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INTERNATIONAL STANDARD

colour inside

Plasma display panels –
Part 2-6: Measuring methods – APL dependent gamma and colour characteristics

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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PLASMA DISPLAY PANELS –

Part 2-6: Measuring methods – APL dependent gamma and colour characteristics

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International Standard IEC 61988-2-6 has been prepared by IEC technical committee 110: Electronic display devices.

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

FDIS	Report on voting
110/636/FDIS	110/652/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.

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

A list of all the parts in the IEC 61988 series, under the general title *Plasma display panels*, can be found on the IEC website.

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

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- withdrawn,
- replaced by a revised edition, or
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PLASMA DISPLAY PANELS –

Part 2-6: Measuring methods – APL dependent gamma and colour characteristics

1 Scope

This part of IEC 61988 defines the measuring methods for gamma and colour gamut characteristics as a function of the APL for a PDP module (plasma display module). Generally, the luminance level of a PDP module is dependent on the APL (average picture level) of input images. Varying the input levels causes a change of the chromaticity of RGB primary colours. This standard also defines the measuring methods of tone characteristics and chromaticity characteristics with varying APLs. This standard is based on the assumption that the inverse-gamma circuit is inside the module.

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.

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

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

IEC 61966-5, *Multimedia system and equipment – Colour measurement and management – Part 5: Equipment using plasma display panels*

IEC 61988-1, *Plasma display panels – Part 1: Terminology and letter symbols*

IEC 61988-2-1, *Plasma display panels – Part 2-1: Measuring methods – Optical and optoelectrical*

CIE 15:2004, *Colorimetry*

ITU-R Rec. BT.709-5, *Parameter values for the HDTV standards for production and international programme exchange*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1, IEC 60107-1 and IEC 61988-1, as well as the following apply.

3.1.1
tone
characteristics of the relationship between input signal level and output luminance

3.1.2
colour difference
difference between two colour stimuli, defined as the Euclidean distance between the points representing them in a specific colour space such as CIE 1976 $u'v'$ colour space.

3.1.3
colour gamut area
two-dimensional maximum area of reproducible colours expressed in the CIE 1976 colour space defined in CIE 15

3.2 Abbreviations

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

APL Average picture level

CCT Correlated colour temperature

LMD Light measuring device

PDP Plasma display

4 Measurement equipment

4.1 Video signal generator

An analogue video signal generator or a digital video signal generator is used. The signal characteristics shall match with the measured PDP module. Input signal, in this document, means a pre-gamma signal and APL means a post-gamma APL.

4.2 Non-contact LMD (light measurement device)

When using a non-contact LMD, the non-contact LMD incorporates a spectroradiometer or a non-contact colorimeter as shown in Figure 1. The detail conditions are defined in IEC 61988-2-1, where a non-contact LMD is described as an LMD.

NOTE: See IEC 61966-5.

4.3 Contact LMD

When using a contact LMD, the measurement probe shall be placed perpendicular to the display surface and include at least 500 pixels in the measurement aperture. It shall be confirmed that the results measured by the contact LMD are the same as the results measured by the non-contact LMD.

5 Measurement conditions

5.1 General

The following standard setup conditions shall be used. Each condition shall be noted on the relevant specification whenever any different conditions other than the standard setup conditions are applied. (See the measuring conditions in IEC 61966-5 and IEC 61988-2-1.)

5.2 Setup conditions

All measurements shall be carried out in a dark room. Illuminance shall be less than 1 lx anywhere on the screen of the PDP module. When this illuminance significantly affects the measurement of the black level, the background subtraction method shall be used. When a different illuminance or the background subtraction method is used, this shall be noted on the report.

The warm-up time shall be longer than 30 minutes with a signal input set at 15 % grey level on full screen without gamma correction, unless other specified measuring methods are used. When different warm-up conditions are used, they shall be noted on the report.

For the measurement of tone characteristics, the conditions of contrast and colour enhancement functions to preserve the tone characteristics of the panel itself shall be applied and noted on the report. The image sticking preventing function (for a still image) shall be turned off, or some procedures in which the function is kept inactive can be applied.

5.3 Measuring layout

The measuring equipment shall be set as shown in Figure 1 for a non-contact LMD and in Figure 2 for a contact LMD. The optical axis of the non-contact LMD should be normal to the centre of the display surface. It is recommended that the measuring distance ℓ_0 of LMD is 2,5V, where V is the effective screen height of the display.

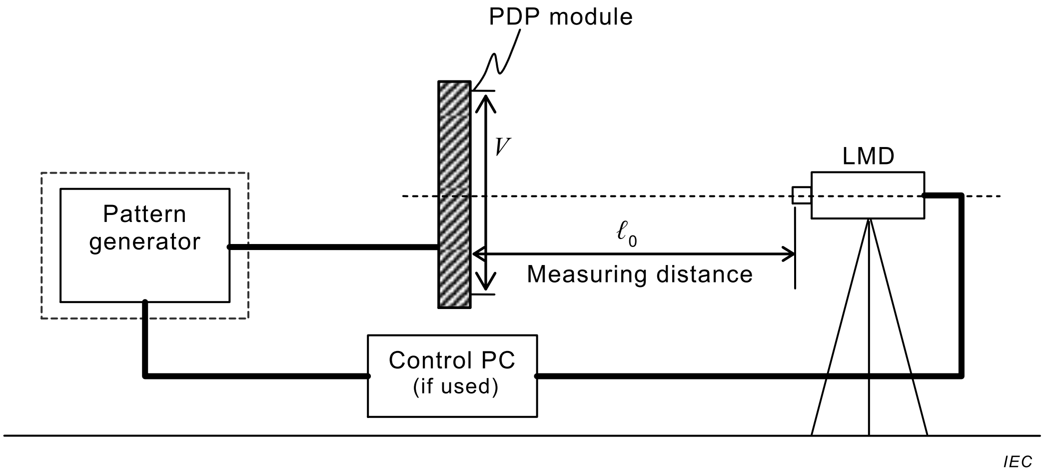


Figure 1 – Measuring layout for non-contact measurement

The measuring layout for a contact LMD is shown in Figure 2. A measurement probe shall be set to the surface of the display.

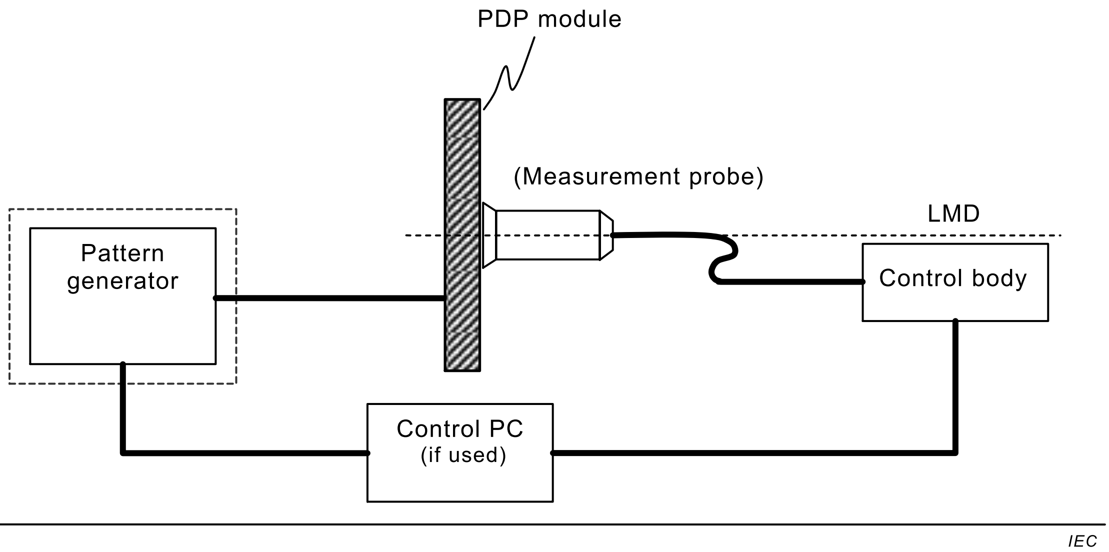
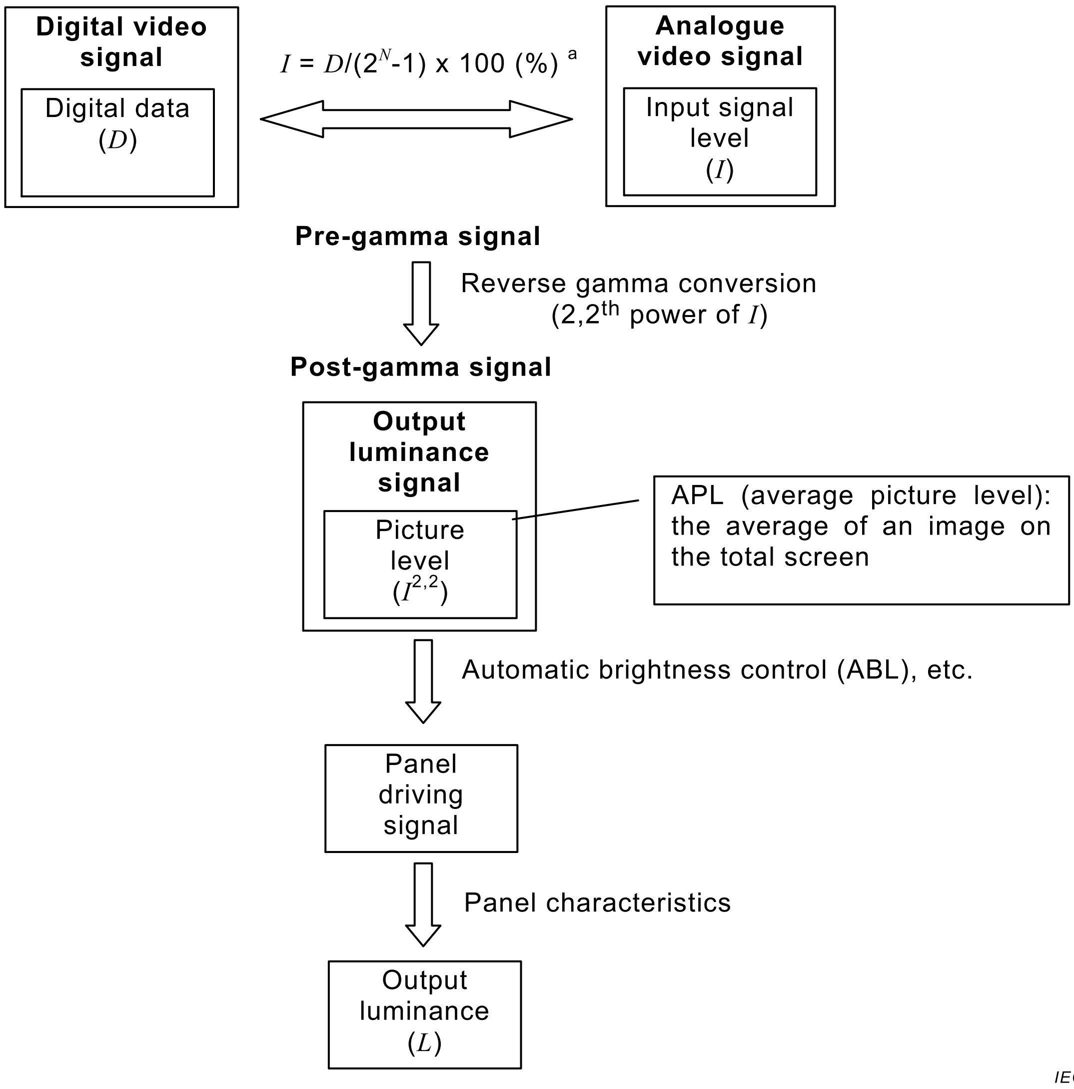


Figure 2 – Measuring layout for contact measurement

5.4 Input signal level and picture level

For the measurement, analogue video signals or digital video signals are used as input signals. The input signal level is the level of the analogue video signal and is indicated in percent (0 % to 100 %, $I_{0\,\%}$ to $I_{100\,\%}$ respectively), while the conventional digital input data is the level of the digital input video signal having a value from 0 to 2^N-1, where N is the number of the bits for the digital video signal. When N is 8, 256 grey steps are used. Basically these input video signals are pre-gamma signals having an applied gamma correction of 2,2. The output luminance level is related to 2,2$^{\text{th}}$ power of the input signal level. The term picture level, which relates to luminance, is used for the output luminance level of the post-gamma signal. Figure 3 shows these relationships.

NOTE In the ITU-R Rec. BT.709-5 8-bit digital video signal, the digital data is compressed to 16 to 235 from 0 to 255. The input signal at level 0 % is the digital data of 16 and the input signal at level 100 % is the digital data of 235. The input digital data is modified to this relationship as shown in Annex A. In this document the procedure of the conventional digital signal is mainly mentioned.



a For the use of the ITU-R Rec. BT.709-5 8-bit digital signal, the relationship between the input signal level and the digital data is as follows:

$$I = (D\text{-}16)/(235\text{-}16) \times 100\ (\%)$$

Figure 3 – Input signals and signal processing in a PDP module

6 Measuring methods of tone characteristics

6.1 Purpose

The purpose of this method is to measure the tone characteristics of a PDP as a function of the APL. The following items are then measured:

a) APL dependent gamma characteristics,

b) signal level and APL dependent CCT (correlated colour temperature), and

c) signal level and APL dependent chromaticity coordinates ($u'v'$).

