High-Image-Quality MVA-Premium Liquid Crystal Display

Through the use of proprietary technologies, FUJITSU has successfully developed the MVA-Premium display, a new liquid crystal display (LCD) featuring a dramatically increased viewing angle, enhanced resolution, extended range of color reproduction, and accelerated response time.

Product Description

FUJITSU’s MVA-Premium technology is an outgrowth of our proprietary high-image-quality liquid crystal technology MVA (Multi-domain Vetical Alignment). The company has taken the original MVA technology and practically applied it in wide-screen panels such as 23.1-in. UXGA (FLC9UXG8V), 20.1-in. UXGA (FLC51UXC8V), and 19.0-in. SXGA (FLC48SXC8V).

MVA-Premium features a dramatically increased viewing angle (160 degrees or more in all directions), increased contrast ratio (500:1), enhanced resolution (UXGA for 23.1-in. and 20.1-in., SXGA for 19.0-in.), extended range of color reproduction, and accelerated response time.

Introduction

Liquid crystal displays (LCDs) are now finding a wider range of applications. In addition to devices such as cellular phones, personal computers, and PDAs, they are being applied to audiovisual equipment including wide-screen television sets. The primary advantages prompting the expanded application of LCDs have been their space- and power-saving features. Further expansion of these devices will depend on the progress made in solving problems in their display characteristics.

The performance of a display device is usually evaluated in terms of its contrast, brightness, viewing angle, color reproduction, resolution, and response speed. Among these parameters, the conventional LCD has a very tough time at achieving a superior viewing angle, brightness, and response speed. The MVA LCD offers a well-balanced technology to improve those parameters.

Features of MVA LCD

Wide viewing angle

The MVA liquid crystal uses a liquid crystal operation mode called VA mode. The VA mode is far superior to other liquid crystal display modes in front viewing contrast, but there are no significant improvements in the quality of the picture display when viewed from an angle. Especially difficult is the reproduction of gray-scale images from an angled view. Fig.1(a) outlines the reason for this.

When voltage is applied to a VA liquid crystal cell, the liquid crystal molecules realign themselves at an angle. When this happens, the birefringence of the liquid crystal increases their transmittance, allowing the generation of gray-scale images. But this transmittance effect holds only when the LC panel is viewed from the front, and other views from a slanted perspective vary with the direction of view, as shown in Fig.1(a) (white is stronger when viewed from the left, and black, when viewed from the right). The variation in the brightness perceived is the result of the incline in the liquid crystal molecules relative to the position of the viewer. The key to solve this problem is the multi-domain technology illustrated in Fig.1(b). This technology controls the liquid crystal molecules so that the molecules in each pixel incline in different directions. This provides the appearance of well-balanced transmittance from the liquid crystal layer, resulting in a well-balanced display picture from all viewing directions.

To ensure an ideal image balance, the inclination of the liquid crystal molecules must be controlled in four directions. This is actually very difficult to accomplish within an area as tiny as a single pixel (approx. 100-300μm).

The most common technique to control the direction of the liquid crystal molecules in conventional displays is the rubbing method. A roller with nylon or polyester brushes within the display rubs the substrate surface (surface of the alignment layer) to align the molecules in the direction of the rubbing. While this method can align the liquid crystal molecules in a single direction, in practical application it fails to control the orientation of the molecules differently within single pixel. For this reason, existing processes have not been able to mass-produce MVA panels.

Rub-less Alignment Control Technology (ADF)

To combat the problem discussed above, FUJITSU has developed a new alignment control technology. The principle is illustrated in Fig.2. Instead of processing the surface of alignment layer, as done in the conventional approach, this technology adopts...
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MVA-Premium features a dramatically increased viewing angle (160 degrees or more in all directions), increased contrast ratio (5000:1), enhanced resolution (UXGA for 23.1-in. and 20.1-in., SXGA for 19.0-in.), extended range of color reproduction, and accelerated response time.
the new concept of processing the underlying structure beneath the alignment layer. Structures installed partly beneath the alignment layer form protrusions.

When the voltage supply is turned OFF, most of the liquid crystal molecules align themselves vertically to the substrate, but those positioned above the protrusions incline slightly towards the substrate due to the slope of the protrusions beneath them. When the voltage is turned ON, the molecules on the sloped protrusions initially start tilting towards the substrate due to the slope of the molecules. This stabilized alignment is attained in the entire pixel. In other words, controlled alignment is achieved over the entire display area starting from the protrusions. The name for this alignment control technology, ADF (Automatic Domain Formation), refers to the automatic arrangement of liquid crystal molecules achieved simply by applying structure-installed substrates to one another.

**Simplified Process**

The ADF technology has helped solve the problems associated with the production of MVA and implement mass production. In practical application, however, it also requires a new process to form the protrusions, and this increases the man-days required for production. To address this issue, FUJITSU has developed a new mass-production technology.

In addition, a protrusion is formed on the color filter-stacked point to provide a cell spacer and create a cell gap between the TFT substrate and color filter substrate. This eliminates the need for the black matrix forming process and spacer distributing process, simplifying the process on the whole.

As mentioned earlier, MVA technology solves several problems in manufacturing processes and produces an extremely high picture quality unattainable by conventional liquid crystal displays. But further progress is needed. To satisfy high-end users accustomed to high-image-quality CRTs, the MVA displays must also offer a superior viewing angle and color reproduction.

**MVA-Premium Technology**

In MVA-Premium, a gradient of electric field acts extensively around the jagged shaped pixel electrode, thereby improving the controllability of the liquid crystal molecules (in conventional MVA, control is limited to the immediate vicinity of the main ITO slit). This innovative technology provides an improved response characteristic. Alignment control by the conventional MVA uses propagating inclination of liquid crystal molecules, starting from protrusions or the vicinity of the slits. In the new technology, the jagged shaped pixel electrode is capable of applying an inclined electric field onto the entire pixel, thereby allowing direct control of the liquid crystal alignment over a wide area. This provides significant

**Simplified TFT substrate design**

Fig.3 illustrates alignment control by a combination of electrode slits and protrusions. As can be seen from the figure, the TFT substrate has no protrusion formed on the surface, and parts of the ITO pixel electrode are etched off (electrode slits). When voltage is supplied, a deformed electric field (diagonal electric field) is generated in the vicinity of the individual slits, providing field distribution and alignment control of the liquid crystal molecules similar to those attained when protrusions are installed. The simultaneous formation of slits with ITO pixel electrodes can eliminate the need for additional processes.

**Simplified color filter substrate design**

Fig.4 shows the newly designed columnar spacer panel. As Fig.4(b) indicates, layers of Red, Green, and Blue resin filters are stacked only on the pixel borders to minimize the leakage of light rays from the borders (stacked RGB color filters prevent the transmission of light rays). This eliminates the need for black matrix (a layer across the pixel to prevent light leakage) required in the existing manufacturing processes.

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In conventional wide-screen displays, the gradual dislocation of the plastic balls compromises the evenness of the displayed images. In these ways, MVA technology is free from this problem and can thus be safely applied to wide-screen displays.

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Technical analysis
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Figure 2 Principle of ADF Alignment Control Technology

Figure 3 Simplified TFT Substrate Design

Figure 4 Newly Developed Columnar Spacer Panel Design

Figure 5 MVA-Premium Technology
improvements, especially in the response from black to higher gray levels. A second beneficial effect is an improved viewing angle characteristic. The jagged shaped pixel technology improves the controllability of the liquid crystal molecules, thereby allowing more stabilized control of the liquid crystal alignment in every corner of the pixel. This technology efficiently orients the liquid crystal molecules in optimal directions for viewing angle, and the optimized panel conditions also widen the range of view-ability.

Table 1 summarizes the 19.0-in., 20.1-in. and 23.1-in. Technical Data.

Product Features

- **Wide viewing angle of 170 degrees or more in vertical and horizontal directions, and 160 degrees or more in all directions**
- **High contrast ratio of 500:1**
- **Extended color reproduction range with an 85% EBU ratio**
- **New panel design based on columnar spacer, featuring adequate resistance to any type of external force, vibration, or other mechanical impact**

**Figure 5** Electrode Design for MVA-Liquid Crystal Display

- **Minimization of flicker by the proprietary flicker-suppression circuit**
- **Wide-screen, high-definition, full-color display**
  23.1-in.: Equivalent to 25-in. CRT, 1600:1200 dots (UXGA)
  20.1-in.: Equivalent to 23-in. CRT, 1600:1200 dots (UXGA)
  19.0-in.: Equivalent to 21-in. CRT, 1280:1024 dots (SXGA)

**Figure 6** Viewing Angle of MVA-Premium Liquid Crystal Display

**Summary**

FUJITSU has been making consistent efforts to design more beautiful displays. The MVA-Premium liquid crystal display meets this design objective by offering a wide viewing angle (160-deg. for all directions), high contrast ratio (500:1) and high color reproduction (EBU ratio of 85%). FUJITSU is convinced that this product has resolved most of the problems associated with conventional liquid crystals and will meet the needs of high-end application. FUJITSU will be working continuously to simplify the manufacturing process, improve the display characteristics, and enhance the beauty of this product.

