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Performance Analysis of GSM System Using SUI Channel

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ABSTRACT: *GSM (Global System for Mobile Communications) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones. A channel is used to convey the information signals. SUI channel model are an extension of the previously work by AT&T Wireless and Ercegetal. The main objective of this paper is to get better performance of GSM system using SUI channel model. Considering this goal, the simulation has been done. The performance is analyzed, which shows satisfactory BER for higher SNR. This result is compared with the performance of GSM system using AWGN channel. BER is affected by a number of factors. By modifying the variables that can be controlled, it is possible to optimize a system to provide the performance levels that are required. This article shows the better performance of GSM system using SUI channel than AWGN channel.*

Keywords – *GSM, SUI, BER, GMSK, AWGN*

I. INTRODUCTION

In telecommunications and computer networking, a communication 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 has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second. Channel models of fixed wireless applications and which contains the definition of a set of six specific channel implementations known as SUI channel.

GSM is a cellular network, which means that cell phones connect to it by searching for cells in the immediate vicinity. There are five different cell sizes in a GSM network- macro, micro, pico, femto and umbrella cells. The coverage area of each cell varies according to the implementation environment. GMSK is a modulation system used in GSM. GMSK (Gaussian Minimum Shift Keying) is a form of modulation used in a verity of digital radio communications system. It has advantages of being able to carry digital modulation while still using the spectrum efficiently. In this paper, the performance of GSM system using SUI channel is analyzed. GMSK modulation system has been followed to perform the analysis and for the simulation purpose, MATLAB software has been used as the simulation tool. The paper is organized as followed. The section II gives the historical backgrounds of GSM system, SUI channel and GMSK modulation. In section III, the modulation techniques have been discussed with necessary figures, which are specially focused on the techniques used in GSM. In section IV, SUI channel models are discussed with the proper information, tables and figures. In section V, the simulation results and comparison between the performances of AWGN channel and SUI channel are shown and discussed and section VI draws the conclusion. Theses information and analysis are useful for the telecommunication system all over the world.

II. BACKGROUNDS

In [1], GSM is the global standard mobile communications with over 90% market share, and is available in over 219 countries and territories. GSM networks operates in a number of different carrier frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G), with most 2G GSM networks operating in the 900 MHz or 1800 MHz bands. GSM has used a verity of voice codec to squeeze 3.1 KHz audio into between 6.5 and 13 Kbit/s. Originally , two codec, named after the types of data channel they were allocated, were used, called Half Rate (6.5 Kbit/s) and Full Rate (13 Kbit/s). These used a system based on linear predictive coding (LPC). In addition to being efficient with bit rate, these codec also made it easier to identify more important parts of the audio, allowing the air interface layer to prioritize and better protect these parts of the signal. GSM was further enhanced in 1997 with the Enhanced Full Rate (EFR) codec, a 12.2 Kbit/s codec that uses a full rate channel. So far, it is known that AWGN channel has shown good performance in GSM system.

In SUI channel model, a set of six channels was chosen to address three different terrain types that are typical of the continental US [2]. This model can be used for simulation, design, and development and testing of technologies suitable for fixed broadband wireless applications [3]. The parameters for the model were selected based on some statistical models. The tables below depict the parametric view of the six SUI channels.

Table 1: The terrain types of SUI channel.

Terrain type	**SUI channels**
C (Mostly flat terrain with light tree densities)	SUI-1. SUI-2
B (Hilly terrain with light tree density or flat terrain with moderate to heavy tree density)	SUI-3. SUI-4
A (Hilly terrain with moderate to heavy tree density)	SUI-5. SUI-6

Table 2: General characteristics of SUI channel.

Doppler	**Low delay spread**	**Moderate delay spread**	**High delay spread**
Low	SUI-1,2 (High K Factor) SUI3		SUI-5
High		SUI-4	SUI-6

Gaussian Minimum Shift Keying or Gaussian filtered Minimum Shift Keying, GMSK, the form of modulation with no phase discontinuities used to provide data transmission with efficient spectrum usage. GMSK modulation is based on MSK, which is itself a form of continuous-phase frequency-shift keying. One of the problems with standard forms of PSK is that sidebands extend out from the carrier [4]. To overcome this, MSK and its derivative GMSK can be used. Here there are no phase discontinuities because the frequency changes occur at the carrier zero crossing points.

III. MODULATION TECHNIQUES OF GSM

GSM uses a form of modulation known as GMSK. MSK and also GMSK modulation are what is known as a continuous phase scheme. This arises as a result of the unique factor of MSK that the frequency difference between the logical one and logical zero state is always equal to half the data rate [5].

GMSK can be generated through two methods:

a) Through filtering of signals using Gaussian filter with a modulation index of 0.5. This method is not widely used because it is difficult to obtain a modulation index of exactly 0.5.

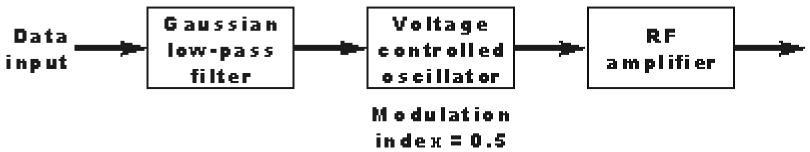


Figure 1 (a): Generating GMSK using Gaussian filter and VCO

b) Another method is where the quadrature modulator is used (phase of the angle is 90^0 to another). This form is also known as I-Q Modulator since it is dependent on the in phase and quadrature of the signals. This enables the modulation index to be set to 0.5 exact. The signal thus cannot be distorted since it is not carried in terms of amplitude elements.

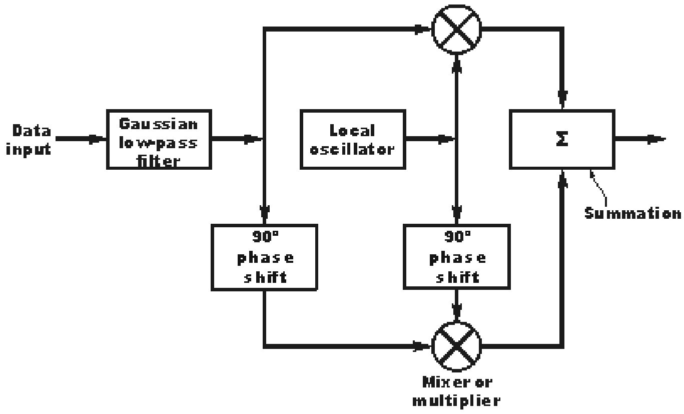


Figure 1 (b): Block diagram of I-Q modulator used to create GMSK

ADVANTAGES OF GMSK MODULATION

There are several advantages to the use of GMSK modulation for a radio communication system. One is obviously the improved spectral efficiency when compared to other phase shift keyed modes. A further advantage of GMSK is that it can be amplified by a non-linear amplifier and remain undistorted. This is because there are no elements of the signal that are carried as amplitude variations [5]. A further advantage of GMSK modulation again arises from the fact that none of the information is carried as amplitude variations.

IV. STANFORD UNIVERSITY INTERIM (SUI) CHANNEL MODEL

In [6], Channel models for fixed wireless applications which contain the definition of six specific channel implementations are known as Standard University Interim (SUI) channels. The general structure for the SUI channel model is shown below in Fig. 2. This structure is for Multi Input Multi Output (MIMO) and includes other configurations like Single Input Single Output (SISO) and Single Input Multiple Output (SIMO) as subset. The SUI channel structure is the same for the primary and interfering signals.

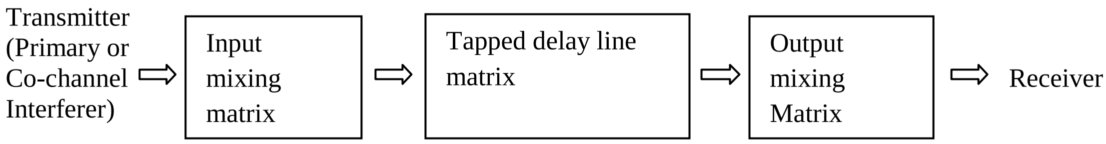


Figure 2: Generic structure of SUI channel model

In [7], there are channel models for SUI-1, SUI-2, SUI-3, SUI-4, SUI-5 and SUI-6. The channel model for SUI-1 is defined below.

Table 3: SUI-1 channel model definition

SUI – 1 Channel				
	Tap 1	**Tap 2**	**Tap 3**	**Units**
Delay	0	0.4	0.9	µs
Power (Omni ant.)	0	-15	-20	dB
K Factor (Omni ant.)	4	0	0	
Power (30^0 ant.)	0	-21	-32	dB
K Factor (30^0 ant.)	16	0	0	
Doppler	0.4	0.3	0.5	Hz
Antenna Correlation:	$P_{ENV} = 0.7$		Terrain type: C	
Gain Reduction Factor:	GRF = 0 dB			
Normalization Factor:	$F_{omni} = -0.1771dB$, $F_{30°} = -0.0371$ dB			

Using this definition of SUI-1, MATLAB codes have been generated to perform a simulation to analyze its performance. The set of SUI channel model specify statistical parameters of microscopic effects (tarred delay line, fading and antenna directivity). To complete the channel model, these statistics have to be combined with microscopic channel effects such as path loss and shadowing (also known as excess path loss) which are common to all six models in the set. Each set models also defines an antenna correlation [8]. The gain reduction factor (GRF) has also been included in the tables to indicate the connection with the K-factor.

POWER DISTRIBUTION

The total power P of each tap:

$$P = |m|^2 + \sigma^2 \tag{1}$$

Where m is the complex constant and σ^2 the variance of the complex Gaussian set. Now, the ratio of power is,

$$K = \frac{|m|^2}{\sigma^2} \tag{2}$$

From equation (2), we can find the power of the complex Gaussian and the power of the constant part as

$$\sigma^2 = P\frac{1}{K+1} \quad and \quad |m|^2 = P\frac{K}{K+1} \tag{3}$$

Here we can see that, for $K=0$, the variance becomes P and the constant part power diminishes, as expected. Note that we choose a phase angle of 0^0 for m in the implementation [9].

V. SIMULATION RESULT AND COMPARISON

The block diagram of the model configuration that has been used for the simulation using MATLAB is given below.

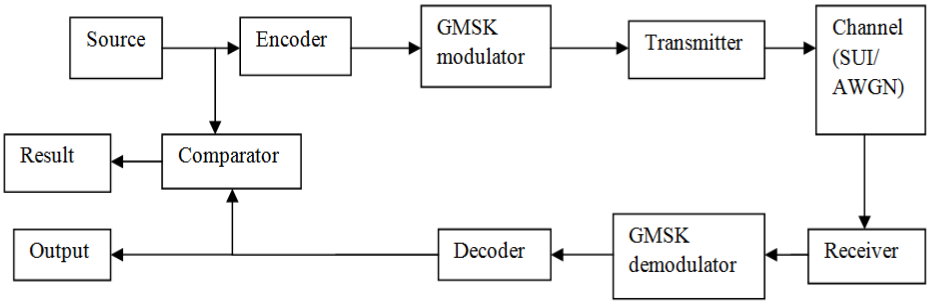
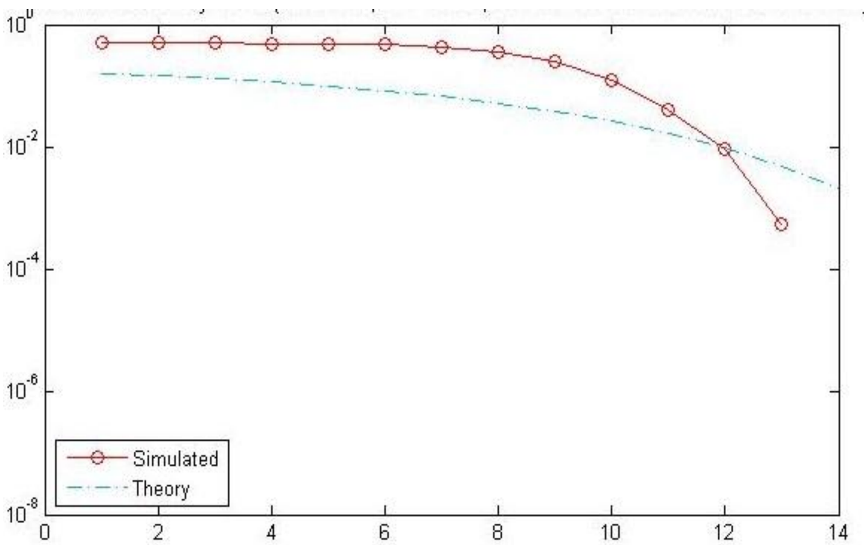
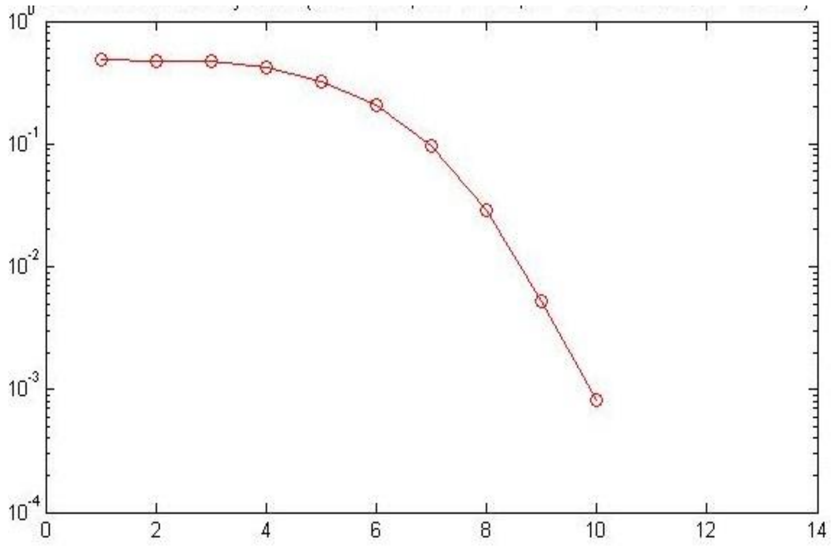


Figure 3: Block diagram of the model configuration for the simulation

For comparing the performance, the AWGN (Additive White Gaussian Noise) channel has been chosen. Here, Fig. 4 shows the BER (Bit Error Rate) Vs. SNR (Signal to Noise Ratio) graphs.



(a)



(b)

Figure 4: Comparison between the performances in GSM system of (a) AWGN channel model and (b) SUI-1 Channel model (simulation result).

Fig. 4 shows that, the BER of SUI-1 channel model is lower than AWGN channel model for the higher SNR. BER is a parameter which gives an excellent indication of the performance of a data link such as ratio or fiber optic system. Since SUI-1 channel model shows lower BER, so it's coding gain is higher. By manipulating the variables that can be controlled, it is possible to optimize a system to provide the performance levels that are expected. This is normally undertaken in the design stages of a data transmission system so that the performance parameters can be adjusted at the design concept stages.

VI. CONCLUSION

In this paper, it is deduced that the bit error rate of SUI-1 channel model in GSM system is lower than the AWGN channel model for higher SNR. This means the coding gain is also higher for SUI-1 channel model. Up to SUI-4, the performances are almost same. For the simulation, GMSK modulation has been used. Reducing the bandwidth and increasing the transmitter power, it is possible to get improved BER. If BER rises to high then the system performance will noticeably degrade. If it is within the limits then the system will operate satisfactorily. With SUI channel modeling, it is possible to get the better performance compared to other channels since it has come up with latest technologies and improved capacity.

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