

PERFORMANCE OF VITERBI CHAIN UNDER RAYLEIGH FADING AND NARROW-BAND INTERFERENCE IN DSS SYSTEMS

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INTRODUCTION

A FEC system consists of a convolutional encoder with Viterbi algorithm is called sometimes as Viterbi chain. It is commonly used in contemporary radio communication systems, going from radio lines to satellite links. Most researches under the chain assume existence of AWGN or rarely fading in a channel.

In the paper the author goes further and investigate the performance of Viterbi chain over a Rayleigh fading and narrow-band interference (NBI) channel. The area of investigations concern DS SS.

The paper consists of the following sections:

- Description of Viterbi chain ,
- Description of a channel,
- Examination of Viterbi chain over NBI and Rayleigh fading channel.

ASSUMPTIONS

The chain fulfills the following assumptions:

- A pseudorandom source with NRZ bits,
- PN sequence is m-sequence based on a prime number Mersenne structure [7,1],
- As an interleaver a block one has been chosen. It consists of 8 columns and 56 rows. The data is stored row-wise and read out column-wise,
- A non-systematic convolutional encoder described by code rate $\Gamma = 1/2$ and generator polynomials $G_1 = 23$ and $G_2 = 33$ (expressed in octal representation),
- Coherent Binary Phase Shift Keying,
- A channel is frequency-selective, slowly Rayleigh fading with NBI.

A SIMULATION MODEL

The structure of the encoder is the same as used in GSM [1]. Bits are coded in blocks. Each block consists of 228 bits. The last 4 bits (zeros) of each block are a tail, which is used for trellis termination. Consequently after the encoder there are 456 encoded bits. These bits are then interleaved, spread, modulated and transmitted to a channel.

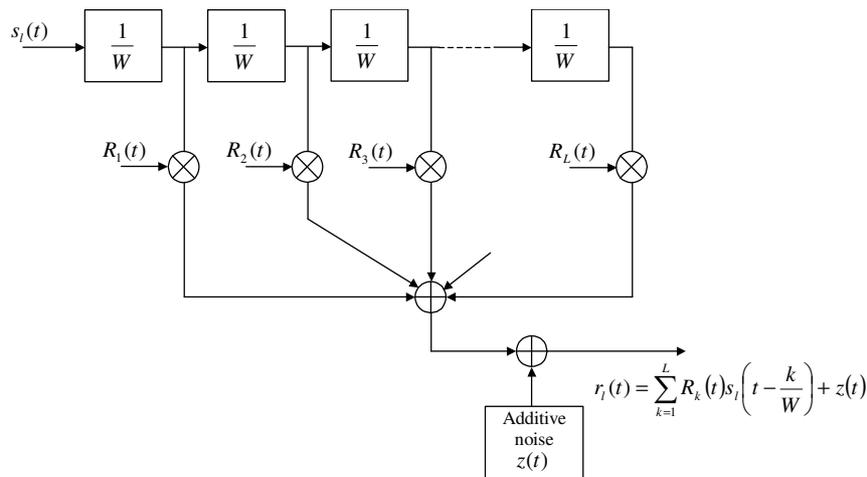


Fig. 1. Tapped delay line model of frequency-selective channel

A selective-frequency slowly fading and NBI channel has been modeled as a truncated tapped delay line with time-variant L fading processes $R_i(t)$ ($i=1,2,\dots,L$) (Fig. 1) [2] [3]. For all practical purposes L is truncated at

$$L = \lfloor T_m W \rfloor + 1 \tag{1}$$

where T_m is a multipath spread, and W is a bandwidth of useful bandpass signal. In urban and suburban areas, typical values of multipath spreads range from 1 to 10 μ s. In our model we assumed 5 μ s. W has been calculated from the following formula:

$$W = R = 2R_{info} \Gamma N \tag{2}$$

where R_{info} is a source rate, Γ is a code rate and N is a length of PN sequence. Assuming that R_{info} is 8kb/s which is not high value but enough for data and voice transmission, Γ and N were given earlier and are $\frac{1}{2}$ and 127, W is equal to 4,064MHz. Substituting T_m and W to (1) we achieve that L is equal to 21.

