Transient Stability Analysis For 6 Bus System Using E-Tap

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Abstract- The intention of this paper is to examine the transient stability of the power system when a symmetrical three phase fault is created at bus by using E-TAP software. Transient stability is the ability of a machine to run at synchronous speed even focused to large disturbances. At this juncture the transient stability analysis is carried out for 6 bus system. The enrichment in stability and the power oscillation is damped out when the fault is cleared within time. The fault is created at bus 4 for 0.3 second and the clear fault time is 0.5 second. If the fault is not cleared within the time the generator losses its synchronism that is the generator goes out of step and produces power oscillations in the output. In order to diminish the power oscillations and bring the system again to stable critical clearing time is used. After the fault is cleared, the system oscillations are damped simultaneously the generator runs in synchronism.

Indexed Terms- Critical clearing time; E-TAP software; Steady state stability; Three phase fault; Transient stability

I. INTRODUCTION

The power system stability is defined as the ability of a synchronous machine to remain in synchronism even after allowed to some disturbances. The power system stability is classified as shown in Fig 1.

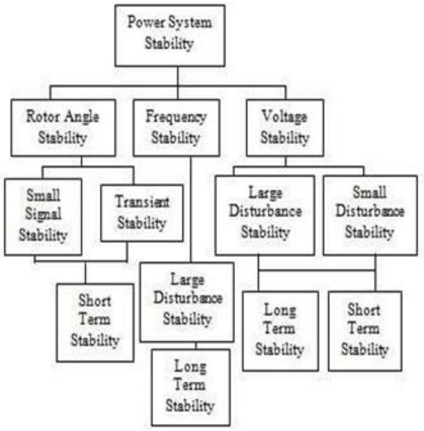

Fig 1. Classification of Power System Stability

Rotor angle stability is the ability of inter-connected synchronous machine to maintain synchronism. [1][2] Rotor angle stability is classified as

- Steady state stability
- Transient stability

Similarly, if a power system is capable of maintaining frequency and voltage value within the nominal range means, this is explained as frequency stability and voltage stability.

The power angle curve illustrates the dynamics of the generator rotor angle. The transients are caused due to sudden addition or rejection of loads, short circuit, and switching operations [3] – [5]. Instability of a system means synchronous machine unable to maintain synchronism and it comes to out of step condition. That is the rotor oscillation goes beyond 180 degree, the machine losses its synchronism therefore 180 degree is the standard transient stability limit. If the generator oscillates outside the limit the system will not be operated in stable operating condition. In order to make the system to be stable critical clearing time is used. The critical clearing time is the maximum allowable time for clearing the fault. However critical clearing time is not adequate decisive factor to assess the transient stability when severe fault occurred in the power system. The oscillation of generator is measured with infinite bus or grid which is represented as slack bus. As rotor oscillates the synchronous machine power output varies.

Under normal operating condition speed of synchronous machine does not change. When synchronous machine losses synchronisms with respect to the other machines, the rotor starts to rotate at higher or lower speed. The system is designed to operate with set of conditions. The conditions considered are short circuits faults, phase to ground fault, phase to phase to ground faults or three phase fault [6] – [9].

II. SOFTWARE USED

The software used for simulation is E-TAP (Electrical Transient Analysis Program). The designer and developer of ETAP is the "Operation Technology, Inc" (OTI). E-TAP is a fully graphical enterprise package. ETAP widely used as analysis software for the design, operation, control, simulation, optimization, monitoring, and automation of power systems [10] – [14]. By using this software we can perform different analysis on a bus system, it includes load flow analysis, arc flash analysis, harmonic analysis, short circuit analysis, and transient stability analysis etc. Transient stability studies includes identifying critical clearing time, preparing and testing load shedding schedule, checking generator rotor angle stability, evaluating relay setting.

