Chapter 16
Optimization of PID Controller for a Hybrid Power System Using Particle Swarm Optimization Technique

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ABSTRACT

With the advancement of technology, power demand is increasing day-by-day. Energy deficiency problem and increasing petroleum/diesel cost have resulted in severe impacts to many technical facts. Introduction of non-conventional energy sources such as wind and photovoltaic energy, which is clean and copiously present in nature, can be possible solutions to these problems. This chapter presents optimization of a Hybrid power system, with one of swarm intelligent algorithms named as particle swarm optimization (PSO). The hybrid system uses PID controllers for controlling its output. It has been done by studying various combinations of diesel engine generator, wind turbine generator, aqua electrolyzer, fuel cell, and battery. With the optimized system parameters, high-quality power supply can be delivered to the load and the frequency fluctuations can also be minimized.

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INTRODUCTION

The present era is expected to experience immense growth and challenges for power generation, supply and utilization. Now-a-days the role of renewable energy sources is increasing in an exponential rate. It is due to the reason that global awareness for the need of environment protection and requirement of reduction in dependency on fossil fuels in the field of power generation. Thus, exploration of many of the nonconventional sources and their integration to conventional sources are done to provide clean energy and supply the load demand in the most intelligent way (M. H. Nehrir et al., 2011; Chandraprabha, Namrata Singh, Shalini Thakur and Rituraj Karan, 2015).

"Hybrid Power Systems (HPS) are small set of co-operating units, generating electricity or electricity and heat, with diversified primary energy carriers (renewable and non-renewable), while the co-ordination of their operation takes place by utilization of advanced power electronics systems" (Sonali Goel and Renu Sharma, 2017). Hybrid power systems by definition have been developed for the production and utilization of electrical power. HPS are independent of central and large electricity grid and integrate numerous different kinds of sources of power. Generally, HPS can work in connection with power grid or they can work alone as standalone system to provide power to different loads, from one to several homes or farms, small industrial plants up to large local customers. When connected to grid, HPS offer electrical power generated by various sources and fed the excess power back in the grid, in case of more power generation than load demand. Main purpose of hybrid power systems is to deliver power to isolated, remote loads where the price of the connection from long distance transmission or distribution grid is very high.

Optimization plays an important role for improving systems performance and effective working. An optimization algorithm is a method of obtaining the optimum solution of a problem that can be achieved by following a technique and comparing numerous solutions iteratively. To find the best solution for large scale optimization problem, evolutionary algorithms are established. Evolutionary algorithms are population-based meta-heuristic algorithm as they are inspired by natural biological evolution or social behavior of living beings. Particle swarm optimization is one of these algorithms. It has the upsides of simple usage, stable convergence characteristics, and good computational effectiveness (Gaing, 2004).

Therefore, a hybrid power system is proposed in this paper with PID controllers optimized by particle swarm optimization technique. The proposed system can also be used in isolated small islands as a standalone system, to reduce fuel consumption of conventionally used in diesel/petrol generation systems and it is also good for global environment protection concerns.

EXISTING HYBRID POWER SYSTEM

This segment depicts the basics of proposed hybrid power system. The generation subsystems comprise wind turbine generator, diesel engine generator, aqua electrolyzer and fuel cell. Aqua electrolyzer is utilized to change over the fluctuating intensity of wind turbine generator into hydrogen and give it as a fuel to fuel cell (Lee & Wang, 2008). In this way power loss due to wind fluctuation can be minimized and system can be fully utilized.

For controlling the output of each subsystem, PID controller is used and for optimizing the controller performance particle swarm optimization (PSO) is used. The feedback gain parameters (k_r, k_{fc}, k_{deg})