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FAULT RIDE THROUGH CAPABILITY OF A SYSTEM UNDER CRITICAL VOLTAGE CONDITIONS

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***Abstract:* :** The main goal of this research is to investigate the condition of the voltage when a fault occurs in the system when under faulty conditions or during fault occurrence .This study focuses on optimizing the flow of voltage through the system by providing a ride through capability.And to improve the power qaulity which is provided to the consumer.Here, by implementing a DVR-FRTC we can improve the quality of the power supplied to any system under any fault conditions. A fault ride-through approach for grid-connected systems, aimed at improving the system's response during voltage sags and limiting the maximum inverter current during symmetrical faults. A constant active current reactive power injection approach was developed for low-voltage ride-through (LVRT) operation of grid-connected system in low voltage grids. The method manages the active and reactive power references and satisfies grid code requirements The faults that we deal here are the voltage sags that occur during the switching the equipment or during the sudden load change the operation.This research examines the perfomance of the system when applied with DVR-FRTC and without it under different sag levels .This resaerch outcome specifies the adaptability of a system to perfom better under any faulty conditions.These tests are performed using MATLAB/SIMULINK to oberve the work of the Fault ride through capability.

***Index Terms* -** Power quality ,Distribution Grid, Fault ride through capability, Voltage sag**.**

Introduction

In electrical power engineering, fault ride through (FRT), sometimes under-voltage ride through (UVRT), or low voltage ride through (LVRT), is the capability of electric generators to stay connected in short periods of lower electric network voltage (cf. voltage sag). It is needed at distribution level (wind parks, PV systems, distributed cogeneration, etc.) to prevent a short circuit at HV or EHV level from causing a widespread loss of generation. Similar requirements for critical loads such as computer systems and industrial processes are often handled through the use of an uninterruptible power supply (UPS) or capacitor bank to supply make-up power during these events. At the same time, a high-quality power supply is required for the proper operation of the EV charging system.However, in practice, the grid supply is subjected to various power quality issues. The voltage quality is the major issue in the distribution grid due to sudden load changes, electric motor.starting, a fault occurring in the distribution grid, accidents in the power line, and energizing the transformers.The poor voltage quality directly affects the EV charging profile and battery life cycle. In recent days, major research focuses on the impact of EV charging on the distribution grid. During high voltage ride-through, reactive power injection is necessary to avoid voltage collapse. The voltage sag condition and power factor correction have been investigated in this study, and various approaches have been explored to enhance the performance of grid-connected systems, such as flexible reactive power compensation devices, maximum power control, and optimum power flow control, among others .Several studies have been conducted to find the optimal method for achieving fault ride-through , and various custom control tools, such as dynamic voltage restorer (DVR) , static compensators , and other reactive power compensation devices, have been implemented as solutions . However, these methods have some significant drawbacks due to overcurrent trip off, derating operation under severe faults, and implementation complexity. Moreover, the urgent requirement for efficient operation is to advance islanding detection . In the system, an enhanced fault detection method for distribution systems was proposed.

