Abstract

Compared to the traditional Twisted Nematic (TN) displays, VA displays have deeper black background color, much higher contrast ratio, much wider viewing angle and better image quality at extreme temperatures. However, the VA display technology has stronger requirements for the display drivers than the TN displays, mainly in terms of higher LCD supply voltage ($V_{LCD}$) and/or higher frame frequency ($f_f$). NXP has extended their LCD driver portfolio to specifically drive Vertical Alignment (VA) displays.
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1. Introduction

NXP extended the LCD drivers to specifically drive the high-contrast, true black background and wide viewing angle Vertical Alignment (VA) displays.

2. Vertical Alignment display technology

Vertical Alignment (VA) is a display technology in which the liquid crystals naturally align vertically to the glass substrates (homeotropic alignment). When no voltage is applied, the polarized light passes through the cell without a change in polarization and the light is completely blocked by the second polarizer set at 90° to the first, creating a perfectly black state. When voltage is applied, the LC molecules rotate to a horizontal position allowing light to pass through and create a white display image.

3. Vertical Alignment (VA) compared to Twisted Nematic (TN) displays

In the traditional Twisted Nematic (TN) displays, the alignment layers used in the top and bottom glasses are oriented orthogonal to each other creating a 90° twist of the LCD molecules. The polarized light passes through the LC medium, where is twisted due to the wave guiding of the LC and passes through the top polarizer (also called analyzer) creating a bright state (this configuration is also called the normally white mode as opposed to the normally black mode in which the polarizer are placed in parallel position). Upon application of an electric field, the LC molecules align parallel to the electric field...
due to their dielectric anisotropy, and the wave guiding nature of the LC medium is lost. Thus, the polarized light from the first polarizer remains unchanged and is blocked by the analyzer, creating the black state.

Compared to the traditional Twisted Nematic (TN) displays, VA displays have deeper black background color, much higher contrast ratio, much wider viewing angle and better image quality at extreme temperatures. This new breakthrough display technology is particularly well suited for applications where the display is

1. exposed to sunlight, i.e. needs to be readable in sunlight,
2. is mounted on a black background, e.g. in instrument clusters in the car or
3. is located sideways from the viewer, e.g. in the center stack of a car, and thus needs to be viewable under a wide angle.

VA displays are in growing demand for many applications, such as automotive, white goods, home, and medical equipment.

However, the VA display technologies have stronger requirements for the display drivers than the TN displays, mainly in terms of higher LCD supply voltage ($V_{LCD}$) and/or higher frame frequency ($f_{fr}$). The requirements depend on the specific VA technology developed by each LCD manufacturer as well as on the multiplex rates (backplane drive configuration) used in application. See Figure 3:
Note that the VA displays in mass production are only available with multiplex rates up to 1:64. The major LCD manufacturing companies are working to develop the VA technology for higher multiplex rates.

Fig 3. VA display requirements
4. NXP LCD drivers meet the VA requirements

Regardless of the manufacturer, NXP expanded its LCD drivers’ portfolio in order to meet the strictest VA requirements in the industry. See Figure 4:

From one side, all the new Chip-On-Glass (COG) and packaged LCD drivers have been specifically designed to drive the VA displays. The maximum value of the $V_{LCD}$ voltage has been increased to 9.0 V in the drivers with multiplex drive mode up to 1:8, to 12 V in the drivers with multiplex drive mode up to 1:9 (PCA8538UG) and to 16 V in the drivers with multiplex drive mode up to 1:18 (PCA8539DUG). Similarly, the frame frequency has been designed programmable in a wider range typically from 60 Hz up to 300 Hz or even up to 360 Hz as in the drivers with multiplex rate up to 1:18.
From the other side, the existing LCD drivers have been upgraded with new versions, which are pin-to-pin compatible with their respective predecessors, but delivering higher V\(_{\text{LCD}}\) and/or higher frame frequency. In such a way, the customers can easily replace the existing NXP LCD drivers with the new ones. This allows the usage of the better performing VA displays with no or minimal hardware and software changes. Table 1 lists the NXP products upgraded to meet the VA display requirements:

<table>
<thead>
<tr>
<th>New NXP product</th>
<th>Predecessor product</th>
<th>Package</th>
<th>Maximum resolution</th>
<th>V(_{\text{LCD(max)}}) [V]</th>
<th>f(_{\text{fr(typical)}}) [Hz]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA85232U</td>
<td>PCA85132U</td>
<td>COG</td>
<td>4 x 160</td>
<td>8.0</td>
<td>117 to 176</td>
<td>f(_{\text{fr}}) programmable, in production</td>
</tr>
<tr>
<td>PCA85233UG</td>
<td>PCA85133U</td>
<td>COG</td>
<td>4 x 80</td>
<td>8.0</td>
<td>150 to 220</td>
<td>f(_{\text{fr}}) programmable, in production</td>
</tr>
<tr>
<td>PCA8576FUG</td>
<td>PCA8576DU</td>
<td>COG</td>
<td>4 x 40</td>
<td>8.0</td>
<td>200</td>
<td>Up to 105 °C, release Nov. 2013</td>
</tr>
<tr>
<td>PCF21219DUGR</td>
<td>PCF2119RU</td>
<td>COG</td>
<td>2 lines x 16 characters</td>
<td>6.5</td>
<td>200</td>
<td>Internal V(_{\text{LCD}}); Release Jan. 2014</td>
</tr>
<tr>
<td>PCA85262ATT</td>
<td>PCA85162T</td>
<td>TSSOP48</td>
<td>4 x 32</td>
<td>8.0</td>
<td>200</td>
<td>Up to 105 °C, release Dec. 2013</td>
</tr>
<tr>
<td>PCA85276ATT</td>
<td>PCA85176T</td>
<td>TSSOP56</td>
<td>4 x 40</td>
<td>8.0</td>
<td>200</td>
<td>Up to 105 °C, release Dec. 2013</td>
</tr>
</tbody>
</table>

Table 1. Existing NXP products upgraded to meet the VA display requirements
5. References

[1] AN10170 — Design guidelines for COG modules with NXP monochrome LCD drivers
[8] R_10015 — Chip-On-Glass (COG) - a cost-effective and reliable technology for LCD displays
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