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Fuzzy Logic Based Islanding Detection Technique for Integrated AC and DC Microgrid System

Abstract: - This research introduces a fuzzy logic-based approach for detecting islanding in an integrated AC to DC microgrid system. Existing power management systems often face limitations related to power sharing and voltage regulation in interlinked micro grids, especially when specific loading conditions are not considered. To tackle these challenges, an independent integrated power management scheme has been implemented. This scheme evaluates unique loading conditions before importing power to mitigate these challenges; the proposed approach focuses on interlinking the AC microgrid, thereby reducing the operational converters during the voltage regulation process in the DC microgrid. This strategy aims to enhance the overall efficiency of the system. designed to be fully autonomous, particularly catering to plug-and-play functionalities. Specifically designed for generators and tie-converters, the proposed approach caters to the unique requirements and functionalities of these components. Validation of the scheme is carried out through various scenarios, confirming its effectiveness in managing power and maintaining superior control of voltage.

Keywords: automated power management system, tie converters, voltage regulation, AC and DC micro grids.

I.INTRODUCTION

Presently, the power infrastructure operates by synchronizing the generation from large-scale power plants, which generate electricity in bulk. This electricity is then lowered in voltage for consumer usage and transmitted through high-capacity lines. The adoption of this centralized method stems from its cost-effectiveness in generating significant electricity quantities compared to the alternative of numerous smaller generation units.

Nevertheless, due to advancements in fuel cell technology, gas turbines, micro-hydro systems, wind turbines, photovoltaic arrays, power electronics, the deregulation of electricity markets, and increasing consumer expectations for enhanced power reliability and quality, the power sector is shifting back towards decentralized and scattered generation methods.

Distributed or decentralized generation refers to resources situated close to the loads they serve, often at customer locations, in addition to conventional centralized generating stations. This approach elevates the overall voltage profile of the system, improves power quality, minimizes losses in transmission and distribution lines, and sees a rise in the deployment of distributed generation (DG) systems within distribution networks. Moreover, it alleviates the need for capacity expansions in transmission and distribution (T&D) infrastructure.

Two categories of islanding detection methods exist: remote and local, with the former branching into passive and active methods. Essential factors including detection speed, non-detection areas, impact on power quality, introduction of harmonics into the grid, and the extent of fault detection zones are considered when assessing the efficiency of IDTs. Local IDTs, for evaluation purposes, utilize locally measured characteristics at the point of common coupling (PCC). Passive methodologies hinge on monitoring characteristics at the point of common coupling (PCC), particularly focusing on disparities in active and reactive power. They utilize data associated with changes in power system parameters to assess the effectiveness of IDTs. Parameters like voltage phase angle, frequency, harmonics, and magnitude are gauged at the PCC.

Passive tech, including over/under frequency/voltage, to assess the effectiveness of IDTs, it relies on locally measured parameters at the point of common coupling (PCC). This includes considerations such as the Rate of change in phase angle difference, rate of change in frequency, frequency deviation per unit power change, and

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rate of change of reactive power. Voltage imbalances and overall harmonic distortion is favored for their simplicity, quick operation, and minimal impact on power quality.

However, during Instances of both islanding and non-islanding situations power system parameters may undergo changes, especially in the presence of nonlinear loads introducing harmonics. Passive IDTs face challenges in detecting IE during small mismatches To evaluate the efficiency of IDTs, these considerations are based on locally measured parameters at the PCC, specifically within power system parameters, leading to the non-detection zone. In the context of IDTs, Preventive and remote techniques are considered, though, have smaller as opposed to passive IDTs. IDTs that are passive, coupled with in the realm of IDTs, signal processing tools collaborate with active and passive techniques, working in tandem to achieve optimal results minimize the NDZ and establish accurate thresholds.

Introduce slight disturbances injecting disturbances into the network is achieved through various methods in the context of IDTs. DG inverters to identify islanding events. Illustrations of active IDTs encompass approaches such as the San-dia voltage shift technology, known as San-dia Active IDT frequency shifts, utilizes methods such as slip mode frequency shifts. Additional examples encompass high-frequency signal injection, phase-locked loop interference, virtual inductor and capacitor implementation, and active frequency drifts.

The N D Z is a crucial factor in when deciding between active and passive methods, various factors come into plays IDTs. Techniques like SMFS, which involves Altering the frequency of the inverter to change the phase angle of the injected current, offer a small NDZ (approximately 59.3 to 60.5 Hz). Active approaches, while reducing NDZ, must address power quality degradation and integration complexity. Techniques like SMFS and SFS cause shifts in current phase angles, SVS induces changes in PCC voltage amplitude, and AFD Introducing asymmetric current waveforms as a means to detect islanding, whereas voltage-centric methods involve injecting distorted signals along the d- and q-axis components, current-centric techniques entail injecting distorted currents.

Transfer trip methods depend on information interchange between distributed generators (DGs) and the utility grid facilitated by transmitters and receivers. Remote islanding detection techniques necessitate the establishment of a communication infrastructure connecting the utility grid and DG, utilizing diverse methods such as Electrical cables carry communications, monitoring and data storage. These approaches exhibit minimal non-detection zones (NDZ) and can promptly and consistently differentiate between islanding and non-islanding incidents without compromising power integrity. However, due to the additional cost of setting up communication infrastructures, remote methods are not practical for small-scale micro grids. Moreover, they are vulnerable to islanding event detection failures in the event of communication link disruptions, requiring backup protection measures.

The literature review indicates that the use of active methods has negative effects on power quality, while the use of distant strategies requires hardware investments. Moreover, in precise matching settings, passive techniques may fail to identify islanding instances. Reactive and active power must be precisely measured and controlled for the power system to operate efficiently. With an emphasis on the significance of accurate measurement and regulation of both active and reactive power to ensure minimal disparities for the dependable operation of power systems, this study attempts to develop an islanding scheme for enhanced responses under zero conditions.

II. MICRO GRID A C TO D C

Hybrid A C/D C micro grids have been strategically designed to enhance the connectivity of various By utilising the special qualities of efficient management for both A C and D C micro grids, distributed generation systems (DG) can be more easily integrated into the power grid. Necessitates careful consideration and control of various parameters. Establishing connections between these micro grids necessitates the implementation of to ensure seamless integration between A C and D C micro grids, the implementation of an interlinking A C / D C converter (IC) is crucial. The interconnecting AC/DC converter's (IC) smooth performance depends on an efficient power management and control technique. The integrated circuit (IC) functions as a load to one micro grid and a supply to another in the hybrid AC/DC micro grid's operational configuration. Ensuring equitable allocation of power demand across the AC and DC sources in both micro grids is crucial for the power management system. The issues of managing and controlling power flow among several distributed sources are explored in this study. In both AC and DC micro grids, effective coordination is necessary to keep a stable and well-balanced power supply.

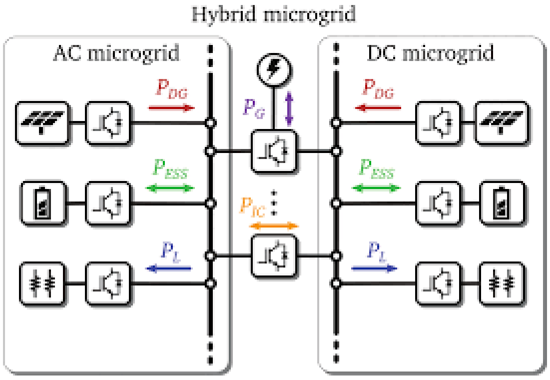


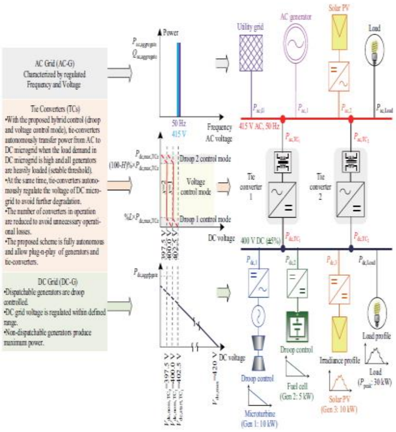
Fig. 1: A C and D C micro grid

The hybrid converter presented in this study can be used as both a chopper and an inverter. This hybrid converter's ability to function depends on MOSFET switching. The Hybrid Converter uses a chopper and an inverter to produce both AC and DC outputs when it receives DC input. The loads then receive the generated power.

The hybrid converter is realized by substituting a single-phase or three-phase Voltage Source Inverter (VSI) for the adjustable switch in the boost circuit. A micro grid is made up of four main parts:

1. The system of distribution
2. Sources of distributed generation (DG)
3. The storage of energy (ES)
4. Loads and controllers

The transition from fossil fuels to alternative energy sources is imperative for addressing environmental concerns and achieving sustainable energy solutions eco-friendly sources is facilitated by renewable energy. Energy storage plays a crucial role in mitigating the instability and volatility associated with renewable sources. Sustainable resources encompass photovoltaic systems, solar cells, wind turbines, batteries, and various other components that can be operated in DC power. Consequently, the development of a DC distribution system or DC microgrid is underway.


AC Grid (AC-G)
Characterized by regulated Frequency and Voltage

Tie Converters (TCs)
•With the proposed hybrid control (droop and voltage control mode), tie-converters autonomously transfer power from AC to DC microgrid when the load demand in DC microgrid is high and all generators are heavily loaded (setable threshold).
•At the same time, tie-converters autonomously regulate the voltage of DC microgrid to avoid further degradation.
•The number of converters in operation are reduced to avoid unnecessary operational losses.
•The proposed scheme is fully autonomous and allow plug-n-play of generators and tie-converters.

DC Grid (DC-G)
•Dispatchable generators are droop controlled.
•DC grid voltage is regulated within defined range.
•Non-dispatchable generators produce maximum power.

Fig. 2: Block schematic of current system

An increasingly significant obstacle arises from the surge in demand for energy due to population expansion, technological advancements, dwindling fossil fuel resources, and emerging environmental concerns such as air pollution and climate change.

In the current landscape, photovoltaic technology emerges as a promising avenue for professionals. Nano-micro grids are being integrated into various grid structures Through the use of various power electronic converters; power produced from a variety of conventional and alternative energy sources is combined in this process. In light of this, a novel topology known as B D H C is implemented to simultaneously drive D C and A C loads from a To meet the demands of D C loads, a novel topology known as Boost Derived Hybrid Converter (BDHC) is implemented, allowing the conversion of DC input to both AC and DC outputs in a single step.

In order to satisfy power demands and manage on-site power generation, this article presents a DC micro grid designed to supply electricity and export excess power to the utility grid when needed. The micro grid controller is at the centre of this configuration and plays a critical role in maintaining a balanced relationship between load management and power generation.

III. FUZZY LOGIC BASED ISD TECHNIQUES FOR INTEGRATED A C & D C MICRO GRID

Determining the value of the generator or storage, which is important for the management of renewable energy, depending on the load and the change in renewable energy in the microgrid.Feasibility issues arise because of the large variations in renewable and demands, which need the use of dispatch able generators or highly power-rated storage systems.

As an alternative, a micro grid with insufficient power generation could link to another micro grid or the utility grid directly or via coordinating converters. Tie-converters allow you to connect a D C micro grid to an A C micro grid or utility grid.

The A C micro grid is described as a regulated voltage and frequency system with enough generation capacity in the imagined interconnected arrangement. Conversely, the D C micro grid operates as a droop-controlled system and has limitations on generation capacity as a result of the increased unpredictability of demands and renewable energy sources. Power is imported from the A C micro grid to make up for power shortages in the D C micro grid during periods of high demand or low renewable power supply

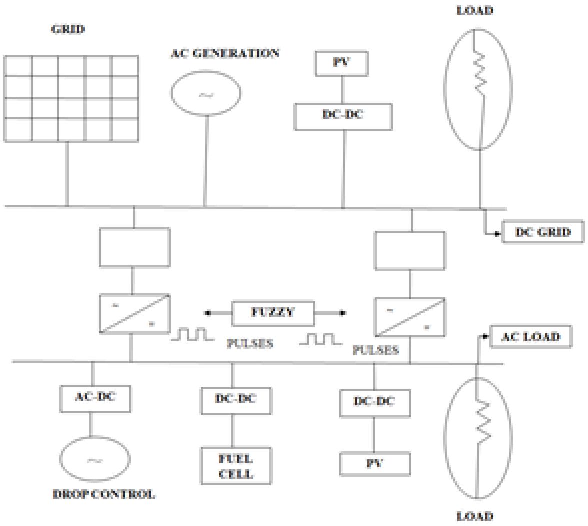


Fig. 3: A visual representation of the Fuzzy Logic system is presented in the block diagram, providing a comprehensive overview of its structure and components. Based ISD Technique Integrated AC and DC micro grid

Efficient and autonomous achievement of the proposed control for tie-converters is the goal, driven by the following objectives in the control scheme:

1) Facilitate power transfer the proposed control scheme aims to facilitate a seamless transfer of power from the A C to D C micro-grid, specifically addressing peak load demand or generation contingencies within the D C micro-grid.

2) Reduce power transmission losses by using tie converters only when demand is at its highest. In the D C micro-grid, the proposed control scheme ensures a seamless transfer of power from the AC source, particularly during instances of peak load demand or generation contingencies and the quantity of tie-converters in use should correspond with the needs for power transfer;

3) Control the D C micro-grid's voltage using droop;

4) Obtain completely autonomous control without relying on the communication network;

5) Turn on the tie-converter and generator plug-and-play functions.

When the voltage in the D C micro-grid falls to the predetermined threshold of Vdc, start, TCx, tie-converter 1 enters the hang 1 control mode. This criterion signifies that the D C micro-grid's generators are all significantly loaded—that is, more than 80% loaded. When Pdc, TCx > L% × Pdc, max, TCx, the tie-converter starts in hang control mode, which facilitates a smooth transition to the voltage regulation mode. In the voltage regulation mode, the tie-converter simultaneously modifies the D C micro-grid's voltage to the nominal value of Vdc, nom, TCx and imports electricity from the A C micro-grid to meet its peak power demand.

The proposed control strategy maintains the natural flexibility of the droop-based system while ensuring efficient performance in a range of operational conditions. The user can customize the values of L% and H% to ensure a smooth transition between modes and to account for measurement errors in voltage and power within the micro-grid under study. This will affect how much tie-converter power is allotted for the droop 1 and droop 2 control modes. The image below shows the circuit diagram of a photovoltaic cell.

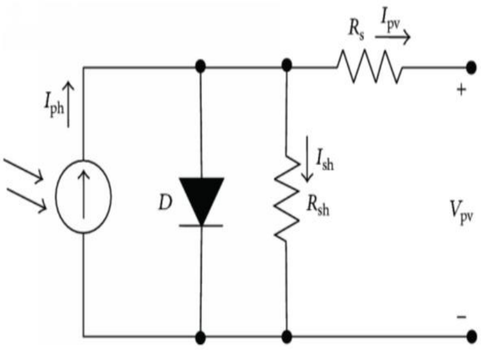


Fig. 4: P V cell circuit

The goal of the suggested voltage regulation mode is to enhance the DC microgrid's overall voltage control capabilities. In particular, at times of peak load demand, the DC microgrid's voltage is adjusted to correspond with the nominal value—a feature that is not present in the power management schemes that are currently in use for networked microsystems. Validation under various load circumstances has validated the efficacy and efficiency of this suggested approach. The fuel cell's circuit diagram is shown below in Figure 5.

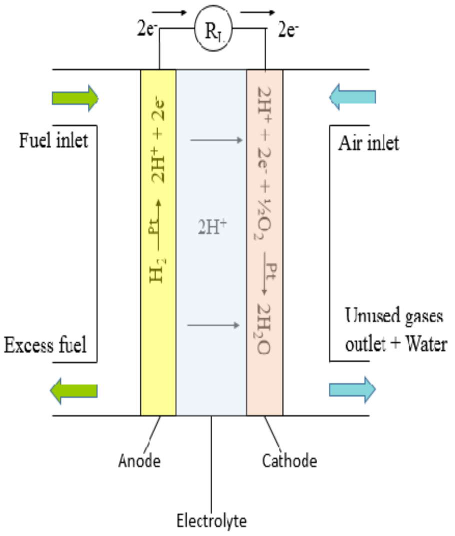
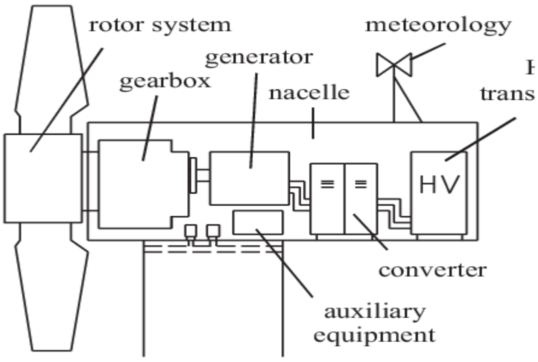


Fig. 5: fuel cell circuit

The circuit diagram and component elements of a wind turbine are shown in the image below. Components of this rotor system include a gearbox, converter, nacelle, generator, and meteorology.



