BY RAY FURLONG*

Camcorder Zoom-Lens Systems

A ZOOM LENS IS ACTUALLY A SYSTEM OF SEVERAL LENSES THAT ARE COMBINED TO PROVIDE VARIABLE MAGNIFICATION OF THE PICTURE WHILE SIMULTANEOUSLY KEEPING THE IMAGE SHARPLY FOCUSED. WHEN THOSE SYSTEMS FAIL AND require troubleshooting, you really need to know what you are doing. That requires a basic understanding of how each of the individual components that comprise the lens system operate, as well as how all those components interact.

There are four basic elements in every modern zoom-lens system. They are: the lens assembly, the zoom control, the focus control, and the iris control. We will look carefully at each of those elements; once we understand how and what they do, we will go on to troubleshooting techniques.

Basic Lens Assembly

The zoom-lens system is designed so that errors in magnification and focus are minimized whenever the system moves back and forth (zooms in or out). That is especially important at the beginning and ending positions of the zooming process. It is also important to keep those errors from becoming excessively large at any of the intermediate positions.

A lens system that is not very critical of the focus throughout the zoom range is called an optically compensated *varifocal* system. Figure 1 illustrates such a system. All three operating positions are shown in that figure. The focal length of the lens is determined by the camera operator who moves a zoom handle forward or backward on the camcorder. That can be either a manual or a powered adjustment. Either way, the lens elements that produce the zoom action are stationary in the lens cylinder. They move as a group, not individually in relationship to each other.

Some of the early variable focal-length lenses contained as many as 15 or more separate groups of elements. Modern camcorders have as few as four. As the number of element groups has been reduced, the complexity of the electronics required to maintain proper zoom/focus characteristics has increased. The optical zoom ratio (the ratio of maximum to minimum power) is, in general, 6:1. But in some designs that range is as large as 15:1 or more.

The lens shown in Fig. 2 is typical of

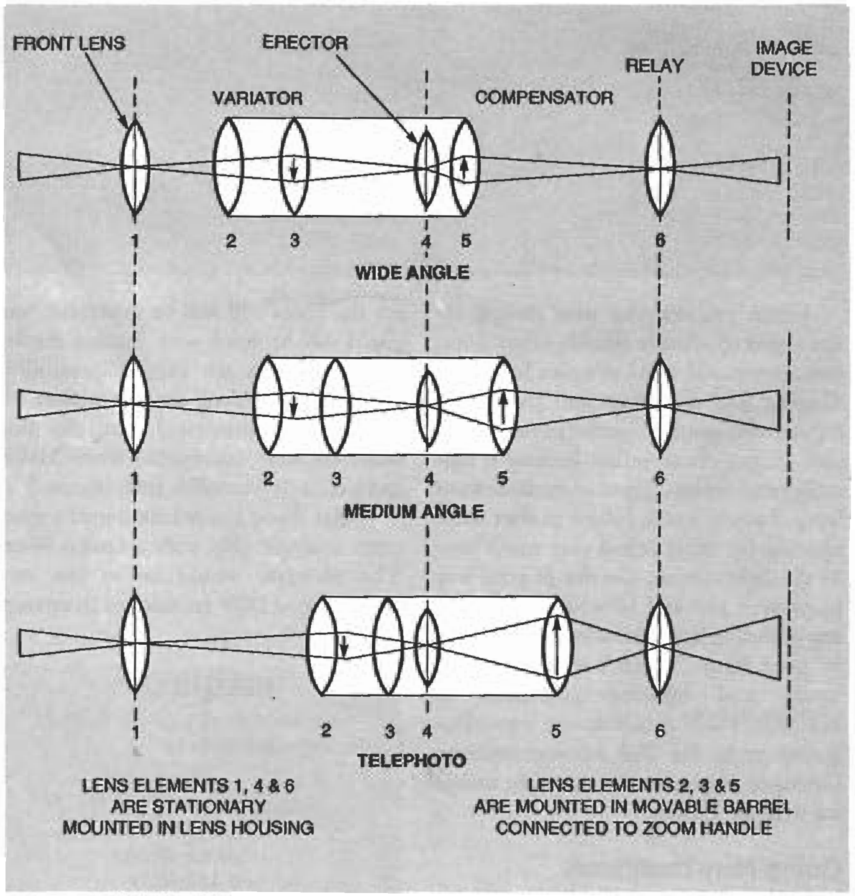

FIG. 1—A SIMPLE SLIDE ZOOM LENS SYSTEM that was used in early video camcorders. The lens elements are shown in all three common positions.

