The University of Texas at Austin
Cockrell School of Engineering

# NOISE REDUCTION OF QUADCOPTER DRONES FROM DIFFERENT FREQUENCY PHASE OFFSETS

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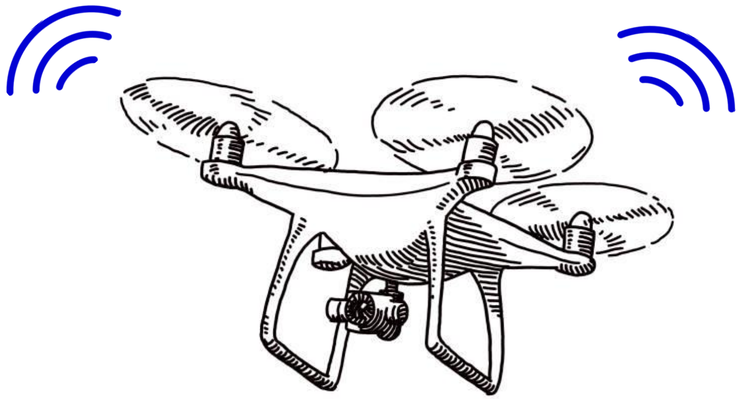
# Motivation



How can we design a **control system** to **reduce noise** on quadcopter drones?

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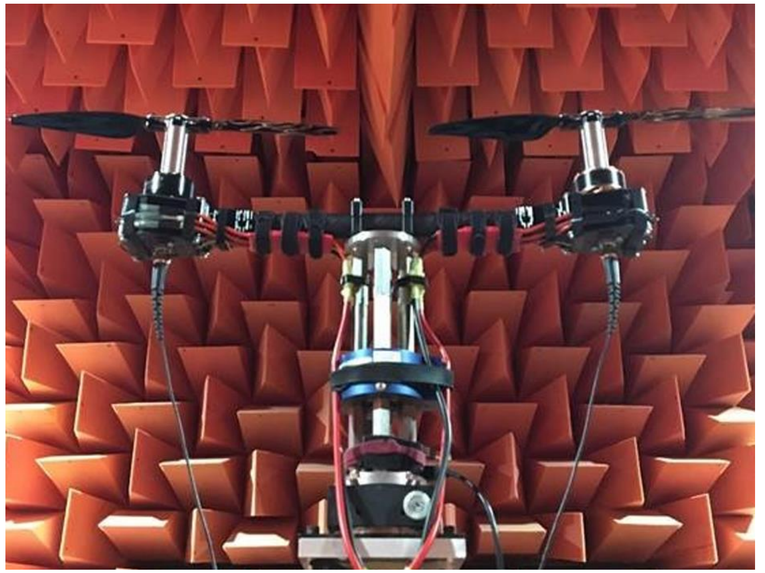
# Main Idea

