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Modelling Analysis and Simulation of Dynamic Voltage Restorer in the Distribution System

Bijwar Jeevan Goud[1], Dr. K. Venkatraman[2]
[1]Mtech scholar, [2]Associate.professor, Department of Electrical and Electronics Engineering, Vardhaman College of Engineering

Abstract: The current power grid is made up of several generating stations and generation centers that are linked by a transmission and distribution network. When customer or buyer purchasing, power efficiency must be involved, because each of the consumer's happiness is the ultimate feature, it must ensure a consistent and uninterrupted power supply. In conjunction with the installation of many components, the function of which is very delicate to voltage adjustments, the activity of the equipment may be impaired. The most important power quality issue in a delivery system that can be addressed with power electronics is voltage drop. In conclusion, it is the most powerful and reliable form of load voltage compensation to use the Secure Power Converter (DVR). Digital storage is a collection of linked systems that inject a controlled voltage into the line by means of an injection transformer. The effectiveness of the camera depends on the particular control technique used in the process. The aim of managing the vital load voltage when the system fails is to preserve a steady voltage magnitude at the fragile load stage. It gives a description of DVR model simulations coded with the usage of MATLAB. Accuracy can be accomplished by utilizing a variety of calibration parameters.

Index Terms: Dynamic voltage restorer (DVR), Power Quality,Voltage Source Converter (VSC), Sinusoidal Pulse Width Modulation (SPWM), voltage sag, voltage swell, Booster Transformer, By-pass switch.

I. INTRODUCTION

The accomplishment of the economic objectives was made possible only by the progress of advanced technology built in the new factories. Only if one decides to maximize productivity and produce optimum profits while retaining elevated expense could they achieve consistency of effort. The explanation for the need for high quality continuous power is largely because of the concurrent implementation of modern manufacturing and processing machinery which requires reliable and fault-free power supply. Factories may be more energy-efficient and more profitable because of advanced electricity supplies.

For instance, certain instruments, including the engine adjustment equipment, a power supply machine, fuel pumping system, gyroscope, etc., are part the controlled class of devices, whose work is based on a full power supply. If a part of the power supply breakdown and a defective configuration therein, triggering a shutdown in the industry, will definitely result in financial loss to the industry concerned. However, since the new infrastructure is not strong enough, the fault can't be easily laid in the side of the utility itself. As seen from the situations, several of the conditions that hinder the operation are the product of mistakes created by various individuals in the same business. For example, in certain cases, these non-linear loads (those non-linear loads) can cause transients that can affect the stability of the power supply.

For instance, major nonlinear loads cause transients that can affect power reliability.

1) Voltage drops
2) Phase interruptions
3) Voltage Interruptions
4) Transients because of lighting loads, condenser Switching, non-linear loads etc.
5) Harmonic distortion

As a result of the above-mentioned operational problems in industry, explosive engines, loss of data in temporary memory, defective robot activity, Useless downtime, Increased retaining price and incineration of required equipment can occur in the industry, particularly in the plastics industry, for example, in the process of the burning of plastic waste in incineration plants. paper and semiconductor industries are situated nearby..

A. *Power Quality Definition*

Power Efficiency, is a measurement that is used by the electrical grid to report the state of the electricity. The characteristic function of High-quality Electricity is the steady supply Voltage, at which the supply frequency is similar to the nominal Voltage value.

B. *Effects of Poor Power Quality*

Certain sectors, such as heavy equipment, semiconductor machines, computers are very sensitive to minor variations in energy supplies. It is important to improve productivity and lowering the power so as to not affect generation or revenues.

The five most often found PQ defects are:

1) *Low Voltage:* when the working value is low due to short circuit voltage.
2) *Dips or Peaks:* fluctuations in the volume of supplies that lead to frequent ups and downs.
3) *Transient:* Fluctuations sinusoidal supply voltage.
4) *Harmonic-Distortion:* voltage or current that is an Integer_Multiple of the Operating Characteristics that are causing the distortion.
5) *Burnout:* Period of voltage with very low or sometimes zero frequency leads to less energy distribution

II. LITERATURE SURVEY

A. The word "power quality" implies an honest variety of magnetic power phenomena which at a certain time and location in the power grid discern voltage and current. The expanded usage of equipement for industry in recent years has generated problems pertaining to electricity efficiency that could be sensitive to such phenomena.

