IEC 62908-22-10

Edition 1.0 2024-11

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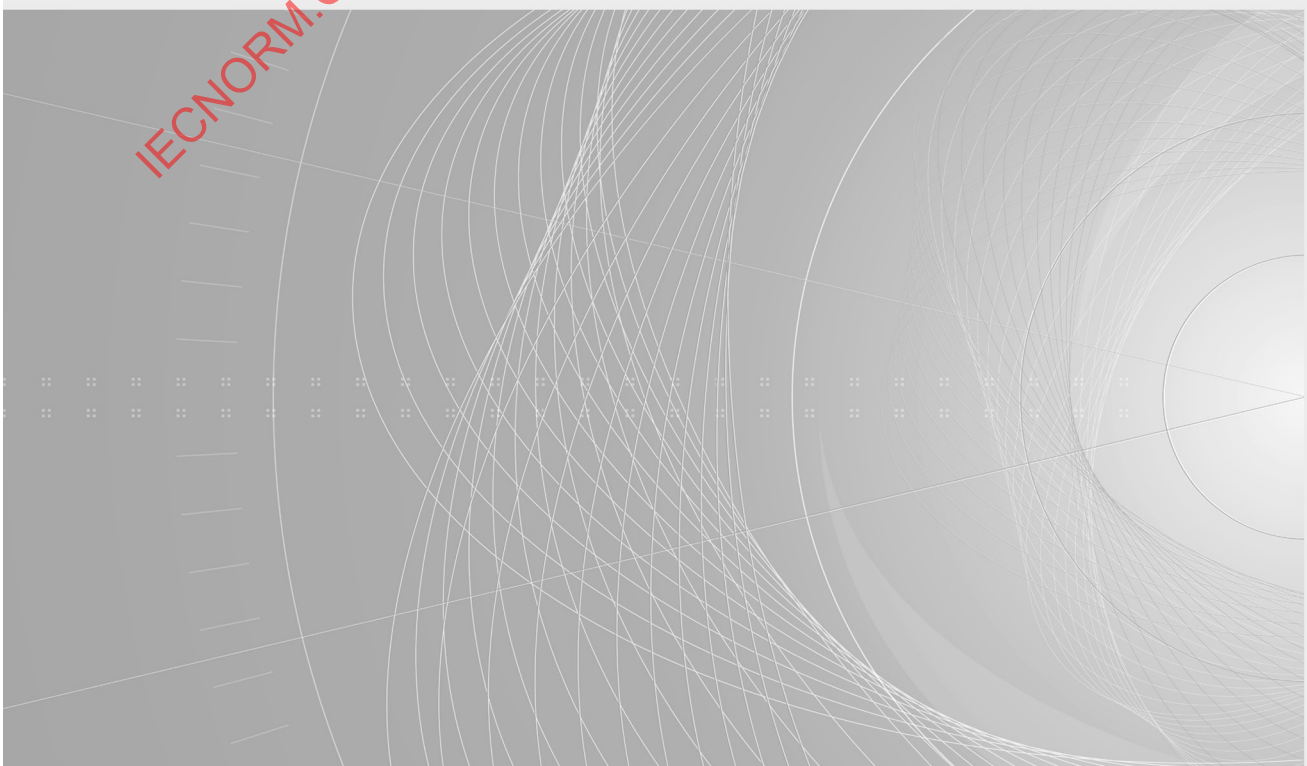
Touch and interactive displays – Part 22-10: Measuring methods of fingerprint recognition performance – Under-display optical imaging fingerprint sensing



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TOUCH AND INTERACTIVE DISPLAYS –

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

Draft	Report on voting
110/1692/FDIS	110/1713/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62908 series, published under the general title *Touch and interactive displays*, can be found on the IEC website.

