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Photography — Spatial resolution measurements of electronic scanners for photographic images —

Part 1:
Scanners for reflective media

Photographie — Mesurages de résolution spatiale de scanners électroniques pour images photographiques —

Partie 1: Scanners pour milieux réfléchissants

Reference number
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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.

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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 16067-1 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 16067 consists of the following parts, under the general title *Photography — Spatial resolution measurements of electronic scanners for photographic images*:

— *Part 1: Scanners for reflective media*

— *Part 2: Film scanners*

Introduction

One of the most important characteristics of an electronic print scanner is the ability to capture the fine detail found in the original print. This ability to resolve detail is determined by a number of factors, including the performance of the scanner lens, the number of addressable photoelements in the image sensor(s) used in the scanner, and the electrical circuits in the scanner. Different measurement methods can yield different metrics that quantify the ability of the scanner to capture fine details.

This part of ISO 16067 specifies methods for measuring the limiting visual resolution and spatial frequency response calculated from a slanted edge (Edge SFR) imaged by a print scanner. The scanner measurements described in this part of ISO 16067 are performed in the digital domain, using digital analysis techniques. A test chart of appropriate size and characteristics is scanned and the resulting data analysed. The test chart described in this part of ISO 16067 is designed specifically for the evaluation of continuous tone print scanners. It is not designed for evaluating electronic still picture cameras, video cameras or bi-tonal document scanners.

The edge SFR measurement method described in this part of ISO 16067 uses a computer algorithm to analyse digital image data from the print scanner. Pixel values near slanted vertical and horizontal edges are used to compute the SFR values. The use of a slanted edge allows the edge gradient to be measured at many phases relative to the image sensor photoelements, so that the SFR can be determined at spatial frequencies higher than the half-sampling frequency, sometimes called the Nyquist limit. This technique is mathematically equivalent to a moving knife edge measurement.

Photography — Spatial resolution measurements of electronic scanners for photographic images —

Part 1: Scanners for reflective media

1 Scope

This part of ISO 16067 specifies methods for measuring and reporting the spatial resolution of electronic scanners for continuous tone photographic prints. It is applicable to both monochrome and colour print scanners.

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 5 (all parts), *Photography — Density measurements*

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 12231, *Photography — Electronic still-picture cameras — Terminology*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12231 and the following apply.

3.1
addressable photoelements
number of active photoelements in an image sensor equal to the number of active lines of photoelements, multiplied by the number of active photoelements per line

3.2
aliasing
output image artefacts that occur in a sampled imaging system for input images having significant energy at frequencies higher than the Nyquist frequency of the system

NOTE These artefacts usually manifest themselves as moiré patterns in repetitive image features or as jagged “stairstepping” at edge transitions.

3.3
digital output level
digital code value
numerical value assigned to a particular output level

3.4
edge spread function
ESF
normalized spatial signal distribution in the linearized output of an imaging system resulting from imaging a theoretical infinitely sharp edge

3.5
effectively spectrally neutral
having spectral characteristics which result in a specific imaging system producing the same output as for a spectrally neutral object

3.6
electronic scanners for photographic prints
scanner incorporating an image sensor that outputs a digital signal representing a still print image

3.7
fast scan direction
scan direction corresponding to the direction of the alignment of the addressable photoelements in a linear array image sensor

3.8
gamma correction
signal processing operation that changes the relative signal levels in order to adjust the image tone reproduction

NOTE 1 Gamma correction is performed in part to correct for the nonlinear light-output versus signal input characteristic of the display. The relationship between the light input level and the output signal level, called the OECF, provides the gamma correction curveshape for an image capture device.

NOTE 2 The gamma correction is usually an algorithm, look-up table or circuit which operates separately on each colour component of an image.

3.9
image sensor
electronic device that converts incident electromagnetic radiation into an electronic signal

EXAMPLE Charge-coupled device (CCD) array.

3.10
resolution
measure of the ability of a digital image capture system, or a component of a digital image capture system, to depict spatial picture detail

NOTE Resolution measurement metrics include resolving power, limiting visual resolution, SFR, MTF and CTF.

3.11
sampled imaging system
imaging system or device which generates an image signal by sampling an image at an array of discrete points, or along a set of discrete lines, rather than a continuum of points

NOTE The sampling at each point is done using a finite-size sampling aperture or area.

3.12
sample spacing
physical distance between sampling points or sampling lines

NOTE 1 The sample spacing may be different in the two orthogonal sampling directions.

NOTE 2 It is measured in units of distance (e.g. micrometres, millimetres).

3.13
sampling frequency
reciprocal of sample spacing

NOTE It is expressed in samples per unit distance [e.g. dots per inch (DPI)]

3.14
scanner
electronic device that converts a fixed image, such as a print or film transparency, into an electronic signal

3.15
scanner opto-electronic conversion function
scanner OECF
relationship between the input density and the digital output levels for an opto-electronic digital capture system

3.16
slow scan direction
direction in which the scanner moves the photoelements (perpendicular to the lines of active photoelements in a linear array image sensor)

3.17
spatial frequency response
SFR
measured amplitude response of an imaging system as a function of relative input spatial frequency

NOTE The SFR is normally represented by a curve of the output response to an input sinusoidal spatial luminance distribution of unit amplitude, over a range of spatial frequencies, and is normalized to yield a value of 1,0 at a spatial frequency of 0.

3.18
spectrally neutral
exhibiting reflective or transmissive characteristics which are constant over the wavelength range of interest

3.19
test chart
arrangement of test patterns designed to test particular aspects of an imaging system

3.20
test pattern
specified arrangement of spectral reflectance or transmittance characteristics used in measuring an image quality attribute

NOTE The test pattern spectral characteristics include the types given in 3.21.1 to 3.21.3.

3.20.1
bitonal patterns
pattern that is spectrally neutral or effectively spectrally neutral, and which consists exclusively of two reflectance or transmittance values in a prescribed spatial arrangement

NOTE Bitonal patterns are typically used to measure resolving power, limiting resolution and SFR.

3.20.2
grey-scale patterns
pattern that is spectrally neutral or effectively spectrally neutral, and which consists of a large number of different reflectance or transmittance values in a prescribed spatial arrangement

NOTE Grey-scale patterns are typically used to measure opto-electronic conversion functions.

3.20.3
spectral pattern
pattern that is specified by the spatial arrangement of features with differing spectral reflectance or transmittance values

NOTE Spectral patterns are typically used to measure colour reproduction.

4 Test chart

4.1 General

This clause defines the type and specifications of the test chart depicted in Figure 1. The test chart can be made in various sizes to correspond to popular print sizes.

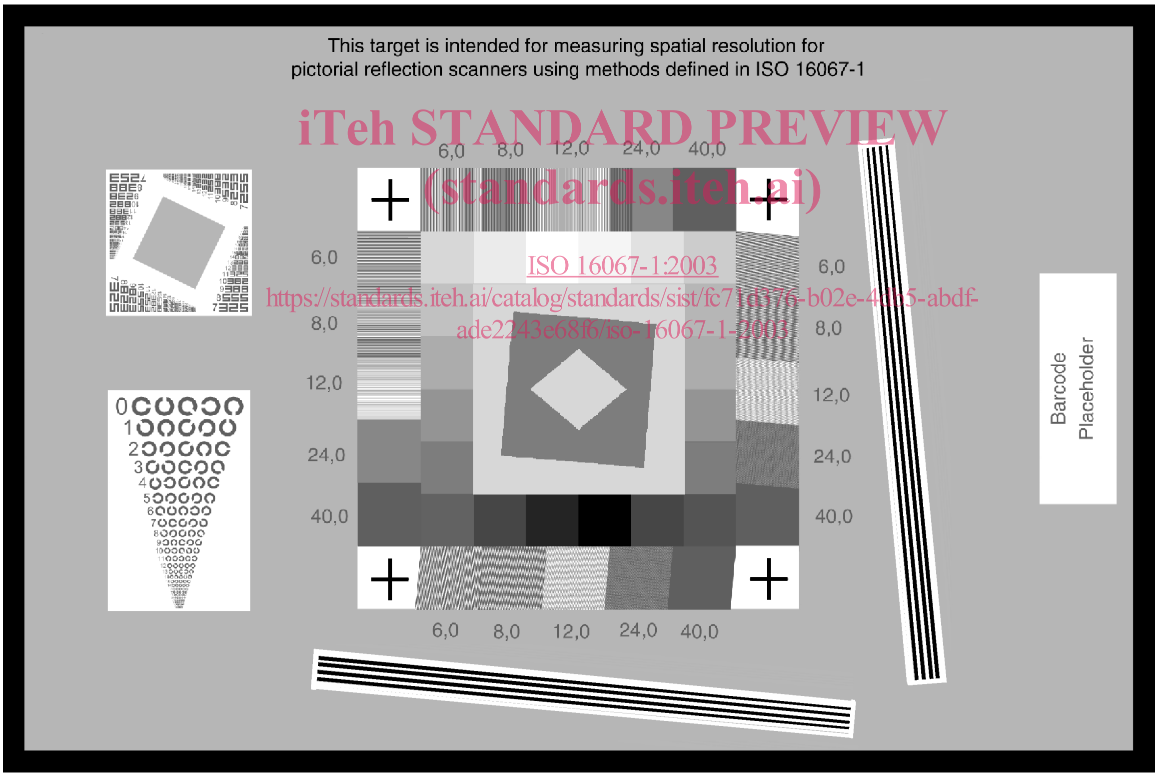


Figure 1 — Representation of test chart

4.2 General characteristics

4.2.1 The test chart shall be a reflection test chart based on current monochrome photographic print material. The print material shall be spectrally neutral with tolerances as specified in ISO 14524, and shall be resistant to fading.

4.2.2 The active height and width of the reflection test chart should be no less than 100 mm. Additional white space may be added to the width or height to include target management data or other test chart elements not defined by this part of ISO 16067.

4.2.3 The test chart shall include grey-scale patterns and should include bitonal elements. Grey-scale patches are necessary to measure the opto-electronic transfer function of the scanner. The bitonal elements may be used to assess limiting visual resolution and aliasing. (See Clause 7.)

4.2.4 The density values of the grey patches shall be in accordance with Annex A. The densities shall be measured as specified in ISO 5.

4.2.5 The target manufacturer should state the spatial frequency at which the target's frequency content is 0,2. These declarations should be cited in both cycles per millimetre (cycles/mm) and equivalent dots-per-inch (DPI), where the DPI value equals 50,8 times the spatial frequency in cycles per millimetre. Suggested wording is, “This target suitable for SFR measurements to XXX cycles per millimetre (xxxx dpi)”.

The spatial frequency content of the edge features should be the same for both near-horizontal, near-vertical, and near-45° edge features, and should be indicated as a graph (Figure 2), or should be characterized with a closed form equation or equations up to the frequency having a 0,2 modulation response.

NOTE An example equation corresponding to Figure 2 is the n-th order polynomial:

$$\text{Target modulation} = C_0 + C_1 \nu^1 + C_2 \nu^2 + C_3 \nu^3 + C_4 \nu^4 + C_5 \nu^5 + C_6 \nu^6 + C_7 \nu^7 \quad (1)$$

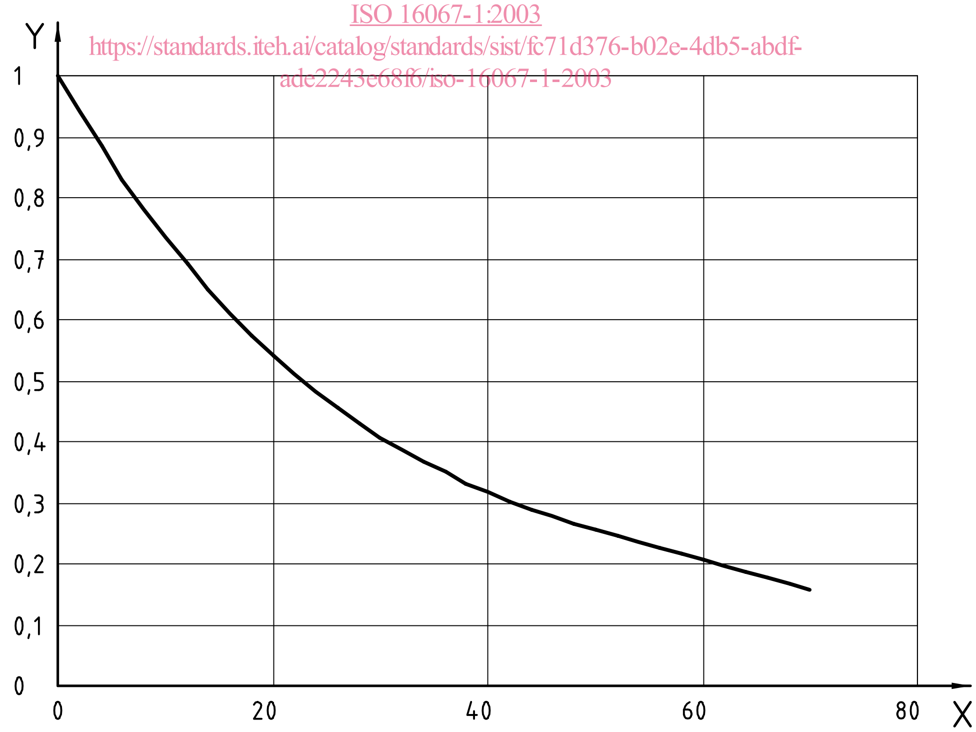
where

ν is the spatial frequency in terms of line pairs per millimetre;

C_i are the polynomial coefficients associated with the ith term

C_0 = 1,000 0e + 00 C_1 = – 1,016 1e – 02 C_2 = – 5,938 9e – 03 C_3 = 5,611 6e – 04

C_4 = – 2,344 3e – 05 C_5 = 5,099 7e – 07 C_6 = – 5,612 0e – 09 C_7 = 2,468 1e – 11



X spatial frequency (in cycles per millimetre)
Y modulation

Figure 2 — Example of the frequency content of a reflection edge's spatial derivative

