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ISO 15739

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Photography — Electronic still-picture imaging — Noise measurements

Photographie — Imagerie des prises de vue électroniques — Mesurages du bruit

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15739 was prepared by Technical Committee ISO/TC 42, *Photography*.

Introduction

Noise is an important attribute of electronic photographic systems. Standardization assists users and manufacturers in determining the quality of images that may be obtained from an electronic still-picture camera. The camera noise measurements described in this International Standard are performed in the digital domain, using digital analysis techniques. For electronic cameras that include only analogue outputs, the analogue signal has to be digitized, so that the digital measurement can be performed. The digitizing equipment has to be characterized, so that the effects of the digitization can be removed from the measurement results. When this is not possible, the type of digitizing equipment used is to be reported along with the measurement results.

Since the noise performance of an image sensor may vary significantly with exposure time and operating temperature, these operating conditions are specified. The visibility of noise to human observers depends on the magnitude of the noise, the apparent tone of the area containing the noise and the spatial frequency of the noise. The magnitude of the noise present in an output representation depends on the noise present in the stored image data and the contrast amplification or gain applied to the data in producing the output. The noise visibility is different for the luminance (or monochrome) channel and the colour (or colour difference) channels. Therefore, this International Standard accounts for these factors in measuring and reporting the camera noise measurements. Annex A gives the construction of an ISO standard camera noise test chart. Annex B specifies the method for determining the components of the digital camera noise from a number of samples. Annex C describes a procedure using a human visual model as a method for weighting the spectral components of the noise.

Many electronic still-picture cameras use extensive signal processing to reduce noise in uniform areas, and the noise levels measured in the large area test defined in this International Standard may not be representative of the noise levels found in the pictures taken by the camera. Therefore, new methods of measuring edge noise have been investigated. One method is described in Annex D. The incremental gain calculation is given in Annex E.

Photography — Electronic still-picture imaging — Noise measurements

1 Scope

This International Standard specifies methods for measuring and reporting the noise versus signal level and dynamic range of electronic still-picture cameras. It applies to both monochrome and colour electronic still-picture cameras.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 7589:2002, *Photography — Illuminants for sensitometry — Specifications for daylight, incandescent tungsten and printer*

ISO 12232:1998, *Photography — Electronic still-picture cameras — Determination of ISO speed*

ISO 14524:1999, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

ITU-R BT.709-5, *Parameter values for the HDTV Standards for production and International programme exchange*

3 Terms and definitions

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

3.1
camera opto-electronic conversion function
camera OECF
opto-electronic conversion function
focal plane opto-electronic conversion function
relationship between the input scene log luminances and the digital output levels for an opto-electronic digital capture system

NOTE The units of measurement for this function are $\log_{10}$ candelas per square metre.

3.2
digital output level
digital code value
numerical value assigned to a particular output level

3.3
digital still camera
DSC
camera incorporating an image sensor which outputs a digital signal representing a still picture, or records a digital signal representing a still picture on a removable medium, such as a memory card or magnetic disk

3.4
electronic still-picture camera
camera incorporating an image sensor which outputs an analogue or digital signal representing a still picture, and/or records an analogue or digital signal representing a still picture on a removable medium, such as a memory card or magnetic disk

3.5
image sensor
electronic device which converts incident electromagnetic radiation into an electronic signal

NOTE A charge coupled device (CCD) array is an example of an electronic signal.

3.6
incremental gain function
change in the output level (digital code value) divided by the change in the input level (luminance or exposure) as a function of the light level

NOTE 1 For the determination of incremental gain values, log input values are not used.

NOTE 2 If the input exposure points are very finely spaced and the output noise is small compared to the quantization interval, the incremental gain function can have a jagged shape. Such behaviour is an artefact of the quantization process and is removed by using an appropriate smoothing algorithm, or by fitting a smooth curve to the data. In some cases, it may be desirable to fit a curve to the input-output data and then determine the incremental gain function by taking the first derivative of the function used for the curve fit.

3.7
incremental output signal
input level (luminance or exposure, not logged) multiplied by the system incremental gain at that level

3.8
incremental signal-to-noise ratio
ratio of the incremental output signal to the root mean square (rms) noise level, at a particular signal level

NOTE This is typically expressed as a graph or table showing the rms noise level versus output signal level for the full range of output signal levels.

3.9
ISO DSC dynamic range
ratio of the maximum luminance level which appears unclipped to the minimum luminance level which can be reproduced with an incremental signal-to-temporal-noise ratio of at least 1, as determined in accordance with ISO 15739

3.10
noise
unwanted variations in the response of an imaging system

3.10.1
total noise
all the unwanted variations captured by a single exposure

3.10.2
fixed pattern noise
unwanted variations which are consistent for every exposure

3.10.3
temporally varying noise
random noise due to sensor dark current, photon shot noise, analogue processing and quantization, which varies from one image to the next

3.11
noise spectral power distribution
curve or equation which expresses the camera output noise as a function of two-dimensional image spatial frequencies

3.12
photosite integration time
total time period during which the photosites of an image sensor are able to integrate the light from the scene to form an image

3.13
signal processing
operations performed by electronic circuits or algorithms which convert or modify the output of an image sensor

3.14
video signal-to-noise ratio
ratio of the maximum (peak) output signal level to the root mean square (rms) noise level in video systems

NOTE 1 This value is typically expressed in decibels (dB).

NOTE 2 This term is not used to express the noise in an electronic still-picture imaging system.

4 Test conditions

4.1 General

The following measurement conditions should be used as nominal conditions when measuring the noise of an electronic still-picture camera. If it is not possible or appropriate to achieve these nominal operating conditions, the actual operating conditions shall be listed along with the reported results.

4.2 Illumination

4.2.1 Characteristics

The noise measurements shall indicate whether a source conforming to the daylight or tungsten illuminant was used. ISO 7589 describes the procedures for determining if the characteristics of the illumination used in a specific speed rating determination test are an acceptable match to the daylight and tungsten sensitometric illuminants.

4.2.2 Daylight illumination

For daylight measurements without the camera lens, a source conforming to the ISO sensitometric daylight illuminant specified in Table 1 of ISO 7589:2002 shall be used. This illuminant is defined as the product of the spectral power distribution of CIE illuminant D55 and the spectral transmittance of the ISO standard camera lens. For measurements with the camera lens in place, the spectral characteristics of the illuminant shall be equivalent to CIE illuminant D55.

4.2.3 Tungsten illumination

For tungsten measurements without the camera lens, a source conforming to the ISO sensitometric tungsten illuminant specified in Table 2 of ISO 7589:2002 shall be used. This illuminant is defined as the product of the average spectral power distribution of experimentally measured sources having a colour temperature of approximately 3 050 K and the spectral transmittance of the ISO standard camera lens. For measurements with the camera lens in place, the spectral characteristics of the illuminant shall be equivalent to the product of the average spectral power distribution of experimentally measured sources having a colour temperature of approximately 3 050 K.

4.2.4 Reflection illumination

For measurements using a reflection test chart, the illumination should meet the uniformity requirements of the measurement procedures described in Clause 5. The sources are positioned so that the angular distribution of influx radiation is at its maximum at 45° to the test chart normal, and is negligible at angles of less than 40° or more than 50° to the normal, at any point on the test chart.

4.3 Temperature and relative humidity

The ambient room temperature during the acquisition of the test data shall be 23 °C ± 2 °C, as specified in ISO 554, and the relative humidity shall be 50 % ± 20 %. Additional measurements at 0 °C and 40 °C are recommended. The normal camera operating temperature (internal rise above ambient) shall be achieved before beginning the tests. If the ambient temperature varies throughout the room, for example as a result of heat generated by light sources, the ambient room temperature shall be measured at a distance of between 0,1 m and 0,2 m from the camera under test.

4.4 White balance

For a colour camera, the camera white balance shall be adjusted, if possible, to provide proper white balance (equal RGB signal levels) for the illumination light source, as specified in ISO 14524.

4.5 Infrared (IR) blocking filter

If required, an infrared blocking filter shall be used, as specified in ISO 14524.

4.6 Photosite integration time

The photosite integration time should not be longer than 1/30 s.

4.7 Colour noise weighting

For colour cameras using a single exposure process, the camera noise may be determined using a weighted sum of the colour outputs to derive the luminance. If the proper luminance weighting values for the RGB channel spectral sensitivities are known, they shall be used to calculate the luminance channel data. If these values are not known, the following weighting, given in ITU-R BT.709, shall be used:

$$Y = 0{,}2125\ R + 0{,}7154\ G + 0{,}0721\ B \quad (1)$$

For colour cameras with luminance and colour-difference outputs, the standard deviation of the camera noise may be computed from the luminance channel standard deviation σ(Y), the red minus luminance channel standard deviation σ (R-Y) and the blue minus luminance channel standard deviation σ (B-Y). The following Equation (2), as specified in 6.2.3 of ISO 12232:1998 shall be used:

$$\sigma(D_H) \text{ or } \sigma(D_L) = [\sigma(\mathrm{Y})^2 + 0{,}64\ \sigma(\mathrm{R\text{-}Y})^2 + 0{,}16\ \sigma(\mathrm{B\text{-}Y})^2]^{1/2} \quad (2)$$

4.8 Compression

If the electronic still-picture camera includes any form of lossy compression, the compression shall be disabled, if possible, during the noise measurements. If the compression cannot be turned off, then measurements should be taken and the compression level reported with the noise measurement result, for example, the actual camera switch setting (fine, standard, etc.) and the approximate average number of bits per pixel.

5 Noise measurement procedures

5.1 General

These measurement procedures shall be used to determine the camera noise, the camera signal-to-noise ratio and the camera dynamic range. The minimum requirement is to specify the signal-to-total-noise ratio and the dynamic range of the digital camera under test. In addition, the fixed pattern and temporal noise components can be expressed individually and the total noise weighted to match a known expression for human visual response.

5.2 Uniform field noise measurement methods

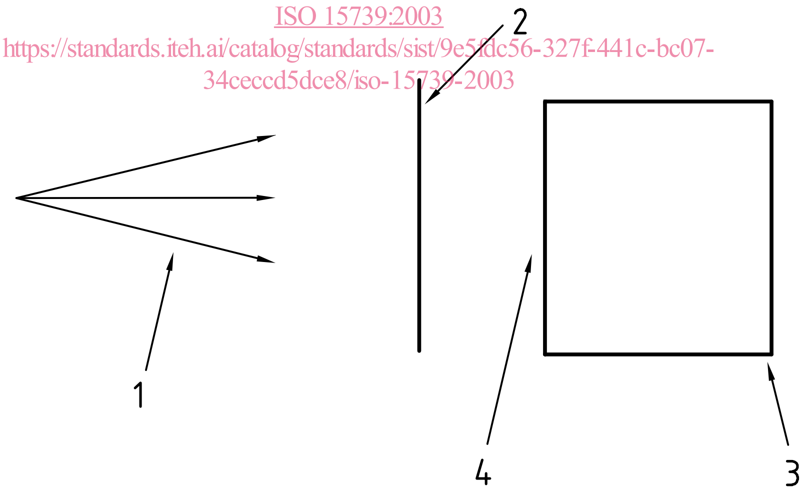
The method of measuring the uniform field noise will be dependent on the type of camera and its level of exposure automation. If the camera lens can be removed, then the sensor noise level can be measured without any shading effects from the lens.

