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ANALYSIS OF AN EMERGENCYCONTROL IN ISTRIBUTION SYSTEMS BY USING MULTIFUNCTIONAL DYNAMIC VOLTAGE RESTORER

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ABSTRACT

The dynamic voltage restorer (DVR) is one of the modern devices used in distribution systems to protect consumers against sudden changes in voltage amplitude. In this paper, emergency control in distribution systems is discussed by using the proposed multifunctional DVR control strategy. Also, the multiloop controller using the Posicast and P+Resonant controllers is proposed in order to eliminate the steadystate error response and to improve the transient response in DVR, respectively. The proposed algorithm is applied to some disturbances in load voltage caused by induction motors starting, and a three-phase short circuit fault. Also, the multiloop controller using the Posicast and P+Resonant controllers is proposed in order to improve the transient response and eliminate the steady-state error in DVR response, respectively. The proposed algorithm is applied to some disturbances in load voltage caused by induction motors starting, and a three-phase short circuit fault. Also, the capability of the proposed DVR has been tested to limit the downstream fault current. The current limitation will restore the point of common coupling (PCC) (the bus to which all feeders under study are connected) voltage and protect the DVR itself. The innovation here is that the DVR acts as a virtual impedance with the main aim of protecting the PCC voltage during downstream fault without any problem in real power injection into the DVR. Simulation results show the capability of the DVR to control the emergency conditions of the distribution systems.

1. INTRODUCTION

VOLTAGEsag and voltage swell are two of the most important power-quality (PQ) problems that encompass almost 80% of the distribution system PQ problems [1]. According to the IEEE 1959–1995 standard, voltage sag is the decrease of 0.1 to 0.9 p.u. in the rms voltage level at system frequency and with the duration of half a cycle to 1 min [2]. Short circuits, starting large motors, sudden changes of load, and energization of transformers are the main causes of voltage sags [3]. According to the definition and nature of voltage sag, it can be found that this is a transient phenomenon whose causes are classified as low- or medium-frequency transient events [2]. In recent years,

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considering the use of sensitive devices in modern industries, different methods of compensation of voltage sags have been used. One of these methods is using the DVR to improve the PQ and compensate the load voltage [6].

Previous works have been done on different aspects of DVR performance, and different control strategies have been found. These methods mostly depend on the purpose of using DVR. In some methods, the main purpose is to detect and compensate for the voltage sag with minimum DVR active power injection [4], [5]. Also, the in-phase compensation method can be used for sag and swell mitigation [6]. The multiline DVR can be used for eliminating the battery in the DVR structure and controlling more than one line [7]. Moreover, research has been made on using the DVR in medium level voltage [8]. Harmonic mitigation [9] and control of DVR under frequency variations are also in the area of research. The closed-loop control with load voltage and current feedback is introduced as a simple method to control the DVR. Also, Posicast and P+Resonant controllers can be used to improve the transient response and eliminate the steady-state error in DVR. The Posicast controller is a kind of step function with two parts and is used to improve the damping of the transient oscillations initiated at the start instant from the voltage sag. The P+Resonant controller consists of a proportional function plus a resonant function and it eliminates the steady-state voltage tracking error.

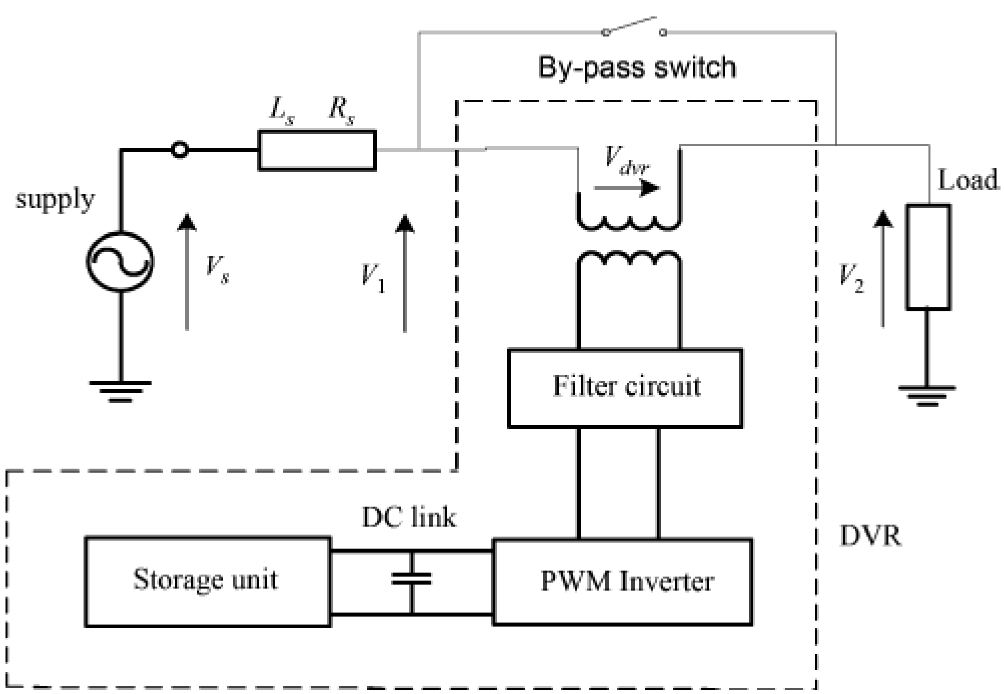

Fig. 1. Typical DVR-connected distribution system.

