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Optimization Techniques for Fuzzy-PID Control of CSC-Based D-STATCOM for Power Quality Improvement

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ABSTRACT- This study focuses on enhancing power quality using a Current Source Converter (CSC) based Dynamic Voltage Restorer (D-STATCOM) controlled by a Fuzzy Logic-PID (Fuzzy-PID) controller. Power quality improvement is a vital aspect of maintaining reliable and efficient electrical power systems. The integration of fuzzy logic with traditional PID control enables adaptive and precise regulation of the D-STATCOM, addressing voltage sags, swells, and harmonic distortions effectively. The Fuzzy-PID controller dynamically adjusts the control parameters, offering superior performance in compensating for power quality disturbances compared to conventional methods. Simulation and experimental results demonstrate that the Fuzzy-PID controlled CSC-based D-STATCOM significantly improves voltage stability, reduces harmonic distortion, and enhances overall power quality. This approach is particularly effective in managing the nonlinear and time-varying nature of electrical loads, making it highly suitable for industrial power systems, renewable energy integration, and smart grid applications. The proposed system ensures robust and reliable power quality improvement, presenting a promising solution for modern electrical infrastructure challenges.

KEYWORDS- FLC-PID Controller, D-STATCOM, Power Quality.

I. INTRODUCTION

Modern electrical power systems depend heavily on power quality, which affects power delivery's dependability and efficiency. Several problems, such as equipment failure, higher energy losses, and decreased system efficiency, can be brought on by poor power quality [1]-[8]. A comparative study of PI and fuzzy logic controllers for D-STATCOM in improving power quality. It evaluates their effectiveness in mitigating voltage sags, swells, and harmonics, demonstrating the superior performance of fuzzy logic control in dynamic conditions [20]. An ANFIS (Adaptive Neuro-Fuzzy Inference System) controller-based PV-DSTATCOM for power quality improvement. It shows enhanced voltage regulation and harmonic reduction in distribution systems integrating photovoltaic sources [21]. This study addresses voltage sag and swell mitigation in distribution systems using D-STATCOM. It presents simulation results that validate the efficacy of D-STATCOM in maintaining voltage stability during transient conditions [22]. This critical analysis reviews various power quality improvement techniques in microgrids, including the use of D-STATCOMs. It discusses the advantages and limitations of different methods, emphasizing the importance of advanced control strategies [24]. The installation of Distribution Static Synchronous Compensators (D-STATCOMs) is one practical way to enhance power quality. In distribution networks, a D-STATCOM is a shunt-connected power electronic device that supports reactive power and regulates voltage, power factor, harmonic mitigation, and harmonic mitigation [9]. It functions by adding reactive electricity to or taking it from the grid, which stabilizes voltage levels and improves overall power quality. One kind of D-STATCOM that uses a current source inverter for reactive power compensation is the Current Source Converter (CSC)-based D-STATCOM. Since CSCs maintain a steady current in contrast to Voltage Source Converters (VSCs), they are especially useful in applications that call for strong current control and minimum harmonic distortion [10]. A fuzzy PID controller adaptively adjusts the PID parameters in real-time by fusing fuzzy logic with conventional PID control. By simulating human thought processes, the fuzzy logic system enables the controller to manage uncertainties and nonlinearities in the power system more skill fully. Comparing this to conventional PID controllers, improved dynamic performance and resilience are achieved. D-STATCOM is based on the CSC topology. The capacitor filter raises the cost of the converter but is utilized on the AC side of the D-STATCOM for enhancing the quality of the output current waveforms. It makes sense. The presence of AC side inductance can cause some harmonics in the output current to be amplified [10]. On the other hand, when D-STATCOM operates using the sinusoidal pulse modulation technique (SPWM) [11], the harmonic component's size is directly proportional to the output's fundamental component. Because the CSC-based D-STATCOM injects a tiny percentage of line current under typical working conditions, current harmonics are minimal. Therefore, when energy storage is utilized to reduce voltage sag in a CSC-based architecture, less energy storage is needed [10]. To address voltage sag, a common power quality concern arising from abrupt load changes in distribution systems, investigating and analyzing the performance of CSC-based D-STATCOM proves beneficial [11]. This system can effectively prevent the spread of voltage irregularities to nonlinear loads within the distribution network. Additionally, it facilitates consistent and adaptable management of power supply, compensates for reactive power, eliminates harmonics, and alleviates voltage fluctuations, including sag and swell occurrences [12]. The inverter circuit's output voltage magnitude in the CP device is directly proportional to the DC link voltage. Therefore, maintaining DC link voltage is crucial while constructing a custom power device based on CSC. Additionally, an attempt has been made to maintain the DC link voltage by utilizing FLC in the D-STATCOM control system.

II. D-STATCOM BASED ON CSC

CSC (Current Source Converter) based D-STATCOM is used for power quality improvement by providing dynamic reactive power support and voltage stabilization in distribution networks. It operates by injecting compensating currents to counteract voltage sags, swells, and harmonics. This technology enhances power factor correction, reduces total harmonic distortion, and improves overall voltage regulation. The robust control algorithms, such as fuzzy logic or PI controllers, are often integrated to enhance performance under varying load conditions. Research highlights its effectiveness in maintaining grid stability and reliability. It is a shunt-connected device that may remove distortion in source current, load current, and supply voltage by injecting an unbalanced current. D-STATCOM was employed in PWM switching control is employed in custom power applications instead of the basic frequency switching method used in FACTS applications since it operates at a low power level. The fundamental setup of a CSC-based D-STATCOM can be changed by a VSC-based one [12]. As seen in figure 1, it is composed of a circuit interfaced with a DC link reactor and coupling transformer. Also as shown in proposed fundamental setup figure 2, is composed of an internal control system, an AC side low pass filter, a coupling transformer, and a three phase CSC powered by SPWM. The application voltage and power rating determine which switching device and modulation strategy to use for setup [13]. For the suggested model, a distribution level convertor topology consisting of a CSC, GTO switch with enough reverse voltage and standing capability is used. These bridge-configured switches, which receive their power from a DC link reactor, serve as a storage component. The following formula can be used to determine the reactive power that CSC will produce.

$$Q = \sqrt{3/2} * V * M * I_{dc} * \cos\theta \qquad (1)$$

Where, I_{dc} is the mean DC link current, V is the converter input's rms value, M is the modulation index, and θ is the phase shift [14]. Three phase LPF filters the CSC's output, consisting of three capacitors linked in a shunt configuration. These filters ensure that coupling transformers produce high-quality sinusoidal output voltage and current waveforms by isolating high-order harmonic components. To implement the recommended D-STATCOM, an external series reactor, Xtr, has been utilized on the low-voltage side of the coupling transformer to adjust the corner frequency of the input filter.

