# DISPLAYS FOR THE INSTRUMENTATION MARKETPLACE

*By Craig Baker, Sharp Electronics*

## INTRODUCTION

Almost every scientific field, from electronics to refining to geographic exploration, uses instrumentation equipment. Consequently instrumentation equipment covers a wide range of products and suppliers. A few basic features tend to cut across this broad spectrum of products. One of these generic features is the visual feedback to the actual end user. Most instrumentation equipment or products incorporate some sort of display mechanism to provide results of some test or sample. In the past, this visual feedback was accomplished in several ways. (Refer to Figure 1.)

- Panel meters
- LEDs, warning indicators
- Paper strip charts
- CRTs
- EL panels
- Character and graphic LCD modules

All of these display methods are still in use today. Each of these methods still provide unique functionality and will continue to exist.

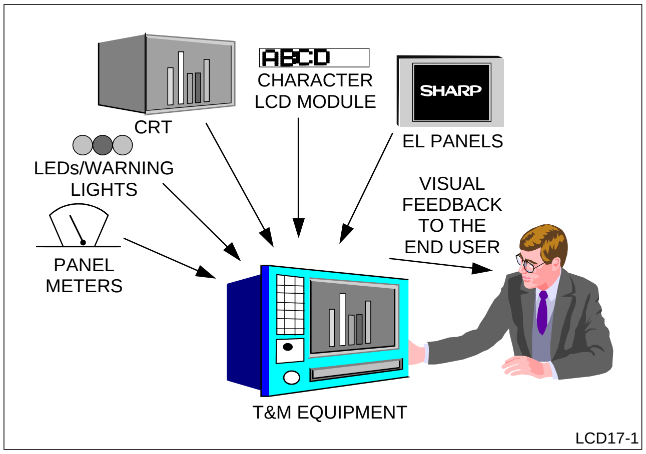


**Figure 1. Visual Feedback Methods**

## NEW POSSIBILITIES WITH LCDs

There are new possibilities being explored with larger VGA format Liquid Crystal Display (LCD) panels. These display panels have long been used in computer laptops, but are only now making serious inroads into the instrumentation marketplace. (Refer to Figure 2.)

## THE DIFFERENCE BETWEEN INSTRUMENTATION AND LAPTOP REQUIREMENTS

The instrumentation marketplace has different requirements than the computer laptop market. The reason is simple – the end applications for Test and Measurement equipment are so varied:

- Electronics – oscilloscopes, multi-meters, logic analyzers, network analyzers, spectrum analyzers
- Gas/water
- Microwave/radio
- Telecommunications
- Medical instruments

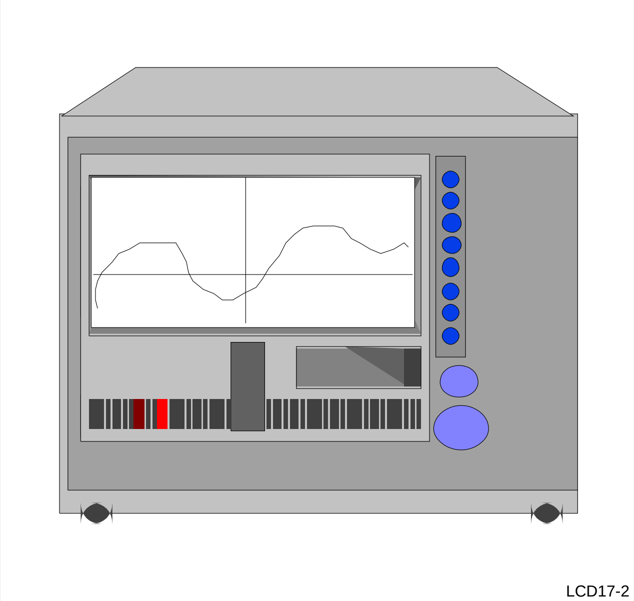


**Figure 2. Digital Oscilloscope With Small Form Factor LCD Panel**

These are simply a few of the many possible end applications. Even though laptop computers are also used for a variety of tasks (i.e., word-processing, spreadsheet, email, database, and presentations), they tend to be extremely similar in basic platform design, operating systems, and end application software. Although the instrumentation marketplace is moving in this direction, a wide variance still exists. A hand-held multimeter is entirely different from gas chromatography. The same cannot be said for two ×486 DX laptops from different manufacturers.

Beyond this, the manufacturing base for these instrumentation products is much wider and diverse. The instrumentation marketplace has hundreds of manufacturers, each producing equipment. The volume per manufacturer can range from as low as several hundred to several thousand units produced per year. The laptop market is almost the direct opposite in nature. The production volume is concentrated on about 10-15 manufacturers, each producing tens of thousands of units.

These market forcesand end product differences have led to different flat panel requirements. These different requirements can be broken out and analyzed separately.

## BRIGHTNESS

Brightness is a key factor. Instrumentation manufacturers have rejected the current crop of laptop LCD panels because they lack brightness. In transmissive CTFT LCD panels, this brightness is directly related to the cold cathode fluorescent tube (CCFT) contained behind the display. This CCFT tube or bulb provides the actual display brightness. The glass cell in front of this backlight acts as a shutter, opening and closing to control the backlight flow to the user. Current computer LCD displays are using a single CCFT rated at about 2.5 – 3.0 W for the entire panel and producing a brightness level of about 70 – 80 nits. Instrumentation manufacturers have determined that at least 100 nits brightness is needed. Basically, the laptop manufacturers would also like a brighter display, but not at the expense of power and, in turn, battery life. Of course, some instrumentation manufacturers do make portable equipment, but instrumentation equipment is usually tethered to a wall socket. Hence, power is not as precious a commodity as for a laptop.

There are two main ways to achieve increased brightness. First, increasing the brightness of the backlight system by adding extra CCFTs (Figure 3). If a single CCFT is bright, two or three are even brighter. The light guide or light pipe design or thickness can be increased. This allows a greater percentage of the CCFT's output to be transmitted to the rear of the display.

A second way to increase brightness is to increase the transmissivity of the actual LCD glass cell. One way to increase this transmissivity is through the aperture ratio. For Active Matrix (or TFT LCD panels) the aperture ratio of each pixel can be increased. The basic idea behind this concept is to reduce the size of the electronics that turns each pixel on and off, thus allowing more area of the active element, and hence, more light, to be transmitted. In Figure 4, the width of the X and Y electrodes might be reduced allowing more aperture, but maintaining the same overall square area. In addition, polarizer film and color filters transmissivity can be improved to also allow more light through the LCD cell, thereby increasing brightness.

A combination of all of these ideas is being used by Sharp to achieve a brighter LCD displays for our new products.

## WIDER VIEWING ANGLE

A wider viewing angle is another key requirement for the instrumentation marketplace. Almost every engineer has experienced the dilemma of holding a test probe at a weird angle and trying to view a display or meter at a very acute off angle. Although significant progress is being made, the current viewing angle of computer-style LCD panels is roughly ±40° in the horizontal direction. The vertical viewing angle is usually specified in terms of 6:00

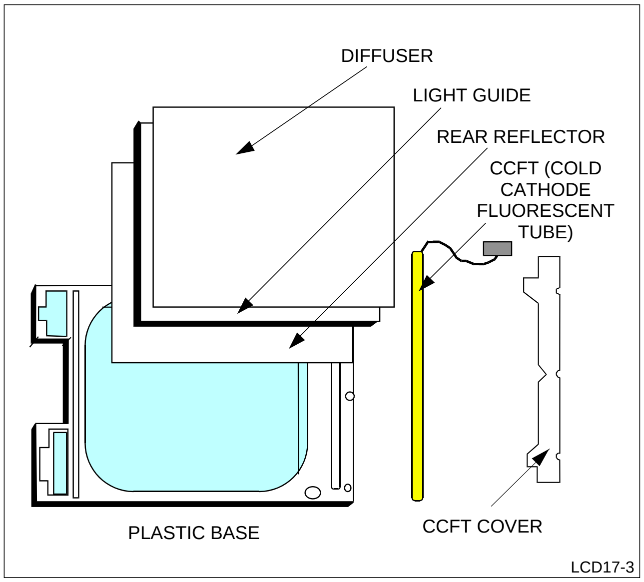


**Figure 3. Building an LCD Backlight System**

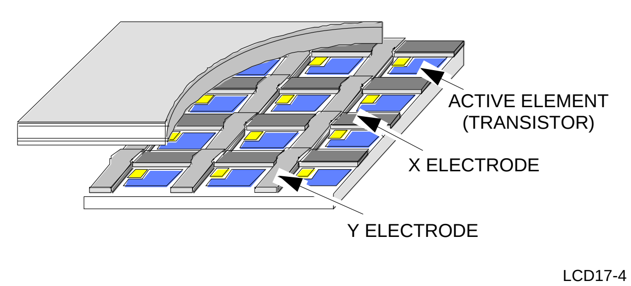


**Figure 4. Structure of Active Matrix Drive System**

or 12:00 viewing angle. In other terms, a panel is processed to provide maximum contrast when viewed from above or below the viewing normal (6 or 12 o'clock) (Figure 5). The end result is a skewed viewing angle in the vertical direction. A 6:00 display may have 30° of viewing angle in this direction, but only 10° in the opposite direction toward 12:00. For laptop manufacturers, this wider viewing angle is also on the wish list, but is not nearly as critical. Usually the laptop is used by an individual sitting directly in front of the display. A hinged clamshell design allows the laptop user to physically adjust the panel for better viewability. Hence, the laptop can be designed to take maximum advantage of the viewing angle. In fact, several end users have mentioned that even a smaller viewing angle may be satisfactory while working on confidential material on long airline flights. This would prevent the person sitting next to you from looking over your shoulder. Instrumentation manufacturers do not often have the luxury of a hinged or movable display system in their mechanical design. However, the viewing angle can be maximized!

Figure 6 shows two different data shift patterns. Many displays have built-in input pins that toggle between the two shift patterns. If the reversed shift pattern was used, the image on the display would appear upside down. The display could be rotated 180° clockwise to right the image. In Figure 6, the CCFT connectors would then appear on the left-hand side. Regardless of how the LCD is manufactured (6:00 or 12:00 viewing), either shift pattern could be used. Indirectly, this allows the user to take full advantage of the built-in vertical viewing angle. As already mentioned, a hinged laptop clamshell is not possible for all instrumentation manufacturers. Many times the display must be physically mounted in a fixed/static position.

