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Indian Journal of VLSI Design (IJVLSID)
ISSN: 2582-8843 (Online), Volume-2 Issue-1, March, 2022

Hybrid Renewable Energy Generation Through Incremental Conductance MPPT

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Abstract: ***The relevance of electricity generation from renewable energy sources is growing every day in the current global energy environment. The scarcity of fossil fuels and the environmental risks connected with traditional power producing methods are the main reasons behind this. The major sources of non-conventional energy are wind and solar which can be harnessed easily. A new system design for hybrid photovoltaic and wind-power generation is introduced within this study. A Modified M.P.P.T. has been proposed to strengthen productivity of this system. The proposed approach employs the Incremental Conductance (IC) MPPT technique. Under varied climatic conditions (Solar irradiance & Temperature), IC is utilized to determine the optimum voltage output of a photo voltaic generator (P.V.G.) within the photo voltaic system (P.V.) structure. The Incremental Conductance is utilized to manage the converter's technology having boosting function. The P.M.S.G. is used to determine the maximum voltage output for varied wind flow rates in wind turbine system. Simulations are conducted in Matlab2019b to test efficacy of the proposed MPPT. The proposed scheme's effectiveness can be supported with simulation results.***

Keywords: ***Incremental Conductance, MPPT, Renewable Hybrid Energy, Solar PV, Wind PMSG.***

I. INTRODUCTION

Conserving the energy and resources currently available, and developing new technology and techniques for creating clean, non conventional sources, are concerns for the present and for the future. Precisely, non conventional sources usage is on the rise [1-3]. Furthermore, research is striving to ameliorate existing sustainable energy technology and flourish new ones that will provide green energies accessible to the whole world. The main purpose for developing renewable energy aims to create a low-cost energy source that does not cause a significant environmental impact [4-5].

India becomes the world 's third highest power consumer as well as third greatest producer of renewable energy, with renewable energy accounting for 38 percent of total installed energy potential (136 Gigawatts from out 373 Gigawatts) in 2020. The Renewable Energy Country Attractiveness Index (RECAI) of Ernst & Young (EY) for 2021 ranks India third, behind the United States and China. India committed to generate 40 percent of its total electrical energy production from non conventional resources by 2030 as part of the Paris Agreement's Planned Nationally Determined Obligations targets in 2016. The Central Electricity Authority of India established a goal in 2018 to produce 57 percent of total electrical energy production from non-conventional resources, until 2027. Also, India has entrenched a goal of generating 175 Gigawatts of renewable energy until 2022 as well as of generating 450 Gigawatts of renewable energy until 2030. [6-7]. If the interest is towards the renewable energy, then solar, wind and biomass power sources are good options. Solar panels may be installed on a home, bio fuel can be used to power automobiles, and geothermal heat can be used to warm a structure, all of which use green energy and minimize reliance on conventional sources [8]. These are renewable energy sources and provide clean energy, which does not contribute to global warming. There will be enough renewable energy to support those who can tap into it [9-10]. This research endeavour includes a hybridized system that amalgamates a wind turbine system comprising of permanent magnet synchronous generator (PMSG) and the solar energy system comprising the photo-voltaic arrays.. To improve the hybrid model's performance, a modified MPPT system can be established that increases energy productivity of subsystems.

II. WIND SOLAR HYBRID ENERGY SYSTEM (WISHES)

The energy systems with renewable sources can be hybridized by combining more than two renewable energy sources. It improves system efficiency and also provides a more balanced energy supply. It can have a variety of equipments for electricity production, like solar panels, small scale hydropower, wind turbines as well as fossil-fuel-powered generators. HRES is an innovative approach of power system integration. By combining multiple RE systems, the hybrid RE system produces the maximum power.

A. Photovoltaic System

A photovoltaic framework, often referred as a PV network or a solar structure, is one that is meant to provide electricity from the sun through the use of photovoltaic technology. Photovoltaic is a term that refers to the process of converting light from the sun

Manuscript received on 19 October 2021 | Revised Manuscript received on 10 October 2021 | Manuscript Accepted on 15 March 2022 | Manuscript published on 30 March 2022.

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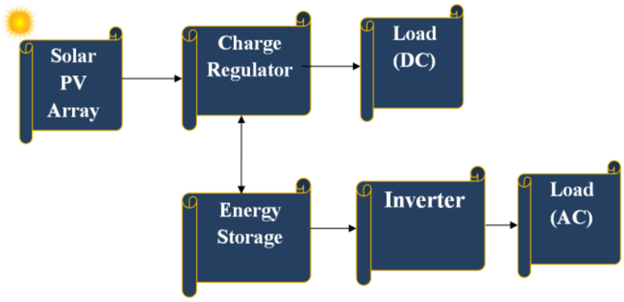

Fig. 1 Schematic Diagram of Solar PV Structure [2]

into electricity using a semiconducting substance that shows the photoelectric effect. The most efficient element in the photo voltaic network can be articulated to be a solar cell. The PV array is made up of several series or parallel connected solar cells that produce the required voltage, current, and power. Miniature roof - mounted and building-integrated Photo voltaic system having a few kilo watts to some tens of kilo watts of capacity to massive utility scale power stations with hundreds of mega watts of capacity are all available [11]. The majority of Photo voltaic installations present in the market today are grid-connected, with standalone or offgrid installations accounting for a small percentage of the marketplace. Solar panels are utilized to directly transform the sun's thermal energy into useful electrical energy. Economic feasibility of the hybrid Photo voltaic system for decentralized energy production has been worked out for small communities with up to 100 families. [12]. Fig. 1 represents the basic block schematic of solar pv structure.

B. Wind Energy System

The kinetic energy generated by air can be converted into electrical energy with the help of an arrangement which is termed as wind energy system. The rotor of a wind turbine serves as an extraction mechanism, turning in response to the wind stream and capturing mechanical energy. The rotor drives the generator, which generates an electrical power. Various multi-string topologies can be used to integrate green energy resources with the distributing networks. [13]. The Permanent Magnet Synchronous Generator have attracted more nowadays, because to its greater power factor operation, increased reliability and dependability, as well as its self-excitation capability in speed varying wind turbines. [14]. A dc-dc boost converter, a rectifier and a grid linked converter make up a speed varying wind energy structure, similar to a low capacity PMSG wind structure. [15]. Fig. 2 represents the basic block schematic of wind energy structure.

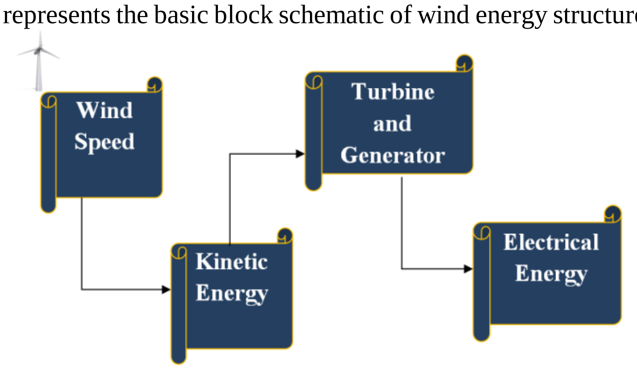

Fig. 2 Schematic Diagram of Wind Energy Structure [2]

C. Proposed Wind Solar Hybrid Energy System

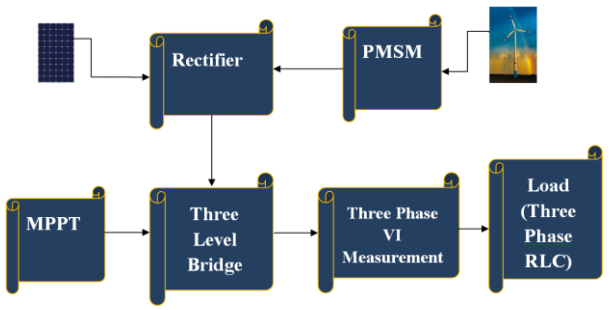

Fig. 3 Schematic layout of Proposed Hybrid Structure [2]

The hybrid network combines 2 or more energy techniques, most commonly wind and solar power. When compared to the single structure, the smaller structure combining solar and wind power has numerous benefits. Several hybrid architectures aren't linked to the power distributing network, allowing them to function offgrid and referred as isolated systems. The main benefit of a wind and solar hybrid network results in improved system reliability. A PV array is coupled to a wind turbine in proposed system. The permanent magnet synchronous machine is directly connected to wind turbine in this method, eliminating the need for a gearbox and resulting in excellent reliability and low maintenance. The universal bridge receives the AC voltage, from the PV array and the PMSM, and converts it to DC. The received signal has been sent over a three-level bridge that transmits power to the loads and is regulated by MPPT. Fig.3 represents the basic block schematic of proposed hybrid structure.

III. MODIFIED MPPT APPROACH

Maximum Power Point Tracking Algorithm (MPPT) is a DC to DC converter which improves the match among the utility grid and the Photo voltaic panels. It transforms the higher-voltage output DC power from the solar panels to the lower-voltage required for charging. A PV module's Maximum Power Point (MPP) defines the voltage under which it generates the maximum power. The maximum power is determined by the solar cell's radiation, temperature, and ambient temperature. Maximum Power Point Tracking improves the efficiency of solar panels by allowing them to run at their maximum power point. Maximum power point production for wind and solar power is now not attainable due to a lack of adequate control logic Even though solar energy and wind power are available, energy losses arise if this MPP isn't monitored via controlling mechanism, and the hybrid system's voltage level does not increase to the appropriate level [16]. The MPPT is generally a connection between the power converter and the PV array in terms of operating point. Because of the variable environmental circumstances and the nonlinear properties of the Photovoltaic arrays, tracing the genuine Max. Power Point becomes a difficult operation. MPPT uses a variety of techniques or algorithms.

Retrieval Number:100.1/ijvlsid.C1204031322
DOI: 10.54105/ijvlsid.C1204.031322
Journal Website: www.ijvlsi.latticescipub.com

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The Perturb and Observe, Incremental Conductance, neural networks, and Fuzzy logic are the most popular maximum power point strategies, although Incremental Conductance (I & C) is extensively employed due to the strong output offered even under quickly changing atmospheric conditions [17]. The slope of the system becomes zero at peak point of power-voltage characteristics of photovoltaic system, which is the basis for incremental and conductance (I&C) MPPT control. The gradient is positive on the left hand side, where power increases gradually, however the gradient is negative on the right hand side, where power decreases gradually.

IV. SIMULATION, RESULTS AND DISCUSSION

In this paper, the hybrid WT/PV structure that unites two sub-systems is proposed as illustrated in Fig. 4.

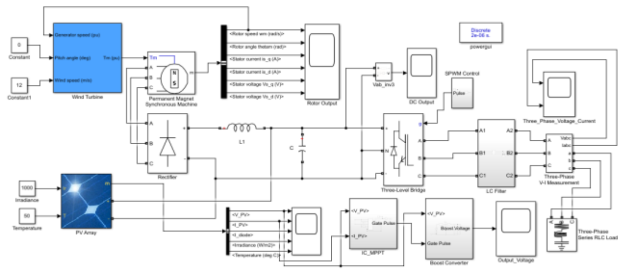

Fig. 4 Simulink Block Diagram of Proposed Hybrid Structure

A boost converter and a Pv generator are included in the Photo Voltaic sub system. A wind energy transformation unit focused on the synchronized permanent magnet generator as well as a rectifier, is included in the WT sub system. A new strategy focused on modified Inc. Cond. MPPT technique is proposed to extract the greatest energy output. Simulation of MPPT algorithm is carried out in Matlab/Simulink as illustrated in Fig. 5.

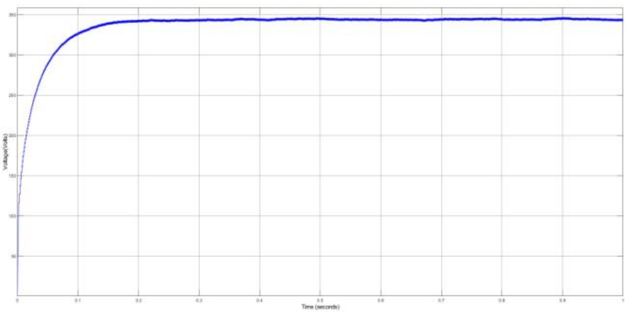

Fig. 5 Single Phase Output Voltage using Boost MPPT algorithm

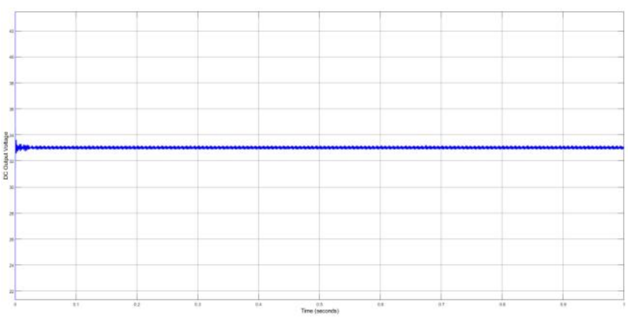

Fig. 6 DC Output Voltage of Wind PMSG

In Fig.6, the output is distorted for a very small interval of time i.e. approximately 20msec and seems does not affect the performance of power system. As this small distortion does not persists for a long time, it can be tolerated and may not affect the accuracy of the system.

