

System Synchronized Brightness Control (SSBC™)

Dramatically Improving LCD and Projection Images

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The Limitations of Electronic Displays

LCDs and projection displays commonly in use today are incapable of achieving the broad range of luminance available from cinema, much less the dynamic range of brightness of the real world. There is a very wide spectrum of lighting in nature. Bright clouds can exceed 10,000 Lux, while nighttime illumination can often measure less than 10 Lux. Natural light ranges exceed the sensitivity range of most imagers – including the human eye, film, and charge-coupled device (CCD) electronic sensors for recording images.

The pupil of the human eye has sophisticated controls that modulate light for sight. Cameras use exposure controls (f-stops and shutters) to regulate captured light. These controls allow the camera to create night and day pictures of similar image quality by dynamically adjusting captured light to match the fixed sensitivity range of the imager.

Now a new technology is being broadly adopted in LCD and projection displays that dramatically improves the quality of displayed images. The approach is based on simultaneously adjusting the brightness of each image frame, while making best use of the grayscale capabilities of the display.

Contrast vs. Grayscale

To understand the impact of this new technology, it is important to have a deeper understanding of two terms used to describe electronic images – contrast and grayscale.

- **Grayscale** is a method of expressing graphic data that provides greater detail and depth to images. Grayscale images differ from black-and-white images by having many shades of gray in between the black and white boundary points. Whereas color graphic data typical of computers is processed in terms of hue, brightness, and contrast data – digital video images are encoded with a full range of grayscale for each of the primary colors – red, green and blue. The digital video image is processed in terms of brightness, where 8 bits (256 gradations) of data is used to represent the pixel for each primary color.
- **Contrast** is the ratio of black to white. It measures how dark black appears when compared to a white or clear pixel. Contrast denotes the difference in visual properties that makes an object (or its representation in an image) distinguishable from other objects and the background of the image. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the light reflected or emitted by an object and other objects within the same field of view. In imaging, contrast also depends on the image source, the medium, and the ambient lighting.

Grayscale more accurately reflects an LCD or projection display's ability to present lifelike images than contrast ratio. While contrast *can be* an important display attribute – without shades of gray,

the LCD or projector will not provide life-like image quality. A wide grayscale range can improve images with very low luminance levels (such as night scenes) by providing greater shadow detail. Wide grayscale can also improve display at very high luminance levels (for example, cloud and sky images) where it brings out highlights.

Grayscale is beneficial for *all* images, but is most dramatically noticeable in dark scenes or Film Noir. With insufficient grayscale resolution, a night scene with high-contrast lighting will make it extremely difficult – if not impossible – to detect shadow details.

Conventional LCDs and Projection Displays

Today's CRT TVs are better at rendering contrast and grayscale than conventional LCDs or projection displays, but still not ideal. The average beam current of a CRT TV can be adjusted to set average image brightness over a moderate range without sacrificing grayscale. But at high brightness levels, gray levels and contrast are lost in CRT TVs.

Conventional LCD and projection displays fall far short of both a CRT display as well as an ideal electronic display. To display a dark image inherently limits the usage of the bright gray levels in the image frame, compressing the contrast of the image and compromising detail... The same is true for bright images where predominantly the bright gray levels are used.

LCDs and projection displays are also incapable of producing absolute blacks. Even in the lowest light portions of an image, the base color of the image is a very dark gray – but not a true black. Unfortunately, conventional LCD technology is limited in this area. While each generation of projector and LCD has become brighter and contrast has improved to some degree, luminance at black levels is still higher than that measured on emissive displays, such as CRTs and plasma displays.

The Ideal Display

With conventional LCD and projection imaging technologies, black level, contrast, and grayscale detail are compromised in dark and bright frames. For an *ideal* electronic display, the overall frame brightness, and the grayscale range would be set independently such that both dark and bright scenes could use the full range of available grayscales. An ideal display would provide the ability to do synchronous adjustment of image brightness, *without* sacrificing any image detail.

