Music Interface Movement System (MIMS)

ECE 411 Team # 5

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What is MIMS?

MIMS is a small MIDI (Musical Instrument Digital Interface) instrument, similar to a digital piano keyboard. Just like any other MIDI controller, it can set each control surface (or sensor) to control a parameter in the DAW (digital audio workstation) on the computer.

Applicable to:

- Amateur music lovers
- Musicians
- Music producers

A type of MIDI instrument

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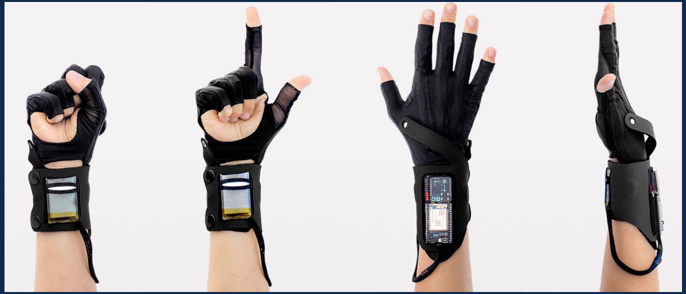
Motivation for designing MIMS



Make music more like movement

- In the past, the use of MIDI often required the player to stand in front of the digital piano keyboard to control the production of digital music. However, music sometimes needs to add some movement elements to make it more sensible. We don't want the player to stand in a fixed position from beginning to end to play.

Intuitive operation

- The complex keys of the original MIDI keyboard are very unfriendly to those who are not familiar with digital music. One of our motivations for designing MIMS is to simplify the operation of generating digital music, so that such people can also enjoy the fun of digital music

Cheap and easy to carry

- Most digital music equipment is costly and very difficult to carry. MIMS is dedicated to reducing the cost of producing digital music while making it convenient for amateurs to carry it along.

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Objective

Wearable

- MIMS is designed to have a wearable function, allowing you to liberate your body without having to stand in front of the laptop all the time.

Simplicity

- After the user has set the configuration in advance, they can play a digital instrument simply by changing the hand movement, or tapping piezos

Small and cheap

- The backpack you carry with you is large enough to hold the MIMS, it is very small and cheap.

A proof of concept on which to develop further...

Alternatives

Closest existing product:

MiMu Gloves:

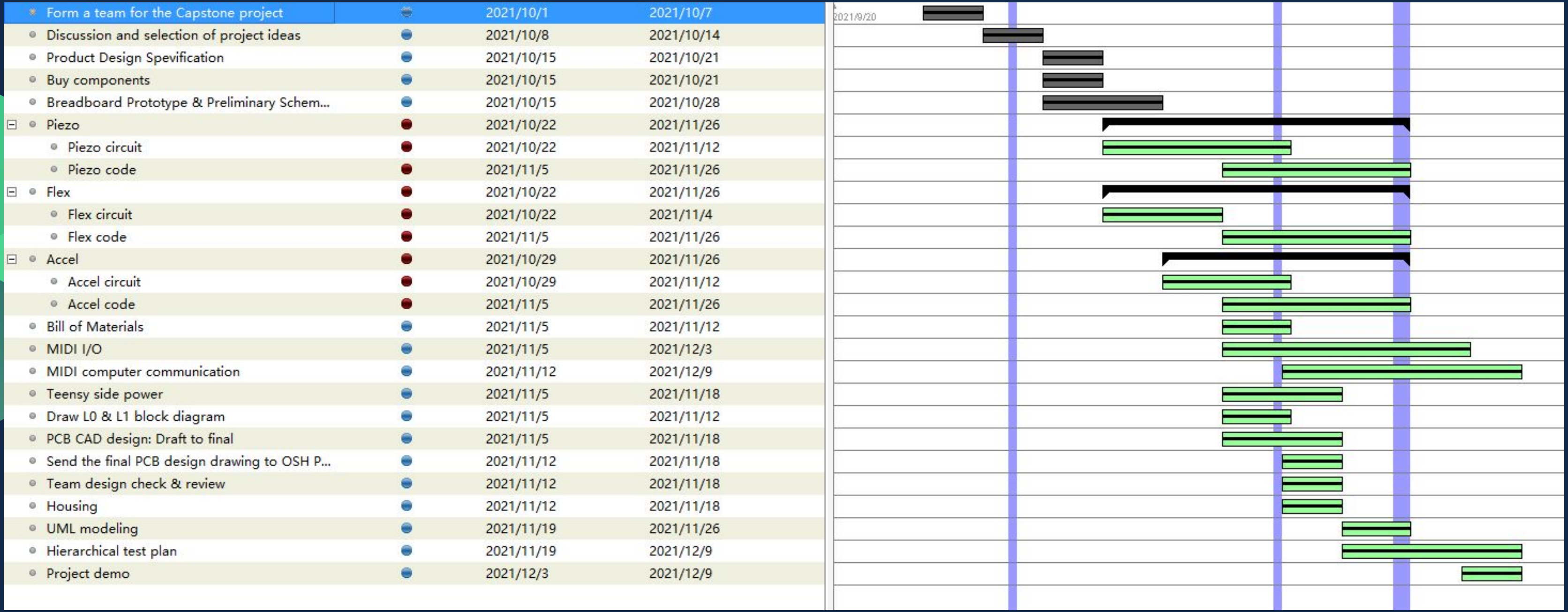
developed by Imogen Heap

MiMu runs through an app versus talking directly via MIDI

Approach

- List types of sensors to use
- Brainstorm musical functions they could control
- Develop analog circuitry to drive those sensors
- Experiment with output
- Develop code to interface with sensor output
- Redesign circuit with ADC to digitize all signals
- Simplify target music functions to be more realistic
- Redevelop code for full design
- Test with full device
- Demo

Approach



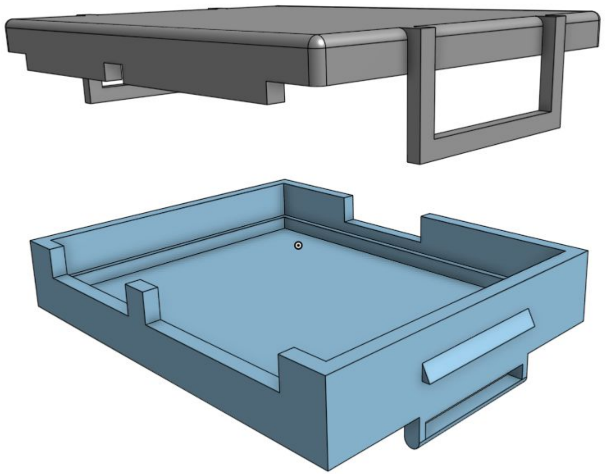
Form a team for the Capstone project	●	2021/10/1	2021/10/7
Discussion and selection of project ideas	●	2021/10/8	2021/10/14
Product Design Spevification	●	2021/10/15	2021/10/21
Buy components	●	2021/10/15	2021/10/21
Breadboard Prototype & Preliminary Schem...	●	2021/10/15	2021/10/28
⊟ Piezo	●	2021/10/22	2021/11/26
Piezo circuit	●	2021/10/22	2021/11/12
Piezo code	●	2021/11/5	2021/11/26
⊟ Flex	●	2021/10/22	2021/11/26
Flex circuit	●	2021/10/22	2021/11/4
Flex code	●	2021/11/5	2021/11/26
⊟ Accel	●	2021/10/29	2021/11/26
Accel circuit	●	2021/10/29	2021/11/12
Accel code	●	2021/11/5	2021/11/26
Bill of Materials	●	2021/11/5	2021/11/12
MIDI I/O	●	2021/11/5	2021/12/3
MIDI computer communication	●	2021/11/12	2021/12/9
Teensy side power	●	2021/11/5	2021/11/18
Draw L0 & L1 block diagram	●	2021/11/5	2021/11/12
PCB CAD design: Draft to final	●	2021/11/5	2021/11/18
Send the final PCB design drawing to OSH P...	●	2021/11/12	2021/11/18
Team design check & review	●	2021/11/12	2021/11/18
Housing	●	2021/11/12	2021/11/18
UML modeling	●	2021/11/19	2021/11/26
Hierarchical test plan	●	2021/11/19	2021/12/9
Project demo	●	2021/12/3	2021/12/9

