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"Power Quality Improvement in Solar PV and Wind Based Energy Sources: A Review"

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Abstract: *Nowadays, The demand of electrical energy is substantially increases due to which fossil fuel consumed at excessive charges. To prevent customers from lagging of energy and to meet their needs, non-conventional Energy system is a precise solution. The overall performance of the electrical distribution companies can be improved by the usage of non-conventional energy resources. There are different forms of Non-Conventional energy resources. Among them Solar PV and wind energy are to be had abundantly in huge quantity and can be considered as reliable source of energy generation. Power Quality is one of the key factors, which influences the economy of a nation. In this Paper, a grid connected Solar PV and Wind based energy sources of hybrid generating system was developed with improved power quality features.*

Keywords: *Solar PV, wind generator, unified control strategy, hybrid power generating system, power quality.*

I. Introduction

As generation and distribution companies in the marketplace have been seeing an increasing interest in the renewable energy sources and also seeing demands from the customers for higher quality power and cleaner electricity, we are in need to switch over for renewable energy generation methods. In order to reduce the greenhouse gas emission and to satisfy the demand of electricity, the trend converges to the use of renewable energy sources. Solar PV and Wind energy technologies have an extensive share in the use in hybrid electricity generating structure, because of emission free and no cost of energy. Hybrid Solar PV and Wind systems are one of the most efficient approaches to supply power directly to a utility grid.

Wind turbine converts kinetic energy of the wind into the mechanical energy or power and the mechanical energy is similarly converted into electrical energy through the variable speed synchronous wind generator. Solar is a non – linear power source, whose radiation changes time to time regularly, whereas the output power of the Solar Photovoltaic (PV) panel varies with temperature and its isolation. A single Solar Photovoltaic (PV) Cell produce low voltage therefore several Number of PV cells are combined to form modules or Solar panel to produce the desired output voltage.

Energy generated from the Solar PV and Wind generator is fed to the DC/AC electrical inverter. DC/AC electrical inverter transfers the energy drawn from the solar PV and wind turbine into the grid further as load by keeping common DC link constant. The inverter serves a twin role, to integrate hybrid systems to the grid and conjointly mitigate the harmonics produced due to nonlinear load and to improve the power quality problems because of nonlinear load.

The proposed control strategy composes of an inner inductor current loop and a voltage loop in synchronous frame of reference. The electrical converter is regulated as the current supply simply by the inner inductor current loop in grid tied operation and Also the voltage controller is employed to regulate the load voltage upon the prevalence of Islanding. The proposed control strategy is increased by introducing a unified load current feed forward, so as to alter problem caused by non-linear native load and implemented by adding the load current is given to the reference of inner current loop. In grid tied mode, DG set injects harmonic current and thus the harmonic component present in the grid current will be mitigated.

II. Problem Formulation

A) Existing System

Integration of Renewable Energy Technology

Renewable energy system consists of a number of alternative energy sources that includes solar PV cell, wind turbine, fuel cells and storage batteries. Among them solar PV and wind are abundantly available in nature. It is a

clean source of energy. In addition, these sources have a lot of advantages such as no air pollution, noiseless, minimum maintenance and free of cost.

Solar PV Technology Review

The renewable energy technique for generation of electrical energy is reliable and mature. The solar photovoltaic (PV) energy is the most promising source of energy considering it is pollution free and abundantly available in nature anywhere within the world. PV energy is especially beneficial in remote areas like deserts or rural zones where the difficulties to transport fuel, coal and the lack of electrical energy grid lines make the use of conventional resources are not possible. The building block of PV arrays is the solar cell and it is basically a p-n junction diode that directly converts light energy into electricity. A good way to maximize the success of the solar PV structures, a high reliability, an inexpensive value, and a consumer- friendly layout should be carried out in the solar PV topologies. Electrical Converter is used to transform dc power of PV into ac and also to inject power to the grid.

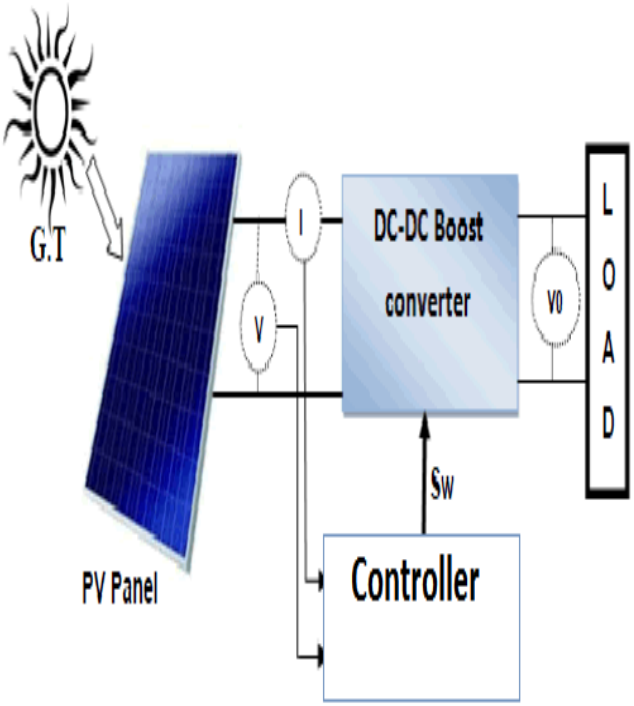

Fig.2.1 Diagram of Solar PV Technology

Wind turbine technology Review

Wind turbine is a device that converts kinetic energy of the wind into mechanical energy and similarly the mechanical energy is again converted into electrical energy. The electrical power produced from the wind depends upon aerodynamically designed blades and rotor construction. Wind energy generation power is kind of totally different from the conventional electricity generation with synchronous generators. Moreover, the variable speed wind turbine in the wind-power market is advantageous as compared to our conventional turbines. The advantages of variable-speed turbines are that their annual energy capture is about 5% greater than the fixed-speed technology, and the active and reactive powers problems can also be easily handled. There is additionally less mechanical stress, and speedy power fluctuations square measures scarce as a result of the rotor acts as a flywheel (storing energy in kinetic form).The main disadvantage of variable-speed wind turbines that it need a power converter that increases the component count and make the control more complex. The overall cost of the power electronics devices is about 7% of the whole wind turbine.

Variable speed wind turbine driving a Permanent Magnet Synchronous Generator (PMSG) is considered in this paper. PMSG is opted over other generators due to its advantages like, self-excitation property, which allows operation at high power factor and efficiency. PMSG also operates at low speed and thus the gearbox can be removed.

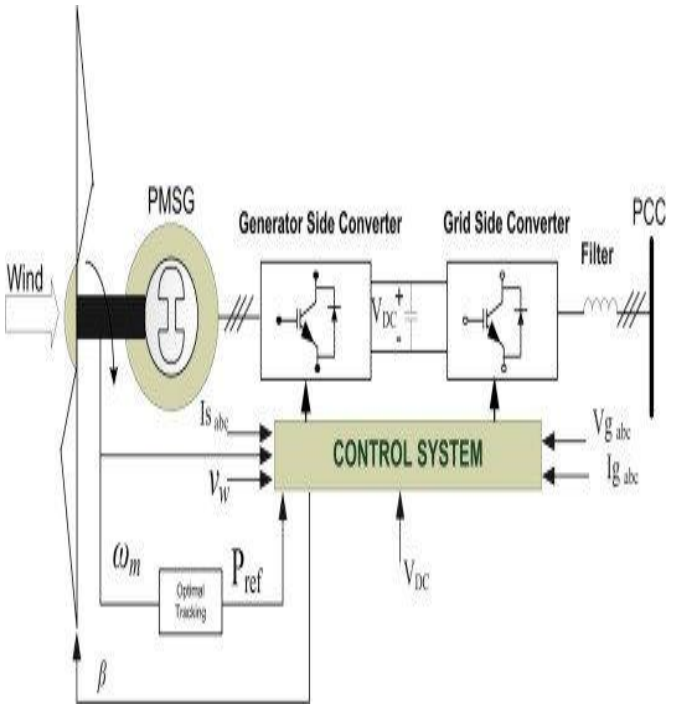

Fig.2.2. Wind turbine Technology using PMSG

Power Quality Issues

In modern years, there has been a better prominence and anxiety for the quality of power delivered to factories, business organizations and habitations. This is due to the increasing convention of harmonic-creating nonlinear loads such as ASD, switched sort power supplies, arc furnaces, electronic fluorescent lamp ballasts etc. Power quality can be defined, as the revision of driving and establishing electronic frameworks so as to keep up the veracity of the power supplied to the system. IEEE criterion 1159 defines power quality to the model of powering and grounding perceptive equipment in an approach that is appropriate for the operation of that apparatus. In the IEEE 100 Legitimate Dictionary of IEEE criterion terms, Power quality is defined as the idea of powering and grounding electronic apparatus in a way that is fitting to the function of that apparatus and well-matched with the assertion wiring system and other coupled apparatus. Superior power quality, however, is not easy to define because what is superior power quality to a refrigerator motor may not be good sufficient for current delicate computers and other sensitive loads. Harmonic trouble comes commonly from apparatus with a non-linear voltage/current features. These days a substantial piece of mechanical, business and local burdens is non-direct, making the alteration intensity on the low-voltage supply network a serious concern. As time goes on, additional and greater gear is being utilized that makes sounds in power frameworks. On the other hand, new and more apparatus is being used that is tending to failure due to harmonics. Computers, communication apparatus, and other power systems are vulnerable to misoperation due to the effects of harmonics. Due to the effect of harmonics, the electric motors has AC misfortunes in the center and copper windings. This can bring about center scalding, winding heating, torque fluctuation, and failure of efficiency in the motors. Harmonics may resulting, increase in perceptible sound from engines and transformers and can energize mechanical resonances in electric engines and their heaps.

