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

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ABSTRACT

The growing demand of electrical energy and fewer or limited resources to fulfil the present energy requirements leads to focus on the renewable energy sources like Wind with integration with the Hydro sources. Today environmental concerns and higher rate of electricity gives importance to the renewable sources of energy. The wind energy today forms a vital source of energy, as it is available in the universe free of cost and provides opportunities for research and development for the future engineers. If Wind Energy is used with some other source like the Solar and Hydro, it can form a very efficient source of energy. In addition, they should be some storage technique adopted to store the energy during availability in excess and discharge during light load conditions. The paper presents the research work carried out to demonstrate the features of the SCIG machine to harness the wind power and provide rated power output under balanced load conditions. The system uses Hydro system, which compliments the Wind system. The battery system is employed to store the energy.

Keywords: Battery, Hydro, SCIG, Wind.

I. INTRODUCTION

Today Wind energy is a very promising option available in front of power engineers. Wind energy provides opportunities like lower generation cost, pollution free environment, and job opportunities in front of engineers. A primary resource of energy considered as Wind energy is to be looked upon in combination with other resources like sun and hydro. The system promises to give a reliable source of energy [1].

It is better to use Wind energy with combination like solar and hydro. The battery system should also be employed to provide power output during light loading conditions and charge the battery during higher power output of Wind and Hydro. The balanced condition resembles the one in which all the three phases carry equal load. The battery system is used as a kind of back up to provide deficit energy during light generating conditions [1] [2].

The system can be employed in places where there is good profile of both Wind and hydro. Although at a time of improper wind profile and lower hydro energy the backup of battery system can be used to restore normal operating conditions [3].

The research work includes the simulation of the whole model in MATLAB/ Simulink. The model is developed in MATLAB for individual Wind and Hydro system along with their battery system and control algorithm. The machine side and grid side converter model is developed in MATLAB [4].

Today the Wind energy comes with many challenges and thus the possible features of the Wind energy are to be harnessed on a large scale. The wind energy should be used in combination with other sources to form a reliable source of energy. In the present day scenario there is a large scope for power integration, where many other sources are to be used in combination.

Today wind energy has a lot of possibilities so it should be used with other sources for reliable operation [5] [6].

The Hydro system has proved its benefits and promises to be a long lasting source. The conventional sources of power generation include the use of Hydro energy on a large scale. But use of the Wind energy along with the Hydro system can form to be a confirm solution for the power demands [2] [3].

II. METHODS AND MATERIAL

1. Wind Hydro Schematic System

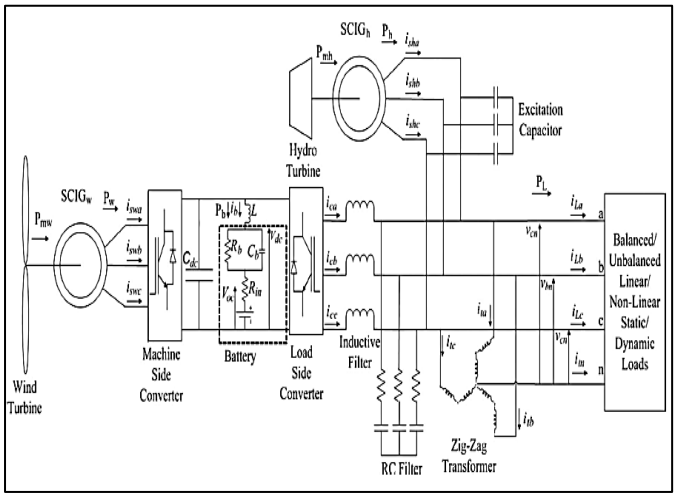

Figure 1. Wind Hydro Schematic system

The Figure 1 above shows the schematic arrangement for the Wind Hydro system. The system involves the use of the SCIG (Squirrel Cage Induction Generator) along with the Machine side converter model for power economy. The system also includes the use of Filters to remove ripples if any in the system. The use of zero sequence reactance is made to remove the zero sequence components if any. Also the filter system is used for the reactive power compensation. The Grid side converter model is used to convert the nature of power supply. The load either balanced or unbalanced is used to consume the generated power. The Hydro system is equipped, which specially uses the fixed speed induction generator. The combination power of both the Wind and Hydro is fed to the load. The battery forms the initial part of the system, during the light power generation span the battery is used to deliver power. Also during high power generation the battery is used to charge itself. Thus, the battery forms the secondary backup of the system.

2. Control Algorithm

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 [1].

