International Journal of Engineering & Technology, 7 (2.19) (2018) 45-49

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A new multifunctional DVR for compensation of voltage sag

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Abstract

Today, power quality is considered as a significant application. i) Highly effectual variable speed drive, ii) sophisticated electronic equipment together with iii) power electronic controller, is utilized to enhance power quality (PQ). Voltage sags are the prevalent PQ disturbances on the distribution system. It occurs on account of the faults developed in the electrical network or by the working of a huge induction motor. It is resolved by utilizing the conventional power device termed DVR (Dynamic Voltage Restorer). It is of small size and also low cost. It proffers quick dynamic response to the disturbance. A multifunctional DVR is utilized here to augment the PQ with the aid of P+ Resonant and Posicast controllers to remove the steady-state error (SSE) and enhance the transient response. Simulation outcome displays that the DVR enables to restrain the emergency scenarios of the distribution systems. The prevailing limitation reinstate the PCC (i.e. point of common coupling) (i.e. the bus to which every feeders are linked) voltage and Defend the DVR itself. The DVR performs as virtual impedance with the chief target of shielding the PCC voltage all through the downstream fault without affecting real power injection in the DVR which is the significant innovation discussed here.

Keywords: *Dynamic Voltage Restorer (DVR); Point of Common Coupling (PCC); Voltage Sag; Emergency Control; Voltage Swell*

1. Introduction

The electrical system comprises of 3 functional blocks like i) generation, ii) transmission and iii) distribution. The technology unit creates abundant electricity to satisfy clients' demand, The transmission systems transport massive power to long distances [1] and the distribution system supply electrical energy to each customer's premises from bulk power structures for making the electrical system reliable [2], [3]. Distribution device locates the end of power system and is linked to the client directly. So the power mostly depends on distribution system on account of the fact that the network failures in the electrical distribution account90-percent of the common client interruptions. In the former days, the power system's reliability generally concentrates on transmission only. But today, distribution structures are also be regarded for reliability valuation.

2. Existing system for power quality

Primarily, for the energy enhancement or device reliability, facts like i) STATCOM (static synchronous compensator), ii) IPFC (Interline Power Flow Controller), iii) SSSC (Static Synchronous Series Compensator), and iv) UPFC (Unified Power Flow Controller) and so forth are introduced. These facts gadgets are designed for the transmission system [11], [12]. But now more interest is on the distribution system for the enhancement of energy quality. These facts are modified and acknowledged as custom power devices.

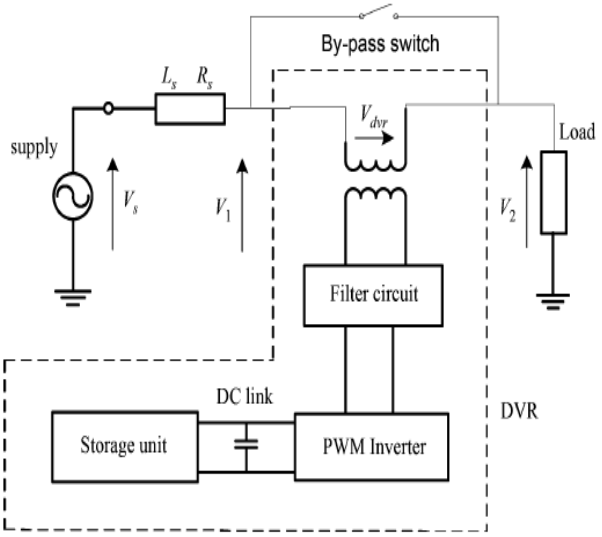

Fig. 1: Typical DVR-Connected Distribution System.

The major conventional electrical devices that are utilized on distribution system for PQ improvement are i) DSTATCOM (Distribution STATIC synchronous compensator), AF (Active Filter), DVR, UPQC (Unified PQ Conditioner) etc. In such conventional energy devices, DVR is used for the power exceptional improvement on the distribution system. That is emergency regulations in distribution systems are mentioned in accordance with the utilization of the multifunctional control strategy of DVR. Similarly, the multi-loop controller utilizing P + Resonant and Posicast controllers is introduced to remove the SSE on DVR and enhance the transient response respectively.

3. Proposed multifunctional DVR

The groundwork of the proposed control strategy in the given paper is that when the fault is no longer ignored via the DVR, an outer feedback loop in the load voltage together with an internal feedback loop of the filter capacitor is contemporarily utilized. To augment the active response of the load voltage, a feed-forward loop is utilized [6]. Moreover, the transient response is enhanced by utilizing the Posicast controller and the SSE is removed by utilizing the P+Resonant controller. As the fault contemporary passes via the DVR, the utilization of the flux manipulate the algorithm, the series voltage is inoculated in the contrary route and, henceforth, the DVR performs like sequence variable impedance.

