Modeling and Simulation of Dynamic Voltage Restorer (DVR) for Power Quality Problems

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Abstract. Power quality has become one of the major concerns in the present era. It has become important especially, with the introduction of sophisticated devices, whose performance is very sensitive to the quality of load supply. Power quality is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or disoperation of end user Equipment's. One of the major problems dealt here is the power sag. Sensitive industrial loads and utility distribution networks all suffer from various types of outages and service interruptions which may result in a significant financial loss. To improve the power quality, custom power devices are used. The custom power term was proposed to designate a new generation devices based on power electronics, designed to operate at medium and low voltage levels, and whose main objective is to improve the service quality of distribution networks. The custom power device considered in this work is DVR. This report presents analysis, modeling and simulation of a Dynamic Voltage Restorer (DVR) test systems using MATLAB. In this work, PI controller and Discrete PWM pulse generator are used for the control purpose. Here different faults are considered for non-linear load. The role of DVR to compensate load voltage is investigated during different fault conditions like single phase to ground and double phase to ground faults and the like

Keywords: power quality, sag, custom power devises, PWM pulse generator.

1 Introduction

The electric power system is considered to be composed of three functional blocks - generation, transmission and distribution. For a reliable power system, the generation unit must produce adequate power to meet customer's demand, transmission systems must transport bulk power over long distances without overloading or jeopardizing system stability and distribution systems must deliver electric power to each customer's premises from bulk power systems. Distribution system locates the end of power system and is connected to the customer directly, so the power quality mainly depends on distribution system. The reason behind this is that the electrical distribution network failures account for about 90% of the average customer interruptions. In the earlier days, the major focus for power system reliability was on generation and transmission only because of more capital cost involved in these functional areas. In addition their insufficiency can cause widespread catastrophic consequences for both society and its environment. But now a day's distribution systems have begun to receive more attention for reliability assessment.

Initially for the improvement of power quality or reliability of the system FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), interline power flow controller (IPFC), and unified power flow controller (UPFC) etc are introduced. These FACTS devices are designed for the transmission system. But now-a-days more attention is on the distribution system for the improvement of power quality these devices are modified and known as custom power devices. The main custom power 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.

In this paper from the above custom power devices, DVR is used with PI controller for the power quality improvement in the distribution system. Here two different loads are considered, one is linear load and the other is sensitive load. Different fault conditions are considered with these loads to analyze the operation of DVR to improve the power quality in distribution system.

2 Power Quality

2.1 A Big Issue

Power quality in electric networks is one of today's most concerned areas of electric power system. The power quality has serious economic implications for consumers, utilities and electrical equipment manufacturers. Modernization and automation of industry involves increasing use of computers, microprocessors and power electronic systems such as adjustable speed drives. Integration of non-conventional generation technologies such as fuel cells, wind turbines and photo-voltaic with utility grids often requires power electronic interfaces. The power electronic systems also contribute to power quality problems (generating harmonics). Under the deregulated environment, in which electric utilities are expected to compete with each other, the customer satisfaction becomes very important. The impact of power quality problems is increasingly felt by customers - industrial, commercial and even residential.

2.2 Simulink Model of the Test System without Fault

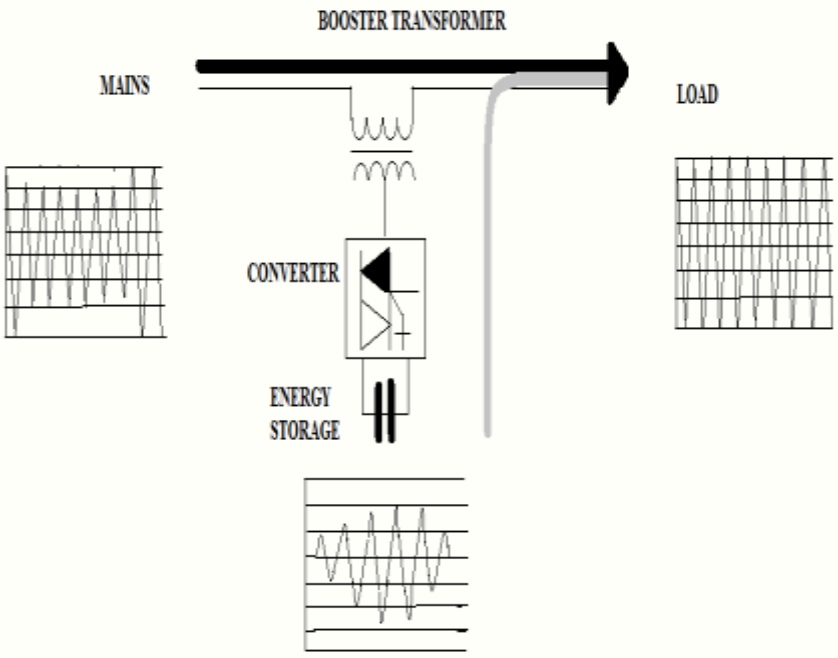

Fig.1. Principle of DVR

In this simulink model we have a system in which two parallel feeders are shown. In both the feeders further loads are also connected in parallel. In one feeder DVR is connected in series with line and the other feeder is kept as it is. PI controller is used for the control purpose. Here DVR system is connected to the distribution system using a booster transformer. Result for the above system in which no fault is created is given below. The output

voltage for both the conditions with DVR and without DVR is same. The first two wave shapes in figure-5.4 represent input voltage and current with respect to time. The next two wave shapes are for load voltage and load current where DVR is connected. The last two wave shapes represents uncompensated load voltage and load current.

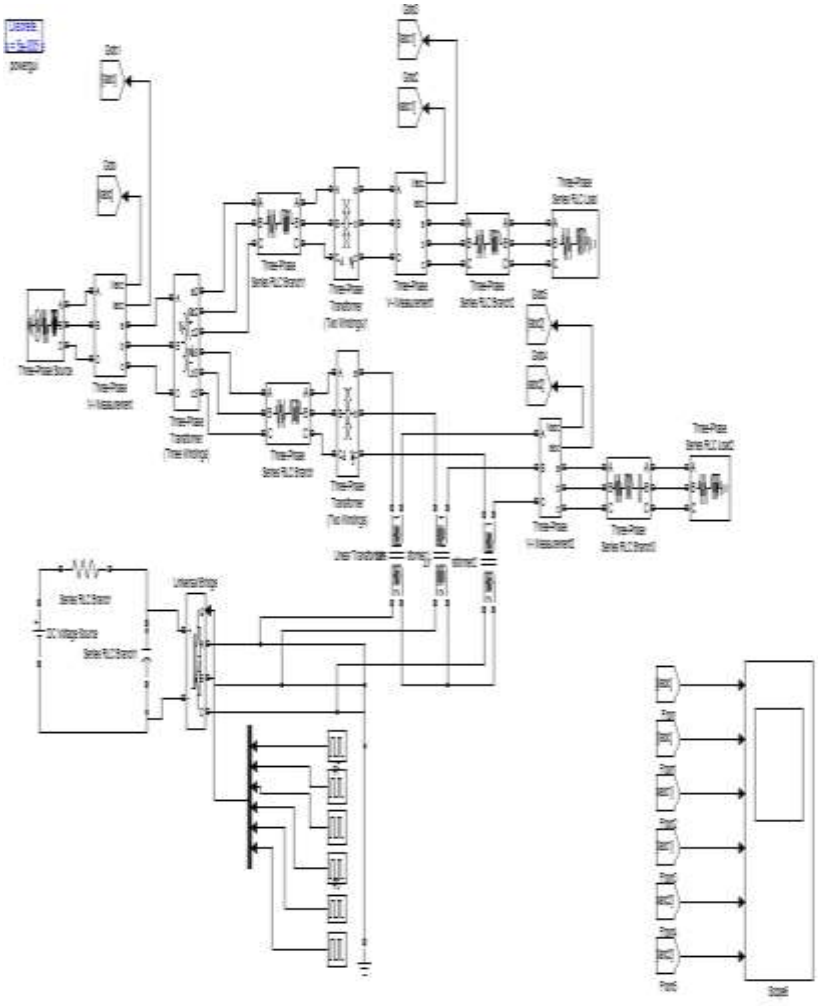

Fig.2. Simulation block for normal system

2.3 Parameters of DVR Test System

The test system employed to carry out the simulations regarding the DVR operation. This system is composed of a 13 KV, 50 Hz generation system, represented by a Thevenin's equivalent, feeding two transmission lines through a three winding transformer connected in Y/Δ/Δ 13/115/115 kV. Such transmission lines feed two distribution networks through two transformers connected in Δ/Y 115/11 kV.

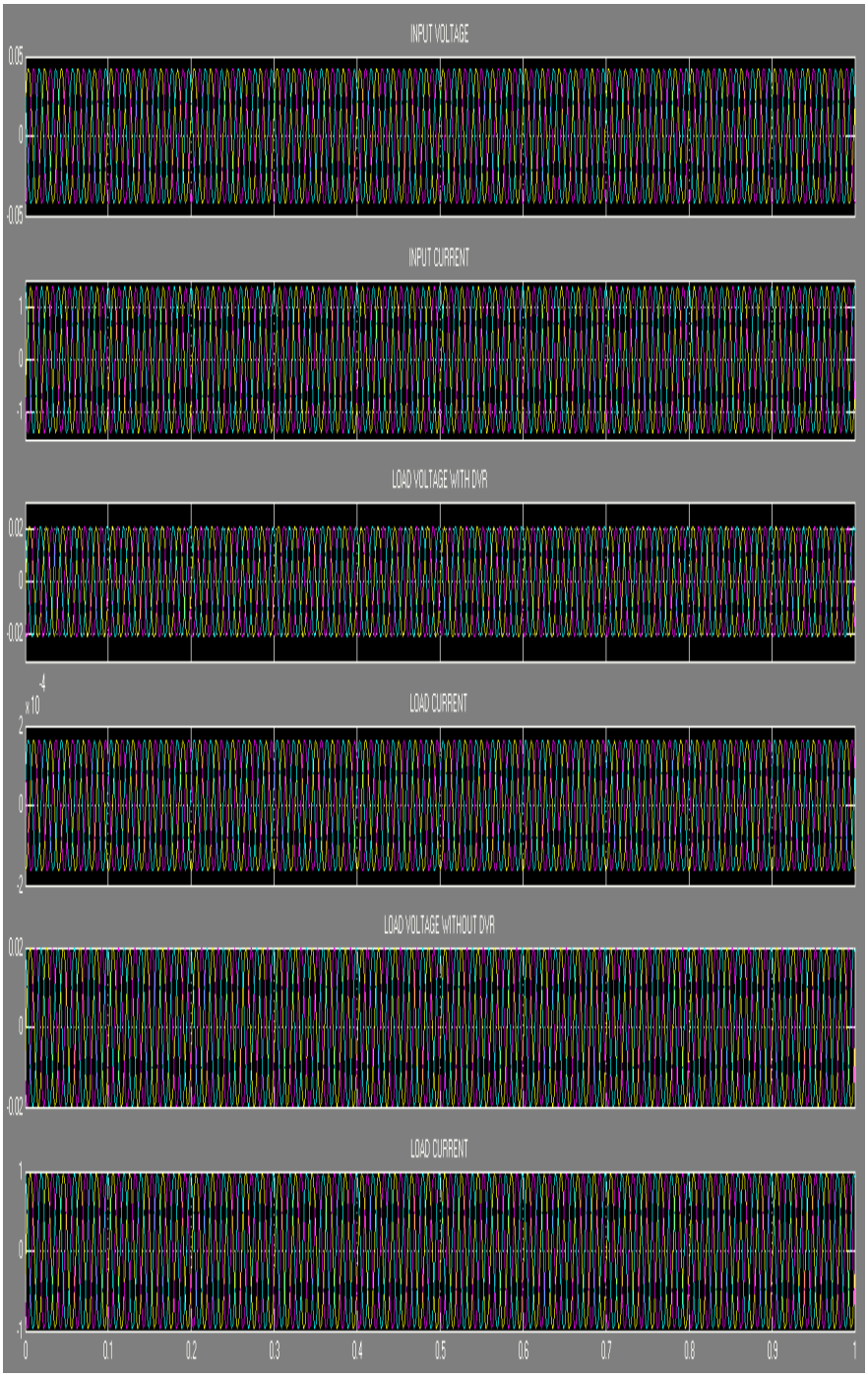

Fig.3. Output for normal system

Table-5.1 System parameters

S.No	System elements	Standards
1.	Source	3-phase, 13KV. 50Hz
2.	Inverter parameters	IGBT based, 3-arms, 6-pulse, carrier frequency= 1080Hz, sample time= 5μs
3.	RL Load	Active power= 1KW, Inductive Reactive Power= 500VAR
4.	3-winding transformer	Y/Δ/Δ 13/115/115 KV
5.	2-winding transformer	Δ/Y 115/11KV

In this test system we have a generating unit of 13kv, 50 Hz. The test system employed to carry out the simulations concerning the DVR actuation. The output from generating unit is fed to the primary of the three winding transformer. Further two parallel feeders of 11kv each are drawn. In one of the feeder DVR is connected in series and other feeder is kept as it is. For this system two different loads are considered one by one with different fault conditions. The two loads are linear load and induction motor load. PI controller is used for the control section. In the figure above a three phase fault is shown to occur in the feeder containing load-1. As a result of fault the three phase source voltages gets reduced in their magnitude which in turn reduces the load voltage magnitude. Hence the use of DVR as a voltage compensating device can be better understood by having a fault near the distribution system. After the voltage sag detection and its duration the required load voltage is restored with the help of control and protection unit of DVR within few minutes

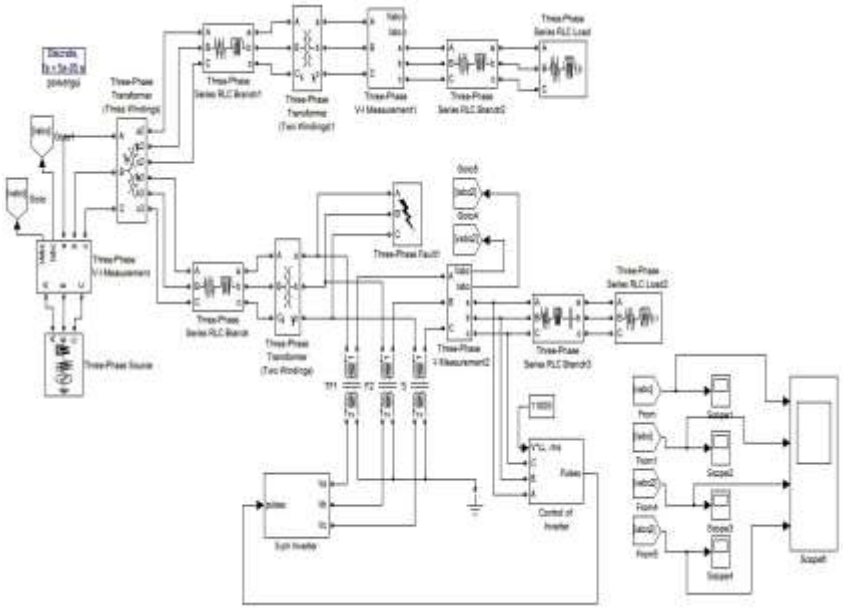

Fig.4. Main Simulink block of DVR

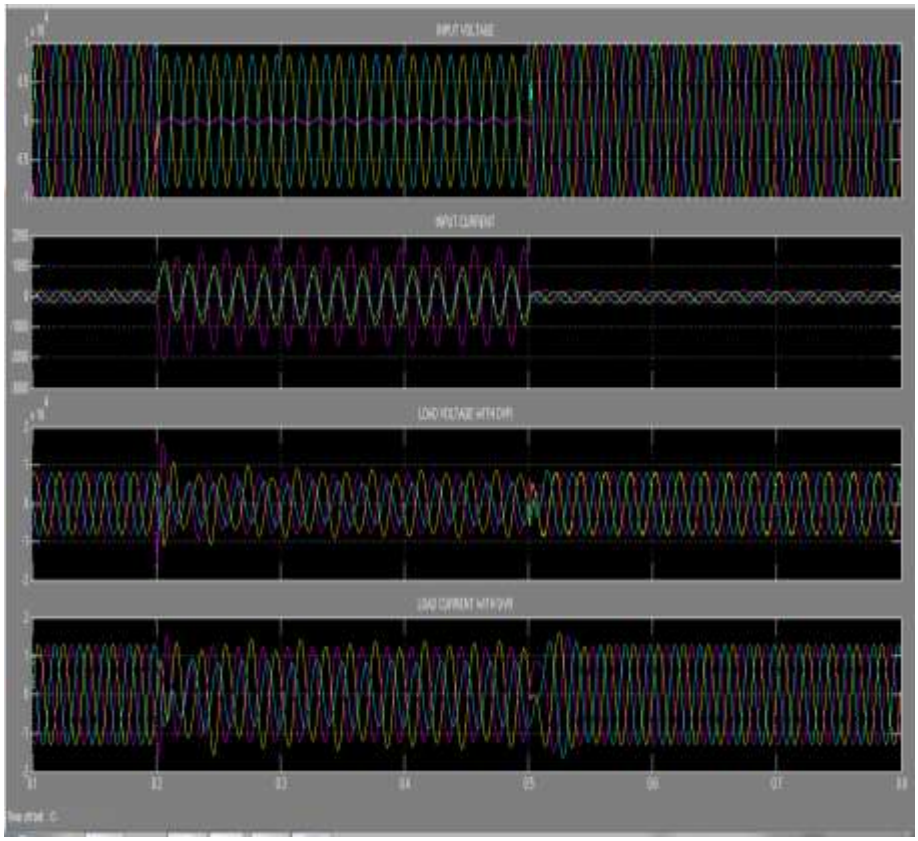

Fig.5. Output results for single line to ground fault

3 Conclusion

In this paper, a fast and cost effective Dynamic Voltage Restorer (DVR) is proposed for mitigating the problem of voltage sag or dip and other fault conditions in industrial distribution systems, specially consisting of the induction motor load. A controller which is based on feed foreword technique is used which utilizes the error signal which is the difference between the reference voltage and actual measured load voltage to trigger the switches of an inverter using a Pulse Width Modulation (PWM) scheme. Here, investigations were carried out for various cases of load at 11kv feeder. It is clear from the results that the power quality of the system with induction motor as load is increased in the sense that the THD and the amount of unbalance in load voltage are decreased with the application of DVR. The effectiveness of DVR using PI controller is established both for linear static load and induction motor load.

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