View–Point on Oscillations in Power Space and Analogical-Tag for it in sense of Longitudinalism

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Abstract: - This paper discuss about the stability of power system on account of oscillations channelized through different parts of it under certain disturbances. Besides this, the longitudinal wave mode proposed to understand the nature of oscillations in power system responsible for the disruptiveness in continuous flow, for disturbances of any type may be either small or large. Which obey the superposition principle, as the oscillation in any part of inter-connected system is the resultant one due to individual effect added by each machine. .

1. INTRODUCTION

Power system is non-linear, complex system and is subjected to different kinds of disturbances, which may be either large or small. Problem of instability in power space (that represent all of the phenomenon and property in concerned with electricity), on account of oscillation channelization through spatial coordinate of it, was recognized in late 1950-60s. Their appearance was recognized, when the power system is pressed to supply increasing load. Increasing load more and more on transmission line by relying generator on excitation system only, as result at certain points in absence of supplementary stabilizing signal it lose its synchronism maintenance capability as synchronizing oscillation become unstable.

Power system stability is defined as the property of power system to remain in the state of operating equilibrium under normal operating condition and also has ability to regain a new acceptable state of equilibrium after being subjected to certain disturbance. In other words power system stability is defined as the tendency of power system to develop restoring between the elements garter than or equal disturbance force in order to restore a state of equilibriums between the elements. In power system, the number of large synchronous machines are employed for generation of electrical power in plant or as motor in industry etc. therefore, it is necessary that all machines of given power system must show the pattern of “mutual synchronism ability” and “synchronism restoration ability” as well between the elements for satisfactorial operation of the system. Thus power system stability indicates the nature pattern of mutual synchronism and restoration capability during normal operating condition or on the account of disturbance within the desirable limits.

The present trend is towards the inter-connection of power system rather than an isolated system, gives the complex network of elements spread over large geographical area, resulting into increased length and increased reactance of the of the system, which yields an acute problem of system stability maintenance. The power system stability problem is based on keeping the interconnected synchronous machines in synchronism (synchronizing torques). In inter-connected system, the torques produced by synchronous generators depends upon the relative angular displacement of the rotor. If, the angular displacement between generators increases, an electrical torque produced tries to reduce that angular displacement.

2. POWER SYSTEM STABILITY CONSIDERATION

In this section, the analogical realism of power system stability is provided (i.e. rubber band analogy) to understand the” mutual synchronism ability” and “synchronism restoration ability” pattern during normal operating or disturbance conditions. Generators connected to each other in inter-connected network through transmission lines are much like number of suspended weights inter-connected to each other by rubber bands. Where, the suspended weights and inter-connected rubber bands are analogous to generators and transmission lines respectively. Initially the weights are in static equilibrium and the rubbers are in stretched condition. This static equilibrium state represents the mutual synchronism ability pattern between the elements.

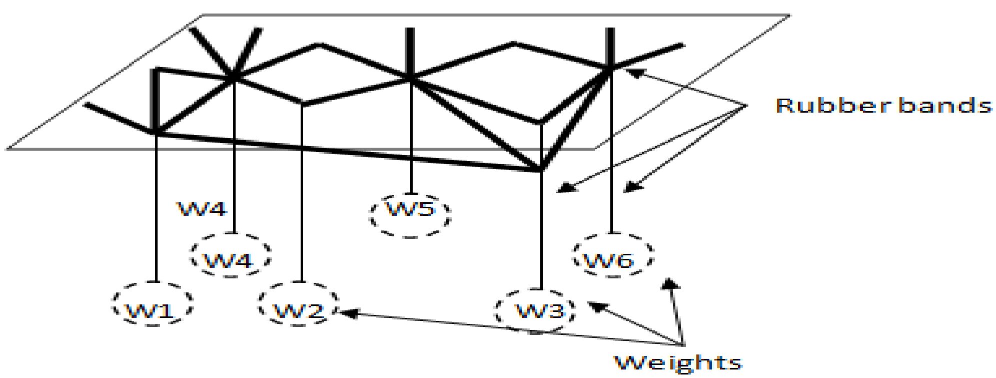


Fig.1 Mass- Rubber band analogy

By pulling one of the weights only, oscillations set-ups in each of the weights due to propagation of disturbances through inter connected rubber bands and cause the other weights to oscillate to. After certain time the oscillations die-out (shows restoration of synchronism) and the static equilibrium is achieved (i.e. to synchronism mutuality) with in desirable limits. While during the oscillations But, if the disturbance is large, so that breaking of rubbers takes place then either the overall system to breakdown completely or some of it so that remaining of it settle down to new equilibrium state.

That means, either system settle down to new equilibrium state or completely breakdown on account of large disturbances depend upon the inter-connectivity.

3. CLASSIFICATION OF POWER SYSTEM STABILITY

Power system stability are classified into three types:-

i. Steady-state stability

Steady state stability is defined as the capability of electrical power system to maintain synchronism between machines within the system if the maximum allowable power transfer within the system exceeds beyond the given permissible limit, the individual or group of machines will not able to operate in synchronism and cause violent fluctuation of the voltage. This permissible limit is known as Steady state stability limit refers to the maximum power which can be transported within the system without loss of stability.

ii. Transient stability

If the disturbance at any point in power space is large, then synchronizing torque not able to return the generator angles to steady state. As result generators lose its mutual synchronism capability and the system exhibits transient instability.

In other words, Transient stability is defined as the ability of power system to maintain mutual synchronism between machines, when subjected to large sudden disturbance due to faults, clearing of faults, sudden load change etc. The power system is said to have transient stability character, if on the account of large sudden disturbance, it has capability to regain and maintain synchronism. Transient stability carried out over a relatively short period of time, which is equal to the time of 1-swing. Normally this time period will be of one second or less (i.e. $t \leq 1$).

iii . Dynamic stability

If the disturbance at any point in power space is small (i.e. small change in loads or in generation condition etc.), then synchronizing torque keep the generators in synchronism mutually but the relative of generator oscillates. Which decay out by the system equipments like PSS (a lead-lag compensator) and the small signal stability of system is achieved. Small signal stability is also known as Dynamic stability. Dynamic stability is defined as the ability of a power system remain in synchronism after the initial swing (transient stability period) until the system has settled down to new steady state equilibrium condition. When sufficient time interval has elapsed after a disturbance, the governor of the prime mover will react to increase or reduce energy input, as may be required to re-establish a balance between energy input and the existing electrical load. This usually occur in about [1- 1.5] sec. after the disturbance. Simply, the ability of system in power space to maintain synchronism between the elements on account of small disturbance is known as dynamic stability. The schematic diagram of power system stability classification is given in fig.2. Small-signal stability phenomenon of the power system are basically characterized by Low frequency oscillation (LFO), created on account of small disturbances in system. These small disturbances lead to a steady increase or decrease in generator angle caused by the lack of synchronizing torque, or to rotor oscillations of increasing amplitude due to lack of sufficient damping torque. Low frequency oscillations are generator rotor angle oscillations having a frequency range between, f Є [0.1, 3.0] Hz.

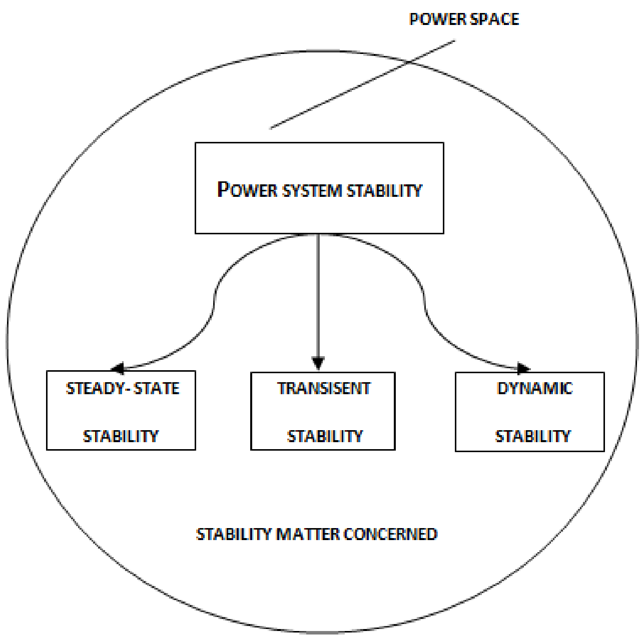


Fig.2 classification of power system stability.

Loss of small-signal stability results channelization of different types of oscillations given below and also shown in fig. 3.

a. Local plant oscillations mode

This oscillation occurs between units at generating station and also between a unit of the station to the rest of power system. Their frequency ranges from [0.2, 2.5] Hz.

b. Inter-plant oscillations mode

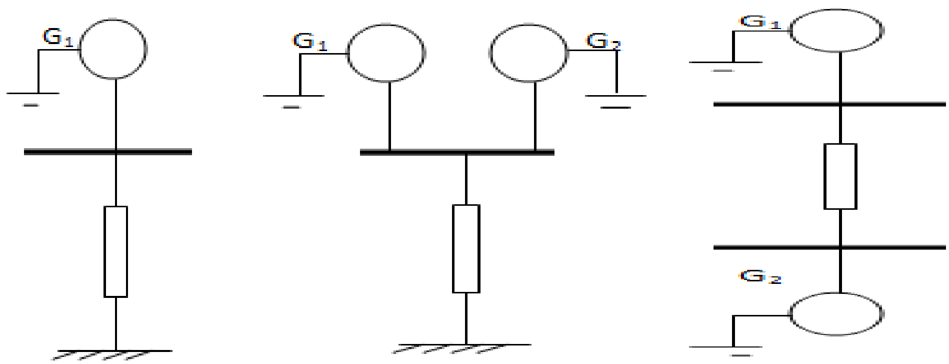
This oscillation take place between two nearby generating plants having frequency range from [1, 2] Hz.

c. Inter-area oscillations mode

This oscillation mode is associated with the swinging of number of different machines in one part of the system with the machines in the other part of the system. Their frequency ranges from [0.2, 0.8] Hz and this oscillation are also called as low frequency oscillation.

d. Global oscillations mode

This oscillation is characterized by common phase oscillation for all generators in an isolated system. The frequency of global mode is under 0.2 Hz.



(a) Local oscillation mode. (b) Inter-Plant oscillation mode. (c) Inter-Area oscillation mode.

Fig. 3 Types of oscillations mode.

4. ANALOGICAL-TAG FOR OSCILLATIONS IN POWER SPACE IN SENSE OF LONGITUDIANLISM.

Phenomenons in universal discourse have certain "Analogical-Tags" in sense of 'Property Uniqueness'. i.e. every phenomenon in nature has certain Analogical realism. For instances, consider the flow of current in wire possible on account of voltage difference, its analogical-tags are as follow. Like, Flow of fluid on account of pressure difference, heat flow on account of temperature difference etc. each of these tags are analogies of the proposed examples in sense of 'flow on account of difference'. Similarly, channelization of oscillations through 'co-ordinate of power space' (i.e. through different apparatus or parts of power system over which power flow) either locally or globally on account of some line of elements (as disturbing force) have Analogical-Tags in sense of wave longitudinality (i.e. property uniqueness). Which, obey the superposition principle. That means, oscillations in power space have Analogical-Tag in sense of Longitudinalism. Any example proposed to understand the nature of power system oscillations, the only example realize to be, that they have ability of restoration longitudinally like spring-mass system, mass-rubber band system etc. But the power oscillations mainly emphasis on the basis of analogical tag in sense of longitudinality due to the fact that, the oscillation localized with any part of power system possible only on the account of fulfilment of superposition principle to determine the resultant oscillation for different sources of disturbance, to gives it unidirectional.

"Analogical-Tag for Power Oscillations available in sense of Longitudianlism".

From power system oscillations point of view, the nature property of every oscillations channelize in power space through spatial coordinate of it either locally or globally under the consideration of disturbances of different types; being similar (in sense of longitudianlism). i.e. power oscillation is resemblance of longitudinal wave for the disturbances of any types. The Analogical-Tags for oscillations channelized under transient disturbance conditions being identical to those of oscillations channelized under small disturbance conditions in sense of longitudinal wave. Thus, one can say that the oscillations in power system posses the nature property of longitudinal wave. The power oscillations possible on account of small or large disturbances within permissible limit (i.e. without breaking the system) cause it to channelize within the system in fulfilment with the nature property's of longitudinal wave. In paper [1] the T-wave conjecture first proposed, where T-wave is name calling for "disturbances" oscillates in system under low frequency oscillations only(i.e. of small disturbances only) which holds the nature of longitudinal wave. And the spring-mass system example proposed to visualize the oscillation developed on account of disturbances introduce into system in static equilibrium and the suppression of it by providing supplementary signal, being of same nature(via damper). The equation obtained in first case represent the oscillation setup in system on account disturbance gives the realization of oscillations channelized in power space and the equation obtained on account introducing damper involves exponential decaying factor gives the realization of suppression of oscillations on account of PSS. But here, in this paper the wave longitudinal mode proposed to be applicable for disturbances of any type may be either small or large.

Consider, an inter-connected system in power space loaded with (n) synchronous machine satisfying the 'mutual synchronism ability' pattern in static equilibrium. On account of external disturbance localization to any one or more on or nearby a machine of given system, the disturbance channelized through-out the system for given pattern of inter-connection. If there is small change in the pattern of inter-connection while all other conditional elements being identical (or one of the machine removed from the same system), then the disturbance or oscillation channelized through same line in two different cases will be different as the unidirectional disturbance possible on account of disturbance for any configurational setup of inert-connected system obeying superposition principle via some internal restoration means (i.e. synchronizing torque) depend only upon the configurational setup of it for identical elements. This shows that the disturbance propagates through any line in a system in particular directional is the resultant of disturbances created by each element during system synchronism restoration ability pattern by some means, on account of disturbance localized either one or more machine which obeys the superposition principle of longitudinal wave.

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