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ORIGINAL PAPER

Study of phasor measurement unit placement in wide area monitoring system of radial distribution network using oppositional-based artificial rabbit optimization

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Abstract
In this article, a new metaheuristic bioinspired technique oppositional artificial rabbit optimization (OARO) technique is enhanced and employed, for phasor measurement unit (PMU) placement in distribution system. Based on PMUs, this study emphasizes their advantages for real-time monitoring. Quite differently, the PMU serves as the system's cornerstone. The goal of this kind of technology is to analyse data quickly and automatically arrive at a decision. Four scenarios are taken into consideration in the simulation study for each test system, and the goal is to minimize costs while taking into account fewer PMU. The first case focuses primarily on the number of PMU set as the objective function; the second case uses the wide area monitoring system (WAMS) data traffic index and installation cost to observe comprehensive observability. The third case focuses on how many PMU are used in conjunction with zero injection bus (ZIB). Finally, ZIB and WAMS are implemented together to reduce data traffic and, eventually, the fitness function. There is artificial rabbit optimization (ARO), inspired by the survival of rabbits, such as detour foraging and random hiding. The behaviour of the rabbits in random searching for food in other region neglecting its own region followed by random hiding amongst all borrowings to reduce the chances for the predators to search them to kill. In this study, an oppositional strategy of rabbits' finding the tunnels is applied for finding the food search space. In addition, the rabbit energy shrink strategy is implemented to transmit rabbits from detour foraging and random hiding. The concept of oppositional-based learning applied to rabbit survival strategy has been mathematically modelled and tested in PMU placement problems in the radial distribution system. The methods are evaluated in radial distribution systems with 33, 69, 85, 118, and 141 buses. In each case, it is found that OARO provides better results on PMU placement for phasor measurement of voltage and current in radial distribution systems.

Keywords Radial distribution system · Phasor measurement unit · Artificial rabbit optimization · Oppositional artificial rabbit optimization · Wide area monitoring system · Zero injection bus

1 Introduction

Electricity is a key component of our society. Therefore, a strong supply continuity with the power grid for their consumers is necessary. So researchers concentrated on electricity network operation and monitoring. To monitoring and record the grid status, wide area monitoring system (WAMS) is used in smart grid system [1]. Wide area measurement systems (WAMS) are primarily concerned with gathering real-time synchronized system measurements and distributing them to data-using applications. Phasor measuring unit (PMU) is a tool used to measure electrical parameters such as voltage, current, phasor angle, frequency with time tag in WAMS system. Modern digital signal processors are used in phasor measurement units, which are capable of measuring 50/60Hz AC waveforms (voltages and currents) at a rate of 48 samples per cycle on average [2]. This phasor measuring technique produces very accurate and high-resolution data. PMU is employed in various power nodes under the con-

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