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Study and Comparison of TAPSK & 16 QAM with Multilevel Coding and Non-Coherent Detection for Different Channel Conditions

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ABSTRACT-Several modulation techniques are defined in digital communication, Error is one of the most important fields in digital communication system. Since error is unavoidable during communication the error correcting codes are used to overcome this problem. Generally the error correcting codes length are derived by considering synchronous detection system however problem induced by these codes are reduce efficiency (because extra bits are needed to be transmitted) because the conditions for non synchronous detection is different. The probability of error for each symbol is not equal and this probability can also be modified by adjusting the shape of symbols also we can improve the spectral efficiency by assigning the different lengths of codes for each symbol depending upon their error probabilities. This paper presents the analysis of Twisted Amplitude Phase Shift Keying (TAPSK) & 16QAM for different channel conditions and different code length we measured the efficiency and the BER for this technique and then compared it with other techniques and the simulation result shows better efficiency and lower BER for TAPSK.

Keywords- Error Correcting Codes; Multilevel Block Codes; Twisted Amplitude Phase Shift Keying (TAPSK); Quadrature Amplitude Modulation (QAM).

I. INTRODUCTION

Error correcting codes are basic need for the digital communication system. The error correcting codes corrects the error during communication at the cost of additional bits transmission which reduces the effective data rate. Presently two error correcting codes (Low density parity check (LDPC) code and Turbo code) are available which closely approach the channel capacity, a theoretical maximum for the code rate at which reliable communication is still possible given a specific noise level. But there may be another solution than only searching for error correcting codes that is to modifying the way they are applied and to modifying the symbol for transmission. This paper deals with analysis of TAPSK 16QAM technique which has capability to increase the efficiency with multilevel block codes when used with non-coherent detection. The rest of paper is arranged as the second section presents the brief literature review about the TAPSK 16QAM and MLBC and the third section presents the model of the simulated system followed by the simulation results and conclusion in next sections.

II. LITERATURE REVIEW

A detail description and analysis of Non coherent Block Coded TAPSK is presented by Ruey-Yi Wei, Shi-Shan Gu and Tzu-Ching Sue [1] they proposed three non-coherent block-coded twisted amplitude and phase shift keying (NBC-TAPSK) schemes which are derived from non-coherent block-coded MPSK. They also propose a new non-coherent detector and a corresponding non-coherent distance for non-constant energy signals over the additive white Gaussian noise (AWGN) channel. At high data rates, NBC-8TAPSK has the best bit error performance among all non-coherent schemes. Ruey-Yi Wei, Tzu-Shiang Lin, and Shi-Shan Gu [2] they derive minimum non coherent distances of block-coded TAPSK (twisted amplitude and phase shift keying) and 16QAM (quadrature-amplitude modulation), both using linear component codes. After that according to the derived distances, non coherent block-coded TAPSK (NBC-TAPSK) and non coherent block-coded 16QAM (NBC-16QAM) are simulated which shows that if the block length is very small, NBC-16TAPSK performs best among all non coherent schemes and NBC-16QAM performs worse due to its small minimum non coherent distance. However, if the block is not short, NBC-16QAM has the best error performance because the code words with small non coherent distances are rare. A literature on Multilevel Codes and design rules presented by Udo Wachsmann, Robert F. H.

Fischer and Johannes B. Huber [3] their paper deals with 2„-ary transmission using multilevel coding (MLC) and multistage decoding (MSD). The known result that MLC and MSD suffice to approach capacity if the rates at each level are appropriately chosen is reviewed. Their simulation results using multilevel binary turbo codes show that capacity can in fact be closely approached at high bandwidth efficiencies. Moreover they also discussed topics relevant in practical applications such as signal set labeling, dimensionality of the constituent constellation, and hard-decision decoding are emphasized. Finally, the combination of signal shaping and coding is discussed and shown that significant shaping gains are achievable in practice only if these design rules are taken into account. Robert Morelos Zaragoza, Tadao Kasamit and Shu Lint [4] presented a Multilevel Block Coded 8-PSK Modulations Using Unequal Error Protection Codes for the Rayleigh Fading Channel they introduces new block coded 8-PSK modulations with unequal error protection (UEP) capabilities for Rayleigh fading channels. UEP is desirable in communications systems where part of the source information is more important, or error sensitive, such as transmission of coded speech and data broadcasting. The proposed block modulation codes are based on the multilevel construction of Imai and Hirakawa [5]. It is shown that the use of binary linear UEP (LUEP) codes [6] as component codes in one or two of the encoding levels provides, in addition to superior UEP capabilities, a higher error performance, at the expense of a very modest reduction in bandwidth efficiency, with respect to conventional multilevel codes. Computer simulation results show that, over a Rayleigh fading channel, a significant improvement in coding gain is obtained by the use of binary LUEP codes as constituent codes in the multilevel construction.

III. TWISTED AMPLITUDE PHASE SHIFT KEYING (TAPSK)

According to the definition and explanation given by [2] the constellation diagram of TAPSK is shown in Fig. 1 (b)(c), where the bit in level a decides the symbol energy. The radiuses of the inner and outer circles are denoted by $r0$ and $r1$, respectively.

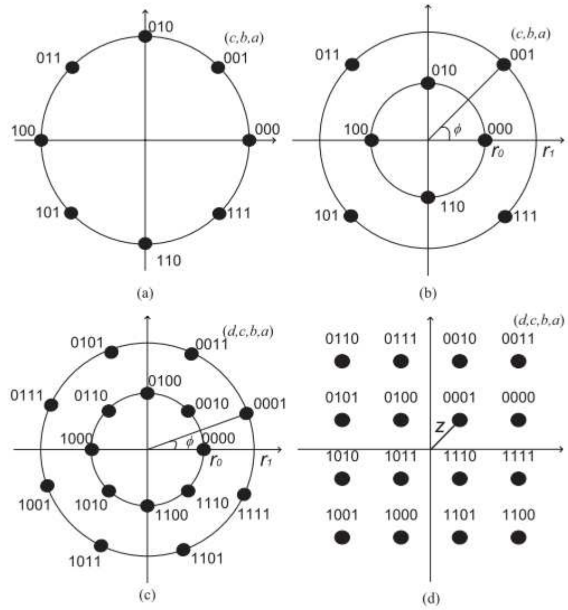

Fig 1. Constellations with bit labeling for (a) 8PSK (b) 8TAPSK (ϕ= π/4) (c) 16TAPSK (ϕ= π/8) (d) 16QAM [2].
The values of $r0$ and $r1$ ($r0 \le 1 \le r1$) satisfy $r20 + r21 = 2$ when $a = 0$ has the same probability as $a = 1$.

IV. QUADRATURE AMPLITUDE MODULATION (QAM)

Figure2 shows the signal constellation diagram for 16 QAM.QAM is the encoding of the information into a carrier wave by variation of the amplitude of both the carrier wave and a "quadrature" carrier that is 900 out of phase with the main carrier accordance with two input signals. That is, the amplitude and the phase of the carrier wave are simultaneously changed according to the information you want to transmit.

In 16-in 16-state Quadrature Amplitude Modulation (16-QAM),there are four I values and four Q values. This results in a total of 16 possible states for the signal. It can transition from any state to any other state at every symbol time. Since 16 = 24, four bits per symbol can be sent. This consists of two bits for I and two bits for Q. The symbol rate is one fourth of the bit rate. So this modulation format produces a more spectrally efficient transmission. It is more efficient than BPSK, QPSK or 8PSK. Note that QPSK is the same as 4-QAM.

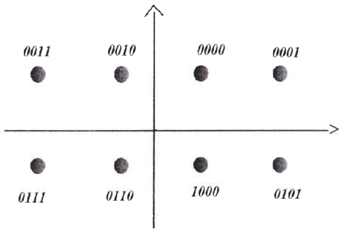

Fig 2- 8QAMConstellation diagram

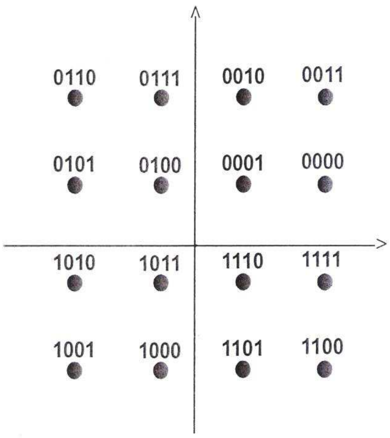

Fig 3- 16QAM Constellation diagram

V. MULTILEVEL BLOCK CODES (MLBC)

For M > 2-ary digital transmission schemes like ASK, PSK, QAM or CPM (incl. FSK) an efficient combining of channel coding and modulation is possible using multilevel-coding (MLC). Transmission schemes with high power and bandwidth efficiency can be designed by this method in various ways. MLC method is based on an iterative partitioning of the set of signal elements of the modulation scheme. The distance structure of MLC-schemes is in principle known as methods of generalized concatenated codes can be applied. Often, design of MLC-schemes is done according to the minimum Euclidean distance criterion.

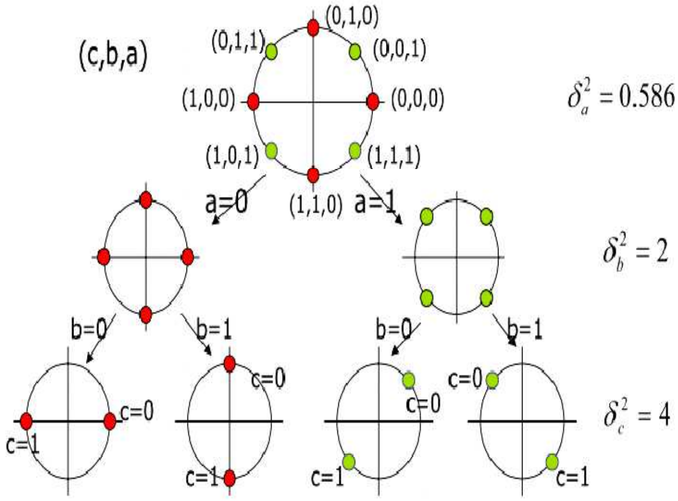

Fig 4. Set partitioning 8psk for multilevel coding

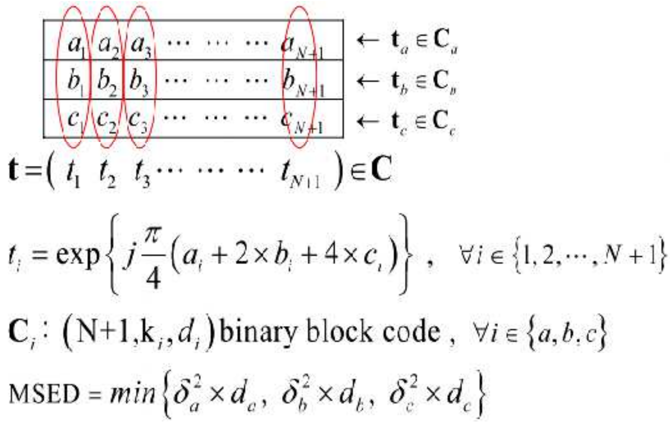

Fig 5. Multilevel block coding

VI. CHANNEL MODELS

In telecommunications and computer networking, a communication channel, or channel, refers either to a physical transmission medium such as a wire or to a logical connection over a multiplexed medium such as a radio channel. A channel is used to convey an information signal, for example a digital bit stream, from one or several senders (or transmitters) to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second.

A. AWGN Channel

Additive white Gaussian noise (AWGN) is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered.

B. Fading Channels

In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process. A fading channel is a communication channel comprising fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.

VII. SIMULATED MODEL

Following diagram shows the basic blocks and interconnections of the blocks of the simulated model.

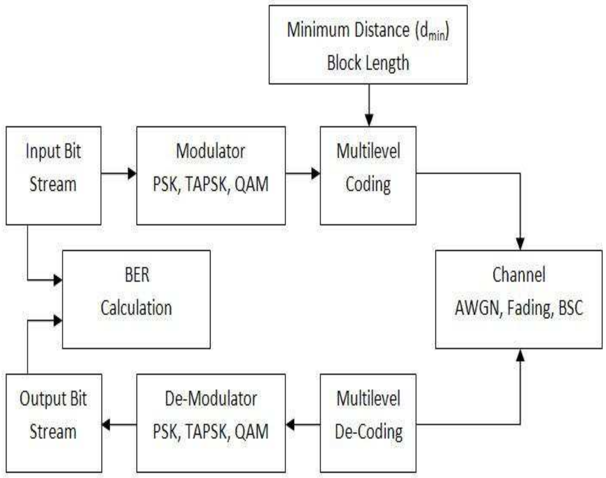

Fig 6. Block Diagram of the Simulated System.

VIII. SIMULATION RESULTS

The proposed model has been simulated for the following input parameters.
Length of Input Bit Stream: 10000.
Minimum Distance (dmin): 4.
Block Length: 63
Channel: AWGN
SNR: from 0 to 20
Ratio (r2/r1): 0.5 for TAPSK only
Rayleigh Fading Channel Properties:
Reflected Paths = 2
Path Gains: -3dB, -3dB
Doppler Shift: 1Hz
Path Delays: 1.2e-6, 1.1e-6 Seconds.
Sampling Time: 1e-6 Seconds

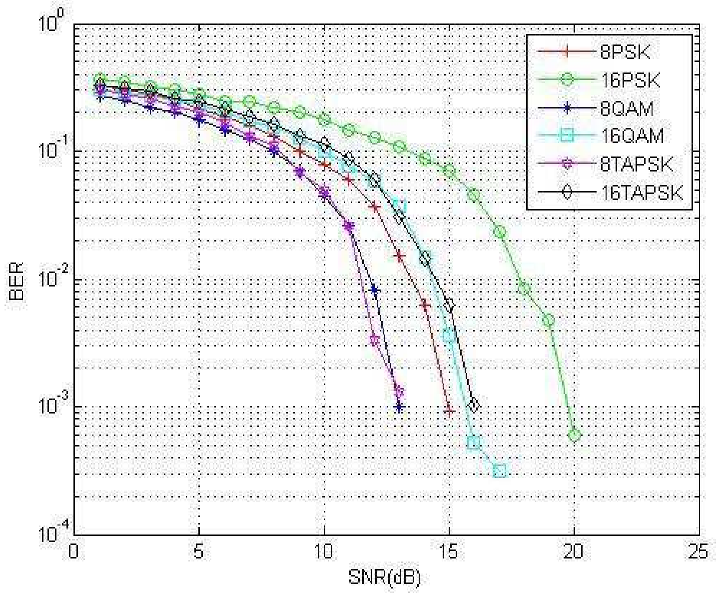

Fig 7. BER performance of different coding techniques for AWGN channel.

The figure shows that the 8TAPSK performs best and followed by 16TAPSK.

TABLE I. SPECTRAL EFFICIENCY COMPARISON FOR THE ABOVE SIMULATION.

Method	Spectral Efficiency (Bits/Sym)
8PSK	2.7244
16PSK	3.1181
8QAM	2.4488
16QAM	3.4488
8TAPSK	2.4488
16TAPSK	2.6772

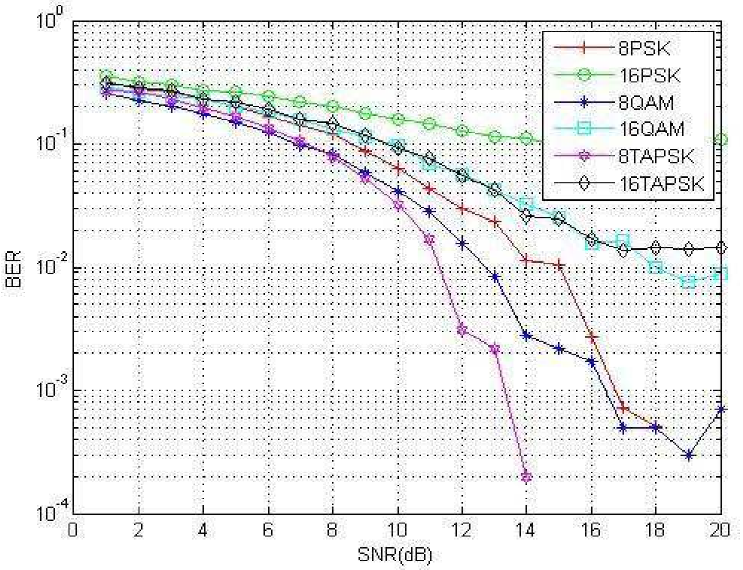

Fig 8. BER performance of different coding techniques for AWGN and Rayleigh Fading. The figure shows that the 8TAPSK performs best

IX. CONCLUSION

The simulation performed for the different modulation techniques with multilevel coding and different channel conditions for non-coherent detection, shows that the 8TAPSK provides a better solution with lower BER and higher spectral efficiency. The result shows that it provides the similar BER and Spectral Efficiency with 8QAM under AWGN channel but greatly outperforms the 8QAM for Rayleigh Fading Channels (as shown in figure 5 8QAM gives 1e-3 BER and 1e-4 BER).

REFERENCES

[1] Ruey-Yi Wei, Shi-Shan Gu and Tzu-Ching Sue "Noncoherent Block-Coded TAPSK", IEEE Transactions on Communications, Vol. 57, No. 11, Nov. 2009.

[2] Ruey-Yi Wei, Tzu-Shiang Lin, and Shi-Shan Gu "Noncoherent Block-Coded TAPSK and 16QAM Using Linear Component Codes", IEEE Transactions on Communications, VOL. 58, NO. 9, Sept. 2010.

[3] Udo Wachsmann, Robert F. H. Fischer and Johannes B. Huber "Multilevel Codes: Theoretical Concepts and Practical Design Rules", IEEE Transactions on Information Theory, Vol. 45, No. 5, July 1999.

[4] Robert H. Morelos-Zaragoza, Tadeo Kamasi and Shu Lin "Multilevel Block Coded 8-PSK Modulations Using Unequal Error Protection Codes for the Rayleigh Fading Channel", San Jose State University 1-1-1995.

[5] H. Imai and S. Hirakawa, "A New Multilevel Coding Method Using Error Correcting Codes" IEEE Trans. Info.

Theory, vol. IT-23, no. 3, pp. 371-376, May 1977.

[6] B. Masnick and J. Wolf, “On Linear Unequal Error Protection Codes,” IEEE Trans. Info. Theory, vol. IT- 13, no. 4, pp. 600-607, Oct. 1967.

[7] Ruey-Yi Wei, Tzu-Ching Sue, Hsi-Hua Wang and Chin-Sung Wang “Noncoherent Block-Coded QAM”, ICC 2007 proceedings.

[8] Karl Heinrich Hofmann “On Uniform Distance Property of Multilevel Block 8-PSK Modulation“,Vol. 5, No. 5 September-October 1994.