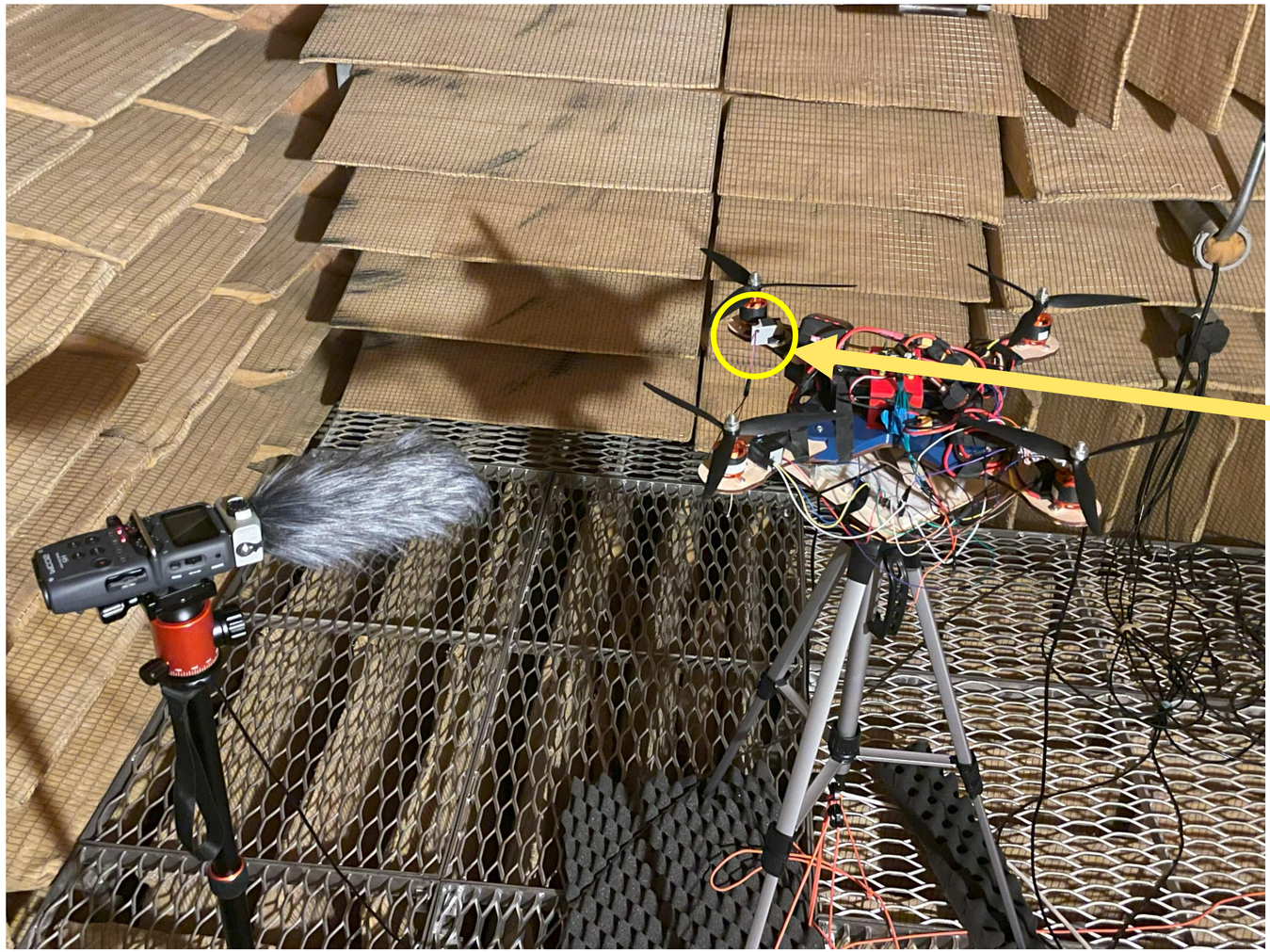

Phase Lock Loop for Drone Propellers

**Controller Design for Propeller Phase Synchronization with Aeroacoustic Performance Metrics**

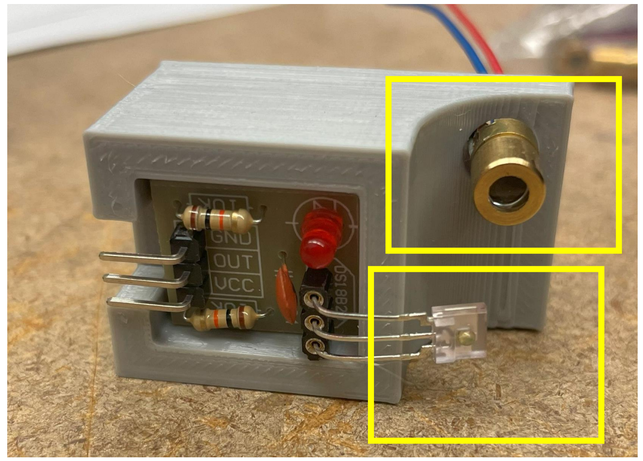


Patterson, A., Schiller, N. H., Ackerman, K. A., Gahlawat, A., Gregory, I. M., & Hovakimyan, N. (2020). Controller design for propeller phase synchronization with aeroacoustic performance metrics. In *AIAA Scitech 2020 Forum* (p. 1494).