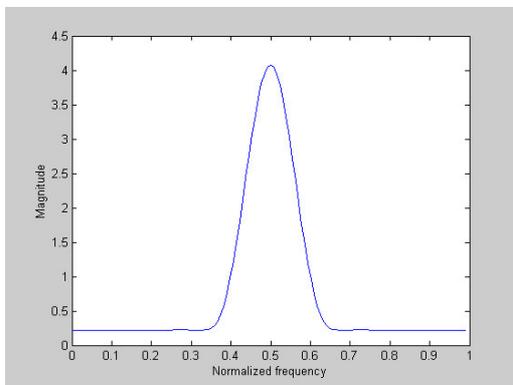


Fig 2a. Magnitude response of modeling filter

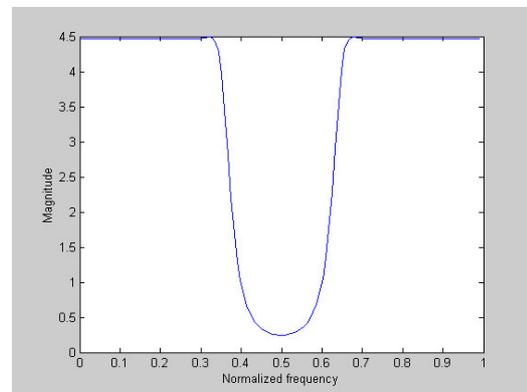


Fig. 2b. Magnitude response of whitening filter

Owing to no sight of line between antennas of transmitter and receiver the magnitude of L fading processes are Rayleigh-distributed and the phases are uniformly distributed. Moreover L fading processes are mutually statistically independent with identical autocorrelation function. Each of the fading process was generated from Jakes model [4]. As additive noise, NBI has been chosen. Such a shape of NBI could correspond for example to BPSK interfering signal from another system. It was obtain as a result of AWGN filtering. The magnitude of modeling filter is given in Fig 2a.

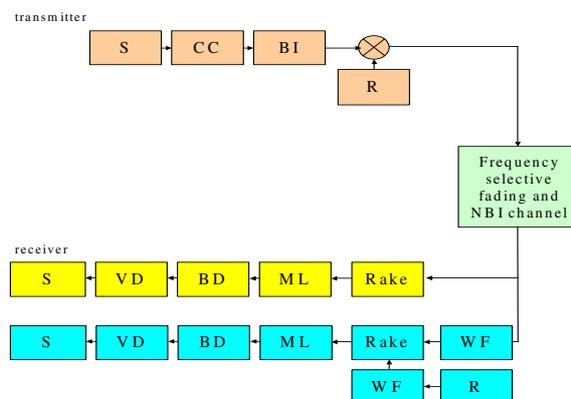


Fig. 3. A block diagram of Viterbi chain for fading selective with NBI channels

A corrupted signal from the output of a channel enters the Rake receiver which has $M < L$ fingers. Since NBI is present in a channel, the Rake demodulator is additionally equipped with whitening filters that whiten NBI, i.e. deprive noise of their inertial correlation. The phenomena of non-white detection is given in [6], [7], [8], [9]. These filters are placed in the signal and replica path. We assumed that modeling filters are known at the receiver. Thus a transmittance of whitening filters are just a reciprocal of modeling one. Its magnitude response is given in 2b. In practice, when we don't know the NBI there is a necessity for estimating them. It could be accomplished by one of well-known method. Well given theory about this is in [10].

Summarizing, the simulated model of Viterbi chain in a DSSS for a fading and NBI channel is shown in Fig.3. Particular abbreviations used in this Fig. have the meaning: S – NRZ source, CC – Convolutional Encoder, BI – block interleaver, R – replica, Rake - Rake receiver, ML – maximum likelihood detector, BD – block deinterleaver, VD – Viterbi decoder, S – sink of data, WF – whitening filter

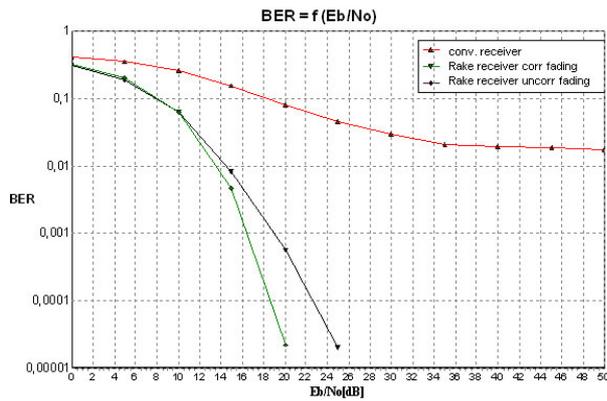


Fig. 4a. Uncoded transmission, $L=21$, $f_m=0,000123$ normalized according to chip duration (T), PN = 127 chips, conventional receiver (matched only to a signal), 4-finger Rake receiver, as an example a BER curve for uncorrelated fading has been drawn, a case of **white noise**

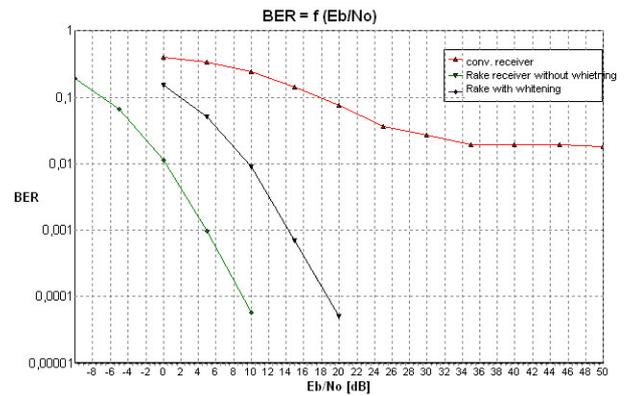


Fig. 4b. Uncoded transmission, $L=21$, $f_m=0,000123$ normalized according to chip duration (T), PN = 127 chips, conventional receiver (matched only to a signal), 4-finger Rake receiver, as an example a BER curve for uncorrelated fading has been drawn, a case of **NBI**

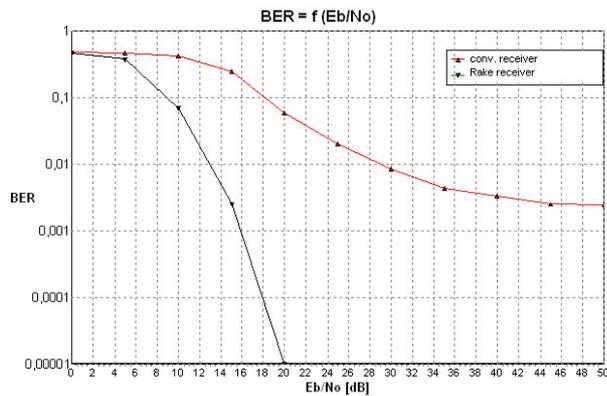


Fig. 5a. Coded transmission, $L=21$, $f_m=0,000123$ normalized according to chip duration (T), PN = 127 chips, conventional receiver (matched only to a signal), 4-finger Rake receiver without whitening filters and 4-finger Rake receiver with whitening filters, a case of **AWGN**

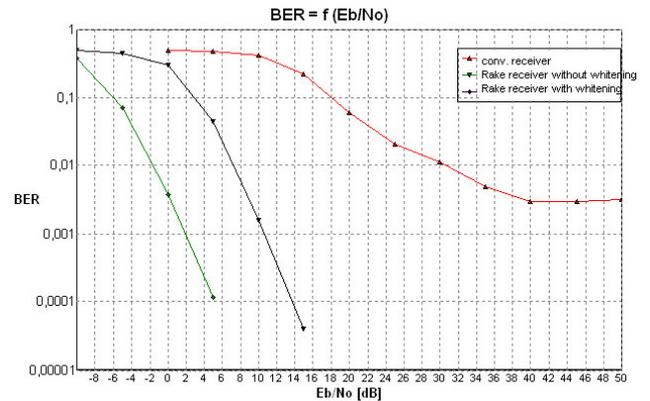


Fig. 5b. Coded transmission, $L=21$, $f_m=0,000123$ normalized according to chip duration (T), PN = 127 chips, conventional receiver (matched only to a signal), 4-finger Rake receiver without whitening filters and 4-finger Rake receiver with whitening filters, a case of **NBI**

RESULTS OF SIMULATIONS

One has run the following simulations:

- No coded transmission, conventional receiver, 4-finger Rake receiver, and just for comparison purposes 4-finger Rake receiver in a case of perfectly interleaved fading processes, AWGN case (Fig.4a),
- No coded transmission, conventional receiver, 4-finger Rake receiver without and with whitening filters, NBI case (Fig. 4b),
- Coded transmission, conventional receiver, 4-finger Rake receiver, AWGN (Fig. 5a),
- Coded transmission, conventional receiver, 4-finger Rake receiver without and with whitening filters, NBI case (Fig. 5b).

CONCLUSION AND DISCUSSION

The goal of work was to study the performance of coded DS SS over fading and NBI channels. It can be seen that these systems (as well as uncoded ones) are completely unprotected from such interferences. The losses coming from unemployment detectors of DS SS receivers of whitening filters reach a dozen or so dBs. Of course gains dependent on the entropy of interferences. The lower the entropy the higher the gains.

It is worth mentioning that a receiver equipped with whitening filters is also optimal for white noise. Then the transmittance of whitening filters is unity.

ACKNOWLEDGMENT

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