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TOUCH AND INTERACTIVE DISPLAYS –

Part 22-10: Measurement methods of fingerprint recognition performance – Under-display optical imaging fingerprint sensing

1 Scope

This part of IEC 62908 specifies the standard measuring conditions and measurement methods for determining the performance of fingerprint recognition systems with under-display optical imaging fingerprint sensing. This document is applicable to use displays as illumination sources of optical imaging fingerprint sensing.

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 61747-30-5, *Liquid crystal display devices – Part 30-5: Optical measuring methods of transmissive transparent LCD modules*

IEC 62341-6-1, *Organic light emitting diode (OLED) displays – Part 6-1: Measuring methods of optical and electro-optical parameters*

IEC 62341-6-4, *Organic light emitting diode (OLED) displays – Part 6-4: Measuring methods of transparent properties*

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 terminology databases for use in standardization at the following addresses:

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

3.1.1
optical imaging fingerprint recognition
<under-display optical imaging fingerprint sensing> recognition method of fingerprint by optical image sensor located beneath the display

3.1.2
fingerprint recognition system resolution
<under-display optical imaging fingerprint sensing> degree of resolution of a fingerprint image acquired by an under-display optical fingerprint recognition system, which is calculated using the contrast transfer function (CTF)

3.1.3
contrast transfer function
CTF
<under-display optical imaging fingerprint sensing> ratio of the final to the initial signal amplitude as a function of the spatial frequency of the initial signal

3.1.4
fingerprint ridge
convex part on the skin of the fingers, which makes contact with an incident surface under normal touch

Note 1 to entry: On the fingers, the unique patterns formed by the ridges make up fingerprints.

3.1.5
fingerprint valley
area between two fingerprint ridges that does not make contact with an incident surface under normal touch

3.1.6
signal-to-noise ratio
SNR
<under-display optical imaging fingerprint sensing> ratio of the required grey level of fingerprint image to the noise grey level

3.1.7
false reject rate
FRR
proportion of verification transaction with wrongful claims of identity that are incorrectly denied

3.1.8
false accept rate
FAR
proportion of verification transaction with truthful claims of identity that are incorrectly confirmed

3.2 Abbreviated terms

CTF contrast transfer function
FAR false accept rate
FRR false reject rate
LMD light measuring device
PPI pixel per inch
SNR signal-to-noise ratio

4 Measuring conditions

4.1 Standard measuring environmental conditions

All tests and measurements shall be carried out under standard atmospheric conditions for testing, unless otherwise specified:

– temperature: 25 °C ±3 °C,
– relative humidity: 25 % RH to 85 % RH, where appropriate,
– air pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar).

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

4.2 Starting conditions of measurements

As specified in IEC 62341-6-1, measurements shall be started after the display and the measuring instruments achieve stability. Turn on the display, then it shall be kept operating for 30 min at least (with a loop of colour patterns rendered on the screen). Sufficient warm-up time shall be taken until the measured luminance variation falls within ±3 %.

5 Measuring system

5.1 Under-display optical fingerprint recognition system

The under-display optical fingerprint recognition system consists of a display and optical imaging sensor located beneath the display as shown in Figure 1. The system uses the light emission of the display for lighting up the fingerprint. The sensor then captures the reflected light from it. Finally, the comparison between the sample fingerprint image with the target one shall be done to complete the recognition and identification. In the process of acquiring fingerprint images, the light produced by the display will pass through the display several times. So the luminance, extinction ratio, light leakage ratio and transmittance of the display without sensor have significant influence on the recognition process. The measurement of these items is specified in Annex A.

NOTE Displays are used as illumination sources of optical imaging fingerprint sensing.