NOTE u' and v' are CIE 1976 UCS diagram coordinates defined in CIE 15.

6.2 Input signals

6.2.1 General

To measure the tone characteristics with a fixed APL, a number of APLs to be evaluated shall be defined first. Nine APLs of 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 % and 90 % should be applied. When other APLs or level selections are used, the levels shall be noted in the report. Four kinds of signals for measurement of the tone characteristics are as follows;

a) 11-step grey bar with fixed APL,

b) single grey window with fixed APL,

c) 11-step RGB bar with fixed APL,

d) single colour window with fixed APL.

6.2.2 11-step grey bar with fixed APL

The details of the signal are as follows:

a) The input signal of the 11-step grey-bar patterns is applied The patterns have 11 windows and the signal levels of the windows, $I_{0\ \%}$ to $I_{100\ \%}$, are at 0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 % and 100 % respectively, or in 8-bit digital input data at 0, 26, 51, 77, 102, 128, 153, 179, 204, 230 and 255 respectively. In the measurement the window at the measuring signal level is moved to the screen centre and each of the remaining 10 unused grey pattern bars shall be displayed either in the top or the bottom groups of the 5 bars as shown in Figure 4. Figure 4 shows just an example of 11 grey-bar patterns. For the measurement of other signal levels, a simple procedure in which the signal levels of the centre window and one of remaining 10 grey bars are exchanged may be applied. If the area of each bar in grey pattern is 0,98 % of the whole screen area, then the whole grey-bar area is 10,78 % (0,98 % × 11). Therefore, the background area is 89,22 % (100 % − 10,78 %).

b) The background level shall be changed to maintain the APL.

c) In Figure 4, the average picture level of the 11-step grey-bar signal is calculated considering the conventional 2,2 gamma conversion as follows:

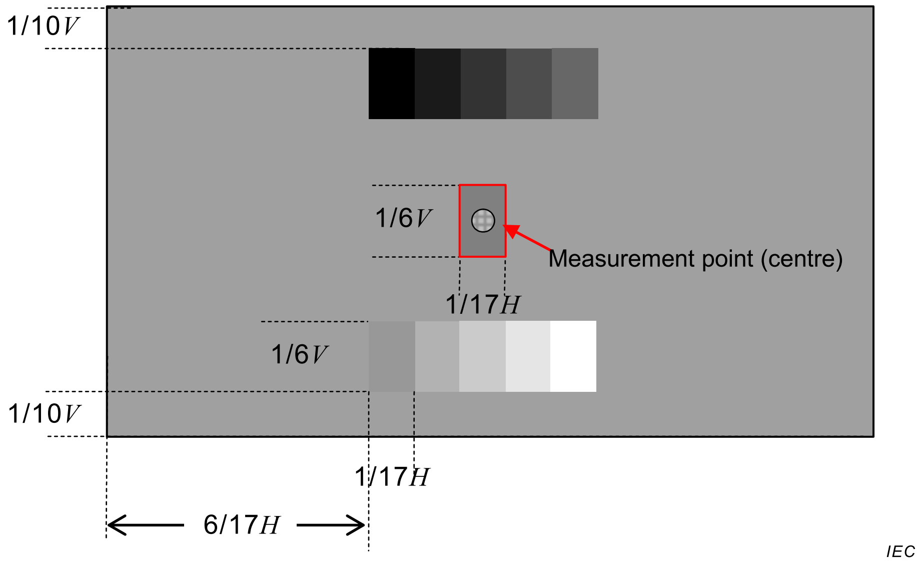
$$\text{APL}(\%) = 10{,}78 \times 0{,}330\,6 + 89{,}22 \times \left(D_{\text{BK}} /(2^{N}\text{-}1)\right)^{2{,}2} \quad (1)$$

where 33,06 % is the picture level of the average of 11-step grey bars and N is the number of bits of the input signal. D_{BK} is an input digital data for background in an N-bit system and is calculated as follows:

$$D_{\text{BK}} = (2^{N}\text{-}1) \times \left((\text{APL}(\%)-3{,}564) / 89{,}22 \right)^{1/2{,}2} \quad (2)$$

NOTE For each R, G and B channel, $D_{\text{BK,R}}$, $D_{\text{BK,G}}$ and $D_{\text{BK,B}}$ for the background input digital data are as follows:

$$D_{\text{BK,R}} = D_{\text{BK,G}} = D_{\text{BK,B}} = D_{\text{BK}}$$



Key

V screen height

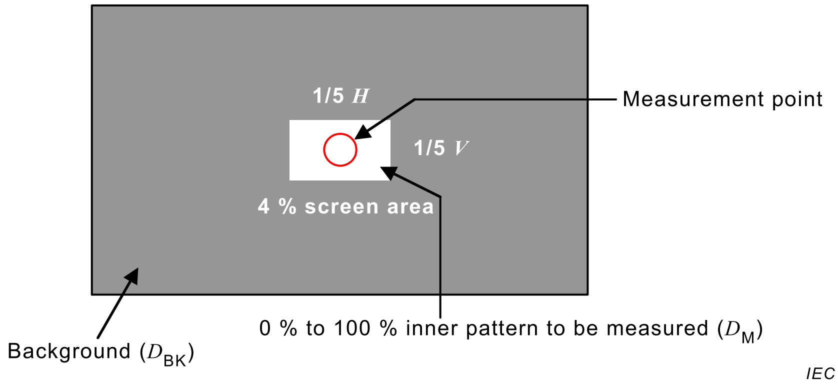
H screen width

Figure 4 – An example of an 11-step grey-bar pattern

6.2.3 Single grey window with fixed APL

The details of the signal are as follows

a) A single window pattern is used to measure the tone characteristics of the PDP as shown in Figure 5. The window is generated with each grey input data to be measured, and the background shall be changed to maintain a specific APL of the total screen area while measuring the window with the changing input signal level I from 0 % to 100 %, ie. $I_{0\ \%}$ to $I_{100\ \%}$ as defined in 6.2.2.



Key

V screen height

H screen width

D_{BK} input digital data for background in N-bit system and

D_M digital input data of 4 % grey window.

Figure 5 – Example of 4 % window pattern for measuring the tone characteristics

b) A 1/5 horizontal and vertical sized window, approximately 4 % of the total screen area, is used.

c) The APL of the pattern in Figure 5 is calculated by reverse gamma correction as follows:

$$\text{APL(\%) of pattern} = 4 \times (D_M/(2^N\text{-}1))^{2,2} + 96 \times (D_{BK}/(2^N\text{-}1))^{2,2} \quad (3)$$

where D_M is the digital input data of the 4 % grey window, D_{BK} is the digital input data of the background, and N is the number of bits of the input signal.

NOTE For the R, G and B component of the window and background, the digital input data $D_{M,R}$, $D_{M,G}$ and $D_{M,B}$, and $D_{BK,R}$, $D_{BK,G}$ and $D_{BK,B}$ respectively is as follows:

$D_{M,R} = D_{M,G} = D_{M,B} = D_M$

$D_{BK,R} = D_{BK,G} = D_{BK,B} = D_{BK}$

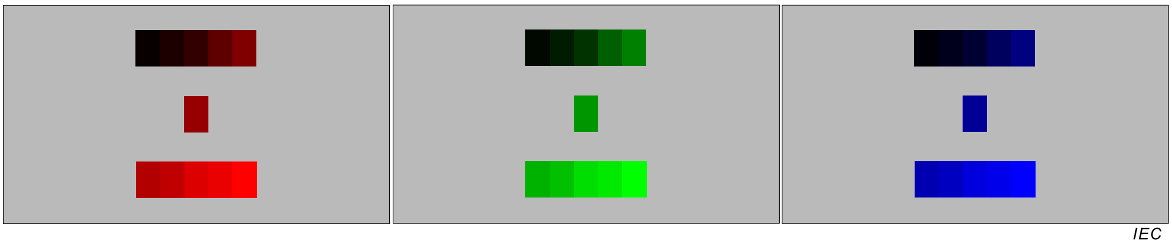
d) The input digital data for background D_{BK} is obtained using the following equation for a specific APL:

$$D_{BK} = (2^N - 1) \times ((\text{APL(\%)} - 4 \times (D_M/(2^N\text{-}1))^{2,2})/96\ )^{1/2,2} \quad (4)$$

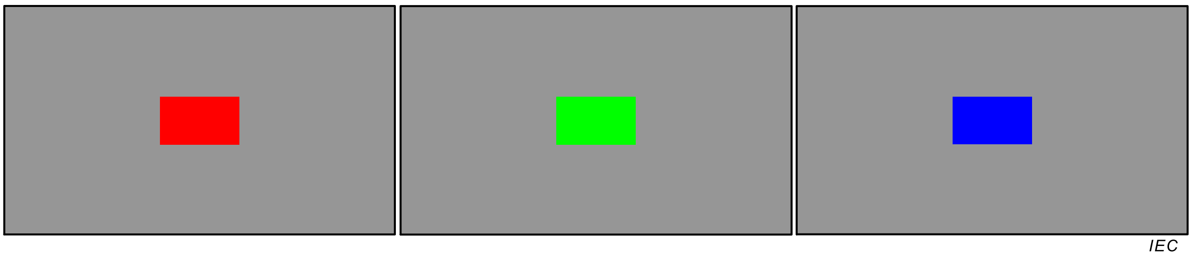
6.2.4 11-step RGB bar and single colour window with fixed APL

The details of the signal are as follows:

a) A bar or single window pattern for each RGB primary is also generated and measured as shown in Figure 6.



a) R-bar, G-bar and B-bar window with varying input levels



b) 4 % R, G and B single window with varying input levels

Figure 6 – RGB bar and single window pattern

b) The input digital data for background D_{BK} of each RGB window bar pattern in Figure 6 a) is calculated by the following equation (5).

$$D_{BK} = (2^N\text{-}1) \times (\ (\ \text{APL(\%)} - 10,78 \times (0,330\,6)/3\ )/89,22\ )^{1/2,2} \quad (5)$$

c) For the input digital data for the background of the R, G and B single window pattern shown in Figure 6 b), the following equations (6), (7), and (8) are used.

$$D_{BK} = (2^N\text{-}1) \times ((\text{APL(\%)} - 4 \times (D_R/(2^N\text{-}1))^{2,2}/3)/96)^{1/2,2} \quad (6)$$

$$D_{BK} = (2^N\text{-}1) \times ((\text{APL(\%)} - 4 \times (D_G/(2^N\text{-}1))^{2,2}/3)/96)^{1/2,2} \quad (7)$$

$$D_{BK} = (2^N\text{-}1) \times ((\text{APL(\%)} - 4 \times (D_B/(2^N\text{-}1))^{2,2}/3)/96)^{1/2,2} \quad (8)$$

where $D_{R,}$ D_G and D_B are the digital data of the window of R, G and B, respectively, and N is the number of bits for the input signal.

The window is generated with each primary colour input data to be measured. The background shall be changed to maintain a specific APL of the total screen area while measuring the window with the changing input signal level I from 0 % to 100 %, i.e. $I_{0\ \%}$ to $I_{100\ \%}$ as defined in 6.2.2.

6.3 Measuring procedure

The following procedure shall be used:

a) A PDP module shall be set in the measuring condition shown in Figure 1.

b) Turn off all functions that enhance the contrast and colour of the display to measure the tone characteristics of the PDP module.

c) Warm up the PDP module with an input signal of full screen white for an hour.

d) Set the APL to 10 %.

e) Input each of the window signals or grey pattern signals to be measured as shown in Figure 4, Figure 5, and Figure 6.

f) Measure the luminance and chromaticity coordinates (u', v') at screen centre by changing the input signal level for each of the 11 input signal levels.

g) Change the APL and repeat e) to f) to measure the tone characteristics for each of the remaining APLs.

NOTE u' and v' are CIE 1976 UCS diagram coordinates defined in CIE 15. The values of u' and v' coordinates are transformed from the measured x and y values using the following equations:

$$u' = 4x/(3 - 2x + 12y) \tag{9}$$

$$v' = 9y/(3 - 2x + 12y) \tag{10}$$

where x and y are CIE 1931 chromaticity coordinates.

Figure 7 shows an example of the result of gamma characteristics in 9 APLs.

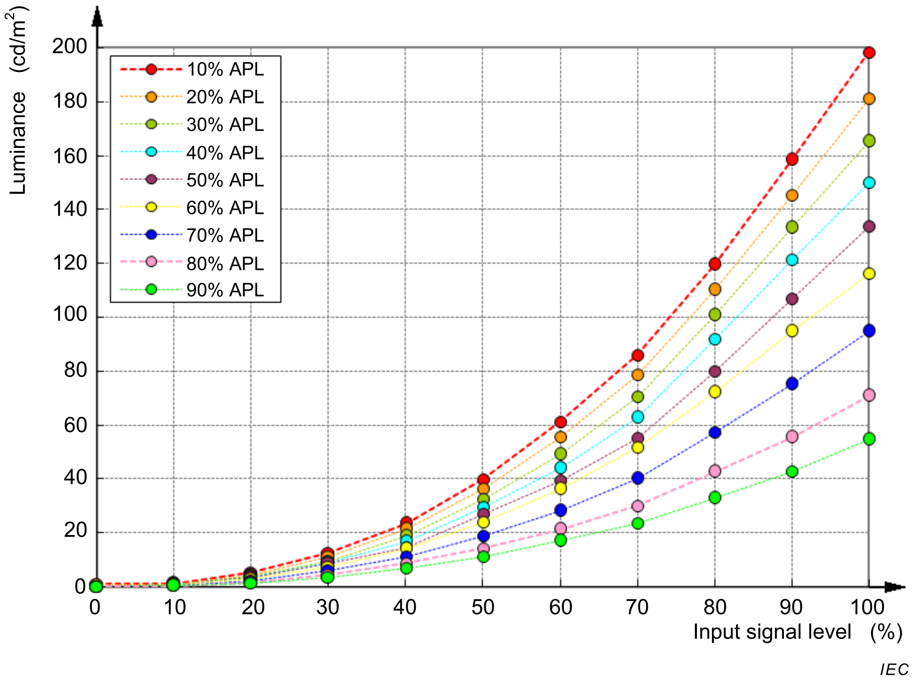


Figure 7 – An example of results of gamma characteristics for each APL

6.4 Expression of results

6.4.1 Measurement report

The measurement report shall include the following items:

a) The measured result of the luminance shall be reported as a table, as shown in Table 1 with input digital data.

Table 1 – An example of a tone measurement report

Input				Output: Display luminance		Output: Picture level
Signal step k	8-bit input digital data D_M (0~255)	Digital data of ITU-R Rec. BT.709-5 8-bit digital video signal[a] D_M (16~235)	Input signal level I (%)	Measured luminance L (cd/m²)	Normalized luminance[b] L_{norm} (%)	Conventional 2,2 gamma (%)
1	0	16	0	0,08	0,00	0,00
2	26	38	10	0,95	0,68	0,66
3	51	60	20	4,12	3,15	2,90
4	77	82	30	9,18	7,10	7,18
5	102	104	40	16,42	12,75	13,32
6	128	126	50	27,48	21,38	21,58
7	153	147	60	40,63	31,64	32,50
8	179	169	70	55,96	43,60	45,35
9	204	191	80	75,83	59,11	61,21
10	230	213	90	99,96	77,93	78,93
11	255	235	100	128,24	100,00	100,00

[a] For the use of the ITU-R Rec. BT.709-5 8-bit digital video signal, the digital data including that of the background, is modified.

[b] Normalized luminance is $(L-L_0)/(L_{100}-L_0)$, where L, L_0 and L_{100} are the measured luminance, the luminance at level 0 % and the luminance at level 100 % respectively.

6.4.2 Gamma calculation

From the measurement result shown above, a nonlinear output characteristic γ, i.e, a relationship between output luminance and input signal level, is calculated. Thus, the average gamma value, γ_j for the j^{th} APL is calculated by the following equation:

$$\gamma_j = \frac{1}{n-2}\sum_{k=2}^{n-1}\frac{\log L_{norm,k}}{\log I_{norm,k}} \tag{11}$$

where j refers to the j^{th} APL (10, 20, 30, ……, 90 APL) and n is the number of input signal steps for an APL. In this measuring method 11 signal steps, where n is 11, are used. $I_{norm,k}$ is the input signal level at each signal step k, which is the normalized value from 0 to 1 of input digital data. $L_{norm,k}$ is the normalized value of the luminance having a value from 0 to 1 measured at each signal step k and is defined as follows:

$$L_{norm,k} = \frac{(L_k - L_0)}{(L_{100} - L_0)} \tag{12}$$

where, L_k is the measurement luminance at the signal step k, L_0 is the luminance at the input of level 0 % and L_{100} is the luminance at the input of level 100 %.

The average gamma value γ_T for all APLs, i.e. the average value of all gammas, $\gamma_1, \gamma_2, \gamma_3, ..., \gamma_m$, is;

$$\gamma_T = \frac{\gamma_1 + \gamma_2 + \gamma_3 + ... + \gamma_m}{m} \tag{13}$$

NOTE 1 m is the number of APLs considered, generally 9, from 10 %, 20 %, …., 90 % APL.

Additionally, the gamma accuracy (%) is quantified from the following equation.

$$\gamma_{accu.} = \left[1 - \frac{|\gamma_S - \gamma_T|}{\gamma_S}\right] \times 100 \tag{14}$$

where γ_S is 2,2 for conventional 2,2 gamma and 1/0,45 for ITU-R Rec. BT.709-5 gamma.

NOTE 2 See the recommendation ITU-R Rec. BT.709-5-5 for the ITU-R Rec. BT.709-5 gamma.

The measured data and the result of the γ calculation shall be reported as shown in Table 2.

Table 2 – Example of gamma reporting form (for each APL)

j	**APL**(%)	γ
1	10	2,17
2	20	2,15
3	30	2,20
4	40	2,25
5	50	2,23
6	60	2,25
7	70	2,33
8	80	2,36
9	90	2,37
Average (γ_T) ± standard deviation		2,25 ± 0,08

The result of the γ calculation shall also be reported as plots for 10 % APL to 90 % APL as shown in Figure 8.

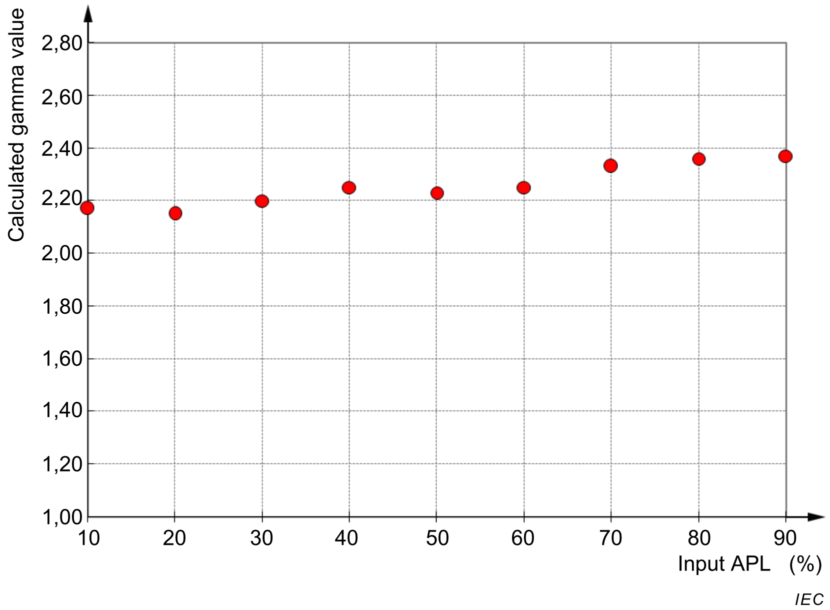


Figure 8 – Example plots for calculated gamma values by APL

The CCT values and $\Delta u'v'$ by APL shall also be plotted as curves, where the horizontal axis shall be the normalized input signal level from 10 % to 100 %, as shown in Figure 9 and Figure 10. If a light measuring device doesn't provide the CCT, then the CCT is calculated from the chromaticity coordinates (x, y) using McCamy's approximation as follows:

$$\text{CCT} = 437\,n^3 + 3\,601\,n^2 + 6\,861\,n + 5\,517 \tag{15}$$

where

$n = (x - 0{,}332\,0)/(0{,}185\,8 - y)$.

