High-Quality Picture Technology for LCD TV AQUOS LC-37BD5

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Abstract

LC-37BD5 has the largest screen in our LCD TV, and has the highest resolution in current LCD TV market of 1366 dots × RGB (Horizontal) 768 dots (Vertical). This paper explains the high quality picture technology to make maximum use of this large screen and high resolution liquid crystal panel as a television.

Introduction

Use of a fixed-pixel display device such as an LCD as a television requires interlaced/ progressive conversion (I/P conversion) of the input video signal as well as resizing or scaling that signal to match the fixed pixel resolution supported by the television by either enlarging or shrinking it. Another issue involves the inability to faithfully reproduce the original picture using normal I/P conversion when video such as that on movie DVDs that has a film source (24 frames per second) is converted to a 480i signal (converting 2 frames to 5 frames for a new frame rate of 60 frames per second), a process known as telecine conversion. This difficulty requires that a determination be made regarding the frame rate of the input video signal. If the signal is judged to be from a film source, the signal must be processed with a special type of I/P conversion known as 2:3 pull-down.

A single-chip digital high-picture-quality LSI was developed to implement this processing in the new class of 37-inch LCD TVs being currently developed. To provide further improvements in picture quality, the chip also offers features such as frame-cycling noise reduction, active contrast control, and color management (**Fig. 1**). The chip leverages its wide-format 16:9 aspect ratio to support multiple pictures, and the LCD's large screen size and high resolution enable it to offer compatibility with computer-driven video signals. The following describes the picture-enhancing technology used by this 37-inch wide-screen LCD TV.

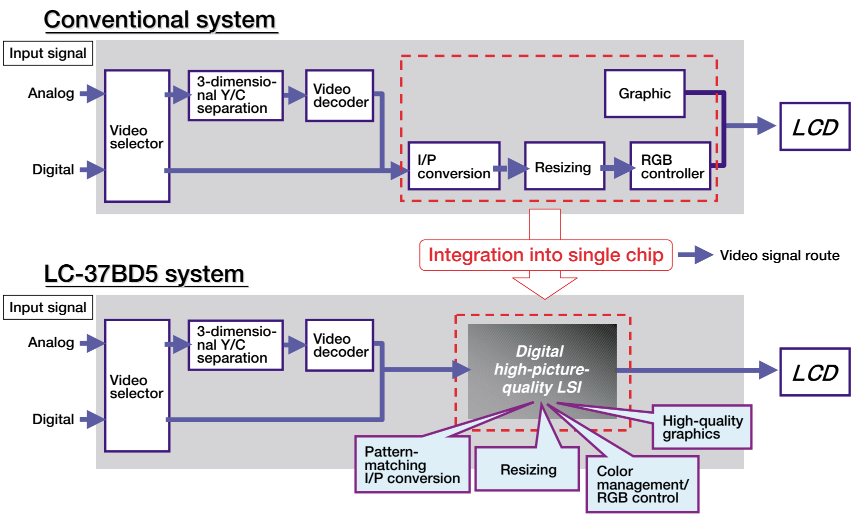

Fig. 1 System block diagram

1. Interlaced/Progressive Conversion (I/P Conversion)

1.1 Pattern-Matching Motion-Adaptive I/P Conversion

Motion-adaptive I/P conversion refers to the process of comparing the current video signal with the previous frame's signal to detect any variations. For pixels where motion is detected, the signal is interpolated from the scan lines immediately above and below that pixel, while for stationary pixels, the signal from the previous field is maintained. In previous motion-adaptive I/P conversion implementations, picture quality suffered as a result of near-horizontal lines and edges appearing broken or aliased when camera motion caused their position onscreen to change. Pattern-matching motion-adaptive I/P conversion harnesses a proprietary algorithm to alleviate the quality deterioration associated with this broken-line or aliasing phenomenon (**Fig. 2**).

