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Study and Filtering of Harmonics in a DC Electrified Railway System

Yacine Djeghader[1], Laid Zellouma[2] , Hocine Labar[3], Riad Toufouti[1], and Zoubir Chelli[1]

[1]*Department of Electrical Engineering, University of Souk ahras –Algeria*

[1]djeghaderyacine@yahoo.fr

[2]*Department of Electrical Engineering , University of El-Oued –Algeria*

[3]*Department of Electrical Engineering , University of Annaba –Algeria*

***Abstract* - The railways are used to transport people, but also for the industry. In this article we present a simulation of real DC traction power supply that intended to transport the natural resources (iron, ore and phosphate) from its source to the industrial areas. We made a model in Matlab/Simulink of a DC traction substation which is located in the mineral line Tebessa - Annaba (in Algeria). Our study focused on the propagation of harmonic currents in the electric network and their filtering solution. The simulations results obtained in this paper for standard operation conditions are presented shows that a value of total harmonic distortion (THD) current exceeds the standards (IEEE 512-1992). In this paper, we present the most effective solution, most used and least expensive to mitigate harmonic currents is the passive filtering, using filters (tuned at frequencies 11 and 13) at two different locations compared to the transformer which supplies the traction substation .In the end we compare the results obtained by determining the THD in each location .**

***Keywords* –Harmonics, Power quality, Passive filter, Railway System, Traction substation.**

I. INTRODUCTION

The railway is a way that meets the country's economy especially in the agricultural and industrial sectors. Railway electrification emerged as means of electrification in late years of nineteen centuries [1] & it came to Algeria in 1930 due to importance of the traffic of mineral line "Tebessa-Annaba» compulsory decided electrifying the railway line, with the implementation of DC traction substations between places of natural resources (iron, ore and phosphate) and the port of Annaba. DC Electrified railways play an important role for domain of transportation because of high efficiency, heavy ridership and fast transportation (high initial torque of series DC motor). However, the electrified railways cause great problems for the power quality of the distribution system feeding the traction system such as injecting harmonics, reactive power compensation and low power factor issue [2-3]. High THD of the system current, harmonics, reactive power consumption, voltage unbalance and flicker and low power factor problems can suffer the power distribution system feeding the traction system greatly [1-4]. Harmonic distortion in the electric system is very vast problem for all electrical power researcher and they continuously worked on the mitigation of harmonic component (specially the harmonics current) in the system to make system neat, clean and consumer avail electrical utilities in very determinant, with high performance and high efficiency [5-6]. These problems can be solved by using a passive filter in the traction substations (applied in our work); because they are cheap, economy and work in the middle and high voltage, eliminate negative sequence current, and also participate in the compensation of the reactive power deficit thus improving the power factor of the power networks [7]. Therefore it was necessary to upgrade and expand the network, adapting safety facilities, and responding to the needs and necessities of modern transportation (safety, regularity, comfort, speed, hygiene, etc ...).

II. DESCRIPTION OF DC TRACTION SUBSTATION

With the development of electrified railway, electric locomotive was applied in railway transportation more and more widely. And they can be harmed security on power system network, production and manufacture badly and more then electrified railway security and reliability in the railway transportation [4]. The electrical power system in study is a DC substation traction system in the mineral line studied in east of Algeria. The power system of DC electrified railways includes traction substations for stepping down and converting the AC voltage to DC. The schematic diagram of the power distribution system of a DC electrified railway is shown in figure 1. The traction substation has feed by a three winding transformers with Y/Y/Δ connections which step downs the 90 kV AC grid voltage to 2x 1236 volts AC. Two six-pulse rectifier units are connected in series to the outputs of the transformer which convert the 1236 volts AC to 1500 volts DC. This connection of two fully 6-pulse converter bridges and requires two 3-phase systems which are spaced apart from each other by 30 electrical degrees. The phase difference effected to cancel out the 6-pulse harmonics (5^{th} and 7^{th}) on the AC and DC side. The DC voltage is then transmitted along the track through overhead contact; with a voltage value of 3000V and direct current of 1000 A. This DC supply system (3000 V and 1000 A) supplies a electric locomotive (3600 Ch), when the positive output of the group rectifier (3KV) connected to this locomotive, while the negative output will be connected to the rail to ensure the return current (figure 1). The locomotive used consists of six DC traction motors each of these motor powered by a voltage of 750 V across a buck chopper [9]