B. Increased voltage In nursing equivalent with maximum grid access, adjustable speed engine drives and power supply condensing systems, in order to minimize effects. This sometimes is the product of the long-term effect on the system's capacity from a variety of organizations. It is also possible to link the area unit in the network. The omission of these capabilities has far more necessary implications due to integrated applications.The observation of power quality is essential to understand magnetic power phenomena inside the electric circuit chosen.

The aim of the observation in such cases is to diagnose the discrepancy between the power supply and hence the fee. In order to assess the power of the nursing partner on the consistency level, it is also planned to measure the electric environment at the selected site. Furthermore, observation may be used to determine the potential output of the load instruments or systems for reducing power efficiency.

III. STRUCTURE AND OPERATION OF DVR

The voltage magnitude is one of the key variables determining the power supply output. For a variety of causes, regular stress sags face tons during delivery. All important loads are extremely unacceptable, such as those on high-tech energy. It is a deep process to maintain sufficient voltage specifications and restore the voltage decrease during tensile interruptions and adjustments.

A DVR is a state-of-the-art electronic switching device containing either GTO or IGBT, an energy storage unit condenser bank and a transformer for the injection system. It can be shown from the figure that the DVR links the device to the load. The underlying theory behind the DVR is that the drive voltage is supplied by means of an injection transformer by a forced transition that, in series, approaches the bus voltage. A DC capacitor bank, which serves as an energy storage center, provides a controlled DC voltage supply.

In standard working environments, the DVR has a slightly smaller voltage scale in which the transformer's diminished voltage and device degradation is offset. However, when a voltage sag is present in the device, the DVR provides a sufficiently high magnitude regulated voltage and the desired phase angle, maintaining uninterruptable and continuous load voltage. The condenser must then be discharged in order to ensure a continuous load supply.

A. *Structure of Dvr*

The two key elements of the DVR are the power circuit and the control circuit. DVR is applied to any parameters that are necessary to monitor signals, such as magnitude, phases, frequency, etc. The control circuit lacks these criteria. The injected voltage is produced by the control signal switches in the power circuit. The basic configuration of the DVR is also defined and presented in this segment to the power circuit. The following are five key components of the power grid, their purpose and specifications.

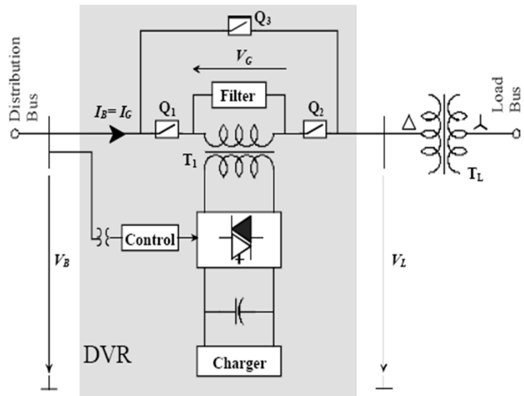


Fig:1 structure of Dvr

1) *Injection-voltage Transformer:* The primary side of the transformer is attached to the main line of transformation, while the secondary side is related to the DVR control circuit. Here is an example of a transformer that uses this means: It is now possible to use a 1 3-phase transformer for 3 phase loads or other three-phase combination, and one phase one for just one phase load. The energy distribution of an electrical device is essentially the same as with a 3-phase DVR. Such a type of interaction between the three phases is called a relationship. If the main end and second end are not winding, this relationship is called the delta type and is typically used in DVR systems...
2) *Voltage Source Inverter:* An PWMVSI (Pulse- Width Modulated Voltage Source Inverter) is widely used. In the previous part of this segment, we saw how a DC voltage is generated by a specific energy storage device. To shift this voltage to a different one, an inverter is required, which gives it an AC signal. To render the current magnitude during sag high, an arrangement is rendered so that a step-up voltage injection transformer is used in the DVR control circuit. A voltage sensor is most suitable for ensuring the voltage is very low..
3) *Passive Filters:* The PWM inverted pulse train is commonly used to transform a sinusoidal current through low passive filters. In order to accomplish this, the harmonics assigned to the AC output must be eliminated by relegating the DC to AC inverter voltage, which normally distorts compensated output voltage. This filter may be placed either on the side of the high-voltage, i.e. on the side of the load or on the side of the low voltage, i.e. the converting inverter...
4) *Energy-Storage:* Various products such as Lead Acid Batteries, Superconducting Magnetic Energy Storage (SMES) and Supercapacitors, both of which are energy storage devices, can be found with the battery. The main position that an energy storage facility performs in a UPS is that they provide a rather high-actual voltage voltage sag. The primary concern that one must ask regarding the energy contained in the battery is whether it is large enough to counteract the impact of the shortened recharge cycles. The chemical poisons generally referred to as lead are in general usage due to their strong charging/recharging capacity.

B. *By-Pass Switch*

In the future the DVR can be a piece of freestanding photo equipment. If there is a fault present in the down side, there would be a defect in the downstream. The control boards and relays are not top rated products, they are just cost efficient pieces that are frequently used. In this scenario, a bypass switch is used to protect the inverter.

IV. DVR OPERATING MODES:

A. *During a Voltage Sag/Swell on the Line*

During the moment of interrupting, the voltage of the energy storage portion (powered by the solar cells) is pre-sagged to the almost zero voltage（Sag Voltage） of the solar power grid, and then the voltage of the reactive power supply (powered by the storage battery) is pumped to reset the pre-sag voltages after the disruption occurs. The computer that tracks the distribution of electricity on the grid injects the contrast between the power flow until the moment of tripping and the power that flows afterwards. Based on DC energy storage analysis as well as DC voltage injection transformer efficiency, it would be a best to provide low potential capacity. The magnitude of the voltage inserted in the high-frequency voltage control of three single-phase DVRs must be described separately. Injected voltages must be matched correctly with the network voltages (i.e. same frequency and the phase angle)

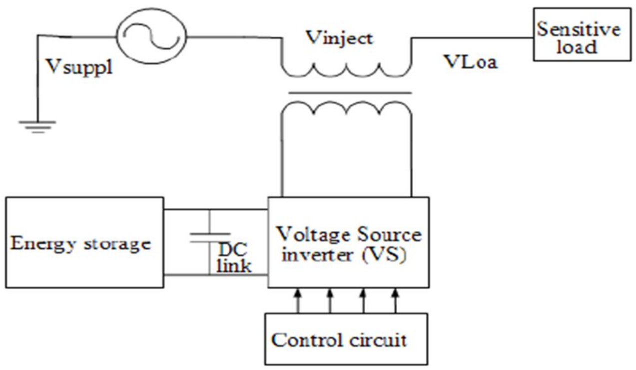


Fig: 2 Block diagram of Dvr

B. During the Normal Operation

DVR cannot provide any load voltage during daily operation as there is no sag. It is in standby if the battery is in sleep mode, or in charging if the battery is in a partly charged condition. The control device may be charged either by itself from the power supply or by being connected into another power source.

C. During a Short Circuit Condition

In this situation, the bypass switch (cross-bar switch) was enabled in order to circumvent the inverter circuit in order to secure the electrical components of the inverter..

V. CONTROL SCHEME BASED ON DISCRETE PWM

Figure 3 shows the control block using the SRF control principle. The SRF principle is used to calculate the reference signal. For the produce of VSI PWM pulses, VL load voltage and VS source voltage are used. To produce the load compare voltage, the derived unit vector is used. The transition from the Park is used to transfer load voltages from the abc frame to the dqO frame as seen in the Figure 3.

