Power Flow Control in Wind Power Systems through Narma L2 & PID Controller

Akanksha[1], Dr. Anita Khosla[2]

[1]PG Student [PSED], EEE DEPT, Manav Rachna International University, Faridabad, India
[2]EEE DEPT, Manav Rachna International University, Faridabad, India

ABSTRACT

This writing article explains a novel application for power management in self-contained energy systems. Using Matlab / Simulink software package, this power system is executed. The presented power management network is designed by the aim to make possible the flow of the power among the wind energy networks and power storage devices for carrying out the load requirements on the basis of Narma-L2 neural Controller and PID Controller model. The chief energy sources of the system is wind renewable resources. For the backup and long term storage purpose, lead-acid battery is utilized. Actual scheduled calculated factors are utilized as inputs for the designed network. For smart grid performance optimization, the developed system and their methodology for supporting gives a appropriate mechanism.

Keywords: **Wind Energy Networks, Matlab/Simulink, wind, Energy Management , battery, Narma-L2 controller, PID controller.**

I. INTRODUCTION

The establishment of renewable energy resources with small outflow and good productivity became exceptionally dominant with the reasons of growing responsibility on global warming, scarcity of fossil power source, unreasonable oil cost and destruction to the atmosphere.

One of the main renewable power resources utilized and studied is wind system. Because of the scattered features of wind energy, self-contained wind energy systems usually requires energy captured elements or some other different types of generation sources to build a hybrid system. Battery bank, super capacitor bank, superconducting magnetic energy storage or an FC-electrolyzer system can be used as a storage device..

There are many reports about power management of hybrid energy system in the published writings among them, Wang and Nehrir, designed a energy management strategy on an ac-linked hybrid wind/PV/FC energy system. Ahmed et al., developed a energy management strategy which studied power fluctuations in a hybrid wind turbine power system. Onar et al], designed a power management strategy algorithm which allocated with a hybrid wind energy system comprising an ultra capacitor bank. Thus, previously observed procedures have been utilized conventional techniques for maintaining hybrid energy systems, like linear PI controller which has proven its instability in controlling different variations in weather conditions. This resulted in developing other approaches led to more robust algorithms with ability to handle various changes dynamically without any major problems; by establishing new management criteria depending upon informational data and the environmental changes.

Moreover, previous studies showed that by utilizing the artificial intelligence techniques in the hybrid vehicle can control the FC system at a observed high-efficiency area. However, this article describes an optimized energy management strategy for the flow of energy in hybrid power systems. Implementation of system is done using neural network and by using pid controller and the performances are compared. The designed method explains an online energy management by an effective control among two power sources comprises wind turbine, battery storage. The main objective is to maintain the flow of the active power among various power sources and to control the state-of-charge (SOC) of the battery at a rational amount.

In this, a self-contained wind renewable power generation network is designed containing wind, and battery components .For short-time backup to deliver transitory power, a battery bank is utilized in the hybrid network .The various energy captured devices can be connected in the developed network with the help of an ac-link bus. The description of the network arrangement, network unit-sizing and the attributes of the main network elements are studied in this article. An overall technique for managing the power is designed for the network to maintain the flow of the power among different and various types of power generation sources. To investigate the efficiency of the system under various conditions, different types of simulation studies have been conveyed out.

II. NETWORK ARRANGEMENT AND UNIT-SIZING

A. Network Arrangement

Fig.1 explains the system layout for the designed hybrid renewable energy system. Wind source are utilized as the chief and prime source whereas the battery is used as a backup and storage device. The whole hybrid power network can be observed as a absolute "green ''energy creation network as all the primary renewable energy generation sources and energy captured devices are environment friendly.

Several different methods are proposed with the help of which we can connect various renewable power resources to design a hybrid system. Each method has as many advantages and disadvantages. With the help of proper power electronics interfacing circuits , different power resources can be integrated to the ac bus. We can combined different power resources to the network when they are available and due to this reason the system can be easily extended.

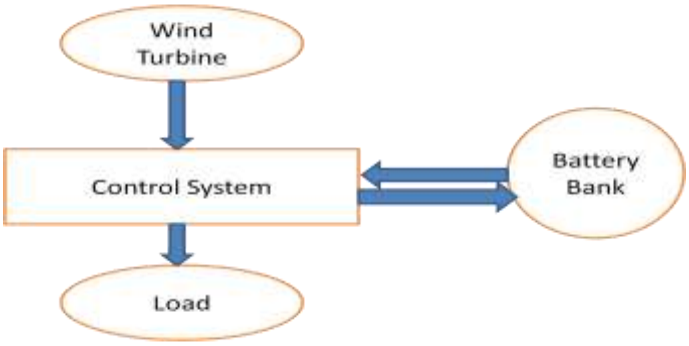

Fig 1.Block diagram of the proposed system

B. Network Unit-Sizing

The unit-sizing process implemented in this article is adopted for a self-contained hybrid power system with the developed design.

