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Relative Stability Advancement of Power System on Account of Fuzzy Based PSS Over Conventional & PID Based PSS, Under Small Oscillation

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Abstract

This paper represent the stability advancement of single machine infinite bus (SMIB) system on account of Fuzzy logic based PSS (FLPSS) over conventional PSS & PID based PSS, under small oscillation by developing model of power system in MATLAB/SIMULINK. Besides this, T-wave hypothesis having longitudinal mode of propagation through coordinate grid of power space (i.e. through different apparatus of power system) being proposed to understand the nature of small signal oscillation in power system responsible for the disruptiveness in continuous flow, and also the concept about space of classical and fuzzy sets have proposed. Where Space of classical sets based on the criterion of Elements Similarity, while Space of Fuzzy sets based on the criterion of Elements with Degree of Membership, for all possible statements of universe.

Keywords: T-wave, power space, longitudinal wave, PID controller, space of classical & fuzzy sets, fuzzy controller.

1. Introduction

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 sudden disturbance.

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.

2. T-wave Conjecture

Power system stability percussion, on account of which small frequency oscillation channelized with in power space (i.e. power system), due to use of high gain exciter system; due to change in load which cause the generator rotor angle to fluctuate; due to the converters of HVDC etc. these low frequency oscillation is therefore referred to as Trouble or T-wave. This T-wave may localized with in plant locally or in between different parts of the power system globally, in range of [0.2, 3.0] Hz. i.e. “channelization of T-wave over spatial co-ordinates of power space is either locally or globally, on account of some line of elements, which hypothesize as longitudinal wave”. That means one can visualize this oscillation with the assumption of longitudinal wave due to the occurrence of disruptive force in power space (i.e. disturbance in power system) over certain intervals responsible for the dissociation in continuous flow. Realization of T-wave channelization in power space may visualize as propagation of longitudinal wave. Consider an observer (O) in generating plant (G) incorporated wit Exciter & AVR as main component of the excitation system, recorded T-wave as of electro-mechanical only, which is of main interest. Suppose, the T-wave oscillation channelized in power system either locally or globally, on account of generator (G) only, but in real practice the ‘T-wave

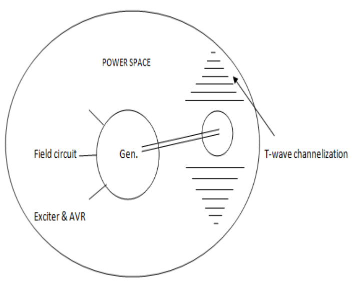


Fig. 1: Schematic diagram of T-wave channelization in power space.

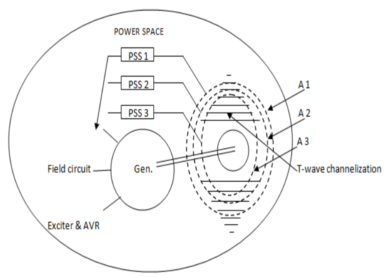


Fig. 2: Schematic diagram represent the effect on suppression of T-wave channelization in power space for different PSSs controller.

