ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

Reactive Power Management through Inter Phase Power Controller

Namburi Nireekshana[1]
Assistant Professor
EEED
Methodist College of Engineering & Technology

Kadikekar Rahul[2]
160721734006
BE, EEED
Methodist College of Engineering & Technology

A. Archana[3]
Assistant Professor
BE, EEED
Methodist College of Engineering & Technology

Barla Goutham[4]
160721734313
BE, EEED
Methodist College of Engineering & Technology

Mukka Akshay Kumar[5]
160721734013
BE, EEED
Methodist College of Engineering & Technology

N. Jagadeeswara Reddy[6]
160721734326
BE, EEED
Methodist College of Engineering & Technology

Abstract:- Effective reactive power management is critical for maintaining voltage stability, improving power factor, and optimizing the efficiency of power systems. This study explores the application of an Inter Phase Power Controller (IPPC) for enhanced reactive power management in electrical grids. The primary objective is to investigate the capability of the IPPC to control reactive power flow between phases, thereby stabilizing voltage levels and reducing power losses across the system. The novelty of this research lies in the integration of the IPPC as a flexible control mechanism that actively balances reactive power between phases, as opposed to conventional static devices like capacitors or reactors. The IPPC allows dynamic real-time adjustments, improving system reliability and minimizing the need for manual interventions. Additionally, it offers the potential for integration with renewable energy sources, enabling better handling of intermittent generation. The article findings demonstrate that using the IPPC significantly improves power factor correction and reduces voltage fluctuations in scenarios with varying loads. Simulations carried out in MATLAB/Simulink confirmed that IPPC integration leads to a reduction in system losses and enhances overall grid stability.

Keywords:- *Electrical Power Systems, FACTS Devices, Power Electronics, Reactive Power.*

I. INTRODUCTION

Reactive power management is a fundamental component of electrical power systems, playing a pivotal role in maintaining voltage levels, improving power quality, and ensuring the efficient operation of the grid. While real power (measured in watts) performs useful work in powering electrical devices, reactive power (measured in volt-amperes reactive, or VARs) supports the voltage necessary for active power to flow through the system. Reactive power, although it does not perform any real work, is essential to energize inductive loads such as transformers, motors, and transmission lines. Proper balance and control of reactive power are crucial for the stability and efficiency of electrical grids[1].

The importance of reactive power has gained greater recognition with the increasing complexity of modern power systems, especially in the context of integrating renewable energy sources, managing decentralized grids, and improving overall system reliability. Any imbalance in reactive power can lead to significant challenges within the power system, such as voltage instability, reduced efficiency, increased losses, and even system-wide blackouts. This paper explores the importance of reactive power, the problems arising from its imbalance, and the involvement of power electronics technology in achieving reactive power balance[2].

➢ *Importance of Reactive Power*

Reactive power is essential for controlling the voltage levels within a power system. It ensures that the voltage remains within a stable range, which is critical for the proper functioning of electrical equipment and the safe transmission of power. Without sufficient reactive power, voltage levels can drop or rise beyond acceptable limits, leading to malfunctions or damage to electrical devices. Conversely, too much reactive power can lead to over-voltage conditions, also causing equipment failure or reduced efficiency. Therefore, maintaining an optimal balance of reactive power is vital for ensuring both the longevity of electrical equipment and the efficiency of the power system as a whole[3].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

Reactive power is also crucial for maintaining system reliability, especially in large interconnected power networks. In modern power grids, where load demand fluctuates frequently, and energy sources are increasingly diverse (including intermittent renewable sources like wind and solar), reactive power management becomes even more challenging. Power systems need to respond dynamically to changes in load and generation, ensuring that voltage levels are kept stable across the network. By managing reactive power effectively, grid operators can prevent voltage collapse, avoid cascading failures, and reduce the risk of blackouts[4].

Additionally, reactive power compensation improves the power factor of a system, which is a measure of how effectively electrical power is being used. A low power factor indicates that more current is needed to deliver the same amount of real power, leading to higher energy losses in the transmission and distribution networks. By compensating for reactive power and improving the power factor, power systems can operate more efficiently, reducing energy losses and minimizing the need for expensive infrastructure upgrades[5].

➢ *Problems Arising from Imbalance of Reactive Power*

Imbalances in reactive power can cause a wide range of problems in power systems, from reduced efficiency and increased operational costs to voltage instability and system-wide outages.

- *Voltage Instability:*

One of the most significant problems associated with reactive power imbalance is voltage instability. Voltage stability refers to the ability of a power system to maintain steady voltage levels at all points within the network, even in the face of disturbances such as changes in load or generation. Reactive power supports voltage control by compensating for voltage drops across transmission lines and inductive loads. When there is a shortage of reactive power, voltage levels can drop, leading to a condition known as voltage collapse. If the system is unable to generate or supply enough reactive power, the voltage can continue to decline until parts of the network are disconnected, potentially causing widespread blackouts[6].

- *Increased System Losses:*

Reactive power imbalances also lead to increased energy losses in the transmission and distribution networks. Since reactive power does not perform useful work but still requires energy to flow through the system, an excess of reactive power increases the total amount of current in the system. This higher current flow leads to greater resistive losses (I^2R losses) in the conductors, transformers, and other electrical components. Over time, these losses can significantly reduce the overall efficiency of the power system, leading to higher operational costs and greater wear and tear on infrastructure[7].

- *Poor Power Factor:*

A low power factor is another common consequence of reactive power imbalance. Power factor is the ratio of real power to apparent power in a system, and it indicates how effectively electrical power is being used. When reactive power is not adequately controlled, the power factor decreases, meaning that more current is required to deliver the same amount of real power. This results in higher transmission losses, reduced capacity in transmission lines, and increased energy costs for both utilities and consumers. Additionally, a poor power factor can lead to penalties for industrial customers, further increasing the financial burden of reactive power imbalance[8].

- *Equipment Overload and Damage:*

Reactive power imbalances can also overload electrical equipment, such as transformers, motors, and generators. Excessive reactive power causes higher current levels to flow through these devices, increasing the risk of overheating, insulation breakdown, and mechanical failure. In the long run, this can lead to reduced equipment lifespan and higher maintenance costs. In severe cases, equipment failure caused by reactive power imbalances can result in costly system outages and the need for emergency repairs or replacements[9].

