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Research paper

A New Multifunctional DVR for Compensation of Voltage Sag

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Abstract

Now days, power quality is an important application. Sophisticated electronic equipments, variable speed drive having high efficiency, and power electronic controller, are used to improve power quality. Voltage sags are the most common power quality disturbance in the distribution system. It occurs due to the fault in the electrical network or by the starting of a large induction motor and this can be solved by using the custom power devices such as Dynamic Voltage Restorer (DVR). It is smaller in size, and provides fast dynamic response to the disturbance and also has lower cost. A multifunctional DVR is used here to improve the power quality with the help of Posicast and P+Resonant controllers to improve the transient response and eliminate the steady-state error. Simulation result shows the capability of the DVR to control the emergency conditions of the distribution systems. 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 virtual impedance with the main aim of protecting the PCC voltage during downstream fault without any problem in real power injection into the DVR.

Keywords: *Point of common coupling (PCC), dynamic voltage restorer (DVR), emergency control, voltage sag, voltage swells.*

1. Introduction

The electrical system is composed of three functional blocks such as generation, transmission and distribution. The technology unit produces ample electricity to meet clients demand, the transmission systems transport bulk power over long distances and the distribution system supply electrical energy to each customer's premises from bulk power structures for making the electrical system reliable. Distribution device locates the end of power system and is connected to the client directly, so the power mostly depends on distribution system due to the fact the electrical distribution network failures account for about 90% of the common client interruptions. In the earlier days, the power system reliability generally focuses on era and transmission only. But now a days distribution structures is also be regarded for reliability assessment.

2. Existing System for Power Quality

Initially for the enhancement of energy pleasant or reliability of the device FACTS units like static synchronous compensator (STATCOM), Static Synchronous Series Compensator (SSSC), Interline Power Flow Controller (IPFC), and Unified Power Flow Controller (UPFC) and so forth are introduced. These FACTS gadgets are designed for the transmission system. But now more interest is on the distribution system for the enhancement of energy quality. These units are modified and acknowledged as custom power devices.

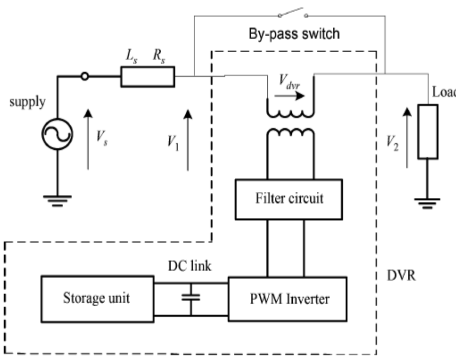

Fig. 1: Typical DVR-connected distribution system

The major custom electrical devices which are used in distribution system for power quality improvement are Distribution STATIC synchronous compensator (DSTATCOM), Dynamic Voltage Restorer (DVR), Active Filter (AF), Unified Power Quality Conditioner (UPQC) etc. From the above custom energy devices, right here DVR is used for the power exceptional improvement in the distribution system.
That is emergency control in distribution systems is mentioned by means of the usage of the multifunctional DVR control strategy. Also, the multi loop controller using Posicast and P+Resonant controllers is presented in order to enhance the transient response and cast off the steady-state error in DVR response, respectively.

3. Proposed Multi-Functional DVR

The groundwork of the proposed control strategy in this paper is that when the fault modern does no longer ignore thru the DVR, an outer feedback loop of the load voltage with an internal feedback loop of the filter capacitor contemporary will be used. Also, a feed forward loop will be used to enhance the dynamic response of the load voltage. Moreover, to enhance the transient response, the Posicast controller and to put off the steady-state error, the P+ Resonant controller are used. But in case the fault contemporary passes through the DVR, the usage of the flux manipulate algorithm, the series voltage is injected in the contrary route and, therefore, the DVR acts like sequence variable impedance.

