OPERATE AN LCD DISPLAY FROM A VGA SYSTEM

A VGA DISPLAY SYSTEM IMPOSES SEVERAL SPECIAL REQUIREMENTS ON A LAPTOP'S LCD CONTROLLER.

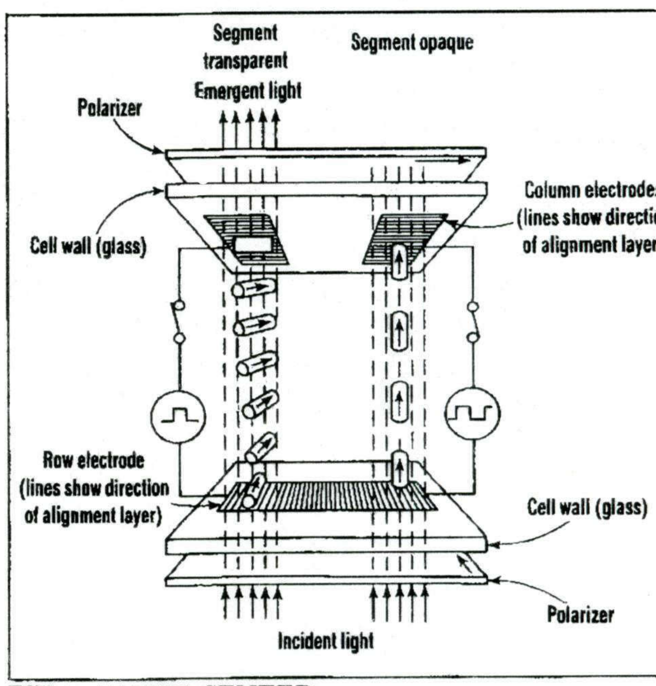
Until recently no one display media offered all the desirable characteristics for a laptop: small size, low power, high contrast, and large viewing angle. Now, however, LCDs can meet all these requirements.

Liquid-crystal material is an organic crystalline compound characterized by a multistate molecular structure, which makes it particularly flexible. An LCD panel is made up of two parallel plain-glass plates that support and protect this crystalline compound *(Fig. 1)*. An electrode matrix deposited on these glass plates divides the liquid-crystal material into a large number of separate tiny liquid-crystal cells, or pixels. The material rotates polarized light passing through it by 90±. By applying an external electric field across a pixel of the material, the rotation can be reduced all the way to zero.

A polarizer placed on the back of the LCD sandwich extracts and passes only polarized light from ordinary nonpolarized light that enters. The liquid-crystal material then rotates this polarized light 90± when it isn't activated by an electric field. Another polarizer at the front of the panel, oriented to polarize at a right angle to the polarizer at the back of the panel, allows almost free passage of the rotated light exiting from the liquid crystal. A pixel would thus appear to be bright. To brighten the display background, many LCD panels employ a special light source behind the display panel, called backlighting. With backlighting, the panel need not depend on the ambient light for brightness.

An electric field applied across the liquid-crystal material in a pixel, however, reduces the material's rotation of its incident light. The front polarizer now tends to block passage of the light. The lower the degree of rotation, the darker the pixel appears. Large LCD panels exploit this light-valving property of the liquid-crystal material to create images.

A VGA-compatible LCD panel must have 307,200 cells—the highest



1. AT THE CENTER of an LCD panel, two parallel plain-glass plates support and protect the liquid-crystal material. An electrode matrix on these glass plates divides the LCD material into a large number of separate cells or pixels.

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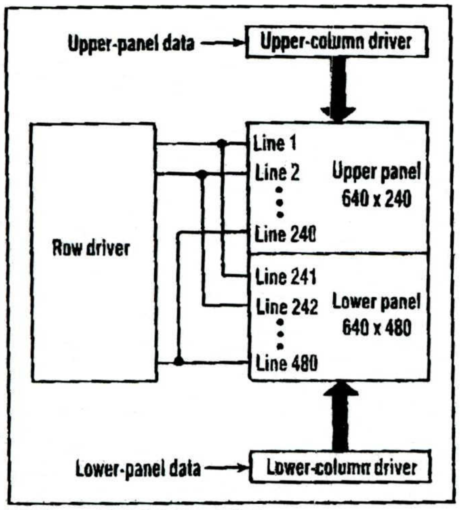


2. ALMOST ALL high-resolution (400-line and larger) LCD panels are organized as dual panels. This arrangement keeps two rows of the display, separated by 240 rows, on at the same time.

resolution under VGA—to accurately resolve a 640-pixel-by-480-line display. Since the brightness of each pixel must be controlled independently to form an image, the panel must offer a way to apply an electric field across any of the 307,200 cells.

To that end, rows and columns of electrodes define the pixel cells. All cells in a row share a common electrode, and all cells in a column share another common electrode. Thus, a VGA panel requires 640 row electrodes along, say, its left vertical edge and 480 column electrodes along its top horizontal edge. To display an image, the display driver activates electrodes one row at a time, sequentially, from the top to the bottom of the display area. This activation occurs at a rate of 10 to 20 kHz. Different voltages applied to the row and column electrodes control the electric fields across the pixels. This LCD scanning scheme is similar to the raster scanning of a CRT. The major difference is that a CRT display controller activates only one pixel at any one time. An LCD controller activates the pixels of an entire horizontal row at one time.

This characteristic of LCDs helps overcome the fact that individual LCD pixels are not as bright as CRT pixels. The LCD's row-scanning scheme keeps every LCD pixel on for a much longer time than CRT pixels are kept on. In a 640-by-480 display, a CRT pixel is on for only one out of 307,200 pixel cycles. In a 640-by-480 LCD panel, a pixel is on for one out of 480 cycles—640 times longer than a CRT pixel. Although the absolute intensity of an individual LCD pixel is low, the perceived intensity of the total display is comparable to that of a CRT display.

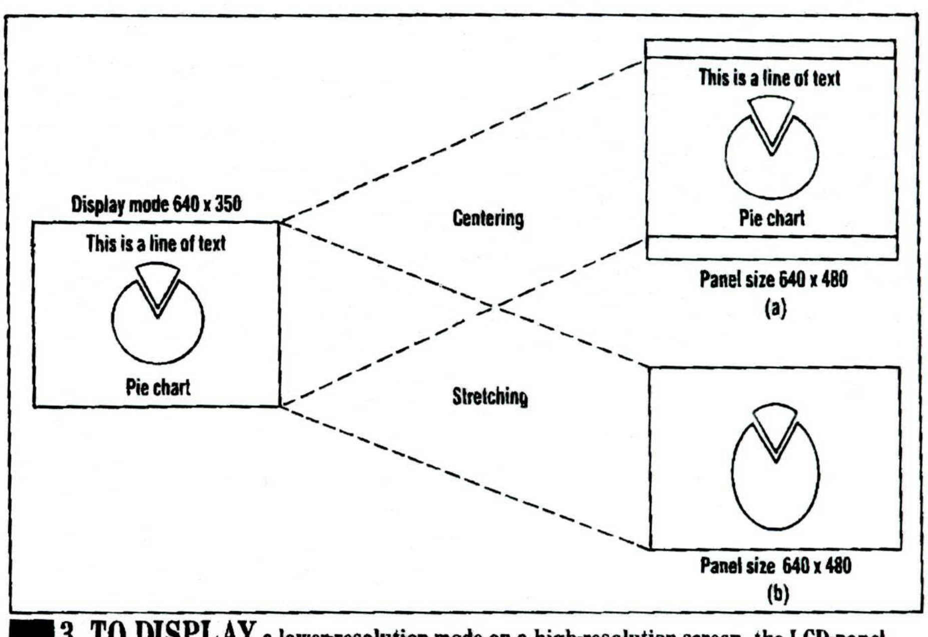
Dual-panel construction is used to further enhance the brightness of LCDs. Today, almost all high-resolution (400 lines and greater) LCD panels incorporate a dual-panel design. The upper and lower halves of the display panel activate in parallel. This arrangement keeps two rows of the display, separated by 240 rows, on at the same time. In a 640-by-480 panel, then, each pixel is on for one out of 240 pixel cycles—a duty cycle of 1/240 *(Fig. 2)*.

Unfortunately, a constant electric field applied across the liquid-crystal material has a tendency to disintegrate the material. To avoid this, the interfacing circuit must periodically switch the polarity of the applied voltage. A pixel that is on will then have an average dc voltage of zero. Naturally, all LCDs must have internal hardware to switch the polarity of the voltage across a pixel, but the display's interface controller must generate the control timing for this hardware. LCDs from different vendors require different frequencies for this timing control signal. A good controller will be flexible enough to accommodate this variable.

Because most LCD panels today provide only monochrome displays, the interface controller circuit need supply only 1 bit/pixel to drive the panel. To drive an entire row of 640 pixels at one time, however, the interface would have to provide 640 line drivers. Supplying that many drivers is physically inconvenient, so most panels have internal shift registers that take 4 or 8 bits at a time from the display interface controller and assemble them internally to drive the 640 pixels.

In a single-drive dual-panel display that uses 4 bits at a time, the pixels for a row in the upper panel clock in first, followed by the pixels for the corresponding row in the lower panel. In a dual-drive panel that uses 8 bits at a time, four pixels for a row in the upper panel and four for the corresponding row in the lower panel clock in at the same time. A controller should be able to drive either type of dual-panel display.

A desktop VGA system supports



3. TO DISPLAY a lower-resolution mode on a high-resolution screen, the LCD-panel controller must use just a portion of the display surface and center a smaller image in it (a), or expand but distort the image to fill the full display surface (b).

color on a CRT color monitor and displays gray scales on a CRT monochrome monitor. Gray-scale LCD panels eventually will become available.

Keeping the time that a pixel is on constant while changing the applied voltage creates a gray scale in an analog-driven monochrome CRT display. In a monochrome LCD, however, the controller is a digital circuit and cannot control the voltage across a pixel. To provide a gray scale, a digital controller must instead change the time that a pixel is on at a constant voltage, using either a frame or a line duty-cycle approach.

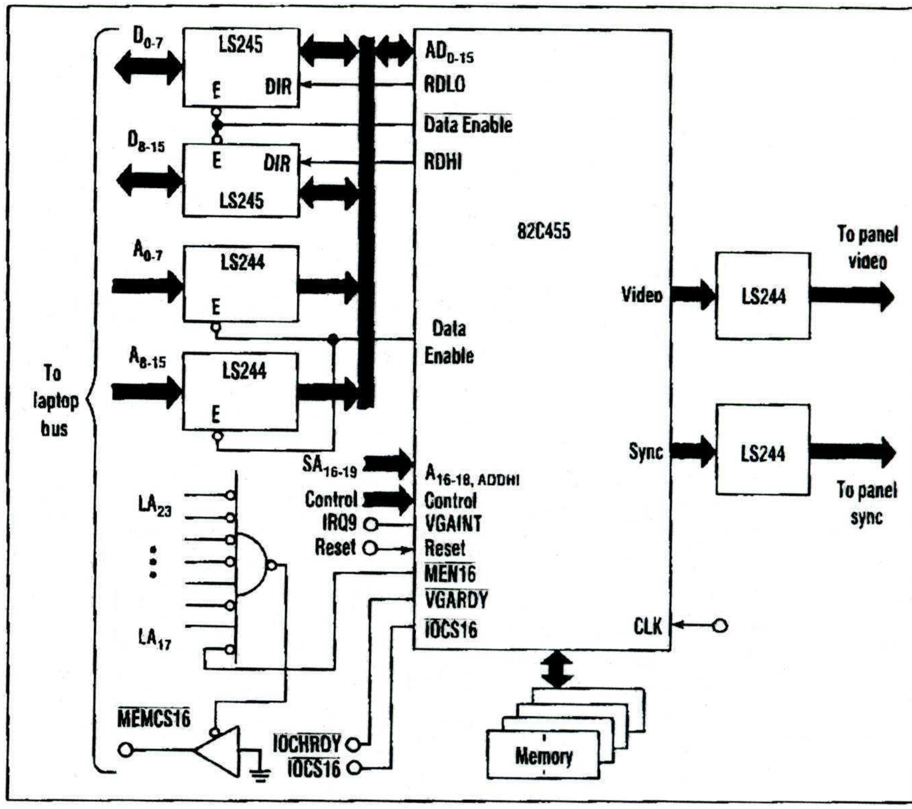
With the frame duty-cycle approach, called frame-rate control (FRC), the controller turns the pixel on in some frames and off in others. This action controls the pixel's average duty cycle, simulating a gray scale. With the line duty-cycle approach, called pulse-width modulation (PWM), a pixel turns on every frame, but not for an entire row-scanning period. Again, the control of the pixel's average duty cycle produces the gray scale.

The PWM-generated gray scale produces less display flickering than the FRC-generated one. The PWM approach requires a special panel, however. As is the case with single- and dual-drive panels, an LCD controller should be able to simulate gray scales with either method.

The VGA standard actually encompasses several resolution modes:

Mode	Resolution	Physical
Low text	40/25	360/720 × 400
High text	80/25	720 × 400
Low graph	320 × 200	320/640 × 400
Med graph	640 × 200	640 × 400
High graph	640 × 350	640 × 350
High graph	640 × 350	640 × 480

A VGA CRT handles the different resolutions by changing the horizontal and vertical sweep rates to the CRT monitor. The CRT, an analog device, adjusts the display to fill the full viewing surface. An LCD, being digital, cannot expand a lower-resolution display mode to fill the entire display surface. With an LCD, since the highest VGA resolution is 640 by



4. THE ONLY ADDITIONAL logic needed to integrate the 82C455 flat-panel VGA controller into a laptop system is supplied by a few buffers and some TTL.

480, the panel must provide 640 times 480—307,200—pixels. To display a lower-resolution mode, the LCD-panel controller can do one of two things. It can use only a portion of the display surface and center a smaller image in it *(Fig. 3a)*. Or it can expand, but distort, the image to fill the full display surface *(Fig. 3b)*. Ideally, the display controller should provide both options.

The 82C455 flat-panel VGA controller from Chips and Technologies Inc. meets these and all other criteria mentioned. In addition to gray-scale support for both the FRC and PWM techniques, the 82C455 can display color images on color LCD panels—although such panels are still in the early stages of development. The 82C455 can directly interface to a CRT display.

The 82C455 has several built in power-saving features. In a power-down mode, the chip refreshes the video dynamic RAM, but no other activity takes place. Another mode shuts off the display, but the video subsystem remains active, again reducing power consumption.

The 82C455 includes a high-performance 16-bit memory and I/O interface to the system microprocessor. Because the video subsystems of laptop computers reside on the motherboard, the 82C455 can share the board's resources. For instance, the video basic I/O system can be combined with the system BIOS and housed in a single ROM, thereby eliminating the need for a separate BIOS ROM. Also, because a VGA system requires 256 kbytes of memory, the 82C455 can directly interface to dynamic RAM comprised of 64k x 4-bit chips or 8-bit SIM modules. The 82C455 can be interfaced to stat-- RAMs using simple circuitry.

The only additional logic needed to integrate the 82C455 into a system are a few buffers and some TTL *(Fig. 4)*. Two 74LS244 and two 74LS245 octal bus-transceiver buffers multiplex the system address and data signals onto the bus of the 82C455. The 82C455 generates all control signals for the buffers. Multiplexing reduces the total number