

A NOVEL SOLAR PHOTOVOLTAIC FED TRANS ZSI-DVR FOR POWER QUALITY IMPROVEMENT OF GRID-CONNECTED PV SYSTEMS

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

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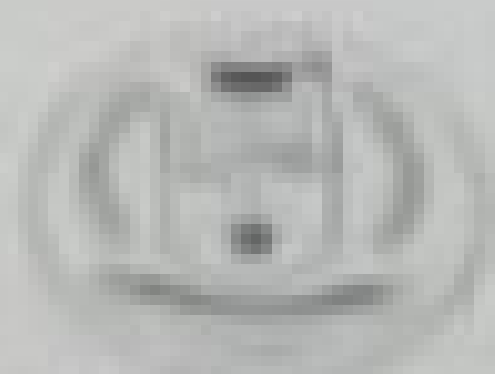
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade “A” by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of N P THARINI (Reg. No. 39140061) and SINDHU V (Reg. No. 39140052) who carried out the project entitled "A NOVEL SOLAR PHOTOVOLTAIC FED TRANS-ZSI DVR FOR POWER QUALITY IMPROVEMENT OF GRID CONNECTED PV SYSTEM" under our supervision from November 2022 to April 2023.

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ABSTRACT

The integration of photovoltaic (PV) systems into the power grid has increased in recent years, leading to various issues related to power quality. One of the most significant challenges is voltage fluctuations, which can cause equipment damage and affect the performance of other connected devices. This paper proposes the use of a Dynamic Voltage Restorer (DVR) to improve power quality in grid-connected PV systems. The DVR is a power electronics device that can mitigate voltage fluctuations by injecting appropriate voltage waveforms into the grid. The proposed system involves the integration of a PV system, DVR, and the grid, and is modeled and simulated using MATLAB/Simulink software. The simulation results demonstrate that the DVR can effectively compensate for voltage fluctuations and maintain the voltage at the desired level. The proposed system improves the power quality of the grid-connected PV system and reduces the likelihood of equipment damage, thereby contributing to the overall reliability and stability of the power grid. The increased use of sensitive and critical equipment pieces such as communication networks, process industries, and precise manufacturing processes is causing power quality issues in today's distribution systems. Transients, sags, swells, and other distortions to the sinusoidal waveform of the supply voltage affect the performance of these pieces of equipment. The DVR can protect the load voltage from problems like sag, swell, and harmonics.

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LIST OF SYMBOLS AND ABBREVIATIONS

DVR	-	Dynamic Voltage Restorer
PV	-	Photovoltaic
VSI	-	Voltage Source Inverter
AC	-	Alternating Current
DC	-	Direct Current
STATCOM	-	Static Synchronous Compensator
PWM	-	Pulse Width Modulation
LCD	-	Liquid Crystal Display
PCC	-	Point of Common Coupling
VL	-	Load Voltage
FACTS	-	Flexible AC Transmission System
VSG	-	Voltage Sag Generator
PQ	-	Power Quality
RE	-	Renewable Energy
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
PMSG	-	Permanent Magnet Synchronous Generator

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Power quality is a critical issue in electrical power systems, as it can affect the reliability and efficiency of power delivery to end-users. A major challenge is the occurrence of voltage sags and swells, which can cause equipment malfunctions or shutdowns, and result in significant economic losses. One solution to this problem is the use of a Dynamic Voltage Restorer (DVR). A DVR is a power electronic device that is installed at the customer's premises, and is designed to provide voltage support and improve power quality. It operates by sensing the voltage at the point of common coupling (PCC), and injecting a compensating voltage to correct any sag or swell in the voltage waveform.

The DVR can be configured to operate in either voltage source or current source mode, depending on the nature of the load and the system requirements. It is typically equipped with a sophisticated control system that monitors the system voltage and current, and adjusts the compensating voltage accordingly. The use of a DVR can help to improve power quality and reliability, reduce equipment downtime, and increase system efficiency. It is particularly effective in sensitive loads such as industrial processes, data centers, hospitals, and other critical facilities where even a brief voltage disturbance can cause significant damage or disruption.

The DVR is a powerful tool for power quality improvement, and can help to ensure a stable and reliable power supply to end-users. DVR, or Dynamic Voltage Restorer, is a power electronic device that is commonly used to improve power quality in grid-connected PV (photovoltaic) systems. Variations in grid voltage can cause voltage sags, swells, and harmonics in grid-connected PV systems, affecting the

performance and lifespan of the PV system. A DVR detects voltage disturbances on the grid and injects compensating voltage to restore the voltage to normal levels. A voltage source inverter (VSI) generates the compensating voltage and is connected in parallel with the grid via a transformer.

The VSI produces a compensating voltage that is equal in magnitude but in phase with the voltage disturbance, effectively cancelling it out. DVRs are especially effective. High-tech devices for communication, sophisticated management, automation, precise manufacturing, and online service are significantly impacted by power quality. Taking voltage sag as an illustration Impact on semiconductor fabrication products with significant financial losses. Transients, sags, disruptions, and other distortions of the sinusoidal waveform are all examples of power quality issues. Voltage sag, which is a sudden, brief decrease in voltage magnitude between 10 and 90% compared to the nominal voltage, is one of the most significant power quality problems.

CHAPTER 2

LITERATURE SURVEY

2.1 Major findings from literature survey

2.2 Existing system block diagram and explanation

2.3 Disadvantages of existing system

2.1 MAJOR FINDINGS FROM LITERATURE SURVEY

1. Author: R. Teodorescu, M. Liserre, and P. Rodriguez (2014)

Title: Grid Converters for Photovoltaic and Wind Power Systems.

Description: This study addresses the continuous operation of grid-connected renewables under the occurrence of grid voltage sags. This is made possible by the addition of an improved management algorithm for a renewable energy source. The low-voltage ride-through algorithm was created in accordance with the voltage profile for grid voltage sags established by IEC 61400-21. Not only instantaneous reactive power but also instantaneous active power under moderate voltage sags was injected to the utility grid in order to comply with grid code requirements and guarantee uninterrupted operation of the renewable agent during voltage sags.

The system's frequency as well as the positive and negative sequences of the three-phase utility grid voltages during unbalanced sags were estimated using a dual second-order generalized integrator frequency-locked loop synchronization method. A DC voltage source was used to simulate the main energy from any form of renewable system, and proportional resonant regulators were used to control the current in a stationary reference frame. An apparent power of 500 kVA three-phase grid-connected renewable system was used to validate the suggested control algorithm. The outcomes of several experimental experiments showed that the improved algorithm behaved as it should.

2. Author: G. S. Chawda, A. G. Shaik, M. Shaik, S. Padmanaban, J. B. Holm-Nielsen, O. P. Mahela, and P. Kaliannan (2015)

Title: “Comprehensive review on detection and classification of power quality disturbances in utility grid with renewable energy penetration”

Description: The use of renewable energy (RE) sources to meet decarbonization goals and satisfy energy demand has increased worry about power quality worldwide. The variable outputs and interacting converters are found to make power quality (PQ) disruptions more prevalent with RE penetration. To deliver clean energy to the customer, PQ disturbances must be identified and minimized. The methods used to identify and categories PQ disturbances in the utility grid with a penetration of renewable energy are critically reviewed in this paper. This review paper's overall goal is to provide various concepts that can be used to extract features from noisy environments in order to identify and categories PQ disruptions.

3. Author: G. S. Chawda, A. G. Shaik, O. P. Mahela, S. Padmanaban, and J. B. Holm-Nielsen (2016)

Title: “Comprehensive review of distributed FACTS control algorithms for power quality enhancement in utility grid with renewable energy penetration,”

Description: Global automation and quickening industrialization require more reliable and high-quality electrical energy production. In order to satisfy the rising demand for electricity, renewable energy sources also known as green energy are widely used as an alternative to conventional energy sources. However, when these sources are integrated into the utility grid, it becomes difficult to keep the network's stability and power quality (PQ). This is because the production from these sources is unpredictable and variable. Devices used in the distributed flexible AC transmission system (DFACTS), such as the dynamic voltage restorer (DVR) and distributed static compensator (DSTATCOM), actively help to mitigate PQ problems brought on by RE penetration.

In order to improve the quality of the power in utility grids with RE penetration, this paper provides a thorough review of different conventional and adaptive control algorithms used to operate DFACTS devices. A summary of the design, experimental

hardware, performance, and viability aspects of these algorithms as described in the literature is what this review aims to do.

4. Author: Y. Han, Y. Feng, P. Yang, L. Xu, Y. Xu, and F. Blaabjerg (2017)

Title: “Cause, classification of voltage sag, and voltage sag emulators and applications: A comprehensive overview,”

Description: The energy crisis is resolved and the environmental issues brought on by the use of conventional energy are lessened by the widespread implementation of wind and photovoltaic energy. When exposed to voltage sag and severe fault events, they run the risk of being arbitrarily tripped from the network, which will suddenly reduce active power production and make the system's fault recovery process more difficult.

Four voltage sag generators (VSGs), including generator-based, shunt impedance-based, transformer-based, and full converter-based VSGs, are discussed and compared in this paper along with a systematic overview of the causes, classification of voltage sag phenomena, and voltage sag emulating techniques. In order to study the LVRT performance of the WT system under grid voltage sag conditions, a closed-loop detection platform based on real-time digital simulator (RTDS) for the converter controller of a permanent magnet synchronous generator (PMSG) set is introduced. Finally, the use of VSG in RES is discussed, along with potential future study directions.

5. Author: A. Ghosh and G. Ledwich (2019)

Title: “Custom power devices: An introduction,” in Power Quality Enhancement Using Custom Power Devices.

Description: The custom power enhances the quality and reliability of power supplied to customers, much like FACTS improves power transmission reliability and

quality by enhancing both power transfer volume and stability. A customer gets a predetermined quality power under this scheme.

This predetermined quality may include a mix of the following requirements:

- The frequency of infrequent power outages.
- The extent and duration of voltage fluctuations that fall within predetermined boundaries.
- Low source voltage harmonic distortion.
- Low source voltage flicker.
- Minimal phase imbalance.
- Supply voltage frequency within predetermined bounds.

6. Author: A. Moghassemi and S. Padmanaban (2020)

Title: “Dynamic voltage restorer (DVR): A comprehensive review of topologies, power converters, control methods, and modified configurations”

Description: A power electronic-based method to reduce and correct voltage sags is DVR. The DVR topologies based on operations, power converters, control strategies, and applications are thoroughly discussed and reviewed in this article. The review compares the state-of-the-art in literature, a study of power quality issues, the DVR principle and its operating modes, the DVR components, the DVR topologies based on energy storage, the DVR topologies based on single-/three-phase power converters, and the DVR topologies based on control units with various stages of control processing.

7. Author: Y. Prakash; S. Sankar (2018)

Title: “Power quality improvement using DVR in power system”

Description: The suggested algorithm is used to address some load voltage fluctuations brought on by the beginning of induction motors and a three-phase short circuit fault. Additionally, the suggested DVR's ability to restrict the downstream fault current has been tested. The current restriction will safeguard the DVR itself and restore the voltage at the point of common coupling (PCC), which is the bus to which all feeders under study are connected.

The concept is to use the DVR as a virtual impedance to protect the PCC voltage during a downstream fault while ensuring that there are no issues with actual power injection into the DVR. The ability of the DVR to manage the emergency conditions of the distribution systems is demonstrated by the simulation results produced using the MATLAB software.

