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Effect of small disturbances on Inter-connected system

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Abstract: The national and international grids in the developed countries constitute a large system that exhibits a range of dynamic phenomena. Certain system disturbances may cause loss of synchronism between a generator and the rest of the utility system, or between interconnected power systems of neighboring utilities. In this paper different types of disturbances are simulated using MATLAB software.

Keywords- small disturbances, stability and different oscillation

I. INTRODUCTION

Power system stability may be broadly defined as the property of a power system that enables it to remain in a state of operating equilibrium under normal operating condition and to regain an acceptable state of equilibrium after being subjected to a disturbance [1]. Instability in a power system may be manifested in many different ways depending on the system configuration and operating mode. Power systems rely on synchronous machine for generation of electrical power; a necessary condition for satisfactory system operation is that all synchronous machines remain in synchronism. This aspect of stability is influenced by the dynamics of generator rotor angles and power–angle relationships. Power systems under steady-state conditions operate typically close to their nominal frequency. A balance between generated and consumed active and reactive powers exists during steady-state operating conditions. Further the sending end and receiving end voltages are typically within 5%. The system frequency on a large power system will typically vary +/- 0.02 Hz on a 50 Hz power system [2]. Power system faults, line switching, generator outage and sudden disconnection/insertion of large blocks of load result in sudden changes to electrical power, whereas the mechanical power input to generators remains relatively constant. These system disturbances cause oscillations in machine rotor angles and can result in severe power flow swings. Depending on the severity of the disturbance and the actions of power system controls, the system may remain stable. It may return to a new equilibrium state, that is referred to as a stable power swing[1].On the other end severe system disturbances, could cause large separation of generator rotor angles, large swings of power flows, large fluctuations of voltages and currents, and eventual loss of synchronism between groups of generators or between neighboring utility systems. Large power swings either stable or unstable, can cause unwanted relay operations at different network locations. This can aggravate further the power-system disturbance and possibly lead to cascading outages and power blackouts.

II. SMALL DISTURBANCE

Due to inter connected system, many small disturbances are occurring in power system. Line outage, sudden increase in Percentage load, Switching of Capacitor bank, Generator outage, Decrease in Generator output etc are certain disturbances that are occur in power system frequently. The disturbances occurring in a power system induce electromechanical oscillations of the electrical generators. These oscillations, also called power swings, must be effectively damped to maintain the system's stability.
Electromechanical oscillations can be classified in four main categories:

Local oscillations: between a unit and the rest of the generating station and between the latter and the rest of the power system. Their frequencies typically range from 0.8 to 4.0 Hz.

Interplant oscillations: between two electrically close generation plants. Frequencies can vary from 1 to 2 Hz.
Inter area oscillations: between two major groups of generation plants. Frequencies are typically in a range of 0.2 to 0.8 Hz.
Global oscillation: characterized by a common in-phase oscillation of all generators as found on an isolated system. The frequency of such a global mode is typically under 0.2 Hz.

Here we are focus on inter area oscillation using MATLAB software with various type of fault.

III. SIMULATION MODEL

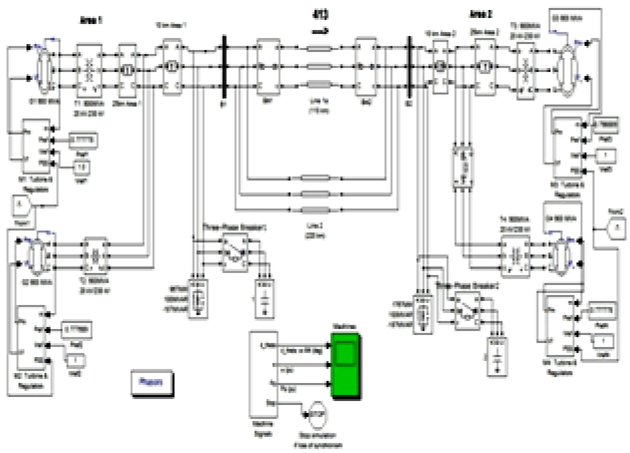

Figure 1. Simulation Model

System shown in Figure 1 have two areas, each area have 900 MVA generating units equipped with fast static exciters. All two generating units represented by the same dynamic model. The machine and the exciter data used in the study are taken from Kundur book of power system stability & control. In this system area 2 is weak system area because load connected to area 2 is greater than the capacity of generator of area 2 so excessive power fed by area 1. Synchronous machine parameter shows in appendix 1.

In this paper, following small disturbances are considered.

1. Line outage
2. Sudden increase in Percentage load
3. Switching of Capacitor bank
4. Generator outage
5. Decrease in Generator output

1. Line outage

There are two parallel lines that connected both the areas of sample power system network shown in Figure 1. Here, Generator 1 & 2 supplies their own load and they also supply 413MW load available in Area 2. If breakers are open then line 1 is disconnected from network. This is called outage of line 1.

For different conditions various waveform are taken using MATLAB. Figure 2 shows waveform of angle difference between two generators (d_theta), acceleration power (Pa), speed of machine (W) during normal condition. First a waveform during normal condition is shown in below Figure 2.

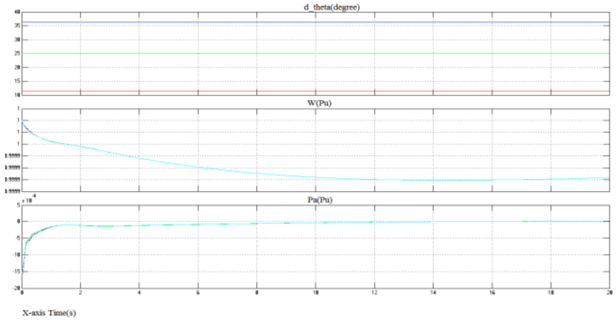

Figure 2

It has been observed from Figure 2 that d_theta, Pa and W maintain constant value during normal condition.
Now effect of line outage on sample system shown in below Figure 3

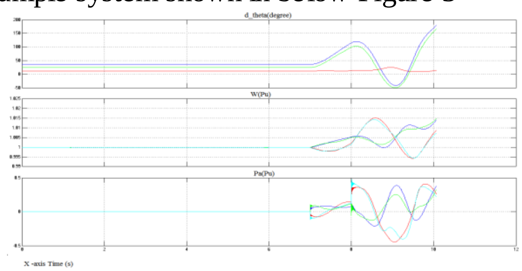

Figure 3

It has been observed from Figure 3 that line 1 is disconnected from the network after the operation of both breakers at 7s. Hence, the system is not able to maintain the stability and may lose the synchronism between two areas.

2. **Sudden increase in Percentage load**:

In this case, load was increase 10% of full load on area 2 and effect of sudden increase in Percentage load on sample system result in out of step even if the increment was so small .

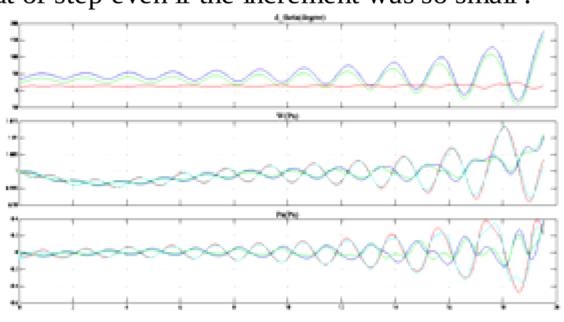

Figure 4

3. **Switching of capacitor Bank:**

In this case, the effect of capacitor bank switching on system stability is checked. Capacitor bank is connected to the load in both areas. Here two conditions are taken:

1. Switching of capacitor bank in area1
2. Switching of capacitor bank in area 2

A. **Switching of capacitor bank in area1**:

300MVAR capacitor bank is connected to the load at 7s to the system & its waveform is shown in Figure 5.

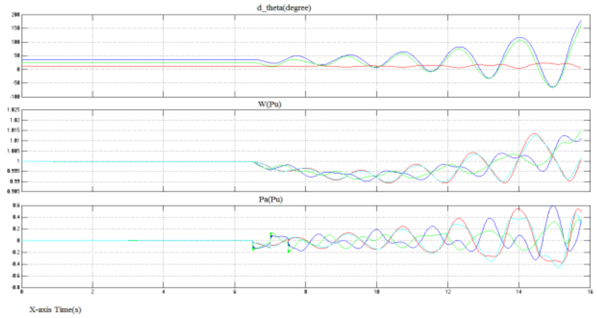

Figure 5

As shown in Figure 5 system is not able to maintain synchronism between the areas.

B. **Switching of capacitor bank in area2**:
Same result was achieved when switching the capacitor bank in area 2.

4. **Generator outage:**
In this case, the generator 4 of area 2 is disconnected for few cycles to check the behavior of system. If generator is disconnected for 2 cycles (40ms) than loss of synchronism occur. System in no longer maintains their stability.

5. **Decrease in Generator output :**
In this case, the output of one of the Generator of area 2 is decreased to check the effect of this small disturbance on system. The output of generator of area 2 is decreased because area 2 is weaker compare to area 1. If the output of Generator of area 1 is decreased, defiantly system became out of step because Generators of area 1 supply extra power to load at area 2.
In this case, the power output of Generator 4 of area 2 is reduced. Rating of Generator is 900MVA; 20KV synchronous machine. I reduced the output from 900MVA to 800MVA.

In this condition sample system is not able to maintain the stability that is shown in below Figure 6

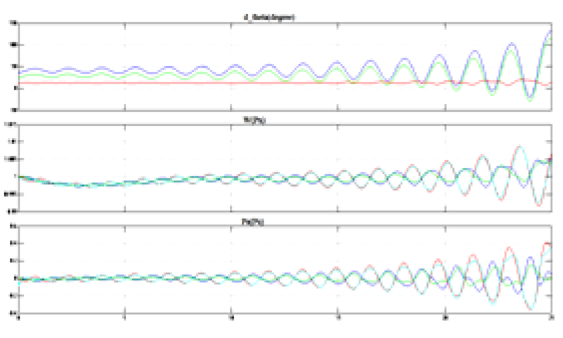

Figure 6

IV. CONCLUSION

In this paper, we simulated different small disturbances that occurred in system very frequently. Even if it is not a fault, system no longer maintains their stability. For maintaining the stability when small disturbance occurred in system, normally Power system stabilizer (PSS) is equipped to die out the small frequency oscillation.

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