III. SYSTEM ELEMENTS ATTRIBUTES

To explore the network presentation and to design an overall technique for managing the power for the system, dynamic models for the prime elements in the developed hybrid power system have been created with the help of MATLAB/Simulink. The models used for the following are: wind energy conversion system, battery and neural network controller.

A. Wind Energy Conversion System

Various reviews have been discussed on Wind Turbine and wind generators. In this article, the designed Wind Turbine model depends on the wind speed and Wind Turbine output power attributes .The output power of the wind turbine is explained by the equation given below:

$$P_m = c_p(\lambda, \beta)\, \rho A/2\, v_{wind}^3$$

Where, P_m defines the mechanical output power of the turbine, c_p defines the performance coefficient of the turbine, λ defines the tip speed ratio of the rotor blade, β defines the blade pitch angle, ρ defines the air density, A defines the turbine swept area and v_{wind} defines the wind speed.

The explained model of the Wind Turbine is proposed as given in Fig 2. The inputs of the wind turbine are the speed of the wind and the speed of the generator, the output of the wind turbine is the torque applied to the generator shaft in the proposed model. The torque of the generator is based on the speed and the power of the generator.

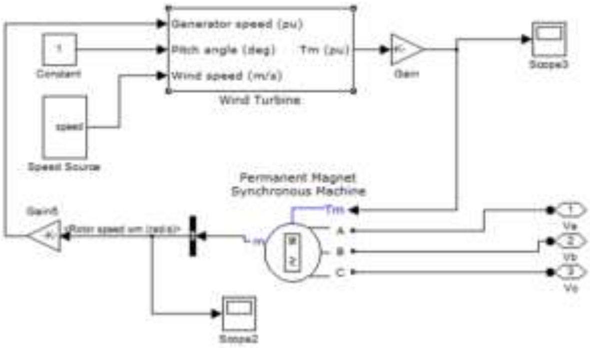

Fig 2.Subsystem Implementation of the WT model

In this article , we have studied about a variable-speed pitch-regulated wind turbine , whereas the participation of pitch angle controller is also very important . Fig 3. Explains the wind turbine output power and speed attributes.

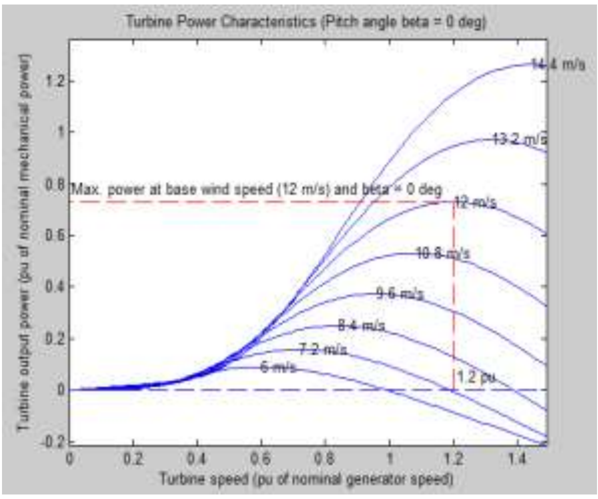

Fig 3. Wind Turbine Speed-Power Characteristics

C. Lead-Acid Battery Model

Battery is one of the main essential parts in hybrid energy system. Batteries are difficult to model because they underwent through typical thermally dependent electrochemical procedures. Therefore, the battery explains the nonlinear function of the different types of cvarious factors.

Lead-acid batteries are the supreme utilized devices to capture and supply energy. There are many different types of batteries like Nickel-Metal Hybrid, Lithium-Ion, Nickel-cadmium.

The simulink model of the Lead-acid battery is implemented as shown in Fig 4.

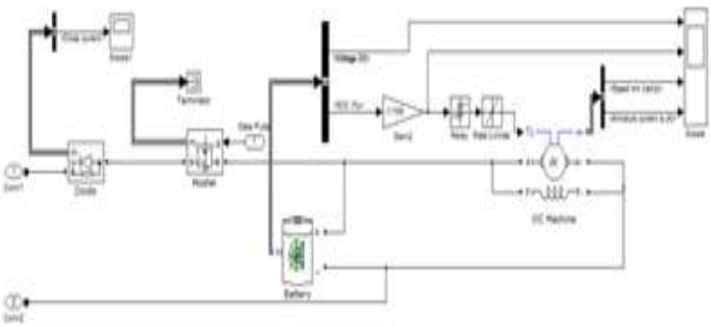

Fig 4. Subsystem implementation of the battery model

The battery curves are given in figure 5

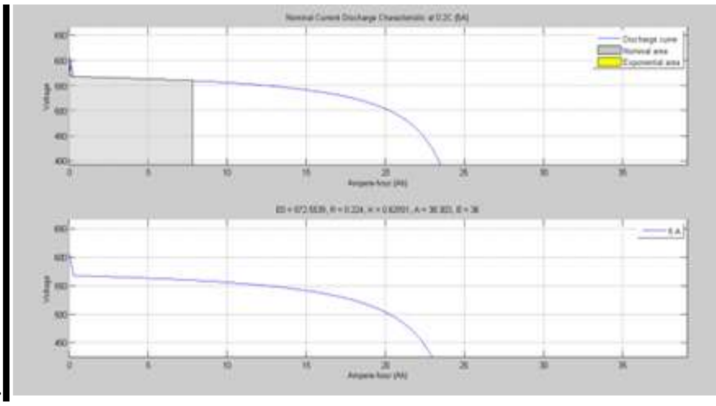

Fig 5. Lead-acid battery characteristics

IV. NEURAL NETWORK CONTROLLER

For the identification and control of dynamic systems, different types of neural network architectures have been designed successfully. Narma-L2 controller is the prime and paramount neural network control architecture. In this method, training is straightforward because the controller is a rearrangement of a neural network plant model, which is going to be trained offline, in batch form. In this method, there is no distinct dynamic instruction for the controller. The other merit of Narma-L2 controller is that the only online computation is a forward pass through the neural network controller.

NARMA-L2 is one of the Neural Network architecture for control, as it is a rearrangement of the plant model. NARMA-L2 stands for Non Linear Auto Regressive Moving Average model. It is referred when the plant model is accounted by the associated form. It is known as feedback linearization technique when the plant model is in associated form. System Identification and Control Design are the two stages for developing of NARMA-L2 controller.

The block diagram of Narma-L2 controller is explained in figure 6.

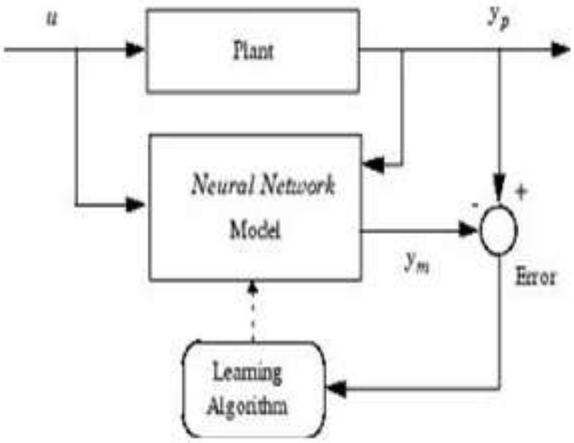

Fig 6. Block diagram of Narma - L2 controller

V. PID CONTROLLER

A proportional–integral–derivative controller (PID controller) is a control loop feedback mechanism (controller) commonly used in industrial control systems. A PID controller continuously calculates an error value as the difference between a desired set point and a measured process variable. The controller attempts to minimize the error over time by adjustment of a control variable, such as the position of a control valve, a damper, or the power supplied to a heating element, to a new value determined by a weighted sum. In this model,

P accounts for present values of the error.

I accounts for past values of the error.
D accounts for possible future values of the error, based on its current rate of change.[1]

VI. SIMULATIONS AND RESULTS

The VSWTG employed at variable speed under normal operation . The VSWTG employs at optimum pitch angle when the wind speeds varies from low to medium. The wind turbine employs at constant speed when the wind speed is high and the pitch angle maintains the speed of the rotor constant. Until the wind turbine reaches rated speed, the output power of the wind turbine employing in this mode is a cubic relation of the rotor speed. The wind turbine is operated at fixed power by maintaining the pitch angle when the rated speed is reached.

Normally, the pitch angle controller employs very smoothly, maintaining the rotor speed so that it does not surpass the rated speed. This pitch controlling mechanism, outhouse aerodynamic power to control the rotor speed from outstretching a runaway condition. If the blade pitch control fails, the wind turbine brakes will be exploited. The wind turbine characteristics are explained in figure 3. For controlling the energy flow in Wind hybrid system , Narma- L2 and PID controllers are successfully implemented in Matlab Simulink environment. The simulation results of the system are given in figure 7 & 8.

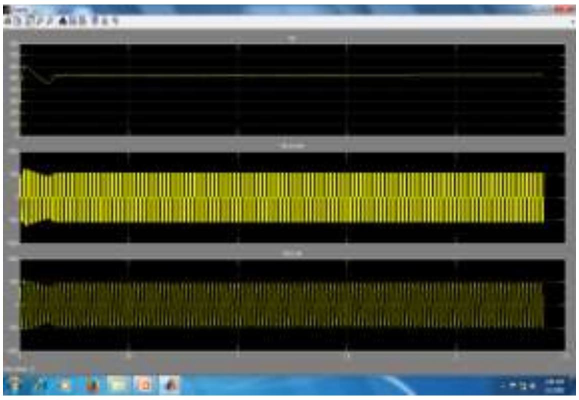

Fig 7. Output waveforms using Narma - L2 controller

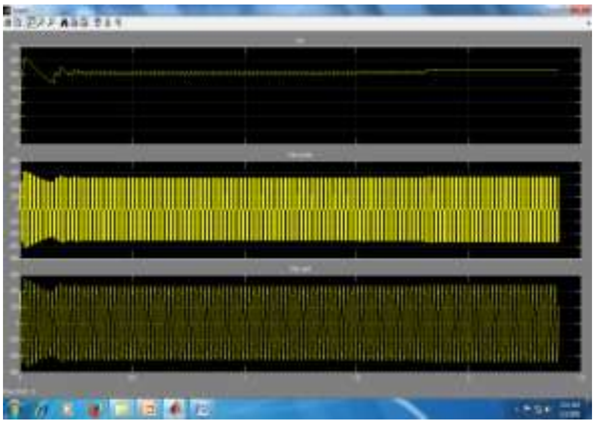

Fig 8. Output waveforms using PID Controller

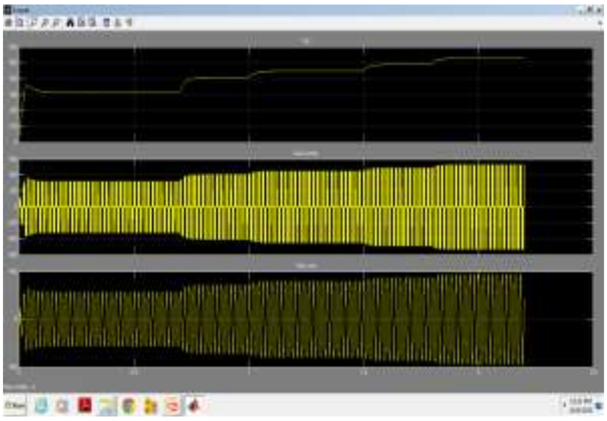

Fig 9. Output waveform without using battery

CONCLUSIONS

For developing stand-alone hybrid power systems, an effective online power management based on the NARMA-L2 or PID controller is created. In this article, a novel WT power system is designed and modelled. The developed algorithm comprises system components and an appropriate energy flow controller. The model has been designed with the help of MATLAB or SIMULINK software package .

The performance of the system is evaluated by using Neural Network controller, PID Controller and without using controller.

Settling time in case of Narma L2 Controller is found to be 0.2 and that in case of pid is 0.3.
It has been observed that Narma L2 controller is a better controller tha PID Controller.
Narma L2 controller leads to better results than PID in terms of robustness and settling time.
It has also been observed that Wind Power System with battery back up is better than Single Wind source system.

APPENDIX:

Table 1. System Component Parameters

	WINDTURBINE	
S.NO	**PARAMETERS**	**VALUES**
1.	Rated output power	10kW
2.	Rated output Voltage	500V
3.	Rated wind speed	12m/s
4.	Pitch angle	0

	ANALYSIS		
S.NO	**PARAMETERS**	**NARMA L2 CONTROLLER**	**PID CONTROLLER**
1.	Steady State Error(%)	0	4
2.	Overshoot(%)	0	20
3.	Settling Time(s)	0.2	0.3

The details of the system component parameters are listed in Table .

ADVANTAGES

- Reduced fuel consumption – by the addition of renewable energy sources and efficient operation of diesel generators.
- Increased Reliability – The two independent power systems provide redundancy and possibly greater overall reliability if the system is properly maintained and controlled.
- Can be the most economic option where fuel is expensive and the renewable energy source is good.
- Reduced environmental impact.
- Lower-lifecycle costs possible for peaky loads, peaky input resources or growing fixed loads.

DISADVANTAGES

- Limited experience of customers and supply utilities with renewable energy.
- Systems are generally more complex.
- Life-cycle economic analysis required – based on detailed system simulation.

REFERENCES

[1]. Y. Wang, K. S. Chen, J. Mishler, S. C. Cho and X. C. Adroher, "A Review of Polymer Electrolyte Membrane Fuel Cells: Technology, Applications, and Needs on Fun- damental Research," Applied Energy, Vol. 88, No. 4, 2011, pp. 981-1007. doi:10.1016/j.apenergy.2010.09.030

[2]. E. Dursun and O. Kilic, "Comparative Evaluation of Different Power Management Strategies of a Stand-Alone PV/Wind/PEMFC Hybrid Power System," Electrical Power and Energy Systems, Vol. 34, No. 1, 2012, pp. 81-89. doi:10.1016/j.ijepes.2011.08.025

[3]. C. Wang and M. H. Nehrir, "Power Management of a Stand-Alone Wind/PV/Fuel Cell Energy System," IEEE Energy Conversion, Vol. 23, No. 3, 2008, pp. 957-967. doi:10.1109/TEC.2007.914200

[4]. N. A. Ahmed, M. Miyatake and A. K. Al-Othman, "Power Fluctuations Suppression of Stand-Alone Hybrid Generation Combining Solar Photovoltaic/Wind Turbine and Fuel Cell Systems," Energy Conversion and Management, Vol. 49, No. 10, 2008, pp. 2711-2719. doi:10.1016/j.enconman.2008.04.005

[5]. O. C. Onar, M. Uzunoglu and M. S. Alam, "Modeling, Control and Simulation of an Autonomous WT/PV/FC/ Ultra-Capacitor Hybrid Power System," Journal of Power Sources, Vol. 185, No. 2, 2008, pp. 1273-1283. doi:10.1016/j.jpowsour.2008.08.083

[6]. A. Tofighi and M. Kalantar, "Power Management of PV/ Battery Hybrid Power Source via Passivity-Based Control," Renewable Energy, Vol. 36, No. 9, 2011, pp. 2440-2450. doi:10.1016/j.renene.2011.01.029

[7]. W. Zhou, C. Lou, Z. Li, L. Lu and H. Yang, "Current Status of Research on Optimum Sizing of Stand-Alone Hybrid Solar Wind Power Generation Systems," Applied Energy, Vol. 87, No. 2, 2010, pp. 380-389. doi:10.1016/j.apenergy.2009.08.012

[8]. X. Li, L. Xu, J. Hua, X. Lin, J. Li and M. Ouyang, "Power Management Strategy for Vehicular Applied Hy- brid Fuel Cell/Battery Power System," Journal of Power Sources, Vol. 191, No. 2, 2009, pp. 542-549. doi:10.1016/j.jpowsour.2009.01.092

[9]. C.-Y. Li and G.-P. Liu, "Optimal Fuzzy Power Control and Management of Fuel Cell/Battery Hybrid Vehicles," Journal of Power Sources, Vol. 192, No. 2, 2009, pp. 525-533. doi:10.1016/j.jpowsour.2009.03.007

[10]. S.Kumaravel and Dr. S.Ashok , "Adapted Multilayer Feedforward ANN Based Power Management Control of Solar Photovoltaic and wind Integrated Power System", 2011 IEEE PES Innovative Smart Grid Technologies – India

[11]. Fengge Zhang, Quanfu Shi, Yuxin Wang, and Fengxiang Wang," Simulation Research on Wind Solar Hybrid Power System Based on Fuzzy-PID Control", Proceeding of International Conference on Electrical Machines and Systems 2007, Oct. 8-11, Seoul, Korea

[12]. OnurOzdal MENGI and Ismail Hakki ALTAS," A Fuzzy Decision Making Energy Management System for a PV/Wind Renewable Energy System", IEEE, 2011.

[13]. Richard W. Wies, Ron A. Johnson, Ashish N. Agrawal, and Tyler J. Chubb, "Simulink Model for Economic Analysis and Environmental Impacts of a PV With Diesel-Battery System for Remote Villages," IEEE Transactions On Power Systems, Vol.20, No. 2. , 2005.