Calnetix chooses SBC62 with two A4D4 OMNIBUS Modules for Magnetic Bearing Embedded Controller.

Calnetix, Inc. uses the SBC62 and a pair of A4D4 I/O modules as the processing core of its stand-alone magnetic bearing controllers. The system is used for a number of different active magnetic bearing applications including: a 100 kW, 60,000 rpm motor/generator, a 3,800 rpm laser circulating fan, a 90,000 rpm turbocompressor, and four different energy storage flywheel configurations (with maximum speeds up to 45,000 rpm). A magnetic bearing system is typically a five-axis system consisting of two radial bearings, each having two orthogonal control axes (x and y), and a thrust bearing with a single control axis.

The magnetic bearing concept is shown in Figure 1. Each control axis has an analog displacement sensor to detect shaft position and a bipolar PWM power amplifier to drive a control coil. The position signals are fed to the controller which runs a digital filter compensation program to produce a command signal for each power amplifier. The basic compensator is a single input - single output (SISO) PID, having an integrator to provide very high stiffness against static shaft loads, proportional gain to provide the baseline positive stiffness to support the shaft rigid body modes, and a lead-lag filter to provide damping for the shaft rigid body modes. The basic PID is almost always followed by additional cascaded biquad filters to further shape the frequency response, to insure stability of all system bending modes.

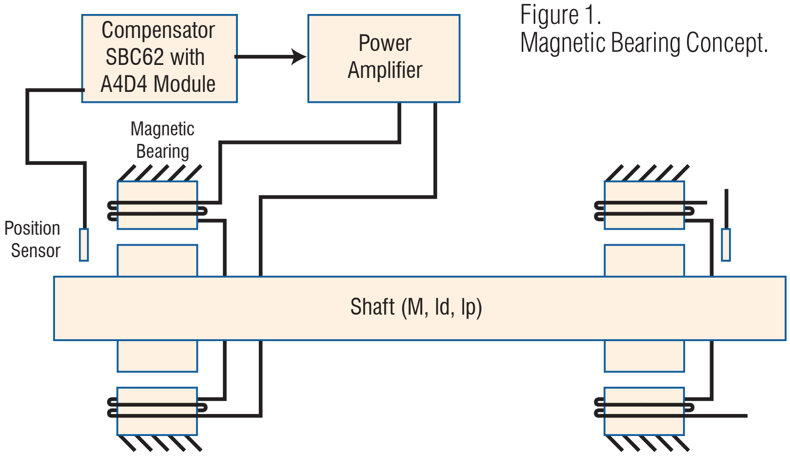

Figure 1.
Magnetic Bearing Concept.

Several further enhancements, required for a truly complete and flexible magnetic bearing controller, are easily implemented on the SBC62 platform due to the speed and memory available. These include:

1. Gain scheduling, or adjusting the compensator as a function of spin speed. This is needed for gyroscopic plants, such as flywheels, which change significantly with spin speed.

2. Adaptive Open Loop Cancellation (AOLC), which places a feed forward control loop around the basic compensation. The AOLC scheme is used to minimize either synchronous displacement or synchronous control current. The former provides extra margin during a shaft critical speed traverse, and the latter minimizes transmitted vibration and power consumption.

3. Multi-Input, Multi-Output (MIMO) Control, which allows cross-coupling between different control axes for difficult to stabilize plants. This has been implemented both as additional PID channels, and as a full state-space matrix.

The SBC62 is programmed using C, the Zuma Toolset, and the TMS320C6x DSP library. The program is stored in the onboard flash memory and loaded automatically at power up. The core function is a cascaded biquad filter routine, which is run under an interrupt triggered at a fixed rate by the onboard DDS. The DDS also triggers conversion of the A4D4 A/D converters, typically at 5 kHz to 20 kHz sample rate, depending on the application. On completion of the filter routine, the results are output through the A4D4 D/A converters. A slower loop performs a number of operations such as serial communication, checking digital I/O, testing for warning/alarm conditions (excess displacement or current command). Shaft spin speed is detected by a once-per-revolution signal from a hall-effect sensor and fed into an external interrupt of the SBC62. A simple interrupt routine determines shaft speed using one of the onboard timers.

Motor and magnetic bearing for canned laser chamber.

High speed motor/generator integrated with magnetic bearings

Energy Storage Flywheel