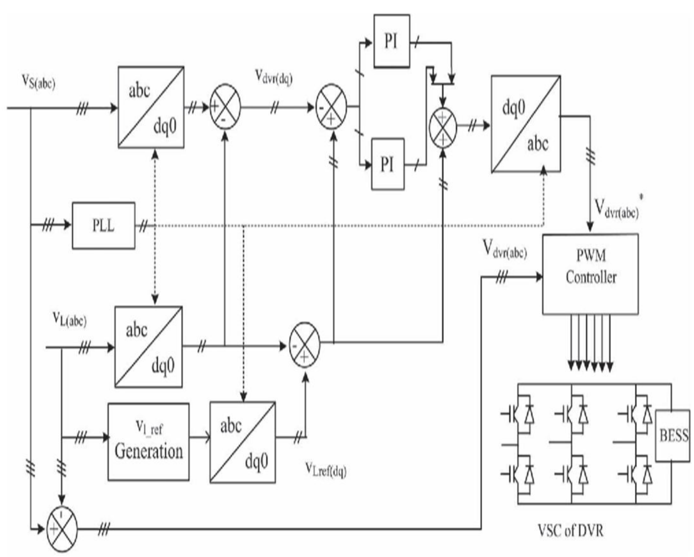


Figure:3, control block diagram of Dvr

A sinusoidal PWM solution provides a quick and effective transition mechanism for the Vsc. The DVR Simulation Program uses a control voltage: an error signal produced by measuring the voltage Ref and the voltage Rms specified by the load core, can be seen in Fig:3. The Pi controller triggers an error signal and produces a reasonable angle sensor for resetting the error to 0. For example, the RMS voltage is changed to the reference value. The assumption of a compromise between contact and the working climate has been accepted..

Modulation or delta angle Added to A-phase Pwm generators, whereas the B&C phase angles are around 240 °_-120 °&120 ° respectively..

$$\begin{bmatrix} v_{Lq} \\ v_{Ld} \\ v_{L0} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\theta & \cos(\theta - 2\pi/3) & \cos(\theta + 2\pi/3) \\ \sin\theta & \sin(\theta - 2\pi/3) & \cos(\theta + 2\pi/3) \\ 1/2 & 1/2 & 1/2 \end{bmatrix} \begin{bmatrix} v_{La} \\ v_{Lb} \\ v_{Lc} \end{bmatrix}$$

The load reference voltage (VLa *, V Lb *, VLc *) &Source-Voltages were futher converted to the Rotatingframe. Dvr voltages are given in the dqO table as

$$v_{Dd} = v_{Sd} - v_{Ld}$$

$$v_{Dq} = v_{Sq} - v_{Lq}$$

Similarly, the Dvr voltage level in the dqo range can be displayed as below.

$$v^*_{Dd} = v^*_{Sd} - v_{Ld}$$

$$v^*_{Dq} = v^*_{Sq} - v_{Lq}$$

Inverse_park's transform technique is utilized to get reference Dvr voltages in abc_referenceframe.

$$\begin{bmatrix} v^*_{dvra} \\ v^*_{dvrb} \\ v^*_{dvrc} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\theta & \sin\theta & 1 \\ \cos(\theta - 2\pi/3) & \sin(\theta + 2\pi/3) & 1 \\ \cos(\theta - 2\pi/3) & \sin(\theta + 2\pi/3 & 1 \end{bmatrix} \begin{bmatrix} v^*_{Dq} \\ v^*_{Dd} \\ v^*_{D0} \end{bmatrix}$$

In the case of VSI, gate pulses are generated using Dvr Reference-Voltage and the actual voltage of the DVR.

VI. SIMULATION OF DVR

The simulation of the DVR control system was accomplished with the use of MATLAB SIMULATION in order to execute its operation. The DVR shown in Figure:5 is a voltage drop/rising simulation. The outcome of the voltage drop simulation is seen in the figure below. The simulation continued from 0.10 s to 0.20 s with a 40 percent voltage decrease.

The parameters used for Dvr-Simulation are given as

S.NO	PARAMETER	RANGE
1	Transformer turns-ratio	1:1
2	Supply-voltage	11Kv
3	Filter capacitance	20e-6F
4	Dc-link voltage	200v
5	Load resistance	0.001ohm
6	Load inductance	0.002H
7	Filter inductance	6e-3H

Fig:4 parameters of the DVR

The figure indicates the input voltage, the injection voltage, the charging voltage and the charging current. If there is a power outage, the Dvr will have a positive voltage portion in all 3-phases. Remember that the voltage of the load stays stable even with changes in the voltage supply.

