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Improvement of Voltage Sag Compensation Scheme for Dynamic Voltage Restorer

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ABSTRACT

This paper deals with improving the voltage quality of sensitive loads from voltage sags using a dynamic voltage restorer. The higher active power requirement associated with voltage phase jump compensation has caused a substantial rise in size and cost of the dc link energy storage system of DVR. To improve sag compensation strategy, this mitigates the phase jump in the load voltage while improving the overall sag compensation time. An analytical study shows that the proposed method significantly increases the DVR sag support time (more than 50%) compared with the existing phase jump compensation methods. The presence of harmonics, voltage and frequency variations deteriorate the performance of the system. In this project the frequently occurring power quality problem- voltage variation is discussed. The voltage sag/dip is the most frequently occurring problem. There are many methods to overcome this problem. Among them the use of FACTS devices is an efficient one. The Fuzzy Logic Controller we can get accurate result for voltage mitigation and harmonic distortion. The proposed control strategies are simulated in MATLAB SIMULINK environment and the results are presented.

Keywords : Dynamic voltage restorer (DVR), voltage phase jump compensation, voltage sag compensation, voltage source inverter (VSI).

I. INTRODUCTION

In industrial distribution systems, the grid voltage disturbances (voltage sags, swells, flicker, and harmonics) are the most common power quality problems. Sag, being the most frequent voltage disturbance, is typically caused by a fault at the remote bus and is always accompanied by a phase angle jump. The phase jump in the voltage can initiate transient current in the capacitors, transformers, and motors. It can also disturb the operation of commutated converters and may lead to glitch in the performance of thyristor-based loads . It is therefore imperative to protect sensitive.

Loads especially from the voltage sags with phase jump transformers, and motors. It can also disturb the operation of commutated converters and may lead to glitch in the performance of thyristor-based loads. It is therefore imperative to protect sensitive loads, especially from the voltage sags with phase jump. To protect sensitive loads from grid voltage sags, custom power devices (such as SVC, D-STATCOM, dynamic voltage restorer (DVR), and UPQC) are being widely used Among these devices, DVR has emerged as the most cost effective and comprehensive solution .

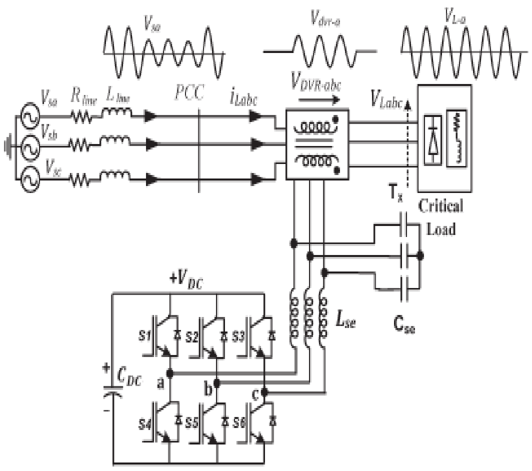


Figure 1. Basic DVR-based system configuration

The system configuration of a series injection transformer, a six-switch voltage source inverter (VSI), and an *LC* filter for removing switching harmonics from the injected voltage. The primary function of the DVR is to inject a voltage with certain magnitude and phase in series with the upstream source voltage such that the load connected downstream always sees the pure sinusoidal voltage at its terminals. Numerous control strategies for DVR have been reported in the literature .The emphasis is on either reducing the voltage rating of DVR by aligning the injected voltage with the source voltage (i.e., in-phase compensation) or minimizing the dc storage capacity by using the reactive power compensation/energy-optimized approach . All of these methods, however, cannot correct the phase jump and thus can result in premature tripping of sensitive loads The only possible way to mitigate the phase jump is to restore the load voltage to the prefault value. Such an approach is addressed as presag compensation. However, the phase jump compensation using the presag method requires a significant amount of active power from the dc link capacitor. The performance of the proposed method is validated using simulation.

II. METHODS AND MATERIAL

A. Proposed Block Diagram

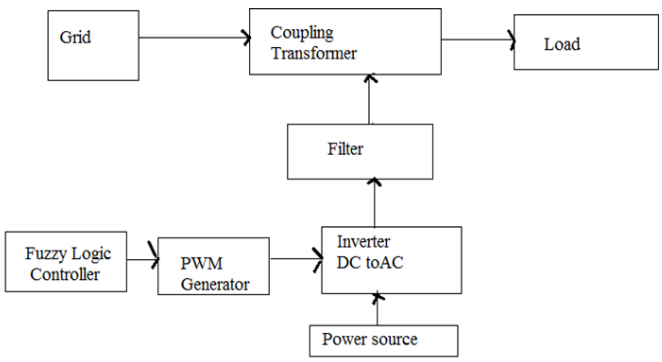


Figure 2. Proposed block diagram

Associated with voltage phase jump compensation has caused a substantial rise Power quality mitigation technique DVR is used. The DVR is a series connected power electronic device used to inject voltage of required magnitude and frequency. It consists of DC to AC inverter which supplies the AC signal. Generate 3 φ AC voltages at any required magnitude, phase and frequency to compensate the load voltage.

The higher active power requirement in size and cost of the dc link energy storage system of DVR. The pulse width modulation generator to encode a message into a pulsing signal. The filters to compensate a signal. The coupling transformer to step up voltage and connect to the load. The existing control strategies either mitigate the phase jump or improve the utilization of dc link energy by reducing the amplitude of the injected voltage. In industrial distribution systems, the grid voltage disturbances (voltage sags, swells, flicker, and harmonics) are the most common power quality problems. Sag, being the most frequent voltage disturbance, is typically caused by a fault at the remote bus and is always accompanied by a phase angle jump. The Fuzzy logic controller is used accurate result for voltage mitigation and harmonic distortion.

Grid-connected PV systems have the major disadvantage that the power output is dependent on direct sunlight, so about 10-25% is lost if a tracking system is not used, since the cell will not be directly facing the sun at all times. Output is also adversely affected by weather conditions such as the amount of dust and water vapour in the air or the amount of cloud cover. This means that, in the national grid for example, this power has to be made up by other power sources: hydrocarbon, nuclear, hydroelectric or wind energy.

Pulse-width modulation (PWM) is a modulation technique used to encode a message into a pulsing signal. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. In addition, PWM is one of the two principal algorithms used in photovoltaic solar battery chargers, the other being maximum power point tracking.

A fuzzy control system is a control system based on fuzzy logic a mathematical system that analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0.Simply put it is fuzzy code designed to control something, usually mechanical.

Filters are circuits which perform signal processing to remove unwanted frequency components from the signal, to enhance wanted ones, or both. Linear or Non linear, Time-invariant or Time variant, also known as shift invariance. If the filter operates in a spatial domain then the characterization is space invariance, Infinite impulse response or finite impulse response type of discrete-time or digital filter.

DC to AC Inverter is an electronic device or circuitry that changes direct current to Ac. The input voltage, output voltage and frequency, overall power handling depends on the design of the specific device or circuitry. Transistor dc to ac inverters is useful in a wide variety of applications. They provide AC power to operate the electric shaver in your car. Inverters may become increasingly important and widely used with the further development of economic low voltage DC power sources such as solar cells, nuclear cells, fuel cells.

The magnetic transformer can sometimes be used to provide DC isolation between circuits, but IMO the term "coupling transformer" is most often used when the device is used for changing the impedance levels. Two main applications of this property are tube audio amplifiers, and high power tube RF emitters used in Radio and TV broadcasting, feeding the large antennas that radiate enough energy to reach receivers at distances of hundreds of miles. In this last role, as RF emitters, sometimes transformers and tubes are used because there are no semiconductor devices capable of standing the high level of power at relatively high frequencies. Transformers are also used in power grid systems, in this case for increasing or decreasing the voltage levels; for instance, they are used, in several steps, to reduce AC voltage; from the hundreds of kV found in high-voltage lines coming from coal or nuclear plants, or from hydroelectric production, down to the 220 V or 120 V AC, at 50 or 60 Hz, used in our homes.

