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An Enhancement of Dynamic Voltage Restorer for the Compensation of Voltage Sag by Using Induction Motor

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ABSTRACT-*In this paper, an enhanced sag compensation strategy is proposed, which mitigates the phase jump in the load voltage while improving the overall sag compensation time. DVR's are used to protect sensitive loads from the effects of voltage sags on the distribution feeder. Power quality has become a considerable issue in modern electrical power system. The extensive use of non linear load has increased the power quality problems such as stability of voltage. This paper proposes with improving the voltage quality of sensitive loads from voltage sags using a dynamic voltage restorer (DVR). The Induction motor is a three phase AC motor and is the most widely used machine. Induction motor characteristic features are- Simple and rugged construction and Low cost and minimum maintenance The voltage sags & swells affect the sensitive loads by nuisance tripping of fast acting relays. In order to overcome this power quality problem, dynamic voltage restorer (DVR) is used. 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. The existing control strategies either mitigate the phase jump or improve the utilization of dc link energy by the following: 1) reducing the amplitude of the injected voltage or 2) optimizing the dc bus energy support. This enhancement can also be seen as a considerable reduction in dc link capacitor size for new installation. By using the simulation results The performance of the proposed method is evaluated.*

Index Terms— DC/DC converter, maximum power point tracking (MPPT), Partial shading condition, Photovoltaic power generation system.

INTRODUCTION

Power Quality problems like voltage sag, voltage swell and harmonic are major concern of the industrial and commercial electrical consumers due to enormous loss in terms of money and time. For high power sensitive loads, the DVR shows promise in providing more cost effective solution than the energy storage capabilities of Uninterrupted Power Supply (UPS. 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. The existing control strategies either mitigate the phase jump or improve the utilization of dc link energy by the following: 1) reducing the amplitude of the injected voltage or 2) optimizing the dc bus energy support. 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. Voltage sag/swell that occur more frequently than any other power quality phenomena is known as the most important power quality problem in power distribution system. Voltage sag is defined as a sudden reduction of supply voltage down 90% to 10% of normal. 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. The system configuration of a DVR is shown in Fig. 1.

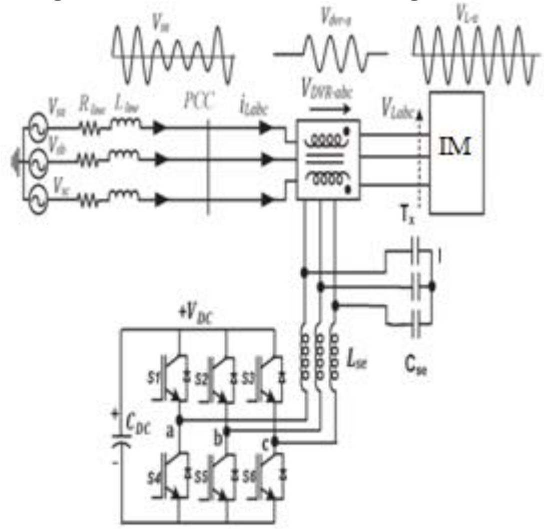

Fig.1. Basic DVR-based system configuration

It consists of a dc link capacitor (serving as an energy reserve for DVR), 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

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downstream always sees the pure sinusoidal voltage at its terminals.

DVR is the efficient and effective modern custom power device used in power system. It employs a series of voltage boost technology using solid (static) state switches of 3-phase VSC that injects voltage into the system; to restore the load side voltage for compensating voltage sags/swells. Other than voltage sags and swells compensation, DVR can also added other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations.

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 pre-fault value. Such an approach is addressed as pre-sag compensation.

DVR is a recently proposed series connected solid state device and is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). It uses a series of voltage boost technology using solid (static) state switches of 3 phase VSC that injects voltage into the system; to restore the load side voltage for compensating voltage sags/swells. In addition to voltage sags and swells compensation, DVR is also useful to compensate line voltage harmonics, to reduce transients of voltage and fault current limitations.

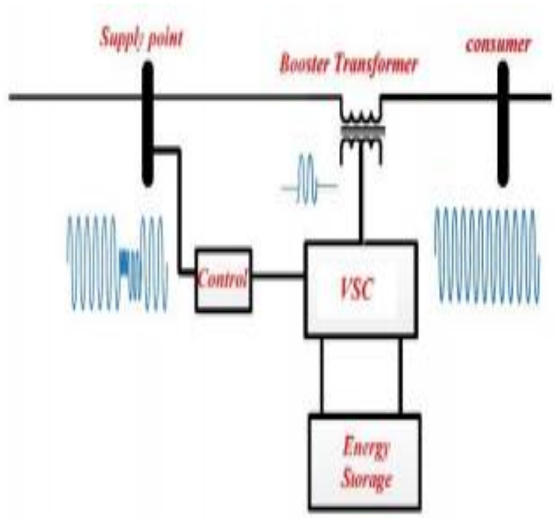

Fig. 2. Basic topology of DVR

The above fig shows the basic construction topology of the dynamic voltage restorer. It consists of the Injecting transformer (also known as boosting transformer), Voltage Source Converter that is responsible for the injection of the power through the energy storage devices either in the form of Capacitors or the Batteries

OVERVIEW OF DVR OPERATION

Different sag compensation approaches are discussed in this paper. The phasor representations of these methods are given in Fig. 2.

