Digital light processing

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IN

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CERTIFICATE

THIS IS TO CERTIFY THAT Mr. Mohit Rana

OF B.TECH FINAL YEAR, ELECTRONICS & INSTRUMENTATION DELIVERED A SEMINAR ON "DIGITAL LIGHT PROCESSING" ON 30 /10 /2009 ACCORDING TO THE U.P. TECHNICAL UNIVERSITY CURRICULUM. HIS PERFORMANCE IN THE SEMINAR WAS EXCELLENT/VERY GOOD/SATISFACTORY.

Mrs. Aruna Pathak — Seminar Guide

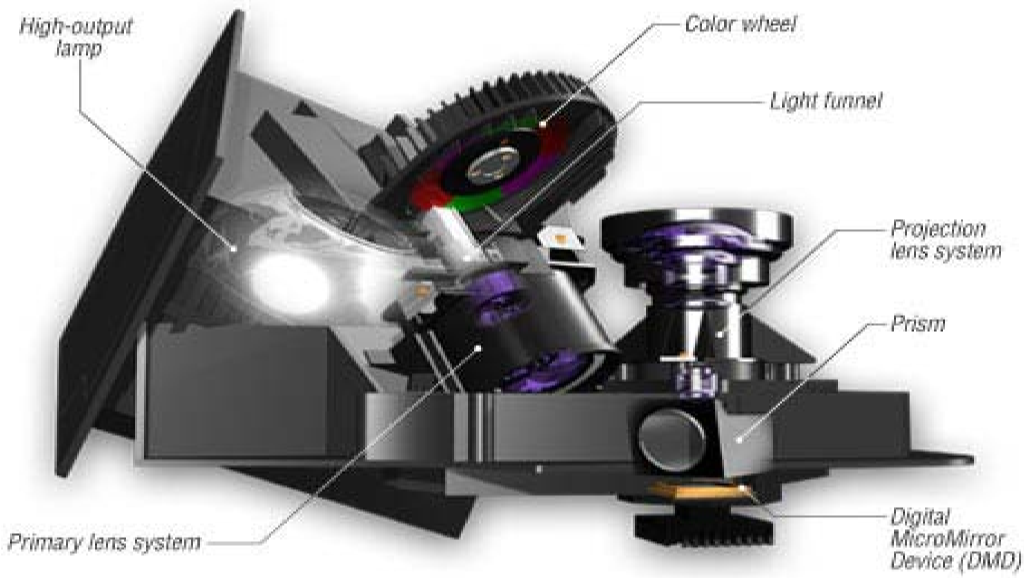
Mr. Umesh Kumar — Head of Department

Ms. Taslima Ahmed — Seminar Coordinator

HISTORY

Digital Light Processing (DLP) Background

Background Information:
Digital Light Processing (DLP) is a display technology developed by Texas Instruments. DLP imaging systems employ either one or three large devices called Digital Micro mirror Devices, or DMDs. The micro mirrors are mounted on the DMD chip and tilt in response to an electrical signal. The tilt directs light toward the screen, or into a "light trap" that eliminates unwanted light when reproducing blacks and shadows.



The origin of DLP:

The first DMD chip was invented by Larry Hornbeck in 1987. Larry, a scientist at Texas Instruments, had been exploring the manipulation of reflected light since 1977. He developed the Digital Micro mirror Device, or DMD: an optical semiconductor capable of steering photons with unparalleled accuracy. This digital micro-mirror - greatly refined - is the basis of modern DLP technology.

Texas Instruments started a project to explore the commercial viability of DMD. TI named the new technology ‘DLP’ and a separate group (now known as the DLP Products Division) was formed to develop the commercial display applications. Texas Instruments demonstrated prototype DLP projectors for the first time in 1994. The new technology was quickly recognised and in 1997, DLP projectors were used to project films at the Oscars, where the first 3-chip DLP technology was revealed to the Hollywood community. And by the end of 2002, Texas Instruments had shipped over two millions DLP subsystems. Texas Instruments remains the sole manufacturer of DLP technology.

A History of Innovation

1977

- Texas Instruments scientist Dr. Larry Hornbeck begins exploring how the principles of reflection can be used to manipulate light.

1987

- Dr. Hornbeck develops the Digital Micromirror Device: an optical semiconductor capable of steering photons with unparalleled accuracy.

1992

- Texas Instruments forms the Digital Imaging Venture Project to explore the commercial viability of the Digital Micromirror Device.

1993

- Digital Light Processing technology is named; the Digital Imaging division (later to become the DLP® Products division) is established to unlock its potential for commercial projection display applications.

1994

- Prototype projectors are used to publicly demonstrate Digital Light Processing™ technology for the first time.

1995

- The DLP® Products division of TI announces its first customer agreements.

1996

- The first commercial DLP® systems are shipped to InFocus, nView and Proxima. Digital Projection signs on to manufacture DLP® projectors.

1997

- February: The Motion Picture Academy of Arts and Sciences chooses DLP® technology to project the Oscars®; DLP® technology has been used at the Academy Awards® ever since.

