A NEW APPROACH TO MULTIFUNCTIONAL DYNAMIC VOLTAGE RESTORER IMPLEMENTATION FOR EMERGENCY CONTROL IN DISTRIBUTION SYSTEMS

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ABSTRACT

The modern and advanced devices preferred in distribution system arrangements to protect consumers against sudden variations in voltage magnitude it is eliminated by using dynamic voltage restorer (DVR). In this development, immediate control in distribution arrangement is explained by using the implementation of multifunctional DVR control strategy technique. Moreover, the multi-loop controller strategy with the two controllers Posicast and P+Resonant is implemented in order to increase the transient system response and vanished the steady-state errors in DVR behavior, equally. The implemented algorithm is employed to some distortions in load voltage affected by induction motors starting problem arises, and a 3-phase short circuit problem may create. Also, the competence of the implemented DVR has been verified to control the downstream problem of current. The current constraint will reestablish the point of common coupling process (PCC) (the bus to which all feeder lines are under study are associated) voltage and control the DVR itself. The improvement here is that the DVR performed as virtual impedance with the main target of compensating and protecting the PCC voltage throughout downstream problems without any fault in real power addition into the DVR. Simulation results display the competence of the DVR to regulate the emergency condition problems of the distribution systems.

Keywords: Multi-Functional Voltage Control, Emergency Control, Dynamic Voltage Restorer (DVR), Voltage Sag, Voltage Swells.

I. INTRODUCTION

Now a days **v**oltage sag and voltage swell are two of the greatest significant power-quality (PQ) complications that incorporate almost80% of the distribution system arrangements cause PQ faults. Conferring to the IEEE 1959–1995 standard paper, voltage sag is the reduction of voltage from 0.1to 0.9 p.u. in the rms voltage level at system main frequency and by the switching period of half a cycle to 1 min. Even in Short circuits, starting bulky motors, sudden variations of load, and energization of transformers are the main reasons of voltage sags presented. Rendering to the description and environment of voltage sag, it can be originate that this is a transient singularity whose reasons are confidential as low- or medium-frequency transient programs. In New Year's, considering the usage of sensitive strategies in modern productions, different approaches of recompense of voltage sags have been required. One of these approaches is by using the DVR to increase the PQ and recompense the required load voltage. Preceding works have been done on dissimilar features of DVR presentation, and different control approaches have been established. These approaches frequently depend on the determination of using DVR. In some procedures, the main perseverance is to distinguish and control for the voltage sag with smallest DVR active power addition. Furthermore, the in-phase compensation technique can be used for sag and swell eliminating process. The multi-line DVR can be used for removing the battery in the DVR arrangement and monitoring more than one line arrangement. Furthermore, investigation has been completed for medium level voltage by using the DVR device. Harmonic removal and modulating of DVR under frequency deviations are also in the area of examination. The closed-loop control arrangement with load voltage and current feedback method is presented as a simple to regulate the DVR in sudden changes. Correspondingly, Posicast and P+Resonant are two more controllers can be used to increase the transient response performance and mitigating the steady-state error problem in DVR. The Posicast controller is a generous of step function type with two fragments and is used to enhance the damping of the transient fluctuations introduced at the starting to produce immediate action from the voltage sag. The P+Resonant controller contains the proportional function addition to a resonant function and it removes the voltage tracking and steady-state problems. The straight feed forward and feedback approaches, symmetrical mechanism arrangement method, superior control, and wavelet package transformation method have also been implemented as dissimilar approaches of monitoring the DVR. In all of the above-mentioned methods, the source of trouble is expected to be on the feeder in which is equivalent to the DVR feeder arrangement. In this paper, a multi-functional control arrangement is developed in which the DVR keeps the load voltage by using these controllers Posicast and P+Resonant, when the source of trouble is parallel to the feeders. On the other hand, throughout a downstream fault condition, the apparatus protects the PCC required voltage, regulate the unwanted high current, and protecting itself from huge fault current. While this latest complaint has been designated by using the flux control mechanism, the DVR suggested there operated like a virtual inductance by a continuous value so that it does not get any active power throughout controlling the fault current. Nevertheless in the developed process when the fault current permits through the DVR, it performs like series adjustable impedance. The basis of the developed control strategy technique in this project is that when the fault current does not permits through the DVR; an outer feedback loop control method of the load voltage with an inner feedback loop control by using the current of the filter capacitor is controlled. In addition, a feed forward loop control method will be preferred to enhance the dynamic response behavior of the required load voltage. Additionally, to enhance the transient response behavior, the Posicast regulator and to avoid the steady-state errors, by selecting the P+Resonant controller we can eliminate the errors.

