Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2014
Advisors	Prof. Meyer, Prof. Thottethodi, George Hadley, and Dr. Johnson
Team Number	01
Project Title	BeatSquare

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Kevin Meyer	CompE	Software, Leadership	May 2014
Ben Pluckebaum	CompE	Software, Prototyping	May 2014
Jonah Ea	CompE	Software, Testing	May 2014
Brennan Tran	EE	Hardware, Assembly	May 2014

Project Description: Provide a brief (2-3 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 BeatSquare is a project based upon a popular flash game that that outputs musical sound based on the configuration of a square button grid. The columns in the grid will represent eight beats in time, while the rows represent individual notes and which are ranked in order by pitch. As the application runs, it loops through each beat in the configuration and outputs up to eight tones per beat, as determined by the configuration. Pressing a button in the grid turns a note on or off at that beat in the configuration, and the button lights up to indicate that a note is active.

This application has no direct counterpart in hardware, and it is a decent tool for generating simple melodies by users of all ages. The goal of the project was to emulate this application, as well as provide several additional functions. This project allows users to adjust the BPM and volume of the played tones, in addition to saving and loading their configurations to and from internal memory, or saving to a .midi file on an SD card.

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

This project required knowledge and experience from several ECE courses, primarily ECE 270, which emphasizes basic digital design, and ECE 362, which teaches skills concerning microcontroller systems and small design projects. Knowledge from software courses such as ECE 264 and 368 was also useful in programming the microcontroller system. Skills learned in ECE 201, 202, and 255 were utilized in determining basic circuit design. Finally, a rudimentary knowledge of operating systems was useful for interfacing with a basic external file system.

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

Several new skills and were acquired during the execution of this project. During the design phase, team members learned how to designed a PCB, which required a knowledge of circuit design as well as working experience with Eagle. Software programming skills were built upon during the development phase, as embedded C applications are slightly different from desktop applications, in both the availability of library functions and in the processing

power required to run the code. During the assembly phase, several team members learned basic soldering techniques and ways to cut and mold plastic for use in packaging.

(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.

Objectives and criteria were done by deciding upon a problem that needed to be solved, and outlining preliminary methods for obtaining these objectives in hardware and software. Once the problem was established, individual components were selected and analyzed for usefulness in solving the problem, and software was prototyped. These were eventually put together into larger systems to simulate full modules of the project. After the custom PCB was designed and fabricated, the prototypes and designs were put into action on the board, and thoroughly tested during implementation and upon completion. The final product was evaluated based on how well it met the problem and the proposed criteria.

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

Economic: The prototype for this project was fairly expensive to design and assemble, but the final product being produced in a manufacturing setting would be relatively inexpensive to produce. It could be made cheaper by introducing a less expensive packaging material, introducing a more efficient system of wiring the components together, and redesigning the PCB to be more space efficient.

Environmental: This project is composed primarily of electronics and plastic, and as such could harm the environment if not properly disposed of. In terms of power consumption, this product draws a maximum of six watts when running, and thus is fairly energy efficient. Very little waste is produced by the product unless the components themselves are not properly recycled upon disposal.

Ethical: The project itself does not have any ethical issues, but there is a patent on a device very similar in design to this one owned by Yamaha, so sale of this product would require obtaining rights from Yamaha before putting it out on the market.

Health & Safety: This device does feature a few small button caps on the surface that could be detached from the main device, and could be hazardous for small children. Disassembling the product could also lead to a risk of electric shock. Finally, this product features flashing LED lights, which could induce seizures at the right frequencies, and should be avoided by individuals with a known sensitivity to such features.

Social: While the operation of this device is not intended for multiple users, it can be displayed as an interesting toy and shown to others, and lent to others for temporary amusement purposes.

Political: As mentioned above, attempting to sell the product without permission from Yamaha could lead to a losing legal battle over the claims outlined in US patent 8008565-B2. It would be better to either legally obtain the rights to sell the device, or open source the design as a hobby project.

Sustainability: Reliability analysis done on the design indicates that the mean time to failure for the entire design is over 9000 years. This indicates that, while failures are certainly possible, the lifespan of the project is by no means short. The product's packaging

is also comprised almost entirely of plastic, which will not disintegrate or rot if left sitting on a shelf for a long period of time. The electronics, however, could gather dust and would be more likely to fail.

Manufacturability: It would not be difficult to automate the production of this project. The components on the PCB are almost all available in tape reels and freely available, and the PCB is relatively simple to fabricate. The packaging material is a common acrylic, though the faceplate on the top side may take some time to cut with a laser cutter not programmed to follow a specific path. If the laser is programmed as such, cutting would take a fraction of this time.

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

Both electrical and computer engineering skills were required in the bulk of the project's design, particularly in PCB design, component interaction, and software design. Additionally, some mechanical engineering knowledge was helpful in the design and assembly of the packaging and physical component placement within the packaging. Some aesthetic design sense was required in the design of the exterior and selection of user-interface parts. Finally, some knowledge of audio and its relation to electrical engineering was needed to implement the audio portion of the design. In short, a combination of electrical, mechanical, and computer skills combined with a small variety of artistic skills was required to implement this project.

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

The project was expected to implement a grid interface that could produce music by manipulating a grid of LED-backlit buttons, as well as save and load configurations to internal memory. All of the design was fabricated, from electrical components to final packaging. The software for handling the LED button matrix, flash memory access, and SD card access works relatively well. However, the audio portion of the design was not actually achieved due to difficulties in implementation with the proposed hardware. Thus, the project as it is designed is not capable of producing sound. This may be possible with editions to the microcontroller's software, and could be improved with a better selection of hardware.