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The state feedforward and feedback methods symmetrical components estimation robust control and wavelet transform have also been proposed as different methods of controlling the DVR. In all of the aforementioned methods, the source of disturbance is assumed to be on the feeder which is parallel to the DVR feeder. In this paper, a multifunctional control system is proposed in which theDVR protects the load voltage using Posicast and P+Resonant controllers when the source of disturbance is the parallel feeders. On the other hand, during a downstream fault, the equipment protects the PCC voltage, limits the fault current, and protects itself from large fault current. Although this latest condition has been described using the flux control method, the DVR proposed there acts like a virtual inductance with a constant value so that it does not receive any active power during limiting the fault current. But in the proposed method when the fault current passes through the DVR, it acts like a series variable impedance (unlike where the equivalent impedance was a constant). Previous works have been done on different aspects of DVR performance, and different control strategies have been found. In some methods, the main purpose is to detect and compensate for the voltage sag with minimum DVR active power injection [4], [5]. Also, the in-phase compensation method can be used for sag and swell mitigation [6]. The multiline DVR can be used for eliminating the battery in the DVR structure and controlling more than one line [7]. Moreover, research has been made on using the DVR in medium level voltage [8]. Harmonic mitigation [9] and control of DVR under frequency variations are also in the area of research. The closed-loop control with load voltage and current feedback is introduced as a simple method to control the DVR. Also, Posicast and P+Resonant controllers can be used to improve the transient response and eliminate the steady-state error in DVR. The Posicast controller is a kind of step function with two parts and is used to improve the damping of the transient oscillations

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2. DVR COMPONENTS AND ITS BASIC OPERATIONAL PRINCIPLE

A. DVR Components

A typical DVR-connected distribution system is shown in Fig. 1, where the DVR consists of essentially a series-connected injection transformer, a voltage-source inverter, an inverter output filter, and an energy storage device that is connected to the dc link. Before injecting the inverter output to the system, it must be filtered so that harmonics due to switching function in the inverter are eliminated. It should be noted that when using the DVR in real situations, the injection transformer will be connected in parallel with a bypass switch (Fig. 1). When there is no disturbances in voltage, the injection transformer (hence, the DVR) will be short circuited by this switch to minimize losses and maximize cost effectiveness. Also, this switch can be in the form of two parallel thyristors, as they have high on and off speed [21]. A financial assessment of voltage sag events and use of flexible ac transmission systems (FACTS) devices, such as DVR, to mitigate them is provided in [22]. It is obvious that the flexibility of the DVR output depends on the switching accuracy of the pulsewidth modulation (PWM) scheme and the control method. The PWM generates sinusoidal signals by comparing a sinusoidal wave with a sawtooth wave and sending appropriate signals to the inverter switches. A further detailed description about this scheme can be found in [23].

B. Basic Operational Principle of DVR

The DVR system shown in Fig. 1, controls the load voltage by injecting an appropriate voltage phasor in series with the

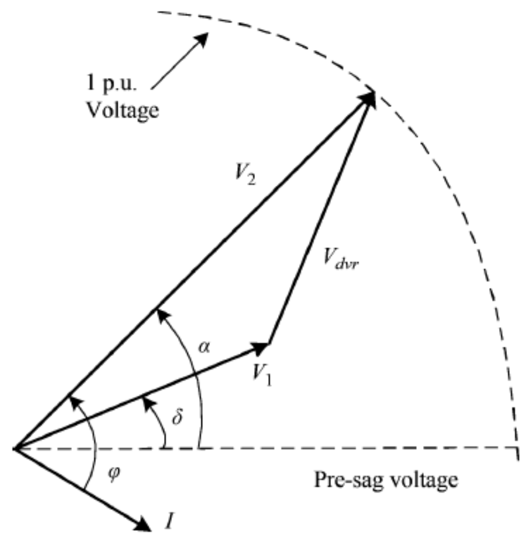

Fig. 2. Phasor diagram of the electrical conditions during a voltage sag.

system using the injection series transformer. In most of the sag compensation techniques, it is necessary that during compensation, the DVR injects some active power to the system. Therefore, the capacity of the storage unit can be a limiting factor in compensation, especially during long-term voltage sags. The phasor diagram in Fig. 2, shows the electrical conditions during voltage sag, where, for clarity, only one phase is shown. Voltages , , and are the source-side voltage, the loadside voltage, and the DVR injected voltage, respectively. Also, the operators I, , , and are the load current, the load power factor angle, the source phase voltage angle, and the voltage phase advance angle, respectively [24]. It should be noted that in addition to the in-phase injection technique, another

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technique, namely "the phase advance voltage compensation technique" is also used [24]. One of the advantages of this method over the in-phase method is that less active power should be transferred from the storage unit to the distribution system. This results in compensation for deeper sags or sags with longer durations. Due to the existence of semiconductor switches in the DVR inverter, this piece of equipment is nonlinear. However, the state equations can be linearized using linearization techniques. The dynamic characteristic of the DVR is influenced by the filter and the load. Although the modeling of the filter (that usually is a simple LC circuit) is easy to do, the load modeling is not as simple because the load can vary from a linear time invariant one to a nonlinear time-variant one. In this paper, the simulations are performed with two types of loads: 1) a constant power load and 2) a motor load.

