Hyundai Develops Direct AC/AC Power Conversion for Elevator Drive

Introduction

The Hyundai Elevator Co., Ltd. manufactures a wide range of elevators, escalators, moving walkways, material handling systems, auto-parking systems and platform screen doors. Within the Hyundai Ichon Head Office & Factory in Korea, the "Hyundai Spirit" – the creative culture that permeates the whole company – is alive and thriving.

Challenge

It is here that a new type of AC/AC converter for elevator drives was conceived and designed. The new converter is capable of converting three-phase (50/60 Hz) line-power to variable-voltage-variable-frequency (VVVF) three-phase AC power *without* a DC-link, the usual intermediate conversion stage required for practically all of today's motor drives. The absence of a DC-link means that the DC storage capacitor is no longer required and this has considerable advantages. Firstly, capacitors are bulky and expensive and need pre-charging circuits to limit the otherwise large inrush currents on starting the drive. Capacitor volume is normally minimised for low voltage applications (such as elevators) by using electrochemical capacitors. These ubiquitous components, however, have the shortest life expectancy of any power electronic devices used in drives and have been the object of much research with the aim of reducing or eliminating them from new converter designs. The rapid growth of low voltage drives (LVDs), typically for low-cost, high-reliability applications such as elevators and heat-pumps have increased pressure on designers to find ways of eliminating large capacitors (as well as inductors) in these applications and Hyundai Elevator took up the challenge of eliminating the DC-link altogether for a high-reliability regenerative drive.

Options

Two options presented themselves for the line-side converter:

1. an active front end rectifier providing high-frequency PWM boost for active-power extraction, still requiring some capacitance

or

2. a line-frequency switched rectifier which puts the line and filter inductances directly in series with the load inductance effectively converting the DC link into a current source. This approach requires only a small capacitor to filter out the high frequency current ripple and to maintain the current source during switching.

Photo: Hyundai Elevator

Yun-Young Choi:

„Using PLECS simulations decreased actual simulation time by 50 % and, more importantly, our learning cycles were considerably shortend.“

Solution

Hyundai Elevator chose the second solution as it was found to best meet the design criteria, namely lowest capacitance and minimal passive component-count.

This radical departure from a conventional voltage-source converter (VSC) topology, required iterative simulations of the possible topologies and their various component combinations.

Hyundai Elevators's original simulation tools proved to be too cumbersome for the efficient evaluation of the multiple options and operating conditions, which had to be considered in this project. This led Hyundai to turn to PLECS® simulaton software, which immediately provided the fast and stable simulations they required.

Conclusion

"We were able to quickly interface our power electronics to our existing MATLAB®/Simulink® controllers and obtain fast and stable simulations", says Yun-Young Choi, Assistant Manager at Hyundai Elevator R&D Institute. "Even beginners, unfamiliar with simulation techniques, are easily able to drag-and-drop components from the rich PLECS Library and get, as it later turned out, exact results. Using PLECS simulations decreased actual simulation time by 50 % and, more importantly, our learning cycles were considerably shortend. We believe that PLECS is an ideal simulation tool for experienced engineers and students alike, and adopting this simulation package was a major contribution to the successful development of our innovative drive."

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