Display Power Characteristics for TV Sets

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Display Power Characteristics

Different Display Types Take Power in Different Ways

- Power-on-Demand
  - Plasma
  - OLED
  - FED/SED
  - LCD/Dynamic backlight
  - Projectors/LED Lamps

- Constant Power
  - LCD (current products)
  - Projectors/Arc Lamp
Power Consumption Dependence on APL

**Conclusion**

PDP and LCD use power in much different ways.

Electric Bill

Power of PDP

Back of Set Power Label

Relative Power Consumption

Average Picture Level (%) -- Peak = 100%
Future LCDs will be Power-on-Demand

• Increase power efficiency with dynamic backlight designs
  • 0D Design
    – Dim entire backlight
  • 1D Design
    – Scan 1D backlight tubes
  • 2D Design
    – Modulate 2D LED array
Most of LCD Power is in Backlight
Dynamically Dim Backlight Depending on TV Signal

- Can get some of 5X Power-on-Demand advantage enjoyed by emissive displays

IMID ’04 Oh, et al
# Dynamic Backlight 42” IPS LCD

<table>
<thead>
<tr>
<th></th>
<th>Improved</th>
<th>Normal</th>
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<tbody>
<tr>
<td><strong>Luminance (cd/m²)</strong></td>
<td></td>
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<tr>
<td>Black</td>
<td>0.5</td>
<td>1.0</td>
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<tr>
<td>White</td>
<td>500</td>
<td>500</td>
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<tr>
<td>Peak</td>
<td>550</td>
<td>-</td>
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<tr>
<td><strong>Contrast ratio</strong></td>
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<tr>
<td>Static</td>
<td>500 : 1</td>
<td>500 : 1</td>
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<tr>
<td>Dynamic</td>
<td>1100 : 1</td>
<td>-</td>
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<tr>
<td><strong>Power consumption</strong></td>
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<td></td>
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<tr>
<td>cumulation</td>
<td>130W</td>
<td>170W</td>
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<tr>
<td><strong>Temperature</strong></td>
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<tr>
<td>front</td>
<td>40°C</td>
<td>45°C</td>
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</table>

IMID ’04 Oh, et al
Set Backlight to Brightest pixels

SID ’04 Takeo, et al
Can Also Adjust Each Lamp Independently for Lower Power

SID '04 Takeo, et al
LED Backlight for LCD can Achieve 2X Power Reduction

Figure 1. LED backlight unit and LCD module

SID '06 Shirai, et al
Future Projection TVs will use Power on Demand LED Lamps

- Increase power efficiency with dynamic LED lamp designs
- Can easily reduce intensity and power of LED lamps for dim TV images
LED Lamp Projector Design

Fig. 1  Light engine with LED light sources

SID ’06 Sakata, et al
LED Light Source Projection TV

55 inch Projection TV

50 inch Plasma TV

Sanyo at CES ‘06
Power Model for Plasma Display TV Set

Antenna

TV Signal

APL Type 1: Pre-Gamma

Inverse Gamma

APL Type 2: Post-Gamma

ABL Circuit

Plasma Display

PDP-TV Set

PDP
Inverse Gamma Function

Gamma = 2.2

Input Percentage of White Level

Output Percentage of White Level
Plasma TV Power Characteristic

Max Power

ABL Threshold

Fixed Power

Post-Gamma APL Input to ABL Circuit
Power Consumption Dependence on APL

Conclusion

PDP and LCD use power in much different ways.
Average Pixel Level (APL)

• APL has major impact on TV power usage

• APL Type 1 (Pre-Gamma) Definition:
  – APL is the time average of the video signal input voltage to the TV set, which is usually expressed as a percentage of the full white signal level voltage.

• APL Type 2 (Post-Gamma) Definition:
  – APL is the time average of the average luminance of all pixels in the TV set, which is usually expressed as a percentage of the peak white luminance level.
Power Model for Plasma Display TV Set

Antenna → TV Signal → APL Type 1: Pre-Gamma → Inverse Gamma → APL Type 2: Post-Gamma → ABL Circuit → Plasma Display
APL of Popular TV Program

The Young and the Restless Soap Opera

Entire Program including Advertisements

Histogram

Mean Post-Gamma
APL: 9.07%

19095 Frames Averaged
30 Minutes 0 Seconds

Frame Number

0 5000 10000 15000 20000

0 10 20 30 40 50 60 70 80 90 100

APL (%)

Post-Gamma APL (%)

Pre-Gamma APL
Post-Gamma APL
Mean Pre-Gamma APL
Mean Post-Gamma APL
Low Budget Animation
Low Budget Animation

Rug Rats Low Budget Animation

Histogram
Mean Post-Gamma APL: 29.09%
15604 Frames Averaged
24 Minutes

Frame Counts

Post-Gamma APL (%)
Summary of Measured APL
JEITA Proposed TV Set Power Measurement Method

Po = 0.167 \times P_w + 0.167 \times P_b + 0.333 \times P_c + 0.333 \times P_t

where:
Po is the output power value that is used for the final power calculations,
Pw is the measured power of the 100% white pattern,
Pb is the measured power of the full black pattern,
Pc is the measured power of the color bar pattern,
Pt is the measured power of the white and black bar pattern.
JEITA Proposal APL Comparison

Summary of Measured APL

Program Number

APL (%)
Proposed New Test Method

- Preserve simplicity of JEITA TV Set test
  - Run test images and measure power
- Modify test images
  - Images must represent real TV signals
- Use special test video disk (tape) for images
  - Must be chosen very carefully in order to be truly representative of real TV signals
Special Test Video Disk

• Measure APL Histograms of many popular TV programs
  – Big job that will take a few months

• Prepare Master Histogram of all TV programs
  – Weight individual program histograms by Nielsen ratings
  – Master Histogram will represent average TV usage

• Prepare Test Video Disk with various video clips
  – Histogram of final disk will be same as Master Histogram
  – Use available public domain video material
\[ Po = W_1 \times P_1 + W_2 \times P_2 + W_3 \times P_3 + W_4 \times P_4 + \ldots \ldots + W_n \times P_n \quad (3) \]

Where:
Po is the output power value that is used for the final power calculations,
P1, P2, P3,…, Pn are the powers that are measured with the various test images,
W1, W2, W3, … , Wn are fixed numbers or Weights defined by the test method.
New Measurement Method Standard

• Build on good ideas of JEITA-METI Standard
  – Simple to measure
  – Robust
• Increased accuracy
• Fair to all technologies
  – LCD, PDP, Projection, CRT, OLED, FED/SED
• Accurate for future display innovations
  – Dynamic LCD Backlight, LED Backlight
  – LED Projector Lamps