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Stability Margin Enhancement of Wind Integrated Power Grid using Power System Stabilizer

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ABSTRACT

This paper emphasizes on analysis of transient stability by introducing three phase Fault using time domain analysis with maximum wind power penetration. The present scenario such as global energy crisis, carbon dioxide emission and global surface mean temperature rise reveals the importance of sustainable development projects. Considering the gradual increase in power demand and wind integration with maximum tapping potential, it is essential to enhance the existing network to improve the voltage stability to accomplish reliable power transfer with minimal network expansion cost. The proposed work aims-to identify the impact of the sudden application of three-phase fault on the power grid. Controller namely Power System Stabilizer is employed for the analysis which improves the transient stability of power system in this work. The proposed methodology has been tested on Kerala grid 220KV-26 bus system with maximum wind penetration and the results were validated by using the test results of IEEE 14 bus system.

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KEY WORDS Transient Stability, Time Domain Simulation, Power system stabilizer, Voltage Stability, Automatic Voltage Regulator.

1. Introduction

The electrical power demand is supplied by various conventional sources like coal, thermal, nuclear etc. However, studies prove that the coal reserve will be exhausted in the next 250 years and this warns us ahead of a major energy crisis. The crisis can create immense pressure on the generation and transmission system but fuels to concentrate more on energy conversion and consumption. Developing sustainable projects can cater to the needs of the present generation without risking the resources for the future generation. The Kyoto Protocol, Johannesburg summit and G20-2016 towards a carbon-free world. It has been widely agreed that at least 10 % of the global energy demand has to be supplied by renewable sources to be able to reduce the emission levels of the greenhouse gasses and to limit the global mean surface temperature to well below. 2°C levels of the greenhouse gasses and to limit the global mean surface temperature to well below 2°C. Wind energy has emerged as the most promising source among the various sources of renewable energy and recent researches prove it to be the most viable and cost economical option for grid connected power generation [1].

Many studies have been carried out in order to improve the voltage profile, reliability and the maximum load ability of the the electric grid. Reference [1] studies the effect of wind integration on the transient fault analysis by connecting a wind turbine at different buses. Reference [2] presents a study of the impact of integrated renewable energy sources on voltage stability by using CPF method. Reference [3] investigates the impact of different wind turbines on power system stability. Reference [4] illustrates a methodology for enhancement of voltage stability margin and there by the wind integration on the large power system. Reference [5] studies the optimal location of RDG s using CPF analysis.

In this paper, the transient stability of systems is analyzed using Time domain simulation. This study proposes the impact of applying severe fault in the grid incorporating maximum wind penetration. A method of using a controller such as power system stabilizer for reducing the damping of power system oscillations has been proposed in this work. IEEE-14 Bus system and Kerala grid 220KV-26 Bus systems are simulated using PSAT [6][7]. All these simulations have been carried out using the PSAT software version 2.1.10. In conclusion, the results of the simulations are compared and analyzed in section [VI &VII].

2. System Modelling

2.1 IEEE 14-Bus Test System

IEEE 14 bus test system model is used for analyzing transient stability in case of large disturbances. The results obtained are used for validating the results of the real-time system. The analysis is done by Time domain simulation by introducing three phase fault at highest loading bus [8]. Theintegration of renewable source will cause a decrease in bus voltage. The effect of fault will be high deviations in rotor angle, speed and decrease in voltage level. A Power system stabilizer is introduced to improve the voltage profile and this controls the damping of power system oscillations

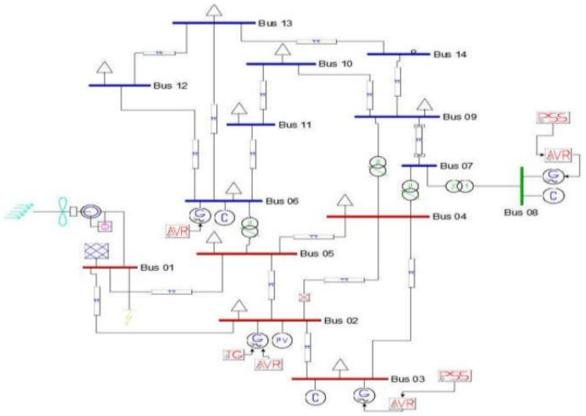

Fig.1 IEEE-14 Bus Test System [14]

