# Color Wheel for Projection Display Applications

## Overview

A color wheel is an optical component used for sequential color management in multimedia projection display systems. The most common application is in a single panel DLP™ projector. The color wheel is a critical component found in all projectors of this type.

Another emerging application for color wheels is in 1-or 2-panel LCoS projection systems.

## Application Details

Figure 1 below shows the location of the color wheel in a typical DLP optical system.

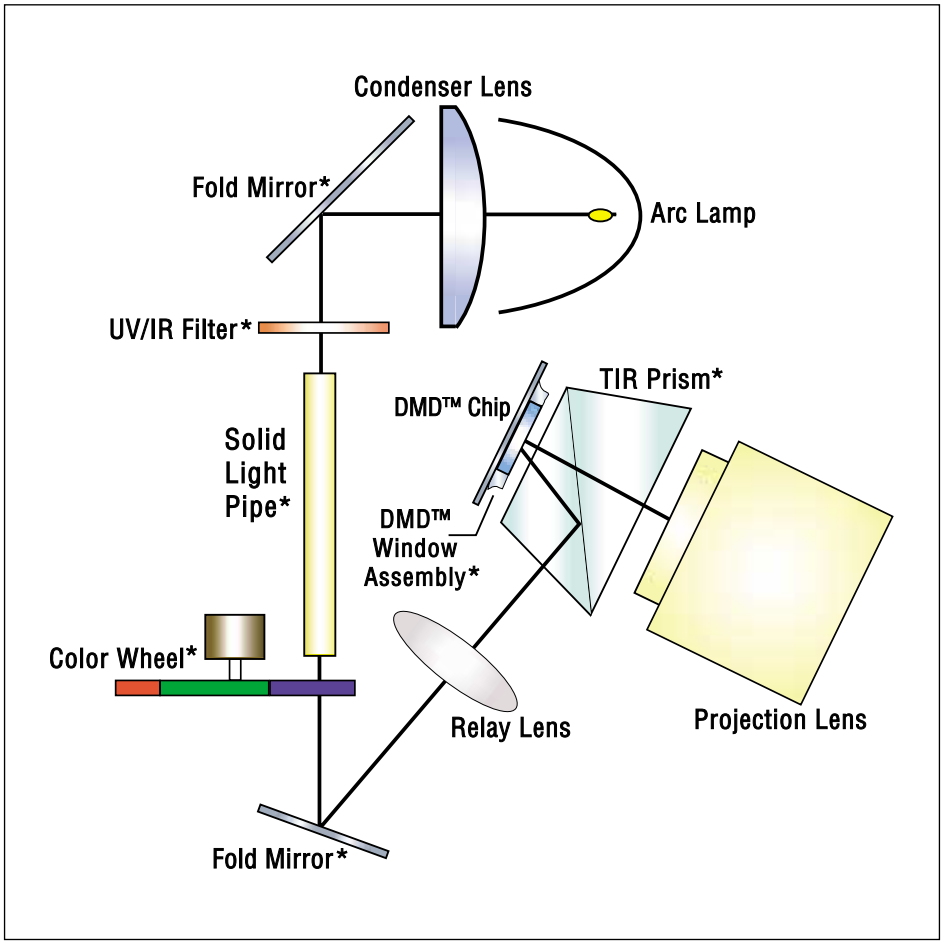


**Figure 1.** Schematic diagram of a typical 1-panel DLP optical system.
*Current OCLI product offering.

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Color wheels sequentially separate the white light of the lamp into red, green and blue wavelengths (in the most common configuration). Figure 2 gives a detailed view of the light path through the color wheel.

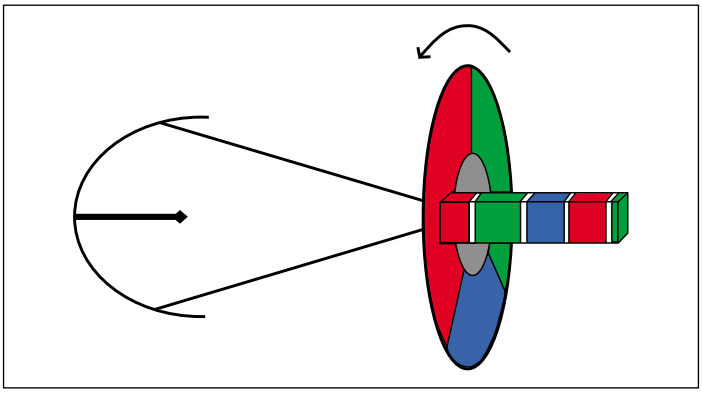
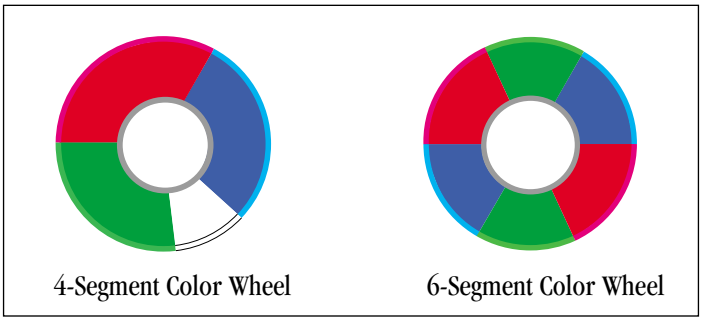