III. SIMULATION DIAGRAM

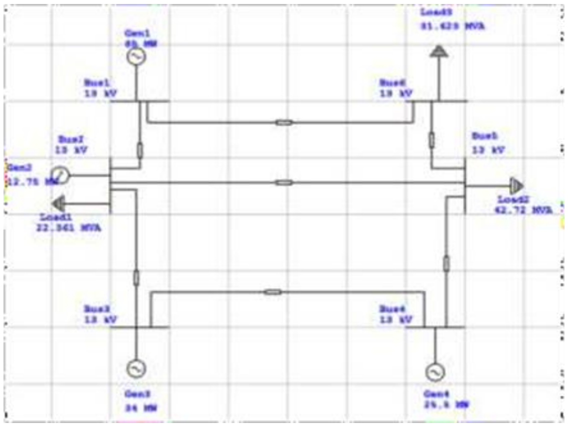

Fig 2. Test System

3.1 Input Data

TABLE I. Transmission Line Parameters of 6 Bus Systems

Line	Bus Code	Resistance (p.u)	Reactance (p.u)
1	1-2	0.05	0.20
2	2-3	0.10	0.50
3	3-4	0.20	0.80
4	4-5	0.10	0.30
5	5-6	0.20	0.40
6	6-1	0.10	0.15
7	2-5	0.20	0.50

TABLE II. Generator Data

Generator No	MVA	Bus type
Generator 1	100	Slack
Generator 2	15	PV
Generator 3	40	PV
Generator 4	30	PV

TABLE III. Load Data

Bus	MW	MVA
Bus 2	20	10
Bus 5	40	15
Bus 6	30	10

Table I consists of transmission line parameters that is resistance and reactance values of each lines represented in per unit. Table II consists of generator data's in MVA and type of bus connected to each generator. Table III consists of load data's that is amount of load connected to the bus in MW and MVA ratings [15] – [19].

IV. LOAD FLOW ANALYSIS

Load flow study deals with the various methods used to obtain the solutions for the power system network. As a result, we will get the magnitude and phase of bus voltages, real and reactive power flow values in all the lines and the line loss data. The buses of power system can be classified as

- Load bus
- Generator bus
- Slack bus

Load bus

Real and reactive power of bus is precise. The voltage is to vary within the limit.

Generator bus

In generator bus we know the P and V values. Load flow analysis is used to find out reactive power and the phase angle.

Swing bus

Swing bus is considered as the reference bus while doing load flow study and also this also known as slack bus. Normally, this bus is used to account for the transmission line losses.

For load flow analysis fast decouple, gauss seidel and Newton Raphson methods are used. In this paper Newton Raphson method is used because its more efficient, take less time and less iteration count. The first generator connected to the bus is kept as slack bus. Initially load flow analysis had to be performed to determine the power consumed by each loads [20] [21].

V. SIMULATION RESULT AND DISCUSSION

The transient stability is analyzed for 6 bus system which is shown in Fig 2. For initial load flow solution Newton Raphson method is used. The maximum number of iteration is 3, the solution precision for initial load flow is 0.000001, the time increment for integration steps is 0.001, the total simulation time will be 5 seconds and the plot time step will be of 10.

The three phase fault is created at bus 4 for 0.3 second and is cleared after 0.5 second with the help of transient stability study case editor. At starting there will not be any power oscillations in the output, the machine runs at synchronous speed. When time is at 0.3 second there will be oscillations in the output, the generator losses its synchronism that is the electrical power output is less than the mechanical power input. When time is at 0.5 second the fault at bus is cleared so the electromechanical oscillations are reduced and the system remains to stable operating condition. In transient stability study case editor in plot section we have to mention the device id that is generator 1 and 2 and plot and tabulate then only the different output plots are generated. Using ETAP the transient stability analysis can generate report by using report manager.

The different plots for Gen 1 and Gen 2 are shown in figure below.

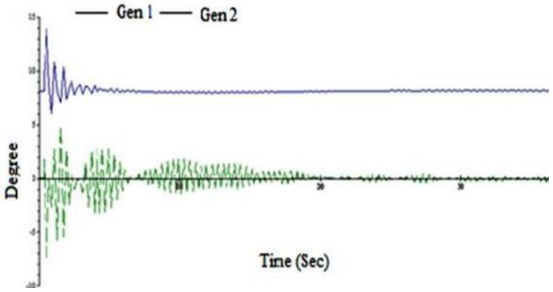

Fig. 3. Generator absolute power angle

Figure 3 shows generator power angle V_S time. When the mechanical power is greater than the electrical power, it produces oscillations in the output. The electro mechanical oscillations are reduced after clearing the fault at 0.5 second.

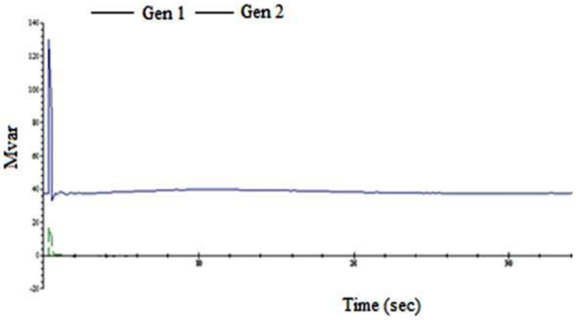

Fig. 4. Generator Reactive power

Figure 4 shows generator reactive power V_S time. The oscillation in the output are reduced when the fault is cleared and steady state power is improved.

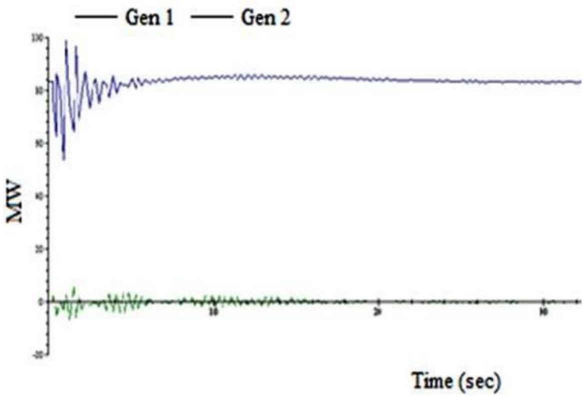

Fig. 5. Generator Electrical Power

Figure 5 shows generator electrical power Vs time. The electro mechanical oscillations are reduced and the power swing is damped out and the system attains stable condition.

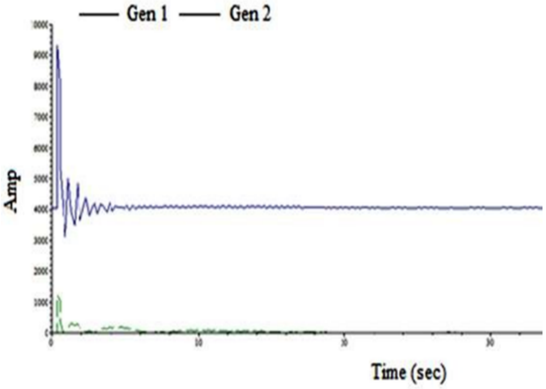

Fig. 6. Generator Terminal Current

Figure 6 shows terminal current Vs time. The oscillations in the terminal current output is reduced and the system reaches stable operating condition at 0.7 seconds.

CONCLUSION

Thus, the transient stability analysis for 6 bus system has been enhanced by creating a three-phase fault on bus 4 and it had been cleared within the time so that the system remains to operate in stable operating condition.

As the result shows that at the beginning the generator is operated at stable operation and when the fault is created then there is a oscillation in the output which represents that the generator loss its synchronism and falling out of step. When the fault is cleared then the oscillation are reduced and produces stable output which shows that the generator has return to normal condition and remains synchronism that is in step.

During fault the oscillation is created in the output of generator and after abnormal condition the power oscillations and power swing are damped out and get better response in the output.

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