TSTE12 Design of Digital Systems 2022

Project Specification

The project task consists of modifying/analyzing/generating a sound signal (in stereo) that is generated by a CD player. The input sound signal shall be converted into digital form and modified on the FPGA board. The result shall be played on loudspeakers attached to the FPGA board, and any graphical presentation can be made on the attached VGA screen and available LED, LCD, red and green LEDs and 7-segment displays. Everything can be controlled using the pushbuttons and switches on the board, using the attached PC, or from an attached keyboard.

All hardware on the board may be used, i.e., push buttons, displays, switches, memories (SRAM and FLASH) etc. The size of the design may be a limitation. Some designs will grow out of space in the FPGA if too many features are added or if the design is described in an unsuitable form. It is however a required that the design must fit in the available FPGA (Altera Cyclon IV 4CE115) found on the DE2-115 FPGA board.

All groups must implement a digital volume control and balance for the incoming sound signal. The resolution of these controls is for the group to decide (minimum is a volume control with 10 levels and 10 levels of left-right balance). The current setting of the controls must be indicated on the VGA screen.

A lot of additional features may be added to the design. A common non-mandatory requirement is the ability to simulate a large room such as a concert hall or church, also known as reverb. It should be possible to turn on and off this effect. A background image and/or animations could be added to the design. Different color schemes, zoom, resolution settings etc. may also be added.

Additional available hardware includes IR remote control and 2GB SD-card.

There are five main alternative tasks to select between (may of course also be combined):

1) Digital oscilloscopes

Use a VGA screen to describe the shape of the sound signals. Exactly what to display and how the display is controlled is for the group to decide. Possible features includes background images, zoom on the signal, freeze of the signal, various triggering, color coding the displayed information etc. Additional analysis operations such as fourier transforms or similar are possible to include.

2) Signal level indicator

Use a VGA screen to give two bar diagrams indicating the average amplitude of the signals in each channel. Some form of averaging algorithm must be used to avoid flicker. Additional possible features includes background images, peak indication, color coding of the information, division into different frequency bands etc.

3) Echo

Add an echo to the sound. Try to use as much as possible of the dynamic range of the signal. In order to reach long delays it is possibly better to use some other format than full precision binary when storing the signal in memory. Additional possible features includes controls on strength and length of the echo, possible presentation of control state using a VGA screen, etc.

4) Loudness control and suppression of the mono sound.

The stereo signal entering the board shall have the sound that is common to the both channels removed. This function should be selectable during execution. A second function is to add a loudness function which amplifies the lowest and highest frequencies. Additional possible features includes controls to allow adjustment of the arriving time of the sound between the channels (to compensate differences in the D/A conversion of the two channels), presentation of current operational mode on an VGA screen, etc.

5) Equalizer (division of the signal into frequency bands)

Create a mono signal of the stereo input and divide it into at least two frequency bands. Play one frequency band on one speaker and the other on the other speaker. Additional possible features includes individual

amplification of each band, more bands, graphic indication of current setting on a VGA screen, amplify different bands differently directly on the stereo signal, etc.

6) Sound storage/replay

Create a system that work like a tape recorder. Store long sequences of sound, compressing it in some suitable way, and allow the playback of the stored data. There is a limited number of 2G SD-card units available to allow storage of larger amount of data in a non-volatile form.

Project meetings shall be carried out according to the following requirements.

1st meeting: The purpose of the meeting is to have the group meet the supervisor for the first time, decide on who will be the project manager of the group, and to get a chance to ask questions about the possible projects. The first name in the project group member list is responsible for signing up a time on the meeting list outside the office of the supervisor. All the others are responsible for getting in contact with the first name in the project group member list.

2nd meeting: A requirement specification shall be handed in to the supervisor at least one day before the meeting, and will be discussed at the meeting. It should contain a description of the expected functionality of the design, and how the design should be controlled.

3rd meeting: Three documents should be presented and discussed at this meeting; a design specification, a project plan, and a time plan. The design specification is a detailed architectural description of the design, and should contain a description of the blocks to implement, how they should communicate with each other, and a specification of their functionality. The project plan and time plan should follow the main structure of the LIPS model. The time plan should describe expected milestones in the design process such as when the design is expected to be complete (VHDL coding of the behavior), how long time expected for debugging, when the hardware should be running as expected, and how long time to spend on the final documentation.

Besides these three meetings described above shall the group meet on its own at least once a week. The purpose of these meetings is to check the current status of the project, that is, how much time has all members spent on the project, what is the current status of the assigned tasks, what new tasks to assign, and a check of the time plan.

Every meeting must have a transcript written that is sent to the supervisor. There is a template transcript available that should be used. The copy of the transcript must be sent to the supervisor no later than 2 days after the meeting.

The final implementation should be presented, and a report handed in at the last meeting. An oral presentation by the complete group must be done. Notes defining the expected outline of the report will be given later.

Finally should individual afterstudy documen (reflection documents) be submitted individually by each project group memeber to the examiner. The document should be based on an afterstudy template containing a few questions that each student should give his/her comments on.

The supervisor will have a list outside his office on which the group may sign up for meetings. This signup should be done at least the day before the expected meeting. Otherwise the supervisor may be unavailable.

Each member of the group must keep track of the amount of time the member spends on the project and on what tasks. This information shall be used both for the weekly reports during the project as well as in the final report where the total cost of the design should be presented. The use of a personal diary is encouraged, where the group member notes how much time and what type project activity he/she has done each day.