



Optical Short Course International

6679 N. Called de Calipso, Tucson, AZ, USA

www.oscintl.com

520-797-9744

In The Box

Optics of Digital Projectors Weekly eNewsletter

Sponsored By:

**The Brand for highest quality and competence in
Light Management Solutions™ for Projection Display**



Download brochure (PDF) => [Light Management Solutions™ for Projection Display](#)

Visit Homepage => www.optics.unaxis.com

Multi-Primary Color in Digital Projectors



Over the past year and a half we have always talked about three colors when discussing the light engines in digital projectors. Red, green, and blue (RGB) have been our main points of discussion and we have also talked about a white segment and a dark green segment in the color wheel in a few issues. Like much of our display technology heritage in digital projectors our color heritage also comes from television technology. The RGB phosphors in television tubes and the associated RGB color standards come from about

1954. Now that we are a bit smarter fifty years later and have some more advanced color technology and calculation capabilities to display “true colors” we have arrived at multi-primary color technology. Rainbow Warriors Rejoice. Gamut buster technology is here for your viewing pleasure.

Color Gamut Comparison

The color gamut of an image is a combination of three parts of the sequential capture, data transfer, and display systems. The image capture or camera sensor is typically not a gamut limiting device or process. The data transfer is typically not a gamut limiting device or process either. The image display has been the weak link in this sequential color gamut production process in the past.

A typical digital projector display with a three color RGB filter wheel might look similar to the color gamut triangle displayed in Figure 1 below. Recall from our early version of In The Box that the display can produce any color within the color gamut triangle of that display. The full red, green, and blue colors would be located at the vertex of the triangle. In this case a saturated green, yellow, cyan, and purple are difficult to achieve with this small color gamut compared to what the camera can record and the human eye can see.

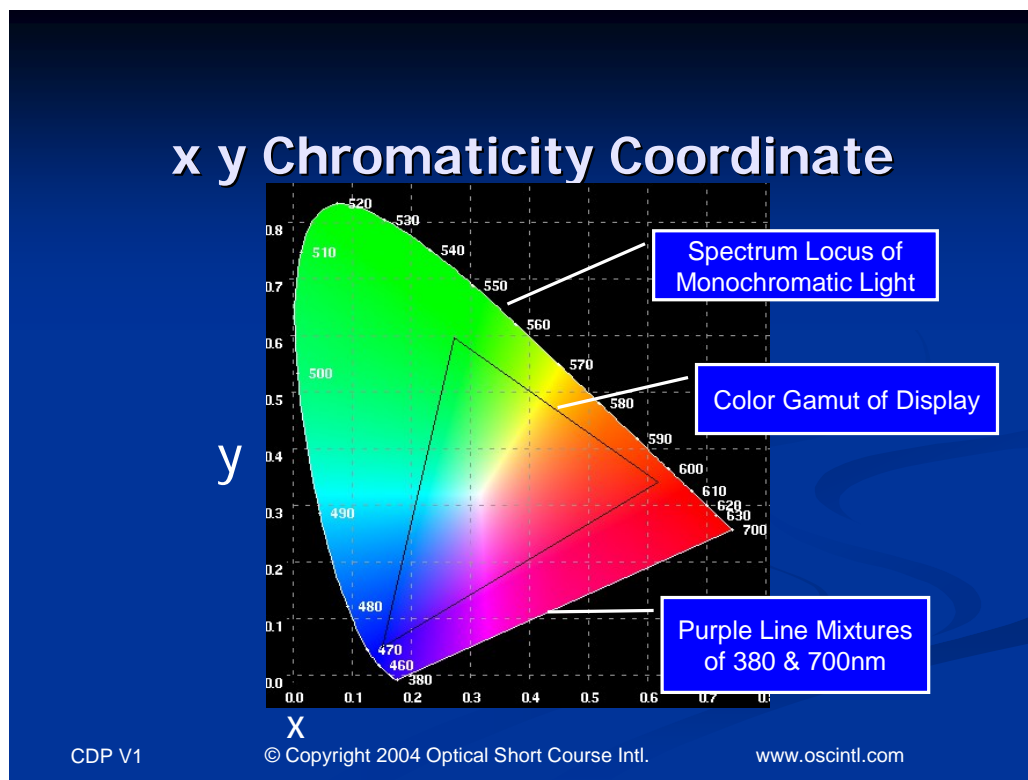


Figure 1. 1931 CIE Chromaticity Diagram

Illustration from our new DVD course Color in Digital Projectors at <http://www.oscintl.com/prod03.htm>

