High-Resolution Color TFT-LCDs for Web-Enabled Medical Devices

Dale Maunu

Thin displays with Web-standard resolution will support tomorrow's upgradable equipment platforms.

Healthcare providers are always trying to improve patient care, and they are embracing medical electronics as a significant enabling force. Breakthroughs in imaging, diagnostics, and treatment seem to be daily occurrences. Yet, although new devices give physicians more patient data all the time, they also make it challenging to manage and use these data effectively. The healthcare industry continues to use personal computer (PC) technology, along with enterprise networking and databases, to assist caregivers in the management of patient data. Information flows from the acquisition device to the diagnostic specialist to the examining physician quickly and efficiently.

This article examines the advantages that color flat-panel displays—specifically, thin-film transistor liquid-crystal displays (TFT-LCDs)—bring to networked diagnostic and monitoring devices. It also looks at possible future uses of the devices and the Web-enabled platform applications facilitated by them. It begins with a discussion of Web-based interface standardization.

Designing medical devices is a multidisciplinary exercise, involving attention to industrial and product design, software, human factors, man-machine interfaces, power supplies, digital and analog circuits, and radiated and conducted emissions, not to mention the actual medical function. Often, the man-machine interface includes some form of high-information-content display. The type of display to be used is typically specified at the beginning of the design process, because the physical size of the display is a determining factor for many industrial designers. Also, the electrical interface with the display has a significant effect on the circuit design, especially because this is the time to be considering electromagnetic interference (EMI).

In addition to all of the things happening inside the device, how the device will actually be used must also be a consideration. The device should be easy to operate. It should also evoke a sense of confidence from the patient. Patients can become uncomfortable seeing a clinician struggling to use new equipment that has just arrived in the ward, hearing complaints that it does not work like the old one, wondering about possible confusion in interpretation. It is easy to see that product configurations vary from manufacturer to manufacturer and that how to use a device is not always obvious.

Potential of the Web-Enabled Platform

Many medical devices are already equipped with networking capability. They allow for centralized monitoring of patients, for example, or for sending images from the x-ray technician to the radiologist. Advancing these to a platform concept, where techniques and features of the World Wide Web are incorporated into the device, essentially creates another kind of Internet kiosk. This kiosk could be used for several purposes.
Remote Use of Medical Devices. Operating medical devices remotely is not a new concept. Indeed, telemedicine has been around for more than 10 years. But many remote-controlled products depend on the use of a PC—meaning more hardware and software to buy and maintain. Moving this functionality to the device itself results in a simpler deployment. A significant benefit of this is that small rural clinics can offer more services despite not having specialists in every area on staff. The same devices that big-city hospitals use can be used in rural clinics, improving the consistency of patient care among disparate populations.

Home Use of Medical Devices. A trend toward more home practice of healthcare combined with the trend toward greater home use of the Internet makes possible the development of what might be termed a virtual house call. A patient would be instructed, via a medical device, on the device's proper operation, and the results of its application would be sent directly to the physician. The Web navigation paradigm allows the patient to operate the device without specialized training. The medical professional is able to see the results immediately. This concept is basically an expansion of the approach taken by cardiologists in monitoring pacemaker function via dial-up modem.

Medical Staff Education. Major medical device manufacturers offer Web-based training in the use of their equipment, but it is based on the use of a PC, not the device itself. Moving this training capability to the device will facilitate the deployment of new equipment and accelerate the training of new staff.

Calibration, Maintenance, and Repair. The Internet kiosk would improve the efficiency of maintenance professionals, who could access schematics, upgrades, patches, and the like, directly from the device.

Additional Device Functionality. The emergence of devices that monitor all vital signs while providing waveforms and alarms has proved the feasibility of assigning multiple functions to a single device. Designing devices with common interface architecture will enable medical professionals to take advantage of
The additional functionality without adding significantly to the time required for training.

