Optical Low Pass Filters Theory and Practice

Summary

In a high-quality, digital imaging system which uses CCD and CMOS sensors, an optical low pass filter (OLPF) is used to eliminate color Moiré fringes. It is important to note that Moiré fringes must be removed passively in the optical system and cannot be removed by post-processing the image. See the difference in figure 1. The left side shows an image from an optical system without an OLPF, the right side shows and image with the same optical system with and OLPF.

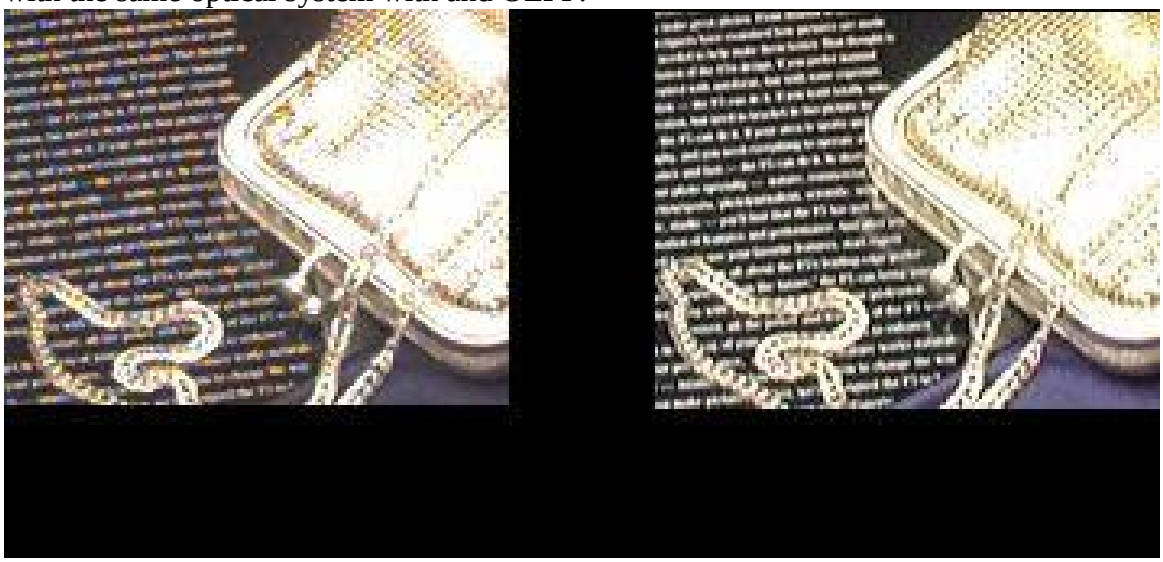

Figure 1. Left, without the OLPF; Right, with the OLPF

Theory

Since CCD and CMOS sensors sample image information at regularly-spaced, discrete points called pixels each sensor has a frequency limit, called the Nyquist frequency, that is defined by the geometry of its pixels. This frequency is equal to the inverse of the two times the pixel pitch. If the lens passes spatial frequency that is greater than the Nyquist frequency of the sensor, it cannot be resolved by the sensor. Worse, spatial frequencies that are greater than the Nyquist frequency will cause aliasing artifacts. These phenomena are often observed as colorful fringes called Moiré fringes, on the image.

An OLPF placed between the lens and the image sensor stops the optical system from passing spatial frequencies greater than the Nyquist frequency of the sensor. The filter cuts the high frequency information and passes only the low frequency information, removing the Moiré fringes from the image.

OLPFs are made of several layers of birefringent optical crystals cemented together. The number of layers and thickness of each layer is defined by the pixel spacing of the sensor

Sunex Inc.
Telephone: +001 760.602.0988
Order samples online at www.optics-online.com

and the application. It follows that each OLPF design must be tuned to a particular sensor and application.

For color imaging, an IR cut-off function is often integrated into OLPF as well. A reflective IR cut-off coating can be applied to an external surface or an absorptive IR cut-off filter layer can be added to the quartz layers.

Practice

- *When installing the OLPF into the digital imaging system it must be placed between the lens and the sensor.* The performance is dictated by the layer thickness and any optical coatings on the external surfaces. The exact location along this z-axis does not affect the performance of the filter significantly.

- *We do not recommend affixing the low pass filter to the sensor cover glass or use it as a sensor cover glass!* Due to surface quality imperfections it is recommended that the filter be place more than 1mm (>1mm) away from the sensor plane. No matter how tight the surface quality specification there are always scratches and digs on the order of the pixel size that will show up in the image as blobs or dust if the filter is too close to the sensor plane.

- *The x-axis and y-axis [length and width] orientation of the OLPF with respect to the sensor is important.* For a 4:3 and 16:9 aspect ration sensors, ensure that the long edge of the filter is square with the long edge of the sensor.

- *The filter will function if the IR cut coating faces the sensor or faces away from the sensor.* The optical performance is the same.

For more information and a selection of standard Sunex Optical Low Pass Filters, please visit http://www.optics-online.com/lpf.asp or call 760.602.0988.

Sunex Inc.
Telephone: +001 760.602.0988
Order samples online at www.optics-online.com