Power System Stability Analysis: A Review

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Abstract— **Power system stability is related to principles of rotational motion and the swing equation governing the electromechanical dynamic behavior. In the special case of two finite machines the equal area criterion of stability can be used to calculate the critical clearing angle on the power system, it is necessary to maintain synchronism, otherwise a standard of service to the consumers will not be achieved. This term stability means "maintenance of synchronism". This paper is a review of three types of stability condition. The first type of stability, steady state stability explains the maximum steady state power and the power angle diagram. The transient stability explains swing equation and inertia constant while dynamic stability deals with transient stability period. There are several methods to improve system stability in which some methods are explained.**

Keywords— Synchronism; Steady State; Transient Response

I. INTRODUCTION

The stability when used in power systems, is that attribute of the system, which enables it to develop restoring forces between the elements thereof equal to or greater than the disturbing forces so as to restore a state of equilibrium between the elements. When operating in a steady state condition if a Sudden change occurs in the system we say that the system has undergone a disturbance from its steady state operating condition. Disturbances can be large or small Depending on their origin. Transmission system faults, sudden load changes, loss of generating unit are examples of large disturbances. A change in the gain of the automatic voltage regulators in the system of a large generating unit is an example of small disturbance.

Fig.1 Power system transmission lines

There are three fundamental assumptions in all stability studies:-

a). Any synchronous frequency currents and voltage are considered in the stator windings and the power system

b). Symmetrical components are used in the representation of unbalanced faults.

c). Generated voltage is considered unaffected by machine speed variations.

For the purpose of analysis, there are three stability conditions as shown in Fig. 2. They are explained in the following sections.

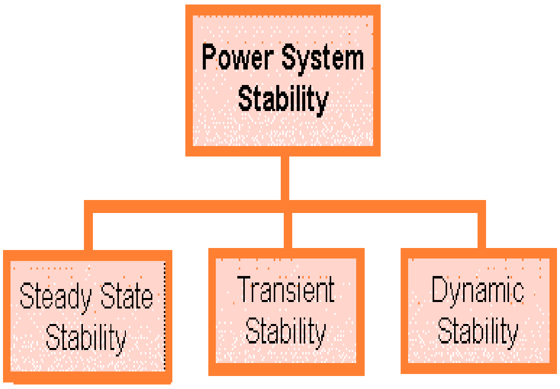


Fig.2. Power system stability conditions

II. STEADY STATE STABILITY

Since the electrical system always subject to small disturbances, the steady state stability requirements are essential for the system to operate properly. The assessment of the steady state stability may be required in planning of electrical power system analysis and synthesis, then the power developed by the generator (G) and motor (M) is given by the equations (1) and (2) respectively.

$$P_G = \frac{D}{B} V_G^2 \cos(\beta - \Delta) - \frac{V_G V_M}{B} \cos(\beta + \delta) \ldots\ldots\ldots (1)$$

$$P_M = \frac{V_G V_M}{B} \cos(\beta - \delta) - \frac{A}{B} V_M^2 \cos(\beta - \alpha) \ldots\ldots\ldots (2)$$

Where A, B & D are the generalized constants of a two terminal pair network.

II. TRANSIENT STABILITY

Transient stability involves large disturbances, usually occurring within one second for a generator close to the cause of disturbance. A sudden large disturbance includes application of faults, clearing of faults, switching on and off the system elements (transmission lines, transformers, generator load etc.). If the machine of the system is found to remain essentially in synchronism with first, second, the system is regarded as being in transiently stable. Transient stability analysis involves some mechanical properties of the machines in the system. After every disturbance, the machines must adjust the relative angles of their rotors to meet the condition of the power transfer involved. The problem is mechanical as well as electrical. Transient stability limit is almost always lower than the steady state limit and hence it is much important. Transient stability limit depends on the type of disturbance, location and magnitude of disturbance.

IV. DYNAMIC STABILITY

Dynamic stability is the ability of the power system to remain in synchronism after the 'initial swing' (transient stability period) until the system has settled down to new steady state equilibrium condition. After the disturbance prime mover react to increase or reduce energy input as may require to re-establish a balance between energy input and exciting electrical load. Time between governors begins to react and steady state re-established is the period when dynamic stability characteristics of a system are effective.

V. POWER ANGLE DIAGRAM

Therefore a curve is drawn showing power vs. load angle δ, called power angle diagram as shown in Fig. 3. The maximum power will occur for δ=90˚.

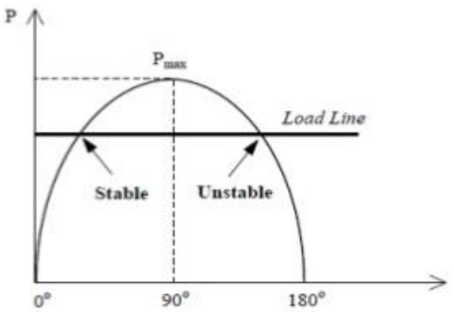


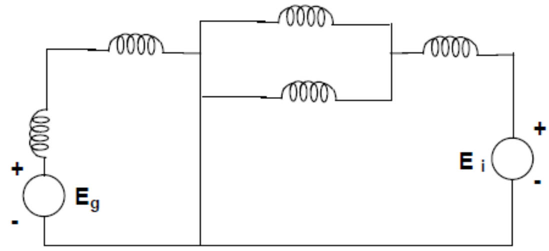
Fig.3 Power angle diagram (P V_S δ)

For the maximum power transfer to occur the following conditions must be satisfied

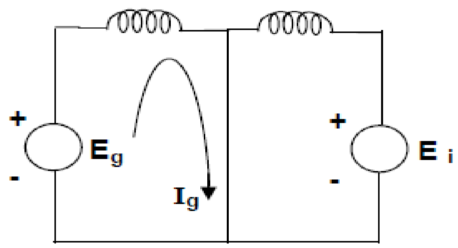
$$X = \sqrt{R^2(4-1)} = \sqrt{3}R \qquad \text{……… (3)}$$

We conclude that, maximum power will be transferred from sending end to receiving end when reactance is$\sqrt{3}$ times its resistance. Power can transferred only if reactance is present. In case of reactance being zero, transfer of power will not be possible.

VI. SHORT CIRCUIT OCCURING IN THE SYSTEM



(a)



(b)

Fig.4 Short Circuit

Short circuit occurring in the system often causes loss of stability even though the fault may be removed by isolating it from the rest of the system in a relatively short time. A three phase fault at one end of a double circuit line is shown in Fig. 4(a) which can be reduced as shown in Fig.4 (b) .It is to be noted that all the current from the generator flows through the fault and this current I_g lags the generator voltage by 90˚. Thus the real power output of the generator is zero. Normally the input power the generator remains unaltered.

V. CONCLUSION

As per the above explanation of some conditions of the stability, power angle diagram and short circuit cases, if the fault is sustained, the load angle δ will increase indefinitely because entire the input power will be used for acceleration. This may result in unstable condition.

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