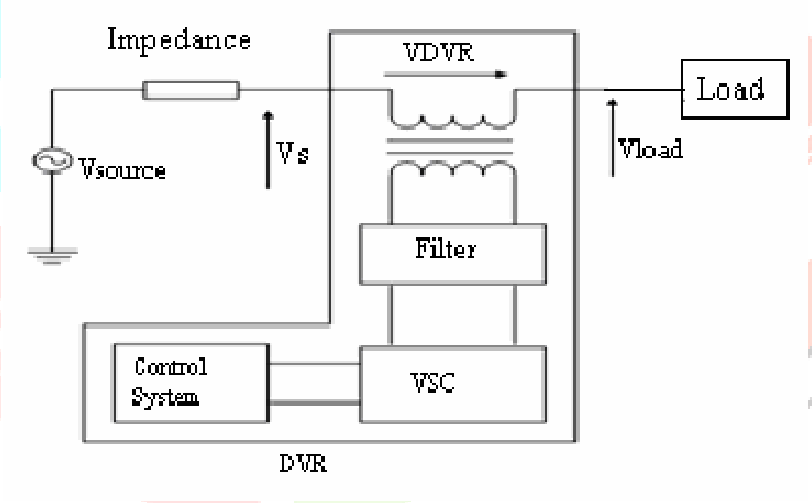

Fig.1. Structure of basic DVR system

DVR components

Figure 1 shows a basic structure of DVR which mainly consists of injection transformer, VSI, filters and a control system in a power system. With DVR installed between the power supply and feeder load, whenever PQ issues are detected at the point of common coupling (PCC), DVR is able to make the load voltage at desired magnitude and phase by adding or subtracting desired voltages in series with the supply and load, thereby maintain load voltage at 1pu . The performance of a DVR in PQ mitigation is mainly dependent on the accuracy of the control techniques that DVR injects the desired voltage to the load-side when voltage disturbance is detected at the supply-side . To be more specific, the main function of a controller in a DVR are detection of any power quality issues in a system, computation of compensating voltage, generation of switching signal to the PWM based VSI, correction of abnormalities in the voltage injection. Therefore, the controller is necessary to manage controlling the magnitude, frequency, and phase angle accurately and fast .

PI controller

A proportional-integral (PI) controller runs the system or plant to be controlled by a weighted sum of the error which is difference between the actual sensed output and desired setpoint and the integral of that value. The integral term of PI controller causes the steady-state error to be zero for a step input. The actuating input signal of PI controller is the difference between Vset and Vt shown in the schematic diagram of PI controller. Output of the controller block is in the form of an angle δ, which introduces additional phaselag/lead in the three-phase voltages. The controller output when compared at Pulse

Width Modulation (PWM) signal generator results in the desired firing sequence. The modulated angle is applied to the PWM generators. The sinusoidal signal control voltage is phase modulated by using the angle δ and the modulated three-phase voltages are given by:

$VA = 1*\sin(\omega t + \delta)$ (1)

$VB = 1*\sin(\omega t + \delta + 2\pi/3)$ (2)

$VC = 1*\sin(\omega t + \delta + 4\pi/3)$ (3)

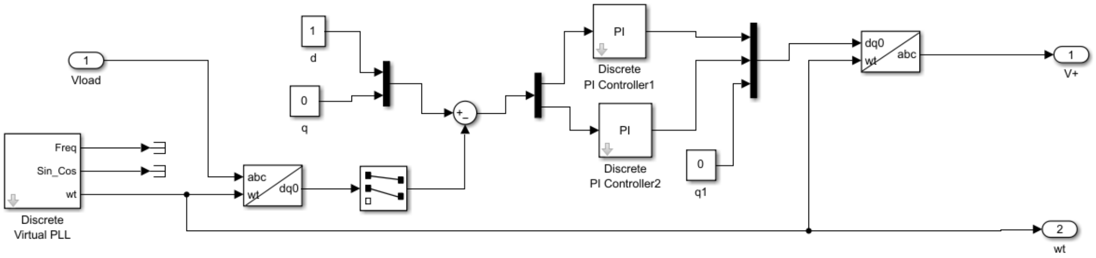

Fig 2.PI controller

To simplify the SRF-PLL control algorithm compared to the existing control algorithm for DVR which shown in Figure 3, the method is described as follows. From Figure 4, the three phase voltage at PCC (Vpcc, abc) where any PQ issues are subjected is first transform into dq0 rotating reference frame (Vd,Vq) using Park's transformation with angular position (ωt)which subscript using PLL, given that, the PLL is locked to the supply voltage. The calculation is shown as below Equation (1).

$$\begin{bmatrix} Vd \\ Vq \\ V0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} cos\omega t & \cos\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) \\ sin\omega t & \sin\left(\omega t - \frac{2\pi}{3}\right) & \sin\left(\omega t + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} Vpcc, a \\ Vpcc, b \\ Vpcc, c \end{bmatrix}$$

After obtaining the value of Vd and Vq, it is then subtracting from the reference of dcomponent and q-component, given that the reference of d-component is the DC value of reference load voltage, while reference of q-component is zero. Now, Vd* and Vq* are obtained which is the error signals in term of d-component and q-component as Equation (2) and (3)

$$Vd* = \mathrm{Vdref} - \mathrm{Vd}$$

$$Vq* = \mathrm{Vqref} - \mathrm{Vq}$$

The Vd* and Vq* are then transformed back to three-phase voltage by using reverse Park's transformation with the calculation shown below Equation (4).

$$\begin{bmatrix} Verr, a \\ Verr, b \\ Verr, c \end{bmatrix} = \frac{2}{3} \begin{bmatrix} cos\omega t & -sin\omega t & 1) \\ \cos\left(\omega t - \frac{2\pi}{3}\right) & -\sin\left(\omega t - \frac{2\pi}{3}\right) & 1 \\ \cos\left(\omega t + \frac{2\pi}{3}\right) & -\sin\left(\omega t + \frac{2\pi}{3}\right) & 1 \end{bmatrix} \begin{bmatrix} Vd * \\ Vq * \\ V0 \end{bmatrix}$$

When the error signal (Verr, abc) is obtained, it is then adding the value of Vpcc, thereby generating a reference load voltage (VLref*, abc). Then, the reference load is compared with the actual load voltage (VL), generating a new error signal for PWM controller to generate gating pulses to V

DVR CIRCUIT

Among the power quality problems (sags, swells, harmonics…) voltage sags are the most severe disturbances. In order to overcome these problems the concept of custom power devices is introduced recently. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks. DVR is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can also added other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations.

Operating modes of DVR:

The basic function of the DVR is to inject a dynamically controlled voltage VDVR generated by a forced commutated converter in series to the bus voltage by means of a booster transformer. The momentary amplitudes of the three injected phase voltages are controlled such as to eliminate any detrimental effects of a bus fault to the load voltage VL. This means that any differential voltages caused by transient disturbances in the ac feeder will be compensated by an equivalent voltage generated by the converter and injected on the medium voltage level through the booster transformer. The DVR has three modes of operation which are: protection mode, standby mode, injection/boost mode.

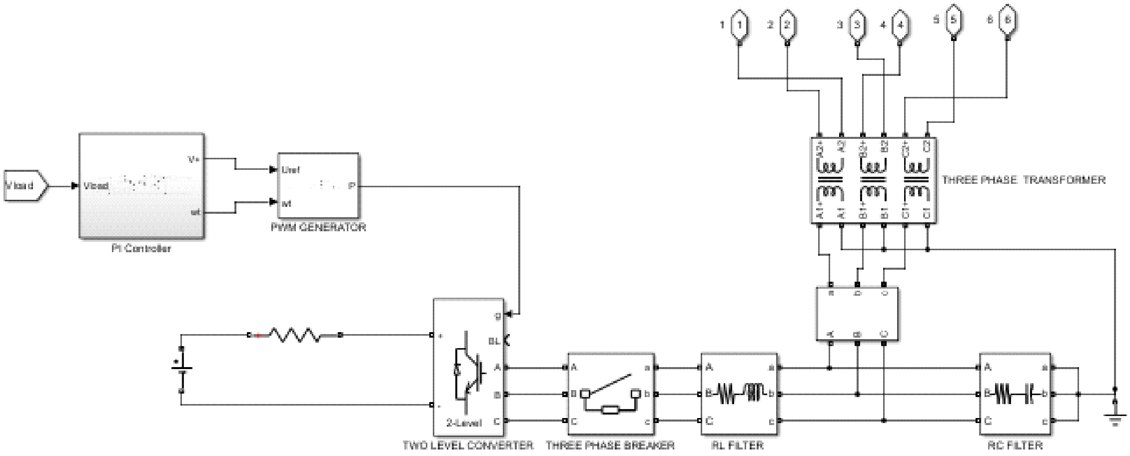

Fig.3 DVR Circuit

- **Voltage injection methods of DVR:**

Voltage injection or compensation methods by means of a DVR depend upon the limiting factors such as; DVR power ratings, various conditions of load, and different types of voltage sags. Some loads are sensitive towards phase angel jump and some are sensitive towards change in magnitude and others are tolerant to these. Therefore the control strategies depend upon the type of load characteristics.

There are four different methods of DVR voltage injection which are
i. Pre-sag compensation method
ii. In-phase compensation method
iii. In-phase advanced compensation method
iv. Voltage tolerance method with minimum energy injection

In-phase compensation method:

This is the most straight forward method. In this method the injected voltage is in phase with the supply side voltage irrespective of the load current and pre-fault voltage. The phase angles of the pre-sag and load voltage are different but the most important criteria for power quality that is the constant magnitude of load voltage are satisfied.One of the advantages of this method is that the amplitude of DVR injection voltage is minimum for a certain voltage sag in comparison with other strategies. Practical application of this method is in non-sensitive loads to phase angle jump.

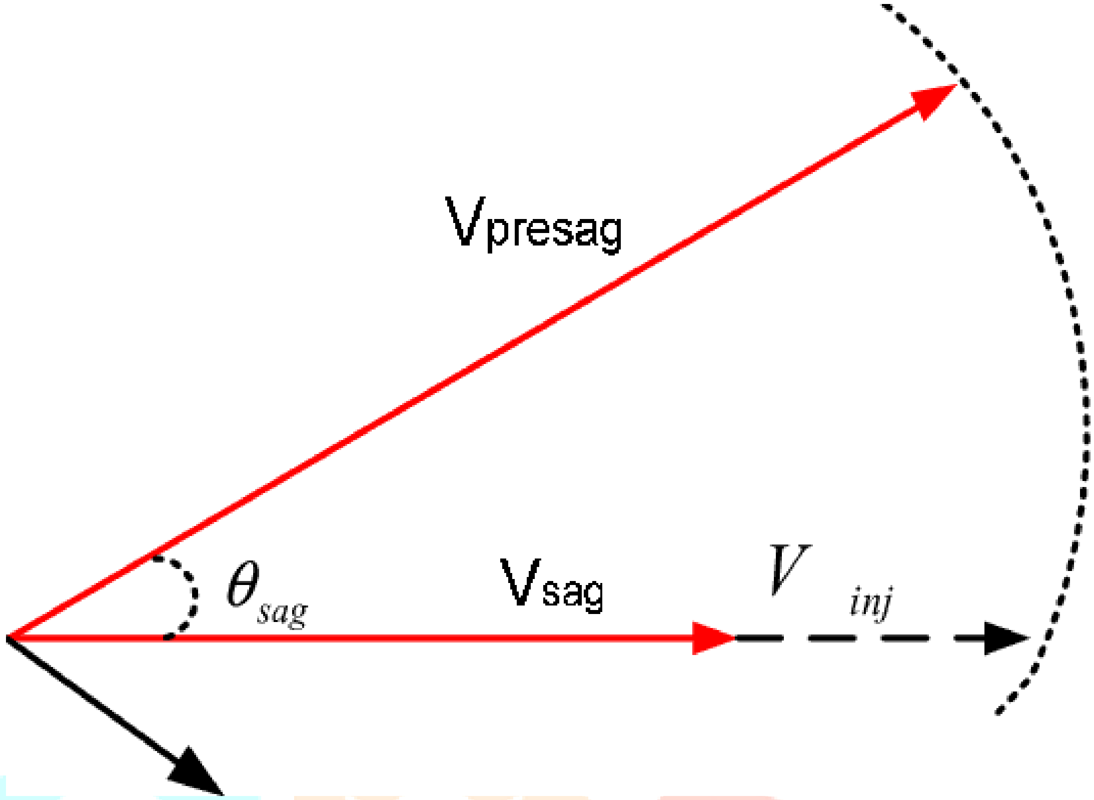

Fig . In Phase Compensation Method

IV. RESULTS AND DISCUSSION

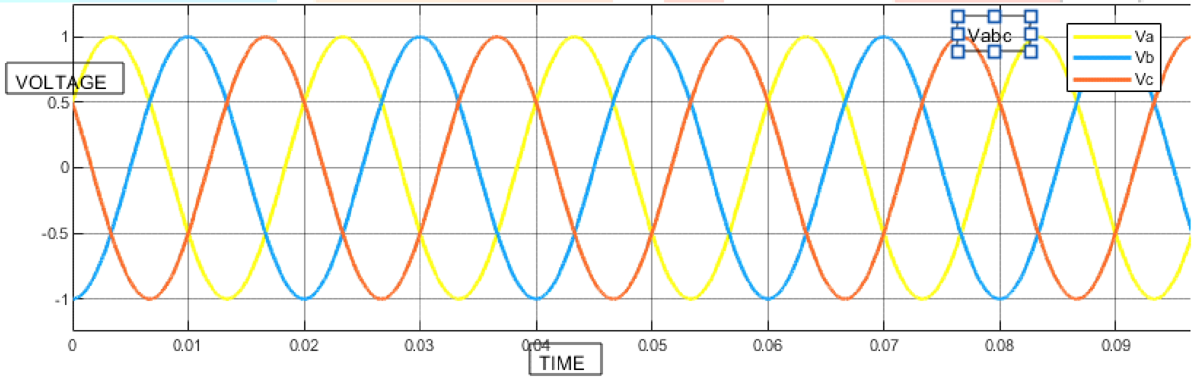

Fig.THREE PHASE VOLTAGE SOURCE

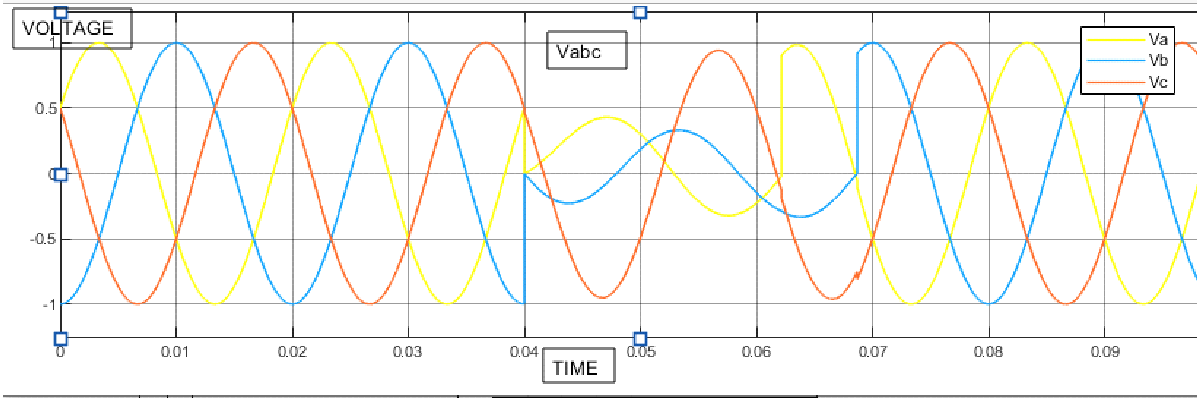

Fig1. LLG fault of voltage sag 60% b/w Phase A&B

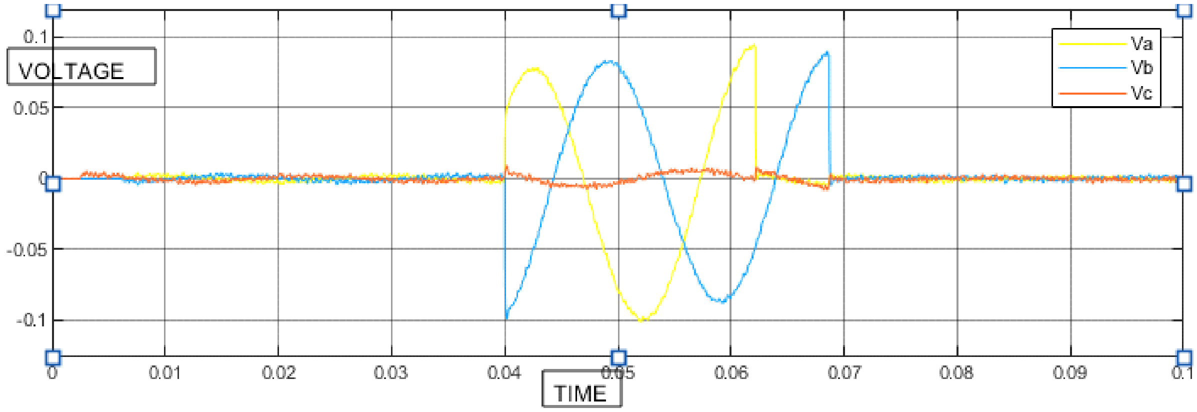

Fig .Voltage injected by DVR to compensate LLG fault

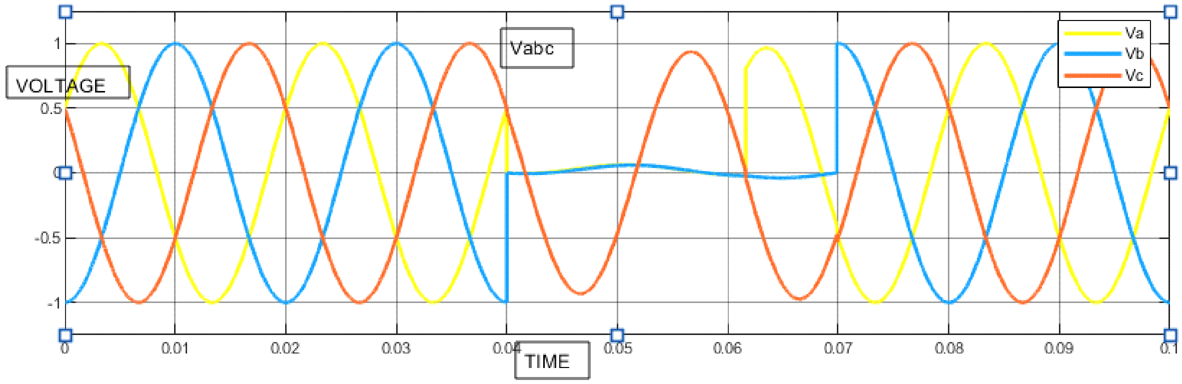

Fig LLG fault of voltage sag 90%

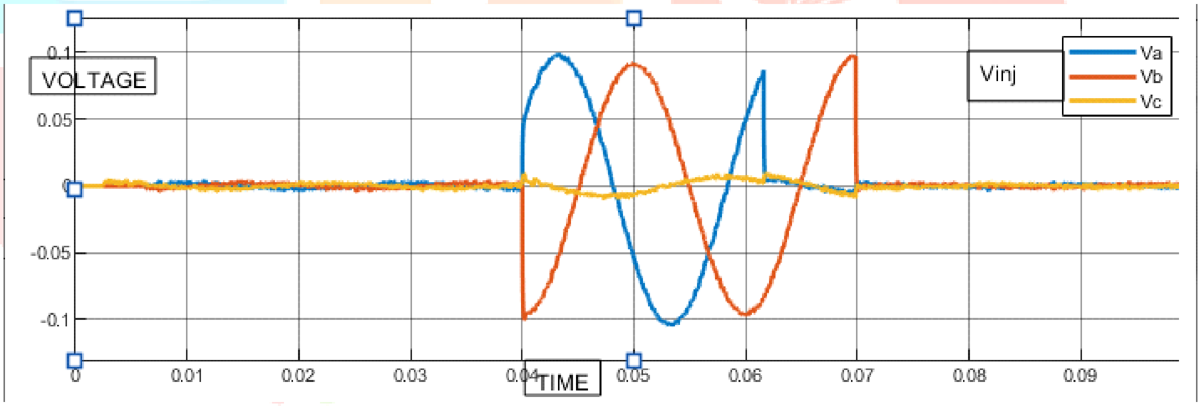

Fig . Voltage injected by DVR to compensate LLG fault

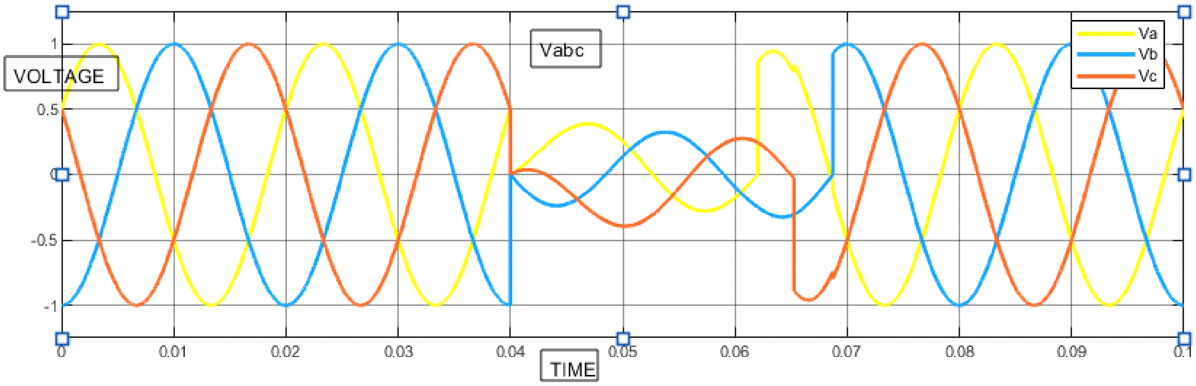

Fig .LLLG fault of voltage sag 60%

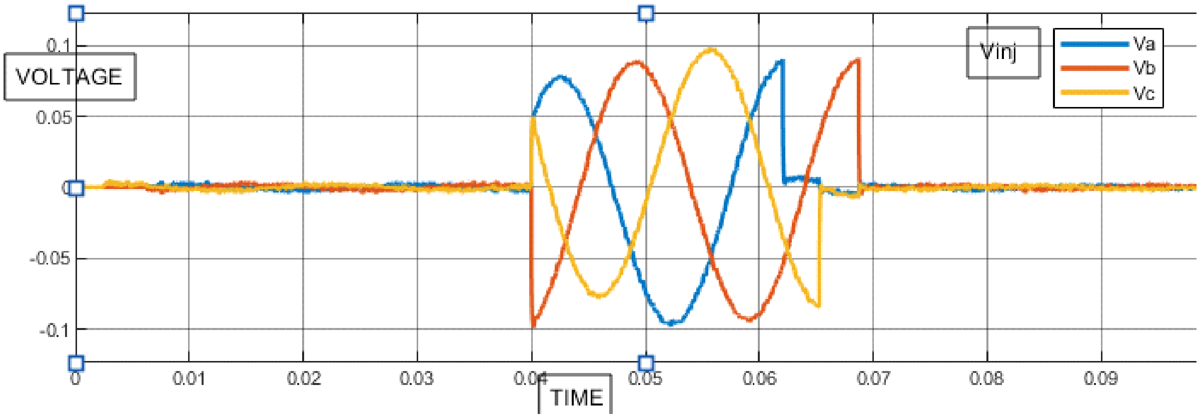

Fig. Voltage compensated for LLLG fault

