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PWM Based Autotransformer for Voltage Sag Control Using MATLAB

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Abstract: This paper present voltage sag control technique is besides custom power devised like dynamic voltage restorer and STATCOM as a solution for mitigation of voltage sag and swell. In this paper proposed system has less number of switching devices and has good compensating capability in comparison to commonly used compensators. Voltage sag is literally one of power quality problem and it become severe to industrial customers. Voltage sag can cause miss operation to several sensitive electronic equipment's. That problem can be mitigating with voltage injection method using custom power device, Dynamic Voltage Restorer (DVR) or controlling the PWM signal. Simulation results are presented for various conditions of sag and swell disturbances in the supply voltage to show the performance of the new mitigation technique.

***Index Terms*—DVR, voltage sag, PWM, voltage swell, sag mitigation, swell mitigation, switched auto transformer, etc.**

I Introduction

The electric power technique is considered to be composed of three functional blocks generation, transmission and distribution and reliable power system, the generation unit must produce adequate power to meet customer's demand, the transmission systems must transport bulk power over long distances without overloading must deliver electric power to each customer's premises from bulk power. The distribution system locates the end of power system and is connected to the customer directly, so the power quality mainly depends on distribution system.

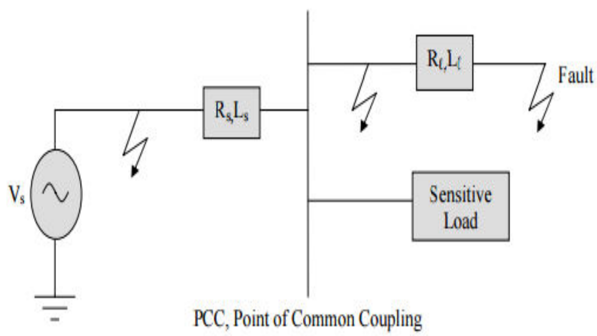

Fig. 1. Voltage sag generator

The voltage sag is a momentary system decrease of the voltage RMS value with the duration of half a cycle up to many cycles. Voltage sag can cause serious problem to sensitive loads that use voltage sensitive components such as adjustable speed drives, process control equipment and computers and voltage sags last until network faults are cleared. In order to increase the reliability of a power distribution system, many methods of solving power quality problems have been suggested.

Another power electronic solution to the voltage regulation is the use of a dynamic voltage restorer. DVR's are a class of custom power devices for providing reliable distribution power quality. They employ a series of voltage boost technology using solid state switches for compensating voltage sags. The DVR applications are mainly for sensitive loads that may be drastically affected by fluctuations in system voltage. A new mitigation device for voltage sag is proposed in [1] using PWM-switched autotransformer. The performance of the compensator for various sag conditions is presented. This paper presents mitigating device for voltage sags/swells disturbances using PWM-switched autotransformer. Here the control circuit based on RMS voltage is used to identify the sag and swell disturbances.

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This compensator has less switching devices and hence reduced gate drive circuit size, but has the capability to supply the required undistorted load voltage and currents.

II.DYNAMIC VOLTAGE RESTORER

The power quality problems like sag, swell, harmonic etc, voltage sag is the most severe disturbances in the distribution system. To overcome these problems the concept of custom power devices is introduced lately. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks.

