Multiphase drives: towards a system approach

The transport of electrical energy by three-phase grid has led, by the past, to the development of three-phase electrical machines. These have benefited from the development of power switches and control components such as Digital Signal Processor (DSP). The performances of the conventional three-phase electrical machines are then increased when used associated with power inverters, especially in the field of variable speed.

However, problems arise both in the VSI and machine when it is desired to increase the transmitted power or when working at low levels of voltages as in automotive. The switches have then to switch voltages and/or currents of higher amplitude (higher unit cost for modules and increased electromagnetic pollution). Moreover, for a given current, increasing power leads to constraints for voltage insulators. This latter effect of stress (rapid aging of dielectrics) is even more pronounced when the machine is classically supplied by a Pulse Width Modulation voltage source inverter. A classic way for solving these problems is the use of multi-levels converters but a split of power by increasing the number of stages of the machine is an alternative. For given power and current the voltage constraints decrease. Multiplying the number of phases allows the use of electronic modules of identical power cost per unit (a positive element in terms of maintenance costs). Moreover, this kind of multiphase structure can increase the fault tolerance of the electromechanical converter since it is possible to work when one phase is open-circuited. In fact, the main idea is to distribute stresses between the converter and the machine. Similarly, in the case of low voltage equipment (e.g. in automotive), the presence of currents of very high intensity generally requires to synthesize one switch by association in parallel of elementary switches. In this case it can be appropriate (in order to reduce oversize of switches) to distribute all these switches and to use more than 3 phases. Again, the multiphase machines are an economical alternative since they can reduce the torque pulsations and hence the noise of electromagnetic origin.

The research problem is the study and development of complete sets including the electronic static converter, the multiphase machine and the vector control. Indeed, the match between the machine and the converter is more necessary than in the case of a three-phase machine since the control of the converter cannot compensate constructive defects of the machine. Thus, a voltage inverter that supplies a machine with a multiphase winding optimized for a sinusoidal magnetomotive force will induce eddy currents of high amplitude in the machine. It is therefore necessary to redesign the coil in order to decrease the sensitivity of the electrical machine.

The adequacy of the electromechanical converter to static power converter is sought at first by acting on the constructive parameters of the multiphase machine. On the other hand, the degrees of freedom offered by the static converter control (choice of vector voltage activated) are used in order to best exploit the multiphase machine (reducing stray currents, working in fault configuration, increasing torque density ...). Thus it is presented a system approach that simultaneously combines the design of machine and the control of electronic power converter.