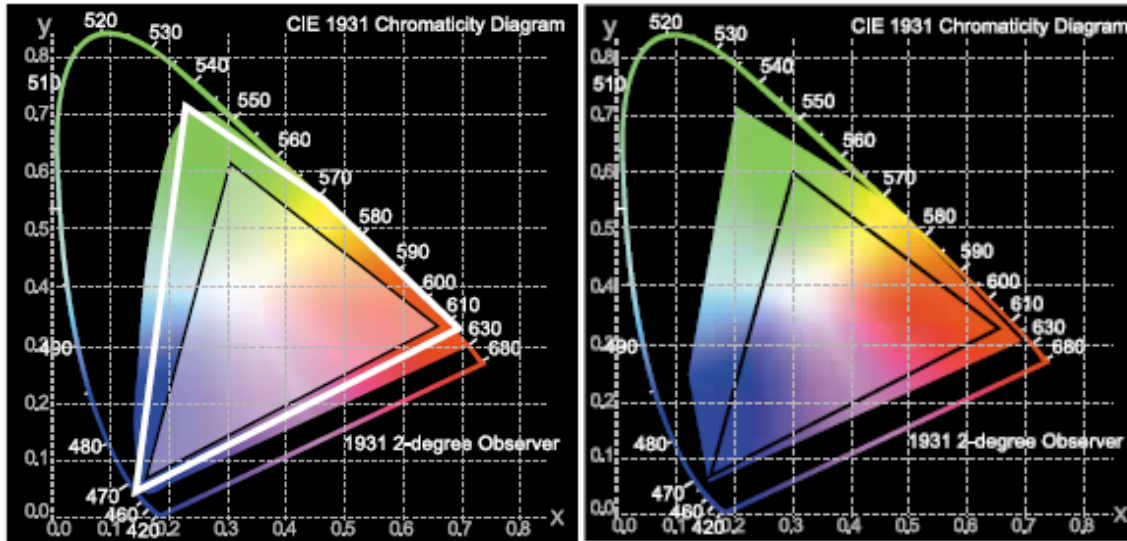


Figure 2. 4 Primary and 5 Primary Multicolor Gamut from Genoa Color Technologies
<http://www.genoacolor.com/techwall.pdf>

Genoa Color Technologies has been leading the development of multi-color primary display technology for the last five years. They have 2 patents issued and about 60 pending worldwide on the concepts, processes, and algorithms to produce multi-color primary displays. They have received many awards from organizations such as CES, CD Tech, Popular Science, and Fortune magazines. They have one issued US Patent 6,870,523. Their technology can increase the color gamut by 35%, as shown in Figure 2, and increase the brightness by 40% and delivers over 1 trillion colors.

In Figure 2 above we can see the RGB color gamut triangle of a typically digital projector. On the left we can see a color gamut from a four color multi-color primary technology from Genoa. This filter wheel would have red, yellow, green, and blue filters as we can see at the vertex of the polygon. In the five color primary solution on the right figure we can see a larger area polygon color gamut with red, yellow, green, cyan, and blue color filters in the wheel.

Where is Multi-Primary Color (MPC) Technology Used?

This technology is being used in LCD, DLP, and LCOS projector technology. Texas Instruments has developed their own MPC technology to work with their formatter board and DLP chips which is called Brilliant Color™. Genoa has worked with LCOS chip manufacturers to use the MPC with their technology. The market can expect to see MPC technology hit the market in 2006 in one and two panel LCOS RPTV's as it has been in the R&D stages with several companies in several of the panel technologies for about two years or more.

In January of 2005 at CES MicroDisplay Corp and Uneed Systems demonstrated a single panel LCOS RPTV with MPC. MicroDisplay may be the farthest company along the development curve as they offer reference design for their controller with Genoa's Keshet™ IC for MPC algorithms and color manipulation processes. Having a chipset

already in a companies reference design means that prototype projectors and pre-production projectors are much closer to market for interested RPTV and front projection companies.

In a discussion with Mr. Simon Lewis, VP Marketing & Business Development for Genoa Color Technology I asked him if there were any surprises about who demands the MPC technology. I thought he would tell me about passionate rainbow warriors who used it in a unique way, but he said, “The surprises we have seen are the large adoption by the main stream TV market of the consumer electronics market, in the big box CE stores they are desperate for some differentiation from their competitors who sit on the same shelf and are adjacent to one another. Our leading adopters of this MPC technology are the companies who are looking for an unfair advantage in the visual comparison when one display is compared to another in the store while displaying the same content.” No where is human color comparison more important and easy to distinguish than in two displays right next to each other.

I asked Simon what is the cost for mainstream RPTV applications that use the Genoa MPC technology and Keshet™ IC chipset, he said, “In a single panel RPTV with a \$500 BOM the total cost including the Keshet™ chipset is well below \$50. There is not a net increase in the color wheel glass area so the costs there are small and because the light from the lamps are used more efficiently and less heat has to be dissipated there are good indications that we might be able to use a smaller lamp and ballast and less of a heat load to cool so we might be trading some of that extra costs for reduced cost in other components of the light engine.” So I guess for the consumers in the big box stores the question will be how much is the extra color gamut and brightness worth to get the advanced color technology out the door?

Unaxis Multi-Primary Color Wheel Info

According to Charlie Hoff, Product Manager of Color Wheel Products at Unaxis Optics 2006 will be the year that MPC technology hits the market in a big way. Charlie says that their MPC Color Wheels are being planned for about 75% RPTV and 25% Front Projection markets. Many leading MPC color companies seek out Unaxis because of their core competence of thin film optical coating technologies.

The important design properties for MPC color filters are the cut-on and cut-off edges, slopes, and average transmission in the particular color band, just like conventional RGB filters. In volume applications users should expect only a couple percent higher cost for MPC color wheels as there is a slight yield reduction with 6 colors versus 3 colors. Charlie uses a semi-custom filter wheel design tool similar to the one on their website, as we discussed in an earlier version of In The Box, and has run many design and cost models, give him a call if you need some design assistance or need some questions answered about MPC color wheels.

TI Multi-Primary Color Info

Texas Instruments calls their MPC technology Brilliant Color™ and they are working hard for a big 2006 launch as well into their DLP products. The first front projector product which is already on the market with this MPC technology is Mitsubishi's MC3000 front projector. This product is a 1000 lumen, 4000:1 ANSI Contrast, with 1280x720 native resolution with the DarkChip2™ DMD and the new DDP3020 with Brilliant Color™ for just under \$3,000. TI expects to have a new white paper on their website after the first of the year which discusses Brilliant Color™.

LCOS MPC Light Engine Layout

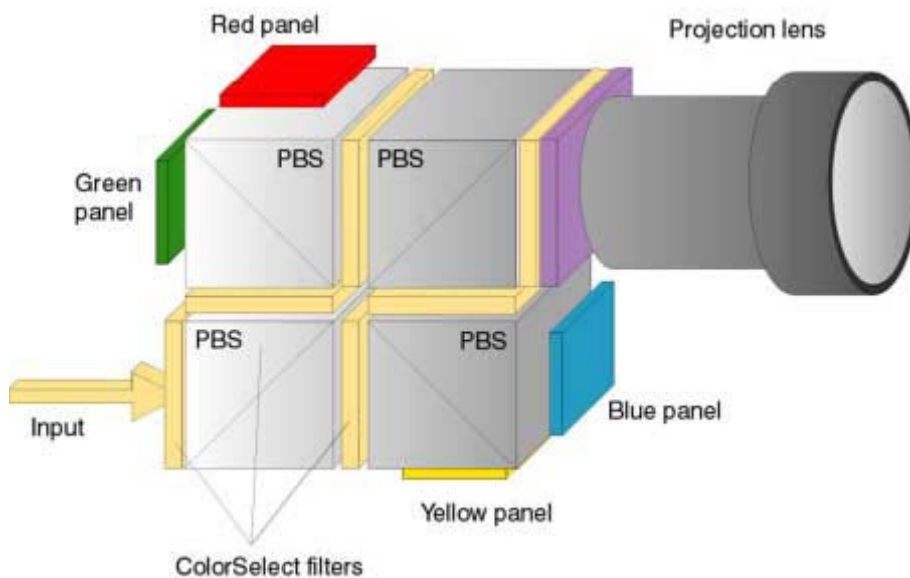


Figure 3. Four Color LCOS Light engine Layout
Courtesy of Genoa Color Technology and ColorLink, Patent Pending

In this light engine example in Figure 3, we can see that there are 4 panels one each for the red, green, blue, and yellow bands. In a two panel light engine configuration there would be two panels and each of the two panels would alternatively show two colors each. For example the first panel would show red and yellow while the second panel would show blue and green alternately to make up the four primary colors of the image.

Signal Processing Multi-Primary Color Technology

In the Genoa Color Technologies Keshet IC family of products the multi-primary color technology processing takes place. The Keshet IC's can take RGB or YCrCb color inputs of up to 10 bits per channel and can handle HDTV or SDTV standards and handles all resolutions up to UXGA and 1080p. The color manipulations are performed at the pixel level at video speeds which is quite impressive.

The basic system block diagram is shown in Figure 4 below. The video inputs come into the front end image processing block and after processing output RGB or YCrCb to the MPC Keshet IC which provide the 4 to 6 primary color outputs to the display driver which in turn talks to the pixel in concert with the color wheel or fixed color filter for a multi-panel system.

System Block Diagram

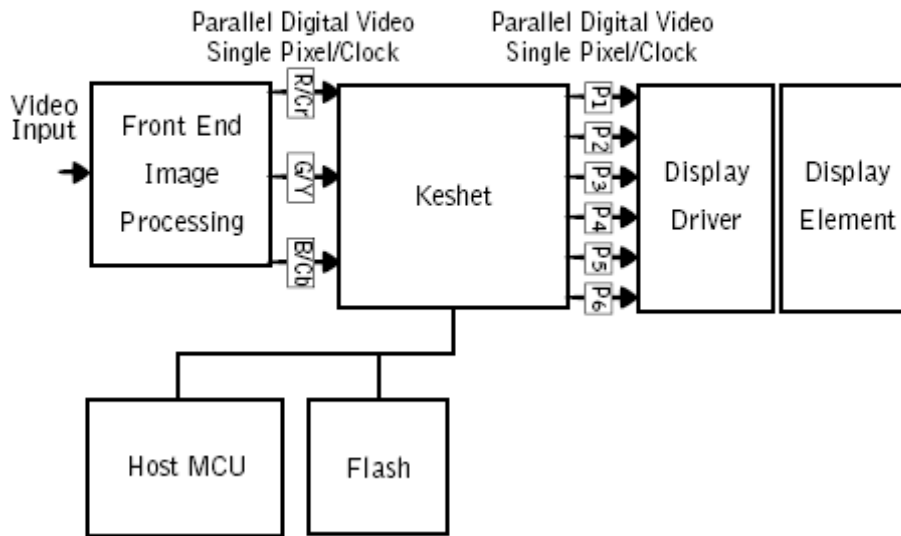


Figure 4. MPC System Block Diagram
 Courtesy of Genoa Color Technologies
<http://www.genoacolor.com>

Keshet Block Diagram

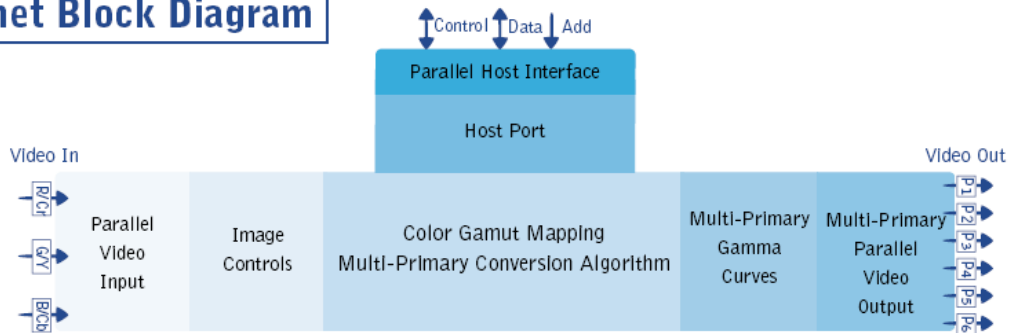


Figure 5. Keshet™ IC System Block Diagram
 Courtesy of Genoa Color Technologies
<http://www.genoacolor.com>

In the Keshet™ Block Diagram we get an idea of what the internal processing to turn the RGB into multi-primary colors. The RGB video input comes in and depending upon how many primaries will be output from 4 to 6 the appropriate multi-primary conversion algorithm is used to decide how much of each of the new 4, 5 or 6 color will be used to create the original color.

If we think about the chromaticity diagram and the relative mixtures of the RGB color there is only one choice of the relative mixtures to create a particular color. When we add 4, 5, or 6 primary color choices the relative mixture magnitude of each of the primary colors becomes a calculation nightmare. This is precisely where Genoa Color Technologies has much of their unique intellectual property in patents on the technology of multi-primary color mixtures and fast algorithms.

An interesting side note is that in the RGB color space much of the original true colors have been compressed to fit into the reduced color gamut of the limited display devices of the past. When these colors were “smashed” to fit into this limited display capability of these devices, no record was kept of how the colors were “smashed”. So reconstructing them to a real world MPC gamut can be a tricky process. In some of the new and proposed digital format standards there are proposals to include meta tags with the images to communicate in a standard way to describe exactly how and by what magnitude the color and other important image parameters were adjusted (or smashed) to be shown on limited displays. In the future with this meta tag data on the image adjustments it will be much easier to reproduce the original image to its true color and other important spatial, temporal, and chromatic properties.

Next the multi-primary colors are remapped to a gamma curve of the display device and then output in a parallel video output for the display driver and modulator to show to the viewer for a visually stunning true color image or video.

Some Free Mind Candy for ITB Readers

Certainly the DMD, LCOS, and LCD players are looking for ways to input this MPC technology into their technology roadmaps and product development plans for the future. It is interesting to think about how some of their existing competitors with new modulators, new solid state light source technology might be able to take advantage of their ability to move quickly in product development efforts and ingrain this exciting technology into their product lines with minimal retooling. If you are involved in one of these area that can take advantage of your enhanced agility, I suggest that you consider how to imbed this technology in your reference design from the start or as soon as possible. Of course if you want to brainstorm the ways give me a call.

Multi Primary Color Summary

We have moved beyond the 50 year old RGB 3 color legacy from the early days of TV into today’s 4, 5, and 6 primary color technology. This technology is easily within reach of leading projector designers and branding companies who want to differentiate their

products on the big box shelves. This differentiation is available to provide the early adopters an unfair visual advantage in the show room for a side by side comparison. This will enable consumers to choose true color solutions and give them a choice on how much it is worth to them in the market place. Viewers can see the difference of a larger true color gamut as they view over 1 trillion colors compared to the old 16.7 million colors.

Here is a business case where the general consumer electronics market will help drive demand for a leading technology that will ultimately benefit the specialized niches. These specialized niches are the rainbow warrior segments of the market the demand and need accurate true color in the projected images for business reasons.

If you need additional information please consider our new DVD course Color in Digital Projectors or if you just need some technical consulting help give us a call or see our consulting services section of the website <http://www.oscintl.com/services.htm>.

OSCI performs technical consulting to help clients with digital projection systems reach their full color potential. We leverage our alliances with the leading companies in the display industry to achieve these objectives for our clients. We also educate our clients about color in digital projectors with our DVD courses Optics of Digital Projectors and our newest course Color in Digital Projectors. See our website for more details: <http://www.oscintl.com>

See our newest DVD short course: Color In Digital Projectors



<http://www.oscintl.com/prod03.htm>

Do your sales people need training? Consider our ecourse on Digital Projector Technology

Would you like to give the gift of education to your customers, clients, or staff? Make a bulk purchase of our ebook on Digital Projector Technology; they will think of you every time they get an answer in our 240page book, filled with details.

http://www.oscintl.com/dpt_ebook.htm