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Mitigation of Crosstalk in Optical Network Using Modulation Techniques

Sumedha Kaushik[1]
#Department of ECE &M. M. University
Ambala,(Haryana) India

Ankur Singhal[2]
#Department of ECE &M. M. University
Ambala,(Haryana) India

Abstract— **Multichannel signal design for cross-talk limited fiber optic systems is considered. We focus on mitigating cross-talk in the form of in Band crosstalk resulting from fiber non-linearities. In-band crosstalk noise can pose important limitations in an optical network. Different modulation techniques are used to improve the performance of system. The analysis indicates that QPSK modulation technique is better than BPSK in terms of crosstalk and power penalty.**

Keywords— **Optical Network, BPSK, QPSK, in band Crosstalk, Power Penalty.**

I. INTRODUCTION

To transmit data from one point to another, some signal path is needed between those points. To create such path a medium is needed to transfer the data. The choice of this medium depends on the requirements and available infrastructure. Examples of media which can be used are air, copper or optical fibers. With these media, radio networks, electrical networks and optical networks can be created [1]. Optical fiber is a remarkable communication medium compared to other media such as copper or free space. An optical fiber provides low-loss transmission over an enormous frequency range of at least 25 THz-even higher with special fibers which are orders of magnitude more than the bandwidth available in copper cables or any other transmission medium [2]. The two major types of fibers are multimode fibers and single mode fibers. Multimode fibers have a larger core, usually either 62.5 μm or 50 μm in diameter. Single mode fiber has a core which is about 8 μm in diameter (the most popular is 8.3 μm in diameter). The diameter with the cladding is 125 μm for both. When the protective opaque covering is added, the diameter of a single fiber strand is about 250 μm. The larger core in multimode fiber makes it is easier to couple to the light source, which may be a light emitting diode (LED). Multimode fiber, however, has significantly higher loss (due to modal dispersion) than single mode fiber and is therefore only used for short distance communications such as within a building or on a corporate campus. All long distance communications utilizes single mode fiber and laser light sources [3]. In optical communication, there are many alternative like digital subscriber line (DSL) and community antenna television (CATV) (cable TV) based networks which provides large bandwidth However, both of these technologies have limitations because they are based on infrastructure that was originally built for carrying voice and analog TV signals, respectively. Among these alternatives, optical fiber access networks are seen as the most future safe solution.

II. OPTICAL NETWORK

Optical networks are digital communications systems that use Light waves (including infrared) as a medium for the transmission or switching of data. By developing the optical networks, larger transmission capacity at longer transmission distance can be achieved. Optical networking is defined as the types of connection between more than two networking devices with the help of fiber optical cables for the sake of computer networking and for other uses such as surfing internet, watching TV, telecommunication and file sharing technology etc is called as the optical networking. Optical networking is based on the optical networks for the purpose of the high rate connectivity in offices or at the home. Optical network based on emergence of optical layer in transport network provide high capacity and reduced cost for new application such as the internet, video and multimedia interaction and advanced digital services. Optical networking offers faster data transfer rates than coaxial cables or other cords and can be stretched over extremely large distances. Optical network is high speed network. There are many networks like ADSL, CATV [4].

III. THEORETICAL MODELS FOR OPTICAL CROSSTALK

Optical crosstalk may critical if low-cost optical components are used, so further research is required to quantify the significance of crosstalk in fibre-radio systems. The impact of optical crosstalk in fibre-radio networks depends on the nature of the modulation scheme used to transmit data via an optical network. The data can either be sent at baseband (intensity modulation or IM) or at an intermediate or RF frequency via subcarrier modulation. The impact of incoherent in-band crosstalk due to multiple reflections along an optical link is considered. The model presented by Moura et al. is modified to analyse in- band optical crosstalk for Binary Phase-Shift-Keying (BPSK) modulation, providing insight into the importance of the RF carrier phase difference. It shows that power penalties are significantly different [5]. D. Castleford et al. investigate analytically and experimentally optical crosstalk effects in fiber-radio, systems incorporating wavelength-division multiplexing. Both in-band and out-of-band crosstalk are considered and the effect of the RF phase difference between the desired and crosstalk channels investigated. It is found that in-band incoherent crosstalk-induced power penalties are less severe than in conventional baseband transmission [6].

