IEC 62077

Edition 2.0 2010-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Dispositifs d'interconnexion et composants passifs à fibres optiques – Circulateurs à fibres optiques – Spécification générique

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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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 second edition cancels and replaces the first edition published in 2001. It constitutes a technical revision.

The changes with respect to the previous edition are listed below:

– having substantially increased the number of terms;
– having added an informative annex for example of filtering technologies;
– having deleted quality assessment procedures.

This bilingual version, published in 2010-12, corresponds to the English version.

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

CDV	Report on voting
86B/2871/CDV	86B/2950/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.

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 web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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 62538;

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

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For update 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 (IEV) – Chapter 731: Optical fibre communication*

IEC 60617-SN, *Graphical symbols for diagrams*

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

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

IEC/TR 61282-9, *Fibre optic communication system design guides – Part 9: Guidance on polarization mode dispersion measurements and theory*

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components*

IEC 61930, *Fibre optic graphic symbology*

IEC/TS 62538, *Categorization of optical devices*

IEC Guide 102, *Electronic components – Specification structures for quality assessment (Qualification approval and capability approval)*

IECQ 01, *IEC Quality Assessment System for Electronic Components (IECQ Scheme) – Basic Rules*

IECQ 001002-3, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure – Part 3: Approval procedures*

ISO 129-1, *Technical drawings – Indication of dimensions and tolerances – Part 1: General principles*

ISO 286-1, *ISO system of limits and fits – Part 1: Bases 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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050(731), together with the following definitions, 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
optical properties of a fibre optic circulator can be defined in terms of an n × n matrix of coefficients where n is the number of ports, and the coefficients represent the fractional optical power transferred between designated ports

NOTE In general, the transfer matrix T is:

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

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:

$$t_{ij} = P_{ij}/P_i$$

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

3.1.4
logarithmic transfer matrix
in general, the logarithmic transfer matrix is as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \ldots & a_{1n} \\ & a_{22} & & \\ & & a_{ij} & \\ a_{n1} & a_{n2} & & a_{nn} \end{bmatrix}$$

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

$$a_{ij} = -10 \log t_{ij}$$

where t_{ij} is the transfer matrix coefficient

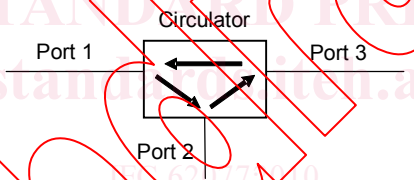
3.1.5
conducting ports
two ports i and j between which t_{ij} is nominally greater than zero

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

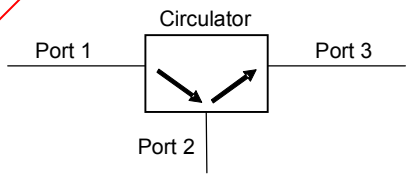
3.2 Component terms

3.2.1
fibre optic circulator
passive component possessing three or more ports which input and output are cyclic. 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 which all ports is input and output. 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 transmitted to port 1



3.2.3
incompletely circulated type
type of circulator which a port is input or output. 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



3.3 Performance parameters

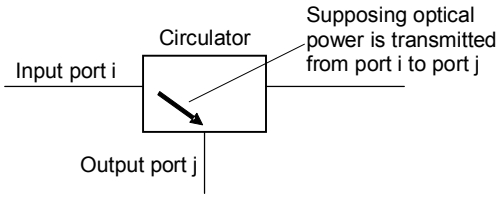
3.3.1
insertion loss
element a_{ij} of the logarithmic transfer matrix of an input port i and output port j which optical power is transmitted. It is the reduction in optical power between an input and output port of a passive component expressed in decibels and defined as follows:

$$a_{ij} = -10 \log (P_j/P_i)$$

where

P_i is the optical power launched into the input port;

P_j is the optical power received from the output port



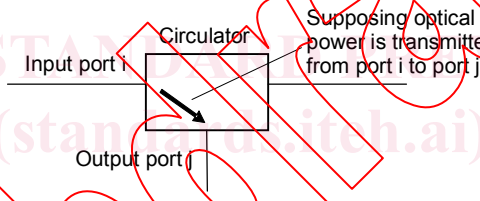
3.3.2
isolation
element a_{ji} of the logarithmic transfer matrix of an output port j and input port i which optical power is transmitted direction opposite to the insertion loss. It is the reduction in optical power between an input and output port of a passive component, expressed in decibels and defined as follows:

$$a_{ji} = -10 \log (P_i/P_j)$$

where

P_i is the optical power received from the input port;

P_j is the optical power launched into the output port



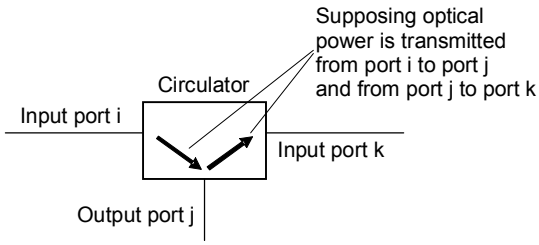
3.3.3
directivity
element a_{ik} of the logarithmic transfer matrix of an port i and port k which optical power is not transmitted. It is the reduction in optical power between i port and k port of a passive component expressed in decibels and defined as follows:

$$a_{ik} = -10 \log (P_k/P_i)$$

where

P_i is the optical power launched into the input port;

P_k is the optical power received from the output port



3.3.4
polarization dependent loss
PDL
for polarization independent circulators, the maximum variation of insertion loss for any state of polarization of P_j

3.3.5
polarization mode dispersion
PMD
the variation of the differential group delay (DGD) over the bandpass wavelength (or frequency) range in accordance with IEC/TR 61282-9

3.3.6
operating wavelength
nominal wavelength, λ, at which a passive component is designed to operate with the specified performance

3.3.7
operating wavelength range;
bandpass
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

3.3.8
return loss
element a_{ij} (where i = j) of the logarithmic transfer matrix. It is the fraction of the input power that is returned from the input port of a passive component. It is defined as:

$$a_{ij} = -10 \log (P_{refl}/P_i)$$

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;
– assessment level;
– normative reference extensions.

An example of a typical circulator classification is as follows:

Table 1 – Example of a typical circulator set classification

Type:	– Three port circulator
	– Completely circulated type
	– Operating wavelength: 1 310 nm
Style:	– Configuration: B
	– Connector type: FC
	– Fibre type: IEC type B 1,2
Variants:	– Means of mounting
Assessment level:	– ……
Normative reference extensions:	– ……

4.1.2 Type

Circulators are mainly divided into types by their configuration.

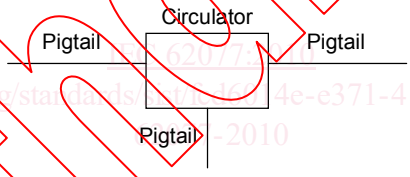
- Port numbers:
- Circulated type:
  - completely circulated type;
  - un-completely circulated type;
- By their operational principles:
  - magneto-optic Faraday effect;
  - magneto-optic Cotton-Mouton effect and Kerr effect.
- By their operating wavelength:
  - short wavelength circulators (e.g. 630 nm);
  - long wavelength circulators (e.g. 1 310 nm, 1 550 nm);
  - other wavelength circulators.

4.1.3 Style

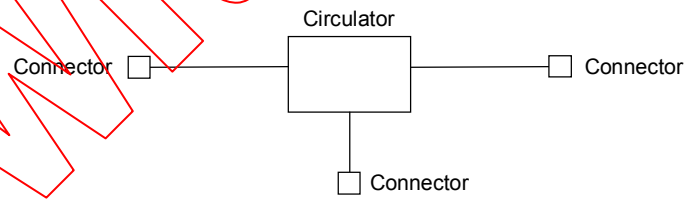
Optical circulators may be classified into styles based upon fibre type(s), connector type(s), cable type(s), housing shape and dimensions, and configuration.

The configuration of the circulator ports is classified as follows:

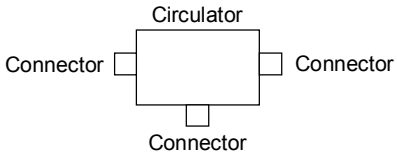
Configuration A – Device containing integral fibre optic pigtails without connector:



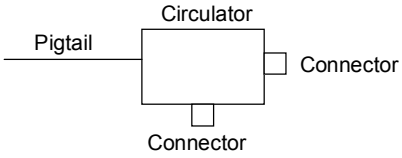
Configuration B – Device containing integral fibre optic pigtails, with a connector on each pigtail:



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



Configuration D – Device containing some combination of the interfacing features of the preceding configurations, for example:



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 Assessment level

Assessment level defines the inspection levels and the acceptable quality level (AQL), of groups A and B and the periodicity of inspection of groups C and D. Relevant specifications shall specify one or more assessment levels, each of which shall be designated by a capital letter.

The following are preferred levels:

– assessment level A:
  - group A inspection: inspection level II, AQL = 4 %
  - group B inspection: inspection level II, AQL = 4 %
  - group C inspection: 24-month periods
  - group D inspection: 48-month periods
– assessment level B:
  - group A inspection: inspection level II, AQL = 1 %
  - group B inspection: inspection level II, AQL = 1 %
  - group C inspection: 18-month periods
  - group D inspection: 36-month periods
– assessment level C:
  - group A inspection: inspection level II, AQL = 0,4 %
  - group B inspection: inspection level II, AQL = 0,4 %
  - group C inspection: 12-month periods
  - group D inspection: 24-month periods

One additional assessment level may be added in the relevant specification. When this is done, the capital letter X shall be used.

4.1.6 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 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 optical connector extensions are given as follows:

- using IEC 61754-4 and IEC 61754-2 to partially define a future specification of the IEC 60874 series for a duplex type “SC/BFOC/2,5” hybrid connector adapter;
- using IEC 61754-13 and IEC 60869-1 to partially define a future specification of the IEC 60874 series for an integrated type “FC” preset attenuated optical connector;
- using IEC 61754-2 and IEC 61073-4 to partially define a future specification of the IEC 60874 series for a duplex “BFOC/2,5” receptacle incorporating integral mechanical splices.

Other 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 61930.

4.2.2 Specification system

4.2.2.1 General

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

Table 2 – The IEC specification structure

Specification level	Examples of information to be included	Applicable to
Basic	– Assessment system rules – Inspection rules – Optical measurement methods – Environmental test methods – Sampling plans – Identification rule – Marking standards – Dimensional standards – Terminology – Symbol standards – Preferred number series – SI units	Two or more component families or sub-families
Generic	– Specific terminology – Specific symbols	Component family