# Experimental Setup



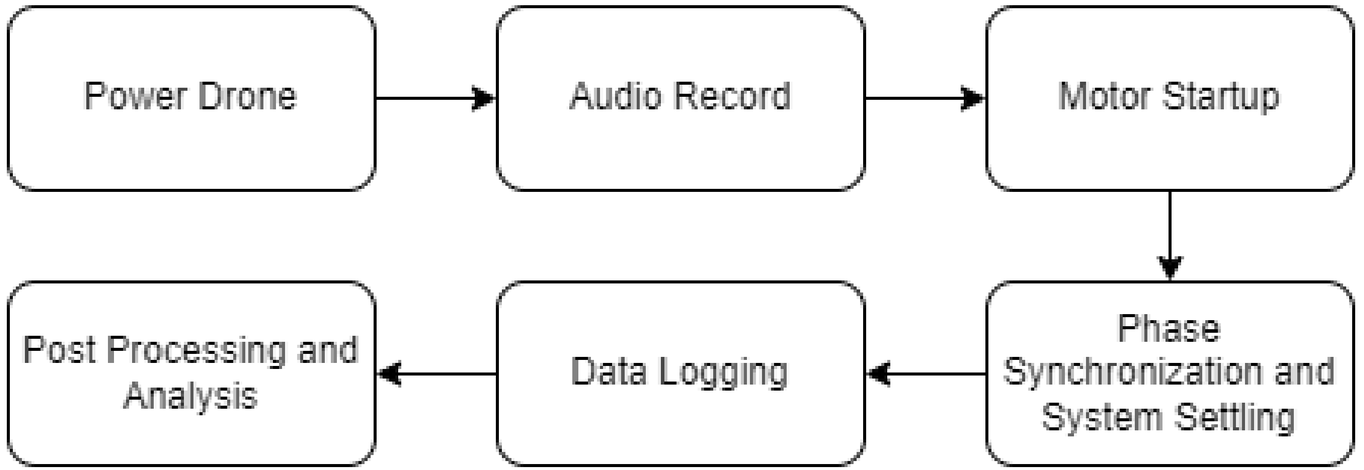
## Laser Tachometer




IR Laser

IR Detector

# Experimental Procedure



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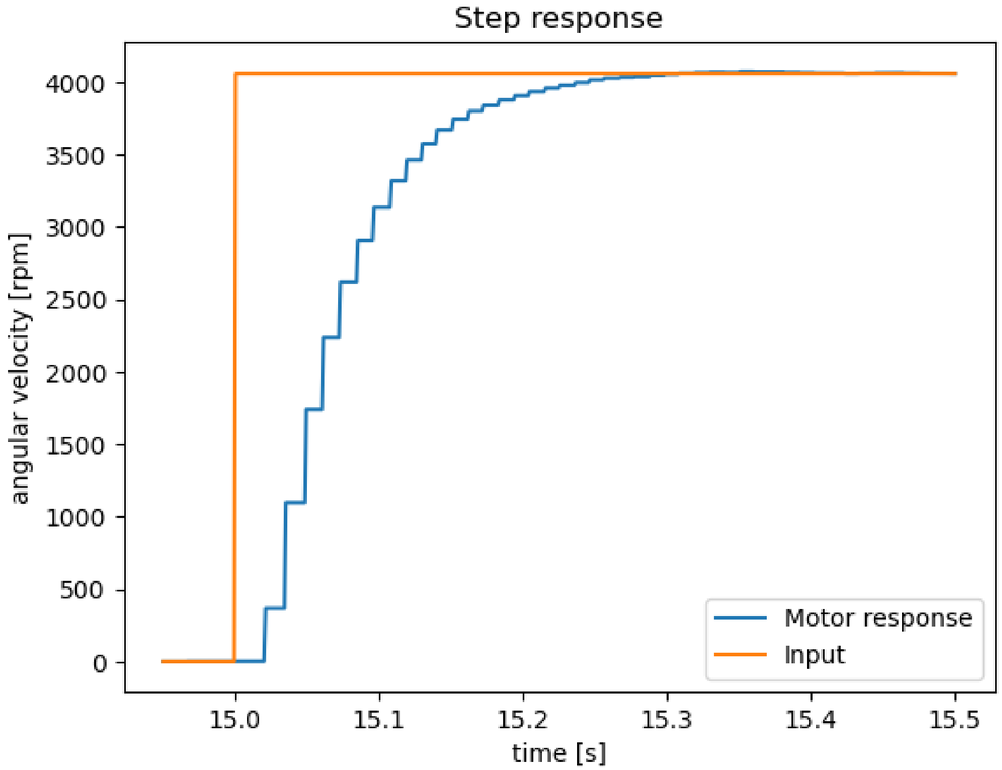
# System Identification

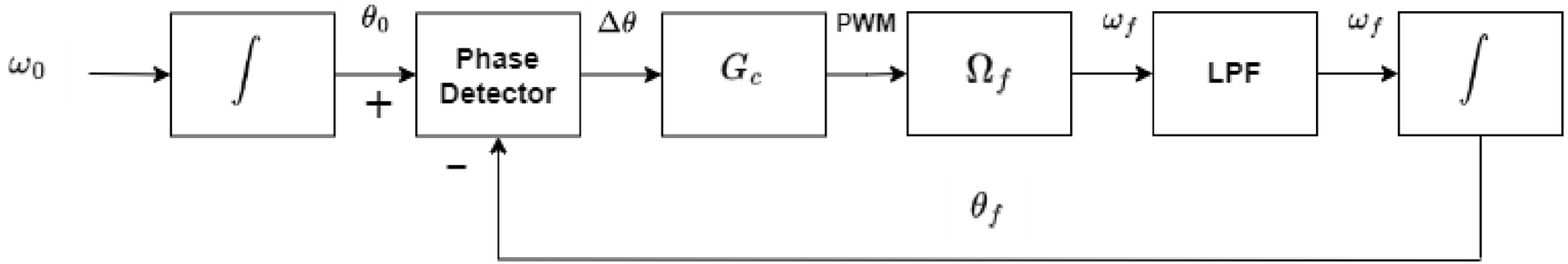



$$\Omega(s) = \frac{2081}{s + 9.708}$$

# Controller Design

## Phase Lock Control System

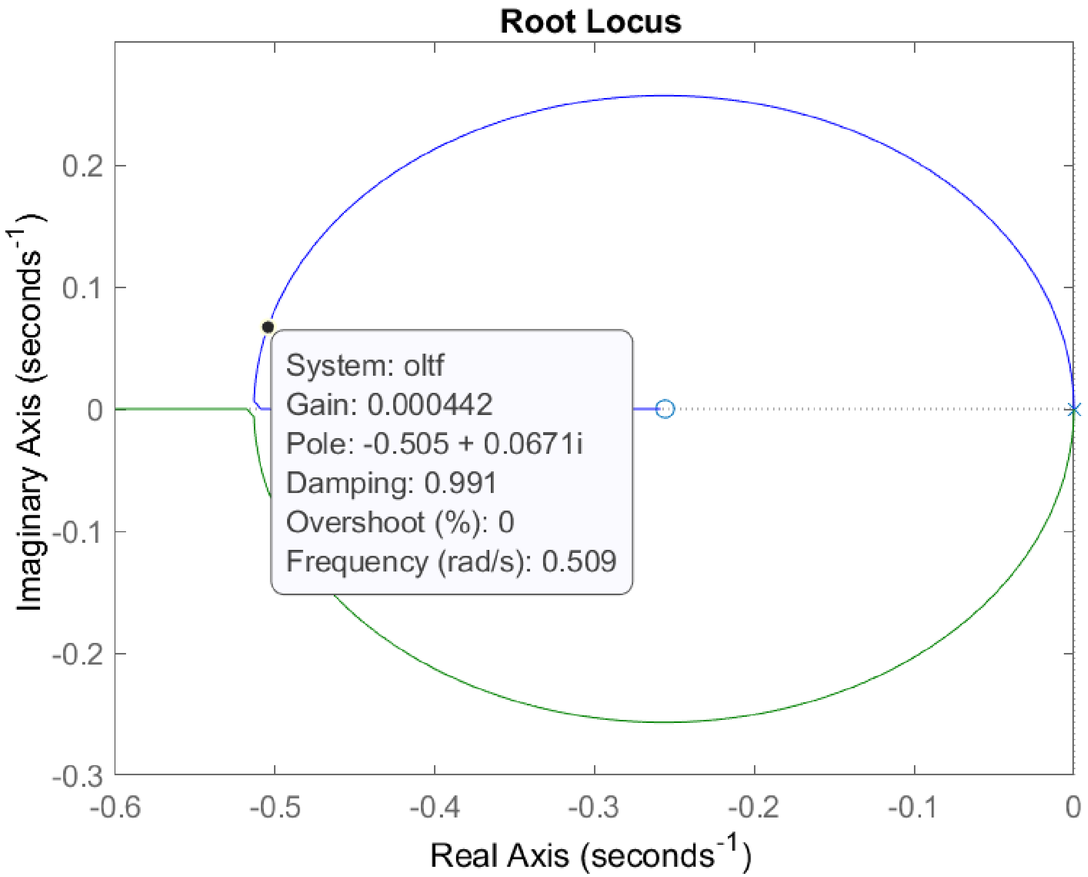
(SR = 500 Hz)




$$G_c(s) = k_d s + k_p + \frac{k_i}{s}$$

$$G_{OL} = \frac{7038(s^2 + 1.111s + 0.333s)}{s^2(s^2 + 611.65s + 5845)}$$

# Controller Design




$$G_{OL} = \frac{7038(s^2 + 1.111s + 0.333s)}{s^2(s^2 + 611.65s + 5845)}$$

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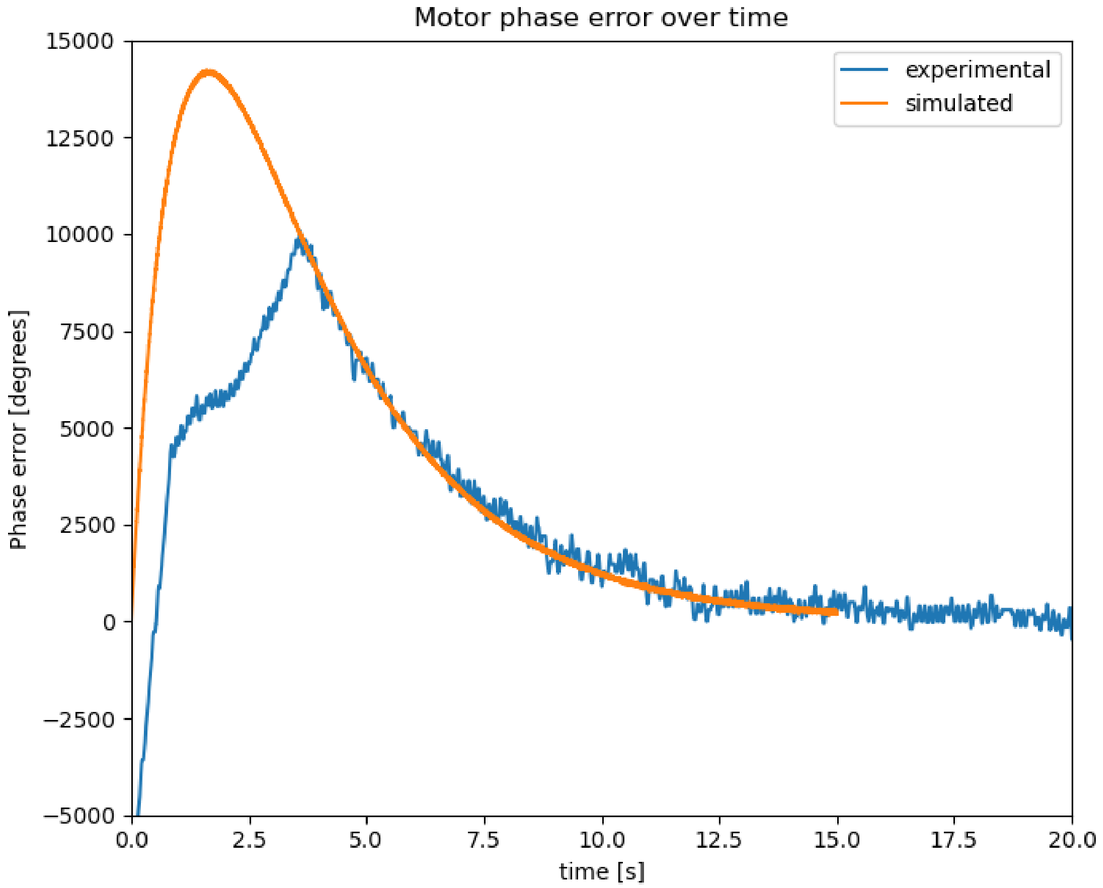
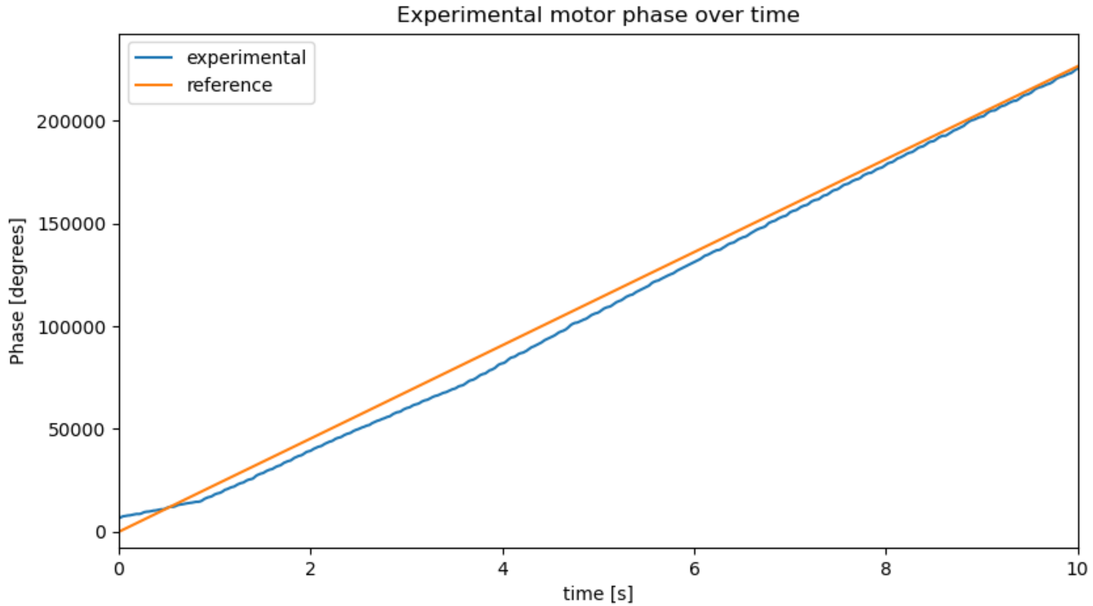
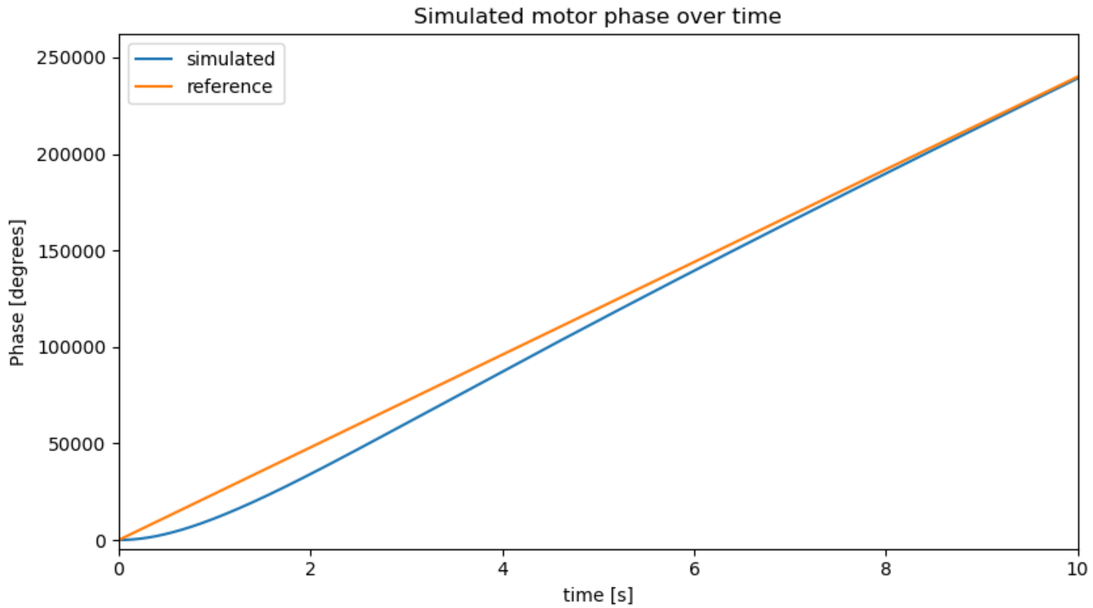
# Controller Performance




## Tachometer Readings

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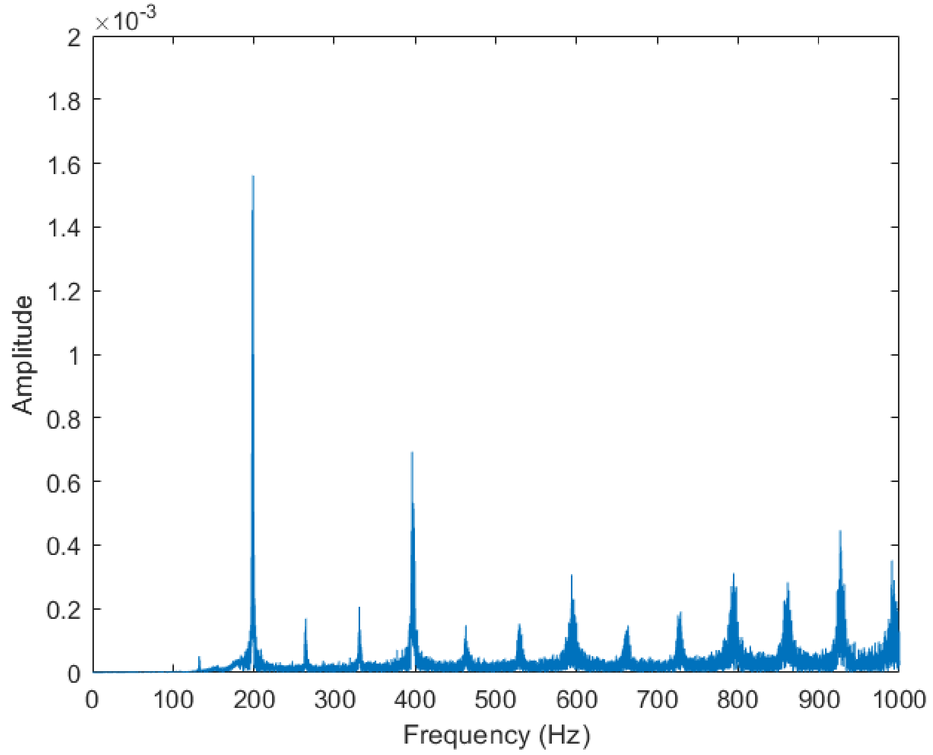
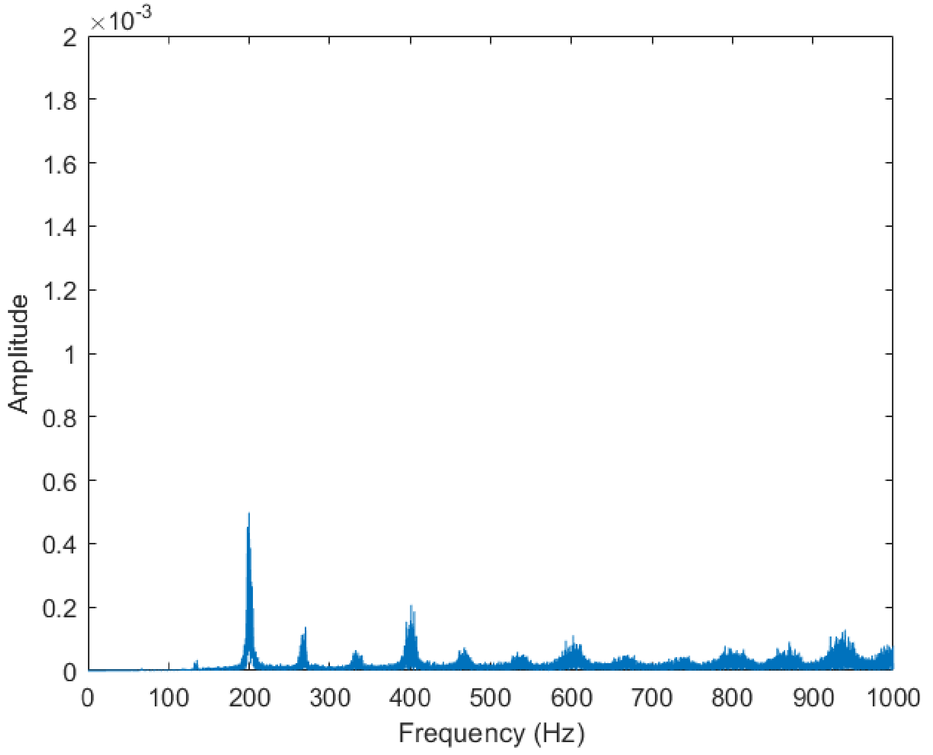
# Acoustic Results

| | Change in Acoustic Power (dB) |
|---|---|
| Conventional Operation | 0 |
| Phase Control | -4.86 |




Frequency spectrum with conventional operation




Frequency spectrum with phase control

# Conclusion

## Contributions:

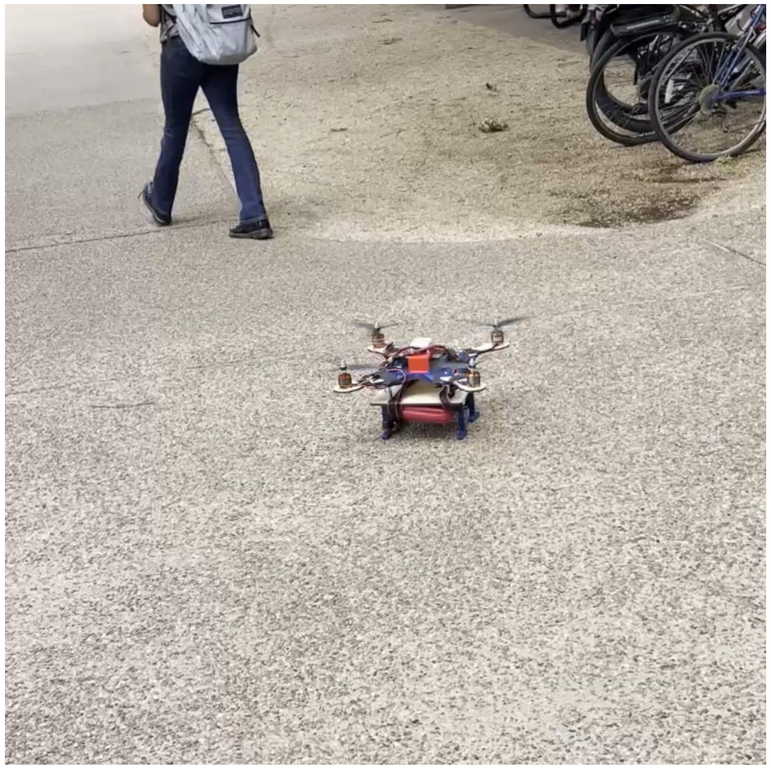
- Extended multirotor phase synchronization noise reduction to the quadcopter design
- Developed low profile, economical control system with only tachometers

## Limitations:

- Changing voltage source
- Tachometer bandwidth
- BLDC motor PWM resolution
- Grounded drone

# Future Work

- Assess acoustic performance while hovering
- Develop modular, seamless integration with proprietary FCs
- Investigate multirotor configurations
- Implement more robust controller



# THANK YOU.


- Phillip A. O. Gavino — Undergraduate Student
- Jack Qiao — Undergraduate Student
- Preston S. Wilson — Project Advisor
- Michael R. Haberman — Project Advisor
- Zhenghui Sha — Project Advisor

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