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USE OF BALANCED AND UNBALANCED LOADS BY USING AN ISOLATED W-H HYBRID MODEL WITH POWER CONVERTERS

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ABSTRACT
In this paper, a new three-phase four-wire load connected to an autonomous W-H(wind –hydro) hybrid system driven by squirrel cage induction generators SCIG, which hasn't been connecting to the grid and where the wind-hydro potential exist constantly. The control of voltage and frequency (VFC) are the main important. The wind system driven by variable speed generator. This hybrid system utilizes back-to-back-connected, two IGBT based voltage- source converters (VSCs) with a battery at its dc link. This hybrid system has bidirectional flow of active- and reactive power, which maintains a constant frequency across the load irrespective of any types of load like linear and non linear loads. The performance has verified by MATLAB-9/Simulink-SimPower Systems software,

KEYWORDS: W-H Hybrid Renewable energy systems, SCIG, VSC, MPPT.

INTRODUCTION
Renewable energy sources have raised its attention world- wide due to rising prices of limited fossil fuels. Renewable energy source are the best and only replaceable source for fossil fuels and plays an important role in reducing the emissions of harmful gases which are the main causes of greenhouse effect. The need of isolated systems that uses renewable energy sources highly depends on modern simulation based control systems.

A renewable energy is a resource which is replaced naturally with some biological effects and can be used again. Examples are: oxygen, fresh water**,** solar energy, timber, geothermal and biomass. Renewable resources may include goods commodities such as wood, paper and leather. Among the renewable energy sources, small hydro power and wind energy have the ability to complement with each other. As regards wind-turbine, these can be built either as constant-speed machines or as variable speed machines, which rotate at a fixed speed regardless of wind speed for constant speed machine and varies in accordance with wind speed for variable speed. Variable speed machine is having certain advantages. They compensate torque and power pulsations dynamically, reduce mechanical stresses, improves system efficiency and power quality. in fixed-speed wind turbines, energy transformation efficiency is very less for widely varying air flow. So to make it more efficient, technology has implemented from fixed speed turbine to variable speed turbine. The grid connected variable speed WECS based on squirrel cage induction generator SCIG use two power converters with a lead acid battery at its DC link. In such systems reliability improves as power converters decouples the squirrel cage induction generator from the grid.

This paper proposed a new three-phase four-wire wind– hydro hybrid system for isolated location. which has not connected to any grid and where the wind and hydro potential exists concurrently. The proposed system uses a variable speed wind-turbine and a constant speed, constant power small hydro electric power driven by squirrel cage induction generator SCIG for both. India ranked 5th in the world for utilizing such wind power and one such location in india is the Andaman-Nicober islands.

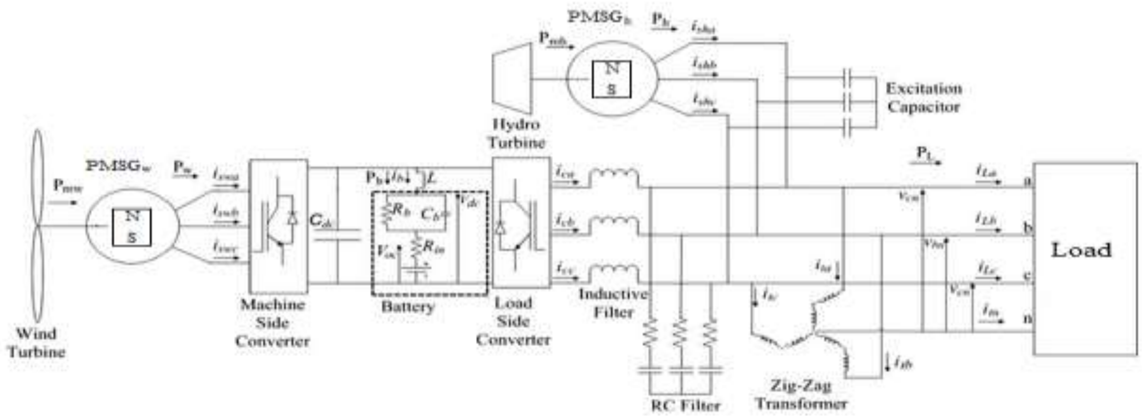

Fig. 1: Schematic diagram of wind–hydro hybrid system

Two IGBT based back to back power converter VSCs, pulse width modulation PWM controlled are connected in between $SCIG_h$ of constant speed small hydro turbine stater (load side)and $SCIG_W$ of variable speed wind turbine stater(machine side) to maintain bi-directional power flow. This proposed system is having three modes of operation. In the first mode of operation excess active power generated by the $SCIG_h$ transferred to BESS(battery energy storage system) through the load side converter. In the second mode of operation if the load power demand is more than the active power generated by $SCIG_h$ but less than the wind-hydro duo generated power then $SCIG_w$ meet the load demand and extra active power stored by the BESS. In the third mode of operation when the load power demand is more than the active power generated by the $SCIG_h$ and $SCIG_w$ then the defcit power supplies by the BESS through the load side converter.

PRINCIPLE AND OPERATION

In the proposed system has two IGBT based converters VSCs which controlled by PWM method. One is load side converter another one is machine ($PMSG_{w)}$ side converter. The proposed hybrid system is based on new control strategy it has the capability of MPT, load balancing, load leveling, harmonic elimination, neutral current compensation. The main objective of the machine side converter ($PWSG_w$) are to provide continuous magnetizing current to the $PMSG_w$ and to achieve MPT. The objective of load side converter is VFC at the load terminals by maintaining active-reactive power balance

A systematic switching strategy adopted for converter operation. A control signal for switching of the load side converter VSCs are generated from the error of the generator stator current and the reference current, rather than the errors of the load side converter current. At the normal frequency the load side VSCs controlled to make the sinusoidal and balanced current of PMSGg. Zigzag transformer and the load side converter proposed to compensate the harmonics and to avoid undesired consequences. The proposed system reducing the requirement of the current sensors as the sensing of load side converter current and load current is not required but it required sensing of the load voltage and stator current of the PMSGg .

The load side converter control strategy is different it maintains the active power flow between the SCIGs and load side. It balances the active power flow by V/F control method and capacitors are connected at the stator terminal to meet the reactive power demand of machine. It can operate for different types of load demand. In one of the case when the active power demand is less for the applied load than the active power generated by the SCIGh then the excess power stores by the BESS. When the active power demand is more than the duo power produced by the machine (SCIGh and SCIGw) then active power supplied by the BESS to meet the load requirement. Excess power generated by the generator stores at the BESS through the converters VSCs. DC link connected between the VSCs to maintain constant flow of power from converter to BESS and BESS to load.

CONTROL OF VSCS

The control of the machine converters to provide required magnetizing current to the SCIGw and to achieve MPT through the torque control mechanism . Load side converters are to control the voltage and frequency irrespective of the connected load.

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MACHINE SIDE CONVERTER CONTROL AND RATING

The proposed algorithm shown in the schematic diagram of machine side controller Speed-Control Loop for MPT and Reference q-axis SCIGw Stator-Current Generation is taken into consideration. The rotor speed (ωrw) of SCIGw is determined from its rotor position (θrw) and the wind speed are sensed. To compute the SCIGw stator current errors , three-phase reference SCIGw currents (iswa, iswb and iswc) are compared with the sensed SCIGw stator currents (iswa, iswb and iswc) and these current errors are amplified with gain(K = 5) to generate gating signals for the IGBTs of the machine-sideVSC by comparing with a fixed frequency of (10 kHz)

