Milestone 1 l EEE3099S

Joseph Stewart l STWJOS003
Nüvit Ilkin Demirtaş l DMRNUV001
Harry Papanicolaou l PPNHAR001

Individual Contributions:

Section	Contributor
Requirement Analysis	Harry
Subsystem Design	Nüvit
Acceptance Test Procedure	Joseph

Requirement Analysis:

Functional Requirements:

The functional objective of the project is to construct a line-following treasure hunter robot that can navigate a maze and identify the location of an object. Specifically, the robot must be able to:

- Navigate a maze by following a line using optical sensors.
- Make decisions on which direction to take should it encounter a diverging path.
- Recognize where a "viewing point" is so that it can attempt to capture information about the environment around the "viewing point".
- Detect where an object of interest is near a viewing point and measure the distance from the viewing point to the object.
- Recall previous object's distances from their respective viewing points, the locations of said viewing points and how to return there from where it currently is.
- Do all the above autonomously after a single user input, that is the turning on of the robot.
- Be able to decide which location to return to by knowing which of the objects were closest to their viewing points.

Constraints:

Many constraints were considered in the brief of this project. Of the ones pertaining to what hardware to use, the following were listed:

- The HC-SR04 Ultrasonic Range Sensor for the Raspberry Pi
- An Arduino 33 nano IoT
- 2 x 18650 3.7V Batteries
- 2 x four channel Bi-directional logic level converters
- A Dual H-bridge Motor Driver L298N module
- A turtle 2WD Mobile Robot Platform
- 4 x SEN0017 Line tracker sensors
- 2 x SEN0038 Wheel encoder

The design constraints are as follows:

- The axle length must be 13.6 cm
- Wheel diameter must be 6.2 cm

Possible Bottlenecks etc.:

- Incorrect code
- Inaccurate machine measurements

Subsystem Design

Subsystem and Sub-subsystem Requirements:

Power:

- Battery:
    - 2 x 18650 batteries (3.7V each) in series minimum and maximum voltage
- Should be able to operate from the bench PSU if needed.
- The entire electronics circuitry should operate at most at a 5V logic level.

Sensing:

- Ultrasonic Sensor:
    - Sensor placement must be in front of the chassis
    - An indicator LED (either Red or green. Preferably red) to represent a “detect state” i.e. the robot has stopped and has begun detecting at the detect line.

- Line Sensor:
    - Line sensors should be placed at appropriate positions on the platform facing down.
    - Indicate the number of sensors used (A max of 5 is allowed.)
- Wheel Encoder:
    - Give the rotation degree of the wheels.

Microcontroller:

- Arduino Nano 33 IoT should be used.
- A motor controller is also necessary for the motor control.

Motor and Platform:

- 2WD Mobile Platform for Arduino should be used.
- The 2WD Mobile Platform for Arduino comes as a kit which includes two drive motors, wheels (and rear caster ball), frame and all mounting hardware.
- Axle length: 13.6 cm
- Wheel diameter: 6.2 cm
- A motor driver dual h-bridge module (L298N) should be used.

Subsystem and Sub-subsystem Specifications:

Power:

- Battery:
    - 2 x 18650 3.7V Batteries

Sensing:

- Ultrasonic Sensor:
    - HC-SR04 Ultrasonic Range Sensor:
        - Working Voltage: DC 5 V
        - Working Current: 15mA
        - Working Frequency: 40Hz
        - Max Range: 4m
        - Min Range: 2cm

        - Measuring Angle: 15 degree
        - Trigger Input Signal: 10uS TTL pulse
        - Echo Output Signal: Input TTL lever signal and the range in proportion
        - Dimension: 45*20*15mm

- Line Sensor:
    - DFRobot Line Tracking Sensor for Arduino:

        - Power supply: 3.3~5V
        - Detecting Range: 1~2cm
        - Operating current: <10mA
        - Operating temperature range: 0°C ~ + 50°C
        - Output interface: 3-wire interface (1 - signal, 2 - power, 3 - power supply negative)
        - Output: TTL(Black for LOW output, White for HIGH output)
        - Module Size: 10mm×28mm (1.1x 0.4 in)
        - Module Weight: About 10g

