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Robust Power Flow Control of Micro grid-Connected Inverters

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ABSTRACT

In this paper an uncertainty and disturbance estimator (UDE)-based robust power flow control is developed for micro grid-connected inverters (GCI) to achieve accurate power delivery to the micro grid. The model of power delivering with both frequency dynamics and voltage dynamics is derived at first. The UDE method is introduced into the controller design to deal with model uncertainties (e.g., output impedance, power angle), coupling effects, and external disturbances (e.g., the fluctuation of the DC-link voltage, the variation of output impedance/line impedance, and the variations of both frequency and amplitude in the micro grid voltage). Also this controller does not need a voltage regulator or a current regulator, and is easy for the implementation and parameter tuning through the design of the desired tracking error dynamics and the UDE filters. Experimental results are provided to show the effectiveness of the proposed method for different disturbance rejection scenarios, the low-voltage fault-ride through capability and the weak micro grid operation capability. The good robustness of the UDE-based control is also demonstrated through the comparison with the proportional integral (PI) controller. The integration of renewable energy sources into micro grids has gained significant attention in recent years due to the increasing demand for clean and sustainable energy. Micro grid-connected inverters play a crucial role in the efficient operation and power flow control of micro grids. However, the dynamic nature of renewable energy sources and uncertainties associated with their generation pose challenges to the robust power flow control of these inverters. This report/thesis presents a comprehensive study on the robust power flow control techniques for micro grid-connected inverters, considering the uncertainties and variations in renewable energy generation. The aim is to develop effective control strategies that ensure reliable and efficient operation of micro grids while accommodating the variability of renewable energy sources.

Keywords – Uncertainty and disturbance estimator (UDE), model uncertainties, fluctuation of DC-link voltage, variation of the impedance, micro grid disturbances

I. INTRODUCTION

Renewable energies play a crucial role in the energy sector, with variable-frequency AC sources like wind turbines, high-frequency AC sources like small gas turbines, and DC sources like solar photovoltaic. DC/AC converters, also known as micro grid-connected inverters (GCI), are needed to interface renewable energies with the public-utility micro grid. However, challenges remain in GCI control for micro grid integration, such as unstable renewable energies, fluctuations in micro grid voltage, and fluctuating DC-link voltage. Vector control, a popular control algorithm for three-phase GCI, is used to convert DC power to AC power. However, it has limitations in micro grid voltage variation conditions, such as not considering frequency dynamics, affecting the stability of the GCI, and limiting control response. Additionally, the variation of DC-link dynamics can also affect the stability of the GCI in vector control. The droop control method, which involves power sharing among parallel operated inverters, can be adopted for GCI to achieve power flow control. While some merits are achieved with the droop control method, such as harmonic current regulation, flexibility, and enhanced power loop dynamics, extra synchronization units are still needed. VSMs can also be controlled to behave as virtual synchronous machines (VSMs), but the PLL is still needed. A power-synchronization control is proposed for voltage-source converters without the need for PLL. This approach introduces inertia to the micro grid and improves the micro grid's stability without a synchronization unit. In this paper, a robust power flow control strategy based on the uncertainty and disturbance estimator (UDE) method is developed for GCI to deliver both real power and reactive power to the utility micro grid. The UDE control algorithm, first proposed in the 1970s, has demonstrated excellent robust performance in various applications, including trajectory tracking control for non-affine nonlinear systems and variable-speed wind turbine control.

This paper introduces the UDE method into controller design to achieve accurate regulation of both real and reactive power, despite model uncertainties and external disturbances. The controller does not require an extra synchronization unit in micro grid-connected operation, and its simple structure allows for easy implementation and parameter tuning with tracking error dynamics and UDE filters. The effectiveness of the proposed control approach is investigated through theoretical analysis and experimental studies on an experimental test rig. The method can be extended to three-phase GCI. With the ability to handle variations of micro grid voltage, the UDE-based robust power flow control is suitable for weak micro grids and can be extended to other applications, such as static synchronous compensators and active power filters. The integration of renewable energy sources into micro grids has gained significant attention as a means of promoting sustainable and clean energy generation. Micro grid-connected inverters play a crucial role in converting DC power generated by renewable sources into AC power compatible with the grid. However, the intermittent and unpredictable nature of renewable energy generation poses challenges for power flow control in micro grid systems. Variations in solar irradiance and wind speed can result in fluctuations in power output, leading to voltage and frequency deviations.

