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`VOLTAGE SAG MITIGATION USING DYNAMIC VOLTAGE RESTORER

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Abstract — Now a day power quality problem has become a major issue to deal with, in order to maintain quality supply. Modern generation greatly depends on electrical energy for improving their life style. Modern equipment like computers, electric motors etc. cannot run without electricity. In order to improve the performance, the equipment demands quality supply. The power quality is affected by various factors of the electrical network. Power quality problems such as voltage and frequency variation, harmonic contents affect the performance of electrical utility and shorten its life time. Such problem has to be compensated to ensure the quality supply. One of the most frequently occurring power quality problems in transmission network is voltage sag/swell. Such problems can cause heavy flow of current reduces the life time of the equipment or can cause over voltage affecting the insulation level of the equipment. Many modern custom devices are present in order to mitigate such problems. Among them, Dynamic Voltage Restorer (DVR) is efficient and cost effective. In this paper, an overview of DVR and control scheme used to control the DVR is presented. The simulation result with the proposed control scheme is also shown.

Keywords- Power Quality, Dvr, Voltage Sag, Voltage Swell, Srf Theory, Spwm.

I. INTRODUCTION

With the increasing use of non-linear loads and complexity of the network, the power system network faces challenges to deliver quality power to the consumers. Electric power been delivered is affected by many factors at the distribution network which has to be compensated to improve the quality and quantity of power been delivered. This chapter discuss about the power quality, its necessity, power quality issues and consequences. Power Quality concerns about the utility ability to provide uninterrupted power supply. The quality of electric power is characterized by parameters such as "continuity of supply, voltage magnitude variation, transients and harmonic contents in electrical signals". Synchronization of electrical quantities allows electrical systems to function properly and without failure or malfunction of an electric device.

1.1 Importance of Power Quality:

PQ expresses the degree of similarity of practical power supply with ideal power supply. 1. If PQ is good then any load connected to the electric network runs efficiently without decreasing its performance. 2. If PQ is poor then any load connected to the network leads either to the failure of the equipment or reduction in its lifetime and performance. In order to prevent the consequences of poor PQ and to improve the utility performance the electric power are analyzed to resolve the PQ issues in order to determine the efficient compensation technique.

1.2 Power Quality problems:

Poor PQ problems ultimately results in economic loss of the power system network. PQ mainly concerns to maintain voltage and current profile i.e. any deviation in these parameters can cause severe damage to the electrical utility and end consumers. An overview of many PQ problems along with their causes and consequences are presented.

1.3 Voltage sag/dip:

The voltage sag or dip can be stated as decrease in nominal voltage level by 10-90% for short duration for half cycle to one minute as shown in fig.2.1. Sometime, voltage sag last for long duration such prolonged low voltage profile referred as 'under-voltage'. Voltage sag is further divided in three categories: instantaneous, momentary and temporary sags respectively.

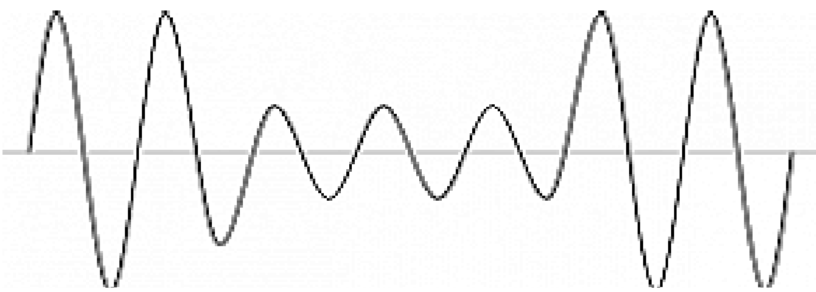

Fig1.1: Voltage sag

Voltage sag are mainly caused due to occurrence of faults in power system, overloading of the electrical network and starting current drawn by heavy electrical loads like motors and refrigerators. Voltage sag in power system network results in failure of relays and contactor, dim light and fluctuating power.

