection in distributed grids with a high amount of distributed generation. The scheme adapts the feeder protection relay settings according to the changes in the connection status of those DGs that have a significant impact on the fault current. The core of the method consists in the identification of the connection status of the DGs using an iterative modified state estimation (SE) program. The approach is illustrated using a realistic 31-node distribution network model.

The Paper 691, coming from Iran, aims to provide new tools and methods focused on the network protection impact of DG. Main problems are for instance failed reclosing, sensitivity or "protection blinding", selectivity problems and failed reclosing. The results of simulation are discussed in this paper.

Paper 692 from Portugal describes network protection system changes that were introduced by Portuguese Distribution System Operator, in order to fit fault ride-through capability of some DG power plants.
This paper show how the regulatory fault-ride-though framework was implemented on wind farms connected to the Portuguese distribution network.

The Paper 744, coming from France, describes a methodology to coordinate, set and optimize the selectivity of the distributed protective relays into the distribution grid. This protection scheme is based on non-communicating relays that use a transmission impedance evaluation based technology adapted for the distribution grids. Each relay must have their own separate set of settings (coefficient and thresholds) for every configuration of the feeder. The only communication that might be added is low speed communication that could allow the relays to adapt the settings for an optimized protection of different feeder configurations. Therefore the relays are independent one from another.

Paper 749 from France presents the effect of distributed generators on the directional algorithm by comparing the cases of Inverter Interfaced Distributed Generators (IIDGs) in PV systems and of synchronous generators (SGs) in CHP plants. Based on the symmetrical components method, the algorithm only uses current measurements to determine fault direction and thereby suppresses the cost of voltage sensors. The results show good performances in both cases during earth faults. However, during line-to-line faults, this algorithm gives better results in case of IIDGs.

The Paper 786, coming from Italy, describes innovative solutions to control unintentional islanding on LV network with high penetration of DG. Enel Distribuzione foresees to implement distributed intelligence in the secondary substations, to ensure the control of unwanted islanding and other equipment of the LV network.

In Paper 924, coming from Iran, the compensation of DG impact on overcurrent protection system of smart micro-grid is presented. A self-adaptive method for smart micro-grid is proposed, which compensates the under reached fault current seen by the relay. Therefore, there is no need to change the settings of protection devices for different operation conditions.

Paper 1312 form the US, introduces the concept of the advanced and adaptive protection for emerging distribution grids. Viable solutions using intelligent electronic devices and appropriate communication systems are presented. Fig. 14 shows the advanced and adaptive protection scheme. The automation and coordination of the protection scheme can

be implemented using a Logic Processor (LP) through communication.

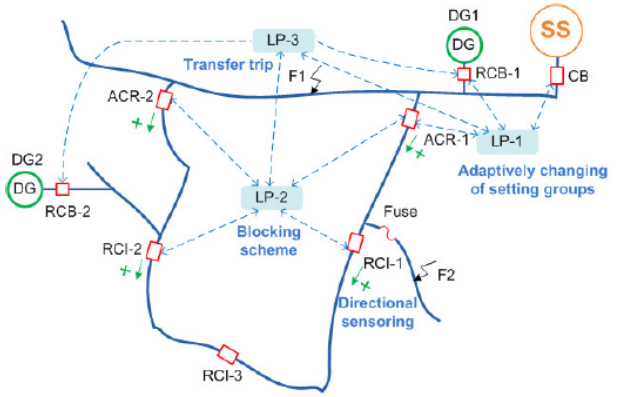

Fig. 14: Advanded and adaptive pretection schemes

This paper introduces a novel concept of advanced and adaptive protection and designs for active distribution networks. It demonstrates the versatility of a combination of local intelligence and centralized management, applying it to a practical example in a real system.

The Paper 1445, coming from Iran, presents a combined adaptive protection method to get improvement in relay reach. The proposed method show the adaptive over-current protection and adaptive under-voltage protection used simultaneously. The Implementation of this algorithm requires relays able to receive both the current and the voltage signals at the same time. The performance of the proposed method is shown in simulation results.

