A Performance Assessment of Narrowband Modulation Schemes over the Flat Rayleigh Fading Channel in Radio-over-Fibre Communication Systems

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Abstract*:*
In this paper the impact of AM-AM and AM-PM distortion on the BER performances of uncoded RoF-BPSK and RoF - QPSK in a flat Rayleigh fading channel are evaluated by the method of computer simulation. It is observed that AM-PM distortion is the dominant factor in performance degradation; but with greater impact on the performance of QPSK. Also, there is a difference in performance degradation for both schemes at very low OBO's i.e. the 0.0-0.3 dB range in comparison with the 0.3-3.0 dB OBO range. This may be attributed to the probability density function (pdf) of the induced ISI and the input back-off (IBO) level. There is an irreducible error rate in the RoF- QPSK case at low OBO's but not in the RoF-BPSK case.

Keywords*:* RoF, Narrowband, Rayleigh, AM-AM/PM, OBO, ISI

1-Introduction

Radio- over- Fiber (RoF) is a technology by which information bearing signals using RF carries are distributed by means of optical components and techniques. Better coverage and increased capacity, centralised upgrading and adaptation, higher reliability and lower maintenance costs, support for future broadband applications, and economic access to mobile broadband are among the most important advantages of RoF[1]. However, RoF systems are vulnerable to non-linearities in the optical subsystem that cause degradation of the system BER performance.

In this paper the impact of the optical subsystem non-linearities, which are expressed as measured AM-AM and AM-PM characteristics, on the performance of phase -modulated narrowband communication systems (i.e. RoF-BPSK and RoF-QPSK) in a flat Rayleigh fading channel at three different Output Back-Off (OBO) levels (i.e. 0.0, 0.3, and 3.0 dB) as well as different AM-AM/PM effects are considered.

2-Simulation Model

In order to evaluate the effects of OBO and AM-AM/PM distortion on the un-coded narrowband modulation schemes in a Rayleigh fading channel, computer simulations were carried out based on the system model presented in Figure 1. The model consists of a data source, a modulator, a transmit Root-

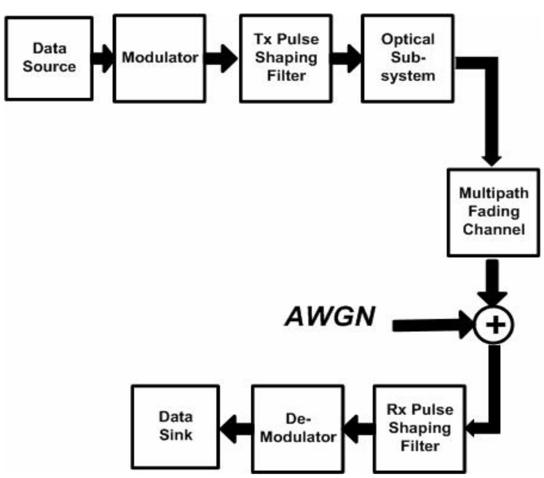


Figure 1: Simulation Model

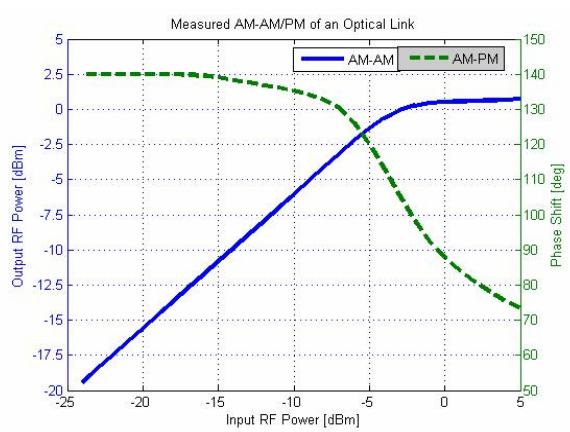


Figure 2: AM-AM / PM Characteristics

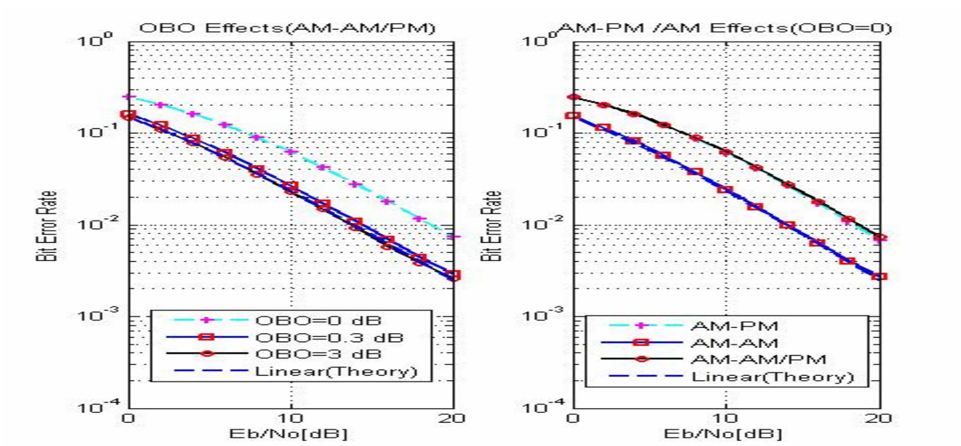
Raised Cosine (RRC) filter (rolloff=0.22, number of taps= 64), the optical subsystem, a Rayleigh fading channel, AWGN, a receive RRC filter, a demodulator, and a data sink respectively. The optical subsystem, which has an overall gain of unit, consists of a laser diode, a 2.2 km length of single-mode fibre, and a PIN diode for the photodetector. It is characterised by the measured AM-AM/PM characteristic [2] which is reproduced in Figure 2. Fading is flat with a fade coherence time of 10 ms. The demodulator includes a phase de-rotation based on an ideal knowledge of the phase rotation introduced by fading. Simulations were carried out for both the BPSK and QPSK modulation schemes at three values of OBO i.e. 0.0, 0.3, and 3.0 dB. Also, the effects of separate AM-AM and AM-PM characteristics were simulated for both cases. Finally, the pdfs of the AM-AM/PM induced ISI over the fading channel are compared for both schemes at the aforementioned OBO values .

3-BER Performance Results

Figure 3 shows the impact of the AM-AM / PM non-linear distortion on the BER performance of BPSK with OBO as a parameter . As can be seen, the AM-PM effect dominates the system performance. At 0.3 and 3.0 dB OBOs, the performances correspond almost to those of a linear system, both results improving significantly on the 0.0 dB OBO case. For example at $BER = 10^{-2}$, by decreasing the OBO from 3.0 dB to 0.3 dB, the E_b / N_o requirement is increased by approximately 0.5 dB, while from 0.3 dB OBO to 0.0 dB OBO it is increased by approximately 5 dB.

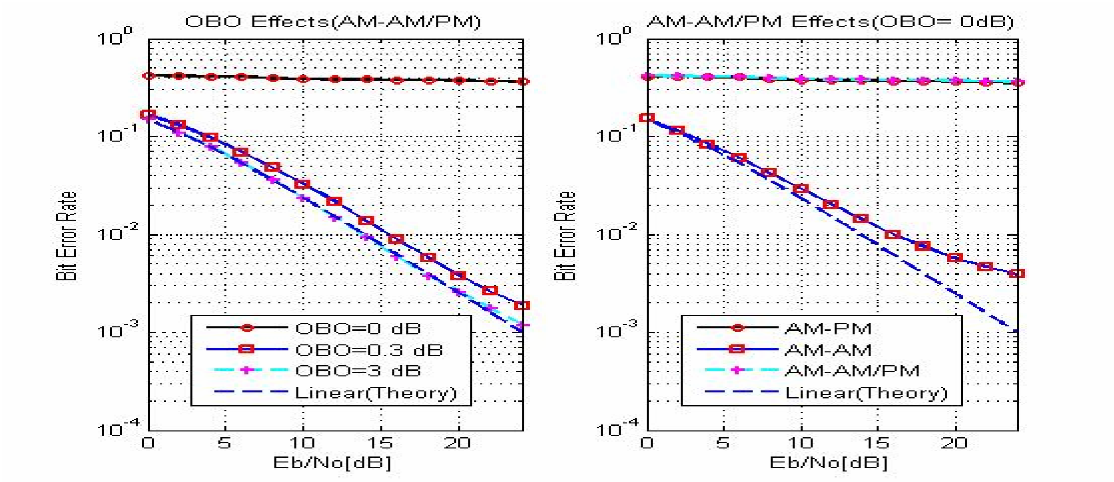
Figure 4 shows the impact of the AM-AM / PM non-linear distortion on the BER performance of QPSK with OBO as a parameter .The AM-PM behaviour , as in the BPSK case, dominates the system performance; but with greater impact when compared with RoF- BPSK. The BER exhibits an irreducible characteristic at low OBO values (in this case 0 dB). In other words, unlike the RoF- BPSK case, by increasing E_b / N_o (or equivalently the input power) better performance can not be achieved at low OBO levels.

A more quantitative description of the BER degradation can be obtained from the conditional pdfs of the demodulated signal which include the AM-AM/PM induced Inter-Symbol Interference (ISI).



(a) (b)

Figure 3: Uncoded BER vs. Eb/No for RoF-BPSK in Rayleigh flat fading channel :(a)AM-AM/PM effects at 0 dB OBO,(b) OBO effects (AM-AM/PM)



(a) (b)

Figure 4: Uncoded BER vs. Eb/No for RoF-QPSK in Rayleigh flat fading channel :(a)AM-AM/PM effects at 0 dB OBO,(b) OBO effects (AM-AM/PM)

Figures 5 and 6 plot the ISI pdf for RoF-BPSK and RoF-QPSK, respectively, with OBO as a parameter . The pdfs were obtained by collecting 10,000 samples from the I-Component and distributing them over 1,000 histogram bins[3] .