8. Author: Sachin Baliram Shahpure and Ramchandra

Title: “Power Quality Improvement using Unified Power Quality Conditioner with Distribution Generation”

Description: (DVR) fixes voltage-related power quality issues, while Distributed Static Compensator (DSTATCOM) fixes current-related issues. The integration of DSTATCOM and DVR using a single DC link is known as the Unified Power Quality Conditioner. The globe is leaning towards using solar PV systems to generate renewable energy due to significant developments in these systems and their affordability for consumers. The DC link typically receives its power from the source side. In this study, the UPQC with a solar PV system is shown.

In the proposed system, a solar PV system is used to supply electricity to the UPQC DC link. It was developed and implemented in the MATLAB Simulink environment. Under varied source voltage variations and unbalanced load conditions, the performance of the suggested system is examined. The proposed system is constructed in the OP4510 real-time digital simulator following MATLAB simulation.

9. Author: Tripurari Nath Gupta; Shadab Murshid; Bhim Singh (2021)

Title: Power Quality Improvement of Single-Phase Grid Connected Hybrid Solar PV and Wind System

Description: This paper proposes an amplitude adaptive notch filter (AANF) based control algorithm for power quality enhancement in single phase utility grid integrated to solar photovoltaic (PV) with a wind energy production system based on permanent magnet synchronous generators. (WEGS). The AANF control is intended to remove the essential part of the load current. The suggested method provides a high level of immunity and insensitivity to power disruptions. The system's primary goal is to provide active power to the load and single-phase grid linked at PCC (Point of Common Coupling), while simultaneously reducing power quality problems like grid current harmonic distortion and load reactive power compensation.

10. Author: Syed Khawar Shah; Ali Hellany; Mahmmoud Nagrial; Jamal Rizk(2014)

Title: Power Quality Improvement Factors: An Overview

Description: In the electronic business, power quality has begun to take center stage. The standards for electricity quality need to be reviewed as power providers adopt smart grid and smart meters. The standard for power quality supplied at the grid level and the factors that influence power quality at the user level are two different categories under which the power quality can be divided. These elements consist of harmonics, voltage variations, sags, transients, unbalanced voltage, etc. These elements will give us comprehensive information about the power infrastructure. This essay will provide an overview of a number of variables that can impact the system's electricity quality.

11. Author: V. Kavitha; K. Subramanian (2017)

Title: Investigation of power quality issues and its solution for distributed power system

Description: Power quality is the collection of all electrical networks as well as the capacity of a system to operate an electrical device satisfactorily. This form of electrical device permits the crucial way is the without constant death of all electrical device. Every piece of electrical technology malfunctions when there are issues with the power supply. A generator, motor, transformer, computer, printer, or household appliance are examples of such electronic devices. These electrical appliances react poorly to poor power quality issues and are also dependent on more severe issues.

This paper discusses the consequences of power quality issues, as well as their causes, remedies, and various methods to fix them. The devices for enhancing power quality are also discussed in this paper. Even the engineers, technicians, and system operators can benefit from becoming well-versed in power quality problems.

12. Author: Tanam Karthik; Mummadi Prathyusha; R Thirumalaivasan; M Janaki(2018)

Title: Power quality improvement using DSTATCOM

Description: The Static Compensator (STATCOM), a voltage source converter (VSC) based diversion connected Flexible AC Transmission System (FACTS) device, is described in this paper. It is a combination of capacitor banks and voltage source converters that enhances the dynamic and static voltage control in transmission systems as well as distribution systems. It is a reactive power return instrument that has the capacity to both generate and consume reactive power. In the electrical and electronic sectors, power quality continues to be crucial.

In this paper, THD is assessed, and DSTATCOM is used to lessen disruptions picked up in the voltage and current waveforms. Using MATLAB/SIMULINK, the distribution system with DSTATCOM and the control strategy for electricity quality enhancement are simulated and validated.

13. Author: Burudi Jahnavi; Srinivas Bhaskar Karanki; Pratik Kumar(2021)

Title: “Power quality improvement with D-STATCOM using combined PR and Comb filter- Controller”

Description: This paper presents a proportional resonant (PR)-controller and comb filter-based Distribution Static Compensator (D-STATCOM). The suggested controller improves current harmonics sensitivity while also simplifying the tuning of the resonant controllers. By using a comb filter, which, unlike PR-controller, does not require tuning for individual harmonics compensation, multiple harmonic compensations in the grid current have been accomplished. In this paper, feedforward and feedback form comb filters are implemented, and the outcomes are contrasted. For reactive power and harmonic compensation, the D-STATCOM topology used a constant switching method called sinusoidal pulse width modulation (SPWM) switching. Results from MATLAB/Simulink are provided to support the theory assertions.

14. Author: Prabir Ranjan Kasari; Manish Paul; Bikram Das; Abanishwar Chakraborti(2017)

Title: “Analysis of D-STATCOM for power quality enhancement in distribution network”

Description: This paper uses the d-q-0 reference frame to demonstrate the DSTATCOM power quality improvement aspects in the distribution system. Numerous PQ issues are present in the form of voltage dips, surges, and variations or fluctuations in the utilities serving residential, business, and industrial customers. These power quality problems have a significant impact on our current electrical networks. This study uses custom power devices to estimate and mitigate voltage sag, swell, fluctuation, and reactive power limiting for various utility usage conditions. Since it is renowned for its adaptability, simplicity of application, dynamic load compensation, and multifunctional operation, the D-STATCOM has been chosen as a compensating device.

15. Author: Systems Ali Moghassemi; Sanjeevikumar Padmanaban; Vigna K. Ramachandaramurthy; Massimo Mitolo (2016)

Title: “A Novel Solar Photovoltaic Fed Trans ZSI-DVR for Power Quality Improvement of Grid-Connected PV Systems”

Description: In order to enhance the power quality of on-grid photovoltaic (PV) systems, a new solar PV fed Dynamic Voltage Restorer (DVR) based on Trans-Z-source Inverter (Trans ZSI) is suggested in this article. In response to a voltage disturbance, a power electronic compensator called DVR is used to inject the required voltage into the Point of Common Coupling (PCC). TransZSI, which, components, and lower voltage stress, is proposed in the proposed DVR in lieu of traditional VSI.

The proposed TransZSI-DVR is more effective than conventional ZSI-DVR and VSI-DVR, according to comparative studies and simulation findings. The PV system's TransZSI-DVR has reduced voltage sag, swell, and interruption. Additionally, the output voltage of the PV system as well as the injected voltage to the PCC have enhanced power quality.

16. Author: Ali Moghassemi; Shayan Ebrahimi; Farzad Ferdowsi (2021)

Title: “A Novel Control Scheme for TransZSI-DVR to Enhance Power Quality in Solar Integrated Networks”

Description: An innovative control method for Dynamic Voltage Restores (DVR) with Transformer-based Impedance Source Inverter (Trans-ZSI) configuration is the subject of this paper, which seeks to analyze and assess its performance. To improve the total performance of solar PV fed TransZSI-DVRs, an Improved Maximum Constant Boost Control (IMCBC) method is suggested. The suggested method aids in lowering THD and reducing voltage tension across the switches. MATLAB/SIMULINK model is put to the test with various power disturbances. The outcomes demonstrate the potency

of the suggested control technique as a corrective strategy for adjusting the voltage at the point of common coupling.

17. Author: Bipin Singh; Arunima Verma; Vinod Kumar Giri

Title: “Power Quality Improvement of Grid Connected PV System”

Description: Under linear and unbalanced loads, the two stage three phase grid connected solar photovoltaic (SPV) technology is used to power quality improvement. The link between the SPV and grid is made up of a DC-DC power converter and a DC-AC power converter. Using a single diode model, a simpler solar PV system is built. (SSDM). By switching between DC-DC power converters to increase the SPV voltage, the maximum power point (MPP) method is used to maximize the SSDM solar PV output voltage. The grid is supplied with AC that has been converted from boosted DC using a three phase DC-AC power conversion. ABC to do, PLL, PI controller, and PWM techniques are used to regulate the DC-AC power converter.

18. Author: Mohamed Idris Salem Abozaed; Ro wad Ali Muhammad Al-Habhab(2022)

Title: “Power Quality Improvement in Grid Connected PV System using Fuzzy Logic Controller based Maximum Power Point Tracing (MPPT)”

Description: This paper uses the (MATLAB/Simulink_R2018a) programmed to study, analyze, and simulate the real behavior of a grid-connected solar photovoltaic system model. The effectiveness of the fuzzy logic controller is then assessed in order to follow the path of the maximum power point. Its work is based on tracking strategies that use the direct control method to regulate the DC commutator's operating cycle, which in turn functions by feeding the inverter with the solar photovoltaic system's maximum output power. A fuzzy logic controller of the kind used in Mamdani was chosen as the tracking technology because it is based on the artificial intelligence approach (fuzzy logic controller).

The outcomes demonstrated the fuzzy logic controller's efficacy, and it tracked the maximum power point with excellent performance in terms of achieving more stability, lowering error, and reducing settling time.

19. Author: Rayappa David Amar Raj; Thabeti Aditya; Madhav Ramrao Shinde(2019)

Title: “Power Quality Enhancement of Grid-Connected Solar Photovoltaic System Using LCL Filter”

Description: The double stage grid connected solar photo voltaic (GCPV) system with a reliable control mechanism and enhanced power quality is thoroughly examined in this article. A dc-dc boost converter is used in this device to convert variable dc voltage to constant dc voltage. To transform constant dc voltage to ac voltage, a power electronic voltage source inverter (VSI) is used. If harmonics are not eliminated in the PV system, they could have a negative impact on the electricity quality. In order to lower the harmonics, an effective passive LCL filter is used in the utility system. In this paper, the systematic LCL filter design is described.

20. Author: Sumit Trimukhe; R A Sanjeevkumar (2013)

Title: “Power Quality Improvement in Grid Connected PV System using Reduced Part Count Multilevel Inverter by Performing Power Balance”

Description: By raising the efficiency of renewable energies and enhancing the quality of the output power, the multilevel inverters are playing a crucial role in the development of renewable energy. Solar-powered photovoltaic cells produce electricity in response to sunlight. The electricity is produced in large part by temperature and radiation. In MLIs, the irradiation of the cells is not uniform; the duty cycle is changed to produce the highest possible power, which may result in voltage and current imbalance. To address this problem, an MLI topology is employed in this paper, in which a H6 bridge is used in lieu of a standard H-bridge. The H6 bridge aids in maintaining the PV panels' duty cycle and enhancing output power and current.

21. Author: Naeem Abas and Saad Dilshad (2022)

Title: "Power Quality Improvement Using Dynamic Voltage Restorer"

Description: In the modern power system, power quality is a crucial issue that can have an impact on utilities and consumers. Numerous issues in the contemporary electric power system were brought on by the integration of renewable energy sources, smart grid technologies, and widespread use of power electronics equipment. The delicate equipment can be harmed by voltage harmonics, voltage droop, and voltage swell. These devices are vulnerable to input voltage variations brought on by system interference. Power quality is therefore crucial for the power system's dependable and secure operation in the modern era, with a rise in delicate and expensive electronic equipment.

The response of the systems to load voltage in situations with and without DVR is assessed. It has been observed that the suggested DVR-based approach successfully controlled the voltage distortion, resulting in a smooth compensated load voltage.

