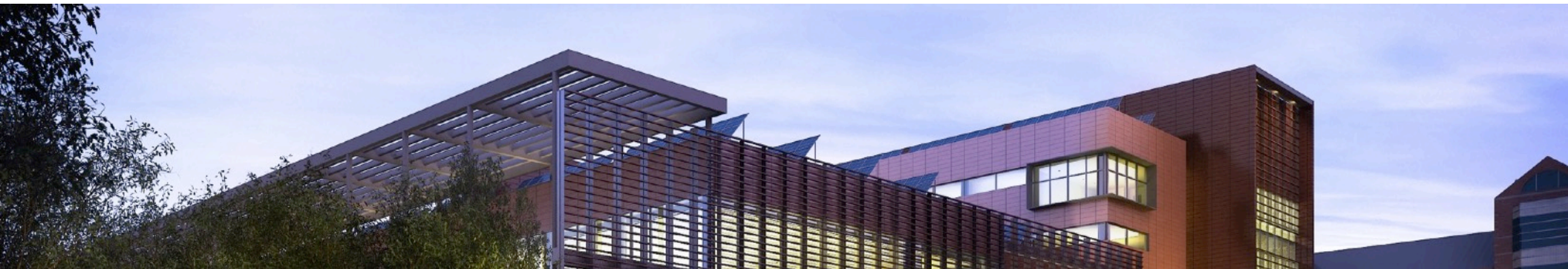


ECE 445 Spring 2017

Multi-Microphone Array

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Introduction

Our Project

- Scalable microphone array
- Portability
- Synchronized arrays for accurate data
- Modular design

