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INTERNATIONAL STANDARD

colour inside

Fibre optic interconnecting devices and passive components – Fibre optic circulators – Generic specification

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC CIRCULATORS – GENERIC SPECIFICATION

FOREWORD

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IEC 62077 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) harmonization of terms and definitions with IEC TS 62627-09;

b) change of Clause 4 regarding requirements.

The text of this International Standard is based on the following documents:

Draft	Report on voting
86B/4624/FDIS	86B/4645/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC CIRCULATORS – GENERIC SPECIFICATION

1 Scope

This document applies to circulators used in the field of fibre optics bearing all of the following features:

– they are non-reciprocal optical devices, in which each port is either an optical fibre or fibre optic connector;

– they are passive devices in accordance with the categorization and definition provided in IEC TS 62538;

– they have three or more ports for directionally transmitting optical power.

An example of optical circulator technology and application is described in Annex A and Annex B, respectively.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*, available at http://www.electropedia.org

IEC 60617, *Graphical symbols for diagrams*, available at http://std.iec.ch/iec60617

~~IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*~~

IEC 60825 (all parts), *Safety of laser products*

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components – Basic tests and measurement procedures*

IEC TR 61930, *Fibre optic graphical symbology*

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices*

ISO 129-1, *Technical ~~drawings~~ product documentation (TPD) – ~~Indication~~ Presentation of dimensions and tolerances – Part 1: General principles*

ISO 286-1, *Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 1: Basis of tolerances, deviations and fits*

ISO 1101, *Geometrical product specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out*

~~ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*~~

ISO 8601-1, *Date and time – Representations for information interchange – Part 1: Basic rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-731, IEC TS 62627-09 and the following apply.

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

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

~~**3.1 Basic terms**~~

~~**3.1.1**~~
~~**port**~~
~~optical fibre or optical fibre connector attached to a passive component for the entry and/or exit of the optical power~~

~~**3.1.2**~~
~~**transfer matrix**~~
~~$n \times n$ matrix of coefficients where n is the number of ports, and the coefficients represent the fractional optical power transferred between designated ports~~

~~Note 1 to entry: In general, the transfer matrix T is:~~

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdots & t_{1n} \\ & t_{22} & & \\ & & t_{ij} & \\ t_{n1} & t_{n2} & & t_{nn} \end{bmatrix} \quad (1)$$

~~where~~

~~t_{ij} is the ratio of the optical power P_{ij} transferred out of port j with respect to input power P_i into port i, that is:~~

$$t_{ij} = \frac{P_{ij}}{P_i} \quad (2)$$

~~**3.1.3**~~
~~**transfer coefficient**~~
~~element t_{ij} of the transfer matrix~~

~~**3.1.4**~~
~~**logarithmic transfer matrix**~~
~~$n \times n$ matrix of logarithmic transfer coefficients of a_{ij} where n is the number of ports~~

~~Note 1 to entry: In general, the logarithmic transfer matrix A is:~~

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ & a_{22} & & \\ & & a_{ij} & \\ a_{n1} & a_{n2} & & a_{nn} \end{bmatrix} \quad (3)$$

where a_{ij} is the optical power reduction, in decibels, out of port j with unit power into port i, that is:

$$a_{ij} = -10\log_{10} t_{ij} \quad (4)$$

where t_{ij} is the transfer matrix coefficient.

3.1.5
conducting port pair
two ports i and j between which t_{ij} is nominally greater than zero

3.1.6
isolated port pair
two ports i and j between which t_{ij} is nominally zero, and a_{ij} is nominally infinite

3.1 Component terms

3.1.1
fibre optic circulator
passive component possessing three or more ports which input and output are cyclic

Note 1 to entry: In the case of 3 ports circulator with port 1, port 2 and port 3, supposing optical power is transmitted from port 1 to port 2, optical power from port 2 is transmitted to port 3.

[SOURCE: IEC TS 62627-09:2016, 3.3.5, modified – The words "passive optical device (component)" have been replaced with "passive component".]