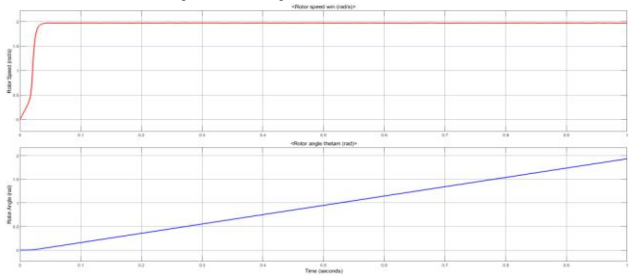

Fig. 7 Rotor speed and angle variations w.r.t. time

In Fig. 7, the rotor angle varies in the range of 0-2 radians. Similarly, the rotor speed also varies in the range of 0-2 radians/second. The Variation of the rotor speed is divided into three operating regions. The brake is configured to halt the wind turbines operations during region (i), when wind velocity is extremely low, resulting in no power generation. In Fig. 7, the region (i) is before zero time. In region (ii), from cut in wind speed to rated wind speed, the objective is to achieve the maximum power output. In Fig. 7, the region (ii) is from zero to 30 msec aprrox. In region (iii), wherein wind velocity is strong, the goal is to maintain the rated speed. In Fig. 7, the region (iii) is from 30 msec to 1 sec approx.

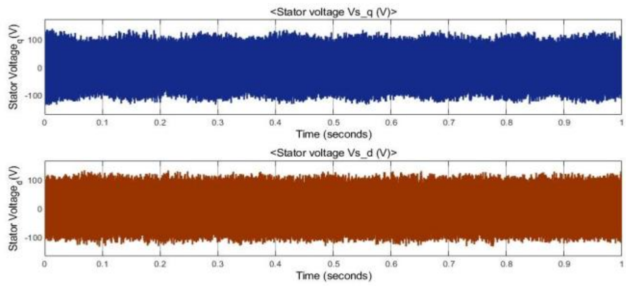

Fig. 8 Stator Voltage variations w.r.t. time

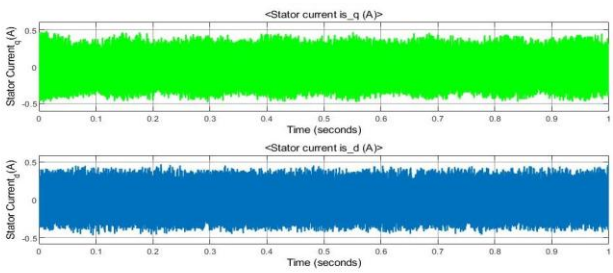

Fig. 9 Stator Current variations w.r.t. time

Fig. 8 and Fig. 9 shows the performance parameters of wind turbine PMSG that is the stator voltage and stator current variations with respect to time. Here, the stator voltage varies up to the value of 100 volts approx. and the stator current varies up to the value of 0.5 amperes approx. Stator voltage and current variations shows the controlling performance of wind turbine permanent magnet synchronous machine.

Retrieval Number:100.1/ijvlsid.C1204031322
DOI: 10.54105/ijvlsid.C1204.031322
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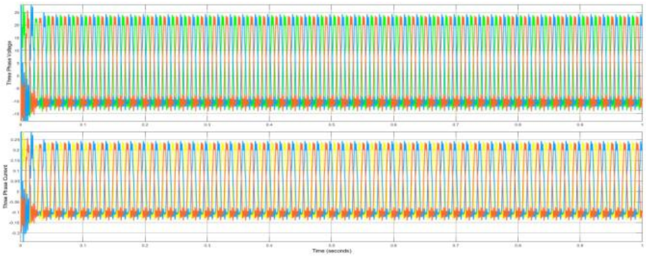

Fig. 10 Three Phase Voltage and Current of Hybrid Energy System

Fig. 10 represents the performance of three phase voltage-current variations with respect to time. The waveforms are drawn as a result of the two subsystem (i.e. solar energy system and wind energy system) outputs. The waveform shows the variation of three phase load. Initially, variations in both the curves occurred to provide initial torque of the system. The disturbance is occurred for a small interval of time say 30 msec approximately. After this period the three phase voltage waveform varies up to 25 volt range and the three phase current waveform varies up to 0.25 ampere range. Hence, the waveforms are analyzed for the voltage and current variations with respect to time.

V. CONCLUSION

A modified MPP tracking strategy for the WT/PV hybrid system has been proposed in this research, with the goal of improving the performance of photo voltaic and wind energy sub-systems by tracking the respective MPP via boost converter control. Modified Incremental Conductance approach is the basis for the method proposed. The PV system's output is determined by temperature and irradiance, while the WT system's output is determined by wind velocity. MATLAB/SIMULINK is used to test the proposed MPPT technique under various environmental circumstances.

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