International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

Hybrid Generalized Integrator for Power Quality Improvement in Wind Energy Generating System

Mr. S. Kranthi Kumar., T.V.N.S Lavanya, B.Venkata Koteswara Rao, K. Venkateswarlu, V. Shalem Raju, M. Jeevan

M. Tech, M.I.S.T.E, Associate Professor,Department of Electrical & Electronics Engineering
Rise Krishna Sai Prakasam Group of Institutions
(208A1A0216),Department of Electrical and Electronics Engineering
Rise Krishna Sai Prakasam Group of Institutions
(208A1A0220),Department of Electrical and Electronics Engineering
Rise Krishna Sai Prakasam Group of Institutions
(218A5A0212),Department of Electrical and Electronics Engineering
Rise Krishna Sai Prakasam Group of Institutions
(218A5A0216),Department of Electrical and Electronics Engineering
Rise Krishna Sai Prakasam Group of Institutions
(208A1A0231),Department of Electrical and Electronics Engineering
Rise Krishna Sai Prakasam Group of Institutions

ABSTRACT

The wind energy generating system (WEGS) aims to provide the required active peak power without high frequency fluctuations even under variable wind speed conditions. The generator speed is adjusted according to the intermittent wind speeds through two voltage source converters (VSCs) connected back-to-back, namely, machine-side VSC (MSVSC) and utility grid side VSC (UGVSC) across the dc-link capacitor. In this paper, the hybrid generalized integrator control is proposed for switching UGVSC and providing dc offset rejection and immunity against oscillatory errors due to subharmonics, thereby improving the power quality (PQ). Fuzzy logic controller (FLC) is implemented for the speed control of the salient pole synchronous generator (SG) driven by the wind turbine. The FLC provides the tracking of the reference speed under high overshoot transient conditions and narrow bandwidth. The switching of MSVSC is obtained by field-oriented control. The dynamic performance is improved by the wind feed forward term, which reduces the oscillation, ensuring balanced and sinusoidal grid currents. The generated power from the WEGS is fed to the grid. The weak grid conditions, namely, grid voltage unbalance, voltage sag, voltage swell, and grid voltage distortion, are considered. The performance of the system is tested on a laboratory prototype. Test results provide the effectiveness of the system with increased wind penetration and performance under weak grid conditions. Moreover, improving the PQ, the grid current total harmonic distortion is found to be less than 5%.

Keywords: Wind Energy Generating System (WEGS), Voltage Source Converters (VSCs), Hybrid Generalized Integrator Control,Fuzzy Logic Controller (FLC), Salient Pole Synchronous Generator (SG), Field Oriented Control, Power Quality (PQ)

INTRODUCTION

The introduction to the paper titled "Hybrid Generalized Integrator for Power Quality Improvement in Wind Energy Generating System" provides a comprehensive overview of the objectives, significance, and methodology of the study, contextualizing the research within the realm of wind energy generation and power quality enhancement. The primary aim of wind energy generating systems (WEGS) is underscored, emphasizing their pivotal role in delivering active peak power while mitigating high-frequency fluctuations, especially in the face of variable wind speed conditions [1].A crucial aspect of WEGS operation lies in the adjustment of generator speed to match intermittent wind speeds, facilitated by two vital components: the machine-side voltage source converter (MSVSC) and the utility grid-side voltage source converter (UGVSC). These converters, interconnected via a dc-link capacitor, enable seamless modulation of power output and integration with the electrical grid. The introduction highlights the importance of effective control strategies for these components in maintaining grid stability and improving power quality [2].

In this paper, the authors propose a novel control technique known as hybrid generalized integrator control to govern the operation of the UGVSC. This innovative approach aims to address specific challenges related to power quality, such as dc offset rejection and immunity against oscillatory errors induced by subharmonics. By leveraging hybrid generalized integrator control, the UGVSC can effectively regulate voltage fluctuations and enhance overall power quality, thereby bolstering the performance and reliability of WEGS [3].Additionally, the introduction discusses the implementation of a fuzzy logic controller (FLC) for speed control of the salient pole synchronous generator (SG) driven by the wind turbine. The FLC is designed to track the reference speed under various transient conditions, ensuring smooth operation and minimizing deviations from desired operational parameters. Moreover, the switching of MSVSC is accomplished through field-oriented control, a technique aimed at optimizing the dynamic performance of the system [4].

An essential aspect of the proposed control strategy is the integration of wind feedforward terms, which play a crucial role in reducing oscillations and ensuring the generation of balanced and sinusoidal grid currents. These terms contribute significantly to system stability and mitigate the impact of wind speed variations on grid-connected power generation [5]. Furthermore, the introduction addresses the consideration of weak grid conditions, including voltage unbalance, sag, swell, and distortion, all of which pose significant challenges to grid-connected WEGS. By evaluating the system's performance under such conditions, the study aims to demonstrate the effectiveness of the proposed control strategy in enhancing grid stability and power quality [6].To validate the proposed control technique, the authors conduct extensive testing on a laboratory prototype of the WEGS. The test results provide empirical evidence of the system's effectiveness in accommodating increased wind penetration and operating under weak grid conditions. Notably, the study highlights improvements in power quality, with the total harmonic distortion of grid currents observed to be less than 5%, underscoring the efficacy of the proposed control strategy [7].the introduction furnishes a comprehensive overview of the objectives, significance, and methodology of the study. By elucidating the challenges encountered by WEGS and proposing innovative control strategies to address them, the paper contributes to the advancement of power quality improvement in wind energy generation systems. Through empirical validation and meticulous analysis, the study strives to corroborate the efficacy of the proposed control technique and chart a course for future research endeavors in this domain [8].

LITERATURE SURVEY

The literature survey conducted for the paper titled "Hybrid Generalized Integrator for Power Quality Improvement in Wind Energy Generating System" delves into a vast array of research articles, technical papers, and industry reports concerning wind energy generation, power quality improvement, and control strategies for voltage source converters (VSCs) in renewable energy systems. This survey aims to comprehensively understand the current state-of-the-art technologies, challenges, and emerging trends within the domain of wind energy generation and power quality enhancement [9].Wind energy generating systems (WEGS) play a crucial role in renewable energy generation, aiming to provide active peak power while minimizing high-frequency fluctuations, especially under variable wind speed conditions. The literature review reveals significant advancements in wind turbine technology and control strategies for optimizing power generation and grid integration. Various studies emphasize the importance of effective control techniques for VSCs in mitigating power quality issues and ensuring grid stability [10].

Central to the operation of WEGS are the machine-side VSC (MSVSC) and utility grid-side VSC (UGVSC), which regulate generator speed and facilitate grid integration. Extensive research has been conducted on different control

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

strategies for VSCs, including generalized integrator control, field-oriented control, and fuzzy logic control. These techniques aim to improve power quality by addressing issues such as dc offset rejection, oscillatory errors, and subharmonics, thereby enhancing the performance and reliability of wind energy systems [11].

Furthermore, the literature survey highlights the importance of addressing weak grid conditions, such as voltage unbalance, sag, swell, and distortion, which pose significant challenges to grid-connected WEGS. Several studies have investigated the impact of weak grid conditions on power quality and proposed various mitigation strategies, including advanced control algorithms and grid support functionalities in VSCs [12].A notable advancement in wind energy research is the integration of wind feedforward terms in control strategies, aimed at reducing oscillations and ensuring the generation of balanced and sinusoidal grid currents. These terms leverage real-time wind speed data to optimize power generation and mitigate the impact of wind speed variations on grid-connected systems. The literature review underscores the effectiveness of wind feedforward control in enhancing system stability and power quality [13].

Moreover, the literature survey explores the testing and validation of control strategies for WEGS through laboratory prototypes and field experiments. These studies provide valuable insights into the performance of control algorithms under real-world operating conditions and demonstrate the effectiveness of proposed solutions in improving power quality and grid stability [14]. The literature survey provides comprehensive insights into state-of-the-art technologies, existing challenges, and emerging trends in wind energy generation and power quality improvement. By synthesizing and analyzing a diverse range of literature, this survey lays the foundation for the development and analysis of the proposed hybrid generalized integrator control strategy. By leveraging advanced control algorithms and addressing weak grid conditions, the paper aims to advance the state-of-the-art in wind energy systems and contribute to the transition towards a more sustainable and reliable energy future [15].

PROPOSED SYSTEM

The wind energy generating system (WEGS) stands as a cornerstone in the realm of renewable energy, dedicated to providing consistent active peak power amidst the variability of wind speeds and unpredictable environmental conditions. Central to the functionality of WEGS are two voltage source converters (VSCs), intricately linked back-to-back via the dc-link capacitor: the machine-side VSC (MSVSC) and the utility grid-side VSC (UGVSC). These components serve a pivotal role in adapting the generator speed to synchronize with intermittent wind velocities, thereby ensuring optimal power output and seamless integration with the grid.Our paper introduces a groundbreaking control strategy termed hybrid generalized integrator control, specifically tailored to govern the operation of the UGVSC. This innovative method addresses precise challenges associated with enhancing power quality, such as mitigating dc offset and providing immunity against oscillatory errors caused by subharmonics. By employing hybrid generalized integrator control, the UGVSC can effectively manage voltage fluctuations, thereby elevating overall power quality and bolstering the performance and dependability of WEGS.

Additionally, our system incorporates a fuzzy logic controller (FLC) to regulate the speed of the salient pole synchronous generator (SG) propelled by the wind turbine. The FLC is meticulously crafted to meticulously track the reference speed, particularly during periods of high overshoot transient conditions and within a narrow bandwidth. This ensures seamless operation and minimizes deviations from desired operating parameters, thereby optimizing the overall performance of the wind turbine system. Furthermore, the switching mechanism of the MSVSC is orchestrated through field-oriented control, a sophisticated technique engineered to refine the dynamic performance of the system. By intricately managing the magnetic flux and torque of the generator, field-oriented control ensures the system's efficiency and stability, even amidst fluctuating wind conditions.

To further augment system performance, we introduce a wind feedforward term, dynamically adjusting control inputs based on real-time wind speed data. This term assumes a pivotal role in mitigating oscillations and ensuring the production of balanced and sinusoidal grid currents. By adapting to variations in wind speed, the wind feedforward term substantially enhances system stability and power quality.Moreover, our system is meticulously designed to account for weak grid conditions, encompassing issues such as voltage unbalance, sag, swell, and distortion, which significantly impact the performance of WEGS. Through rigorous evaluation under these challenging conditions, we aim to underscore the robustness and efficacy of our system in preserving grid stability and power quality.