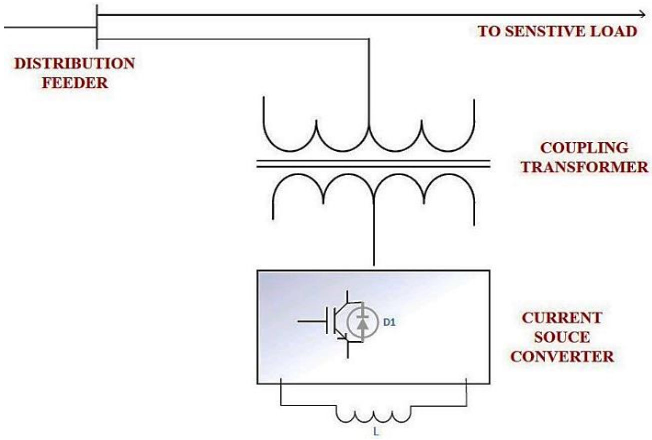

Figure 1: Schemetic Diagram of CSC based D-STATCOM

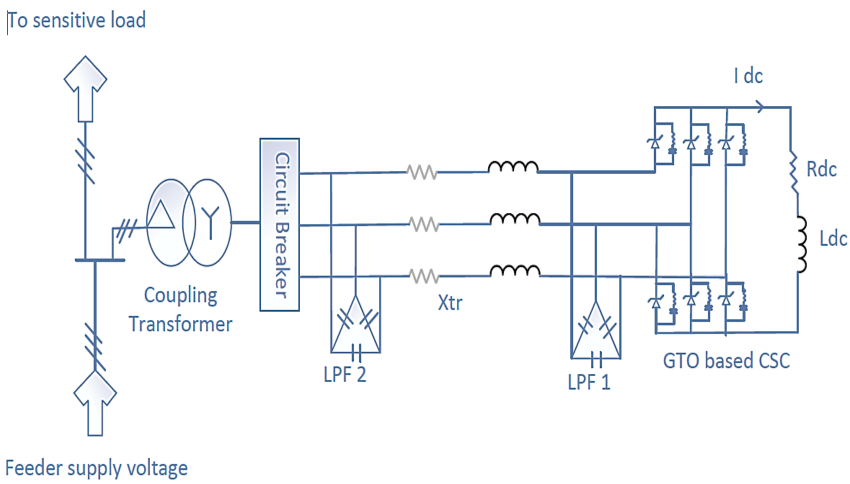

Figure 2: Current Source Converter based D-STATCOM setup

III. PROPOSED CONTROL APPROACH

Using park transformation relations, the load currents from the ILa, ILb, and ILc are changed to d-q-0 frame as follows:

$$I_d = 2/3\,[i_{La}\sin\theta + i_{Lb}\sin(\theta - 2\pi/3) + i_{Lc}\sin(\theta + 2\pi/3)] \qquad (2)$$

$$I_q = 2/3[i_{La}\cos\theta + i_{Lb}\cos(\theta - 2\pi/3) + i_{Lc}\cos(\theta + 2\pi/3)] \qquad (3)$$

$$I_0 = 1/3[i_{La} + i_{Lb} + i_{Lc}] \qquad (4)$$

The PCC voltage Vt is matched with these signals using the Phase Locked Loop (PLL). The D-Q component is sent through LPF in order to extract the DC component of ILd and ILq. The proportional integral Derivative (PID) receives the error between V_{dcref} and V_{dc} detected at the D-STATCOM output terminal. Its output is then taken as the current loss component and added to the DC component Id*. The second PID controller, which regulates the PCC voltage, receives the error between V_{tref} and V_t. Iq is increased by the output of this controller, Iq*.

