
**Digital cameras — Measurement
method for image stabilization
performance —**

**Part 1:
Optical systems**

*Caméras numériques — Méthode de mesure de la performance de
stabilisation de l'image —*

Partie 1: Systèmes optiques



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee 42, *Photography*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The image stabilization function is important for digital cameras and has become a selling point in marketing materials. Therefore, the measurement methods and its reporting method are then very important to compare the image stabilization performance among cameras based on their brochures.

The Camera & Imaging Products Association (CIPA) issued CIPA standard DC-011 in 2012 to specify how to measure and describe the optical image stabilization performance of digital cameras. When image stabilization performance is measured and described according to this standard, end users have unbiased and useful information to help them select from a variety of digital cameras (see Bibliography).

This document is based on the CIPA standard, which is referenced in the Bibliography. The standardized measurement method primarily includes performance assessment with simulated handheld camera movements.

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Digital cameras — Measurement method for image stabilization performance —

Part 1: Optical systems

1 Scope

This document defines the measurement method of optical image stabilization performance for still images compensating for handheld blur consisting of two rotational components, yaw and pitch.

It applies to consumer digital cameras with optical image stabilization for still images. Apparatuses such as camcorders and mobile phones with still image shooting functionality are within the scope of this document.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

image stabilization

camera function that prevents handheld blur by using a means of camera movement detection

Note 1 to entry: Even if a camera function uses a means of camera movement detection, it is not regarded as an image stabilization function if its primary means of blur mitigation is shortening exposure time based on exposure control program optimization.

3.2

optical image stabilization

function that compensates for image displacement on the focal plane due to movement of a handheld camera by moving a part or whole of the optical system and/or image sensor, based on a means of camera movement detection

3.3

handheld blur

loss of image sharpness caused by movement of a handheld camera during exposure

3.4

stop

number that expresses a doubling or halving of the amount of light let in when taking a picture and which is typically represented by an exposure value

Note 1 to entry: For instance, the difference between exposure times of 1/1 000 s (TV10) and 1/500 s (TV9) or 1/125 s (TV7) and 1/60 s (TV6) is one stop.

Note 2 to entry: "TV n " expresses that time value of APEX equals to n . See Annex C of Reference [5] for APEX.

3.5 handheld blur threshold

level of handheld blur at which image stabilization performance is determined

Note 1 to entry: In this document, this level is 63 μm of motion in the focal plane on one frame of 35 mm film, where one frame means the picture size (24 mm $\times$ 36 mm).

3.6 average vibration angle

expected deflection angle of camera rotation under handheld vibration during exposure

Note 1 to entry: The handheld vibration is given as the vibration waveform data that is specified in document.

Note 2 to entry: The average vibration angles are given as amount of angle in degrees of each exposure time as shown in Figure 7. The values are statistical expectation and are calculated from average of oscillation amplitude from peak to bottom of the vibration waveform when certain exposure time is applied.

3.7 35 mm film equivalent focal length

focal length of a lens attached to a camera with a sensor size of 24 mm $\times$ 36 mm (originated from 35 mm film) that produces the same field of view as the camera system with a lens at a given focal length for which the 35 mm sensor equivalent focal length is specified

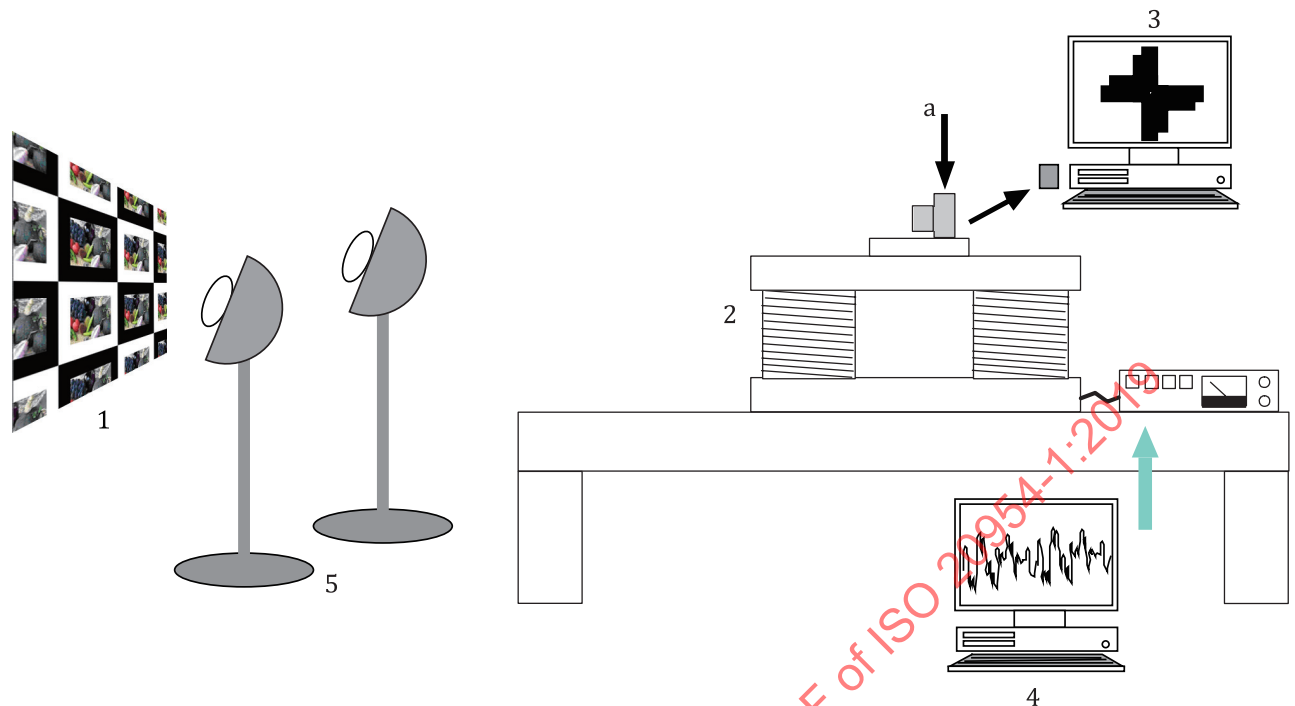
4 Measurement method

4.1 General

The objective of this document is to specify how to measure optical image stabilization performance of a camera held in the user's hands. Accordingly, a measurement session would better simulate a real shooting situation if the camera was actually held by a test photographer. However, this makes it difficult to eliminate variation among individual photographers or how well the camera is designed for handheld shooting. In order to cancel these effects, the test camera shall be mounted on a vibration generator that shakes the camera with a simulated handheld vibration waveform, and image stabilization performance shall be measured with images of a test chart specified by this document.

This document specifies two waveforms that simulate the important characteristics of how a camera shakes when it is held by hand. These waveforms were developed by analysing extensive measurement data and adding further theoretical observations.

Figure 1 shows an overview of the measurement method. Annex E collaterally gives additional explanations for background of specifying measurement method, vibration generator, vibration waveform and reference information.



Key

- 1 chart
- 2 vibration generator
- 3 pc for handheld blur measurement
- 4 vibration waveform
- 5 variable brightness
- a Release operation.

Figure 1 — Overview of measurement method

4.2 Equipment and environment for measurement

4.2.1 Test chart

For this document, the test chart shall meet following requirements. Specifications and usage of the test chart are described in [Annex B](#) and alternatives are described in [Annex C](#).

- a) The chart shall contain orthogonal edges consisting of a dark portion and a bright portion near the centre.
- b) The contrast ratio of the dark portion to the bright portion shall be 1:4 or more.
- c) The dark and bright portions shall be wide enough to accommodate the total image degradation which is described in [4.4.1](#), when the image stabilization (IS) function is OFF within the exposure time range for measuring the image stabilization performance.

4.2.2 Lighting

Lighting shall be flicker-free. The light source should illuminate the chart with minimal direct reflection and illuminance variation.

4.2.3 Temperature and humidity

The temperature and humidity should be $(23 \pm 2) ^\circ\text{C}$ and 30 % to 70 %, respectively.

4.2.4 Vibration generator

4.2.4.1 General

For the measurements in this document, a CIPA-certified vibration generator should be used. If a non-certified vibration generator is used, it shall satisfy the amplitude and phase characteristics under the excitation conditions specified in [4.2.4.2](#).

4.2.4.2 Excitation conditions

This subclause describes the required specifications for the amplitude and phase characteristics of the vibrations generated by the vibration generator excited with sine waves. [Table 1](#) shows the properties of the sine waves that shall be used to measure the amplitude and phase characteristics. [Table 2](#) and [3](#) respectively show the input sine wave combinations that shall be used to measure the vibration amplitude characteristics and phase characteristics. To measure the amplitude and phase characteristics, the vibration generator shall be excited in both yaw and pitch directions simultaneously, carrying a load weighing at least as much as the test objects, i.e. camera, storage media, battery and lens. [Figure 2](#) is an overview of how to verify the vibration generator using these waveforms.