Localized with any parts of power system on account of the fulfilment of the principal of superposition to determine the resultant oscillation for different sources of disturbances'. The schematic diagram of T-wave channelized in power space by generator shown in fig. (1). Now, the task of observer is to damp-out this T-wave from power space. For such purpose the observer using the assumption that, T-wave oscillation is longitudinal in nature. For these, he introduces the analogical realism as the classical spring-mass system experiment. In which a block of mass 'm' is suspended from the one end of light spring having spring constant 'k', whereas the other end is fixed. Therefore, the solution of equation is, $x(t) = a \cos(\omega t + \phi)$. But in order to damp-out these free oscillation, the damping force must to be introduced in system, here nature of force is proportional to velocity (i.e. $f(t) = r.dx/dt$). And, the nature of solution of this equation is determined by the limit of parameter's evolve in conjugate as per desired relation. Here in this example three cases evolve. For λ □ μ, motion is non-oscillatory; critically damped motion, for $\lambda = \mu$ & damped oscillatory motion, for $\lambda < \mu$. Where, $\lambda = r/m$. In each of three cases, the oscillations die-out but in different mode. Considering the solution of equation for case (iii). $x(t) = a \exp.(-rt/2m) \cos(\omega' t + \phi)$. On comparing the two solutions it is concluded that the amplitude of oscillation decay-out on the introduction of damper system but their mode of decay depend upon, how their parameters conjugate. Thus, from this spring-mass conjecture, it is concluded that the solution of longitudinal T-wave oscillation in power space is possible only by, providing the damp signal to the system. That means in order to damp-out the T-wave oscillation in power system, the stabilizing signal must be added to it (here , to excitation system) and such an auxiliary device termed as power system stabilizer (PSS). Now, the observer concluded that in order to maintain system stability the tasks not complete with the installation of PSS only but the proper selection of PSS parameter tuning mechanism is of great importance to achieve the goal of system stabilization as fast as possible. Since, power space is highly non-linear and subjected to different kinds of stress. Whereas, the conventional PSS designed based on linearized model therefore it is difficult to stabilize efficiency in power space with such limitations. Different kind of PSSs has proposed on the basis of Artificial Intelligence (AI) techniques to solve the problem of stabilization in power space more effectively than conventional approach. The different types of AI are Fuzzy logic, Artificial Neural Network (ANN), Genetic Algorithm (GA) etc. At late 1980's PID power system stabilizer were also proposed and it proves to be effective for wide range of loading conditions than conventional one relatively, but as not robust as AI based PSSs. The schematic diagram represents the effect on suppression of T-wave channelization in power space for different PSSs controllers are shown in fig. (2).

3. Concept of Fuzzy Logic

The "Law of Excluded Middle" states that, X must either be in set A or in set not-A. That means there are two categories A and not- A, which contain the entire universe given by Aristotle may considered as father of classical set theory. According to Aristotle, any given element of the universe may fall in to either one group or to the other (i.e. elements of same categories have unique set of solution). Which gives the concept of classical set theory with crisp boundary. Thus a classical set is a container that wholly include or exclude any given element. In space of classical set, there are infinitely unique sets possible each of specific elements.

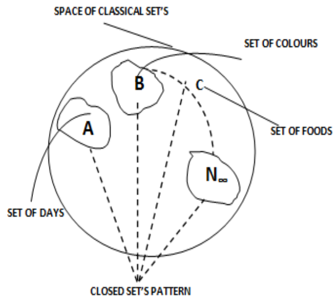


Fig. 3: Space of Classical set's.

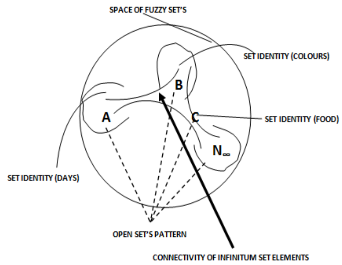


Fig. 4: Space of Fuzzy set's.

Also, these infinitely unique sets are closed in nature wise as defined earlier that classical sets have crisp boundary. The schematic diagram of the space of classical set is given in fig. (3). From the given figure, one can consider that set A represent the set of days only similarly, Set B represent the set of colours , set C represent the set of foods and so on. Thus, each set represent the collection of elements of similar types (i.e. elements similarity formalism). For instance, consider a classical set A of birds from the universe of discourse such as, parrot, peacock, sparrow etc. all of these elements are the members of set A ,while all other remaining elements are not members of set A. In other words each set represent the collection of elements of same alike. "Space of classical sets based on the criterion of Elements Similarity".

But, In 1965 Lofty A. Zadeh introduces the concept of 'Fuzzy set' on the basis of membership functions. According to Lofty Zadeh, "as complexity rises, precise statements lose meaning and meaningful statements lose precision". One can say that, fuzzy logic is based on the everyday natural language of ordinary people. The truthness of any statement from the fuzzy point of view becomes a matter of degree, while from the classical point of view the statement may be completely accepted or denied.

In space of fuzzy set's, there are infinitely different sets possible each with certain specific elements which characterize the identity of that set having higher degree, in addition with all other elements of the universe whose value decreases down to zero as member of that set . Thus, these infinitely different sets with certain elements dominancy in terms of the value that elements owe to characterize the identity for each of these are open in nature wise as defined earlier that classical sets have crisp boundary. The schematic diagram of the space of fuzzy set is given below in fig (4). From the given figure, one can consider that, in space of fuzzy set's, set A not only represent the set of days but it also involves the all other elements of different sets with certain degree. Similarly with set B, set C so on. That means, each of the set contain the elements of all other different sets with the certain degree. . For instance, consider a fuzzy set A of birds from the universe of discourse such as, parrot, peacock, sparrow etc. all of these elements determine the identity of set and holds the membership of set A, while all other remaining elements such as reptiles family, water animals, foods etc. are also open to be the members of set A but with certain degree of matter. The elements which are absolutely odd to set A holds the zero value of membership to set A. While those elements which are absolutely even to set A holds the highest membership (i.e. unity). Whereas, all other remaining elements holds the membership of set A in between (0, 1). "Space of Fuzzy sets based on the criterion of Elements with Degree of Membership". Thus, Space of classical sets based on the criterion of Elements Similarity, while Space of Fuzzy sets based on the criterion of Elements with Degree of Membership, for all possible statements of universe.

4. Simulink Implementation

In this section the Generalise Simulink diagram of SMIB system with-out PSS, with PSS, with PID PSS and with Fuzzy PSS have proposed shown below in fig. (5). and also the output response of system for each of the different controllers are shown fig. (6) & (7).

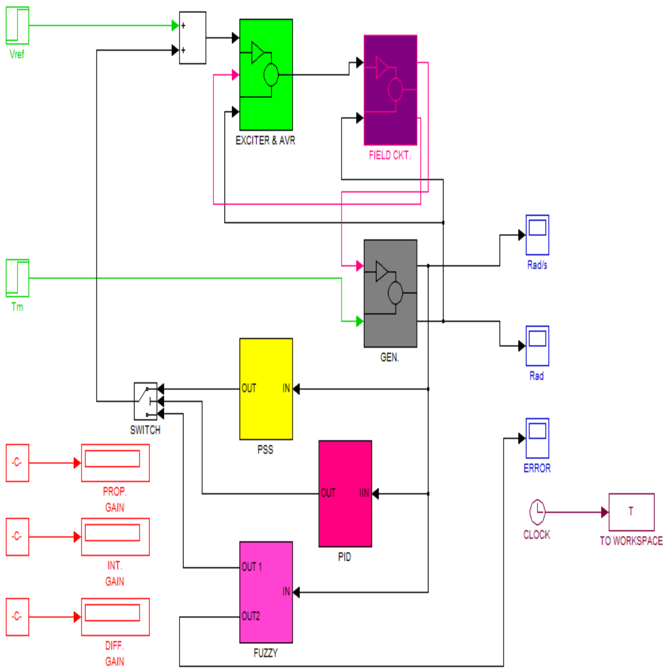
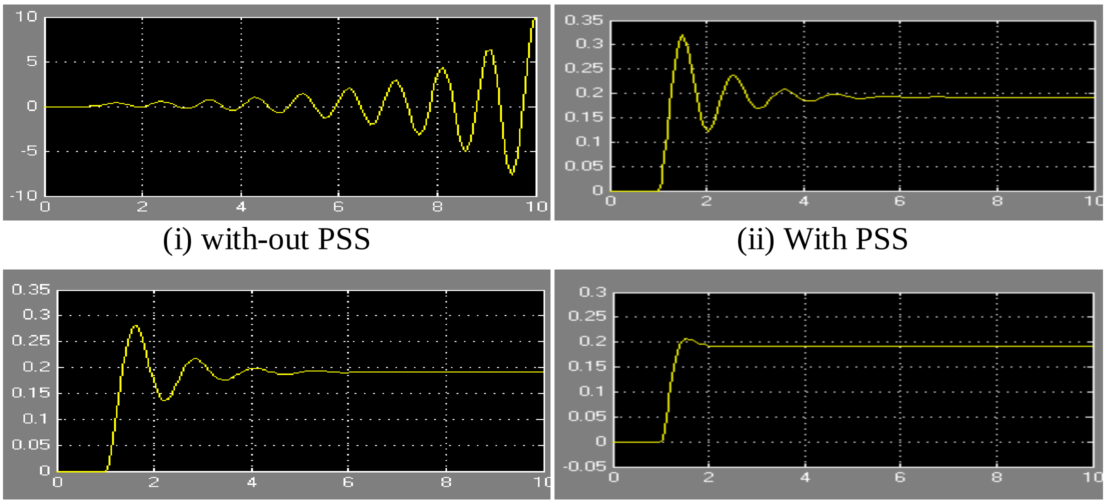


Fig. 5: Generalised Simulink diagram of SMIB system.