The colour difference $\Delta u'v'$ is defined as follows,

$$\Delta u'v' = \sqrt{(u'_{i}-u'_{o})^{2} + (v'_{i}-v'_{o})^{2}} \quad (16)$$

where u'_o, v'_o are the pre-defined chromaticity coordinates and u'_i, v'_i are the measured chromaticity coordinates. The pre-defined chromaticity value shall be reported, and if the pre-defined chromaticity values vary with input level, these shall also be reported. In this example, the pre-defined $u'v'$ value is (0,198, 0,468) for a CCT value of 6 500 K of daylight.

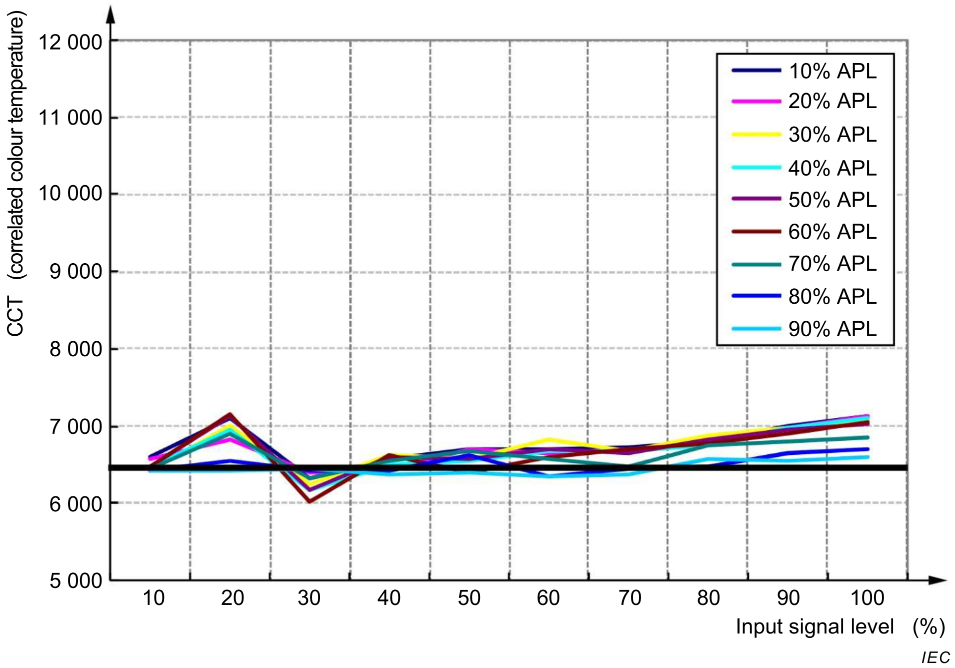


Figure 9 – Example plots for CCT characteristics by APL

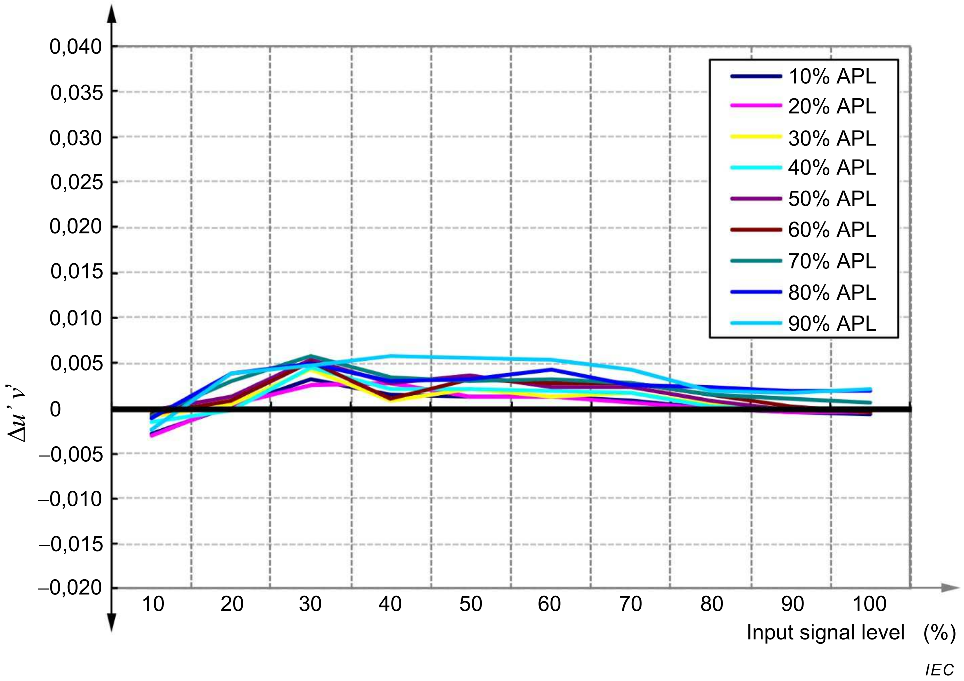


Figure 10 – Example plots for $\Delta u'v'$ characteristics by APL

7 Measuring methods of colour gamut by APL

7.1 Purpose

The purpose of this method is to measure primary and secondary colour accuracy and quantify the colour gamut of a PDP as a function of APL, and then to measure the following item:

- Chromaticity coordinates x and y of RGB primary and secondary colours (cyan, magenta and yellow) for each APL.

NOTE The secondary colour are cyan (C) = G(100 %) +B (100 %), magenta (M) = R (100 %) + B (100 %), and yellow (Y) = R (100 %) + G (100 %), respectively.

7.2 Primary and secondary colour patterns by APL

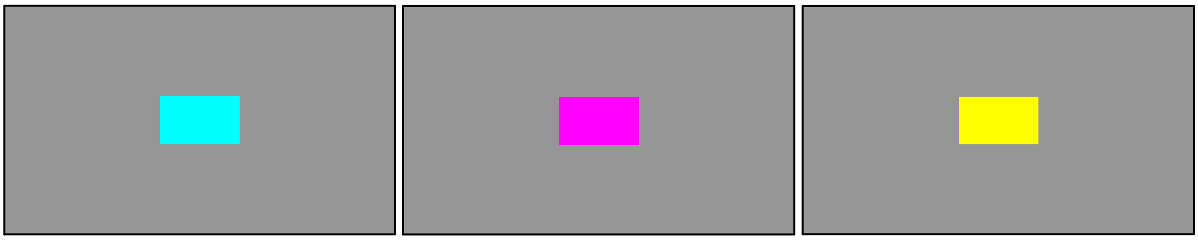
To measure the primary colour with a varying APL, the colour window pattern shown in Figure 6b) shall be used. The secondary colours C, M, and Y can also be measured in the same manner as shown in the following Figure 11. The input level of each window shall be set at 100 % for the colour. The input digital data of the background for each primary colour R, G and B single window pattern given in 6.2.4 c) is used. For the input digital data for the background for each secondary colour C, M and Y single window pattern shown in Figure 11, the following equations (17), (18), and (19) are used.