- *Voltage Fluctuations and Power Quality Issues:*

Reactive power imbalance can also cause voltage fluctuations, which lead to power quality issues such as flickering lights, harmonic distortion, and equipment malfunctions. Voltage fluctuations are particularly problematic for sensitive industrial processes and electronic devices, which require stable voltage levels to operate correctly. Power quality issues can lead to increased downtime, reduced productivity, and higher operational costs for industrial and commercial users[10].

➢ *Power Electronics Technology Involvement in Reactive Power Balance*

Power electronics technology has become increasingly important in modern power systems for managing reactive power and maintaining system stability. The advent of power electronic devices, such as FACTS (Flexible AC Transmission Systems) and power converters, has revolutionized reactive power control by offering faster, more dynamic, and more efficient solutions compared to traditional mechanical devices like capacitors and inductors[11].

- *Flexible AC Transmission Systems (FACTS):*

FACTS devices are a family of power electronics-based controllers that are used to enhance the controllability and stability of power systems. These devices can inject or absorb reactive power in real-time, allowing for precise control of voltage levels, power flow, and system stability[12].

- *Power Converters:*

Power converters are widely used in modern power systems to manage the flow of real and reactive power, especially in the context of integrating renewable energy sources like wind and solar power. These converters, typically based on power electronic components like insulated-gate bipolar transistors (IGBTs) and diodes, enable efficient conversion between AC and DC power, while also providing reactive power support to the grid[13].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

- *Energy Management Systems (EMS):*

Power electronics are also integrated into energy management systems (EMS), which are used to monitor, control, and optimize the performance of power systems. EMS platforms incorporate advanced algorithms to predict reactive power demand, dispatch reactive power resources, and ensure that voltage levels are kept within safe operating limits. By integrating power electronics with EMS, grid operators can achieve better control over reactive power flows and improve overall system stability[14].

II. LITERATURE SURVEY

A literature survey in the context of reactive power management through Inter Phase Power Controllers (IPPC) involves reviewing existing research and studies on reactive power, its importance, the challenges caused by its imbalance in power systems, and the application of modern technologies like power electronics to address these challenges.

➤ *Reactive Power Management in Power Systems*

Reactive power management has been a critical area of study in electrical engineering for decades, largely due to its importance in maintaining voltage stability, improving power quality, and enhancing the overall efficiency of power systems. In early studies, traditional methods such as the use of capacitor banks and synchronous condensers were proposed for managing reactive power. These methods provided basic control over voltage levels and power factor but were often limited by their inability to respond dynamically to changing load conditions. As power systems evolved, more sophisticated methods were required[15].

A notable work by **Kundur (1994)** in *Power System Stability and Control* provides an in-depth discussion on the role of reactive power in ensuring system stability. The study highlights how inadequate reactive power supply can lead to voltage collapse, a problem that can have severe consequences for the reliability of power systems. Kundur's work laid the foundation for further research into dynamic reactive power compensation techniques, which are more suitable for modern, highly interconnected power networks[16].

➤ *Problems Caused by Reactive Power Imbalance*

Numerous studies have explored the negative effects of reactive power imbalance in power systems, particularly focusing on its impact on voltage stability, power losses, and equipment degradation. For example, **Van Cutsem and Vournas (1998)**, in their book *Voltage Stability of Electric Power Systems*, provide detailed analyses of how reactive power shortages can lead to voltage instability, especially during peak load conditions. Their research emphasized the need for dynamic reactive power support in the form of flexible devices capable of compensating for fluctuations in reactive power demand[17].

Similarly, **Bergen and Vittal (2000)** in their book *Power Systems Analysis* explore the mathematical modeling of power systems and demonstrate how reactive power imbalance can lead to increased system losses and reduced efficiency. Their research provided theoretical insights into how unbalanced reactive power flows increase I^2R losses and place additional stress on transformers and transmission lines, leading to higher operational costs and maintenance needs[18].

Sarma and Patnaik (2011) in *Reactive Power Control in Power Systems*, have highlighted the growing challenges posed by renewable energy sources, which introduce intermittent generation and further complicate reactive power management. Their work discusses how reactive power imbalances can lead to power quality issues like voltage fluctuations, which are particularly problematic for sensitive industrial processes and electronic devices[19].

Simulink has been extensively used in studies on reactive power compensation and power electronics applications due to its versatility in modeling dynamic systems. For example, **Banerjee et al. (2017)** used MATLAB/Simulink in their study *Simulink-Based Modeling of Reactive Power Compensation Using STATCOM* to simulate the performance of a STATCOM in a grid with fluctuating loads. Their research demonstrated the effectiveness of STATCOM in stabilizing voltage levels and improving power quality, providing valuable insights for future applications of power electronics in reactive power management[20]-[21].

Jovic et al. (2019) in *Reactive Power Flow Control in Power Systems Using IPPC: A Simulation Approach* used **PSCAD** to model the behavior of IPPCs in a multi-phase distribution network. Their simulations showed that IPPCs could significantly improve voltage stability and reduce power losses, particularly in grids with high levels of distributed generation[22].

The literature survey highlights the critical importance of reactive power management in maintaining voltage stability, improving power quality, and reducing system losses in modern power systems. The problems arising from reactive power imbalance, such as voltage instability, poor power factor, and equipment overload, underscore the need for advanced compensation techniques. Power electronics technology, particularly through the development of FACTS devices and IPPCs, has proven to be a highly effective solution for dynamic reactive power control. Emerging research on IPPCs shows great promise for balancing reactive power across phases in complex grids, offering a more flexible and scalable approach to reactive power management.

III. PROPOSED FACTS DEVICE

➤ *Working Principle of Reactive Power Management through Inter Phase Power Controller*

The Inter Phase Power Controller (IPPC) is a cutting-edge technology used in reactive power management that focuses on controlling the flow of reactive power between phases in an electrical power system. Traditional reactive power compensators such as capacitors, reactors, and Static Var Compensators (SVCs) operate primarily on a single phase. In contrast, the IPPC provides a novel approach by allowing inter-phase power flow control, which offers dynamic and real-time adjustments, especially useful for complex multi-phase power grids.

Reactive power is required to maintain voltage stability and support inductive loads, and its management is crucial for preventing voltage instability, improving the power factor, and reducing system losses. The IPPC works by controlling the phase angles and magnitude of reactive power in each phase, redistributing power among phases to ensure that voltage levels remain within acceptable limits. This control is achieved using power electronics-based devices, which allow rapid adjustments in reactive power flow, enabling real-time voltage stabilization.

