International Journal of Engineering & Technology, 7 (4) (2018) 5156-5159

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i4.20746
Research paper

Design of TCM decoder for accurate detection on AWGN and Rayleigh environments

Arshad B. Salih [1] *, Ayoub Esam Kamal [1], Zuhair Shakor Mahmood [1]

[1] *Northern Technical University, Kirkuk Technical Institute, Iraq*
**Corresponding author E-mail: arshadsalih83@gmail.com*

Abstract

Wireless communications are made an expanded growth during the last decade. Channel is importantly considerable in communication studies where signals are fading and attenuated due to channel disturbances. Today's technologies are completely relying on digital signals by adapting devices which understand only digital representation of data. Such techniques shrink the energy required to operate the devices and reduced the cost of deploying such systems in personal and industrial fields. Encryption of data and preparing the signal with good immunity for noise are the main subjects in this paper. Design of Trellis Coding Modulation (TCM) where digital signal can be encoded and modulated at the same paradigm will be illustrated. Decoder of TCM will be deigned to retrieve the original transmitted signal over AWGN and Rayleigh channel with minimum error.

Keywords: *Decoder; Encoder; AWGN (Additive White Gaussian Noise); Viterbi Decoder; TCM (Trellis Coding Modulation); Demodulation.*

1. Introduction

Telecommunication system is subjected to multiple factor in which degrading the performance, noise such AWGN, fading and shadowing are the major issues may threat any communication system. Optimal diversity is proposed to implement a channel that resisting the fading; the receiver may detect the superposition of the signals coming from diversity antennas.
Performance of different communication systems under fading channel effects is examined at [1]. Different modulation techniques are added to under fading channel and hence, performance metric such as bit error rate is analyzed for each iteration. After measuring the BER for the particular communication system, results found that bit error rate BER is increasing with high SNR, whereas the resulted BER at lower signal to noise ratio is remained small. These outcomes look logical since small signal to noise ratio leads to smaller signal power as compare to the noise power and hence noise will dominate the channel with bigger density. In other word, BER can be improved by enhancing the SNR. Afterwards the performance resulted by the whole channels are compared to evaluate the more accurate model that can be more reliable under noise circumstances. The binary phase shift keying (BPSK) modulation is used to achieve better performance [1]. Multi input multi output (MIMO) transmission is having a noticeable effect on the performance of wireless transmission. However, MIMO applications are the key technique of advanced future transmission by using a several antennas at the transmitter with same number of antennas to be placed at the receiver. The diversity approach is a way to permit the data to be transmitted with high rate in modern wireless communication [3]. When system is being simulated under different configuration of antennas in RX and TX and data is transmitted under AWGN, RICIAN channel of fading, performance is studied to find the optimum antenna configuration when zero forcing receivers were used on the remote side of communication system [3]. In this system, a MPSK modulation technique was used and bit error rate is obtained with the mentioned system conditions. Results showed that BER is improved at present of AWGN with RICIAN channel as compared to the standalone AWGN. Diversity approach is important to increase system performance and it is achievable by installing a number of transmitted antennas at transmitter end and similar set at the receiver [3].
Combination technology can be used to create a super position of the received signal. The advantage of diversities in wireless communication is their strength as methods to enhance the system performance at the time of transmission and receiving of signals. The post detection method of multipath rays is discussed at [4]. Signals are detected by multiple antennas and then it needs to be combined over the fading Rayleigh channel, the orthogonal frequency division multiplexing technique is involved in this study [4]. The system is simulated to analyze post detection combination technique in the above system characteristics; the bit error rate is found improving with the deployment of PDC method at large channels number. Spatial diversity can be increased with high channel order of configuration that decreases the BER automatically at the rated signal to noise ratio. Performance of the OFDM system is increasing by deployment of larger number of antenna configuration, for example: L=2 is drawing lower performance than L>2 [5].
In this paper, we are going to perform coding techniques as trellis coding at transmitter and decoding of the receiver data by Viterbi decoder. This study is including the technical steps to perform encoder and decoder design using Matlab.