1998

- June: DLP® Products receives an Emmy Award for Outstanding Achievement in Engineering Development from the Academy of Arts and Sciences. Dr. Larry Hornbeck also received an Emmy for inventing DLP® technology.

1999

- January: The first DLP® projector specifically engineered for home theater is shown by Dream Vision.
- June: DLP Cinema® projector technology is publicly demonstrated for the first time on two screens in Los Angeles and New York.

2000

- March: TI announces agreements with Christie and Barco to manufacture digital cinema projectors with DLP Cinema® technology.
- May: The world's first sub-3-lb. DLP® projector is introduced by PLUS Corporation, demonstrating DLP® technology's capability to lead the market in portable projectors.

2001

- January: Sharp announces the first 16:9 projector, greatly anticipated by home theater enthusiasts.
- March: Mitsubishi launches a flagship DLP® HDTV based on HD1 chipset.
- June: The first sub-2-lb.projector is announced by InFocus with its ground-breaking LP120 DLP® projector.

2002

- January: Samsung announces their first DLP® HDTV, priced at $3,999.
- April: HP enters the projector market with DLP® technology.
- May: Dell enters the projector market with DLP® technology.
- June: NEC is named the third DLP Cinema® manufacturer partner.

2003

- March: DLP Cinema® 2K resolution chip is introduced at ShoWest.

2004

- DLP® becomes number one supplier of microdisplay technology, according to TSR.
- InFocus becomes first TI customer to ship 1 million DLP® projectors.

2005

- January: HP, Optoma and Radio Shack introduce the first "Instant Theater" projectors, incorporating sounds system and DVD player with DLP® projection into one, consumer-friendly unit.

2006

- January: DLP® technology achieves greater than 50% market share in the worldwide front projection market for first time.
- January: TI introduces DLP® HDTVs with LED technology.
- March: DLP Cinema® projectors surpass 1,000 deployed milestone; 1,200 projectors deployed worldwide.

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1. INTRODUCTION

DLP is based on a micro electro mechanical systems (MEMS) device known as the Digital Micro mirror Device (DMD). The DMD microchip is a fast, reflective digital light switch. It can be combined with image processing, memory, a light source, and optics to form a DLP system capable of projecting large, bright, seamless, high contrast colour images with better colour fidelity and consistency than current displays.

1.1 DIGITAL MICROMIRROR DEVICE (DMD)

In DLP projectors, the image is created by microscopically small mirrors laid out in a matrix on a semiconductor chip, known as a Digital Micro mirror Device (DMD). Each mirror represents one or more pixels in the projected image. The number of mirrors corresponds to the resolution of the projected image. 800x600, 1024x768, 1280x720, and 1920x1080 (HDTV) matrices are some common DMD sizes. Rapidly toggling the mirror between these two orientations (essentially on and off) produces gray scales, controlled by the ratio of on time to off time.

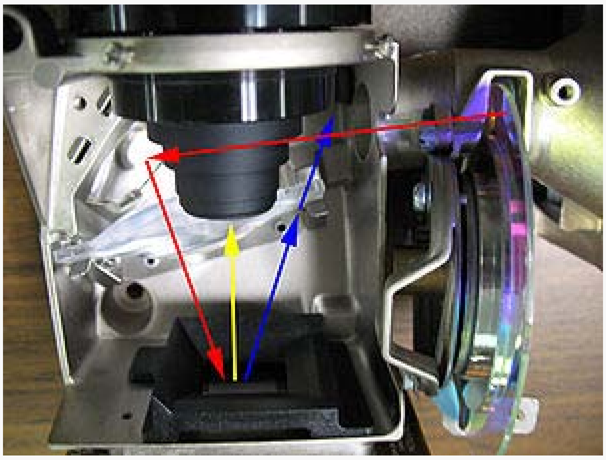
1.2 TYPES OF PROJECTORS

There are two primary methods by which DLP projection systems create a color image, those utilized by single-chip DLP projectors, and those used by three-chip projectors.

1.2.1 SINGLE-CHIP PROJECTORS







Interior view of a single-chip DLP projector, showing the light path. Light from the lamp enters a reverse-fisheye, passes through the spinning color wheel, crosses underneath the main lens, reflects off a front-surfaced mirror, and is spread onto the DMD (red arrows). From there, light either enters the lens (yellow) or is reflected off the top cover down into a light-sink (blue arrows) to absorb unneeded light.

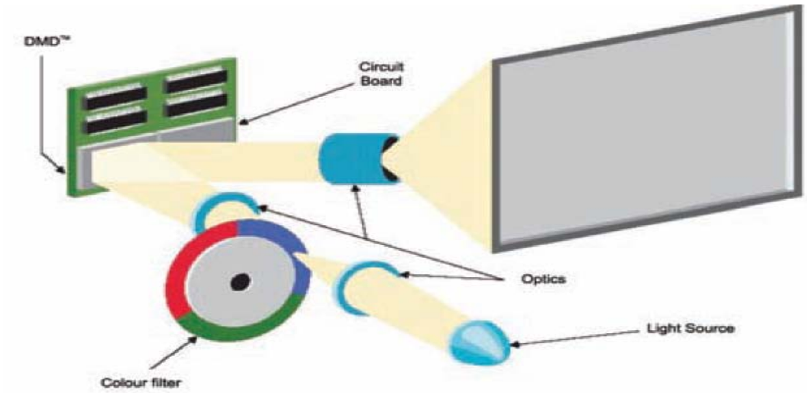
In a projector with a single DLP chip, colors are either produced by placing a color wheel between the lamp and the DLP chip or by using individual light sources to produce the primary colors, LEDs or LASERs for example.

