Motor Overvoltage and Power Losses Analysis in Industrial AC Drives Based on Si and SiC Devices

Summary

In recent years, SiC based switches have become an attractive solution in the field of high-speed motors for replacing traditional Si based switches, mostly because of their higher switching frequency capability. The adoption of SiC devices in three-phase inverters has a series of advantages and drawbacks. The advantages include higher converter efficiency and the possibility to increase the switching frequency, which results in the reduction of heat sink size and inductive elements. The insulation stress on the electric machine due to the overvoltages caused by high dv/dt and long cables are the main drawbacks of the drive when SiC devices are used.

The research activity was sponsored by Fidia S.p.A, which is active in the realization of machine tools. The aim of the company was to realize an industrial inverter based on SiC devices controlled by an FPGA. A new converter was designed, built and tested. This converter offers the possibility to perform fair comparisons between different switch configurations: all-Si, Si-SiC and all-SiC. The comparison reveals remarkable losses reduction in all-SiC configuration however, serious problems at the motor terminals were found even with few meters of connecting cable.

In order to solve this problem, a detailed study of the drive was conducted and a more accurate model of the cable was derived. Using this model, formulae used for RL filter design were derived and a filter was designed, build and tested. A new issue emerged from the experimental results when RL filter was used in combination with all-SiC. An unpredicted additional motor overvoltage was detected which was due to the combination of the filter resistor parasitic inductance and the high dv/dt. The design formulae were readapted and then experimentally were validated. Finally, a circuital solution for the compensation of the resistor parasitic inductance issue was proposed.