3.1.2
completely circulated type
type of circulator where all ports ~~can~~ function as both input and output

Note 1 to entry: In the case of a 3 port circulator with port 1, port 2 and port 3, where optical power is transmitted from port 1 to port 2, optical power from port 2 is also transmitted to port 3 and optical power from port 3 is also transmitted to port 1 (see Figure 1).

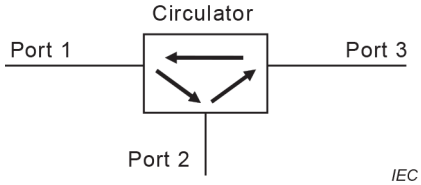


Figure 1 – Completely circulated type configuration

3.1.3
incompletely circulated type
type of circulator where a port is either an input or an output

Note 1 to entry: In the case of 3 ports circulator with port 1, port 2 and port 3, supposing optical power is transmitted from port 1 to port 2, optical power from port 2 is transmitted to port 3 and optical power from port 3 is not transmitted to port 1 (see Figure 2).

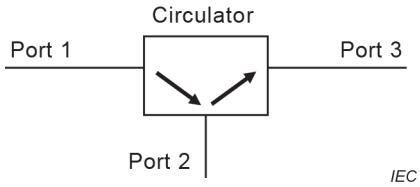


Figure 2 – Incompletely circulated type configuration

3.2 Performance ~~parameters~~ terms

3.2.1
insertion loss

~~element a_{ij} of the logarithmic transfer matrix of an input port i and output port j to which optical power is transmitted~~

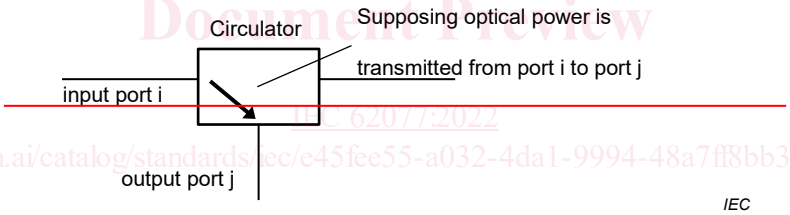
~~Note 1 to entry: The insertion loss is the reduction in optical power between an input and output port of a passive component (see Figure 3), expressed in decibels and defined as follows:~~

$$a_{ij} = 10\log_{10}\left(\frac{P_j}{P_{in}}\right) \quad (5)$$

~~where~~

~~P_{in} is the optical power launched into the input port;~~

~~P_j is the optical power received from the output port~~



~~Figure 3 – Insertion loss~~

attenuation
reduction of optical power in an operating wavelength range, when transmitted from an input port to an output port for a fibre optic circulator

Note 1 to entry: The insertion loss (attenuation) is expressed in decibels and defined as:

$$a_{ij} = -10\log_{10}\left(\frac{P_j}{P_i}\right)$$

where

P_i is the optical power launched into the input port;

P_j is the optical power received from the output port.

Note 2 to entry: Figure 3 shows the insertion loss (attenuation) for fibre optic circulators.

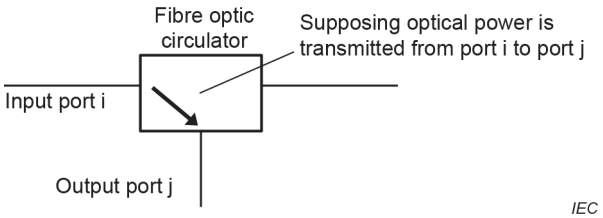


Figure 3 – Insertion loss

Note 3 to entry: The insertion loss (attenuation) is wavelength, polarization, temperature and port pair dependent. Generally, the insertion loss is the maximum value over operating wavelength range, all polarization state and all conducting port pairs.

