Faculty of Engineering and Computer Science
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11. For software, the code must be composed by you or by the group submitting the work, except for code that is attributed to its sources by numerical reference.

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A signed copy of this form must be submitted to the instructor at the beginning of the semester in each course.

I certify that I have read the requirements set out on this form, and that I am aware of these requirements. I certify that all the work I will submit for this course will comply with these requirements and with additional requirements stated in the course outline.

Course Number:	ENGR 290	Instructor:	Dr. Rastko Selmic
Name:	Andre Hei Wang Law	I.D. #	4017 5600
Signature:		Date:	20/09/2022

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.

Approved by the ENCS Faculty Council February 10, 2012

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Course Number:	ENGR 290	Instructor:	Dr Rasiko Selmic
Name:	Hamza Sedqi	I.D. #	40103843
Signature:		Date:	20/09/2022

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Course Number:	ENGR290	Instructor:	Dr. Rastko Selmic
Name:	Abdoullah Ayadi	I.D. #	40176086
Signature:	Ayadi	Date:	2022-10-02

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.

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Course Number: ENGR 290
Name: Matei Razvan Garila
Signature: Matei Razvan Garila

Instructor: Dr. Rastko Selmic & Dmitry Rozhdestvenskiy
I.D. # 40131709
Date: October 3rd, 2022

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.
Approved by the ENCS Faculty Council February 10, 2012

Technical Assignment 1

ENGR 290 - Introductory Engineering Team Design Project - Fall 2022
Concordia University, Montreal QC

Instructor: Dr. Rastko Selmic - Dmitry Rozhdestvenskiy

Due: October 3rd, 2022

Prepared by: Matei Razvan Garila - 40131709
Abdoullah Ayadi - 40176086
Hei Wang Andre Law -40175600
Hamza Sedqi - 40103843

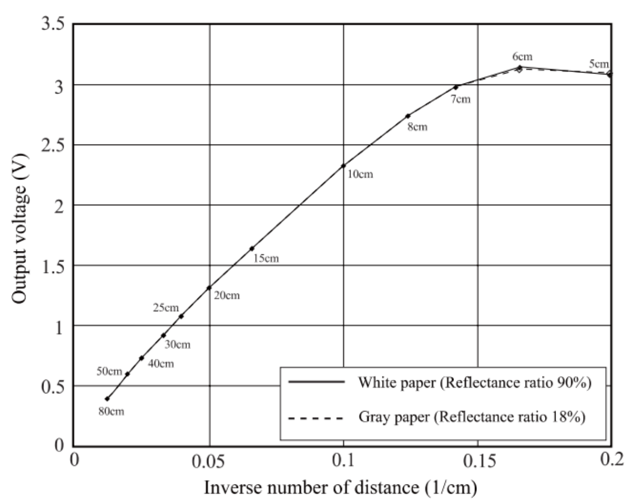
“We certify that this submission is the original work of members of the group and meets the Faculty's Expectations of Originality”

Sensor	ADC Vref, V	Actual distance reading, cm/ADC value										Expected reading (ADC value)		Error, %	
		Trial 1		Trial 2		Trial 3		Average		Standard deviation					
		15 cm	40 cm	15 cm	40 cm	15 cm	40 cm	15 cm	40 cm	15 cm	40 cm	15 cm	40 cm	15 cm	40 cm
IR	3.3 V	15/ 340	37/ 144	15/ 342	36 /141	15/ 340	37/ 141	15/ 340.6	36.7 /142	0/ 1.15	0.577/ 1.73	496 .48	232. 73	19.5 7%	38.9 9%
US	N/A	15/-	40/-	15/-	40/-	15/-	40/-	15/-	40/-	0/ -	0/ -	-	-	-	-

Calculations:

Sample Calculation for Standard Deviation

Std of IR 40cm: $\sqrt{\left(\frac{(37-avg)^2+(36-avg)^2+(37-avg)^2}{N-1}\right)} = \sqrt{\frac{0.6667}{3-1}} = 0.577$