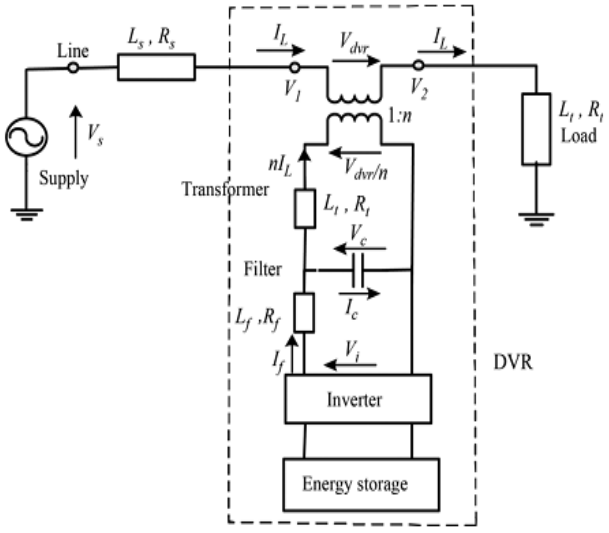

Fig.2: Distribution Gadget with the DVR.

As in Fig. 2 the injected load voltage is restrained with the aid of the prevailing DVR [7]. It is separated from the circuit, and the battery is attached in sequence with a diode when the downstream fault arises so that the energy doesn't enter the dc-link capacitor and the battery. The inductance is utilized in the main to stop bulk oscillations in the current. The active energy is observed with the assistance of the impedance.

In this paper,the PCC voltage is utilized as the main reference signal whilst the DVR performs like variable impedance. On account of this, the real-electricity absorption is destructive for the dc-link capacitor along with a battery. [3] To resolve this issue, impedance inclusive of a resistance and an inductance is linked in parallel with the dc -link capacitor. This capacitor is detached from the circuit, and the battery is attached with a diode when the downstream fault arises so that the energy doesn't enter the dc-link capacitor and the battery

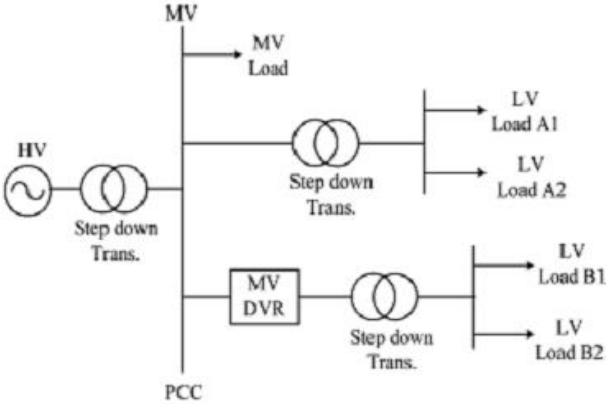

Fig. 3: DVR Join In A Medium-Voltage Level Electricity System.

Proposed Method for Utilizing the Flux-Charge

The given paper proposes an algorithm for the DVR to overhaul the PCC voltage, control the fault current, consequently, safeguard the DVR components. The flux -charge mannequinis utilized so that the DVR acts as a virtual inductance with a variable value in series with the distribution feeder. To do this, the DVR needed to be restrained to inject a required voltage having the contrary polarity in typical cases. It is stated that over current trippin is now not feasible until extra verbal exchange betwixt the DVR and the downstream facet over modern circuit breaker (CB) is available. If it is compulsory to function the over modern CB at PCC, verbal exchange betwixt the PCC breaker and DVR may have to be made and this can be done without difficulty by means of delivering a sign to the breaker when the DVR is in the fault-current limiting mode as the DVR is just placed after PCC. It has also to be cited which the reference flux is attained by integrating the difference of the DVR load-side voltage and PCC reference voltage.

a) Basic Operational Principle of DVR

The DVR device regulates [4] the load voltage through injecting a voltage phasor in collection with the machine that uses the injection series transformer. In the sag compensation techniques, it is imperative that in the course of compensation, the DVR injects live energy to the system. Therefore, the storage component limits the compensation, specifically at some stage in continuing voltage sags. The benefit of this method over the in-phase method is that much less energetic power be transferred from the storage unit to the distribution system. It effects in compensation in longer durationssags /deeper sags. The semiconductor switches in the inverter called DVR, convert this equipment to nonlinear. Nevertheless, the equations are linearized utilizing linearization techniques. The dynamic characteristics in DVR are biased with the aid of the load and the filter [9], [10]. Although the modeling of the filter (that commonly is an easy LC circuit) [8] is handy to do, the load modeling is not as easy owing to the fact that the load can fluctuate from an invariant linear-time to a variant nonlinear-time. In the given paper, the simulations are completed with the aid of 2 load types: 1) a constant power load and 2) a motor load. As the load voltage is restricted by DVR via injecting Vdvr.

