High Value-Added IT Display - Technical Development and Actual Products

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Abstract

The "multi-display" expands the desktop area to increase the amount of information displayed at a time and improve the work efficiency. The demand for multi-display environments is now higher than ever because they allow the users to recognize differences that cannot be noticed when only one display is used and also to correct with high accuracy; colors, uniformity and incomplete image displays. In an environment in which one person uses multiple displays, the bezel size of the display should be designed to be narrow. Moreover, when the number of displays is increased, it is also required that they should be "easy to install." Uniform display performance and improved ease of installation are advantageous to end users as well as to the constructors and systems developers of multi-display environments.

1. Introduction

A "multi-display" system that connects more than one display to a single computer expands the desktop area and increases the amount of information displayed at a time and thereby improves the work efficiency. The typical environment in which such a system is useful may be seen in the "financing and securities" field, where a trader often monitors the movement of stock prices on multiple displays. Also, in the "medical" field, the multi-display system is useful when a doctor arranges electronic charts for example, together with X-ray and MRI images to observe the processes of treatment.

This paper introduces the function and implementation of display systems that can offer more advanced work environments in the "financing and securities" and "medical" fields, by taking the newly developed "90 Series (LCD1990SXi/2090UXi/2190UXi)" IT display products as examples.

2. Adjacent Installation of Displays

When two displays are installed side by side for example, the "differences in colors" and "differences in uniformity" between the two displays are more noticeable than when they are installed at a distance. This is a result of the quality of the two displays, which may not be uniform. To obtain a "uniform display performance," it is required that the displays are capable of correcting visibly recognizable factors such as the brightness, color and uniformity.

2.1 Color Correction

The color variance is dependent on the display characteristics of the backlight and LCD panel. Since the backlight color is usually not adjustable, the displayed colors should be corrected by correcting the LCD panel drive signal based on consideration of its characteristics.

In general, the LCD panel is designed so that the output brightness characteristic is the relative value of the panel drive signal level raised to the 2.2th power (gamma 2.2). However, the actual products need correction of individual variances. To maintain the color constant regardless of the brightness level, processing for making the RGB output brightness ratio constant all over the range of input signal level by taking the gamma characteristic in consideration. This processing is executed by the image processor IC (ASIC) of the display device.

The input signals to current display devices, such as DVI digital signals are 8-bit signals for each of the RGB (256 tones). If the ASIC applies gamma characteristic correction processing based for example on 8-bit computation to the 8-bit signals, the number of output tones would decrease due to the rounding error. To prevent a decrease in tones, the computations for correction are generally executed using a larger number of bits than 8 bits. The number of bits was 10 with the previous 80 Series products that were used as the basis for the 90 Series, but the 90 Series products have increased the num-

ber of bits to 12 to achieve higher accuracy.

In addition, the 90 Series combines the three methods, including the ordered dither technique*, random dither technique** and the temporal control of the output signal of each pixel, to achieve a smooth display definition regardless of the gamma curve.

The color variance is measured for each display device and the result is stored in the EEPROM of the device. The amount of correction is the difference between the measurement result and the ideal gamma characteristic. We have improved the accuracy of the computations and adopted multi-tone expression of the panel drive signals to reduce the decrease in the number of tones as well as to correct the color variance.

2.2 Uniformity Correction

The color correction for reducing the variance between display devices as described in the previous section is applied to the center of the display panel of each device. Similarly, the panel display can be made uniform by dividing it into certain areas and applying corrections to each area (for the uniformity correction implemented based on this concept, see "Wide Gamut Display Using LED Backlight - Technical Developments and Actual Products" on pages 75 to 79 of this issue). The 90 Series was marketed after incorporating this function in the ASIC.

The correction points in the screen are of 14×11 grids. The intervals between grids are processed by linear complement and the correction value is applied to all of the LCD panel pixels (1,600 horizontal dots and 1,200 vertical lines with a UXGA model). **Fig. 1** shows an example of application of this technique, showing brightness uniformity with and without the uniformity correction.

The contour lines represent the difference in brightness of 10cd/m^2. When the uniformity correction is off, the brightness is highest at the center and tends to decrease as the image periphery is approached. This tendency can be attenuated when the uniformity correction is on.

Examples of specific numerical requirements for uniformity can be seen in medical standards. For instance, DIN-V-6868-57[2] requires that the difference in brightness between the screen center and the four corners should be no more than 15%. As this difference was about 30% with the general LCD displays, it has been necessary to deal with the DIN V 6868-57
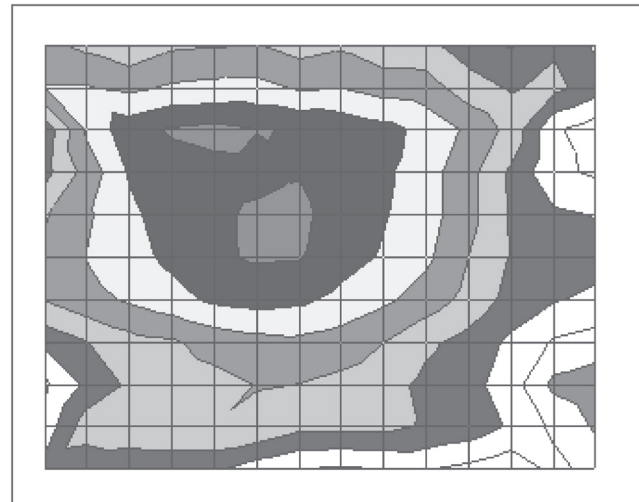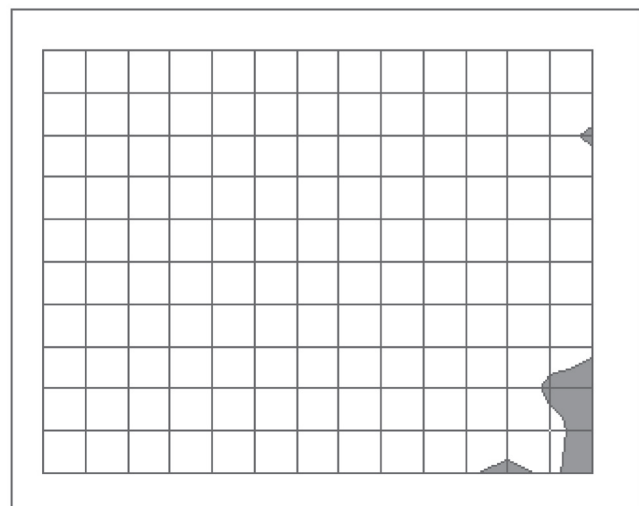
standard requirement by means of "panel sorting." However, the uniformity correction function incorporated in the 90 Series has a performance that is high enough to meet the said standard.

2.3 Edge Sharpness Corrections

In order to receive RGB analog signals optimally and to convert them from analog to digital, a transmission bandwidth that

Uniformity correction OFF

Uniformity correction ON

Fig. 1 Uniformity Correction Effects (brightness).

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*Tone expression method based on the ratio between the bright and dark sections of a small area.[1]

**Shading expression method based on the bright/dark probability by varying the threshold value of each pixel using a random number.[1]

is a few times larger than the fundamental component of the input signal is necessary. If, for example, the fundamental wave of UXGA (60Hz) is 81MHz, then the transmission bandwidth should ideally be higher than 560MHz. However, the waveforms are in fact usually deteriorated because their harmonic components are reduced due to the characteristics of the signal output circuitry and transmission cables. If such inferior signals were displayed, the image would be less sharp and appear to be blurred. This is because the waveform deterioration affects the adjacent dots as well as the original target dots.

To enable optimum image display even when inferior signals are received, we have provided the 90 Series with a "digital waveform equalizer" that can apply corrections to images after AD conversion. Unlike scaling filters that are used in the magnification of low-resolution images, this equalizer can function even when the display resolution is optimum. We have adopted it to compensate for the effects on adjacent dots in order to obtain the sharpest possible images, even with analog input signals. In the example shown in **Fig. 2**, the image that was only displayed with 1 white dot before the correction was displayed with 4 white dots after correction. The image was corrected using the "digital waveform equalizer," to display 3 more white dots, so that its sharpness was improved as indicated in the "Image" area.

As this function makes it possible to attenuate the effects of transmission cables, it is also useful in the connection of long cables as described later.

3. Freedom from Installation Restrictions

3.1 Reduced Bezel Width

One of the basic requirements for the multi-display environment is to make the sizes of the bezels outside the image dis-
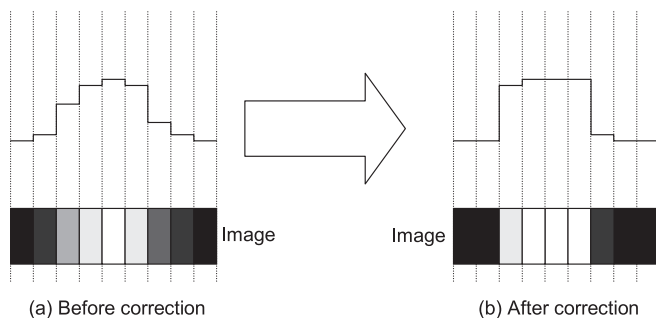
play area as narrow as possible. However, there are various problems to be overcome in reducing the thickness of the plastic parts used as the bezels. These problems include the non-combustibility related to safety as well as those of molding failure (material packing failure), poor mold release, appearance failure or warping in the case of thin-wall moldings of an environment-friendly material. To solve these problems, we adopted a high-rigidity polycarbonate, PC-ABS material that has twice the fluidity of previous materials (and non-halogenated fire retardant material) for the 90 Series.

We packed this material uniformly and effectively by basing the thickness and heat radiation conditions on the fluidity analysis. The mold was fabricated by placing the material inlet optimally and predicting the gas generation positions. We succeeded thus in achieving a favorable molding quality in which the weld lines were not noticeable.

Thanks to the uniform packing of the material, we could facilitate the management of the molding temperature and pressure and molded an ultra-narrow bezel that can be released easily from the mold release and does not warp.

3.2 Stand Attaching/Detaching Mechanism

Installation on a VESA standard arm can be made easier if the stand can be attached or detached by simply operating an integrally mounted lever and without the need to remove a screw as in previous stands. Easy installation is a great advantage for the manufacturers of multi-display environments and it also contributes to improvements in the productivity and serviceability.

The key point that made easy installation possible with the 90 Series was the structure, with which the heavy display and stand can be held without using a screw. With this structure, the L-shaped plate section A of the stand are designed to hold the display by attaching it to section B of the shield plate as shown in **Fig. 3**.

(a) Before correction   (b) After correction
Fig. 2 Example of digital waveform equalizer effect.

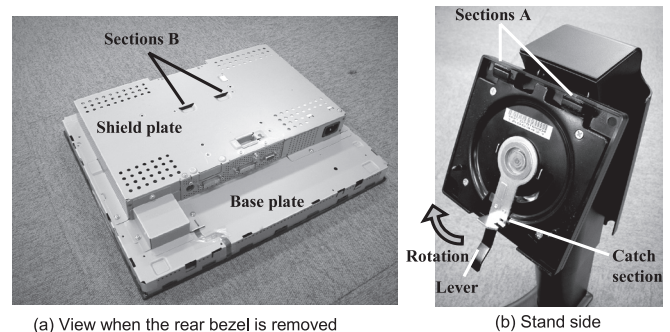(a) View when the rear bezel is removed   (b) Stand side
Fig. 3 Stand attaching mechanism.

The shield plate is fixed on the base plate that holds the LCD panel in order to alleviate the stress (weight of the display) applied to the attaching mechanism.

To help detach the stand, a lock-like lever catch is installed on the stand side so that a twist disengages it from the shield plate, inside the display (Fig. 3 (b)). For safety purposes, the lever can only be operated by the two step operation of pulling and rotating so that the user cannot accidentally operate the lever.

3.3 Connection of a Long Cable

We also considered the restrictions in the layout of the computer and displays when designing the 90 Series. The displays can be installed at a distance from the video signal source thanks to the "long cable compensation function."

(1) RGB Analog Signals
In the financing and securities field, there are market information distribution systems that exchange RGB analog signals through LAN cables such as the CAT5 cables. Also, systems based on coaxial cables distributed in a building and analog waveform equalizers installed on the receiving sides have been used since prior to the dissemination of the Internet and LAN environments. These systems are still under use in some buildings.

An increase in the lengths of the LAN or coaxial cables also increases the differences in the length of time between the RGB signals, and these differences result in phase differences between the RGB signals on the receiving parties as well as color deviations in the images displayed on them.

Assuming the use of the 90 Series in systems as described above, we incorporated the following functions in each of the RGB channels of the 90 Series;
1) sampling phase control of video signal A/D converter;
2) horizontal position control of digitized video signal;
3) image cutoff correction using a digital waveform equalizer.

As a result, when 5C2V coaxial cables are used, for example, the image can be displayed without an analog waveform equalizer even when the cable length is as long as about 100 meters.

(2) DVI Digital Signal
The DVI digital signal standardized by VESA is disseminated widely. However, the image has often subject to fine noise interference derived from decoding errors due to impedance matching between the transmitting and receiving parties and to waveform skew. These problems have been dealt with by "changing the matching impedance" or by "modifying the board wiring pattern."

The 90 Series are provided with waveform equalizers at the DVI signal receiving end, so that the user can adjust the DVI signal skew in steps. This has made it possible to obtain images without decoding errors even when the cable length is longer than 10 meters, provided that the clock frequency and cable characteristics are optimal.

4. Future Development

The multi-display system enhances the intellectual productivity by "increasing the amount of displayed information." In the future, it is expected that environments in which one person uses multiple displays will increase in general office work as well as in the financing and securities and medical fields.

The space that one person occupies is often limited in general office work. This means that a further reduction in the bezel width will be required. The same effect may also be achieved by reducing the display weight in order to reduce the footprint of the stand.

On the other hand, from the viewpoint of "increasing the amount of displayed information," it may also be required to increase the resolution and/or screen size. An increase in the resolution will make it necessary to prevent signal waveform deterioration and ensure reliability because it is accompanied with an increase in the transmission signal frequency, while an increase in the screen size will make it necessary to solve problems such as increased uniformity, a drop in brightness and a deterioration of the ease of installation.

5. Conclusion

The "uniform display performance" featured in the 90 Series makes the sorting of LCD panels unnecessary, due to "non-uniform display" during installation of multiple displays. Together with the "high ease of installation," it will contribute to productivity improvements for the various systems manufacturers and systems designers.

References

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