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INTEGRATION AND POWER CONTROL OF A HYBRID MICRO GRID WITH AND WITHOUT DSTATCOM: A REVIEW

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Abstract

Hybrid microgrids are electrical systems that combine multiple energy sources and storage technologies to provide reliable and sustainable power supply. Unlike traditional microgrids that rely on a single energy source, hybrid microgrids integrate a mix of renewable energy sources (such as solar, wind, and hydro) with conventional energy sources (such as diesel generators or the main power grid) and energy storage systems (such as batteries or fly-wheels). DSTATCOM (Distribution Static Synchronous Compensator) is a power electronic device used in electrical power systems to improve power quality and enhance system performance. It is primarily deployed at the distribution level to compensate for reactive power, regulate voltage, and mitigate power quality issues. Overall, DSTATCOM plays a crucial role in improving power quality, voltage regulation, and grid stability in distribution systems.

Keywords: DSTATCOM, MATLAB, Microgrid, Power Control.

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1. INTRODUCTION

Traditional microgrids were primarily designed to provide electricity to remote or off-grid areas that were not connected to the main electrical grid. They served as standalone systems to meet the energy needs of a specific community or facility.

(a) Energy Generation: Traditional microgrids often relied on conventional fossil fuel-based generators, such as diesel generators, for electricity generation. Renewable energy sources were less commonly used due to cost and technological limitations.

(b) Storage Capacity: Energy storage was limited in traditional microgrids, and if present, it was usually in the form of small-scale battery systems or basic flywheel technologies. The storage capacity was relatively low, leading to a higher reliance on immediate power generation to meet demand.

(c) Grid Connection: Traditional microgrids operated independently and were not typically connected to the main grid. They functioned as isolated systems, providing localized power without any interaction or exchange with the larger grid.

New or Modern Microgrids have expanded beyond remote or off-grid areas and are being implemented in urban and suburban settings as well. They serve a broader range of purposes, including enhancing grid resilience, integrating renewable energy sources, reducing peak demand, and improving energy efficiency.

(a) Energy Generation: New microgrids prioritize the use of renewable energy sources, such as solar, wind, and hydro power, for electricity generation. They take advantage of advancements in renewable energy technologies, including cost reductions and improved efficiency.
(b) Storage Capacity: Energy storage plays a crucial role in new microgrids, enabling the balancing of supply and demand and ensuring a stable power supply. Battery storage systems, with higher capacity and longer durations, are commonly utilized to store excess energy for later use during periods of high demand or low renewable energy generation.
(c) Grid Connection: Unlike traditional microgrids, new microgrids often have the capability to connect to the main grid. This grid interconnection allows for the exchange of electricity between the microgrid and the larger grid, facilitating the import or export of power as needed. It provides flexibility, resilience, and the ability to monetize excess energy generation.
(d) Advanced Controls and Management: New microgrids leverage advanced control systems and sophisticated algorithms to monitor, manage, and optimize energy flows within the grid. These intelligent control systems enable real-time monitoring, load balancing, and efficient utilization of energy resources.
(e) Smart Grid Integration: New microgrids are often integrated with the concept of a smart grid, which involves the application of digital technologies and two-way communication systems. This integration enables enhanced monitoring, data analytics, and demand-response capabilities, resulting in improved energy management and grid efficiency

2. LITERATURE REVIEW

[1] Mesut E. Baran et al. deals with the benefit of the collaborative operation of the power supply linked to the DC grid is that the DC voltage signal is regulated. Throughout the instance of irregular or failure circumstances of an AC utility line in which the induced energy is distributed to the loads attached to the DC grid, the DC grid system works in stand-alone configuration. Adjustments in the generated electricity and the energy absorbed by the load can be balanced in the DC gird as a chunk of power. Due to the necessity with just one AC grid linked inverter, system costs and losses decrease.

[2] Bhim Singh et al. 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

[3] Gunjan Varshney et al. 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 Power 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] Anant Naik et al. proposes a combination of three key techniques used to produce the present reference. The results are collected using these three methods for the same arrangement under safe and inconsistent circumstances of feed voltage. Shunting active power blocking is effective and the performance of these systems is primarily dependent on the control methods used to produce electricity comparison. MATLAB / Simulink is used to model and simulate the different device components.

[5] M. F. Shousha et al. offers a time space wave tracking system which is an improved a-b-c comparability model based on the p-q principle with a desirable line sensor to solve the problem of shunting efficient energy amplifiers (SAPF) in non-ideal hands. The improved formula includes computations smaller than the regular p-q hypothesis. Therefore, it's very easy to implement this algorithm in a digital signal processor (DSP). Even in comparison to the proposed approach are three monitoring methods: Instant Reactive Power Theory (IRPT), Synchronous Reference Frame (SRF), and Synchronous Detection Method (SDM).

[6] P. Rao et al. discusses standard PI command methodology with new approaches to input control. A STATCOM is an device that can constructively assist a bus. It requires voltage converters linked on one side to an energy storage element, while on the other side to the power system.

[7] Bhim Singh et al. Article explores three distinct approaches to assess the current allowance for a DSTATCOM. Comparative methods are the theory of instantaneous reactive force, the concept of synchronous frame comparison and a fresh algorithm focused on Adaline.

[8] Bhim Singh et al. suggested A STATIC Distribution Compensator (DSTATCOM) to mitigate the reactive power and unbalance caused by different distributed system inputs. An evaluation of three different methodologies is generated to obtain relative signals for a DSTATCOM These are a concept of immediate reactive power,

a synchronous comparative image model and a brand new Adaline-based algorithm. An efficient approach for extracting the current reference data is the Adaline-based algorithm.

[9] A. Sode-Yome et al. offers a comparison of FACTS instruments for static voltage stabilization analysis. Under usual and contingent conditions , various performance measurements are differentiated, including PV curves, voltage models, and energy failures. The article provides a guide for utilities to provide a suitable FACTS unit choice for enhancing the charging margin and stabilizing static voltage.

[10] Mei Shan Ngan et al. recommended a Hybrid AC/DC micro - grid to minimize the method of numerous DC/AC/DC or AC/DC/AC transitions in a specific AC or DC grid, that also helps mitigate power losses owing to overturn transition.

[11] Z. Yang et al. studied on an optimization algorithm, based on the micro - grid (MG) principle for fragile structures. Hybrid generation technology will smoother the process while mitigating disruptions due to the erratic availability of electricity from PV and wind generation. Power interchange with the power network is also available when surplus arises in the micro - grid.

[12] Ambrish Chandra et al. discuss the implementation of a new control strategy for an efficient three-phase shunt filter to regulate terminal load voltage, eliminate harmonics, correct allocation of power variable and balanced nonlinear structures. For a three-phase, independent bipolar gate transistor (IGBT), an efficient detector (AF) with a dc-bus-condenser is used. The AF command algorithm uses two closed loop PI controllers. The AF dc bus voltage and the three-phase storage voltages are being used as response inputs in the PI controllers. The AF command algorithm provides input streams of three-phase requirement.

[13] Ali et. al., growing interest on grid interconnection of MHPPs have emerged recently, majorly to get the financial benefits of no consumption of fuel by MHPPs turbines, power capacity improvement of local grids to meet up the rising demand and to keep the electric supply continue in the system. However, there still exist various issues related to the grid interconnection that should be examined. Therefore, this work investigates and presents the major requirements along with key issues and challenges encountered during the grid interconnection of MHPPs with some possible solutions by reviewing the available literature on a single place.

[14] Saponara et al., analyses trends in renewable-energy-sources (RES), power converters, and control strategies, as well as battery energy storage and the relevant issues in battery charging and monitoring, with reference to a new and improved energy grid. An alternative micro-grid architecture that overcomes the lack of flexibility of the classic energy grid is then described. By mixing DC and AC sources, the hybrid micro-grid proposes an alternative architecture where the use of bi-directional electric vehicle chargers creates a micro-grid that directly interconnects all the partner nodes with bi-directional energy flows.

[15] Syahputra et al., proposes the planning of hybrid micro-hydro and solar photovoltaic system for rural areas of Central Java, Indonesia. The Indonesian government has paid great attention to the development of renewable energy sources, especially solar and hydropower. One area that has a high potential for both types of energy is the province of Central Java, located on the island of Java, Indonesia. In this research, we conduct field research to determine the ideal capacity of solar and micro-hydro hybrid power plants, electricity load analysis, and optimal design of hybrid power plants. Data on the potential of micro-hydro plants are obtained by direct measurement on the Ancol Bligo irrigation channel.

[16] Canziani et al., was designed based on interviews with members of the community on energy use, social-economic aspects, and factors such as expected growth and available funds. The construction followed a participatory approach, involving the community in specific stages of the project. This hybrid microgrid is composed of a 6 kWp photovoltaic system and two wind turbines of 3 kW each. It has two coupled 4 kW inverters that deliver power to a 230 V AC distribution line to which all the community loads are connected. Energy is stored using a VRLA 800 Ah, 48 V battery bank, which is designed to work at 50% DOD. The installed microgrid has proven very effective in supplying the average daily demand of 23 kWh at an almost steady power of 1–1.2 kW. During almost 2 years of monitoring, it has presented a 10% loss of load due to peak increases in demand, technical problems, and occasional low solar and wind resources.

[17] Akinyele et al., studied discusses microgrid (µgrd) planning using small hydro, solar and diesel resources for 100 offgrid houses in Nigeria. The work introduces the technical, environmental, economic and policy (TEEP) analysis approach. The technical aspect considers the component sizing, electricity generated, unmet demand (ud), loss of power probability (LOPP) and availability (Avb); the environmental part evaluates the emissions generated by the µgrd compared to when only a diesel-based µgrd is employed to service the load; the economic perspective of the study is based on the evaluation of the net present cost (NPC) and the cost of unit energy produced (CoE). The paper examines 4 different configuration scenarios such as: SHP only, SHP + PV, SHP + PV + diesel, and diesel only µgrds, which are determined based on standard sizing methodologies.

[18] Talaat et al., discussed the various optimization techniques used to reduce the total cost of integrated energy sources. In addition, it examines the use of up-to-date methods to improve the performance of the electrical grid. A case study is conducted to analyze the impact of using artificial intelligence when integrating RESs. The results of the case study prove that the use of artificial intelligence helps to improve the accuracy of operation to provide effective and accurate prediction control of the integrated system. Various optimization techniques are combined with ANN to select the best hybrid model.

3. CONCLUSION

The literature survey provides a comprehensive overview of the importance of simulation in studying hybrid microgrids, the various techniques and tools available, and the key aspects of modeling, control, and performance analysis. It also highlights the need for further research to address existing gaps and explore new directions in hybrid microgrid simulation.

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