Low Cost, High Performance Easy to Use Drives for Permanent Magnet Synchronous Motors (PMSM)

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There is an increase in demand from end users for more energy efficient motor control systems to lower the operating cost. Also, with the US Department of Energy (DOE) regulations increasing the minimum efficiency requirements for Motors, Permanent Magnet Synchronous Motors (PMSM) are being used in more applications that have traditionally used AC Induction motors. The 4th generation of the KBVF drive adds high performance and robust PMSM control while keeping the simple-to-use interface and are ready to use out of the box with the performance the KBVF platform has been known for.

AC Induction Machines Vs Permanent Magnet Synchronous Machines

AC Induction motors and Permanent Magnet Synchronous Motors (PMSM) both have similar constructions. They have a stator, which is fixed and provides a rotating electromagnetic field, and the rotor, which is the moving part that provides the mechanical rotation due to the interaction with the stator's electromagnetic field. The difference is in the construction of the stator.

AC Induction Motor

The stator consists of three phase windings, which produce the rotating magnetic field when power is applied.

The rotor consists of a set of copper or aluminum bars that are shorted by end rings. The complete rotor assembly resembles a cage, that is why it is referred to as a "Squirrel Cage Induction Motor".

The rotating magnetic field in the stator induces a current in the rotor. This creates an opposing magnetic field in the rotor that causes it to rotate in the direction of the stator's magnetic field. The rotor of the Induction motor always lags the speed of the magnetic field in the stator. The difference between the rotating magnetic field in the stator and the mechanical speed is known as "slip". For currents to be induced into the rotor, the speed of the rotor must be less than that of the stator's rotating magnetic field. Therefore, Induction motors are referred to as asynchronous machines.

Permanent Magnet Synchronous Motor (PMSM)

The Permanent Magnet Synchronous Motor (PMSM) is also know by other names such as Brushless Permanent Magnet (BPM) and Permanent Magnet AC. These names refer to the same technology.

The stator of a PMSM has a similar construction as an AC Induction motor. The windings are distributed to have a sinusoidal flux.

The rotor has magnets that can be either attached to the surface of the rotor, which is

referred to as a Surface Permanent Magnet (SPM) Motor or the magnets can be buried in the rotor, which is referred to as an Interior Permanent Magnet Motor (IPM).

The magnetic field in the rotor aligns with the field in the Stator and follows the magnetic field.

There is no difference between the speed of the electrical field in the stator and the mechanical speed. Therefore, the PMSM is referred to as a synchronous motor.

The SPM type is commonly used for its simplicity compared to an IPM type.

Benefits of a Permanent Magnet Synchronous Motor vs an AC Induction motor

- Higher power density. This refers to the ratio of the power output to the physical size of the motor. The equivalent PMSM motor can be smaller in size, which can be a benefit in applications where space is a limitation.
- Inherently more efficient due to the absence of rotor I^2R losses.
- Flatter Efficiency curve than an AC Induction motor which provides more energy savings at speeds below the rated speed.
- PMSM can increase efficiencies up to 15% compared to an AC Induction motor.
- Lower temperatures due to less power losses. This has the benefit of longer bearing and insulation life and reduces the amount of heat that is transferred into the surrounding environment.
- Better power factor (P.F.) throughout the speed range because it does not require a magnetizing current to create the magnetic field. The magnetizing currents in an AC Induction motor affect efficiency and PF. The PF at light loads and no load are poor due to the magnetizing current.
- It is a synchronous machine. The electrical and mechanical speed are the same offering more precise speed control.
- Lower rotor inertia. The high torque to inertia ratio allows the PMSM to have better acceleration.
- The operating cost savings will pay for the initial increased cost of the PMSM.
- Drop-in replacement for AC Induction motor.

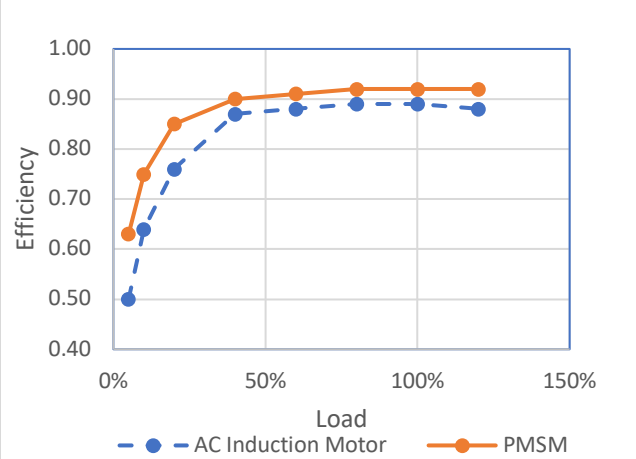

Figure 1:Typical AC Induction Motor vs PMSM Efficiency

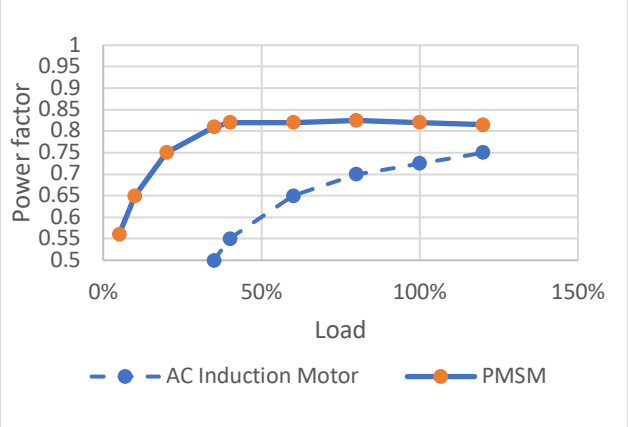

Figure 2: Typical AC Induction vs PMSM Power Factor

KBVF

The KBVF 4th generation VFD uses a high-performance sensorless Field Oriented Control (FOC) algorithms to control a PMSM. The drive uses the Motor parameters, the current, and phase voltage measurements to estimate the rotor position. This information is used to provide the optimum torque and efficiency required at each operating point.

Sensorless FOC control improves reliability and robustness and reduces system cost because a mechanical sensor (encoder) is not required.

KBVF offers drive solutions from 1/10 - 5HP in an IP20 package. NEMA 1 and NEMA 4 packages are also available.

Advantages of a KB PMSM Solution

- Matched to the motor. KB provides a motor and drive solution that does not require programming and is ready to use with the motor out of the box. The customer can also supply their preferred motor and the KB drive can be tuned to work with the supplied motor.
- If the off-the shelf solution does not meet the application requirement KB can customize the motor control solution for your application. KB has extensive experience working with OEMs to provide the correct solution for their application. Custom software, hardware, enclosure, or a complete custom solution is possible
- Supports Surface Permanent Magnet (SPM) or Interior Permanent Magnet (IPM) PMSM types.
- "Wind milling". The KBVF can start into a spinning load or recover smoothly from a power loss.

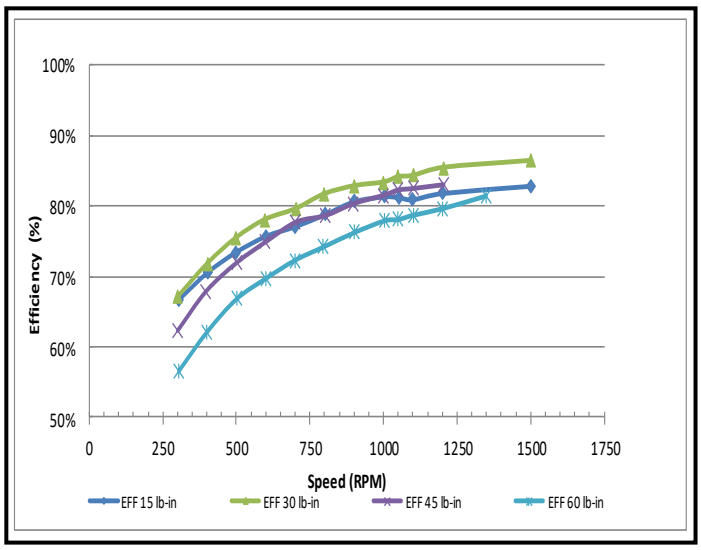

Figure 3: KBVF System Efficiency with a US Motors 1 HP PMSM

Conclusion

A PMSM drive solution can be used in almost all applications where an AC Induction motor is currently used (variable or constant torque). Variable speed applications like Fans, blowers and pumps will benefit from the increase in efficiency of a PMSM system at reduced speeds and light loads.

Applications can also benefit from an increase in the system efficiency and power density to convert an application to direct drive or at least reduce the size and cost of the power transmission devices (gearboxes, belts, etc.) required.

A PMSM solution can provide reduced operating system cost when all the benefits of the technology are taken into consideration.

Figure 4: KBVF IP20 PMSM Drives