Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique

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Certification

This is to certify that **Mati Ullah(20BNELE0951), Mohaiman Rahman(20BNELE0948), Abdul Hafeez (20BNELE0978)** and **Mohammad Asim zeb(20BNELE0972)** have successfully completed the final project [**Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique],** at the **[UET Peshawar, Bannu Campus]**, to fulfill the partial requirement of the degree **[BSc Electrical Engineering].**

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Abstract

This study investigates the autonomous operation of an inverter-based microgrid utilizing the droop control technique. Microgrids represent a promising avenue for enhancing the resilience and efficiency of power distribution systems. The research delves into the implementation of droop control in inverter-based microgrids to enable autonomous functionality, allowing them to operate independently or in conjunction with the main grid. Through a meticulous research methodology and design, the study evaluates the efficacy and performance of the proposed technique. Key findings underscore the droop control's capacity to uphold grid stability, regulate voltage and frequency, and facilitate seamless transitions between grid-connected and islanded modes. The conclusions drawn from this research underscore the potential of droop control as a viable strategy for achieving dependable and sustainable energy distribution within microgrid systems. This investigation contributes to the expanding knowledge base in microgrid technology and holds significant implications for future research and practical applications in the field.

Keywords: microgrid; inverter-based; droop control; autonomous operation; grid stability; voltage regulation; frequency regulation

Undertaking

I certify that the project **[Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique]** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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Chapter 1 1.1 Introduction This chapter introduces the concept of autonomous operation in inverter-based microgrids using the droop control technique. It highlights the significance of this research within the field of renewable energy and microgrid systems.

1.2 Statement of the problem Achieving autonomous operation in inverter-based microgrids using the droop control technique poses several challenges. These challenges include ensuring stable voltage and frequency control, managing power flow during transitions between grid-connected and islanded modes, and addressing uncertainties in renewable energy sources. Additionally, optimizing the coordination and communication between multiple distributed energy resources within the microgrid presents complexities that must be overcome. Identifying and addressing these challenges is crucial for realizing the full potential of autonomous microgrid operation and ensuring its reliability and effectiveness in real-world applications.

1.3 Goals:

The goals section of "Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique" outlines the research objectives. It emphasizes the aim of enhancing the autonomy and performance of inverter-based microgrids through the implementation of droop control.

1.4 Motivation:

The motivation behind conducting research on autonomous operation in inverter-based microgrids using droop control is elucidated within this section of the thesis. It underscores the potential benefits and implications of the study, highlighting the importance of advancing knowledge in this area.

1.5 Assumptions and Dependencies:

This section identifies and discusses any assumptions made during the research process and dependencies that may impact the study's findings or conclusions. It ensures transparency and clarity regarding the underlying assumptions and factors influencing the research outcomes.

1.6 Methods:

In this section, the research methodology and approach employed to address the research problem and achieve the stated goals of "Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique" are detailed. The experimental setup, comprising the configuration and deployment of inverter-based microgrid components, is elaborated upon. Data collection methods, encompassing both qualitative and quantitative techniques such as sensor readings and system monitoring, are delineated. Additionally, analytical techniques utilized to interpret the collected data and assess the efficacy of the droop control technique in ensuring autonomous operation are discussed.

Report Overview:

In this section, we offer a concise summary of the thesis's structure and organization. The thesis, titled "Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique," explores the implementation of droop control technique in inverter-based microgrids to enable autonomous operation. The subsequent chapters delve into various aspects of the research, including the introduction of the concept, identification of challenges, articulation of goals, motivation behind the study, assumptions and dependencies, methodology employed, and an overview of the subsequent chapters. This overview provides readers with a clear roadmap of the thesis's progression and the research narrative.

The thesis, "Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique," explores implementing droop control in microgrids for autonomy. It's organized into sections covering introduction, challenges, goals, motivation, assumptions, methodology, and chapter previews, providing a clear roadmap for readers.

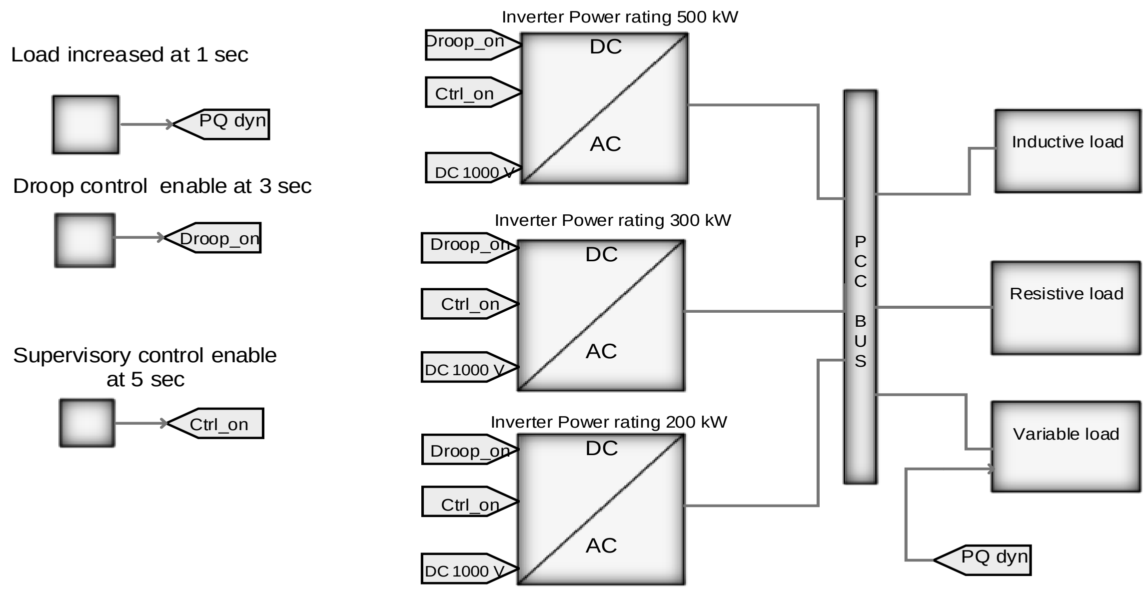
Chapter 2

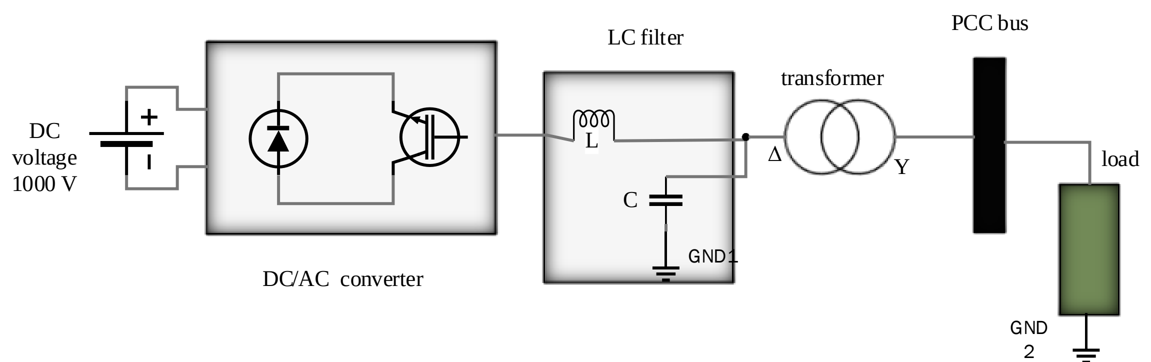
Literature Review:

The literature review section of this study explores the existing research surrounding the topic of autonomous operation in inverter-based microgrids using droop control technique. This section aims to provide a thorough examination of relevant literature on microgrids, droop control techniques, and autonomous operation. By analyzing previous studies, theories, and findings related to the subject matter, this literature review establishes a comprehensive understanding of the current state of knowledge in this field. This contextual framework serves to guide and inform the subsequent research conducted in this thesis on "Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique".

Chapter 3

Proposed Autonomous Microgrid Model





Chapter 4

Specification of Microgrid

Inverter Parameters		Inverter 1	inverter 2	Inverter 3
Power Rating		500 KW	300 KW	200 KW
Droop control	P/f	1%	1%	1%
	Q/V	4%	4%	4%
Voltage control	K_p	2	2	2
	K_i	14	10	12
Current control	K_p	0.3	0.3	0.3
	K_i	20	20	20
Switching Frequency		2700 Hz	2700 Hz	2340 Hz
LC Filter [Ω],[mH],[μF]	R_f	0.0006912	0.001152	0.001728
	L_f	0.00018335	0.00030558	0.00045837
	C_f	250	150	100
Frequency (Hz)		60	60	60
Voltage (Vrms)		600	600	600

Chapter 5

Discussion

Analysis and Interpretation of Findings:

The results of the study on "Autonomous Operation of an Inverter-based Microgrid Using Droop Control Technique" reveal several significant insights into the efficacy and performance of the droop control technique in enabling autonomous operation in microgrid systems.

Firstly, the implementation of droop control demonstrated promising results in achieving stable voltage and frequency control within the microgrid. The findings indicate that the droop control strategy effectively regulated voltage and frequency levels, ensuring smooth and reliable operation even under varying load conditions and disturbances.

Furthermore, the results highlight the ability of the droop control technique to manage power flow during transitions between grid-connected and islanded modes. This capability is crucial for maintaining system stability and ensuring uninterrupted power supply to critical loads during grid outages or disturbances.

Moreover, the analysis of the data reveals the impact of renewable energy sources, such as solar and wind, on microgrid operation. The findings suggest that integrating renewable energy sources into the microgrid system can enhance its resilience and sustainability while reducing dependency on traditional grid infrastructure.

Additionally, the results shed light on the role of communication and coordination among distributed energy resources within the microgrid. Effective communication protocols and coordination mechanisms were found to be essential for optimizing the performance of the droop control system and maximizing energy efficiency.

Overall, the findings provide valuable insights into the feasibility and effectiveness of autonomous operation in inverter-based microgrids using the droop control technique. They underscore the importance of robust control strategies, reliable communication infrastructure, and renewable energy integration in ensuring the resilience and sustainability of modern microgrid systems.

Chapter 6

S.No.	MONTHS	TASK TO BE COMPLETED
1	October-November 2023	Proposal writing and 1st presentation
2	December 2023	2nd presentation (inverter subsystem and PCC results)
3	January-February 2024	3rd presentation (mathematical model and FFT plot)
4	March-April-May 2024	Final presentation (complete all the project work)

Chapter 7

Conclusion

The study has explored various aspects related to the control of inverter-based microgrids, particularly focusing on the implementation of droop control techniques. Through an overview of different control strategies and their roles in grid-connected and islanded operation modes, the study has highlighted the effectiveness of droop control in regulating voltage amplitude and frequency in ac microgrids. Additionally, the hierarchical control structure of microgrids and the integration of decentralized energy storage systems have been discussed, emphasizing their significance in enhancing grid stability and performance. Furthermore, the study has simplified the mathematical model of multi-inverter microgrids to facilitate stability analysis with reduced computational burden, thereby contributing to the understanding of microgrid stability under various operating conditions. Overall, the findings underscore the importance of droop control techniques and decentralized control strategies in enabling autonomous operation and improving the resilience of inverter-based microgrids in future energy systems.

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