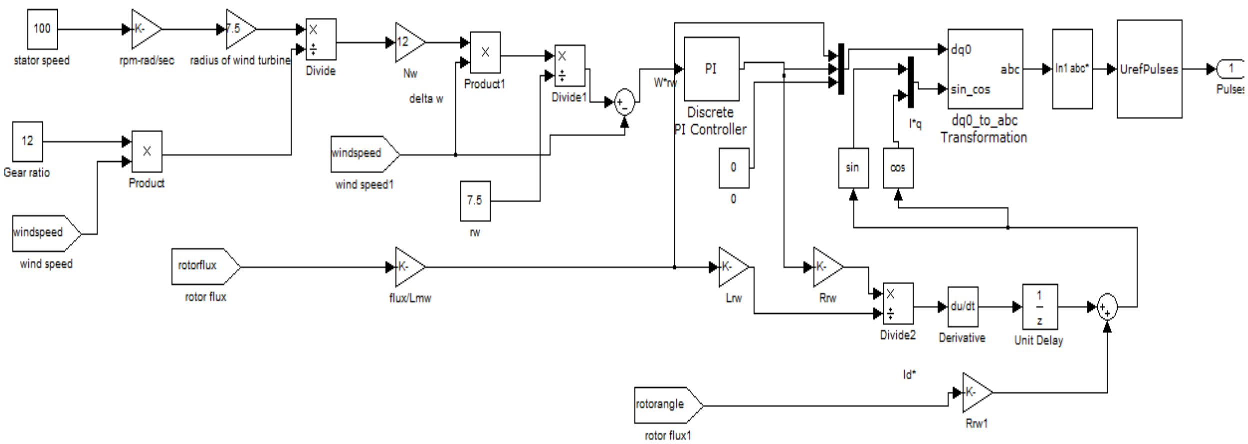


Fig: MATLAB Simulation diagram of machine side converter control scheme

The system is designed for an isolated location with the load varying from 40 to 100 kW at a lagging power factor (PF) of 0.8. The maximum active-power flow through the machine- side converter Psw = 50 kW and from the calculation max reactive power flow will be $Q_{sw} = V_{msc} /(2\pi f L_m) = 16.5$ kvar.

where Vmsc is the maximum line voltage generated at the SCIGw terminals, which is 415 V, at a frequency (f) of 50 Hz generated at a wind speed of 12 m/s. The ratings of the switching devices (IGBTs) are decided by the maximum voltage across the device and the maximum current through it.

The VA rating (VAmsc) of the machine side cconverter is

$$\sqrt{2}VAmsc = Psw + Q2 = 552 + 18.42 = 56 \text{ kVA},$$

and the maximum rms machine-side converter current as

$$\sqrt{Isw} = VAmsc/(3Vmsc) = 80.7 \text{ A}$$

LOAD SIDE CONTROL AND RATING

Load side converter only meant for voltage and current control. The power balance in the dc-link is maintained by two way power flow from generator to battery and battery to load by transferring the extra surplus power from the generator SCIGw to the battery or battery supplying the required power to the load in case of deficit between load demand and generated power. Constant value of the load voltage is maintained by the load side converter by supplying the required reactive power to the load. To generate gate signals for IGBTs of the converters on load side, the amplified current error signals (amplified with gain K=5) are compared with a triangular carrier wave of a fixed frequency (10Khz) having unity frequency.