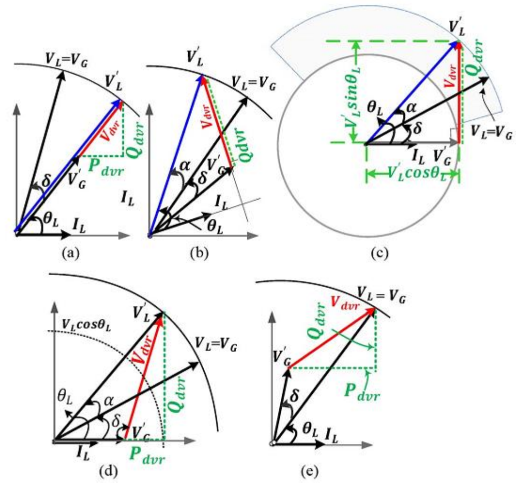

Fig. 2. Per-phase phasor representation of the basic compensation topologies for DVR. (a) In-phase injection. (b) Quadrature injection. (c) Quadrature injection limiting case. (d) Energy-optimized injection. (e) Pre-sag injection.

The phasors $\vec{V}_G$ and $\vec{V}_G'$ represent the rated and sagged grid voltages, respectively, whereas $\vec{V}_L$ and $\vec{V}_L'$ are the load voltages before and after the sag. To effectively highlight the differences among these methods, P_{DVR} and Q_{DVR} are also incorporated in the phasor diagrams. This is mainly to illustrate the amount of active and reactive powers demanded by each method. All of the quantities are drawn considering the load current ($\vec{I}_L$) as reference phasor.

A. In-Phase Compensation

In this type of compensation, DVR injects the smallest possible voltage magnitude in phase with the sagged grid voltage. However, as seen from Fig. 2(a), this method cannot correct the phase jump. The DVR-injected voltage magnitude and angle are given as

$$V_{DVR} = \sqrt{2}\left(V_L - V_G'\right) \quad (1)$$

$$< V_{DVR} = \theta_L \quad (2)$$

B. Quadrature Injection (Reactive Compensation)

In this method, the DVR injects voltage in quadrature with the load current, i.e., it corrects the sag with only reactive power. Using Fig. 2(b), the injected voltage magnitude and angle are given as

$$V_{DVR} = \sqrt{2}\sqrt{V_L^2 + V_G^{'2} - 2V_L V_G^{'} \cos(\alpha + \delta)} \quad (3)$$

$$< V_{DVR} = \frac{\pi}{2} \quad (4)$$

Where δ is the phase jump in the grid voltage due to the sag and α is the phase jump induced due to reactive power compensation. The maximum sag depth ($\Delta V_{sag,max}$) that can be compensated using quadrature injection is closely related with the load power factor and can be expressed as

$$\Delta V_{Sag} \leq (1 - \cos\theta_L) \quad (5)$$

The corresponding maximum injected voltage is given as

$$V_{DVR-max} = \frac{V_G^{'}}{1-\Delta V_{Sag,max}} \sin\theta_L \quad (6)$$

Fig. 2(c) shows the limiting case for quadrature injection where DVR supports the full load reactive power whiles the grid operates at unity power factor.

C. Energy-Optimized Injection

To enhance the performance of the quadrature injection method is developed for the sag depth deeper than the limit, where the DVR injects certain active power. The DVR voltage magnitude and injection angle can be calculated from Fig. 2(d)

$$V_{DVR} = \sqrt{2}\sqrt{V_L^2 + V_G^{'2} - 2V_L V_G^{'} \cos(\theta_L)} \quad (7)$$

$$< V_{DVR} = \tan^{-1}\left(\frac{V_L(\sin\theta_L)}{V_L \cos(\theta_L - V_G^{'})}\right) \quad (8)$$

