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EQUIVALENT MODELLING OF INVERTER AIR CONDITIONERS FOR PROVIDING FREQUENCY REGULATION SERVICE

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***Abstract*— Inverters are used in many applications now-a-days. One among the major applications is Dynamic Voltage Restorer (DVR), this exertion explains the built-in photovoltaic based dynamic voltage restorer (DVR) for alleviation of voltage hang down and engorge mitigation. Photo Voltaic (PV) model, DVR model and local grid model are implemented and the results of simulation are presented. In order to improve the efficiency of the PV system Incremental Conductance (INC) algorithm based Maximum Power Point Tracker (MPPT) is connected. The hybrid multilevel inverter is used for exchange of real and reactive power to the sensitive load from PV system. Modeling of the proposed system was developed by MATLAB Simulink. The objective of the proposed system is to study the system behavior, which allows the renewable energy sources for mitigating voltage disturbances. This paper attempts to study and analyze the performance of a DVR based on a new 63-level hybrid multilevel inverter, using minimum required numbers of switches with fuzzy logic controller to compensate balance voltage**

***Index Terms*— Dynamic Voltage Restorer, Maximum Power Point Tracker, Hybrid multilevel inverter, Phase Opposition Disposition (PODPWM)**

I. INTRODUCTION

Power quality is of great importance in all modern environments where electricity is involved, power quality can be essentially influenced by an important factor like quality service. One of the major concerns in electricity industry today is power quality problems. Presently, most of the power quality problems are due to different fault conditions. These conditions cause voltage sag, voltage swell, transients, voltage interruption and harmonics. These problems may cause the apparatus tripping, shutdown commercial, domestic and industrial equipment, and miss process of drive system. Dynamic voltage restorer (DVR) can provide the lucrative solution to mitigate voltage sag by establishing the appropriate voltage quality level, necessary. It is recently being used as the active solution for mitigation of power quality problems.

II. PROPOSED POWER SYSTEM MODELING

The proposed power system model comprises PV system, DVR, energy storage devices and hybrid multilevel inverter, Phase Opposition Disposition

A. DYNAMIC VOLTAGE RESTORER

The Dynamic Voltage Restorer (DVR) is fast, flexible and efficient solution to voltage sag problem [2]. It is a powerful electronic based device that provides three phase controllable voltage source, whose voltage vector (magnitude and angle) adds to the source voltage during sag event, to restore the load voltage to pre-sag conditions. It is designed for protecting the whole plant with loads in the range of some MVA. It can restore the load voltage within few milliseconds.

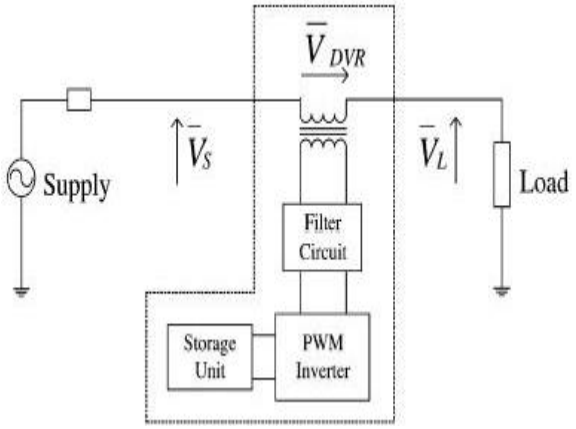


Fig.1 Schematic diagram of DVR

The Fig.1 represents the schematic diagram of DVR.

It contains the basic configuration and components as follows:

III. DVR BASIC CONFIGURATION AND COMPONENTS

During voltage sags, the DVR injects a voltage to restore the load supply voltages. The DVR needs a source of this energy. Two types of system are considered, one using stored energy to supply the delivered power and the other having no internal energy storage, where energy is taken from the incoming supply through a shunt converter.