- Wheel Encoder:
    - Voltage:+5V
    - Current:<20mA
    - Resolution: 20 PPR
    - Weight: 20g

Microcontroller:

- Arduino Nano 33 IoT (SAMD21G18A)

    - Processor
        - 256KB Flash
        - 32KB Flash
        - Power On Reset (POR) and Brown Out Detection (BOD)
    - Peripherals
        - 12 channel DMA
        - 12 channel event system
        - 5x 16 bit Timer/Counter

    - 3x 24 bit timer/counter with extended functions
    - 32 bit RTC
    - Watchdog Time
    - CRC-32 generator
    - Full speed Host/Device USB with 8 end points
    - 6x SERCOM (USART, I^2C, SPI, LIN)
    - Two channel I^2S
    - 12 bit 350ksps ADC (up to 16 bit with oversampling) 10 bit 350ksps DAC
    - External Interrupt Controller (up to 16 lines)

- DFRduino Romeo-All in one Controller V1.1(SKU:DFR0004)
    - Atmega 168/328
    - 14 Channels Digital I/O
    - 6 PWM Channels (Pin11,Pin10,Pin9,Pin6,Pin5,Pin3)
    - 8 Channels 10-bit Analog I/O
    - USB interface
    - Auto sensing/switching power input
    - ICSP header for direct program download
    - Serial Interface TTL Level
    - Support AREF
    - Support Male and Female Pin Header
    - Integrated sockets for APC220 RF Module and DF-Bluetooth Module
    - Five I2C Interface Pin Sets
    - Two way Motor Drive with 2A maximum current
    - 7 key inputs
    - DC Supply: USB Powered or External 7V~12V DC。
    - DC Output：5V /3.3V DC and External Power Output
    - Dimension：90x80mm

Motor and Platform:

- 2WD Mobile Platform for Arduino
    - Two differential drive
    - Caster ball included

- Complete chassis with mounting hardware
- Dimensions: 170mm diameter base
- Weight: 400g

- Motor Specification

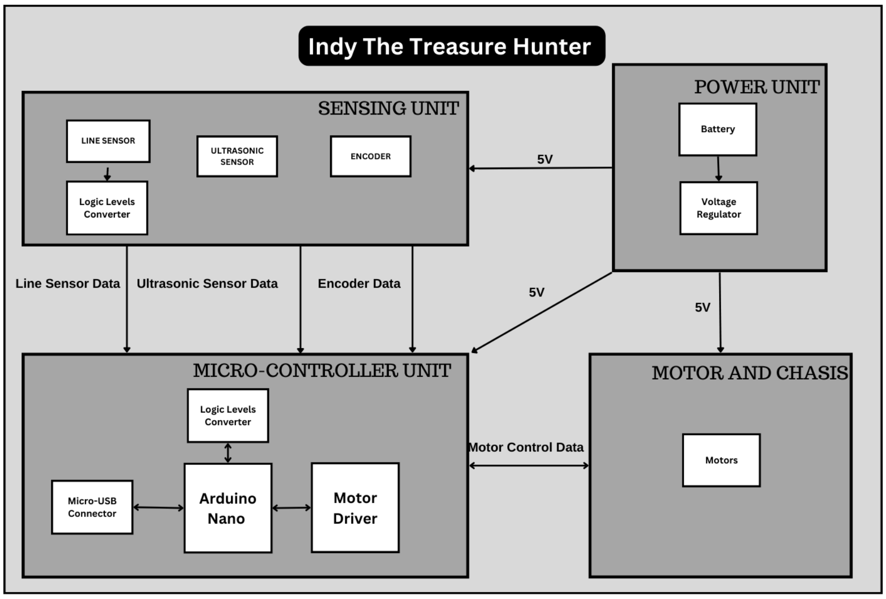
  - Gear Ratio 1:12
  - No-load speed (3V): 100RPM
  - No-load speed (6V): 200Rpm
  - No-load current (3V): 60mA
  - No-load current (6V): 71mA
  - Stall current (3V): 260mA
  - Stall current (6V): 470mA
  - Torque (3V): 1.2Kgcm
  - Torque (6V): 1.92Kgcm
  - Size: 55mm x 48.3mm x 23mm
  - Weight: 45g