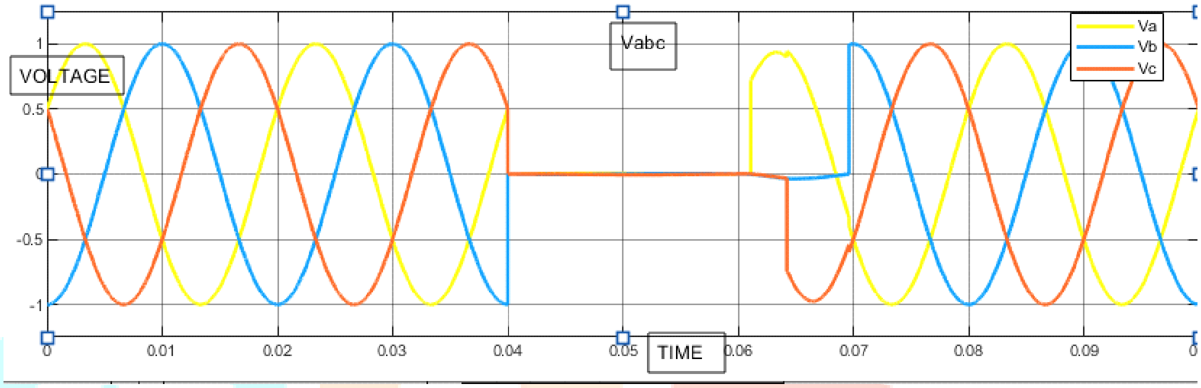

Fig .LLLG fault of voltage sag 90%

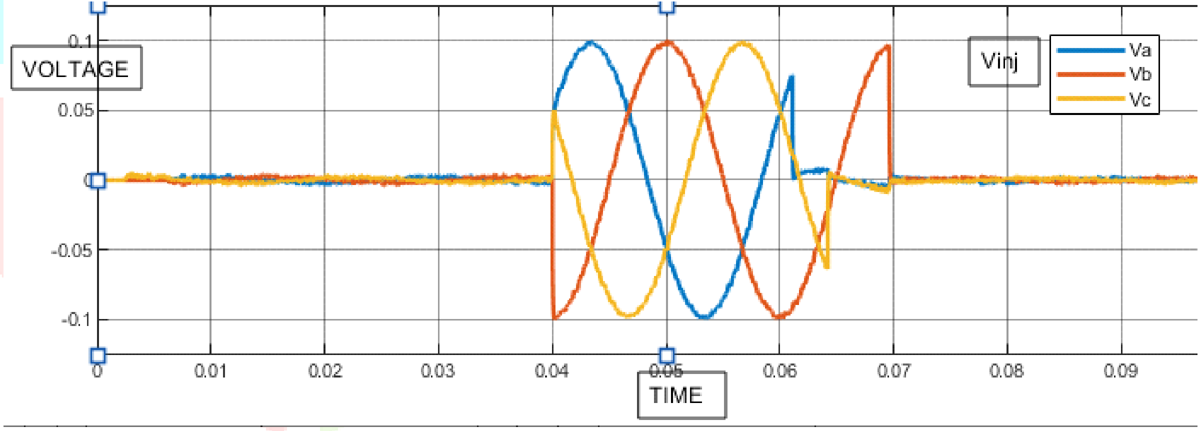

Fig. Voltage compensated for LLLG fault

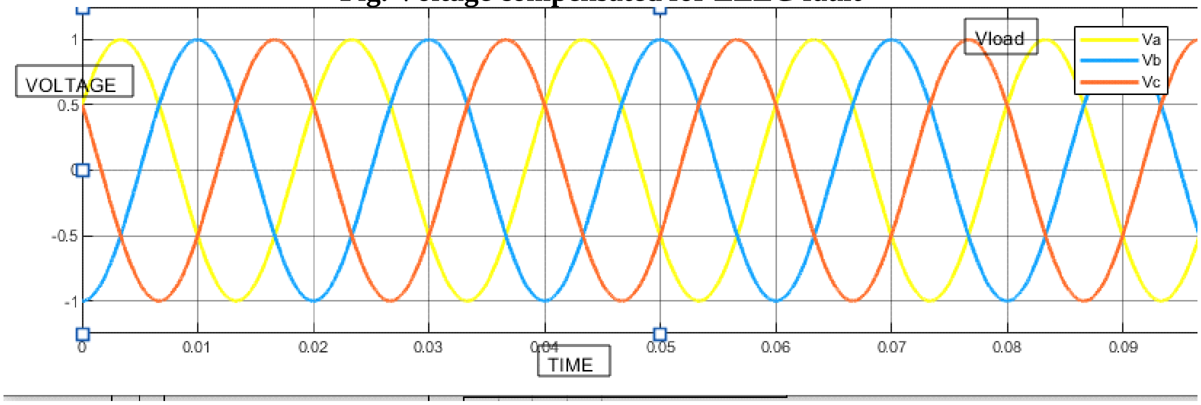

Fig.THREE PHASE VOLTAGE TO LOAD

Results

Fault	SAG(%)	With FRTC
LLG	90	stable operati
LLG	60	stable operati
LLLG	90	stable operati
LLLG	60	stable operati

- **Concluision**

This paper deals with the performance analysis of Dynamic Voltage Restorer (DVR) against voltage sag. The impact of voltage sags on sensitive equipment is severe. Therefore, DVR is considered to be an efficient solution due to its relatively low cost and small size, also it has a fast dynamic response.The simulation results clearly show the performance of a DVR in mitigating voltage sags during various fault conditions. The DVR handles both balanced and unbalanced situations without any difficulties and injects the appropriate voltage component to keep the load voltage balanced and constant at the nominal value.

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