EE 192: Mechatronic Design Laboratory
Project Proposal
Group 10

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Contents

Overall Strategy

The overall strategy will incorporate at least two runs. The first run will be a slow run in which the wheels will likely not slip in a turn of the tightest radius, and the second run will be more aggressive. With our first run, the primary goal will be to have a robust and consistent execution of track following. Subsequent runs will explore handling at increased speeds, which will likely result in a loss of consistency, but might result in a better overall score. The position and orientation of the car with respect to the track will be deduced from measurements from inductive sensors on a boom approximately one car length ahead, as well as an array of reflectance sensors beneath the car. The speed of the car will be deduced from optical quadrature encoders which measure the rotation of the wheels. The control algorithm has not decided, but will likely be a PID controller. The preliminary controller will only consider position error of a single point, and not the yaw error of the car. We will need approximately 21 I/O lines: 4 for the SPI to ADC (which will connect to the inductance sensors on the boom), 8 for reflectance sensors under the car, 4 for quadrature encoders on the wheels, 1 for the steering servo, and 4 for the motor drive.

Should time allow, we will also explore a rudimentary implementation of electronic stability control for use on the aggressive run, possibly incorporating an IMU. The electronic stability control will be implemented through the actuation of servos which apply braking pressure to slow either the left or right rear wheel. This would help reduce yaw error on tight turns in which the car has a large understeer.

Hardware Design

Attachments to Vehicle

- DC Motor
- NiMH Battery pack and mount
- Steering servo
- ESC braking (2 braking servos and braking pads) and mount
- DC-DC converter
- Front boom
- Inductive sensors and light sensors (for line sensing)
- Reflective quadrature encoder breakouts (for measuring wheel speed) (Avago AEDR-8300K)
- 75 LPI encoder code strips (on face of inner wheel hubs)
- Electronics mount
- NI Single-Board RIO (embedded controller CPU+FPGA)
- 2 break-out boards (one for power and motor control, the other for control logic)
- Mode select switch (6+ position rotary switch)
- Main breaker switch
- Flag (attached to breaker)

Detailed Mechanical Drawings of Vehicle

See attached Figures 3, 4, 5, and 6.

List of Special Materials

Electronics

- 4x Allegro AEDR-8300K 75LPI reflective quadrature encoders (see attached)
- 4x 7” 75LPI reflective encoder code strips
- 2x High slew-rate servomotors (for back wheel braking)
- 4x IRLB3034PBF HEXFET MOSFET (195A max, 0.0016 Ω R_{DSon})
- 1x Quad 4-to-1 MUX (74HC453, exact device TBD)
- 1x Dual inverter (74HC2G04, exact device TBD)
- 1x TI ADS7953 16ch 12-bit 1 MS/s SPI ADC
- 1x Samtec High Density Connector SEAM-40-03.0-S-06-2-A-K-TR (provided by NI)

Mechanical

- 1/16” 6061 aluminum sheet
- 1/2” thick Ultra-soft Polyurethane Rubber

Motor Drive Circuitry

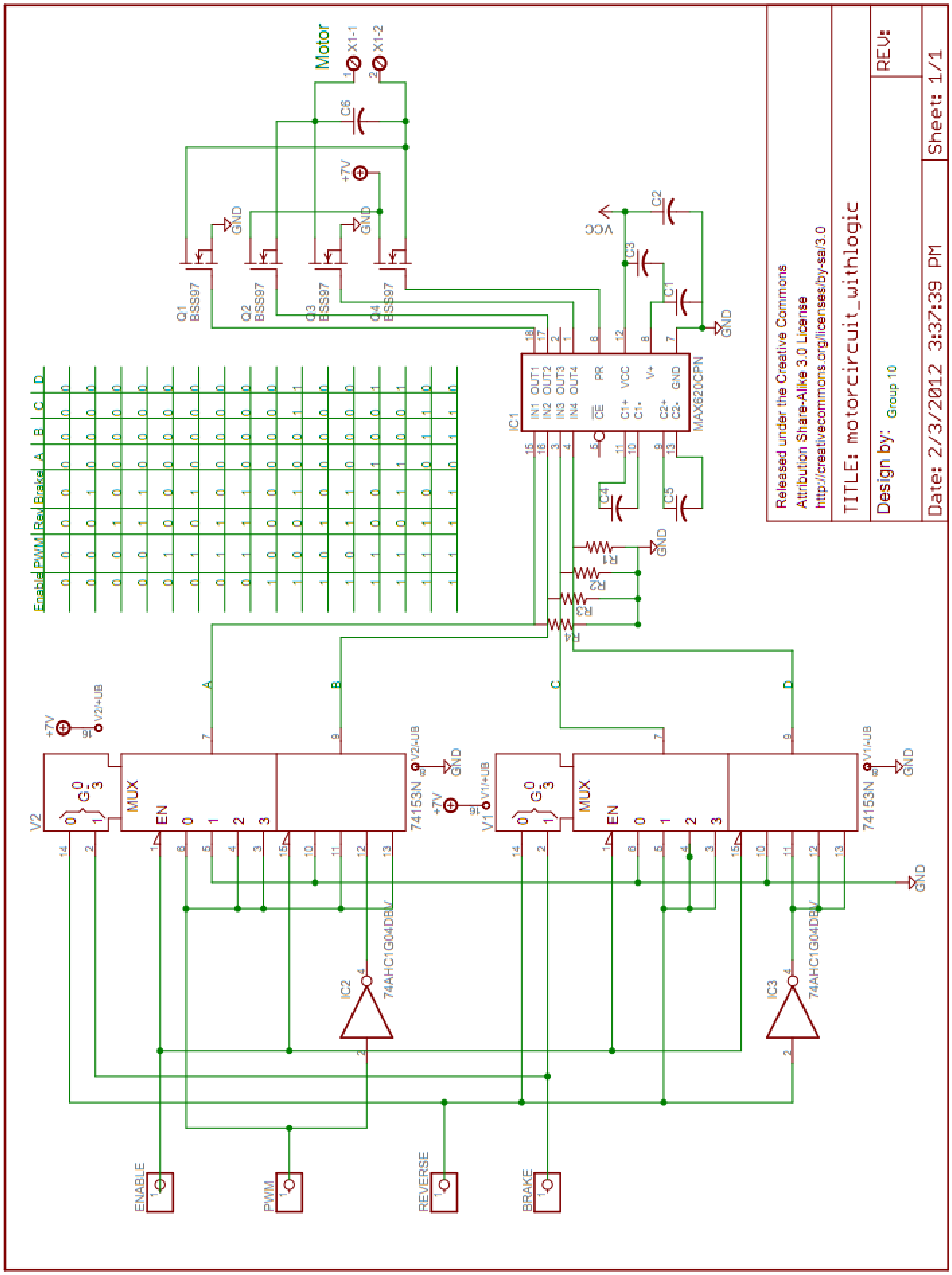

Figure 1: Motor control schematic.

Software Strategy

A good software strategy will allow for the ability to have a conservative and robust strategy, as well more aggressive strategies for subsequent runs. We will focus first on filtering of sensor data and ignoring of data points which suggest situations which are not possible, either because of violation of the rules or because of an unlikely discontinuity in behavior. In order to do this, we will need to know the distribution of noise in the signal from our sensors. In addition, our conservative strategy will focus on precise steering, which will require careful consideration of the sensitivity of the position error to the signal from the inductance sensors, and the degree to which we will be able to discern real position error from perceived position error, which will be subject to unmeasured mechanical disturbances in the boom as well as sensor noise. The conservative strategy will focus only on minimizing the error between a fixed point on the car and the distance to the track. Only short-circuit braking will be used, if needed.The aggressive strategy will focus on handling at high speeds. Both position error and yaw error will be accounted for. Furthermore, we will not necessarily follow the center of the track, but instead follow larger radius turns that can be taken without the car losing sight of the track.

If time allows, we can explore more sophisticated AI and optimal control techniques, such as probabilistic state estimation and track learning.

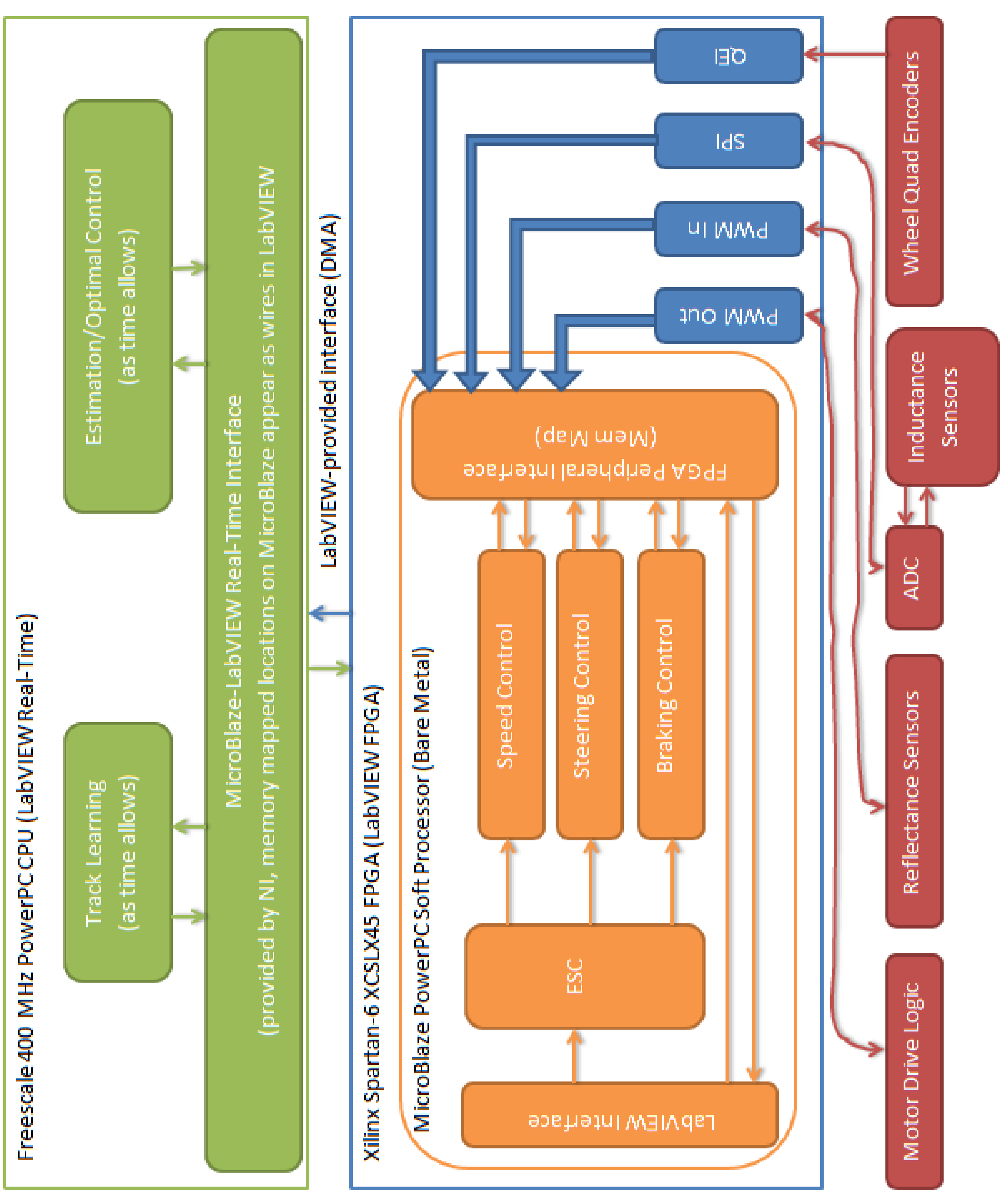

Figure 2: Software block diagram for the car.