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"Performance Assessment Of Distributed Generation System To Improve The Power Quality Using Disturbance Mitigation Techniques"

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Abstract: The major power quality issue is voltage sag & swell that can cause mal- operation of sensitive electronic equipment. The power system is a complex network of generation, transmission, and distribution entities. With the increasing integration of alternating energy sources like wind-solar power, grid stability and power quality have become significant concerns. This research work suggest a technique like voltage sag control through desired power devices known as Dynamic Voltage Restorer (DVR) and STATCOM. A modified control system with compact switching devices and improved compensating capability is presented. The proposed technique utilizes voltage injection and pulse width modulation (PWM) signal control to mitigate sag/swell disturbances. The designed system results reflect the effectiveness of the desired mitigation methods or technique under various conditions. This project focuses on modeling and analyzing a DVR with a PWM-based controller using simulink, Highlight the most efficient control techniques for improving the power quality.

Index Terms **-** DVR, Voltage Sag, PWM, Voltage Swell, Sag Mitigation, Swell Mitigation, Switched Auto Transformer etc.

I. Introduction

Voltage sag/swell is a prevalent power quality issue affecting industrial operations and sensitive equipment. It can cause mal - operation, failure, or reduced efficiency of electrical devices and machines. The different factors generate the voltage problem in power system such as voltage drop and rise, This problems include load changing or switch on the motor and non-linear loads. The microprocessor-based system affected due to the sensitive loads and that can be important. To remove these problems and power electronics-based systems as a Dynamic-Voltage-Restorer (DVR) had been buildup. DVR can mostly balanced voltage drop & rise, ensuring constant function of sensitive devices. By adjust the classification after found a fault, DVR activated & continues power supply and keep the system stability. This project work explains the use of DVR in situation like voltage drop or rise for improve the power quality.

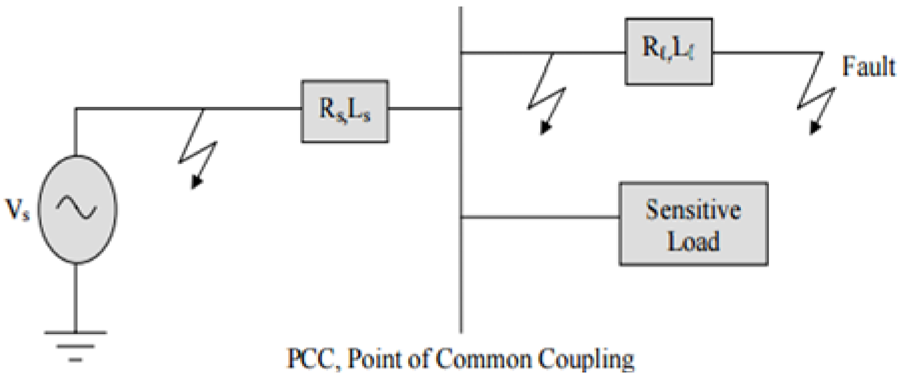

Fig. 1.1- Voltage Sag generator

The DVR is a custom power device designed to mitigate power quality issues. It features a Pulse Width Modulated (PWM) Voltage Source Inverter (VSI) system, enabling independent generation or absorption of real or reactive power. The DVR's primary function is to inject three-phase voltages in series and synchronize with the grid voltages, correcting anomalies in supply voltage or load current. Voltage sags caused by faults, such as unsymmetrical or symmetrical faults, can significantly impact sensitive loads. The DVR addresses this issue by injecting individual voltages to restore the desired voltage level, ensuring reliable operation of sensitive equipment. By providing fast and precise voltage correction, the DVR increased the stability of power quality.

