ENTIC-lab
Answers to WP questions

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Índex

Before doing any certain task, the related questions must be answered in this file.
You must update this file as many times as necessary with the format
WPAnswers_g_t.pdf
(Keep the Atenea task in draft status until you finish the Lab-Project part A)

Question 0.1: How often must you deliver a Gantt Diagram updated version?

- At the beginning of each WP

- **Each lab session**

- At the beginning and at the end of Parts A and B

Question 0.2: If you are the team 7 of subgroup 63, which is the right filename for deliver the Final Report in Atenea at the end of the semester? What is the deadline day for deliver this document?

The filename would have to be FinalReport_63_7 and the deadline for this document to be delivered is 14/01/2021.

Question 0.3: What penalization will have you if you deliver a document one week later?

- 15%

- **30%**

- 50%

Question 0.4: When you must deliver the Answers to the WP questions?

- At the beginning of each WP

- At the end of each Part

- **Continuously during the semester, when you need the answer of each question%**

Question 0.5: How you plan to avoid the "Hitchhiker and Couch Potatoes" in your team?

In order to avoid the "Hitchhiker and Couch Potatoes" in our team, what we will do is to make sure that there is good communication between us and that we all understand what our task is and what we are doing at all times. If in any case there were a problem, the teacher would be notified quickly in order to solve it as soon as possible.

1 WP1 - Mechanical

Calculate how much additional weight is necessary if the holes are not made in the ROUV elbows PVC structure. Inner diameter of PVC pipe: 16 mm.

We can calculate the total volume with the folowing formula

$$\text{Total volume} = \#\text{Tubes} \cdot \pi r^2 l$$

Then we find the weight for each group of tubes

$$8 \cdot \pi \cdot 0.8^2 \cdot 15 = 241.27 cm^3$$

$$2 \cdot \pi \cdot 0.8^2 \cdot 10 = 40.21 cm^3$$

$$4 \cdot \pi \cdot 0.8^2 \cdot 5 = 40.21 cm^3$$

Then using a conversion factor we can calculate the total weight with the sum of the previously calculated volume, $241.27 + 40.21 + 40.21 = 321.69 cm^3$.

$$\text{Weight} = 321.69 cm^3 \cdot \frac{1 dm^3}{1000 cm^3} \cdot \frac{1 m^3}{1000 dm^3} \cdot \frac{1 kg}{1 dm} \cdot \frac{1000 g}{1 kg} = 0.321 g$$

Which is the maximum voltage applicable to the electrical motor? Which current is demanded by the motor at the maximum speed?

The maximum voltage aplicable to the electrical motor is 12V and the current by the motor at maximum speed is $2.5 A$.

Question 1.3: **Include a picture of the initial and final Gantt diagrams of WP1, making a reflexion about the progress and explaining any delay in the development of the tasks.**
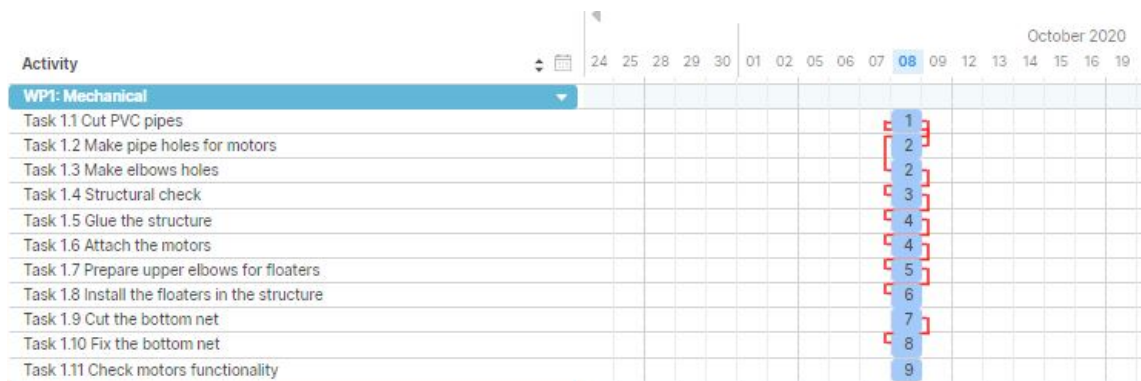
The last task had to be delayed due to not having enough time to complete it. We wasted more time than necessary fixing an error during assembly. But finally everything worked out correctly.

2 WP2 - Electrical

Question 2.1: **In the market there are different types of switches. Which type among the switch models shown in Fig. 2.2 are we using in this project?**

We are going to use a DPDT switch because the motor is just compatible with it.

Question 2.2: **The ROUV motors are the core of nautical bilge pumps Johnson L450 model (specifications are available in ATENEA Support Documents section). Which is the electrical power required for one ROUV motor? Calculate the total electrical power the ROUV battery must supply. Which is the fuse value in your stock material? What are you protecting with this fuse?**

According given datasheet L450: $V = 12$, $I = 2.5$. We will use three motors to have X3 power than before.

$$P = 3VI = 3 \cdot 12 \cdot 2.5 = 90W$$

The value of the fuse in our stock material is 5A acording to the manual given. With this fuse we are protecting the cirquit from getting overloads or overcurrents.

Question 2.3: **You must make some soldering to electrically connect different parts of your vehicle. You can watch some videos in YouTube about how to solder like, for example, https://youtu.be/xrVCkEoY_8M . Which is the use of the sponge we have in the solder holder?**

Sponge is used to clean soldering tip when it is hot, cleaning is so important to make a strong welders.

Question 2.4: **Now it is time to make all the connections with the flexible wires inside the box to control the ROUV motors. Draw a sketch of the complete electrical circuit using the CAD schematic software https://www.tinycad.net/. In ATENEA Support Documents section an specific library for ENTIC is available. If you need more information to do this, you can search images in internet about "DPDT motor".**
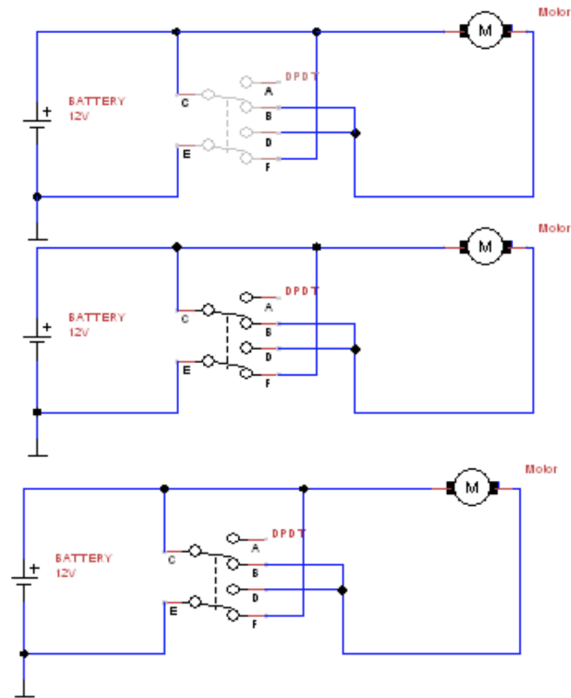
Question 2.5: Update yoursketch of the electrical circuit (include the fuse and the DB9 connector)
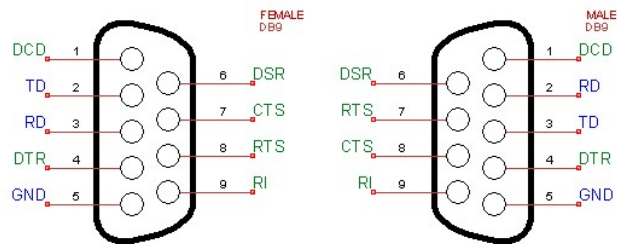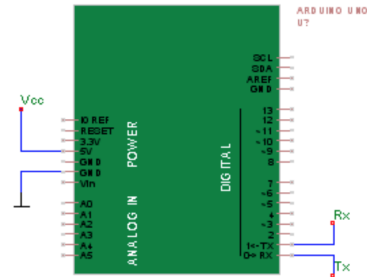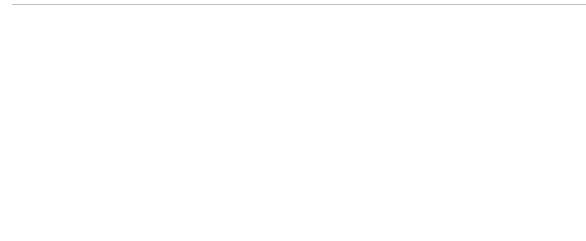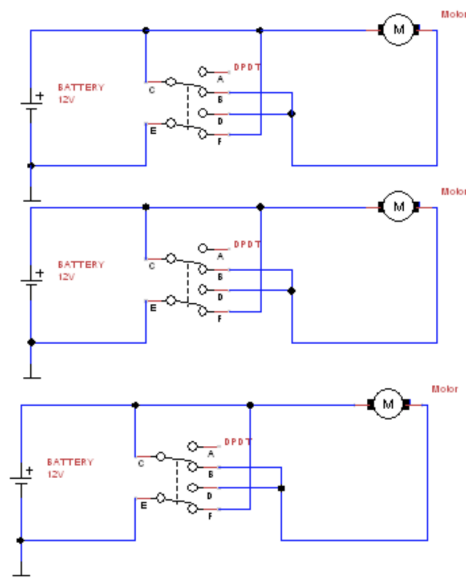
3 WP3 - Electronics

Question 3.1: **Which pressure increase will be observed at 3 m depth?**

$$0.986 \cdot \frac{3}{10} = 0.2958 Atm$$

Question 3.2: **Will this pressure depend or not on the atmospheric pressure at water surface? Why?**

If what we want is to calculate the real pressure that will be exerted on the ROUV, we must also take into account the atmospheric pressure on the surface. On the other hand, if what we want is only to calculate the increase with respect of this, it will not be necessary.

