Fault Diagnosis in High Power Drives Based on Multilevel Converters

The first goal of the project is the development of fault diagnostic techniques for multilevel converters in order to obtain high power adjustable speed drives with fault tolerance. The second goal of the project is the study of the motor thermal behaviour when fed by the converter in fault tolerance mode and corresponding motor efficiency analysis.

Main Project Team	
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Funding Agencies	
FCT	**169,372€**
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Indicators	
Journal Papers	2
Conference Papers	7
Concluded Msc	5

Two Main Publications

A. M. S. Mendes, M. Bandarabadi, S. M. A. Cruz, **Fault diagnostic algorithm for three-level neutral point clamped AC motor drives, based on the average current Park's vector**, IET Power Electronics, Vol. 7, No. 5, pp. 1127-1137, May, 2014

B. Baptista, A. M. S. Mendes, S. M. A. Cruz, A. J. M. Cardoso, **Temperature Distribution Inside a Three-Phase Induction Motor Running with Eccentric Airgap,** Przeglad Elektrotechniczny, Vol. 88, No. 1a, pp. 96-99, January, 2012

PROJECT WEBPAGE URL
http://multilevel.co.it.pt/

Fig. 1 Interior details of the developed prototype.

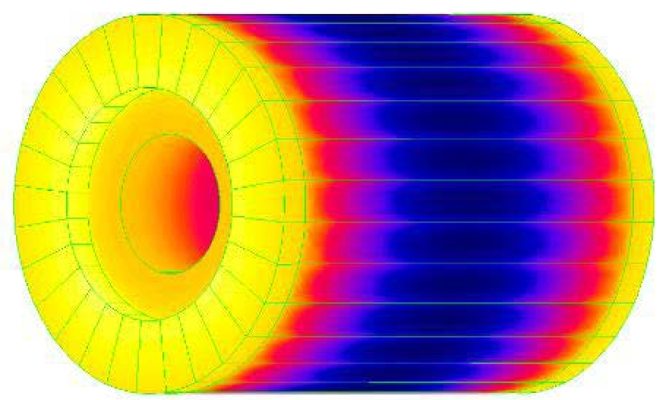

Fig. 2 3D Thermal result of the three phase induction motor

GENERAL MOTIVATION AND OBJECTIVES

The multilevel converter topology can be found in several high power applications such as pumps and fans, power generation plants and cement industry, as well as in electric vehicles and renewable energy systems, among others.

Despite all the investigation dedicated to the multilevel converter, one of the issues that was not yet fully investigated is the fault diagnosis of the converter switches. The semiconductor switches faults can generate disturbances on both AC motor and mains voltage due to an unexpected performance on the multilevel converter. These adversities are particularly important in high power adjustable speed drives (ASD) applications, where high reliability constitutes a major requirement.

Therefore, the main motivation of this research is the investigation and implementation of self-diagnostic and fault-tolerant control strategies in high power adjustable speed drives, based on multilevel converter topology. Taking into account that a large percentage of electrical failures in the motor is usually related to stator coil insulation problems due to overheating, it is important to understand how the temperature imposes limitations on the performance of the machine. As a result, it is important to study the behaviour of the motor when fed with non-ideal conditions, resulting from a post-fault drive reconfiguration, in order to identify the thermal sources in the electric machine.

CHALLENGE

One of the challenges of this work is the development of an online fault diagnostic method able to detect and to identify the IGBT that has a permanent fault of open circuit type.

The diagnostic algorithm should be based on electrical quantities already used by the drive controller in order to avoid extra costs in this type of variable speed drives. Usually the available quantities are the motor current and line voltage. To achieve this goal, dedicated printed circuit boards with current and voltage sensors will be developed.

Another challenge for this project is the development of a data acquisition system to simultaneously measure electrical, mechanical and thermal quantities, particularly for the rotor circuit temperature. All the information related to rotor temperature should be acquired through a wireless system to be designed under the project.

To get information about magnetic quantities of the three-phase induction motor, 2D and 3D finite element models of the tested machine will be developed. These models will be useful to estimate motor iron losses and to analyse the unbalance magnetic pull.

WORK DESCRIPTION AND ACHIEVEMENTS

It will be investigated and implemented a high power adjustable speed drive prototype, based on multilevel converter topology with self-diagnostic and fault-tolerance. The prototype includes one rectifier and one inverter, both implemented with IGBT semiconductors technology.

It is expected that this system be able to diagnose faults in the utility grid, in the multilevel converters and in the AC motor. The obtained diagnostic result will be useful to select the appropriate reconfiguration steps in the drive by the main control system in order to keep the motor in operation with the best performance as possible.

After IGBT fault detection, the faulty IGBT will be isolated and the faulty converter continues the operation with two legs. For the inverter faulty case, the motor phase which was connected to the inverter faulty leg will be connected to the DC link middle point. For the rectifier faulty case, the phase of the grid which was connected to the rectifier faulty leg will be connected to the DC link middle point.

The induction motor performance will be analyzed, under normal and post-fault working conditions, based on some parameters such as efficiency, power factor, voltage and current distortions, losses in the electric and magnetic circuits, among others. These models will be useful to estimate iron losses in the induction motor and analyze the unbalanced magnetic pull.