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A Hybrid Power Generation With Solar and Wind System Using Multi-Level Inverter

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ABSTRACT

With the increasing concerns on energy issues, the development of renewable energy sources is becoming more and more attractive.Anew kind of wind-PV hybrid generated system that comprises of wind and photovoltaic generation subsystems as input to a cascaded H-bridge multilevel inverter is developed in this paper. In conventional methods the inverter with solar and wind energy sources are used. In this method a seven and three levelmultilevel inverter with wind–PV hybrid generation system as input are proposed for application to remote and isolated areas. The wind and the solar light are captured in greatest degree, as well as the multilevel inverter using pulse width modulation technique is adopted. The objectives of this hybrid system are, to satisfy the load power demand and, presence of high number of output levels in inverter to maintain the dc output voltage level of the inverter to produce a nearly sinusoidal output. This reduces harmonics in inverter output voltage. This paper discusses about the control of seven-level and three level H-bridge cascaded multilevel inverter with Fast Fourier Transform analysis in inverter output voltage through simulation.

Key Words:

Cascaded H-Bridge, PWM, SPWM.

1. INTRODUCTION

Solar and wind are the renewable energy sources. The solar and wind energy sources are becoming more important since it produces less pollution and the cost of fossil fuel energy is rising, because of shortage of fossil fuels and greenhouse effect. Now a days , fossil fuel is the main energy supplier of the world wide economy, but it is a major cause of ecological problems (such as global warming, air pollution etc.). The need of

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producing more energy combined with the interest in green energy technologies results in an increased development of power distribution systems using renewable energy sources (RES) such as wind energy, solar, hydro, biomass, wave energy, tidal power and geo thermal energy .

Among various types of renewable energy sources, solar energy and wind energy have become very popular and demanding due to advancement in power electronic techniques. Solar technologies tap directly into the infinite power of the sun and use that energy to produce heat, light and power. Wind is one of the most environment friendly, clean and safe energy resources. The development of solar power generation should be integrated with that of the wind power generation systems since both forms of renewable energy have inherently random property and they can compensate the lack of energy for each other. Hence, the wind and solar power system therefore has higher reliability to deliver continuous power than either individual source.

The objective of this proposed project is to propose a novel multilevel inverter using hybrid solar and wind power system in order to simplify the power system and reduce harmonics and the cost effect. Multilevel inverter using combination of solar and wind was implemented by PWM modulation technique. Pulse Width Modulation method is a fixed dc input voltage is given to the inverters and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and in this method is known as pulse width modulation (PWM CONTROL). Which is confirmed by MATLAB, the MATLAB is used to confirm the seven level and three level output voltage of inverter.

2. CONSTRUCTION AND WORKING OF SOLAR AND WIND POWER SYSTEMS

2.1 BLOCK DIAGRAM OF THE PROPOSED PROJECT

Fig. 2.1 shows the block diagram of the hybrid power generation system with solar and wind using multi level inverter

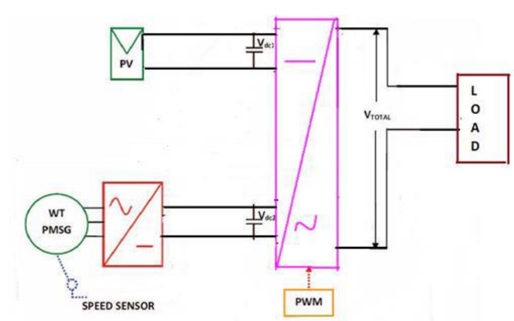

Fig 2.1 block diagram of a hybrid power generation with solar and wind using multi level inverter

The wind turbine is followed by a PMSG generator, which generates an AC voltage which is further rectified to DC voltage through a rectifier unit. The input for the inverter unit is taken from the DC link, the dc link is given to multi level inverter. The solar system generates a dc voltage. The output of the solar is given to the multi level inverter. The multilevel inverter is a device which converts dc to ac output voltage. The ac voltage is fed into utility.

