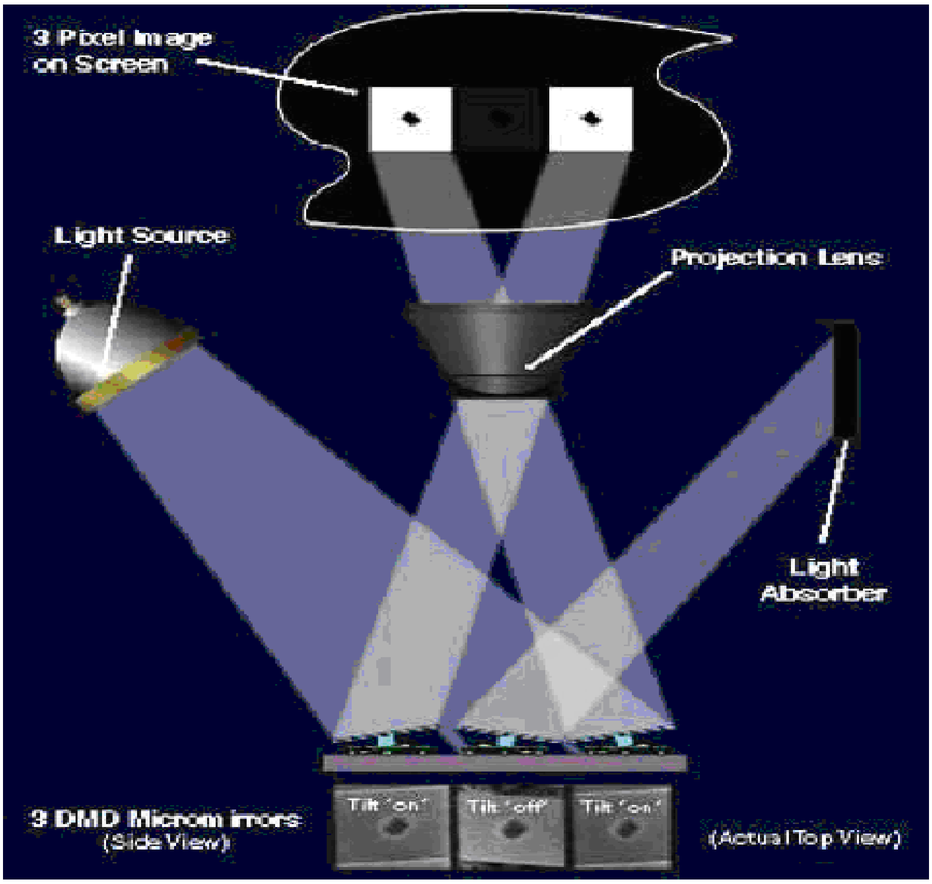
DIGITAL LIGHT PROCESSING



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Abstract

This paper is an attempt to give a wide view of Digital Light Processing (DLP) technology, which is a micro mirror device finding application in many fields .DLP has bought a revolution in the video projection environment.It provides all digital projection displays that offers superior picture quality in terms of resolution, brightness, contrast and colour fidelity This was the invention of Larry Hombeck, a scientist from Texas instruments in 1987. The paper illustrates the advantages of DLP over existing projection technologies . The winning of two Emmy awards for broadcasting excellence by DLP products is an example for its technical excellence. Based on thousands of hours of life and environmental testing ,the DLP systems exhibited inherent reliability. Human eyes see more visual information and perceive higher resolution with DLP.It has revolutionized the audio and video industry. As a conclusion, DLP is only choice of digital visual communication , today and in the future.

Introduction

DEFINITION:

Digital Light Processing (DLP) is a system for projecting images that's based on a unique optical semiconductor chip from Texas Instruments. The chip contains millions of tiny mirrors that are individually moved by digital signals in synchronization with a light source and color wheel. The result is a sharp projected image that's clearly visible in a normally lit room Digital Light Processing (DLP™) is a revolutionary new way to project and display information. Based on the Digital Micro mirror Device (DMD™) developed by Texas Instruments, DLP creates the final link to display digital visual information. DLP technology is being provided as subsystems or "engines" to market leaders in the consumer, business, and professional segments of the projection display industry. In the same way the compact disc revolutionized the audio industry, DLP will revolutionize video projection.

DLP has three key advantages over existing projection technologies. The inherent digital nature of DLP enables noise-free, precise image quality with digital gray scale and color reproduction. Its digital nature also positions DLP to be the final link in the digital video infrastructure. DLP is more efficient than competing transmissive liquid crystal display (LCD) technology because it is based on the reflective DMD and does not require polarized light. Finally, close spacing of the micromirrors causes video images to be projected as seamless pictures with higher perceived resolution. For movie projection, a computer slide presentation, or an interactive, multi-person, worldwide collaboration—DLP is the only choice for digital visual communications, today and in the future.

Digital Light Processing: How It Works

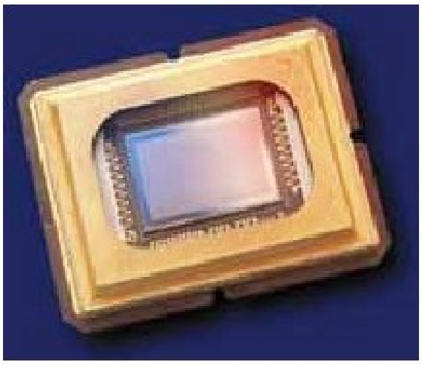
In the same way a central processing unit (CPU) is the heart of a computer, a DMD is the cornerstone of DLP. One-, two-, and three-chip DLP systems have been built to serve different markets. A DLP -based projector system includes memory and signal processing to support a fully digital approach. Other elements of a DLP projector include a light source, a color filter system, a cooling system , and illumination and projection optics.

A DMD can be described simply as a semiconductor light switch. Thousands of tiny, square, 16 x 16Êmm mirrors, fabricated on hinges atop a static random access memory (SRAM) make up a DMD (**Fig 1**). Each mirror is capable of switching a pixel of light. The hinges allow the mirrors to tilt between two states, +10 degrees for "on" or -10 degrees for "off." When the mirrors are not operating, they sit in a "parked" state at 0^0 .

Depending on the application, a DLP system will accept either a digital or an analog signal. Analog signals are converted to digital in the DLP's or the original equipment manufacturer's(OEM's) front-end processing.

Any interlaced video signal is converted to an entire picture frame video signal through interpolative processing. From here, the signal goes through DLP video processing and becomes progressive red, green, and blue (RGB) data. The progressive RGB data are then formatted into entire binary bit planes of data.