The IPPC uses a combination of active and passive components to modulate the flow of reactive power. Power electronics devices such as Insulated Gate Bipolar Transistors (IGBTs) and Gate Turn-Off Thyristors (GTOs) are used to control the switching operations, enabling the IPPC to inject or absorb reactive power as required. These switches are controlled by an intelligent control system that continuously monitors voltage levels, power flows, and load conditions, adjusting the reactive power output to match the real-time needs of the grid.

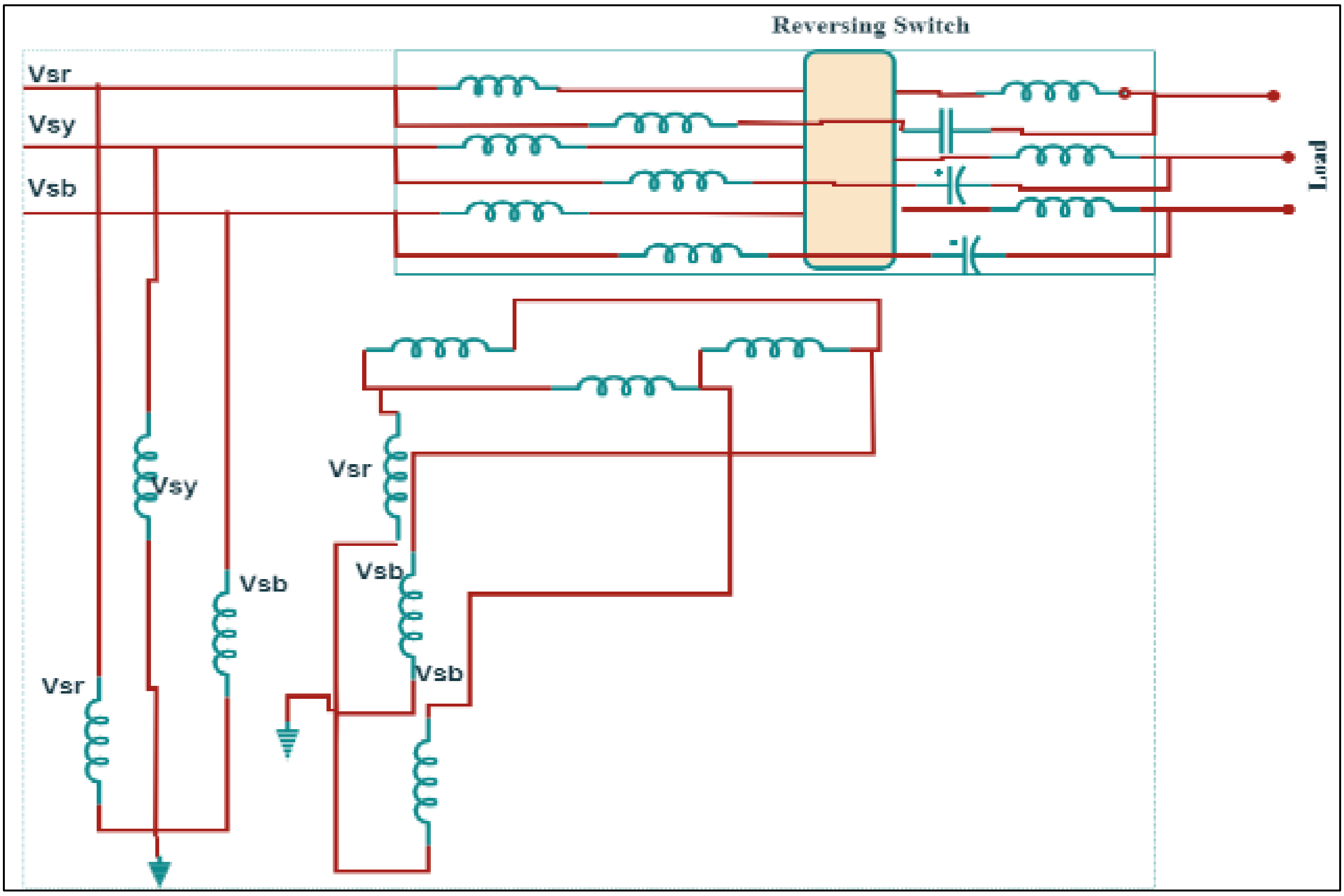

Fig 1 Schematic Diagram of IPPC

➢ *Working Mechanism*

- *Phase Angle Control:*

By adjusting the phase angle between different phases, the IPPC can transfer reactive power from one phase to another. This reduces imbalances and stabilizes voltage levels.

- *Magnitude Control:*

The IPPC can also modulate the magnitude of reactive power by switching capacitors and reactors on or off, ensuring that the required reactive power is either absorbed or injected into the system.

- *Dynamic Response:*

Unlike static compensation devices, the IPPC can dynamically respond to changes in the grid. This makes it highly effective in environments with fluctuating loads or varying power generation, such as grids with high penetration of renewable energy sources.

➢ *Operation of the IPPC*

The operation of an IPPC can be broken down into several stages that allow it to manage reactive power dynamically. These stages are critical to ensuring that the system maintains voltage stability, improves efficiency, and reduces operational losses.

- *Stage 1: Monitoring and Sensing-*

The IPPC begins its operation by continuously monitoring the grid's voltage levels, power factor, and reactive power demands through voltage and current sensors. These sensors provide real-time data to the control system, which analyzes this information to detect any imbalance in reactive power flow between phases. The control system uses this data to determine whether reactive power should be injected or absorbed by the system to maintain stability. This real-time monitoring ensures that the IPPC can respond quickly to fluctuations caused by load variations or sudden changes in generation.

- *Stage 2: Control Signal Generation-*

Once the control system detects an imbalance, it generates control signals that dictate the operation of the power electronic switches. The control signals are based on complex algorithms that calculate the amount of reactive power needed to be transferred between phases to restore balance.

- *Stage 3: Switching and Power Flow Control-*

The generated control signals are sent to the power electronic devices, such as IGBTs or GTOs, which control the reactive power flow between phases. Depending on the grid's requirements, the IPPC will either inject reactive power into a phase that is under-supplied or absorb reactive power from a phase that has an excess.

- *Stage 4: Fault Management and Protection-*

In the event of a fault or abnormal condition, the IPPC is equipped with protection mechanisms that prevent damage to the equipment and maintain system stability. For instance, if the IPPC detects a severe over-voltage or under-voltage condition, it can temporarily disconnect from the grid to prevent further damage. After the fault is cleared, the IPPC can reconnect and resume normal operation.

