G Suppl. 39 Optical system design and engineering considerations

- Provides background and methodologies used in the development of optical interface specifications
- Covers the definition of spectral bands as well as the parameters of system elements
- Wide range of line codes are described, including NRZ, DP-QPSK, and QAM
- Both worst-case and statistical optical transmission systems design methodologies are described
- Forward error correction techniques are discussed and their application to link design is described
- Transverse and longitudinal compatibility are defined
- Other design aspects such as power safety and optically switched network are covered
- Extensive review of the analytical methods used to determine the impact of optical impairments, as well as optical parameter measurement methods

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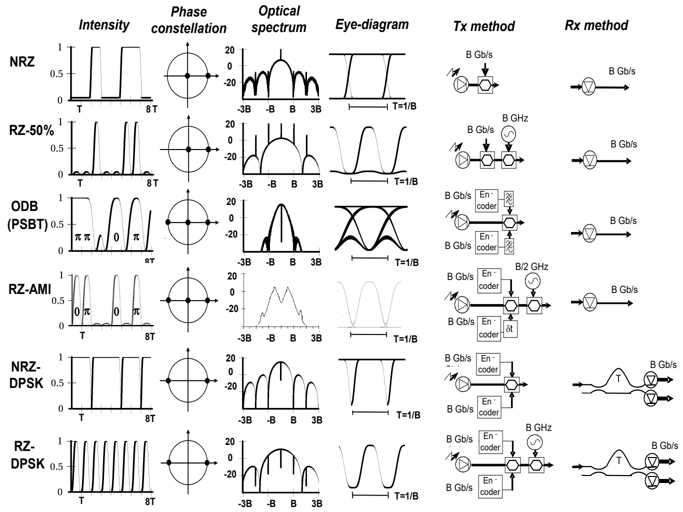

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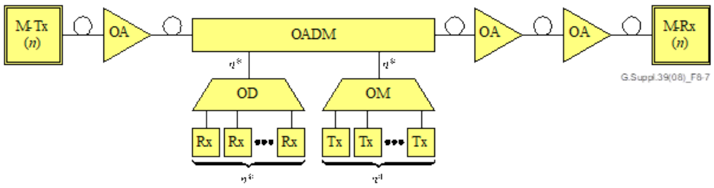

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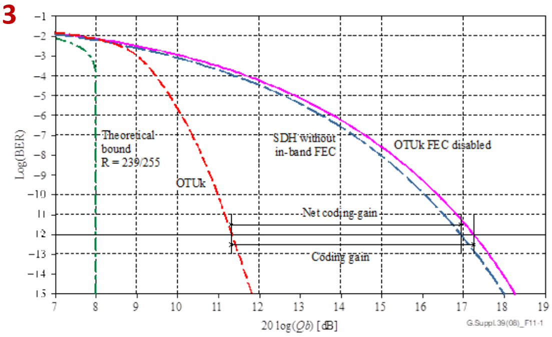

ITU-T G Suppl. 39 – Optical system design and engineering considerations

This supplement serves as a compendium for technical definitions, design aspects, and analysis methods useful for devising recommendations for optical transmission systems.

Spectral bands

Fibre optics transmission systems use a variety of spectral bands, as imposed by type of transmitter, fibre type and presence of optical amplifiers. G Suppl. 39 defines the spectral bands for both single mode and multi-mode systems.

Line coding considerations (1)

As optical transmission systems have evolved, the possible set of line codes has grown. G Suppl. 39 contains a large section that gives a description of most of these codes, including non-return to zero (NRZ), dual-polarization quadrature phase shift keying (DP-QPSK), higher order quadrature amplitude modulation (QAM), and various combinations of all these techniques. For each of these codes, the mathematical principle is presented, and if warranted, the typical transmitter and receiver design. Then, the system-level impairment profile for each of the codes is compared. Lastly, multi-dimensional coding techniques are described.

Optical network topologies (2)

G Suppl. 39 describes various network topologies that can be used in optical transmission systems. Point-to-point systems, both single and multiple WDM channel types, are illustrated, as well as networks with repeaters. Bus structured systems are also presented, including those with add drop multiplexers with single channel tributaries and multiple channel tributaries.

Worst-case and statistical design methods

Worst-case analysis is a deterministic design method. The link margin is calculated based on the worst performance levels for each element of the link (transmitter, channel, and receiver). The very important effect of chromatic dispersion is analysed at length. Polarization mode dispersion (PMD), the effect of FEC use, and noise concatenation are covered. The various forms of crosstalk are given a thorough treatment. The impact of non-linear impairments and simulation-based modelling is discussed.

Complex systems that have many elements in the signal path tend to have excessive margin if worst-case design is used. Statistical design can resolve this problem. The generic approach is to consider the performance parameters of each element as a random quantity described by a distribution. Then probability thresholds can de defined so that the parameter will be worse than the threshold value with a small probability. Then the system designer can determine how these probabilities combine to produce the system outage probability. The application of this method to link loss, chromatic dispersion, and PMD are illustrated.

Forward Error Correction (3)

Traditional optical systems did not attempt to correct errors because the raw error levels were good enough for voice applications. As systems have gone to higher speeds and applications have become more error sensitive, forward error correction (FEC) has become commonplace. In-band and out-of-band FEC schemes are described, as well as how their performance can be described in terms of coding gain. Hard decoding and soft decoding methods are explained. The uses of the coding gain are illustrated, including reduction of Tx and Rx performance requirements, and relaxation of network parameters.

Compatibility

The optical transport network has a large scale, and multiple vendors are producing the elements. It is important to understand how these will interwork. Transverse and longitudinal compatibility are defined, and the differences in parameter requirements is described. Joint engineering is also considered.

Optical switching and eye safety

The technology needed to create a switched optical network has developed, and this greatly increases the flexibility of the system. However, it also causes optical power transients to occur, and these can impair the transmission on other channels sharing the same infrastructure.

Optical power levels have become high enough that various safety issues arise. G Suppl. 39 describes the best practices to ensure that the personnel working on the network avoid injury, and that the network itself does not cause collateral damage.

For more information, please visit the ITU-T Study Group 15 website at: www.itu.int/go/tsg15