The DVR harmonic filter comprises Lf inductance, an Rf resistance, and a Cf capacitance. The Posicast controller augments the transient response. Note that more than 1 feeders related to a frequent bus are utilized, namely “PCC,” from now on V1 and V2 are replaced with Vpcc and Vl, respectively, to make a general sense. A simple technique to proceed is to deliver the error signal to the DVR's PWM inverter. But the issue is that the transient oscillations started at the beginning 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 is utilized just earlier than transferring the sign to the DVR’s PWM inverter.

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

Here, the 3-phase short circuit is utilized in bus "26: FDR G," as well as the functionality of the DVR on shielding the voltage in bus "05: FDR F" is deliberate. The DVR parameters and the control machine specs are provided in Appendices A as well as 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 is recovered and, lastly, at 311 ms, the separated line is rejoined to the device through the breaker. [2] The DVR begin the compensation subsequent to the sag detection. As can well be considered in the enlarged figure, the DVR restored the voltage to an everyday structure with attenuation of the oscillations at the beginning of the compensation in much below half of a cycle. The quantity and structure of the oscillations also rely 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.

c) Starting the Induction Motor

Induction motor is begun out on a 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 around0.8 p.u. The

motor velocity reaches the nominal price in a. [5] 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. Nevertheless, amid 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

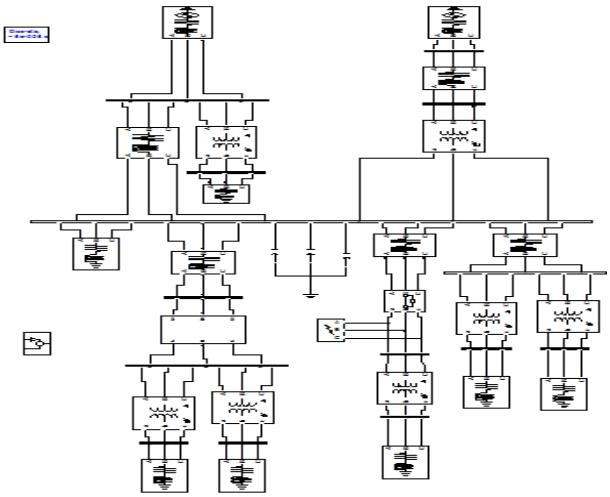

Fig.4: The Figure Exhibits Matlab/Simulink Circuit of the Proposed System with Short Circuit Fault Applied.

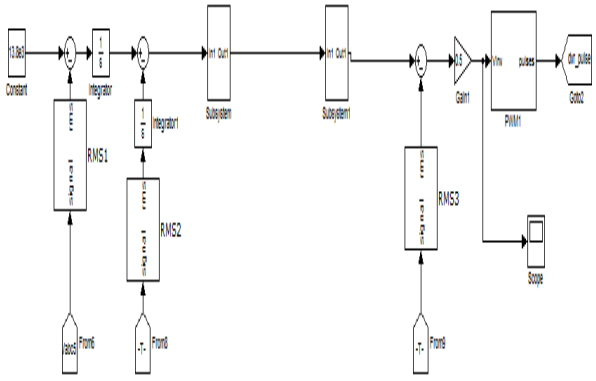

Fig. 5: DVR Subckt.