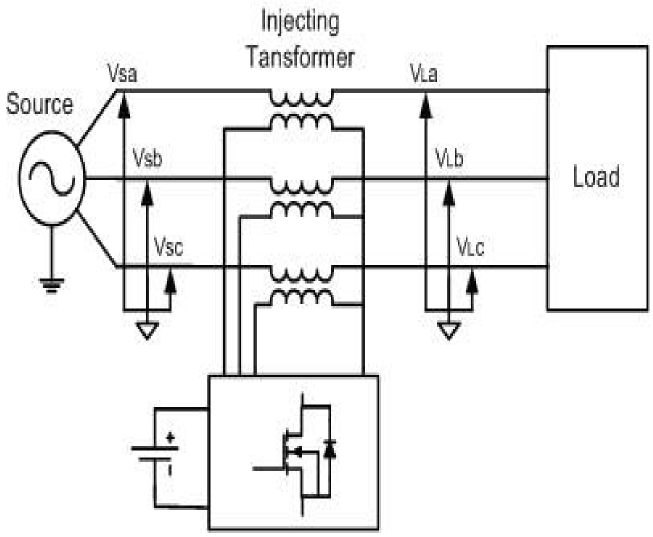

Fig. 2.Schematic diagram of DVR System

III Mathematically expressed

$$VL(t) = Vs(t) + Vinj(t) \quad (1)$$

Where VL(t) is the load voltage, Vs(t) is the sagged supply voltage and Vinj(t) is the voltage injected by the mitigation device as shown in Fig. 2 Under nominal voltage conditions, the load power on each phase is given by

$$SL = ILVL* = PL - jQL \quad (2)$$

Where I is the load current, and, PL and QL are the active and reactive power taken by the load respectively during a sag. When the mitigation device is active and restores the voltage back to normal, the following applies to each phase

$$SL = PL - j\,QL = (PS - j\,Qs) + (Pinj - jQinj) (3)$$

Where the sag subscript refers to the sagged supply quantities. The inject subscript refers to quantities injected by the mitigation device.

The real and reactive power is given by

$$Pp = |Vp| \sum_{q=1}^{n} |Vq| (GpqCos\delta pq + BpqSin\delta pq) \quad (4)$$

$$Qp = |\,Vp| \sum_{q=1}^{n} |Vq| (GpqSin\delta pq - BpqCos\delta pq) \quad (5)$$

The compensation for voltage sags using a DVR can be performed by injecting/absorbing reactive power or real power. When the injected voltage is in quadrature with the current at the fundamental frequency, compensation is achieved by injecting reactive power and the DVR itself is capable of generating the reactive power because DVR is self-supported with dc bus. But, DVR voltage can be kept in quadrature with the current only up to a certain value of voltage sag and beyond which the quadrature relationship cannot be maintained to correct the voltage sag i.e. if the injected voltage is in phase with the current, DVR injects real power and hence an energy storage device is required at the dc side of VSI.

IV.Voltage sag compensation

The ac converter topology is employed for realizing the voltage sag compensator. This paper considers the voltage mitigation scheme that use only one shunt type PWM switch[1] for output voltage control as shown in Fig. 3. The autotransformer shown in Fig. 2 is used in the proposed system to boost the input voltage instead of a two winding transformer. Switch IGBT is on the primary side of the autotransformer. The voltage and current distribution in the autotransformer is shown in Fig. 4. It does not provide electrical isolation between primary side and secondary side but has advantages of high efficiency with small volume. The compensator considered is a shunt type as the control voltage developed is injected in shunt. The relationships of the autotransformer voltage and current are expressed in Eq. (6),

$$\frac{V_L}{V_P} = a = \frac{I_S}{I_L} = \frac{N_2+N_1}{N_1} \quad (6)$$

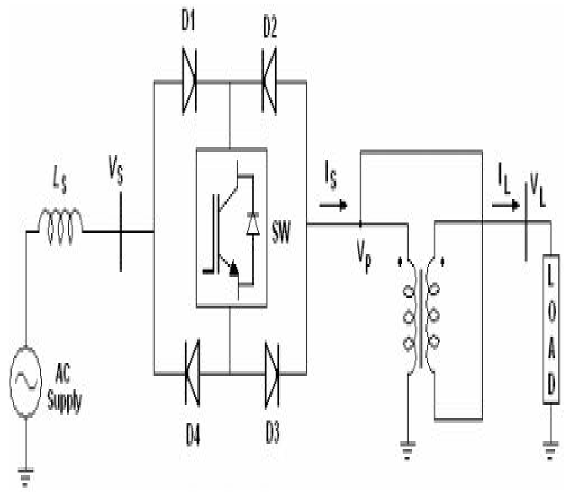

Fig. 3. Voltage Sag and Swell mitigating

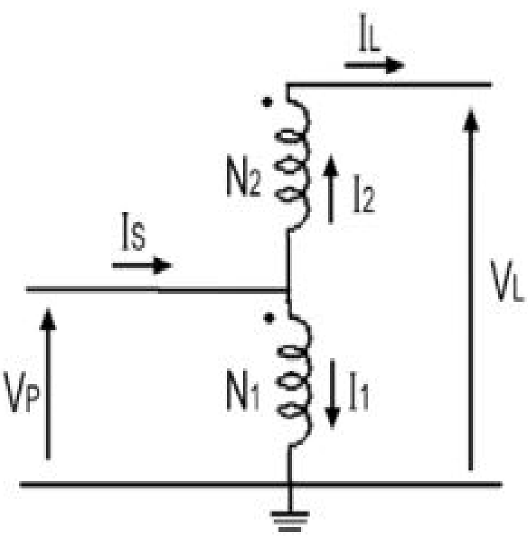

Fig. 4. Autotransformer voltage and current

The autotransformer in Fig. 3 does not offer electrical isolation between primary side and secondary side but has advantages of high efficiency with small volume.

V. SIMULATION

In this Paper, multi-level inverter is used to achieve high power from medium voltage source. The main feature is the lower harmonic distortion content due to the multiple voltage levels at the output. Therefore it can eliminate the use of filter circuits. The multilevel inverter can operate at both fundamental switching frequency and higher switching frequency.

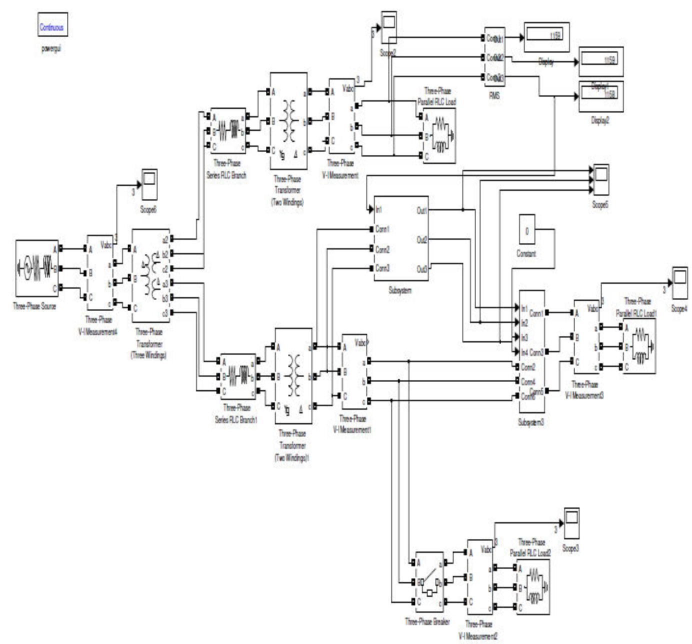

Fig.5 Simulink model

In this paper the modeling and simulation of three phase voltage sag control technique is done using MATLAB/SIMULINK.

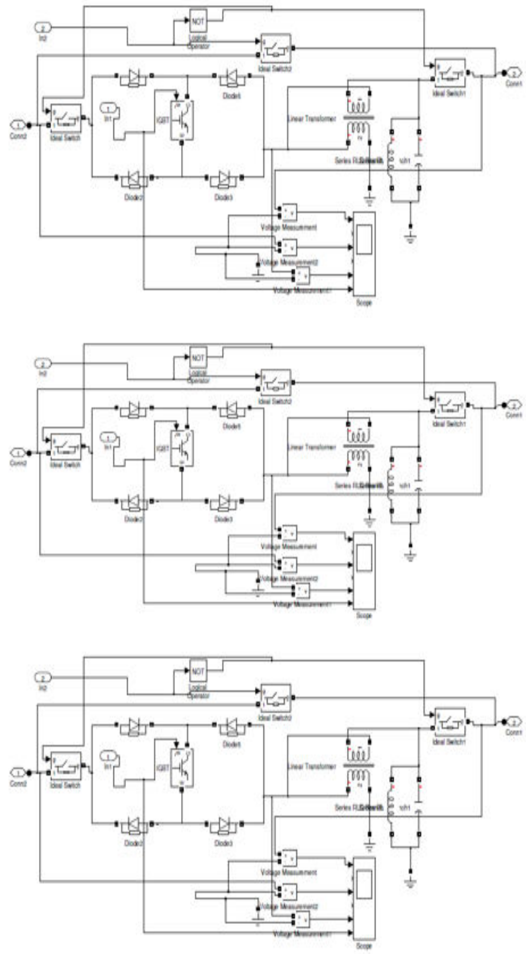

Fig.6 Model of 3-phase PWM switched auto transformer

The load voltage and current are same as supply voltage and current. When a disturbance occurs, an error voltage which is the difference between the reference RMS voltage and the load RMS voltage is generated.

VI.RESULTS AND DISCUSSION

All simulation results of the proposed voltage sag control for auto tranformer.Three phase autotransformer 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.

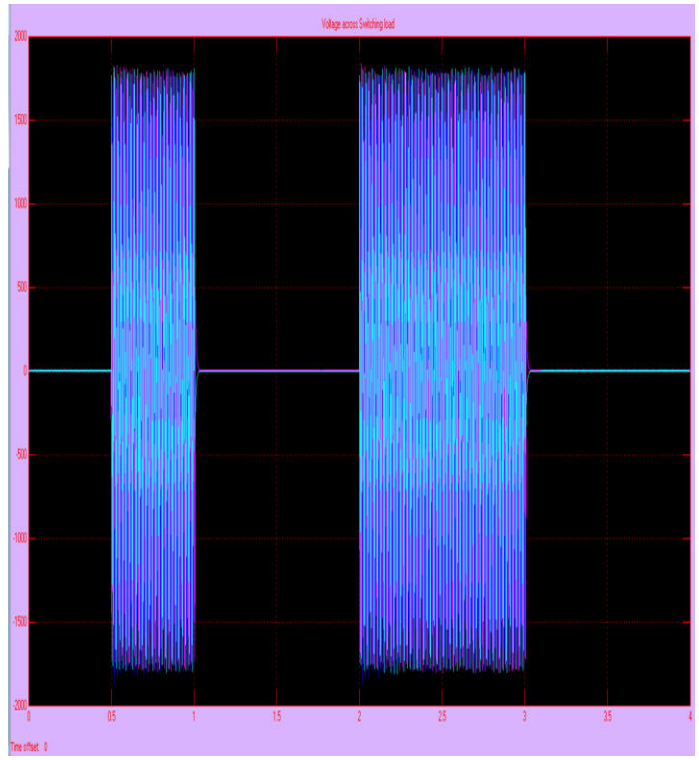

Fig.7 The simulation waveform of voltage across switching load

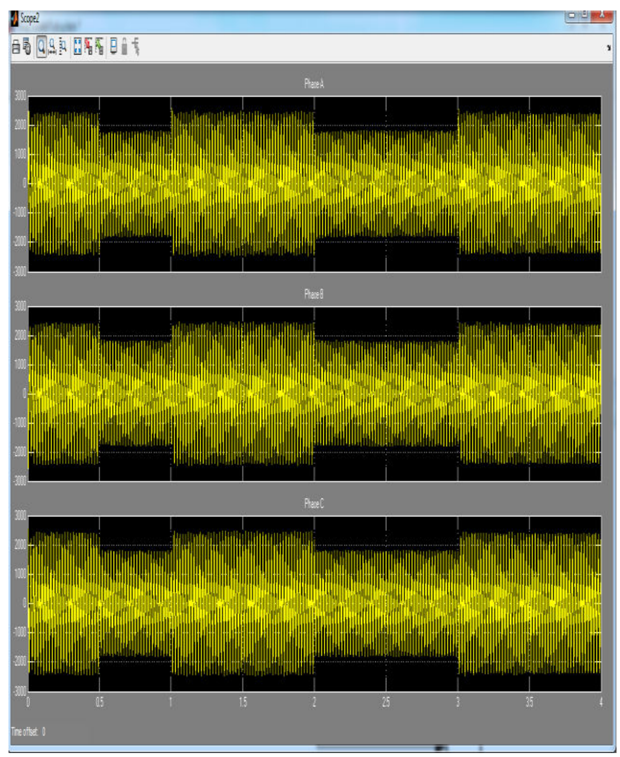

Fig.8 Performance of Voltage Sag generated by the switching Load

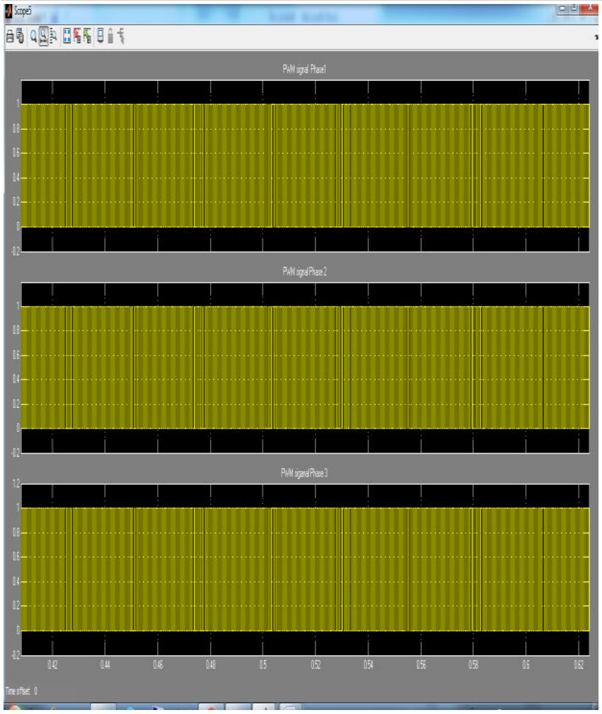

Fig.9 PWM signals for Voltage sag control

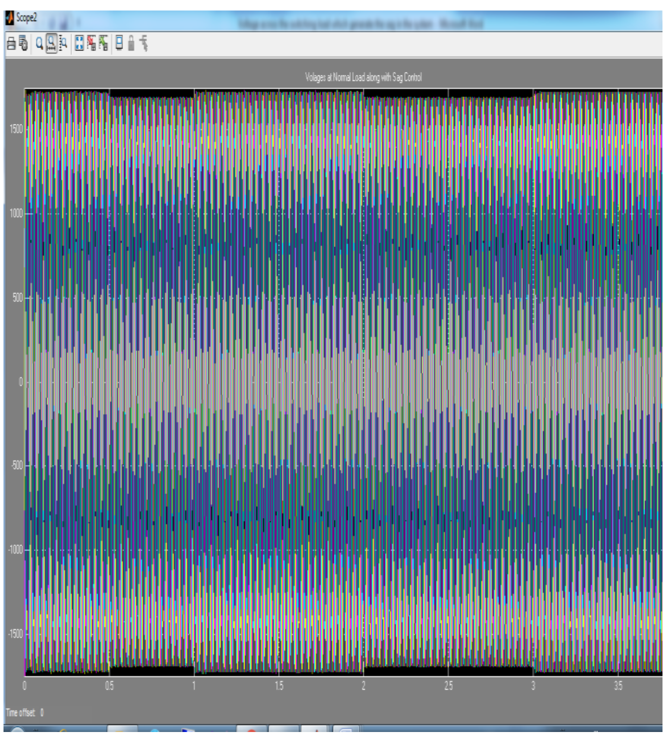

Fig.10 This Waveform of source voltage

VII.CONCLUSION

This paper present modeling and simulation of standalone three phase voltage sag control using MATLAB/SIMULINK. The voltage sag compensator based on PWM switched autotransformer has been presented in this study. Control circuit based on RMS voltage reference is discussed. The proposed technique could identify the disturbance and capable of mitigating the disturbance by maintaining the load voltage at desired magnitude within limits.

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