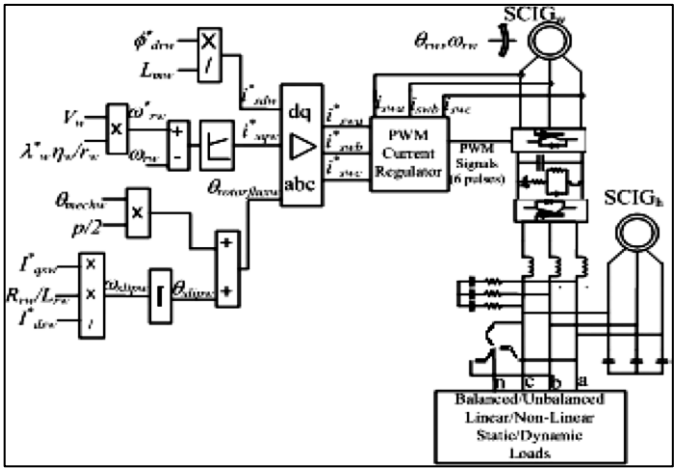

Figure 2. Machine side Converter model

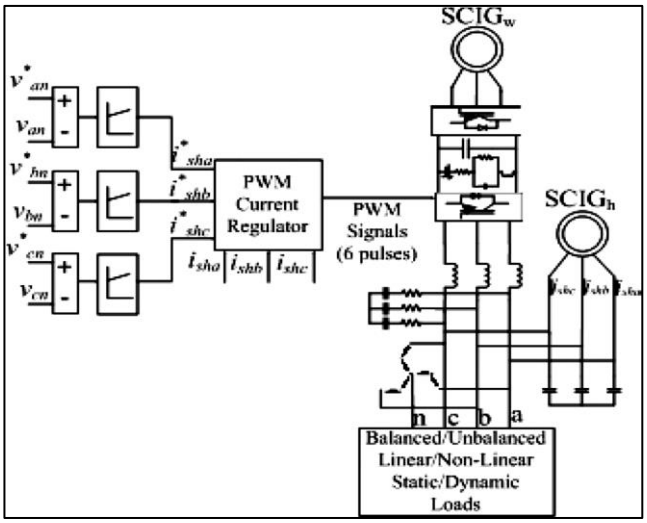

Figure 3. Load side Converter model

The objectives of the machine (SCIG*w*) side converter are to achieve optimum torque for MPT for SCIG*w* and to provide the required magnetizing current to the SCIG*w*. The control strategy for the machine (SCIG*w*) side converter control is shown in Fig 2. The objectives of the load-side converter are to maintain rated voltage and frequency at the load terminals irrespective of connected load. The power balance in the system is maintained by diverting the surplus power generated to the battery or by supplying power from the battery in case of deficit between generated power and load

requirement. Similarly, the required reactive power for the load is supplied by the load-side converter to maintain constant value of the load voltage. The control strategy for the load-side converter control is shown in Fig 3. The control algorithm is developed in MATLAB Simulink model.

3. Design of Wind- Hydro Hybrid System

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.

III. RESULTS AND DISCUSSION

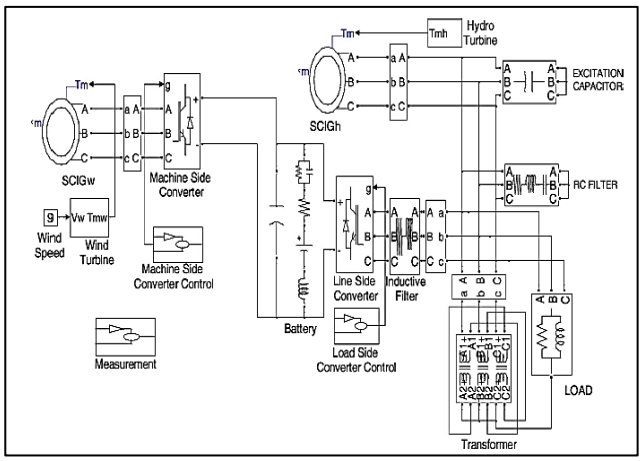

Figure 4. Wind- Hydro System

The system shows the outline of the Wind- Hydro system. There are two type of generator one is the fixed speed and the other is the variable speed.