To validate the efficacy of our proposed control strategy, extensive testing is conducted on a laboratory prototype of the WEGS. The resulting empirical evidence substantiates the effectiveness of our system, particularly in accommodating increased wind penetration and operating under weak grid conditions. Notably, significant improvements in power quality are observed, with the total harmonic distortion of grid currents measuring less than 5%, attesting to the efficacy of our control strategy. Our proposed system embodies a holistic approach to enhancing power quality and grid stability within wind energy generating systems. By harnessing innovative control strategies and addressing the challenges posed by variable wind speeds and weak grid conditions, our system contributes to the advancement of renewable energy technologies, paving the way for a more sustainable and reliable energy future.

METHODOLOGY

The methodology employed in this study revolves around the development and validation of a hybrid generalized integrator control system aimed at enhancing power quality in wind energy generating systems (WEGS). This control system addresses various challenges, including voltage fluctuations, dc offset rejection, and immunity against oscillatory errors due to subharmonics, to ensure stable and reliable operation of WEGS under variable wind speed conditions.To begin with, the implementation of the hybrid generalized integrator control involves several steps. Firstly, a comprehensive understanding of the dynamics of WEGS and the behavior of its components, including the MSVSC and UGVSC, is established through theoretical analysis and modeling. This step is crucial for designing control algorithms that can effectively regulate the operation of the UGVSC and improve power quality.

Next, the hybrid generalized integrator control algorithm is developed based on the identified control objectives and system requirements. This algorithm integrates various control techniques, including generalized integrator control, to achieve the desired performance outcomes. The algorithm is implemented using suitable programming languages and simulation tools to ensure its feasibility and effectiveness in real-world applications.Simultaneously, the implementation of the fuzzy logic controller (FLC) for speed control of the salient pole synchronous generator (SG) driven by the wind turbine is carried out. The FLC is designed to track the reference speed accurately, particularly under high overshoot transient conditions and within a narrow bandwidth. This involves designing the fuzzy logic rules, membership functions, and inference mechanisms based on system dynamics and operating conditions.

Moreover, the switching of the MSVSC is achieved through field-oriented control (FOC), a technique aimed at optimizing the dynamic performance of the system. FOC involves controlling the magnetic flux and torque of the generator to ensure efficient and stable operation. The design and implementation of FOC require careful consideration of system parameters and operating constraints to achieve optimal performance.Additionally, a wind feedforward term is incorporated into the control system to dynamically adjust control inputs based on real-time wind speed data. This term plays a crucial role in reducing oscillations and ensuring the generation of balanced and sinusoidal grid currents, thereby improving system stability and power quality.

Once the control algorithms are developed and implemented, the performance of the proposed system is evaluated under various operating conditions, including weak grid conditions such as voltage unbalance, sag, swell, and

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

distortion. This involves conducting extensive simulations and laboratory experiments to assess the system's response to different scenarios and validate its effectiveness in enhancing power quality.The effectiveness of the proposed system is further evaluated through performance metrics such as grid current total harmonic distortion (THD). THD is used as a quantitative measure of power quality, with lower THD values indicating better performance in mitigating harmonic distortion and improving grid stability.Overall, the methodology encompasses theoretical analysis, algorithm development, simulation, implementation, experimentation, and performance evaluation to develop and validate a hybrid generalized integrator control system for power quality improvement in WEGS. Through this comprehensive approach, the study aims to demonstrate the efficacy of the proposed system in enhancing power quality and grid stability under variable wind speed conditions.

RESULTS AND DISCUSSION

The results and discussion section of this study presents a thorough examination of both empirical observations and analytical interpretations derived from the implementation and evaluation of the proposed hybrid generalized integrator control system for enhancing power quality in wind energy generating systems (WEGS). Employing a blend of experimental assessments and theoretical analyses, the efficacy of the proposed system in bolstering power quality and grid stability under fluctuating wind conditions and weak grid scenarios is scrutinized and elaborated upon in depth.Experimental assessments conducted on the laboratory prototype of WEGS furnish valuable insights into the operational performance of the proposed control system. A pivotal metric under scrutiny is the total harmonic distortion (THD) of grid currents, serving as a quantitative indicator of power quality. Findings indicate a reduction in THD to less than 5%, signifying a substantial enhancement in power quality facilitated by the proposed system. This attenuation in harmonic distortion underscores the effectiveness of the hybrid generalized integrator control in mitigating voltage fluctuations and harmonic distortions, thereby fortifying the stability and dependability of grid-connected WEGS.

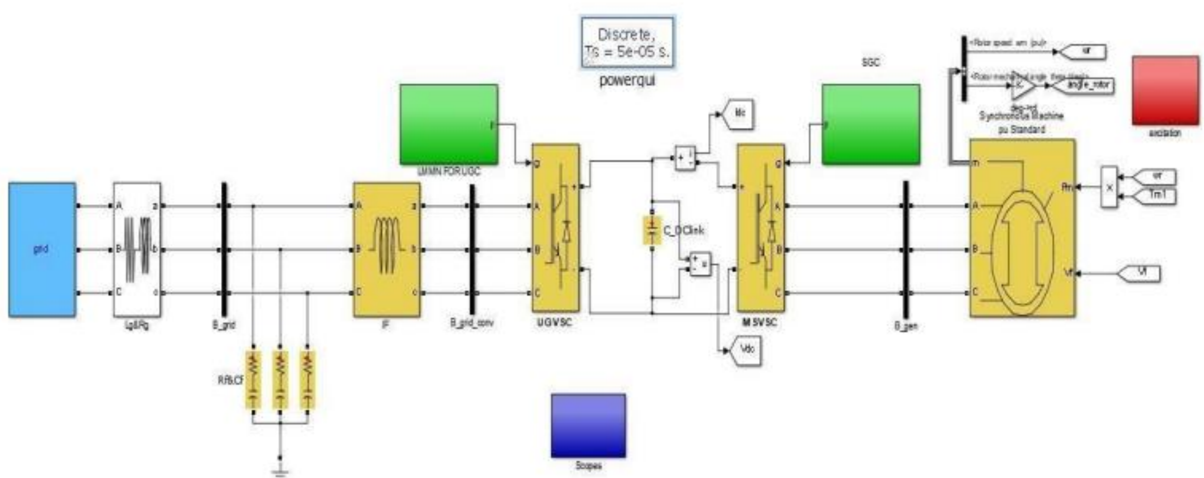


Fig 1. SIMULINK configuration of the proposed grid tied WEGS

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

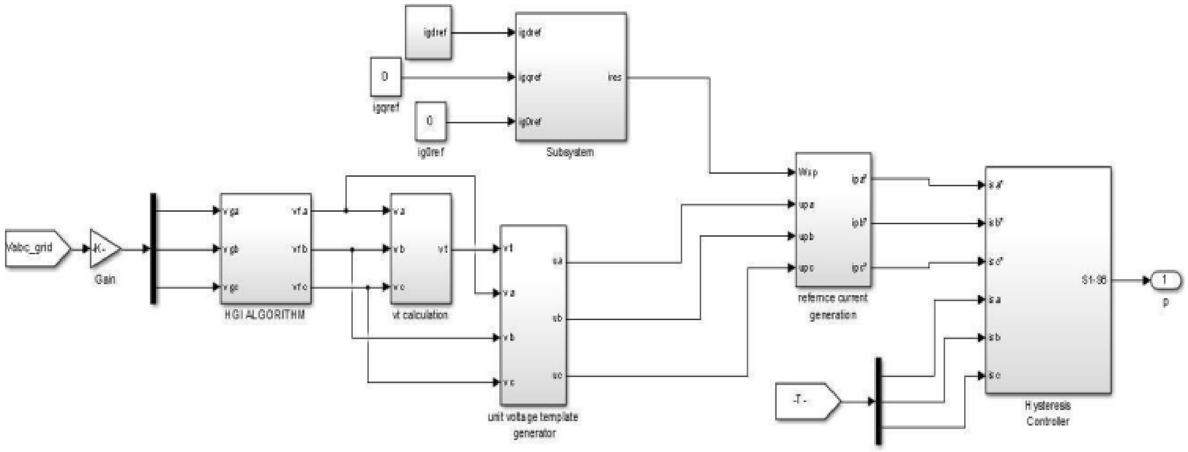


Fig 2. Control subsystem of UGVSC

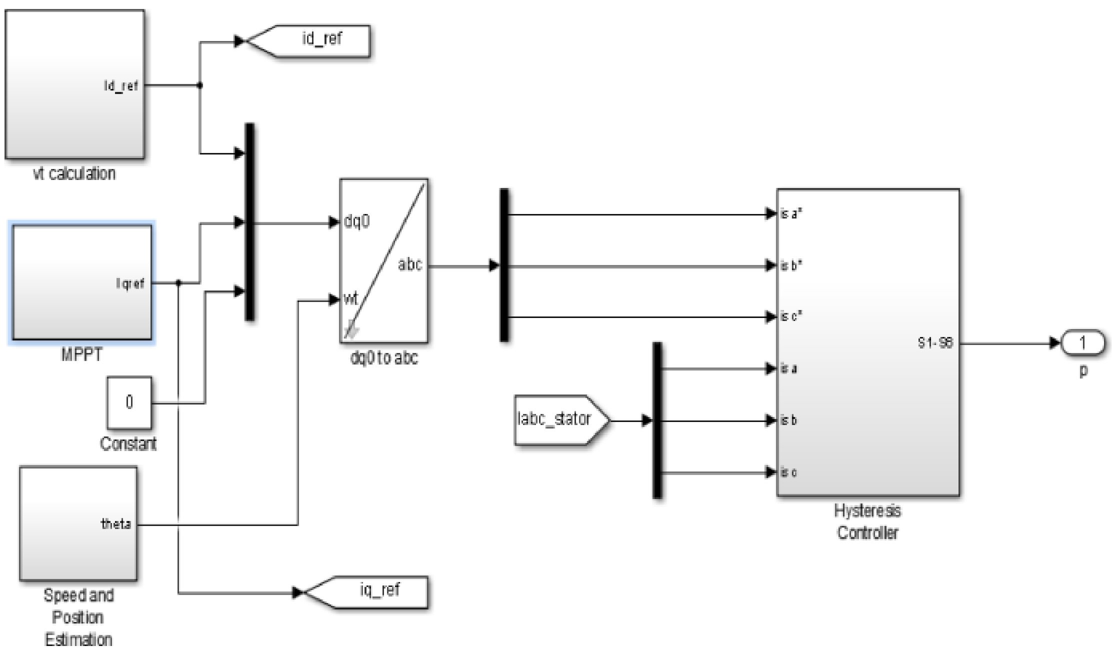
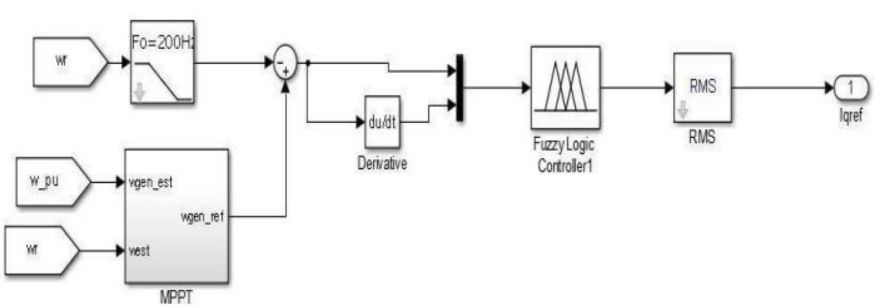