The color wheel is divided into multiple sectors: the primary colors: red, green, and blue, and in many cases secondary colors including cyan, magenta, yellow and white. The use of the secondary colors is part of the new color performance system called Brilliant Color which processes the primary colors along with the secondary colors to create a broader spectrum of possible color combinations on the screen.

The DLP chip is synchronized with the rotating motion of the color wheel so that the green component is displayed on the DMD when the green section of the color wheel is in front of the lamp. The same is true for the red, blue and other sections. The colors are thus displayed sequentially at a sufficiently high rate that the observer sees a composite "full color" image.

In early models, this was one rotation per frame. Now, most systems operate at up to 10x the frame rate.

1.2.2 HOW IT WORKS?



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 colour 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 mirrors, fabricated on hinges atop a static random access memory (SRAM), make up a DMD. 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 degree.

Depending on the application, a DLP system will accept either a digital or an analogue signal.

Analogue signals are converted into digital in the DLP’s front-end processing. Any interlaced video signal is converted into 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 is then formatted into entire binary bit planes of data. 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 640x480 pixels, the central 640x480 mirrors on the device will be active. The other mirrors outside this area will simply be turned to '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 colour reproduction. At this point, DLP becomes a Simple optical system. After passing through condensing optics and a colour filter system, the light from the projection lamp is directed at the DMD. When the mirrors are in 'on' position, they reflect light through the projection lens and onto the screen to form a digital, square-pixel projected image.

1.2.3 THREE CHIP PROJECTORS

A three-chip DLP projector uses a prism to split light from the lamp, and each primary color of light is then routed to its own DLP chip, then recombined and routed out through the lens. Three chip systems are found in higher-end home theatre projectors, large venue projectors and DLP Cinema projection systems found in digital movie theatres.

The three-chip projectors used in movie theatres can produce 35 trillion colors, which many suggest is more than the human eye can detect. The human eye is suggested to be able to detect around 16 million colors, which is theoretically possible with the single chip solution.

1.3 LIGHT SOURCE

In DLP projectors high-power LEDs or LASERs are used as a source of illumination.

1.3.1 LED-BASED DLPs:

Advantages of LED illumination include instant-on operation and improved color, with increased color saturation. Ordinary LED technology does not produce the intensity and high lumen output characteristics required to replace arc lamps. The special patented LEDs used in all of the Samsung DLP TVs are PhlatLight LEDs, designed and manufactured by US based Luminus Devices. A single RGB PhlatLight LED chipset illuminates these projection TVs.

1.3.2 LASER-BASED DLPs:

The first commercially-available LASER-based DLP HDTV was the Mitsubishi L65-A90 LASERVUE in 2008, which also eliminated the use of a color wheel. Three separate color LASERs illuminate the DMD in these projection TVs, producing a richer, more vibrant color palette than other methods.

2. DMD

2.1 BASIC PRINCIPLE:

A digital micromirror device is an optical semiconductor that is the core of DLP projection technology, and was invented by Dr. Larry Hornbeck and Dr. William E. "Ed" Nelson of Texas Instruments in 1987.

A DMD chip has on its surface several hundred thousand microscopic mirrors arranged in a rectangular array which correspond to the pixels in the image to be displayed. The mirrors can be individually rotated ±10-12°, to an on or off state. In the on state, light from the projector bulb is reflected into the lens making the pixel appear bright on the screen. In the off state, the light is directed elsewhere, making the pixel appear dark.

To produce greyscales, the mirror is toggled on and off very quickly, and the ratio of on time to off time determines the shade produced. Contemporary DMD chips can produce up to 1024 shades of gray.

The mirrors themselves are made out of aluminium and are around 16 micrometres across. Each one is mounted on a yoke which in turn is connected to two support posts by compliant torsion hinges. In this type of hinge, the axle is fixed at both ends and literally twists in the middle. Tests have also shown that the hinges cannot be damaged by normal shock and vibration, since it is absorbed by the DMD superstructure.

Two pairs of electrodes control the position of the mirror by electrostatic attraction. Each pair has one electrode on each side of the hinge, with one of the pairs positioned to act on the yoke and the other acting directly on the mirror. The majority of the time, equal bias charges are applied to both sides simultaneously.