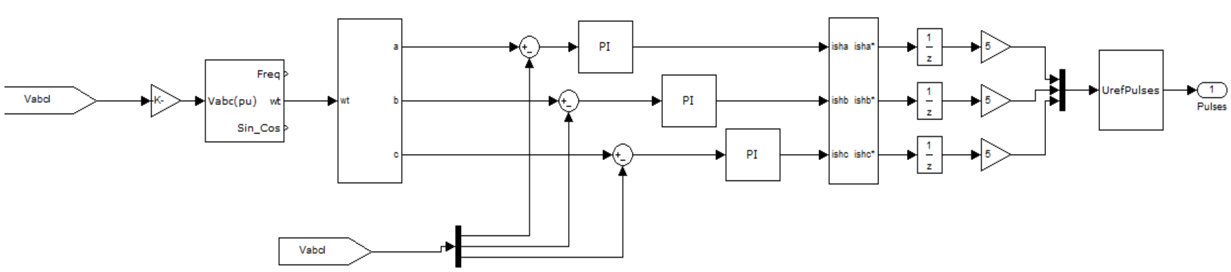


Fig:MATLAB simulation diagram of Control scheme of laod side converter

The rating is determined when the load connected at its maximum value of 100Kw at 0.8 pf . the reactive power flow through the converter & the load is same which is calculated as (Q=100/0.8)*0.6=75 Kvar. The maximum current for the switching device will be 1.25*(11.1+221.3)=290.5 A .where 1.25 is the safety margin taken for the safety purpose and the maximum value of DC-link voltage taken as 750 V.

SIMULATION AND MATLAB BASED MODELING

The electrical system simulated by using sim power system set tool boxes and MATLAB using simulink. The simulation done on MATLAB version-9. The different kinds of loads are modeled at different wind speed using resistive, inductive and capacitive elements and combined rectifier-fed resistive loads with LC filter. The balanced and unbalanced loads are modeled using the breakers in each individual phase. The MATLAB model for the proposed W-H hybrid system is shown in the figure.

Different dynamic conditions applied to check the performance of the W-H hybrid system with the systematic control algorithm. Here the proposed W-H hybrid system is studied with all kinds of electrical loads with different wind speed i.e balanced load at a wind speed of 11m/shaving 20Kw of load in single phase, unbalanced load at an wind speed of 8m/s at 20 kw power in single phase , with the balanced and unbalanced load at an wind speed of 10m/s with three single phase bridge rectifier of 16kw and linear load of each 5kw,consatant balanced linear loads, mixed loads. It has seen that in all the above condition W-H hybrid system performed in a systematic desirable manner. Especially under balanced and unbalanced condition the non linear loads are balanced within the desired limit with both wind and hydro generator (SCIGh,SCIGw) currents and load voltages.

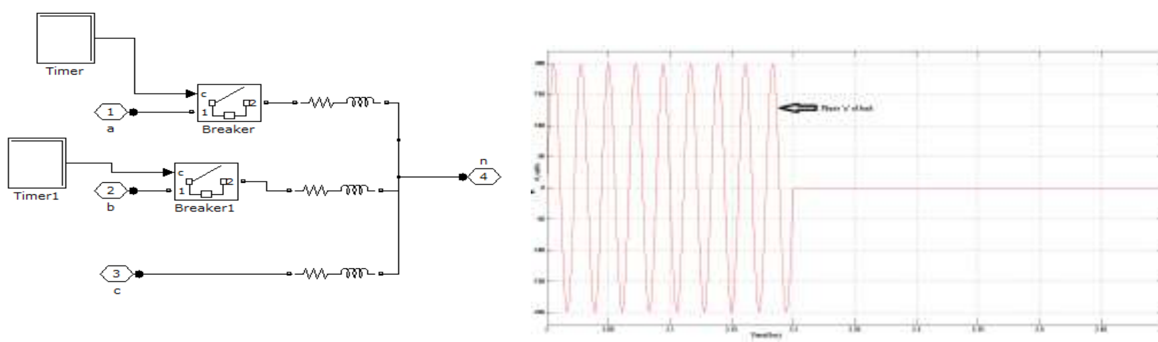
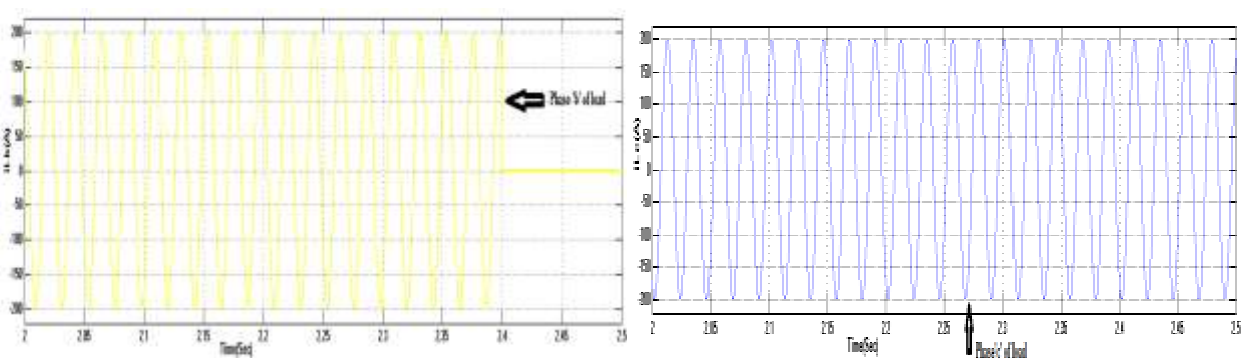