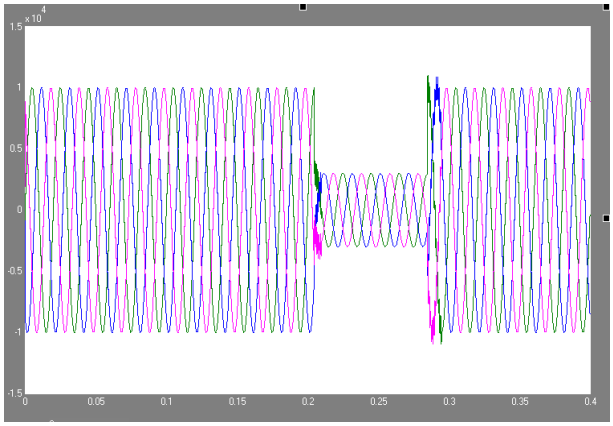

Fig. 6: The RMS Voltage of PCC Drops to 0.25 P.U. During the Fault

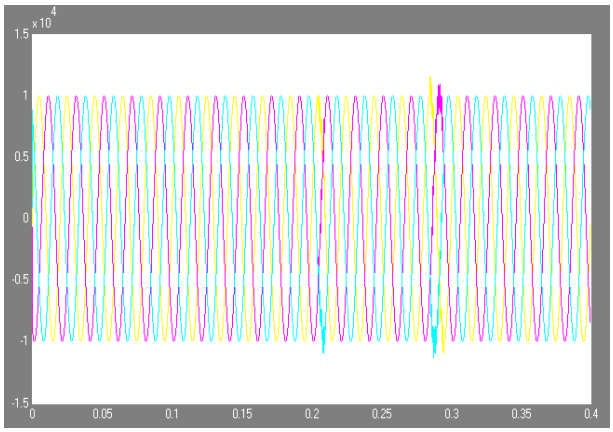

Fig. 7: Displays the PCC Voltages of the Proposed System.

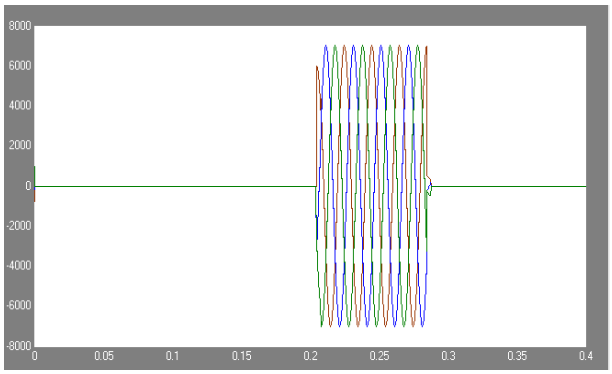

Fig. 8: Shows the Injected Voltage of DVR

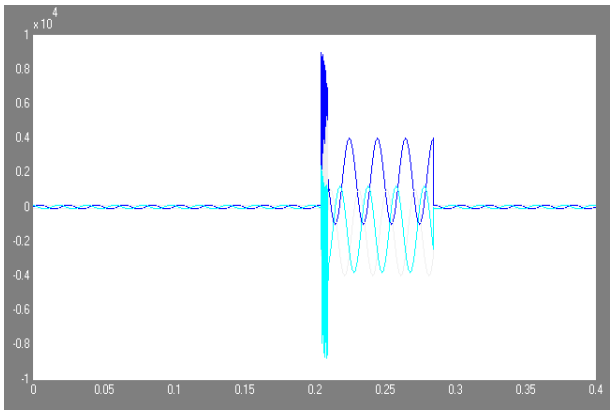

Fig. 9: Displays the Three-Phase Currents.