B. Power Flow Analysis And Maximum Compensation Time

As explained earlier, the presag method is the most energy intensive method, and the injected power can be quite high even for shallow sag depths. The active power associated with the presag method can be expressed in terms of sag depth, phase jump, and load power factor as given in the following:

$$Ppresag = \sqrt{3}VlIL(\cos(\emptyset L) - (1 - \Delta Vsag)\cos(\emptyset L - \delta) \quad (1)$$

The DVR is relatively high (> 0.4 p.u.) for the presag method. The theoretical power flow analysis conducted previously holds true as long as there is a DVR active power for a range of variation in sag depth (0.1 ≤ ΔVsag ≤ 0.9) and power factor (0.4 ≤ cos θL ≤ 0.9). The phase jump δ is fixed at +45◦. As seen from the graph of fig 2, the active power supplied by significant amount of energy in the dc link capacitor. However, in the actual system, since it has a finite amount of energy, the voltage across the dc link capacitor Vdc reduces. The following relationship should be satisfied at all time in order to achieve the adequate operation of DVR-VSI

$$\frac{Vdvr}{nt} \leq \frac{mi-mmax\, Vdc}{2} Z \quad (2)$$

where nt is the turns ratio of the series transformer and mi−maxis the maximum modulation index of VSI. Vdvr is the injected phase to neutral voltage.Vdc is the dc link voltage. As soon the dc link voltage decreases below Vdc−min, i.e., the limit set by (12), the DVR controller must stop the Compensation process to avoid harmonics contamination in the load voltage. The energy stored in the dc link capacitor is equal to

$$Ec - dc = \frac{1}{2} Cdv\, V2dc \quad (3)$$

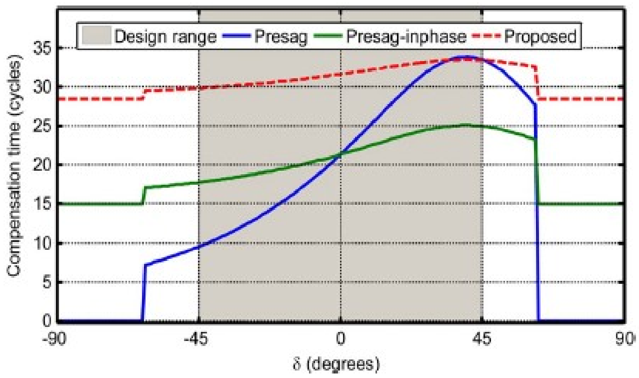
The power flow out of the dc link capacitor in the steady state is given as

$$Pc - dc = \frac{1}{2} Cdc \frac{d}{dt} V2dc \quad (4)$$

Considering a lossless DVR system, the dc power in (14) can be equated with the ac power of (11) to find the capacitor size. However, owing to the flow of active power, the dc link voltage drops, and the limit in (12) can be violated.

C. Analytical Study On Compensation Time with Different Approaches

In this section, a comparative study is presented to determine the maximum compensation time achieved using the aforementioned phase jump compensation methods. These include the following: 1) the presag; 2) the method given in [16], named as presag–in-phase in this paper; and 3) the proposed method. The maximum compensation time is one cycles with a phase jump of +45◦ is taken as reference. Using (15), the value of the dc link capacitor is obtained as 9000 μF. The sag depth is varied over a range of values from 50% of nominal grid voltage, keeping the power factor and phase jump fixed at 0.7 lagging and +45◦, respectively.



Analytically computed DVR-injected magnitude and maximum compensation times are provided in fig 2. Note that the DVR voltage magnitudes are shown after the first one cycle of compensation as all of the three methods perform identically for the first cycle. As seen from fig.2, both the presage and proposed methods have the same Vdvr magnitude for a sag depth greater than the limit in (6), i.e., 30%. However, as noticed from fig.2, t_c−max is highest for the proposed method for all values of sag depths. For the designed range of.50% sag depth, it can be seen that the presag–in-phase method improves the compensation time from one cycles over the presag method. The proposed method further improves it to5 cycles. Moreover, for the sag depth lower than 50%, the proposed method can withstand any sag duration by operating in the self-supporting mode. The significant improvement in the compensation time is due to the least possible utilization of dc link active power, thus resulting in the slowest discharging of the dc link capacitor. Note that the proposed method does not result in higher injection voltage magnitude than the design limit of 0.7 p.u., which is clear in fig.2, depicts the scenario where the phase jump is varied from −45◦ to +45◦ for a sag depth of 0.5 p.u. and other boundary conditions from Table I. As seen from the graph, the maximum compensation time is highest for the proposed method. It can also be noted that the presag method becomes unable to correct the phase jump beyond −45◦ and +45◦ due to violation of (12).

III. RESULTS AND DISCUSSION

A. Simulation Result

A simulation model for the DVR system, with the parameter given in Table I, is developed and simulated for the performance evaluation. The dc link capacitor of 9000 μF, as computed in the previous section, is used for this study. As the intention is to maintain the rated voltage across the load terminals without any phase jump, the sensitive load is represented by an $R-L$ load.

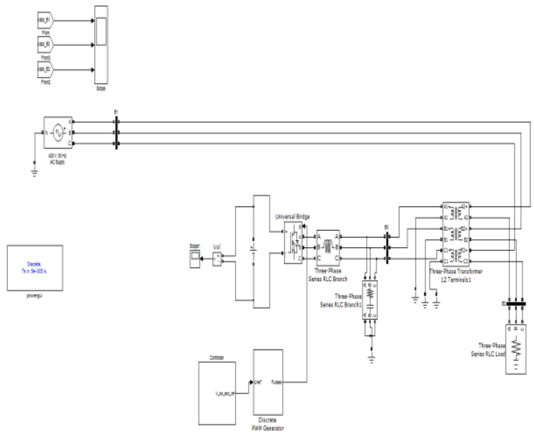


Fig.2.simulink proposed diagram

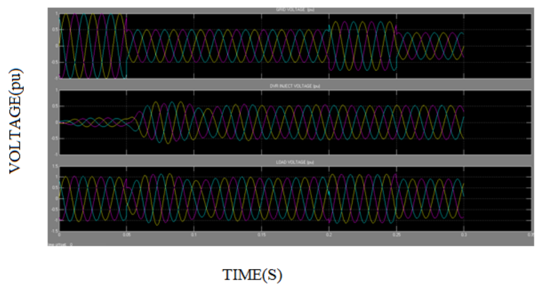


Figure 3. Simulation results for the proposed sag compensation method for 50% sag depth. (a)Grid voltage. (b)DVR Inject voltage. (c) Load voltage.

Table 1. Parameters of DVR Compensation

No.	Voltage	Per unit voltage
1	Grid voltage	415v
2	Sag	0.5p.u
3	Swell	6
4	DVR Inject voltage	0.5p.u
5	Sag depth	o.5p.u
6	Phase jump	45
7	Compensation time	1 cycle
8	Frequency	50 Hz

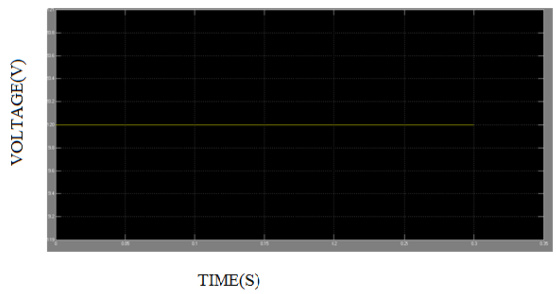


Figure 4. DC Link Voltage

IV. CONCLUSION

In this project, an enhanced sag compensation scheme has been proposed for the capacitor-supported DVR. To improves the voltage quality of sensitive loads by protecting them against the grid voltage sags involving the phase jump. It also increases compensation time by operating in MAP mode through a controlled transition once the phase jump is compensated. To illustrate the effectiveness of the proposed method, an analytical comparison has been carried out with the existing phase jump compensation schemes. It is shown that the compensation time can be 1 cycles for the designed limit of 50% sag depth with 45◦ phase jump. Further extension in compensation time can be achieved for intermediate sag depths. Among the different methods to mitigate the voltage sag, the use of DVR is the best method. The FACTS devices like DVR, helpful in overcoming the voltage unbalance problems in power system.DVR is a series connected device and injects voltage to compensate the voltage imbalance. We can get accurate result for voltage mitigation and harmonic distortion.

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