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Development of a Power Quality Situationing in power System By Using Fuzzy-PI Controllers - A Review

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Abstract – *Power quality is a critical aspect of modern power systems, ensuring reliable and efficient electricity supply to consumers. Power quality issues such as voltage fluctuations, harmonic distortions, and frequency variations can lead to operational inefficiencies, equipment damage, and disruptions in the power supply. This research focuses on the development of a power quality situationing system for power systems using Fuzzy-PI controllers.*

The proposed system leverages Fuzzy-PI controllers to effectively assess and manage power quality conditions. Fuzzy logic provides a mechanism to model and control complex and uncertain systems, making it suitable for addressing the dynamic and non-linear nature of power quality issues. The Fuzzy-PI controllers combine the benefits of fuzzy logic with Proportional-Integral (PI) control to ensure precise and responsive control actions..

Keywords: **Power Quality, Power System, Fuzzy Logic, Fuzzy-PI Controllers Voltage Fluctuations**

I. INTRODUCTION

Renewable Power quality is a crucial factor in the reliable and efficient operation of modern power systems. It refers to the degree to which the voltage, frequency, and waveform of the electrical supply meet the requirements of various electrical devices and equipment. Poor power quality can lead to operational disruptions, equipment malfunctions, and financial losses for both consumers and power utilities. As power systems become more complex and interconnected, maintaining optimal power quality becomes increasingly challenging.

Common power quality issues include voltage sags, swells, harmonics, flicker, and frequency variations. These issues can stem from various sources such as lightning strikes, equipment malfunctions, and the increasing integration of renewable energy sources. Addressing power quality challenges requires advanced control strategies that can swiftly detect disturbances and implement corrective actions.

Fuzzy logic has gained prominence in various control applications due to its ability to handle uncertainty, imprecision, and non-linearity. Fuzzy logic allows for the representation of expert knowledge and linguistic variables, enabling more human-like decision-making processes. This makes it particularly suitable for addressing the dynamic and intricate nature of power quality issues.

In this context, this study focuses on the development of a power quality situationing system using Fuzzy-PI controllers. The combination of fuzzy logic with Proportional-Integral (PI) control aims to provide an intelligent and responsive approach to managing power quality disturbances. The system's primary objectives are to accurately identify different power quality situations, assess their severity, and initiate appropriate control actions to mitigate their effects.

The proposed power quality situationing system aims to contribute to the following:

Disturbance Detection: The system will effectively detect various power quality disturbances, such as voltage fluctuations, harmonic distortions, and frequency deviations.

Categorization: It will categorize the severity of power quality issues based on predefined criteria, allowing for differentiated response strategies.

Fuzzy-PI Control: The utilization of Fuzzy-PI controllers will ensure precise and adaptive control actions in response to the detected disturbances.

Dynamic Adjustment: The system will dynamically adjust control parameters based on real-time data, enabling efficient and timely response to changing power quality conditions.

Operational Efficiency: By swiftly mitigating power quality disturbances, the system will enhance the operational efficiency of power systems and reduce the potential for equipment damage and downtime.

This research aims to contribute to the advancement of power quality management by integrating fuzzy logic and PI control techniques. The subsequent sections of this paper will delve into the methodology, simulation studies, results, and discussions, providing insights into the effectiveness of the proposed power quality situationing system in maintaining stable and reliable power supply.

II. Literature Review

B. gopal et al. (2012), this work proposed power quality improvement for isolated pico- hydropower generation based on an asynchronous generator using conventional electronic load controller (ELC). ELC has a six-pulse uncontrolled bridge rectifier with an auxiliary load and a chopper. It produces harmonic distortion in current and terminal voltage of the generator. A 24- pulse rectifier and a chopper are used in proposed ELC. A polygon wound autotransformer with 24-pulse rectifier is used for reducing the harmonic content to meet the power quality requirement as standardized by IEEE standard 519 [6].

Mr S Dinesh Kumar et al. (2015), this work deals with a noon-isolated 24-pulse controlled rectifier. It consist a polygon transformer with it to reduce current harmonic injection in AC mains to meet the requirement as prescribed by the IEEE-519 standard with varying loads. It contains the comparison of 6-pulse, 12-pulse and 24-pulse converter with a set of power quality indices. The proposed converter is capable to suppress up to 21st harmonics in AC mains. Using this proposed converter, system has less than 8% total harmonic distortion (THD) in input current with variable loads [7].

R. Tamiz Nesan, J. Jegadish (2015), this work deals with 24-pulse converter which has four 6-pulse converters are connected in parallel with two three phase transformers for obtaining the desired phase shift. It’s primarily focuses on harmonics reduction because the use of converters introduces harmonics in input currents. 24-pulse converter is able to reduce 5th, 7th, 11th and 13th which are injected by the use of 6-pulse and 12-pulse converters. However, AC output voltage would have 23th and 25th but it can be simply filtered out [8].

Alvaro Ortiz Monroy et al. (2012), this work proposed Transformer Rectifier Unit (TRU) which has four 6-pulse converters and four three phase zigzag-star connected windings configuration with phase shifts of 15o, 30o, 45o and 60o respectively. Simulation results are compared with 12-pulse TRU [9].

Chen Xiao-qiang and Qiu Hao (2015), this work deals with a configuration of zigzag connected autotransformer based 24-pulse controlled rectifier, which is used to feed direct controlled torque for induction motor drives. Simulation results shows that it reduces the harmonic content in AC main as well as DC mains. Effect of nature of load and load variation is also described in this. Comparison of 6-pulse, 12-pulse and 24-pulse converters is also done using different set of power quality indices at AC mains as well DC mains [10].

K. Santosh kumar et al. (2013), this work proposed Electronic Load Controller (ELC) for isolated Pico-hydropower generation using Asynchronous generator (AG). ELC has a six-pulse uncontrolled bridge rectifier with an auxiliary load and a chopper. It produces harmonic distortion in current and terminal voltage of the generator. A 24-pulse rectifier and a chopper are used in proposed ELC. A polygon wound autotransformer with 24-pulse rectifier is used for reducing the harmonic content to meet the power quality requirement as standardized by IEEE- 519 standard [11].

K. Srinivas (2012), this work proposed that the transformer rectifier unit introduces undesirable harmonic content in line currents which may lead to shut down of devices or may not be tolerated by power sensitive equipment. There is a significant opportunity to use of converters that produce low harmonic contents in AC current main source. It is well known, to increase the number of pulses in converters total harmonic distortion (THD) can be reduced to a greater extent with it power quality is improved. This work describes the effect of increasing the number of pulses on the performance of converters using THD indices [12].

Sonika Raghuvanshi, Nagendra Singh (2014), this work proposed the multi-pulse converters to reduce total harmonic distortion (THD). Phase shift is introduced by zigzag configuration of transformers. This work has 24, 36, 48 and 60-pulse multi-pulse controlled rectifier for reduction of THD which leads to enhance power quality. Resistor is used as load so all the results are obtained for this [13].

Mamta N. Kokate, Preeti V. Kapoor (2013), for high power application, conventional two level inverter has many limitations. The Multi-Level Inverter (MLI) began with three level inverter which has been very popular for high voltage and high power applications. The basic concept behind this is to use of series-parallel combinations of power semi-conductor switches and DC sources for achieving high power capability. Three levels MLI has three levels which has smoother signal pattern than conventional, this results in reduction of harmonics. This work deals with different topologies of three level MLI and SPWM technique to generate switching pattern for three levels and five levels MLI [14].

Gobinath.K et al. (2013), this work deals with improvement of power extracting methods. From solar cells, MLI is used for effectively extracting power. MLI enhance the wave shape of AC output voltage signal pattern. Seven levels with reduced switches topology is used in this paper work. Selective Harmonics Elimination Stepped Signal pattern (SHESW) technique is used to reduce lower order harmonics which in turn reduces total harmonic distortion (THD). Switches in inverter are controlled by fundamental switching scheme. Appropriate selection of switching angles gives reduction of harmonics. 3rd and 5th harmonics are eliminated in this work. This topology reduces initial cost and complexity [15].

R. Dharmaprakash, Joseph Henery (2014), this work deals with 2-level and 3-level inverter of diode clamped multilevel inverter (DCMLI) configuration. Switching tables is proposed in this dissertation-I work. Sector

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identification is used for selection of voltage vector from switching table to generate gate signals. The DCMLI can be extended to n-level inverter with new topology. Line to line voltages is compared as well as THD of both inverters is compared. With affecting its simplicity, direct torque control of induction motor can be easily achieved [16].

