

Week 4

Using motors/props

PID tuning

Administration

- Make sure you include all requested info in reports, and submit your code.
- Be sure to make suggested corrections in canvas
- Practice flying

Milestones (overview)

1. Show assembled quad in rig with props
2. P controller (pitch DOF) with props in test rig
3. D controller (pitch DOF) with props in test rig
4. PD controller (pitch DOF) with props in test rig.
5. Test filter values in imu

(Stretch goal) PID controller (pitch DOF) with props in rig

Propeller safety

- Treat props as if they are -----→
- Penalties to grade for not following safety procedures (in addition to possibly hurting yourself)

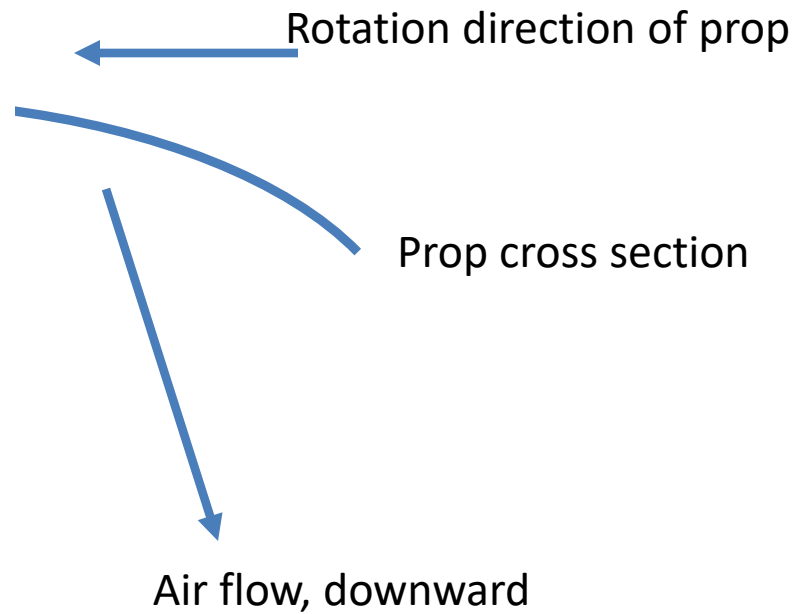
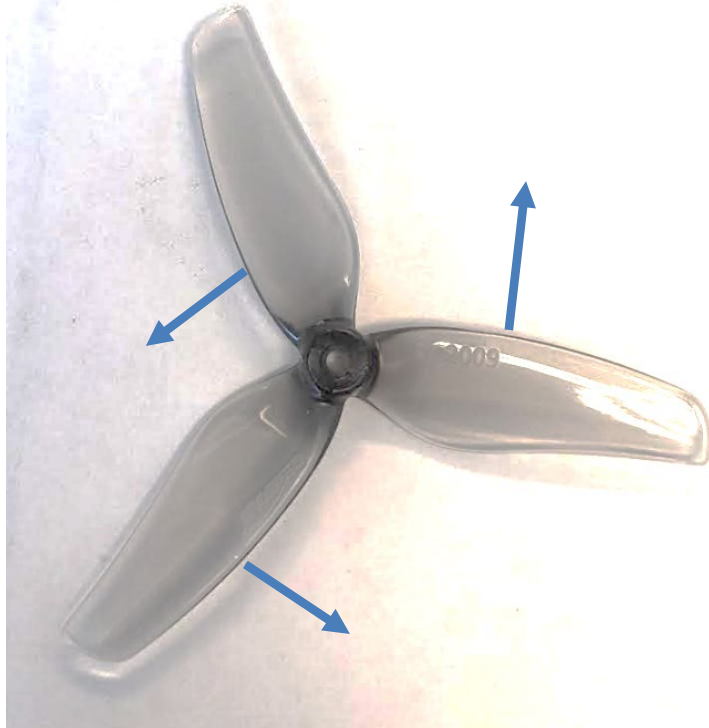


Propeller safety

- Safety glasses on at all times during class/after hours, starting once the first props are put on.
 - Tip speed >200 f/s
- Treat quadrotor with connected battery as if it could spin motors at full force at any time.
 - Whenever props are on, and battery connected, you must wear safety glasses.
 - Don't have one person always handling the quad and the other coding
- Do not touch propellers while in motion, or allow them to touch anything.
- Ensure propellers are tightly attached (ask for help if needed)
- If propellers on, do not power up quad unless you confirm that it is secured.
- Do not execute motion of propeller unless partner is ready.
- If quad is out of control, hold down and disconnect battery

