Dynamic Voltage Restorer For Compensation of Voltage Sag And Voltage Swell

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Abstract- *Nowadays power quality is the biggest issue in power sector. Everyone demands for reliable and good power quality. There are different problems in power quality like harmonic distortion, flicker, notching, transient, etc. Voltage sag and swell are the major problems in power quality. Dynamic voltage Restorer (DVR) is a custom power device used for mitigation of voltage sag and swell. DVR is connected in series by using the injection transformer to inject the appropriate voltage to mitigate voltage sag/swell and maintain the load voltage constant. For the generation of this compensating voltage there are two steps which are reference voltage generation and gate pulse generation for IGBT's of VSC. In this project two methods are used for reference voltage generation via Synchronous Reference Frame (SRF) theory. These methods detect the voltage sag/swell condition and give the reference voltage. Hysteresis controller is used for gate pulse generation in both methods. Simulations are carried out for addition of three phase RL load, removal of load and also for three phase system fault.*

Keywords- Power Quality, DVR, Voltage Sag/swell, VSI, MATLAB /SIMULINK

I. INTRODUCTION

One of the significant worries in power industry today is power quality issues to touchy burdens. This is expected To the appearance of a substantial quantities of refined electrical and electronic hardware, for example, PCs, Programmable rationale controllers, variable speed drives, et cetera. The utilization of these types of gear all the time Requires control supplies with high calibre. Control Quality issues incorporate an extensive variety of unsettling influences, for example, voltage droops/swells, voltage intrusion, glint, music twisting, drive transient, Furthermore, interferences. Control conveyance frameworks, ought to in a perfect world give their clients a continuous stream of vitality with a smooth sinusoidal voltage at the contracted greatness level and recurrence. In any case, in rehearse, control frameworks, particularly dispersion frameworks, have various nonlinear burdens, which fundamentally influence the nature of the power supply. As a consequence of these nonlinear burdens, the immaculateness of the supply waveform is lost in many spots. These winds up delivering many power quality issues.

II. OBJECTIVES

One of the significant worries in power industry today is power quality issues to touchy burdens. This is expected To the appearance of a huge quantity of modern electrical and electronic hardware, for example, PCs, programmable rationale controllers, variable speed drives, et cetera. The utilization of these is the different goals defined and situated for perception in the proposal are:

1) To review and examine the entire appropriation framework and their issue.
2) To build up a scientific model of different segments DVR System, Voltage Sag, and Three-Phase Inverter with Yield.
3) To look at and examination proposed show with and without Dynamic Voltage Restorer (DVR) framework utilizing MATLAB /SIMULINK.
4) To review the state of created DVR framework for Distinctive case like voltage list, swell, amid blame and clearing deficiency

III. EXISTING SYSTEM

Existing system consist of Voltage sag, VSC, SRF Theory etc. Due to this there is a change in the quality of the power.

A. Voltage Sags

Voltage sag is defined as a sudden reduction of supply voltage down 90% to 10% of nominal, followed by a short recovery period. According to the standards a typical duration of sag is 10 ms to 1 minute. Voltage sag can cause loss of production in automated processes since voltage sag can trip a motor or cause its controller or malfunction. Voltage swell is defined as a sudden increase of supply voltage up 110% to 180% in rms voltage at the network fundamental frequency with duration from 10 ms to 1 minute. Switching off a large inductive load or energizing a large capacitor bank is a typical system event That causes swells. To compensate

the voltage sag/swell in a power distribution system, appropriate devices are needed to be installed at suitable locations. These devices are typically placed at the point of common coupling (PCC) which is defined as the point where the ownership of the network Changes. The DVR is one of the custom power devices which can improve power quality, especially, voltage sags and voltage swells. As the root/basic concerns is for the quality of supply as a result of more sensitive loads in the system conditions, an appropriate understanding of the devices for eliminating power quality problems is important. This would allow us to make use of the functions of such devices in a better way with efficient control techniques.

B. VSC

Generally Pulse-Width Modulated Voltage Source Inverter (PWMVSI) is used. In the previous section we saw that an energy storage device generates a DC voltage. To convert this DC voltage into an AC voltage a Voltage Source Inverter is used. In order to boost the magnitude of voltage during sag, in DVR power circuit a step up voltage injection transformer is used. Thus a VSI with a low voltage rating is sufficient to defined as the point where the ownership of the network changes. The DVR is one of the custom power devices which can improve power quality, especially, voltage sags and voltage swells. As the root/basic concerns pure sine wave and balanced is for the quality of supply as a result of more sensitive loads in the system conditions, an appropriate understanding of the devices for eliminating power quality problems is important. This would allow us to make use of the functions of such devices in a better way with efficient control techniques.

C. SFR

SFR theory also used in this method .But the problem of the voltage changes is not properly done. IN this method also the voltage fluctuations is there. It means that at the time of over voltage there is change is the output voltage.

IV. BLOCK DIAGRAM

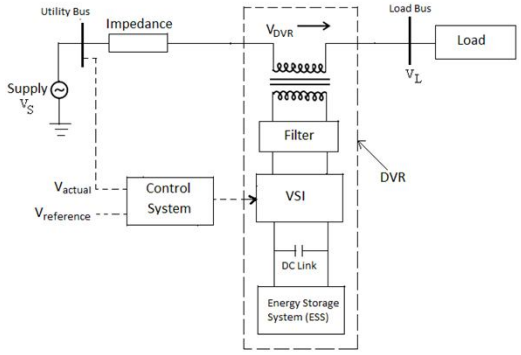

Figure 1. BLOCK DIAGRAM OF DVR SYSTEM

IV. BLOCK DIAGRAM EXPLANATION

A. Input source(generation)

This block is known as input source. The input which is generated that will be given to this. It consists of main supply voltage. Again this input is given to the step down transformer.

B. Injection Transformer

Injection transformer is utilized to interface the DVR to the circulation arrange by means of High Voltage winding and infuses the remunerating voltage produced by VSC after the identification of any unsettling influence in supply voltage by control circuit. Another primary assignment of infusion transformer is that it will confine the coupling of commotion and detach VSC and control circuit from the framework.

C. Voltage Source Converter (VSC)

VSC is a power electronic device used to generate the compensating voltage. Output voltage of VSC should be

- pure sine wave and output
- phase sequence as that of system
- of required magnitude
- for required duration
- practically instantaneous

C. Harmonic filter

Symphonious sift is utilized to channel through the high recurrence Part from the yield voltage of inverter.

D. Storage device

It is essentially used to supply the important vitality to VSC to create the repaying voltage. In this paper DC voltage source is utilized for this reason.

E. Control circuit

Control circuit consistently screens the supply voltage. The capacity of control framework is to distinguish the unsettling influence in the supply voltage, contrast it and the set reference esteem and afterward produce the changing heartbeats to the VSC to create the DVR yield voltages.

V. SRF THEORY

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i. Clark's Transformation

Of course these signs are changed over in a-b-c facilitate framework. In this change there are taking after strides.

$$\begin{bmatrix} v_{s\alpha} \\ v_{s\beta} \end{bmatrix} = \sqrt{\left(\frac{2}{3}\right)} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_{sa} \\ v_{sb} \\ v_{sc} \end{bmatrix}$$

ii. Park's Transformation

Now this signal is converted in rotating o-d-q frame by using Equation (2).

$$\begin{bmatrix} v_d \\ v_q \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} v_{s\alpha} \\ v_{s\beta} \end{bmatrix}$$

For this change θ is acquired from stage bolt circle

(PLL) square. vd and vq contain both dc and air conditioning part. Low pass sift is utilized to channel through the air conditioner segment and just dc part is utilized further. Presently drooped source voltage in d-q outline which is subtracted from consistent set reference voltage in d-q casing and which gives the remunerating voltage in d-q outline. Presently by applying reverse Park's and Clark's Transformation

Independently banner is changed in a-b-c encourages system as

iii. Reverse Park's Transformation

$$\begin{bmatrix} v^*_{s\alpha} \\ v^*_{s\beta} \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} v_{ddc} \\ 0 \end{bmatrix}$$

iv. Reverse Clark's Transformation

$$\begin{bmatrix} v^*_{sa} \\ v^*_{sb} \\ v^*_{sc} \end{bmatrix} = \sqrt{\left(\frac{2}{3}\right)} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v^*_0 \\ v^*_{s\alpha} \\ v^*_{s\beta} \end{bmatrix}$$

V*sa, v*sb and the v*sc are the reference source Voltages

VI. FOURIER TRANSFORM

In this technique Fourier Transform is utilized to distinguish the Sizes of voltage list or swell. Fourier square from MATLAB Simulink is utilized to get this greatness which performs Fourier investigation on info motion for principal recurrence and gives its size and stage edge. In this reproduction of DVR in-stage remuneration procedure is utilized as a part of which just voltage greatness is adjusted .In this method one reference voltage is set for both voltage hang and swell condition. Fourier change is connected to every stage to figure extent of every stage. These extents are subtracted from set reference voltage which gives the plunge or ascent of voltage in particular stage for droop or swell condition.

Reference voltage and yield voltage of VSC are contrasted and mistake is given with Hysteresis transfer which gives the best possible door heartbeats to IGBT's of VSC to deliver required repaying voltage to alleviate droop or swell.

V. HYSTERESIS CONTROL

Contrasting and other PWM techniques hysteresis controller is anything but difficult to execute, has basic o quick reaction. Hysteresis controller work o between an infusion voltage Vi n j and a ref DVR Vref and produces legitimate entryway beats for the inverter. In light of these door beats, VSC produces required remunerating voltage which is infuse Transformer. This infusion ought to fulfill the VL=VS + V inj Fig. 5 demonstrates the guideline of hysteresis controller for one leg of VSC. Where dabbed line demonstrates the upper and lower confine, centre line is the reference voltage got after Change and triangular line is the yield if VSC. Upper and lower hysteresis points of confinement are 1 and - 1 separately. At the point when the blunder is going from low breaking point as far as possible switch 1 is "on" for that span and turn 2 is off. Also, when blunder is going from maximum point of confinement as far as possible switch 2 is 'on'.

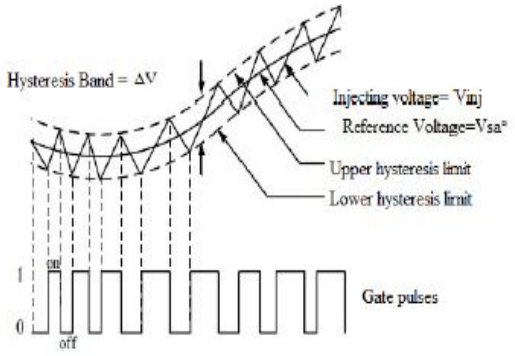

Fig.5 Principle of Hysteresis Controller

Figure 2.

VI. SIMULATION AND RESULT

Diverse conditions are mulled over to check the execution of DVR. A basic dissemination connect with DVR is re-enacted in MATLAB Simulation. Voltage droop is made by transitory association of load and framework blame. While voltage swell is made by impermanent expulsion of load by utilizing electrical switch. DVR is associated in the framework utilizing infusion transformer to infuse required voltage. Initial three Simulations are done utilizing Fourier Transform Technique for reference voltage era and comparing result are appeared with SFR hypothesis result.

Table 1.

TABLE 1 System Parameter

System Parameter	Rating
Three Phase Source 1	400V, 50Hz
Three Phase Source 2	350V, 50Hz
Three Phase Load 1	P= 10KW, Q= 100VAR
Three Phase Load 2	P= 10KW, Q= 100VAR
DC Voltage Source	700V
Switching Frequency	50µs
Injection Transformer Ratio	320/400V

A. Simulation of DVT using FT

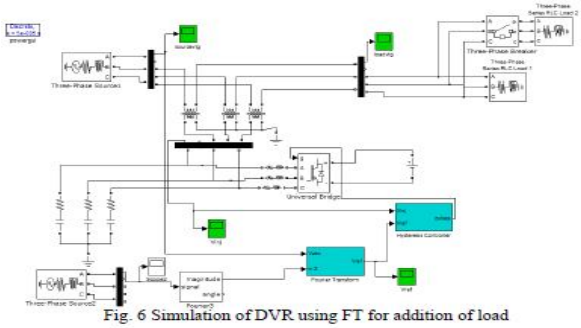

Fig. 6 Simulation of DVR using FT for addition of load

Figure 3.

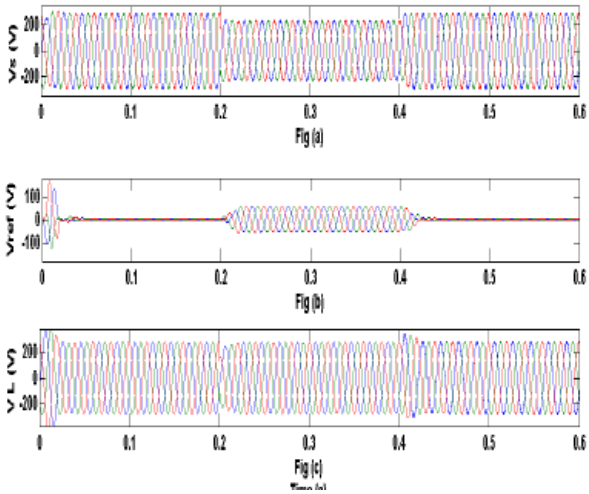

Figure 4. (a) Source voltage, (b) Reference voltage and (c) Load voltage

In this technique Fourier Transformation is utilized to distinguish the voltage list in the framework. Fig.6 demonstrates the straightforward framework with DVR associated for the remuneration of voltage droop brought about by expansion of load with the assistance of electrical switch. A three stage load is added for some span to make voltage hang as appeared in Fig.7 (a). Every stage voltage is gone through the FT piece which will give greatness of every stage. This size is subtracted from set reference voltage which gives the required measure of reference voltage to repay the voltage droop.

This voltage is differentiated and the yield voltage of inverter and screw up is given to Hysteresis controller which gives suitable entryway heartbeats to inverter. Thusly inverter makes required measure of voltage to reduce voltage hang which is injected through imbuing transformer. Fig. 7(b) and 7(c) shows the reference voltage got after change and enduring burden voltage after pay independently. Simulation of DVR for three phase fault

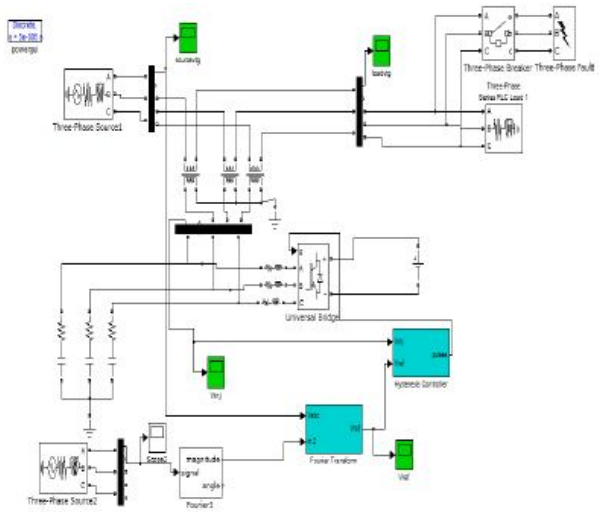

Figure 5. Simulation of DVR for 3_ fault

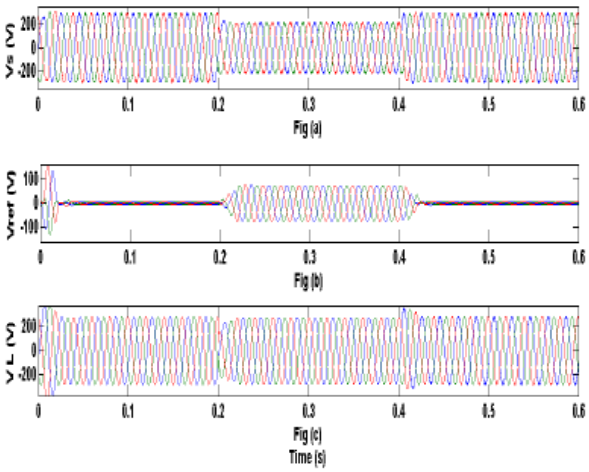

Figure 6. Source voltage, (b) Reference voltage and (c) Load voltage

Same methodology is rehashed just rather than expansion of load three stage blame is made for some length and cleared with the assistance of electrical switch. Again the control circuit will screen the source voltage and figure the part of voltage to relieve the voltage droop. Fig. 8 demonstrates the reproduction of framework containing DVR for keeping up the heap voltage steady after framework blame and Fig. 9 demonstrates the source voltage, reference voltage and remunerated load voltage individually. Detached sift is utilized to channel through the contortion in the yield voltage of inverter.

D. Simulation of DVR for voltage swells

Voltage swell is made by impermanent expulsion of load. To begin with both the heaps are associated in the framework. Stack 2 is expelled for some length. Because of sudden expulsion of load, voltage swell is happened for that length. For this re-enactment Source 2 is of 300V. Control procedure will recognize the voltage swell and give suitable signs to VSC to create the required voltage. The counter stage voltage part is infused by DVR to repay voltage swell. Fig. 10 demonstrates the re-enactment of framework with DVR and Fig. 11 demonstrates the source voltage, reference voltage and consistent load voltage individually.

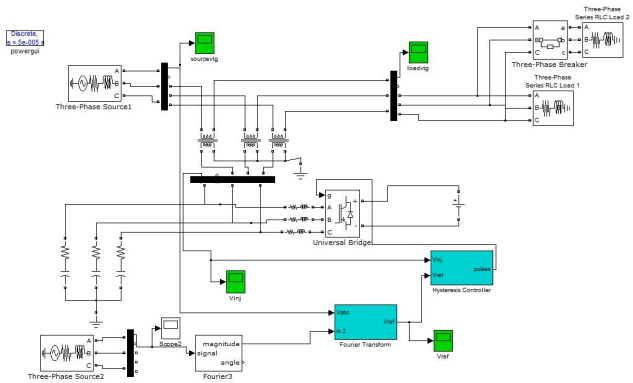

Figure 7. Simulation of DVR for voltage swells

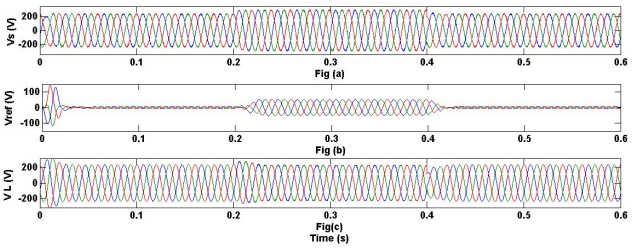

Figure 8. Source voltage, (b) Reference voltage and (c) Load voltage

E. Simulation of DVR using SRF Theory

Fig. 12 demonstrates the recreation of DVR for the pay of voltage hang brought about by expansion of load. In this re-enactment three stage stack 2 is included for the span from 0.2s to 0.4s and evacuated with the assistance of three stage electrical switch. For sudden change in the heap there is voltage hang for that term as appeared in Fig. 13(a). Control circuit changes over the source voltage in d-q outline and is subtracted from another set voltage d-q part. At that point by the converse change it is changed over in a-b-c outline. Fig. 13(b) demonstrates the reference voltage of required greatness, stage and length. This voltage is contrasted and the yield voltage of inverter and mistake is given to hysteresis hand-off which will produce door beats for inverter. Fig. 13(c) demonstrates the remunerated load Voltage. Latent sift is utilized to channel through the twisting in the yield voltage of inverter [9].Similarly re-enactment of framework with DVR for three stage blame and voltage swell by evacuating the heap for some term should be possible.

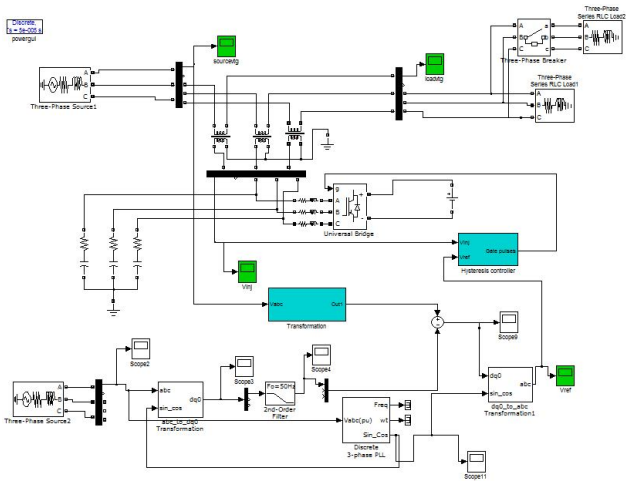

Figure 9. imulation of DVR using FT for voltage sag

Fig.14 shows the results for voltage sag caused by three phase fault and Fig.15 shows the results for voltage swell [9].

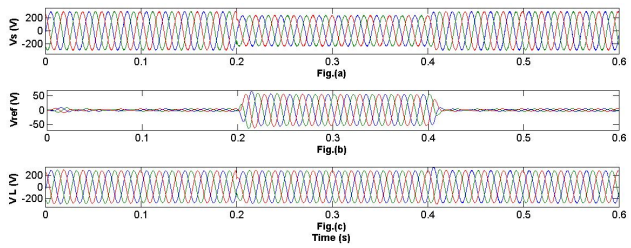

Figure 10. Source voltage, (b) Reference voltage and (c) Load voltage

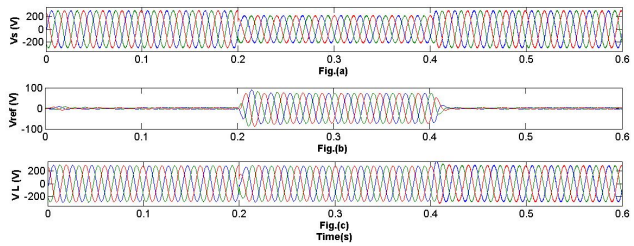

Figure 11. Source voltage, (b) Reference voltage and (c) Load voltage

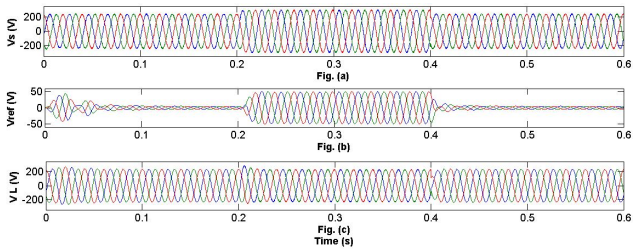

Figure 12. Source voltage, (b) Reference voltage and (c) Load voltage

VII. CONCLUSION

This paper portrays the fundamental structure and standard of Dynamic Voltage Restorer (DVR). SRF hypothesis and Fourier Transform for voltage droop/swell location and reference voltage era and hysteresis controller for entryway beat era are talked about. Distinctive conditions are taken for making voltage Sag/swell. Voltage droop is made by expansion of load and by three stage blame while voltage swell is made by sudden expulsion of load from the framework. Execution of DVR for these conditions is confirmed in MATLAB simulink. Fourier Transform system include a little measure of additional voltage at the beginning and end purpose of voltage droop/swell event while SRF procedure gives the best pay contrasted with FT strategy. Comes about demonstrate that DVR is the best gadget to moderate voltage hang/swell and along these lines keeps up the heap voltage steady

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