D. Pre-sag Compensation

In this method, both load voltage magnitude and phase are restored to pre-sag values. However, this phase jump correction requires an additional active power from the dc link capacitor. A positive phase jump leads to an increase in angle between the grid voltage and the load current, increasing the active power burden on DVR compared to negative phase jump. Using Fig. 2(e), the injected voltage magnitude and angle can be written as

$$V_{DVR} = \sqrt{2}\sqrt{V_L^2 + V_G^{'2} - 2V_L V_G^{'} \cos(\delta)} \quad (9)$$

$$< V_{DVR} = \tan^{-1}\left(\frac{V_L \sin\theta_L - V_G^{'} \sin(\theta_L - \delta)}{V_L \cos\theta_L - V_G^{'} \cos(\theta_L - \delta)}\right) \quad (10)$$

POWER FLOW ANALYSIS AND MAXIMUM COMPENSATION TIME

The pre-sag 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 pre-sag method can be expressed in terms of sag depth, phase jump, and load power factor as given in the following:

$$P_{presag} = \sqrt{3}V_L I_L(\cos(\theta_L)) - (1 - \Delta V_{sag})\cos(\theta_L - \delta) \quad (11)$$

As seen from the graph of Fig. 3, the active power supplied by DVR is relatively high (>0.4 p.u.) for the pre-sag method. Fig. 3 shows the DVR active power for a range of variation in sag depth (0.1≤ΔVsag ≤0.9)and power factor(0.4≤cosθL≤0.9). The phase jump δ is fixed at+25◦.

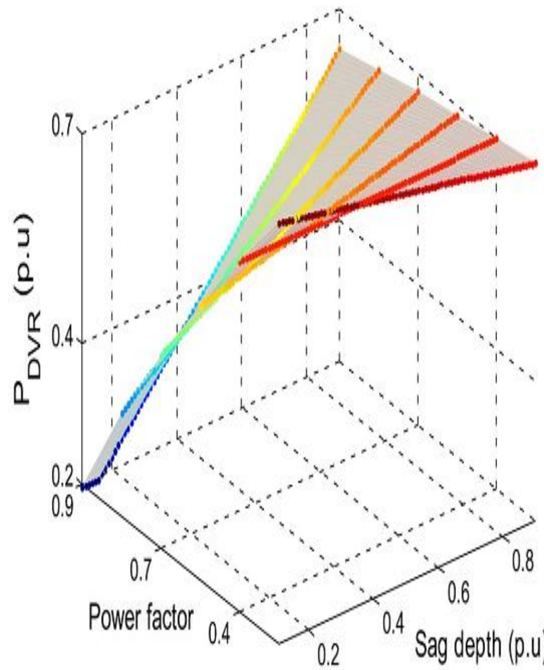

Fig.3. Active power associated with the pre-sag compensation method for different sag depths (phase jump=25◦).

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 [18]:

$$\frac{V_{dvr}}{n_t} \leq \frac{m_{i-max} V_{dc}}{2} \quad (12)$$

Where n_t is the turns ratio of the series transformer and m_{i-max} is the maximum modulation index of VSI. V_{dvr} is the injected phase to neutral voltage. V_{dc} is the dc link voltage. The energy stored in the dc link capacitor is equal to

$$E_{c-dc} = \frac{1}{2} C_{dc} V_{dc}^2 \quad (13)$$

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

$$P_{c-dc} = \frac{1}{2} C_{dc} \frac{d}{dt} V_{dc}^2 \quad (14)$$

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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. This limitation restrains the DVR operation even though there is sufficient amount of stored energy in the dc link capacitor as shown in Fig. 4.

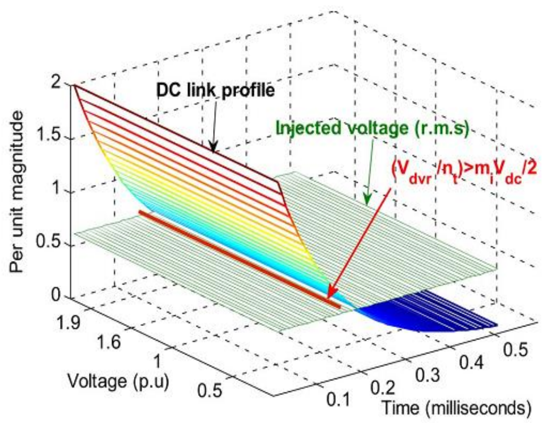

Fig.4. DC link capacitor voltage profile during pre-sag injection.

Furthermore, the gradient of the dc link voltage d_{vdc}/d_t is directly proportional to the DVR-injected active power, i.e., P_{dvr}.

1) The energy stored in the dc link capacitor can further be utilized.

2) The rate of change (fall) of the dc link voltage can further be optimized.

