A Dynamic Voltage Restorer with Voltage Sag and Voltage Swell Compensation

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Abstract: In recent years utility distribution system experiences various types of disturbances. The major problems are voltage sag and swell, there is need to compensate it .Today most of the distribution companies are using many electrical and electronics components based on semiconductor devices for improving power quality. There are various methods are used for compensation of sag and swell voltage. In this paper Dynamic voltage restorer is used for compensation which is most popular and widely used method. Here, DVR is used with self-supported system. In this proposed work DVR's life time is improved by replacing battery with super capacitor. Super capacitor are most suitable short duration of energy requirement i.e. for compensation of sag and swell. The controlling of DVR can be done by SRF controller. The overall work is carried out in MATLAB Simulink.

Keywords: DVR, voltage sag, voltage swell, SRF controller

I. INTRODUCTION

Power quality involve voltage, frequency, and waveform. Good power quality can be defined as steady supply voltage that stays within the prescribed range, steady ac frequency closed to rated value and smooth voltage curve waveform. Without proper power electrical device or load may malfunction, fail prematurely or not operate at all .There are many ways in which electric power can be of poor quality and many more causes of such poor quality power .The electric power industry comprises electricity generation ,transmission and distribution. The electricity then moves through wiring system of end user until it reaches the load. During this quality of power may changes and disturbances or called power quality problems occur. The number of power quality issues including voltage sag, swell, flicker, harmonics, transients etc. has different causes.

Voltage sag are most of the common power disturbance that impact sensitive equipment. The main sources of sag are large increase in current due to faults and abrupt increase in system impedance. Voltage sag are caused by reduction in the load with poor voltage regulation. Voltage sag means that decrease in normal voltage from 10% to 90% of its RMS value which last for a cycle less than one minute .Voltage swell, in contrast, can be defined as increase in RMS voltage above the nominal value which last for a cycle greater than one minute. Switching off of large load, energization of capacitor bank are considered as a causes of voltage swell.

In present scenario power quality is directly related to distribution system because of it is situated at the end power system and directly connected to customer. If any disturbance is occur in distribution system, a huge amount of losses may happen, therefore loss of productivity and competitiveness. Hence it is necessary to improve quality of power. In order to improve quality of power, there is number of custom power devices are available which protects the load from voltage sag, swell harmonics etc. DVR is a series connected device installed between source and load. DVR inject the voltage in to the system to compensate the disturbances occur due to supply. This paper represent analysis of DVR with self-supported system for sag swell compensation. SRF control technique is used for control of self-supported DVR

II. INTRODUCING DVR

DVR is a series connected device. It is connected in utility distribution feeder at point of common coupling. The main objective of DVR is to increases power utilization capacity of a distribution feeder and protect the loads from voltage sag and swell coming from the network. In addition to its main task which is voltage sag and swell compensation, DVR can also added other feature such as harmonic compensation. These are a problem because spikes consume power and sags reduces efficiency of some devices. DVR saves energy through voltage injections that can affect phase and wave shape of power being supplied.

The basic principle of DVR is to inject voltage of magnitude and frequency necessary to restore load side voltage to desired amplitude and waveform, even when source voltage is unbalance and distorted. Generally DVR generate or absorb independently controllable real and reactive and reactive power at load side. In other words DVR is a solid state DC to AC switching power converter that inject set of three phase AC output voltage in series with transmission line. DVR is design according to voltage needed in secondary of transformer.

2.1 Components of DVR

The conventional DVR consist of:

1. Series injection transformer: Basic function of injection transformer is to increases voltage supplied by filtered VSI output to desired level while isolating DVR circuit from distribution network.
2. Energy storage device: The energy storage such as capacitor, battery is responsible to supply energy source in DC form .Energy source may vary according to design and manufacturer of DVR
3. Filter: Filter is used to eliminate unwanted harmonics components generated in VSI section.
4. Inverter: The variable output voltage is achieved by voltage source inverter (VSI). Solid state semiconductor devices with turn on capability are used in inverter circuit.

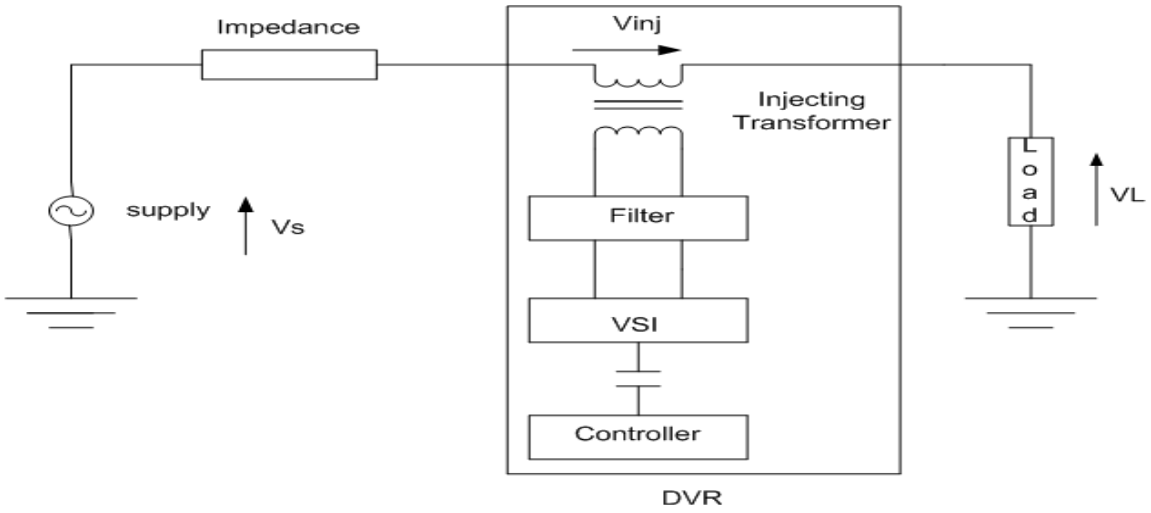

Fig.1 structure of DVR

III .PROPOSED SYSTEM CONFIGURATION

The proposed system configuration of self-supported DVR connected to distribution system to restore the voltage of three phase critical load is as shown in fig 2 and has been modelled in MATLAB Simulink. DVR connected system consist of source, inverter, control block, filter, injection transformer and load. Three phase voltage source is connected to the load through three phase series injection transformer. The equivalent voltage supply of each phase is connected to PCC through short circuit impedance or we called series RL branch. The three phase DVR is connected to the line to inject voltage in series using three phase transformer. Lf is a filter component used to filter out ripples in the injected voltage. A three leg VSC with IGBT is used and capacitor as a storage is connected to its dc bus.

The different supply voltage disturbance are generated by using source. The disturbance at source side affect the performance of load. The disturbance can be compensated by DVR. The compensated voltage obtained from DVR is injected in to the system through injection transformer. The voltage is inserted in such a way that load voltage is constant in magnitude and is undistorted, although supply voltage is not constant in magnitude or is distorted. DVR is built with VSI, the operation of VSI depends on control signal is received from control unit. The reference voltages required for VSI are generated from control unit. SRF theory is used for controlling of DVR. The active power injection to compensator is coming from super capacitor.