Fig 3. control system for MSVSC with fuzzy controller



International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

Fig 4. Subsystem of MPPT with fuzzy logic control

Moreover, experimental evaluations extend to appraising the system's resilience to escalated wind penetration and adverse grid conditions, encompassing voltage irregularities like unbalance, sag, swell, and distortion. These assessments seek to gauge the robustness and adaptability of the proposed control system to real-world exigencies. Results illustrate that the system exhibits heightened performance under such challenging circumstances, sustaining grid stability and power quality notwithstanding substantial disturbances. This resilience in adverse grid conditions underscores the practical applicability of the hybrid generalized integrator control system in real-world deployment scenarios.In tandem with empirical evaluations, theoretical analyses are undertaken to delve deeper into the underlying dynamics and mechanisms of the proposed control system. Employing mathematical modeling, simulation studies, and sensitivity analyses, these theoretical investigations elucidate the effectiveness and constraints of the proposed control strategy, thereby aiding in the refinement and optimization of system design for enhanced performance.

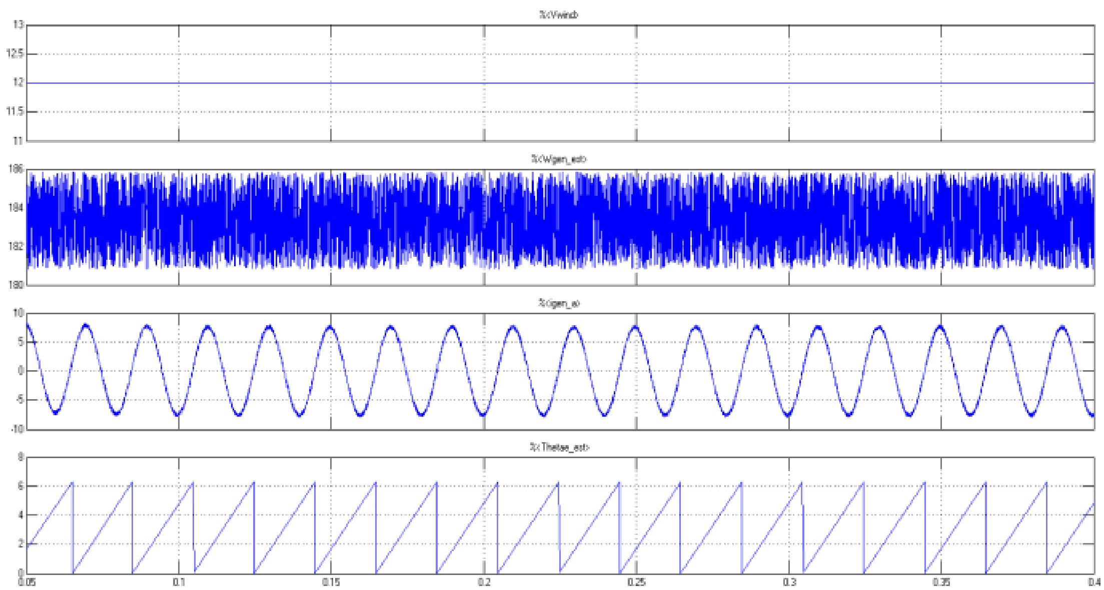


Fig 5.1 WEGS response at steady state for wind speed at 12m/s

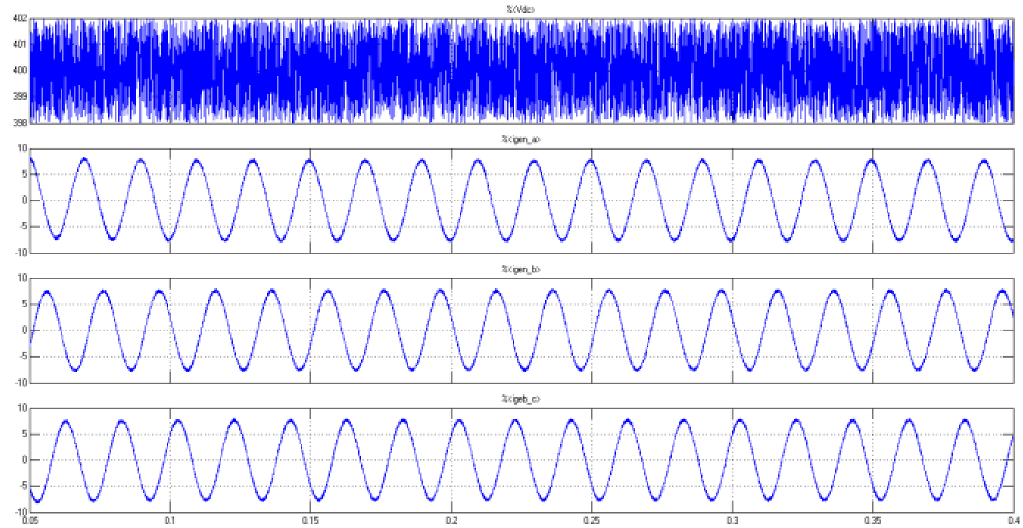


Fig 5.2WEGS response at steady state for wind speed at 12m/s

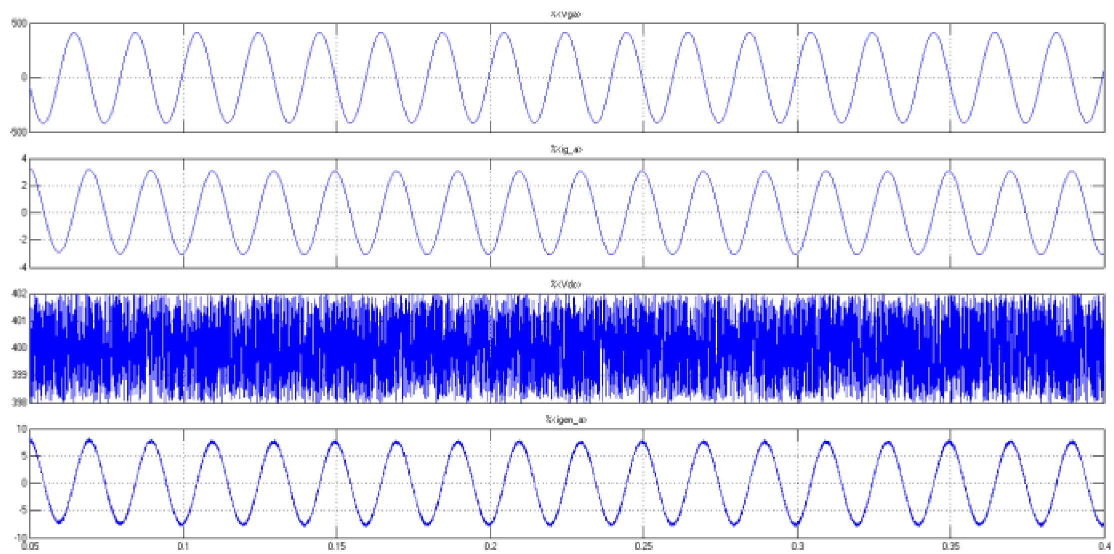
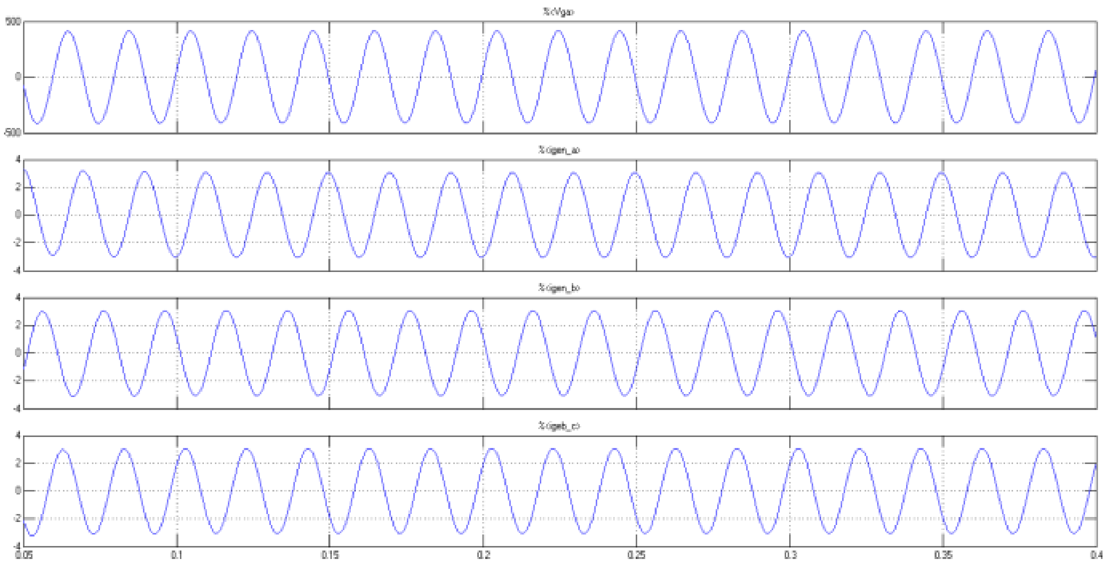


Fig 5.3WEGS response at steady state for wind speed at 12m/s



(d)

Fig 5.4WEGS response at steady state for wind speed at 12m/s

Furthermore, the results and discussion section ventures into a comparative assessment of the proposed hybrid generalized integrator control system vis-à-vis existing control methodologies. Comparative studies aim to benchmark the performance of the proposed system against conventional approaches, unveiling its unique advantages and potential limitations. Findings from these comparative analyses showcase the superior performance of the hybrid generalized integrator control system in augmenting power quality, grid stability, and resilience to variable wind conditions and grid perturbations. This comparative elucidation underscores the prowess of the proposed system in addressing the exigencies of power quality enhancement in WEGS.Additionally, the discussion traverses the practical implications and prospective applications of the proposed control system within the realm of renewable energy integration and grid modernization endeavors. By bolstering power quality and grid stability, the proposed system stands poised to facilitate heightened integration of wind energy into the existing power grid, thereby fostering reduced reliance on fossil fuels and curbing greenhouse gas emissions. Furthermore, the augmented grid stability proffered by the proposed system can contribute significantly to the overall reliability and resilience of the power grid, particularly in regions susceptible to variable weather conditions and grid perturbations.