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the lens system in many modern camcorders. It uses a device called a complicated cam to move the lens elements to produce the necessary zoom ratio. The complicated cam is a cylinder that has machined slots to position the lens elements in varying degrees of zoom or macro. (Macro is the opposite of zoom; it is used to focus on an object that is in close proximity to the lens.) The relationship of the two lens elements to each other changes according to the zoom and macro ranges. Also, the lens elements shift in direction depending on whether they are zooming in or zooming out.

The rear zoom element comes further forward during macro than it does during zoom. That is what moves the focal distance closer to the front lens. The precision of the lens group's movement is controlled by the complicated cam. To compensate for focus errors during the zoom process, an adjustable back-focus lens is located in the rear of the lens assembly. It is adjusted to eliminate errors throughout the full zooming range of the lens and to maintain image focus on the pickup device. No electronics are required to monitor movement of the lens-element groups.

In older camcorders, zoom controls were often simple electric motors that were fed a reversible voltage to change the rotational direction of the zoom barrel connected to the complicated cam. The zoom and focus functions were separate in those types of lenses.

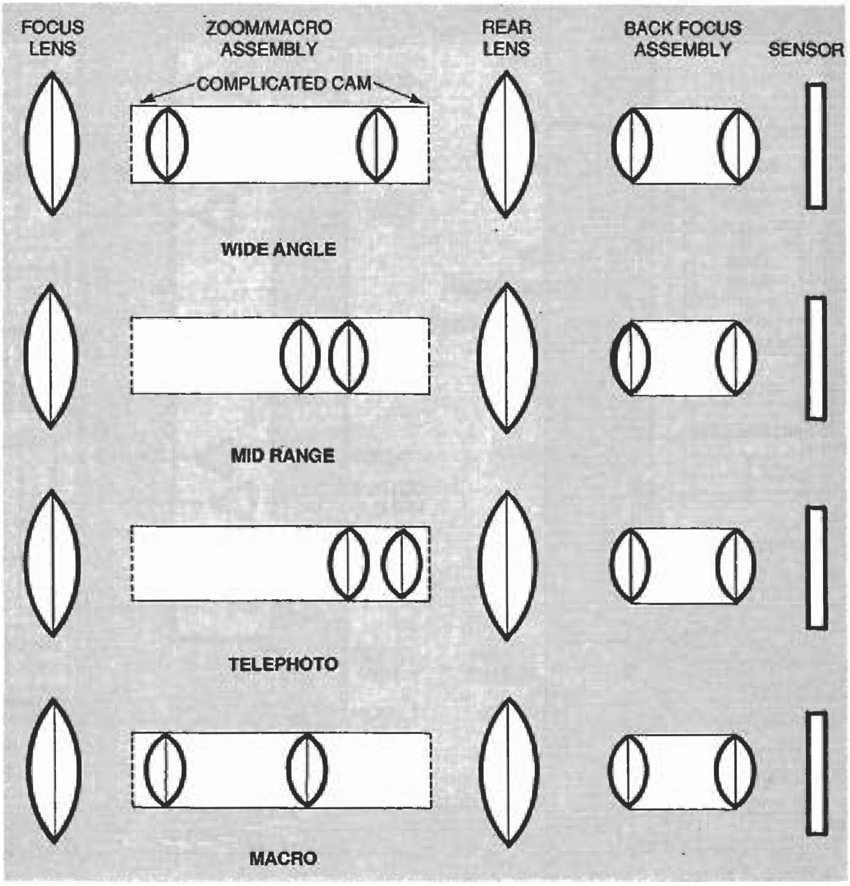

FIG. 2—MODERN CAMCORDER LENSES consist of fewer elements. Here's a look at how the elements appear in the four most commonly used positions.