2.2 EXISTING SYSTEM BLOCK DIAGRAM AND EXPLANATION

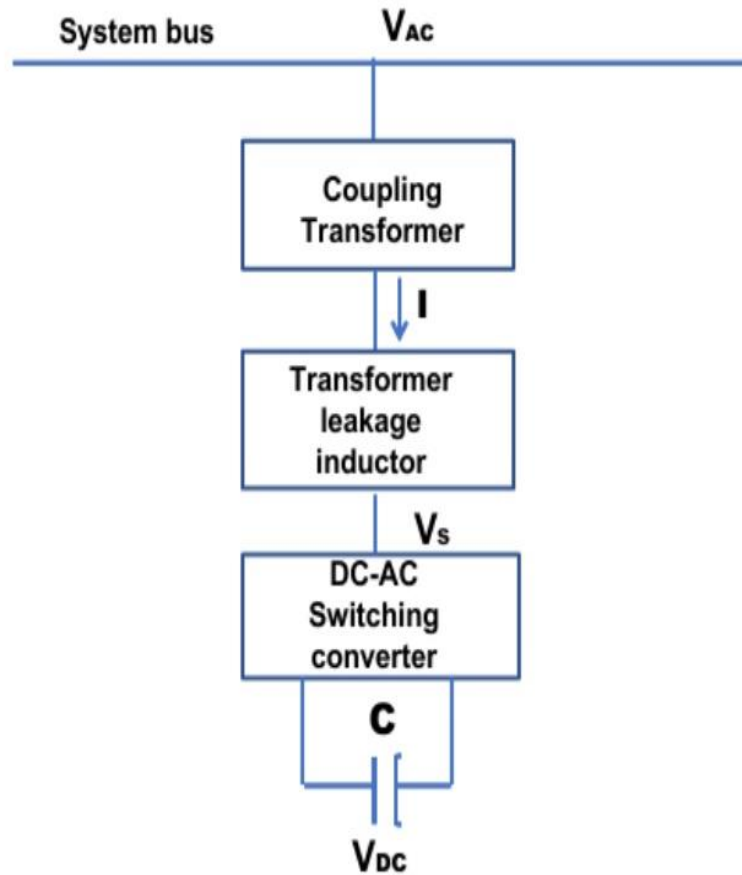


Fig: 2.1 Block diagram of Existing System

Grid-connected PV systems are becoming more common because they can provide sustainable electricity. Solar energy's erratic nature, however, has the potential to disrupt the power infrastructure and degrade the quality of the electricity delivered to users. A STATCOM (Static Synchronous Compensator) can be applied in this situation to enhance power quality. In order to add reactive power to the system, a STATCOM is a power electronic device that is linked in parallel to the grid.

Thus, it can assist with voltage regulation, lower voltage fluctuations, and enhance power factor. A STATCOM can offer the following advantages in relation to a PV system that is grid-connected.

2.3 DISADVANTAGES OF EXISTING SYSTEM

- Only used for reactive power compensation.
- Coupling Transformer is required.
- The consumption of reactive energy will be important.
- In transmission line the voltage drop can be big but their distance would matter.
- Unequal power distribution among switches.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 Problem identification

3.2 Scope of the project

3.3 Objective

3.4 Methodology

3.5 Block diagram

3.6 Real time applications

3.7 IEEE Standards

3.8 Constraints

3.9 Trade-Offs

3.9.1 Advantages

3.9.2 Disadvantages

3.1 PROBLEM IDENTIFICATION

The problem identification for power quality improvement using DVR (Dynamic Voltage Restorer) could include the following:

- Voltage sags and swells are the most common power quality issues that affect the performance of sensitive loads. These issues can cause interruptions, disruptions, or equipment damage. DVR can be used to mitigate these issues.

Voltage flicker is another common power quality issue that causes variations in the luminous flux of lighting systems. This issue can affect the performance of sensitive loads, such as welding machines, CNC machines, etc. DVR can be used to mitigate this issue.

- Voltage unbalance can cause problems such as overheating, excessive vibration, and premature failure of three-phase motors. DVR can be used to mitigate this issue.
- Harmonics are the distortion of the power system waveforms caused by non-linear loads. They can cause overheating, vibrations, and damage to equipment. DVR can be used to mitigate this issue.
- Transients are short-duration voltage disturbances that can cause equipment damage, data loss, or downtime. DVR can be used to mitigate this issue.

Overall, the use of DVR can help to improve power quality and minimize the impact of power quality issues on sensitive loads, thus increasing the efficiency and reliability of the power system.

3.2 SCOPE OF THE PROJECT

Dynamic Voltage Restorer (DVR) is a device used to mitigate voltage sags, swells, and other power quality issues in power distribution systems. Grid-connected photovoltaic (PV) systems can also suffer from such issues due to various reasons such as grid faults, fluctuating load demand, and variations in solar irradiance.

In this context, a DVR can be used to improve the power quality of a grid-connected PV system. By injecting the appropriate voltage waveform at the point of common coupling (PCC), a DVR can compensate for voltage sags and swells caused by grid faults or other disturbances. This will help in maintaining a stable voltage level at the PCC and ensure the safe and reliable operation of the PV system.

3.3 OBJECTIVE

The objectives of the proposed work are as follows

- To reduce the voltage, drop across the grid.
- To maintain the transmission of constant current across the grid.
- To satisfy the load demand of the grid, an efficient control strategy should be developed with PV source

3.4 METHODOLOGY

The major problem identified here is that we are unable to receive the maximum amount of current that we are transmitting. In-order to avoid this, we are implementing this method.

In this work, we are reducing the voltage sags or swells that developed while transmitting the power from transmission to receiver end in the grid. Here, we are using renewable energy i.e., Solar to compensate the drop occurred. The solar energy which is DC, is converted to AC and is injected in-order to compensate the maximum current. And after that AC source, a Trans Z-Source is added which is also called as

a constant current source, which maintains constant current so that maximum current is received at the end.

It is used to,

- To improve the power quality of on-grid Photovoltaic systems.
- To reduce the voltage, drop across the grid.
- To maintain the transmission of constant current across the grid.
- To satisfy the load demand of the grid, an efficient control strategy should be developed with PV source.

3.5 BLOCK DIAGRAM

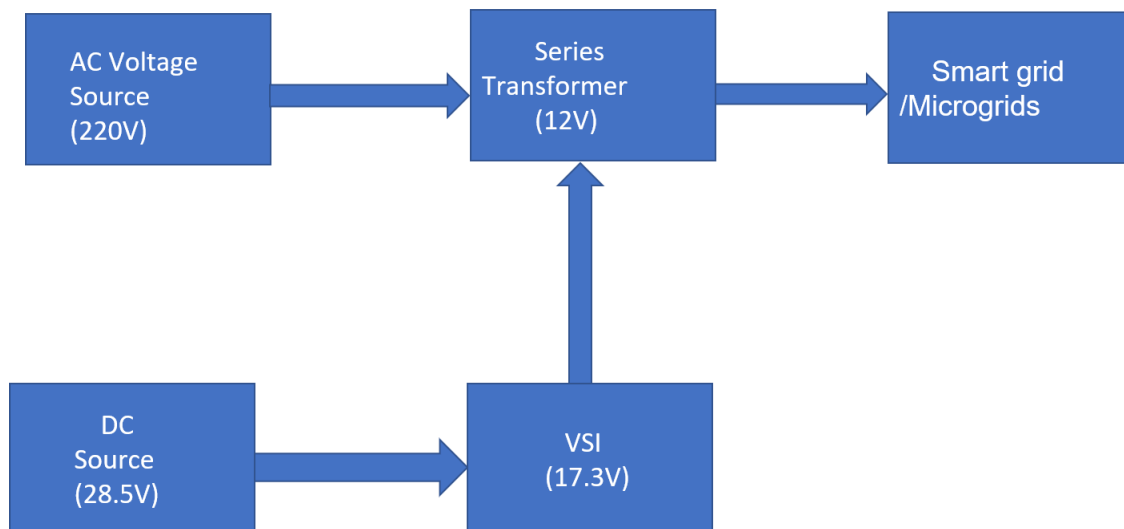


Fig: 3.1 Block diagram

PV array: The PV array turns solar energy into direct current power.

DC-DC converter: The DC-DC converter modifies the DC electricity produced by the solar panel array to the necessary voltage level for the inverter.

Inverter: The inverter transforms the DC energy produced by the PV array into grid-compatible AC electricity. To ensure that the AC electricity meets the grid operator's quality requirements, the inverter also regulates its voltage and frequency.

Grid filter: Before being fed into the grid, the AC energy produced by the inverter is filtered to remove any undesirable harmonics or other noise.

Grid connection: Through a connection point, the AC energy produced by the inverter is fed into the grid.

Monitoring and control system: The monitoring and control system keeps an eye on the PV system's performance and modifies the inverter's settings to make sure the AC energy it produces meets the grid operator's standards for quality.

This block diagram demonstrates how a grid-connected PV system can be planned and managed to make sure that the energy it produces meets the standards set by the grid operator. The grid's power quality can be improved, which can result in a more steady and reliable energy supply, by managing the voltage, frequency, and harmonics of the AC electricity produced by the PV system.

3.6 REAL-TIME APPLICATIONS

1. Voltage stabilization:

The output voltage of a grid-connected PV system can vary due to changes in weather conditions, cloud cover, and other factors. A DVR can help to stabilize the voltage and ensure that it remains within a predefined range. This will help to ensure that the PV system operates optimally and that the electricity generated is of high quality.

2. Voltage regulation:

In some cases, the voltage on the grid may drop below the minimum required level, which can cause problems for the PV system. A DVR can be used to regulate the voltage and ensure that it remains within the required range. This will help to ensure that the PV system continues to operate even when the grid voltage is low.

3. Fault current limitation:

When a fault occurs in the power distribution system, the current can increase to a dangerous level, which can damage the PV system. A DVR can be used to limit the fault current and protect the PV system from damage.

4. Harmonic mitigation:

The output of a PV system can contain harmonics, which can cause problems for other equipment connected to the same power distribution system. A DVR can be used to mitigate these harmonics and ensure that the electricity generated by the PV system is of high quality.

3.7 IEEE STANDARDS

- 1. IEEE 1815-** This standard provides guidelines for the design and implementation of communication networks for distributed energy resources, in order to maintain power quality and reliability.
 - The implementation of the IEEE 1815 standard in a DVR involves using the protocol to transmit and receive control signals and data between the DVR and other grid components. The protocol is used to establish a communication link between the DVR and other devices, and to exchange data related to voltage regulation, fault detection and isolation, and other aspects of grid operation.

- In practice, the implementation of the IEEE 1815 standard in a DVR involves programming the device with the necessary communication protocols and interfaces to enable it to communicate with other components of the grid. This may involve the use of specialized software or firmware, as well as hardware components such as communication modules and interfaces.
- Overall, the use of the IEEE 1815 standard in the implementation of dynamic voltage restorers has been shown to be effective in improving power quality in electrical grids. By enabling real-time communication between DVRs and other grid components, the standard helps to ensure that the voltage in the grid remains within acceptable limits, thereby reducing the risk of power outages and other power quality issues.

2. IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems: This standard outline technical requirements for the interconnection and interoperability of distributed energy resources (DER) with electric power systems.

- The IEEE 1547 standard includes specifications for voltage and frequency regulation, which are critical for maintaining grid stability. The standard also addresses issues such as islanding, which occurs when a DER continues to generate power even if the grid goes down. Islanding can be dangerous for utility workers attempting to repair the grid and can also damage equipment.
- To comply with the IEEE 1547 standard, PV system owners and installers must follow specific procedures for testing and verifying the performance of their systems before connecting them to the grid. This includes testing for compliance with voltage and frequency requirements and ensuring that the system can disconnect from the grid in the event of a fault.

