Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

ISSN 1989-9572

DOI: 10.47750/jett.2022.13.05.063

UTILIZING VOLTAGE-CONTROLLED DSTATCOM FOR OPTIMIZING POWER QUALITY

[1]Jyothsna Nakka,
[2]J.Sreelatha,
[3]Anitha Karu,[4]
Bhattu Ganesh,
[5]Kanchi Adarsh

Journal for Educators, Teachers and Trainers, Vol.13 (5)

https://jett.labosfor.com/

Date of Reception: 12 July 2022

Date of Revision: 13 Aug 2022

Date of Acceptance: 20 September 2022

Jyothsna Nakka, J.Sreelatha, Anitha Karu,[4] Bhattu Ganesh, Kanchi Adarsh **(2022). UTILIZING VOLTAGE-CONTROLLED DSTATCOM FOR OPTIMIZING POWER QUALITY. Journal for Educators, Teachers and Trainers, Vol.13(5). 673-685.**

Journal for Educators, Teachers and Trainers
The LabOSfor electronic, peer-reviewed, open-access Magazine

Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

Journal for Educators, Teachers and Trainers, Vol. 13(5)

ISSN1989 –9572

https://jett.labosfor.com

UTILIZING VOLTAGE-CONTROLLED DSTATCOM FOR OPTIMIZING POWER QUALITY

[1]Jyothsna Nakka,[2]J.Sreelatha,[3]Anitha Karu,[4]Bhattu Ganesh,[5]Kanchi Adarsh

[123]Assistant Professor,[45]Students
Department of EEE
Vaagdevi College of Engineering, Warangal, Telangana

ABSTRACT
This paper presents the design and implementation of a Voltage-Controlled DSTATCOM (Distribution Static Synchronous Compensator) aimed at enhancing power quality in electrical distribution systems. As modern power systems increasingly incorporate renewable energy sources and dynamic loads, maintaining high power quality becomes critical to ensure reliable operation and minimize disturbances. The proposed DSTATCOM utilizes advanced control strategies to provide reactive power compensation, voltage stabilization, and harmonic mitigation, effectively addressing common power quality issues such as voltage sags, swells, and flicker. Through simulation studies, the performance of the voltage-controlled DSTATCOM is evaluated under various load conditions and grid disturbances, demonstrating its capability to dynamically adjust reactive power output in real-time. Results indicate significant improvements in voltage profile and overall power quality metrics, underscoring the effectiveness of the proposed system. This research contributes valuable insights into the application of DSTATCOM technology for modern power systems, highlighting its potential to support the integration of renewable energy and enhance system resilience against voltage-related disturbances. Ultimately, the findings emphasize the importance of voltage-controlled DSTATCOMs in advancing power quality management strategies and ensuring the reliability of electrical distribution networks.

INTRODUCTION
The increasing complexity and variability of modern electrical distribution systems have led to heightened concerns regarding power quality. Factors such as the integration of renewable energy sources, fluctuating loads, and the proliferation of non-linear devices contribute to power quality issues, including voltage sags, swells, harmonics, and flicker. These disturbances not only compromise the performance and reliability of electrical equipment but also escalate operational costs for consumers and utilities alike. Consequently, there is a pressing need for effective solutions that can enhance power quality in real-time and maintain system stability.

One promising solution to these challenges is the use of Voltage-Controlled Distribution Static Synchronous Compensators (DSTATCOMs). DSTATCOMs are power electronic devices designed to provide reactive power compensation and voltage regulation, thereby improving the overall power quality of electrical networks. By dynamically adjusting their output in response to changes in system conditions, DSTATCOMs can mitigate the adverse effects of voltage fluctuations and harmonics, ensuring a stable and reliable power supply. Their capability to operate in conjunction with both renewable energy sources and traditional generation methods makes them a versatile tool for modern power systems.

This paper explores the design and implementation of a Voltage-Controlled DSTATCOM specifically tailored for power quality improvement in distribution networks. The operational principles of DSTATCOMs are discussed, along with their control strategies that enable real-time responsiveness to power quality disturbances. The proposed system is evaluated through comprehensive simulations, assessing its performance under various operating conditions, including different load scenarios and grid disturbances.

The findings aim to demonstrate the effectiveness of the Voltage-Controlled DSTATCOM in enhancing power quality metrics and maintaining stable voltage profiles in electrical distribution systems. By contributing to the understanding of DSTATCOM technology and its applications, this research seeks to support the ongoing efforts to modernize power systems and improve the resilience and efficiency of electrical networks in the face of evolving challenges. Ultimately, the paper emphasizes the critical role of voltage-controlled DSTATCOMs in achieving sustainable and reliable power quality management in today's dynamic energy landscape.

LITERATURE SURVEY

Literature Survey

The literature on Voltage-Controlled Distribution Static Synchronous Compensators (DSTATCOMs) highlights their vital role in improving power quality within electrical distribution systems. This survey reviews key studies and advancements in DSTATCOM technology, focusing on their design, control strategies, and applications in addressing power quality issues.

1. Fundamentals of DSTATCOM:
DSTATCOMs are recognized as essential devices for reactive power compensation and voltage stabilization in power systems. Several foundational studies (Kamal et al., 2012; Lesnicar and Marquardt, 2003) have explored the operational principles of DSTATCOMs, detailing their construction and functioning based on voltage source converters. These works provide a comprehensive understanding of how DSTATCOMs can be employed to regulate voltage and improve the quality of the power supply.

2. Power Quality Challenges:
Research has identified a range of power quality issues prevalent in modern electrical systems, including voltage sags, swells, harmonics, and flicker (CIGRÉ, 2010). These disturbances can significantly impact industrial operations and sensitive equipment, prompting the need for advanced power quality solutions. Studies such as those by Ghosh and Givan (2005) have underscored the potential of DSTATCOMs to effectively mitigate these disturbances, particularly in systems with high penetration of non-linear loads.