2. Wireless system characteristics

The communication system in general consists of three fundamental parts: source of information, the channel which separates the source from the destination and receiver destination where signal of transmitter is terminated [6]. Transmitters are designed for information emission; techniques such as modulation and coding are performed at transmitter side. Process that used for converting the signal into compatible format matching the physical channel requirements and strengthen the immunity against noise and other channel disturbances. Information may get encryption at source before they are emitting into channel. Encoding of data may enhance the reliability and secure the transmitted information [7]. Encryption process is ensuring that only the designated receiver is going to receive the information and no unauthorized access will be permitted. Figure 1 is illustrating the communication system major sections.

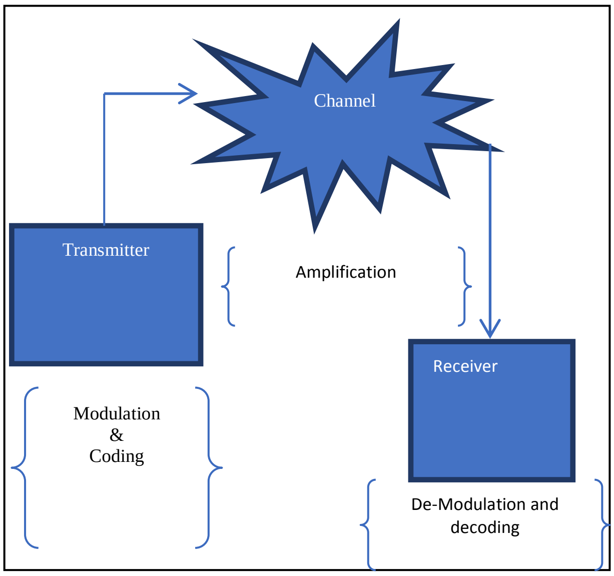

Fig. 1: Communication System Components.

Signal is modulated for obtaining the analogue equivalent version that suites the channel. Modulation involves signal multiplication with higher frequency carrier. This carrier is holding the signal information alongside the channel towards receiver. Binary shift keying (BSK), Binary phase shift keying (BPSK) and Quadrature Amplitude Modulation (QAM) are most popular examples of digital modulation. Furthermore, Amplitude modulation (AM), Phase modulation (PM) and Frequency modulation (FM) are common analogue modulations schemes. As signal travels from transmitter through the channel, it could get attenuation and scattered due to channel physical properties like surrounding environments and atmospheric condition. As signal arrived into the receiver, amplification process may start to enlarge the signal power for performing the recovery process. Decoder and demodulator are the main parts in the receiver. Signal is firstly demodulated and then decoded [8].
If S(n) is the signal generated by information source, D(n) is noise signal which reflect the channel unwanted components.

$$Tx = S[n]^\wedge \quad (1)$$

$$Rx = Tx^\wedge + D[n] \quad (2)$$

$$Rx = S[n]^\wedge + D[n] \quad (3)$$

Where S(n)^ is the coded version of source signal S(n) and Rx is representing the received signal.

3. Channel modeling

Channel is invoked potential rank in communication studies. Usually, channel formed physical wire in case of wire communications (copper wire) or optical cables as in optical communications [9]. Form the other hand, wireless communication involves no cables to convey signals from source to destination. Channels can be modelled according to their actions on the signals. In this study, we performed digital signals transmission over Additive White Gaussian noise (AWGN) channel. Rayleigh fading environments are also being simulated to determine the performances of the communication system under sever and moderated level of disturbances. However, the channel equation is given by the following terms:
For S[n] transmitted signal, D[n] is the noise component.

$$Ch = S[n] * F[n] + D[n] \quad (4)$$

Where, F[n] is equivalent to fading effects. Noise can be simulated as random vector with 'n' dimensions. Similarly, fading is random vector of 'n' dimensions [10] [11].

4. Proposed system

Signal is formed using a large number of bits, firstly a (10e5) bits are generated randomly (random here stands for bit wised amplitude).