➢ *Advantages of IPPC in Reactive Power Management*

- *Dynamic and Real-Time Control:*

One of the most significant advantages of the IPPC is its ability to provide dynamic, real-time control of reactive power flows. Unlike traditional compensation methods, which often involve static devices that cannot adjust quickly to changing conditions, the IPPC can react instantly to fluctuations in load or generation, ensuring that voltage levels remain stable and power quality is maintained.

- *Improved Voltage Stability:*

The IPPC improves voltage stability by managing reactive power flow between phases, ensuring that voltage levels remain within acceptable limits even during periods of high demand or load fluctuations. This is particularly important in preventing voltage collapse, which can lead to blackouts.

- *Enhanced Power Quality:*

By balancing reactive power across phases, the IPPC helps reduce power quality issues such as voltage sags, swells, and flicker. This is particularly beneficial for industrial customers with sensitive equipment that requires stable voltage levels.

- *Integration with Renewable Energy:*

As more renewable energy sources are integrated into the grid, the need for dynamic reactive power compensation increases. The IPPC can easily be integrated with renewable energy systems such as wind and solar farms, providing the necessary reactive power support to stabilize voltage levels and improve grid integration.

- *Improved Power Factor:*

The IPPC contributes to power factor correction by balancing reactive power flows between phases. This leads to improved power factor, which reduces energy losses and can help avoid power factor penalties for industrial customers.

➢ *Applications of IPPC in Power Systems*

- *Voltage Stability in Transmission Systems:*

In large transmission systems, voltage stability is a critical concern, particularly during periods of high demand or when integrating renewable energy sources. The IPPC can be used to maintain voltage stability by dynamically managing reactive power flows between phases, preventing voltage collapse and ensuring reliable power delivery.

- *Power Quality Improvement in Distribution Networks:*

In distribution networks, power quality issues such as voltage fluctuations and harmonic distortion can have a significant impact on industrial processes and sensitive equipment. The IPPC can be used to balance reactive power across phases, improving power quality and reducing the risk of equipment damage or downtime.

- *Integration with Renewable Energy Systems:*

As the share of renewable energy in the grid continues to grow, so does the need for dynamic reactive power compensation. Wind and solar farms often experience fluctuations in generation, which can lead to voltage instability. The IPPC can be integrated with these systems to provide the necessary reactive power support, improving the reliability of renewable energy integration.

- *Microgrids and Smart Grids:*

In microgrids and smart grids, where decentralized generation and load balancing are common challenges, the IPPC can play a vital role in managing reactive power. By dynamically controlling power flow between phases, the IPPC ensures that microgrids remain stable and can integrate seamlessly with the larger grid.

IV. RESULTS

Proposed system IEEE (beauregard, Ref No.8) IPPC 120 has been considered. MATLAB Simulink software considered. Table .1 depicts required parameters for proposed system.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

Table 1 Required Parameters

Parameter	Value	Injection Ratio
Transformer (MVA)	100	64%
Total MVAR	211	84%
Voltage across L or C in KV	93.6	54%
Input	13KV, 50Hz	

$$\textbf{Voltage Injection Ratio} = \frac{\textbf{INJ-IPPC}}{\textbf{IPPC-120}}\ \% \qquad \textbf{(1)}$$

In this article 13KVsystem has been considered, input voltage step- up into 115kv and stepdown into 11kv.

