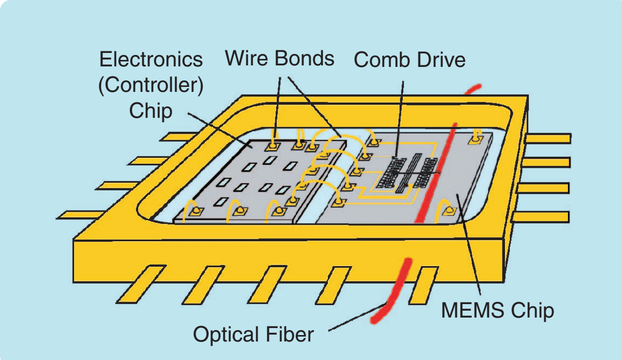

FIGURE 6 Multichip package containing MEMS device, control electronics, and optical fibers. MEMS controllers are ideally implemented in the same package or even on the same chip, and thus must have low complexity. To save space, controllers are typically implemented with operational amplifiers.

Since the added sensors and actuators significantly change the device dynamics, additional modeling based on physical principles and FEA is needed to determine the modified dynamics. Finally, on-chip signal conditioning is needed to detect capacitance changes, which are on the order of stray or parasitic capacitances. The signal conditioning now occupies significant real estate, resulting in reduced device yield per chip. A control system designed using standard robust feedback methods can compensate for lateral pull-in and significantly extend the range of travel of the mechanical shuttle.

MEMS CONTROLLER IMPLEMENTATION AND PACKAGING

The VOA controller is implemented using a dSPACE controller board with a sampling time of 12 μs, the minimum sampling time possible with this device. In practice, MEMS controllers must be integrated using fast analog VLSI devices. Consequently, the controllers must be simple.

Integration of MEMS relies on simultaneous fabrication of the device, actuators, sensors, signal conditioning, and control circuitry [7]. Figure 6 shows a multichip system design for the VOA, which includes the device, actuators, lateral sensors, controller IC chip, and optical fiber interconnect.

An additional issue for control design is that the package can change the dynamical model of the device. For instance, damping, which is difficult to model using finite element techniques, depends on the degree of vacuum and, hence, on the packaging. Control systems must be designed to be robust against variable damping coefficients in the system and other packaging effects.

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Optical Image Stabilization for Digital Cameras

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Capturing clear, crisp pictures can be a challenge, even for professional photographers. Motion, light levels, or the use of a telephoto lens can compromise clarity. In particular, whenever a tripod is not used, snapshots may blur due to jitter. When the photographer's hands are not steady, the camera lens rotates with the camera body, and the resulting lens movement causes the focal image to blur. These problems are exacerbated when slow shutter speeds are used.

To address these problems, global electronics manufacturer Panasonic has formed a collaborative partnership with lens maker Leica. Together they have introduced an image stabilization system in the Lumix line of digital cameras. Dubbed MEGA Optical Image Stabilization (MEGA OIS), the system detects movement of the camera before a picture is snapped.

When the photographer lines up a shot, two angular rate sensors within the Lumix camera detect pitch and yaw motion of the camera body. Shigeo Sakaue, manager of the DSC Business and Development Center in the Network Business Group, explains: "The image is stabilized by using angular rate sensors, called gyrosensors, to detect how quickly the camera is moving in both vertical and horizontal directions. Then, a corrective lens is moved in the direction opposite to that of the detected data" to counteract jitter.

A filter/amplifier circuit distinguishes between intentional panning and jitter. Information for jitter is extracted and sent to Panasonic's processor Venus Engine II. The processor calculates a correction value and sends the data to the control circuit at a rate of 4 kHz. This speed is up from 480 Hz in the company's previous-generation cameras. Panasonic's Sakaue states, "In previous models, this MEGA OIS was done with software. The detection data from the gyrosensors was sent to a microcomputer CPU inside the LSI for processing. A part of the new Venus Engine II uses hardware to handle this processing." The accompanying increase in speed is claimed to provide more precise image stabilization. After processing the instructions from the CPU, the control circuit moves the lens to the specified position, refocusing the image. A dedicated controller drives the lens. A vertical/horizontal linear trace mount, which can move through 360°, supports the OIS lens.

OIS can operate in two modes. In the first mode, which provides continuous compensation for jitter, the lens is constantly moving. Since compensation is always on, the photographer can compose shots using the camera's LCD screen and see the actual focusing conditions in real time. Takayuki Hayashi, chief engineer of the First Device Development Group, explains that "the advantage of mode 1 is that the image in the LCD monitor is always free of hand shake, but when correction is needed, the scope of correction may be a bit narrow." The second mode, which performs image stabilization, processes corrections when the shutter is pressed. Because the lens stays centered until the shutter button is activated, this mode provides compensation in all directions. According to Mr. Hayashi, although there may be some jitter in the LCD monitor image, the corrective lens remains near the center of the frame in mode 2 until the shutter button is pressed. Both modes lead to clearer pictures compared to unstabilized systems. Mr. Hayashi explains, "In mode 1, the corrective lens moves to provide continuous correction based on the detection data of the gyrosensors. Mode 2 maintains a lower lever of continuous correction, but provides highly precise correction the instant that the shutter button is pressed."

The Mega OIS system is offered on ten models of Lumix digital cameras, ranging in price from US$349.95 for a 5-Mpixel model with 3X zoom to US$699.95 for an 8-Mpixel camera with a 12X zoom capability. With consumer electronics makers constantly adding new features and technologies to their products, we can expect to see a proliferation of this control technology to a larger range of devices in the future.

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