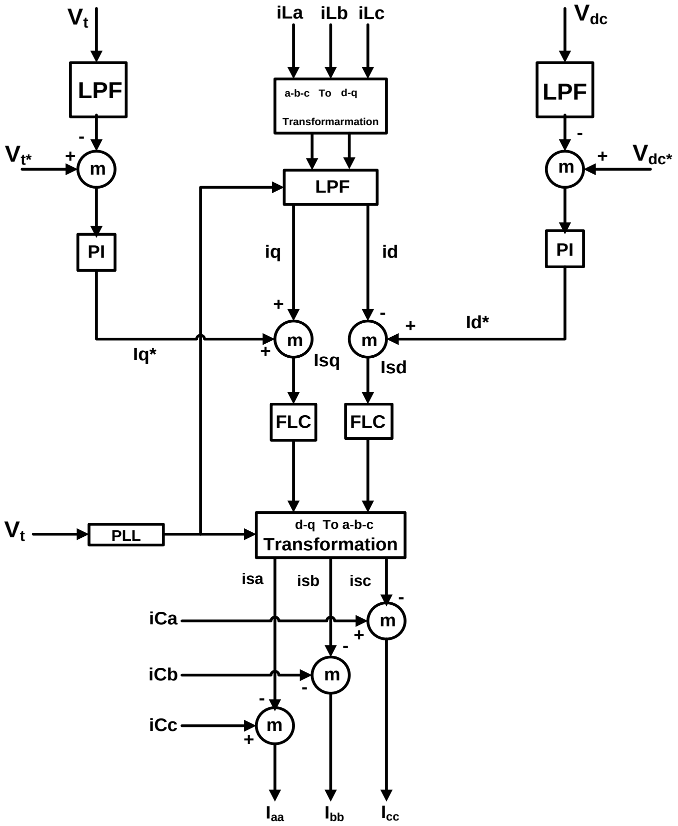

Figure 3: Block diagram of D-STATCOM control system

- ***FLC-PID Precis***

Power quality improvement is a critical aspect of modern electrical systems, and Dynamic Voltage Restorers (D-STATCOM) play a pivotal role in this domain. Integrating Fuzzy Logic-PID (Fuzzy-PID) controllers with D-STATCOM enhances its performance by leveraging the adaptive capabilities of fuzzy logic and the precision of PID control. Fuzzy-PID controllers adjust the D-STATCOM parameters dynamically, ensuring optimal compensation for voltage sags, swells, and harmonic distortions. Research indicates that Fuzzy-PID controlled D-STATCOM systems provide superior voltage regulation, reduced harmonic distortion, and improved overall power quality compared to conventional controllers [13]. This approach is particularly effective in handling the nonlinear and time-varying nature of electrical loads. Applications include industrial power systems, renewable energy integration, and smart grids. The synergy of fuzzy logic and PID control in D-STATCOM systems ensures robust and reliable power quality improvement, making it a promising solution for modern electrical infrastructure challenges [18].

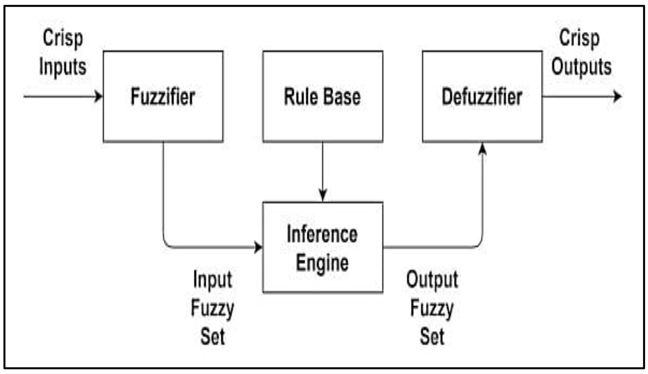

Figure 4: Fuzzy Logic controller

FLC is a very basic controller. There are three stages to it: input, processing, and output. Using the membership function and linguistic values for each rule, the input stage combines the rules. Each rule's output is produced and the results of the rules are combined during the processing stage. This combined result is finally converted into numerical values at the output stage. Triangular and trapezoidal membership functions are most frequently utilized in FLC controllers. However, the location of the fuzzy controller is more crucial than the function curves. Figure 4 depicts the basic structure of FLC. Two FLC blocks are used in the proposed fuzzy-PID controller for error signals d and q. Every controller has one output and two inputs. The derivative of the PID controllers' output and the abc to dq transformation are two inputs to FLCs, as seen in Figure 5. The d and q axis error, current, and derivative of these errors from the PID controller are the additional terms that FLCs accept as input. To eliminate inaccuracy from the FLC output, an integrator is employed [16].

