Computer Systems Design Lab

SYSC 4805 (Fall 2022)

Instructor: Dr. Mostafa Taha
Carleton University
Department of Systems and Computer Engineering

Lab 1: Introduction, and IR Obstacle Avoidance Sensor Sept 8th and 9th, 2022

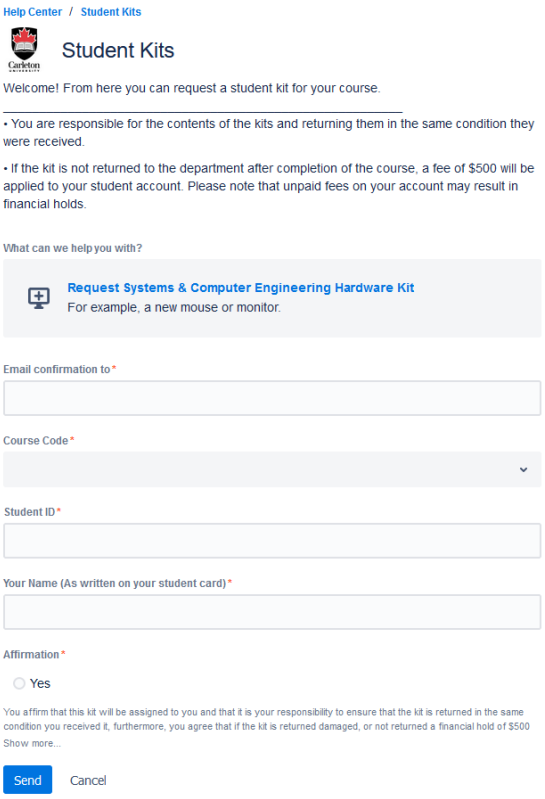
In this lab, we will conduct the following tasks:

Task 1: Pick up the SYSC 4805 Kit

After you meet and great your group members,

(a) Assign one member to be responsible for picking up the kit.

(b) The selected member should use the following link to register the request.
https://sysc.atlassian.net/servicedesk/customer/portal/2



(c) Go with your team to your TA with the confirmation email to pick up one kit. The TA will write down your names and your student ID numbers.

(d) Check the content of your kit to make sure it is complete. It is your responsibility to return the kit in the same condition as it was received, with everything listed below is included and in a perfect working condition. In the unfortunate situation where some components

were no longer working, it is extremely important to identify those components to your TA, separate them in a clearly marked bag, and write down why you think they are not working. Tech services will have to replace these components with new working ones before giving this kit to a different group of students.

(e) Some cautionary notes on using the SYSC 4805 kit.

a. The kit is new to this year, and costs around $500.

b. The Arduino due board itself can be powered by 7-12V, however the ARM Cortex-M3 SAM3X8E ship onboard can tolerate a *maximum of 3.6 V* at any of its inputs. The internal chip actually runs at a maximum of 1.95V. Please be extremely careful on the voltage level applied to the Arduino board inputs.

c. The Cytron Motor Controller Board highlighted below, must not be placed directly on the metal of the car chassis. Doing so will create short circuits everywhere on the board. The motor driver board must be installed only using spacers with sufficient height to allow the board to operate away from the metal chassis.

d. Please try to reserve the jumper cables highlighted below, as connected together as much as possible. The motor driver board above will need 9 connection wires, that are best to be attached together as a bus. All the other sensors will need multiple connection wires.

e. We have small breadboards which can be used one per sensor. This will allow free placement of the sensors anywhere on the chassis. We also have one bigger board to test sensors, and build circuits as you wish.

f. The solid core wires highlighted below are best to be used to distribute VCC and GND to all the small breadboard on the chassis. The keep a low profile, that does not interfere with the operation of the sensors.

