e-ISSN:2582-7219

# INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 7, July 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

# Mitigation of Power Quality Issues Using Dynamic Voltage Restorer (DVR)

**Prathipa P, Rathidevi P**

Final Year Master of Engineering in Power System Engineering, Department of Electrical and Electronics Engineering, J.J. College of Engineering and Technology, Tiruchirapalli, Tamil nadu, India

Assistant Professor ( Sr.G), Department of Electrical and Electronics Engineering, J.J. College of Engineering and Technology, Tiruchirapalli, Tamil nadu, India

**ABSTRACT:** In the modern power system, power quality is a crucial topic that can have an impact on consumers and utilities. Service interruptions can result in severe financial loss for utility distribution networks, sensitive industrial loads, and important industrial load activities. This includes distribution grid voltage sags and swells, which are thought to be the most prevalent type of power quality issues. Different techniques have been devised to protect sensitive loads from voltage disturbance and to maintain a steady voltage in the system, but DVR is thought to be the most effective and efficient approach. To explain and comprehend the functioning of the DVR under sag situations, simulation results were provided with PI control strategy. PI controller is a powerful tool to vary the triggering pulse of the devices and to vary the output voltage in order eliminate the voltage swell or sag occurring in the distribution network. The voltage across the storage device, capacitor Vc and the line voltage are the reference to decide to absorb or inject the power in the line. Voltage sag is one of the most severe power quality disturbances to be dealt with by the industrial sector, as it can cause severe process disruptions and results in substantial economic loss. Voltage sag mitigation can be done using dynamic voltage restorer (DVR) and inter-line dynamic voltage restorer (IDVR). One of the main factors which limit capabilities of DVR in compensating long-duration voltage sags is the amount of stored energy within the restorer. In order to overcome this limitation, IDVR has been proposed where two DVRs each compensating a transmission line by series voltage injection, connected with common dc-link. When one DVR compensates voltage sag, the other DVR of the IDVR replenish the dc-link energy storage. The control strategy adopted for generating reference signal plays a key role in deciding the dynamic behavior of a system. In the existing IDVR system, the amount of real power that a line can transfer to dc-link energy storage depends on the load PF.

**KEYWORDS:** DVR, PI Controller, Voltage Sag, Compensator, Power Quality.

## I. INTRODUCTION

Power quality refers to how well the electricity delivered to electrical equipment matches the desired characteristics. It is an essential aspect of electrical power distribution and consumption, and it encompasses a wide range of parameters that impact the performance, reliability, and safety of electrical equipment.

In today's digitally-driven world, power quality is more important than ever before. Most electrical and electronic equipment in industries, offices, and homes require high-quality power to function correctly. The efficiency and productivity of equipment depend heavily on power quality. Poor power quality leads to increased downtime, more fault conditions, and, in some cases, complete equipment failure [01-03]. In addition, machines that rely on high-quality power run more efficiently, reduce energy waste, and decrease the risk of equipment damage, resulting in a significant reduction of operating costs.

### 1.1 THE MAIN FACTORS THAT IMPACT POWER QUALITY

The measure of electrical power's capacity to meet the requirements of the devices, is influenced by multiple factors. Here are some of the significant factors:

Voltage Level Many electronic devices work within a specific voltage range. Variations in the voltage level can cause the equipment to malfunction and cause power quality problems. Low voltages, for instance, can lead to reduced efficiency, and equipment damage, whereas high voltages can cause overheating and even equipment failure [04-07].

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

**Unbalanced Voltage**

Unbalanced voltage is a power quality issue where the three phases of a three-phase power system have different magnitudes, creating an asymmetrical waveform. This asymmetry can be caused by unbalanced loads, faulty connections, or phase-to-ground faults. Unequal voltage levels in different phases of the system can cause unbalanced current flow, leading to overheating of equipment and reduced operating efficiency. Negative or zero-sequence components in the voltage waveform can lead to ground fault current flow, causing damage to equipment and creating safety hazards [08-10].

**Voltage Sag**

Voltage sag or dip is a temporary reduction of voltage below the normal level that lasts for a few cycles to a few seconds. It is caused by a sudden increase in load, a voltage drop in the power grid, or a fault in the system [11-12].

**Voltage Swell**

Voltage swell is a temporary increase in voltage above the normal level that lasts for a few cycles to a few seconds. It is caused by sudden changes in load or when a fault on the system is cleared [13-14].

**Voltage Interruption**

Voltage interruption is a complete loss of voltage for a short period of time. It can be caused by a fault in the distribution system or by lightning strikes, and it can last from a few milliseconds to a few minutes. This interruption can cause equipment to shut down or reset, causing damage or data loss.

**Flicker**

A flicker is a momentary or sustained variation of voltage characterized by rapid changes in magnitude. It is caused by sudden changes in load, such as the starting of large motors, or by the operation of certain power system equipment like arc furnaces, welding machines, or large drives. The variation in voltage can cause lighting to flicker, which can be noticeable and annoying to occupants. Flicker events are measured by their frequency and depth, and they can impact the performance and lifetime of electronic equipment.

**Electrical interference**

Interference occurs when noises from other sources, such as other electrical systems, power lines, or even radio transmissions, get mixed in with the electrical signal. Electrical noise can result in signal degradation that can interfere with the equipment's functioning.

**Lack of grounding**

Grounding refers to connecting an electrical circuit to the earth. This helps ensure stability, reduce noise and interference, and prevent shocks from electrostatic buildup. Without proper grounding, sensitive electronic equipment can malfunction or become damaged.

**Harmonics**

Harmonics are higher-frequency electrical signals that contaminate the power delivered by utilities to businesses and homes. Electronic devices with nonlinear loads produce harmonics that can interfere with distribution equipment's operation and cause damage to electrical equipment [15-17].

**Power Factor**

Power Factor (cosφ) is the relation between apparent power and active power. Inefficient systems tend to have more apparent power than active power, leading to wastage of energy and possibilities of equipment damages.

**Transients**

Transients refer to sudden and brief fluctuations in voltage or current that occur over a short period of time. They can be caused by events such as lightning strikes, switching operations, or faults in the power system. Transients can range from a few microseconds to several milliseconds in duration, and they can have a significant impact on the operation and reliability of electrical systems and equipment. Transient voltage surge suppressors, surge protective devices, and other protective measures can be implemented to limit the effects of transients on electrical systems and equipment.

**Mitigating power quality problems**

There are several ways to overcome power quality problems. Some of the common solutions are:

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

Conduct a power quality analysis;
The first step to overcome power quality problems is to conduct a power quality analysis. This involves measuring power quality parameters such as voltage, current, frequency, and harmonics to identify any adverse power quality events.
Implement voltage regulation;
Installing voltage regulation equipment, such as voltage regulators, stabilizers or transformers, can help regulate voltage fluctuations and maintain a stable power supply.

**Use power conditioning equipment**
Power conditioners, such as surge protectors, uninterruptible power supplies (UPS), and harmonic filters can help to mitigate the effects of power quality issues.
Use high-quality electrical equipment Using high-quality electrical equipment, such as motors, transformers, and inverters, can reduce the occurrence of power quality problems.

**Improve grounding and bonding**
Proper grounding and bonding of electrical systems can help to eliminate ground loops and reduce noise and interference.

**Train personnel**
Training personnel on power quality issues and how to troubleshoot electrical equipment can help to identify and resolve power quality problems quickly. Work with a power quality specialist. Consulting with a power quality specialist can help to identify potential power quality problems and provide recommendations for resolving them. Overall, overcoming power quality problems requires a multifaceted approach that includes identifying the root cause of the problem and implementing appropriate corrective measures.

## II. PROPOSED SYSTEM

### 1.1 BLOCK DIAGRAM

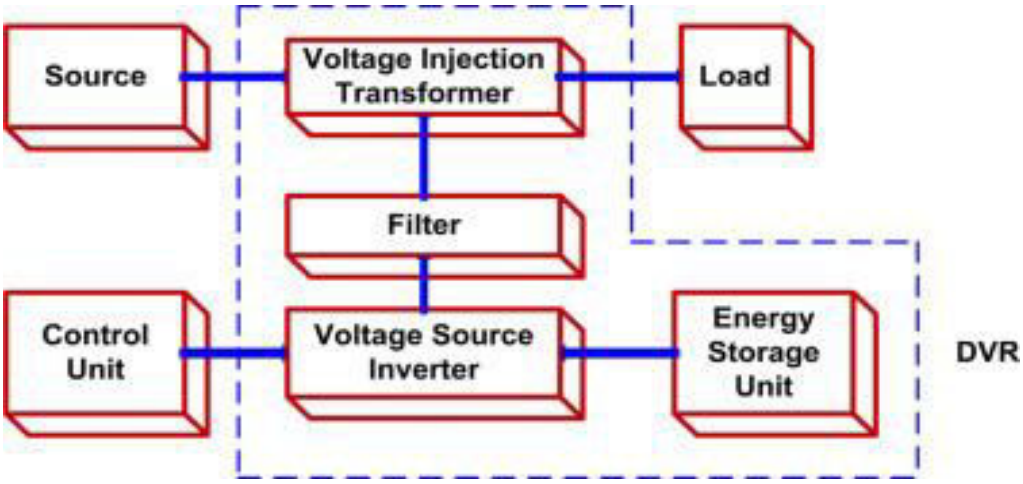


Fig 1 Block diagram of DVR

The DVR has actually a voltage source converter, Storage device capacitor and filter to remove the unwanted ripples present in the output. The whole set up is connected in series with the load through a current transformer or coupling transformer. As the DVR is connected in series with the line, it will inject voltage in the line directly. Therefore the DVR is a powerful series compensating device to remove voltage sag or swell and it is illustrated in figure 1.
It will mitigate both voltage sag and swell that is increase in the voltage or decrease in the voltage caused due to load variation. If the voltage sag and swell or mitigated immediately, it may slowly damage the apparatus in the load side or it may affect the input side that is apparatus of the other's. The voltage sensor provided in the load will sense and give it to controller, according to feedback the controller will vary the firing angle of the inverter.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

### 2.2 CIRCUIT DIAGRAM

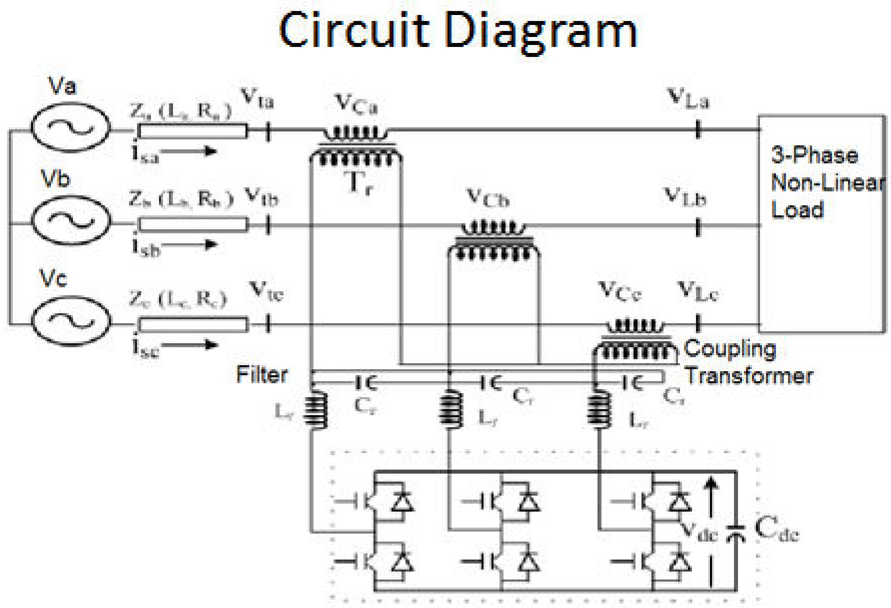


**Fig 2 Circuit Diagram of DVR**

Power quality (PQ) is an important issue in power systems that reflects a measure of quality of energy supply to the consumers. Power electronics-based equipment is increasing in power systems that cause voltage distortions which may damage a sensitive appliance in the distribution grid. Besides, many electrical and electronic equipment is susceptible to power supply disturbances in modern industrial establishments. The most vital power quality issues affecting large commercial and industrial customers are momentary power interruptions and voltage sags. Usually, these PQ issues are associated with the faults that occur in the supplying power systems. Voltage sags are very common since they can be associated with the faults that happen remotely to the customer. Further, these PQ problems with about 4–5 cycles may cause an extensive malfunction to the sensitive equipment. Therefore, an appropriate solution is necessary to handle this problem. A Dynamic voltage restorer (DVR) is a custom power device (CPD) that can protect sensitive equipment against voltage disturbances and improve power quality in electrical distribution systems. In recent years, many CPDs have been developed to meet the need of the industries and their critical load establishment. The DVR is one of the most promising CPDs used to improve the power quality before feeding it to the sensitive load to protect electric appliances from damage. The circuit diagram of DVR is shown in the figure 2

DVR is the combination of a voltage source inverter (VSI), which can impose the voltage in series through a series injection transformer (SIT) with the power distribution system during voltage sag. The required voltage compensation can be achieved by adopting the pulse width modulation (PWM) technique for VSI. The DVR's performance mainly depends upon the control system that includes voltage disturbance detection, reference generation, voltage & current control and PWM switching strategy. The main objective of the control system is to compensate for the disturbance at the earliest using a fast detection technique, optimum control variables for the control circuit and a suitable PWM switching methodology. Many such compensation methods and control techniques are proposed in the literature along with various DVR topologies which are analysed and studied in this chapter.

The capacitor will release energy to the line when the line voltage is lower than the capacitor voltage. The converter will then function as an inverter, transforming the voltage from the DC capacitor into an AC voltage that will be fed to the line. In a similar manner, the capacitor will absorb the energy from the line when the line voltage is larger than the capacitor voltage. As a rectifier, the converter will now transform the line's ac voltage to dc, which it will then store in the capacitor.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

## III. SIMULATION DIAGRAM

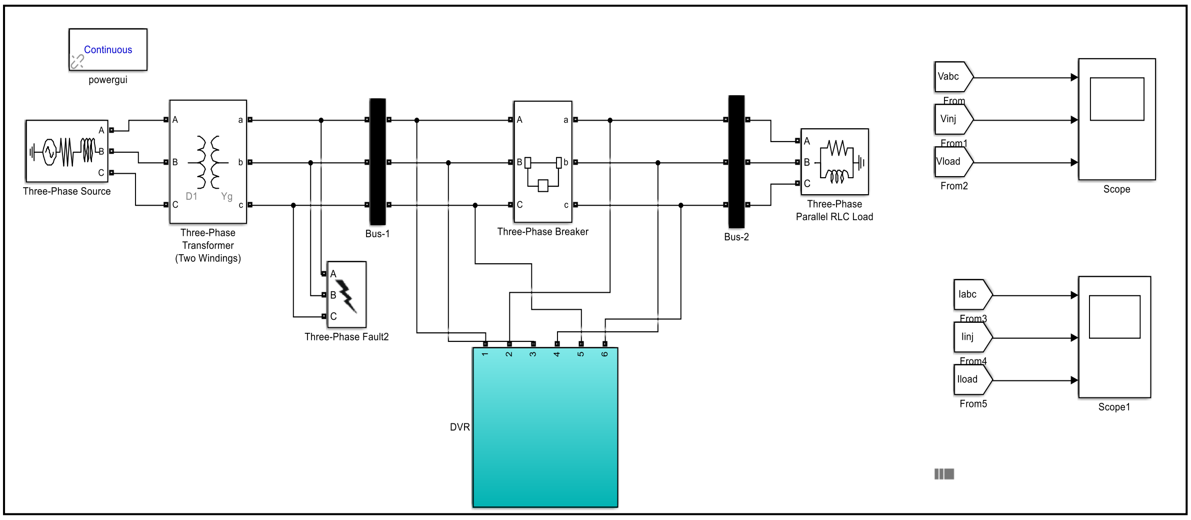


Fig 3 Simulink Diagram

The simu-link diagram and the outputs with various conditions are shown in the figure 3, 4 and 5.

### 3.1 SIMULATION OUTPUTS

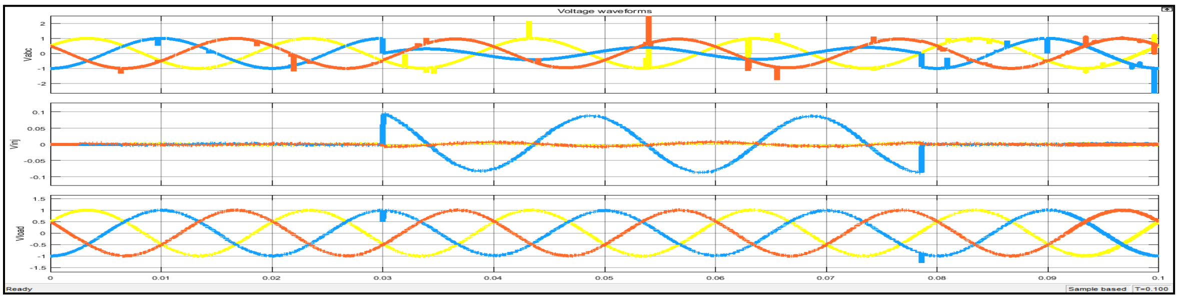


**Fig 4 Output Wave form of DVR without compensation**

The output waveform without compensation is depicted in figure 13.

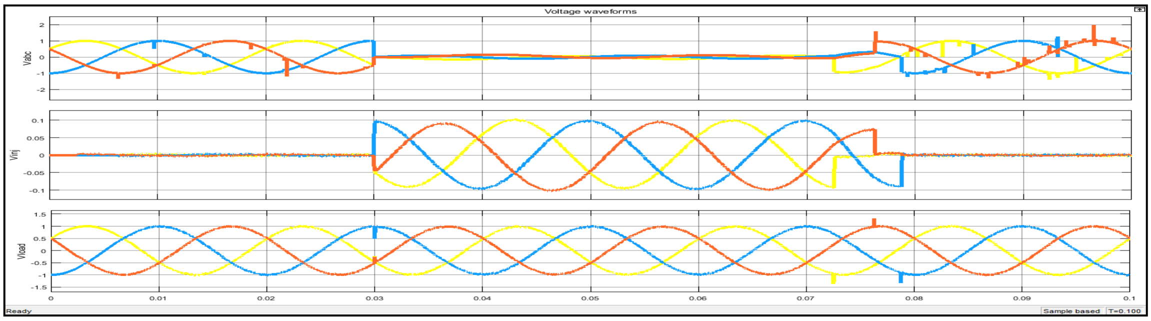


**Fig 5 Output waveform of DVR with compensation**

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

## IV. CONCLUSION

In the research, the main objectives is for the utilization of the studied equipment,(DVR) to mitigate voltage sag in load voltage profiles due to different symmetrical and unsymmetrical faults and reducing the distortion level occurring in the cases of harmonic generating sensitive load in distribution networks and thus highly improving the power quality of the system. This research has studied the characterization of voltage unbalances and its impact with special attention on PI control based mitigation techniques. In order to protect critical loads from more severe faults in the distribution network, the series connected voltage source converter known as Dynamic Voltage Restorer (DVR) is more suitable and satisfactory. Being reliable and cost effective, it was adopted to be the optimal solution for the compensation of voltage. The highly developed graphics facilities available in MATLAB/SIMULINK were used to carry out extensive simulation studies on DVR. The control scheme used is PI-controller technique. The voltage fluctuation and power outage can be reduce employing the DVR (a series connected custom power protection device) which protects the precision manufacturing process and highly sensitive electronic equipment. Therefore, DVR is considered to be an effective method due to its small size, low cost and fast dynamic response. The simulation results show the performance of a DVR in mitigating different faulty conditions. The DVR can handle both balanced and unbalanced conditions easily and injects the appropriate voltage components to correct rapidly the supply voltage to keep the load voltage constant and balanced at the nominal value. Also DVR is able to reduce the level of THD in the case of networks which are connected to the harmonic generated load.

## V. FUTURE SCOPE

The proposed system of mitigating power quality issues such as voltage sag, Voltage swell and many other problems can be extended by using various algorithms to tune the firing circuit through controller. The controller can also be modified or enhanced for the control of firing circuit. Therefore the power quality issues solving technique will be enhanced.

## REFERENCES

[1] Iqbal, Ahsan, et al. "Voltage stability enhancement in grid-connected microgrid using enhanced dynamic voltage restorer (EDVR)." AIMS Energy 9.1 (2021): 150-177.

[2] Benali, Abdelkrim, Mounir Khiat, and Mouloud Denai. "Voltage profile and power quality improvement in photovoltaic farms integrated medium voltage grid using dynamic voltage restorer." *International Journal of Power Electronics and Drive Systems*

[3] Pal, R., Gupta, S. Topologies and Control Strategies Implicated in Dynamic Voltage Restorer (DVR) for Power Quality Improvement. *Iran J Sci Technol Trans Electr Eng* **44**, 581–603 (2020). https://doi.org/10.1007/s40998-019-00287-3

[4] Essam A. Al-Ammar, Azhar Ul-Haq, Ahsan Iqbal, Marium Jalal, Almas Anjum,"SRF based versatile control technique for DVR to mitigate voltage sag problem in the distribution system,Ain Shams Engineering Journal,Volume 11, Issue 1,2020,Pages 99-108,ISSN 2090-4479,

[5] A. V. Khergade, R. J. Satputaley, V. B. Borg, hate and B. Raghava, "Harmonics Reduction of Adjustable Speed Drive Using Transistor Clamped H-Bridge Inverter Based DVR With Enhanced Capacitor Voltage Balancing," in *IEEE Transactions on Industry Applications*, vol. 56, no. 6, pp. 6744-6755, Nov.-Dec. 2020, doi: 10.1109/TIA.2020.3013823

[6]A. Mohamed Eltamaly, Y. Sayed Mohamed, A. -H. Mustafa El-Sayed and A. N. Abd Elghaffar, "Enhancement of Power System Quality Using PI Control Technique with DVR for Mitigation Voltage Sag," *2018 Twentieth International Middle East Power Systems Conference (MEPCON)*, Cairo, Egypt, 2018, pp. 116-121, doi: 10.1109/MEPCON.2018

[7] H. Soomro, A. S. Larik, M. A. Mahar, A. A. Sahito, and I. A. Sohu, "Simulation-based Analysis of a Dynamic Voltage Restorer under Different Voltage Sags with the Utilization of a PI Controller", *Eng. Technol. Appl. Sci. Res.*, vol. 10, no. 4, pp. 5889–5895, Aug. 2020.

[8] S. P. Singh, A. H, Bhat, and A. Kumar, "Fuzzy logic based dynamic voltage restorer for addressing various power quality problems," *2016 IEEE 7th Power India International Conference (PIICON)*, Bikaner, India, 2016, pp. 1-5, doi: 10.1109/POWERI

[9] Karimi, Hamid, Mohsen Simab, and Mehdi Nafar. "Compensation of voltage sag and voltage interruption using DVR-PV based on the fuzzy-adaptive controller." *International Transactions on Electrical Energy Systems* 30.6 (2020): e12376.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707267 |

[10] H. S. Thaha and T. R. D. Prakash, "Use of Fuzzy Controller Based DVR for the Reduction of Power Quality Issues in Composite Micro-Grid," 2020 International Conference on Renewable Energy Integration into Smart Grids: A Multidisciplinary Approach to Technology Modelling and Simulation (ICREISG), Bhubaneswar, India, 2020, pp. 131-136

[11] Mehmet Tumay, Ahmet Teke, K.Cagatay Bayindir & M.Ugras Cuma in "Simulation and Modelling of a Dynamic Voltage Restorer" Cukurova University, Faculty of Engineering and Architecture, Department of Electrical & Electronics Engineering,01330, BalcalÕ, Adana,

[12] T.Devaraju & V.C.Veera Reddy in "Performance of DVR under different voltage sag and swell condition" ARPN Journal of Engineering and Applied Sciences , VOL. 5, NO. 10, OCTOBER 2010

[13] S.Sadaiappan & Dr.P.Renuga in "Modeling and simulation of series compensator to mitigate power quality problems" International Journal of Engineering Science and Technology , Vol. 2 (12), 7385- 7394 , 2010.

[14] Mahmoud A. El-Gammal, Amr Y. Abou-Ghazala & Tarek I. ElShennawy in "Dynamic Voltage Restorer (DVR) for Voltage Sag Mitigation" International Journal on Electrical Engineering and Informatics Ǧ Volume 3, Number 1, 2011

[15] Rosli Omar and Nasrudin in "Modeling and simulation for voltage sag/swell mitigation using dynamic voltage restorer (DVR)" Journal of Theoretical and Applied Information Technology.

[16] H.P. Tiwari and Sunil Kumar Gupta in "Dynamic Voltage Restorer against Voltage Sag" International Journal of Innovation, Management and Technology, Vol. 1, No. 3, August 2010.

[17] S.V Ravi Kumar and S. Siva Nagaraju in " Simulation of D-Statcom and DVR in Power Systems" Asian Research Publishing Network (ARPN), Vol. 2, No. 3, June 2007


INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INNO SPACE SJIF Scientific Journal Impact Factor

# INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com