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6.115 Spring 2024
Final Project Proposal
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Karaoke Saxophone

Introduction

The saxophone is a modern instrument that typically has a brass body and a reed attached to a mouthpiece. To create sound, one can use their mouth to vibrate the reed, which produces a sound wave that cascades throughout the body of the instrument. Different openings and keyholes are used to tune this sound to a specific note, and the resulting instrument is capable of several octaves of play. This instrument is delicate, requiring fine tuning and construction to produce a consistent sound. As a result, the saxophone is expensive, and there is a high barrier of entry to anyone who wants to learn one of the most fundamental instruments in jazz. And as someone who has played the saxophone for over 10 years, I have personally experienced the difficulties in getting a saxophone serviced or repaired, as it requires an expert who knows a great deal about the ideal operation of the instrument. Ultimately, the saxophone is an instrument prevalent throughout modern music, primarily jazz, but high costs and maintenance make it difficult for beginner musicians to have access to a quality instrument.

In my final project, I hope to show that there can be a cheap saxophone with quality sound–through digitization. There may be concerns about the quality of the sound produced, but these can be addressed by attempting to produce as ideal of sound resolution as possible. Furthermore, in a similar vein to learner pianos, I hope to develop an instructional tool that can teach beginners basic songs note by note, further democratizing access to educational resources in a traditionally closed off domain. In short, I plan to create a replica of a modern tenor saxophone that is identical to a traditional saxophone with key placement and sound, but different in the way sound is produced, instead using the keys pressed to output a digitally stored signal and a mouthpiece to regulate intonation. A separate configuration will also be available that teaches you a song by displaying the key mappings for a note and waiting until you press the right one–in essence, a karaoke machine.

Hardware/Software

This project will consist of several distinct parts that communicate via traditional communication protocols. They can be separated into inputs, outputs, and displays.

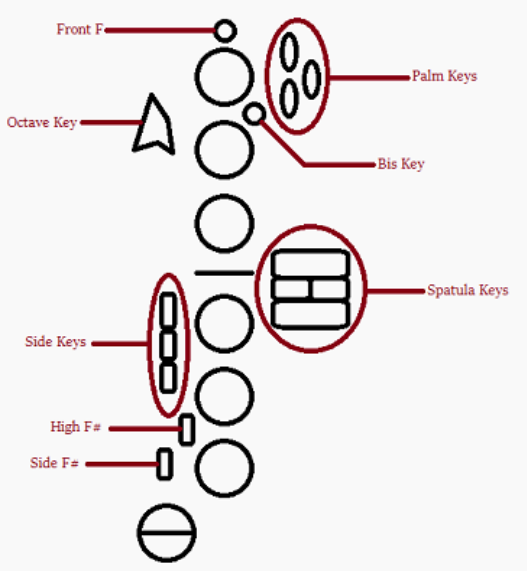
Inputs**:**

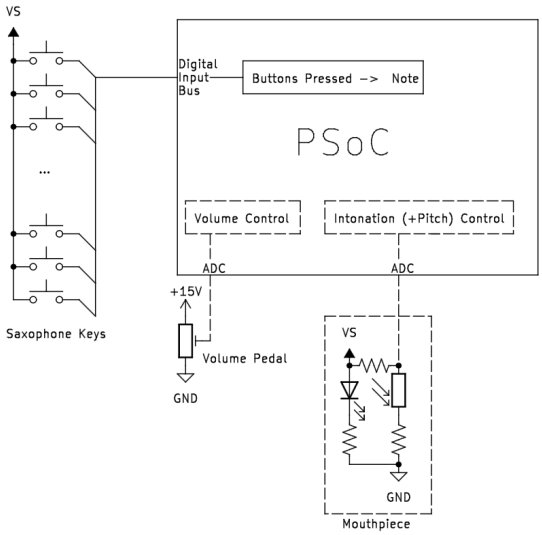
First, we need the key mappings to be registered and converted to the equivalent note. We take a number of parallel keys connected to input pins on the PSoC and constantly register which ones are pressed; next is converting to a note to play through internal digital logic. In order to add more complexity to the project, we need to control the volume and intonation of the notes. I plan to do this through two systems. The first is a pedal to control volume. The pedal I plan to use is a sewing machine foot pedal, in essence a large potentiometer. The pedal will be powered with 15V, GND, and a middle sense pin in a 0.13 inch diameter jack. The sense will be connected to a scaling block and a digital input pin.

