# INTERFACE & INTERCONNECTION FOR 4-INCH & 6-INCH TFT / LCDs

*Alan Dragon, Field Applications Engineer*

## INTRODUCTION

Sharp Electronics Corporation has introduced a series of small TFT (Thin Film Transistor) LCD modules to be used in a wide range of video applications. These displays are well suited for use in Portable TV/VCR Entertainment Systems, Test/Control Equipment, Control and Entertainment displays for Aviation, along with Automotive, Navigational and Imaging Applicatons. The current product line-up includes diagonal sizes of 3", 4" and 5.7" (Table 2, page 2). With three formats available (234V x 32.5H, 234V x 720H, 240V x 720H), NTSC and PAL Video Standards can be supported by various models within the product line (Note 1). All 4" and 5.7" models are available with a 6 o'clock or a 12 o'clock viewing direction for optimum performance with any mounting orientation.

Sharp TFT LCDs use the normally white mode of operation for an excellent contrast ratio and superior color reproducibility. This is characterized by a contrast ratio of 30:1 with a light output of 120 nits (35 foot-lamberts). With these specifications, the TFT LCD modules can be used in various lighting environments.

The possibility of battery operation is enhanced by the low power consumption of the TFT display. Total power is typically 2.6 watts, with 1.7 watts of that total being consumed by the backlight.

## VIDEO SIGNAL STANDARDS

### NTSC/PAL

It will be useful to understand the video standards of NTSC and PAL before explaining the actual interface of the TFT displays. NTSC (National Television System Committee) and PAL (Phase Alternation Line) are two different color encoding methods for broadcasting or sending color video information. Most countries around the world have adopted one of these two standards. The remaining countries have adopted SECAM, which is based on the PAL Standard (Table 3). This application note will concentrate on the timing characteristics of the NTSC and PAL Standards and leave the explanation of color encoding and decoding methods up to video textbooks.

Note 1: The current product line reflects improvements made to earlier models (Table 1).

**Table 1.**
**Transition from Prototype Models to Current Production Models**

| CURRENT MODEL | PROTOTYPE MODEL |
|---|---|
| LQ4RE01<br>NTSC/PAL<br>6 o'clock | LQ424Y02 [NTSC 6 o'clock]<br>LQ424P01 [PAL 6 o'clock] |
| LQ4RA01<br>NTSC/PAL<br>6 o'clock | LQ424A01 [NTSC 6 o'clock]<br>LQ6MA01 [PAL 6 o'clock] |
| LQ4RE02<br>NTSC/PAL<br>12 o'clock | LQ4NA02 [NTSC 12 o'clock]<br>LQ4MA02 [PAL 12 o'clock] |
| LQ6RA01<br>NTSC/PAL<br>6 o'clock | LQ6NA01 [NTSC 6 o'clock]<br>LQMA01 [PAL 6 o'clock] |
| LQ6RA02<br>NTSC/PAL<br>12 o'clock | LQ6NA01 [NTSC 12 o'clock]<br>LQ6MA02 [PAL 12 o'clock] |
| LQ6RA02<br>NTSC/PAL<br>12 o'clock | LQ6NA02 [NTSC 12 o'clock]<br>LQ6MA02 [PAL 12 o'clock] |

The basic difference between NTSC and PAL is the number of lines per frame. NTSC uses 525 lines per frame at a 60 Hz field rate and PAL uses 625 lines per frame at a 50 Hz field rate (Table 4).

When an image is broken up into more horizontal lines, the resolution and image quality improve accordingly. Both standards consist of two interlaced fields. These two fields (designated odd and even) make up one full frame. The alternating odd and even fields make the actual frame rate 1/2 of the field rate (Figure 1). Although the two fields alternate, the human eye will superimpose and blend the odd and even fields to give the appearance of one continuous and flicker-free image.

**Table 2.**
**Sharp's Small TFT Color LCD Modules**

| MODEL | DIAGONAL SCREEN SIZE (INCHES) | PIXEL FORMAT (V x H) | INPUT CAPABILITY | BACKLIGHT | VIEWING DIRECTION | EFFECTIVE VIEWING AREA (W x H) (mm) | DOT PITCH (W x H) (mm) | OUTLINE DIMENSIONS (W x H x L) (mm) | WEIGHT (GRAMS) | INTERFACE |
|---|---|---|---|---|---|---|---|---|---|---|
| LQ4RE01 | 4 | 234 x 479 | NTSC/PAL | N/A | 6 o'clock | 81.9 x 61.8 | 0.171 x 0.264 | 122 x 100 x 6.6 | 135 | N/A |
| LQ4RE02 | 4 | 234 x 479 | NTSC/PAL | N/A | 12 o'clock | 81.9 x 61.8 | 0.171 x 0.264 | 122 x 100 x 6.6 | 135 | N/A |
| LQ4RA01 | 4 | 234 x 479 | NTSC/PAL | HCFT/Built-in | 6 o'clock | 81.9 x 61.8 | 0.171 x 0.264 | 110.2 x 85.8 x 20.7 | 170 | Analog RGB |
| LQ4RA02 | 4 | 234 x 479 | NTSC/PAL | HCFT/Built-in | 12 o'clock | 81.9 x 61.8 | 0.171 x 0.264 | 110.2 x 85.8 x 20.7 | 170 | Analog RGB |
| LQ4NC01 | 4 | 234 x 479 | NTSC | HCFT/Built-in | 6 o'clock | 81.9 x 61.8 | 0.171 x 0.264 | 110.2 x 85.8 x 20.7 | 180 | Composite/Analog RGB |
| LQ4NC02 | 4 | 234 x 479 | NTSC | HCFT/Built-in | 12 o'clock | 81.9 x 61.8 | 0.171 x 0.264 | 110.2 x 85.8 x 20.7 | 180 | Composite/Analog RGB |
| LQ6RA01 | 5.7 | 240 x 720 | NTSC/PAL | CCFT/Built-in | 6 o'clock | 113.8 x 87.6 | 0.158 x 0.365 | 149.4 x 117 x 23 | 310 | Analog RGB |
| LQ6RA02 | 5.7 | 240 x 720 | NTSC/PAL | CCFT/Built-in | 12 o'clock | 113.8 x 87.6 | 0.158 x 0.365 | 149.4 x 117 x 23 | 310 | Analog RGB |
| LQ6NC01 | 5.7 | 240 x 720 | NTSC | CCFT/Built-in | 6 o'clock | 113.8 x 87.6 | 0.158 x 0.365 | 149.4 x 117 x 23 | 320 | Composite/Analog RGB |
| LQ6NC02 | 5.7 | 240 x 720 | NTSC | CCFT/Built-in | 12 o'clock | 113.8 x 87.6 | 0.158 x 0.365 | 149.4 x 117 x 23 | 320 | Composite/Analog RGB |
| LQ6MC01 | 5.7 | 240 x 720 | PAL | CCFT/Built-in | 6 o'clock | 113.8 x 87.6 | 0.158 x 0.365 | 149.4 x 117 x 23 | 320 | Composite/Analog RGB |
| LQ6MC02 | 5.7 | 240 x 720 | PAL | CCFT/Built-in | 12 o'clock | 113.8 x 87.6 | 0.158 x 0.365 | 149.4 x 117 x 23 | 320 | Composite/Analog RGB |
| LQ323Y11 | 3 | 234 x 382.5 | NISC | N/A | 6 o'clock | 61.7 x 44.5 | 0.161 x 0.190 | 94.2 x 78.5 x 61 | 80 | N/A |
| LQ323P07 | 3 | 234 x 382.5 | PAL | N/A | 6 o'clock | 61.7 x 44.5 | 0.161 x 0.190 | 94.2 x 78.5 x 61 | 80 | N/A |

Note: All specifications are subject to change.