Dramatic improvements in the quality of the displayed image can now be realized in both LCD and projection displays, where it is possible to independently control the light source which sets image brightness and the passive imaging display which sets the pixel grayscale levels.

(Note: In order to simplify the explanation of this new technology in the remainder of this paper, the LCD terminology – not projection technology – will be used. The light source for an LCD is typically called a *backlight* and the passive imaging device is simply called the *LCD*. These terms will be used in this paper. However, all of the principals apply to projection displays that are made up of a projection lamp and a passive microdisplay imager, such as 3LCD™ and DLP™ front projectors and rear projection TVs. Generally, these principals apply to passive displays having an illumination source.)

In summary, an ideal LCD display would:

- Improve gray level detail by optimizing the utilization of grayscale levels;
- Achieve darker blacks and brighter whites;
- Improve color contrast; and
- Reduce power consumption.

SSBC – Improving the Performance of Video Displays

In order to address the limitations of LCDs with respect to image quality, black level, utilization of grayscale, and contrast, Fergason Patent Properties (FPP) has developed the System Synchronized Brightness Control (SSBC™) technology. The main concept of SSBC is based on *synchronous modulation of grayscale range and backlight intensity*. This technology can be used to improve the image detail and contrast for displays generally, and televisions specifically. SSBC control moves LCDs a huge step forward toward achieving the characteristics of the ideal display.

Fergason SSBC technology dynamically characterizes the brightness of a video or photographic input image using an embedded algorithm. A digital microprocessor chip uses the frame pixel information to synchronously set the brightness of the LCD backlight, as well as optimize the gray level utilization of the image input to the LCD display module. It adjusts each video frame to use the optimized range of pixel gray levels.

SSBC enables a display with a much broader dynamic range of frame brightness, while optimizing image detail and contrast within each frame. Figure 1 schematically illustrates the fundamental processes involved in the implementation of SSBC technology. The input video image is processed in the system media processor or similar computer controller. Based on embedded algorithms, the controller outputs a signal to the LCD backlight to control the light intensity and the image average brightness. Simultaneously, the video signal is processed to improve the image detail by using more of the available gray levels.