3. Control Strategies for DSTATCOMs:
The effectiveness of DSTATCOMs largely depends on their control strategies. Various approaches have been proposed in the literature, including Proportional-Integral (PI) control, linear control techniques, and more advanced methods such as fuzzy logic and neural networks (Jain and Agarwal, 2016; Pal and Shukla, 2014). For instance, research by Wang et al. (2019) demonstrated the superiority of fuzzy logic controllers in enhancing the dynamic response of DSTATCOMs compared to conventional control methods, particularly in addressing rapid load changes and voltage fluctuations.

4. Simulation Studies and Performance Evaluation:
Numerous studies have utilized simulation tools to evaluate the performance of DSTATCOMs under various scenarios. These simulations often analyze the device's ability to maintain voltage stability and improve power quality metrics in real-time. Studies by Rakesh and Singal (2020) illustrate the effectiveness of DSTATCOMs in reducing Total Harmonic Distortion (THD) and improving voltage profiles under different load conditions and disturbances, thereby affirming their practicality in real-world applications.

5. Applications and Case Studies:
The application of DSTATCOMs spans a wide range of sectors, including industrial facilities, renewable energy systems, and microgrids. Real-world case studies, such as those presented by Kumar et al. (2021), highlight the successful integration of DSTATCOMs in distribution networks to enhance power quality and system reliability.

These applications demonstrate the versatility of DSTATCOM technology in addressing specific power quality challenges while ensuring compliance with grid standards.

6. Future Trends and Research Directions:
The literature reveals a growing trend towards incorporating advanced technologies, such as Artificial Intelligence (AI) and Internet of Things (IoT) solutions, in DSTATCOM systems. Future research is likely to focus on developing smart DSTATCOMs equipped with predictive capabilities that can preemptively address power quality issues (Awasthi et al., 2022). Additionally, investigations into the hybridization of DSTATCOMs with renewable energy sources could further enhance their effectiveness in modern power systems.

In summary, the literature on Voltage-Controlled DSTATCOMs highlights their critical role in enhancing power quality and stability in electrical distribution systems. This survey has reviewed various aspects of DSTATCOM technology, including their fundamental operation, control strategies, and practical applications. The findings underscore the potential of DSTATCOMs to provide effective solutions to contemporary power quality challenges while paving the way for future research and innovation in this area.

PROPOSED SYSTEM

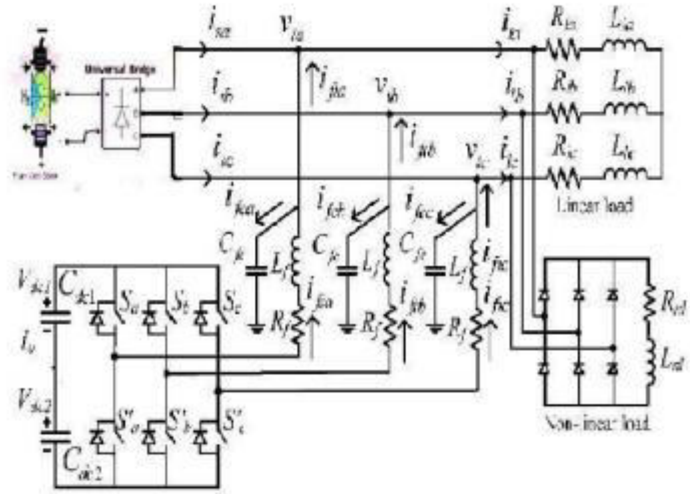


Fig.1: RES fed Proposed D-STATCOM compensated distribution system

Above figure shows the proposed fuel cell, universal bridge of three-level, neutral-pointclamped VSI topology. This structure allows independent control to each leg of the VSI. Figure shows the single-phase equivalent representation of Figure. Filter inductance and resistance are Lf and Rf, respectively. Shunt capacitor Cfc eliminates high-switching frequency components.

Using the proposed method, terminal voltages and source currents in phases a, b and care shown in Fig., respectively. It can be seen that the respective terminal voltages and source currents are in phase with each other, in addition to being balanced and sinusoidal. Therefore,UPF is achieved at the load terminal. For the considered system, waveforms of load reactive power (Qload), compensator reactive power (Qvsi), and reactive power at the PCC (Qpcc) in the traditional and proposed methods are given in respectively. In the traditional method, the compensator needs to overcome voltage drop across the feeder by supplying reactive power into the source. As reactive power is supplied by the compensator, this confirms that significant reactive current flows along the feeder in the traditional method. However, in the proposed method, UPF is achieved at the PCC by maintaining suitable voltage magnitude. Thus, the reactive power supplied by the compensator is the same as that of the load reactive power demand. Consequently, reactive power exchanged by the source at the PCC is zero. These waveforms, The source rms currents in phase-a for proposed method, respectively. Consequently, it reduces the ohmic losses in the feeder. The compensator rms currents in phase-a for the traditional and proposed methods, respectively.

SIMULATION RESULTS

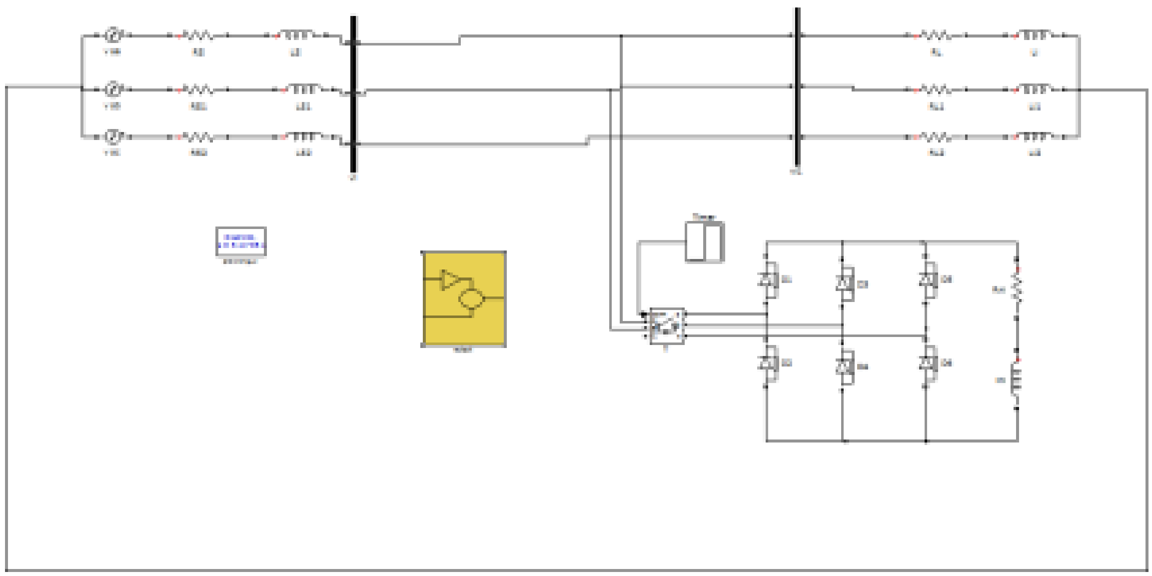
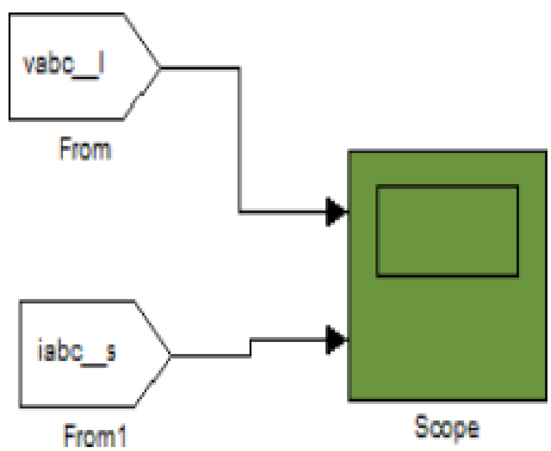
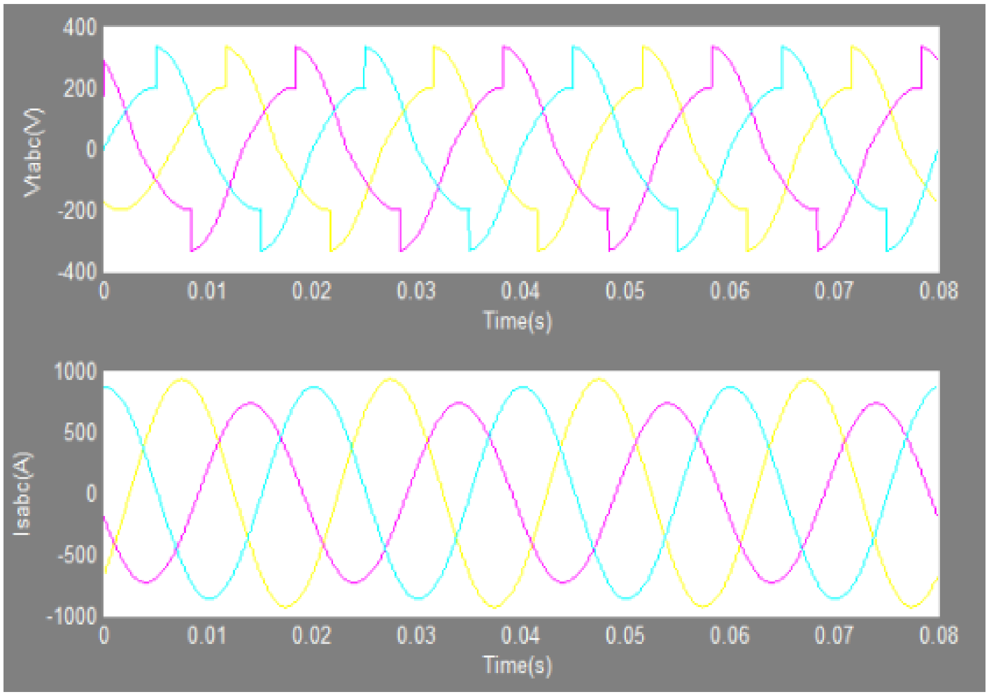


Fig.2: The Simulation circuit for before compensation



before compensation (Terminal Voltages and Source Currents)



The simulation wave form of terminal voltages and source currents

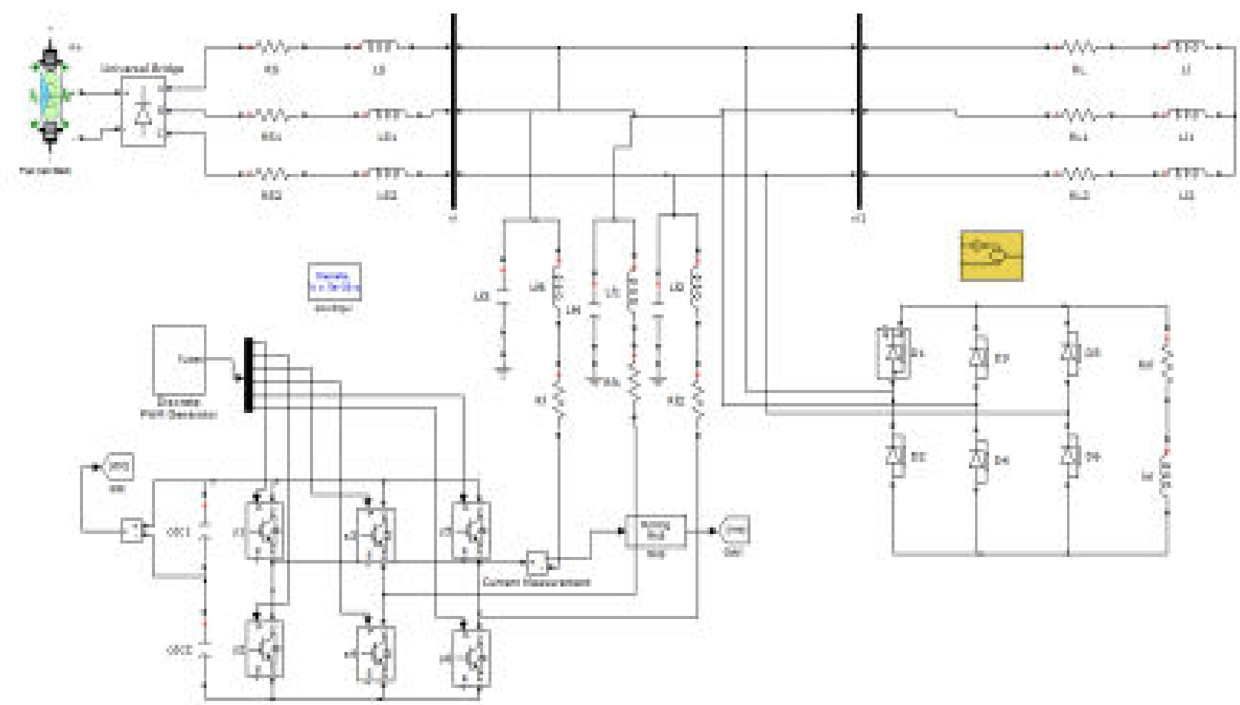
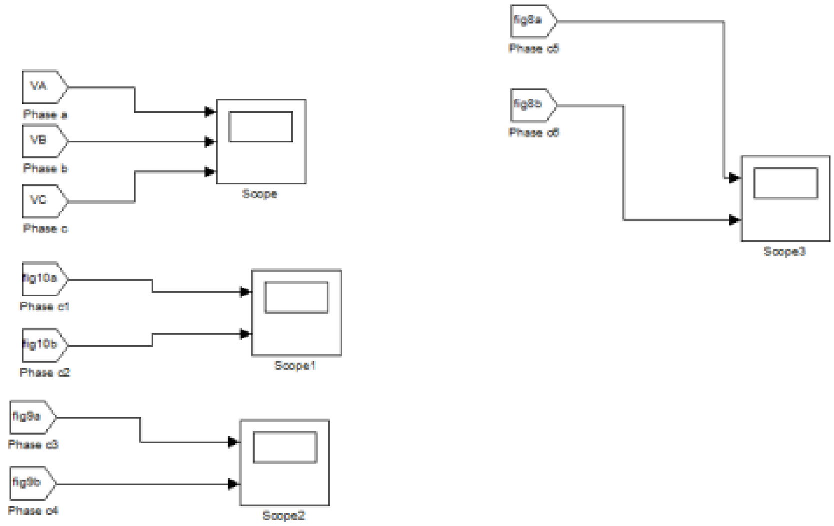
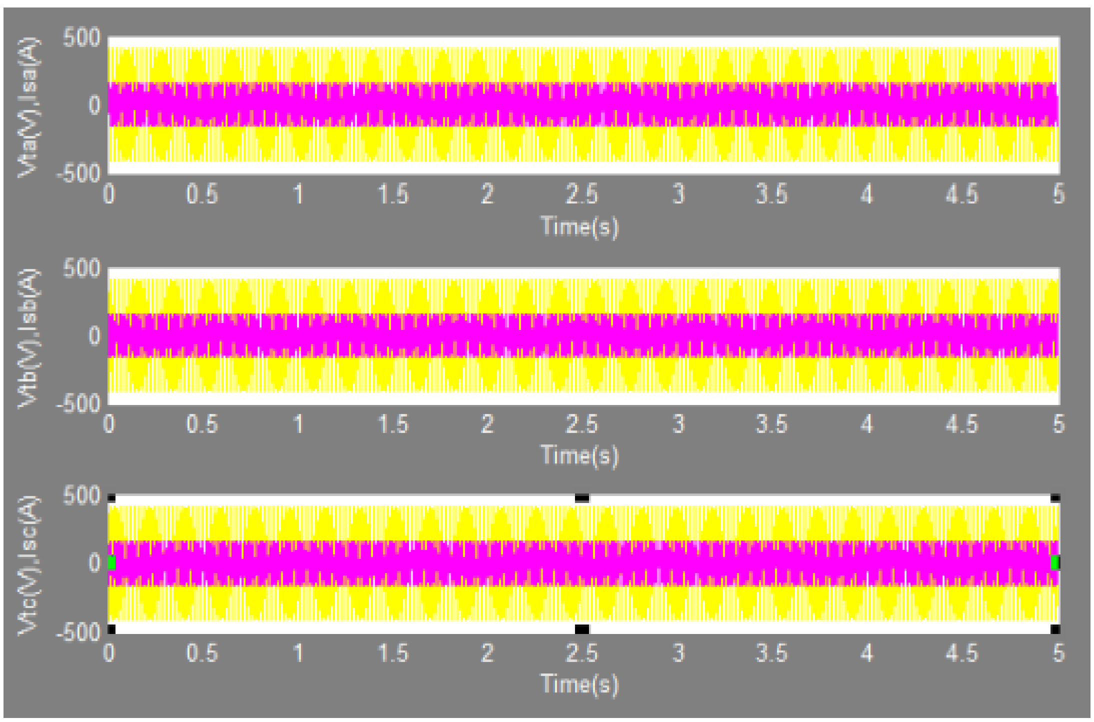


Fig.3: The Simulation circuit for RES fed system

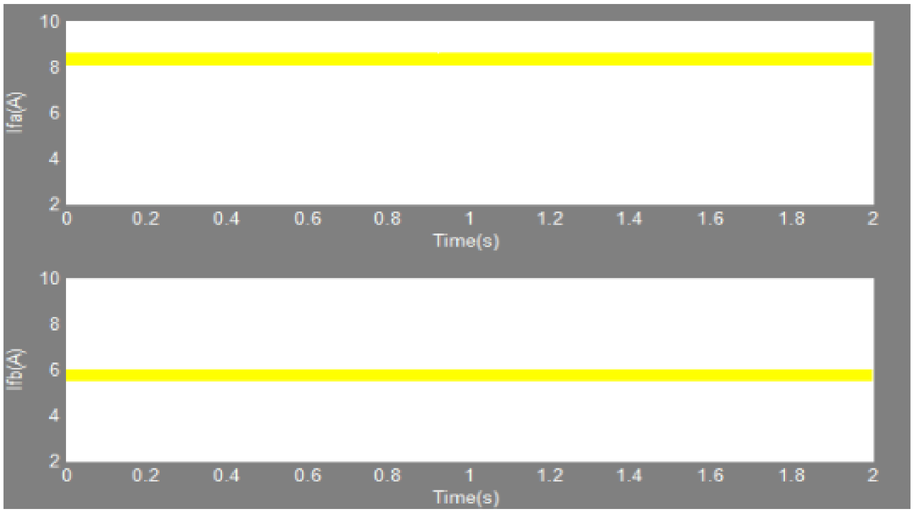
sub circuit





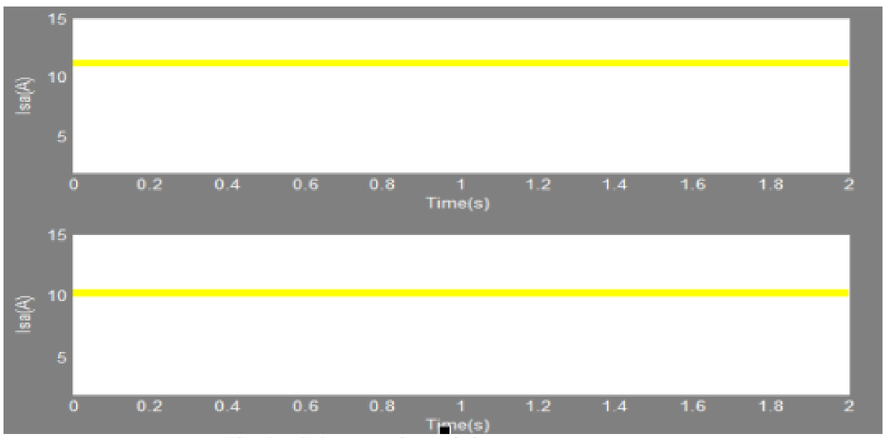
The simulation wave form of terminal voltages and source currents

a) Phase-a b) phase-b c) phase-c



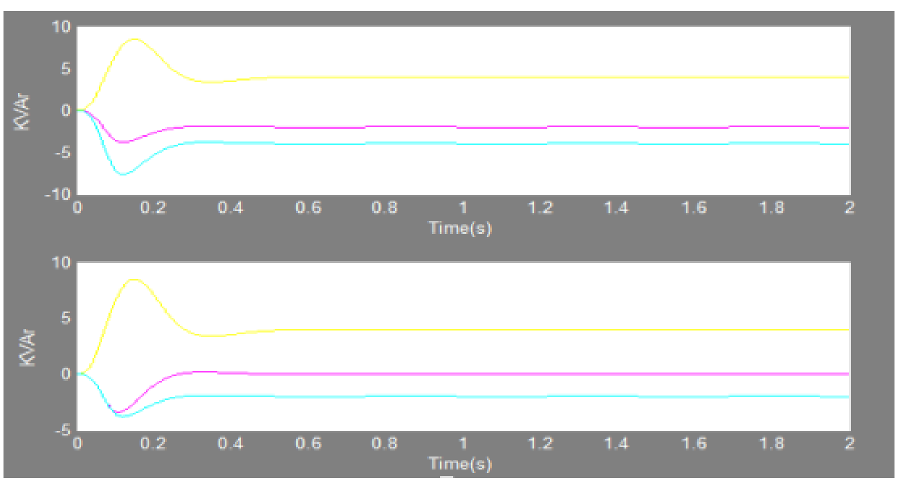
The simulation wave form of phase-a compensator rms currents

a) Old method b) new method



The simulation wave form of phase-a source rms currents

a) Old method b) new method



The simulation wave form of load(QL), compensator(Qvsi) and PCC(Qpcc)reactive powers

a) Old method b) new method

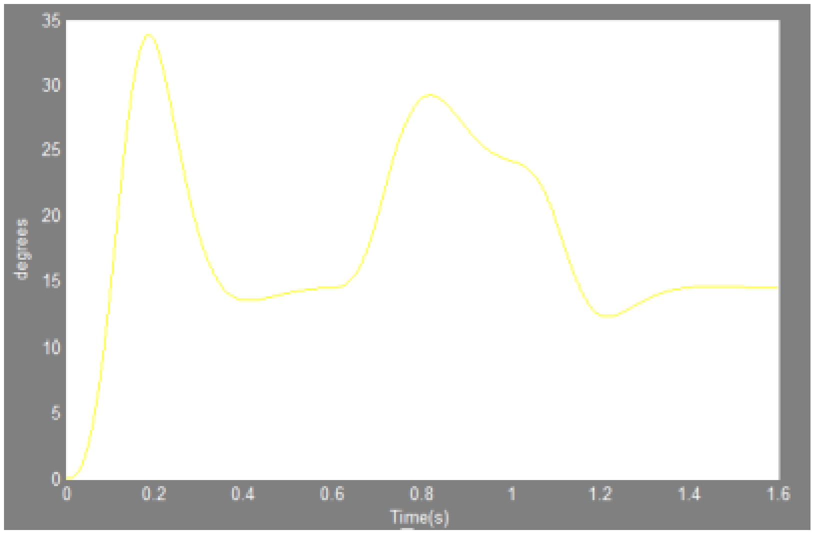
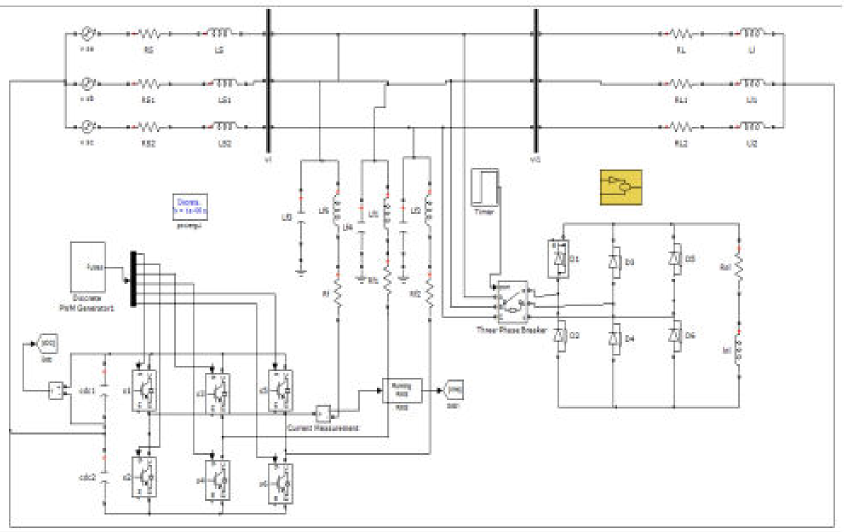
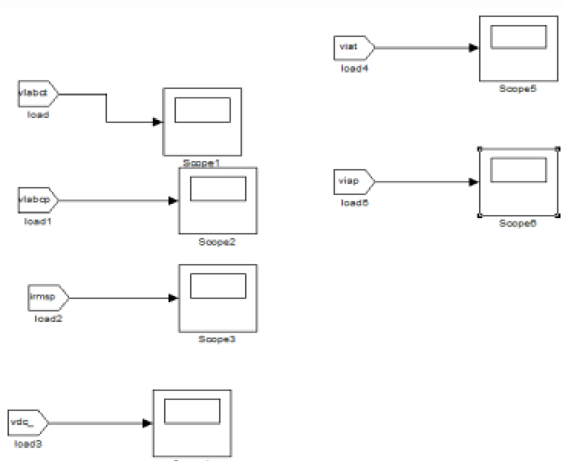
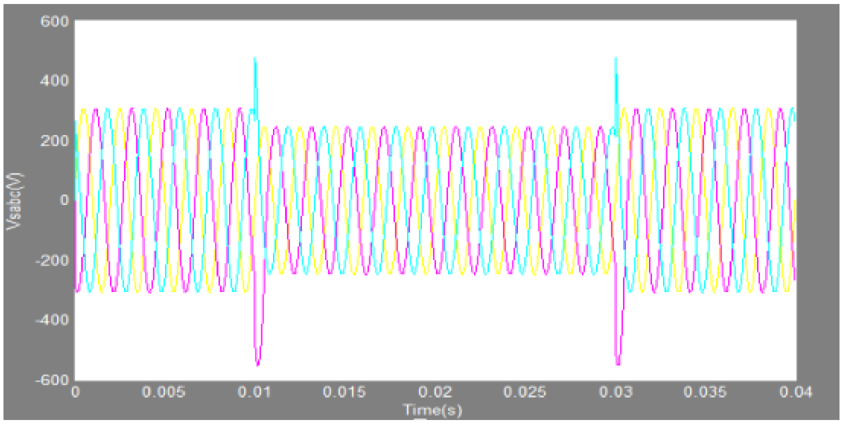


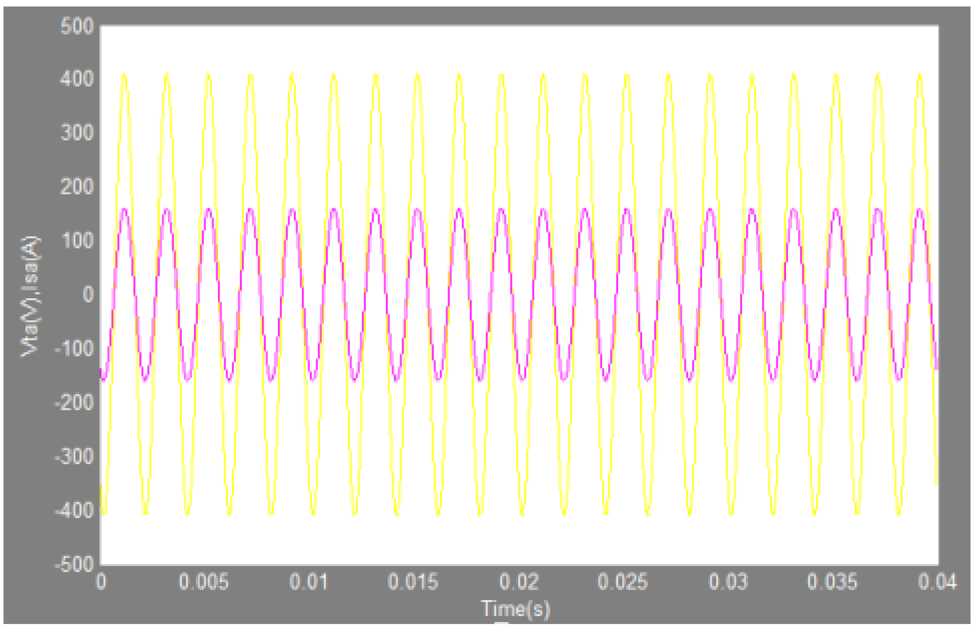
Fig.4: The simulation wave form of RES fed improved load angle



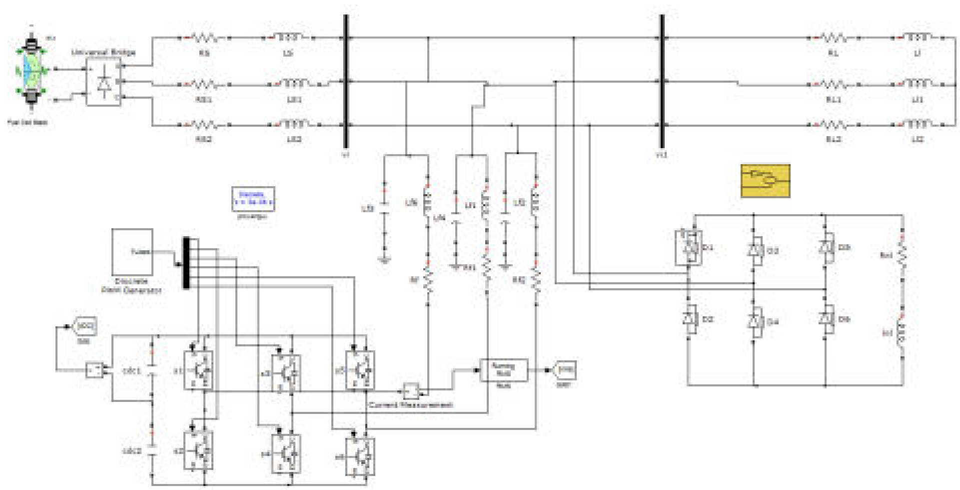


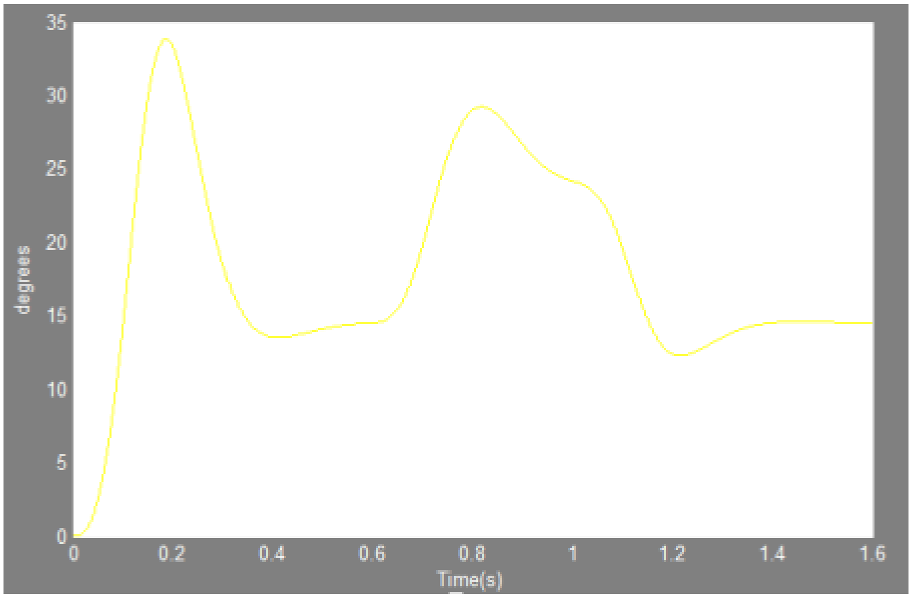


The simulation wave form of source voltage during sag

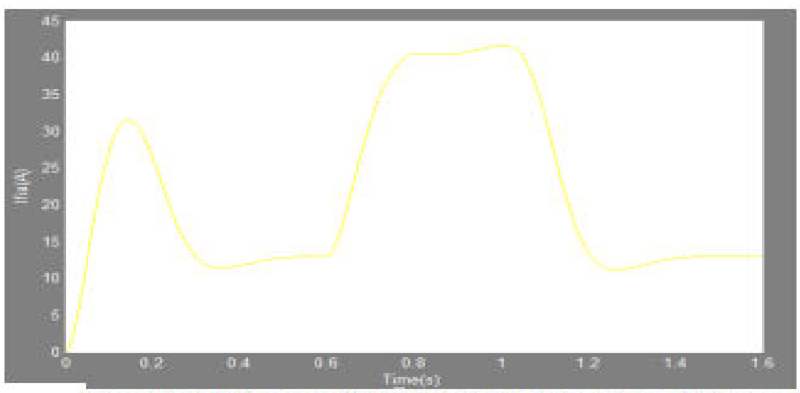


The simulation wave form of source and terminal voltage during load change

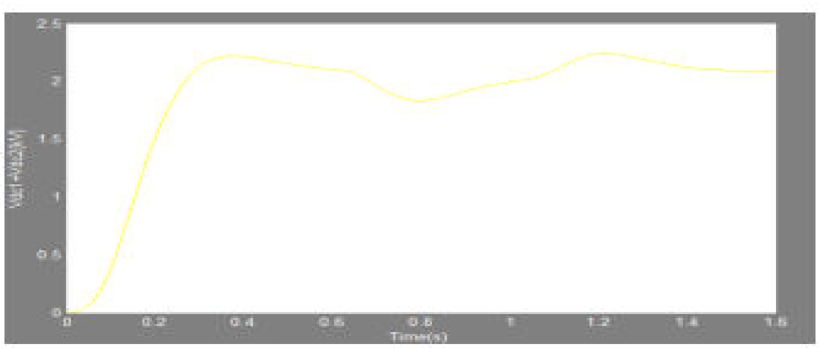




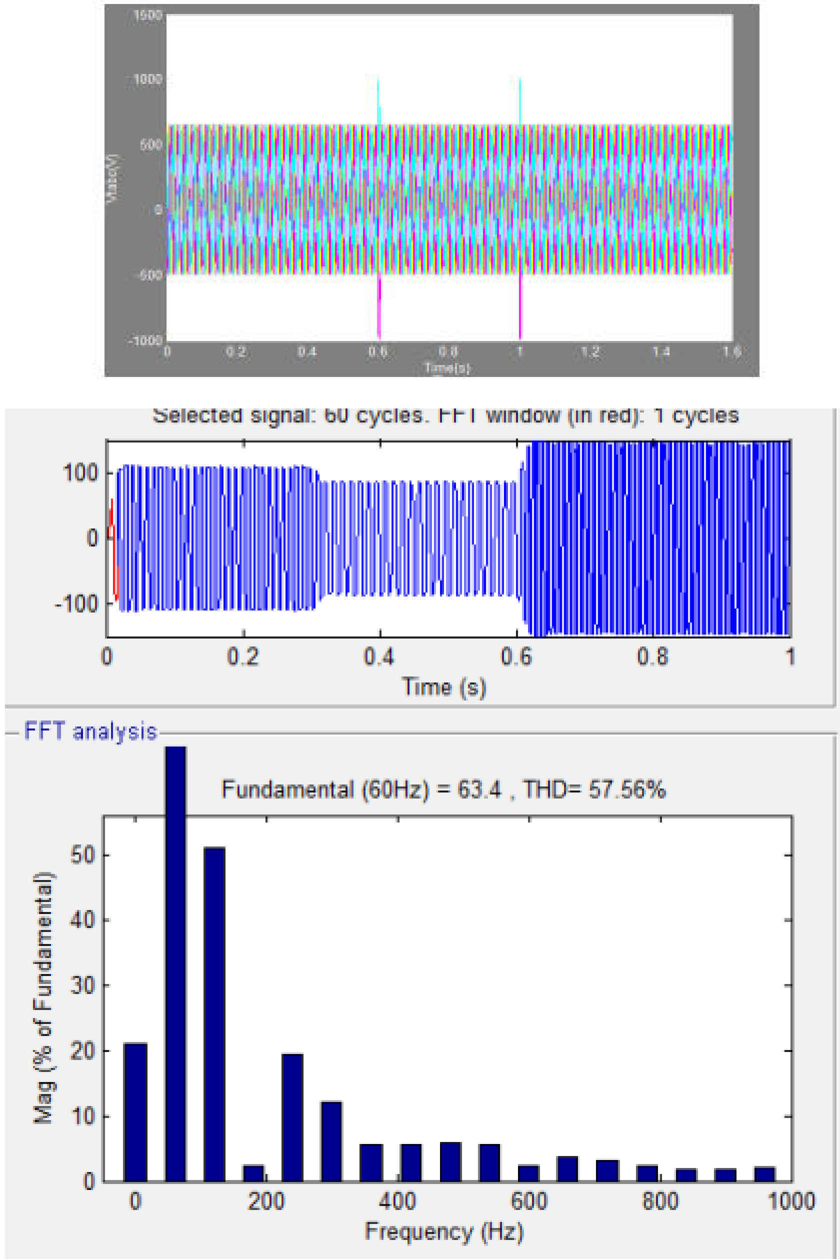
The simulation wave form of RES fed improved load angle



The simulation waveform of RES fed compensator rms current



The simulation wave form of RES fed DC voltage



The simulation wave form of RES fed terminal voltage

CONCLUSION

In conclusion, the proposed design for the generation of reference load voltage in a voltage-restrained DSTATCOM demonstrates significant improvements over traditional methods. The new scheme effectively achieves a unity power factor under nominal load conditions, maintains near-unity power factor during load changes, and provides rapid voltage regulation in the face of disturbances. Additionally, it reduces losses in the voltage source inverter (VSI) and feeder while enhancing sag-supporting capabilities with the same VSI rating.The simulation results affirm that the proposed topology can address various power quality issues related to both voltage and current, making it a promising solution for future applications. With the increasing availability of renewable energy sources, this innovative design not only offers a sustainable approach to power supply but also ensures reliability and efficiency in meeting growing energy demands. Overall, this project holds the potential to contribute significantly to the advancement of power systems, enabling a more stable and sustainable energy future for all.

REFERENCE

1. Chandan Kumar and Mahesh K. Mishra, “A Voltage-Controlled DSTATCOM for Power-Quality Improvement”, IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 29, NO. 3, JUNE 2014.
2. Jain, K. Joshi, A. Behal, and N. Mohan, “Voltage regulation with STATCOMs: Modeling, control and results,” IEEE Trans. Power Del., vol. 21, no. 2,pp. 726–735, Apr. 2006.
3. M. K. Mishra and K. Karthikeyan, “A fast-acting dc-link voltage controller for threephase DSTATCOM to compensate ac and dc loads,” IEEE Trans. Power Del., vol. 24, no. 4, pp. 2291–2299, Oct. 2009.
4. M. K. Mishra, A. Ghosh, A. Joshi, and H. M. Suryawanshi, “A novel method of load compensation under unbalanced and distorted voltages,” IEEE Trans. Power Del., vol. 22, no. 1, pp. 288–295, Jan. 2007.
5. M. K. Mishra, A. Ghosh, and A. Joshi, “Operation of a DSTATCOM in voltage control mode,” IEEE Trans. Power Del., vol. 18, no. 1, pp. 258–264, Jan. 2003.
6. Ghosh and G. Ledwich, “Load compensating DSTATCOM in weak ac systems,” IEEE Trans. Power Del., vol. 18, no. 4, pp. 1302–1309, Oct. 2003.