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BER Analysis of ADSL with RS Encoding Over AWGN Channel

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Abstract: In wireless, satellite, and space communication systems, reducing error is critical. High bit error rates of the wireless communication system require employing various coding methods on the data transferred. Channel coding for error detection and correction helps the communication system designers to reduce the effects of a noisy transmission channel. The purpose of this paper is to study and investigate the performance of Reed-Solomon code that is used to encode the data stream in digital communication. The performances were evaluated by applying to binary phase sift keying modulation scheme in symmetric Additive White Gaussian Noise channel. Reed-Solomon codes are best for correcting burst errors and find wide range of applications in digital communications and data storage.

Keywords: DSL, ADSL, FEC, BER.

I. INTRODUCTION OF ADSL

Digital Subscriber Line (DSL) is an always-on internet connection that uses your existing telephone line and gives you an internet connection several times faster than a traditional dial-up account .There are two general categories of DSL: symmetric and asymmetric. Symmetric DSL provides the same service bit-rate in both directions upstream (from the user to the network) and downstream (from the network to the user). Asymmetric DSL provides downstream bit-rate more than upstream bit-rate. DSL service has a fixed cost and allows you to talk on the telephone and be on the internet at the same time, using the same telephone line. Typical telephone cabling is capable of supporting a greater range of frequencies (around 1MHz). With DSL modems, the digital signal is not limited to 4 kHz of voice frequencies, as it does not need to travel through the telephone switching system.DSL modems enable up to 1MHz of bandwidth to be used for transmitting digital (data) along side analogue (voice) signals on the same wire by separating the signals, thereby preventing the signals from interfering with each other. Although ADSL (Asymmetric Digital Subscriber Line) transmission systems are widely used today in many countries as the primary high-speed service access solution for residential and small office customers there remain open questions in terms of quality of service and transmission performance. One of them is that most ADSL performance models [1] cover stationary error sources like crosstalk, radio interference and background noise but don't take into account impulsive noise as a typical non-stationary impairment. The reason might be that "the causes of impulses are so diverse that any distillation for engineering and measurement purposes necessarily has some bias"[2].

Nevertheless impulsive noise is injected into copper lines often with a very high magnitude compared to background noise level and contains spectral components which overlap with the used ADSL frequency bands. Therefore this electromagnetic disturbance cannot be neglected and needs to be investigated in order to determine the resulting impairments on the bit-error statistics of the transmission system and to search for specific optimizations which cope with this phenomenon. ADSL (Asymmetric Digital Subscriber List) is a type of digital data transmission and Internet access technology consisting of transmission over symmetric copper telephone line pairs. This is a method of Internet access through the telephone line (Switched Telephone Network, PSTN) that does not prevent regular use of the line for calls. ADSL is a type of Broadband connection, whose name comes from the fact that the download (from the network to the computer) and upload (from the computer to the network) capacity are not coincident, but that the former is greater than the latter. After all, most Internet users receive more information than they broadcast[4].

For ADSL to work, it is necessary to have a telephone line and a modulation system that separates frequencies from voice and data, through the installation of discriminating filters (called splitters, microfilters or DSL filters) and an ADSL router provided by the company that provides the service.

This type of urban copper cabling was traditionally implemented, but in the late decades of the twentieth century were gradually replaced by fiberglass, a material that offered better conduction and performance, thus accommodating even better methods of transmitting digital information, such as cable modem or Ethernet.

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II. SYSTEM MODEL OF ADSL

The Binary-Input RS Encoder block creates a Reed-Solomon code with message length K and codeword length N by specifying both N and K directly in the dialog box. The symbols for the code are binary sequences of length M, corresponding to elements of the Galois field GF (2^M), where the first bit in each sequence is the most significant bit[4]. The restrictions on the degree M of the primitive polynomial and the codeword length N are as follows:

(a). If you do not select Specify primitive polynomial, N must lie in the range $3 < N < 2^{16}–1$.

(b). If you do select Specify primitive polynomial, N must lie in the range $3 \leq N < 2^{16}–1$ and M must lie in the range $3 \leq M \leq 16$.

Suppose M = 3, $N = 2^3-1 = 7$, and K = 5. Then a message is a binary vector of length 15 that represents 5 three-bit integers. A corresponding codeword is a binary vector of length 21 that represents 7 three-bit integers. The following figure shows the codeword that would result from a particular message word. The integer format equivalents illustrate that the highest order bit is at the left[20].

