ENMT221 Term 4 Project:

Line following race

Version 1.4

1 Introduction

This design and build project is intended to develop your ability to create a simple, integrated mechatronic system - a line following robot. You will conduct electronic simulation and circuit board layout, design mechanical parts in CAD, fabricate and test your robot, and finally communicate your design and project outcomes in a report.

This document has a version number at the top. As the project is revised every year, it is likely that the details here will need to be updated over the next few weeks. When this is done the version number will be incremented.

1.1 Marking

This assignment counts for 35 % in total.

- 5 % demonstration *(group mark)*
- 15 % circuit and PCB design *(group mark)*
- 15 % report *(individual mark)*

As the report is individually assessed, this is expected to be sufficient to deal with cases of uneven workload. However, if group members are uncontactable/don't adequately contribute, please contact the lecturer.

1.2 Schedule

The key dates in the project are as follows:

PCB submission	**Thursday 26 Sept., midnight**	In order to get the PCBs produced in time, this is about the latest we can order them
Demos	17 October	Each group will be allocated a time slot in which to demonstrate your robot.
Report	Friday 18 October, midnight	Individual online submission on Learn.

1.2.1 Labs

Your first priority is to design the robot circuit and PCB, as the PCBs must be ordered from overseas and take some time to arrive. We encourage you to get started learning KiCAD before the start of term. We will use the Lab A sessions as drop-in times to ask for advice on circuit and PCB design and simulation. Construction of the robots will begin in Week 3-4.

2 Robot functional model

A block diagram of the robot is shown in Figure 2.

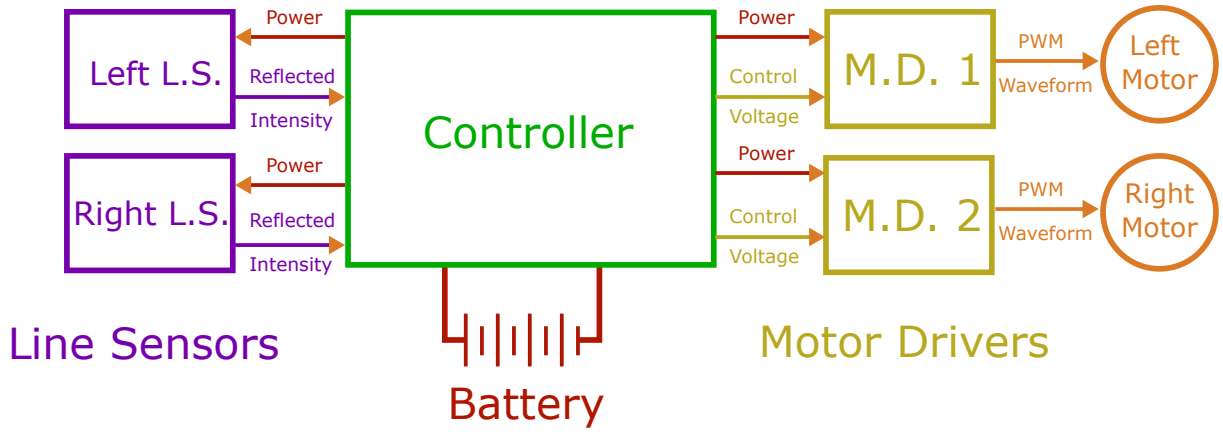


Figure 1: Block diagram of robot

2.1 Summary of operation

Each line sensor produces a voltage indicating whether it is positioned over the black line, over the white background, or partially over the black line. At minimum, two line sensors are required (one each side of the line). Based on the voltage from the line sensors, the controller (using a microcontroller) calculates a drive signal for each motor (a voltage representing values between off and full scale). The motor drivers convert this signal into a high power PWM signal to physically drive the motors.

2.2 Split of work

Each group member must demonstrate contribution to all areas (circuit, mechanical design, software, and testing of the robot) in their report.