The seven and three level cascaded H-bridge multilevel inverter block with wind and photovoltaic generation systems as input sources block diagram is shown in Fig 2.1. The block diagram consists of a solar panel, wind energy system, full bridge DC-AC inverter. The level dc voltage sources of solar and wind are obtained from the solar array and wind speed. The output from the solar panel and rectified wind turbine ac voltage is given to the multi level inverter. By applying the Pulse-With-Modulation (PWM) control scheme to the power switches in the multi level inverter.

The solar array and wind turbine simultaneously. Diode rectifier is used at the wind output to convert ac power obtained from wind module into dc power to be fed to the multilevel inverter. Seven and three level cascaded H-bridge inverter is used. The voltage output of cascaded H-bridge multilevel inverter is given to a resistive load. The solar and wind power generation system using Three-level cascaded H-bridge inverter is similar to seven-level cascaded H-bridge inverter.

3. CONTROL STRATEGY

3.1 Introduction to Pulse-Width Modulation (PWM)

Pulse Width Modulation method is a fixed dc input voltage is given to the inverters and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and in this method is known as pulse width modulation (PWM CONTROL).

A modulation technique used to encode a message into a pulsing signal. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to

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electrical devices, especially to inertial loads such as motors.

In addition, PWM is one of the two principal algorithms used in photovoltaic solar battery chargers, the other being maximum power point tracking.

The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast rate. The longer the switch is on compared to the off periods, the higher the total power supplied to the load. The PWM switching frequency has to be much higher than what would affect the load (the device that uses the power), which is to say that the resultant waveform perceived by the load must be as smooth as possible. The rate (or frequency) at which the power supply must switch can vary greatly depending on load and application, for example the basic concept behind multilevel inverter/converter is to use low power rating devices instead of high power rating devices to build up medium voltage inverter system. The power rating of devices used in the multilevel inverter topologies is reduced, thereby reducing the cost.

Sinusoidal Pulse width modulation

Sinusoidal Pulse Width Modulation (SPWM) Figure 3.5 explains the generation of a sinusoidal PWM signal, which finds more applications in industries. the gating signal can be generated by comparing a sinusoidal reference signal with a triangular carrier wave and the width of each pulse varied proportionally to the amplitude of a sine wave evaluated at the center of the same pulse. The output frequency (fo) of the inverter can be found by using the frequency of the reference signal (fr).

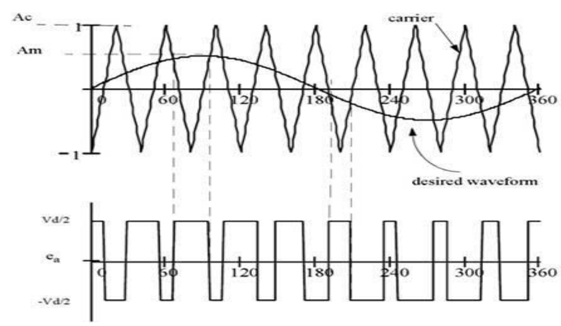

Fig 3.5 Generation of Sinusoidal pulse width modulation

4. SYSTEM OPERATION

4.1 OPERATION OF THE MULTILEVEL INVERTER

The proposed three and seven level are load connected MLI is an enhanced version of the inverter. It consists one inverter is connected in cascade. Fig 4.1 shows the proposed hybrid power generation with solar and wind using multilevel inverter.

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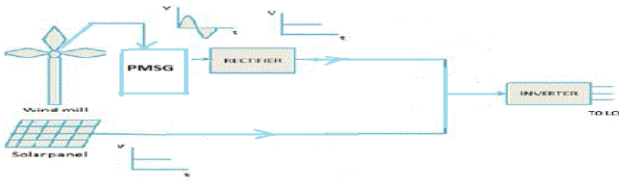

Fig 4.1 The proposed hybrid power generation system with solar and wind using multilevel inverter.

