Playing Tones Using Lasers

ECE230 – Introduction to Embedded Systems – Final Project

Winter 2015-2016

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February 22, 2016

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Introduction

For our project, our aim was to use lasers in some way. After brainstorming ideas, we decided to make a laser-based instrument. Five lasers shine onto five different phototransistors and act like strings, so that disrupting a beam causes a tone to be played from a speaker. There are five different speakers and five different lasers. Each of the five combinations of a laser, phototransistor, and speaker act independently, so multiple notes can be played at the same time.

User Guide

This project works just like a real harp, but with lasers instead of tangible strings.

When using a normal harp, if a chord is strummed, the tone will play for a short time according to what string is plucked. For this project, 5 laser beams are visible, representing 5 strings. If one of the laser beams is disrupted, a tone is played on a speaker for half a second. Similar to a real stringed instrument, if the beam is continuously blocked, it will not keep generating notes. The laser must be unobstructed, then plucked again for the note to play. Each of the five lasers correspond to their own speaker which only plays their respective sound, so every string can be strummed at the same time without affecting one another. The possible notes in descending order are E, concert A, D, G, and C, making the project a viola/violin. There is a potentiometer on top of the box that controls the volume of the instrument.

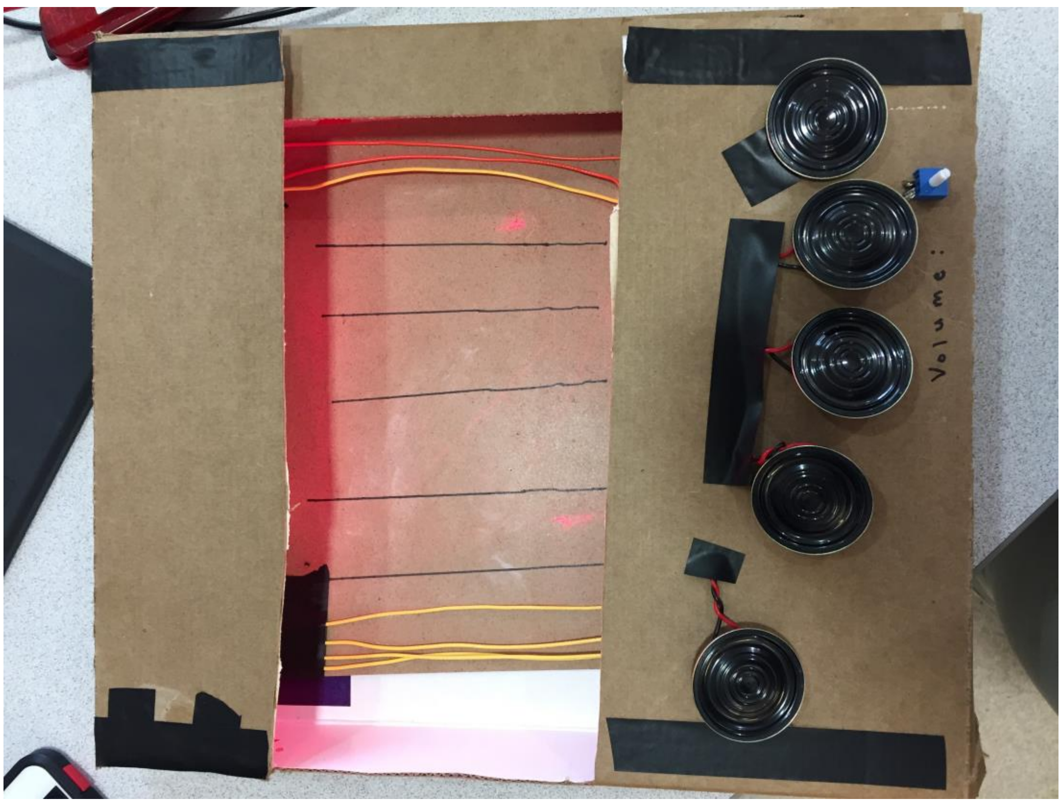

Figure 1. Top view of our project.

