International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 9 (2015) pp. 21675-21682

http://www.ripublication.com

Integration of Wind and Hydro Power Generation and Its Forecasting

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Abstract

The new era of electricity generation focus on the renewable sources of energy like wind energy and hydro energy leading to floating grid. The issues related in short term forecasting is maintaining the grid frequency within the limits. The wind energy and hydro energy are based on the seasonal monsoon weather which varies with the year. With such a variation in generation, the base load stations like Thermal and Hydro stations has to be optimized with this kind of varying load and needs good energy management. In India, Tamilnadu plays a major role in renewable sources of energy. The main demerits of wind are intermittency and power factor maintenance. The optimization of the base loads like Thermal and Hydro is difficult due to the wide variation in power generation due to intermittency. This project reveals about integrating the power generated from wind and hydro generation in the grid and as a result of which the fuel cost of thermal power generation can be reduced. In addition to this we should also consider the grid stability i.e. maintaining the grid frequency within limits. The southern grid in India experiences the problem of having unpredictable grid demand management. This problem can be addressed by short term forecasting of the wind and hydro flow that will be available for a required period of time.

Keywords: Wind Forecasting, Hydro Forecasting

Introduction

Green energy sources are highly monsoon dependent. Availability of the sources by time is quite difficult to commit. So that integration of both wind and hydro power becomes challenging.There are lot of issues to be taken into consideration while bringing these power units to the grid. Current scenario predominantly depends on green energy sources like Bio-mass, solar, wind, hydro etc.., Though they have various advantages , we practically face serious problems due to floating grid (i.e. maintaining the grid voltage and frequency in limits).On the other hand, forecasting plays a major role in planning and estimation of any event. Planning involves three types namely short term, intermediate and long term. Wind speed and its direction are the main parameters for forecasting wind power. Water inflow and Dam storage are main parameters for forecasting hydro power. Load forecasting can be done using GMDH.

Wind power is characterised by wind velocity, wind direction, size of the turbine, height of the hug and shear length etc. The power output of each individual turbines installed at different locations will be connected together to obtain the overall generation of wind power. Similarly, the hydro power is affected by inflow, storage, discharge, installed capacity, turbine and generator efficiency etc..,

This paper considers the real time data's taken from Wind farm at Coimbatore and Hydro Power Plant at Mettur.

Forecasting

Forecasting is defined as the process of creating events happened where their actual outcomes are not yet been observed. In other words, it can be explained as estimating the variables of interest with future data concealed in it. To be more specific, prediction of some values using the data available is termed as forecasting. An uncertainty decides about the degree of forecasting and accuracy.

Forecasting becomes important to avoid losses of power generated in power system.

Good predicted values can be obtained if historical data's given are up to date.

Short term forecasting suits good for operation of power plants. Due to the dissatisfaction of demand by the power supplied, then maintenance of grid frequency arises.

In this paper, GMDH (Group Method of Data Handling) is used here as a tool for forecasting both wind and hydro power generation. The GMDH is formed by using general laws of procedures which finds the best solution by performing the sorting of tough polynomial models. This method is called as external criterion.

GMDH is a ideal tool comprising of several inputs and single output is a subset of components of the base function

Y(x1,…, xn)=a0+Σ$aifimi$=1 where

f -elementary functions dependent on different sets of inputs

a- coefficients

m - Numberof the base function components.

Modelling of Wind Turbine

The power in the wind is given by the rate of change of energy:

$$P = dE/dt = \frac{1}{2} v^2 (dm/dt) \quad \ldots \qquad (1)$$

Where E=mas

From equation (1), the power can be defined as:

$P=\frac{1}{2}\rho A v^3$

According to the German scientist Albert Betz, the wind turbine will be able to convert maximum of 59.3% of kinetic energy into mechanical energy. This is referred to Betz Limit. As a result of this, theoretically the maximal power capability of any wind turbine design is 0.59.This also termed as power coefficient and is designated as,

Cp =0.59

Wind power is characterised as,

P (avail) = $\frac{1}{2}\rho A v^3 C p$

The length of the turbine blades yields the swept area of the turbine using the equation for the area of a circle,

$A = \pi r^2$

r- radius is equal to the blade length.

Computation Using Sample Data

Swept Area,l = 52 m,
Wind velocity,v = 0.95 m/sec
Density of air, ρ = 1.23 kg/m^3
Power Coefficient, Cp = 0.4
The blade length is taken as swept area,
l=r=52m
$A = \pi r^2 = \pi x\ 52^2$=8945 m^2
$P = \frac{1}{2}\rho A v^3 Cp$
=½ x 1.23 x 8495 x 0.95^3 x 0.4 =0.0018 MW

Simulation Results and Discussion

Wind and Hydro power integration in Figure 1 consists of wind turbine model, stipulated hydro input to be connected to the grid. The input to the wind turbine model is the forecasted wind speed for next 12 months and for hydro, the voltage profile for next 1 year will be the input.

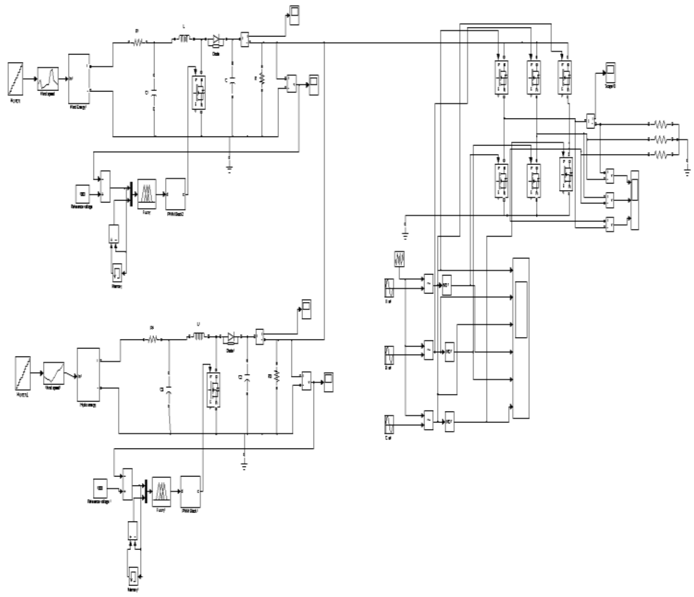

Figure 1: Simulation Model of Wind and Hydro Integration

Wind turbine model with PMSG in Figure 2 with different wind speed for next one year input is taken into consideration for converting it to corresponding DC signal as shown in Figure 5.

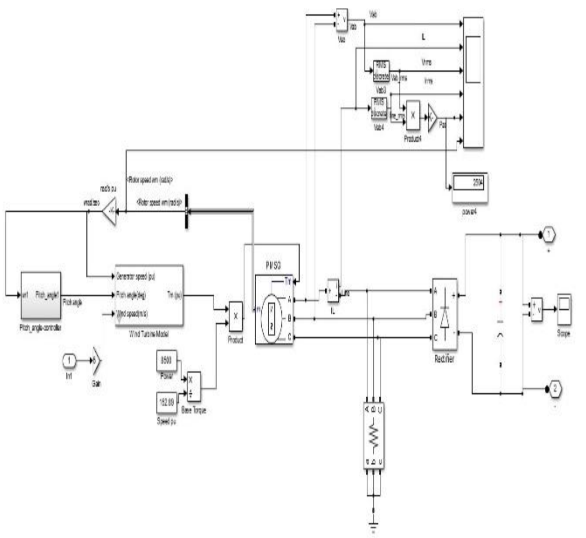

Figure 2: Simulation Model of Wind Turbine

The stipulated Hydro model in Figure 3 with different voltage profile for next 1 year input is converted to the respective rectified DC output as shown in Figure 6.

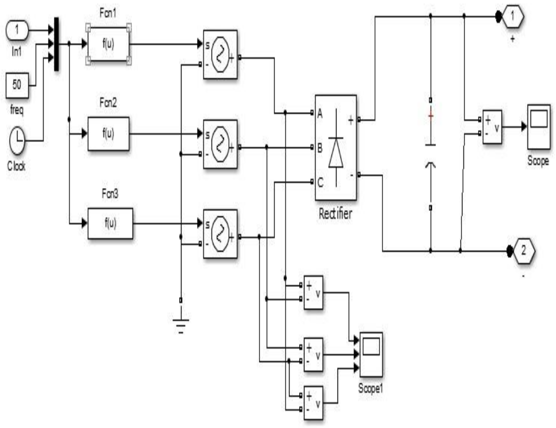

Figure 3: Simulation of stipulated Hydro Model

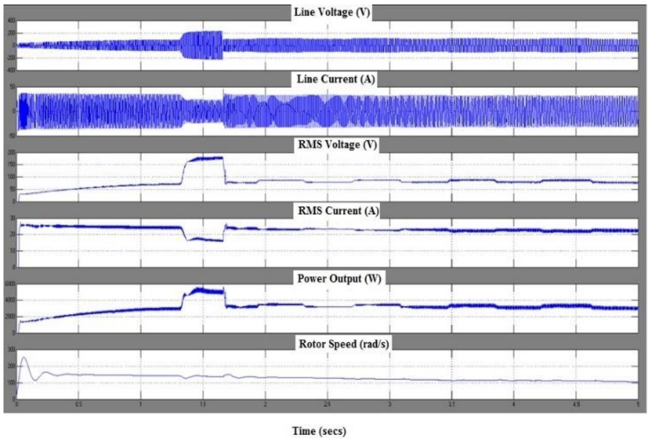

Figure 4: Wind Generator Outputs

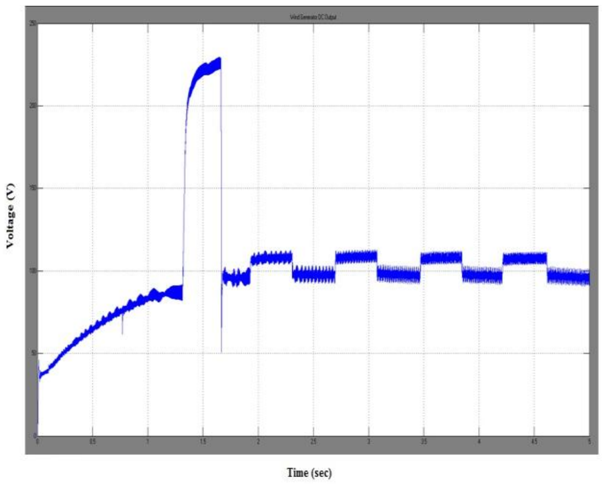

Figure 5: Wind Generator DC Output

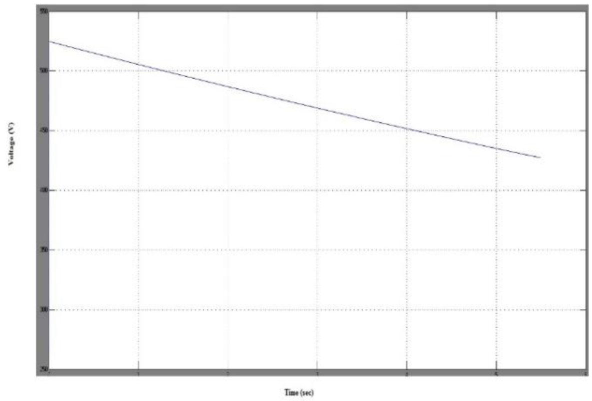

Figure 6: Simulated DC Output of Hydro

The Figure 7 depicts the DC grid Output after integration of wind and hydro power generation with the boosted voltage.

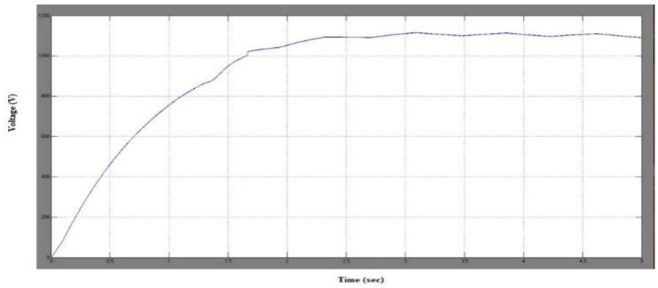

Figure 7: DC Grid Output

The Figure 8 is the PWM pulse waveform and the corresponding three phase inverted output voltage waveform after integration yielding the required out as shown in Figure 9.

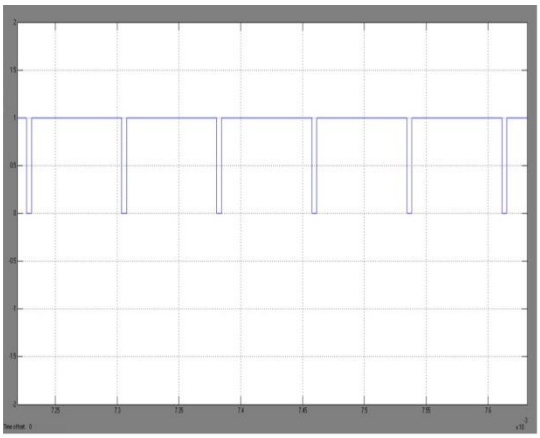

Figure 8: PWM Pulse

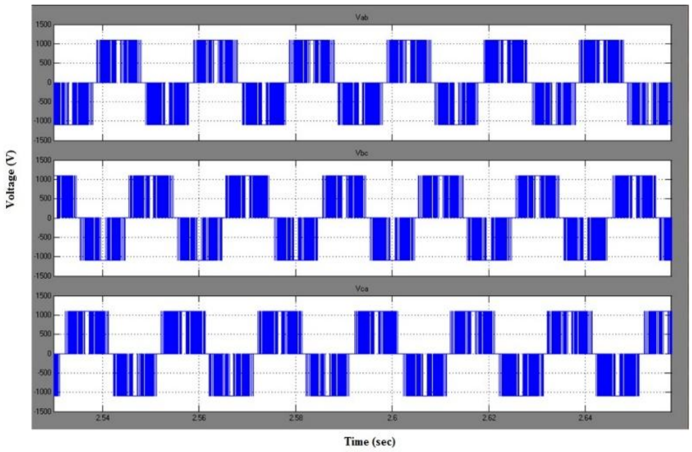

Figure 9: Three Phase Inverter Output

Conclusion

The paper clearly illustrates the need for going to renewable energy, the benefits of forecasting and also the impacts of wind and hydro generation. Using fuzzy logic, the integration to the grid is implemented which yields agood voltage stability and grid frequency in the grid thereby increasing the power generation. The main objective of the paper: meeting out the intermittency of wind with help of hydro power generation is accomplished by parallel switching idea with fuzzy technique. This concept can be extended further with unit commitment of thermal power generation.

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