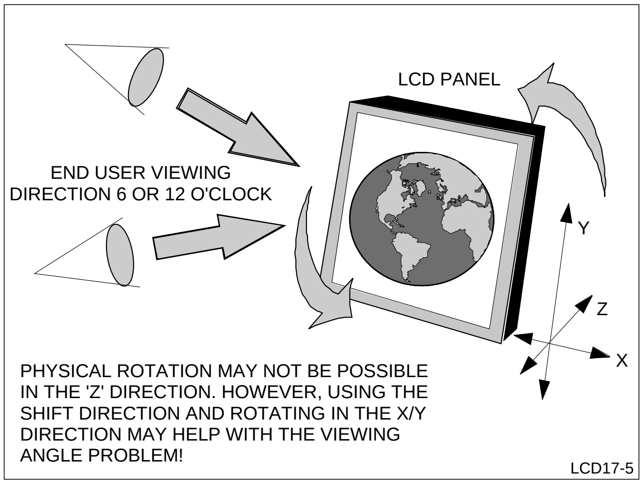


Figure 5. Viewing Angle

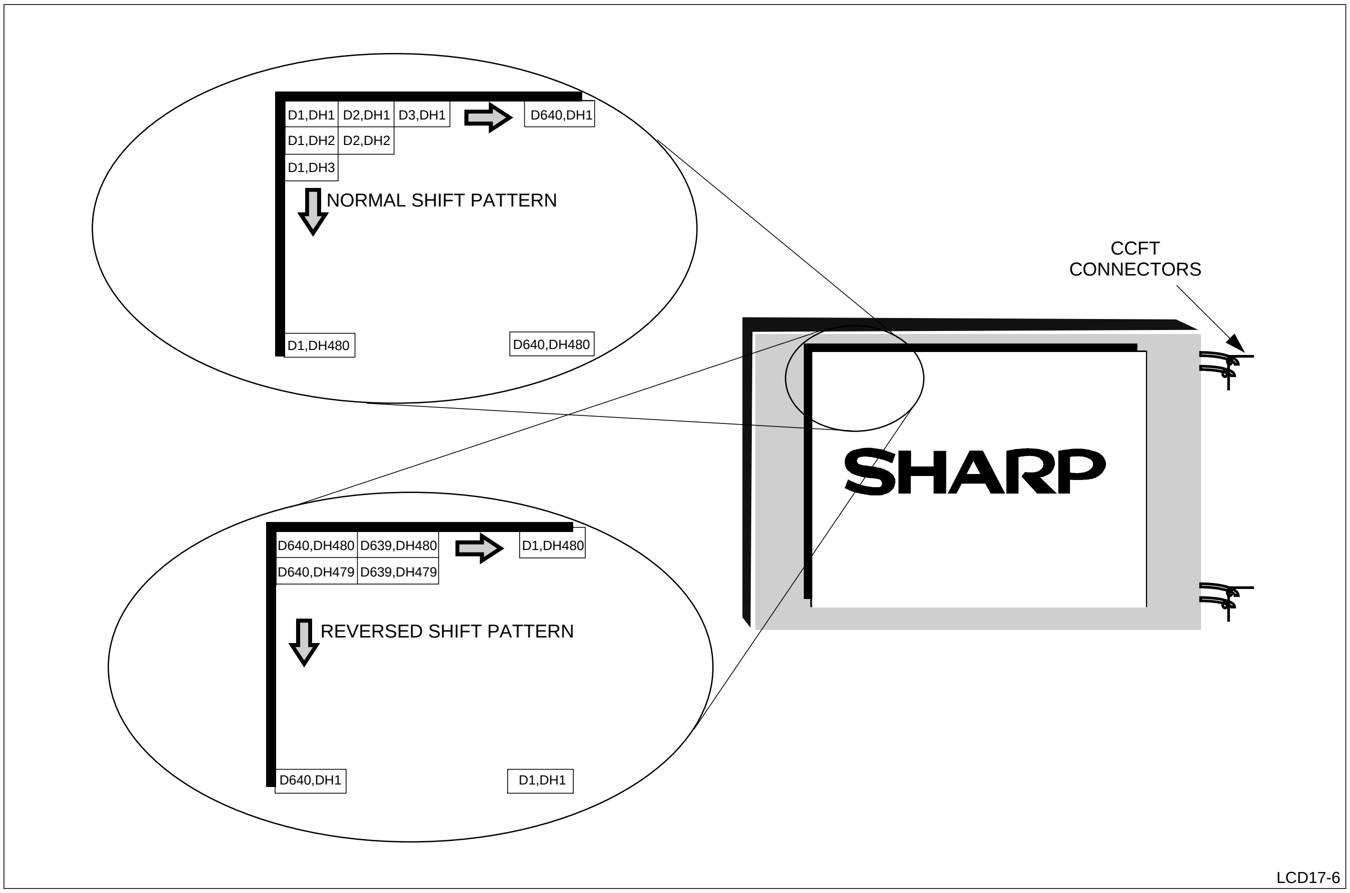


Figure 6. Display Position

In this case, the instrumentation manufacturer can use this shift pattern idea to position the wider portion of the vertical viewing angle toward the eventual end user.

This rotation idea has been developed using existing techniques (Figure 5). LCD manufacturers are looking into several other design changes for the future to achieve a better viewing angle. The majority of the future design changes involve some modification to the actual LCD cell itself. One method involves a modification of the alignment layer at the subpixel level inside the LCD cell. This alignment layer helps in the arrangement of the LCD fluid as shown in Figure 7. This is one of the basic design techniques involved with creating an LCD display as shown in Figures 8-10.

The end result of this modification is symmetrical viewing angles. The LCD display is now easily readable regardless of the viewing angle of the user. This alignment layer modification is more commonly known as dual domain. Although this dual domain technique has been known for some time, the process equipment to fabricate the glass cell is only now becoming available.

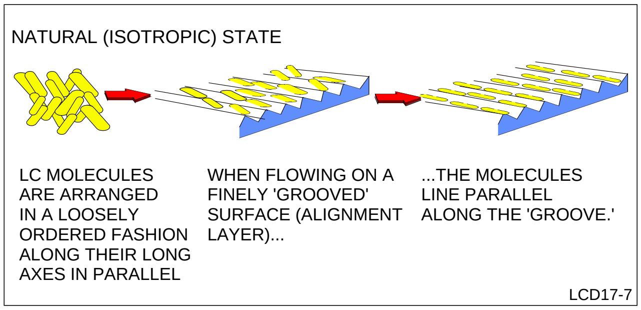


Figure 7. Liquid Crystal Molecular Arrangement

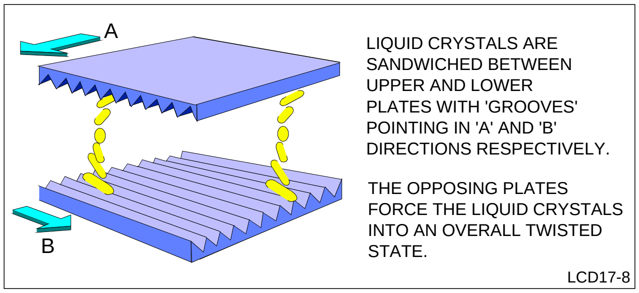


Figure 8. Liquid Crystals in Stacked Structure

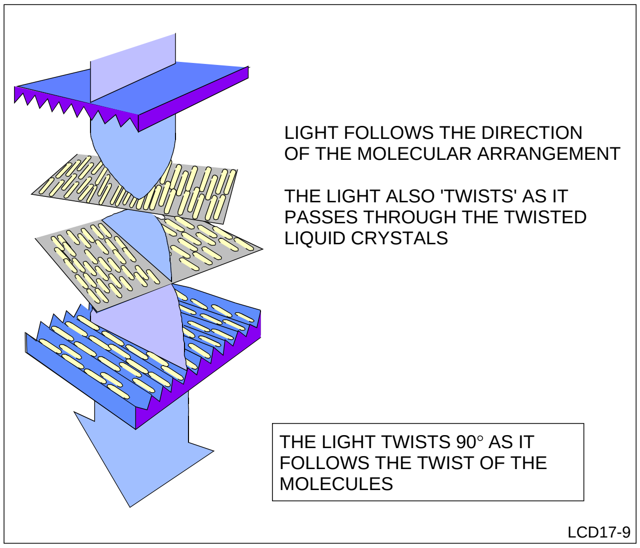


Figure 9. Principles of an LCD

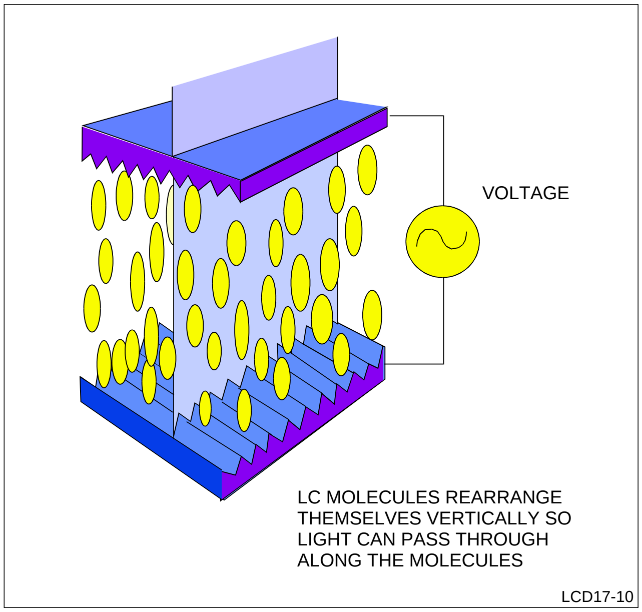


Figure 10. Molecular Rearrangement

## MECHANICAL DESIGN CONSIDERATIONS

Many of the current instrumentation manufacturers are using small CRT displays. Flat LCD panels provide a superior mechanical solution when compared to a CRT. The CRT is very bulky. Mechanical design and product aesthetics are compromised when CRTs are shoehorned into a given instrumentation box. Critical real-estate must be turned over to accommodate the CRT tube extending behind the display. Simply take a look at the current digital oscilloscopes or logic analyzers. The CRT and associated electronics take up almost 50% of the total footprint. The LCD panel takes significantly less room. The current CRT displays require 7 to 13" depth, while many current flat panels require only 1/3".

However, LCD displays do have their own mechanical design needs that must be met. A majority of the instrumentation products have control features (knobs, pushbutton, switches) located on the right-hand side of the instrument (Figure 2). An extremely thin left-hand edge adds to the mechanical difficulties. This mechanical design has been established to service the right-handed majority. The majority of existing LCD displays are in direct conflict with that arrangement. Currently, the CCFT connections are located along the right-hand side of the display. This is so the backlight power supply can also be placed on the right-hand side. (Refer to Figures 5 and 6.) Again, this LCD design method was established to service the laptop market. The end result is that the controls for brightness and contrast also wind up on the right-hand side. The majority of laptops fall into this category – again, to service the right-handed majority. The rotation feature mentioned earlier that shifts the data into the LCD panel in reverse order can help solve this dilemma. Once this feature is implemented, the picture would appear upside down! To correct this, the LQ64D141 panel rotates 180°, placing the CCFT connectors on the left-hand side. The data interface would then be located on the right-hand side. A simple data interface cable can be designed perpendicular to the display itself. The shift idea mentiond in the viewing angle solution also can be employed to help solve this mechanical design problem.

Front protective covers over the LCD panel are another mechanical design problem that must be considered. The instrumentation products tend to encounter harsher environments then generic business laptop computers. Instrumentation manufacturers understand this requirement and are trying to design a product that meets these needs. Unfortunately, no easy solution for protecting the LCD panel currently exists. Anti-reflective coated glass may also be incorporated. Some of these techniques tend to create optical problems or interference, commonly referred to as Newton rings. These optical problems can seriously degrade the performance of the LCD panel, and front protective covers should be avoided if possible. It is suggested to allow at least a $1/16$" space between the cover glass and the LCD.

Beyond the rotation feature, the LQ64D141 and many newer LCD panels have been designed with extremely thin border areas. This means a larger portion of the front surface area is actual usable active area. (Refer again to Figure 11.)

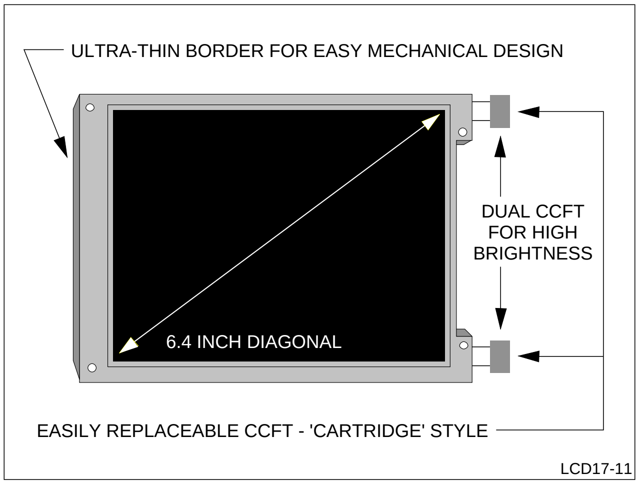


**Figure 11. LQ64D141**

## INTERFACE – DIGITAL vs. ANALOG

Some LCD panels include the electronics to handle waveforms that mirror the control signals of a CRT. Other LCD panels are strictly digital interface panels. As far as the newer graphic controller devices are concerned, this is not really an issue. The majority of the Graphic chipset manufacturers incorporate both CRT (analog) and LCD (digital) interfaces into their products. However, if the instrumentation manufacturer is using an in-house design or older graphics chip, then the likelihood that both analog and digital interfaces being supported must be considered. Basically, this analog data is usually converted to digital information internal to the panel itself using a series of A/D converters, phase lock loops, additional frame memory, etc. Each technique has its own advantagesand disadvantages.

### Analog Interface

- Advantages
  - Good when using older graphics controller or in-house design that does not incorporate dual analog and digital interfaces.
  - Data transmission paths can be longer; i.e., close to CRT cabling.

- Disadvantages
  - The added circuitry does have an added cost, which increases the cost of the panel.
  - For higher resolutions and higher color depth, faster and more accurate A/D converters are needed. For example, the sample rate for VGA is about 25 MHz, while the sampling rate for SVGA is about 40 MHz. The implication is that the A/Ds will become more expensive and difficult to obtain.
  - Some error could be introduced as the data converts from digital to analog and then back to digital.

### Digital Interface

- Advantages
  - Industry standard accepted way of interfacing to the LCD panel.
  - Most graphics controllers already include this feature.
  - It is potentially lower in cost.
  - There is no chance to introduce errors into the system.
- Disadvantage
  - Transmission length can be somewhat limited.

## DISPLAY RESOLUTION

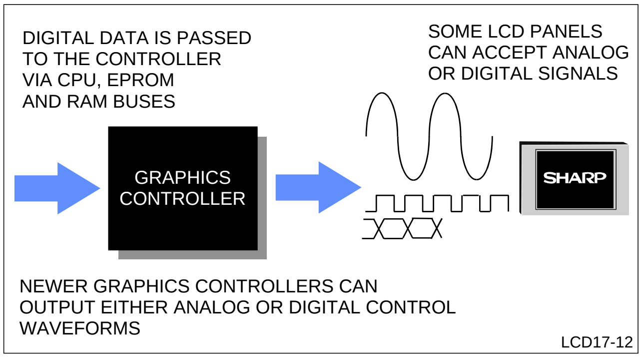


**Figure 12. Newer Graphics Controllers**

The current crop of PC laptops are VGA (640 × 480 pixels) resolution. The next high-end generation of laptops will probably use SVGA (800 × 600 pixels) resolution. Instrumentation manufacturers produce such a wide variety of products that a variety or resolutions are possible. However, several market forces are creating a gravitational pull toward the VGA format.

Flat panel graphics controllers from Chips and Technology, Western Digital, Cirrus Logic, Opti, Trident, and others are readily available. The display controllers are optimized to work on LCD panels that are basic multiples of the VGA format (i.e., ¼ VGA, ½ VGA, VGA, and greater than VGA). These complex integrated circuits make LCD flat panel control much easier than designing the circuitry yourself. In fact, many of the IC graphics vendors have even designed prototype boards incorporating their graphics controllers. The boards are basically plug-and-play, and usually include VL and PCI bus interfaces, various support for a variety of LCD panels, power sequencing, 3.3 V and 5 V operation, etc.

Although the instrumentation market is extremely large, the current usage of flat panels is rather small. The end result is that the laptop market, and hence, the VGA format, is rather dominant. Flat panel manufacturers, such as Sharp, understand both of the market forces at work. However, the economies of scale are such that it makes sense to try to service both markets with a small number of high-volume products. One way to accomplish this goal is to use the same LCD glass cell, but attach a different backlight and bezel system to accommodate the given end user. If this is the case, VGA resolution makes the most sense.

PC-related software is fairly standardized on VGA or greater type resolutions. Instrumentation manufacturers tend to create the their own customized application software. However, a combination of both may be more practical. For example, suppose a telecommunications engineer tests a PBX with a logic analyzer. He then pulls out a laptop to type up the visit/call report. A marriage of the two platforms would provide the user with a single machine to accomplish both tasks. Again, VGA resolution is critical. If such a marriage in technology takes place, the instrumentation end usage could even increase since a given piece of equipment could serve in this dual role.

Finally, many of the current instrumentation applications are already close to the VGA-style format. Logic analyzers and digital oscilloscopes are roughly 500 × 400 pixel format, which is close to the 640 × 480 VGA resolution. Instead of a flat panel manufacturer producing new designs and new glass masks, it simply makes sense to produce the VGA format. With the superior 'convergence' and crispness of a flat panel display, the user will be pleased with the perception of much crisper images and traces.

## RESPONSE TIME

Response time varies between different LCD technologies. The most popular technologies are Passive (or better known as STN) and Active (or TFT). These two LCD technologies have response times of 300 ms for STN and roughly 50 ms for TFT. In basic terms, this response time measures the basic delay in the LCD panel when changing a pixel or group of pixels from black to white. Considering that the response time of a CRT is fast enough to support video rates, the TFT LCD is the obvious choice, but not always needed. Cost and end application are important factors. Currently, the color STN displays are roughly 50% of the cost of the color TFT display. Monochrome STN displays are even less expensive – about 20% of the cost of color TFTs. The glass cell processing costs and associated electronics account for the majority of this large cost delta. This makes both monochrome and color STN displays quite attractive. While STN may be perfect for many instrumentation applications, it may be completely unsuitable for others. It really depends on the information being displayed to the user. If the information is not changing quickly (static), like a gauge or level indicator, then STN may be suitable. If the information changes quickly, such as with a digital oscilloscope or a patient monitor, then TFT (i.e., faster response time) is a must.

## PIXEL PITCH vs. SCREEN SIZE

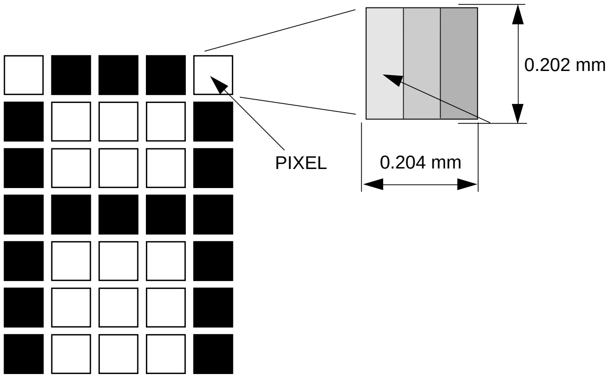
The VGA display format is 640 x 480 pixels. Each pixel consists of an RGB element, for lack of a better word, ‘sub-pixel.’ In graphics LCD panels, these pixels are lined up in a simple strip and row format. Clearly, the overall screen size is closely related to the size of the pixel (or pixel pitch).

Problems occur on the extreme ends of the size spectrum. The dot pitch of a very small 6.4 diagonal VGA CTFT display is 0.204(H) × 0.202(V) mm. For text that is formatted in 8 × 16 pixel blocks, this results in very small text size. Icons and function keys in Windows-associated programs also appear somewhat small. However, for instrumentation products, a small pixel is an advantage! Most instrumentation manufacturers tend to produce custom software menus and text. In this case, character size is not limited to 8 × 16 blocks. Small pixel pitch can be a benefit, especially in curve trace measurements. Fine resolution allows exact measurements and good zoom capabilities. (Refer to Figure 12.)

Many instrumentation manufacturers are constrained to an overall screen size. Rack-mounted systems tend to require an overall height of 7". This results in an LCD panel size that must be below 160 mm in height. Instrumentation manufacturers would like to include the largest diagonal screen size given this constraint. Overall thickness is not that great of a demand from the instrumentation marketplace. Sharp’s solution is the use of bent tab driver technology. This means bending the actual LCD driver tabs behind the glass cell and backlight attachment. This results in a very small border or outline. Screen size/diagonals are maximized while panel dimensions are kept to a minimum.

## COLOR DEPTH

Color depth is the number of digital bits per RGB pixel. A 9-bit color TFT panel corresponds to three bits for each primary color (Red, Blue, Green). The total number of displayable colors is 512 (i.e., $2^9$). A 16-bit panel corresponds to 4096 displayable colors. The total number of displayable colors needed for the instrumentation marketplace is still not well defined. Human factor studies have shown that a logic analyzer requires only 8 – 10 different color shades. This should be enough to show trace waveforms and display on-screen menu selections. On the other hand, thermal sensing equipment or ultrasound equipment may need to show subtle changes in temperature across a surface. This is typically done with very precise changes in color. This type of application requires higher color depth – perhaps thousands of colors. Medical equipment is an excellent example. With real color capabilities, MRI imaging, color ultrasounding, and detailed human anatomy files are all possible. One can even display a photo of the patent.



**NOTE:**
PIXEL: Smallest spatial-information element on any display is called a pixel.

SUB-PIXEL: A pixel can further be divided to achieve color. Sub-pixels are used ONLY for color creation and are not used to display information.

**Figure 13. Display Definitions**

The tradeoff in color depth is closely associated with the cost of the equipment design and the cost of the panel itself. Additional video RAM memory is needed to store the additional color information. This results in higher parts costs and more board space. The LCD panel costs for added color depth are not as significant, and in some cases, due to manufacturing volume, could be inversely related. The TAB LCD drivers that attach to the LCD glass cell are now primarily 3, 4, and 6 bits per color. The manufacturers of these TAB IC devices need large volumes to enjoy good economies of scale. This, in turn, drives down the cost of ICs and the LCD panels.

## QUALITY LEVELS

Good quality products are extremely important to today’s high-tech instrumentation manufacturers. There is great concern that moving away from CRTs to LCD panel displays will impact display quality. This important concern needs to be addressed. CRTs have inherent problems all by themselves. Curved front glass leads to parallax in some images near the left and right side of the CRT. Centering and expansion of the displayed image on a CRT can also be a problem since the image is painted across the inside of the tube itself. Convergence at the edges suffers.

These quality concerns tend to be lumped into two major segments – front of screen performance and long-term reliability.

### Front of Screen Performance

The current state-of-the-art of manufacturing LCD panels is just now maturing. Front of screen cosmetic defects, such as small (less than 1 pixel) bright and dark spots, are allowed and accepted. Many LCD suppliers incorporate these small allowable defects into actual specifications for customers. The idea is that the customer would use these inspection or defect specifications to judge whether a given panel was within acceptable cosmetic levels. The reason that these small defects exist is in many ways related to the design and process of the glass LCD cell itself. For a color VGA format TFT display, over 900,000 (one for each sub pixel) transistors need to be fabricated on the glass cell. In some cases, dust or contamination cause problems with one or more of these transistor elements resulting in a short or open circuit – hence, a bright or dark spot. The processing on the inside of a CRT is simply not as complicated. Yes, it's true, that LCD suppliers can and do produce displays that are defect-free, but cost tends to be the drawback. LCD suppliers could tighten the outgoing criteria of a good display to be defect-free and simply destroy non-conforming panels. This would, in turn, lower yield and drive up costs. In the past, PC laptop manufacturers have accepted certain levels of defects in order to enjoy acceptable costs from the LCD suppliers.

One should carefully review the Incoming Inspection Standard to fully understand the quality issues.

### Long-Term Reliability

Instrumentation products tend to stay in use for many years. In some cases, the life span of a given piece of instrumentation equipment could be well over 10 years. Not only is the life span incredibly long, but the average daily use is extremely high. It is not unheard of for a piece of instrumentation equipment to be left turned on indefinitely. A quick calculation tells you that instrumentation manufacturers are designing for a worst-case scenario of maybe 90K hours (24 hours × 365 days/year × 10 years). In contrast, PC manufacturers realize that the useful life of a laptop is not nearly as long. 5K hours tends to be the design criteria for most industry-wide laptops – a large difference by anyone's standard. Several problems exist with such strict instrumentation life requirements. The most obvious is the cold cathode fluorescent tube (CCFT) backlight. Most CCFT backlights are rated for a lifetime of 10K hours. The lifetime of 10K hours for the CCFT is determined when the CCFT output reaches the 50% level of brightness. The CCFT bulb is still lit, but slightly dim compared to a new CCFT. This makes replacement a necessary evil. Quick and inexpensive replacement of the CCFT bulb and connector is a must. A 'cartridge' CCFT bulb replacement technique has gone a long way to solve this problem. This allows the CCFT and associated connector to be removed and replaced without disassembling the actual display. Not only does this save time, but it prevents possible damage to other portions of the LCD assembly. The 'cartridge' replacement CCFT could be accomplished at the instrumentation manufacturing facility. This reduces the need to return the display to the LCD supplier for repair, and drastically cuts the customer's down time.

Instrumentation manufacturers need to consider CCFT replacement when incorporating LCD panels into their design. The end instrumentation package should allow easy removal of the LCD panel for CCFT replacement. A simple removable front plastic cover bezel could overlay the LCD panel and allow easy access.

## EMI REQUIREMENTS

Instrumentation manufacturers are especially sensitive to EMI interference. Like Laptop manufacturers, instrumentation manufacturers must also pass FCC regulations. However, instrumentation equipment requirements are often even more stringent. A piece of microwave test equipment measures systems and end applications using the frequency domain. Increased noise and EMI interference can cause false readings. Instrumentation manufacturers have learned a great deal about EMI interfaces while using CRTs. Many of these techniques can be transferred to flat panels. The flat panel manufacturers themselves have also taken on the burden of trying to help reduce EMI emissions. Flat panels tend to emit EMI from two signal source locations – data interface and CCFT interface. Several techniques can reduce EMI problems:

- Better cabling techniques – Again, a major source of EMI radiation is centered around the interface connections and cables associated with the LCD panel. Thicker gauge wire and grounding plains on flex cables tend to lower EMI emissions. LCD manufacturers have surrounded the faster switching clock and data lines with extra ground pins to aid in this effort.
- EMI shields – A thin metal-coated mylar shielding can be wrapped around the back of the entire display subsystem to prevent leakage. LCD manufacturers have even begun to incorporate these ideas into the display panel itself. EMI coatings and film that would be incorporated behind the backlight assembly are currently being designed and tested.

- Input filters – Along with additional ground schemes, input filters are designed into the LCD panel. These tend to be reserved for the fast running data clock line that operates around 28 MHz for a CTFT VGA display.

## COSTS

The current marketplace for small CRTs is somewhat confusing. A small six monochrome CRT could run as low as $200. A slightly larger color version could run well over $800. The availability of these small CRTs remain in question. CRT manufacturers have repeatedly dropped the small CRT form factor in favor of the larger and more profitable portion of the market. The end result is higher pricing and limited availability for small form factor CRTs. At the same time, additional LCD production capacity is improving. The effect is that LCD prices are dropping. In comparable volumes, LCDs are now cost competitive with CRTs, especially if one considers the support electronics, such as power supplies.

## GETTING STARTED WITH LCD PANELS

The actual design replacement of a CRT in a piece of instrumentation equipment may not be all that difficult. Most of the basic building blocks of the graphic system remain the same. Some graphics controllers do exist that only function with CRTs. Most major producers of graphics controller integrated circuits (i.e., Chips and Technology, Western Digital, Cirrus Logic, S3, Opti, etc.) produce combination chips that function with both CRTs and LCD flat panels at the same time. This SimulSCAN$^{TM}$ possibility is actually quite a nice feature. It would allow the instrumentation manufacturer to incorporate an LCD panel into the piece of equipment. In addition, an extra CRT jack or plug could allow a free-standing monitor. Both displays could be active at one time. The end result is that instrumentation manufacturers need to select the appropriate graphics controller IC to ease this design change.

The configuration of the video memory and graphics BIOS will remain the same. However, the actual firmware located in the graphics BIOS EPROM must be changed to incorporate the LCD. Again, the larger graphic chipset house has made this almost painless and provides standard BIOS setups for a range of industry standard LCD flat panels. If the instrumentation equipment is taking advantage of one industry standard CPU bus structure (ISA, PCI, or VL), then the integration is even easier. Numerous third party companies, and even the graphics chipset manufacturers, provide development slot cards that include the controller, CPU bus interface, video memory, and BIOS EPROM – almost everything needed to interface to an LCD flat panel display. (Refer to Figures 13 and 14.)

The large power supply and cooling fan is no longer needed when crossing over to an LCD display. These items can be removed. Instead, a small inverter (power supply) must be included to light the CCFT tube. The primary function of the inverter is to convert a regulated DC voltage to a high voltage, relatively low current AC waveform. The inverter itself can be quite small when compared to the power supply of the CRT. Complete CCFT inverters are roughly about 2" wide and 4 – 5" long. CCFT inverters can be obtained from various sources, such as TDK, Endicott Research Group, Xentek, and others.