On automatic exposure cameras having through the lens (TTL) exposure control and no manual exposure control override capability, the test chart and measurement methods described in 5.6 shall be used.

5.3 Cameras with removable lenses

5.3.1 General

This method involves the exposure of the electronic still-picture camera sensor directly to specific quantities of uniform illumination with the lens removed. The illumination shall have the spectral characteristics specified in 4.2 and shall be produced by a small source at a distance, such that the largest dimensions of the source and the sensor are no greater than one twentieth of the distance between them, as shown in Figure 1. Reflective surfaces shall not be placed where they could cause additional illumination to be incident on the sensor.



Key

1 light source
2 test density
3 camera under test
4 lens removed

Figure 1 — Illumination for cameras with removable lenses

5.3.2 The camera OECF shall first be measured according to ISO 14524.

5.3.3 The light source shall be fixed level with combined short term and supply amplitude variations of less than ± 2 %.

5.3.4 The light source shall be adjusted to give the maximum unclipped level from the camera. If necessary, an appropriate neutral density filter should be used to cover the camera exposure control sensor, in order to adjust the signal level to provide the maximum unclipped level from the camera.

5.3.5 Test densities shall completely cover the area exposed, when the camera lens was removed.

5.4 Whole camera

5.4.1 General

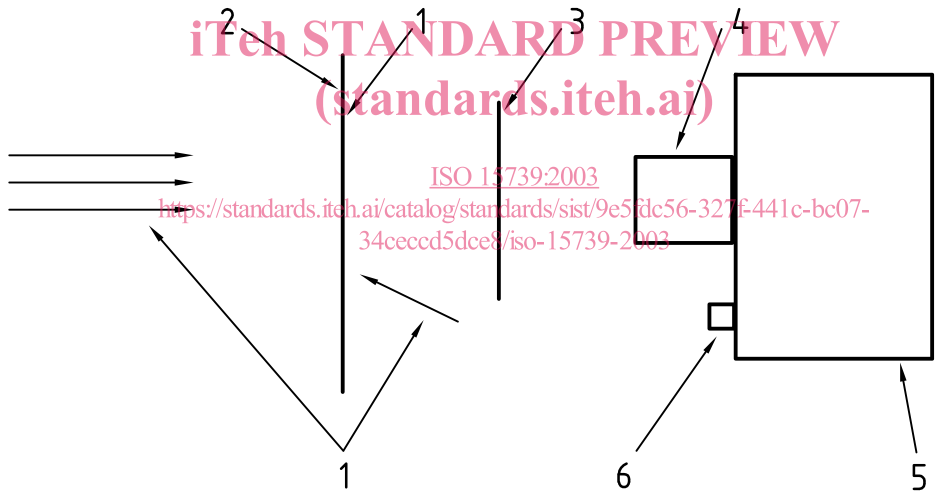
These measurements shall be used for all cameras that use manual exposure control, or exposure control based on a separate exposure control sensor.

5.4.2 The camera OECF shall first be measured according to ISO 14524.

5.4.3 The light source shall be fixed level with combined short term and supply amplitude variations of less than ± 2 %.

5.4.4 If the camera lens focus is adjustable, it shall be set to infinity.

5.4.5 The diffuser shall be uniform and close to the camera, preferably less than one tenth of the minimum focus distance of the camera under test, to prevent diffuser blemishes from influencing the noise measurements. The diffuser may be illuminated by either transmissive or reflective light (see Figure 2).



Key

1 uniform fixed level light source
2 diffuser
3 test density
4 camera lens
5 camera under test
6 camera exposure control sensor

Figure 2 — Uniform field noise measurements

5.4.6 The light source and diffuser shall be adjusted to give the maximum unclipped signal level from the camera. If necessary, an appropriate spectrally neutral density filter shall be used to cover the camera exposure control sensor to adjust the signal level, in order to provide the maximum unclipped signal level from the camera.

5.4.7 Test densities shall only cover the camera lens.