Mouse Version 5.0

Objectives:
- Provide stable power to the components of the mouse w/ regulators
- Use different IR sensors to read consistent values from sensors
- Reduce mouse skidding by increasing gearbox gear ratio (and reducing rpm)
- Add a gyroscope for accurate turns

Many websites (like this one HERE) mention that stepper motors work well, but for now we'll keep experimenting with the brushed DC motors from ServoCity.

Bryant's Wolfiemouse on GitHub: HERE

Motors
- Medium.com, choosing parts for micromouse: HERE
    - Explains choice of motors
    - 600rpm may be ideal speed
- Phone call to servocity- Motors run fine at 5V just slower, and current draw from stall is mostly linear to voltage supplied to the motors

Power
- University of Nevada, micromouse analysis document: HERE
    - Explains choice of battery
    - Lithium polymer battery best choice for performance and rechargeability
- University of Munich, micromouse analysis document: HERE
    - Includes schematic of two voltage regulators to regulate 9V to 5V and 3.3V
- Youtube analysis of LiPo batteries: HERE
- Understanding RC LiPo Battery Ratings: HERE
    - 2S means 2 LiPo cells in series (we're looking for 2S 7.4V batteries)
    - 30C means that a battery allows discharge of 30 times its max mAh rating
    - Use 1C charging to maximize battery life (match the max mAh rating)
    - Middle wire used to balance and monitor the charge between multiple cells
    - **LiPo batteries are prone to fires**
        - Charging batteries cannot be left unattended when charging
        - DO NOT OVERCHARGE
        - LiPo batteries should be stored in safe pouches when charging and storing
- Switching regulator vs linear regulator: HERE
    - Replace linear regulators w/ switching regulators and test
- Stack exchange on power to motors and arduino: HERE
    - Switching regulator also recommended, and tips provided if using linear regulator

        - Order in which ground wires are connected together also emphasized- motor driver ground should be connected closest to the power supply ground to mitigate noise and ground loops (current circulating within the ground wires of the circuit due to varying voltages at each ground node
        - Includes a diode going to the regulator to block reverse current from regulator back to power supply node
            - Same lack of diode problem also mentioned by IEEE Berkely: HERE
                - can prevent current from flowing in reverse from MCU into regulator into motor driver
            - ~~Unfortunately not much voltage to work w/ (7.4V down to required 6V for motors)... Would rather not spend it on a diode (0.2-0.5V drop)~~
            - We're working w/ 5V now that 5V supply to motors still keeps the motors moving- there's room for 0.7V drop on a diode to prevent current from flowing in the opposite direction

<u>Capacitors</u>

- Altium, capacitor article: HERE
    - Tantalum capacitors are lame (replace cap going to regulator)- ceramic capacitors perform better
    - Polymer capacitors can replace electrolytic capacitors, but they're more expensive in exchange for better performance

<u>Microcontroller/Processor</u>

- ~~AVR128DA64 is the best fit option after considering various SAM controllers (faster alternatives to Arduino and the ATmega4809)~~
    - ~~Most SAM controllers are not compatible w/ 5V+ supply to match Sharp IR sensors and maximize IR reading resolution~~
    - ~~MPLAB IDE required for PIC controllers would be difficult to get accustomed to~~
    - ~~AVR128DA64 Slightly faster than ATmega4809 (20MHz) at 24MHz~~
    - ~~Programmable via UPDI~~
- Sharp IR sensor output voltage is within 3.3V, so we can choose a 3.3V controller
- AT32UC3L0256 is the fastest Microchip mcu that still uses AVR architecture (within our familiar bounds)
    - Runs at 50MHz, examples for spi, pwm, and adc provided by Microchip on atmel studio
    - Programmable via JTAG or aWire (Microchip's proprietary protocol) using atmel ICE programmer
    - Requires a bunch of external components for JTAG, reset switch, and power
    - ADC issue:

        - ADC: pg 809 of the datasheet says that Vadvresp should have max 1.98V, and a typical value of 1.8V- the input analog voltage to read should also stay within this range
        - The Sharp IR sensor has a min output voltage of 0.55V (at 15cm), and a max change in output voltage of 1.95V at 15->2cm and typical 1.65V, so this adds to about 2.5V output max
        - To solve this we need to scale down the voltage coming from the IR sensor using a voltage divider
            - An R1 of 330 ohms and an R2 of **750 ohms** would drop down 2.5V to 1.736V, so we'll go with that
        - This voltage divider solution was always an option so these 3.3V MCUs were always possible… smh

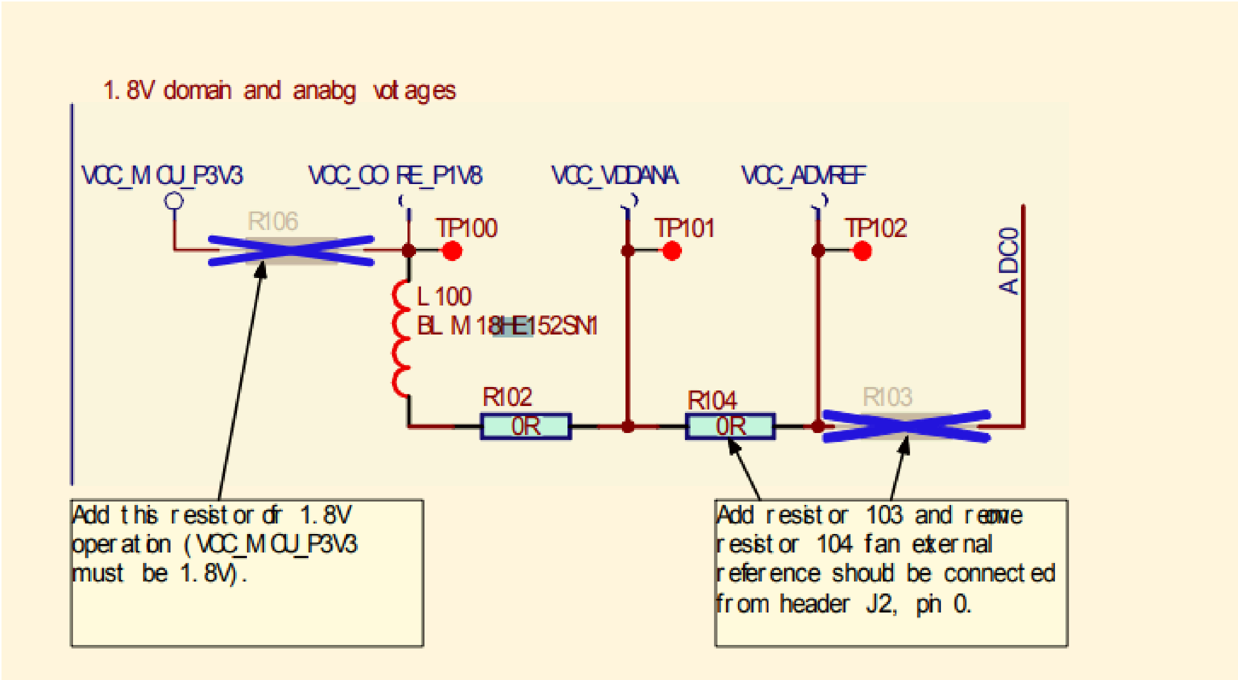
5/24/2023:

- Completed power, motor, and ir sensing BOM
- Next up: updating fusion (traces, shifting components), considering gyroscope, considering new controller, update fusion w/ appropriate connector after hosim gets back w/ lipo battery connector type, add a switch for power

- New video by Veritasium encapsulating micromouse history and meta: HERE
    - Ditch encoders for regular dc motors once gyroscope/IMU is incorporated
    - Add a fan to keep the mouse on the track when making diagonal turns
    - Mouse body has to be within 11cm to make diagonal turns
    - 4 wheels meta

8/6/2023:

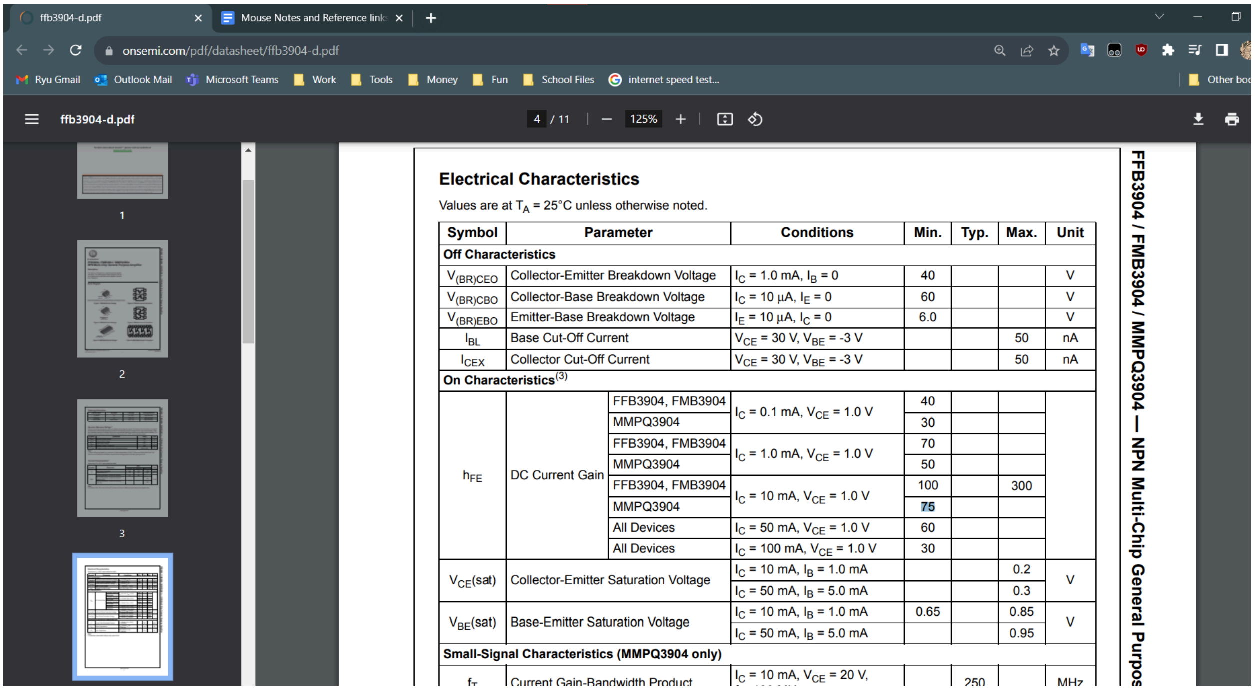
- Updated BOM is looking like
    - Power BOMs for 3 switching regulators
        - Outlined in spreadsheet, but need to update capacitors and resistors to smaller 0602 packages
    - Switch for power, connector for battery
    - IMU BOM
        - Capacitors, pull-up resistors?, IMU ic
    - MCU BOM
        - Capacitors, mcu, switch for reset
        - Regulator to supply 1.8V to VDDcore and VDDana (pg 791 on datasheet)
        - Circuitry for ADC
            - The damn thing needs a ferrite bead on its analog supply and analog voltage reference pins holy shit



    - Screenshot taken from UC3-L0 Xplained development board schematic: [HERE]
    - BLM18HE152SN1 ferrite bead which is thankfully still active
  - IR sensor BOM
    - Capacitor, ir sensor, BJT array, resistor to provide voltage at base
  - DIP switch, LEDs for debugging and mode switch
  - Motor BOM
    - Motors, motor driver ic, capacitor
  - Diodes to prevent current flow through regulators in the wrong direction

<u>BJT to control IR sensors</u>

- Npn BJT transistor array IC used to control 4 IR sensors
- BJT's should be used to sink current to ground from the IR sensors
- Calculating resistor value for base (for MMPQ3904 transistor array ic):



FFB3904 / FMB3904 / MMPQ3904 — NPN Multi-Chip General Purpos

Electrical Characteristics

Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Unit
Off Characteristics							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		I_C = 1.0 mA, I_B = 0	40			V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage		I_C = 10 µA, I_E = 0	60			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage		I_E = 10 µA, I_C = 0	6.0			V
I_{BL}	Base Cut-Off Current		V_{CE} = 30 V, V_{BE} = -3 V			50	nA
I_{CEX}	Collector Cut-Off Current		V_{CE} = 30 V, V_{BE} = -3 V			50	nA
On Characteristics(3)							
h_{FE}	DC Current Gain	FFB3904, FMB3904	I_C = 0.1 mA, V_{CE} = 1.0 V	40			
		MMPQ3904		30			
		FFB3904, FMB3904	I_C = 1.0 mA, V_{CE} = 1.0 V	70			
		MMPQ3904		50			
		FFB3904, FMB3904	I_C = 10 mA, V_{CE} = 1.0 V	100		300	
		MMPQ3904		75			
		All Devices	I_C = 50 mA, V_{CE} = 1.0 V	60			
		All Devices	I_C = 100 mA, V_{CE} = 1.0 V	30			
V_{CE}(sat)	Collector-Emitter Saturation Voltage		I_C = 10 mA, I_B = 1.0 mA			0.2	V
			I_C = 50 mA, I_B = 5.0 mA			0.3	
V_{BE}(sat)	Base-Emitter Saturation Voltage		I_C = 10 mA, I_B = 1.0 mA	0.65		0.85	V
			I_C = 50 mA, I_B = 5.0 mA			0.95	
Small-Signal Characteristics (MMPQ3904 only)							
f_T	Current Gain-Bandwidth Product		I_C = 10 mA, V_{CE} = 20 V,		250		MHz

- 200mA max collector cut-off current (Ic)
- 75 min current gain hFE
- Base current (Ib) = Ic/hFE, so 200mA/75 = 2.67mA
- Safe base current is around 5~10 times more than Ib, so 26.7mA
- Base resistor value should be Rb = (V-Vbe)/Ib_safe
    - V = supplied voltage at collector, so 5V
    - Vbe is base-emitter voltage drop, so 0.65V min
    - Rb = (5-0.65)/(26.7mA) = 163.125
        - We'll go w/ **180 Ohms**

<u>Battery connectors</u>

- JST connector types: [HERE]
    - The HOSIM 7.4V lipo battery uses a 3 position XH JST connector and some other proprietary XT or CT connector look-a-like

- Left off on motor section and adding capacitor to motor driver ic

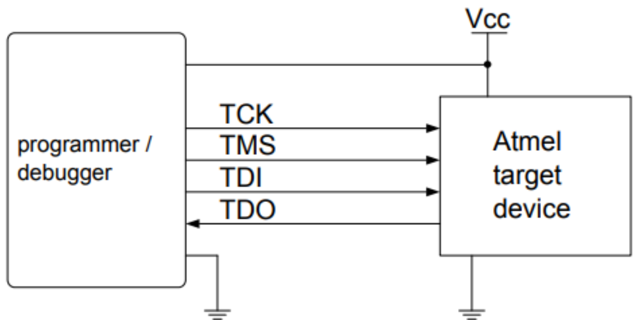
<u>JTAG to program AT32UC3L0256</u>

- Link to atmel ice user guide: [HERE]
- TH pins should be configured like so for JTAG (pg 30):

4.3.2. JTAG Physical Interface

The JTAG interface consists of a 4-wire Test Access Port (TAP) controller that is compliant with the IEEE® 1149.1 standard. The IEEE standard was developed to provide an industry-standard way to efficiently test circuit board connectivity (Boundary Scan). Atmel AVR and SAM devices have extended this functionality to include full Programming and On-chip Debugging support.

Figure 4-5. JTAG Interface Basics



4.3.2.1. AVR JTAG Pinout

When designing an application PCB, which includes an Atmel AVR with the JTAG interface, it is recommended to use the pinout as shown in the figure below. Both 100-mil and 50-mil variants of this pinout are supported, depending on the cabling and adapters included with the particular kit.

Figure 4-6. AVR JTAG Header Pinout