**Table 3. International Television Standards**

| LINES PER FRAME: 525<br>FIELD RATE: 60 Hz<br>COLOR CODING: NTSC | LINES PER FRAME: 625<br>FIELD RATE: 50 Hz<br>COLOR CODING: PAL | LINES PER FRAME: 625<br>FIELD RATE: 50 Hz<br>COLOR CODING: SECAM |
|---|---|---|
| Antiqua, West Indies | Algeria | Afars and Issas |
| Bahamas | Australia | Arab Republic of Egypt |
| Barbados | Austria | Bulgaria |
| British Virgin Islands | Bahrain | Czechoslovakia |
| Canada | Bangladesh | East Germany |
| Chile | Brunei | France |
| Costa Rica | Brazil (525/60) | Greece |
| Cuba | Denmark | Haiti |
| Dominican Republic | Federal Republic of Germany | Hungary |
| Ecuadoron Republic | Finland | Iran |
| El Salvador | Hong Kong | Ivory Coast |
| Guatemala | Iceland | Iraq |
| Japan | Ireland | Lebanon |
| Mexico | Italy | Luxembourg |
| Netherlands Antiles, West Indies | Jordan | Mauritius |
| Nicaragua | Kuwait | Monaco |
| Panama | Malaysia | Morocco |
| Peru | Netherlands | Poland |
| Phillipines | New Zealand | Reunion |
| St. Kitts, West Indies | Nigeria | Saudi Arabia |
| Samoa (U.S.) | Norway | Tunisia |
| Surinam | Oman | USSR |
| Province of Taiwan | Pakistan | Zaire |
| Trinidad, West Indies | Oatar | |
| Trust Territory of Pacific | Singapore | |
| United States of America | South Africa | |
| | Spain | |
| | Sweden | |
| | Switzerland | |
| | Tanzania | |
| | Thailand | |
| | Turkey | |
| | United Arab Emirates | |
| | United Kingdom | |
| | Yugoslavia | |

**Table 4. NTSC and PAL Timing Standards**

| NTSC | PAL |
|---|---|
| Lines / Frame: 525<br>Lines / Field: 262.5<br>Field Rate: 60 Hz<br>Frame Rate: 30 Hz<br>Display Period: 24 OH<br>Horizontal Interval: 63.5 µs (1H)<br>Vertical Interval: 16.7 ms (262.5H)<br>Vertical Blanking: 1.42 ms (22.5H)<br>Vertical Sync Pulse: 254 µs (4H) | Lines / Frame: 625<br>Lines / Field: 312.5<br>Field Rate: 50 Hz<br>Frame Rate: 25 Hz<br>Display Period: 28 OH<br>Horizontal Interval: 64.0 µs (1H)<br>Vertical Interval: 20.0 ms (312.5H)<br>Vertical Blanking: 2.08 ms (32.5H)<br>Vertical Sync Pulse: 256 µs (4H) |

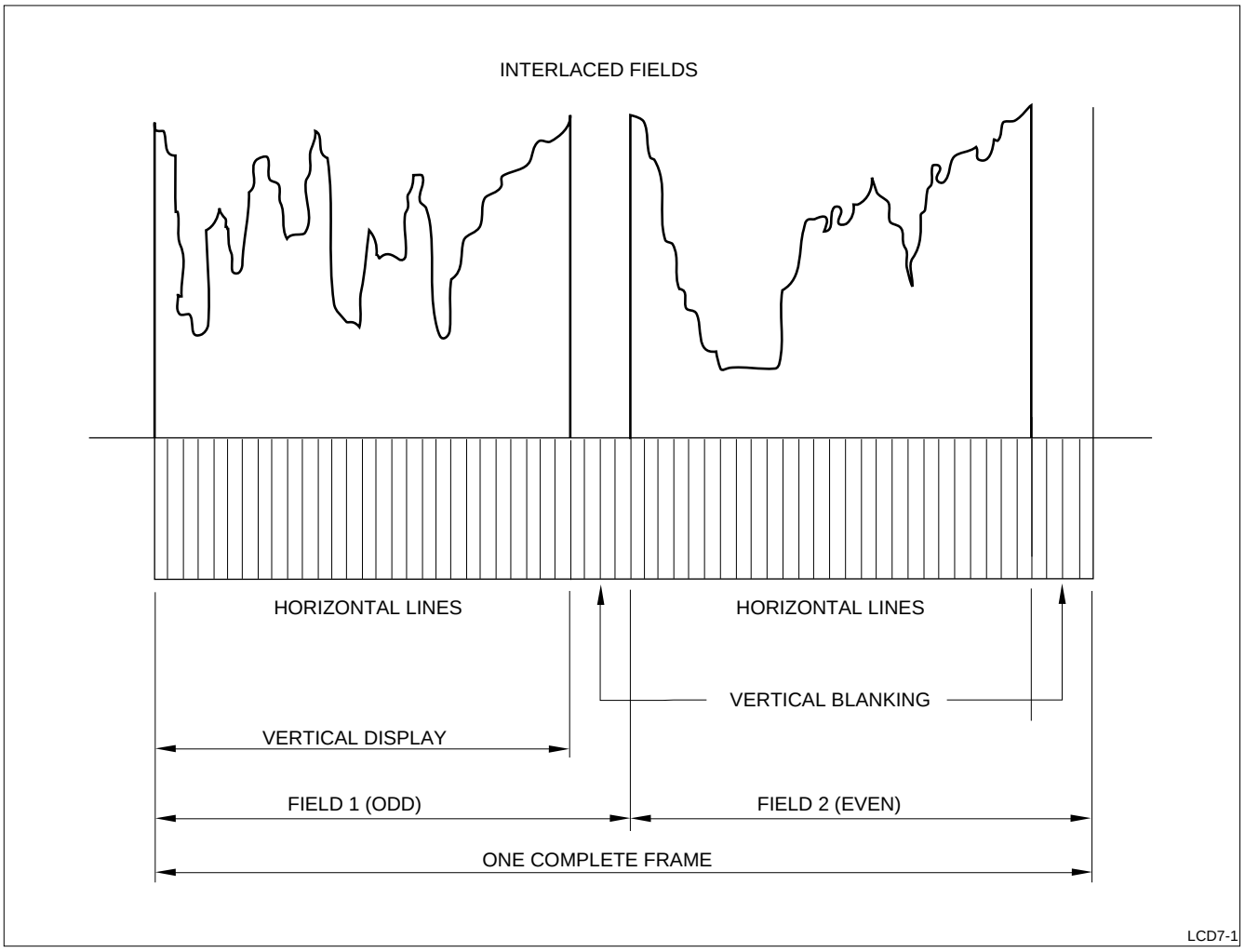


**Fig. 1. Interlaced Fields**

**Composite/Non-Composite Video Signals**

Video signals can be transmitted in a variety of formats. Sharp TFT LCD modules will support the following video configuration:

- Composite Video - Video information is combined with horizontal and vertical sync and color burst information into one signal (Figure 2).
- Analog RGB (non-composite) - Separate red, green and blue video signals used in conjuction with composite sync or separate horizontal and vertical sync (Figure 3).
- Composite Sync - Horizontal and vertical sync are combined into one signal (Figure 4).