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#	Category	item	Description	Instances per kit
1	Core	Robot Chassis	Comes with a 5 AA battery holder + 2 encoders	1
2		AA Batteries	Rechargeable 1.5 AA batteries - 1.5 Volts	5
3		Motor Driver	Cytron 4 Channel 7-25V, 1.5A Brushed DC Motor Controller	1
4		Spacers	To mount the Motor Driver Board	1
5		Arduino Due	Arduino Due 32bit ARM Microcontroller	1
6	Sensors	Line Follower	To detect map/playground edges.	2
7		Obstacle detection IR sensor	Digital On/Off obstacle detection sensor with manual sensitivity adjustment	2
8		Laser Range Finder - I2C	Time of Flight (TOF) range finder with I2C interface - 4 cm to 400 cm	2
9		Ultrasonic Sensor	distance sensor.	2
10		Analog Distance Sensor	Sharp GP2Y0A51SK0F Analog Distance Sensor - 2cm to 15cm	2
11		Cable for distance sensor	3-Pin Female JST Cable for Sharp Distance Sensors	2
12		IMU	MinIMU-9 v5 Gyro, Accelerometer and Compass (LSM6DS33 and LIS3MDL Carrier).	1
13	Wiring	M-F, M-M and Jumper wires	Generic wires to build circuits on the breadboard.	1
14		Plug	Terminal to 2.1mm Barrel Jack plug for the Arduino	1
15		USB A to Micro USB cable	Arduino Due programming cable	1
16		Terminal Breadboards	Small breadboards, one board per sensor	1
18	Resistors	10 Kohm	2 x 10 KOhm is required for the I2C bus of the Laser range finder.	2
21		1.2 Kohm	voltage divider	2
22		2.2 Kohm	voltage divider	2

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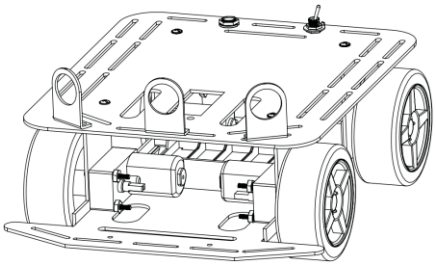
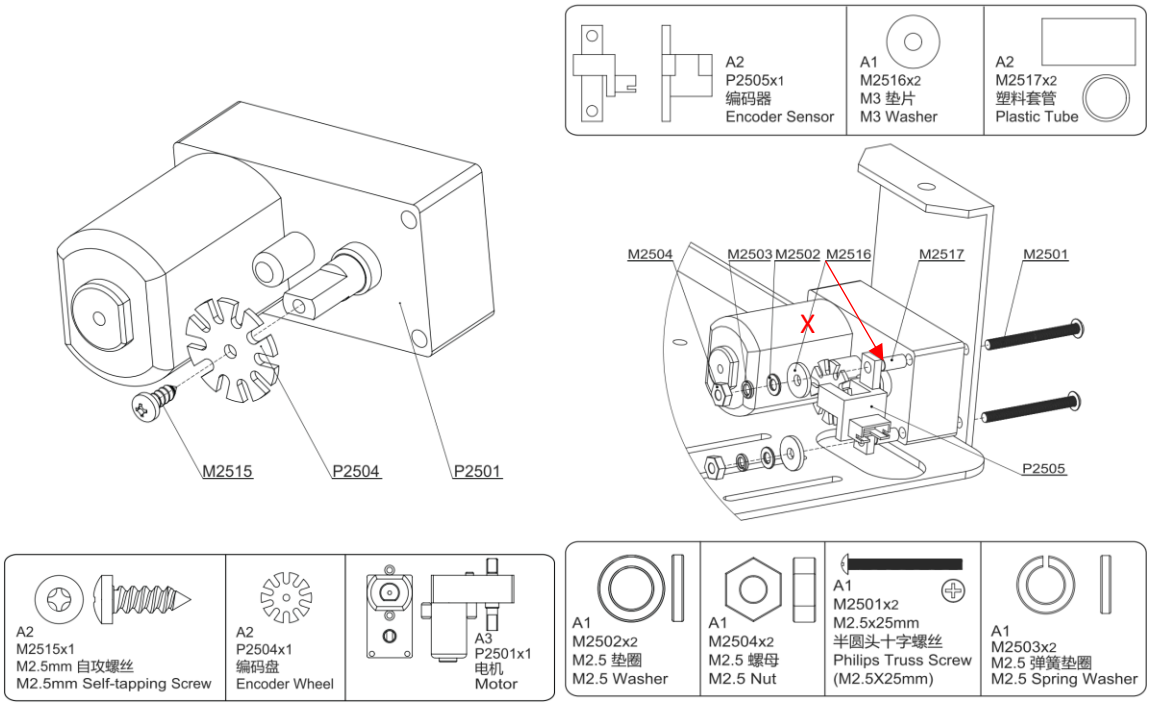
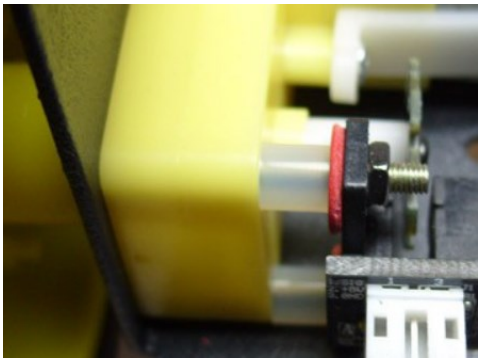
Task 2: Build the basic robotic chassis:



