

Author: Christopher Maina Muriithi.

Title: Power System Analysis with Metaheuristics.

Publisher: Doch Sustainable Solutions Ltd, Nairobi.

Publication Date: 2026.

ISBN:978-9914-35-873-5.

url: <https://dochsustainableolutions.co.ke/power-systems-analysis-with-metaheuristics/>

Abstract

Modern electric power systems are becoming increasingly complex due to the integration of renewable energy sources, distributed generation, electric vehicles, and intelligent control technologies. Traditional analytical techniques alone are often insufficient to address the nonlinear, large-scale, and multi-objective nature of contemporary power system problems. This book presents a comprehensive and practical approach to power systems analysis using metaheuristic optimization techniques, combining classical power system theory with modern computational intelligence methods.

The text begins by establishing the fundamental principles of power system modeling, including the formation of network equations, bus admittance matrix development, and load flow analysis. Classical numerical methods such as the Gauss–Seidel method, Newton–Raphson method, and Fast Decoupled Load Flow method are introduced with detailed mathematical derivations and practical MATLAB implementations, providing a solid foundation for power system analysis. For example, the MATLAB implementations included in the book demonstrate the iterative solution of load flow problems and the formation of network matrices used in system studies.

Building on these classical methods, the book introduces a wide range of metaheuristic optimization algorithms that have become powerful tools for solving complex engineering problems. Algorithms such as Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Simulated Annealing (SA), Genetic Algorithm (GA) and other swarm intelligence techniques are explained from both theoretical and practical perspectives. Their applications to optimal power flow, economic dispatch, voltage stability assessment, and system planning are illustrated through worked examples.

A unique contribution of this book is the introduction of the Boda-Boda Optimization Algorithm (BBOA), a novel swarm-inspired optimization method derived from the dynamic and adaptive navigation patterns observed in motorcycle transport systems. The algorithm demonstrates strong exploration and exploitation capabilities, making it suitable for solving highly nonlinear optimization problems in power systems.

To bridge theory and practice, the book includes extensive MATLAB codes, simulation exercises, and real-world case studies, enabling students, researchers, and practicing engineers to implement and test algorithms directly. The examples emphasize practical applications in modern power networks, including renewable integration, smart grid operation, and large-scale system optimization.

Overall, this book serves as both a teaching resource and a research reference, providing readers with the theoretical foundations, computational tools, and algorithmic strategies necessary to analyze and optimize modern electric power systems.