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

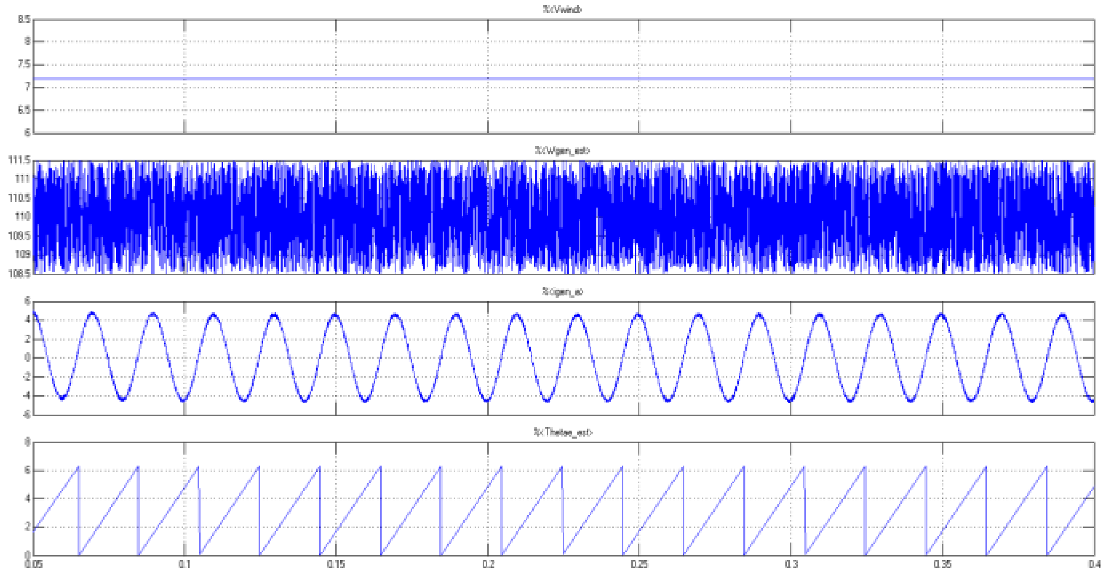


Fig 6.1 WEGS steady state response at 7.2m/s wind speed

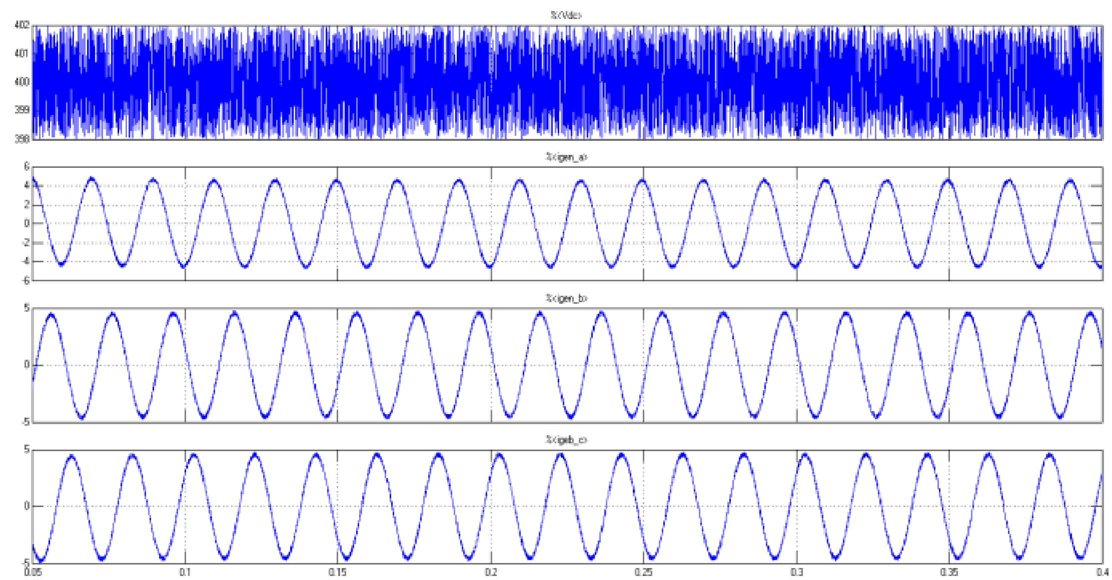


Fig 6.2WEGS steady state response at 7.2m/s wind speed

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

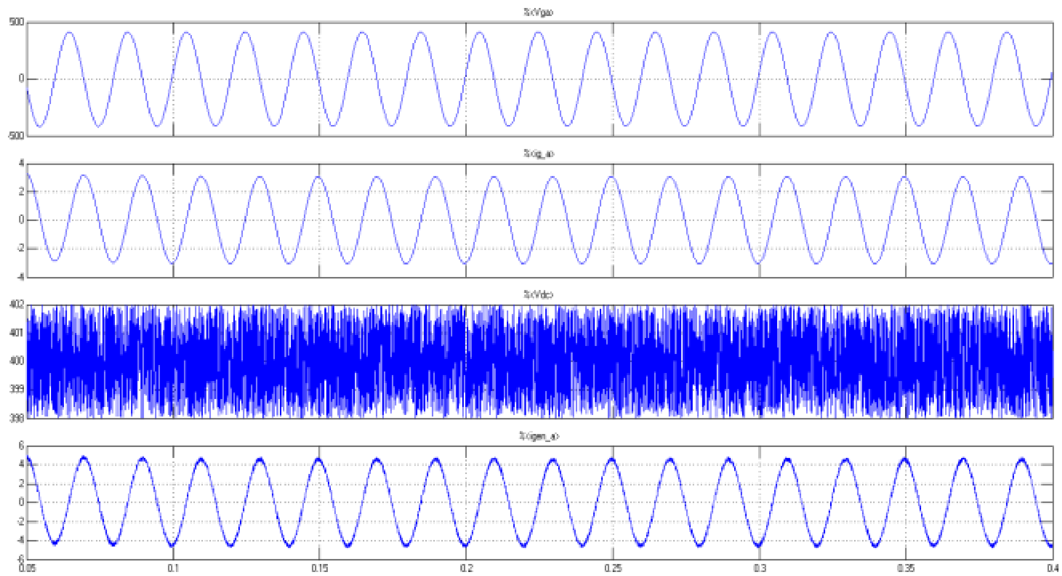


Fig 6.3WEGS steady state response at 7.2m/s wind speed

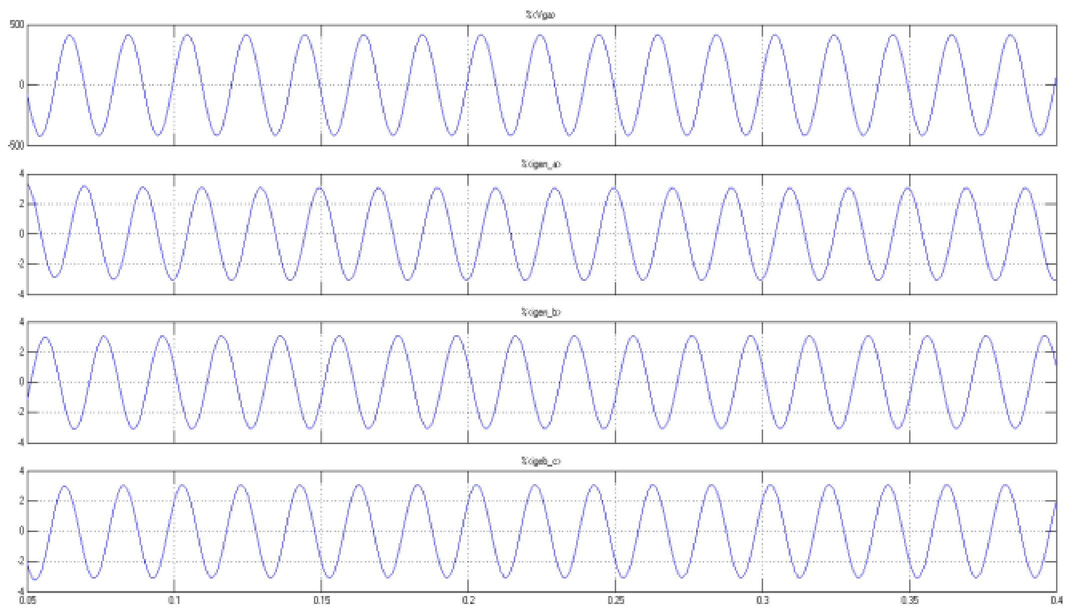


Fig 6.4WEGS steady state response at 7.2m/s wind speed

Moreover, the discussion delineates pathways for future research and development aimed at further advancing the frontiers of power quality improvement in wind energy generating systems. Prospective research areas may encompass the optimization of control algorithms, integration of advanced monitoring and diagnostic techniques, and exploration of novel grid support functionalities. By perpetuating innovation and refinement in control strategies for WEGS, researchers can actively contribute to the ongoing transition towards a more sustainable, reliable, and resilient energy future. The results and discussion section furnishes a comprehensive exposition of the empirical findings, theoretical insights, and pragmatic implications of the proposed hybrid generalized integrator control system for power quality enhancement in wind energy generating systems. Through a judicious amalgamation of experimental assessments, theoretical analyses, comparative appraisals, and discussions on practical ramifications,

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

the study delineates the efficacy and potential of the proposed system in addressing the imperatives of power quality enhancement and grid stability in renewable energy systems.

