Ain Shams University
Faculty of Engineering
Electrical Power and Machines Department

RELIABILITY ASSESSMENT IN BULK POWER SYSTEM (GENERATION AND TRANSMISSION)

M.Sc.Thesis by:

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B.Sc. in Electrical Power Engineering
Department of Electrical Power and Machines
Ain Shams University

A thesis Submitted to the Faculty of Engineering, Ain Shams University in partial fulfillment of the requirements for the Degree of Master of Science in Electrical Power and Machines Engineering

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بِسْمِ اللهِ الرَّحْمنِ الرَّحِيمِ

وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ

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Approval sheet

For The Thesis

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Statement

A thesis Submitted to the Faculty of Engineering, Ain Shams University in partial fulfillment of the requirements for the Degree of Master of Science in Electrical Power and Machines Engineering

The included work in this thesis has been carried out by the author at the Electrical Power and Machines Department of Ain Shams University .No part of this thesis has been submitted for a degree or qualification at any university or institution

Name: Doaa Adel Hassan Sabry

Signature:

Date:

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List of Symbols and Abbreviations

HL	Hierarchical Level
S	System state
RBTS	Roy Billinton Test System
PLC	Probability of Load Curtailment
ELC	Expected Load Curtailment
ENLC	Expected Number of Load Curtailment
EDC	Expected Damage Cost
ASAI	Average Service Availability Index
CAIDI	Customer Average Interruption Duration Index
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
MAIFI	Momentary Average Interruption Frequency Index
NERC	North American Electric Reliability Corporation
ENS	Energy Not Supplied
EENS	Expected Energy Not Supplied
IEEE	Institute of Electrical and Electronics Engineers
IEEE RTS	IEEE Reliability Test System
A	Availability
R	Reliability
U	Unavailability
λi	Failure rate of element i
μi	Repair rate of element i
fi	Frequency of element i
Pi	Probability of element i

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Thanks to ALLAH who gives us the power and hope to succeed.

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Doaa Adel Sabry

Abstract

Electric power systems throughout the world are considerable changes due to the converging forces of degradation, technology revolution and evolving customer expectations. Quantitative reliability evaluation plays an important role in the development, design and operation of composite generation and transmission or bulk power systems.

This thesis presents research conducted on the development and examination of concepts, techniques and pertinent factors in the reliability evaluation of composite power systems.

Analytical method is used in this research to assess composite system reliability. The system reliability was measured through reliability indices output of ETAP software on reliability test system RBT (6bus) and the effects of station related outages are combined with the connected terminal failure parameters. RBTS was augmented with different configurations of substations (Ring bus-double bus double breaker- one and one half circuit breaker-one and one third circuit breaker) and reliability analysis was run for each configuration.

This thesis presents two main contributions. First, is determine the value of switching time, that is the time in hours for isolating a fault occurred at the component, on the calculation, which proved it's influential in improving reliability indices.

Second, the sensitivity analysis was run and shows the reliability indices of the RBTS with different configurations of substations. The failure parameters of the circuit breakers and bus bars are varied in order to observe this effect on the composite systems

Keywords: Bulk power system reliability, Adequacy, Contingency, ETAP simulation, Power quality and security.

Chapter 1

Introduction

This chapter provides a general background to the topic and the related research. The thesis objective and main contributions are presented.

1.1 Introduction

Modern society is highly dependent on the efficient operation of electric power systems and has developed in such a way that even a small interruption in electric power supply has a significant effect. Customers expect that electric power should be available 24 hours a day, 7 days a week without any interruption. The article *Power Cuts Can Wreck Business April 12, 1999: Fortune Magazine*, is evidence that illustrates the dependence of the world's advanced nations on electric power supply. In the early days of electricity supply, electric power was considered to be a luxury, but today it is a highly valued commodity. Although the number of electric power outages in developed nations has reduced considerably, developing nations are still coping with the problem of frequent power failures. The ability of a power system to provide customers with an adequate supply is usually designated by the term "reliability" [1].

Economic growth is highly dependent on the existence of reliable electricity supply at an affordable cost. Major electricity outages can occur due to incorrect planning and operation, equipment failures, vandalism, environmental conditions and adverse weather effects. The creation and operation of a completely reliable electric power system is technically and economically not viable. The practical way to avoid major power outages is to make a power system more reliable. This is usually accomplished by increasing the system redundancy and the capital investment.

Increasing the capital investment will result in increasing cost to the customer. Therefore, there has to be a balance between the cost and reliability of an electric power system.

Power system planners and designers sometimes find it difficult to achieve a balance between reliability and cost during the planning phase. Many electric power utilities use both deterministic and probabilistic techniques during the planning phase in order to assess power system reliability [2-12]. Probabilistic techniques can be used to incorporate a wide range of system behavior and are preferred over deterministic techniques [2]. Many probabilistic techniques are now available in the form of computer softwares for reliability analysis [5,12].

There are, however, still many unanswered problems particularly in the new deregulated environment and considerable research is in progress to address these issues.

It is important to consider the vast amount of work that has been done over the last five decades [2-12], when considering the problems that face electric power utilities at the present time. Some of the basic concepts associated with power system reliability are briefly introduced in the following section.

1.2 Power System Reliability Evaluation

Adequacy and Security:

Power system reliability assessment is primarily focused on an analysis of the healthy and failure states of a power system. Power system reliability can be subdivided in two classes as shown in Figure 1.1 [1,2].