Case-2 DVR System with Induction Motor

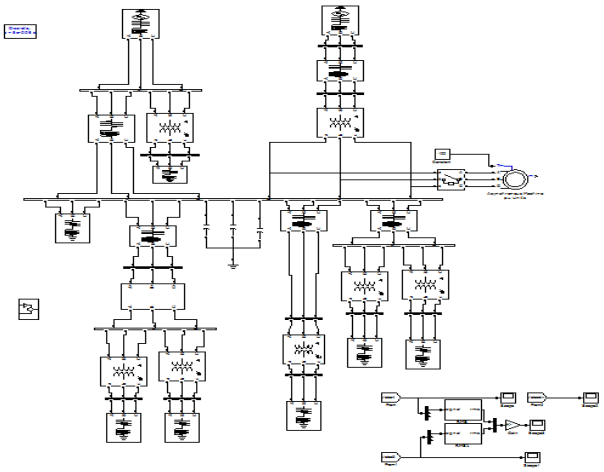

Fig. 10: Displays the Simulation Circuit of the DVR with Induction Motor

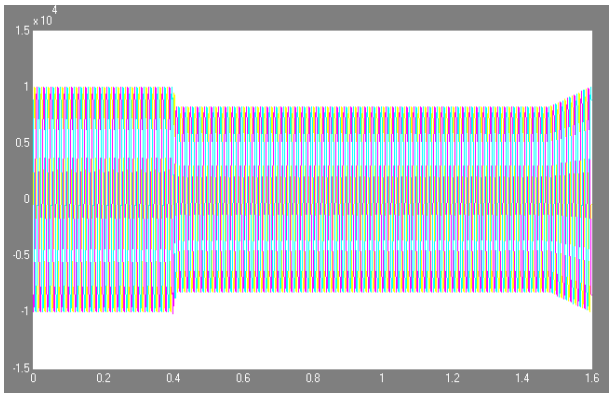

Fig. 11: PCC Voltages with Induction Motor

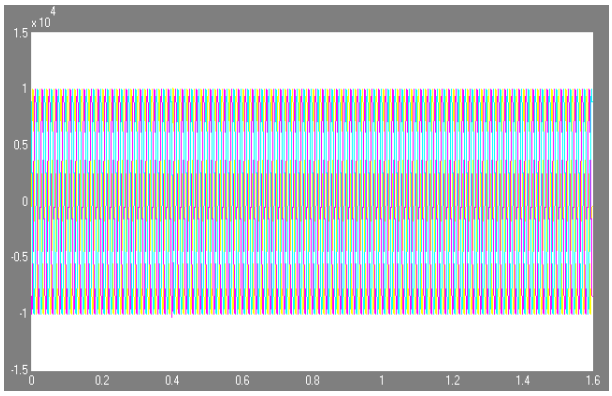

Fig. 12: Output load Voltages.

Case-3 DVR System under Fault Current Limiting

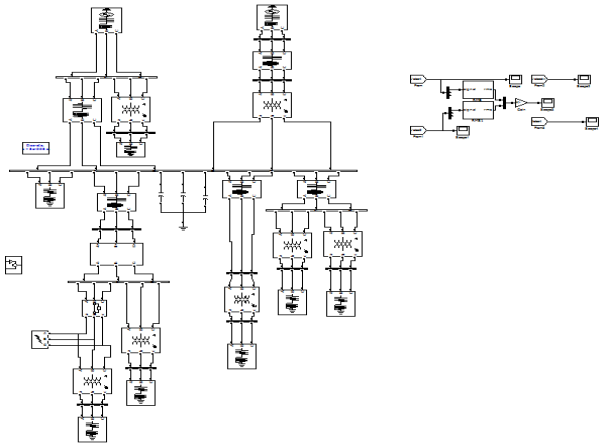

Fig. 13: Displays the MATLAB/SIMULINK Circuit of the Proposed DVR under Fault Current Limiting with DVR

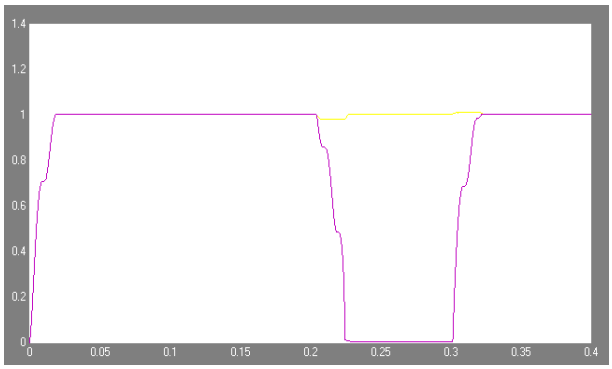

Fig. 14: The Figure Displays the RMS Voltages of Load and PCC

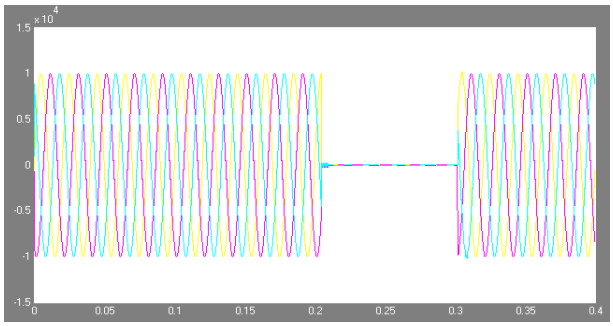

Fig. 15: Displays the Load Voltages

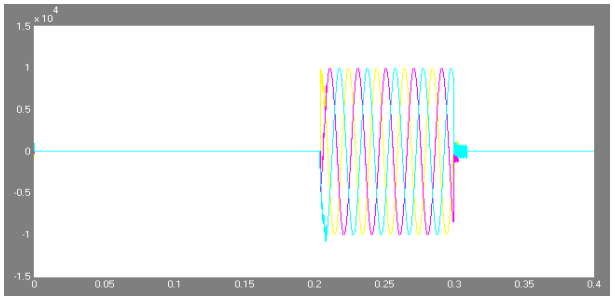

Fig. 16: Displays the Injected Voltages.

5. Conclusion

In this project work, a multifunctional DVR is proposed; additionally, a closed-loop control system is utilized aimed at its control to boost the damping of the DVR response. As well, for further enhancing the transient response and eradicating the SSE, the Posicast and also P+Resonant controllers are used. As the second function of this DVR, by means of the flux-charge model, the equipment is controlled so that it confines the downstream fault currents as well as shields the PCC voltage throughout these faults by acting as variable impedance.

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