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Modelling Of Converter Characteristics of Wind Energy Conversion System during Voltage Sags

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ABSTRACT
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 maximum power point tracking (MPPT) algorithm along with standard perturbs and observe method will be used for the system. 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. This paper addresses dynamic modeling and control of a grid-connected wind–PV–battery hybrid system with versatile power transfer. The hybrid system, unlike conventional systems, considers the stability and dispatch-ability of its power injection into the grid. The hybrid system can operate in three different modes, which include normal operation without use of battery, dispatch operation, and averaging operation. This paper also indicates the merits of the proposed system.
Keywords: wind energy conversion system, permanent magnet synchronous generator, voltage sags, maximum power point tracking (MPPT).

I. INTRODUCTION

With increasing concern of global warming and the depletion of fossil fuel there is need to preserve the fuel reserves in the earth for the future generations. Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands. Wind energy is alone capable of supplying large amounts of power but its presence is highly unpredictable. Similarly solar energy is available throughout the day but it depends on sun intensity. The integration of renewable energy sources and energy storage systems has been one of the new trends in power electronic technology. Combining multiple renewable resources via a common dc bus of a power converter has been prevalent because of convenience in integrated monitoring and control and consistency in the structure of controllers as compared with a common ac type.

II. PROPOSED MODEL

Several methodologies are present for optimal design or unit sizing. A wind turbine system model was developed and compared with a real system and Dynamic performance of a wind and solar system is analyzed and the fig (1) shows the proposed model of the hybrid circuit.

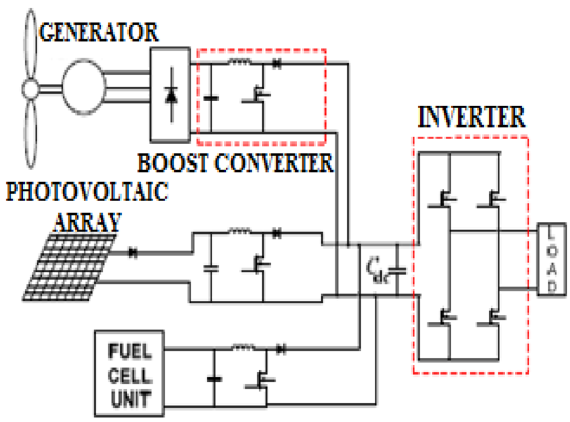

Fig1.Model of Proposed Hybrid Circuit.

III. MAXIMUM POWER POINT OF THE SYSTEM

In the proposed system both the wind turbine and the photovoltaic array must be adjusted to operate at their point of maximum power. The perturbation observation method is adopted in this paper for both the wind turbine and the photovoltaic array for its simplicity and accuracy. The algorithm starts by choosing an initial reference rotor speed for the wind turbine and an initial reference voltage for the photovoltaic array. The corresponding output powers of the two systems are measured. If this power does not correspond to their maximum powers, then their initial reference values are incremented or decremented by one step. If this adjustment leads to an increase in their output powers then the next adjustment is made in the same direction and vice-versa. The above steps are repeated till the maximum power points of the wind turbine and photovoltaic array are reached. Fig.2 indicates the perturbation observation method followed in this paper.

