ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 4, April 2013

BER PERFORMANCE OF GMSK USING MATLAB

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Abstract— **GMSK is most prominent standards around the world. Global System for Mobile communication (GSM), Digital European Cordless Telephone (DECT), Cellular Digital Packet Data (CDPD), Digital communications system in the 1800 MHz band (DCS1800 in Europe), Personal communications services in the 1900 MHz band (PCS1900) in U.S., all use GMSK as their modulation format. The reason GMSK is used for GSM is its High spectral efficiency, MSK uses phase variation for modulation so better immune to noise. Non linear amplifiers are used to give better response and consumes less power so low battery usage which is an important parameter in cellular technologies. Gaussian Minimum Shift keying modulation scheme is a derivative of MSK. In GMSK, the side lobe levels of the spectrum introduced in MSK are further reduced by passing the modulating NRZ data waveform through a pre modulation Gaussian pulse-shaping filter. ISI degrade the performance of GMSK. In this paper we suggested the methods for reduction in the ISI. GMSK performance is improved by using optimum filters, Viterbi-adaptive equalization and soft decision Viterbi decoding.**

Index Terms— **Bit Error Rate (BER), Gaussian filter, Gaussian Minimum Shift Keying (GMSK), Inter Symbol Interference (ISI), Minimum Shift Keying (MSK), Signal to Noise Ratio (SNR).**

I. INTRODUCTION

The increasing demand in the amounts of data to be transferred through the wireless media arise the need for different modulation methods. In telecommunication systems the information is transmitted by means of some kind of modulation of high frequency electromagnetic waves. If the data to be transmitted is digital, digital modulation schemes are used [2].They present different tradeoffs between cost and tolerance to noise and other disturbances, spectral efficiency etc. One of the most widely used digital modulation technique is Gaussian Minimum Shift Keying (GMSK). GMSK is a member of the minimum shift keying (MSK) modulation family. In the GMSK the phase of the carrier signal is continuously varied by the antipodal signal, which has been shaped by the Gaussian filter. Since it is type of MSK, it has a modulation index of 0.5. Gaussian filter concentrates the energy, allowing for the lower out of band power [16]. The constant envelope allows GMSK to be less susceptible to a fading environment.

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II. RELATED WORK

Lee, Chung, and Kim [11] analyze coherent demodulation of a GMSK signal, using a MSK-type receiver. Use of a simple MSK-type receiver to detect GMSK results in a degradation of about 0.3 dB at BER $=10^{-5}$ when compared to MSK (that is, filters matched to MSK result in negligible degradation when used with GMSK).

Turkmani and Carter [12] study the impact of co-channel interference (CCI) on GMSK (BT = 0.3) in a Rayleigh fading environment using an MSK-type receiver. They found that the irreducible error rate decreases with the fading rate values as would be encountered in GSM.

Smith and Wittke [13] investigate the symbol error probability of GMSK using differential demodulation in a Rician fast fading environment. With the effect of the 22 infinite sequence of ISI considered, the conditional and average probability of error is formulated and compared for filter bandwidth and average SNR, with and without fading. It is shown that, for BT = 0.6, GMSK has an equivalent error performance comparable to MSK.

For low signals probability of error of MSK is better than GMSK. For higher signals probability of error of GMSK is better as compared to probability of error of MSK [17].

III. GAUSSIAN FILTER

A filter with Gaussian impulse response can be used as pre-filtering of the symbols prior to the continuous phase modulation. Its purpose is to control the modulated signal bandwidth. The Gaussian filter is characterized by its BT product (B-is the -3dB bandwidth, T is the symbol period=$1/f_{\text{symbol rate}}$). The lower the BT product, the narrower the modulation bandwidth and the higher the inter symbol interference. The width of the Gaussian filter is determined by the bandwidth-time product BT. For GSM the bandwidth-time product (BT) is 0.3 and for CDPD the bandwidth-time product (BT) is 0.5. The impulse responses of Gaussian filter for GSM and CDPD is shown in figure 1 and 2 respectively.

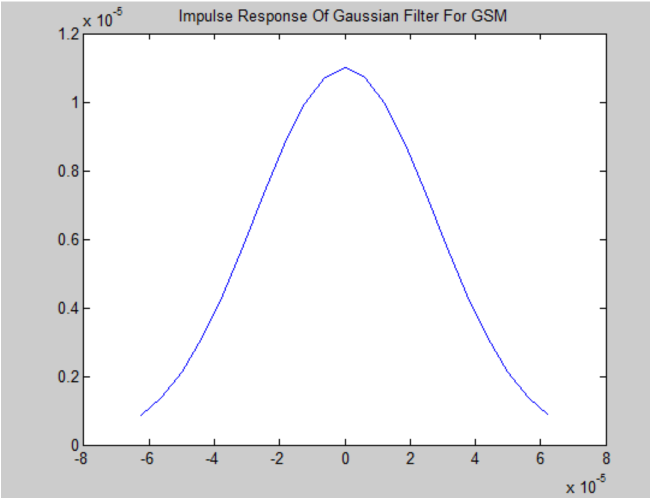

Fig.1 Impulse response of Gaussian filter for GSM

BT = 0.28 can be adopted as the digital modulation for conventional UHF (300-1000 MHz, IEEE designation) mobile radio communications without carrier frequency drift where the out-of-band radiation power in the adjacent channel to the total power in the desired channel must be lower than -60 dB.

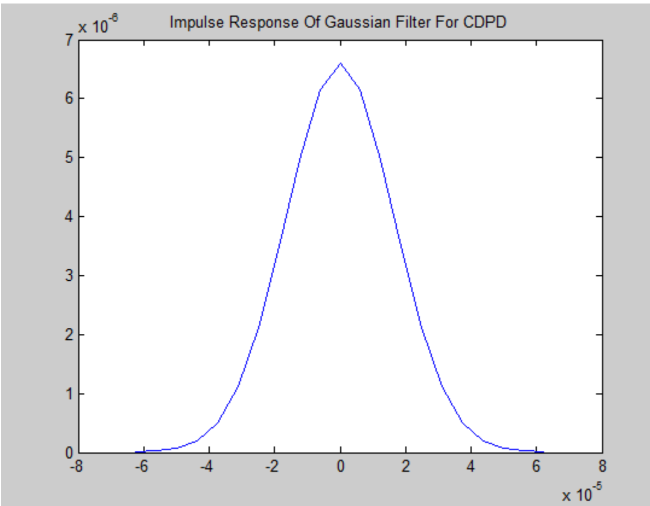

Fig.2 Impulse response of Gaussian filter for CDPD

IV. Minimum Shift Keying

Minimum Shift Keying (MSK) is a continuous phase (CP) Frequency Shift Keying (FSK) binary modulation format. FSK is the digital equivalent of analog frequency modulation (FM). MSK is a form of FSK, with modulation index h = 0.5 yielding the minimum frequency separation for orthogonal signaling over a signaling interval of length T [8]. MSK is popular in wireless communications because of its desirable characteristics. Desirable characteristics for digital modulation for land mobile radio are compact output power spectrum, applicability of class-C nonlinear power amplifiers, high immunity to noise and interference, and ease of implementation [14]. Minimum Shift Keying (MSK) modulation satisfies the above requirements for non-coherent MSK demodulation:

$$P_e = \frac{1}{2}\exp\left(-\frac{1}{2}\frac{E_b}{N_0}\right) \quad (1)$$

Where P_e is the probability of bit error.

V. Gaussian Minimum Shift Keying

To make the MSK output power spectrum more compact, the pre modulation LPF should meet the following conditions narrow bandwidth and sharp cut off to suppress high frequency components, small overshoot impulse response to prevent excess deviation of the instantaneous frequency, and preservation of an integrated filter output pulse capable of accommodating a 90 degree phase shift to ensure coherent demodulation [5]. A pre modulation Gaussian LPF satisfying the above requirements is adopted for Gaussian Minimum Shift Keying (GMSK) modulation, where the data sequence (i.e., an information pulse train) is passed through a Gaussian LPF filter, and the output of the filter is MSK modulated [10]. The width of the Gaussian filter is determined by the bandwidth-time product BT (e.g., BT = 0.3 for GSM and BT = 0.5 for CDPD). The trade-off of having a more compact spectrum is that a pre modulation filter spreads the signal pulse and, thus, introduces inter-symbol interference (ISI) in the transmitted signal. The Gaussian pre modulation filtering spreads the pulse over an interval greater than T (the bit duration, equivalent to the inverse of the bit rate R), making GMSK a partial response signal (in a full response signal, the pulse is confined to the interval T). Differentially encoded rectangular data stream is filtered using a Gaussian low pass filter of 3-dB band width [7]. The impulse response of the Gaussian filter is given by

$$h(t) = \frac{1}{\sqrt{2\pi}\sigma T} exp\left(\frac{-t^2}{2\sigma^2 T^2}\right) \quad (2)$$

Where

$$\sigma = \frac{\sqrt{\ln(2)}}{2\pi BT}, \quad (3)$$

With BT=0.3 for GSM.

B is the 3dB bandwidth of the filter. The square pulse response g(t) of the Gaussian low pass filter is:

$$g(t) = h(t) * rect\left(\frac{t}{T}\right) \quad (4)$$

Where the rectangular function rect(x) is defined by:

$$rect\left(\frac{t}{T}\right) = \begin{cases}\frac{1}{T}, for|t| < \frac{T}{2} \\ 0, otherwise\end{cases} \quad (5)$$

.

VI. GMSK Bit Error Rate

The bit error rate for GMSK was first found in for AWGN channels, and was shown to offer performance within 1 dB of optimum MSK when BT=0.3.The bit error probability is a function of BT, since the pulse shaping impacts ISI [15]. The bit error probability for GMSK is given by,

$$P_e = Q\left(\sqrt{\frac{2\alpha E_b}{N_0}}\right) \quad (6)$$

Where α is a constant related to BT by α=0.68 for GMSK with BT=0.3. Where Q(t) is the Q-function

$$Q(t) = \frac{1}{\sqrt{2\pi}}\int_t^{\infty} exp\left(\frac{-\alpha^2}{2}\right) d\alpha \quad (7)$$

For GMSK, the BERs of coherent and non coherent demodulation will be degraded from these optimum values because of the ISI introduced by the pre modulation Gaussian filtering [1]. The GMSK modulation is a certain kind of binary digital modulation, its BER performance bound in the high SNR condition. Schemes that rely on more than two levels (e.g. QAM, QPSK) require better signal to noise ratios (SNR) than two-level schemes for similar BER performance. The performance of a GMSK modem is generally quantified by measurement of the signal-to-noise ratio (SNR) versus BER.

VII. Optimum IF Pre detection Filter

At the receiver, an IF band pass filter (i.e., a pre detection filter) is used to pass the signal, but to band-limit the noise entering the receiver (and filter out adjacent channel interference) [4]. The optimum IF filter bandwidth-time constant, BT, maximizes the signal power relative to the noise power.

VIII. INTERSYMBOL INTERFERENCE (ISI)

Inter symbol interference (ISI) is a situation in which the energy from one symbol slot is spread out over neighboring symbol slots. ISI introduced either by the channel, when the RMS delay spread becomes an appreciable fraction of the bit period, or by the filtering of the data pulses, in order to reduce the out of band power, before the modulation process [6]. ISI significantly degrade the ability of the receiver to differentiate a current symbol from the diffused energy of the adjacent channels therefore decreases the bit error rate (BER) performance.

IX. TECHNIQUES USED

The quadrature channels of the modulator and demodulator must be time synchronized, amplitude balanced, and in phase quadrature to minimize overall system degradation. Implementations making use of in-phase and quadrature channel mixers to realize the conversion and matched filters as low-pass equivalents are particularly advantageous because of their compatibility with microwave integrated-circuit fabrication techniques [9]. At the receiver, an IF band pass filter (i.e., a pre detection filter) is used to pass the signal, but to band-limit the noise entering the receiver (and filter out adjacent channel interference). The optimum IF filter bandwidth-time constant maximizes the signal power relative to the noise power. Viterbi-adaptive equalization and soft decision Viterbi decoding is used to cope with the severe time and frequency-selective distortions caused by propagation phenomena. A soft-decision Viterbi algorithm allows the performance of some GSM traffic and control channels to be considerably improved with respect to hard decisions. Improvement can be achieved with a not too heavy increase of hardware complexity. Linear equalization is required in GSM to mitigate the ISI introduced by the pre modulation filtering, multipath, and pre detection band pass filtering [3]. GSM specifications require that equalizers should be able to compensate for delay spreads up to 16µs. Adaptive linear equalization facilitates the mitigation of ISI introduced by the channel (e.g., by dynamic multipath), as well as ISI due to filtering.

X. SIMULATION RESULTS

Bit error rate (BER) performance of MSK and GMSK is tested for different values of SNR using MAT LAB. Table 1 shows the BER performance of MSK and GMSK.

Table 1. BER performance of MSK and GMSK

SNR	BER(MSK)	BER(GMSK)
0	0.5	0.3032
1	0.4506	0.2664
2	0.3549	0.2263
3	0.2664	0.1843
4	0.1894	0.1424
5	0.1267	0.1028
6	0.0792	0.0683
7	0.0459	0.0407
8	0.0242	0.0213
9	0.0114	0.0094

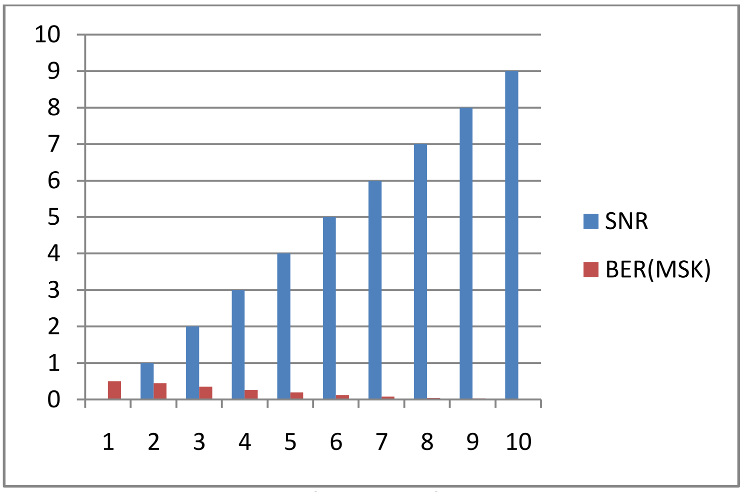

Fig. 3 BER performance of MSK

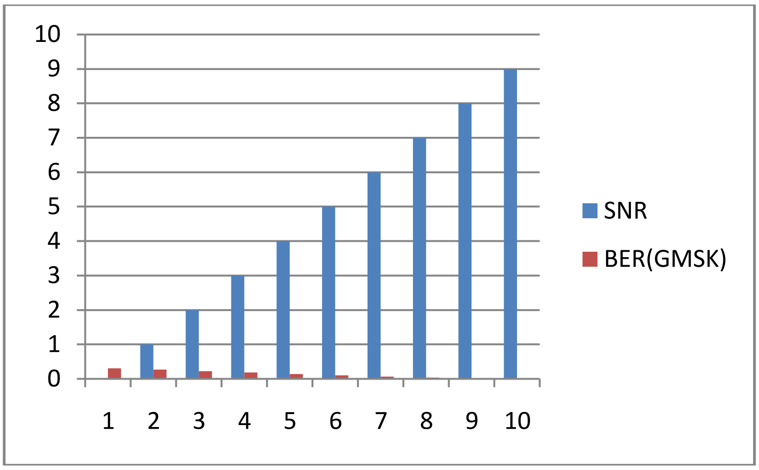

Fig. 4 BER performance of GMSK

Figure 3 and 4 shows BER Vs SNR graph for MSK and GMSK. For higher values of SNR GMSK is better as compared to MSK.

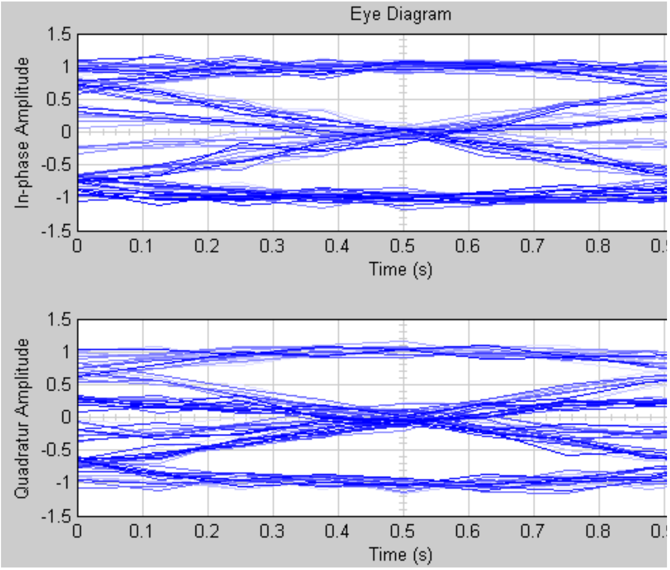

Fig. 5 Eye diagram of GMSK with ISI

ISI significantly degrade the ability of the receiver to differentiate the original signal from the noise, therefore decreases the bit error rate performance. Figure 5 shows the eye diagram of GMSK with inter symbol interference.

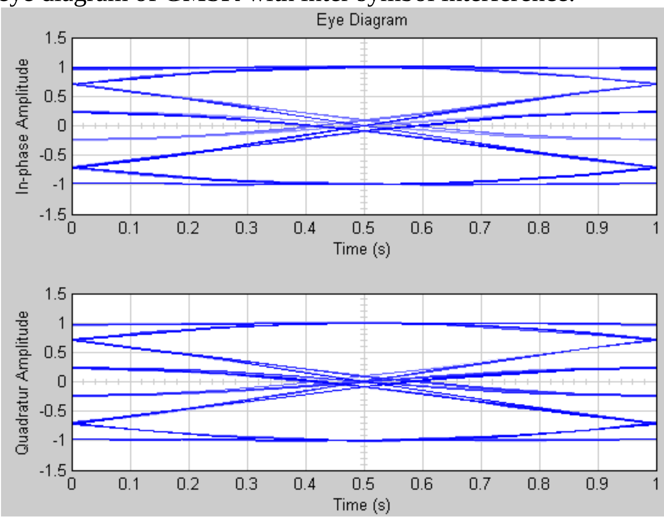

Fig. 6 Eye diagram of GMSK without ISI

Inter symbol interference is reduced by applying different techniques discussed in this paper. Figure 6 shows eye diagram of GMSK without inter symbol interference (ISI).

XI. Conclusion

The goal of this research is to make a significant contribution to the field of communications by finding better ways to modulate and demodulate GMSK in the mobile radio environment. GMSK is a result of the attempts to improve the MSK power spectrum. GMSK is a more compact spectrum, with the application of the low pass filter, helping to reduce its spectral side lobes. In this paper we described the BER performance of GMSK with non coherent detector in AWGN environment. It is observed that GMSK is slightly superior to MSK when the interference signal is strong. This observation confirms that GMSK possesses attractive power spectrum properties for a digital communication. Further we can obtain optimum result by using co-relaters or matched filters as receivers. The probability of error of GMSK can be reduced by increasing number of transmitted symbols.

Acknowledgment

Dharma Devi author wishes to express her sincere gratitude to Mrs. Abhilasha Sharma Astt. Prof. ACET Eternal University BARU SAHIB for guiding her throughout the current research work.

REFERENCES

[1] K. Murota and K. Hirade, “GMSK Modulation for Digital Radio Telephony,” IEEE Trans. Comm., COM-29, No. 7, pp. 1044-50, May 1978.
[2] Dr. Rappaport , Wireless Communications Principles and Practice.
[3] William C.Y.Lee, Mobile cellular telecommunications analog and digital systems.
[4] Kiran K. Kuchi, “Spectral Occupancy and Error Rate Considerations of GMSK Modulation for PCS Applications,” Master’s thesis, Dept. of Electrical Eng., The Univ. of Texas at Arlington, December 1997.
[5] Feher, Applications of Digital Wireless Technologies to Global Wireless Communications, Prentice Hill1997, ISBN 0-13-214272-4, 1997.
[6] Radio/Modem Reference Design Guide, Issue 1, Revision 0, RAM Mobile Data, Woodbridge, NJ, 1991.
[7] Steve Kau Yao and J. H. Reed, Differential detection of GMSK signals. Technical report, Virginia Tech, October 1994.
[8] Rodger E. Ziemer and Carl R. Ryan. Minimum-shift keyed modem implementations for high data rates. IEEE Communications Magazine, pages 28{37, October 1983.
[9] J. S. Ismail Lakkis and S. Kato, A simple coherent GMSK demodulator. *IEEE*, pages A–112 –A–114, 2001.
[10] ABHIJIT PATAIT Efficient GMSK Modulator Targets GSM Designs,www.commsdesign.com/design_corner/OEG20020708S0 008; 2002.
[11] Sang U. Lee, Young M. Chung, and Jae M. Kim. On the bit error probabilities of GMSK in the rayleigh fading channels, June 1988.
[12] S. Smith and P. H. Wittke. Differential detection of GMSK in rician fading. IEEE Transactions On Communications, 42(2-4): l 216{20, February-April 1994.
[13] A. M.D. Turkmani and P. P. S. Carter, Software investigation of co-channel interference in a digital cellular radio system. Technical report, The University of Liver pool, UK, 1990.
[14] John B. Anderson, Digital transmission engineering, Wiley-IEEE Press, 2005.
[15] M. Mammela and R. Broderson. "Constant Envelope Multicarrier Modulation: Performance Evaluation in AWGN and Fading Channels", MILCOM2005, 2: 807-813, Oct.2005.
[16] R. Y. Yen and H.-Y. Liu. "A general moment generating function for MRC diversity over fading channels with Gaussian channel gains: Research Articles", Int. J. Commun. Syst., 20(3): 265-272, 2007.
[17] M. R. McKay, A. Zanella, I. B. Collings, and M. Chiani. "Optimum Combining of Rician-Faded Signals: Analysis in the Presence of Interference and Noise", IEEE International Conference on Communications (ICCS07), 1096-1101, June 2007.