ECE 477 Design Review
Team 12 – Spring 2008

Outline

- Project overview
- Project-specific success criteria
- Block diagram
- Component selection rationale
- Packaging design
- Schematic and theory of operation
- PCB layout
- Software design/development status
- Project completion timeline
- Questions / discussion

Project Overview

- The Two Wheel Deal is a self-balancing personal transportation vehicle
- Based on inverted pendulum problem
- Similar to the commercial Segway i2 (picture to right)
- Practical alternative to short range transportation

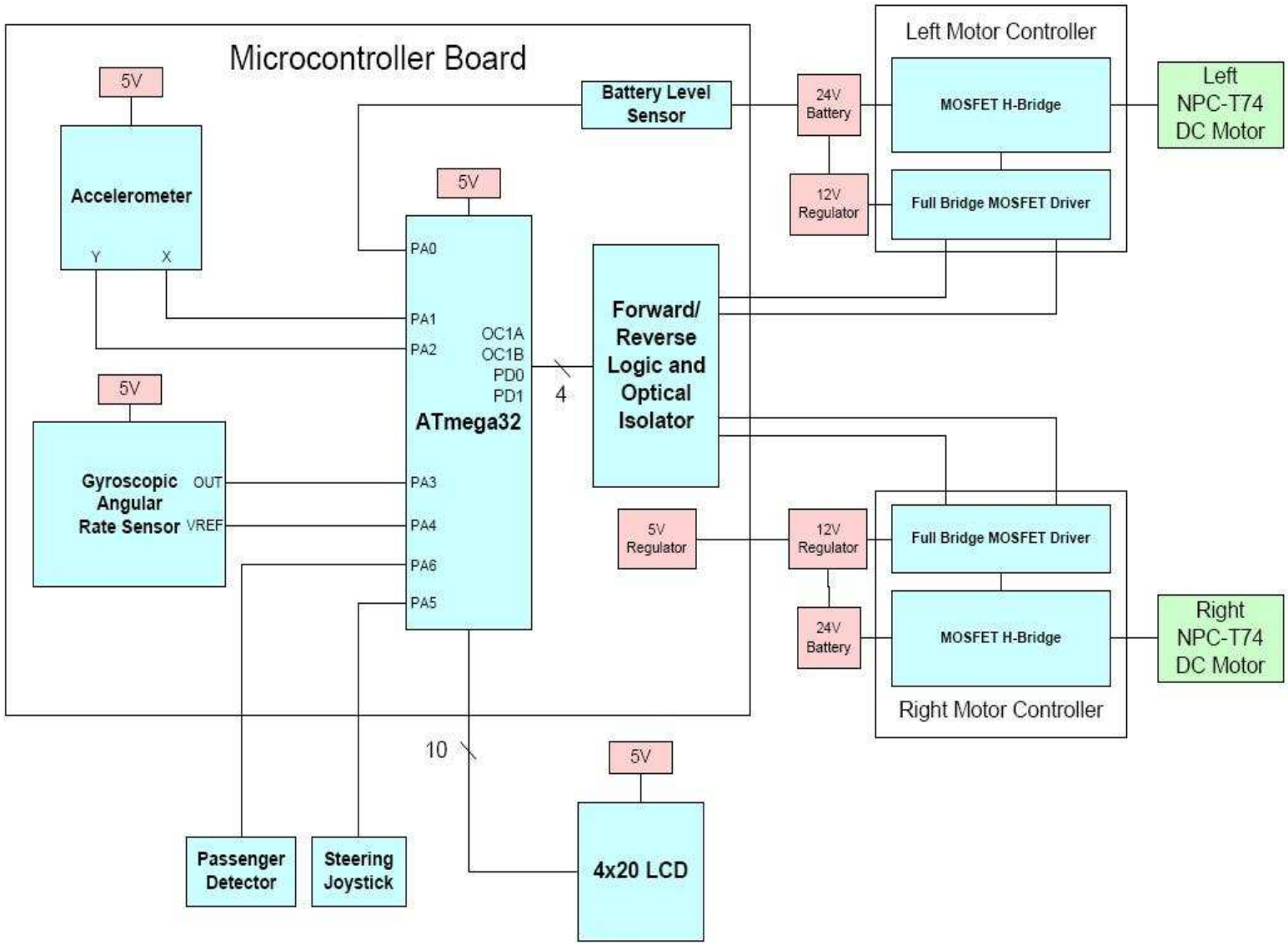
Project Overview

- Tilt angle is measured by an accelerometer
- Angular rate is measure by a gyroscope
- Power is supplied from two 12V, sealed, lead acid batteries.
- Two 24V DC motors drive the vehicle and are controlled independently by h-bridges
- Turning is controlled by a thumb joystick
- Forward/reverse controlled by leaning
- LCD displays battery life and other data

Project-Specific Success Criteria

- An ability to…
  - independently control two high current electric motors.
  - shut down if no rider or low battery.
  - display sensor data to rider on LCD.
  - balance a passenger autonomously.
  - move and turn through use of navigation controls.

Block Diagram



Component Selection Rationale

- Microcontroller Constraints
  - 2 16-bit PWM outputs for precision
  - 6 10 bit ATD inputs
  - At least 12 general I/O pins
  - Memory for math libraries
  - Atmel ATmega32
    - 2 16-bit PWM, 8 10-bit ATD, 32 GIO pins,
    - 32 kB Flash
    - DIP package

Component Selection Rationale

- Sensor Constraints
  - Accelerometer: Analog Devices ADXL203
    - Dual-axis
    - Low-G range (±1.7 g)
    - High sensitivity
  - Angular Rate Sensor: Melexis MLX90609E2
    - Medium sensitivity (±150 °/s)
    - Low cost

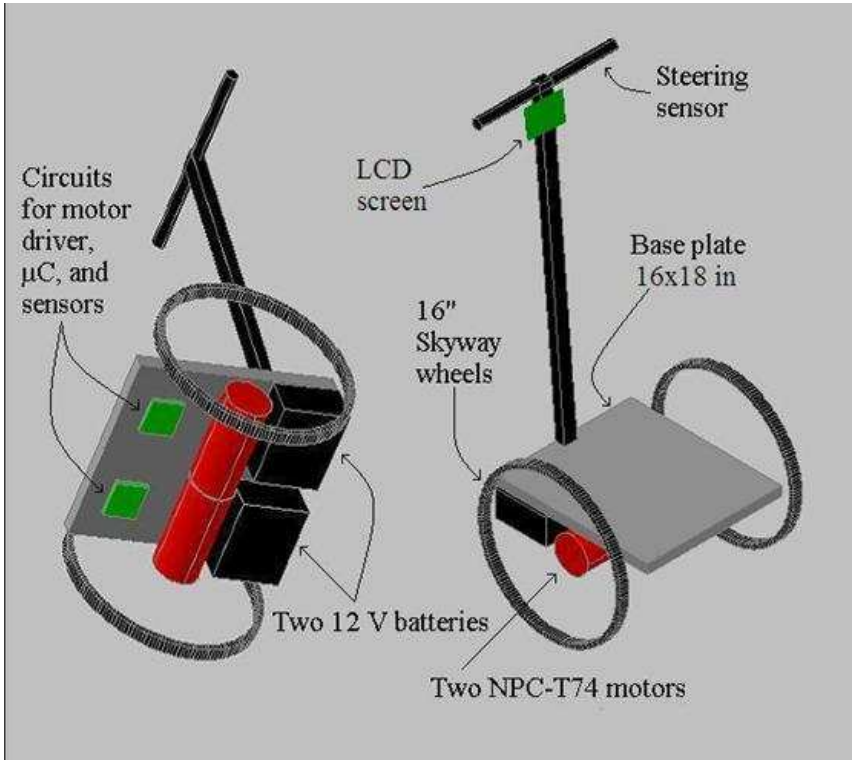
Component Selection Rationale

- Motor Constraints
  - Top Speed: 10 mph
  - Max Recovery Angle @ 10mph: ±10º
  - 100 kg passenger

