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SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Transmission media and optical systems characteristics –
Characteristics of optical components and subsystems

Characteristics of adaptive chromatic dispersion compensators

ITU-T Recommendation G.667

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ITU-T Recommendation G.667

Characteristics of adaptive chromatic dispersion compensators

Summary

ITU-T Recommendation G.667 contains parameters and definitions for devices providing adaptive chromatic dispersion compensation. These devices are needed for transmission and detection of optical signals in a system exhibiting high levels of dynamic variation of chromatic dispersion which would otherwise impair system operation. Single and multichannel line adaptive dispersion compensators are described, as well as single and multichannel adaptive dispersion compensating transmitters and receivers which may comprise electrical or optical forms of chromatic dispersion compensation. Information on single channel and multichannel adaptive chromatic dispersion compensation implementation, as well as principles of adaptive dispersion compensation, can be found in informative appendices.

Source

ITU-T Recommendation G.667 was approved on 14 December 2006 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Characteristics of adaptive chromatic dispersion compensators

1 Scope

This Recommendation contains parameters and definitions for devices providing adaptive chromatic dispersion compensation needed for transmission and detection of optical signals in a system exhibiting dynamic variation of chromatic dispersion. The adaptive dispersion compensating devices described include both single and multichannel applications. This Recommendation defines requirements and key parameters for adaptive dispersion compensators (ADC). This Recommendation distinguishes line adaptive dispersion compensators from adaptive dispersion compensating transmitters and receivers which may comprise electrical as well as optical forms of chromatic dispersion compensation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T G.650.2] ITU-T Recommendation G.650.2 (2005), *Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable.*
- [ITU-T G.652] ITU-T Recommendation G.652 (2005), *Characteristics of a single-mode optical fibre and cable.*
- [ITU-T G.653] ITU-T Recommendation G.653 (2006), *Characteristics of a dispersion-shifted single-mode optical fibre and cable.*
- [ITU-T G.654] ITU-T Recommendation G.654 (2006), *Characteristics of a cut-off shifted single-mode optical fibre and cable.*
- [ITU-T G.655] ITU-T Recommendation G.655 (2006), *Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable.*
- [ITU-T G.656] ITU-T Recommendation G.656 (2006), *Characteristics of a fibre and cable with non-zero dispersion for wideband transport.*
- [ITU-T G.661] ITU-T Recommendation G.661 (2006), *Definition and test methods for the relevant generic parameters of optical amplifier devices and subsystems.*
- [ITU-T G.662] ITU-T Recommendation G.662 (2005), *Generic characteristics of optical amplifier devices and subsystems.*
- [ITU-T G.665] ITU-T Recommendation G.665 (2005), *Generic characteristics of Raman amplifiers and Raman amplified subsystems.*
- [ITU-T G.666] ITU-T Recommendation G.666 (2005), *Characteristics of PMD compensators and PMD compensating receivers.*
- [ITU-T G.671] ITU-T Recommendation G.671 (2005), *Transmission characteristics of optical components and subsystems.*

3 Terms and definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined in [ITU-T G.671]:

- channel frequency range;
- channel insertion loss;
- channel insertion loss deviation;
- phase ripple;
- insertion loss;
- polarization dependent loss;
- polarization dependent reflectance;
- polarization mode dispersion.

This Recommendation uses the following term defined in ITU-T Rec. G.692:

- maximum central frequency deviation.

This Recommendation uses the following term defined in ITU-T Rec. G.698.1:

- maximum spectral excursion.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 ADC transmitter: An optical transmitter containing adaptive chromatic dispersion compensation functionality.

3.2.2 ADC receiver: An optical receiver containing adaptive chromatic dispersion compensation functionality.

3.2.3 dispersion compensation parameter: This parameter depends on the type of dispersion compensation device, and describes the achievable dispersion compensation performance of an ADC.

For an ADC transmitter, the transmission performance related to dispersion of the ADC transmitter can be changed adaptively according to the dispersion change of the optical transmission link in which it is operating. The dispersion compensation parameter is the dispersion accommodation value of the optical transmitter signal that can be achieved by the ADC transmitter over the channel frequency range.

For a line ADC, the dispersion compensation value between the input port and the output port of the line ADC can be changed adaptively according to the dispersion change of the optical transmission link in which the line ADC is operating. The dispersion compensation parameter is the dispersion compensation value between the input port and the output port that can be achieved by the line ADC device over the channel frequency range.

For an ADC receiver, the dispersion tolerance of the receiver can be changed adaptively according to the residual dispersion value of the optical transmission link. The dispersion compensation parameter is the acceptable residual dispersion value of the optical input signal to the ADC receiver over the channel frequency range while the BER remains lower than the specified limit.

3.2.4 dispersion compensation tuning range: The difference between the maximum value of the dispersion compensation parameter and the minimum value of the dispersion compensation parameter of an ADC device (measured as ps/nm).

