Multilevel Inverter based Grid connected Hybrid Power Generation System with Energy Storage

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Abstract : Consumers expect efficient of power which is obtained from high quality output voltage. It is achieved by reducing the Total Harmonic Distortion (THD) by using the filters. This paper presents a comparison of Total Harmonic Distortion using different multilevel inverters in a Hybrid Renewable Energy Generation System (HREGS) connected to energy storage system considering the controller in both time and frequency domain. The proposed controller provides excellent transient and steady state performance than that of the existing one. The Multilevel Inverter (MLI's) are efficient than the ordinary single level inverter. The MLI produce output which is nearly sinusoidal as a result the harmonic content will be reduced and the efficiency will be better.

IndexTerms - Total Harmonic Distortion (THD), Multilevel Inverter (MLI's), Hybrid Renewable Energy Generation System (HREGS)

I. INTRODUCTION

Electricity has emerged as a key function in mankind. So, it's important to offer energy to all individual. Because of energy crisis demand, the up rise in the price and the exhaustible nature of fossil gas and the worsening global environment have the made the usage of renewable energy as the best method for the electricity generation in the present energy era. The solar energy and wind energy are playing a dominant role in the generation of electricity. The concept of Hybrid Renewable Energy Generation System (HREGS) is very much efficient by utilizing the solar energy and wind energy. The solar energy is obtained from solar Photovoltaic (PV) panels and wind energy is harnessed through wind turbine.

An Energy Storage System (ESS) is used to store energy generated. The Battery, Super capacitor, Superconducting magnetic energy storage (SMES) are used as energy storage system. The solar energy radiation will be higher in the afternoon and it has to be utilized in a proper manner. And, also the wind velocity depends on the difference between the areas of high pressure and low pressure. They both are independent of each other and this mismatch makes the usage of energy storage units in the residents. Therefore, it stores the energy when the demand is lower than the generation and supplies energy when the demand is higher than the generated power. And, this has become the chief for the concept of Smart Grid implementation. The control of AC/DC converter is of great importance for the integration of the energy storage unit in HREGS.

The conversion of direct current (DC) into alternating current (AC) is achieved by a converter and is called as an inverter. The reverse operation i.e. conversion of AC into DC is done by the Rectifier. For the better power quality, the converter harmonics must be less and it also prevents the damage of the equipment. Hence, it is a must to benefiting inverter than the conventional inverter. The conventional inverter has the disadvantage of higher harmonics content and it's efficient to use the multilevel inverters which are presently hiked in the usage because of its lower order harmonics.

II. METHODOLOGY

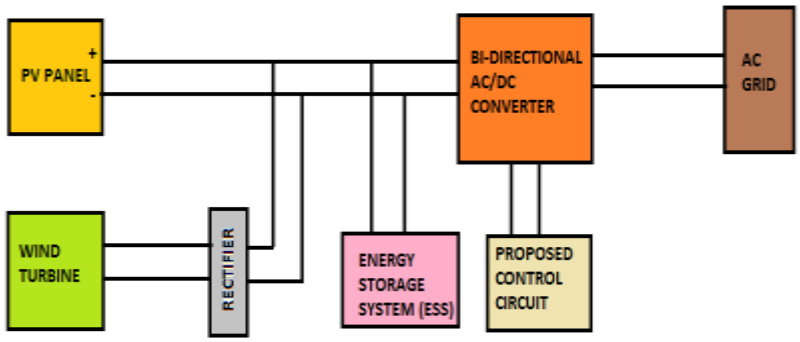

Figure 1.1: Block diagram of the proposed system

The block diagram for the proposed system is shown in the Figure 1.1. It consists of the following components.

PV PANELS: It is a power electronic semiconductor device which generates electricity when the sunlight falls on it. They are also called as "Solar panel". The conversion of direct sunlight into electricity is achieved using the Photovoltaic technologies through the PV panels. These panels produce Direct current (DC). These panels depend upon the technology used and the life span for these is around 25years. These panels are available in wide range of ratings and can be chosen depending upon the requirement of the load.

WIND TURBINE: It is a device which converts the moving air kinetic energy into electrical power. The moving air kinetic energy is also called as wind energy. The wind turbine blades revolve around 13-20 revolutions per minute depending upon the capacity of the wind power plant. They provide higher efficiency when the wind velocity is high and vice versa. The life span for these turbines is around 25years.

RECTIFIER: A Rectifier is a converter which converts AC into DC. This operation is achieved by the Rectifier. Since, the wind turbine provides AC power its necessary to convert it into DC so as to connect with the solar panels as they produce DC power for the concept of Hybrid Power Generation for higher efficiency.

BI-DIRECTIONAL AC/DC CONVERTER: The bi-directional AC/DC converter acts as both inverter and rectifier depending upon the operation performed. When the power is supplying to the grid it acts as a inverter and when the energy is to be stored in the battery it acts as a rectifier for conversion process as battery stores energy in DC.

ENERGY STORAGE SYSTEM: An energy storage system is a device used to store the energy. There are various types of energy storage devices such as battery bank, super capacitors etc. They store energy in the form of DC. They store energy when the load requirement is lower and supplies energy when the load requirement is higher than the generation. The Nickel metal hydride battery is used because of its higher efficiency.

CONTROL CIRCUIT: The control circuit is designed by using two domains such as Time domain and frequency domain. It controls the operation of the system and provides better transient and steady state performance as the two domains are taken into account. The conventional controller was designed either in time domain or frequency domain

AC GRID: It is a network which is interconnected for supplying of electrical power to the consumers from the generating station. They are designed to supply voltages at high amplitudes.

III. WORKING PRINCIPLE

The HREGS system obtained from connecting solar and wind in parallel are already implemented in the country. The generated power from solar is Direct Current (DC) and that of the wind is Alternating current (AC). Hence a rectifier is connected on the wind energy generation system to connect solar and wind in practical. The energy generated is given to the grid. But this process undergoes so many losses due to the unwanted disturbances so called as Harmonics. The harmonics are produced in the converter system while converting from AC-DC or DC-AC depending upon the required operation

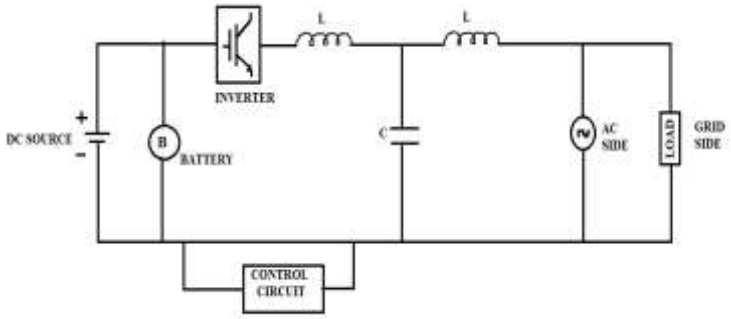

Figure 3.1: Circuit diagram, of the proposed system

The power generated is given to the converters to convert it into AC from DC when it's been supplied to the grid and another converter converts DC into AC when storing in the energy storage device. The rectifier acts as inverter when the pulse is given to it and acts as a rectifier when the pulses are not given to it.

The operation of inverter produces lower order harmonics which makes the system more disturbed and results in the lower efficiency. The filter design would also be high if the harmonics is more in the system. After these filtrations, the power is given to the grid for the domestic use.

IV. SIMULATION AND RESULTS

The simulation of the proposed is obtained using MATLAB using Simulink. A comparison of 3 level and 5 level inverter results are obtained using the simulation of the circuit. The results are obtained using the FFT analysis in the circuit simulation.

Table 1: Comparison of the results

Parameters	1 level Inverter	3 level Inverter	5 level Inverter
Input Voltage	220V	220V	220V
Grid current	10A	10A	10A
THD of fundamental in the output voltage	9.23%	0.08%	0.08%
THD of fundamental in the output current	11.79%	2.03%	1.38%

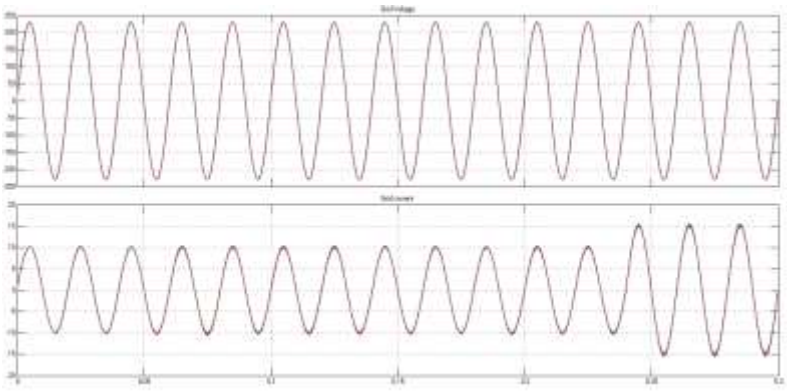

Fig 4. 2: Grid voltage and current waveform

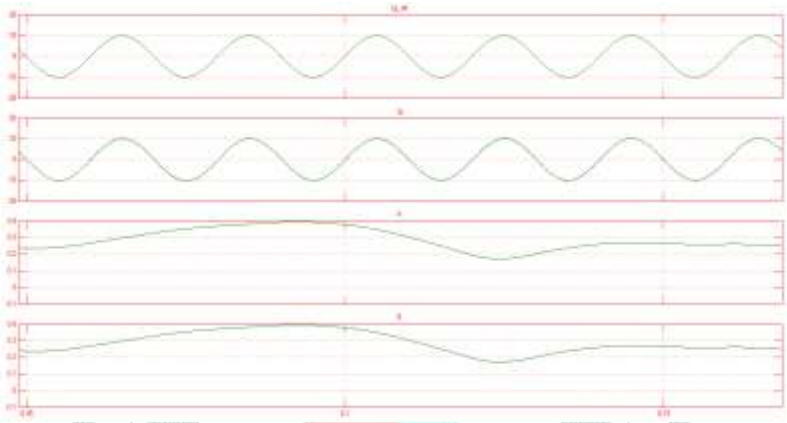

Fig4.3: Reference grid current waveform

IV. CONCLUSION

In the Existing days the consumers are expecting good power quality. To establish this, the output voltage quality should be good. It is achieved by reducing the unwanted disturbances by using the filters which reduces the total harmonic distortion. The reduction of Total Harmonic Distortion (THD) is obtained by using multilevel inverters instead of ordinary single level inverters. The usage of multilevel inverters provides nearly a sinusoidal output waveform due to which the output is of staircase form. As the number of levels of the inverters increased, the output waveform was becoming almost sinusoidal and it resulted in the reduction of Total Harmonic Distortion. The principle thought behind outlining the proposed framework is to enhance the output voltage quality and making it nearer to sine wave. To accomplish a decent quality output voltage, Total Harmonic Distortion of the output voltage waveform ought to be less.

A MATLAB simulation of multilevel inverters are done where the comparision of results for a 3-level and 5-level inverter are obtained. The hardware results of multilevel inverter is proposed in this undertaking study. The results showed that, higher the number of levels, lower will be the Total Harmonic Distortion and better will be the quality of the output voltage.

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