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INTERNATIONAL STANDARD

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Touch and interactive displays – Part 12-10: Measurement methods of touch displays – Touch and electrical performance

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Touch and interactive displays – Part 12-10: Measurement methods of touch displays – Touch and electrical performance

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TOUCH AND INTERACTIVE DISPLAYS –

Part 12-10: Measurement methods of touch displays – Touch and electrical performance

FOREWORD

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IEC 62908-12-10 has been prepared by IEC technical committee 110: Electronic displays. It is an International Standard.

This second edition cancels and replaces the first edition published in 2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) added hovering performance measurement methods, especially in-plane characteristics at a constant distance from the touch sensor;
b) added pen touch performance.

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

Draft	Report on voting
110/1434/CDV	110/1480A/RVC

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.

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

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- withdrawn,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

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TOUCH AND INTERACTIVE DISPLAYS –

Part 12-10: Measurement methods of touch displays – Touch and electrical performance

1 Scope

This part of IEC 62908 specifies the standard measuring conditions and measurement methods for determining touch and hovering performance of a touch sensor module. This document is applicable to touch sensor modules, where the structural relationship between touch sensor, touch controller, touch sensor module, display panel, touch display panel, and touch display module is defined in IEC 62908-1-2.

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

IEC 62908-1-2, *Touch and interactive displays – Part 1-2: Generic – Terminology and letter symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1 and IEC 62908-1-2 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

4 Measuring conditions

4.1 Standard measuring environmental conditions

Measurements shall be carried out under the standard environmental conditions:

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

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

4.2 Standard atmospheric conditions for reference measurements and tests

If the parameters to be measured depend on temperature, pressure and humidity, and their dependence on temperature, pressure and humidity is unknown, the atmospheres to be specified shall be selected from the following values, as shown in Table 1. The selected values shall be noted in the relevant specifications.

Table 1 – Standard conditions for reference measurements and tests

Temperature [a] °C	**Relative humidity** [a, b] % RH	**Air pressure** [a] kPa
(20, 25, 30, and 35) ± 3	45 to 75	86 to 106

[a] Including extreme values.

[b] Absolute humidity ≤ 22 g/m^3.

4.3 Standard positioning equipment and setup

The standard positioning equipment for touch performance shall be the positioning machine equipped with a test bar, a moving arm, and a stage onto which the touch sensor module is placed, as shown in Figure 1. The positioning machine shall move its arm and stage to place the test bar on or over the touch sensor module.

There are three types of positions associated with a given test: target, actual and reported positions. The target position is a desired measurement location in physical space referenced to a fixed datum on or over the touch sensor module surface. The actual position is the actual location of contact or hovering during test, referenced to the same fixed datum, which can differ from the target position due to test bar placement error. The reported position is the location reported by the touch controller.

As shown in Figure 2, the reported positions from the touch controller are analysed to define performance measures with respect to the target positions.

The touch sensor module and the stage shall be aligned correctly while setting up the measurement equipment, because a misalignment between them can introduce coordinate shifts or rotation between the actual touch positions and target positions; each positioning machine has its inherent accuracy, which means that an actual touched position does not coincide with its target position. The performance measurements based on the target positions can include errors due to the accuracy of the positioning machine. The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The test bar of the selected diameter shall be attached to the moving arm. In case of measurement of the pen touch performance, instead of the test bar, a selected touch pen (stylus pen) shall be attached to the moving arm.

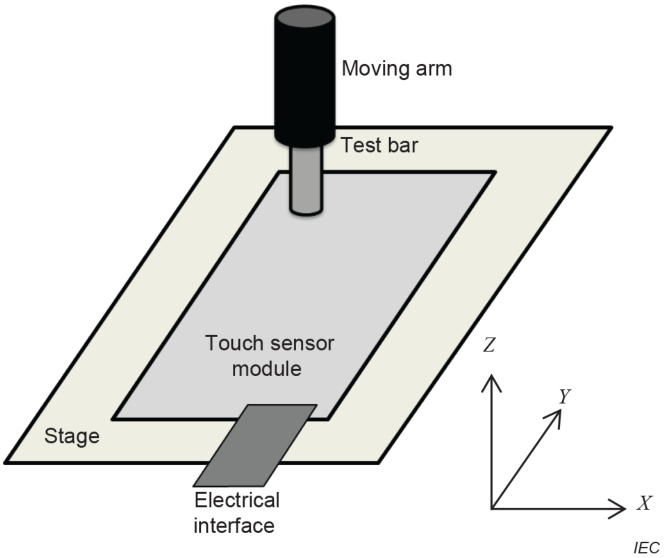


Figure 1 – Composition of test equipment

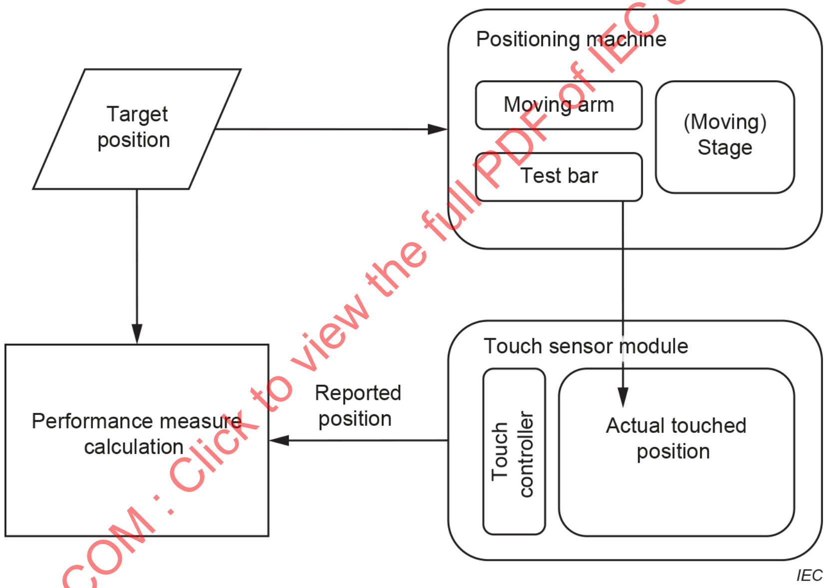


Figure 2 – Concept of performance measurement

4.4 Human operator alternative to standard positioning equipment

Under certain circumstances, for example if the display under test is too large for suitable positioning equipment to be available, a suitably designed test arm may be manually positioned to enable completion of a subset of the tests described in this document. In this situation, the test arm needs to be designed carefully to minimise the reasonable achievable error between actual and target positions when conducting measurements. An example of such a test arm can consist of a rod with a sliding tip (Figure 3, left), whose materials are chosen so that contact between the rod and the display does not trigger a touch event (Figure 3, middle), whereas contact between the sliding tip and the display does trigger a touch event (Figure 3, right). Such a test arm can be placed accurately and reliably by the human operator with the sliding tip away from the display, subsequent to which a measurement can be made by sliding the tip into contact with the display.

The human operator alternative is not recommended for hovering performance measurements because it is difficult to ensure the accuracy of positions, including the height.

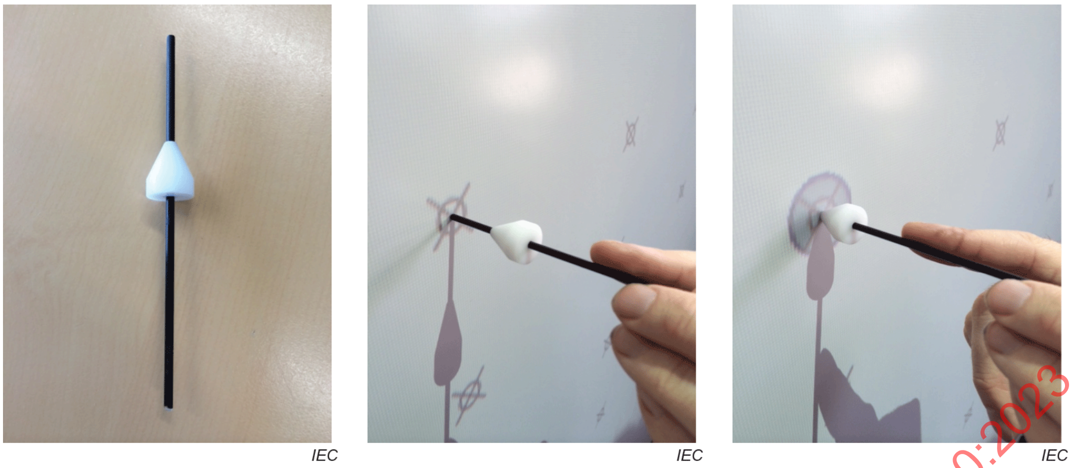


Figure 3 – Example of manual test tool (left), positioning without triggering a touch event (middle) and recording a touch event (right)

4.5 Test bar and touch pen

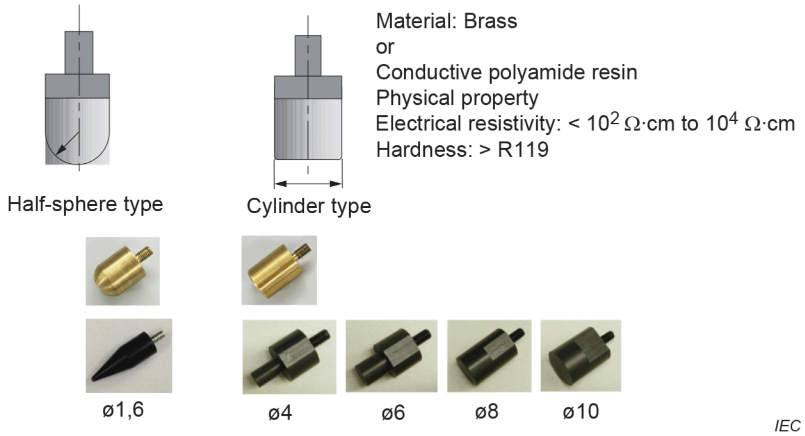
The parameters of the test bar shall be size, shape, and material. Examples of suitable sizes and shapes of the test bar are shown in Figure 4. The material parameters for the test bar shall be appropriately chosen given the device category under test.

When the touch sensor module is a capacitive touch system, the test bar shall be electrically conductive and shall additionally be grounded in order to avoid potential performance degradation due to electrical noise, unless otherwise stated. A test bar may have an insulating layer on the base to model the effect of a gloved finger.

