

## Chapter 5

# Conclusions

In the previous 4 chapters, a Spectrum-Sliced WDM (SS-WDM) system was analyzed under various conditions. Some important results have been obtained, and these will be summarized in this Chapter. Also, recommendations for future work will be made.

The first important contribution of this thesis was to validate a different method to evaluate the receiver performance in an SS-WDM system, the Saddlepoint Approximation. The Saddlepoint Approximation has been used in the past for various types of problems, not only in the area of fiber optics communications. It is a method which is almost as simple as the most popular method used in the field, the Gaussian Approximation but gives results which are much better. In Chapter 2, the Saddlepoint Approximation was applied to a simple SS-WDM system with no interchannel interference and using a rectangular filter. The results obtained were compared to those obtained previously by Arya in [18], and it was shown that the Saddlepoint Approximation yielded results which matched exactly the results obtained with the exact calculation. While the exact calculation involved the calculation of integrals involving the pdfs of the received signals, which is a complex task, the Saddlepoint Approximation used Moment Generating Functions which are much easier to handle.

Another important contribution of this thesis was the evaluation of the effect of Butterworth filters in receiver performance. Previous works had used the Gaussian Approximation and a Chi-Square Approximation to evaluate the receiver performance when different Butterworth filters were used. When using the Saddlepoint Approximation the main objective was to compare the results obtained with those obtained with the Chi-Square Approximation. Both methods are somewhat similar but have one major difference. The Chi-Square Approximation assumes that when the data signal and noise are added the resulting signal also has a chi-square distribution. We did not make such assumption when using the Saddlepoint Approximation. Even though the noise and the data signal each have a chi-square distribution, the sum will not be chi-square distributed.

The results obtained with the Saddlepoint Approximation are similar to those obtained with the Chi-Square Approximation for higher filter orders but for lower filter orders the results are closer to those obtained with the Gaussian Approximation. This indicates that the Chi-Square Approximation is accurate only for filters that resemble rectangular filters.

In Chapter 4, the biggest contributions of this thesis were made. The prime objective of this thesis was to evaluate receiver performance when interchannel interference caused by filter overlap was present. The effects of single-sided and double-sided interchannel interference were evaluated. We used three methods to do this, the Saddlepoint Approximation, the Chi-Square Approximation and the Gaussian Approximation. The results obtained with the Saddlepoint Approximation are considered to be the most accurate, as the correct moment generating function is used in this case whereas approximate probability density functions are assumed in the other cases.

The Chi-square approximation gave good results when channel overlap was small, but for larger values of channel overlap the results became too optimistic. When overlap became large the results approached that of the Gaussian approximation.

It was also shown the existence of an optimum overlap to maximize total system throughput. This optimum was obtained as 5% of interchannel interference. As overlap increased from zero, initially more channels could be fitted within a given bandwidth, but this was then countered by the required bandwidth per channel increasing. It was shown that at the optimum point of operation the system could operate with a total throughput of 135 Gb/s for a BER of  $10^{-9}$  and 220 Gb/s for a BER of  $10^{-6}$ . As a final conclusion, we proved that double-sided interchannel interference degrades system performance much more aggressively than single-sided interference.

For future work, some suggestions can be made. The first one is the use of another method, the Chernoff Bound, to evaluate receiver performance, as this method has been used in other works in the past to evaluate receiver performance. Another idea would be to test a different type of modulation scheme in the system. We worked in this thesis exclusively with ON-OFF Keying (OOK), so it would be interesting to obtain results also for a modulation scheme like Frequency-Shift Keying (FSK).

Another possibility for future work would involve the Karhunen-Loeve expansion used in Chapter 3 to obtain the energy equations. When using the Karhunen-Loeve expansion, we assumed all eigenvalues to be the same, but to obtain more accurate results we would need to obtain the eigenvalues corresponding to the different filter shapes. In Chapter 4 we used rectangular filters to evaluate the effects of interchannel interference on the system, some work can also be done using first-order Butterworth filters while using the Saddlepoint Approximation. As a final possibility for future work in this area, simulation of the system using the optical simulation tool BNeD would be a good idea as different parameters could be changed during the simulation. This would be better than testing our results experimentally, as different parameters could be changed which would be more difficult experimentally.