TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Institute of Energy Systems
and Electrical Drives
Gußhausstrasse 25-29/370
1040 Vienna, Austria
www.ieam.tuwien.ac.at

Sensorless Control for Synchronous Motors

Increased reliability with lower production and maintenance costs – high energy efficiency – new: silent version also available

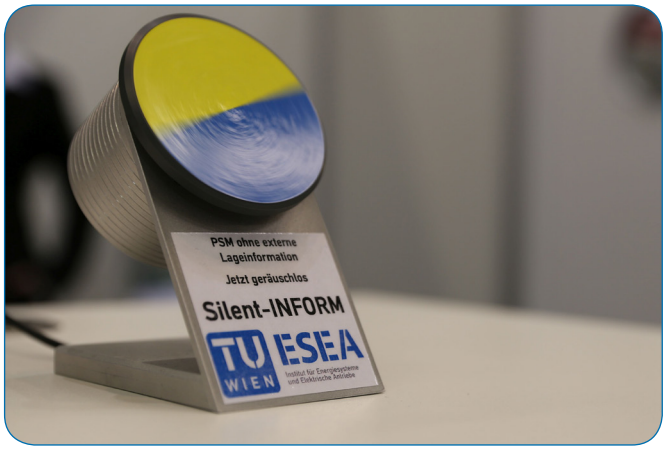
Permanent magnet motors (PM motors) are well known for being highly dynamic and offering a high power density. The efficiency of PM motors is superior to that of induction motors (e.g. in the kilowatt power range: 90% compared to 85%). PM motors are therefore growing in importance as regards use in efficiency-sensitive applications such as propulsion in battery driven vehicles (which will expand range) or heating and air conditioning (24/7 service) and refrigerators and freezers (energy-performance label A+++).

Synchronous-reluctance motors (SyR motors) 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.

Nevertheless, many sensible uses of PM motors are not yet a reality because up to now the use of a position encoder was considered necessary – especially in cases where 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 PM 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 PM 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 in the PM motor, the position of the rotor must be known. This is determined either by a position sensor on the shaft of the PM motor – this is the most accurate method – or by hall sensors in the PM motor.

If it is not desired that the aforementioned encoder be set up or it is not possible for technical reasons, the position information must be determined without special sensors. This is referred to as sensorless control for PM motors. The position of the rotor is determined from the present 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.

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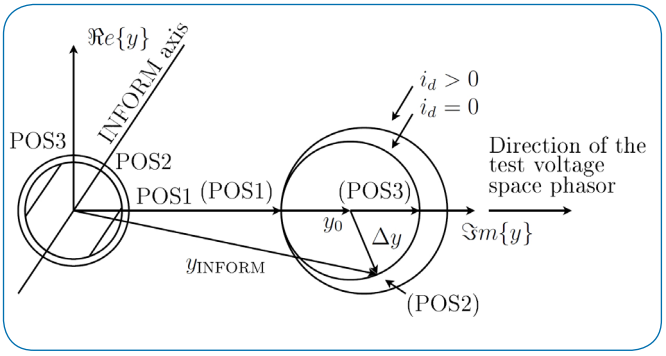
The high speed range is covered with a back EMF model where the rotor position is calculated by using an electrical model of the PM motor. At low speed and at a standstill this method will fail because the induced voltage is too small in relation to zero.



Determination of Rotorposition y_{INFORM}

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 PM 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.

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

- Analysis of the current slope due to voltage pulses from the inverter.
- The space phasor of the current change moves along a circuit with offset (see y_{INFORM} in figure above).
- The track speed is double the speed of the rotor.

In the event of low speeds, for instance when the motor is started up, the exact position very often needs to be measured. Here, there have so far been audible oscillations. Now, a method has been found to adapt these pulses so that soundwaves occur only in a frequency range that is no longer audible.

Results

The full torque of the drive is available even from standstill – within a few milliseconds! This control technology has already demonstrated its practicality in the most various applications and with many thousands of drives in everyday use.

It has become evident that sensorless PM motors are energy and costefficient in use for both conventional and highly unusual uses.
This technology is suitable for challenges uses in production machines, ventilation and air-conditioning technology, motor vehicles and medical technology as well as in special environmental conditions.
With the current development step towards noiselessness, it is possible to implement noise-sensitive applications as well – in ventilation or for special low-noise environments, for instance.

The advantages for you

- Your permanent magnetic 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 is lowered.
- Your drive's volume becomes smaller.
- For installation and repair, you no longer require matching between the encoder and the position of the magnets in the motor.
- Possible faults when wiring and servicing the sensor and drive are ruled out.
- Across the entire speed range, your drive remains without perceptible noises caused by the control technoloy.
- Your drive system has overload capability and you still have full control regarding the boot-up process. This means that the risk of a blocked rotor is prevented.

TU Vienna helps you to implement this technique for sophisticated drives solutions, in the range from a few watts up to several kilowatts.

Contact:
O.Univ.Prof. Dr. Manfred Schrödl
TU Wien - Institute of Energy Systems
and Electrical Drives
+43 1 58801 370212
manfred.schroedl@tuwien.ac.at
http://www.ieam.tuwien.ac.at/home/EN/