OneLight Spectra

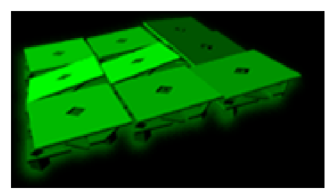
ONELIGHT SPECTRA

APPLICATION NOTE - DLP CONTRAST AND STRAY LIGHT

The OneLight Spectra uses a MEMS based spatial light modulator manufactured by Texas Instruments as the heart of its light engine technology. This chip is commonly called a DLP (digital light processor) chip. The DLP chip provides many useful capabilities but to use it effectively in your application it is important to understand its characteristics and optical properties and to bear these in mind when designing your application.
OneLight's spectrally programmable light engine uses the Texas Instruments digital light processor as a digital switch. This micro-electro-mechanical system (MEMS) chip can be programmed to control illumination with software, providing complete digital control over wavelength selection, intensity, exposure time, and timing sequences. This chip is a low-cost fully developed product widely used by many companies producing digital projectors and rear-projection televisions.

OneLight uses this array of tiny mirrors to control the distribution of color in light. Its light engine splits the white light from a bright lamp into its constituent colors – much like a prism projects a rainbow of color onto a wall on a sunny day – and then projects this rainbow onto the DLP chip. The microscopic computer-controlled mirrors can be switched on and off at high speed to select and change the color distribution of the light, enabling the technology to switch between or blend together multiple wavelengths of light at great speed.

This true platform technology replaces many complex mechanical systems for shaping and controlling illumination with a single high-performance device. Now, instead of engineering complex opto-mechanical light sources, OneLight customers can program the light distribution they need nearly instantly and then combine data about the light illuminating their subject with their image data.



DLP Chip with rainbow spectrum and close-up of microscopic mirrors

DLP CHARACTERISTICS - The chip consists of tiny mirrors that tilt through an angle of +12 or -12 degrees. They are bi-stable, having only two active positions, but are designed to switch rapidly between these two positions.
Switching occurs as a result of electrostatic attraction between energized electrodes at the corners of the mirrors. The movement of the mirrors is along an axis between two opposing corners of the mirror. A third position can occur when the system is not powered. In this state the mirrors "float" in an approximately horizontal position. While the mirrors are too small to observe with the naked eye, their approximate dimensions can be seen by walking close to a projection screen during a presentation on a well-focused DLP projector. Then the individual squares of each mirror can be seen on the projection screen.
All spatial light modulators and most image display or image capture devices have characteristics that define their performance. Among these are resolution, speed, contrast ratio, dynamic range,

efficiency or gain, background or offset, gamma and other parameters such as color or wavelength characteristics.

The Texas Instruments DLP chip used in the OneLight Spectra is a matrix of aluminum mirrors on a darkened silicon substrate that is hermetically sealed behind a glass window. The wavelength response of the DLP is determined by the reflectivity of aluminum (about 90%) the transmission characteristics of the window material (upper and lower bounds of 350-2500 nm) and diffraction effects resulting from the periodic structure of the mirrors.

Fill factor is an important characteristic of image sensors, image display systems and spatial light modulators. It refers to how much of the surface of a spatial array can be used to sense, modulate or generate light. A perfect imaging element would have a 100% fill factor. Although the DLP chip has a high fill factor, it does have a narrow gap between the mirrors that allows light to strike the silicon substrate. The mirrors are quite thin, but their edges also catch some light and cause it to propagate in various directions, regardless of the tilt of the mirrors directing most of the light. This means there will always be some light propagating from the DLP chip, regardless of the on or off state of the individual DLP mirrors. This stay light creates a lower limit on the performance of the DLP contrast in image display applications.

The native contrast specification of the DL chip is about 1000:1. When optical systems are factored in this reduced by reflections from multiple optical surfaces and other sources of scattered light. Anti-reflection coatings are an important factor in optical system design to reduce this scatter. The current on-off contrast of a OneLight Spectra OSVIS-500 is typically between 800:1 and 850:1. This must be taken into account when designing applications. Some examples of this are outlined below.

Monochrome Imaging Example – if the OneLight Spectra is being used as the illumination source in an imaging system there will always be a small amount of light illuminating the subject. Consider a situation where all wavelengths are turned on to maximum and a 10-bit monochrome camera (1024 grey levels) is used. The camera exposure time, gain and offset has been adjusted to so that the signal from a white surface is 1000 grey levels and that a true black level signal (camera capped) is 5 grey levels. In this situation if all the mirrors of the DLP chip in the Spectra were set to be off there would still be a residual signal of about 1-2 grey levels superimposed on the black level signal.

Colour Imaging Example – Consider a situation where all wavelengths are turned on to maximum and a 10-bit RGB color camera (1024 grey levels) is used. The camera exposure time, gain and offset has been adjusted to so that the signal from a white surface is 1000 grey levels for the red channel and a true black level signal (camera capped) is 5 grey levels. The blue illumination light channel is adjusted to be about 80% of the brightness of the red channel output to correct for blue channel system response and the green illumination channel is adjusted to 60% of red channel output to correct for green channel system response. In this situation if all the mirrors of the DLP chip in the Spectra were set to be off there would still be a residual signal of about 1-2 grey levels (average value 1.18) superimposed on the black level signal for the red channel, similar to that of the monochrome camera example. The blue channel maximum signal is now 80% of mirror signal available resulting in its contrast ratio being reduced from 850:1 to about 680:1. This will mean that when all mirrors for the blue channel are off the image channel will have about 1-2 grey levels (average level 1.47) superimposed on it. The green channel will have 60% of mirror signal resulting in contrast ration being reduced to 510:1 This will mean that when all mirrors for the green channel are off the image channel will have about 2 grey levels (average level 1.96) superimposed on it. For more accurate image representation and display, background images may need to be subtracted or otherwise taken into account in calculations or image processing.

Narrow Band Imaging Example – Consider a situation where all wavelengths are turned on to maximum and a monochrome or 10-bit RGB color camera (1024 grey levels) is used. The camera exposure time, gain and offset has been adjusted to so that the signal from a white surface is 1000 grey levels for a 20 nm narrow band green channel and a true black level signal (camera capped) is 5 grey levels. The narrow band green signal contains 10% of the energy normally emitted with all mirrors on. In this situation if all the mirrors of the DLP chip in the Spectra were set to be off there would still be a residual signal of about 11-12 grey levels (average value 11.76) superimposed on the black level signal for the image. In order to maximize the information available or the dynamic range and contrast of the image this background should be accounted for by either subtraction or some other image processing.

Short Exposure Time Imaging Example – Consider a situation where all wavelengths are turned on to maximum and a monochrome or 10-bit RGB color camera (1024 grey levels) is used. The camera exposure time, gain and offset has been adjusted to so that the signal from a 20% grey surface is 1000 grey levels for a 100 nm band of illumination channel and a true black level signal (camera capped) is 5 grey levels. The 100 nm band signal contains 40% of the energy normally emitted with all mirrors on. In this situation if all the mirrors of the DLP chip in the Spectra were set to be off there would still be a residual signal of about 3 grey levels (average value 2.94) superimposed on the black level signal for the image. If the camera integration time is fixed, the image background signal will be constant at this value. If the light source integration time is shortened to correct for a very brightly reflecting sample, the background will stay constant, but the brightness of the sample can be compensated for by shortening or lengthening integration time of the light source. This illustrates one strategy for maximizing information available exposure time control and background subtraction.

There are of course many ways to manage the interaction of light, sample and exposure time and while there are many common strategies, most solutions will be unique to the particular application and will rely on the knowledge of the investigator to develop the most effective strategy.