  – NPC-T74 brushed gearmotor
  - Top Speed: 11 mph
  - 19º recovery angle at 10 MPH
  - 200 lb output shaft load rating

Packaging Design

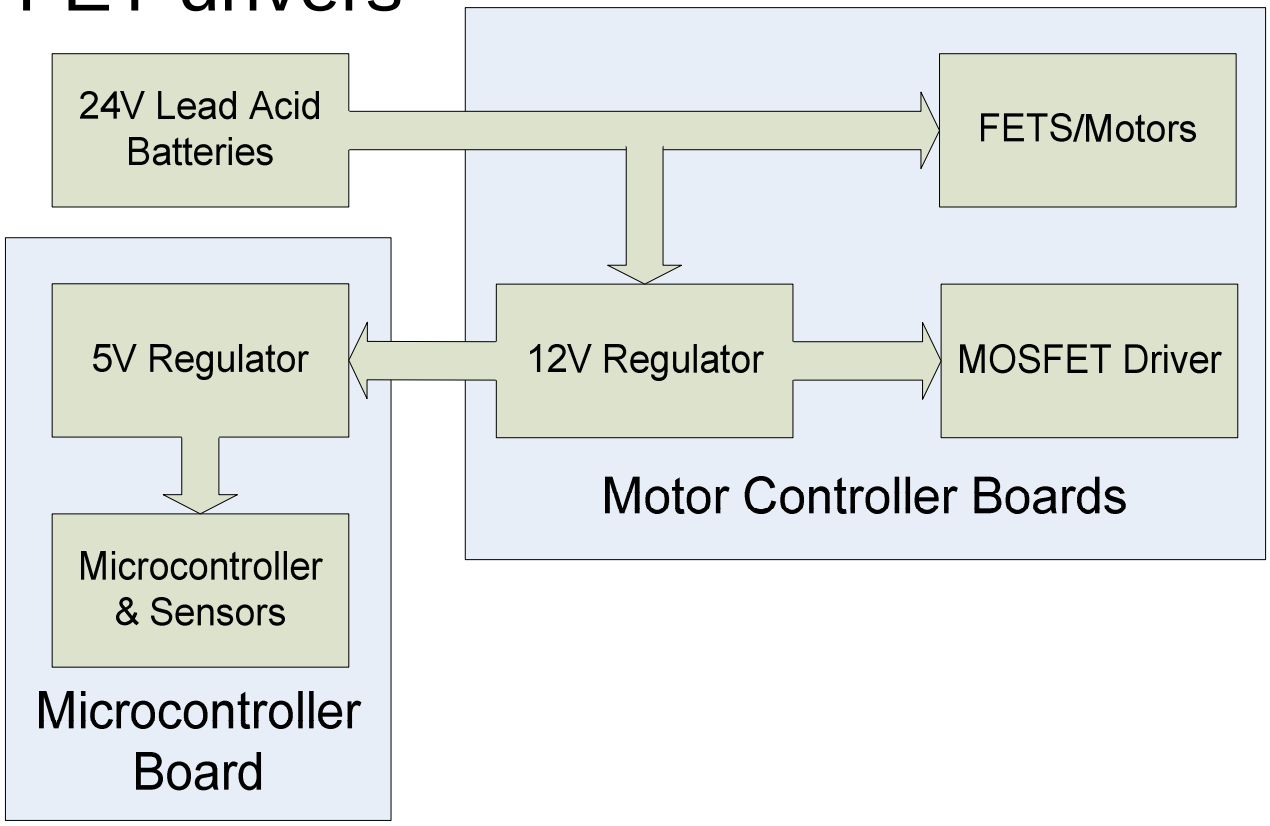
- Size Constraints
  - Fit in a car
  - 18”x24” footprint
  - 5” ground clearance
- Weight Constraints
  - Less than 80 lbs
  - 250 lb payload
- Circuitry Placement
  - Batteries, PCB, sensors, LCD, joystick

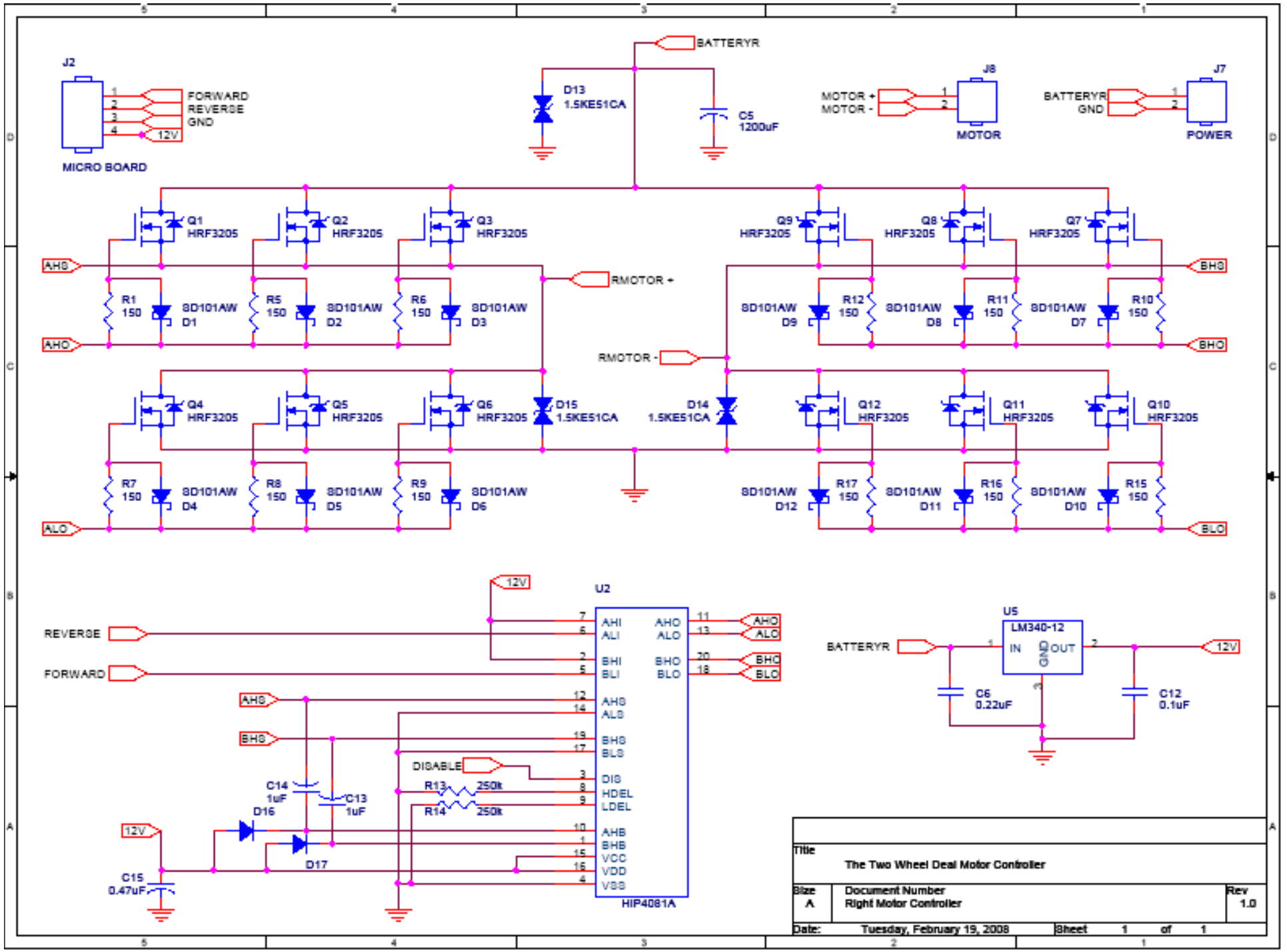


Theory of Operation

Power Supply

- High current for the motors
- Stable 5V for the Sensors and Microcontroller
- 12V for FET drivers




J2
FORWARD
REVERSE
GND
12V
MICRO BOARD
BATTERYR
D13
1.5KE51CA
C5
1200uF
J8
MOTOR +
MOTOR -
MOTOR
J7
BATTERYR
GND
POWER
Q1 HRF3205
Q2 HRF3205
Q3 HRF3205
Q9 HRF3205
Q8 HRF3205
Q7 HRF3205
AHS
BHS
RMOTOR +
R1 150
SD101AW D1
R5 150
SD101AW D2
R6 150
SD101AW D3
SD101AW D9
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SD101AW D8
R11 150
SD101AW D7
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AHO
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Q4 HRF3205
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Q10 HRF3205
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DISABLE
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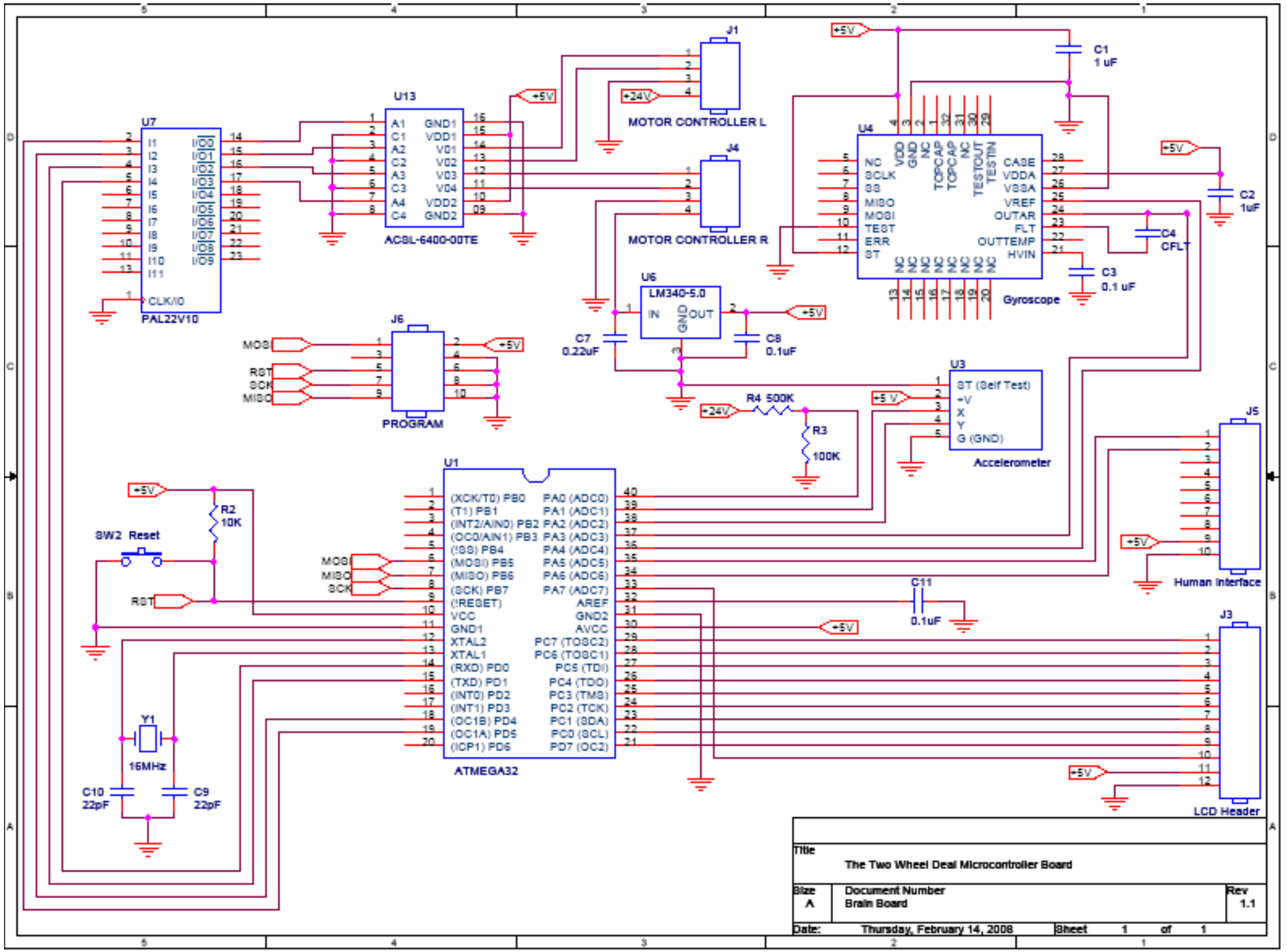
AHB
BHB
VCC
VDD
VSS
HIP4081A
C14 1uF
C13 1uF
D16
D17
R13 250k
R14 250k
C15 0.47uF
U5
LM340-12
IN
GND
OUT
C6 0.22uF
C12 0.1uF
Title
The Two Wheel Deal Motor Controller
Size A
Document Number
Right Motor Controller
Rev 1.0
Date: Tuesday, February 19, 2008
Sheet 1 of 1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J4
MOTOR CONTROLLER R
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PROGRAM
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Accelerometer
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100K
U1
ATMEGA32
R2
10K
SW2 Reset
Y1
16MHz
C10
22pF
C9
22pF
C11
0.1uF
J5
Human Interface
J3
LCD Header
+5V
+24V
MOSI
MISO
SCK
RST
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The Two Wheel Deal Microcontroller Board
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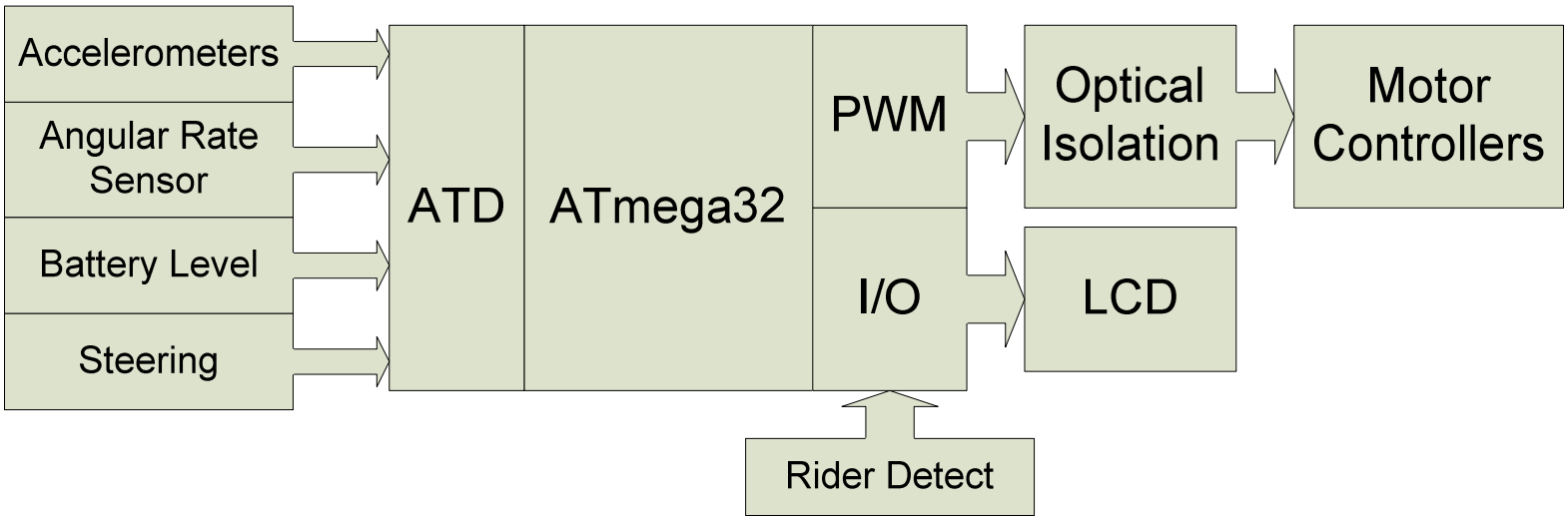
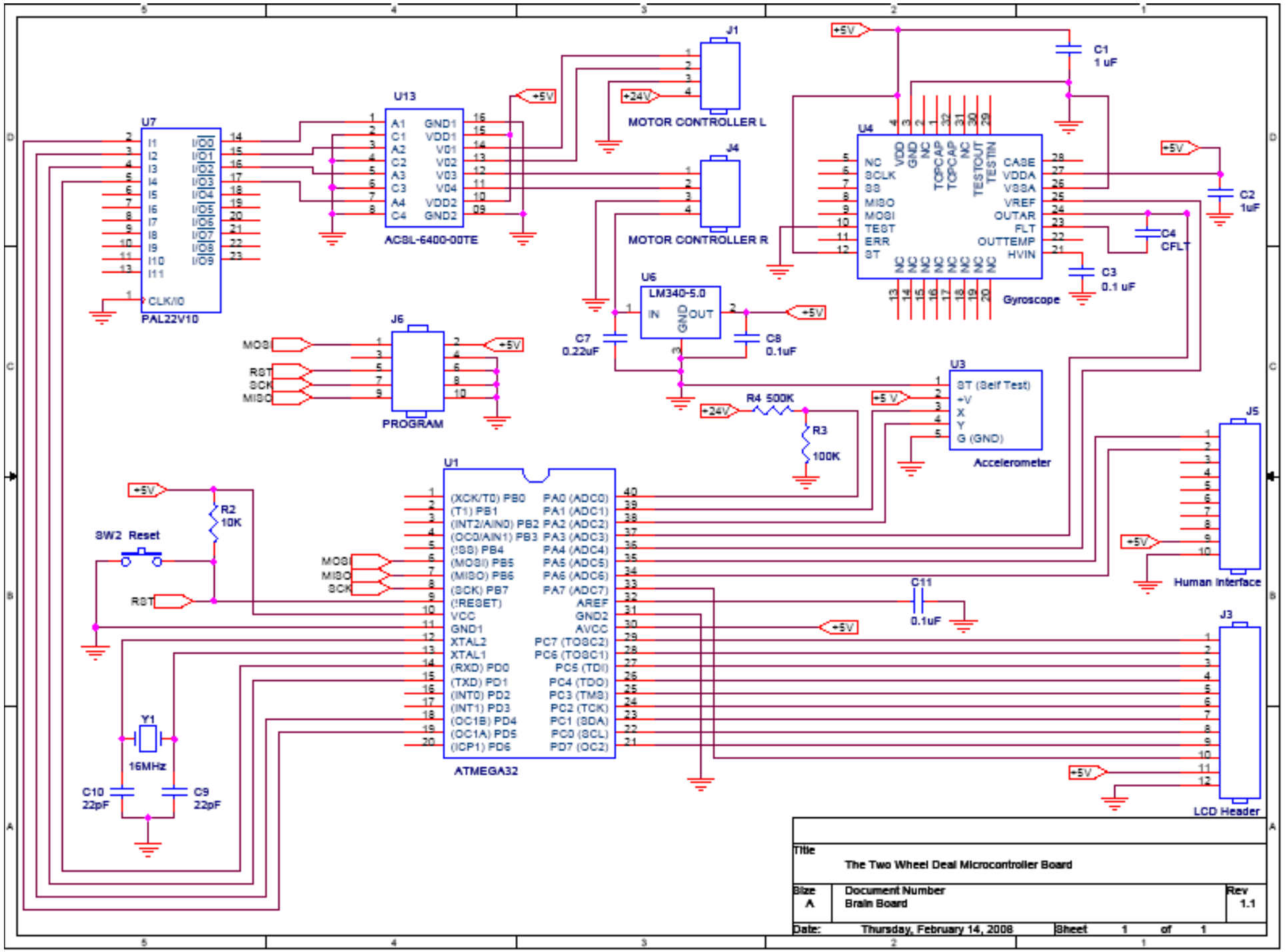
Microcontroller & Sensors

