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Reduction of Harmonics using Passive Filter based Z-source DVR

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ABSTRACT:In recent years nonlinear loads such as UPS, Induction motor, and other power electronics devices became the major demand in our daily life and industries. But these nonlinear loads are the major cause of generation of harmonics. As we know that the rise of harmonics in the source of power is a major cause of power quality distortion. To overcome the problem of harmonics and to improve the quality of power we have need to reduction in the harmonics. In this paper, A DVR is modelled with storage unit as a battery with ultra-capacitor and Z source inverter with passive filter and fuzzy logic controller is proposed.

KEYWORDS:. DVR, Passive Filter, Z-Source Inverter, Fuzzy Logic controller, Ultra Capacitor.

I.INTRODUCTION

At the present time, it has been an increased concern about the effects of nonlinear loads on the power quality. The present design of electrical load devices is to increase energy efficiency with electronics Devices. These non-linear loads are any loads which draw current which is not sinusoidal in the nature which inject the harmonic in the system. While nonlinear devices are not new, their increased use means a larger percentage of any power system tends to be nonlinear. One of the major drawbacks of the nonlinear load is the harmonics injection to the power system. The effect of harmonics in power system and on the power quality greatly rises due to the use of electronic devices and other high frequency producing devices. With the increase in the application of electronics to almost every electrical load, non-linear loads are also frequent in commercial and even residential power systems. These nonlinear loads behave non-linearly towards the power quality. Even with a pure sinusoidal voltage supply, their currents are non -sinusoidal, but still repeated in steady state. Hence they contain other spectral components, the current harmonics, frequencies which are a multiple of the fundamental supply frequency. Harmonic current causes overheating of motors, cables, transformers, creating additional dielectric stress or mechanical stress[1]. In this paper a brief overview and study on the harmonics are discussed. Passive filter with Z-Source inverter is used to mitigate the harmonics.

II. OVERVIEW OF HARMONICS

Harmonics are unwanted components in the sinusoidal waveform of the AC Power supply. Harmonics always occur as integral multiples of the fundamental frequency.
That is, the third order harmonic will have a frequency of three times the fundamental frequency; 150 Hz which is 3 times the fundamental 50 Hz frequency. Harmonics affect power quality, efficiency and life of the equipment. It is therefore necessary that Harmonics in any power system must be monitored and mitigated.
The harmonics can arise in three ways:
1) With the application of a non-sinusoidal driving voltage to a circuit containing nonlinear impedance.
2) With the application of a sinusoidal driving voltage to a circuit containing nonlinear impedance.
3) With the application of a non-sinusoidal driving voltage to a circuit containing linear impedance.

Harmonic can be reduced by suitable methods such as filters i.e. active filter and passive filter. By using a mathematical technique known as Fast Fourier Transforms (FFT), the distorted AC waveform can be resolved into its component waveforms. Of the measured harmonics, the even harmonics(harmonics whose frequency are the

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fundamental frequency which multiplied by even numbers such as 100Hz(4 *50) or 100Hz(2*50) get cancelled out and have very negligible effect. For the study of Harmonics, only the odd harmonics are considered because odd harmonics are very harmful.[2].

Odd harmonics may be expressed as:

$$in = In \cos 2nft$$

Where n = 3, 5, 7...etc. and In is the amplitude of harmonic portion of order n.

In fact, even harmonics may be expressed as:

$$in = In \sin 2nnft$$

Where n = 2, 4, 6...etc. and In is the amplitude of harmonic fragment of order n.

The fig 1 shows the distorted wave form of the 3rd order harmonic in a system

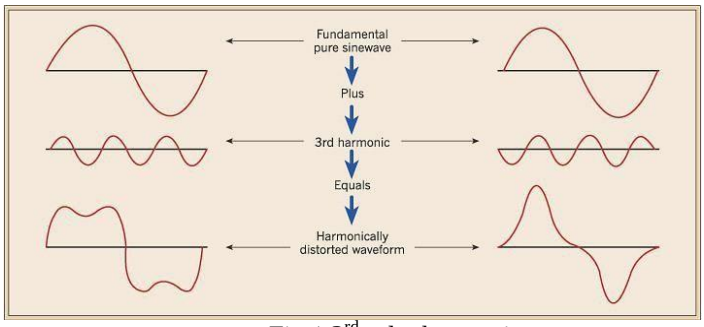

Fig.1 3rd order harmonics

In a three-phase system the characteristic harmonic currents are represents as:

$$i_R = I_{1m}\cos(\omega t) - I_{5m}\cos(5\omega t) + I_{7m}\cos(7\omega t) - I_{11m}\cos(11\omega t) \quad (1)$$

$$i_Y = I_{1m}\cos(\omega t - 120^\circ) - I_{5m}\cos(5\omega t - 240^\circ) + I_{7m}\cos(7\omega t - 120^\circ) - I_{11m}\cos(11\omega t - 240^\circ) \quad (2)$$

$$i_B = I_{1m}\cos(\omega t + 120^\circ) - I_{5m}\cos(5\omega t + 240^\circ) + I_{7m}\cos(7\omega t + 120^\circ) - I_{11m}\cos(11\omega t + 240^\circ) \quad (3)$$

The total harmonic distortion (THD) is a measure of effective value of the harmonic components of a distorted waveform. It can be calculated for either current distortion or either voltage distortion.[3].

III. DYNAMIC VOLTAGE RESTORER (DVR)

Dynamic voltage restorer is the fastest and more efficient solution to voltage sag, swell and for harmonic reduction. Dynamic voltage restorer (DVR) is a custom power device that provides three-phase controllable voltage source, whose voltage vector (magnitude and angle) inject to the source voltage during sag and to restore the load voltage during swell conditions. Dynamic voltage restorer is also called as a static voltage compensator (SVC).

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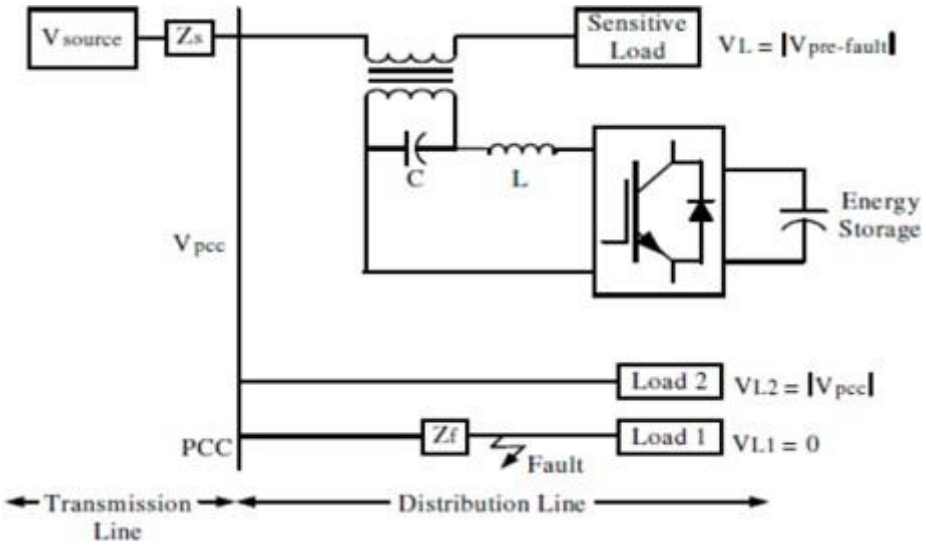

Fig.2 Role and Location of the DVR

Fig.2 is a simplified circuit for the role and location of the DVR in the distribution system. When a fault, as shown in the figure, occurs on the line which feeding Load 1, its voltage suddenly fall to zero. Also when Load 2 voltage experiences sag which magnitude is equal to the voltage at the Point of common coupling, and the voltage of the sensitive load protected by the Dynamic voltage restorer is restored to its pre fault value. In the DVR, battery is used as a DC for voltage injects and absorb. A passive filter is used in the DVR to reduction in the harmonics. A fuzzy logic controller is used in this work in order to provide more stability to the network as well as to offer crisp outputs.[4].

IV. PASSIVE FILTER

Passive filters are used to reduce the harmonics by using the series and parallel resonant filters. In passive harmonic filter a filter is connected parallel with the load and in series with the inductance and capacitance is a current acceptor. A capacitor is a parallel filter which is in parallel filter with the nonlinear load and is in series with the inductance and capacitance. The passive filter passes as much current as the harmonics voltage nears the filter resonant frequency point. The passive filter thus eliminates the harmonics which is the multiple of the fundamental frequency. A capacitor is connected in series with an inductance is a passive filter. The harmonic frequency which is reduced must be equal to the resonant frequency of the circuit. Low impedance of the filter and the impedance of the network thus eliminate the harmonic current. The passive filters are basically used in order to protect the power system by reducing the harmonic current to enter the power system by providing a low impedance path. The most popular Passive filters consisting of tuned series L-C circuits, and may produce undesired side effects, particularly in the presence of capacitor which is used for power factor correction. Passive filters are of two types

Series Passive filter.

Series filter consist of a capacitor and a parallel inductor and presents a large impedance .Series passive filter has the property of purely inductive type and LC tuned characteristics .The operating principle of this passive filter is given by these two component connected in series that AC line reactor improve system magnitude of inductance in system that alters the path of current drawn in the rectifier circuit [5].

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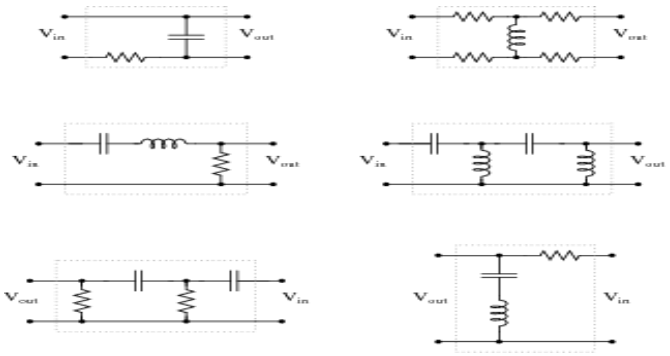

Fig.3Series Passive Filters

Shunt Passive Filter

Shunt passive filter is the most common method for the reduction of harmonic component in the distribution system. Shunt passive harmonic filter are basically designed on principle of either r band pass filter or either single tuned technology. Shunt type Passive filter are connected in system parallel with load. Shunt Passive filter offers very low impedance in the networks at a tuned frequency to divert all the related current and at given tuned frequency.[5].

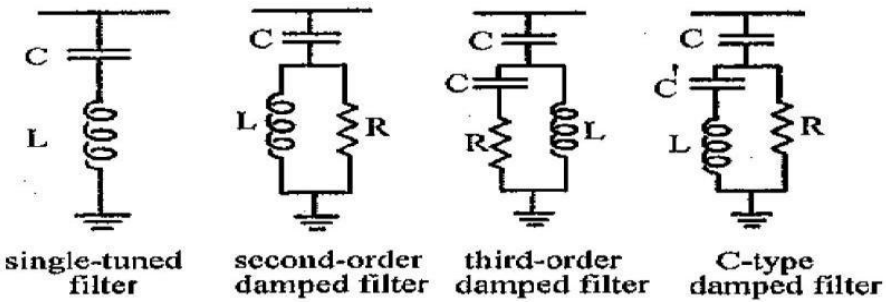

Fig.4 Shunt Passive filters

V. PROPOSED MODEL

The proposed DVR model for harmonic reduction isshown in Fig.5. And proposed model for Z-Source inverteris shown in Fig.6. And Fuzzy logic controller which is used to increase system stability is shown in fig.7.Proposed model of passive filter which is used to reduction in the harmonics is shown in the fig.8. In this proposed model a DC source is used with Ultracapacitor or Super capacitor which is connected along with it to increase system storage capacity. Z-Source inverter is used with passive filter for harmonic reduction.

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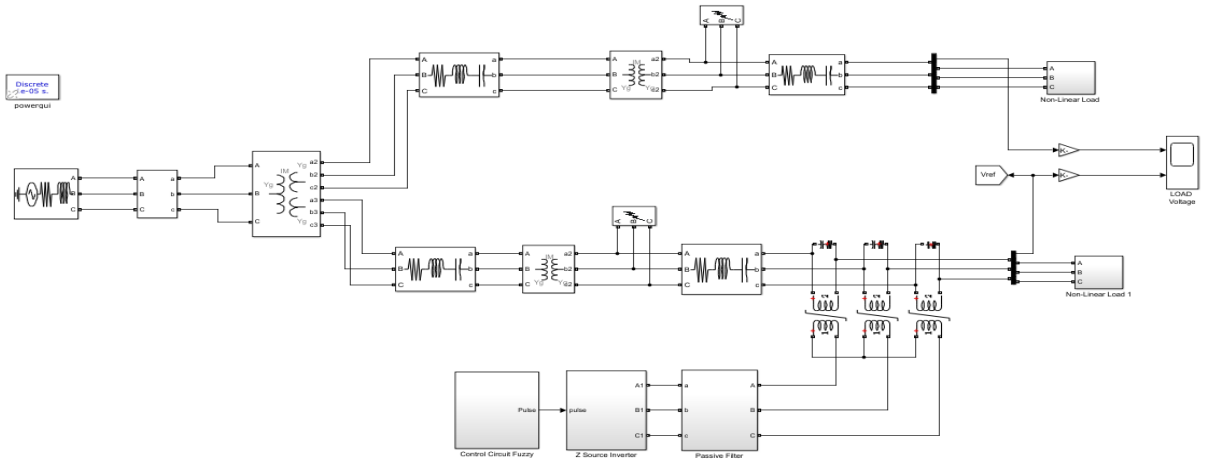

Fig.5 Proposed Simulink model

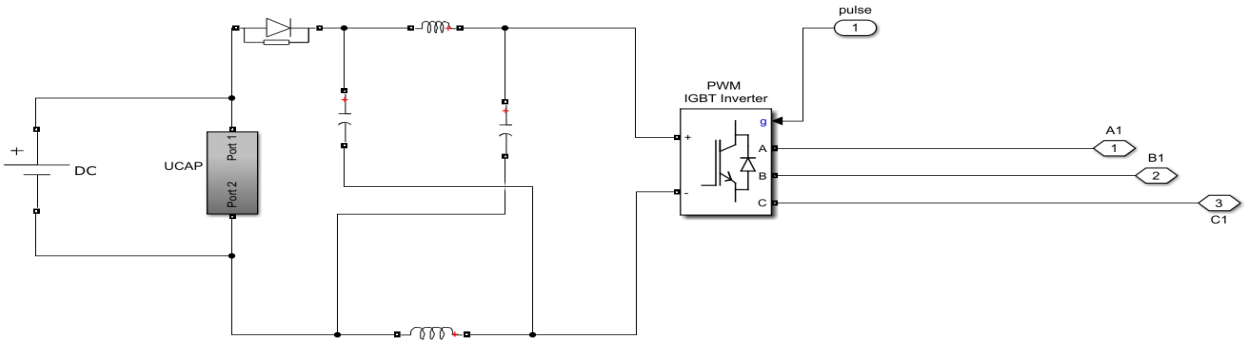

Fig.6 Z Source inverter

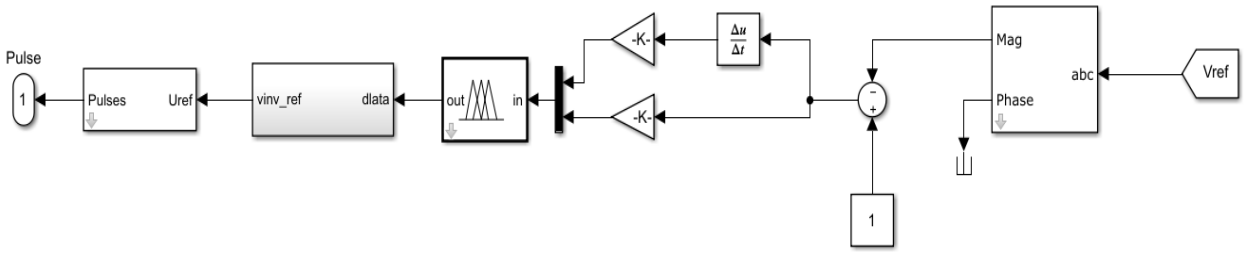

Fig.7 Fuzzy Logic controller

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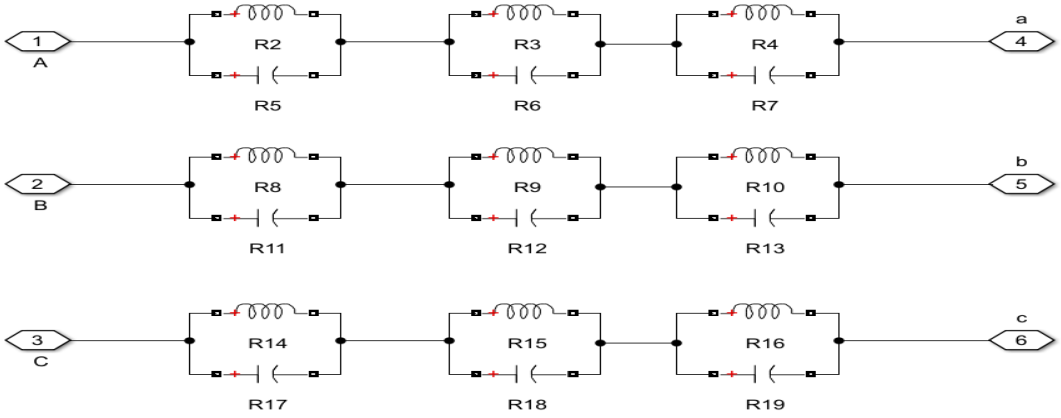

Fig.8 Model of Passive Filter

VI. SIMULATION RESULTS

In figure 9 the profile of harmonic distortion without Passive filter is shown when the fault is applied across the input. In fig. 10 the profile of reduction in the harmonic using passive filter based DVR is shown.

