# HPV Propulsion System

# Team Hardware Review Memo

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# Introduction/Overview

This team has been working towards a regenerative braking system for an existing HPV. The design has undergone a few minor modifications as well as one major modification over the past few weeks due to changes in the project sponsor/client as well as in the engineering requirements. The biggest change is that there will no longer be a second method of power input into the vehicle. Our design will now be solely a kinetic energy recovery or regenerative braking system, retrofitted to an existing HPV that our client has chosen for us. For this hardware review, our goal was to decide on the placement of parts on the existing vehicle and finish designing our clutch and flywheel. The current state of the design can be seen in figures A.1 and A.2 in Appendix A

# CAD Design

The appendix (Appendix B) shows the newly drawn CAD images of our group. Because we have redesigned our vehicle, our team members need to redraw our Solidworks. We draw an old vehicle into a new CAD to help us continue the design. For example, reset the two brackets to fix the new shaft, which is used to connect our clutch and flywheel to the existing propulsion system. According to Appendix B, we can conclude that the size of the car frame is 75’’ x 38’’ x 34.5’’. The entire body is made of Alloy Steel, and our subsequent axle and flywheel designs are all made of steel.The size of the body does not include the size of the wheels and handles.The future goal is to perform finite element analysis on the frame or flywheel to ensure that the minimum deflection can be met under the condition of sufficient force. We will also conduct safety tests on the frame and clutch, and the specific safety test plan needs to be discussed by the team members. Appendix C shows our flywheel and clutch CAD, drawn by the team members. The specific dimensions and specifications are given in the design below.

# Clutch Design

For the clutch design, an excel tool was used to find values necessary for the clutch size and material, wear, and maximum forces and torques applied. These are shown in Table 1. We plan to test a single plate Pit bike clutch to see if it meets the requirements. If so, we plan to install this pit bike clutch, otherwise, it will be disassembled and used for parts in order to make the clutch work as needed.

***Table 1: Clutch Design Tool***

| | | | |
|---|---|---|---|
| Material | | | cork on steel or cast iron |
| Surface Finish | | | |
| Outer diameter | D | in | 4 |
| Inner Diameter | d | in | 3 |
| Thickness | th | in | 0.25 |
| Actuating Force | F | lb | *200* |
| Contact Pressure | P | psi | 36.37827271 |
| Wear Coefficient (Clutch) | K | in^3*min/(lbf*ft*h) | 0.00013 |
| Wear Coefficient (Flywheel) | K | in^3*min/(lbf*ft*h) | 0.000017 |
| Coeff. of Friction | u | | 0.5 |
| Angular Velocity | v_ang | rad/s | 0.3912559018 |
| Peripheral Velocity | V | ft/min | 2.934419263 |
| time used | t | hour | 100 |
| Revolutions | | rpm | 147.5 |
| Desired Safety Factor | | | 1.5 |
| | | | |
| Max Pressure | P_a | psi | 36.37827271 |
| Clutch Wear | w | in | 1.387738355 |
| Flywheel Wear | w_ | in | 0.1814734771 |
| Contact (Normal) Force | F | lbf | 171.4285714 |
| Frictional Force | fric | lbf | 85.71428571 |
| Torque Capacity | T | lb-ft | 12.5 |
| Max Torque | SFT | lb-ft | 8.333333333 |

# Flywheel Design

While our flywheel was originally designed to receive input from a hand-crank, it has now been reduced to only receiving input in the form of regenerative braking. This will allow for the system to be more easily adapted to the existing HPVC vehicle that the team has acquired. The team's flywheel has been designed around the idea of a nominal input power/output power, in a design tool based in excel. Now that the flywheel will only operate as an energy storage device,  the team is going to review the calculations, and alter design as needed to maintain the functionality as an energy storage device only. The flywheel will most likely serve as the backing for our clutch, depending on design, which will require a flywheel that will not deflect significantly.