Figure 2. Top view of Speaker/Potentiometer design

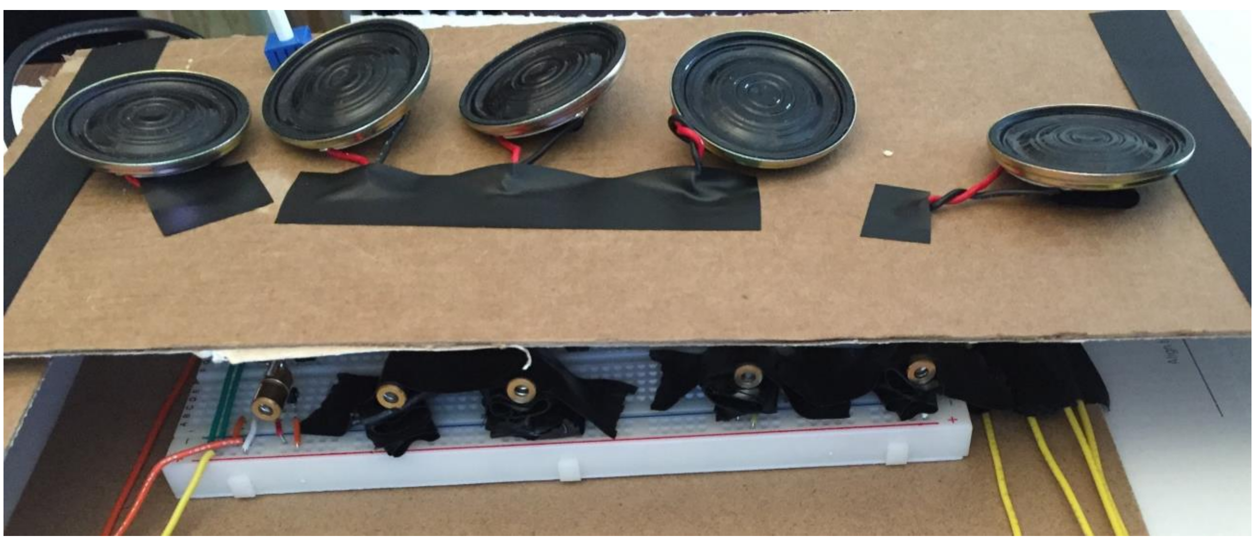

Figure 3. Interior view of lasers on the breadboard

Hardware Design

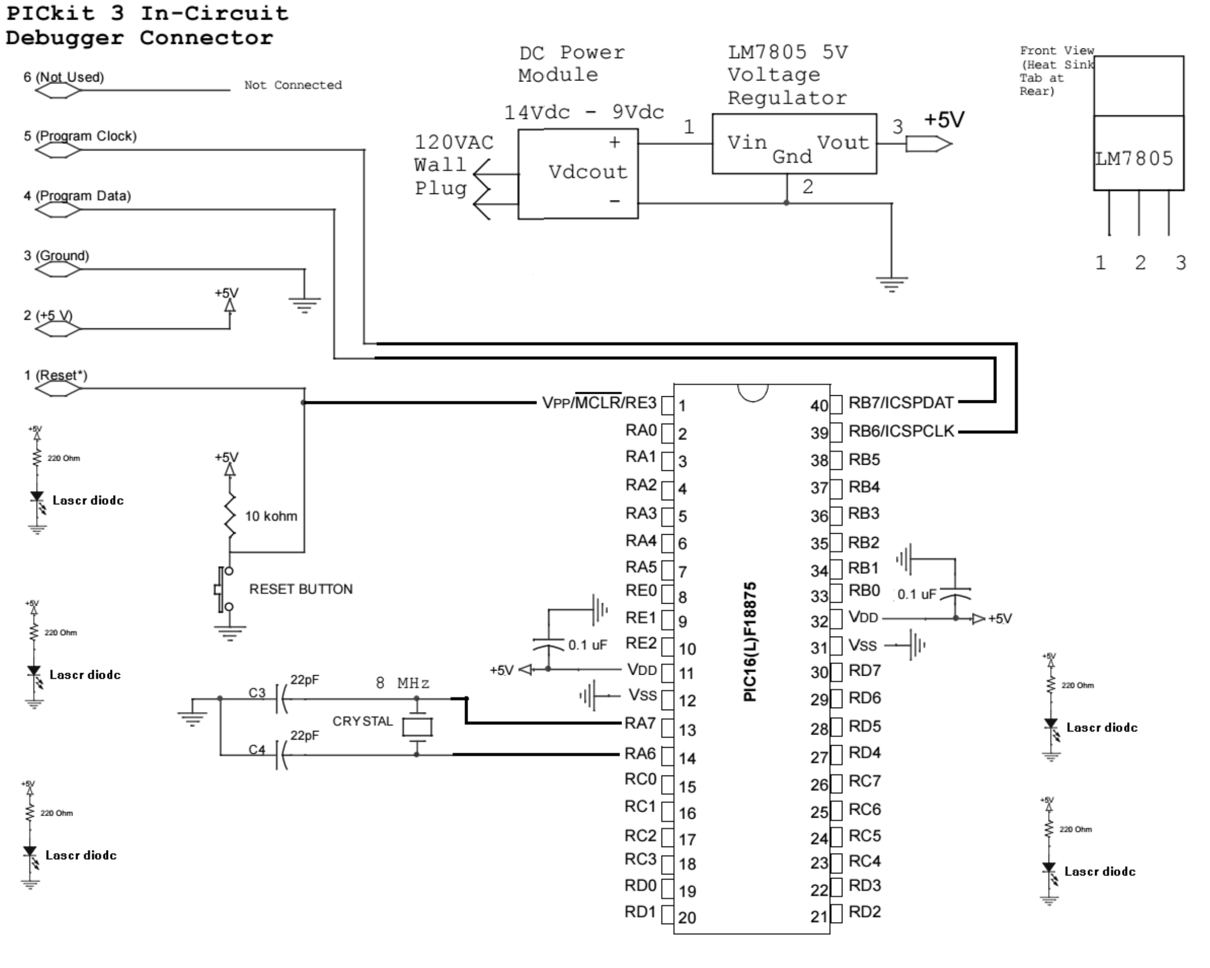