Question 3.3: **Analyse the circuit of Fig. 4.2 and obtain the output voltage VS. Then, find the dependence of VS on the relative variation due to deformation (x) and on the power supply voltage (V).**

$$\frac{V - V_1}{R_o(1 + x)} = \frac{V_1}{R_0(1 - x)} \qquad\qquad \frac{V - V_1}{(1 + x)} = \frac{V_1}{(1 - x)}$$

$$\frac{V - V_2}{R_o(1 - x)} = \frac{V_2}{R_o(1 + x)} \qquad\qquad \frac{V - V_2}{(1 - x)} = \frac{V_2}{(1 + x)}$$

$$(V - V_1)(1 - x) = V_1(1 + x)$$

$$(V - V_2)(1 + x) = V_2(1 - x)$$

Now we isolate V_1 and V_2 :

$$V_1 = \frac{V(1 - x)}{2} \qquad\qquad V_2 = \frac{V(1 + x)}{2}$$

$$V_s = V_2 - V_1 \ so \ Vs = -V \cdot x$$

Question 3.4: **The datasheet of the sensor is available in Atenea. Identify there the full scale output, and then deduce the sensor sensitivity and its value when the supply voltage is not 10 V but 5 V.**

Sensor sensitivity is $O = V \cdot P$. So when we have 2 voltages $O_1 = V_1 \cdot P$ and $O_2 = V_2 \cdot P$

We know that $O_1 = 0.4\frac{mV}{kPa}$ at $V_1 = 10V$. Then, we calculate O_2.

$$O_2 = \frac{O_1 \cdot V_2}{V_1} = \frac{0,4 \cdot 5}{10} = 0,2\frac{mV}{kPa}$$

What output voltages V_0 will provide the sensor at the water surface (at P=100 kPa) and at 3 m depth?

Since $O = \frac{V}{P}$, then

$$V_s = O \cdot P = 0,2 \cdot 100k = 20mV$$

$$V_{3m} = O \cdot P = 0,2 \cdot 130k = 26.3mV$$

In a real case and due to changing atmospheric conditions, the pressure at the water surface can be different than 100 kPa, discuss how you could fix such effect and obtain the correct pressure data.

To solve this problem, we are going to measure the atmospheric pressure in the laboratory so that we avoid errors.

Analyse the circuit of Fig. 4.4 and obtain its gain expression V0/(V2-V1) when R1/R2=R4/R3. Identify the role of Rg as a gain trimmer without compromising the R1-R4 resistance matching.

$$V_1 \cdot G_1 + (V_1 - V_2) \cdot G_g + (V_1 - Vx) = 0$$

$$(V_2 - Vx) \cdot G_3 + (V_2 - V_1) \cdot G_g + (V_2 - V_o) \cdot G_4 = 0$$

$$(V_2 \cdot G_3 \cdot G_g) - V_1 \cdot G_3 \cdot (G_1 + G_2 + G_g) =$$

$$= (V_0 \cdot G_2 \cdot G_4) + (V_1 \cdot G_g \cdot G_2) - G_2 \cdot V_2 \cdot (G_3 + G_4 + G_g)$$

Let's assume $G_2 \cdot G_4 = G_1 \cdot G_3$, then we isolate:

$$V_0 = \frac{V_2 - V_1 \cdot (G_3 \cdot G_g + G_2 \cdot G_3 + G_2 \cdot G_g + G_4 \cdot G_2)}{G_2 \cdot G_4}$$

$$\frac{V_0}{V_2 - V_1} = 1 + \frac{R_1 - R_4}{R_g} + \frac{R_4}{R_3}$$

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Compare this result with the gain expression provided by the manufacturer using the resistor values shown in the INA126 datasheet.

$$G = 5 + \frac{80k\Omega}{R_g}$$

$$R_4 = R_1 = 40k\Omega \qquad R_2 = R_3 = 10k\Omega$$

Identify the saturation voltage of the amplifier

$$5V - 0,75V = 4,25V = V_{sat}$$
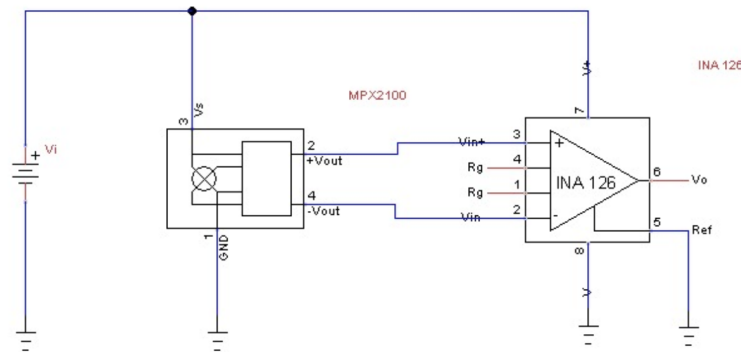
Which amplifier gain is necessary to obtain the maximum amplifier voltage output for 3m depth? Which Rg resistor value will provide this gain?