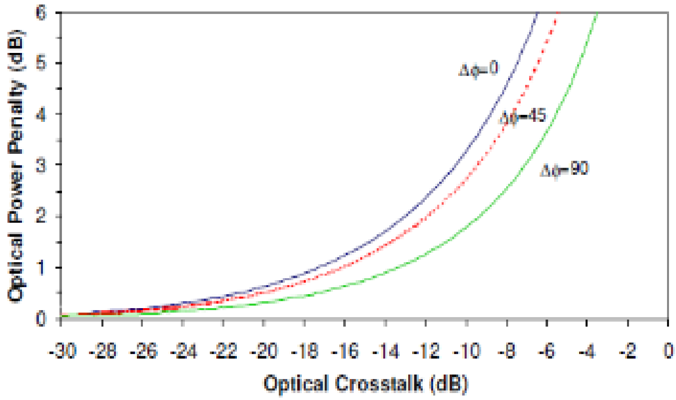

Fig.1Theoretical optical power penalties for BPSK modulation versus in-band optical crosstalk with frequency re-use as a function of RF carrier phase difference.

It shows that the power penalties arising from in-band optical crosstalk in a fibre-radio WDM system depend on the RF phase difference between the crosstalk and signal carriers. For example at a crosstalk level of -12 dB, the power penalty is reduced by approximately 1.5 dB when Δφ is changed from 0 to 90°. The difference in power penalties also increases with the crosstalk level. Another important observation from Figure is that the crosstalk- induced optical power penalty is significantly worse for baseband data transmission. The difference is due to the modulation format and the associated data recovery in the receiver. It is also apparent that a large power penalty is still present for a 90° RF phase difference, even though no crosstalk electrical signal is present at the output of the receiver.

The penalty is caused by the presence of the crosstalk optical carrier, which beats with the signal data sidebands thereby varying the resulting signal data amplitude. The results are based on the worst-case power penalty for a specific modulation format, which for ASK may occur for an average decision threshold or a phase-tracking decision threshold. The dependence on modulation format is clear, with BPSK the least sensitive to crosstalk, followed by QPSK modulation and then ASK modulation [5].

Dalma Novak et al. analyzed that Crosstalk -induced power penalties in fiber-radio WDM networks are reduced compared to baseband modulation for the case of in-band crosstalk. In addition, in contrast to baseband modulated optical links, the crosstalk channel in fiber-radio systems can be filtered electrically if the crosstalk signal carries a different wireless frequency. However, a power penalty is still observed for the case of in-band crosstalk, even for perfect electrical filtering of the crosstalk channel [7].

IV. PROPOSED WORK

Channels are reconstructed with help of Cbea algorithm. Cbea Algorithm is a Cross spectrum Blind channel Equalization Algorithm. Cbea Algorithm is used in this thesis to improve the performance of system in terms of crosstalk. It assumes that we have access to two observations, corresponding to the outputs of two channels excited by the same input. It proposes a new algorithm which estimates the channels using as basic tool the phase of the cross spectrum of functions of the observations. The proposed method is computationally attractive, requires small input sample sizes, and performs well in low signal-to-noise ratios. Steps for algorithm for Cbea are as follow:

1. Use Len for estimation of channel. Where Len represents the output sequences.
2. Calculate Cross spectrum of $X_1$and X_2.Where X_1 and X_2 represent observation of sequences.
3. Using Real Spectrum, the minimum phase & equivalent sequences are calculated.
4. Estimating the phase of h_{min} and h_{max} and estimation of length of h_{min} and h_{max}.
5. Normalize these values with respect to maximum value.
6. Reconstruction of channel using normalized values.

By using these steps crosstalk is removed to some extent and channels are aligned.

