DESIGN OF MB-OFDM TRANSMITTER BASEBAND USING FPGA ARCHITECTURE

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ABSTRACT

Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) is a suitable solution to implementation of high speed data transmission in ultra wideband spectrum by dividing the spectrum available into multiple bands. The baseband of transmitter is one of the most important parts in MB-OFDM system. The structure of MB-OFDM system transmitter is introduced in this and the design of transmitter baseband based on FPGA is described in detail. The design has been validated with Xilinx Virtex or Altera FPGA. The results show that all modules designed has achieved the expected purpose both in precision and resource, with simplicity and high efficiency and can meet the demand of MB-OFDM systems.

KEYWORDS

Frequency Division Multiplexing, Multiband Orthogonal Frequency Division Multiplexing, Field Programmable Gate Array, High data rate, Wireless Network.

INTRODUCTION

In recent years, UWB communication systems have received significant attention from both the industry and the academia. In February 2002, the Federal Communications Commission (FCC) allocated 7,500 MHz of spectrum (from 3.1 GHz to 10.6 GHz) for use by UWB devices[1][2]. This ruling has helped to create new standardization efforts, like IEEE 802.15.3a[3], that focus on developing high speed wireless communication systems for personal area network. A multi-band orthogonal frequency division multiplexing (MB-OFDM) ultra wideband (UWB) system is being considered for the physical layer of the new IEEE wireless personal area network (WPAN) standard, IEEE 802.153a[3].The standard aims at the high data transmission rates. Field programmable gate array (FPGA) technology is not only a key technology in digital system, but also plays an important role in application specific integrated circuit (ASIC) design field because of its design flexibility, and higher integration [5]. The technical line for the implementation of MB-OFDM transmitter baseband module with Xilinx series FPGA is introduced in this paper. It has been proved by the simulation results that the design of MB-OFDM transmitter baseband based on FPGA has good characterizes such as simple structure, easy implementation, high reliability and so on. The design of MB-OFDM transmitter baseband based on FPGA is discussed also provides performance results of the MB-OFDM system based on Xilinx Vertex or Altera.

FREQUENCY DIVISION MULTIPLEXING (FDM)

WiMAX air interface is based on OFDM/OFDMA physical layer (PHY). To understand how OFDM and OFDMA work, it is useful to start with it's "mother" namely FDM (Frequency Division Multiplexing). Spacing is put between two adjacent sub-carriers. In FDM system, signals from multiple transmitters are transmitted simultaneously (at the same time slot) over multiple frequencies. Each frequency range (sub-carrier) is modulated separately by different data stream and a spacing (guard band) is placed between sub-carriers to avoid signal overlap.

ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

Sub-carriers are closely spaced until overlap. Like FDM, OFDM also uses multiple sub-carriers but the sub-carriers are closely spaced to each other without causing interference, removing guard bands between adjacent sub-carriers. This is possible because the frequencies (sub-carriers) are orthogonal; meaning the peak of one sub-carrier coincides with the null of an adjacent sub-carrier. In an OFDM system, a very high rate data stream is divided into multiple parallel low rate data streams. Each smaller data stream is then mapped to individual data sub-carrier and modulated using some sorts of PSK (Phase Shift Keying) or QAM (Quadrature Amplitude Modulation) i.e. BPSK, QPSK, 16-QAM, 64-QAM. OFDM needs less bandwidth than FDM to carry the same amount of information which translates to higher spectral efficiency. Besides a high spectral efficiency, an OFDM system such as WiMAX is more resilient in NLOS environment. It can efficiently overcome interference and frequency-selective fading caused by multipath because equalizing is done on a subset of sub-carriers instead of a single broader carrier. The effect of ISI (Inter Symbol Interference) is suppressed by virtue of a longer symbol period of the parallel OFDM sub-carriers than a single carrier system and the use of a cyclic prefix (CP).

LIMITATION OF FDM OVER OFDM

Frequency division multiplexing (fdm) is a technology that transmits multiple signals simultaneously over a single transmission path, such as a cable or wireless system. Each signal travels within its own unique frequency range (carrier), which is modulated by the data. Orthogonal fdm's (ofdm) spread spectrum technique distributes the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the "orthogonality" in this technique which prevents the demodulators from seeing frequencies other than their own. The benefits of ofdm are high spectral efficiency, resiliency to RF interference, and lower multi-path distortion. One is Frequency Division Multiplexing where your bandwidth is divided in multiple subcarrier which are not overlapping with each other such as Orthogonal frequency division multiplexing is a technique which allow subcarrier to overlap and therefore, you can save bandwidth but you will be more subject to intercarrier interference. OFDM is used in LTE (which is 3.9G and LTE advanced which is 4G).

OFDM uses many carriers per a given spectrum that are very close to each other, however in an exact distance one from another so they remain orthogonal to each other. FDM uses only a single carrier per spectrum. 2G and 3G (3G uses FDM together with CDMA) use FDM.

NEED OF MB-OFDM

Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) is required to implementation of high speed data transmission in ultra wideband spectrum by dividing the spectrum available into multiple bands. The baseband of transmitter is one of the most important parts in MB-OFDM system

APPLICATION

Orthogonal Frequency Division Multiplexing (MB-OFDM) is a suitable solution to implementation of high speed data transmission in ultra wideband spectrum by dividing the spectrum available into multiple bands.

OVER VIEW OF FPGA

Field-programmable gate array (FPGA) technology continues to gain momentum, and the worldwide FPGA market is expected to grow from $1.9 billion in 2005 to $2.75 billion by 2010. Since its invention by Xilinx in 1984, FPGAs have gone from being simple glue logic chips to actually replacing custom application-specific integrated circuits (ASICs) & processors for signal processing and control applications.

BENEFITS OF FPGA

- **Performance**

Taking advantage of hardware parallelism, FPGAs exceed the computing power of digital signal processors (DSPs) by breaking the paradigm of sequential execution and accomplishing more per clock cycle. Controlling inputs and outputs (I/O) at the hardware level provides faster response times and specialized functionality to closely match application requirements.

- **Time to market**

FPGA technology offers flexibility and rapid prototyping capabilities in the face of increased time-to-market concerns. **Cost** – The nonrecurring engineering (NRE) expense of custom ASIC design far exceeds that of FPGA-based hardware solutions. . The very nature of programmable silicon means that there is no cost for fabrication or long lead times for assembly. As system requirements often change over time, the cost of making incremental change.

- **Reliability**

While software tools provide the programming environment, FPGA circuitry is truly a “hard” implementation of program execution. FPGAs, which do not use operating systems, minimize reliability concerns with true parallel execution and deterministic hardware dedicated to every task.

- **Long-term maintenance**

Digital communication protocols, for example, have specifications that can change over time, and ASIC-based interfaces may cause maintenance and forward compatibility challenges. Being reconfigurable, FPGA chips are able to keep up with future modifications that might be necessary. As a product or system matures, you can make functional enhancements without spending time redesigning hardware or modifying the board layout.

ANALYSIS OF PROBLEM

In previous technique, it doesn’t use a MB-OFDM technique. The system combines OFDM modulation technique with a multi banding approach, which divides the available spectrum into several sub-bands. For highly dispersive channels, an orthogonal frequency-division multiplexing (OFDM) transmitter is more efficient for sending multipath energy than an equivalent single-carrier system using the same total bandwidth. OFDM systems possess additional desirable properties, such as high efficiency, flexibility which is important because the regulatory rules for UWB devices have not been finalized throughout the entire world. This describes the design of a UWB system optimized for very high bit-rate, low-cost for wireless networks like personal computing (PC), consumer electronics (CE), and mobile applications.

PROPOSED WORK AND OBJECTIVE

Structure of MB-OFDM Transmitter Baseband is

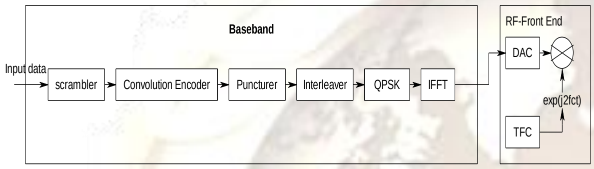

Figure1:Structure of MB-OFDM Transmitter Baseband

Basically we are implementing the digital baseband blocks of MB-OFDM and its major components as follows & it is implemented with the help of VHDL code [7].

1] Scrambler
2] Encoder
3] Puncture
4] Interleaver
5] Qpsk
6] IFFT

Following are basic elements of MB-OFDM that has taken one by one

Scrambler- In telecommunications, a scrambler is a device that transposes or inverts signals or otherwise encodes a message at the transmitter to make the message unintelligible.

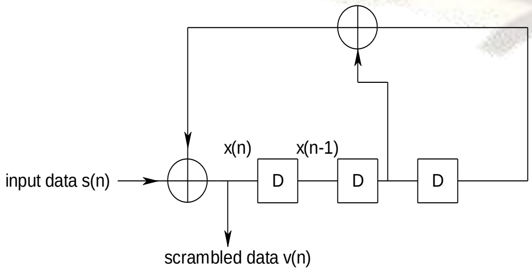

Figure.2.Scrambler

Encoder- In telecommunication, a convolutional code is a type of error-correcting code in which each *m*-bit information symbol (each *m*-bit string) to be encoded is transformed into an *n*-bit symbol, where *m*/*n* is the code *rate* ($n \geq m$) and the transformation is a function of the last *k* information symbols, where *k* is the constraint length of the code.

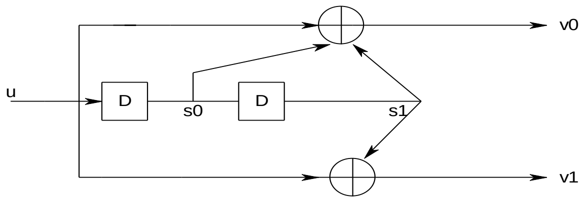

Figure.3. Feed Forward Convolution Encoder**.**

Puncture- Puncturing is the process of deleting some bits from the code word according to a puncturing matrix. The puncturing matrix (*P*) consists of zeros and ones where the zero represents an *omitted* bit and the one represents an *emitted* bit. It is usually used to increase the rate of a given code. Puncturing can be applied to both block and convolution (mat lab representation of matrix) .This matrix implies that the first bit is always transmitted while every other second bit is omitted. For turbo codes the same decoder.

Interleaver- An Interleaver is a device that rearranges the ordering of sequence of symbols in a deterministic manner

Qpsk -QPSK systems need only digital demux circuit.

IFFT- IFFT is a core of the baseband of MB-OFDM transmitter. The bit streams will be modulated on various frequencies carrier by IFFT. In many applications high-speed performance is required. For this purpose, conventional multi-carrier techniques are usually chosen, but this result in the lowering of spectrum efficiency. The speed enhancement is the key contribution of the main processing blocks in OFDM system. This proposed work will provide high speed data transmission in ultra wideband spectrum by dividing the spectrum available into multiple bands. Field programmable gate array (FPGA) technology is not only a key technology in digital system, but also plays an important role in application specific integrated circuit (ASIC) design field because of its design flexibility, and higher integration.

CONCLUSIONS

OFDM which provides us the higher transmission data rate in many application, so we can also presented this OFDM in multiband, which can perform parallel data transmission operation by using MB-OFDM i.e multiband orthogonal frequency division multiplexing with the help of FPGA. Orthogonal Frequency Division Multiplexing (MB-OFDM) is a suitable solution to implementation of high speed data transmission in ultra wideband spectrum by dividing the spectrum available into multiple bands. The baseband of transmitter is one of the most important parts in MB-OFDM system. The structure of MB-OFDM system transmitter is introduced in this paper and the design of transmitter baseband based on FPGA is described in detail. The design has been validated with Xilinx Vertex FPGA. The results show that all modules designed has achieved the expected purpose both in precision and resource, with simplicity and high efficiency and can meet the demand of MB-OFDM systems. This paper is implemented as system level design in HDL language we will prefer the know language that is VHDL. There are number of software for writing VHDL code like Altera, Xilinx, Active HDL etc. In FPGA implementation we have to do both things simulation and FPGA realization in that case /for that there is a need of FPGA kit either Xilinx or Altera. Finally after the compilation it will give an generalized information or result regarding total LE [logical elements] consumes which reflects the size [small/large] of the circuit.

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