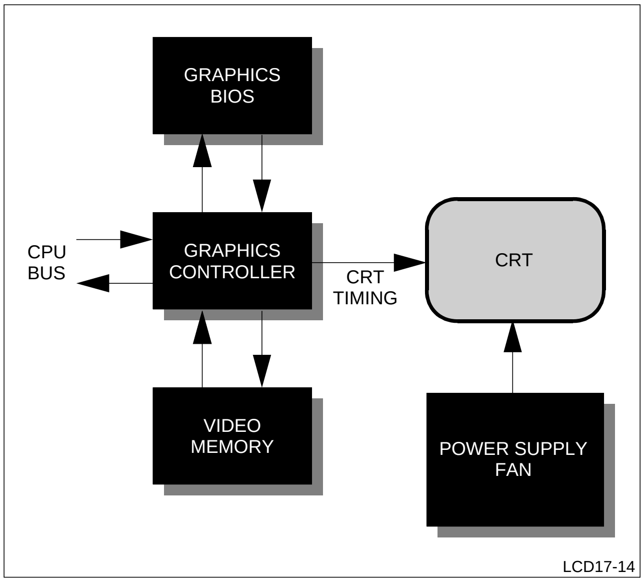


Figure 14. CRT vs. LCD

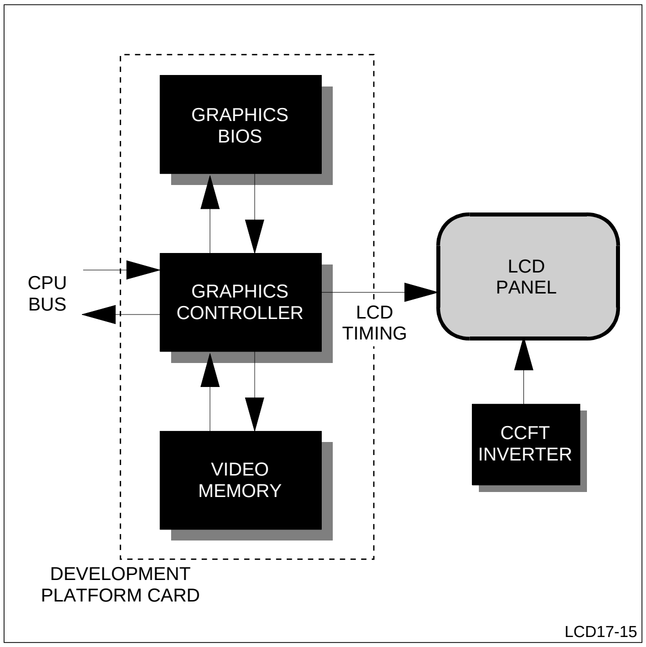


Figure 15. CRT vs. LCD (cont'd)

## SUMMARY – A CURRENT EXAMPLE

The Sharp LQ64D141 (Figure 15) is a good example for meeting instrumentation market needs. The feature set on the LQ64D141 is rich and includes:

- Dual Backlight CCFT design for high brightness – greater than 100 nits.
- Easily replaceable cartridge type CCFT bulbs – easy field maintenance.
- Thicker backlight guide for greater brightness and uniformity.
- Bent tab driver design for small overall outline.
- Rotation feature to allow user selectable viewing angle.
- Rotation feature to allow user-selectable viewing angle and mechanical design considerations.
- Black matrix layer to reduce ambient light reflection.

## GLOSSARY

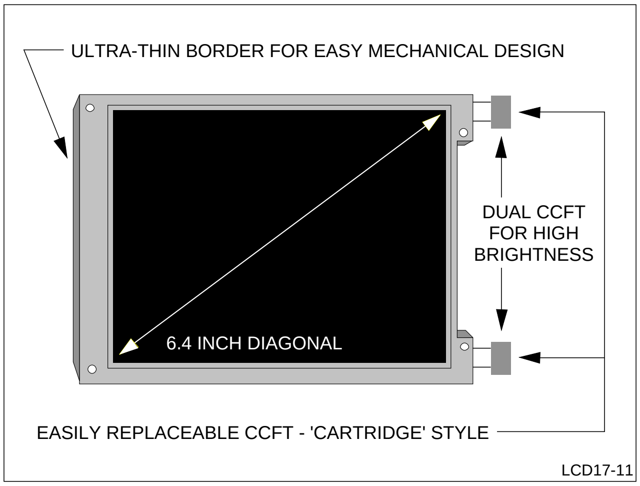


Figure 16. LQ64D141

**Instrumentation** – Test and Measurement.

**CTFT** – Color Thin Film Transistor. One kind of liquid crystal display, commonly referred to as active matrix. At each sub-pixel, an active element (thin film transistor) can be turned on and off to control the passing of light.

**CCFT** – Cold Cathode Fluorescent Tube. Used in most types of liquid crystal displays behind the glass cell to provide light.

**VGA** – a standard video resolution that corresponds to 680 columns by 480 rows (640 × 480).

**SVGA** – Super VGA (800 × 600), see VGA.

**LCD** – Liquid Crystal Display.

**FSTN/STN** – Film Super Twist Nematic/Super Twist Nematic. LCD without integral drive transistors.

**EL** – Electro Luminescent – Common flat panel display that emits light through field excitation of a phosphor.

**Nits** – Unit of brightness; equals 1 candela/m$^2$.

**Transmissivity** – Percentage of light transmitted through a given optical element.

**Aspect Ratio** – Ratio of area that is transmissive divided by the total area of a pixel.

**Active Matrix** – see CTFT.

**Viewing Angle** – The total range of angles where a display can be seen with contrast remaining above a specified value.

**EMI** – Electromagnetic interference.

**Pixel** – Picture element comprised of red, green, and blue subpixels for a color display.

**Pixel Pitch** – Horizontal and vertical center to center distance between subpixels.

**Alignment Layer** – Material that induces zero field alignment of liquid crystals through Vander Waals interaction of the molecules, and surface energy.

**VL Bus** – High-speed data bus used primarily in 486-based PCs.

**PCI Bus** – High-speed data bus used in Pentium-based PCs, and the bus of choice in most current PC system designs.

**Graphics Controllers** – VLSI designed to provide the appropriate data waveforms to a graphics LCD for correct operation.

## TRADEMARK ACKNOWLEDGEMENT

SimulSCAN™ is a registered trademark of Cirrus Logic.

# NOTES

**LIFE SUPPORT POLICY**
SHARP components should not be used in medical devices with life support functions or in safety equipment (or similiar applications where component failure would result in loss of life or physical harm) without the written approval of an officer of the Sharp Corporation.

SHARP

**NORTH AMERICA**
SHARP Electronics Corporation
Microelectronics Group
5700 NW Pacific Rim Blvd., M/S 20
Camas, WA 98607, U.S.A.
Phone: (360) 834-2500
Telex: 49608472 (SHARPCAM)
Facsimile: (360) 834-8903

**EUROPE**
SHARP Electronics (Europe) GmbH
Microelectronics Division
Sonninstraße 3
20097 Hamburg, Germany
Phone: (49) 40 2376-2286
Telex: 2161867 (HEEG D)
Facsimile: (49) 40 2376-2232

**ASIA**
SHARP Corporation
Integrated Circuits Group
1, 2613-banchi, Ichinomoto-cho
Tenri-shi, Nara Pref. 632, Japan
Phone: (07436) 5-1321
Telex: LABOMETA-B J63428
Facsimile: (07436) 5-1532

Editions: No. 1, 1995
Printed and bound in the U.S.A.

Ref. No. SMT95006