INTERNATIONAL STANDARD

IEC 61947-2

First edition
2001-09

Electronic projection – Measurement and documentation of key performance criteria –

Part 2: Variable resolution projectors

Reference number
IEC 61947-2:2001(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/catlg-e.htm) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/JP.htm) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 61947-2

First edition
2001-09

Electronic projection – Measurement and documentation of key performance criteria –

Part 2: Variable resolution projectors

International Electrotechnical Commission 3, rue de Varembé Geneva, Switzerland
Telefax: +41 22 919 0300 e-mail: inmail@iec.ch IEC web site http://www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE X

For price, see current catalogue

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRONIC PROJECTION – MEASUREMENT AND DOCUMENTATION OF KEY PERFORMANCE CRITERIA –

Part 2: Variable resolution projectors

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61947-2 has been prepared by subcommittee 100C: Audio, video and multimedia subsystems and equipment, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this standard is based on the following documents:

FDIS	Report on voting
100/268/FDIS	100/418/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

Annexes A, B, D, and G form an integral part of this standard.

Annexes C, E, F, H, I and J are for information only.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

This standard was developed to ensure a common, meaningful description of key performance parameters for variable resolution projectors (for example, CRT or laser projectors). The measurement methods and test signals correlate closely to typical uses involving computer-generated text and graphics displays. These measurements evaluate the actual viewable image that emanates from variable resolution projectors. The resulting performance specifications are conservative in nature and allow any display device to be used beyond its rated specifications with degraded performance. The point at which this degraded performance is no longer useful is highly subjective and strongly affected by the environment and the application.

This standard is designed to specify a means of measuring and quantifying the performance of variable resolution projectors and is not intended to provide design goals for manufacturers of such equipment.

ELECTRONIC PROJECTION – MEASUREMENT AND DOCUMENTATION OF KEY PERFORMANCE CRITERIA –

Part 2: Variable resolution projectors

1 Scope

This part of IEC 61947 specifies requirements for measuring and documenting key performance parameters for CRT and laser-based projectors and other variable resolution projectors that are capable of multiple variable resolutions and in which the image is raster-scanned.

The provisions of this standard are designed to codify the measurement of the performance of variable resolution projectors and are not intended to provide design goals for manufacturers of such equipment.

This standard is intended for variable resolution projectors (including projection displays that are capable of multiple variable resolutions) that are designed for use with primarily discrete colour (RGB) raster-scanned video, text, and graphics signals generated by computer equipment.

NOTE These devices may also accept composite or component television video signals encoded to NTSC/RS170A, PAL, SECAM, or future HDTV, or ATV standards, which are fully described in their respective documentation and are not within the scope of this part of IEC 61947. In this part of IEC 61947, all of these signals are referred to as television video (TV video) (see IEC 60107-1 [27]).

Displays with fixed resolutions (i.e. individual pixel light sources or matrix displays such as liquid crystal, DMD, plasma, or electroluminescent panels), are not fully addressed by this standard, and reference should be made to IEC 61947-1.

Factors outside the scope of this standard that may have a bearing on projector performance are listed in annex E. A discussion of considerations informing the development of standard appears in annex C.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61947. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61947 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(845):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting*

IEC 61947-1, *Electronic projection – Measurement and documentation of key performance criteria – Part 1: Fixed resolution projectors*[1)]

---

1) To be published.

ISO 3741:1999, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for reverberation rooms*

ISO 7779:1999, *Acoustics – Measurement of airborne noise emitted by information technology and telecommunications equipment*

3 Definitions

For the purposes of this part of IEC 61947, the following definitions apply.

3.1
active matrix display
display that uses switches at each pixel to select those pixels to which a voltage will be applied

3.2
active viewing area
horizontal and vertical dimensions in millimetres (inches) of the boundary of the array of pixels. It may also be expressed in square millimetres or square inches

3.3
aperture ratio (fill factor)
light transmitting/reflecting area of a pixel times the number of pixels divided by the active viewing area (light transmitting area and light blocking area)

3.4
aspect ratio
proportions of a projected picture area, for example, the width compared to the height. It is usually expressed in standard ratios such as 4:3, 16:9, or others

3.5
blanking
process of the beam turning off (blanking) which occurs during horizontal and vertical retrace (flyback)

3.6
CIE
Commission Internationale de l'Eclairage (International Commission on Illumination)

NOTE The CIE is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the art and science of lighting.

3.7
CIE chromaticity values
Cartesian coordinates used to define a colour in CIE colour space

NOTE The 1931 chromaticity values are designated x and y. In 1976, the CIE defined a more uniform colour space. The 1976 CIE chromaticity values are u′ and v′.

3.8
colour mapping
means for accurately displaying colour signals or altering sets of colour signals in a controlled manner

3.9
contrast ratio
luminance or illuminance ratio of a light area of the image to the dark area of the same image

3.10
correlated colour temperature (CCT) of the white-point
temperature, in kelvins, of the black-body radiator, the chromaticity of which is closest to the chromaticity of a particular light, for example from a display screen, as measured in the 1960 CIE (u, v) uniform chromaticity space

NOTE An algorithm for computing the CCT of the white-point, either from 1931 CIE (x, y) coordinates or from 1960 (u, v) coordinates, appears in Wyszecki and Stiles [1]. A graphical nomogram also appears in this work. Alternatively, a successful numerical approximation has been derived by C. S. McCamy [2]. Given CIE 1931 coordinates (x, y), McCamy's approximation is CCT = 437 n3 + 3 601 n2 + 6 831 n + 5 517, where n = (x - 0,3320)/(0,1858 – y). This approximation, the second of three proposed, is close enough for any practical use between 2 000 K and 10 000 K. In units of 1960 u ,v chromaticity, it is agreed that the concept of CCT of the white-point has little meaning beyond the distance of 0,01 from the Planckian locus (see Robinson et al [3]), where the distance is specified by

$$\Delta uv = \sqrt{(u_1 - u_2)^2 + (v_1 - v_2)^2}$$

Most commercial colourimeters will report the CCT of the white-point from 0,0175 u, v units above the Planckian locus to 0,014 u, v units below this locus.

3.11
digital micromirror device (DMD)
semiconductor light micromirror array. The DMD can switch incident light on or off in discrete pixels within microseconds to produce projection display systems

3.12
optical distortion
situation in which an image is not a true-to-scale reproduction of an object due to the optics of the system

NOTE There are many types of distortion, such as anamorphic, barrel, curvilinear, geometric, keystone, panoramic, perspective, radial, stereoscopic, tangential, and wide-angle.

3.13
f/number
focal length of a projection lens divided by the diameter of the lens aperture

3.14
fall time
time, in milliseconds, for the image brightness to change from 90 % of its maximum value to 10 % of its maximum value

3.15
focal length
distance between the centre of the focusing lens or mirror and the focal spot. Shorter focal length projection lenses produce larger screen images for a given distance from the screen

3.16
focus
adjustment of an optical system to achieve the greatest possible sharpness

3.17
four corners
centres of the four corner points (see figure A.2), located at 10 % of the distance from the corners to the centre of point 5

3.18
front screen projection
image projected on the audience side of a light-reflecting screen

3.19
illuminance
quotient of a luminous flux incident on an element of the surface containing the point by the area of that element.

Unit: lux (lx)

3.20
light source life expectancy
time that the light source can keep its projected light output as measured in this standard, higher than 50 % of the initial value when tested with a duty cycle of 2 h on and 15 min off

3.21
liquid-crystal display (LCD)
display made of material, the reflectance or transmittance of which changes when an electric field is applied

3.22
luminance
luminance (L) in a given direction is the luminous intensity per unit of projected area of any surface, as viewed for that direction

Unit: candela per square metre (cd/m^2)

3.23
luminous flux
quantity derived from radiant flux by evaluating the radiation according to its action upon a selective receptor, the spectral sensitivity of which is defined by the standard 1931 CIE spectral luminance efficiency function for the photopic V(λ) function

NOTE Quantity of light expressed in lumens and directed in a given direction.

3.24
luminous intensity
luminous flux per unit solid angle emitted or reflected from a point source

Unit: candela

3.25
object
slide or transmissive/reflective image forming panel, such as an LCD, that is illuminated and imaged by the optics onto a viewing screen

3.26
peak angle
angle at which maximum luminance is observed

3.27
photometric units
units of light measurement based on the response of the average human observer. The response of the average human observer is defined by the 1931 CIE spectral luminance efficiency function for the photopic V(λ) function

3.28
pixel
smallest element of a display space that can be independently assigned a colour or intensity

3.29
projection distance
distance between the projector and the screen measured in linear units (i.e., metres, feet, or inches). This distance is considered to be the distance from the image displayed on the screen to the outermost element of the projection lens

3.30
rear screen projection
image projected through a light transmitting screen to the audience side of the screen

3.31
response time
sum of the rise and fall times divided by 2. It is measured at (23 ± 5) °C ambient temperature after 15 min in operation:

$$t_{res} = \frac{t_r + t_f}{2}$$

3.32
rise time
time, in milliseconds, for the image brightness to change from 10 % of its maximum value to 90 % of its maximum value

3.33
scan rate

3.33.1
vertical scanning
rate (hertz) at which one complete image (frame) is drawn

3.33.2
horizontal scanning
rate (kilohertz) at which each line of the display is scanned

3.34
screen gain
measure of the projector screen luminance as compared to the luminance of a block of magnesium carbonate illuminated with the same projection source, which serves as the standard for a gain of 1,0

NOTE Gains are typically measured perpendicular to the centre of the screen.

3.35
standard viewing position
for display devices the screen of which is an integral part of the projection device, the standard viewing position is the reference position for measurements, and is specified by the standard viewing distance measured from the horizontal plane on which the display under test is placed

3.36
steradian
SI unit of solid angle: solid angle that, having its vertex at the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere

[IEV 845-01-20]

3.37
transmission
measure of the amount of light that is transmitted by an optical medium relative to the total amount of incident light

3.38
vertical lines
number of active lines in a picture

3.39
viewing angle/half gain
angle between the direction of maximal reflection and the direction where the luminance drops to 50 % of its value

NOTE This quantity should be measured in the centre of the viewing screen.

3.40
visible light
electromagnetic radiation to which the human observer is sensitive through the visual sensations that arise from the stimulation of the retina of the eye

NOTE The spectral range is typically considered to have a range of 380 nm to 780 nm (3 800 Å to 7 800 Å).

3.41
zoom lens
focusing lens that has a second, primary adjustment for focal length

NOTE This capability allows smaller or larger image sizes from a fixed projection distance. The zoom ratio is typically stated in a range of screen width/projection distance ratios, for example, a 1:2 to 1:4 zoom lens could focus a 10 m or a 5 m wide image from a 20 m throw distance.

4 General requirements

This part of IEC 61947 is intended to specify a complete description of the product. In accordance with these intentions, a complete specification (see example in annex D) shall be used in product descriptions. If a particular specified measurement was not performed, the complete specification shall include the text "not measured" or "data not available" under that measurement section.

NOTE The use of partial specifications in product descriptions is not recommended since many of the specified measurements are interrelated (for example, resolution and light output).

All measurements and specifications shall conform to the following.

– The measurements of light output, visual resolution, and blanking found in this standard are interrelated and shall be measured and specified as a set.
– The parameters and measurement criteria specified in this document allow for a wide variety of equipment performance. Secondary, non-conforming specifications are permitted to allow flexibility for special features of various products and technologies, but shall be displayed in the same type face font and density at least 25 % smaller in size.
– A sample from normal production runs shall be used to establish the specifications. Results from measurements of preproduction and prototype units shall be identified as preliminary specifications.
– The sample units shall not be adjusted or enhanced beyond normal production parameters, especially in a way that would reduce the normal operating life of any component or of the entire display.
– All optical, electrical focus, and convergence controls shall be adjusted for the sharpest display over the largest possible percentage of the illuminated area, using appropriate patterns from an internal or external test generator as needed.

– The equipment shall be allowed to stabilize without further adjustment for a minimum of 15 min, at a nominal ambient room temperature of (23 ± 5) °C, before taking measurements.

NOTE Measurement could also be taken after 1 h of operation with all covers in place, white raster, as intended for normal use.

– Measurements shall take place in a lightproof room where the only source of illumination is the projector. Less than 1 % of the light on the screen shall be from any source other than the projector. The projector should be operated with all covers in place as in normal operation.

– The display device shall be adjusted for a 4:3 (horizontal:vertical) aspect ratio, if it is capable of it. The horizontal and vertical size of the scanned area shall be adjusted to the maximum usable diagonal size of the light modulator or source, such as a light valve or CRT, with the specified aspect ratio.

– Displays designed for only one aspect ratio shall be adjusted to, and measured at, the design aspect ratio that shall be specified with the light output.

– Devices that use a separate screen shall be positioned relative to the screen in accordance with the angle, height, and distance specified in the manufacturer's set-up instructions.

– Displays with integral screens shall be adjusted so as to fill exactly their viewing screens. The displays shall not delete nor hide any data in the corners or edges in the horizontal dimension. The vertical dimension shall then be adjusted to achieve a 4H:3V aspect ratio, if applicable.

– All measurements shall be taken with no adjustments made between measurements.

– Measurements shall be specified in international units, or both international and national units, with international units listed first.

5 Light output measurement and specification

The light output specification shall be stated in lumens for projectors with separate screens, and in candela per square metre (nits) for displays with self-contained screens.

The following conditions shall be met.

– Input signals shall be supplied by a standard test signal source, as specified in annex B.

– The light meter shall be photopically and cosine corrected, calibrated, and traceable to a national standard.

– A special test pattern (see figure A.1) shall be used to set the controls for making measurements. The black level (or brightness control) shall be set to the point where the maximum number of signal level blocks on the top line, representing 0 %, 5 %, 10 % and 15 % signal levels, are visible and distinct from the adjacent signal level blocks.

The video gain (contrast or picture control) shall be advanced from minimum until the maximum number of signal level blocks in the lower line of the pattern, representing the 85 %, 90 %, 95 %, and 100 % signal levels, are visible and distinct from the adjacent signal level blocks, or until the picture no longer increases in brightness as limited by automatic brightness circuitry.

In the event of controls interacting, they shall be readjusted in sequence in order to achieve the described conditions on the screen. The controls shall remain at these settings for all measurements. The total number of signal level blocks distinguishable in this pattern shall be stated in the specification.

A 100 % full-white image shall be used for the CCT and screen illuminance measurements.

For display devices where the screen is not an integral part of the viewing system, the CCT shall be measured by placing a cosine corrected colorimeter in the plane of the focused image.

For display devices the screen of which is an integral part of the projection device, the CCT shall be measured by focusing a colorimeter at the centre of the screen. The measurement field shall be at least 3 pixels by 3 pixels. The projection system shall be adjusted until the desired CCT is obtained.

The equipment shall be stabilized without further adjustment for at least 15 min before making any colour or other measurement. All measurements shall be made in a darkened room.

Light from the projector shall be measured with a photopically corrected, cosine corrected light meter, the calibration of which is traceable to a national standard.

NOTE Meters may suffer from errors due to such problems as spectral mismatch of tristimulus filters. Also, scanning or pulsed source displays may saturate the meter. For diagnostics, solutions, and further information concerning light meters, see annex I.

For display devices where the screen is not an integral part of the viewing system, the screen illuminance shall be measured with a light meter, the sensor of which is placed in and parallel to the plane of the focused image at the centre of each of nine equal rectangles and four corners (see figure A.2), or the detector can be placed at the viewing space design centre.

The measurement field shall be at least 3 pixels by 3 pixels. The average of the nine readings in lux (lumens per square metre) shall be multiplied by the number of square metres covered by the image at the plane of the meter readings. The result shall be taken as the light output of the projector, in lumens.

The light output specification shall also state the aspect ratio of the display, horizontal and vertical scan rates, CCT and the lens throw distance ratio and type.

For display devices where the screen is an integral part of the projection device, the luminance of the screen is measured in candela per square metre (nits) at the centre of each of the nine equal rectangles (see figure A.2) or the detector can be placed at the designed viewing distance.

The standard viewing distance shall be four times the screen height and the standard viewing angle shall be selected as the peak angle in order to obtain the maximum luminance of the white picture at the centre of the screen.

Luminance shall be measured for nine zones. The measurements shall be made and specified at the maximum horizontal and minimum vertical rate, and the minimum horizontal and maximum vertical rate within the capability of the equipment. The measurement field shall be at least 3 pixels by 3 pixels. An average of the nine readings shall be taken in order to calculate the light output specification, in candela per square metre (nits).

5.1 Light output specifications

5.1.1 Light output specification for projectors with a separate screen

Example:

Light output measurement conditions: 6 500 K CCT, 4:3 aspect ratio, and a 2:1 HD6 lens; (higher luminous flux values are better)

– 180 lm at 15,75 kHz horizontal and 90 Hz vertical;

– 220 lm at 36 kHz horizontal and 40 Hz vertical.

5.1.2 Full-black light level specification

Measurements shall be made at the same signal as the black rectangles for contrast ratio measurement (see figure A.3).

Example:

– Full-black light level: 1,2 lm at 15,75 kHz horizontal and 90 Hz vertical.

5.1.3 Luminance specification for devices with an integral screen

Example:

Luminance measurement conditions: 9 300 K CCT, 4:3 aspect ratio, and a total screen viewing angle of 60° horizontal, 20° vertical (higher luminance values are better)

– 27 cd/m^2 (nit) at 15,75 kHz horizontal and 70 Hz vertical;

– 31 cd/m^2 at 33 kHz horizontal and 57 Hz vertical.

NOTE Direct comparisons can be made between displays with and without integral screens using candela per square metre, if both screens have the same horizontal and vertical angles of view. If this is not the case, mathematical conversions may be made, but will result in unreliable data of questionable value.

5.2 Light output uniformity

The average of nine readings used in the light output measurement shall be taken as the reference for the light output uniformity measurement. An additional four points, as in figure A.2, shall be measured, with the maximum deviation of the resulting 13 measurements stated as a percentage as in the following example. The measuring field shall be at least 3 pixels by 3 pixels.

NOTE See annex C for further information on light output measurement.

5.2.1 Example of a uniformity specification

– Brightest measurement locations: 10 % greater than average;

– Dimmest measurement locations: 5 % less than average.

5.3 Contrast ratio

The contrast ratio shall be determined from illuminance values, or luminance for devices with an integral screen, obtained from a black-and-white "chessboard" pattern consisting of 16 equal rectangles (see figure A.3). The white rectangles shall be at full specified light output, as previously measured, with all controls at the same settings.

Illuminance measurements in lux (candela per square metre with internal screen units) shall be made at the centre of each of the bright (white) rectangles and the dark (black) rectangles. The average illuminance or luminance value of the bright rectangles shall be divided by the average illuminance or luminance value of the dark rectangles. The contrast ratio shall then be expressed as this ratio:1 (for example, bright rectangles with an average value of 15 lx and dark rectangles with an average value of 0,10 lx provide a contrast ratio of 150:1).

5.4 Blanking measurement and specification

The blanking (that portion of the raster that is forced to black to conceal the retrace or "flyback") shall be equal to the retrace time. The blanking time shall also be in phase with the retrace. In raster-scanned systems, the unblanked picture display time (active horizontal = T_{ah} and active vertical = T_{av}) shall be used in the visual resolution calculation and is the scan time less the effective blanking time.

$$T_{ah} = T_{sh} - T_{ebh}$$

$$T_{av} = T_{sv} - T_{ebv}$$

where

T_{ah} is the active horizontal unblanked display time;

T_{sh} is the horizontal scan time;

T_{ebh} is the effective horizontal blanking time;

T_{av} is the active vertical unblanked display time;

T_{sv} is the vertical scan time;

T_{ebv} is the effective vertical blanking time.

The effective blanking time shall be taken as the maximum time from the start of blanking or retrace to the end of blanking or retrace.

NOTE In some devices a retrace does not exist; for example, in laser projectors where a rotating polygon scanner is used as a horizontal deflector.

5.5 Effective blanking time

The effective blanking time shall be taken as the sum of the following:

– the out-of-phase time of the blanking and the retrace;

– the larger of the blanking or retrace times at their maximum time, as achieved by adjusting the controls for hold, position, phase, size or any others that might be applicable;

– the unblanked picture display time that has a non-linearity greater than ±10 % compared to the centre of the screen.

Example:

If both the blanking and retrace times equal 6,0 µs, but are 0,5 µs out-of-phase relative to each other (due to component tolerances, frequency sensitive circuitry, or "phasing/centring" control settings), the effective blanking is 6,5 µs. This effective blanking, while not actually blanked for 0,5 µs, is the time that the video cannot usefully be viewed, either because it is actually blanked or because it occurs during retrace and is backwards and overlapped.

NOTE In some devices a retrace does not exist; for example, in laser projectors where a rotating polygon scanner is used as a horizontal deflector.

5.6 Blanking specification

Example:

Blanking (lower time values are better):

– horizontal blanking: 5,8 µs or less;

– vertical blanking: 850 µs or less.

The above blanking specifications do not apply to TV video inputs (NTSC, PAL, SECAM, etc.), if any, of the measured display device. TV video requires its own special blanking format to eliminate objectionable spurious signals (VIR, VITS, closed captioning, burst, etc.) from being displayed. It is encouraged that this special blanking format be used, but only during the display of the TV video.

6 Variable resolution projector characteristics

6.1 Visual resolution measurement and specification

6.1.1 Description and general requirements

The visual resolution specification is formulated to allow users of large screen displays to correlate the computer display directly to that of the large screen display. This specification consists of a horizontal resolution measurement and a vertical resolution measurement. The visual resolution specification is essentially the number of unblanked pixels that are measured as the pixel density is increased to the point at which the modulation depth decreases to 33 % of the contrast measurement.

For devices that do not allow enough variability in the scan rate, to implement the pixel-density increase in this procedure, an alternative procedure shall be performed in accordance with annex G.

The following formula shall determine the modulation depth:

$$\%\ \text{modulation depth} = 100\ D_{\text{mod}} = 100 \left[\frac{L_{\text{peak}} - L_{\text{valley}}}{L_{\text{white}} - L_{\text{black}}} \right]$$

where

L_{white} and L_{black} are luminance measured from full-screen white and black;

and

L_{peak} and L_{valley} are peak and valley luminances measured from a grille pattern.

The measurements of L_{peak} and L_{valley} shall first be window-averaged over one pixel width (to minimize sensor-noise effects), and shall then be averaged over all the peaks and valleys in the grille (to minimize grille aliasing effects).

NOTE 1 For more details on methodology, see the VESA Flat Panel Display Measurement Standard [4].

NOTE 2 Full white and black levels are measured with a large-area contrast test pattern (see figure A.3). The data used to determine the contrast can be reused here. The modulation depth is the peak-to-peak measurement from the minimum light output (black) to the maximum light output (within the constraints of the light output measurement and specification). As the modulation depth decreases, the minimum light output may change to dark grey and the maximum light output may change to light grey. The actual numbers are significant in this measurement only to establish the 100 % and 33 % points (see figure A.6).

Measurement of the modulation depth shall be made with the same conditions, control settings, and video levels as used in the light output specification by use of a pattern generator (see annex B) with a test pattern of equal width (50 % duty cycle) white and black bars (see figures A.4 and A.5).

6.1.2 Horizontal resolution

Horizontal resolution shall be measured with a high-resolution optical analyser capable of measuring 1/10 the size of the smallest pixel to be measured at the image size chosen by the manufacturer of the display. The measurement shall be perpendicular to the vertical parallel lines being measured (see figure A.4).

The pattern generator shall be adjusted to the highest horizontal scan rate within the specified capability of the display device being measured and to a vertical scan rate which maintains the original size and aspect ratio of the picture as defined in 3.4.

6.1.3 Vertical resolution

Vertical resolution shall be measured with a high-resolution optical analyser perpendicular to the horizontal parallel lines being measured (see figure A.5). The pattern generator shall be adjusted to the lowest vertical scan rate within the specified capability of the display device being measured and to a horizontal scan rate that maintains the original size and aspect ratio of the picture as defined in 3.4.

If the vertical resolution limit is reached at a modulation depth greater than 33 %, the modulation depth percentage shall be stated along with the vertical resolution in the specifications.

NOTE 1 The vertical resolution may be limited by the maximum number of scan lines at the highest horizontal and lowest vertical scan rates and the vertical blanking time of the display. This will be the maximum vertical resolution specification, regardless of any higher measurements which could be erroneous due to aliasing and line pairing.

NOTE 2 The lowest vertical scan rate may produce an objectionable flicker, depending on the persistence characteristics of the display.

6.1.4 Procedure

See figure A.6 for equipment set-up and the depth of modulation measurement example.

Conduct the test as follows.

– The display system controls for the black level (brightness control), video gain (contrast or picture control), CCT image, and zoom setting are left unchanged from the illuminance or the luminance and contrast measurements.
– The test generator is set to the chessboard rectangle pattern used in the contrast measurement where a full 100 % modulation can be measured (see figure A.3).
– The pattern is then changed to the resolution pattern of either the horizontal lines or the vertical lines (see figures A.4 and A.5).
– The width (time duration) of the lines is reduced (the number of lines is increased) at the generator until the modulation depth of the picture of the display being measured is reduced to 33 % of the value measured with the chessboard pattern in figure A.3 as per figure A.6. This point is defined as the 33 % modulated pixel limit.
– Resolution measurements shall be made in each of the nine rectangular zones (see figure A.2) and averaged. Divide the amount of time that corresponds to the width of a single line at the 33 % modulated pixel limit into the active (unblanked) display time to yield the visual resolution in pixels. Alternatively, the total number of both light and dark lines displayed at the 33 % modulation depth can be counted and reported.
– Visual resolution is then determined by specifying the number of pixels displayed at the 33 % modulated pixel limit, referring to horizontal or vertical resolution as appropriate.

In summary, to calculate the visual resolution,

– determine the unblanked display time (see 6.1.4.1 and 6.1.4.2 for examples of calculations of T_{ah} and T_{av});
– calculate the number of pixels visible during the unblanked display time by dividing the unblanked display time by the pixel time at the 33 % pixel limit (see the example given in 6.1.4.3).

NOTE The unblanked display time may be measured with the pattern shown in figure A.1.

The horizontal unblanked display time can also be calculated by subtracting the horizontal blanking time specification of the display being measured from the horizontal line time at the measured scan rate.

The vertical unblanked display time can be measured or calculated by subtracting the vertical blanking time specification of the display being measured from the vertical refresh time of the test generator.

6.1.4.1 Unblanked horizontal display time (T_{ah}) calculation

Example:

If the test generator operates at a 15,748 kHz horizontal scan rate and the display's horizontal blanking specification is 5,5 µs, the unblanked horizontal line time is calculated as follows:

$$T_{ah} = 63{,}5\ \mu s - 5{,}5\ \mu s = 58\ \mu s$$

where 63,5 µs is 1 s divided by the number of line scans per second (15,748 in this example).

6.1.4.2 Unblanked vertical display time (T_{av}) calculation

Example:

If the test generator operates at a 60,0 Hz vertical scan rate and the display's vertical blanking specification is 850 µs, the unblanked vertical line time is calculated as follows:

$$T_{av} = 1\ 666\ \mu s - 850\ \mu s = 816\ \mu s \text{ or } 0{,}816\ ms$$

where 1 666 µs is 1 s divided by the number of frames per second (60 in this example).

6.1.4.3 Visual resolution (B) calculation

Example:

When the 33 % pixel limit is reached, the vertical lines are 55 ns black and 55 ns white, equivalent to 55 ns pixels. The visual resolution can then be calculated as follows:

$$B = T_{ah}/\text{pixel time} = 58\ \mu s/0{,}055\ \mu s = 1\ 055 \text{ pixels horizontal resolution}$$

where 58 µs is the active display time of one line and 0,055 µs equals 55 ns pixel time.

6.1.4.4 Visual resolution specification

Example:

Visual resolution (both measurements made at the specified light output; higher pixel values are better):

- 1 055 pixels horizontal at 33 % modulation depth at 36 kHz;
- 1 024 pixels vertical at 42 % modulation depth at 40 Hz

6.1.4.5 Specification of multiple resolution and scan rate combinations

Example:

Visual resolution (measured at the specified light output; higher pixel values are better):

- 1 300 pixels horizontal at 33 % modulation depth at 64 kHz;
- 968 pixels horizontal at 33 % modulation depth at 31 kHz;
- 1 100 pixels vertical at 33 % modulation depth at 40 Hz;
- 1 024 pixels vertical at 42 % modulation depth at 60 Hz.

6.2 Video frequency response specifications

Signals for these measurements shall be a 700 mV peak-to-peak sine wave or step at the appropriate video input connectors with a standard 75 Ω input termination.

Video frequency response shall be made at an identified circuit point with the following three parameters listed in the specifications.

a) Frequency response at the highest frequencies where the video output decreases by 3 dB using a sine wave signal.

   Example:

   (higher frequency values are better): 28 MHz at –3 dB at the CRT cathodes.

b) The rate of roll-off per octave (doubling of frequency) above the –3 dB point using a sine wave signal.

   Example:

   (lower roll-off rate values are better): 12 dB/octave roll-off;

c) The rise and fall times of a step (10 % – 90 % points) specifying overshoot and ringing;

   Example

   (measured with 10 % overshoot and 6 ns ringing; lower time values are better): 12 ns rise time and 15 ns fall time.

6.2.1 Frequency response specifications

Example:

Frequency response (rise and fall times of 28 ns measured with 10 % overshoot and 6 ns ringing):

– 35 MHz at –3 dB RGB video frequency response at the CRT cathode;

– 6 dB/octave roll-off.

6.3 Viewing angle (half/gain) specification for devices with an integral screen

This is the angle between the normal or peak angle perpendicular to the centre of the viewing screen and the observer in the horizontal (left and right) and vertical (up and down) direction where the intensity of luminance drops to 50 % of its value, for example, total screen viewing angle of 60° horizontal and 20° vertical (full angle at 1/2 intensity).

6.4 Input signal format compatibility

Manufacturers shall supply customers with a list of compatible modes, video standards and, if necessary, hardware description.

6.5 Response time

The response time shall be specified by the light valve manufacturer, for example, less than 50 ms for the photoelectric light valve.

6.6 Colour measurements

The following conditions shall be met.

- The colour-measuring instrument shall have a photometric accuracy of ±5 % and a colour accuracy of ±0,008 in 1931 CIE chromaticity values (x and y) for all colours. It shall also be able to measure the CCT and the 1976 CIE chromaticity values u' and v'. Colorimeters shall be calibrated for the particular light source measured. All filter-lased instruments shall be evaluated for sensitivity to saturated colours (or monochromatic light sources) if the projector uses narrow-band primaries (see F.2 and annex I for details).
- For display devices where the screen is not an integral part of the viewing system, the CCT shall be measured by placing appropriate equipment in the plane of the focused image at the spot where the centre of the screen would be located. The measuring field shall be at least 3 pixels by 3 pixels.
- For display devices the screen of which is an integral part of the projection device, the CCT is measured by using the appropriate equipment at the centre of the screen. Adjust the projection system until the desired CCT is obtained.
- The CCT at which colour measurements are performed shall always be specified.