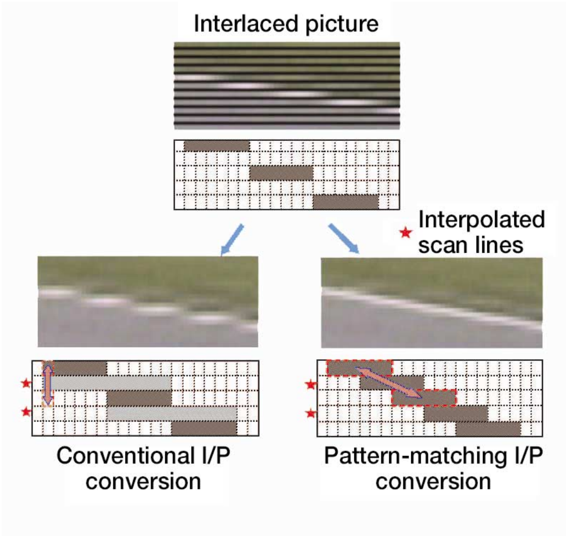

Fig. 2 Pattern-matching motion-adaptive I/P conversion

This algorithm works by extracting pattern information of a given length from the picture data, allowing it to calculate a correlation (hence, pattern-matching) between upper and lower scan lines, a calculation that is impossible when the conversion process focuses on individual pixels. The algorithm then uses that correlation to generate a new pattern at an intermediate position between the two patterns, smoothing near-horizontal lines and edges to produce a high-quality picture. Although the I/P conversion itself continues to be based on motion-adaptive processing, the analysis of motion and picture data surrounding interpolated pixels here enhances the quality of the conversion process by allowing it to limit edge fluctuations.

1.2 Auto 2:3 Pull-Down

The LC-37BD5 features auto 2:3 pull-down to automatically detect film-source video streams and create a corresponding progressive picture. This feature enables the product to use pattern-matching motion-adaptive I/P conversion for normal video sources but switch automatically to a completely progressive picture for film sources. The 2:3 pull-down feature works for film-source high-definition video as well.

2. Noise Reduction

Customers have noted that motion blur (picture artifacts) can occur when frame-cycling noise reduction is performed too aggressively. Although the noise reduction algorithm used in the LC-37BD5 uses a frame-cycling approach, the algorithm's advanced noise analysis allows it to limit this feeling of blur.

In concrete terms, the video signal is converted from real-space data to high-frequency domain data. Noise analysis then takes advantage of the fact that while the motion component of inter-frame variation appears concentrated in a specific frequency domain due to the high correlation between neighboring pixels, the noise component appears distributed evenly over all frequency domains because there is no correlation between neighboring pixels. The algorithm reduces the amount of motion blur around picture edges by limiting the extent to which the noise reduction process is applied in those areas.

In order to facilitate the display of video sources generated by progressive-scan DVD players with little noise, the noise reduction feature can be used on both progressive and interlaced signals.

3. Resizing and Edge Correction

Since the LC-37BD5 displays video signals in a variety of formats including 480i, 480p, 1080i, and 720p on a fixed-format panel with a horizontal resolution of 1,366 pixels and a vertical resolution of 768 pixels, the signals must be resized. In order to ensure that this resizing operation can be performed with a high degree of quality, the scaling unit's filter characteristics can be set freely according to the format of the input video signal. Also supported is the creation of pictures where the scaling factor differs at the screen's center and edges, as is the case with "smart" stretch operations that convert a video signal from a 4:3 to a 16:9 aspect ratio.

The LC-37BD5 uses two types of edge correction that are built into the single-chip digital high-picture-quality LSI. One of these is a typical limiter HPF (high pass filter) enhancement where the high-frequency component of the input video signal as calculated using a horizontal FIR (finite impulse response) filter is subject to limiter processing. The resulting signal is then added to the brightness signal. This limiter processing refers to the clipping of amplitude using the absolute value of the difference in the brightness of the pixels on either side of the pixel in question. Because the nonlinear processing used by strong clip operations can produce aliasing noise, the sampling point is temporarily doubled to ensure that the edge correction process produces as little aliasing as possible. The other type of edge correction involves DFC (depth of focus control). When a video image is simply magnified, its edges seem to become soft and blurry. A feature was added to the chip to counteract this effect by mimicking the way a camera's depth of field can be lengthened by stopping down the aperture of its lens. This DFC feature is aimed at achieving further improvements in picture sharpness (**Fig. 3**).

