A SURVEY ON COHERENT AND NON COHERENT RECEIVER FOR GMSK SIGNAL

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Abstract— GMSK is an effective modulation scheme, used in many wireless communication systems (like GSM system). Implementation of GMSK receiver is more complex than other linear receiver, since GMSK signal is non-linear in nature. GMSK receiver can be implemented in two ways, they are coherent and non-coherent. There are various synchronization algorithms used for designing coherent and non-coherent receiver for GMSK signal. This paper give a survey on different algorithm used to estimate the various parameters of coherent and non-coherent receiver for GMSK signal and also includes the comparison of coherent and non-coherent receiver and their performance are emphasized in terms of BER, time delay.

Keywords— Gaussian Minimum Shift Keying (GMSK), Coherent, Non-Coherent, Global System for Mobile Communication (GSM), Time Delay, Synchronization, BER (Bit Error Rate).

1. INTRODUCTION

Gaussian minimum-shift keying (GMSK) is a continuous-phase FSK (frequency shift keying) where pre-modulation Gaussian low pass filter is used to shape MSK (special form of FSK). By using this filter sudden transition in the frequency modulation pulses of an MSK signal is eradicated. Thus bring about a narrow spectrum with attenuated side lobes [1]. GMSK is an effective digital modulation scheme adopted by standards like GSM (Global System for Mobile communication), DECT (digital European cordless telecommunication) and CT-2 (cordless telephone- 2G) [2].

GMSK receiver can be implemented either coherently or non-coherently depending on the standards requirements. In coherent receiver the carrier phase $\phi = 2\Pi f c t o$ (where *to* is the time delay and fc is the carrier frequency) is estimated to compensate the channel phase shift. In this typical coherent detector, pilot tones are transmitted in the data spectrum at a convenient frequency, which is extracted at the receiver and the channel impairment is deduced from the receiver tone. The carrier reference signal is renovated at the receiver side by use of information from the channel.

Non coherent receiver does not need carrier phase information and use methods like square law (push detection or energy detection) to recover the transmitted data at receiver end. There are two types of non-limiter /discriminator and differential detection [3]. Limiter/discriminator has a hard limiter tailed by a band pass filter. The limiter is used to eliminate the amplitude noise of the received signal**.** The ensuing signal is a constant-envelope sinusoid and is demodulated by the discriminator. In differential detection, as a substitute of using absolute carrier phase, information is encoded using the carrier phase differences. At the receiver, it is then recovered by attaining the difference in phase of received signal at current time and at past time, usually at multiples of the symbol period. Because only the phase difference of the carrier is used in the transmission and detection, the requirement for carrier recovery is eliminated in non-coherent receiver and it is simpler to implement.

In digital transmission system, the transmission chain contains several oscillators for modulation and demodulation, up-and down convertor, clocking symbol and bit streams and sampling. The synchronization functions of the receiver have to be tied up to the received signal. There is no mechanism to correct frequency or phase in the received signal. The receiver has to 'dig out' the synchronization data from the received signal In differentially coherent or non-coherent systems, adequately accurate frequency adjustment is enough, Where as in coherent system, accurate phase recovery is also needed.

2. synchronization

In order to infer information correctly, a communication transmitter must be synchronized with the corresponding receiver [4]. This can be accomplished in both analog and digital domains. A digital receiver samples the signal at an apt instant within the symbol period, and the carrier phase is estimated. On the other hand, analog components such as voltage-controlled oscillators (VCOs) and phase-locked loops (PLLs) can permit a receiver to adjust its behavior based on the parameters of the incoming signals or the desired signals [5].

Synchronization has to be done at least in the following levels: 1. Carrier recovery 2. Symbol timing recovery 3. Frame synchronization [6].

2.1 Carrier Recovery— All wireless Communications receiver systems are usually independent of transmitting systems and have their own oscillators with frequency and phase offsets and instabilities. In addition Doppler shift may also contribute to frequency differences in mobile radio frequency communication systems. All these frequency and phase variations must be estimated using information in the received signal to reproduce or recover the carrier signal at the receiver and permit coherent demodulation. Carrier recovery can be accomplished with a simple band-pass filter at the carrier frequency or with a phase-locked loop, or both. Different methods must be functioning to recover the carrier for different modulation.

2.1.1 Non-data-aided— This method does not rely on any knowledge of the modulation symbols. They are used for simple carrier recovery schemes or as the initial method of coarse carrier frequency recovery (e.g. Maximum likelihood frequency error detectors.).

2.1.2 Multiply-filter-divide--In this method of non-data-aided carrier recovery a non-linear operation is applied to the modulated signal to create harmonics of the carrier frequency with the modulation detached. The carrier harmonic is then filtered by band pass filter and frequency divided to recover the carrier frequency. The example of open-loop carrier recovery is Multiply-filter-divide, which is favored in burst transactions since the acquisition time is typically shorter than for close-loop synchronizers.

2.1.3 Costas loop-- Carrier frequency and phase recovery as well as demodulation can be established using a Costas loop of the suitable order. A Costas loop which is similar to PLL that uses coherent quadrature signals to measure phase error which is used to discipline the loop's oscillator at the receiver.

2.1.4 Decision-Directed-- In this, the symbol decoder output is fed to a comparison circuit and the phase difference between the decoded symbol and the received signal is used to restraint the local oscillator.

2.2 Symbol Timing Recovery--In wireless communication systems, a coherent receiver should know the accurate symbol timing in order to correctly demodulate the transmitted symbols from the transmitter. Numerous well-known symbol timing recovery methods have been used for estimating the ideal sampling point of the symbol, including Gardner timing recovery, late-early timing recovery, Mueller-Muller timing recovery and Squaring timing recovery.

2.2.1 Gardner timing recovery-- The Gardner timing recovery algorithm requires two samples per symbol and knowledge of the previous symbol timing to estimate the timing error for current symbol. Timing error computation for either the I or Q rail is computed as follows:

$$e = \{x[nT] - x[(n-1)T]\}x[nT - T/2]$$

Where T is symbol duration. When the timing error is calculated, the Gardner timing adjustment algorithm is applied:

1. If $e = 0$, no timing adjustment is essential for the succeeding symbol
2. If $e < 0$, a timing advance is essential for the succeeding symbol
3. If $e > 0$, a timing delay is essential for the succeeding symbol

2.2.2 Late-early timing recovery-- Late-early symbol timing recovery is one of the simplest methods and is widely used in digital communications. This method takes three samples spaced by *Ts* (sampling duration), with the duration *T*. The early samples are sampled at $nT - Ts$ and late samples are sampled at $nT + Ts$. The difference between the late and early samples is the timing error. Based on the timing error, the next symbol timing sampling time is either advanced or delayed until the timing error is reduced. The timing error computation for the I or Q rail is calculated using the following equation:

$$e = \{x[nT + Ts] - x[nT - Ts]\}x[nT]$$

Once the timing error is computed, the late-early timing adjustment algorithm for the I or Q rail is performed:

1. If $e = 0$, no timing adjustment is essential for the succeeding symbol·
2. If $e > 0$, a timing advance is essential for the succeeding symbol
3. If $e < 0$, a timing delay is essential for the succeeding symbol.

2.2.3 Mueller-Muller timing recovery-- The Mueller-Muller timing recovery algorithm requires only one sample per symbol and knowledge of the previous symbol to estimate the timing error. Timing error calculated for either I or Q as follows:

$$e = \hat{x}[(n-1)T]x[nT] - \hat{x}[nT]x[(n-1)T]$$

Where $\hat{x}[\bullet]$ is the decision symbol of the sample $x[\bullet]$. When the timing error is computed, the Mueller-Muller algorithm is applied.

1. If $e = 0$, no timing adjustment is essential for the succeeding symbol.
2. If $e > 0$, a timing advance is essential for the succeeding symbol.
3. If $e < 0$, a timing delay is essential for the succeeding symbol.

2.2.4 Squaring timing recovery— the first step is squaring of the input signal and then the resultant spectral component at symbol rate is found by filtering operation.

2.3 Frame Synchronization -- In wireless communication, the frame synchronization is defined as the process in which , the incoming frame alignment signals i.e., a distinctive bit sequences or sync words are detected while the stream of framed data is being received. Thereby, passing the data bits within the frame to be extracted for decoding or retransmission.

3. RECEIVER STRUCTURE

3.1 Coherent receiver— In [11] this paper the symbol-by-symbol coherent detector for GMSK signal with BT = 0.3 on both AWGN and a multipath fading channel is designed and BER parameter is estimated. The designed receiver shows better performance than the existing receiver. The proposed receiver in this paper reduce the power consumption of GSM handsets using conditional equalization as more than 70% of the time the channel is considered to be weakly dispersive.

3.2 Non-Coherent receiver – In [12] this paper , an attractive Non-coherent receiver structure followed by a nonlinear equalizer, which contain s a RAM and a Viterbi detector, which is capable of equalizing nonlinear multipath fading channels. The cumulative bit error rate (BER) is estimated for a set of channels with different delay with same ms delay spread. In Rician fading model it shows better performance.

4. REVIEW OF ALGORITHM

4.1. Synchronization algorithm – In [7]-[10] this paper, the hybrid receiver architecture is designed using modified synchronization algorithm which contain both coherent and non-coherent and the parameter like symbol timing error and frequency offset for both coherent and non-coherent, and carrier offset in case of coherent receiver. In this the received signal is converted from radio frequency (RF) to baseband real and imaginary components of the received baseband signal are x and y. these signal are oversampled, and then digitally frequency discriminated, and passed into low-pass filter to obtain raw digital data. This data is passed into FFT for synchronization preamble bits detection. After detection, parameter like carrier frequency offset is estimated in hybrid manner and sampling time error is estimated in feed forward manner. Frequency offset is estimated and fed back to VCO during preamble period. The detection mode is selected by using the above estimation. Finally demodulated data is obtained after synchronization. Coherent receiver shows better performance than Non-coherent receiver. The following figure depicts the synchronization method.

Figure 1.block diagram of synchronization method.

4.2. Squaring algorithm — In [13] this paper, the new digital GMSK demodulator is designed using squaring algorithm in a feed forward manner on AWGN channel. In [10] paper, transmission preamble bits are required to estimate symbol timing error. Even though it gives good performance, the implementation becomes complex. Squaring algorithm is linear in nature, whereas GMSK is non-linear. Thus, the complex envelope of GMSK signal can be converted into two orthogonal signals. Symbol timing error is obtained by assuming GMSK signal as a combination of two orthogonal linear modulations. The performance is evaluated and it is shown that, the designed receiver is less complex than pervious method.

5. CONCLUSION

In this paper various algorithms for designing coherent and non-coherent receivers for GMSK signal is studied for wireless communication (with BT=0.3 (for GSM)). The techniques discussed in this paper are synchronization and squaring methods. The BER (Bit Error Rate) is analyzed for both the techniques and the result obtained shows that squaring is better than synchronization. Implementation of coherent receiver is a complex process but results in better BER whereas, implementation of non-coherent receiver is a comparatively a simpler process with low performance. Thus coherent receiver with squaring technique is recommended.

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