Paper 1502 from Italy, the coordination of Interface Protection Systems (IPS) for DG applications in MV distribution networks is proposed. The result summary, which includes three-phase, two-phase and single-phase to ground fault simulations, is reported.

Applications

Paper 38 from UK introduced a fault localization method in DC Marine power system using multiple injections at two different locations. The experimental test results which were derived from a 30kW, 400V twin bus DC marine system demonstrator show that a fault can be located accurately regardless of the existence of system passive filters.

The Paper 41, coming from Egypt, presents a low cost, high performance overcurrent relay used in several protection applications like, overcurrent, earth fault, restricted earth fault, second harmonic inhibition, and fifth harmonic inhibition. The designed hardware platform can be used also for over/under voltage and load shedding protection with simple modification. Also, by adding voltage modules to the relay, it can be converted to a very powerful directional overcurrent relay with simple addition in the firmware package.

Paper 82 from Czech Republic, discusses the performance and functionality of the combination of Low-power stand-alone sensors and IEDs. For the first time in MV applications, we report testing performed on the combination of sensors and IEDs with digital output according to the IEC 61850-9-2LE format. Accuracy measurements performed on prototypes show high promise both for metering and protection applications. The influence of cable lengths up to 100 m on the accuracy of existing sensor products in combination with new IEDs is discussed and good performance for protection functions like differential protection is proven.

In Paper 113, coming from Netherlands, the automated analysis of a distribution grid protection scheme as well as the results of the project is discussed. All transmission and distribution grids in the Stedin (a Dutch grid operator) service area were checked on a proper protective system. Due to the fact that 170 distribution grids have to be checked, the analysis of the networks has been automated.

“Centralised Busbar Protection for Smarter Grids” is the title of Paper 120, coming from UK. The specifications and expectations of busbar protection at distribution grid have increased over the last few years thanks to increasing levels of interconnections at the distribution grid due to distributed generations. Economical versions of Numerical busbar protection have become a norm at the distribution levels. According to lessons learned and in order to meet the expectation of both the performance and cost numerical version of centralised busbar schemes have been evolved.

The application of wide-area protection concepts in micro-grids is presented in Paper 212, coming from Iran. A new methodology for detecting the faults in a micro-grid is proposed relying on the communication infrastructure of the micro-grid. The decision to trip is based on analysing the power flow directions of different devices installed on the line ends. The protection is performed in a central controller by checking the power flows of each line ends.

The Paper 277, coming from UK, contains a description of an adaptive protection scheme that has been implemented and demonstrated in a hardware in the loop simulation environment using commercially available protection hardware and IEC 61850 communications. The implementation is based on an actual 11kV system which includes distributed generation and network automation. IEC 61850 communications offers several benefits for the implementation of adaptive protection, but also presents some limitations which are discussed in the paper. An alternative approach to overcome a number of the limitations is also presented.

Paper 442, coming from Brazil, presents a virtual panel with three protective relays containing features and functionality of digital relays for testing the functions of protection and

coordination. The primary purpose of this development is to train future professionals who will work in the area of protection of electrical systems.

In the Paper 454 from Indonesia, a case study improving the reliability of MV distribution networks is presented.

By utilizing Opal-RT's eMEGAsim real-time simulator, Hardware-in-the-Loop testing of process bus performance for differential protection is presented for three different scenarios. The results are shown in Paper 479 from Sweden. For all the three scenarios, the tripping time is very similar which means that traditional hardwired implementation of differential protection for a two winding transformer can be replaced with process bus implementation.

Paper 596, coming from Belgium, presents a review of transient effects of differential types of distributed generation units on overcurrent protection system. In most papers and technical documents, DGs are modelled by an ideal AC voltage source and transformer. However as it was described along the paper, the steady state and transient of the waveforms, when DG is modelled as an exact model including all dynamics, are completely different from the waveforms generated by ideal model. For designing a repayable, secure and optimized protection system in presence of DGs, it is important not to use ideal power sources for the DG modelling.

The Paper 616, coming from France, show an interesting solution avoiding ships to their auxiliary engines at berth by providing electrical power directly from onshore electrical system as shown in Fig. 15and Fig. 16.

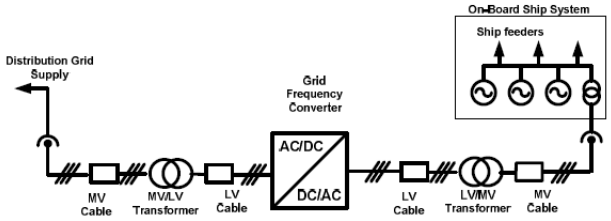

Fig. 15: The Shore Connection Distribution Grid Architecture

Paper 619 from the UK describes the practical implementation of an active fault level monitoring system to facilitate the integration of distributed generation (DG) within 11kV distribution networks. The laboratory tests have demonstrated that the IntelliRupter and PM7000 devices can be successfully combined and used to provide a fault level prediction within 4.5% of the measured fault level for the test cases considered. Using control functionality of the IntelliRupter to provide a disturbance, there is the possibility of predicting the fault level in real-time without causing any customer disturbance.

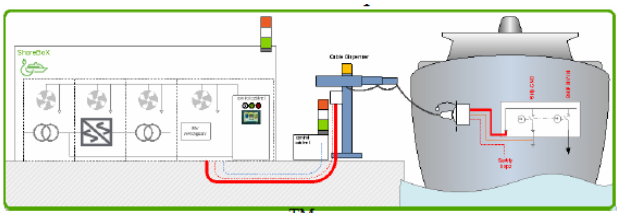

Fig. 16: Compact Shore BoX™ Solution

Paper 731, coming from Italy, describes an innovative method to implement the protection system of a distribution network foreseeing a closed-ring operation plant based on a Smart Grid architecture. The comparison between traditional (radial) network scheme and proposed "meshed" configuration as described on the last chapters of this paper, highlight several advantages for customers and DSO, in terms of: customer's satisfaction and network operation. Enel Distribuzione is committed to this project as an enabling factor for the future networks (smart grids).

The Paper 753, coming from the United Arab Emirates, provides a comprehensive analysis and solution for sympathetic tripping in distribution network. The proposed scheme discussed in this paper is possible to implement in all new distribution feeders, as modern relays have the facility to implement.

The title of Paper 754, coming from Germany, is "Early Detection of Tree Faults". This paper proposes a new protection function that incorporates measurements errors in a way that enables detection of very high values of fault resistances. Results show that the function could detect till about 10^6 Ω. Based on that, tree faults could be detected at very early stages of occurrence of the fault. In high voltage level, the function can detect very high values of fault resistances and at the same time keeps secure against other non-fault phenomena like power swing, voltage instability and load encroachment.

The Paper 919, coming from the USA, show how new technologies are expanding the tools that distribution engineers can use to both simplify and improve overcurrent coordination. Pulseclosing has merits on its own, but it is also an enabling technology that allows for new and better ways to perform distribution system automation and overcurrent protection. Pulseclosing, pulsefinding, and communication-enhanced coordination overcome many coordination constraints and allow for an unlimited number of fault interrupting devices to be used in series.

The Paper 931, coming from Brazil, presents the development, implementation, simulation results and field tests of an automated digital fault recording analysis system.

Paper 939, coming from Brazil, presents the development of a custom Intelligent Electronic Device (IED) for distribution feeder recloser protection and automation. The IED was designed according to specific requirements of the overhead distribution networks from the Brazilian electric

utility COPEL. The project aims to create a modular hardware and software solution, that could fit the today`s utility needs of a multifunctional device, such as a high-impedance protection function, and also future capabilities, in order to fit the newest Smart Grids scenarios of COPEL.

The Paper 1085, coming from Netherlands, describes a method for determining dynamic short circuit withstand capability of installations in meshed cable MV-networks, during switching on a fault. This method proves that the dynamic short circuit withstand capability of the installations in the MV-rings can dynamically withstand the immediate occurring fault current after switching on a fault. Before applying this method the necessary data of all installations needed to be available. It is also important that during calculations, the networks (cable lengths, installation details and network structure) need to be programmed correctly. Calculating a wrong current value may have disastrous effects on human safety.