II Dynamic Voltage Restorer

A DVR is a series connected custom device that injects the appropriate/desired voltage to the load bus in order to maintain the voltage profile. However, in standard condition it is in stand-by mode. The compensating voltage is injected by three single phase transformers whose property can be controlled. These voltages are in synchronism with the load voltage. DVR has three mode of operation.

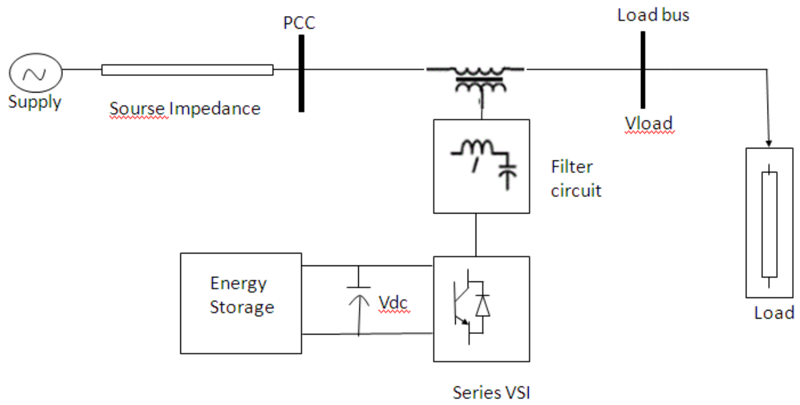

Fig.2.1 Dynamic voltage restorer

DVR is series connected compensating devices that restore/maintain the voltage profile at the sensitive loads under voltage unbalance. It is usually connected in the distribution network between Common Point of Coupling (PCC) and load. Shows the location of DVR in power system network. The disturbance in the system is detected by control scheme used which generates the triggering pulses for VSI. Passive filters are used to filter out the harmonic content of injected voltage. DVR injects the filtered output voltage through injection transformer.

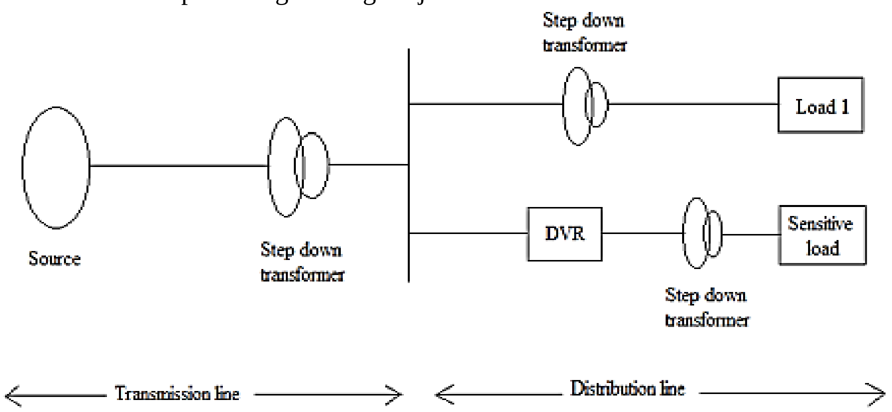

Fig. 2.2 Location Of DVR

DVR consists some additional equipment as follow.

1. VSI
2. Injection transformer
3. Passive filter
4. Energy storage unit
5. Control unit

Control circuit steadily observe the system. Its function is to detect any disturbance in the system done by comparing the supply voltage with reference voltage and generate the switching command signals for VSI in order to generate the compensating voltage by DVR.

III. SINUSOIDAL PULSE WIDTH MODULATION

In this modulation technique are multiple numbers of output pulse per half cycle and pulses are of different width. The width of each pulse is varying in proportion to the amplitude of a sine wave evaluated at the centre of the same pulse.

The gating signals are generated by comparing a sinusoidal reference with a high frequency triangular signal. The rms ac output voltage.

