

SEMI D85-0724

GUIDE FOR TONE REPRODUCTION CURVES FOR TRANSPARENT DISPLAYS

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (§) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and §§§) the symbols are used to reference more than one section or paragraph, respectively.

1 Purpose

1.1 sRGB is an IEC recommended default color space for multimedia systems and equipment (IEC 61966-2-1:1999). This Guide uses an approximately 2.2 gamma function for tone reproduction. However, it was optimized for a self-luminous CRT display viewed under a dimly lit environment. As the viewing environment of transparent displays are quite different from that of a CRT, an image displayed on the transparent displays would not give viewers the same visual appearance.

1.2 To reduce the visual mismatch between the sRGB standard and a transparent display, tone correction should be done in the signal processing pipeline. There are two types of underlying transparent display technology, absorptive (chiefly LCDs) and emissive (chiefly electroluminescent, including OLEDs and micro-LEDs). Absorptive devices work by selectively reducing the intensity of the light passing through the display, while emissive devices selectively add to the light passing through the display. As the optical principles of the two major types of transparent display, absorptive transparent display (ATD) and emissive transparent display (ETD), are quite different, they should be studied individually.

2 Scope

2.1 This Guide provides guidelines on tone reproduction curves for transparent displays (ATD and ETD) to obtain similar on-screen visual appearance under different surround conditions using sRGB input signals. This Guide standardizes the method to determine display parameters for implementing the tone reproduction curves. This Guide provides guidelines on light booth design for transparent ATD.

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 This Guide is applicable to RGB-type ATD and ETD flat panel displays under indoor lighting conditions. It does not account for outdoor viewing conditions.

3.2 This Guide is not suitable for an ETD with switchable optical transparency.

3.3 This Guide is not suitable for an ATD with side emitting backlight.

4 Referenced Standards and Documents

4.1 CIE Standards¹

CIE 159 — A Colour Appearance Model for Colour Management Systems: CIECAM02

¹ International Commission on Illumination, CIE Central Bureau, Babenbergstrasse 9/9A, 1010 Vienna, Austria, Telephone: +43.1.714.31.87, <https://cie.co.at>

4.2 IEC® Standards²

IEC 61966-2-1:1999 — Multimedia Systems and Equipment – Colour Measurement and Management – Part 2-1: Colour Management – Default RGB Colour Space – sRGB

IEC/TR 62977-2-4:2018 — Electronic Displays – Part 2-4: Transparent Displays – Overview of Application Scenarios

IEC/TR 62977-2-5:2018 — Electronic Display Devices – Part 2-5: Transparent Displays – Measurements of Optical Characteristics

IEC 62341-6-4:2017 — Organic Light Emitting Diode (OLED) Displays – Part 6-4: Measuring Methods of Transparent Properties

4.3 SID Standards³

IDMS v1.1 — Information Display Measurements Standard

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *ATD* — absorptive transparent display (chiefly transparent liquid-crystal display [T-LCD])

5.1.2 *ETD* — emissive transparent display (chiefly transparent organic electroluminescence display (T-OLED) and transparent micro light emitting diode display [T-μLED])

5.2 Definitions

5.2.1 *ATD White Point Luminance* — a luminance measure comprised of on-screen white and through-screen backlighting.

5.2.2 *ATD Black Point Luminance* — a luminance measure comprised of on-screen black and through-screen backlighting.

5.2.3 *ETD White Point Luminance* — a luminance measure comprised of on-screen white under dark condition.

5.2.4 *ETD Black Point Luminance* — a luminance measure comprised of on-screen black under dark condition.

5.2.5 *ETD Through-Screen Luminance* — a luminance measure comprised of on-screen black and through-screen backlighting.

5.2.6 *surround luminance* — the surround is defined as the field outside the display. Surround luminance is the mean luminance of the viewing field excluding the display area. It can be measured by an array luminance detector.

5.2.7 *tone reproduction curve* — a tone transfer function which maps the non-linear display value form a standard viewing condition to various viewing conditions for preserving visual image appearance. The term is different to electro-optical transfer function (EOTF) which maps the non-linear signal value into display light.

5.2.8 *transparent display* — display modules which show images on the screen and allow objects to be viewed through the screen.

6 Luminance Measurement

6.1 ATD

6.1.1 *Measurement Geometry* — d:0 geometry (diffuse illumination with 0-degree detection) should be used for the measurement of ATD gray-scale luminance, ATD white point luminance and ATD black point luminance.

² International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.919.02.11, <http://www.iec.ch>. IEC trademark is owned by International Electrotechnical Commission.

³ Society for Information Display, 1475 S. Bascom Ave., Ste. 114, Campbell, CA 95008-4006, USA; Telephone: +1.408.879.3901, <https://www.sid.org/>.

6.1.2 Methods

6.1.2.1 33-step IDMS constant-pixel-level grayscale patterns should be used for measuring ATD grayscale luminances. EOTF of the grayscale is generated by plotting the gray levels against the ATD grayscale luminances. Gamma value can be derived from the EOTF data by means of the log-log gamma determination. It is equivalent to the log-log gamma measurement with a 33-step snaking constant pixel level pattern describing in IEC 62341-6-4:2017.

6.1.2.2 33-step IDMS constant-pixel-level grayscale patterns with a white patch at the center should be used for measuring ATD white point luminance.

6.1.2.3 33-step IDMS constant-pixel-level grayscale patterns with a black patch at the center should be used for measuring ATD black point luminance.

6.2 ETD

6.2.1 *Measuring Geometry* — d:0 geometry (diffuse lighting with 0-degree detection) should be used for the measurement of ETD grayscale luminance, ETD white point luminance and ETD black point luminance.

6.2.2 Methods

6.2.2.1 33-step IDMS constant-pixel-level grayscale patterns should be used for measuring ETD grayscale luminances under dark condition. EOTF of the grayscale is generated by plotting the gray levels against the ETD grayscale luminances. Gamma value can be derived from the EOTF data by means of the log-log gamma determination (2021). It is equivalent to the log-log gamma measurement with a 33-step snaking constant pixel level pattern describing in IEC 62341-6-4:2017.

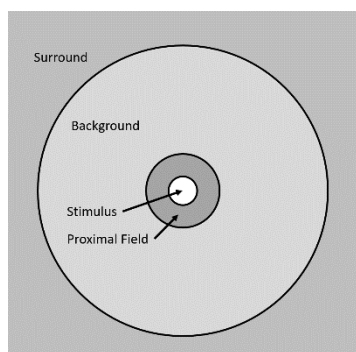
6.2.2.2 33-step IDMS constant-pixel-level grayscale patterns with a white patch at the center should be used for measuring ETD white point luminance.

6.2.2.3 33-step IDMS constant-pixel-level grayscale patterns with a black patch at the center should be used for measuring ETD black point luminance.

7 Tone Reproduction Curves

7.1 Surround Conditions

7.1.1 IEC 61966-2-1 sRGB is the most commonly applied standard for computer-controlled displays. The guide is to obtain similar image appearance as with the sRGB standard across different surround conditions by use of the tone reproduction curves. The surround conditions defined in CIE 159:2004 for CIECAM02 color appearance model are applied in the Guide.



#1 The viewing angles of the stimulus, proximal field and background are about 2, 4, and 10 respectively

Figure 1
Specification of Components of the Viewing Field⁴

⁴ Fairchild M.D. *Color Appearance Models*, 3ed., Wiley (2013): p. 144.