Case Study: Electric Go-Kart

You want to build an electric go-kart. You have a rolling chassis and some parts to choose from. You need to finish the implementation by selecting components and making a plan for assembling the system safely and robustly. The assignment instructions are below; and supporting information is in the appendix.

You may work with a partner and turn in 1 document for the pair. Assignment is due Wed 5/30 in class.

Tasks to Complete:

1) Select a Motor and Battery Pack configuration & Make Performance Estimates:

You have 2 motors available and 2 types of batteries to choose from. Select the motor you prefer and configure your batteries to produce an appropriate voltage and current.

- Select a gear ratio for a maximum speed of 25 mph.
- From the plot provided for the motor you choose, extract parameters including winding resistance R and motor constant k.
- Calculate the predicted range of your go-kart when driving 25 mph on a flat racetrack, and make sure this range is at least 25 miles (1 hour). Also calculate this average power demand and current draw at this operating point.
- Calculate the maximum velocity when going up a 5% grade. Calculate the power demand and current draw at this operating point. The curves provided go up to a higher torque than rated torque on the motors' web pages. You can assume that the rating on the web page is continuous torque, and the curve goes up to the maximum short-term peak torque. Use the short term peak torque capability for this grade climbing calculation.

Note: This project is not about optimizing performance so don't spend a bunch of time trying to create the "best powerplant". Just characterize what you have chosen.

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2) Determine Electrical Hazards and isolation strategy

Before working on your system establish how dangerous it is. At what body resistance would various physiological effects occur? What conditions could result in those body resistances?

For the voltage you selected what safety precautions do you need to take in working on the vehicle?

What design elements are needed to keep users of the completed vehicle, as well as people maintaining mechanical systems on the vehicle safe? Some considerations include:

- Relative to the frame, is your tactive system (high-power electrical system) grounded or floating?
- If it's floating, will you use an "insulation monitoring device" IMD to monitor whether it is floating?

- Are the electrical connections open, covered by one or more layers of insulation, or enclosed in an insulating box?
- What creepage and clearance distances are needed at different points in your system?
- Are there ways of shutting off the power?

3) *Component mounting:*

Study the chassis photo provided with the approximate component mounting locations. Assume all mounting tabs will be welded to the frame. For each component:

- Select a tab material and geometry (make a sketch) for the component mounting.
- Complete calculations to convince yourself that the mounts won't break.
- List the loading scenarios considered and the assumptions made in the calculation.
- Comment on why you selected your tab design/configuration. In addition to the above considerations (location and strength) you may want to include the cost of material, describe the steps required to fabricate the mounts, and safety factor you selected.
- Select bolt size, material/grade, torque setting, and (if desired) the method to ensure the bolt won't break or come loose.

4) *Place appropriately sized Fuses in the system:*

The motor controller manuals include suggested wiring diagrams. They may include suggestions on some fuse placement, but these may or may not include all the fuses you need, or all the considerations that affect the fuse choice and location. Make a new sketch of the wiring diagram with all the fuses included, indicating which end of any wire they are located at. Select the fuses to be used. We'll use fuses from Littelfuse, because they offer a wide range of types to choose from. The online catalog at Mouser.com may be easier to use than the littelfuse web site. Specify the type, value, and price of the fuse(s) you select, and list the datasheet parameters that you considered to ensure it will work right for your application and how you know those are adequate. For example, if some parameter is 7, did you choose that to be more than 5, less than 10, or did it need to be exactly 7? Why?

5) *Wire Sizing and Type:*

The wiring diagram is provided but you must select the wire gauge, conductor type (stranded vs solid), and insulation type/ratings for this application. List your requirements, and then find wire that meets them at the Home Depot web site. To narrow the list of options, select wire that is in stock in West Lebanon, unless you need something special that is not in stock there.

6) *Ensure your wire harness assembly is mechanically robust:*

Mark up the kart chassis photo with sketches of where you will mount components and the wires connecting them. Identify places where you may need to provide strain relief and/or protection from abrasion.

Identify all connections and then sketch/plan each one with appropriate torque/assembly instructions. Please specify factors you took into consideration when establishing the torque specs and assembly instructions.

7) ***Identify Fault Scenarios to see if your design is adequate:***

Provide a simple FMEA list (does not need to be fully comprehensive, but list at least 6 possible fault scenarios) to help you establish if you have appropriate fault protection in your system.

What to turn in:

- Summarize your design
  - Include a wiring diagram. Label components with model information.
  - Include a chassis photo with location of major components and mounting tabs sketched on the photo
  - Summarize the predicted performance of your go-kart
  - Provide instructions for safely working on the kart
- In the appendix include all your work to complete tasks 1-7

Appendix: System Specs

- Rolling chassis weight is 130 lbs (59 kg). Includes seat and steering (not shown)
- To get the total weight, add the additional weight of the powertrain components you add and the driver to the rolling chassis weight.
- Wheel diameter is 10"
- Rolling resistance coefficient, Crr = 0.02
- Coefficient of drag, Cd = 0.5 (this includes the drag on the driver's body)
- Frontal area, $A_f = 0.5\ m^2$


3″
24″
9″
21″

Tab steel options are anything available for McMaster-Carr https://www.mcmaster.com/#standard-steel-bars/ (click on the "About Steel" at the top of the page. I suggest low-carbon (mild) steel or 4130 (which is easy to weld)

Appendix: Component Sources

- Motor options
  - https://www.motiondynamics.com.au/unite-my1020-36v-800w-3000-rpm-28.5a.html
  - https://www.motiondynamics.com.au/unite-my1020-1000w-3000-rpm-48v-dc-motor.html
- Motor controller options
  - Curtis instruments Model 1229, rated 200 A or 250 A at up to 36 V or 200 A at up to 48 V. https://assets.curtisinstruments.com/Uploads/Datasheets/50215_1229_RevC2.pdf
  - Motion Dynamics, rated up to 48 V, 50 A. https://www.motiondynamics.com.au/12v-48v-dc-speed-control-50a-external-case-model.html

- Battery options
  - http://www.batteryspace.com/LiFePO4-Prismatic-Batteries.aspx
  - http://www.batteryspace.com/ni-mhbatteries.aspx
- You may use any fuse by Littlefuse that is available at Mouser.com
- You may use any wire found at HomeDepot.com that is available at the West Lebanon store