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Robust PID based power system stabiliser: Design and real-time implementation

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ABSTRACT

This paper addresses a new robust control strategy to synthesis of robust proportional-integral-derivative (PID) based power system stabilisers (PSS). The PID based PSS design problem is reduced to find an optimal gain vector via an H_∞ static output feedback control (H_∞-SOF) technique, and the solution is easily carried out using a developed iterative linear matrix inequalities algorithm. To illustrate the developed approach, a real-time experiment has been performed for a longitudinal four-machine infinite-bus system using the Analog Power System Simulator at the Research Laboratory of the Kyushu Electric Power Company. The results of the proposed control strategy are compared with full-order H_∞ and conventional PSS designs. The robust PSS is shown to maintain the robust performance and minimise the effect of disturbances properly.

1. Introduction

From the view point of control engineering, a power system is a highly nonlinear and large scale multi-input multi-output (MIMO) dynamical system including numerous variables, protection devices, and control loops, with different dynamic responses and characteristics [1]. The *power systems stabilisers* (PSSs) which are widely used for mitigating the effects of low frequency oscillation modes improve the performance and functions of power systems during normal and abnormal operations. The PSSs keep the power system in a secure state and protect it from dangerous phenomena.

Most of continuous control loops such as PSSs operate directly on generator units, and are located at power plants. These controls are usually linear, continuously active, and use local measurements. Recently, several advanced control design approaches based on optimal control, robust control, adaptive control and intelligent control have been developed for power system stabilisation and oscillation damping [2–10]. Despite of the merits of such controls, power system utilities still prefer the simple proportional-integral-derivative (PID) and lag-lead PSS structures.

The parameters of conventional PSSs with simple structures are commonly tuned online based on experiences and trial and error approaches, they are incapable of obtaining good dynamical performance for a variety of disturbances and operating conditions. Complex and high order power system stabilisers are also inapplicable for real-world power systems. On the other hand, the modern and post modern control theory such as H_∞ optimal control cannot be directly applied to the PID based PSS design problem. Indeed, until recently, it was not known how to even determine whether stabilisation of a nominal system was possible using PID controllers [11]. Therefore, an appropriate formulation of PSS in a robust PID control design (such as presented one in this paper) can be considered as a significant contribution.

The PID controller, because of its functional simplicity, is widely used in industrial applications. However, their parameters are often tuned using experiences or trial and error methods. Unfortunately, it has been quite difficult to properly tune of PID gains, because many industrial systems are often burdened with problems such as structure complexity, uncertainties and nonlinearities.

Over the years, many different parameter tuning methods have been presented for PID controllers. A survey up to 2002 is given in Refs. [12,13]. Most of these methods present modifications of the frequency response method introduced by Ziegler and Nichols [14]. Some efforts have also been made to find analytical approaches to tune the parameters [15–17]. Several tuning methodology based on robust and optimal control techniques are introduced to design of PI/PID controllers [18–22].

In parallel with other industries, the PID controllers are commonly used in power systems control and operation. However, because of expanding physical setups, functionality and complexity of power systems, it is very difficult to maintain a desired performance for a wide range of operation using conventionally tuned PID based power system controllers. Although the most of recent addressed approaches introduce high order control structure which have been proposed based on new contributions in modern

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