Clairvoyante
1601 S. De Anza Blvd.
Suite 215
Cupertino, CA 95014
t: 408.200.7300
f: 408.200.7305
www.clairvoyante.com

Application Note

Measuring Display Resolution with Contrast Modulation Methodology

Introduction

Illustrated below are a conventional RGB Stripe subpixel arrangement and a higher-efficiency PenTile RGBW™ subpixel arrangement (Figure 1). Using fewer subpixels, the PenTile RGBW pattern on the right renders information at the same resolution as a conventional RGB Stripe pattern. Displays made using the PenTile RGBW pattern offer improvements in cost performance and power efficiency compared to conventional RGB Stripe displays, due to the combined effect of increased aperture ratio and improved light transmission through the white (clear) subpixel.

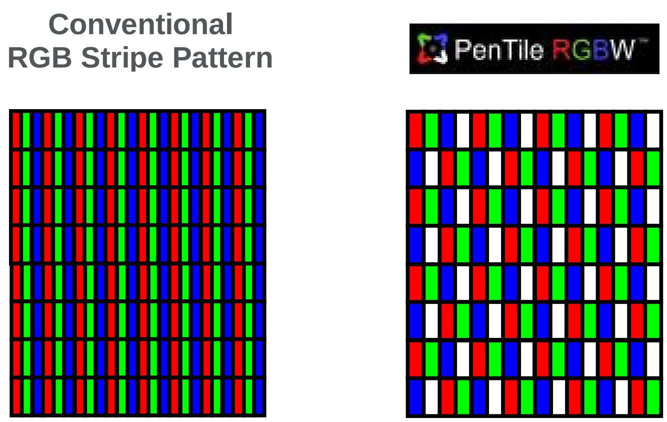


Figure 1

A conventional RGB Stripe subpixel arrangement (left), and a PenTile RGBW subpixel arrangement (right) utilizing 33% fewer subpixels. Despite the difference in subpixel count, the resolution is equivalent.

A consistent methodology for determining resolution independent of display technology or subpixel layout is provided by the Video Electronics Standards Association, a non-profit corporation formed in 1989 which "promotes and develops timely, relevant, open standards for the display and display interface industry, ensuring interoperability and encouraging innovation and market growth." Novel subpixel arrangements such as PenTile RGBW, as well as other emerging new display technologies, prompt the question of how resolution should be measured when technology and structural differences complicate direct comparison. This document explains how VESA's definition of resolution applies in the comparison of the conventional RGB Stripe pattern to Clairvoyante's PenTile RGBW architecture.

VESA Flat Panel Display Measurement Standards

The VESA Display Metrology Committee defines resolution in Section 303-7 of Flat Panel Display Measurements Standard Version 2.0 [1] as "the number of alternate black and white lines that can be displayed with a stated minimum contrast modulation", and establishes a contrast modulation threshold (C_T) of 50% as the standard for displaying crisp edges on text and graphics.

[1] VESA Display Metrology Committee, "Video Electronics Standards Association Flat Panel Display Measurements Standard Version 2.0," Section 303.7 Resolution from Contrast Modulation, pp. 76-77, June 1, 2001.

VESA FPDM Standard Section 303-2 [2] provides 1x1 grille test patterns (Figure 2 at right) and a measurement methodology appropriate for determining the maximum number of alternating black and white lines that meet or exceed 50% contrast modulation.

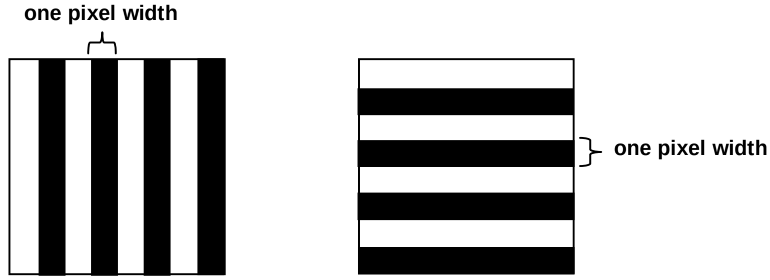


Figure 2a
1x1 vertical grille test pattern for horizontal contrast modulation

Figure 2b
1x1 horizontal grille test pattern for vertical contrast modulation

Contrast modulation (C_m) is defined in VESA FPDM Standard Section 303-7 as the difference between the white-line luminance (L_w) and black-line luminance (L_b) divided by the sum of the white-line luminance and the black-line luminance. To determine the white-line luminance and the black-line luminance, one must compute a luminance profile of the alternating black and white lines and perform a moving window average. The averaging window is one pixel wide. Please note that one pixel width encompasses three subpixels on an RGB Stripe display, and only two subpixels on a PenTile RGBW display. The white luminance is the maximum value of the moving window average, and the black luminance is the minimum value, which typically occurs 180 degrees out of phase:

$$\mathbf{C_m} = \frac{\mathbf{L_w - L_b}}{\mathbf{L_w + L_b}}$$

where $\mathbf{L_w}$ is the white-line luminance and $\mathbf{L_b}$ is the black-line luminance

The horizontal contrast modulation for a 1x1 vertical grille on an RGB Stripe display is theoretically 100% (see Horizontal Contrast Modulation: RGB Stripe, below). On a PenTile RGBW display, the same 1x1 vertical grille exhibits a theoretical horizontal contrast modulation of approximately 85% to 100% — well above the aforementioned 50% threshold (see Horizontal Contrast Modulation: PenTile RGBW, below). ***Therefore RGB Stripe and PenTile RGBW displays are capable of rendering the same horizontal resolution*** as defined by VESA FPDM Standard Section 303-7, despite the fact that the PenTile RGBW pattern employs 33% fewer subpixels.

Note that certain non-ideal effects such as cross-talk or light leakage may degrade the contrast modulation (even for RGB Stripe displays), but this is a relatively minor factor; given the theoretical calculations there is a considerable performance margin which allows actual displays of both patterns to easily exceed the 50% threshold.

The vertical contrast modulation on a 1x1 horizontal grille is theoretically the same (100%) for a PenTile RGBW display as it is for an RGB Stripe display (see Vertical Contrast Modulation: RGB Stripe and PenTile RGBW, below). ***Therefore RGB Stripe and PenTile RGBW displays are capable of rendering the same vertical resolution***, as defined by VESA FPDM Standard Section 303-7.

The following sections provide detail of the calculation of contrast modulation for RGB Stripe and PenTile RGBW displays in both the vertical and horizontal axis.

[2] VESA Display Metrology Committee, "Video Electronics Standards Association Flat Panel Display Measurements Standard Version 2.0," Section 303-2 N x N Grille Luminance and Contrast, pp. 62-63, June 1, 2001.

Horizontal Contrast Modulation: RGB Stripe

A magnified view of a 1x1 vertical grille test pattern rendered on an RGB Stripe display is shown below (Figure 3) with a corresponding table of data values (Figure 4).

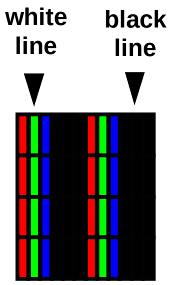


Figure 3. 1x1 vertical grille on RGB Stripe

	white line									black line	
255	255	255	0	0	0	255	255	255	0	0	0
255	255	255	0	0	0	255	255	255	0	0	0
255	255	255	0	0	0	255	255	255	0	0	0
255	255	255	0	0	0	255	255	255	0	0	0

Figure 4. Data values for segment of RGB Stripe display

The RGB Stripe luminance (Y) values corresponding to the data values in Figure 4 appear at the right (Figure 5). Note that these luminance values are color-filter dependent, and assume luminance values typical of mobile phone color filters:

$$Y_{red} = 25$$
$$Y_{green} = 62.5$$
$$Y_{blue} = 12.5$$

25.0	62.5	12.5	0.0	0.0	0.0	25.0	62.5	12.5	0.0	0.0	0.0
25.0	62.5	12.5	0.0	0.0	0.0	25.0	62.5	12.5	0.0	0.0	0.0
25.0	62.5	12.5	0.0	0.0	0.0	25.0	62.5	12.5	0.0	0.0	0.0
25.0	62.5	12.5	0.0	0.0	0.0	25.0	62.5	12.5	0.0	0.0	0.0

Figure 5. Luminance values for segment of RGB Stripe display

The total luminance for a sample comprising the four-row sample pictured in Figure 5 is provided as Figure 6. Then calculating the moving window average luminance from these values and normalizing the results yields the graph pictured in Figure 7.

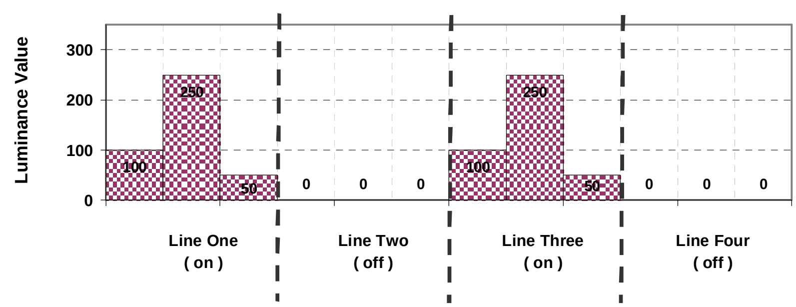


Figure 6. Total luminance for four-row horizontal sample of RGB Stripe display

The calculated contrast modulation of this RGB Stripe panel is 100%. Note that cross-talk and light leakage may marginally degrade this contrast modulation on a real panel.

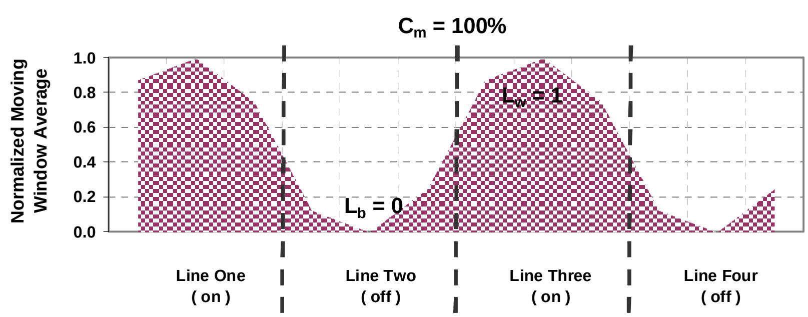


Figure 7. Moving-window-average luminance for RGB Stripe display

Horizontal Contrast Modulation: PenTile RGBW

A magnified view of a 1x1 vertical grille test pattern rendered on a PenTile RGBW display is provided below (Figure 8) with a corresponding table of data values (Figure 9). Note that modulation of black and white lines is accomplished with a two-subpixel width, compared to the RGB Stripe display which requires three.

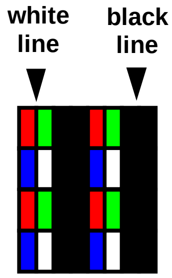


Figure 8. 1x1 vertical grille on PenTile RGBW

white line						black line	
255	255	0	0	255	255	0	0
255	255	0	0	255	255	0	0
255	255	0	0	255	255	0	0
255	255	0	0	255	255	0	0

Figure 9. Data values for segment of PenTile RGBW display

The PenTile RGBW luminance (Y) values corresponding to the data values in Figure 9 appear in Figure 10 (right). Again, these luminance values are color-filter dependent, and assume luminance values typical of mobile phone color filters:

$Y_{red} = 25$
$Y_{green} = 62.5$
$Y_{blue} = 12.5$
$Y_{white} = 100$

25	62.5	0	0	25	62.5	0	0
12.5	100	0	0	12.5	100	0	0
25	62.5	0	0	25	62.5	0	0
12.5	100	0	0	12.5	100	0	0

Figure 10. Luminance values for segment of PenTile RGBW display

The total luminance for a sample comprising the four-row sample pictured in Figure 10 is provided as Figure 11. Then calculating the moving window average luminance from these values and normalizing the results yields the graph pictured in Figure 12.

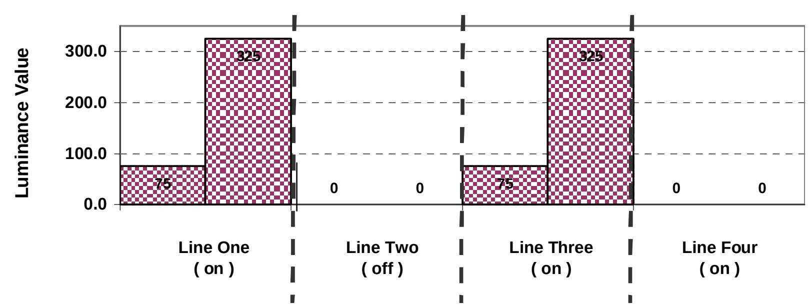


Figure 11. Total luminance for four-row horizontal sample of PenTile RGBW display

The calculated contrast modulation of this PenTile RGBW panel is 100%. Note that cross-talk and light leakage may marginally degrade this contrast modulation on a real panel.

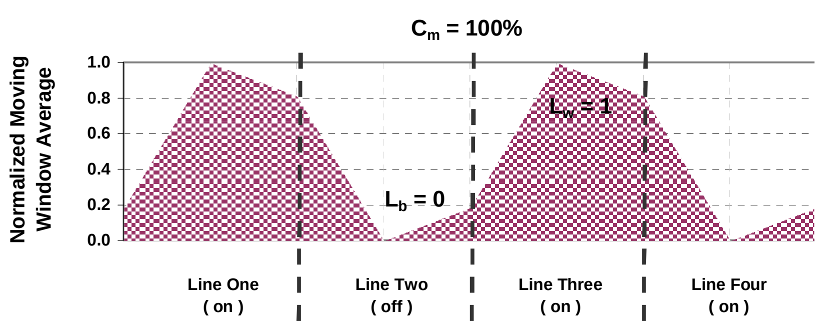


Figure 12. Moving-window-average luminance for PenTile RGBW display

In addition, a PenTile RGBW display can operate in an alternative mode that shifts the mapping of the blue subpixels. A magnified view of a 1x1 vertical grille test pattern rendered with this alternative mapping is provided below (Figure 13) with a corresponding table of data values (Figure 14). Note that modulation of black and white lines is still accomplished with a two-subpixel width.