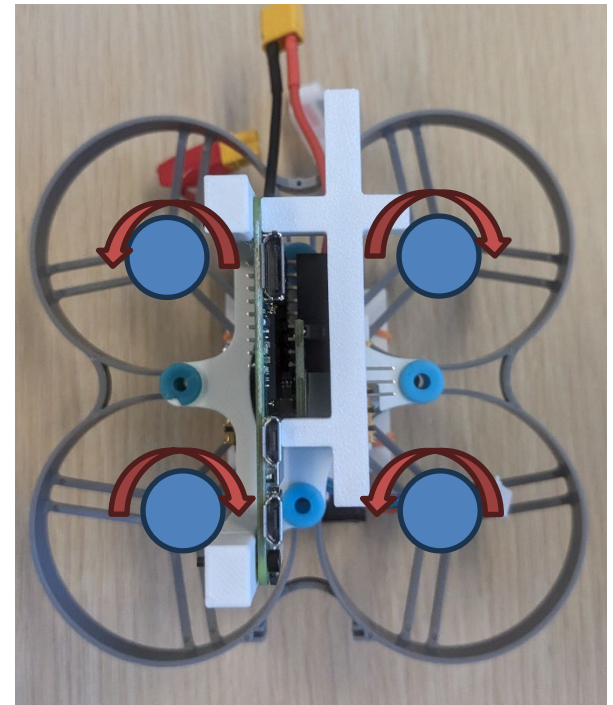
Attaching Props

Ensure correct orientation of prop,
observing its curvature



Adding propellers

- Ensure props are for the correct direction and securely tightened.
- Check props clear Pi/wires/rubber bands
- Ensure no motor speeds above 1000.
- Ensure safe propeller usage.
- Safety glasses!

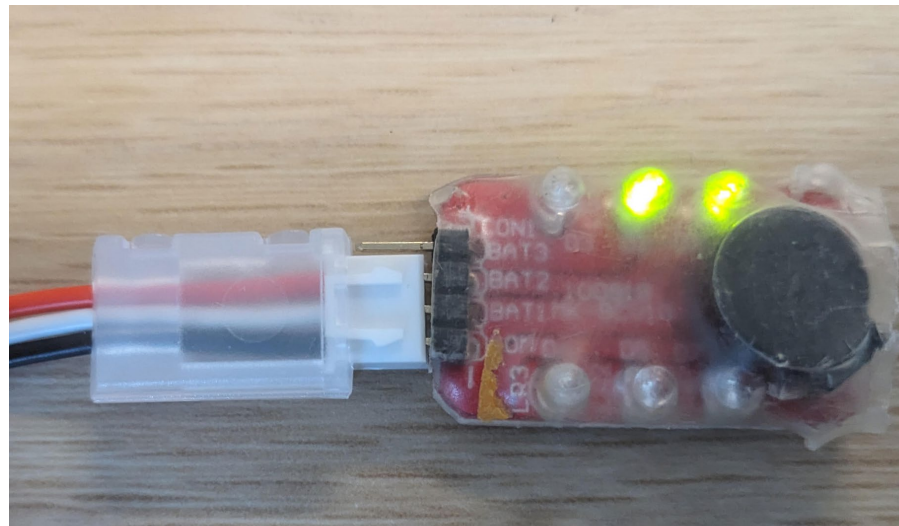


Battery Safety

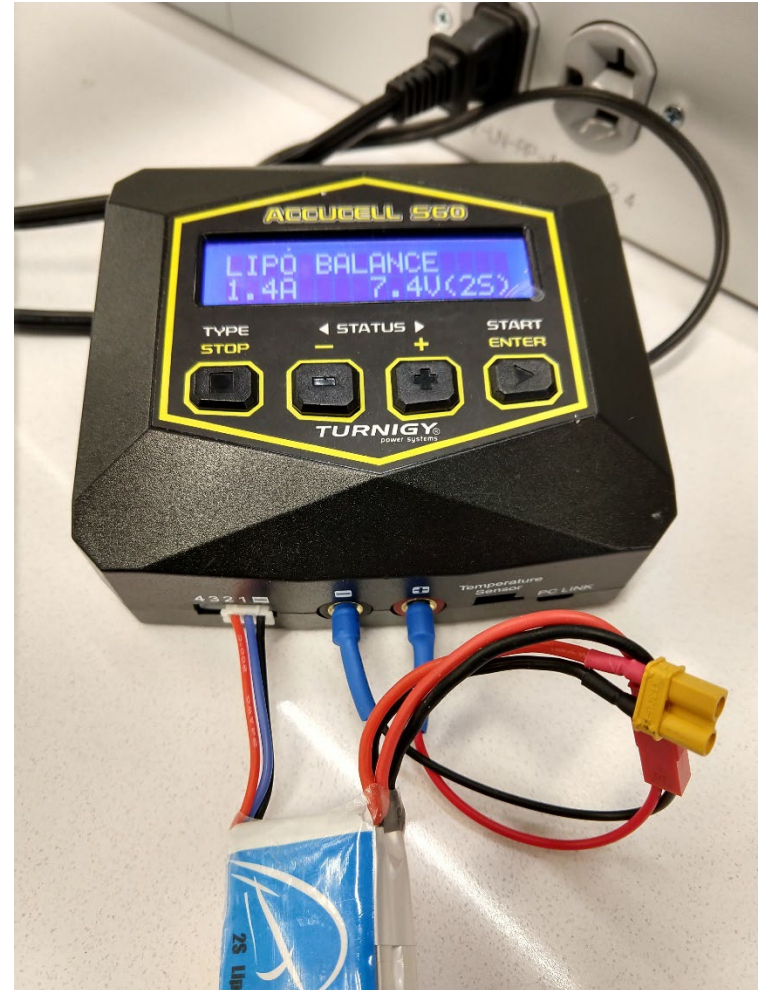
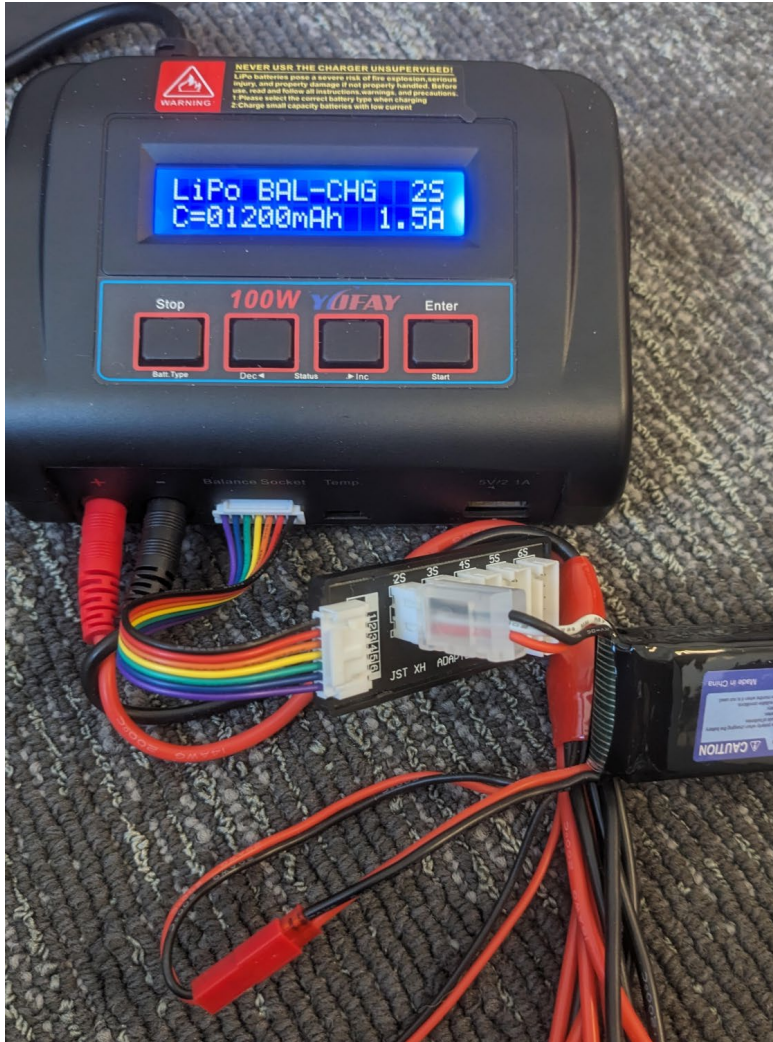
- Do not modify wiring while battery plugged into robot
- **Do not power using USB any more**
- Battery safety!!
 - Do not short (don't keep near metal objects that could short it as well)
 - Do not charge or use, without a person watching
 - Do not unplug battery cable adaptor from charger
 - Store robots without battery