A. INVERTER CIRCUIT

The Voltage Source Inverter (VSI) or simply the inverter, converts the DC voltage of the energy storage unit (or the DC link) to a controllable three phase AC voltage. The inverter switches are normally fired using a sinusoidal Pulse Width Modulation (PWM) scheme. Since the vast majority of voltage sags see n on utility systems are unbalanced, the VSI will often operate with unbalanced switching functions for the three phases, and must therefore treat each phase independently. Moreover, a sag on one phase may result in a swell on another phase, so the VSI must be capable of handling both sags and swells simultaneously. Another topology of the DVR is the use of the multi - inverter system in the cascade. This method gets rid of the injection transformer used in the basic configuration of the DVR. This arrangement is often called a transformer-less or multilevel or a cascade inverter DVR.

B. FILTERING UNIT

The nonlinear characteristics of semiconductor devices cause distorted waveforms associated with high frequency harmonics at the inverter output. To overcome this problem and provide high quality energy supply, a harmonic filtering unit is used. These filters can be placed either in the inverter side or in the line side.

C. SERIES INJECTION TRANSFORMER

Three single-phase injection transformers are used to inject the missing voltage to the system at the load bars. To integrate the injection transformer correctly into the DVR, the MVA rating, the primary winding voltage and current ratings, the turn-ratio and the short-circuit impedance values of transformers are required. The existence of the transformers allow for the design of the DVR in a lower voltage level, depending upon the stepping up ratio.

D. PHOTOVOLTAIC CELL

Photovoltaic cell generates electricity from the sun. PV panel works under the phenomenon of photoelectric effect. It directly converts sunlight into electricity. The diagram of PV based system.

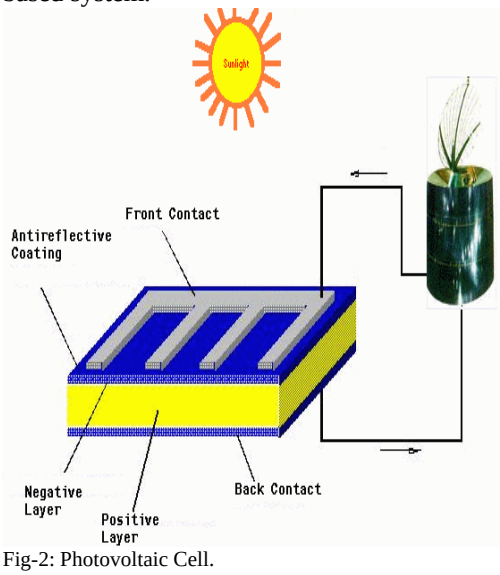


Fig-2: Photovoltaic Cell.

E. Energy Storage Devices

Energy storage unit is dependable for energy storage in DC form, Super-Capacitors, Superconducting Magnetic Energy Storage (SMES), lead acid batteries and Flywheels are generally used as energy storage devices. In proposed model energy generated from PV is stored in SMES and supply to DVR at the time of unavailability of solar irradiation.

IV. FUZZY LOGIC CONTROLLERS

In fuzzy logic, basic control is determined by a set of linguistic rules which are determined by the system. Since numerical variables are converted into linguistic variables, mathematical modeling of the system is not required. The fuzzy logic control fig.5 is being proposed for controlling the inverter action on DVR. The fuzzy logic controller has two real time inputs measured at every sample time, named error (e) and error rate (de) and one output named actuating signal for each phase. The input signals are fuzzified and represented in fuzzy set notations as membership functions. The defined „IF-THEN" rules produce output (actuating) signal and these signals are defuzzified to analog control signals for comparing with a carrier signal to control PWM inverter

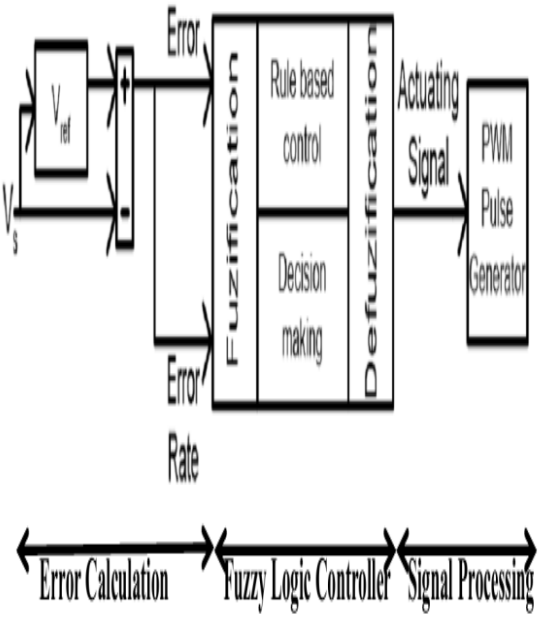


Fig.4.1 Fuzzy Controller.

A. Comparison of THD for DVR and DVR with Fuzzy Control

Table.3 shows the comparison of THD values for open loop DVR and DVR with fuzzy control at each phase of load voltage.

B. SIMULATION RESULTS AND DISCUSSIONS

Simulation results are given from fig.6 to fig.9. Now, the disturbances in voltage are compared with the desired voltage. Based on this comparison, error signal to the SMC. This in turn reduces the error signal to as small as a value possible. Depending upon this error signal, the modulating signal is varied which in turn changes the PWM signals obtained. Accordingly, the desired MOSFETS are gated and the necessary voltage is obtained at the inverter output. Fig 6 shows that load voltage before interfaced with DVR. Fig7

shows that load voltage after interfaced with DVR. Fig 8 & 9 shows that THD of the proposed system without and with DVR.

During the normal voltage the DVR in ideal condition.PV system absorb the power from renewable source and it's store in capacitor. The MPPT boost converter boosts the PV output voltage. During swell period the converter reduce the system voltage to maintain per unit value. During sag period the capacitor voltage is inverted and system voltage is boosted in to per unit value. Here the MLI is perform the inversion action with low THD. During the normal voltage the DVR in ideal condition.PV system absorb the power from renewable source and it's store in capacitor. The MPPT boost converter boosts the PV output voltage. During swell period the converter reduce the system voltage to maintain per unit value. During sag period the capacitor voltage is inverted and system voltage is boosted in to per unit value. Here the MLI is perform the inversion action with low THD.

C. SPACE VECTOR PWM (SVPWM) CONTROL

The Sinusoidal Pulse Width Modulation (SPWM) has got a few different supplementary names in relation with the triangular carrier waveforms. Symmetrical SPWM, when triangular carrier was symmetric. Generally SPWM have got a few different supplementary names in relationship with the position of the carrier signal to the modulation wave. Synchronous SPWM, both signals were synchronous with each other if the carrier frequency is a multiple of the sine wave frequency (fs = k*fm). Asynchronous SPWM, both signals were asynchronous, when the carrier frequency is not a multiple of the sine wave frequency (fs≠ k*fm) Based on the applications of PWM signals to multilevel inverters, the multilevel sinusoidal PWM can be classified according to carrier and modulating signal.

D. Phase Opposition Dispositions (POD)

The carrier waveforms are all in phase above and below the zero reference value however, there is 180 phase shift between the ones above and below zero respectively. The significant harmonics, once again, are located around the carrier frequency fc for both the phase and line voltage waveforms. The three disposition PWM techniques that are APOD, PD and POD generate similar phase and line voltage waveforms. Furthermore, for all of them, the decision signals have average frequency much lower than the carrier frequency.

E. Cascaded H-Bridges

A single-phase structure of an m-level cascaded inverter is illustrated in Figure 31.1. Each separate dc source (SDCS) is connected to a single-phase full-bridge, or H-bridge, inverter. Each inverter level can generate three different voltage outputs, +Vdc, 0, and –Vdc by connecting the dc source to the ac output by different combinations of the four switches, S1, S2, S3, and S4. To obtain +Vdc, switches S1 and S4 are turned on, whereas –Vdc can be obtained by turning on switches S2 and S3. By turning on S1 and S2 or S3 and S4, the output voltage is 0. The ac outputs of each of the different full-bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs. The number of output phase voltage levels m in a cascade inverter is defined by m = 2s+1, where s is the number of separate dc sources. An example phase voltage waveform for an 11-level cascaded H-bridge inverter with 5 SDCSs and 5 full bridges is shown in Figure 31.2. The phase voltage van = va1 + va2 + va3 + va4 + va5. For a stepped waveform such as the one depicted in with steps, the Fourier Transform for this waveform follows.

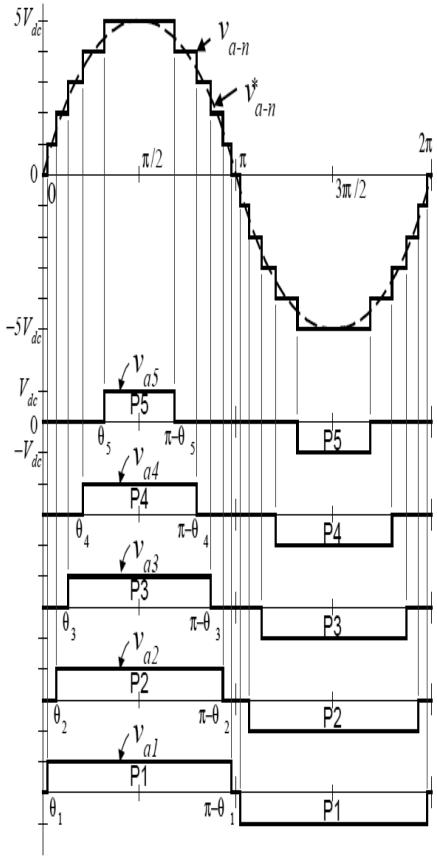
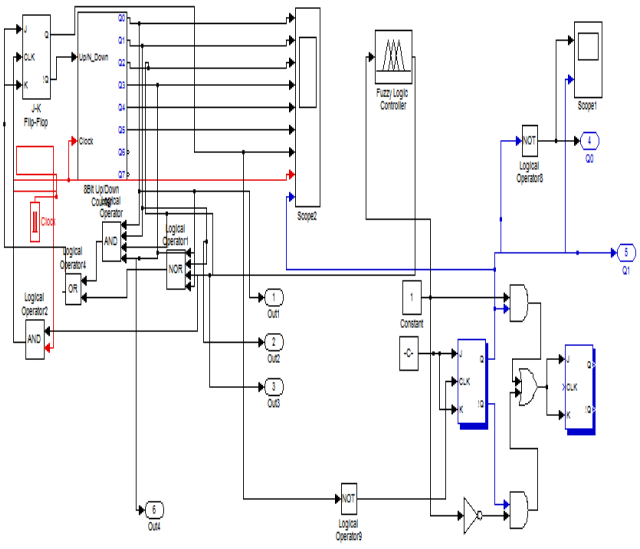


