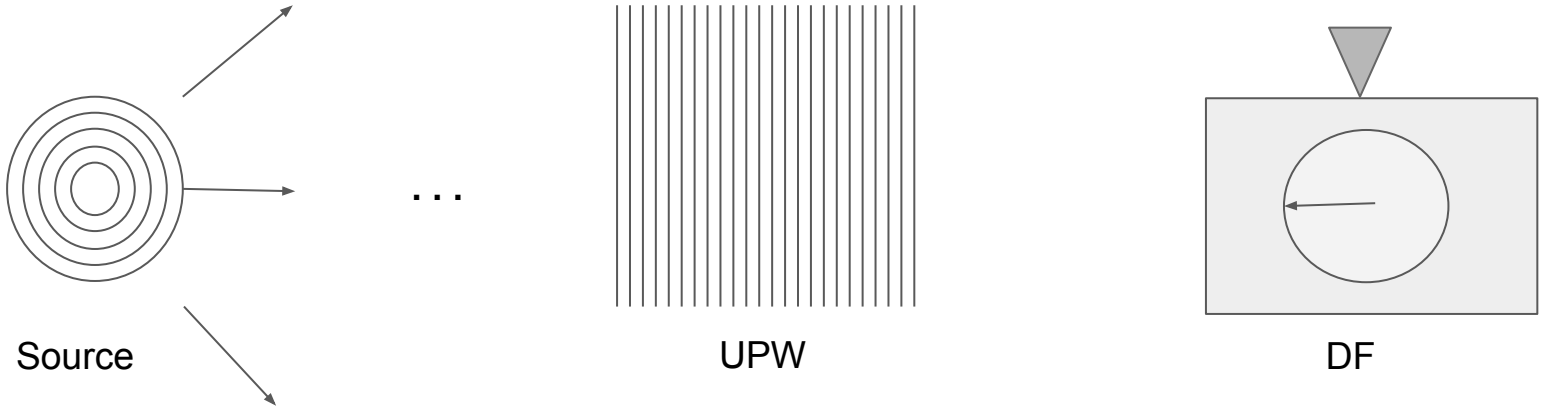
# Pseudo-Doppler Direction Finder

Amanda Ke, Melissa Li, Jimmy Mawdsley

MIT | 6.101 Analog Electronics Laboratory | April 14 2016

# Background and Project Goals

Determines direction toward signal source (RF, acoustic, etc.)

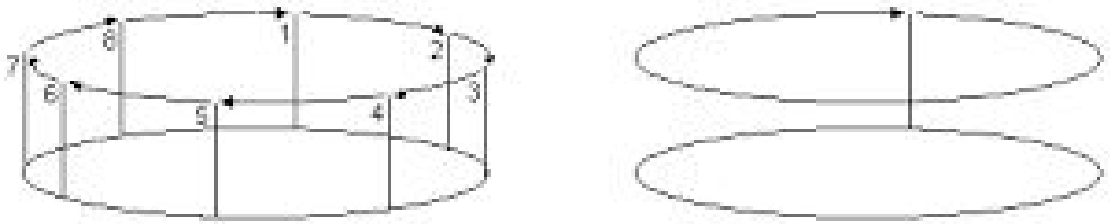



RDF applications: aerial navigation, tracking, locating pirate radio stations...

# Pseudo-Doppler Direction Finding

Synthesize a rotating effective antenna by switching between elements in an array