- Dual H-Bridge Driver
  - Logic voltage: 5VDC (has onboard 5V regulator if you would like to power from 12V)
  - Drive voltage: 5-35VDC
  - Drive current: 2A(MAX single bridge)
  - Max power dissipation: 25W
  - Size: 43*57mm

Inter-subsystem interactions:

- The motors will be connected to the encoder.
- The encoder and the sensors will all be connected to the microcontroller.
- The battery will be connected to all the peripherals.

UML or OP diagrams where possible:



Acceptance Test Procedure:

Figures of Merit:

- Line Following Accuracy
    - The robot should accurately follow the designated line throughout the maze.
- Object Detection Speed
    - The robot's object detection should be fast and responsive.
- Maze Completion Time
    - The robot should complete the maze within a reasonable timeframe.
- Path Planning Efficiency
    - The robot's path planning algorithm should efficiently navigate the maze an avoid unnecessary detours.
- Object Identification Reliability
    - The robot should reliably identify objects and navigate to the closest one.
- Line Recovery Performance
    - The robot should be able to recover quickly if it temporarily loses the line.
- Battery Life in Real Conditions
    - The robot's battery should be sufficient for completing the task under real-world conditions.
- Consistency Across Runs

    - The robot's performance should be consistent across multiple runs of the same size.
- Adaptability to Maze Variability
    - The robot should be able to handle different maze layouts and configurations.

Experiment Design:

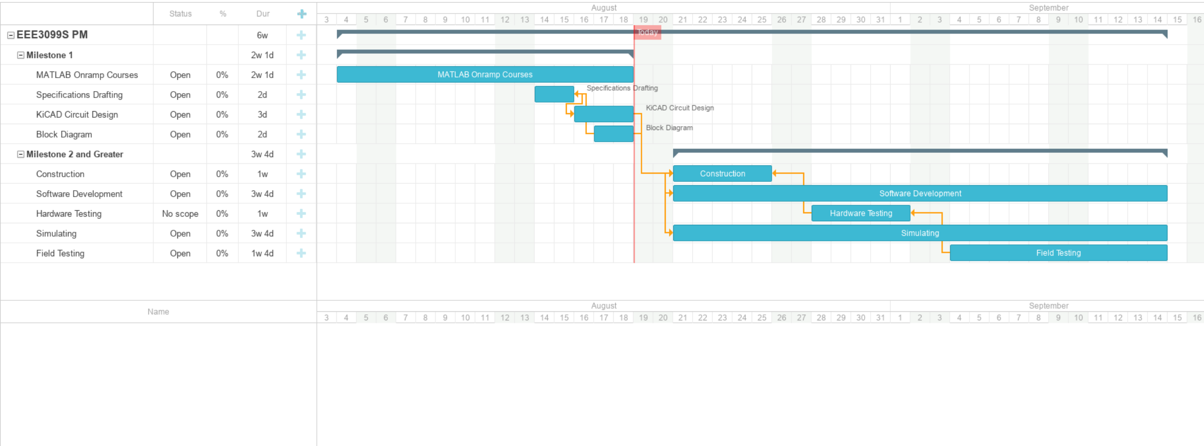
- Line Following Accuracy
    - Set up a complex maze with intricate line tracks and measure how consistent the robot stays on the line.
- Object Detection Speed
    - Place an object in the robot's path and measure the time it takes for the robot to detect and react to the object's presence.
- Maze Completion Time
    - Time the robot's completion of the maze with different maze configurations and analyze the average completion time.
- Path Planning Efficiency
    - Create a maze with multiple possible paths and measure the robot's chosen paths to assess the efficiency of its navigation decisions.
- Object Identification Reliability
    - Randomly place objects in the maze and evaluate whether the robot consistently detects and navigates to the nearest object based on the detect line.
- Line Recovery Performance
    - Intentionally disrupt the line and assess how swiftly the robot regains the correct path.
- Battery Life in Real Conditions
    - Run the robot through the maze multiple times and measure the battery drain to ensure it can sustain the entire competition without needing frequent recharging.
- Consistency Across Runs
    - Run the robot through the same maze configuration multiple times and compare its performance metrics (e.g., completion time, accuracy) to evaluate its consistency.
- Adaptability to Maze Variability
    - Design and test various maze layouts with different line track complexities and object placements to assess the robot's adaptability.

Acceptable Performance Definition:

The line-following robot is considered to have achieved acceptable performance when it successfully completes the maze navigation task within a reasonable time frame, accurately detects objects placed along the maze, and effectively navigates to the object closest to its corresponding detect line. The robot should consistently follow the designated line, and demonstrate stable performance across multiple runs of the same maze configuration.

Development Timeline:

Project Management:



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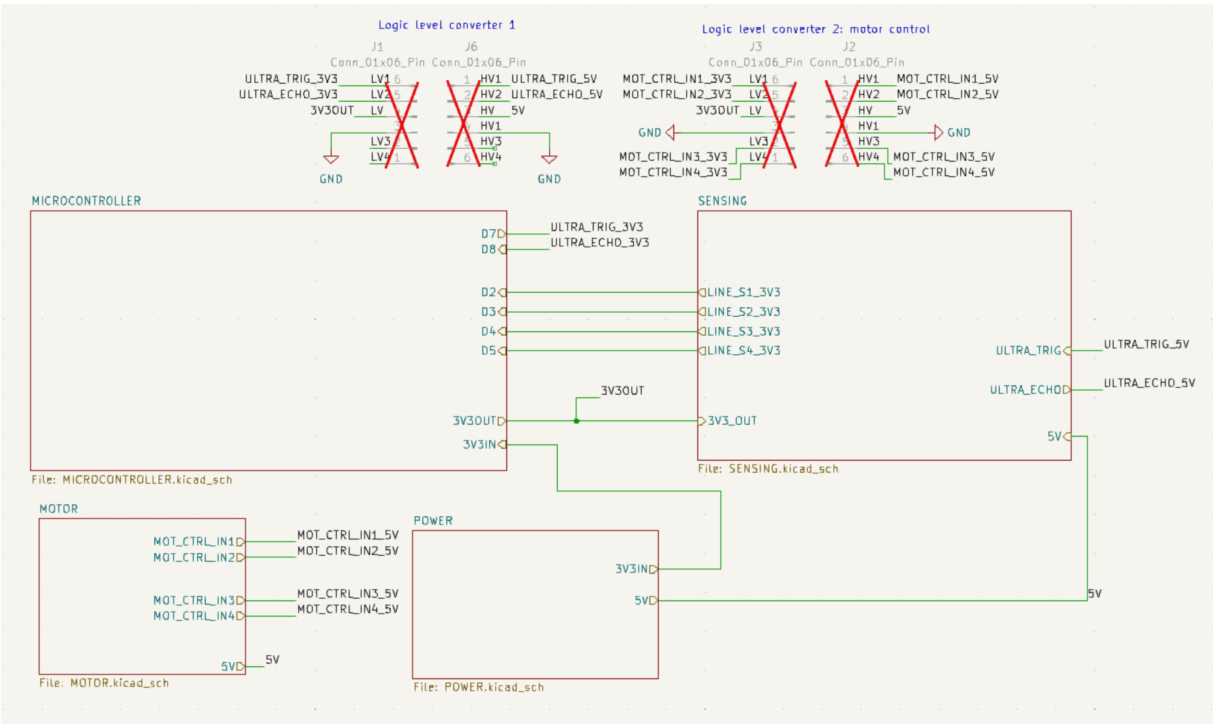
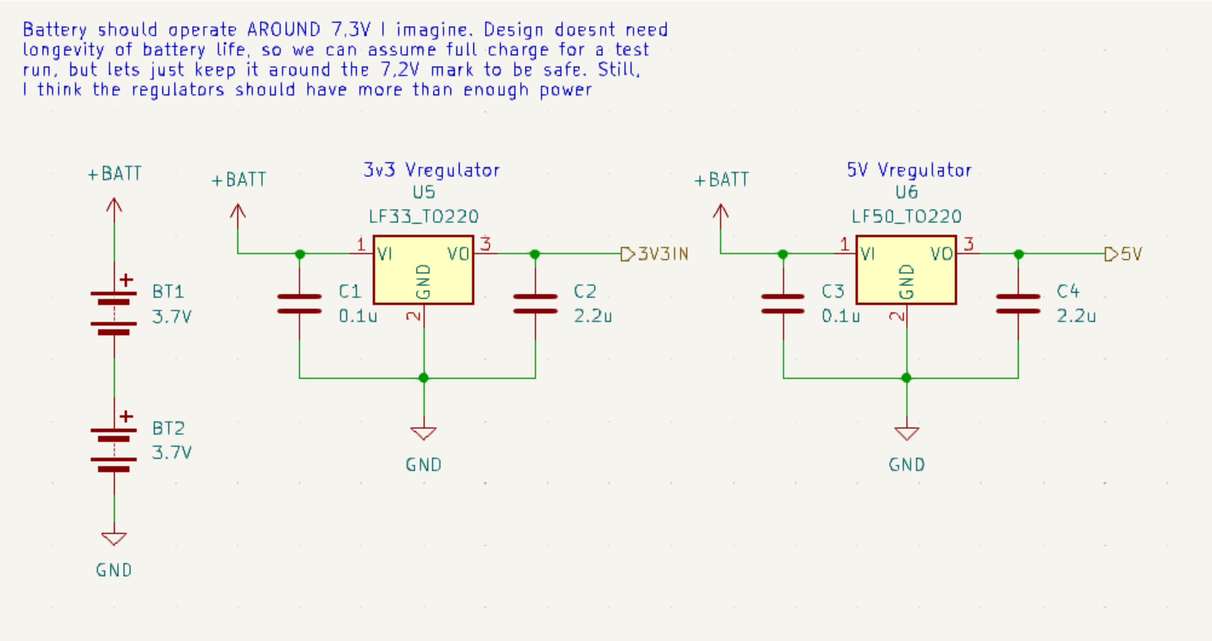
Circuit Design:

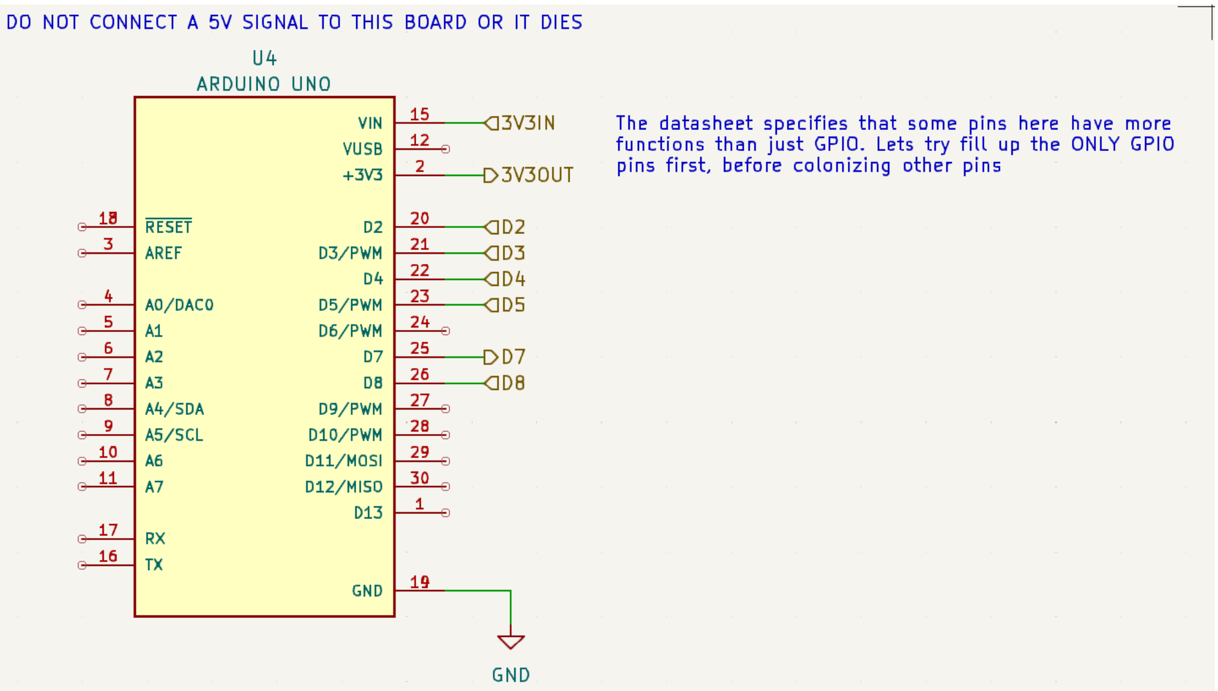
Subsystems:



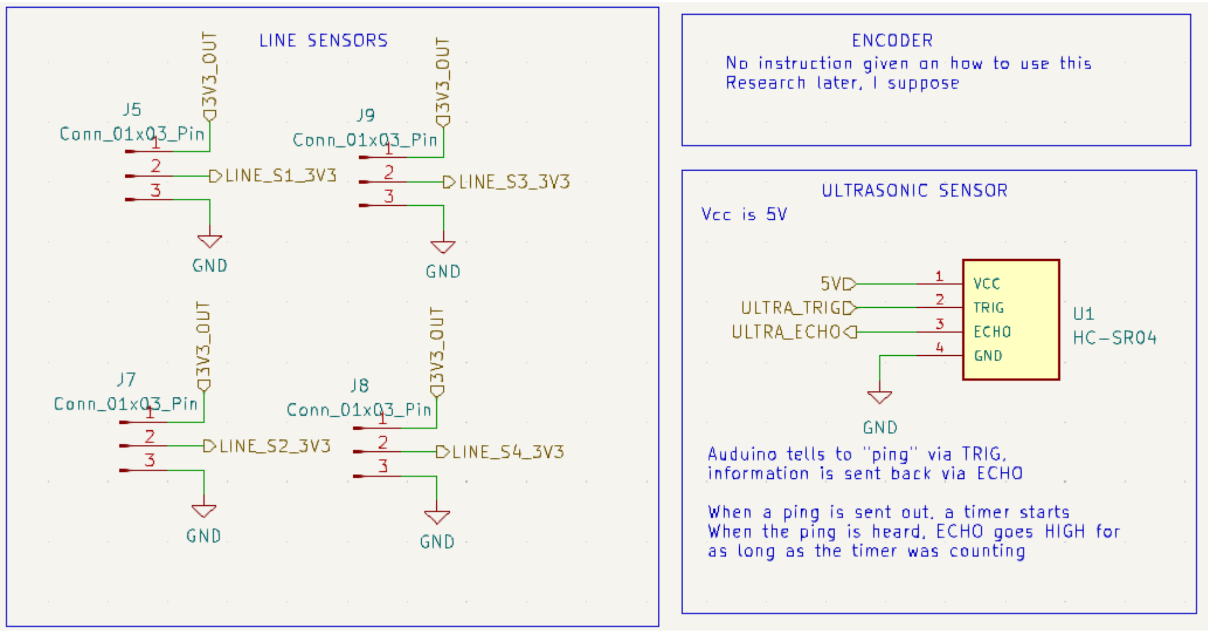
Power:



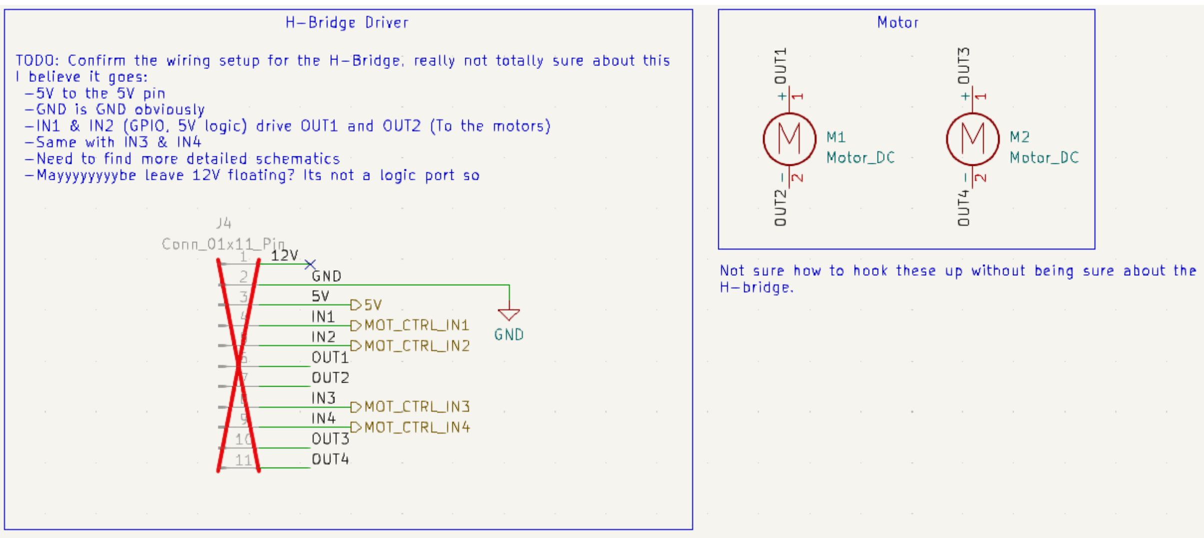
Microcontroller:



Sensing:


LINE SENSORS
J5
Conn_01x03_Pin
3V3_OUT
LINE_S1_3V3
GND
J9
Conn_01x03_Pin
LINE_S3_3V3
J7
LINE_S2_3V3
J8
LINE_S4_3V3
ENCODER
No instruction given on how to use this
Research later, I suppose
ULTRASONIC SENSOR
Vcc is 5V
5V
ULTRA_TRIG
ULTRA_ECHO
VCC
TRIG
ECHO
GND
U1
HC-SR04
Auduino tells to "ping" via TRIG,
information is sent back via ECHO
When a ping is sent out, a timer starts
When the ping is heard, ECHO goes HIGH for
as long as the timer was counting

Motor:


H-Bridge Driver
TODO: Confirm the wiring setup for the H-Bridge, really not totally sure about this
I believe it goes:
-5V to the 5V pin
-GND is GND obviously
-IN1 & IN2 (GPIO, 5V logic) drive OUT1 and OUT2 (To the motors)
-Same with IN3 & IN4
-Need to find more detailed schematics
-Mayyyyyyyybe leave 12V floating? Its not a logic port so
J4
Conn_01x11_Pin
12V
GND
5V
IN1
IN2
OUT1
OUT2
IN3
IN4
OUT3
OUT4
MOT_CTRL_IN1
MOT_CTRL_IN2
MOT_CTRL_IN3
MOT_CTRL_IN4
Motor
OUT1
OUT2
M1
Motor_DC
OUT3
OUT4
M2
Motor_DC
Not sure how to hook these up without being sure about the
H-bridge.

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Joseph Stewart:


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Joseph Stewart

has successfully completed **100%** of the self-paced training course

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has successfully completed **100%** of the self-paced training course

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DIRECTOR, TRAINING SERVICES

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Course Completion Certificate

Joseph Stewart

has successfully completed **100%** of the self-paced training course

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Nüvit Ilkin Demirtaş:


MathWorks | Training Services

Course Completion Certificate

Nuvit Ilkin Demirtas

has successfully completed **100%** of the self-paced training course

MATLAB Onramp

DIRECTOR, TRAINING SERVICES

9 August 2023


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has successfully completed **100%** of the self-paced training course

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has successfully completed **100%** of the self-paced training course

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has successfully completed **100%** of the self-paced training course

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