3 PCB design

You are strongly encouraged to produce a good PCB design for fabrication.

- Having the experience of designing and fabricating a PCB from scratch will be highly beneficial for learning
- Using a PCB will allow a neater robot, and assembling components onto a PCB is a fast process
- If you encounter errors in your fabricated PCB, you will be able to correct these in the design in your report

Those who do not submit PCBs in time for fabrication, or whose PCBs do not work, will lose many of the marks for PCB and circuit design, and need to use vero-type strip to assemble their circuits.

3.1 PCB design rules

If you wish you may use separate PCBs (up to 3 designs per group) for different parts of your circuit (e.g. line sensors) so they can be positioned remotely. No PCB dimension may exceed 100 mm. If several copies of a PCB are required, please indicate this in your submission.

Detailed design rules can be found here: https://jlcpcb.com/capabilities/Capabilities . To ensure reliable fabrication, it is best not to make trace sizes and clearances too close to the stated minimum.

4 Course and performance evaluation

The robots will be raced in a time trial format, and successful completion of the course, plus the time taken to do so, will be used to derive the performance mark.

- 2% will be awarded to all groups whose robots successfully complete the course
- A score out of 3% will be calculated based on the time taken. These marks will be awarded based on ranking, i.e. the fastest robot in the class will score 3%, and the slowest 0%.

4.1 Course layout

The course will:

- Be contained within an area of 2.4 × 1.2 m.
- Comprise of a flat reflective white surface with a matte, reduced-reflective black line.

The line will:

- Be between 15 mm and 20 mm wide
- Have a total length of no more than 15 m
- Have a minimum radius of curvature of 80 mm to the centre of the line
- Be separated orthogonally by at least 80 mm centre to centre
- Not intersect itself

4.2 Timing

- Robots must start from stationary (pushing the robot is not allowed)
- The course will have timing gates at each end (width no less than 200 mm)
- The time will start when the front of the robot passes the first timing gate, and end when the front of the robot passes the final timing gate
- Each group will have the opportunity to make 3 trials in the final demonstration, with the best result taken.

To allow you to test your robots, a course will be provided in the mechatronics lab.

5 Rules

To create a fair design challenge, and manage the complexity of the project, there are a number of rules for your robot designs and restrictions on the components that can be used.

It is hoped that that all groups will stick to the spirit of the project rather than trying to find sneaky ways to circumvent the rules. Any conduct that your lecturer considers to breach these rules may lead to disqualification, at his complete discretion. You are encouraged to seek clarification beforehand if necessary.

5.1 Power source

Your robot must be powered from no more than 4 AA NiMH rechargeable batteries. While you are welcome to use other batteries in testing, only the batteries we provide may be used in the race.

5.2 Motors

Only the motors provided may be used. Your robot must use no more than four motors in total. You may choose whether to use:

- Multicomp MM10
- Multicomp MM28

5.3 Allowable electrical/ electronic components

With the exception of purely decorative components (LEDs, beeper, etc.), only the components listed in Appendix A are allowed. If you would like to request another component is added to the list, please email me.

5.4 Materials for mechanical build

- 100g of 3D printed PLA to be 3D printed.
- Perspex sheet 4.5 mm thick with a bounding box of 200 $\times$ 200 mm
  Submitted as a single .dxf file
  It is recommended to put your group numbers on your parts so they can be more easily tracked to you.
- M3 screws, washers, and nuts
- Rubber bands, thread etc. may be used for tyre tread, pulleys etc.

