Advisol
Advanced Visual Solutions

Experts in 3D projection polarizing filters

Improving circularly polarized displays with new Advisol circular polarizers

Technical note

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The Advisol circularly polarizing filters will be made from now in 90º/90º configuration. This gives improved ghosting rejection for viewing with the RealD circular glasses.

The following article explains the reasons behind this design change and its significance.

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1 Circular versus linear 3D display considerations

Linearly polarized 3D projection display has much better ghosting rejection than circularly polarized display. However, this superior ghosting rejection is very sensitive to the viewer's head orientation. When the viewer tilts his head, the ghosting rejection of linearly polarized displays deteriorates rapidly. On the other hand, in circularly polarized displays the ghosting rejection is much more tolerant to the viewer's head orientation. This is the main motivation for using circularly polarized displays.

2 Background: the ghosting phenomenon in passive 3D displays

A general scheme of a passive 3D display is shown in Figure 1. This scheme is valid for both rear and front projection setups.

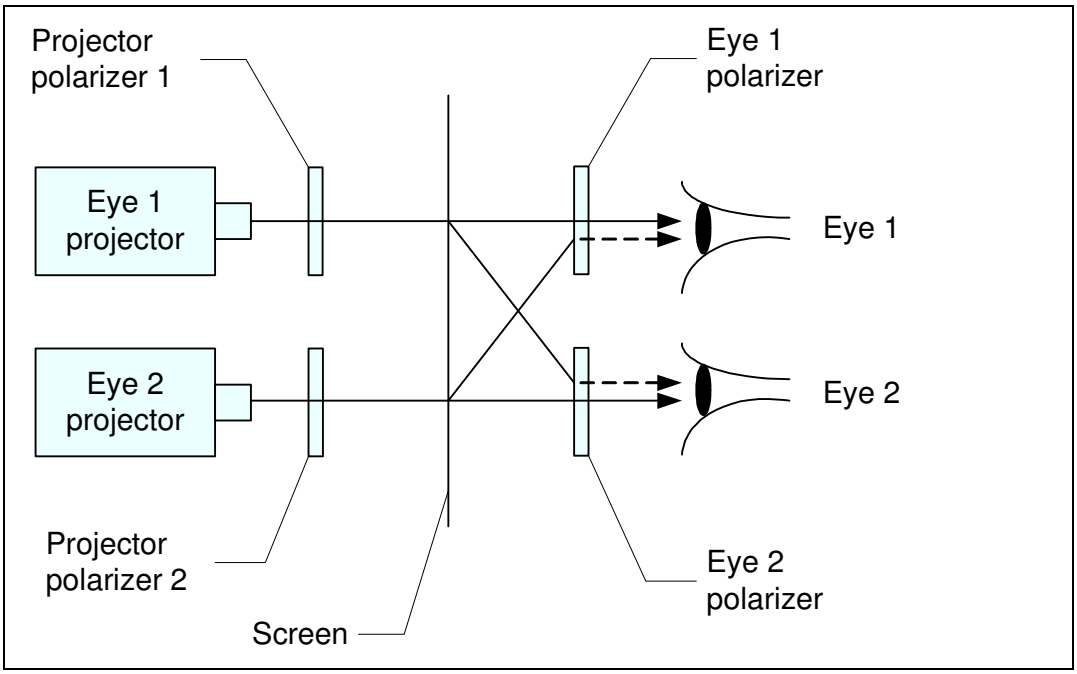

Figure 1: Scheme of a passive 3D display

The light of the projected stereo images is scattered by the screen, and reaches both lenses of the viewer's glasses. These lenses contain polarizers, whose role is to block the other eye light, so that Eye 1 will receive light only from Eye 1 projector, and Eye 2 from the Eye 2 projector. However, this blocking is not perfect, and a small amount of light penetrates the polarization barrier, as shown in Figure 1 by the dotted arrows.

Due to this leakage each eye sees a weak trace of the other eye image. This creates image artifacts known as “ghosting”. Since ghosting severely impairs the 3D display quality, it should be reduced to minimum.

A good quantitative measure of the ghosting level is the ratio between the main (same eye) light and the parasitic (other eye) light intensities that reach the viewer’s eyes. This ratio will depend in general on the wavelength. But if the intensities are measured by a photopic detector, like a common lux meter, we get a single number which reflects the apparent ghosting strength as perceived by a human observer. We call this ratio “display extinction”.

For best ghosting rejection, the display extinction should be as high as possible. In general, this parameter may be different for different eyes.

