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FPGA BASED MP3 DECODER

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ABSTRACT

The goal this project is to design an MPEG Layer III (MP3) player using a Xilinx Virtex 5 FPGA board. Hardware description language such as VHDL is used through drive external peripherals, including the stereo AC97 codec and LCD controller. The increasing density and capacity of these devices make it possible to implement an entire embedded system on a single chip. The system will read an MP3 from a compact flash memory, decode the MP3 bit stream to 16 bit pulse code modulated (PCM) outputs using a standard MP3 decoding algorithm, and play the output into an external speaker. The software and hardware designs are integrated on the Xilinx Embedded Development Kit platform. In this project, data compression techniques are used in MP3 encoding and decoding are explored and tested on hardware. Digital design using a Field Programmable Gate Array (FPGA) devices is a rapidly evolving field. The AC97codec converts the digital PCM outputs through an analog sound wave, and the LCD controller displays the title and author information of the selected song. C programming language is used towards run on a Micro blaze 32 bit processor.

KEYWORDS: Xilinx Virtex FPGA board, Stereo AC97 codec , LCD controller , compact flash memory , EDK kit.

INTRODUCTION

Field Programming Gate Array is rapidly evolving field in digital design today. The project goal are to (1) understand hardware and software code design using FPGA, (2) know the specifications set by the ISO/IEC 11172-3 standard for encoding and decoding MP3 files, and (3) build a FPGA-based MPEG Layer III (MP3) system.

HARDWARE REQUIREMENTS

A . Virtex 5 kit

Figure:

Virtex 5 is ready to use digital circuit development platform.
Xilinx Vertex5 FPGA, 1136-pin BGA package.256Mbyte DDR2 SODIMM with 64-bit wide data.10/100/1000 ethernet PHY and RS232 serial port. Mobile USB2 ports for programming and hosting. HDMI video up to1600x1200 and 24-bit color. Programmable clocks upto 400Mhz.AC97 codec with line-in, line-out, mic and headphone. GPIO includes eight LEDs, two buttons, two aixs navigation switch, eight slide switches, 16x2 character LCD. Real time power monitors on all power rails.

SYSTEM DESCRIPTION

MP3 bit stream that is preloaded onto a compact flash memory (CFM) is given as the inputs to the FPGA MP3 player system. Using pushbuttons, the user will be enabled scan through the MP3 file list, and then select, play, pause, and/or stop the song. In addition, volume control is triggered by a change in the on-board rotary encoder dial position. The outputs of the MP3 decoder is LCD screen that is used to display MP3 related information (i.e. song title and author) and the reconstructed MP3 audio in digital format, that is, 16-bit pulse code modulated (PCM) outputs and play the audio files through an external speaker. The PCM outputs need to be converted to analog format via the on-board stereo ac97 codec hardware chip before the audio can be heard with an external speaker.

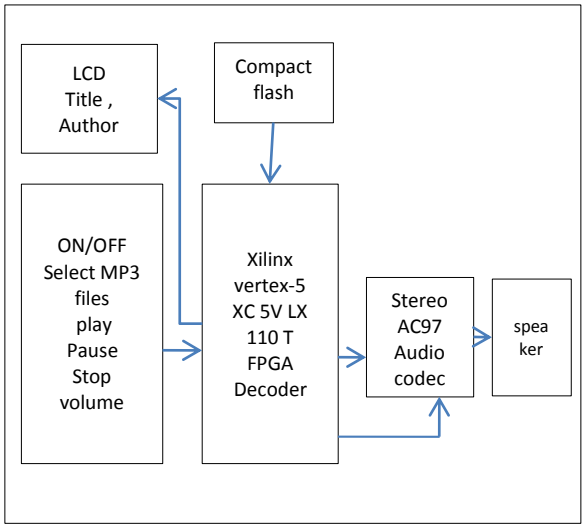


Fig: Block Diagram

The system includes:

MP3 Decoder

A MP3 decoder runs on the Xilinx Virtex-5 XC5V LX110T FPGA that will decode the selected MP3 stream with the sampling frequency specified in the MP3 header. Sampling frequency is 44.1 kHz. The software and hardware designs are integrated on the Xilinx EDK platform with C programming language used to run on the Xilinx software-based Micro blaze 32-bit processor.

External Peripherals

VHDL drives all external peripherals. Most applications use devices by means of high-level device-generic commands. Driver software receives these generic high-level commands and break them into a series of low-level device-specific commands. The peripherals used in the FPGA MP3 player system are the pushbuttons, LCD screen, rotary encoder, compact flash memory, stereo ac97 codec, and the external 512 MB DDRAM

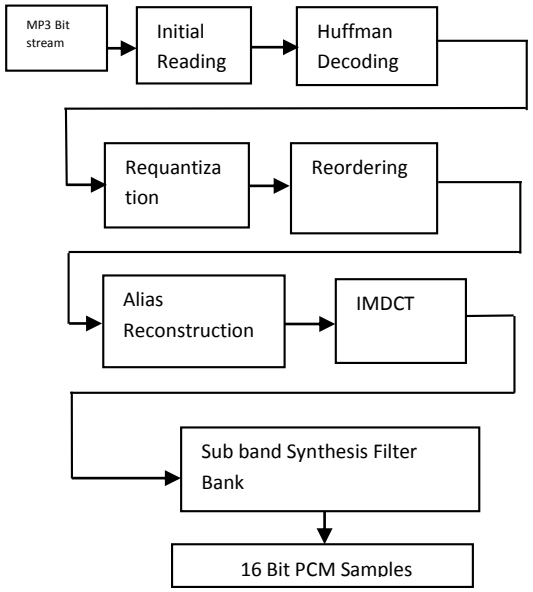
User Interface
The user interface provides the inputs to control the MP3 player, such as scanning, selecting, playing, pausing, and stopping the MP3 files. It will also allow outputting related information (i.e., title and author of the song) on the LCD. The LCD is capable of displaying 2 lines of 16 characters.

Compact Flash Memory Card
The 1 Gb capacity ML50X FAT 16 compact flash memory (CFM) card supplies the preloaded MP3 files for the MP3 decoder system in the FPGA. MP3 files are loaded onto to the CFM using a PC and memory card reader.

Onboard Stereo Audio AC97 Codec
The AC97 codec (AD1981B) is used to convert the PCM format signal from the MP3 decoder into an audio signal, which is fed into an external speaker through an audio jack.

FLOWCHART

I. Flow Chart



Initial Reading –

- MP3 bit stream as input.
- Incoming data stream is split into individual frames.
- Bit rate and sampling frequency is obtained by analyzing each frame.

Huffman Decoding –

- Used for lossless data compression.
- Technique to assign shorter binary codes to more frequent samples and vise versa.
- Transform incoming data into scale factor and symbols representing 576 frequency lines.
- Compares input sequence with information in Huffman table and produces symbol when match found.

Re-quantization –

- The Huffman decoder output is scaled up for different frequency spectrum ranges and sorted by increasing frequency ranges.

Reordering –

- In order to increase the efficiency of the Huffman coding the frequency lines for the short window case were reordered into sub bands first, then frequency and at last by window, since the samples close in frequency are more likely to have similar values.
- In the mp3 decoding process the reordering block will process and re-sort the samples by sub bands, then on windows and then on increasing frequency.

Alias reconstruction –

- In the mp3 encoding process, anti-aliasing filters have been added to the signal. Special designed butterfly filter is used to obtain a correct reconstruction of the signal in the mp3 decoding process, calculations are applied to each frequency spectrum range to reconstruct the aliasing artifacts.

IMDCT –

- A counterpart of the MDCT in the encoding stage of mp3 file.
- DCT is an energy compaction transformation for real number signals.

Sub-band Synthesis Filter Bank –

- Signals from different frequency spectrum ranges are combined using synthesis polyphase filter bank.
- The output of the synthesis polyphase filter bank is in PCM format.

BACKGROUND INFORMATION ON THE MP3 FORMAT

International Organization for Standardization (ISO) stated the need to reduce the size of audio files without any noticeable quality loss in the 1980ies Audio video compression technique was developed by a working group called Moving Picture Expert Group (MPEG). The audio part of the standard includes three modes with increasing complexity and performance. The third mode, called Layer III, manages to compress music by a factor of 12 with almost no audible degradation. This technique is known as MP3 and has become very popular and widely used in applications today. In the ISO standard document 11172-3 the specifications of MP3 encoding and decoding can be found.

NEED OF MP3

The need to reduce the size of audio files without any noticeable quality loss was stated in the 1980ies by the International Organization for Standardization (ISO). A working group within the ISO known as the Moving Pictures Experts Group (MPEG), developed a standard that contained several techniques for both audio and video compression. The audio part of the standard included three modes with increasing complexity and performance. The third mode, called Layer III, manages to compress music by a factor of 12 with almost no audible degradation. This technique is known as MP3 and has become very popular and widely used in applications today. The specifications of MP3 encoding and decoding can be found in the ISO standard document 11172-3.

PCM CD QUALITY	1.1	1.4Mbps
Layer 1	4.1	384kbps
Layer 2	8.1	192kbps
Layer 3	12.1	128kbps

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