Grid Interconnection of Renewable Energy Sources and Performance Improvement of Power- Quality at Distribution Level

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Abstract –Due to disperse nature of renewable energy resources (RES), electricity generation is often taking place in small scale but main drawback is power quality. So to improve power quality issues, integration of renewable energy into the utility grid can be done either at transmission level or the distribution level depending on the scale of generation. The renewable resources like solar energy, wind energy, fuel cells, biomass energy, etc. are interconnect using various power electronics converters. Generally voltage source inverters are used to interface the intermittent RES in distributed system.

This paper presents integration of solar energy and wind energy resources for distribution level using multi-level inverter and its control strategy to achieve the voltage profile of system. Usually, the photovoltaic energy sources generate power at variable low dc voltage, while the variable speed wind turbines generate power at variable ac voltage. Thus, the power generated from these renewable sources are interconnect using various converters before connecting on dc-link. The voltage source inverter is a key element of a distributed generation system as it interfaces the renewable energy source to the grid and delivers the generated power. This concept of interconnection of solar and wind energy is designed and simulated in MATLAB-Simulink for non-linear load.

Keywords- *Renewable Energy Sources, Power Quality, Distribution, Grid Interconnection, DG, THD.*

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I. INTRODUCTION

Recent developments and trends in the electric power consumption indicate an increasing use of renewable energy resources (RES) like solar energy, wind energy, biomass, fuel cells, etc. Maximum energy demand is supplied by the burning of fossil fuels. Due to use of fossils fuels in tremendous amount it goes increasing air pollution, global warming, diminishing of fossil fuels and their increasing cost have made it necessary to look towards RES as a future energy solution.

Solar energy and wind energy is clean, inexhaustible, unlimited and environmental friendly source of energy. However all renewable energy sources have drawback but their characteristics have attracted the energy sector to use renewable energy sources on a larger scale. Wind and solar sources is dependent on unpredictable factors such as weather and climatic conditions. Due to both sources complementary nature, some of these problems can be overcome the weaknesses of one with the strengths of the other. This brings us to the hybrid solar-wind power plant [1] concept. Hybrid energy stations haveproven to be advantageous for decreasing the depletion rate of fossil fuels as well as supplying energy to remote rural areas, without harming the environment.

In this paper RES are integrated at distribution level is termed as distributed generation (DG).A multi-level converters [2] are used for conversion of power to standard bus voltage (AC or DC) and its control strategy to achieve the voltage profile of the system. Multi-level converters having the advantages of the low total harmonic distortion (THD) due to increase in level of converters. As the levels of the converters increases smooth output is obtained. This paper presents, the use of renewable energy based system because they have capability to reduce the emission of carbon and other harmful gases up to approximately 80% to 90% in environments as well as the clean and green energy (power) can be generated. Due to use of multi-level converter based hybrid system with L-C filter before the point of common coupling (PCC), it results in the power quality [3].

II. PROPOSED SYSTEM

The proposed system consists of RES connected to the dc-link of a grid-interfacing inverter as shown in Figure 1. This configuration is fit for the stand-alone hybrid power system used in remote area. Before reaching towards load centers, the conversion of electricity from wind and solar are carried out. The two energy sources are connected in parallel to a common DC bus line through their individual converters. Then such a DC power is converted back to AC power at fundamental grid frequency of 50 Hz by using multi-level inverter.

The multi-levelconverter is a key element of a DG system as it interfaces the renewable energy source to the grid and deliversthe generated power.In case of photo voltaic system generated power is at very low DC voltage. While wind turbine generates power at AC voltage. Thus, power generated requires conditioning i.e. in case of PV system DC/DC conversion is carried out by boost converter and in case of wind turbine generated AC/DC conversion required.

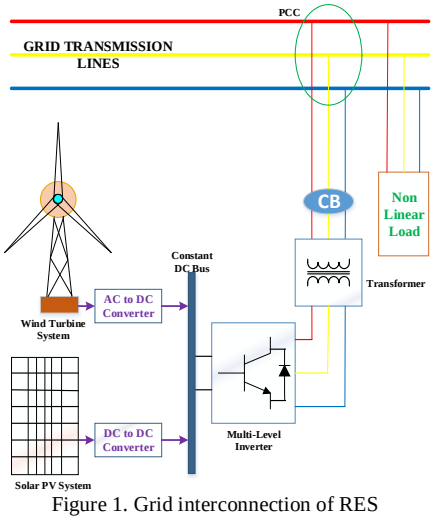

Figure 1. Grid interconnection of RES

A. *Wind Power*

Wind is natural phenomenon related to movement of air masses caused primarily by the differential solar heating of the earth's surface. The wind turbine [4] captures the winds kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical generator. An important factor in how much power your wind turbine will produce is the height of its tower hence turbine is mounted on a tall tower to enhance the energy capture.For input to wind generator i.e. asynchronous machine, the reference voltage and power are provided in Matlab-simulink.

B. *Solar Power*

The solar modules (photovoltaic cell [5] generate DC electricity whenever sunlight falls in solar cells. PV cell is very similar to that of the classical diode with a PN junction formed by semiconductor material. When the junction absorbs light, the energy of absorbed photon is transferred to the electron-proton system of the material, creating charge carriers that are separated at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as current through an external circuit. To obtain high power, numerous such cell are connected inseries and parallel circuits on a panel (module) [6], the solar array or panel is a group of a several modules electrically connected in series parallel combination to generate the required current and voltage.

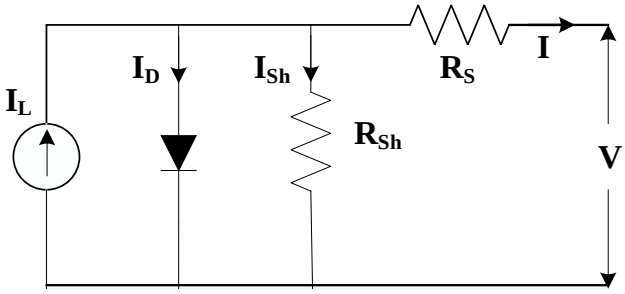

Fig ure 2. Photo-Voltaic model

As shown in Figure 2, a solar cell can be represented by a current source parallel with a diode, a high resistance and series with a small resistance. The above model contains a current source, one diode, internal shuntresistance (R_{Sh}) and a series resistance (R_S) which represents the resistance inside each cell of module. The total current (I) which is given by solar panel is the difference between the photo current and the normal diode current (I_D). Photo-Voltaic cell [7] is a P-N junction. When light incident on theP-N junction of the solar cell, electron hole pair is generated inthe depletion layer of solar cell. So if a load is connected to theterminal of solar cell, the excess charges i.e. a current flow through the load.

III. Hybrid Solar-Wind System

A hybrid RES system usually consist of two or more renewable energy sources used together to provide to improve system efficiency. The best hybrid combination of all renewable energy systems is a stand-alone wind system [8] with solar photovoltaic system and is suitable for most of the applications, taking care of seasonal changes. This system having advantages of additional energy production through wind during monsoon months compensate the less output generated by solar. Similarly, during winter when the wind is dull, solar photovoltaic takes over. The hybrid solar wind power system [9] is as shown in Figure 1.

Solar-Wind Hybrid power system have some applications such as: (i) Remote and rural village electrification, (ii) Ideal for cell phone recipient stations, (iii)Residential colonies & apartments for general lighting, (iv) Street lighting, etc. Emission of greenhouse gases as well as harmful gases are reduced with the use of renewable energy based system.

