Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Fall 2009
Advisors	Prof. Meyer and Dr. Johnson
Team Number	2
Project Title	The “Drink Mixer”

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
David Estes	EE	Software/Audio	December 2009
Levi Cowsert	EE	Hardware/Packaging	December 2009
Adam Johnson	EE	Software Development	December 2009
Susanne Schmidt	EE	Hardware Development	May 2010

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The “Drink Mixer” is a digital audio mixer with individual input equalizer control as well as master output control. It is intended to fulfill the audio mixing needs of an aspiring DJ or band. The goal of this project is to create a great sounding board with low noise and effects processing capability. The prototype will have eight (mono) input channels, right and left main mix output, and two auxiliary mix outputs. Each channel will have its own set of equalization, gain, and pan controls, as well as independent fader control for the main and auxiliary mixes. It will also be capable of adding effects as well as saving and loading scene settings.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

In this project David contributed by providing a top down view of the project and past experience in audio processing. Courses like ECE 440 and ECE 438 provided experience with digital signal processing, while his own curiosity gave him the tools to experiment with embedded Linux well before the start of the design project. Levi contributed to hardware design and product packaging, as well as hardware debugging. His previous work in AutoCAD and CATIA V5 helped him greatly when designing the “Drink Mixer’s” packaging. Adam’s work in Purdue University’s *Vertically Integrated Projects* program gave him experience with PCB design and embedded programming which assisted him as he was helping to design the project’s user interface and develop the related firmware.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Because of the project's complexity, learning and practicing a top-down implementation strategy became very important to the "Drink Mixer's" design. Flowcharts and block diagrams helped tremendously in breaking the project into manageable parts, which could be prototyped and tested independently. Component selection is also a new skill for many of the design team members; navigating component selection tables on Digikey and Mouser will no longer be a challenge in future professional work.

Knowledge of PCB design was deepened this semester for all of the team members. Learning how to overcome pervasive software glitches in PADS layout and schematic software was key to circuit board design. Hardware debugging, soldering, and fly wiring were new skills for some team members, and learning to program a digital signal processor deepened team members' knowledge of audio mixer operation and technical requirements. Finally, learning about embedded Linux and inter-microcontroller communication protocols deepened our technical background.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

This project, while performing a useful function, also stemmed from a desire to learn. The team chose a project that would be challenging. Performing mixing operations on audio required specific objectives to be set for the two main tasks the prototype would need to perform: interacting with the user and audio processing. From these objectives, project specific success criteria were created. When evaluating these criteria, it was decided that multiple processors should be used with communication between each other. This led to an analysis of what specific processes would need to happen simultaneously in the mixer. These included user interface controls for each channel, a display showing all relevant settings, and the audio mixing processes. It was decided that each channel would require its own processor, the audio mixing would require a digital signal processor, and another processor running embedded Linux would be used to oversee all of the other processors and run the display. Once this synthesis of ideas and solutions occurred, construction of the device began. Testing occurred throughout the construction process to verify that separate components and sections worked individually before adding them together as a whole.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: It was desirable to keep the cost for the "Drink Mixer" as low as possible. Several of the microcontrollers were chosen because they were readily available and did not need to be purchased.

Environmental: The first prototype of this device contains leaded solder and mercury in the touch screen. This can be hazardous to the environment if not disposed of properly, but disposal instructions are contained in the user manual. The casing is made of aluminum, so it can easily be recycled. As long as the user disposes of the device properly, there are no environmental concerns.

Ethical: The Drink Mixer was made as safe as possible, using components that were known to be safe and reliable. During testing there was one component found to be significantly more unreliable than most, that component being the h-bridge. This component will be replaced and its interface redesigned in future prototypes and production models to ensure safety and ethical integrity.

Health & Safety: Each of the different microprocessors contained within the product were critically analyzed, and their mean time to failure was calculated. It was also determined that the weakest link in the processors is the ADSP-21262 SHARC Processor, with the highest failure rate. The schematic has been broken up into several different functional blocks, and each of these blocks analyzed for critical failures. Each of these critical failures was then looked at and a probable cause determined, along with its severity and consequences. It has also been determined that there are incredibly few possibilities of an error or malfunction that could cause harm to the user or bystanders. As a result of this, almost any error that would occur is simply a nuisance or functionality error.

Social: As this device will be used in a social setting, the packaging was created to be attractive and as compact as possible.

Political: The “Drink Mixer” is free of patent infringement both literally and under the doctrine of equivalents. The concept of mixing audio is rather old and can no longer be patented. Several patents were looked into including patents on the ornamental design, also known as packaging and control layout, as well as audio mixing systems. There is no threat for infringement due to our control layout. Also, patents that describe audio mixing systems reference prior art for the same functions that the “Drink Mixer” is capable of.

Sustainability: The packaging of the device was created with a long life in mind. It should be able to endure a fair amount of physical abuse. Upgradeability was also taken into consideration in the design stages. The USB drives used for programming are also there in hopes of future wireless or Ethernet capabilities.

Manufacturability: Careful consideration was taken to ensure that all of the PCBs were of a size that would fit appropriately in the packaging, alongside other components that weren’t on the PCBs. Many harnesses were necessary to connect the PCBs and other components to each other as well as to the terminal blocks, which provided power.

(f) Description of the multidisciplinary nature of the project.

Creating a digital audio mixer required many skills not covered in the realm of Electrical Engineering. The hardware and software for the project were within the scope of Electrical Engineering, but the packaging required branching out more towards Mechanical Engineering. Outside of engineering, challenges faced included technical writing for the reports that were due once a week, as well as financial responsibility when choosing the most cost effective parts.

(g) Description of project deliverables and their final status.

The “Drink Mixer” is safely packaged and all of the hardware has been completed, but the final programming is incomplete. The analog to digital converters are currently not communicating properly with the DSP, and as such the audio portion is not currently functional. Even though audio is non-functional, three of the five project specific success criteria were accomplished. The two that were not accomplished were: 1. An ability to digitally mix audio and adjust individual levels; and 2. An ability to display amplitude of output signal. It is not possible to display the amplitude of an output signal without first having the signal pass through the system.

The “Drink Mixer” is currently capable of the following: 1. An ability to adjust individual equalizer settings for the input channel; 2. An ability to display channel settings on an LCD display; and 3. An ability to save and load scene settings. There are RPG’s on each channel to adjust the gain of the input as well as change settings on the LCD display. There are buttons to turn channels on or off, lighting up green or red respectively. The LCD display is used to save and load settings, as well as give detailed information about gain and equalizer settings for each channel. Along with loading the saved scene settings information onto the LCD display, buttons will light up appropriately and the motorized faders will move to the saved locations.