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Probabilistic reliability indices evaluation of electrical distribution system accounting outage due to overloading and repair time omission

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ABSTRACT

This paper presents a methodology for modifying failure rate and repair time of a distributor segment accounting the outage due to overloading and omission of critical repair time termed as repair tolerance time. Necessary relations have been derived for modifications of failure rate and repair time of a distributor and these modified failure rate/repair time have been used to evaluate average failure rate, average outage duration and average outage duration per year for distribution systems. The methodology has been implemented on a meshed distribution network and results have been compared with those obtained with unmodified failure rates/repair times.

1. Introduction

Reliability assessment of power system is an important issue. Considerable attention has been focussed on reliability evaluation of bulk power system in comparison to distribution systems. Hence distribution system has been the weakest link between the source of supply and customer. This is due to the fact that generation and transmission system are capital intensive and outages in these systems may affect large area and large number of customers. It has been standard practice to evaluate reliability of distribution system separately because: (i) distribution networks mostly connected to transmission system through one supply point and the load point indices evaluated for bulk power system may be used if needed as input values for the reliability evaluation of distribution network and (ii) on average 90% interruptions of the customer is observed due to distribution network. Average failure rate, average outage duration, and average annual outage time are the basic indices evaluated based on the exponential distribution functions for failure time and repair time. This leads to justification for assuming constant failure rates and repair rates for each distributor segment. Various analytical methods for reliability evaluation of a distribution network has been described in literature. Since repair rate is much larger than failure rate, approximate relations are used for obtaining reliability indices of series parallel systems. Average reliability indices are evaluated using analytical techniques whereas simulation techniques are used to generate distribution of these indices [1,2].

Allan et al. [3] developed modelling aspects and evaluated reliability indices of distribution systems. Billinton and Grover [4] developed methodology for reliability evaluation of transmission and distribution systems. Billinton and Kumar [5] considered common cause outages and weather effects and developed a procedure for reliability evaluation of transmission network. Gangel and Ringlee [6] presented techniques for the estimation of service interruptions initiated in a distribution system. Various modelling aspects to determine failure and repair rates have been presented. Wojczynski and Billinton [7] discussed and developed a procedure for evaluating the effects of distribution system reliability index distribution on interruption costs for reliability worth estimates. Volkanavski et al. [8] developed an algorithm for power system reliability assessment using fault tree analysis. Minimal cut-set and the frequency duration methods have been used for planning and design of industrial power distribution system [9–12]. Several variations of Monte Carlo simulation methods have been developed to probabilistically evaluate long term reliability of power system [13–15]. Li et al. [20] investigated the impact of covered conductors on distribution reliability and safety. Ghosh et al. [21]

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