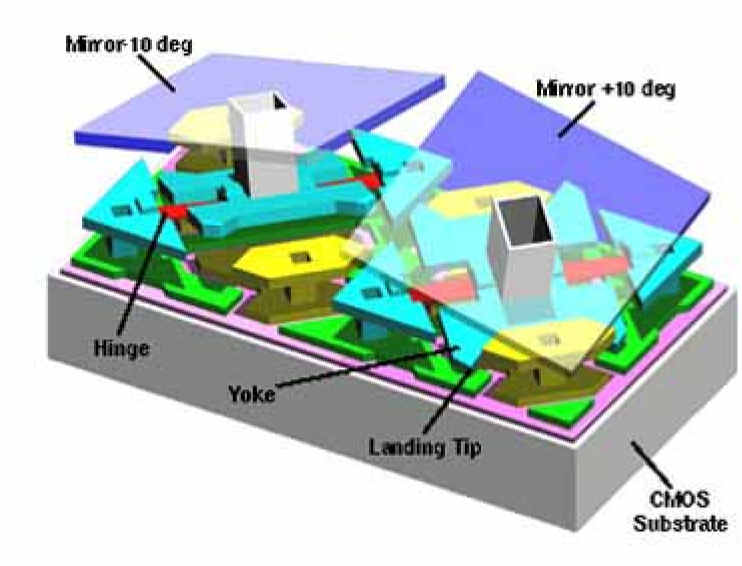
To move the mirrors, the required state is first loaded into an SRAM cell located beneath each pixel, which is also connected to the electrodes. Once all the SRAM cells have been loaded, the bias voltage is removed, allowing the charges from the SRAM cell to prevail, moving the mirror. When the bias is restored, the mirror is once again held in position, and the next required movement can be loaded into the memory cell.

The bias system is used because it reduces the voltage levels required to address the pixels such that they can be driven directly from the SRAM cell, and also because the bias voltage can be removed at the same time for the whole chip, so every mirror moves at the same instant.

2.2 DMD Architecture

The world is rapidly moving to an all-digital communications and entertainment infrastructure. DMD and DLP technologies are introduced in the context of that infrastructure.

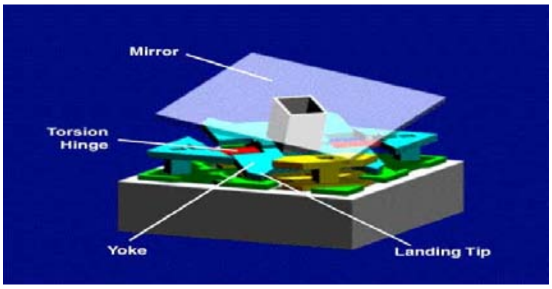
The DMD light switch is a member of a class of devices known as micro-electromechanical systems.



The DMD is monolithically fabricated by CMOS-like processes over a CMOS memory. Each light switch has an aluminium mirror, 16 um square, that can reflect light in one of two directions, depending on the state of the underlying memory cell. Rotation of the mirror is accomplished through electrostatic attraction produced by voltage differences developed between the mirror and the underlying memory cell. With the memory cell in the on (1) state, the mirror rotates to +10 degrees. With the memory cell in the off (0) state, the mirror rotates to -10 degrees.

2.3 The Mirror as a Switch

The address circuit and electromechanical superstructure of each pixel support one simple function, the fast and precise rotation of an aluminium micro mirror, 16 µm square, through angles of +10 and -10 degrees. **Figure** illustrates the architecture of one pixel.



When the mirror rotates to its on state (+10 degrees), light from a projection source is directed into the pupil of a projection lens and the pixel appears bright on a projection screen. When the mirror rotates to its off state (-10 degrees), light is directed out of the pupil of the projection lens and the pixel appears dark. Thus, the optical switching function is simply the rapid directing of light into or out of the pupil of the projection lens.

2.3.1 DMD Cell Structure

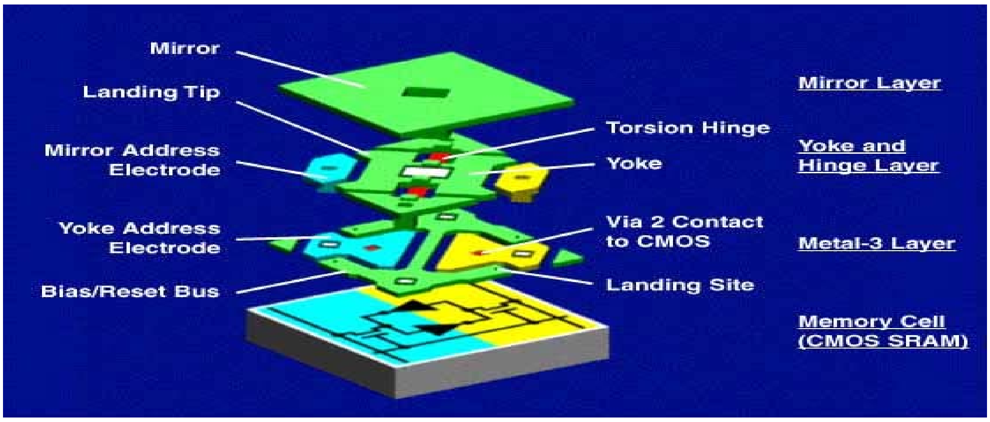


Figure shows the pixel structure of in an exploded view illustrating how the various layers interrelate, including the underlying static random access memory (SRAM) cell that is used to address the pixel.