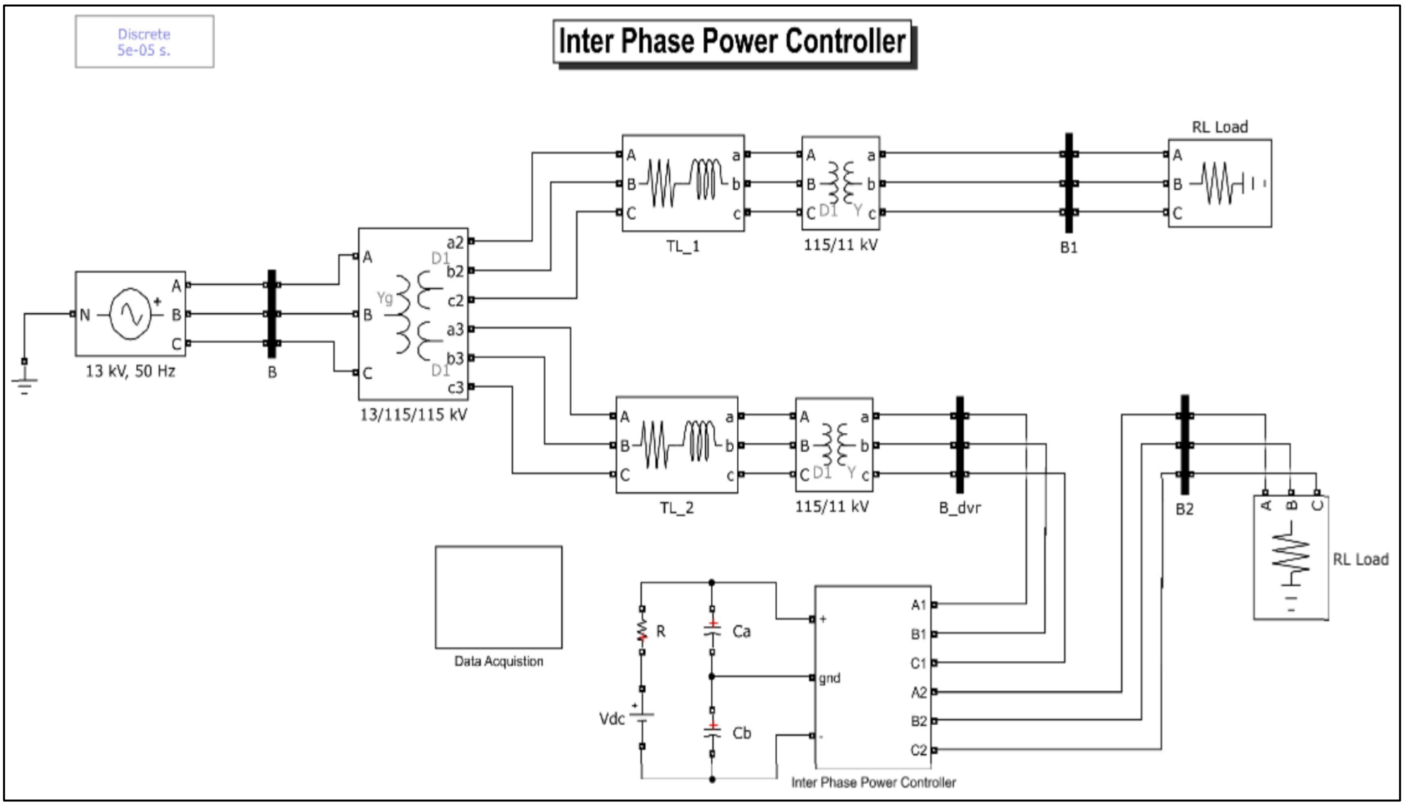

Fig 2 Simulink Diagram of Proposed System

Figure.2 represents a **Single Line Diagram** (SLD) of an **Inter-Phase Power Controller (IPPC)** used in a three-phase power system. The IPPC is designed to manage the power flow and enhance voltage stability in transmission lines.

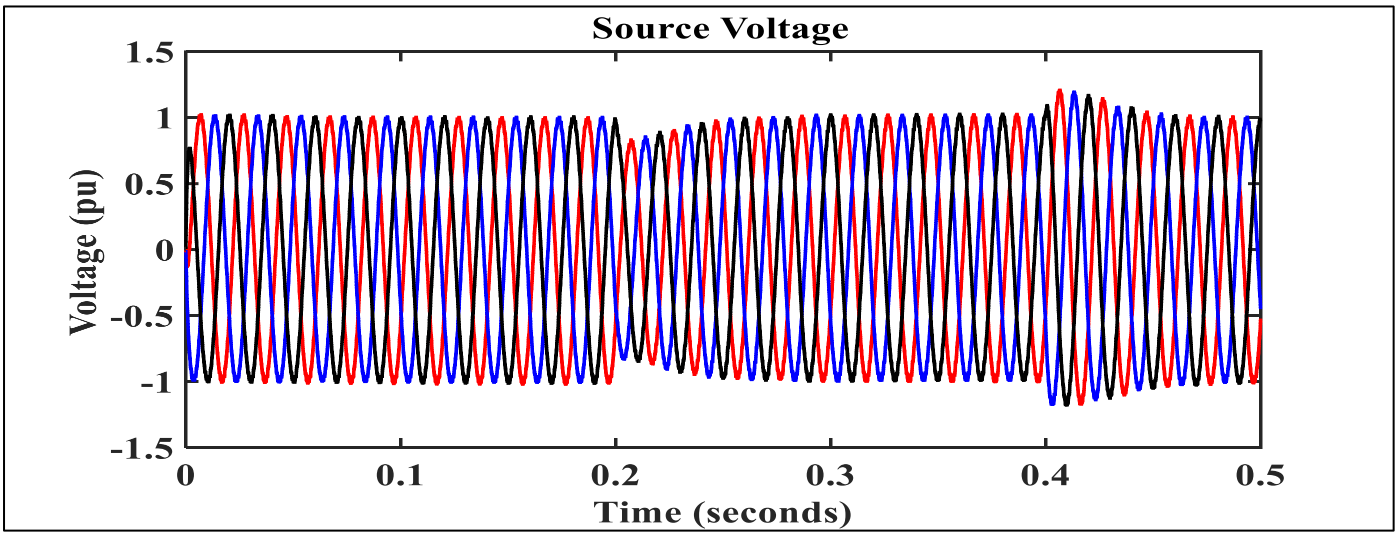

Fig 3 Representation of Source Voltage

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

The figure.3 depicts the **Source Voltage** over time in a per-unit (pu) system. The voltage is measured in per-unit values, ranging from -1.5 pu to 1.5 pu. Initially, the voltage waveform is consistent and sinusoidal. This indicates that the source voltage is stable and operating under normal conditions. The figure likely illustrates a voltage sag or transient disturbance occurring midway through the monitoring period. Such behavior could be due to a fault, load switching, or some form of control action (like from a voltage regulator or dynamic voltage restorer) that aims to correct the voltage but results in oscillations.

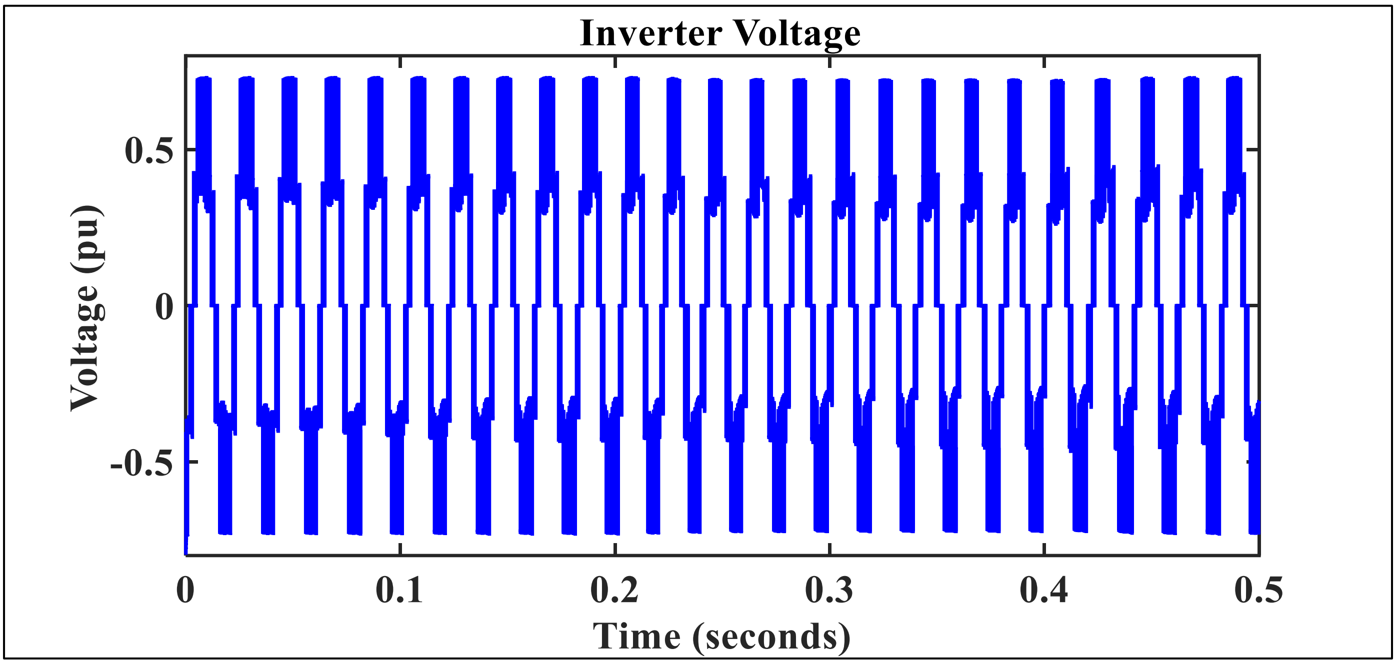

Fig 4 Representation of Inverter Output Voltage

The figure.4 depicts the Inverter Voltage over time in a per-unit (pu) system. This inverter voltage waveform shows stable operation, with the inverter generating a controlled PWM signal over time. The pattern indicates that the inverter is working as expected, producing a voltage output that is suitable for further filtering to achieve a sinusoidal output or directly used in applications that can handle high-frequency components.

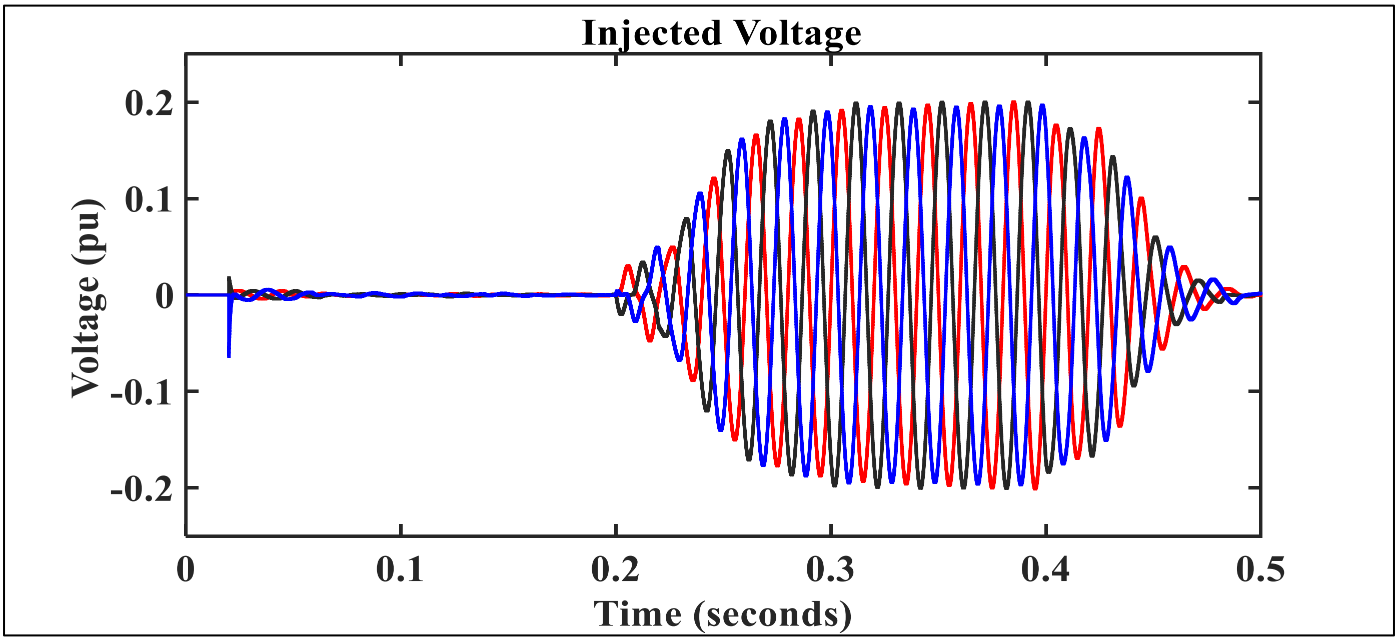

Fig 5 Representation Injected Voltage in Transmission Line

The figure.5 illustrates the Injected Voltage in a per-unit (pu) system over time, and it likely represents the voltage introduced into the transmission line during a fault condition or to compensate for such an event.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

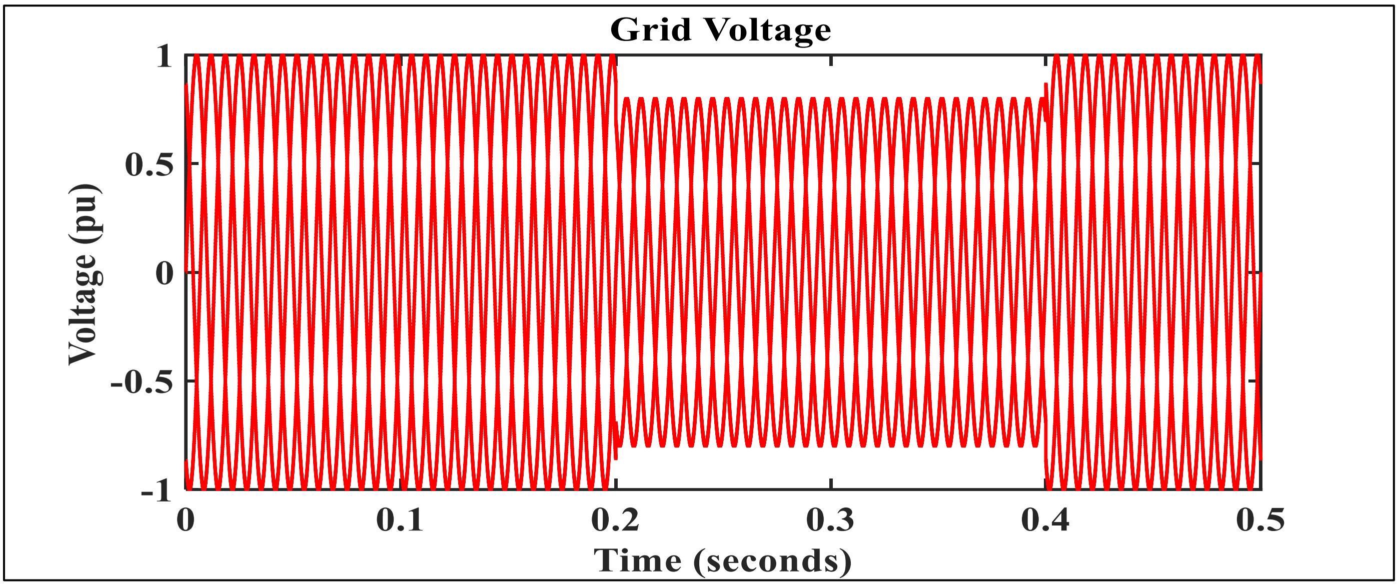

Fig 6 Representation of Grid Voltage

The figure.6 depicts the Grid Voltage in a per-unit (pu) system over a time interval of 0.5 seconds. This waveform likely illustrates the voltage behavior of the grid during normal operation and a disturbance event. The voltage sag indicates a disturbance between 0.2 and 0.4 seconds, with recovery following soon after. The grid's ability to return to normal levels suggests that the power system has effective compensating or protection mechanisms i.e inter phase power controller in place to mitigate such faults and restore voltage stability quickly.

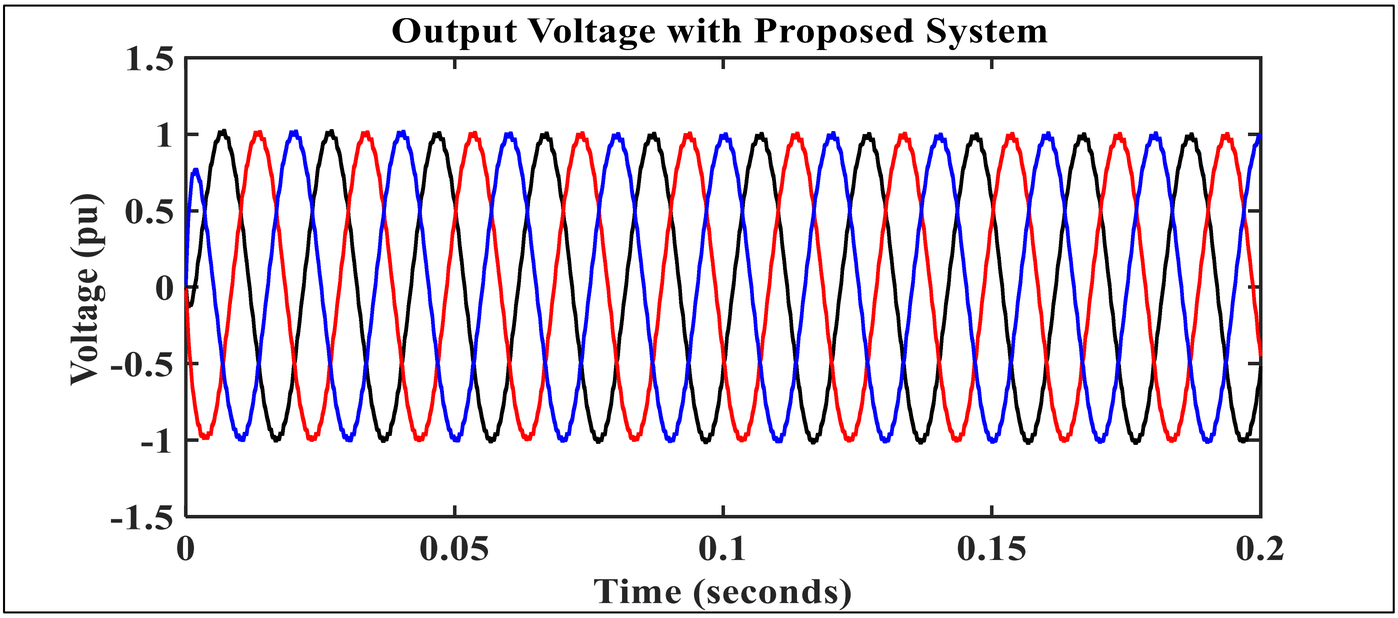

Fig 7 Representation of Load Voltage

The figure.7 illustrates the Output Voltage with the Proposed System over time after applying the Inter-Phase Power Controller (IPPC). The waveform appears stable and balanced, demonstrating the effectiveness of the IPPC in maintaining grid voltage stability. The IPPC's role is to manage and stabilize the phase voltages, especially during disturbances such as faults or voltage sags. The stable, clean waveform suggests that the IPPC is effectively maintaining voltage levels across the three phases, ensuring they are in phase and balanced. The three-phase voltages overlap closely, indicating synchronized operation and minimal phase deviation. This is crucial for maintaining power quality and preventing issues like unbalanced loads or harmonic distortion.

➢ *Improvement Compared to Previous Grid Voltage*

In comparison to figure 6 & figure 7 where disturbances or voltage sags were present, this waveform shows a corrected and regulated voltage output. The application of the IPPC has evidently restored and maintained the grid voltage to its nominal sinusoidal form. The absence of voltage dips or irregularities further supports the conclusion that the IPPC has mitigated the effects of any disturbances that may have occurred.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT1752

The figure.7 demonstrates the success of the IPPC in regulating and stabilizing the grid voltage. The output voltage waveform shows that the IPPC has maintained the integrity of the grid voltage, ensuring it remains balanced, sinusoidal, and free of disturbances. This outcome illustrates the efficacy of the proposed system in enhancing power quality and reliability within the transmission network.

V. CONCLUSION

In modern power systems, the management of reactive power plays a crucial role in ensuring voltage stability, improving power quality, and enhancing overall grid efficiency. The Inter Phase Power Controller (IPPC) presents an innovative and dynamic solution to these challenges by enabling precise control over reactive power flow between phases. Unlike traditional methods of reactive power compensation, such as capacitors and reactors, which often lack flexibility and rapid response, the IPPC leverages advanced power electronics to provide real-time adjustments, making it highly suitable for today's complex, multi-phase power systems. The ability of the IPPC to respond dynamically to fluctuating loads and varying generation sources—particularly in grids with high penetration of renewable energy—makes it an indispensable tool for improving system stability. Its integration not only helps prevent voltage collapse but also reduces power losses and improves power factor, contributing to the overall efficiency and reliability of the power network. By balancing reactive power flows across phases, the IPPC enhances power quality, reduces operational costs, and extends the lifespan of critical infrastructure components. Furthermore, the IPPC’s flexibility and scalability make it applicable across a wide range of settings, from industrial power systems and distribution networks to large-scale transmission grids and renewable energy installations. Its ability to seamlessly integrate with other advanced technologies, such as microgrids and energy storage systems, positions it as a future-proof solution for the evolving demands of the energy sector.