Battery charging

- Each group has limited batteries
- Recharge a battery when voltage alarm beeps
- When taking a fresh battery charge any empty batteries you can.
- Be sure to recharge all batteries before next class
- Hold connector when unplugging
- Ensure settings are as shown in picture on next page
- To charge, press start, wait for confirmation, and press start again



Battery charging



Quad assembly

Do not power the board on until milestone 1 is checked off

1. Have me flash a new program on board
2. Attach PI with 3 small screws
3. Attach PCB,PI, PCB bracket with 1 big screw
4. Attach props
5. Attach test rig (so pitch DOF can move freely)
 - Keep wire short, <1 inch
 - Use cardboard to keep from damaging table

Milestone 1

- Have us check off on quad

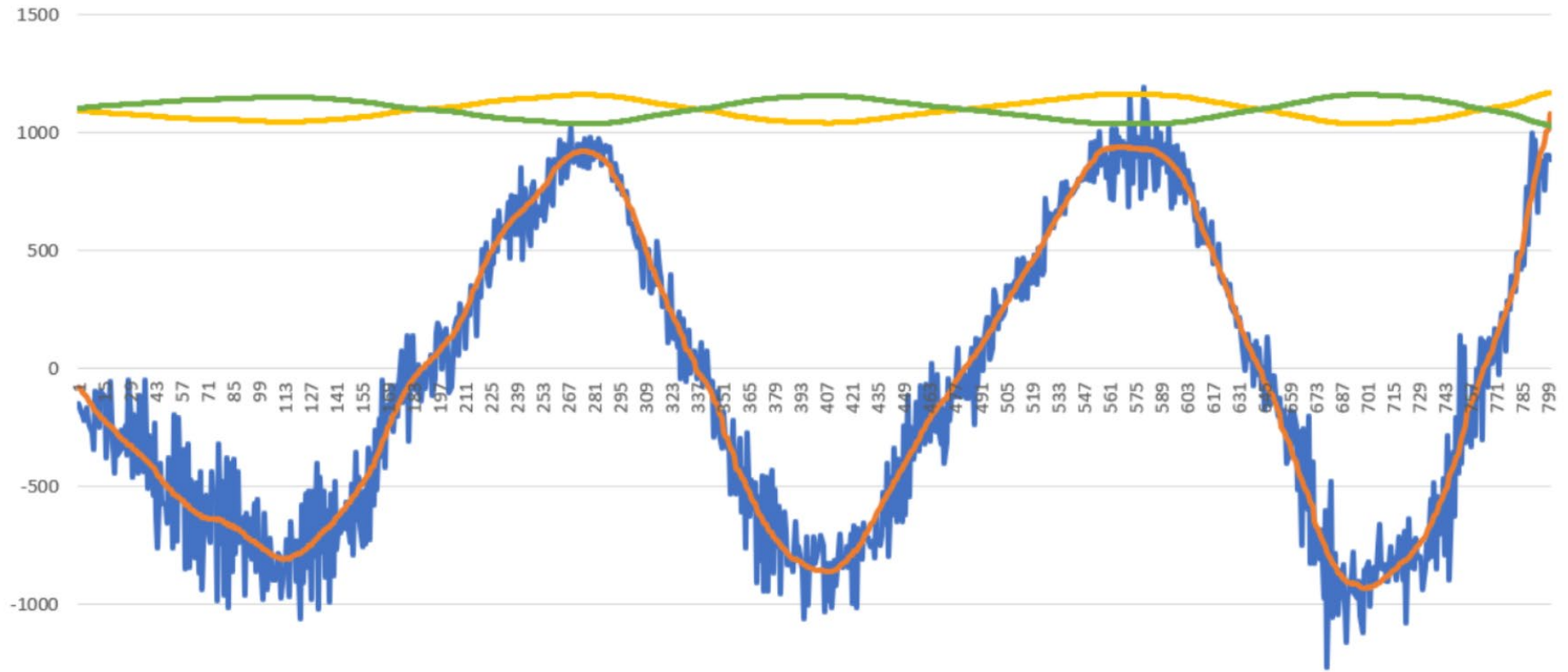
Proportional controller

- Use code updates to command motors
 - No change needed
 - Be sure to call `motor_enable()` before loop, but after IMU calibration.
- Use
 - `Thrust_neutral` = 500
 - `Thrust_amplitude` = 100
 - Adjust P_{gain} so the motors on high side stop at a tilt of approximately 20 degrees
 - Test by turning off D controller (set $D_{\text{gain}}=0$)

Milestone 2

- Turn off motors and exit program if:
 - Pitch have absolute values > 45 degrees
 - Gyro rate limit
 - User presses Control+c
 - Joystick kill
 - Joystick timeout
- P controller is apparent, no lag
- Generate and show plot of how motor speeds and pitch angle (both from accel and complementary filter) change vs time
 - Still moved by hand.

Milestone 2 plot example



Derivative (D) controller

- Desired Pitch angular velocity is 0. where pitch_velocity is read directly from gyro.
- Larger the velocity, the stronger the motors will try to bring velocity to 0.
- Correct signs cause robot to feel viscous/resists motion
- Incorrect signs cause robot to try to increase velocity
- Make sure no motor speed exceeds 1000
- Test by turning off P controller (set $P_{\text{gain}}=0$)

Milestone 3

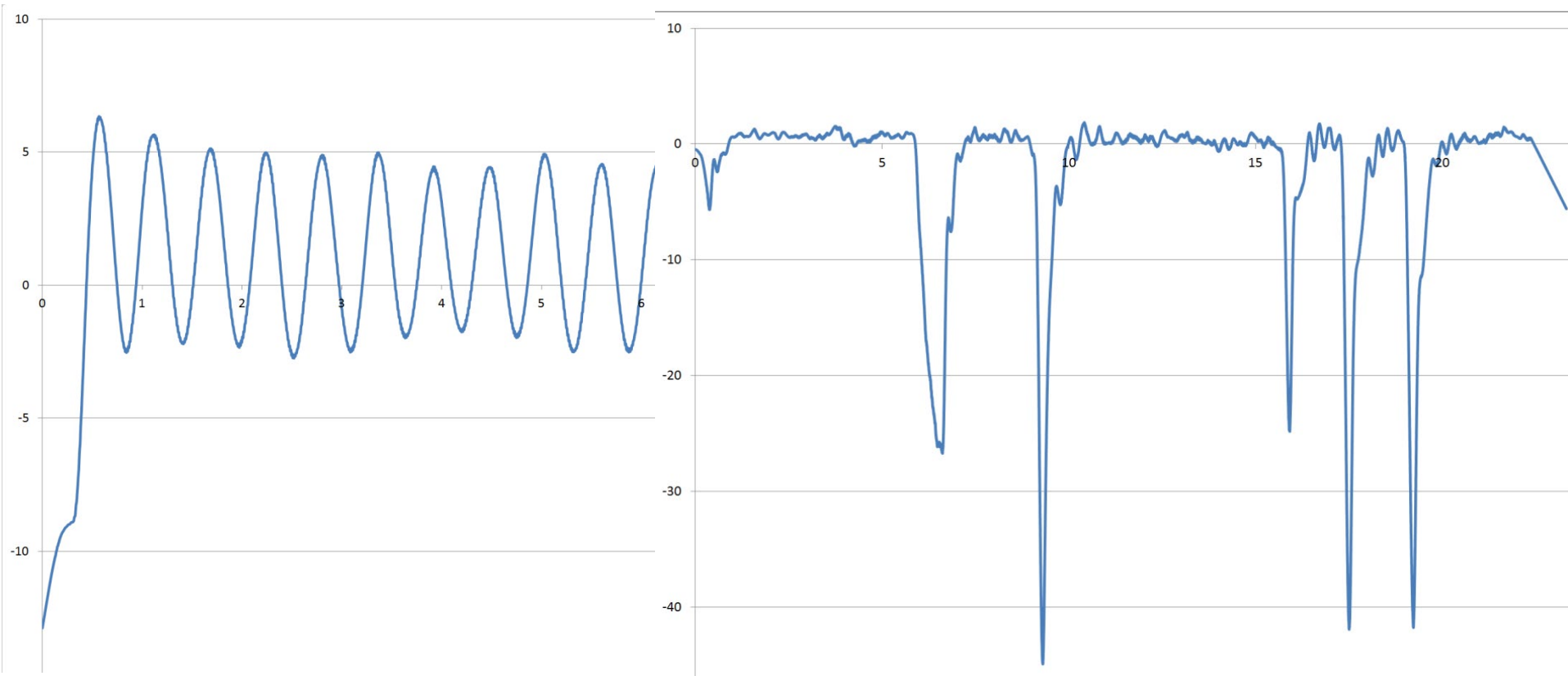
- D controller is apparent, no lag
- Safety limits still work
- Graph showing 4 motor pwm values, Pitch value (from filter), Gyro value (speed), vs time.

PD controller

- Hints for adjusting P and D
 1. First turn off D and increase P gain until it is just strong enough to lift to zero pitch.
 2. Slowly add D gain until oscillations disappear
 3. Slowly add P until it just starts to oscillate.
 4. Goto 2 until you cant improve
- Too much P, slower oscillations around desired angle, too little, no correction
- Too much D, High speed oscillations not at set point, too little will not stop P oscillations

Graph pitch response

Underdamped (too much P or too little D)



Milestone 4

- PD controller is apparent, no lag
 - Can hold position, track joystick commands
- Safety limits still work
- Graph showing 4 motor pwm values, Pitch value (from filter), Pitch value from Complementary filter.

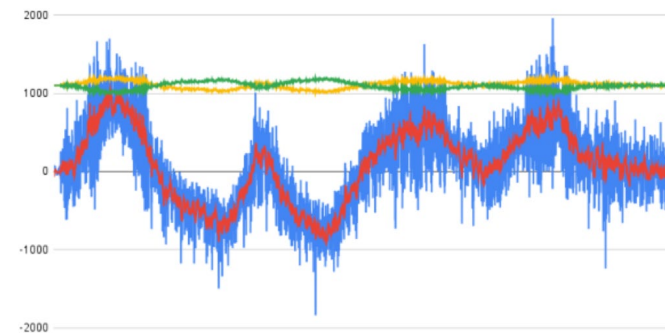
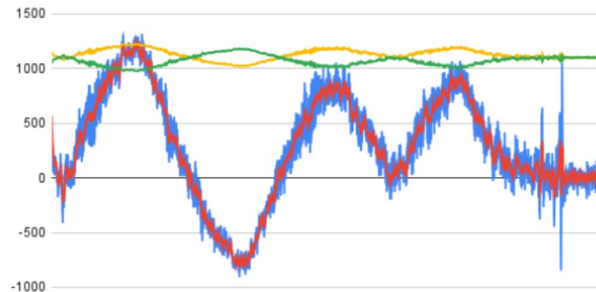
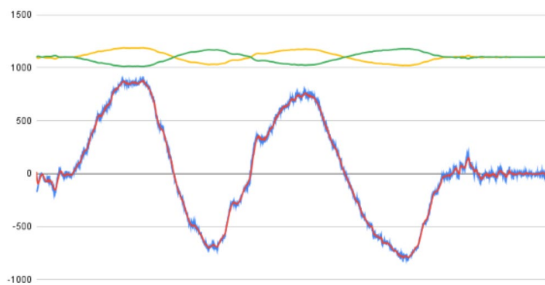
Milestone 5, DLPF

- Change filter bandwidth on IMU
- graph the effect different bandwidth (there are 3 choices) has on angle sensing (from accel and from complementary filter)

5.3.10 Register 0x40: ACC_CONF

Accelerometer configuration register.

Bit	Name	Access	Reset value	Description										
[7:4]	acc_bwp	RW	0x0A	<div>This parameter influences the bandwidth of the accelerometer low pass filter. For details, see section 4.4.1. Possible values:</div> <table><tr><th>acc_bwp</th><th>Filter setting</th></tr><tr><td>0x08</td><td>OSR4 (4-fold oversampling)</td></tr><tr><td>0x09</td><td>OSR2 (2-fold oversampling)</td></tr><tr><td>0x0A</td><td>Normal</td></tr><tr><td>others</td><td><i>reserved</i></td></tr></table>	acc_bwp	Filter setting	0x08	OSR4 (4-fold oversampling)	0x09	OSR2 (2-fold oversampling)	0x0A	Normal	others	<i>reserved</i>
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0x08	OSR4 (4-fold oversampling)													
0x09	OSR2 (2-fold oversampling)													
0x0A	Normal													
others	<i>reserved</i>													



Stretch milestone

- PID controller is apparent, no lag
- Safety limits still work
- Graph showing 4 motor pwm values, Pitch value (from filter), all vs time.