***Table 2: Flywheel Calculations***

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **M.O.I. disk** | | | **KE** | | | **Angular Velocity** | | | | **Momentum** |
| r | 0.1 | m | I_d | 0.015 | | KE_d | 11.184 | KJ | w_d | 38.61605 | Rad/s | | 115.8481765 |
| m | 3 | kg | | | | | | | | 6.145936 | rev/s | | |
| H | 3.728 | KW | | | | | | | | 368.7561 | rpm | | |
| t | 3 | s | | | | | | | | | | | |
| rho | 7700 | kg/m^3 | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | **Volume** | | | | **Thickness** | | | | | | |
| | | | v_d | 0.000389 | m^3 | | h_d | 0.01240168388 | m | | | | |
| | | | | | | | | 12.40168388 | mm | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | **M.O.I hoop** | | | **KE** | | | **Angular Velocity** | | | | **Momentum** |
| | | | I_h | 0.03 | | KE_h | 11.184 | KJ | w_h | 27.30567 | Rad/s | | 81.9170312 |
| | | | | | | | | | | 4.345833 | rev/s | | |
| | | | | | | | | | | 260.7500 | rpm | | |

## Sensory & Display Hardware

Our sensory display prototype hardware and software consists of an Arduino Uno microcontroller connected to a reed switch module. Also connected to the Arduino is a 14x2 character mini LCD display and a 9 volt battery to power the display. The Arduino takes a 5v power input. The Arduino, 9v battery, wires, a switch for the display backlight, and resistors have all been acquired. To be acquired are a neodymium magnet, a hall effect sensor, and a larger display. We plan on using a hall effect sensor rather than the reed switch due to its increased durability and accuracy. For the program logic, I will first initialize variables and starting conditions, such as turning on and prepping the display and beginning the sensor reception loop.  Next I will start the calculateSpeed() timer, and then I will calculate my speed with this formula: speed = ( conversion_factor * wheel_circumference ) / ( timer.time() ). Then I will reset the variables for the loop and return the speed. Speed calculated here can then be used for calculating energy stored in the flywheel. Refer to Appendix D for Arduino setup.

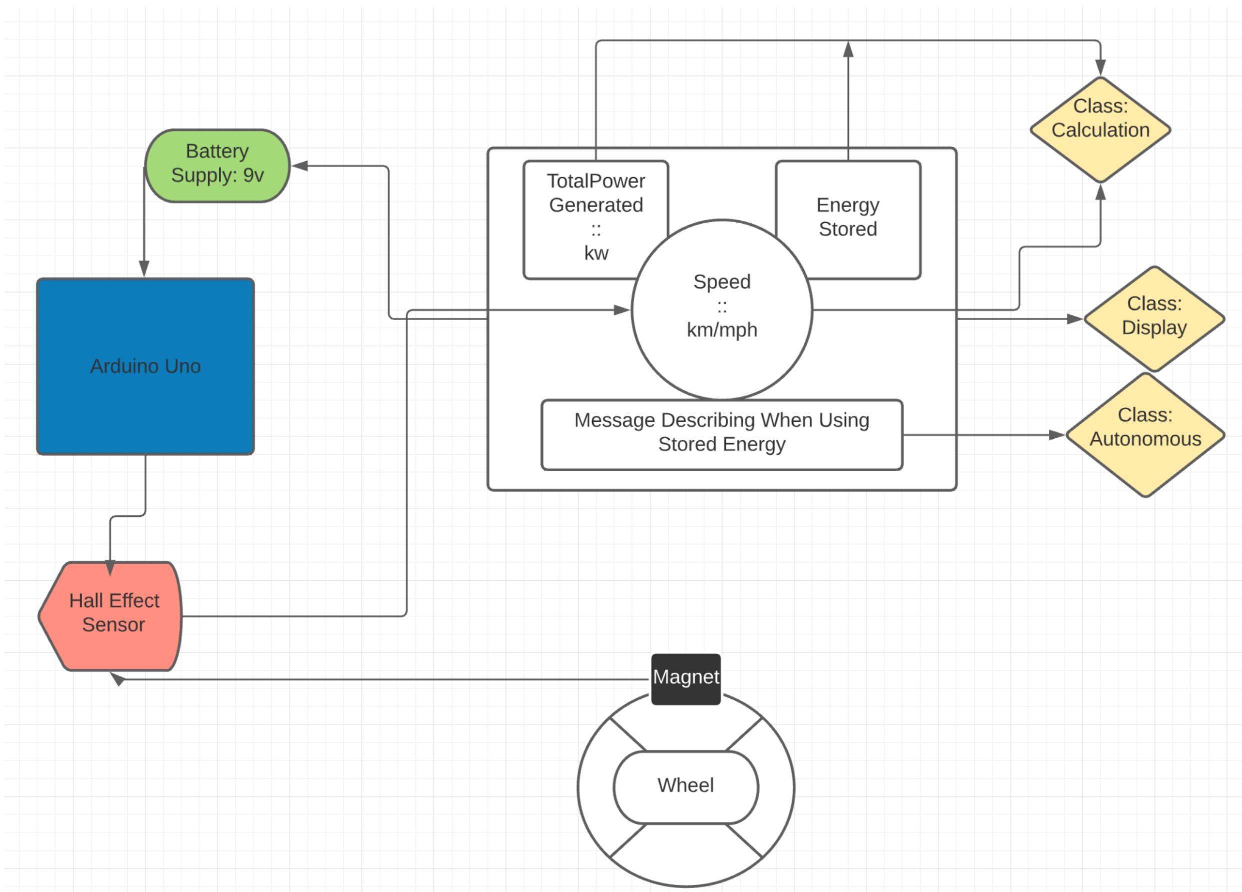


Figure 1: Hardware and Software Flow Diagram

# Purchase Order

Pit Bike Clutch: GOOFIT Heavy Duty Manual Clutch Set for 50cc 70cc 90cc 110cc 125cc Dirt Pit Bike

Flywheel: Stock Steel

Display: SunFounder IIC I2C TWI Serial 2004 20x4 LCD Module Shield for Arduino R3 Mega2560

