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智慧型太陽光電故障診斷技術研究

Study of Intelligent Fault Diagnosis Technologies for PV Systems

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摘　要

台灣太陽光電裝置容量已經超過7GW，這些中小型分散式能源的運轉與維護模式有別於傳統大型水火力電廠，因此研發太陽光電系統故障診斷技術刻不容緩。本文首先介紹太陽光電監控系統的重要組成元件以及相關國際標準對於監測參數的要求，接著蒐集太陽光電系統可能的故障種類，洞悉較常發生的故障型態。此外，本文詳細彙整各種太陽光電故障的診斷技術，這些技術包含各種電氣與非電氣量測法、應用人工智慧模型法、量測與模擬比較法，以及統計與信號處理法等，並涵蓋在線(Online)與離線(Offline)的診斷方式。最後，本文提出太陽光電系統故障診斷未來的技術挑戰，包含模型的精確度要求、各種診斷技術之間的互補與關聯性、人工智慧應用於太陽光電系統故障診斷的趨勢，以及多重故障與在線即時診斷技術的重要性。本文整理的內容可以提供國內太陽光電案場平日維護與故障診斷的參考。

Abstract

The installed capacity of photovoltaic (PV) systems in Taiwan has exceeded 7GW. The operation and maintenance mode of these small and medium-sized distributed generation resources is different to that of traditional large-scale hydro or thermal power plants. Therefore, it is important to develop fault diagnosis technologies for PV systems. This paper first introduces the important components of a PV monitoring system and the requirements of relevant international standards on monitoring parameters. Next, this paper investigates the commonly seen PV fault types. Then, this paper summarizes various PV fault diagnosis techniques in detail, including methods of electrical and non-electrical measurement, artificial intelligence (AI) models, comparison of measurement and simulation, statistical and signal processing, online and offline diagnostic technologies, etc. Finally, this paper proposes potential technical challenges concerning PV fault diagnosis in the future, including the requirements for model accuracy, complementarity and correlation among various diagnostic techniques, the trend of AI applications in PV fault diagnosis, and the importance of real time multiple faults disgnosis. The contents in this article may serve as reference for PV maintenance and fault diagnosis in Taiwan.

關鍵詞(Key Words)：太陽光電(Photovoltaic)、運轉與維護(Operation and Maintenance)、故障診斷(Fault Diagnosis)、監控系統(Monitoring System)、人工智慧(Artificial Intelligence)、統計與信號處理(Statistics and Signal Processing)。

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架空輸電線應用保護網屏蔽電場之效能探討

Using Protective Net to Shield Electric Field of Overhead Transmission Lines

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摘　要

架空輸電線路使用之保護網(Protective Net)對於屏蔽低頻電場(Electric Field)可得到良好效果；本文以台灣電力公司供電單位制定之規章文件以及電磁理論為基礎，計算輸電線產生之電場強度值，再運用有限元素數值分析軟體(COMSOL Multiphysics)模擬69kV單回線帶電導體下方設置保護網情形，探討網面於不同尺寸及金屬材質時之屏蔽效能，供作為日後檢討、設計與施工之參考。

Abstract

Protective net may yield favorable results in shielding low frequency electric field. Based on electromagnetic theory and the regulations formulated by the Power Supply Department of Taiwan Power Company, this paper aims to calculate the intensity of the electric field intensity generated by transmission lines; apply a finite element numerical analysis software titled COMSOL Multiphysics to simulate the situation of setting up protective net under the conductor of a 69kV single-circuit line; and discuss the shielding effectiveness of the net surface of different sizes and metal materials, to serve as a reference for future review, design and construction.

關鍵詞(Key Words)：架空輸電線(Overhead Transmission Line)、保護網(Protective Net)、電場屏蔽(Electric Field Shielding)。

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69kV 線路保護電驛標置協調 PC 化程式研究

A Study of Using PC Program to Calculate 69kV Line Protection Relay Setting

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摘　要

本公司69kV輸電線路之保護電驛規劃中主保護使用線路差流保護(87L)，後衛保護使用多區間測距(21/21N)電驛及方向性過電流(67/67N)電驛，在後衛保護的保護協調計算均透過Aspen軟體以人工方式計算達成，若改以69kV PC化程式計算21/21N標置設定，除了單以變壓器阻抗考量外，多了視在阻抗的計算功能，使得測距保護更加全面。另程式可自動選取須計算之線段，可有效減輕工作人員工作負擔，縮短計算時間。藉由適度調整各區間的延時設定，可以較以往有更準確的保護及加速事故隔離時間。本文以墾丁P/S、楓港P/S兩個完成電驛全面數位化轄區，將兩區之輸電線路保護之21/21N三區間阻抗以69kV PC化程式計算，並分析其效益。