(a) Start with building the Encoder Sensor Assembly:



Please make sure the red-solored M3 Washer (with code: M2516) goes betweeen the Plastic Tube (with code: M2517) and the Encoder body (with code: P2505), as indicated by the red arrow in the above image. This will allow for more space between the encoder wheel and the sensor body. The finished Encoder Sensor Assembly should look like the following image:



(b) The rest of building instructions can be found here: https://www.robotshop.com/media/files/pdf2/rob0025-instruction_mannual_v2.0.pdf

(c) Don't install the Arduino Due board or the other boards/sensors on top of the robotic chassis until after completing all the lab experiments (Lab 4) and testing all the units independently. A suggested placing map will be provided at the end of Lab 4.

Task 3: Install Arduino IDE:

A quick installation instructions of Arduino IDE v2.0, that are specific to Arduino Due to be used in this course, can be found by clicking on the "Quickstart Guide" from this link: https://docs.arduino.cc/hardware/due

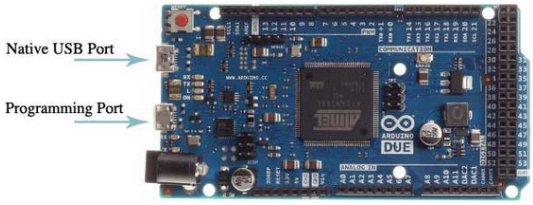
More detailed instructions, along with getting started tutorials and other help resources can be found here: https://docs.arduino.cc/software/ide-v2. In this course, we will be using Arduino IDE 2.0, however any previous version should work as well. Please make sure to accept installing the USB drivers at the end of installing the Arduino IDE.

Task 4: Get to know your Arduino Due:

The Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button.

