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# IEC TR 62343-6-9

Edition 1.0 2015-06

# TECHNICAL REPORT

colour inside

## Dynamic modules – Part 6-9: Design guide – Study of mechanisms and measurements of crosstalk in wavelength-selective switches



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IEC TR 62343-6-9, which is a Technical Report, has been prepared by subcommittee SC86C: Fibre optic systems and active devices, of IEC technical committee TC 86: Fibre optics.

The text of this Technical Report is based on the following documents:

| Enquiry draft | Report on voting |
|---|---|
| 86C/1300/DTR | 86C/1321/RVC |

Full information on the voting for the approval of this Technical Report 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 parts in the IEC 62343 series, published under the general title *Dynamic modules*, 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 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- withdrawn,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.

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# INTRODUCTION

A dense wavelength division multiplexing (DWDM) system for fibre optic communication was developed in the late 1990’s. The first generation DWDM systems were point-to-point optical networks. In the mid-2000’s, second generation DWDM systems, typically ring networks, were developed. One of the key optical components for DWDM systems is a wavelength division multiplexing device. An AWG (arrayed waveguide grating) module has been mainly deployed for first and second generation DWDM systems.

Due to the increasing demand for communication capacity, more flexible optical communication systems, such as mesh networks, have been required. In the past several years, the third generation of DWDM systems, the optical cross-connect system, has been developed and deployed by some communication network carriers and is expected to be deployed worldwide. A wavelength-selective switch (WSS) module plays a key role in realizing the optical switch function in the optical cross-connect system, so that the performance of the WSS directly impacts on the performance of the optical cross-connect systems, such as the capacity, transmission distance, etc.

For AWG modules, only static performance, such as insertion loss, bandwidth, pass-band ripple, polarization dependent loss (PDL), polarization mode dispersion (PMD), coherent crosstalk, etc., has been evaluated. In addition to static performance, dynamic performance during switching or changing attenuation should be taken into consideration for the WSS as a key module of optical cross-connect systems.

For dynamic performance parameters, the influence not only on the controlled channel but also on other channels should be considered.



Considering this background, the influence of WSS dynamic crosstalk on cross-connect system performance and the measurements of dynamic crosstalk has been demonstrated.



This Technical Report is based on Optoelectronic Industry and Technology Development Association (OITDA) – Technical Paper (TP), TP15/TP-2013, "Dynamic crosstalk measurement for wavelength selective switches”.

# DYNAMIC MODULES –

## Part 6-9: Design guide – Study of mechanisms and measurements of crosstalk in wavelength-selective switches

## 1 Scope

This part of IEC 62343, which is a Technical Report, describes a study of the impact of WSS dynamic crosstalk on the optical network and includes dynamic crosstalk measurement examples for three types of WSS. The generating mechanism and the generation factor of dynamic crosstalk in WSS are clarified, and the evaluation of same-channel crosstalk and different-channel crosstalk is shown to be necessary.

## 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 61300-3-21, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-21: Examinations and measurements – Switching time*

IEC 61300-3-29, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-29: Examinations and measurements – Spectral transfer characteristics of DWDM devices*



## 3 Abbreviations

| | |
|---|---|
| ADD | add port |
| AWG | arrayed waveguide grating |
| COM | common port |
| CW | continuous wave |
| DLP | digital light processor |
| DRP | drop port |
| DUT | device under test |
| DWDM | dense wavelength division multiplexing |
| EXP | express port |
| LCOS | liquid crystal on silicon |
| MEMS | micro electro mechanical system |
| OE | optical-to-electrical |
| PDL | polarization dependent loss |
| PMD | polarization mode dispersion |
| TLS | tuneable laser source |
| Tx | transmitter |
| Rx | receiver |
| WSS | wavelength selective switch |

# 4 Study of dynamic crosstalk for WSS

## 4.1 Static crosstalk and dynamic crosstalk

WSSs can be considered as the combination of optical spatial switches, variable optical attenuators, and DWDM devices such as AWG modules. For the WSS, dynamic crosstalk, which is the interference between ports and channels during switching and changing attenuation, is generated in addition to static crosstalk.

Static crosstalk has been studied, and the definition and standard measurement methods for WDM devices such as AWG modules have been established. In addition to static crosstalk, dynamic crosstalk for WSSs has to be considered because WSSs vary attenuation and switch ports during operation.

Two types of dynamic crosstalk are considered in this Technical Report: same-channel crosstalk (coherent crosstalk), and different-channel crosstalk (power crosstalk). In this sense, the word of channel refers to the signal at a particular wavelength.

The impact on signal quality of same-channel crosstalk to cross-connect systems is considered to be larger than that of different-channel crosstalk, which may be negligible.

The classification of dynamic crosstalk and static crosstalk and that of same-channel crosstalk and different-channel crosstalk are independent. Therefore, four combinations (dynamic-same-channel crosstalk, dynamic-different-channel crosstalk, static-same-channel crosstalk, and static-different-channel crosstalk) have to be considered.



Table 1 and Table 2 show the features of static and dynamic crosstalk and same-channel and different-channel crosstalk, respectively.



**Table 1 – Static crosstalk and dynamic crosstalk**

| Crosstalk | Description |
|---|---|
| Static crosstalk | Crosstalk generated during static state, that is without switching ports or changing attenuations |
| Dynamic crosstalk | Crosstalk generated during dynamic state, such as switching ports and changing attenuations |

**Table 2 – Same-channel crosstalk and different-channel crosstalk**

| Crosstalk | Description |
|---|---|
| Same-channel crosstalk | Crosstalk between same channels. The impact to the cross-connect systems is larger than that of different-channel crosstalk. |
| Different-channel crosstalk | Crosstalk between different channels. The impact to the cross-connect systems is smaller than that of same-channel crosstalk. |

## 4.2 Generation mechanism of dynamic crosstalk

### 4.2.1 Configuration example of optical switching functionality

Figure 1 shows an example block diagram of optical switching functionality in optical mesh networks. This node is known as a route and select topology, since incoming data are first routed by the ingress WSS to its correct optical path, where an egress WSS selects the correct data from all its input ports before multiplexing and passing into the transmission fibre. This example configuration of a switching functionality is composed of four WSSs. Using multichannel WSSs, the number of switching optical ports can be increased and can realize cross-connect systems having many paths. Each WSS is connected to each transmission line through WDM IN and WDM OUT ports, and the number of WSS pairs is equal to the number of transmission paths.

Data in the form of DWDM signals are applied to the switching node from the ingress transmission line (transmission fibre) via the WDM IN port into the ingress WSS. This WSS demultiplexes and routes the incoming channels to the correct ongoing path. Some channels are transmitted directly through the switching node so that they pass from the EXP OUT port of the ingress WSS to the EXP IN port of the egress WSS that is associated with the required WDM OUT port. Data that is to be switched out of the transmission fibre within the node are dropped out through the DRP OUT port of the ingress WSS into the associated optical receiver, Rx. Replacement data are then added into the egress WSS from the optical transmitter, Tx, via the add port ADD IN. This added data are subsequently multiplexed with other channels in the egress WSS and then passed into the transmission line via the WDM OUT port.

For the purpose of switching paths, the WSS is controlled to change routing paths and attenuation of any path, if necessary. Dynamic crosstalk is generated in the process.

Multiplexers and demultiplexers can also be composed of optical couplers or splitters rather than WSSs.

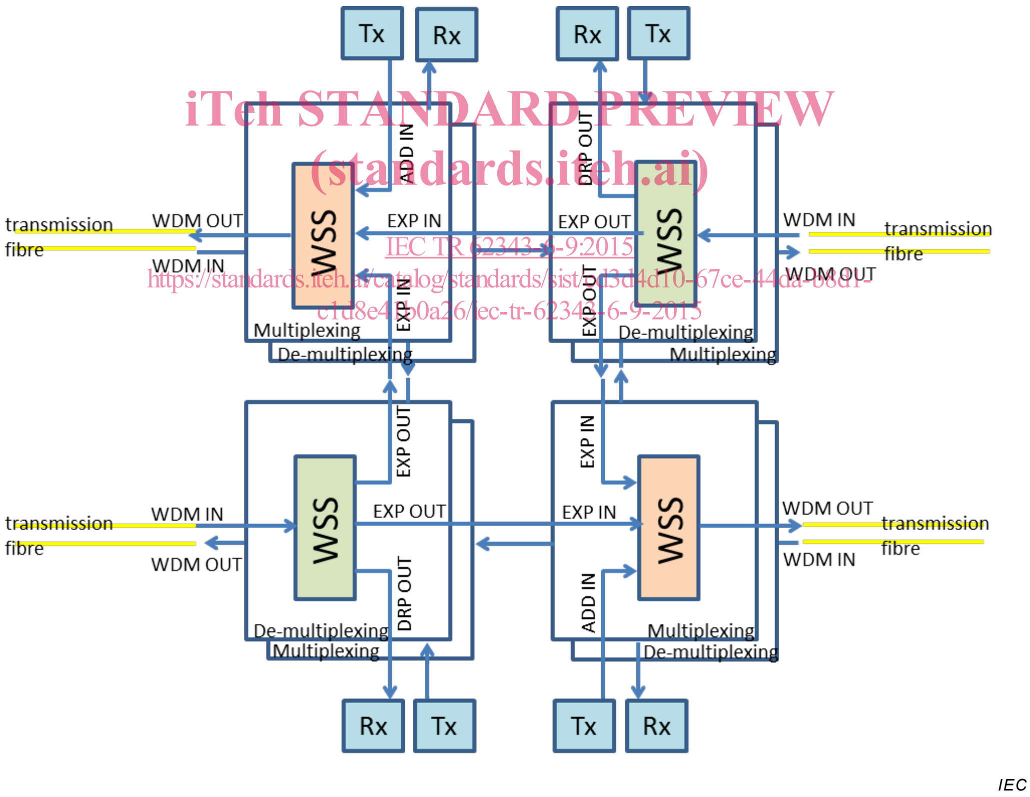




**Figure 1 – Block diagram of optical switching function**

### 4.2.2 Generation mechanism

Table 3 summarizes the generation mechanisms of same-channel and different-channel crosstalk.

Figure 2 shows the port that generates dynamic crosstalk for WSS in multiplexing and demultiplexing functions, where COM shows the common port where the multiplexed signals are input or output, and $P_1$ to $P_n$ shows the branching ports where demultiplexed signals are input or output. Figure 2a) shows the generating mechanism of different-channel crosstalk in port 2, when switching from port 1 ($P_1$) to port $n$ for a demultiplexing WSS. Figure 2b) shows