LED Backlighting for LCD-HDTV

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LCD-HDTV requirements

- Brightness: 450 nits
- Moving Pictures:
  - LCD switching speed < 16 ms
  - Dynamic Backlighting
- Viewing angle > 160°
- Color gamut > 72% NTSC
- HDTV
  - I 1080x1920
  - P 720x280

Backlight Performance!
Performance parameters

- **Backlight**
  - Lamp Flux (lumen)
  - Optical Efficiency
  - Intensity Distribution

- **Brightness Enhancement Films**
  - Brightness Gain
  - Polarization Recovery Efficiency
  - Transmission Angle

- **LCD & Polarizers**
  - LCD Transmission
  - Transmission Angle

- **Color Filters**
  - C/F transmission vs. Color Gamut
# B/L Flux Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>LCD Brightness</td>
<td>450 cd/m²</td>
</tr>
<tr>
<td>LCD Transmission</td>
<td>3%</td>
</tr>
<tr>
<td>Target B/L Brightness</td>
<td>15000 cd/m²</td>
</tr>
<tr>
<td>Optical Gain (1xBEF &amp; 1xDBEF)</td>
<td>2.3</td>
</tr>
<tr>
<td>Required B/L Brightness</td>
<td>6522 cd/m²</td>
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<table>
<thead>
<tr>
<th>Display Size</th>
<th>Brightness</th>
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<tbody>
<tr>
<td>18” 4:3</td>
<td>2048 lm</td>
</tr>
<tr>
<td>22” 16:9</td>
<td>2775 lm</td>
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</tbody>
</table>

- 50%: 4098 lm
- 60%: 3415 lm
- 70%: 2927 lm
- 5450 lm
- 4542 lm
- 3893 lm
Light sources for Backlighting

- **LEDs**
  - Red, Green and Blue Lumileds Luxeon emitter array
- **Cold Cathode Fluorescent Lamps**
  - Edge-lit
  - Direct-Lit

**Excluded**
- **Hot Cathode Lamps**
CCFL Edge-Lit Backlight

- Thin! Total backlight thickness 8 ~ 12 mm.
- Cold Cathode Lamps, diameter 2 ~ 3 mm, about 4 W per lamp
- Very good brightness uniformity by mixing in light guide
- Brightness limited by # of lamps and thickness of light guide, 6 lamps max with a 6 ~ 9 mm lightguide
CCFL Direct Backlight

- High Brightness due to large # of lamps: typically 6 ~ 12 CCF Lamps, depending on screen size
- Larger thickness than edge-lit backlights: 20 ~ 50 mm
- Uniformity is worse than for an edge lit system due to dependence on individual lamps
Power LED Backlight

- Edge lit type, instead of CCFL an array of power LEDs (Luxeon™ Emitter Array) is used along top and bottom
- Array of Red, Green and Blue emitters
  - Color performance
  - Efficacy
- Additional mixing light guide
- Emitter count 36 ~ 140 depending on display size and single or double edge illumination
Luxeon B/L modules

- Arrays of red, green and blue emitters
- Binned and matched to create 9000 K white backlight
- Pitch ~ 9 mm

**Module performance:**
- 60~75 lm/inch standard
- 125 lm/inch best lab results (typical in 1~2 years)
- 2.5 ~ 3.5 W / inch (driving conditions, color temperature)
RGB Luxeon B/L features

- No mercury and 50,000~100,000 hr life
- Increased Color Gamut using standard color filters
- (Dynamic) White point adjustment in back light
- Fast switching speed ( < 1 us) of all three color channels
  - Motion artifact reduction (blinking backlight)
  - Potential use for color sequential
  - Dynamic brightness control
- High Brightness
B/L Brightness Comparison
Conclusions

- **HD-LCD TV** stretches CCFL backlight flux output to its limits
  - panel transmission
  - large viewing angle
- **LED B/L is interesting alternative**
  - optical design is more complicated (color mixing optics)
  - high flux output
  - no mercury
  - long lifetimes
  - color performance (color gamut ~ 100% NTSC)
  - dynamic backlight features (motion artifacts)