The Paper 1143 from Portugal shows that oscillographic disturbance records from protecting units are becoming increasingly important to the network operation and maintenance. These records can be used for applications such as determining incorrect relay settings, relay coordination checks, fault location and analysis of complex events. The aim of this paper is to present the solutions being used and tested by EDP to achieve cost effective automatic disturbance data retrieval.

The Paper 1226, coming from the USA, presents novel solutions for protection, control, and metering in electric power systems using Rogowski coils as current sensors. Presented solutions include advanced differential protection systems for power transformers, power cables, and capacitor banks. Also, unique systems that effectively integrate protection, control, and metering functions were developed and successfully implemented.

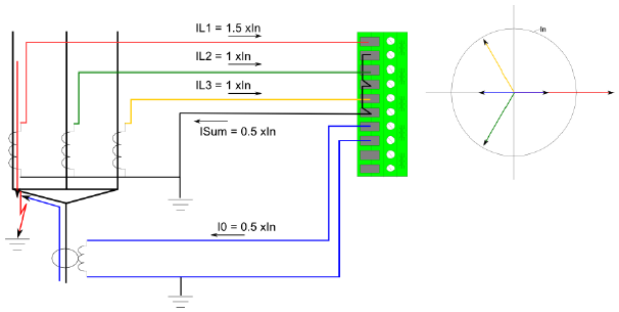

Fig. 17: Measurement of a cable end fault

Paper 1240 from Finland discusses improved protection methods against internal arc faults, emphasizing monitoring technologies that enable preventive protection. A new protection IED is introduced, incorporating a cable end differential protection algorithm along with traditional overcurrent, earth fault and arc protection functions. This cable end differential protection function utilizes measured phase currents and measured zero-sequence current and calculates a differential current over the cable end. The measurement of a cable end fault is shown in Fig. 17.

The Paper 1399, coming from the USA, describes protection operation analysis in smart grids. Fig. 18 shows the process of protection operation analysis.

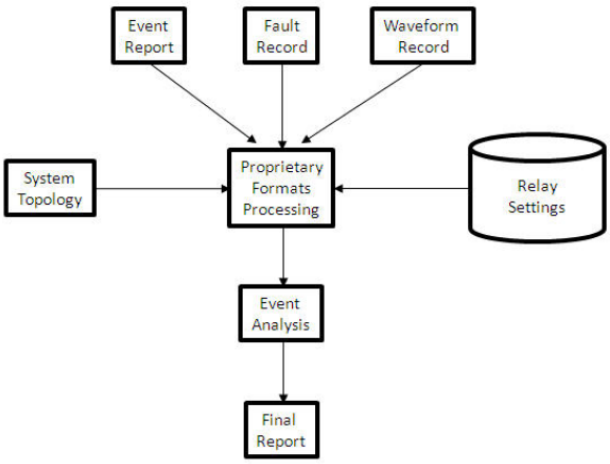

Fig. 18: Protection operation analysis process

The use of the different standard data formats and naming conventions allows the development of automatic fault analysis tools that will improve the quality of electric power systems event analysis and significantly reduce the required time based on the elimination of the manual conversion of proprietary data formats.

Algorithms, Simulations

Paper 228, coming from Egypt, propose an Artificial Bee Colony (ABC) algorithm to optimize the coordination of directional overcurrent protection relays. Three case studies were evaluated and implemented on looped 3-bus, 6-bus, and 8-bus systems. The obtained results from the proposed ABC algorithm is compared to those using Linear Programming (LP) and Particle Swarm Optimization (PSO) techniques to demonstrate the effectiveness of the ABC in such problems that are highly constrained.

The Paper 446, coming from China, presents an accurate track modelling for fault current analysis of DC railways based on RTDS (Real-time Digital Simulator). With the introduction of skin effect for rails during short-circuit transient conditions, an integrated RTDS simulation model of short-circuit fault is proposed.

The Paper 468 from China proposes a centralized decision-making and distributed revising Under Frequency Load Shedding (UFLS) scheme based on the use of information sharing technology.

Paper 663 from Brazil presents a high impedance fault (HIF) location method in distribution systems. The estimation of the HIF location is carried out by using an artificial neural network (ANN). The ANN inputs are both

three phase currents and its energy of the Wavelet Coefficients obtained during the HIF. In order to collect HIF data to assist the development of HIF modelling and database building, staged fault tests were performed on a distribution feeder at Energisa, in Boa Vista town.

