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Edition 1.0 2010-05

TECHNICAL REPORT

colour
inside

Dynamic modules –
Part 6-3: Round robin measurement results for group delay ripple of tunable dispersion compensators

IEC/TR 62343-6-3:2010(E)

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DYNAMIC MODULES –

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FOREWORD

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IEC 62343-6-3, which is a technical report, has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86C/917/DTR	86C/952/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 of 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 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- withdrawn,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.

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

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INTRODUCTION

The most important means of enhancing the technology for communication systems are networking, faster speed, and longer distance. In long-distance, high-speed communication systems operating at 40 Gbps or more, dispersion is known to limit transmission distance. Various tunable dispersion compensators (TDCs) have been commercialized in order to minimize the degradation of signals caused by chromatic dispersion. However, the group delay (GD) in TDCs is known to have ripples dependent on the principles of TDC operation, and such GD affects signal degradation.

IEC TC86 (*Fibre optics*) describes several methods of measuring chromatic dispersion (CD). One example is IEC 61300-3-38, but it does not specify a measurement method for group delay ripple (GDR). The representative passive component for compensating for chromatic dispersion is dispersion compensation fibre (DCF), but given its principles, the GD has no ripples. Conversely, many TDCs use the interference effect, which explains why there are ripples.

Under these circumstances, round robin testing has been conducted by using various TDCs and diverse GD measurement methods. This technical report, based on the findings from round robin testing, examines the direction of standardization for GDR measurement methods.

This technical report is based on and translated from OITDA document- TP06/SP DM-2008 (Group Delay Ripple Measurement Method for Tunable Dispersion Compensators－Technical Paper).

DYNAMIC MODULES –

Part 6-3: Round robin measurement results for group delay ripple of tunable dispersion compensators

1 Scope

This technical report describes the round robin measurement results for the group delay ripple (GDR) of tunable dispersion compensators (TDCs). It briefly explains the four typical TDCs measured and four typical methods of measuring group delay (GD), as well as the GDR round robin measurement results of TDCs, and an analysis of repeatability and differences among these measurement methods. This technical report also proposes suitable measurement parameters and a new parameter of phase ripple instead of GDR.

2 Normative references

The following referenced documents are indispensable for the application 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/PAS 61300-3-38, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-38: Group delay and chromatic dispersion*

IEC 62343-1-2, *Dynamic modules – Part 1-2: Performance standards – Dynamic chromatic dispersion compensator with pigtails for use in controlled environments (Category C)*

3 Abbreviated terms

For the purposes of this document, the abbreviated terms apply.

CD	chromatic dispersion
DGD	differential group delay
DUT	device under test
EOP	eye opening penalty
FBG	fibre Bragg grating
FSR	free spectral range
GD	group delay
GDR	group delay ripple
MPS	modulation phase shift
MZ	Mach-Zender
PLC	planar lightwave circuit
PPS	polarization phase shift
RBW	resolution bandwidth
SWI	swept wavelength interferometry
TDC	tunable dispersion compensator
VIPA	virtually imaged phased array

4 Types of tunable dispersion compensators (TDCs)

Various TDCs have been announced and commercialized in the market. The following briefly describes typical TDCs.

4.1 Virtual imaged phased array (VIPA)

Figure 1 shows the structure of a virtually imaged phased array (VIPA). The input light from a single-mode fibre is line-focused onto a glass plate. The glass plate is coated on both sides and collimated light is emitted from the reverse side of the glass after multiple reflections on the glass plate. The light from the glass plate is focused onto a curved mirror. The reflected light travels back to the glass plate and is finally coupled to the fibre. The 3-dimensional mirror is moved to vary the optical distance for each wavelength, thereby changing the CD.

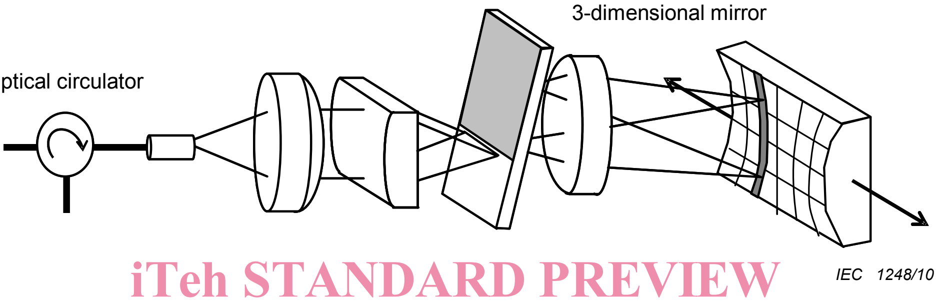


Figure 1 – Structure of the VIPA

4.2 Fibre Bragg grating (FBG)

An FBG periodically changes the refraction index of the optical fibre core, thereby forming a grating to generate Bragg diffraction, which functions as a reflection filter. Gradually changing the pitch of Bragg diffraction varies the reflection return time according to wavelength, thereby generating CD. The temperature of the fibre formed in the FBG can be varied or given tension to change the FBG pitch. This principle is used to change the CD.

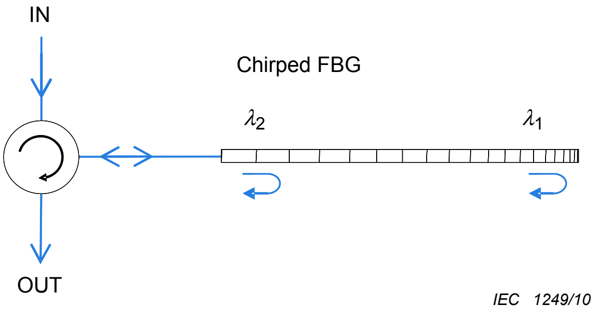
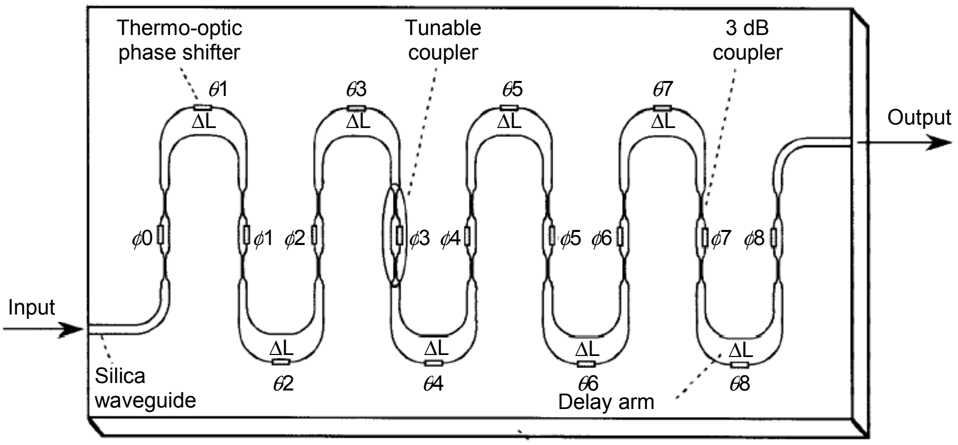


Figure 2 – Chirped fibre grating

4.3 Planar lightwave circuit (PLC)

A ring resonator can be formed on a quartz lightwave circuit. The resulting interference effect can then be used to produce periodic loss and GD characteristics over the wavelength. Moreover, the ring resonator can be replaced with MZ interference circuits in multiple stages to produce similar effects. The temperatures of some of these interference circuits can be varied to change the CD.



IEC 1250/10

Figure 3 – PLC (MZ interference circuit)

4.4 Etalon

Etalon is an optical cavity housing a pair of parallel reflective mirrors. Multiple reflection interference between two filters yields a cyclic spectrum and dispersion characteristics. The period of the cyclic spectrum is called free spectral range (FSR). The operating wavelength and FSR can be adjusted by changing the optical distance between both mirrors. A Gires-Tournois interferometer (shown in Figure 4 below) is suitable for dispersion compensation.

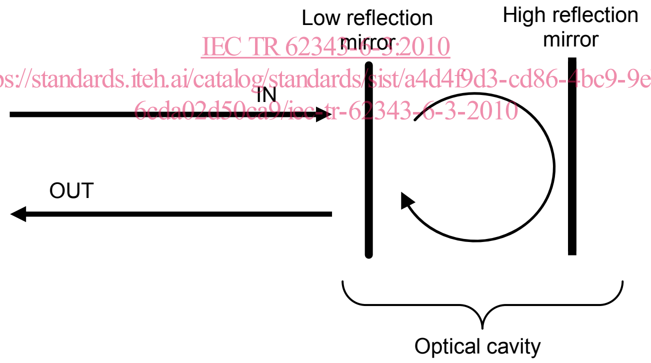


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Figure 4 – Etalon (Gires-Tournois interferometer)

5 Measurement methods

The following describes the representative methods of measuring GD. Refer to IEC/PAS 61300-3-38 for details.

5.1 Modulation phase shift (MPS) method

The MPS method is used to calculate GD and CD by adding amplitude modulation to output light from a wavelength-variable light source, receiving it with a receiver through a device under test (DUT), and then analyzing the wavelength dependence of the phase of the demodulated signal received. The wavelength resolution depends on the signal's modulation frequency. Because there is a trade-off between wavelength resolution and measurement accuracy, modulation frequency is an important measurement parameter.

5.2 Modulation phase shift-Mueller matrix (MPS-Mueller) method

The MPS-Mueller method combines the MPS method with a process to produce four polarization states of modulated light entering the DUT, and then solving the Mueller matrix for each phase calculated, thereby calculating GD and CD in an average polarization state. Similarly to the MPS method, modulation frequency becomes an important measurement parameter.

5.3 Polarization phase shift (PPS) method

The PPS method expands on the MPS method by adding hardware to divide the light beam transmitted through the DUT into two orthogonal polarized beams. The two polarization states are analyzed and GD and CD are calculated for an average polarization state. Similar to the MPS method, modulation frequency becomes an important measurement parameter.

5.4 Swept wavelength interferometry (SWI) method

Unlike the method above, the SWI method does not modulate the light beams measured. The wavelength of the wavelength-varied light source is swept before entering the receiver via the Mach-Zehnder (MZ) interferometer. With two paths through the MZ interferometer, one as the reference path and one through the interfered signal into the receiver are analyzed to determine the phase of light. The resultant findings are then used to calculate GD and CD. That is how this method works. Since the setting of wavelength resolution and measurement accuracy can be changed to oppose each other, wavelength resolution becomes an important measurement parameter.

6 DUTs and test parameters

Table 1 lists the DUTs measured and the measurement methods used. For the MPS and SWI methods, products from two different manufacturers identified as (A) and (B), respectively, were used depending on the test date. The PPS and MPS (A) methods used the same measuring equipment, with only the measurement method being switched over. The same is true of the MPS-Mueller and MPS (B) methods. Moreover, the SWI (A) method is based on a homodyne-type interferometer, while the SWI (B) method is based on a heterodyne-based interferometer.

Table 1 – DUTs and measurement methods used in round robin testing

DUTs	Measurement methods
VIPA	PPS, MPS (A), SWI (A)
FBG (1) FBG (2) FBG (3)	PPS, MPS (A), SWI (A) MPS-Mueller, PPS, MPS (A) MPS-Mueller, PPS, MPS (A)
PLC	MPS-Mueller, MPS (B), SWI (B)
Etalon	MPS-Mueller, MPS (B), SWI (B)

MPS (A)	MPS mode of PPS test equipment
MPS (B)	MPS mode of MPS-Mueller test equipment
SWI (A)	Homodyne type
SWI (B)	Heterodyne type