Abstract

To protect 69kV transmission lines, Taipower applies differential current relays (87L) as the main protection, while multi-zone distance protection relays (21/21N) and directional overcurrent relays (67/67N) as the back-up protection. Currently, the latter (back-up protection) uses Aspen software to manually calculate the protection coordination time interval (CTI). When calculated by the 69kV PC-based program, the relay setting of 21/21N not only considers transformer impedance, but also apparent impedance to ensure comprehensive protection. In addition, the program may automatically select any line segment for calculation, which can increase work efficiency and lessen human errors. Proper adjustment of the delay settings of each 21/21N zone has a positive influence on the accuracy of protection and the acceleration of accident isolation time as compared with before. The contents of this study includes using KenTing P/S and FengKang P/S to demonstrate comprehensive digitalization of power stations, applying 69kV PC program to calculate the two regions 21/21N three-zone transmission line protection setting, and discussing the resulting-in benefits.

關鍵詞(Key Words)：輸電線路保護(Line Protection)、測距保護(Distance Protection)、饋入效應(Infeed Effect)、視在阻抗(Apparent Impedance)、欠區(Under Reach)。

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金門智慧電網推動架構之能源物聯網之應用與發展

The Application and Development of Energy IoT upon the Smart Grid Architecture of Kinmen

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摘 要

金門地屬離島，電網未與台灣本島相聯，其孤島型電網可作為台灣發展智慧電網與能源物聯網之先期示範場域。為進一步擴增綠能與智慧節能設施，透過公民電廠營運以發展智慧綠能社區並分享利潤，有利於激勵民眾參與、強化地方與再生能源之鏈結、創造在地就業機會與促進地方良好關係。本研究旨在於金門地區創立公民電廠首例，並導入智慧電網中能源物聯網技術，以建構虛擬電廠示範，進而作為台灣本島相關技術與政策發展之參考依據。本文彙整了金門公民電廠推動現況，同時針對金門未來發展再生能源之可能情境，報告中透過未來淨負載曲線推估，分析未來金門電網可能遭遇的問題，並針對這些問題提出虛擬電廠運作的架構及需量反應商業模式，並開發虛擬電廠與區塊鏈需量反應與綠電交易平台。

Abstract

The power system in Kinmen is an islanding power grid; in other words, not connected to the main grid in Taiwan. Therefore, it is suitable to be used as an early-stage demonstration field for the future development of smart grid and Energy Internet of Things (EIoT) in Taiwan. In order to further expand green energy and smart energy-saving facilities, the operation of civic power plants (CPPs) is implemented to inspire the development of smart green energy communities and profit sharing. Not only that, it may also stimulate public participation, strengthen the linking between local communities and the entities of renewable energy, create local employment opportunities, and promote harmonious local relations. This research aims at establishing the first CPP case in Kinmen, at the same time introducing new EIoT technologies to build a virtual power plant (VPP) demonstration system. The results of this research may serve as reference basis for developing related technologies and policies for the Taiwan main island. This article summarizes the development status of the CPP in Kinmen. In addition, the future net load curve of Kinmen is estimated according to the possible scenarios of its future renewable energy to analyze the potential problems in Kinmen. Accordingly, this research proposes the architecture of VPP and operational modes for demand response. A VPP platform with Blockchain-based demand response and green energy trading has also been planned and implemented.

關鍵詞(Key Words)：公民電廠 (Civic Power Plant)、虛擬電廠 (Virtual Power Plant)、能源物聯網 (Energy Internet of Thing)、需量反應 (Demand Response)、區塊鏈平台 (Blockchain Platform)。

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IEC 61850 變電所與 GOOSE 服務應用研析

A Study of IEC 61850 Substation and GOOSE Service Application

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摘 要

因應大規模分散式能源併入電網及推動智慧電網發展，台電公司致力推動並導入IEC 61850國際標準，希望藉由整合通訊介面與通訊協定提升調度之靈活性。目前台電公司逐年建置IEC 61850變電所，透過數位化與標準化方式對變電所內各項設備資訊進行整合。與傳統變電所控制方式相比，IEC 61850標準引入通用物件導向變電所事件(Generic Object Oriented Substation Event, GOOSE)服務，於間隔層(Bay Level)之智慧電子裝置(Intelligent Electronic Device, IED)可彼此進行溝通，於此，國外亦有許多相關研究報告，運用IED的GOOSE服務搭配邏輯節點進行保護協調等實際應用。本文將對GOOSE服務與國外相關案例進行研析。

Abstract

In response to more and more decentralized energy integrated into the power grid and the promotion of smart grid development, Taiwan Power Company (TPC) is committed to promoting and implementing IEC 61850 to enhance the flexibility of dispatching by integrating communication interfaces and protocols. TPC has implemented IEC 61850 in its substations year by year, looking forward to integrating information of various equipment-through the efforts of digitalization and standardization. Compared with traditional substation control methods, the IEC 61850 standard introduces the Generic Object Oriented Substation Event (GOOSE), which allows intelligent electronic devices (IED) in bay level to communicate with each other. In this paper, we will analyze the GOOSE service and related cases in foreign countries.

關鍵詞(Key Words)：智慧電子裝置(IED)、通用物件導向變電所事件(GOOSE)、IEC 61850。

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應用智慧電表大數據分析技術分析低壓用戶之用電移轉潛力

A Study on Analyzing Big Data of Smart Meter to Estimate the Load Shedding Potential of Low Voltage Customers

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摘　要

本研究應用支持向量機機器學習理論，以智慧電表每分鐘提供之實功及虛功兩個電力參數做為特徵，建立冷氣開或關運轉狀態辨識之二維分類器模型，並實際導入金門地區5戶低壓用戶做性能驗證及需量反應用電移轉之潛力分析。研究結果顯示，各測試戶於2021年6月至9月測試期間之平均召回(Recall)辨識率均達85%以上，代表於冷氣實際開啟狀態之時間下，有85%的比例可成功被本模型正確辨識出來，而平均最大之用電移轉時數約13,212分鐘，約為220小時。本研究成果對於未來的低壓需量反應聚合商於即時需求狀況下尋找DR潛在用戶之應用極為有助益，可協助評估一定區域之冷氣配合需量反應之潛力卸載容量。

Abstract

This study proposes a machine learning based SVM (Support Vector Machine) binary classifier model which uses parameters of active and reactive power collected by smart meters as the input features to differentiate the on/off status of air conditioners. The proposed model is tested out of 5 low voltage buildings in Kinmen county for the purposes of performance evaluation and demand response load shifting estimation. The result shows that the recall metrics are all above 85% during the period from June to September 2021, which indicates that 85% of the air conditioners with run mode time can be correctly identified by the proposed model, and the maximum load shifting time is averagedly 220 hours. The results of this research may serve as reference for future applications of low-voltage demand response, aggregators to identify their potential DR users, and load shedding potential evaluation of air-conditioners located in certain areas.

關鍵詞(Key Words)：支持向量機(Support Vector Machine)、機器學習(Machine Learning)、智慧電表(Smart Meter)、分類器(Classifier)、需量反應(Demand Response)。

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社區能源管理系統與 AMI 用戶端通訊整合精進研究

Advanced Research on Communication Integration between Community Energy Management System and AMI Clients

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摘 要

本報告以無線通訊技術，針對鳳山智慧綠社區之公寓式建築設計與整合Route B通訊系統，目的是改善國內首次推動AMI電表至用戶端最後一哩路(Route B)所建置的通訊品質，藉由通訊設備提供更多更廣泛的應用服務。選定Wi-SUN RF通訊技術進行新Route B通訊結構的開發。以既有通訊系統為基礎，針對智慧閘道器通訊架構簡化，搭配訊號中繼器的使用，提升距離電表位置較遠之處Wi-SUN訊號的修正，提供另外一種經濟與低成本的通訊模式，供台電公司後續建置Route B通訊設備的重要參考。

本次進行智慧綠社區興達及核三備勤宿舍區共366戶之Route B基礎設施建置更新，其項目包含AMI電表HAN通訊模組、用戶端通訊模組、Meter Gateway通訊閘道器等。為有效管理所安裝之通訊設備運作情形，本案開發專屬維運平台，提供相關維護人員操作及監視設備狀態。同時為解決社區伺服器硬碟容量有限問題，建置資料備援系統，透過自動排程方式，定期將366戶之每分鐘電力資料備份儲存，以延長保存期限。

Abstract

This project uses wireless communication technology to design and integrate the Route B communication system for the apartment-style building of Fengshan Smart Green Community with the purpose to improve the first domestic implementation of AMI meters to the last mile (Route B) of the user terminal. The communication quality provides more and more extensive application services through communication equipment. We select Wi-SUN RF communication technology to develop a new Route B communication structure. Based on the existing communication system, the smart gateway communication architecture is simplified, and the use of a signal repeater improves the correction of Wi-SUN signals far away from the meter, providing another economical and low-cost communication mode, also providing important reference for Taiwan Power Company to build Route B communication equipment.