For reflection-based optical systems, the reflectivity of the contact end of the test bar shall be chosen to be spectrally representative of human skin.

In all cases, the appropriate properties (including size, shape and material) of the test bar shall be reported.

In case of measurement of the pen touch performance, the selected touch pen shall be applied instead of the test bar. The touch pen corresponding to the touch sensor module shall be selected, because there are several types of touch pens (see IEC TR 62908-1-3). The information of the selected touch pen and related properties (i.e., tilt angle of touch pen, pressure of touch pen, etc.) shall be reported.



NOTE ø (test bar diameter) = 4 mm, 6 mm, 7 mm, 9 mm, or 12 mm.

Figure 4 – Examples of test bars

5 Touch performance measurement methods

5.1 General

Fundamental touch performance measurement methods are described in Clause 5. They shall be applied during the characterization of a touch sensor module to provide a good user experience. (See Annex A regarding electrical performance measurement methods of touch sensors.)

5.2 Accuracy test

5.2.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate how close touch positions are reported relative to their target positions.

5.2.2 Test procedure

5.2.2.1 General

For the accuracy measurement, one of the following two methods can be selected. The first method is a straightforward method to evaluate the distance between each target point and its corresponding reported point. The second method is an indirect method where target grid points are estimated from reported points. This method can tolerate coordinate shifts which are caused by a misalignment between the touch sensor module and the stage while setting up the measurement equipment.

5.2.2.2 Method 1

The active area is defined as the area where touch is recognized. The centre area is defined as the rest of the active area without the edge area as shown in Figure 5. The edge area is defined as an area with the width of W from the edge of the active area. The origin and axis direction shall be defined.

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The test bar of the selected diameter size, shape and material shall be attached to the moving arm. For a precise measurement of the accuracy, the test equipment should be set up properly. The measurement points in the test grid are evenly spaced along both X and Y axes, away from the origin and spanning the whole active area of the touch sensor panel as shown in Figure 6.

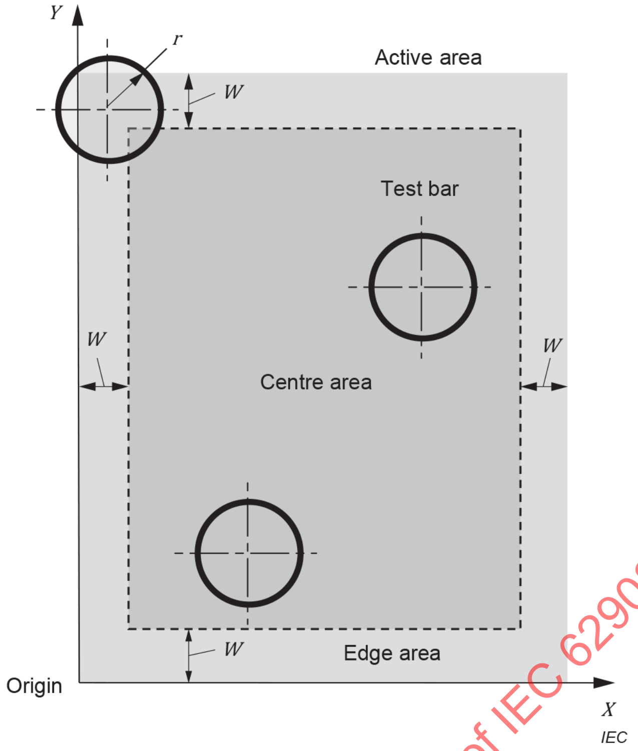
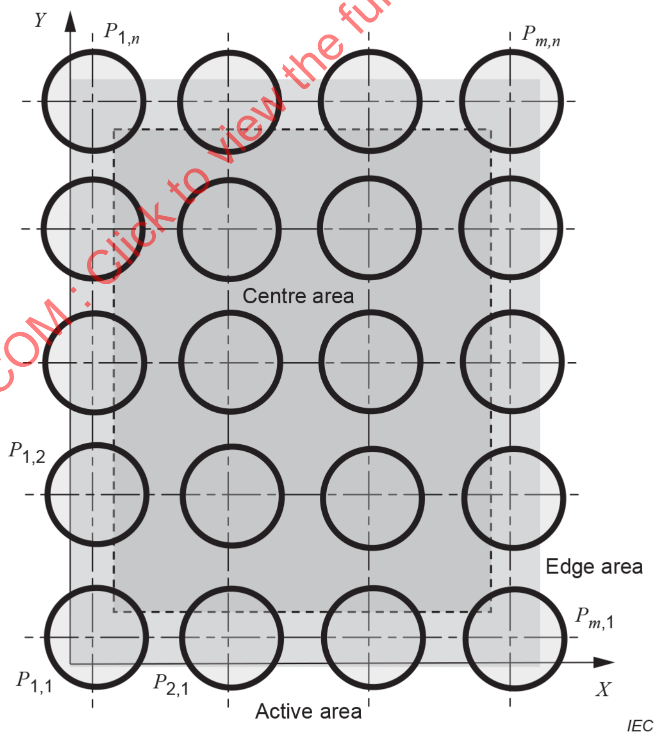


Figure 5 – Location of edge area and centre area



NOTE m, n: number of points in the X and Y direction.

Figure 6 – Point grid

At each target grid point (i, j), lift the test bar down and up, and collect the touch reports p times. As shown in Figure 7, the accuracy is defined as the distance between the target coordinate and the mean reported coordinate.

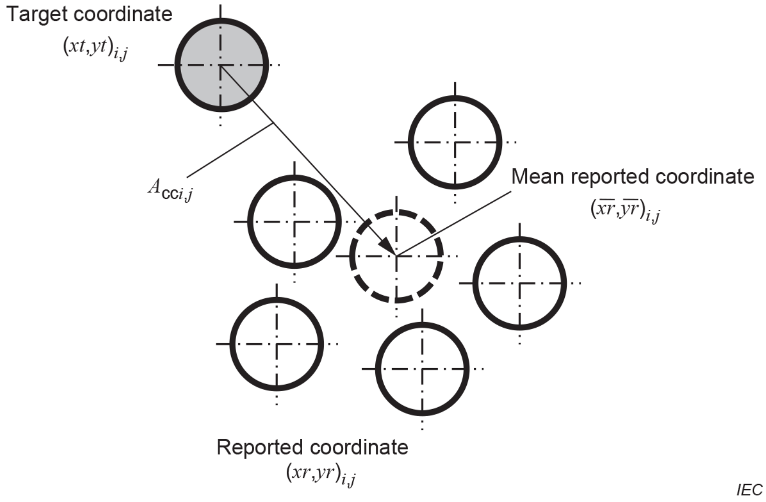


Figure 7 – Accuracy definition

In the centre area, calculate the accuracy, that is, the maximum of accuracy, the standard deviation of accuracy and the average of accuracy, as shown in Formula (1) to Formula (5). In the edge area, the accuracy is calculated in the same manner.

$$A_{\text{ccmax}} = \max(A_{\text{cc}i,j}) \tag{1}$$

$$A_{\text{cc}\sigma} = \sqrt{\frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(A_{\text{cc}i,j} - A_{\text{ccmean}})^2}{q}} \tag{2}$$

$$A_{\text{ccmean}} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(A_{\text{cc}i,j})}{q} \tag{3}$$

$$A_{\text{cc}i,j} = \sqrt{(\overline{xr}_{i,j} - xt_{i,j})^2 + (\overline{yr}_{i,j} - yt_{i,j})^2} \tag{4}$$

$$\overline{xr}_{i,j} = \frac{\sum_{k=1}^{p} xr_{i,j,k}}{p}, \overline{yr}_{i,j} = \frac{\sum_{k=1}^{p} yr_{i,j,k}}{p} \tag{5}$$

where

p	is the number of reports at a target point (1,2,…);
q	is the number of measurement points = m x n;
i, j, k	is the k-th data in number of reports (p) at a target point(i, j);
$A_{\text{cc}i,j}$	is the distance between the target coordinate and the mean reported coordinate;
A_{ccmax}	is the maximum of accuracy;
$A_{\text{cc}\sigma}$	is the standard deviation of accuracy; and
A_{ccmean}	is the average of accuracy.

In case of measurement of the pen touch performance instead of the test bar, the selected touch pen shall be applied.

5.2.2.3 Method 2

The test bar shall be placed at m x n target grid points equally spaced by a distance d in both horizontal and vertical directions. When the touch sensor module is a capacitive touch system, d shall be smaller than or equal to one fourth of the sensor channel pitch, and m x d and n x d are greater than or equal to the sensor channel pitch. At each target grid point (i, j), collect the touch reports 50 times to 100 times in one of the following two ways:

1) lift the test bar down and up for each report at each target;
2) keep the test bar stationary at each target.

The data from 1) and 2) is used in the calculation of repeatability.

Calculate the mean point ($\overline{x}_{i,j}$, $\overline{y}_{i,j}$) of the reported points at (i, j).

Then find the best fitted grid

$$\left(X_{i,j}, Y_{i,j}\right) = \left(\left(i-1\right)d + x_{\text{best}}, \left(j-1\right)d + y_{\text{best}}\right) \quad i = 1,\cdots,m, j = 1,\cdots,n \tag{6}$$

which minimizes the mean square distance

$$\sum_{\substack{i=1,2,\ldots,m,\\ j=1,2,\ldots,n}} \{(X_{i,j} - \overline{x}_{i,j})^2 + (Y_{i,j} - \overline{y}_{i,j})^2\} \tag{7}$$

from

$$\left(\overline{x}_{i,j}, \overline{y}_{i,j}\right) \quad i = 1,\cdots,m,\ j = 1,\cdots,n \tag{8}$$

The shifts (x_{best}, y_{best}) for the best grid are obtained by equating the derivatives of the distance by x_{best} and y_{best} to zero, and are calculated as

$$\left(x_{\text{best}}, y_{\text{best}}\right) = \left(\frac{\sum_{\substack{i=1,2,\ldots,m,\\ j=1,2,\ldots,n}} \overline{x}_{i,j}}{mn} - \frac{(n-1)d}{2}, \frac{\sum_{\substack{i=1,2,\ldots,m,\\ j=1,2,\ldots,n}} \overline{y}_{i,j}}{mn} - \frac{(m-1)d}{2}\right) \tag{9}$$

The accuracy at (i, j) is defined as the distance between the grid point ($X_{i,j}$,$Y_{i,j}$) and the mean point ($\overline{x}_{i,j}$, $\overline{y}_{i,j}$).

$$A_{\text{cc}i,j} = \sqrt{\left(X_{i,j} - \overline{x}_{i,j}\right)^2 + \left(Y_{i,j} - \overline{y}_{i,j}\right)^2} \tag{10}$$

An example of a measurement result and the corresponding calculation of accuracy is shown in Figure 8.