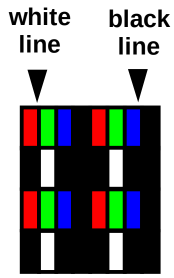


Figure 13. 1x1 vertical grill PenTile RGBW (alternative mapping)

white line black line

255	255	255	0	255	255	255	0
0	255	0	0	0	255	0	0
255	255	255	0	255	255	255	0
0	255	0	0	0	255	0	0

Figure 14. Data values for segment of PenTile RGBW display (alternative mapping)

The PenTile RGBW luminance (Y) values corresponding to the data values in Figure 14 appear at the right (Figure 15). Again, these luminance values are color-filter dependent, and assume luminance values typical of mobile phone color filters:

Y_{red} = 25
Y_{green} = 62.5
Y_{blue} = 12.5
Y_{white} = 100

25	62.5	12.5	0	25	62.5	12.5	0
0	100	0	0	0	100	0	0
25	62.5	12.5	0	25	62.5	12.5	0
0	100	0	0	0	100	0	0

Figure 15. Luminance values for segment of PenTile RGBW display (alternative mapping)

The total luminance for a sample comprising the four-row sample pictured in Figure 15 is provided as Figure 16. Then calculating the moving window average luminance from these values and normalizing the results yields the graph pictured in Figure 17.

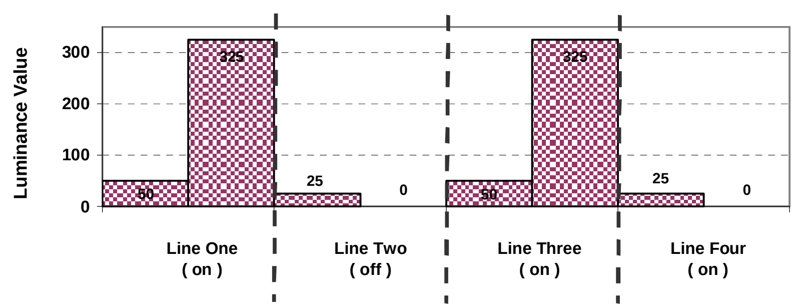


Figure 16. Total luminance for four-row horizontal sample of PenTile RGBW display (alternative mapping)

The calculated contrast modulation of this PenTile RGBW display using the alternative mapping is 87.5%. Note that cross-talk and light leakage may marginally degrade this contrast modulation on a real panel.

Both versions of PenTile RGBW mapping perform far above the 50% contrast threshold.

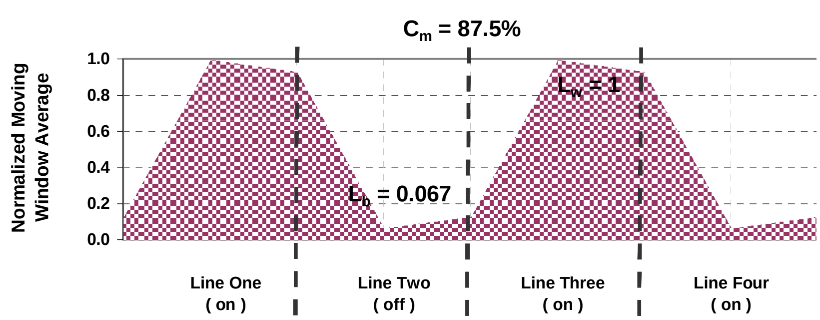


Figure 17. Moving-window-average luminance for PenTile RGBW display (alternative mapping)

Vertical Contrast Modulation: RGB Stripe and PenTile RGBW

A magnified view of a 1x1 horizontal grille test pattern rendered on an RGB Stripe display and a PenTile RGBW display is provided below (Figure 18).

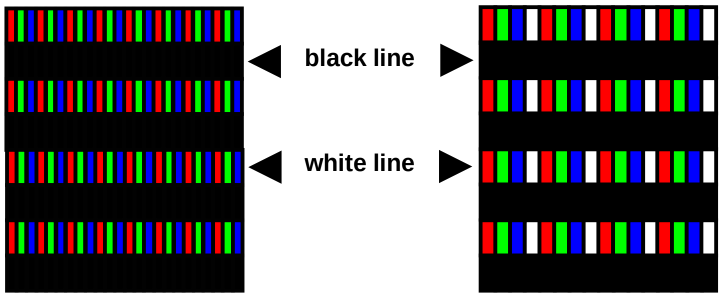


Figure 18. The RGB Stripe (left) and PenTile RGBW (right) subpixel arrangements exhibit the same vertical resolution.

Horizontal lines on either subpixel arrangement have the same vertical luminance profile, and thus the same contrast modulation. Theoretically both patterns have no luminance in the black lines (L_b=0), and therefore C_m=100% in both cases — well above the minimum contrast modulation threshold of 50%. Again, Note that cross-talk and light leakage may marginally degrade this contrast modulation on real panels.

Summary

As new display technologies emerge, a device-independent definition of resolution is essential. VESA FPDM Standard Sections 303-2 and 303-7 (attached) provide a means for determining effective resolution which does not rely on physical structure, and instead focuses on objective measurements of performance which relate directly to human visual perception. Applying this measurement methodology, PenTile RGBW delivers resolution equivalent to conventional RGB Stripe while providing a flexible mix of cost reduction, performance improvement, and power savings.

FPDM

VESA

VIDEO ELECTRONICS STANDARDS ASSOCIATION

DISPLAY METROLOGY COMMITTEE

FLAT PANEL DISPLAY MEASUREMENTS STANDARD

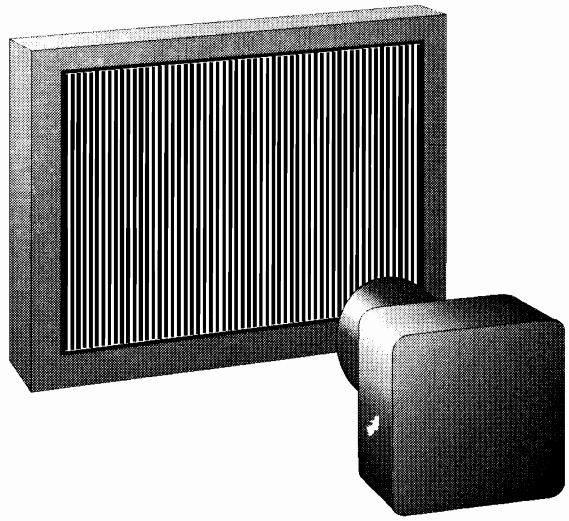
Version 2.0

Abstract: *This is a standard to provide measurement procedures to quantify flat panel display characteristics. Performance criteria or performance minima are not specified; rather, a series of measurements are clearly detailed to enable unambiguous and reproducible measurements of displays using the simplest instrumentation that will provide adequate results. All measurements need not be performed. The measurements that are most applicable to the display purposes can be selected as desired. Diagnostics and metrological difficulties are addressed, and technical discussions are presented to assist those unfamiliar with light measurements.*

June 1, 2001

303-2 N × N GRILLE LUMINANCE AND CONTRAST

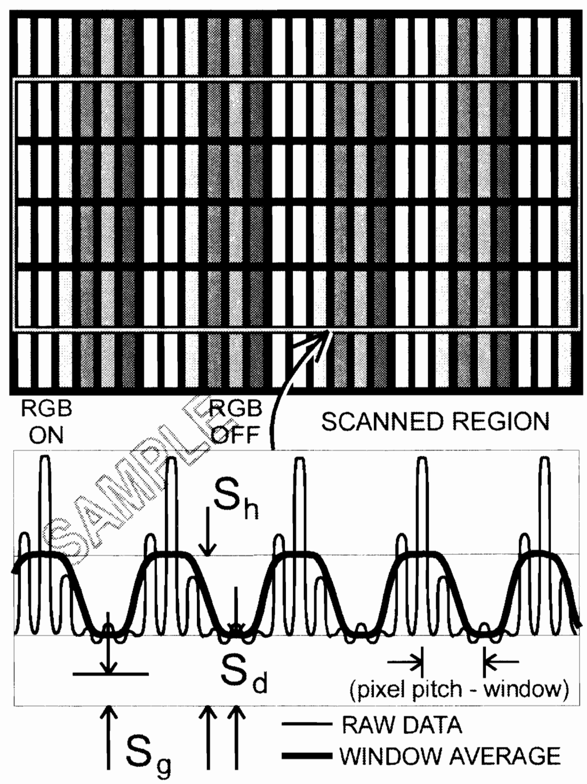
WARNING
This measurement can be grossly inaccurate unless proper accounting (and/or correction) is made for veiling glare or lens flare (A101-2).



