Fuzzy Based Model Predictive Load Frequency Control of Multi-Area Power System

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ABSTRACT:

Reliable load frequency control (LFC) is very important for a modern power system with multi-source power generation and has been the primary focus of studies on advanced control theory and applications. This paper proposes a distributed model predictive control (DMPC) scheme for the load frequency control (LFC) problem of the deregulated multi-area interconnected power system with contracted and un-contracted load demands. The traditional LFC of interconnected power system is modified to take into account the effect of bilateral contracts on the dynamics. The MPC is based on a simplified system model of the Nordic power system, and it takes into account limitations on tie-line power flow, generation capacity, and generation rate of change. The participation factors for each generator are optimization variables, and suggestions are made as to how one can ensure tie-line power transfer margins through slack-variables, and pricing information through the objective function. In the proposed scheme, the limit position of the governor valve is modelled by a fuzzy model and the local predictive controllers are incorporated into the non-linear control system. The effectiveness of the proposed non-linear constraint DMPC was demonstrated by simulations.

INTRODUCTION:

A modern power system is a large-scale, geographically dispersed, and complexly interconnected system with distributed generators. The main objectives of the load frequency control (LFC) of such a system are to maintain the system frequency at the scheduled value and ensure zero area control error (ACE), so that the generated power and load on the system remain balanced. Various advanced LFC schemes have been developed over the last few decades, such as modern optimal control theory-based proportional–integral–derivative schemes, full state feedback control strategy, adaptive and variable structure schemes, robust schemes, intelligent schemes, and networked control schemes. Pandey et al. present a literature survey of LFC schemes for both conventional and distribution power systems. Since modern power systems are increasingly growing in size and utilize multiple power sources, traditional centralized controllers are becoming less reliable and more difficult to use for the required computations. The failure of such controllers results in the breakdown of the entire system LFC. Conversely, in a distributed framework, each subsystem is controlled by an independent controller. This also reduces the computational load and affords flexibility of the system structure. However, it is very important when using a distributed control framework to employ an optimal global power system strategy.

With the on-line solution of the optimization problem, DMPC has become an efficient strategy to control many large-scale systems in industry, due to its advantages of managing on-line the tradeoff between disturbance attenuation and control (and/or state) constraints. The DMPC strategy has been applied to power system or smart grid for improving the efficiency of the overall system, nevertheless, few of them consider the deregulated environment which is a significant characteristics of the modern grid. In this paper, we extend the work and apply the DMPC scheme to solve the LFC problem of multi-area interconnected power system in deregulated environments. In our scheme, the overall system is decomposed into several subsystems and an MPC controller is applied to each subsystem to drive the tie- line power and frequency deviations to zero in the presence of load changes, while the interconnection between control areas is considered. The subsystem-based MPCs exchange their measurements and predictions by incorporating this information in their local control objectives. The novel contribution of this paper is the application of DMPC to the LFC of the deregulated power system, considering GRC and load reference set-point constraint, and also conditions of contracted loads and contract violations. Comparisons of response with contracted and un-contracted loads and computational burden have been made between DMPC, centralized MPC (cent-MPC) and decentralized MPC (decent-MPC).

MULTI-AREA POWER SYSTEM AFTER DEREGULATION:

A large-scale power system consists of a number of interconnected control areas which are connected by tie-lines. Each area typically consists of GENCOs and DISCOs. Here, for the sake of clarity, the formulation presented in this section is based on the three-area deregulated power system with two GENCOs and two DISCOs in each area, which is shown as Figure 1. All the symbols of power system used in the paper are provided in NOMENCLATURE. The notation Δ is used to indicate a deviation from steady state.