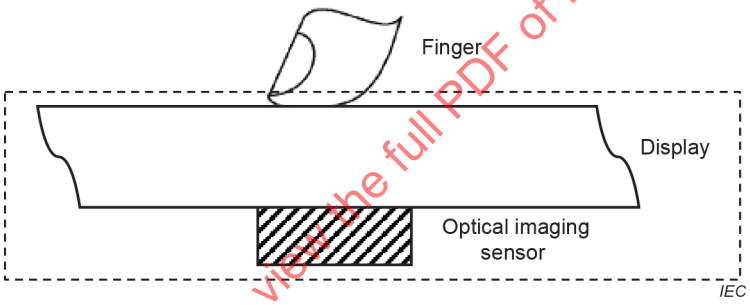


Figure 1 – Structure diagram of under-display optical imaging fingerprint recognition system

5.2 Standard equipment and setup

A flow chart of the measuring system is shown in Figure 2. The measuring system consists of the under-display optical fingerprint recognition system and the fingerprint recognition grey-level equipment.

As shown in Figure 3, the fingerprint recognition grey-level equipment shall access and process measurement data from the optical imaging sensor to define performance measures with respect to the target. This equipment shall access and process data with a specific format at 8 bits per pixel (8 bpp or 256 grey-levels) [1][1]. For the false accept rate (FAR) and false reject rate (FRR), the measurement data processing unit is used to match the correct data of fingerprints.

1 Numbers in square brackets refer to the Bibliography.

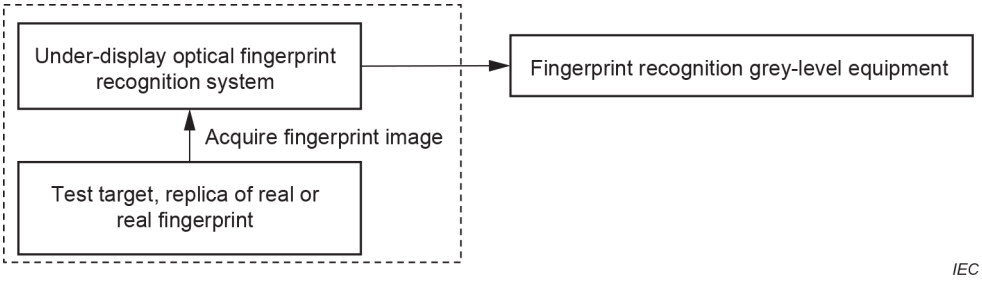


Figure 2 – Flow chart of measuring system

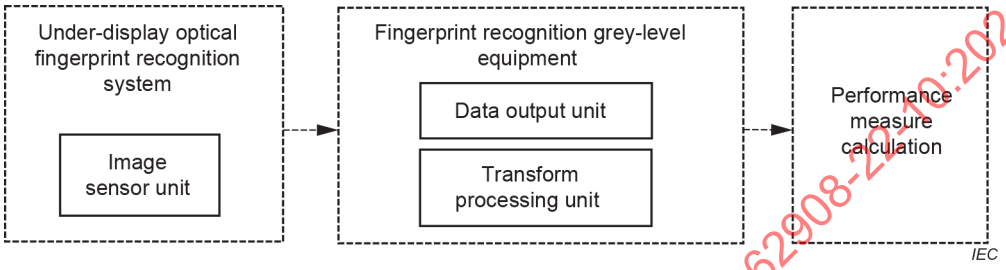


Figure 3 – Concept of performance measurement

6 Measurement method of fingerprint recognition performance

6.1 Fingerprint recognition system resolution

6.1.1 Purpose

It is difficult to recognize fingerprint ridges from fingerprint valleys and isolating detail points from low resolution fingerprint image. The purpose of the measurement is to determine the fingerprint recognition system.

The fingerprint recognition system is measured based on a threshold contrast transfer function (CTF) associated with the test target. Resolution is defined here as the number of alternate black and white lines that can be captured with a minimum CTF modulation.

6.1.2 Measuring conditions

The following measuring conditions apply:

a) Apparatus:
   - driving signal equipment;
   - driving power source.

b) Test target:

   The test target consists of repeating pairs of black and white stripes, which can be fabricated on additional substrates, such as chrome-on-glass. An example test target is shown in Figure 4. The spatial frequency of the test target in this document is expressed using cycles/mm.

NOTE Based on the definition of pixel per inch (PPI), the vertical and horizontal stripe patterns are widely used. Refer to [3]. Figure 4 is widely used for fingerprint recognition related tests.

Dimensions in millimeters

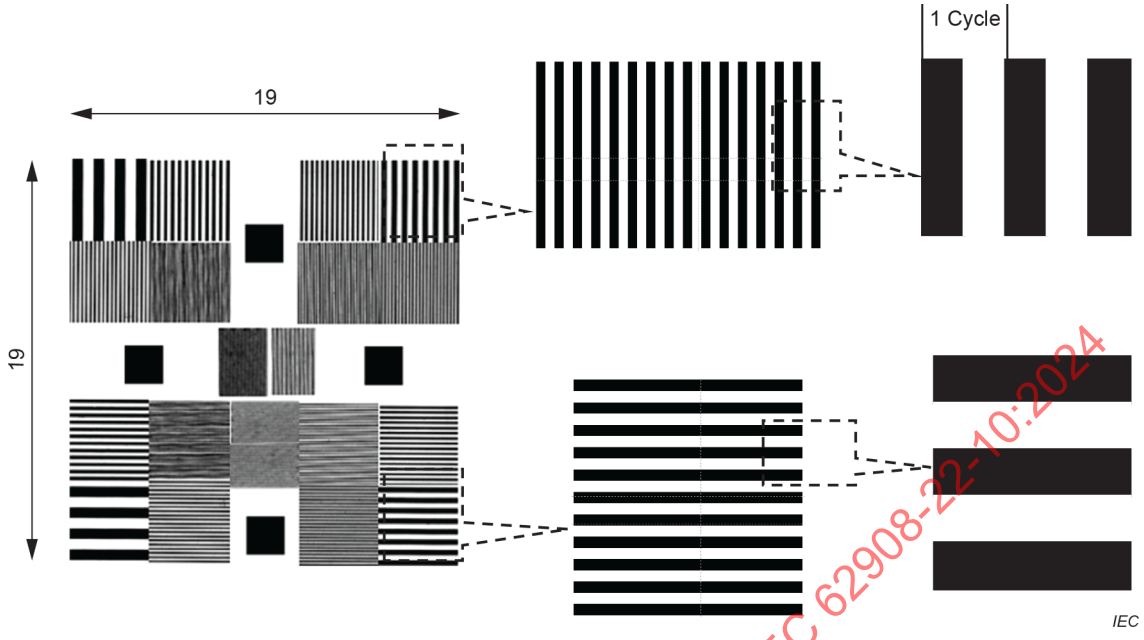


Figure 4 – Example of test target

6.1.3 Measurement method

The measurement method shall be as follows:

a) Set the fingerprint recognition system under the standard measuring environmental conditions.

b) Create a window pattern in the fingerprint recognition region as shown in Figure 5. Set the window at the desired colour Q at the highest luminance level. Measurement shall be started after the display luminance achieves stability.

c) Set the 1 cycle/mm test target as the reference frequency at position P_0 (the centre of the fingerprint recognition region). Acquire the image and read the grey-levels data.

d) Set the other frequency test target at the centre of the fingerprint recognition region. Repeat steps b) and c).

e) Calculate the modulation contrast C_i and the value of CTF using the following formulae:

$$C_i = \frac{g_{\text{max},\,i} - g_{\text{min},\,i}}{g_{\text{max},\,i} + g_{\text{min},\,i}} \tag{1}$$

$$C_{\text{CTF}}(i) = \frac{C_i}{C_1} \tag{2}$$

where

$g_{\text{max},i}$ is the maximum grey-levels of the i cycles/mm test bar black and white stripe measured;

$g_{\text{min},i}$ is the minimum grey-levels of the i cycles/mm test bar black and white stripe measured;

i is the number of pairs of the black and white stripes of a test target within 1 mm;

C_i is the modulation contrast of the i cycles/mm test bar black and white stripe measured;

C_1 is the modulation contrast of the 1 cycles/mm test bar black and white stripe measured.

NOTE According to the definition of CTF, calculation of CTF using $g_{max,\ i}$ and $g_{min,\ i}$ is referred to as MTF in IEC 61747-30-5. In general, $g_{max,\ i}$ is the maximum grey-levels of black stripes in the test area, and $g_{min,\ i}$ is the minimum grey-levels of white stripes in the test area.

Other usage scenarios (such as wet and dry hands, at high and low temperature, and with a protect film) can be used when agreed on by the interested parties but shall be stated in the report.

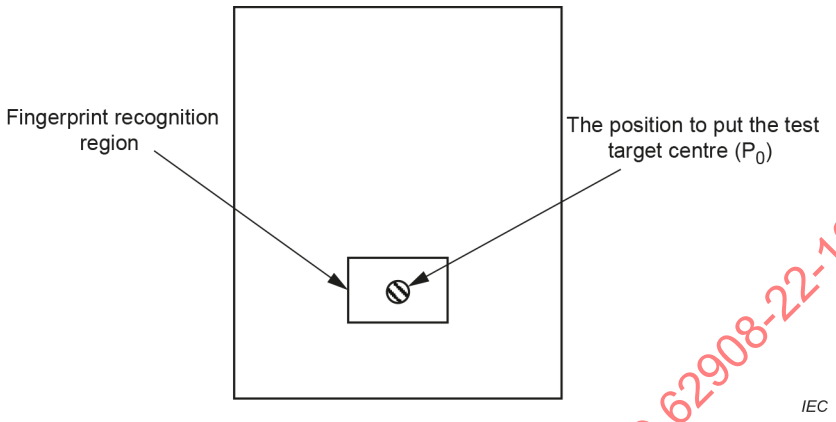


Figure 5 – Test pattern for resolution measurement

6.1.4 Reporting

The CTF for each frequency and threshold shall be reported. The horizontal and vertical resolution shall be reported with a description of the measuring conditions and test target. The reflection characteristics of the test target should also be reported.

6.2 SNR

6.2.1 Purpose

The purpose of the measurement is to determine the ability of the fingerprint recognition system to recognise some special points in the fingerprint, such as sweat pore and incipient ridges.

6.2.2 Measurement method

The measurement method shall be as follows:

a) Set the fingerprint recognition system under the standard measuring environmental conditions.

b) Create a window pattern in the fingerprint recognition region as shown in Figure 5. Set the window at the desired colour Q at the highest luminance level. Allow the display luminance to stabilize.

c) Set the replica of a real fingerprint in the centre of the fingerprint recognition region.

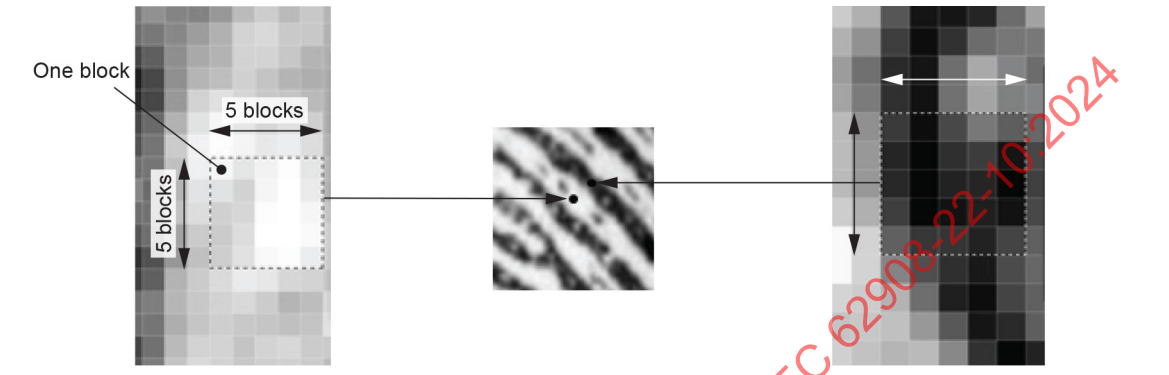
d) Acquire the image and read the grey-levels data of an $n \times n$ pixels block (n = 5, for example) in the valley region and record the average value of t blocks (t = 10, for example) as g_{wa} as shown in Figure 6 a). The pixels block is usually selected from the centre of the valley region.

e) Acquire the image and read the grey-levels data of an $n \times n$ pixels block (n = 5, for example) in the ridge region that is near the valley region in step d) and record the average value of t blocks (t = 10, for example) as g_{ba}, as shown in Figure 6 b). The pixels block is usually selected from the centre of the ridge region.

f) Calculate the SNR RSN using Formula (3):

$$R_{SN} = 20 \times \log\left(\frac{g_{wa} - g_{ba}}{g_{ba}}\right) \quad (3)$$

g) Repeat the steps from c) to f) to measure and calculate the SNR of pixels blocks in other test points and other replicas. Calculate the SNR using Formula (3).



a) 5 × 5 pixels block in the valley region b) 5 × 5 pixels block in the ridge region

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Figure 6 – Example of $n \times n$ pixels block in the valley and ridge region [1]

6.2.3 Reporting

The values n, t, L_{wa}, L_{ba}, R_{SN}, number of replicas N_{rep}, and replicas specification shall be reported with a description of the measuring conditions.

6.3 FAR and FRR

6.3.1 Purpose

The purpose of the measurement is to utilize FAR and FRR to evaluate the performance of the fingerprint recognition system.

6.3.2 Measurement method

The measurement method shall be as follows:

a) Set the fingerprint recognition system under the standard measuring environmental conditions.

b) Create a window pattern in the fingerprint recognition region as shown in Figure 5. Set the window at the desired colour Q at the highest luminance level. Allow the display luminance to stabilize.

c) Use real fingerprints for this test.

d) Match the correct fingerprint with the target fingerprint N_1 times and record the times of false rejection as R. Calculate the FRR R_{FRR} using Formula (4).

e) Match the incorrect fingerprints with the target fingerprint N_2 times and record the times of false acceptation as A. Calculate the FAR R_{FAR} using Formula (5).

$$R_{FRR} = \frac{R}{N_1} \times 100\% \quad (4)$$

$$R_{\mathrm{FAR}} = \frac{A}{N_2} \times 100\% \tag{5}$$

f) Measure the FAR and FRR according to steps b) and c) in different usage scenarios (such as wet and dry hands, at high and low temperature, and with protect film).

6.3.3 Reporting

The values N_1, N_2, R, A, FRR and FAR shall be reported with a description of usage scenarios and measuring conditions, including the information about the fingerprints which are used for this test.

Annex A
(normative)

Measurement method for optical parameters

A.1 General

In the process of acquiring fingerprint images, the light produced by the display will pass through the display several times. So the luminance, extinction ratio, light leakage ratio and transmittance of the display without sensor have significant influence on the recognition process. These items are particularly important for the communication between supply chain companies in the industry, including display module factories, optical imaging sensor factories and terminal factories. For example, when a terminal vendor designs and verifies the fingerprint recognition performance, the terminal vendor will require the panel vendor to submit optical performance reports of the display panel. Based on the reports, the terminal vendor will judge the optical performance of the display panel and put forward improvement requirements to the panel vendor. The matching design of the display module and optical imaging sensor has a great impact on optical performance. To ensure the consistency of supply chain data accumulation, measurements of these items for the display without sensor are specified in Annex A.

A.2 Standard lighting conditions

A.2.1 Darkroom conditions

The luminance contribution from the background illumination reflected off or transmitted through the test display, or both, shall be less than 0,01 cd/m^2 or 1/20 of the display's black state luminance, whichever is lower. If these conditions are not satisfied, then background subtraction is required, and it shall be noted in the report. In addition, if the sensitivity of the LMD is inadequate to measure at these low levels, then the lower limit of the LMD shall be noted in the measurement report.

A.2.2 Ambient illumination conditions

The ambient illumination conditions shall be consistent with those specified in IEC 62341-6-4.

A.2.3 Ambient illumination spectra

The ambient illumination spectra shall be consistent with that specified in IEC 62341-6-4.

A.3 Standard setup conditions

A.3.1 Starting conditions of measurements

As specified in IEC 62341-6-1, measurements shall be started after the display and the measuring instruments achieve stability. It is recommended that, when the display is first turned on, it be operated for at least 30 min with a loop of colour patterns rendered on the screen. Sufficient warm-up time has been achieved when the luminance of the test feature to be measured varies by less than ±3 % over the entire measurement.

A.3.2 Conditions of measuring equipment

The general conditions of this measurement shall be as follows.

a) The standard measurement setup is shown in Figure A.1. The LMD shall be a luminance meter, colourimeter, or a spectroradiometer 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. The sensitivity and dynamic shall meet the requirement of the test task.

b) The light measuring device shall be aligned perpendicularly to the region to be measured on the image generating surface of the display.

c) The relative uncertainty and repeatability of all the measuring devices shall be maintained by following the instrument supplier's recommended calibration schedule.

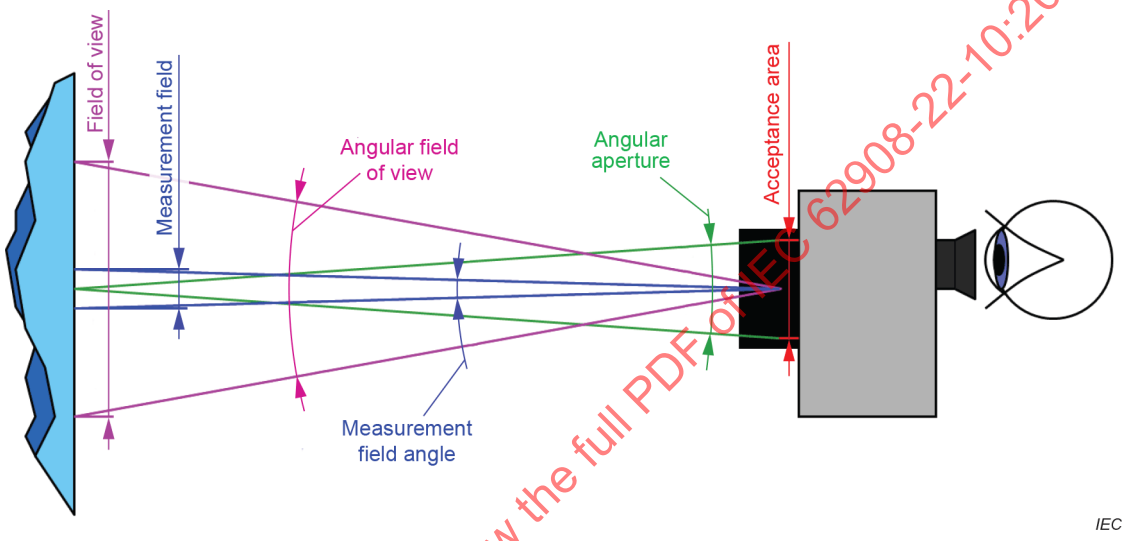

Figure A.1 – Layout diagram of measurement setup

A.4 Luminance

A.4.1 Purpose

The purpose of this measurement is to determine the luminance in the display active area.

A.4.2 Measuring equipment

The apparatus shall be as follows:

– LMD;
– driving signal equipment;
– driving power source.

A.4.3 Measurement method

The measurement method shall be as follows:

a) Set the display and the LMD under the standard measuring environmental conditions.

b) Set up the measurement following the layout diagram shown in Figure A.1.

c) Create a window pattern in the fingerprint recognition region as shown in Figure 5. Set the window at the desired colour Q at the highest luminance level. Allow the display luminance to stabilize.

d) Measure the display luminance L_{Q0} for colour Q at position P_0.

e) Repeat for other display colours as needed.

A.4.4 Reporting

The display luminance L_{Q0} for colour Q shall be reported with a description of measuring conditions.

A.5 Extinction ratio

A.5.1 Purpose

The purpose of this measurement is to evaluate the display's ability to transmit light.

A.5.2 Measuring equipment

The apparatus shall be as follows:

– LMD;
– driving signal equipment;
– driving power source;
– polarization analyzer;
– display mount that can rotate the display about the fingerprint recognition region by 360°.

A.5.3 Measurement method

The measurement method shall be as follows:

a) Set the display and the LMD under the standard measuring environmental conditions.

b) Set up the measurement following the layout diagram shown in Figure A.2. Attach the analyser to the fingerprint recognition region and ensure the whole region is covered.

c) Create a window pattern in the fingerprint recognition region as shown in Figure A.2. Set the window at the desired colour Q at the highest luminance level. Allow the display luminance to stabilize.

d) Rotate the display around P_0 by 360°. Measure the luminous power every 5°.

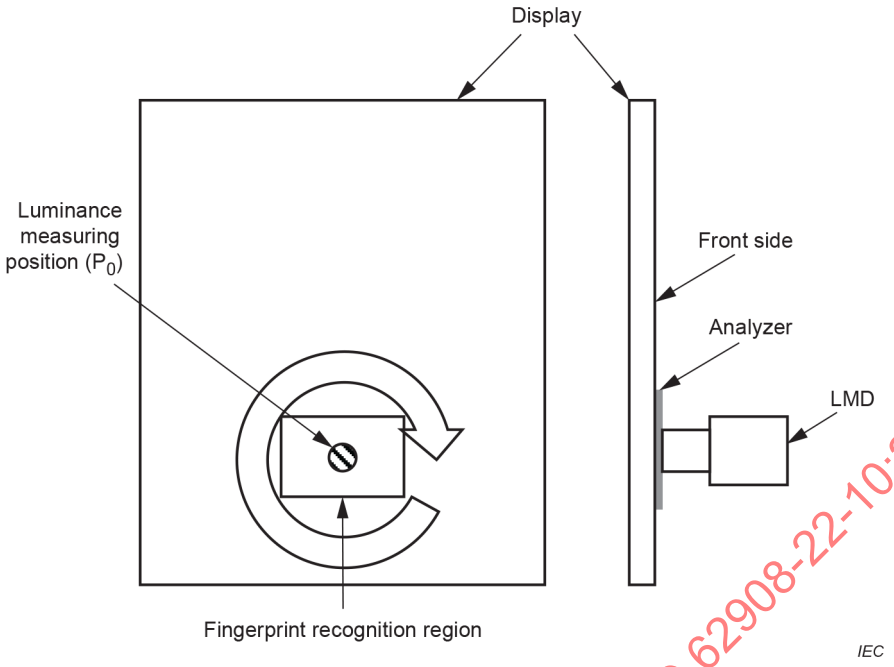

Figure A.2 – Measuring configuration for extinction ratio measurement

e) The extinction ratio δ is calculated by Formula (A.1):

$$\delta = 10 \times \lg \frac{P_{max}}{P_{min}} \quad \text{(A.1)}$$

where

P_{max} is the maximum luminous power value;

P_{min} is the minimum luminous power value.

A.5.4 Reporting

The maximum and minimum luminous power values P_{max} and P_{min}, extinction ratio δ, and the type of polarization analyzer shall be reported with a description of measuring conditions.

A.6 Light leakage ratio

A.6.1 Purpose

The purpose of this measurement is to determine the ability of the display to eliminate the stray light.

A.6.2 Measuring equipment

The apparatus shall be as follows:

– LMD;
– driving signal equipment;
– driving power source;
– higher reflector.