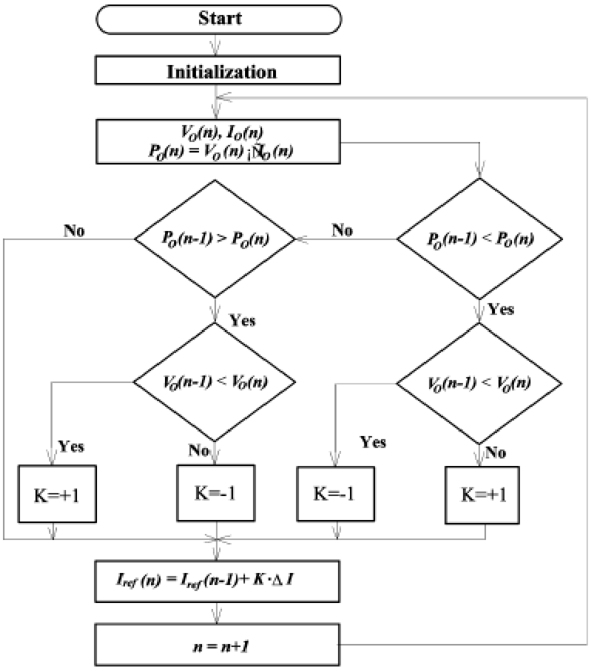

Fig2.Perturbation observation method.

IV. SIMULINK MODEL OF PROPOSED SYSTEM

The model of the proposed hybrid system is shown in fig.3. This hybrid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy. The simulation results are presented to illustrate the operating principle, feasibility and reliability of this proposed system. There are two modules of PV cells in the designed PV Array. There are two rows of 11 cells in each PV module. The voltage developed at the parallel connection between the parallel connection of the PV modules is measured here with the inclusion of the display block of simulink.The wind turbine is coupled with PMSG to supply the developed Mechanical Torque (Tm). This value is when multiplied with Base Torque gives the Actual value of the Torque needed for the PMSG The rectifier connected after PMSG performs the duty of converting the AC power into DC power to be utilized along with generated wind DC power for united converting into AC power to be supplied to load. The Wind Power (Wp) is computed here to analyze the quantity of power that is acquired from the wind energy system. It is the joint multiplication of the measured Voltage and Current in RMS. The product is immediately multiplied by $\sqrt{3}$ gain factor.

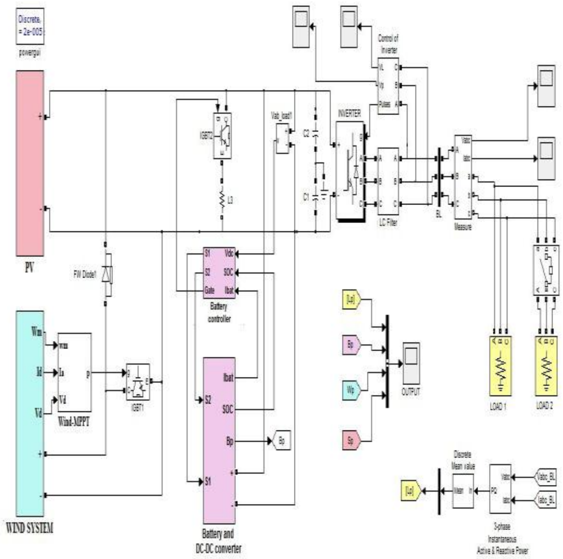

Fig3.Composite Simulation Model of Proposed Hybrid System.

V. SIMULATION RESULTS

TIME	Characteristics
0-1s	1) Solar energy with full irradiance 2) Wind Turbine tends towards base speed of 12m/s after 0.5 s 3) Battery gives partial supply to load 4) Load is 10 KW
1-2s	1.Wind achieves 5.6 KW 2.Battery stores 5 KW
2-3s	1.Solar Energy Reduced by 15 % 2.Battery stores 3.5 KW
3-4s	1.Wind speed decreases by 25 % to 9m/s 2.Battery gives partial supply to load
4-5s	1.Load is increased by 40 % 2.Battery is responsible to overcome 40 % load demand
5-6s	Load demand comes to previous point

TABLE.1.Life Cycle of Hybrid System.

TIME (sec)	LOAD (× 10^4) W	SOLAR (×10^4) W	WIND (× 10^4) W	BATTERY POWER (×10^4) W	BATTERY ACTION	REMARKS
0 – 1	1	0.92	0 (0-0.8 s)	+0.08	Supplying	G < L
		0.92	0.03 (0.8 s)	+0.05		
1 – 2	1	0.94	0.56	−0.5	Charging	G > L
2 – 3	1	0.78	0.56	−3.4	Charging	G > L
3 – 4	1	0.78	0.2	+0.02	Supplying	G ≤ L
4 – 5	1.4	0.78	0.2	+4.2	Supplying	G < L
5 – 6	1	0.78	0.2	+0.02	Supplying	G ≤ L

TABLE.2. Load Sharing Between Solar & Wind Systems Supported by Battery.

