IEC 62906-5-6

Edition 1.0 2020-04

INTERNATIONAL STANDARD

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Laser displays –
Part 5-6: Measuring methods for optical performance of projection screens

IEC 62906-5-6:2020-04(en)

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INTERNATIONAL
ELECTROTECHNICAL
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ICS 31.260 ISBN 978-2-8322-8233-5

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FOREWORD

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International Standard IEC 62906-5-6 has been prepared by IEC technical committee 110: Electronic displays.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
10/1187/FDIS	110/1198/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62906 series, published under the general title *Laser displays*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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LASER DISPLAYS –

Part 5-6: Measuring methods for optical performance of projection screens

1 Scope

This part of IEC 62906 specifies the standard measurement conditions and measuring methods for determining the optical performance of a projection screen in terms of its photometric characteristics, including screen gain and speckle contrast, from different viewing directions. These methods are only applied for the case in which the projection screen and a laser projector are integrated and used with a fixed configuration as a set to create a real image. Both front and rear projection screens, with a flat surface, are included. This document excludes projection screens which are classified as optically see-through screens, including head-up displays.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845, *International Electrotechnical Vocabulary (IEV) – Part 845: Lighting* (available at www.electropedia.org)

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 62906-1-2, *Laser display devices – Part 1-2: Terminology and letter symbols*

IEC 62906-5-2, *Laser display devices – Part 5-2: Optical measuring methods of speckle contrast*

IEC 62471-5, *Photobiological safety of lamps and lamp systems – Part 5: Image projectors*

CIE S 014-1, *Colorimetry – Part 1: Standard Colorimetric Observers*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845, IEC 62906-1-2 and CIE S 014-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
screen gain
relative deviation from Lambertian distribution of light from the screen

3.1.2
peak gain
maximum screen gain of the screen

3.1.3
half-gain angle
viewing angle from normal at which the screen gain drops to half of the peak gain

3.1.4
screen colour shift
chromaticity difference between images projected on the screen and a reference reflectance or transmittance target

3.2 Abbreviated terms

DUT Device under test

LMD Light measuring device

LPD Laser projection display

NOTE DUT in this document means the combination of the LPD and the screen.

4 Standard measuring conditions

4.1 General

Unless stated otherwise, the following conditions shall be applied. During the measurement, optical radiation safety shall be implemented in accordance with IEC 60825-1 for the products classified above Class 2M, and/or IEC 62471-5 for RG2 and RG3.

4.2 Environmental conditions

Measurements shall be carried out under the standard environmental conditions:

– temperature: 25 °C ± 3 °C,
– relative humidity: 25 % to 85 % RH,
– atmospheric pressure: 86 kPa to 106 kPa.

When different environmental conditions are used, they shall be noted in the measurement report.

4.3 Power supply

The power supply for driving the LPD in the DUT shall be adjusted to the rated voltage within ±0,5 %, and the frequency shall be supplied at the rated frequency within ±0,2 %.

4.4 Warm-up time

The measurements shall be carried out after the light output is sufficiently stable. The warm-up time is defined as the time elapsed from when the supply source is switched on, and a full level of input signal is applied to the LPD in the DUT, until the repeated measurements show a variation in illuminance of no more than ±5 %. The illuminance shall not vary by more than ± 5 % over the entire measurement.

4.5 Measurement coordinate system

The viewing direction is the direction under which the observer looks at the point of interest on the DUT surface (screen surface). During the measurement, the LMD simulates the observer, by aiming the LMD at the point of interest on the DUT from the viewing direction. The viewing direction is defined by two angles: the angle of inclination θ (relative to the surface normal of the DUT) and the angle of rotation Φ (also called azimuth angle) as illustrated in Figure 1. Although the azimuth angle is measured in the counter-clockwise direction, it is related to the directions on a clock face as follows: Φ = 0° is the 3-o'clock direction ("right"), Φ = 90° the 12-o'clock direction ("top"), Φ = 180° the 9-o'clock direction ("left") and Φ = 270° the 6-o'clock direction ("bottom").