3. CONTROL STRATEGY

There are three basic control strategies as follows. *1. Pre-Sag Compensation* The supply voltage is continuously tracked and the load voltage is compensated to the pre-sag condition. This method results in (nearly) undisturbed load voltage, but generally requires higher rating of the DVR. Before a sag occur, VS = VL = Vo. The voltage sag results in drop in the magnitude of the supply voltage to VS1. The phase angle of the supply also may shift.

The DVR injects a voltage VC1 such that the load voltage (VL = VS1 + VC1) remains at Vo (both in magnitude and phase). It is claimed that some loads are sensitive to phase jumps and it is necessary to compensate for both the phase jumps and the voltage sags. The voltage injected by the DVR is always in phase with the supply voltage regardless of the load current and the pre-sag voltage (Vo). This control strategy results in the minimum value of the injected voltage (magnitude). However, the phase of the load voltage is disturbed. For loads which are not sensitive to the phase jumps, this control strategy results in optimum utilization of the voltage rating of the DVR. The power requirements for the DVR are not zero for these strategies 3. Minimum Energy Compensation Neglecting losses, the power requirements of the DVR are zero if the injected voltage (VC) is in quadrature with the load current. To raise the voltage at the load bus, the voltage injected by the DVR is capacitive and VL leads VS1 shows the in-phase compensation for comparison. It is to be noted that the current phasor is determined by the load bus voltage phasor and the power factor of the load. Implementation of the minimum energy compensation requires the measurement of the load current phasor in addition to the supply voltage. When VC is in quadrature with the load current, DVR supplies only reactive power. However, full load voltage compensation is not possible Unless the supply voltage is above a minimum value that depends on the load power factor.

CONCLUSION

In this paper, a multifunctional DVR is proposed, and a closed-loop control system is used for its control to improve

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the damping of the DVR response. Also, for further improving the transient response and eliminating the steady- tate error, the Posicast and P+Resonant controllers are used. As the second function of this DVR, using the flux-charge model, the equipment is controlled so that it limits the downstream fault currents and protects the PCC voltage during these faults by acting as a variable impedance. The problem of absorbed active power is solved by entering n impedance just at the start of this kind of fault in parallel with the dc-link capacitor and the battery being connected in series with a diode so that the power does not enter it. The simulation results verify the effectiveness and capability of the proposed DVR in compensating for the voltage sags caused by short circuits and the large induction motor starting and limiting the downstream fault currents and protecting the PCC voltage.

REFERENCES

[1] J. A. Martinez and J. Martin-Arnedo, “Voltage sag studies in distribution networks- part II: Voltage sag assessment,” *IEEE Trans. Power Del.*,vol. 21, no. 3, pp. 1679–1688, Jul. 2006.

[2] 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.

[3] P. Hcine and M. Khronen, “Voltage sag distribution caused by power system faults,” *IEEE Trans. Power Syst.*, vol. 18, no. 4, pp. 1367–1373, Nov. 2003.

[4] S. S. Choi, B. H. Li, and D. M. Vilathgamuwa, “Dynamic voltage restoration with minimum energy injection,” IEEE Trans. Power Syst., vol. 15, no. 1, pp. 51–57, Feb. 2000.

[5] C. Fitzer, M. Barnes, and P. Green, “Voltage sag detection technique for a dynamic voltage restore,” IEEE Trans. Ind. Appl., vol. 2, no. 1, pp.203–212, Jan./Feb. 2004.

[6] C. Benachaiba and B. Ferdi, “Voltage quality improvement using DVR,” Electt. Power Qual. Utilisation, Journal, vol. XIV, no. 1, 2008.

[7] D. M. Vilathgamuwa, H. M. Wijekoon, and S. S. Choi, “A novel technique to compensate voltage sags in multiline distribution system-the interline dynamic voltage restorer,” IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1603–1611, Oct. 2006.

[8] J. G. Nielsen, M. Newman, H. Nielsen, and F. Blaabjerg, “Control and testing of a dynamic voltage restorer (DVR) at medium voltage level,” IEEE Trans. Power Electron., vol. 19, no. 3, pp. 806–813, May 2004.

[9] M. J. Newman, D. G. Holmes, J. G. Nielsen, and F. Blaabjerg, “A dynamic voltage restorer (DVR) with selective harmonic compensation at medium voltage level,” IEEE Trans. Ind. Appl., vol. 41, no. 6, pp. 1744–1753, Nov./Dec. 2005.

[10] A. K. Jindal, A. Ghosh, and A. Joshi, “Critical load bus voltage control using DVR under system frequency variation,” Elect. Power Syst. Res., vol. 78, no. 2, pp. 255–263, Feb. 2008.