Comparison of bit-error ratios for receiver models with integrate-and-dump and realistic electrical filters using the Gaussian approximation

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Abstract: A comparison of receiver models with integrate-and-dump and Bessel electrical filters, using the Gaussian approximation of the voltage probability density functions, show that the bit-error ratios are comparable but the decision thresholds differ significantly.

OCIS codes: (060.2330) Fiber optics communications

The design and performance evaluation of optical fiber communications systems relies on the accurate estimation of performance measures such as the bit-error ratio (BER) and *Q*-factor. Since exact calculations of these quantities are difficult, they are often obtained using simple approximate transmission and receiver models. A commonly used approximate receiver model is the integrate-and-dump receiver, which consists of an optical pre-amplifier, rectangular optical band-pass filter, square-law detector and an integrate-and-dump electrical filter. The principal advantage of this model is that there are closed form expressions for the optimal BER and *Q*-factor that involve a small number of parameters [1]. However, the integrate-and-dump filter is physically unrealizable. In this paper, we compare the integrate-and-dump receiver to a receiver that is identical to it, except that the electrical filter is a fifth-order Bessel filter. Previous comparative studies of receiver models focused on comparing the Gaussian approximations to the probability density functions (pdfs) of the received voltage to the exact pdfs for a particular filter model [1,2]. Different filter models have not been compared.

Our simulations are for a back-to-back system with no transmission effects. To account for pattern dependences in the receiver we use the 8-bit sequence 11101000 which contains all the 3-bit patterns of zeros and ones. For each receiver we use the method in [3] to compute the BER. We first compute means and variances of the voltage in each bit and obtain Gaussian pdfs from these moments. We then compute the minimum BER and decision threshold from the average pdfs for the marks and spaces.

Our results are for 10 Gb/s RZ and NRZ pulse formats with a peak power of 1 mW, an extinction ratio of 20 dB in the spaces, and an OSNR of 15 dB. We vary the bandwidth of the Bessel filter from 2–12 GHz and compare the optimal BER and decision threshold to those obtained using the integrate-and-dump filter and to a receiver with an infinite bandwidth electrical filter. Figure 1 shows the results for a RZ-raised cosine pulse with pulse duration of 33 ps.

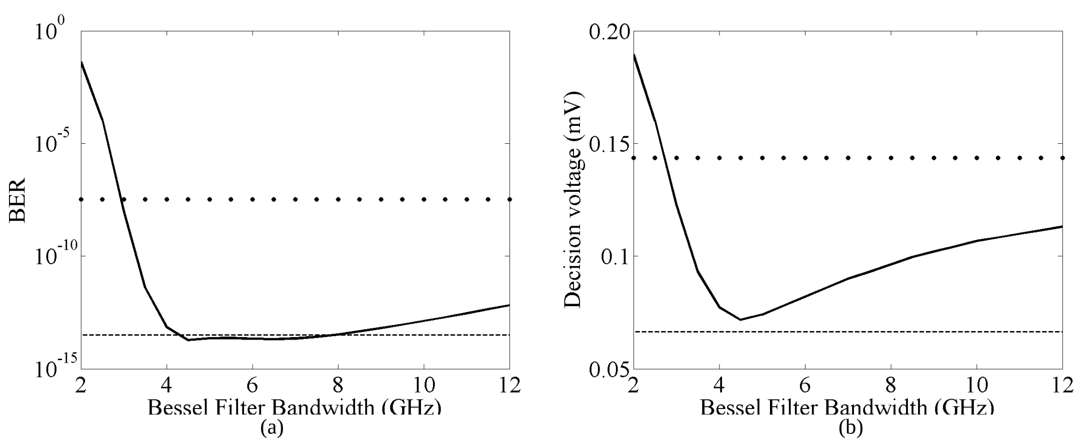

Fig. 1. The solid curves show (a) the BER and (b) the decision threshold versus the Bessel filter bandwidth for the RZ format. The corresponding results for the integrate-and-dump and infinite bandwidth filters are shown by dashed and dotted lines, respectively.

For filter bandwidths less than 4.5 GHz, the large amount of inter-symbol interference (ISI) results in large values of the BER and decision thresholds. For filter bandwidths in the range of 4.5–8 GHz, the optimal BER is almost constant since an increase in the standard deviations of the marks and the spaces is balanced by an increase in the means of the marks and a decrease in the means of the spaces. Figure 2 shows the results for an NRZ format with a rise time of 30 ps. For the NRZ format, ISI in the spaces is insignificant for filter bandwidths greater than 5 GHz.

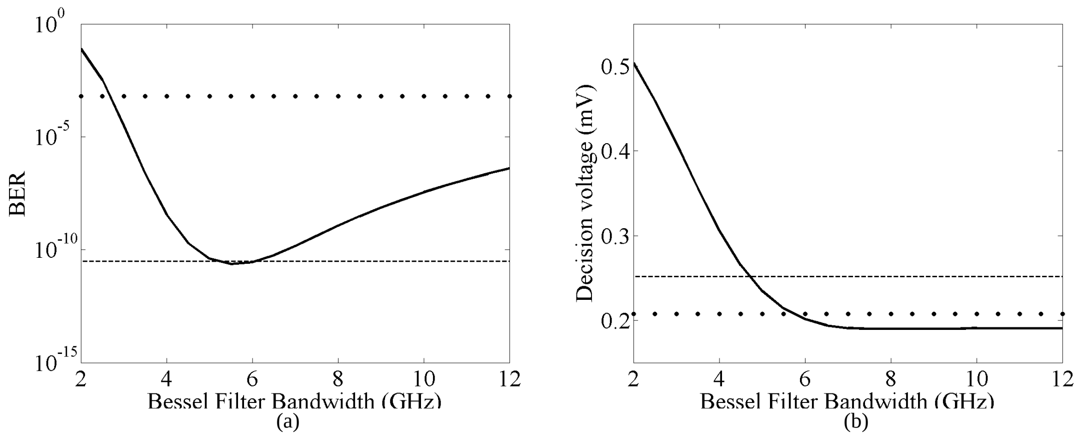

Fig. 2. The same results as in Fig. 1, but for the NRZ format.

In conclusion, for the RZ format, the optimal BER with the integrate-and-dump filter is comparable to that obtained using Bessel filters with bandwidths in the range 4–9 GHz. However the range of agreement is much smaller for the NRZ format.

References:

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