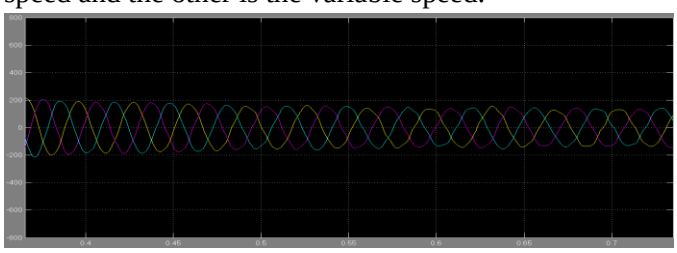

Figure 5. Isw response with time

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

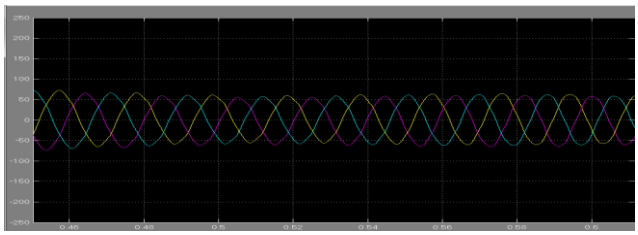

Figure 6. Ish response with time

The Fig 6 above shows the response of the wind current (Ish) with respect to time. Also it is noted that the response presents sinusoidal operating condition.

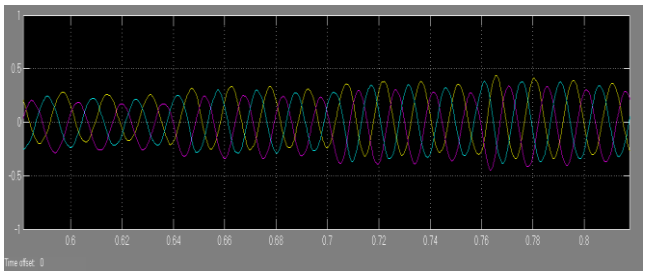

Figure 7. Ic response with time

The Figure 7 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.

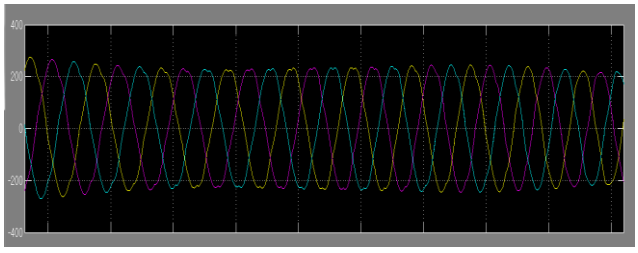

Figure 8. Vl response with time

The Figure 8 above shows the response of the three phase Load voltage (VL) with respect to the time. The nature is again observed to be sinusoidal.