$$D_{\mathrm{BK'}} = (2^N\text{-}1) \times \left((\mathrm{APL}(\%)-4 \times 2 \times (D_\mathrm{C}/(2^N\text{-}1))^{2,2}/3)/96\right)^{1/2,2} \quad (17)$$

$$D_{\mathrm{BK}} = (2^N\text{-}1) \times \left((\mathrm{APL}(\%)-4 \times 2 \times (D_\mathrm{M}/(2^N\text{-}1))^{2,2}/3)/96\right)^{1/2,2} \quad (18)$$

$$D_{\mathrm{BK}} = (2^N\text{-}1) \times \left((\mathrm{APL}(\%)-4 \times 2 \times (D_\mathrm{Y}/(2^N\text{-}1))^{2,2}/3)/96\right)^{1/2,2} \quad (19)$$

where D_C, D_M and D_Y are the digital data of the window of C, M and Y, respectively, and N is the number of bits for the input signal. In this measurement D_C, D_M and D_Y are 2^N-1.



IEC

Figure 11 – 4 % C, M, and Y single window pattern

7.3 Measuring procedure

The following procedure shall be used for measuring the colour characteristics.

a) A PDP module shall be set in the measuring condition shown in Figure 1.

b) Turn off all functions that enhance the contrast and colour of the display to measure the tone characteristics of the PDP module.

c) Warm up the PDP module with an input signal of full screen white for an hour.

d) Set the APL to 10 %.

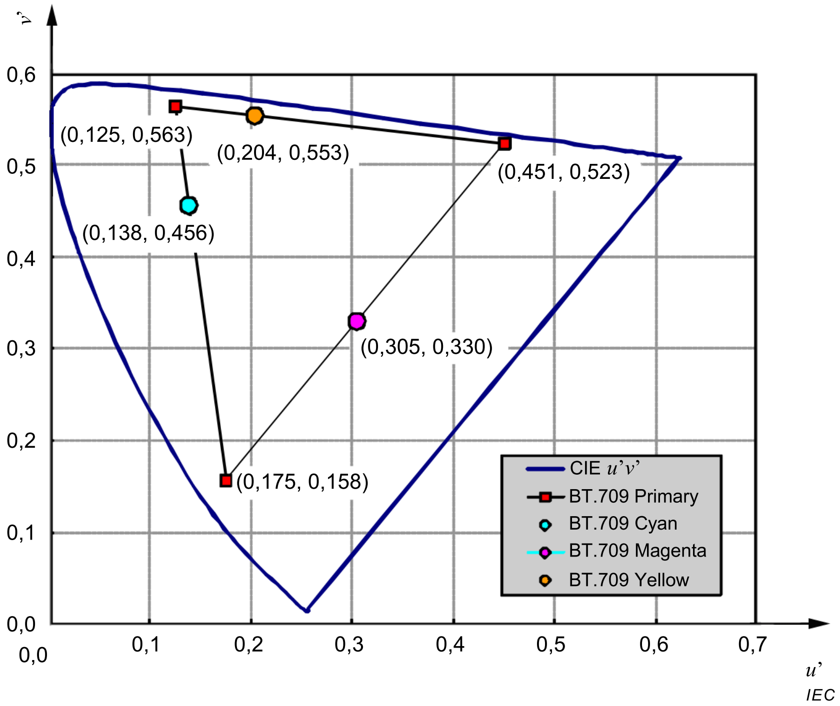
e) Input each R, G, B, C, M, and Y single window pattern as shown in Figure 6b) or Figure 11, where the input signal level of each single colour window is 100 %, and measure the chromaticity coordinates (u', v') and CCT at screen centre.

f) Change the APL and repeat e) to measure the primary and secondary colour accuracy for each remaining APL.

7.4 Evaluation of colour accuracy

The reference standard coordinates of the primary colours are generally available from ITU-R Rec. BT.709-5.

The measured colour data is compared to the ITU-R Rec. BT. 709-5 values shown in Figure 12 in order to check for deviation of $\Delta u',v'$.



Key

BT.709 means ITU-R Rec. BT.709-5.

Figure 12 – ITU-R Rec. BT.709-5 standard coordinates of primary and secondary colours

7.5 Evaluation of colour gamut

The colour gamut area is used to evaluate the colour range of the display. Generally, it can be calculated with the $u'v'$ coordinate system. The area of the ITU-R Rec. BT.709-5 colour gamut in the (u', v') diagram is $|u'_R v'_G + u'_G v'_B + u'_B v'_R - v'_R u'_G - v'_G u'_B - v'_B u'_R|/2$, which is 0,064 9 and used for the reference colour gamut area. Similarly, the area of n polygons for the overlapped colour gamut area between the reference and the display under test is calculated from the following equation (20).

$$|u'_1 v'_2 + u'_2 v'_3 + u'_3 v'_4 \ldots + u'_{n-1} v'_n + u'_n v'_1 - v'_1 u'_2 - v'_2 u'_3 - v'_3 u'_4 \ldots - v'_{n-1} u'_n - v'_n u'_1|/2 \quad (20)$$

From the results of the colour gamut area, the relative gamut ratio and gamut reproducibility are calculated as shown in equations (21) and (22). An example of gamut areas for the evaluation of the colour gamut is shown in Table 3.

$$\text{Relative gamut ratio (\%)} = \frac{\text{Display colour gamut area}}{\text{Reference colour gamut area}} \times 100 \quad (21)$$

$$\text{Gamut reproducibility (\%)} = \frac{\text{Overlap colour gamut area}}{\text{Reference colour gamut area}} \times 100 \qquad (22)$$

Table 3 – An example of gamut areas for evaluation of colour gamut

	Red		Green		Blue		Colour gamut area
sRGB (ITU-R Rec. BT.709-5)	u'_R	v'_R	u'_G	v'_G	u'_B	v'_B	0,064 9
	0,450 7	0,522 9	0,125 0	0,562 5	0,175 4	0,157 9	
Measured colour gamut	u'_R	v'_R	u'_G	v'_G	u'_B	v'_B	0,061 5
	0,440 7	0,533 9	0,118 4	0,552 2	0,166 2	0,167 6	
Overlapped colour gamut							0,057 8

Figure 13 shows an example of the measured colour, sRGB (ITU-R Rec. BT.709-5), and of the overlapped gamut area for evaluation of the colour gamut.

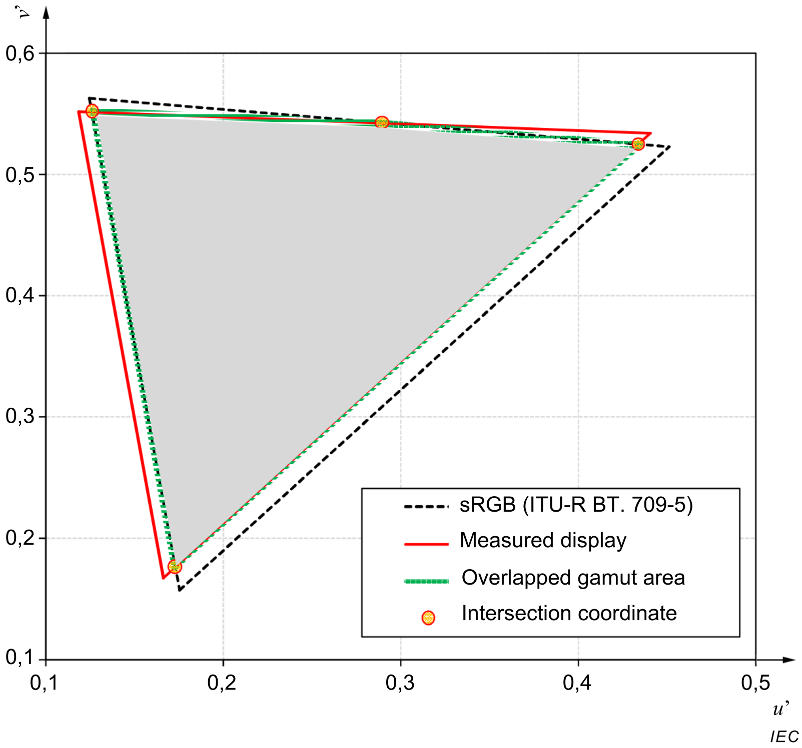


Figure 13 – Example showing a measured primary, a reference, and an overlapped gamut area

7.6 Expression of results

The measured result and the colour coordinates data shall be reported as a table, as shown in Table 4 with the reference colour standard. Additionally, the colour gamut evaluation result can also be reported in Table 4. Figure 14 shows an example of the measured colour gamut plots by APL.

Table 4 – An example of primary and secondary colour measurement report

APL	Colour	Input signal level	Reference coordinates		Measured coordinates		Δ *u*'*v*'	Relative gamut ratio	Gamut reproducibility
		(R, G, B)	*u*'	*v*'	*u*'	*v*'		(%)	(%)
10 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,390	0,509	0,062	95,7 %	95,9 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,176	0,502	0,079		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,179	0,255	0,097		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
20 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,400	0,511	0,052	96,2 %	96,2 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,164	0,516	0,060		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,178	0,242	0,084		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
30 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,411	0,512	0,041	97,3 %	96,6 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,155	0,529	0,045		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,177	0,224	0,066		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0.204	0,553			–		
40 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,420	0,514	0,032	99,1 %	97,3 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,150	0,532	0,039		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,176	0,213	0,055		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
50 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,429	0,515	0,023	99,4 %	97,6 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,146	0,534	0,035		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,176	0,208	0,051		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		

APL	Colour	Input signal level	Reference coordinates		Measured coordinates		Δ *u'v'*	Relative gamut ratio	Gamut reproducibility
		(R, G, B)	*u'*	*v'*	*u'*	*v'*		(%)	(%)
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
60 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,431	0,517	0,020	100,2 %	98,1 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,144	0,536	0,032		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,176	0,202	0,045		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
70 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,435	0,518	0,016	100,5 %	99,0 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,140	0,541	0,026		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,174	0,196	0,038		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
80 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,440	0,520	0,011	102,4 %	99,7 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,136	0,550	0,016		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,176	0,188	0,030		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		
90 % APL	Red	(100 %, 0 %, 0 %)	0,451	0,523	0,446	0,522	0,005	105,0 %	100,0 %
	Green	(0 %, 100 %, 0 %)	0,125	0,563	0,134	0,556	0,011		
	Blue	(0 %, 0 %, 100 %)	0,175	0,158	0,172	0,180	0,022		
	Cyan	(0 %, 100 %, 100 %)	0,139	0,456			–		
	Magenta	(100 %, 0 %, 100 %)	0,305	0,330			–		
	Yellow	(100 %, 100 %, 0 %)	0,204	0,553			–		

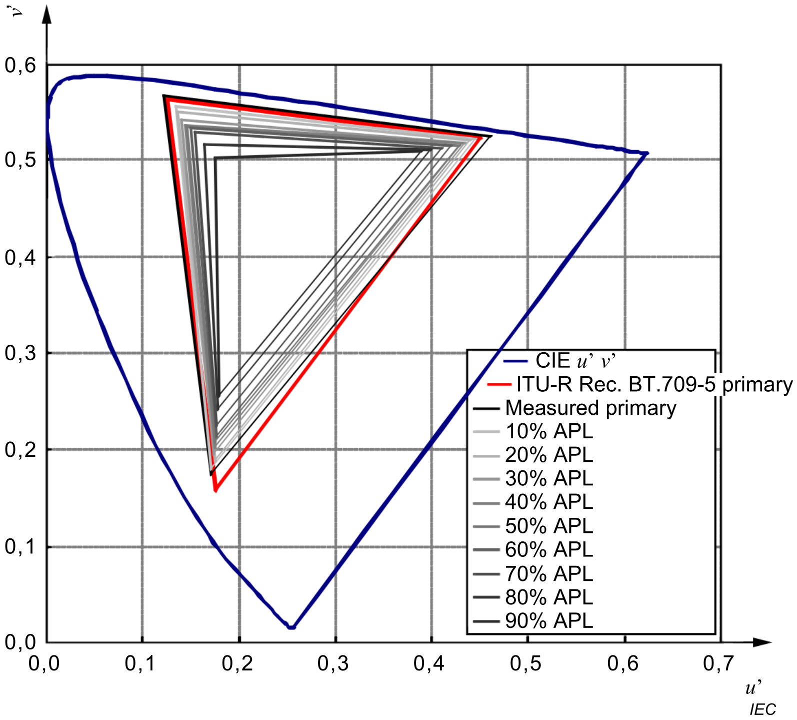


Figure 14 – The measured colour gamut plots by APL

Annex A
(informative)

Use of ITU-R Rec. BT.709-5 signal

In ITU-R Rec. BT.709-5 the digital data of the 8-bit digital video signal is compressed to 16 to 235, but not to 0 to 255. The relationship between the input signal level and the digital data in ITU-R Rec. BT.709-5 is shown in Table A.1.

Table A.1 – Digital data and signal level in ITU-R Rec. BT.709-5

Signal level I (%)	**Digital data** D_M
0	16
10	38
20	60
30	82
40	104
50	126
60	147
70	169
80	191
90	213
100	235

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch