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Edition 4.0 2016-12

INTERNATIONAL STANDARD

colour inside

Fibre optic interconnecting devices and passive components – Fibre optic isolators –
Part 1: Generic specification

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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

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC ISOLATORS –

Part 1: 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 61202-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This fourth edition cancels and replaces the third edition published in 2009. It constitutes a technical revision.

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

a) the terms and definitions were reconsidered;
b) quality assessment level was deleted from classification;
c) the clause numbers of Annexes A and B have been rearranged.

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

CDV	Report on voting
86B/3989A/CDV	86B/4033RVC

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

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

A list of all parts in the IEC 61202 series, published under the general title *Fibre optic interconnecting devices and passive components – Fibre optic isolators*, can be found on the IEC website.

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC ISOLATORS –

Part 1: Generic specification

1 Scope

This part of IEC 61202 applies to isolators used in the field of fibre optics, all exhibiting 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 containing no opto-electronic or other transducing elements;
- they have two optical ports for directionally transmitting optical power.

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*

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

IEC 60695 (all parts), *Fire hazard testing*

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

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

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

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

ISO 286-1, *Geometrical product specification (GPS) – ISO code system for tolerances on linear sizes – 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, 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 and definitions

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

3.1.2
input port
port for the entry of optical power

Note 1 to entry: An isolator is a directional device. The input port should be clearly marked.

3.1.3
output port
port for the exit of optical power

Note 1 to entry: An isolator is a directional device. The output port should be clearly marked.

3.1.4
backward direction
<optical isolator> operational direction in which the power of the optical source launches into the output port of an isolator

Note 1 to entry: This is the direction of optical power isolation.

3.1.5
forward direction
<optical isolator> operational direction in which the power of the optical source launches into the input port of an isolator

Note 1 to entry: This is the intentional direction of optical power transmission.

3.2 Component terms and definitions

3.2.1
fibre optic isolator
non-reciprocal optical device intended to suppress backward reflections along an optical fibre transmission line while having minimum insertion loss in the forward direction

Note 1 to entry: Fibre optic isolators are commonly used to avoid reflections back into laser diodes and optical amplifiers, which can make the laser and amplifiers oscillations unstable, and cause noise in the fibre optic transmission system.

3.2.2
bulk isolator based on magneto-optic effect
type of isolator with discrete components including a suitable magneto-optic crystal (ferro-magnetic crystal or paramagnetic glass, diamagnetic glass, etc.), of which the fundamental principle is based on magneto-optic effect

Note 1 to entry: The technology of a bulk isolator based on magneto-optic effect is described in Annex A.

3.2.3
in-line isolator
type of isolator with optical fibre for the entry input and output of the light

3.2.4
optical waveguide isolator
type of isolator with planer epitaxial magneto-optic crystal layers on a suitable substrate

Note 1 to entry: The technology of an optical waveguide isolator is described in Annex B.

3.2.5
polarization-dependent optical isolator
type of isolator not designed to have performance independent of the state of the polarization of the incident light

3.2.6
polarization-independent optical isolator
type of isolator in which the optical performance characteristics are independent of the polarization state of the incident light

3.2.7
polarization maintaining optical isolator
type of isolator with a polarization maintaining optical fibre for input and output, designed to maintain polarization of the light, and which is adjusted to the optical axis of the polarization maintaining optical fibre

3.2.8
single-stage isolator
type of isolator composed of a basic isolator unit such as a set of polarizer, faraday rotator and analyser

3.2.9
dual-stage isolator
double-stage isolator
type of isolator composed of two basic isolator units connected in tandem for the purpose of obtaining more backward loss

3.2.10
PMD compensated optical isolator
type of isolator designed to compensate the polarization mode dispersion which is intrinsic to the birefringent crystal

3.3 Performance parameter terms and definitions

3.3.1
operating wavelength
wavelength at which a passive optical component is designed to operate with the specified performance

3.3.2
operating wavelength range
specified range of wavelengths including all operating wavelengths

Note 1 to entry: In the case of an optical isolator as nominally a wavelength independent and wavelength non-selective device, passband is nominally same as operating wavelength range.

3.3.3
insertion loss
maximum value of logarithmic transmission coefficient, a_{ij} (where i ≠ j) within the passband for conducting port pair

Note 1 to entry: It is the optical attenuation from a given port to a port which is another port of conducting port pair of the given port of a passive device. Insertion loss is a positive value in decibels. It is calculated as:

$$IL = -10\log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

where

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

P_{out} is the optical power received from the other port of the conducting port pair.

Note 2 to entry: In the case of an optical isolator as a non-reciprocal device, IL is defined as the maximum value of attenuation from the input port to the output port.

Note 3 to entry: In the case of an optical isolator as nominally a wavelength independent and wavelength non-selective device, passband is nominally same as operating wavelength range.

Note 4 to entry: In the case of a polarization-independent isolator, IL is defined as the maximum value for any state of polarization of P_{in}.

Note 5 to entry: In the case of a polarization-dependent isolator, IL is defined as the linearly polarized light which coincides with the polarizing direction of the polarizer in the isolator of P_{in}.

3.3.4
isolation
minimum value of a_{ij} (where i ≠ j) for isolated port pair

Note 1 to entry: In case of an optical isolator, isolation is the minimum attenuation value of backward direction.

Note 2 to entry: Isolation is a positive value expressed in dB.

3.3.5
polarization dependent loss
PDL
for polarization independent isolators, maximum variation of insertion loss caused by a variation in the state of polarization (SOP) over all the SOPs.

3.3.6
polarization mode dispersion
PMD
for polarization-independent isolators, average delay of the travelling time between the two principal states of polarization (PSP), when an optical signal passes through an optical isolator

3.3.7
return loss
value of a_{ij} (where i = j) of the logarithmic transfer matrix

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

$$RL_i = -10\log_{10}\left(\frac{P_{refl}}{P_i}\right)$$

where

P_i is the optical power launched into a port;

P_{refl} is the optical power received back from the same port.

Note 2 to entry: For an optical isolator, return loss is defined for the input port and the output port.

4 Requirements

4.1 Classification

4.1.1 General

Fibre optic isolators shall be classified as follows:

- type;
- style;
- variant;
- environmental category;
- normative reference extensions.

An example of a typical isolator classification is as follows:

Type:	–	Name: Type OIFR
		bulk isolators based on the Faraday rotation
	–	Operating wavelength band: C-band
	–	Polarization sensitivity: polarization independent
	–	Configuration: C
Style:	–	Connector type: SC
	–	Fibre type: IEC type B 1.1
	–	Means of mounting
Variant:	–	……………………..
Normative reference extensions:		

4.1.2 Type

Isolators are divided into types.

- By their fabrication technology:
  - bulk isolators based on the magneto-optic effect;
  - optical waveguide isolators;
  - other fabrication technologies.
- By their polarization selectivity:
  - polarization dependent isolators;
  - polarization independent isolators;
  - polarization maintain optical isolator.
- By their operational principles:
  - magneto-optic Faraday effect;
  - magneto-optic Cotton-Mouton effect and Kerr effect.
- By their operating wavelength band:
  - O-band (e.g. nominal wavelength of 1 310 nm);
  - C-band (e.g. nominal wavelength of 1 550 nm);
  - L-band (e.g. nominal wavelength of 1 590 nm);
  - other wavelength band isolators.

4.1.3 Style

Optical isolators 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 isolator ports is classified as showed in Figures 1 to 4:

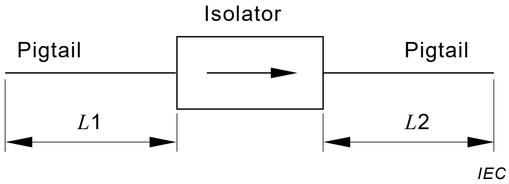


Figure 1 – Configuration A – Device containing integral fibre optic pigtails without connector

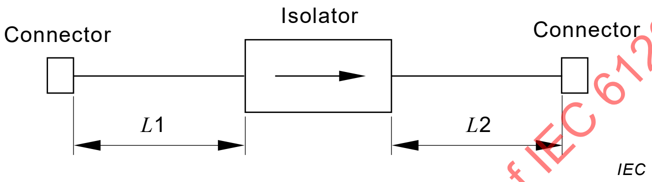


Figure 2 – Configuration B – Device containing integral fibre optic pigtails, with a connector on each pigtail

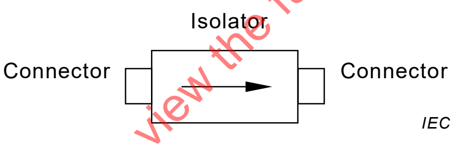


Figure 3 – Configuration C – Device containing connectors as an integral part of the device housing

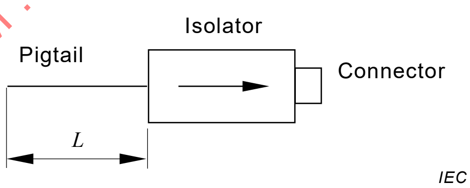


Figure 4 – Configuration D – Device containing some combination of the interfacing features of the preceding configurations

4.1.4 Variant

The isolator 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 independent standards specifications or other reference documents integrated into relevant specifications.

Unless a specified exception is noted, additional requirements imposed by an extension 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 fibre optic isolator configurations require special qualification provisions which shall not be imposed universally. This accommodates individual component design configurations, specialised field tooling, or specific application processes. In this case, requirements are necessary to guarantee 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 splice 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.

Some commercial or residential building applications can require direct reference to specific safety codes and regulations or incorporate other specific material flammability or toxicity requirements for specialised locations.

Specialized field tooling can require an extension to implement specific ocular safety, electrical shock or 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 IEC 60027 (all parts) and IEC 60617 (all parts).

4.2.2 Specification system

4.2.2.1 General

This document is part of a two-level IEC specification system. This system is shown in Table 1. There are no sectional specifications for isolators.

Table 1 – Two-level IEC specification structure

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

Specification level	Examples of information to be included	Applicable to
Generic	Specific terminology Specific symbols Specific units Preferred values Marking Selection of tests Qualification approval and/or capability approval procedures	Component family

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 document. 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.

When units are converted, a note shall be added in each relevant specification, and the conversion between systems of 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 isolators to be used shall be defined and selected preferentially from IEC 61300 (all parts).

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.

NOTE No reference component is generally used to fibre optic isolators.

4.2.4.3 Gauges

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

NOTE Gauge is not generally used for fibre optic isolators.

4.2.5 Test data sheets

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

Data sheets 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 style 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 the following information:

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

4.3 Standardization system

4.3.1 Interface standards

No interface standard is used for fibre optic isolators. When either the input port or output port has an optical connector, the optical connector shall accord with the relevant optical connector interface standard.

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 "once-off" basis to prove any product's ability to satisfy the "performance standards" requirement. Each performance standard has a different set of tests and/or severities (and/or groupings) and 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 for their application (particularly with regard to attenuation and return loss) in conjunction with the interface standards of inter-product compatibility. Certain conformance of each individual product to this standard will be ensured.

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, 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 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 or 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 the defined threshold. At this point, the “useful life” ends and the “wear-out region” begins, and the component shall 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 done by utilizing the performance testing, but increasing duration and severity in order 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 . A large number of the test and measurements standards already exist.

With regard to interface, performance and reliability standards, once all three of these standards are in place, the matrix given in Table 2 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 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 can cross-refer. In addition, the products can all be subject to a quality assurance programme that could be under IEC qualification approval, capability approval, technology approval (as Table 2 attempts to demonstrate), or even a national or company quality assurance system.

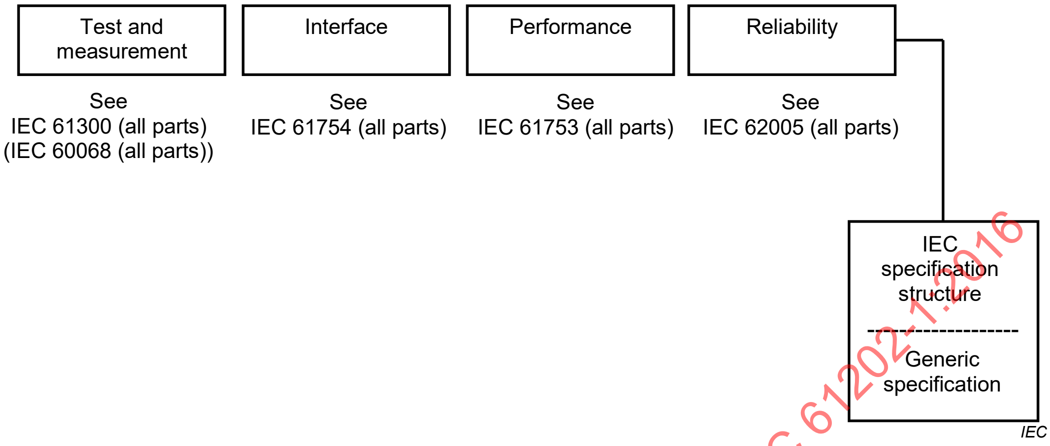


Figure 5 – Standards currently under preparation

Table 2 – Standards interlink matrix

	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

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

When non-flammable materials are required, the requirement shall be specified in the specification, and IEC 60695 (all parts) 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 requirements

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

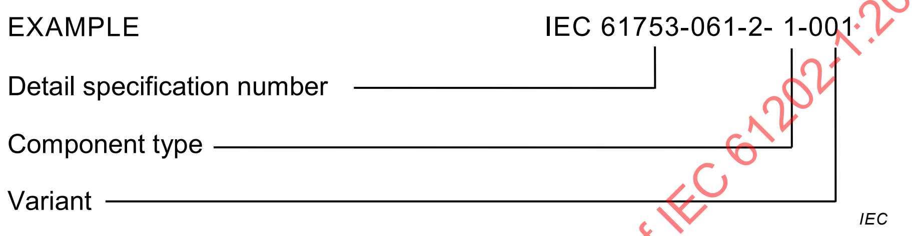
4.6 Identification and marking

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 detail specification shall be assigned a variant identification number. The number shall consist of the number assigned to the performance specification followed by a two-digit dash number. The first digit of the dash number shall be sequentially assigned to each component type covered by the detail specification. The last three digits shall be sequentially assigned to each variant of the component.



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) forward direction;
g) 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, according to ISO 8601);
d) variant identification number(s) (see 4.6.1);
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 connector parts, the manufacturer shall mark these with the expiry date (year and week numbers, according to ISO 8601) together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

4.9 Safety

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

The optical isolator 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:

WARNING – 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 a fibre optic 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 IEC 60825-1, the relevant standard on safety.

Annex A
(informative)

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

A.1 General

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

Figure A.1 shows a polarization-dependent optical isolator. The isolator consists of the Faraday rotator and the pair of polarizer which the polarization is arranged at the relative angle of 45°. In the forward direction, the light transmitted through the polarizer transmits through the analyser without loss due to 45° rotation by the Faraday rotator. In the backward direction, the light passed through the analyzer does not pass through the polarizer, due to perpendicular to the direction polarization.

Figure A.2 shows a polarization-independent optical isolator. The isolator consists of the Faraday rotator and the pair birefringent crystal which the optical axis is arranged at the relative angle of 45°. The light ray of this type is different between the forward direction and the backward direction, due to a non-reciprocal of the faraday rotator and the pair birefringent crystal.

A.2 Faraday rotator

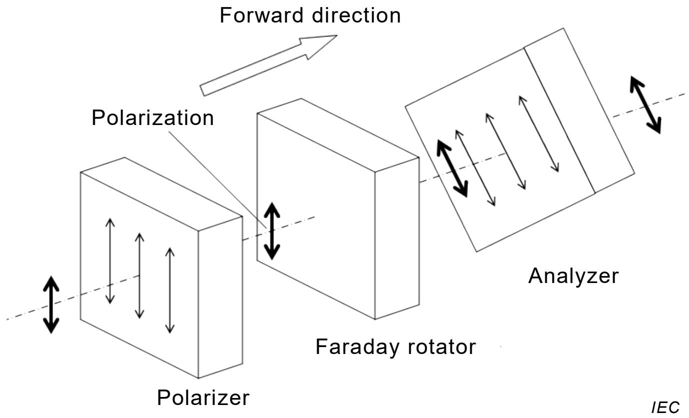
The direction of polarization rotation is dependent on only the direction of magnetic field.

A.3 Analyser

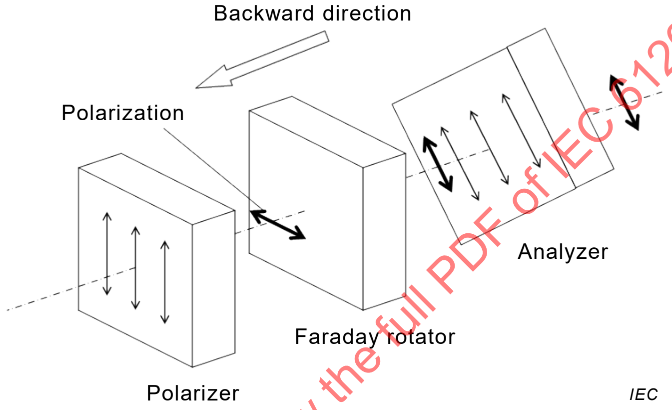
Analyser is the same as polarizer.

A.4 Birefringent crystal

Any light is separated into different directions due to a different refractive index of the birefringent crystal for ordinary and extraordinary rays.



a) Polarization in the forward direction



b) Polarization in the backward direction

Figure A.1 – Polarization dependent optical isolator