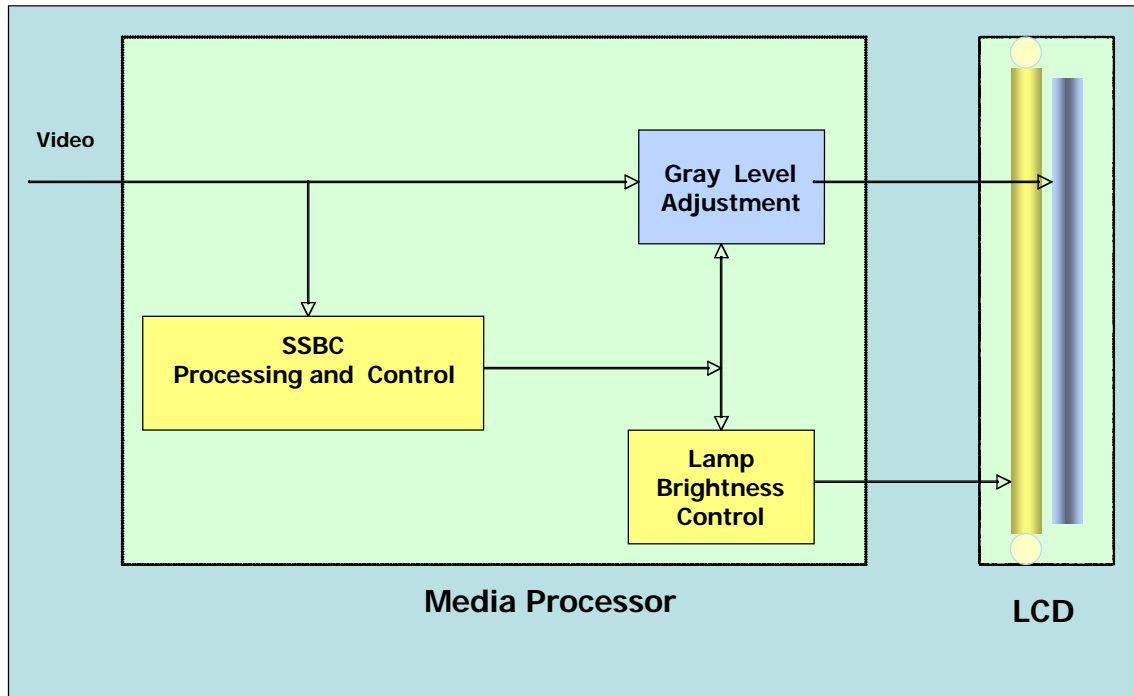


Figure 1. The fundamental processes involved in the implementation of SSBC technology.

The following image (Figure 2) illustrates a dark input image before using SSBC technology. The graph shows the distribution of gray levels in the input image. Note that most of the pixels are at low grayscale levels and that the brighter gray levels are not utilized. Since the video gray levels are compressed to decrease overall image brightness, the image detail is lost and contrast is compromised.



Figure 2. A dark input image before using SSBC processing technology. (Graphics from Seiko Epson Presentation.)

The next image (Figure 3) presents the same input image after it was processed using the SSBC concept. The grayscale distribution is stretched to make greater use of the full grayscale range. The lamp is synchronously turned down to maintain overall image brightness at the level of the input frame. The image brightness would have increased if the data stretch alone had been used. This results in vastly improved image detail and much higher contrast.

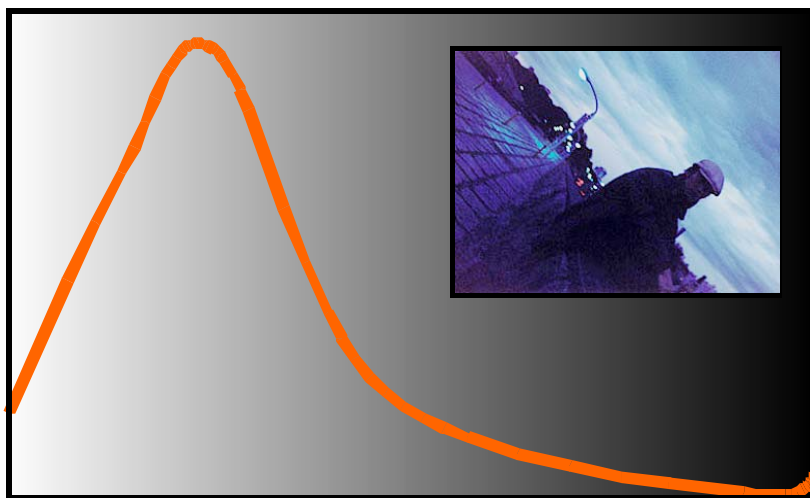


Figure 3. An enhanced image using SSBC processing technology. (Graphics from Seiko Epson Presentation.)

A more complete description of the process is shown in Figure 4. Again, the input image is processed and the controller adjusts the backlight illumination level and increases the range of grayscales used. The illustration also shows that not only can the white brightness of the image be adjusted, but also that each of the primary colors that make up the image can be independently controlled.