Sensors: Hall Effect Sensor US1881 Latching

Magnets: 1.26 x ⅛ Neodymium magnets

# Schedule


Figure 2: Gantt chart

# Appendices

## APPENDIX A

Figure A.1: Current State of Design

Figure A.2: Close-up of Regenerative Braking System

# APPENDIX B

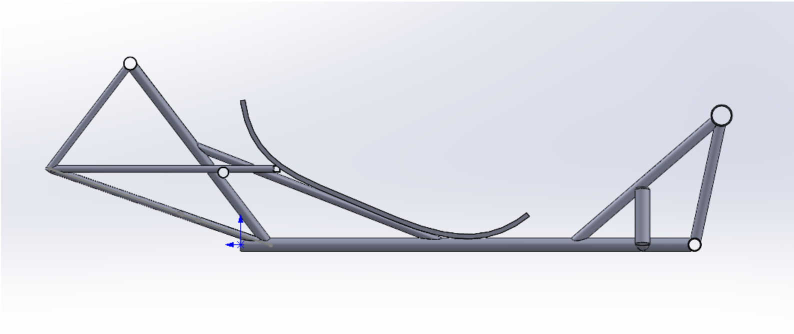

Figure B.1: Left View of frame

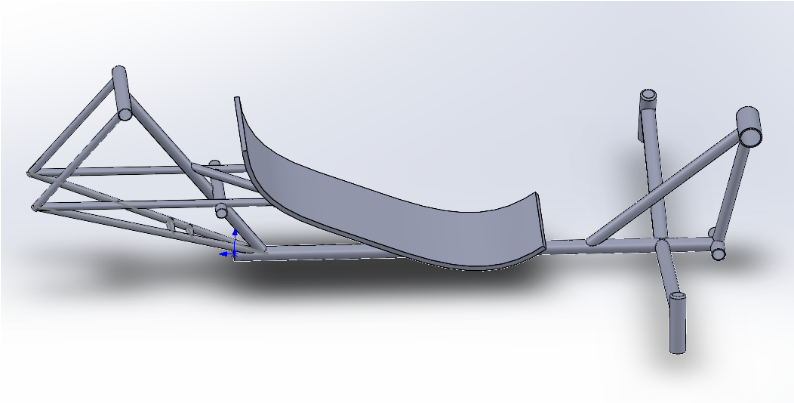

Figure B.2: Side view of the frame

