White Paper

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Response Time and Moving Image Playback on LCD Monitors

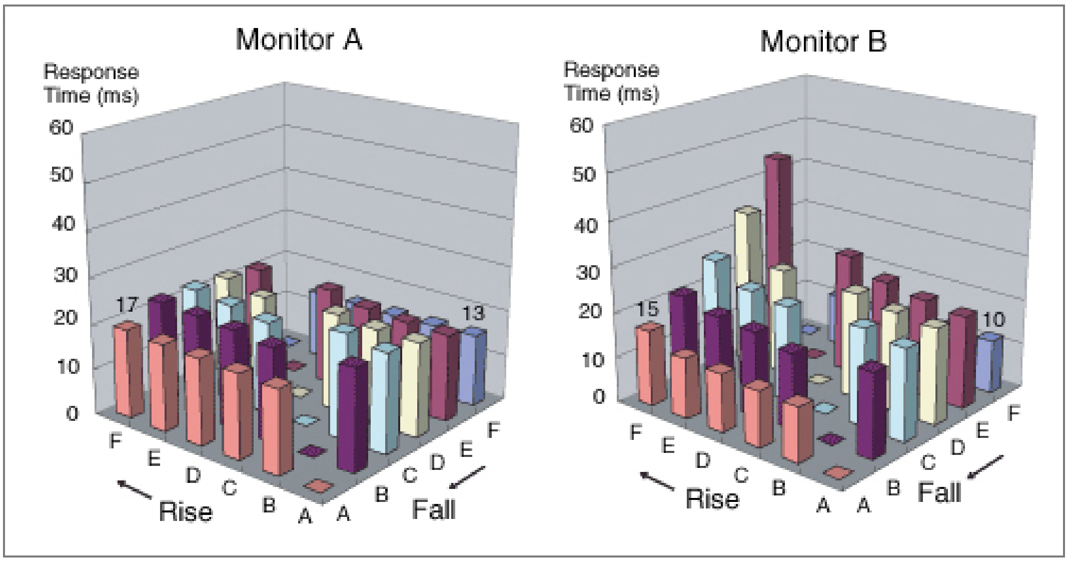
Recently, the widespread use of the Internet and PCs equipped with CD or DVD drives has brought us more opportunities to look at moving images on screen. This increase in motion picture content means that computer monitors must be able to display not only still images, but moving ones as well. With CRT monitors, this is not an issue as its first widespread use of CRT technology was for televisions beginning in the 1950's. However, with LCD monitors gaining in popularity and gradually replacing CRT monitors in both the office and the home, the LCD's ability to display moving images is becoming an important consideration for the consumer. To help consumers gauge how well an LCD monitor can display moving images, manufacturers usually include a specification called "response time" in their product literature. Both manufacturers and IT publications often cite a fast response time as an indication that the monitor can play video or games with little or no blurring. But what is response time and how helpful is it in determining how well an LCD monitor can display moving images?

Response time is the amount of time it takes for a pixel, the smallest unit of a picture on an LCD panel, to go from off to on and back to off again. In other words, it refers to how quickly a panel can transit from black to white to black again. It is measured in milliseconds (ms, 1/1000 second). Lower numbers mean faster transitions and therefore faster response times. Although the way response time is measured can vary by manufacturer, the most common way is to measure it as the time required for the transition from 10% to 90% and from 90% to 10% of the required brightness. These transitions are called the "rise time" and the "fall time" respectively.

If a response time is slow, the transition from one image (or frame) to another can produce an afterimage or blurring effect. This problem occurs not only when looking at motion pictures but also when scrolling. For this reason, panels with faster response times are typically recommended for the display of moving images.

Although the response time as described above tells us the time required to turn a pixel on (white) and off (black) to the again, it does not indicate the time to transit between gray levels. Since virtually all moving images include gray levels, and the frequency of gray-gray transitions is typically far greater than black-white transitions, we can conclude that any response time specification needs to include both types of transitions in order to make an accurate assessment of a monitor's suitability for displaying moving images. Furthermore, liquid crystal molecules respond faster to high voltage needed for a black-white transition than to low voltage needed for transitions between grays. Therefore, even though going from one grayscale level to another is less of a jump than going from black to white, the gray-gray transition can actually take longer. This means that two LCD panels with the same black-white response time but different gray-to-gray response times will have different moving picture playback capabilities. Accordingly, black-white response time alone is insufficient to evaluate a monitor's capability to display moving images.

Let's take a look at a hypothetical example of two monitors with different black-white and gray-gray response times and see how they compare.



The figures above measure luminance changes during both the conventional pixel on-off (white-black) transitions but also the gray-gray transitions at various points on a panel. Black-white response time refers only to the time it takes to make the transition directly from A (black) to F (white) back to A again. Gray-to-gray transitions, however, include all the letters in between. If we compare just the white-black response time between the two panels above, Monitor B appears to be superior for playing back moving images because the response time is only 25 ms (15 ms rise time + 10 ms fall time) while for Monitor A it is 30 ms (17 ms rise time + 13 ms fall time).

However, looking at all the transition times, we can see that for Monitor A, they are almost uniform at various gray levels. On the other hand, Monitor B shows that the transition from each measurement point to A (black) and F (white) are fast, but slower between midtones such as C, D, and E. We can conclude that Monitor B has slower and non-uniform response times in the gray levels. This can result in ghosting or an afterimage effect during the playback of moving images.

We can conclude that not only is the black-white response time important, but also the speed and uniformity of gray-gray transitions. This is why both factors should be considered when selecting an LCD monitor for displaying moving images.

An ideal response time specification for LCD monitors would cover both the black-white and gray-gray transmissions. Unfortunately, no such objective industry-wide standard currently exists. However, the Video Electronics Standards Association of the United States is drafting such a standard for implementation in 2005. EIZO is contributing to the formation of this standard by serving on VESA's Japan Metrology Committee. The adoption of this standard and widespread implementation by manufacturers will give consumers a more reliable criterion for determining the ability of LCD monitors to display moving images.