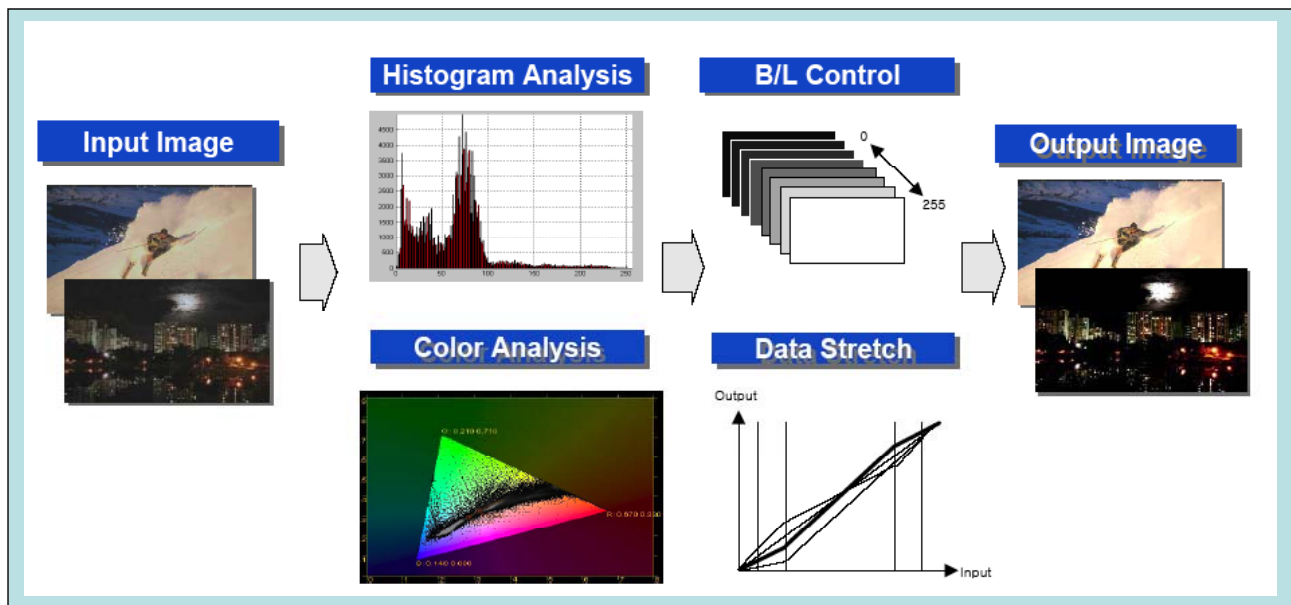


Figure 4. An SSBC process integrating color processing. (Graphic from LG.Philips LCD SID04 Presentation.)

SSBC Technology Options

The beauty of the SSBC approach is that it can be implemented in both LCD and projector displays without increasing cost. Display manufacturers must make an initial investment to implement the SSBC processing. Software and firmware can be integrated into the media processor chip used in televisions and video-capable monitors with minor incremental ongoing cost.

SSBC control may be used with CCFL backlights in LCDs and with commercial arc lamps in projectors where a variable iris may be used to modulate the lamp. SSBC principles are applicable to the next generation of LCD televisions with LED backlights. SSBC allows another dimension of image optimization by enabling the independent modulation of the backlight color through system synchronized color control.

SSBC control can also be used to decrease power consumption, especially when ambient light sensing is integrated as an input variable into the control algorithm. A new generation of notebook computer LCDs will be introduced making use of this feature.

Commercialization of SSBC Technology

Leading LCD and projection manufacturers have quickly adopted SSBC technology and a wide variety of televisions are currently available with the improved imaging capability. Panasonic LCD TVs and home projectors are now widely available with the SSBC feature, called “AI” by Panasonic in flat panels and “Dynamic Iris” in projectors. Matsushita Electric Industries (Panasonic’s parent company) was the earliest licensee of FPP’s IP, completing an agreement in October 2001.

LG.Philips LCD also offers a broad range of television LCD modules with integrated SSBC. These modules are used across the LGE line of LCD televisions and are also integrated into televisions of other brands. The LPL license agreement was finalized in December 2003.

FPP completed a licensing agreement with Seiko Epson Corporation in March of 2005. Epson is producing 3LCD engines and modules for front and rear PTV. “We are proud that Epson, the world leader in 3LCD projection, has decided to enhance the performance of its products with the SSBC IP,” stated Dr. James Fergason, the inventor and chairman of FPP.

