Chapter 3

Passive LCDs and Their Addressing Techniques

Passive LCDs can be divided into two main groups: segmented LCDs and passive-matrix LCDs (PMLCDs). The former are today used in monochromatic applications like simple calculators, digital watches and simple instrumentation and climate control equipments. They are not suitable for high-information-content and graphical applications because of their limited resolution. High-performance calculators, organizers, notebooks, portable computers, projectors and LCD-TVs, exploit almost invariably active-matrix displays. Nonetheless, PMLCDs have still a market in applications that meet the following criteria: simple fabrication process, limited resolution, dimensions and price, 1 or 2 colors, and limited tolerable viewing angle. For instance, they are used in mobile telephones, Personal Digital Assistants (PDAs), word processors, automotive applications, logic analyzers, oscilloscopes, electrocardiographs, etc.

The main target of this chapter is to describe techniques that are amenable to address passive LCDs. Addressing implies the conversion of the information to be displayed into sequential voltage pulses in order to individually switch on (or switch off) the display elements (segments or pixels). There are three main methods by which this can be achieved: direct addressing, passive-matrix addressing, and active-matrix addressing. All these techniques are closely related to the type of display to be driven. In this chapter we will discuss the first two approaches, while the related driver circuit schemes and implementation issues will be treated in Chapter 4. The active-matrix addressing techniques and correlated drivers will be treated in Chapters 5 and 6, respectively.

3.1 Seven-Segment Displays and Direct Addressing

The first alphanumeric displays had seven segment electrodes and exploited direct addressing (also referred to as static drive) schemes. A seven-segment display is made up of 2 substrates of glass, each with ITO (transparent) electrodes patterned on their surface. The substrates are sandwiched together leaving a small gap between them which is filled with LC material. The electrode arrangement is illustrated in Fig. 3.1. Each segment is formed by two ITO electrodes placed over two glass plates...
(front and rear substrates) filled with the LC mixture. In the simplest case, the rear electrode is common to all segments to form a single back plane which is taken out as a single connection. Electrodes on the other glass plate are taken out independently in order to connect them externally. The intersection of top and bottom electrodes forms a segment. In general, a display with \( n \) segments needs \( n+1 \) connections and \( n \) drivers to electrically drive each segment.

![Electrodes of a seven-segment LCD: (a) upper electrodes, (b) common electrode](image)

To avoid ionization of the LC molecules, process that reduces the LC display life, the waveform across the segment must be dc free. Therefore, to turn on the segment a pulse driving voltage is used.

Figure 3.2 shows a possible voltage sequence applied to one of the segments. A square waveform with 50% duty cycle is applied to the backplane. The refresh frequency, \( 1/T \), is chosen sufficiently low to contain power consumption but high enough to avoid flickering.

A square voltage with the same characteristics is also applied to the upper electrode. Of course, the voltage across the segment (the last waveforms in Fig. 3.2) is the difference between the voltages applied to the upper and back plane electrodes. When these waveforms are out of phase a net voltage is applied to the segment. If this voltage is greater than \( V_{\text{SAT}} \), then the segment is driven into the ON state (Fig. 3.2a). Usually, the voltage across the ON segments is chosen to be about three times the threshold voltage \( (V_{\text{TH}}) \). A segment is turned OFF only when the waveforms applied to the segment electrode and the back-plane are in phase (Fig. 3.2b).

A simple driving circuit suitable for a seven-segment LCD is depicted in Fig. 3.3. It exploits seven XOR gates (whose truth table is shown in the same figure) to generate the voltage applied to the segment, according to the input bit and clock signal.

As long as the display is limited to numerals, it is possible to achieve a reasonably high image contrast even with the gradual T/V curve offered by the TN method.