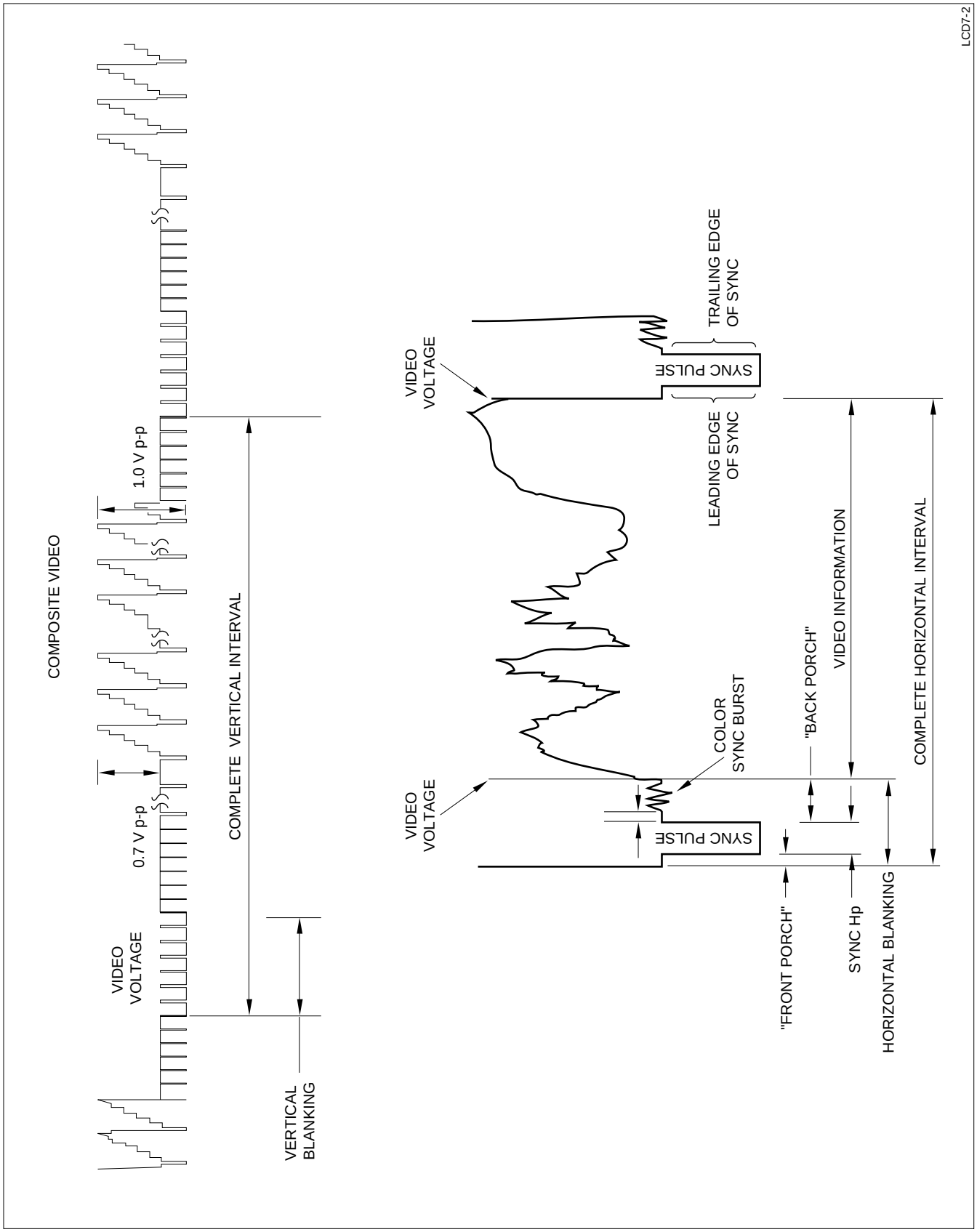


**Fig. 2. Composite Video**

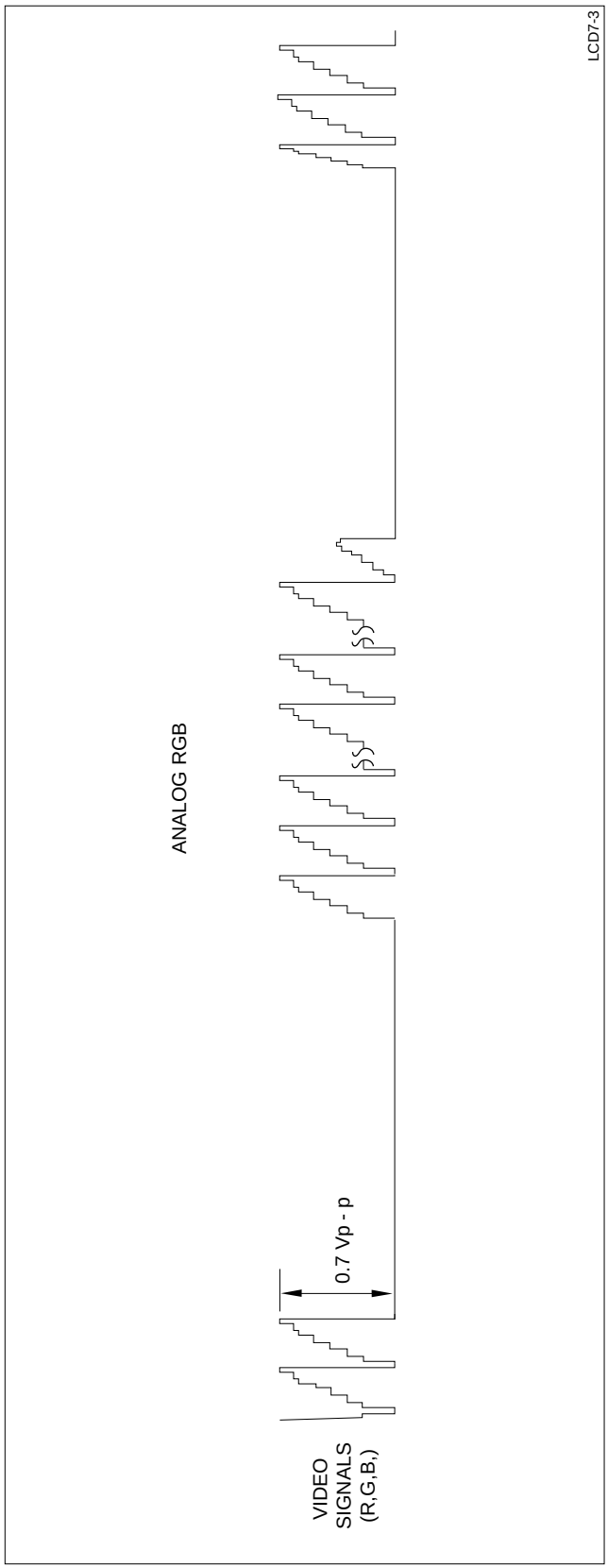


Fig. 3. Analog RGB (non-composite)

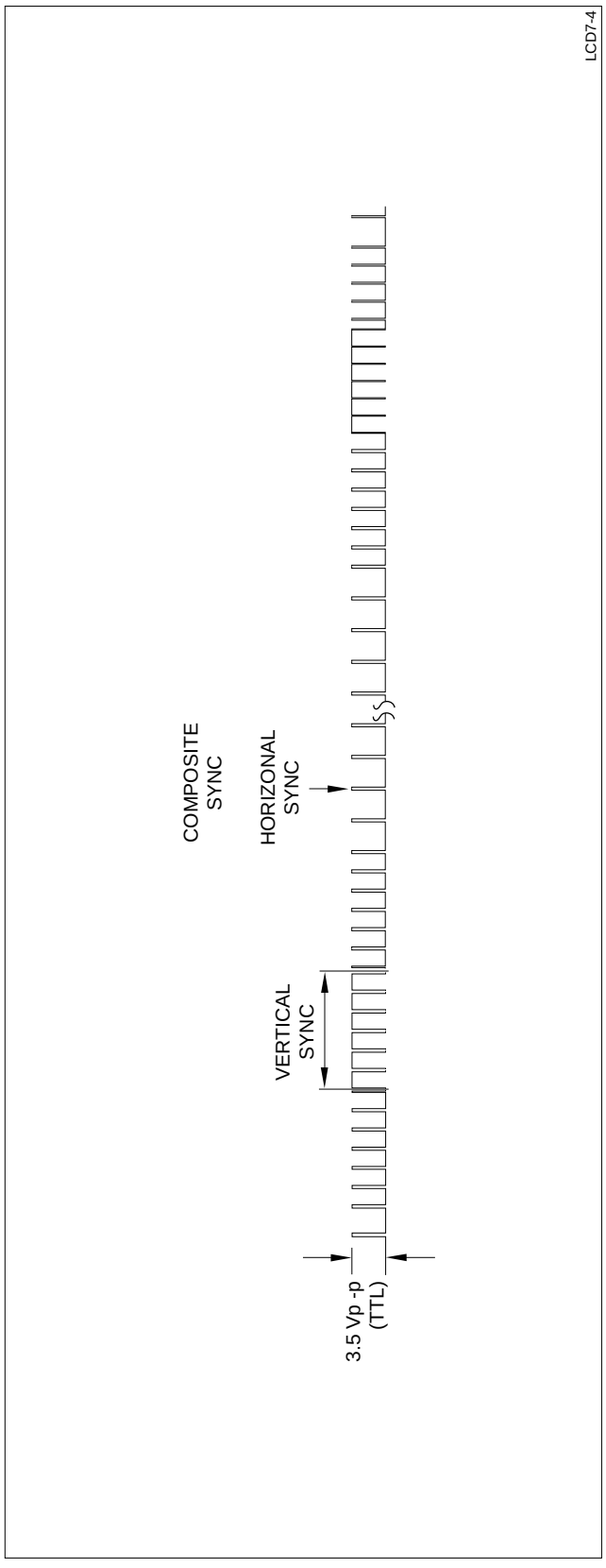


Fig. 4. Composite Sync

## GENERAL INFORMATION

### Viewing Direction

All 4" and 5.7" color TFT LCD modules are offered with a choice of viewing direction. The last digit of the part number will indicate the viewing direction. A "1" will indicate a 6 o'clock viewing direction while a "2" indicates a 12 o'clock viewing direction. The relationship of the viewing direction optimizes the contrast ratio for +10° to -30° in the vertical axis and the 12 o'clock viewing direction optimizes the contrast ratio for +30° to -10° in the vertical axis (Figure 5). The horizontal viewing angle remains even and consistent for all TFT modules.

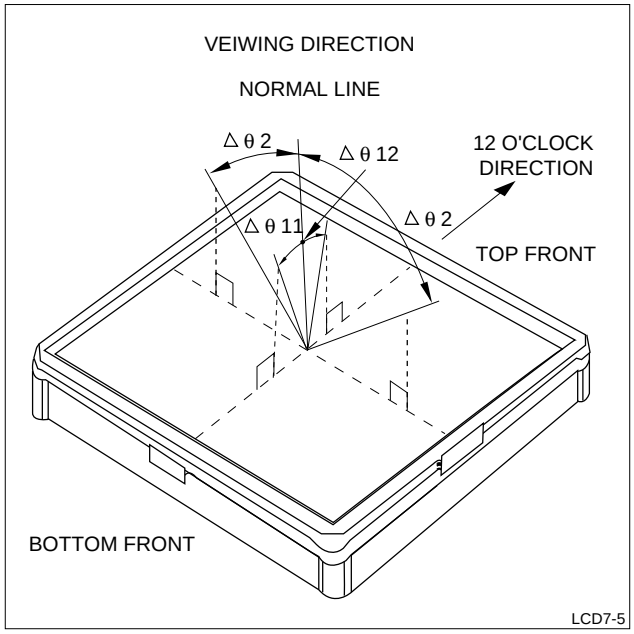


**Fig. 5. Viewing Direction**

### Interlaced Operation

As described earlier, NTSC and PAL video signals consist of two interlace fields. When these fields are viewed on a monitor by the human eye, they appear as one continuous image. In a CRT monitor, these two fields are interwoven on the screen (Figure 6). In a Sharp TFT LCD there are either 240 or 234 lines printed on the glass depending on the model (Note 2). Since the odd and even fields consist of 240 lines each, the fields are scanned on the same lines of the LCD one after another (Figure 7). As with a CRT, the eye integrates these two fields into one complete frame and the resulting image appears to be a full 480 lines on the LCD.

Displaying the video information on the PAL version of the LCD is more involved. The odd and even fields

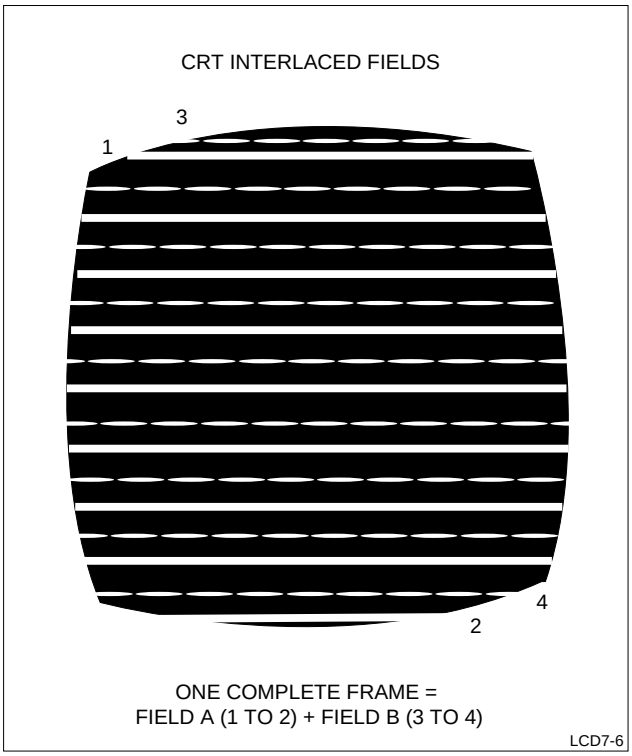


**Fig. 6. Interlaced Operation**

are made up of 280 lines each. In order to display the information on the 240 line LCD as done in the NTSC mode, the video signal must be reduced to 240 lines/field. This is done by removing 40 lines/field through a method called MBK-PAL (MaBiki "Thinning in Japanese). In this method every seventh line is removed by using the following algorithm (Figure 8):

(14n + 11)H, (12n + 19)H even field

(n=1, 2, 3, ... 20)

(14n + 16)H, (14n + 22)H odd field

### Pixel Configuration

Each pixel of Sharp's small color TFT LCDs consists of 3 sub-pixels. These red, green, and blue sub-pixels can operate at any output level to give full color capability to each pixel. A 234 V x 382.5 H, 234 V x 479 H or 240 V x 720 H pixel format is availiable depending of the particular TFT LCD model. The pixel format is defined as the number of sub-pixels (RGB). The actual number of pixels is as follows: 234 V x 128 H (128 x 3 RGB approx. 382.5), 234 V x 160 H (160 x 3 RGB approx. 479), 240 V x 240 H (240 x 3 RGB approx. 720). The LCDs use a delta pixel configuration with each addressable pixel residing on the same line (Figure 9). This configuration makes the LCD displays well suited for video information.

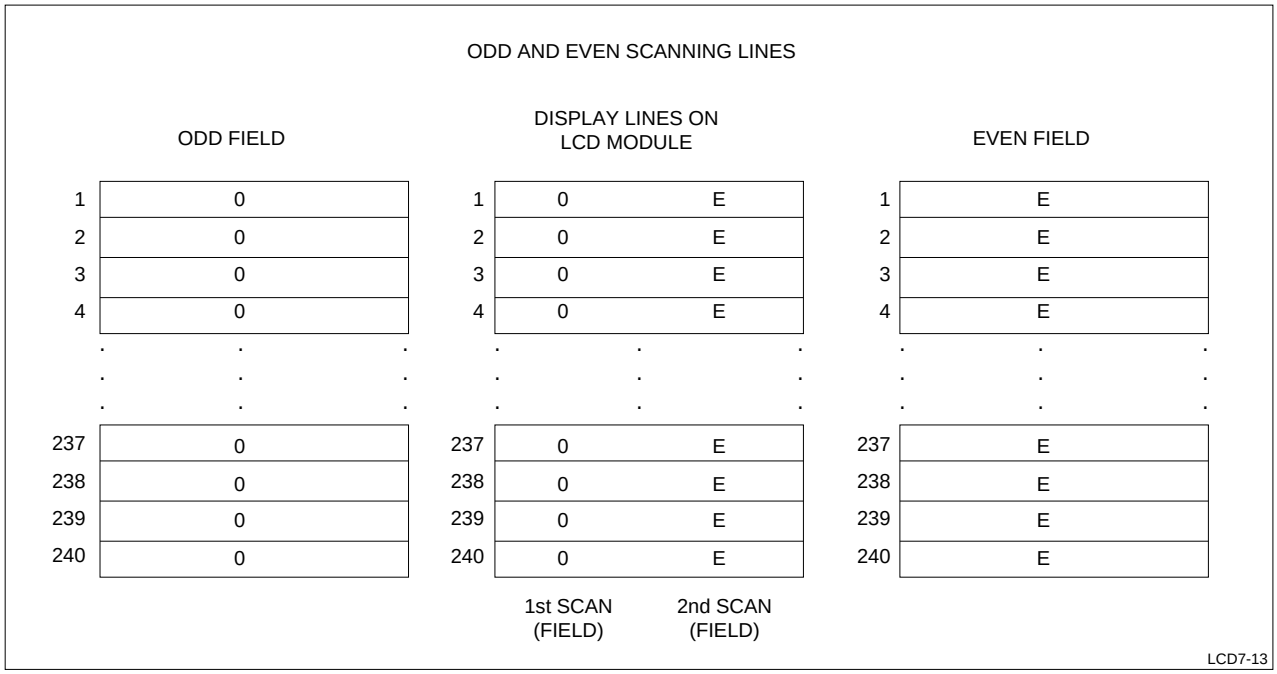


**Fig. 7. Odd and Even Scanning Lines**

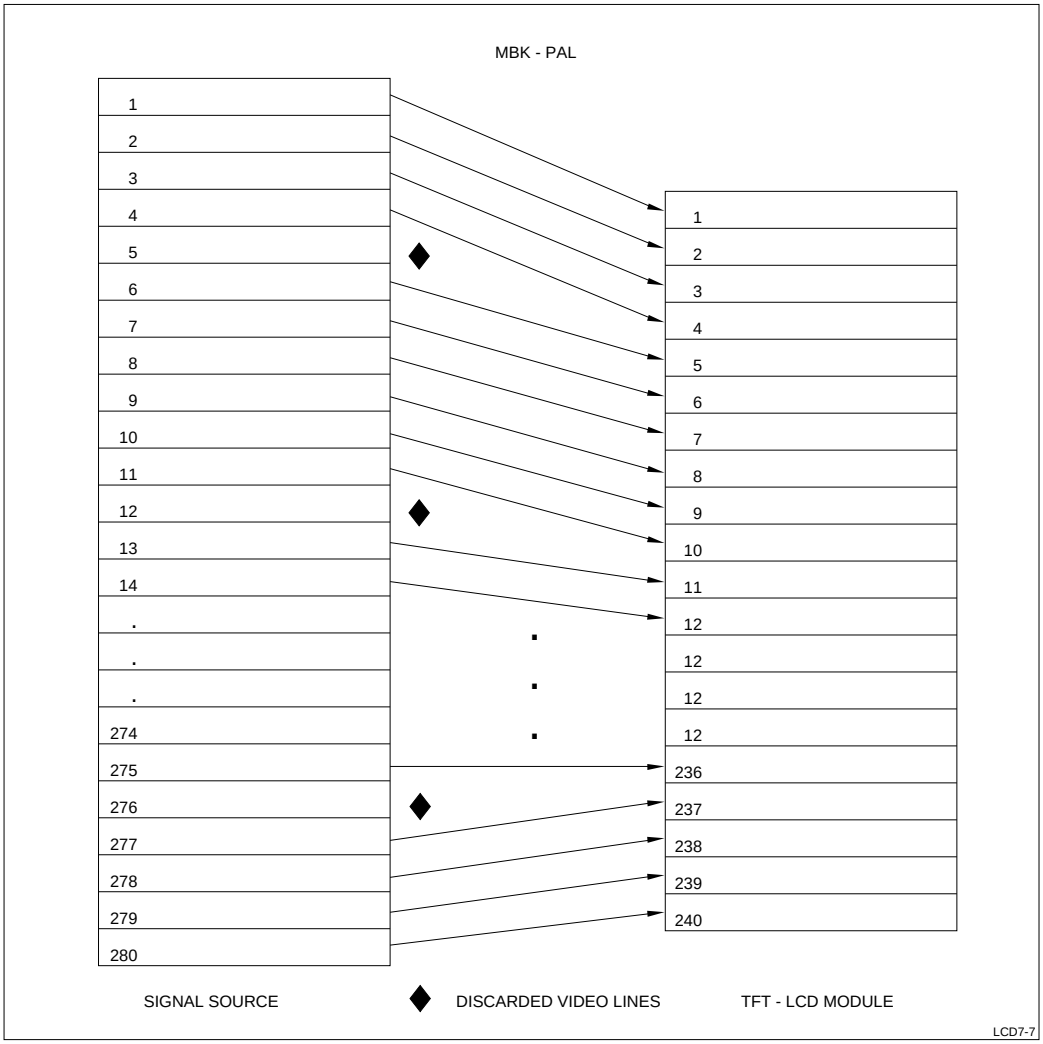


**Fig. 8. MBK-PAL Method**

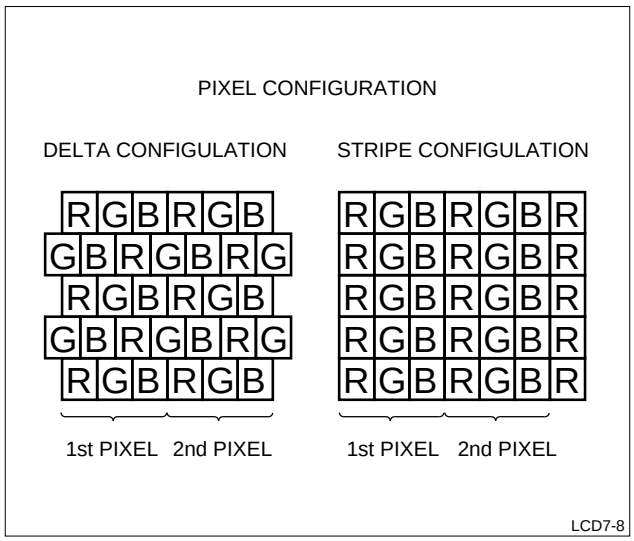


**Fig. 9. Delta Pixel Configuration**

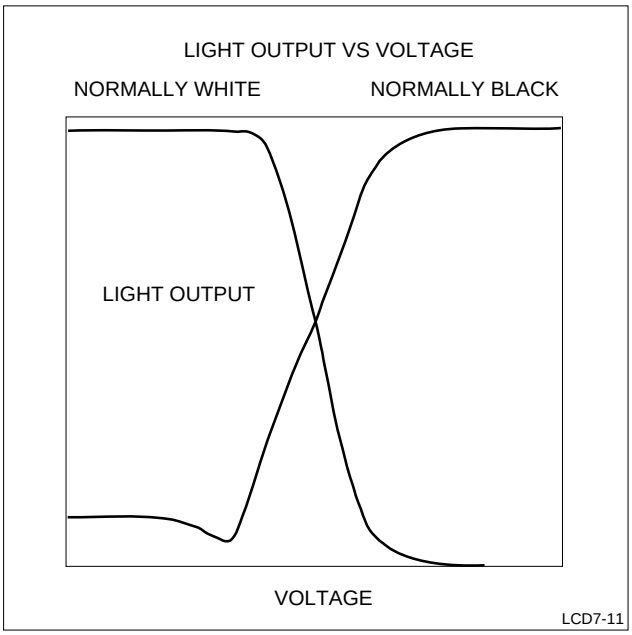


**Fig. 10. Light Output vs. Voltage**

### Normally White Mode

Sharp Color TFT LCD modules operate in the normally white mode. This gives Sharp TFT displays a higher contrast ratio than those using the normally black mode. The main difference between normally white mode and normally black mode is the orientation of the linear polarizers. Normally white polarizers are perpendicular to each other (Figures 11a). When the power is removed in a normally black mode (Figure 11b), the liquid crystal material does a 90° twist. There is still some light at low voltages that will pass through in this configuration (Figure 10). The normally white mode will not let this light through in the off state due to the perpendicular arrangement of the polarizers.

Note 2: The LCD models which have 234 lines drop the last 6 lines in each field to accept the 240 line NTSC input.

### Gamma Correction

Gamma correction refers to the exponential variation in the signal input to provide a linear transfer function from the signal source to the display-luminance output. The luminous output of the LCD is not directly proportional to the display-signal input under normal conditions. This is due to the characteristics of the LC material. A similar condition occurs in a CRT monitor where the luminous output of the phosphors are not directly proportional to the signal input. In order to compensate for this non-linear response, a gamma correction is applied to the monitor (LCD or CRT) to give a linear luminous output (figure 16). Although values vary among monitors, the gamma correction factor for Sharp LCDs is 2.2. This is the same as the accepted value for most CRT monitors.

Gamma is defined as the power exponent used to approximate the curve of display-luminance output versus signal input amplitude. When using a factor of 2.2, for example, a 50% - of-full-scale input voltage will result in a 22%-of-full-scale luminous output (0.5/2.2 = 0.22).

All Sharp small color TFT modules have the gamma correction built into the module with the exception of LQ323Y11/P07 and LQ4RE01/2. Sharp's basic design policy is all color TFT LCDs without built-in interfaces will have to be supplied with an external gamma correction, whereas all color TFT LCDs with a built-in interface do not need an external gamma correction.

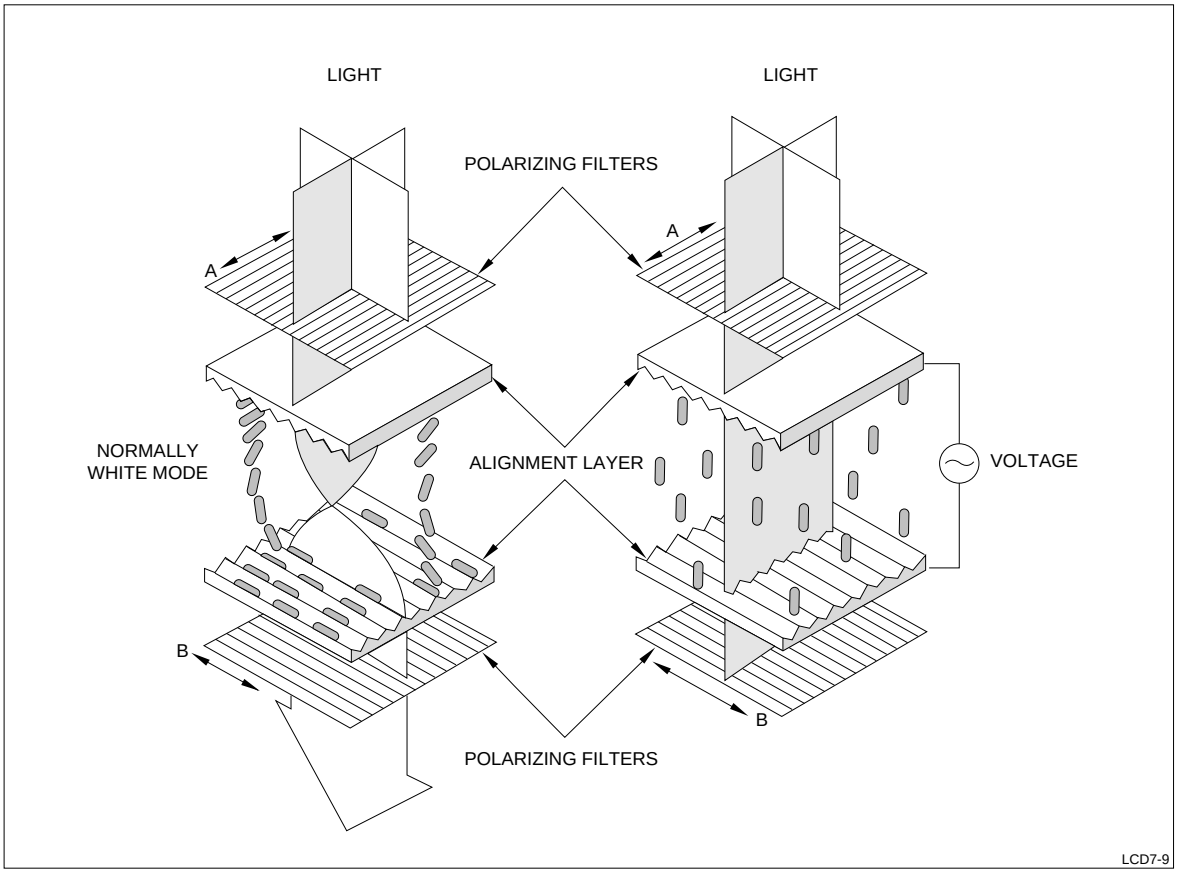


**Fig. 11a. Normally White Mode**

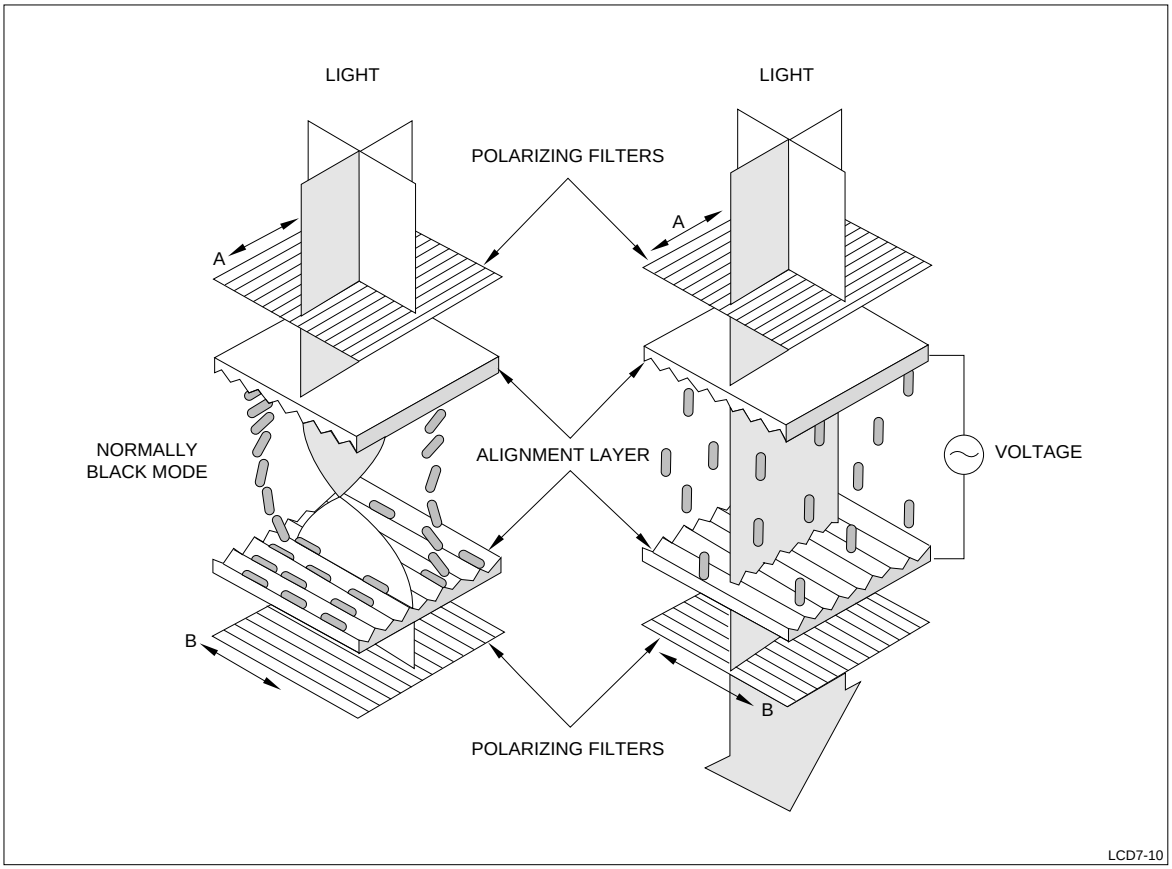


**Fig. 11b. Normally Black Mode**

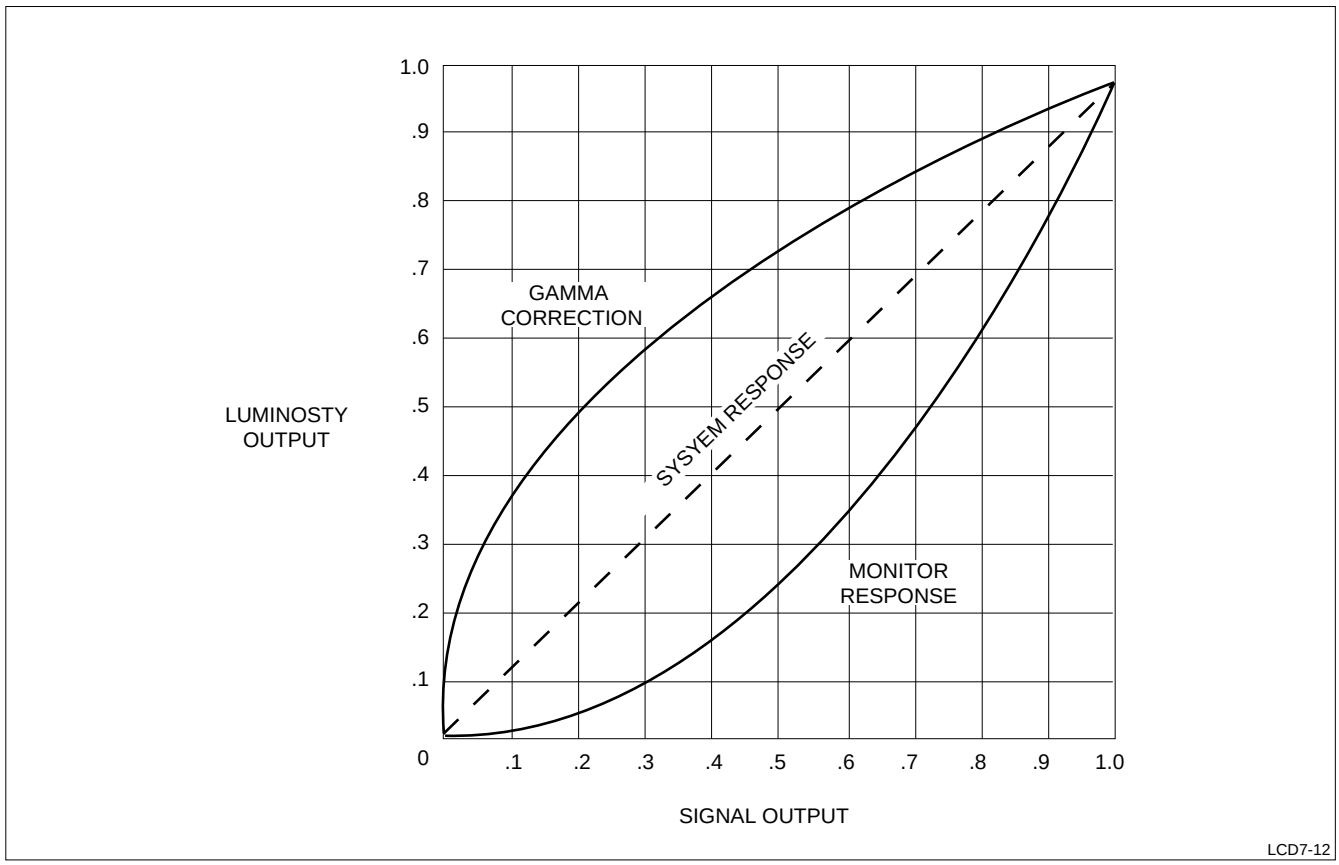


**Fig. 12. Linear Luminous Output**

## Connectors

All the TFT modules use Flat Printed Circuit (FPC) cables and connectors for signal I/O connection. The various modules come with either 16 or 20 conductor cables/connectors with a 1.0 mm or 1.25 mm pitch. Refer to Table 5 for the configuration with each model. The 1.0 mm and 1.25 mm Pitch FPC cables/connectors can be obtained from varous companies including the following:

- ELCO (Laguna Hills, CA, 714-830-8383)
  1.00 mm/1.25 mm FPC connectors
- Molex (Lisle, IL, 708-969-4550)
  1.0 mm/1.25 mm FPC connectors
- Parlex (Salem, NH 603-893-0040)
  1.0 mm/1.25 mm FPC cables, custom cables with connectors
- Sumitomo (Freehold, NJ, 908-409-3990)
  1.00 mm/1.25 mm FPC cables/connectors.

All the LCD module connectors/cables, along with their mating connectors/cables, are referenced in their individual specifications.

**Table 5.**
**COLOR TFT LCD PRODUCTS THAT REQUIRE MATING FLEX CIRCUIT CABLES**

| DISPLAY MODEL | CONNECTOR/CABLE ON LCD | MATING CONNECTOR/CABLE |
|---|---|---|
| LQ323Y11 | 16 Conductor FPC Cable; 1.0 mm pitch | 16 Conductor FPC Connector; 1.0 mm pitch |
| LQ323P07 | 16 Conductor FPC Cable; 1.0 mm pitch | 16 Conductor FPC Connector; 1.0 mm pitch |
| LQ4RE01/2 | 16 Conductor FPC Cable; 1.0 mm pitch | 16 Conductor FPC Connector; 1.0 mm pitch |
| LQ4RA01/2 | 20 Conductor FPC Connector; 1.25 mm pitch | 20 Conductor FPC able; 1.25 mm pitch |
| LQ4NC01/2 | 20 Conductor FPC Connector; 1.0 mm pitch | 20 Conductor FPC Cable; 1.0 mm pitch |
| LQ4RB03 | 16 Conductor FPC Connector; 1.0 mm pitch | 16 Conductor FPC Cable; 1.0 mm pitch |
| LQ4RB11 | 16 Conductor FPC Connector; 1.0 mm pitch | 16 Conductor FPC Cable; 1.0 mm pitch |
| LQ6RA01/2 | 20 Conductor FPC Connector; 1.25 mm pitch | 20 Conductor FPC able; 1.25 mm pitch |
| LQ6NC01/2 | 20 Conductor FPC Connector; 1.0 mm pitch | 20 Conductor FPC Cable; 1.0 mm pitch |

**Backlight**

The backlight on the 4" and 5.7" TFT LCD modules is replaceable. The replacement backlight modules can be obtained from Sharp as needed. The backlight on the 4" modules uses HCFTs (hot cathode fluorescent tubes) and on the 6" modules the backlight uses CCFTs (cold cathode fluorescent tubes). The main differences between the two technologies are: 1) HCFTs have to pre-heat the filament, 2) HCFTs tend to have a higher light output, and 3) HCFTs will have a shorter life.

The Sharp partn umber forthe 4" replacement backlight module is LQ0B01 and the part number for the 6" replacement module is LQ0B04.

The input for backlight modules varies from 110 Vrms @20-50 kHz for the HCFT modules to 330 Vrms @20-50 kHZ for the CCFT modules. These modules also require an ignition voltage of 600 - 800 Vrms for initial discharge of the backlight tubes.

Inverters to drive these voltages are presently available from Sharp and also from Endicott Research Group, Endicott, NY (607-754-9187). These inverters usually run off an input of either +5 V, +12 V or +24 V DC. The Sharp part numbers for the inverters are LQ0J06 for the 4" modules and LQ0J04 for the 6" modules. The LQ0J06 comes with an input voltage connector and two output cable assembles to connect directly to the backlight module. The LQ0J04 also comes with an input voltage connector, but can connect directly to the backlight module without cables.

**Handling/Cleaning**

The face of the Color TFT LCD modules consists of an outer polarizer. The polarizer is made from a soft material and care should be taken not to scratch this surface. Any scratch to the surface will adversely affect the operation and quality of the display. All mounting configurations should include some type of clear protective covering to prevent any damage to the polarizer and module. The protective laminate, shipped with the module, should only be removed immediately before the protective covering is placed in front of the face of the module.

If some dust happens to get on the surface of the display, it should be blown off with an ionized air gun to prevent any static build-up of dust. Wiping the unit with a cloth will scratch and damage the polarizer. If, in the worst case, dirt or a smudge appears on the glass, Sharp recommends using a soft, dry cloth with a very small amount of petroleum benzene.

As with any LCD display, do not expose the display to prolonged direct sunlight/UV rays as the filters and LC material will degrade over time. A clear protective antiglare filter that also filters UV may provide the best all-around solution to protect the LCD from the environment.

## INTERFACING TO THE DISPLAY MODULE

Interfacing to the various modules varies from model to model. Each model will be examined and their interfacing requirements defined.

### LQ323Y11/P07

These two display modules support either NTSC (LQ323Y11) or PAL (LQ323P07) video standards. They require an external interface to control the input data and sync signals, along with an external backlight. DC input voltages of +5.0 V, +13.0 V, -8.0 V and -20.0 V also must be provided. To prevent damage to the LCD, the power voltages to the source and gate drivers must be applied in the following power on/off sequence:

On: +5.0 V-->+13.0 V-->-20.0 V-->-8.0 V

Off: -8.0 V-->-20.0 V-->+13.0 V-->+5.0 V

Separate RGB video signals, alternating in polarity, must be used to input the data. The FRP signal output (TTL level clock signal = 1/2 horizontal sync frequency) should be combined with the RGB video signals to give the alternating video inputs. The alternating video signals prevent electrochemical degradation of the LC material which can be caused by applying either all negative or all positive voltages.

Composite horizontal and vertical sync is also required as an input to these units. A separate horizontal and vertical sync output from the module can be used to sync video overlays on the screen.

Vcom (common electrode driving signal) is a required clock signal, in phase with the alternating video signal, which controls the amplitude of the video signal. Controlling the amplitude of this signal will control the contrast of the LCD module.

These displays can be easily controlled by using one of Sharp's interface ICs for LCDs. These interface ICs have onboard gamma correction and polarity inversion among other useful features. The IR3P89 is a general purpose color LCD interface IC which processes RGB video into RGB signals suitable for input into the LCD module. This part only performs basic functions and does not have any chroma processing capabilities. The IR3P90B (NTSC) and IR3P96 (PAL) can accept either a composite video input or separate RGB input and has the capability of performing extensive video/chroma processing. Depending on the application, one of these ICs will be able to efficiently fulfill the 3" TFT LCD interface requirements.

There are only two adjustments available to modify the visual performance of the modules. Vcom, as described earlier, is an input signal that will change the display contrast. H-POS is an adjustment on the module that can readjust the image if it is not centered horizontally. All other controls are preset during production and should not be adjusted by the user to maintain optimum performance of the module.

### LQ4RE01/2

These modules accept either NTSC or PAL video inputs by changing the TTL level of the mode change terminal. An external backlight along with a series of input voltages and processing signals are required to drive these units. The input DC supply voltages required are +5.0 V, +13.0 V, -8.0 V and -20.0 V. These voltages supply the power for the source and gate drivers and should be applied in the following power on/off sequence:

On +5.0 V-->+13.0 V-->-20.0 V-->-8.0 V

Off -8.0 V-->-20.0 V-->+13.0 V-->+5.0 V

The video input signals required are composite sync along with separate RGB signals alternating in polarity by using the FRP output signal. The FRP signal is a TTL level clock signal operating at 1/2 the horizontal sync frequency. The FRP signal when combined with the analog video signal should give a combined alternating signal of 5 Vp-p. The polarity of the video signal must be alternated to prevent the LC material from electro chemical degradation.

As with the 3" modules, Sharp interface chips IR3P89, IR3P90B and IR3P96 can be used on the LQ4RE01/2 models to perform the required processing of the interface signals.

Horizontal and vertical sync are also available as outputs to synchronize video overlays on the screen such as time/channel indication for a TV application.

There are a series of adjustments that can be used to adjust the visual characteristics of the LCD. Vcdc (common electrode driving signal) is a DC bias input that can be used to optimize the contrast of the display. This adjustment is optimized during manufacturing and should not be readjusted by the user under normal operating conditions. If operating conditions change, such as a reduction in the input power voltage level, Vcdc can be readjusted to optimize the performance of the display module by using the adjustment method described in the TFT-LCD module specification. The H-Pos (horizontal position) control on the module can adjust the position of the picture on the display. All other controls are preset at the factory and should not be touched in order to assure optimum performance.

### LQ4RA01/2, LQ6RA01/2

These 4" and 5.7" modules are compatible with both NTSC and PAL Video standards. The replaceable backlight is already incorporated into these units and the user need only supply a DC-AC inverter to power the backlight. The video section requires DC power supply voltages of +5.0 V and -8.0 V applied in the following power on/off sequence:

On +5.0 V-->-8.0 V

Off -8.0 V-->+5.0 V

The video drive signals consist of composite sync and separate RGB analog video signals. The sync accepts a standard composite sync signal or a standard composite video input (1.0 Vp-p). The video inputs consist of separate (3) RGB analog signals (0.7 Vp-p). There are two sets of video RGB inputs that can be multiplexed by a TTL control signal (VSW) for displaying two separate video sources. The horizontal and vertical sync outputs can be used to synchronize overlays on the display an might be done in a television application.

As with all of the color TFT LCD modules, there are adjustments to control the display visual characteristics. Brightness (BRT) and contrast (Vcdc) can be adjusted by changing the DC voltage to these two inputs. For optimum performance Sharp recommends not readjusting Vcdc under normal operating conditions. There are also a number of adjustments on the back of the module. Most of these have been adjusted at the factory for optimum performance and display quality. The adjustments that are user accessible are contrast, brightness and horizontal position. The contrast (Vcdc) and brightness adjustments as indicated, can be adjusted either externally or on the module itself.

**LQ4NC01/2, LQ6NC01/2, LQ6MC01/2**

This series of 4" and 5.7" modules operates from a composite video input. The "N" series is compatible with a NTSC input and the "M" series is compatible with a PAL input. The backlight is in a modular form and can be easily replaced.

The video section requires a DC power supply of +5.0 V and -6.0 V to be powered on/off simultaneously. As with all of the modules, the video signals should be applied after the supply voltages. The video input signals consist of a composite video input along with separate (3) RGB analog video inputs. The separate RGB video inputs synchronized with the horizontal and vertical sync outputs can be multiplexed with the composite video input to give onscreen overlapping images.

The demodulation of the color burst is performed internal to the module and the color gain (COL) and tint (TIN) can be adjusted either on the back of the module or external to the module by changing the DC input voltage. Contrast and brightness may also be adjusted on the module or externally. The horizontal position control on the back of the module can be used to center the image, but all other adjustments on the back of the module are performed at the factory and should be left alone for optimum operation of the module.

## CONCLUSION

Sharp will also be introducing a series of new small TFT color LCD modules. The LQ4RB03 will have a similar interface to the LQ4RE01, but will include the backlight module and come in a slightly more compact package. The LQ4RB11 and LQ6RB11 are 4" and 5.7" LCDs that will also be similar to the LQ4RE01 interface, but will have an optional backlight module and a lower resolution. These units will be targeted toward more cost sensitive applications.

Sharp is also working on increasing the temperature range of the TFT color modules. Sharp's initial goal is to introduce units with a storage temperature of -30° C to +80° C and an operating temperature of -10° C to +70° C. By 1993 Sharp plans to have units available with the capability of a storage temperature of -30° C to +90° C and an operating temperature of -30° C to +85° C. Sharp's efforts to fulfill these goals will concentrate on all aspects of the LCD module: driver/interface ICs, interconnect technology, backlighting technology, polarizer technology, and the LC glass structure itself. Sharp is very confident it can meet the demand for modules which are subject to severe environmental conditions.

With a variety of models available, Sharp's small TFT color LCD modules can meet the design requirements needed for compact monitor applications. The variety of available models also offers a range of cost/performance options. The realm of applications is only limited by the imagination of the designer.

## REFERENCES

*Raster Graphics Handbook*. Second Edition. Conrac Division, Conrac Corporation. New York: Van Nostrand Reinhold Company. 1985.

*TV/Video Sync: Primer and Product Note Opt. 005-1.* Hewlett/Packard. November, 1981.

## 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 reserves the right to make changes in specifications at any time and without notice. SHARP does not assume any responsibility for the use of any circuitry described; no circuit patent licenses are implied.

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, 1993
Printed and bound in the U.S.A.

Ref. No. SMT92026