

“Review Paper on Multiobjective Optimal Placement of Switching Devices in Electrical Distribution Systems Using BAT Algorithm”

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Abstract

Most power outages are caused by unexpected distribution network failures. In a competitive market, service quality and reliability have become the core elements of business. To improve the reliability of the distribution system, this paper proposes a value-based approach to extract load distribution change calculation and find a new location for the feeder participants so that the customer intervention charges are reduced.^[1] In this paper we suggest an addition technique to recognize types and positions of guarding schemes to minimize the brownout cost, the LCC and the financing cost in accordance with system necessity restraints. This research aims to help conclusion maker in providing appropriate securing scheme allocations in energetic disposal system.^[5] This paper presents a new expression for sectionalizing maneuver placement communicable into concern interruption, sustenance and investments costs. The expression of sectionalizing switches is a combinational forced addition problem accompanying a non-undeviating, non-differentiable objective function. A answer methods based on the addition method of fake annealing, is proposed to decide (i) the number of sectionalizing switches and (ii) the locales of the switches. The projected resolution methodology can offer a all-encompassing optimum resolution for the sectionalizing maneuver placement question that involves the reliability, investment and support costs. This paper determines a review of united states of america-of-the-art in multi objective transformative algorithms used to capacity schemes planning questions.^[15]

Keywords: Distributed generation, multi-objective optimization algorithm, distribution reliability indices

1. Introduction

Electric capacity manufacturing has confronted many new challenges in the deregulated surroundings. There has happened raised pressure on the power utilities to exploit network property in a more excellent manner and lower outage occasion on account of mistakes. The distribution network supports the conclusive link betwixt the most transmission method and the

clients. It has existed reported that 80% of the department dealing with customers interruptions are due to declines in the dispersion networks. In order to upgrade service dependability, various alternatives to a degree reducing the lengths of person who produces crops and including revised protection and switch gear are used to the disposal network to gain next improvement in dependability and therefore the duty to the power customers.^[2] To humble the belongings of losses in power allocation, securing tools, to a degree reclosers, fuses, and sequestering switches can be equipped, increasing the dependability of a network and, thus lowering allure SAIFI and SAIDI indications. This paper presents a method to underrate the SAIFI or SAIDI index of a disposal comedian who sets up joke. It does so by recognizing place the guarding devices endure be equipped and that types bear be secondhand, while guaranteeing that operational and cost restraints are gratified.^[4] The orderly selection and distribution of guarding devices admit confining the effect of faults on the dispersion comedian who sets up joke, minimizing the number of consumers stirred by protective scheme movement and, thereby, underrating the comedian who sets up joke reliability indications.^[6] Protective schemes, to a degree fuses, reclosers, and Segregating switches, play an important act in dependability of allocation methods; they defeat the annual disappointment rate and outage event, that influence each load point significantly, so reducing the total consumer break cost. In addition, it is main to recognize the type and region for guarding devices and switches for belittlement capital expense cost and maximizing consumer benefits.^[8] Determining the appropriate quantity of switches and their placements poses a significant challenge in the planning of distribution systems. Utilities rely on their historical experience, customer information, and various other factors when choosing an adequate number of switches.^[10] The growing sensitivity of customer loads to short disturbances has compelled utilities to take into account momentary interruptions that happen within their systems. This has led to a resurgence of interest in momentary reliability metrics like the Momentary Average Interruption Frequency Index (MAIFI) and the Momentary Average Interruption Event Frequency Index (MAIFIE).^[12]

2. PROBLEM FORMULATION

Pareto optimality concepts:

Concepts of Pareto Optimality In numerous real-world optimization scenarios, multiple objectives often need to be optimized at the same time. Consequently, techniques for multiobjective optimization have been employed to address these types of challenges. A typical multiobjective problem can be represented by the following equation:

$$\begin{aligned} \min F(x) &= (f_1(x), f_2(x), \dots, f_k(x))^T \\ x &\in S \quad x = (x_1, x_2, \dots, x_n)^T \dots\dots\dots(1) \end{aligned}$$

where $f_1(x)$, $f_2(x)$, $\dots$, $f_k(x)$ represent the k objective functions, $(x_1, x_2, \dots, x_n)$ are the n optimization parameters, and $S \in \mathbb{R}^n$ denotes the solution or parameter space. To achieve the optimal solution for multiobjective problems, some objectives are typically converted into constraints, or the objective vector may be simplified to a scalar optimization problem. This can

be done through methods such as objective weighting, distance functions, Min–Max formulation, and the Lexicographic approach. Nevertheless, all traditional methods used to tackle multiobjective problems have significant limitations. An alternative strategy is to explore the solution space for a collection of Pareto optimal solutions, from which the decision-maker can select the final design. In the context of a minimization problem involving two solution vectors x and y within S , x is said to dominate y , denoted as $x \preceq y$, if:

$$\begin{aligned} \forall i \in 1, 2, \dots, K | f_i(x) \leq f_i(y) \wedge \\ \exists j \in 1, 2, \dots, K | f_j(x) < f_j(y). \dots\dots\dots(2) \end{aligned}$$

The solution set for a multiobjective optimization problem comprises all nondominated solutions, which is referred to as the Pareto optimal set or Pareto optimal front.

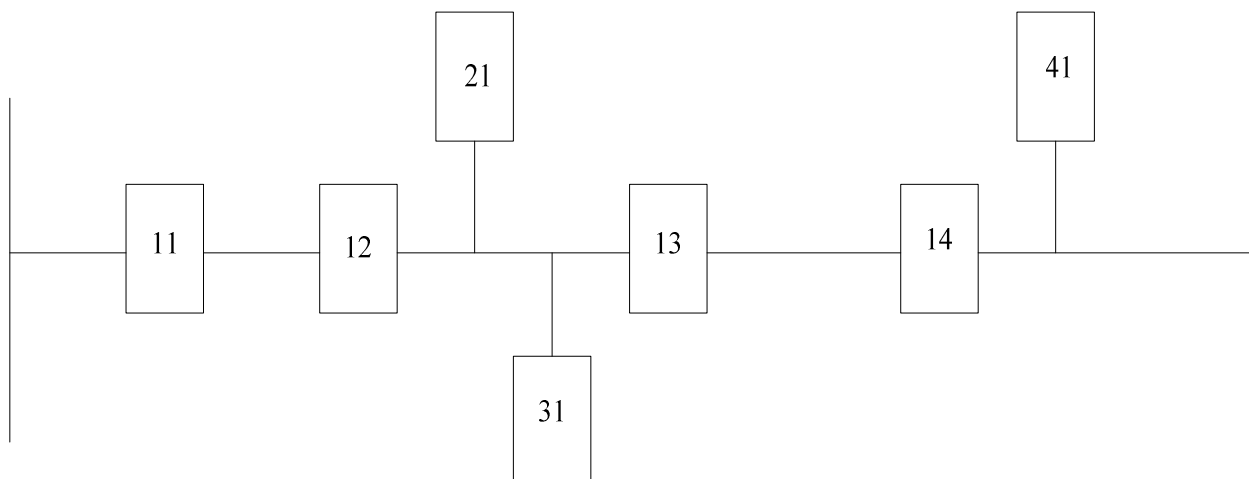
Distribution feeder model:

A straightforward feeder within a distribution system that comprises multiple main and lateral sections, with the feeder load potentially supported by an interconnection with adjacent feeders. The distribution feeder can be illustrated as a tree graph G , where node o_i represents tap connections or load points [1]. Given that each edge in the tree graph has a distinct end node, the edge (o_i, o_j) can be referred to as edge j . This corresponds to section j of the distribution system. Let $s(i)$ denote the immediate predecessor of edge i , provided that graph G includes edge $(o_{s(i)}, o_i)$. The set of predecessors for edge i is defined by the following equation:

$$S_i = \{i, s(i), s(s(i)), s(s(s(i))), \dots\} \dots\dots\dots(3)$$

S_i , the section path, contains all sections belonging to the path that connects section i to the energy source.

A Simple 7 – Load Point Radial System



Recloser: This device provides both switching and protective functions, which are utilized to manage both permanent and temporary faults. When a fault occurs downstream of a recloser, only the sections downstream are isolated. Consequently, all loads supplied by the upstream sections remain unaffected by the power interruption. This capability reduces the number of customers experiencing interruptions due to its fault isolation feature. Additionally, reclosers are equipped with a trip/reclose function that helps prevent momentary faults from escalating into permanent interruptions. Generally, reclosers can be installed in both main and lateral sections.

Fuse: A fuse serves solely a protective function and lacks switching capabilities. It isolates a fault by melting its fuse-link. A fuse can only create an open circuit and cannot clear a momentary fault independently. Installation of fuses on the main feeder is prohibited.

Switch: A switch does not provide any protective function. It can minimize downtime by isolating only the faulty part of the circuit, allowing for the restoration of both upstream and downstream sections of the faulted area.

