ON SOME ASPECTS OF AUTOMATIC GENERATION CONTROL OF INTERCONNECTED THERMAL AND HYDRO-THERMAL POWER SYSTEMS

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CERTIFICATE

It is certified that the thesis entitled, 'ON SOME ASPECTS OF AUTOMATIC GENERATION CONTROL OF INTERCONNECTED THERMAL AND HYDRO-THERMAL POWER SYSTEMS', by Shri Debapriya Das, has been carried out under our guidance at the Indian Institute of Technology, New Delhi and that this research work has not been submitted elsewhere for the award of any other degree or diploma.

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ABSTRACT

In this thesis a comprehensive analysis of discrete-mode automatic generation control (AGC) of a two-area reheat thermal and hydrothermal systems considering AGC strategies based on conventional area control error (ACE) and new area control error (ACEN) has been presented.

Chapter-1 introduces the AGC problem of interconnected power systems in general and presents a critical survey of the past work in this field of AGC. It clearly lays down the objectives and motivations of the research pursued in the thesis.

Chapter-2 presents a systematic method of obtaining discrete-time state-space model of a two-equal area reheat thermal system. Optimum value of R in the uncontrolled and unconstrained mode is obtained using the concept of maximum degree of stability by analyzing eigenvalues of the system. Investigations reveal that the degree of stability is maximum for speed regulation parameter R = 10.0 Hz/pu MW. The variation in the degree of stability in the range $2 \leq R \leq 10$, however, is quite small. A comprehensive approach using ISE technique has been suggested for obtaining optimum value of speed regulation parameter R in the presence of generation rate constraint (GRC) considering conventional integral and proportional integral controllers. Studies reveal that the dynamic responses for a wide range of R (i.e. $2 \leq R \leq 10$) hardly differ from one another for all practical purposes. Investigations show that there is nothing sacrosanct to use a low value of R (such as R = 2.40 Hz/pu mw) as is usually the practice and that higher values of R

can well be preferred so long as there is little sacrifice in the dynamic responses since higher values of R are envisaged to lead to simpler and cheaper realization of the governor. Investigations also show that the P-I controllers provide better dynamic responses than integral controllers. Moreover, an optimum P-I controller can permit relatively a higher value of R than an optimum integral controller for the governor design.

Chapter - 3 deals with discrete-mode automatic generation control of an interconnected reheat thermal system considering a new area control error (ACEN) based on tie-power deviation, frequency deviation, time error and inadvertent interchange. Optimum integral and proportional integral controllers using the concept of stability margin and ISE technique have been obtained with conventional ACE and ACEN. Dynamic performances of the system for a step load perturbation with optimum controllers based on ACE and ACEN are obtained and compared. Investigations reveal that the controller based on ACEN always guarantees zero steady state time error and inadvertent interchange unlike in the case of a controller based on conventional ACE. The settling time for tie-power and frequency deviations following step load perturbation is however, somewhat more with the controller based on ACEN as compared to the controller based on ACE.

Chapter - 4 presents investigations pertaining to discrete-mode AGC of an interconnected reheat thermal system with control strategy based on new area control error (ACEN) considering a realistic value of generation rate constraint. The optimum value of (inadvertent interchange bias setting) and optimum gain settings for integral and P-I controllers have been obtained using ISE technique in the presence of GRC. A detailed sensitivity analysis is carried out in order to understand the effect of wide variation of important system parameters such as inertia constant (H), steam chest time constant (T_t), reheat time constant (T_r), reheat coefficient (K_r), nominal phase angle of voltage (δ_{12}), speed regulation parameter (R) and the base load condition (P_D) on optimum gain settings and dynamic performance in the presence of GRC. Investigations reveal that the optimum value of α is not affected by GRC. Although the optimum K_I decreases slightly,the dynamic responses deteriorate considerably in the presence of GRC. Studies show that while the unconstrained optimum value of K_I is acceptable in the constrained mode, the unconstrained optimum P-I gain settings are not acceptable in the presence of GRC.

Studies also reveal that P-I controllers based on ACEN provide better dynamic performance than integral controllers. Detailed sensitivity analysis reveals that the nominal optimum P-I controller setting for AGC based on ACEN in the presence of realistic generation rate constraint is quite robust and need not be reset following a substantial change in H, T_t, K_r, T_r, R, δ_{12} and P_D from their nominal values.

Chapter - 5 deals with AGC of a two-area hydro-thermal system in discrete-mode considering AGC strategy based on new area control error (ACEN). Discrete-time state space model of the system has been developed considering reheat type steam turbine in area-I and hydroturbine in area-II. The optimum values of inadvertent interchange bias settings (α_1, α_2), integral and proportional-integral (P-I) gain settings have been obtained using the integral squared error (ISE) technique with and without generation rate constraints (GRCs).

Investigations reveal that the optimum values of inadvertent interchange bias settings for both the area are not affected by the presence of GRCs. Further, investigations reveal that the controllers based on the new area control error should be preferred over those using the conventional area control error as these provide the much required zero steady-state time error and inadvertent interchange accumulations along with acceptable dynamic responses irrespective of whether the perturbation is in the thermal area or in the hydro area. Studies also show that P-I controllers provide superior dynamic responses both with and without GRCs as compared to those with simple integral controllers.

Detailed investigations reveal that in the discrete-mode of AGC of a two-area hydrothermal system for all practical purposes the optimum integral and proportional-integral controllers in the unconstrained-mode (neglecting GRCs) are acceptable even for the constrained-mode (considering GRCs). Thus for obtaining more or less optimum integral and P-I gains in the discrete-mode of AGC, the GRCs can be neglected from the mathematical model.

Chapter - 6 deals with the analysis of AGC of a two-area reheat thermal system considering variable structure controllers (VSCs) operating in sliding mode. A systematic method is suggested for obtaining switching hyperplanes. Optimum gain settings of VSC are obtained both in the unconstrained (neglecting GRC) and constrained (considering GRC) modes using ISE technique. Dynamic performance of the system obtained with optimum VSC strategy is compared with that obtained considering optimum conventional integral control strategy with and without GRC. Investigations reveal that there is significant improvement in system dynamic performance with VSC than with integral controller. A detailed sensitivity analysis in the presence of GRC is carried out considering wide variation of significant system parameters with VSC and compared with the sensitivity analysis results obtained with conventional integral controller. It is seen that the variable structure controller is found to be quite insensitive to wide variation of system parameters.

Chapter - 7 brings out the significant conclusions of the entire work and the scope for further research.

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