An important factor that determines the display extinction is the extinction of the polarizers used in the projector and the eye filters. This extinction is a measure of the transmission of a crossed-eye stack, for example a stack made of Projector polarizer 1 and Eye 2 polarizer. Ideally, this transmission should be 0, and the corresponding extinction infinite. However, even if the polarizers were ideal (infinite polarizer extinction), the display extinction would have been finite. This is due to the fact that the screen introduces a certain amount of depolarization. Depolarized light cannot be blocked even by ideal polarizers.

In typical 3D displays, the main contribution to ghosting comes from the screen depolarization. Nevertheless, with a given screen, polarizers with better extinction will give better ghost rejection.

3 The common circular polarizers

The common circular polarizers used in 3D projection displays (both in the projector and the glasses filters) are made of two materials: a linear polarizer and a quarter wave retarder, as shown in Figure 2. Both these materials are non isotropic, and have certain preferred directions. Therefore, the common two-component circular polarizer is also non-isotropic.

The transmission of a stack of two ideal orthogonal circular polarizers is independent of their relative orientation. However, in the common circular polarizers, like the one shown in Figure 2, the transmission of an orthogonal stack depends on the relative orientation of its polarizers. This raises a question whether there is a preferred relative orientation, which will lead to best display extinction.

4 Optimal circular polarizer orientation

For best ghosting rejection, the linear component of the circular polarizer of a given eye projector must be perpendicular to the direction of the linear component of the other eye filter in the viewer’s glasses. Thus, the linear component of Projector polarizer 1 should be perpendicular to the linear

component of the Eye 2 polarizer, etc. This statement is supported by theoretical arguments, and can be verified experimentally.

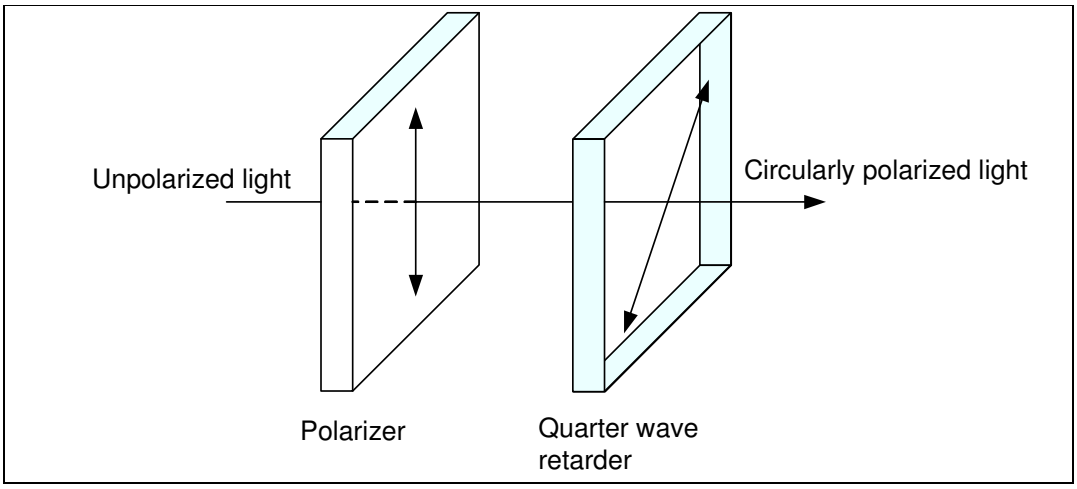

Figure 2: Common two-component circular polarizer

The experimental setup for the measurement of the display extinction is shown in Figure 3. The figure shows two polarizers mounted on rotation stages to allow precise angular adjustment. The polarizer near the projector simulates the projector polarizer, while the polarizer near the detector simulates the glasses filter. The measurement is done in two stages: in first stage we measure the light intensity I with same eye polarizers. In second stage we replace the eye polarizer by its orthogonal, and measure the light intensities in the two orientations, perpendicular (I_X), and parallel ($I_=$) to the projector polarizer. The two extinctions are calculated from the ratios:

$$\text{Perpendicular extinction} = \frac{I}{I_X}$$

$$\text{Parallel extinction} = \frac{I}{I_=}$$

Table 1 shows experimentally measured display extinction values for perpendicular and parallel filter orientations. We see that for the perpendicular setup the performance is improved almost by a factor of 2.

Table 1: Extinctions for different polarizer orientations

No.	Parameter	Value
1	Perpendicular extinction	78
2	Parallel extinction	44

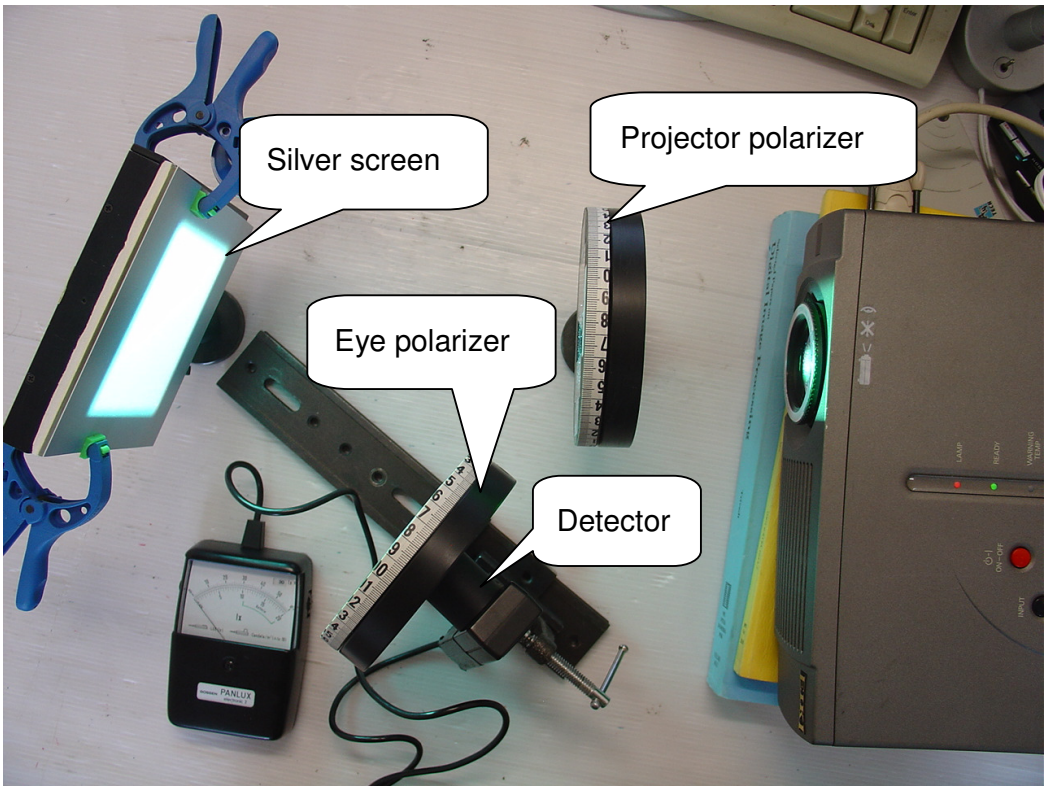

Figure 3: Experimental setup for measurement of extinction in a 3D display setup

5 Linear polarization extinction

The extinction of a linearly polarized setup was measured too, and the result was 150, significantly higher than in the circular polarizers setup. But a misalignment of 5º between the polarizers reduces the extinction to 80, which is the value measured for the circular setup in the perpendicular orientation.

The conclusion is that the linear setup has a better display extinction, but in order to exceed the performance of the corresponding circular setup, the angular misalignment between the linear polarizers must be less than 5º.

6 Directions of linear components in commercial circular glasses

Unfortunately there is no standard for the directions of the linear components of circularly polarized glasses. In Advisol we collected three samples of commercial glasses with different orientations of the linear components, as shown in Table 2. To our best knowledge, the Polaroid glasses are not on the market anymore.

Table 2: Directions (transmission) of linear components in commercial circularly polarized glasses (as viewed from screen)

Brand	Type	Left eye filter	Right eye filter
RealD	Plastic	Horizontal	Horizontal
APO, Berezin	Cardboard	Vertical	Horizontal
Polaroid	Cardboard	45º	135º

7 Adjustment of the projector circular polarizers

If all glasses in the audience are the same, it is possible to adjust the projector circular polarizers for best ghosting rejection. They should be oriented in such manner that their linear component direction will be perpendicular to the linear component direction of the other eye filters. This will guarantee highest display extinction.

The projector circular polarizers can be freely rotated only in DLP projectors, which emit unpolarized beam. The polarization structure of LCD projectors allows only 45º or 135º directions for the linear polarization component. Any other direction will cause color distortion.

LCoS projectors are linearly polarized. In these projectors it is advantageous to align the linear component of the projector polarizer with the projector polarization in order to obtain maximal light transmission. However, this may be incompatible with the direction required for best ghosting rejection.

8 New design of Advisol circular filters

Up to now the Advisol circular filters were oriented at 45º/135º. This orientation has the following advantages:

1. It works equally well with both DLP and LCD projectors
2. It gives the same (medium) performance with all glasses oriented at 0º or 90º

In an effort to improve the quality of its filters, Advisol decided to change the design of its circular filters to 90º/90º. This is optimized for viewing with RealD glasses, hoping that these glasses will become a standard.

The new filters contain an additional polarization transformer to make them equally usable for both LCD and DLP projectors as before. This additional component has no effect on DLP projectors.