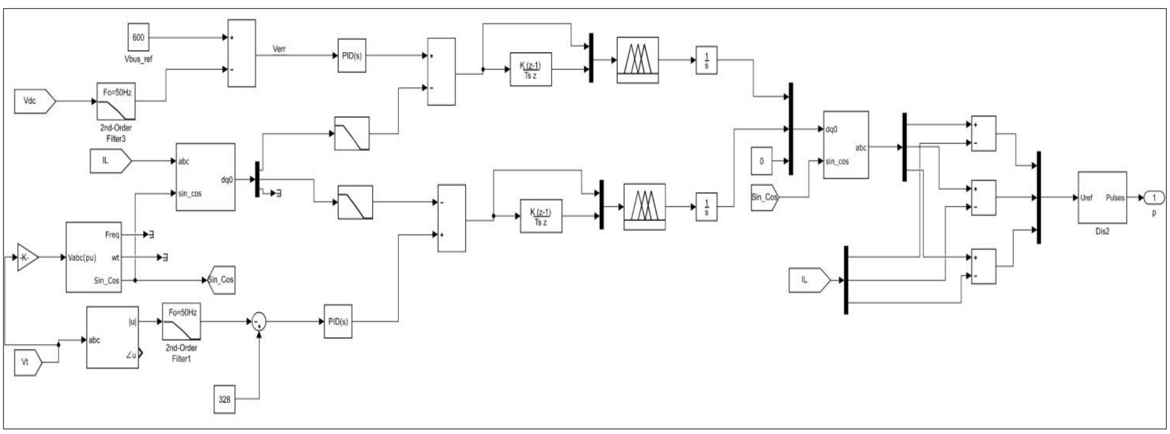

Figure 5: Simulink diagram of Fuzzy-PID Controller

Table 1: Rule Base for FLC

de(i)\ $e(i)$	NB	NS	Z	PS	PB
NB	NB	NB	NS	NS	Z
NS	NB	NB	NS	Z	Z
Z	NS	NS	Z	PS	PS
PS	Z	PS	PS	PB	PB
PB	Z	Z	PS	PB	PB

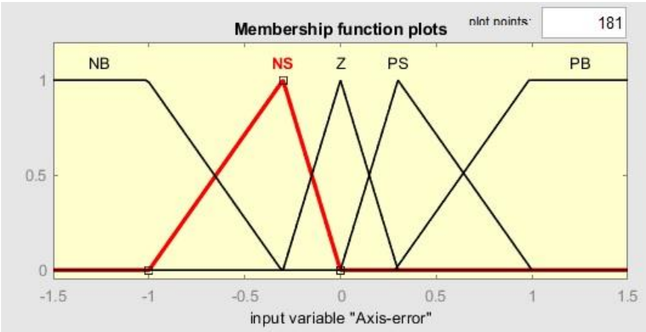

Figure 6: Axis error (I/P-1) Fuzzy PID Controller

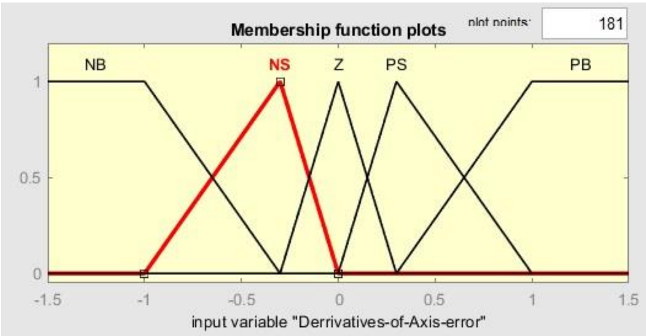

Figure 7: Derivatives of axis error (I/P-2) Fuzzy PID Controller

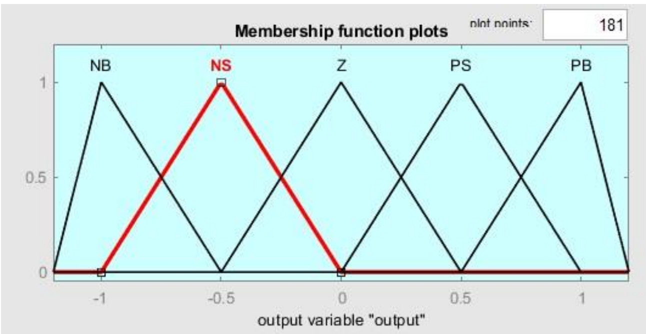

Figure 8: Output Fuzzy PID Controller

Five memberships are utilized in this paper as input and output variables, respectively, to represent negative large, negative small, zero, positive small, and positive big. Using the FIS editor in MATLAB, a fuzzy interface system with a triangle membership function is created. The 25 fuzzy rules that were used are displayed in Table 1. The link between input and output is provided by the fundamental fuzzy rules [17]. MATLAB 2018a is used to formulate fuzzy rules, and following their examination, the parameter for an input and output is shown in figure 6, 7 & 8 respectively. This method achieves the benefits of improved sag voltage and better-leveled DC output from the inverter by tuning the output coefficient of the PID controller to the appropriate level. Compared to PID controller, FLC controller enhances the inverter output voltage more effectively.

IV. SIMULATION RESULT AND DISCUSSION

By employing MATLAB-2018a software the propose system has been simulated. The simulation scenario of a proposed system is start with a three phase sources with a rating of 230 & 50 Hz. These three phase supply is fed to the non-linear load with a rating of (25.1ohm & 300e-3) & (0.05 & 25e-3) via the power transmission line. The CSC based D-STATCOM with an integration of low pass filter (LPF) is propagate in the system for the improvement of voltage profile & reduction of harmonics. The Simulink model of CSC based D-STATCOM for power quality improvement has been simulated under steady state & dynamic change in load condition with three framework as shown in figure 9.

Initial simulation framework is simulate under normal load condition without CSC based D-STATCOM & non-linear load with both the three phase circuit breaker are closed respectively. Figure 10 show the waveform of load voltage (V_L) & load current (I_L) under initial framework condition. From this waveform it is remark that there is no voltage sag taking place across the load.

The secondary framework of this model is simulated without a CSC-based D-STATCOM, but with a sudden change in load condition during the time interval from 0.4 to 0.6 seconds. During this transition period, from 0.4 to 0.6 seconds, the three-phase circuit breaker-2 closes and then opens. Figure 11 illustrates the waveforms of load voltage (V_L) & load current (I_L), showing that a voltage sag occurs during the switching interval from 0.4 to 0.6 seconds. Figure 12 depicts the waveforms of voltage (V_{PCC}) & current (I_{PCC}) at the point of common coupling under the same load change condition without the CSC-based D-STATCOM.

The final framework of this model is simulated with a CSC-based D-STATCOM under load changes during the 0.4 to 0.6-second interval. In this approach, both three-phase circuit breakers 1 and 2 are operated within this switching interval. Figure 13 shows the waveforms of load voltage (V_L) & load current (I_L), demonstrating that there is no voltage sag and the voltage profile is improved in the proposed system. Figure 14 presents the waveform of the DC link reactor voltage (V_{DC}) under a certain load change condition with a fuzzy-PID controller. It is observed that the magnitude of the DC link reactor voltage decreases from its initial value during the 0.4 to 0.6-second interval, indicating an improved voltage profile.

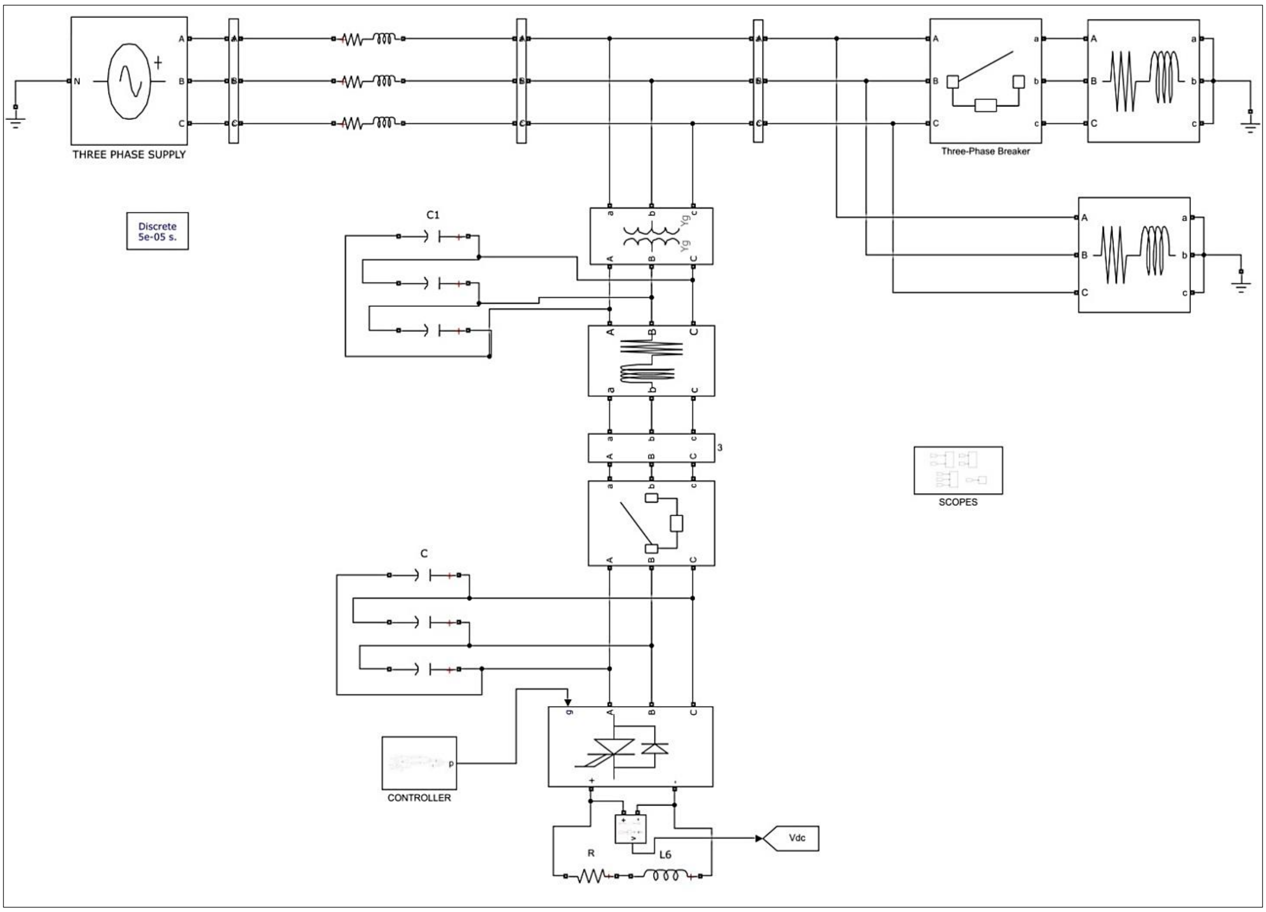

Figure 9: Simulink model of proposed Fuzzy-PID controlled CSC based D-STATCOM system

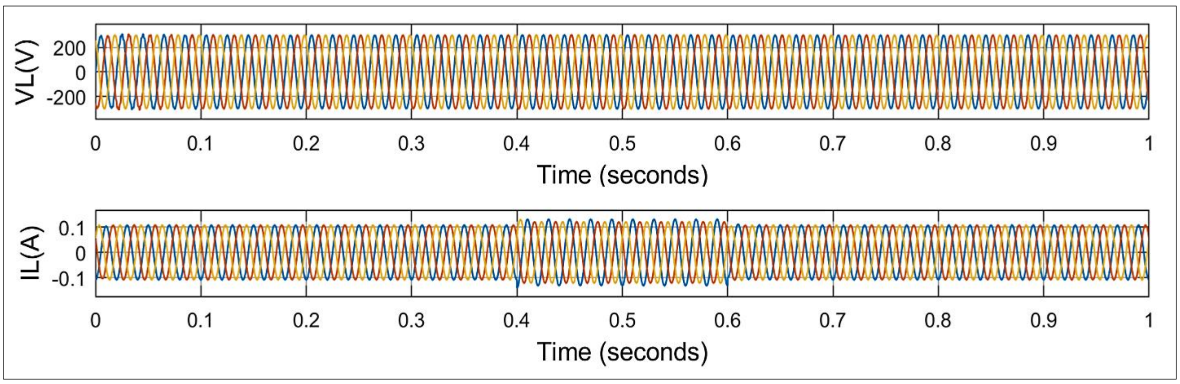

Figure 10: Waveforms of load voltage and load current under normal load conditions

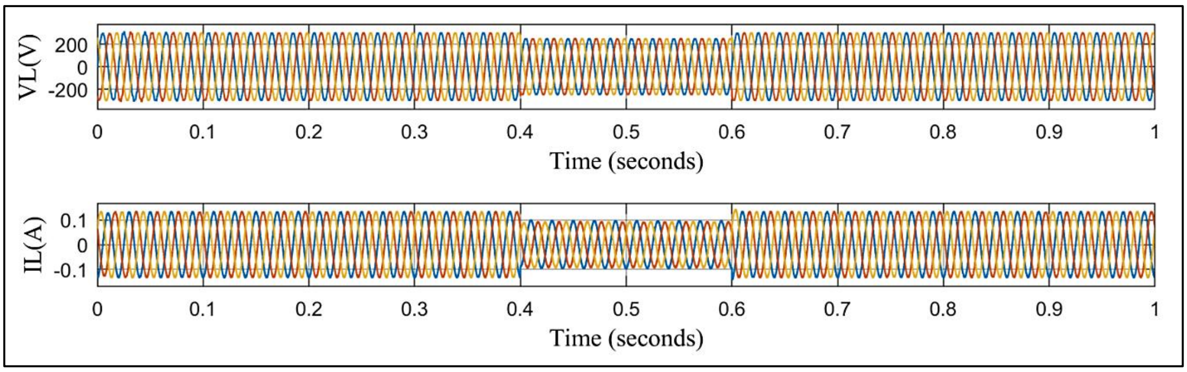

Figure 11: Waveforms of load voltage and load current without D-STATCOM under varying load conditions

