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Journal of the SID

The quarterly *Journal of the SID* publishes original work dealing with the theory and practice of information display. Coverage includes hard and soft copy; the underlying chemistry, physics, physiology, and psychology; measurement techniques; and all aspects of the interaction between equipment and its users.

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The Society for Information Display

A survey of the components of display-measurement standards*

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D. J. Bechis

Abstract — Several display standards are reviewed and distinctive elements are compared. With flat panel displays becoming more common and the CRT displays being so well established, the associated standards activities can be somewhat bewildering, even overwhelming. This paper attempts to identify complementary and inconsistent elements of related display standards.

Keywords — *Display measurement, standards, standards organizations.*

1 Introduction

The growing number and diversity of display applications and technologies and the growing interdependence of users and manufacturers of display devices are both driving a seemingly endless number of standards (1-5). Standards exist because they provide a commercial benefit. Users are assured a certain level of performance, equipment builders can adequately specify their display requirements, and display manufacturers can more easily sell their products.

In November 1994, a workshop was held at the National Institute of Standards and Technology which focused on display standards issues. A number of conclusions were reached: 1) Few companies can afford to follow all the display standards activities in the traditional time-consuming manner which may include costly travel. 2) Few of those working on standards are able to follow what other standards-making bodies are preparing. 3) It would be helpful if people could gain immediate access to all the work being done on display standards. 4) Many would welcome a workshop where display measurement standards were demonstrated in a laboratory. 5) The standards development process can be better implemented in a more timely manner to reduce overlap and inconsistencies. 6) Users of displays need a solid bedrock of measurement standards in order to pick the best display for their application. To successfully address these observations a compilation of existing display standards would be required.

2 Comparisons of display standards

In this paper we attempt to examine a number of display standards and compare their component parts. This is a first step in providing such a comparison and is not comprehensive in that some display standards are not yet included. The listing of components of standards is found in the table as column headings. The standards reviewed are from the following organizations: ISO – International Standards Organization ANSI – American National Standards Institute; EIA – Electronics Industries Association; EC – International Electrotechnical Commission; VESA – Video Electronics Standards Association; SAE – Society of Automotive Engineers; MPR – from the Swedish National Board for Measurement and Testing; and standards from the US military.

There are several entries in the component columns of the table — the first two columns — which need explanation, although most entries will be self-explanatory to display technologists. Small area luminance includes character and individual dot or pixel luminances, whereas large area luminance integrates the luminance contributions over an area of the screen. Under Luminance and Colors the term "gamma" has historical origins with CRTs and refers to the electrooptic transfer function or power-law dependence of the luminance (or any color) upon voltage $L(V) \propto V^{\gamma}$, where γ is a constant typically near 2.3. Loading is the change in luminance of white as the area of the white changes, that is, the luminance can depend upon area L(A). Under Line width, Positive refers to narrow black lines on white vs. Negative, white lines on black. MTF is the modulation transfer function, and MTFA is its area. Character modulation quantifies character generation contrast as with, for example, a one-on-two-off pixel arrangement. Raster modulation characterizes the visibility of separate raster lines using a full-field all-on uniform pattern. Small area linearity provides a metric for localized character misalignment, whereas large area linearity quantifies line separation uniformity about the screen. Defects, Spurious Illumination

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Display Standards Survey Summary Table

COMPONENT \ STANDARD		ISO 9241 Part 3	ISO 9241 Part 7	ISO 9241 Part 8	ISO 13406 Draft 2	ANSI HFS-100 1988	ANSI IT7.215 1992	EIA TEB 27	EIA TEP 105	VESA (1)	NIDL (2) Part 1 Mono.	NIDL (2) Part 2 Color	SAE ARP 1782	SAE ARP 4260	MPR 1990:8 1990:10	Air Force AFGS 87213A	IEC SC 47C
Display Type	CRT	●	●	●		●		●	●	●	●	●	●		●	●	
	Flat panel				●									●	●	●	●
	Projection						●										
Initial setup		●	●	●	●	●	●				●	●	●				
Colorimetric Attributes																	
Warm-up L(t)											●					●	
Luminance	Small area	●		●		●							●	●	●		
	Large area	●		●	●	●	●		105	●	●	●	●	●	●	●	
	No. of levels												●			●	
	Gamma									●	●	●					
White point	Small area			●		●									●		
	Large area			●	●	●			105-11-A	●	●	●	●		●	●	
Colors	Gamut			●	●												
	Default colors			●	●	●							●			●	
	Gamma									●	●	●					
Uniformity	Luminance	●			●	●	●			●	●	●	●	●	●	●	
	Chromaticity			●	●	●				●	●	●	●	●		●	
Contrast	Contrast ratio	●			●	●			105-10	●			●	●		●	●
	Small area	●				●				●							●
	Large area	●			●	●	●		105-10	●			●	●		●	
	with Ambient	●			●	●			105-10	●			●			●	●
Loading L(A)											●						
Halation											●						
View angle					●								●		●	●	
Polarization														●			
Resolution																	
Resolution from addressability														●			
Resolution Addressability Ratio							●	●	105	●	●	●				●	
Line width	Mono. Negative	●			●	●			105-7-A	●	●	●	●		●		
	Mono. Positive	●			●	●		●						●		●	
	Color Negative	●				●		●	105-9	●		●	●			●	
	Color Positive	●															
Crosstalk														●			
Modulation	Monochrome						●		105-17		●				●	●	
	Color											●					
	Raster	●									●	●			●		
	MTF								105,-3,-8		●	●			●	●	
	MTFA					●									●		
	Character	●			●	●									●	●	
Convergence				●						●		●	●				

Display Standards Survey Summary Table - Continued

		ISO				ANSI		EIA		VESA	NIDL		SAE		MPR	Air Force	IEC
		9241			13406	HFS-100	IT7.215	TEB	TEP		Part 1	Part 2	ARP	ARP	1990:8	AFGS	SC 47C
		Part 3	Part 7	Part 8	Draft 2	1988	1992	27	105		Mono.	Color	1782	4260	1990:10	87213A	
Geometric Attributes																	
Linearity	Small area	●			●	●											
	Large area	●								●	●				●	●	
Waviness	Small area	●			●	●					●				●		
	Large area	●							105		●				●		
Size	Small area	●		●	●	●				●					●		
	Large area	●								●	●		●		●		
Orthogonality		●				●				●			●		●		
Tilt		●				●				●			●				
Trapezoid		●				●				●			●				
Reflection	Specular		●		●				105-13	●	●		●	●	●	●	●
	Diffuse		●		●				105-12		●		●	●	●	●	●
Fill factor		●			●												
Temporal Attributes																	
Stability	Jitter	●				●					●				●	●	
	Flicker	●			●	●					●				●	●	
Bandwidth							●			●							
Phosphor	Decay								105-14	●							
	Saturation								105-16								
Image retention														●			
Pixel response					●									●			●
Defects	Blemishes																
	Spurious Illum.								105								
	Pixel				●									●			
Degradation									105-15							●	
Physical Attributes	(Other)				●										●		●
	Size									●						●	
	Weight									●						●	
	Tilt									●							
	Viewing area									●							
Display Environment		●	●	●	●	●				●			●			●	
Equipment	Specifications	●	●	●	●	●	●				●	●	●	●	●		
	Calibration	●	●	●	●	●	●				●	●	●	●	●		

(1) VESA Standard: Display Specifications and Test Procedures.
(2) NIDL: Procedures for Evaluation and Reporting the Capabilities of High Performance Display Monitors for Imagery Applications.

refers to an unwanted background luminance which cannot be eliminated by brightness adjustments. For more details and identification of these measurements, refer to the standards documents.

3 Comments and observations

From the table it is evident that there is a great deal of overlap among the various display standards, yet the methods of measurements for the same measurand, or component of the standard, are not the same. In addition, one finds a wide range of detail describing precisely how any measurement is to be made and reported. Take, for example, the measurement of resolution.

Of the standards surveyed, measurement procedures for evaluating the resolution of a visual display involve luminance modulation or line-width measurements. There is some agreement among the standards that resolution measurements be performed in a darkened room with test patterns displayed at the maximum luminance. For color displays, resolution measurements of tricolor white are usually required, and line width is measured at the full-width-half-maximum of the luminance profile.

However, line-width measurement methods vary in several ways. Most standards specify line width to be measured across one-pixel wide lines, while others specify character stroke width to be measured across a variety of text characters of various pixel widths including "M," "H," and "m." Standards intended for testing stand-alone CRTs exclude video amplifier effects on line width by restricting the measurement to raster scan lines.

Luminance modulation methods also vary in several ways. While most require darkroom conditions, there is some disagreement among standards regarding ambient illumination and test patterns used for luminance modulation measurements. Most standards specify measuring luminance modulation across one-pixel-on/one-pixel-off grille patterns while others specify the use of text consisting of "MEME", "m", or "e" characters. A minority of standards specify using the shrinking raster method to determine resolution at specified levels of modulation. Other standards intended for stand-alone CRTs further restrict the shrinking raster method to the measurement of raster scan lines, thereby, eliminating video amplifier effects.

Perhaps the greatest disparity among existing standards for measuring resolution is the variety of special techniques, or lack thereof, for analyzing the line width and luminance modulation profiles of a color shadowmask CRT. Methods include connecting the peaks of the luminance profile, numerically filtering the profile data, fitting the profile with a Gaussian curve, and using moving beam methods to eliminate shadowmask effects altogether. Inconsistencies among the various standard measurement methods produce differences in results which make a fair comparison of display resolution impossible.

Better communication between standards bodies should provide a more uniform consensus on measurement methods. With the current interest in electronic information transfer over networks, it is natural to ask if such standards activities can be coordinated electronically and not require the travel which presently makes participation so difficult. The traditional iterative meeting process seems too slow for the rapidly advancing display technologies. It may, indeed, be time to consider an electronic solution.

Improvements might be realized if a buffet of measurement standards existed from which manufacturers and users could pick and choose. Developing that set of measurement procedures that is unambiguous, that applies to multiple display technologies, and that is practical and cost-effective to utilize is one approach to establishing standards that would move the technology in a Positive direction.

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