

Design a nine-level modular multilevel converter for DC railway electrification system

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ABSTRACT

A recuperating converter is highly demanded in traction power substation to deliver the braking energy generated by a traction vehicle. Conventional voltage source inverter had been implemented in the traction power station. However, large AC line filters must be installed to improve the quality of AC voltages and currents. This paper proposes to install a nine-level Modular Multilevel Converter (MMC) as a recuperating converter. The main aim is to eliminate the need of AC line filters while producing good quality of AC voltage and current waveforms. The MMC is designed and modelled using MATLAB/Simulink Simulation tool. A centralized control of balancing all the sub-module capacitor voltage level is proposed with Third Harmonic Voltage Injection Level Shifted Pulse Width Modulation (THVI-LSPWM) technique. The simulation results prove that with the application of MMC, good quality of ac voltages and currents are being produced. The Total Harmonic Distortion indexes are found less than 3.5 % without using any AC line filters in the system. In addition, the classic DC link capacitance has also being eliminated.

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1. INTRODUCTION

Electric trains draw massive power from the utility grid to accelerate from standstill. They are then worked as generators upon reaching next passenger station. It is predicted that approximately 50% of the regenerative braking energy can be reproduced [1-3]. The regenerative energy had been stored using onboard or wayside energy storage system [4-7]. These systems are fully equipped with different energy sotrage modules, such as batteries, fuel cell, flywheels, and ultracapacitors.

Alternatively, the regenerative energy can be transmitted back to the power grid without using energy storage elements [8-10]. Figure 1 (a) illustrates one of the recuperative converter system proposed in [8]. Although a conventional Voltage Source Inverter (VSI) is capable to deliver the energy back to the power grid, an installation of AC filters is a must. These filters are used to suppress undesired harmonics components. In order to eliminate the AC filters, this paper proposes to replace the conventional VSI with a Modular Multilevel Converter (MMC) as shown in Figure 1 (b).