IEC 60876-1

Edition 4.0 2012-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Dispositifs d'interconnexion et composants passifs à fibres optiques – Commutateurs spatiaux à fibres optiques – Partie 1: Spécification générique

IEC 60876-1:2012

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.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you 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It also gives information on projects, replaced and withdrawn publications.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 on-line 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 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

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.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).
Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 60876-1

Edition 4.0 2012-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Dispositifs d'interconnexion et composants passifs à fibres optiques – Commutateurs spatiaux à fibres optiques –
Partie 1: Spécification générique

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX V

ICS 33.180.20

ISBN 978-2-83220-663-8

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC SPATIAL SWITCHES –

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.
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 60876-1 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 2001. It constitutes a technical revision. The changes with respect to the previous edition are to remove quality assessment procedures and to reconsider definitions.

This bilingual version (2013-02) corresponds to the monolingual English version, published in 2012-07.

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

CDV	Report on voting
86B/3276/CDV	86B/3339/RVC

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

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

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

A list of all the parts in the IEC 60876 series, published under the general title *Fibre optic interconnecting devices and passive components-Fibre optic spatial switches* can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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.

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 SPATIAL SWITCHES –

Part 1: Generic specification

1 Scope

This part of IEC 60876 applies to fibre optic switches possessing all of the following general features:

– they are passive in that they contain no optoelectronic or other transducing elements;

– they have one or more ports for the transmission of optical power and two or more states in which power may be routed or blocked between these ports;

– the ports are optical fibres or fibre optic connectors.

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 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

IEC 60617 (all parts), *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 60825-1, *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/TR 61930, *Fibre optic graphical symbology*

IEC 62047-1, *Semiconductor devices – Micro-electromechanical devices – Part 1: Terms and definitions*

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: 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 part of IEC 60876, the definitions given in IEC 60050-731 apply, together with the following definitions.

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 optical power

3.1.2
transfer matrix
optical properties of a fibre optic switch can be defined in a $n \times n$ matrix of coefficients (n is the number of ports)

Note 1 to entry: The T matrix represents the on-state paths (worst-case transmission) and the T° matrix represents the off-state paths (worst-case isolation).

3.1.3
transfer coefficient
element t_{ij} or $t°_{ij}$ of the transfer matrix

Note 1 to entry: Each transfer coefficient t_{ij} is the worst-case (minimum) fraction of power transferred from port i to port j for any state with path ij switched on. Each coefficient $t°_{ij}$ is the worst-case (maximum) fraction of power transferred from port i to port j for any state with path ij switched off.

3.1.4
logarithmic transfer matrix

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

where

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

t_{ij} is the transfer coefficient.

Note 1 to entry: Similarly, for the off state, $a°_{ij} = -10 \log t°_{ij}$

3.2 Component definitions

3.2.1
optical switch
passive component processing one or more ports which selectively transmits, redirects or blocks optical power in an optical fibre transmission line

3.2.2
switch state
particular optical configuration of a switch, whereby optical power is transmitted or blocked between specific ports in a predetermined manner

3.2.3
actuation mechanism
physical means (mechanical, electrical, acoustic, optical, etc.) by which a switch is designed to change between states

3.2.4
actuation energy
input energy required to place a switch in a specific state

3.2.5
latching switch
switch that maintains its last state and specified performance level when the actuation energy which initiated the change is removed

3.2.6
non-latching switch
switch that reverts to a home state or undefined state when the actuation energy which initiated a change is removed

3.2.7
blocking
inability to establish a connection from a free input port to a free output port due to the existence of some other established connection

Note 1 to entry: Blocking and various degrees of non-blocking operation functionalities are of various types. “Strict-sense non-blocking” refers to a switch matrix in which it is always possible to establish a connection between any free input port and any free output port irrespective of previously established connections.
“Wide-sense non-blocking” refers to a matrix in which it is always possible to establish a desired connection provided that some systematic procedure is followed in setting up connections. Some multistage switching architectures fall into this category.
“Rearrangeably non-blocking” refers to a switch matrix in which any free input port can be connected to any free output port provided that other established connections are unconnected and then reconnected as part of making the new connection.