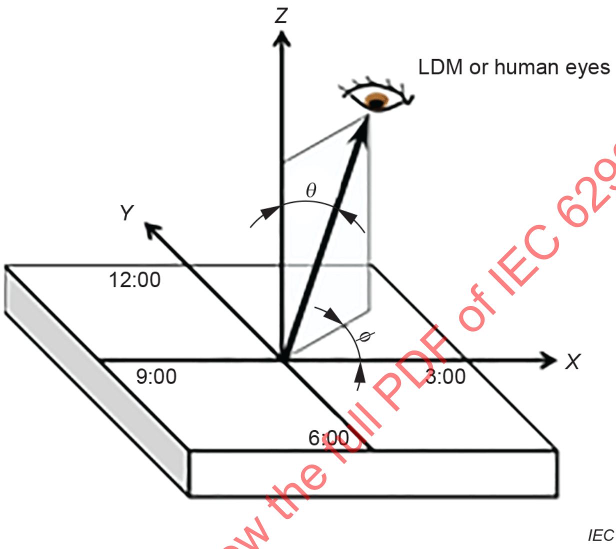


Figure 1 – Coordinate system for projection direction and viewing direction

4.6 Darkroom conditions

The luminance contribution from the background illumination reflected off the screen shall be less than 1/20 of the lowest black level of the display. If these conditions are not satisfied, then background subtraction is required and it shall be noted in the report. The average reflectance of the inner walls of the measurement room shall be lower than 3 %.

4.7 Measuring facilities

The configuration and operating conditions of the measuring equipment shall comply with the structures specified in each item. The sensitivity and the dynamic range of each measuring equipment shall be checked if it is suitable for the required task. To ensure repeatable measurements, the following requirements shall be applied.

a) Luminance meter: Filtered luminance meters are generally considered not to be accurate enough for laser projector measurements. Spectral measurement instruments are preferred for these narrow bandwidth light sources. Filtered luminance meters shall only be used if they are calibrated with a precision spectral radiance meter. However, it is noted that this calibration is valid only for a given spectral distribution of the light source (e.g. red, green, blue primaries, in addition to white and black), and the luminance meter will need a unique calibration factor for every different spectral distribution.

b) Illuminance meter: Filtered illuminance meters are generally considered not to be accurate enough for laser projector measurements. Spectral measurement instruments are preferred for these narrow bandwidth light sources. Filtered illuminance meters shall only be used if they are calibrated with a precision spectral irradiance meter. However, it is noted that this calibration is valid only for a given spectral distribution of the light source (e.g. red, green, blue primaries, in addition to white and black), and the illuminance meter will need a unique calibration factor for every different spectral distribution. Many illuminance meters employ diffusers to capture the incident illumination. These tend to also be valuable in scrambling projector polarization and smoothing speckle non-uniformity. The validity of using diffusers for the illuminance measurement was reported in [1][1]. If a light scrambling element (such as a diffuser) is not employed in the illuminance meter, then its insensitivity to polarization and speckle shall be confirmed with a precision spectral irradiance meter that uses a diffusing element.

c) Spectral radiance/irradiance meter: The narrow spectral line widths of the projector laser sources usually require the use of a spectroradiometer with relatively small spectral bandwidths for accurate results. A spectroradiometer can be configured with an integrating sphere or cosine-corrected diffuser to measure the spectral irradiance of the projector directly. The following requirements are given for these instruments:

   – the spectroradiometer wavelength accuracy shall be < 1 nm;
   – the wavelength measuring range shall be at least 380 nm to 780 nm;
   – it is recommended to use a spectroradiometer with a spectral bandwidth of < 5 nm (full-width-at-half-maximum). The higher resolution spectrometer produces a more accurate colour measurement, especially for lasers sources;
   – the spectral bandwidth of the spectroradiometer shall be an integer multiple of the sampling interval. For example, a 2,5 nm sampling interval can be used for a 2,5 nm or 5 nm bandwidth.

   An alternative method of spectral irradiance can be implemented by using a spectral radiance meter with a diffuse reflectance standard. If measurements are taken at large incident angles, such as in the case of short-focus projectors, it is recommended to use the spectral radiance meter with a reflectance standard or integrating sphere with a thin entrance port wall.

d) Speckle contrast measuring equipment: An imaging camera which is constructed according to IEC 62906-5-2 shall be applied.

5 Installation and adjustment of the DUT

5.1 Placement of the projector and the screen

The screen's optical properties can be very dependent on the optical configuration of the projected light on the screen. Therefore, the screen shall be measured in the same optical geometry as the intended projector and use case. The LMD is located at the normal view to the screen. The measurement distance shall be the same as the standard audience viewing distance which is decided by a manufacturer or a supplier. The projection distance from the projection device to the screen, projection direction, viewing mode, height and tilted angle of the installation shall be reported.

5.2 Focusing of the projector

A factory-provided alignment pattern, or a pattern as shown in Figure 2, can be used to focus the projector at the optimal projection distance. The projector focus shall be adjusted until the centre and edge features of the projected image at the image plane are the sharpest.

