Optimal Design of Modified Power System Stabilizer Using Multi Objective Based Bio Inspired Algorithms

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ABSTRACT

In this article, a multi objective and a novel objective based Power System Stabilizer (PSS) design is proposed for a modified Heffron - Philips model (MHP) using bio inspired algorithms. A conventional Heffron – Philphs (CHP) model is developed by taking infinite bus voltage as reference, whereas MHP model is developed by taking transformer high voltage bus voltage as reference, which makes independent of external system data for the PSS design. PSS parameters are optimized using differential evolution (DE) algorithm and Firefly (FF) algorithm to obtain better dynamic response. The proposed method is tested on various operating conditions under different typical disturbances to test efficacy and robustness. Simulation results prove that better dynamic performance is obtained with the proposed stabilizers over the fixed gain stabilizers. This method of tuning would become a better alternative to conventional stabilizers as conventional stabilizers require retuning of parameters mostly when operating condition changes, which is a time-consuming process and laborious. Eigen value analysis is also done to prove the efficacy of the proposed method over the conventional methods.

KEYWORDS

Differential Evolution, Eigenvalues, Firefly Algorithm, Modified Heffron - Philhips Model, Power System Stabilizer

INTRODUCTION

Power System is a huge interconnected and highly nonlinear network that suffers from various disturbances. Hence it has become a big challenging issue to every power engineer to face this disturbance and protect the system from these disturbances. In a generator, the behavior of the electromechanical coupling between the rotor and rest of the system resembles with behavior of spring mass and damper system following any disturbance. Oscillations in the range of 0.2 to 3.0 Hz exited by the disturbances in the system may limit the power handling capacity or sometimes causes loss of synchronism and leads to failure of the total system. (Schleif, Hunkins, Martin, & Hattan, 1968), (Demello & Concordia, 1969) have mentioned that power system stabilizers can be used as auxiliary controllers to counter the instability problems by producing additional damping in
the system that arose in the power system. After (E. V. Larsen & Swann, 1981) (E. Larsen & Swann, 1981) has given an exhaustive coverage of general tuning procedures of PSS and concepts related to PSS applications using different signals. (Kundur, Klein, Rogers, & Zynno, 1989) gave a detailed PSS design methodology and implementation of PSS in Ontario Hydro generating station. (Gibbard, 1988), (Gibbard & Vowles, n.d.), (Gibbard & Vowles, 2004) did very useful work in the design of power system stabilizers. Similarly, from the last few decades various techniques have been suggested to design power system stabilizers. It includes traditional techniques like robust control, sliding mode and output - feedback control techniques.

A robust fast-output sampling feedback control based PSS is presented in (Gupta, Bandyopadhyay, & Kulkarni, 2003), (Gupta et al., 2003). Further, (Nechadi, Harmas, Hamzaoui, & Essounbouli, 2012), (Sambariya & Prasad, 2016), (Sambariya & Prasad, 2016), (Bandal & Bandyopadhyay, 2007), (Nechadi et al., 2012) proposed fuzzy sliding mode based PSS design techniques on SMIB system and multi machine systems. These tuning techniques require lot of parameters and involve more number of mathematical calculations. (Shayeghi, Shayanfar, Safari, & Aghmasheh, 2010), (Janardhanan & Kariwala, 2008) proposed PSS design techniques on the basis of optimization methods. The above-mentioned design methods are based on conventional techniques, which may be time consuming and laborious processes. PSS design using artificial intelligence techniques (Hoang & Tomsovic, 1996), (Kvasov, Menniti, Pinnarelli, Sergeyev, & Sorrentino, 2008), (El-Zonkoly, Khalil, & Ahmied, 2009), (Bhati & Gupta, 2013), (Sambariya, Gupta, & Prasad, 2016), and hybrid methods such as neuro-fuzzy techniques by (Ruhua You, Eghbali, & Nehrir, 2003) (M. Ramirez-Gonzalez & Malik, 2008), (Miguel Ramirez-Gonzalez & Malik, 2008), (Ghadimi, 2015), (Mohammadi & Ghadimi, 2015) are developed since few decades. But these techniques are complex and involve many particles for optimization process. From the last one and half decade, bio inspired algorithms are emerged for solving complex engineering problems. Many authors such as (Abido, 1999),(Do Bomfim, Taranto, & Falcao, 2000), (Abdel-Magid, Abido, Al-Baiyat, & Mantawy, 1999), (Abido, 2000), (Abido, 2002), (Karaboga & Basturk, 2008), (Shayeghi et al., 2010), (Rafiee & Meyabadi, 2012), (Naresh, Ramalinga Raju, & Sai Krishna, 2012), (Shrivastava, Dubey, & Kumar, 2013), (Shrivastava et al., 2013), (Abd-Elazim & Ali, 2015), (Sambariya & Prasad, 2015) (Mohammadi & Ghadimi, 2015), (Sambariya et al., 2016) proposed bio inspired based tuning techniques for the PSS design. The above-mentioned power system stabilizers (Table 1) require considerable expertise and also the knowledge of system parameters external to the generating station. But during normal operation of the system, these parameters will vary and take much time to find, if they are not readily available. This may lead to poor performance of the system. Moreover, tuning of PSS using conventional techniques may difficult and take much time, when operating conditions are changing from one to another.

This motivates the authors to propose an effective controller to overcome above mentioned drawbacks. Here an attempt is made to design robust power system stabilizers using Differential Evolution and FF algorithms on MHP model over a wide range of operating conditions under various disturbances. MHP model is proposed by (Gurunath Gurrala & Sen, 2008) which is developed by taking the high voltage bus of step up transformer at generator side as reference instead of infinite bus voltage. The very advantage of this model is as stated by (Gurunath Gurrala & Sen, 2008) “this makes the model independent from the external system information and it makes for any PSS design the parameters can be easily modified to accommodate major structural changes in the system from time to time by local measurements”. (Gurunath Gurrala & Sen, 2011), (G. Gurrala, Sen, & Padhi, 2009) did useful work on the design of PSS. In their work PSS is designed conventionally which may take much time for the design especially when operating condition changes. The main objective this paper is to propose DE and FF based power system stabilizers on MHP model to yield better dynamic performance over the fixed gain stabilizers by considering two typical objective functions. This method of tuning is simple, may become an attractive alternative to the fixed gain conventional stabilizers and makes them better suited for practical applications of real plants.
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