3.2.5 dispersion compensation tuning time: For an ADC transmitter or a line ADC, this is the time duration from the start of a change of the dispersion compensation parameter to the time after which it remains within the limits of the new target value plus and minus the specified tolerance. This is illustrated in Figure 3-1.

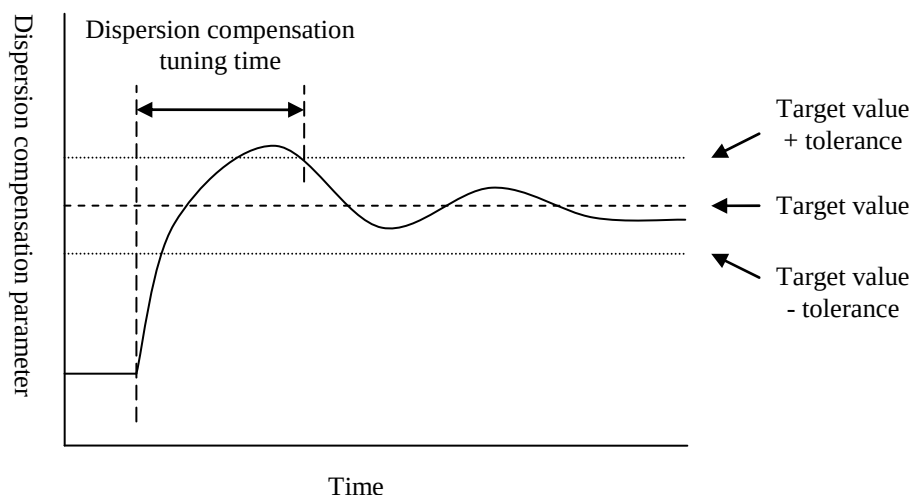


Figure 3-1 – Illustration of dispersion compensation tuning time for an ADC transmitter or a line ADC

For an ADC transmitter, the specified tolerance is the specified error of the dispersion accommodation value.

For a line ADC, the tolerance is the specified error of the dispersion compensation value.

For an ADC receiver, the dispersion compensation tuning time is the time duration from a step change of the input signal residual dispersion to the time after which the BER remains lower than the specified limit. This is illustrated in Figure 3-2.

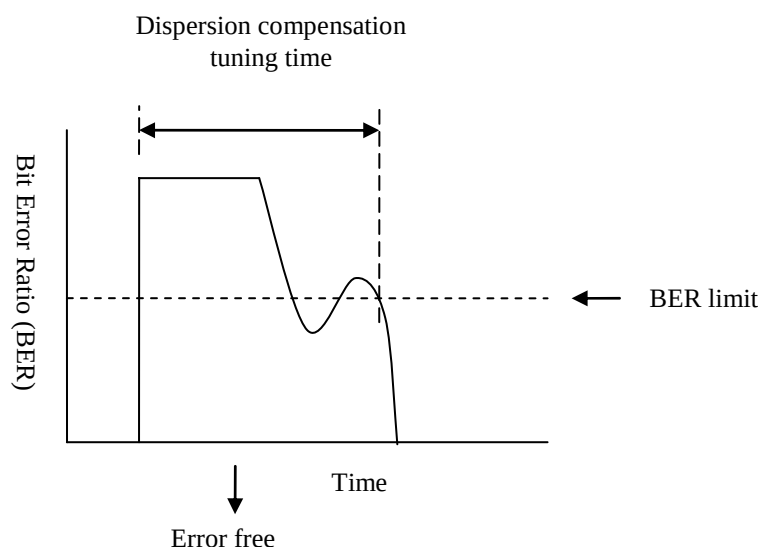


Figure 3-2 – Illustration of dispersion compensation tuning time for an ADC receiver

NOTE – The tuning time will depend on the range between the current state and the new target state.

3.2.6 maximum rate of change of dispersion compensation parameter: This is the maximum rate of change of link chromatic dispersion with time that can be adequately compensated for by the ADC device.

This parameter depends on the type of the dispersion compensation device.

For an ADC transmitter or a line ADC, this is the maximum value of the rate of change of link chromatic dispersion with time (in ps/nm/s) that can be compensated for while maintaining the residual dispersion of the link within the specified tolerance.

For an ADC receiver, this is the maximum value of the rate of change of link chromatic dispersion with time (in ps/nm/s) that can be tolerated while meeting the specified BER.

3.2.7 minimum optical signal-to-noise ratio: The value of optical signal-to-noise ratio (OSNR) at point MPI-R to achieve the specified BER for the optimum link residual dispersion. This parameter depends on the type of optical system.

For a single-channel system, this is the minimum value of the ratio of the signal power to the noise power density (referred to 0.1 nm) at the signal wavelength.

For a multichannel system, this is the minimum value of the ratio of the signal power in the wanted channel to the highest noise power density (referred to 0.1 nm) in the range of the central frequency plus and minus the central frequency deviation or the maximum spectral excursion.

3.2.8 OSNR penalty due to chromatic dispersion: The difference in the optical signal-to-noise ratio at point MPI-R to achieve the specified BER between optimum link residual dispersion and the worst value for all specified values of link residual dispersion.

3.2.9 ADC receiver sensitivity: The value of mean received power at point MPI-R to achieve the specified BER. This must be met for the optimum link residual dispersion with a worst-case transmitter, but does not have to be met with degradations of the optical path other than dispersion.

3.2.10 ADC receiver sensitivity penalty due to chromatic dispersion: The difference in the mean received power at point MPI-R to achieve the specified BER between optimum link residual dispersion and the worst value for all specified values of link residual dispersion. This does not have to be met with degradations of the optical path other than dispersion.

4 Abbreviations

This Recommendation uses the following abbreviations:

ADC	Adaptive Dispersion Compensation
ADC-Rx	Adaptive Dispersion Compensating Receiver
ADC-Tx	Adaptive Dispersion Compensating Transmitter
BER	Bit Error Ratio
DEMUX	Demultiplexer
DFE	Decision Feedback Equalization
EDC	Electrical Dispersion Compensation
FBG	Fibre Bragg Grating
FFE	Feed Forward Equalization
LADC	Line Adaptive Dispersion Compensator
M-ADC-Rx	Multichannel Adaptive Dispersion Compensating Receiver
M-ADC-Tx	Multichannel Adaptive Dispersion Compensating Transmitter
M-LADC	Multichannel Line Adaptive Dispersion Compensator
MLSE	Maximum Likelihood Sequence Estimation
MPI	Main Path Interface
MUX	Multiplexer
NRZ	Non-Return to Zero
OA	Optical Amplifier
O-E-O	Optical-Electrical-Optical (conversion)
OSNR	Optical Signal-to-Noise Ratio
PDL	Polarization-Dependent Loss
PMD	Polarization Mode Dispersion
RZ	Return to Zero
S-ADC-Rx	Single-Channel Adaptive Dispersion Compensating Receiver
S-ADC-Tx	Single-Channel Adaptive Dispersion Compensating Transmitter
S-LADC	Single-Channel Line Adaptive Dispersion Compensator
VIPA	Virtually-Imaged Phased-Array
VSF	Vestigial Side Band
WDM	Wavelength Division Multiplexing

5 Reference configurations

ADCs are intended to be used to reduce dispersion-induced signal degradations in optical transmission systems with dynamic dispersion change. Therefore, characteristics of ADCs must be considered – at least in part – in conjunction with a whole transmission system.

ADCs are expected to be used in at least two applications:

The first is to use the ADC to compensate for slow changes of link dispersion over time due to environmental effects, such as temperature. This is referred to as a slow change link dispersion application.

The second is to use the ADC to compensate for sudden step changes of link dispersion due to switching or other transmission link re-configuration process. This is referred to as a step change link dispersion application.

A generic configuration of a transmission system with ADC(s) is shown in Figure 5-1. It consists of a transmitter terminal, a receiver terminal and a transmission link in-between with optional line ADC(s). A single-channel system contains a single-channel transmitter and receiver terminal while a multichannel transmitter and receiver terminal is used in a multichannel system.

In the following clauses optical line ADCs (LADC) are distinguished from ADC transmitters and receivers. A black box approach is applied for the line ADCs, ADC transmitters and receivers. Monitoring and control (if present) is included in the black box. Further information concerning the implementation options of all of these devices can be found in Appendix I and details of the underlying technology used in them are contained in Appendix II.

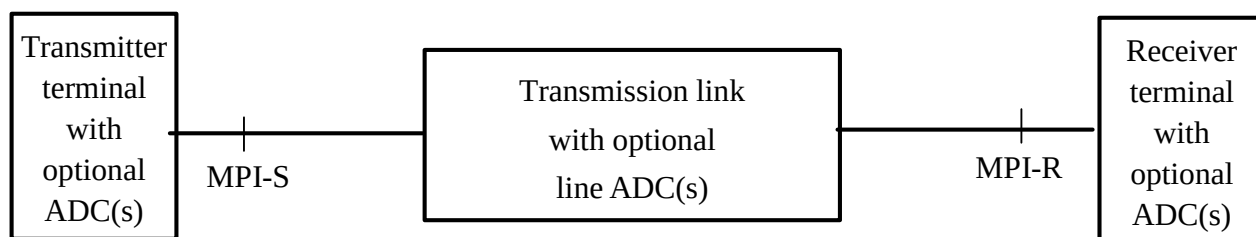


Figure 5-1 – Generic configuration of a transmission system with ADCs

5.1 Line ADCs

Line ADCs have an optical input port and an optical output port and no O-E-O conversion is performed on the signal passing from one to the other. A single-channel line ADC (S-LADC) can handle a single-channel optical signal while a multichannel line ADC (M-LADC) is constructed for a multichannel optical signal. Both types are illustrated schematically in Figures 5-2 and 5-3 respectively.



Figure 5-2 – Reference configuration of a single-channel line ADC (S-LADC)