INTEGRATION OF RENEWABLE ENERGY SOURCES IN POWER SUPPLY SYSTEM

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***ABSTRACT* -** Economic growth and rising per capita energy consumption, coupled with conducive policy, regulatory framework, fiscal incentive have accelerated development of renewable energy (RE) generation in the country in past few decades. Presently, in renewable generation portfolio, wind constitutes major share and penetration of solar generation is also increasing, However, it is characterized by intermittency & variability. Increasing renewable penetration presents numerous challenges to the system planner as well as grid operator. This paper identifies challenges in grid integration of large scale renewable as well as suggests suitable measures to address them. Need for requirement of other control infrastructure like establishment of Renewable Energy Management Centers (REMC) equipped with advanced forecasting tools as well as Real time measurement/monitoring schemes through WAMS applications, dynamic reactive compensation, energy storage to provide balancing services etc. It also highlights potential of renewable generation in deserts and transmissions plan that serve as a road map up to year 2050**.** The proposed system presents power-control strategies of a grid-connected hybrid generation system with versatile power transfer. This hybrid system allows maximum utilization of freely available renewable energy sources like wind and photovoltaic energies. For this, an adaptive MPPT algorithm along with standard perturbs and observes method will be used for the system. Also, this configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind energy and Solar cell operating voltage in the case of output power from solar energy. Permanent Magnet Synchronous Generator is coupled with wind turbine for attaining wind energy conversion system. Theinverter converts the DC output from non-conventional energy into useful AC power for the connectedload. This hybrid system operates under normal conditions which include normal room temperature inthe case of solar energy and normal wind speed at plain area in the case of wind energy. The simulationresults are presented to illustrate the operating principle, feasibility and reliability of this proposed system.Renewable energy is characterized by intermittency and variability which presents various challenges in its grid integration for maintaining grid stability & security. On the other side, due to large demography, demand varies over the day/week/month as well as on seasonal/regional basis. In order to address above challenges especially in high penetration regime, there is a need to introduce more flexibility with quick ramping features in generation portfolio with mix of various fuel technologies especially Hydro & Gas as well as demand side flexibility. Considering envisaged renewable penetration level by 12th plan and beyond as well as need of identifying challenges.

Keywords- *wind energy, solar energy, hybrid, MPPT, , three phase inverter, grid connection.*

I. INTRODUCTION

power is the most vital input for the growth of any economy. Therefore, it is considered as a core industry as it facilitates development across various sectors, such as manufacturing, agriculture, commercial, education, railways etc. to achieve economic growth. Energy needs of the country is growing at a very fast pace to meet high GDP growth rate. Present peak electricity demand of the country is above 145GW(Jun'15) which is expected to grow to about 200GW & 283GW by the end of 2016-17 (12th plan) & 2021-22 (13th plan) respectively as envisaged in the 18th EPS report of CEA. To meet growing demand and to reduce supply-demand gap, there is a need of large capacity addition through conventional as well as from renewable energy sources. India is endowed with abundant Renewable Potential which presents an excellent solution to meet challenges like meeting long term energy requirements, attaining energy security along with affordability, addressing climate change concerns etc. Government is also promoting development of renewable generation through an attractive mix of fiscal and financial incentives as well as conducive policy environment. It is envisaged that more than 30 GW renewable generation capacity shall be added in the 12th Plan period and 20 GW solar by 2018-19. MNRE has also projected about 175 GW renewable capacity by 2022. Renewable energy is characterized by intermittency and variability which presents various challenges in its grid integration for maintaining grid stability & security. On the other side, due to large demography, demand varies over the day/week/month as well as on seasonal/regional basis. In order to address above challenges especially in high penetration regime, there is a need to introduce more flexibility with quick ramping features in generation portfolio with mix of various fuel technologies especially Hydro & Gas as well as demand side flexibility.

To facilitate RE grid integration, POWERGRID carried out studies and identified ―Green Energy Corridor. It covers transmission infrastructure requirement both at Intra state, for evacuation & absorption of RE power in the host state, as well as Inter-state, for transfer of RE power out of the host state. Strong grid interconnection shall also help in enlarging power-balancing area, Intermittent/variable nature of RE sources results in wide variations in quantum and direction of power flow on the transmission corridors. This requires placement of Dynamic reactive compensation in the form of STATCOM/SVC at strategic locations to provide dynamic voltage support for smooth operation and maintaining grid security. This shall also help in addressing fault ride through issues in RE generators.

II. BLOCK DIAGRAM OF SOLAR-WIND HYBRID SYSTEM

The block diagram of a solar wind hybrid system is as shown in Fig.1.

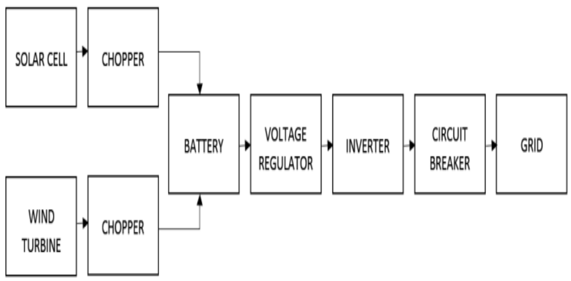

Fig. 1. Block diagram of solar-wind hybrid system connected to grid.

Choppers are used after the solar and wind systems to control the output voltage of solar and wind. A battery is used in order to provide a continuous power to load as wind and solar energies are uncertain during islanding operation. However the usage of batteries for large scale power generation is not possible. A voltage regulating chopper is used to monitor the output level of the voltage which comes out of inverter in order to match it with that of the grid voltage. An inverter converts a DC voltage to an AC voltage in a proper phase sequence, so that the obtained output is in phase with the grid voltage. Circuit breaker is used to connect the solar wind hybrid system to the grid to synchronise the generated power with the grid.

2.1. CONTROL OF SOLAR ENERGY

A solar cell basically is a p-n semiconductor junction. When exposed to the light, a DC current is generated. The generated current varies linearly with the solar irradiance. The equivalent electrical circuit of an ideal solar cell can be treated as a current source parallel with a diode shown in Fig 2.

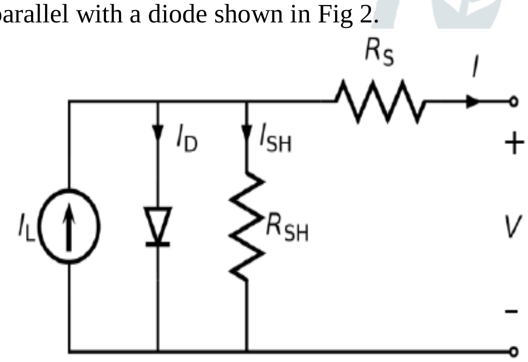

Fig. 2: Equivalent electrical circuit of a solar cell

2.2 CONTROL OF WIND ENERGY

The Wind energy is one of the fastest growing renewable energies in the world. The generation of wind power is clean and non-polluting; it does not produce any by-products harmful to the environment. For a particular wind speed, there is a specific turbine rotational speed which generates the maximum power. The maximum power point tracking (MPPT) for each wind speed increases the energy generation. However, the MPPT control for each wind speed generates the output power fluctuations. But, the introduction of fuel cells and flywheels has reduced the above problem. The power versus wind speed curve for the wind turbine is as shown in the Fig 3.

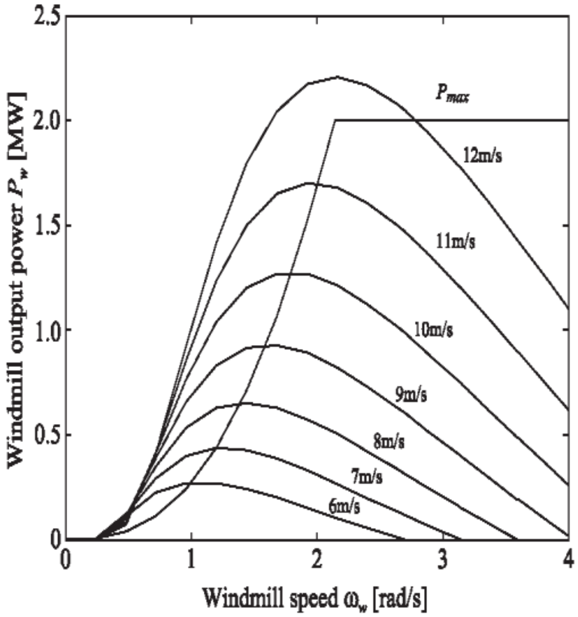

Fig. 3. power versus wind speed curve for the wind turbine

The wind mill speed of the wind turbine can be varied by varying the pitch angle. Also from Fig (5) it can be noted that for a particular wind speed there will be a particular wind speed for which the power is maximum. Hence the smart controller must be capable of determining the pitch angle to extract maximum power under a given condition.

V. CONTROL OF POWER FROM AND TO BATTERY

A battery is used in order to provide a continuous power to load as wind and solar energies are uncertain. A battery being a chemical device has some restrictions while operating it such as the minimum and maximum State of Charge (SOC) , maximum charging and discharging currents and so on. Hence the smart controller must be capable of controlling all these requirements.

2.3 INVERTER CONTROL

A three phase inverter is used just after the voltage regulating chopper in order to supply the power to the local loads and also to the grid. In order to connect the solar-wind hybrid system to the grid, the generated voltage must be in phase with the grid voltage. Hence inverter control is made such that it takes the grid voltage as the reference and generates control pulses to the inverter, so that a voltage having same phase sequence and same frequency as that of the grid voltage is generated. Once the solar-wind hybrid system is connected to the grid, the power angle of generated voltage must be increased slightly, in order to ensure that all the generated power (P) flows to the grid according to the equation shown below.

P = EV/X sin□

The smart controller must be capable of increasing the power angle of generated power after connecting to the grid.

III. METHODOLOGY

3.1 SIMULINK MODEL OF THE SOLAR-WIND HYBRID SYSTEM CONNECTED TO THE GRID

The system is consists mainly as following; Photovoltaic array converts the sun irradiance and generates dc voltage and current, the DC-DC boost converter controlled by maximum power point tracking (MPPT) using (P&O) algorithm to track the maximum power point of the array. The MPPT control of the controller is based on perturb and observe algorithm . The VMPPT and power extracted from solar cell for the given variation in irradiance. The battery management system is modelled to control the charge and discharge rates of the battery in order to improve the life of the battery then the three phase Inverter converts the dc voltage to AC for grid interfacing or supply to the local load.

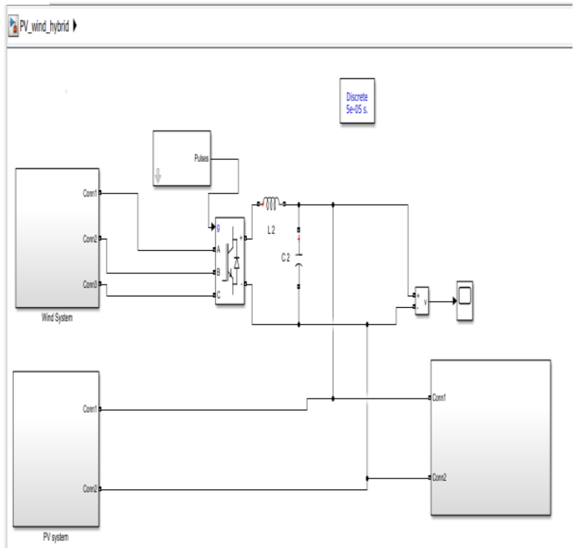

FIG. 4. Simulink model of solar wind hybrid system connected to grid

3.1.1 Perturb & Observe MPPT Algorithm

This MPPT algorithm continuously maximizes the power generated by PV systems by controlling the voltage. The Perturb and observe (P&O) algorithm is extensively used MPPT techniques for solar PV applications due to its coherence in design and implementation with good production. This algorithm track maximal Power Point by measuring the PV attributes are perturbs the operating point of PV module to get the position change in direction. When there is a rate of change of power with respect to voltage is zero, the maximal power point is reached. When the PV panel voltage is perturbed by a small gain, the resulting in change power of is positive then the system is going in the direction of MPP and to keep on perturbing in the same direction i.e δ' is increased. If P is negative, then the system going away from the direction of MPP and the sign of perturbation supplied has to be changed i.e δ' is reduced. The identical step is to continue till maximal power point is reached. The equivalent voltage at which MPP is reached is known as reference point (Vref). Fig. (5) Shows Flowchart of Perturb and Observe (P&O) algorithm.

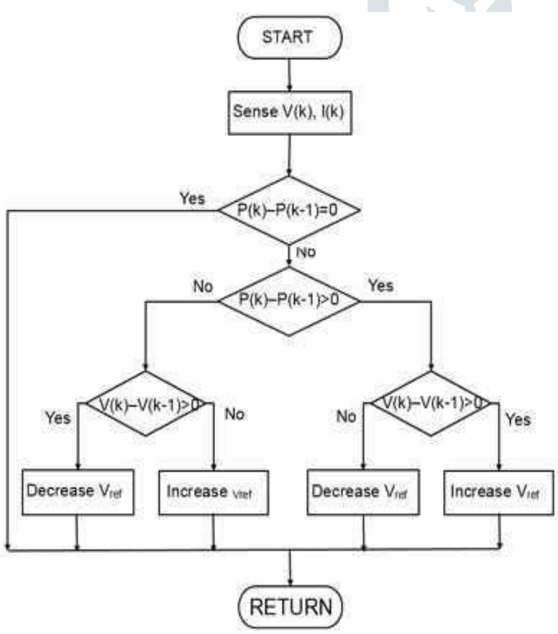

Fig. 5. Shows Flowchart of P and O algorithm

IV. RESULTS AND DISCUSSIONS

Fig.6. shows the inverter output current i.e. 3-phase A.C. current with magnitude around 10 amps

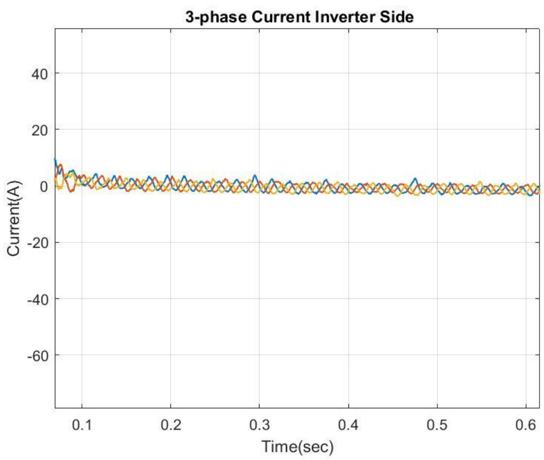

Fig.6. INVERTER SIDE CURRENT

The figure 7 is showing the tuned Vdc at 800Volts. The desired Vdc is attained using PID controller and has taken approximately 0.1 sec to reach to the 800V level.

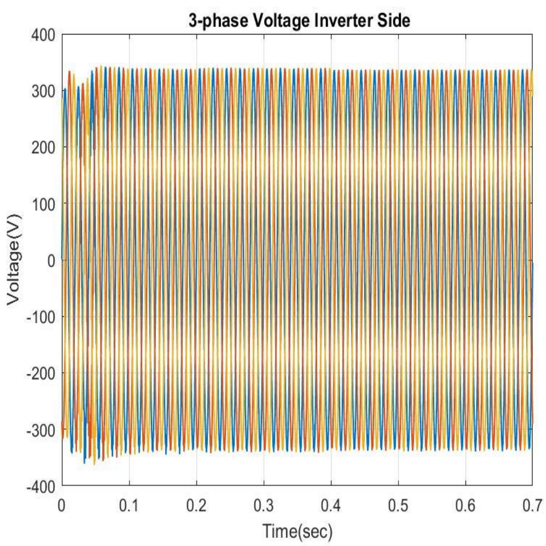

FIG.7. INVERTER SIDE VOLTAGE

Figure 7 and 8 are displaying the synchronisation of the grid and the PV power system. Two loads with various capacities are considered in the simulation. The first load in the system is 24KW from 0.2 secs to 0.4 sec. the second load is of 13 KW capacity and is available in the system from 0.3 sec to 0.5 sec then again 24KW load switched on.

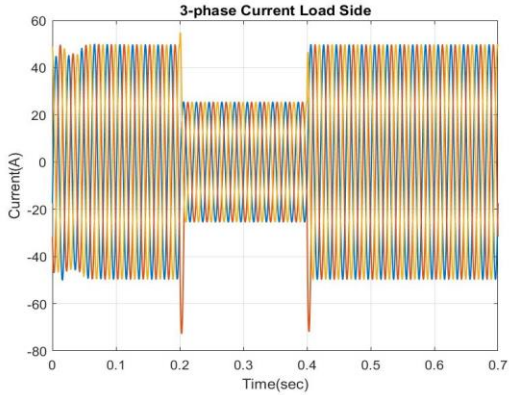

FIG.8. LOAD SIDE CURRENT

Fig 9 shows the Load side output voltage i.e. 3-phase A.C. voltage with magnitude around 350 volts provided to loads

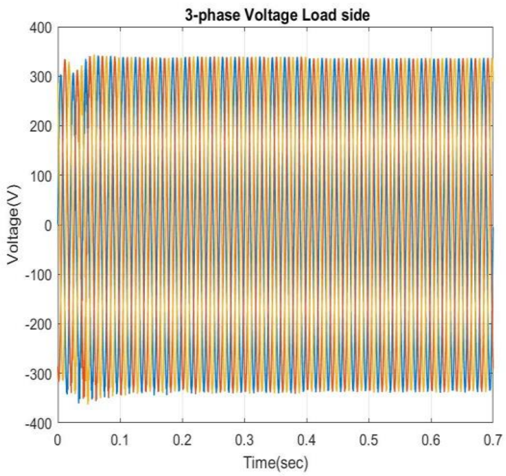

FIG. 9. LOAD SIDE VOLTAGE

The figure 10 is showing the tuned Vdc at 800Volts. The desired Vdc is attained using PID controller and has taken approximately 0.1 sec to reach to the 800V level.

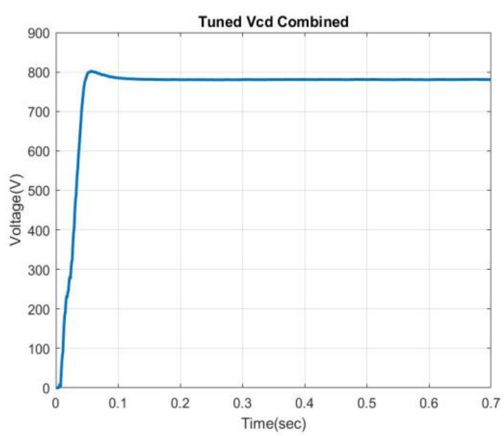

FIG.10. TUNED VDC

V. CONCLUSION

In this paper, a novel PV/WT hybrid power system is designed and modelled for smart grid applications. The developed algorithm comprises system components and an appropriate power flow controller. The model has been implemented using the MATLAB/SIMULINK software package, and designed with a dialog box like those used in the SIMULINK block libraries. The available power from the PV system is highly dependent on solar radiation. To overcome this deficiency of the PV system, the PV module was integrated with the wind turbine system. The dynamic behavior of the proposed model is examined under different operating conditions. Solar irradiance, temperature and wind speed data is gathered from a 28.8kW grid connected solar power system located in central Manchester. The developed system and its control strategy exhibit excellent performance for the simulation of a complete day. The proposed model offers a proper tool for smart grid performance optimization.

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