IV. Simulation Models

A. *Simulink model of wind turbine*

Figure. 2 shows the simulation model of wind turbine. Turbine is main part of wind energy generation system [10]. Aerodynamic design of turbines coverts the wind energy into the mechanical power. This mechanical power is delivered to the rotor of asynchronous generator which coverts it into the electrical form. Output of this system is AC and fed to the bridge rectifier to convert into DC form for constant bus voltage.

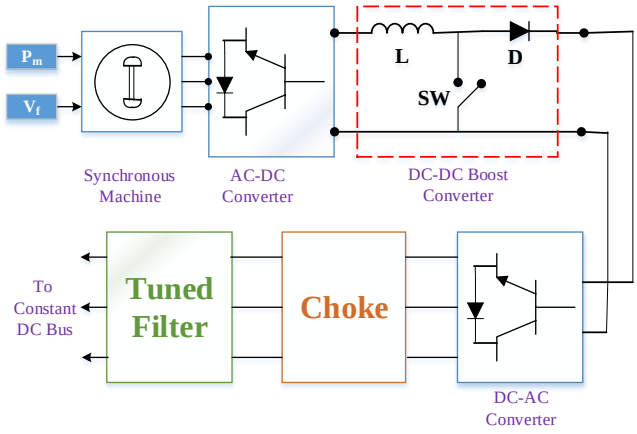

Figure 2.Wind Turbine Model

B. *Simulink model of PV model*

Figure 3 shows the simulation model of PV system [9].

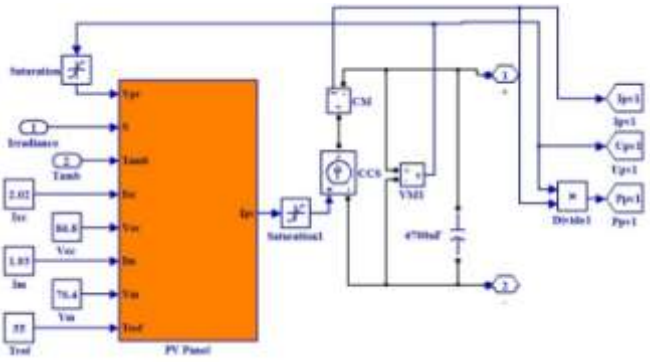

Figure 3. Simulation model of PV system

This explain detail about the each PV cell characteristic [11]. Output of the PV cell is conditioning by using the DC/DC converter and then fed to the multi-level inverter.

C. *Simulink model of proposed hybrid system*

Figure. 4 shows the simulation model of hybrid system. Both system output is given to the multi-level inverter. This output is fed to filter circuit having L-C filter [12]. Conditioned output is fed to main grid through a transformer. Circuit breakers are used for protection.

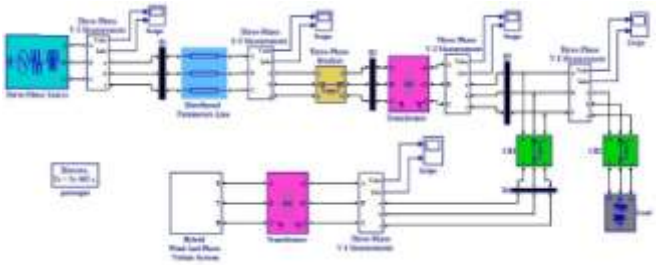

Figure 4.Simulation model of hybrid system

IV. MULTI-LEVEL INVERTER

The controller plays an important role in controlling and maintaining the proper functioning of the whole system by limiting the system parameter in specified ranges.With the advancement of power electronics and emergence of new multi-level converter topologies [13], it is possible to work at voltage levels beyond the classic semiconductor limits, so multi-level inverters have been widely used for high-power high-voltage DG applications. Due to higher number of sources, lower EMI, lower % THD in output voltage and less stress on insulation, they are widely used.A converters or regulators are used to step up the PV-array voltage close to the specified dc-link voltage, as shown in Figure1. The converter is operated in by-pass mode when the PV-array voltage is higher than the dc-link voltage, and the inverter will function as an MPPT [6]. The MPPT will switch operation modes between converter (buck or boost) when the output voltage of a PV array is close to the dc-bus voltage. Total harmonics distortion is reduced in the output wave form without decreasing in inverter output power. In power quality[3], the multi-level inverters can appropriately replace the existing system that uses traditional multi-pulse converters without the need of the transformers. An inverter converts DC input voltage into AC output voltage of variable magnitude and frequency.