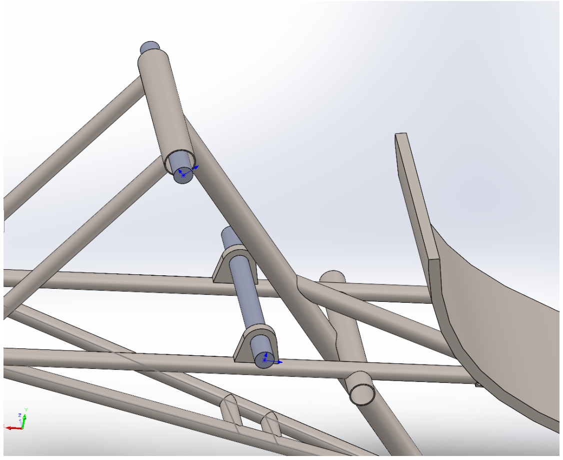

Figure B.3: Two supports and shaft

# APPENDIX C

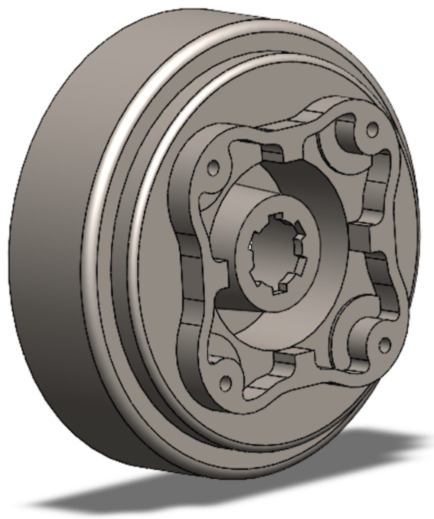

Figure C.1: Clutch CAD

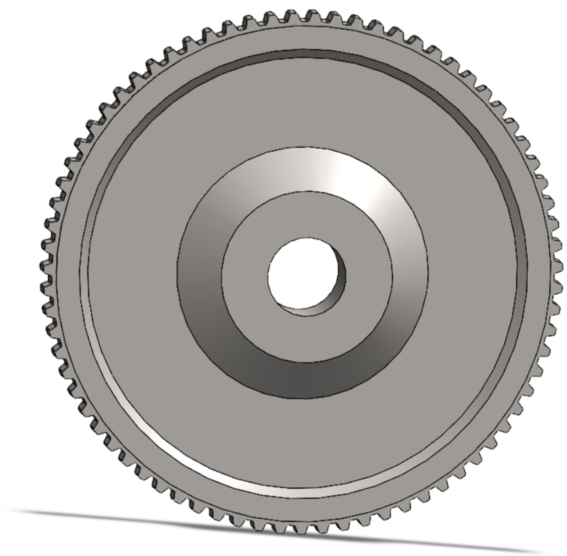

Figure C.2: Flywheel CAD

APPENDIX D

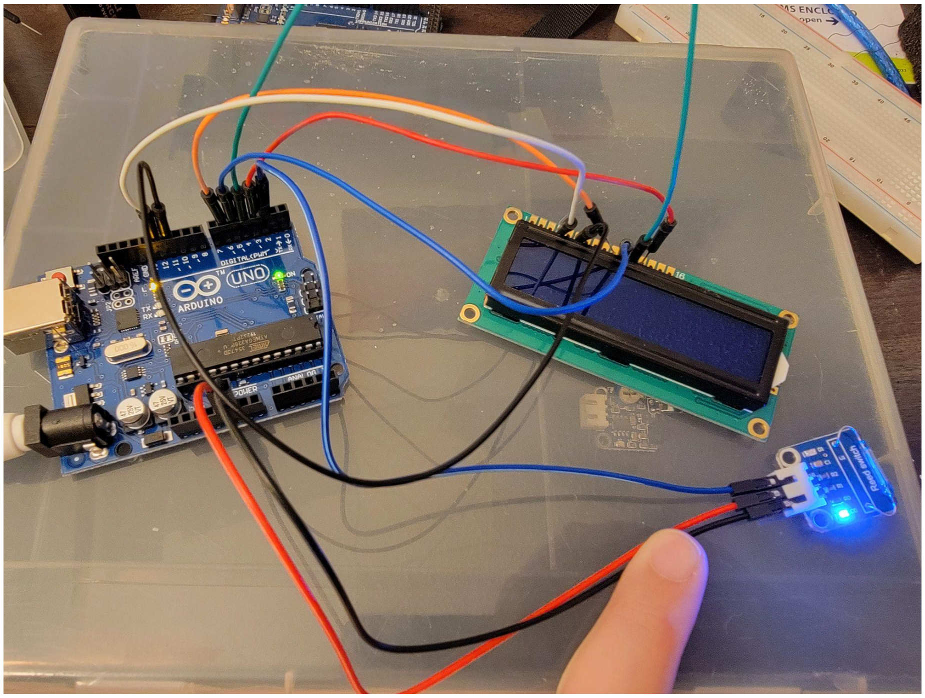


Figure D.1

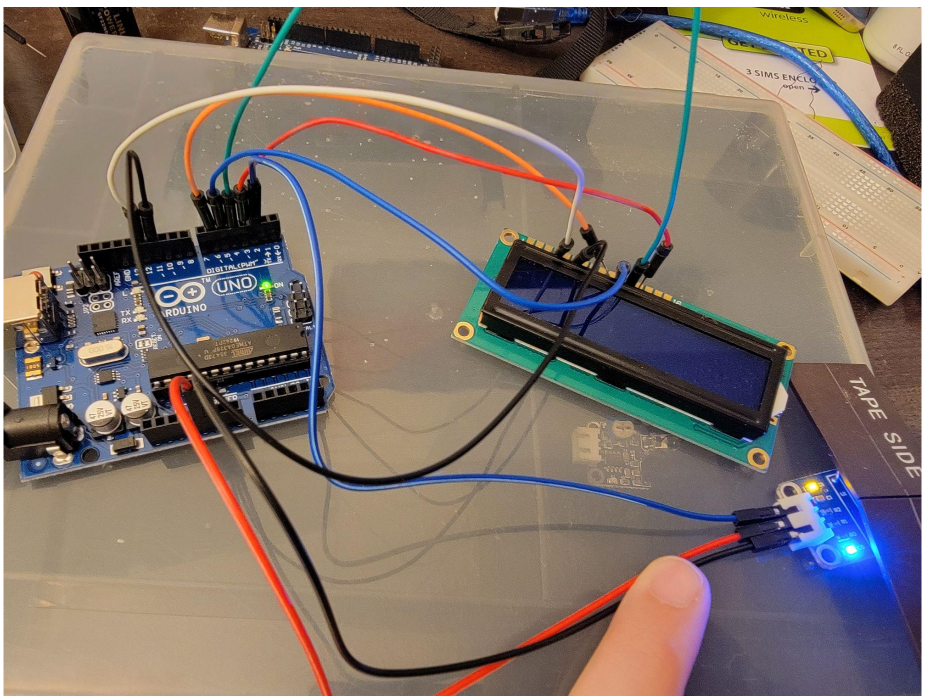


Figure D.2

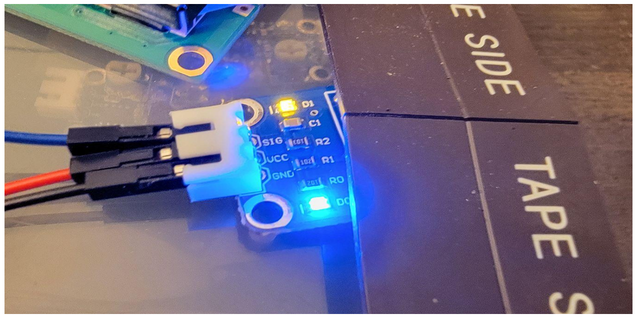

Figure D.3