Other licensing agreements have been concluded with Sharp in December 2005 and Samsung in January 2006. A range of new SSBC LCDs from these suppliers this year is planned for 2006. “There is now wide acceptance among LCD and projection technologists that SSBC can dramatically improve video performance,” reported Chuck McLaughlin, VP of Licensing for FPP.

Various developers refer to the synchronous modulation of lamp or backlight brightness and image gray levels by different names. Examples of alternate marketing terms include:

- Fergason Patent Properties: System Synchronized Brightness Control (SSBC)
- Matsushita/Panasonic: AI and Dynamic Iris
- Seiko Epson: Adaptive Dynamic Range Control (ADRC)
- Samsung: Image Synchronized Brightness Control (ISBC) and Dynamic Contrast
- LG.Philips LCD: Adaptive Dynamic Image Control (ADIC)

Current IP Status

FPP has been awarded two U.S. Patents covering the SSBC technology:

- U.S. Patent 5,717,422 with 25 claims
- U.S. Patent 6,816,141 additional 46 claims

Additional patent filings are pending, and international patents are expected to be issued in the near future. A comprehensive list of patents can be found on the company's Web site, at www.fergasonpatents.com.

SSBC Features and Benefits Summary

Ferguson Patent Properties SSBC technology provides more cinema-like video performance in LCDs and projectors. It improves image detail, particularly in both dark and bright images. SSBC control also improves contrast and viewing angles, and uses algorithms to conserve or reduce backlight power.

Features and benefits of SSBC technology are continually being implemented commercially. The next commercial generation of SSBC provides synchronized RGB optimization, additional power saving algorithms for use in laptops and handhelds, and improved video in cameras, cell phones, and handheld devices.

SSBC offers a giant step forward over conventional image display by simultaneously improving dynamic range, contrast, and enhancing image sharpness and color gamut through video data "stretching" and improving the sharpness and gray levels of images.

About Ferguson Patent Properties

Ferguson Patent Properties develops, demonstrates, and licenses display-related IP. The company was founded in 2001 by the inventor, Dr. James L. Ferguson, who has assigned a portfolio of more than 35 issued U.S. Patents and foreign counterparts to the company. Dr. Ferguson was recently recognized by the U.S. Patent and Technology Offices as a leading independent inventor, and will receive the 2006 MIT-Lemelson Prize for Invention.

The company maximizes the value of the FPP patent portfolio to licensees by providing technical support services and creating or acquiring related and synergistic intellectual property, including Trademarks and Copyrights. In addition to the SSBC program, FPP is actively developing licensees for its StereoMirror™ 3D monitors and RetroVue™ out-the-window-view head mounted projector for use in simulators.

For more information on SSBC technology or Ferguson Patent Properties, please visit www.fergasonpatents.com, or contact the company's Licensing Agent: Charles McLaughlin, 650.323.7155, chuck@mcgweb.com.

Appendices

References and Sources of Additional Information

1. Samsung SID Paper

- Image Synchronized Brightness Control, page 492 • SID 01 Digest

2. Epson Presentation

- Novel Projection System Based on Adaptive Dynamic Range Control Concept, IDWR, 2003

Acronyms and Definitions

Source: Wikipedia free Web encyclopedia.

AMLCD	An active matrix liquid crystal display (AMLCD) is a type of flat panel display, currently the overwhelming choice of notebook computer manufacturers, due to light weight, very good image quality, wide color gamut, and response time. The most common example of an active matrix display contains, besides the polarizing sheets and cells of liquid crystal, a matrix of thin-film transistors (TFTs) to make a TFT LCD. These devices store the electrical state of each pixel on the display while all the other pixels are being updated. This method provides a much brighter, sharper display than a passive matrix of the same size. An important specification for these displays is their viewing -angle.
Brightness	Brightness is an attribute of visual perception in which a source appears to emit a given amount of light. In other words, brightness is the perception elicited by the luminance of a visual target. Brightness was formerly used as a synonym for the photometric term luminance and (incorrectly) for the radiometric term radiance. According to Federal Standard 1037C, "brightness" should now be used only for non-quantitative references to physiological sensations and perceptions of light.
CCD	A charge-coupled device (CCD) is a sensor for recording images, consisting of an integrated circuit containing an array of linked or coupled, capacitors. Under the control of an external circuit, each capacitor can transfer its electric charge to one or other of its neighbors. CCDs are used in digital photography and astronomy (particularly in photometry, optical and UV spectroscopy and high speed techniques such as lucky imaging).
CCFL	Cold Cathode Fluorescent Lamps. A fluorescent lamp is a type of lamp that uses electricity to excite mercury vapor in argon or neon gas, resulting in a plasma that produces short-wave ultraviolet light. This light then causes a phosphor to fluoresce, producing visible light. Unlike incandescent lamps, fluorescent lamps always require a

	ballast to regulate the flow of power through the lamp. In a compact fluorescent light bulb, the ballast is integrated with the lamp, allowing it to be used in the sockets for incandescent lamps.
Contrast	<p>In visual perception, contrast is the difference in visual properties that makes an object (or its representation in an image) distinguishable from other objects and the background.</p> <ul style="list-style-type: none"> • In visual perception of the real world, contrast is determined by the difference in the color and brightness of the light reflected or emitted by an object and other objects within the same field of view. • In imaging, contrast depends additionally on the image source, the medium, and the ambient lighting. <p>For example, in the case of graphical computer displays, contrast depends on the properties of the picture source or file and the properties of the computer display, including its variable settings. For some screens the angle between the screen surface and the observer's line of sight is also important.</p>
CRT	The cathode ray tube or CRT is the display device that was traditionally used in most computer displays, video monitors, televisions and oscilloscopes. The CRT developed from Philo Farnsworth's work was used in all television sets until the late 20 th century and the advent of plasma screens, LCDs, DLP, OLED displays, and other technologies. As a result of this technology, television continues to be referred to as "The Tube" well into the 21 st century, even when referring to non-CRT sets.
DLP	Digital Light Processing (DLP) is a technology used in projectors and video projectors. DLP was originally developed by Texas Instruments, and it remains the primary manufacturer of such technology, which is used by many licensees who market products based on TI's chipsets.
Grayscale	<p>In computing, a grayscale digital image is an image in which the value of each pixel is a single sample. Displayed images of this sort are typically composed of shades of gray, varying from black at the weakest intensity to white at the strongest, though in principle the samples could be displayed as shades of any color, or even coded with various colors for different intensities. Grayscale images are distinct from black-and-white images, which in the context of computer imaging are images with only two colors, black and white; grayscale images have many shades of gray in between. In most contexts other than digital imaging, however, the term "black and white" is used in place of "grayscale"; for example, photography in shades of gray is typically called "black-and-white photography". The term monochromatic in some digital imaging contexts is synonymous with grayscale, and in some contexts synonymous with black-and-white.</p> <p>Grayscale images are often the result of measuring the intensity of light at each pixel in a single band of the electromagnetic spectrum (e.g. visible light).</p> <p>Grayscale images intended for visual display are typically stored with 8 bits per</p>

	sampled pixel, which allows 256 intensities (i.e., shades of gray) to be recorded, typically on a non-linear scale. The accuracy provided by this format is barely sufficient to avoid visible banding artifacts, but very convenient for programming.
LCD	A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is prized by engineers because it uses very small amounts of electric power, and is therefore suitable for use in battery-powered electronic devices. Each pixel (picture element) consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other.
LED	A light-emitting diode (LED) is a semiconductor device that emits incoherent narrow-spectrum light when electrically biased in the forward direction. This effect is a form of electroluminescence. The color of the emitted light depends on the chemical composition of the semiconducting material used, and can be near-ultraviolet, visible or infrared.
Lux	Lux is the SI unit of illuminance. It is used in photometry as a measure of the perceived intensity of light.