
**Optics and photonics — Optical transfer
function — Principles of measurement of
modulation transfer function (MTF) of
sampled imaging systems**

*Optique et photonique — Fonction de transfert optique — Principes de
mesure de la fonction de transfert de modulation (MTF) des systèmes
de formation d'image échantillonnés*



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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 15529 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 1, *Fundamental standards*.

This third edition cancels and replaces the second edition (ISO 15529:2007) which has undergone a minor revision to include measurement and test procedures for aliasing of sampled imaging systems.

Introduction

One of the most important criteria for describing the performance of an imaging system or device is its MTF. ISO 9334 covers the conditions to be satisfied by an image system for the MTF concept. These conditions require that the imaging system be linear and isoplanatic.

For a system to be isoplanatic, the image of a point object (i.e. the point spread function) must be independent of its position in the object plane to within a specified accuracy. There are types of imaging systems where this condition does not strictly apply. These are systems where the image is generated by sampling the intensity distribution in the object at a number of discrete points, or lines, rather than at a continuum of points.

Examples of such devices or systems are: fibre optic face plates, coherent fibre bundles, cameras that use detector arrays such as CCD arrays, line scan systems such as thermal imagers (for the direction perpendicular to the lines), etc.

If one attempts to determine the MTF of this type of system by measuring the line spread function of a static narrow line object and calculating the modulus of the Fourier transform, one finds that the resulting MTF curve depends critically on the exact position and orientation of the line object relative to the array of sampling points (see Annex A).

This International Standard specifies an "MTF" for such systems and outlines a number of suitable measurement techniques. The specified MTF satisfies the following important criteria:

- the MTF is descriptive of the quality of the system as an image-forming device;
- it has a unique value that is independent of the measuring equipment (i.e. the effect of slit object widths, etc., can be de-convolved from the measured value);
- the MTF can, in principle, be used to calculate the intensity distribution in the image of a given object, although the procedure does not follow the same rules as it does for a non-sampled imaging system.

This International Standard also specifies MTFs for the sub-units, or imaging stages, which make up such a system. These also satisfy the above criteria.

A very important aspect of sampled imaging systems is the "aliasing" that can be associated with them. The importance of this is that it allows spatial frequency components higher than the Nyquist frequency to be reproduced in the final image as spurious low frequency components. This gives rise to artefacts in the final image that can be considered as a form of noise. The extent to which this type of noise is objectionable will depend on the characteristics of the image being sampled. For example, images with regular patterns at spatial frequencies higher than the Nyquist frequency (e.g. the woven texture on clothing) can produce very visible fringe patterns in the final image, usually referred to as moiré fringes. These are unacceptable in most applications if they have sufficient contrast to be visible to the observer. Even in the absence of regular patterns, aliasing will produce noise-like patterns that can degrade an image.

A quantitative measure of aliasing can be obtained from MTF measurements made under specified conditions. This International Standard defines such measures and describes the conditions of measurement.

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1 Scope

This International Standard specifies the principal MTFs associated with a sampled imaging system, together with related terms, and outlines a number of suitable techniques for measuring these MTFs. It also defines a measure for the “aliasing” related to imaging with such systems.

This International Standard is particularly relevant to electronic imaging devices such as digital still and video cameras and the detector arrays they embody.

Although a number of MTF measurement techniques are described, the intention is not to exclude other techniques, provided they measure the correct parameter and satisfy the general definitions and guidelines for MTF measurement as set out in ISO 9334 and ISO 9335. The use of a measurement of the edge spread function, rather than the line spread function (LSF), is noted in particular as an alternative starting point for determining the OTF/MTF of an imaging system.

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 9334, *Optics and photonics — Optical transfer function — Definitions and mathematical relationships*

ISO 9335, *Optics and photonics — Optical transfer function — Principles and procedures of measurement*

ISO 11421, *Optics and optical instruments — Accuracy of optical transfer function (OTF) measurement*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document the terms and definitions given in ISO 9334 and the following apply.

3.1.1

sampled imaging system

imaging system or device, where the image is generated by sampling the object at an array of discrete points, or along a set of discrete lines, rather than a continuum of points

NOTE 1 The sampling at each point is done using a finite size sampling aperture or area.

NOTE 2 For many devices “the object” is actually an image produced by a lens or other imaging system (e.g. when the device is a detector array).