

Reliability Assessment of Redundant Electrical Power Supply Systems using Fault Tree Analysis, Reliability Block Diagram, and Monte Carlo Simulation Methods

Rabah Benabid
Electrical Engineering
Department, CRNB
A/O, Djelfa, Algeria
rabah_benabid@yahoo.fr

Djemai Merrouche
DTN, CRNB
A/O, Djelfa, Algeria
merrouche_dj@yahoo.com

Aissa Bourenane
DTN, CRNB
A/O, Djelfa, Algeria
bourenane.aissa@gmail.com

Robertas Alzbutas
Lithuanian Energy Institute
Kaunas University of
Technology
Kaunas, Lithuania
robertas.alzbutas@gmail.com

Abstract—This paper deals with the reliability assessment of electrical power supply systems under redundancy. For doing so, three probabilistic safety analysis (PSA) methods are proposed and developed namely fault tree analysis (FTA), reliability block diagram (RBD), and Monte Carlo Simulation (MC) method. The FTA method is performed using RiskSpectrumPSA® software and the RBD and MC methods are coded using Matlab software. The electrical power supply system reliability is analyzed and enhanced considering various cases of redundancy. The FTA method is based on qualitative and quantitative reliability assessment. The quantitative assessment calculates the failure probability of the top event, and the qualitative approach determines the minimal cut sets (MCS). However, the RBD and MC methods are proposed to compute the system failure probability. The considered methods are applied on three case studies and the obtained results are compared to each other. The obtained results show that the three methods provide almost the same results. Furthermore, the reliability of the electrical power supply is clearly enhanced with the number of redundant components.

Keywords—electrical power system reliability; probabilistic safety assessment; fault tree analysis; reliability block diagram; Monte Carlo simulation; Redundancy; RiskSpectrumPSA software; minimal cut sets; qualitative and quantitative safety assessment.

I. INTRODUCTION

The electric energy is considered as the heart of the industry development, the human's life comfort and the operation safety of industrial installations. This electric energy must be reliable and must have the best quality in order to fulfill the predefined industrial installations requirements. Generally, the reliability of a system is defined as the probability that this system can perform its intended function for a specified interval under stated conditions. Therefore, the electrical power supply system of an industrial installation must be designed in a manner that provides a best quality and reliability of electrical power. For this, some critical industries need a high level of electrical power supply reliability and don't allow its loss. However, an unreliable electrical power

supply system can cause severe accidents [1]. Therefore, the electric power supply reliability must be continuously evaluated and assessed. This evaluation can be performed during different lifetime stages of the installation (e.g. design, construction, operation, aging, and/or decommissioning).

Various approaches for systems reliability assessment have been proposed in the literature [2], where, the electrical power supply reliability is usually performed using either the deterministic or the probabilistic methods. The deterministic assessment of electric power reliability is generally based on N-1 and N-2 methods. The N-1 method considers the outage of one electric component (e.g. transmission line, generator, or transformer) and check if the electric parameters of power system remain in the nominal interval of variation. The N-2 method considers the failure of an electric component and the maintenance of another one.

The probabilistic assessment of power system is based on the analysis of all possible events that may occur according to their probabilities in order to compute the failure probability of the overall system. The most popular methods used for power system reliability assessment are: Fault Tree Analysis (FTA), Reliability Block Diagram (RBD), Markov chain, and Monte Carlo Simulation (MC).

The reliability evaluation of electrical systems using FTA has been widely proposed [3-9]. In [6], the qualitative and quantitative reliability assessment of an electrical power supply system is presented using FTA and Minimal Cut Sets (MCS). In [7, 8], the FTA is used to evaluate the power system reliability at the load points. The quantitative and qualitative FTA assessments were used to identify the most important elements in the power system. In [9], the FTA method is applied for customer reliability assessment of a distribution power system.

Many practical uses can be highlighted for utilization of RBD in reliability assessment. In [10], RBD and FTA methods are developed for reliability analysis of a fire pump. Likewise,

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and COG EMR Other systemic analysis approaches for quality and stability of systems as well as for safety and robustness analysis tools are also proposed One chapter is dedicated to energy management and another is focused on Monte Carlo algorithms for electrical systems and networks sizing The aim of this book is to summarize design methodologies based in particular on a systemic viewpoint by considering the system as a whole These methods and tools are proposed by the most important French research laboratories which have many scientific partnerships with other European and international research institutions Scientists and engineers in the field of electrical engineering especially teachers researchers because of the focus on methodological issues will find this book extremely useful as will PhD and Masters students in this field

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