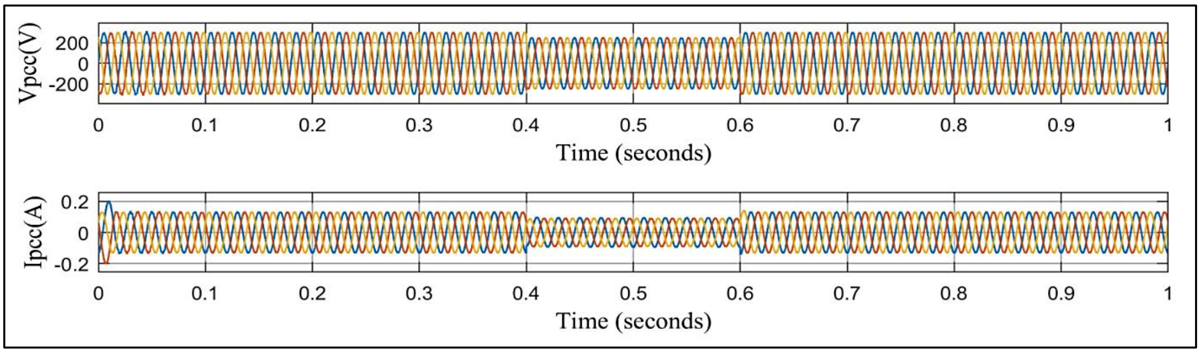

Figure 12: Waveforms of voltage and current at the point of common coupling without D-STATCOM under varying load conditions

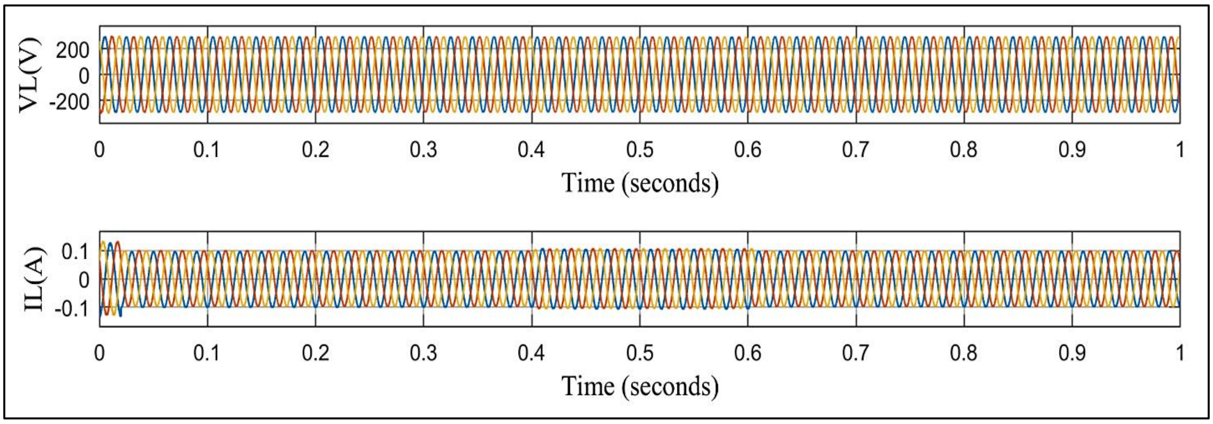

Figure 13: Waveforms of load voltage and load current with D-STATCOM under specific changes in load conditions.

