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Transient Stability Analysis of Industrial Plant

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Abstract —*Industrial power system, Transient stability analysis is done to ensure the stable synchronized operating of industrial systems experiencing sever fault, unaccepted load variation or heavy systems disturbance. In industrial power system, instabilities are normally occurred due to faults.3 Phase fault are more severe than single fault or ground fault. Transient stability analysis is performed by simulating post fault behavior generator after three phase fault. In this paper, Transient stability analysis of industrial plants is presented using Electrical Transient Analysis Program - 7.5.5(ETAP). Here, power is produced by two generator of rating 16.5 MW, 11.8 MW and one generator keeping in spares. Transient stability analysis is performed with both machines and with and without grid support of 22Kv. By this analysis it is observed that phase angle oscillations of both the machines are far below than synchronization limit.*

Keywords- *Transient stability analysis, ETAP, Power Angle, Synchronization power, Dynamic and steady state stability*

I. INTRODUCTION

Transient Stability is confirmed the adequacy of system parameters and ratings of different equipments for the reliable operation of the system under different source configurations (operating philosophy) and maximum load condition. If the fault is occurred, it is cleared within stipulated time and systems continue remains in synchronism. Transient stability analysis is conducted to show the behavior of system post large disturbance such as occurrence of 3-Phase fault. Therefore, critical fault clearing time of system to keep system in synchronism can be obtained. This critical clearing time is useful to decide relay settings during Relay Co-ordination. Earth fault is not made much more difference related to instability and it is cleared within prescribes time. Therefore, only three phase fault are considered for transient stability study. Minimum value of critical fault clearing time comes out to be 0.2 s at 33kV. i.e. 3-Phase fault must be cleared in time lesser than this to maintain synchronous operation of Generators. Similarly, corresponding values of fault clearing time at 66kV, 6.6kV and 0.415kV are 0.2, 1 and 1 sec respectively [1, 2, 3, 4].

II. METHODOLOGY

Stability of synchronous generators is judged by rotor angle and it is defined with respect to reference so that it is necessary to have selection of mode of operation of power sources. For transient stability analysis, four modes of generators are selected (1) Swing mode (2) Voltage controlled mode (3) Power factor controlled mode (4) MVAr controlled mode. Any power systems, one bus should be keeps slack but adjust the power difference. If there is more than one generator, big generator keeps in swing mode whereas when grid support with the generators, grid should be keeps in swing mode. In our system, Grid has operated in swing mode and in case of only generators STG-1 has considered to operate with the grid. Other sources have been considered to operate in Voltage controlled mode. 100MVA has been selected for all analysis. Different base values of voltage such as 11kV, 6.6kV, 3.3kV and 415V have been selected for different system voltage levels. Following equations have been used for calculation [1, 2, 3, 4, 5];

- Base impedance = $(kV)^2$ / Base MVA
- Source fault MVAsc = $\sqrt{3}$*Vs*Ifs
- Source impedance = Vs / ($\sqrt{3}$*Ifs)

Where, Vs is the Source voltage kV and Ifs is indicated Fault current in kA. To simulate the transient stability behavior, three phase fault are created and observed effect of this fault on generators power angle, on big motors and systems voltage profiles.

III. OUTCOMES AND PARAMETER SETTING

The outcomes of Transient Stability analysis are; (1) Relative power angle of synchronous generators with respect to common reference/slack bus.(2) Values of Exciter voltages and Exciter currents before, during and after disturbance. (3) Values of Speed, reactive power, terminal current, real power etc corresponding to Synchronous Generators during the time of simulation interval. Similarly, values pertaining to the Induction motors like real power requirement, reactive power, slip, bus voltage throughout the simulation period [1, 2, 3, 4].