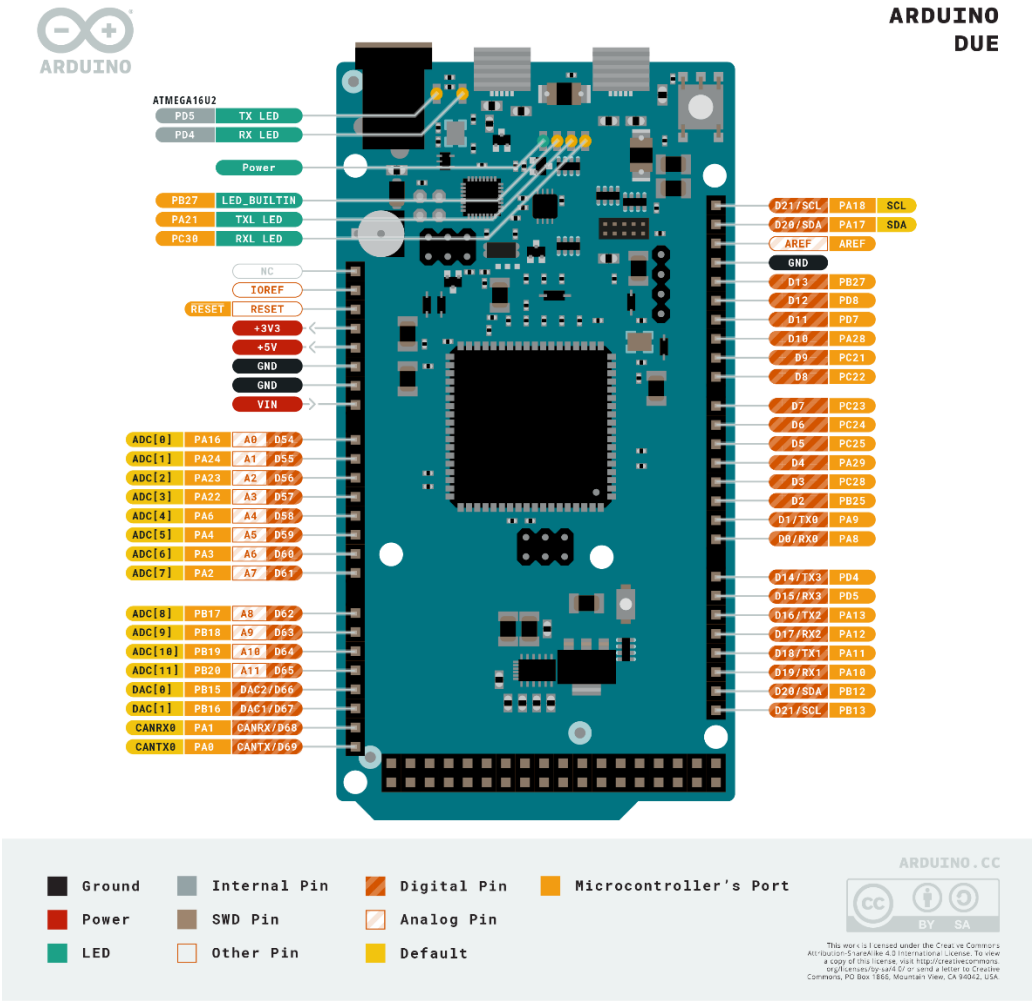
Here are a couple of important notes:

(a) The Arduino Due can be powered via the USB connector or with an external power supply. The power source is selected automatically. During initial testing, it is easier to use the programming port, that is close to the power socket, to both power the board and program it, using only one cable. During actual operation of the robotic car, we will use the power socket to power the board directly from the battery holder. Warning: You should never supply voltage via the 5V or 3.3V output pins, as doing so bypasses the regulator, and can damage your board.



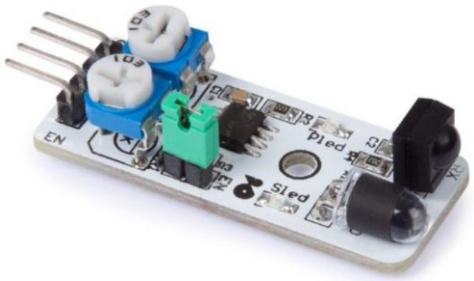
(b) Warning: Unlike most Arduino boards, the Arduino Due board runs at 3.3V. The maximum voltage that the I/O pins can tolerate is 3.3V. Applying voltages higher than 3.3V to any I/O pin could damage the board. 5V pin output is only provided by the Arduino board for your convenience however, it should never be used to test the Arduino inputs themselves.