In case of measurement of the pen touch performance, instead of the test bar, the selected touch pen shall be applied.

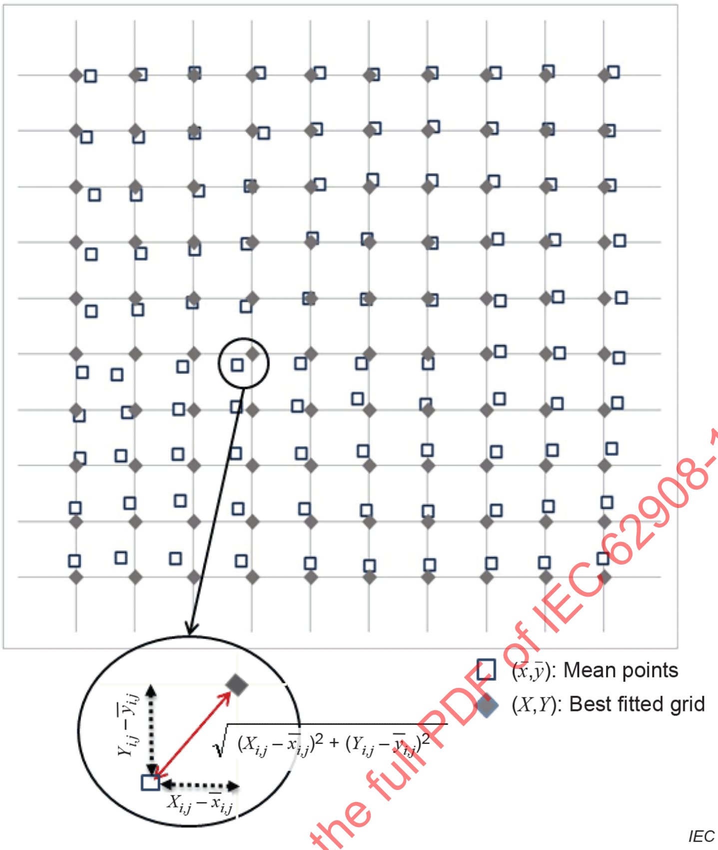


Figure 8 – Example of measurement result and calculation of accuracy

5.2.3 Report

The following items shall be reported:

– selected measurement method;

– selected size, shape and material of the test bar or the selected touch pen and properties (tilt angle of touch pen and pressure of touch pen);

– width of edge area W;

– target position;

– number of measurements at each point;

– maximum of accuracy for all points in each area;

– average of accuracy for all points in each area; and

– standard deviation of accuracy for all points in each area.

5.3 Repeatability or jitter test

5.3.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate how precisely touch positions are reported, given a sequence of touches in the same target position, where "precise" means that the reported positions are "close to each other".

5.3.2 Test procedure

5.3.2.1 General

For the repeatability or jitter measurement, one of the following two methods can be selected, as in the case of accuracy measurement.

The repeatability is defined with the same reported data collected for accuracy measurement at target grid point (i, j) by lifting the test bar down and up for each report. The jitter is defined with the reported data collected by keeping the test bar stationary at target grid point (i, j). The repeatability measurement is applicable to the jitter measurement.

5.3.2.2 Method 1

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The test bar of the selected diameter shall be attached to the moving arm.

At each target grid point (i, j), lift the test bar down and up, and collect the touch reports p times, As shown in Figure 9, the repeatability is defined as the distance between the reported coordinate and the mean reported coordinate.

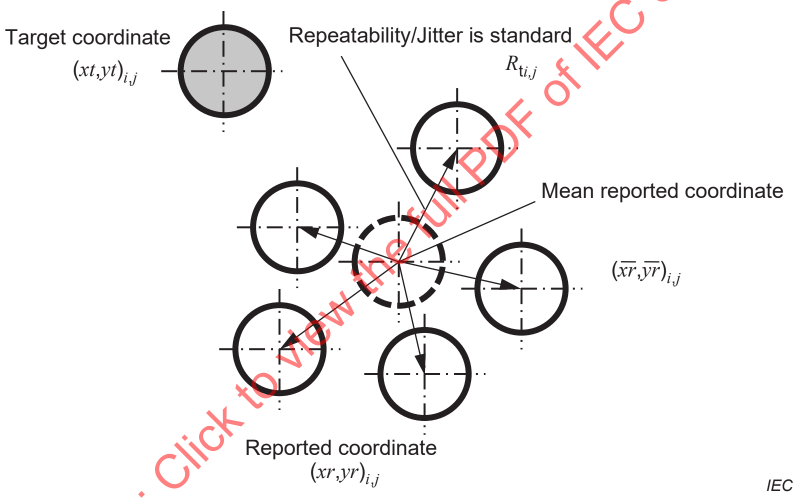


Figure 9 – Repeatability in the touch sensor module

In the centre area, calculate the repeatability, that is, the maximum, standard deviation and the average, as shown in Formula (11) to Formula (15). In the edge area, the repeatability is calculated in the same manner.

$$R_{\text{tmax}} = \max(R_{\text{t}i,j}) \tag{11}$$

$$R_{\text{t}\sigma} = \sqrt{\frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(R_{\text{t}i,j} - R_{\text{tmean}})^2}{q}} \tag{12}$$

$$R_{\text{tmean}} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(R_{\text{t}i,j})}{q} \tag{13}$$

$$R_{\mathrm{t}i,j} = \sqrt{(xr_{i,j} - \overline{xr}_{i,j})^2 + (yr_{i,j} - \overline{yr}_{i,j})^2} \tag{14}$$

$$\overline{xr}_{i,j} = \frac{\sum_{k=1}^{p} xr_{i,j,k}}{p}, \overline{yr}_{i,j} = \frac{\sum_{k=1}^{p} yr_{i,j,k}}{p} \tag{15}$$

where

p	is the number of reports at a target point (1,2,…);
q	is the number of measurement points = $m \times n$;
i, j, k	is the k-th data in number of reports (p) at a target point (i,j);
$R_{\mathrm{t}i,j}$	is the distance between the target coordinate and the mean reported coordinate;
R_{tmax}	is the maximum of repeatability;
$R_{\mathrm{t}\sigma}$	is the standard deviation of repeatability; and
R_{tmean}	is the average of repeatability.

In case of measurement of the pen touch performance instead of the test bar, the selected touch pen shall be applied.

5.3.2.3 Method 2

The repeatability is defined with the same reported data collected for the accuracy measurement at target grid point (i, j) by lifting the test bar down and up for each report. Calculate the standard deviation $\sigma_{i,j}$ as the root mean square distance between the reported points at target grid point (i, j) and their mean point $\left(\overline{x}_{i,j}, \overline{y}_{i,j}\right)$.

The repeatability is defined as

$$R_{\mathrm{t}} = \max_{i,j}\left(\sigma_{i,j}\right) \tag{16}$$

An example of a measurement result for repeatability is shown in Figure 10.

In case of measurement of the pen touch performance instead of the test bar, the selected touch pen shall be applied.

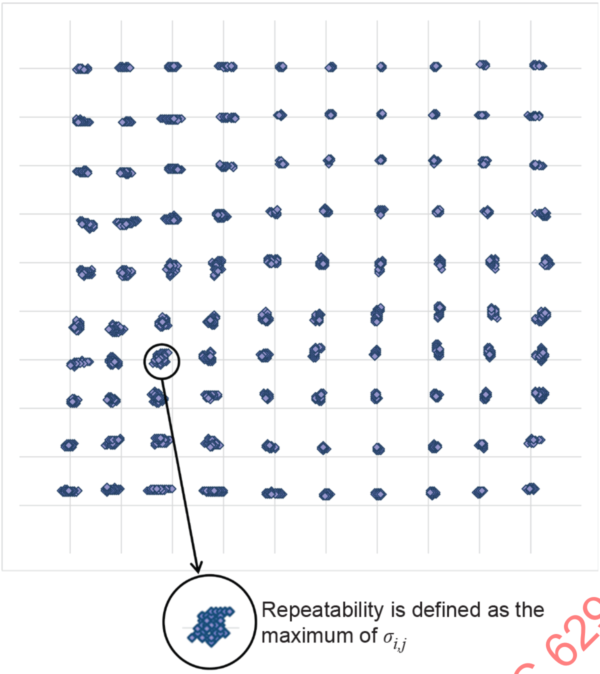


Figure 10 – Example of measurement result for repeatability

5.3.3 Report

The following items shall be reported:

– selected measurement method;

– selected size, shape and material of the test bar or the selected touch pen and properties (tilt angle of touch pen and pressure of touch pen);

– width of edge area W;

– target position;

– number of measurements at each point;

– maximum of repeatability or jitter for all points in each area; and

– average of repeatability or jitter for all points in each area.

5.4 Linearity test

5.4.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate how precisely straight lines can be drawn.

5.4.2 Test procedure

5.4.2.1 General

For the linearity measurement, one of the following two methods can be selected as in the previous cases.

5.4.2.2 Method 1

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The test bar of the selected diameter shall be attached to the moving arm. The test bar touches and drags from one edge of the panel to the opposite edge. The dragging speed is in the range 5 mm/s to 50 mm/s. The path of the dragging operation is chosen to be horizontal, vertical or diagonal across the panel (see Figure 11).

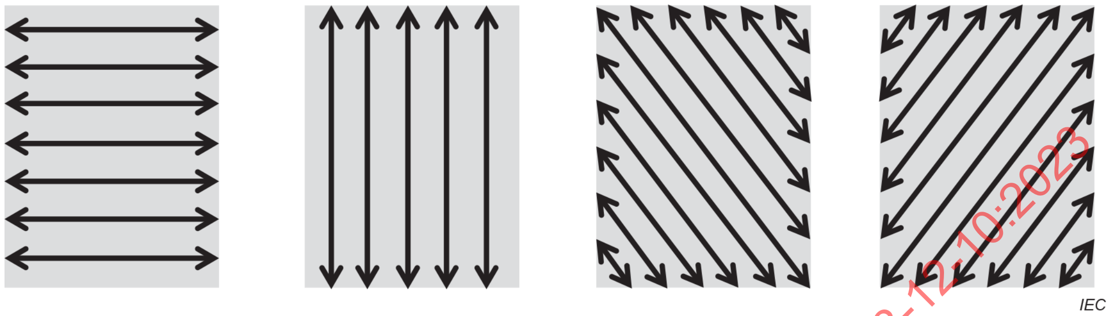


Figure 11 – Dragging line for linearity test

The centre of the distance between the reported point and straight line is calculated by the formula in Figure 12. The edge measurement start point for the line is positioned in the same way as shown in Figure 6.