REFERENCES

[1]. N. Namburi Nireekshana and K. R. Kumar, “A Modern Distribution Power Flow Controller With A PID-Fuzzy Approach: Improves The Power Quality”, Accessed: Sep. 28, 2024. [Online]. Available: https://www.academia.edu/download/112956747/ijeer_120124.pdf

[2]. N. Nireekshana, N. Ravi, and K. R. Kumar, “A Modern Distribution Power Flow Controller With A PID-Fuzzy Approach: Improves The Power Quality,” Int. J. Electr. Electron. Res., vol. 12, no. 1, pp. 167–171, 2024.

[3]. N. Nireekshana, R. Ramachandran, and G. V. Narayana, “A New Soft Computing Fuzzy Logic Frequency Regulation Scheme for Two Area Hybrid Power Systems,” Int J Electr Electron Res, vol. 11, no. 3, pp. 705–710, 2023.

[4]. N. Nireekshana, R. Ramachandran, and G. V. Narayana, “A Peer Survey on Load Frequency Contol in Isolated Power System with Novel Topologies,” Int J Eng Adv Technol IJEAT, vol. 11, no. 1, pp. 82–88, 2021.

[5]. N. Nireekshana, R. Ramachandran, and G. Narayana, “A Novel Swarm Approach for Regulating Load Frequency in Two-Area Energy Systems,” Int J Electr Electron Res, vol. 11, pp. 371–377, 2023.

[6]. M. Chethan and R. Kuppan, “A review of FACTS device implementation in power systems using optimization techniques,” J. Eng. Appl. Sci., vol. 71, no. 1, p. 18, Dec. 2024, doi: 10.1186/s44147-023-00312-7.

[7]. N. Nireekshana, R. Ramachandran, and G. V. Narayana, “An innovative fuzzy logic frequency regulation strategy for two-area power systems,” Int. J. Power Electron. Drive Syst. IJPEDS, vol. 15, no. 1, pp. 603–610, 2024.

[8]. Namburi Nireekshana, Onteru Divya, Mohammed Abdul Saquib Adil, Rathod Rahul, and Mohammed Shoaib Mohiuddin, “An Innovative SSSC Device for Power Quality Enhancement,” Feb. 2024, doi: 10.5281/ZENODO.10670526.

[9]. N. NIREEKSHANA, R. RAMACHANDRAN, and G. NARAYANA, “An Intelligent Technique for Load Frequency Control in Hybrid Power System,” 2023, Accessed: Sep. 28, 2024. [Online]. Available: https://www.academia.edu/download/107660997/latest.pdf

[10]. A. Mousaei, M. Gheisarnejad, and M. H. Khooban, “Challenges and opportunities of FACTS devices interacting with electric vehicles in distribution networks: A technological review,” J. Energy Storage, vol. 73, p. 108860, 2023.

[11]. N. Nireekshana, “Control of a Bidirectional Converter to Interface Electrochemical double layer capacitors with Renewable Energy Sources”, Accessed: Sep. 28, 2024. [Online]. Available: https://methodist.edu.in/web/uploads/naac/2019-11-19%2012_45_38pm%20151.pdf

[12]. R. Gadal, A. Oukennou, F. El Mariami, A. Belfqih, and N. Agouzoul, “Voltage Stability Assessment and Control Using Indices and FACTS: A Comparative Review,” J. Electr. Comput. Eng., vol. 2023, no. 1, p. 5419372, 2023.

[13]. Namburi Nireekshana, A. Archana, Setla Manvitha, Mohammed Saad Ahmed, Nisar Ahmed Khan, and Akellu George Muller, “Unique Facts Device for Power Quality Mitigation,” Feb. 2024, doi: 10.5281/ZENODO.10652911.

[14]. Namburi Nireekshana, K. Pulla Reddy, Reyya Bose Babu, Bonda Sunder, G. Sumanth Kumar, and P. Vivekananda Raj, “Static Var Compensator for Reactive Power Control,” Feb. 2024, doi: 10.5281/ZENODO.10638477.

[15]. N. Nireekshana, "Reactive Power Compensation in High Power Applications by Bidirectionalcasceded H-Bridge Based Statcom", Accessed: Sep. 28, 2024. [Online]. Available: https://methodist.edu.in/web/uploads/naac/2019-11-19%2012_45_47pm%20152.pdf

[16]. L. L. Grigsby, Power system stability and control. CRC press, 2007. Accessed: Oct. 17, 2024. [Online]. Available: https://www.taylorfrancis.com/books/mono/10.1201/9781420009248/power-system-stability-control-leonard-grigsby

[17]. J. Machowski, Z. Lubosny, J. W. Bialek, and J. R. Bumby, Power system dynamics: stability and control. John Wiley & Sons, 2020. Accessed: Oct. 17, 2024. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=9X_PDwAAQBAJ&oi=fnd&pg=PA19&dq=+Power+System+Stability+and+Control+&ots=zP73K_OSty&sig=Rmv-Kn3CPF6ygMpPMG98OTP1454

[18]. X.-F. Wang, Y. Song, and M. Irving, Modern power systems analysis. Springer Science & Business Media, 2010. Accessed: Oct. 17, 2024. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=JSg5F_ma-20C&oi=fnd&pg=PR2&dq=Power+Systems+AnalysiS&ots=WkPDzSLTen&sig=bgyH7w4iMxIgzZiqnkryY0GtByQ

[19]. N. Mahdavi Tabatabaei, A. Jafari Aghbolaghi, N. Bizon, and F. Blaabjerg, Eds., Reactive Power Control in AC Power Systems: Fundamentals and Current Issues. in Power Systems. Cham: Springer International Publishing, 2017. doi: 10.1007/978-3-319-51118-4.

[20]. R. C. Bansal, "Automatic reactive-power control of isolated wind–diesel hybrid power systems," IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1116–1126, 2006.

[21]. X. Qiao, J. Bian, C. Chen, and H. Li, "Comparison and analysis of reactive power compensation strategy in power system," in 2019 IEEE Sustainable Power and Energy Conference (iSPEC), IEEE, 2019, pp. 689–692. Accessed: Oct. 17, 2024. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8975301/

[22]. D. Murali and M. Rajaram, "Active and reactive power flow control using FACTS devices," Int. J. Comput. Appl., vol. 9, no. 8, pp. 45–50, 2010.