Expected ADC IR (Approximation):
At 15cm: 1.6V
At 40cm: 0.75V

Sample Calculation for ADC:

$ADC\ (15cm) = \frac{Vin*1024}{Vref} = \frac{1.6V*1024}{3.3V} = 496.48$

Sample Calculation for Error, %:

$Error\%15cm = \frac{Expected-Avg}{Expected} * 100\% = \frac{496.48-340.6}{496.48} * 100\% = 19.57$

Noteworthy Interactions of the Measurements:
<u>US Sensor:</u>
-Values are precise from 10cm even up to 220cm
-The distance measurement below below 10cm are imprecise

<u>IR Sensor:</u>
-The distance measurement at 40cm displays a lower value (37-38cm)
-The distance measurement are precise at 15cm

1) Explain how you calculated the Vref.

- Vref is basically the full scale / maximum value the A/D can convert. So a larger
- Vref, generally speaking, means larger dynamic range, lower resolution. Smaller
- Vref, generally speaking, has a smaller dynamic range, higher resolution. We trade off dynamic range for resolution by increasing or decreasing the value of Vref.

2) Did both sensors have the same performance for the distance range in this assignment?

The IR sensor had more accurate readings at the different ranges, while we noticed that the US sensor readings were close, but a little off. On the other hand at sub 10cm distances the IR sensor was no longer reliable while the US sensor gave more accurate measurements.

3) How did each sensor behave when the obstacle was in its close proximity? Did you see something strange? Explain what went wrong and why.

As it is clearly mentioned in the datasheets, the IR sensor has a detecting distance of 10 to 80cm, when the distance was under 10cm the sensor displayed unreliable readings and was no longer accurate. The US sensor has a detecting distance of 2 to 400cm, which allows it to still display accurate readings even at very close distances.

4) Where is in the datasheet the sensor's output vs. distance values can be found (for each sensor)? (Give the datasheet you used a revision number, page and paragraph.)

US sensor: Cytron Technologies HC-SR04 User's manual V1.0 May 2013 - Page 7

IR sensor: SHARP GP2Y0A21YK Sheet No.: E4 -A00201EN - Page 6

5) How did you convert ADC readings to distance?

We used the analogRead() arduino function in order to read the voltage and map them to the integer values between 0 and 1023. The logic behind this is that the closer the distance is, the higher the ADC values are (i.e very close ADC values will be 1024). We can see this as the brightness of the led D3 is at its brightness (higher voltage, higher brightness, closer distance)..

6) Given that you do not have to indicate or use actual distance expressed in cm in any way, how would you write your code that controls the LEDs without converting the ADC readings into distance (in cm) in your code? (Rationale: the distance in cm uses floating point variables, which are not "native" for the microcontroller used for this assignment and the project. It results in huge code inflation and decrease of overall system's performance. Keep this in mind for your final project code.)

1. Find (from the datasheet) and define the ADC values for both sensors at max and min ranges.
2. Get result from ADCH and ADCL registers (adc_val)
3. a = (max - min) / (ADC_Max - ADC_Min)
4. b = max - a * ADC_Max
5. distance = a * adc_val + b

7) Did you observe something strange in the LED L's behavior when it is connected to one sensor, but not to another? If so, explain what happened.

When connected to the US sensor, the L LED would light up at longer distances, we believe this happens because our target was too small for the sensor to catch it and the waves would hit something further away which would then trigger the L LED. The IR sensor did not have the same problem.

8) Write a few sentences (no limit) about what you have learned in this assignment, what surprised, shocked and/or enlightened you, what difficulties you experienced, what kind of help you could have profited from, etc.

Most of our problems were related to the software aspect of the project. We faced numerous difficulties trying to code both sensors in C. We also had to learn a new programming language (Arduino), which is a completely new coding language for Electrical and Computer Engineers. Learning the functionality of the uCU (Atmega 328) is an interesting skill that we had to learn for this assignment. Understanding the configuration of the pins and using them to achieve expected results was attainable but challenging at the same time.

Overall, the experiment went well even though we would have appreciated an introduction to arduino and on how to work with ADC.

HC_sensor_code_team_15

```
// Engr 290 HW 1

#include <stdlib.h>
#include <avr/io.h>
#include <util/delay.h>

/*
Speed of Sound is 340 m/s
340 m/s = 29 microseconds/cm
*/

long duration, distance;

void setup(){

  Serial.begin(9600);

  // Initialize I/O
  DDRB|=(1<<PB3);        // Set PB3 as output (Trig) (Shared w/ D3 LED)
  DDRD&=!(1<<PD2);       // Set PD2 as input (Echo)
  DDRB|=(1<<PB5);        // Set PB5 as output (Shared w/ Yellow LED)

  pinMode(LED_BUILTIN, OUTPUT);

}

void loop(){

  // Pulse Wave
  PORTB&=!(1<<PB3);      // Set PB3 to low
  _delay_us(2);        // Delay 2 microseconds
  PORTB|=(1<<PB3);       // Set PB3 to high
  _delay_us(10);         // Delay 10 Microseconds
  PORTB&=!(1<<PB3);      // Set PB3 to low
  _delay_us(10);
  pinMode(LED_BUILTIN, OUTPUT);
  _delay_us(10);
```

```
  duration = pulseIn(PD3, HIGH);
  distance = duration * 0.034 / 2;
  if(distance > 0){
    Serial.print("Distance: ");
    Serial.print(distance);
    Serial.print(" cm");
    Serial.println();
  }


  float y;
  float x;
  if (distance >= 15 && distance <= 40){
    y= (-255/25) * (distance-15) + 255;
  }else if(distance < 15){
    y=255;
  }else{
    y = 0;
  }

  if(distance > 40 || distance < 15){
    digitalWrite(LED_BUILTIN, HIGH); // Set L LED to high when distance >
40cm || < 15cm
    delay(10);
  }else{
    digitalWrite(LED_BUILTIN, LOW); // Set L LED to low when distance >
15cm || < 40cm
    delay(10);
  }

analogWrite(11,y);
delay(100);

}
```

IR_sensor_code_team_15

```
// ENGR 290 HW 1

#include <stdlib.h>
#include <avr/io.h>
#include <util/delay.h>

//Parameters
const int gp2y0a21Pin  = A0;

//Variables
int gp2y0a21Val;
long duration, distance;

void setup() {

  //Init Serial USB
  Serial.begin(9600);
  //Init distance ir
  pinMode(gp2y0a21Pin, INPUT);

  // Pulse Wave
  PORTB&=!(1<<PB3);     // Set PB3 to low
  _delay_us(2);       // Delay 2 microseconds
  PORTB|=(1<<PB3);      // Set PB3 to high
  _delay_us(10);        // Delay 10 Microseconds
  PORTB&=!(1<<PB3);     // Set PB3 to low
  _delay_us(10);

  pinMode(LED_BUILTIN, OUTPUT);

}

void loop() {


  pinMode(LED_BUILTIN, OUTPUT);
```

```
  _delay_us(10);

  gp2y0a21Val = analogRead(gp2y0a21Pin);

  float Vout = float(gp2y0a21Val) * 0.0048828125; // Conversion analog to
voltage
  int distance = 13 * pow(Vout, -1) * 2; // Conversion volt to distance

  Serial.print(gp2y0a21Val);
  Serial.print(F(" - "));
  Serial.println(distance);

  float y ;
  float x;
  if (distance >= 15 && distance <= 40){
    y = (-255/25) * (distance-15) + 255 * -1;
  } else if(distance < 15){
    y = 255;
  }else{
    y = 0;
  }

  if(distance > 40 || distance < 15){
    digitalWrite(LED_BUILTIN, HIGH); // Set L LED to high when distance >
40cm || < 15cm
    delay(10);
  }else{
    digitalWrite(LED_BUILTIN, LOW); // Set L LED to low when distance >
15cm || < 40cm
    delay(10);
  }

analogWrite(11,y);
delay(100);

}
```