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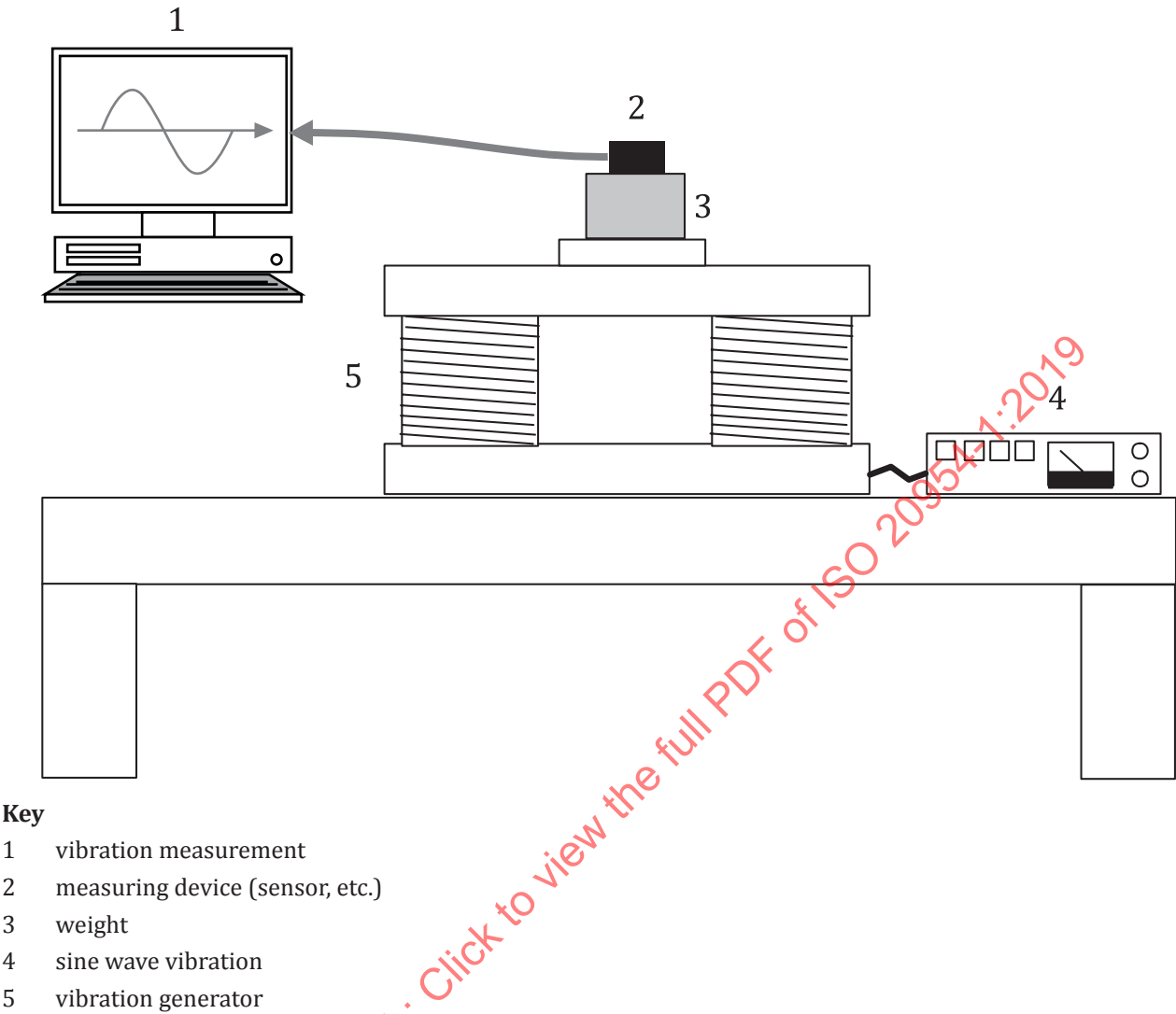


Figure 2 — Overview of vibration generator verification scheme

Table 1 — Combinations of sine wave frequency and amplitude for vibration generator verification

	Frequency (Hz)	Amplitude (degree)
a	0,1	2
b	0,5	2
c	1	1
d	5	0,2
e	10	0,1

Table 2 — Yaw and pitch combinations (for amplitude characteristic evaluation)

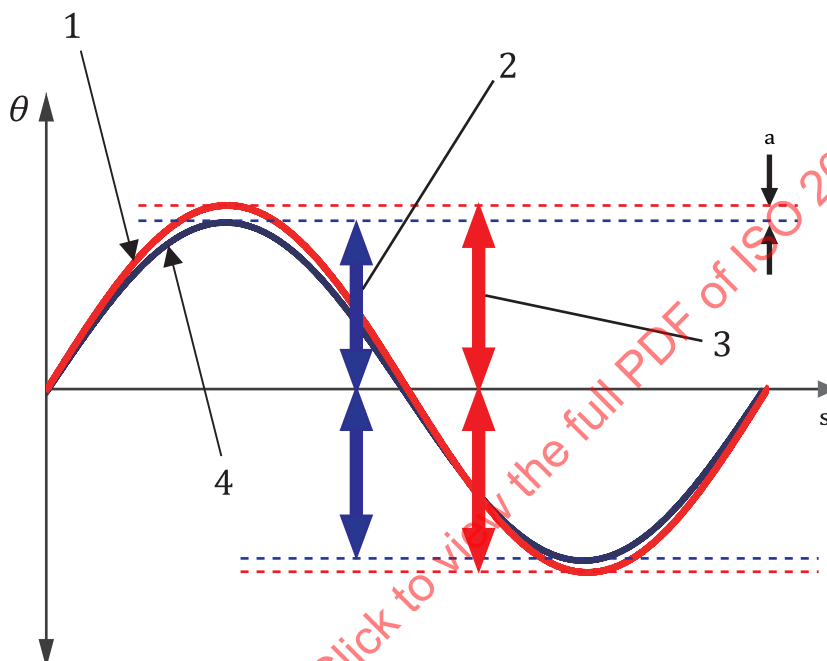
	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5
Yaw	a	b	c	d	e
Pitch	c	d	e	a	b

Table 3 — Yaw and pitch combinations (for phase characteristic evaluation)

	Pattern 6	Pattern 7
Yaw	c	d
Pitch	d	c

4.2.4.3 Amplitude characteristics

The amplitude of the measured vibration from the vibration generator shall be within $\pm 5\%$, inclusive, of the amplitude of the input sine wave for all excitation conditions, Patterns 1 through 5, shown in [Table 2](#). See [Figure 3](#).



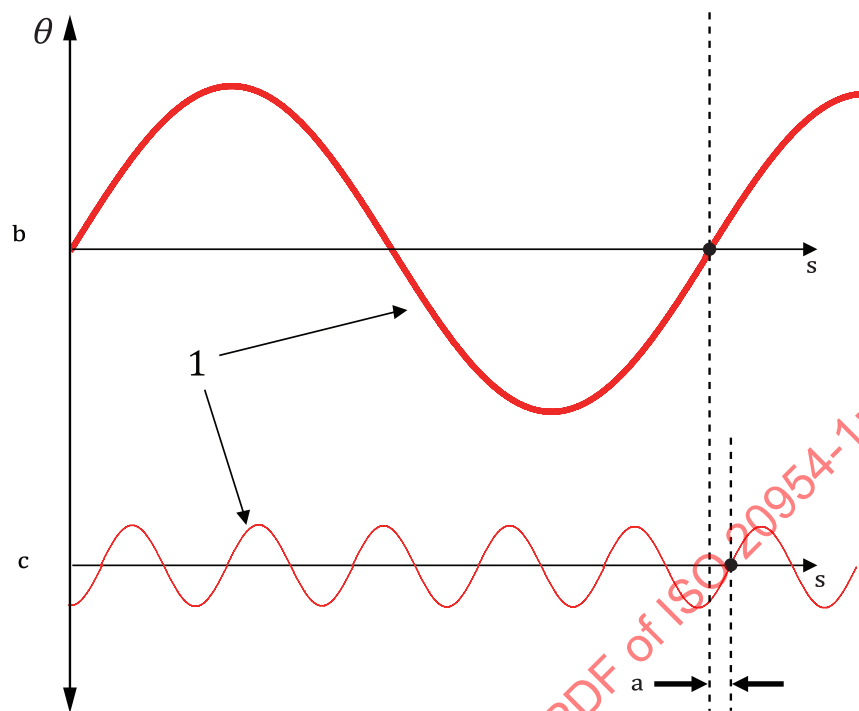
Key

- 1 measured vibration form vibration generator
- 2 amplitude of input sine wave
- 3 amplitude of measured vibration of vibration generator
- 4 input sine wave
- ^a Difference in amplitude values.

Figure 3 — Illustration of amplitude differences

4.2.4.4 Phase characteristics

The phase difference between the measured yaw and pitch vibrations shall be 90° or less when the vibration generator is excited by both Patterns 6 and 7 in [Table 3](#). See [Figure 4](#). The phase difference between the zero cross position of the low frequency waveform and the zero cross position of the high frequency waveform shall be within 90° of high frequency waveform.

**Key**

- 1 measured vibration form vibration generator
- a Phase difference.
- b Yaw or pitch.
- c Pitch or yaw.

Figure 4 — Illustration of phase differences

4.2.5 Vibration waveform

There are two types of vibration waveforms that shall be used to verify optical image stabilization performance: WB-L and WB-H defined in [Annex A](#). One or both shall be used based on the total mass of the test camera according to the following criteria. Total mass refers to the camera body, including storage media and battery, and lens.

- Selection criterion I: WB-H shall be used for a total mass of 600 g or more.
- Selection criterion II: WB-L shall be used for a total mass of less than 400 g.
- Selection criterion III: Both WB-L and WB-H shall be used for a total mass of 400 g or more but less than 600 g.

Both waveforms consist of two axis components: yaw and pitch. Both yaw and pitch components shall be excited at the same time (see [Annex A](#)).

4.2.6 Shooting distance

The shooting distance should be about 20 times the 35 mm film equivalent focal length.

If the space does not allow this shooting distance, the distance may be changed to the maximum amount available. But even when in this case, in order to avoid significant shifts orthogonal to the optical axis, it is desirable that the shooting distance is as close to 20 times the 35 mm film equivalent focal length as possible.

4.3 Settings of camera to be measured

4.3.1 Shooting mode

- a) The mode with the shortest latency time should be used because shooting shall begin as soon as possible after the camera is turned on. (The shooting modes should retain as many of the settings in 4.3.2 to 4.3.12 as possible after the camera is turned off. It is also convenient to use a mode that allow for easy changing of the exposure time.) For cameras without the capability of changing exposure time, the factory shipping setting should be used.
- b) No mode that applies extreme edge enhancement to images shall be used because such modes influence the amount of image degradation measured. Typically, these are modes optimized for specific scenes.

4.3.2 Optical image stabilization mode

When a purpose of the measurement is a “nominal value” which is mentioned and required in 5.2, the factory shipping setting should be used for the optical image stabilization mode.

4.3.3 Image quality mode (compression ratio)

Although no specific compression ratio is specified, a high image quality mode setting with low compression ratio should be used.

4.3.4 Image quality mode (number of recorded pixels)

The maximum number of recorded pixels available for the camera should be set. However, settings that use more pixels than the number of effective pixels of the image sensor by pixel interpolation, image processing, or other means shall not be used.

4.3.5 Sensitivity

The sensitivity should be set to a constant value with minimal image noise.

4.3.6 Flash

Flash shall not be used.

4.3.7 Electronic (digital) zoom

Electronic (digital) zoom shall not be used.

4.3.8 Focus control

A focus control method that allows the camera to focus on the test chart shall be used.

4.3.9 White balance

The white balance shall be adjusted in accordance with light source.

4.3.10 Exposure

The exposure shall be such that there is no colour channel containing areas where detail is lost due to pixel saturation or clipping in the image.

4.3.11 Aperture

The aperture shall be kept constant if possible when shooting at the same focal length and exposure time.

4.3.12 Aspect ratio

The factory shipping setting should be used.

4.4 Measurement procedures

4.4.1 Brief description of the procedures

Two quantities, measured handheld blur amount and reference handheld blur amount, shall be compared to quantify optical image stabilization performance. To obtain these values, four additional quantities are used: intrinsic image degradation amount, total image degradation amount, reference image degradation amount, and theoretical handheld blur amount. These terms are used uniquely as variables in the calculation procedure in this document and explained hereinafter. [Table 4](#) gives symbols and units of the values.

Intrinsic image degradation amount is loss of image sharpness caused by factors unique to the camera, such as optical performance, effective number of pixels, and image processing. It does not include handheld blur. When measuring optical image stabilization performance, subtracting intrinsic image degradation amount excludes most of the effects of camera elements that are not part of the image stabilization function. See [4.5.1 a\)](#).

Total image degradation amount is the measured amount of loss of sharpness of an image taken by a test camera excited with a vibration waveform while the image stabilization function is enabled. See [4.5.1 d\)](#).

Reference image degradation amount is the expected amount of loss of sharpness in an image taken by a test camera excited with a vibration waveform while the image stabilization function is disabled. This value is the square root of the sum of the squares of intrinsic image degradation amount and theoretical handheld blur amount. See [4.5.1 c\)](#).

Theoretical handheld blur amount is the theoretically calculated amount of handheld blur that would be measured from an image taken by a test camera excited with a vibration waveform while the image stabilization function is disabled. See [4.5.1 b\)](#).

Measured handheld blur amount is the amount of handheld blur that remains uncompensated after enabling the image stabilization function of the camera. This value is calculated by subtracting intrinsic image degradation amount from the total image degradation amount. See [4.5.1 f\)](#).

Reference handheld blur amount is the baseline value against which to compare measured handheld blur amount to determine optical image stabilization performance. This value is calculated by subtracting intrinsic image degradation amount from reference image degradation amount, and represent the handheld blur with the image stabilization function disabled. See [4.5.1 e\)](#).

Table 4 — Symbols and unit

Symbol	Meaning	Unit	Specified in
t_E	Exposure time	s	ISO 516
$D_{\text{intrinsic}}(t_E)$	intrinsic image degradation amount	μm	4.4.3 , 4.5.1
$D_{\text{total}}(t_E)$	total image degradation amount	μm	4.4.4 , 4.4.5 , 4.5.1
$D_{\text{reference}}(t_E)$	reference image degradation amount	μm	4.5.1
$B_{\text{theoretical}}(t_E)$	theoretical handheld blur amount	μm	4.5.1
$B_{\text{reference}}(t_E)$	reference handheld blur amount	μm	4.5.1
$B_{\text{measured}}(t_E)$	measured handheld blur amount	μm	4.5.1
$\theta(t_E)$	average vibration angle	degree	3.6
$K_{\text{threshold}}$	handheld blur threshold	μm	3.5
P_{optical}	optical image stabilization performance	stop	4.5.3

Table 4 (continued)

Symbol	Meaning	Unit	Specified in
f_{35}	35 mm film equivalent focal length	mm	4.5.1
$D_{\text{intrinsic,pixel}}(t_E)$	intrinsic image degradation amount	pixel	4.5.2
$D_{\text{total,pixel}}(t_E)$	measured image degradation amount	pixel	4.5.2
$N_{\text{diagonal,35}}$	diagonal length of one Frame of 35 mm Film	μm	4.5.2
$N_{\text{diagonal,pixel}}$	diagonal length of the captured Image	pixel	4.5.2
$N_{\text{vertical,pixel}}$	the number of recorded pixels in vertical direction	pixel	4.5.2
$N_{\text{horizontal,pixel}}$	the number of recorded pixels in horizontal direction	pixel	4.5.2

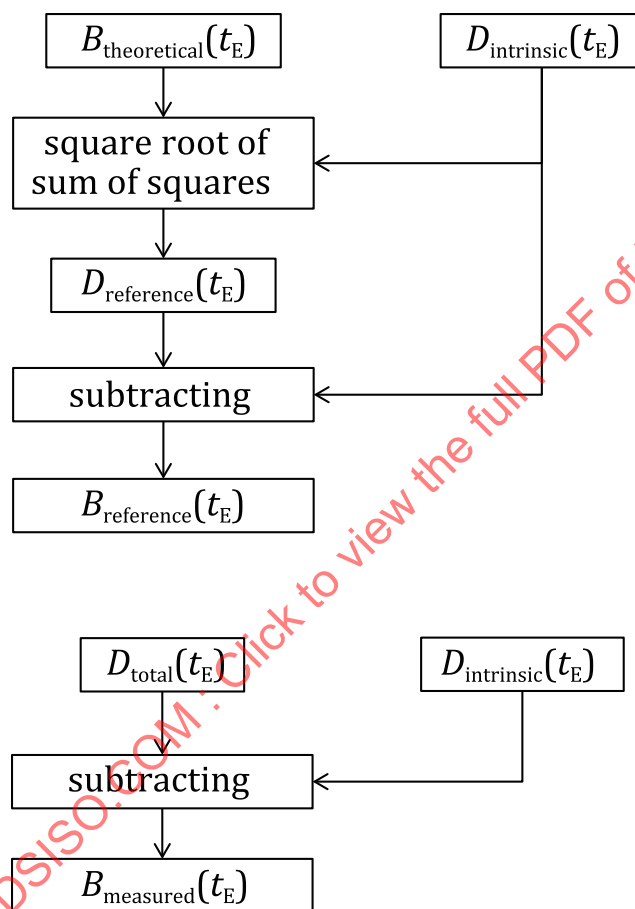


Figure 5 — Calculation flow

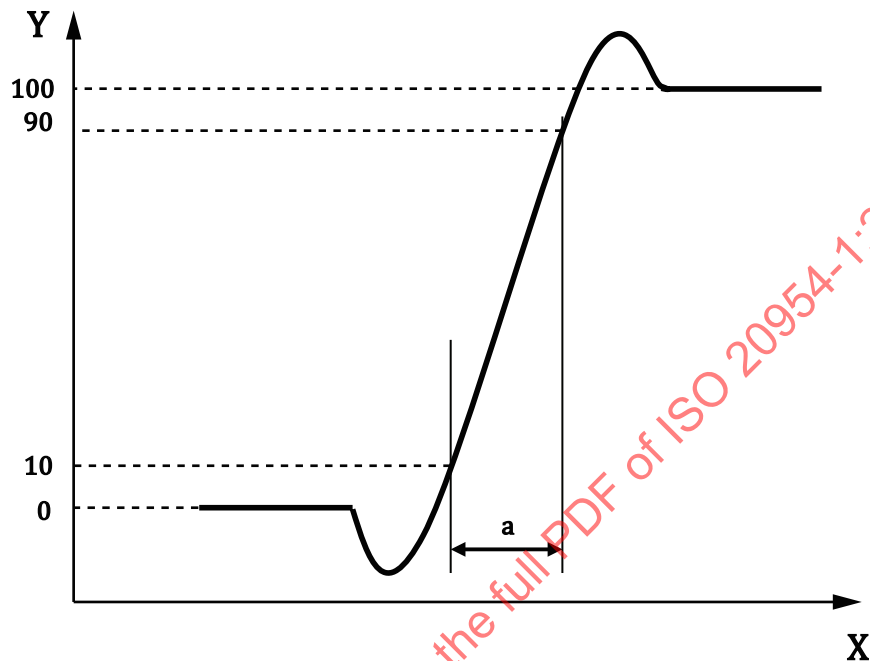
4.4.2 Calculating value from captured image

Analysing captured image yields the intrinsic image degradation amount and total image degradation amount. This section describes the calculation steps from captured image.

The intrinsic image degradation amount and measured total image degradation amount shall be measured in accordance with the following:

- The image shall be inverse gamma corrected (typically $\gamma = 2,2$, but some variation may occur) in order to linearize the tone reproduction as much as possible;
- For stable measurements, multiple points on the boundary of the black and white portions near the centre of the chart image shall be selected, and the measured results from c) shall be averaged over them; and

- c) The signal levels at the central points on the boundary between the black and white portions of the captured image of the chart shall be normalized from 0 % to 100 %. In this regard, the black level as 0 % and the white level as 100 % shall be assessed from stable and flat portion that is not affected by undershoot or overshoot due to edge enhancement processing as shown in [Figure 6](#). The number of pixels in the section between 10 % to 90 % of the signal level (see A in [Figure 6](#)) shall be calculated and then multiplied by 10/8.



Key

X pixel

Y signal level, expressed in percent

a The number of pixels in the section between 10 % to 90 % of signal levels.

Figure 6 — Measuring blur

4.4.3 Measurement of intrinsic image degradation amount

- Mount a camera to be measured on the vibration generator.
- Turn on the camera. Adjust the shooting distance by adjusting the position of the camera and/or the test chart.
- Set the camera and the lighting for a desired exposure time.
- Take at least 10 images with the vibration generator off. There is no specified upper limit to the number of images, but all images shall be used without selection. Optical image stabilization should be turned off. A remote release button or remote control should be used when possible.
- Reduce the exposure time sequentially by at most one stop at a time. Shoot at least 10 images for each exposure time. Continue shooting until data is collected within the necessary exposure time range. When shooting at different exposure times, measurement conditions other than the lighting should not be changed.

The shooting environment and camera settings in [4.4.3](#) should generally not be changed in the measurement of total image degradation amount of [4.4.4](#) and [4.4.5](#).

4.4.4 Measurement of total image degradation amount (for selection criteria I and II in 4.2.5)

- a) Mount the camera to be measured on the vibration generator. Oscillated movements of the vibration generator and the whole test camera shall be the same. When measuring a camera with a long-barrel lens (e.g. high-powered zoom lens), the vibrations of the camera body and the lens might not match due to lens deflection of the lens barrel. In this case both the lens and the body shall be fixed to the vibration generator respectively so that the vibrations of the camera and the lens match. The verification of synchronization between the vibration generator and the camera shall be executed. An example of verification method and its criteria are given in [Annex D](#).
- b) Turn on the camera. Set the exposure time so that the measured handheld blur amount is at or around the handheld blur threshold for determining optical image stabilization performance mentioned in 4.5.3. After the setting is completed, turn off the camera.
- c) Excite the vibration generator using one of the vibration waveforms in 4.2.5. The vibration generator should be continuously excited until h) below is completed.
- d) While the generator is vibrating, turn on the camera to be measured. If the settings from b) have changed, reset them as soon as possible.
- e) Turn on the camera's optical image stabilization and start shooting immediately. Shoot at approximately 1 s intervals for a total of 10 shots. However, finish shooting 30 s after turning on the camera even if 10 shots have not been taken. If shooting at 1 s intervals or acquiring a total of 10 images is not possible, these numbers may be changed. Turn off the camera afterward (see NOTE 1). Each shooting timing and intervals shall be performed at different position of the waveform (see NOTE 2). The shooting operation shall not affect the vibrating state. A remote release button or a remote control should be used when possible.

NOTE 1 The use case assumed in this document is the typical one that the user turns on the camera power, shoots about 10 images immediately and then turns off the power subsequently. In such a use case, there are cameras whose image stabilization performance varies depending on the time from the turning on/off the power supply. Therefore, unless the procedure for turning on/off the power supply of the camera is monitored and controlled, a difference can occur in the measurement result.

NOTE 2 If shooting timing is performed every time at the same position of the waveform, there is a possibility that the measurement result is biased.

- f) Repeat d) and e) and take 200 or more shots. There is no upper limit to the shooting count, but all images shall be used without selecting only the favourable ones.
- g) Reduce or increase the exposure time by at most one stop at a time and repeat Steps b) to f) above. When shooting at different exposure times, measurement conditions other than lighting should not be changed.
- h) Finish the measurement when the following two measurement results are obtained: the longest exposure time at which the measured handheld blur amount does not exceed the handheld blur threshold for determining optical image stabilization performance, and the shortest exposure time at which it exceeds the said threshold.

4.4.5 Measurement of total image degradation amount (for selection criterion III in 4.2.5)

- a) Mount the camera to be measured on the vibration generator. Oscillated movements of the vibration generator and the whole test camera shall be the same. When measuring a camera with a long-barrel lens (e.g. high-powered zoom lens), the vibrations of the camera body and the lens might not match due to lens deflection of the lens barrel. In this case both the lens and the body shall be fixed to the vibration generator respectively so that the vibrations of the camera and the lens match. The verification of synchronization between the vibration generator and the camera shall be executed. An example of verification method and its criteria are given in [Annex D](#).

- b) Turn on the camera. Set the exposure time so that the measured handheld blur amount is at or around the handheld blur threshold for determining optical image stabilization performance mentioned in 4.5.3. After the setting is completed, turn off the camera.
- c) Excite the vibration generator using one of the vibration waveforms in 4.2.5. The vibration generator should be continuously excited until h) below is completed.
- d) While the generator is vibrating, turn on the camera to be measured. If the settings from b) have changed, reset them as soon as possible.
- e) Turn on the camera's optical image stabilization and start shooting immediately. Shoot at approximately 1 s intervals for a total of 10 shots. However, finish shooting 30 s after turning on the camera even if 10 shots have not been taken. If shooting at 1 s intervals or acquiring a total of 10 images is not possible, these numbers may be changed. Turn off the camera afterward (see NOTE 1). Each shooting timing and intervals shall be performed at different position of the waveforms (see NOTE 2). The shooting operation shall not affect the vibrating state. A remote release button or a remote control should be used when possible.

NOTE 1 The use case assumed in this document is the typical one that the user turns on the camera power, shoots about 10 images immediately and then turns off the power subsequently. In such a use case, there are cameras whose image stabilization performance varies depending on the time from the turning on/off the power supply. Therefore, unless the procedure for turning on/off the power supply of the camera is monitored and controlled, a difference can occur in the measurement result.

NOTE 2 If shooting timing is performed every time at the same position of the waveforms, there is a possibility that the measurement result is biased.

- f) Repeat d) and e) using both kinds of waveforms and take 100 or more shots for each waveform. There is no specified upper limit for the shooting count, but all images shall be used without selection.
- g) Reduce or increase the exposure time by at most one stop at a time and repeat b) to f) above. When shooting at differing exposure times, measurement conditions other than the lighting should not be changed.
- h) Finish the measurement when the following two measurement results are obtained: the longest exposure time at which the measured handheld blur amount does not exceed the handheld blur threshold for determining optical image stabilization performance, and the shortest exposure time at which it exceeds the said threshold.

4.5 Calculation of optical image stabilization performance

4.5.1 Calculation of basic values

The six quantitative values are used to calculate optical image stabilization performance: intrinsic image degradation amount, theoretical handheld blur amount, reference image degradation amount, measured image degradation amount, reference handheld blur amount, and measured handheld blur amount.

The main objectives of these values are as follows:

- Remove the effects of factors other than camera shake from the total image degradation amount measured in 4.4.4 and 4.4.5.
- Enable the calculation of optical image stabilization performance even for cameras incapable of turning off the optical image stabilization function.

Methods of calculating these values are shown below.

a) Intrinsic image degradation amount

For each image captured according to the method in 4.4.3, calculate the square root of the sum of the squares of the yaw and pitch of the intrinsic image degradation amounts, and then average the total over all of the images of each exposure time. If the averaged intrinsic image degradation amount is in pixels, convert it into a 35 mm film equivalent amount in micrometres (μm) according to the method in 4.5.2 below. Use at least 10 values in calculating the average.

b) Theoretical handheld blur amount

Calculate theoretical handheld blur amount for each exposure time using Formula (1). Because the average vibration angles differ among selection criteria I, II and III in 4.2.6, use the value associated with the vibration waveform used in the measurement. See Figure 7 and 8.

$$B_{\text{theoretical}}(t_E) = f_{35} \times \tan(\theta(t_E)) \times 1\,000 \quad (1)$$

c) Reference image degradation amount

Calculate reference image degradation amount using Formula (2). Intrinsic image degradation amount and theoretical handheld blur amount measured at the same exposure time shall be used in this equation. See Figure 5 and 9.

$$D_{\text{reference}}(t_E) = \sqrt{D_{\text{intrinsic}}(t_E)^2 + B_{\text{theoretical}}(t_E)^2} \quad (2)$$

d) Total image degradation amount

For each image captured according to the methods in 4.4.4 and 4.4.5, calculate the square root of the sum of the squares of the yaw and pitch of the total image degradation amounts, and then average the total over all of the images of each exposure time. If the averaged measured image degradation amount is in pixels, convert it into the 35 mm film equivalent amount in micrometres (μm) according to the method in 4.5.2 below. Use at least 200 values to calculate the averages for 4.4.4, and at least 100 values for each case in 4.4.5. In the latter case, the same number of values shall be averaged in each case.

e) Reference handheld blur amount

Calculate reference handheld blur amount using Formula (3). Reference image degradation amount and intrinsic image degradation amount that were measured at the same exposure time shall be used in this calculation. Factors that might affect images taken, such as sensitivity, should be identical. See Figure 5.

$$B_{\text{reference}}(t_E) = D_{\text{reference}}(t_E) - D_{\text{intrinsic}}(t_E) \quad (3)$$

f) Measured handheld blur amount

Calculate measured handheld blur amount using Formula (4). Total image degradation amount and intrinsic image degradation amount that were measured at the same exposure time shall be used in this calculation. Factors that might affect images taken, such as sensitivity, should be identical. If the measured handheld blur amount is a negative value, set the value to 0 μm . See Figure 5 and 10.

$$B_{\text{measured}}(t_E) = D_{\text{total}}(t_E) - D_{\text{intrinsic}}(t_E) \quad (4)$$

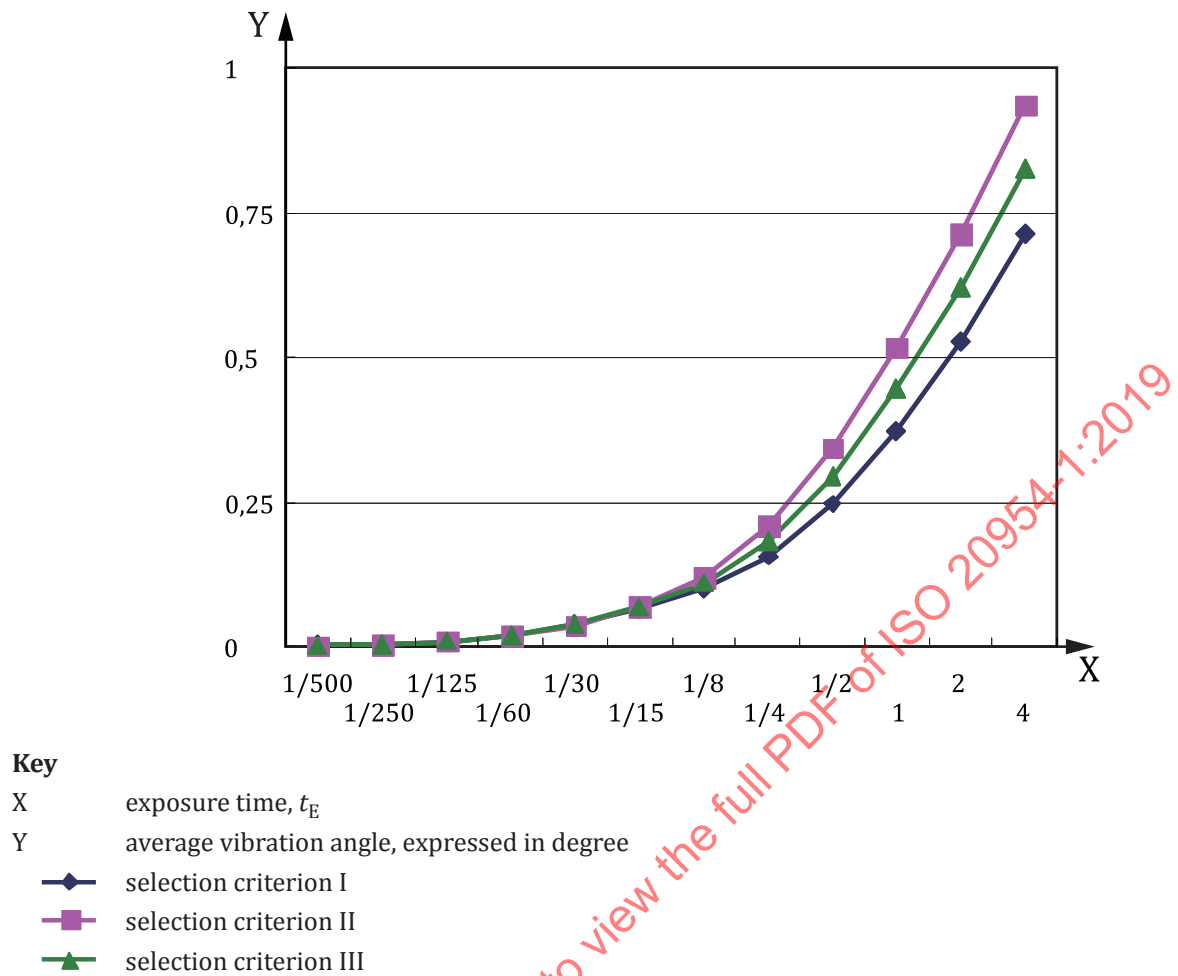


Figure 7 — Average vibration angle

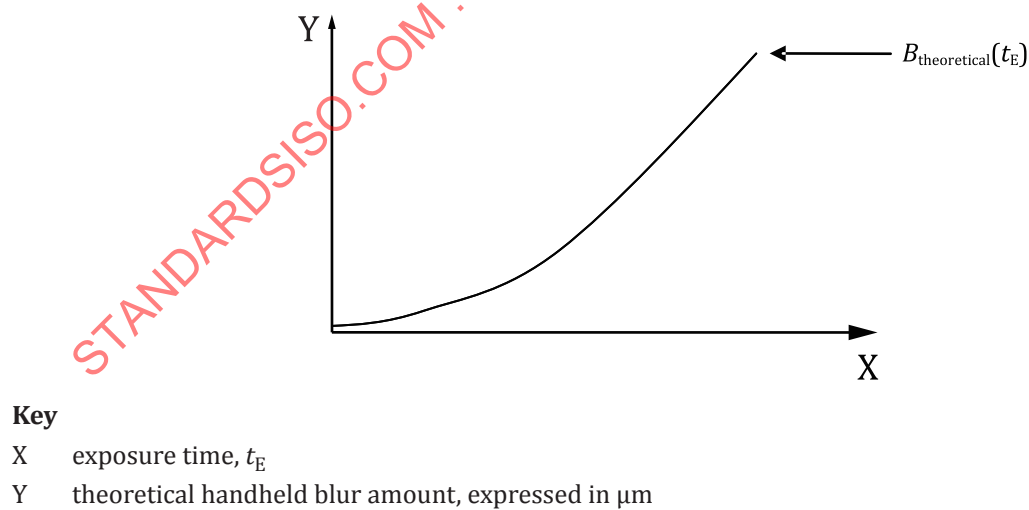
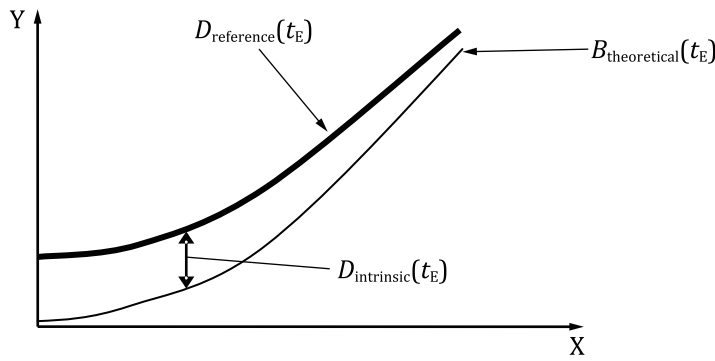


Figure 8 — Theoretical handheld blur amount

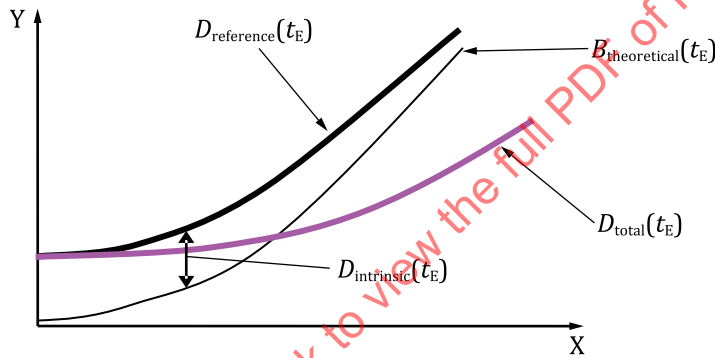


Key

X exposure time, t_E

Y theoretical handheld blur amount or reference image degradation amount, expressed in μm

Figure 9 — Reference image degradation amount



Key

X exposure time, t_E

Y theoretical handheld blur amount, reference image degradation amount or total image degradation amount, expressed in μm

Figure 10 — Measured image degradation amount

4.5.2 Method of converting intrinsic image degradation amount and measured image degradation amount into 35 mm film equivalent values

In order to determine optical image stabilization performance, the measured intrinsic and total image degradation amounts shall be converted into 35 mm film equivalent values in micrometre (μm) using [Formulae \(5\)](#) and [\(6\)](#).

$$D_{\text{intrinsic}}(t_E) = \frac{D_{\text{intrinsic,pixel}}(t_E) \times N_{\text{diagonal,35}}}{N_{\text{diagonal,pixel}}} \quad (5)$$

$$D_{\text{total}}(t_E) = \frac{D_{\text{total,pixel}}(t_E) \times N_{\text{diagonal,35}}}{N_{\text{diagonal,pixel}}} \quad (6)$$

a) Diagonal length of one frame of 35 mm film

One frame of 35 mm film is 24 mm in the vertical direction, and 36 mm in the horizontal direction. Accordingly, the diagonal length is the square root of the sum of the squares of 24 and 36.

b) Diagonal length of image

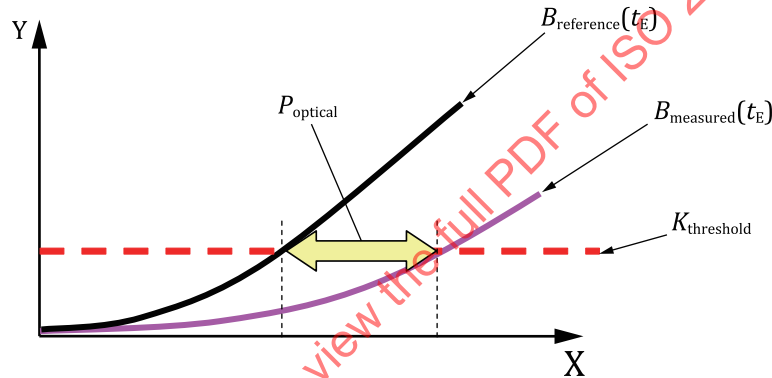
Calculate the diagonal length of the Image (in pixels) as in [Formula \(7\)](#):

$$N_{\text{diagonal,pixel}} = \sqrt{N_{\text{vertical,pixel}}^2 + N_{\text{horizontal,pixel}}^2} \quad (7)$$

4.5.3 Calculation of optical image stabilization performance

Calculate the optical image stabilization performance (see [Figure 11](#)) using the reference handheld blur amount and measured handheld blur amount calculated in [4.5.1](#). In this method, the difference between exposure times where both reference handheld blur amount and measured handheld blur amount are at the handheld blur threshold respectively is calculated in terms of the number of stops with 0,5 increments. Fractions less than 0,5 stop are dropped.

The exposure time to be calculated shall be in actual value. For example, although the exposure time is set to 1/1 000, actual exposure time is 1/1 024 which equals to the reciprocal of 2 to the power of 10.



Key

X exposure time, t_E

Y reference handheld blur amount or measured handheld blur amount, expressed in μm

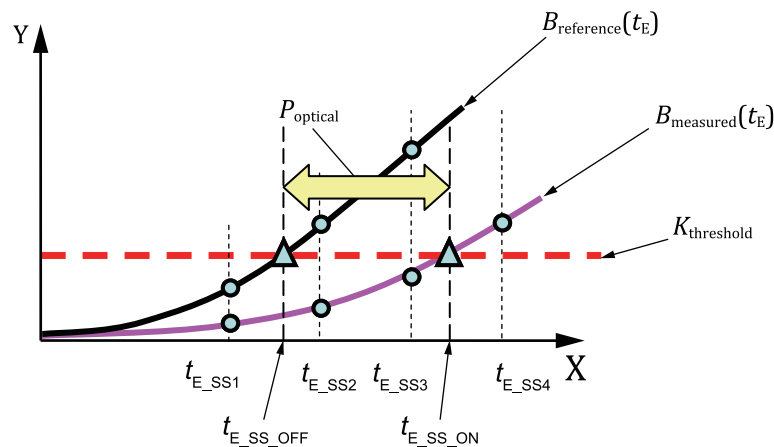
Figure 11 — Optical image stabilization performance

Both the reference and measured handheld blur amounts are sampled at discrete exposure times with intervals of one stop at most. Accordingly, calculation of the difference in exposure times shall be done using interpolation.

Using [Figure 12](#) as an example, $t_{E_SS_OFF}$, the exposure time at which the reference handheld blur amount equals the handheld blur threshold, is calculated by drawing a line connecting the two points on the reference blur amount curve corresponding to t_{E_SS1} and t_{E_SS2} and determining the exposure time at the intercept of this line and the threshold by linear interpolation on the log scale.

Likewise, $t_{E_SS_ON}$, at where the measured handheld blur amount equals the handheld blur threshold for determining optical image stabilization performance, is calculated by drawing a line connecting the two points on the measured handheld blur amount curve corresponding to t_{E_SS3} and t_{E_SS4} and determining the exposure time at the intercept of this line and the threshold by linear interpolation on the log scale.

The difference between $t_{E_SS_OFF}$ and $t_{E_SS_ON}$ is the number of stops indicating the optical image stabilization performance.

**Key**X exposure time, t_E Y reference handheld blur amount or measured handheld blur amount, expressed in μm **Figure 12 — Optical image stabilization performance calculation method****5 Presentation of results****5.1 Common requirements**

Abridged reporting of the capture conditions is acceptable and often preferable for a nominal value such as description in brochures by its device manufacturer or casual user information. When it is not the nominal value such as a test result by laboratory, reporting all of conditions is important for full technical reports. Following requirements shall be applied both to the nominal value and the non-nominal value.

- Optical image stabilization performance shall be described using "stops."
- For zoom lenses, the focal length (35 mm film equivalent) at which the measurement was made or information replacing the focal length (such as "telephoto end") shall clearly be stated.
- When using the methods of this document to measure optical image stabilization for other components besides yaw and pitch, care shall be taken not to mix yaw/pitch corrections with corrections for other components in the measurement results.

5.2 Requirements for the nominal value

- Values shall be rounded down to the nearest 0,5-stop. For example, 2,7 stops is rounded down to 2,5 stops.
- The name of optical image stabilization mode shall be reported unless only the performance of the factory shipping setting for the optical image stabilization mode is reported.
- If the optical image stabilization performance is only attainable under specific conditions, such conditions shall be expressly stated unless such conditions are easily understood by users from other source of information.

5.3 Requirements for the non-nominal value

- The name of optical image stabilization mode shall be reported. If test camera has not optical image stabilization mode, write "not available".

b) The shooting distance should be reported.

5.4 Examples of presentation

This clause gives a presentation example of the results in the form of a table. [Annex F](#) collaterally gives presentation examples in brochures by CIPA standard DC-011-2015.

Laboratory or company	<u>NN</u>
Device manufacturer	<u>OO</u>
Device being tested	Interchangeable lens with image stabilization mechanism model <u>PP</u> 24-105 mm F4 with <u>QQ</u> (camera body)
Focal length	100 mm (450 mm on a 35 mm film equivalent)
Image stabilization mode	IS1
Shooting distance	About 15 times focal length on a 35 mm film equivalent
Image stabilization performance	2,5 stops

Annex A (normative)

Vibration waveforms

A.1 Procurement of the vibration waveforms

Vibration waveforms supplied by CIPA shall be used. The waveforms which are in text format, named WB-H-xxx.txt and WB-L-xxx.txt, respectively, can be obtained from the CIPA¹⁾ website.

A.2 Description

The waveforms are provided as angle data changing in the time direction for 32 s. Data sampling frequency is 500 Hz. The 'xxx' in the test waveform file names is a 3-digit number giving the waveform version. If a vibration waveform has been revised, version differences are managed with these numbers.

The waveforms WB-H and WB-L are given in [Figure A.1](#).

Both vibration waveforms are composed of the biaxial components of pitch and yaw. Vibrations shake in both the pitch direction and yaw direction simultaneously.

It is possible that vibration waveforms will be revised to reflect changes in camera shape, how pictures are taken, and the development of image stabilization technology. The waveforms also have possibility of revision along with such changes.

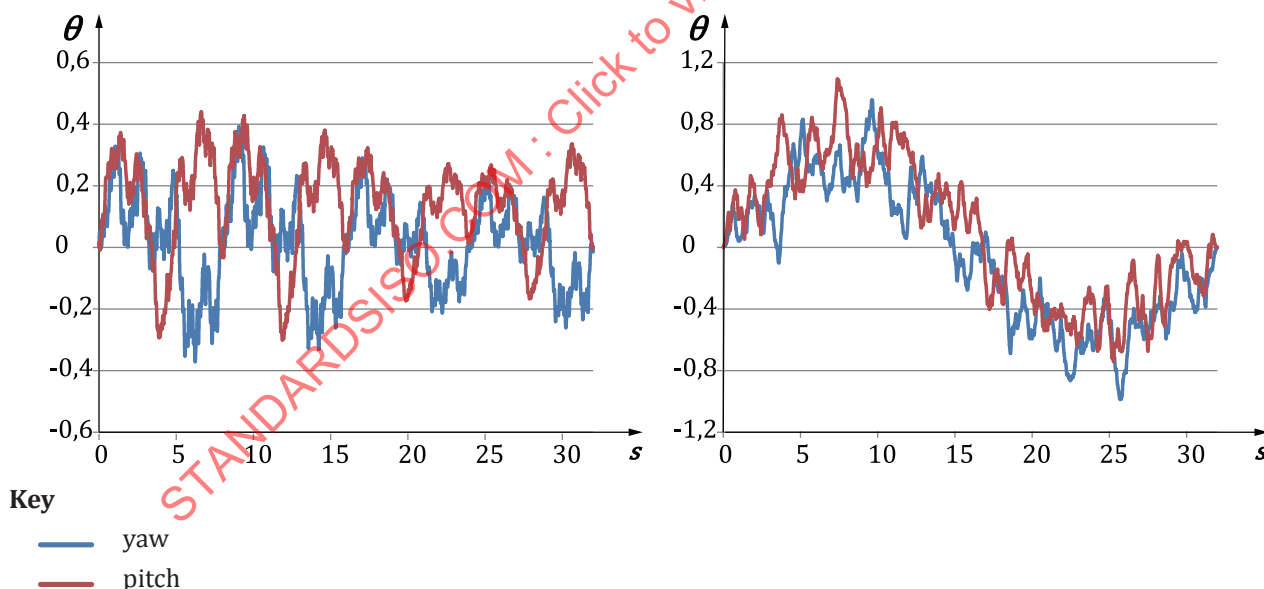


Figure A.1 — Waveforms WB-H (left) and WB-L (right)

1) http://www.cipa.jp/image-stabilization/contents_e/guide_e.html. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Annex B (informative)

CIPA test chart method

B.1 Specifications of the test chart

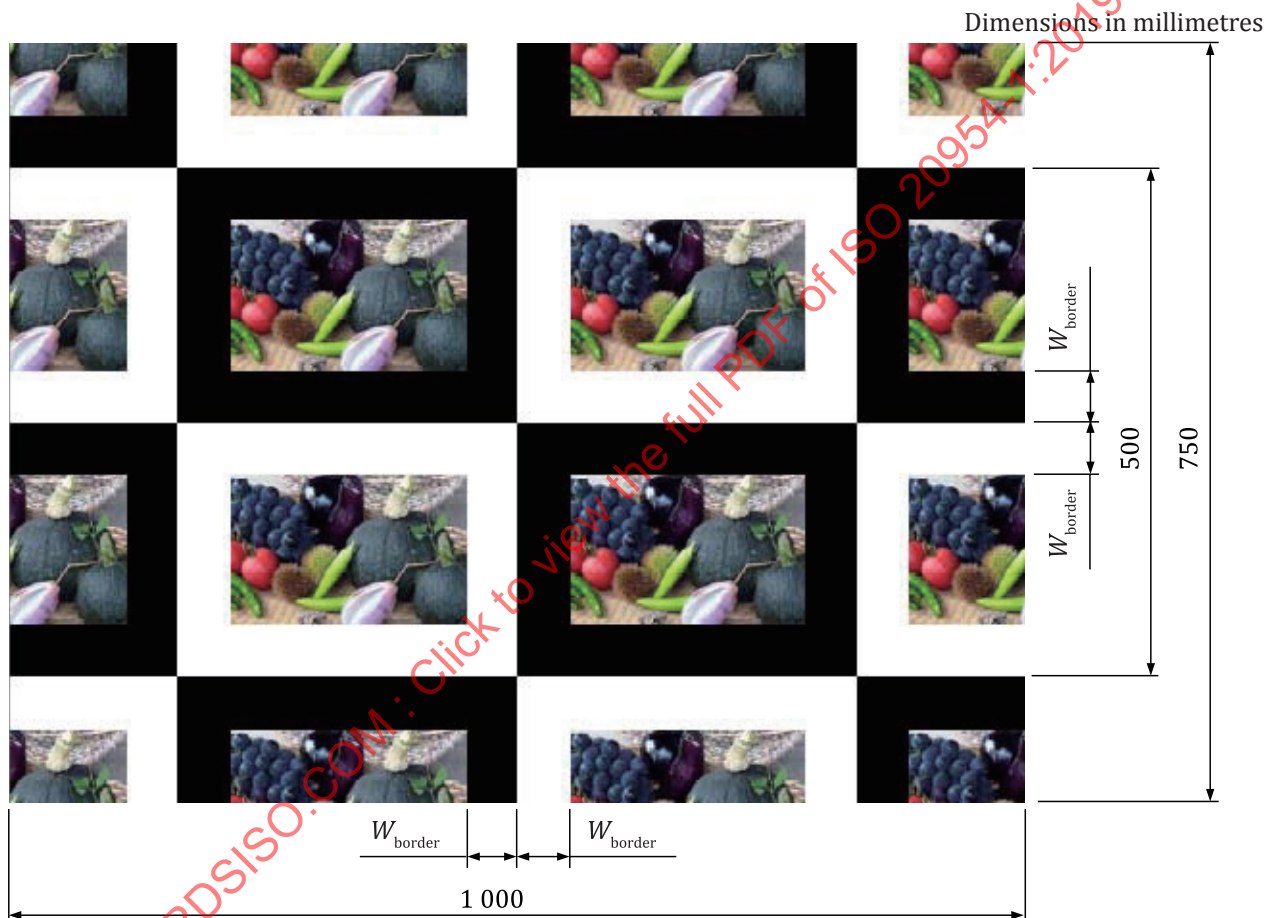


Figure B.1 — CIPA measurement chart

The Specifications of CIPA measurement chart in [Figure B.1](#) is as follows.

- The dimensions of the chart are 1 000 mm × 750 mm.
- The chart contains multiple natural colour images surrounded by black and white borders of a fixed width.
- The reflectance ratio of the black to white borders is 1:20 or higher, and the width of the borders, which corresponds to W_{border} in [Figure B.1](#), is wider than the maximum expected total image degradation amount, which is defined in [Figure B.2](#) and is converted to length on subject plane from length on focal plane depending on its image magnification ratio. W_{border} of CIPA measurement chart is 50 mm for reference.
- The natural image portion depicts real subjects and cover the widest area possible under the abovementioned conditions.

B.2 Image area

Adjust the shooting distance by adjusting the position of the camera and/or the test chart so that one of the areas enclosed by the dotted lines in [Figure B.2](#) fills the entire picture frame.

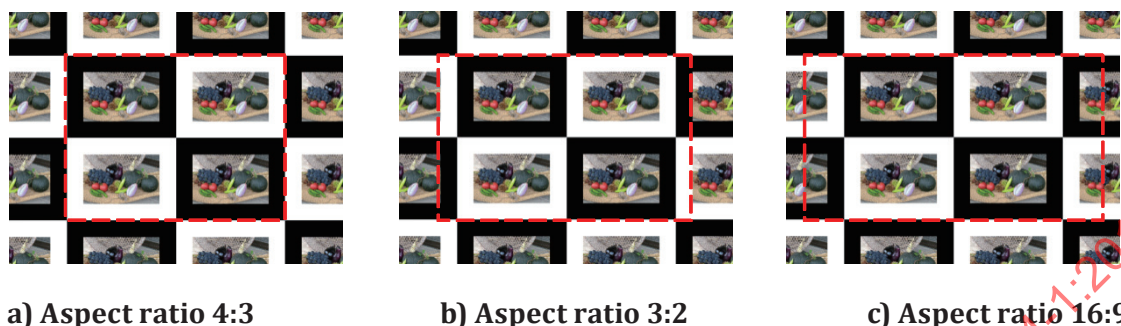


Figure B.2 — Image area for camera mounted on stationary vibration generator

B.3 Measurement software

CIPA distributes measurement software as “Handheld blur measurement software” which assumes images are of the CIPA measurement chart taken at a distance of about 20 times the 35 mm film equivalent focal length.

Handheld blur measurement software is used to calculate the intrinsic image degradation amount and total image degradation amount of the captured image of the test chart taken in accordance with [4.4](#). This software outputs intrinsic image degradation amount and total image degradation amount in pixels. The CIPA measurement chart shall be used without fail when this software is used. Refer to the instruction manual for the handheld blur measurement software for details on how to measure intrinsic image degradation amount and total image degradation amount.

Annex C (informative)

Slanted edge test chart method

C.1 Specifications of the test chart

The chart that is used for the slanted edge analysis shall be compliant with the chart requirements for slanted edge analysis mentioned in ISO 12233. The preferred chart mentioned in ISO 12233 is shown in [Figure C.1](#). See ISO 12233:2017, Clause 6 for SFR and e-SFR.

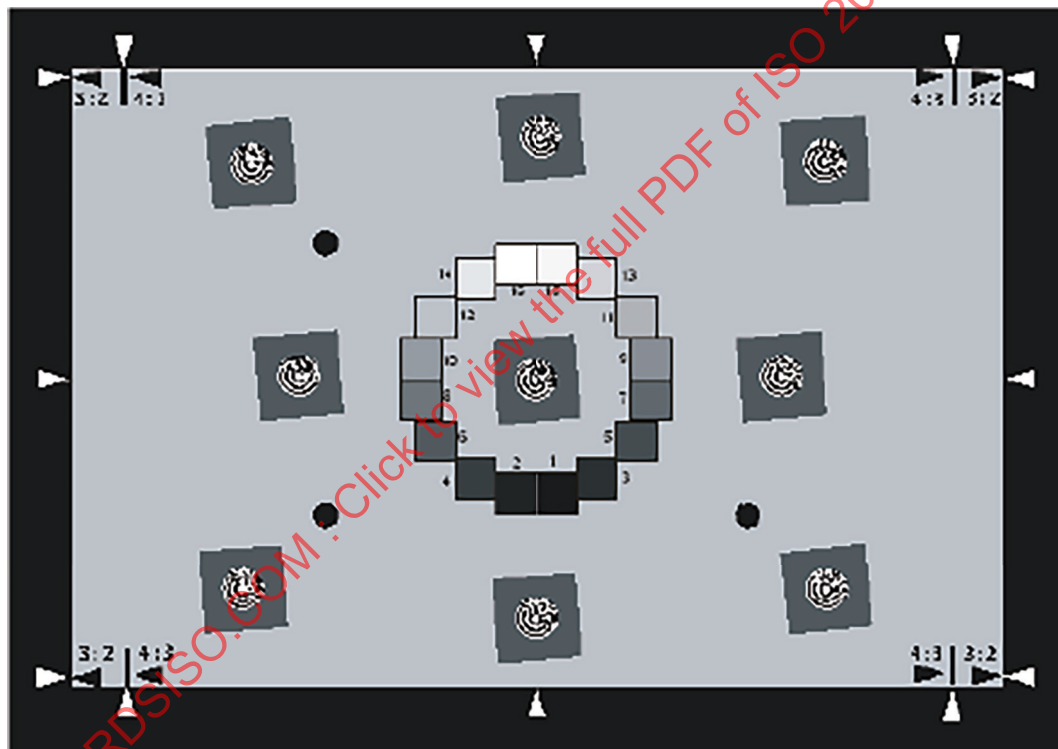


Figure C.1 — Low contrast e-SFR test chart

C.2 Image area

The chart shall be framed so that the chart height marked by the white arrows is as close to the image height of the camera as possible.

C.3 Methodology

C.3.1 Selection of the edge region of interest (ROI)

The user selects the region containing the slightly slanted edge. If the image is coloured, a luminance record is created before the SFR calculation is performed. The result is a two-dimensional matrix of data of values, (n lines, m pixels). See item A in [Figure C.2](#).

C.3.2 Transformation into effective exposure

The image code values shall then be linearized by gamma ($\gamma = 2,2$). Each pixel value in the ROI is now transformed in to an equivalent target reflectance value. See item B in [Figure C.2](#).

C.3.3 Estimate the location of the edge

C.3.3.1 Estimation of edge location (offset) and slope

This is done in two steps. See items C1 and C2 in [Figure C.2](#).

— Compute one-dimensional derivative

For each line of pixels perpendicular to the edge, the data are multiplied with a Hamming-window vector of the same length (m). For each line of pixels in the resulting array, the derivative of the linearized image data is computed using a $[-\frac{1}{2}, +\frac{1}{2}]$ finite impulse response (FIR) filter. The result is an array which is the same size as the input ROI.

STANDARDSISO.COM : Click to view the full PDF of ISO 20954-1:2019

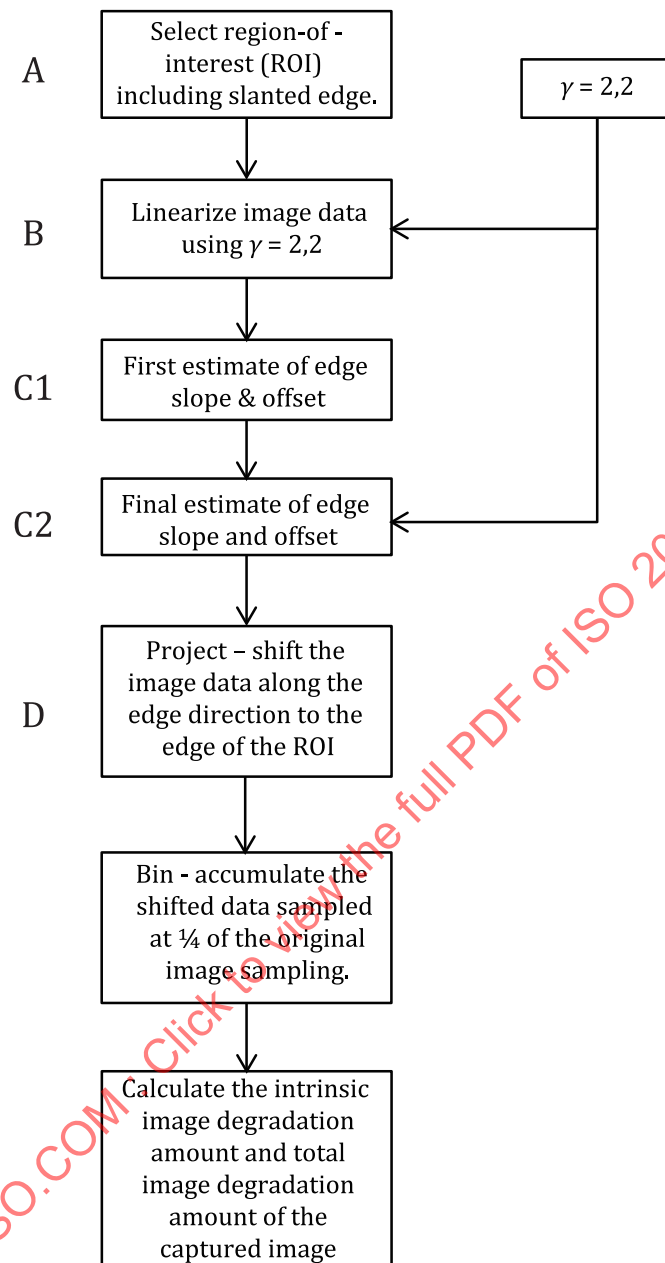


Figure C.2 — Flow-chart of e-SFR measurement algorithm

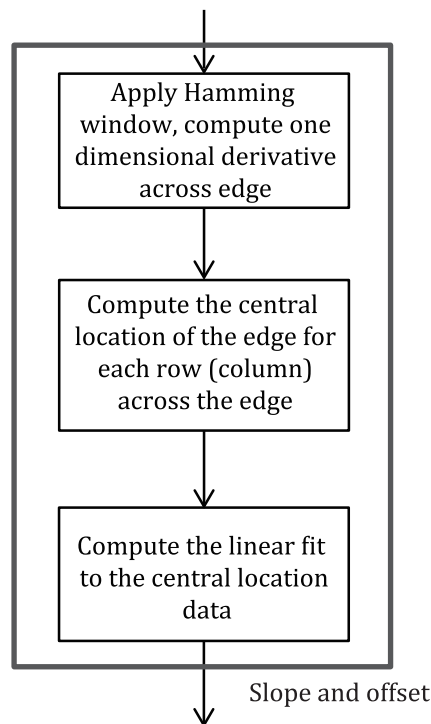


Figure C.3 — Parts of element C in [Figure C.2](#)

- Compute location of the edge for each line of data

The one-dimensional centroid of this derivative matrix is calculated line-by-line, to determine the position of the edge on each line. The result is a vector of centroid locations $(1, n)$.

- Estimate slope and location of the edge

A linear best-line fit to the centroid locations as a function of line number is then calculated. That is, from the function;

$$y = mx + b \quad (\text{C.1})$$

where

y are the set of centroid location and

x are the set of line location $(1, n)$,

and compute the best-fit values for the slope, m , and offset, b .

Error messages shall be reported if any centroid is within 2 pixels of either side of the input image edges, or if the edge does not contain at least 20 % modulation.

C.3.3.2 Final estimation of edge location

For each line of pixels perpendicular to the edge, the location of the centroid of the line is computed from the below equation;

$$y_1 = m_1 x + b_1 \quad (\text{C.2})$$

where y_1 represents the vector of centroid location computed as illustrated [Figure C.3](#). This results in a vector of y' values.

The transformed image data are multiplied with a Hamming-window vector of the same length (n). In this case, the Hamming window function is centred at y' for each line. For each line of pixels multiplied with thus-centred Hamming window array, the derivative of the image data is computed using a $[-\frac{1}{2}, +\frac{1}{2}]$ finite impulse response (FIR) filter. The results is an array which is the same size as the input ROI.

C.3.3.3 Compute final location of the edge for each line of data

The one-dimensional centroid of this derivative matrix is calculated line-by-line, to determine the position of the edge on each line. The result is a vector of centroid locations $(1, n)$.

C.3.3.4 Estimate final slope and location of the edge

A linear best-line fit to the centroid locations as a function of line number is then calculated. That is, form the function;

$$y = mx + b \quad (C.3)$$

where

y are the set of centroid location and

x are the set of line location $(1, n)$,

and compute the best-fit values for the slope, m , and offset, b .

C.3.4 Forming a super-sampled line-spread function array

A one-dimensional super-sampled edge spread function shall be formed using the data of the truncated two-dimensional ROI image data. Using the first line as reference points, the data points from all the other lines shall be placed into one of four "bins" between these reference points, according to the distance from the edge for that particular line. This creates a single super-sampled "composite" edge spread function, having four times as many points along the line as the original image data.

From this vector, a corresponding Line-Spread function array shall be derived by computing the length-3 discrete derivative. The derivative vector is computed using a $[-\frac{1}{2}, 0, +\frac{1}{2}]$ finite impulse response (FIR) filter, meaning that the derivative value for pixel "X" is equal to $-1/2$ times the value of the pixel immediately to the left, plus $1/2$ times the value of the pixel to the right. The results is a vector which is the same size as the super-sampled edge-spread function.

C.4 Measurement software

There are several commercially available software tools that can be used to determine the line spread function from a slanted edge based on the ISO 12233 approach. See ISO 12233:2017, Annex D for algorithm of software tool.

A list of suppliers for software and hardware is available from the standards section of the www.imaging.org website by accessing the digital camera resolution tools subsection.

Annex D **(informative)**

Verification of vibration generator

CIPA provides the following documents, data, software, and CIPA measurement chart to support further verification of performance of the vibration generator:

- a) Verification Method of Vibration Apparatus, which specifies in detail the method for verifying performance of the vibration generator;
- b) two (2) test waveforms;
- c) two (2) sets of average vibration angles of the test waveforms as function of exposure time;
- d) handheld blur measurement software (FindsBlur) with manual and instructions for use; and
- e) CIPA measurement chart.

Information on the distributed materials is available from the CIPA²⁾ website.

2) http://www.cipa.jp/image-stabilization/index_e.html

Annex E (informative)

Additional information

E.1 Background of specifying measurement method

The simplest way to measure optical image stabilization performance is to compare images with and without image stabilization and quantify the difference as the effect of optical image stabilization. Before comparison, intrinsic image degradation amount is removed from the total image degradation amount for both the on and off images. This easily removes image degradation caused by factors other than camera shake, producing fairer measurement results.

In this document, the camera is excited with specified vibration waveforms using a vibration generator of guaranteed accuracy. Accordingly, measured handheld blur amount with optical image stabilization turned off will theoretically be similar among cameras, exhibiting only subtle individual differences. In fact, many cameras measured showed no significant difference.

Some fully automated cameras on the market cannot disable optical image stabilization. This makes it difficult to measure all cameras based on the stabilization disabled images. This trend is predicted to grow in the future.

In this document, optical image stabilization performance is calculated from the reference handheld blur amount, which is equivalent to the handheld blur amount with optical image stabilization disabled, and the measured handheld blur amount, which is measured with optical image stabilization enabled.

E.2 Vibration generator

In measuring a camera's optical image stabilization performance, the most realistic scenario is to capture the test chart with a handheld camera. However, the magnitude and characteristics of handheld camera shake vary among individuals, and even the same person will produce different results with different cameras, shooting conditions.

It is essential to eliminate such uncertainties in order to measure and describe optical image stabilization performance. Using a vibration generator to simulate handheld camera shake is an effective means of achieving this. The vibration generator uses an electric signal called a vibration waveform to create vibrations (see Figure E.1).

There are cameras for which the IS measurement result is sensitive to high frequency vibration caused by the vibration generator apparatus and/or mounting of the test camera on the vibration generator.

When measuring such a camera, it is advised to conduct a simple test to insure that high-frequency vibration, not included in the vibration waveform, is not transmitted to the camera. See [4.4.4](#) a) and [4.4.5](#) a).