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Issues and Advancement in Wide Area Monitoring System and Microgrids Protection

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ABSTRACT

The sectors that provide energy require methods to deal with network-wide problems that frequently result in broad blackouts in power system networks. Protection and control methods play a vital role in minimising the effects of a severe disturbance by stopping further system deterioration, bringing the system back to normal, and preventing future disturbances from occurring. The use of Phasor Measurement Unit (PMU) based Wide-Area Measurement Systems (WAMS) in power system protection and control has been encouraged by ongoing technological advancements in measurement and communication. This has led to better management of system security through sophisticated control and protection strategies. This study conducts a thorough analysis of current advancements in this area. The survey emphasises major problems and challenges and focuses on WAMS-based adaptive relaying and control applications.

Index Terms –Protection, Microgrid, WAMS, EMS, SCADA, PMU, PDC.

INTRODUCTION

Microgrids can work even if the primary power system is down, and they can improve grid dependability, reduce grid disturbances, and serve as a grid resource for quicker system reaction and recovery. In order to promote sustainability and reduce reliance on fossil fuels, microgrids may also be used to include renewable energy sources, such as solar and wind power, into the local electrical supply. Additionally, MGs can improve the robustness of the power system, decrease gearbox losses, and give more control and flexibility over the energy supply. Despite the potential advantages, one of the significant obstacles to the introduction of microgrids in a number of nations is the lack of unified operating and connectivity standards. The "island operation" is one illustration. The regulatory framework currently prohibits distributed generators that are categorized as micro/mini generation from operating in islanded mode due to safety and stability issues during the restoration process. Some generator types, such as energy self-producers using the grid in parallel, can, nevertheless, function independently of the distribution system.

The development and adoption of new technologies may be aided by sufficient standardization, and via carefully crafted operating contracts (such as those that use microgrids to support the grid), the power grid itself can even be improved. In order to contextualize the proposed regulations, [1] intended to compile discussions of features and crucial issues. It did this by stating the key factors that need be taken into account for small- and medium-sized microgrids' stable and safe operation in all operating modes. Due to the widespread use of DC loads, integration of solar photovoltaic (PV) and energy storage technologies, and the absence of frequency and reactive power management concerns, direct current (DC) microgrid is now gaining relevance. Due to the numerous distributed generators (DGs), loads, utility grids, and energy storage systems (ESSs) connected to the DC bus with power electronic converters, planning and protection of such microgrid are challenging. Protection and planning, two key facets of DC microgrids, are critically summarized in [2]. The supply of constant, high-quality power is the main issue. While ensuring the security, dependability, and safety of the system, it should be taken care of. In both working modes, the protection strategy must be dependable, focused, quick, and vulnerable. The design of AC microgrids, DC microgrids, and hybrid microgrids, as well as the related protection problems and solutions, are meticulously studied in [3].

ISSUES IN MORDERN POWER SYSTEM

[4] provides information about the architecture of microgrids, prerequisites for microgrid protection, and various threats to the microgrid's security. It also explored numerous protection challenges through the critical analysis of several sorts of solution techniques. We have discovered that while creating a protective system for the microgrid, prior understanding of crucial circumstances is crucial. Earthing systems, fault types, relay types, and microgrid topology are necessary requirements. A thorough literature review reveals restrictions on protection. The level, nature, and position of the fault as well as the source or generator's type and output level all influence the necessary protection Regarding various protection challenges, microgrid topology, size, and operational modes, a critical study of various protection methods and their approach to solutions is also included. Different protection strategies can be used to address various microgrid protection concerns. Each of these methods is described in depth along with benefits and drawbacks.

The ways for finding solutions to the problems are also examined. Due to changes in short circuit power, fault currents for micro grid operations when linked to the grid and when operating islanded are different. Faults can also result in loss of stability, single phase connections, islanding, overcurrent, earth leakage, loss of sensitivity, disconnecting generators, and overcurrent relays having a shorter range of operation Bidirectional power flow and changes in voltage profiles are among the issues that might develop depending on where the faults are in relation to the dispersed generators and the existing protective systems. Due to the unpredictability of their power production, distributed generators like synchronous generators, induction generators, and inverter interfaced protection units vary their power output whenever a fault occurs. The primary protection concerns include altering the fault current level, device discrimination, decreasing the reach of impedance relays, reverse power flow, sympathetic tripping, islanding, single phase connection, and selectivity. [5]. [6] took into account the use of machine learning for intrusion detection in microgrid applications. [7] shown that for HV/EHV transmission lines, the use of a smart grid system with renewable resources is not yet taken into consideration.

MICROGRID PROTECTION

Adaptive protection techniques with dynamic fault current magnitude and islanding protection are appropriate for faults and events occurring in islanded and grid-connected modes. It works well to handle issues with false tripping, loss of coordination, blinding of protection, low fault current, and cyber security risks. Differential protection methods are appropriate for faults/events that occur in islanded and grid-connected modes, as well as for unbalanced faults, high impedance faults, false tripping, and balanced faults. The microgrid's false tripping issue can be resolved with a distance protection system. For the mitigation of unbalanced faults and faults occurring in grid-connected and islanded modes, a directional protection strategy may be appropriate.