According different causes of instability problems, several enhancements can be made to improve the system stability are;(1) Improve configuration and system design (2) Increase synchronizing power (3) Design and selection of rotating equipment – use induction motors, increase moment of inertia, reduce transient reactance, improve voltage regulator and exciter characteristics (4) Application of Power System Stabilizers (PSS) (5) Add system protection – fast fault clearance, system separation, etc. (6) Add load shedding scheme [1, 2, 3, 4].

IV. RESULTS ANALYSIS

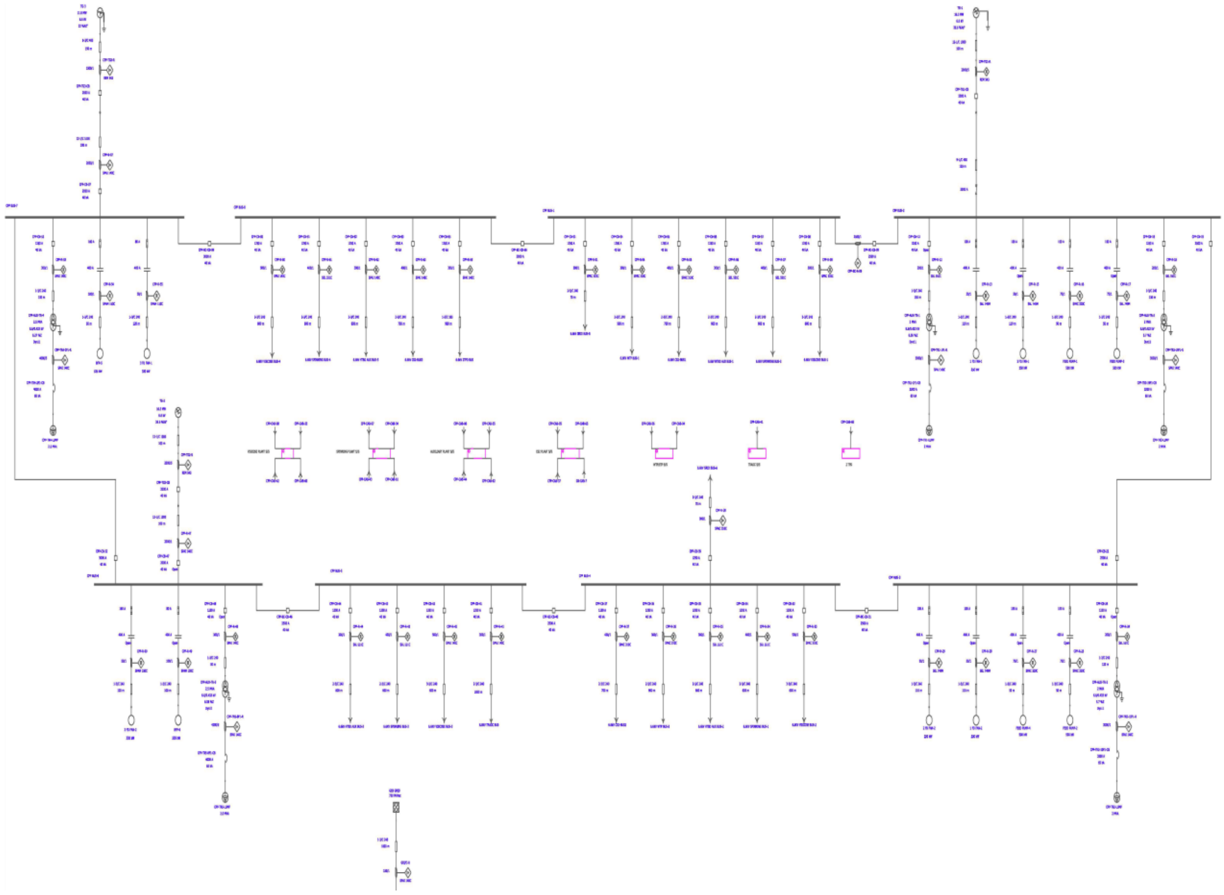

Fig.1. Single line diagram of industrial plant

Industrial palnt is 175 bus system within plant steam based generation (by three generator 2*15.6MW &1*11.8 MW, G1/G2=15.6 MW, G3=11.8 MW) with 22kV Grid support for black start and emergency. Total 175 branch of the plant formed by 37 transformer (distributions & furnace), 74 line/cable, 64 tie circuit. Transient stability analysis is conducted using ETAP-7.5.5. single line diagram are shown in Fig.1.