Fig, 6: Wind turbine circuit schematic including all of its parts

IV RESULTS

Graphical representation of the output waveform the generator and the power from the bit-converter the visual representation of the output waveform is illustrated in Figure. 7 below.

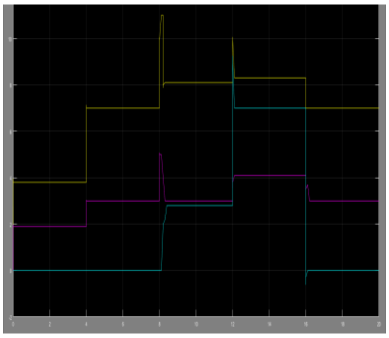


Fig. 7: Generators and tie-converter power of A C and D C Micro-grid system

Figure 8 displays graphical representation of the output waveform is portrayed in the figure the D C micro-grid voltage in an A C and D C micro-grid system.

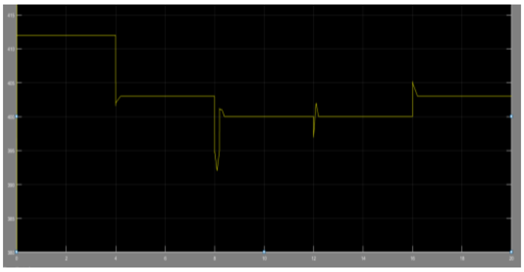


Fig. 8: D C micro-grid voltage

Figure 9 below illustrates the figure illustrates the o/p wave form of the D C micro-grid load demand in an A C and D C micro-grid system.

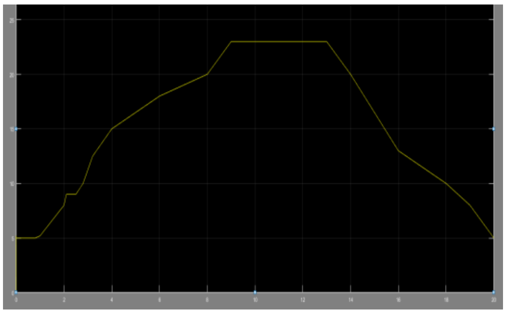


Fig. 9: D C micro-grid load requirement

Figure 10 below displays the provided figure displays the o/p wave form of the D C micro-grid load demand in an Integrated A C and D C Micro-grid system.

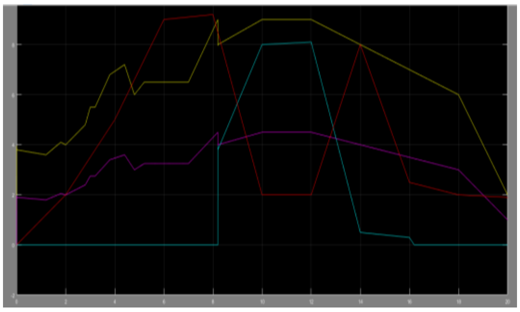


Fig. 10: Power from tie-converters and generators

Figure 11 below illustrates the figure showcases the o/p wave form of the D C micro-grid load demand in an Integrated A C and D C Micro-grid system.

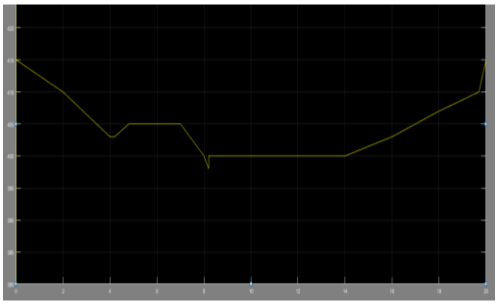


Fig. 11: D C micro-grid (V)

V. CONCLUSION

A self-governing power control system has been suggested for networked A C - D C micro-grids with different setups. This demonstrated plan efficiently handles D C micro-grid power outages, exhibiting efficiency and independence. Notably, the proposed prioritization has led to a reduction in the number of operational tie-converters, mitigating unnecessary losses. The scheme showcases improved A key component of the suggested plan has been controlling voltage inside the D C micro-grid. Through validation in two distinct situations, each of which represents a different load state within the D C micro-grid, the resilience and dependability of this technique have been confirmed.

VI. REFERENCES

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