Gantt chart

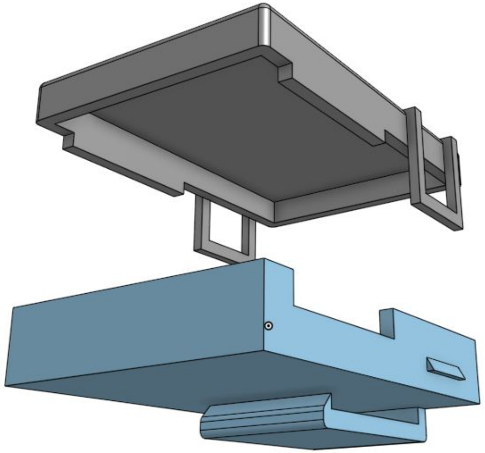
Requirements

- Must be wearable
- Must translate hand movements to MIDI events
- Should be able to emulate tremolo and/or vibrato effects using hand movements
- Should be able to play notes like an instrument while using the other hand for effects
- Must connect to a computer via USB, should be powered by USB
- Must use at least 3 different types of sensors
- Must translate digital and analog inputs into MIDI
- Must be compatible with existing MIDI software to appear as a MIDI instrument on an external computer
- Should have LEDs that may activate in response to individual sensor input

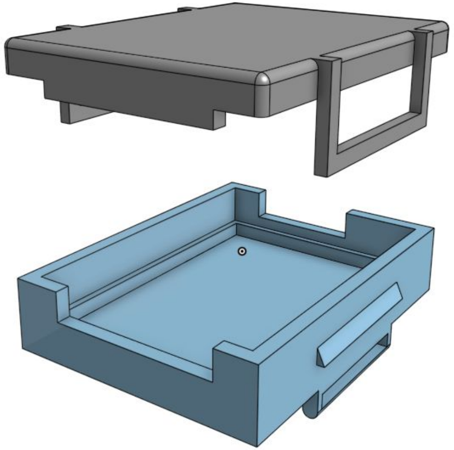
Design (CAD)



Left hand side



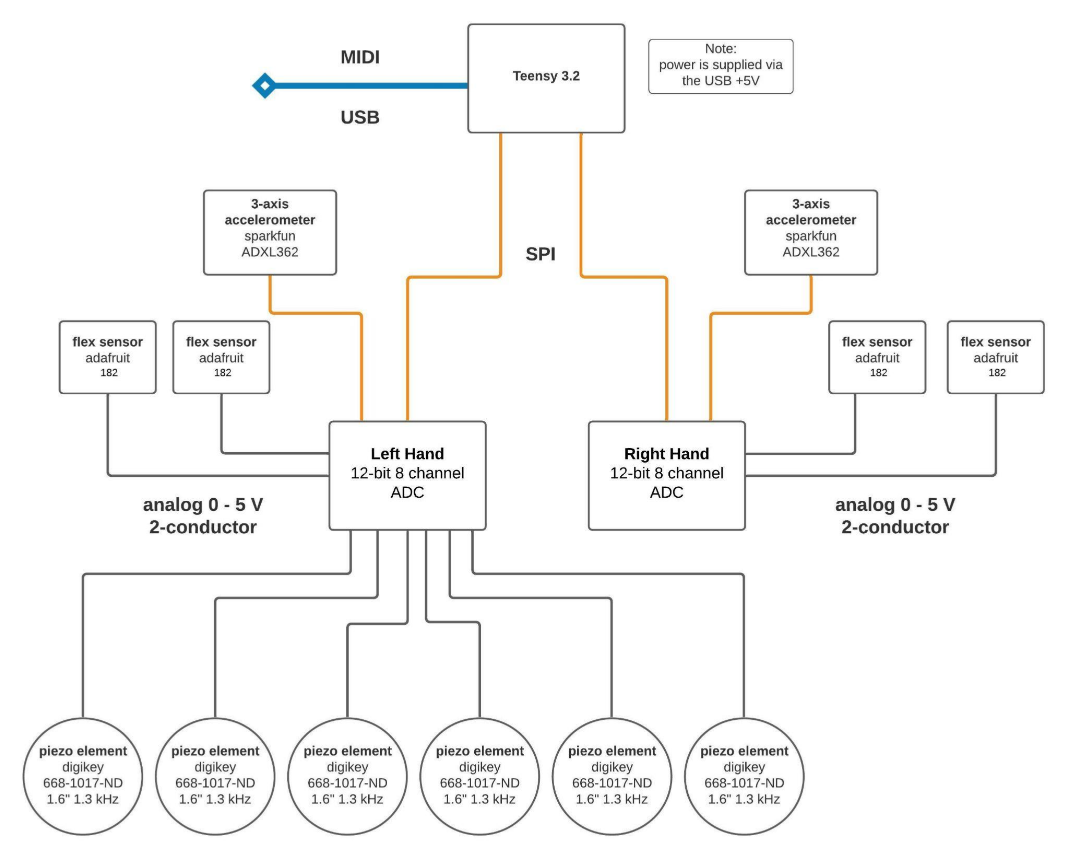
MCU



Right hand side

Design

- Piezo sensor
- Flex sensor
- Accelerometer
- ADC
- Teensy 3.2


MIDI
USB
Teensy 3.2
Note:
power is supplied via
the USB +5V
SPI
3-axis accelerometer sparkfun ADXL362
3-axis accelerometer sparkfun ADXL362
flex sensor adafruit 182
flex sensor adafruit 182
flex sensor adafruit 182
flex sensor adafruit 182
Left Hand 12-bit 8 channel ADC
Right Hand 12-bit 8 channel ADC
analog 0 - 5 V
2-conductor
analog 0 - 5 V
2-conductor
piezo element digikey 668-1017-ND 1.6" 1.3 kHz
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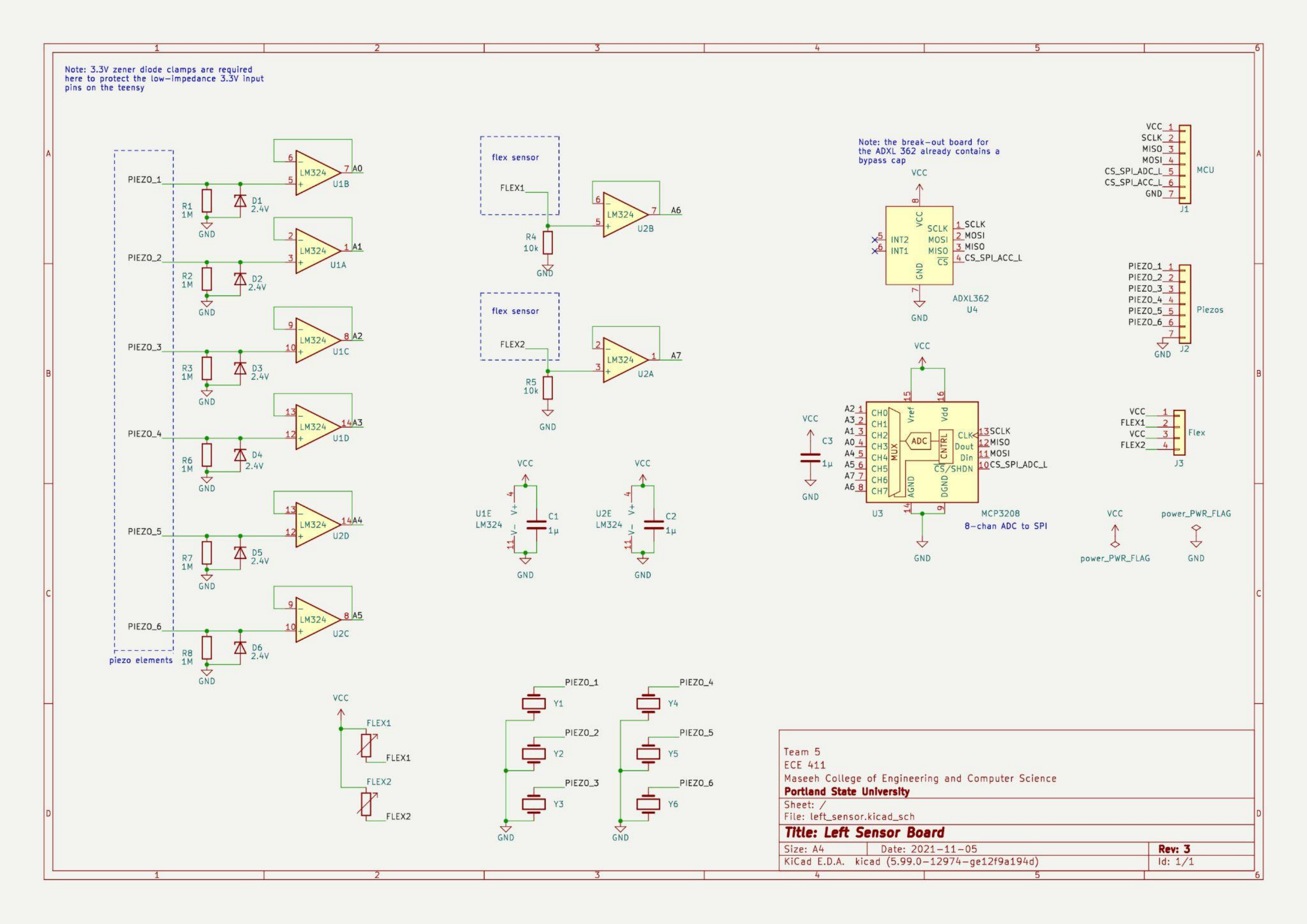
L1 Diagram

Design



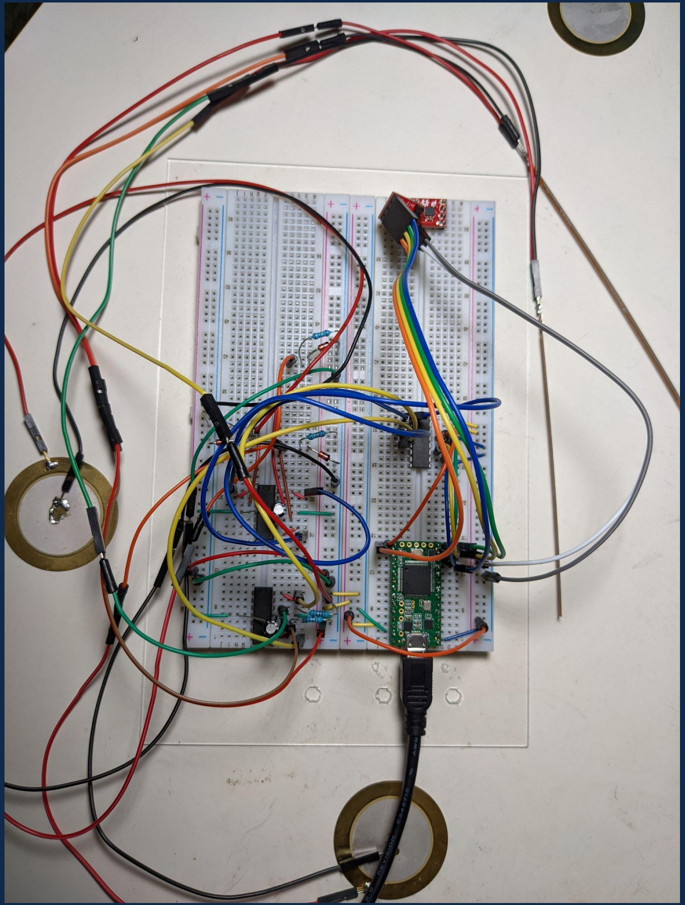
Note: 3.3V zener diode clamps are required here to protect the low-impedance 3.3V input pins on the teensy

Note: the break-out board for the ADXL 362 already contains a bypass cap

Team 5
ECE 411
Maseeh College of Engineering and Computer Science
Portland State University
Sheet: /
File: left_sensor.kicad_sch
Title: Left Sensor Board
Size: A4 Date: 2021-11-05 **Rev: 3**
KiCad E.D.A. kicad (5.99.0-12974-ge12f9a194d) Id: 1/1

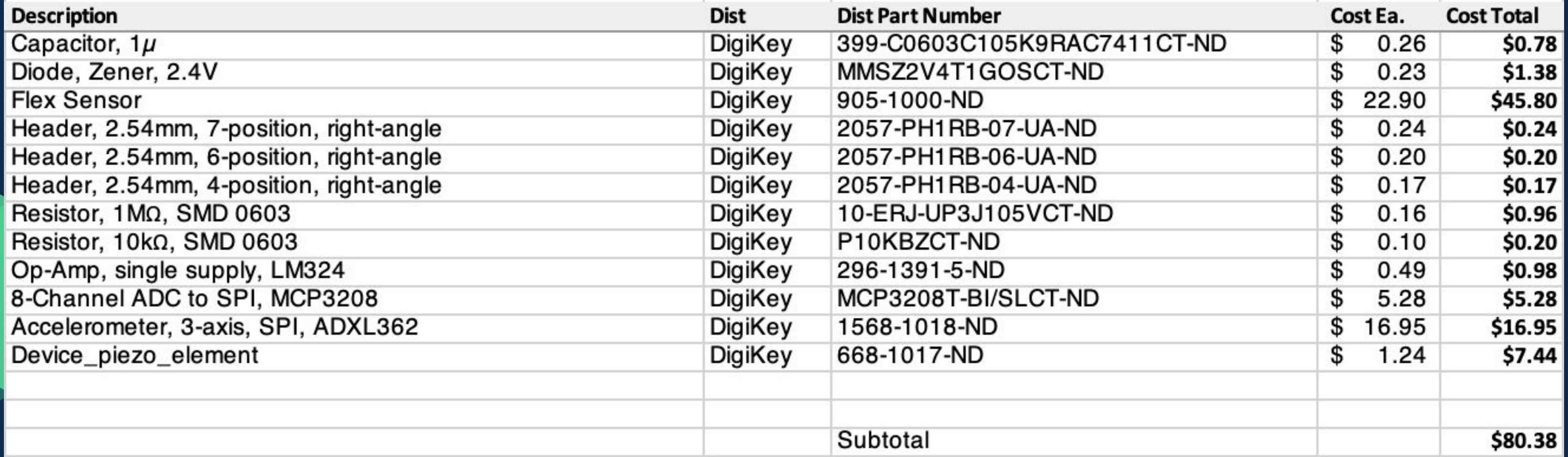
Implementation

- 2 hand mounted devices
  - 6 piezo sensors on one arm
  - 2 flex sensors on each hand (4 total)
  - 1 accelerometer on each hand (2 total)
- Each hand device connected to the MCU via SPI and power lines



Implementation

BOM segment



Description	Dist	Dist Part Number	Cost Ea.	Cost Total
Capacitor, 1μ	DigiKey	399-C0603C105K9RAC7411CT-ND	$ 0.26	$0.78
Diode, Zener, 2.4V	DigiKey	MMSZ2V4T1GOSCT-ND	$ 0.23	$1.38
Flex Sensor	DigiKey	905-1000-ND	$ 22.90	$45.80
Header, 2.54mm, 7-position, right-angle	DigiKey	2057-PH1RB-07-UA-ND	$ 0.24	$0.24
Header, 2.54mm, 6-position, right-angle	DigiKey	2057-PH1RB-06-UA-ND	$ 0.20	$0.20
Header, 2.54mm, 4-position, right-angle	DigiKey	2057-PH1RB-04-UA-ND	$ 0.17	$0.17
Resistor, 1MΩ, SMD 0603	DigiKey	10-ERJ-UP3J105VCT-ND	$ 0.16	$0.96
Resistor, 10kΩ, SMD 0603	DigiKey	P10KBZCT-ND	$ 0.10	$0.20
Op-Amp, single supply, LM324	DigiKey	296-1391-5-ND	$ 0.49	$0.98
8-Channel ADC to SPI, MCP3208	DigiKey	MCP3208T-BI/SLCT-ND	$ 5.28	$5.28
Accelerometer, 3-axis, SPI, ADXL362	DigiKey	1568-1018-ND	$ 16.95	$16.95
Device_piezo_element	DigiKey	668-1017-ND	$ 1.24	$7.44
		Subtotal		$80.38

Total cost of a single device (including casing): $140.11

Some parts used in prototyping were reused for the final device.

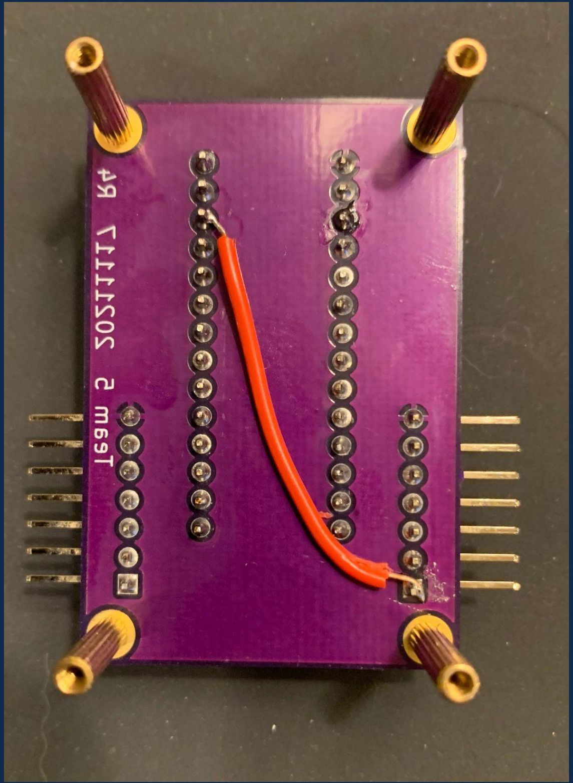
Testing

3 basic tests:

- Unit Test 1:
  - Full PCB continuity test
- Unit Test 2:
  - Test for valid voltages on analog sensor inputs
- Integration Test:
  - Test that the device plugged in to the computer is sending valid MIDI messages for each sensor

Testing: continued

- Tested piezo output with high freq. scope to ensure that impulse voltage wouldn’t blast MCU
- Adjusted impedances on SPI inputs
- Workarounds for various PCB flaws



Results

- Must be wearable
- Must translate hand movements to MIDI events
- ~~should be able to emulate tremolo and/or vibrato effects using hand movements~~
- Should be able to play notes like an instrument while using the other hand for effects
- Must connect to a computer via USB, should be powered by USB
- Must use at least 3 different types of sensors
- Must translate digital and analog inputs into MIDI
- Must be compatible with existing MIDI software to appear as a MIDI instrument on an external computer
- ~~Should have LEDs that may activate in response to individual sensor input~~

All “musts” achieved. Some “shoulds” not achieved.

Results

- Teensy plugs into a computer via USB and is instantly recognized as a MIDI instrument.
- 6 piezos
  - Each plays a different sound on a single digital drum instrument
  - Intensity of piezo hit translates to volume of drum sound
- 4 flex sensors
  - Each plays a different note on a single digital tone instrument
- 2 accelerometers
  - Left accel. controls pitch/volume of flex sensor instrument
  - Right accel. is left open for future development

The Future

This device has a lot of room for improvement.

- Software upgrades could expand operation of each sensor
- Accelerometer can identify unique motions for various operations
- Room for more flex sensors and piezos
- Viable market for motion activated musical interfaces

Lessons Learned

- MIDI is easy
- SPI and accelerometers are hard
- PCB design is easy… to mess up
- always check the obvious things first
- A hot air rework station will instantly remove all the components from your board, if used properly
- A good understanding of OOP C++ goes a long way
- git is that reliable friend who takes everything too literally
- Having a solid and clear vision is the most important first step

Contributions

- Bill Green
  - Schematics, PCB design, code, inventory
- Wenyu Bi
  - CAD design, fabricating, documentation
- Shutong Li
  - Scheduling, test designs, board assembly
- Nick Porter
  - Design, MIDI to DAW interfacing, code reviews