Design a Standalone Photovoltaic System with Integration of Asymmetric Double H Bridge Multilevel Inverter

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ABSTRACT
Renewable energy sources play an essential role to meet the future energy demands in both rural and urban locations. Because of growing awareness of negative impact of fossil-fuel on the environment, it is very necessary to integrate renewable energy into the power grid to improve dependability and power generating quality. Solar energy is getting the most scientific interest of all non-conventional energy resources. Photovoltaic (PV) cells are used to convert the Solar energy into electrical energy. There is no emission of harmful greenhouse gas thus it's environmentally friendly. Solar (PV) system produces DC voltages, so to get AC power there is a need of power converters. A multilevel inverter can create a defined output voltage from several DC voltage levels at its input, whereas traditional PE converters can only flip between two voltage levels. The main problem with these power inverters is that they contain harmonics which affects the power quality. To overcome this problem different multilevel inverters and modulation techniques are adopted to get smooth AC waveform. An Asymmetric double H bridge MLI model is simulated in MATLAB/SIMULINK software. The proposed MLI is generating a 15-level output by feeding PV panel output in input side. To trigger the switches, multicarrier PWM technique is used and THD calculation is done by FFT analysis tool which is 8.16%. For getting maximum PV output, MPPT perturb and observe algorithm is employed.

General Terms
Renewable Energy, Multicarrier PWM technique, Multilevel Inverter

Keywords
Multilevel Inverter, Solar PV system, double H-bridge MLI, THD, MATLAB/SIMULINK software

1. INTRODUCTION
Renewable energy sources are viewed as a feasible alternative to fossil-fuel-based conventional energy. The research into obtaining energy from other sources such as solar, wind, and tidal is quickly advancing. One of the most significant is that the energy extraction from PV systems. The photovoltaic systemgenerates DC electricity [1]. The technique, which is used to get more power from a photovoltaic field is Maximum power point tracking [2]. MPPT works as a dc link. A dc–dc converter is used to provide a suitable dc connection of adequate magnitude [3]. The MPPT controller is a system component that provides the maximum amount of power to the load (batteries/motors) [4]. Many research on different MPPT methods, such as perturb and observe (P&O), differential techniquehave been described in different research to increase the efficiency and tracking performance [2]. But, because of simplicity, the P&O method is the most efficient and simple PV application method [5]. Grid integration and freestanding PV-fed systems both employ power electronics interfaces [6]. The Power inverter plays an important role in this. The DC nature of PV panel electricity must be converted into AC to fulfil household and industrial power demands. Multilevel inverters (MLIs) are a relatively the new form of power electronics converter. They're commonly used in the conversion of dc to ac power [1]. The appropriate combination of several input DC sources, and power semiconductor devices produces a staircase output voltage waveform in MLIs. As a result, In terms of performance, MLIs perform better than two-level converters[7]. There are two configuration options for the MLI's dc voltage sources: symmetrical and asymmetrical. Symmetrical configuration with equal input voltage magnitude to each H-bridge, and asymmetrical configuration with unequal input voltage magnitude to each H-bridge The THD for output voltage can be calculated as part of the research [6]. More levels are created in the asymmetrical mode than in the symmetrical mode. Previous research has proven the usage of a simple H-bridge for polarity creation (negative and positive), but the high voltage stress on the bridge switches prevents it from being employed in high voltage applications[3]. According to prior research, three primary topologies of the inverter are diode-clamped multilevel inverter/neutral-point-clamped (NPC), flying capacitor multilevel inverter, and cascaded multilevel inverter. Cascaded Multilevel inverter topology is the most preferred/used among these MLI [8]. The number of components rises dramatically with the number of layers in both NPC and FC designs, resulting in control strategy complexity, high volume, and expense. Increasing the quantity of levels using a cascaded H-bridge structure is a practical and effective approach [9]. Basic inverter designs inadvertently create harmonic values that could damage the electric equipment (load). Multilevel technology is encouraged by methods of lowering the harmonic content of the converter unit[10]. Power quality is affected by harmonic distortion, which causes energy loss and interference with electrical devices [11]. PWM is used to control the output voltage. The multicarrier PWM technique is used in this paper. In a multicarrier PWM scheme, carrier signals and the reference signal are compared, and the resulting pulses are utilized to switch devices at the appropriate voltage levels[12]. For modularity and flexibility, the power circuits are regulated by different multi-carrier PWM approaches[13]. There are different types of multicarrier pulse width