5. Conclusion

On the basis of MATLAB/SIMULINK model of single machine infinite bus system with different controllers, the simulation graphs obtained for two different case help to acknowledge the relative stability advancement of system for the given sets of parameters with different controllers. The output response of system obtained by using different controllers are characterized in to two parts, depend upon the external network impedance and generator output. For low value of it, the constant K_5 is negative and K_5 is positive for the high value of it. On this occasion the AVR introduce a negative synchronizing and positive damping torque component, for +ve K_5 constant.

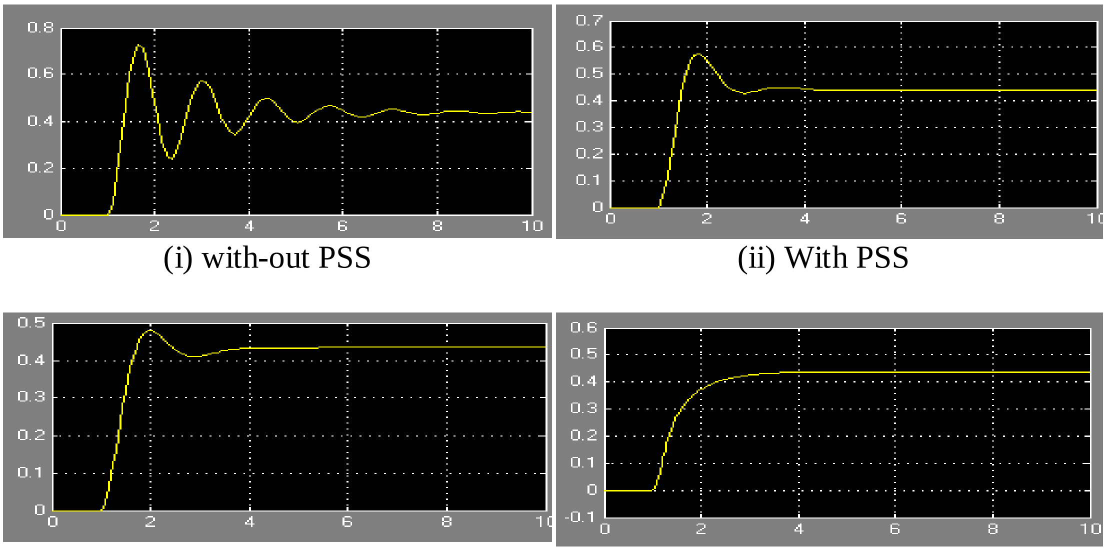
Whereas, it introduces positive synchronizing and negative damping torque component for –ve K_5 constant. However, the generator model proposed here with the negligible amortisseurs effect. The output response of system with CPSS shows comparatively more ripple and oscillation then PID-PSS before reaching the steady state point for –ve K_5 constant, while FLPSS show more excellent response. Whereas, for +ve K_5 constant the ripple is less and it disappears up to FLPSS turns. Thus, CPSS; PIDPSS and FLPSS will cause and improve the stability performances of power system as the power oscillations are effectively damped-out but from the stability advancement point of view on account of small oscillations, FLPSS should be preferred over PID-PSS after CPSS.



(i) with-out PSS (ii) With PSS

(iii) with PID-PSS (IV) With FLPSS

Fig. 6: Angular displacement response of system for –ve K_5 under different conditions.



(i) with-out PSS (ii) With PSS

(iii) with PID-PSS (IV) With FLPSS

Fig. 7: Angular displacement response of system for +ve K_5 under different conditions.

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