Module	Polycrystalline Solar Panel TSP 230
Encapsulation	Glass/PVB/Cells/PVB/Glass
Size and Number of cells	125mm×125mm
Maximum power	180w
Maximum power voltage(Vmp)	36.00V
Maximum power current(Imp)	5.00A
Open circuit voltage(Voc)	43.20V
Short circuit current(Isc)	5.80A
Model size(mm)	1700*860*9mm
Weight	38kgs
Operating Temperature	40°C to+85°C

TABLE .3 .Ratings of Polycrystalline Solar Panel TSP 230.

The working performance of different solar panel models is represented through simulation results. The difference in the output occurs due to the differed voltage and current ratings of the panel. The derived voltage and current ratings depend on the physical conditions prevailing in its vicinity and on its physical characteristics.

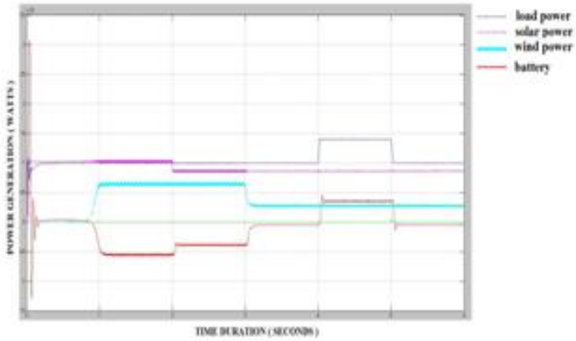

Fig4. Load sharing action performed by the hybrid energy in polycrystalline solar pane, 1TSP230.

The load demand to fulfill is 10 KW throughout the time scale except at 4 to 5 sec when it increases to 14 KW. Solar energy drops its irradiance to 15 % from 2 sec. Wind turbine initially rotating at 5m/s excels to base speed 12m/s after 0.5 sec. It's rotating speed is decreased to 25% of its base speed. All these conditions are clearly observed in the below graphs.(figure 5-9). The Maximum Voltage is of PV Array is observed at around 640 V. the curve in figure 5 below explains that the varying irradiance is the deciding factor of the maximum voltage derived.

Time	Solar energy	Wind energy	Battery	Load
0-1		Speed Tends Towards Base Speed		
1-2			Significant Charging	
2-3	Irradiance Drop	Speed falls		
3-4				
4-5			Mainstay Load Sharing	Additional Load Attached
5-6				

TABLE.4. Major Landmarks of Proposed Hybrid System.

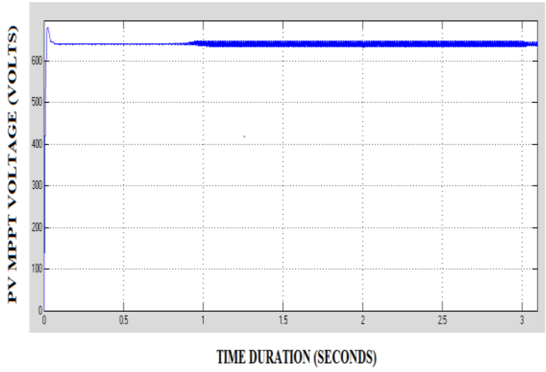

Fig5. Phase Voltage observed at the PV array.