Firstly, it can be seen that the ISI distribution due to nonlinearity only (i.e. in the absence of AWGN and fading) becomes more spread and skewed as the OBO decreases. This leads to an increase in BER degradation as the distortion increases. Due to the spreading and skewness, the tail of the pdfs are shifted towards the zero detection thresholds within the symbol-to-bit de-mappers for BPSK and QPSK and by

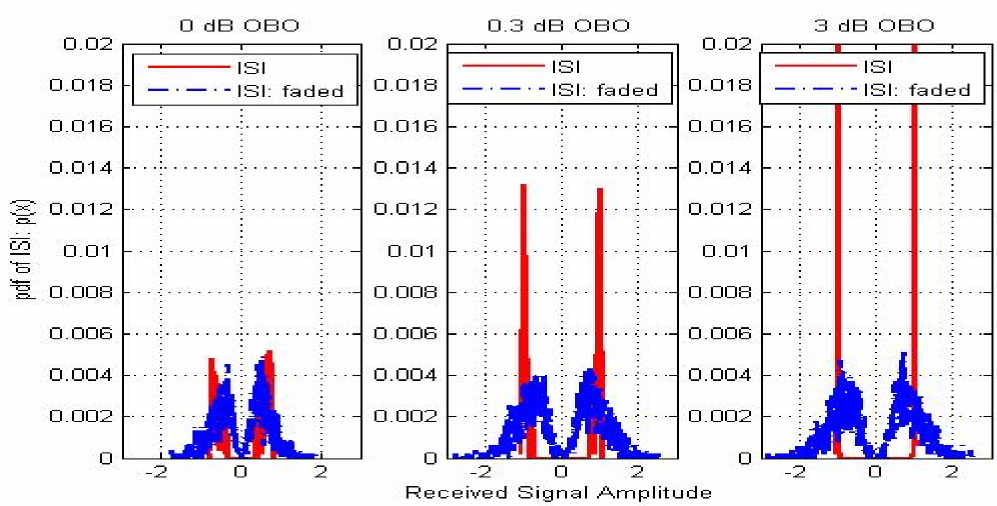


Figure 5: The pdf of AM-AM/PM induced ISI for RoF-BPSK over a flat Rayleigh fading channel at different OBO levels

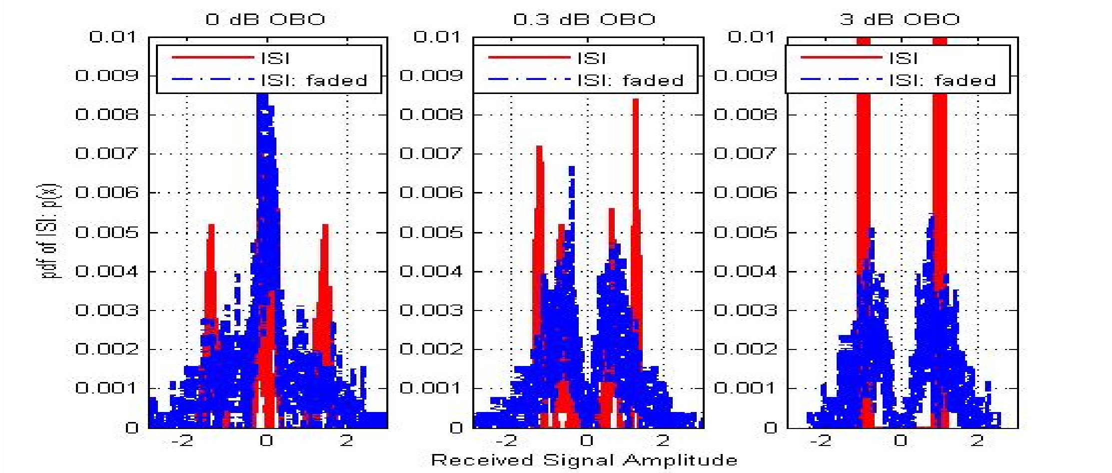


Figure 6: The pdf of AM-AM/PM induced ISI for RoF-QPSK over a flat Rayleigh fading channel at different OBO levels.

decreasing the OBO level it is more likely that the distorted signal plus noise values will cross these thresholds. Secondly, because of fading the pdfs become more spread and skewed especially for small OBO values which in turn degrades BER performance even more.

4-Conclusion

In this paper the effects of an optical subsystem's non-linearities on the system BER performance of RoF -BPSK and RoF -QPSK over a flat Rayleigh fading channel were studied. The results demonstrate that the AM-PM behaviour dominates the system performance in both cases , with QPSK affected more than BPSK. This was explained in terms of the pdfs of the ISI for various OBO levels. Also, an irreducible error floor may be observed at low OBO values for the RoF- QPSK system. The performance of wideband modulation schemes is the subject of further investigation by the authors.

References:

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