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Performance Analysis of ADSL with DMT and RS Encoding Technique

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Abstract: The objective of Digital Subscriber Line (DSL) is to propagate signal from the transmitter to the receiver over telephone lines. In communication industry Asymmetric Digital Subscriber Line (ADSL) is widely used because it can handle both phone services and internet access services at same time. As the communication industry develops, its main concern is to maximize the user handling capacity of communication systems. For this purpose, ADSL uses Discrete Multitone (DMT) modulator with QAM bank. But as the number of users increases the system complexity and interference also increases. The communication channel is not free from the effects of channel impairments such as noise, interference and fading. These channel impairments caused signal distortion and Signal to Ratio (SNR) degradation. One method that can be implemented to overcome this problem is by introducing channel coding. Channel encoding is applied by adding redundant bits to the transmitted data. The redundant bits increase raw data used in the link and therefore, increase the bandwidth requirement. So, if noise or fading occurred in the channel, some data may still be recovered at the receiver. While at the receiver, channel decoding is used to detect or correct errors that are introduced to the channel. So first design an Asymmetric Digital Subscriber Line (ADSL) with Discrete Multitone (DMT) modulator having 16-QAM banks. Then analyze this ADSL system with different interleaving schemes to reduce the interference and improve the performance of system

Keywords: DSL, ADSL, DMT, BER

I. INTRODUCTION OF ADSL

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.

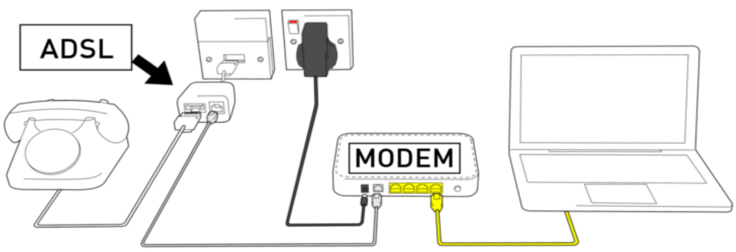

Figure 1. Asymmetric Digital Subscriber Line.

II. SYSTEM MODEL OF ADSL

For residential and commercial users with an ongoing need for broadband data access, but who do not send out correspondingly large data streams, Asymmetric Digital Subscriber Line (ADSL) services work well. This service is so named because the data rate sent to the user (downstream) is much greater than the data rate sent from the user (upstream). This asymmetric model is based on typical Internet usage patterns.

For example, a user sends a Web page request (small amount of upstream data) and receives the HTML for the Web page with graphics and sound (large amount of downstream data). Various services, such as cable modems, satellite services, and DSL exist to provide such access[1].

An ADSL system uses existing telephone wire to allow bidirectional data communications between a user and the telephone company's Central Office (CO). Some other popular services, such as an ISDN line or a standard dial-up modem, also use the phone lines to communicate. However, those services prevent the simultaneous operation of standard analog phone service on the same phone line. An important advantage of ADSL is that it allows the Plain Old Telephone System (POTS) signal to co-exist with the ADSL data signal.

The ADSL physical layer was designed so that it could peacefully co-exist with the standard POTS spectrum. The two services can co-exist because the ADSL spectrum only uses the frequencies above POTS. The POTS spectrum goes from near DC to approximately 4 kHz. A frequency guard band is placed between the POTS spectrum and the ADSL spectrum to help avoid interference [23]. The ADSL spectrum starts above the POTS band and extends up to approximately 1.1 MHz. The lower part of the ADSL spectrum is for upstream transmission (from the customer to the CO) and the upper part of the spectrum is for downstream transmission. There are actually two different ways that the upstream and downstream spectra can be arranged as shown in Figure 2.

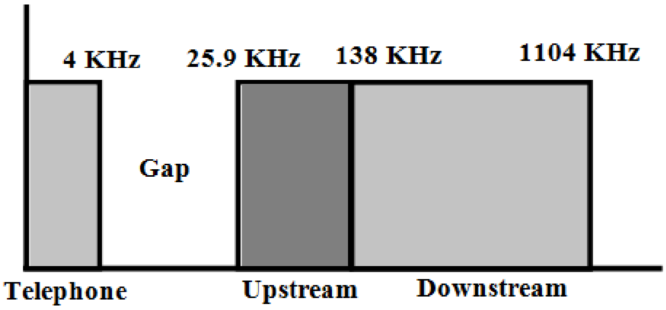

Figure 2. ADSL Frequency Plan.

In a Frequency Division Multiplexed (FDM) system, the upstream and downstream spectra use separate frequency ranges. They can vary for different implementations, but typically the upstream band is from 25 to 200 kHz and the downstream band is from 200 kHz to 1.1 MHz. Other divisions are also permitted within the ADSL standard. This system is free from the occurrence of a type of interference called self-crosstalk. One drawback, however, is that the downstream bandwidth is reduced in comparison to an echo-cancelled system [4].

An echo-cancelled system allows the downstream band to overlap with the upstream band. The upstream band still uses the frequencies from 25 to 200kHz, but the downstream band can now extend over the upstream band. The main advantage of this system is that it significantly extends the available downstream bandwidth. However, it does require echo-canceling circuitry due to the full-duplex transmission. In addition, the presence of self-crosstalk causes additional interference. A block diagram of a typical ADSL transmitter/receiver pair is shown in Figure 3.

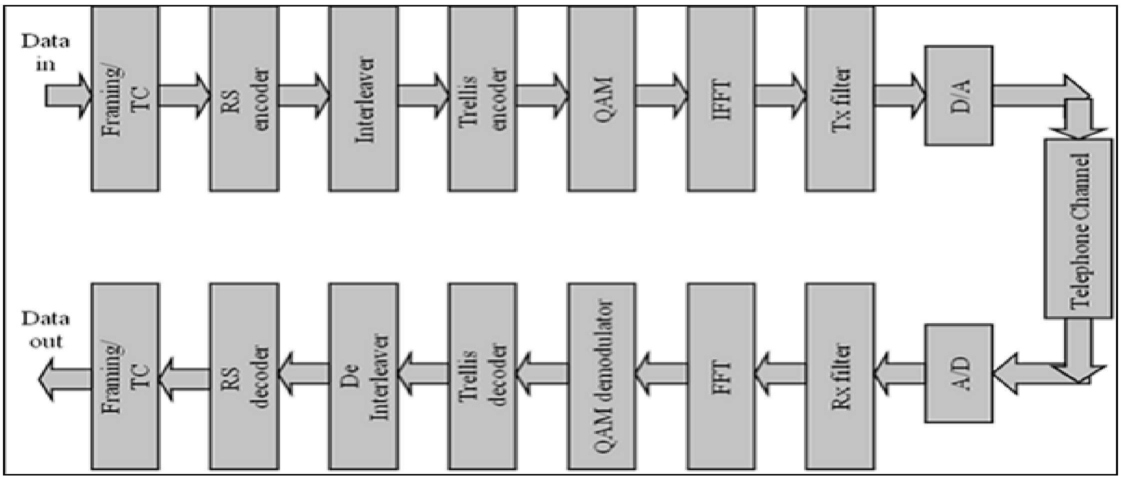

Figure 3. Block Diagram of ADSL

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III. ADSL PERFORMANCE ANALYSIS

Simulation of Asymmetric Digital Subscriber Line (ADSL) system is done in Simulink tool of MATLAB. The simulation results are plotted in term of the performance of ADSL system that is Bit Error Rate (BER). 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.

