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Review of Control Technique Implementation of DSTATCOM in a Distributed Power Generation System

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A B S T R A C T

This paper presents a comprehensive review of control techniques employing compound monitors for enhancing the performance and reliability of distributed power generation systems. The increasing integration of renewable energy sources and the advent of distributed generation have brought forth complex challenges related to system stability, reliability, and efficient energy management. To address these challenges, various control strategies utilizing compound monitors have emerged, leveraging advanced monitoring, analysis, and control algorithms. The review encompasses an in-depth analysis of diverse compound monitoring techniques applied to distributed power generation systems, including but not limited to microgrids, hybrid systems, and interconnected networks. Emphasis is placed on the integration of multiple monitoring methodologies, such as data-driven techniques, predictive algorithms, machine learning, and hybrid control systems.

1. Introduction

The evolution of power generation systems is witnessing a paradigm shift towards distributed architectures, prompted by the integration of diverse energy sources and the pursuit of enhanced sustainability. This transformation brings forth a myriad of complexities, necessitating advanced control techniques to ensure the stability, reliability, and optimal operation of distributed power generation systems. Central to this endeavor is the utilization of compound monitors—sophisticated control strategies that amalgamate multiple monitoring technologies and algorithms to effectively manage the complexities inherent in these systems. Power quality issues encompass a broad spectrum of challenges that affect the consistency, reliability, and efficiency of electrical power. These issues manifest in various forms and can arise from multiple sources within the power system. According to the IEEE dictionary "Power quality is the concept of achieving the desirable output for device service by supplying advantageous power and grounding to the sophisticated equipment"[1]. There are several obstacles to be met by the electrical power network in order to provide customers with reliable performance. The problem caused by the power quality is condenser bank failure, over voltages, voltage loss, and increased current due to harmonics, etc. The utilization of solid-state converters in systems leads to an increase in power quality issues because they are prone to power quality issues themselves and they often produce issues reducing the quality of power, as they include solid state converters. The power quality concerns have become important by the use of solid-state devices in power electronics. There are several reasons for energy efficiency that can be classified in terms of current, voltage variation etc. as organic and man-made. Natural causes include faults, lightning and climatic conditions, such as tornadoes, equipment incapacity, etc.

2. Literature Review

Addressing power quality issues is critical not only for the longevity and efficiency of electrical equipment but also for ensuring uninterrupted and reliable power supply across industries and sectors. Some literatures are presented below.

Singh et al. (2014) Introduces topologies, state-of-the-art, performance, technological factors, future trends and potential applications to improve power quality. The objective of this study is to discuss a broad view of DSTATCOMs for researchers, technicians and community concerned in improving power quality. A categorized catalog of some recent study papers is also provided for quick comparison. [1].

Arya et al. (2014), suggested a control strategy for extracting basic parts from generator twisted load flows. Such derived components are used for estimating the flows of reference origin to obtain measurements of the DSTATCOM gating. The above-mentioned control algorithm is applied to alleviate the greater requirement for reactive power, distortion in terms of harmonics, and load stabilization under linear / nonlinear conditions. [2].

Latran et al. (2015), provides a detailed description of DSTATCOM single-phase (two-wire) and three-phase (three or four-wire) devices configurations, and control policies to resolve various storage system PQ issues. In addition, the DSTATCOM technology is performed with thorough explanation, comparison, and discussion. In addition, there is an in-depth overview of up-to - date technologies, practical issues and some future DSTATCOM research areas. This aims to bring a broad view of the state of DSTATCOM technology to scientists who are grappling with the payment of PQ problems in manufacturing devices. [3].

Varshney et al. (2015), proposed an improved power efficiency for a three-phase wireless Static Distribution Compensator (DSTATCOM) that is supplied via the Photovoltaic (PV) network. The DSTATCOM is a three-legged source voltage with a DC Connection (VSI). The photovoltaic (pv) system serves to maintain the tension required for the DC connection. In reactive power compensation it is possible to achieve the improvement in power efficiency by adjusting the power factor. In this journal, the efficacy of DSTATCOM is demonstrated using Powing Factor Correction (PFC) and Zero Voltage Regulation (ZVR) d-q and P-Q equilibrium designs. The efficacy of DSTATCOM based on PV is confirmed with simulation tests. [4].

Awasthi et al. (2016), aims at developing a voltage source-based D-STATCOM converter that injects reactive power into the manufacturing circuit. D-STATCOM's input voltage results in system voltage being implemented using the PI controller in MATLAB / Simulink for the purpose of controlling the output of VAR.D-STATCOM. [5].

Ahirwar et al. (2016), describes the design and configuration of an Instant Reactive Power Theory order by DSTATCOM. In the method of Complete Harmonic Elimination, traditional IRPT and adapted version are presented and configured. This article discusses both sinusoidal lattice and non-sinusoidal voltages with performance. The compensator is able to enhance the power factor, control voltage, the harmonics in the existing feed and provide load balance. [6].

Dadjo et al. (2016), taking into consideration of MGs various control behavior, they can be separated into two parts as local control and organized control. The local MG controller controls the current, voltage and power balance at the local level of each device, while organized balance in a MG is accountable for power distribution and energy storage between dispersed sources and charges. Coordinated control structure can be either centralized or distributed. It offers a versatile reach for system architecture and improved managerial oversight. In hierarchical policy, there are several control selections for each one is available. [7].

Panos et al. (2016), with the depletion of fossil energy, the overall energy supply and demand relationship has been strained. ''2014 World Energy Outlook'' pointed out that: It is estimated that global energy demand will increase by 37% between 2012 and 2040 and global coal demand will grow by 15%. [8].

Raveendra et al. (2017), provides a utility services manual with a suitable FACTS tool to increase the flow rates and reliable voltage. The performance of the DSTATCOM control unit is measured using both linear and nonlinear fabrication costs on the right-side of the right. Simulation findings show that DSTATCOM with IRPT-based FLC can increase energy quality by reducing reactive flows and transient flows with higher circuit-vibrant performance than DSTATCOM with traditional IRPT-based PI systems. [9].

Gupta et al. (2017), presents a distinction between the performance of the two control algorithms Adaptive neuro-fuzzy inference system focusing on the lowest average cube (ANFIS-LMS) and the lowest average circle-oriented hyperbolic tangent-based command method (HTF-LMS) for the three-phase DSTATCOM (Distribution panel compensator). A Shunt compensator consists of a three-legged VSC (voltage supply converter) and a three-phase zigzag transformer to remove faults that are generated by nonlinear functions. [10].

Kumar et al., (2017), A microgrid (MG) is a revolutionary method of operating and managing hybrid generation systems with storage devices to deliver loads in stand-alone or grid-tied mode. The control of the system is critical and complicated when different DGs are combined and each DG has different characteristics. The suitable choice of power electronic converters and proper control methods are essential to operate DGs according to the load requirement. [11].

Yang et al., (2017), A DC feeder connected to a distributed power source with relatively obvious intermittent characteristics for supplying power to common types of loads. A DC feed line connects distributed power sources and ESDs with relatively smooth-running characteristics to provide power to higher-demand types of loads. Compared with the AC MG, the DC MG as only one level of voltage conversion equipment between each distributed power source and the DC bus, which reduces the construction cost of the entire system and makes it easier to implement the control. [12].

Islam et al., (2018), They are DC bus signaling, droop mechanism, fuzzy regulator etc. Aimed at primary level control, decentralized control method is used. The distributed secondary level control uses algorithm of consensus. The genetic algorithm (GA) and algorithm of particle swarm used for tertiary control. [13].

Meng et al., (2018), an appropriate robust and smart control scheme for consistent and predictable action is an essential requirement for a MG with any kind of bus topology. Main objective of employing smart and robust DC controller is intended to maintain an effective and safe flow of required energy to load from power sources. [14].

Jha et al., (2019), presented some disadvantages of DC MG clusters are the optimal coordination among agents and surplus of accurate information allocation among the clusters owing to communication device limitations. [15].

Leng and Polmai (2019), studies proposed the use of battery facility, tie-up generator, connection between DC sub grid and main grid, and the nature of adjacent MGs to satisfy the power output and demand in a MG. The energy grid has historically been used for backup electricity, but the key challenges are decreased reliability of the DC MG infrastructure due to the unavoidable phase of electrical power transfer from AC to DC and the lack of utility grid capacity in some areas. So, for continuous power supply, the DC MG cluster is an alternative approach to the grid-connected DC MG. In MG networks, in the event of a power surplus or shortage, each MG can intake or fascinate power from its neighboring MG. [16].

Ghadiriyan and Rahimi (2019), a DC MGs control mechanism has to execute multiple control actions, such as management of voltage, accurate sharing of current, electricity imports and export, energy storage synchronization, running cost minimization, etc. This numerous control measures govern the operation, configuration and execution of a specific control scheme in a MG in order to provide a robust economic activity way. [17].

Chi et al., (2019), As a clean, efficient secondary energy source, electric energy plays an irreplaceable role in the country's economic development, social operation and people's lives. At the same time as social progress and economic prosperity, the electric power industry has also experienced rapid development. However, electrical energy is also a major consumer of fossil energy. Traditional energy consumption methods and power supply models have brought huge driving forces and economic benefits to social development, but have also caused serious environmental pollution problems. [18].

Kang et al., (2019), The use of the battery energy storage (BES) system is not sufficient when rapid demand variations occur in the system. Due to high power density, UC can deliver or absorb the immediate burst of power and hence are used to handle instant spikes in load demand. The combination of the BES system and supercapacitor (SC) is called the hybrid energy storage system. These can manage short-term and long-term power mismatches in DG systems. [19].

Guerrero et al., (2020), In the industrial revolution, countries around the world have gradually established a system of industrialized development relying on energy. With the rapid development of the world economy, fossil fuels such as coal, oil and natural gas the associate editor coordinating the review of this manuscript and approving it for publication was Huaqing Li have been consumed at an alarming rate and have caused severe environmental problems such as acid rain, fog and global warming. [20].

Cantarero, (2020), At the same time, economic development in developing countries is accompanied by a great deal of energy waste. Therefore, renewable energy has received great attention from people. Accelerating the change of energy structure and developing renewable energy are particularly important for sustainable development of the economy and improvement of the environment. [21].

Tong et al., (2020), In order to prevent drastic climate change from causing harm to humans, how to use wind energy, solar energy and other renewable energy to generate electricity and reduce fossil energy consumption is the key to transforming the energy structure and achieving sustainable economic development and is the future direction of development of the power industry. [22].

Benlahbib et al., (2020), based on these issues, the development of DG has become a necessary way to solve the environmental issues. Different DG units can be combined and operated in parallel to maintain the continuous power supply to the loads. The DGs like photovoltaic (PV) and wind produce intermittent power. The incorporation of the energy storage devices (ESDs) like the battery, ultracapacitor (UC) can eliminate these disadvantages. [23].

Srinivasan and Kwasinski, (2020), MG is classified according to the network structure and functional characteristics and can be divided into AC MGs, DC MGs. The characteristic of the DC MG is that the distributed power source, energy storage device and load in the system are all connected to the DC bus. The power electronic inverter system connects the DC network to the external AC grid. Via electronic power converters, DC micro power grids can supply power to AC and DC loads with various voltage levels and load variations can be controlled by the ESDs on the DC side. [24].

Sallam et al., (2020), considering the characteristics of distributed power supply and the demand of users for different levels of power quality, two or more DC MG can form dual or multiple circuit power supply mode. [25].

3. Conclusion

In conclusion, this review has delved into the realm of control techniques employing compound monitors for enhancing distributed power generation systems. The landscape of energy generation is undergoing a transformative shift, with an increasing emphasis on decentralized, distributed sources and the integration of renewable energy. In navigating this dynamic environment, the role of effective control techniques becomes pivotal in ensuring the stability, reliability, and optimal performance of these systems.

Throughout this review, a diverse array of compound monitoring strategies has been explored, highlighting the fusion of advanced monitoring technologies and control algorithms. From data-driven approaches to the integration of machine learning and predictive analytics, these techniques offer promising avenues for improving the operation and management of distributed power generation.

However, while significant progress has been made, challenges persist. The scalability of these techniques, interoperability among diverse systems, and the integration of emerging technologies present ongoing areas for exploration. Additionally, the need for standardized frameworks and robust methodologies to facilitate the implementation and deployment of compound monitors remains crucial.

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