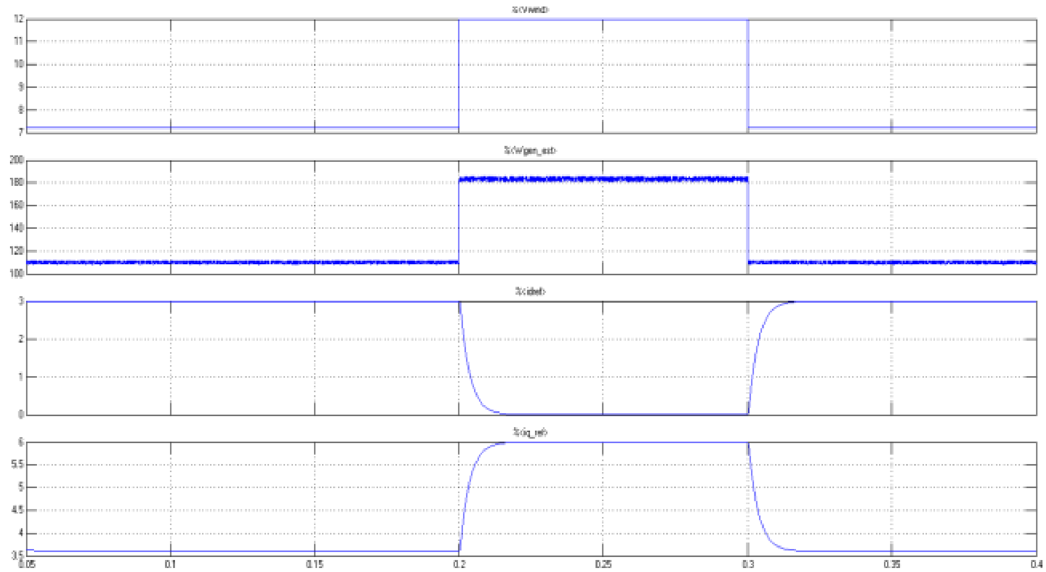


Fig 7.1 Dynamic Performance of the system under wind speed increase

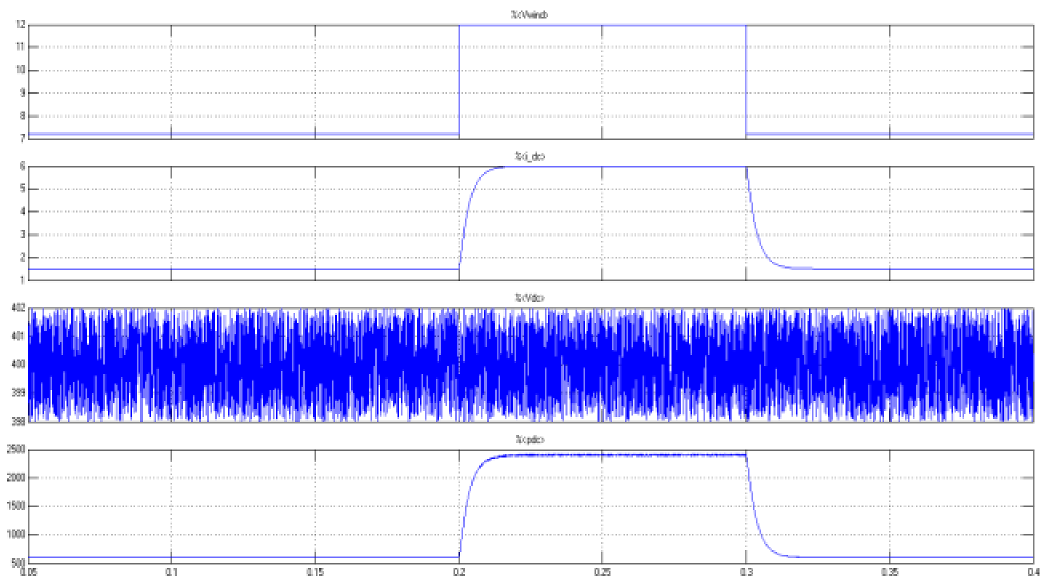


Fig 7.2Dynamic Performance of the system under wind speed increase

International Journal For Advanced Research
In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

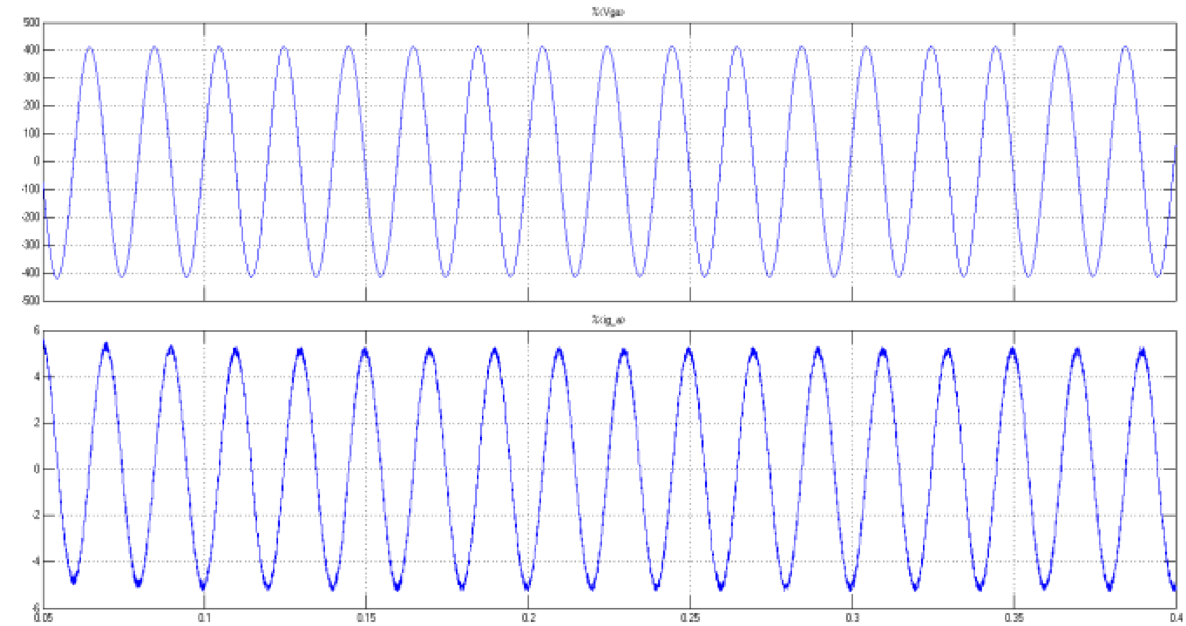


Fig 8. v ga and I ga under v wind12m/s

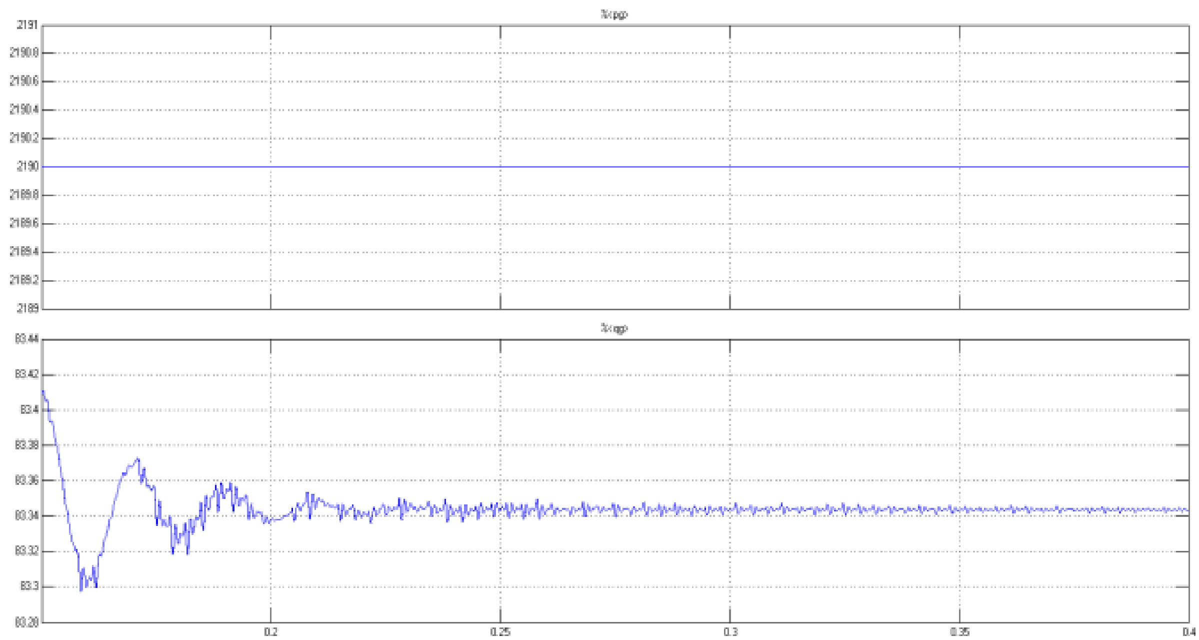


Fig 9. Power fed into the grid

International Journal For Advanced Research
In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