(c) Datasheet of the Atmel SAM3X8E ARM Cortex-3M CPU, tutorials, and other help resources can be found in: https://docs.arduino.cc/hardware/due



Task 5: Test the VMA330 IR Obstacle Avoidance Sensor Module

Prepared By: Mahmoud Sayed



Introduction

The VMA330 is an inexpensive solution for obstacles detection for robotics applications. For applications with moving parts like RC Cars, it can be used to alert the control system about the existence of a potential obstacle in the direction where the module is facing. It also can be used in stationery parts of machine for counting purposes, like counting the number of boxes moving on top of a conveyor belt. Its working principle is a much simpler version of the idea of the Radar: sending a signal and detecting its reflection. However, the VMA330 module does not measure distances, it just indicates the presence or absence of an object in front of the module. The transmitted signal here is bursts of Infrared (IR) that is generated through a Light Emitting Diode (LED). The reflected signal is sensed using an HS0038BD IR receiver, which is basically a PIN diode connected to an Automatic Gain Control (AGC) preamplifier, coated by an epoxy layer that acts as a bandpass filter that allows only the specific IR frequency to come through. The module produces a digital on/off signal to indicate the detection state, which can be directly interfaced to a digital IO pin in a controller. It also comes with two adjustable potentiometers that control the emitted IR intensity and the bursts frequency. In table 1, a summery for the VMA330 specifications can be found.

Table 1: VMA330 module specifications.

Operating Voltage	3.3V to 5V
Output Type	On/Off
Distance Range	2 to 40 cm
Operating Temperature	-10° C to +50° C
I/O Interface	GND, VCC, OUT, and EN (usually unused)
Dimensions	45×16×10 mm
Weight	9g

Experiment 1:

In this experiment, we will test the basic functionality and performance of the VMA330 module.

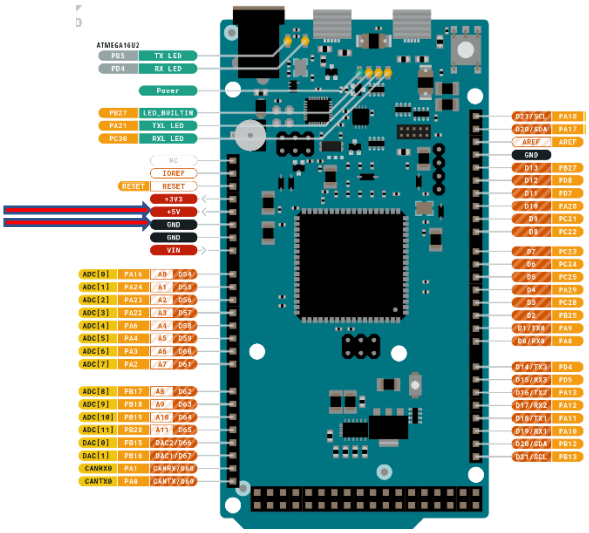
Required Equipment:

1- VMA330 module.
2- The Arduino Due board.

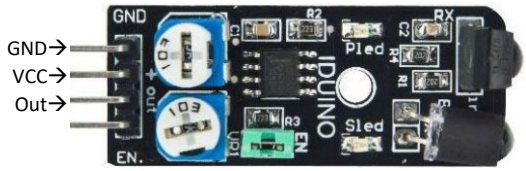
3- Voltmeter.
4- Breadboard.
5- Jumper wires.

Procedure:

1- **Find a 5V power supply**: Ideally, we would use a variable power supply to provide the required 5V voltage. However, to reduce the amount of bench top tools, we will the Arduino Due board itself to provide the 5V. Connect the Arduino Due board to your laptop using the provided USB cable. Connect the voltmeter to the GND and +5V outputs of the Arduino Due highlighted below and measure the provided voltage.



2- **Make the connections**: With the power supply's output disabled or turned off, use a breadboard to connect the VCC and GND pins of the VMA330 module to the +ve and GND terminals of the power supply (GND terminal is different from the Earth terminal). Make sure that you do not make connections with the power supply while its output is alive, and make sure that turning on the power supply will give the pre-configured voltage to the circuit.