This brings another important variable in the power flow analysis which is the "maximum compensation time t_{c-max}." It is the direct measure of "useful" stored charge/energy in the dc link capacitor. The t_{c-max} can be determined from the boundary condition of (12) and (14) as given in the following:

$$t_{c-max} = \frac{C*\left[V_{dc}^2-\left(\frac{2*V_{dvr}}{m_{i-max}*n_t}\right)^2\right]}{2*P_{dvr}} \qquad (15)$$

PROPOSED COMPENSATION SCHEME

The work presented in this paper proposes an enhanced sag compensation method to extend the DVR compensation time. It optimizes the gradient of the dc link voltage (d_{vdc}/d_t)by regulating the amount of active power injected by DVR. In the proposed method, the controller restores both phase and amplitude of the load voltage to the pre-sag value and then initiates a transition toward the minimum active power (MAP) mode. The overall operation sequence and implementation of the proposed compensation method is discussed in the following subsections.

A. Phase Jump Detection and Pre-sag Restoration

For detecting the phase jump, two PLLs are employed (one over the load voltage and another over the source voltage), giving θVL and θVg, respectively. As soon as the sag is detected, the first step is to determine the DVR initial injection angle that avoids the phase jump at the load side. This is done by freezing the load voltage PLL that gives the pre-sag angle (θVLp).On the other hand, the unrestricted grid voltage PLL gives the grid voltage phase (θVg). The difference between these two angles gives the initial angle of injection

$$\theta_{init} = \theta_L + \left(\theta_{vLP} - \theta_{Vg}\right)$$
$$= \theta_L + \delta \qquad (16)$$

Note that, in the steady state, both angles will be identical, and thus, the difference will be zero. For sag detection, the absolute difference between the reference load voltage (1 p.u.) and the actual grid voltage (p.u.) in synchronous reference frame is calculated as follows

$$\Delta V_{sag} = \left|1 - \sqrt{V_{gd}^2 + V_{gq}^2}\right| \qquad (17)$$

As soon as ΔVsag >0.1, it is recognized as a voltage sag.

B. Controlled Transition toward the MAP Mode

Once the pre-sag voltage is successfully restored, after one cycle, a smooth transition toward the MAP mode is initiated and completed over the next one to two cycles. The final injection angle of DVR (θfin)is given as

$$\theta_{fin} = \begin{cases} \frac{\pi}{2} + \gamma \ , if \Delta V_{sag} \leq (1 - cos\theta_L) \\ \pi - \tan^{-1}\left(\frac{V_L(\sin\theta_L)}{V_L\cos(\theta_L - V_G')}\right), if \Delta V_{sag} > (1 - cos\theta_L) \end{cases} \qquad ((18)$$

A detailed derivation of (18) is given in Appendix C. The first part of (18) represents the self-supporting mode of operation in which the DVR absorbs active power (relatively very small amount) from the grid to overcome the system losses and thus maintains a constant voltage across the dc link capacitor. The term γ indicates the reduction in θfin due to loss component and is determined by the dc link (fuzzy) controller. The second part of (18) represents a case where the self-supported dc link cannot be maintained due the constraint in (5). To ensure a smooth changeover, a transition ramp is defined between the initial and final operating points, as given in the following:

$$\theta_{trans} = \theta_{init} + \frac{\theta_{fin} - \theta_{init}}{\Delta T}(t) \qquad (19)$$

Where ΔT determines the slope of the transition curve and is chosen as 30 ms.

C. Iterative Decrement in Injection Angle

In self-supporting mode, the DVR can compensate the sag for an indefinitely long time. However, for deeper sag depths, there is certain nonzero active power injected by DVR. This causes a reduction in the energy stored in the dc link capacitor, and consequently, its voltage reduces (gradually). To maintain the required voltage at the inverter output side, the controller increases the modulation index mi until it reaches mi−max. This is the limiting case as explained by (12), beyond which the controller goes into over modulation and cannot maintain the rated load voltage. To avoid this over modulation condition, an iterative control loop is used, which constantly monitors the dc link voltage and decreases θfin in (18) to keep Vdc>Vdc−min and is given as

$$\theta_{fin} = \theta_{fin} - \in \qquad (20)$$

Where €is chosen as 0.01 rad.

D. Operation Sequence

Fig. 5(a)–(c) depicts the overall operation sequence of the proposed phase jump compensation scheme. The transition from high active power mode (pre-sag) to MAP mode is shown in three steps. The illustration is for the case where the sag depth is more than the limit in (5) and there is a positive phase jump associated with the sag. As discussed previously and shown in Fig. 5(a), DVR initiates the compensation by supplying high active power to the load (Vr1≫Vx1) and restores both magnitude and phase of the load voltage to pre-sag values.

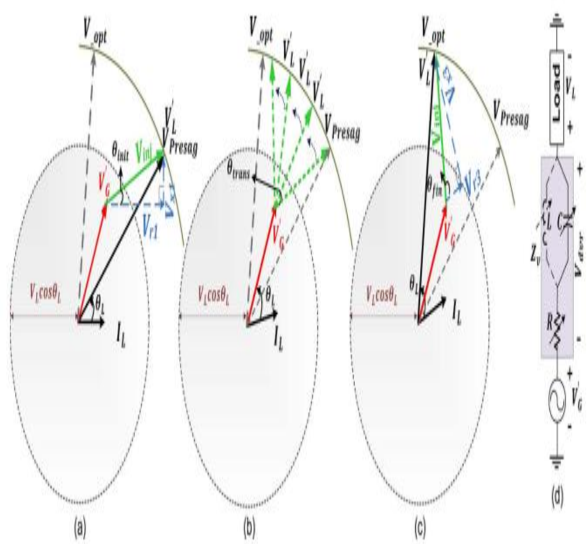

Fig. 5. Phasor diagram for the proposed sag compensation method. (a) Pre-sag restoration, (b) intermediate transition, (c) final load voltage with MAP injection, and (d) DVR visualization as the

variable virtual impedance changes from resistive to dominant capacitive (for sag) or inductive (for swell).

ANALYTICAL STUDY ONCOMPENSATION TIME WITH DIFFERENT APPROACHES

To determine the maximum compensation time achieved using the aforementioned phase jump compensation methods a comparative study is presented in this section. These include the following: 1) the pre-sag; 2) the method given, named as pre-sag–in-phase in this paper; and 3) the proposed method. Table I shows the various design parameters used for the comparison. The maximum compensation time of 200 ms (10 cycles) with a phase jump of +45◦ is taken as reference.

TABLE I
DVR SYSTEM PARAMETERS
(BOUNDARYCONDITIONS)

Parameter	Value
Grid voltage (L-L) (rms) V_{base}	415 V
Line frequency	50 Hz
Nominal Power (Base kVA)	10 kVA
Nominal Load power factor	0.7 Lagging
Maximum compensation time	10 cycles
Maximum sag depth	0.5 p.u
Maximum phase jump	$\pm 45^0$
Maximum injected voltage	0.7 p.u
Transformer turns ratio	1:1
DC link Capacitance value	9000 μF

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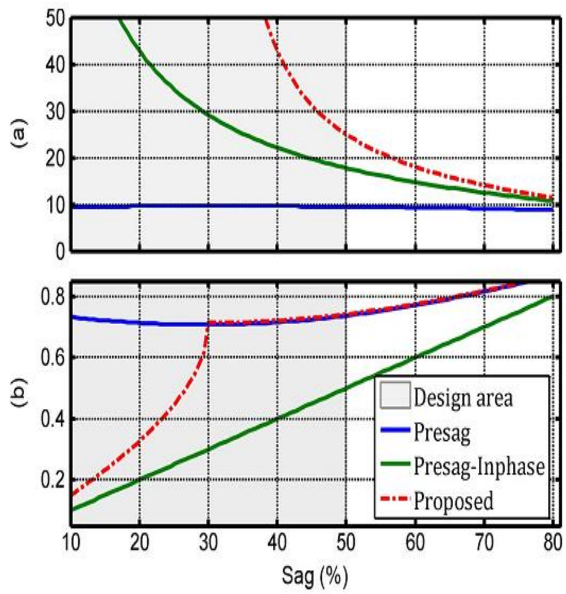

Fig. 6. Maximum compensation time and DVR-injected voltage for various sag depths with different methods. (a) Compensation time cycles. (b)V_{DVR} p.u.

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. Fig. 7depicts the scenario where the phases jump is varied from −90◦ to +90◦ 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 pre-sag method becomes unable to correct the phase jump beyond−60◦ and+60◦ due to violation

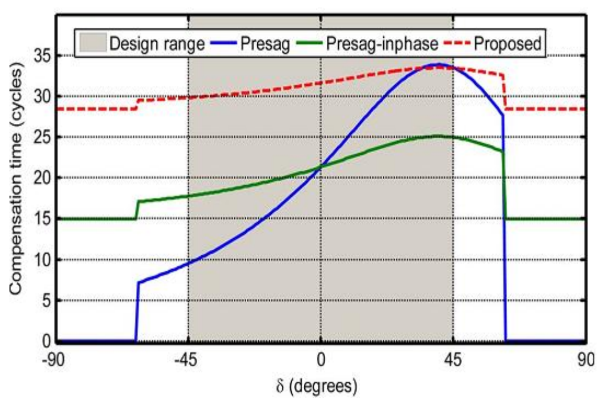

Fig.7. Maximum compensation time for a range of variation in phase jump

OVERALL DVR SYSTEM CONTROL SCHEME

To obtain the reference load voltage, the control system is divided into two sub modules: 1) phase jump detection plus DVR injection angle calculation and MAP injection. To achieve a decoupled active and reactive power control, the phase of the line current is considered as the reference and is obtained by the PLL. The phase jump detection block computes the DVR initial (pre-sag injection) angle and final (MAP injection) angle. Fig. 8depicts the detailed block diagram of the proposed phase jump compensation method.

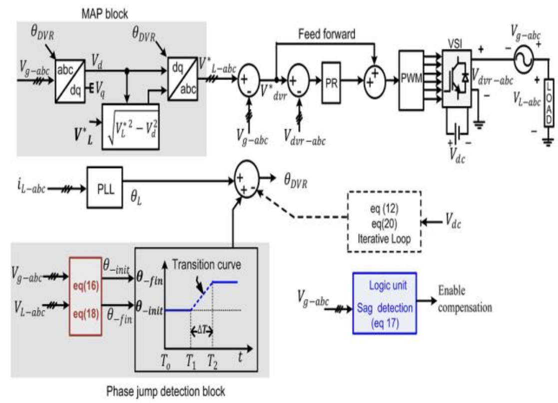

Fig.8. Detailed block diagram of the proposed phase jump compensation method with MAP injection

A logic unit is employed to constantly monitor the As shown in Fig. 8, the obtained DVR reference voltage V∗dvr is compared with the actual voltage in the stationary reference frame. A fuzzy controller with a large gain at the grid fundamental frequency is used for accurate tracking of V∗dvr. To compensate for DVR system losses, V∗dvr is added as a feed forward signal to the output of the Fuzzy controller. The dc link voltage is constantly monitored in an iterative control loop to regulate the injected voltage angle, thus avoiding over modulation. Note that this block is only required when the sag depth is close to the system design limit.

INDUCTION MOTOR

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. Other commonly used name is squirrel cage motor due to the fact that the rotor bars with short circuit rings resemble a squirrel cage (hamster wheel).An electric motor converts electrical power to mechanical power in its rotor.

The Induction motor is a three phase AC motor and is the most widely used machine. Its characteristic features are-

- Simple and rugged construction
- Low cost and minimum maintenance

- High reliability and sufficiently high efficiency
- Needs no extra starting motor and need not be synchronized
- An Induction motor has basically two parts – Stator and Rotor

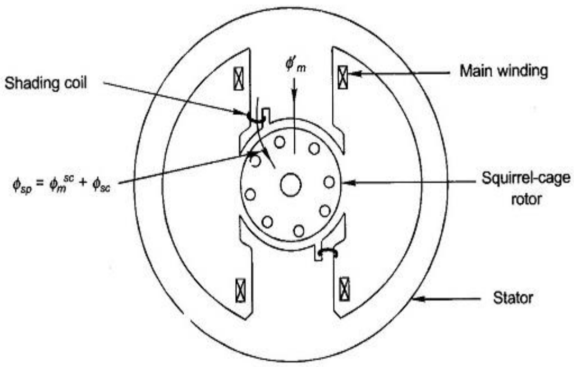

Fig.9. : diagram of induction motor

Principle of operation

When a three-phase supply is connected to the stator windings, a rotating magnetic field is produced. As the magnetic flux cuts a bar on the rotor, an e.m.f. is induced in it and since it is joined, via the end conducting rings, to another bar one pole pitch away, current flows in the bars.

SYNCHRONOUS SPEED:

The speed of the rotating magnetic field is referred to as synchronous speed (NS). Synchronous speed is equal to 120 times the frequency (F), divided by the number of poles (P).

$$.N_s = 120\frac{F}{P} \quad (21)$$

STEADY-STATE REPRESENTATION

The traditional methods of variable-speed drives are based on the equivalent circuit representation of the motor shown below.

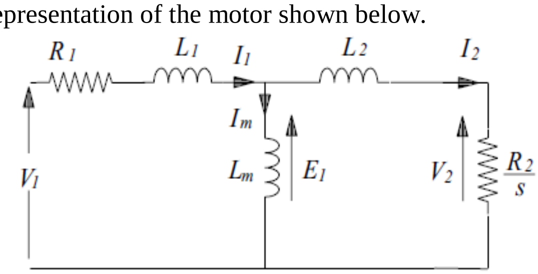

Fig.10.Steady-state equivalent circuit of an induction motor

Power in the rotor circuit,

$$p_2 = 3I_2^2\frac{R_2}{s} = 3V_2I_2 = \frac{3sR_2E_1^2}{R_2^2+(s\omega_1L_2)^2} \quad (22)$$

The output power

$$P_o = P_2 - 3I_2^2R_2$$

$$= (1-S)P_2 = \omega_0 T$$

$$= \frac{(1-s)\omega_1}{P}T$$

Advantages

The advantages of induction motors are:

1. They are robust and sturdy.
2. They can operate in a wide range of industrial conditions.
3. Induction motors are cheaper in cost. The construction is simple.
4. Induction motors do not have accessories such as brushes, slip rings or commentators
5. Low Maintenance.
6. Very little maintenance is required for induction motors.
7. It does not require any complex circuit for starting.
8. The three phase motor is self starting while the single phase motor can be made self-starting simply by connecting a capacitor in the auxiliary winding.

SIMULATION RESULTS

The effectiveness of the proposed method is evaluated through MATLAB/Simulink-based simulation results

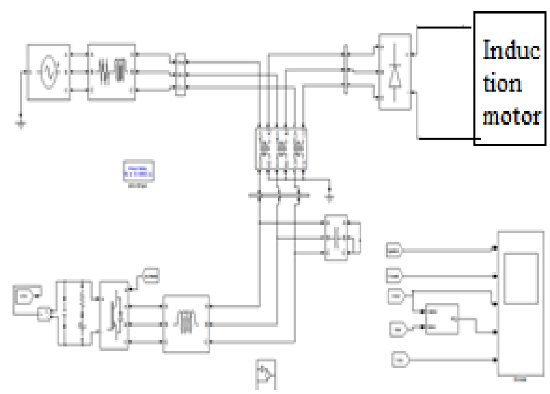

Fig 11.Block diagram of simulation

SIMULATION RESULTS

A simulation model for the DVR system, with the parameter given in Table I, is developed and simulated for the performance evaluation.

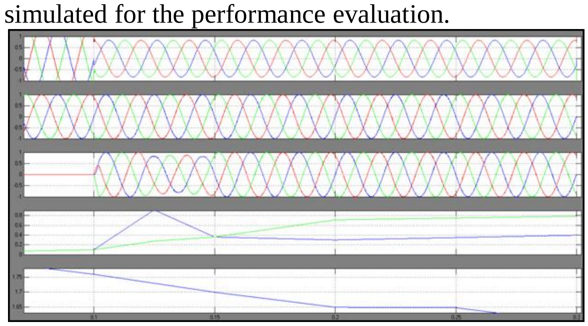

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Fig. 12. Simulation results for the proposed sag compensation method for 50%sag depth. (a) PCC voltage. (b) Load voltage. (c) DVR voltage. (d) DVR active and reactive power. (e) DC link voltage.

As shown in fig 12(a),a sag depth of 50% [higher than the limit in (5)] is considered with a phase jump of+25◦. A symmetrical voltage sag, for ten cycles, is initiated at time t=0.1s. As noticed from Fig. 12(b), the load does not see any change in the voltage phase or magnitude. The DVR injected voltage and active–reactive power profiles are shown in Fig. 12(c) and (d), respectively. Fig. 12(e) shows a constant drop in dc link voltage; however, once the controller goes into MAP mode, a slower fall rate can be noticed.

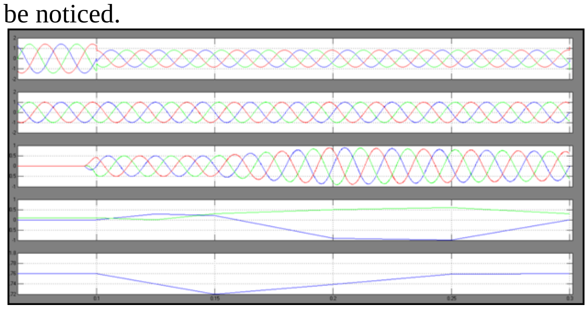

Fig.13. Simulation results for the proposed sag compensation method for 23% sag depth. (a) PCC voltage. (b) Load voltage. (c) DVR voltage. (d) DVR active and reactive power. (e) DC link voltage.

As shown in fig 13, a sag depth of 23% is considered with a phase jump of +25◦. As seen from the results in Fig. 13, the DVR successfully compensates the load voltage phase and magnitude with the proposed method. Since the voltage sag depth is lower than the limit, the controller settles in the self-supporting mode. A reduction in dc link voltage will be seen in fig 13(e), during the first two cycles (phase jump restoration plus transition period), but as the controller moves into self-supporting mode, the dc link voltage is regulated back to the reference value. This can be noticed from Fig. 13(d) as well, where the injected active power is positive for the first two cycles and negative onward.

TABLE II
DVR SYSTEM DATA FOR THE SIMULATION STUDY

Source Chroma 61703	Supply voltage: 50 V-rms, 50 Hz Source Impedance: $R_g = 0.047\ \Omega$ and $L_g = 160\ \mu H$
DVR	DC link capacitors, $C_{dc} = 1100\ \mu F$ Reference DC link voltage = 55 V Filter inductor, $L_f = 5$ mH C_f =50 μF Transformer turns ratio 1:1
Load	R = 11 Ω and L = 80 mH Nominal Load voltage = 50 V Rating = 250 W
Compensation time	10 cycles (200 ms)

CONCLUSION

This paper aims to propose a induction motor for the DVR for voltage mitigation in the distribution utilities. An enhanced sag compensation scheme has been proposed for the capacitor-supported DVR proposed in this paper. The proposed strategy improves the voltage quality of sensitive loads by protecting them against the grid voltage sags involving the phase jump. The most important is to make a good choice of rule base and parameters of membership functions. The reference load terminal of the DVR has been extracted by obtaining the reference voltages. The performance of DVR has been observed to be satisfactory for various power quality problems like voltage sag, voltage swell in supply voltage. The performance of DVR has been observed to be satisfactory for various power quality problems like voltage sag, voltage swell in supply voltage. Therefore an induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. Needs no extra starting motor and need not be synchronized. An Induction motor has basically two parts – Stator and Rotor. Moreover, it is able to provide self-supported dc bus of the DVR through power transfer from ac line at fundamental frequency. The effectiveness of the proposed method has been evaluated through simulation results and validated.

REFERENCES

[1] J. A. Martinez and J. M. Arnedo, “Voltage sag studies in distribution networks—Part I: System modeling,”IEEE Trans. Power Del., vol. 21, no. 3, pp. 338–345, Jul. 2006.

[2] J. G. Nielsen, F. Blaabjerg, and N. Mohan, “Control strategies for dynamic voltage restorer, compensating voltage sags with phase jump,” inProc. IEEE APEC Expo., 2001, pp. 1267–1273.

[3] J. D. Li, S. S. Choi, and D. M. Vilathgamuwa, “Impact of voltage phase jump on loads and its mitigation,” inProc. 4th Int. Power Electron. Motion

Control Conf., Xi'an, China, Aug. 14–16, 2004, vol. 3, pp. 1762–1176.
[4] M. Sullivan, T. Vardell, and M. Johnson, "Power interruption costs to industrial and commercial consumers of electricity," IEEE Trans. Ind. Appl., vol. 33, no. 6, pp. 1448–1458, Nov./Dec. 1997.
[5] J. Kaniewski, Z. Fedyczak, and G. Benysek, "AC voltage sag/swell compensator based on three-phase hybrid transformer with buck–boost matrix-reactance chopper,"IEEE Trans. Ind. Electron., vol. 61, no. 8, pp. 3835–3846, Aug. 2014.
[6] M. Castilla, J. Miret, A. Camacho, J. Matas, and L. de Vicuna, "Voltage support control strategies for static synchronous compensators under unbalanced voltage sags,"IEEE Trans. Ind. Electron., vol. 61, no. 2, pp. 808–820, Feb. 2014.
[7] P. M. Garcia, F. Mancilla, and J. M. Ramirez, "Per-sequence vectorswitching matrix converter modules for voltage regulation,"IEEE Trans. Ind. Electron., vol. 60, no. 12, pp. 5411–5421, Dec. 2013.
[8] C. Kumar and M. Mishra, "A multifunctional DSTATCOM operating under stiff source,"IEEE Trans. Ind Electron., vol. 61, no. 7, pp. 3131–3136, Jul. 2014.
[9] P. Kanjiya, B. Singh, A. Chandra, and K. Al-Haddad, "SRF theory revisited to control self-supported dynamic voltage restorer (DVR) for unbalanced and nonlinear loads,"IEEE Trans. Ind. Appl., vol. 49, no. 5, pp. 2330–2340, Sep./Oct. 2013.
[10] C. Wessels, F. Gebhardt, and F. W. Fuchs, "Fault ride-through of a DFIG wind turbine using a dynamic voltage restorer during symmetrical and asymmetrical grid faults,"IEEE Trans. Power Electron., vol. 26, no. 3, pp. 807–815, Mar. 2011.
[11] Y. W. Li, D. M. Vilathgamuwa, F. Blaabjerg, and P. C. Loh, "A robust control scheme for medium-voltage-level DVR implementation,"IEEE Trans. Ind. Electron., vol. 54, no. 4, pp. 2249–2261, Aug. 2007.

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