Appendix A: Allowable electronic components

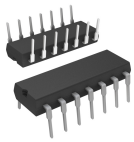
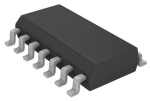
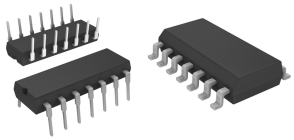
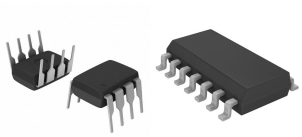
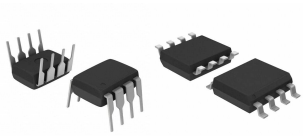
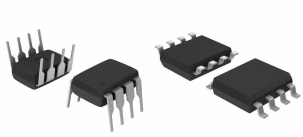
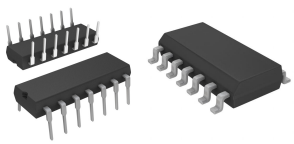
Note: We may have to make some changes to the components depending on stock availability, this should be confirmed by the first week of term.

5.4.1 Sensors

Image	Part Number	Description
	TCRT5000	Reflective optical sensor

Note: a maximum of 5 reflective optical sensors may be used in your design.

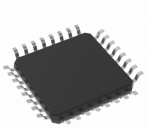
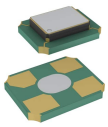
5.4.2 Opamps and comparators

Image	Part Number	Description
	MCP6274	Quad opamp, DIP package
	NCS20034DR2GOSCT-ND	Quad opamp, SOIC package
	MCP6274	Quad opamp, DIP or SOIC package
	MCP6272	Dual opamp, DIP or SOIC package
	MCP6271	Single opamp, DIP or SOIC package
	LM2903	Dual comparator, DIP or SOIC package
	LM2901	Quad comparator, DIP or SOIC package

5.4.3 Transistors

Image	Part Number	Description
	BSR802NL6327HTSA1	MOSFET N-channel 20V 3.7A, SC59 package
	IRLD014PBF1	MOSFET N-channel 60V 1.7A 4DIP

5.4.4 Microcontroller and related

Image	Part Number	Description
	ATMEGA328-PU	AVR series Microcontroller IC 8-Bit 20MHz 32KB, DIP package
	ATMEGA4808-AFR	AVR series Microcontroller IC 8-Bit 20MHz 48KB, TQFP package
	DF18CC1-9.216MHZ-T	9.216 MHz , Cl=18pF Crystal (surface mount)
	HC-49/U-S9216000ABJB	9.216 MHz, Cl=18pF Crystal (through hole)
	KC7050K20.0000C1GE00	20 MHz Crystal Oscillator (surface mount)

Note: a maximum of 1 microcontroller may be used in your design.

5.4.5 Miscellaneous

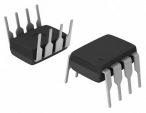
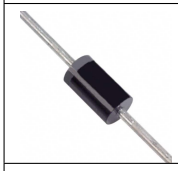
Image	Part Number	Description
	ICM7555IPAZ	555 Timer IC, DIP package
	N6L50T0C-102-3030	1 k 0.1W potentiometer, top adjust
	N6L50T0C-103-3030	10 k 0.1W potentiometer, top adjust
	XLUR12D	5 mm red LED
	151051VS04000	5 mm green LED
	151051BS04000	5 mm blue LED
	JS202011CQN	Switch, slide, DPDT, 300 mA 6V
	MJTP1230	Tactile Switch SPST-NO Top Actuated Through Hole
	1N4004	1A diode
	SB130-T	30 V 1A Schottky diode
	Keystone 2462	2 cell AA battery holder)

Image	Part Number	Description
	MCP1700-1802E/TO	1.8 V 200 mA voltage regulator
	MCP1700-3302E/TO	3.3 V 250 mA voltage regulator

Note: we will supply groups with a maximum of 5 LEDs.

5.4.6 Standard passive components

The following fixed resistors and capacitors will be available:

- 1/2 W, 1% tolerance through hole resistors in the E12 value series
- 1/4 W, 1% tolerance resistors in 0805 surface mount packages in the E12 value series
- Ceramic capacitors in 1206 surface mount packages in the E6 value series
- Ceramic capacitors in the 5 mm pitch through hole packages in the E6 value series
- Electrolytic capacitors in through hole packages in the E6 value series from 10 μF to 100 μF