Background Information

Aptura™ lighting technology makes ClearLCD™ TV come alive

Although LCDs are well accepted for computer monitor applications, they still show two major drawbacks for TV applications. The first drawback becomes apparent while watching fast moving scenes as in sport matches: severe motion artifacts. The second shortcoming is observed while watching an LCD TV in a reduced ambient illumination room: the contrast falls short.

Introduction

Flat-panel displays for televisions and PC monitors are steadily increasing in popularity as manufacturers provide a wider choice of models, and prices are driven down. Extensive research has shown that picture quality is the most important criterion that consumers base their decision on when deciding to purchase a new TV, taking precedence over design, screen size, sound quality and functionality. Picture quality therefore is the feature most emphasized by Philips in developing TV sets and monitors.

Competing with CRT & PDP

The enormous success of LCD-based flat panels is not only due to the convenience of their 'flatness', but also because of their excellent resolution compared to 'conventional' cathode ray tubes (CRTs) and plasma display panels (PDPs). However, there are two key areas where LCD technology could not match the near-perfection of CRTs and PDPs: motion performance and black level performance.

LCD motion performance

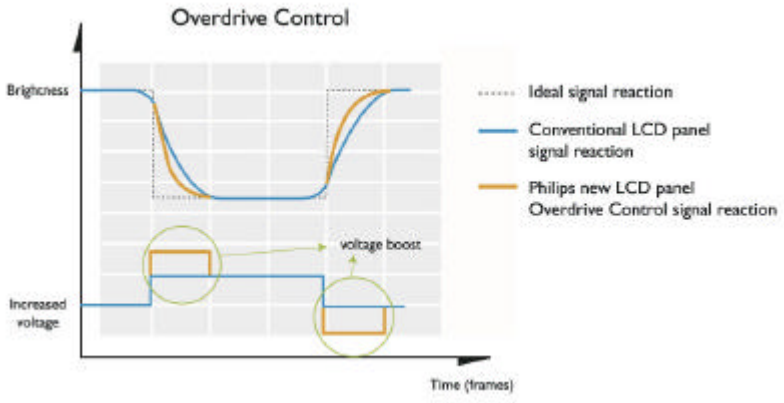
CRT/PDP motion performance

LCD black level performance

CRT black level performance

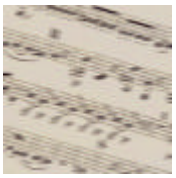
Improving motion portrayal

Blur due to motion is prevalent in LCDs and can have several causes; one of them can be diminished by a good overdrive control. By changing the physics of the Liquid Crystals, the structure of the LCD panel and a technology called “Overdrive Control” the average response time is improved to 5 ms. Overdrive Control increases the voltage to accelerate the liquid crystal reaction speed, what means that the response time is speeded up, resulting in a better motion behavior of the LDC panel, but rather blurry.



