Design and Development of Frequency Hopping Spread Spectrum Transmitter

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Abstract - This proposed work is a Time Division Multiple Access - (TDMA)-based radio interface proposal for the Universal Mobile Telecommunication System (UMTS). The Frequency Hopping Spread Spectrum transmitter system is most widely used in the communication domain. The algorithm is based on recently developed estimation methods that use redundancy introduced by the cyclic prefix. A modified Maximum Likelihood (ML) estimator for the Additive White Gaussian Noise (AWGN) channel is used to meet both implementation requirements and performance requirements for frequency-selective fading multiuser environments, and this system is very popular because it is a secure communication model which utilizes the Pseudo Noise Sequence as a carries signal. Simulation results for a typical UMTS mobile channel environment shows that the uncoded symbol error rate of a coherently modulated system using our synchronization scheme is virtually indistinguishable from that of a system with no time and frequency offset. The overall design is modeled and simulated using MATLAB-Simulink and RTL designed and obtained result using Xilinx ISE 13.1.

Key words: FHSS (Frequency Hopping Spread Spectrum), TDMA (Time Division Multiple Access), PN Sequence, Frequency Synthesizer, Xilinx.

I. INTRODUCTION

To improve the performance of short-range wireless communications, channel quality must be improved by avoiding interference and multi-path fading. Frequency hopping spread spectrum (FHSS) is a transmission technique where the carrier hops from frequency to frequency. For frequency hopping, a mechanism must be designed so that the data can be transmitted in a clear channel and avoid congested channels. Adaptive frequency hopping is a system which is used to improve immunity toward frequency interference by avoiding using congested frequency channels in hopping sequence. Mathematical modeling is used to simulate and analyze the performance improvement by using frequency hopping spread spectrum with popular modulation schemes, and also the hopping channel situations are investigated.

Certain application needs system to transmit the original information without a loss of information and make it difficult to the unwanted users to receive the original information. This is called secure communication. Such communication is very important in military applications where techniques called spread spectrum modulation is used. Even the spread spectrum modulation is used for commercial application also. The interference in the transmission channel may be unintentional interference caused because the user may be transmitting through that same channel. Sometimes the interference is created intentionally by a hostile transmitter to ‘jam’ the transmission. Those problems can be solved using spread spectrum modulation.

Spread spectrum is one of the techniques which spread the narrow band signal over wide frequency band and at the receiver the original signal is received by de-spreading the signal.

A multiuser Time Division Multiple Access - Orthogonal Frequency Division Multiplexing (TDMA-OFDM) system, the evolution process of different radio interface proposal for the Universal Mobile Telecommunication System (UMTS) which is standardized to European Telecommunication Standard Institute (ETSI). To fulfill the requirement the system uses OFDM technique in the transmitter [1].

The FHSS transmitter is implemented for TDMA system; it uses the PN sequence for hopping from one carrier frequency to other carrier frequency. In this the optimal joint maximum likelihood estimator for time and frequency offset of the additive white Gaussian noise (AGSN) channel has been presented for broadcasting. It will be protected from fading effect in decoding at the receiver.
In narrow band signal estimation is not accurate as compare to the wide band OFDM system, in order to provide the more reliable communication the system utilizes the wide band signal, the frequency hopping spread spectrum transmitter will make the ISM band into number parts that is frequency slots, these slots separated by some MHz frequency.

A spread-spectrum transmission provides three main advantages:

- Avoids narrow band interference
- Difficult to intercept spread spectrum signals.
- Provides minimal interference when sharing the frequency band with other Conventional transmissions.

The two most common types of spread spectrum transmission are frequency hopping spread spectrum (FHSS) and direct sequence spread spectrum (DSSS). [2].

Applications the projects are it can be used for different wireless communication system for transmitter, depending upon the range of communication or application the different bandwidth and the carrier frequency are used. And widely used for military applications because it provides secure communication.

Definitions of FHSS

A system is defined to be a spread spectrum system if it fulfills the following requirements

The modulated signal occupies a more bandwidth than required minimum bandwidth necessary to send the data.

The spectrum spreading is accomplished by means of a wideband spread signal, often called a code signal, which is independent of data.

At the receiver, de-spreading is accomplished using the same code sequence operating in synchronism with the transmitter [2].

II. OVERVIEW LITERATURE OF SURVEY

This section discusses many journal papers and IEEE documents which provide much information about theory of the relevant design, existing designs and techniques and new ideas which are related to my project. Before building the system the above consideration are taken into account for developing the proposed system.

In this paper they have analyzed and simulated the bit error rate (BER) performance in FH/FSK system platform with noise and narrow-band jamming. The artificial noise jamming only in the large error rate conditions (when the error rate is above 0.1) are ineffective than noise jamming [3].

Collaborative broadcast scheme that utilizes cooperative communication technique and exploits frequency (channel), spatial and multuser diversities to resist jamming and enhance communication efficiency. Demerit of this system is, UFH-based source node provides uncertainty in its channel [4].

In FHSS synchronization of transmitter and receiver is necessary. In case, if the receiver is not synchronized with transmitter due to any reason, the recovery of the original information from its spread spectrum is merely impossible. To overcome this problem they propose a technique in which a code is combined and sent with the modulated signal before using the FHSS technique. Using this transmission code they can synchronize the receiver with transmitter at any instant of time. In this proposed work the system is design for analog communication, and this project is implemented using MATLAB simulink, this simulink is just a software design that consists of the no of building blocks connected as per the design. Limitations are it is older communication technology i.e, analog communication [5].

In this paper, the design, the performance and applications of jamming systems for frequency-hopped communication countermeasure based on Armored Vehicles are investigated with the background of link simulation system for communication countermeasure system in field operations and with the assistant software of MATLAB-Simulink toolbox. The disadvantage is, the signal propagation and processing time is limited, so the interference duration must satisfy chip time limit [6].

The designed system shows how to increase bandwidth efficiency and enhancement blocking probability in cellular system by using techniques of Dynamic Frequency Hopping where data transmission of the wireless regional area network system are performed in parallel with spectrum sensing without any interruption. The demerit is, DFH relaying on the measurement based approach require substantial amount of signaling overhead for communication from a base station to its mobiles. MATLAB programming language was used to implement the desired application [7].
III. SYSTEM DESIGN AND IMPLEMENTATION

A. Matlab Simulink Design

The input binary data applied to the encoder on transmitter side. The encoder encodes the input sequence according to some error control coding technique. The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter \( p \) produces zero with probability \( p \) and one with probability \( 1-p \). The Bernoulli distribution has mean value \( 1-p \) and variance \( p(1-p) \). The Probability of a zero parameter specifies \( p \), and can be any real number between zero and one, in this project design the probability is 0.5 as shown in fig (1). The Binary Cyclic Encoder block creates a systematic cyclic code with message length \( K \) and codeword length \( N \). The number \( N \) must have the form \( 2^M-1 \), where \( M \) is an integer greater than or equal to 3. This block accepts a column vector input signal containing \( K \) elements. The output signal is a column vector containing \( N \) elements. The cyclic encoder output bits are formed into packets and each packet is of 625 bits this is done in order to avoid the bit by bit modulation of information. The bandwidth which is used is -39 MHz to +39 MHz and the 79 possible carriers are utilized in this project. The modulation is done by multiplying the Modulated information and the modulated carriers signal totally the modulation scheme is FSK. And the frequency hop generator generates the carrier frequency as shown in fig (1) [8].

B. FPGA Implementation

In modulator the baseband signal is combined with the hop frequency or carrier frequency generated by the frequency hopping block. The carrier frequency generated by this will be random since it is controlled by PN- sequence generator. The modulated output will be sum of these two, which is spread over entire frequency band. The base band signal is generated by using binary generator block; this data is in the forms of ones and zeros. The output of the binary generator is encoded using cyclic encoder, then the encoded signal is sent to modulator for modulation. In this proposed work the modulator is used is GPSK, schematic diagram of FHSS transmitter as shown in the fig (2).

![Figure 1: Matlab-Simulink FHSS Transmitter Model.](image1)

![Figure 2: Schematic view of FHSS Transmitter](image2)

![Figure 3: RTL Schematic view of FHSS Transmitter](image3)

Fig (3) shows internal schematic of Transmitter. Which comprises of many individual blocks internally connected together such as cyclic encoder, binary generator, SIPO register, buffer and FSK modulator. Initially the input \( \text{Sin} \) is given to binary generator which generates single bit random output by using LFSR technique. This is given to SIPO register which takes serial binary data and gives parallel output. After 4 clock cycles 4 bit output is generated by the SIPO shift register, this 4 bit output is to perform convolution operation (Matrix multiplication) in cyclic encoder. This is to correct the error which is added during signal transmission through channel.

Some redundant bits are added and given to buffer all the data stored in 625 channels once the buffer is full it transmits the data bit by bit to FSK modulator. The modulator modulates the data and gives 12 bit data output. This is spread over channel.
IV. RESULTS

The fig (4) shows the output of FHSS transmitter. The output is as a noise but the data is available at large spike in the each fig (4), the overall the transmitter output looks like a noise. The output looks like noise; hence we can provide the secure communication through Frequency Hopping Spread Spectrum System. The output of FHSS is cannot be Hacked by the unauthorized person because the hopping frequency is known to designer mean an authorized person.

Fig (5) shows the result of Frequency hopping spread spectrum transmitter, the input data applied to the transmitter is obtained at the output of the transmitter as shown in the fig(5), the low power technique that is clock gating is applied to the coding part hence it takes less power.

V. CONCLUSION

The frequency hopping spread spectrum transmitter is designed in matlab simulink with by adding the good features because whatever the previous paper which are done those have the limitations over small range communication. In order achieve this by using different technology like TDMA architecture which can be designed using FHSS system, this project is designed on Matlab Simulink and the optimized RTL designed and result is obtained using Xilinx tool. The transmission of information along FHSS is planned and achieved.

REFERENCES