3- **Check the operation**: Move an obstacle in front of the module to check its functionality. The module has small mounted LED that should change its state based on the presence or absence of an obstacle. Also, measure the output voltage of the module on the Out pin, using a voltmeter in both cases. If the module's detection state does not change, try to adjust the potentiometers slightly.
4- **Measure the distance**: Measure the maximum and minimum distances at which the module can detect an obstacle. Adjust the potentiometers slightly till you get the best stable performance.
5- **Report the measurements**: Write down the measurements you got in table 2

Table 2: Experiment 1 Measurements

	Vcc = 5V	Vcc = 3.3V
Voltage when there is an obstacle		
Voltage when there is no obstacle		
Maximum detection distance		
Minimum detection distance.		

6- **Change the supply voltage to 3.3V**, by using the 3.3V output of the Arduino Due board. Repeat the measurements.
7- **Apply a direct light source:** Use a light source (like the flashlight of your mobile phone) to illuminate the IR receiver. Does this change the module's detection state?

Experiment 2:

In this experiment, we will interface the VMA330 module with the Arduino Due board. The Arduino board should utilize the VMA330 module as an obstacle detector and indicate the presence or absence of an obstacle by displaying a message on the computer using the serial monitor.

Required Equipment:

1- Arduino Due board.
2- VMA330 module.
3- Breadboard.
4- Jumper Wires.

Procedure:

1- **Make the connections:** Using the breadboard, connect the GND pins of the Arduino and the VMA330 together, connect the output pin of the module to a digital IO pin in the Arduino, and connect the Vcc pin of the module to the 3.3V pin in the Arduino. **CAUTION:** Do not connect the Vcc pin of the module to the 5V pin of the Arduino (Why?)
2- **Write your code:** Develop an Arduino sketch that does the following:
   - The Arduino reads the digital value of the IO pin, at which the output pin of the VMA330 is connected, once every 500 msec.
     >> You can use the functions: `digitalRead()` and `delay();`
   - The Arduino should turn on its LED (pin 13) when there is an obstacle and turns if off when there is no obstacle detected.
     >> You can use the function: `digitalWrite(13,HIGH);` and `digitalWrite(13,Low);`
   - The Arduino should send the reading value to the computer using the serial terminal to be displayed on the serial monitor.
     >> You can use the function: `Serial.println();`
     Make sure you include your group number in the serial message itself, for instance, you can use `Serial.println("Group ## >> No obstacles (Sensor reading is 1)");`
3- **Take pictures** of the following and include them in your report:
   - The Turned on LED when there is an obstacle detected.
   - The Turned off LED when there is no obstacle detected.

- A screenshot from the messages displayed on the serial monitor showing the different displayed messages.

Discussion

1- Is there a difference in the module performance when operated with 3.3V compared to 5V?
2- What is the IR wavelength emitted by the LED in the VMA330 module?
3- What is the importance of the bandpass filter (the epoxy layer) for the module's operation? What will happen if this filter is removed?
4- Why shouldn't the module be powered by 5V when connected to the Arduino Due, although the Arduino provides a 5V power pin?

Report Instructions

General:

- The report should be submitted before the beginning of the next lab. After that, there will be a penalty of 25% if the report submitted in the following 24 hours. If the report submitted 24 to 48 hours late, it would receive a penalty of 50%. No report will be accepted afterwards.
- The first page (cover page) should include your group names, the lab number, and the lab date.
- Organization is extremely important: Divide your report into sections, use captions for figures and headings for tables, …etc.

Lab 1: Your report should include the following

- A picture of the assembled robot chassis.
- Description of the difficulties you faced while assembling the chassis, if any.
- Table 2 (Completed).
- Answer to the question in Task 5, Experiment 1 – step 7.
- The required screenshots and pictures in Experiment 2 – step 3.
- Answers to the discussion questions.

End of Lab 1.