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A literature survey on load–frequency control for conventional and distribution generation power systems

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ABSTRACT

In this paper an extensive literature review on load–frequency control (LFC) problem in power system has been highlighted. The various configuration of power system models and control techniques/strategies that concerns to LFC issues have been addressed in conventional as well as distribution generation-based power systems. Further, investigations on LFC challenges incorporating storage devices BESS/SMES, FACTS devices, wind–diesel and PV systems etc have been discussed too.

Contents

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1. Introduction

Load–frequency control (LFC) is of importance in electric power system design and operation. The objective of the LFC in an interconnected power system is to maintain the frequency of each area within limits and to keep tie-line power flows within some pre-specified tolerances by adjusting the MW outputs of the generators so as to accommodate fluctuating load demands. A well designed and operated power system must cope with changes in the load and with system disturbances, and it should provide acceptable high level of power quality while maintaining both voltage and frequency within tolerance limits.

Subjected to any disturbance, the nominal operating point of a power system changes from its pre-specified value. As a result the deviation occurs about the operating point such as nominal system frequency, scheduled power exchange to the other areas which is undesirable.

The LFC issues have been tackled with by the various researchers in different time through AGC regulator, excitation controller design and control performance with respect to parameter variation/uncertainties and different load characteristics. As the configuration of the modern power system is complex, the oscillation incurred subjected to any disturbance may spread to wide areas leading to system black out. In this context, advance control methodology such as optimal control, variable structure control, adaptive control, self-tuning control, robust and intelligent control were applied in LFC problem.

The further research in this area has been carried out by use of various soft computing techniques such as artificial neural network (ANN), fuzzy logic and fusion of these such as neuro-fuzzy, neuro-genetic etc. to tackle the difficulties in the design due to non-linearity in various segregated components of the controller. The controller parameters plays a vital role for its performance, thus it should be tuned properly with suitable optimization techniques. In this context, the application of genetic algorithm (GA), particle swarm optimization (PSO), simulated annealing (SA) etc. is exploited to address the optimization objective. Due to non-linearity in the power system components and also the uncertainty in the system parameters, the performance differs from actual models, so robust control design is indispensible to achieve acceptable deviation in frequency about the nominal operating point. Various robust control techniques such as Riccati equation, H_∞, μ-synthesis, robust pole assignment, loop shaping, linear matrix inequality (LMI) has been adopted to tackle the LFC problems.

Now, there is rapid momentum in the progress of the research to tackle the LFC in the deregulated environment, LFC with communication delay, and LFC with new energy systems, FACTS devices, and HVDC links as well.

This survey paper comprehensively highlights the LFC problems in conventional and distribution generation based power system. A comprehensive review on conventional power system as single area, multi-area with interconnection, the power system with HVDC links and control problem in the deregulation environment is presented. Further LFC issues in renewable energy systems and its integration with the grid is also discussed. In addition to this, the recent trends in LFC such as communication delays, wide area monitoring, phase measurement unit and penetration of different renewable energy sources impact on the LFC is also discussed. The layout for survey carried out on LFC is shown in Fig. 1.

2. Type of power system models

The conventional power system that has been in use since centuries from the generation and transmission level to the distribution was mainly dominated by hydro, thermal and nuclear

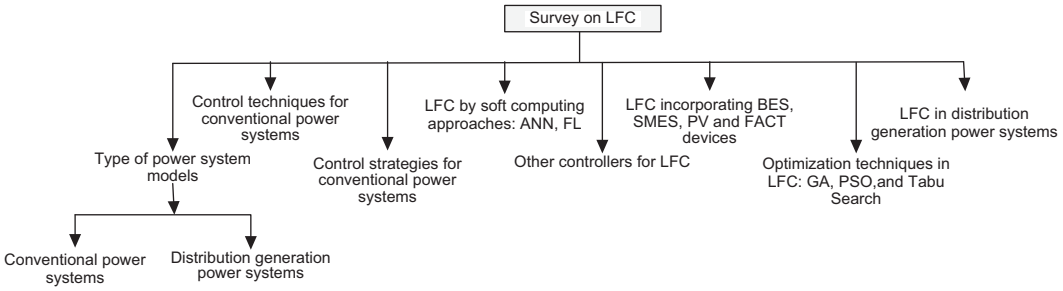

Fig. 1. Illustration of survey on LFC.