Journal of Engineering and Applied Sciences 13 (1): 235-237, 2018
ISSN: 1816-949X

Performance Enhancement of MPSK at High Data Rate

Hadi Athab Hamed
Al-Furat Al-Awsat Technical University, Babil, Iraq

Abstract: M-ary Phase Shift Key (MPSK) is an essential digital modulation scheme that supports high data rate and Frequency Division Multiplexing (FDM). M-ary systems increase the bandwidth efficiency but higher transmission power is required to obtain an acceptable Bit Error Rate (BER). The performance and constellation diagrams of MPSK signals are analyzed. In this study a general theoretical approach is proposed to enhance the performance of MPSK. The probability of bit error is decreased when the signal is transmitted through dual carrier frequencies and dual constellation diagrams to handle the higher data rate to be transmitted for high order MPSK scheme.

Key words: M-ary phase shift key, constellation diagram, probability of bit error and energy per bit to noise ratio, essential digital modulation, performance and constellation diagrams, frequencies

INTRODUCTION

Digital communication systems outperform analogue systems in terms of robustness to channel impairments, greater noise immunity, easier multiplexing of different types of information like, data, video, voice and flexibility. Hence, there are a great investigation for a digital communication systems with low Bit Error Rate (BER) and efficient bandwidth at low Signal to Noise Ratio (SNR) relatively. This has led to great interest in M-ary digitally modulated signals such as M-ary Phase Shift Keying (MPSK) (Staley *et al*., 2001). The increasing of the information rate is accompanied with the following retardation: increased system complexity, increased transmitted power, Inter Symbol Interference (ISI) and difficulties in information signal detection. MPSK is used for data transmission, Rradio Teletype (RTTY) Transmission, ZigBees, WiFi transmissions, satellite communication, video conferencing, GSM, CDMA, radar (Limin *et al*., 2010; Agrawal and Yadav, 2017), etc. MPSK is superior to all other digital modulated techniques that it reduces the ratio of peak to average power, when it is used with Orthogonal Frequency Multiplexing (OFDM) (Garcia-Armada, 2006). By Li *et al*. (2011), the performance of MPSK is evaluated over extended Raylegh fading channel. In Suthar *et al*. (2009), the BER as a measure of performance of M-ary modulation techniques in cellular Mobil communication is investigated. By Ghosh *et al*. (2012), MPSK-OFDM system was discussed, a comparative study of BER against SNR had been analyzed under multipath fading and AWGN channel. By Song and Cheng (2014), the relation between the exact BER and the approximate BER for MPSK signal had been realized through fading channels.

M-ary MPSK mathematical expression: In Binary Phase shift Key (BPK), the symbol represents a data bit. In MPSK, the symbol represents $m = \log_2 M$ data bits. The carrier phase takes one of M possible symbol values. The mathematical expression of MPSK is:

$$S_K = \sqrt{\frac{2E_s}{T}\cos(2\pi f_c + \theta_K)\ 0 \le t \le T} \tag{1}$$

$$K = 1, 2, ..., M$$

Where:

E_s = The signal Energy per symbol
T = Symbol duration
f_c = The carrier frequency which is equal to integer multiple of the symbol rate = n_c/T

$$\theta_k = \frac{2\pi}{M}(k-1) \tag{2}$$

Therefore, each m-tuples of binary data stream is represented by a symbol with a particular phase (Haykin, 2001).

MPSK constellation diagram: The signal constellation is a representation of M-ary digitally modulated signals. In MPSK, it displays all possible symbols for a given modulation scheme on two dimensions. Each symbol is represented by two coordinates, the horizontal and vertical. The polar representation of the signal is $(\sqrt{E_s}, \theta_K)$. All the points of signal are equally distributed on a circle centered at the origin with radius $\sqrt{E_S}$ and angle with the horizontal axis. Gray coding is usually applied to distribute the signal points in the constellation with one-bit difference to any two adjacent points

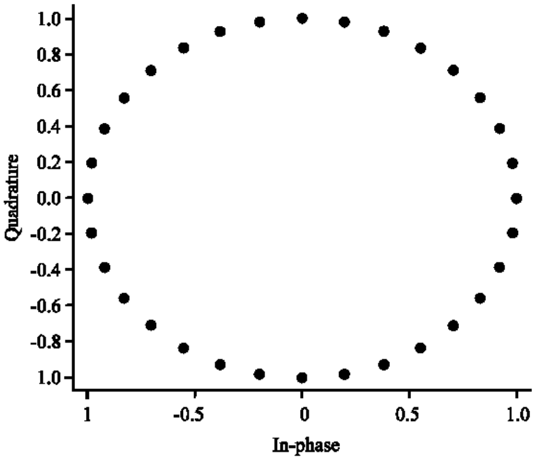

Fig. 1: Constellation diagram of 32PSK (Scatter plot)

(Proakis and Salehi, 2008). Figure 1 shows the constellation diagram of 32PSK using MATLAB as an example.

BIT ERROR PROBABILITY OF MPSK THROUGH AWGN CHANNEL

The Probability of Bit Error (PBE) is usually a measure for the performance of modern digitally modulated signals. Additive white Gaussian noise (AWGN) is the most common type of noise which have the great influence on the performance of MPSK systems. For coherent MPSK, the symbol error probability is (Ziemer and Tranter, 2002):

$$\mathrm{PSE} = \mathrm{erfc}\left(\sqrt{\frac{E_s}{N_0}}\sin\left(\frac{\pi}{M}\right)\right) \tag{3}$$

Where:

erfc(.) = The complementary error function

N_0 = The Noise spectral density

The probability of bit error or the BER is easily derived from Eq. 3 when the energy per bit:

$$E_b = \frac{E_s}{\log_2 M} \tag{4}$$

The probability of bit error for different schemes is shown in Fig. 2, using MATLAB.

Proposed system for MPSK technique: The performance of MPSK is usually measured in terms of signal power and bandwidth. Figure 2 shows the increase of E_b/N_O which is a form of signal to noise ratio at high value of M to maintain an acceptable level of probability of bit error. The proposed system is to divide the constellation diagram for high order MPSK to two parts which are transmitted with two separated carrier frequencies according to Eq. 5 and 6:

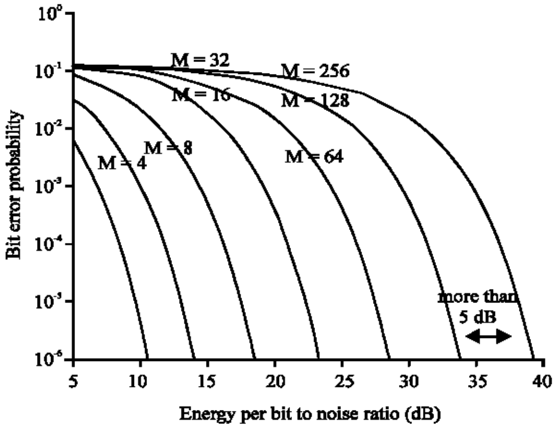

Fig. 2: Bit error probability against E_b/N_O

$$\begin{aligned} S_{k1} &= \sqrt{\frac{2E_s}{T}}\cos(2\pi f_{c1}t + \theta_{K1})\ 0 \le t \le t \\ \theta_{k1} &= \frac{2\pi}{M/2}(K_1 - 1), k_1 = 1, 2, \ldots, \frac{M}{2} \end{aligned} \tag{5}$$

$$\begin{aligned} S_{K2} &= \sqrt{\frac{2E_s}{T}}\cos(2\pi f_c t + \theta_{K2})\ 0 \le t \le T \\ k_2 &= \frac{M}{2} + 1, \frac{M}{2} + 2, \ldots, M \\ \theta_{k2} &= \frac{2\pi}{M/2}\left(K_2 - \frac{M}{2} - 1\right) \end{aligned} \tag{6}$$

where, fc_1, fc_2 are the carrier frequencies to transmit first and second part of constellation, respectively. Then, as an example, 256 PSK can be divided to 2×128 (two constellation diagrams), each constellation can be transmitted with different carrier frequency which exhibits the improvement of energy per bit to noise ratio more than 5 dB at 10^{-6} probability of error as shown in Fig. 2. This approachhas many advantage to improve the performance of MPSK system especially at high data rate and improve the detection and recognition of signals but an accurate and complicated synchronization is requested for coherent demodulation of signals.

CONCLUSION

The constellation diagram and the performance of MPSK are investigated. The graphical representation of bit error probability against E_b/N_O exploits that the higher order of M are more spectrally efficient but high probability of bit error. System enhancement is proposed, by using dual constellation and dual carrier frequencies.

SUGGESTIONS

The suggestion for future research is design of coherent synchronization and demodulation of the proposed system also the application of proposed system to M-ary QAM. The proposed system is considered as a first step toward the hybrid MPSK-MFSK systems.

REFERENCES

Agrawal, D. and J.S. Yadav, 2017. Investigation of the effectiveness of modulation technique for wireless communication with QPSK base encoding. Intl. J. Sci. Res. Comput. Sci. Eng. Inf. Technol., 2: 548-555.

Garcia-Armada, A., 2006. SNR gap approximation for M-PSK-based bit loading. IEEE. Trans. Wirel. Commun., 5: 57-60.

Ghosh, A., B. Majumder, P. Paul, P. Mullick and I.G. Thakurta *et al.*, 2012. Comparative study of Bit Error Rate (BER) for MPSK-OFDM in multipath Fading channel. Intl. J. Adv. Eng. Technol., 4: 465-474.

Haykin, S., 2001. Communication Systems. 4th Edn., John Wiley and Sons, New York, USA.,.

Li, Y., S. Tang and X. Ge, 2011. The bit error rate performance of MPSK over extended Rayleigh fading channel. Proceedings of the IET International Communication Conference on Wireless Mobile and Computing (CCWMC'11), November 14-16, 2011, IET, Shanghai, China, ISBN:978-1-84919-505-8, pp: 192-195.

Limin, C., L. Yin and W. Guojin, 2010. Symbol timing and carrier frequency united estimation for MPSK signals. Proceedings of the International Conference on Computer Application and System Modeling (ICCASM'10) Vol. 5, October 22-24, 2010, IEEE, Taiyuan, China, ISBN:978-1-4244-7235-2, pp: V5-610-V5-613.

Proakis, J.G. and M. Salehi, 2008. Digital Communications. 5th Edn., McGraw-Hill, New York, pp: 95-148.

Song, X. and J. Cheng, 2014. Quantifying the accuracy of high SNR BER approximation of MPSK and MDPSK in fading channels. Proceedings of the 27th Biennial Symposium on Communications (QBSC'14), June 1-4, 2014, IEEE, Kingston, Ontario, Canada, ISBN: 978-1-4799-3972-5, pp: 105-108.

Staley, T.L., R.C. North, J. Luo, W.H. Ku and J.R. Zeidler, 2001. Performance evaluation for multichannel reception of coherent MPSK over frequency selective fading channels. IEEE. Trans. Veh. Technol., 50: 877-894.

Suthar, R., S. Joshi and N. Agrawal, 2009. Performance analysis of different M-ARY modulation techniques in cellular mobile communication. IP. Multimedia Commun. Special Issue IJCA., 2011: 25-29.

Ziemer, R.E. and W.H. Tranter, 2002. Principles of Communication Systems, Modulation and Noise. 5th Edn., John Wiley and Sons, New York, USA., Pages: 398.