Touchscreen Synthesizer

Project Scope Proposal

EECS 452
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1. Project Overview

1.1 Project Scope – overview of our project

The goal of this project is to create a proof of concept for a touchscreen synthesizer. The project will consist of implementing basic synthesizer functions, interfacing with a touchscreen, and outputting various graphical user interface pages to a display. At a bare minimum there should be a single graphical user interface page for the synthesizer controls and the synthesizer keyboard. Ideally however, there would be multiple pages to increase the amount of effects that can be included in the synthesizer, and a live visual effects screen page would also be included. More information about bare minimum, possible, and stretch goals is provided in the project description (see Section 2).

1.2 Project Background – Why our goal is worthwhile

A synthesizer is a sound producing electronic instrument that is used by music artists to generate a broad range of sounds and tones. Typically, a synthesizer also allows the artist to apply different effects, such as filtering and resonance. It is usually controlled by an analog interface consisting of buttons, switches, sliders, knobs, piano keys, and turntables. Furthermore, synthesizers are often used at music concerts, allowing disc jockeys (DJs) to create music and apply various effects in real time.

A touchscreen synthesizer performs all of the features of a typical synthesizer, but it does not utilize an analog interface for control. Instead, a touchscreen is used to control all of the features of the synthesizer. The touchscreen relieves the user from having to physically push buttons, flip switches, move sliders, or turn knobs. Additionally, because it utilizes a display, a touchscreen synthesizer allows for stunning visual effects to be synchronized with the music.

The primary audience of this project will be professional DJs and hobby enthusiasts.

1.3 DSP Concepts – How our project will use DSP concepts

The project will use digital signal processing concepts to read input data from the touchscreen, generate waveforms, generate and apply filters to waveforms, output audio signals, and output graphical user interface pages to a display screen. These tasks can be broken down into 3 fundamental groups:

1. Touchscreen Interface
2. Sound Generation
3. Graphical User Interface

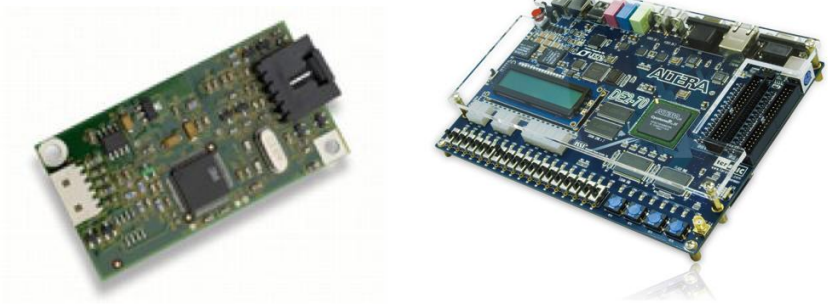
1.4 Project Hardware – The hardware required for developing our project

The project will make use of the following hardware:

1. Altera DE2-70 FPGA Board
2. Touchscreen
3. Touchscreen controller
4. VGA Monitor Display
5. Audio Speakers

The Altera DE2-70 FPGA Board and VGA Monitor Display are already available in the EECS 452 DSP Laboratory. The EECS 452 DSP Laboratory also has a touchscreen and accompanying controller.

However the touchscreen is not ideal for use with a synthesizer because it is only single-touch. A single-touch touchscreen cannot easily produce polyphonic tones because the user cannot press down multiple keys simultaneously.



1.5 COE Design Expo – How our project will be demoed at the COE Design Expo

At the College of Engineering Design Expo, our project setup will consist of a touchscreen controlled synthesizer that can be played by visitors. The project should at least meet the bare minimum requirements outlined in the project goals section.

1.6 Project Credibility – References that bolters our projects credibility

The Touchscreen Synthesizer project is based off of a similar project developed by students at the University of Cornell in the course ECE 4760. The students at Cornell created an intuitive waveform and rhythm generator that was controlled through a touchscreen interface. The Touchscreen Synthesizer project looks to expand upon Cornell students' project by increasing waveform generation and filter functionality and by adding a graphical user interface display. More information can be found about the Cornell project at:
http://people.ece.cornell.edu/land/courses/ece4760/FinalProjects/s2008/nic4_jps79/nic4_jps79/index.html

2. Description of project

2.1 Project Goals - details on our goals, the system concept, and the feasibility of our project

This section lists the goals planned for the project. The "Bare Minimum Goals" are the set of objectives that will be completed by the Design Expo. The "Possible Goals" list contains the goals that we would like to see implemented if there is sufficient time. The "Stretch Goals" category holds the list of aspirations for the project that will most likely not be reachable during this semester. The "Stretch Goals" are also possible goals for a later group to implement.

<u>Bare Minimum Goals</u>

- Monophonic synthesizer with one octave
- Single GUI display page for visual feedback from the touchscreen
- Basic waveforms (frequency adjustable): Sine, Square, Triangle, Saw-Up and Saw-Down
- Filters (frequency adjustable): High Pass, Low Pass
- HEX and LED visual effects

Possible Goals

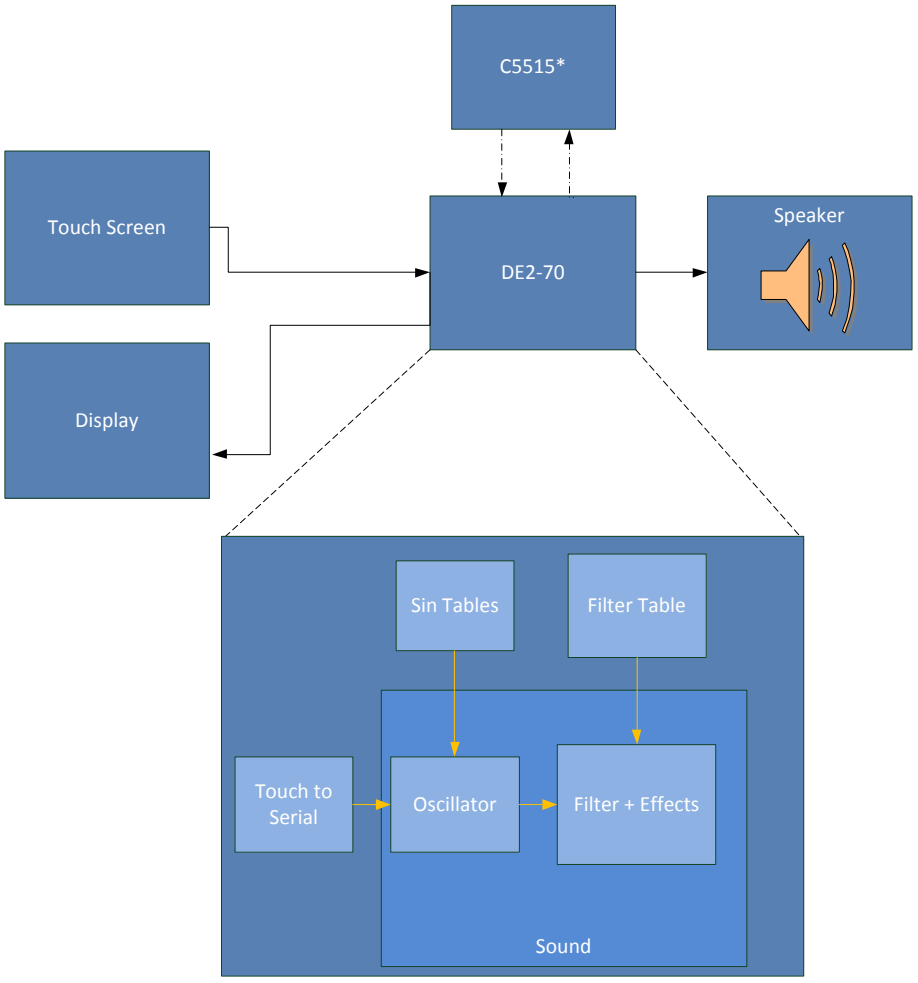
- Polyphonic, two note, or one note and one effect, with multiple octaves
- Filters (frequency adjustable): High-Pass, Low-Pass, Notch
- Audio Special Effects: Pitch-bending, Vibrato (waver pitch)
- Display page for graphical visual effects

Stretch Goals

- Envelopes: Attack, Decay, Sustain, Release
- Audio Special Effects: Delay, Echo, Reverberation
- Tabs at the top of the GUI display pages to increase the screen real estate

2.2 System Architecture – An overview of the layout of our project

The Altera DE2-70 FPGA board will be the core of the design. It will receive serial input from a touch screen controller, with the touchscreen overlaid on an output display for visual feedback when changing the synthesizer parameters. The FPGA will have cascading modules that generate the base oscillator, apply effects and filters. If necessary, the FPGA could direct data through the CC5515 for intensive processing that the FPGA could not handle. The sound will be output through either the on board DE2-70 audio codec or an audio codec of our design.



2.3 Contingency Plan – Predictions on what could go wrong and our associated contingency plans

There are several aspects of our project that are potential problem points. Finding an appropriate touchscreen is the first step in our project. Without a multi-touch touchscreen, polyphony will be less intuitive (requiring a chord hold button). But without the aforementioned touchscreen, we can still make do with the touchscreen currently in the laboratory.

It is possible that the DE2 may not have adequate resources to accommodate our synthesizer design. This could require us to route to and from the CC5515, or another controller, if not completely move the project off the FPGA and on to a microcontroller.

Section 2.1 describes a bare minimum synthesizer design: monophonic with one octave single GUI display page with a small number of waves and effects. If we can design a synthesizer that meets these minimum requirements, that synthesizer can be presented at the College of Engineering Design Expo. Our team can continue to work on the additional features with the reassurance that we will have a demo-able fall back project. As we become more confident in the additions to this design we will add them to our demo project until the design expo.

Preliminary parts list

1. FPGA Board: Altera DE2-70
2. Touchscreen: 3M MicroTouch EXII-7720SC
3. Touchscreen Serial Controller 5405210 spec
4. VGA Monitor Display
5. Audio Speakers

3. Milestones

3.1 Milestone 1 (achievable by Mar 15)

Touchscreen and graphical user interface display integration and producing basic sounds (connecting these aspects in not necessary at this point, but would be extremely desirable). In order to achieve this we will have to:

- Understand the touchscreen to serial interface
- Develop a module to translate this serial data to key and fx data
- Develop an output module to output to the display module
- Develop a wave and pitch generation module with an output module

3.2 Milestone 2 (achievable by April 3rd)

Touchscreen display and sound are integrated, notes are playable with some if not most effects implemented. This includes the filters, and any pitch shifting effects we add. In order to achieve the first milestone we will have to:

- Connect the display module and the sound module to the serial output module
- Develop a filter module to route the source oscillator to
- Develop an effects module to route the post filter output through

3.3 Milestone Concerns

Milestone 1:
Because all other modules depend on receiving touch data, developing an interface to the touchscreen could hold up our project. The touchscreen is one of the primary DSP components of our project and without it out project's title would be completely invalid.

Milestone 2:
The concern of milestone 2 would be that the DE2-70 is not capable of housing the code we design. This could require us to design a new project architecture, possibly using the C5515.

4. Team Dynamics

4.1 Team Member Contributions – a description of how each member of the team will contribute to the project

Division of labor is as follows:

Arun Dutta: will focus on the touch interface.
Frank Laritz: will focus on generating the graphics display.
Maxim Markov: will focus on sound generation. He will be in charge of filter generation.
Muneet Parhar: will focus on sound generation. She will be in charge of wave form generation.
Theodore Tremper: will focus on the touch interface.

The touchscreen interface will be developed by Arun and Theodore. Both have had a wide range of experiences adapting to new programing languages and hardware. In addition, they have also both voiced great interest in working on this part of the project. Sound generation shall be handled by Maxim and Muneet. Both have a good set of skills in digital signal processing and mathematics. Frank shall be working on the graphics display. Frank is the most experienced with this sort of work because of his experience in graphic displays from past projects.

4.2 Team Organizational Plan – Meeting times and locations

In order to track the progress of our project, as well as to ensure that all milestones and goals are achieved by their respective deadlines, our group will hold weekly mandatory meetings on Sundays. Our group also plans to dedicate a great portion of our time to working in the lab throughout each week. All five team members should be able to be present in the lab during our dedicated lab section on Tuesdays. In addition to this lab time, each of us will be responsible for dedicating ten or more hours each week to work on our parts of the project individually, if deemed necessary. Around deadlines, each team member will be expected to contribute more time in order to accomplish our goals successfully.

The means of communication that our group will take advantage of besides basic forms of communication (i.e. email, phone, and Skype) will include google documents and a CTools site. A CTools site has already been set up and will be used primarily to upload important project documents, and

to send out important announcements about upcoming milestones and/or deadlines. For the most part, our team will try to coordinate meeting up and working together. However, under certain circumstances when our group will not be able to meet in person, we will take advantage of google documents.

5. References and Citations

1. EXII Series Page:
http://solutions.3m.com/wps/portal/3M/en_US/TouchSystems/TouchScreen/Solutions/TouchScreenControllers/EXII-Controller/

2. EXII Reference Guide:
http://multimedia.3m.com/mws/mediawebserver?mwsId=66666UuZjcFSLXTtMxfclxT2EVuQEcuZgVs6EVs6E666666--&fn=EXII_Serial-Cntrls_RefGuide.pdf

3. EXII Picture:
http://solutions.3m.com/3MContentRetrievalAPI/BlobServlet?lmd=1225401647000&locale=en_US&assetType=MMM_Image&assetId=1180606328047&blobAttribute=ImageFile

4. DE2-70 Picture:
http://www.altera.com//univ/images/boards/de2_70.jpg

5. Cornell Project:
http://people.ece.cornell.edu/land/courses/ece4760/FinalProjects/s2008/nic4_jps79/nic4_jps79/index.html

6. Apple Ipad Touch Screen
http://www.directfix.com/mm5/merchant.mvc?Screen=PROD&Store_Code=GHT&Product_Code=IP-2387&Category_Code=DIG#.TzLCXsiHowQ