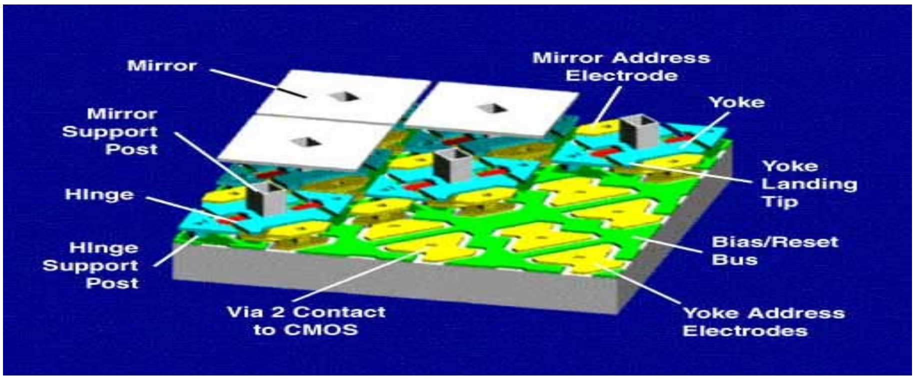


Figure shows a progressive cutaway view of a 3 x 3 array of pixels.

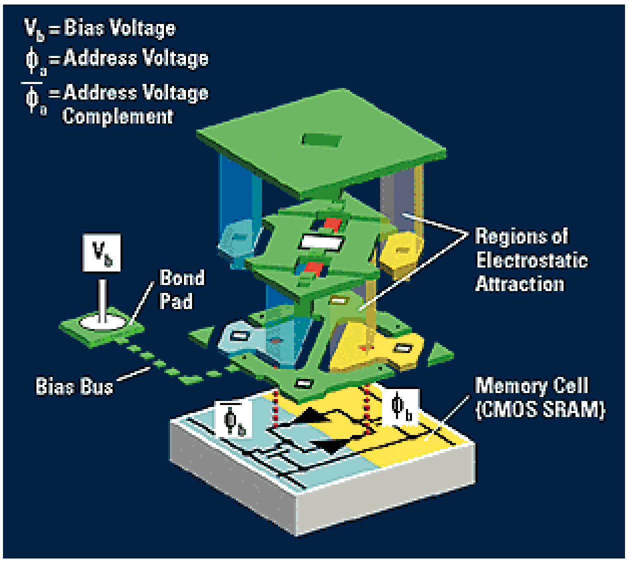


Figure depicts how each layer is electrically interconnected and defines the bias and address voltages that must be applied to the pixel for proper switching action.

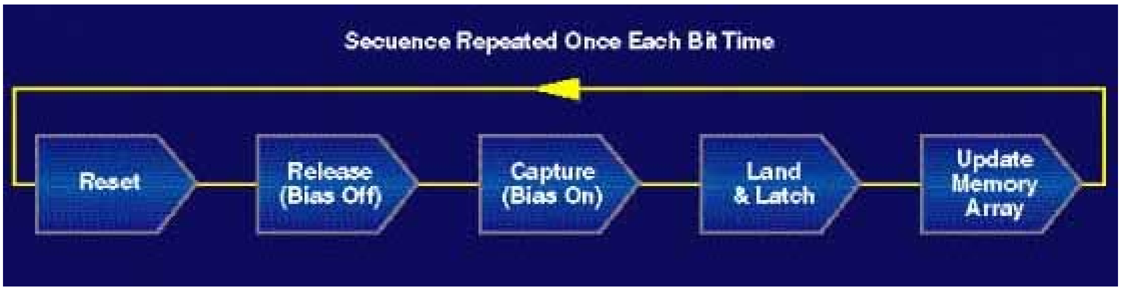
The DMD pixel is a monolithically integrated MEMS superstructure cell fabricated over a CMOS SRAM cell. Air gaps are in between the metal layers of the superstructure. The air gaps free the structure to rotate about two compliant torsion hinges. The mirror is connected to an underlying yoke which in turn is suspended by two thin torsion hinges to support posts. The yoke is electro statically attracted to the underlying yoke address electrodes. The mirror is electro statically attracted to mirror address electrodes. The mirror and yoke rotate until the yoke comes to rest against mechanical stops that are at the same potential as the yoke. The position of the mechanical stops limits the mirror rotation angle to +10 or -10 degrees.

The state of the SRAM cell (1, 0) determines which mirror rotation angle is selected. Because geometry determines the rotation angle, as opposed to a balance of electrostatic torques as in earlier TI devices, the rotation angle of +10 or -10 degrees is precisely determined.

The address electrodes for the mirror and yoke are connected to the complementary sides of the under lying SRAM cell. The yoke and mirror are connected to a bias bus fabricated at the Metal- 3 layer. The DMD mirrors are 16 µm square. They are arrayed to form a matrix for maximum use of light.