1 Numbers in square brackets refer to the Bibliography.

5.3 Standard projector setup conditions

The projector settings shall be configured in the same way for all tests. Any pre-sets (such as viewing mode, iris or dynamic power control turned on/off) shall be reported, and any deviations from the factory default settings shall be reported. The LMD shall be placed in front or in back of the screen for front and rear projection, respectively, and its position relative to the screen shall remain constant throughout all measurements. Any deviation from the LMD position shall be noted in the measurement report.

5.4 Standard image measurement locations

Unless otherwise specified, all measurements shall be taken in the defined image plane at the locations indicated in Figure 3. The common measurement locations are identified by locations P_1 to P_9 in the active area, as illustrated in Figure 3. The active screen area is divided into nine equal-sized boxes, with the measurement area centred within each box and identified by the corresponding numbering shown in Figure 3. Each box is 1/3 the horizontal size (H) and vertical size (V) of the active area. Centre screen measurements are taken at location P_5. Any deviation from the above coordinate system shall be reported.

In Figure 4 an example of DUT setup is shown; the projector is set in front of the projection screen. In the figure, L is the distance between the image screen and projector, and β is the tilt angle of the DUT related to the centre axis of the projector.

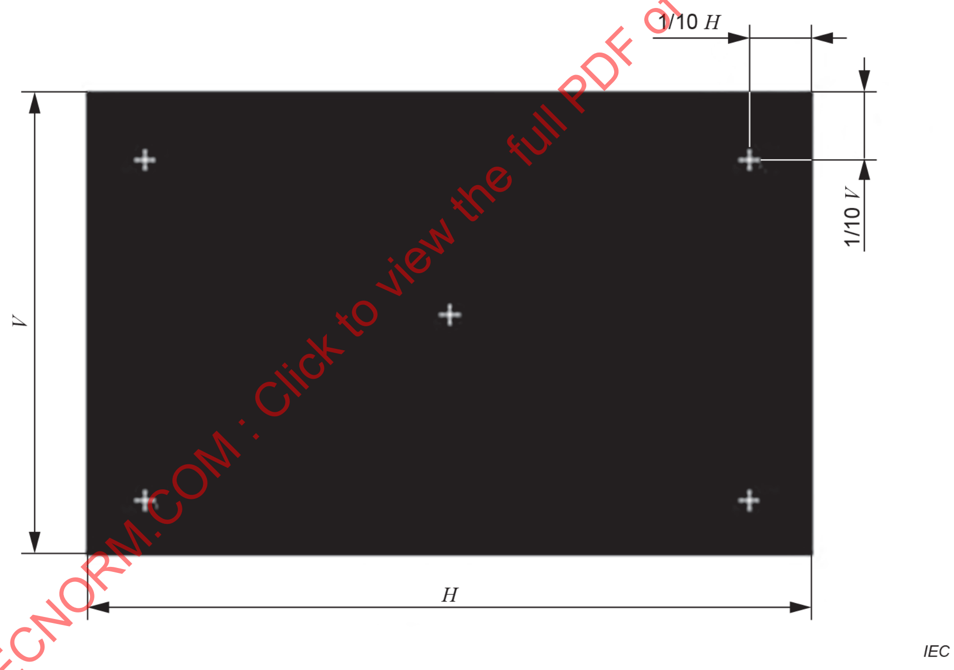


Figure 2 – Example of image pattern with horizontal size H and vertical size V used for alignment