Transient stability study has been conducted for different operating philosophy of plant and in different time domains. This analysis is con ducted with operating philosophy of generation G1 connected in with grid. Generator is loaded up to 90% of capacity and remaining load is tackled by grid. Three phase fault is created for 1 second at 6.6 Kv and observed the transient behavior of generators, motors and power systems.

It is found that the relative power angle of the synchronous generator reaches 84˚ and it is far below to maximum limit. Generator is attained is rated speed within stipulated time and generator voltage is also settled to its normal values within specific time. Voltage profile at other running buses of system found to be within safe limits of system parameters. Largest Motor load behavior has also been analyzed under transient too. Motor capacity is 1400 KW and it is connected to 6.6 KV bus. It is found that that motors get reaccelerated and reaches to their rated speed. Finally, it is concluded that the system would be remain stable for fault is existed in the system for more than 1s also but it is advisable to clear the fault within 1s and therefore this time period are considered in study. Different parameter such as phase angle, speed, active and reactive power, exciter voltage and current are also oscillated with respect to time when fault occurs. It is found all these oscillation within prescribe limit. Different parameters variations are presented in fig .2 to fig.7.

Fig.2. Generation Angle Oscillation

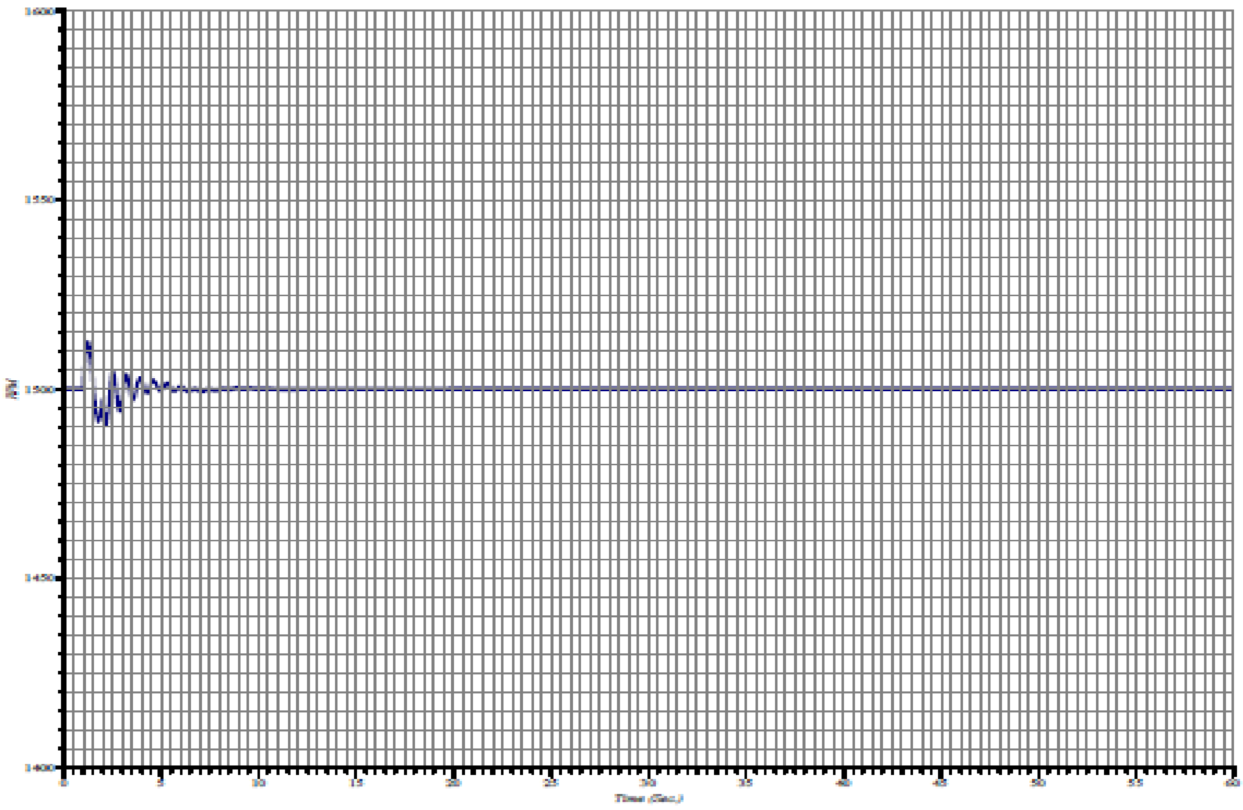

Fig.3.Generator Speed Oscillation

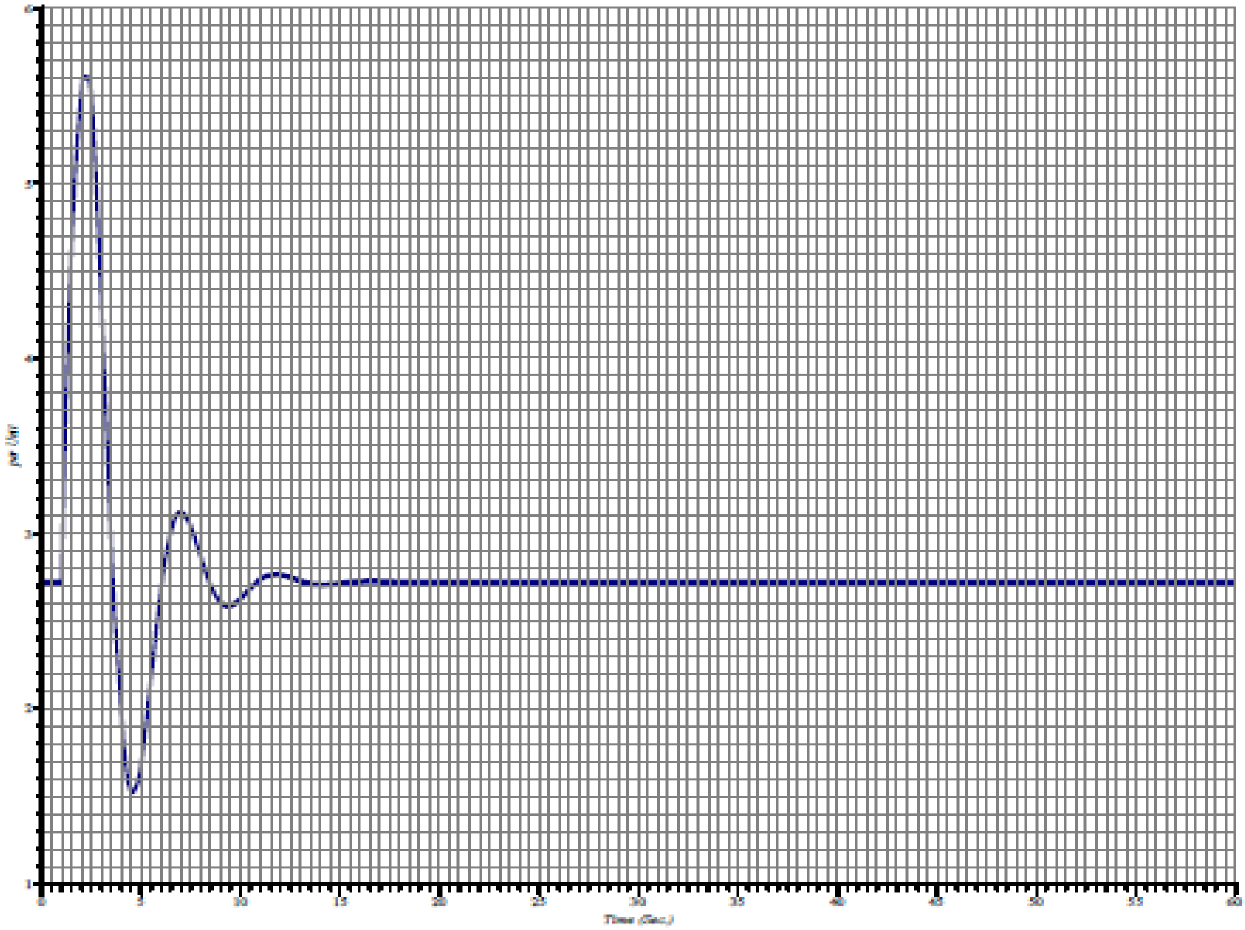

Fig.4. Exciter voltage

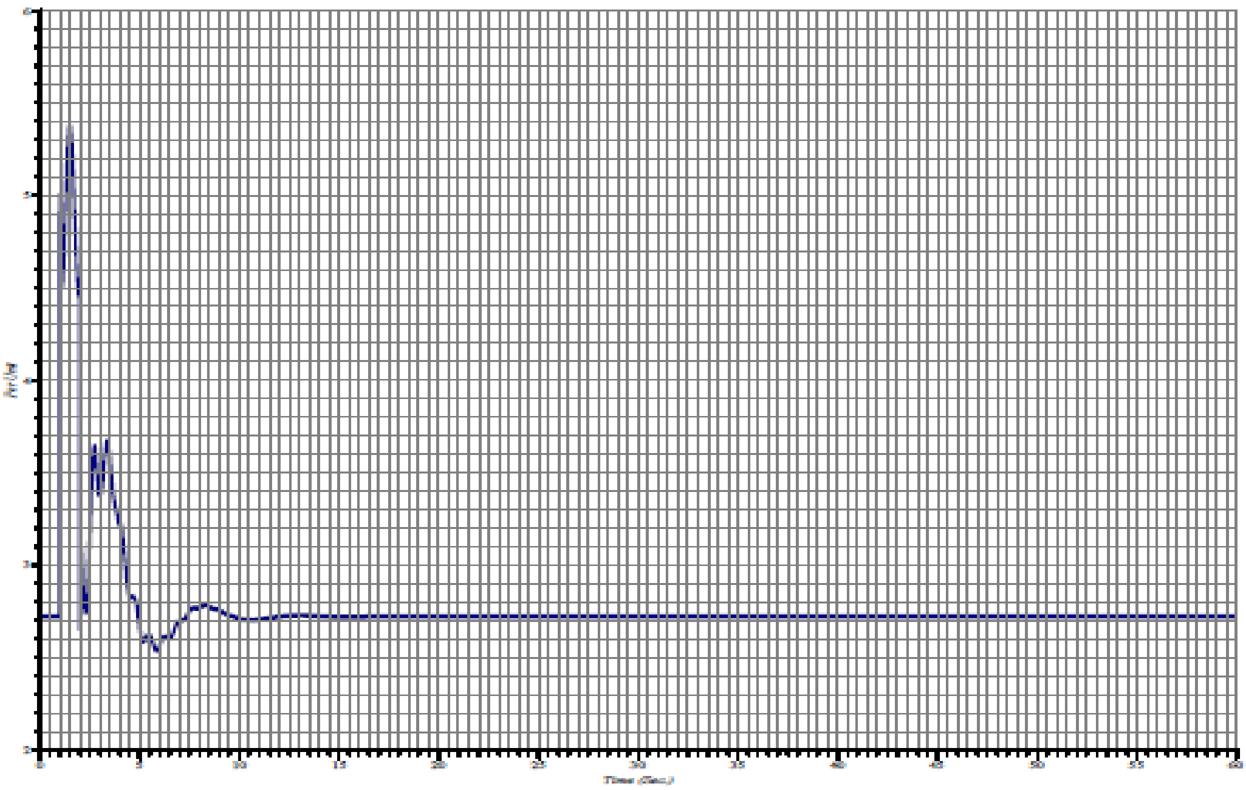

Fig.5.Exciter Current

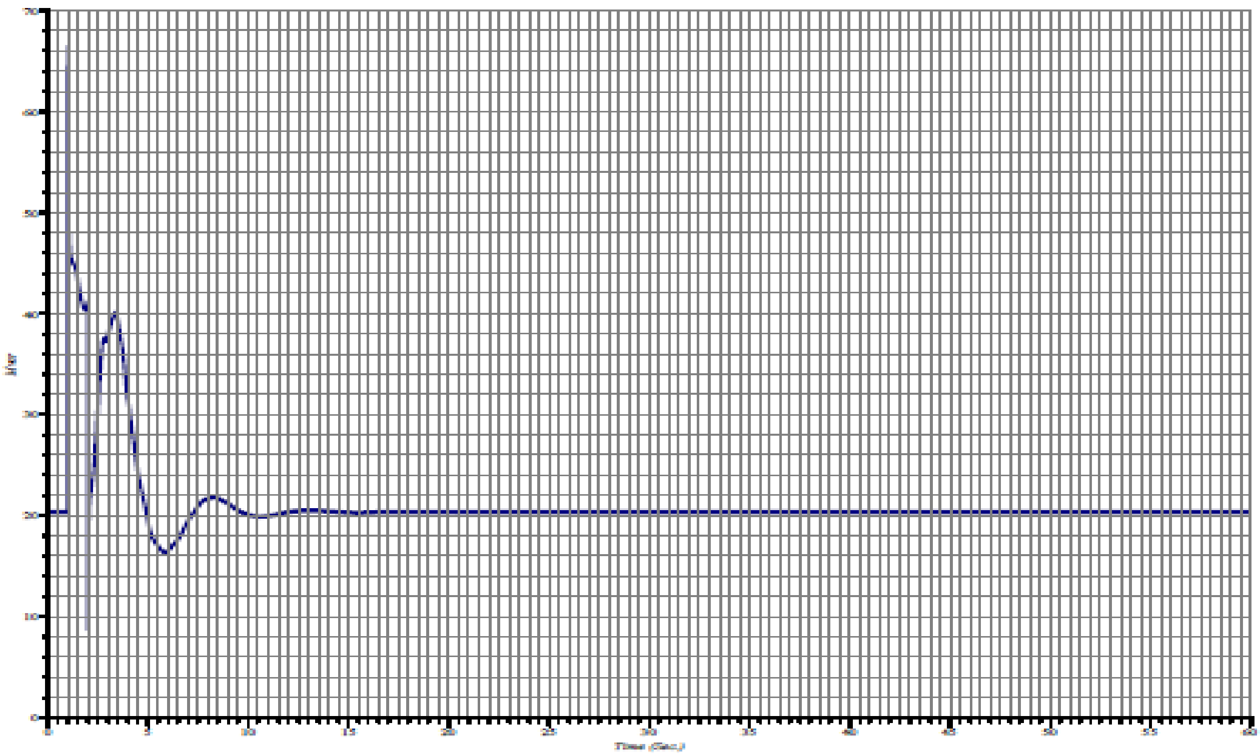

Fig.6. Reactive Power

Fig.7. Active Power

V. CONCLUSION

Transient stability analysis has performed for industrial plant to ensure post disturbance stable operation of the plant. Major disturbance which are affected to plant operation are 3 phase fault. Transient behaviors of plant equipment such as Generator and motor have checked for post fault time period of 1 second. It is found that all parameters oscillations are deviated within stipulated time and system remains in synchronism.

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