2.3.2 The Address Sequence

The DMD accepts electrical words representing gray levels of brightness at its input and outputs optical words. The light modulation or switching technique is called binary pulse width modulation. An 8-bit word is input to each digital light switch of the DMD yielding a potential of 28 or 256 gray levels.



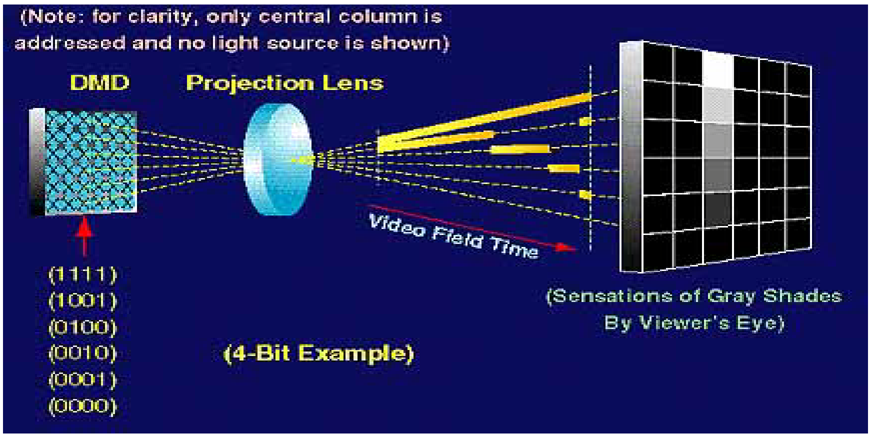
The address sequence to be performed once each bit time can be summarized as follows:
1. Reset all mirrors in the array.
2. Turn off bias to allow mirrors to begin to rotate to flat state.
3. Turn bias on to enable mirrors to rotate to addressed states (+10/-10 degrees).
4. Keep bias on to latch mirrors (they will not respond to new address states).
5. Address SRAM array under the mirrors, one line at a time.
6. Repeat sequence beginning at step 1.

2.4 GRAYSCALE AND COLOUR OPERATION

Grayscale is achieved by binary pulse width modulation of the incident light. Color is achieved by using color filters, either stationary or rotating, in combination with one, two, or three DMD chips.

The DMD light switch is able to turn light on and off rapidly by the beam-steering action of the mirror. As the mirror rotates, it either reflects light into or out of the pupil of the projection lens, to create a burst of digital light pulses that the eye interprets as an analog image. The optical switching time for the DMD light switch is ~2 us.

The technique for producing the sensation of grayscale to the observer's eye is called binary pulse width modulation. The DMD accepts electrical words representing gray levels of brightness at its input and outputs optical words, which are interpreted by the eye of the observer as analog brightness levels. The details of the binary pulse width modulation (PWM) technique are illustrated in *Figure*.



For simplicity, the PWM technique is illustrated for a 4-bit word (2^4 or 16 gray levels). Each bit in the word represents time duration for light to be on or off (1 or 0). The time durations have relative values of 2^0,2^1, 2^2, 2^3, or 1, 2, 4, 8. The shortest interval (1) is called the least significant bit (LSB). The longest interval (8) is called the most significant bit (MSB). The video field time is divided into four time durations of 1/15, 2/15, 4/15, and 8/15 of the video field time. The possible gray levels produced by all combinations of bits in the 4-bit word are 2^4 or 16 equally spaced gray levels (0, 1/15, 2/15 . . . 15/15). Current DLP systems are either 24-bit color (8 bits or 256 gray levels per primary color) or 30-bit color (10 bits or 1024 gray levels per primary color).

2.5 ELECTRONIC OPERATION

The DMD pixel is inherently digital because of the way it is electronically driven. It is operated in an electrostatically bistable mode by the application of a bias voltage to the mirror to minimize the address voltage requirements. Thus, large rotation angles can be achieved with a conventional 5-volt CMOS address circuit.

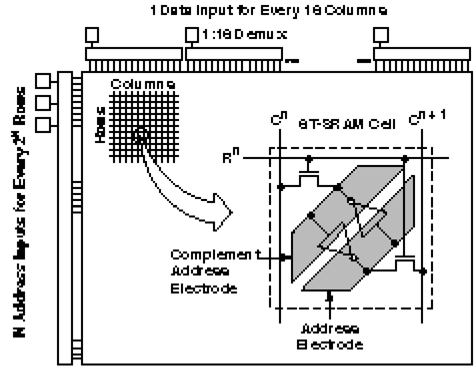


Figure 10. Organization of the DMD chip

The organization of the DMD chip is shown in *Figure 10*. Underlying each DMD mirror and mechanical superstructure cell is a six-transistor SRAM. Multiple data inputs and demultiplexers (1:16) are provided to match the frequency capability of the on-chip CMOS with the required video data rates. The pulse width modulation scheme for the DMD requires that the video field time be divided into binary time intervals or bit times. During each bit time, while the mirrors of the array are modulating light, the underlying memory array is refreshed or updated for the next bit time. Once the memory array has been updated, all the mirrors in the array are released simultaneously and allowed to move to their new address states.