Fig 3.6.1 output of 63 level cascade Hybrid inverter

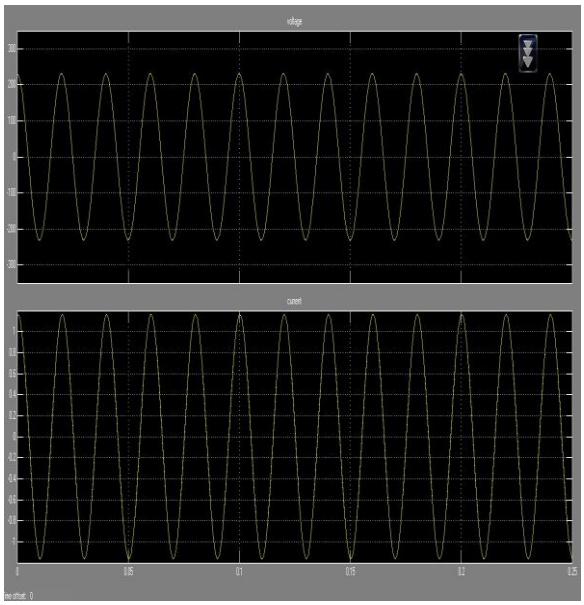
F. Overview of Simulink diagram

c.Pod and fuzzy logic controller

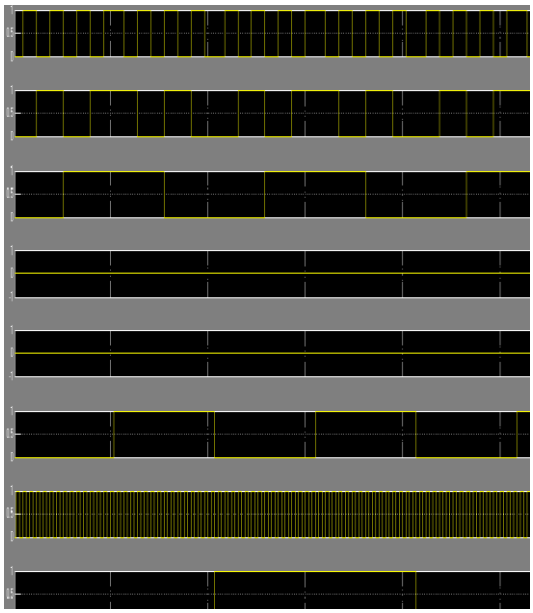


V. RESULT

A. *Final output waveform*



B. *pod and fuzzy logic controller output waveform*



C. *Total Harmonic Distortion*

Fig.17. Shows the Fast Fourier Analysis for the output current which predicts the Total Harmonic Distortion as 20.25 % for the fundamental frequency.

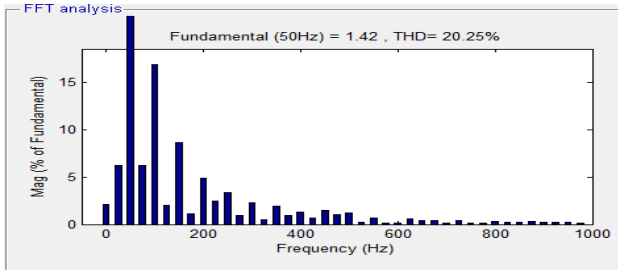


Fig.17. FFT Analysis of Output Current without grid interfacing inverter

Fig.18. Shows the Fast Fourier Analysis for the output current which predicts the Total Harmonic Distortion as 12.51 % for the fundamental frequency.

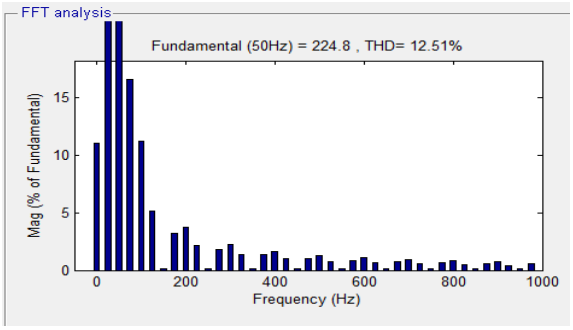


Fig.18. FFT Analysis of Output Current with grid interfacing inverter

VI. CONCLUSION

The simulation of the module layout was successfully carried out using MATLAB Simulink software and the obtained waveforms were observed. In this project a high efficiency grid-tied photovoltaic system using a hybrid multilevel inverter is proposed. Modular configuration is proposed in this project. Due to its modular structure, malfunctioning of any module section will not affect the entire system. POD modulation technique is proposed. The proposed Hybrid MLI can achieved high efficiency and low harmonics and it can reduce the voltage stress on the power switches and also reduces the no of switches. In addition to reducing voltage dip and engorge, DVR can also ensure of ephemeral in voltage, line voltage harmonics mitigation and fault current margins.

The output response of the Photovoltaic (PV) system is analyzed. It is observed that the total harmonic distortion without interfacing inverter is 20.25% and with interfacing inverter is 12.51%. This system would show its feasibility in practice.

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