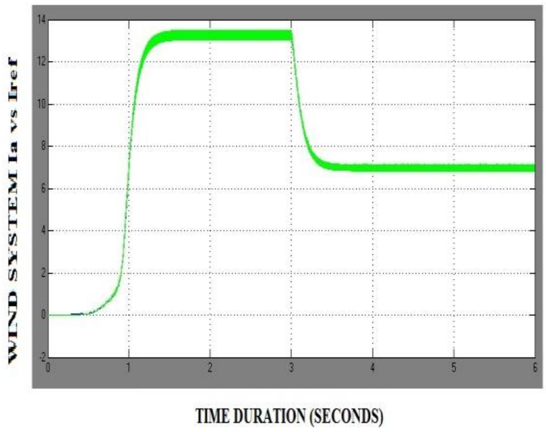

Fig6.The relative variation curve of Actual Current (Ia) and Reference Current (Iref).

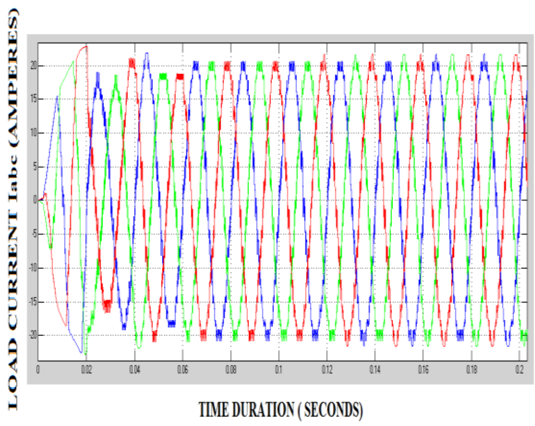

Fig7.The load current supplied to the load is sinusoidal in nature as depicted in the simulation.

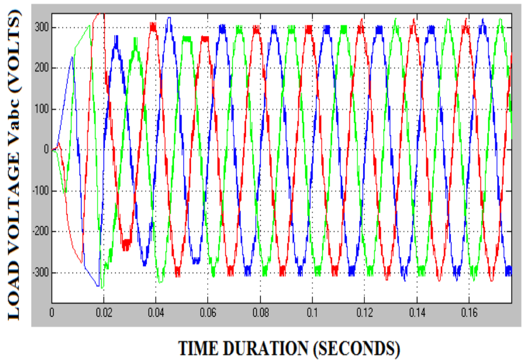

Fig8.Three Phase Voltage Supplied to the Load by The Inverter.

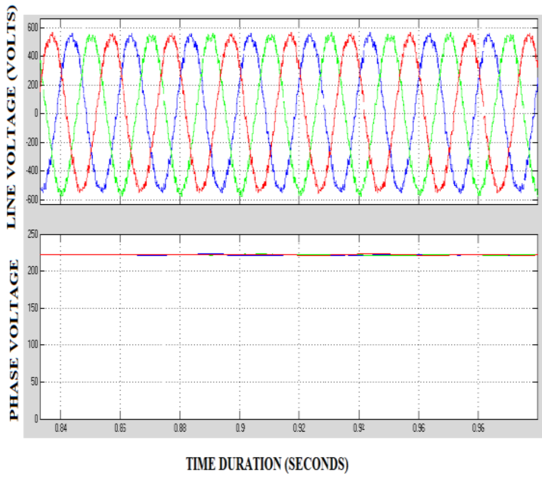

Fig9.AC Line Voltage and Phase Voltage given by the Inverter.

By analyzing all the above simulation results it is observed that the proposed system gives constant power at all conditions and the inverter output voltage readings are noted for every instant of time and the readings are given in table. 4.

TIME	PHASE VOLTAGE
1 s	230
2 s	230
3 s	230
4 s	230
5 s	230
6 s	230

TABLE.5.Inverter Output Voltage.

VI. CONCLUSION

It is concluded that in the controlled operation discussed above it is very clear that load demand is met from the combination of PV array, wind turbine and the battery. An inverter is used to convert output from solar & wind systems into AC power output. Circuit Breaker is used to connect an additional load of 5 KW in the given time. This hybrid system is controlled to give maximum output power under all operating conditions to meet the load. Either wind or solar system is supported by the battery to meet the load. Also, simultaneous operation of wind and solar system is supported by battery for the same load. This entire process helps to generate power continuously to meet the load demand without any interruption.

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