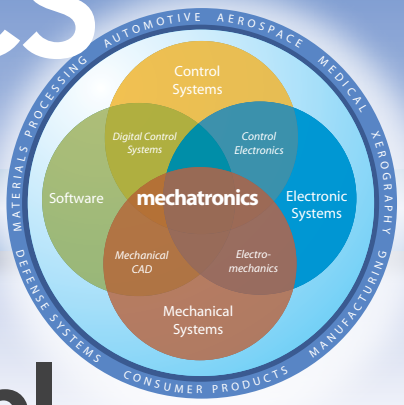
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS AND SOFTWARE IN DESIGN



FLYING HEADS: A Mechatronics Marvel

Kevin Craig, Ph.D. is a professor of mechanical engineering at Rensselaer Polytechnic Institute in Troy, NY. Check out his blog at www.designnews.com/mechatronicszone

As a mechanical engineering graduate student at Columbia University in the early 1980s, I would often hear my fellow students talk about "flying heads" and wondered what exotic application they were working on. Later, I learned the application of the air bearing to the read-write heads of the computer hard-disk drive (HDD) was the key technological breakthrough that enabled this "flying heads" mechatronic marvel.

Now, I regularly use the HDD in my teaching as the premier example of the application of a mechatronic approach to design. My information about this device comes from many sources, but a new book, "Hard Disk Drive Mechatronics and Control" by A.A. Mamun, G. Gup and C. Bi, does a wonderful job putting it all together.

Slightly more than 50 years old, the HDD is an integrated multidisciplinary engineering system like no other. The many technologies that are vital to the disk drive and its ever-expanding capabilities include magnetics, material science, electronics, sensors, actuators, mechanics, tribology, signal processing, controls and manufacturing science. In the HDD, a binary bit is stored in a tiny segment of the surface of a circular disk by magnetizing the medium coated on the surface. An inductive head does the writing and a magneto-resistive head does the reading, both flying over the disk surface by air-bearing technology.

Mechatronics engineers are being asked to innovate plant dynamics, sensors, actuators and control algorithms — the four main components of any modern mechatronic system. With rapidly changing technology and demands for greater performance, achieving reliable HDD performance can be daunting and requires a model-based, integrated approach to design. Among the many challenges HDD designers face:

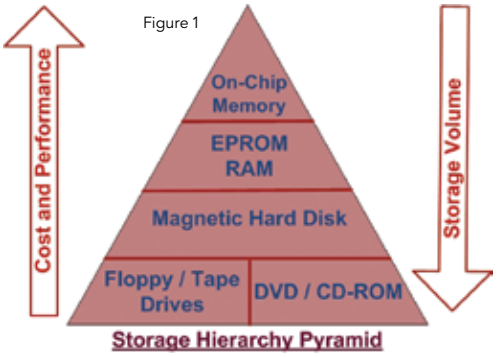
- Design control of the read-write head assembly, using a rotary voice-coil actuator to move to a track (track seek) and then center on the track (track following).
- Design and control of the disk system (10,000 rpm or more), using a brushless dc motor with the spindle mounted in fluid dynamic bearings.
- Creation of the magnetic pattern on disks during manufacturing (bit density as much as 100 Gbyte per sq inch).

In short, the HDD is the undisputed embodiment of a computing system featuring online, direct-access, non-removable, non-volatile, low-cost information storage. Figure 1, below, shows the disk drive's place in the information storage pyramid.

For me, three statements in particular illustrate the awesome engineering accomplishments in HDD development. In 1956, 5 Mbytes of data was stored on 50 24-inch diameter disks. Today, 100 Gbytes is stored on one 3.5-inch diameter disk! Imagine flying a jumbo jet at more than 500 mph at a height above the ground of less than 0.1 inch and changing lanes only a fraction of an inch wide, each time following the new lane with the same precision. This is the challenge facing the control of the read-write head of the HDD.

BY KEVIN CRAIG

Figure 1



The hard disk drive will maintain its key in the data storage pyramid because of its large capacity, fast access and low cost.

In addition, suppose we ask the read-write head to move a distance of 100 tracks. For a typical control system, a 2 percent settling time would correspond to a position error of ±2 tracks. However, for an HDD, the required limit of position error is 10 percent (writing) and 15 percent (reading) of one track for all movements from one track to another! And there might be 100,000 circular tracks on a 3.5-inch disk!

New recording technologies, such as perpendicular magnetic recording and heat-assisted magnetic recording, will greatly increase the bit density of the disk. The HDD will maintain its data-storage position of dominance because of its large capacity, fast access and low cost, but advances will come from mechatronics engineers doing what they do best: model-based integrated system design.

Dive deeper into this Mechatronics marvel. Watch Kevin's latest tutorial on the hard disk's evolution and explore the issues facing engineers today: http://rbi.ims.ca/5698-516