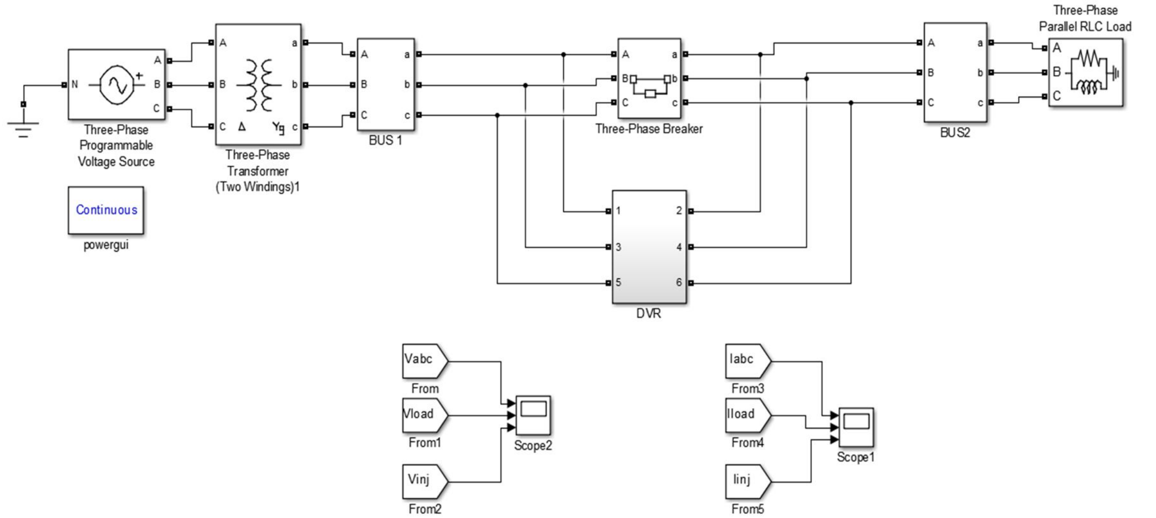
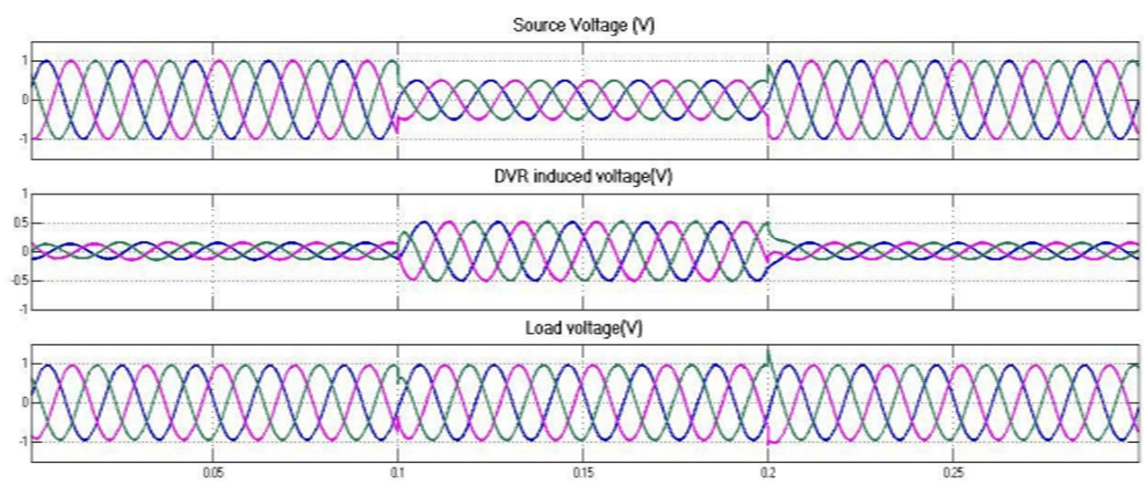


Fig:5 Matlab simulation diagram of Dvr

It is often found that the load voltage has minor transient currents at 0.10 s and 0.20 s, however the amplitude of the load voltage and the load current remain constant during this span of time. A full study of the DVR test was conducted using Matlab Simulation. Output is examined to adjust for voltage decreases with alternative Dc Storage capacities in order to achieve the normal voltage at the time of the test. In order to examine the impact of DC storage on curvature compensation, many circumstances with various load conditions are regarded. These multiple conditions are listed below..

A. *Voltage sag Compensation*

The load shall be deemed to be fully immune. The voltage drop is triggered by an ohm fault on the supply side. MA TLAB is used for simulation studies.



[Time s]

Figure:6, simulation of 3-phase voltage sag

The purpose of the work is to show that the proposed recording system will minimize the voltage decrease. For this purpose, the grid is supplied with a 40 percent voltage reduction of 0,1 s. In Fig:6 you can see the source voltage and load.

The DVR is now attached to the computer with the proposed control device. The figure indicates the voltage given to the device by an injection transformer with a recorder that keeps the load voltage uniformly.

B. Compensation of Voltage Swell

The second experimental study has been carried out to prove the potential to compensate voltage changes in the proposed Dvr. The mains voltage was increased by 30% from 0.1s to 0.2s in this situation, over the length of the mains voltage. The DVR is now attached to the computer with the proposed control device. Figure: 7 indicates an injection transformer to keep the load voltage constant for the device by the Dvr PI power. The display reveals that the load voltage is held by Dvr in the usual range.

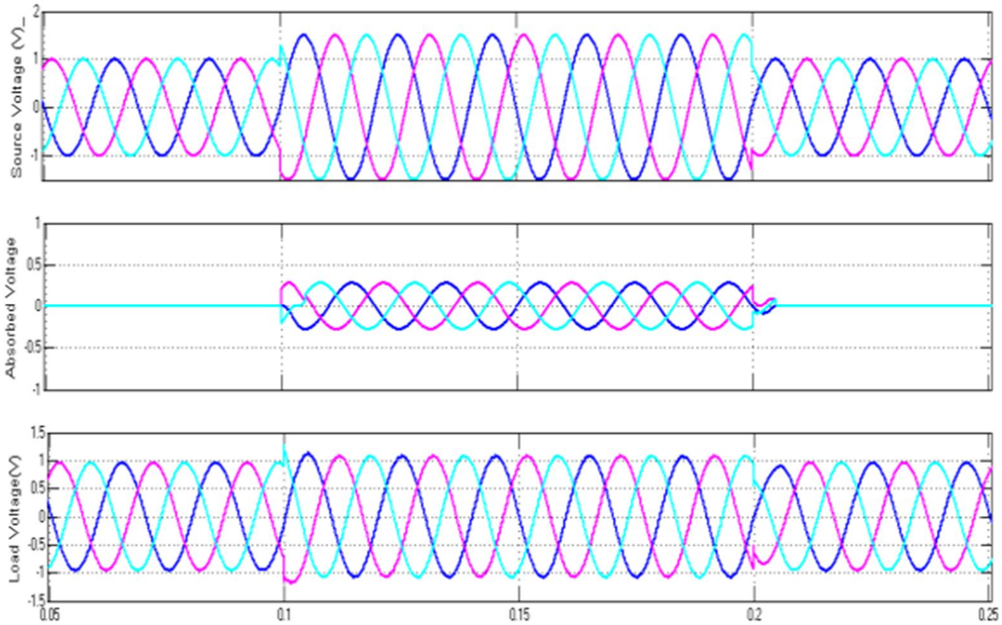


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Fig:7 simulation of 3-phase voltage swell

C. Compensation of Unbalanced Loads

In order to quickly fix some difference in power voltage, the DVR took charge of both smooth and irregular situations without any difficulty and boosted a suitable voltage portion to unalter the load voltage balance to a standard value.

Figure:8 demonstrates the change of the load voltage with the DVR feature, where the booster injects the absent compensated voltage. Figure:

D. Unbalanced Voltage Sag

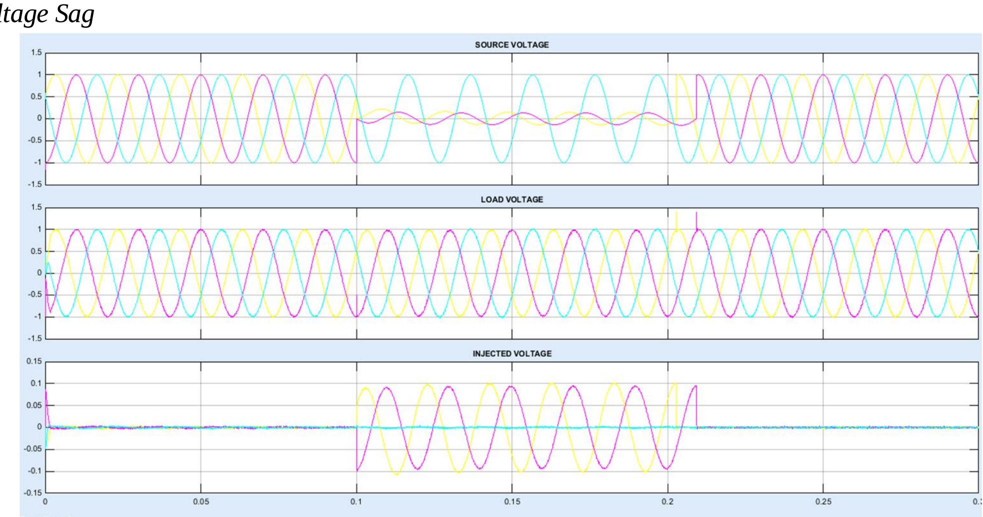

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Fig:8 simulation of 3-phase unbalanced voltage sag

