GENERAL OVERVIEW OF HOW MAGNETIC BEARING CONTROLLER WORKS

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Magnetic bearings do not function on their own; they require multiple components working together as a unique system. Calnetix's Insight™ Magnetic Bearing Controller consists of several models with different power and voltage ratings to cover the requirements of a broad range of machines.

The very simple rotor and magnetic bearing system shown in Figure 1 shows the basic relationship between the MBC and a machine rotor supported on Active Magnetic Bearings (AMB). The components of an AMB system in the machine are the electromagnetic actuators – often thought of as the bearings – and the position sensors. The actuators and sensors are connected to the MBC through cables. The actuators, sensors, MBC and connecting cables form the AMB system. The key components of the MBC are outlined in the box in Figure 1. The A Digital Signal Processor (DSP) board in the MBC has a sensor electronics section that drives the machine mounted position sensors and demodulates (detects) the return signal. The DSP executes a control algorithm (the compensator) and produces a command signal for the power amplifiers. The control program in the DSP also handles levitation logic, fault and trend monitoring and diagnostic functions. The amplifier board converts a command signal from the DSP to drive a control current through the AMB actuator coils.

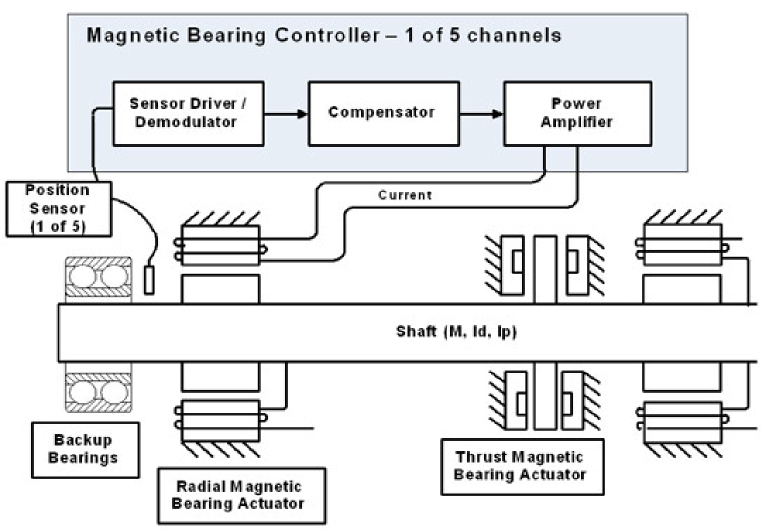

Figure 1

Figure 2 describes the basic operation of the magnetic bearing control loop. When the rotor moves or vibrates in response to some force – whether control force, external force, or unbalance – the position sensor detects the motion and converts it to a voltage with the help of electronics located in the MBC. The sensor voltage is read into the Digital Signal Processor (DSP) – the brain of the MBC. The DSP compares the rotor position to the set point or desired position to determine the error – this is the value the control loop will try to minimize. The required correction is calculated from the error using a compensator algorithm. The correction (command) is sent to the power amplifier to drive the required current through the AMB actuator coils. The actuator converts the current into an electromagnetic flux, which creates a force on the rotor. The motion or response of the rotor to the control force, and all external forces are governed by the rotordynamic characteristics of the machine.

An AMB system produces stiffness and damping forces that control rotor position. In contrast to the mechanical or fluid forces provided by conventional bearings, magnetic bearing forces are produced by a magnetic field at the actuator surface. The AMB produces reaction forces opposing the rotor displacement (stiffness) and also reaction forces out of phase with rotor displacement (damping). The stiffness and damping vary versus frequency of excitation. The variation of magnetic bearing stiffness and damping with excitation frequency is defined primarily by the compensator transfer function. The compensator – together with the characteristics of the position sensor, MBC power amplifier and magnetic bearing actuator (electromagnet) – define the stiffness and damping characteristics of the magnetic bearing system. The compensator is created by Calnetix control engineers using the rotordynamic model of the machine and dynamic models of the AMB components.

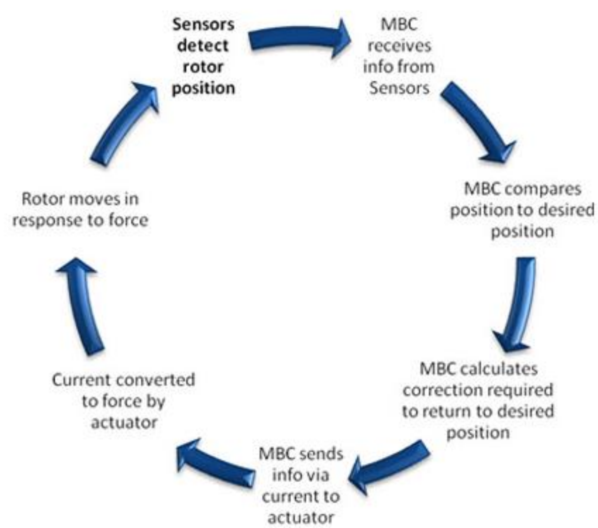

Figure 2

The characteristics of the magnetic bearing compensator, fault limits and operation options are defined in a parameter file (also called design file). This file is compiled by Calnetix to create an image that can be stored in flash on the DSP board in the MBC. Machine specific characteristics, such as sensor calibration values, operating hours, fault log and event log are stored in Non-Volatile RAM on the DSP board.