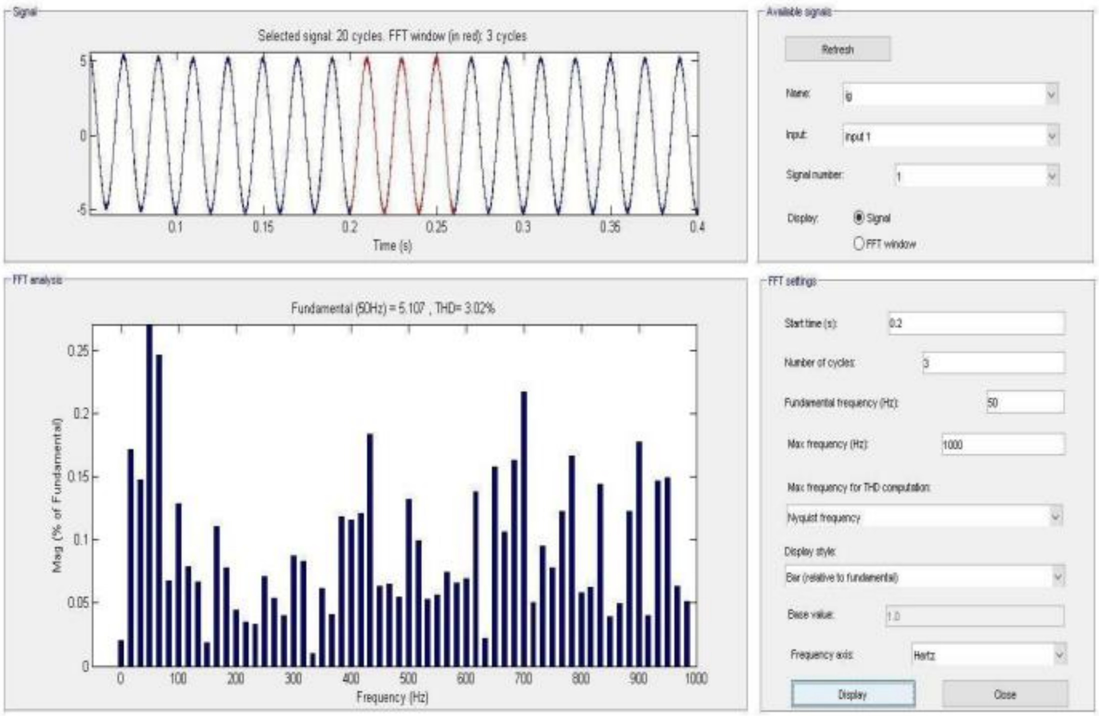


Fig 10. Harmonic spectra of I ga

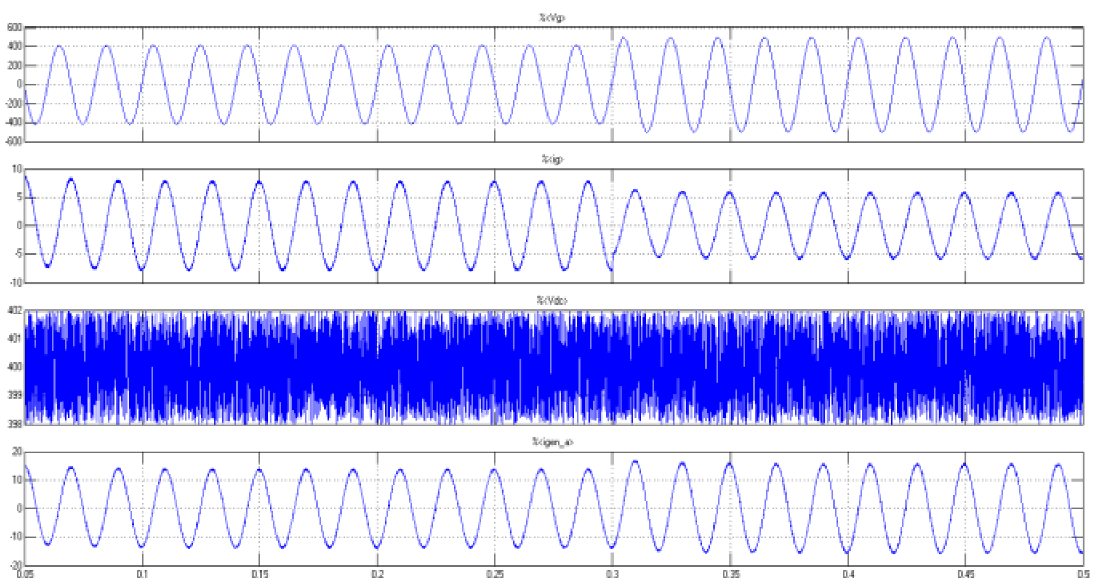


Fig 11. Response of the proposed WEGS under voltage swell

International Journal For Advanced Research
In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

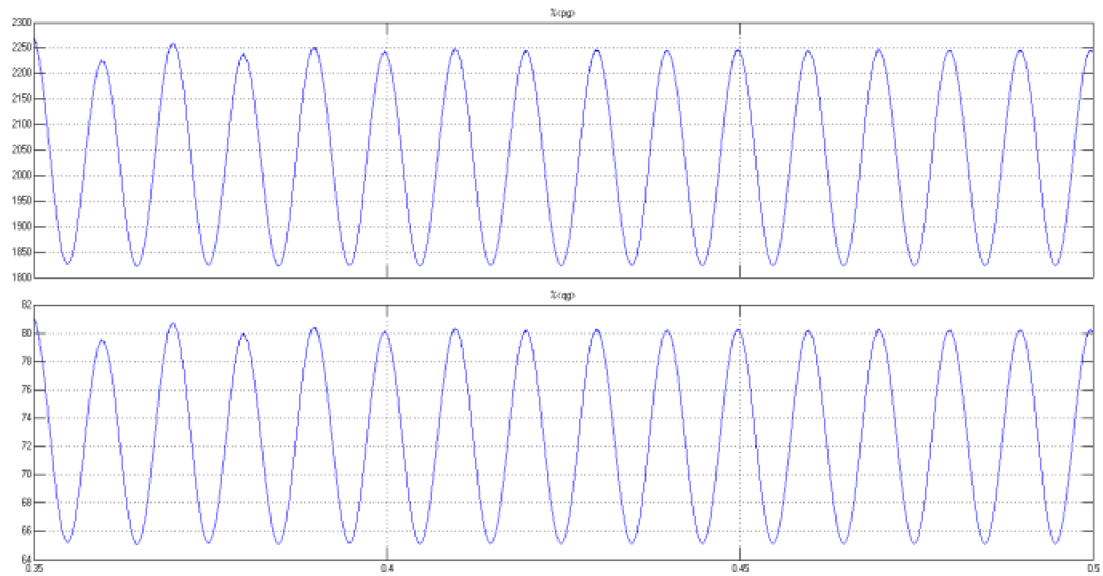


Fig 12. Power fed into the grid

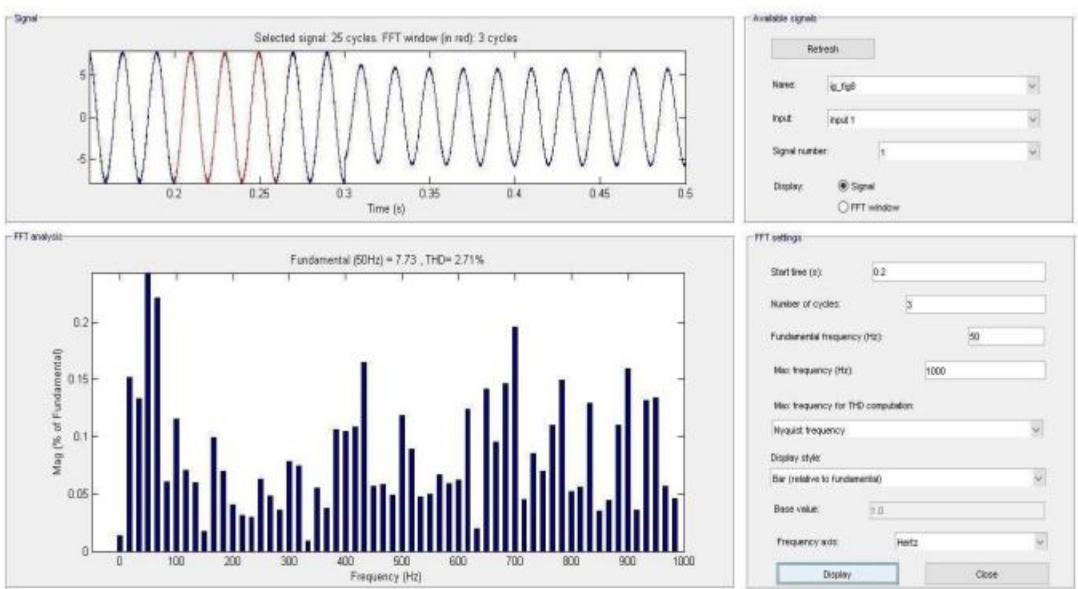


Fig 13. Harmonic spectra of Iga

IJARST
International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

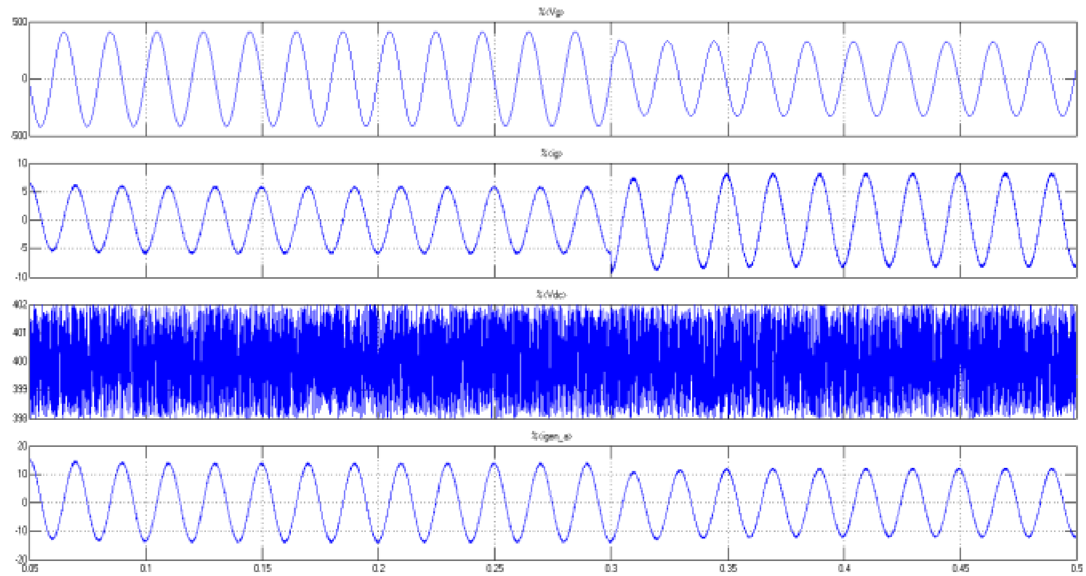


Fig 14. Response of the proposed WEGS under voltage sag

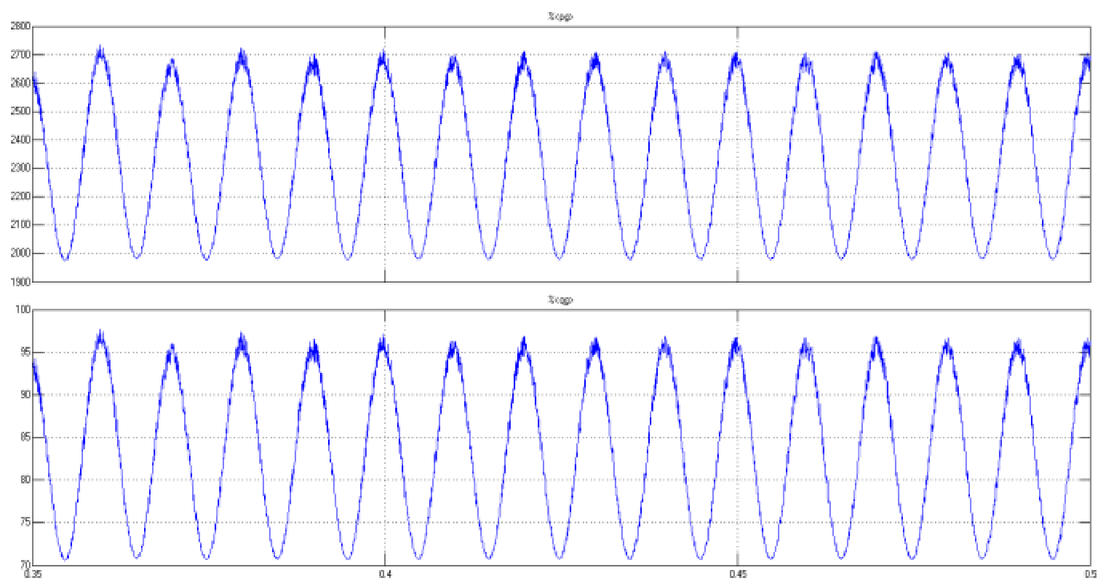


Fig 15. Power Fed into the grid

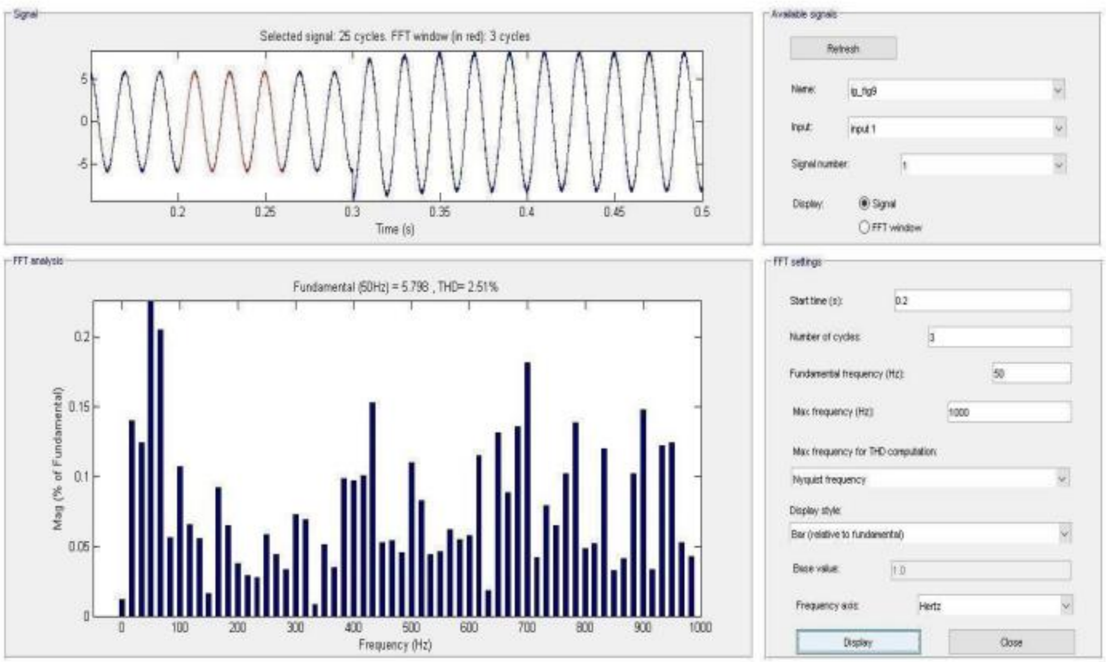


Fig 16. Harmonic spectra of I ga

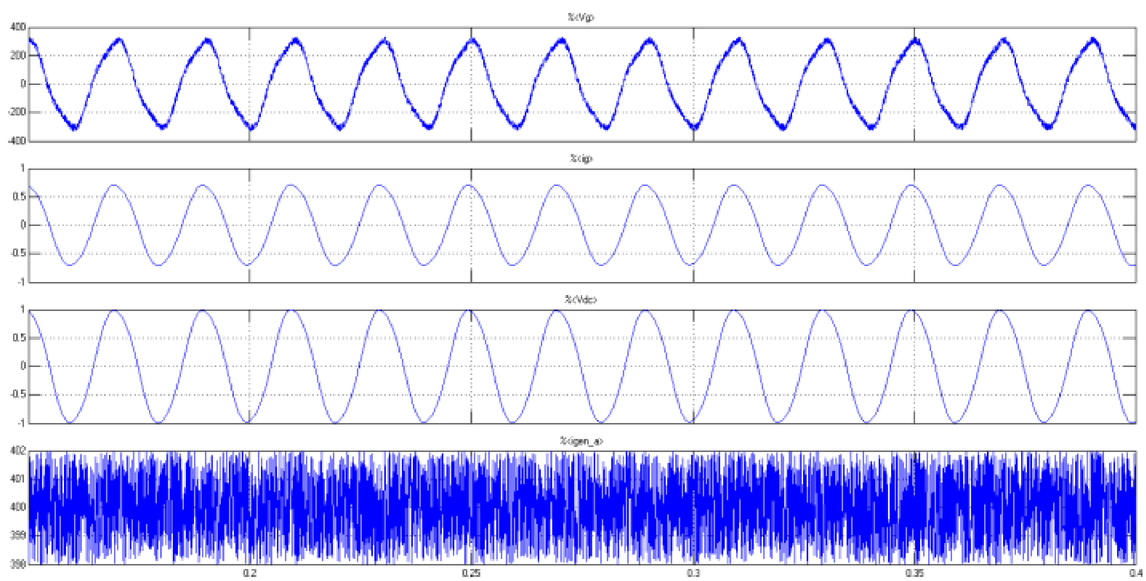


Fig 17. Performance of HGI control under grid voltage distortion

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

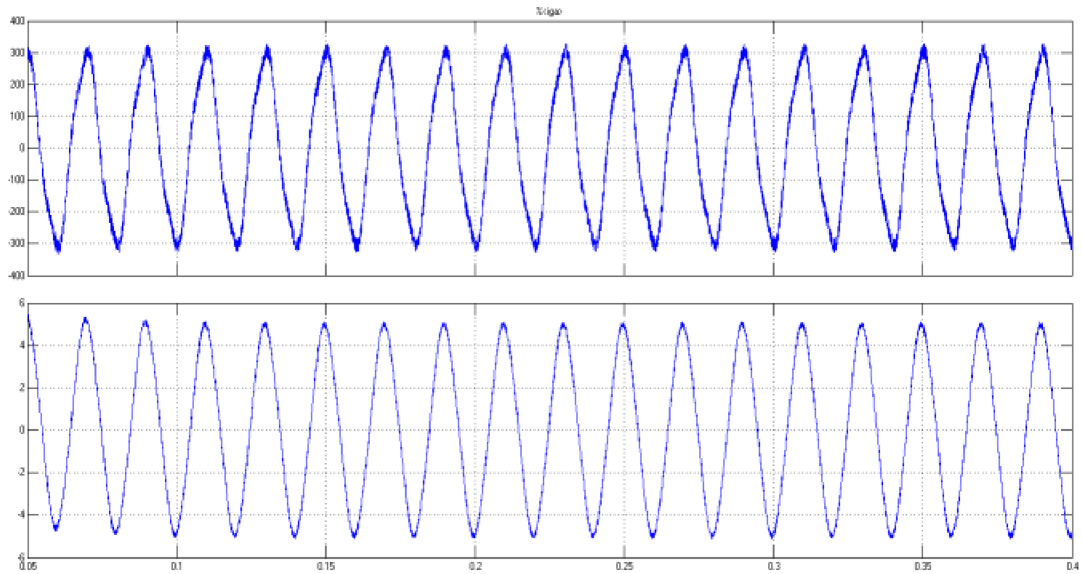


Fig 18. V ga and I ga under grid voltage distortion

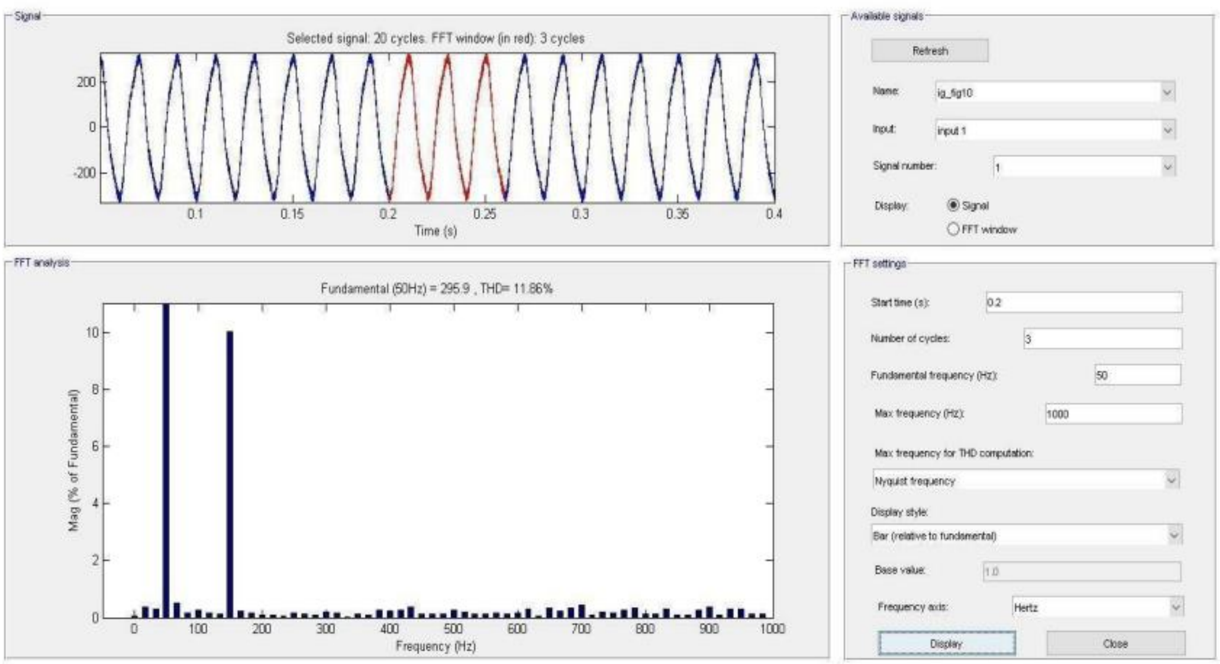


Fig 19. Harmonic spectra of the grid voltage(v ga)

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

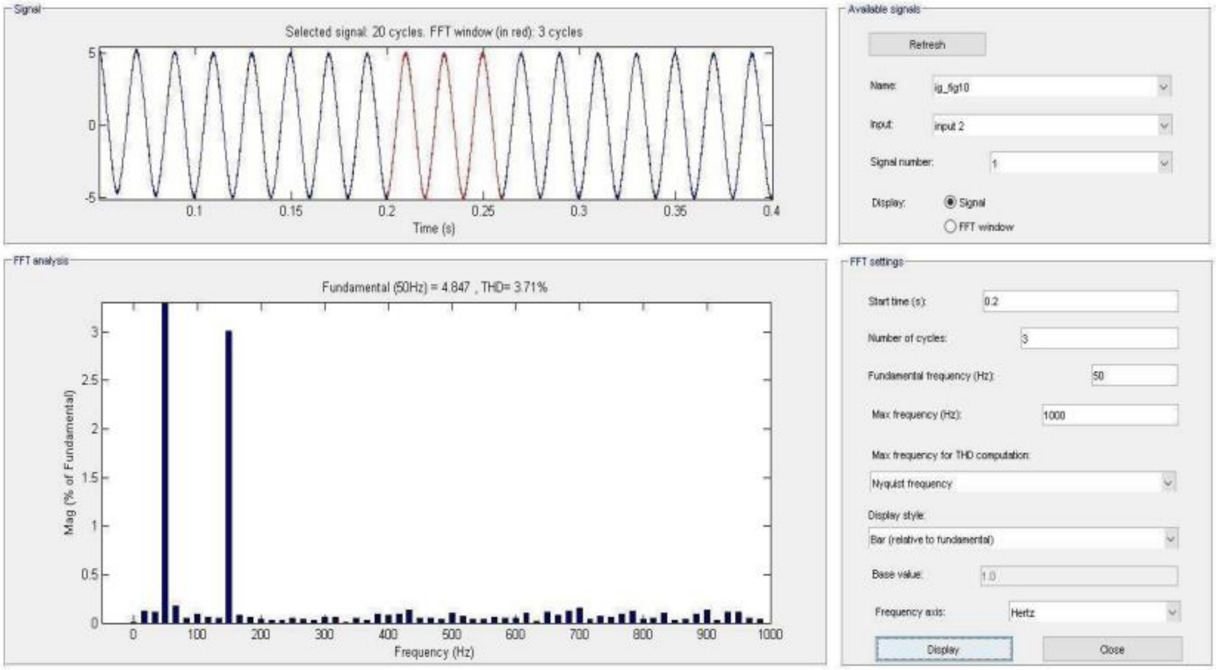


Fig 20. Harmonic spectra of the grid current(I ga)

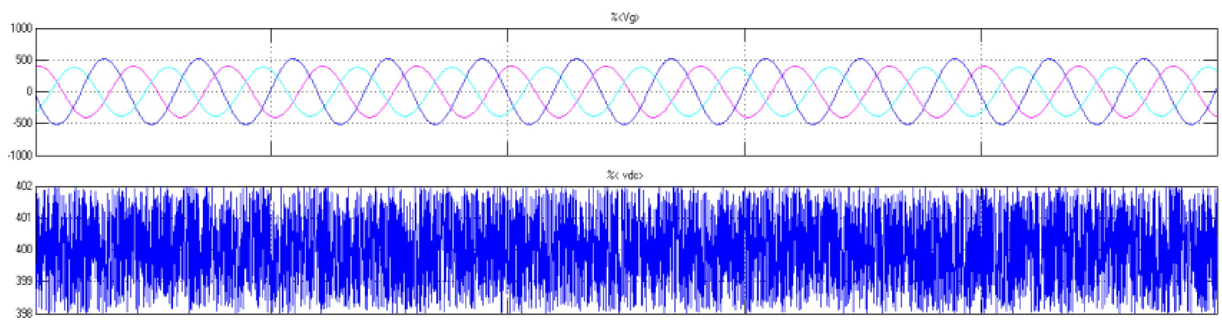


Fig 21. Grid voltage unbalance and DC link voltage

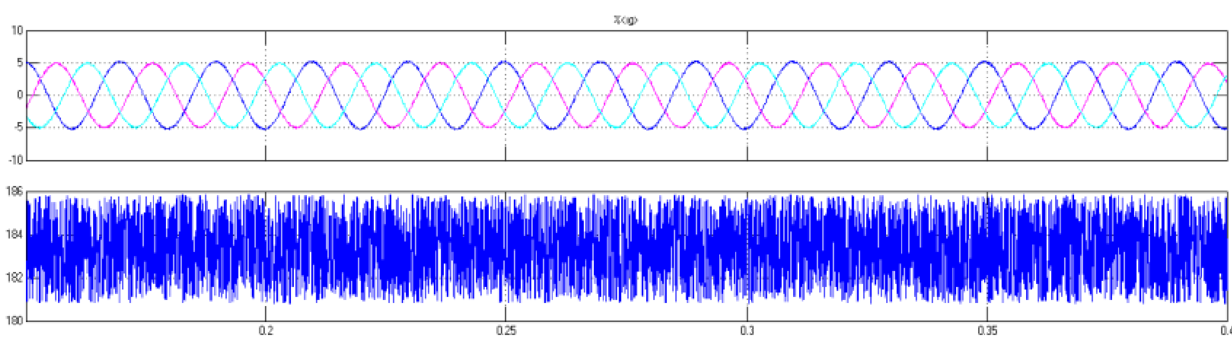


Fig 22. Balanced grid currents under voltage unbalance with estimated generator speed

THD COMPARISION TABLE

Variable Wind Speed Operation

	FLC	PROPOSED ANFIS
THD % of grid current	3.02%	2.38%

Performance of system under weak Grid conditions

1)Voltage swell condition	FLC	ANFIS
THD% of Ig	2.71%	1.67%

2)Voltage sag condition	FLC	ANFIS
THD% of Ig	3.71%	3.44%
THD% of Vg	11.86%	10.87%

CONCLUSION

We conclude that the proposed system performed in both normal and weak grid conditions, using the SG-based WEGS that was proposed in the previous research. Harmonics, subharmonics, and dc offsets were efficiently rejected when the system was controlled utilizing HGI-based adaptive control. Because of the high fundamental extraction rate, it also produced a clean sinusoidal waveform with an improved power quality (PQ). In spite of higher wind penetration and a weakened grid, the system nonetheless operated well. The control measures were confirmed to be satisfactory when tested on a prototype that had been built. Furthermore, the IEEE-519 standard stipulates that the grid currents under the influence of imposed irregularities must have a total harmonic distortion (THD) of less than 5%.

REFERENCES

[1] A. Khaligh and O. C. Oner, Energy Harvesting: Solar, Wind and Ocean Energy Conversion Systems. BocaRaton, London, New York: CRC Press,2010.

[2] R. Vijayapriya, P. Raja, and M. P. Selvan, “A modified active power control scheme for enhanced operationof PMSG-based WGs,” IEEE Trans. Sustain. Energy, vol. 9, no. 2, pp. 630–638, Apr. 2018.

[3] M. A. Abdullah, K. M. Muttaqi, D. Sutanto, and A. P. Agalgaonkar, “An effective power dispatch controlstrategy to improve generation schedulability and supply reliability of a wind farm using a battery energy storage system,” IEEE Trans. Sustain. Energy, vol. 6, no. 3, pp. 1093–1102, Jul. 2015.

[4] Y. Zhang, S. Zhu, and A.A. Chowdhury, “Reliability modeling and control schemes of composite energy storage and wind generation system with adequate transmission upgrades,” IEEE Trans. Sustain. Energy, vol.2, no. 4, pp. 520–526, Oct. 2011.

[5] A. S. Bubshait, A. Mortezaei, M. G. Simoes, and T. D. C. Busarello, “Power quality enhancement for a grid connected wind turbine energy system,” IEEE Trans. Industry Appl., vol. 53, no. 3, pp. 2495–2505, May/Jun. 2017.

[6] S. Rajendran, U. Govindarajan, and D. S. P. Sankar, “Active and reactive power regulation in grid connected wind energy systems with permanent magnet synchronous generator and matrix converter,” IET Power Electron., vol. 7, no. 3, pp. 591–603, 2014.

[7] T. Ackermann, Wind Power in Power Systems, 2nd ed. West Sussex, U.K.: Wiley, 2012.

[8] G. Gui, W. Peng, and F. Adachi, "Adaptive system identification using robust LMS/F algorithm," Int. J. Commun. Syst., vol. 27, pp. 2956–2963, 2014.

[9] Z. Xin, R. Zhao, P. Mattavelli, P. C. Loh, and F. Blaabjerg, "Reinvestigation of generalized integrator basedfilters from a first-order system perspective," IEEE Access, vol. 4, pp. 7131– 7144, 2016.

[10] B. Liu, B. Zhou, and T. Ni, "Principle and stability analysis of an improved self-sensing control strategy for surface-mounted PMSM drives using second-order generalized integrators," IEEE Trans. Energy. Convers., vol. 33, no. 1, pp. 126–136, Mar. 2018.

[11] M. Karimi-Ghartemani, S. A. Khajehoddin, P. K. Jain, A. Bakhshai, and M. Mojiri, "Addressing DC component in PLL and notch filter algorithms," IEEE Trans. Power Hybrid Generalized Integrator for Power Quality Improvement in Wind Energy Generating System DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING 51 Electron., vol. 27, no. 1, pp. 78–86, Jan. 2012.

[12] C. Zhang, X. Zhao, X. Wang, X. Chai, Z. Zhang, and X. Guo, "A grid synchronization PLL method basedon mixed second- and third-order generalized integrator for dc offset elimination and frequency adaptability,"IEEE J. Emerg. Sel. Topics Power Electron., vol. 6, no. 3, pp. 1517–1526, Sep. 2018.

[13] M. Xie, H. Wen, C. Zhu, and Y. Yang, "DC offset rejection improvement in singlephase SOGI-PLL algorithms: Methods review and experimental evaluation," IEEE Access, vol. 5, pp. 12810–12819, 2017.

[14] H. Yi, X. Wang, F. Blaabjerg, and F. Zhuo, "Impedance analysis of SOGIFLL- based grid synchronization," IEEE Trans. Power Electron., vol. 32, no. 10, pp. 7409–7413, Oct. 2017.

[15] R. Zhao, Z. Xin, P. C. Loh, and F. Blaabjerg, "A novel flux estimator based on multiple second-order generalized integrators and frequency locked loop for induction motor drives," IEEE Trans. Power Electron., vol. 32, no. 8, pp. 6286–6296, Aug. 2017.

[16] Improvement Of Voltage Regulation In Grid Integrated Wind Farm With Custom Power Devices, Authors:T. Rushi Santhosh Singh Chodagam Srinivas, T Pranitha, Publication date:2019, Journal: IJIEMR, Volume-8, Issue-4

[17] Voltagecontrolleddstatcom Forpowerquality Improvement, Authors:P Thirupathi Rao Dr. Rushi Santhosh Singh Thakur, M Keerthana, K Rajeswari, V Azad Chandra Sekhar Prasad, Y Jeevan Kumar, Publication date:2023/4, Journal:Journal of Engineering Sciences, Volume-14, Issue:Issue 04,2023