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Harmonics Reduction in Variable Speed Drives Through the Injection of Numerous Compensation Strategies: A Review

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ABSTRACT:

In recent years, power quality has become the most prominent issue in the field of electrical engineering.A nonstandard voltage, current, or frequency is the result of a power quality problem.Various forms of outages affect utility distribution networks, sensitive industrial loads, and vital commercial operations, and service disruption can result in considerable financial losses.Voltage sag is one of the primary issues addressed here.Power quality issues can be mitigated thanks to rapid advancements in power electronics technology.This research focuses on issues such as voltage sag and other power quality issues.Many technologies, including STATCOM, tap changing transformers, UPFCs, and DVRs, are available to help with voltage sag issues.The dynamic voltage restorer, which injects both voltage and power into the system, is the most commercially viable method for mitigating voltage sag.The Dynamic Voltage Restorer is a power electronics-based device that can swiftly reduce voltage sag in the system and restore the load voltage to its pre-fault value.This article begins with an overview of important power quality issues for a DVR as well as voltage sag reduction using power electronics controllers.The functioning and components of DVR are then explained.Using the Sinusoidal Pulse Width Modulation (SPWM) method, this thesis proposes using the error signal to regulate the triggering of switches in an inverter.MATLAB SIMULINK was used to model and simulate the proposed DVR.

DVR (dynamic voltage restorer): A DVR is a voltage source converter that is linked in series with the supply through an injection transformer to recover voltage sag or swell.The DVR is the most technologically advanced and cost-effective technology for reducing voltage sag in distribution systems.The DVR's energy storage is in charge of delivering active power during voltage sag.If the energy comes from a neighboring feeder, the device is known as an interline dynamic voltage restorer.

Introduction:

"Reliability" is a vital phrase for utilities and their consumers in general, and it is critical for businesses functioning in a highly competitive market since it impacts profitability, which is a driving force in the sector.Despite the fact that electrical transmission and distribution networks have attained an extremely high degree of dependability, disruptions are unavoidable.Voltage waveform disturbances can create issues with the functioning of electrical and electronic equipment.To keep the production going, users require a continuous sine wave form, constant frequency, and symmetrical voltage with a constant rms value.More complicated instruments sensitive to voltage disturbances such as voltage sag, voltage swell, interruption, phase shift, and harmonic have emerged from the industry's growing need to enhance efficiency and minimize variations.Because sensitive loads are extremely vulnerable to transient voltage fluctuations, voltage sag is regarded the most severe.In certain circumstances, particularly in high-tech sectors like semiconductor factories, these disruptions can result in the full stoppage of an entire production line, resulting in significant economic implications for the afflicted company.The DVR is a power quality device that can safeguard these businesses from the majority of these disruptions, such as voltage sags and swells caused by distant system problems.If the supply grid is not completely disconnected due to breaker tripping, a DVR adjusts for these voltage excursions.

The power electrical core of new Custom Power devices like DVR is modern pulse-width modulated (PWM) inverters capable of creating accurate high-quality voltage waveforms.Because the quality of the applied control strategy has such a big impact on the entire control system's performance, a high-performance controller with quick transient response and strong steady-state characteristics is required.Sag detection, voltage reference generation, and transient and steady-state regulation of the injected voltage are the primary considerations for a DVR's control system.Voltage sags, voltage swells, interruptions, phase shifts, harmonics, and transients are all common power quality issues.Voltage sag is the most severe of the disruptions because sensitive loads are most vulnerable to transient voltage fluctuations

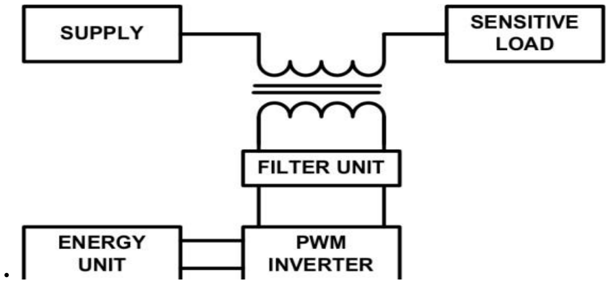

Fig. 1 Typical applications of DVR and its output

To reduce voltage sags and enhance power quality, a wide-area solution is needed. Using a digital video recorder (DVR) is a novel method.As illustrated in Fig.1, the fundamental functioning concept is to detect a voltage drop and inject the missing voltage in series to the bus.The use of DVR to safeguard sensitive loads from voltage sags has become a cost-effective option. The DVR is a quick, versatile, and cost-effective way to solve voltage sag issues.As illustrated in Fig.1, a DVR is made up of an energy storage unit, a PWM inverter, a filter, and an injection transformer.

Futures of DVR:

- Compared to the SMES device, DVR has a cheaper cost, smaller size, and a faster dynamic reaction to disturbances.
- DVRhas the ability to manage active power flow.
- DVR also has a higher energy capacity and lower prices. It also requires less maintenance.
- UPS is not only expensive, but it also necessitates a high degree of maintenance because batteries leak and must be changed every five years or so.

Location of DVR:

The utilities major distribution feeder has a DVR linked to it.As illustrated in Fig 4.2, this DVR position mitigates the effects of failures on the neighboring feeder on a specific group of customers.The load and the fault are supplied through a point of common coupling (PCC).By applying the voltage divider rule, the voltage sag in the system maybe determined.

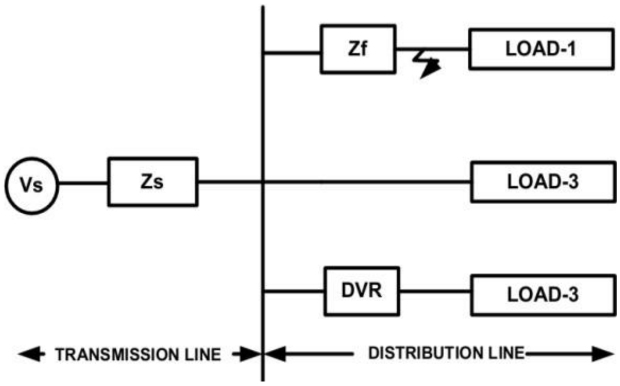

Figure 2LocationofDVR

In Fig. 2, a DVR is inserted at the 440 V low voltage four-wire level.For the load to be protected from voltage dips, the increase in impedance caused by inserting a tiny rated DVR might be substantial.By doing so, the percent change in impedance can be enhanced by a factor of several hundred.There are certain benefits to installing a DVR at the LV level:A majority of electric customers only have access to the LV-level, therefore the DVR can be put by the customer at the customer domain or by the utility at the utility domain.The distribution transformer lowers the short-circuit level, making it simpler to safeguard the DVR.

- The impedance rise when the DVR is inserted for the protected load might be significant, affecting the site short circuit level and protection.
- It's possible that non-linear and time-varying load currents will generate greater load voltage distortion and load voltage fluctuation.
- Zero sequence voltage dips can occur, and the DVR hardware and control should be able to provide positive, negative, and zero sequence voltages to adequately compensate loads linked between phase and neutral.

1.2 Fundamental Configuration: The converter, line-filter, and injection transformer are shown in Fig.1.1 as some of the basic parts of a DVR.By-pass equipment Disconnection equipment DC-link and energy storage

1.2.1 Converter: The converter is most likely a Voltage Source Converter (VSC), which PWMs the DC from the DC-link/storage to the AC-voltages fed into the system.A VSC is a power electronic system that comprises of a storage device and switching devices that can create a sinusoidal voltage at any frequency, amplitude, or phase angle.The VSC is utilized in the DVR application to temporarily replace or produce the missing portion of the supply voltage.Metal Oxide Semiconductor Field Effect Transistors (MOSFETs), Gate Turn-Off thyristors (GTOs), Insulated Gate Bipolar Transistors (IGBTs), and Integrated Gate Commutated thyristors (IGCTs) are the four major types of switching devices (IGCT).Each has advantages and disadvantages.

The IGCT is a new small device with improved performance and durability that permits VSCs with extremely high power ratings to be built.The DVR can adjust for dips that are beyond the capacity of previous DVRs utilising traditional devices, thanks to the extremely advanced converter architecture using IGCTs.Storage devices are used to provide energy to the VSC through a dc connection in order to generate injected voltages.

1.2.2 Line-Filter: The line-filter is used to decrease the PWM VSC's switching harmonics.

1.2.3 Injection Transformer:
Injection transformers are used in most DVR applications to guarantee galvanic isolation and simplify converter topologies and protection.The Injection/Booster transformer is a specifically constructed transformer that aims to reduce noise and transient energy coupling from the primary to the secondary sides.Its primary responsibilities include:
1) connecting the DVR to the distribution network through HV-windings and Transforms, and coupling the injected compensatory voltages created by the voltage source converters to the incoming supply voltage.
2) The Injection/Booster transformer also serves to isolate the Load from the system (VSC and control mechanism).

1.2.4 DC-Link and Energy Storage: The VSC uses a DC-link voltage to synthesise an AC voltage into the grid, and active power injection is required to restore supply voltages during the vast majority of voltage drops.Two major duties are performed by the dc charging circuit.

1) Following a sag compensation event, the first duty is to charge the energy source.
2) The second objective is to keep the dc link voltage constant.

1.2.5 By-Pass Equipment: A bypass channel for the load current must be guaranteed for faults, overloads, and service.
Mechanical and thyristor bypasses are depicted in Fig. 4.1.

1.2.6 Modes of Operation
Protection mode, standby mode (during steady state), and injection mode are the three basic functioning modes of the DVR (during sag).

1.3 Protection Mode: If system characteristics, particularly current on the load side, exceed predefined limitations, the VR will be disconnected from the system.The primary purpose of isolation is to protect the DVR from overcurrent on the load side caused by a short circuit or high inrush currents.As shown in Fig. 4.4, the control system detects faults or abnormal circumstances and controls bypass (transfer) switches to remove the DVR from the system and prevent harm.S1 will be closed during the overcurrent phase, while S2 and S3 will be opened, allowing current to flow in another direction.The consequences of further disruptions that the DVR might produce on the system are avoided by disconnecting it from the system while it is in a fault status.Due to a short circuit on the load or high inrush currents, the DVR is protected from over current on the load side.

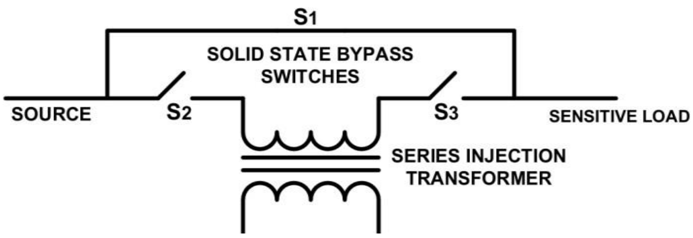

Figure 3 the aspect of power switches

1.3.1 Standby Mode:

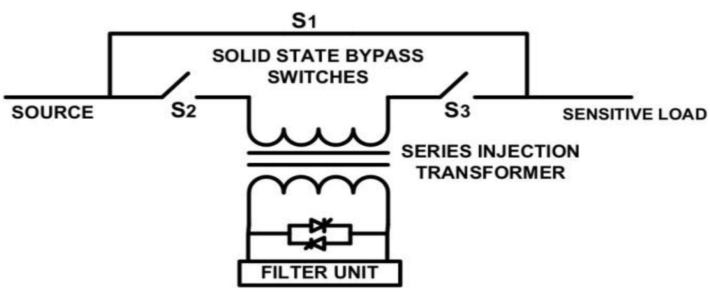

Figure 4 the view of standby mode

In standby mode (typical steady state circumstances), the DVR may short circuit or inject a tiny amount of voltage to compensate for voltage drops caused by transformer reactance or losses.In steady state, short circuit DVR operation is typically favored since the minor voltage drops do not disrupt the load requirements.Solid-state bypass switches, as illustrated in Fig. 4.5, are utilized to execute short circuit operation and are installed between the inverter and the secondary (low side) of the series injection transformer.To work successfully if the distribution circuit is weak, a little compensating voltage must be injected.The injected voltages and magnetic fluxes are nearly nil during short circuit operation, allowing full load current to flow through the primary.The DVR will be in regular mode for most of the time.During typical standby mode operation, the voltage drop across the DVR is determined by the injection transformer's short circuit impedance.

1.3.2 Injection Mode:

The Dynamic Voltage Restorer's principal role is to compensate for voltage disruptions in the distribution system.As soon as the sag is detected, the DVR switches to injection mode.Three single-phase ac voltages with the necessary magnitude, phase, and wave shape are injected in series to accomplish compensation.The feasibility of correcting voltage sag is determined by the types of voltage sags, load circumstances, and DVR power rating.Due to the high cost of capacitors, the DVR should maintain the same load voltage with the least amount of energy dissipation for injection.Pre-sag, phase advance, voltage tolerance, and in phase technique are some of the voltage injection options available.

1.4 Voltage injection methods:

Compensation of voltage sags/swells is influenced by a variety of parameters, including DVR power rating, load circumstances, and voltage sags/swells kinds.Some loads are extremely sensitive to phase angle jump, whereas others are somewhat unaffected.As a result, the compensation approach is determined by the kind and characteristics of the DVR-connected load.DVR voltage injection may be done in three distinct ways, as shown below.

1.4.1 Compensation for Pre-Sag:

DVR injects the differential voltage between the pre-fault and during-fault voltages into the system using this approach.The DVR adjusts for both magnitude and phase angle in this approach.The primary disadvantage of this method is that it need a larger energy storage device.It is the best method for obtaining the same load voltage as the pre-fault voltage, but because injected active power cannot be controlled, high capacity energy storage is necessary.The vector diagram for the pre-fault control approach for a voltage sag event is shown in Fig 4a.Because it adjusts for both magnitude and phase angle, this technique is best suited to loads sensitive to phase angle jumps.V pre-fault and V Sag are the voltages at the point of common coupling (PCC) before and during the sag, respectively.The voltage injected by the DVR in this example is VDVR, which can be calculated as:

$$V_{DVR}=\sqrt{(V_L^2+V_S^2-2V_L V_S\cos\delta)} \tag{4.11}$$

And the required angle of injection θinj is calculated as:

$$\theta_{inj} = \tan^{-1}\frac{V_S\sin\theta}{V_S\cos\theta - V_L} \tag{4.12}$$

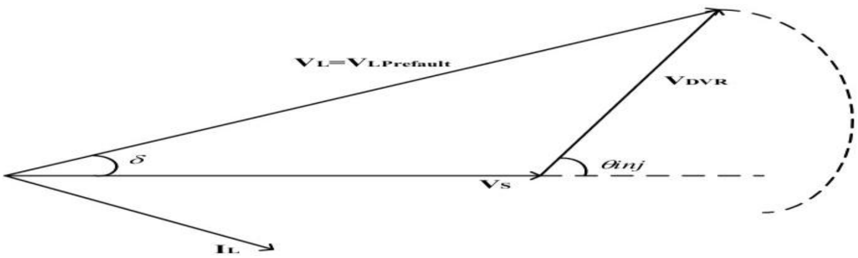

Figure 5 Vector diagram for pre-sag compensation

1.4.2 InPhaseCompensation:

In Phase compensation technique is designed to compensate for the voltage magnitude only. In this method jumps in the phase angle is not compensated .The injected voltage is in phase with supply voltage. As shown in Fig 3.6 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 is satisfied.

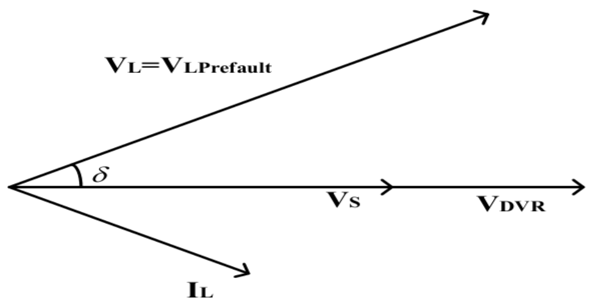

Figure 6Vector diagram for in Phase compensation

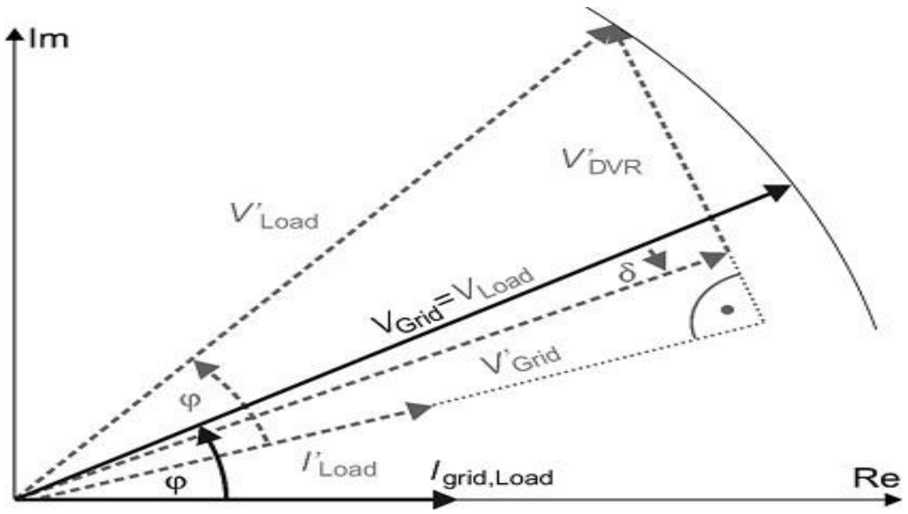

Figure.7. Energy optimized compensation

1.4.3 Energy Optimized Compensation:

Another approach is to compensate for the sag by utilising as much reactive power as feasible.As a result, the DVR voltage is adjusted so that the required compensation voltage is set perpendicular to the load current.The mainconcept behind this technique is to draw as much active power from the grid as possible, reducing the amount of active power required from the DC-link.It is feasible to compensate sag using pure reactive power as long as the voltage sag is relatively shallow, and therefore the compensation period is not restricted.The voltages for energy-optimized correction are shown in Figure 4.8.Apart from the huge benefit of requiring no active power, this method has two main drawbacks in most instances.A phase leap occurs on the one hand, and the needed DVR voltage amplitude e might become extremely large on the other.Furthermore, only shallow sags may be compensated with pure reactive power.If there is a deep slump, this technique will require a lot of Active power. a large amount of Active power is also needed with this strategy.

1.5 Working of DVR:

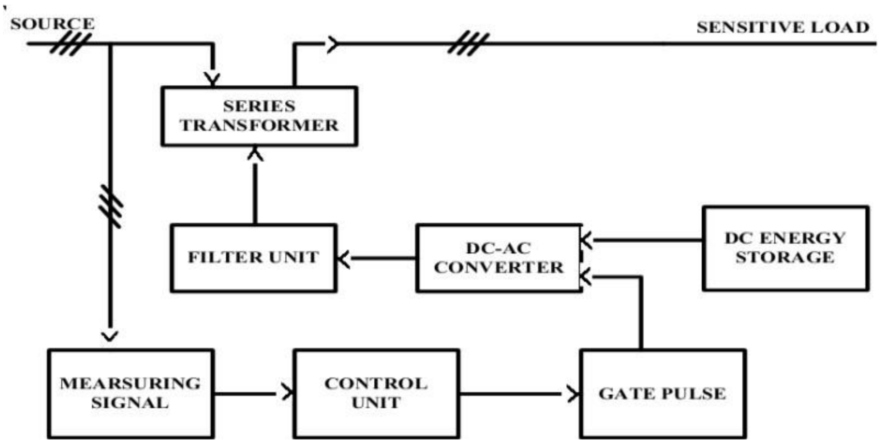

Figure 8 Function blocks of designed DVR

Voltage sags are the most severe of the voltage transients (sags, swells, harmonics, etc.).To minimise the amount of voltage sags, users might enhance end-use devices or employ protective devices.However, a Dynamic Voltage Restorer is a good overall solution for reducing voltage sags and restoring load voltage to pre-fault levels (DVR).It's a solid-state DC to AC switching power electronic converter that connects the feeder and the sensitive load with three single-phase AC voltages in series.Using a DVR is a more dependable and quick way to ensure that clients have a steady supply of energy.The primary disadvantages of DVR include standby losses, equipment expenses, and the need for extensive design research.By analysing the control unit signals, the PWM inverter unit generates the needed missing voltage, which is then injected into the system through injection transformers.

1.6 Control strategyofDVR

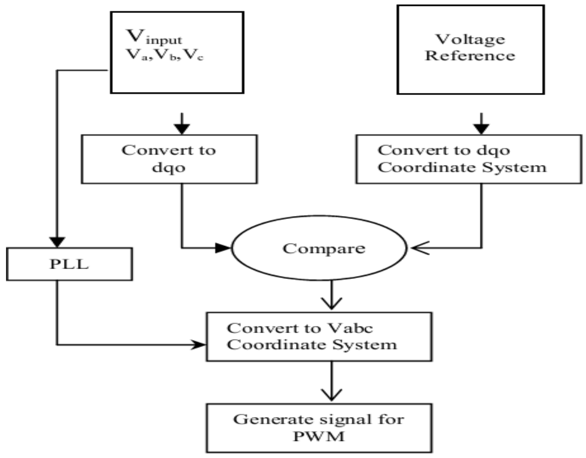

Figure-9 Flowchart of feed forward control techniquefor DVR based on dqo transformation

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The basic functions of a controller in a DVR are to detect voltage sag/swell events in the system, compute the correcting voltage, generate trigger pulses to the Sinusoidal PWM based DC-AC inverter, correct any anomalies in the series voltage injection, and terminate the trigger pulses once the event has passed.In the absence of voltage sags/swells, the controller may be utilized to move the DC-AC inverter into rectifier mode, which will charge the capacitors in the DC energy link.DVR is controlled via the dqo or Park's transformation.The dqomethod returns the sag depth and phase shift, as well as start and finish timings.The instantaneous space vectors are used to express the Quantities.To begin, transform the voltage from the abc to the dq0 reference frame.Zero phase sequence components are disregarded for the sake of simplicity.The feed forward dq0 transformation for voltage sags/swells detection is depicted in Figure-3.10 as a flow chart.Each of the three stages includes a detecting procedure.The control is based on a voltage reference being compared to the observed terminal voltage (Va,Vb,V c).When the supply voltage falls below 90% of the reference value, voltage sags are recognized, whereas voltage swells are identified when the supply voltage rises to 25% of the reference value.The error signal is modulated to provide a commutation pattern for the voltage sourceconverter's power switches (IGBTs).The commutation pattern is created using the sinusoidal pulse width modulation (SPWM) method, which also controls voltages.

Figure-4.10 is a block schematic of a phase locked loop (PLL).The PLL circuit generates a unit sinusoidal wave that is phased with the mains voltage.

$$\begin{bmatrix} Vd \\ Vq \\ Vo \end{bmatrix} = \begin{bmatrix} cos\theta & \cos(\theta-2\pi/3) & 1 \\ -sin\theta & -\sin(\theta-2\pi/3) & 1 \\ 1/2 & 1/2 & 1/2 \end{bmatrix} \begin{bmatrix} Va \\ Vb \\ Vc \end{bmatrix} \qquad (4.14)$$

Equation defines the transformation from three phase system abc to dqo stationary frame. In this transformation, phase A is aligned to the d -axis that is in quadrature with the q-axis. The theta (θ) is defined by the angle between phase A to the d-axis..

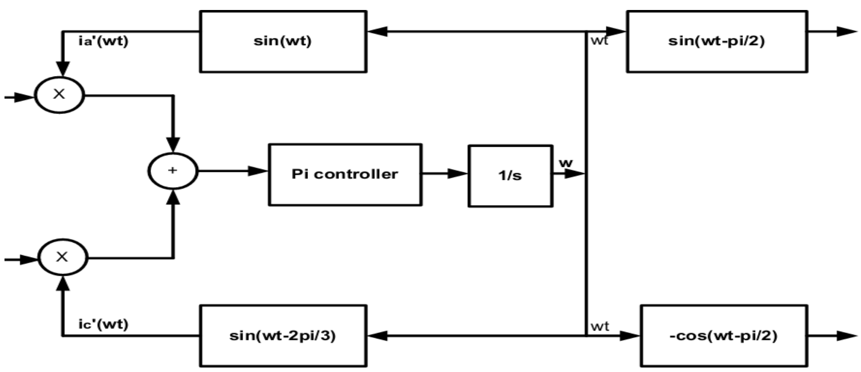

Figure1.11BlockdiagramofPLL

Conclusion and future work

Conclusion: The primary goals of this paper are to use the investigated equipment to reduce voltage sag and voltage swell.To safeguard essential loads from more severe distribution network faults.Extensive simulation studies are been out using the MATLAB/SIMULINK tool.The error signal is generated by comparing the supply voltage to the reference voltage, which is then sent to the gate pulse production circuit as a reference sine wave, which is then compared to the carrier signal to generate inverter pulses.The PLL circuit extracts angle from source voltage so that it may be used with any frequency supply and the error signal will be synchronised with the supply frequency.

Future Work:

- Use the error signal as a reference for pulse generation, and
- connect the DVR to the main supply through a Boosting Transformer.
- Test the performance under varied voltage sag and swell conditions.

REFERENCES

[1]. Rosli Omar and NasrudinAbd Rahim Faculty of Electrical Engineering, University Teknikal Malaysia Melaka, Malaysia Department of Electrical Engineering , Faculty of Engineering , University of Malaya, Kuala Lumpur, Malaysia “Mitigation of Voltage Sags/Swells Using Dynamic Volt Age Restorer (DVR)” in ARPN Journal of Engineering and Applied Sciences VO L.4,NO. 4, JUNE 2009

[2]. Christoph Meyer , Student Member, IEEE , Rik W. De Doncker , Fellow, IEEE , Yun Wei Li , Member, IEEE , and FredeBlaabjerg, Fellow, IEEE “Optimized Control Strategy for a Medium-Voltage DVR—Theoretical Investigations and Experimental Results” in IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 23, NO. 6, NOVEMBER 2008

[3]. H. Ezoji Electrical & Computer Engineering Department, Babol University of Technology, A. Sheikholeslami, Electrical & Computer Engineering Department, Babol University of Technology, M. Tabasi Electrical & Computer Engineering Department, Babol University of Technology, M.M. Saeednia Electrical & Computer Engineering Department, Babol University of Technology "Simulation of Dynamic Voltage Restorer Using Hysteresis Voltage Control ” in European Journal of Scientific Research ISSN 1450-216X Vol.27 No.1 (2009), pp.152-166

[4]. Mahmoud A. El-Gammal Dean of the Faculty of Engineering, Pharos University in Alexandria, Egypt, Amr Y. Abou-Ghazala, Electrical Engineering Dept., Faculty of Engineering, Alexandria University, Egypt, Tarek I. El-Shennawy, Alexandria National Refining and Petrochemicals Co. (ANRPC), Alexandria, Egypt “Dynamic Voltage Restorer (DVR) for Voltage Sag Mitigation” in International Journal on Electrical Engineering and Informatics - Volume 3, Number 1, 2011

[5]. FirouzBadrkhaniAjaei, SaeedAfsharnia, AlirezaKahrobaeian, and ShahrokhFarhangi “A Fast and Effective Control Scheme for the Dynamic Voltage Restorer” in IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 26, NO. 4, OCTOBER 2011

[6]. Michael John Newman,Member, IEEE , Donald Grahame Holmes, Senior Member, IEEE , John Godsk Nielsen, Member, IEEE , and FredeBlaabjerg, Fellow, IEEE “A Dynamic Voltage Restorer (DVR) With Selective Harmonic Compensation at Medium Voltage Level” in IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 41, NO. 6,NOVEMBER/DECEMBER 2005

[7]. Poh Chiang Loh , Member, IEEE , D MahindaVilathgamuwa, Senior Member, IEEE , SengKhai Tang, and HianLih Long “Multilevel Dynamic Voltage Restorer” in IEEE POWER ELECTRONICS LETTERS, VOL. 2, NO. 4, DECEMBER 2004

[8]. Chris Fitzer, Mike Barnes, Member, IEEE, and Peter Green,” Voltage Sag Detection Technique for a Dynamic Voltage Restorer” in IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 40, NO. 1, JANUARY/FEBRUARY 2004