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| **Abstract:** |  |
| Enhancing power quality (PQ) in electrical distribution systems is vital for maintaining a stable and reliable power supply, especially for sensitive industrial and commercial loads prone to voltage disturbances. With the increasing integration of renewable energy sources (RES) and the widespread adoption of advanced electronic devices, modern power grids face growing challenges in addressing voltage sags, swells, and harmonics, threatening equipment performance and system reliability. This study proposes a comprehensive solution by implementing a Three-phase Dynamic Voltage Restorer (DVR) integrated with a Fuzzy Logic Controller (FLC). The selection of FLC stems from its ability to mimic human decision-making and handle non-linear, imprecise data, offering superior adaptability and precision compared to traditional control methods. Unlike conventional algorithms, which struggle under fluctuating grid conditions and complex disturbances, FLC dynamically adjusts the output of DVR based on real-time reference and load voltage measurements. This ensures optimal compensation and consistent voltage regulation across varying operating scenarios. The DVR, strategically placed downstream of a transformer within a three-phase supply network, detects voltage disturbances and compensates for deviations in real time. The developed optimization model demonstrates the effectiveness of proposed system, achieving an impressive 95% efficiency in correcting voltage disturbances and significantly reducing total harmonic distortion (THD) to 2.41%. Furthermore, the system showcases exceptional performance in handling voltage sags, reducing them to as low as 0.68% and an ultra-fast response time of less than 0.5 ms, surpassing the capabilities of conventional methods. The FLC-based DVR system offers robust voltage regulation, improved fault resilience, and enhanced grid stability by addressing critical PQ challenges exacerbated by the transition to RES and increased dependency on sensitive loads. Its advanced features make it a transformative solution for mitigating voltage disturbances in grid-connected systems, ensuring reliability and efficiency in the face of modern energy demands. | |