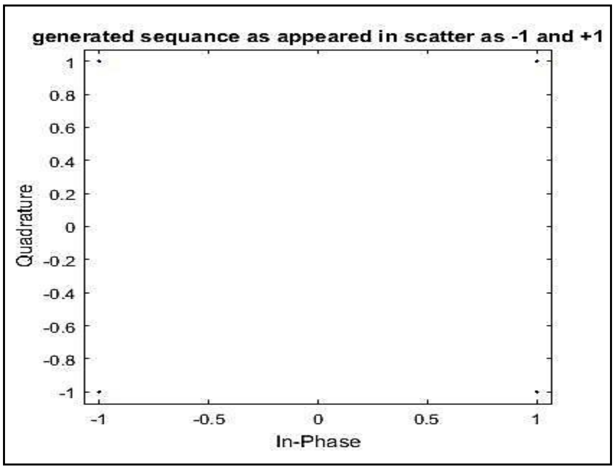

Fig. 2: QPSK Signal at the Modulator Output.

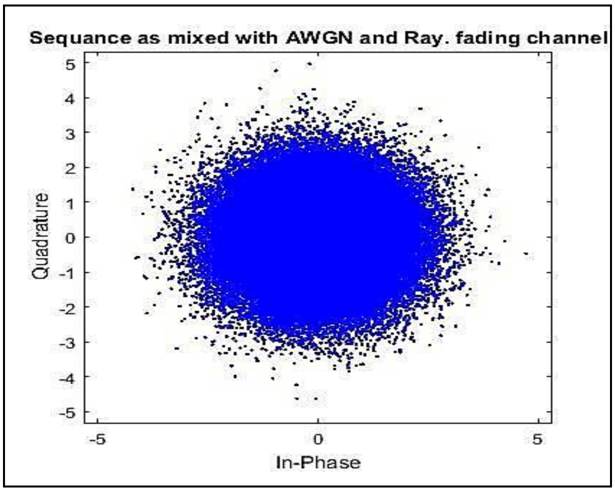

Fig. 3: Noise Impact of Modulated Signal.

The generated signals are later processed by QPSK modulator in order to perform the mapping of those signals (bits) to (-1 and +1) Figure 2. The following diagram is showing the performed process during the first stage of simulation, where signal is undergone noise as in Figure 3.
After highlighting the system response to the noise, the coming concern of this study is to encode and to decode the information stream with intention of trellis encoder and Viterbi decoder design.

4.1. Encoder design

For encrypting of data before insert them into the channel, trellis encoder is utilized. Firstly, code rate must be defined which reflect the ratio between the code bits and data bits for example ½ code rate means each one bit from data will be coded into two bits. Figure 4 is depicting the block diagram of trellis encoder.

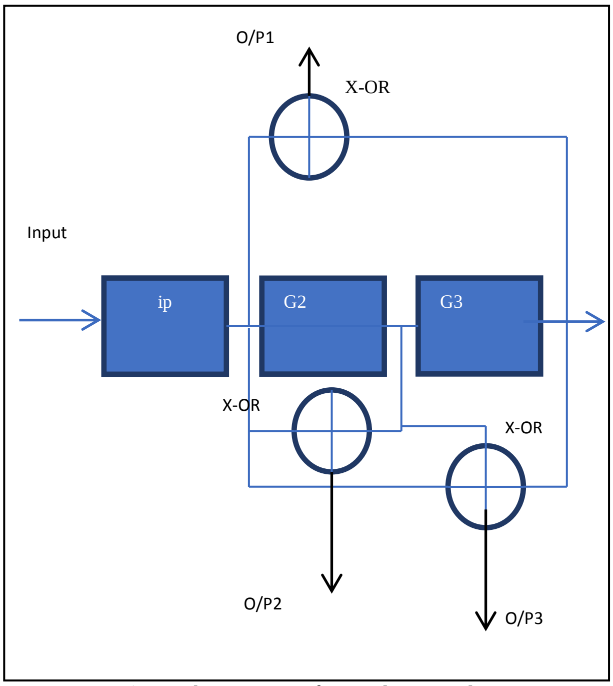

Fig. 4: The Structure of Convolution Coder.

Code rate is decided with number of x-or gates in shift register blocks as shown in Figure 4. The convolution encoder can be derived from the trellis diagram and transition table. The outputs can be given as per the following expressions:

Table1: The Transition Table of Convolution Encoder

IP	C.S.	OP1	OP2	OP3	N.S.
0	00	0	0	0	00
1	00	1	1	1	10
0	01	1	0	1	00
1	01	0	1	0	10
0	10	0	1	1	01
1	10	1	0	0	11
0	11	1	1	0	01
1	11	0	0	1	11

For the above design, transition table is obtained with light of the following questions:

$$op1 = ip + G3 \tag{5}$$

$$op2 = ip + G2 \tag{6}$$

$$op3 = ip + G2 + G3 \tag{7}$$

The same table can be produced by using trellis diagram as in figure 4.

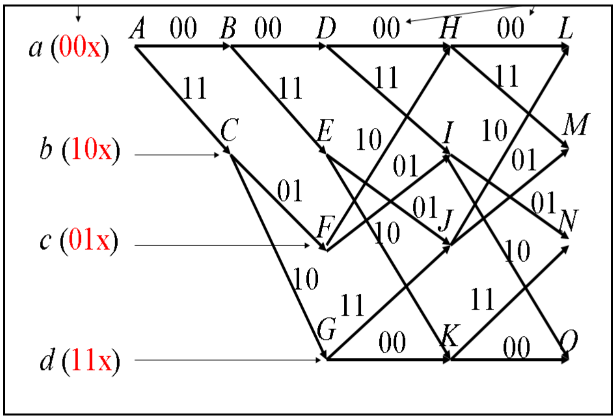

Fig. 5: Trellis Diagram That Obtain from Transition Table.

4.2. Viterbi decoder

A Viterbi decoder uses the Viterbi algorithm for decoding a bit-stream that has been encoded using convolutional code or trellis code. There are other algorithms for decoding a convolutional encoded stream (for example, the Fano algorithm). The Viterbi algorithms are the most trending resource for decoding as they do the maximum likelihood decoding. It is most often used for decoding convolutional codes with constraint lengths k<=10, but values up to k=15 are used in practice. However, the decoding process can be shown in Figure 6.

The process to recover the original information sent by receiver is the responsibility of trellis decoder. It happens when bit is corrupted by noise in the channel such as bit is received as one but actually it sent as zero. In this case, the need of smart system to perform decoding with consideration of noise presence is seem must. The Viterbi decoding is dependent on what so-called maximum likelihood detection where received stream is tracked bit by bit to derive the original bits. This is achievable by choosing the minimum hamming distance in trellis diagram as shown in the Figure 6.

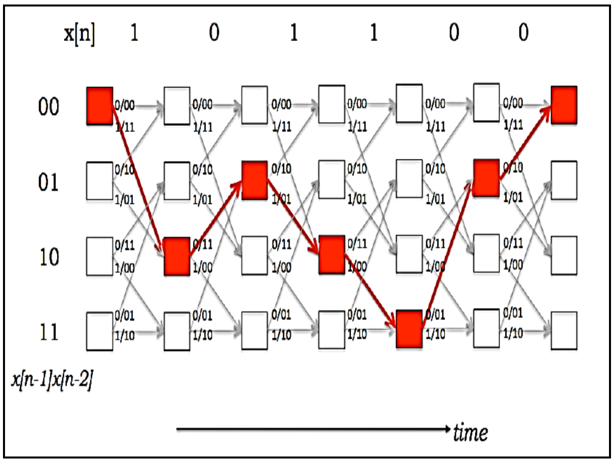

Fig. 6: The Minimum Hamming Distance to Derive the Transmitted Stream in Viterbi Decoder.

5. Conclusion

Digital communications gained great attention because their participation to facilitate the technology and reduce the adaptation cost. In this paper, the structure of wireless communication system is illustrated with intention to highlight the major challenges faced by designer in different parts of the said communication chain. Proper formation of the transmitted signal is strongly relying on modulation and coding process; where signal's immunity to the obstacles in channel is enhanced. Communication source is producing a stream of bits and the receiver can only process and understand the digital format only, such is adapted by digital communication systems to improve the service quality and reduce the deployment cost. Modulation is performed by using higher frequency carrier to convert the digital bits into analogue format that is transportable through the wireless channel. Modulation techniques are varying depending on the application. In Binary Shift Keying (BSK) two bits can be transmitted at once where in Quadrate Phase Shift Keying (QPSK) four bits or more can be transmitted at once. For such reason QPSK is preferred in this study, convolutional coding is done over the generated bits as such coding is efficient from security perspectives. Noise resistivity is approved better in convolutional coder. Ultimately, Viterbi decoder is implemented to retrieve the original transmitted data. Noise presence in received signal can be overcome by Viterbi decoder, Hamming distance is calculated for each path of trellis diagram and minimum loss path is chosen. Diversity is proven of their capability to combat noise and multipath fading effects, it is implemented by deploying number of transmitters and receivers at source and destination ends. The signal of better power can be received and considered after analysing of super position signal form all receivers.

References

[1] A. Manikanta Raghu1, B. Prabhakara Rao, "Performance of Adaptive Bit Interleaved Coded Modulation in Different Fading Environment", *International Journal of Advanced Technology and Innovative Research* Volume.07, IssueNo.13, September-2015, Pages: 2620-2625.

[2] Ramasiva Shankar T.M, Aruna Kumari S, "Adaptive Bit Interleaved Coded Modulation For Mobile Radio Ofdm Systems By Using Rician Fading Channel", *International Journal of Advanced Technology in Engineering and Science* www.ijates.com Volume No.02, Special Issue No. 01, September 2014 ISSN (online): 2348 – 7550.

[3] C. Padmaja1, Dr.B.L.Malleswari, "Performance analysis of Adaptive Bit-interleaved Coded Modulation in OFDM using Zero Padding Scheme", *IOSR Journal of Mobile Computing & Application (IOSR-JMCA)* e-ISSN: 2394-0050, P-ISSN: 2394-0042.Volume 2, Issue 1. (Mar. - Apr. 2015), PP 44-49, www.iosrjournals.org.

[4] Xiaodong Li, AikChindapol, and James A. Ritcey, "Bit-Interleaved Coded Modulation with Iterative Decoding and 8PSK Signaling", *IEEE Transactions on Communications*, VOL. 50, NO. 8, AUGUST 2002.

[5] F. Schreckenbach, N. G¨ortz, J. Hagenauer, G. Bauch, "Optimized Symbol Mappings for Bit-Interleaved Coded Modulation with Iterative Decoding", *International Journal of Advanced Technology in Engineering and Science*, 2016.

[6] Bouazza Boubakar, Lego Stephane Y., Garadi Ahmed, Clency Perrine, RodolpheVauzelle, "A Novel Constellation Shaping Technique for Bit-Interleaved Coded Modulation". *Springer*, 2016.

[7] Lutz H.-J. Lampe1 and Robert F.H. Fischer, "Noncoherent Coded Modulation for Fading Channels", *IEEE Transactions on Communications*, VOL. 44, NO. 18, AUGUST 2015.

[8] Amir Ingber, and Meir Feder, "Parallel Bit Interleaved Coded Modulation: BICM without Asymptotic Assumptions", *IEEE Journal on Selected Areas in Communications*, 2015.

[9] Menka, "Equalization and Channel Estimation for Cellular MIMO-OFDM", *International Journal of Advanced Research in Computer Science and Software Engineering*, Volume 3, Issue 9, September 2013.

[10] Andreas Ahrensa, Soon XinNgb, Volker K¨uhna, LajosHanzob, "Modulation-mode assignment for SVD-aided and BICM-assisted spatial division multiplexing", *scinecedirect* 2016.

[11] Jun Tong, Student Member, Li Ping and Xiao Ma, "Superposition Coded Modulation with Peak-Power Limitation", *IEEE Transactions on Information Theory*, VOL. 55, NO. 6, JUNE 2009.