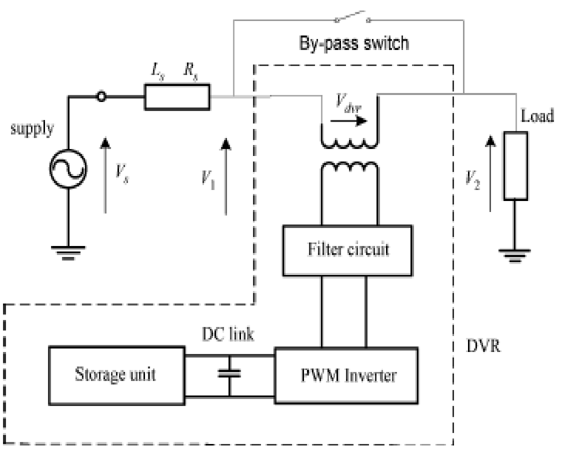

Fig.1.Typical DVR-Connected Distribution System

But in case the fault current permits through the facts device i.e. DVR, by using the flux control phenomena the series voltage is introduced to add the in the opposite direction and, consequently, the DVR performed like as series flexible impedance. The residue of this paper is planned as following discursion.

II. DVR COMPONENTS AND ITS BASIC OPERATIONAL PRINCIPLE

2.1 DVR Components

A distinctive DVR-connected distribution system arrangement is drawn in Fig. 1, where the DVR involves the basic parameters like as series-interconnected injection transformer, a voltage-source inverter (VSI), an energy storage parameter and an inverter output filter that is linked to the dc link.

Before injecting the inverter produced output to the device, it is necessary to filtered so that harmonics owing to switching conditions in the inverter are vanished. It must be prominent that when using the DVR in real time considerations, the transformer will be operated in parallel by selecting a bypass switching parameter (Fig. 1). When there is no troubles in voltage generations, the injection device i.e. transformer will be acts as short circuited by this adjustment to diminish losses and enhances cost effectiveness.

Furthermore, this power electronic switch can be in the procedure of two parallel power electronic devices like as thyristors (SCR's), as they have extra ordinary switching capabilities like on and off speed. A financial calculation of voltage sag proceedings and use of convenience ac transmission system arrangements (FACTS) parameters, like as DVR, to compensate them is presented. It is clear that the flexibility of using the DVR output depends on the working of the switching pulse accuracy that is controlled by pulse width modulation (PWM) arrangement.

The PWM produces sinusoidal indications by equating a sinusoidal wave and a saw tooth wave that sends appropriate pulses to the inverter switches.

2.2 Basic Operational Principle of DVR

The DVR arrangement illustrated in Fig.1 simulating the required load voltage by providing the extra required voltage with the phasor V_{odvr} in series with the arrangement device using the injecting the voltage by series transformer.

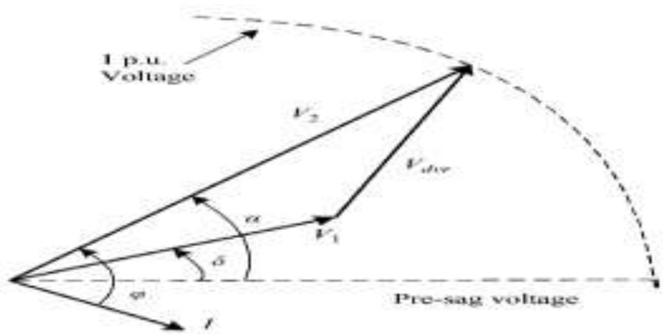

Fig.2. Phasor Diagram of the Electrical Conditions During Voltage Sag

In most of the sag controlling methods, it is essential that throughout compensation, the DVR addition some active power to the entire system. Consequently, the ability of the storage component can be a controlling factor in protection mechanism, particularly during continuous voltage sag problems.

The phasor diagram shown in Fig. 2 that shows the electrical circumstances at the time of voltage sag, where, for simplicity, only one phase is displayed. Source side VoltagesV_1,V_2andV_{dvr}, the loadsidevoltages, and the DVR injected the insufficient voltage, individually.

Also, the parameters operation current I and are the load current, the angle of load power factor, the angle of source phase voltage, and the voltage phase side angles, correspondingly. It must be prominent that in adding to the in-phase addition method, another method, like as “the phase improvement voltage compensation performance” is also considered. One of the benefits of this technique over the in-phase technique is that less active power must be shifted from the storage component to the distribution organization. This consequence results in protection of deeper sags or sags with long time durations.

Owed to the presence of semiconductor devices in the DVR inverter arrangement, this piece of apparatus is nonlinear. Nevertheless, the state equations can be produce linear using linearization methods. The dynamic waveforms of the DVR are predisposed by the filter and the consumers i.e. load. While the simulating of the filter (that generally with a simple LC parameters) is easy to develop, the load simulating and controlling is not as simple since the load can differ from a linear time invariant arrangements to a nonlinear time-variant one. In this project, the simulations are developed with two kinds of loads: 1) a continuous power load arrangement and2) a motor load.

As Fig. 3 displays, the load voltage is controlled by the DVR through addingV_{dvr}. For ease, the bypass switch device drawn in Fig. 1 is not obtainable in this figure. Here, it is supposed that the required load has a operated resistance $R_L$and an inductance L_L.

The Posicast controller is preferred in order to expand the transient operating response. Fig. 4 exposes a special control block diagram of the fact device DVR. Identify that that suitable to function of real time specifications, we are placing with many number of feeders associated to a single bus, expressly functioned to perform the Point of Common Coupling (PCC),” from the voltages of, V_1 , and V_2 and will be substituted with V_{dvr} , individually, to make a comprehensive sense.

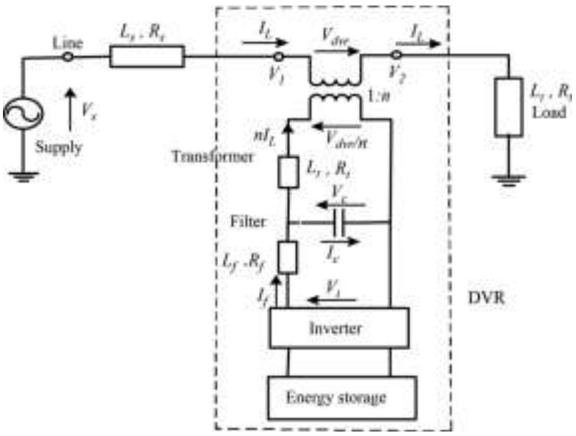

Fig3.Distribution System With The DVR

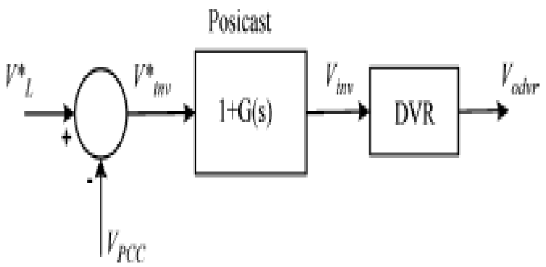

Fig4.Open-Loop Control Using The Posicast Controller

As exposed in the given figure, in the open-loop control technology, the voltage on the source side arrangement of the DVR $V_{pcc}$is associated with a load-side required reference voltageV_L^* so that the essential addition voltage $V_{inv}^*$is calculated. A simple technique to continue is to maintain the error indication into the PWM modulation technique of the DVR. But the difficult with this is that the transient fluctuations introduced at the start immediate from the voltage sag might not be damped adequately.

To expand the damping, as exposed in Fig. 4, the Posicast controller can be preferred just before conveying the signal to the PWM modulator of the DVR. The controller transfer function can be calculated as follows:

1+G(s)=1+$\frac{\delta}{1+\delta}(e^{-sT_{d/2}}$-1)…(1)

