IEC 62077

Edition 3.0 2015-11

INTERNATIONAL STANDARD

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

IEC 62077:2015-11(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC 62077

Edition 3.0 2015-11

INTERNATIONAL STANDARD

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 33.180.20

ISBN 978-2-8322-2988-0

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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 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.

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.

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

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

A bilingual version of this publication may be issued at a later date.

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*

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:

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

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:

$$t_{ij} = \frac{P_{ij}}{P_i} \tag{2}$$

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:

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

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

$$a_{ij} = -10 \log_{10} t_{ij} \tag{4}$$

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

3.2 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).

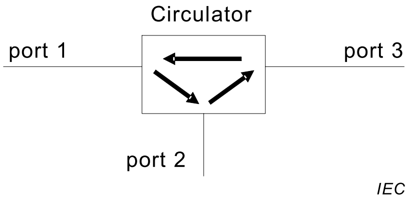


Figure 1 – Completely circulated type configuration

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).

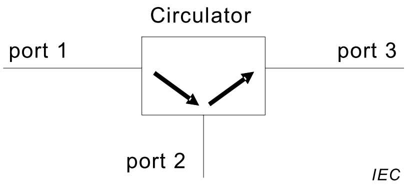


Figure 2 – Incompletely circulated type configuration

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:

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

where

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

P_j is the optical power received from the output port

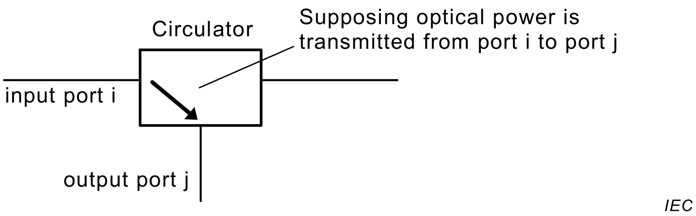


Figure 3 – Insertion loss

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:

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

where

P_i is the optical power received from the input port;

P_j is the optical power launched into the output port

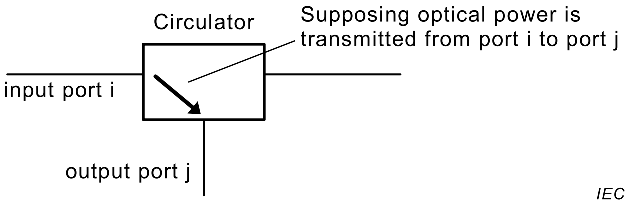


Figure 4 – Isolation

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).

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

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:

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

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:

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

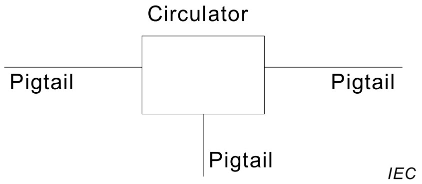
Circulators are mainly divided into types according to their configuration.

- 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.

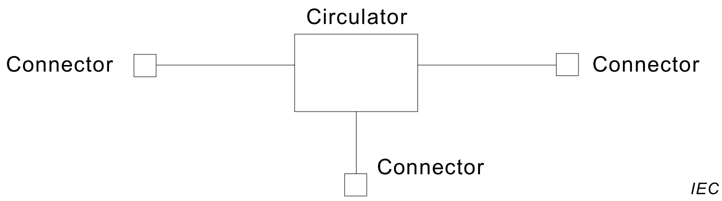
4.1.3 Style

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

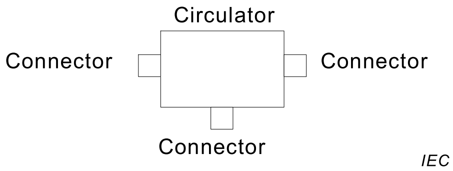
The configuration of the circulator ports is classified as follows (See Figure 5):



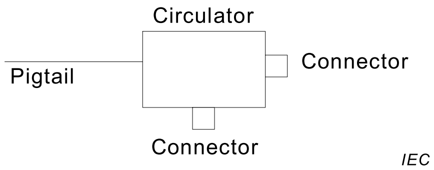
a) Configuration A – Device containing integral fibre optic pigtails without a connector



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 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.

