Sensorless Identification and Plug-in Control of AC Synchronous Motor Drives
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Recently, high efficiency AC Synchronous Motors are replacing DC and Induction Motors (IM) in a growing number of applications, and the sensorless control is a key enabling technology for this process. High anisotropy motors (SyRM & PM-SyRM) are inherently suited for sensorless control, but they are characterized by complex magnetic structure. Appropriately chosen strategy and good parameters identification are required.

Addressed research problems

1) Sensorless Self-identification
The knowledge of the machine magnetic parameters is of top importance for the control of synchronous drives. In particular, SyRM and PM-SyRM have highly nonlinear current to flux linkage relationships. Also, inverter nonlinearities must be evaluated.

2) Sensorless Control
Sensorless control of synchronous drives is a notable challenge. The literature presents many hybrid strategies combining model based observers and HF injection, but requiring specific optimization and tuning. The thesis tries to find a universal plug-in control suitable for a large number of motor types.

Novel contributions

1) Sensorless Self-identification
A standstill method is proposed and experimented tested on SyRM and PM-SyRM, with promising results. High robustness against parameters estimation is achieved. The method was further improved with closed loop position estimation.

A novel test is used to evaluate the flux linkage contribution introduced by (eventual) PM at standstill.

2) Sensorless Control
Specific issues of pure SyRMs are investigated, including 0-current and high cross-saturation regions. Use of MTPA and minimum flux linkage are extensively discussed, together with the feasibility and accuracy of the adopted observer are evaluated. Automatic tuning procedure is also suggested.

Journal Papers:

Conference Papers:

PM flux evaluation at standstill is obtained via DC excitation on the zero torque locus.

Future work

- Test different self-commissioning methods, especially for PM motors (e.g. speed ramps)
- Improve the sensorless control dynamic and automate the tuning procedure, obtaining a universal plug-in sensorless control
- Extend the research to IPM and SPM machines

List of attended classes

Hard skills:
- DQ3ERV - Advanced control in electrical energy conversion: a practical approach to real-time implementation (didattica d’eccellenza) (17/10/2017, 20h)
- O1Q4W6R - Mathematical-physical aspects of electromagnetism (28/9/2016, 15h)
- O5Q18B5R - Optimization methods for engineering problems (10/4/2016, 30h)
- O6Q5KRV - Evaluation di impatto ambientale di campi magnetici ed elettrici a frequenza industriale (27/6/2016, 20h)
- IEEE International Machines and Drives Conference IEMDC 2017 (21/5/2017, 30h)
- PSIM training seminar, offered by PowerSys (17/11/2017, 30h)
- 17th European PhD School: Power Electronics, Electrical Machines, Energy Control And Power Systems (23/9/2016, 30h)
- Summer Course on Power Electronics and Applications (17/7/2016, 30h)
- XXIII International Conference on Electrical Machines (ICEM) (4/9/2016, 30h)
- JMag basic and advanced course, offered by Powensys (4/10/2016, 14h)

Soft skills:
- O1LWHRV - Communication (20/8/2016, 5h)
- O1Q54B5R - Communication II (18/11/2016, 12h)
- O8XTRV - Project management (20/9/2016, 5h)
- O1Q5NVR - Public speaking (20/8/2016, 5h)
- O5PRCRV - Public speaking II (13/7/2016, 12h)
- O1Q5NRV - Writing Scientific Papers in English (20/6/2016, 15h)