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Edition 3.0 2015-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Dispositifs d'interconnexion et composants passifs fibroniques – Circulateurs fibroniques – Spécification générique

IEC 62077:2015-11(en-fr)

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

FOREWORD

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

This bilingual version (2019-09) corresponds to the monolingual English version, published in 2015-11.

This third edition cancels and replaces the second edition published in 2010. This edition constitutes a technical revision.

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

a) harmonization of some terms and definitions with other generic specifications,
b) deletion of assessment level.

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

CDV	Report on voting
86B/3862/CDV	86B/3918/RVC

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

The French version of this standard has not been voted upon.

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

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

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

1 Scope

This International Standard 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 is described in Annex A.

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 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*

IEC TR 61930, *Fibre optic graphical symbology*

ISO 129-1, *Technical drawings – Indication 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*

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3 Terms and definitions

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

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:

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

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.

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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

3.2 Component terms

3.2.1
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.

3.2.2
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).

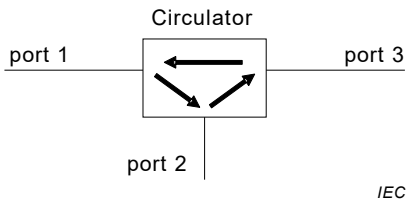

Figure 1 – Completely circulated type configuration

3.2.3
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).

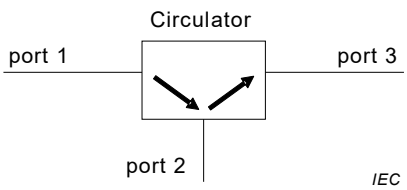

Figure 2 – Incompletely circulated type configuration

3.3 Performance parameters

3.3.1
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:

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

where

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

P_j is the optical power received from the output port

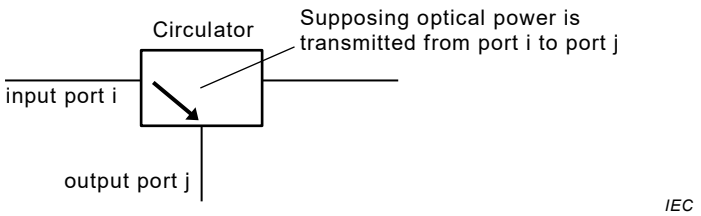

Figure 3 – Insertion loss

3.3.2
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

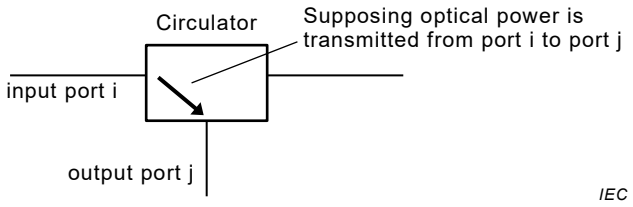

Figure 4 – Isolation

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).

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

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 classified as follows:

– type;
– style;
– variant;
– normative reference extensions.

An example of a typical circulator classification is given in Table 1:

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Table 1 – Example of a typical circulator set classification

Type:	– Three port circulator
	– Completely circulated type
	– Operating wavelength range: O-band
Style:	– Configuration: B
	– Connector type: SC
	– Fibre type: IEC Category B 1.2
Variants:	– Means of mounting

4.1.2 Type

Circulators are mainly divided into types according to their configuration.

- Port numbers;
- Circulated type:
  - completely circulated type;
  - incompletely circulated type;
- Operational principles:
  - magneto-optic Faraday effect;
  - magneto-optic Cotton-Mouton effect and Kerr effect;
- Operating wavelength range:
  - O-band;
  - C-band;
  - L-band;
  - other wavelength circulators.

4.1.3 Style

Optical circulators may be classified into styles based upon fibre type(s), connector type(s), cable type(s), housing shape and dimensions, and configuration.

The configuration of the circulator ports is classified as follows (See Figure 5):

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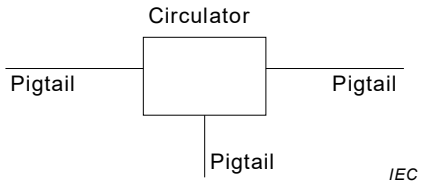
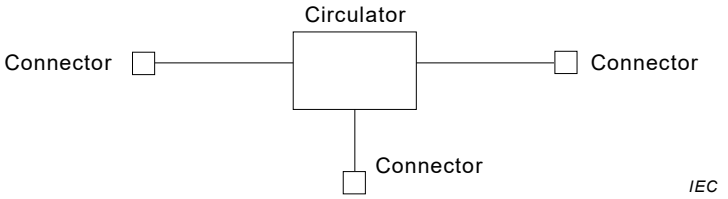
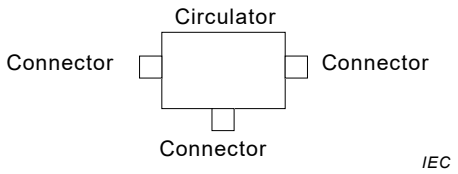


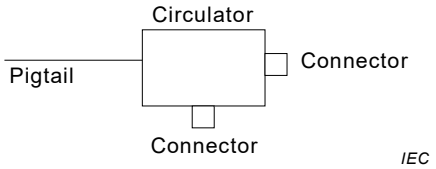
a) Configuration A – Device containing integral fibre optic pigtails without a connector



b) Configuration B – Device containing integral fibre optic pigtails, with a connector on each pigtail



c) Configuration C – Device containing connectors as an integral part of the device housing



d) Configuration D Example – Device containing some combination of the interfacing features of the preceding configurations

Figure 5 – Optical circulator style configurations

4.1.4 Variant

The circulator variant identifies those common features which encompass structurally similar components. Examples of features which define a variant include, but are not limited to, the following:

– position and orientation of ports on housing;

– means of mounting.

4.1.5 Normative reference extensions

Normative reference extensions are used to identify integrated independent standards specifications or other reference documents as relevant specifications.

Unless otherwise specified, additional requirements of extensions are mandatory. Usage is primarily intended to merge associated components to form hybrid devices, or integrated functional application requirements that are dependent on technical expertise other than fibre optics.

Some optical fibre circulator configurations require special qualification provisions which shall not be imposed universally. This accommodates individual component design configurations, specialized field tooling or specific application processes. In this case, the requirements are necessary to assure repeatable performance or adequate safety, and provide additional

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guidance for complete product specification. These extensions are mandatory whenever used to prepare, assemble or install an optical fibre circulator, either for field application usage or preparation of qualification test specimens. The relevant specification shall clarify all stipulations. However, design and style dependent extensions shall not be imposed universally.

In the event of conflicting requirements, precedence shall be given, in descending order, as follows: generic over mandatory extension, over relevant, over detail, over application specific extension.

Examples of requirements to normative extensions:

– some commercial or residential building applications may require direct reference to specific safety codes and regulations or incorporate other specific material flammability or toxicity requirements for specialized locations;
– specialized field tooling may require an extension to implement specific ocular safety, electrical shock, burn hazard avoidance requirements, or require isolation procedures to prevent potential ignition of combustible gases.

4.2 Documentation

4.2.1 Symbols

Graphical and letter symbols shall, whenever possible, be taken from the IEC 60027 series, IEC 60617 and IEC TR 61930.

4.2.2 Specification system

4.2.2.1 General

This generic specification is part of a three-level IEC specification system. Subsidiary specifications shall consist of relevant specifications. This system is shown in Table 2. There are no sectional specifications for circulators.

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