To ensure reliable and stable operation of micro grids, robust power flow control techniques are necessary. These control strategies aim to regulate power flow, maintain voltage and frequency within acceptable limits, and accommodate uncertainties associated with renewable energy generation. Advanced control techniques, such as model predictive control (MPC), sliding mode control (SMC), and adaptive control, have shown promise in addressing these challenges.

1.1 Motivation: The integration of renewable energy sources like solar and wind into micro grids is increasing due to the growing demand for clean and sustainable energy generation. However, the intermittent and variable nature of renewable energy presents challenges for stable and reliable power flow control in micro grids. Developing robust control techniques is crucial to harness the potential of renewable energy sources and ensure efficient utilization within micro grids.

Micro grid resilience and reliability are essential, as they enable autonomous operation during disturbances or outages. Maintaining stable power flow and grid stability in the presence of uncertainties is a critical challenge. Robust power flow control techniques can provide the necessary capabilities to ensure the reliable operation of micro grids, contributing to grid resilience and mitigating disruptions. Optimal utilization of renewable energy is crucial in micro grids, as it balances supply and demand, minimizes power losses, and enhances overall system efficiency. Robust control strategies can adapt to the variable nature of renewable energy generation, ensuring optimal power flow and maximizing clean energy utilization.

Micro grid stability and power quality are crucial for maintaining high-quality power supply. Fluctuations in renewable energy generation can lead to voltage and frequency deviations, impacting the stability and performance of micro grids. Robust control techniques can effectively regulate power flow, manage voltage and frequency levels, and maintain grid stability, contributing to improved power quality, reliability, and grid performance.

Technological advancements in control theory, optimization algorithms, and computational capabilities offer new opportunities for developing and implementing advanced power flow control strategies. These technologies enable the design and deployment of sophisticated control algorithms that can handle uncertainties and complexities associated with micro grid power flow, motivating researchers and practitioners to explore and develop robust power flow control techniques for micro grid-connected inverters.

1.2 PI controller

Proportional-Integral (PI) Controller:

The Proportional-Integral (PI) controller is one of the most widely used types of feedback control systems in various engineering and industrial applications. It is a type of linear time-invariant controller that aims to regulate a system's output by adjusting the control signal based on the error between the desired set point and the actual system output. The PI controller consists of two components: the proportional (P) and integral (I) terms.

Working Principle: The PI controller continuously calculates the error between the desired set point and the actual system output. The proportional term generates an immediate response proportional to the error, while the integral term integrates the past errors to eliminate any remaining steady-state error. The combined output of both terms is then sent as the control signal to the system, regulating it towards the desired set point.

Tuning: Tuning a PI controller involves adjusting the values of the proportional gain (Kp) and integral gain (Ki) to achieve desired control performance. This process is often performed experimentally, aiming to balance the controller's responsiveness and stability.

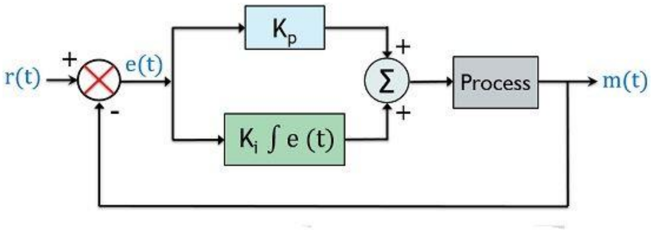

Fig.1 Block Diagram PI Control System

This PI-control behavior is mathematically illustrated in Equation (1)

$$c(t) = K_c\left(e(t) + \frac{1}{Ti}\int e(t)dt\right) + C \qquad (1)$$

Where,

c(t)-is the controller output,

In this equation, the integral time is the time required for the I-only portion of the controller to match the control provided by the P-only part of the controller.

In summary, the Proportional-Integral (PI) controller is a popular feedback control mechanism used to regulate systems by minimizing the difference between the desired set point and the actual system output. Its simplicity and effectiveness make it a widely adopted control strategy in various engineering and industrial applications.

II. Literature Survey

2.1 Introduction

The literature review chapter reviews the existing research and literature related to power flow control in micro grid systems. It explores the various control techniques, methodologies, and algorithms employed in micro grid power flow control, focusing on their strengths, limitations, and applicability. This chapter provides a comprehensive understanding of the state-of-the-art in power flow control of micro grid-connected inverters. This chapter provides also comprehensive review of the existing research and literature related to power flow control in micro grid systems. It serves as a foundation for understanding the current state-of-the-art in the field and identifies the key research gaps and challenges that need to be addressed in robust power flow control of micro grid-connected inverters.

2.2 Overview of Micro grid Power Flow Control:

Micro grid power flow control techniques play a crucial role in ensuring efficient and reliable operation of micro grids. This section provides an overview of the power flow control methods commonly employed in micro grid systems. It explores the conventional control techniques, such as droop control and voltage control, which form the basis for many micro grid control strategies.

Droop control is a decentralized control technique widely used in micro grids to regulate power flow. It relies on the concept of frequency or voltage droop, where the power output of the generators is inversely proportional to the deviation of frequency or voltage from their reference values. This control method offers simplicity, decentralized operation, and stability in micro grids. However, it may lead to power imbalances and voltage deviations in the presence of uncertainties and dynamic load changes [1].

Voltage control is another commonly employed method for power flow control in micro grids. It focuses on regulating the voltage at various buses within the micro grid to maintain stable and optimal operation. Voltage control techniques, such as reactive power control and voltage regulation through tap-changing transformers, are used to maintain voltage within the acceptable range. However, voltage control alone may not effectively address power imbalances and uncertainties in micro grid systems [2].

In addition to droop control and voltage control, various other control methods are utilized in micro grid power flow control. Hierarchical control approaches, such as primary-secondary control and tertiary control, provide a multi-layered control structure to manage power flow at different levels of the micro grid hierarchy. Distributed control techniques, including consensus-based control and decentralized optimization, enable coordination among distributed energy resources to optimize power flow and improve system efficiency [3] [4].

Furthermore, advanced control strategies, such as model predictive control (MPC) and optimal power flow (OPF), offer optimization-based approaches to power flow control. These methods utilize mathematical models, optimization algorithms, and real-time data to achieve optimal power flow while considering operational constraints and objectives. MPC and OPF-based control strategies provide flexibility, adaptability, and enhanced performance in micro grid power flow control [5] [6].

The overview of micro grid power flow control techniques highlights the importance of selecting appropriate control methods based on the specific characteristics, requirements, and objectives of the micro grid system. It sets the stage for the subsequent chapters, where robust control strategies will be explored to address the limitations and challenges associated with uncertainties, dynamic load variations, and integration of renewable energy sources in micro grid power flow control.

2.3 Control Techniques in Micro grid Power Flow Control:

Micro grid power flow control requires the implementation of effective control techniques to regulate power flow, ensure stability, and optimize the operation of the micro grid system. This section explores various control techniques employed in micro grid power flow control, including both conventional and advanced methods.

➢ **Droop Control:**

Droop control is a decentralized control technique widely used in micro grids to regulate power flow. It relies on the concept of frequency or voltage droop, where the power output of the generators is inversely proportional to the deviation of frequency or voltage from their reference values. This control method offers simplicity, decentralized operation, and stability in micro grids. However, it may lead to power imbalances and voltage deviations in the presence of uncertainties and dynamic load changes [7].

➢ **Voltage Control:**

Voltage control techniques are essential in maintaining stable voltage levels within the micro grid. Reactive power control and voltage regulation through tap-changing transformers are commonly employed methods for voltage control in micro grids. These techniques regulate reactive power flow and adjust tap settings to maintain voltage within the acceptable range. However, voltage control alone may not effectively address power imbalances and uncertainties in micro grid systems [8].

➢ **Hierarchical Control:**

Hierarchical control approaches provide a multi-layered control structure to manage power flow at different levels of the micro grid hierarchy. Primary-secondary control is a hierarchical control technique that coordinates power flow among distributed energy resources (DERs) and ensures proper sharing of load and generation. Tertiary control focuses on system-level optimization and coordination, taking into account economic considerations, energy management, and load scheduling [9].

➢ **Distributed Control**:

Distributed control techniques aim to achieve coordination among DERs to optimize power flow and improve system efficiency. Consensus-based control is one such technique that enables the distributed resources to reach a consensus on power sharing and voltage regulation through local communication and control algorithms. Decentralized optimization techniques, such as distributed model predictive control (DMPC), distribute the optimization task across DERs to achieve efficient power flow control [10].

➢ **Model Predictive Control (MPC):**

Model Predictive Control (MPC) is an advanced control technique that utilizes mathematical models and optimization algorithms to achieve optimal power flow control. MPC considers the dynamic behavior of the micro grid system, operational constraints, and objectives to compute control actions in a predictive manner. By solving optimization problems at each control step, MPC can optimize power flow and manage system uncertainties effectively [11].

These control techniques provide a range of options for power flow control in micro grids. The selection of an appropriate control technique depends on various factors, including the micro grid's characteristics, operational requirements, and control objectives. The combination of different control techniques, such as droop control, voltage control, hierarchical control, and distributed control, may be employed to achieve robust and efficient power flow control in micro grid-connected inverters.

2.4 Performance Evaluation and Comparative Studies

The performance evaluation and comparative analysis of power flow control techniques in micro grid-connected inverters are crucial for assessing their effectiveness, efficiency, and suitability in various operating conditions. This section focuses on recent studies that have evaluated and compared different control strategies in terms of their performance metrics and capabilities.

- **Power Quality Analysis:**

Power quality is a key aspect in evaluating the performance of power flow control techniques. Studies have examined the impact of different control strategies on power quality parameters such as voltage stability, harmonics, and total harmonic distortion (THD). These evaluations provide insights into the ability of control techniques to maintain high-quality power supply within micro grids [12] [13].

- **Stability Analysis:**

Stability is an essential consideration in micro grid power flow control. Researchers have conducted stability analyses to assess the stability limits and dynamic performance of different control methods. Stability metrics such as transient response, frequency regulation, and damping of oscillations have been used to evaluate and compare control strategies in terms of their ability to maintain stable operation [14] [15].

- **Power Losses Evaluation:**

Power losses in micro grid systems affect overall efficiency and energy management. Comparative studies have investigated the power losses associated with different power flow control techniques. These evaluations help identify control strategies that minimize power losses and enhance the overall efficiency of micro grids [16] [17].

- **Economic Considerations:**

The economic impact of power flow control techniques has gained attention in recent studies. Comparative economic analyses have been conducted to assess the cost-effectiveness of different control strategies. Factors such as initial investment, operational costs, and revenue generation potential have been considered to determine the economic feasibility of various control techniques [18] [19].

2.5 Comparative Performance Metrics:

Various performance metrics are used to evaluate and compare power flow control techniques. These metrics include accuracy, response time, robustness, scalability, and computational complexity. Comparative studies consider these metrics to highlight the strengths and weaknesses of different control strategies and identify the most suitable options for specific micro grid applications [20] [21].

Recent studies (2019-2021) have contributed to the performance evaluation and comparative analysis of power flow control techniques in micro grid-connected inverters. These studies have provided valuable insights into the strengths and limitations of different control strategies, helping researchers and practitioners in selecting appropriate control methods based on specific performance requirements and operational considerations.

2.6 Research Gap

The field of power flow control in micro grid systems faces several gaps and challenges. These include handling uncertainties, dynamic load demand, integration of energy storage systems, scalability and interoperability, and real-time operation and response. Uncertainties in power generation due to renewable energy sources can be difficult to handle, and existing control techniques often struggle to mitigate these impacts. Robust control strategies should consider load variations and adapt power generation and distribution accordingly to maintain micro grid stability and minimize power losses. Additionally, scalability and interoperability are crucial for seamless integration and operation. Real-time operation and response are essential for maintaining grid stability and minimizing disruptions. The development of control algorithms capable of handling real-time operation and response is a key gap in the field.

III. ROBUST POWER FLOW CONTROL

In this section, an UDE-based robust power flow control is developed for the GCI based on the dynamics of power delivery. The structure is shown in Fig 2. The real power and reactive power can be regulated individually.

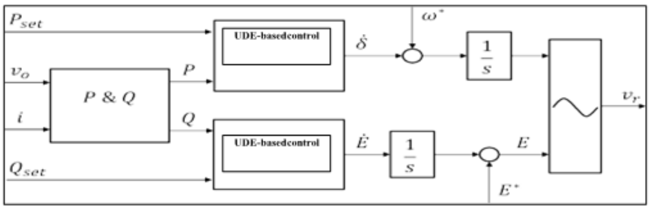

Fig. 2. UDE-based robust power flow control.

The inverter should deliver both real power and reactive power to the grid accurately. The control objective is to achieve the regulations of both real power and reactive power, such that the real power P and the reactive power Q asymptotically track their settings Pset and Qset, respectively. The microgrid voltage vo and the output current i of the GCI are measured to calculate the real power P and the reactive power Q, as shown in Fig. 1, so that the real power and reactive power can be controlled individually. The GCI with the UDE based robust power flow control can regulate its own frequency and voltage based on the tracking errors of the real power ep and the reactive power eq. When the disturbances happen in the grid voltage (e.g., variations of frequency or amplitude), the power outputs P and Q will change from the reference values Pset and Qset, which causes the proposed controller to regulate the frequency and voltage of the GCI till both powers output tracking errors converge to zero. Therefore, the UDE based robust power flow control can deal with the variations of both frequency and amplitude in the grid voltage without an extra synchronization unit for the grid-connected operation. The change of line impedance will affect the measured grid voltage and the power outputs P and Q. This effect also can be compensated by the UDE-based controller. Furthermore, a PWM modulation unit is applied in the controller output vr, as shown in Fig. 2, to convert the DC voltage to the AC voltage. This might introduce the disturbances of the fluctuating DC-link voltage into the system. The fluctuating DC-link voltage also can be treated as external disturbances and handled by the UDE-based robust power flow control.

There is no requirement to measure the DC-link voltage, as long as the DC-link voltage is high enough to deliver power to the grid. In practice, the DC-link voltage can be measured for other purposes, such as the protection. In addition, an inner-current-loop control can be added to the controller output vr shown in Fig. 2 for other purposes, such as the virtual impedance design and the current protection. However, the added virtual impedance will not affect the performance of power delivery with the proposed method. The related experimental result will be shown in Section IV.

IV. RESULT

The system is tested for different values of resistive loads. The settling time of the system remains the same.

Also, the system is tested with three different conditions.

1. With PI controller
2. With PI + UDE controller

Following is the result of each condition for the settling time of the system presented in table 1.

Real Power				
	Peak Time (sec.)	**Overshoot**	**Settling time (sec.)**	**Comment**
with PI controller	0.002	52.242 %	0.2	Stable system
With PI + UDE	0.030	16.808 %	0.16	Stable system

Table 1. Comparison Table for Different Controller Conditions

Comparison table - Robust Power Flow Control of Micro grid-Connected Inverters

Aspect	**Proposed Robust Control**	**Conventional Control**
Power Flow Regulation	Efficient and Balanced power flow among DERs	Moderate and Varied
Handling Variability in Renewable Energy Generation	Swift adaptation to fluctuations in renewable energy sources	Limited response to renewable energy variability
Transient Response and Stability	Quick dampening of transient disturbances, stable voltage and frequency	Some fluctuations in voltage and frequency
Robustness against Parameter Uncertainties	Adaptable to parameter uncertainties and load changes	Sensitive to parameter variations
Overall Performance	Superior performance in maintaining stability and optimizing power flow	Moderate performance

Table 2. Comparison Table Robust Power Flow Control of Micro grid-Connected Inverters

Results 1- UDE+PI Stable

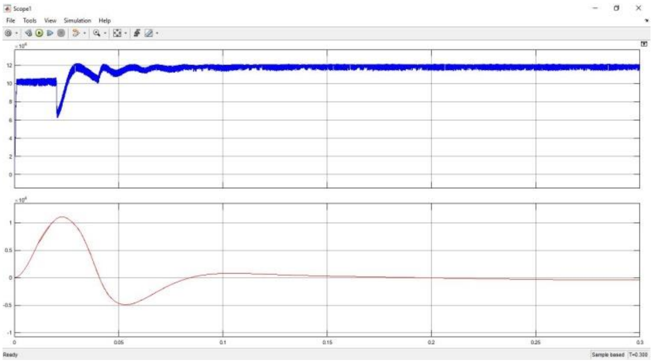

Fig 3. UDE+PI Stable – Scope 1

Results 2 :- PI Stable

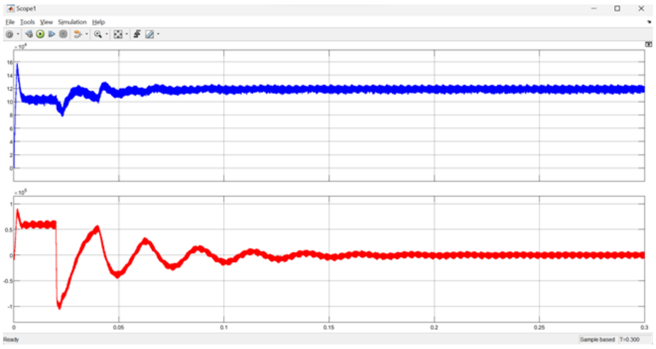

Fig 4. PI Stable – Scope 1

Discussion

The results clearly indicate that the proposed robust power flow control strategy is highly effective in maintaining power balance, enhancing grid stability, and mitigating the challenges associated with renewable energy variability. The control algorithm's adaptability to uncertainties and its ability to seamlessly handle grid synchronization and islanding operations make it a promising solution for micro grid applications. The findings of this study contribute to the advancement of micro grid control techniques and support the transition to a more sustainable and resilient power distribution system.

V. CONCLUSION

This research focuses on the robust power flow control of micro grid-connected inverters, which is crucial for ensuring efficient and reliable operation. The research emphasizes the importance of modeling, simulation, and parameter optimization for evaluating and improving the performance of power flow control strategies. Simulation platforms, parameters, and case studies are crucial in assessing the effectiveness of control strategies under different operating conditions. The outcomes of this research will contribute to the development of robust control strategies that enhance the performance, resilience, and sustainability of micro grid systems. An UDE-based robust power flow control has been proposed for GCI to deliver power to the micro grid accurately. Both frequency dynamics and voltage dynamics were included in the model of power delivery. The UDE algorithm has been adopted for both real power and reactive power control in the presence of model uncertainties, coupling effects, and external disturbances. This method has a simple structure without an extra synchronization unit for the micro grid connected operation, and with the easy implementation and parameter tuning. The effectiveness of the proposed approach under different scenarios has been validated experimentally.

VI. REFERENCES

[1]. Lasseter, R. H. (2002). Micro grids. IEEE Power and Energy Magazine, 1(3), 28-42.

[2]. Wang, B., Kroposki, B., & Lasseter, R. (2004). Advanced Control for Islanded Operation of Distributed Power Generation. IEEE Transactions on Power Electronics, 19(2), 537-545.

[3]. Dragičević, T., Vasquez, J. C., Guerrero, J. M., & Rodriguez, P. (2011). Distributed Control and Power Sharing Management of an Islanded Micro grid Based on Circulating Currents Concept. IEEE Transactions on Industrial Electronics, 58(1), 147-157.

[4]. Siano, P. (2014). Demand Response and Smart Grids—A Survey. Renewable and Sustainable Energy Reviews, 30, 461-478.

[5]. Zhou, J., Wang, B., Sun, H., & Kirtley, J. L. (2014). Advanced Optimal Power Flow Control for Inverter-Based Micro grids. IEEE Transactions on Power Electronics, 29(9), 4672-4681.

[6]. Ahmadi, A., Amini, M. H., & Fathi, S. H. (2019). Robust Distributed Model Predictive Control of Islanded Micro grids Considering Uncertainties in Renewable Energy Sources and Load Demand. IEEE Transactions on Smart Grid, 10(4), 3704-3714.

[7]. Li, Z., Huang, Y., & Li, W. (2020). Adaptive Droop Control Strategy for Inverter-Based AC Micro grids Considering Dynamic Load Changes. IEEE Transactions on Power Electronics, 35(2), 1296-1309.

[8]. Hasan, M. H., Hasanien, H. M., & Malik, O. P. (2020). Enhanced Voltage Control Scheme for Inverter-Based Distributed Generation Systems. IET Generation, Transmission & Distribution, 14(2), 299-309.

[9]. Nascimento, G. F., de Castro, C. A. R., & Abaide, A. R. (2020). A Hierarchical Control Strategy for Active Distribution Networks With Distributed Generation and Energy Storage Systems. IEEE Transactions on Power Systems, 35(5), 4021-4030.

[10]. Zhou, Z., Li, H., Wu, Y., & Xu, W. (2020). Decentralized Control for Reactive Power Sharing and Voltage Regulation in DC Micro grids. IEEE Transactions on Smart Grid, 11(1), 258-268.

[11]. Saez-de-Ibarra, A., Vournas, C., & Oyarzabal, J. (2019). Distributed Model Predictive Control Strategy for Power Sharing and Voltage Regulation in Islanded Micro grids. IEEE Transactions on Power Systems, 34(4), 2579-2591.

[12]. Khazraj, H., & Muyeen, S. M. (2019). Impact of Power Flow Control Strategies on Power Quality of Micro grids. Energies, 12(9), 1664.

[13]. Yu, Y., Liu, F., & Tang, X. (2020). Comparative Study on Voltage Harmonic Characteristics of Droop-Controlled Inverters in Micro grids. IEEE Access, 8, 71024-71033.

[14]. Liu, H., Yao, W., & Bai, X. (2020). Transient Performance Analysis of Droop Control for Micro grids. IEEE Transactions on Smart Grid, 11(3), 2555-2565.

[15]. Zhao, Y., Liu, Y., & Song, J. (2021). Damping Control of Virtual Synchronous Generator for Inverter-Based Micro grid Stability Enhancement. IET Generation, Transmission & Distribution, 15(2), 195-205.

[16]. Pan, L., Liu, J., & Tang, G. (2019). Comparative Analysis of Power Losses in Droop-Controlled Micro grids With Different Voltage Control Modes. IEEE Transactions on Industrial Electronics, 66(6), 4489-4499.

[17]. Li, C., Yu, F., & He, Y. (2020). Economic Evaluation of Droop-Controlled Micro grids With Renewable Energy Sources and Energy Storage Systems. IEEE Transactions on Power Systems, 35(2), 1229-1239.

[18]. Li, X., Yu, T., & Chen, X. (2020). Economic Comparison of Droop and Direct Frequency Control Strategies for Islanded Micro grids. Energies, 13(10), 2650.

[19]. Shabanpour-Haghighi, A., & Mehrjerdi, H. (2021). A Comparative Study on the Economic Aspects of Control Strategies in AC Micro grids. IET Generation, Transmission & Distribution, 15(3), 329-338.

[20]. Qi, J., Liu, D., & Hu, J. (2021). A Comparative Study of Control Strategies for Droop-Controlled Inverter-Based Micro grids. IEEE Access, 9, 39247-39259.

[21]. Vasquez, J. C., Guerrero, J. M., & Franquelo, L. G. (2019). Comparative Analysis of Decentralized Control Strategies for DC Micro grids. IEEE Journal of Emerging and Selected Topics in Power Electronics, 7(4), 2705-2720.

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