modulation, such as phase disposition (PD), phase opposition disposition (POD), alternative phase opposition disposition (APOD), phase shifted (PS), and hybrid PWM[14].This research presents a double H bridge configuration connected with three solar PV cells, each of which produces separate constant voltage. For modulation, multicarrier phase opposition disposition (POD) PWM is implemented. Also, for maximum power point tracking, P&O algorithm is employed, which ensures that maximum power is delivered to the output side.

2. METHODOLOGY

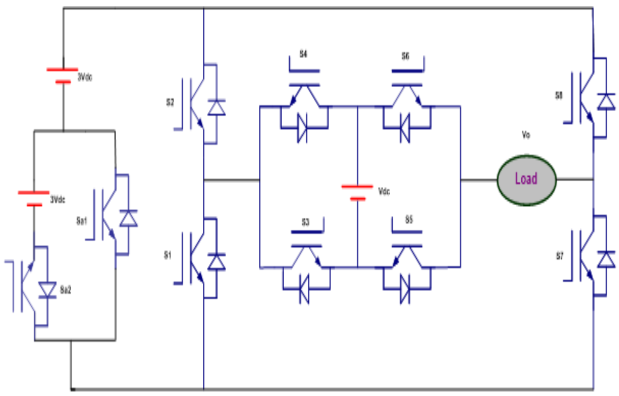
This model is 100mHsimulated in MATLAB/SIMULINK Software. THD of inverter output voltage is calculated using the Power GUI tool and FFT analysis. Table 1 shows the model parameters.

Table 1. Simulation Parameters

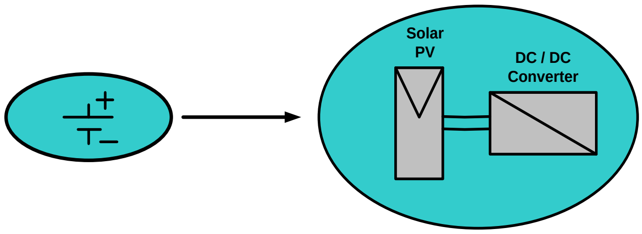
Sine wave frequency	50 Hz
Switching frequency for switches	1000 Hz
The levels of Output voltage	15 levels
Total number of carriers	14 carrier signals
Resistive (R) Load	100Ω
Inductive (L) Load	100Mh
Power Switches used in model	IGBT Power Switch
No. of Power Switches	10
Total DC Sources used	3
Different magnitudes of DC voltage sources	$V_1 =$ 120 V
	$V_2 =$ 120 V
	$V_3 =$ 40 V

3. DOUBLE H-BRIDGE MULTILEVEL INVERTER

The topology consists of three dc power sources and 10 switches. The configuration of every dc voltage source is asymmetrical.The circuit is composed of two generators, a level, and a polarity generator. The polarity generator generates output voltage with both polarities (positive and negative), whereas level generator generates output voltage at various levels. Figure 1 shows the basic block diagram of double H bridge- MLI.



(a)



(b)

Fig 1: (a) Block Diagram of Asymmetric Double H Bridge-MLI (b) replacement of DC sources with PV cells and converters

4. SIMULATION MODEL

4.1 Main Power Circuit

It consists of three Photovoltaic (PV) panels that generate steadyDC voltages. For getting maximum PV output, MPPT perturb and observe algorithm is used. The proposed MLI is generating a 15-level output and PV panel output is fed to it as an input. The simulation modelwith PV panels is shown in Figure2.

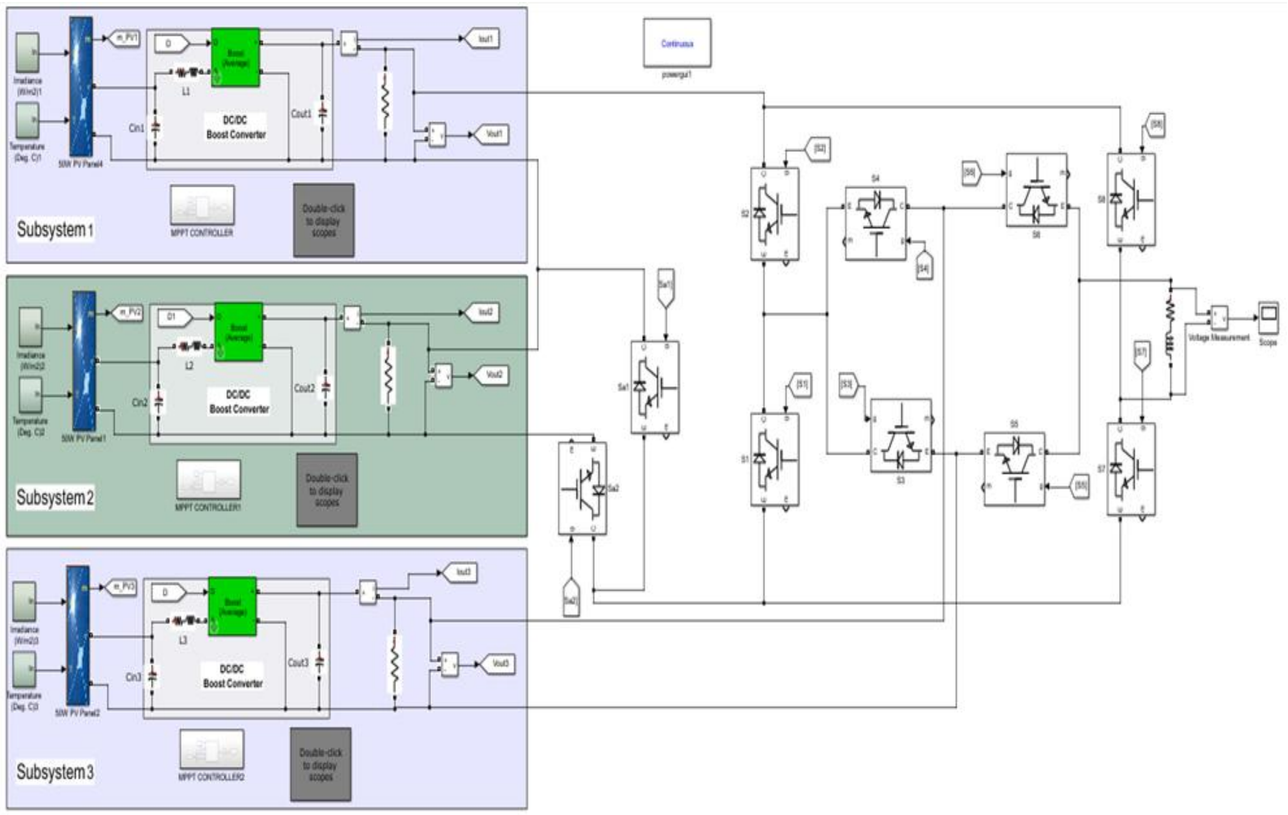


Fig 2: Simulation model for power circuit

4.2 Generalized Control Circuit

The switches are triggered using the multicarrier PWM technique. Figure 3 shows the multilevel inverter's generalized control strategy.

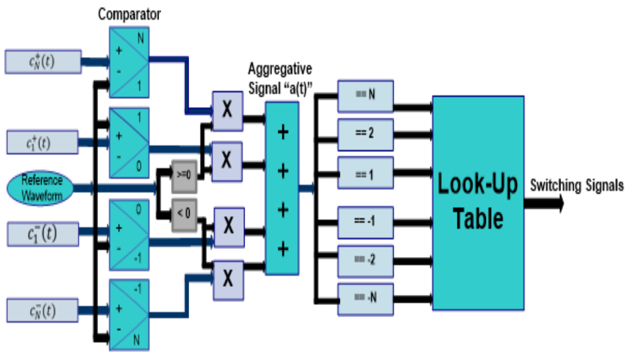


Fig 3: Generalized Double H bridge- MLI control scheme

Multicarrier phase POD-PWM is the control method employed. By combining comparators, logic, and relational operators, fourteen carriers are produced. Figure shows the carrier waveform for POD-PWM.