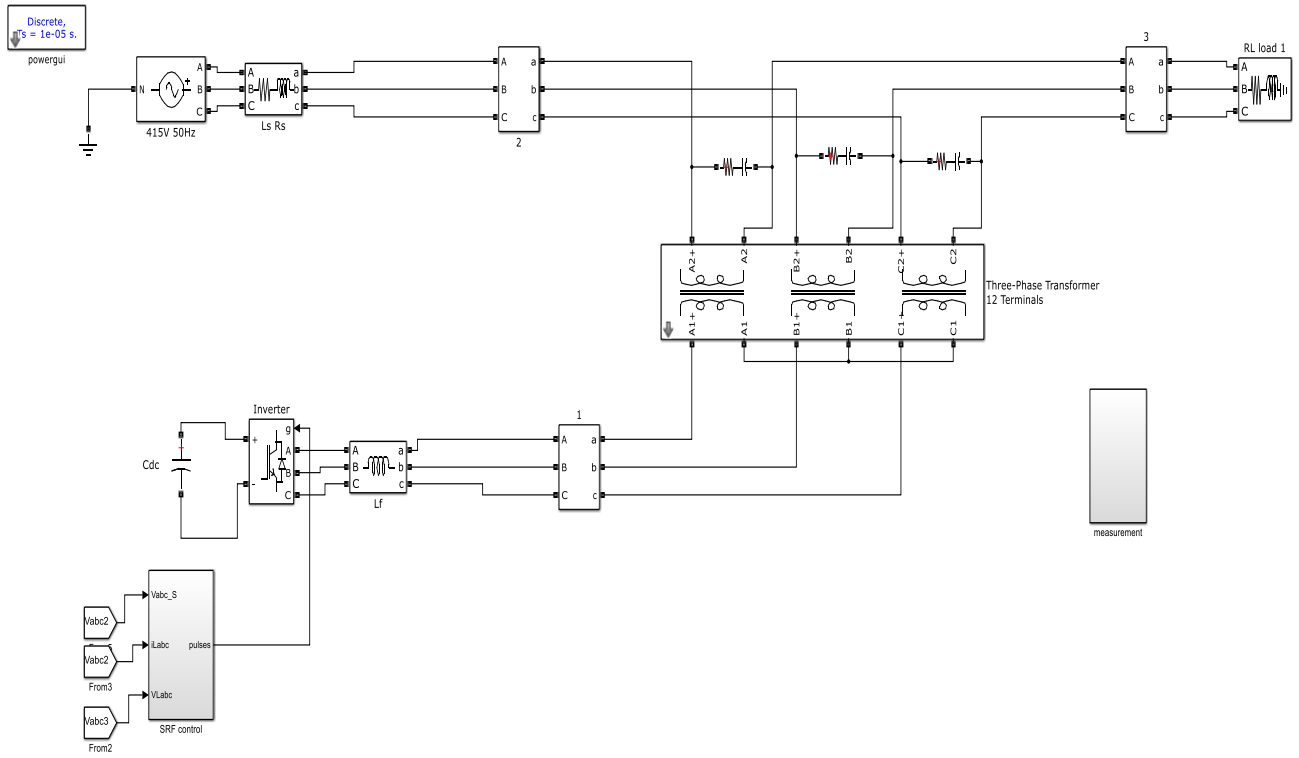

fig 2 MATLAB model of self-supported DVR connected system

IV CONTROL SCHEME OF DVR

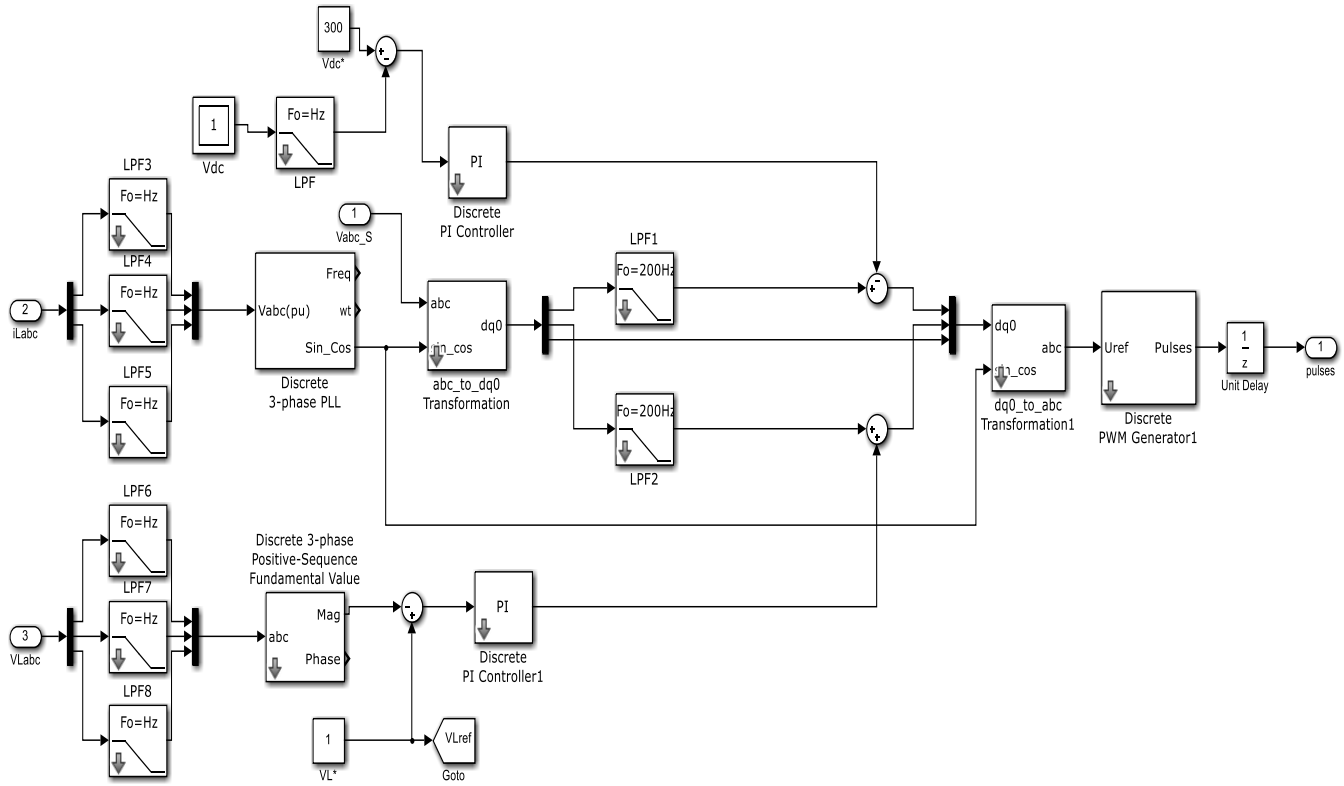

Fig 3. SRF control method of DVR

The control strategy of DVR is as shown in fig 3. SRF theory is used for control of self supported DVR. Volatge at PCC are converted to rotating reference frame using parks transformation .The dqo frame express voltage error and phase shift information as instantaneous space vector with start and end times.Voltage is converted from abc reference frame to dqo reference.The harmonic and ocillatory componenets are elimanated using low pass filter. In order maintain DC bus volatge of self supported capacitor,a PI controller is used at DC bus voltage. The ampliude of load voltage terminal V_L is controlled to its reference voltage V_L* using another PI controller. The output of PI controller is considered as a reactive componenet for voltage regulation of load terminal voltages. Amplitude of load voltage V_L at PCC is calculated from AC voltages. Reference load voltages in abc frame are obtained from reverse parks transformation.The error between sensed load voltages and reference load voltages are used over a controller to generate gating pulses to VSI of DVR.

V MEASUREMENT BLOCK

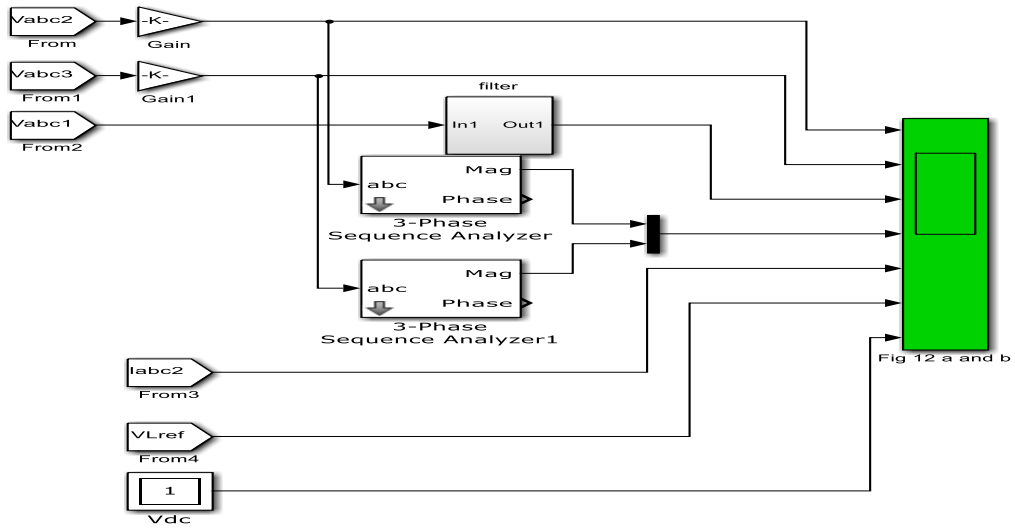

Fig.4 Scope Measurement Block of Proposed System

VI. SYSTEM PARAMETERS

Sr.No	System Quantity	Specification
1	Supply voltage	415V,50Hz,3-phase
2	Impedance	R=0.01Ω,L=3mH
3	3-phase injection transformer	10KVA 200V,300V
4	Inverter Sample time Snubber resistance	3Arms,IGBT/Diode based. 1µs,2µs 1 MΩ
5	Capacitance	32mF,300V
6	PI controller	K_{p1}=0.5,K_{i1}=0.35,ts=10µs K_{p2}=0.1,K_{i2}=0.5,ts=Ts
7	PWM frequency	10KHZ
8	PLL	Kp=180,Ki=3200,Kd=1 50Hz

The test system employes to take out the simulation regarding DVR actuation.

VI.SIMULATION RESULTS

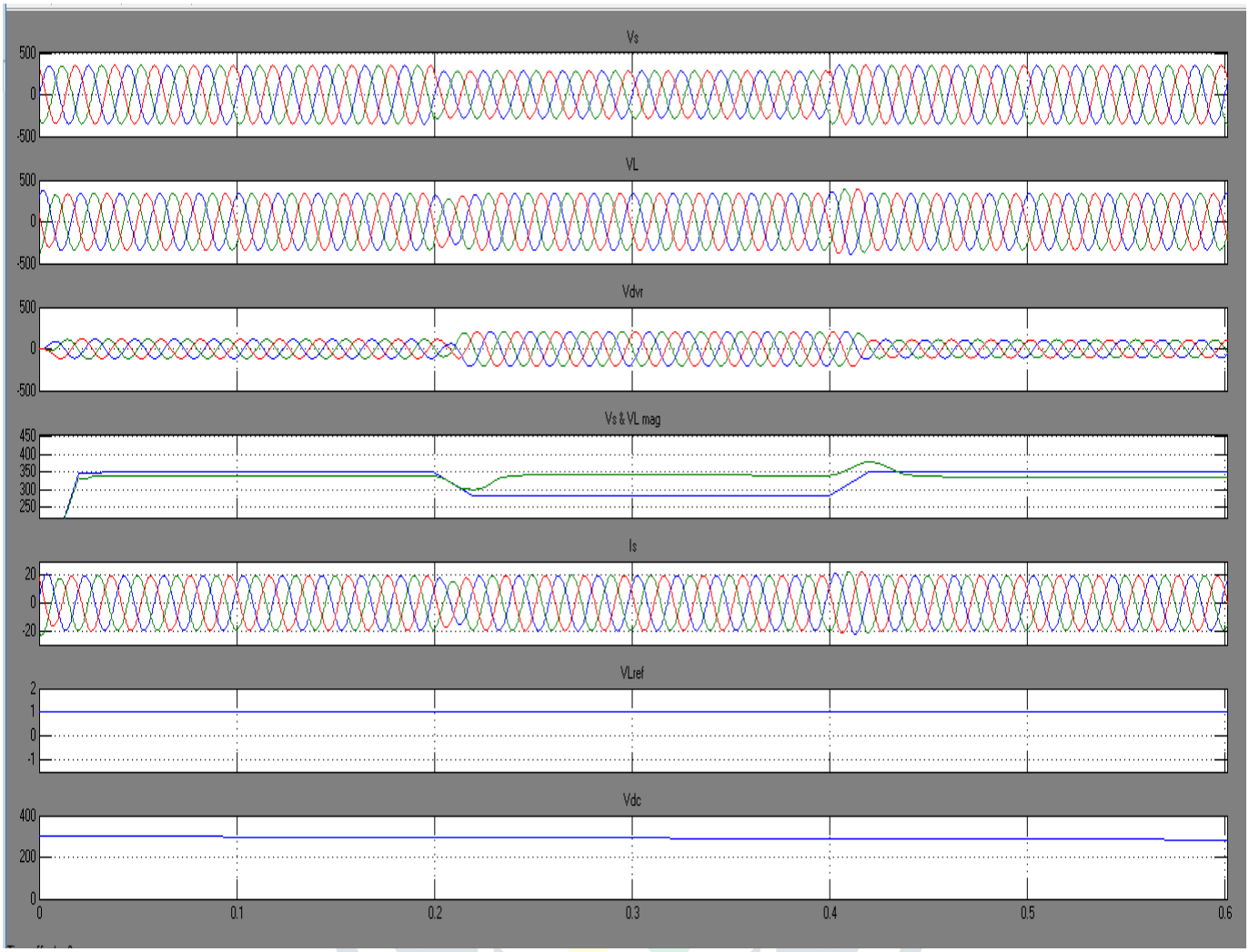

Fig. 5 a) Dynamic performance of capacitor supported DVR during

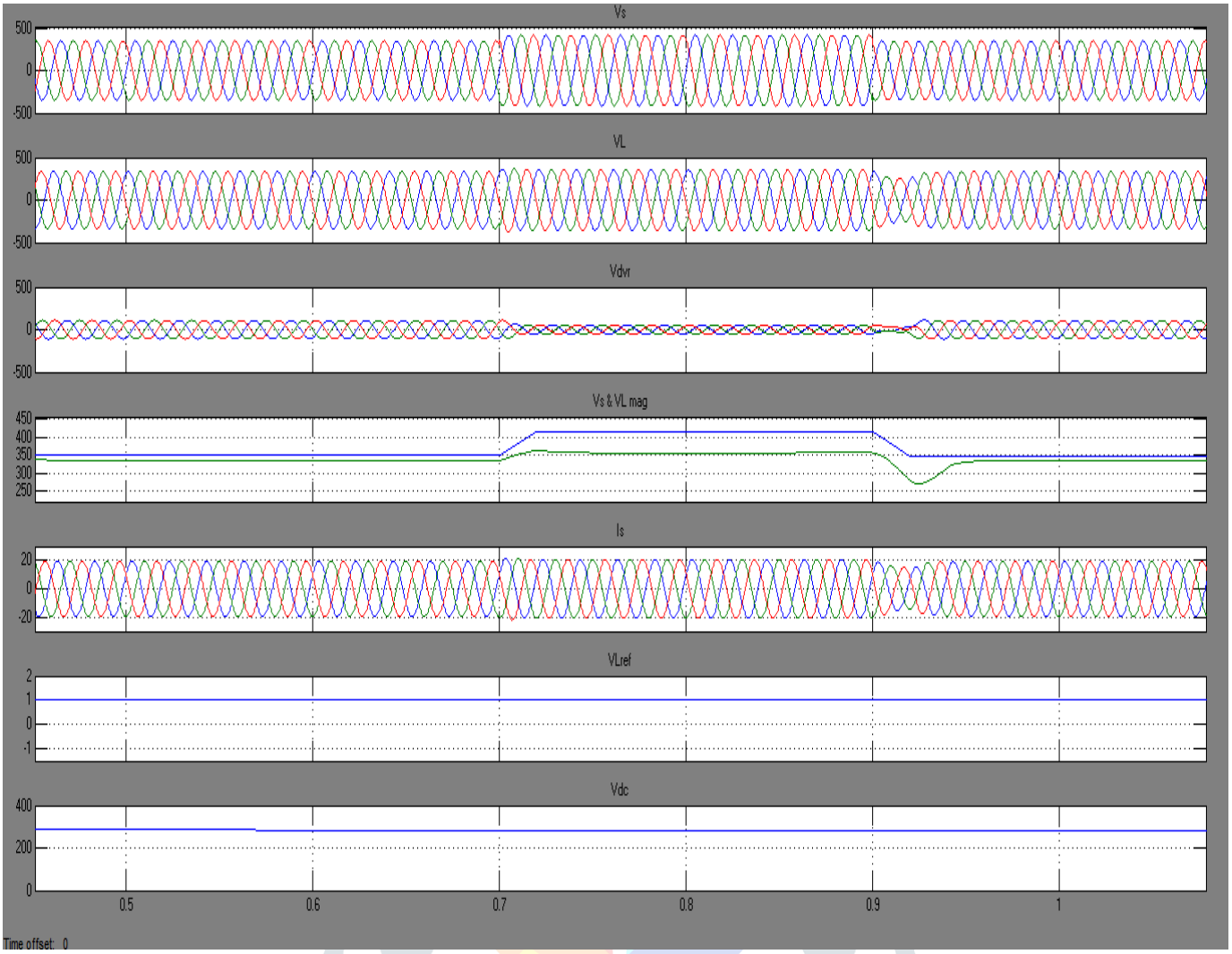

Fig 5. b) Dynamic performance of capacitor supported DVR during .

The performance of self-supported DVR for compensation of voltage sag and swell is as shown in fig 5.a) and Fig 5 b) respectively. It is observed that injected voltage is in quadrature with supply current .From the above fig it is observed that sag is created for a time duration of 0.2 to 0.4. Similarly swell is created for a time duration of 0.7 to 0.9 DVR respond to sag and swell and inject appropriate amount of voltage during sag and swell event at t=0.2 to 0.4sec and t=0.7 to 0.9 respectively. Therefore sag swell is mitigated and voltage level is boosted up to few extent level. It is observed that load voltage is regulated to constant amplitude under both sag and swell condition.

VIII. CONCLUSION

The modelling and simulation of DVR has been presented using MATLAB Simulink. The control technique based on SRF theory has been used for estimating reference DVR voltages. Self-supported DC bus is used as a storage. It is concluded that DVR is consider to be efficient solution due to its relatively low cost and small size. Also it has fast and dynamic response. The proposed system model and simulation results shows that DVR is able to compensate both voltage sag and swell quickly and provide excellent voltage regulation

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