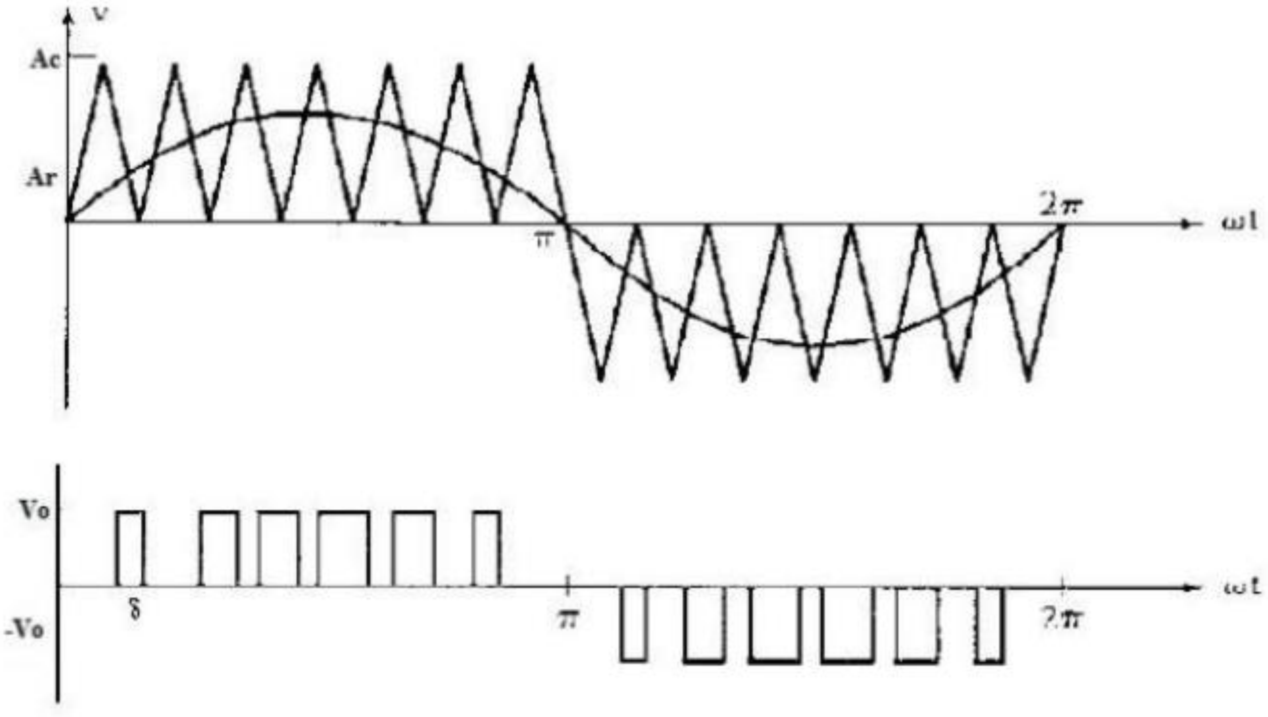

Fig.3.1 SPWM technique

The most common and popular technique for generating True sine Wave is Pulse Width Modulation (PWM). Sinusoidal Pulse Width Modulation is the best technique for this. This PWM technique involves generation of a digital waveform, for which the duty cycle can be modulated in such a way so that the average voltage waveform corresponds to a pure sine wave. The simplest way of producing the SPWM signal is through comparing a low power sine wave reference with a high frequency triangular wave. This SPWM signal can be used to control switches. Through an LC filter, the output of Full Wave Bridge Inverter with SPWM signal will generate a wave approximately equal to a sine wave. This technique produces a much more similar AC waveform than that of others. The primary harmonic is still present and there is relatively high amount of higher level harmonics in the signal.

IV. SYNCHROOUS REFERENCE FRAME THEORY (SRF):

Shows the control block of the DVR proposed in synchronous reference frame theory which is used for the control of self supported DVR. The voltage at PCC is converted to rotating reference frame using abc-dqo conversion. Using low pass filter(LPF) harmonics and oscillatory components of voltage are eliminated. The components in d-axis and q-axis are

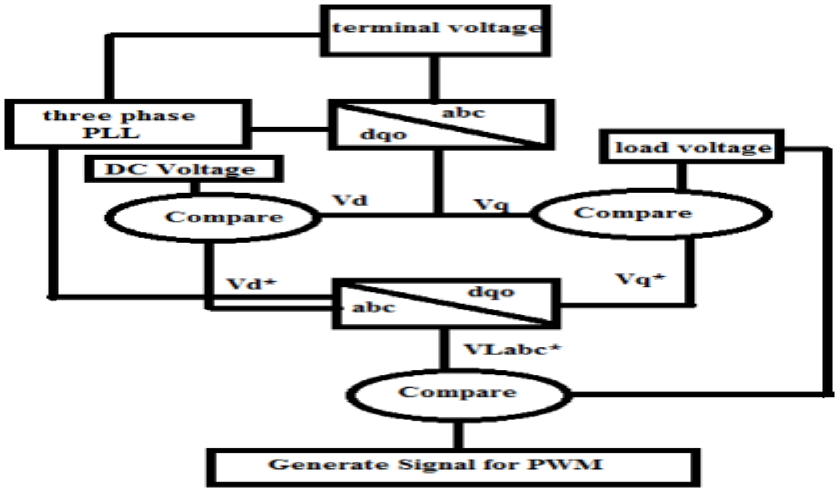

Fig. 4.1 SRF control strategy

Three phase reference supply voltage (VLa*,VLb*,VLc*) are derived using sensed load voltages, terminal voltage (Vta,Vtb,Vtc)and dc bus voltage(Vdc) of the DVR. SRF method is used to obtain the direct axis (Vd) and quadrature axis (Vq) components of load voltage. By Park's transformation three phase load voltage is converted to dqo frame.To synchronies these signals with the terminal voltage a three phase PLL is used.The dq components are passed through LPF to extract dc components of Vd* and Vq*.

V. Dynamic voltage restorer simulation and result:

(A) System parameter and rating:-

Sr No.	Parameter	Parameter rating
1	Supply Voltage(Vrms)	415 Volt
2	Line Impedance	R=0.01ohms L=1e-3H
3	Filter Inductance	2e-3H
4	DC Bus Voltage	700 Volt
5	Series transformer turns ration	1:1
6	Filter capacitance	35e-6 F
7	Load active power	1000Watt
8	Load inductive reactive power	5000VAR
9	Line Frequency	50Hz

