Technical note: Understanding Polarizer Transmission

What is transmission?

Optical elements manipulate light beams. This manipulation always involves a certain amount of light loss. This loss is quantified in the transmission specification of the optical element. Figure 1 illustrates schematically the effect of a filter on a beam of light.

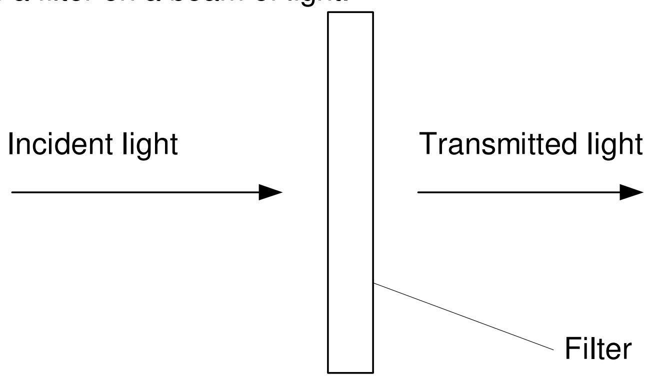

Figure 1: The transmission scenario

The filter transmission T is defined as the ratio between the incident and the transmitted light intensities:

$$T = \frac{I_t}{I_i}$$

Since (passive) filters cannot amplify light, the transmission value is always smaller than 1.

The characteristics that affect transmission

The value of the transmission is affected by the following characteristics:

- Illumination geometry (in particular, incident beam incidence angle)
- Wavelength of incident light
- Polarization of incident light

In quoting the transmission value, all three characteristics must be specified.

Interpreting transmissions quoted in polarizer specification

In most cases, transmission values are quoted without a full specification of the transmission scenario characteristics.
When the polarization of the incident light is unspecified, it is usually assumed that the quote relates to unpolarized incident light.
When the illumination geometry is unspecified, it is normally assumed that the quote relates to a collimated beam with normal incidence.
If the wavelength is not specified, there is no reasonable assumption that one can make. The quoted transmission value may be photopic transmission (see below), an average transmission over a certain spectral band (the visible band if the context is display), maximal transmission in this band, etc.

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Photopic transmission

The most useful transmission quote for the display industry is the photopic transmission. This transmission is measured with a common luxmeter, as shown in Figure 2. The photopic transmission T_P is given by the ratio:

$T_P = I_2/I_1$

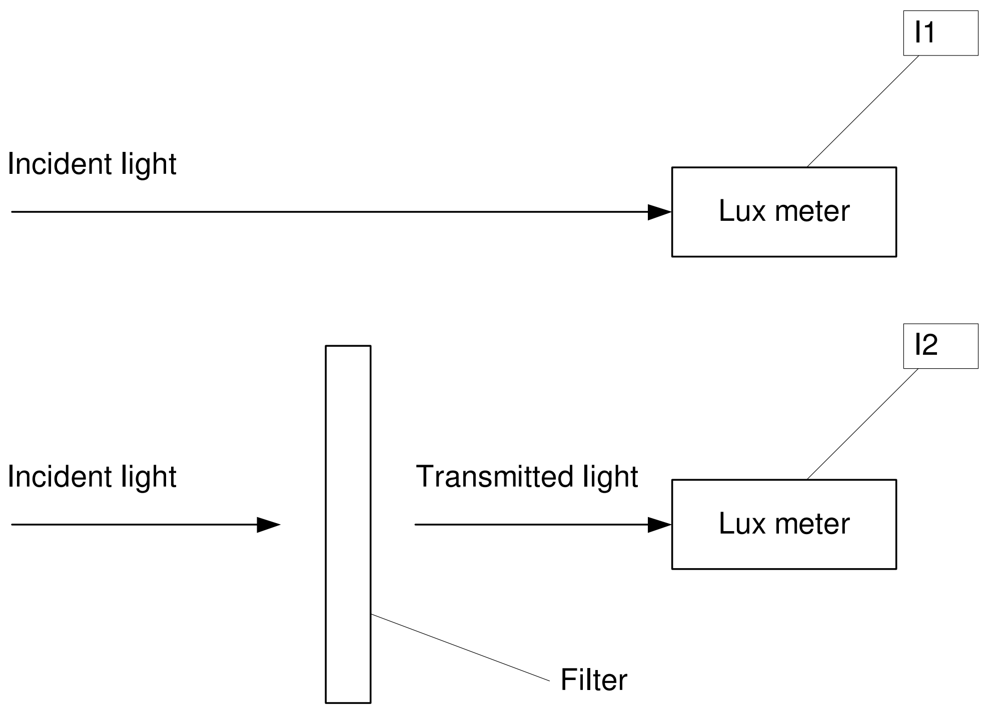

Figure 2: Measuring photopic transmission

Photopic transmission can be used to express the drop in the Lumen value of the projector beam:

$L_{filtererd} = L_{projector} \cdot T_p$

Equation 1

This is illustrated in Figure 3. The value of 40% for photopic transmission is common for polarizing filters.

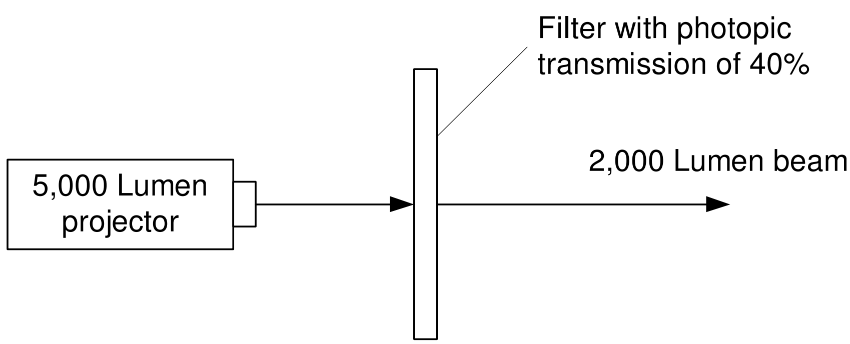

Figure 3: Calculating Lumen value drop with photopic transmission

Photopic transmission is not an intrinsic property of the filter, since it depends on the spectrum of the incident light. However, most of commercial projectors use MH arc lamps, which have very similar spectra compared to each other. If the photopic transmission is measured with a projector using MH lamp as the light source, then the resulting T_p value can be used to evaluate the Lumen drop in all projectors with MH lamp.

Photopic transmission and LCD projectors

LCD projectors emit partially polarized light beams. In such beams, the transmission of a linearly polarizing filter will depend on its orientation. In these projectors Equation 1 is valid only when the filter is oriented at 45º or 135º. Since these are the standard filter orientations in projection 3D displays, one can use Equation 1 in such displays regardless whether DLP or LCD projectors are used.
With LCD projectors, any orientation of a linearly polarizing filter other than 45º or 135º will cause color distortions.

Spectral transmission

Spectral transmission is a transmission characterization that appears in advanced technical data sheets. The spectral transmission is a function that describes the transmission value as a function of wavelength. This is an advanced characterization, which is normally not needed in daily practice. Spectral transmission can be used to predict the photopic transmission for any beam with a given spectrum.

Example: transmission characteristics of Advisol polarizing filters

<u>Advisol polarizing filters</u>

Advisol offers four types of polarizig filters:

- Standard: no AR coating
- H: AR coated substrate (only one facet coated)
- HAR: AR coated substrate with AR coated polarizer
- AR: Polarizer encapsulated between AR coated glass plates

<u>Photopic transmissions</u>

The photopic transmissions of the three filter types are given in Table 1. They were measured using a projector with MH lamp as light source.

Type	Photopic transmission (%)
Standard	42.3
H	44.0
AR	46.0

Table 1: Photopic transmissions

<u>Spectral transmissions</u>

The spectral transmission curves of the three filter types are shown in
Figure 4. They were measured with an unpolarized light source. Note that the transmission increase beyond 700nm indicates loss of polarizing power.

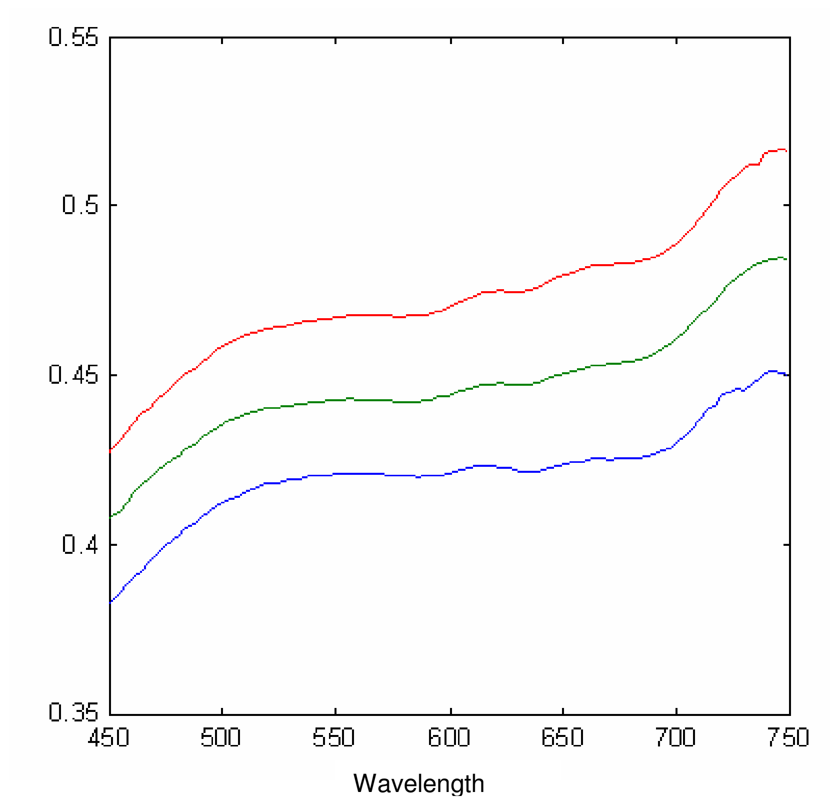

Figure 4: **Spectral transmission curves of the Advisol polarizers. Red: AR type, Green: H type, Blue: standard**