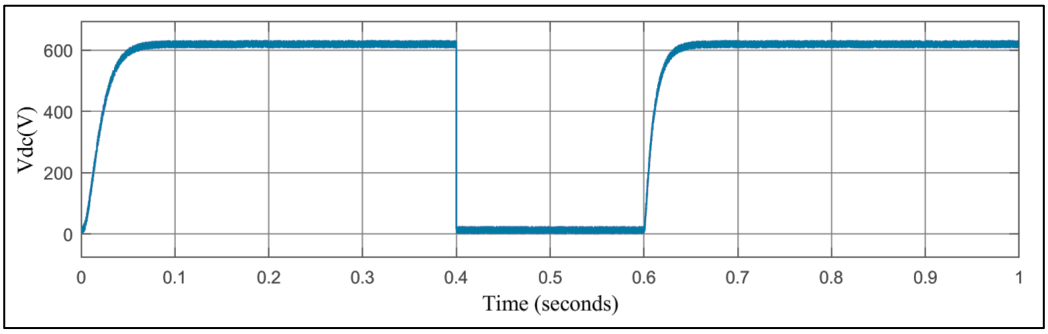

Figure 14: DC link reactor voltage regulated by a Fuzzy-PID controller

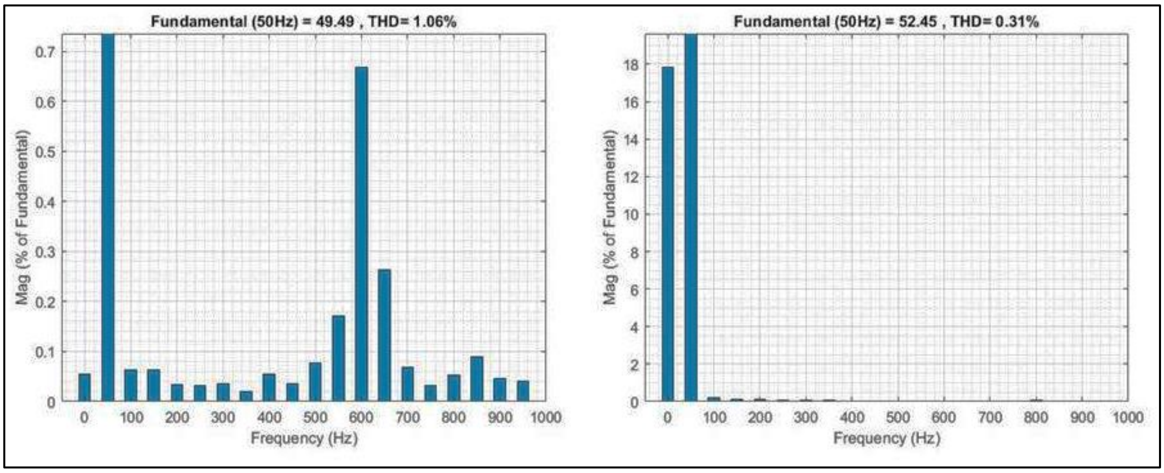

Figure 15: THD of Source Current

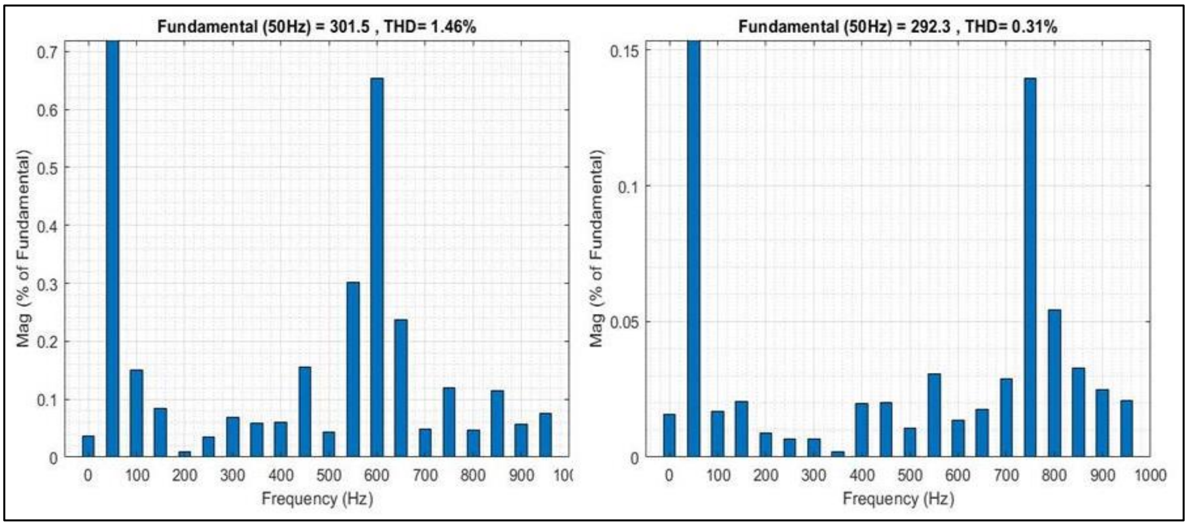

Figure 16: THD of load voltage (V_L)

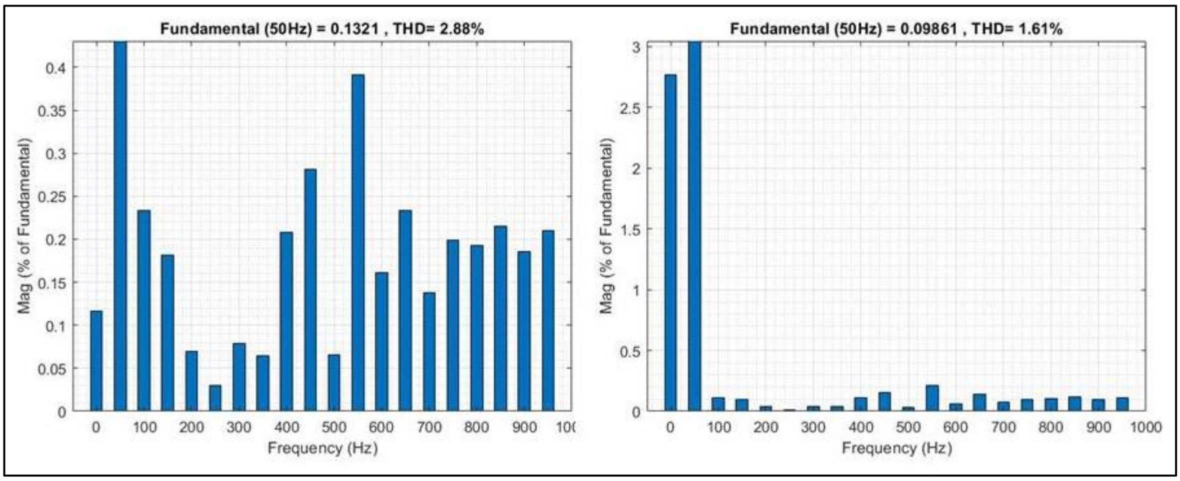

Figure 16: THD of load current (I_L)

V. HARMONICS EXAMINATION

Figure-15 shows the harmonics spectrum simulation result of Source current, Figure-16 shows the harmonics spectrum simulation result of load voltage (V_L) and Figure-17 shows the harmonic spectrum simulation result of load current (I_L). In the Figure-15, 16 & 17 there are 2 Figure implies, left hand side figure shows in case of without CSC based D-STATCOM and right hand side figure shows in case of with CSC based D-STATCOM. In this remark it is observe that the total harmonic distortion (THD) is low in case of with CSC based D-STATCOM as compare to case of without CSC based D-STATCOM. This examination shows the reduction of harmonics spectrum, which is improved the proposed system power quality.

VI. CONCLUSION

This paper introduces a proposed Fuzzy-PID controller for a CSC-based D-STATCOM, aimed at mitigating voltage sag, improving load voltage and current spectrum harmonics profile, and maintaining the DC-link voltage profile under varying load conditions in a distribution system. The implementation of the Fuzzy-PID controlled D-STATCOM demonstrates significant improvement in maintaining a stable voltage profile. The adaptive control mechanism allows for real-time adjustments, effectively mitigating voltage sags, and ensuring voltage levels remain within acceptable limits under various load conditions. The Fuzzy-PID controlled D-STATCOM shows rapid response to power quality disturbances. This swift adaptability ensures that the system can promptly correct issues, maintaining high-quality power delivery. Voltage sag is induced by switching a large non-linear load (RL) in the distribution system for a duration of 0.4 to 0.6 seconds, during which the load voltage experiences a dip. The CSC-based D-STATCOM effectively mitigates this voltage sag during sudden load changes. Both simulation and experimental results corroborate the effectiveness of the Fuzzy-PID controlled CSC-based D-STATCOM. The system consistently demonstrates superior performance in voltage regulation and harmonic reduction compared to conventional controllers. Overall, the study confirms that the Fuzzy-PID controlled CSC-based D-STATCOM is a highly effective solution for improving power quality, the DC-link voltage stabilizes after load variations, and thereby minimizing ripple exhibit into the distribution system by the CSC based D-STATCOM, offering significant improvements in voltage stability and harmonic mitigation.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] IEEE, "IEEE recommended practices and requirements for harmonics control in electric power systems," IEEE Std. 519, 1992.