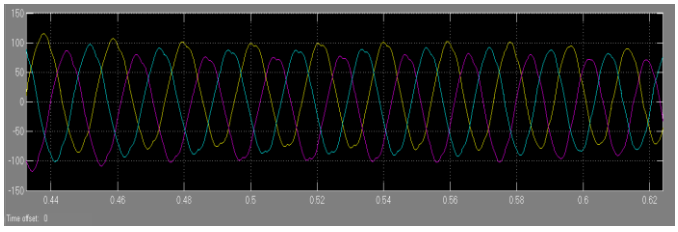

Figure 9. IL response with time

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

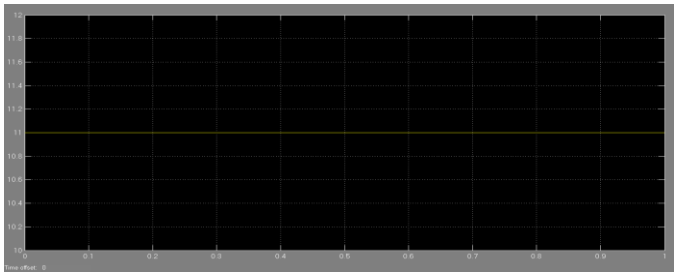

Figure 10. Wind speed response with time

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

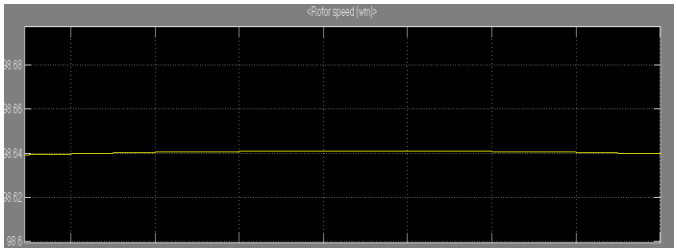

Figure 11. Wind speed response with time

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

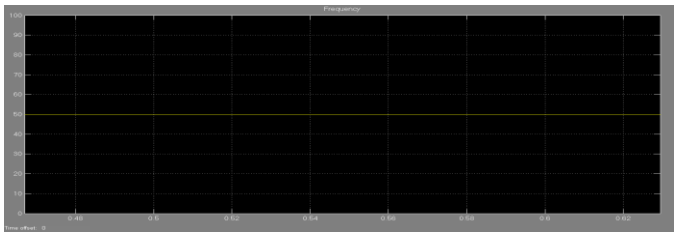

Figure 12. Frequency response

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

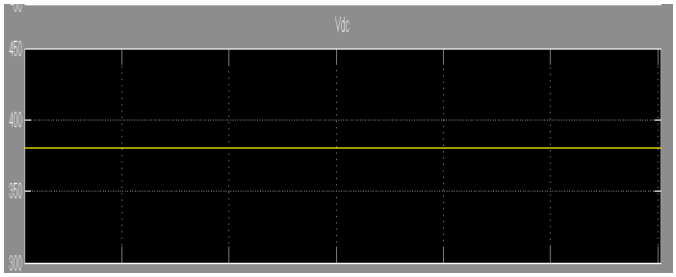

Figure 13. Vdc with respect to time

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

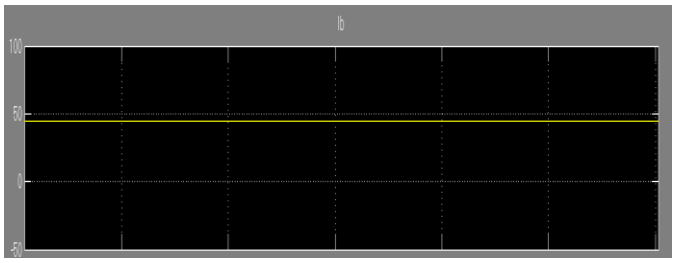

Figure 14. Ib with respect to time

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

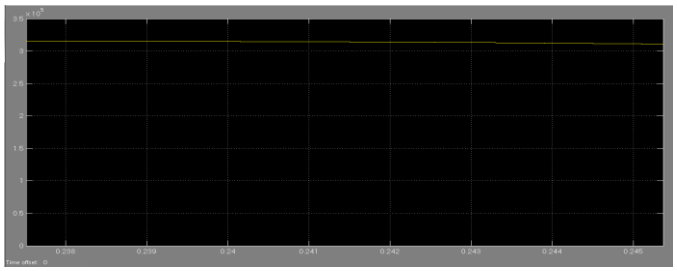

Figure 15. Pw with respect to time

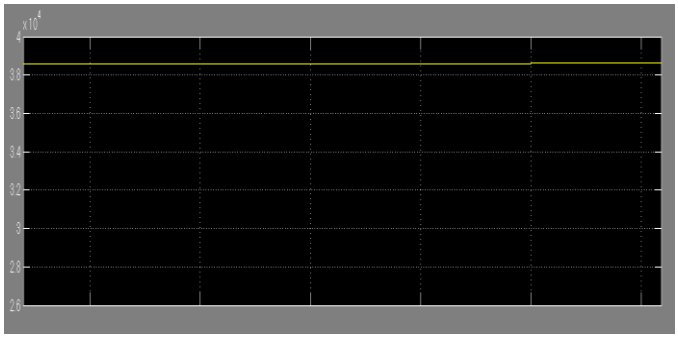

Figure 16. PL with respect to time

Fig 15 and 16 shows the response of Wind Power and Load power requirement with respect to time. During balanced conditions it is found that both the system wind and hydro are delivering optimum power above the requirement of the load. Thus the need which is required to fulfil the load requirement is met and thus is there an extra need to fulfil the required of charging the battery. In this case the power generated is more than the load requirement and thus the power generated is used to charge the battery. Thus the battery can be used to deliver charge during light power generation conditions. Also SCIG machines have low cost, low maintenance, higher efficiency, lower operating cost [7] [8]. Thus this forms the balanced operating conditions when all the phases are operating. Thus this forms the overall working of the system.

IV. CONCLUSION

In this research work, the capabilities of both the Wind and Hydro system are showed. The response of the system in the MATLAB/ Simulink model is showed. The various characteristic like Wind speed, Current and voltage response, battery-operating characteristics are shown. During balance operating conditions, it is found that the Wind and Hydro system are charging the battery. The same can be used to deliver power from battery during low power generation. The SCIG machine is to be used because they have low cost, low maintenance, higher efficiency. Thus, the research work is presented in the paper and importance is given on the use of Hybrid system.

V. REFERENCES

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