Applications

- Sound localization
- Source tracking

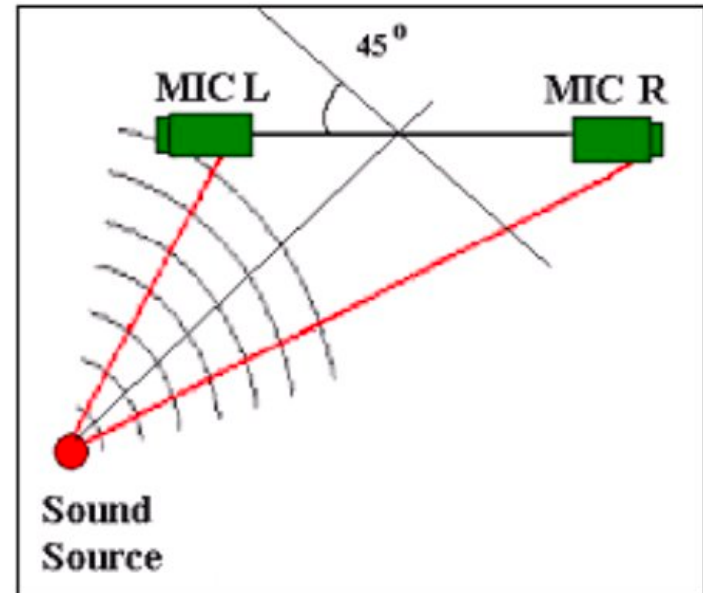


Figure 1: Visual Representation

“Sound Camera” - 3D Imaging

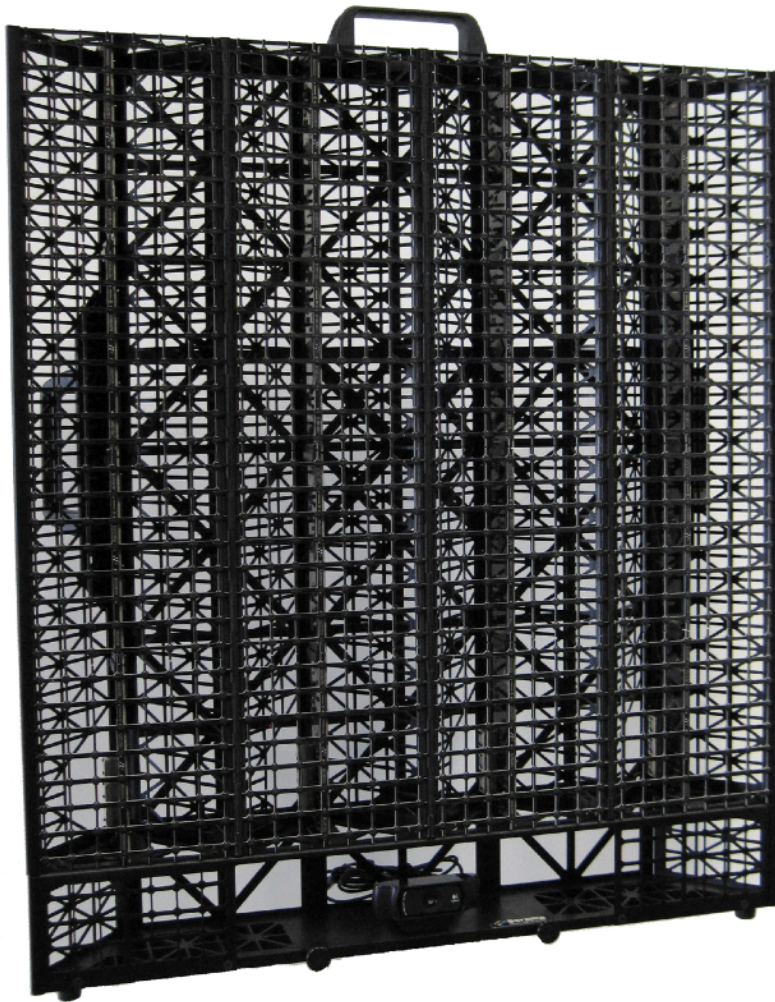


Figure 2: World’s largest microphone array (4096 microphones) [1]

Objectives

- Sample sound on multiple microphone arrays
- Synchronize sampling rate of microphones on different arrays
- Save onto external storage

Design

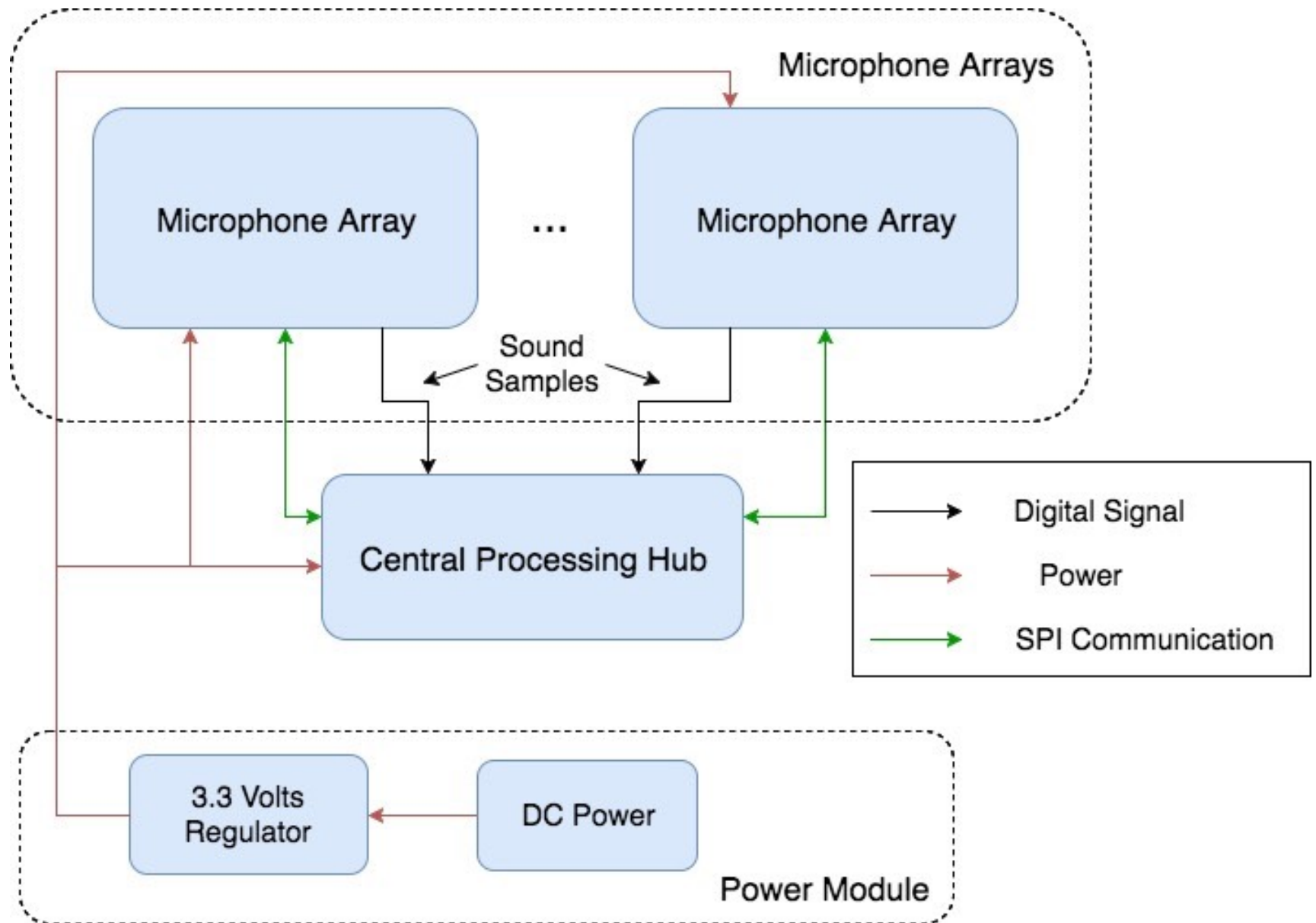


Figure 3: General Block Diagram

Requirements

Power Supply

- 3.3 V +/- 0.3 V

Microphone Array

- Sample from 4 analog MEMS microphones

Processing Unit

- Synchronize sampling between arrays
- Save sound data

STM32F411CEU6

- Up to 5x SPI w/
full-duplex I²S
- 1x USB 2.0 OTG
- Potential
expandability
- External storage