Effective antenna moves toward/away from source → Doppler shift



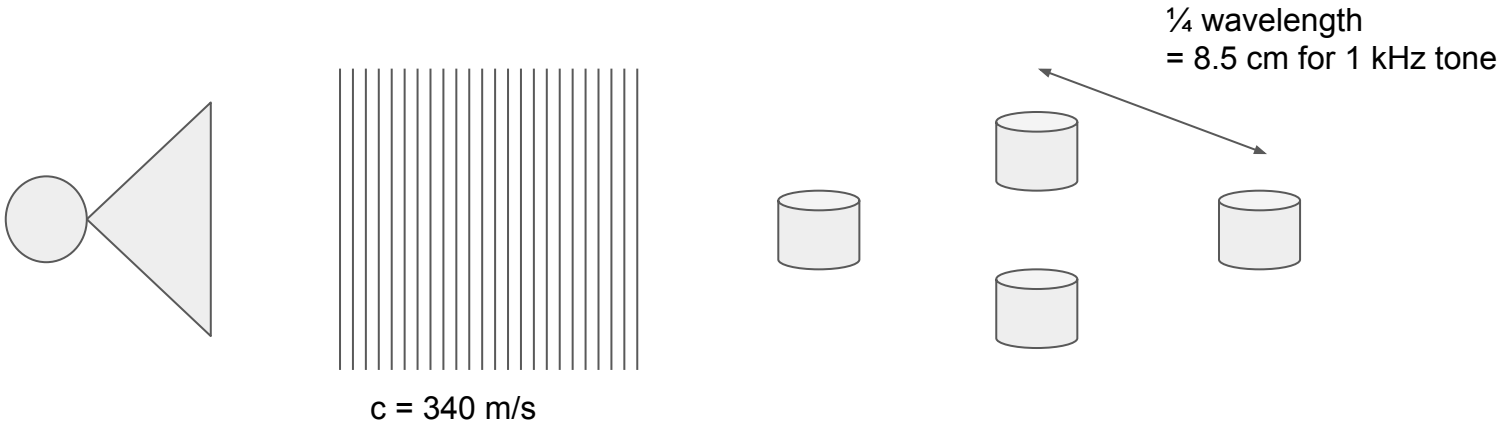

Typically use a soft-switching profile to reduce phase discontinuities

# Motivation

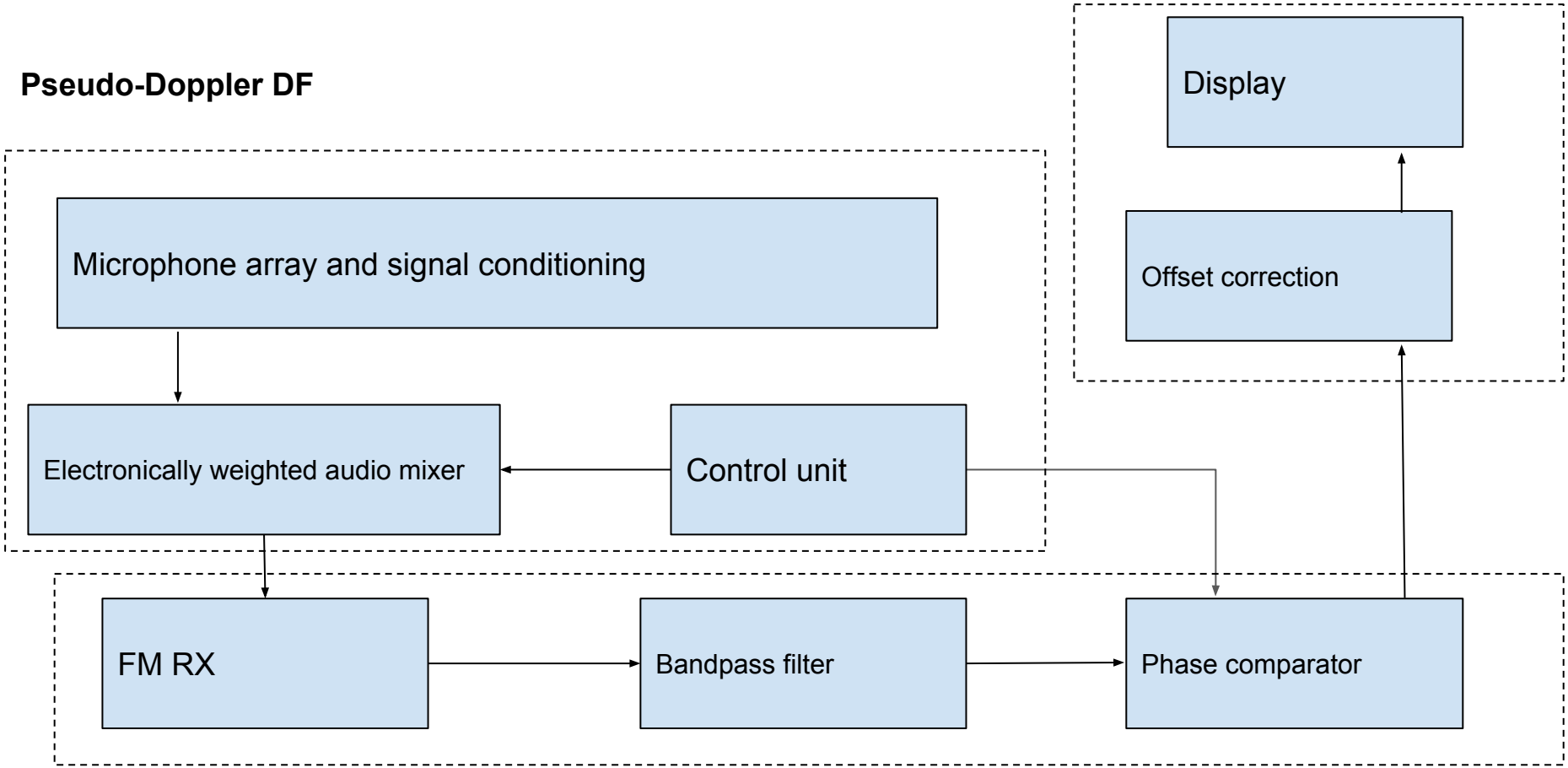
Originally idea: Radio Direction Finder (RDF) operating in FM band…

Same principle of operation holds for audio frequency

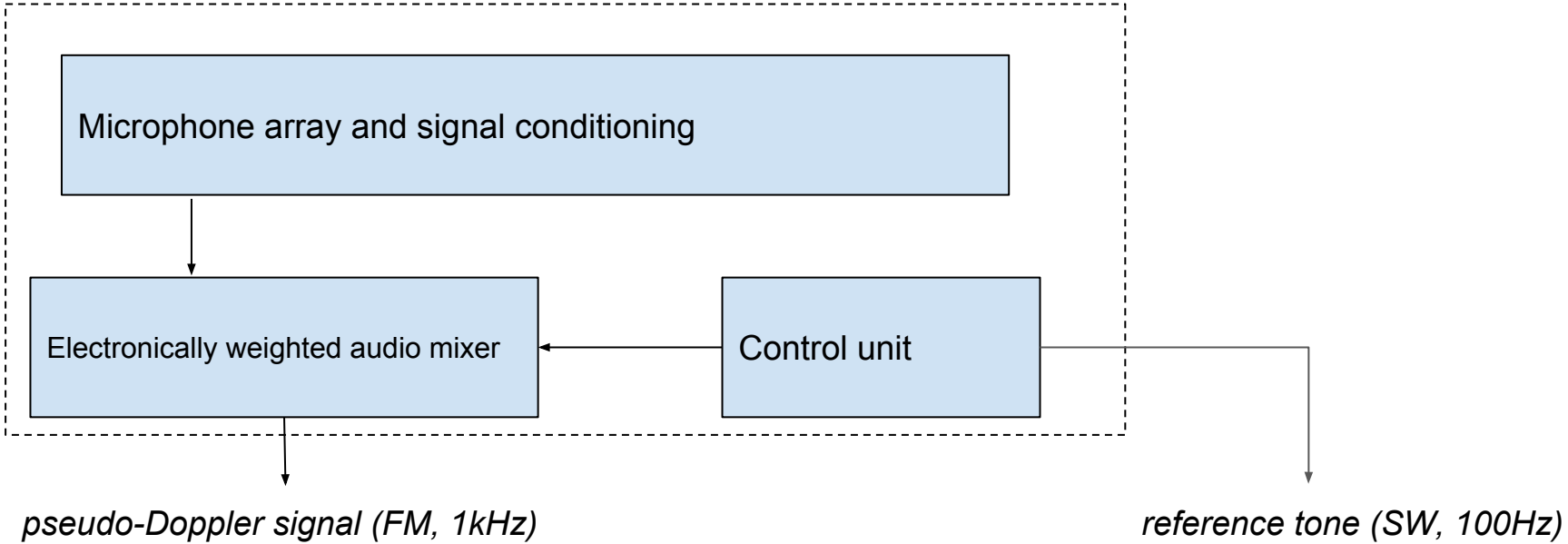
Analog solutions for most of the functionality



# High-Level Block Diagram

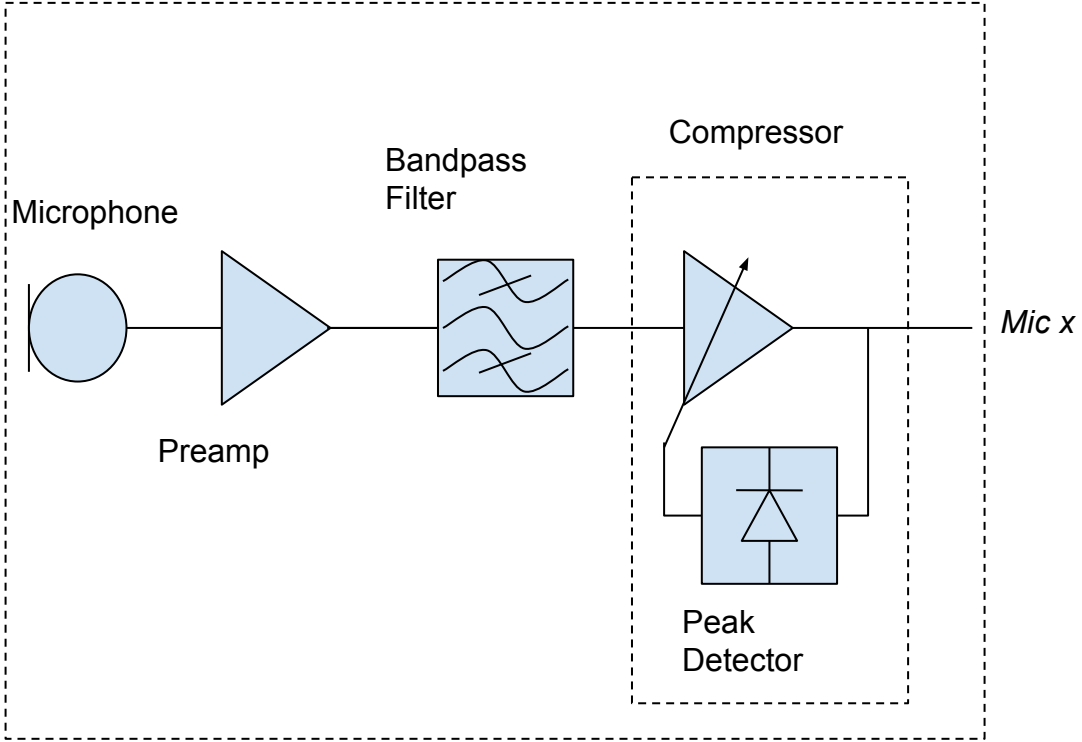


# Overview: Signal Acquisition Module



# Close-Up: Signal Acquisition Module

## Signal Conditioning - Block Diagram




Considerations:

- Why is AGC needed?
- Why is BPF needed?

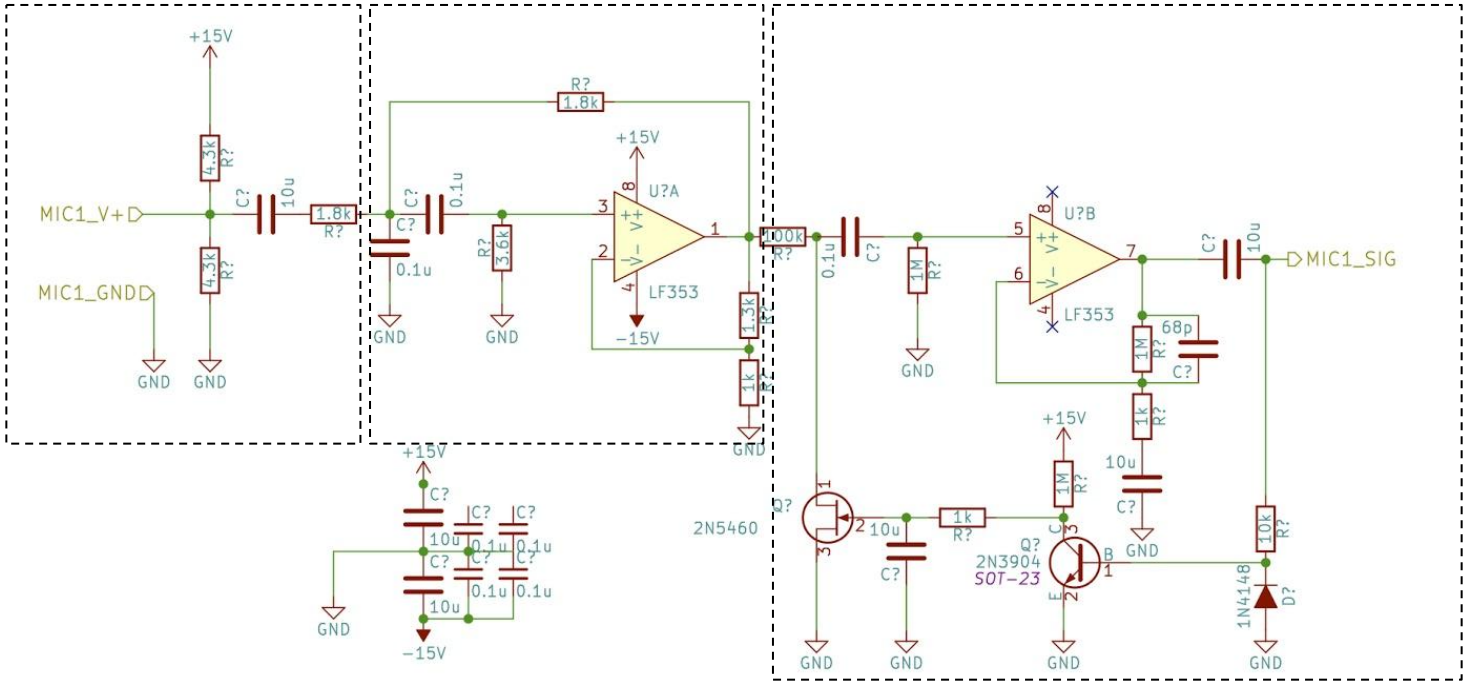
# Close-Up: Signal Acquisition Module

## Signal Conditioning - Implementation

mic input stage

band-pass filter with gain

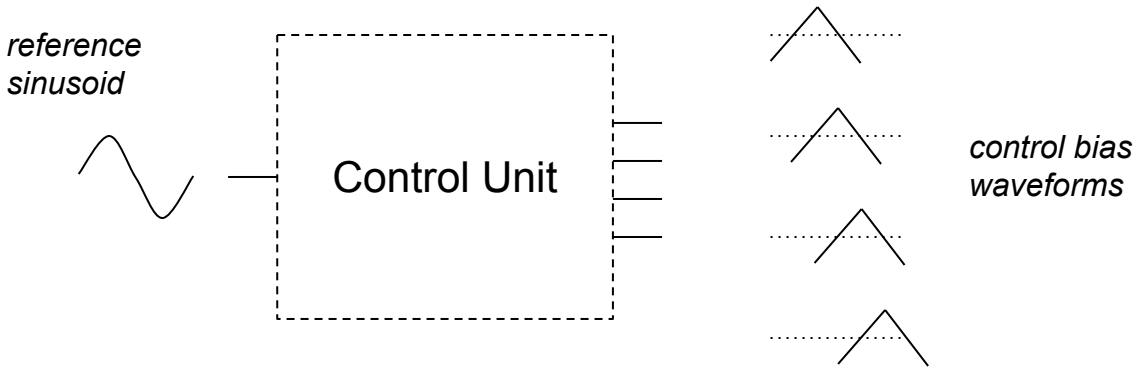
compressor (with gain)




Complications with multipath?

# Close-Up: Signal Acquisition Module

## Control Unit - Block Diagram



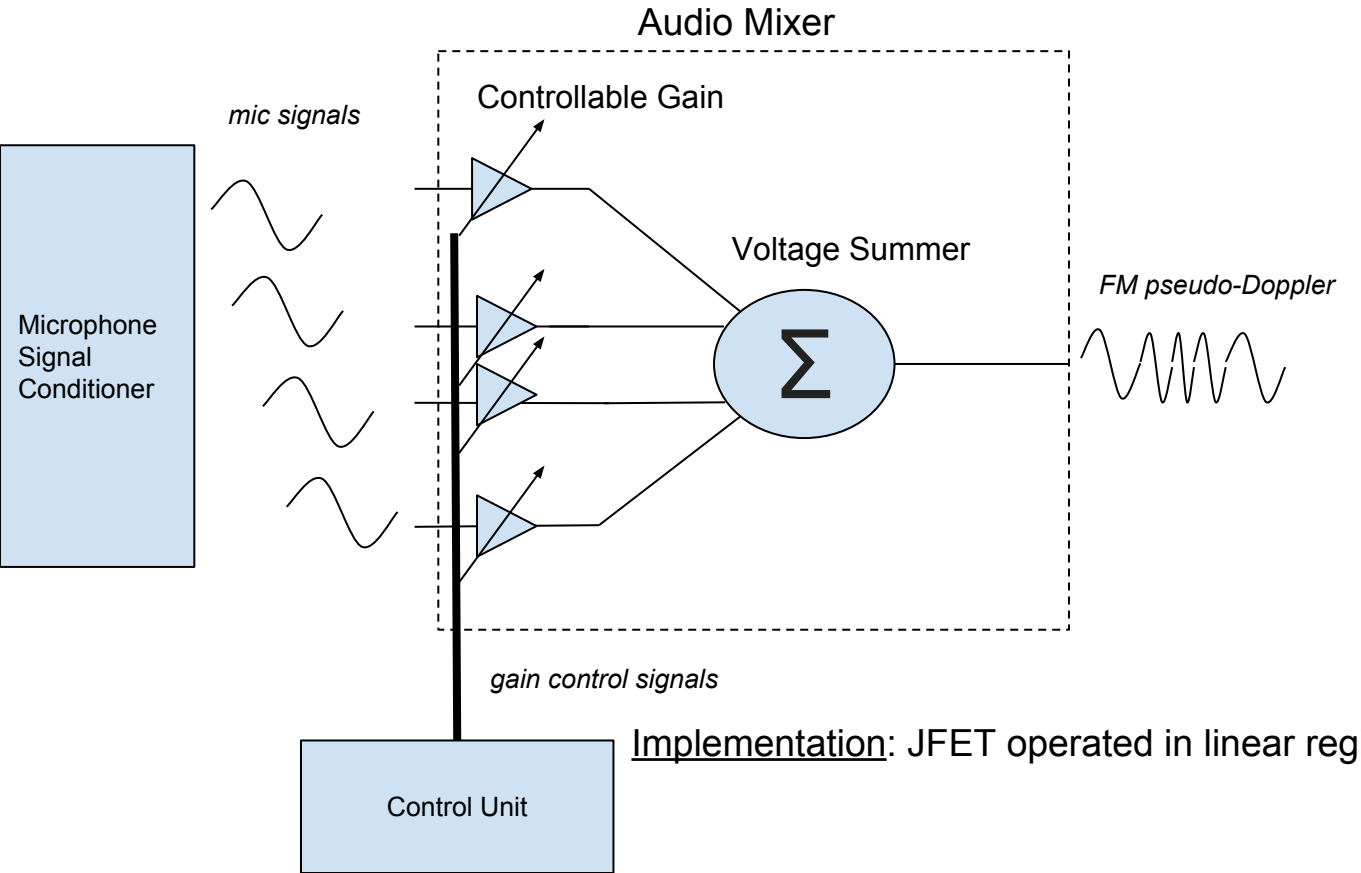

Considerations:

- Shape of bias waveform?
- How to make quadrature?

Implementation: reference sinusoid → square wave → triangle (zero offset) → comparator → quadrature

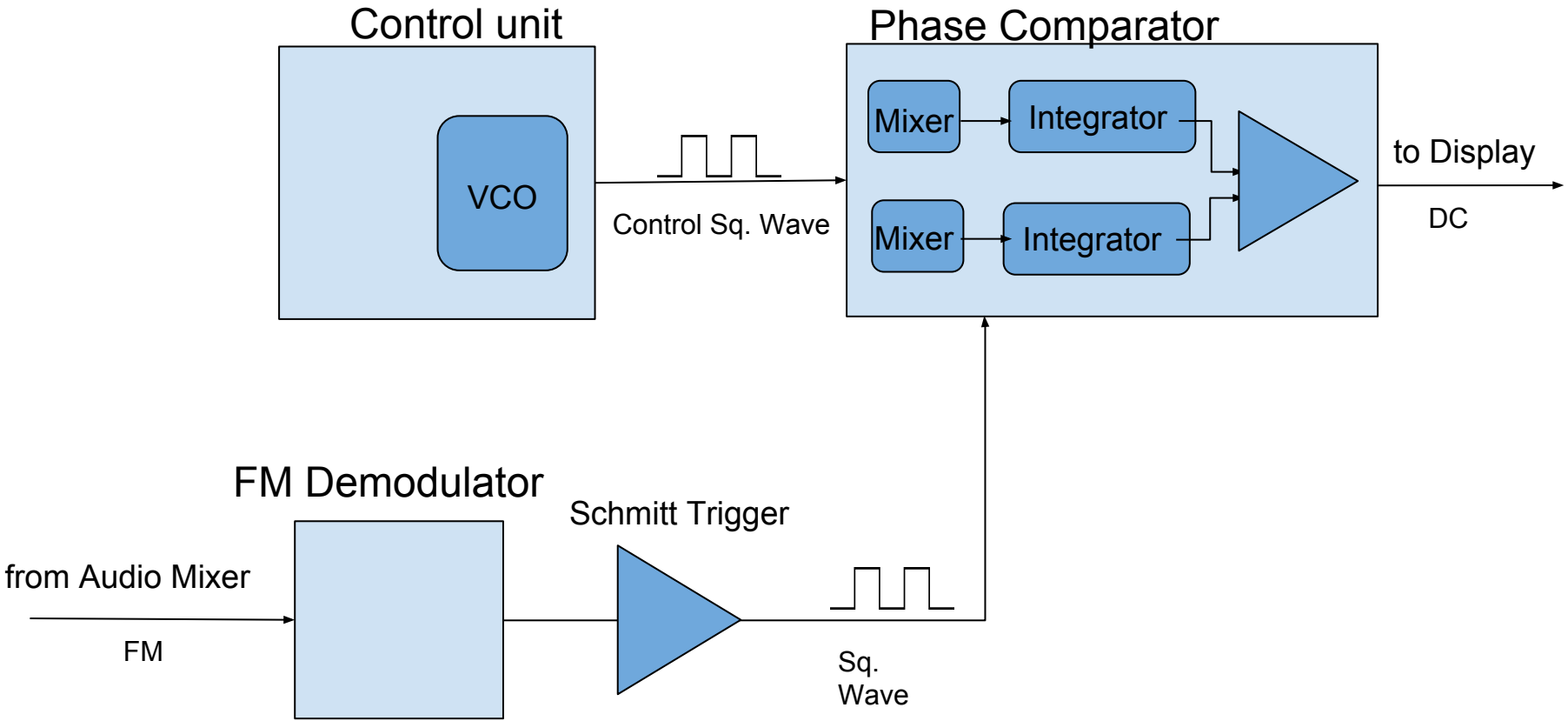
# Close-Up: Signal Acquisition Module

## Voltage Controlled Audio Summer - Block Diagram



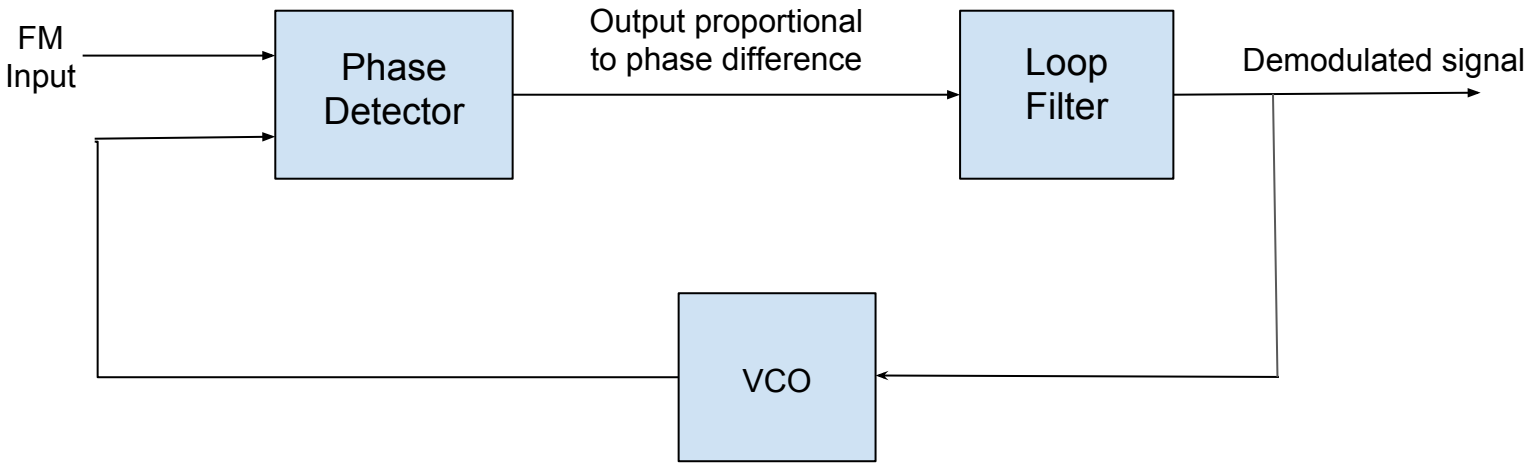

Implementation: JFET operated in linear regime for voltage controlled gain

# Phase Extraction

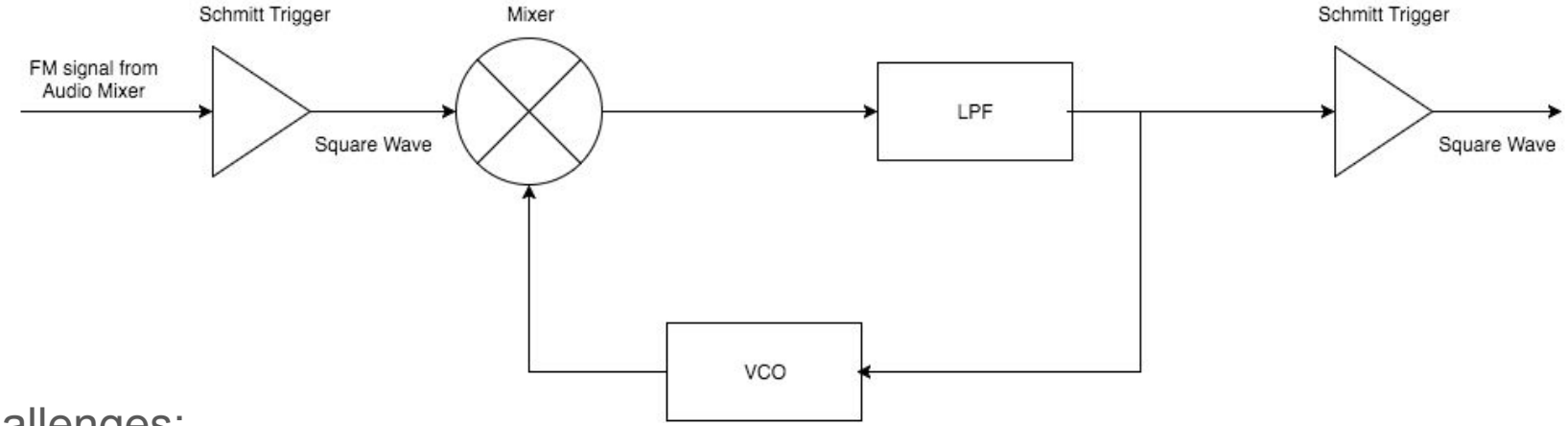


# FM Demodulator

1st-order Phase locked loop



# Close-Up: FM Demodulator

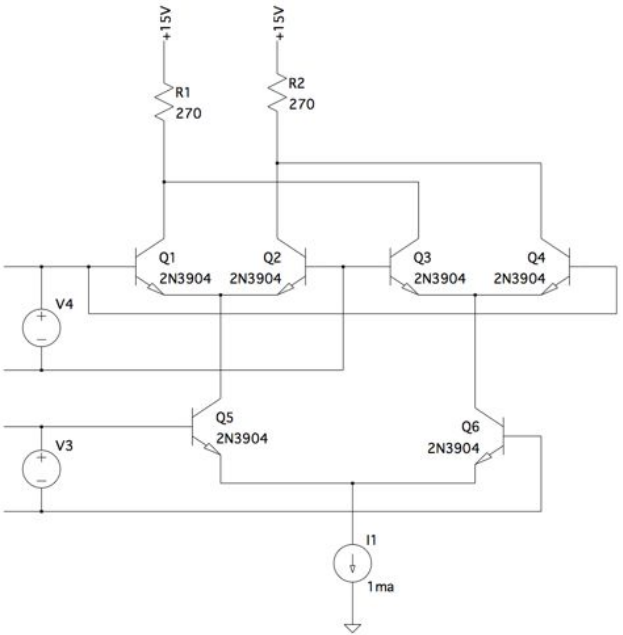


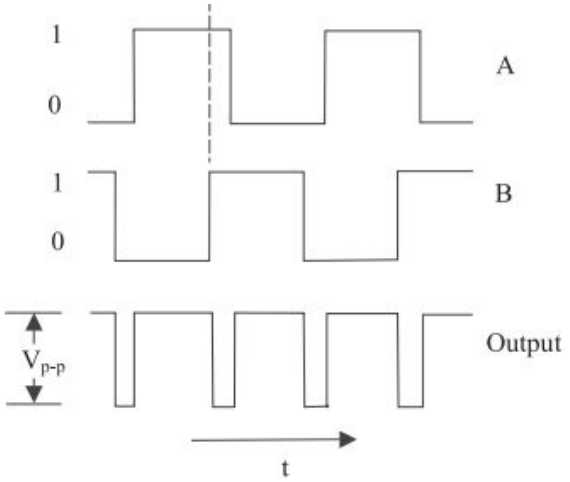

Challenges:

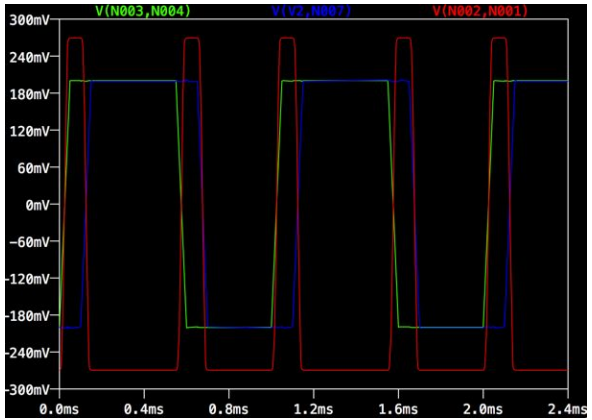
- Tuning the low pass filter
- Jitter

# Gilbert Cells and Mixing

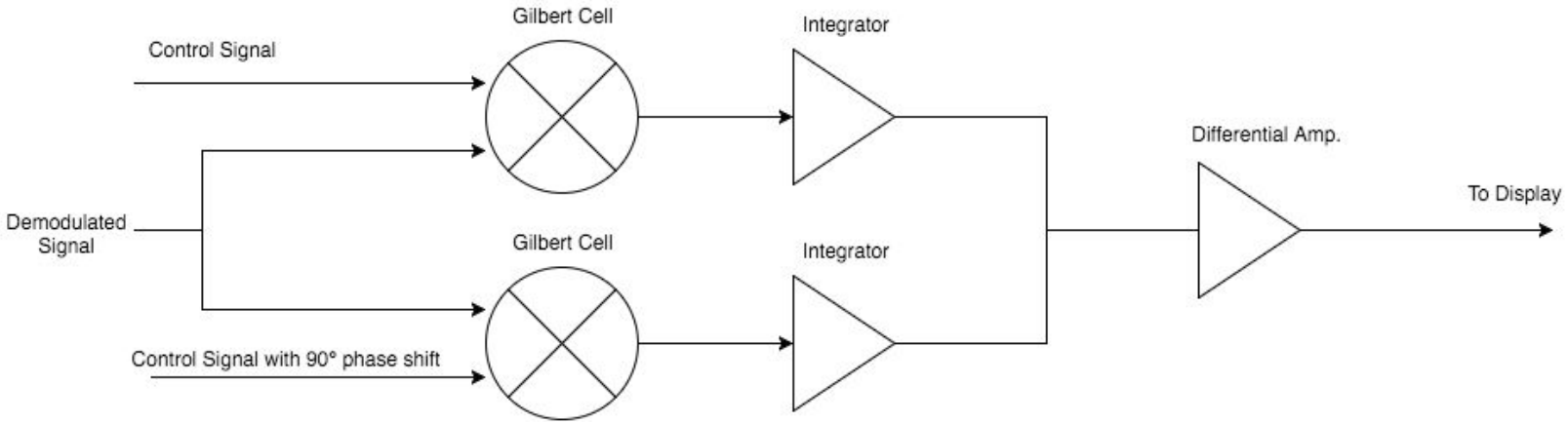
## Schematic



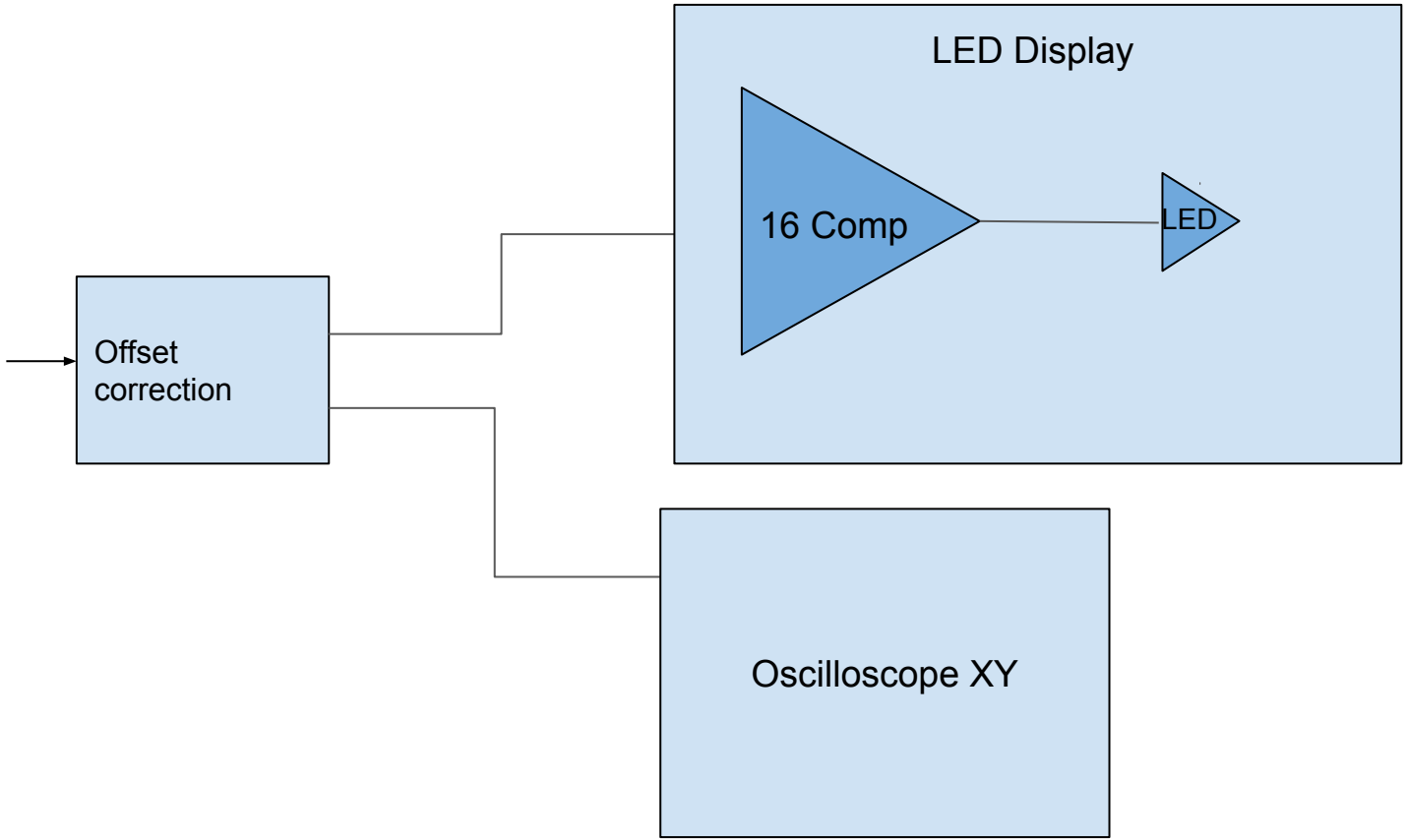
# Phase comparison



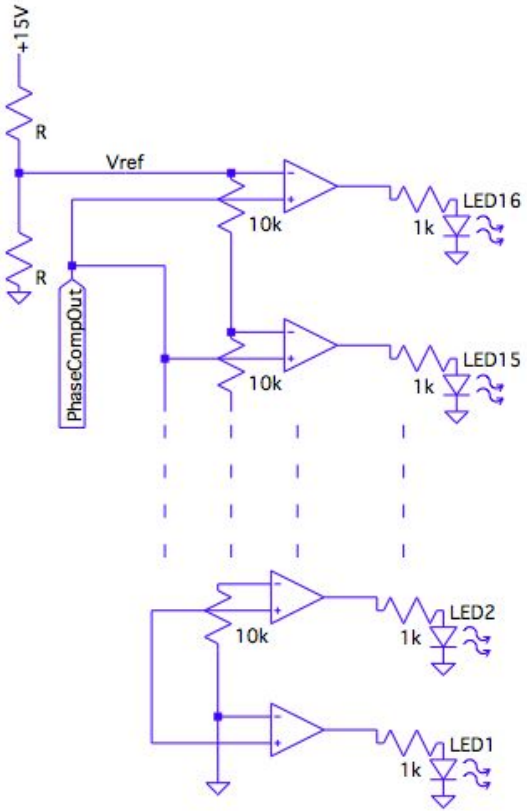

Challenges:

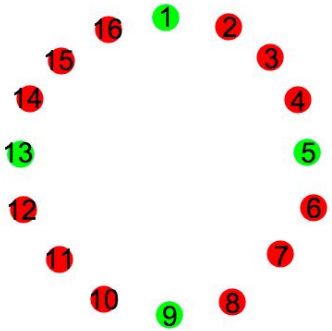
- Asymmetry of components

# Display



# LED Display



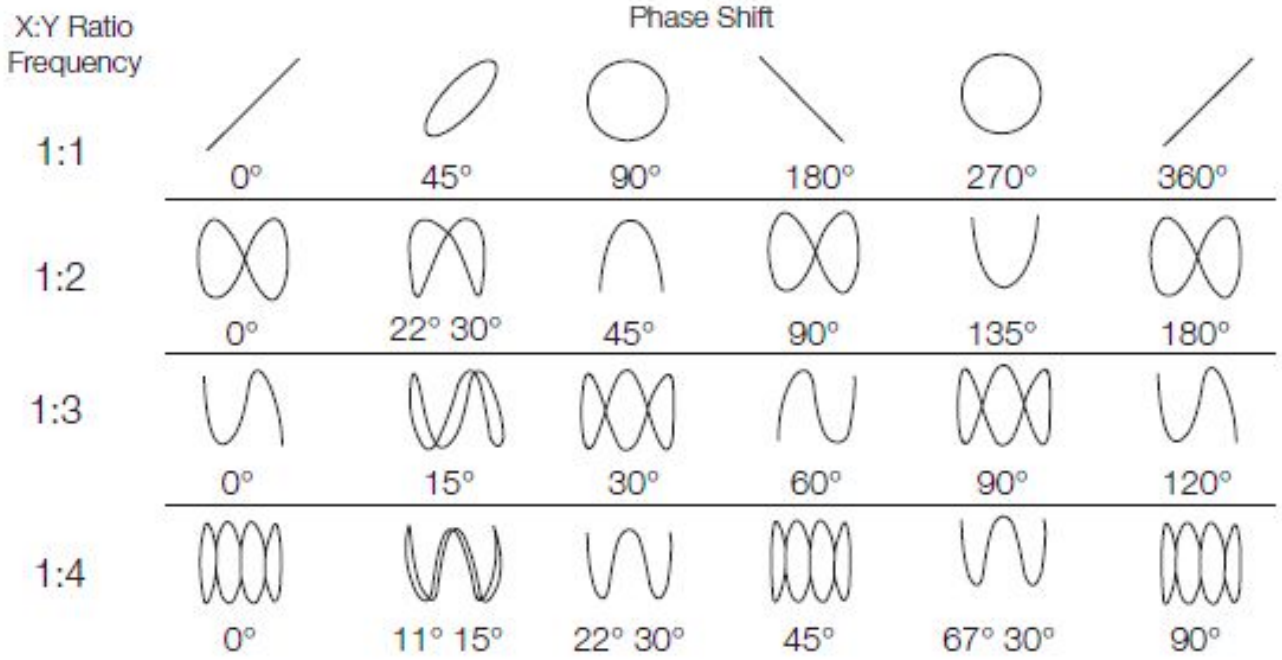

## Negative Terminals

- 0, Vref/15, 2Vref/15, ... 14Vref/15, Vref

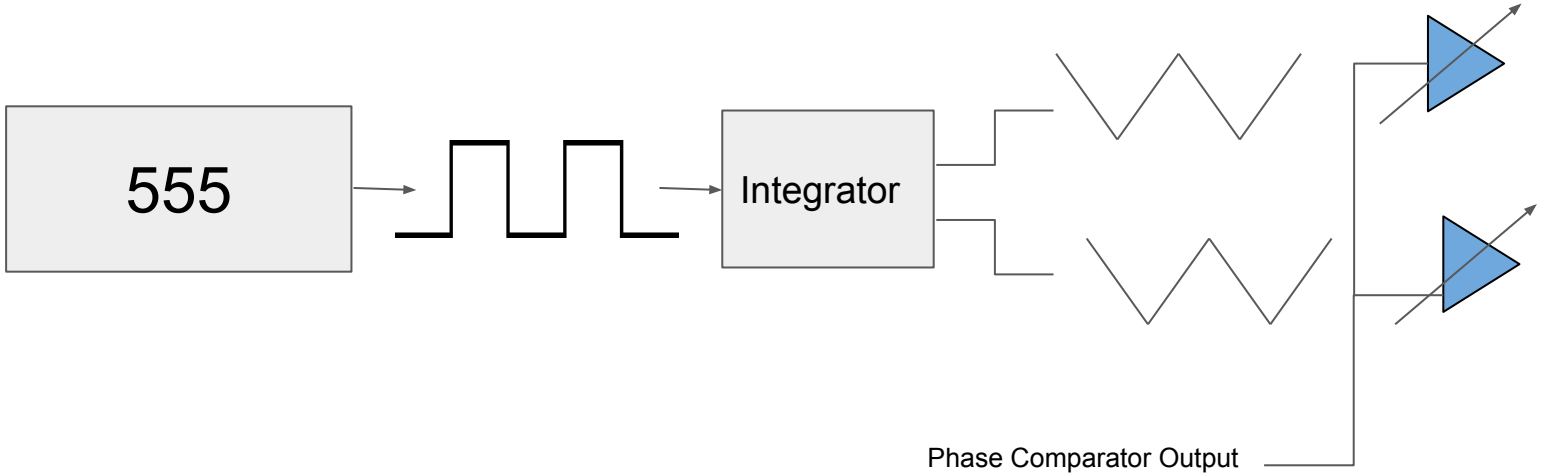
## Positive Terminals

- All connected at phase comparator output

# Oscilloscope XY Display



# Oscilloscope XY Display



# Schedule

| **Week of** | **Tasks** |
|---|---|
| April 11 | Begin building individual modules |
| April 18 | Continue building individual modules. Begin integrating/debugging modules |
| April 25 | Continue integrating/debugging modules. Begin working on stretch goals |
| May 2 | Continue working on stretch goals. Demonstration of complete system |

# Concluding Remarks

Expected outcome:

- Complete PD-DF system that can point toward speaker with good accuracy
- Extensions: lay out a PCB, redesign for RF, more elaborate interface

Next steps:

- Finish up individual modules (design, construction, test)
- Test interconnected modules

# Questions?