Fig 2. MATLAB simulation of unbalanced load



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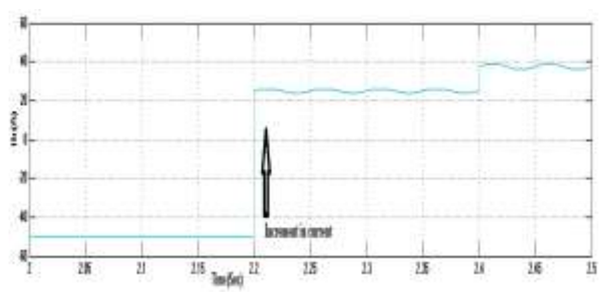
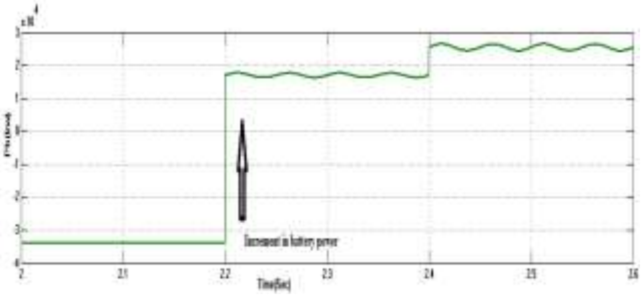
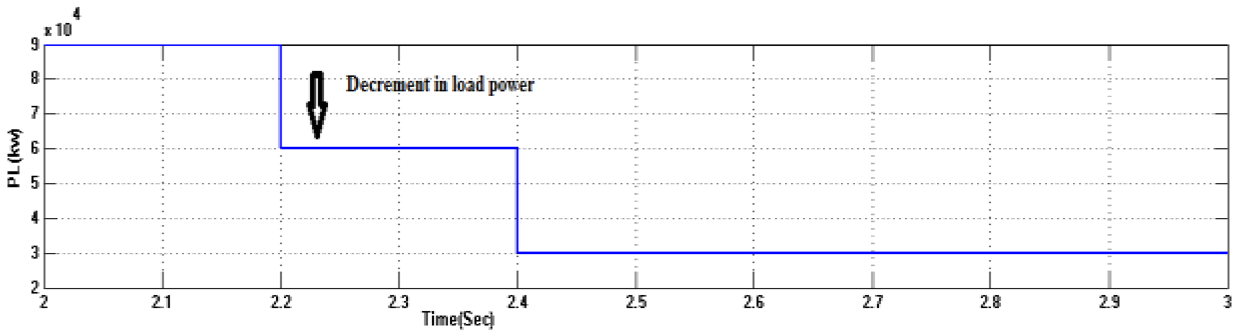