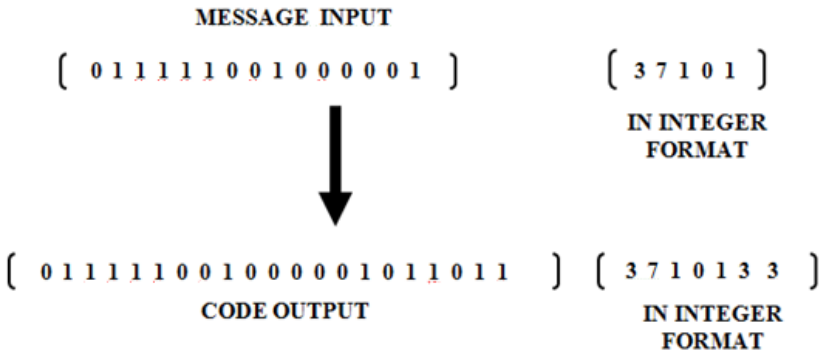

Figure 1. Algorithm of Reed-Solomon (RS) Encoding

The main parameters of RS Encoding block are codeword length, message length, primitive polynomial and generator polynomial. The Primitive polynomial represents the primitive polynomial in descending order of powers. The Generator polynomial represents the generator polynomial in descending order of powers whose entries are in the range from 0 to 2^M-1.

III. ADSL PERFORMANCE ANALYSIS

First the ADSL system is analyzed with different Interleaving schemes. The five interleaving Schemes namely Matrix, Helical, Random, Block and Convolutional are analyzed and the Bit Error Rate (BER) of ADSL system with these interleaving schemes is calculated to check the system performance. Analysis was done by observing the simulation result and tabulating the analysis results to make it more convenient to be read. In the performance analysis of ADSL system the transmitted signal, received signal and bit error rate of the systems are analyzed. First calculate the BER for the ADSL system with different interleaving schemes such as Matrix, Helical, Random, Convolutional and Block interleaver. The BER is calculated with error rate calculation block. In this block the transmitted and received signals are compared to calculate the BER.

Table 1. BER of ADSL with Interleaver

	Block	Helical	Matrix	Random	Convolutional
For Non – Interleaved Data					
Bit Error Rate	0.0005551	0.0005554	0.0005544	0.0005534	0.0005544
Total Error Bits	8615	8605	8605	8589	8605
Total Bits	15520000	15520000	15520000	15520000	15520000
For Interleaved Data					
Bit Error Rate	0.5001	0.4999	0.5002	0.5002	0.07414
Total Error Bits	7762000	7758000	7763000	7763000	1150600
Total Bits	15520000	15520000	15520000	15520000	15520000

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Table 2. FER of ADSL with Interleaver

	Block	Helical	Matrix	Random	Convolutional
For Non – Interleaved Data					
FRame Error Rate	0.0262	0.0262	0.0262	0.02615	0.0262
Total Error Frames	524	524	524	523	524
Total Frames	20000	20000	20000	20000	20000
For Interleaved Data					
Frame Error Rate	0.9967	0.9941	0.9969	0.9964	0.04095
Total Error Frames	19940	19880	19940	19930	819
Total Frames	20000	20000	20000	20000	20000

From these tables it is clear that while analyzing the different interleaving schemes of ADSL system with different interleaving schemes, the convolutional interleaving is well suited for it.

IV. CONCLUSION

In this era, as technology advances the corporate companies designed many user interface technologies to handle maximum number of users without changing the frequency bandwidths. ADSL (Asymmetric Digital Subscriber Line) is such a technology for digital data transmission and Internet access technology consisting of transmission over symmetric copper telephone line pairs. This is a method of Internet access through the telephone line that does not affects regular use of the line for calls. As the number of users increases the complexity of ADSL DMT Modulator increases. So, ADSL system is designed to withstand with interference and fading in communication channel. Channel coding and Interleaving is needed for a system in order to sustain in any type of environment especially in multipath fading channel. By observing the results, it is found that when convolutional interleaver is used with CRC coding under the influence of AWGN channel the BER and FER rate is less than the other interleaving schemes namely Block, Helical, Matrix, Random. It is concluded that convolution interleaving is best suited scheme for proposed system.

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