(B) DVR Simulation :-

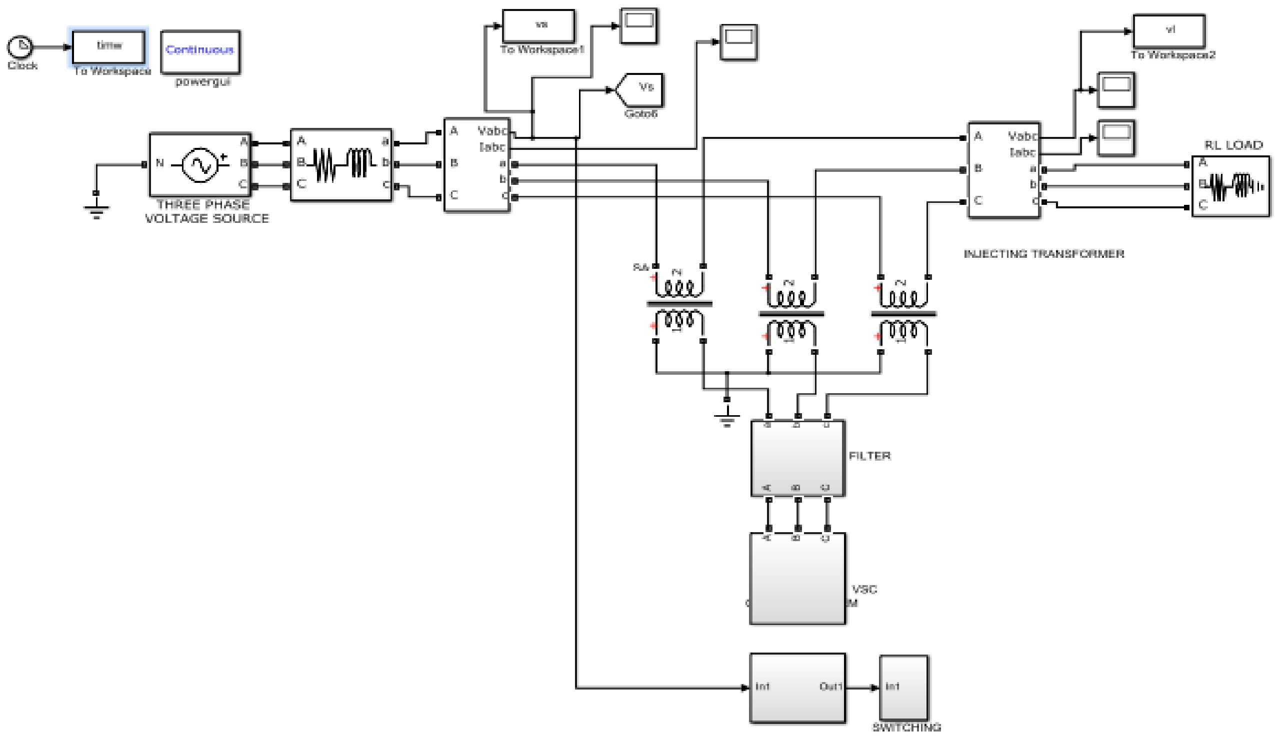

Fig. 5.1 DVR Simulation

A simulation has been carryout without and with dynamic voltage restorer. It has 3phase, 415V, 50 Hz, distribution line. Check the system performance at time of sudden load increase on the system. Inductive load connect via programmable source for 0.05 to 0.1 ms to the normal healthy system. Analyze the performance of system at time of sudden load connected.