The focus of Paper 765, coming from UK, is to develop a new islanding detection algorithm that is based on Phase Angle Difference from the voltage phase angle measurement received from a Phasor Measurement Unit (PMU). The new algorithm will compensate for the time delay caused by satellite and internet communication, and the length of the window of measurement.

The last Paper in this block (1049), coming from Germany, presents a novel, very fast protection algorithm that is based on directional comparison. The algorithm is robust against many states and phenomena appearing in the network, e.g. load flow fluctuation, power swings or frequency deviations. The method is also robust against some phenomena connected with secondary system design like CTs saturation, synchronisation deviation or the transient effects in CVTs.

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

	Paper No. Title	MS a.m.	MS p.m.	RIF	PS
No. 38	Fault location in a DC Marine Power System			X	X
No. 41	Design of Prototype non Directional Overcurrent Relay Micro-Controller-Based				X
No. 82	Total Accuracy of the Whole Measuring Chain – Sensor & IED				X
No. 100	Investigation of the Impact of DG on the Behavior of NDEDC Protection Systems				X
No. 113	Automated Analysis of Distribution Grid Protective Schemes				X
No. 119	Transient Earth Fault Detection on Compensated Earthed System				X
No. 120	Centralized Busbar Protection for Smarter Grids				X
No. 122	Earth Fault Protections with Sensors				X
No. 202	Detection of High Impedance Faults in Medium Voltage Distribution Networks using Discrete Wavelet Transform				X
No. 212	Application of Wide-Area Protection Concepts in Micro Grids				
No. 228	Coordination of Directional Overcurrent Relays using Artificial Bee Colony				X
No. 277	Demonstration of Adaptive Overcurrent Protection using IEC 61850 Communications				X
No. 368	Grounding Fault Location in DC Railway System				X
No. 375	A new Fault Location Technique on Radial Distribution Systems using Artificial Neural Network				
No. 423	Oscillation Phenomena in Isolated High Voltage Networks caused by Lightning Strokes				X
No. 431	Improving Network Performance by Recognition and Location of Self-Extinguishing Faults				X
No. 442	Didactic Software Tool for Protections Functions of Digital Relays, Studies and Verification of Coordination and Selectivity				X
No. 446	Accurate Track Modeling with Skin-Effect for Protection Improvement in DC Railway System based on RTDS				X
No. 454	Improving Reliability on MV Distribution Line in the System connected to Distributed Generator in South Sumatra, Indonesia, a Case Study				X
No. 458	Transient Equivalent Circuit of Single-Phase Earth Faults on Isolated Neutral System				X
No. 468	Under Frequency Load Shedding Scheme based on Information Sharing Technology				X
No. 479	Performance Evaluation of Protection Functions for IEC 61850-9-2 Process Bus using Real-Time Hardware-In-The-Loop Simulation Approach				X
No. 495	New Solution on Identification of High-Impedance Earth-Fault in Compensated MV Network				X
No. 545	Effect of the Presence of Distributed Generation on the Studies of Overcurrent Protection Coordination		X		X

