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Implementation of Proportional-Integral-Observer Techniques for Load Frequency Control of Power System

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Abstract

This paper presents the implementation of Proportional-Integral-Observer(PI-Observer) based state feedback control for Load Frequency of single area isolated power system model. The general application of PI-Observer has been realized in areas of robotic and mechanical system. The PI-Observer is used to estimate both the original states and the unknown inputs generally disturbances, modeling errors or the other non-linearities present in the system. The estimation error of the PI-Observer is gradually reduced by the proportional and integral feedback loop that appreciably improves the observer dynamics. A single area linear power system model is taken as a test case to implement the proposed methodology which is then compared with full state Luenberger observer based state feedback control for load frequency control of power system. MATLAB/SIMULINK is extensively used for modeling & simulation of power system and observer. The dynamic responses are compared and discussed on the basis of error dynamics, system states, peak overshoot and settling time. Lastly it was found that response of PI-observer based state feedback control scheme is quite appreciable as compared to Luenberger observer based state feedback schemes.

Keywords: Load Frequency Control; Luenberger observer; LQR ;PI-Observer systems; state feedback control.

1.Introduction

In the complex structure of geographically distributed and interconnected power system, the generation and load within each area is to be matched and the scheduled power interchange and system frequency should be close to their nominal values for the stable operation of power system. The general idea of controlling the frequency is to maintain the balance between the generated power and the consumed power. Since the existence of alternating current power systems, different philosophies have been applied to maintain the supply frequency. The most common control modes are the Isochronous control, Droop control and Load Frequency Control. In the isochronous control mode, a big

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generator will be assigned the task of maintaining the frequency and the rest of generators will be running at constant power output. Whereas in the droop control mode, all generators will respond to the frequency deviation. However Load Frequency control (LFC) is achieved by adding a supervisory control loop to the droop control loop in order to achieve better performance. The main aim of LFC is to maintain zero steady state frequency deviation and to track the load demands. The Load Frequency controller design with better performance has received considerable attention during the past years and many control strategies have been developed for LFC problem[1]. The expression of PI-Observer was founded by Wojciechowski for control single-input single-output (SISO) systems and later it is used by other to control multivariable systems. The PI-observer and Luenberger observer has the same structure as the extended state observer for disturbance estimations, however the PI-observer has an extra integral feedback loop of estimation error. This loop with proportional feedback loop generate the name of PI-observer and offers additional degrees of freedom for the estimation task in two aspects, first in enhanced robustness of estimations and second in estimations of step disturbance and variation in system parameters. The PI techniques can be estimate the disturbance and unknown effects of system in the form of unknown input of the states. In this paper the development of PI-Observer design and its applications for Load Frequency control for power system is explored and discussed.

2.General design of observer

In practice all the states of the system cannot be measured due to number of reasons including cost or that state may not be physically measurable therefore a method for reconstructing system states by using measured inputs and outputs of the system is the design basis of observer technique which is first proposed and developed by Luenberger in the early sixties of the last century[2]. Later PI observer has been introduced to improve the robustness of estimation against the both known and unknown input effecting to the system, the so-called Unknown Input Observer (UIO). In this design, the disturbances can be considered as unknown inputs. Several paper concentrate on state estimation with unknown inputs . The observer technique has been continuously developing upgrading and different directions of observer design are improved, for example optimal observer design and nonlinear observer design on the basis of different structure of observers for different engineering applications can be classified as shown in fig 1.

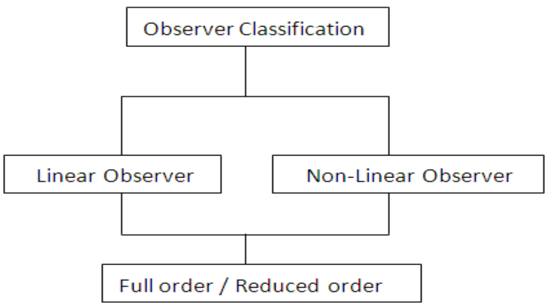

Fig. 1. Classification of Observer

The basic use of observer is to estimate the unmeasured states and can also be used as disturbance estimation by augmenting an additional state in the basic state space equation of the system[3].

2.1. Structure of Luenberger Observer

State reconstruction and estimation are used in different types of applications like signal processing, telecommunications, and fault detection. The gains of the observer is the main parameter to estimate unmeasured states from the known inputs and the outputs of the system. An observer estimates all of the system state variables and has mathematical model to produce an estimate of the actual state vector x however the observer dynamics will never exactly equal the system dynamics and the performance of the observer depends on the output error which