**XGA as a Web Interface Standard**

The Internet has evolved to the point where Web designers can create completely distinctive sites that most people can nevertheless explore with ease owing to common navigation conventions. But most designers expect that site visitors are using a standard browser with a certain minimum resolution.

Some sites are functionally resolution-independent but still expect access at some minimum resolution. Increasingly, this resolution is 1024 × 768 pixels, termed extended graphics array (XGA). Establishing a minimum resolution makes it possible to design site content for automatic accommodation by a visitor’s system. Whether or not a visitor has previously encountered a particular Web site, that visitor can expect to accomplish whatever he or she set out to do because the navigation convention is well understood.

This has bearing on medical devices. The Web-based navigation convention of using displays with XGA resolution is becoming prevalent in both work and home computing environments. Software tools to aid in the development of the user interface exist. Because such development is standards-based, one interface can be used on a variety of systems. Bringing XGA resolution to medical devices creates several possibilities:

- Training in use of the device requires less time with an established interface standard; and, owing to familiarity with the interface, the device is more likely to be employed correctly and accurately.
- Information recorded with one device can be displayed on other devices without the need to create special software.
- Using the same minimum XGA resolution on the diagnostic or monitoring device display as on the doctor’s computer screen promotes a consistent presentation of images.
- Medical professionals can receive their training on the device they are actually using, and that training can also be made available on-line without alteration, resulting in reduced training costs for both physicians and device manufacturers.

At first glance, XGA seems like a compromise. The most popular display used in medical devices today is 10.4-in. video graphics array (VGA: 640 × 480), whereas medical workstations are using super-extended graphics array (SXGA: 1280 × 1024). The lower-resolution devices do not now need more pixels. On the other hand, by offering more pixels, workstations are able to improve productivity.

The advantage of XGA is twofold. First, increasing pixel resolution in existing devices would enable them to provide greater functionality. For example, vital-signs monitors could display detailed graphs of the patient's vital-signs history as well as current information. Second, Web design tools allow for automatic scaling of image content based on the available resolution. Therefore, existing user-interface designs could be scaled to look the same on higher-resolution displays. The device would thus be able to offer new high-resolution functionality when it became available.

**Attributes of Color TFT-LCDs**

Resolution is not the only winning aspect of color TFT-LCDs considered for incorporation into medical devices. Front-of-screen performance, longevity, portability, durability, and EMI suppression also are key attributes.

The front-of-screen performance of modern color TFT-LCDs is among the best available. TFT-LCDs have contrast ratios up to 500:1, luminance above 350 nits, response times below 40 milliseconds, and color saturation over 70% of NTSC. NTSC refers to the National Television System Committee of the Electronics Industries Association, which establishes standards for television and video in the United States.

TFT-LCD displays offer visual performance far superior to that of cathode-ray tubes (CRTs). CRTs struggle to achieve contrast better than 100:1 and luminance of more than 130 nits. Color...
saturation and response time have traditionally been their strong suits, but recently introduced color TFT-LCDs equal CRTs for color and are just a little behind in response time. This gap in response time has been steadily closing with the help of techniques such as fast forward driving.

Generally, static images look better on a TFT-LCD than rapidly changing images. The latter—MTV videos as an extreme example—look better on a CRT. However, that CRT advantage is not as strong with respect to computer-generated as opposed to camera-generated content. And, if the camera images are relatively slow moving, as in most medical applications, there is virtually no discernible performance difference.

Most of the TFT displays made for the medical market offer redundant backlights—two independent fluorescent lamps—and feature lifetimes of 50,000 hours. In the event that the display is used in a relatively dark environment so that the luminance can be reduced, it may operate for as long as 80,000 hours. Additionally, most displays are designed with cartridge-style backlights. This means that the lamps can be replaced and the original luminance restored even if the device is 5 or 10 years old. Replacement can be accomplished without having to disassemble the display itself.

