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# Simulation of the DVR for the Mitigation of Power Quality Problems

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**ABSTRACT: This paper presents a procedure for modelling and simulation of a DVR (Dynamic Voltage Restorer) for the mitigation of power quality problems such as voltage sag, harmonics, voltage swell, transients etc. The technique used here is the control of DVR using PI control. The power quality problems occur due to the occurrence of heavy loads and light load conditions which results in the improper voltage and bad frequencies. Te major problem that arises due to this are the voltage sags and the voltage swells. In order to remove these problems various power electronic devices are used. The process is known as compensation. This can be done in series or shunt. One of the most effective devices which are found to use now a days is the Dynamic Voltage Restorer. The control is done with the help of PI controller. The proposed model has been simulated and the results have been presented in this paper.**

**Keywords:** DVR, Power quality, compensation, THD, Harmonics, PI controller, Voltage sag, voltage swell

## I. INTRODUCTION

As we know that the term quality means the standard or the degree of excellence of something. So here the quality of power means the degree of lossless power being transmitted through the line. Lesser the losses greater will be the quality of power. But practically a lossless power flow or power transfer is not possible. The amount of voltage at the sending end is never equal to the voltage we get at the receiving end. In order to mitigate or to remove these losses compensation is done. One of the most efficient power devices has been found out i.e. the dynamic voltage restorer (DVR). This compensator is most helpful in mitigating the power quality problem such as Voltage Sags or Swells. It is also very helpful in mitigation of other power quality issues such as harmonics, flickers, interruptions etc. thus improving the efficiency during continuous operations. Variety of controlled strategies has been developed for this device and in order to remove the problems. It provides a reliable power quality. The DVR is mainly used for sensitive loads that are drastically affected by the disturbances occurring in the system voltage.

## II. POWER QUALITY PROBLEMS

The most important reason that we are interested in power quality is the economic value. There are various economic impacts on the users and the suppliers due to poor power quality. The various power quality problems that arise are:

- *Transients*: transient or surge refers to the event that is undesirable and momentary in nature. There are two types of transients impulsive and oscillatory.
- *Interruptions*: interruption means to stop in between. Here it is referred to when the supply voltage has been zero or less than 0.1 pu for a period of time say more than 1 min are called interruptions. These are the results of power system faults, equipment failure and control malfunction.
- *Voltage sag or dip*: sags occur during system faults and the voltage decreases to between 0.1 and 0.9 pu in rms voltage or current at the power frequency for a duration of 1 min.
- *Voltage swell*: swells occur during system faults and the voltage increases to between 1.1 to 1.8 pu in rms voltage or current at the power frequency for duration of 1 min. These faults are not as common as sags.
- *Harmonics*: Harmonics are the sinusoidal waves or currents with frequencies that are integral multiple of the frequency at which supply system is designed to operate.

## III. THE DVR AND THE PI CONTROLLER

### *A. The DVR*

The DVR is a custom power electronic device which is used to mitigate voltage sags and swells.It is a kind of series voltage controller connected in series with the load. The connection of DVR is made with coupling transformer in series with the ac system.

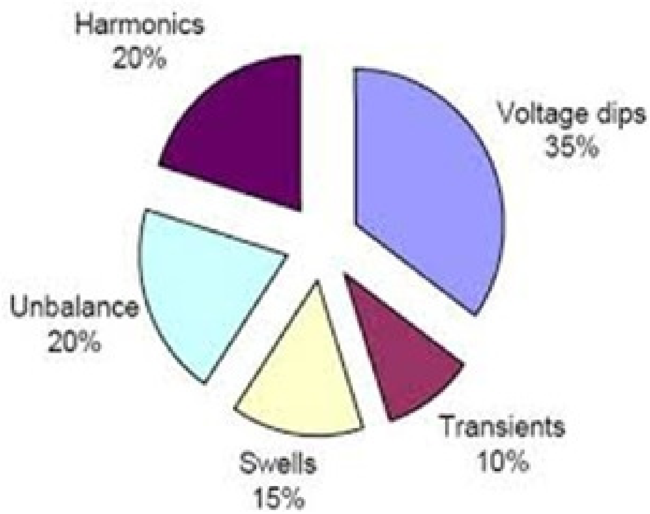


**Fig. 1.** Comparison of Power Quality Problems.

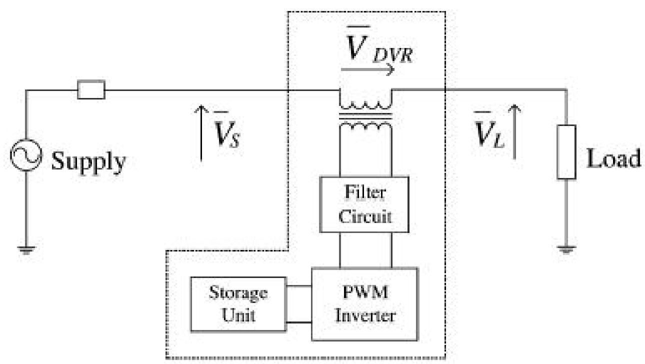


**Fig. 2.** The DVR.

*B. PI Controller*

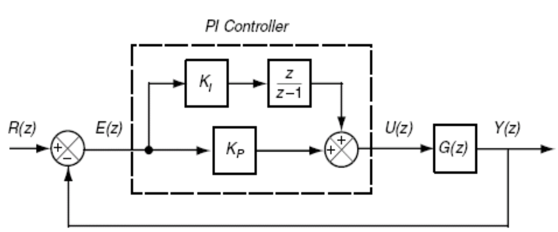


**Fig. 3.** The PI Controller.

The Proportional-Integral controller or the PI controller is used to compute and transmit a controlled output signal at every sample time, T, to the final control element. The resulted controlled output from the PI controller is affected by the controller tuning parameters and the controller error. PI controllers have two tuning parameters to adjust. Integral action enables PI controllers to get rid of offset. Thus, PI controllers provide a balance of difficulty and ability that makes them the most widely used algorithm in the process control applications.

C. *THD*

*The THD is the ratio of the root mean square of the harmonic content to the root mean square value of the fundamental quantity, expressed as a percentage of fundamental.*

Harmonics are the frequencies that are integral multiples of the waveform fundamental frequency. If the given fundamental waveform is of 50Hz, the 2nd, 3rd, 4th and 5th harmonic components will be at 100Hz, 150Hz, 200Hz and 250Hz respectively. Thus, harmonic distortion is the extent to which a waveform deviates from its original value. It is a result of the summation of all the harmonic elements. The ideal sine wave does not contain any harmonics. Thus, there is no distortion and the result is a perfect wave.

Total harmonic distortion is the sum of all harmonic components of the voltage or current waveform divided by the fundamental component of the voltage or current wave:

$$THD = \frac{\sqrt{(V_2^2 + V_3^2 + V_4^2 + \dots + V_n^2)}}{V_1} * 100\%$$

Therefore, we get the percentage which compares the harmonic components to the fundamental component of a signal. The higher the percentage, the higher distortion that will be present.

## IV. THE SIMULATION AND RESULTS

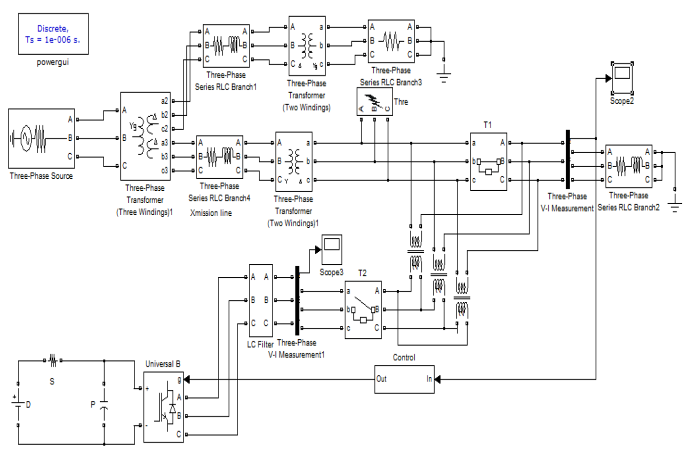


**Fig. 4.** Test system implemented in MATLAB/SIMULINK to carry out the various DVR simulations.

Fig.4 shows the test system which is used to carry out the various DVR simulations. The DVR coupling transformer is connected in delta in the DVR side. It has got the leakage reactance of 0.01. The systems are composed by a 13 kV, 50 Hz generation system, feeding two transmission lines through a 3-winding transformer connected in Y/Δ/Δ, 13/115/115 kV. The transmission lines feed two distribution networks through two transformers connected in Y/Δ, 11/15kV. The simulations are carried out as follows.

Here the DVR uses a PI controller for the compensation of the voltage.

**A.** *DVR Simulations and Results for Voltage Sags*

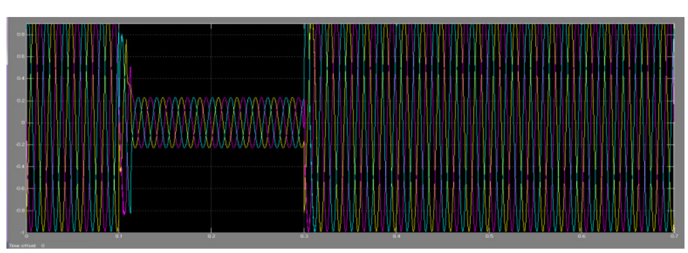

**Fig. 5 (a).** Voltage at the load point with three phase fault without DVR.

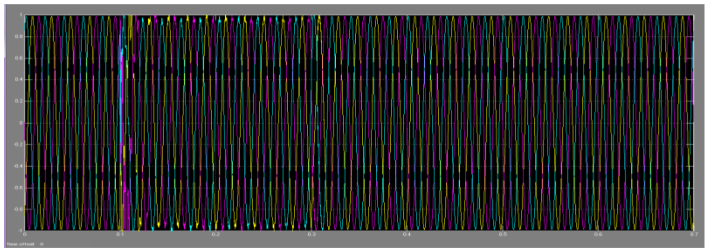

**Fig 5. (b).** Voltage at the load point with three phase fault with DVR.

The first simulation contains no DVR and a three-phase short-circuit fault is applied at point A, via a fault resistance of 0.66 Ω, during the period 100-300 rms. The voltage sag at the load point is 80% with respect to the reference voltage as shown in Fig.5 (a).

The second simulation is carried out using the same scenario as above, but now DVR is connected to the system, then the voltage sag is mitigated almost completely, and the rms voltage at the sensitive load point is maintained at 99.9% as shown in Fig.5 (b).

## V. CONCLUSION

Thus we can see that with the help of the above model the degree of compensation has been increased. The model generated sag of 80% and can help in compensating the voltage sag of 80% and we get a compensated voltage up to 99.9% of the reference voltage. Also the THD which is acceptable should be not more than 5%.

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