IEC 60876-1

Edition 5.0 2014-08

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

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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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CONTENTS

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

Part 1: Generic specification

FOREWORD

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International Standard IEC 60876-1 has been prepared by subcommittee SC86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This fifth edition cancels and replaces the fourth edition that was published in 2012 and constitutes a technical revision.

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

a) addition of definitions for the terms for "normally-on; "normally-off" and "crosstalk";

b) addition of a new Annex E.

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

CDV	Report on voting
86B/3713/CDV	86B/3788/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.

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.

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

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- replaced by a revised edition, or
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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – IBRE 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 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

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

IEC 60695-11-5, *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 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 60050-731, together with the following, apply.

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

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

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, $a°_{ij} = -10 \log_{10} t°_{ij}$.

3.1.5
switch state
particular optical configuration of a switch, whereby optical power is transmitted or blocked between specific ports in a predetermined manner

3.1.6
actuation mechanism
physical means (mechanical, electrical, acoustic, optical, etc.) by which a switch is designed to change between states

3.1.7
actuation energy
input energy required to place a switch in a specific state

3.1.8
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.

3.1.9
normally on
condition where a port pair is in a conducting state when there is no actuation energy applied for a non-latching switch

3.1.10
normally off
condition where a port pair is in an isolated state when there is no actuation energy applied for a non-latching switch

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

3.2.3
non-latching switch
switch that reverts to a home state or undefined state when the actuation energy which initiated a change is removed

3.2.4
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)

Note 1 to entry: Annex A shows an example of magnet-optic effect swich technologies.

3.2.5
mechanical switch
optical switch which realises the switching function by driving of the movable part

Note 1 to entry: Annex B shows an example of mechanical swich technologies.

3.2.6
micro-electromechanical system switch
MEMS switch
optical switch using MEMS technology, as defined in IEC 62047-1

Note 1 to entry: Annex C shows example of micro-mechanical system swich technologies.

3.2.7
thermo-optic effect switch
TO switch
optical switch which uses the thermo-optic effect (phenomenon of refractive index change caused by temperature variation)

Note 1 to entry: Annex D shows an example of thermo-optic effect swich technologies.

3.3 Performance parameter definitions

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

3.3.2
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:

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

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.

3.3.3
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 a port of a passive component and is defined as follows:

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

where

P_i is the optical power launched into a 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.

3.3.4
crosstalk
ratio of the output power of the isolated input port to the output power of the conducting input port for an output port

3.3.5
latency time

3.3.5.1
latency time
t_l

<switching from isolated state to conducting state> elapsed time for the output power of a specified output port to reach 10 % of its steady-state value from the time the actuation energy is applied, when switching from an isolated state to conducting state, normally-off for a non-latching switch, or a latching switch

SEE: Figure 1.

3.3.5.2
latency time
t_l'
<switching from conducting state to isolated state, normally-off for a non-latching switch> elapsed time for the output power of a specified output port to reach 90 % of its steady-state value from the time the actuation energy is removed. when switching from a conducting state to isolated state, normally-off for a non-latching switch

SEE: Figure 1.

3.3.5.3
latency time
t_l'
<switching from conducting state to isolated state, for a latching switch> elapsed time when the output power of a specified output port reaches 90 % of its steady-state value from the time the actuation energy is applied, when switching from a conducting state to isolated state, for a latching switch

SEE: Figure 1.

Note 1 to entry: See Annex E.

3.3.6
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

3.3.7
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

3.3.8
bounce time

3.3.8.1
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 from the first time the output power of a specified output port reaches to 90 % of its steady-state value

SEE: Figure 1.

3.3.8.2
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 from the first time the output power of a specified output port reaches 10 % of its steady-state value

SEE: Figure 1.

3.3.9
switching time

3.3.9.1
switching time
t_s
<switching from isolated state to conducting state> switching time is defined as follows:

$$t_s = t_l + t_r + t_b$$

where

t_l is the latency time;

t_r is the rise time;

t_b is the bounce time.

3.3.9.2
switching time
t_s’
<switching from conducting state to isolated state> switching time is defined as follows:

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

where

t_l’ is the latency time;

t_f is the fall time;

t_b’ is the bounce time.

3.3.10
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

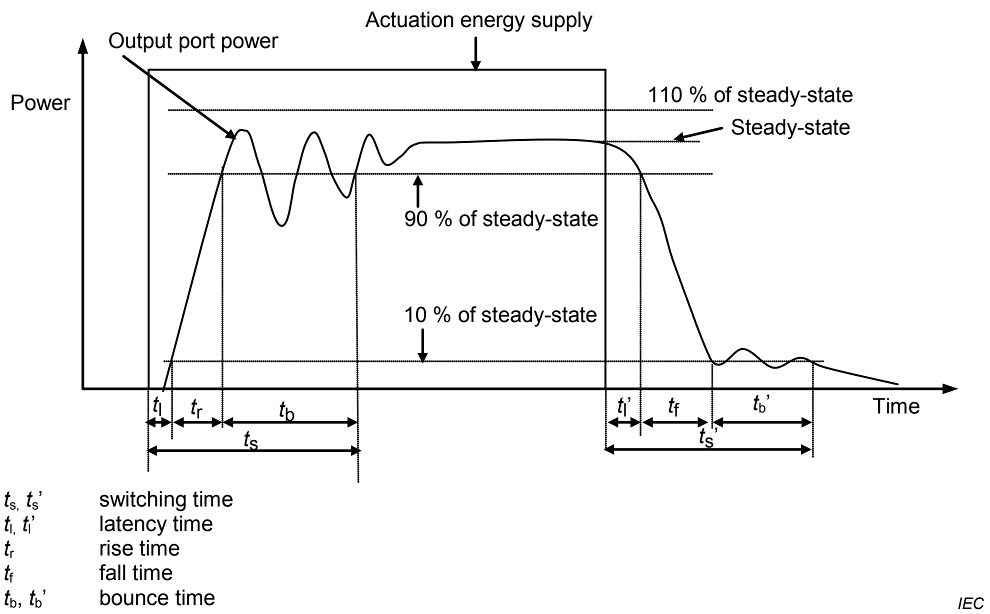
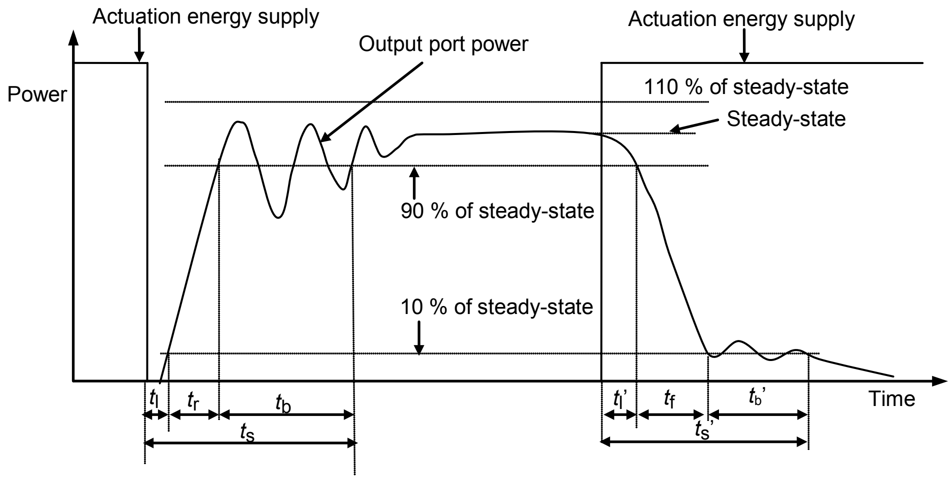
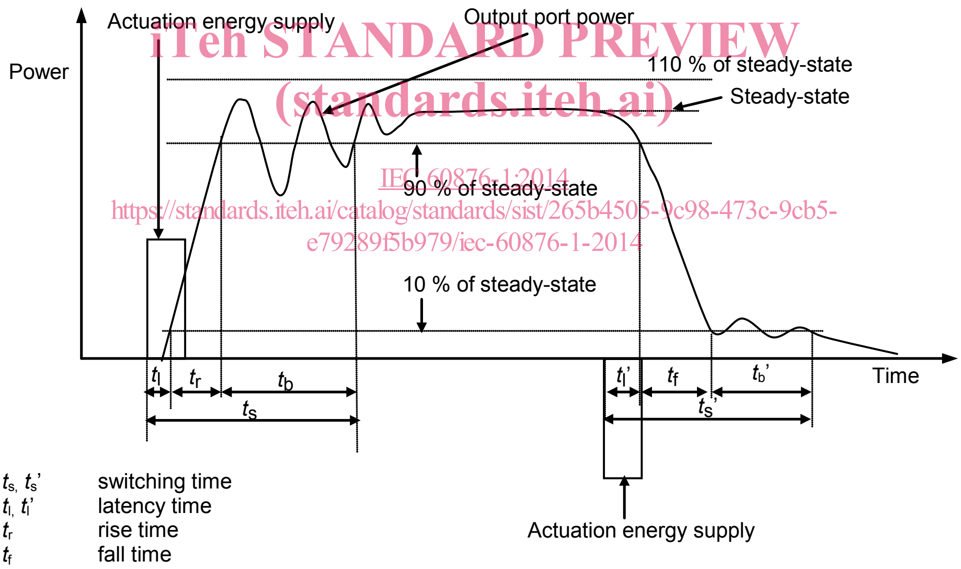


Figure 1a – Non-latching switch, normally off



t_s, t_s’	switching time
t_l, t_l’	latency time
t_r	rise time
t_f	fall time
t_b, t_b’	bounce time

Figure 1b – Non-latching switch, normally on



t_s, t_s’	switching time
t_l, t_l’	latency time
t_r	rise time
t_f	fall time
t_b, t_b’	bounce time

Figure 1c – Latching switch

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

Note 1 to entry: If, 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.

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.