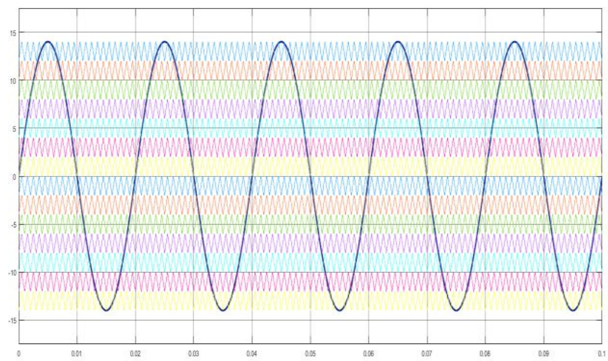


Fig 4: Multicarrier waveform

5. RESULTS

The proposed topology for double H bridge-MLI comprises of 10 IGBT switches and three DC voltagesources is simulated in MATLAB/SIMULINK software. By using POD-PWM technique, the switches are triggered.

5.1 Output Voltage Waveform

The maximum magnitude of 15-level AC output voltage is approximately 280V by triggering the power switches S2, S3, S6, S7, and Sa2 for positive side and on the negative side the switches S1, S4, S5, S8, and Sa2 are triggered for getting maximum output.

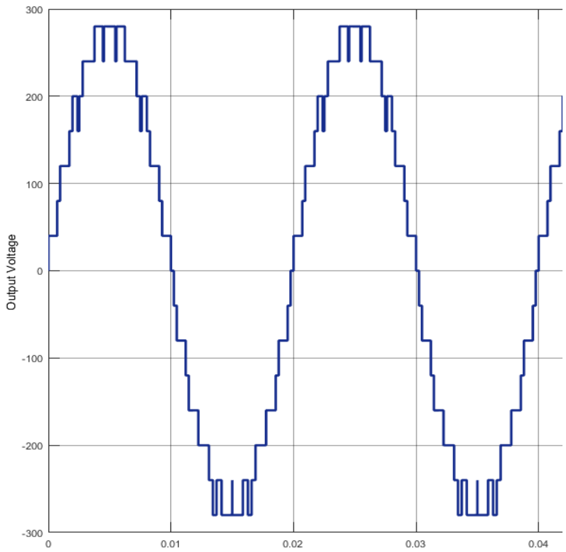


Fig 5: Output voltage waveform

5.2 The THD Analysis

Harmonic content in the output is measured by THD. For calculating the THD, FFT analysis tool is used. Figure 6 shows the THD at 281.4 for multicarrier POD-PWM, that is about8.16 %.

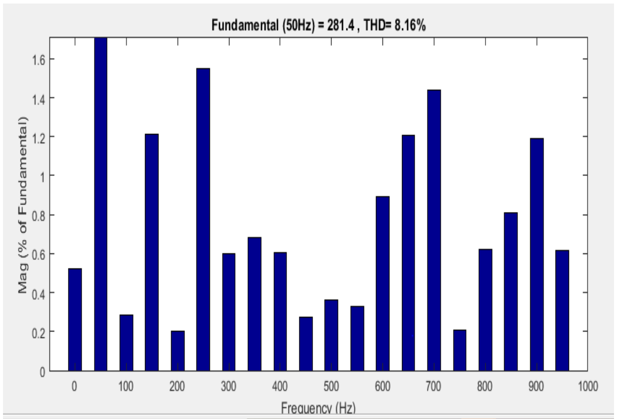


Fig 6: Output waveform of THD

6. CONCLUSION

This research focused on solar PV system's applications for the Double H-bridge-multilevel inverter. The main circuit of a double H-bridge is modelled in MATLAB/SIMULINK with IGBT Power switches, and the switches are triggered by multi-carrier POD PWM technique. The double H-bridge MLI topology, which is used in this research having many advantages, like,superior output voltage will be produced. Using the MPPT perturb and observe algorithms, the maximum PV output is obtained. The THD calculation is done by the FFT analysis tool which is 8.16%at 281.4.This proposed topology can be analyzed with the grid-integrated systems and the output can be integrated with other clean energy production. This topology having applications in drives and renewable energy system.

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