V. RESULT &DISCUSSION

By using different modulation techniques like ASK, BPSK, QPSK in frequency reuse WDN system, it is estimated that tolerance power of BPSK modulation technique in case of In Band crosstalk is better than other modulation techniques. It is analysed by using RF phase difference. In this case, tolerance power of BPSK IS -17.3 dB is achieved. It can be further improved by using different techniques and different algorithm. Here we are using Advanced CBEA Algorithm.

By using this algorithm it is proposed that in -band crosstalk in optical network is improved up to -18. 5dB. Thus QPSK shows better result in comparison to the BPSK modulation technique.

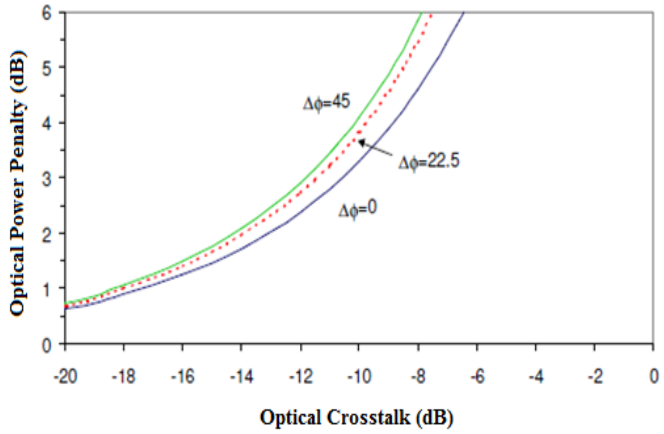

Fig. 5 Optical power penalties for in-band crosstalk for QPSK modulation.

Fig. 5 only considers a 45° area since QPSK points are separated by 90°, resulting in a symmetry about 45°, 135°, 225° and 315°. for QPSK modulation the minimum power penalty is obtained for in-phase RF carriers, with the power penalty increasing as the RF phase difference goes to 45°. 1 dB power penalty occurs at -18.5 dB for the worst-case, compared to -17.3 dB for the best case (same as BPSK worst-case). Hence QPSK modulation results in 1.2 dB tighter crosstalk tolerance relative to BPSK modulation. However, it is still better than baseband intensity modulation. Using this modulation relation between phase, crosstalk and power penalty has been studied. Now cbea algorithm is used to align channel. Input to this algorithm is as follow:

"Cross-Spectrum Based Blind Channel Identification"

INPUTS:

Snr : signal-to-noise ratio for additive noise processes
LEN : number of output symbols to use in the estimation
CC : length of the cepstrum window (rectangular here)
Qq : length of the autocorrelation window (rectangular here)
X_1,X_2 : the observation sequences (single-input, double-output)
h_1,h_2 : the actual sub-channels (for alignment purposes only)
N_1,N_2 : (over)-estimates of the lengths of h_min(n), h_max(n)

OUTPUTS:

Rec : A matrix containing the estimated h_1 (n) as its first row, and the estimated h_2 (n) as its second row.

h : the actual channel h(n), from which h_1(n) and h_2(n) can be obtained by oversampling by a factor of 2.

function [Rec,h]=cbea(snr,LEN,CC,Qq,X_1,X_2,h_1,h_2,N_1,N_2)
cbea(1.5,1,20,20,135,125,120,110,130,130)

ans =

Columns 1 through 17

0	0	0	0	0	0	0	0	0	0	120	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	110	0	0	0	0	0	0

Columns 18 through 21

0	0	0	0
0	0	0	0

It is analysed that by keeping all parameter constant, phase of the channels are aligned. And crosstalk is removed to some extent.

VI. Conclusion

Various modulation techniques have studied. And it is analysed that QPSK shows better result in comparison to BPSK. A 1dB power penalty occurs at -18.5 dB for the worst-case, compared to -17.3 dB for the best case (same as

BPSK worst-case). Hence QPSK modulation results in 1.2 dB tighter crosstalk tolerance relative to BPSK modulation. At this QPSK modulation technique CBEA algorithm is applied. And alignment of different channels take place using this algorithm and crosstalk is removed. And channels are reconstructed.

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