3.2.8
magneto-optic effect switch
MO switch
optical switch which uses the magneto-optic effect (phenomenon of polarization state change in transmitted light and reflected light due to a magnetic field)

3.2.9
mechanical switch
optical switch, which realises the switching function by driving of the movable part

3.2.10
micro-electromechanical system switch
MEMS switch
optical switch using MEMS technology, as defined in IEC 62047-1

3.2.11
thermo-optic effect switch
TO switch
optical switch which uses the thermo-optic effect (phenomenon of refractive index change caused by temperature variation)

3.3 Performance parameter definitions

3.3.1
insertion loss
element a_{ij} (where i ≠ j) of the logarithmic transfer matrix

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

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

where

P_i is the optical power launched into the input port, and

P_j is the optical power received from the output port.

Note 2 to entry: The insertion loss values depend on the state of the switch.

3.3.2
return loss
element 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 the input port of a passive component and is defined as follows:

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

where

P_i is the optical power launched into the input port, and

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

Note 2 to entry: The return loss values depend on the state of the switch.

3.3.3
operating wavelength
λ
nominal wavelength at which a passive component is designed to operate with the specified performance

3.3.4
latency time

3.3.4.1
latency time
t_l
<switching from isolated state to conducting state> elapsed time when the output power of a specified output port reaches 10 % of its steady-state value of the output power from the time the actuation energy is applied

SEE: Figure 1

3.3.4.2
latency time
t_l'
<switching from conducting state to isolated state> elapsed time when the output power of a specified output port reaches 90 % of its steady-state value of the output power from the time the actuation energy is removed

SEE: Figure 1

3.3.5
rise time
elapsed time when the output power of the specified output port rises from 10 % of the steady-state value to 90 % of the steady-state value

3.3.6
fall time
elapsed time when the output power of the specified output port falls from 90 % of the steady-state value to 10 % of the steady-state value

3.3.7
bounce time

3.3.7.1
bounce time
t_b
<switching from isolated state to conducting state> elapsed time when the output power of a specified output port maintains between 90 % and 110 % of its steady-state value of the output power from the first time the output power of a specified output port reaches to 90 % of its steady-state value of the output power

SEE: Figure 1

3.3.7.2
bounce time
t_b'
<switching from conducting state to isolated state> elapsed time when the output power of a specified output port maintains between 0 % and 10 % of its steady-state value of the output power from the first time the output power of a specified output port reaches to 10 % of its steady-state value of the output power

SEE: Figure 1

3.3.8
switching time

3.3.8.1
switching time
t_s
<switching from isolated state to conducting state> the switching time is defined as follows:

$$t_s = t_l + t_r + t_b$$

where

t_l is latency time;

t_r is rise time;

t_b is bounce time.

3.3.8.2
switching time
t_s'
<switching from conducting state to isolated state>the switching time is defined as follows:

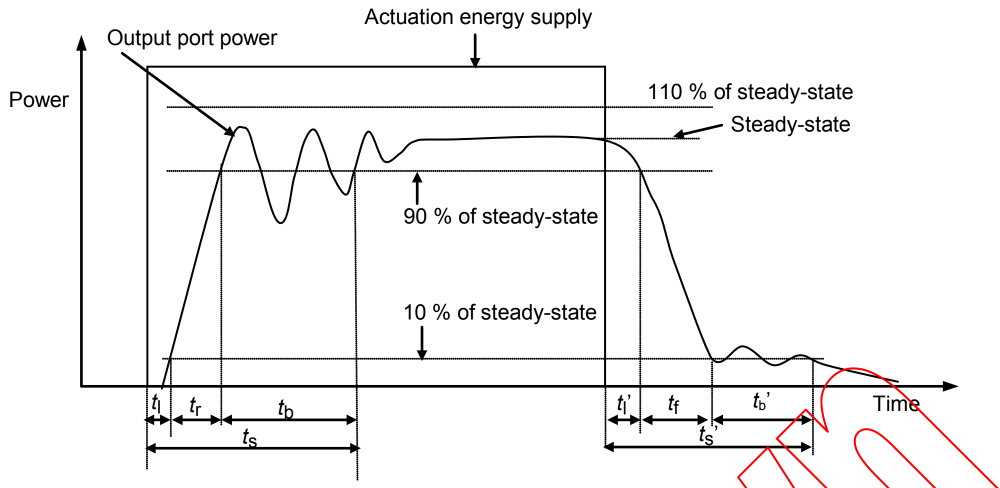
$$t_s' = t_l' + t_f + t_b'$$

where

t_l' is latency time;

t_f is fall time;

t_b' is bounce time.



t_s, t_s' Swithing time
t_l, t_l' Latency time
t_r Rise time
t_f Fall time
t_b, t_b' Bounce time

IEC 1321/12

Figure 1 – Representation of latency time, rise time, fall time, bounce time, and switching time

Note 1 to entry: In the case in which, for any reason, the steady-state power of the isolated state is not zero, all the power levels leading to the definitions of latency time, rise time, fall time, bounce time, and thus of switching time, should be normalized subtracting from them the steady-state power of the isolated state, before applying such definitions.

3.3.9
switching time matrix
matrix of coefficients in which each coefficient S_{ij} is the longest switching time to turn path ij on or off from any initial state

4 Requirements

4.1 Classification

4.1.1 General

Fibre optic spatial switches shall be classified based on the following:

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

Table 1 is an example of a switch classification.

Table 1 – Example of a typical switch classification

Type:	1×2 mechanical switch
Style:	– Configuration B – IEC type A1 a fibre – F-SMA connector
Variants:	Means of mounting
Assessment level:	A
Normative reference extensions:	....

4.1.2 Type

4.1.2.1 General

Switches are divided into types by their actuation mechanism, latching and topology (optical switching function).

There are multiple actuation mechanisms of switches. The following is a non-exhaustive list of examples of current technologies used in the industry:

- magneto-optic effect (MO);
- mechanical;
- micro-electromechanical system (MEMS);
- thermo-optic effect (TO).

Switches are divided into two types based on the latching function as follows:

- latching switch;
- non-latching switch.

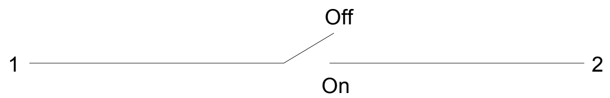
There are an essentially infinite number of possible topologies. Each topology is illustrated by a schematic diagram and defined by a unique transfer matrix.

The following device topologies include only those which are in common use within the industry at present. The schematic diagrams which follow do not necessarily correspond to the physical layout of the switch and its ports.

The examples given in 4.1.2.2 to 4.1.2.4 apply to unidirectional switches only, where $t_{ij} \neq t_{ji}$. For bi-directional switches, $t_{ij} = t_{ji}$ in each transfer matrix below.

4.1.2.2 Single-pole, single-throw switch

Figure 2 shows a single-pole, single-throw switch.



IEC 1322/12

Figure 2 – Single-pole, single-throw switch

This switch has one input port and one output port. Figure 3 shows the transfer matrix describing the device.

$$T = \begin{bmatrix} t_{11} & t_{21} \\ t_{12} & t_{22} \end{bmatrix}$$

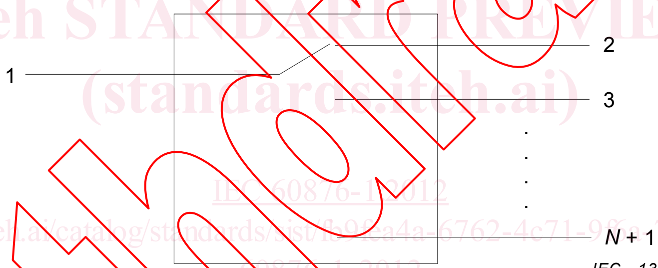
IEC 1323/12

Figure 3 – Transfer matrix for one input port and one output port

Ideally, t_{12} is 1 and the other coefficients are 0 when the switch is on. When the switch is off, all coefficients are 0.

4.1.2.3 Single-pole, *N*-throw switch

Figure 4 shows a single-pole, *N*-throw switch.



IEC 1324/12

Figure 4 – Single-pole, throw switch

This switch has one input port and *N* output ports. Figure 5 shows the transfer matrix describing the device.

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdot & \cdot & \cdot & t_{1N+1} \\ t_{21} & & & & & \\ \cdot & & & & & \\ \cdot & & & t_{ij} & & \cdot \\ \cdot & & & & & \\ t_{N+11} & \cdot & & & & t_{N+1N+1} \end{bmatrix}$$

IEC 1325/12

Figure 5 – Transfer matrix for one input port and *N* output ports

Ideally, in the first position of the switch, t_{12} is 1 and the other coefficients are 0. In the generic *i*-th position of the switch, the $t_{1\ i+1}$ transfer coefficient is 1 and the others are 0.

4.1.2.4 *N*-port matrix switch

Figure 6 shows an *N*-port matrix switch.