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Analysis of Wind-Hydro Hybrid System Using Battery Storage in Un-Balanced Condition

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ABSTRACT

Wind energy forms to be a dominant source of energy for the ever-increasing power demand. For the past years wind energy has been a reliable source for power demand. Wind energy can be used along with other sources of energy like the Hydro system to form an efficient and consistent method to harness electrical energy. Although wind energy is efficient and reliable, there is always uncertainty of power. Hence wind energy should be used along with a Hydro system. There are cases when wind and hydro both operate to its optimum level. In such a case battery storage system should be used to store the excess power generated. This research uses the SCIG machine in case of variable for wind and fixed speed for hydro for analysis.

Keywords: Battery, Hydro, SCIG, Wind.

I. INTRODUCTION

This research work is a performance analysis of the WTG and the Hydro generator for power generation. Initially conventional methods of power generation were employed. Now importance is given to the use of renewable sources of energy like wind, solar, tidal etc. Now wind energy sectors open many opportunities for the power engineers. Wind energy also poses many threats like high initial cost, uncertainty of wind speed, skilled labour. Wind energy should be used in combination with other sources like the Hydro system in this case. Renewable sources of energy form a clean source of energy do not create any pollution and are available free of cost, also wind energy is a long lasting source of energy [1] [2].

Thus, wind energy is to be given prime importance for power generation. This research work makes use of both the integrated wind and hydro system. In case of high power generation from wind and hydro system, the battery employed in the system can be used to charge itself. Also during light power generation, the same battery can be used to deliver output. This ensures reliable mode of operation [3][4].

II. METHODS AND MATERIAL

1. Wind Hydro Schematic System

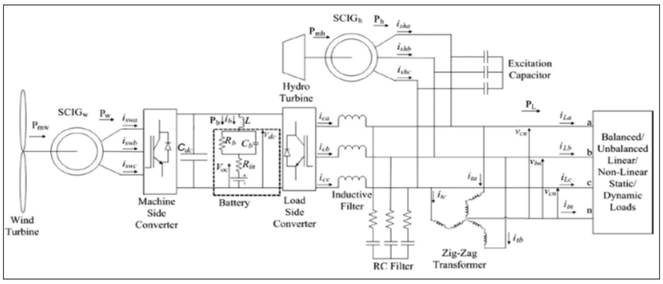

Figure. 1 Wind Hydro Schematic system

The Fig 1 above shows the schematic arrangement of the Wind and Hydro system, the system makes use of the battery system also as discussed before. The use of excitation capacitors is made for reactive power compensation and also to improve the voltage profile. The use of inductors is made to remove the ripples available in the power circuit. The use of Zig Zag transformer is made to remove the zero sequence components available in the circuit. There are two converters used namely the Grid side and machine side converter. The use of coupling capacitor is made to maintain the dc link voltage [5].

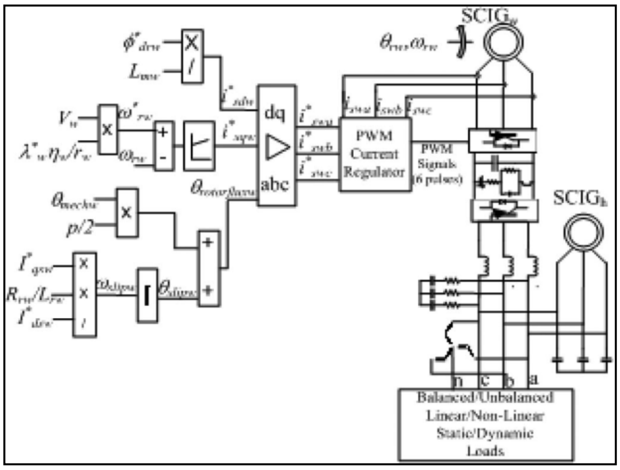

Figure 2. Machine Side Converter

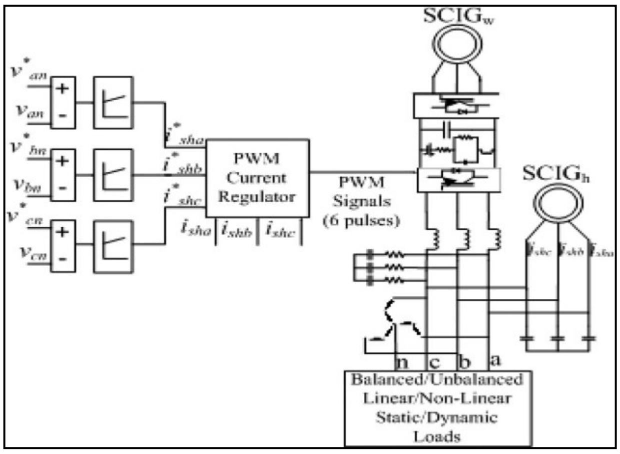

Figure 3. Load Side Converter

The Fig 2 and Fig 3 above shows the arrangement for Machine side and Load side converter. The algorithm for the same is developed in MATLAB/ Simulink model. The system operates on the MPT system (Maximum Power Tracking) system. Where the Machine side converter is used to provide MPT and also for the magnetizing current. The grid side converter performs the control of magnitude of the frequency and load voltage. The objectives of the machine (SCIGw) side converter are to achieve optimum torque for MPT for SCIGw and to provide the required magnetizing current to the SCIGw [1][6][7].

2. Design Specifications

The system is designed for a load varying from 30 to 90 kW at a lagging power factor (pf) of 0.8. 60 KW is the average load considered of the system. The ratings are considered for SCIGs, battery capacity, machine-side converter, specifications of wind turbine, load-side converter, gear ratio, battery voltage etc.

The hybrid system being considered has a hydro turbine of 35 kW and Wind Turbine of 55 kW. Both turbines are coupled to SCIGs. The rating of the SCIGw is equal to the rating of the wind turbine, which is 55 kW. The rating of the SCIGh should be equal to the rating of the hydro turbine, which is 35 kW. The rating of SCIGh is taken as 37 kW [8][4].

III. RESULTS AND DISCUSSION

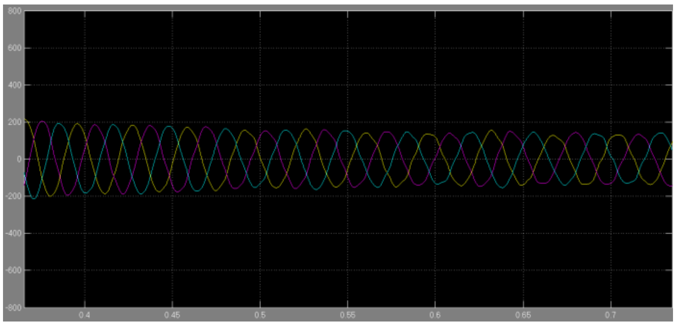

Figure 4. Isw response with time

The Fig 4 above shows the response of the wind current (Isw) with respect to time. Also it is noted that the response presents sinusoidal operating condition.

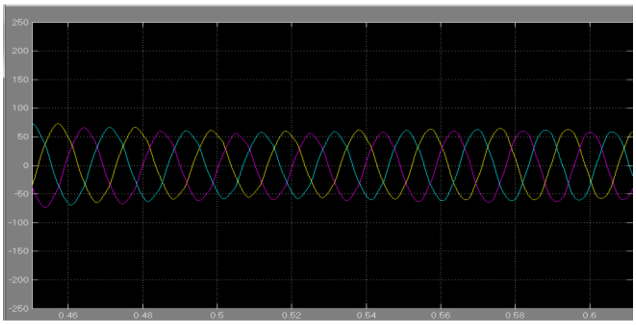

Figure 5. Ish response with time

The Fig 5 above shows the response of the wind current (Ish) with respect to time. Also it is noted that the response presents sinusoidal operating condition.

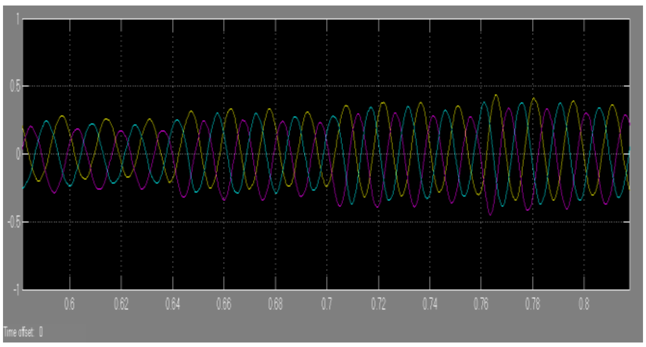

Figure 6. Ic response with time

The Figure 6 above shows the response of the Load Side Converter current I_c with respect to the time, also the nature is observed to be sinusoidal.

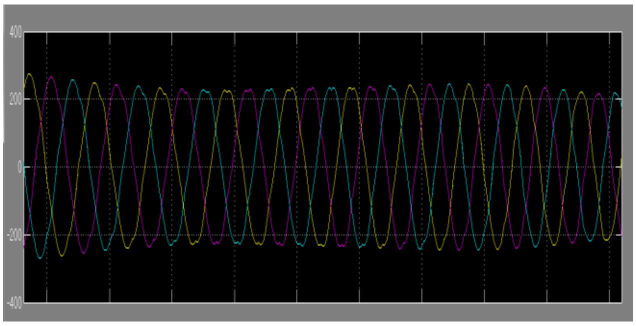

Figure 7. Vl response with time

The Figure 7 above shows the response of the three phase Load voltage (VL) with respect to the time. The nature is again observed to be sinusoidal.

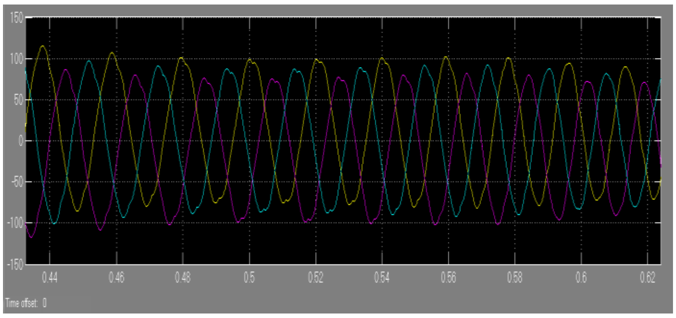

Figure 8. IL response with time

The figure above shows the response of the three phase load current with respect to the time. The response is observed to be sinusoidal.

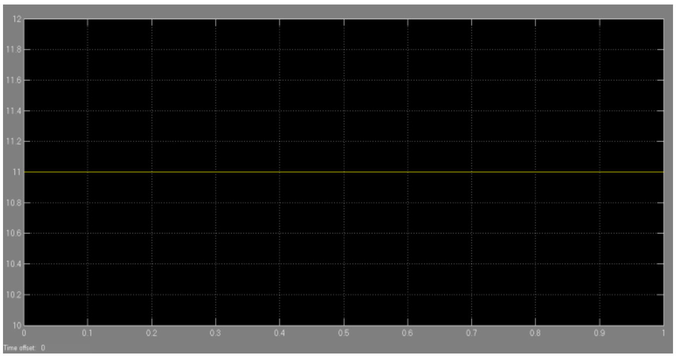

Figure 9. Wind speed response with time

The Figure above shows the Wind velocity, it is observed that the wind speed is 11 m/s for the balanced operating conditions.

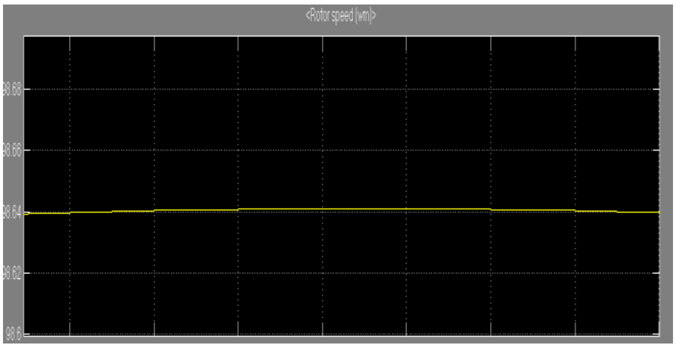

Figure 10. Wind speed response with time

The figure above shows the response of Rotor Speed with respect to time. It is almost 98 rad/ secs.

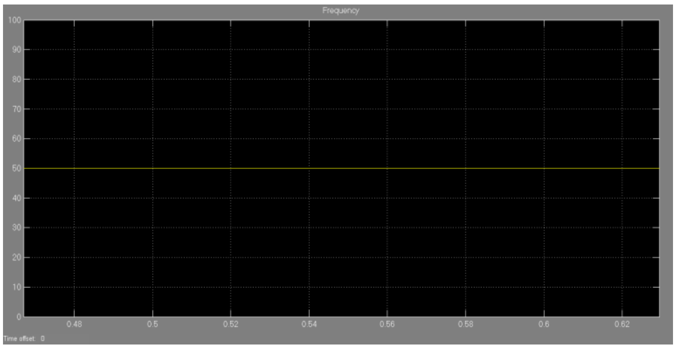

Figure 11. Frequency response

The figure response presents the system frequency is operating at 50 Hz of normal frequency.

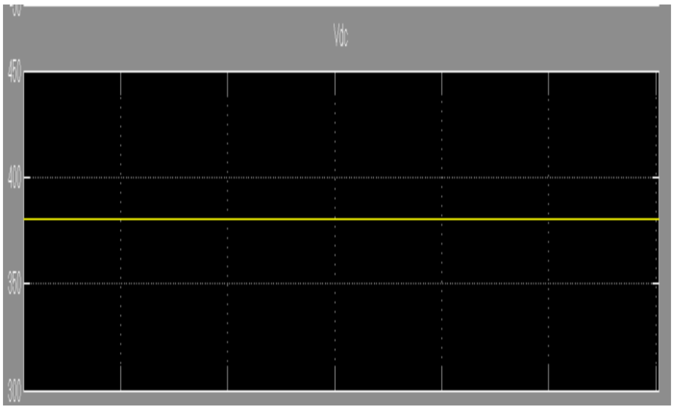

Figure 12. Vdc with respect to time

The battery Voltage is maintained at 370 volts as shown in the Figure 13 above.

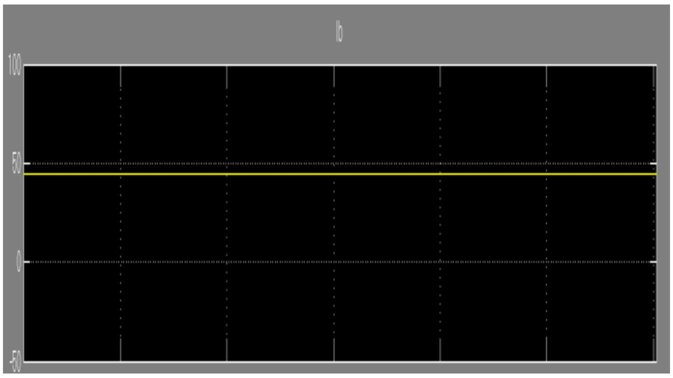

Figure 13. Ib with respect to time

The figure above shows the response of the Battery current Ib which is maintained at 48 A.

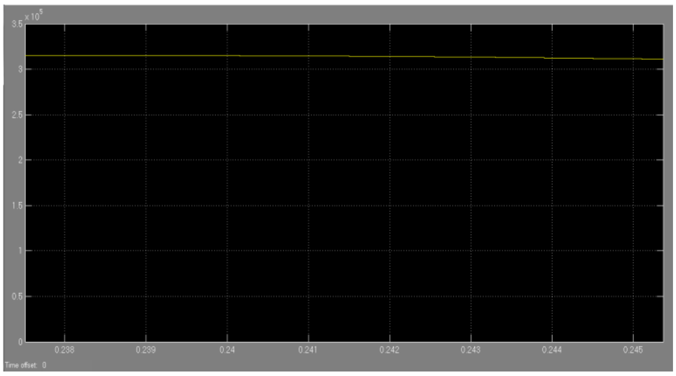

Figure 14. Pw with respect to time

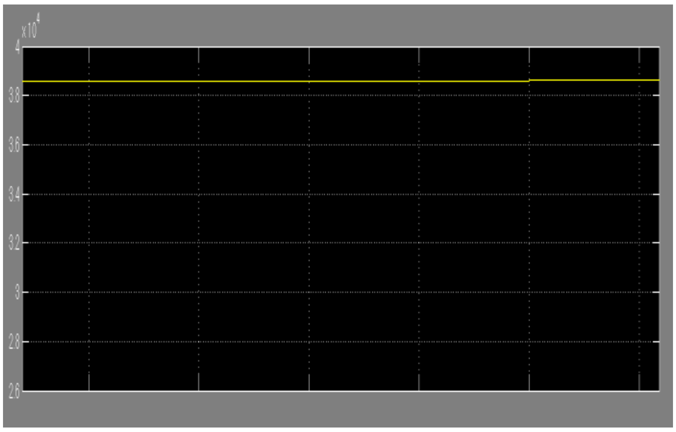

Figure 15. PL with respect to time

Fig 14 and 15 shows the response of Wind Power and Load power (PL) requirement with respect to time.

IV. CONCLUSION

The Unbalanced Condition resembles uneven load distribution on each of the phases this is specifically done to match the load. In such a case, that mechanical power corresponding to a maximum performance is around 20 kW. The input of mechanical power to the SCIGh (hydro) is taken as around 35 kW. The power generated through SCIGh is 33.3 kW. Thus, the total power generated is (33.3 + 20) kW = 53.3 kW. The system is initially started with balanced 3, 1-Φ linear loads (each of 30 kW) connected between each phase and neutral terminal. As the power produced by the system is comparatively less than the required electric power for electrical loads of 90 kW, in this case the battery is supplying the deficit power.

V. REFERENCES

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