B) Proposed System

Proposed Hybrid Power System

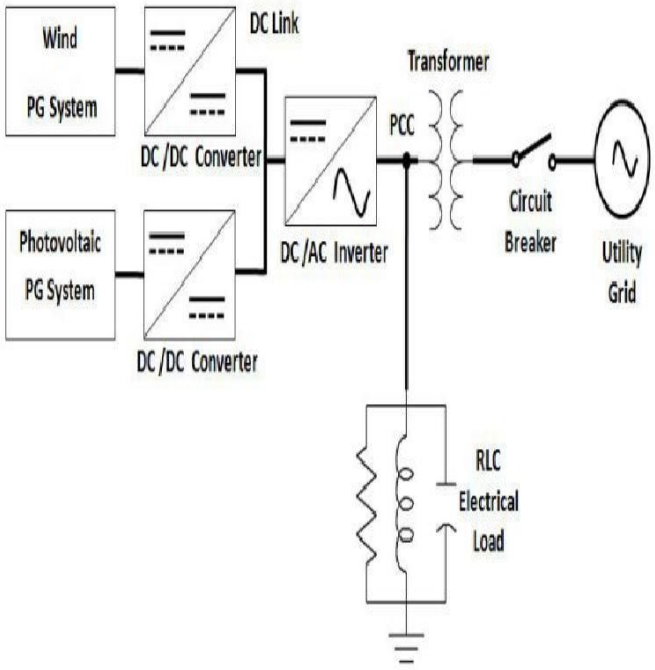

Fig.4.1 General Structure of the Proposed Model

The proposed hybrid system consists of a wind and a photovoltaic system as shown in Fig 1.Wind and solar systems are connected to the grid through inverter which serves as a dual purpose. The inverter is designed in such way to integrate the hybrid systems to the grid and also to eliminate the harmonics and to improve the power quality problems, which increases system efficiency. The system supplies the load and when there is excess generation, the power is delivered to the grid. Manual switch is used to connect the sources with grid. Converters were designed in order to meet the constant dc bus voltage.

III. System Configuration

DC/DC Converter Model

DC-DC converters can be used to convert an uncontrolled dc voltage to a controlled dc output voltage. The regulation is normally achieved by PWM at a set frequency and the switching device is generally BJT, MOSFET or IGBT. Due to the variable characteristics of the wind the output voltage from PMSG is also varied. Therefore an uncontrolled rectifier with boost converter is used in order to meet constant DC bus voltage. Similarly, a converter is designed with solar panel to meet the constant DC bus voltage.

DC/AC Inverter Model

Wind and solar systems are connected to the grid through an inverter which serves as a dual purpose. The inverter is designed in such a way to integrate the hybrid systems to the grid and also to eliminate the harmonics and to improve the power quality problems. The inverter is regulated as the current source just by the inner inductor current loop in grid connected operation and the voltage controller is used to regulate the load voltage during Islanding operation. The proposed control strategy is discussed in the next section.

IV. Proposed Unified Controller For Inverter Model

The proposed control strategy consists of an inner inductor current loop and a voltage loop in the synchronous reference frame. The inverter is regulated as a current source just by the inner inductor current loop in grid-tied operation, and the Voltage controller is to regulate voltage during islanding mode. The grid current in the grid-tied mode and the load voltage in the islanding mode are distorted under nonlinear load. A unified control strategy is designed to perform two operations. First, the traditional inductor current loop is used to control the three-phase inverter in DG to act as a current Source with a given reference in the Synchronous Reference Frame (SRF) [2]. Second, voltage controller is presented to supply reference for the inner inductor current loop, where a proportional plus- integral (PI) compensator and a proportional (P) compensator are employed in *d*-axis and *q*-axis.

The proposed control strategy is enhanced by introducing a unified load current feed forward, in order to deal with the issue caused by the nonlinear local load, and this scheme is implemented by adding the load

current into the reference of the inner current loop. In the grid-tied mode, the DG injects harmonic current into the grid for compensating the harmonic component of the grid current, and thus, the harmonic component of the grid current and the load voltage will be mitigated, and improved quality of the load voltage.

V. Conclusion

In this paper, we are developing grid connected solar PV and wind hybrid power system in MATLAB/SIMULINK software. Corresponding converters are modeled for solar PV and wind energy system. The hybrid system is connected to the load and also to the grid through a manual switch. Dual purpose inverter to be designed with an unified control strategy in order to improve the power quality problem and to integrate hybrid power generating system to grid. Also we analyzing the THD analysis shows that the controller very well improves the power quality as well as connects the renewable sources to the grid.

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