PRACTICAL IMPLEMENTATION OF THE BRIDGE CONFIGURED WINDING FOR SELF-BEARING MACHINES

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ABSTRACT

Every electrical machine has a substantial magnetic flux. It transpires that if even a relatively small asymmetry of flux distribution exists in the air gap, a large unbalance magnetic force will pull the rotor towards the stator in the direction of the smallest airgap. Such a property is exploited in the so-called self-bearing machine where, as well as functioning as a motor or generator, the machine can also produce lateral forces.

Previously, self-bearing machines have been achieved either by incorporating a secondary set of winding in the machine or by exciting individual coils with individual power supplies. While these machines operate successfully they inherently suffer from poor specific power rating and they are very expensive.

An elegant development has been pioneered whereby terminals for torque/power generation are segregated from terminals for magnetic bearing action [1]. If nothing is connected the latter the machine behaves EXACTLY as it would have done with a normal winding in place. There are no redundant windings in the machine lateral force is produced using the existing machine winding.

The practical implementation of the bridge configured winding is described in this paper. The nature of the idea is such that currents which produce the machine torque are divided into two parallel paths in each phase. A small supply between mid points of each path provides the current which will be responsible for lateral forces. Using this “bridge” idea, virtually any electrical machine can be configured to have the ability to produce lateral forces. This configuration demands no changes whatsoever to the main (torque-producing) electrical supply for the machine.

We have rewound an existing 3-phase 4-pole permanent magnet brushless motor according to this scheme. Coils in each phase are connected in a bridge fashion and linked to other phases at a common star point thereby retaining its original 3-phase connection. Each bridge in a phase is connected to a bearing-inverter which will inject the ‘bearing’ currents. These bearing-inverters are isolated from each other by using isolation transformers. Since there are three electrical phases, there is some redundancy in the generation of lateral force. Even if one single bearing-inverter should fail, it is still possible to achieve arbitrary magnitudes and orientation of lateral force. We have demonstrated that the machine is able to function as a motor or generator and lateral forces can be produced. A full active control is now underway.

Self-bearing machines having a single set of winding machines have lower losses for the same performance when compared to their dual winding set counterparts. This bridge-like connection is essentially a single set of winding scheme where all conductors in the machine carry both categories of currents simultaneously. It also preserves the flexibility of having star- or delta-connections and easily extended to any polyphase machines with many winding schemes to meet special needs. Furthermore, the bridge configured winding offers convenient locations for injecting currents for condition monitoring. With the capability to inject very small test forces into a machine between the rotor and stator, a very large amount of additional information can be found about the mechanical health of that machine. Another advantage is that the same scheme can be used as a magnetic bearing by merely reconnecting the terminals of the bridges. The motor supply is replaced with a straightforward DC supply that provides the bias current and the bearing-inverters remain where they are to provide perturbation currents. It may also possible to exploit self-sensing with the bridge configured winding scheme.

Reference

[1] Khoo, W.K.S, Fittro R.L. and Garvey S.D.‘AC polyphase self-bearing motors with a bridge configured winding’, 8th ISMB, 26-28 Aug. 2002, Japan.