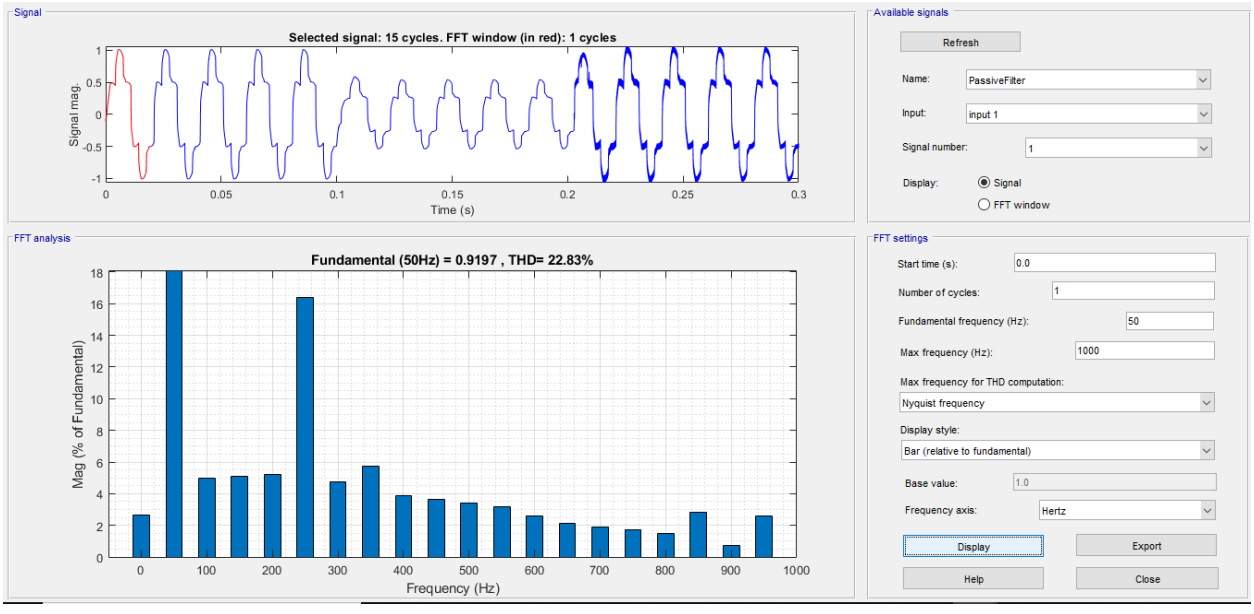

Fig.9 Harmonics distortion without DVR

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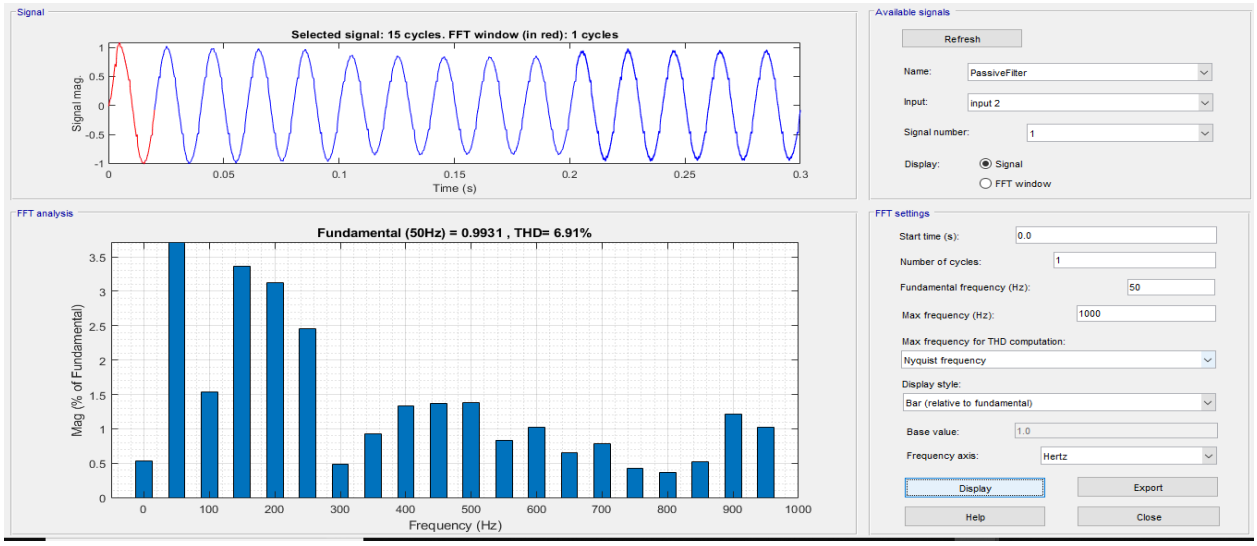

Fig.10 Reduction of Harmonics using Passive Filter based DVR

VI.CONCLUSION

The proposed model is simulated in MATLAB/SIMULINK. In this DVR model, apassive filter is used with Z-source inverter and also used fuzzy logic controller. This gives improved results in harmonic reduction. Z source inverter has two degree of freedom as modulation index and short through duty ratio. Ultra capacitor with DC battery increases the storage system of DVR. It has been observed that in DVR, when passive filter and fuzzy logic controller is used together they are very efficient for reduction in the harmonics and for improvement of power quality in power system.

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