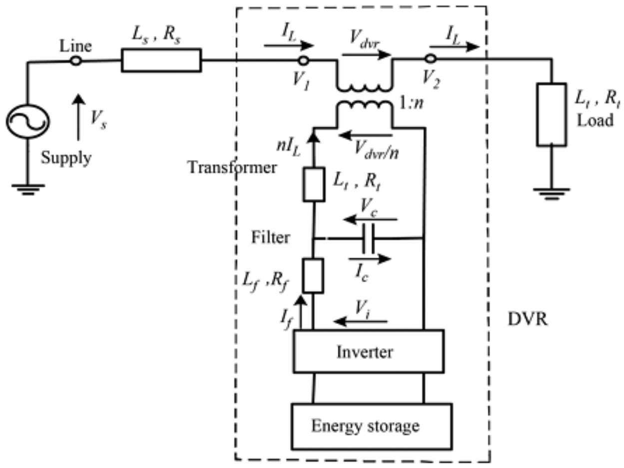

Fig. 2: Distribution gadget with the DVR

As Fig. 2 shows, the load voltage is regulated with the aid of the DVR through injecting. This will be separated from the circuit, and the battery will be connected in sequence with a diode simply when the downstream fault occurs so that the energy does no longer enter the battery and the dc-link capacitor. It should be stated right here that the inductance is used in the main to stop massive oscillations in the current. The active energy stated is, therefore, absorbed with the aid of the impedance.

In this paper, the PCC voltage is two used two as two the majorref erence signal two and the DVR acts like variable impedance. For this reason, the absorption of real electricity is harmful for the battery and dc-link capacitor. To solve this problem, impedance inclusive of a resistance and an inductance will be connected in parallel with the dc -link capacitor. This capacitor will be separated from the circuit, and the battery will be connected in collection with a diode simply when the downstream fault takes place two so that the power does now not enter the battery and the dc-link capacitor. The active power cited is, therefore, absorbed with the aid of the Impedance.

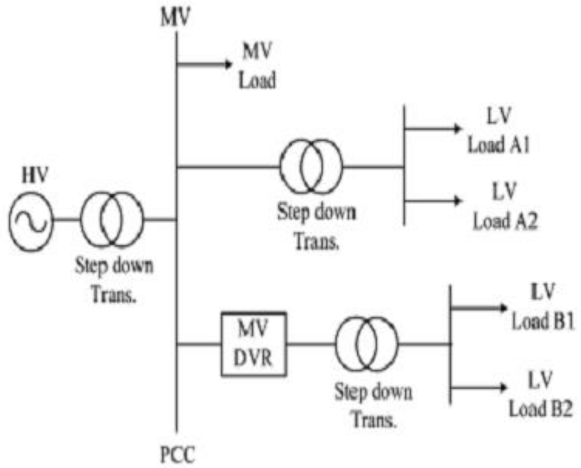

Fig. 3: DVR join in a medium-voltage level electricity systems

Proposed method for using the flux-charge model In this part, an algorithm is proposed for the DVR to repair the PCC voltage, restrict the fault current and therefore, protect the DVR components. The flux -charge mannequin right here two is used in a way so that the DVR acts as a virtual inductance with a variable value in series with the distribution feeder. To do this, the DVR need to be controlled in a way to inject a desirable voltage having the contrary polarity with respect to typical cases. It be stated that over current tripping two is now not feasible in this case, until extra verbal exchange between the DVR and the downstream facet over modern circuit breaker (CB) is available. If it is essential to function the over modern CB at PCC, verbal exchange between the DVR and the PCC breaker may have to be made and this can be without difficulty carried out by means of sending a sign to the breaker when the DVR is in the fault-current limiting mode as the DVR is just placed after PCC. It have to also be cited that the reference flux is derived through integration of the subtraction of the PCC reference voltage and the DVR load-side voltage.

Basic Operational Principle of DVR

The DVR device controls the load voltage through injecting an fantastic voltage phasor in collection with the machine the usage of the injection series transformer. In most of the sag compensation techniques, it is imperative that in the course of compensation, the DVR injects some lively energy to the system. Therefore, the ability of the storage unit can be a limiting thing in compensation, specifically at some stage in long-term voltage sags. One of the blessings of this method over the in-phase method is that much less energetic power be transferred from the storage unit to the distribution system. This effects 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 with the aid of the filter and the load. Although the modeling of the filter (that commonly is a easy LC circuit) is handy to do, the load modeling is not as easy due to the fact the load can fluctuate from a linear time invariant one to a nonlinear time-variant one. In this paper, the simulations are carried out with two sorts of loads: 1) a constant power load and 2) a motor load. As the load voltage is regulated with the aid of the DVR through injecting Vdvr.

