Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Fall 2007
Advisors	Profs. Meyer and Johnson
Team Number	2
Project Title	Hooked on Harmonix

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Bryan Hermsen	EE	Hardware	May 2008
Curtis Verner	EE	C programming	May 2008
Tom Bottonari	CompE	VHDL	May 2008
Vikram Anand	EE	Hardware	May 2008

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 Hooked on Harmonix game system is an entertaining learning tool to help aspiring musicians learn to play the electronic keyboard. The game play of the project reflects the success of the popular Guitar Hero video game by Harmonix Music Systems and RedOctane. The Hooked on Harmonix system connects with an external MIDI keyboard and VGA monitor to provide user input and visual output for the game. The game system comes with 5 preloaded MIDI files, which can be selected by the user from the song selection screen. When a song is selected, the MIDI file is parsed in software to create a note array with all necessary note information. Based upon the MIDI song, bars corresponding to each note of the song descend at the proper time from the top of the VGA monitor. When these bars reach the keyboard icon at the bottom of the screen, the user must play the appropriate key. The input from the MIDI keyboard is decoded in hardware, and the user input is compared to the expected note.

In order to accomplish this complex game play, an FPGA with a soft processor is used to perform all of the necessary computations and programming logic. The soft processor is coded in C to perform the MIDI parsing functions and to control the audio output and bar display timing. The FPGA hardware is configured with VHDL to control the VGA video output as well as the game menus and scoring.

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

Many ECE skills were utilized in the design and construction of the Hooked on Harmonix game system. The skills and knowledge that were most often used in this project were C programming, VHDL programming, microprocessor interfacing, and digital circuits. C programming skills were instrumental in developing the software functionality required to parse MIDI file information and to control the game play. VHDL programming and hardware logic design was extremely important in developing hardware that would control VGA output, sprite displays, game menus, and input from a MIDI keyboard. Microprocessor interfacing and digital logic knowledge laid the foundation for the complex logic involved in designing the Hooked on Harmonix game play.

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

Many new technical knowledge and skills were obtained in overcoming the many challenges that came with developing a complicated system on a very versatile FPGA. PCB design skills were acquired through the process of designing a four layer PCB board with a 240 pin FPGA and many unique and complex integrated circuits such as the Rohm MIDI LSI. C and VHDL programming skills were further developed in the development of the project's software, and problem solving skills and strategies were improved as many difficult problems surfaced throughout the course of the project.

(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.

The first step taken in the design of the Hooked on Harmonix game system was to define the objectives and criteria of the project. Basic objectives were developed and then further refined into five project specific success criteria. With the objectives established, the challenges of each objective were analyzed to develop an approach that would best fit the unique problems to be solved. An overall block diagram was created to provide a big picture view of what needed to be implemented in the final design of the project. This block diagram was then divided into functional blocks, which each team member could analyze in greater detail and synthesize a solution.

When all of the individual blocks had been synthesized, they were combined and interfaced in the design of the final schematic. This schematic was then used to drive the PCB layout for the system circuitry. The PCB was then populated one functional block at a time to ensure functionality. As the PCB was constructed, testing was performed throughout the process. This prevented an accumulation of errors which could have significantly complicated the testing process. Testing was also performed on a development board in order to develop the software and hardware for the FPGA core of the Hooked on Harmonix system. After the PCB had been populated, this testing was transferred to the prototype PCB for a more accurate test. The evaluation of the project showed that all 5 of the main objectives for the Hooked on Harmonix project were achieved.

(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: This project was designed to be as cheap as possible in order to fit into the consumer electronic product category and to fit the limited budget of the team members. These considerations ruled out the possibility of incorporating a large LCD screen into the project packaging, in favor of using an existing video display device.

Environmental: This device provides virtually no harm to the environment in its natural life cycle. Therefore, all environmental considerations had to be taken into account in the manufacturing stages. All ROHS compliant parts were used, in order to minimize the amounts of lead and other harmful substances commonly found in electrical components. Also, should this product be taken to market, instructions for possible disposal/recycling would be included in the user's manual.

Ethical: Hooked on Harmonix poses a few ethical concerns that would need to be taken into consideration, should the device be taken to market. For example, permission would need to be obtained from the artists of the songs chosen to be stored on the device. Furthermore, since this product interfaces with other products (i.e. keyboard, monitor, speakers), these input/output lines will need to be better protected against to ensure their safety, should something short in our device and deliver too much current/voltage to them.

Social: The Hooked on Harmonix game system provides a positive social impact due to the importance of musical education in children and young adults. This project provides people with an entertaining method of learning an important skill that can develop into

Manufacturability: The parts used in the design and construction of this system were carefully chosen for the ease of manufacturability. Multiple FPGA options existed with various styles of packaging, but a plastic quad flat pack package was chosen over ball grid area options due to manufacturability considerations.

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

Designing and constructing the Hooked on Harmonix system required skills from various engineering/technology disciplines. The programming of the FPGA and Nios II processor clearly require knowledge of computer programming. The layout of the PCB, placement of resistors and capacitors, and power supply design along with regulatory components (such as bypass capacitors and resistors) all fall under the domain of electrical engineering. The actual soldering of the components onto the PCB is a skill commonly used in electrical engineering technology (EET). Finally, the drilling and fitting of the external device casing required some degree of mechanical engineering skills.

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

The final Hooked on Harmonix system consists of the PCB enclosed in a black casing. The exterior of this casing contains buttons for powering and resetting the system, as well as ports for interfacing various external devices to the system. The Hooked on Harmonix system satisfies all of the intended project success criteria (PSSCs), including having the ability to decode MIDI songs, to generate graphical output based on the MIDI song data, and to provide a performance score based on the user input. However, the code programmed onto the FPGA/Nios II is still somewhat unstable in that it does not always function correctly. For example, certain keys may remain red in color when they should have reverted to normal, or there may be timing delays between the bar display and the audio output. As a result, the code would surely be made more robust for future iterations.