3. Objective function:

This paper introduces a Mult objective optimization approach aimed at achieving optimal reliability in distribution networks while concurrently reducing system costs. Numerous reliability indices are utilized to assess electric power distribution systems. The indices most frequently employed by electric utilities include the system average interruption frequency index (SAIFI) and the system average interruption duration index (SAIDI). These indices quantify the effects of power outages in terms of the frequency of interruptions and their respective durations. Consequently, we have identified three objectives to minimize: SAIFI, SAIDI, and total cost. The total cost encompasses the average costs associated with interruptions (both temporary and permanent) as well as the fixed costs related to the investment in the purchase and installation of switches and protective devices. The mathematical formulations for the three objective functions can be defined as follows:

(1) SAIFI, $f_1(x)$: the system average interruption frequency index (sustained interruptions) is utilized to indicate the average frequency of sustained interruptions experienced by each customer. To compute the index, apply the following formula:

$$SAIFI = \frac{\sum_{i \in B} Li Ni}{NT}$$

$$SAIFI = \sum_{i \in B} \{ \sum_{j \in U_i} T_j [2\lambda_i + \gamma_i - \lambda_i x_j - (\lambda_i + \gamma_i) y_j] (\prod_{k \in c_j} x_k y_k) \}$$

where λ_i is permanent failure rate of load point i due to outages in section s . It depends on the circuit topology and location of protective devices.

(2) SAIDI, $f_2(x)$: the system average interruption duration index is commonly known as customer minutes of interruptions, and it is designed to show the average duration that a customer experiences interruptions over the course of a year. To compute the index, apply the

following equation:

$$SAIDI = \frac{\sum_{i \in B} H_i N_i}{N_T}$$

where

B = set formed by all sections of a feeder; N_i = number of customers in section ; N_T = total number of customers on the feeder; H_i = estimation on the number of hours per year that a section is without service; and I_i = estimation of the number of interruptions per year suffered by section .

To estimate and , we need to know the permanent and temporary failure rates of each section. These rates are usually obtained from the feeder history of interruptions.

(3) Total cost (TC), $f_3(x)$: this objective function represents the total of the fixed costs linked to capital investments in switches and protective devices, along with the costs incurred from interruptions. This cost is articulated by the equation below:

$$TC = FC + \sum_{i=1}^n \sum_{s=1}^m (CIPis + CITis)$$

Where,

$$CIPis = C_{is} (ris) Li' \lambda_{is}$$

$$CITis = C_t Li' \gamma_{is}$$

$$C_{is}(ris) = (Res_s(\%) * fr(ris) + Com_s(\%)*f_c(ris) + Ind_s(\%)*f_i(ris))$$

where FC represents the fixed cost that encompasses the expenses for acquiring and installing switches and/or protective devices. The interruption costs associated with each load point i resulting from outages in section s comprise both the costs of interruptions caused by permanent faults (CIPis) and the costs of interruptions due to temporary faults (CITis).

4. Summary of objectives, test systems and methods used in literatures for Optimal Placement of Switches and Protective Device

Techniques	Reference	Minimize Objective	Test system
Novel Algorithm	Jen – Hao Teng, Chan – Nan Lu ,2002	CIC	5 - Bus
	Jen – Hao Teng, Chan – Nan Lu, 2006	FCIC	3-Bus
Tabu Search Algorithm	Luis G. Wesz da Silva, 2008	TC	134-Bus
Non - linear Binary Programming	Eduardo Zambon, Debora Z. Bossois, 2009	SAIFI, SAIDI	7-Bus
	Gustavo D. Ferreira, Arturo S. Bretas, 2011	SAIFI, MAIFI	51-Bus
Binary Programming	Rosawan bupasiri, 2003	SAIFI, SAIDI, TC	7-Bus
	F. Soudi, K. Tomsovic, 1999	SAIFI, SAIDI, CAIDI, ASAI	9-Bus
	Jin – Man Sohn, Jong – Keun Park, 2006	TCR	26-Bus
	F. Soudi, K. Tomsovic, 1998	SAIFI	7-Bus

5. Conclusion

This document introduces a new algorithm for FA planning. Using straightforward calculations, the suggested search rules can be employed to identify the most suitable feeders for automation, as well as the optimal quantities and placements of automated feeder and tie switches. The findings demonstrate that the proposed approach significantly outperforms the GA-based method in terms of solution efficiency.^[2] In this paper, a new method for the integrated placement and replacement of control and protective devices within distribution network feeders has been introduced. The issue was formulated as a MINLP. This model takes into account the key physical factors of the problem that have a direct impact on investment costs and the enhancement of reliability indices.^[3] This paper introduced a more comprehensive NBP model compared to the one suggested by Soudi and Tomsovic [2], which is capable of identifying superior solutions for the allocation of protective devices within a distribution feeder. Additionally, our model accommodates any arbitrary divisions of feeders, thereby allowing the original model proposed by Soudi and Tomsovic to be viewed as a specific instance. Numerical results from tests conducted on 36 distribution feeders demonstrate the enhancements in the SAIDI and SAIFI indices achieved with our new model.^[4] This paper introduces a binary programming method aimed at enhancing the efficiency of distribution protective design. The method determines the type and placement of protective devices on a distribution feeder with the goal of reducing the SAIFI. Future research will concentrate on computational challenges and will tackle the trade-offs between load and customer-oriented reliability indices, in addition to considerations of temporary and permanent faults.^[9]

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