IEC 61300-3-53

Edition 1.0 2015-02

# INTERNATIONAL STANDARD

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## Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-53: Examinations and measurements – Encircled angular flux (EAF) measurement method based on two-dimensional far field data from step index multimode waveguide (including fibre)



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International Standard IEC 61300-3-53 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 86B/3850/FDIS | 86B/3875/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61300 series, published under the general title, *Fibre optic interconnecting and passive components – Basic test and measurement procedures,* can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
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# FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

# Part 3-53: Examinations and measurements – Encircled angular flux (EAF) measurement method based on two-dimensional far field data from step index multimode waveguide (including fibre)

## 1 Scope

This part of IEC 61300 is intended to characterize the encircled angular flux of measurement step index multimode waveguide light sources, in which most of the transverse modes are excited. The term waveguide is understood to include both channel waveguides and optical fibres but not slab waveguides in this standard.

Encircled angular flux (EAF) is the fraction of the total optical power radiating from a step index multimode waveguide's core within a certain solid angle. The EAF is measured as a function of the numerical aperture full angle. The basic approach is to collect, for every measurement, two dimensional far field data using a calibrated camera and to convert them mathematically into encircled angular flux.



## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.



IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

## 3 Terms and definitions

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

**3.1**
**encircled angular flux**
EAF
fraction of the total optical power radiating from a step index multimode waveguide's core within a certain solid angle

**3.2**
***fθ* lens**
lens converting the angle of incidence of the input beam, $\theta$, into the output beam height, $h$

Note 1 to entry: The relationship between them is $h = f\theta$, where $f$ is the focal length of the lens.

**3.3**
**numerical aperture**
NA
sine of the vertex half-angle of the largest cone of meridional rays that can enter or leave the core of an optical waveguide, multiplied by the refractive index of the medium in which the cone is located.

**3.4**
**far field pattern**
FFP
angular distribution of light radiating from a waveguide's core, which corresponds to the optical power distribution on a plane normal to the waveguide axis some distance from its end facet.

Note 1 to entry: The distance depends on the largest waveguide cross section, $a$, the wavelength, lambda and the angle, $\varphi$, to the optical axis. It is abbreviated to FFP. In the far field region the shape of the distribution does not change as the distance from the waveguide end facet increases; the distribution only scales in size with distance, $L$.

$$L >> \frac{2a^2(\cos\varphi)^2}{\lambda}$$

**3.5**
**far field image**
far field pattern formed on an imaging device

**3.6**
**centroid**
optical centre of the far field image

**3.7**
**neutral density filter**
ND
filter that attenuates light of all colours equally



## 4 Standard atmospheric conditions

The standard atmospheric conditions are specified in IEC 61300-1.

## 5 Apparatus

### 5.1 General

The optical source multimode waveguide shall be long enough to ensure that all cladding modes are stripped by passage through the waveguide. Often the fibre coating or tight buffer is sufficient to perform this function. Alternatively a cladding mode stripper shall be used in the source launch optical multimode fibre. An example of a typical cladding mode stripper which would be suitable for optical fibre is sufficient windings of the fibre around a mandrel of an appropriate diameter. The windings also have a more important essential effect to fully fill the transverse modes across the maximum mode field diameter. It should be checked that all of the transverse modes of the fibre are sufficiently well excited. This can be done by comparing the FFPs for different lengths of the launch fibre or different light sources. Once the FFP no longer changes in form as the launch fibre length is increased there is no need to increase the length further.

### 5.2 Measurement method 1: *fθ* lens imaging

#### 5.2.1 General

In theory, this measurement method, which is effectively a coherent optical method to Fourier Transform the near field to the far field using a lens, does not operate well using very wideband optical sources. Experimentally it has been shown to operate sufficiently well for sources up to 30 nm bandwidth which are most commonly used.

Figure 1 below shows the apparatus configuration. The measurement system consists of a micro-positioner, a far field broadband optical system, a camera and computer (beam analysis module). An appropriate type of camera (detector) should be chosen to suit the wavelength.

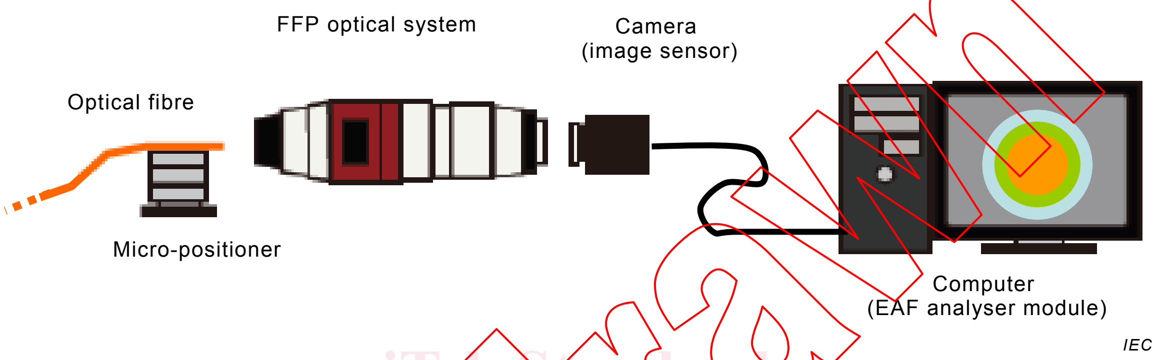


**Figure 1 – Apparatus configuration: Measurement method 1: *fθ* lens imaging**



#### 5.2.2 Micro-positioner

The micro-positioner shall have a function of fixing an optical waveguide and moving in three directions (X, Y, Z). In addition yaw and pitch controls are recommended.

#### 5.2.3 FFP optical system

As shown in Figure 2, basically, an *fθ* lens can directly convert input the light from the multimode waveguide to a far field image, however, scaling the far field image in order to fit the image sensor in the camera and adjustment of the light intensity in order to prevent saturation may be required. The FFP optical system shall be chosen to operate at the measurement wavelength across the required measurement bandwidth to match that of the detection system. See Annex A for more information.

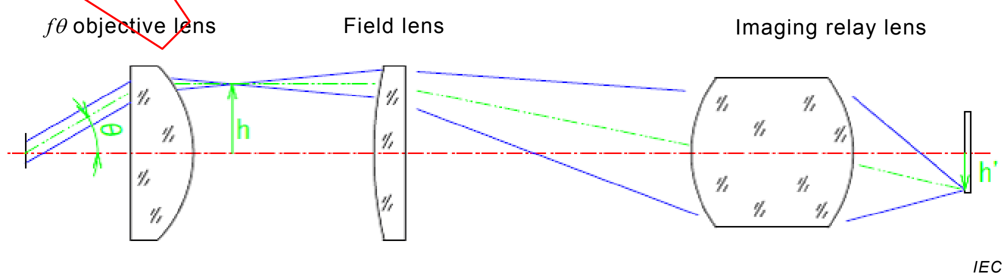


**Figure 2 – Far field optical system diagram**

#### 5.2.4 Camera

Although, the detector is typically a charge-coupled device (CCD) or a complementary metal oxide semiconductor (CMOS) camera, other types of array cameras may be considered. The type of image sensor shall be chosen by the measurement wavelength. Absolute radiometric measurement of flux (optical power flow) is not required.