(1)Where δ and T_d are represent the step behavior overshoot and the switching period of damped performance signal, correspondingly. It must be renowned that the Posicast regulator has limited minimum high-frequency gain; therefore, low sensitivity to noise. To get the suitable values of δ and T_d, primary the DVR model will be resultant according to Fig. 3, as follow:

$$V_i = V_e + I_f R_f + L_f \frac{dI_f}{dt}$$

$$I_f = I_c + n.I_c$$

$$I_c = C_f + \frac{dV_e}{dt}$$

$$V_{dvr} = n[V_c - n\left(I_L R_{t+} L_t \frac{dI_t}{dt}\right)]$$

$$V_2 = V_1 + V_{dvr} ..(2)$$

(2)Then, consider the equation (2) and the knowledge of damping and the time delay in the control strategy, δ and T_d are calculated as follows:

$$T_d = \frac{2\pi}{\omega r} = \frac{\pi}{\sqrt{\frac{1}{L_f C_f} - \frac{R^2}{4L_f^2}}}$$

$$\delta = e^{-\varepsilon\pi/\sqrt{1-}}\varepsilon^2 = \frac{e^{-R_f \pi}\sqrt{C_f}}{\sqrt{4L_f - R_f^2 C_f}} ..(3)$$

(3)The Posicast controller mechanism works by pole elimination process and proper regulation of its parameters is necessary. For this reason, it is sensitive to incorrect data of the system damping resonance frequency condition. To avoid this sensitivity and it is demonstrated in Fig. 5, the open-loop controller used to convert to a closed loop controller by providing a multi-loop feedback path parallel to the accessible feed forward path.

Addition of a feed forward and a feedback path arrangement is generally referred to as two-degrees-of freedom (2-DOF) control apparoachment in the literature. As the name specifies that, 2-DOF control maintains a DOF for selecting fast dynamic tracking arrangement by feed forward path provided and a second degree of Freedom for the independent smooth controlling of the scheme disturbance protection from the feedback path. The feedback process contains of an outer voltage loop control and a quick inner current Loop controller.

To reduce the steady-state voltage problems by providing tracking error process $V_L^* - V_L$, clearly by use less intensive P+Resonant compensator is additional to the outer voltage loop part. The ideal parameter P+Resonant neutralize or can be scientifically expressed as (4)

$$G_R(s) = K_p + \frac{2K_1 s}{s^2 + \omega_0^2} ..(4)$$

Where K_p and K_d represents gain margin constants and $\omega_o = 2\pi * 50 rad/\sec$ is the regulator resonant frequency. Hypothetically, the resonant controller propagates by providing an infinite gain at the resonant occurrence of 50 Hz (Fig. 6) to power the steady-state voltage problems reaches to zero. The general resonant controller, but functioned like a network with an infinite performance factor, which is not reached in real time operations. A most usefulness of (non-ideal) compensator is calculated as (5)

$$G_R(s) = K_p + \frac{2K_1 \omega_{cut} s}{s^2 + 2\omega_{cut} s + \omega_0^2} ..(5)$$

Where ω_{cut} is denotes the compensator cutoff frequency by which is 1 rad/sin this feature.

Scheming the frequency reaction of (5), as in Fig. 6, it is well-known that the resonant peak at the moment has a specified gain margin of 40 dB which is adequately high for vanishing the voltage tracking error. In addition, a wider bandwidth is observed around the resonant frequency, which neutralizes the tendency of the compensator to slight convenience frequency adjustable conditions. At different harmonic frequencies implemented, the behavior of the non-ideal regulator is equivalent to that of the ideal one.

III. PROPOSED MULTIFUNCTIONAL DVR

In accumulation to the abovementioned technologies of DVR, it can be preferred in the medium-voltage level (as in Fig. 7) to defend a group of customers when the reason of interruption is in the downstream of the DVR's feeder and the higher fault current allows through the DVR itself controlled to operate.

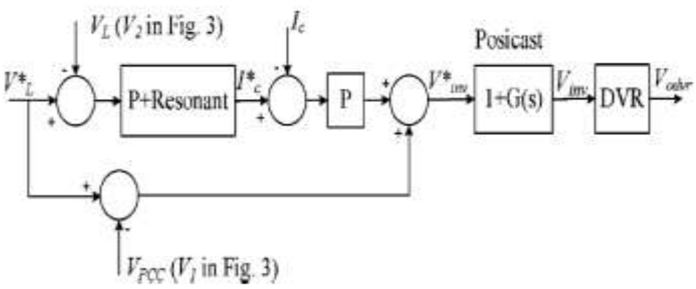

Fig.5.Multiloop Control Using the Posicast and P+Resonant Controllers

In this condition, the apparatus can boundary the fault current and protect the loads in parallel feeders awaiting the breaker mechanism and switched off the faulted feeder.

