ST Micro LED Backlight System

LED Backlights For TVs

- Why LEDs ?
- Types of LED BL
- The Local Dimming technique
- Local Dimming problems
- Panel data compensation
- Modeling the backlight



CCFL Backlight always on





Why LEDs ?

- CCFL technology is very similar to fluorescent tube strip lights.
- CCFL light output and color quality degrade over time more than LEDs.
- CCFL lamps contain poisonous heavy metals that can get into the environment at manufacture and end-of-life, LEDs are less toxic, and are sealed in a package.
- CCFL lamps are much more fragile than LEDs.
- CCFL lamps are difficult to dim, but LEDs are very easy to dim.
- The light from LEDs is more focused, so can be used more efficiently.
- LEDs come in all kinds of colors.
- LED technology is still improving.









Direct Lit LED Backlight

LEDs are surface mounted on a circuit board, and shine directly on the back of the LCD.





Edge Lit LED Backlight

LEDs are mounted on the edge of a transparent light guide. The light is trapped in the light guide until it hits an extraction feature, causing it to exit the light guide and illuminate the LCD panel.





Why Local Dimming LED Backlight ?

- The liquid crystal in an LCD works like a valve, restricting the amount of light of each color that passes through each pixel.
- The liquid crystal cannot stop all the light.
- The light leakage causes dark areas of the image to be brighter than desired.
- If an area of the image contains few bright pixels, the backlight can be dimmed in that area.
- The black levels will get darker in proportion to the reduction in backlight brightness.
- Dimming the backlight also reduces power consumption. With typical movie material power is reduced by around 50%.



Local Dimming LED Backlight

- Using LEDs, specific areas of the backlight can be dimmed (depending on the image content)
- Certain areas of the image are kept bright.
- Certain areas of the image are dimmed.





LED BL with Local Dimming

In the bright regions of the image the LED backlight is fully on resulting in high light output.

In the dark regions of the image the backlight is dimmed so less backlight leaks this has the following advantages:

- The blacks get blacker (less backlight leakage)
- The contrast ratio increases (in bright regions the backlight is fully on, in dark regions the backlight is locally turned down)
- Because in an average TV or movie scene there is sufficient amount of dark areas so the LED's can be turned down, the power consumption goes down.

LCD panel with *LED* backlight

LCD panel with CCFL backlight







Basic Local Dimming Problems

- Reducing the backlight brightness in some areas changes the overall brightness of the image in those areas.
- Very little reduction is possible without causing noticeable changes to the image.
- The goal is not to change the image, but just to display it in the best way possible.
- Modulating the brightness could cause visible flicker.



Local Dimming - Concept

- Based on simultaneous modulation of backlight and panel data
- The goal is to decrease the brightness of the backlight in an area, to make blacks appear blacker, while increasing the panel brightness to maintain the original brightness of the pixels.



- The brightness of a pixel is the brightness of the backlight multiplied by the brightness (transmittance) of the panel.
- L1 is the amount of light with no local dimming. BL1 is backlight set to nominal setting. P1 is the original panel data.
- L2 is the amount of light with modulated backlight (BL2). P2 is scaled panel data. L2 = L1. The final brightness must be unaltered.



Pixel Compensation Problems

- Pixel data must be increased by the same proportion that backlight brightness is decreased.
- All calculations and compensations must be performed on linear pixel data.
- Pixel data is normally gamma compensated, which is not linear.
- Care must be taken to minimize clipping of panel data.
- Typically the pattern of light from any one "zone" of the backlight does not have sharp edges, and some of that light spreads right across the display.
- A very fine balance must be maintained between the backlight brightness, and the compensated panel pixel values (better than 1%).
- The panel pixels do not respond immediately to new data, but the LEDs do, causing transitory imbalances that appear as flicker.



Input Gamma Tables

All processing implemented in linear light space for high precision and accuracy.



Output Gamma Tables

Gamma correction to compensate for panel non-linearity.





Zones and Grids

- The backlight is physically divided into a number of horizontal, and vertical zones, typically in a regular pattern.
- The brightness of each zone can be independently controlled. Some systems use RGB LEDs, and some use white LEDs.
- To make calculations simpler, zones are sub-divided into a number of virtual grids.





Modeling The Light In The Backlight

- Each zone contributes some light to every pixel in the display.
- Having decided how bright to make each zone (based on image content) we must then use a mathematical model of the backlight to calculate the backlight brightness for every pixel so we know how much to compensate each pixel.
- The model requires over 4608 parallel calculations, running in real time (about 800MHz), which is not practical.
- So we create virtual grids, finer than the zones (perhaps 16X), and calculate the total backlight brightness only for the grid points. Two dimensional linear interpolation of the 4 grid points surrounding a pixel is used to calculate the brightness at that pixel.
- This method reduces the number of calculations to 144, which is much more manageable.





Zone Contour Tables

- Zone contour tables carry information about spatial light distribution from a specific zone. Used for pixel modulation.
- Number of tables limited by memory and grid size





Zone Brightness Calculations

- To calculate the amount of required pixel modulation within each individual zone (Znm), the amount of spilled light from every other zone (ΣΣ Zij) on the screen must be taken into account.
- Requires significant hardware resources and clever parallel processing.



Block Diagram





Comms Formatter

Very flexible hardware block enabling:

- Interfacing with a variety of LED Backlight drivers
- Flexible configuration of the zones, grids, zone shapes
- Programming in assembly for speed