Figure 4. PicKit 3, power, and configuration connections

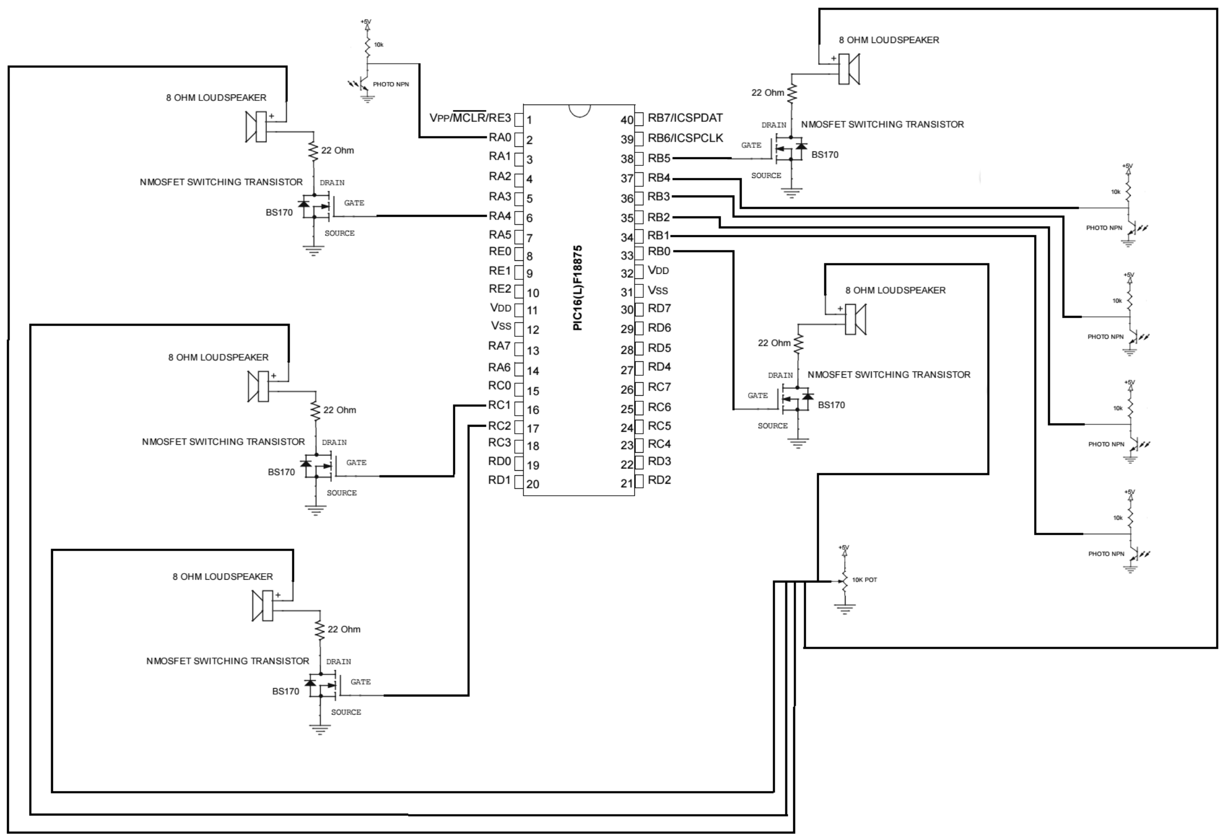

Figure 5. PIC pin connections

Software Design

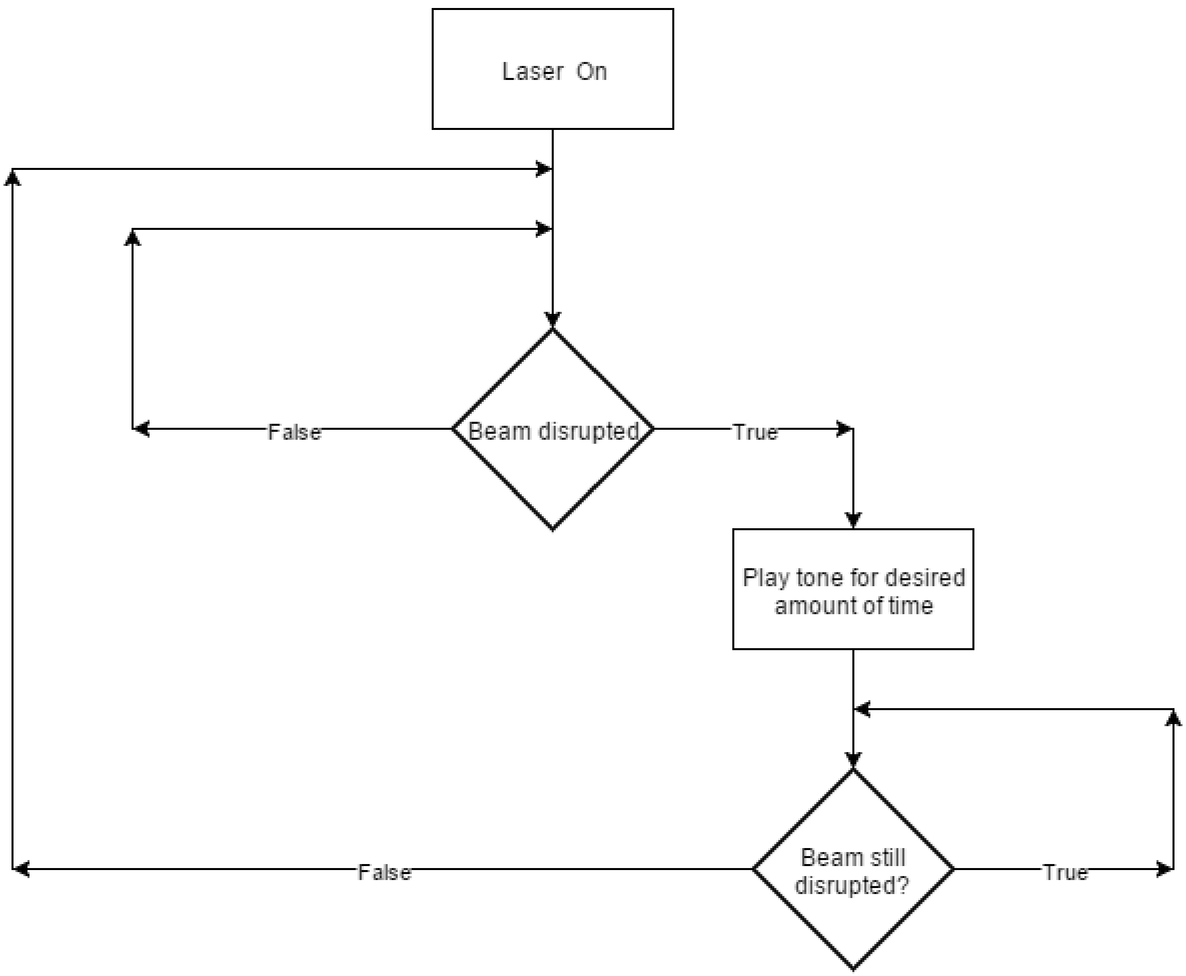

Figure 6. Flowchart of software design for each laser/phototransistor/speaker combination

Objective and Specifications

The main objective of our design was to use lasers. We settled on using lasers to produce different tones.

To do this, we had to use the newest version of the PIC, PIC16F18875, from MICROCHIP. Due to the fact we were using 5 lasers and 5 speakers, we needed 5 Compare and Capture modules, which our normal PIC (PIC16F887) did not provide us. We used 5 phototransistors, 5 speakers, and 5 lasers for this project. All of the speakers are connected to a single potentiometer, which controls the volume the speakers play at.

To improve our design, we decided to cover the breadboard, and put the potentiometer and speakers on the top of the box covering the breadboard. We kept the lasers inside of the box, and simply cut holes to allow the laser to shine through and against the phototransistors.

Test Plan and Results

To build this project, we worked incrementally from a small setup to our final project. We started by developing a simple hardware and software design that would work for a single laser, phototransistor, and speaker combination. During this phase, we struggled to learn the vernacular of the microcontroller, since we were using a new PIC device that allowed for more CCP modules. After considerable research and discussions with Dr. Miller, we came up with a working solution that played a note from the speaker for a short duration when the laser was blocked.

After this first milestone, we added another string system to ensure our software would work when multiple interrupts were triggered. After this began functioning as planned, we mounted the setup on a clipboard and built the hardware for all five strings that would play at different frequencies. During this phase, large amounts of static noise began occurring when multiple tones were played at the same time. Through testing on an oscilloscope, we were able to solve this problem by adding a capacitor across the potentiometer that controlled the volume of the strings. The PICKIT device could have also been a source of static issues while it was plugged into the board, so loading the program directly onto the PIC device and removing the PICKIT mitigated this problem as well.

Once the code and hardware were working correctly, we build a box to hold the system out of cardboard for aesthetic purposes. The final problem within our system was ensuring that the lasers consistently hit the phototransistors. The lasers would continually shift slightly so that their beams would miss the phototransistors. To fix this, we initially tried to tape the lasers to the board, but we realized that was not an effective solution and decided to instead move the phototransistors to a position that the lasers will consistently hit. After we completed this, our project worked as we had planned for it to from the beginning.

Bill of Materials

Part	Quantity	Source	Price
PIC16F18875	1	Dr. Miller	-
Laser diode	5	Amazon	$1.60
Speaker	5	Parts room	$1.00
Phototransistor	5	Parts room	$0.50
Box	1	Mail Room	-
Wire spool	1	Amazon	$8
Breadboard	2	Parts room	$5
BS170 NMOSFET Transistor	5	Parts room	$0.50
Potentiometer	1	Parts room	$0.50
Clipboard	1	Dollar Tree	$1.00
22 Ω resistor	5	Parts room	$0.25
10k Ω resistor	5	Parts room	$0.25
22 pF capacitor	2	Parts room	$0.50
0.1 µF capacitor	5	Parts room	$0.50
8 MHz crystal oscillator	1	Parts room	$1.00
Push button	1	Parts room	$1.00
Power	1	ECE230 Lab Kit	-

Future Plans

Further work on this project would focus on adding a feature that would “teach” someone to play songs on the instrument. The lasers would be connected to the PIC instead of directly to the power source, and a push button would be added that would trigger an interrupt to temporarily take control of the project when pressed. During this interrupt, lasers would be turned off and notes would be played according to a simple song like “Hot Cross Buns”. Since the user would be able to see which strings need to be blocked and hear how long they needed to wait in between tones, they would then know how to play the song once the interrupt sequence is complete.

Another step to improve this project would be to make the hardware more secure. The system currently relies on solderless breadboards and a cardboard casing. In the future, we would like to solder the components together and build a heavier-duty case in the machine shop to make things overall sturdier.

References and Acknowledgements

We would like to thank the following people:

Professor Chris Miller:

For his advice and guidance with using a new PIC device and some code