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A Novel Harmonic Compensation Algorithm for High Speed Drives

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Abstract : The past few years study of very high speed electrical drives have seen a resurgence of interest. An inventory of the number of scientific papers and patents dealing with the subject makes it relevant. In fact democratization of magnetic bearing technology is at the origin of recent developments in high speed applications. These machines have as main advantage a much higher power density than the state of the art. Nevertheless particular attention should be paid to the design of the inverter as well as control and command. Surface mounted permanent magnet synchronous machine is the most appropriate technology to address high speed issues. However, it has the drawback of using a carbon sleeve to contain magnets that could tear because of the centrifugal forces generated in rotor periphery. Carbon fiber is well known for its mechanical properties but it has poor heat conduction. It results in a very bad evacuation of eddy current losses induce in the magnets by time and space stator harmonics. The three-phase inverter is the main harmonic source causing eddy currents in the magnets. In high speed applications such harmonics are harmful because on the one hand the characteristic impedance is very low and on the other hand the ratio between the switching frequency and that of the fundamental is much lower than that of the state of the art. To minimize the impact of these harmonics a first lever is to use strategy of modulation producing low harmonic distortion while the second is to introduce a sinus filter between the inverter and the machine to smooth voltage and current waveforms applied to the machine. Nevertheless, in very high speed machine the interaction of the processes mentioned above may introduce particular harmonics that can irreversibly damage the system: harmonics at the resonant frequency, harmonics at the shaft mode frequency, subharmonics etc. Some studies address these issues but treat these phenomena with separate solutions (specific strategy of modulation, active damping methods ...). The purpose of this paper is to present a complete new active harmonic compensation algorithm based on an improvement of the standard vector control as a global solution to all these issues. This presentation will be based on a complete theoretical analysis of the processes leading to the generation of such undesired harmonics. Then a state of the art of available solutions will be provided before developing the content of a new active harmonic compensation algorithm. The study will be completed by a validation study using simulations and practical case on a high speed machine.

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