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Optimal selection switching of remote terminal unit using reliability index in electric power distribution systems

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Abstract

Remote terminal units (RTUs) can trip the circuit in case of a fault in a power system when work with the central control room. RTUs are used to monitor faults at different parts of the power system. This paper presents optimal placement of RTUs by using Particle Swarm Optimization (PSO) technique to minimize customer outage, travel costs and improve System Average Interruption Duration Index (SAIDI). The method is applied to IEEE 13 Node Test Feeder. The Results show as the number of RTUs installed in nodes with many customers is increased, SAIDI improves.

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Keywords: Reliability indices, SAIDI, RTU, Remote terminal units , PSO, Optimization, Power System, Distribution system.

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1. Introduction

Supply of reliable power to customers is a huge concern for utilities. Today's power systems focus on the reliability and quality of power delivered to the customers. Smart grid technology needs modern approaches of power system operation and control [1]. One of the interests of a smart grid automation is to decrease customers's interruption time. This time can be minimized depending on the distribution system structure and topology, fault detection capability of the system. This reconfiguration can be achieved by some maneuver operations using RTUs placement in the network [2]. In case of failing RTUs can trip the circuit with the help of central control unit. These devices should be optimally placed to achieve maximum performance in monitoring faults at different locations of the power system. RTUs are connected with the central control room through a communication system [3]. In this paper PSO is employed to find optimal location for RTU installation in the power system to minimize customer outage cost, utility travel cost and SAIDI. SAIDI is a measure of how many interruption hours that an average customer will experience in a year [4]. The problem of RTUs placement is formulated. The formula to find SAIDI is given. RTUs are added to the system and SAIDI is computed. Data for IEEE 13 node are in [5].

2. Methodology

SAIDI is a measure of the number of interruption hours that an average customer will experience in a year as,

$$\text{SAIDI}=\frac{\text{Total duration of customer interruptions}}{\text{Total number of customers}} = \text{(hours/year)} \tag{1}$$

$$\text{SAIDI}=\sum_{i=1}^{m}(\text{SAIDI}_{p,i}+\text{SAIDI}_{T,i}) \tag{2}$$

$$\text{SAIDI}=\sum_{i=1}^{m}[(\text{D}_{p,i}/\text{n})\square\lambda_{p,i}+(\text{D}_{T,i}/\text{n})\square\lambda_{T,i} \tag{3}$$

Where:

$\text{SAIDI}_{p,i}$ = contribution to SAIDI due to permanent fault on component i

$\text{SAIDI}_{T,i}$ = contribution to SAIDI due to temporary fault on component i

$\text{D}_{p,i}$ = sum of customer interruption durations in hours due to a permanent fault on component i

$\text{D}_{T,i}$ = sum of customer interruption durations in hours due to a temporary fault on component i

Where:

$$\text{D}_{p,i} = \sum_{j=1}^{S_{P,i}} d_{P,i,j} \tag{4}$$

$$\text{D}_{T,i} = \sum_{j=1}^{S_{T,i}} d_{T,i,j} \tag{5}$$

Where:

$d_{P,i,j}$ = interruption duration for customer j due to a permanent fault on component i,j = 1,2,3,…. $\text{S}_{P,i}$

$d_{T,i,j}$ = interruption duration for customer j due to a temporary fault on component i,j = 1,2,3,…. $\text{S}_{T,i}$

When there is a permanent fault on component i, there are $\text{S}_{P,i}$ customers experience a sustained interruption. Due to switching operations to restore service, different customers may experience different interruption durations,