Flat Panel Displays
Overcoming High-Ambient Light Conditions

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Sr. Applications Engineer

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Ferdinand Tercenio

Senior Applications Engineer – REA Display Business Unit

- Provide Technical Customer Support on LCD applications in the Americas
  - Advise solutions to common LCD problems
  - Debug and troubleshoot customer’s application
  - Work with NLT Technologies in Japan to resolve advanced technical issues
- Examine REA LCD RMA issues requiring further analysis
  - Scrutinize panel failure
  - Investigate for reasons of failure
- Assist of building demonstration computers and display housings for field demo program
  - Manage Inventory
  - Design and Specify custom peripherals
  - Add software support
  - Debug systems
- 12 years engineering experience in the Display BU
Renesas Technology & Solution Portfolio
Display Module Solutions
Sophisticated solutions  Sustainable support

LED Backlight LCDs
- Low power consumption
- Long life LEDs
- Thin profile and lightweight design
- Replaceable LED light source unit

Wide Format LCDs
- More data on a single screen
- 16:9 aspect ratio
- Low power consumption
- Long life LEDs
- Thin profile and lightweight design
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Industrial Mobile Displays
- Robust feature sets
- Long-term product support
- Amorphous silicon (A-Si) displays
- Low-temperature polysilicon (LTPS) displays

Enhanced View TFT (EVT)
- Suited for a variety of ambient-light environments
- Proprietary transflective LCD technologies
  - Reflective-Enhanced View TFT (R-EVT)
  - Transmissive-Enhanced View TFT (T-EVT)

Wide Format TFT (WFT)
- More data on a single screen
- 16:9 aspect ratio
- High luminance and wide color gamut
- Superior image quality
- Ultra-wide viewing angles
- 2D/3D displays
- On-cell touch
- PCAP touch

Emerging Technologies
- Robust feature sets
- Long-term product support
- Amorphous silicon (A-Si) displays
- Low-temperature polysilicon (LTPS) displays

Enhanced View TFT (EVT)
- Proprietary transflective LCD technologies
  - Reflective-Enhanced View TFT (R-EVT)
  - Transmissive-Enhanced View TFT (T-EVT)
Innovation
‘Enabling The Smart Society’

**Challenge:**
“In the smart society, obtaining information anywhere one goes will be typical. Usually it is through a display and being able to view these information under the sun via a portable devices or fix stations will require some classes of displays.”

**Solution:**
“This class will introduce you to the technologies that are used to overcome high ambient light conditions, understand what light can do to displays and what NLT can do to provide and help solve these problems.”
Agenda

- Properties of Light
- Viewability in High Ambient Light Conditions
- Solutions for High Ambient Light Conditions
- Technology Overview
Properties of Light
Properties of Light

- **Specular Reflection** - the mirror-like reflection of light.
Properties of Light

- **Refraction** – the change in direction of light when passing through one transparent medium to another.
Properties of Light

- **Diffusion** – incident light is reflected in many directions

![Diffusion reflection diagram]
Properties of Light

- **Glare** – Reduction of contrast of the source image due to high incident light reflections.
Issues Affecting FPD Viewability in High Ambient Light
Environmental conditions

- Outdoor or direct sunlight
Reflection & Glare in Strong Sunlight

Standard AG surface

High reflection
Low contrast

Enhanced for sunlight readability

Low reflection
Improved contrast
Attributes That Affect Viewability

- Front of screen peak luminance
- Contrast

**Standard Clear Surface**

**Enhanced Panel**
Clearer but still whitish

Higher Luminance and More Contrast
Solutions for High Ambient Light Conditions
CCFL Backlight Systems

- High bright CCFL
  - Touch panels will reduce a display’s luminance and increase surface reflections making it harder to see.
  - Extreme brightness of 1100 nits offsets the reduction of luminance and reflection.

High bright CCFL backlight system
NL8060BC31-36
1100 nits
LED Backlight Systems

- High bright LED
  
  To improve backlight life, NLT Technologies, Ltd. optimized the LED alignment and heat dissipation design achieving a high bright LED backlight system comparable to high bright CCFL backlights.

High bright LED backlight system
NL10276BC24-21F
800 nits @ 50mA/circuit
1000 nits @ 70mA/circuit
## CCFL vs. LED Backlight Systems

<table>
<thead>
<tr>
<th>Light source type</th>
<th>CCFL</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light source type</td>
<td>Linear type</td>
<td>Spot type</td>
</tr>
<tr>
<td>Drive method</td>
<td>AC</td>
<td>DC</td>
</tr>
<tr>
<td></td>
<td>High voltage INV creates harmonic noise</td>
<td></td>
</tr>
<tr>
<td>Dimming range</td>
<td>15 to 100%</td>
<td>0 to 100%</td>
</tr>
<tr>
<td>Thermal property</td>
<td>Significant thermal independence</td>
<td>Linear thermal independence</td>
</tr>
<tr>
<td>Optical property deviation</td>
<td>Luminance: ±10% Chromaticity: ±0.010</td>
<td>Luminance: over 10% Chromaticity: ~0.025</td>
</tr>
<tr>
<td>Power consumption</td>
<td>High</td>
<td>40% lower than CCFL</td>
</tr>
<tr>
<td>Thermal performance</td>
<td>Low start-ability and shorter life at low temperatures</td>
<td>Exothermic</td>
</tr>
<tr>
<td>Environmental</td>
<td>Small amount of Mercury</td>
<td>Mercury free</td>
</tr>
</tbody>
</table>
CCFL vs. LED Backlighting

- Relative luminance vs. temperature

![Graph showing relative luminance vs. temperature for CCFL and LED](image)
Brightness Enhancement Film (BEF)

- The film is inserted into a backlight to direct diffusive light from a light source.

Diagram:
- BEF film
- Backlight
- Light from a light source
- Directed and enhanced light
- Polarizer
- LCD panel
- Polarizer
Reflective Polarizer Film (DBEF, APCF and etc...)

- Reflective polarizer made of multi layer plastic film.
- Reflects and transmits light from backlight selectively.

On the film S wave is reflected and goes back into a backlight and recycled.

The recycled light is mixed with S and P wave again.
Reflective Polarizer Film (DBEF, APCF and etc...)

- By using the Reflective Polarizer Film, the brightness is boosted 1.3 to 1.6 times.
- By adding with another BEF film in a backlight, the brightness can be boosted further more.

![Graph showing luminance ratio and viewing angle](image)
AG & AR Passive Enhancement Films

- Anti-Glare (AG) - diffuses reflection
- Anti-Reflective (AR) - negates reflection
Anti-Reflection Film

The difference in reflection index and path creates a phase difference that negates the effect.
# AR Film Details

## Front

<table>
<thead>
<tr>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low index layer (SiO2 and etc.)</td>
</tr>
<tr>
<td>High index layer (TiO2, ITO, Nb2O5 and etc.)</td>
</tr>
<tr>
<td>SiO2</td>
</tr>
<tr>
<td>High index layer (TiO2)</td>
</tr>
<tr>
<td>SiO2</td>
</tr>
<tr>
<td>Hard coat or Anti-glare layer</td>
</tr>
<tr>
<td>Base film (TAC, PET and etc.)</td>
</tr>
<tr>
<td>Adhesive material</td>
</tr>
</tbody>
</table>

## Back
# AG Film Details

## Front

<table>
<thead>
<tr>
<th>Plastic layer including silica or plastic beads</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC (Triacetylcellulose)</td>
</tr>
<tr>
<td>PVA (Polyvinyl alcohol)</td>
</tr>
<tr>
<td>TAC (Triacetylcellulose)</td>
</tr>
<tr>
<td>Adhesive material</td>
</tr>
</tbody>
</table>

