METHODS FOR SELECTING THE GROUP SIGNAL POWER LEVEL CONSIDERING NONLINEAR INTERFERENCE IN DWDM FIBER-OPTIC COMMUNICATION SYSTEMS

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ABSTRACT

This paper investigates methods for selecting the optimal group signal power level in Dense Wavelength Division Multiplexing (DWDM) fiber-optic communication systems. Increasing optical power leads to nonlinear effects in optical fiber, particularly four-wave mixing (FWM). The influence of amplified spontaneous emission (ASE) noise generated by optical amplifiers is also considered. The dependence of transmission quality on channel power and number of channels is analyzed. Calculations of nonlinear interference power, amplifier noise and Q-factor are performed. The obtained results make it possible to determine optimal optical power levels that ensure reliable data transmission in DWDM systems.

1. Introduction

Modern telecommunication networks are characterized by rapid growth of traffic volume. To increase network capacity, Dense Wavelength Division Multiplexing (DWDM) technology is widely used [1]. DWDM enables transmission of dozens or hundreds of optical channels through a single fiber.

However, increasing optical power and the number of channels leads to nonlinear effects in the optical fiber. One of the most significant nonlinear phenomena is four-wave mixing (FWM), which generates additional spectral components and causes inter-channel interference [2].

Another factor affecting signal quality is amplified spontaneous emission (ASE) noise generated in optical amplifiers. The accumulation of ASE noise degrades the signal-to-noise ratio and reduces system performance [3]. Therefore, selecting an optimal optical power level is an important task in DWDM system design.

2. Method for Selecting Group Signal Power

The power of four-wave mixing components can be estimated by the following expression:

$P_{ijk} = \eta \cdot D_{ij} \cdot (\gamma^2 / \alpha^2) \cdot P_i P_j P_k L^2$,

where η is the FWM efficiency coefficient, Dij is the degeneracy factor, γ is the nonlinear coefficient of the fiber, α is the attenuation coefficient, Pi, Pj, Pk are the powers of interacting channels, and L is the interaction length.

According to ITU-T recommendations, the total optical power in DWDM systems should not exceed +23 dBm [4]. In this work, the group signal power is selected as 20 dBm.

The channel power is calculated as:

$P_{ch} = P_{group} - 10 \log N$.

3. Input Parameters for Calculations

Parameter	Symbol	Value
Number of channels	N	18, 64, 100
Transmission rate	B	10 Gbit/s
Span length	L	120 km
Fiber attenuation	α	0.2 dB/km
Amplifier gain	G	30 dB
Spontaneous emission coefficient	nsp	1.4
FWM efficiency	η	0.8

4. Calculation Results

Channels	Channel Power (mW)	Q-factor	FWM Power
18	5.55	708.3	2.22×10^{-5}
64	1.56	203.09	7.59×10^{-5}
100	1	130.34	1.18×10^{-4}

The results show that increasing the number of channels reduces the power of each channel but increases the influence of nonlinear interference.

5. Recommendations for Power Optimization

• optimization of optical channel power levels,
• limitation of total optical power to +23 dBm,
• gain equalization of optical amplifiers,
• optimal selection of channel spacing,
• use of unequal channel spacing to reduce FWM effects [5].

6. Conclusion

This study analyzed the influence of group signal power on nonlinear interference in DWDM systems. The results demonstrate that increasing optical power intensifies nonlinear effects, particularly four-wave mixing. Optimal selection of channel power makes it possible to maintain acceptable transmission quality in modern fiber-optic communication networks.

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