3.2.2
isolation

~~element a_{ji} of the logarithmic transfer matrix of an output port j and input port i to which optical power is transmitted in the direction opposite to the insertion loss~~

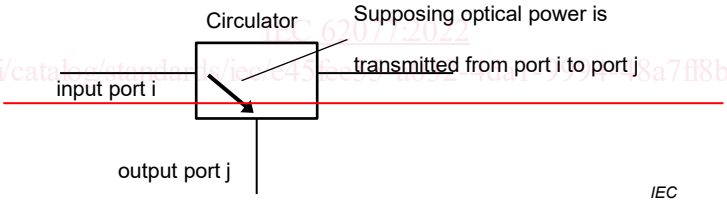
~~Note 1 to entry: The isolation is the reduction in optical power between an input and output port of a passive component, expressed in decibels and defined as follows:~~

$$~~a_{ji} = 10\log_{10}\left(\frac{P_i}{P_j}\right)~~ \quad (6)$$

~~where~~

~~P_i is the optical power received from the input port;~~

~~P_j is the optical power launched into the output port~~



~~**Figure 4 – Isolation**~~

reduction of optical power in an operating wavelength range, when transmitted from an output port to an input port for a fibre optic circulator

Note 1 to entry: The isolation is expressed in decibels and defined as follows:

$$a_{ji} = -10\log_{10}\left(\frac{P_i}{P_j}\right)$$

where

P_i is the optical power received from the input port;

P_j is the optical power launched into the output port.

Note 2 to entry: Figure 4 shows the isolation for fibre optic circulators.

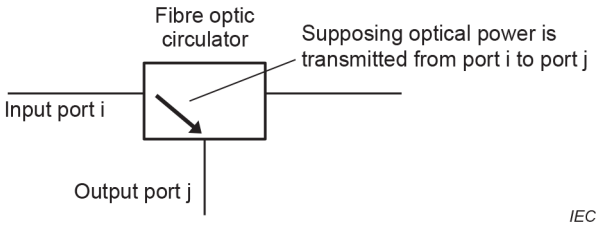


Figure 4 – Isolation

Note 3 to entry: The isolation is wavelength, polarization, temperature and port pair dependent. Generally, the isolation is the minimum value over operating wavelength range, all polarization state and all isolated port pairs.

~~**3.3.3**~~
~~**directivity**~~
~~element a_{ik} of the logarithmic transfer matrix port i and port k, which are not port pair for insertion loss (IL), return loss (RL) or isolation (Iso)~~

~~Note 1 to entry: For example, the transmission matrix for a 4-port incompletely circulated type optical circulator, the symbol *Dir* indicates directivity as in Equation (7).~~

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} = \begin{bmatrix} RL & IL & Dir & Dir \\ Iso & RL & IL & Dir \\ Dir & Iso & RL & IL \\ Dir & Dir & Iso & RL \end{bmatrix} \quad (7)$$

~~where~~

~~*Dir* is the directivity;~~

~~*IL* is the insertion loss;~~

~~*Iso* is the isolation;~~

~~*RL* is the return loss.~~

~~**3.3.4**~~
~~**operating wavelength**~~
~~nominal wavelength, λ, at which a passive component is designed to operate with the specified performance~~

~~**3.3.5**~~
~~**operating wavelength range**~~
~~specified range of wavelengths from $\lambda_{i\,min}$ to $\lambda_{i\,max}$ close to a nominal operating wavelength λ_i, within which a passive component is designed to operate with the specified performance~~

~~**3.3.6**~~
~~**return loss**~~
~~element a_{ii} in Equation (8) of the logarithmic transfer matrix~~

~~Note 1 to entry: It is the fraction of the input power that is returned from the input port of a passive component and defined as:~~

$$a_{ii} = 10\log_{10}\left(\frac{P_{refl}}{P_i}\right) \quad (8)$$

~~where~~

~~P_i is the optical power launched into the i port;~~

~~P_{refl} is the optical power received back from i port~~

4 Requirements

4.1 Classification

4.1.1 General

Fibre optic circulators ~~shall be~~ are classified ~~as follows~~ either totally or in part in the following categories:

~~– type;~~

~~– style;~~

~~– variant;~~

~~– normative reference extensions.~~

– technology;

– port numbers;

– circulated type;

– wavelength band;

– interface style.

An example of a typical fibre optic circulator classification is given in Table 1.