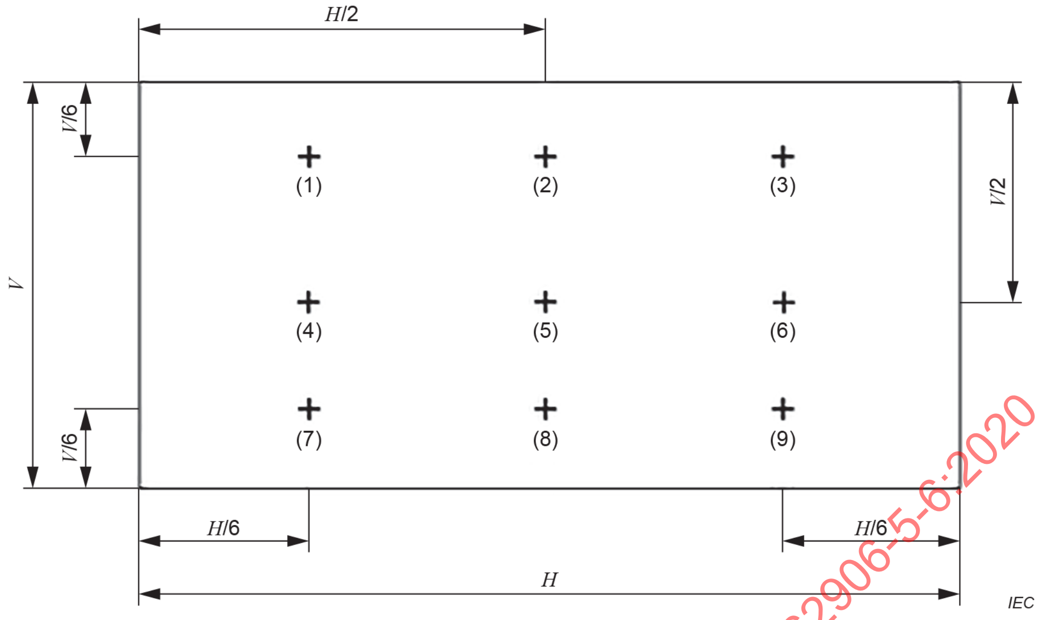


Figure 3 – Standard measurement locations on the screen (nine measurement points)

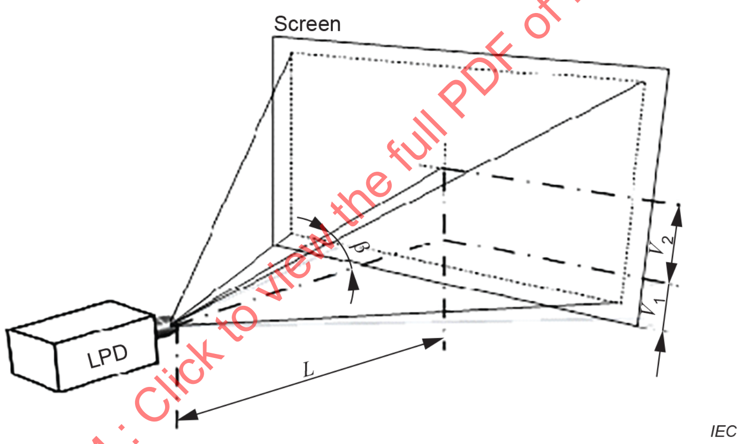


Figure 4 – Example of DUT setup

6 Signal patterns

The pattern shall be full screen (see Figure 5) and the input RGB signal either 100 % white or 100 % of R, G, or B. The RGB signal value shall be noted in the measurement report.

NOTE In case of a white signal pattern, screen colour shift can occur (see Annex A).

Figure 5 – Full screen patterns

7 Measuring methods

7.1 Screen gain

7.1.1 Purpose

The purpose of this method is to measure the screen gain of laser projection displays.

7.1.2 Measuring equipment and conditions

a) An illuminance meter and a luminance meter, or a luminance meter with a near Lambertian reference target having a known reflectance and transmittance factor, respectively. The reference reflectance target which has a reflectance factor of over 98 % and under 102 % can be used. The reference reflectance target shall be calibrated before use according to the following formula:

$$R_{\text{std}} = \pi \frac{L_{\text{std}}}{E} \quad (1)$$

where R_{std} is the calibrated luminous reflectance factor [2] for the measurement configuration, L_{std} is the measured luminance from the reference reflectance target, and E is the measured illuminance.

R_{std} represents the deviation of the luminous reflectance factor of the reference reflectance target from the ideal Lambertian diffuser. L_{std} shall be measured at the viewing direction which is used for the screen gain or speckle contrast measurement. The illuminance E shall be measured so that the measurement plane is identical with the screen surface. The position of the LPD or the screen can be adjusted for that purpose. The illuminance E can be calculated by the known R_{std} and the measured L_{std}.

b) If the DUT is set as the rear projection configuration, a transmission diffuser which is calibrated in a similar way as 7.1.2 a) can be used as a reference transmittance target. In this case, the luminous transmittance factor shall be used for the calibration. The illuminance E shall be measured at the back side of the screen, while the luminance L_{std} shall be measured at the front side of the screen. The measurement of L_{std} includes the optical loss by absorbance of the screen material, or back reflection and scattering. If the reference transmittance target has a different spectral transmittance at each dominant wavelength of LPD, it can cause a calibration error. In such a case, the calibration of the reference transmittance target shall be done with the light source which has the same spectral properties as the LPD. Even if the light source for the calibration does not have the same spectral properties as the LPD, both the scattering and spectral properties of the reference transmittance target shall be calibrated using a spectroradiometer.

c) Geometry arrangement: The projector shall be located at the position which is the same as the product specification. The LMD is located at the normal view to the screen (Figure 6). The measurement field of the LMD shall be centred in the centre of the screen.

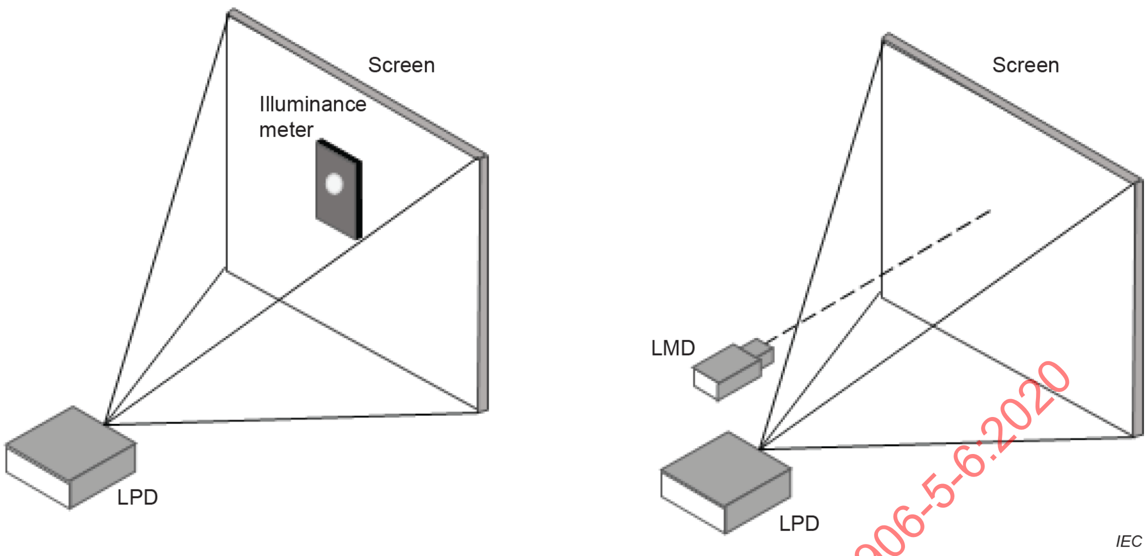


Figure 6 – Measuring geometry of screen gain

7.1.3 Measuring methods

7.1.3.1 Measuring method using an illuminance meter

a) Measure the incident illuminance (E), at the intersection of the normal with the screen using an illuminance meter.

b) Measure the luminance (L_0) of the light reflected at the intersection of the normal to the screen using a luminance meter.

c) The screen gain G is calculated:

$$G = \pi \frac{L_0}{E} \tag{2}$$

7.1.3.2 Measuring method using a reference reflectance target

a) Place the reference reflectance target with known R_{std} at the same location as the screen. Make sure that the reference reflectance target fills the field of view of the luminance meter.

b) Measure the luminance of the reference target (L_{std}). Replace the reference target with the screen and measure the luminance of the screen (L_0).

c) The screen gain G is calculated by Formula (3), which is derived from Formulae (1) and (2):

$$G = R_{std} \frac{L_0}{L_{std}} \tag{3}$$

7.2 Screen gain directivity and half-gain angle

7.2.1 Purpose

The purpose of this method is to measure the screen gain directivity and half-gain angle of laser projection screens.

7.2.2 Measuring conditions

a) Measuring instruments: An illuminance meter, or a luminance meter with a near Lambertian reference reflectance target having a known gain. A transmission diffuser may be used as a reference target for the rear projection measurement, as in 7.1.2.

b) The projector shall be located at the position which is the same as the product specification.

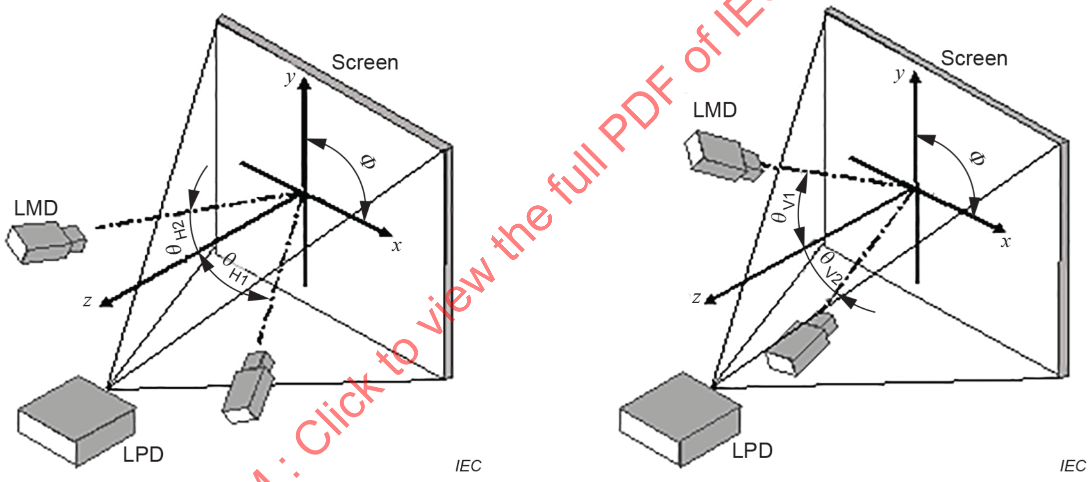
c) The LMD can be rotated around the screen centre normal in the horizontal (Φ = 0°) and vertical (Φ = 90°) planes, optionally in the planes at the azimuthal angle of Φ = ±45°.

7.2.3 Measuring methods

a) Measure the gain G normal to the screen using one of the methods described in 7.1.3. Measure the luminance L_0 of the screen normal to its surface and the luminance $L_{\Phi\theta}$ at the desired angles as shown in Figure 7.

b) Gains at angles θ_H (ϕ = 0° or 180°) and θ_V (ϕ = 90° or 270°) can be determined by the method described in 7.1.3 and Formula (2).

c) Half-gain angle: Determine the angles θ_{H1} and θ_{H2}, where the gain has fallen to 50 % of the gain measured normal to the screen. The half-gain angle θ_H in the horizontal direction is given by $\theta_H = (\theta_{H1} + \theta_{H2}) / 2$. The same calculation applies for the vertical direction.



a) Measurement on the horizontal direction **b) Measurement on the vertical direction**

Figure 7 – Viewing direction measurement in both horizontal and vertical directions

7.3 Screen gain uniformity

7.3.1 Purpose

The purpose of this method is to determine the average screen gain and its uniformity. This method shall not be applied to the case where the screen gain at each of the measurement points is not designed for a certain single viewing point of an observer (e.g. cinema screen with high screen gain).

NOTE This method can be typically applied to a screen with a Fresnel lens (see Annex B), for example, rear projection or ultra-short throw projection displays, whose screen contains a transmissive or reflective Fresnel lens inside.

7.3.2 Measuring conditions

The following measuring conditions apply:

a) Apparatus: An illuminance meter, or a luminance meter with a near Lambertian reference reflectance target having a known gain or a transmission diffuser as described in 7.1.2 a).

b) Geometry arrangement: The projector shall be located at the position which is the same as the product specification. The LMD is set at the single vantage point or normal to the screen from each measurement point. The measurement points are specified in Figure 3. The measurement distance shall be the same as the intended audience viewing distance. For the vantage point measurement, the LMD shall be set near the exit pupil of the Fresnel lens, if a Fresnel lens is used to enhance the screen directivity toward the viewer (see Annex B). The LMD shall pivot about its entrance pupil.

7.3.3 Measuring methods

a) Measure the screen gain G using one of the methods described in 7.1.3 at the nine measurement points. If other measurement points are adopted, the number and the location on the screen shall be reported.

b) Determine the maximum G_{max} and minimum G_{min} screen gain. The average of the screen gain G_{a} can be calculated by Formula (4).

$$G_{\mathrm{a}} = \frac{1}{N}\sum_{n=1}^{N} G_{\mathrm{n}} \tag{4}$$

c) The percent deviation of the highest and lowest screen gain relative to the average, $U_{\text{G-high}}$ and $U_{\text{G-low}}$ respectively, can be calculated by the Formulae (5) and (6).

$$U_{\text{G-high}} = \left(\frac{G_{\mathrm{max}} - G_{\mathrm{a}}}{G_{\mathrm{a}}}\right) \times 100\ (\%) \tag{5}$$

$$U_{\text{G-low}} = \left(\frac{G_{\mathrm{min}} - G_{\mathrm{a}}}{G_{\mathrm{a}}}\right) \times 100\ (\%) \tag{6}$$

d) Report the maximum G_{max} and minimum G_{min} screen gain, the average screen gain G_{a}, and the percent deviations $U_{\text{G-high}}$ and $U_{\text{G-low}}$ respectively.

7.4 Angular characteristics of speckle contrast

7.4.1 Purpose

The purpose of this method is to measure the speckle contrast from the different viewing directions.

NOTE The angular characteristics of speckle contrast are dependent on the type of screen, as well as on the spatial coherence of the projected laser light (see Annex C).

7.4.2 Measuring conditions

a) Measuring instruments: the LMD applied for this measurement shall be an imaging camera constructed according to IEC 62906-5-2.

b) The projector shall be located at the position which is the same as the product specification.

c) The LMD can be rotated around the screen centre normal in the horizontal (Φ = 0°) and vertical (Φ = 90°) planes.

7.4.3 Measuring methods

a) Place the LMD and LPD as indicated in Figure 8. The measurement distance shall be the same as the intended audience viewing distance.

b) The projection image of the DUT shall consist of a spatially uniform pattern of each RGB image, respectively. The projected image shall completely cover the field of view of the LMD for any viewing direction used in the measurement.

c) Focus the LMD on the projected image on the screen.

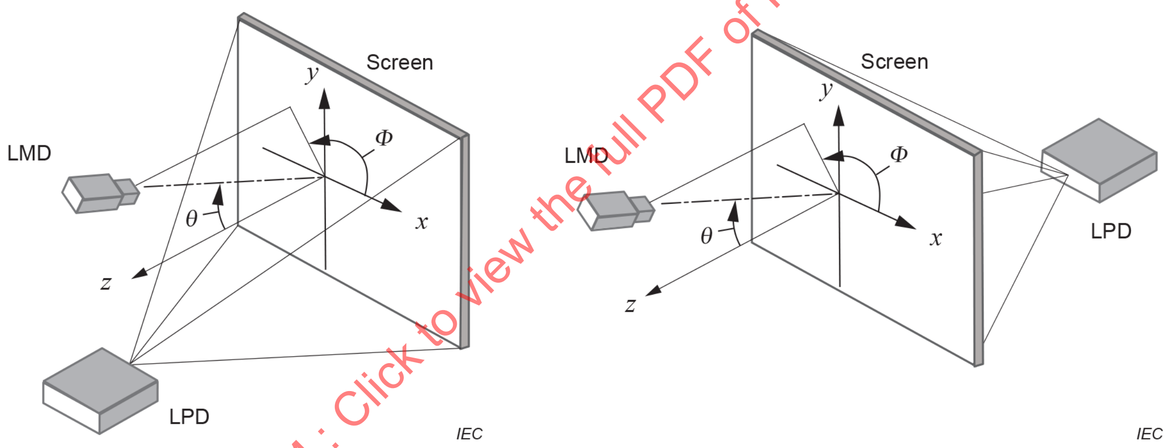
d) Capture the image. The exposure time shall be determined so as not to saturate the imaging device.

e) Calculate the speckle contrast C_S using the following Formula (7):

$$C_\mathrm{S} = \frac{\sigma}{\overline{I}} \tag{7}$$

where σ is the standard deviation of the speckle pattern and I is the average of the speckle pattern (see IEC 62906-5-2).

f) Measure the speckle contrast C_S at the desired polar (θ) and azimuthal (Φ) angles and report the speckle contrast for each combination of θ and Φ to get the angular characteristics of speckle contrast.



a) Front projection **b) Rear projection**

Figure 8 – Measuring geometry of speckle contrast with changing viewing direction

Annex A
(informative)

Screen colour shift

A.1 Purpose

The purpose of this method is to determine the chromaticity difference between images projected on the screen and a reference reflectance/transmittance target.

A.2 Measuring conditions

The following measuring conditions apply:

a) Apparatus: colorimeter or spectroradiometer.

b) A calibrated reference reflectance/transmittance target which is colour neutral and has a flat spectral response.

c) Signal pattern: full-screen white (100 % RGB) of the LPD.

The screen colour shift can change under each different light source because the spectral distribution of the reflectance or transmittance of the screen may not be uniform in the whole spectral range in the measurement. The valid value of the screen colour shift can be obtained by the combination of the LPD and the screen, which are to be used as a set.

A.3 Measuring methods

The screen colour shift can be measured relative to the reference reflectance/transmittance target.

a) Measure the colour (u'_{ref}, v'_{ref}) of the reference reflectance/transmittance target at the intersection of the normal to the screen.

b) Measure the colour (u'_{screen}, v'_{screen}) of the screen at the same location where the target had been located.

c) The screen colour shift is calculated as:

$$\Delta u'v' = \sqrt{\left(u'_{\text{ref}} - u'_{\text{screen}}\right)^2 + \left(v'_{\text{ref}} - v'_{\text{screen}}\right)^2} \tag{A.1}$$

d) The measurement can be done from the different viewing directions (θ and Φ) using Formula (A.1). Also, the multi-point measurement can be applied, such as the nine-point measurement.

e) Report the screen colour shift at each viewing direction and measurement point.

Annex B
(informative)

Screen directivity using a Fresnel lens

The directivity of a screen is influenced by various factors, such as the optical components or light-diffusing material used in the screen. For the optical components in particular, the Fresnel lens, which is used to control the divergent angle, has strong impact on the directivity of the screen. Figure B.1 shows the relationship between the focal length of the Fresnel lens and the projection distance.

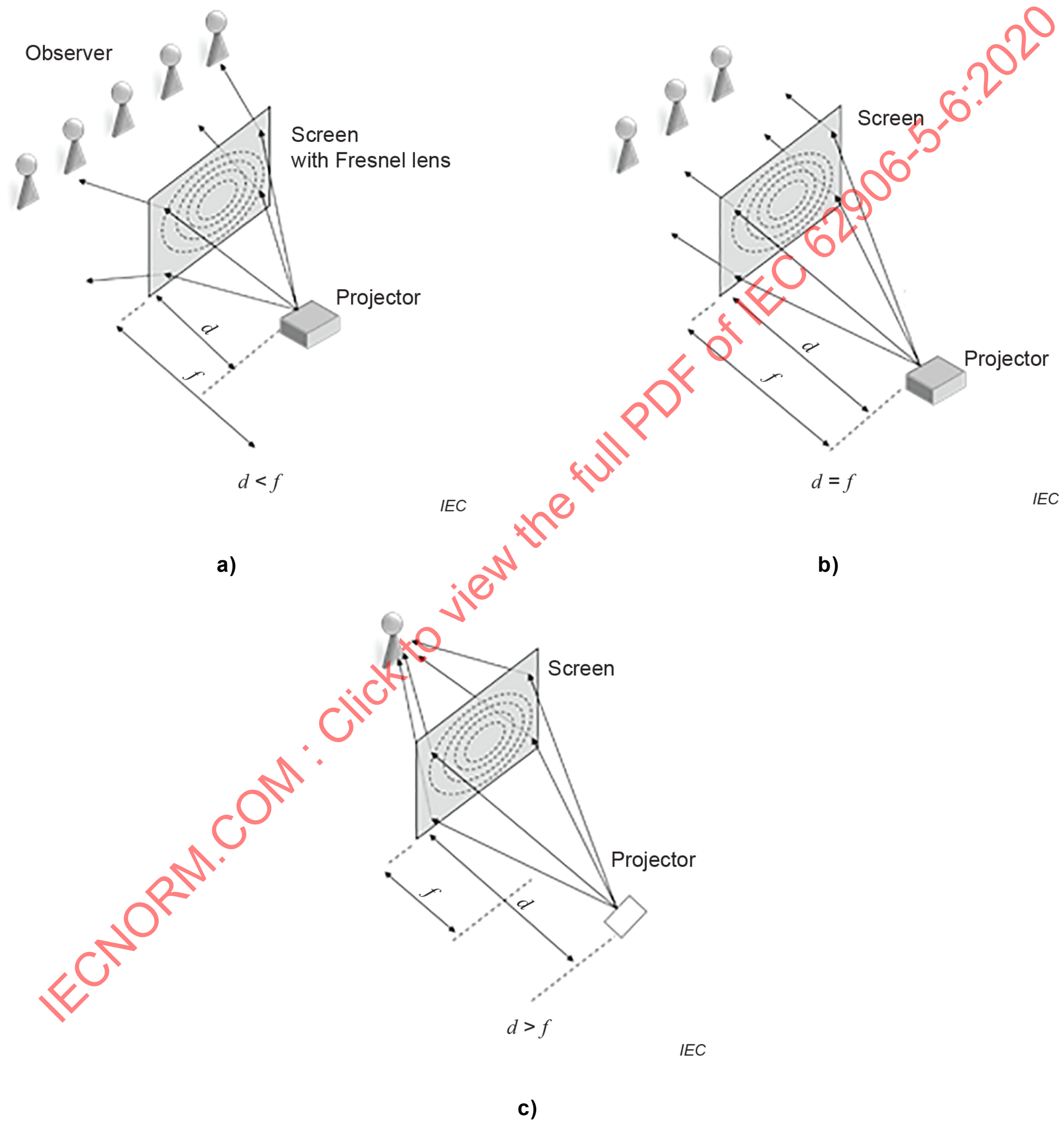


Figure B.1 – Directivity of the screen under different setups