## Back
Glass Overlay vs. Direct Bonding

Glass Overlay

Direct Bond + AR Coating

Surface reflection about 0.2%
Direct Bonding

AR coated glass attached directly to the LCD surface using bonding material
## Solution Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Weight</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>High bright backlight</td>
<td>High</td>
<td>Middle to heavy</td>
<td>Very complex</td>
</tr>
<tr>
<td>AG or AR film</td>
<td>Low</td>
<td>Low</td>
<td>Good</td>
</tr>
<tr>
<td>Bonding and Special overlays</td>
<td>Very High</td>
<td>Very heavy</td>
<td>Very complex</td>
</tr>
</tbody>
</table>
Technology Overview
Enhanced View TFT (EVT)

- Proprietary transflective LCD technologies
  - Reflective-Enhanced View TFT (R-EVT)
    - Formerly known as SR-NLT
  - Transmissive-Enhanced View TFT (T-EVT)
    - Formerly known as ST-NLT

- Suited for a variety of ambient-light environments
## R-EVT – Reflective-Enhanced View TFT

*Backlight ON or OFF – Highly reflective surface, great for direct sunlight applications where backlight is normally off for maximum power savings*

<table>
<thead>
<tr>
<th>Daytime/Bright Light</th>
<th>Nighttime/Weak Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Surface</td>
</tr>
<tr>
<td>LCD Panel</td>
<td>LCD Panel</td>
</tr>
<tr>
<td>Backlight OFF</td>
<td>Backlight ON</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Display uses ambient light and features excellent visibility</td>
<td>Display uses backlight as light source to guarantee excellent visibility in weak light</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backlight can be switched ON/OFF to minimize energy consumption</td>
</tr>
</tbody>
</table>
R-EVT Mechanism

Regular TN pattern model

R-EVT pattern model

Transflective pattern

Transmissive area
R-EVT Mechanism

With full flat reflective pattern only frontal reflection can be seen.

Tiny bumpy reflective pattern makes the reflection more diffused.

The reflection pattern design is the most crucial. Refraction index from gap between the reflective pattern and air has to be taken into consideration.
R-EVT has a medium contrast property between complete reflective and transmissive.
R-EVT Comparison

**Standard TN with BL Off**
Reflection ratio: ~0%

**R-EVT with BL Off**
NEC NL10276BC20-10
Reflection ratio: 35%
R-EVT Comparison

**NLT NL10276BC20-10**

**Backlight ON @ 175 nits**

**Reflection ratio:** 35%

**Contrast ratio:**
- Transmissive: 150:1
- Transflective: 15:1

**Backlight OFF @ 0 nits**

To contain reflection, even for R-EVT, AR is recommended as best.
# T-EVT – Transmissive-Enhanced View TFT

*Backlight ON – High efficient backlight + proprietary AR*

<table>
<thead>
<tr>
<th>Daytime/Bright Light</th>
<th>Primary Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diagram" /></td>
<td>Guarantees clear, vivid color image displays even in high ambient light by using a high-luminance backlight as a light source to minimize the surface reflection of outdoor light</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nighttime/Weak Light</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2" alt="Diagram" /></td>
<td>Display uses backlight as light source to guarantee excellent visibility in weak light</td>
</tr>
</tbody>
</table>
T-EVT – Transmissive-Enhanced View TFT

- T-EVT is better in bright ambient
Contrast Ratio in Sunlight

Direct Bonding

ST-NLT

Normal LCD

3:1 is minimum contrast ratio to see image in sunlight
Competitive Comparison

Competitor LCD

800 nits

T-EVT
NLT NL10276BC30-18C
600 nits
200 nits lower but more viewable
Examples of High Bright LED Backlight Systems

NL6448BC20-30C/30F
900 nits

NL6448BC33-70C/70F
800 nits

NL8060BC21-11C/11F
800 nits
Advantages of R-EVT & T-EVT

- R-EVT & T-EVT products carry full manufacturer’s warranty.

- NLT uses “passive” enhancements and avoids the reliability pitfalls of high brightening or overdriving lighting components by “brute force”. (R-EVT)

- While most customers shop “peak luminance” figures what they should buy is “contrast”. (R-EVT & T-EVT)

- An NLT T-EVT panel @ 375 nits equals a standard panel @ 810 nits. Overdriving backlights is not needed.

- In standard TN, increasing the peak (white) luminance, black level also rises making the panel no better in contrast. It may actually cause “wash out”. Our T-EVT maintains contrast.
NLT LED Driver Board

- Same footprint as CCFL boards
- Support up to 6 series LED strings
- Compact size
# High Bright LED Backlight Systems

## NLT LED driver line up

<table>
<thead>
<tr>
<th>Size</th>
<th>Part No.</th>
<th>LED driver board</th>
<th>Driver board harness</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5</td>
<td>NL6448BC20-30/30D</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>6.5</td>
<td>NL6448BC20-30C/30F</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>8.4</td>
<td>NL6448BC26-26/26D/27/27D</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>8.4</td>
<td>NL6448BC26-26C/26F/27C/27F</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>8.4</td>
<td>NL8060BC21-10/10D/11/11D</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>8.4</td>
<td>NL8060BC21-10C/10F/11C/11F</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>9</td>
<td>NL8048BC24-09/09D</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>10.4</td>
<td>NL6448BC33-70/70D/71/71D</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>10.4</td>
<td>NL6448BC33-70C/70F/71C/71F</td>
<td>104PW01F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>10.4</td>
<td>NL8060BC26-35/35D/36/36D</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>10.4</td>
<td>NL8060BC26-35C/35F/36C/36F</td>
<td>104PW01F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>10.4</td>
<td>NL10276BC20-18/18D</td>
<td>104PW02F</td>
<td>104CBL01</td>
</tr>
<tr>
<td>12.1</td>
<td>NL8060BC31-46/46D/47/47D</td>
<td>121PW02F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>12.1</td>
<td>NL8060BC31-46C/46F/47C/47F</td>
<td>104PW03F</td>
<td>121CBL02</td>
</tr>
<tr>
<td>12.1</td>
<td>NL8060BC31-50C/50F</td>
<td>104PW03F</td>
<td>121CBL03</td>
</tr>
<tr>
<td>12.1</td>
<td>NL12880BC20-05/05D</td>
<td>104PW03F</td>
<td>121CBL03</td>
</tr>
<tr>
<td>15</td>
<td>NL10276BC30-34D</td>
<td>150PW02F</td>
<td>150CBL02</td>
</tr>
</tbody>
</table>
LED Lifetime @ Temperature

- 25°C
- 55°C
- 70°C
- 80°C

Relative Luminance vs Hours of Operation

- 100 (%)
- 50 (%)
- 1
- 10
- 100
- 1000
- 10000
- 100000 (Hrs)
LED Lifetime vs. Drive Current @ Temperature

Relative Luminance vs. Hours of Operation

- 8mA 70°C
- 14mA 70°C
- 20mA 70°C
Additional Comments

■ Power is not free

- Higher power designs are typically more complex, larger & expensive.

- Higher power in the form of heat.

- Higher operating temperatures create opportunities for failure.

- Larger mechanical “footprint” dictates larger product designs.
Summary

- Properties of Light
- Viewability in High Ambient Light Conditions
- Solutions for High Ambient Light Conditions
- Technology Overview
Innovation
Questions?
‘Enabling The Smart Society’

- **Challenge**:  
  “In the smart society, obtaining information anywhere one goes will be typical. Usually it is through a display and being able to view these information under the sun via a portable devices or fix stations will require some classes of displays.”

- **Solution**:  
  “This class will introduce you to the technologies that are used to overcome high ambient light conditions, understand what light can do to displays and what NLT can do to provide and help solve these problems.”

- Do you agree that we accomplished the above statement?
Please Provide Your Feedback...

- Please utilize the ‘Guidebook’ application to leave feedback

or

- Ask me for the paper feedback form for you to use...
Thank You!