Voltage Regulator

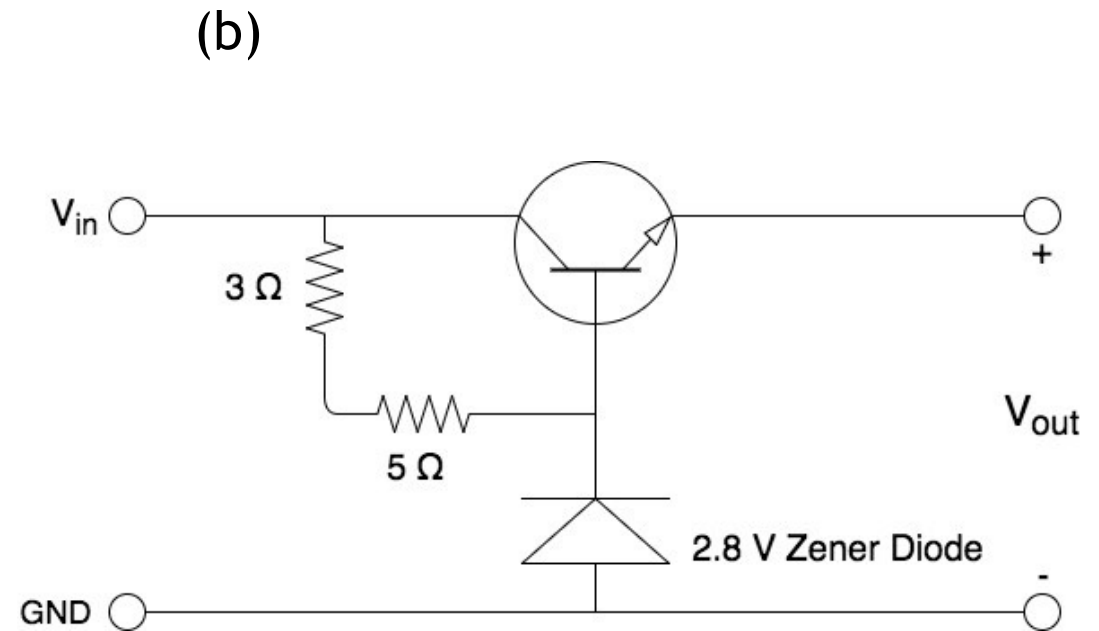
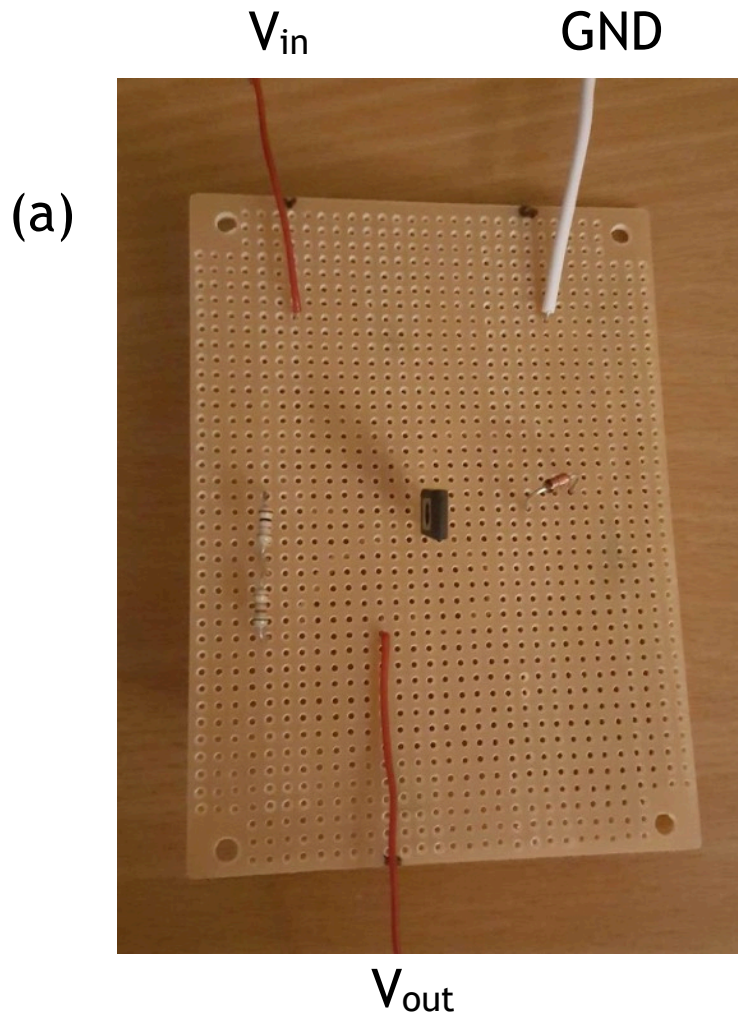
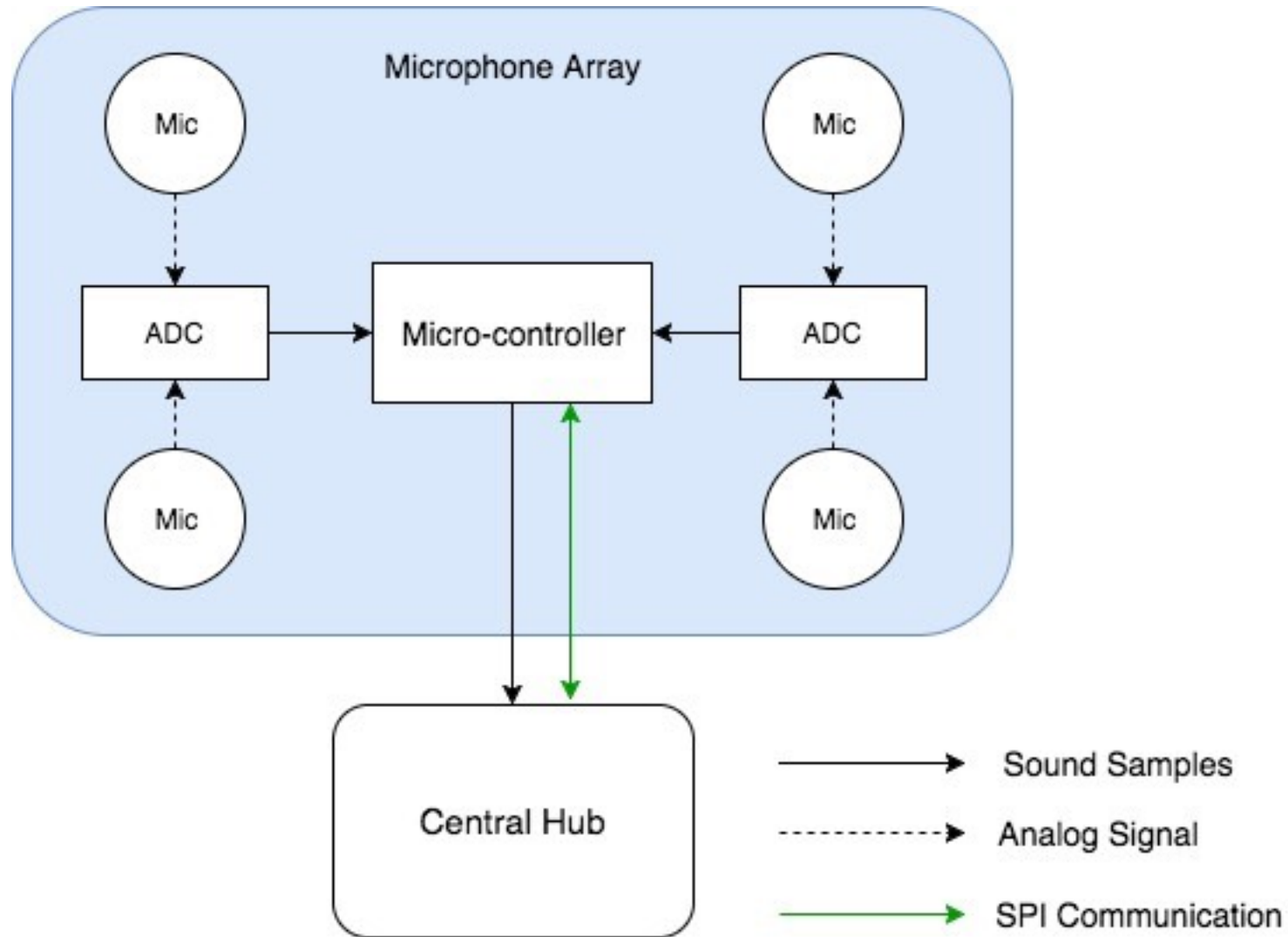


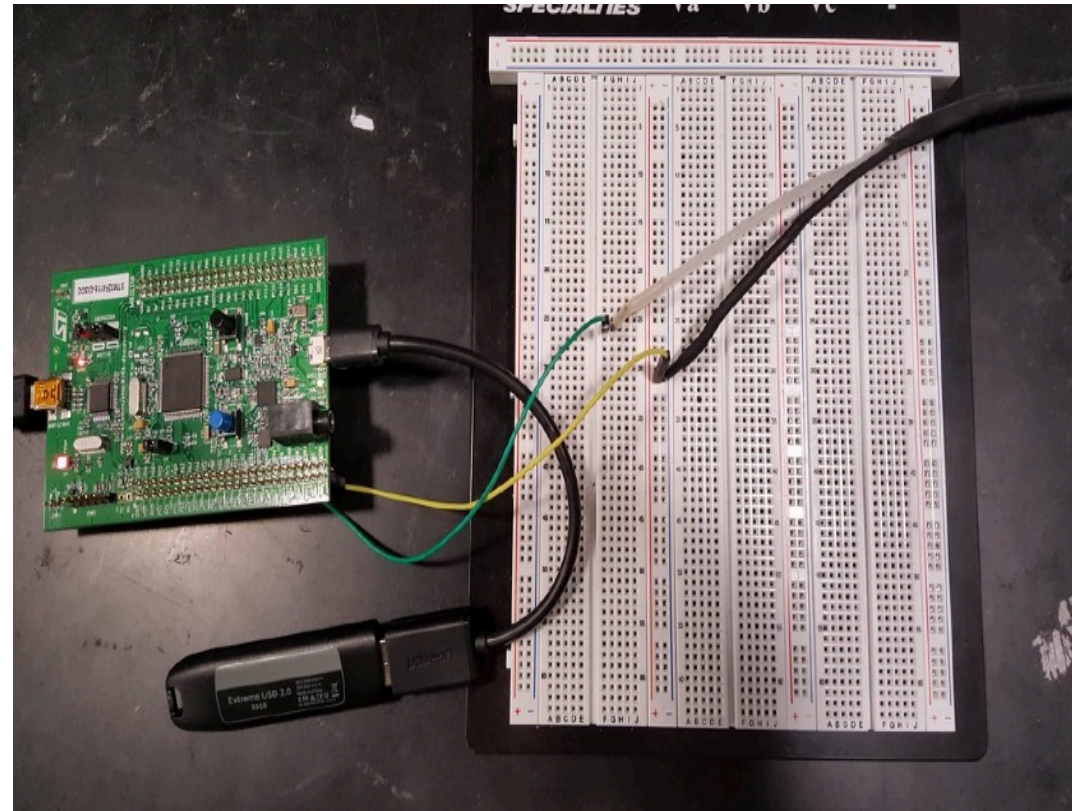
Figure 5: (a) Voltage regulator on perf board, (b) Circuit diagram of voltage regulator

Microphone Array Block Diagram



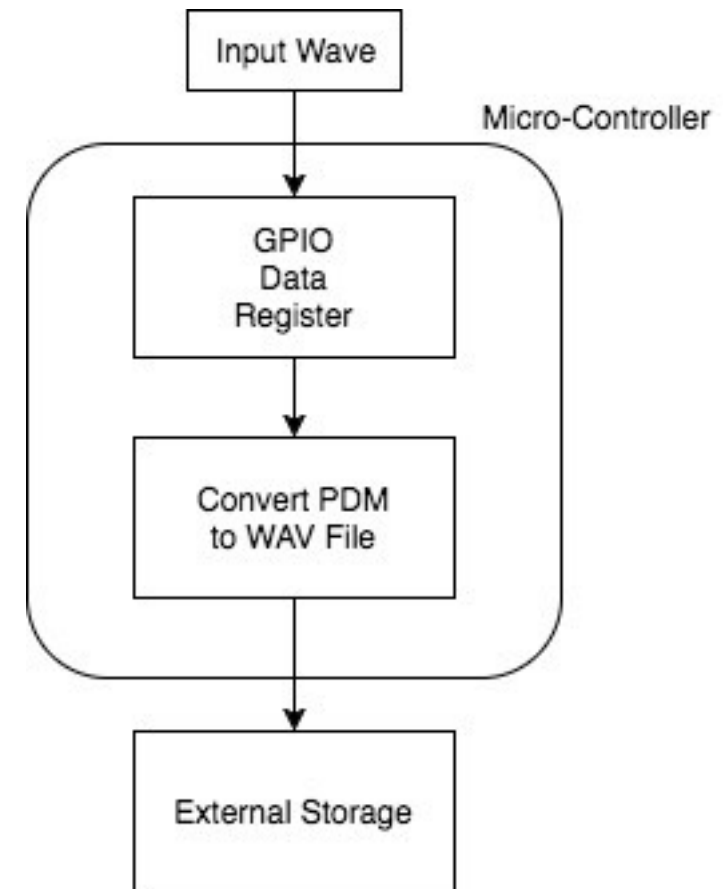
Microphone Array - Prototype

- Generate a 20 kHz & 200 Hz wave
- Writing the wave data into GPIO data register
- Convert the data into a WAV file and save



Microphone Array - I/O Mapping

- The input wave is read into the GPIO data register
- Initially stored in PDM format
- Converts the PDM data into WAV format
- Write the content of the data register onto USB



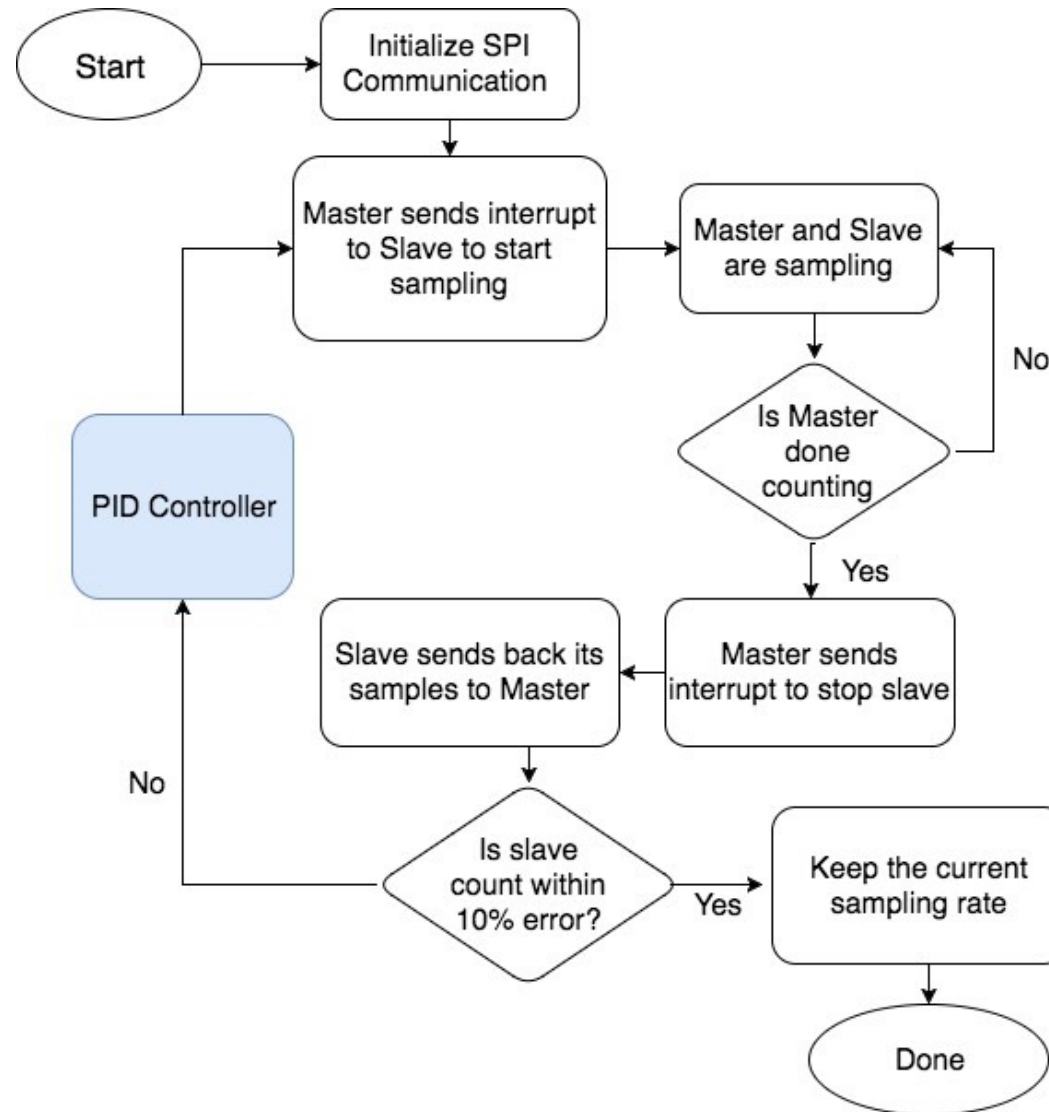
Microphone Array Results



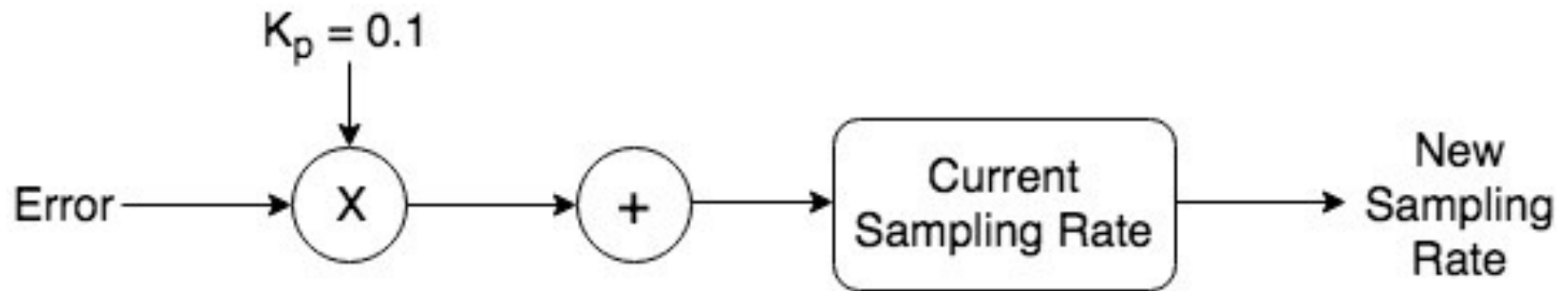
Input 20 kHz and oscillated

Input 200 Hz

Synchronization Algorithm



Proportional - Integral - Derivative (PID) Controller Synchronization



$$y(t) = K_p \times e(t)$$

Figure 7: Proportional Control

Synchronization Considerations

- How accurate can we reach target frequency?
- How quickly?

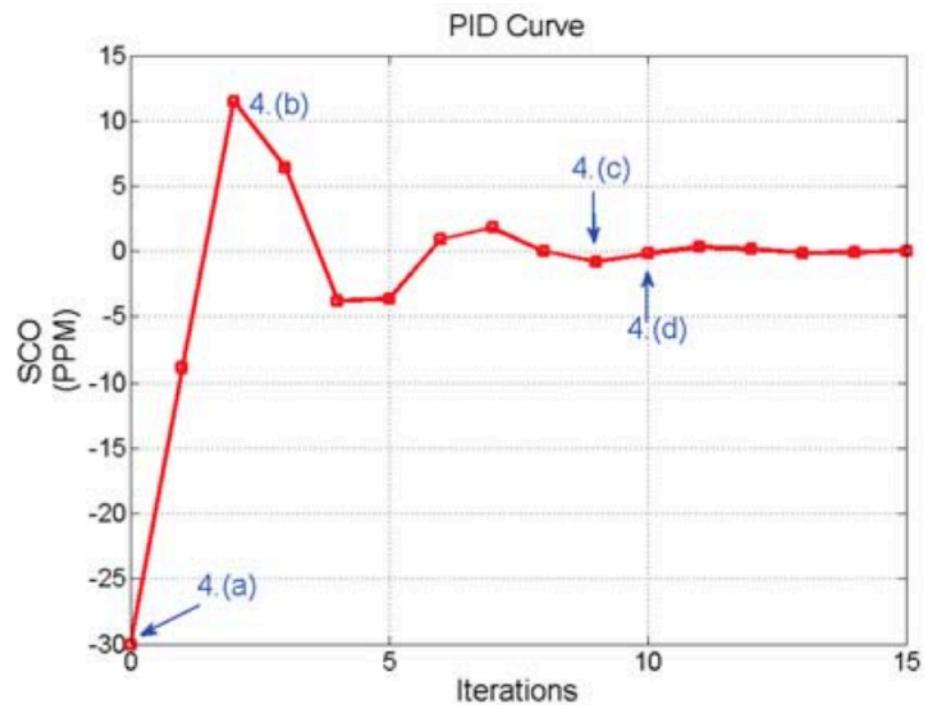


Figure 6: Theoretical PID Curve for Proposed Synchronization Scheme [2]

Conclusion

Conclusion

- Generate ~ 3.3 V
- Able to sample sound from onboard microphone
- Record and save from two I/O pins
- Save sound data that varies with changes in frequency

Future Work

- Implement system on our own hardware
- Integrate communication protocol
- Incorporate multiple microphone arrays
- Scale upwards

Questions?



- [1] [sorama.eu](https://www.sorama.eu/node/201), “Sorama builds World’s Largest Microphone Array”, 2017.
[Online]. Available: <https://www.sorama.eu/node/201>
- [2] [ieeexplore.ieee.org](http://ieeexplore.ieee.org/document/6737858/), “Sampling Clock Synchronization with PID controller for optical OFDM systems”, 2017. [Online]. Available: <http://ieeexplore.ieee.org/document/6737858/>