For the mitigation of LOM problems and defects during grid-connected and islanded modes, digital protection methods and microprocessor-based protection schemes may be appropriate. Digital protection techniques and microprocessor-based protection strategies may be useful for the mitigation of LOM issues and flaws during grid-connected and islanded modes. The reduction of false tripping, LOM, resynchronization problems, and failures during grid-connected and islanded modes may be accomplished by using an under/over voltage protection strategy. The level of the fault current can be limited using a fault current limiter. For the reduction of faults in grid-connected and islanded modes, data-driven classifiers and travelling wave-based protection methods may be appropriate.

To address the DC grounding concerns, a reconfigurable grounding-based protection strategy is helpful. The absence of zero-crossing issues in the DC microgrid can be mitigated by using the DC interruption prevention method. All forms of microgrid protection concerns cannot be handled by the universal protection plan for all types of AC or DC microgrids. As a result, the appropriate protection plan must be designed depending on the kind, size, layout of the structure, installation location, operational modes, etc. of the microgrid, and any necessary modifications must be made when any of the aforementioned situations alter the characteristics of the microgrid.

The adaptive protection strategy lowers reliance on the communication connection, centralised controller, and microgrid architecture by having the capacity to change the approach in response to conditions. By adding a high resistance dump load together with the DC CB to put out the arc created by the DC protection devices' activity, DC microgrid protection issues might be lessened. This report gave academics and engineers this crucial knowledge that will aid in further investigation into the problems with microgrid protection and their remedies. [8] describes a suggested approach that, in both grid-connected and island mode, may detect and identify incorrect situations without halting or upgrading the present system.

WIDE AREA MONITORING AND PROTECTION

With the penetration of the Microgrids into main power systems, the monitoring and protection is also necessary with new aspects. So, to overview the whole power system with this new aspect WAMS is used. Wide-Area Measurement Systems (WAMS) give system operators a new way to keep an eye on, manage, and safeguard power systems over a large geographic region. With the help of Wide-Area Measurement Systems (WAMS), system operators now have a new way to keep an eye on, manage, and safeguard the electrical infrastructure across a large geographic region. The use of Phasor Measurement Unit (PMU) based Wide-Area Measurement Systems (WAMS) in power system protection and control has been encouraged by ongoing technological advancements in communication and measurement for better management of the system security through advanced control and protection strategies [9]. The three interrelated sub-processes of data collecting, delivery, and processing make up the WAMS process [10]. These subprocesses are carried out by the measurement, communication, and energy management subsystems, respectively. With the aid of dynamic information about power systems, power system operators may overcome challenges in generation, operation, and planning that may occur from system restructuring. Additionally, it has been shown that WAMS systems can control and monitor a wide range of jobs in real time, including everything from powerful generators to basic home appliances. Online data and information from the entire system have shown to be essential for the secure operation and control of connected systems, such as power systems. System data resources, sometimes referred to as measurement tools, have usually provided data and information [11].

The relevance, format, amount, sampling rate, and other characteristics of the data offered by data providers vary greatly. Operational and non-operational data resources are the two categories of data resources that are discussed in distinct subsections. Two operational data sources that will be examined are Synchronised Phasor Measurement System (SPMS) and Supervisory Control and Data Acquisition (SCADA). The Phasor Measurement Unit (PMU), Phasor Data Concentrator (PDC), and communication system make up an SPMS. PMUs are often put at distant locations. They determine the voltage and current phasors and stamp the measured phasors with the GPS time. Data is gathered from several PMUs, invalid data is rejected, and the time stamps are aligned by a PDC. Data transmission between PMUs and one or more PDCs is handled by the SPMS communication system [12]. Each component of SPMS will be covered in detail in each of the following three subsections. A novel transmission grid protection method employing a broad area system's phasor synchronised measurement methodology is presented in [13]. [14] explains the use of 1P (Internet Protocol)-based communications for time transfer systems and two primary forms of delay-critical wide-area power system protection. The most complicated decision-making mechanisms, like as Florida's FALS and southern Sweden's SPS against voltage collapse, use SCADA for information collecting and only provide a few seconds for action [15].

OVERCURRENT PROTECTION

The degree of fault currents in microgrid also varies in the event of highly RESs incorporation into electricity grid. Traditional overcurrent protection may be unable to discriminate between short-circuit currents and typical load currents. [16] proposes a harmonic-based protection strategy that does not rely on communication to guarantee trustworthy overcurrent protection of islanded microgrids in order to overcome this problem. The adaptive harmonic voltage achieves coordination for fastened to high resistance faults and decreases the total relays' operating time. The efficiency of the suggested protection criterion is verified by simulation findings in [17], and the outcome of this work offers useful technical support for enhancing overcurrent protection in independent power systems with two parallel-operating generators. A micro phasor measurement unit (PMU)-based adaptive protection strategy is suggested in [18], and it proved successful and adequate in reducing the detrimental effects of distributed generation (DG) in the distribution network. Using DIGSILENT, Power Factory, the research [19] thoroughly evaluates the two levels of two SC cases—three-phase and single line-to-ground SC.

With directional overcurrent relays that may be utilised to isolate the fault and prevent false tripping owing to a change in topologies, an overcurrent protection system that aims to provide total element protection is devised. [20] proposes a new inverse-time over-current protection rectification technique based on an enhanced evolutionary algorithm. The backup optimisation level is added to this scheme, giving the main protection and backup protection independent impedance acceleration coefficients. This optimises the action characteristic curve of the protection, giving the main protection and backup protection, particularly the remote backup protection, better speed and selectivity as well as increasing the diversity of the sample solution space and the dependability of the optimisation results. The impact of each sort of network issue/data integrity on the performance of the protection system may be confirmed using the tests that [21] presented using corrupted Sampled Values frames to evaluate the impacts on the tripping times of functions of a genuine Intelligent Electronic Device.

DISTANCE PROTECTION

Transmission networks' distance protection is susceptible to failure during a power swing. Power swing blocking (PSB) is a feature of distance relays that stops the relay from running during a power swing. The relay, however, will be able to locate and fix any issue during a power swing. [22] provides a method for determining the maximum rate of change of a (dI/dV) ellipse circumference, which may be used to detect symmetrical/unsymmetrical flaws through power swing. This work also demonstrates the capacity to identify a large number of high impedance faults (HIFs) in single mode (slow/fast) or multi-mode power swing, as well as the capability to identify faults in asymmetrical power swing. A wide-area backup protection scheme based on network distance relays operation has been proposed in [23] in order to improve the accuracy and performance of the network protection system. Because there is little data exchanged between these devices—only a small amount—there is no need to synchronise them in order to send and receive data. [24] discusses many power swing styles and how to spot them. Power swings may be categorised into three main categories: stable, unstable, and multi-mode power swings, according to research. This is a difficult task because of complexity including non-sinusoidal current waveform and changeable frequency. Three In [25], several fault categories for resolving distance relay mis-operation in power networks brought on by the infeed impact of PV power plants were proposed.

ADAPTIVE PROTECTION SCHEMES

Switching from grid-following to grid-forming inverter control is the way to ensure grid resilience when inverter-based resources are being integrated into the current power system at a rapid rate. The use of extra fault ride through methods shouldn't jeopardise the stability of the power system. To stop relays from operating incorrectly, use adaptive protection. Using a wide area network, [26] proposes an adaptive protection strategy for the second stage zero-sequence current and phase over-current relays, which may cover more lines than conventional relays. The experimental findings demonstrate that the suggested adaptive protection scheme is possible from the viewpoint of protective performance, including the execution time, thanks to the development of a simulating system for the proposed MAWAPS. An adoptive fault ride through system for grid-forming inverters under symmetrical fault situations is designed and implemented in [27]. In order to execute the proposed method, a three-bus inverter-based grid-forming model is employed in MATLAB/Simulink. This model verifies the proposed scheme's optimum, fault-tolerant, harmonic, and spike-free behaviour at both the AC and DC side of the grid-forming inverters. [28] suggested an adaptive directional overcurrent protection method that anticipates an n-1 contingency state of the smart electrical network with measuring points, a quick communication network, and digital relays with remote communication capacity and has consistent time performance for real-time applications for the load currents using short circuit. [29] Proposed protection method for parallel and single circuit transmission lines based on 3D-phase surface concept in wide area monitoring system (WAMS) with phase synchronisation units (PMUs) and real-time data with grid communications infrastructure, particularly in protecting transmission and distribution substations. With the help of the Koopman Mode Analysis (KMA) technique and fault current data from Phasor Measurement Units (PMUs), [30] presents a synchronised phasor measurement-based comprehensive wide area back-up protection scheme for transmission lines. An improved optimisation approach has been given in [31] as a solution to the challenging non-linear coordination problem of distance relays and DOCRs. A strategy for the best coordination of distance relays and directional over current relays in the super distribution network was put out in [32]. It was based on the usage of communication links.

CONCLUSION

This article's goal was to provide an overview of microgrid protection that designers and researchers might use to address problems that emerged when working with actual microgrids. At the moment, wide-area protection is a very challenging study topic. This study conducts a thorough analysis of the state of broad area protection and control applications in the power system. This article evaluates the SCADA/EMS system and locally implemented protection measures critically and pinpoints the system bottlenecks. To address these issues, requirements for a wide-area protection system have been defined. There are three different designs that might be used for a broad area protection scheme, either as a distinct multilayered structure or as an addition to the current SCADA/EMS system. The relaying and control techniques mentioned in the literature are categorically categorised in this research. The integration of WAMS-based adaptive relaying schemes with traditional protection schemes that include fault detection, fault identification, and fault localization is one of the key challenges in the implementation of this relatively new technology. There are existing control methods available for a variety of system stability issues, such as tiny signal stability, voltage instability, rotational instability, etc. The techniques for coping with signal transmission delays in an adaptive way should yet be improved.

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