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Sensorless Control for Synchronous Motors

Increased reliability with lower production and maintenance costs

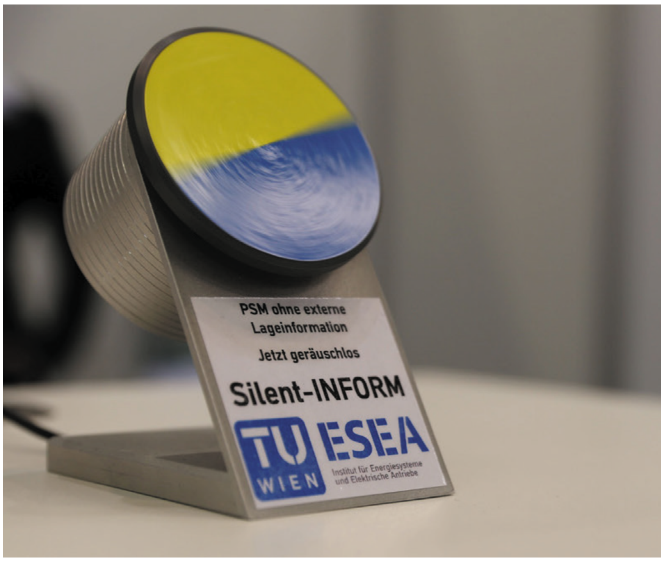
Permanent magnet synchronous motors (PSM) are well known for being highly dynamic. Because of this, they have been used in robotics and machine tools for some time. The efficiency of PSMis superior to that of induction motors (e.g. in the kilowatt power range: 90% compared to 85%). PSM are therefore growing in importance regarding use in efficiency-sensitive applications such as drives in battery powered vehicles (to expand range) or heating and air conditioning (24/7 service) and refrig- erators and freezers (energy- performance label A+++).

Synchronous reluctance motors (SynRM) do not require magnets containing costly rare earth metals. They feature a simple and at the same time rugged design, and are therefore more and more used in high speed applications.

Many beneficial applications of PSM and SynRM 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. Defects in sensors or their wiring are responsible for many motor breakdowns. Particularly for safety-critical applications and in difficult environmental conditions, one would like to avoid sensors. However, production and maintenance costs as well as construction volume can be reduced for traditional drives as well.

Objective

The aim of Prof. Manfred Schrödl and his team at TU Wien was originally to develop a new type of control that does not require an extra motion or position sensor and nevertheless ensures the maximum torque – according to current consumption – at each operating point. Thus it should be made possible to accelerate and brake synchroneous motors in a targeted manner, starting from a standstill, under a changeable load and in a „jerk-free“ fashion. In a second step, the focus was on achieving noiselessness for the control technology found.



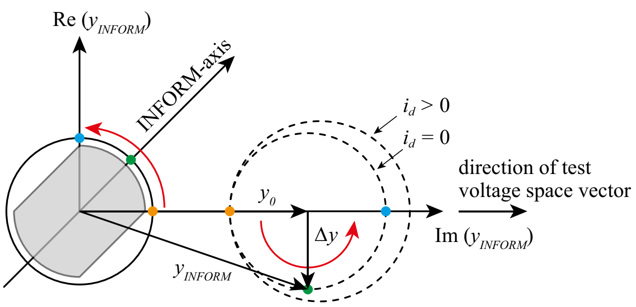
Approach

For synchronous motors, field-orientated controls are often used. This refers to the application of the stator current in such a way that the maximum torque constantly arises in the machine with the given current amplitude. This maximum torque is achieved by applying the current at a specific angle relative to the rotor. To allow this to happen, the position of the rotor must be known. This is determined either by a position sensor on the shaft of the motor – this is the most accurate method – or by hall sensors in the motor.

If it is not desired that the aforementioned encoder be set up or it is not possible for technical reasons, the position in- formation must be determined without special sensors. This is referred to as sensorless control for synchroneous motors. The position of the rotor is determined from the pre- sent current and voltage values. Short electric test pulses are sent through the cables and the actual position of the rotor can be derived from the electric reaction to this.

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. The INFORM® method invented by Prof. Schrödl makes it possible to cover this lower speed range. It takes advantage of the magnetic properties of the synchroneous motor as well as an asymmetry determined by the position of the rotor. Thus, the rotor position can be determined by means of the assessment of test pulses, which last only a few millionths of a second.



Determination of rotor position y_{INFORM}

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

- analysis of the current slope due to voltage pulses from the inverter
- Swith turning rotor, the space phasor of the current change moves along a circular path with offset (see y_{INFORM} in figure above)
- the track speed is double the speed of the rotor

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 synchronous motors. It has become evident that sensorless synchronous motors are energy and cost-efficient in use for both conventional and highly unusual applications.

Applications

- automation and production machines
- machine tools and heavy equipment
- ventilation and air-conditioning
- medical technology
- automotive
- emergency units
- drives in special environments (such as: corrosive, low-noise; very low, very high or widely fluctuating temperatures or pressures)

Your benefits

- Your synchronous motor can be controlled in a highly dynamic, stepless and „jerk-free“ manner.
- Your drive has the highest possible torque – starting from a standstill.
- You save the costs for motion or position sensors. The amount of cabling required 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.

Contact

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