RESEARCH ARTICLE

GRID INTEGRATION OF SOLAR PHOTOVOLTAIC SYSTEM USING 25LEVEL SUB-MULTILEVEL INVERTER.

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Manuscript Info	*Abstract*
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The sub-multilevel electrical inverter could be a replacement topology for multilevel Inverters that are improved or advanced multilevel inverter topology. The projected sub-multilevel inverter uses a reduced range of switching devices and series association within the Power circuit while not compensating the levels. The multilevel inverters are within the center of attraction for the researchers in recent years. this is often owing to it holds advantageous feature to produce improved power quality. The proposed scheme of 25Level sub-multilevel electrical inverter tends to produce a generalized kind to the multilevel inverters that may produce a nearly sinusoidal output voltage. output voltage quality depends on the number of voltage levels of the inverter. Special attention is required to induce the most effective sub-multilevel concerning criteria just like the range of switches, standing voltage on the switches, the range of DC voltage sources, number of output voltage levels on switches and so. the foremost motivation behind this inverter topology is to realize the high power quality, low total harmonic distortion, less magnetic attraction interference, lesser the higher power stability, and reliability. The Simulation strategies of voltage responses and THD responses for asymmetric and symmetric photovoltaic array associated with the three-phase 25-level CSMLI(cascaded Sub- multilevel Inverters) are being carried under the MATLAB environment.

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Introduction:-
By the passing of each day, as electricity demand is increasing and solely traditional sources or conventional sources of energy so, this huge power demand can't be only dependable over these kinds of energy sources, therefore brooding about some various solution is extremely necessary. Besides this, the main drawback of these conventional power plants is the production of pollution. therefore if we tend to choose renewable energy, it'll be higher however throughout the year the generation of all renewable energy power plants. since it's free of cost and abundant in nature. The grid-tied PV system is additional stable than a different PV system. Since there's no use of the battery, therefore, it tends to reduce its opportunity cost, therefore, we tend to choose the grid-connected topology. If generated solar power is mingled to the traditional grid, then it will fulfill the energy demand from morning to

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afternoon (total 6 hours primarily in sunny days) that is specific time vary once the star PV system will be fed to the grid. As no battery backup is there, meaning the utility can continue to provide to the rest of the period of time. Grid-connected systems have established benefit in natural disasters conjointly by providing emergency power provides within the affected places once utility power is interrupted. Since PV energy is usually costlier as compared to utility-provided power therefore, the utilization of grid-connected systems is increasing.

An electrical phenomenon system is formed from numerous electrical phenomenon solar cells. one little PV cell will generate regarding one or 2 Watts of power approx. For increased power output, PV cells could connect along to make high power panels. relying upon the ability station capability or the ability generation compatibility, cluster of panels is connected to make associate degree Array. solar PV systems sometimes created from numerous solar arrays. The performance of panels and characteristics could have an effect on entire system performance, supporting the potency or the presentation of the individual part or panel. Besides the solar PV module, the system parts include numerous parts therefore on be compatible with the grid-connected system. The introduced Sub-Multilevel Inverter topology has advantageous features over multilevel inverter scheme with less number of semiconductor switches that enhances to decreases power switching losses. To illustrate the effectiveness of the proposed scheme, various simulation cases have been generated with different combinations and system conditions. Later the proposed scheme has been connected to the grid and different simulation cases have been generated and the optimized combination was selected. So, it has been observed from the study that working performance of CHB MLI scheme and Batteryless grid photovoltaic system is best and would be proved to be a better option as compared to isolated hybrid systems in future.

The approach of the paper tends to prove that higher levels of multilevel inverters provide higher power efficiency along with the overall efficiency of the system. Therefore the multilevel Inverter configurations are high on demand that can hold efficient power Quality, low switching losses along with high voltage capabilities. MLI's provides less power switching losses and very low harmonic distortion that maintains system stability to constant. Results have been discussed in the later section using MATLAB/Simulink. The planned of 25- level sub-multilevel inverter, having conventional cascaded hybrid bridge (CHB) multilevel inverters can be simulated for both uneven (asymmetrical) and even (symmetrical) kind which is being victimized through MATLAB computer code.

Methodology and Basic Principle
The projected topology contains two H-Bridges that are linked to a common DC Source. There are bidirectional switches in the form of four IGBTs are used in the cascading circuit to conduct both positive and negative voltage levels and then two hybrid bridges consisting of 4 IGBT are attached further. In three phase system topology of 25level sub-multi level inverter scheme, as a source of DC, each inverter includes a set of four arrays along with 12 power semiconductors devices i.e. IGBT's the output of that, is able to produce voltages with stepped waveforms. The Modulation is carried out by all the IGBT's connected in a cascading circuit through the designed MATLAB function. The MATLAB function is provided with the following programming to trigger the gate pulses of IGBT's attached on the system. Moreover, by varying the values of DC input, the level of H bridges increases too. this is what known as new Hybrid H-bridge Inverter topology. The DC inputs here refers to PV arrays having different or the same voltage levels depends on solar irradiance and temperature. Below is showing the basic structure of 25level Sub-multilevel topology. For three phase system, each phase consists of 4 arrays arranges in series attached to the given circuit arrangement. Therefore three-phase system connected to grid consists of a total of 12 PV arrays assembled on it. The Simulink results are discussed in the later section.
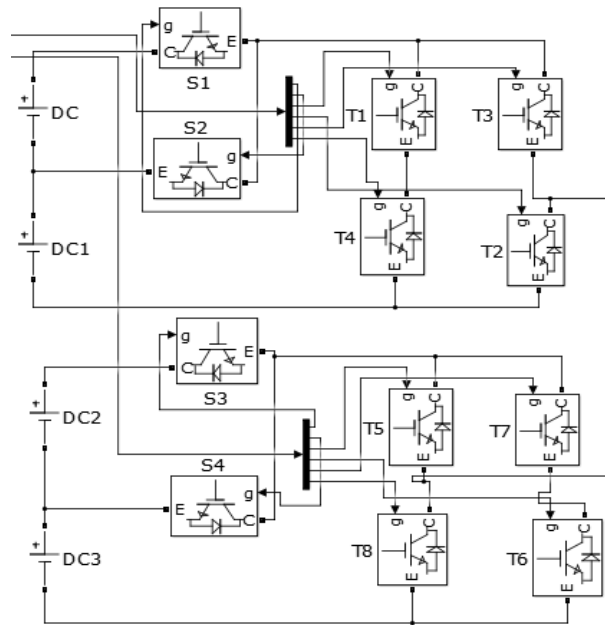
Fig.: 1. Basic Single Phase representation of CHB 25level Sub Multilevel Inverter Connected to DC sources

Sub-multilevel is defined as further subparts of multilevel topology, that is as shown in the figure. Each multilevel is connected to its two subparts in order to make a sub-multilevel topology. The cascaded Sub-multi-level inverters provide a better response when compared to other multilevel topologies because of the presence of balanced input voltage and freewheeling diodes.
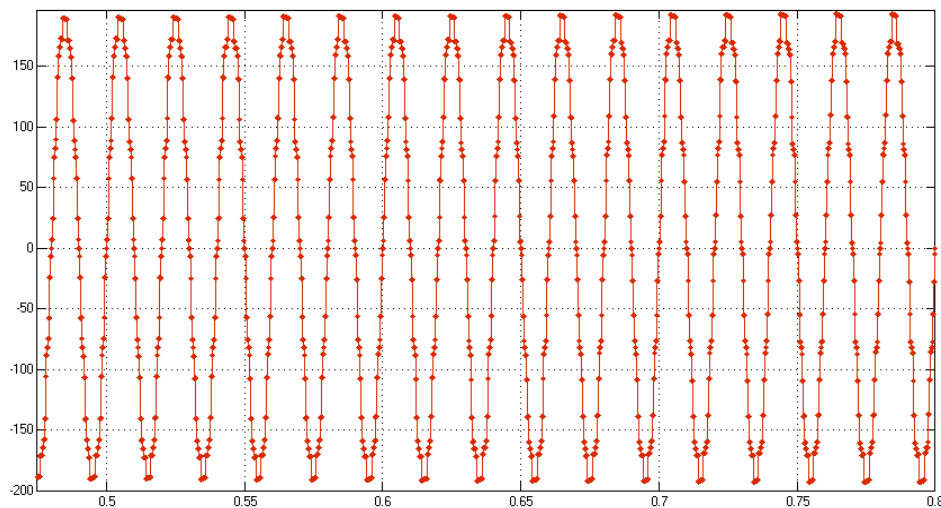
Fig.: 2. Showing Harmonic waveforms for Cascaded 25level Sub MLI Connected To PV Array on MATLAB

In this configuration the output percentage THD we get is very low but not exactly zero because due to this, the level of the inverter reaches infinity which is not a feasible solution for practical realization and hence the level of inverter is made limited to 25-levels and the output percentage THD is controlled with the implementation of the proposed PWM technique in 25-level CHB multilevel inverter.
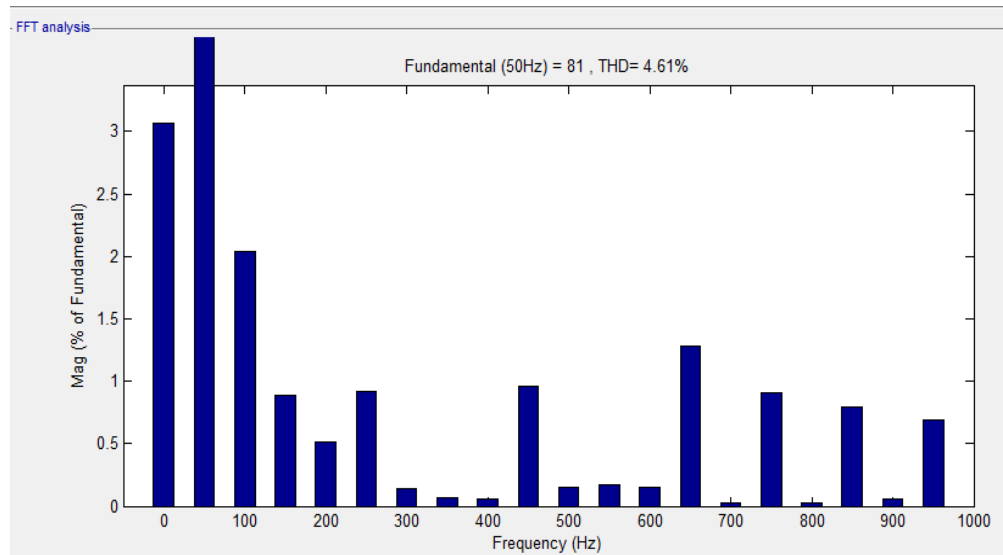
Fig.: 3. Showing THD Response on Of CHB 25level Sub Multilevel Inverter connected to PV arrays

In case of 25level CHB based sub-multilevel inverter in place of PWM technique, MATLAB function is being designed to provide so as to trigger the gates of respective switching circuits. This kind of techniques yields more or less the same output fundamental component only but attains the lower order harmonic distortion levels. The cascaded multilevel inverters for different levels are modeled in the MATLAB/SIMULINK environment. The implementation of the proposed technique reduces the THD value significantly that is only 4.61%. The evaluated THD values very much satisfying the limits prescribed by the different standards for THD.

Simulation Results and FFT/THD Analysis
Talking about the 25level based sub-multilevel topology, which is a new topology that requires a lesser number of switching components, fewer carrier signals, and gate drive circuits may compare to the conventional cascaded multilevel inverter. Thus, the overall cost and complexity of circuits of these inverters are greatly reduced. They also offer simple and more reliable control of the inverter and the efficiency of the inverter is increased as compared to conventional CHB inverters. The single phase of this topology can be seen in below MATLAB figure.
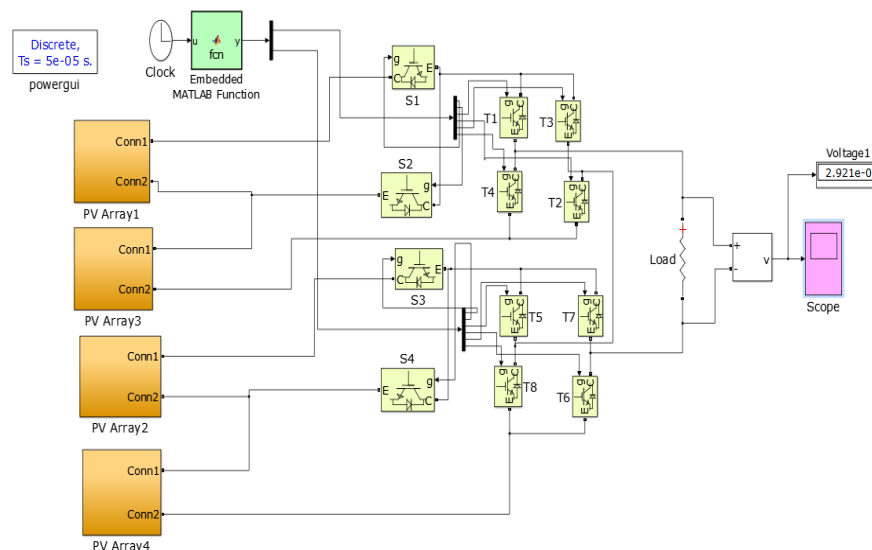

Fig.: 4. Single Phase Diagram of CHB 25level Sub Multilevel Inverter Connected to PV Arrays

Sinusoidal PWM is a novel modulation technique that is being proposed in this paper for 25Level sub-multilevel voltage source based inverter and simulation is done in the MATLAB/SIMULINK and its working & performance status are also analyzed. The output parameters like output percentage THD, Voltage/Current level are analyzed for three phase 25Level sub-multilevel . This modulation technique tends to provide higher modulation indexes, thus the % THD levels are low so its highly preferable for the practical applications. Switching losses or voltage drop across the switches is controlled by PWM modulation; by the way of switching angle control harmonics are eliminated.

To synthesize 25-level ph voltage, 3 firing angles are required. The same 3 switching angles can be used in all the three phases with delaying viz., 00, 120 and 240 electrical degrees for phases A, B, and C respectively. The three-phase 25-level cascaded H-bridge MLI o/p voltage response is discussed.The ac output of every H-bridge is connected in series such the synthesized output voltage wave is that the addition of all of the individual H-bridge's outputs. 25level Symmetrical Cascaded Sub MLI Connected To PV System on the grid is showing below.
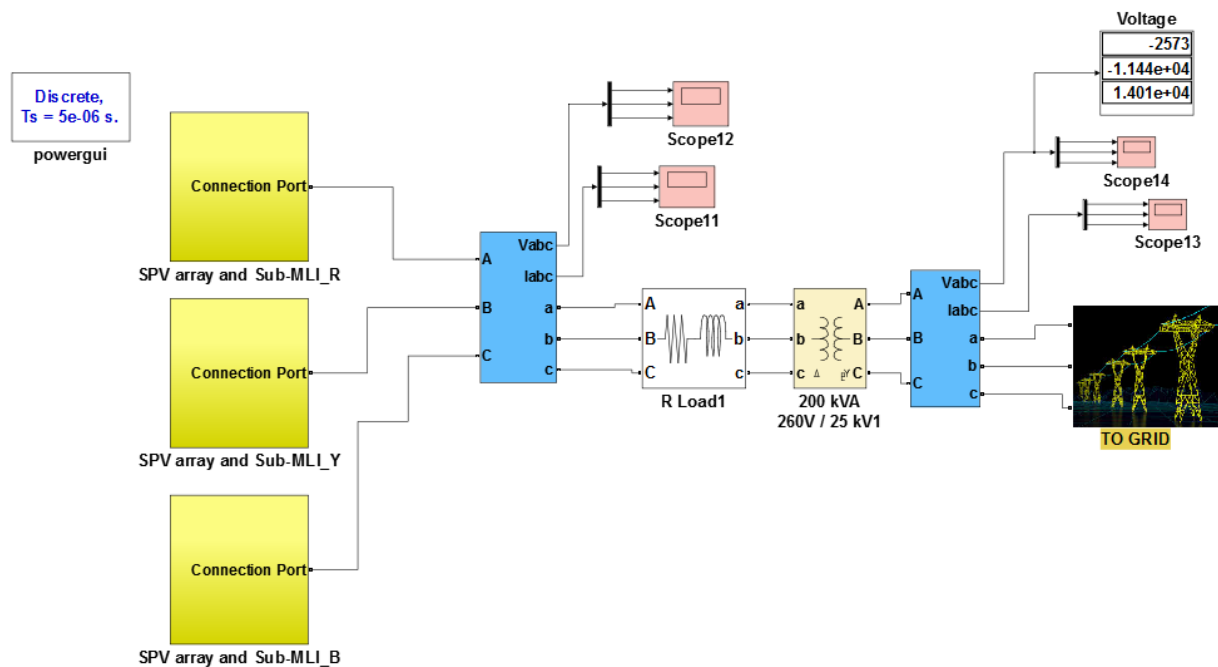
Fig.: 5. Grid-connected 25level Symmetrical Cascaded Sub MLI Connected To PV System

For a three-phase system, the output of 3 identical structure of single-phase cascaded inverter is connected in either star or delta configuration. this sort of inverter will manufacture N level voltages.

$$Van=Va_1+Va_2+Va_3+\ldots\ldots\ldots+Va_n \qquad \text{......................(i)}$$
$$Van=Vb_1+Vb_2+Vb_3+\ldots\ldots\ldots+Vb_n \qquad \text{......................(ii)}$$
$$Vcn=Vc_1+Vc_2+Vc_3+\ldots\ldots\ldots+Vc_n \qquad \text{......................(iii)}$$

Hence, the output voltage of Associate in forming N-level H- bridge multilevel inverter is that the addition of all the individual inverter outputs. Van is a voltage of phase A, Vbn is a voltage of phase B and Vcn is a voltage of phase C respectively. The electric potential diff. between A phase and B phase is Vab, which might be written as follows,
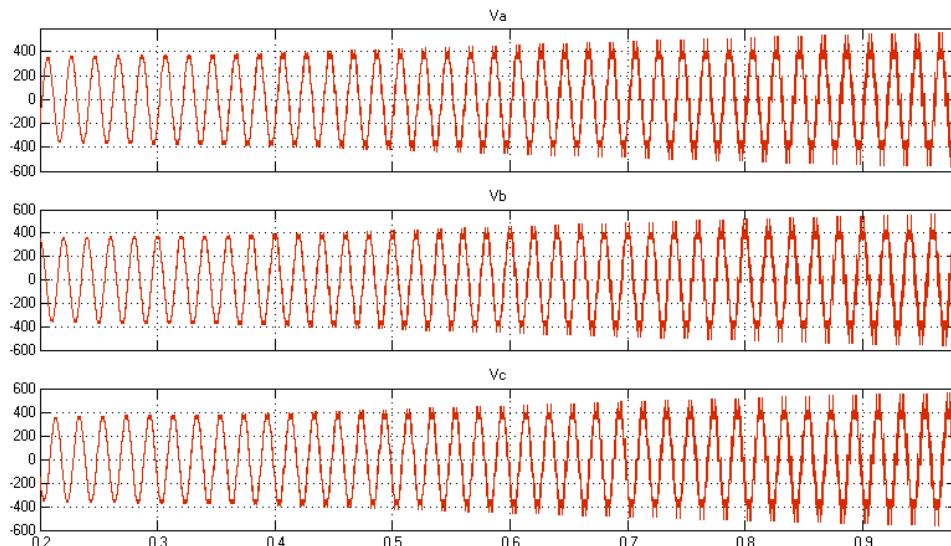
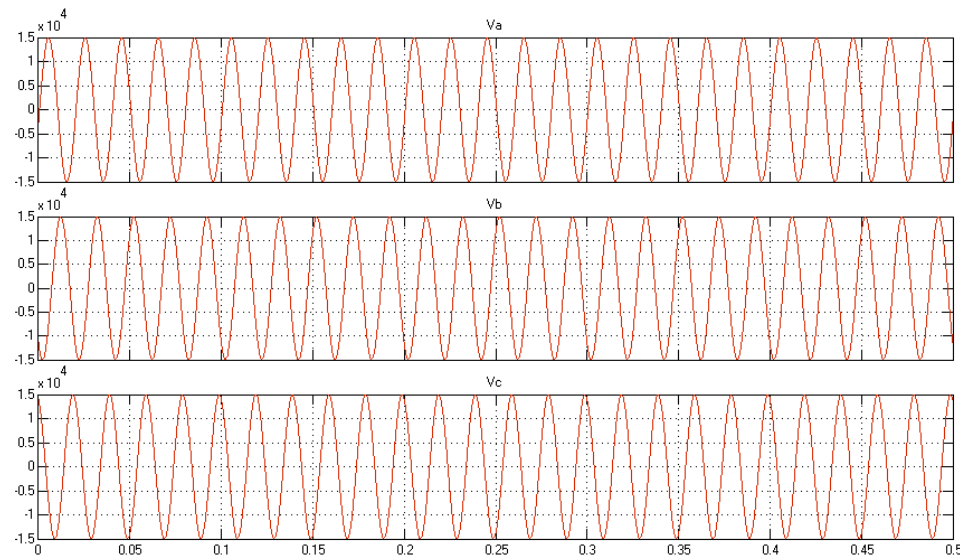$V_{ab} = V_{an} - V_{bn}$

V_{ab} is line voltage

V_{an} is phase A voltage with reference to point N and

V_{bn} is section B voltage with reference to point N

The voltage response for all three phases of 3phase 25sub-MLI can be shown.

**Fig.: 6.Voltage Three Phase 25level Sub-MLI Of V-I Measurement Block1**

Fig.: 7.Showing Voltage Response on Three Phase Grid-connected of 25level Symmetrical Cascaded Sub MLI (From V-I Measurement2)

The advantage of the three-phase system is that the triple harmonics elements within the line voltages are eliminated by common-fraction(of one-third) cycle phase shift feature. Therefore, solely non-triple harmonic elements have to be compelled to be eliminated from phase voltage. In single-phase nine-level wave, the 3rd, 5th, and 7th harmonics are eliminated from output phase voltage. Thus, the ninth(9th) harmonic is that the lowest harmonic part in phase voltage of the single-phase system, whereas the 13th harmonic is that the lowest harmonic part in phase voltage of 3 Phase system. The THD data analysis for all three phases of 3phase 25sub-MLI can be shown.
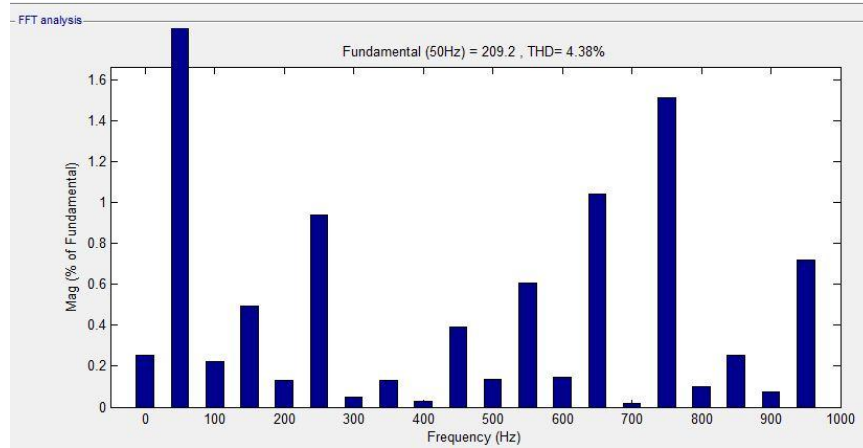
Fig.: 8.THD Analysis of 25level Symmetrical Cascaded Sub MLI For R Phase
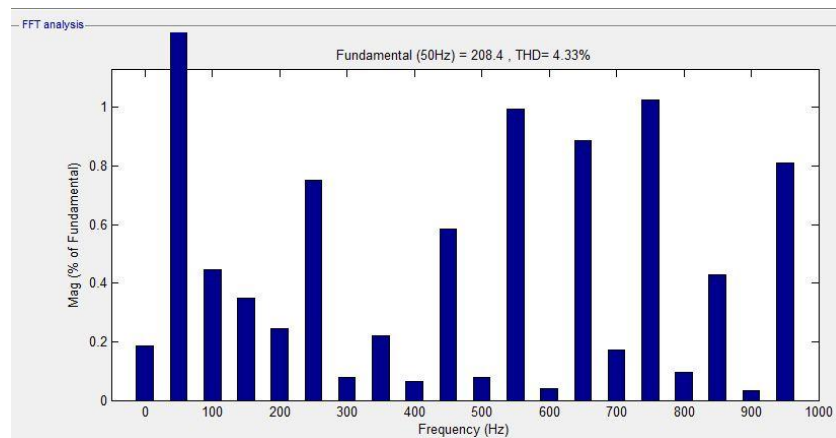
Fig.: 9.THD Analysis of 25level Symmetrical Cascaded Sub MLI For Y Phase
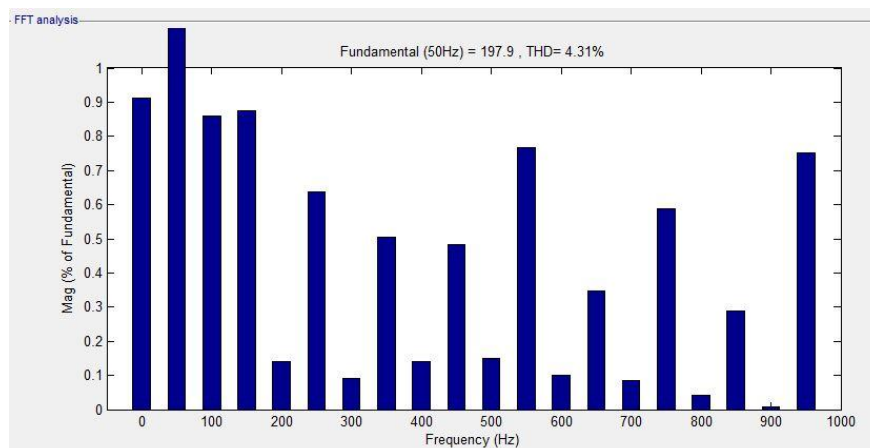
Fig.: 10.THD Analysis of 25level Symmetrical Cascaded Sub MLI for B Phase

The fundamental frequency is taken into account as $50Hz$ for *THD*. Since there's fewer harmonic within the voltage waveform, the MLI will be used directly for the combination of the three-phase grid system. This topology is often applied to high voltage applications by increasing the input DC voltage values.

THD of the output waveforms we found for 25level sub-multilevel CHB inverter for grid-connected PV system are 4.38% for R phase, 4.33% for Y phase and 4.31% for B phase respectively.thus all the phases hold nearly same THD response which shows that the system is quite stable.

Conclusions:-

The Sub-Multilevel inverters are most well-liked for both medium and high power rating applications, that provides the outputs nearly sinusoidal and a decrease of overall harmonic distortion throughout the operation of the multilevel inverter. Since the variety of levels can be increased from the output voltage that improves the power quality and it reduces the harmonic losses. CH-MLI have inherently superior harmonic performance as compared to the traditional 2-level inverter and conjointly can be operated at a lower switching frequency comparatively. To illustrate the effectiveness of the proposed scheme, various simulation cases can be generated with different combinations and system conditions. So, it has been observed from the study that working performance of CHB Sub-Multilevel inverter scheme that Batteryless grid photovoltaic system is best and would be proved to be a better option as compared to isolated hybrid systems in future. PWM modulation technique is applied so as to produce the switching pulses for the power semiconductor switches. The fundamental frequency of 50 Hz is used in this technique. Compare to other conventional MLI, since it holds less THD and switching losses. The Proposed Twenty five Level Asymmetric Inverter is used to reduce the number of an active element with less THD. The three-phase voltage response and THD data are also discussed through simulation to understand this topology comprehensively and effectively. The only disadvantage for cascaded multilevel H-bridge electrical converter is that the would like separate DC sources. The advantages of cascaded Sub-multilevel H-bridge inverter topology that we concluded in this paper are described as following:

  i.   The cascaded series structure permits an ascendible, modularized circuit layout and packaging because of the identical structure of every H-bridge.
  ii.   No further use of clamping diodes or voltage equalization capacitors is needed.
  iii.   Switching repetition for inner voltage levels is feasible since the phase voltage is o/p of the addition of every H- bridge.

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