Design Criteria – HVP – Regenerative Braking

Overview:

This design criteria:

This design criteria is to help decide the specifications we need for the motors, controllers (inverters if AC motors) and regenerative braking. As such, at the end of each bullet point, where appropriate a **[M]** or **[C]** has been appended to the end. This is to show which part of the system it is specific to. If specific to a component but for regenerative braking in particular, **(regen)** may be added.

Regenerative braking:

The basic concept behind regenerative braking, is the use of the rotational energy of the wheel to generate electrical energy whilst slowing the vehicle down. This allows us to "regain" some of the energy used to speed up the vehicle, instead of losing this as thermal energy using conventional brake pads.

We do this by requesting "negative torque" to the controller, which will apply a load over the wheel, thus generating a current which we can use to recharge the battery slightly. Whilst it may not charge by much for a single braking period, the idea is the many braking cycles should add up to a not insignificant amount of energy savings, and potentially allow us to reduce the size of the battery and therefore mass.

Inputs:

- Electrical Energy (AC or DC dependent on motor selection) [M/C]
- Cooling (liquid/air dependent on motor and inverter selection) [M/C]
- Pedal input (CAN?) [C]
- CAN input [C]
- Vibration [M/C]
- Large and sudden movements [M (part of USM)]
- Water & dust from the environment [M]
- Some forces from the wheels [M]
- Torque (-ve) [M (regen)]

Conditions:

- Process CAN/pedal data and send required power to Motor [C]
- Pull power from motor if regen braking requested [C (regen)]
- Don't send too high a voltage to the battery [C (regen)]
- Transfer heat from components to coolant [M/C]
- Convert electrical energy to torque [M]

Outputs:

- Torque to the wheels [M]
- Heat output; Convection and via coolant [M/C]
- Unwanted vibrational/sound energy [M]
- Feedback motor data to CAN? [C]
- Electrical energy back to battery charge circuit [C (regen)]

Constraints:

Geometric:

- Whilst HVP would take priority over suspension design, motor should not be too large or difficult in size to design around for the USM team.
- Space for the motor controller should be considered, especially since 2 controllers may have to be used depending on which motor-controller configuration we choose.
- Space to pass high voltage lines to the outboard motor needs to be considered

Commercial:

- Time constraint due to lead times on the motors and controllers
- Financial constraints; Motors and their controllers can be extremely expensive

Requirements:

- Must send appropriate voltage to motors [C]
- Must send safe and appropriate power back to battery [C (regen)]
- Must be able to withstand a decent amount of stress from the wheel [M]
- Must send power to outboards motors in a safe way [C-M]
- Must be able to brake without causing lockup [C]

Rules/Safety:

- EV2.2.1 Power limits (+80kW total max permitted for 2 motor RWD)
- EV2.2.2 Regenerative braking power is permissible and unrestricted
- EV4.3 Separation of Traction System and Grounded Low Voltage System
    - Important to consider when integrating the controller and motor
- Alot of rules in EV4.4.3 must be abided by in order for outboard motors to be permitted (we must follow)

Goals:

- An efficient drivetrain with minimal losses through power conversion etc.
- A drivetrain that isn't overly heavy. (important for motor choice)
- Range increase over previous year/FS class entry without sacrificing lap times.
- Choice of components should not be overly expensive. This is very important when choosing motors.
- As high a ΔRange to ΔMass ratio as possible over previous generations.
- Safe integration of outboard motors