



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم



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التوثيق الإلكتروني والميكرو فيلم



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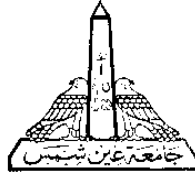


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AIN SHAMS UNIVERSITY
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Electrical Power and Machines Engineering

Optimal Power Restoration in Power Distribution Network considering Optimal Number and Allocation of Remote-Controlled Switches

A Thesis submitted in partial fulfillment of the requirements of the degree of

Doctor of Philosophy in Electrical Engineering

(Electrical Power and Machines Engineering)

by

Doaa Adel Hassan Sabry

Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

Faculty of Engineering, Ain Shams University, 2019

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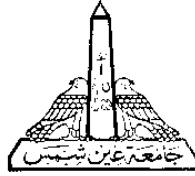
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Cairo - (2021)



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Statement

This thesis is submitted as a partial fulfilment of Doctor of Philosophy in Electrical Engineering Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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ABSTRACT

The distribution system reliability evaluation considers the ability of the distribution system to transfer energy from bulk supply points such as typical transmission system end-stations, and from local generation points, to customer loads. The reliability is evaluated by the customer-oriented reliability indices, such as system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI), and energy not supplied (ENS). Different parameters are used in the distribution system to measure the system reliability. The objective of the study is to evaluate the reliability of the distribution system and to investigate more reliable and cost-effective ways of improving the reliability performance of distribution networks.

Power system reliability is an essential factor in the quality of supply and is directly related to the number and duration of outages. The dissertation focuses on improving the network reliability indices utilizing proper strategy plan to restore service to interrupted customers as quickly as possible after an outage. This study proposes a methodology to determine optimal areas that have similar energizing times in order to speed up the restoration process. The method is based on the combination of heuristic and discrete optimization techniques. The heuristic technique is applied to find initial solution that is close to the optimal solution. The methodology defines the optimal backbone using shortest path method subject to technical and topological constraints. Upgrading manual switches to remote-controlled switches (RCSs) enhances restoration capability and therefore system reliability. The optimal selection of upgraded switches consider both functional and economic requirements.

The main contribution of this dissertation is the proposal of a new simplified recursive equivalent reliability evaluation method to deal with a complex distribution system in lower analytical computational time. The reliability network recursive equivalent method provides a simplified approach to the reliability evaluation as it considers element-by-element equivalent principles. Also, the reliability indices of any node can be recursively obtained based on those of neighbor nodes only, while reliability information of the rest of the network is not required at all. The simplified recursive equivalent approach avoids the traditionally required procedure of finding the failure modes and their effect on the individual load points and results in a significant reduction in computer solution time. The proposed methodology provides simplified equivalent approach irrespective of the network topology as it is used in the bidirectional power flow case and non-radial network's structures.

The proposed recursive method considers the impact of lower limit failures on upper limit customers, and study the impact of upper limit failures on lower limit customers. Moreover, a novel RCSs zone concept is defined and introduced into the recursive process for more simplification and to save the computation time. It is clear that when a failure happens in the upper limit, the services of the entire lower limit will be interrupted but when the fault happens in the lower limit the service to the upper limit can be restored via closing

one available RCS, otherwise the service cannot be restored. The recursive equivalent reliability evaluation method is applied to a study case and the system indices results are compared with the results obtained by using FMEA and simulation method. The results have shown that both the simulation and analytical approaches are very much comparable, proving that any of these methods can be used to assess the reliability of a distribution network.

The dissertation begins with a brief introduction about power systems, followed by a review of the literature pertaining to the topic. The dissertation then describes how to carry out reliability evaluation by three different methods, The FMEA method is applied, the new simplified recursive method and the simulation method.

The proposed method is validated via simulation using 39-bus standard system and a part of real network. The advantage of the proposed method in terms of reliability indices is demonstrated through a comparison with other literature.

As the customer interruption cost varies from residential to commercial and industrial customers and it depends also on the duration of interruption so the methodology has been proposed for a residential, commercial, and industrial customers. In addition, the customer interruption cost (CIC) in part of actual distribution network are calculated to evaluate the reliability worth indices (ECOST) and expected energy not supplied (EENS). It was concluded based on the presented results that however installing RCSs was increased reliability of the system to some level. After that level, there is no significant benefit of installing extra number of RCSs as the reliability indices were almost saturated.

Keywords

Reliability, availability, distribution system, performance evaluation, SAIDI, SAIFI, restoration, backbone, substation new design

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DECLARATIONS

This dissertation, titled “Optimal Power Restoration in Power Distribution Network considering Optimal Number and Allocation of Remote-Controlled Switches,” is declared my own study. “I know the meaning of plagiarism and declare that all of the work in the document, save for that which is properly acknowledged” quotation from other authors have been duly referenced. This dissertation has neither in part nor entirety been submitted to any other universities for any other degree. This dissertation is being submitted in fulfillment of the academic requirements for the degree of PhD in Electrical Engineering in the Faculty of Engineering, Ain Shams University.

Signed:

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