Optimal Placement of PMUs in Algerian Network using a Hybrid Particle Swarm-Moth Flame Optimizer (PSO-MFO)

(Full text in English)

Mansouri Anfal[1], Hellal Abdelhafid[2]

[1]LACoSERE Laboratory, Electrical Engineering Department, Amar Telidji University of Laghouat, Algeria
[2]The National *Polytechnic* School of EL Harrach, Algeria

Abstract

PMU and their application have brought revolution in wide area monitoring. Optimal placement of PMU is one step towards the concept of smart grid. In this paper, a hybrid Particle Swarm - Moth-Fame method (PSO-MFO) is presented to optimize placement of PMUs "Phasor Measurement Units" for power system observability. The optimal placement problem (OPP) is formulated such that minimizing the number of PMU installations and to maximize the measurement redundancy. The placement algorithm has been tested on 3 standards IEEE-bus 14, 30 and 57 buses. In addition, the results are compared with other methods reported in relevant literature dealing with the subject. The simulation results show that the determined optimal PMU placements by the proposed method can guarantee good observability of the system states. As another test, for the observability whole system, the proposed method is applied to 68-bus Algerian network.

Keywords: Smart Grid, Phasor measurement unit (PMU), optimal PMU placement (OPP), Particle Swarm Optimiser (PSO), Moth-Flame Optimizer (MFO).

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1. Introduction

One of fundamental concept of the smart grid is to make the power grid more "aware" of its operating state with having the ability to self-heal. These characteristics can be integrated into the network by implementing a phasor measurement units based wide area measurement system. Such a system will allow better monitoring and real-time control of the grid [1].

The Phasor Measurement Unit (PMU) is considered to provide synchronized phasor measurements of voltages and currents from widely dispersed locations in a power system called synchrophasor technology. As strategical placement of PMU is of major concern today, a suitable methodology to determine optimal location for PMU placement to make system completely observable has to be considered [2].

Several optimization techniques have been proposed to solve the problem of optimal PMUs placement (OPP). Through literature, we cite depth first search (DeFS), minimum spanning tree (MST) [3], simulated annealing (SA)[4], Tabu search (TS)[5], genetic algorithms (GA)[6], differential evolution (DE)[7], immune algorithms (IA)[8], particle swarm optimization (PSO) [9], a modified discrete binary version of particle swarm algorithm (BPSO) and ant colony optimization (ACO) [10].

In this paper, a novel meta-heuristic algorithm was used to find optimal number and optimal placement of PMU and maximum redundancy for obtain fully observability of the system IEEE 14-bus, IEEE 30-bus, IEEE 57-bus.

It has also been applied to it to the 68-bus Algerian system.

The main contribution of this work lies in investigating the feasibility of using PSO-MFO algorithm for the PMU placement problem, in addition to the best position for PMUs, measurement redundancy is achievable.

A comparison between the proposed method to the existing ones show that our approach achieves higher System Observability Redundancy Index (SORI).

2. PMU in Smart Grid

Smart Grid is a sophisticated, digitally controlled power system in which electrical power can be delivered to consumers with greater reliability, efficiency and flexibility compared to the traditional power system. SG helps to reduce peak demand, shifting the operation of non-critical loads to off-peak hours, efficient management of electric vehicle charging, and better utilization of renewable energy sources, etc.

Figure 1 illustrates the application of PMUs in a typical SG. The electrical network represents a four bus network in which the main grid and renewable energy sources called distributed generation units or DGs are interconnected. To monitor the buses in the network, PMUs are used. PMUs are placed at two buses, allowing full observation of the four buses. All the loads and DGs are connected to the grid through smart meters [4].