Carlo Cecati et al. (2010), this work deals with photovoltaic (PV) system with power electronics devices. This paper has two stages: a DC/DC converter and MLI modulated with PWM. The care should be taken due cascading of converters and there may be problem with MPPT. Single phase H-bridge cascade MLI is used with integrated fuzzy logic controller (FLC). This work proposes the use of fully FLC and an H-bridge power sharing algorithm. Improved performance of inverter over 2-level inverter at low-medium power is proposed [17].

Haitham Abu-Rub et al. (2010), this work proposed that, getting high efficiency and minimum total harmonic distortion (THD) at switching frequency with medium-voltage (MV) multilevel inverter (MLI). Industries are facing common problems that are effective power quality with increased power rating of switches by minimizing switching frequency. Common remedy is taken into account by increasing the level of inverter that will give low harmonic distortion at medium voltage at low switching frequency which in turn reduces the device losses and increase life span of devices [18]. [5]

III. METHOD

The power The electric power is generated in power system in AC and transmited and distributied also in AC. The power is transmitted from main station to the different user with the help of transmission and distribution lines. The transmission lines covers long distance and its voltage are very high. The voltage will decide size of the conductor . These type of problems are solve by HVDC. High power transmission is used In HVDC transmission system

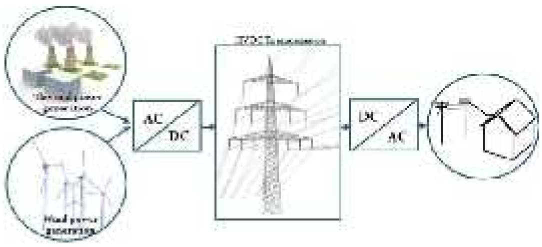

Fig. 1- Diagram of HVDC .

In HVDC system AC power is converted into DC and transmitted. At the end of the transmission, DC power is converted into AC power with the help of inverters. There are three section in HVDC system converter section, transmission section and an inverter section .

The converter station may have 6, 12, or 24-pulse thyristor bridge controlled rectifier and inverter station also have thyristor bridges but this will work in opposite mode.

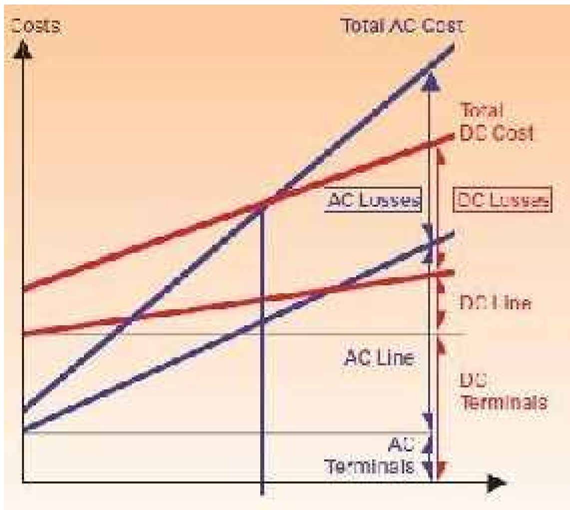

Fig. 2: Total Cost vs Distance .

Advantages of HVDC system compare to HVAC Systems:

- only two conductors are needed in DC transmission for a single line but minimum three lines need in AC transmission. we can doubled the capacity of the DC line by Using two conductors and ground return, but in AC system double circuit line at least six conductors for line are needed.
- The power transportation is economical in DC transmission and efficient but transmission losses are in AC transmission for long distances.
- The DC link does not require to maintaining synchronization between both ends AC links require.
- Automatic controller controls the power easily in DC links.
- Reactive power is not require in DC links for transmission , so it short out stability problems .
- Due to no reactance line length in not a problem.

Components of HVDC System:

The required components of HVDC system are given below

1.converters, 2. converter transformer 3. filters, 4. smoothening reactor,

5. shunt capacitor.

IV. CONCLUSION

In the rapidly evolving landscape of scientific research, review papers play a crucial role in synthesizing existing knowledge, highlighting trends, and providing insights into the state of a particular field. Review papers offer a comprehensive overview of the latest advancements, methodologies, challenges, and future directions within a specific domain, contributing to the dissemination of knowledge and guiding further research endeavors.

Review papers serve as valuable resources for researchers, scholars, and practitioners seeking to grasp the breadth and depth of a subject without delving into individual research articles. They assist in bridging the gap between specialized research and the broader scientific community by presenting complex concepts in a coherent and accessible manner. Moreover, review papers aid in identifying gaps in knowledge, revealing areas that warrant further investigation or innovation.

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