6.6.1 Colour chromaticity

Set up a white screen at the desired CCT. The u', v' chromaticity of the nine zones of the screen, as shown in figure A.2, is measured using the procedure described for measuring CCT in clause 5.

Similarly, set up a screen with the primary colours red, blue and green and measure the u', v' chromaticity of the centre of the screen.

A colour chromaticity example for a CCT of 6 500 K is as follows:

white: u'= 0,198, v'= 0,468

red: u'= 0,477, v'= 0,528

green: u'= 0,076, v'= 0,576

blue: u'= 0,175, v'= 0,158

Given the u', v' coordinates of each of the primaries, a colour gamut "efficiency" can be defined as the area of the triangle of the primaries in u', v' space, divided by the area subtended by the spectrum locus in that space (see annex J for details).

6.6.2 Colour uniformity

Set up white, red, green, and blue colours on the screen and for each colour measure the u', v' chromaticity at the centre of each of the nine equal rectangles described in figure A.2. Calculate the average chromaticity value (u'_0 and v'_0) of the nine measurements for each colour. Also measure the u', v' chromaticity at the four corners of the screen.

Record the maximum deviation in u' and v' of the 13 measurements from the average value for each colour. If u'_l, v'_l represent the spots with maximum deviation from the average values u'_0, v'_0, a measure of the colour uniformity for each colour is given by:

$$\Delta u'v' = [(u'_1 - u'_0)^2 + (v'_1 - v'_0)^2]^{½}$$

6.7 Keystone correction

Keystone correction is the specification of the angular tilt range in degrees (between the centre ray of the projected beam and a line orthogonal to the screen) over which the projector can display a rectangular image with equal length top and bottom edges and equal length right and left edges.

Positive angles indicate that the screen centre-line orthogonal is above the projector, (projection is up). Negative angles indicate that the screen centre-line orthogonal is below the projector (projection is down).

Example:

Keystone correction: +15°, –5°

7 Range of focus and image size

This is the minimum and maximum distance from the screen from which a sharp focus and image size (diagonal) can be obtained.

Example:

Range of focus is 1,22 m to 4,27 m (4 feet to 14 feet) with a diagonal image size of 1,78 m to 3,05 m (70 inches to 120 inches) (4:3 aspect ratio).

8 Audio characteristics

Describe the number and each type of audio input and output connections including impedance, signal level, and type of connector. If multiple audio/video inputs are available, report the method of selection between them and the signal isolation in dB. Report any special audio features such as stereo.

Report the power output and the frequency response in accordance with ISO 3741.

Example:

Output power when driving into an 8 Ω load is 5 W. Total harmonic distortion for the frequency range 20 Hz to 20 kHz is less than 1 %.

9 Light source specification

If a lamp is used, the following information shall be reported:

– lamp type, identification code;
– lamp wattage, CCT, and life expectancy (50 % or shutdown) (see 3.20);
– user or dealer serviceable lamp;
– any special handling requirements for safety.

Example: Metal-halide lamp, 400 W, 500 h

If a CRT is used, the following information shall be required:

– size (diagonal raster size);
– focus method;
– life expectancy (when operated at levels used within the specifications).

10 Noise: maximum sound level

Make the measurement in accordance with ISO 7779 and report the result.

Example:

Less than 45 dBa

NOTE Measurement could also be taken after 1 h of operation with all covers in place, white raster, as intended for normal use.

11 Power consumption

The projector shall be connected to a regulated power source, with voltage held constant to within ±0,5 % of the nominal voltage. Report the power, in watts, drawn by the projector when operating with all function controls set to, or operating in, their highest power consuming mode. Also report the input voltage.

Example: 400 W at 120 V a.c.

12 Weight

The weight (including that of the a.c. power supply and specified lenses) shall be given in kg and/or pounds.

13 Dimensions

Length, width, and height shall be given in metres and/or inches.

14 Recommended practices

14.1 Recommended practice 1 – Sync hierarchy

If the display device accepts more than one sync source, the following hierarchical preference should be used even if sync signals are present at more than one input:

- separate horizontal and vertical sync (<1,0 V to >5,0 V peak-to-peak video into 75 Ω);
- separate composite horizontal and vertical sync (<1,0 V to >5,0 V peak-to-peak video into 75 Ω);
- composite sync mixed with the monochrome or green video (<0,2 V to >0,5 V peak-to-peak sync plus 0 V to 1,0 V peak-to-peak video into 75 Ω).

14.2 Recommended practice 2 – DC restoration

A black level clamp standard for display devices is described in annex A, figure A.7. The 1,0 µs horizontal sync and the 2,0 µs total blanking should be adequate for most future CRT-based, raster-scanned displays, as it is extremely difficult to achieve faster horizontal retrace times with the necessary magnetic deflection systems.

In some instances, no "back porch" is available for sampling and clamping. The display should have the capability to change (manually or automatically) the sampling point to the sync tip and offset the black level as needed to maintain a black background. If there is no sync in the video signals, the first edge of the horizontal sync may be used.

14.3 Recommended practice 3 – Sync

See annex A, figure A.7. The deflection circuits should be triggered by the first edge of the input sync (in standard negative sync systems, this is the falling edge; in positive systems, this is the rising edge). This first edge should correspond to the beginning of the blanked retrace time in the display, regardless of the scan frequency. The horizontal deflection circuit should accept and trigger to the same edge (falling edge in negative sync systems) of phase correct, inverted sync pulses (known as equalization/serration pulses) during vertical sync.

The horizontal deflection circuits should accept a 1,0 µs or larger sync pulse, separate or composite. The vertical deflection circuit should accept a 180 µs or larger sync pulse, separate or composite.

14.4 Recommended practice 4 – Scan range labelling

It is suggested that multiscan displays have a small label near the input connections that lists the horizontal and vertical scan rates and blanking times as shown in the sample label in figure A.7.

Annex A
(normative)

Figures

0 % = BLACK 100 % = WHITE

IEC 1649/01

Figure A.1 – Test patterns/measurements set-up

The pattern in figure A.1 is a fully illuminating white pattern. The height of each small rectangle is equal to 10 % of the height of the image area; the width of each small rectangle is equal to 5 % of the width of the image area; and the distance between two patterns is equal to 5 % of the height of the image area.

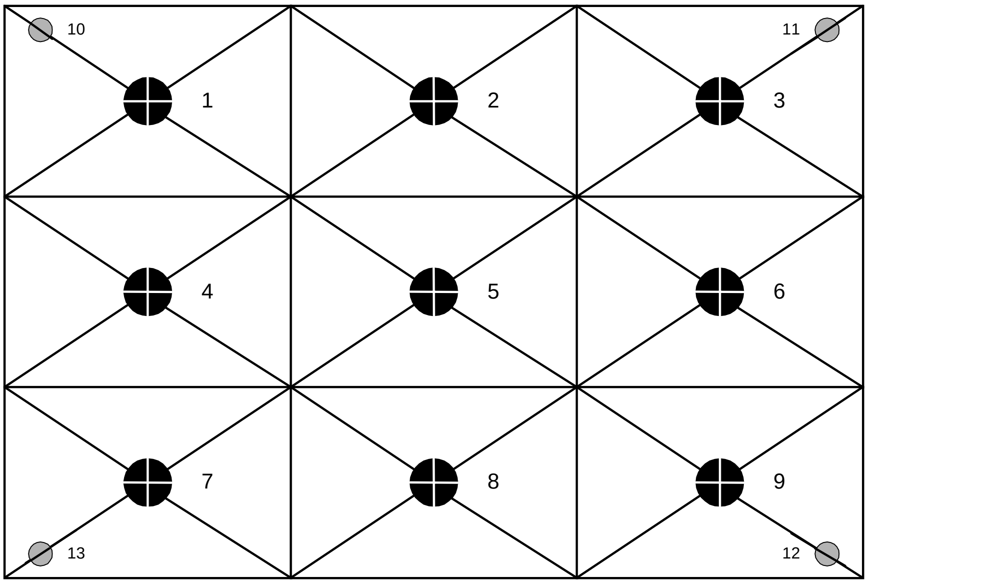


Figure A.2 – Thirteen-point measuring grid

Figure A.2 is an example of the nine zones to be established for measurement. The centre of each zone is to be used for light output and visual resolution measurements. The four corner points 10, 11, 12 and 13 are located at 10 % of the distance from the corner itself to the centre of point 5.

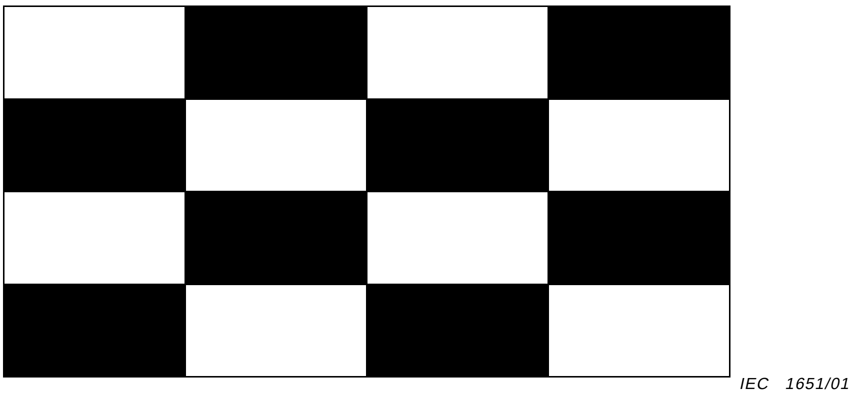


Figure A.3 – Contrast measurement

Figure A.3 is a pattern of 16 rectangles of alternating white and black used to measure the large-area contrast ratio.

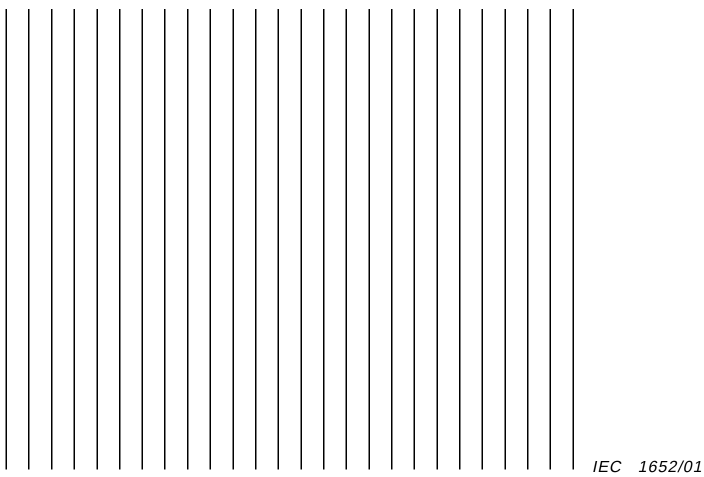


Figure A.4 – Vertical alternating lines

Figure A.4 is a pixel width pattern with alternating white and black vertical lines used for making the small-area contrast ratio measurement.

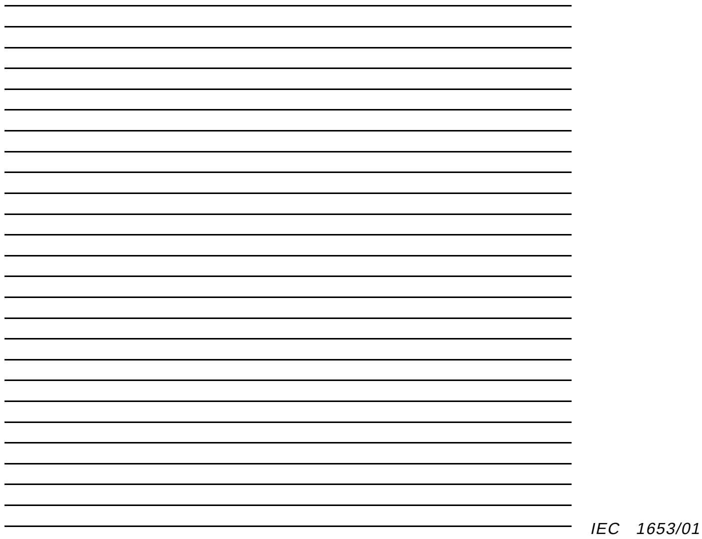


Figure A.5 – Horizontal alternating lines

Figure A.5 is a pixel width pattern with alternating white and black horizontal lines used for making the small-area contrast ratio measurement.

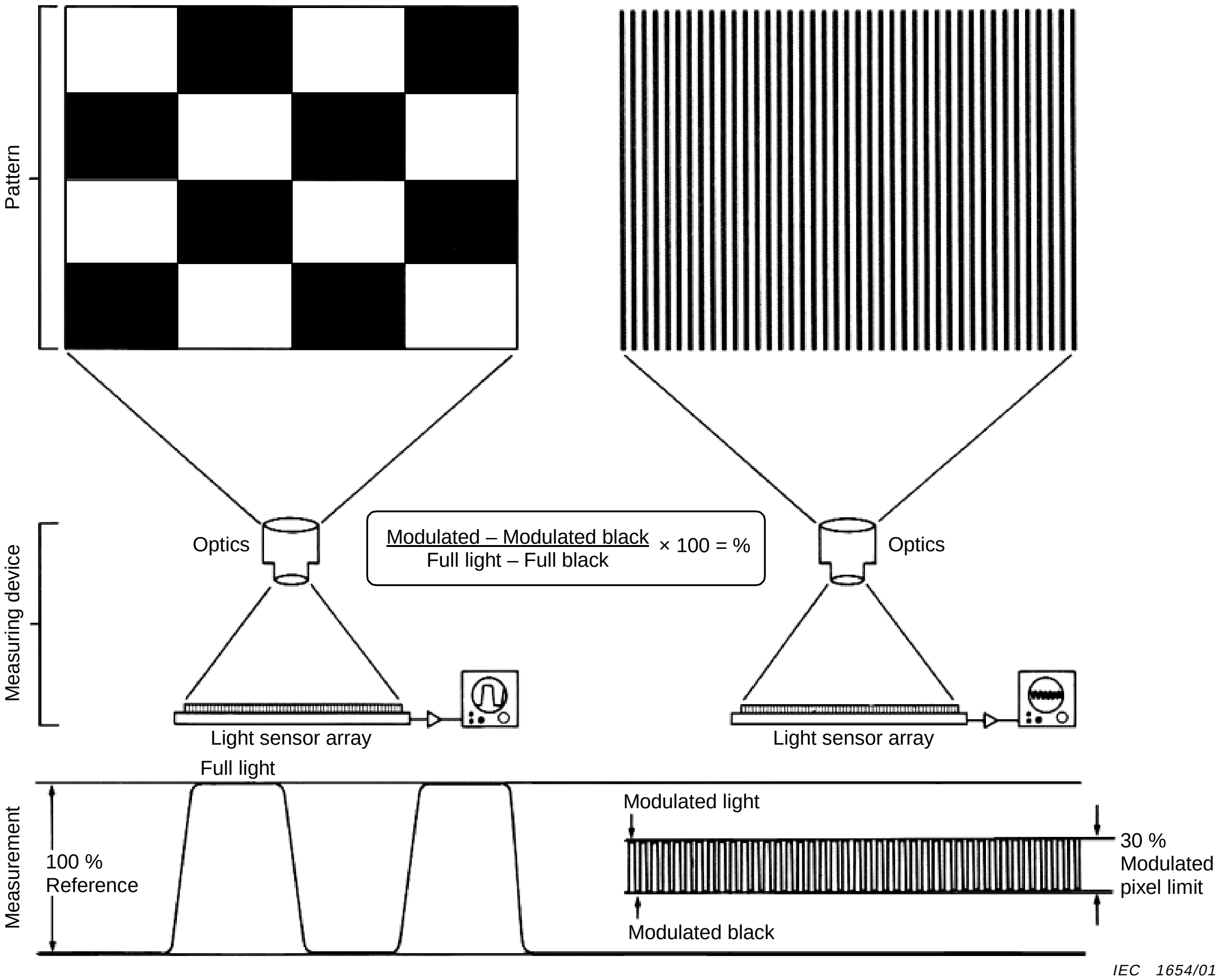
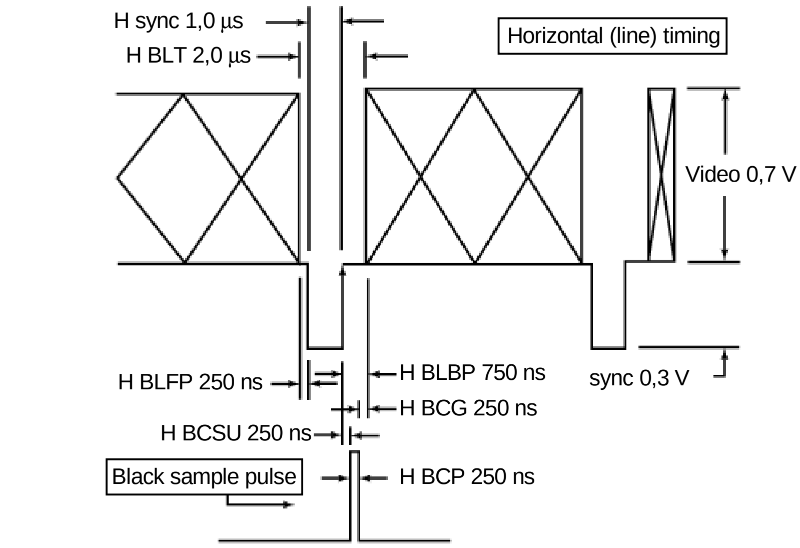


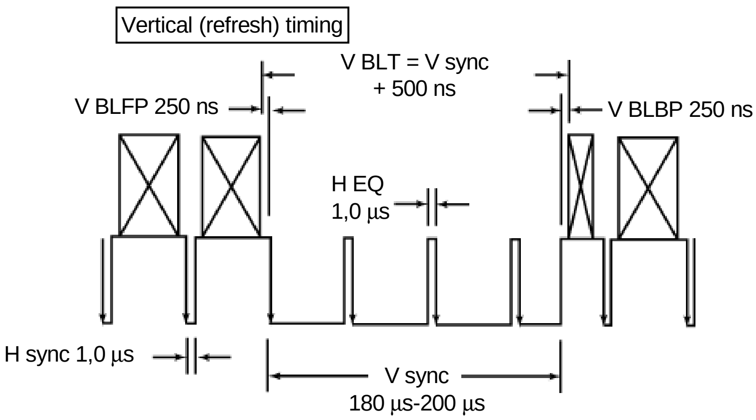
Figure A.6 – Resolution equipment set-up/depth of modulation measurement

Figure A.6 is an illustration of the configuration and reading of the optical measuring device used in figures A.4 or A.5.

Signal timings



(a) Black sampling pulse relationship to the horizontal sync pulse when there is a minimum of 500 ns "back porch"



(b) Phase and width relationships of horizontal sync, horizontal equalization, and vertical sync

	Scan range	Blanking
Horizontal	15,5 KHz-36,2 KHz	5,7 µs
Vertical	45,0 KHz-79,5 KHz	850 µs

(c) Suggested label format to be placed near the input connectors of multisync displays

IEC 1655/01

Figure A.7 – Sync and blanking timing

Annex B
(normative)

Pattern generator specifications

The pattern generator needed for these measurements shall have as a minimum the following specifications.

– The ability to maintain output levels within 1 % when switching from pattern to pattern and during 8 h of operation.

– Three identical red, green, and blue outputs at 700 mV (±1 %), 75 Ω.

– An easy method for entry of the horizontal and vertical scan rates as independent frequencies. The device shall also have automatic internal rounding to the nearest even vertical divisor and a readout in microseconds (µs).

  Continuously adjustable video pixel rates of 50 % on and 50 % off (±1 %) with pixel widths from greater than 250 ns to less than 5 ns. Rise and fall times shall be less than 20 % of the minimum pixel size at any desired combination of scan rates with a readout in ns (see figures A.4 and A.5).

  A pattern generator, the video pixel rate of which exceeds the specified capability of the projector under test, can be used. If the pattern generator does not meet the above specification, then the pattern generator used should be described in the complete sample specification.

– Adjustable horizontal and vertical blanking and centring with readout in microseconds. Resolution of the adjustments for blanking shall be at least as fine as 0,1 µs of a micro-second (see figure A.1).

Annex C
(informative)

Considerations in formulating this standard

C.1 General

The intent of this standard is to codify the creation of uniform specifications that are useful to the non-expert user in the evaluation of large screen displays.

NOTE This concept correlates to the U.S. Federal Trade Commission's (FTC) high-fidelity power and distortion measurement standards for the audio industry.

C.2 Light output measurement

The purpose of measuring the total luminous flux of a projector, as reported in lumens, is to allow users to calculate the illuminance of a projector and screen combination in an installation given that the screen is a variable in each application.

Screens are available with gains from less than 1 to over 20 and viewing angles from 180° to less than 20°. The ultimate aim of an installation is to provide a given amount of luminosity and contrast, both of which depend on factors beyond the luminous flux of the projector.

Illuminance (expressed in lux) is the luminous flux (expressed in lumens) from the projector incident on the surface per unit area (for example, square metre) of a projection screen. Luminance (expressed in candela per square metre), which quantifies the light intensity from a surface, is the luminous flux (for example, lumens) per unit solid angle (expressed in steradians) subtended by the light-measurement device per unit area (expressed in square metres) of the emitter, measured about a given direction relative to a projection screen (for example, perpendicular to the screen).

Example:

A projector illuminance of 300 lx will lead to a screen luminance of $300/\pi$ or 95,5 cd/m^2, assuming the screen scatters light uniformly in all directions and does not absorb any light, i.e., screen gain = 1. Assuming, for this example, a 1,8 m^2 image area is projected onto a lambertian screen of gain = 1, the light output (computed from the 300 lx illuminance of the projector) is 300 lx $\times$ 1,8 m^2 or 540 lm, and is equal to the light output computed using the screen luminance, 95,5 cd/m^2 $\times \pi \times$ 1,8 m^2 = 540 lm. (Here, π is the half-space-integrated beam pattern of a lambertian screen.)

In general, the light output for a lambertian screen having a gain of 1 may be computed as follows:

$$\Phi = \pi L A$$

where:

Φ is the luminous flux, in lumens;

L is the luminance, in candela per square metre;

A is the area of image, in square metres.

The pattern chosen (see annex A, figure A.1) is a typical representation of contemporary workstations that have black characters on a white background. It is important to have the entire screen fully illuminated and the 5 % and 95 % illuminated rectangles clearly discernible.

Changes in the scan rate may affect the light output because the spot size is usually fixed. If the spot size is small enough to accommodate 1 000 scan lines without overlap, the same display will have a substantially large amount of black, unscanned area with a picture format of only 200 scan lines. The combination of maximum horizontal and minimum vertical scan rates yields the most scan lines; minimum horizontal and maximum vertical scan rates yield the fewest.

C.3 Visual resolution measurement

The depth of modulation used to determine resolution, ~33 % in this standard, means that the resolution test procedure will yield results that may be much more conservative than previous practices. Traditional measurements of parallel lines at 5 % or 10 % depth of modulation are not useful with the small text and graphics in use today. The purpose of the visual resolution specification is to establish the number of pixels that, when grouped into characters and graphics symbols, are easily and correctly recognized by the intended audience. The 33 % modulation depth parameter was derived empirically through various experimental viewings.

Artificially high numbers for resolution can be measured at greatly reduced light output in most CRT-based projectors. Visual resolution measured at the specified light output circumvents the practice of measuring artificially high numbers at greatly reduced light output in CRT-based projectors. Since the resolution measurement depends upon the useful unblanked (active) video time, the effective blanking must be specified exactly. Reverse pixels during unblanked retrace are only a degradation of the picture.

It is important to note that higher resolutions than the visual resolution specification can be displayed, but at the expense of brightness, contrast, and edge definition. The resolution is always limited by the bandwidth of the electronic circuit, by the response behaviour of the amplitude modulation of the beam (electron-beam or light-beam) and by the shape of the beam. Inadequate bandwidth causes a reduction of contrast in the scanned plane (horizontal) versus the line plane (vertical), thus allowing characters whose lines are formed of multiple pixels to achieve a high modulation depth, while adjacent single pixel characters are barely discernible due to their low modulation depth. This causes the vertical portions of characters virtually to disappear, while the horizontal portions are quite vivid (see figure C.1).

C.4 Possible causes for measurement errors

Assuming that the measurement and display conditions have been set up carefully in accordance with this standard, there are still several factors that can lead to measurement errors and widely varying results when performing light measurements on a projection system. Issues to be watchful of are briefly discussed in clause 5 and in annexes F and H.

C.5 Input signal levels

Analogue input signal levels for R, G, and B should be 0,7 V.

Effects of inadequate bandwidth

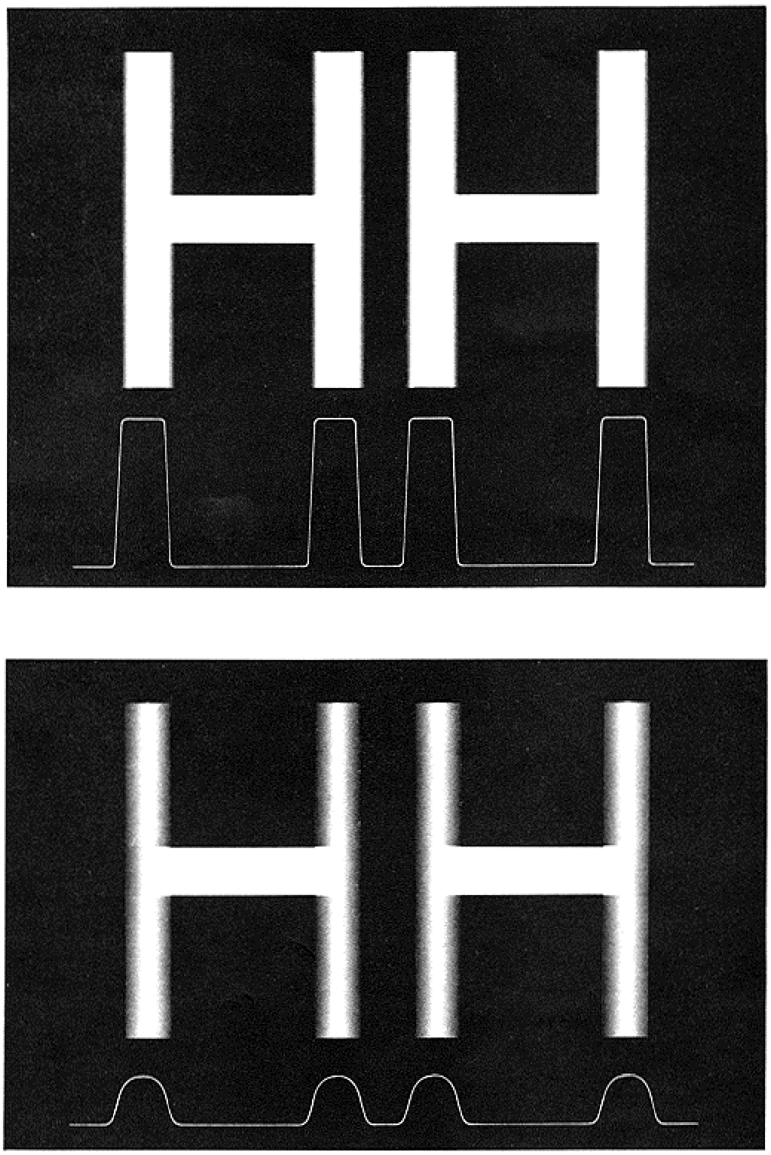

IEC 1656/01

Figure C.1 – Simulation of lowered resolution

Annex D
(normative)

Complete sample specification

XYZ brand, Model 123 data projector (specification based on July 1996 measurements)

Light output measured with 2:1 HD6 lens:

- 180 lm
- 6 500 K CCT
- 4:3 aspect ratio
- Horizontal and vertical frequency

or

Light output measured with 67-inch diagonal lenticular screen:

- 60 cd/m^2
- 6 500 K CCT
- ±60° viewing horizontal angle
- ±30° viewing vertical angle

Full black light level: 1,2 lm

Light output uniformity (across image area)

- Brightness zone: 10 % > than average
- Dimmest zone: 5 % < than average

Contrast ratio: 150 to 1

Blanking time: 2 µs minimum horizontal and 850 µs minimum vertical

Resolution (pixels) at light output: 1 055 horizontal by 1 024 vertical

Frequency response (at the CRT cathode): 120 MHz (–3dB point) and –12 dB per octave roll-off

Response time (10 % – 90 %): 8 ns rise time and 10 ns fall time

Input signal format compatibility: RGB analogue, BNC 75 Ω termination, composite video,

RS-232 for computer control, VGA 15 pin HD

Colour chromaticity

White:	u' = 0,198,	v' = 0,468
Red:	u' = 0,477,	v' = 0,528
Green:	u' = 0,076,	v' = 0,576
Blue:	u' = 0,175,	v' = 0,158

Colour uniformity

White:	$\Delta u'$ = 0,011,	$\Delta v'$ = 0,015
Red:	$\Delta u'$ = 0,008,	$\Delta v'$ = 0,010
Green:	$\Delta u'$ = 0,015,	$\Delta v'$ = 0,012
Blue:	$\Delta u'$ = 0,007,	$\Delta v'$ = 0,008

Audio: 5 W r.m.s. audio power into an 8 Ω load; total harmonic distortion: <1 %, 20 Hz to 20 kHz

Light source: 9-inch (8,5-inch raster diagonal) electromagnetic focused CRT, or 1 000 W Xenon, 1 200 h, user replaceable

Power: 400 W at 120 V a.c.; 108 V a.c. to 140 V a.c.

Annex E
(informative)

Other issues, outside the scope of this standard, that may affect picture clarity

Other factors affecting picture clarity and resolution that are only partially addressed or not covered in this standard are as follows.

- Misconvergence of multiple light sources (i.e. red, green, blue CRTs): inability of convergence circuits to maintain convergence at various scan rates or brightness levels.
- Uneven focus: includes the lack of or inaccurate dynamic beam focus, poor optical corner focus, non-corrected axial misalignment (tilt) focus, corner spot deformation, and optical path aberrations such as diffraction, astigmatism, etc.
- Geometry distortion (distorted or inadequate keystone and pincushion correction circuitry): inability of geometry correction circuitry to track various scan rates.
- Sync trigger instability: "jitter", "swim", or "drift" can cause a reduction of resolution by dithering pixels to a larger size, or thickening and blending scan lines.
- Poor vertical resolution: vertical resolution of this type of equipment is generally restricted by deflection capability, sync trigger instability, spot shape and size, interlace inaccuracy, and dynamic linearity instability. While all these factors are difficult to quantify and measure and are generally of minor importance until approaching the 700 scan line performance range, they become critical in displays over 1 000 scan lines.
- Dynamic spot deformation and size variance: may result from poor high-voltage regulation in CRT-based systems.
- Picture flicker: may result from fast phosphor response in CRT-based systems, or noise amplitude modulation of laser systems.
- Uneven light output, hot spots, and defocused spots: may result from the type of screen, its condition, installation, and environment. A flexible flat screen that is wrinkled, or is so loosely mounted that it moves with air currents, can seriously degrade the viewed image.
- Ringing in the video/deflection circuits: ringing in the video circuits may generate smearing or "ghosts". Ringing in the deflection circuits can cause non-linearity (which can vary with scan rates).
- Shading or colouring of the viewed image (from the top to the bottom): can be caused by poor vertical low-frequency response.

These issues should be considered, studied, and quantified so that test and measurement procedures, along with meaningful specifications, where possible, can be defined and established.

Annex F
(informative)

Possible causes of photometric measurement errors

F.1 Size of measured spot

When measuring the luminance of a projection system with an integral display, the minimum number of pixels that has to be measured to make an accurate luminance measurement depends on the pixel fill factor of the display. When the fill factor is below 100 % and the measuring field of view (FOV) of the photometer is very small, the number of display pixels in that spot may change as the photometer is moved to different regions of the display. It is a good practice to have a measurement FOV that covers at least 25-50 display pixels.

F.2 Colour measurement

Filter colorimeters are typically accurate for measuring colour only when used to measure broadband sources that are spectrally similar to the light source used to calibrate the colorimeter. Most manufacturers use an illuminant A incandescent source at 2 856 K to calibrate their filter colorimeters and therefore specify colour accuracy only for that source. The main drawback of filter colorimeters is the error introduced by the spectral mismatch of the instrument's filters from the theoretical CIE colour-matching functions. Although the integrated error may be within 1 % or 2 %, it is typical to find much higher mismatches in narrow regions of the spectrum. This makes filter colorimeters unsuitable for measuring sources (like the red phosphor of CRTs, LCDs backlit by triphosphor fluorescent lamps and laser-based projection) that have sharp spectral peaks that may fall in a region of spectral mismatch of the colorimeter's filters. Since colour is being analysed using three or four filters, this error can be compounded when the source's peak energy falls in the region of greatest mismatch of two or more filters.

Spectroradiometry is the most accurate method of measuring colour. The complete spectral power distribution of a source is measured, and tristimulus values X, Y, and Z are obtained by integrating the spectral data mathematically with the CIE colour matching functions. The calculated tristimulus values are then used to compute CIE chromaticity coordinates and luminance, which provide a complete description of the colour of the source. As long as the spectral accuracy is known, it is possible to specify the colour accuracy of a spectroradiometer for different sources.

Annex G
(normative)

Alternative method for measuring resolution using the NIDL grille contrast method

The following process provides a theoretical estimate of horizontal resolution due to the assumption of a linear correlation in the video bandwidth fall off and other factors. The reported resolution using this method may be lower than the device measured is capable of.

The NIDL grille [5] contrast measurement method provides a convenient way to determine horizontal and vertical ANSI pixel resolution at many screen points without having to change the addressable pixel format, i.e., scan rates, between measurements.

Small-area luminance contrast ratios are measured on horizontal and vertical grille test patterns (alternating white and black horizontal or vertical lines of equal width, i.e., 50 % duty cycle) covering the entire screen as depicted in figures A.4 and A.5.

A spatially resolving light measuring device (LMD) such as a photodiode array, a CCD array, or a travelling spot microphotometer is used to measure the luminance profiles of each grille test pattern. There should be at least 10 detector elements per display pixel.

Measurements are made for a series of horizontal grille test patterns consisting of n-lines-on/n-lines-off, and for a series of vertical grille test patterns consisting of n-pixels-on/n-pixels-off, where n = {1, 2, 3...}.

From the resulting luminance modulation curves, determine:

a) L_{valley}, the modulated luminance level of the grille black lines; and
b) L_{peak}, the modulated luminance level of the grille white lines.

Compute the modulation depth, D_{mod}, relative to the average white, L_{white}, and average black, L_{black}, luminance levels measured on the ANSI large-area contrast test pattern, a 4 × 4 chess-board consisting of 16 equal rectangles as depicted in figure A.3.

$$D_{\text{mod}} = \frac{L_{\text{peak}} - L_{\text{valley}}}{L_{\text{white}} + L_{\text{black}}}$$

For the purposes of this method, resolution is defined as the maximum number of alternating black and white lines that can be displayed with a threshold modulation depth, D_{mod}, of 33 % or more. Applying the NIDL grille method, the resolution in number of pixels is estimated from the $n \times n$ grille data using linear interpolation:

$$\text{Resolution in pixels} = \frac{\text{number of addressable pixels}}{n_{\text{r}}}$$

where n_{r} is the calculated grille line width in pixels for which the value of the luminance modulation depth, D_{mod}, is estimated by linear interpolation to be equal to the resolution threshold of 33 %.

If D_{mod}(1 pixel on/1 pixel off) >33 %, then $n_r = 1$ and the resolution is equal to the number of addressable pixels.

If D_{mod}(1 pixel on/1 pixel off) <33 %, use linear interpolation to calculate the value of n_r from the measured D_{mod} values nearest to 33 %. Use values of D_{mod}(n pixel on/n pixel off) such that $D_{mod}(n) < 33\ \% < D_{mod}(n + 1)$, measured for grille patterns of lines n pixels wide lines and (n + 1) pixels wide lines.

$$n_r = n + \frac{D_{mod}(n_r) - D_{mod}(n)}{D_{mod}(n+1) - D_{mod}(n)} \quad \text{for } D_{mod}(n) < 33\ \% < D_{mod}(n+1)$$

Example: Assume a display with format consisting of 1 024 addressable pixels for which $D_{mod}(1)$ is measured to be 17 % for 1-pixel grille patterns, and $D_{mod}(2)$ is measured to be 68 % for 2-pixel grille patterns. Interpolate between these two data points to calculate the value of n_r, for 30 % modulation depth:

$$n_r = 1 + \frac{0,3 - 0,17}{0,68 - 0,17} = 1,2549$$

Use the value of n_r to compute the fraction of addressable pixels that are resolvable:

$$\text{Resolution} = \frac{1\,024}{1,2549} = 816 \text{ addressable pixels}$$

Annex H
(informative)

Photometer precision and veiling glare

Assuming that the measurement and display conditions have been set up carefully in accordance with this document, there are still several factors which can lead to measurement errors and widely varying results when performing light measurements on a projection system. A brief listing of issues to be watchful of are listed below.

H.1 Photometer precision

Apart from the photometric accuracy of 10 % specified in this standard, it is also important to check the precision of the photometer. The precision of a photometer is a good measure of the repeatability of a measurement. A good diagnostic procedure is to wait for the projection system to be stable and then measure the centre of a white screen 10 or more times over a 5 min interval. If the standard deviation of the measurements is more than 2 % of the average illuminance (or the luminance if the display is integral to the system) level, the photometer may not be useful to make repeatable measurements.

H.2 Integration time

If the integration time taken by the photometer to make a measurement is too short, then the refresh rate of the projection display can affect the measurement. For example, when the refresh rate is 80 Hz and the integration time of the photometer is 0,0925 s, a single measurement could be performed on 7 or 8 refresh cycles depending on when it is initiated, and this can introduce a variance of 15 % in the measured value. If the integration time of the photometer is fixed, this problem also contributes to the imprecision of the photometer. However, if it is possible to vary the photometer's integration time, the user should choose it so that the integration time is a multiple of the display's refresh rate. Some photometers automatically measure the refresh rate and change the integration time accordingly.

H.3 Veiling glare

Contrast measurements are typically made by measuring white and black rectangles on a checkerboard pattern displayed on the projection system. When the luminance of a projection system with an integral display is measured using a spot photometer, a phenomenon called lens flare or "veiling glare" can greatly influence the black measurement. Any light-measuring device (LMD) that employs a lens is susceptible to veiling glare. Veiling glare results from light outside the aperture field of view of the LMD scattering and reflecting at the lens surfaces, imperfections in the glass and dirt on the glass, barrel, iris, and other mechanical parts of the lens. This results in a corrupted measurement. Thus an LMD measuring the luminance of a black rectangle on a white background could result in a falsely higher luminance measurement, or a reduced contrast ratio measurement.

There are at least two methods to indicate the sensitivity to veiling glare of the light-measuring device. Both involve measuring the luminance level of a black rectangle (patch) on a white background, varying the patch to cover from 5 % of the total screen size to 100 % of total screen size.

Place a black mask (made from glossy black plastic) across the patch, tilting it slightly to eliminate specular reflections from the projector. Be sure the mask is displaying only reflections from a dark area of the room, or from a light trap (such as a glossy black cone).

Alternatively, a glossy black cone with an apex of 45° can be used (see [6]). The cone is placed in front of the LMD so that the outer (larger) diameter faces the LMD and prevents any light from the display from reaching the LMD lens. The inner diameter (aperture) should be small enough to keep out stray light but large enough to prevent vignetting between the LMD aperture and the aperture of the cone. Using either one of the masks mentioned above would provide a quick indication of the sensitivity of the LMD to veiling glare.

Be aware of the back-reflections from walls and objects in the room, i.e., reflections due to the screen being illuminated. Such reflections can also corrupt luminance measurements. Care must be taken to account for this effect. Methods are currently being investigated [2]. Performing luminance measurements by projecting the image onto a black felt screen with a diffuse white standard as the target would minimize both reflections and veiling glare. Note that if it is possible to avoid veiling glare in the LMD, back-reflections and ambient illumination, any observed halation probably arises from veiling glare in the projection lens or halation in the source.

Either of the above methods can be used for large-area measurements. However, for small-area contrast ratios (SACR) the cone may not be effective (especially for black targets 5 mm in diameter or smaller). One solution would be to use a replica mask. Use a glossy black target, the same width as the SACR pattern. Place the mask over the pattern and use similar procedures to those described above to determine the luminance without LMD glare. A piece of calibrated neutral-density filter film can be used to verify the measurement. Measure the white luminance and the filter luminance. How closely this measured transmission compares to the calibrated transmission can serve as a check. Precautions should be taken when performing these measurements. Attaching a mask to the screen assumes that the screen surface is designed to be treated roughly. Some screen surfaces can be damaged by such a procedure.

Annex I
(informative)

Light measuring devices

There are several light-measuring device technologies that may be appropriate for a particular measurement task. For an overview of these technologies, see references [7], [8], [9], [10]. It should be remembered that even if an instrument is calibrated and is specified to measure a particular photometric or colorimetric quantity, it may not provide the results intended. Accuracy and reproducibility should be verified by means of redundant equipment and diagnostics.

In particular, scanning narrow-spectrum high-power sources (i.e. lasers, LEDs, etc.) may be difficult to measure with some light-measuring devices. The high-intensity pulse may saturate the device. Additionally, the measurement of colour may be difficult due to the narrowband spectrum of these light sources. Diagnostics for these problems as well as others can be found in references [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21].

In the case of saturation, use of calibrated metal-evaporated neutral density filters could provide a means for correction [13]. A set of filters with optical densities of 0,2; 0,5; and 1,0 should suffice. They are relatively inexpensive and can be obtained from most optical supply distributors. Additionally, individual manufacturers should be contacted as they may have unique solutions.

Annex J
(informative)

Figure of merit for projection display colour gamut

This annex describes a metric for the colour gamut of a three-primary projector system, developed at the US National Information Display Laboratories (NIDL). An argument from first principles might conclude that a proper gamut metric would be a volume in a CIE uniform colour space, in which equal distances correspond approximately to equal colour differences. However, such a volume would depend on the gains of the primaries, and on the white of the display. These quantities are not subject to rigorous control in a projector system, and thus cannot be used in a metric that usefully characterizes the system. Another possible metric might involve colorimetric purity of the primaries, but again this metric is not useful because it depends on the white-point.

On the other hand, the chromaticities of the projector primaries are stable enough to characterize a projector system, so these chromaticities can be the basis of a metric. The metric should reside in a chromaticity space for which uniformity is attributed. One uniform-colour space, CIELUV [22], has embedded in it a chromaticity space (u',v') that is used widely in the display industry for such metrics as screen uniformity [23], [24]. Also, there are ANSI standards that specify measurement of chromaticities in (u',v') coordinates [25]. Furthermore, the area in a uniform chromaticity space has long been regarded as a reasonable figure-of-merit for colour gamut [26]. Therefore, the metric advanced in this annex is the area of the triangle subtended by the primaries (r,g,b) in the chromaticity space whose coordinates are (u',v').

To give meaning to a single value of the area metric, it is expressed as a percentage of the area subtended by the entire spectrum locus in ($u'v'$) space, which is the maximum gamut of any projector system, no matter how many primaries are used in the system.

NOTE The area of the spectrum locus is computed as the area of the polygon the vertices of which are the chromaticities of spectral lights from 380 nm to 700 nm in increments of 1 nm. The computed value of this area is 0,1952.

The gamut-area metric for a three-primary system is derived as follows.

If the measurement device measures CIE (x, y) values but not (u', v') values, then

a) measure CIE (x, y) values for each primary at full-on (with the other primaries turned off); denote the (x, y) values as (x_r, y_r) for the red primary, (x_g, y_g) for the green primary, and (x_b, y_b) for the blue primary;

b) transform each of the (x, y) pairs defined above to the CIE 1976 (u', v') coordinate system, using the following equations:

$u' = 4x/(3 + 12y – 2x)$

$v' = 9y/(3 + 12y – 2x)$

c) Compute the area of the projector gamut (for three primaries, the rgb triangle) in (u',v') space, divide by 0,1952, and multiply by 100 % to obtain percentage of gamut coverage, G_p.

G_p = 100(1/0,1952){Area of the gamut}

In the case of a three-primary system, the area of the rgb triangle can be computed with the following formula:

$$\text{Area of rgb triangle} = 1/2 \{ (u'_r - u'_b)(v'_g - v'_b) - (u'_g - u'_b)(v'_r - v'_b) \}$$

Alternatively, if the coordinates (u',v') are directly available from the measurement instrument, it is possible to omit steps a) and b) and to proceed directly to step c).

EXAMPLE CALCULATION:

The following coordinates were measured on a particular projector:

Red: u'_r = 0,443, v'_r = 0,529

Green: u'_g = 0,124, v'_g = 0,567

Blue: u'_b = 0,186, v'_b = 0,120

From these coordinates, the gamut-area metric (percentage of gamut coverage) is G_p = 36 as computed from the equation in step c). That means the projector has access to 36 % of the area inside the spectrum locus.

Bibliography

[1] G. Wyszecki and W. S. Stiles, *Colour Science*, second edition, Wiley, 1982, pp. 224-228.

[2] C. S. McCamy, *Colour Res. Appl.* 17, 1992, pp. 142-144 (with erratum in *Colour Res. Appl.* 18 1993, p. 150).

[3] A. Robinson, *J. Opt. Soc. Am.* **58**, 1968, pp. 1528-1535.

[4] VESA Flat Panel Display Measurement Standard, Version 1.0, May 1998, Section 303-2

[5] NIDL Publication No. 171795-036 *Draft Display Monitor Measurement Methods* under discussion by EIA (Electronic Industries Association Committee) JT-20 Part 1: *Monochrome CRT Monitor Performance* Draft Version 2.0 July 12, 1995, pp. 51-65.

Copies are available at no charge from the National Information Display Laboratory, P.O. Box 8619, Princeton, NJ 08543-8619, Phone: 609/951-0150, Fax: 609/734-2313, e-mail: nidl@nidl.org, Homepage: http://www.nidl.org.

[6] P. A. Boynton and E. F. Kelley, *Accurate Contrast Ratio Measurements Using a Cone Mask* Society for Information Display International Symposium Digest of Technical Papers, Boston, MA, May 11-16, 1997, vol. XXVIII, pp. 823-826 (May 1997).

[7] *Handbook of Applied Photometry*, Casimer DeCusatis, ed., AIP Press, NY, 1997. See chapters 4 and 6. Available from Springer-Verlag.

[8] A103 Light Measuring Devices, Video Electronics Standards Association (VESA) Flat Panel Display Measurement Standard (FPDM), ver. 1.0 (May 1998). Available from VESA. See http://www.vesa.org.

[9] A219 Collimated Optics, VESA FPDM, ver. 1.0 (May 1998).

[10] A226 Equipment Based on Fourier Optics, VESA FPDM, ver. 1.0 (May 1998).

[11] *Methods of Characterizing Illuminance Meters and Luminance Meters*, International Commission on Illumination (CIE) Publication 69 (1987). Available from CIE (see http://www.cie.co.at/cie/)

[12] *Handbook of Applied Photometry*, Casimer DeCusatis, ed., AIP Press, NY, 1997. See chapters 4 and 6.

[13] P. A. Boynton, E. F. Kelley, S. Highnote, R. Hurtado, *Diagnostics for light measuring devices in flying-spot display measurements. Projection Displays 2000: Sixth in a Series,* Proceedings of the SPIE Vol. 3954, pp. 42-51 (2000). Available from SPIE (see http://www.spie.org).

[14] A109 *Color Measurement Diagnostics*, VESA FPDM, ver. 1.0 (May 1998).

[15] A101 *Veiling Glare and Lens Flare Errors*, VESA FPDM, ver. 1.0 (May 1998).

[16] A102 *Spatial Invariance and Integration Times*, VESA FPDM, ver. 1.0 (May 1998).

[17] A106 *Detector Linearity Diagnostics*, VESA FPDM, ver. 1.0 (May 1998).

[18] A107 *Polarization Effects Diagnostics*, VESA FPDM, ver. 1.0 (May 1998).

[19] A110 *Temporal Response Diagnostics*, VESA FPDM, ver. 1.0 (May 1998).

[20] A111 *Array Detector Measurements*, VESA FPDM, ver. 1.0 (May 1998).

[21] P. A. Boynton and E.F. Kelley, *Stray light elimination in making projection display measurements*, *Flat Panel Display Technology and Display Metrology,* Proceedings of the SPIE Vol. 3636, pp. 232-239 (1999). Available from SPIE (see http://www.spie.org).

[22] Commission Internationale de l'Eclairage (CIE), *Colorimetry* (Second Edition), Publication CIE 15.2, Bureau Central de la CIE, 1986.

[23] P. J. Alessi, CIE guidelines for coordinated research evaluation of colour appearance models for reflection print and self-luminous display image comparisons, *Colour Res. Appl.* **19** (1994), 48-58.

[24] ISO 9241-8 (*Colour requirements for CRTs*) and ISO 13406-2 (*Measurement requirements for LCDs*).

[25] ANSI Electronic Projection Standards IT7.227 (*Variable Resolution Projectors*) and IT7.228 (*Fixed Resolution Projectors*).

[26] W. A. Thornton, Colour-discrimination index, *J. Opt. Soc. Amer.*, **62** (1972) 191-194.

[27] IEC 60107-1, *Methods of measurement on receivers for television broadcast transmissions – Part 1: General considerations – Measurements at radio and video frequencies*

Standards Survey

The IEC would like to offer you the best quality standards possible. To make sure that we continue to meet your needs, your feedback is essential. Would you please take a minute to answer the questions overleaf and fax them to us at +41 22 919 03 00 or mail them to the address below. Thank you!

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
1211 Genève 20
Switzerland

or

Fax to: **IEC**/CSC at +41 22 919 03 00

Thank you for your contribution to the standards-making process.

Nicht frankieren
Ne pas affranchir

Non affrancare
No stamp required

A Prioritaire

RÉPONSE PAYÉE
SUISSE

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
1211 GENEVA 20
Switzerland

Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: *(e.g. 60601-1-1)*

....

Q2 Please tell us in what capacity(ies) you bought the standard *(tick all that apply).* I am the/a:

- purchasing agent ❑
- librarian ❑
- researcher ❑
- design engineer ❑
- safety engineer ❑
- testing engineer ❑
- marketing specialist ❑
- other...

Q3 I work for/in/as a: *(tick all that apply)*

- manufacturing ❑
- consultant ❑
- government ❑
- test/certification facility ❑
- public utility ❑
- education ❑
- military ❑
- other...

Q4 This standard will be used for: *(tick all that apply)*

- general reference ❑
- product research ❑
- product design/development ❑
- specifications ❑
- tenders ❑
- quality assessment ❑
- certification ❑
- technical documentation ❑
- thesis ❑
- manufacturing ❑
- other...

Q5 This standard meets my needs: *(tick one)*

- not at all ❑
- nearly ❑
- fairly well ❑
- exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

- standard is out of date ❑
- standard is incomplete ❑
- standard is too academic ❑
- standard is too superficial ❑
- title is misleading ❑
- I made the wrong choice ❑
- other ....

Q7 Please assess the standard in the following categories, using the numbers:
(1) unacceptable,
(2) below average,
(3) average,
(4) above average,
(5) exceptional,
(6) not applicable

- timeliness ....
- quality of writing....................................
- technical contents...................................
- logic of arrangement of contents ....
- tables, charts, graphs, figures...............
- other ....

Q8 I read/use the: *(tick one)*

- French text only ❑
- English text only ❑
- both English and French texts ❑

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

....
....
....
....
....
....
....
....
....
....
....
....

ISBN 2-8318-6001-6

9 782831 860015

ICS 37.020; 33.160.60; 35.140

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND