Reliability Communication

PLUS Vision Corp.
Caution:

A. How to explain about LCD Reliability

Required to explain objectively. It is mandatory to communicate the test results just as fact. Ex. “When third party conducted the test, it got the following results.”

(Never convince that All LCD machines result in suffering degradation of picture quality, etc.)

B. Never quote/edit for use

Any quote/edit for the following material is prohibited.
Note:

This study was carried out by an independent company - the Munsell Color Science Laboratory (MCSL) at Rochester Institute of Technology - at the request of Texas Instruments (TI). The findings of the study, and their interpretation, should be attributed to MSCL/TI and not to PLUS Vision Corp. PLUS Vision Corp.'s endorsement should not be implied.

Questions concerning this study may be addressed in the first instance to PLUS Vision Corp. at: plusvision@plus.co.jp with subject of “Picture Reliability”.
Texas Instruments
Picture Reliability
Picture Reliability

As projector use steadily increases in an expanding sphere of applications, picture reliability is becoming a key customer concern.

1. Picture reliability should be expected for the lifetime of a projector.

2. DLP™ technology is *immune* to degradation, guaranteeing optimum picture reliability.

3. DLP™ technology’s picture reliability results in lower total cost-of-ownership.
Anecdotal evidence suggested LCD picture quality degrades over time

No empirical evidence of this: conducted side-by-side test of LCD vs. DLP™ technology

5 LCD projectors and 2 DLP™ technology-enabled projectors tested

Experiment duration ~4000 hours: picture reliability attributes compared

Conclusion: test results strongly supported anecdotal evidence
Expanding Power of Projection

- Office projectors go home for the weekend
  - Movies
  - Video games
  - Sports parties

- Educational uses
  - Projector in classroom
  - “Oral reports” now require PowerPoint presentations
  - Projector as technology integrator

- Houses of worship

- Commercial
  - Projected advertisements
    (airports, malls, etc.)

- Public entertainment (e.g. sports bars, karaoke, etc.)

As projector use steadily increases in an expanding sphere of applications, picture reliability is becoming a key customer concern.
Example: Education Market

Education could account for 20% of worldwide projector market

In 2005: 700,000-800,000 units per year

DTC and other data

Long-Term IT Investments

- High volume, phased deployment
- Longevity of investment is key: picture reliability is more important
Picture Reliability
IT Buyer Expectations

How long do you expect a data projector's picture reliability to last before it begins to degrade?

- Within 6 months
- Within 1 year
- Within 2 years
- Within 3 years
- More than 3 years
- Don't know

Merrill Research data

◆ Average usage of 75 hours/month for large corporations (900 hrs/year) - Pacific Media
Aided Care-About Results

Picture reliability should be expected for the lifetime of a projector.

When IT buyers are made aware of the picture reliability issue:

- 61% said picture reliability is either a very or extremely important purchasing criterion
- 87% of IT buyers said they would pay a 20% premium for a projector with picture reliability that lasts twice as long

Merrill Research
Picture Reliability Tests

- Conducted by Munsell Color Science Laboratory (MCSL) at Rochester Institute of Technology
- Began in May 2002
- The goal was to evaluate picture reliability of DLP™ technology vs. LCD technology over time
- Sample of five LCD and two projectors enabled by DLP™ technology
- Measurement included:
  - Luminance/brightness
  - Full On/Full Off (FOFO) contrast
  - ANSI contrast
  - FOFO and ANSI contrast for red, green, and blue colors
  - Color chromaticity for white, red, green, and blue
# Picture Reliability Experiment

Results at 4000 hours

<table>
<thead>
<tr>
<th></th>
<th>LCD 5 units</th>
<th>DLP™ 2 units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contrast</strong></td>
<td>Falling (5 of 5)</td>
<td>Steady</td>
</tr>
<tr>
<td><strong>Uniformity</strong></td>
<td>Steady</td>
<td>Steady</td>
</tr>
<tr>
<td><strong>Brightness</strong></td>
<td>Steady</td>
<td>Steady</td>
</tr>
<tr>
<td><strong>Colorimetry</strong></td>
<td>Failure - color shift (5 of 5)</td>
<td>Consistent</td>
</tr>
<tr>
<td><strong>Visible Picture Defect</strong></td>
<td>Failure - visible defect (5 of 5)</td>
<td>Consistent picture</td>
</tr>
</tbody>
</table>
Time to Failure

Failure = visible picture defect
Experiment Results

LCD 1

Photo at 24 hours

LCD 2

LCD 3

LCD 4

LCD 5

DLP™ 1

DLP™ 2

3312 Hours
Progressive Degradation

LCD 2

24 hours 1440 hours 2256 hours 3312 hours
LCD Projector Architecture

- Light from lamp split into primary colors: red, green, blue
- Light is modulated by one panel for each color
- Output from each panel is optically recombined to create on-screen image
LCD Degradation Theory

All 5 LCD projectors experienced the same degradation pattern

1. Blue Channel Polarizer
   • Failure: Reduces the polarization effect
   • Reason: Polymers/dyes break down due to exposure to high intensity light
   • Results: poor extinction in blue channel causes overall blue tint to image

2. Blue Panel
   • Failure: Panel transmits the light when it is not supposed to/vice versa
   • Reason: loss of LC alignment due to alignment layer breakdown; breakdown of LC molecules
   • Results: lowered contrast in blue channel, large blemishes onscreen

3. Rest of the System
   • Failure: Signs of degradation in the red and green polarizers and panels
   • Reason: Same as for blue channel
   • Results: lowered contrast, blemishes of various colors

Blue polarizer shows poor extinction (3:1)

Blue panel should be black here
DLP™ technology is *immune* to degradation, guaranteeing optimum picture reliability.

- DLP™ system components are robust to long term light exposure
- Reflective technology minimizes light absorption
- All-digital – unaffected by aging
- 100,000 hours lifetime
- Reliable semiconductor process
Test Conclusions

- Marked difference in picture reliability over time between LCD- and DLP™ technology-enabled projectors.
- DLP™ technology demonstrated picture reliability over the test period.
- Image quality defects caused by optical degradation were highly visible for LCD.
- Downward trends in optical performance for LCD on most of the parametric data.
- Image degradation for LCD was permanent: not recoverable by lamp replacement.
Total Cost of Ownership

DLP™ technology offers at least 33% saving in Total Cost of Ownership

- Projectors that degrade quickly:
  - Must be replaced far sooner
  - Impair perceived quality of presentations

- Projector lifetime cost of ownership is far lower for DLP™ technology-based projectors

DLP™ technology offers at least 33% saving in Total Cost of Ownership

Theoretical sample case:
- 10 year program
- 100 projectors
- $2,000 per unit
- LCD projectors replaced at least twice
- DLP™ technology-based projectors replaced at most once

- LCD TCO: $600,000 (minimum)
- DLP™ TCO: $400,000 (maximum)
Conclusion

As projector use steadily increases in an expanding sphere of applications, picture reliability is becoming a key customer concern.

1. Picture reliability should be expected for the lifetime of a projector.

2. DLP™ technology is *immune* to degradation, guaranteeing optimum picture reliability.

3. DLP™ technology’s picture reliability results in lower total cost of ownership.
Picture Reliability Comparison

**DLP™**
- DLP™ at 24 hours
- DLP™ at 3312 hours

**LCD**
- LCD at 24 hours
- LCD at 3312 hours