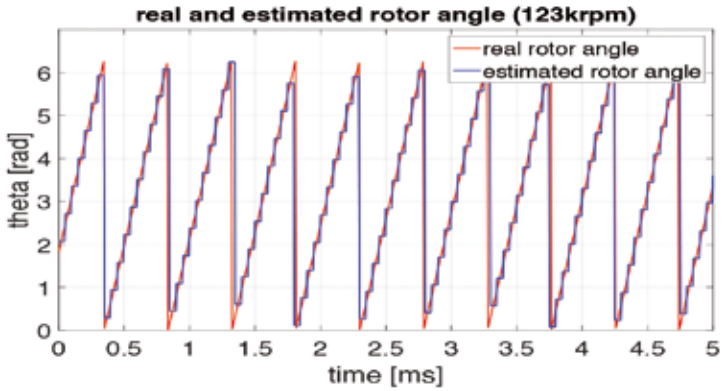
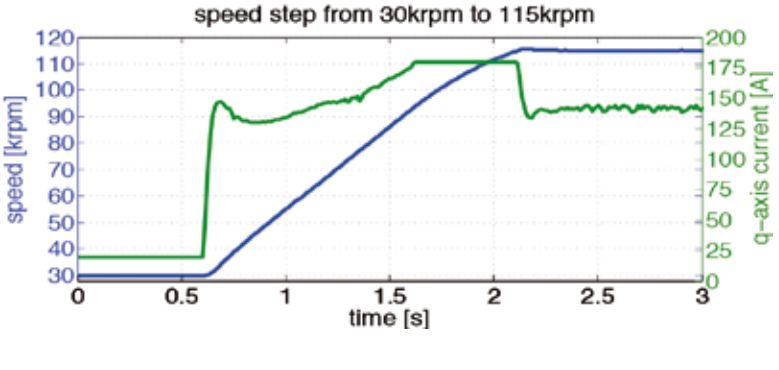
Design and control of super high-speed electrical machine for a fuel-cell compressor for automotive applications

High-speed electric drives are gaining popularity in various applications: pumps, compressors, blowers, hybrid-electric vehicles and micro gas turbines. This is thanks to the advantages of such drive solutions, among the others the increase of the power per kilogram ratio of the machine.
This advantage, is particularly well suited in mobile applications such as electric vehicles where space and weight saving is a mandatory target in order to improve the system's consumption and emissions. Another important advantage is the reduction/removal of intermediate speed-up gearbox thanks to the adoption of a high speed motor: this yields an immediate improvement of the system reliability and a reduction of its maintenance cost.
Nevertheless, the operation of the motor at high speed requires a particular system design. Traditional bearings are normally avoided for high speed machines and a bearing-less solution or air bearing configurations are adopted. The latter is particularly advantageous in high speed compressors, where the air bearing can be fed directly by the compressor outlet. Such solutions introduce additional requirements on the drive, e.g. when it comes to the design of the start-up procedure. Further, the mechanical constraints in the use of position resolvers for high speed permanent magnet synchronous motors call for efficient sensor-less control algorithms based on speed estimators. The electrical peculiarities of such high speed machines (such as low stator inductance and resistance) can cause a series of problems with the stability of the control, if the position and speed of the rotor are not known with high precision.
EDLab conducted a research in cooperation with Alpitronic and BMW to develop and implement an electric drive for a super-high speed compressor for fuel cells (i.e. 130,000 rpm) designed for an electric vehicle. A control scheme, based on a sensorless Extended Kalman filter algorithm, has been implemented and successfully tested in a real drive system with three different compressor prototypes. Experimental measurements at full speed and in dynamic response have been successfully performed.





Ingegneria dei sistemi elettrici
Electric systems

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Research in cooperation with:

Main research topics:

- EDLab is mainly devoted to the study, design and experimental validation of advanced issues related to the design and the control of electrical motors for variable speed drives for any industrial, commercial and home application.

- A distinctive recognized feature of EDLab is the development of researches in tight synergy between the motor designers and the control designers.