Motion blur reduction step by step

LCD with slow LC

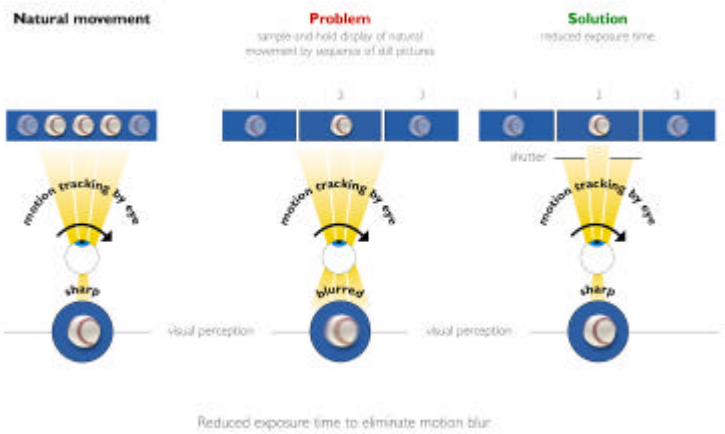


LCD with fast LC & Overdrive Control

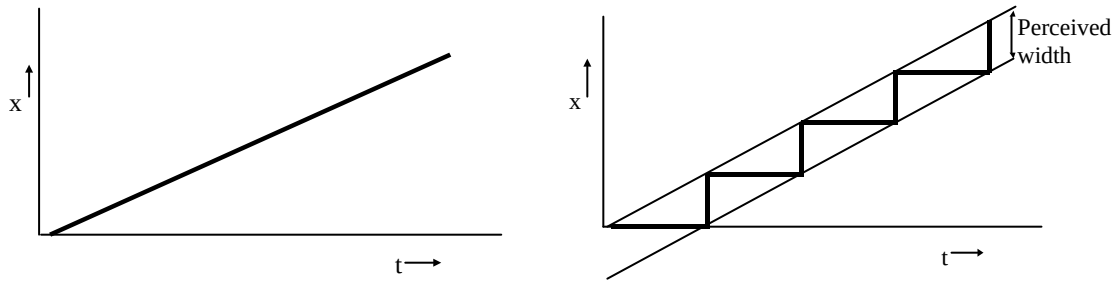
Picture looks better but still blurry

Ultimate step in motion blur portrayal

However, having reduced the response time of the panel through the application of Overdrive Control, the motion artifacts are far from over because the final smearing of the image occurs in the human eye. This is because the eye can only perceive moving objects as sharp, as long as the eye can track these moving objects.



This tracking by the eye is only possible for movements that are close-to-linear. This is where the LCD panels with a continuous backlight fail. Due to the sample (at frame rate) and hold (over a frame period) principle of the LCD, the movement of objects on the screen is not a continuous movement but a staircase.



The location versus time diagram of a horizontally moving point, left in real life, right as shown on an LCD display with a continuous backlight. Also shown is the apparent width of the object on the LCD screen.

Interestingly enough, the absence of an image does not contribute to image smearing, while an image at the wrong place does. This phenomenon is exploited in the CRT to the extreme, where each part of the image is only present for less than a millisecond. By adopting a dynamic scanning backlight, which illuminates each part of the panel for only a short moment, this principle can also be applied to LCD displays.

This leads to the concept of a backlight with a small illumination duty cycle. However, a small duty cycle is not in itself enough to solve the problem because the backlight illumination phase (i.e. the illumination timing in relation to the writing sequence) is also important. For optimum representation of motion, the following timing has to be obeyed for each line on the panel:

1. The image is written during addressing
2. The pixels get a time to respond
3. The panel is illuminated for a short instant.

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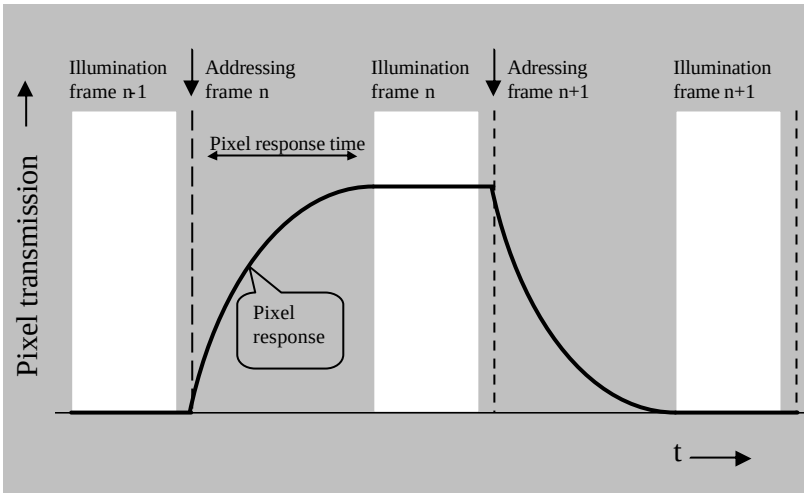
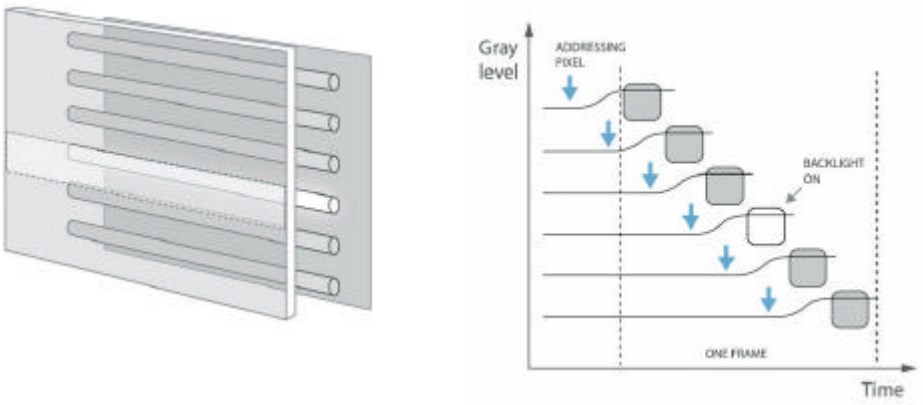
Ideally the pixel response time is less than 2/3rds of the frame time when the illumination time is 1/3rd of the frame time. The maximum response time can be allowed to the panel when the illumination is ignited and switched off again just before the new image is written into the panel.



The timing of the illumination for a given line of the panel, in relation to the addressing of that line and the pixel response time.

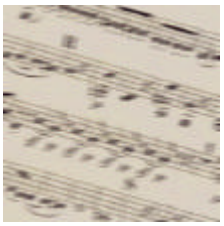
Since the timing has to be chosen such that for each line of the display the light is switched off just before the new image is written into the panel, a free-running backlight system with small duty cycle will therefore not work. Instead, a synchronized system is needed. An image is usually written into the panel, line-by-line, from top to bottom, during almost the entire frame time. So from the timing point of view the LCD illumination must also scroll down from the top of the screen to the bottom, in phase with the addressing of the panel.



By activating each of the lamps only a short while, motion portrayal is improved.

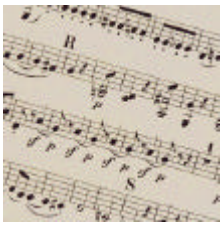
Motion blur reduction step by step

LCD with slow LC



LCD with fast LC & Overdrive

Picture looks better but still blurry

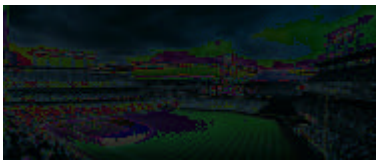


+ Scanning Backlight

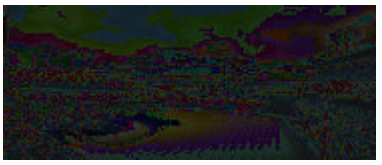
Extreme motion sharpness

Improving contrast

When using LCD TV in an environment with reduced illumination, it is quite apparent that LCD panels have poor contrast in dark scenes because even in the dark state there is always some light leakage. This is particularly noticeable when the panel is viewed at an angle. In dark scenes, the contrast of the displayed image can be improved up to five times better than before by reducing the luminance of the backlight unit and stretching the video for better detail, the Dynamic Contrast Enhancer in the Philips ClearLCD TVs.



Dynamic Contrast Enhancer off



Dynamic Contrast Enhancer on

The Dynamic Contrast Enhancer is not constantly active, but depends on the video content. When a very bright picture is displayed a better contrast is not necessary. When a dark picture such as a nighttime or poorly lit scene is displayed, however, the contrast enhancer will be activated resulting in excellent black level with maximum detail effect and high contrast. Better contrast can be achieved by a reduction of the illumination duty cycle.

Additional benefit

An additional benefit of the backlight dimming technology is a much-improved viewing angle in dark screens– a well-known limitation of LCD TV screens. With ClearLCD™ it is now possible to view the LCD TV from much wider angles, greatly enhancing shared viewing enjoyment in the living room.

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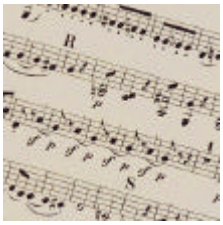
The enabling technology: Aptura™ lighting technology

The Philips Aptura™ lighting technology facilitates both scanning and dimming simultaneously. With non-scanning dimmable backlights, there is no clear demarcation in illumination between frames so that a dimming action on one frame may spill over into neighboring frames. With a scanning backlight, however, because of the accurate in-phase timing of the illumination with the addressing of the panel, it is possible to address each complete frame independently of the previous or subsequent frames. This allows much faster response to changes in illumination than is possible with non-scanning dimmable backlights, a feature that is particularly advantageous with transitions from dark to bright scenes. Aptura™ lighting technology is able to dim 1:10, this way the dynamic contrast will increase 10 times. The ability of the Aptura™ lighting technology is 4 to 6 times lower to currently available products. The usage of the power consumption is proportional to the dimming rate.

The scanning backlight in LCD devices comprises hot-cathode fluorescent lamps (HCFL) instead of cold-cathode (CCFL), enabled by special software developed by Philips Consumer Electronics. To avoid 50 Hz (Europe and Asia-Pacific) or 60 Hz (USA) field flicker, each individual lamp in the LCD panel is illuminated for a small time period at a frame rate of 75 Hz (instead of 50 Hz) or 120 Hz (instead of 60 Hz). For improving motion portrayal the LCD illumination must have a small duty cycle while on the other hand luminance should not be sacrificed nor should costs be allowed to escalate. With a duty cycle of 35%, a light source is required that can give three times as much peak luminance as is needed in a non-scanning application. The Aptura™ technology uses 8 Fluorescent Lamps with a diameter of 16 mm because of their exceptionally high light output and established high reliability. For a 32” backlight system, 8 of these light sources are sufficient to reach a superior light output of 550 cd/m2 at a 35% duty cycle.

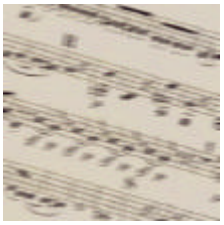
The light sources have heat control of the electrodes, because we want to guarantee a lifetime of more than 60.000 hours in spite of the dynamic lamp load caused by dimming and the higher peak currents required for scanning.

Summarize



Original Incoming picture

LCD with slow LC



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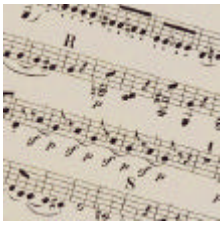

+ Scanning Backlight

Extreme motion sharpness

ClearLCD™ is a major advance in Philips' goal of achieving maximum picture quality in its LCD TV products. The aim is a greater enjoyment and stress-free use by consumer and business users. The development of ClearLCD™ is a perfect example of the combination of television and lighting technologies, resulting from outstanding and innovative co-operation between three of Philips' main activities. The result is considered a major breakthrough for the television industry and adds to the long list of achievements of a company that is a world leader in lighting and consumer electronics.

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About Royal Philips Electronics

Royal Philips Electronics of the Netherlands (NYSE: PHG, AEX: PHI) is one of the world's biggest electronics companies and Europe's largest, with sales of EUR 30.4 billion in 2005. With activities in the three interlocking domains of healthcare, lifestyle and technology and 159,200 employees in more than 60 countries, it has market leadership positions in medical diagnostic imaging and patient monitoring, color television sets, electric shavers, lighting and silicon system solutions. News from Philips is located at www.philips.com/newscenter.