LCD Design Guide

The following contains basic criteria to guide you design a Custom LCD or adopt a Standard Module to match customers' requirements.

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1. Display Content – icons, segments and dot arrays

The LCD display content is the first thing that comes to the design. It contains character icons, segments, graphic dot arrays, or any combination. We differentiate also between the standard models and customer adapted LCDs, called customized.

Icons are the images on the glass that specifically complement your produce. These images can be shaped according to your need and count as one pixel or segment on LCD. Examples would be company logo, signal strength indicator, etc.

Segments: Such as 7 segment numeric character (for displaying 0-9), or 14 segment alpha-numeric character (for displaying 0-9 & A-Z).

Dot Arrays: These dot arrays can be made in almost any size and dot count. Examples would be character displays that use a series of 5x7 dot arrays to create a string of alpha numeric characters, or the larger 320 x 240 graphic arrays that make images along with variable size alpha-numeric characters.

2. Display Shape and Dimensions

To integrate the display to your project properly, the shape and size are very important factors. You may choose common rectangle, polygon or with arc edge for your design. Dimensions you need consider are the outline dimension, the viewing area and the thickness.

3. Technology – TN, HTN, STN or FSTN

The type of technology used is determined by the specific performance requirements you set for the display that you are designing. Since several variations will do a fine job, the ultimate consideration is cost. So here is a quick breakdown of the technologies we offer.

TN: Low costs, poor viewing angle, average contrast. Color: Black and Gray (can be Positive or Negative). Static driving preferred, but operates well up to a 32:1 Multiplex rate. LCD Glass favorite.

STN: Medium costs, average viewing angle, average contrast. Color: Yellow-Green and Gray background (Positive display), Blue background (Negative display). Works well at high Multiplex rates. LCD Module favorite, high end LCD glass choice.

FSTN: Medium costs. Good viewing angle, excellent contrast. Color: Black and White (can be Positive or Negative). Works well at high Multiplex rates. Higher end LCD Module favorite.
4. **Viewing Mode – type of polarizer**

The viewing mode is controlled by the rear polarizer, and how much it does or does not reflect light. LCDs are offered in three basic light transmission modes: reflective, transflective and transmissive.

<table>
<thead>
<tr>
<th>Reflective type</th>
<th>Transflective Type</th>
<th>Transmissive type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective</td>
<td>Transflective</td>
<td>Transmissive</td>
</tr>
</tbody>
</table>

**Reflective:** In the reflective mode, ambient light is used to illuminate the display. This is achieved by combining a reflector with the rear polarizer. It works best in an outdoor or well-lit office environment with low power consumption.

**Transflective:** Mixture of the reflective and transmissive types, with the rear polarizer having partial reflectivity. They are combined with a backlight for use in all types of lighting conditions. The backlight can be left off where there is sufficient outside lighting, conserving power. In darker environments, the backlight is turned on to provide a bright display. Transflective LCDs will not "wash out" when operated in direct sunlight.

**Transmissive:** Have a transparent rear polarizer and do not reflect ambient light. They require a backlight to be visible. They work best in low light conditions with the backlight on continuously. Most common is transmissive negative image.

5. **Viewing Direction – 6:00, 12:00, 3:00 or 9:00**

Viewing direction (or bias angle) is the direction from which the display will look the best. It is set during the manufacturing process, and cannot be changed later by rotating the polarizer. Viewing direction is specified as positions of a clock face. A twelve o’clock viewing direction (12:00) means that the optimum direction is above the normal to the displays, while a part with a six o’clock viewing direction (6:00) is best viewed from below the normal. 9:00 means from the left and 3:00 the right, which two are uncommon.
6. Operating Environment – temperature, indoor/outdoor

When selecting a Liquid Crystal Display Module or LCD Glass, it is very important to identify the range of its environmental temperature. Standard Liquid Crystal Displays do not have an extremely wide temperature range, and that range can be affected by solar radiation, ventilation and extremes at different times of the year. Also, you need to be aware of the type of backlighting and control circuitry selected can influence the overall temperature range of the environment.

Another thing to consider that is pertinent to the LCD temperature range is that the contrast of the display will change over that range. Your design needs to make allowances for this fact by either adding temperature compensating circuitry to your design, or selecting one of our LCD modules that already have built-in temperature compensation circuitry.

<table>
<thead>
<tr>
<th>Operating Temperature</th>
<th>Storage Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Range</td>
<td>0°C to 50°C</td>
</tr>
<tr>
<td></td>
<td>-20°C to 60°C</td>
</tr>
<tr>
<td>Wide Range</td>
<td>-20°C to 70°C</td>
</tr>
<tr>
<td></td>
<td>-30°C to 80°C</td>
</tr>
</tbody>
</table>

Also other temperature ranges are possible, but not very common.

7. Drive Method – static or multiplex

The Drive Method specifies how each segment of the LCD display is connected to the LCD driving circuitry. There are two methods offered.

Static Drive: LCD Glass or LCD Modules with a simple segment displays are the only parts that have an option of Static Drive. The Static Drive configuration means that there is an individual control line to select each LCD segment and there is only a single common line that connects to them all. This configuration produces the best display with the widest temperature range, but it requires more interconnections (>Cost in pins and controller) that a multiplexed display would require.

Multiplexed Drive: The Multiplexed Drive configuration means that each control line selects several LCD segments and the final selection is made by selecting the correct backplane /common that also connects to several LCD segments. This configuration uses less interconnection which is cost effective for smaller display and mandatory for high density dot array displays where there are more dots than LCD ledge space to provide interconnects. This configuration degrades the temperature and image performance slightly.

8. Connecting Method – metal pin, elastomer strip, heat seal or FPC

There are several methods to connect the LCD with its control circuitry.

Elastomers (Zebra Strips): Elastomers are silicon strips of alternating conductors and insulators. These materials are generally soft and compliant and can be easily compressed between the Liquid Crystal Display and circuit board. Elastomers require a bezel to squeeze the display and circuit board together. This method will yield a higher conductor interconnection than pins, potentially less costly than pins, but requires a specialized compression bezel.
**Metal Pins:** Attached to the display to allow the user to either mount the display in a socket or solder it directly into a circuit board. From an end user standpoint, pins are the easiest to use since there is no requirement for a compression bezel or expensive heat seal bonding equipment.

**Heat Seal:** The heat seal flex cable is a flexible cable with conductive traces that is bonded to the LCD glass and can either be bonded to the PCB or plugged into a specialized connector on the PCB. The advantage of a heat seal cable is the high density of conductors that can be used on this cable and it has reach.

**FPC (Flexible Print Circuit):** A circuit substrate of patterning Cu electrode with Polyimide film as a base. Usually offers more flexibility than Flexible Flat Cables.

**TAB (Tape Automated Bonding) and COG (Chip On Glass):** Please see Assembly Type.

**9. Backlighting – LED, EL or CCFL**

**LED** - Consists of surface mount LEDs, which are situated in series along the bottom of a shallow plastic tray (Array) or the edges of display (Edge).

- Available Colors: Yellow-Green (standard), White, Red, Amber, Green, Blue, Orange,
- Life time: long, typically 50,000 hours, Yellow-Green can be 100,000 hours
- Operating temperature range: -30 to +80 °C
- Requires low voltage DC. No DC/AC inverter required
- Simple connection +5 VDC (Anode) and ground (Cathode)
- Two methods: matrix (array) or edge lighting
- Most popular backlight and future developing trend.
EL - A thin membrane consisting of two coated electrode plates with an aluminum reflector. When AC voltage is applied to the electrodes, the electrons collide with the light emission core. The energy given off is light. Inverter (DC to AC) is used to power electro luminescent lamps.

- Available Colors: White (standard), Blue, Yellow-Green
- Service Life: 4000 hrs (driven with inverter, 20°C temp, 70% humidity) and 1500 hrs (driven with a fixed power supply and frequency generator, 20°C temp, 70% humidity)
- Operating temperature range: -20 to +50 °C
- Less and Less popular because of the short life and inverter used.

CCFL - A miniature high voltage cold cathode (field emission) lamp made of lead-glass with mercury inside that provides fluorescent back lighting or edge lighting. Use a diffusing light guide. High brightness, high efficiency and vibration-proof.

- Available Colors: White (standard)
- Life time: 15,000; 20,000 hours
- Operating temperature range: -20 to +50 °C
- Low power consumption and excellent lighting characteristics
- Easy intensity control
- Low heat generation and thin diameter lamp
- Most popular for big display 5.7” or bigger, TV and monitor
10. Assembly Type – COB, COG or TAB

Assembly type refers to how LCD controller/drivers IC chips are mounted. The most common types are COB, TAB and COG. There are also other variants based on these types.

COB (Chip On Board)

COB is a popular IC mounting method that provides wire bonding as the direct attachment of bare die to laminated printed circuit boards. The driver is formatted into an area on the PCB. Electrical connections are made by micro diameter gold wires. The entire area is then covered with epoxy. Most of our LCD modules use COB mounting method.

Advantages

• Very compact
• Space savings over SMT assembly
• Cost savvy compared with SMT, since there is no plastic package

TAB (Tape Automated Bonding)

LCD controller and/or driver electronics are encapsulated in a thin, hard bubble package, of which the drive leads extend from the bubble package on a thin plastic substrate. The adhesive along the edges is used to attach the TAB to the LCD glass and/or PCB.

TAB mounting method uses the same type of integrated circuits as COG technology - Gold Bumped Flip Chips. After this type of IC chip is produced, a gold bump is placed on the IC chip and then sealed onto the polyimide board. (This procedure is called ILB or Inner Lead Bonding) and is how the TCP IC is produced.

Advantages

• Offers compactness (IC and its interfacing circuitry can be bent behind the LCD glass panel)
• Some times more cost-effective than COG, if a designer has to integrate a keypad or indicator around the display.
• The active area is centered (differently from COG).
• Can provide interfacing at very fine pitches.

Disadvantages

Consist of:
LCD, Metal (Plastic) bezel,
Elastomer (Heat Seal), Print circuit board and driving LSI

Consist of:
LCD, TAB driving LSI (or Print circuit board)
• The bonding area is weak. Less reliable than COG.
• More expensive than COG. Even though TAB LCD modules use the same type of IC as COG, tape automated bonding requires a package.

COG (Chip on Glass)

COG is one of the high-tech mounting methods that uses gold bump or flip chip ICs, and implemented in most compact applications. COG integrated circuits were first introduced by Epson. In flip-chip mounting, the IC chip is not packaged but is mounted directly onto the glass as a bare chip. Because there is no package, the mounted footprint of the IC can be minimized, along with the required size of the glass. This technology reduces the mounting area and is better suited to handling high-speed or high-frequency signals.

Advantages
• Very space economical. COG LCD modules can be as thin as 2 mm
• Cost effective over COB, especially in graphic LCD modules, because much less IC’s are required.
• More reliable than TAB, because of the weakness in the bond area of TAB.

Disadvantages
• COG can only be used at a certain resolution level where the lines are not too fine. At very fine pitches COG becomes difficult to test, and TAB is the preferred approach.
• It may be more cost-effective to use TAB or COB, if a designer has to integrate a keypad or indicator around the display.
• The active area is not centered within the outline but offset, because of the area where the circuits are.

Since the Chip-On-Glass integrated circuit has been invented by Epson, COG technology became very popular due to the demand for more compact applications. In the near future we will see this IC mounting method finding its applications in some other equipment than cellular phones, PDA’s, computer network servers, satellite receivers, etc.