This simultaneous update of all mirrors, when coupled with the PWM bit-splitting algorithm, produces an inherently low-flicker display. Flicker is the visual artifact that can be produced in CRTs as a result of brightness decay with time of the phosphor.

Proper operation of the DMD is achieved by using the bias and address sequence is *detailed as*

1. *Memory ready: all the memory cells under the DMD have been loaded with the new address for the mirrors.*
2. *Reset: all mirrors are set in parallel(voltage pulse is applied)*
3. *Unlatch: the bias is turned off to unlatch mirrors and allow them to release and begin to rotate to flat state.*
4. *Differentiate: retarding fields are applied to the yoke and mirrors in order to rotationally separate the mirrors that remain in the same state from those that are to cross over to a new state.*
5. Land and latch: the bias is turned on to capture the rotationally separated mirrors and enable them to rotate to the addressed states, and then settle.
6. Update memory array (one time at a time): the bias remains turned on to keep the mirrors latched so as to prevent them from responding to changes in the memory, while the memory is written with new video data.
7. Repeat sequence beginning at step 1.

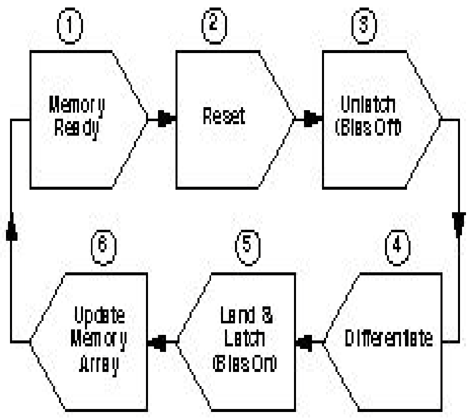


Figure 11. DMD address and reset sequence

The bias voltage has three functions.

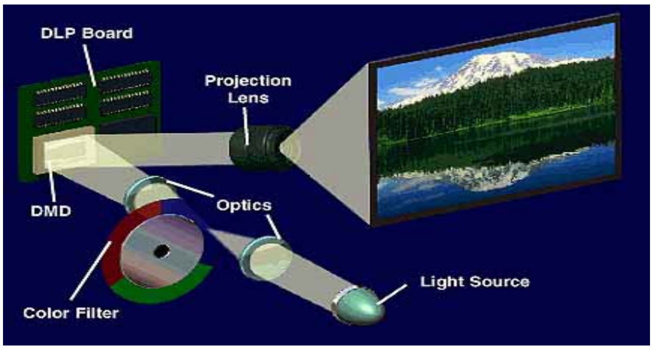
First, it produces a bistable condition to minimize the address voltage requirement, as previously mentioned. In this manner, large rotation angles can be achieved with conventional 5-volt CMOS.

Second, it electromechanically latches the mirrors so that they cannot respond to changes in the address voltage until the mirrors are reset.

The third function of the bias is to reset the pixels so that they can reliably break free of surface adhesive forces and begin to rotate to their new address states.

3. PROJECTION OPTICS

DLP optical systems have been designed in a variety of configurations distinguished by the number of DMD chips (one, two, or three) in the system. The one-chip and two-chip systems rely on a rotating color disk to time-multiplex the colors.



The one-chip configuration is used for lower brightness applications and is the most compact. Two-chip systems yield higher brightness performance but are primarily intended to compensate for the color deficiencies. For the highest brightness applications, three-chip systems are required.

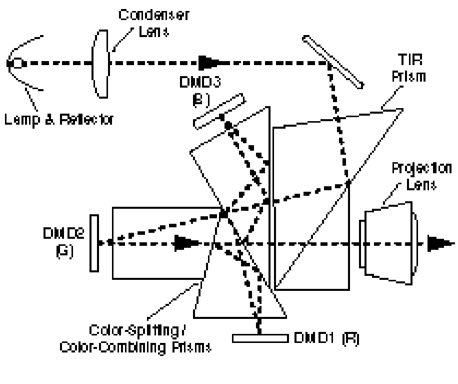


Figure 14. DLP three-chip optical system

A DLP optical system with three chips is shown in *Figure 14*. Light from a metal halide or xenon lamp is collected by a condenser lens. For proper operation of the DMD light switch, this light must be directed at 20 degrees relative to the normal of the DMD chip .To accomplish this in a method that eliminates mechanical interference between the illuminating and projecting optics, a total internal reflection (TIR) prism is interposed between the projection lens and the DMD color-splitting/-combining prisms.

The color-splitting/-combining prisms use dichroic interference filters deposited on their surfaces to split the light by reflection and transmission into red, green, and blue components. The red and blue prisms require an additional reflection from a TIR surface of the prism in order to direct the light at the correct angle to the red and blue DMDs. Light reflected from the on-state mirrors of the three DMDs is directed back through the prisms and the color components are recombined. The combined light then passes through the TIR prism and into the projection lens because its angle has been reduced below the critical angle for total internal reflection in the prism air gap.

