CHAPTER 2

SYSTEM SOLUTION: PREVAILING TECHNIQUES

Describes the survey of current trend in design of PSS for single and multi-machine systems using classical methods. MATLAB & Code Composer Studio is used for testing the design with various set of parameters.

2.1 Introduction

The need to understand the various stability improvement techniques for power system stabilizer is an important process which motivates the researcher to improve design and performance of conventional power system stabilizers. The study of mathematical model and simulation model for power system stabilizer is done by researchers.E.V.Larsen and D.A.Swann [1] at all discussed the basic concept of applying power system stabilizer. Any one from these three input shaft speed, A.C. bus frequency and electrical power can be applied to PSS. Analysis shows that PSS with speed as an input, performance will decrease as the system become weaker. With frequency as an input, system is less sensitive to oscillations with single unit and more sensitive between areas for the same. With power as an input, system is less sensitive to high frequency noise and more sensitive to low frequency phenomena. Michael J. Basler and Richard C. Schaefer [2] have described the basic concept and need of PSS for improvement power system stability. Here, the various types of instability are discussed and the effect of synchronizing and damping torque is analyzed. For improvement of stability of hydro turbine Generator, the single and double input PSS is used. The conclusion is that the single input PSS produce large amount of noise and give poor damping compared to dual input PSS, which provide more effective damping and less noise in the stabilizing signal.Instability is normally through oscillations of increasing amplitude. The instability occurs that can be of two forms [2].

1) Steady increase in rotor angle due to lack of sufficient synchronizing torque.

2) Rotor oscillations of increasing amplitude due to lack of sufficient damping torque.

There are three types of Oscillations that are produced due to occurrence of any disturbances in power system. The disturbances occurring in power system include electromechanical oscillations of electrical generators. These oscillations are also called power swings and these must be effectively damped to maintain the system stability. Electromechanical oscillations can be classified in four main categories [2].

1**). Local oscillations**: - These types of oscillations occur between a unit and rest of generating station and between the later and rest of power system. Their frequency typically ranges from 0.2 Hz to 2.5 Hz.

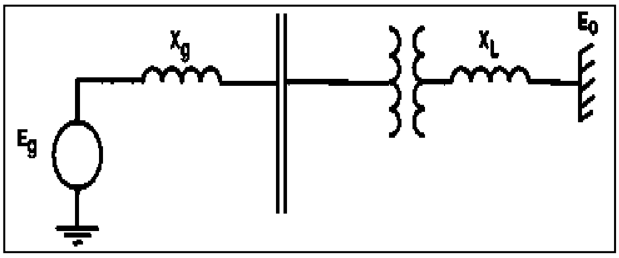

Fig. 2.1 Local oscillations

2). I**nterplant oscillations**: - These types of oscillations occur between two electrically close generating plants having frequency can ranges from 1 Hz to 2 Hz.

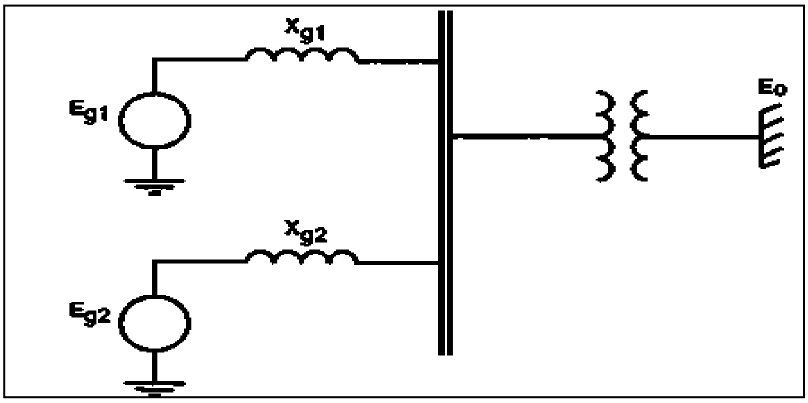

Fig. 2.2Interplant oscillations

3). **Interarea oscillations**: - These types of oscillations occur between two major groups of generating plants. The frequency in the range of 0.2 Hz to 0.8 Hz. it is also generally called low frequency oscillations.

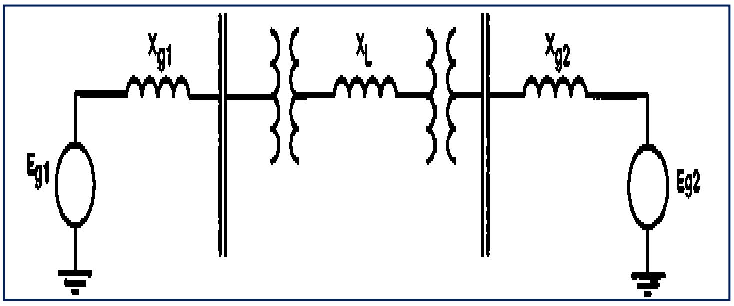

Fig. 2.3Inter area oscillations

But Classical control of power system stabilization gives poor performance under heavy loading condition. These problems can be overcome by using different control techniques like intelligent control, Smart control and Adaptive control

2.2 Review of complex control methods

During the last two decades, the control theory has experienced a rapid expansion as a result of the challenges of the stringent requirements posed by modern systems, such as flight vehicles, weapon control systems, robots, chemical processes and the availability of low-cost computing power. The control system analysis and design can be divided into the three areas [3].

2.2.1 Classical control

It is generally characterized by frequency domain methods like Routh-Hurwitz, Root Locus, Nyquist, Bode, Nichols etc. The central concept of frequency-domain approach is that of transfer function. This approach is appropriate for linear time-invariant systems, especially for Single Input, Single Output (SISO) control systems where the graphical techniques are very efficient [4].It overcomes the difficulties, by handling nonlinear & multivariable control configurations with the help of state-space methods. Gh. shahgholian and M. Arezomand [5] at all discussed the study of dynamic behavior and stability of SMIB system. The analysis of linear zed model of synchronous generator has been carried out using MATLAB Simulink. The SMIB system response and Eigen value analysis with PSS & AVR for different value of time constant and stabilizer gain has obtained. The result shows that to maintain the system stable, the value of T_w must be kept high. The variation in K_p affects the all-time response parameters, but not affects the final value of the generator speed to reach in steady state.M.J.shawon and Mohammad H. shawon [6] have presented comparative analysis of different excitation system with and without PSS. The work is carried out with single and double input PSS considering different loading condition. During light loading condition, variation of active power and terminal voltage is less, but with increment of the loading, severe fluctuation has been observed. The result is that with double input static excitation PSS has less settling time and overshoot compared to D.C, A.C excitation system with single input PSS.

J. Faiz, Gh.shahgholian and M. arezoomand [7] have analyzed the block diagram of AVR system with stabilizer and simulation of system for different value of stabilizing gain(Ks) and time constant(Ts) is done. The performance of system without compensation, with stabilizer and with PID controller is compared. Analysis shows that with higher value of Ks and lower value of Ts, overshoot and settling time is less and with increase in Ks , both rise time and peak time decreases. The basic requirement of any control system is that it should be stable. In case of modern control methods accurate model of the plant is required to satisfy this requirement. In real world it is generally difficult to accurately represent a complex process by a mathematical model. In such models, the degree of mathematical precision required to completely describe every aspect of the process, is either prohibitive or non-trivial. Also, if the values of the parameters of the process models are partially known, ambiguous, or vague, the control algorithm based on such incomplete information, will not usually give satisfactory results [8]. Dependence on the accurate model brings some difficulties of modern control theory which motivates a new trend of research, so-called robust methods, which allows including uncertainty of the mathematical model into formulation of the problem [9].

2.2.2 Intelligent control

It is a control method that tries to mimic human decisions making, planning control strategies, and learning new functions whenever the environment does not allow or does not justify the presence of a human operator [10]. Fuzzy control systems, machine learning, fuzzy computation, evolutionary computation and genetic algorithms which uses various AI (artificial intelligent) computing approaches also come into the category of intelligent control. Variable Structure Controller or PID controller whose parameters are being tuned with fuzzy also comes into the category of intelligent controller. [11]

R. Ramya and Dr.k.selvi [12] have presented a fuzzy logic PSS design to overcome the drawback of CPSS. Here mamdani method is used for fuzzification and centroid method is used for defuzzification. The system is subjected to three phase to ground fault shown by simulation. The comparison of output active power for system with CPSS, FPSS and without PSS has been done. The conclusion is that The FLPSS provide less settling time and thus the system become quickly stable than CPSS.D.K.Sambariya and Rajendra [13] Prasad proposed a FLPSS design with different membership functions for SMIB system. Here, triangular, trapezoidal, Gaussian, sigmoid and polynomial types MF are used. The responses of CPSS, without PSS and FPSS with diff MF have been compared. The analysis shows that design of FPSS with Gaussian MF gives best performance compared to other and provides good damping and improves the dynamics over wide range of operating condition.N.S. Khalid and M.W. Mustafa [14] at all discussed the use of takagisugenofuzzy logic for PSS design. The performance has analyzed for two different defuzzication methods. The takagisugeno fuzzy logic PSS is more efficient and compact than Mamdani’s method. If the dynamics are highly nonlinear, trial-and-error procedure is used in defining the rules. The analysis shows that FPSS with weighted sum defuzzication method produce very less overshoot and become stable compared to FPSS with weighted average method and CPSS.

2.2.3 Smart Control

The concept of smart control was first introduced nearly two decades ago by Saridis. Despite its significance and applicability to various processes, the control community has not paid substantial attention to such an approach [15]. In recent years, smart control has emerged as one of the most active and fruitful areas of research and development (R & D) within the spectrum of engineering disciplines with a variety of industrial applications.

Almost all information-processing needs of today are met by digital computers [16]. So we can consider their possibility of information processing techniques that are different from those used in conventional digital computers. Neural networks are constructed with neurons that connected to each other [17]. There are many types of neural networks for various applications in the literature. A common used one of these is multilayered perceptron (MLP) [18].

Dr. Jagdish Kumar and P. Pavan Kumar [19] have described a design of power system stabilizer based on ANN. The parameters of PSS are tuned by ANN. Two inputs active and reactive power are given to ANN. Here, feed forward neural network is used and trained by back propagation algorithm. Analysis shows that CPSS with fixed parameter settings can only provide good damping under some particular operating condition. But, the parameters are updated in real time by ANN, thus ANN- PSS provide good dynamic performance over a wide range of operating time and it take very less time to make the system stable. A.K.Ahouli and T. Guesmi[20] have proposed the design of GA based PSS for improving both transient stability and voltage regulation. Here, optimization problem is to minimize the power system oscillations after a disturbance and error is defined by speed deviation. GA works with coding of the parameters to be optimized. It employs search procedure for selection and finds the fittest solution to reach to the global optimum solution. The stability of the SMIB system has been examined for different control techniques [21]. Analysis shows that with constant field E_{fd}damping level is very poor, with AVR the system loss synchronism in third swing. With PSS, system takes more time to become stable. And GA optimized PSS controller has good damping and system very quickly become stable [35].

Artificial neural networks emulate the learning process of biologic neural networks, so that the network can learn different patterns using a training method, supervised or unsupervised [22]. ANFIS uses a hybrid learning algorithm to identify the membership function parameters of single-output, Sugeno type fuzzy inference systems (FIS). A combination of least-squares and back-propagation gradient descent methods are used for training FIS membership function parameters to model a given set of input/output data.This is the major training routine for Sugeno-type fuzzy inference systems [23] [36].

2.2.4 Adaptive control

Adaptive control can improve the performance of a robust control design by providing better information about the nominal model and expanding the uncertainty region for which the desired performances can be guaranteed [24].P.R.Gandhi and S.K.Joshi [25] have proposed the design of GA based PID-PSS and ANFIS- PSS for the improvement of system stability. Two different operating conditions are taken for analysis of response of rotor angle and rotor speed. Nonlinear analysis shows that system become quickly stable using ANFIS- PSS compared to GA- PSS and time response parameters are also improved by using ANFIS-PSS.N.A.Mohamedkamari and I. Musirin [26] et al discussed the different optimization techniques for tuning PSS. Three methods EP, PSO and IPSO are used for optimizing the parameters Tw, T1 and T3 of PSS.EP use biological evaluation process to achieve optimal solution. PSO technique is based on behavior of fish schooling and bird flocking. The speed response of system with different control technique is compared. The analysis shows that Iteration-PSO(IPSO) technique give better optimal solution and faster computational time and lead to better tuning of lead lag PSS controller compared to EP-PSS, CPSS and PSO-PSS.

F.Mayouf and F.Djahli [27] have proposed the design of Genetic-Fuzzy controller for improving stability of generator for SMIB system. Here, for design of FLC, universe of discourse [-1, 1] is chosen and mamdani method is used for fuzzification. The scaling factor of fuzzy controller is optimized by GA. The result shows that the system oscillations are quickly damped using genetic fuzzy stabilizer (GFEG) compared to other methods [34].

An adaptive control system measures a certain performance index (IP) of the control system using the inputs, the states, the outputs and the known disturbances. From the comparison of the measured performance index and a set of given ones, the adaptation mechanism modifies the parameters of the adjustable controller and/or generates an auxiliary control in order to maintain the performance index of the control system close to the set of given ones [28] (i.e., within the set of acceptable ones).

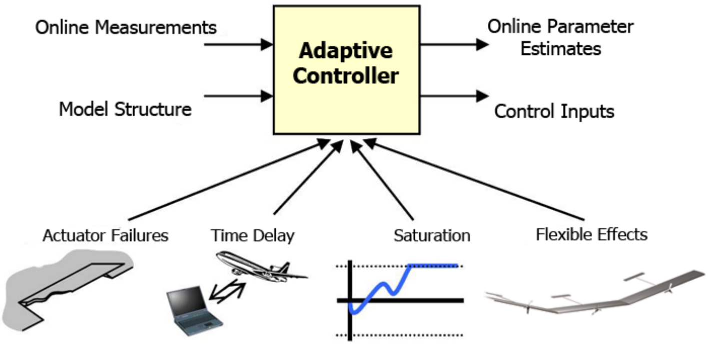

Fig. 2.4 Adaptive control

Note that the control system under consideration is an adjustable dynamic system in the sense that its performance can be adjusted by modifying the parameters of the controller or the control signal. The above definition can be extended straightforwardly for "adaptive systems" in general [29] (Landau 1979).Haseena K. A. and Ancy Sara Varghese's [30] have design of different controller for improvement of system stability. The analysis is carried out for SMIB system. The results are compared with Conventional PSS, pole placement PSS and Robust PSS with step changes in reference voltage for three different operating points (3). The result shows that RPSS design using H∞ controller gives more robust and reliable performance compared to CPSS and FPSS.A conventional feedback control system will monitor the controlled variables under the effect of disturbances acting on them, but its performance will vary. Evolutionary methods are based on evolutionary process such as natural evolution [31]. Adaptive control systems have been investigated for over four decades. Since the beginning, for the sake of mathematical tractability, adaptive control theorists confined their attention to time invariant systems with unknown parameters. The accepted philosophy was that is an adaptive system was fast and accurate when the plant parameters were constant but unknown, they would also prove satisfactory when the parameter varied with time, provided the latter occurred on a relatively slower time scale. Based on these general principles, adaptive control was extensively studied and numerous globally stable and robust adaptive control algorithms were derived [32]. Extensive computer simulations of adaptive control algorithms have revealed that when there is large error in the initial parameter estimated, the tracking error is quite often oscillatory with unacceptably large amplitudes during the transient phase. In the highly, competitive industrial world, new classes of problem are arising where such variations in parameter are quite common. It was to cope with such situations that the new approach of control is required [33].

2.3 Discovering of control problem

2.3.1 Complex control problem

Renuka T.K and shobhaManakkal [37] have analyzed the model of excitation system with AVR and PSS for SMIB system. The system is subjected to 5% step change in mechanical input. The FPSS design is applied to mathematical model of a synchronous machine. The response of speed deviation has observed for four different operating conditions. The analysis shows that TFPSS has less overshoot and settling time compared to CPSS and it take only 3 sec to reach in steady state for all operating condition, but CPSS take 8 sec to reach the same. The action of a PSS is to extend the angular stability limits of a power system by providing supplemental damping to the oscillation of synchronous machine rotors through the generator excitation. This damping is provided by an electric torque applied to the rotor that is in phase with the speed variation. Once the oscillations are damped, the thermal limit of the tie-lines in the system may then be approached. This supplementary control is very beneficial during line outages and large power transfers [38, 39]. However, power system instabilities can arise in certain circumstances due to negative damping effects of the PSS on the rotor.

The reason for this is that PSSs are tuned around a steady-state operating point; their damping effect is only valid for small excursions around this operating point. During severe disturbances, a PSS may actually cause the generator under its control to lose synchronism in an attempt to control its excitation field [40].

(3) Paper entitled, "Comparison of Different Design Methods for power System Stabilizer Design - A Review", International Journal for Scientific Research & Development, ISSN (online): 2321-0613, Vol. 2, Issue 08, 2014.