(C) Open loop simulation:-

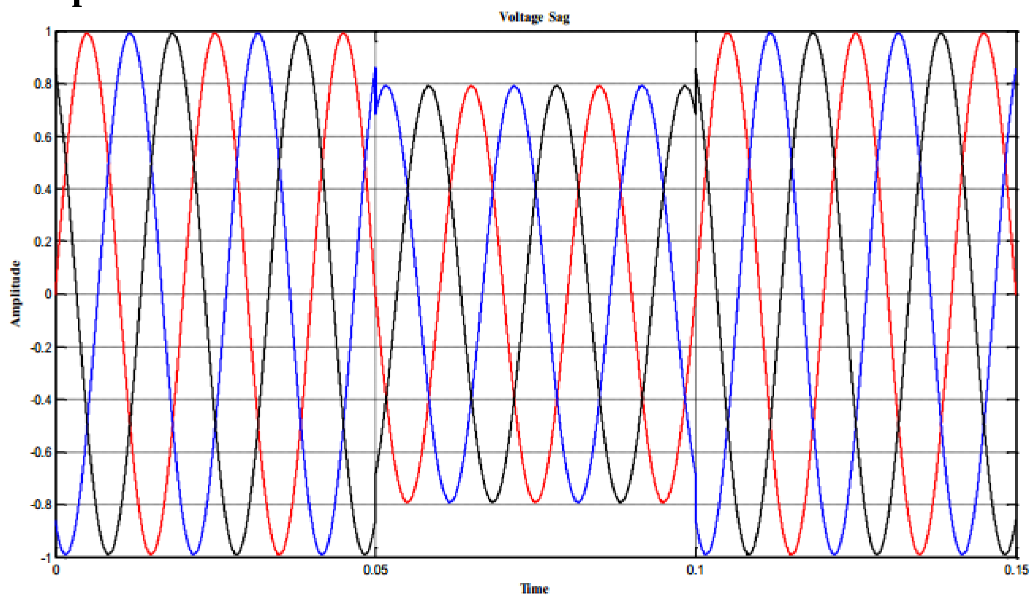

Fig. 5.2 output voltage without DVR

(D). DVR Injected Voltage:-

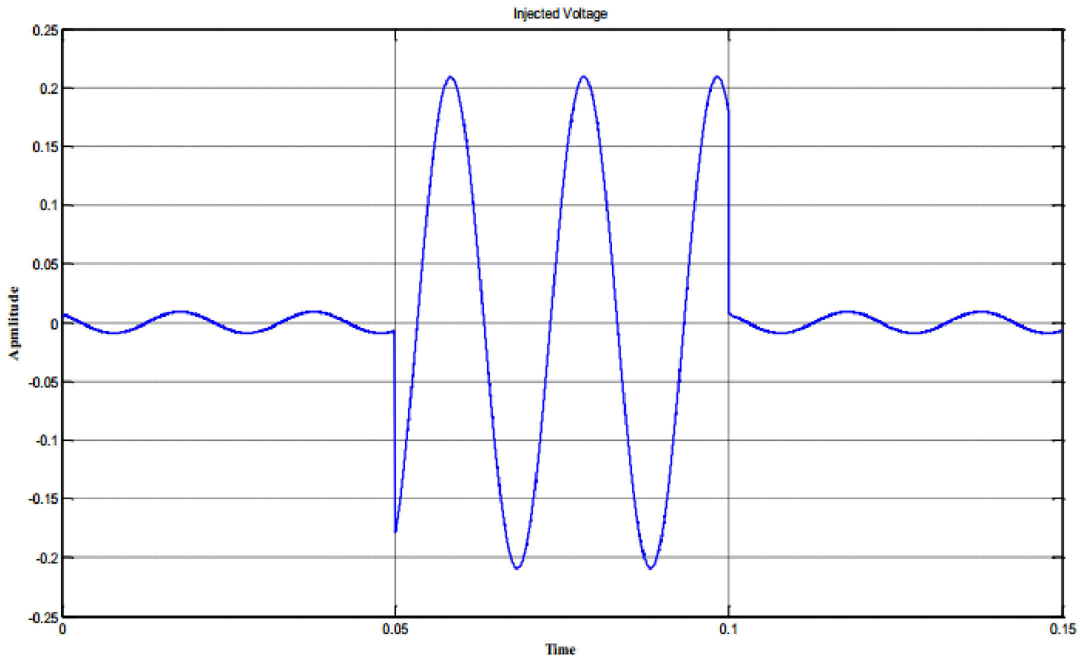

Fig. 5.3 one phase voltage injected by DVR

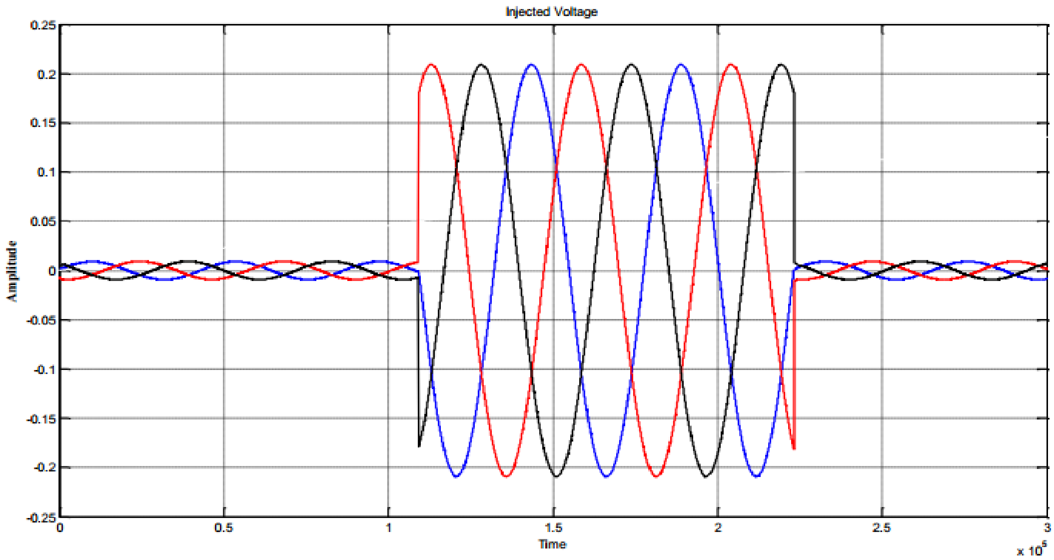

Fig. 5.4 three phase voltage injected by DVR

(F). **Closed loop System Output Voltage:-**

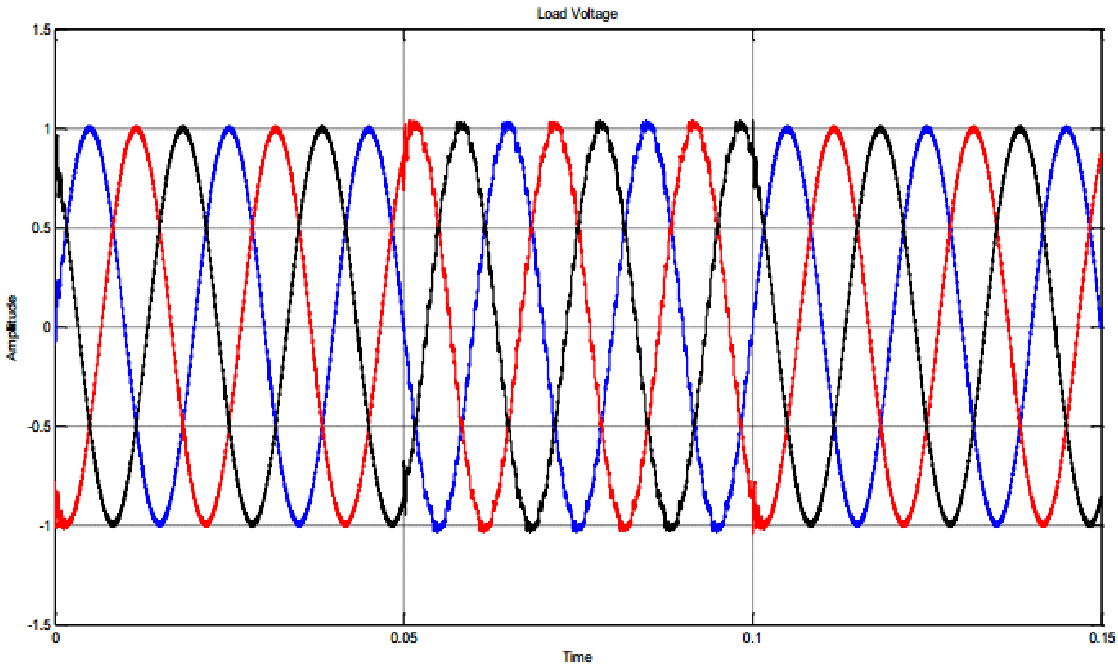

Fig. 5.5 System output with DVR

VI. CONCLUSATION

A new methodology has been developed to control DVR, named SRF theory to inject active power and to eliminate the three phase disturbances in the utility side. The three phase distortions created using the three phase fault block and the performance of DVR was analyzed. The sinusoidal PWM technique is used to provide the gate signals for the inverter. The overall performance is satisfactory to protect the load from utility voltage problems.

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