**Figure 2.** Light from the lamp being separated by the color wheel.

## Color Wheel Design

A color wheel is an opto-mechanical assembly that contains multiple pieces of dichroic-coated glass arranged in arc segments mounted to a motor, which rotates at a specified speed. Normally, color wheels contain 3 to 6 color segments for sequentially separating red, green and blue wavelengths. Very commonly, a white segment (usually a section of anti-reflection coated glass) is added to assist in boosting lumens projected to the screen. The light passes through the area on the color wheel called the clear aperture. The clear aperture is the usable dichroic area between the epoxy fillet on the inner edge and the outer edge, which has an edge chip specification. The two pictures below show an example of a four-segment and a six-segment color wheel. Note in the picture the inner epoxy fillet is the gray area and the outer edge aperture is shown as a different color than the color segment.




## Assembly Details

Precise tooling is needed to attach the segments to the motor. Such precision tooling allows assembly with the tight tolerances needed for minimizing the run-out of the glass (flatness), minimizing the gaps between segments, and centering the dichroic segments onto the motor (see chart below entitled "OCLI Color Wheel – Typical Tolerances"). Another important aspect of the tooling is that it must be designed to minimize edge chips.

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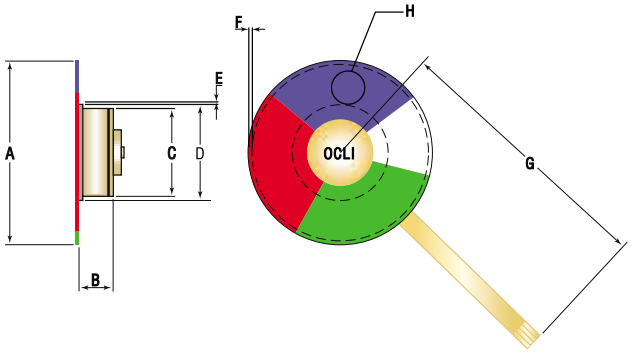
When attaching the dichroic segments to the color wheel motor it is important to note the customer requirement for orientation of the glass (coated side up or down). When the coating on the glass is facing the motor, it is called "dichroic coating down" and when facing away from the motor it is called "dichroic coating up." The light path in the projector determines the requirement for dichroic orientation up or down. Light from the lamp is typically directed through the dichroic coating side of the segment. During operation the color wheels maximum operating temperature specification is 85° C.

## Functional Characteristics/Definition of Terms:

- Outer Diameter of Color Wheel: The outer diameter is determined by the spot size and/or the clear aperture needed.
- Number of Filter Segments: The number of segments per wheel can be changed to adjust system characteristics (e.g. 6 segments for faster refresh rate, or an added white segment for more lumens).
- Segment Angle Sizes: Segment angle sizes are determined by the application. Factors affecting segment angles are spot size, color wheel segment angle tolerance, delay constant to DMD as well as other system-dependent parameters.
- Dichroic Surface Quality (Scratch/Dig): The surface quality spec is for the clear aperture area.
- Timing Index Mark (Color/DMD Synchronization): A timing mark or index mark is used to synchronize the color wheel to the DMD electronics. Timing marks are typically located on the side of the motor or in the center area on the top of the color wheel.
- Precision Balancing: Precision balancing is in accordance with ISO 1940 balance specifications for rotating motors.
- Clear Aperture (usable dichroic area): The usable dichroic area of the integrating rod determines the size of the clear aperture. See Figure 3 for calculation of clear aperture.




A = Outer diameter, color wheel
B = Assembly height
(from base plate to back F glass)
C = Motor outer diameter
D = Hub diameter
(NCLR wheels > 44mm)
E = Ep XY fillet
F = Edge chip spec
G = FPC cable length
H = Clear aperture

CLEAR APERTURE CALCULATION

1. Color wheel with hub
Clear Aperture = (A-D)/2-E-F
2. Color wheel without hub
Clear Aperture = (A-C)/2-E-F

**Figure 3.**

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- Dichroic spectral design: The dichroic spectral design determines the color output of the system. The typical color wheel is a 4-segment color wheel consisting of a red, green, white, and blue segment. Please see Figure 4 for typical color wheel spectral performance. The dichroic spectral performance must typically be kept to a tolerance of approximately ±1%, and the spectral stability with respect to temperature variation needs to be approximately 0.1 nm per 100° C.

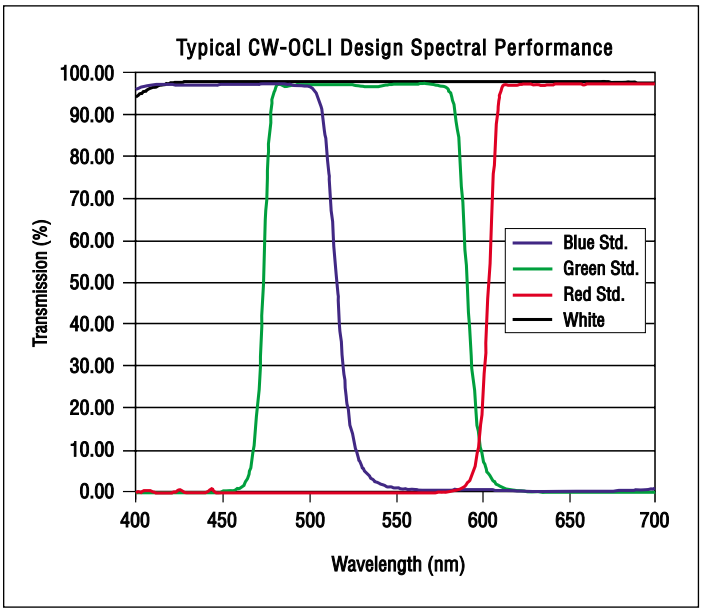


**Figure 4.**

- Motor Specifics: OCLI color wheels use reliable motors with speeds from 7200 to 10800 RPMs: There are four standard motor sizes. For a given application, the size of the motor is chosen by the outer diameter of the color wheel and the clear aperture needed. The chart below shows standard motor sizes and the outer diameter wheel sizes each can accommodate.

| Motor Size Diameter | Wheel Size Outer Diameter | Motor Speed RPM | Clear Aperture |
|---|---|---|---|
| 14 mm | 35 mm – 44 mm | 7200 – 10800 | 8.5 mm – 12.5 mm |
| 20 mm | 40 mm – 50 mm | 7200 – 10800 | 8 mm – 13 mm |
| 24 mm | 50 mm – 60 mm | 7200 – 10800 | 11 mm – 16 mm |
| 62 mm | 80 mm – 108 mm | 3200 – 7400 | 6 mm – 20 mm |

# Color Wheel for Projection Display Applications

- Color Wheel Assembly Noise Characteristics: The color wheel is assembled and balanced to provide an overall low noise performance. To measure the noise, a wheel is isolated in an acoustical sound chamber and a microphone is placed at either 40 mm, 0.5 m or 1 m above the color wheel. The noise test is typically performed at 7200 RPMs. The mounting bracket used in projectors can amplify the noise and vibration of any color wheel. OCLI can assist customers in designing brackets that provide for lowest system noise performance.

## Specifications

OCLI color wheels are manufactured to meet and exceed all the requirements for high quality DLP display systems. Typical tolerances for our color wheels are shown in the chart below.

**OCLI Color Wheels – Typical Tolerances***

| | |
|---|---|
| Segment Angle | ± 0.5° |
| Run-Out | 0.15 mm max |
| Gap (between segments) | 1° max |
| Balance | G6.3 ISO 1940 Specification |
| Timing Mark (depends on motor size) | 14 mm motor: ± 4°, 20 mm, 24 mm, 62 mm motor: ± 3° |
| Glass Thickness | 1.0 mm ± 0.05 mm |
| Dichroic Surface Quality | 80 – 50 Scratch/Dig |
| Edge Chip (On Outer Diameter) | 1 mm max |
| Inner Edge Chip (between segments) | 0.3 mm max |
| MTBF | 20,000 hours |

* Subject to Revision

## For More Information

For more information regarding OCLI color wheels and other optical components for projection display applications, contact your local OCLI sales representative, visit our Website at www.ocli.com, or call (707) 525.6957.


Optical Coating Laboratory, Inc.
2789 Northpoint Parkway • Santa Rosa, CA 95407-7397
Phone: 707 525-6957 • Fax: 707 525-7841