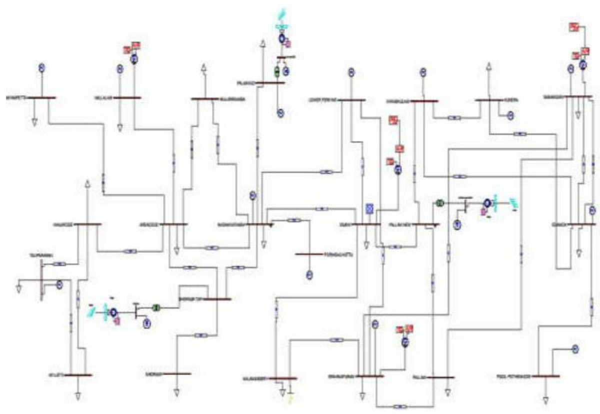

Fig. 2 Kerala grid 220 KV-26 Bus system [4]

Fig.1 shows the test model of IEEE 14 bus system. The model consists of 11 loads and 5 generators connected to 14 bus systems. Here a wind farm is connected to bus –1, bus-2 is PV bus and bus-3, 6 and 8 are synchronous compensator buses[9]. Loads were modeled as constant PQ load. A three phase fault is introduced at Bus-1 and PSS are connected to the corresponding AVRs of generators at bus 3 and 8.

2.2 Kerala grid with maximum wind penetration

Kerala grid 220 KV-26 bus system was modeled with hydro projects at Idukki and Sabarigiri, NTPC thermal power plant at Kayamkulam, diesel power plant at Nallalam and wind farms at Agali, Kanjikode and Ramakalmedu[10].

Fig.2 represents the model of wind integrated Kerala grid model with 26 buses, 32 transmission lines, 3 transformers, 10 generators and 18 loads [11].A three phase fault is applied at Kalamassery bus, which is the large loaded bus. Power system stabilizers are connected at AVRs of Idukki and Sabarigiri generators.

3. Results and Discussion

3.1 Transient stability

The capability of a power grid to regain an acceptable state of equilibrium after a severe disturbance is known as transient stability [12]. The inability of the power system to maintain synchronism during faulted condition is termed as transient instability. Some major issues arise in the form such as inadequate synchronizing torque produce nonlinear angular separation, large rotor angle deviations and uneven voltage profile [13].