2.3.2 General Problems with Intelligent Controller

The Performance of classical control and intelligent control systems between the transient strategiesusually not reliable [40]. This problem may be avoided by using a hybrid control scheme, which combines an intelligent controller with a conventional controller. In fact, in most cases, there are no pure neural or fuzzy solutions, but rather hybrid solutions when intelligent control is used to augment conventional control. The lack of satisfactory formal techniques for studying the stability of intelligent control systems is a major drawback.W. J. Chang, C. C. Ku [41] at el discussed that a passive affine fuzzy controller design method for a Single Machine Infinite Bus Power (SMIBP) system with external disturbances. In order to approximate the trajectories of the SMIBP system accurately, the affine Takagi-Sugeno (T-S) fuzzy model is employed to analyse the stability of the system. For resisting the perturbation from the load side or environment, the passivity theory can be employed to attenuate the external disturbance and to achieve system stability. To overcome the problems of controller, simulation results are provided to show that the proposed fuzzy controller can achieve the strict input passivity and Lyapunov stability for the SMIBP system [41].

2.3.3 Structuring of control problem

Decomposing the overall control problem: Decomposition is a general approach to solving a problem by breaking it up into smaller ones and solving each of the smaller ones separately, either in parallel or sequentially [42]. (When it is done sequentially, the advantage comes from the fact that problem complexity grows more than linearly.) The overall control problem is decomposed into a hierarchical structure of elementary and compound control problems. For each elementary or compound control problem a clear specification of the control objective in terms of the control variable is given. Such a specification indicates, how the controller should respond to disturbance [43].

Defining control problems: For each elementary control problem a model of the plant should be derived that is used, together with the objective specification, to design a control algorithm. Because of the controlled variable cannot always be measured or directly controlled, candidate measured and controlled variable should be chosen that have a close relationship to the controlled variable as shown in Fig 2.5.

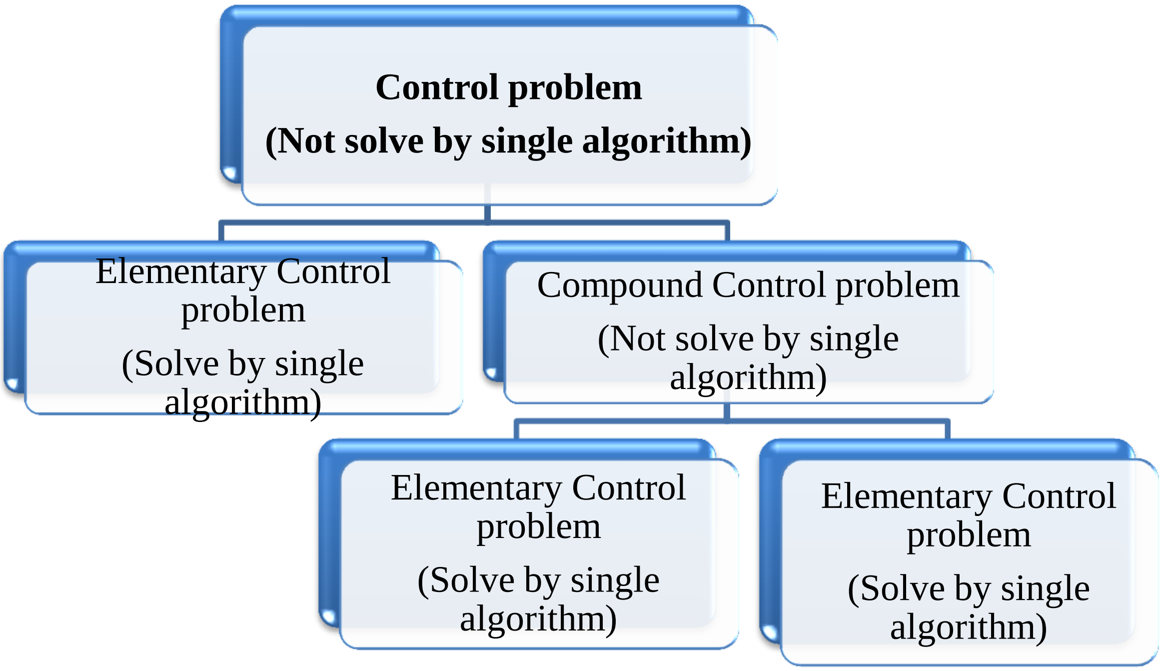

Fig. 2.5Classification of various control problems

The definition of a complex control problem starts with the observation that there are basically two kinds of control problem. The first kind of control problems are those that can be solved as a whole. For instance, if a control problem has been solved before, then any new problem that is similar in nature to this problem can be solved by an identical solution. Solving the control problem requires some tuning or re-calculation of control system parameters; the structure of the control problem needs not to be determined. The second kinds of control problems are those that need to be divided into a set of partial control problems in order to solve them. A partial control problem can either be an elementary or a compound control problem [44].

2.3.4 Structuring a control problem for power system stabilization

For the structuring of the control problem the design of the controller requires for the power system stabilization to damp out oscillations by providing supplementary signal in the excitation system, it seen as a compound control problem. It consists of the partial control problem. Power systems, in general, have non-linear characteristics and their parameters depend upon the operating conditions. For the PSS to continue to provide optimal or near optimal performance as operating conditions change, it is desirable to track the changes in the system parameters on-line and determine control most appropriate for the currentoperatingconditions [45]. An adaptive controller can provide excellent performance and improve the dynamic performance of the plant by allowing the Parameters of the controller to adjust on-line in realties the operating conditions and/or system parameters change [46]. A number of examples of the development and successful implementation of adaptive PSSs based on analytical and artificial intelligence techniques, that are capable of being employed in the power systems, are described[47].

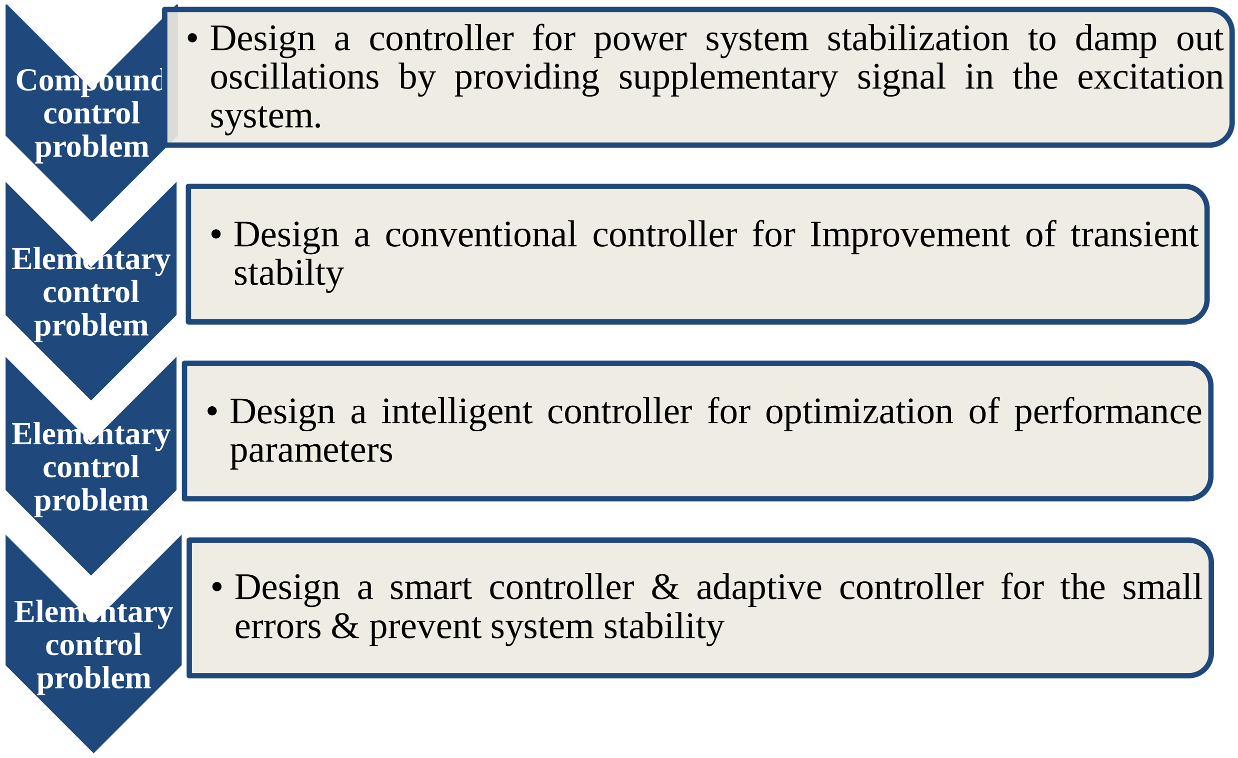

Fig. 2.6 Structuring of soft computing for power system stabilization

2.3.5 Development of the structure for the multiple model adaptive controllers

Fig 2.7 shows the Design of robust multiple model adaptive controllers which identify the performance of control strategy. While developing an elementary control problem, it should respond for the different loading condition of the power system stabilization [47] [48]. So that selects a control algorithm in such a way that able to operate with the present loading condition with the help of compound control problem. Also the elementary control problem can also be one that selects the performance parameters for the different loading condition and another used to identify the best control on the performance parameters.

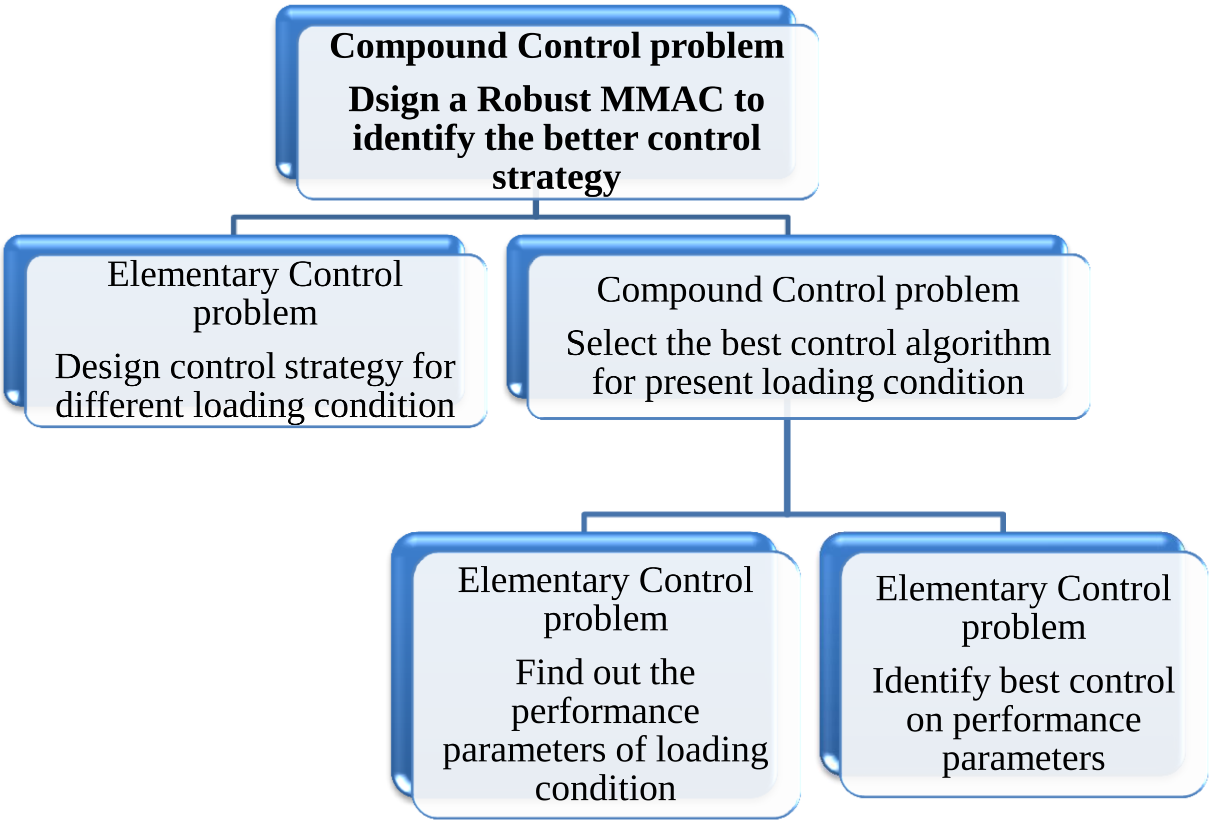

Fig. 2.7Development a Structure of robust MMAC for power system stabilization

2.4 Concluding Remarks

Because elementary control problems can generally is solved using the design methods known from the control systems, this concept is given no special attention hereafter? Rather, a design of controller has to operate with the different operating conditions. Considering the nature of the system the fuzzy decision will select the appropriate controller so that the controller will able to operate for the single machine and multimachine system also.