The volume pedal will also be used to control whether or not a note is played. A series of thresholds will be used to determine gain on the waveform, and having the minimum gain be zero would result in a range of the pedal corresponding to no note played. This is in response to the concern that the saxophone would always be playing, as no keys pressed is a note in itself.

The second, a reach goal for my design, is to add a mouthpiece imitation of intonation. The general idea of the design would be to have some LED constantly outputting light in the direction of a photoresistor connected to a voltage divider and input pin. The photoresistor would then be mechanically blocked by some mechanism controlled by the mouth. Every time a falling edge is observed, we can count that as the start of whatever note is currently pressed.

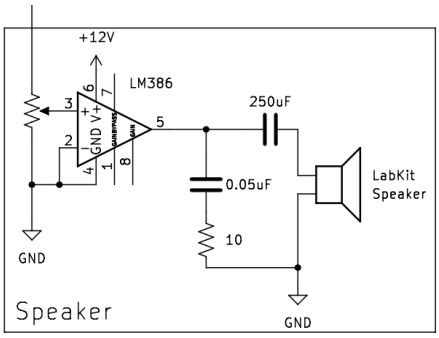
The diagram for the system of inputs is below.



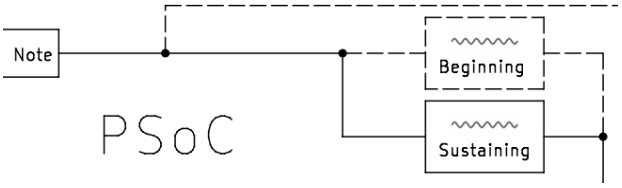


Outputs:

We need the sound to be generated as a result of PSoC input. The sound can be created via the PSoC's DAC output pins connected to an audio amplifier and speaker. I can store the waveform of each corresponding note and periodically send values to the DAC when chosen. Musical notes are usually less than a kilohertz in their frequency, which means the values sent can be a very infrequent interrupt without blocking other code.



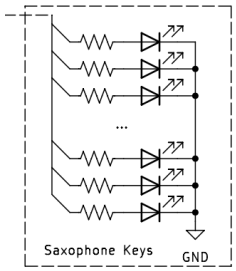
The largest concern in sound quality, besides the unchangeable resolution limitations of the DAC and the quality limitations of the kit speaker, is imitating how a note is sustained for variable durations.



To compensate, another expansion of my project is to have two stages for each note: beginning and sustaining. Beginning will be triggered whenever the mouthpiece detects a falling edge and sustaining will be the waveform that is sent for a variable amount of time (and also the one that is sent in initial

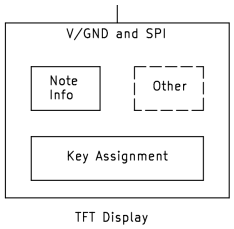
versions). When the start of another note is detected, the beginning of the new sound waveform will be sent.

Another potential expansion of the project would be to make keys light up when they are meant to be pressed. Although mostly invisible to the person playing the saxophone, they can be justified in a pedagogical sense, as any instructor watching their student play the saxophone might want to see what notes they should be pressing against those that they do press. These can be generated by connecting LEDs to digital output pins controlled in software.



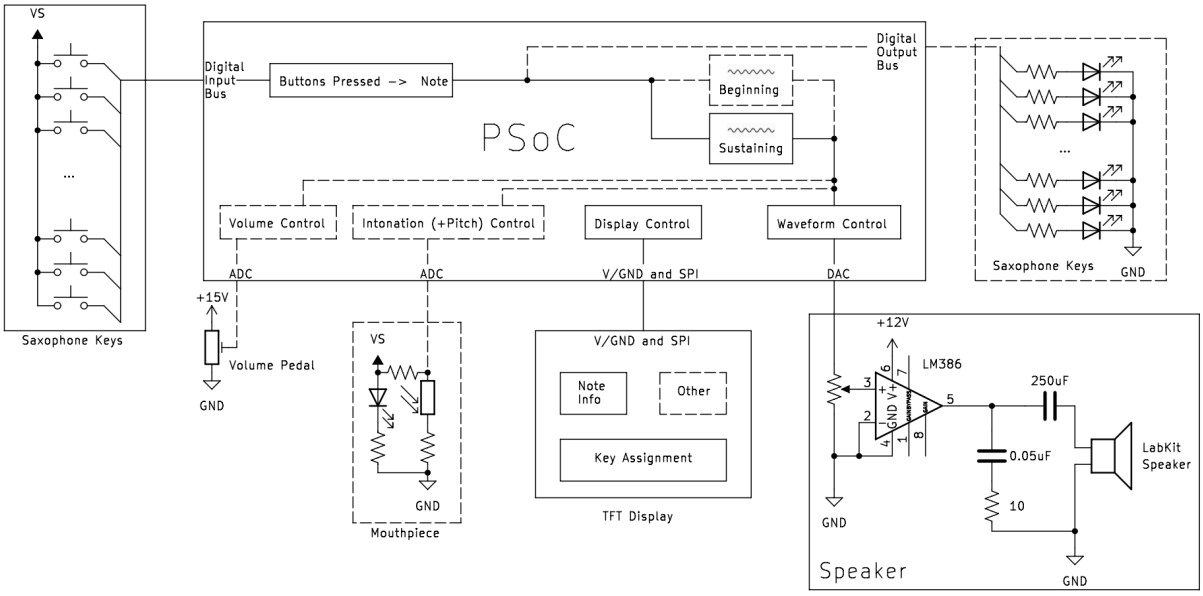
Displays:

In order to communicate the note that needs to be played, as well as how to play it, I thought to use the PSoC to communicate with a TFT display over 8 bit SPI. The display would need to contain the note that is currently played, a visual of the keys pressed and desired keys pressed for the karaoke version, as well as other relevant information. The TFT will be mostly interfaced in software.



Project Scope

I fully believe that creating both the saxophone and the karaoke feature are achievable and reasonable benchmarks for competence in my final project. In order to make my project exciting, I can add additional features, like the mouthpiece regulating intonations and the volume pedal. For the project to be perfect, the last steps would come from adding features like a sheet music follower to the display, using variability in the photoresistor divider to regulate slight pitch modulation, and adding support for quick musical uploads, all things to make the saxophone more realistic.



Additional Components

All that is required is the display and a set of high quality buttons, switches, and the sewing machine pedal for the analog inputs. I ordered a TFT Display in the parts order and will procure the buttons, switches, and other circuit components from the departament. The sewing machine pedal I bought on Amazon, and I will also source a connector to power and read out the voltage divider.

For the actual body of the saxophone, there are several levels of complexity that can be achieved, but the most ideal, time permitting, is layered acrylic with a hollow center for cables. These materials can be found, cut, and joined in EDS. The mouthpiece can be made with 3D printed plastic that is held open with a spring.

Timetable

Week (starting on)	Tasks
April 15	Order parts, design sound system and test output of a generated saxophone note.
April 22	Develop the beta mechanical system and inputs and connect to digital logic on the PSoC.
April 29	Connect the TFT Display and add the karaoke features.
May 6	Start adding the additional control signals and add any additional features that are feasible.
May 13	Test the system and present the final design.