3.2 Test system Results

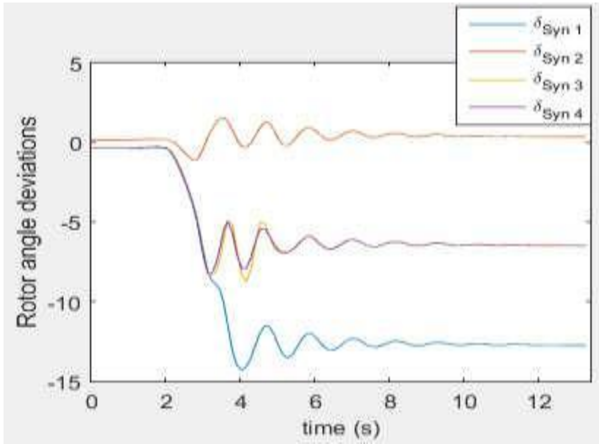

Fig.3 Rotor angle deviations of test system with PSS

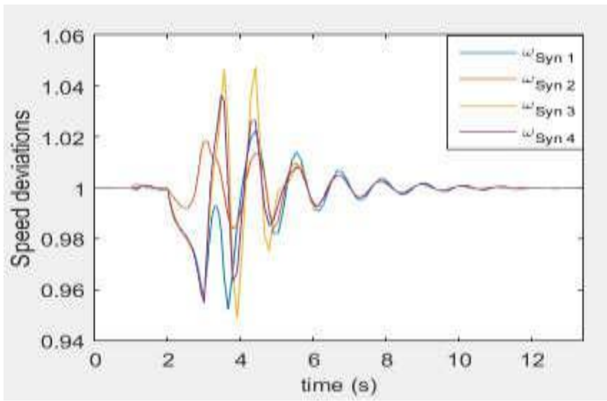

Fig.4 Speed deviations of test system with PSS

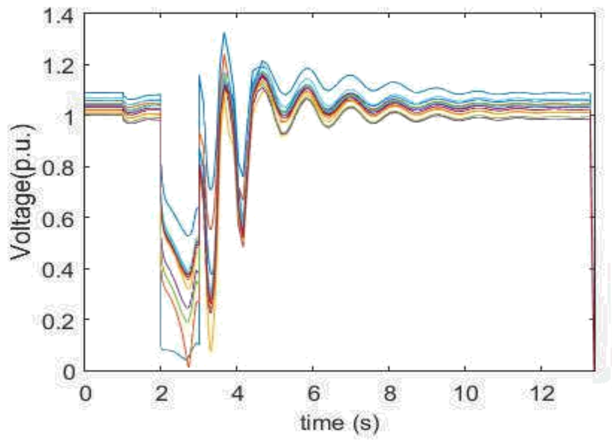

Fig.5 Voltage profile during fault

Fig.3 shows Rotor angle deviations of the test system with PSS. Here Time is marked along the X axis, Fault occurred at 2 seconds and cleared at 4 seconds and Rotor angle deviations are marked along the Y-axis. Figures 4 & 5 represents the speed deviations of IEEE 14 Bus test system and voltage profile. From results, it has been identified that after critical clearing time the system regains the stability.

3.3 Design of PSS

An attempt has been made to improve the Transient stability (synchronizing torque) and small signal stability (damping torque) using the Power system stabilizer. The damping generator rotor angle swing is improved by PSS control. The controller is added to generator's automatic voltage regulator. Generator output power will depend on the mechanical torque of turbine[14].Severe fault conditions might alter the Torque.PSS identifies the change in generator output power, controls the excitation value and reduces the rapid power fluctuation [15].

3.4 Real Time system results without PSS

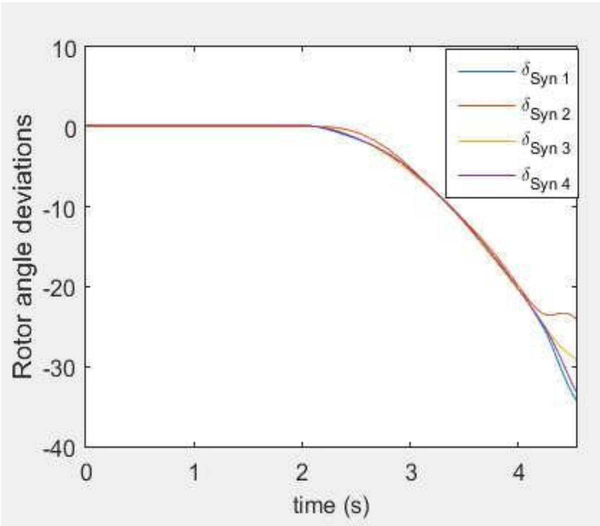

Fig.6 Rotor angle deviations of test system without PSS

Figure 6 shows that without connecting PSS damping of rotor angle are occurred.

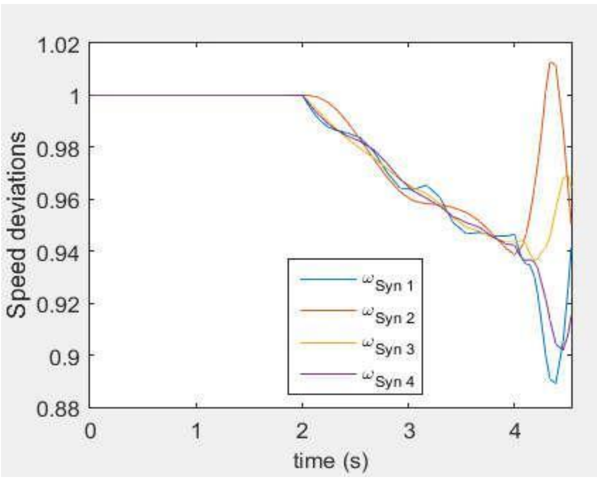

Fig.7 Speed deviations of test system without PSS

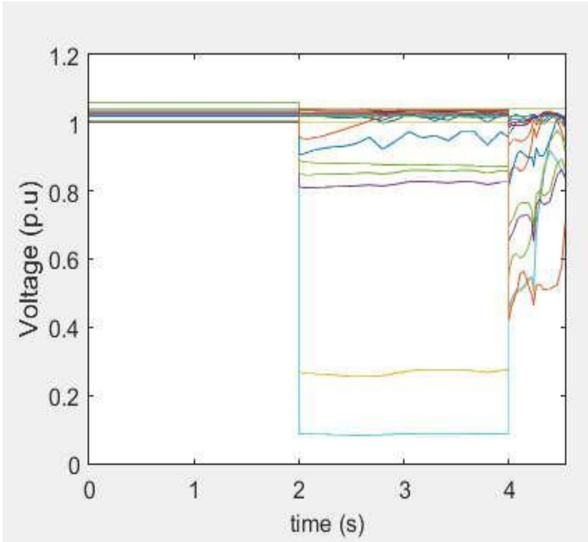

Fig.8 Voltage profile during fault without PSS

Fig.7 shows the speed deviations without connecting the controller. Voltage profile reduced dangerously in Fig.8. Hence the system is not safe with severe fault conditions without PSS.

3.5 Real Time system results with PSS

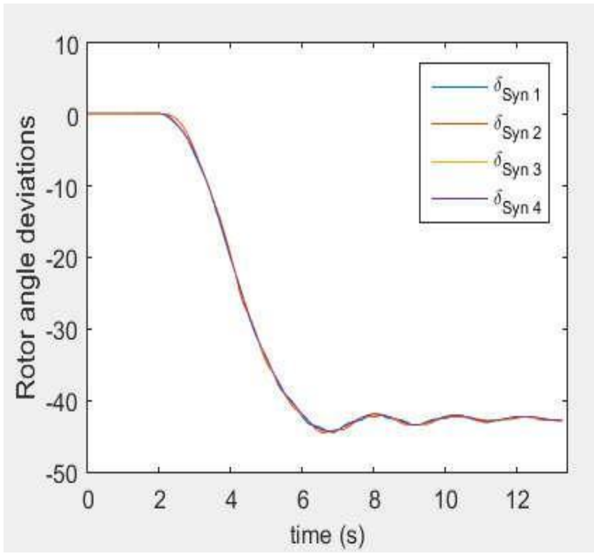

Fig.9 Rotor angle deviations of test system with PSS

Fig. 9 shows the action of stabilizer on transient stability. The performance and security of the entire system can be improved by introducing PSS.

Fig 10 & 11 shows the effect of PSS in speed deviations and voltage profile. Comparing the real-time system results with and without power system controller has been proved that the system will regain stability after critical clearing time during severe fault conditions.

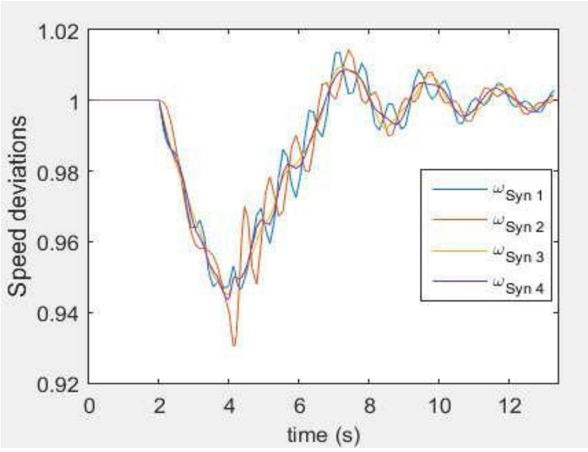

Fig.10 Speed deviations of test system with PSS

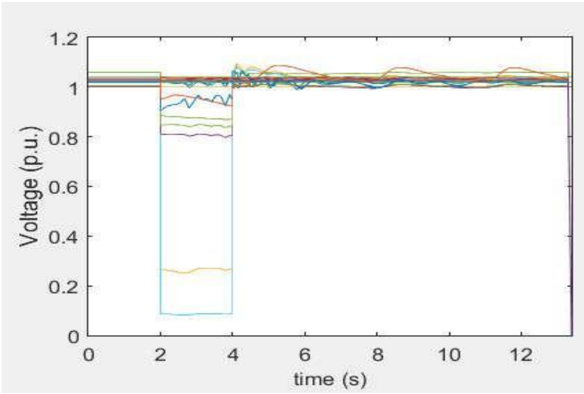

Fig.11 Voltage profile during fault with PSS

4. Conclusion

Modeling and simulation of IEEE 14 Bus test system and Kerala grid 220 KV-26 BUS system for transient analysis has been conducted in this paper. The ability of Power System Stabilizer to increase the voltage stability, Synchronizing torque, speed deviations and system security in the practical power system are illustrated. A new methodology for enhancing grid stability by using the Power system controller is also presented. The results appear to be quite promising when applied on Kerala grid 220 KV-26 bus practical systems.

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