The DVR harmonic filter has an inductance of Lf, a resistance of Rf , and a capacitance of Cf . The Posicast controller is used in order to improve the transient response. Note that due to the fact in real situations, we are dealing with more than one feeders related to a frequent bus, namely "the Point of Common Coupling (PCC)," from now on V1 and V2 will be replaced with Vpcc and Vl, respectively, to make a generalized sense. A easy method to continue is to feed the error signal into the PWM inverter of the DVR. But the trouble with this is that the transient oscillations initiated at the begin instant from the voltage sag may want to no longer be damped sufficiently. To enhance the damping, as proven in Fig. 4, the Posicast controller can be used just earlier than transferring the sign to the PWM inverter of the DVR.

Proposed Method for Using the Flux-Charge Model Three-Phase Short

In this part, the three-phase short circuit is utilized on bus "26: FDR G," and the functionality of the DVR in protecting the voltage on bus "05:FDR F" will be studied. The DVR parameters and the control machine specs are provided in Appendices A and B. At 206 ms, the fault is utilized at 286 ms, and the breaker works and separates the line between buses "03: MILL-1" and "26: FDR G" from the system. At 306 ms, the fault will be recovered and, finally, at 311 ms, the separated line will be rejoined to the device by the breaker. The DVR will begin the compensation just after the detection of sag. As can be considered in the enlarged figure, the DVR has restored the voltage to everyday structure with attenuation of the oscillations at the start of the compensation in much less than half of a cycle. It is really worth noting that the quantity and structure of the oscillations depends also on the time of making use of the fault. As can be viewed in the enlarged figure, the voltage fee of segment B is nearly zero; this section has minimum oscillation when the fault starts.

Starting the Induction Motor

Along induction motor is started out on bus "03: MILL-1." The motor specifications are furnished in Appendix C. The long motor starting modern-day will purpose the PCC voltage (bus "03: MILL-1" voltage) to drop. The PCC rms voltage drops to about 0.8 p.u. The motor velocity reaches the nominal price in about 1 s. During this period, the PCC bus is below voltage sag. From 1.4 s, as the pace tactics nominal, the voltage also approaches the regular condition. However, during all of these events, the DVR continues the load bus voltage (bus "05: FDR F" voltage) at the normal condition.

4. Simulation Results Case-1 Proposed Method

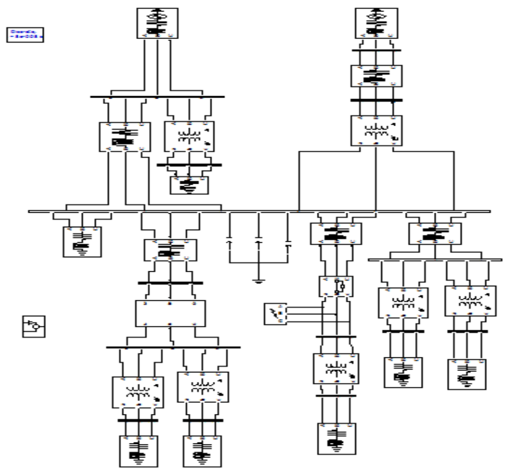

Fig. 4: The figure shows Matlab/simulink circuit of the proposed system with short circuit fault applied

