Reliability improvement using ant colony optimization applied to placement of sectionalizing switches

Boyi Zhang*, Peter Crossley

School of Electrical and Electronic Engineering, The University of Manchester, Manchester M1 3BP, UK

Abstract

Asset management and automation are acknowledged by distribution utilities as a useful strategy to improve service reliability, but the challenge facing decision makers is how to maximize the long-term return on a project whilst minimizing the investment and operation costs. The objective of this paper is reliability improvement by installing the optimum number of sectionalizing switches at appropriate locations in an electricity distribution network. This is achieved by adding new switches and the relocation of existing switches. Determining the number and location of switches become an optimization problem efficiently solved using an ant colony optimization (ACO) algorithm. The performance of this approach is assessed in the paper and illustrated using various case studies on a typical UK distribution network. Test results show that the proposed ACO methodology provides an optimum solution based on a trade-off region between the reliability indices and cost of multiple switches.

© 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

Keywords: Ant colony optimization (ACO); Distribution networks; Reliability; Sectionalizing switch

1. Introduction

The majority of supply interruptions are due to failures in the distribution network [1] and consequently in a competitive market environment. Reliability improvement is the main driver for the distribution utilities to launch research and demonstration projects [2]. An effective method to reduce customer minutes lost is greater and more effective use of automated and remote controlled sectionalizing switches and feeder breaker automation. This
approach will reduce customer restoration time and minimize the region of a network affected by a short-circuit fault. The effectiveness depends on the number, location and type of sectionalizing switches and feeder breakers.

Relevant publications related to reliability improvements in distribution networks [3-6] are included in the references. Teng and Liu [3] introduced an ant colony system based method for sectionalizing switch relocation. Hosseini, Shayanfar and Fotuhi-Firuzabad [4] described a static series voltage regulator is used for reliability improvement. A differential search algorithm was proposed in [5] to find the optimum number and location of remote controlled switches for reliability optimization problem and in [6], an optimized energy storage systems was used for reliability improvement and cost minimization.

Reliability improvement and minimization of switch costs are considered in formulating the objective function in this paper. The ant colony optimization (ACO) with hype-cube (HC) framework is adopted, which has the ability to find near optimal solution close to global minimum in a finite number of steps. The main contribution of this paper is the introduction of an ACO algorithm for installation and relocation of sectionalizing switches. Furthermore, the benefit-to-cost (BCR) analysis is also investigated.

The mathematical formulation of the objective function is presented in Section 2 and in Section 3, the placement of sectionalizing switches is addressed. Section 4 describes the ACO algorithm and benefit-cost analysis and the numerical case studies are presented and discussed in Section 5. The main conclusions of the paper are summarized in Section 6.

2. Problem formulation

2.1. Objective function and constraints

The primary objective this paper is to resolve the two conflicting objectives: system reliability improvement; and minimization of the cost of sectionalizing switches. Reliability improvement is modelled as the reduction of unserved energy cost. A multi-objective optimization problem has many objectives and the solution is a trade-off between each existing objective. Normally, there is no situation in which all of the objectives can be satisfied simultaneously in the best possible way. Consequently, to obtain the best configuration of the system, the two functions described above must be transformed into a single objective function by aggregating all the objectives in a weighted function:

\[ \text{Min } J = \omega_1 \cdot \text{ECOST} + \omega_2 \cdot \text{SC} \]  

where ECOST is the system expected outage cost to customers ($) and SC is the cost of sectionalizing switches ($); \( \omega_1 \) and \( \omega_2 \) are the weighting factors given to the reliability index and the cost of switches.

2.2. Distribution network reliability assessment

A customer connected to any load point in such a network requires all the components between the load and the supply to be operating [1]. Failure-mode-and-effect analysis (FMEA), based on examining all the failure events and their effects on the system, is used for the reliability assessment performed in this paper. The system failure events are enumerated first. For a failure event, the scope of the failure is determined by searching the open or closed status of upstream circuit breakers. The isolation zone is then confirmed by the location of the upstream and downstream sectionalizing switches and the appropriate tie-switch. Subsequently, all the load points are classified based on their interruption times. Finally, the consequence of each contingency and a value for total system reliability are evaluated.

![Sample system](image)
دریافت فوری
متن کامل مقاله
امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات