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Date: 18 December 2020

Origin: International

Latest date for receipt of comments: 13 January 2021

Project No. 2017/03006

Responsible committee: EPL/47 Semiconductors

Interested committees:

Title: Draft BS EN IEC 62977-3-4 Electronic displays. Part 3-4: Evaluation of optical performance – High dynamic range displays.

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



110/1276/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC 62977-3-4 ED1

DATE OF CIRCULATION:

2020-12-18

CLOSING DATE FOR COMMENTS:

2021-02-12

SUPERSEDES DOCUMENTS:

110/1194/CD, 110/1206A/CC

IEC TC 110 : ELECTRONIC DISPLAYS

SECRETARIAT:

Japan

SECRETARY:

Mr Yoshi SHIBAHARA

OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 100

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

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TITLE:

Electronic displays – Part 3-4: Evaluation of optical performance – High dynamic range displays

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CONTENTS

1		
2		
3	FOREWORD	5
4	INTRODUCTION	7
5	1 Scope	8
6	2 Normative references	8
7	3 Terms, definitions and abbreviated terms	8
8	3.1 Terms and definitions	8
9	3.2 Abbreviated terms	11
10	4 Standard measuring equipment	11
11	4.1 Video signal generator	11
12	4.2 Measuring equipment	12
13	4.3 Test equipment block diagram	13
14	5 Standard measuring conditions	13
15	5.1 Standard measuring environmental conditions	13
16	5.2 Power supply	13
17	5.3 Warm-up time	13
18	5.4 Standard darkroom conditions	13
19	5.5 Adjustment of HDR display	14
20	6 Measuring methods of optical characteristics	15
21	6.1 Peak luminance	15
22	6.1.1 Peak luminance variation by black and white pattern	15
23	6.1.2 APL by the window and background level	15
24	6.1.3 Test pattern for peak luminance	16
25	6.1.4 Measuring method	16
26	6.2 Black luminance and contrast ratio	17
27	6.2.1 Test patterns for black luminance	17
28	6.2.2 Contrast ratio	17
29	6.2.3 Local contrast ratio	18
30	6.2.4 Measuring method	18
31	6.2.5 Contrast ratio with ambient illumination	19
32	6.3 Luminance loading	19
33	6.3.1 Luminance loading	19
34	6.3.2 Measuring method	20
35	6.4 Transition time and duration of peak luminance	20
36	6.4.1 Test pattern for transition time	20
37	6.4.2 Measurement of Rise-time and Fall-time	20
38	6.4.3 Measuring method of duration time and interval	21
39	6.5 Tone reproduction	22
40	6.5.1 Test pattern of tone reproduction	22
41	6.5.2 Measuring method of gamma	22
42	6.5.3 Gamma and colour saturation gamma	23
43	6.5.4 Reference curves of HDR EOTF	24

44	6.5.5	Measuring method of tone reproduction	27
45	6.5.6	Grey scale accuracy	28
46	6.5.7	System gamma of HLG HDR.....	28
47	6.6	Tone mapping	29
48	6.7	Chromaticity reproduction	31
49	6.7.1	General	31
50	6.7.2	Chromaticity/colour gamut area evaluation	33
51	6.7.3	Test pattern of chromaticity reproduction	34
52	6.7.4	Chromaticity reproduction accuracy evaluation	37
53	7	Reporting	37
54	7.1	Requirement of reporting	37
55	7.2	Recommendations of measurement results reporting	38
56	Annex A (informative)	Colour gamut variation by luminance boosting according to	
57		colour saturation.....	39
58	A.1	Background	39
59	A.2	Colour gamut variation by luminance boosting	39
60	A.3	Chromaticity gamut limits according to Y (Mac-Adam limits) by colour	
61		saturation gamma	40
62	Annex B (informative)	Input codes for HDR display measurement.....	42
63	B.1	General.....	42
64	B.2	Input code assignment corresponding to display gamma.....	42
65	Annex C (informative)	Measurement of HDR reference white	45
66	C.1	Purpose	45
67	C.2	Measuring method	45
68	C.3	Input code for HDR reference white	45
69	Bibliography.....		47
70			
71	Figure 1 –	Measuring layout for non-contact measurement	13
72	Figure 2 –	Measuring layout for close-up type LMD.....	14
73	Figure 3 –	Example of white luminance curve by white window area	15
74	Figure 4 –	General window pattern with $A\%$ area	16
75	Figure 5 –	$A\%$ APL pattern with $A\%$ area white.....	16
76	Figure 6 –	Input patterns for black luminance.....	17
77	Figure 7 –	Graphical example of Rise time and Fall time of peak luminance	21
78	Figure 8 –	Multi-colour pattern for grey scale measurement.....	22
79	Figure 9 –	OETF and EOTF curves	25
80	Figure 10 –	Tone mapping for PQ curve.....	29
81	Figure 11 –	Non-supported image for PQ HDR tone mapping	31
82	Figure 12 –	Supported image for PQ HDR tone mapping	31
83	Figure 13 –	BT.2020 and DCI-P3 gamut in xy colour space	32
84	Figure 14 –	BT.2020 and DCI-P3 gamut in $u'v'$ colour space	33
85	Figure 15 –	Multi-colour pattern with centre reference colour for chromaticity	
86		reproduction measurement	37

87	Figure A. 1 – Examples of colour saturation gamma due to white boosting	40
88	Figure A. 2 – Examples of Mac-Adam limits (at $Y = 80\%$ intersection)	41
89	Figure B. 1 – Input code assignment for PQ HDR (10 bit)	42
90		
91	Table 1 – Input code values for gamma and colour saturation gamma measurement	23
92	Table 2 – Examples of measuring range for PQ grey scale measurement	26
93	Table 3 – Examples of pattern inputs for HLG grey scale measurement	27
94	Table 4 – Input code values for tone mapping evaluation	30
95	Table 5 – Primary colour of BT.2020 and DCI-P3	32
96	Table 6 – XYZ ↔ RGB conversion matrix for BT.2020 colorimetry	34
97	Table 7 – XYZ ↔ RGB conversion matrix for DCI-P3@D65 colorimetry	34
98	Table 8 – Colour reference pattern target values	35
99	Table 9 – RGB inputs of colour reference pattern for BT.2020 colorimetry	36
100	Table B. 1 – PQ input code values for image-signal black	43
101	Table C. 1 – HDR reference white in BT.2408	46
102		
103		
104		
105		
106		
107		
108		
109		
110		
111		
112		

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ELECTRONIC DISPLAYS –

Part 3-4: Evaluation of optical performance – High dynamic range displays

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

CDV	Report on voting
110/XX/CDV	110/XX/RVC

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

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

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

- 165 • reconfirmed,
- 166 • withdrawn,
- 167 • replaced by a revised edition, or
- 168 • amended.

169

170

171 The National Committees are requested to note that for this publication the stability date
172 is 2024.

173 THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED
174 AT THE PUBLICATION STAGE.

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INTRODUCTION

This document is intended to describe the measurement and evaluation of optical performances of High Dynamic Range (HDR) displays as a reference for forthcoming standards to make the work of the involved experts more efficient and to avoid duplication of efforts.

HDR is the ability to render bright portions of the image with a higher luminance compared to Standard Dynamic Range (SDR) displays. Also, HDR content preserves details in the darkest and brightest areas of a picture that are lost when using SDR standards such as Rec. ITU-R BT.709 (see 3.1.4). It also allows for more natural, true-to-life colours that are closer to how we see them in real life.

For measurements of HDR displays, many considerations are required in order to do the measurements in a proper manner. For example,

- 1) Very low level of luminance should be measured, which requires a careful treatment of stray light from the emission from the display and from the ambient light. Subtle colour change can be problematic especially observing the dark area.
- 2) The HDR content consists of 10 bits or more. The measurement of resolution of luminance level, especially resolution of luminance of dark black and the brighter are essential.
- 3) HDR TVs have some very unique modes of operation that have not been utilized in displays in the past. There are also some very unique content/commands/performance information contained in the source material. HDR displays also have limited ways in how they can be driven. All of these are intrinsically tied together. Plus the modes and adjustments in HDR TVs or monitors are depending on the maker's intention.

Proper source content is critical to evaluating HDR performance material including the driver (and interface). In SDR displays, it may be possible to separate these issues with evaluation of "panels", but for HDR displays it may not be possible to separate these issues because HDR displays include the internal processing part for HDR video signal such as EOTF and tone mapping, etc. in addition to essential driving parts for display panel.

ELECTRONIC DISPLAYS –

Part 3-4: Evaluation of optical performance – High dynamic range displays

1 Scope

This part of IEC 62977 specifies the standard measurements of optical characteristics of an electronic display which includes drivers or EOTF controllers for HDR content in the darkroom conditions. The measuring methods stipulated in this document are in order to evaluate HDR display systems at the reference master mode that complies with the HDR standards by ITU-R BT.2100 and ITU-R BT.2390.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Recommendation ITU-R BT.2020-2: *Parameter values for the ultra-high definition television systems for production and international programme exchange*, 2015

Recommendation ITU-R BT.2100-2: *Image parameter values for high dynamic range television for use in production and international programme exchange*, 2018

Report ITU-R BT.2390-0: *High dynamic range television for production and international programme exchange*, 2016

IEC 62341-6-1 Ed.2:2017, *Organic Light Emitting Diode (OLED) Displays – Part 6-1: Measuring methods of optical and electro-optical parameters*

IEC 62341-6-3 Ed.2:2018, *Organic Light Emitting Diode (OLED) Displays – Part 6-3: Measuring methods of image quality*

IEC TS 62341-6-5:2018, *Organic Light Emitting Diode (OLED) Displays – Part 6-5: Measuring methods of dynamic range properties*

IEC 62977-2-1, *Electronic displays – Part 2-1: Measurement of optical characteristics – Fundamental measurements (CDV)*

IEC 62977-2-2, *Electronic displays – Part 2-2: Measurement of optical characteristics – Ambient performance (FDIS)*

CIE 015, *Colorimetry*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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 peak luminance

maximum measured display luminance at the centre of the screen for a specific input signal in the required measuring condition

Note 1 to entry The peak luminance should be measured as the highest luminance value for a white input with a specific input APL during the stable luminance condition.

Note 2 to entry If the peak luminance is different between full range and narrow range input code values (refer to Rec. ITU-R BT.2100), the higher luminance shall be selected.

Note 3 to entry In some displays, the peak white luminance can be larger than the sum of the RGB peak luminances while the RGB chromaticities are maintained.

3.1.2 dynamic range

range of the lowest to the highest luminance

Note to entry The unit of dynamic range can be expressed in terms of the number of stops using the formula $\text{Log}_2[\text{dynamic range}]$ expressed as a ratio of highest luminance to the lowest luminance that the display can render by non-zero value.

3.1.3 high dynamic range

span of image luminance and contrast that is larger than normally possible in standard dynamic range (SDR) image and SDR content ^[20]

Note 1 to entry In this document, “high dynamic range” is abbreviated as “HDR”, for example, “An HDR display is capable of rendering HDR content.”

Note 2 to entry In case of Recommendation ITU-R BT.2100, the dynamic range of HDR display is recommended from $\leq 0,005$ to $\geq 1\,000$ cd/m² for reference viewing environment.

3.1.4 standard dynamic range

span of image luminance that is normally possible for the conventional video display as specified, for example, by Rec. ITU-R BT.709 and Rec. ITU-R BT.2020

Note 1 to entry SDR displays have a reference reproduction using a luminance range constrained by Recommendation ITU-R BT.2035 § 3.2 ^[4] for video applications, or SMPTE RP 431 ^[24] for cinema applications.

Note 2 to entry: SDR is defined and constrained by ITU-R BT.601 or ITU-R BT.709 or ITU-R BT.2020.

3.1.5 average picture level

APL

average of input signal pixel values in RGB or average level percentage of display pixels before or after EOTF of input signals expressed as a percentage of the range based on a white input

Note to entry Post-EOTF APL is also called ALL (Average Luminance Level), and calculated by averaging of post-EOTF signal pixels (linear code values).

3.1.6 code value

digital value of an image signal component consisting signal pixel expressed as a specified format such as RGB

3.1.7**opto-electrical transfer function****OETF**

optical to signal transfer function which is used in image acquisition devices such as digital cameras for mapping scene luminance to digital code values prior to encoding, transmission, and/or compression

Note 1 to entry If OETF and EOTF consist of or close to a power function generally in SDR system, the function is called nonlinear encoding (gamma correction) and nonlinear decoding (inverse gamma correction), respectively where its exponent is called gamma or gamma value.

Note 2 to entry In conventional non-constant luminance systems, the nonlinear decoding is done in the RGB domain, whereas it is done in the $YC_B C_R$ domain for constant luminance systems.

3.1.8**electro-optical transfer function****EOTF**

mathematical function of inverse OETF and system gamma by optical-to-optical transfer function usually used for display systems such as TV and monitors that maps digital code values to displayed luminance

Note to entry Generally, also called nonlinear decoding which is the reciprocal of nonlinear encoding but custom decoding is also available in many display products.

3.1.9**optical-to-optical transfer function****OOTF**

mathematical function that maps captured luminance by a camera to displayed luminance by a display device according to rendering intent or peak luminance of the display

3.1.10**chromaticity reproduction accuracy**

capability to render target chromaticity to within a certain level of accuracy

Note to entry In order to reproduce target chromaticity in a large colour space such as BT.2020 to within the third or fourth decimal place in chromaticity coordinates, the display would need enough colour gamut coverage and may need the display bit depth of 10 to 14 bits.

3.1.11**white boosting**

luminance increase of displayed (highlight) white beyond R+G+B luminance, that is, highlight level is increased with a corresponding decrease in colour saturation toward achromatic colour, with a corresponding loss of R+G+B primary colour additivity (see Annex A)

Note to entry: An ideal display has unity of tone additivity for all inputs where tone additivity function is sum of the R, G, and B tones divided by the grey tone.

3.1.12**colour saturation tone function**

luminance variation of R , G , B , C , M , and Y for (r, g, b) input (N, n, n) , (n, N, n) , (n, n, N) , (n, N, N) , (N, n, N) , and (N, N, N) , respectively, where $n \in \{0, 1, \dots, N\}$, and N is the number of quantization levels per primary colour

Note 1 to entry An ideal display renders constant colorimetric hue for the inputs.

Note 2 to entry When the luminance at maximum saturation is subtracted from the colour saturation tone function (bias correction), and the resulting function obeys a power law, its exponent is called colour saturation gamma.

3.1.13**HDR display**

display rendering with EOTF and OOTF which accommodates to HDR content

Note to entry HDR display can also display SDR content by changing EOTF and its related functions such as tone mapping and system gamma.

3.1.14**HDR content**

image content mastering with OETF which is described in Rec. ITU-R BT.2100

Note to entry The colour distribution container of HDR content should comply with BT.2020.

3.1.15**tone mapping**

image processing technique of display system to map one set of tone range to another to approximate the appearance of HDR content, when said content requires a wider dynamic range beyond the display's capability to reproduce the full range of light intensities ranging from the darkest to the highest target luminance levels

Note to entry Tone mapping should preserve the chromaticity of original image.

3.2 Abbreviated terms

For the purposes of this document, the following abbreviations apply.

ABC	auto brightness control
APL	average picture level
CIELAB	CIE 1976 (L*a*b*) colour space
DUT	device under test
HDR	high dynamic range
SDR	standard dynamic range
OETF	opto-electrical transfer function
EOTF	electro-optical transfer function
OOTF	optical-to-optical transfer function
PQ	perceptual quantizer (PQ tone curve as defined in Rec. ITU-R BT.2100)
HLG	hybrid log-gamma (tone curve as defined in Rec. ITU-R BT.2100)
OLED	organic light emitting diode
RGBCMY	red, green, blue, cyan, magenta and yellow

4 Standard measuring equipment**4.1 Video signal generator**

A digital video signal generator is used. The DUT should support 10 bit or greater than 10 bit signal and colour range signal input of ITU-R BT.2020. It shall be reported by "Supported" or "Not supported" in the test report of Clause 7. It is important that for each measurement result, metadata conditions are defined, checked and reported. Otherwise, the results may not be reproducible. The metadata format is included in the reporting in 7.1. As an example of test signal format:

ST 2084 EOTF, 10-bit RGB Limited Range, BT.2020 primary encoding,

ST 2086 metadata: P3D65, 1 000 nit peak, 0,005 nit min.

MaxCLL no data, MaxFALL no data

NOTE This item from the current text seems to reinforce an agreement that the metadata condition is important therefore the metadata condition should be specified and reported.

Input signal or input data, in this document, means the transferred code values by the OETF of PQ HDR or HLG HDR (refer to Rec. ITU-R BT.2100 and Rep. ITU-R BT.2390).

NOTE For the HDR displays, the video signal shall comply with HDR content, 10 bit or over 10 bit with high dynamic range.

4.2 Measuring equipment

Optical properties of displays shall generally be expressed in photometric or colorimetric units using the CIE 1931 standard colorimetric 2-degree observer (see ISO 11664-1). Luminance can be measured by a photometer, and CIE tristimulus values (X , Y , Z) or CIE chromaticity coordinates by a colorimeter. A spectroradiometer may also obtain photometric and colorimetric values through a numerical conversion of the measured spectral radiance data. The following requirements are given for these instruments:

The LMD shall be a luminance meter, colorimeter, or a spectroradiometer. For DUTs that have sharp spectral peak full-width-at-half-maximums (FWHMs) smaller than 20 nm, such as laser displays, LCDs with fluorescent lamp backlights or LED with narrow-peak phosphors, quantum-dot phosphors, or narrow-spectrum OLEDs, a spectroradiometer should be used. A filter colorimeter should generally not be used for light sources with sharp spectral peaks. If they are used, the colorimeter must be calibrated with a narrow bandwidth spectroradiometer to give the same results for the specific spectrum. Report the spectroradiometer characteristics of spectroradiometer which is used for calibration. For light sources with sharp spectral peaks, the maximum bandwidth of the spectroradiometer shall be ≤ 5 nm. The higher resolution spectroradiometer produces a more accurate colour measurement, especially for lasers sources. The spectroradiometer shall be capable of measuring spectral radiance over at least the 380 nm to 780 nm wavelength range, with a maximum bandwidth of 10 nm for smooth broadband spectra (i.e. broad spectrum with no sharp spikes).

The following additional best practices shall be followed:

- 1) The LMD shall be focused on the image plane of the display and generally aligned perpendicular to the display surface at the centre of the active display area, unless stated otherwise.
- 2) The relative uncertainty and repeatability of all the measuring devices shall be maintained by following the instrument supplier's recommended calibration schedule.
- 3) If the light level of the display is temporally modulated, then the LMD integration time shall be synchronized with the modulation frequency. If the LMD is not capable of synchronizing, then the LMD integration time shall be at least 200 cycles of the fundamental Fourier Transform frequency light of the modulated light in order to measure the luminance to better than 5 %.
- 4) If LMD measurements are taken for displays with temporal light modulation (including LCD backlights), the temporal high peak luminance of these displays can cause detector saturation errors. The accuracy of these measurements can be checked by attenuating the light with a neutral density filter with known characteristics. If the change in signal amplitude of the detector is proportional to the transmittance of the neutral density filter, then there are no detector saturation errors. This method can be used for measuring the time-averaged screen luminance.
- 5) If the LMD is to measure a dim measurement area, the LMD field of view should avoid containing a bright background. If this is not possible, then a frustum or stray-light-elimination tube (SLET) shall be used [1].
- 6) Response meter: The Response meter should be capable of producing a linear response to rapid changes in luminance. The Response Meter's response time T_{LMD} and sample time should be less than one tenth the minimum transition time. The Response meter need not be dark field corrected, and does not require photopic correction unless the colour of the test pattern changes significantly as it changes between L_W (full white) and L_K (full black).

Additional conditions of measurement equipment are given in IEC 62977-2-1.

4.3 Test equipment block diagram

Refer to IEC 62977-2-1. An example of the block diagram is shown in Figure 1. Optical axis of the optical test equipment shall be centered on the screen and perpendicular to the display surface.

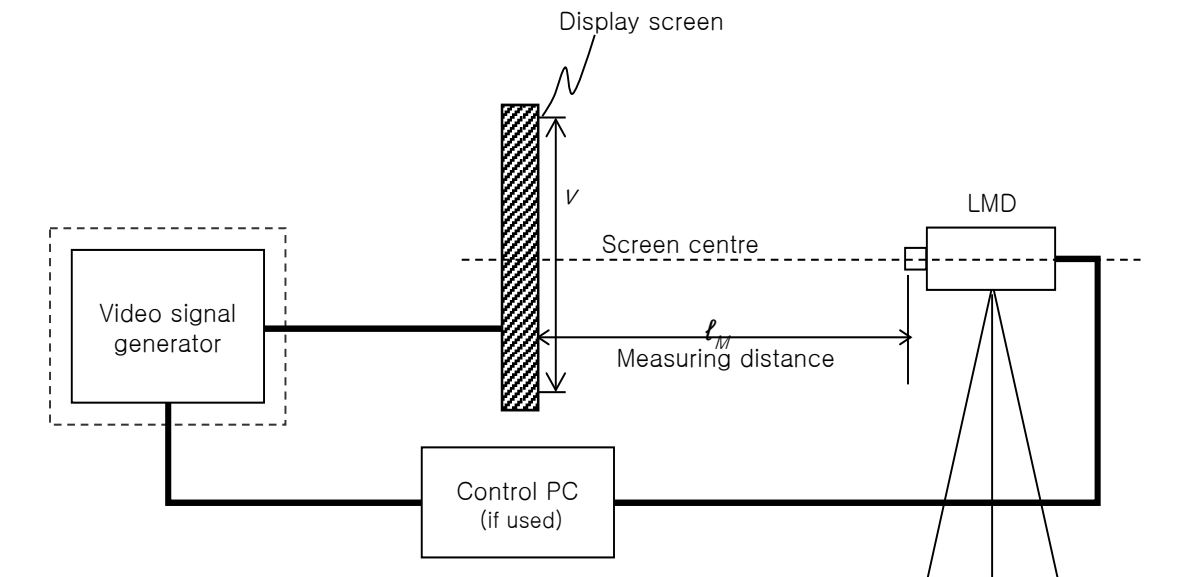


Figure 1 – Measuring layout for non-contact measurement

5 Standard measuring conditions

5.1 Standard measuring environmental conditions

Refer to 5.1 in IEC 62977-2-1. It defines as follows;

- temperature: $25\text{ °C} \pm 3\text{ °C}$,
- relative humidity: 25 % to 85 %,
- atmospheric pressure: 86 kPa to 106 kPa.

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

5.2 Power supply

The power supply for driving the DUT shall be adjusted to the rated voltage $\pm 2\%$. In addition, the frequency of the power supply shall provide the rated frequency $\pm 1\%$.

5.3 Warm-up time

Measurements shall be started after the displays and measuring instruments achieve stability. The DUT shall be turned on first and operated for at least 30 minutes prior to the measurement. Some display technologies may need a loop of colour patterns rendered on the screen during the warm-up period. Sufficient warm-up time has been achieved when the luminance of the test feature to be measured varies by less than $\pm 3\%$ over the entire measurement period (e.g. uniformity measurements) for a given display image.

5.4 Standard darkroom conditions

The luminance contribution from the background illumination reflected from the test display shall be below $0,000\ 5\text{ cd/m}^2$ while the display is off in the darkroom under the illumination below $0,01\text{ lx}$. In this document, if there is no comment for ambient lighting, the measurement is performed under the darkroom conditions. If the test pattern generates stray light, the stray light elimination methods such as frustum or stray light elimination tubes should be used. The LMD shall have sufficient signal-to-noise ratio suitable to measure the low luminance of black.