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Sensorless Control for Synchronous Reluctance Motors

High energy efficiency without rare earth metals, increased reliability at lower production and maintenance costs

Synchronous reluctance motors (SyRM) do not require magnets containing rare earth metals, the extraction and availability of which are increasingly subject to discussion, they feature a simple and at the same time rugged design, and are therefore more and more used in high-speed applications.

However, many beneficial applications of SyRMs have not yet been realised to date merely because the use of a position sensor was considered necessary – in particular if a high starting torque is required. With their superior efficiency of around 90% compared to 85% of asynchronous motors – for example in the output range of several kW – they become more and more attractive for energy sensitive applications. They do not need rare-earth magnets and are characterised by their simple and rugged design. For this reason, they are increasingly used in high-speed applications.

In contrast to permanent magnet synchronous motors (PSM), a SyRM does not show any resulting magnetic forces in a currentless state; it is therefore highly attractive for a number of applications, e.g. with magnetic bearings. Proven stator technology of an asynchronous machine may be used for setting up a SyRM so that only the rotor needs to be replaced. Switching to this very energy-efficient technology is therefore quick and easy.

Defects in sensors or their wiring are responsible for many motor breakdowns. In particular for safety-critical applications and in difficult environmental conditions, sensors are rather avoided. But also for conventional drives, production and maintenance costs as well as construction volume may be reduced easy.

Objective

The aim of Prof. Manfred Schrödl and his team at TU Wien originally was to develop a new type of control that does not require an extra motion or position sensor but that would still ensure the maximum torque – according to current consumption – at each operating point. It should thus allow for the targeted "jerk-free" acceleration and braking of a permanent magnet synchronous motor from a standstill under variable load. Now the focus is on constructing motors without rare earth metals.

Sensorless controlled synchronous motor without rare-earth metals

Approach

For SyRMs, "field-oriented" controls are used almost exclusively. It implies that the stator current is applied in such manner as to constantly produce the maximum torque in the machine with the given current amplitude. It is achieved by applying the current at a specific angle relative to the rotor. This in turn requires information about the rotor's position in the SyRM, which is supplied by a position sensor to date.

If it is not desirable or not possible for technical reasons to mount a sensor for determining the position, we talk about sensorless control. The rotor's position is then calculated from the actual current and voltage values.

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The electric reaction to applied test pulses allows for determining the rotor position unambiguously. For high speeds, a so-called voltage model (EMF model) is used that establishes the rotor position from the actual current and voltage values with the aid of electric machine models. At low speeds and at a standstill, however, this method will fail as the voltage induced is too small or equals zero. Covering the lower speed range becomes possible through the INFORM method invented by Prof. Schrödl. It utilises the SyRM's magnetic characteristics as well as an asymmetry defined by the rotor's position. By analysing test pulses of only a few millionths of a second, the rotor position may be determined.

INFORM stands for "INdirect Flux detection by Online Reactance Measurement" and means:

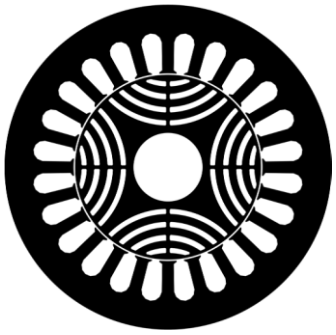
Analysis of the current slope due to voltage pulses from the inverter.

- With turning rotor, the space phasor of the current change moves along a circular path with offset
- Track speed is double the rotor speed

This method functions particularly well for SyRMs as they always feature considerable differences in longitudinal and transverse inductance. High asymmetry in the magnetic characteristics of a SyRM is the ideal basis for sensorless control. At lower speeds such as when starting up the motor, the exact position needs to be measured very frequently. It is possible to adapt the pulses so that the issued soundwaves are within a frequency range that is beyond the audible range.

Tried and tested

The full torque of the drive is available even from a standstill – within a few milliseconds! In most varied applications and with several thousand units in daily use, this control technology has already demonstrated its suitability for practical use in permanent magnet synchronous motors. It has become evident that sensorless synchronous motors are energy and cost-efficient in use for both conventional and highly unusual applications. This technology is suitable for challenging uses in production machines, ventilation and air-conditioning technology, motor vehicles and medical technology as well as in special environmental conditions.



Reluctance motor with distinct flux guides and flux barriers

It is also possible to realise noise-sensitive applications – in ventilation systems or for special low-noise environments, for instance.

Your benefits

- Your synchronous motor requires no rare earth metals.
- It enables highly dynamic, stepless and "jerk-free" control.
- Your drive disposes of the highest possible torque – from a standstill.
- You save the costs for motion or position sensors. The wiring effort decreases.
- Your drive's dimensions become smaller.
- You do no longer need to match the position sensor and the magnets' position in the motor when mounting or repairing the system.
- Possible wiring and maintenance errors of the connection between sensor and controller are excluded.
- Your drive remains without perceptible noises caused by the control – across the entire speed range.
- Your drive has overload capability while you remain in full control of the start-up process; the risk of blocking is reduced.
- TU Wien will be happy to support you to implement this technology for sophisticated drive solutions ranging from a few watts up to several kilowatts.

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