The International Journal Of Engineering And Science (IJES)
|| Volume || 4 || Issue || 12 || Pages || PP -44-49|| 2015 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

# Transfer Function Modelled Isolated Hybrid Power Generation System

[1]Shailendra Singh Hada , [2]Kamal Arora
[1]*M.tech Scholar [Power system], Dept. of EE, C.P.U.., kota, Raj.India*
[2]*Assistant professor, Dept. of EE, C.P.U.., kota, Raj.India*

**ABSTRACT**

*Energy demand is steadily increasing. Thus it is very important to accomplish the continually increasing power demand. Wind energy is emerging as primary and competitive renewable energy choice due to gradual advancement in its technology and the reduction in hybrid system component cost. However, each of the aforesaid technologies has its own limitations. Energy generation with Multisource hybrid is an substitute (with proper control) contains great potential to provide higher quality and more reliable power to the customers than a single resource based system, which exhibit higher reliability and lower cost for generation of power in isolated area than by applying only one source of energy.*

***Keywords*** *- Hybrid power generation, small signal stability analysis, load management, ultra capacitor, electrolyzer, BESS.*

Date of Submission: 10 December 2015 Date of Accepted: 20 December 2015

## I. INTRODUCTION

Power generation via hybrid system may include all different kinds of available renewable energy along with their accessible energy storage assembly. The power required by the all connected loads supplied effectively via the hybrid power generation and energy storage system with proper control and effective coordination among various subsystems.[1-4]Due to technical progress and promoted experience on the WPGS, It reduces electricity generation cost which may close to the one of traditional fossil fuel energies. The energy storage systems is used for storing and releasing energy at an adequate time, Which play a substantial role in a hybrid system .Battery energy storage system (BESS) and ultra-capacitor systematically stores an electric energy.[5-9] The study Aqua electrolyzer where the supply fuel cell has been carried out by aqua electrolyzer but the supply of fuel in fuel cell has not been carried out by gas turbine yet. Development of transfer function models for wind-fuel cell-gas turbine-BESS for isolated hybrid energy system is the main objectives of the present work.[10-13]

## II. SYSTEM MODELING

The wind speed has complimentary features which may reduce the capacity of the energy storage system. Hence fuel cell and/or diesel generator may be integrated with such sources along with the energy storage system such as battery energy storage system. The generation system comprises wind turbine generator along with gas turbine, fuel cell and battery energy storage converts in to supply hydrogen fuel for fuel cell.[4-6] The battery energy storage subsystem connected to the load side. When the load demand increases, the BESS releases enough energy to meet the load within a very short delay. The gas turbine is a stand by source which may start up automatically to deliver power to the system only when total power generated by the WTG, FC is insufficient even if the BESS may have enough stored energy.[7,8]

## III. POWER, FREQUENCY DEVIATIONS AND CONTROL STRATEGY

Maintain the scheduled frequency under varying demand and supply conditions are very important to provide good quality of supply to the consumers. In power systems, if generating power varies, then the frequency fluctuates depending on variation of generating power. Active power balancing is required to maintain Frequency at desired level between the generation and demand. A hybrid system including WTS as one of the generating unit requires special control strategies as it is highly fluctuating by nature. The strategies to be adopted to alleviate mismatch between generation and demand can be done by controlling the gas turbine electric power-generating unit. The PI controller is a conventional approach to do so. The power control strategy is obtained by using the difference of power demand reference $P_L$ and total power generation $P_S$.[9-11]

$$\Delta P_e = P_S - P_L$$

By controlling ΔPe and Δf, the system can supply high quality power to the load. The Δf is calculated by net power variation, as shown by the expression in valid ideal condition.

$$\Delta f = \frac{\Delta P_e}{K_{sys} + D}$$

In actual practice, there will be a delay in the frequency characteristics and, hence, the above equation modification is obtained by controlling inherent time delay between system frequency variation and power deviation. The transfer function for system frequency variation to per unit power deviation can be expressed by

$$G_{sys}(s) = \frac{\Delta f}{\Delta P_e} = \frac{1}{K_{sys}(1 + sT_{sys})} = \frac{1}{M_s + D}$$

## IV. WIND – GAS TURBINE - FUEL CELL AND BESS HYBRID SYSTEM

The block diagram of the hybrid system is shown in figure.1.This includes Wind turbine generator, along with Gas turbine, Fuel cell and Battery energy storage system.[11]

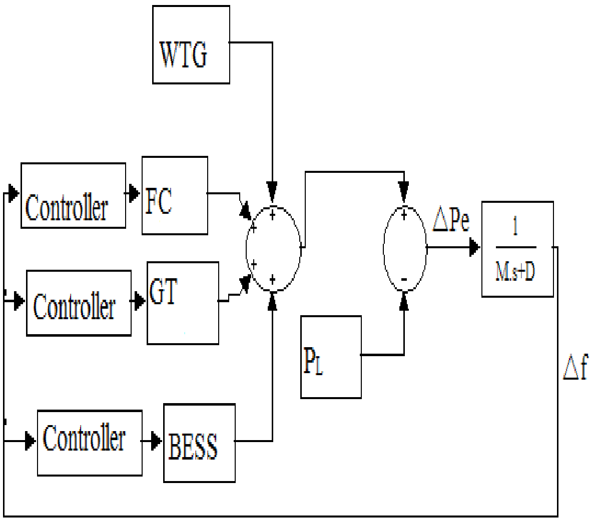



**Figure 1**- Wind–Gas-turbine- Fuel cell and BESS Hybrid System

The resultant power generation can be expressed as:-

$$P_S = P_{WTG} + P_{GT} + P_{FC} \pm P_{BESS}$$

Where<<<
1. Output power from wind turbine generator.
2. Output power from Gas turbine.
3. Output power from fuel cell.
4. Exchange power of BESS.

## V. OBJECTIVE FUNCTION

The objective functions are Mean Squared error (MSE), Integral of Time multiplied by absolute error (ITAE), Integral of absolute error (IAE) and integral of squared error (ISE).These integral performance criteria have their own advantages and disadvantages[8]

$$MSE = \frac{1}{t}\int_0^{\tau} (e(t))^2 dt \quad ITSE = \int_0^{\tau} e(t)^2 dt$$

$$ISE = \int_0^{\tau} e(t)^2 dt \quad ITAE = \int_0^{\tau} t\,|e(t)|dt$$

Here integral of the square of frequency deviation is chosen as the objective function. To minimize the objective function here control techniques are used.[9]
The DG comprise of WTG, AE, FC, DEG, and BESS. The various components of the DG with transfer functions and parameter values are shown in Table 1.[12,13]

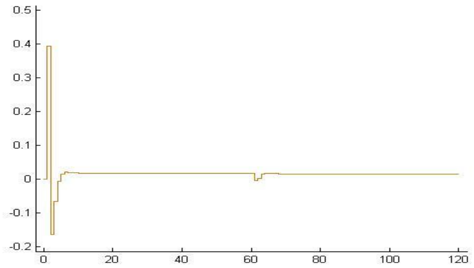
**Table 1. Various components of DG with transfer functions and Description**

| Component | Transfer function | Notations | | Description |
|---|---|---|---|---|
| Wind turbine generator | $G_{WTG}(s) = \frac{K_{WTG}}{T_{WTG}S + 1}$ | $K_{WTG}$= | Gain of wind turbine generator | The output power is not constant and it varies with wind speed fluctuation at that instant. To overcome the fluctuation in wind turbine we use battery. |
| | | $T_{WTG}$= | Time constant of wind turbine generator | |
| Gas Turbine | $G_{GT}(s) = \frac{K_{GT}}{T_{GT}s + 1}$ | $K_{GT}$= | Gain of Gas Turbine | Gas turbine has high demand because of their low weight, compactness and multiple fuel applications. |
| | | $T_{GT}$= | Time constant of Gas Turbine | |
| Fuel cell | $G_{FC}(s) = \frac{K_{FC}}{T_{FC}s + 1}$ | $K_{FC}$= | Gain of fuel cell | Fuel cells are good energy sources to provide reliable power at steady state, but they cannot respond to electrical load transients as fast as desired |
| | | $T_{FC}$= | Time constant of fuel cell | |
| Battery energy Storage system | $G_{BESS}(s) = \frac{K_{BESS}}{T_{BESS}s + 1}$ | $K_{BESS}$= | Gain of battery energy storage system | Batteries are considered a major cost factor in small-scale standalone power system. The usage of battery energy storage systems (BESS) has created a greater focus on the reduction of adverse effects of the frequency deviations. |
| | | $T_{BESS}$= | Time constant of battery energy storage system | |