**Table 1**

<table>
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<tr>
<th>Model</th>
<th>Display Size</th>
<th>Display Capacity</th>
<th>Dot Pitch</th>
<th>Display Area</th>
<th>Color Number of Display</th>
<th>Contrast</th>
<th>Brightness</th>
<th>Viewing Angle</th>
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<tbody>
<tr>
<td>FLC59UXC8V-02</td>
<td>Diagonal 59 cm (23.1-in.)</td>
<td>1600×RGB(H)×X1200 (V)</td>
<td>0.239 (H)×X0.239 (V)</td>
<td>470.4 (H)×X565.8 (V)</td>
<td>1637.6 (H)×X1501.8 (V)</td>
<td>500:1</td>
<td>250cd/m² (Typical)</td>
<td>Vertical 170 deg., Horizontal 160 deg.</td>
</tr>
<tr>
<td>FLC51UXC8V</td>
<td>Diagonal 51 cm (20.1-in.)</td>
<td>1600×RGB(H)×X1200 (V)</td>
<td>0.239 (H)×X0.239 (V)</td>
<td>406.8 (H)×X390.0 (V)</td>
<td>376.3 (H)×X321.5 (V)</td>
<td>500:1</td>
<td>250cd/m² (Typical)</td>
<td>All other directions 160 deg. (Assumed symmetrical in both directions, vertical and horizontal)</td>
</tr>
<tr>
<td>FLC485XC8V</td>
<td>Diagonal 48 cm (19.0-in.)</td>
<td>1600×RGB(H)×X1200 (V)</td>
<td>0.239 (H)×X0.239 (V)</td>
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Fig.6 shows the viewing angle characteristics of MVA-Premium LCD. The third beneficial effect is the ease of pixel design for high-resolution displays. In the conventional MVA, the liquid crystal molecules around the middle of the gap between the protrusion and slit are indirectly controlled via the propagation of the inclination. The drawback of this method is that it eliminates any degree of freedom in the distance between the protrusion and slit, thereby making it impossible to set a wide space distance. The fine ITO electrode resolves this constraint by allowing direct control of the liquid crystal molecules. Moreover, it is also advantageous for the design of pixel corners, another important requirement for high-resolution.

The last few paragraphs have described the profound improvements in display characteristics attainable through the use of the jagged shaped pixel electrode. Another improvement not discussed was the adoption of entirely new resin materials for the color filters, which has allowed an improvement not discussed was the adoption of entirely new resin materials for the color filters, which has allowed an improved viewing angle (160-deg. for all directions), high contrast ratio (500:1) and high color reproduction (EBU ratio of 85%). FUJITSU is convinced that this product has resolved most of the problems associated with conventional liquid crystals and will meet the needs of high-end application. FUJITSU will be working continuously to simplify the manufacturing process, improve the display characteristics, and enhance the beauty of this product.

### Product Features

- **Wide viewing angle of 170 degrees or more in vertical and horizontal directions, and 160 degrees or more in all directions**
- **High contrast ratio of 500:1**
- **Extended color reproduction range with an 85% EBU ratio**
- **New panel design based on columnar spacer, featuring adequate resistance to any type of external force, vibration, or other mechanical impact**

### Minimization of Flicker by the proprietary flicker-suppression circuit

- **Wide-screen, high-definition, full-color display**
  - 23.1-in.: Equivalent to 25-in. CRT, 1600 dots (UXGA)
  - 20.1-in.: Equivalent to 23-in. CRT, 1600 dots (UXGA)
  - 19.0-in.: Equivalent to 21-in. CRT, 1280 dots (SXGA)

- **Fast response time of 25 ms (ton on/off)**

- **Extended life and replaceable backlight**
  - The backlight has an expected lifetime of 50,000 hours, and the cold-cathode tube is easily replaceable.

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### Figures

- **Figure 5**: Electrode Design for MVA-Liquid Crystal Display
- **Figure 6**: Viewing Angle of MVA-Premium Liquid Crystal Display

### Bibliography