Scientific Journal Impact Factor (SJIF) : 1.711
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745
ISSN (PRINT) : 2393 - 8161

Dynamic Voltage Restorer (DVR) Through MATLAB Simulation

Mr. Sushant S. Sananse[1], Ms.AlkaThakur[2]
[1]*Dept. of electrical Engg, SSSIST, Sehore*
[2]*Associate Professor, Dept. of electrical Engg, SSSIST, Sehore*

Abstract - Electricity excellence has become an increasing challenge to utilities and customers. Voltage sag/Swell is the most not unusual type of energy excellent disturbance within the distribution device. Voltage sags/swells arise both inside the transmission and distribution network and the techniques used for the reimbursement are specific. This paper presents and verifies the use of dynamic voltage restorer (DVR) to defend sensitive hundreds from the consequences of voltage sag/swell on the distribution feeder. DVR is one of the custom strength devices that are used as an effective solution for the protection of sensitive masses towards voltage disturbances in power distribution machine. For mitigation of voltage sag/swell by using DVR it's miles important for the DVR control gadget to stumble on the start and end of a voltage sag/swell and to decide the sag/swell value and any related segment shift. The DVR, which is used in series with a touchy load, must be capable of reply quickly to a voltage sag/swell if end users of sensitive device are to revel in no voltage sags/swell. The DQO theory is used for the detection of sags/swells, whereas the manipulate of the voltage supply inverter (VSI) is done with the help of Sinusoidal Pulse Width Modulation (SPWM) The simulation was completed with the help of SIMULINK & MATLAB and the effects have been determined to be in accordance with idea.

Keywords: Dynamic Voltage Restorer (DVR), d-q-o theory, Sinusoidal Pulse Width Modulation (SPWM), Voltage sag/swell.

I. INTRODUCTION

From previous few years because of the proliferation and development of voltage-sensitive load equipment in industries there's a various impact on health facility equipment, automatic manufacturing strains, pc centers which ends up degradation of energy excellent. While "electricity high-quality" is a handy time period for plenty, it's far the pleasant of the voltage in place of electricity or modern-day that is in reality described with the aid of the term in [1]. Voltage satisfactory problems inside the shape of voltage sags, voltage harmonics, and voltage swells can purpose extreme technique disruptions, resulting in vast monetary and/or data losses [1], Voltage sag is a short-term lower within the rms ac voltage (10%–90% of the nominal voltage) on the power frequency of length from 0.5 cycles to one minute [4]. Voltage sag is commonly due to brief-circuit faults, which includes a single-line-to-ground fault in a power system and with the aid of the startup of induction motors of huge scores [4]–[6]. Voltage swell is defined as a short duration rise in r.m.s voltage from 1.1 p.u. to above for the duration of 0.5 cycles to one minute. [7]. The principle motives for voltage swells are switching big capacitors or the elimination of large masses [8]

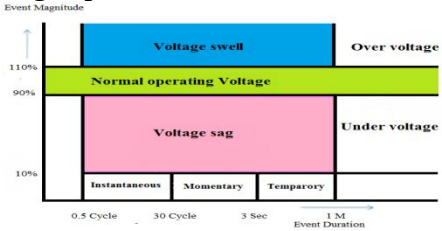


Figure 1.Voltage reduction standards of IEEE Std. 1159-1995

Dynamic voltage restorer (DVR) is an electricity electronic converter-primarily based tool, designed to protect critical loads from deliver facet voltage disturbances. Through inserting a voltage of desired importance and phase perspective, it restores the burden-side voltage to be a balanced, sinusoidal and nominal value, even when the supply voltage is unbalanced or distorted. further, the DVR compensates for both steady-nation and dynamic voltage best troubles, and is able to producing or soaking up active and reactive strength at its ac terminals [3], [4].

II. THE CONCEPT OF THE DVR IN THE DISTRIBUTION SYSTEM

2.1. DVR operation and components

DVR is a device which operates when the source voltage is unbalanced or distorted. DVR restores the load-side voltage to the desired amplitude by injecting a voltage of required magnitude. In other words we can say that the main function of the DVR is to regulate the waveform of load voltage when any sag or swell occurs, the desired value of required voltage will be injected to the load point. Following equation explains the basic principle of DVR.

$$\text{Source Voltage} + \text{DVR Voltage} = \text{Load Voltage} \quad \ldots \quad (1)$$

Detect 1 suggests the configuration of the DVR along with an inverter, series or injection transformer, inverter manipulate device and energy storage. The primary characteristic of a DVR is the protection of touchy load from any disturbances coming from network. The primary components of the DVR are summarized under.

2.2. Injection transformers

In a 3-segment device, either 3 single-section transformer units or one 3 phase transformer unit can be used for voltage injection purpose (Zhan et al., 2000).

2.3. Capacitor bank

DVR has a big DC capacitor to make certain stiff DC voltage input to inverter.

2.4. Inverter

Voltage source inverter (VSI) of low voltage and high current with step up injection transformer is used to transform dc storage into ac shape (Ravi et al., 2007).

2.5. Passive filters

To transform the inverted PWM waveform right into a sinusoidal waveform Passive filters are used. That is accomplished with the aid of eliminating the undesirable harmonic additives generated VSI movement. Better orders harmonic components distort the compensated output voltage (Zhan et al., 2000).

2.6. Garage unit

Its miles chargeable for power storage in DC shape. Flywheels, batteries, superconducting magnetic power storage (SMES) and awesome capacitors may be used as power storage devices. It elements the real strength requirements of the system whilst DVR is used for compensation (Banaei et al., 2006). The basic concept of a DVR is to inject the lacking voltage cycles into the system via series injection transformer each time voltage sags are present within the device supply voltage.

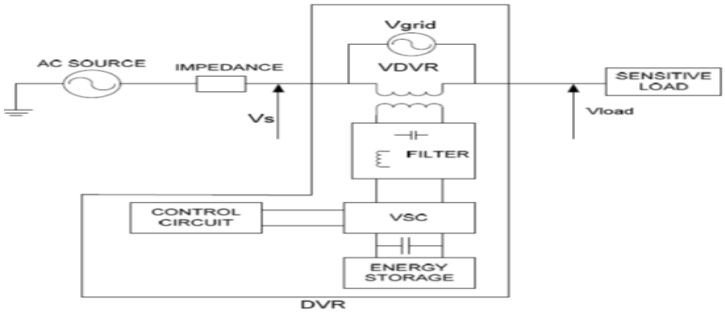


Figure 2. Conventional circuit configuration

III. IN-PHASE COMPENSATION METHOD

The inoculation voltage is in phase with the source voltage. When the source voltage droplets due to sagging glitches in the network, the inoculation voltage shaped by the Voltage Source Inverter (VSI) will inject the missing voltage based on the drop voltage scale. This technique can be shown in Figure 3.

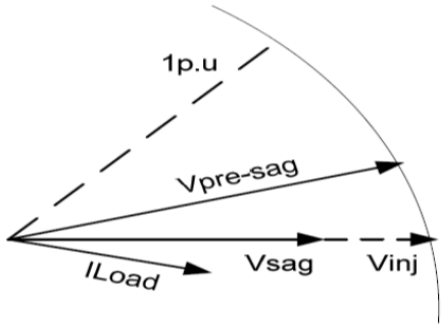


Figure 3. In-Phase compensation technique

The phasor figure to show the scale and angle of voltage inoculated by the DVR (v_{inj}) is shown in Fig.4. v_{inj} is the vector alteration amid $v_{\mathrm{Pre-Sag}}$ and v_{Sag}. The main drawback of this procedure is that it necessitates a higher capacity energy storage device

$$v_{inj} = v_{\mathrm{Pre-Sag}} - v_{Sag} \qquad \ldots\ldots\ldots (2)$$

3.1. Pre-sag method

In this method, there is a alteration between Vpre-sag and the sag voltage (Vsag). The inoculation voltage will inoculate the alteration voltage between them as shown in Figure 4.

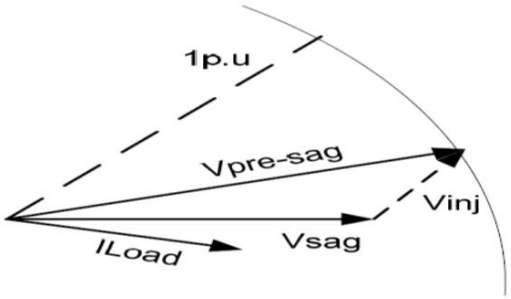


Figure 4. Pre-sag compensation technique

IV. d-q-0 TRANSFORMATION

Direct–quadrature–0 transformation also referred to as Park's transformation is mathematical transformation used to simplify the evaluation of three-segment circuits. In the case of balanced 3-

section circuits, software of the d-q-0 transformation reduces the 3 AC portions to 2 DC portions. Simplified calculations can then be completed on these imaginary DC portions before appearing the inverse remodel to recover the real three-section AC results.

The dq0 approach gives the sag intensity data with begin and stop instances. The quantities are expressed as the on the spot space vectors [17]. First off convert the voltage from a-b-c reference frame to d-q-0 reference with the aid of using following equation.

$$\begin{bmatrix} v_d \\ v_q \\ v_0 \end{bmatrix} = [T] \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \qquad \text{..... (3)}$$

$$\begin{bmatrix} v_d \\ v_q \\ v_0 \end{bmatrix} = \begin{bmatrix} \cos(\theta) & \cos(\theta - \frac{2\pi}{3}) & 1 \\ -\sin(\theta) & -\sin(\theta - \frac{2\pi}{3}) & 1 \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \qquad \text{..... (4)}$$

Where,

T is the transformation matrix, va ,vb ,vc are instantaneous supply voltage of section A, B and C respectively and vd, vq, v0 are d-axis, q-axis, zero-axis element of reference frame respectively.

The theta (θ) is described via the perspective between segments A to the d-axis [17]. Above equation defines the transformation from 3 voltages a, b, c to dq0 stationary frame. In this transformation, section A is aligned to the d-axis this is in quadrature with the q-axis.

The control is based on the contrast of a voltage reference and the measured terminal voltage. The voltage sags is detected while the deliver voltage drops beneath 90% of the reference voltage. Both the voltages need to be converted to dq frame and the difference in voltage in d-q frame offers injected voltage in identical frame of reference. Then the d-q frame signal to be transformed to abc frame of reference the usage of inverse transformation given as follows:

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = [T]^{-1} \begin{bmatrix} v_d \\ v_q \\ v_0 \end{bmatrix} \qquad \text{.... (5)}$$

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & \frac{1}{2} \\ \cos(\theta - \frac{2\pi}{3}) & -\sin(\theta - \frac{2\pi}{3}) & \frac{1}{2} \\ 1 & 1 & \frac{1}{2} \end{bmatrix} \begin{bmatrix} v_d \\ v_q \\ v_o \end{bmatrix} \qquad \text{.... (6)}$$

These inoculated voltage in abc frame of orientation act as the controller signal for the voltage source inverter. The pulses to the switches are produced using sinusoidal PWM technique (SPWM).

V. SIMULATION RESULTS

A MATLAB simulation is accomplished to find out the overall performance of DVR for repayment of voltage sag using d-q idea. A three-φ electricity gadget with the parameters given in table 2 is simulated the usage of sim power machine block set. An RL load is considered for the have a look at. A voltage supply inverter is designed the usage of MOSFET as the switching devices and DC voltage for the inverter calculated as 800V.

TABLE 1. System parameter and constant valve

Parameter	Valve
Source voltage per phase	200V
DC Bus Voltage	800V
Filter Inductance	0.17µH
Filter Capacitance	26µF
Load Resistance	40 Ω
Load Inductance	60mH

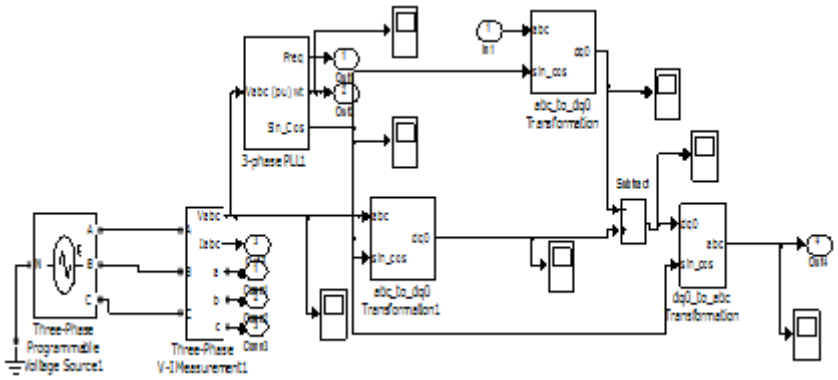


Figure 5. Shows the d-q transformation in MATLAB/SIMULINK for generation of reference voltage.

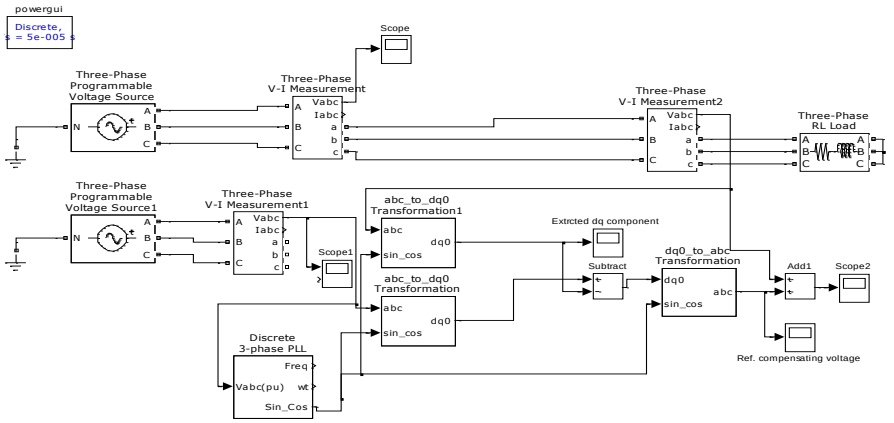
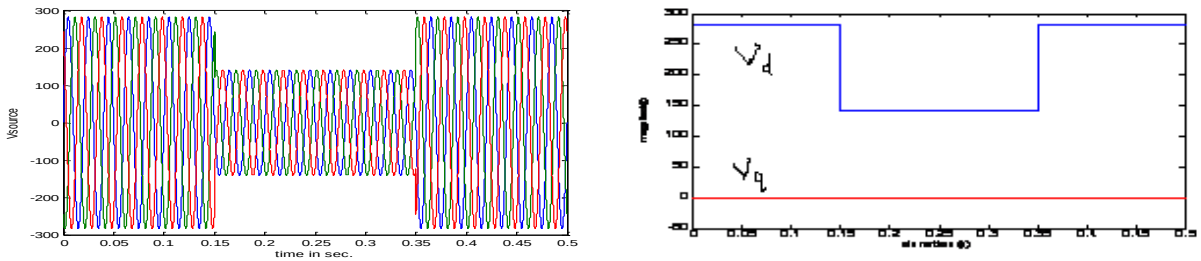


Figure 6. Simulink diagram showing generation of reference voltage using d-q theory

Three phase programmable voltage source has been used for creating 50% voltage sag for the duration of 0.2s and start time of sag is 0.15s and end time is o.35s as shown in Fig. 7



(a) (b)

Figure 7. (a) source voltage with sag, (b) shows v_d and v_q component

The injection voltage is generated by evaluating the reference voltage in d-q body with d-q reference frame voltage of the actual strength gadget voltage. The difference in these voltages is to be injected through the voltage source inverter. This voltage will act because the reference compensating voltage for the inverter. this is shown in Fig. 8

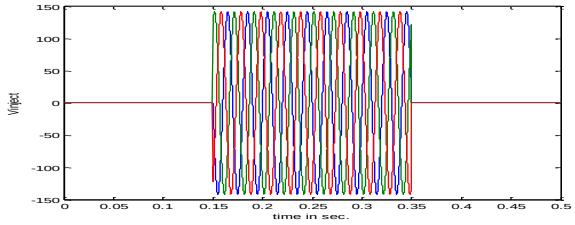


Figure 8. shows Reference voltage

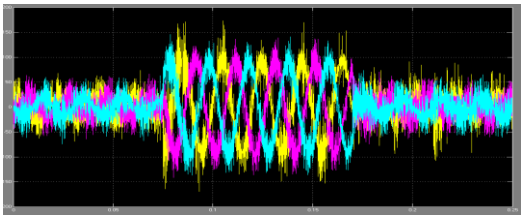


Figure 9. Voltage to be injected

A sine triangular PWM approach is used to generate pulses to the switches of three section inverter. The output of the three segment inverter is attached in series with the transmission line with the help of series transformers as shown in Fig. 9 PLL block is used to synchronize the supply voltage and the injected voltage

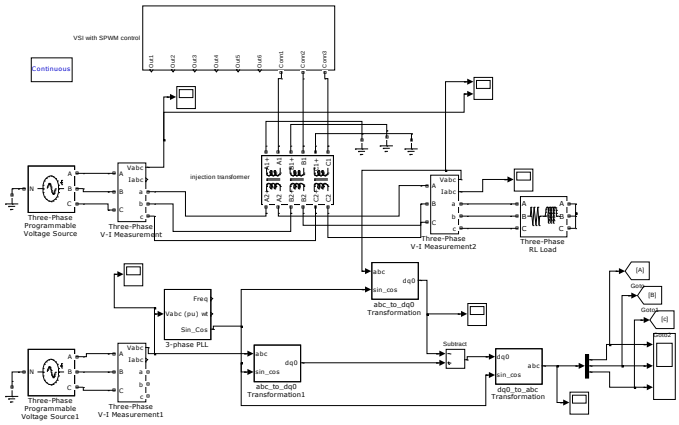


Figure 10. Simulink diagram showing the DVR in the distribution system

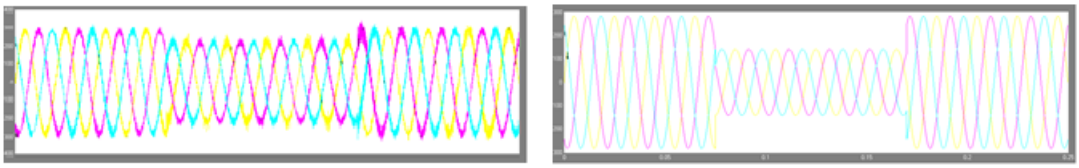


Figure 11. Three phase load voltage

VI. CONCLUSION

This paper has proposed and modeled the Dynamic Voltage Restorer (DVR) based on sinusoidal PWM method using MATLAB/SIMULINK. The reference voltage generated based totally on d-q reference concept. the primary blessings of this DVR is low price and it's control is simple. The DVR can mitigate long period sag additionally. The validity of proposed approach is accepted by using results to the simulated in MATLAB/SIMULINK.

REFERENCES

[1] Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, "*Electrical Power Systems Quality*", Chapter 1 & 2 pp. 1-30, Second Edition, Tata McGraw-Hill, 2004.

[2] M. H. J Bollen, *Understanding Power Quality Problems, Voltage Sags and Interruption*, Piscataway, NJ: IEEE Press, 1999

[3] Sincy George and Vivek Agarwal "A DSP Based Control Algorithm for Series Active Filter for Optimized Compensation under Non-Sinusoidal and Unbalanced Voltage Conditions" *IEEE transaction on Power Delivery, vol.22, issue 1, January 2007,* pp. 302-310.

[4] Sincy George and Vivek Agarwal "Optimum Control of Selective and Total Harmonic Distortion in Current and Voltage under Non-sinusoidal Conditions" *IEEE transaction on Power Delivery, vol. 23, issue 2, April 2008,* pp. 937-944.

[5] Ian K.P. Ross, MIEE, Omniverter Inc. "voltage sags: an explanation - causes, effects and correction -part I" November/ December 2007

[6] IEEE Standards Board (1995), "IEEE Std. 1159-1995", IEEE Recommended Practice for Monitoring Electric Power Quality". IEEE Inc. New York.

[7] S.S. Choi, J. D. Li and D.M. Vilathgamuwa, "A generalized voltage compensation strategy for mitigating the impacts of voltage sags/swells," *IEEE Trans. on Power Delivery*, vol. 20, no.3, pp.2289-2297, July 200

[8] Fawzi AL Jowder "Modeling and Simulation of Dynamic Vltage Restorer (DVR) Based on Hysteresis Vltage Control" in The *33rd Annual Conference of the IEEE Industrial Electronics Society (IECON)*

[9] Changjiang Zhan, Vigna Kumaran Ramachadaramurthy, Atputharajah Nicholas Jenkins, "Dynamic Voltage Restorer Based on Voltage-Space Vector PWM Control," *IEEE Trans. Induistrial Applications*, vol. 37, No.6 pp. 1855-1863, November/December 2001in Proc.

[10] Saripalli Rajesh, Mahesh K. Mishra, and Sridhar K , "Design and Simulation of Dynamic Voltage Restorer (DVR) Using Sinusoidal Pulse Width Modulation (SPWM)" 16th *NATIONAL POWER SYSTEMS CONFERENCE*, 15th-17th DECEMBER, 2010

[11] H.P.Tiwari, "Capacitor Rating Selection for Voltage Sag Compensation in DVR System"*International Journal of Innovation, Management and Technology,* Vol. 1, No. 3,August2010 ISSN: 2010-0248 .