E. Unbalanced Voltage Swell

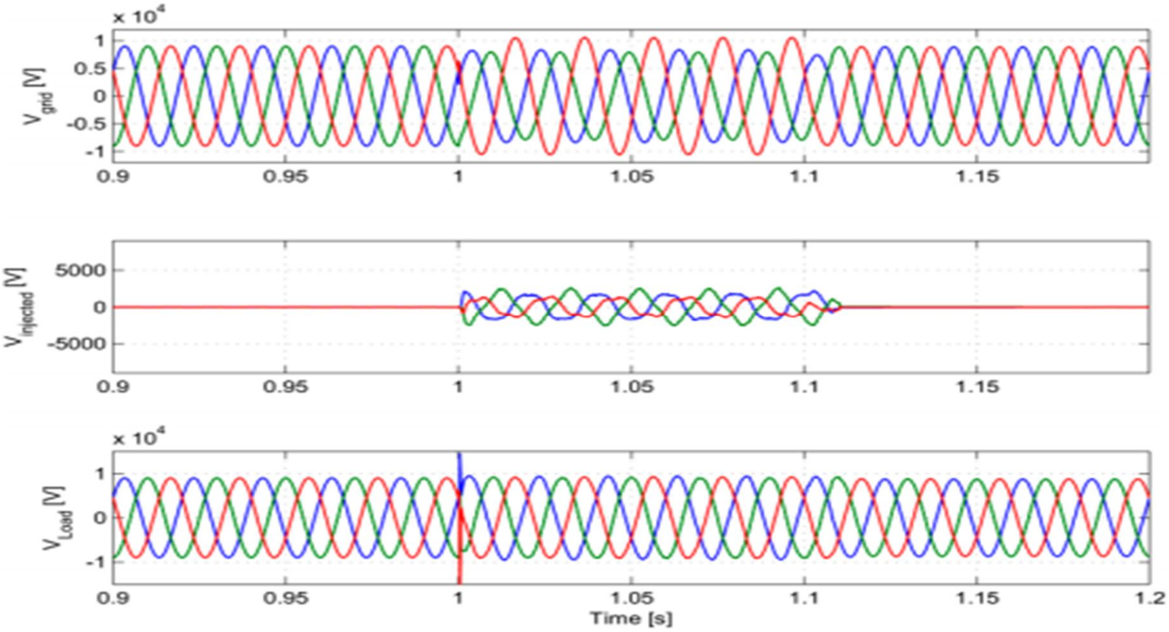

Fig:9 simulation of 3-phase unbalanced voltage swell

VII. CONCLUSION

In this project, he identified problems of power quality such as voltage drops, spikes, and erratic load conditions. The article points forth the methods of reimbursement for a non-standard electronic power recorder. The project details the architecture and deployment of the DVR for drop, peaks, unsustainable loads and detailed outcomes. Voltage Source Transfer (VSI) is achieved using Sinusoidal Pulse Width Modulation. The control technique has been evaluated in several various operational environments and has often been found to be quite stable. For the visualization and rendering and simulation of DVR utilizing sophisticated graphic techniques contained in the Matlab Model. The simulations conducted here demonstrate that Dvr provides strong voltage control capability.

This is where the benefit of the proposed solution is checked and perceived to be free or zero. This suggested solution has been tested scientifically. The impact of the harmonics on the network and the voltage decrease induced by the Dvr link can be checked in the real experimental setup. The DVR test is conducted as part of the upcoming test.

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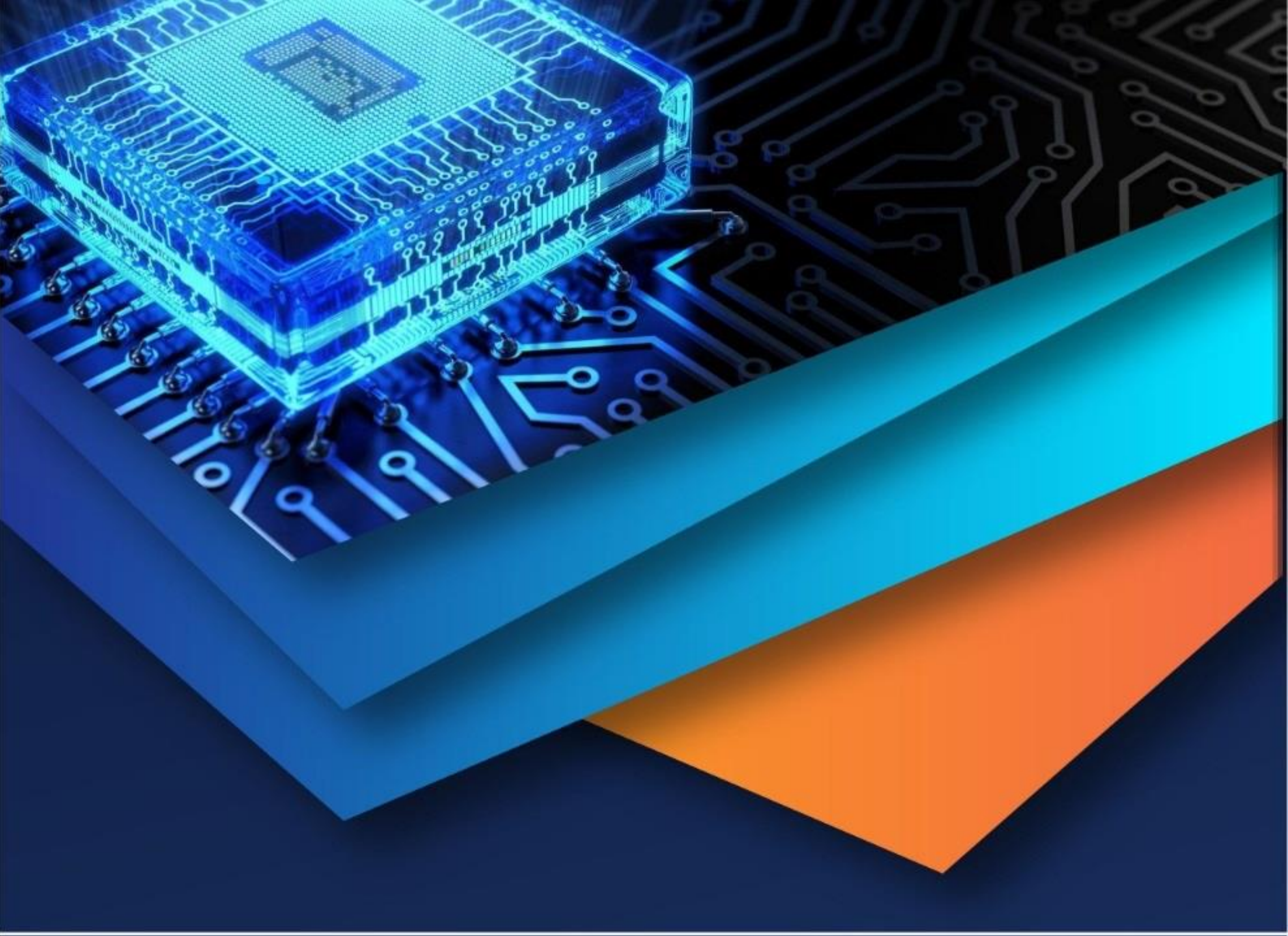
AUTHOR'S PROFILE

Dr. K. Venkatraman received the BE degree in Electrical Engineering from Raja Mahendra College of Engineering Ibrahimpatnam India in 2010.The PG degree in power quality from NIT Tiruchirappalli India in 2012 and the Ph.D in power electronics from NIT Tiruchirappalli India in 2016.He has teaching experience of about four years and working with the EEE Department of vardhaman college of engineering, he taught the subjects including Power Electronics, Power system-1,2 and Power quality and published the Research papers on the power electronics and power system.

Bijwar Jeevan Goud, PG Scholar
Dept of EEE, Vardhaman College of Engineering, Shamshabad-501218



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