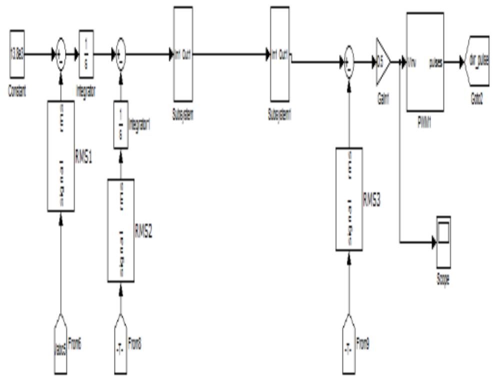

Fig. 5: DVR subckt

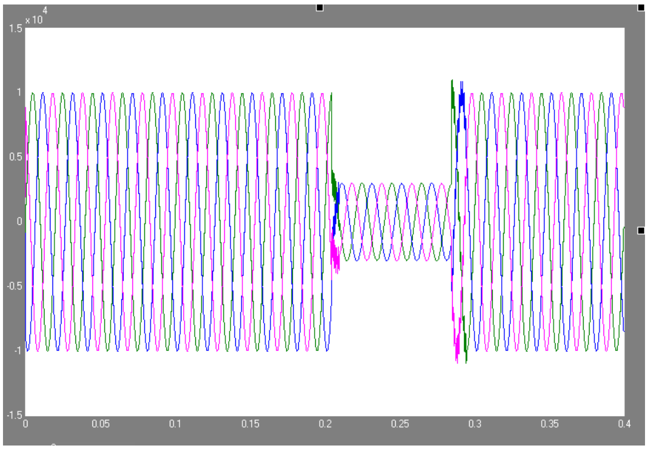

Fig. 6: The rms voltage of PCC drops to about 0.25 p.u. during the fault

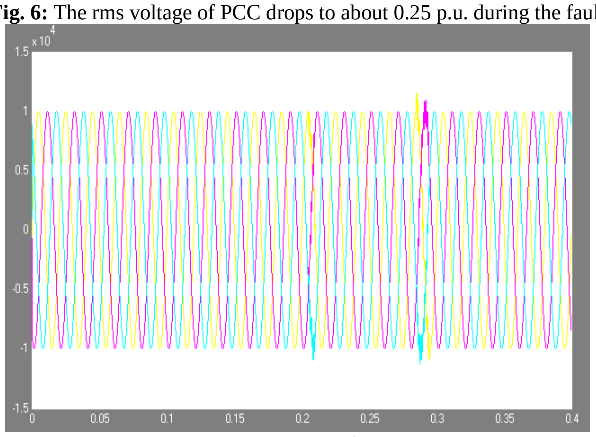

Fig. 7: Shows the PCC voltages of the proposed system

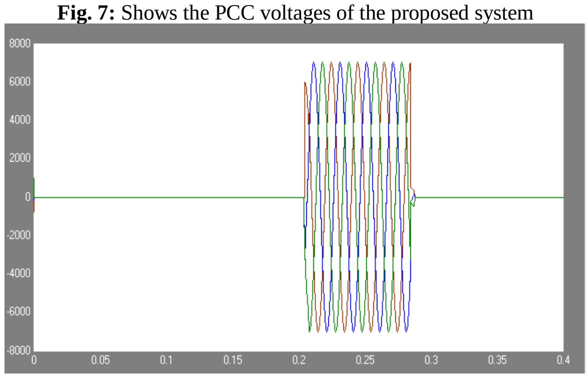

Fig. 8: Shows the injected voltage of DVR

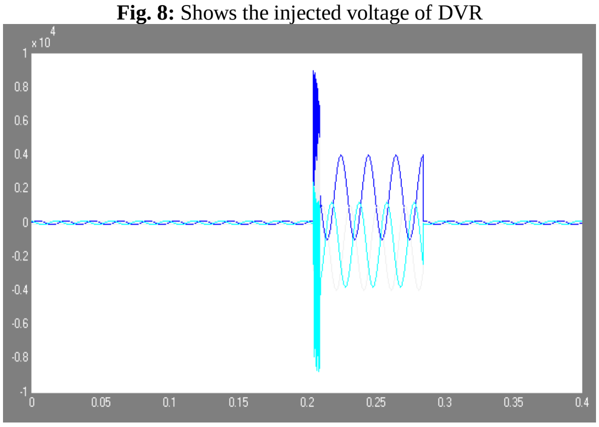

Fig. 9: Shows the three phase currents

Case-2 DVR System with Induction Motor

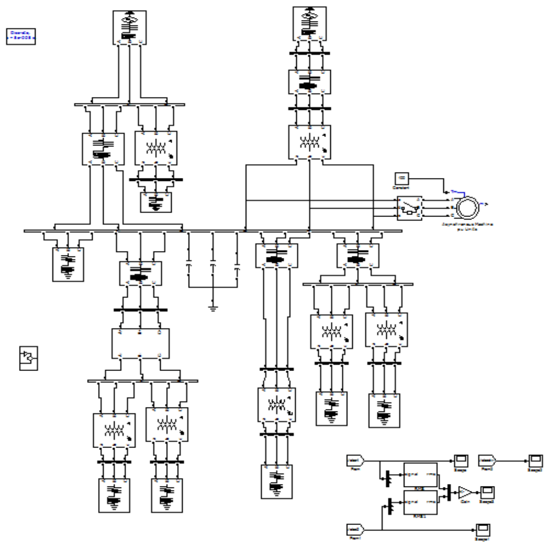

Fig. 10: Shows the Simulation circuit of the DVR system with induction motor

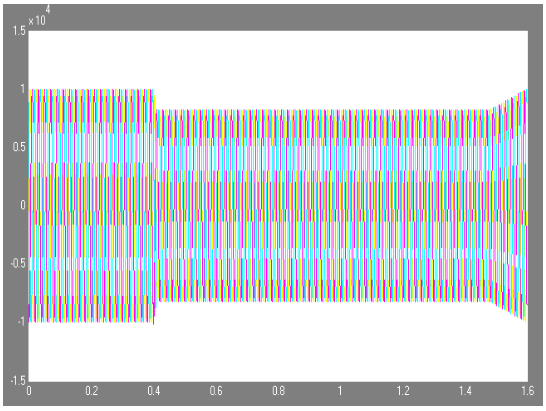

Fig.11: PCC voltages with induction motor

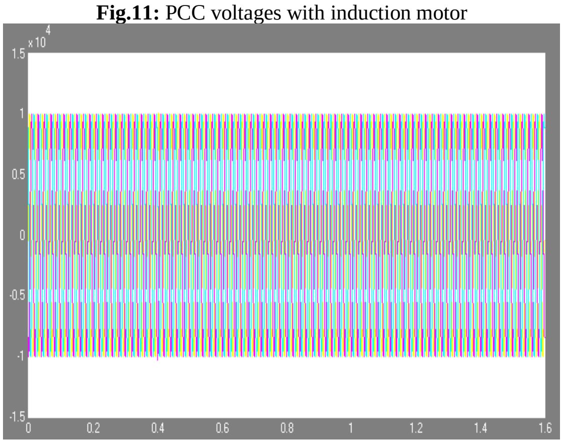

Fig. 12: Output load voltages

Case-3 DVR System under Fault Current Limiting