	Paper No. Title	MS a.m.	MS p.m.	RIF	PS
No. 557	A new Principal based on Pearson Correlation Coefficient to avoid Mal-Operation of the Restricted Earth-Fault Protection				X
No. 582	A new Single Phase Fault Location Method of Noneffectively Grounded Networks for DA Systems				X
No. 596	A Review of Transient Effects of different Types of Distributed Generation Units on Overcurrent Protection System				X
No. 606	Novel Algorithm for Earth-Fault Location in Compensated MV Networks				X
No. 607	Application of Novel Cumulative Phasor Sum Measurement for Earth-Fault Protection in Compensated MV-Networks			X	X
No. 616	Protection Plan and Safety Issues in the Shore Connection Applications				X
No. 619	Implementation of an Active Fault Level Monitoring System for Distributed Generation Integration				X
No. 654	Unwanted Island Maintaining in LV Grids: Analyses and possible Solutions. A Study based on the Real-Time Digital Simulator				X
No. 663	High Impedance Fault Location – Case Study using Wavelet Transform and Artificial Neural Networks				X
No. 677	Distributed Generator Status Estimation for Adaptive Feeder Protection in Active Distribution Grids				X
No. 691	Power Quality Customer Financial Impact/Risk Assessment Tool				
No. 692	Adaption of Protections for Compatibilization with Fault-Ride-Through Capability of Wind Farms				X
No. 731	Innovative Protection System on Distribution Network				X
No. 744	Protection Scheme bases on Non Communicating Relays Deployed on MV Distribution Grid		X		X
No. 749	Performance of Directional Relays Without Voltage Sensors: Impact of Distributed Generation Technologies				X
No. 753	A Comprehensive Analysis and Solution for Sympathetic Tripping in Distribution Networks				X
No. 754	Early Detection of Tree Faults				X
No. 765	Islanding Detection Method using Phase Angle Difference for Regional Distributed Generation Protection				X
No. 783	Toward an Uniform MV System Earthing in EDP Distribuição – Project Challenges and QoS Improvements				X
No. 786	Innovative Solutions to Control Unintentional Islanding on LV Network with High Penetration of Distributed Generation		X		X
No. 903	Fault Location System for Primary Feeders based on Short Circuit Model Considering the Uncertainties of Parameters Involved				X
No. 919	New Technology yields Three Ways to Overcome Coordination Constraints on the Distribution System				X
No. 924	Compensation of DGs Impact on Overcurrent Protection System of Smart Micro-Grids				
No. 931	Automated Digital Fault Recording Analysis System				X
No. 939	Custom Distribution Feeder Recloser IED with High Impedance Protection Function				X

	Paper No. Title	MS a.m.	MS p.m.	RIF	PS
No. 953	The Fault Location Technology using Transient Signals for Single Phase Earth Fault in Non-Solidly Earthed Network				X
No. 994	Touch of the Conductor with Earth Surface in Resonant Earthed Medium Voltage Systems				X
No. 1003	Detecting Faults in MV Network using GPRS				X
No. 1049	Ultra-Fast Relay with Low Requirements According to Communication		X		X
No. 1062	Fault Detection using new Low-Power Sensors and Low-Voltage Measurements Lead to Cost Reduction				X
No. 1081	Factors Affecting the Earth Fault Current in Large-Scale Rural Medium Voltage Cable Network				X
No. 1085	Method for Determining Dynamic Short Circuit Withstand Capability of Installations in Meshed Cable MV-Networks, During Switching on a Fault				X
No. 1092	Fast Selective Earth Fault Localization using the New Fast Pulse Detection Method		X		X
No. 1143	Fast and Secure Automatic Retrieval of Data From Multi-Vendor Devices - The Portuguese Experience				X
No. 1188	Neutral Grounding Resistor Failure Detection Verification				X
No. 1206	Smart Earths Connector				X
No. 1210	Detection of Single Phase Earth Fault in Compensated Network with C0 Estimation				X
No. 1214	Neutral Fault Management in LV Network Operation Supported by AMR System			X	X
No. 1226	New Protection Schemes Based on Novel Current Sensors for Up-to-Date Grid				X
No. 1228	Verifying the Indication Method for High-Resistance Earth Faults Implemented in Centralized Protection System				X
No. 1240	Improving Medium Voltage Switchgear Protection in Compensated Distribution Networks				X
No. 1309	The Influence of Additional Earthing of Healthy Phase for Earth Fault Location on Safety of Compensated Networks				X
No. 1312	Advance and Adaptive Protection for Active Distribution Grid		X		X
No. 1317	Evaluation of New Earth Fault Localization Methods by Earth Fault Experiments			X	X
No. 1399	Protection Operation Analysis in Smart Grids				X
No. 1405	Advanced Protection of Overhead Lines in the Event of Interrupted Conductor				X
No. 1443	Fault Identification Using Multiple Information Sources in Smart Distribution Grids				X
No. 1445	Adaptive Protection in Active Distribution Networks Based on Integrated Protection				
No. 1502	Coordination of Interface Protection Systems for DG Applications in MV Distribution Networks				X