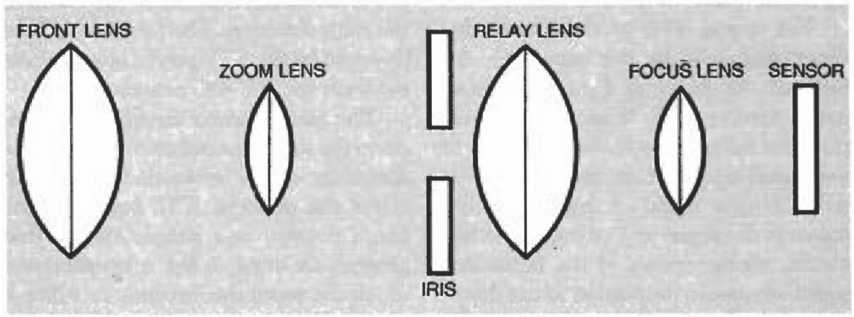

FIG. 3-THIS FOUR-ELEMENT INNER FOCUS LENS is used in many current Hitachi camcorders. Similar systems can be found in camcorders from other manufacturers.

How Focus Works

To produce sharp, high-resolution pictures, the camera lens must have good optical qualities. Equally important, the image that the lenses produce must be accurately focused on the sensor. The final element that determines picture resolution is the image sensor itself. It takes a high-quality lens coupled to a high-quality image sensor to produce a high-resolution picture.

Focusing is handled by moving the lens closer to or further away from the image sensor. The lens is closest to the sensor when it is focused on distant objects (such as landscapes), which are said to be at optical infinity. For most normal-focal-length camcorder lenses, infinity means anything further than 30 feet (10 meters) away. Focusing on subjects closer than infinity demands moving the lens away from the sensor. That is done with either a helical-thread lens (that can be operated manually or be driven by a gear-reduced miniature DC motor), or by an internal sliding lens assembly (that is driven by either a linear-drive or a stepping motor).

Focusing is very straightforward with manual-focus lenses. The helical-thread lens is rotated (manually or electronically) until the image in the viewfinder is sharp. That method leaves two variables: Is the viewfinder properly focused? Is the operator's eye properly focused to the viewfinder? An auto-focus system, on the other hand, removes the viewfinder from the focus system, leaving the alignment of the auto-focus system as the only remaining variable.

Figure 3 is a block diagram of the lens system that is used in many current Hitachi camcorders, and similar systems are found in many other brands of camcorders. The lens consists of only four elements and has a stationary front-lens element. The focus-lens element is located at the rear of the lens assembly, and functions as a back-focus element. The zoom lens has been reduced to a single lens-element group, and the complicated cam has been eliminated. Many lens-con-

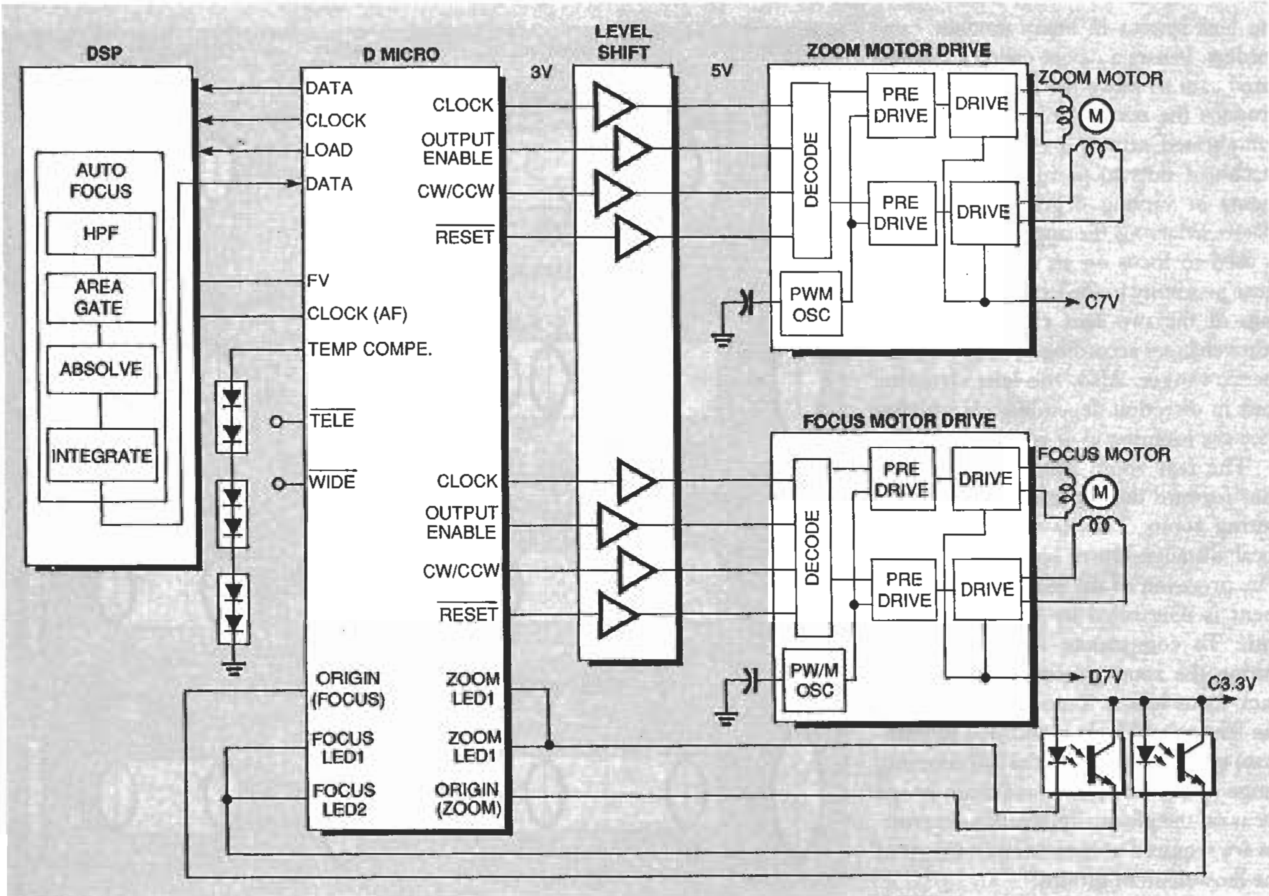

FIG. 4—A BLOCK DIAGRAM of the zoom/focus drive system. Note that zoom control circuitry is virtually identical to the focus control circuitry.

trol functions are now provided entirely by electronics.

The system relies on the actual video signal processed by the camcorder for focusing. As shown in Fig. 4, the luminance portion of the video signal is sampled and fed to the auto-focus portion of the digital-signal-processing (DSP) IC as an evaluation signal. A high-pass filter converts the signal to a voltage. The frequency characteristics of the luminance signal increase in proportion to the sharpness of the focused image, and the developed voltage increases accordingly—the higher the voltage, the sharper the luminance signal and the better the focus.

That signal goes through its own signal processor to provide information to the digital microprocessor, which evaluates the data and determines whether or not the image is in focus. If it is not, it outputs motor-control data to the drive circuit to move the focus motor in the appropriate direction to bring the image into focus. The control data consists of four elements: the output-enable signal, the direction of rotation signal (C/CCW), the clock signal, and the reset signal.

The focus-drive motor is a small stepping motor driven by a 6-volt pulse from the focus-drive IC to rotate the motor in the right direction. The focus-drive IC is powered by the C7V power bus originating from the DC-DC converter.

The zoom-control circuitry is identical to the focus-control circuitry, with the exception of the evaluation signal that starts the process. The input for the zoom control is a simple switch that grounds an input to the microprocessor to tell the zoom the direction in which it should go (telephoto/wide). That information is compiled by the microprocessor and is output to the motor drive IC to rotate the zoom motor in the proper direction.

Since there is no back-focus assembly, the focus and zoom circuits must constantly interact to compensate for lens irregularities as well as normal focusing. That information is calibrated by the focus portion of the alignment procedure.

The first step in adjusting auto focus is the zoom/focus tracking. The lens is automatically run through the full zoom range, and focus tracks along with zoom to eliminate any lens errors. When this process is finished, the information is stored and recalled to use as the zoom lens is moved. This means that the focus lens has become a back focus lens during the zooming process.

Now you know just about everything there is to tell about how the zoom-lens system works. Next time we will look at the troubleshooting procedures you will need to successfully service camcorder zoom-lens systems. EN