4. USES AND FEATURES OF DLP

4.1 THE ADVANTAGE OF DLP

a) **Brighter:** DLP projectors are among the brightest available because DLP technology brings more light from lamp to screen, resulting in more effective presentations—even when ambient light is difficult to control.

b) **Sharper:** DLP projection's unique reflective technology comes closest to producing the exact mirror image of an incoming video or graphic signal, resulting in projection that's seamless.

at any resolution.

c) **Versatile:** DLP technology allows projectors to be small and light, often weighing as little as 1 kg—making them versatile enough for use in conference rooms, living rooms and classrooms.

d) **More reliable:** Display systems using DLP technology are able to recreate their incoming source material with each projection, ensuring a full-impact projection experience that will not fade over time.

e) **Consistent picture quality:** A data projector based on DLP technology delivers knockout picture quality again and again because, being all-digital, it recreates its image source every time of use. Unlike competing analogue technologies such as LCD, the semiconductor that makes DLP projection possible is virtually immune to heat, humidity, vibration and other factors.

4.2 DLP FEATURES

Clarity: DLP technology comes closer than any other display solution to reproducing the exact mirror image of its source material. That's why images projected by DLP technology are always crystal clear. The thousands of mirrors making up the DMD at the heart of DLP technology are spaced less than one micron apart, resulting in a very high 'fill factor.' By minimising the gaps between pixels in a projected image, DLP projection systems create a seamless digital picture.

Brightness: DLP projection systems outshine the alternatives because, being mirror-based, they use light more efficiently. While other technologies lose a certain amount of light in transit, the microscopic mirrors in a DLP projection system bring more light from lamp to screen.

Colour: DLP technology reproduces a range of colours up to eight times greater than of analogue projection systems. In televisions and home theatre systems, DLP projection creates rich blacks and darker shades than is possible with other technologies. At the movies, DLP Cinema technology projects no fewer than 35 trillion colours. DLP colours are becoming even more brilliant with the introduction of sequential colour recapture or SCR—an innovation that will enable DLP projection systems (video projectors) to bring up to 40 per cent more lumens to the screen than was possible earlier.

Reliability: DLP technology makes video projectors, home theatre systems and televisions more robust and more reliable. The digital nature of DLP technology means that, unlike other display solutions, it's not susceptible to heat, humidity or vibration—environmental factors that can cause an image to degrade over time. DLP projection systems display an original-quality picture time and again with no hassle and minimal maintenance. More than one million systems have been shipped since 1996.

Life-span: A DLP-based HDTV set should last indefinitely because the digital micromirror device behind it is very reliable. There is no maintenance or alignment required for DLP-based sets as they age. The only consumer replaceable component is the DLP light source (lamp), which will last for 8000 hours and costs around $250 to replace.

4.3 FUTURE USES OF DLP

DLP has a number of potential uses beyond home theatre, 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 and medical imaging. A number of these technologies are already in development. Scientists and developers are likely to discover even more uses for DMDs and DLP technology in the future.

DISCOVER WHAT YOU CAN DOWITH DLP TECHNOLOGY

Companies and engineers all over the world are using DLP Discovery products to change lives and make the products we use better.

DLP Discovery products enable solutions for non-traditional and non-display applications such as:

- **Medical** - An accurate and non-invasive way to look into the body.
- **Direct Imaging** - Improve throughput performance of high precision PCB manufacturing.

- **Structured Lighting** - Precise and real-time measurements for many industries - from dermatology to in-line inspection systems.
- **Hyper Spectroscopy** - Base quality decisions on the ability to thoroughly analyze material composition - detect impurities, identify chemical compositions, and so much more.

4.4 WHY DLP HDTV OVER PLASMA AND LCD?

AMAZING COLOR

More color with DLP

DLP HDTVs have twice the colors of other HDTV technologies and can create up to 200 trillion accurate colors. The combination of six color processing and millions of tiny mirrors make precise colors that last and last.

NO MOTION BLUR

Say bye-bye to motion blur

Performing up to 1,000 times faster than other technologies, the DLP chip delivers a precise, razor-sharp picture with no lag time between frames. So when you watch spor ts and action packed programs on a DLP HDTV the picture will always be sharp.

5. REFERENCE:

1. Digital Light Processing™: A New MEMS-Based Display Technology
   Larry J. Hornbeck
   Texas Instruments

2. Emerging Digital Micromirror Device (DMD) Applications
   Dana Dudley, Walter Duncan, John Slaughter
   DLPTM Products New Applications
   Texas Instruments, Inc.

6. SUMMARY:

DLP is rapidly becoming a major player in the rear-projection TV market, with sales of two million systems. Over 70 manufacturers offered models during the year 2006, up from 45 the previous year. DLP was the top selling 1080p HDTV technology through November 2006 as well as the leading micro display projection technology with 43 per cent of the market share. DLP HDTVs are available from leading manufacturers, including Mitsubishi, NVision, Panasonic, Philips, RCA, Samsung, Toshiba and more.