$$G = \frac{v_{sat}}{v_{in}} = \frac{4.25}{0.02635} = 161.5$$

$$R_g = \frac{80}{163.46 - 5} = 504.86\,\Omega \approx 510\,\Omega$$

Draw the sensor+amplifier schematic using the CAD schematic software https://www.tinycad.net/

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Question 3.12: **Obtain in the lab 10 measurement points along the measurement range. Draw its graphical representation, calculate and plot the linear regression and the linearity error (lineal regression straight line – measured points).**

Preassure[Atm]	Voltage[V]
0	1.96
0.1	1.97
0.15	1.98
0.2	1.99
0.25	1.995
0.3	2.00
0.35	2.003
0.4	2.01
0.45	2.013
0.5	2.019

Taula 1: Voltage output respect to Preassure input

Voltage output respect to Preassure input

Voltage output respect to Preassure input
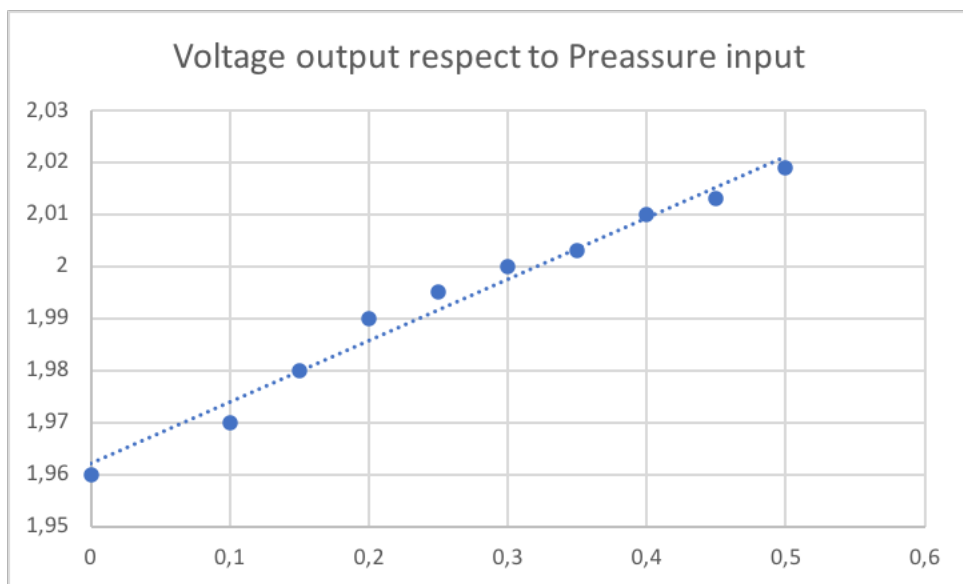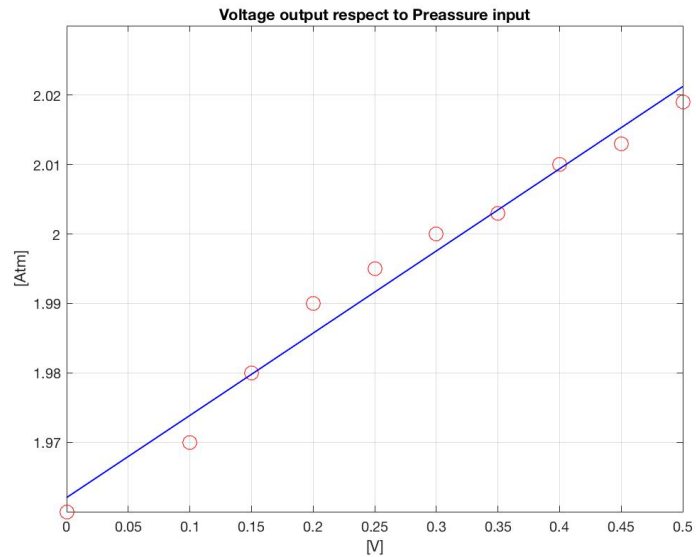
```matlab
clear;
x = [ 0;  0.1;   0.15;  0.2;  0.25;  0.3;  0.35;  0.4;  0.45;
    0.5];
y = [1.96;  1.97;  1.98;  1.99;  1.995;  2.00;  2.003;  2.01;
    2.013;  2.019]

plot(x, y, 'ro', 'MarkerSize', 10);
grid on;
% Get the fit
coeffs = polyfit(x, y, 1);
% Get the x values for the fit at higher resolution.
xFit = linspace(x(1), x(end), 300);
% Get the estimated y values
yFit = polyval(coeffs, xFit);
% Plot them as a line.
hold on;
xlabel('[V]')
ylabel('[Atm]')
title('Voltage output respect to Preassure input')
plot(xFit, yFit, 'b-', 'LineWidth', 1);
```

Question 3.13: **Calculate the digital data range provided by the acquisition circuit in measurements from 0 to 3m of water depth. Consider that the 10 bit A/D converter of the Arduino assigns 0 to a 0V input and 1023 (210-1) to a 5V input.**

The expected values from the arduino measurement acquisition should be inside the interval

$$[\frac{V_0}{5} \cdot 1023, \frac{V_{0.3}}{5} \cdot 1023] = [\frac{1.96}{5} \cdot 1023, \frac{2.00}{5} \cdot 1023] = [401.0, 409.2]$$

Question 3.14: **Explain briefly what is the purpose of the following functions, used in the sketch of Fig. 4.5: Serial.begin(), analogRead(), Serial.println() and delay().**

- **Serial.begin():** Sets the data rate in bits per second for serial data transmission.

- **analogRead():** Reads the value from the specified analog pin.

- **Serial.println():** Prints data to the serial port and skip the line.

- **delay():** Pauses the program for the amount of time specified as parameter.

Question 3.15: **While acquiring measures with the Arduino, smoothly increase the pressure to simulate a depth change from 0 m to 3 m. Do the measurement results displayed on the serial monitor match with the theoretical ones obtained in Question 3.13? If not, explain why. NOTE: If you are at home, use the potentiometer or the temperature sensor instead of the pressure sensor.**

Preassure[Atm]	Arduino output
0	391
0.1	392
0.15	392
0.2	393
0.25	394
0.3	395
0.35	396
0.4	397
0.45	399
0.5	399

Taula 2: Arduino output respect to Preassure input

FALTA EXPLICAR PERQUE NO ES IGUAL A LA PREGUNTA 3.13

Question 3.16: **Include a picture of the initial and final Gantt diagrams of WP3, making a reflexion about the progress and explaining any delay in the development of the tasks.**
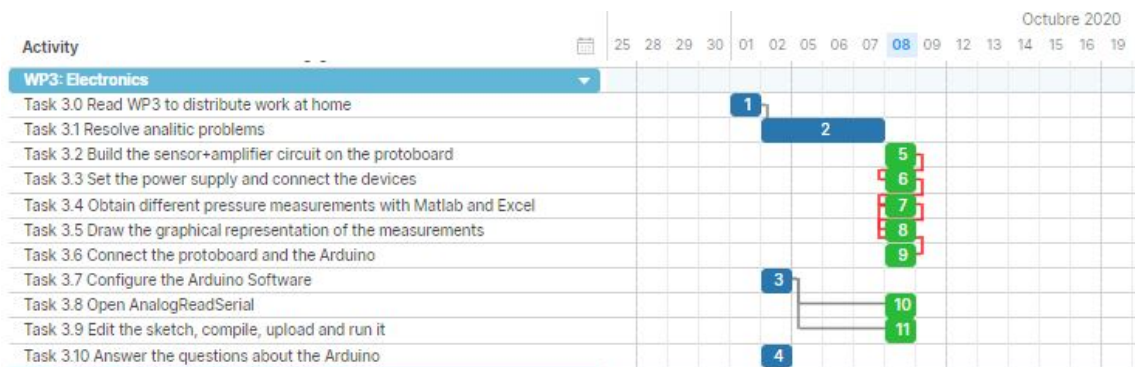
We completed the work in time because everything turned out as planned. We distributed the questions among the members before going to the lab and, once there, we knew exactly what to do and could benefit from the two hours to finish all the practical tasks.

4   WP4 - Communications

Question 4.1: **Encode in plain binary (2 bytes) the following measured value: 663. Determine the pressure corresponding to this value.**

We can see that $663_{10} = (2^0 + 2^1 + 2^2 + 2^5 + 2^8)_{10} = 10010111_2$

Question 4.2: **Encode in ASCII the following measurement data: 25, 663, 1012.**

25: 50 53
663: 54 54 51
1012: 49 48 49 50

Question 4.3: **Go to the Arduino language reference and identify which types are suitable to work with the numeric data provided by the A/D converters. What code length (in bytes) corresponds to each type?**

Question 4.4: **Compare the screen captures obtained and explain the differences found. What sequence of bytes is really sent in each case?**

Question 4.5: **List the serial port(s) COMx available in your computer.**

The computer has the following ports:

- Arduino Uni (COM10)

- Arduino Uni (COM3)

- Arduino Uni (COM5)

- Arduino Uni (COM8)

- Arduino Uni (COM9)

- Communication Port (COM1)

- Intel(R) Active Management Technology - SOL (COM4)

- USB Serial Port (COM11)

- USB Serial Port (COM6)

- USB Serial Port (COM7)

Identify the cables color connected at the RS-232 send and receive pins.

Send cables: Green, blue, black. Receive cables: Orange, white, gray.
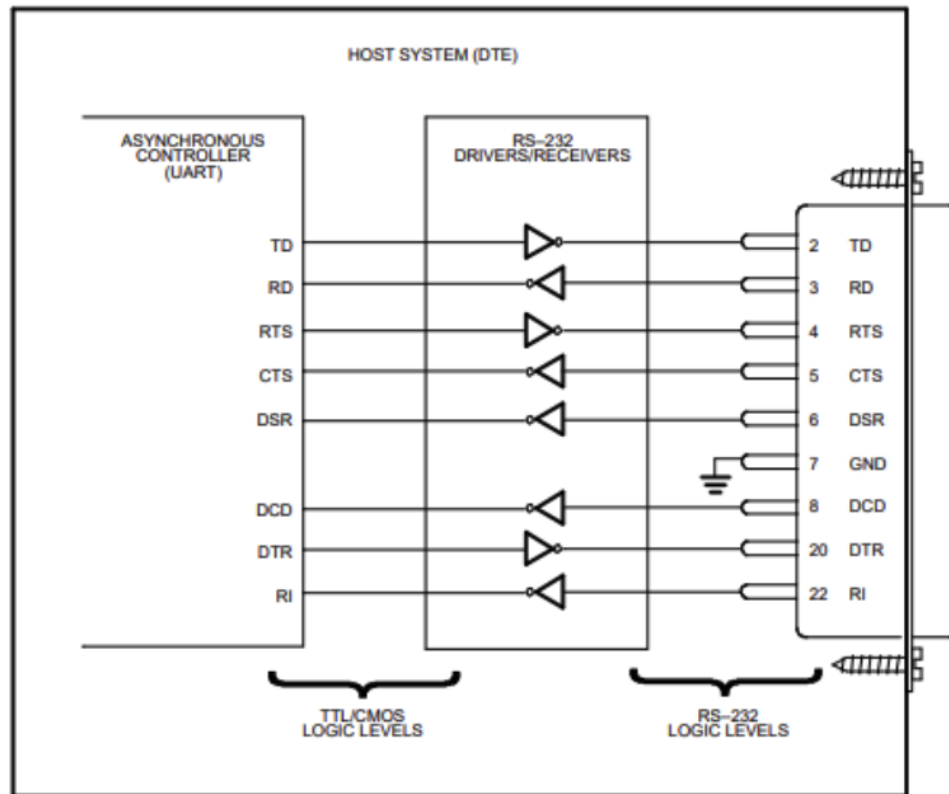
Calculate which time-base must be selected in the oscilloscope to see 10 bits on the screen at the transmission rate selected by default in Terminal.

Capture the waveform displayed on the oscilloscope. Determine the voltage levels, bit period and the number of bits per character. Which level indicates the idle state? Using an ASCII table explain the waveforms displayed for 3 different characters.

We can see in the picture the transmision and reception of character 'A' wich in binari is 01000001 , high voltaje= 0 , low voltaje =1,

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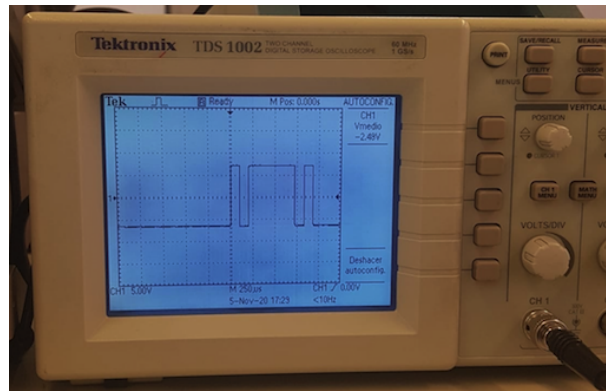
Question 4.9: **What is the reason to use RS-232 to communicate with the ROUV, instead of using USB (which is available in both the Arduino and the computer)?**

The reason why we used RS232 communication instead USB cable is that the total system mix some features from different systems and RS232 can be used as base and let us communicate.

Question 4.10: **Capture the waveform displayed on the oscilloscope. Obtain the voltage levels of the signal. Which level corresponds to the idle state?**

The voltage levels are:
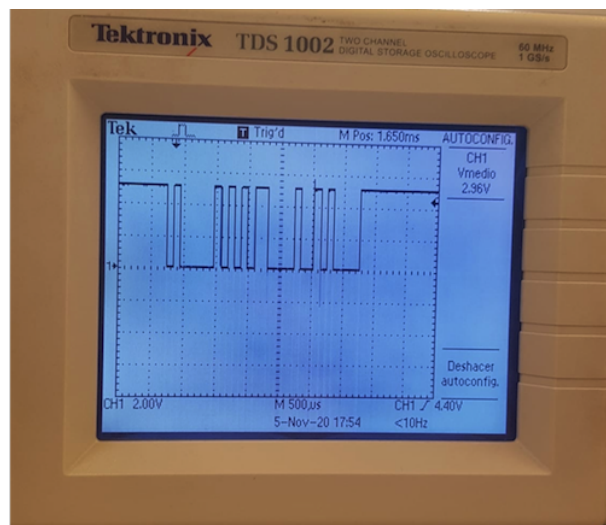
- high voltage: 5V when 1.

- low voltage: 0V when 0.

Draw the schematic (using the CAD schematic software https://www.tinycad.net/.) of the level shifter circuit, including only the transmission path (from the Arduino Tx pin to the RS-232 DB9-female connector). What are the appropriate values of capacitors C1, C2, C3 and C4?

The schematic is the following one

Podem veure al manual els següents valors recomanats, per tant, com que el nostre voltatge va de 5V a 0V, els que agafarem seran $C1 = 0.1\mu F$ i $C2 = C3 = C4 = 0.47\mu F$
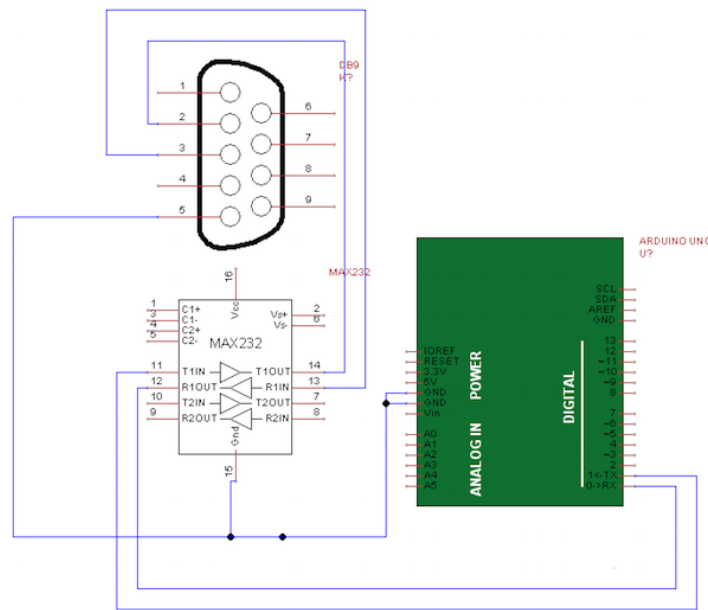
V_{CC} vs CAPACITOR VALUES

V_{CC}	C1	C2, C3, C4
3.3 V ± 0.3 V	0.1 μF	0.1 μF
5 V ± 0.5 V	0.047 μF	0.33 μF
3 V to 5.5 V	0.1 μF	0.47 μF

Figure 4. Typical Operating Circuit and Capacitor Values

Question 4.12: **Describe the difference(s) between the sketches of Figs. 4.1 and 4.3 seen from the user.**

The code in figure 4.3 works as follows. It prints the message "Send 'S' to start"as long as key 'S' is not pressed or there are no ports avaliable. Once there is a port avaliable and key 'S' is pressed it prints "Starting measurement"and works the same way figure 4.1 does.

Question 4.13: **Explain why the Rx input pin of the Arduino must be in high impedance state (i.e. not connected) when a compiled sketch is being uploaded.**

That is made in order to avoid problems when it comes to having a busy pin. Therefore when we upload an sketch we should be in high impedance.

Question 4.14: **Modify the sketch ENTIC-Analog2Serial-bidir to stop data sampling & transmission when any of the following conditions is true: 1) timeout, i.e. data values must be sent for only 2 minutes; 2) end command from user, i.e. the Arduino receives the character 'E'.**

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```
1
2    int sortida = 0;
3
4    void setup() {
5        Serial.begin(9600);
6        while(Serial.avaliable() <= 0 || Serial.read() 1= 'S') {
7            Serial.println("Send 'S' to start");
8            delay(200);
9        }
10        Serial.println("Starting measurement");
11    }
12
13    void loop() {
14        for(int i = 0; i < 600; i++) { //Timeout set to 2 minutes
15            if(Serial.avaliable() > 0 and Serail.read() == 'E')
16                break; //Exit the loop
17            else {
18                sortida = analogRead(A0);
19                Serial.println(sortida);
20                delay(200);
21            }
22            while(Serial.avaliable() <= 0 || Serail.read() != 'S');
23
24        }
25    }
```

Question 4.15: Explain and justify where these three components should be placed in Fig. 4.5:

a) The resistor setting the amplifier gain (see WP3).

It should be placed under the amplifier INA, otherwise it wouldn't leave enougth space inside the box because it has to be situated between the end 1 and 8 of the amplifier. Nonetheless this year because of covid that wouldn't be a problem wich allows us to put it wherever we find it easier.

b) The jumper for the serial reception path (see Fig. 4.2).

The jumper should be set in the top right part of the board, since it would fit there. But this year it wont be a problem.

c) The protection diode for the Arduino power input (see Fig. 4.4).

Where we have space left, between the 12V and the Vin of the Arduino.

Question 4.16: Using Fig. 4.5 as floorplan, draw a schematic describing how the circuits must be implemented on the interface-PCB. Identify and label all interconnection signals with the Arduino and the base PCBs (strip pins & sockets), describe the placement of all electronic components and add cables whenever additional connections were necessary. Use a colour code to improve the readability and usefulness of the schematic (i.e. red for power supply tracks & cables, black for GND, etc.)

Question 4.17: Include a picture of the initial and final Gantt

diagrams of WP4, making a reflexion about the progress and explaining any delay in the development of the tasks.

5   WP5 - Nom

Question 5.1: **Write the instructions to open the serial port using Matlab. Write also the instructions to close the serial port (which will be used once the measurements and collection of data finishes).**

```matlab
%To open serial port we will use

serialPort = serial('COM8','BaudRate',9600,'Terminator'
    ,'CR/LF');
fopen(serialPort);

%To close the serial port we will use :
fclose(serialPort);
delete(serialPort);
clear serialPort;
```

Question 5.2: **Write the Matlab instructions to start&stop the measures on the ROUV (you will be sending data from the computer through the control box and finally to the Arduino). Synchronization with the sketch running in the Arduino (ENTIC-Analog2Serial-bidir or alternative) will be necessary.**

```matlab
%For start reading from the serial port we must type:

fprintf(serialPort,'%s\n','S'); %is used to send a
    value (S in this case) from Matlab to Arduino
fread(serialPort); %read binary data from device
scaned = fscanf(s,'%d'); %read ASCI data from device,
    and format as text;
%To stop reading:
stopasync;
```

Question 5.3: **Write the Matlab instructions to read and plot 1000 values from the serial port.**

```matlab
serialPort = serial('COM8','BaudRate',9600,'Terminator'
    ,'CR/LF');
fopen(serialPort);

```

```matlab
4  x=zeros(1,1000); %vector with 1000 empty values
5  for n=1:1000
6      x(n)=fscanf(serialPort,'%d');
7  end
```

Question 5.4: **Write the instructions to appropriately convert the values received from the Arduino to the actual depth (m) of the ROUV. Indeed, these values have to be plotted vs. time (s). Explain firstly the numerical conversions needed (which factors the data have to be multiplied for and how to achieve time units from the measures obtained).**

To convert the values received from the Arduino to the actual depth(m) we will use data format that goes from 0 to 1023 (0 = 0V, 1023 = 5V). We will use the equation $V = S \cdot P$ where V= Voltage, S = Sensibility, P =Pressure.We will use Pressure so P = V/S. With the pressure we will apply Hydrostatic pressure $p = d \cdot g \cdot h$ where p= pressure, d= density of of water,g=gravity h = height. So we need height that will be the actual depth $h = p/(d \cdot g)$.

```matlab
1  serialPort = serial('COM8','BaudRate',9600,'Terminator'
       ,'CR/LF');
2  fopen(serialPort);
3  format = '%d'; %//the format of the files that we want
       to read.
4
5  time=zeros(1,1000);
6  depth=zeros(1,1000);
7  for n=1:100
8      x(n)=fscanf(serialPort,'%d');
9      depth(n)=x(n)*
10     time(n)=(n-1)*100; %time in ms
11 end
12 plot(time,depth);
```

Question 5.5: **Write the instructions to create, fill and close the file resultats.txt using Matlab.**

```matlab
1  %Instructions to create, fill and close the file
       resultats.txt
2
```

```matlab
file = fopen('resultats.txt','w');
%To fill the document we use :
fprintf(file, '%3d %6d %9d\n', y);

%To close the file we use :
fclose(file);
```

Question 5.6: **Develop the whole Matlab code to display depth real-time data (depth vs. time). It is important that you apply some way of avoid noisy points in the graph. Explain your solution. It is also interesting to record (and plot) the maximum and minimum depth during ROUV journey.**

```matlab
serialPort = serial('COM3','BaudRate',9600,'Terminator','CR/LF');
samples = 1000;
x = zeros(1,1000);
depth = zeros(1,1000);
time = zeros(1,1000);
max_depth = 0;
min_depth = 0;

for n = 1:samples
    fopen(serialPort)
    fprintf(serialPort,'%s\n','S')
    a=fscanf(serialPort,'%d');
    x(n)=a;
    depth(n)=x(n)*
    if(depth(n)<max_depth)
        max_depth=depth(n);
    end
    if(depth(n)>min_depth)
        min_depth=depth(n);
    end
    time(n)=(n-1)*100;
    timet=t';
    deptht=d';
    plot(timet, deptht);
    title('Depth vs Time');
```

```
26        xlabel('Time [ms]');
27        ylabel('Depth [m]');
28        grid
29        drawnow;
30  end
31
32  fclose(serialPort);
```

Question 5.7: **Paste a couple of representative graphs obtained from Maltab plots.**

Question 5.8: **Develop the Matlab code to represent data from "resultats.txt" (open, read, plot and close instructions should be used).**

```
1  %opens for reading
2  file = fopen('resultats.txt','r');
3  formatSpec = '%d %d'; %format of the data stored in the
        file
4  sizeA = [2 Inf]; %Data structure where data read will
        be stored
5  A = fscanf(file,formatSpec,sizeA) %read from file
6  fclose(file); %closing the file
7  plot();
```

Question 5.9: **Include a picture of the initial and final Gantt diagrams of WP5, making a reflexion about the progress and explaining any delay in the development of the tasks.**

6   Part A Conclussion

Question 6.1: **Include a picture of the initial and final Gantt diagrams of WP6-water tests, making a reflexion about the progress and explaining any delay in the development of the tasks.**