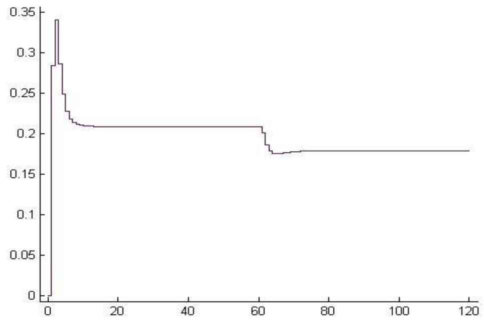
## VI. SIMULATION RESULTS AND DISCUSSIONS

In this section, time domain simulated response of the studied hybrid system under various operating points and different disturbance Conditions are carried out. Total power absorbed by the connected loads is assumed to be Ps = 1.0 p.u. under normal operating condition.
All results for all components are given below:

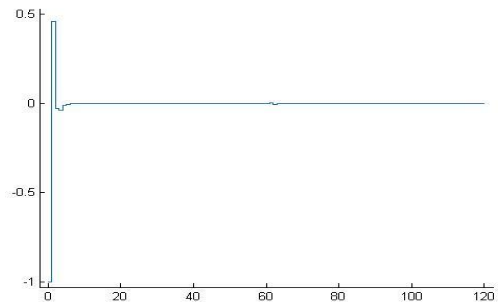
a) Battery



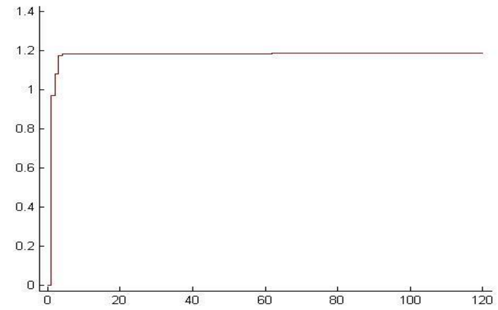

b) Diesel generator



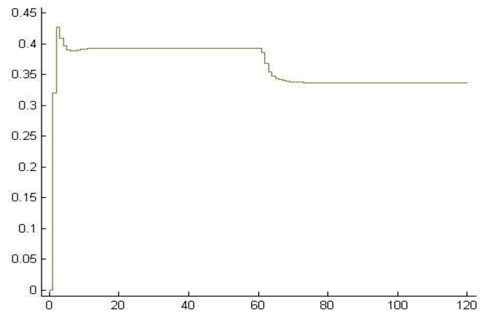
c) Error



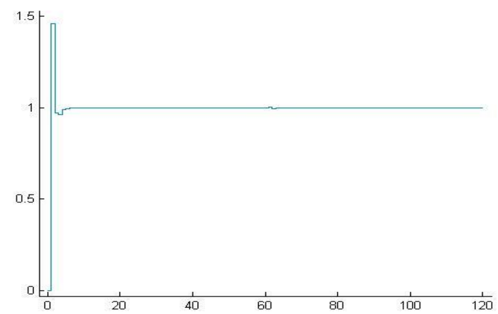

d) Feed-Back



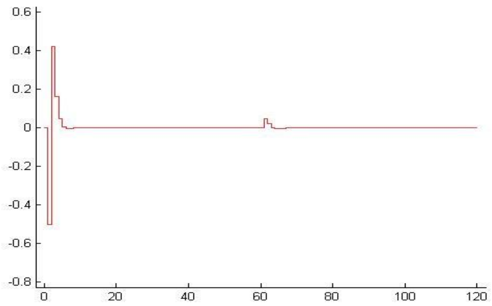

e) Fuel Cell



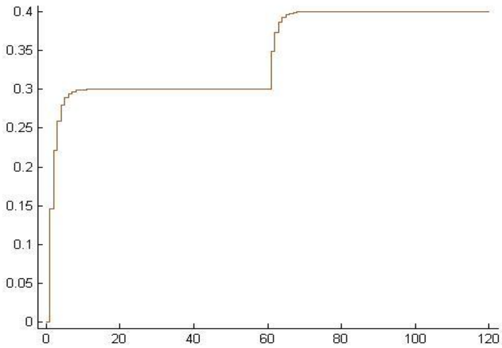

f) Hybrid



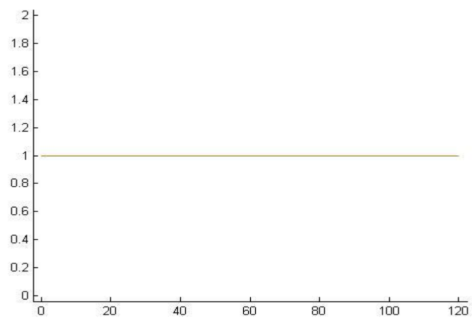
g) Output




h) Wind Energy




i) Reference-input




## VII. CONCLUSIONS

In this paper small signal stability of an autonomous hybrid power system using PI controller presented. The effectiveness of the proposed control schemes in improving the hybrid power system small scale stability has been verified through time domain simulations under variation in generation or load or both. The studies conducted in this thesis yield the following conclusions.

1. The autonomous hybrid energy system requires an automatic control of generation system to eliminate the mismatch in supply and demand under varying condition of load and generation. The employed mathematical models for the WTG, GT, FC, and BESS are represented by first order transfer functions to simplify the tasks of system simulation
2. In this paper, reduction in the frequency deviation to eliminate the mismatch in supply and demand under varying condition of load and generation, the output power from the sources is regulated using PI controller.

