Design of a Novel Spectrum Sequential Display with a Wide Color Gamut and Reduced Color Breakup

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Abstract

- **RGB color sequential displays**
  - No color filters
  - Necessity to run at high refresh rate for preventing flicker and color breakup

- **Alternative color sequential display**
  - Two color filters per pixel
    • Cyan and magenta
  - Two type of spectra
    • Blue-green and green-red
  - Advantage
    • Wide gamut four primary display
    • Low refresh rates without color breakup or flicker
Introduction

◆ Color sequential displays
  – No filters
    • Red, green, and blue backlight sequentially
  – Disadvantage
    • High rate refresh as 180Hz to avoid flicker
    • Color breakup
      – 600Hz refresh to avoid color breakup (impossible)

◆ Advantage of the proposed display
  – More brightness
  – Higher resolution
  – 100Hz rate without flickers
  – Less color breakup
Display design

◆ Properties
  – Two color filters per pixel
  – Two different backlight spectra time sequentially
    • Three standard LEDs; red, green, and blue
    • Blue and green LED in field 1
    • Green and red LED in field 2
**Color filter design 1**

- Green filter (497~569nm) and magenta filter
  - Same coordinates between RGB primaries and RGB LEDs respectively
- Deficit
  - Smaller color gamut to cover the EBU color gamut at red and blue color points

![Fig 1. Lamp spectra of field 1 and field 2](image1)

![Fig 2. Chromaticity coordinates](image2)
Color filter design 2

– First step
  • Tune of the blue and red primary by changing the low and high cut off wavelengths of the magenta filter
  • Extension of blue and red primaries on chromaticity coordinates

Fig 3. Lamp spectra of field 1 and field 2
Fig 4. Chromaticity coordinates
- Second step
  - Tune of the green filter to the cyan filter
  - Red and green LEDs on
    - Match of the red and green primaries with EBU
  - Blue and green LEDs on
    - Match of blue with EBU
    - Transformation of a green primary to a cyan primary

![Fig 3. Lamp spectra of field 1 and field 2](image1)

![Fig 4. Chromaticity coordinates](image2)
– White point tuning
  • Choice of the correct ration of the intensities of individual red, green and blue LEDs after color filter design

◆ Combination of filters
  – Two color filters combination
  – Two backlight spectra combination

Filter $\times$ Back lights = Result color on the filter

Fig 5. Combination of spatial color filter
Robustness for color filter variations

- Two design aspect of the filters
  - Cutoff wavelengths
    - Color points of the primaries
    - Size of color gamut
  - Slope of the filter
    - Little effect on the color points of the primaries

- Result after second filter design
  - 10 % higher display luminance covering the EBU gamut
Signal processing

- Matrix mixing technique
  - Multi-primary color mapping technique to calculation of the drive signals for the two fields
- Spectrum sequential addressing scheme

Fig 6. Result of each field and combination and addressing
Visibility of color breakup artifacts

◆ Method to evaluate
  – Front-of-screen performance
    • Between spectrum sequential displays and RGB color sequential display

◆ First evaluation about flickers and color breakup
  – 180Hz
    • 90 (180/2) frame rate for the spectrum sequential display
    • 60 (180/3) frame rate for the color sequential display
  – Result
    • Low flickers on both displays
    • Higher color breakup on color sequential displays
Second evaluation about the same preference

- Decreasing of the refresh rate in spectrum sequential display from 180 until preference of both methods are equal
- Same preference at 90~100Hz
  - Lower color breakup than color sequential displays
**Conclusion**

- Spectrum sequential display technique
  - Outperform of performance than conventional LCDs
    - Higher luminance and resolution
    - Lower flickers and color breakup