SEMI D65-1011
MEASUREMENT METHOD FOR THE COLOR BREAKUP OF FIELD SEQUENTIAL COLOR DISPLAY

This Standard was technically approved by the FPD – Metrology Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on September 12, 2011. Available at www.semiviews.org and www.semi.org in October 2011.

1 Purpose

1.1 Field sequential color technique in the flat panel display has become more and more important. The effect of color breakup (CBU) occurs in the panels in which the field sequential technique is used. There are still no adaptive measurement standards to quantify the quality of color breakup. To standardize the classification of color breakup for flat panel displays is necessary.

2 Scope

2.1 This Standard is to design and implement the measurement method of color breakup. This Standard is applicable to the color breakup phenomenon on the field sequential color display. The testing method proposed in this standard includes dynamic CBU and static CBU. The correct testing method setting shall be used to measure the dynamic or static CBU.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 These methods are applied to field sequential color displays.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI D58 — Terminology and Test Pattern for the Color Breakup of Field Sequential Color Display

4.2 *ISO/CIE Standard*[1]

ISO 11664-5:2009/CIE S-014-5/E — Colorimetry – Part 5: CIE 1976 L*u*v* Colour Space and u', v' Uniform Chromaticity Scale Diagram

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *CBU* — color breakup

5.1.2 *CBI* — color breakup index

5.1.3 *Cpd* — cycle per degree

5.1.4 *f* — frame rate

5.1.5 *FSD* — field sequential display

5.1.6 *ppf* — pixel per frame

5.1.7 *SS* — scroll speed

[1] International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, http://www.iso.org

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5.1.8 *ST* — seen-threshold

5.2 *Definitions*

5.2.1 CBI_{ij} — the color breakup index (CBI) of color transition pattern with color *i* to color *j*. Color *i* and color *j* could be white(W), black(K), red(R), green(G), blue(B), cyan(C), magenta(M), and yellow(Y).

5.2.2 *frame rate* — the number of frames per second is shown on a display.

5.2.3 *resolution* — the number of pixels on each screen line.

6 Apparatus

6.1 *Color Camera System* — A device used for measuring and recording the color picture onto the storage media. The exposure time shall be longer enough to capture completely a frame time of sequential display.

6.1.1 *Parallel Trajectory System* — A color camera with a stage that moves in the parallel trajectory.

6.1.2 *Rotation Pursuit System* — A color camera on the synchronizing and rotational stage.

6.2 *High Speed Camera System* — A device used for recording fast moving objects as a photographic image onto the storage media, recording typically over 1000 frames per second. A problem for high speed cameras is the needed very bright light for a signal image, so the user should deal with the problem when capture the color breakup image.

6.2.1 *Parallel Trajectory System* — A high speed camera with a stage that moves in the parallel trajectory.

6.2.2 *Rotation Pursuit System* — A high speed camera on the synchronizing and rotational stage.

6.3 Software implementation for quantitative visual analysis.

7 Procedure

7.1 *Measuring Conditions*

7.1.1 *Environment Conditions*

7.1.1.1 In order to obtain accurate measured data, the following environment conditions are required.

- Temperature: 25 ± 5°C
- Humidity: 25% to 85%RH
- Air flow: no wind
- Dark room: the illuminance <1 lx

7.1.2 *Measuring Distance*

7.1.2.1 Measuring distance is 3H (where H is the height of the measured display device).

7.1.3 *Viewing Direction*

7.1.3.1 The basic viewing direction of this test is perpendicular angle.

7.1.4 *Warm-Up Time*

7.1.4.1 The display must be warmed up for a minimum of 30 minutes. Longer warm-up time is encouraged to the point that the display exhibits less than 5% drift per 5 minutes. Special situations arise where either a longer or shorter warm-up is required. In such a case deviations must be reported to all interested parties.

7.2 *Testing Pattern*

7.2.1 A proposed testing pattern is a checker board pattern. Even in the same color transition pair, the CBU phenomena are different in the different color transitions (i.e., black to white vs. white to black) of the same color transition pair. For this reason, we the testing pattern as 2 × 2 checker board pattern. Then the two different color breakups could be captured at the same time. There are six primary colors, name Red (R), Green (G), Blue (B), Cyan (C), Magenta (M), and Yellow (Y), and two achromatic colors, name white (W) and black (K), were used to form a testing pattern. Since the opposite color transition could make the serious problem of color breakup, eight color

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transition pairs are selected to be the testing pattern. White and Black color transition pairs are shown in Figure 1. Red and Cyan color transition pairs are shown in Figure 2. Green and Magenta color transition pairs are shown in Figure 3. Blue and Yellow color transition pairs are shown in Figure 4.