The major benefit of incorporating a TFT display into medical equipment is the contribution to portability. TFT-LCDs are light; a 12.1-in. display weighs just over 1.5 lb. They have very small borders, allowing industrial designers to create sleek bezels and compelling form factors. The thickness of a TFT display is typically a half-inch or less. This profile enables designers to minimize the overall depth of the product.

Despite being made with glass only 0.5 or 0.7 mm thick, a TFT-LCD is surprisingly durable. Whereas CRTs are typically able to withstand a shock of about 30 G, TFT-LCDs can withstand 150 G. This ruggedness ensures that the device will continue to operate even when subjected to a variety of seemingly inevitable mishaps.

One thing the TFT-LCD is not good at handling is torque. It is vitally important that the LCD be designed so as

**EMI Suppression**

The most serious technical challenge in designing medical electronic devices typically involves suppression of EMI. Upgrading to a TFT-LCD with XGA resolution can actually make this easier, because most XGA TFT-LCDs incorporate some form of advanced suppression.
technology. One technique is to use a complementary metal oxide semiconductor/transistor-transistor logic (CMOS/TTL) interface and reduce the clock frequency by doubling the number of data lines for the display. For example, instead of sending data in 18- or 24-bit-wide lines at 65 MHz, the designer can send it at two pixels per clock, or 36- or 48-bit-wide lines at 32 MHz. Reducing the clock speed—and therefore the slew rate of the clock—is more beneficial than doubling the data lines is detrimental. This technique is most commonly used in LCD desktop monitors.

Another technique commonly employed at XGA resolution is the move to a low-voltage-differential signaling (LVDS) interface. This is the interface used in notebook computers. LVDS offers the advantage of being based on a few differential pairs. These differential pairs cancel each other’s noise, and the actual interface does not radiate. Also, it is easier to send the display interface signal a long distance than with a CMOS/TTL interface; a meter or more is possible. The major graphics controllers, especially those used in notebook PCs, have LVDS built in.

**The Value Proposition**

Predicting future trends is not science. The path to be taken in medical electronics development will lead through a political and economic landscape. The U.S. population is aging, and baby boomers are spending their wealth on living healthier and longer. The future of the healthcare industry is quite bright, based on the increasing demand for medical services that these facts signal.

But people in general, especially in America, seem to prefer not to be responsible for their own decisions; hence, the prevalence of lawsuits stemming from life-style choices. In addition, some feel that companies should be held responsible if consumers are not completely happy with the products they buy, and should accept product returns even if the item performs flawlessly.

In response to this, some companies have become extremely specialized, and build products that are platform-based. The idea is that once a platform has been proven successful, only minor changes in it will be needed to satisfy the requirements of various markets. The automobile companies have embraced the platform concept for years.

Moving to higher-resolution displays in medical devices is an application of the platform approach. While making more resolution available than is perhaps needed today, the medical device manufacturer can still sell the platform that does today’s task reliably. And when new software functionality becomes available, it can be sold for the reliable established platform that has already been deployed in the field. This flexibility, combined with advances in telemedicine and integrated healthcare services, enhances the overall value proposition for the medical device customer significantly.

**Conclusion**

The advantages of incorporating high-resolution displays into medical devices, then, include enhanced device functionality, the ability to move to a Web-based interface for easier implementation and reduced training costs, remote network access enabled by the device itself, and better market position through the creation of platform products that offer an enhanced value proposition because of their easy upgradability.

The particular benefits of using color TFT-LCDs for these devices are their low power consumption, light weight, durability, front-of-screen performance, and low emissions. With field-replaceable backlights, the displays can be returned to original performance levels even after years of use, reinforcing the advantage presented by being able to introduce functional upgrades to the base platform. The combination of color TFT-LCDs with networked, Web-enabled devices lends a strong technological boost to the ongoing effort to improve the delivery of patient care.

Dale Maunu is associate director of business development and procurement for Optrex America Inc. (Plymouth, MI). He can be reached at 734-416-8500.