DESCRIPTION: Measure the small area luminances at the center of the screen of horizontal and vertical grille test patterns consisting of alternating white and black horizontal or vertical lines covering the entire screen. Calculate the contrast ratio obtained (or other suitable contrast metric). **Units:** cd/m^2 if absolute luminance is needed, none for contrast (a ratio). **Symbol:** C_G (optionally C_m)

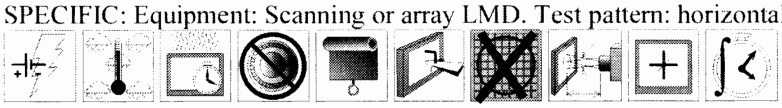
The difficulty is to accurately determine the luminance of the black line L_b between white lines L_w of the same width without corruption from, for example, the lens system of the LMD or reflections between the LMD and the FPD. We call for the contrast ratio $C_G = L_w / L_b$, here, but other contrast metrics may be used provided they are documented and all interested parties agree to their use. [Optionally, the Michelson contrast is $C_m = (L_w - L_b)/(L_w + L_b)$.] An $n \times n$ grille is either horizontal or vertical alternating white and black lines each having a width of n pixels. It is important in such measurements to attempt to account for any contrast-reducing glare (veiling glare) in the measurement system. One use of C_m is found in 303-7 in determining the actual resolution of a display.

Note: Black and white are described here. Gray shades (or colors) may also be used provided all interested parties are in agreement and all reporting documentation clearly describes any changes.



SETUP: Alternatively display a horizontal grille and then a vertical grille test pattern and arrange for a spatially resolving LMD to measure the luminance profiles at screen center. Start with 1 × 1 grilles. Some display technologies will display a noticeable flicker when displaying a 1 × 1 horizontal grille; should that be the case, then use a 2 × 2 horizontal grille instead. A correction must be made for veiling glare (see Veiling Glare and Lens Flare Errors section A101-1). Arrange to measure an integral number of rows (or columns). See Section 301 for standard setup details.

SPECIFIC: Equipment: Scanning or array LMD. Test pattern: horizontal grille, vertical grille.



PROCEDURE: With an array or scanning LMD, measure luminance profiles for both horizontal and vertical grille patterns subject to above setup conditions. Obtain the net signal S as a function of distance with any background subtracted (this is the background inherent in the detector if a nonzero signal exists for no light input). A correction for veiling glare S_g must be made (see A101-1Veiling Glare and Lens Flare Errors for proper procedures). See the figure for an illustration of the pixel configuration and data.

ANALYSIS: Perform a running average (moving-window-average filter, see A218 for details) of each luminance profile where the averaging window width is as close as possible to the pixel pitch as rendered by the LMD. For an array detector this is however many detector array pixels are needed to cover one display pixel. There should be at least 10 or more detector pixels per display pixel, if possible. For example, if an array detector is used and with the magnification of the imaging lens there are 53 array pixels which cover the DUT pixel pitch, then the running average window width is 53 array pixels wide. From the resulting modulation curve determine (1) the net level of the grille black lines $S_b = S_d - S_g$, where S_d is the minimum of the grille black lines, and (2) the net level of the grille white lines between the specified black lines $S_w = S_h - S_g$, where S_h is the average maximum of the grille white lines. Compute the grille contrast ratio $C_G = S_w/S_b$ for horizontal and for vertical grille patterns. In summary:

Analysis (Sample Data)	
Orientation	*Ver.*
Grille	*1 x 1*
Glare: S_g	*1772*
High: S_h	*7559*
Dim: S_d	*2467*
$S_w = S_h - S_g$	*5787*
$S_b = S_d - S_g$	*695*
$C_G = S_w/S_b$	*8.3*
C_m	*0.786*
Orientation	*Hor.*
Grille	*2 x 2*
Glare: S_g	*1342*
High: S_h	*7623*
Dim: S_d	*1983*
S_w	*6281*
S_b	*641*
C_G	*9.8*
C_m	*0.814*

$$\begin{aligned} S_w &= S_h - S_g \\ S_b &= S_d - S_g \\ C_G &= S_w/S_b \\ C_m &= \frac{S_w - S_b}{S_w + S_b} \end{aligned}, \quad \text{where} \quad \begin{cases} S_g = \text{glare correction} \\ S_h = \text{white line average (high)} \\ S_d = \text{black line average (dim)} \\ S_w = \text{net white value} \\ S_b = \text{net black value} \\ C_G = \text{grille contrast} \\ C_m = \text{Michelson contrast or contrast modulation} \end{cases}$$

The sample data shown here are net CCD counts from a photopic camera. The CCD counts S are only proportional to the luminance values.

REPORTING: Report the grille contrast ratio C_G as a number to no more than three significant figures. Also report the type of grille pattern used. It is suggested that the mask, net white, and net black signals be presented as well. The luminance of the white and black lines may be reported if the device is properly calibrated for absolute luminance measurements.

Reporting Results - Sample Data		
Grille Contrasts	Horizontal Grille	Vertical Grille
Grille type:	*2 x 2*	*2 x 2*
C_G	*3.1*	*2.3*
L_w	*13.8 cd/m²*	*9.82 cd/m²*
L_b	*4.45 cd/m²*	*4.41 cd/m²*
L_{ave}	*9.13 cd/m²*	*7.12 cd/m²*

COMMENTS: Grille contrast ratio measurements are required for the determination of true resolution because spatial resolution capabilities of the DUT may or may not be closely correlated with the addressability. The contrast ratio of a display is very sensitive to an accurate black measurement, and hence any veiling glare measurement, see Uncertainty Evaluations (A108) in the Metrology Appendix. There may be complications associated with making small area contrast measurements, see Veiling Glare and Lens Flare Errors (A101).

303-7 RESOLUTION FROM CONTRAST MODULATION

(effective resolution)

DESCRIPTION: We measure the resolution capabilities of a display compared to its addressability based on a threshold contrast modulation (Michelson contrast) associated with grille patterns.

Addressability refers to the number of pixels that can be separately controlled. **Resolution** refers to how well those pixels can appear separate and distinct to the eye. Describing resolution with a simple number, such as 1600 x 1200 pixels, is an approximation to a complicated subject. We define resolution here as the number of alternate black and white lines that can be displayed with a stated minimum contrast modulation (Michelson contrast), the threshold contrast modulation C_T. If the display fails to meet this criterion for a specified addressability, then the addressability cannot be claimed as resolution in describing the display—the actual resolution would be lower than the addressability. In the case of a CRT, displaying more pixels than that will lower the contrast modulation below the minimum acceptable visibility of lines. In the case of discrete-pixel FPDs, such lowering of the resolution capabilities can arise from excessive inter-pixel crosstalk. Here, the contrast modulation is defined as:

$$C_m = \frac{L_w - L_b}{L_w + L_b}$$

We use two criteria to allow us to assign meaningful numbers to realizable resolution for two common applications. We examine the values for horizontal and vertical resolution separately.

Text resolution (and graphics) require crisp edge definition and clear whites and blacks. We define the resolution for this use as the maximum number of alternating black and white lines that can be displayed with a threshold contrast modulation C_T of 50 % or more. A contrast modulation of 50 % produces alternating lines that are highly visible.

Image resolution typically does not require sharp changes in luminance. For monitors displaying images rather than text, we define the resolution using a minimum C_T of only 25 %. A pattern of alternating black and white lines with 25 % contrast modulation is still visible.

Demanding a higher contrast modulation threshold for text than for images can mean that the claimed resolution may be lower for text in some cases. Two thresholds are suggested above depending upon the task. Other thresholds may be used if necessary provided all interested parties are in agreement. Different tasks may require different thresholds to be used.

SETUP: None. Measurements of N × N grille contrast modulations are specified in 303-2.

PROCEDURE: None. Measurements of N × N grille contrast modulations are made in 303-2.

ANALYSIS: Calculate the resolution in number of resolvable pixels:

$$\text{Resolution} = \frac{\#\text{ of Addressable Lines}}{n_r}$$

where n_r is the calculated grille line width in pixels for which the value of C_m is estimated by linear interpolation to be equal to the contrast modulation threshold C_T, for example, 25 % as depicted in Fig. 1. $C_m(n)$ specifies the contrast modulation from an $n \times n$ grille.

If $C_m(1) > C_T$ (e.g., 25 %), then $n_r = 1$ and the resolution is equal to the number of addressable pixels. For $C_m(1) < C_T$, use linear interpolation to calculate the value of n_r from the measured C_m values nearest to the threshold C_T (e.g., 25 %). In general, use values of C_m such that $C_m(n) < C_T < C_m(n+1)$, measured for grille patterns of n-pixels wide lines and $(n+1)$-pixels wide lines.

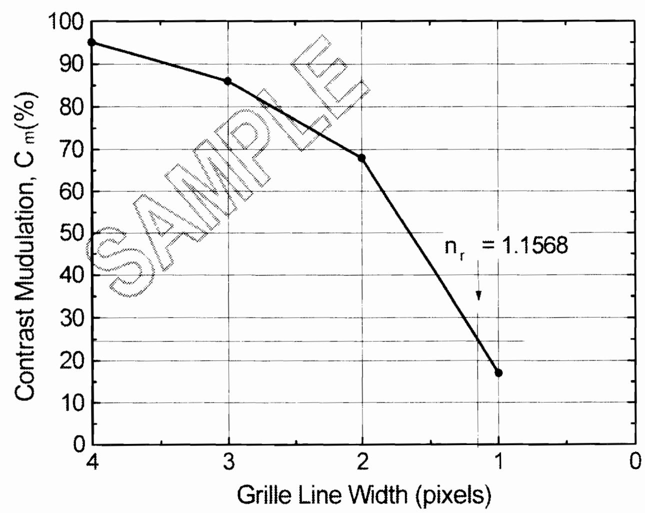


Fig. 1. Use linear interpolation to determine the value of n_r *from contrast modulation measurements.*

$$n_r = n + \frac{C_T - C_m(n)}{C_m(n+1) - C_m(n)}, \quad \text{for } C_m(n) < C_T < C_m(n+1)$$

Example: Let CT = 25 %, C_m = 17 % for 1-pixel grille patterns, and C_m = 68 % for 2-pixel grille patterns. Interpolate between these two data points to calculate the value of n_r for 25 % modulation, that is, using C_T = 25 %: for n = 1, $C_m(1)$ = 0.17; $C_m(2)$ = 0.68. For these values, n_r and the resolution are found to be

$$n_r = n + \frac{C_T - C_m(n)}{C_m(n+1) - C_m(n)} = 1 + \frac{0.25 - 0.17}{0.68 - 0.17} = 1.1568$$

$$\text{Resolution} = \frac{\text{\# of Addressable Lines}}{n_r} = \frac{1024}{1.1568} = 885 \text{ lines}.$$

Apply this criterion to the measured contrast modulation data C_m to assess the resolution capabilities of the display in units of pixels in both horizontal and vertical directions.

REPORTING: Report the integer number of resolvable pixels using the values of C_m obtained in previous sections. Report as a pair of numbers for horizontal and vertical directions, $C_{mH} \times C_{mV}$, for each measurement location on the screen required.

Worst location is defined as the test location on the screen where the minimum combined horizontal and vertical contrast modulation occurs. The combined contrast modulation is the magnitude calculated using the root-mean-of-squares:

$$C_m = \sqrt{(C_{mH}^2 + C_{mV}^2)/2},$$

where C_{mH} is horizontal contrast modulation and C_{mV} is vertical contrast modulation of white lines.

Reporting Results — Sample Data			
Threshold:	25 % (0.25)		
Horizontal		Vertical	
C_{mH} 1x1	0.17	C_{mV} 1x1	0.34
C_{mH} 2x2	0.68	C_{mV} 2x2	0.88
C_{mH} 3x3	0.86	C_{mV} 3x3	0.94
C_{mH} 4x4	0.95	C_{mV} 4x4	0.98
n	1	n	—
n_r	1.157	n_r	1
Addressability	1024	Addressability	768
Resolution	885	Resolution	768

COMMENTS: Resolution is often the first specification one asks about a display. It is essential to distinguish between the concepts of *addressability* and *resolution*:

- ***Addressability*** states the number of locations at which a pixel (dot) can be displayed on the screen. However, that does not guarantee that the spot of light is small enough to actually *distinguish* adjacent addressable spots.
- ***Resolution*** is the number of pixels (or lines) that can be adequately distinguished across the screen.
- *Contrast modulation* C_m is considered by some to be the best and most complete single-metric description of the ability of a display to exhibit information.
  If the display were perfect, the screen would show a series of full white bars with perfectly black bars between them, yielding a C_m of 100 %. In reality, several factors combine to spread the light out so that the pattern is one of light and dark gray bars, not black and white. Among these are:
- The ability of the display to form a narrow line, e.g., problems with crosstalk.
- The accuracy with which the three color beams merge together (in the case of a CRT).
- Halation – the leakage of light from bright areas of the image into the dark areas because of reflections off the covering material, the interior parts of the display, and the display pixel surface.

A pixel definition based solely on C_m relies only on relative peak and valley luminances independent of absolute luminance. The ANSI pixel defined in ANSI/NAPM IT7-215 limits the allowable luminance rolloff at higher frequencies by requiring the peak luminance of the display at the highest spatial frequency does not degrade below 30 % of the low-frequency peak luminance, specifically that of the 4 x 4 checkerboard pattern. The ANSI pixel modulation is defined as the (peak - valley) luminance of a 1-on/1-off grille relative to the (white - black) luminance of the ANSI large-area 4 x 4 checker board test pattern. Using linear interpolation, an estimate of the ANSI pixel can be computed using results obtained by measurement procedures described in FPDM Sections 303-2 (NxN Grille Contrast Ratio) and 303-9 (Checkerboard Contrast Ratio).