Laser Digital Cinema™

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Outline

• Digital Cinema Benefits

• Laser Digital Cinema™ Goals

• Laser

• Digital

• Cinema

• Summary
Digital Cinema Benefits

• Movie makers
  » Picture quality invariance between screening and theater
  » All-electronic production

• Distributors
  » Costs of duplication and delivery
  » Speed of distribution (overnight delivery, anti-pirating)
  » Digital encryption (anti-pirating)

• Exhibitors
  » No splicing for trailers, advertisements
  » Increased usage (education, town hall, pay-per-view, etc.)
  » Schedule flexibility
  » Equipment reduction (platters, racks, trailers)

• Audiences
  » Exceptional image quality (improved color, absent of artifacts)
  » Pristine showing over time (no degradation)
  » Flexible schedules allow convenience
Laser Digital Cinema™ Goals

- **Provide absolute digital color accuracy**
  - 24-bit (27, 30-bit potential)
  - Take advantage of digital SLM switching
  - Use laser sources for primary spectral invariance
  - Use pulsed sources for true digital color

- **DPSS laser technology advantages**
  - Color saturation
  - Brightness
  - Contrast
  - Life-cycle cost

- **Fiber-optic distribution**
  - Efficient time sequential color
  - Allows single backup system for entire theater
  - Other promotional usage (e.g. lobby laser light show)
RGB OPO-based system* (4294-10)

- Primaries at 628 nm, 524 nm, 449 nm
- PRF ~16 kHz (for 24-bit system)
- $M^2 < 1.2$ for red, blue;
  $\sim 2$ for green
- Wall-plug efficiency 11 lm/W

*Courtesy: Q-Peak, Inc.
Linear PWM (simple 4-bit case)

- Frame time divided into time-weighted bits
- CW illumination provides time-integrated gray scale

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1 0 1 1 = \frac{11}{15} = 73%
1 0 0 1 = \frac{9}{15} = 60%
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Timing pulses

Frame time
• Finite switching time of mirror affects low gray levels
• Integrated illumination becomes non-linear
- Use DMD as a gate for each laser pulse
- Provides true gray level reproduction at low levels

1 0 0 1 = $\frac{9}{15} = 60\%$

Frame time

Pulsed illumination

On-screen illumination

MSB

LSB
Data taken using Roadster X4*

* Courtesy Christie Digital Systems
Data taken using Roadster X4*
* Courtesy Christie Digital Systems
• Lowest bits can be faithfully represented

• Total energy per pulse falls within “on” time
• Use video trigger to synchronize Q-switch driver

• Increase rep rate to 64 kHz
  » Provides $2^{10}$-bit per color
  » Allows increased frame rate (180 Hz)
  » Enables laser engine sharing among three single-chip projectors
- Single laser engine feeds three single-chip projectors
Summary

• Digital Cinema is coming!

• Use of pulsed laser system enables many additional advantages in performance

• Laser Digital Cinema™
  » True digital color accuracy
  » Allows scalability for increased bit depth
  » Enables increased functionality in projection system and theater design