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 – Specific units – Preferred values – Marking – Selection of tests – Capability approval procedures	Component family
Blank detail	– Quality conformation test schedule – Inspection requirements – Information common to a number of types	Groups of types and/or styles having a common test schedule
Detail	– Individual values – Specific information – Completed quality conformance test schedules	Individual component(s)

4.2.2.2 Blank detail specifications

The blank detail specification lists all of the parameters and features applicable to a fibre optic circulator, including the type, operating characteristics, housing configurations, test methods, and performance requirements. The blank detail specification is applicable to any fibre optic circulator design and quality assessment requirement. The blank detail specification contains the preferred format for stating the required information in the detail specification.

Blank detail specifications are not, by themselves, a specification level. They are associated with the generic specification.

Each blank detail specification shall be limited to one environmental category.

Each blank detail specification shall contain:

- the minimum mandatory test schedules and performance requirements,
- the preferred format for stating the required information in the detail specification,
- in case of hybrid components, including connectors, addition of appropriate entry fields to show the reference normative document, document title and issue date.

4.2.2.3 Detail specifications

A specific circulator is described by a corresponding detail specification, which is prepared by filling in the blanks of the blank detail specification. Within the constraints imposed by this generic specification, the blank detail specification may be filled in by any national committee of the IEC, thereby defining a particular circulator as an IEC standard.

Detail specifications shall specify the following, as applicable:

– type (see 4.1.2);
– style (see 4.1.3);
– variant(s) (see 4.1.4);
– part identification number for each variant (see 4.6.2);
– drawings, dimensions required (see 4.2.3);
– test schedules (see 4.2.5);
– performance requirements (see 4.5).

4.2.3 Drawings

4.2.3.1 General

The drawings and dimensions given in relevant specifications shall not restrict themselves to details of construction, nor shall they be used as manufacturing drawings.

4.2.3.2 Projection system

Either first-angle or third-angle projection shall be used for the drawings in documents covered by this generic specification. All drawings within a document shall use the same projection system and the drawings shall state which system is used.

4.2.3.3 Dimensional system

All dimensions shall be given in accordance with ISO 129-1, ISO 286-1 and ISO 1101.

The metric system shall be used in all specifications.

Dimensions shall not contain more than five significant digits.

Conversion between systems of units shall be done correctly. When units are converted, a note shall be added in each relevant specification. Conversion between metric and imperial units shall use a factor of 25,4 mm to 1 inch.

4.2.4 Tests and measurements

4.2.4.1 Test and measurement procedures

The test and measurement procedures for optical, mechanical, climatic, and environmental characteristics of circulators to be used shall be defined and selected preferably from the IEC 61300 series.

The size measurement method to be used shall be specified in the relevant specification for dimensions which are specified within a total tolerance zone of 0,01 mm or less.

4.2.4.2 Reference components

Reference components, if required, shall be specified in the relevant specification.

4.2.4.3 Gauges

Gauges, if required, shall be specified in the relevant specification.

4.2.5 Test reports

Test reports shall be prepared for each test conducted as required by a relevant specification. The reports shall be included in the qualification report and in the periodic inspection report.

Reports shall contain the following information:

– title of test and date;
– specimen description including the type of fibre, connector or other coupling device. The description shall also include the variant identification number (see 4.6.2);
– test equipment used and date of latest calibration;
– all applicable test details;
– all measurement values and observations;
– sufficiently detailed documentation to provide traceable information for failure analysis.

4.2.6 Instructions for use

Instructions for use, when required, shall be given by the manufacturer and shall include:

– assembly and connection instructions;
– cleaning method;
– safety aspects;
– additional information, as necessary.