The solar system generates a dc voltage. The output of the solar is given to the multilevel inverter. The multilevel inverter is a device which converts dc to ac output voltage. The ac voltage is fed into utility. The wind turbine is followed by a PMSG generator, which generates an AC voltage which is further rectified to DC voltage through a rectifier unit. The input for the inverter unit is taken from the DC link, the DC link is given to multilevel inverter.

4.1.1 Operation of the proposed seven-level multilevel inverter

Seven-level inverter is composed of a capacitor selection circuit and a full-bridge power converter, which are connected in cascade. Operation of the seven-level inverter can be divided into the positive half cycle and the negative half cycle of the utility. For ease of analysis, the power electronic switches and diodes are assumed to be ideal, while the voltages of both capacitors C1 and C2 in the capacitor selection circuit are constant and equal to Vdc/3 and 2Vdc/3, respectively.

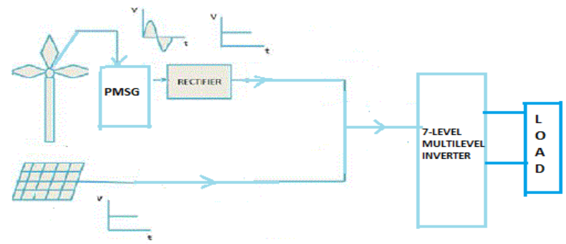

Fig 4.2 Operation of the proposed seven-level multilevel inverter.

Since the output current of the solar and wind power generation system will be controlled to be sinusoidal and in phase with the utility voltage, the output current of the seven-level inverter is also positive in the positive half cycle of the utility. The operation of the seven-level inverter in the positive half cycle of the utility can be further divided into four modes, as shown in Fig.4.3

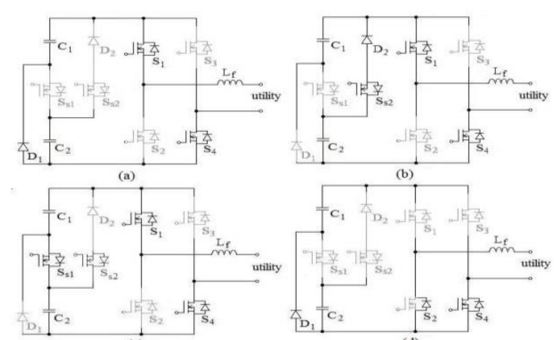

Fig. 4.3 operation of seven-level inverter in the positive half cycle, (a) mode 1, (b) mode 2, (c) mode 3, (d) mode 4.

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Mode 1

The operation of mode 1 is shown in Fig. 4.3 (a). Both SS1 and SS2 of the capacitor selection circuit are off, so C1 is discharged through D1 and the output voltage of the capacitor selection circuit is Vdc/3. S1 and S4 of the full-bridge power converter are on. At this point, the output voltage of the seven-level inverter is directly equal to the output voltage of the capacitor selection circuit, which means the output voltage of the seven-level inverter is Vdc/3.

Mode 2

The operation of mode 2 is shown in Fig.4.3 (b). In the capacitor selection circuit, SS1 is off and SS2 is on, so C2 is discharged through SS2 and D2 and the output voltage of the capacitor selection circuit is 2Vdc/3. S1 and S4 of the full bridge power converter are on. At this point, the output voltage of the seven-level inverter is 2Vdc/3.

Mode 3

The operation of mode 3 is shown in Fig. 4.3(c). In the capacitor selection circuit, SS1 is on. Since D2 has a reverse bias when SS1 is on, the state of SS2 cannot affect the current flow. Therefore, SS2 may be on or off, to avoiding switching of SS2. Both C1 and C2 are discharged in series and the output voltage of the capacitor selection circuit is Vdc. S1 and S4 of the full-bridge power converter are on. At this point, the output voltage of the seven-level inverter is Vdc.

Mode 4

The operation of mode 4 is shown in Fig. 4.3(d). Both SS1 and SS2 of the capacitor selection circuit are off. The output voltage of the capacitor selection circuit is Vdc/3. Only S4 of the full-bridge power converter is on. Since the output current of the seven-level inverter is positive and passes through the filter inductor, it forces the anti-parallel diode of S2 to be switched on for continuous conduction of the filter inductor current. At this point, the output voltage of the seven-level inverter is zero. Therefore, in the positive half cycle, the output voltage of the seven-level inverter has four levels: Vdc, 2Vdc/3, Vdc/3 and 0.

In the negative half cycle, the output current of the seven-level inverter is negative. The operation of the seven- level inverter can also be further divided into four modes, as shown in Fig.4.4. A comparison with Fig. 4.3 shows that the operation of the capacitor

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selection circuit in the negative half cycle is the same as that in the positive half cycle. The difference is that S2 and S3 of the full-bridge power converter are on during modes 5, 6 and 7, and S2 is also on during mode 8 of the negative half cycle. Accordingly, the output voltage of the capacitor selection circuit is inverted by the full-bridge power converter, so the output voltage of the seven-level inverter also has four levels: -Vdc, -2Vdc/3, -Vdc/3 and 0. In summary, the output voltage of the seven-level inverter has the voltage levels: Vdc, 2Vdc/3, Vdc/3, 0, -Vdc/3, - 2Vdc/3 and -Vdc.

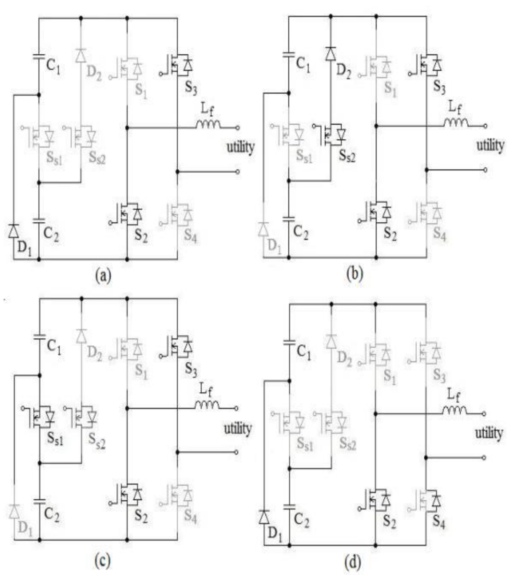

Fig. 4.4 operation of seven-level inverter in the negative half cycle, (a) mode 5, (b) mode 6, (c) mode 7, (d) mode 8.

The seven-level inverter is controlled by the current mode control, and pulse-width modulation (PWM) is use to generate the control signal for the power electronic switch.

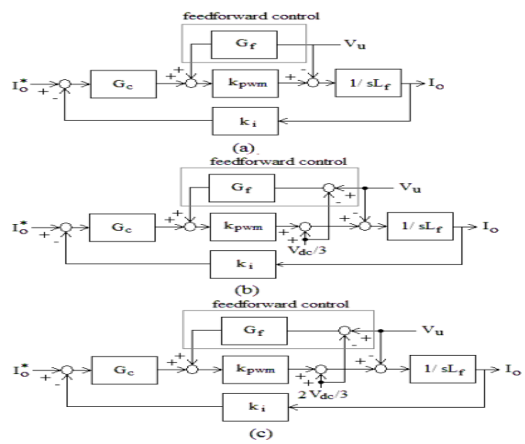

Fig. 4.5 model of seven-level inverter under different range of utility voltage,(a) in the range of smaller than Vdc/3, (b) in the range of (Vdc/3, 2Vdc/3), (c) inthe range of higher than 2Vdc/3.

4.1.2 Operation of the proposed three-level multilevel inverter

The cascaded H-bridge inverter has drawn tremendous interestdue to the greater demand of medium-voltage high-power inverters. Itis composed of multiple units of single-phase H-bridge power cells.

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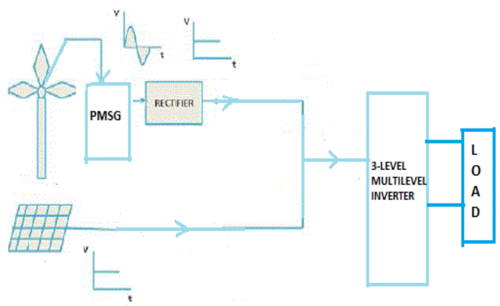

Fig 4.7 Operation of the proposed three-level multilevel inverter.

The H-bridge cells are normally connected in cascade ontheir ac side to achieve medium voltage operation and lowharmonic distortion .The single phase H-bridge cell, which is thebuilding block for the cascaded H-bridge inverter is associatedwith separate dc source.

SIMULATION RESULTS

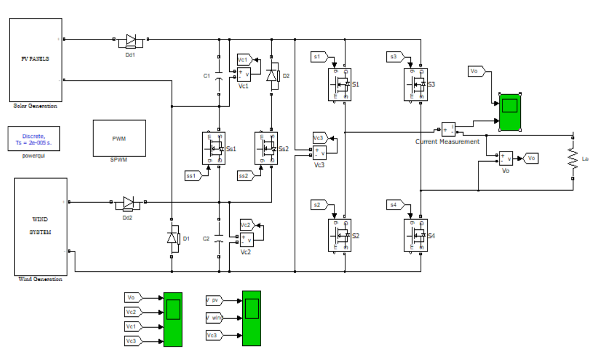

fig 5.1 simulation model of hybrid power generation using seven-level inverter

Table 5.1 Parameters of Hybrid Power Generation Using Seven-Level Inverter

Seven –level inverter	
Solar cell temperature	25°C
Wind turbine speed	12 m/s
Capacitor C_1, C_2	1000μF
PWM frequency	15360 Hz
Output voltage of inverter	600V
Output current of inverter	60A

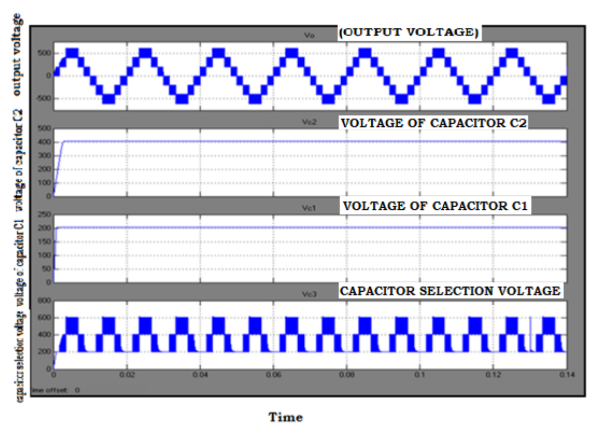

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fig 5.2 voltage waveforms of capacitors C1,C2

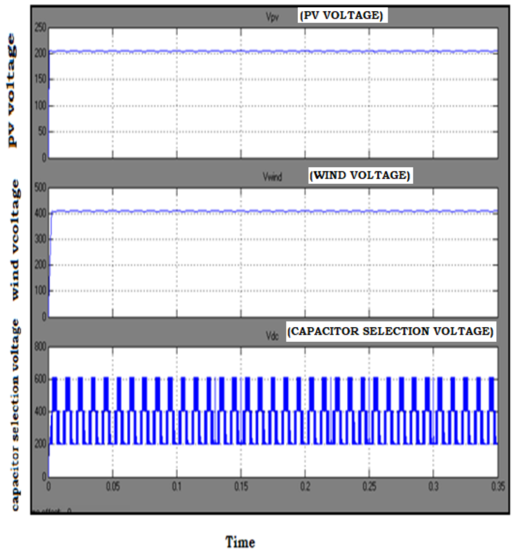

fig 5.3 output voltage waveforms of solar and wind

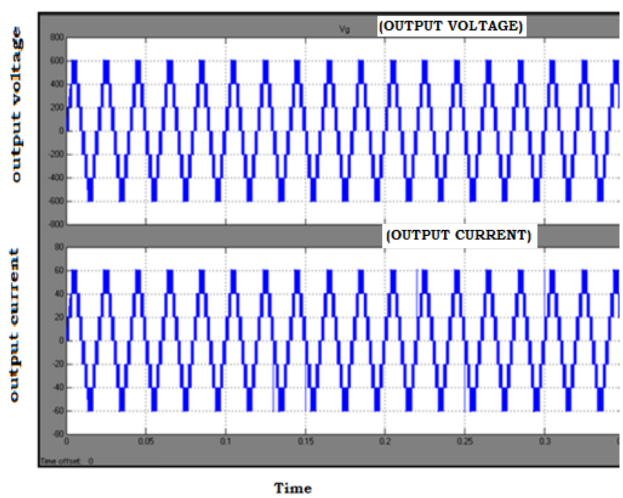

fig 5.4 output voltage and current waveforms of 7-level inverter

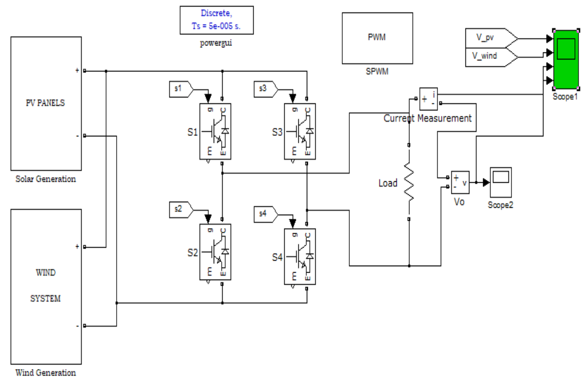

fig 5.5 simulation model of hybrid power generation using three-level inverter

Table 5.2 Parameters of Hybrid Power Generation Using Three-Level Inverter

Three–level inverter	
Solar cell temperature	25°C
Wind turbine speed	12 m/s
PWM frequency	15360 Hz
Output voltage of	400V

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inverter	
Output current of inverter	0.8A

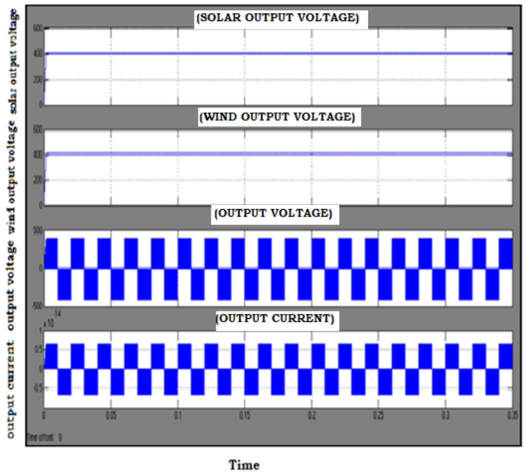

fig 5.5 output waveforms of hybrid system using Three-level inverter

CONCLUSION

In this proposed project seven and three level cascaded H-bridgemultilevel inverter is used to get sinusoidal stepped output waveform, it is used to also reduces the harmonics in output voltage and theoutput results of both inverters are compared by using theMATLAB/SIMULINK.The seven and three level cascaded H-bridgemultilevel inverter fed by solar and wind energy source have beenillustrated in simulation results by using MATLAB. Many people livein isolated areas far from the main utility grid. In such remote orisolated areas, the wind-solar hybrid generation system is particularlyvaluable and attractive. Since the cost of conventional energyresources are increasing every year, this system is going to beeconomical in future. Besides the cost, the environmental benefits arelikely to facilitate the widespread use and acceptance of this system.Thus the above proposed system is reliable and economical for remoteapplications.

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