## REFERENCES


[1] P. Wang, R. Billinton, "Reliability benefit analysis of adding WTG to a distribution system," IEEE Trans. Energy Convers., vol.16, no. 2, pp. 134–139, Jun. 2001.

[2] Iglesias I.J, L. Garcia, A. agudo. I. Cmz and L.Arribas, "Design and simulation of a standalone Wind-Diesel Generator with a Flywheel Energy Storage System to Supply the Required Active and Reactive power", IEEE Conference 2000, pp:1381-1386.

[3] Kundur P, "Power System Stability and Control," Electrical engineer's reference book, pp 598.

[4] Senjyu T, Nakaji T, Uezato K, and Funabashi T, "A hybrid power system using alternative energy facilities in isolated island," IEEE Trans. Energy Convers., vol. 20, no. 2, pp. 406–414, Jun. 2005.

[5] Ray P.K., Mohanty S.R., Kishor Nand, "Proportional-integral based small signal analysis of hybrid distributed energy system," Journal on Energy conversion and Management, pp. 1943– 1954, 2011

[6] Xiangjun Li, Songb Y.J. and Hanb S.J., "Frequency control in micro-grid power system combined with electrolyzer system and fuzzy PI controller", Journal of Power Sources, 180 (2008) 468–475.

[7] Satish R, Kumar P, Murali V, "Design of PI Controller by using Bacterial Foraging Strategy to Control Frequency for Distributed Generation," Proceedings of IEEE ICETECT, 2011.

[8] Shakib A.D., Balzer G, "Optimization of battery application for wind energy storage," International conference on renewable energies and power quality, Granada, Spain; 23th to 25th March, 2010.

[9] Motin A.H. , Yuya I., Akie U., N Urasaki, T Senjyu, A Yona, A.Y Saber, "A minimal order observer based frequency control strategy for an integrated wind-battery-diesel power system",A journal on Energy 46 (2012) 168-178.

[10] Shakib A.D., Balzer G, "Optimization of battery application for wind energy storage," International conference on renewable energies and power quality, Granada, Spain; 23th to 25th March, 2010.