V. RESULTS

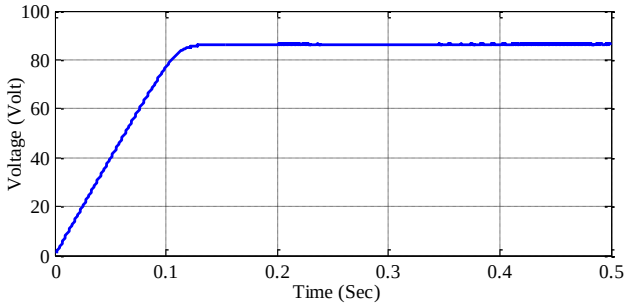

Figure 5. Common DC Link Voltage Waveform

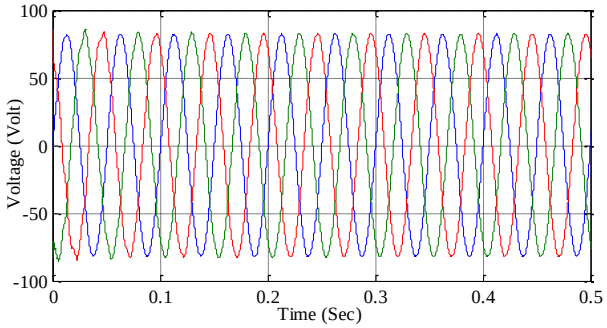

Figure 6. Grid voltage waveform after interconnection

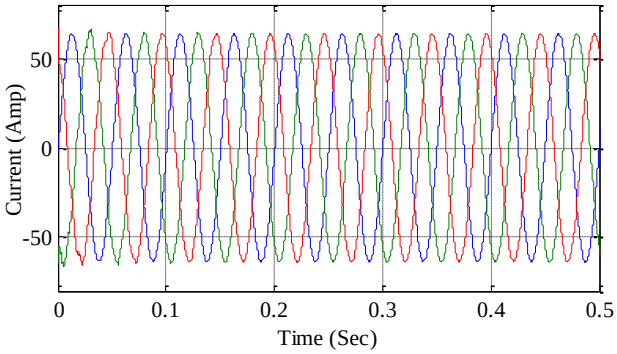

Figure 7. Grid current waveform after interconnection

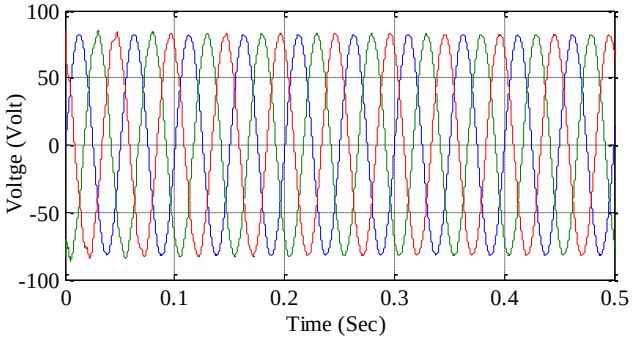

Figure 8. Hybrid system voltage waveforms

VI. CONCLUSION

Wind and solar having complementory nature, so during interconnection any source problems can be overcome the weakness of one with strength of other. Proposed system having less carbon emission and hence produced green energy. In this system multi-level converters are used which having the low THD. Multi-level converters improves power quality at interconnection. Proposed system can be used to supply energy at rural areas without harming the environment. With the use of multi-level converter based grid interconnection system and using filter, it results in improvement of voltage profile.

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