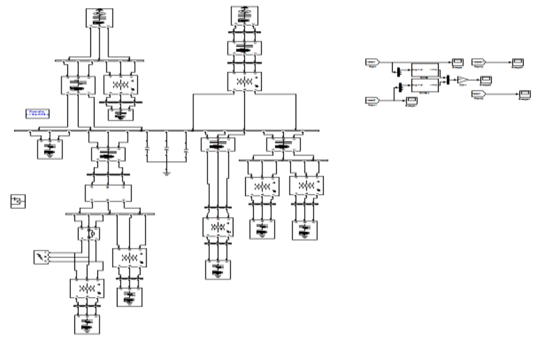

Fig. 13: Shows the MATLAB/SIMULINK circuit of the proposed DVR system under fault current limiting with DVR

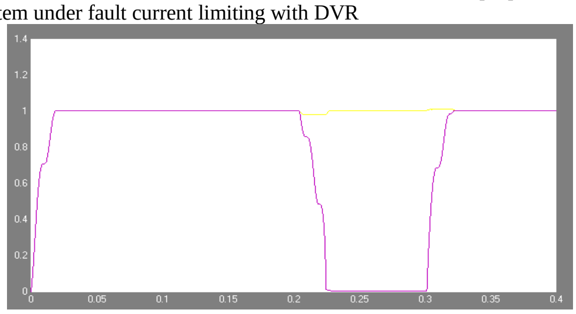

Fig. 14: The figure shows the RMS voltages of load and PCC

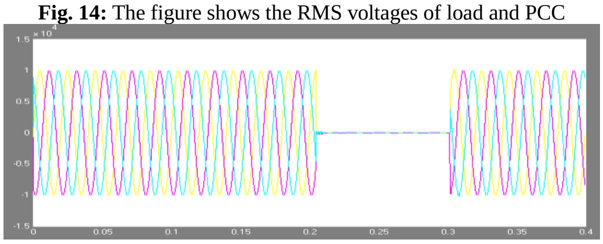

Fig. 15: Shows the load voltages

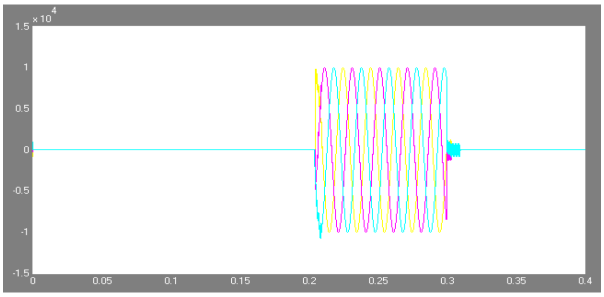

Fig. 16: Shows the injected voltages

5. Conclusion

In this project work, a multifunctional DVR is proposed, and a closed-loop control system is used for its control to improve the damping of the DVR response. Also, for further improving the transient response and eliminating the steady-state 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 variable impedance.

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