This time, the route B infrastructure of 366 households in the smart green communities of

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Xingda's and the Third Nuclear Power Plant's dormitory areas will be updated. The project includes AMI meter HAN communication module, client communication module, meter gateway communication gateway, etc. In order to effectively manage the operation of the installed communication equipment, this project develops an exclusive maintenance platform to operate and monitor the status of the equipment. At the same time, in order to solve the problem of the limited hard disk capacity of community servers, a data backup system was built to periodically store the per minute electricity data of 366 households through automatic scheduling to extend the data storage period.

關鍵詞(Key Words)：先進讀表基礎建設(Advanced Meter Reading Infrastructure, AMI)、路徑B(Route B)、Wi-SUN。

5G 耗能及其對電能之影響研析

5G Power Consumption and Its Impact on Electrical Energy

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摘 要

隨著科技演進，民眾連網的需求提升，未來將會有更多的設備連上網路，亦加速產業智慧化推動。每一代通訊技術的演進都會連動影響著電網，例如新通訊技術耗能的增加，民眾用電習慣的改變，再生能源電網通訊等。在這樣的科技轉變下，本篇研究的重點依現有文獻綜整5G耗能要點，持續收集系統耗能研究關鍵要素，俾導入後續研究。

Abstract

Accompanied with the evolution of communication technology and the increasing demand of the public for the Internet, more and more devices will be connected to the Internet, so as the accelerated pace of grid intelligence. The emergence of new communication technologies has a great impact on the operation of power grids, e.g., increase of energy consumption, altering the public's electricity consumption habits, and grid communication of renewable energy. In view of such technological changes, this paper aims to discuss the impacts of 5G on power grids.

關鍵詞(Key Words)：5G(5th Generation Mobile Networks, 5G)、節能(Energy Saving)、基地台耗能(Base Sstation Energy Consumption)、第三代合作夥伴計畫(3rd Generation Partnership Project, 3GPP)。

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電廠之無線通訊效能評估與研究

A Research on Power Plant Wireless Communication Performance Evaluation

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摘 要

無線通訊技術於智慧電網提供了通訊系統可擴展性、彈性和較低安裝成本。因此，新一代無線通訊技術用作電網控制之可行性評估一直被電力公司所探討。首先，本研究針對現行常用之通訊技術介紹及使用中之無線通訊頻譜作一說明，為建置新一代無線通訊系統，須對現有之無線通訊系統效能評估以作為日後建置專頻專網應用之參考。

有鑑於電廠係智慧電網重要的一環，本研究在實作部分乃選擇一電廠進行現有之無線通訊效能量測評估。所利用之量測儀器包括掃頻儀及頻譜儀，量測場域特別針對廠區發電機組之控制室進行評估，並將各量測場域之通訊效能優劣列表比較。同時，研析現有使用之頻譜中是否有干擾信號出現將對日後專頻專網建置使用造成影響。最後，對現有無線通訊技術運用於電廠之量測結果提出結論供台電公司未來在改善與規劃建構新一代無線通訊系統之有效參考依據。

Abstract

The application of wireless communication technology on smart grids has the features of system scalability, flexibility and lower installation costs, so as it has been widely discussed among electric utilities. In this paper, we first introduce the commonly used communication technologies and wireless communication spectrum. Next, we evaluate the performance of existing wireless communication systems, such as 4G, 5G and WiFi. At the same time, whether there are unwanted interference signals in the spectrum currently in use are also analyzed. Lastly, conclusions are drawn on the measurement results of the existing wireless communication technologies applied to power plants, to serve as a reference for Taipower to plan its wireless communication system in the future.

關鍵詞(Key Words)：智慧電網 (Smart Grid)、5G (5th Generation Wireless Systems)、干擾 (Interference)、通訊系統(Communication System)、頻譜(Spectrum)。

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