- 16MHz
- ATD for Sensors
- Isolated PWM for Motor Controllers
- Logic Circuit for FET drivers
- Parallel Interface to LCD

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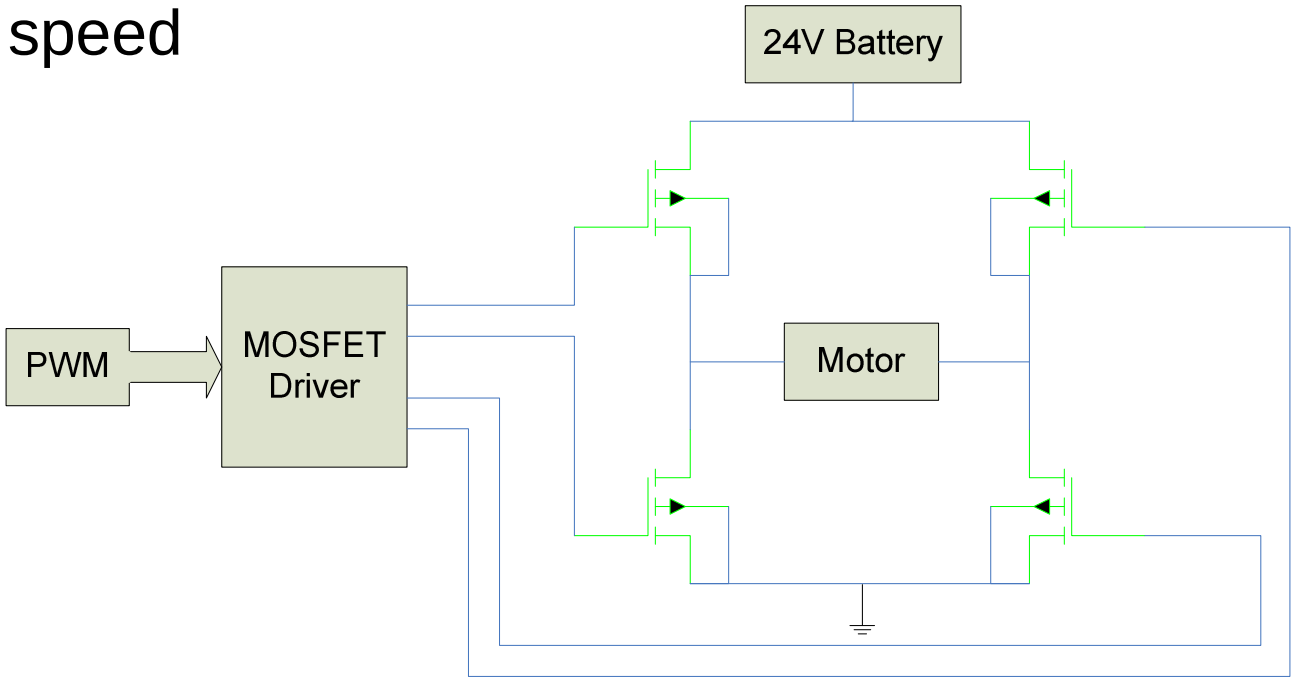
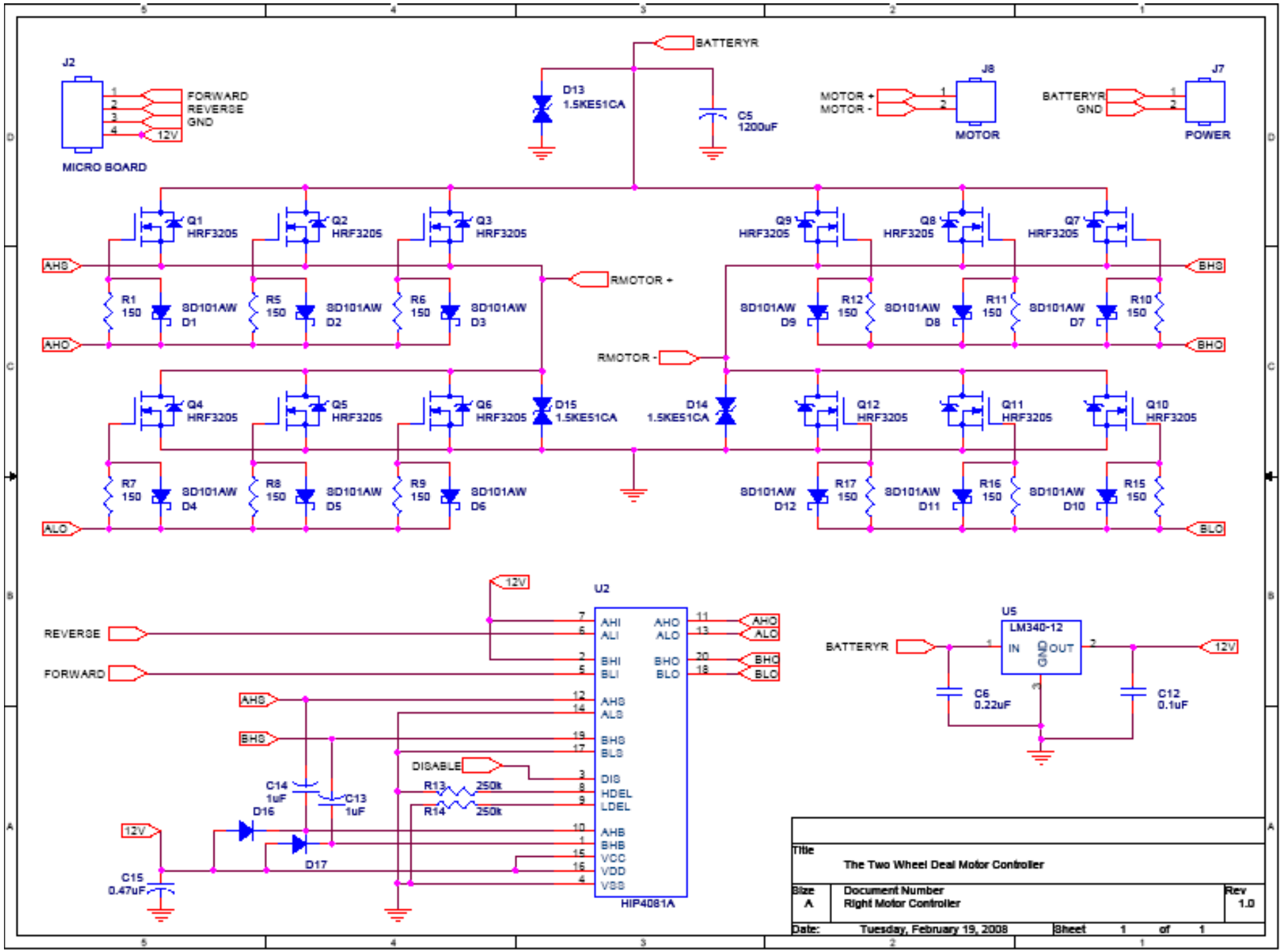
Motor Controller

- H-Bridge FET Driver
- 3 100A MOSFETs per leg
- Shoot-through prevention
- Voltage spike compensation using TVS diodes
- 2kHz switching speed

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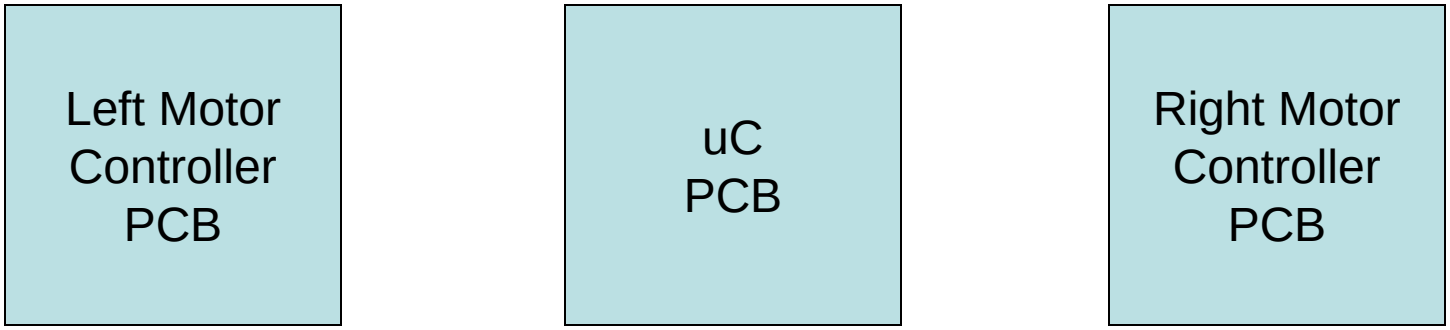
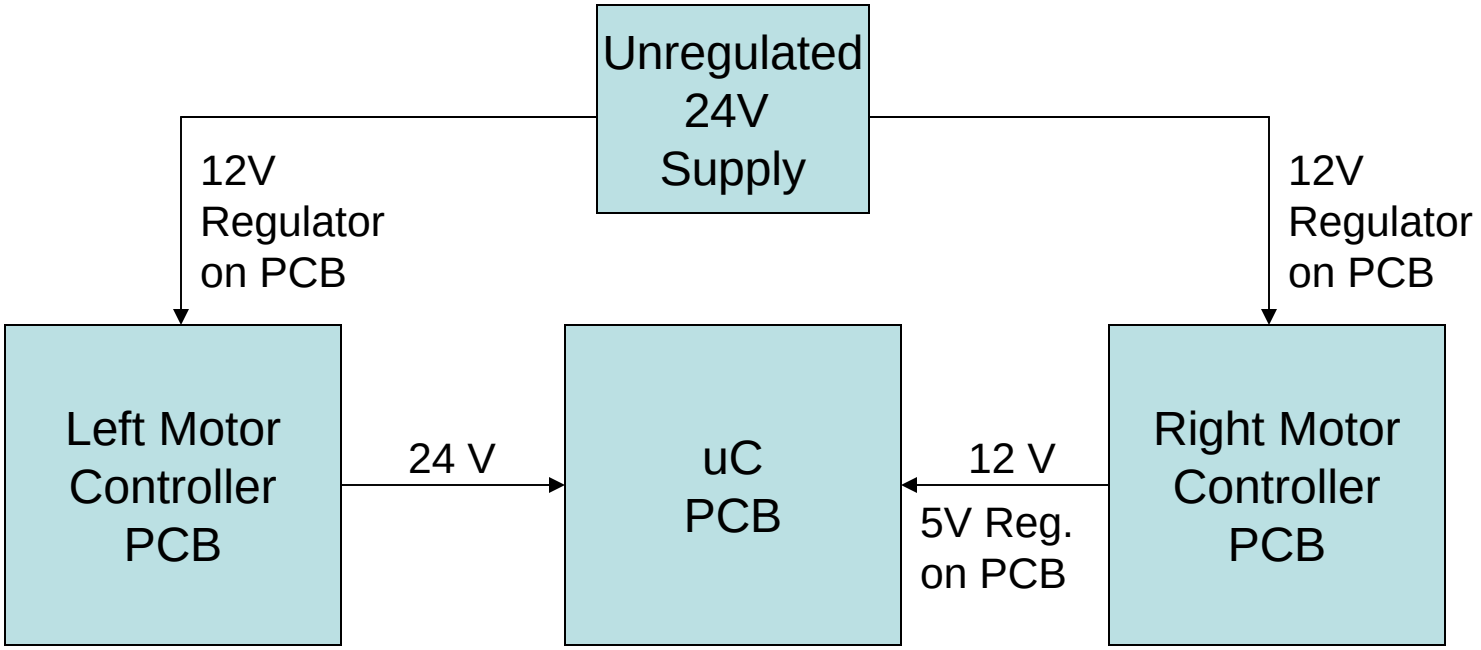
PCB Layout

- 3 PCBs Advantages
  - Separate switching circuit from sensitive digital signals



PCB Layout

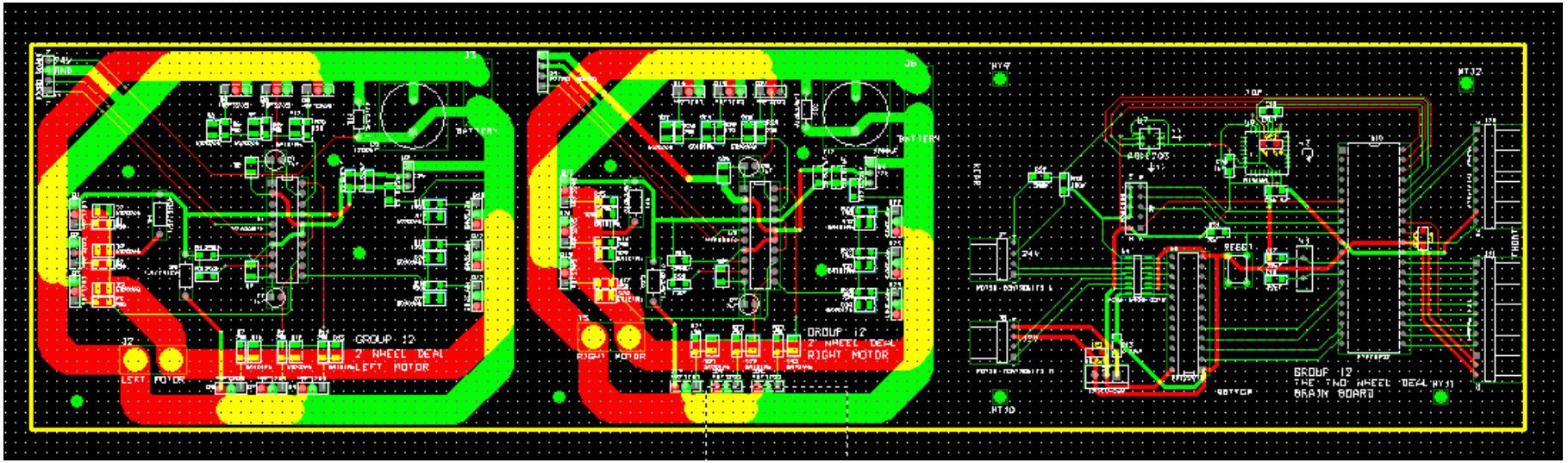
- 3 PCBs Disadvantages
  - More power supply connections
  - More parts – Regulators, Connectors



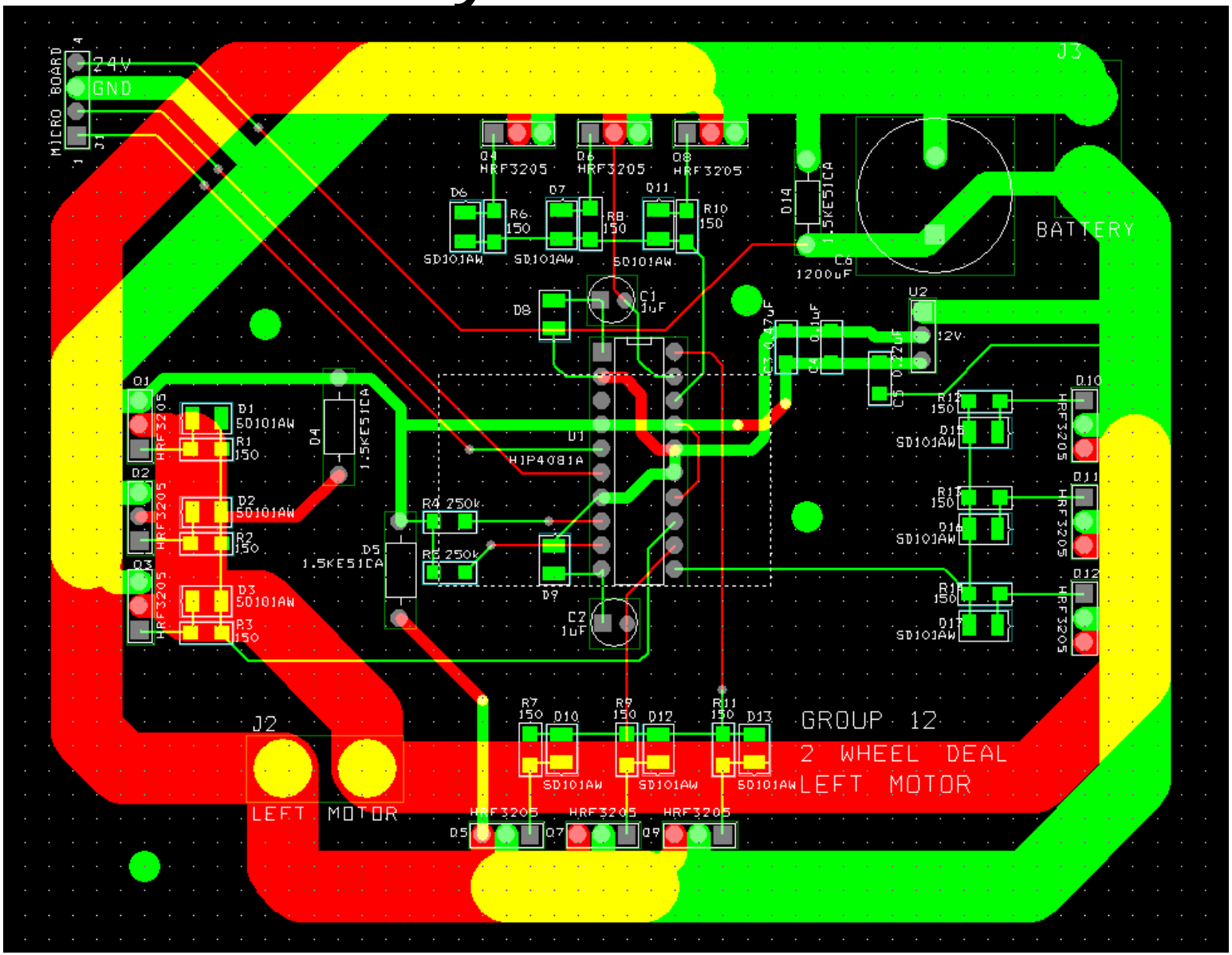
PCB Layout

- 3 PCB’s

  Left Motor Right Motor



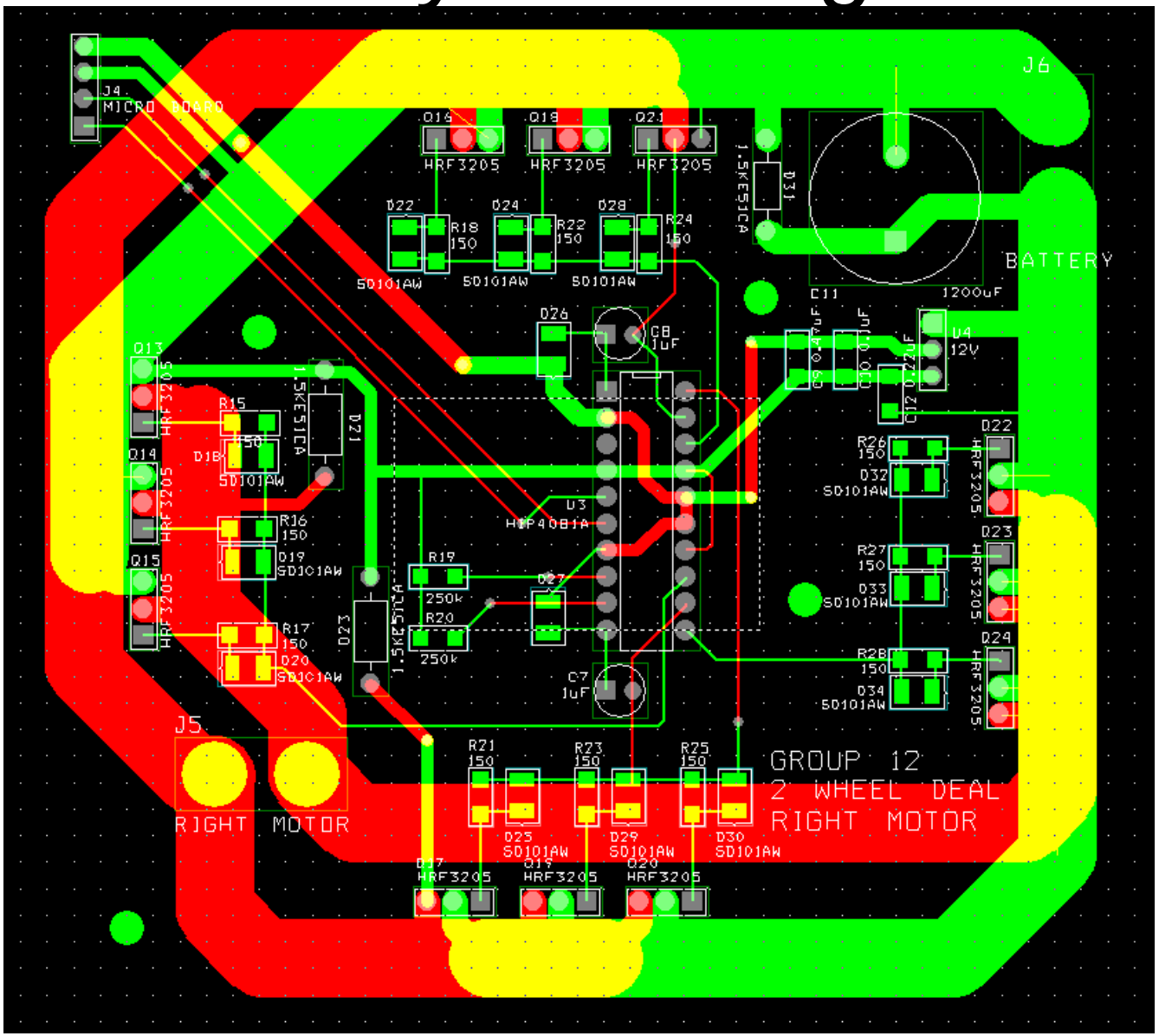
PCB Layout – Left Motor



PCB Layout – Left Controller

- Power
  - Holes for wires to be soldered
  - 300 mil supply rail traces
  - 100 mil traces to transistors
  - Traces have coppper pore
  - 24 V for Power Supply Level
- Mounting
  - Mount using transistors
  - Mounting holes added
- Diodes
  - Voltage Suppression

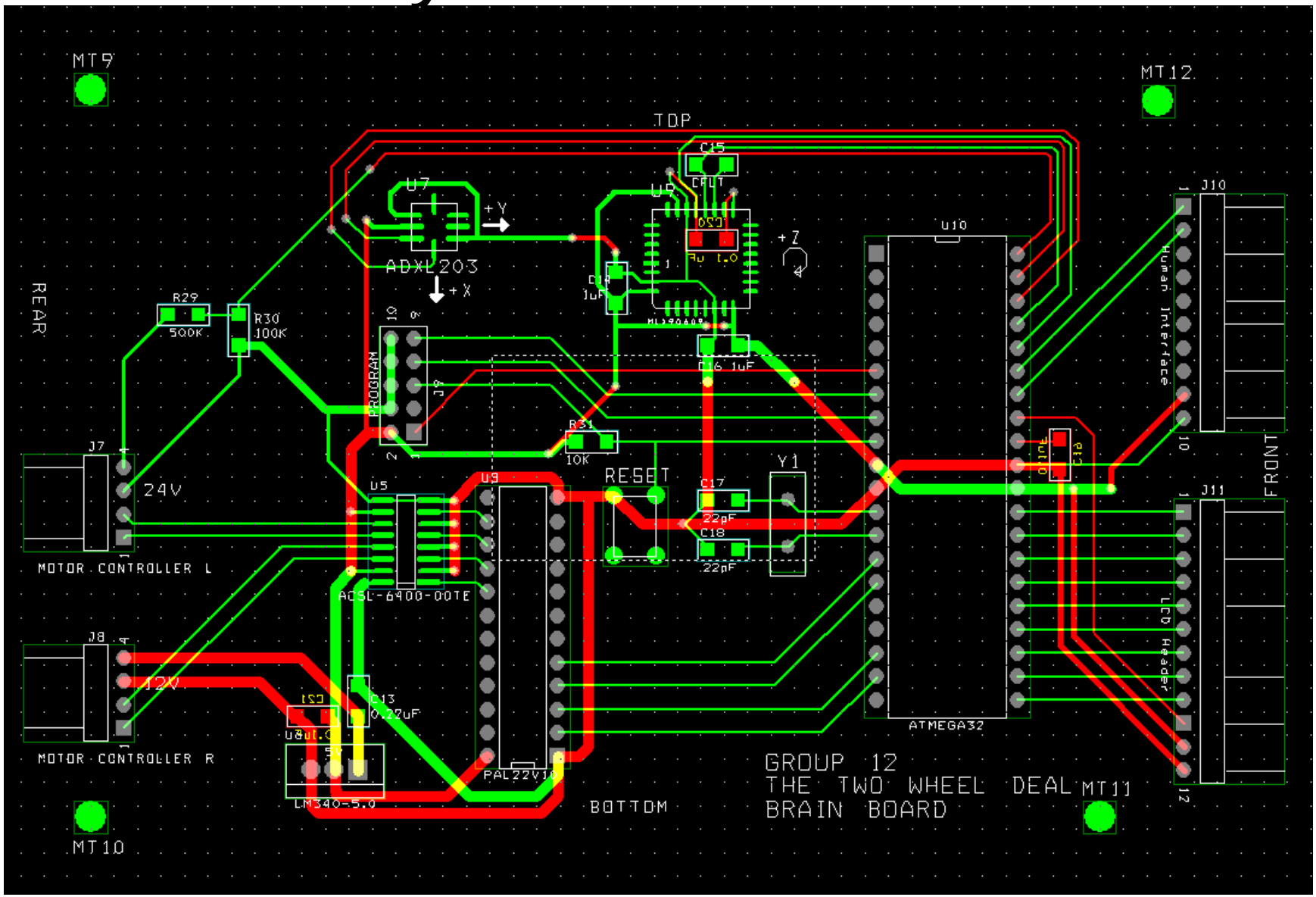
PCB Layout – Right Motor



PCB Layout – Controller Differences

- Left Controller
  - 24V connector for battery level detection
- Right Controller
  - 12V connector for microcontroller supply
  - Linear Regulator

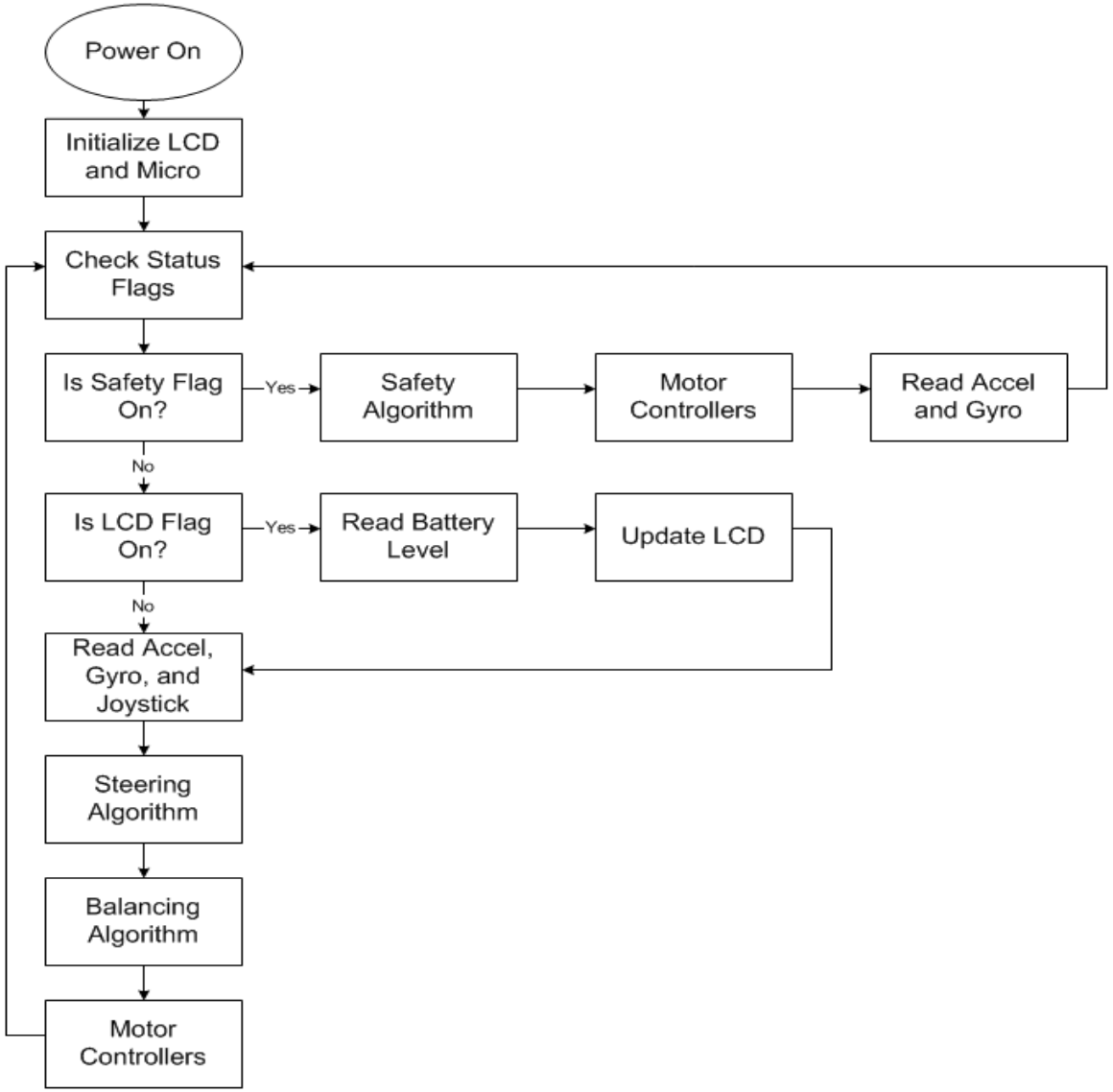
PCB Layout - Microcontroller



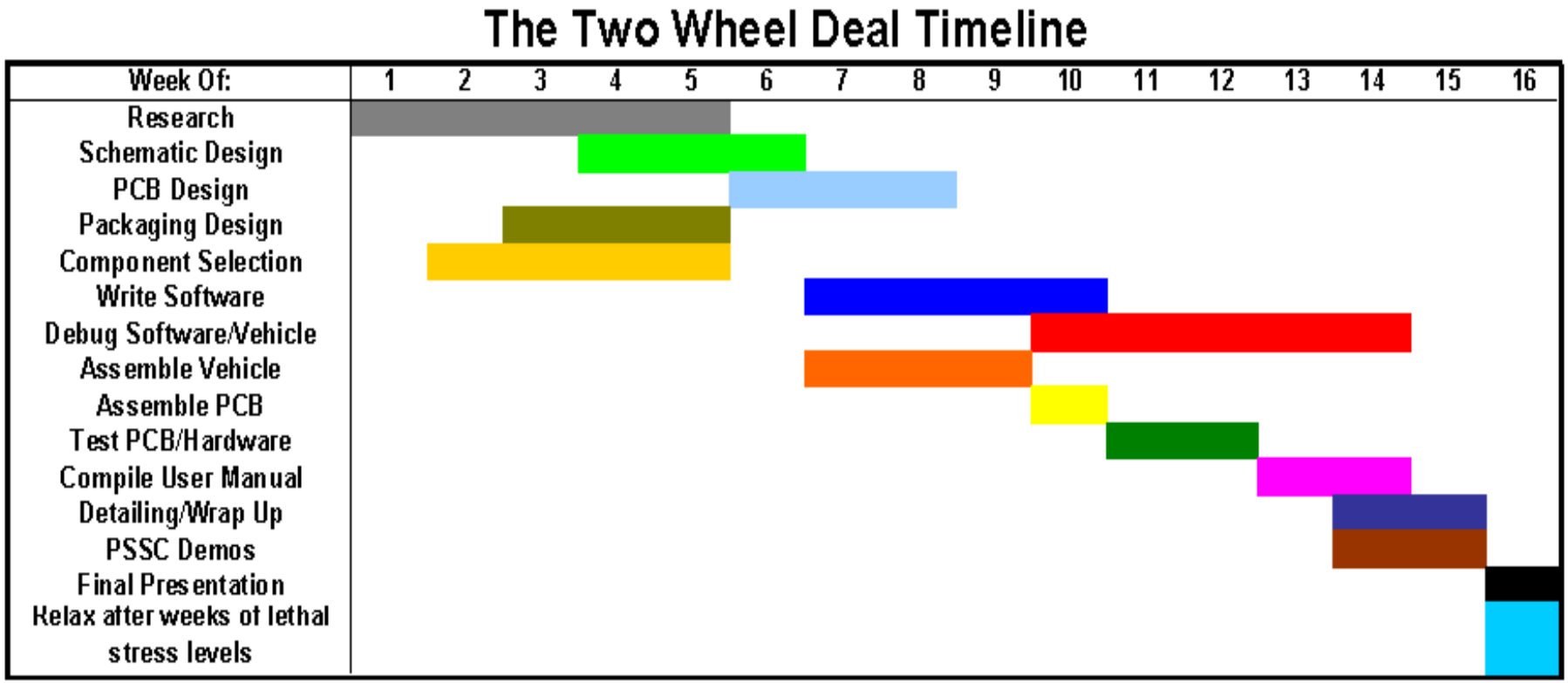
PCB Layout – Microboard

- LCD Header (12 Pins) – 1 byte of data
- Gyro Accel (2 pins each) – Close for accuracy
- PLD (4 pins) – Traces larger for more power
- Oscillator (2 pins) – Close for no noise
- SPI Program (4 pins) – Easy Programming
- Unused / General I/O (3 pins) - Expandability
- Reset
- Optical Isolator – Motor inductive feedback
- Signal Header – Easy Connection
- Regulator
- Power – larger traces to power all components

Software Design



Project Completion Timeline



Questions & Discussion