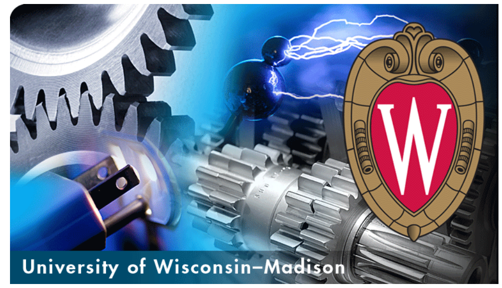


# Permanent Magnet Synchronous Motor Self-Sensing Drive System

**INVENTORS • Robert Lorenz, Thomas Jahns, Takahiro Suzuki, Shih-Chin Yang**

WARF: P100196US01

View U.S. Patent No. 8,531,143 in PDF format.

**The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing "position sensorless" drive systems in surface permanent magnet synchronous motors.**

## OVERVIEW

Permanent magnet synchronous motors (PMSM) provide torque through the interaction of a magnetic field generated by one or more armature coils and one or more permanent magnetic elements. These motors are known as "synchronous motors" because the magnetic field generated by the current supplied to the coils must be synchronized with the position of the magnetic field of the permanent magnets. Surface permanent magnet synchronous motors (SPMSMs) place the permanent magnets on the surface of the rotor. Due to the improvement of magnet materials and manufacturing methods, this simple structure is especially suitable for high-precision motion control systems.

High performance motor drives require precise, high bandwidth rotor position information which may be accomplished by a variety of means, including the classical approach of physically mounting discrete, high-resolution position sensors (i.e., encoders or resolvers) on the rotor or its shaft and attaching fragile signal wires and connectors between the sensor and the controller. Attaching discrete rotor position sensors substantially decreases the reliability of the motor drive by introducing additional electrical cables and connectors that are less robust than the motor power cables and connectors. As a result, there is interest in developing self-sensing (position sensorless) motor drive systems by using the motor itself as a position sensor. In addition to increasing system reliability, self-sensing position detection techniques can also reduce system cost by removing high resolution position sensors.

Low speed self-sensing operations require position dependent electrical properties in the motor, also known as spatial saliencies. Typically, motor self-sensing techniques exploit magnetic saliency by tracking the electrical changes caused by the spatially varying signals. Unfortunately, the spatially varying signals produced by the cylindrical magnetic surface associated with SPMSMs have a very low signal-to-noise ratio. As a result, SPMSM self-sensing drive systems currently demonstrate very low performance compared to systems using the encoder or resolver. Methods for improved self-sensing rotor position estimation using SPMSMs as sensors are needed.

## THE WARF ADVANTAGE

Since its founding in 1925 as the patenting and licensing organization for the University of Wisconsin-Madison, WARF has been working with business and industry to transform university research into products that benefit society. WARF intellectual property managers and licensing staff members are leaders in the field of university-based technology transfer. They are familiar with the intricacies of patenting, have worked with researchers in relevant disciplines, understand industries and markets, and have negotiated innovative licensing strategies to meet the individual needs of business clients.

## THE INVENTION

UW-Madison researchers have developed a permanent magnet synchronous motor system that enables position sensorless rotor position estimation, which has been demonstrated to be effective even when a smooth cylindrical permanent magnet is positioned on the surface of the rotor. The system includes a rotor with a permanent magnet surface providing multiple angularly spaced magnetic poles and a stator fitting around the rotor so that the rotor can rotate within the stator. Within the stator, angularly spaced teeth extend inward toward the rotor, and electrically conductive coils are wound around at least some of the teeth to apply a magnetic field to the teeth. The system also may employ concentrated windings that will accentuate the stator-based saliency detected by the system.

The power electronic drive attached to the motor not only provides the basic power conversion input, but also injects an electrical excitation signal into the coils at a frequency higher than the primary power conversion drive frequency. The primary power conversion input frequency is controlled to produce torque and thereby control rotation of the rotor. The superimposed high frequency injected signal is used to track rotor position by detecting variations in the injected signal that are functionally related to the rotor position and to the magnetic saturation of the stator teeth caused by the rotor magnetic fields.

This injection-based, saliency tracking method permits position sensorless operation for SPMSMs having little to no saliency on the rotor, eliminating the need for the inclusion of a separate position sensor in such systems. The system also is adaptable to a wide range of stator designs.

## APPLICATIONS

- Permanent magnet motors for small consumer appliances or industrial control systems

## KEY BENEFITS

- Eliminates need for a separate position sensor for low speed operations
- Improves system reliability and reduces system cost by removing unnecessary and relatively fragile motor components

## ADDITIONAL INFORMATION

**Related Portfolios**
**WEMPEC-Funded WARF IP**

**Tech Fields**
Engines & Power Electronics - Motors

## CONTACT INFORMATION

For current licensing status, please contact Emily Bauer at emily@warf.org or 608-960-9842.