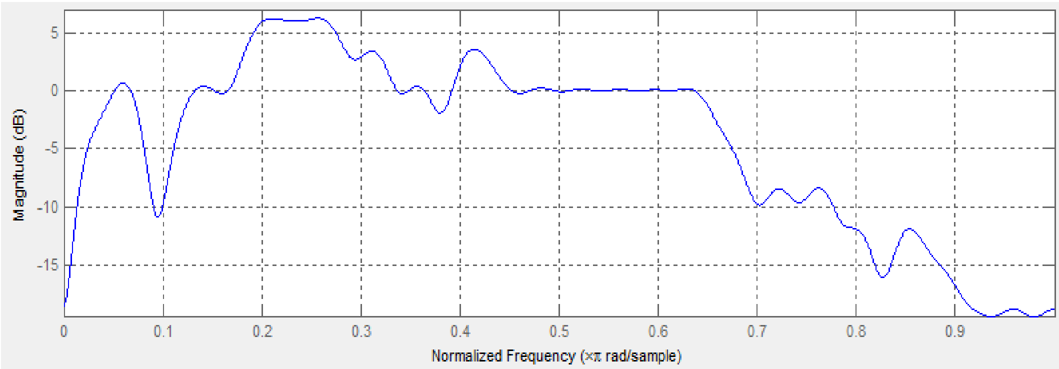

Figure 4. Magnitude Response of FIR Filter Designed in FDA Tool

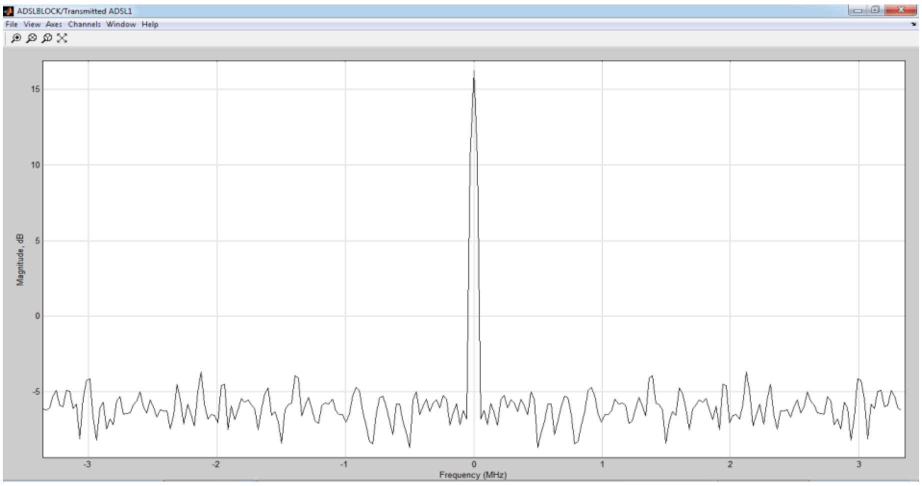

Figure 5. Transmitted Signal of ADSL Before DMT Modulator.

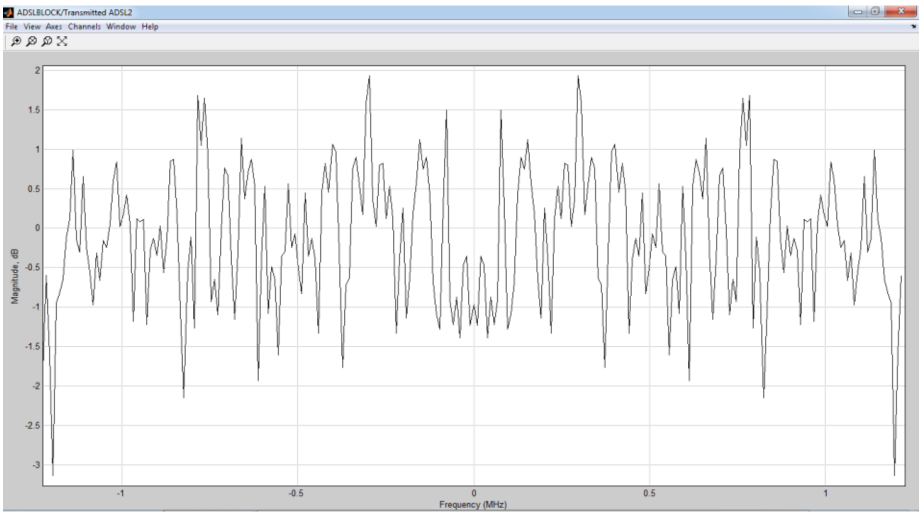

Figure:6. Transmitted Signal of ADSL

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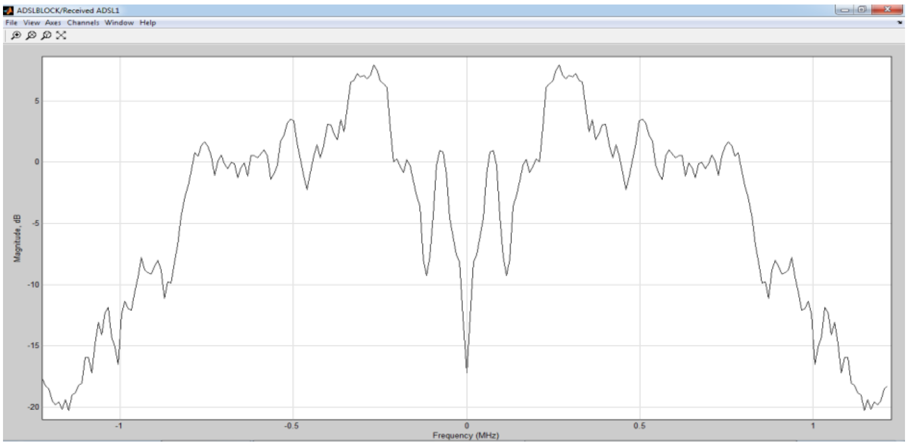

Figure 7. Received Signal of ADSL

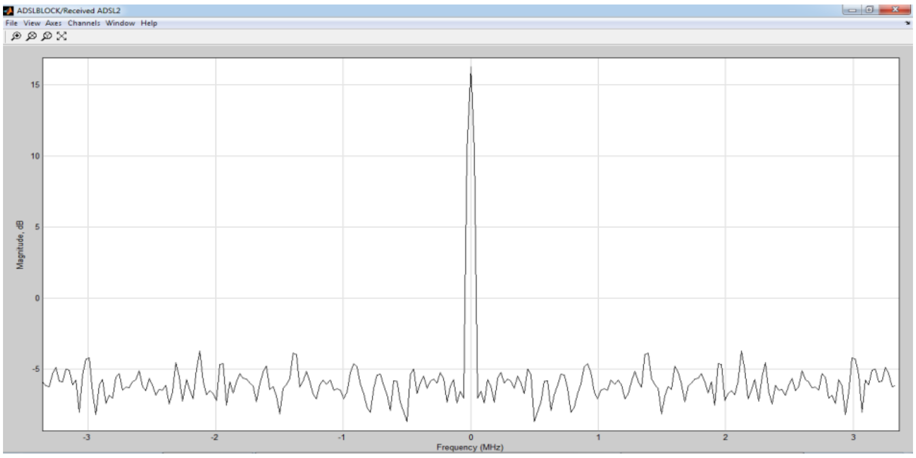

Figure 8. Received Signal of ADSL after DMT Demodulator

The Figure shows the transmitted and received signal of ADSL system. To plot these signals spectrum scope is used. The Spectrum Scope block computes and displays the periodogram of the input. From the plot of transmitted and received signal it is clear that the received signal is so much distorted as comparison to transmitted signal due to channel. The simulation results are plotted in term of the performance of ADSL system that is transmitted, received signal. Now the Bit Error Rate (BER) of ADSL system is 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 Block Interleaver

For Non – Interleaved Data	
Bit Error Rate	0.0005551
Total Error Bits	8615
Total Bits	15520000
For Interleaved Data	
Bit Error Rate	0.5001
Total Error Bits	7762000
Total Bits	15520000

Table 2. BER of ADSL with Helical Interleaver

For Non – Interleaved Data	
Bit Error Rate	0.0005554
Total Error Bits	8605
Total Bits	15520000

For Interleaved Data	
Bit Error Rate	0.4999
Total Error Bits	7758000
Total Bits	15520000

Table 3. BER of ADSL with Matrix Interleaver

For Non – Interleaved Data	
Bit Error Rate	0.0005544
Total Error Bits	8605
Total Bits	15520000
For Interleaved Data	
Bit Error Rate	0.5002
Total Error Bits	7763000
Total Bits	15520000

Table 4. BER of ADSL with Random Interleaver

For Non – Interleaved Data	
Bit Error Rate	0.0005534
Total Error Bits	8589
Total Bits	15520000
For Interleaved Data	
Bit Error Rate	0.5002
Total Error Bits	7763000
Total Bits	15520000

Table 5. BER of ADSL with Convolutional Interleaver

For Non – Interleaved Data	
Bit Error Rate	0.0005544
Total Error Bits	8605
Total Bits	15520000
For Interleaved Data	
Bit Error Rate	0.07414
Total Error Bits	1150600
Total Bits	15520000

Table 6. FER of ADSL with Block Interleaver

For Non – Interleaved Data	
Frame Error Rate	0.0262
Total Error Frames	524
Total Frames	20000
For Interleaved Data	
Frame Error Rate	0.9967
Total Error Frames	19940
Total Frames	20000

Table 7. FER of ADSL with Helical Interleaver

For Non – Interleaved Data	
Frame Error Rate	0.0262
Total Error Frames	524
Total Frames	20000
For Interleaved Data	
Frame Error Rate	0.9941
Total Error Frames	19880
Total Frames	20000

Table 8. FER of ADSL with Matrix Interleaver

For Non – Interleaved Data	
Frame Error Rate	0.0262
Total Error Frames	524
Total Frames	20000
For Interleaved Data	
Frame Error Rate	0.9969
Total Error Frames	19940
Total Frames	20000

Table 9. FER of ADSL with Random Interleaver

For Non – Interleaved Data	
Frame Error Rate	0.02615
Total Error Frames	523
Total Frames	20000
For Interleaved Data	
Frame Error Rate	0.9964
Total Error Frames	19930
Total Frames	20000

Table 10. FER of ADSL with Convolutional Interleaver

For Non – Interleaved Data	
Frame Error Rate	0.0262
Total Error Frames	524
Total Frames	20000
For Interleaved Data	
Frame Error Rate	0.04095
Total Error Frames	819
Total Frames	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.

Table 11. BER of ADSL with Different Interleaver

Sr. No.	Interleaving Scheme	BER
1.	Block Interleaver	0.5001
2.	Helical Interleaver	0.4999
3.	Matrix Interleaver	0.5002
4.	Random Interleaver	0.5002
5.	Convolutional Interleaver	0.07414

Table 12. No. of Error Frames in ADSL with Different Interleaver

Sr. No.	Interleaving Scheme	No. of Error Frames
1.	Block Interleaver	19940
2.	Helical Interleaver	19880
3.	Matrix Interleaver	19940
4.	Random Interleaver	19930
5.	Convolutional Interleaver	819

IV. CONCLUSION

In this era, as technology advances the corporate companies designed many user interface technology to handle maximum number of users without changing the frequency bandwidths. ADSL (Asymmetric Digital Subscriber List) 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 effects 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 with 0.07414 BER and 0.04095 FER.

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