[2] A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices. London: Kluwer Academic Publishers, 2002.

[3] E. Acha, V. G. Agelids, O. Anaya-Lara, and T. J. E. Miller, Power Electronic Control in Electric Systems, 1st ed., Oxford, UK: Newness Power Engineering Series, 2002.

[4] R. C. Dugan, M. F. McGranaghan, and H. W. Beaty, Electric Power Systems Quality, 2nd ed., New York: McGraw Hill, 2006.

[5] H. Akagi, E. H. Watanabe, and M. Aredes, Instantaneous Power Theory and Applications to Power Conditioning. NJ: John Wiley & Sons, 2007.

[6] K. R. Padiyar, FACTS Controllers in Transmission and Distribution. New Delhi: New Age International, 2007.

[7] A. Moreno-Munoz, Power Quality: Mitigation Technologies in a Distributed Environment. London: Springer-Verlag London Limited, 2007.

[8] E. F. Fuchs and M. A. S. Mausoum, Power Quality in Power Systems and Electrical Machines. London: Elsevier Academic Press, 2008.

[9] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. London: Wiley, 2013.

[10] M. D. Singh, R. K. Mehta, and A. K. Singh, "Current source converter based D-STATCOM for voltage sag mitigation," International Journal for Simulation and Multidisciplinary Design Optimization, vol. 6, pp. A5, 1–10, 2015, France, doi: 10.1051/smdo/2015005.

[11] N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design. New York, NY: John Wiley & Sons, 1989.

[12] E. Acha, V. G. Agelidis, O. Anaya-Lara, and T. J. E. Miller, Power Electronic Control in Electrical Systems. Newnes Power Engineering Series. Oxford: Elsevier, 2006.

[13] B. Han, S. Moon, and G. Karady, "Static synchronous compensator using thyristor PWM current source inverter," Proceedings of IEEE Transactions on Power Delivery, vol. 15, pp. 1285–1290, 2000.

[14] H. F. Bilgin and M. Ermis, "Design and implementation of a current source converter for use in industry applications of D-STATCOM," Proceedings of IEEE Transactions on Power Electronics, vol. 25, pp. 1943–2957, 2010.

[15] S. Bhim, P. Jayaprakash, and D. P. Kothari, "A T-connected transformer and three leg VSC based D-STATCOM for power quality improvement," Proceedings of IEEE Transactions on Power Electronics, vol. 23, pp. 2710-2718, 2008.

[16] C. Resul, D. Besir, and A. Fikret, "Fuzzy-PI current controlled D-STATCOM," Gazi University Journal of Science, vol. 24, pp. 91–99, 2011.

[17] S. Deepa and M. Ranjani, "Dynamic voltage restorer controller using grade algorithm," Cogent Engineering, vol. 2, pp. 1017243, 1-11, 2015, doi: 10.1080/23311916.2015.1017243.

[18] S. Singh, S. Kewat, B. Singh, B. K. Panigrahi, and M. K. Kushwaha, "A Multifunctional Three-Phase Grid Coupled Solar PV Energy Conversion System Using Delayed µ-Law Proportionate Control for PQ Improvement," IEEE Transactions on Industry Applications, vol. 58, no. 1, pp. 554-564, Jan.-Feb. 2022, doi: 10.1109/TIA.2021.3131923.

[19] T. S. Saradhisatwik, U. Gankidinishma, U. Hemanthchandra, V. Sailaja, and R. Mahalakshmi, "Power Quality Improvement in Solar Powered Standalone System using D-STATCOM," 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 2022, pp. 593-596, doi: 10.1109/ICSSIT53264.2022.9716537.

[20] B. Revanth, N. Bhimsha, V. Lekhana, and R. Sinha, "Comparative Study of PI and Fuzzy Logic Controlled D-STATCOM For Improving Power Quality," 2023 4th International Conference for Emerging Technology (INCET), Belgaum, India, 2023, pp. 1-5, doi: 10.1109/INCET57972.2023.10170380.

[21] Y. M and V. S. K. Devi, "ANFIS Controller based PV-DSTATCOM for Improving Power Quality," 2023 First International Conference on Advances in Electrical, Electronics and Computational Intelligence (ICAEECI), Tiruchengode, India, 2023, pp. 1-7, doi: 10.1109/ICAEECI58247.2023.10370820.

[22] R. S. Telgote, S. Nandurkar, and S. R. Deore, "D-Statcom Based Voltage Sag And Swell Improvement Of Distribution System," 2022 Interdisciplinary Research in Technology and Management (IRTM), Kolkata, India, 2022, pp. 1-6, doi: 10.1109/IRTM54583.2022.9791665.

[23] A. A. Nafeh, A. Heikal, R. A. El-Sehiemy, and W. A. A. Salem, "Intelligent fuzzy-based controllers for voltage stability enhancement of AC-DC micro-grid with D-STATCOM," Alexandria Engineering Journal, vol. 61, no. 3, pp. 2260-2293, 2022, doi: 10.1016/j.aej.2021.07.012.

[24] S. Choudhury and G. K. Sahoo, "A critical analysis of different power quality improvement techniques in microgrid," e-Prime - Advances in Electrical Engineering, Electronics and Energy, vol. 8, p. 100520, 2024, doi: 10.1016/j.prime.2024.100520.

[25] S. Yadav, R. K. Patel, and V. P. Singh, "Bearing Fault Classification Using TKEO Statistical Features and Artificial Intelligence," Journal of Intelligent and Fuzzy Systems, vol. 1, no. 2023, pp. 4147–4164, 2023, doi: 10.3233/JIFS-224221.

[26] S. Yadav, R. K. Patel, and V. P. Singh, "Multiclass Fault Classification of an Induction Motor Bearing Vibration Data Using Wavelet Packet Transform Features and Artificial Intelligence," Journal of Vibration Engineering and Technologies, vol. 11, pp. 3093–3108, 2023, doi: 10.1007/s42417-022-00733-3.

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