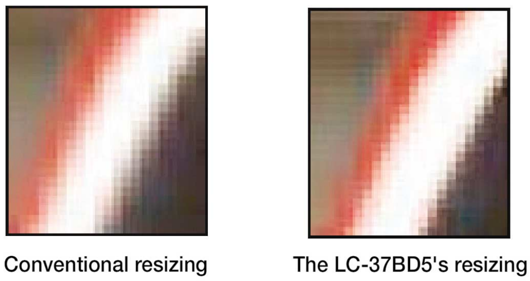

Fig. 3 Resizing

4. Active Contrast Control

The active contract control feature analyzes the distribution of brightness in a given picture and provides nonlinear control over the brightness signal according to the particular scene being displayed. The real-time implementation of the type of control illustrated in **Fig. 4**, which emphasizes the reproduction of dark tones in dark scenes but focuses on overall contrast in bright scenes, enables the LC-37BD5 to display pictures with a wide dynamic range.

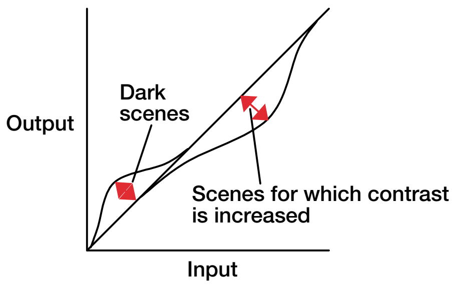

Fig. 4 Active contrast control

5. Color Management

The color management feature provides independent control over luminance (V), saturation (S), and hue (H) for each of the six hues of red (R), green (G), blue (B), cyan (C), magenta (M), and yellow (Y). This approach allows color reproduction to be fine-tuned according to the characteristics of the particular display device being used: for example, yellow hues can be offset towards the red region or the red hues made more brilliant (**Fig. 5**).

By making color adjustments accessible, the LC-37BD5 allows individual viewers to tweak hue settings according to their own preferences, for example by making only skin tones appear reddish or yellowish.

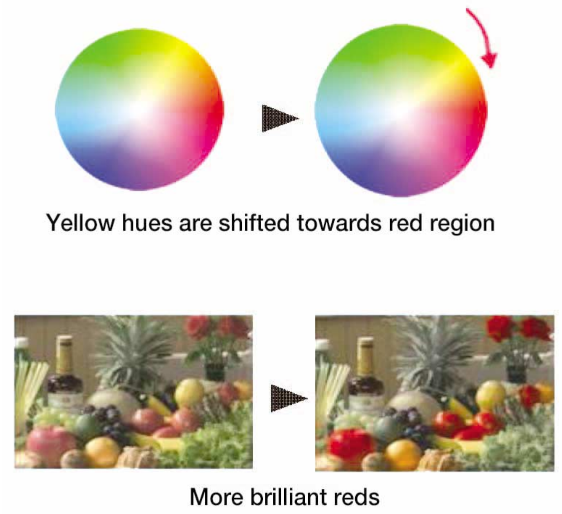

Fig. 5 Color management

6. Multiple Pictures

The multiple picture feature allows the LC-37BD5 to display two pictures, with the main picture on the left side of the screen and the sub-picture on the right side of the screen. The main picture is capable of displaying a 480i, 480p, 1080i, or 720p signal, while the sub-picture can display a 480i signal. For example, the left side of the screen can be used to view a BS digital satellite high-definition picture while the right side of the screen is used to view a terrestrial broadcast. When viewing two 480i pictures, the auto 2:3 pull-down motion-adaptive I/P conversion and noise reduction features can be applied to both signals. Additionally, a freeze-frame feature allows viewers to capture scenes as still pictures.

7. Computer Input

In addition to television video signals, the LC-37BD5 is capable of displaying computer-output video signals at up to SXGA resolutions. An automatic synchronization feature (auto-sync) allows the panel to sync with most computer video output, making it compatible with a variety of screen formats (resolutions) and frame frequencies.

8. High-Quality Graphics

The LC-37BD5's ability to enhance the quality of input video signals is complemented by the high-quality graphics processing used to display menus, which is capable of displaying 16.77 million colors with alpha channel blending. While PDP (plasma display panels) do not handle graphics with gradients well as a result of their use of dithering to display color gradations, LCD panels are able to display dither-free gradients without difficulty. Menu screens take advantage of this gradient-friendly capability to make the menus more attractive and easier to understand (**Photo 1**).

Photo 1 Menu screen

Conclusions

As future LCD TVs continue to grow in screen size and resolution, Sharp will continue its development of technologies that enable additional picture enhancement as part of its commitment to deliver the maximum possible LCD panel performance.

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