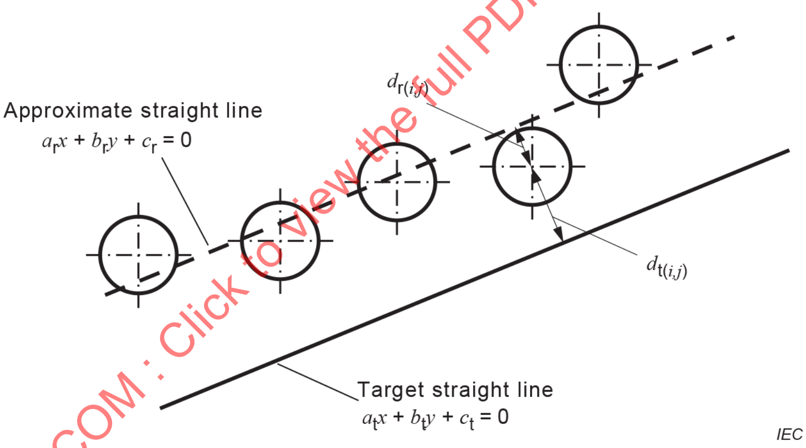


Figure 12 – Linearity definition

The distance between the target line and the reported line is measured and determines the linearity of the touch sensor module, and is calculated as follows:

$$d_{r(i,j)} = \frac{\left|a_r x_{r(i,j)} + b_r y_{r(i,j)} + c_r\right|}{\sqrt{a_r^2 + b_r^2}} \tag{17}$$

$$d_{t(i,j)} = \frac{\left|a_t x_{r(i,j)} + b_t y_{r(i,j)} + c_t\right|}{\sqrt{a_t^2 + b_t^2}} \tag{18}$$

$$L_r = \max\left(d_{r(i,j)}\right) \tag{19}$$

$$L_t = \max\left(d_{t(i,j)}\right) \tag{20}$$

In case of measurement of the pen touch performance instead of the test bar, the selected touch pen shall be applied.

5.4.2.3 Method 2

Draw m parallel lines in a chosen direction (vertical, horizontal or diagonal) of equal spacing d with a touch object at a speed S in the range 5 mm/s to 50 mm/s. When the touch sensor module is a capacitive touch system, the length of each line shall be greater than or equal to three times the sensor channel pitch, d is smaller than or equal to one fourth of the sensor channel pitch, and $m \times d$ is greater than or equal to the sensor channel pitch. For each drawn line, calculate the linearity of the reported data (x_i, y_i), i = 1,….n as the maximum distance between the reported points and the best fitted line. If the best fitted line is represented as '$ax + by + c = 0$', then the coefficients a, b, c and the linearity are calculated as in Formula (21) and Formula (22).

$$\begin{aligned}
a &= S_{xy} \\
b &= \lambda - S_{xx} \\
c &= -a\overline{x} - b\overline{y} \\
\overline{x} &= \frac{1}{n}\sum_{i=1}^{n} x_i \\
\overline{y} &= \frac{1}{n}\sum_{i=1}^{n} y_i \\
S_{xx} &= \sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2 \\
S_{yy} &= \sum_{i=1}^{n}\left(y_i - \overline{y}\right)^2 \\
S_{xy} &= \sum_{i=1}^{n}\left(x_i - \overline{x}\right)\left(y_i - \overline{y}\right) \\
\lambda &= \frac{S_{xx} + S_{yy} - \sqrt{D}}{2} \\
D &= \left(S_{xx} - S_{yy}\right)^2 + 4S_{xy}^2
\end{aligned} \tag{21}$$

$$L = \underset{i=1,2,\ldots,n}{\text{Max}}\left(\frac{\left|ax_i + by_i + c\right|}{\sqrt{a^2 + b^2}}\right) \tag{22}$$

The linearity of the touch sensor module is defined as the maximum of the linearity of the m lines drawn in a direction. Diagonal, horizontal and vertical drawing directions shall be tested.

An example of measurement and calculation of linearity is shown in Figure 13.

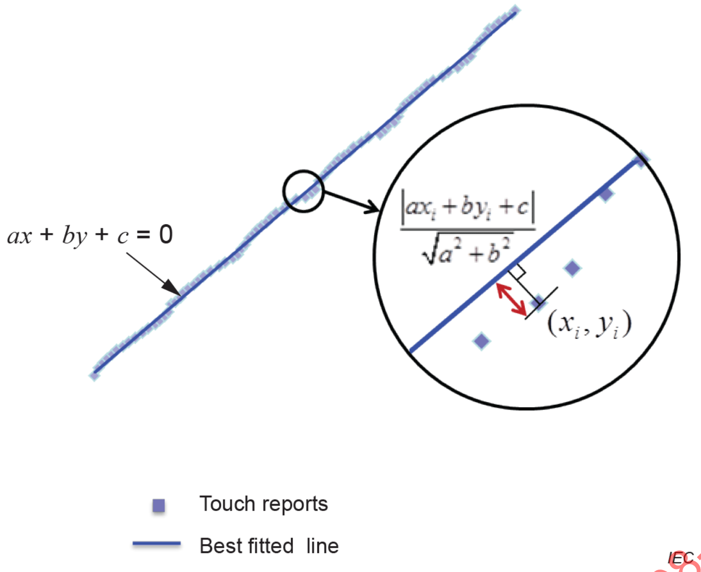


Figure 13 – Example of measurement and calculation of linearity

In case of measurement of the pen touch performance, instead of the test bar, the selected touch pen shall be applied.

5.4.3 Report

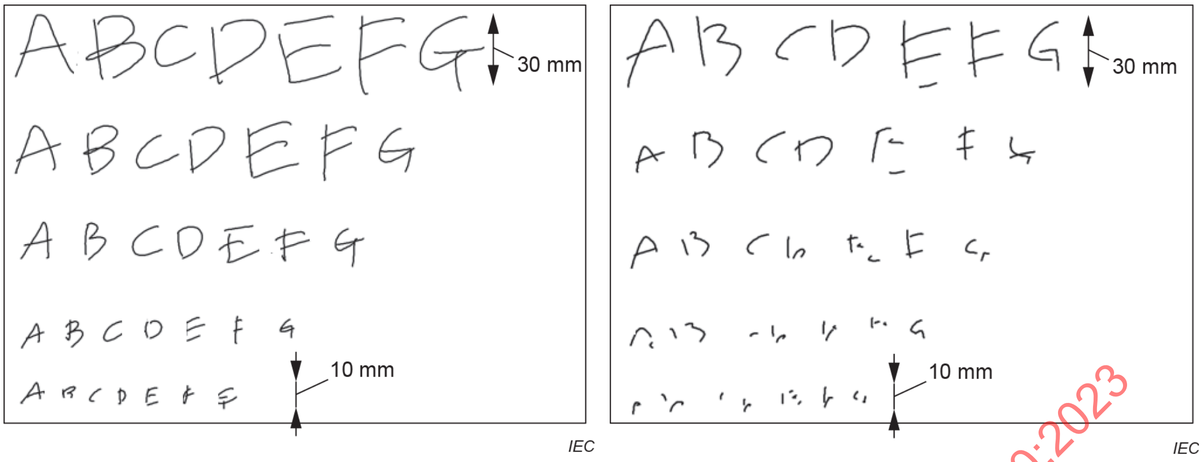
The following items shall be reported:

- selected measurement method;
- selected size, shape and material of test bar or the selected touch pen and properties (tilt angle of touch pen and pressure of touch pen);
- chosen slide pattern and measuring line position;
- width of edge area W;
- maximum of linearity for all points in each area;
- average of linearity for all points in each area; and
- standard deviation of linearity for all points in each area.

5.5 Reproducibility test

5.5.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate how exactly the reported touch traces coincide with the actual user's touch traces. An example showing the difference in reproducibility for two available touch systems is shown in Figure 14, where the characters are written by a person in the same way for both systems.



a) **Handwriting with touch system A**

b) **Handwriting with touch system B**

Figure 14 – Example of reproducibility test results

5.5.2 Test procedure

5.5.2.1 General

For the reproducibility measurement, an arm capable of moving the test bar in a circular trajectory with variable radius and velocity is required. A minimum radius is typically half of the sensor channel pitch under test and a typical angular velocity is 1 080 °/s.

5.5.2.2 Preparation

Collect the touch report data at equally spaced target points on a reference circle by using the arm. Then determine the radius R_{ref} and the centre of the reference circle from the reported touch data by calculating the best fitted circle $x^2 + y^2 + AX + BY + C = 0$ with Formula (23) to Formula (25), where (x_i, y_i), $i = 1,...,m$ are the reported touch coordinates.

$$\begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} \sum_{i=1} x_i^2 & \sum_{i=1} x_i y_i & \sum_{i=1} x_i \\ \sum_{i=1} x_i y_i & \sum_{i=1} y_i^2 & \sum_{i=1} y_i \\ \sum_{i=1} x_i & \sum_{i=1} y_i & \sum_{i=l} 1 \end{pmatrix}^{-1} \begin{pmatrix} -\sum_{i=1} \left(x_i^3 + x_i y_i^2 \right) \\ -\sum_{i=1} \left(x_i^2 y_i + y_i^3 \right) \\ -\sum_{i=1} \left(x_i^2 + y_i^2 \right) \end{pmatrix} \quad (23)$$

$$R_{ref} = \sqrt{\frac{A^2 + B^2}{4} - C} \quad (24)$$

$$P_{centre} = \left(\frac{-A}{2}, \frac{-B}{2} \right) \quad (25)$$

5.5.2.3 Analysis

Collect the touch reports with the arm while rotating 30 times, and find R_{min}, R_{max} as the distances to the nearest and farthest points from the centre of the reference circle, respectively (see Figure 15). The reproducibility is then defined with Formula (26).

$$R_d = \frac{|R_{max} - R_{ref}| + |R_{min} - R_{ref}|}{R_{ref}} \times 100 \quad (26)$$

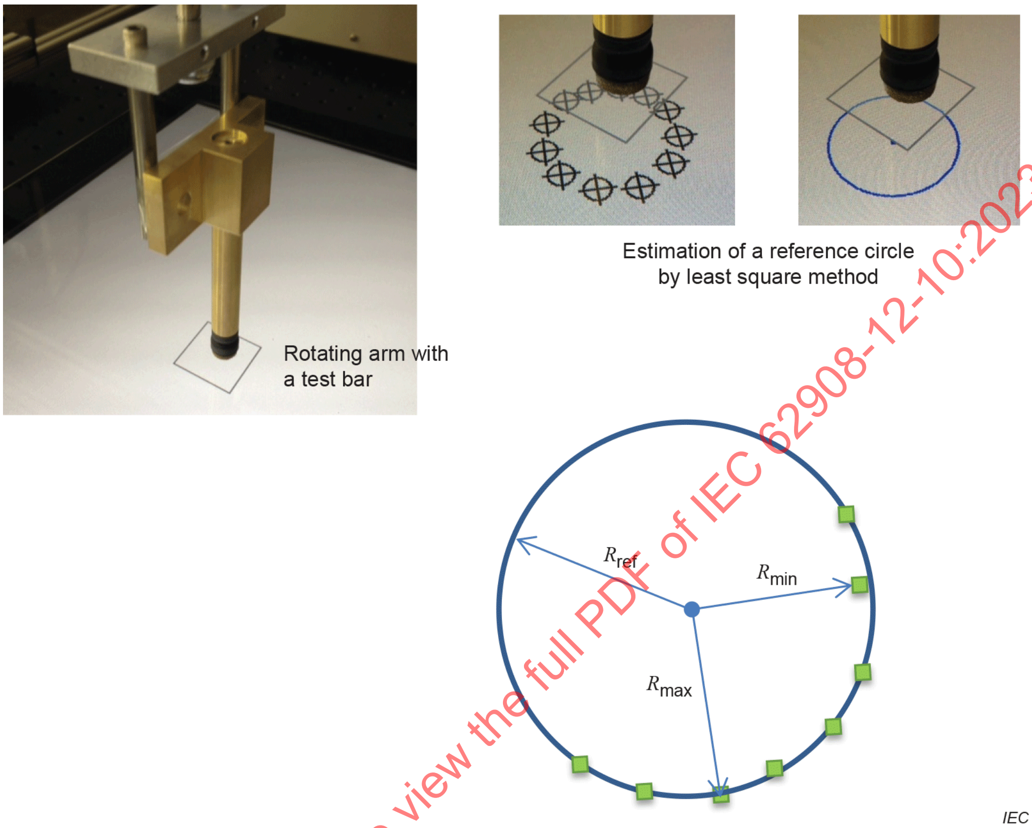
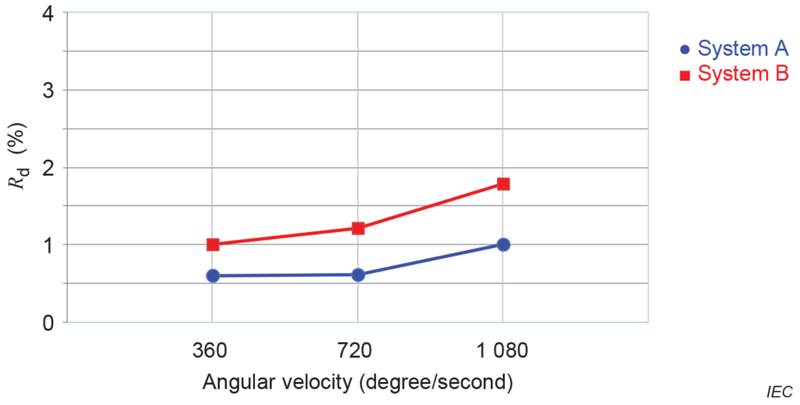


Figure 15 – Reproducibility test procedure

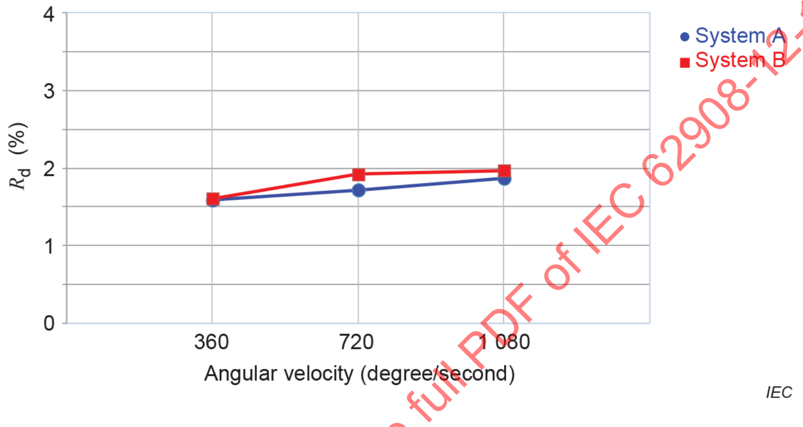
5.5.3 Report

The value of reproducibility is reported along with the size, shape and material of the test bar, the radius of the rotation and the angular velocity. Instead of the test bar, when the selected touch pen is applied, the information of the selected touch pen and related properties (i.e., tilt angle of touch pen, pressure of touch pen, etc.) shall be reported.

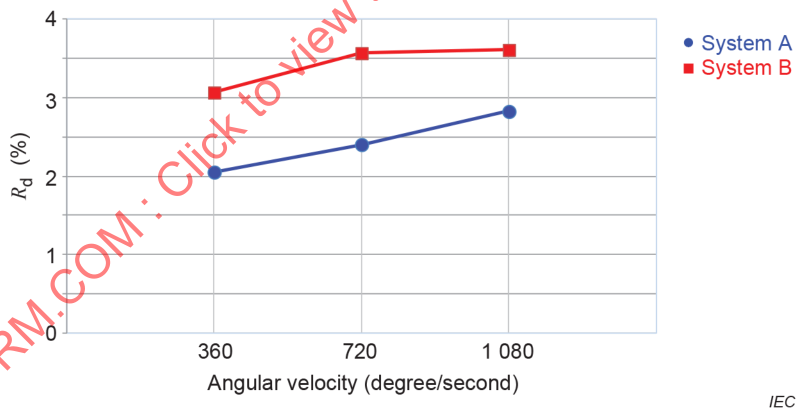
Examples of reproducibility measurements showing the dependence on the rotation radius and angular velocity are shown in Figure 16.



a) radius 25 mm



b) radius 40 mm



c) radius 80 mm

Figure 16 – Examples of measurements of reproducibility – Velocity dependence

5.6 Signal-to-noise ratio (SNR) test

5.6.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate the ratio of signal level to noise level from the touch controller as defined in Figure 17.

NOTE This test might not be applicable to some touch technologies.

5.6.2 Test procedure

The touch sensor module under test shall be attached to a stage and connected to the electrical interface. Without any touch contact, the signal from the touch controller is collected. The signal is again collected, this time with the touch contact. The SNR value is then calculated as follows.

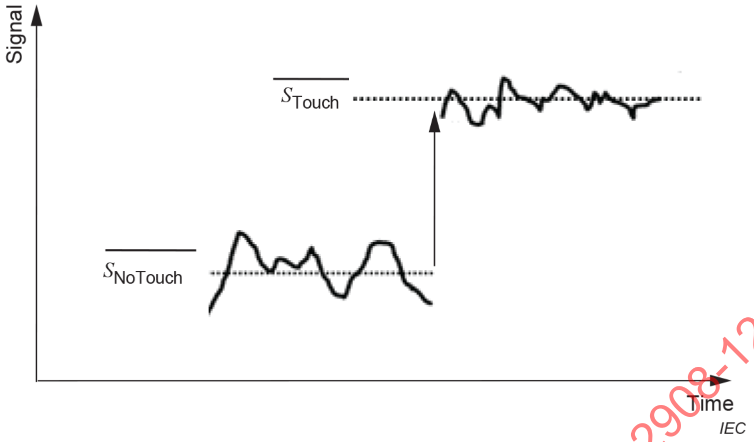


Figure 17 – SNR definition concept

$$\overline{S_{\text{NoTouch}}} = \frac{\sum_{k=1}^{k=m} S_{\text{NoTouch}}[k]}{m} \tag{27}$$

$$\overline{S_{\text{Touch}}} = \frac{\sum_{k=1}^{k=n} (S_{\text{Touch}}[k] - \overline{S_{\text{NoTouch}}})}{n} \tag{28}$$

$$N_{\text{NoTouch}} = \sqrt{\frac{\sum_{k=1}^{k=m} (S_{\text{NoTouch}}[k] - \overline{S_{\text{NoTouch}}})^2}{m}} \tag{29}$$

$$N_{\text{Touch}} = \sqrt{\frac{\sum_{k=1}^{k=n} (S_{\text{Touch}}[k] - \overline{S_{\text{Touch}}})^2}{n}} \tag{30}$$

$$SNR_{\text{NoTouch}} = \frac{\overline{S_{\text{Touch}}}}{N_{\text{NoTouch}}} \tag{31}$$

$$SNR_{\text{Touch}} = \frac{\overline{S_{\text{Touch}}}}{N_{\text{Touch}}} \tag{32}$$

$$SNR_{\text{NoTouch}}[\text{dB}] = 20\log(SNR_{\text{NoTouch}}) \tag{33}$$

$$SNR_{\text{Touch}}[\text{dB}] = 20\log(SNR_{\text{Touch}}) \tag{34}$$

where

m is the number of reports when not touched;

n is the number of reports when touched;

S_{touch} is the signal level when touched;

$S_{\text{No Touch}}$ is the signal level when not touched;

N_{Touch} is the noise level when touched; and

$N_{\text{No Touch}}$ is the noise level when not touched.

5.6.3 Report

The following items shall be reported:

– selected size, shape and material of the test bar;
– width of edge area W;
– measurement positions; and
– minimum SNR among the points.

5.7 Report rate test

5.7.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate the interval between the touch events interrupt signals from the touch controller. The touch controller senses and reports the touched coordinates periodically. The shorter the reported coordinates interval, the more reported the coordinates are during a given period, which corresponds to an increased update rate and a more fluid user experience.

5.7.2 Test procedure

The touch display under test shall be attached to a stage and connected to the electrical interface. The selected test bar shall be attached to the moving arm. The test bar touches and drags from one edge of the top to the opposite edge of the bottom diagonally (see Figure 18). The dragging speed is selected as being between 5 mm/s and 50 mm/s.

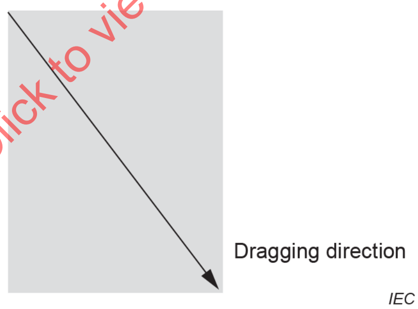


Figure 18 – Dragging direction for reporting time measurement

During the dragging, touch event interrupt signals are generated from the touch controller, and the reciprocal of the time between the interrupt signals is measured as the report rate (see Figure 19).

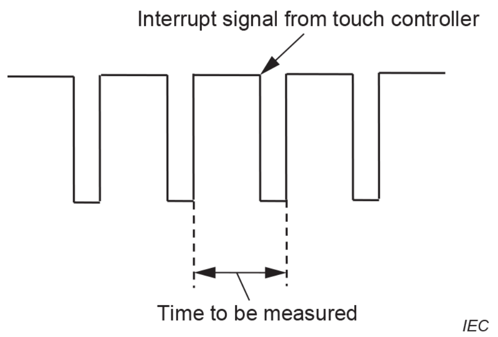


Figure 19 – Reporting time interval measurement

5.7.3 Report

The minimum value, mean value and maximum value among the measured report rate values, the selected size, shape and material of the test bar and the selected dragging speed shall be reported.

5.8 Latency test

5.8.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate the response time between the actual and reported touch.

5.8.2 Test procedure

The touch sensor module under test shall be attached to a stage and connected to the electrical interface. The selected test bar shall be attached to the moving arm. The test bar touches the target points on the touch sensor module in idle mode. The time between the actual touch signal generated from the moving arm and the interrupt signal from the touch controller are measured. The onset of the touch signal represents the time when the test bar touches the surface of the touch module as shown in Figure 20. For example, the touch signal should be generated by an image processing, sound processing, or electrical method.

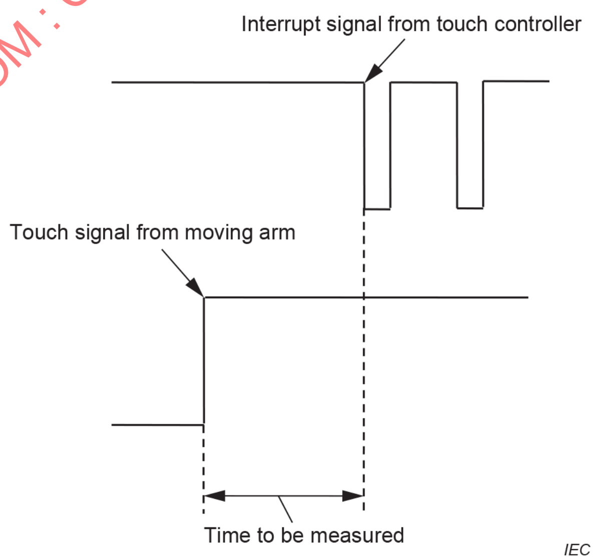


Figure 20 – Latency measurement

In case of measurement of the pen touch performance instead of the test bar, the selected touch pen shall be applied.

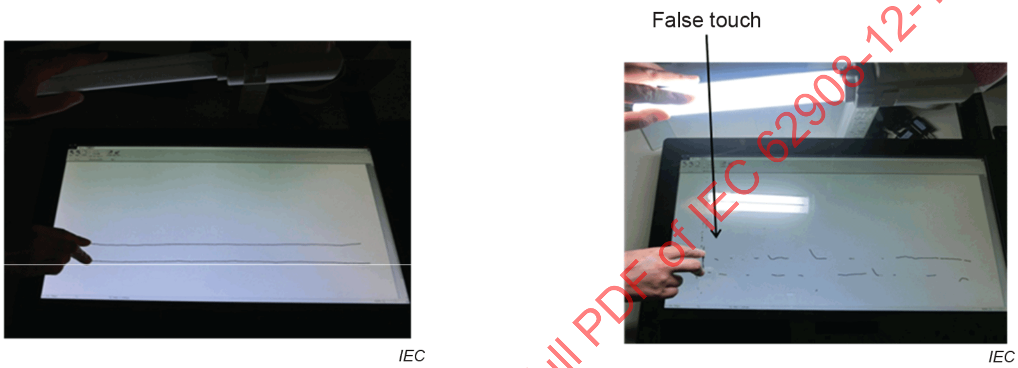
5.8.3 Report

The worst-case (maximum) value, median value and minimum value for each contact point and the selected size, shape and material of the test bar shall be reported. Instead of the test bar, when the selected touch pen is applied, the information of the selected touch pen and related properties (i.e., tilt angle of touch pen, pressure of touch pen, etc.) shall be reported,

5.9 Electrical noise immunity test

5.9.1 Purpose

The purpose of this test is to indicate the tolerance of touch sensors and modules against any external noise that couples into them. Touch systems are often used under electrically noisy environments such as with fluorescent lamps, AC adapters and chargers. An example of the effect of external noise on touch performance is shown in Figure 21.



a) **Fluorescent lamp is OFF**

b) **Fluorescent lamp is ON**

Figure 21 – Example of the effect of external noise

5.9.2 Test procedure

Inject sinusoidal noise from a signal generator into a test bar on a touch sensor module as shown in Figure 22, with the test conditions stated below. Measure the maximum tolerated amplitude (V) at each noise frequency, where "tolerated" means that the pass criteria below are met for any voltage level in [0, V]. Classify the noise amplitude into the following two classes.

Class A: Pass criterion is met throughout the test period.

Class B: Pass criterion is met after the first touch is reported, where the missing touch between the start of the noise injection and the first touch is neglected.

a) Test conditions:

Amplitude:	1 $V_{\text{p-p}}$ to 50 $V_{\text{p-p}}$
Wave form:	Sinusoidal
Frequency range:	5 kHz to 500 kHz
Frequency steps:	5 kHz for 5 kHz to 100 kHz
	5 kHz or ≤ 5 % of the frequency for 100 kHz to 500 kHz
Test bar size:	9 mm diameter
Position:	at the intersection of both direction channels near the centre of the touch sensor
Test period:	200 ms or greater touch time per frequency / amplitude pair

b) Pass criterion:

No false touch is reported or there is no missing touch, where the false touch is a touch whose position is more than D mm away from the reported position without noise injection. A typical value of D is accuracy + repeatability or 1.

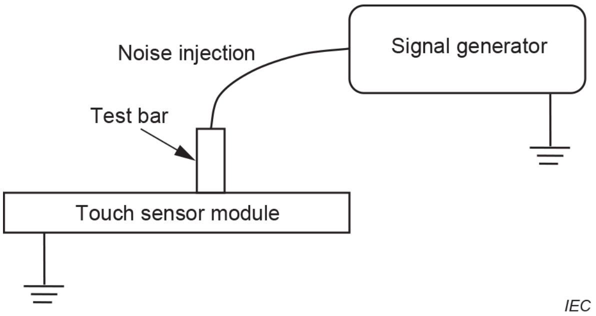


Figure 22 – External noise injection

5.9.3 Report

Plot the maximum tolerated amplitudes for Class A and Class B versus the injected frequency as shown in Figure 23.

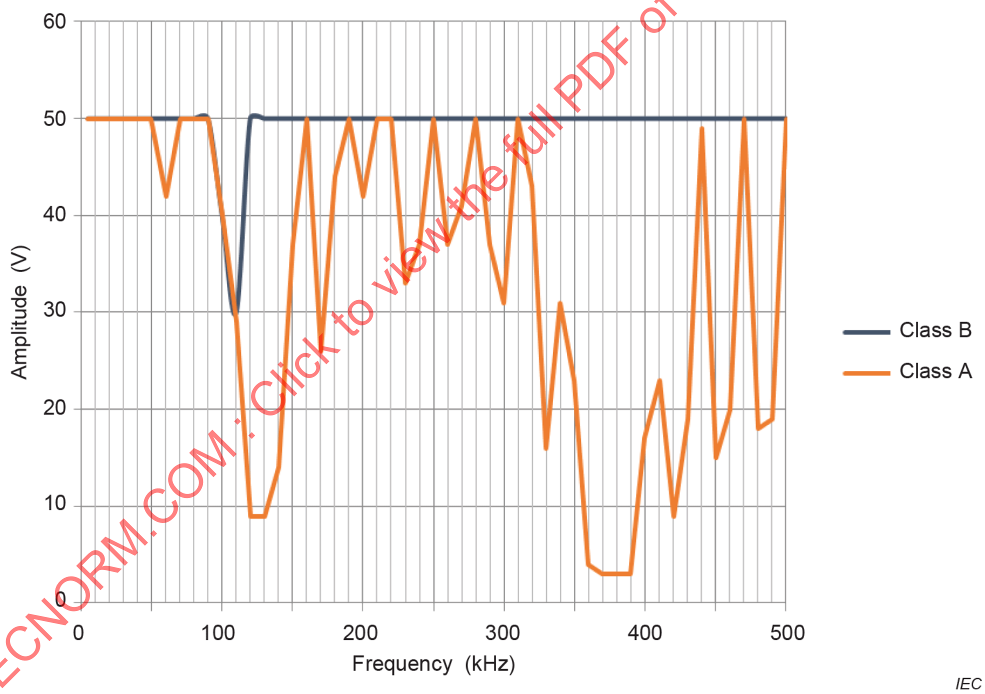


Figure 23 – Report of external noise immunity

5.10 Water droplet immunity test

5.10.1 Purpose

The purpose of this test is to indicate the tolerance of touch sensors and modules against any water droplet that couples into them (see Figure 24).

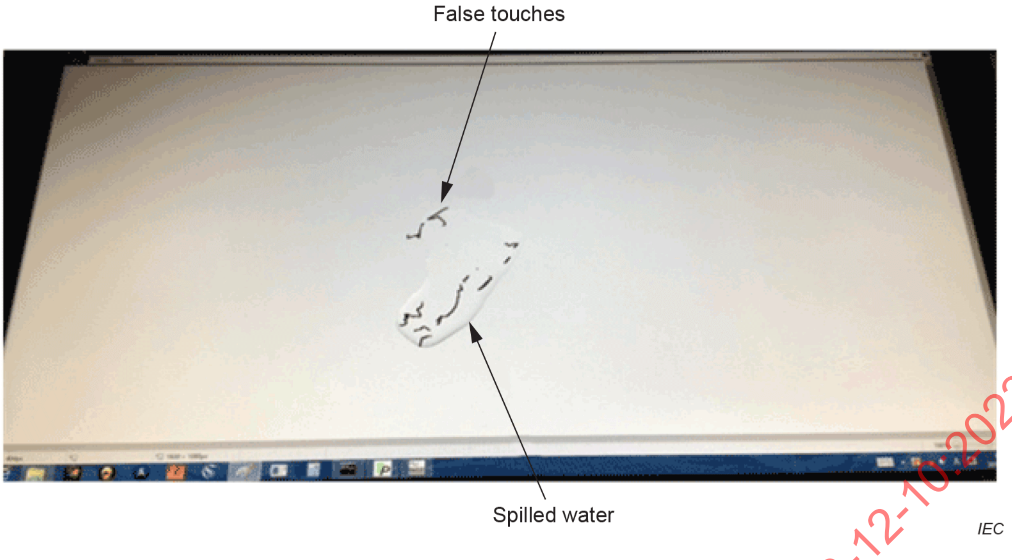


Figure 24 – Example of water drop effect

5.10.2 Test procedure

Drop water on the centre of the touch sensor with a small amount at a time while measuring the amount of spilled water. The conductivity of the water is to be larger than 5 mS/m, which typical potable water meets. Find the maximum amount of spilled water before erroneous touch events start to be generated (see Figure 25).

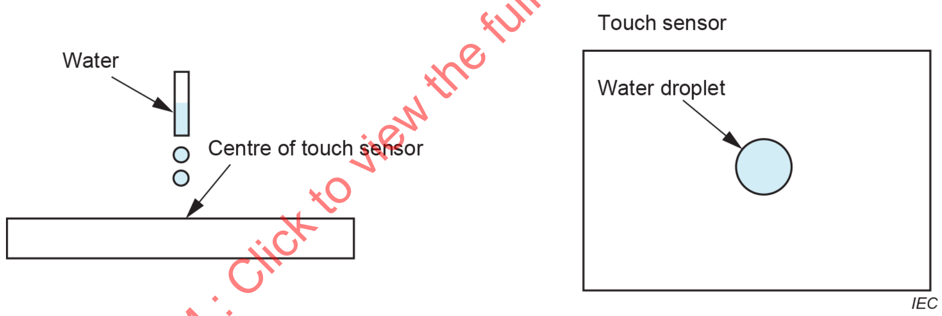


Figure 25 – Water droplet test procedure

5.10.3 Report

The maximum amount of water is reported prior to the generation of the first erroneous touch event.

5.11 Optical noise immunity test

5.11.1 Purpose

The purpose of this test is to indicate the tolerance of touch sensors and modules against the ambient optical environment, for example DC sources (such as ambient illumination from sunlight) and AC sources (such as fluorescent illumination, or other interfering sources such as remote controls) that couple into them. For example, ambient illumination can result in decreased sensitivity to real touch events or false events being reported.

5.11.2 Test procedure

The touch sensor module system under test shall be exposed to an optical noise source, whose properties (including position and angular emission distribution) will be reported with the results of the test. For example, for ambient light testing, illumination at a specified lux level and spectrum shall be directed at the touch system.

Examples of suitable illuminants include CIE Illuminant A (model incandescent source), Illuminant F (model fluorescent source), or a blackbody illuminant such as D55, D65 or D75.

The accuracy, repeatability and other tests described in this document can then be carried out under such increased ambient light conditions.

5.11.3 Report

According to the test carried out (accuracy, repeatability or other), along with the ambient light condition employed.

5.12 Power consumption test

5.12.1 Purpose

The purpose of this test is to measure the power consumption of the touch sensors and modules in each operation mode (for example, active mode with touch, active mode without touch, idle mode and sleep mode).

5.12.2 Test procedure

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The selected test bar shall be attached to the moving arm. While the central point of the touch sensor module is being touched, the current and voltage values from the touch controller shall be measured and the power consumption calculated. This procedure is repeated in idle mode and sleep mode (or other modes as appropriate).

5.12.3 Report

The measured power consumption in each measured mode, along with a description of the mode, shall be reported.

5.13 Perpendicular hover distance test

5.13.1 Purpose

The purpose of this test is to measure the maximum distance between the touch sensors and modules and the finger at which the touch controller reports a touch event and minimum distance, but not to report a touch event.

5.13.2 Test procedure

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The selected test bar shall be attached to the moving arm. After the touch is applied, the moving arm moves upward vertically away from the touch sensor module until the touch controller no longer reports the touch. When the touch controller does not report the touch event, the distance between the touch sensor module and test bar shall be measured. Likewise, the moving arm moves downward vertically towards the touch sensor module until the touch controller reports the touch event. When the touch controller starts to report the touch event, the distance between the touch sensor module and test bar shall be measured. The test shall be conducted with and without hover detection enabled, when available, and in both active and idle modes (see Figure 26).

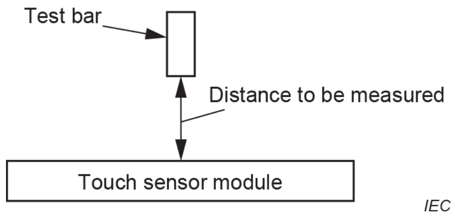


Figure 26 – Perpendicular hover distance measurement

5.13.3 Report

The maximum, median and minimum distance values corresponding to each target point, the direction, active or idle and hover feature enable or disable states and the selected size, shape and material of test bar shall be reported.

6 In-plane hovering performance measurement methods

6.1 General

Hovering performance measurement methods are described in Clause 6, especially in-plane characteristics at a constant distance from the touch sensor. They shall be applied during characterization of hovering performance to provide a good user experience for users who make non-contact input operations on the touch sensor. The distances from the touch sensor are specified by the supplier or determined based on the measurement results described in 5.13.

NOTE In the measurement methods of Clause 6, no data can be acquired when the touch technologies do not correspond to hovering.

6.2 Accuracy test

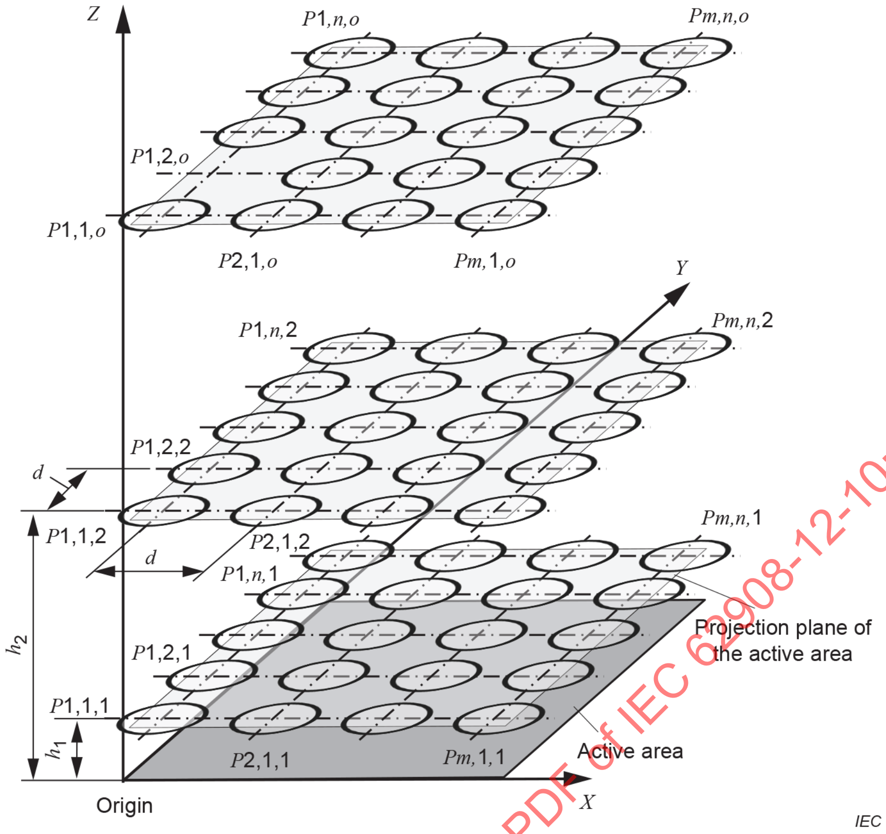
6.2.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate how close sensing positions are reported relative to their target positions for hovering.

6.2.2 Test procedure

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The active area is defined as the sensing area of the touch sensor module. The test bar of the selected diameter size, shape and material shall be attached to the moving arm. For a precise measurement of the accuracy, the test equipment should be set up properly. The measurement points in the test grid are evenly spaced along both X and Y axes, away from the origin and spanning the entire projection plane of the active area at a certain distance h from the outermost surface of the touch sensor module as shown in Figure 27. The test bar shall be placed at $m \times n$ target grid points equally spaced by a distance d in both horizontal (X-axis) and vertical (Y-axis) directions while keeping a certain distance h (Z-axis) from the outermost surface of the touch sensor module. The distance d shall be smaller than or equal to the diameter size of the test bar. At each target grid point (i, j, l), collect the reports 50 times to 100 times, keeping the test bar stationary at each target. Distances h are determined according to the application or purpose.

When the touch sensor module is a capacitive touch system, the effects of surrounding conductors shall be eliminated or compensated.



NOTE *m*, *n*, *o*: number of points in the *X*, *Y* and *Z* direction.

Figure 27 – Point grid

At each target grid point (i, j, l), lift the test bar down and up, and collect the reports p times. As shown in Figure 28 and Figure 29, the accuracies are defined as the distance between the target coordinate and the mean reported coordinate for the in-plane of the XY coordinates and Z coordinate, respectively.

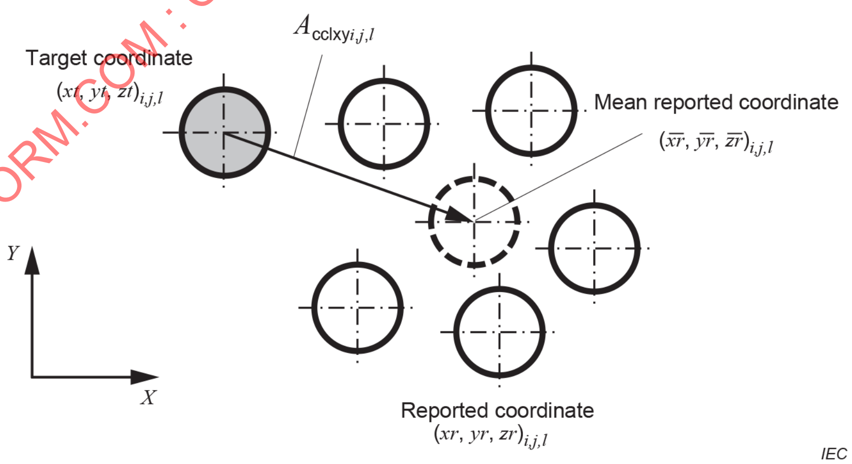


Figure 28 – Accuracy definition for in-plane of *XY* coordinates on the target projection plane (*l*) of the active area

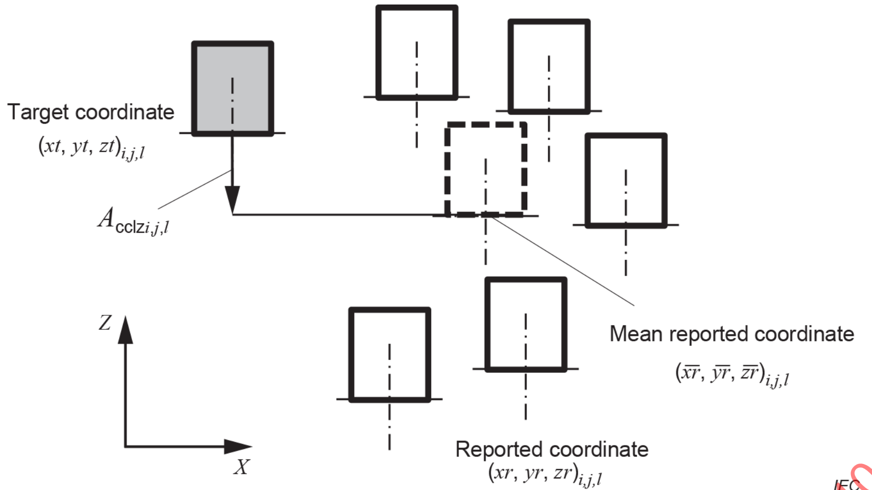


Figure 29 – Accuracy definition for *Z* coordinate on the target projection plane (*l*) of the active area

$$A_{\text{cclxymax}} = \max(A_{\text{cclxy}i,j,l}) \tag{35}$$

$$A_{\text{cclzmax}} = \max(A_{\text{cclz}i,j,l}) \tag{36}$$

$$A_{\text{cclxy}\sigma} = \sqrt{\frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(A_{\text{cclxy}i,j,l} - A_{\text{cclxymean}})^2}{q}} \tag{37}$$

$$A_{\text{cclz}\sigma} = \sqrt{\frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(A_{\text{cclz}i,j,l} - A_{\text{cclzmean}})^2}{q}} \tag{38}$$

$$A_{\text{cclxymean}} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(A_{\text{cclxy}i,j,l})}{q} \tag{39}$$

$$A_{\text{cclzmean}} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(A_{\text{cclz}i,j,l})}{q} \tag{40}$$

$$A_{\text{cclxy}i,j,l} = \sqrt{(\overline{xr}_{i,j,l} - xt_{i,j,l})^2 + (\overline{yr}_{i,j,l} - yt_{i,j,l})^2} \tag{41}$$

$$A_{\text{cclz}i,j,l} = \sqrt{(\overline{zr}_{i,j,l} - zt_{i,j,l})^2} \tag{42}$$

$$\overline{xr}_{i,j,l} = \frac{\sum_{k=1}^{p} xr_{i,j,l,k}}{p}, \quad \overline{yr}_{i,j,l} = \frac{\sum_{k=1}^{p} yr_{i,j,l,k}}{p}, \quad \overline{zr}_{i,j,l} = \frac{\sum_{k=1}^{p} zr_{i,j,l,k}}{p} \tag{43}$$

where

p is the number of reports at a target point (1,2,…);

q is the number of measurement points = $m \times n$;

i, j, l, k is the k-th data in number of reports (p) at a target point (i, j, l);

$A_{cclxy\,i,j,l}$ is the distance between the target coordinate and the mean reported coordinate of XY coordinates with respect to the projection plane (l) of the active area;

$A_{cclz\,i,j,l}$ is the distance between the target coordinate and the mean reported coordinate of the Z coordinate with respect to the projection plane (l) of the active area;

$A_{cclxymax}$ is the maximum of accuracy of the XY coordinates with respect to the projection plane (l) of the active area;

$A_{cclzmax}$ is the maximum of accuracy of the Z coordinate with respect to the projection plane (l) of the active area;

$A_{cclxy\sigma}$ is the standard deviation of accuracy of the XY coordinates with respect to the projection plane (l) of the active area;

$A_{cclz\sigma}$ is the standard deviation of accuracy of the Z coordinate with respect to the projection plane (l) of the active area;

$A_{cclxymean}$ is the average of accuracy of the XY coordinates with respect to the projection plane (l) of the active area; and

$A_{cclzmean}$ is the average of accuracy of the Z coordinate with respect to the projection plane (l) of the active area.

6.2.3 Report

The following items shall be reported:

– selected size, shape and material of the test bar;
– target position;
– number of measurements at each point;
– maximum of accuracy for the XY coordinates of all points in each area on the projection plane of the active area;
– maximum of accuracy for the Z coordinate of all points in each area on the projection plane of the active area;
– average of accuracy for the XY coordinates of all points in each area on the projection plane of the active area;
– average of accuracy for the Z coordinate of all points in each area on the projection plane of the active area;
– standard deviation of accuracy for the XY coordinates of all points in each area on the projection plane of the active area; and
– standard deviation of accuracy for the Z coordinate of all points in each area on the projection plane of the active area.

6.3 Repeatability or jitter test

6.3.1 Purpose

The purpose of this test is to measure the ability of touch sensors and modules to indicate how precisely positions are reported, given a sequence of hovering detects in the same target position, where "precise" means that the reported positions are "close to each other".

6.3.2 Test procedure

The repeatability is defined with the same reported data collected for accuracy measurement at target grid point (i, j, l) by lifting the test bar down and up for each report. The jitter is defined with the reported data collected by keeping the test bar stationary at target grid point (i, j, l). The repeatability measurement is applicable to the jitter measurement.

The touch sensor module under test shall be attached to the stage and connected to the electrical interface. The test bar of the selected diameter shall be attached to the moving arm.

When the touch sensor module is a capacitive touch system, the effects of surrounding conductors shall be eliminated or compensated.

At each target grid point (i, j, l), lift the test bar down and up, and collect the reports p times, As shown in Figure 30 and Figure 31, the repeatability is defined as the distance between the reported coordinate and the mean reported coordinate for the in-plane of the XY coordinates and Z coordinate, respectively.

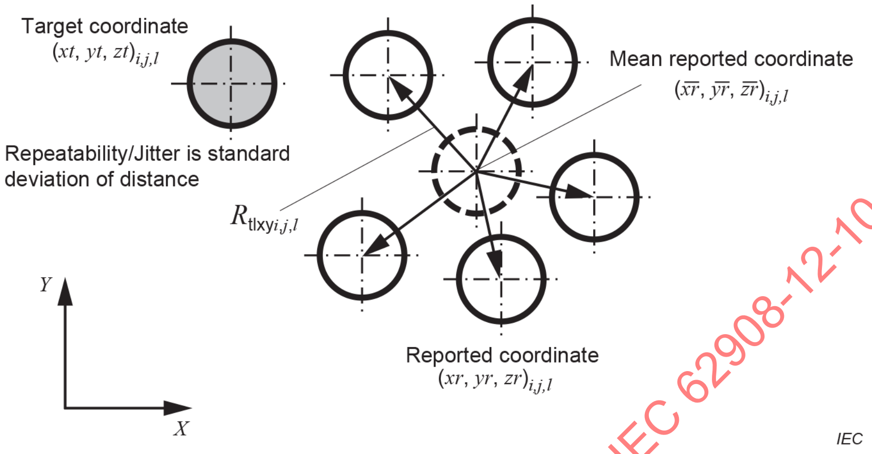


Figure 30 – Repeatability for in-plane of XY coordinates on the target projection plane (*l*) of the active area

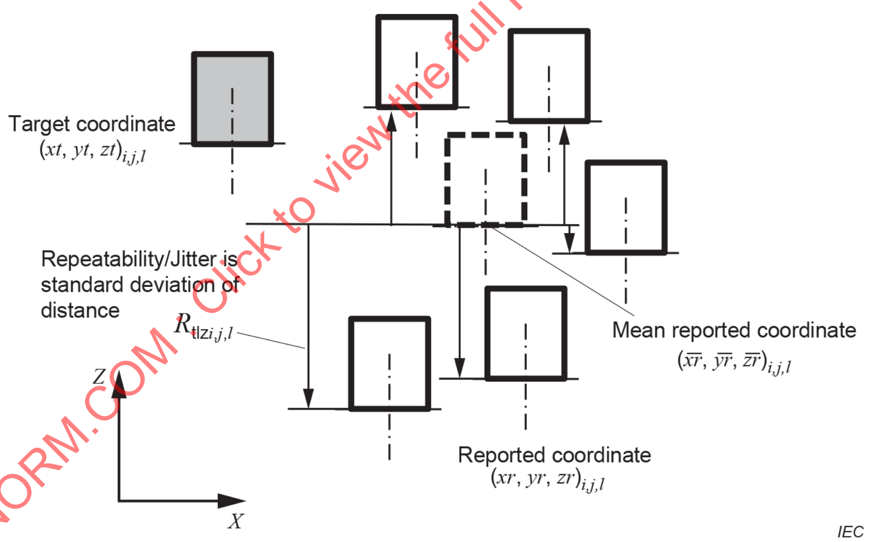


Figure 31 – Repeatability for Z coordinate on the target projection plane (*l*) of the active area

$$R_{\text{tlxymax}} = \max(R_{\text{tlxy}i,j,l}) \tag{44}$$

$$R_{\text{tlzmax}} = \max(R_{\text{tlz}i,j,l}) \tag{45}$$

$$R_{\text{tlxy}\sigma} = \sqrt{\frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(R_{\text{tlxy}i,j,l} - R_{\text{tlxymean}})^2}{q}} \tag{46}$$