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OPTIMIZED COMPENSATION TECHNIQUE FOR VOLTAGE SAGS/SWELLS USING ARTIFICIAL NEURAL NETWORK (ANN) ALGORITHM FOR DYNAMIC VOLTAGE RESTORER (DVR)

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Abstract:

Good electrical power system is an issue that is concerned to most of the electrical utilities and consumers in general. Since in an ideal situation, all sensitive and non-sensitive electrical equipments should assumed to operate with the supply voltage, and should obey the ohms law, that is current is directly proportional to the applied voltage the current/voltage wave forms should be purely sinusoidal, but contrary to that, the current/voltage wave forms should be non-sinusoidal in nature. However, with the introducing of customs devices, the viable solution for mitigating voltage sags/swells is the dynamic voltage restorer (DVR). In this paper, Widrow-Hoff (W-H) weight updated algorithm is employed for the generation of voltage sags. In the same vein, Artificial Neural Network (ANN) is used based on Leas Square Estimation (LMS) which mitigate the problem of voltage sags/swells in order to have a good sinusoidal sine wave. MATLAB environment is employed for the complete simulation model in this work. However, this proposed algorithm gives better control strategy and optimization in selecting (DVR) among the various customs devices for enhancing good mitigation technique.

Keywords: *Custom device sags swells and literature review.*

INTRODUCTION

Electrical power system in an ideal way should be capable of supplying their consumers with constant electricity which gives a purely sinusoidal voltage magnitude. In most power system equipment are operated with non-sinusoidal voltage/current wave forms which lead to the poor power quality of the system, which have adverse effect to the supply utilities and even the consumers. Due to the non-sinusoidal of power supply the need for good quality of power supply is needed (Ezinlarasan & Balasurbramania 2013). In another development, poor power quality is a serious concerned to both utilities and the consumers. With the introduction of sensitive equipment such as adjustable speed drives, air conditioners etc. these are all sensitive in nature which produced poor power quality because they are non-linear loads (Jain & Phulambrikar 2012). Custom device such as dynamic Voltage Restorer (DVR) is a viable solution which mitigate the voltage sags/swells (Jain & Phulambrikar 2012). The most method of mitigating power quality problem are: one the equipment should be less sensitive to disturbances, which will allow it to ride-through without any disturbances (Bollenl, 2000).

Methodology

This paper work is aimed at detailing of a new optimized approach for the three phase Dynamic Voltage Restorer (DVR), control system which gives a dynamic and viable solution with better time response and mitigated technique of the voltage flicker. In this paper, Artificial Neural Network algorithm is utilized based on (LMS) is employed for the compensation of the sags in power system network.

ANN is one of the Artificial Neural Network family which is the must viable solution in mitigating voltage sags/swells.

$$V_s(K) = \sum_{n=1,2,3...}^{N} \left[\omega_{1n} \sin(n\omega k\Delta t) + \omega_{2n} \cos(n\omega k\Delta t) \right]$$

$$\omega_{11} \sin(\omega k\Delta t) + \omega_{21} \cos(\omega k\Delta t) + \sum_{n=2,3.....}^{N} \left[\omega_{1n} \sin(n\omega k\Delta t) + \omega_{2n} \cos(n\omega k\Delta t) \right] \quad (3.1)$$

Where w_{1n} and w_{2n} are the magnitude of the trigonometry quantities which are the nonlinear parts of the load current to be measured, and n is the harmonic order required. In vector form

$$\bar{i}_L(k) = \bar{w}^T \bar{X}(k) \quad (3.2)$$

And weight matrix is given by the equation in (3.3) below

$$\bar{w}^T = [w_{11} w_{21} \ldots w_{1N} w_{2N}] \quad (3.3)$$

Sine and cosine can be evaluated as:

$$\bar{X}(k) = \begin{bmatrix} \sin(k\omega\Delta t) \\ \cos(k\omega\Delta t) \\ . \\ . \\ . \\ \sin(Nk\omega\Delta t) \\ \cos(Nk\omega\Delta t) \end{bmatrix} \quad (3.4)$$

Where, $\Delta t =$ Sampling time

$\omega = 2\pi f$

$n =$ Number of samples of voltage component, and

$f =$ Fundamental frequency of the supply system.

The sine $\sin(n\omega k\Delta t)$ and cosine $\cos(n\omega k\Delta t)$ are resolved as in equation 3.5 below.

$$\bar{W}(k+1) = \bar{W}(k) + \frac{\alpha e(k)\bar{Y}(k)}{\bar{Y}^T(k)\bar{Y}(k)} \quad (3.5)$$

$$\bar{Y} = \begin{bmatrix} \sin(n\omega k\Delta t) \\ \cos(n\omega k\Delta t) \end{bmatrix} \quad (3.6)$$

Complete SIMULINK Model of DVR

Figure 2.1 depicts the complete simulation model of the dynamic voltage restorer using the application of MATLAB environment. The simulation is done via the SIMULINK library browser of the MATLAB environment. 3- Φ Power system was considered via a bus line at the (PCC). Three series injected transformers are used in the simulation. Nonlinear load model was connected at the load terminal for the generation of the harmonics drawn by the load. The complete model of the ANN controller was also integrated with the model for the compensation of the voltage sags/swells. The simulation results of the simulation model are discussed in chapter four for further investigation of the control algorithm. Non linear load of RL circuit is considered for the detection of harmonic, also diode bridge rectifier was used in the non linear load model because of its harmonic content due to the conversion of AC signal into DC signal.

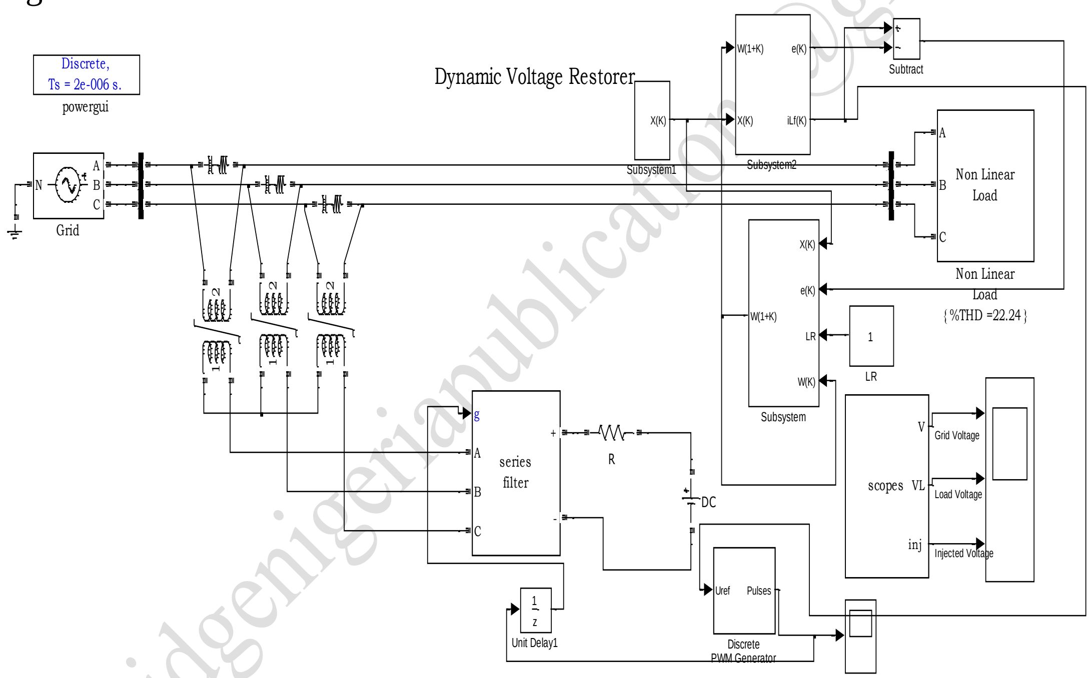


Figure 2.1 Complete Simulation Model of the Dynamic Voltage Restorer

Results and Discussion

This described the results of the simulation of various simulation model of the DVR without and with the control algorithm. Figure 4.1 shows the grid voltage showing the nominal, swell and sag respectively, while the other result in the same figure 4.1 depicts the compensated voltage after applying the Artificial Neural Network (ANN) algorithm. This shows that the control algorithm have successfully compensated the power quality problems of both sag and swell respectively.

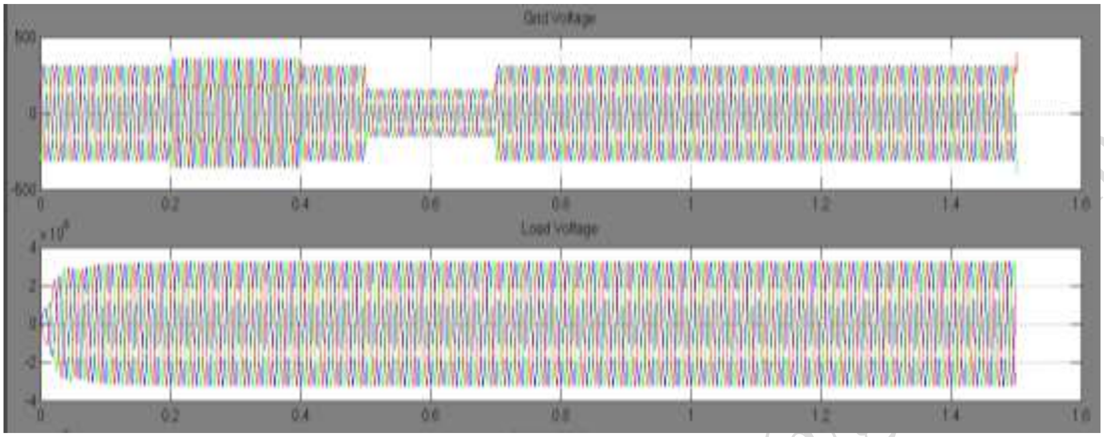


Figure 4.1Up, Grid voltages showing the nominal/swell/sag respectively, down Compensated voltage after applying ANN Controller

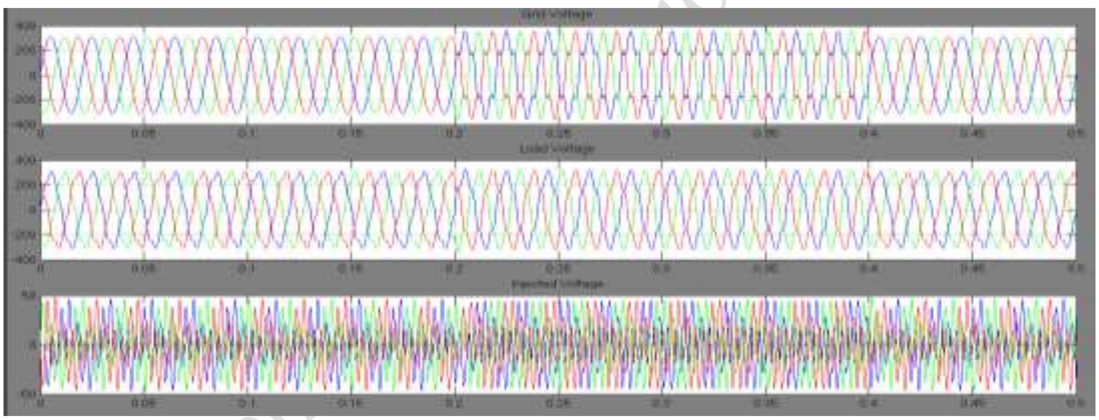


Figure 4.2 Up, Grid voltage Nominal and swell voltages. Middle, Load voltage after compensation with ANN Algorithm. Down, injected voltage due to series transformers

Figure 4.2 depicts the voltage swell compensated voltage and injected voltage respectively. The result of the grid voltage as in figure 4.2 shows the nominal voltage and the swell before applying the control algorithm. In the load voltage of Figure 4.2, also the voltage was compensated by applying the ANN control algorithm, but with small content of harmonic due to the RL non linear load. However, an injected voltage in Figure 4.2 shows that the whole three phase wave form is having harmonic content in it.

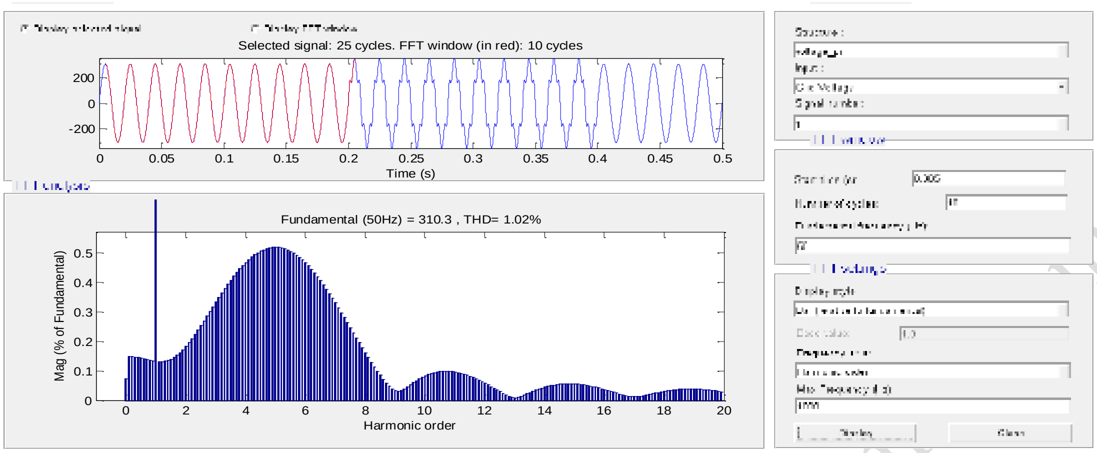


Figure 4.3 shows the Fast Fourier Transform analysis of the grid voltage due to swell as shown in the FFT window of Figure 4.3 from 0.2 to 0.4, the result of the FFT shows that, a %THD was obtained to be 1.02% which satisfied the IEEE 519-2014 harmonic standard limit. This means the the harmonic content in the wave form is very minimal.

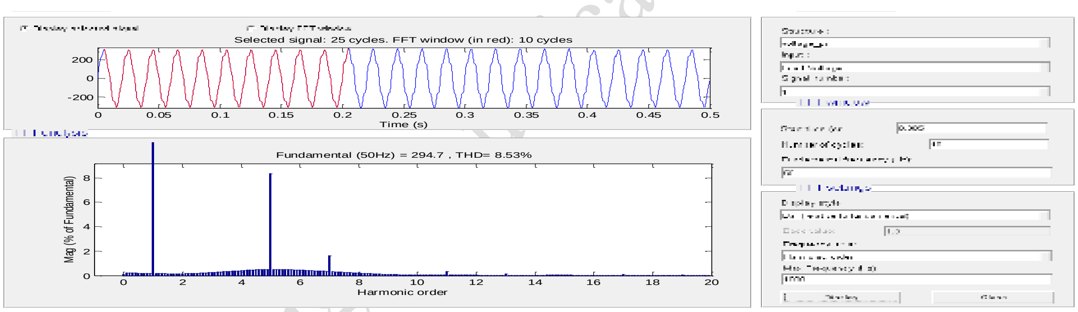
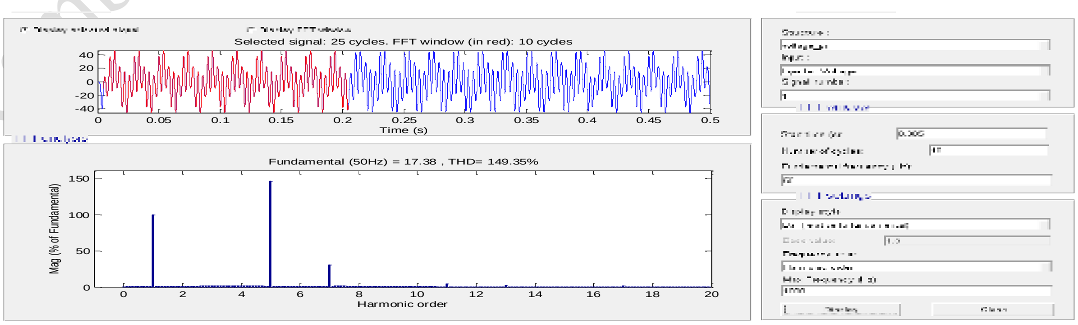


Figure 4.4 Fast Fourier Transform (FFT) Analysis of the Load Voltage of Figure 4.2

In Figure 4.4, the harmonic content in the load voltage was found to be 8.53% which is the %THD, this means the %THD does not obeyed the harmonic standard of IEEE 519-2014 norm



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