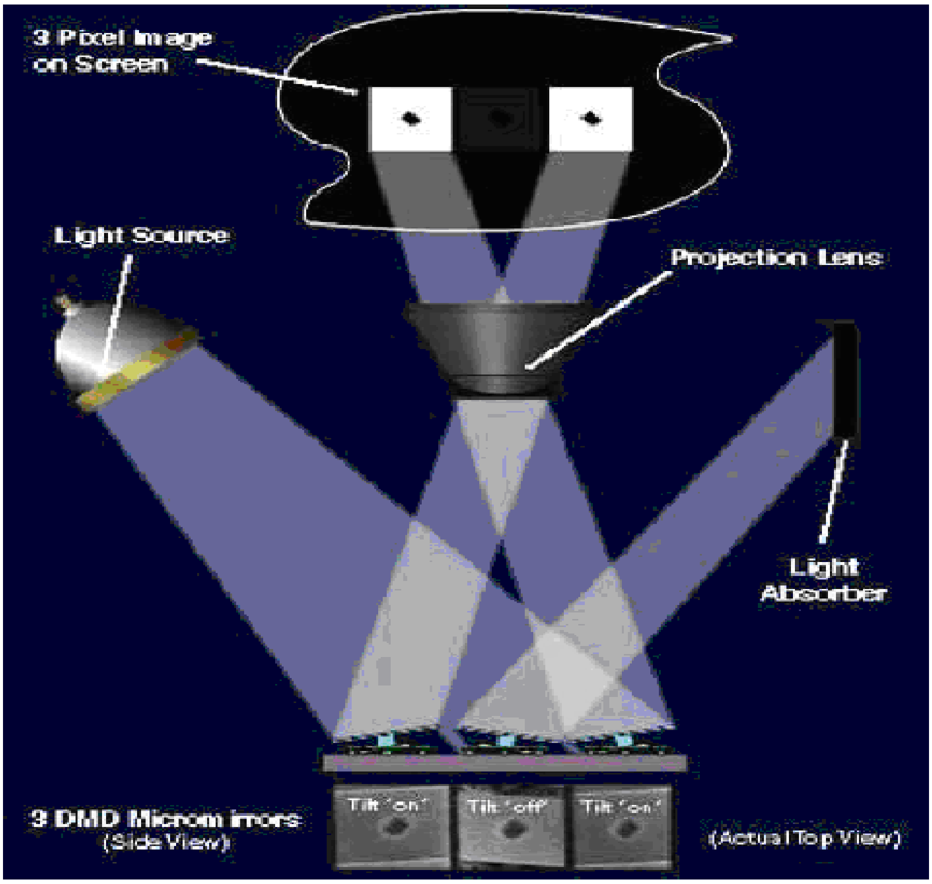
Figure 1



Once the video or graphic signal is in a digital format, it is sent to the DMD. Each pixel of information is mapped directly to its own mirror in a 1:1 ratio, giving exact, digital control. If the signal is 640 x 480 pixels, the central 640 x 480 mirrors on the device will be active. The other mirrors outside of this area will simply be turned to the off position.

By electrically addressing the memory cell below each mirror with the binary bit plane signal, each mirror on the DMD array is electro-statically tilted to the on or off positions. The technique that determines how long each mirror tilts in either direction is called pulse width modulation (PWM). The mirrors are capable of switching on and off more than 1000 times a second. This rapid speed allows digital gray scale and color reproduction.

At this point, DLP becomes a simple optical system. After passing through condensing optics and a color filter system, the light from the projection lamp is directed at the DMD. When the mirrors are in the on position, they reflect light through the projection lens and onto the screen to form a digital, square-pixel projected image



DLP's Origins

The DMD chip was invented in 1987 by TI scientist Larry Hornbeck, who had been exploring the manipulation of reflected light since 1977. In 1992, TI started a project to explore the DMD's commercial viability. A year later, it named the new technology DLP and formed a separate group (now called the DLP Products division) to develop commercial display applications.

In 1994, TI demonstrated prototype DLP projectors for the first time. The technology's promise was quickly recognized. In 1997, the Academy of Motion Picture Arts and Sciences chose DLP to project film at the Oscars, where the first three-chip DLP technology was demonstrated to the Hollywood community.

In 1999, DLP Cinema was first demonstrated to the public with the release of *Star Wars Episode I: The Phantom Menace*. By December 2002, TI had shipped 2 million DLP subsystems.

DLP Products has also received two Emmy Awards, for broadcast excellence in 1998 and for technology and engineering in 2003. In 2002, Hornbeck was elected a fellow of the International Society for Optical Engineering and received the David Sarnoff Medal from the Society of Motion Picture and Television Engineers.

The Digital Advantage

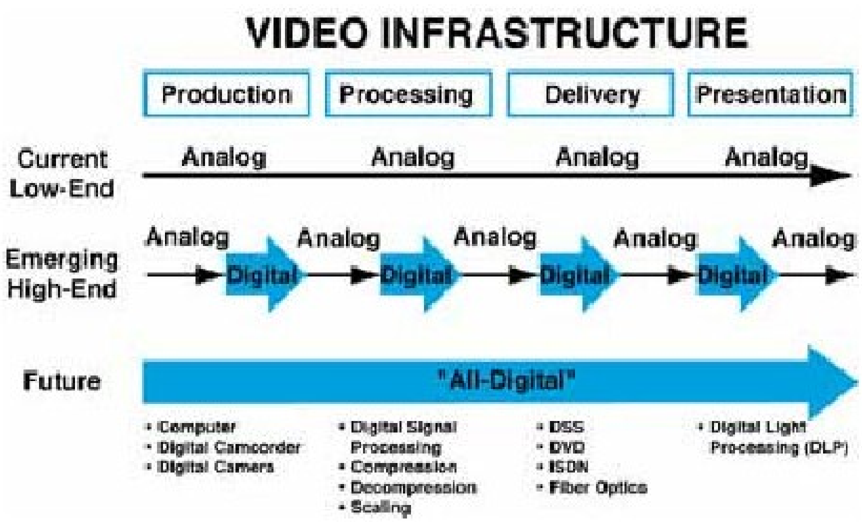
The audio world started the trend toward digital technology well over a decade ago. Recently, an abundance of new digital video technology has been introduced to the entertainment and communications markets. The digital satellite system (DSS) quickly became the fastest selling consumer electronics product of all time, selling record numbers of units in its first year of introduction. Sony, JVC, and Panasonic have all recently introduced digital camcorders.

Epson, Kodak, and Apple are a few of the companies that now have digital cameras on the market. The digital versatile disc (DVD), a widely anticipated new storage medium, will feature full-length films with better than laser disc video quality by placing up to 17 gigabytes of information on a single disc.

Today we have the ability to capture, edit, broadcast, and receive digital information, only to have it converted to an analog signal just before it is displayed. DLP has the ability to complete the final link to a digital video infrastructure as well as to provide a platform on which to develop a digital visual communications environment. Each time a signal is converted from digital to analog (D/A) or analog to digital (A/D), signal noise enters the data path. Fewer conversions translates to lower noise and leads to lower cost as the number of A/D and D/A converters decreases. DLP offers a scalable projection solution for displaying a digital signal, thus completing an all-digital infrastructure(fig 3)

Another digital advantage is DLP is accurate reproduction of gray scale and color levels. And because each video or graphics frame is generated by a digital, 8- to 10-bits-per-color gray scale, the exact digital picture can be recreated time and time again. For example, an 8-bits-per-color gray scale gives 256 different shades of each of the primary colors, which allows for 256^3, or 16.7 million, different color combinations that can be digitally created .DLP can generate digital gray scale and color levels. Assuming 8 bits per color, 16.7 million digitally created color combinations are possible. Above are several combinations of different gray scale levels for each of the primary colors and the resultant digitally created pixel colors.

Figure 3



The Reflective Advantage

Because the DMD is a reflective device, it has a light efficiency of greater than 60%, making DLP systems more efficient than LCD projection displays. This efficiency is the product of reflectivity, fill factor, diffraction efficiency, and actual mirror "on" time. LCD's are polarization-dependent, so one of the polarized light components is not used. This means that 50% of the lamp light never even gets to the LCD because it is filtered out by a polarizer. Other light is blocked by the transistors, gate, and source lines in the LCD cell. In addition to these light losses, the liquid crystal material itself absorbs a portion of the light. The result is that only a small amount of the incident light is transmitted through the LCD panel and onto the screen. Recently, LCDs have experienced advances in apertures and light transmission, but their performance is still limited because of their dependence on polarized light.

Seamless Picture Advantage

The square mirrors on DMDs are 16 μm^2, separated by 1 µm gaps, giving a fill factor of up to90%. In other words, 90% of the pixel/mirror area can actively reflect light to create a projected image. Pixel size and gap uniformity are maintained over the entire array and are independent of resolution. LCDs have, at best, a 70% fill factor. The higher DMD fill factor gives a higher perceived resolution, and this, combined with the progressive scanning, creates a projected image that is much more natural and lifelike than conventional projection displays (**Figure 5**),

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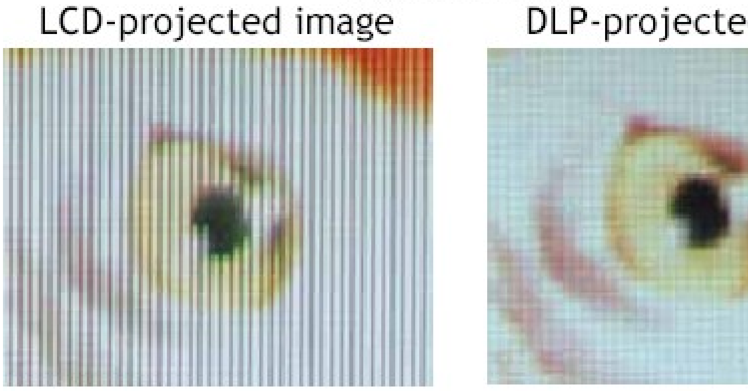
Figure 5:

Photograph used to demonstrate the DLP advantage. This digitized photograph of a parrot was used to demonstrate the seamless, filmlike DLP picture advantage detailed in Figures 6a and b.

A leading video graphics adapter (VGA) LCD projector was used to project the image of the parrot shown in **Figure 5**. In **Figure 6a**, the pixelated, screendoor effect common to LCD projectors can be easily seen. The same image of the parrot was projected using a DLP projector and is displayed in **Figure 6b**. Because of the high fill factor of DLP, the screen-door effect is gone. What is seen is a digitally projected image made up of square pixels of information. With DLP, the human eye sees more visual information and perceives higher resolution, although, as demonstrated, the actual resolution shown in both projected images is the same. As the photographs illustrate, DLP offers compellingly superior picture quality.

Figure 6a & 6b



Reliability

DLP systems have successfully completed a series of regulatory, environmental, and operational tests. Standard components with proven reliability were chosen to construct the digital electronics used to drive the DMD. No significant reliability degradation has been identified with either the illumination or projection optics. Most of the reliability concerns are focused on the DMD because it relies on moving hinge structures. To test hinge failure, approximately 100 different DMDs were subjected to a simulated 1 year operational period. Some devices have been tested for more than 1 trillion cycles, equivalent to 20 years of operation. Inspection of the devices after these tests showed no broken hinges on any of the devices. Hinge failure is not a factor in DMD reliability.

The DMD has passed all standard semiconductor qualification tests. It has also passed a barrage of tests meant to simulate actual DMD environmental operating conditions, including thermal shock, temperature cycling, moisture resistance, mechanical shock, vibration, and acceleration testing. Based on thousands of hours of life and environmental testing, the DMD and DLP systems exhibit inherent reliability.

Future uses of DLP

DLP has a number of potential uses beyond home theater, television and film projection. DLP image projectors are becoming more common in business environments. Other applications that could incorporate its high-definition image creation are:

- Photo finishing
- Three-dimensional visual displays
- Holographic storage
- Microscopes
- Spectroscopes
- Medical imaging

Conclusion

Simply put, DLP is an optical system driven by digital electronics. The digital electronics and optics converge at the DMD. Using a video or graphics input signal, DLP creates a digitally projected image with unprecedented picture quality. DLP has three key advantages over existing projection technologies. The digital nature of DLP enables digital gray scale and color reproduction and also positions DLP to be the final link in the digital video infrastructure. Because it is based on the reflective DMD, DLP is more efficient than competing transmissive LCD technologies. Finally, DLP has the ability to create seamless, film-like images. DLP makes images look better. You've heard the digital revolution, now see it with Digital Light Processing.

DLP projection displays have been demonstrated for use in applications ranging from standard television to institutional projection systems. Video processing technology has been developed to address video signal conversion and enhancement for DLP display. The digital video processing solutions have been developed to maintain the superior quality of the DMD based display.

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