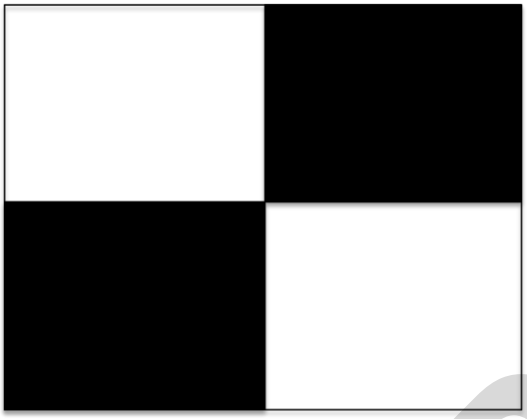

Figure 1
CBU Measurement Checker Board Test Pattern 1

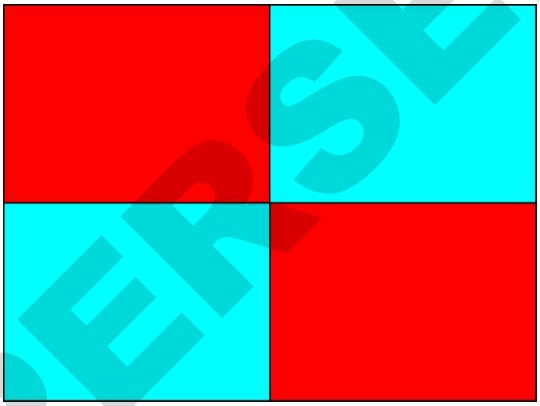

Figure 2
CBU Measurement Checker Board Test Pattern 2

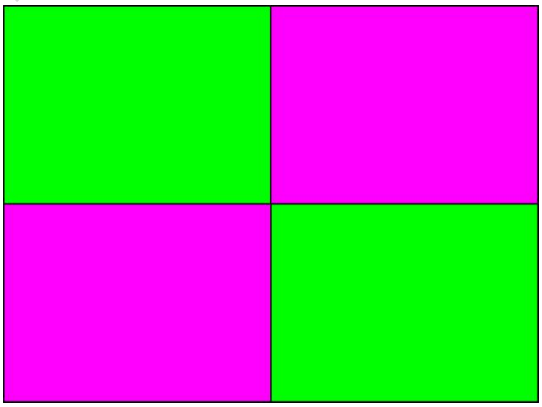

Figure 3
CBU Measurement Checker Board Test Pattern 3

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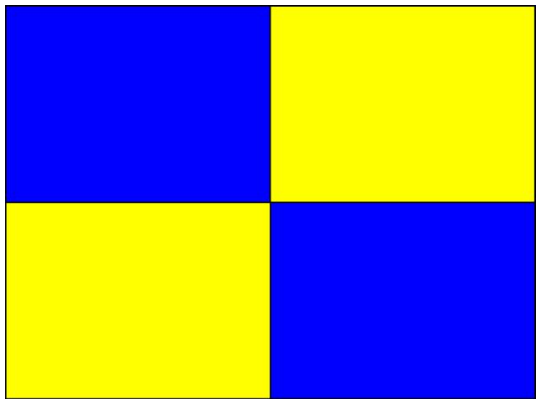

Figure 4
CBU Measurement Checker Board Test Pattern 4

NOTE 1: Testing patterns are not limited.

7.3 *Testing Method*

7.3.1 *Structure*

7.3.1.1 The setting of color breakup measurement structure is shown on Figure 5. A rotating or linear moving capture system is used to capture the color breakup phenomenon. A pattern generator is used to present the testing pattern on the field sequential display (FSD).

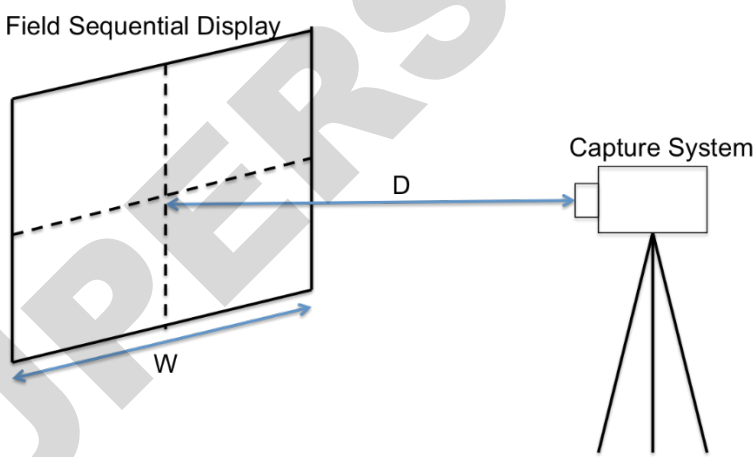

Figure 5
Demonstration of Color Breakup Measurement Setting

7.3.2 *Scroll Speed*

7.3.2.1 Eye saccade is the major reason why we can see the color breakup phenomenon. A saccade is a fast movement of an eye. The peak angular speed of the eye during a saccade reaches up to 100°/sec when we focus on a target[11.1][11.2]. The scroll speed (SS) of CBU measurement can be calculated using Equation 1.

$$SS = \frac{100 \cdot D \cdot \tan(\frac{\pi}{180}) \cdot Resolution}{frame\ rate \cdot W} \tag{1}$$

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