- Overall, the IEEE 1547 standard plays a critical role in ensuring the safe and reliable integration of PV systems and other DERs into the utility grid.
- 3. IEEE 519** - Standard for Recommended Practice and Requirements for Harmonic Control in Electric Power Systems: This standard provides guidance on the control of harmonics, which are undesirable electrical disturbances that can cause power quality problems.
- Implementing the IEEE 519 standard in a Dynamic Voltage Restorer (DVR) involves controlling the voltage waveform at the point of common coupling (PCC) to ensure that the voltage disturbances caused by the load do not exceed the limits set by the standard.
 - The DVR is designed based on the control strategy, taking into account the power rating, switching frequency, and control algorithms required to achieve the desired compensation.
 - The DVR are tested under different load conditions to validate its performance and ensure compliance with the IEEE 519 standard.
 - The DVR are monitored regularly to ensure that it continues to meet the standard requirements, and maintenance is performed as necessary to prevent failures and ensure reliable operation.
 - Overall, implementing the IEEE 519 standard in a DVR requires a thorough understanding of power electronics, control theory, and power system analysis, as well as expertise in designing and implementing power quality solutions.
- 4. IEEE 1668-2020:** This standard provides guidelines for the design and installation of voltage sag ride-through devices for sensitive loads. These

devices help to maintain the supply voltage to sensitive loads during voltage sags and other power quality disturbances.

- IEEE 1668 is a standard that specifies the technical requirements for Dynamic Voltage Restorer (DVR) systems that are used in power quality improvement for grid-connected photovoltaic (PV) systems. The standard provides guidelines for the design, testing, installation, and maintenance of DVRs used in grid-connected PV systems.
- The IEEE 1668 standard specifies the requirements for the design and operation of DVRs in grid-connected PV systems, including the voltage and current ratings, control algorithms, and performance characteristics. The standard also specifies the testing procedures and performance requirements that must be met by the DVRs.
- IEEE 1668 is an important standard that provides guidelines for the use of DVRs in power quality improvement for grid-connected PV systems. By following the standard, designers and installers can ensure that their systems are safe, reliable, and meet the necessary performance requirements.

5. IEEE 1159-2019: This standard provides guidelines for monitoring the power quality of electrical power systems. It covers the monitoring of voltage variations, flicker, harmonics, and other power quality issues that affect the performance of power systems.

- The IEEE 1159 standard provides guidelines for assessing the compatibility of the DVR with the PV system and the power grid. This includes recommendations for measuring and analysing power quality parameters such as voltage regulation, harmonic distortion, and flicker.

- In addition to the guidelines provided by IEEE 1159, the integration of DVR technology in grid-connected PV systems requires proper design and installation to ensure that the system functions properly and safely. This includes appropriate selection and sizing of components, as well as coordination with protective devices and other control systems.
- By using IEEE 1159 in conjunction with DVR technology, grid-connected PV systems can achieve improved power quality, reduced downtime, and enhanced efficiency, leading to increased renewable energy utilization and a more stable power grid.

3.8 CONSTRAINTS

COST: Depending on the equipment or technology being used, improving power quality measures can be expensive to adopt. For businesses or households with restricted resources, cost can be a significant barrier.

COMPATIBILITY: Equipment for enhancing power quality must be functional with the current electrical system. Additional electrical system modifications may be necessary for device upgrades, which can be time-consuming and expensive.

SPACE: To be installed, power quality improvement devices need a real location. Installation of these devices may be hampered by a lack of room, particularly in densely populated areas or small buildings.

INTERFERENCE: Electromagnetic interference is a problem that some power quality improvement devices can cause, interfering with the functioning of other electrical devices. Making sure that the installation of these devices doesn't interfere with other equipment is crucial.

TECHNICAL EXPERTISE: Power quality enhancement devices need to be installed and maintained properly, which calls for technical knowledge. Lack of technological

expertise may result in improper installation, which could cause the equipment to function poorly or even sustain damage.

REGULATORY REQUIREMENTS: When installing electricity quality improvement devices, it might be necessary to adhere to legal requirements. Penalties that are both legal and financial may result from failure to comply with these standards.

3.9 TRADE OFFS

3.9.1 ADVANTAGES

VOLTAGE REGULATION: Even when the utility's voltage fluctuates, DVR can control the system's voltage and keep it within reasonable bounds. This guarantees a steady and dependable power source for the connected loads, which can lengthen their lifespan and lower the possibility of equipment damage from voltage fluctuations.

MITIGATION OF VOLTAGE SAGS AND SWELLS: Voltage sags and swells are frequent power quality problems that can have an impact on the functionality of delicate machinery. By introducing a compensating voltage into the system, DVR can alleviate these problems by stabilizing the voltage and lessening the effects of voltage fluctuations on the loads.

FAST RESPONSE TIME: DVR is very good at reducing problems with power quality because of its quick response time, which is usually only a few milliseconds. The connected loads are safeguarded from voltage fluctuations and other power quality issues thanks to this quick reaction time.

COST-EFFECTIVE: When compared to other options, like UPS systems or backup generators, DVR is a more affordable solution for power quality enhancement. A DVR can be put in the system at key points to safeguard important loads, obviating the need for pricey backup power options.

INCREASED ENERGY EFFICIENCY: DVR can increase the energy efficiency of the linked loads by controlling the voltage in the system. This is because voltage changes can cause energy losses in the system, which DVR can help reduce.

3.9.2 DISADVANTAGES

COST: Installing and maintaining DVRs can be costly, and the expense might not always be necessary.

EFFICIENCY: The DVR may cause extra system losses that lower the PV system's overall efficiency.

MAINTENANCE: To make sure that DVRs are operating correctly, they need to undergo routine maintenance, just like any other electrical devices. This could take a lot of effort and money.

LIMITED EFFECTIVENESS: DVRs might not always be able to boost electricity quality. The DVR might not be able to completely compensate, for instance, if the voltage disturbance is too severe or if there is a lot of harmonic distortion.

COMPLEXITY: The use and management of DVRs can be complicated, and they may call for specialized knowledge.

RELIABILITY: A DVR's dependability may be a problem, especially in challenging conditions or when there is a lot of electrical interference or spikes

CHAPTER 4

PROJECT DESCRIPTION

4.1 Proposed block diagram and explanation

4.2 Advantages of propose system

4.3 Hardware Description

4.3.1 Power supply

4.3.2 Microcontroller

4.3.3 LCD Module

4.3.4 Transformer

4.3.5 Voltage regulator

4.3.6 Bridge rectifier

4.3.7 Power MOSFET

4.3.8 IRF840 MOSFET

4.3.9 DC-DC Converter

4.4 Software Requirement

4.4.1 MATLAB/SIMULINK

4.1 PROPOSED BLOCK DIAGRAM AND EXPLANATION

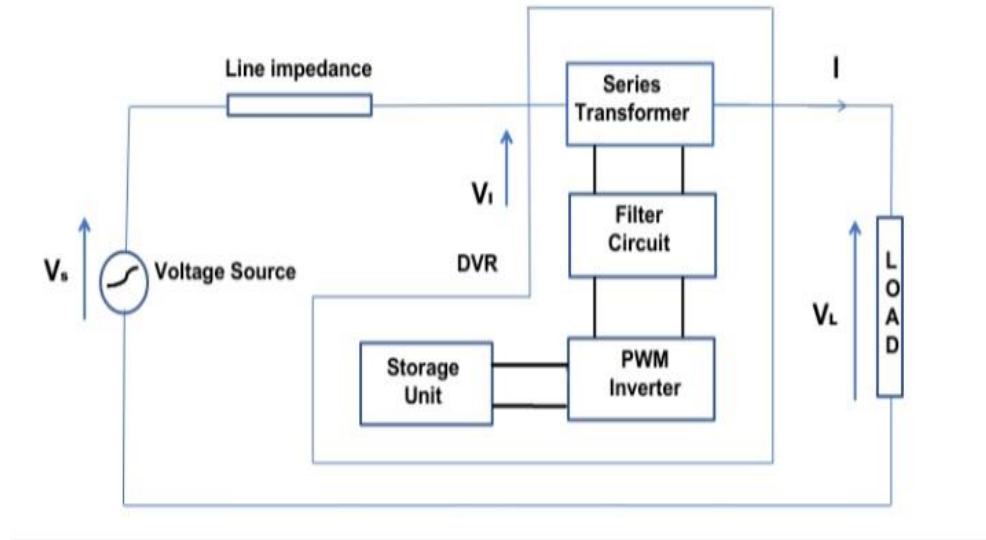


Fig: 4.1 Block diagram of Proposed System

The DVR works by detecting the grid's voltage waveform and then adding a compensating waveform to remove any voltage peaks or troughs. Pulse-width modulation (PWM) methods are used to create the compensating waveform.

Voltage sags or swells in a grid-connected PV system can happen for a number of reasons, including changes in load demand, power system faults, or abrupt changes in the PV system's output. The efficacy and lifespan of PV system components like inverters, capacitors, and transformers may suffer as a result of these voltage variations.

The DVR can aid in reducing these voltage variations and enhancing the grid-connected PV system's total power quality. The DVR can also aid in enhancing the effectiveness of the PV system and lowering energy losses by maintaining a stable voltage waveform.

Overall, the addition of a DVR to a PV system that is linked to the grid can result in better power quality, greater dependability, and lower maintenance expenses. To guarantee optimum performance and compatibility with current power system components, the DVR must be correctly designed and integrated with the PV system.

It aims in, Minimizing the error of voltage injection. Reduced rating of voltage source converter. Detection of start/stop points of voltage disturbances, Reduction in transients. Mitigation of voltage disturbances, Reduction in injected voltage.

4.2 ADVANTAGES OF PROPOSED SYSTEM

- Minimize the error of voltage injection.
- DVR is small in size and is a better power effective device as compared to others link UPS, SMES and DSTATCOM.
- DVR is mostly preferred because it is less expensive. If compared to DSTATCOM and UPS, DVR is a lot cheaper
- Reduced rating of voltage source converter
- Detection of start/stop points of voltage disturbances,
- Reduction in transients,
- Mitigation of voltage disturbances,
- Reduction in injected voltage

4.3 HARDWARE DESCRIPTION

4.3.1 POWER SUPPLY

- Rectifier- The output of a rectifier, which transforms AC to DC, varies.
- Transformer- Transforms mains AC power from high voltage to low voltage.
- Smoothing - reduces the DC's extreme variation to a tiny wave.
- Regulator - by fixing the DC output voltage, this device removes ripple.

4.3.2 MICROCONTROLLER

- A microcontroller can be used in a Dynamic Voltage Restorer (DVR) system to control and monitor the operation of the system. The microcontroller can be used to implement the control algorithm, read sensor data, and communicate with other components of the system.
- By using a microcontroller in a DVR system, it is possible to implement sophisticated control algorithms and monitor the operation of the system in real-time. This can improve the performance and efficiency of the DVR system and provide more advanced functionality, such as fault detection and self-diagnosis.

4.3.3 LCD MODULE:

- An LCD module is a commonly used display device that can be used in a variety of electronic systems, including Dynamic Voltage Restorer (DVR) systems. In a DVR system, an LCD module can be used to display important information such as the voltage at the load bus, the reference voltage, and the status of the system.

- In a DVR system, the LCD module can be used to display important information such as the voltage at the load bus, the reference voltage, and the status of the system. By using an LCD module in a DVR system, it is possible to provide important information to users in a clear and concise manner, improving the usability and effectiveness of the system.

4.3.4 TRANSFORMER

- A transformer designed to reduce the voltage from primary to secondary is called a step-down transformer. The transformation ratio of a transformer will be equal to the square root of its primary to secondary inductance (L) ratio.
- A transformer is an essential component in a DVR system. It is used to couple the DVR to the power system and to step up or step down the voltage as required. The inverter generates a compensating voltage waveform, which is then injected into the power system through the transformer to protect sensitive equipment from voltage sags.

4.3.5 VOLTAGE REGULATOR

- The voltage regulator is used to regulate the voltage that is injected into the system ensuring that the voltage remains constant at the load.
- The combination of a DVR and a voltage regulator is an effective solution for protecting sensitive loads from voltage disturbances and ensuring a reliable and stable power supply
- The function of a voltage regulator is to maintain a constant DC voltage at the output irrespective of voltage fluctuations at the input and (or) variations in the load current.

4.3.6 BRIDGE RECTIFIER

- A bridge rectifier can be used in a Dynamic Voltage Restorer (DVR) to rectify the incoming AC voltage and provide a DC voltage for the inverter stage of the DVR. The inverter stage is responsible for generating the compensating voltage to restore the voltage at the load bus.
- The bridge rectifier consists of four diodes arranged in a bridge configuration, which allows for the conversion of AC voltage to DC voltage. The AC voltage is applied to the input of the bridge rectifier, and the output of the bridge rectifier provides a pulsating DC voltage.
- Overall, the bridge rectifier is an important component of the DVR, as it provides the DC voltage necessary for the inverter stage to generate the compensating voltage to restore the voltage at the load bus.

4.3.7 POWER MOSFET

- Power MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors) can be used in a Dynamic Voltage Restorer (DVR) as the switching devices in the inverter stage. The inverter stage is responsible for generating the compensating voltage to restore the voltage at the load bus.
- The power MOSFETs are typically arranged in a bridge configuration, such as an H-bridge or a full-bridge. The gate of each MOSFET is controlled by a pulse width modulated (PWM) signal generated by a controller.
- power MOSFETs are a key component of the DVR, as they are responsible for generating the compensating voltage to restore the voltage at the load bus. Proper selection and use of these devices is critical to the successful operation of the DVR.

4.3.8 IRF840 MOSFET

- The IRF840 is a power MOSFET that can be used in a Dynamic Voltage Restorer (DVR) as a switching device in the inverter stage. The IRF840 is an N-channel MOSFET with a maximum voltage rating of 500V and a maximum current rating of 8A.
- When using the IRF840 in a DVR, multiple MOSFETs are typically connected in a bridge configuration, such as an H-bridge or a full-bridge, and controlled by a pulse width modulated (PWM) signal generated by a controller.

4.3.9 DC-DC CONVERTER

Input Capacitor: The input capacitor is used to filter out any AC ripple voltage on the input voltage source. It also provides a source of energy to the converter during the switching cycle.

Power Switch: The power switch is used to switch the input voltage on and off at a high frequency, typically in the range of tens of kHz to several MHz. The power switch can be either a MOSFET or a bipolar transistor.

Inductor: The inductor is used to store energy during the ON time of the power switch and release the energy during the OFF time. The inductor also filters out any high-frequency noise generated by the switching action.

Output Capacitor: The output capacitor is used to filter out any AC ripple voltage on the output voltage. It also provides a source of energy to the load during the OFF time of the power switch.

Diode: The diode is used to provide a path for the current to flow from the inductor to the output capacitor during the OFF time of the power switch.

Control Circuit: The control circuit is used to regulate the output voltage by adjusting the duty cycle of the power switch. The control circuit can be implemented using an integrated circuit (IC) or a microcontroller.

4.4 SOFTWARE REQUIREMENT

4.4.1 MATLAB/SIMULINK

- MATLAB can be used to simulate and model the operation of a Dynamic Voltage Restorer (DVR) system. Using MATLAB, it is possible to develop models of the DVR system, including the inverter stage, controller, and load, and simulate the behavior of the system under different operating conditions.
- By using MATLAB to simulate and model the operation of a DVR system, it is possible to optimize the performance of the system and ensure that it operates efficiently and effectively in real-world applications.

CHAPTER 5

RESULTS

5.1 Simulation block diagram

5.2 Simulation explanation

5.3 Simulation results

5.4 Simulation comparison

5.5 Hardware design

5.6 Hardware results

5.6.1 Input/Set values

5.6.2 Output values

5.7 Hardware comparison

5.1 SIMULATION BLOCK DIAGRAM

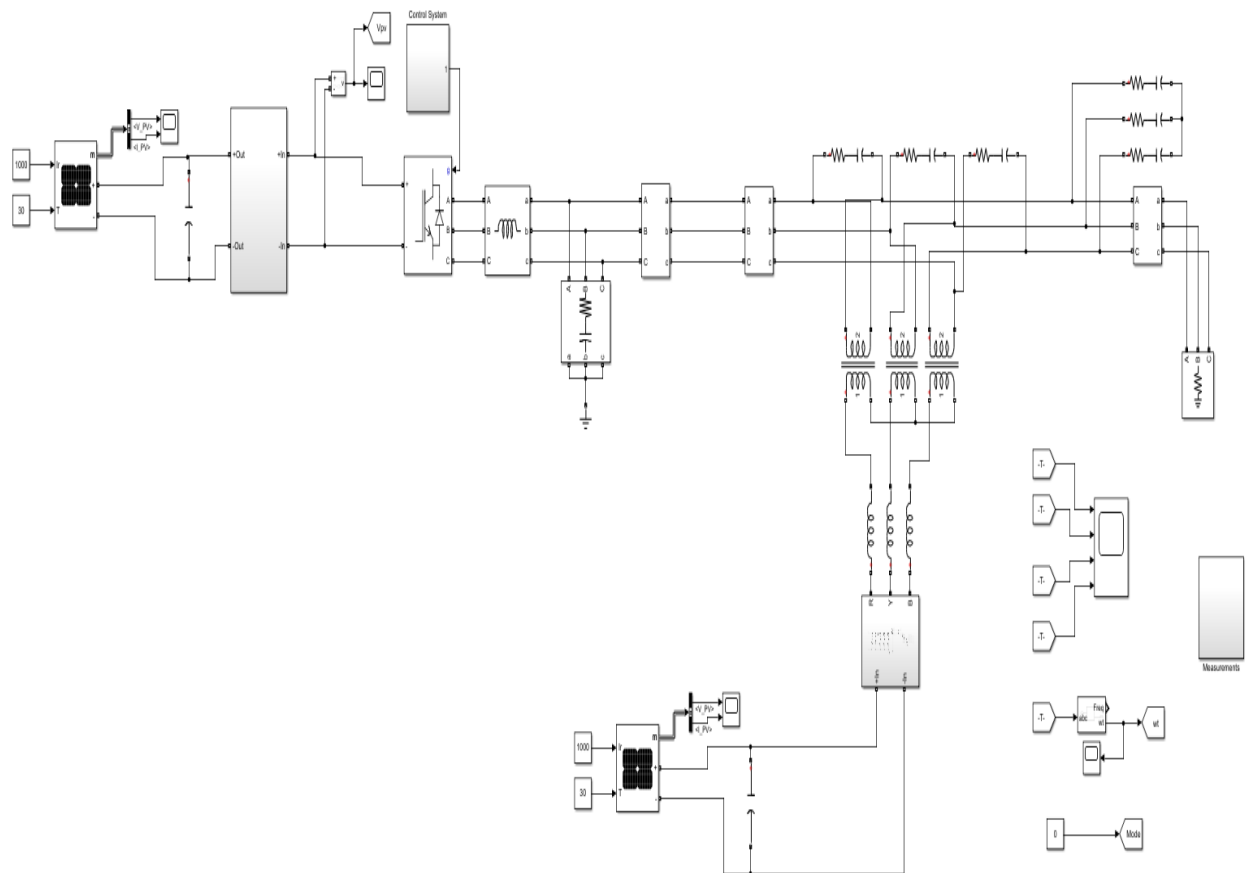


Fig:5.1 Simulation Block Diagram

5.2 SIMULATION BLOCK DIAGRAM EXPLANATION

PV ARRAY: A photovoltaic (PV) array is a collection of solar cells that are interconnected to form a module or a larger solar panel. Solar cells are devices that convert sunlight directly into electrical energy through the photovoltaic effect.

PV arrays are used to harness the sun's energy and generate electricity in both residential and commercial applications. They are typically installed on rooftops, open fields, or other suitable areas where they can receive maximum sunlight exposure.

The size of a PV array can vary depending on the power needs of the system it's designed to support. Arrays can be configured in series or parallel connections to achieve the desired voltage and current levels required for a specific application.

In addition to their environmental benefits, PV arrays offer long-term cost savings over traditional energy sources. They require minimal maintenance and have a lifespan of up to 30 years or more, making them a reliable and efficient source of renewable energy.

LINEAR TRANSFORMER: A series RL branch is a circuit that consists of a resistor (R) and an inductor (L) connected in series. The RL branch is a type of passive electronic circuit and is commonly used in applications such as filters.

In an RL circuit, the inductor opposes changes in current flow while the resistor dissipates energy in the form of heat. When a voltage source is applied to the circuit, an initial current begins to flow through the inductor. As the current increases, the voltage across the resistor also increases, which in turn reduces the voltage across the inductor. This results in a decrease in the rate of change of the current, causing the inductor to oppose the change in current flow.

The behavior of an RL circuit can be described mathematically using differential equations. The time constant of the circuit, which is the product of the resistance and the inductance, determines the rate at which the current changes in the circuit.

SERIES RL BRANCH: A series RL branch is a circuit that consists of a resistor (R) and an inductor (L) connected in series. The RL branch is a type of passive electronic circuit and is commonly used in applications such as filters, power supplies, and signal processing.

In an RL circuit, the inductor opposes changes in current flow while the resistor dissipates energy in the form of heat. When a voltage source is applied to the circuit, an initial current begins to flow through the inductor. As the current increases, the voltage across the resistor also increases, which in turn reduces the voltage across the inductor. This results in a decrease in the rate of change of the current, causing the inductor to oppose the change in current flow. The behaviour of an RL circuit can be described mathematically using differential equations. The time constant of the circuit, which is the product of the resistance and the inductance, determines the rate at which the current changes in the circuit.

UNIVERSAL BRIDGE: A universal bridge is a type of electrical circuit that is used to measure the values of resistance, capacitance, and inductance of a device under test (DUT). It is called "universal" because it can be used to measure a wide range of components and is not limited to any specific type or value. The universal bridge typically consists of four arms, each containing a known resistance, capacitance, or inductance element, and a galvanometer or meter to measure the balance or difference between the arms. By adjusting the values of the known elements, the bridge can be balanced, and the values of the unknown components.

Overall, the universal bridge is an important tool for accurately measuring the properties of electronic components and is widely used in electronics, physics, and engineering applications.

CONTROL SYSTEM: A control system is a system of devices, equipment, and software that manages and regulates the behavior of other systems or processes. It is

used to ensure that a particular process or system performs in a desired manner by regulating its inputs, outputs, and other variables.

There are two main types of control systems: open-loop control systems and closed-loop control systems. Open-loop control systems operate without feedback, while closed-loop control systems use feedback to adjust their outputs based on the system's performance.

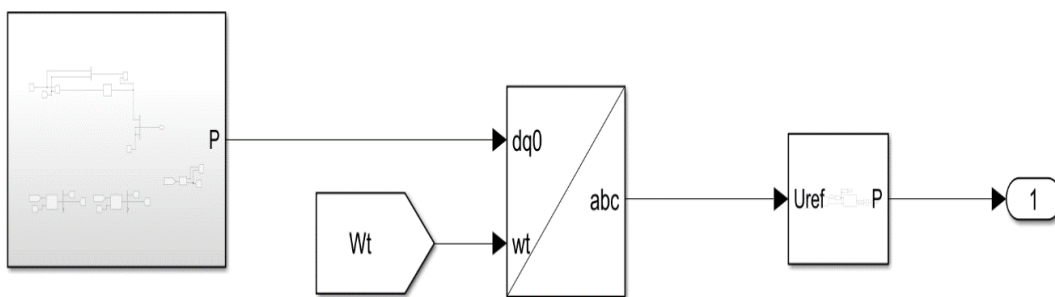


Fig: 5.2 Control system

SUBSYSTEM: A subsystem is a smaller system within a larger system. It is designed to perform a specific function or task within the larger system. The uses of subsystems are numerous and can vary depending on the system in question. Here are some common uses of subsystems:

1. **Modularity:** Subsystems can be designed to be modular, meaning they can be easily replaced or upgraded without affecting the rest of the system. This makes maintenance and upgrades easier and more efficient.
2. **Optimization:** Subsystems can be designed to optimize specific functions or processes within a larger system. For example, a subsystem in a manufacturing plant may be designed to optimize energy efficiency, reduce waste, or increase production capacity.

3. Customization: Subsystems can be customized to fit specific needs or requirements within a larger system. This allows for greater flexibility and adaptability in various applications.
4. Complexity management: Subsystems can be used to break down complex systems into smaller, more manageable parts. This simplifies the design, construction, and maintenance of the overall system.
5. Standardization: Subsystems can be standardized to ensure compatibility with other systems or components. This can reduce costs and improve efficiency by allowing for interchangeability and ease of integration.

Overall, the use of subsystems can lead to more efficient, reliable, and cost-effective systems in a variety of applications.

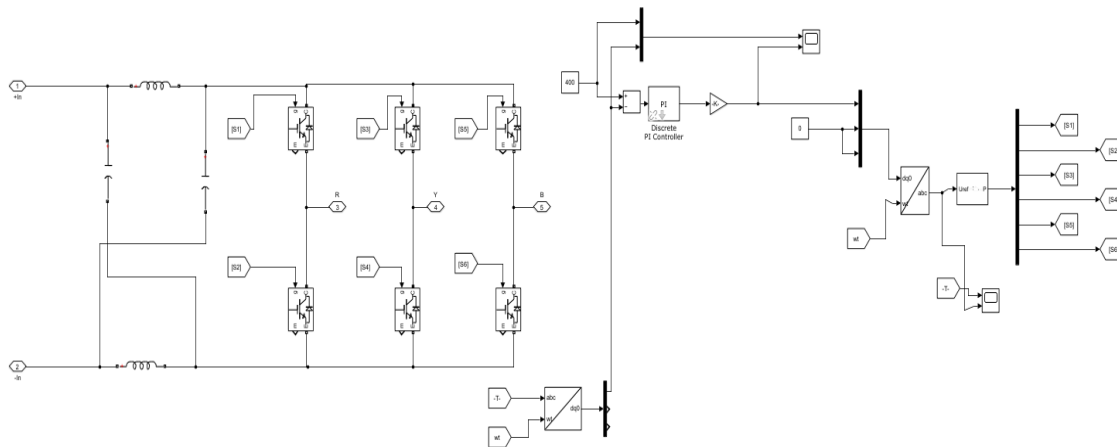


Fig: 5.3 Subsystem

PLL: A Phase Locked Loop (PLL) is an electronic circuit that can synchronize the frequency of an output signal with that of an input reference signal. It consists of three main blocks: a Phase Detector (PD), a Low Pass Filter (LPF), and a Voltage Controlled Oscillator (VCO).

The Phase Detector compares the phase of the input signal and the output signal of the VCO, and produces an error signal proportional to the phase difference. This error signal is filtered by the Low Pass Filter to remove unwanted high frequency components, and then used to adjust the frequency of the VCO.

The VCO generates an output signal whose frequency is proportional to the input voltage. By adjusting the input voltage to the VCO, the frequency of the output signal can be made to track the frequency of the input reference signal.

PLLs are used in a wide variety of applications, including clock recovery, frequency synthesis, and demodulation of frequency modulated signals. They are also used in many digital communication systems to recover the timing and carrier frequency of the received signal.

5.3 SIMULATION RESULTS

The behavior of a grid-connected photovoltaic (PV) system using a dynamic voltage restorer (DVR) to enhance power quality can be modelled and examined using modelling.

STEP 1 - Making a model of the PV system that is connected to the grid would be the first stage. The PV array, the inverter, and the grid link would all be part of this arrangement. The model would also include information on the system's electrical characteristics, such as the grid's voltage and frequency, the PV array's power output, and the power usage of any loads attached to the system.

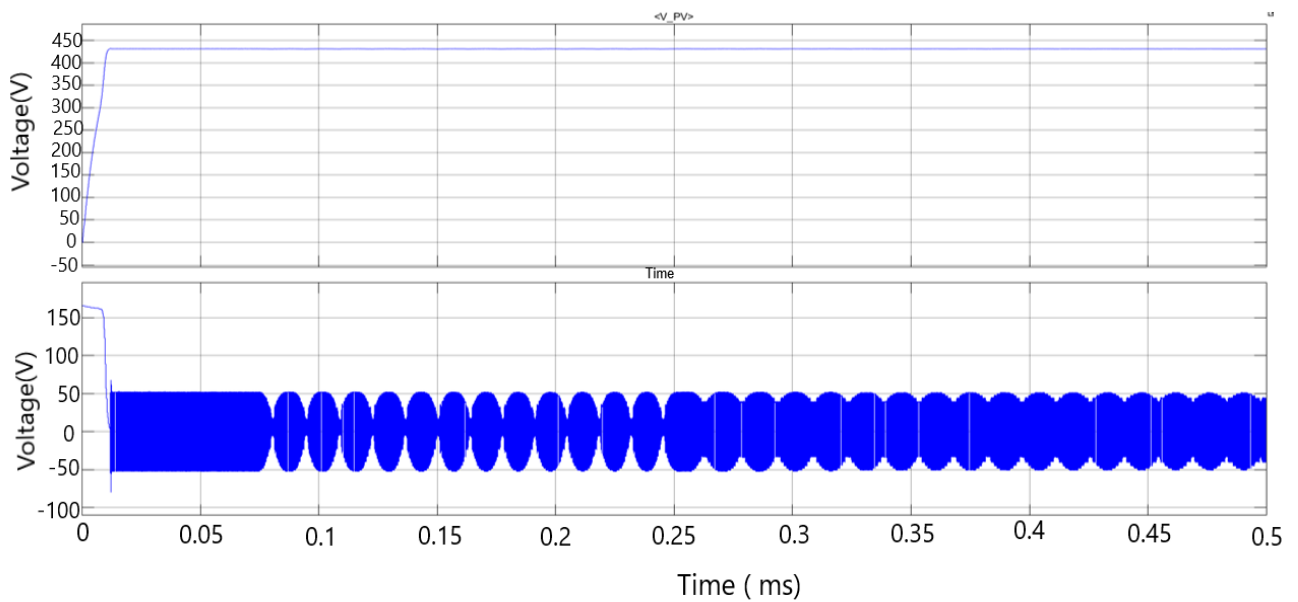


Fig: 5.4 Supply voltage

STEP 2 - The DVR would then be added to the variant after that. The DVR is a tool that has the ability to inject voltage into the system to compensate for voltage disturbances brought on by grid fluctuations or abrupt changes in load demand. The working parameters of the DVR, such as its voltage and current ratings, control scheme, and voltage injection reaction time, would need to be included in the model.

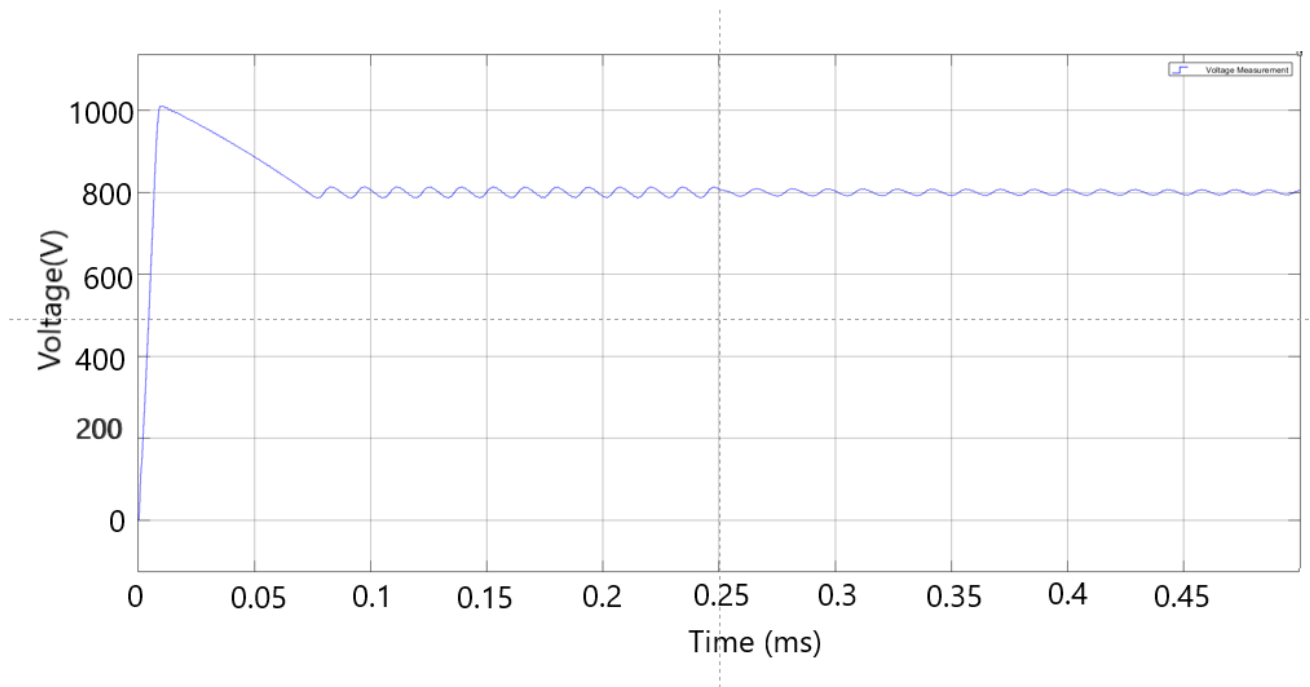


Fig: 5.5 Load Voltage

STEP 3 - Once the model is complete, the simulation can be run to examine how the system performs in different scenarios. The simulation, for instance, could be used to examine how the system reacts to sudden shifts in load demand or to voltage fluctuations in the grid. The simulation could also be used to assess how well the DVR works to reduce these disturbances and enhance electricity quality.

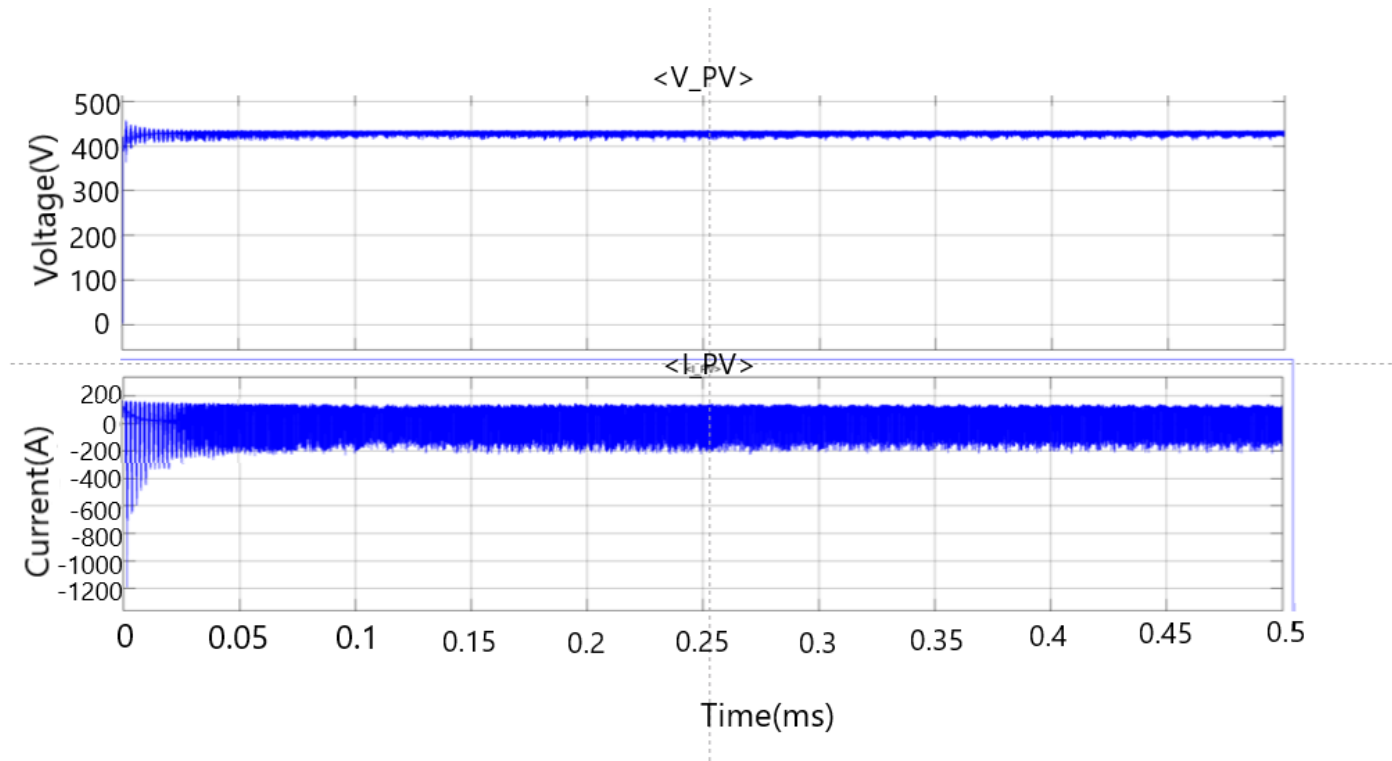
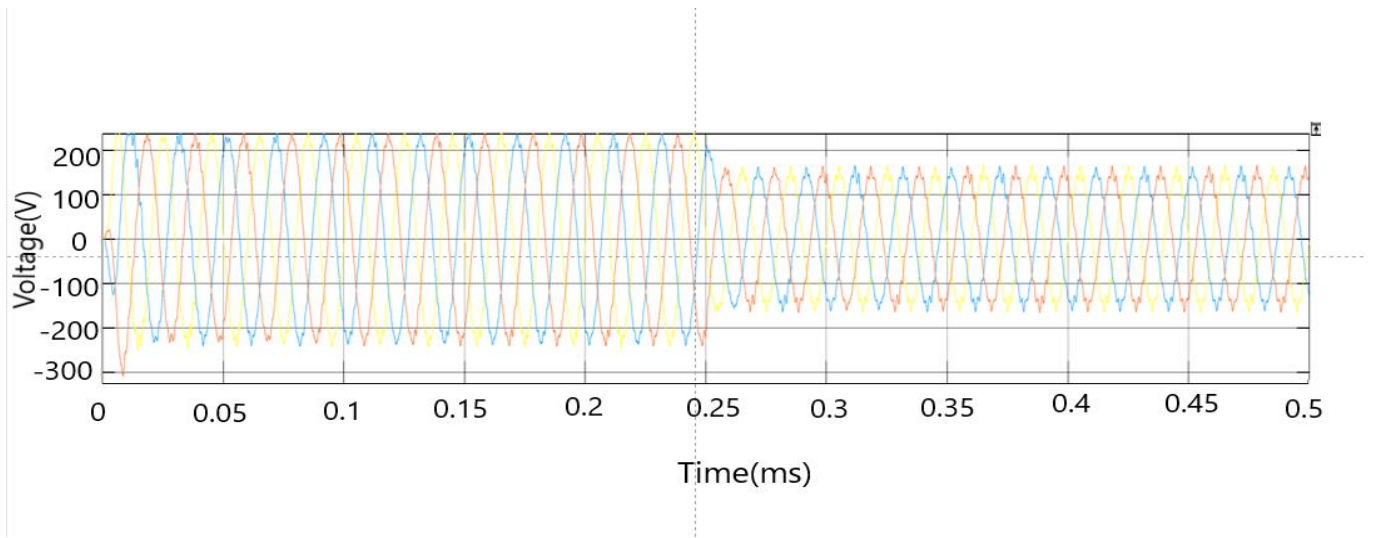
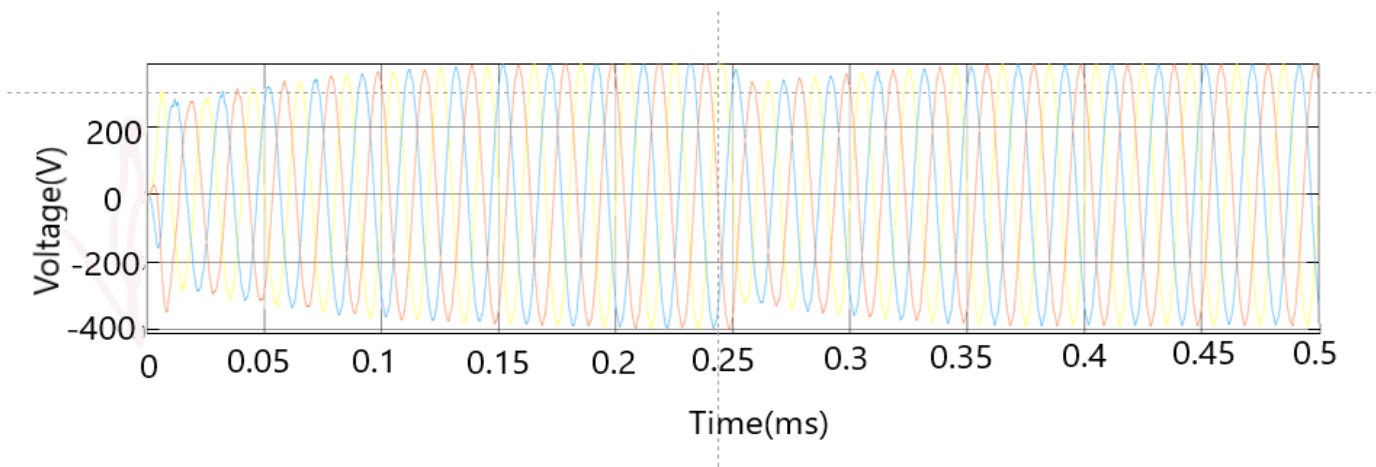


Fig: 5.6 Injected Voltage

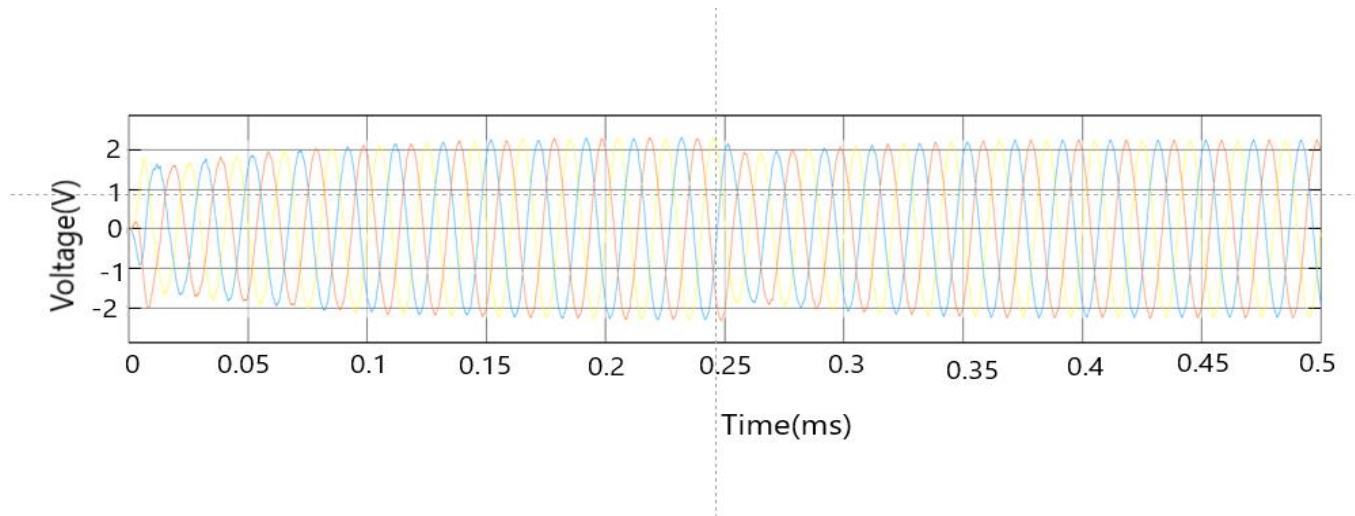
STEP 4 - Finally, the simulation's output could be examined and used to modify the system's architecture or the DVR's management scheme. The simulation may, for instance, show that the DVR is injecting too much voltage into the system or that it is not responding to voltage disturbances fast enough. On the basis of these discoveries, modifications could be made to enhance system functionality and guarantee that it complies with the necessary power quality standards.



(A). Transmission wave form



(B). Voltage sag / Swell



(C) Compensated Voltage

5.4 SIMULATION COMPARISON

Table: 5.1 Simulation comparison

S No		STATCOM	DVR
1.	Input Voltage (DC)	440V	440V
2.	Output Voltage (AC)	13V	17V
3.	Distance between supply and load	100m	500m
4.	Efficiency	84%	98%

5.5 HARDWARE DESIGN

This is the hardware implementation of Dynamic Voltage Restorer (DVR) designed for mitigation of voltage sags. In this the arrangement is of 10 sub circuits, DVR coupling network, Opto-coupler circuit, Isolated power supply circuit, Load, Line Impedance, microcontroller, isolated transformer, and the 3 transformers are: 1) for DVR DC Supply, 2) for trigger circuit, 3) for control circuit

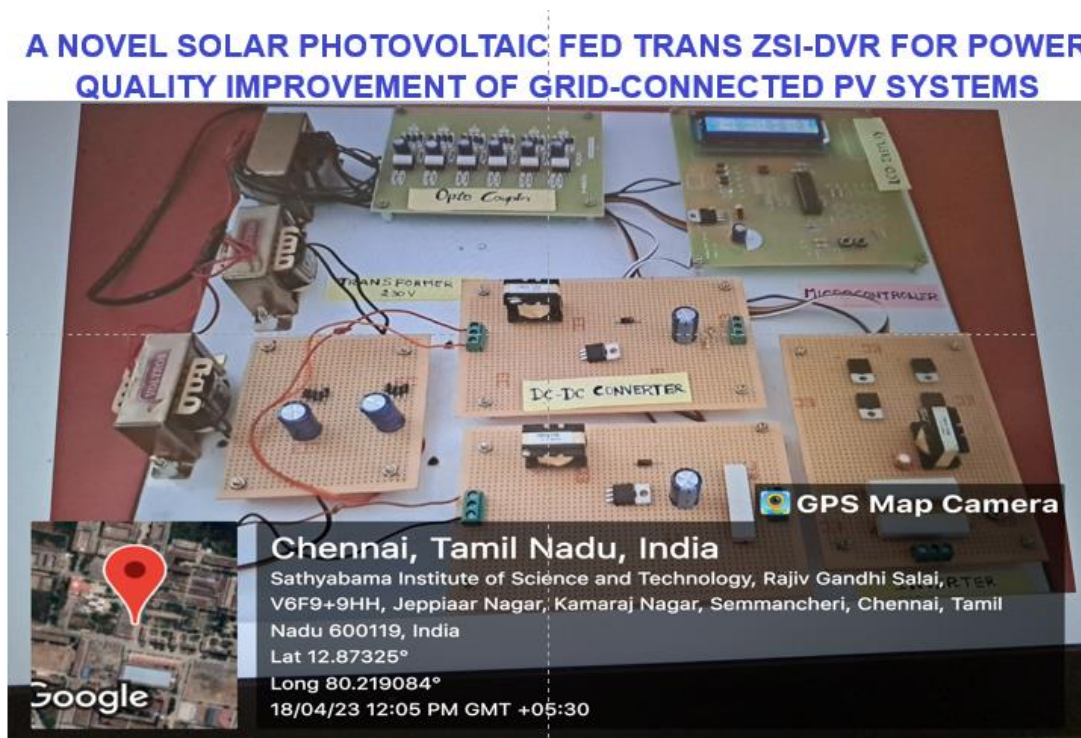


Fig: 5.8 Hardware Design

From the power supply transformer is receiving 230V AC. It is then stepped down to 12V using bridge wave rectifier in the opto-coupler board 12V AC is converted to 5V DC and the voltage regulator receives the 5V. So, that the microcontroller and LCD runs in this 5V.

So, now in the opto-coupler board the primary side consists of 5V and the secondary side consists of 12V. From this secondary side the 12V will be coming to the DC-DC converter. So, now the input of the converted will be 12V. Both the converters will be connected by a common bus system. So, that in both the converters the output voltage will be balanced due to load balancing. If any one of the input is removed from the converter side the output voltage will be maintained without any changes. Then in the inverter side the received DC output is converted to AC and is used for households. Here, if the load is increased also the output voltage will be balanced.

5.6 HARDWARE RESULTS

5.6.1 INPUT AND SET VALUES

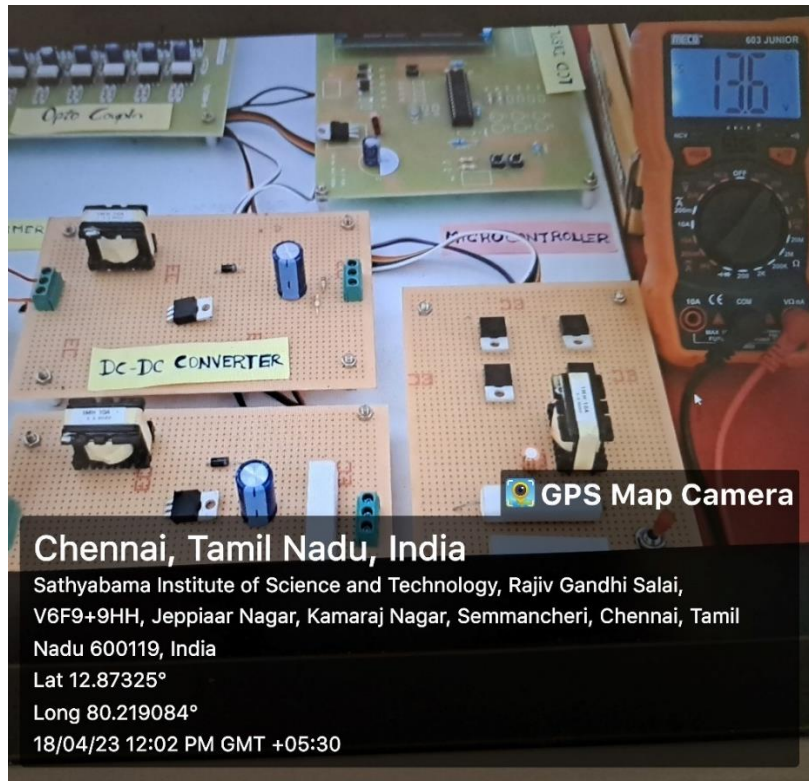


Fig: 5.9 Input Value

12 volts is the input power for the DC-DC converter. If we examine the converter using a multimeter, it will receive almost 13.6V. It resembles 12V. Since both converters are connected by a common bus system, if we check in another converter, it will also be getting the same input voltage.

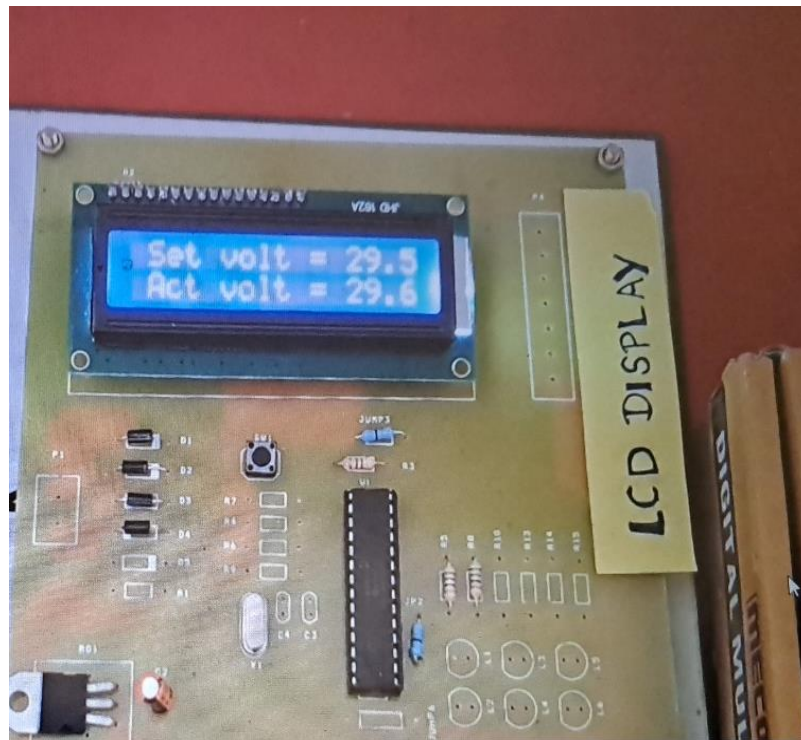


Fig: 5.10 LCD Display

5.6.2 OUTPUT VALUES



Fig: 5.11 Output Value

When it comes to the output, the LCD display's default output voltage is 29.5V. Currently, a Multimeter can be used to determine the output voltage, which is 28.4V. It's comparable to 29.5V. The LCD's output value was fixed to be 29.5 volts, but we actually got 28.4 volts.



Fig: 5.12 Output Value

Moving on to the inverter side, we only got DC output voltage from the DC-DC converter, so we had to convert it to AC voltage. Therefore, to transform DC to AC, we used an inverter circuit. We got nearly 17.2V AC after converting the AC voltage, and if we applied a single load, we would get 17.2AC. Increasing the load while maintaining steady output voltage.

5.7 HARDWARE COMPARISON

Table: 5.2 Hardware comparison

S No		STATCOM	DVR
1.	Input Voltage (DC)	230V/12V	230/12V
2.	Output Voltage (AC)	14V	17.6V
3.	Distance between Supply and Load	10m	20m
4.	Efficiency	86%	98%

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The power quality of a grid-connected photovoltaic (PV) system can be improved using a dynamic voltage restorer (DVR). A DVR is a power electronics device that can inject voltage into the system to compensate for voltage sags and swells. By connecting a DVR in parallel with the PV system, the voltage regulation capabilities of the system can be improved, leading to better power quality for the connected loads.

The DVR operates by continuously monitoring the grid voltage and injecting a compensating voltage when necessary. The compensating voltage is generated by an energy storage system, which can be either a battery or a capacitor. The DVR can respond to voltage disturbances within a few milliseconds, making it an effective solution for improving power quality.

In addition to voltage regulation, the DVR can also improve the overall efficiency of the PV system by reducing power losses due to voltage sags and swells. The use of a DVR can also increase the lifespan of the PV system components by reducing the stress on the system caused by voltage fluctuations.

Overall, the use of a DVR in a grid-connected PV system can significantly improve power quality and system efficiency, leading to improved reliability and reduced maintenance costs.

6.2 CONCLUSION

- In grid-connected PV systems, the dynamic voltage restorer (DVR) can be a useful tool for enhancing power quality. DVR can be used to reduce voltage sags, swells, and transients brought on by various failures, switching activities, and significant variations in load.
- The PV system can function at peak levels and prevent potential harm from voltage fluctuations thanks to the DVR's quick and precise voltage management.
- DVR use in grid-connected PV systems has a number of advantages, including better system stability, better power quality, and less downtime. The demand for dependable and effective power quality solutions like DVR will only increase as renewable energy sources like PV continue to gain prominence.

6.3 FUTURE SCOPE

- **Implementation of advanced control algorithms:** Researchers are developing advanced control algorithms to improve the performance of DVRs. These algorithms can help in improving the response time of the DVR, making it more effective in mitigating voltage sags and swells.
- **Integration with renewable energy sources:** With the increasing use of renewable energy sources such as solar and wind power, the integration of DVRs with these sources is becoming more important. DVRs can help in stabilizing the voltage output from these sources, making them more reliable and efficient.
- **Application in electric vehicles:** As electric vehicles become more popular, there is a need for reliable and efficient charging infrastructure. DVRs can be used to stabilize the voltage at charging stations, ensuring that the charging process is fast and efficient.

- **Use in smart grids:** Smart grids are becoming more popular, and DVRs can play a crucial role in these systems. DVRs can help in improving the reliability and stability of the grid, ensuring that power quality is maintained at all times.
- **Development of modular designs:** The development of modular designs for DVRs can help in improving their flexibility and scalability. This can make them more suitable for a wide range of applications, from small residential systems to large industrial installations.

Overall, the future scope of a project involving a DVR is quite broad and offers many opportunities for innovation and development. With the increasing demand for reliable and efficient power systems, the role of DVRs is likely to become even more important in the coming years.

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