DLP (Digital Light Processing)

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DLP technology

• By Texas Instruments
• Most mature **large-screen** technology for **projectors** but is fast becoming the most mature for **small-screen** projectors, too.

• Uses
  – Maskless Lithography
    • Mainly PCBs
  – Head up display (HUD)
  – Small-screen and big screen display
    • wearables
    • screenless TVs
  – 3D printing
DLP Size

• 2 million full HD pixels into an 11.9 millimeter diagonal area
DLP in Lithography

• Maskless lithography solutions
  – Used in PCB patterning, solder masks, laser marking.

• Programmable light steering DLP technology is used to directly expose patterns onto photoresist films without the need for contact masks.

• Advantages (in comparison to other PCB printing methods)
  – Reduces material cost,
  – improves production rates, and
  – allows for rapid changes of the pattern (even better for DP).
  – Higher reliability
  – No mask cost
DLP in Lithography

• Highest resolution available:
  – Chipset for lithographic applications with a 4 million pixels (2560 x 1600).
  – For light wavelength 400-700nm
  – Pixel pitch: 7.6um
  – Can be de-magnified to print features ~1um [6]
  – Max Pattern Rate for binary bits: 9,527 Hertz
How does DLP work?

• Based on digital micro-mirror devices (DMDs),
  – one mirror for each pixel
• DMD controller enables programmable pattern rates
• Each tilt-and-roll pixel (TRP) deflects the light from red, green, and blue light sources (usually LEDs) onto its assigned area of the screen with intensity controlled by the duty cycle of on/off illumination of the pixel.

Simplified Diagram
Dealing with RGB data

24-bit RGB Image → 8-bit Red Image → 8 Red Bit-Planes

24-bit RGB Image → 8-bit Green Image → 8 Green Bit-Planes

24-bit RGB Image → 8-bit Blue Image
Dealing with RGB data (cont’d)

• DLPC900 controller takes as input 16-, 20-, 24-, or 30-bit RGB data at up to 120-Hz frame rate
• 24-bit RGB input: each color has 2.78ms time slot
• Each color has 8 bits $\rightarrow$ pulse width modulation
  – Mirror can either be on or off
  • The bit weight controls the amount of time the mirror is on

Figure 15. Bit Partition in a Frame for an 8-Bit Color
References

### DLP Chipsets for Lithography

<table>
<thead>
<tr>
<th>DMD Number</th>
<th>Micromirror Array</th>
<th>Array Diagonal</th>
<th>Controller</th>
<th>Micromirror Driver</th>
<th>Max Pattern Rate</th>
<th>Optimized Wavelengths</th>
<th>Pixel Pitch</th>
<th>Pixel Orientation</th>
<th>EVM</th>
<th>DMD Package Dimensions (lxwxh)</th>
<th>DMD 100u Price ($U.S.)</th>
<th>Controller 100u Price ($U.S.)</th>
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</thead>
<tbody>
<tr>
<td>DLP6500FYE</td>
<td>1920 x 1080</td>
<td>0.65&quot;</td>
<td>DLPC900</td>
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<td>9,500 Hz (binary)</td>
<td>420-700 nm</td>
<td>7.6 μm</td>
<td>Orthogonal</td>
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<td>DLPA200</td>
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<td>420-700 nm</td>
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<td>Discovery 4100</td>
<td>40.64 x 31.75 x 6.01 mm</td>
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Typical projection system optics [6]