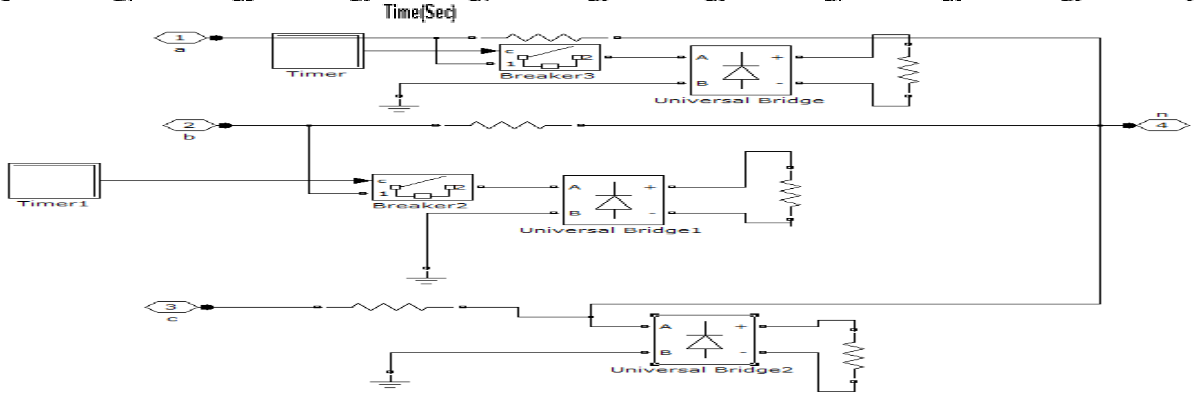
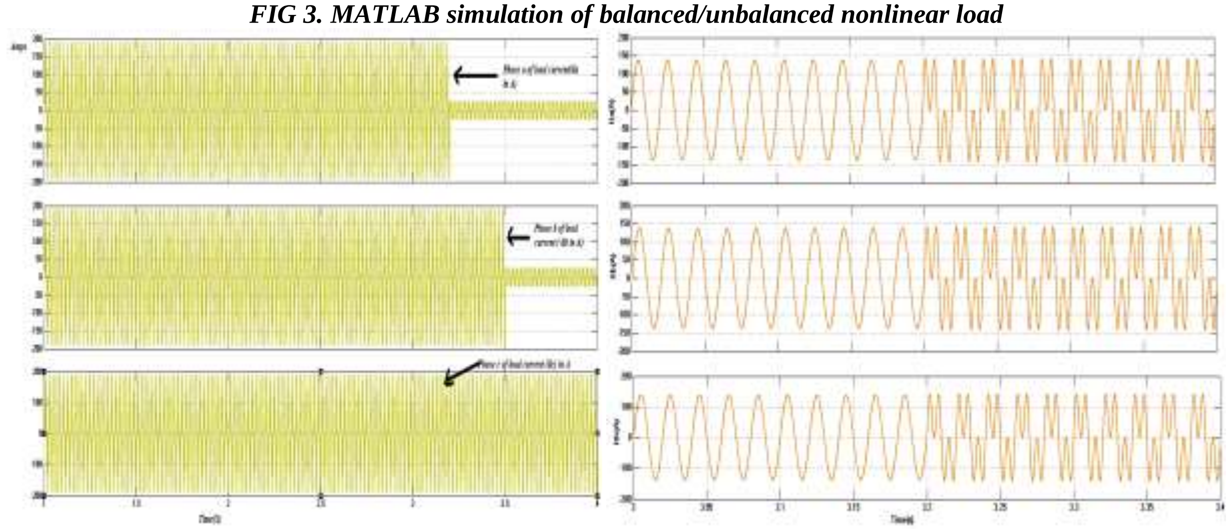
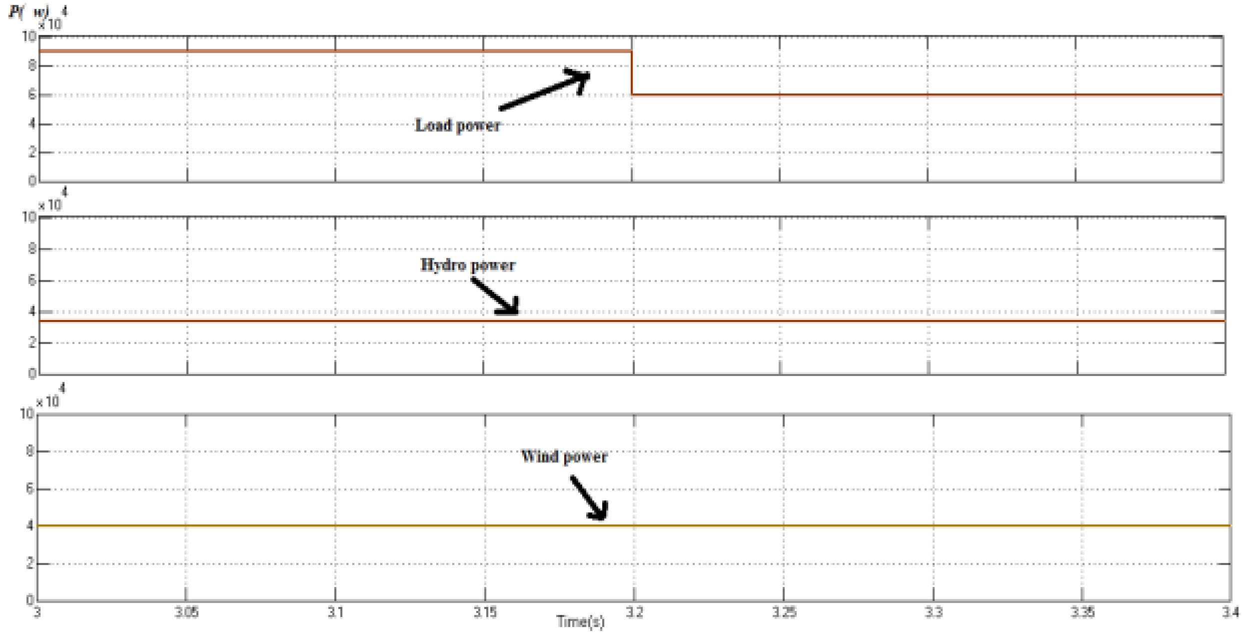


FIG 3. MATLAB simulation of balanced/unbalanced nonlinear load





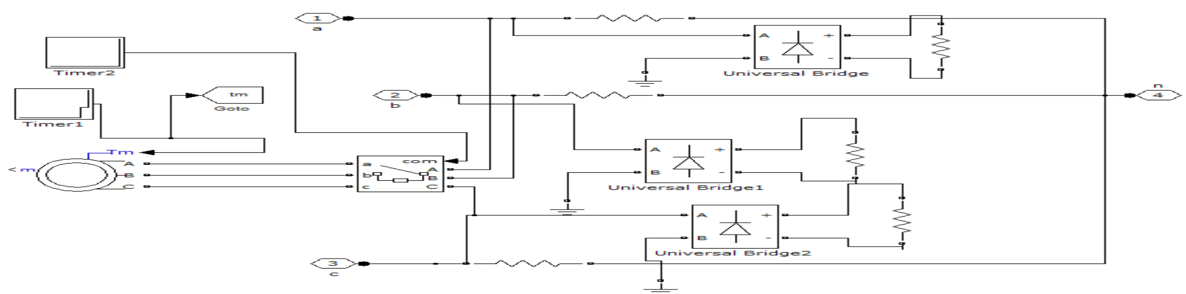
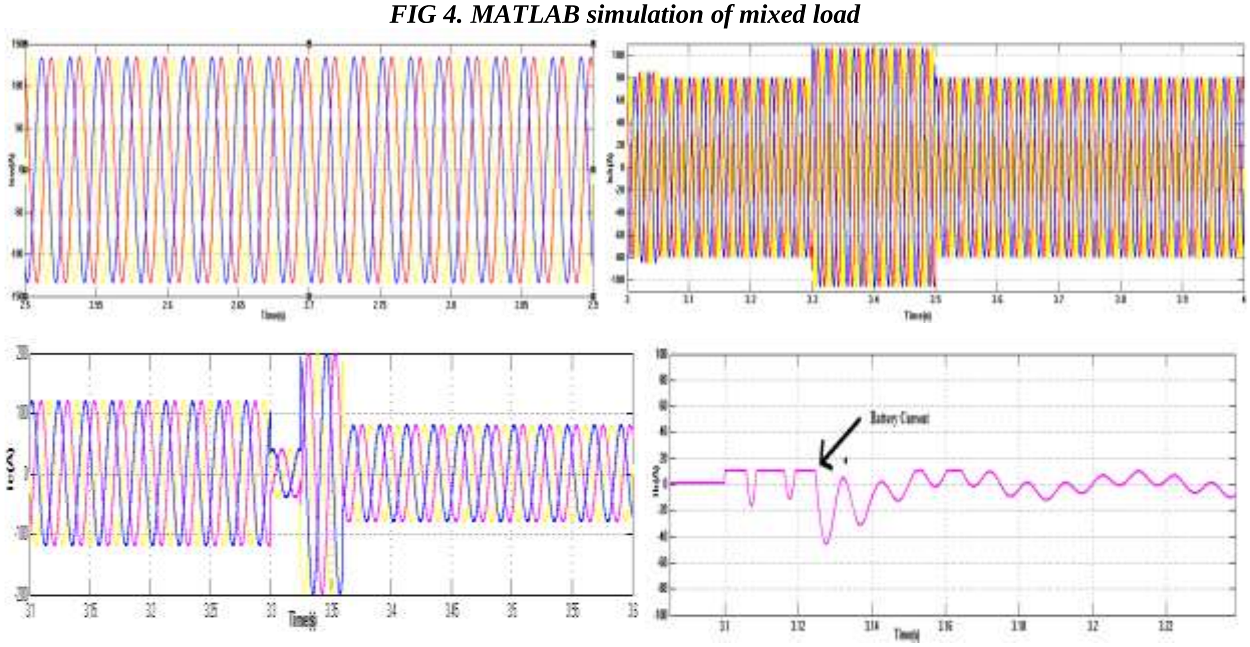
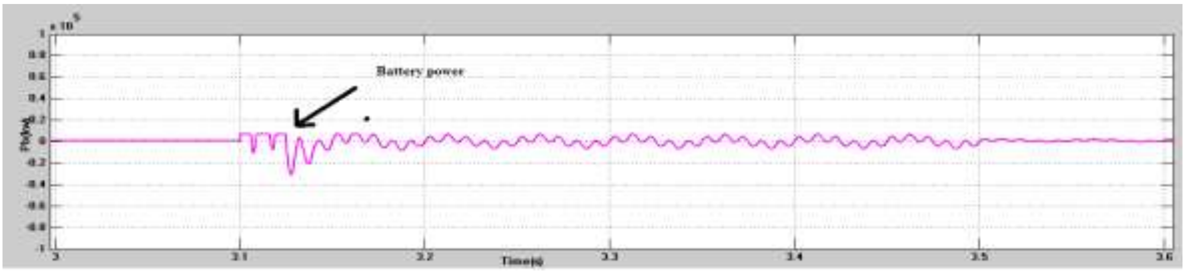


FIG 4. MATLAB simulation of mixed load





CONCLUSION

The renewable energy sources have the ability to complement with each other. There are many locations which are far away from the grid station but exists the wind hydro potential simultaneously. For such location a 3 phase four wire wind-hydro hybrid model (W- H model) with generator for hydro turbine SCIGh and generator for wind turbine SCIGw along with the converters VSCs on machine side and load side with a BESS has been modeled by using MATLAB-9 simulink and sim power tools. The performance of the system demonstrated under various states of electrical and mechanical conditions and obtained the desired result within the balanced limit.

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