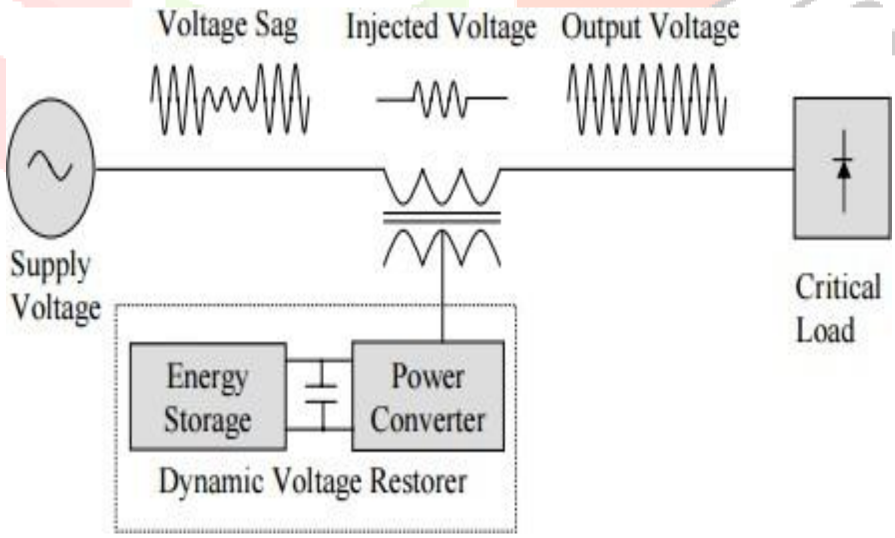

Fig. 1.2- block diagram of DVR

II. Power Quality Problems

A. Voltage sags

Voltage sag/swell refers to a brief reduction in voltage magnitude, typically lasting from a few cycles to several seconds. According to IEEE standards, voltage sag means the level of voltage decrease in RMS voltage between 0.1 and 0.9 per unit (pu) for a duration of 0.5 cycle to 1 minute. General reasons of voltage drop consider the system faults, transformer power supply, and heavy load switching, that can affected the devices performance and reliability.

B. Interruptions

The interruption is a most countable reduction in voltage value, Mostly the below 0.9 per unit (pu), consider less than 1 minute. It mostly occurs as a result of a fault on the source system, potentially following a voltage sag. The time period of a disturbance is a key factor, as the maximum value remains relatively constant. At the time of takes for the protection system to respond, the system experiences the fault's impact as a sag, which can then escalate to an interruption if not mitigated

C. Transient higher voltages drops

Overvoltage consider as an improvement in Root Mean Square (RMS) voltage value exceeding 1 per unit (pu) for a duration longer than one minute, typically ranging from 1 to 1.2 pu. Common causes include shifting off major loads, active capacitor banks, poor transformer tap settings, and inadequate voltage regulation. Due to over voltage equipments may be damage or failure. The voltage drops are short-term over voltages consider between 0.5 cycles and 1 minute, often considered with SLG faults, where non-faulted phases consider as voltage rises, typically between 1.1 and 1.8 pu.

D. Harmonic issues

The most of the power electronic devices, like a variable speed drives and continue power supplies, has most concerns about harmonic distortion in power systems. These devices can generate the harmonics problem into the system while being sensitive to voltage distortions themselves. Harmonic effect can lead to adverse effects, including excessive transformer heating, overloading, and failure of power factor correction capacitors, ultimately compromising system reliability and efficiency.

E. Voltage imbalance

Unequal load distribution among the three phases in a power system can handle to voltage imbalance. This type problem is often caused by asymmetrical loads in industrial settings or transposed transmission lines. Voltage unbalance push the effects on three-phase equipment, such as transformers, motors, and rectifiers, resulting in overheating due to excessive negative sequence currents. Furthermore, asymmetry can compromise the performance of converters, leading to harmonic generation and decreased overall system efficiency.

Different Technique for Voltage Sag Mitigation

Voltage Sag reduction Effective voltage sag reduction requires an understanding of existing methods. The number of different devices and techniques are implement to reduce the voltage drop problem, and a consideration of this technique could be help to find out the required solution for specific applications.

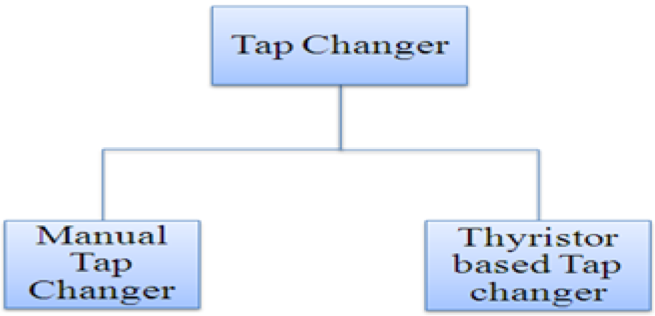

Fig. 1.3-Tap Changer block diagram

III. Voltage Sag& Mitigation Topology

Voltage Sag Mitigation Strategies

Voltage sags can result in significant economic losses, making mitigation strategies a worthwhile investment. Different techniques are present to reduce the voltage drop problem, with operating principles, advantages, and disadvantages. Some basic methods include:

Mitigation Methods

1. Device-level solutions: Design of Equipment modifications to increased the ride-through capability.
2. System-level solutions: Changes in Network configuration , like a installing FACTS devices or Dynamic Voltage Restorers (DVRs).
3. Power adjusting equipment: Devices like UPS systems, surge protectors, and voltage regulators.

Benefits and Drawbacks

Each mitigation method has its strengths and weaknesses. Understanding these factors is crucial for selecting the most important result for a specific application. By analysis the costs and benefits of various mitigation strategies, industries can reduce the impact of voltage sags and improve overall power quality.

Sag Proofing Transformers

Voltage drop-Proofing Transformers for Voltage drop reduction

Voltage drop proofing transformers are also known as voltage drop compensators, are buildup to reduce voltage drop (sag) by balancing the transformer turns ratio by static switches. The number of machines is connected in series with the load and can balance the voltage drop down around 40% retained voltage.

Benefits and Limitations

Voltage drop-proofing transformers provide the no of benefits, including:

1. Low maintenance: They are normally maintenance-free system and do not require energy storage devices.
2. Constant operation: They can balanced the voltage drop compensation. However, voltage drop-proofing transformers also have some limitations:

1. Limited capacity: They are currently resent for relatively small loads, up to approximately 5 kVA.
2. Added losses: The series connection of the transformer increases system losses.
3. Dependence on transformer reliability: Any transformer failure can lead to an present loss of supply.

Applications

Voltage drop-proofing transformers can be a best solution for uses where voltage sag mitigation

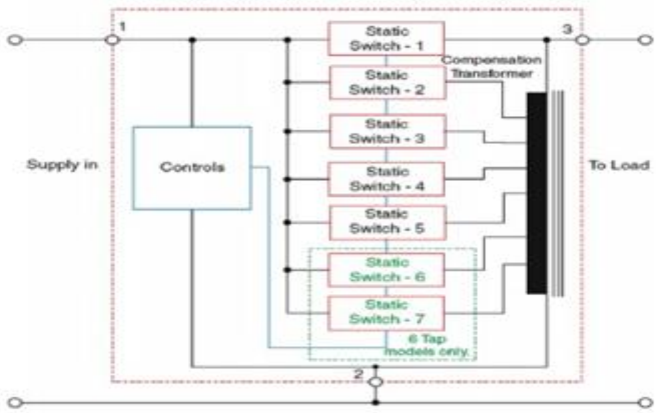

Fig. 1.4 Block Diagram of voltage drop Proofing Transformer

IV. PROPOSEDMETHODOLOGY

Implementation

Performance Analysis

The PWM technique based autotransformer is evaluated for its effectiveness in mitigating voltage drop and voltage upl disturbances. A MATLAB/SIMULINK model is developed to analyze the system's performance.

Configuration

The model consists of:

1. RLC load: The sensible load requiring constant voltage supply.
2. System parameters: Desired parameters are used for simulation.

Analysis Objective

The analysis aims to assess the PWM technique autotransformer's ability to regulate voltage and mitigate disturbances, ensuring a stable supply to the sensitive RLC load.

- L_1=2.4mH,nT1:nT2=4,C_{T1}=25μF,
- C_{T2}=100μF
- Switchingfrequency20kHz
- L_F= 2.8mH,C_F=10μF
- Sensitive load phase impedance=144+91jOhm
- Load voltage=1000v
- Nominal frequency=50 Hz

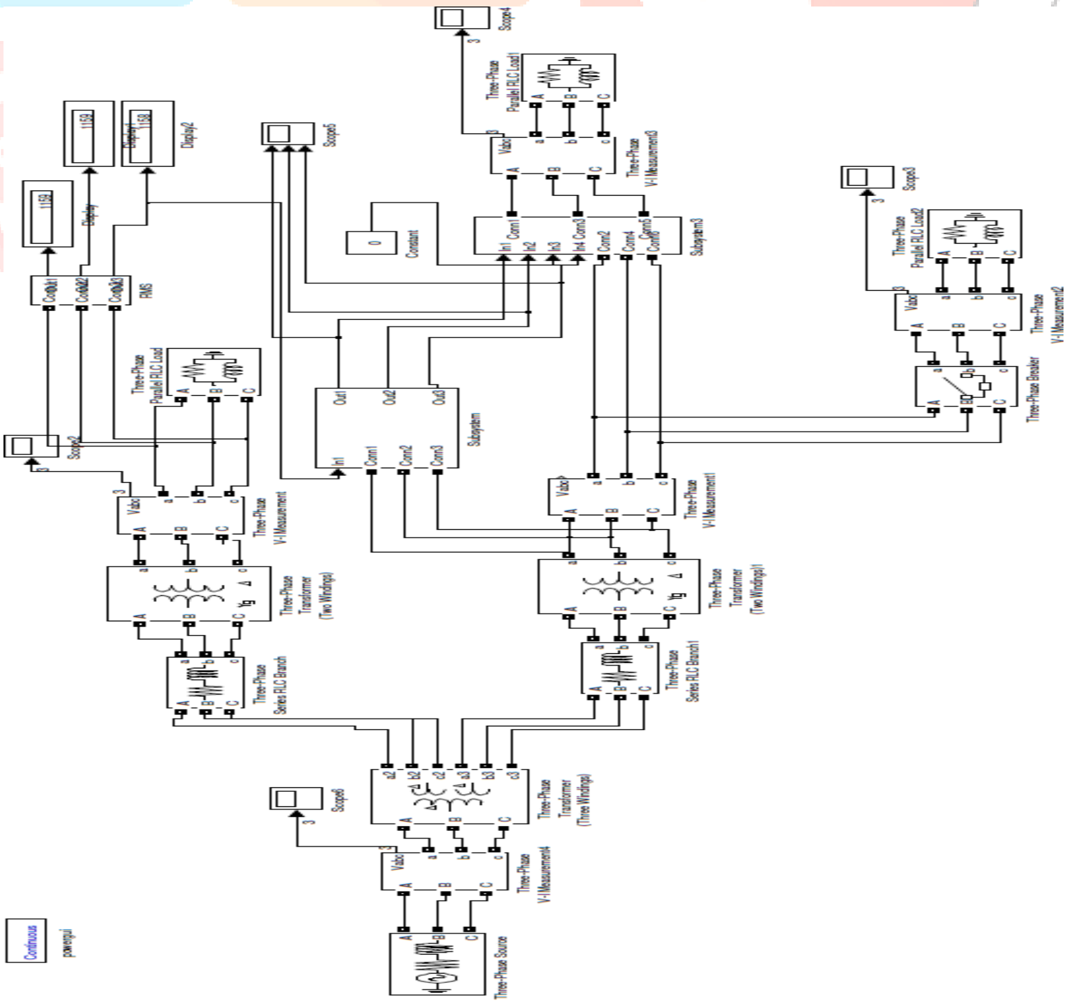

Fig: 1.5- System simulation model

IV. RESULTS AND DISCUSSION

All simulation results of the proposed voltage sag control for auto transformer. Three phase autotransformers implement done on MATLAB/Simulink. The simulation results are discussed for three phase auto transformer and voltage sag control. The simulation is carried out in following as

LOAD:

- 10e4Watt, 5 e4V
- Gain:0.3
- Frequency:[1/1500]Hz
- Constant: 1100

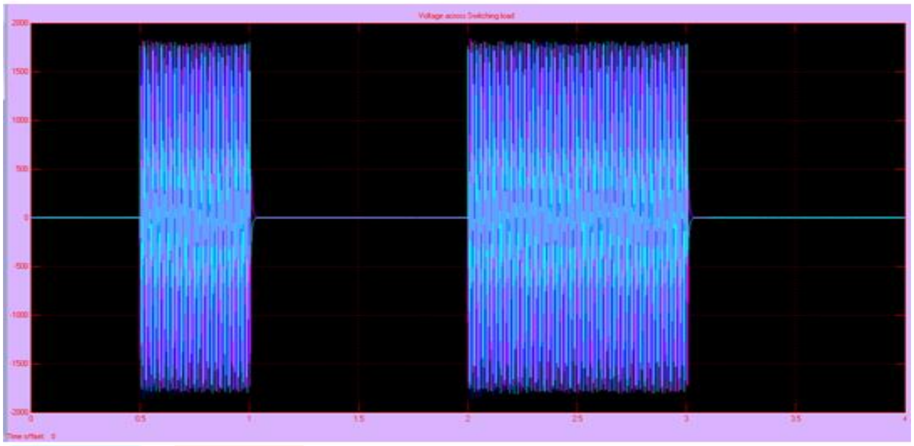

Fig. 5.1 The simulation wave form of voltage across switching load

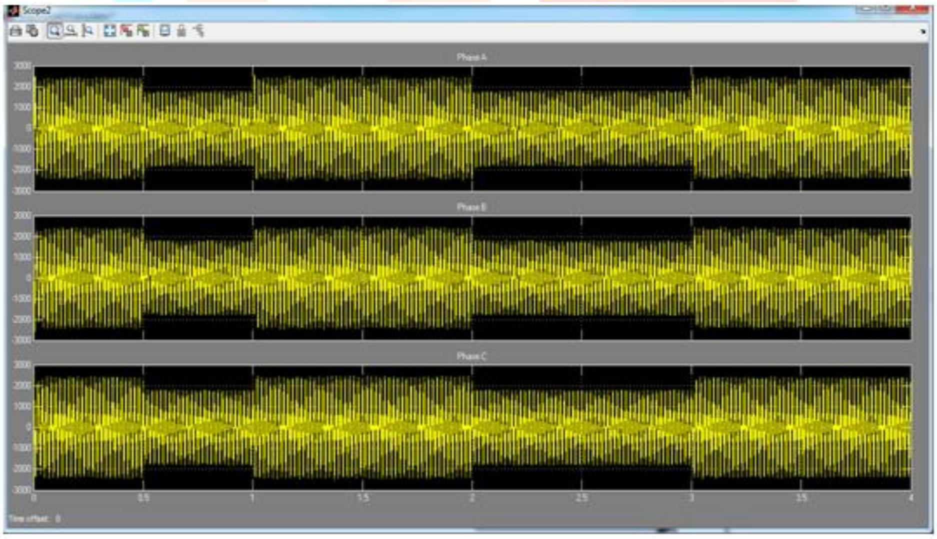

Fig. 5.2 Performance of Voltage Sag generated by the switching Load

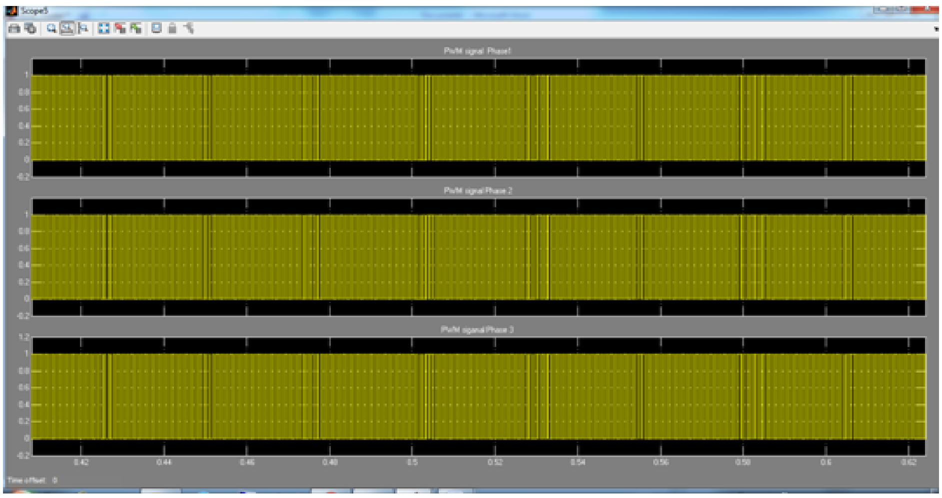

Fig. 5.3 PWM signals for Voltage sag control

V. Conclusion

Voltage sag is a significant issue in power supply networks. This study:

1. Modeled a 3-phase power system: For sag generation and analysis.

2. Presented a voltage sag compensator: Based on pulse width modulation (PWM) switched autotransformer.

3. Discussed control circuit: Utilizing RMS voltage reference.

Key Findings

The proposed technique effectively:

1. Identifies voltage disturbances

2. Mitigates sag: Maintaining load voltage within desired limits.

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