Chapter 10
Identification of Reliability Critical Items in Large and Complex Rail Electrical Networks

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ABSTRACT

Rail electrification network, within the concept of smart grid, integrates various technologies and is operated in an environment where the behavior and failure modes of the system are difficult to model. It has been proven that modern electrical networks are rather complex, involving multi-dependencies between components (also called system variables) and uncertainties about these dependencies. Modeling and quantification of the reliability for a large system, which requires the handling of dependencies and uncertainties is a complex task, especially for the system where high availability is required. System design includes historical experiences and evidence; therefore, system correctly performs its intended functions. However, wrong method or system model for the purpose of reliability analysis can lead to over or underestimation of the system reliability. In this work, Hierarchical Bayesian Networks are applied to model and assess the reliability of a large and complex rail electrification network and the reliability critical items are identified.

INTRODUCTION

A smarter and intelligent grid, also called a smart grid is equipped with advanced communication, sensing and control technologies at generation, transmission, and distribution level to perform these tasks in efficient, intelligent, dynamic and smart ways. The smart grid helps improving energy-efficiency, reduced CO\textsubscript{2} emission and safe and reliable, stable and greener power supplies for different applications. Smart grid can achieve the above mentioned tasks by utilizing advanced techniques for dynamic demand response, variable pricing, distributed generation and their incorporation to the main electric grid. For details on the application of smart grid and associated concepts readers are referred to (Hassan, Pasha, Yuen, Huang & Wang, 2013; Ahmad, Hassan & Shah, 2014; Hassan et al., 2016; Palfreyman, 2012)

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and references there. Railway Electric Smart Grid (RSG) is the next generation of the electrical power system that form from interdependent and integrated networks. RSG is aimed to manage both the rail traffic and rail electrification in an integrated way. So that different problems such as capacity limitations and changes in the planned operation schemes can be solved efficiently and on real time basis. For this, the RSG has to integrate the operation of railway and the electrification in intelligent ways (Pilo de la Fuente, Mazumder & Gonzalez Franco, 2014; Palfreyman, 2012). For example, (NASCAR, 2014) has presented a smart DC micro-grid solution for reducing braking energy losses in railway traction and power systems during operation times. This study investigated the possibility to store the energy and re-use it in other applications within the concept of smart grid. In this way, the Energy Management System will optimize energy flow by selecting the right operation mode of train, controlling the energy converters and the storage system’s state of charge. The classical rail electrification systems and their controls cannot address these problems. The modern electric traction system controls, converts and transmits electric energy to the trains and other Installations along the line via the contact line system and return circuit and using smart grid concept. The reliability of RSG operation is, amongst others, dependent on the reliable traction power supply of rail electrification system and its different technical components. A number of consequences will occur if the rail electrification is less reliable, including loss of train operation. The reliability of a rail electrification system ensures the availability of the supply of traction power. The influence of the reliability on availability can be seen in Figure 1. For instance, negative effect on train service due to unavailability of traction power supplied through the rail electrification network has negative consequences. The traction power supply for railways must be designed accordingly.

Figure 1. Effect of reliability on system availability
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