To boundary the fault current, a flux-charge diagram has been implemented and used to create DVR act like a excellent virtual inductance which does not collect any active power from the external requirement and, therefore, operate the dc-link capacitor and battery as displayed in Fig. 1. However in this design, the value of the internal inductance of DVR is a constant one and the required reference of the control loop method is injects the flux of the transformer winding terminals, and the PCC voltage is not calculated in the control loop.

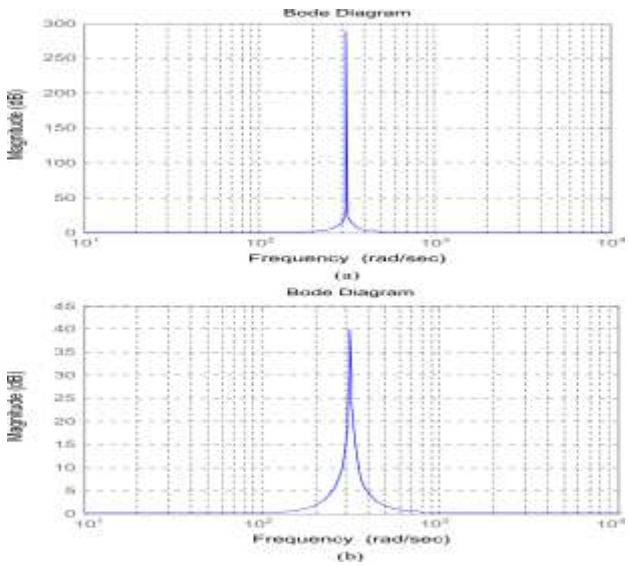

Fig6 Typical Magnitude Responses of the (A) Ideal and (B) Non-Ideal P+Resonant Controller

The large fault current reason the PCC voltage drop and the customer loads on the different feeders associated to this bus will be pretentious. Additionally, if not forbidden accurately, the DVR capacity also throws in to this PCC voltage sag in the procedure of protecting the absent voltage, hence additional worsening the fault criteria.

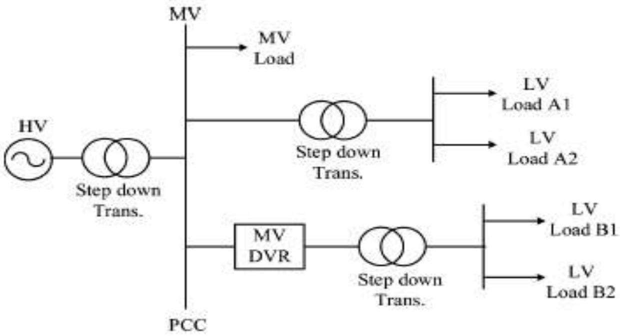

Fig.7 DVR Connected In a Medium-Voltage Level Power System

In this project, the PCC voltage is preferred as the main required reference signal and the DVR performed like changeable impedance. For this cause, the combination of real power is dangerous for the battery and. To work out this trouble, impedance with a resistance and an inductance will be associated in parallel to the capacitor connected dc-link. This capacitor will be estranged from the circuitry, and the battery will be coupled in series through a diode just when the downstream problem presented so that the power does not come into the battery and the capacitor connected dc-link. It must be noted here that the inductance is used mainly to avoid large fluctuations in the current.

IV. CONCLUSION

In this project, a multi-functional DVR is implemented, and a closed-loop control system arrangement is selected for its control to enhance the damping response f the DVR behavior. Also, for further enhancing the transient reaction and neutralizing the steady-state losses, the Posicast and P+Resonant regulators are selected. As the second property of this DVR, by this the flux-charge consideration, the apparatus is prohibited so that it restrictions the downstream problems currents and compensates the PCC voltage during these faults by performing like as changeable impedance.

The difficulty of fascinated active power is controlled by adjusting impedance just at to create of this type of fault in parallel with the capacitor connected dc-link and the battery being associated in series through a by-pass diode consequently that the power does not allows into it.

The MATLAB/simulation outputs tested and verified the performance and ability of the implemented DVR in neutralizing for the voltage sags affected by short circuits and the huge induction motor starting and preventive the downstream problems from currents and compensating the PCC voltage.

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