4.3 Standardization system

4.3.1 Interface standards

Interface standards provide both manufacturer and user with all the information required to make or use the product in conformity with the physical features of that standard interface. Interface standards fully define the features essential for the mating and unmating of optical fibre connectors and other components. They also serve to position the optical datum target, where defined, relative to other reference datum.

Interface standards ensure that connectors and adapters that comply with the standard will fit together. The standards may also contain tolerance grades for ferrules and alignment devices. Tolerance grades are used to provide different levels of alignment precision.

The interface dimensions may also be used to design other components that will mate with the connectors. For example, an active device mount can be designed using the adapter interface dimensions. The use of these dimensions combined with those of a standard plug provides the designer with assurance that the standard plugs will fit into the optical device mount. They also provide the location of the plug's optical datum target.

Standard interface dimensions do not, by themselves, guarantee optical performance. They guarantee connector mating at a specified fit. Optical performance is currently guaranteed via the manufacturing specification. Products from the same or different manufacturing specifications using the same standard interface will always fit together. Guaranteed performance can be given by any single manufacturer only for product delivered to the same manufacturing specification. However, it can be reasonably expected that some level of performance will be obtained by mating a product from different manufacturing specifications, although the level of performance cannot be expected to be any better than that of the lowest specified performance.

4.3.2 Performance standards

Performance standards contain a series of tests and measurements (which may or may not be grouped into a specified schedule depending on the requirements of that standard) with clearly defined conditions, severities, and pass/fail criteria. The tests are intended to be run on a "one-off" basis to prove the ability of a given product to satisfy the "performance standards" requirement. Each performance standard has a different set of tests and/or severities (and/or groupings) that represents the requirements of a market sector, user group or system location.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with a performance standard but should then be controlled by a quality assurance/quality conformance programme.

It is possible to define a key point of the test and measurements standards when these are applied (particularly with regard to insertion loss and return loss) in conjunction with the interface standards of inter-product compatibility. This ensures conformance of each individual product to this standard.

4.3.3 Reliability standards

Reliability standards are intended to ensure that a component can meet performance specifications under stated conditions for a stated time period.

For each type of component, the following shall be identified (and appear in the standard):

- failure modes (observable general mechanical or optical effects of failure);
- failure mechanisms (general causes of failure, which may be common to several components);
- failure effects (detailed causes of failure, specific to component).

These are all related to environmental and material aspects.

Initially, just after component manufacture, there is an "infant mortality phase" during which many components would fail if they were deployed in the field. To avoid early field failure, all components may be subjected to screen process in the factory, involving environmental stresses that may be mechanical, thermal and humidity-related. This is to induce known failure mechanisms in a controlled environmental situation to occur earlier than would normally be seen in the unscreened population. For those components that survive (and are then sold), there is a reduced failure rate since these mechanisms have been eliminated.

Screening is an optional part of the manufacturing process, rather than a test method. It will not affect the "useful life" of a component, defined as the period during which it performs according to specifications. Eventually other failure mechanisms appear, and the failure rate increases beyond some defined threshold. At this point, the useful life ends and the "wear-out region" begins, and the component must be replaced.

At the beginning of useful life, performance testing on a sampled population of components may be applied by the supplier, by the manufacturer, or by a third party. This is to ensure that the component meets performance specifications over the range of intended environments at this initial time. Reliability testing, on the other hand, is applied to ensure that the component meets performance specifications for at least a specified minimum useful lifetime or specified maximum failure rate. These tests are usually carried out by utilising the performance testing, but increasing duration and severity to accelerate the failure mechanisms.

A reliability theory relates component reliability testing to component parameters and to lifetime or failure rate under testing. The theory then extrapolates these to lifetime or failure rate under less stressful service conditions. The reliability specifications include values of the component parameters needed to ensure the specified minimum lifetime or maximum failure rate in service.

4.3.4 Interlinking

Standards currently under preparation are given in Figure 6. A large number of the test and measurement standards exist already and quality assurance qualification approval standards have existed for many years. With regard to interface, performance and reliability standards, once these three standards are all in place, the matrix given in Table 6 demonstrates some of the other options available for product standardization.

Product A is fully IEC standardized, having a standard interface and meeting defined performance standards and reliability standards.

Product B is a product with a proprietary interface but which meets a defined IEC performance standard and reliability standard.

Product C is a product which complies with an IEC standard interface but does not meet the requirements of either an IEC performance standard or reliability standard.

Product D is a product which complies with both an IEC standard interface and performance standard but does not meet any reliability requirements.

Obviously the matrix is more complex than shown since there will be a number of interface, performance and reliability standards which may cross-refer. In addition, the products may all be subject to a recognized quality assurance programme including qualification approval, capability approval, technology approval or even a national or company quality assurance system.

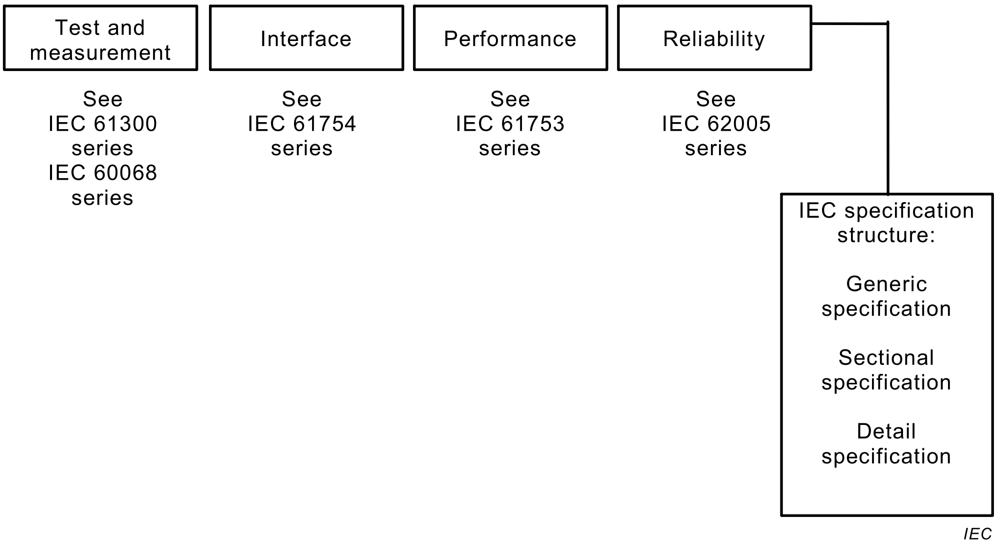


Figure 6 – Standards currently under preparation

Table 3 – Standards interlink matrix

Product type	Interface standard	Performance standard	Reliability standard
Product A	YES	YES	YES
Product B	NO	YES	YES
Product C	YES	NO	NO
Product D	YES	YES	NO

4.4 Design and construction

4.4.1 Materials

4.4.1.1 Corrosion resistance

All materials used in the construction of circulator sets shall be corrosion resistant or suitably finished to meet the requirements of the relevant specification.

4.4.1.2 Non-flammable materials

When non-flammable materials are required, the requirements shall be specified in the relevant specification and IEC 60695-11-5 shall be referenced.

4.4.2 Workmanship

Components and associated hardware shall be manufactured to a uniform quality and shall be free of sharp edges, burrs or other defects that will affect life, serviceability, or appearance. Particular attention shall be given to neatness and thoroughness of marking, plating, soldering, bonding, etc.

4.5 Performance

Circulators shall meet the performance requirements specified in the relevant specification.

4.6 Identification and marking

4.6.1 General

Components, associated hardware and packages shall be permanently and legibly identified and marked when required by the relevant specification.

4.6.2 Variant identification number

Each variant in a relevant specification shall be assigned a variant identification number. The number shall consist of the number assigned to the relevant specification followed by a dash and a four digit number. The first digit of the four-digit number shall be sequentially assigned to each component type covered by the relevant specification. The last three digits shall be sequentially assigned to each variant of the component (see Figure 7).

EXAMPLE

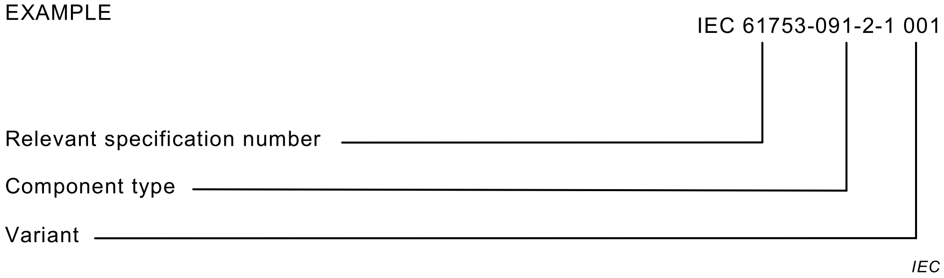


Figure 7 – Example of a variant identification number

4.6.3 Component marking

Component marking, if required, shall be specified in the relevant specification. The preferred order of marking is as follows:

a) port identification;
b) manufacturer's part number;
c) manufacturer's identification mark or logo;
d) manufacturing date;
e) variant identification number;
f) any additional marking required by the relevant specification.

If space does not allow for all the required marking on the components, each unit shall be individually packaged with a data sheet containing all of the required information which is not marked.

4.6.4 Package marking

Package marking, if required, shall be specified in the relevant specification. The preferred order of marking is as follows:

a) manufacturer's identification mark or logo;
b) manufacturer's part number;
c) manufacturing date code (year/week; see ISO 8601);
d) variant identification number(s) (see 4.6.2);
e) type designations (see 4.1.2);
f) any additional marking required by the relevant specification.

When applicable, individual unit packages (within the sealed package) shall be marked with the reference number of the certified record of released lots, the manufacturer's factory identity code and the component identification.

4.7 Packaging

Packages shall include instructions for use when required by the specification (see 4.2.6).

4.8 Storage conditions

Where short-term degradable materials, such as adhesives, are supplied with the package of circulator parts, the manufacturer shall mark these with the expiry date (year and week numbers, see ISO 8601) together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

4.9 Safety

Optical circulators, when used on an optical fibre transmission system and/or equipment, may emit potentially hazardous radiation from an uncapped or unterminated output port or fibre end.

The optical circulator manufacturers shall make available sufficient information to alert system designers and users about the potential hazard and shall indicate the required precautions and working practices.

In addition, each relevant specification shall include the following:

WARNING NOTE

Care should be taken when handling small diameter fibre to prevent puncturing the skin, especially in the eye area. Direct viewing of the end of an optical fibre or an optical fibre connector when it is propagating energy is not recommended, unless prior assurance has been obtained as to the safety energy output level.

Reference shall be made to the IEC 60825 series, the relevant standard on safety.

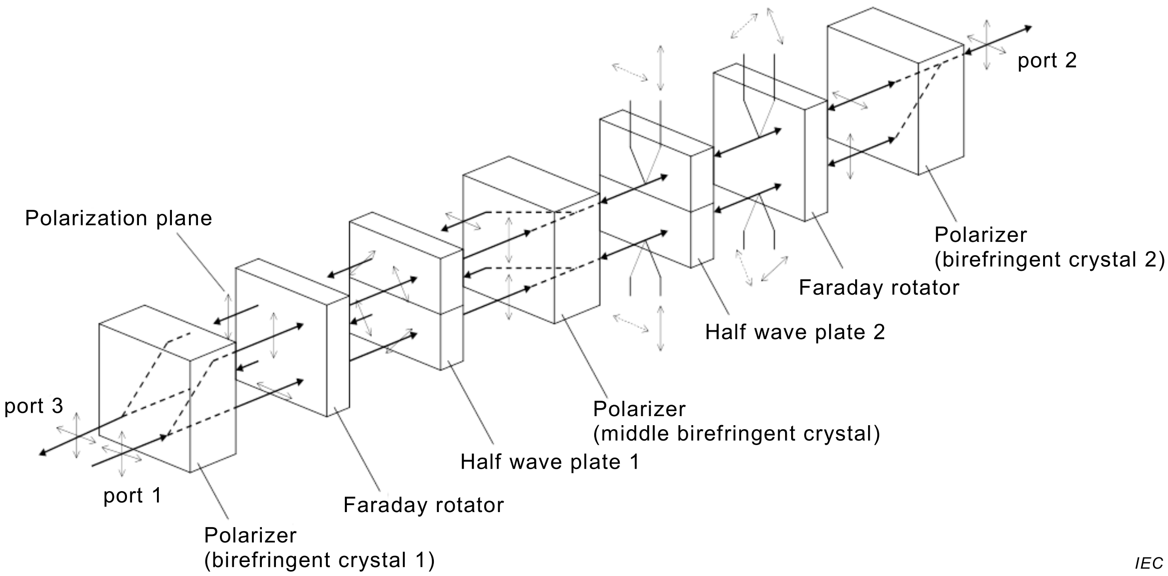
Annex A
(informative)

Example of technology of bulk circulator based on magneto-optic effect

The bulk circulator based on magneto-optic effect consists of the following typical discrete components.

Figure A.1 shows an example of a circulator based on magneto-optic effect. The circulator consists of a Faraday rotator, a polarizer (birefringent crystal) and a half-wave plate. The incident light from port 1 is separated to two cross-polarizations by the birefringent crystal 1. Two cross-polarizations are paralleled by the half-wave plate and Faraday rotator. Two polarizations are combined by the birefringent crystal 2, exit from port 2. In the reverse direction, the incident light from port 2 is separated into two cross-polarizations by the birefringent crystal 2. Two cross-polarizations are paralleled by the half-wave plate and Faraday rotator where the polarization direction crosses between the forward direction and reverse direction. Two polarizations are shifted by the middle birefringent crystal, due to the direction of polarization. As a result, two polarizations are combined by the birefringent crystal 1, exit from port 3.

NOTE The function of the polarizer (birefringent crystal) is to separate the input light into different directions due to a different refractive index of the birefringent crystal for ordinary and extraordinary rays.



NOTE Polarization plane depends on the direction of propagating light

solid line:	from port 1 to port 2
broken line:	from port 2 to port 3

Figure A.1 – Example of a circulator

Annex B
(informative)

Example of application of a circulator

Figure B.1 shows the filter in which a circulator is used. The filter consists of a circulator and a fibre Bragg grating (FBG). The fibre Bragg grating (FBG) reflects particular wavelengths of light and transmits other wavelengths. A circulator is used in order to pick up particular reflected wavelengths.

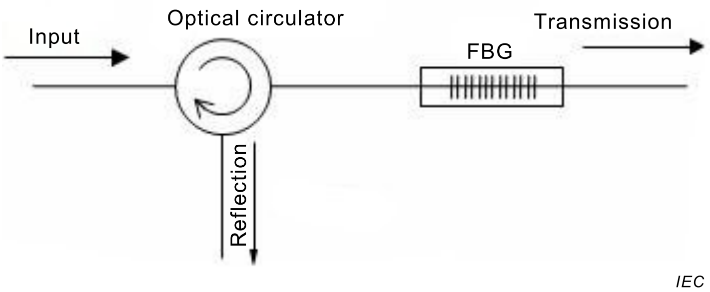


Figure B.1 – Example of application of a circulator

Bibliography

IEC 60068 (all parts), *Environmental testing*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 61300-2 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2: Tests*

IEC 61300-3 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3: Examinations and measurements*

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard*

IEC 61754 (all parts), *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces*

IEC 61978-1, *Fibre optic interconnecting devices and passive components – Fibre optic passive chromatic compensators – Part 1: Generic specification*

IEC 62005 (all parts), *Reliability of fibre optic interconnecting devices and passive components*

IEC TS 62538, *Categorization of optical devices*

____

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch