Electrical and Computer Systems Engineering Department

ENCS4380

HW_1

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Section number: 2

Date: 29/10/2021

Q1 HW_1 Anas Nimer 1180180

a) lets define two quantities k and l have measured values $k \mp \Delta k$, $l \mp \Delta l$, where $\Delta k, \Delta l$ are their absolute errors

* we wish to find ΔZ, where $Z = k + l$

$$Z \mp \Delta Z = k \mp \Delta k + l \mp \Delta l$$

the maximum possible error in Z $\quad \Delta Z = \Delta k + \Delta l$

* we wish to find ΔZ, where $Z = k - l$

$$Z \mp \Delta Z = k \mp \Delta k - l \mp \Delta l$$
$$= (k - l) \mp \Delta A \mp \Delta B$$

$$\pm \Delta Z = \mp \Delta k \mp \Delta l$$

So, the maximum value of error ΔZ is again $\Delta k + \Delta l$

so, the error in this question will be $1.6 \mp 0.1 = \mp 1.7$

So, if the measured temp in celsius then the accuracy $T \mp 1.7$ celsius b)

Hysteresis error = $\frac{\text{Maximum output}}{\text{sensitivity}} = \frac{20\ mV}{10\ mV\ mm^{-1}}$

$= \boxed{2\ mm}$

c) current SNR = $\frac{\text{Signal current}}{\text{Noise current}} = \frac{10\ \mu A}{3.27\ pA + 0.82\ pA}$

$= \frac{10\ \mu A}{4.09\ pA}$

$= \boxed{2.44 \times 10^6}$

current SNR = $20 \log(2.44 \times 10^6) = \boxed{127.748}$ dB

d) avg output, $\bar{X} = \frac{140 + 139 + 141 + 142 + 138 + 139 + 142 + 144}{8}$

$= 140.63$

$P_n = \left[1 - \left|\frac{x_n - \bar{x}}{\bar{x}}\right|\right]$ let $x_n = x_5$

$P_5 = \left[1 - \left|\frac{138 - 140.63}{140.63}\right|\right]$

$= [1 - |-0.0187|]$

$= 1 - 0.0187$

$\boxed{P_5 = 0.9813}$

$\boxed{\% P_5 = 98.13}$

Q2 :

Temperature measuring system is a first order system, ~~we can write~~

$$a_1 \frac{dy}{dt} + a_0 y(t) = x(t) \longrightarrow (1)$$

from equ 1 we can substitute a ~~sinusoi~~ sinusoidal input and get

$$\tau \frac{dy}{dt} + y(t) = K A \sin(\omega t) \longrightarrow (2)$$

in our case we have $\tau = 1.5s$, period = 20s

$$f = \frac{1}{20} = 0.05\ s^{-1}, \quad \omega = 2\pi f = 0.314$$

thus the input is $x(t) = 50 \sin(0.05) + 350$

by solving the equ for the input x(t) we get the following steady state response

$$y(t) = 350K + \frac{KA}{\sqrt{1+(\omega\tau)^2}} \sin(\omega t - \arctan(\omega\tau))$$

~~by solving the equ~~

by subsitution of the values we get

$$y(t) = 350K + \frac{K * 50}{\sqrt{1+(0.314 * 1.5)^2}} \sin(0.314t - \arctan(1.5 * 0.314))$$

$$= 350K + K * 45.23 \sin(0.314t - 0.44) \longrightarrow (3)$$

we now that the sinc function has maximum value of 1, and minimum value of -1

$$-1 \leq \sin(x) \leq 1 \longrightarrow (4)$$

by using 3 and 4 we can determine the maximum and minimum value of the temp system as following:

minimum when sin = -1

$$y(t) = 350k + k * -45.23$$
$$= k(350 - 45.23)$$
$$= 304.77\ K \longrightarrow (5)$$

maximum when sin = 1

$$y(t) = 350k + k * 45.23$$
$$= k(350 + 45.23)$$
$$= 395.23\ K \longrightarrow (6)$$

finally, the time lag can be calculated by using the phas shift and the angular freq, as following

phase shift = θ = 25.23

angular freq = W = 0.314

~~$= timelag = \frac{32.1}{0.314} =$~~

$$timelag = \frac{25.23}{360} * 20 = 1.402\ s$$

Q3

We have a thermometer in this question so we can conclude that the system is a first order system, thus, we can use the equations used in question 1.

we have the following parameters

$$\tau = 28\,s$$

$$f = \frac{2}{60} = \frac{1}{30}\,s^{-1}$$

$$w = 2\pi f = 0.20933\ rad.s^{-1}$$

now we can calculate the phase shift θ,

$$\theta = -\arctan(w.\tau)$$

$$= -\arctan(0.20933 * 28)$$

$$= -1.4015\ rad$$

finally, the delay (time lag)

$$delay = \frac{\theta}{w} = \frac{1.4015}{0.20933} = 6.695\ s$$

Q4

Accelerometer sensor is second order sensor, thus we can use the following steady state response in order to solve the question

$$M(w) = \frac{1}{\sqrt{\left[1-\left(\frac{w}{w_n}\right)^2\right]^2+\left[2\zeta\frac{w}{w_n}\right]^2}}$$

we know that Dynamic error is given by:

$$M(w) - 1$$

since the dynamic error is given from the question to not exceed ±5%
we have to solve the following mathmetical identical.

$$|M(w) - 1| \leq 5\%$$

$$-0.05 \leq M(w) - 1 \leq 0.05$$

$$0.95 \leq M(w) \leq 1.05$$

because the term M(w) cannot be larger than 1, we can exclude the condition ≤ 1.05 from the identical

$$M(w) \geq 0.95$$

we have the following parameters $\zeta = 0.6$, $f = 150\ Hz$, $w = 942.5$

now we have to solve equ for above parameters

$$\sqrt{\left[1-\left(\frac{w}{w_n}\right)^2\right]^2+\left[2\zeta\frac{w}{w_n}\right]^2} \leq 1.052631$$

$$\left[1-\left(\frac{w}{w_n}\right)^2\right]^2+\left[2\zeta\frac{w}{w_n}\right]^2 \leq 1.108032$$

$$1-2\left(\frac{w}{w_n}\right)^2+\left(\frac{w}{w_n}\right)^4+\left(2\zeta\frac{w}{w_n}\right)^2 \leq 1.108032$$

now we will assume $x=\frac{w}{w_n}$, and subsitute value of ζ

$$1-2(x)^2+(x)^4+[1.2x]^2 \leq 1.108032$$

we can rearrange the identical

$$x^4-0.56x^2-0.108032 \leq 0$$

$$\left(x-\sqrt{\frac{0.56+\sqrt{0.433728}}{2}}\right)\left(x+\sqrt{\frac{0.56+\sqrt{0.433728}}{2}}\right) \leq 0$$

$$-0.59 \leq x \leq 0.59$$

x can not be negative, so we can exclude the condition $x \geq -0.59$

$$x \leq 0.59$$

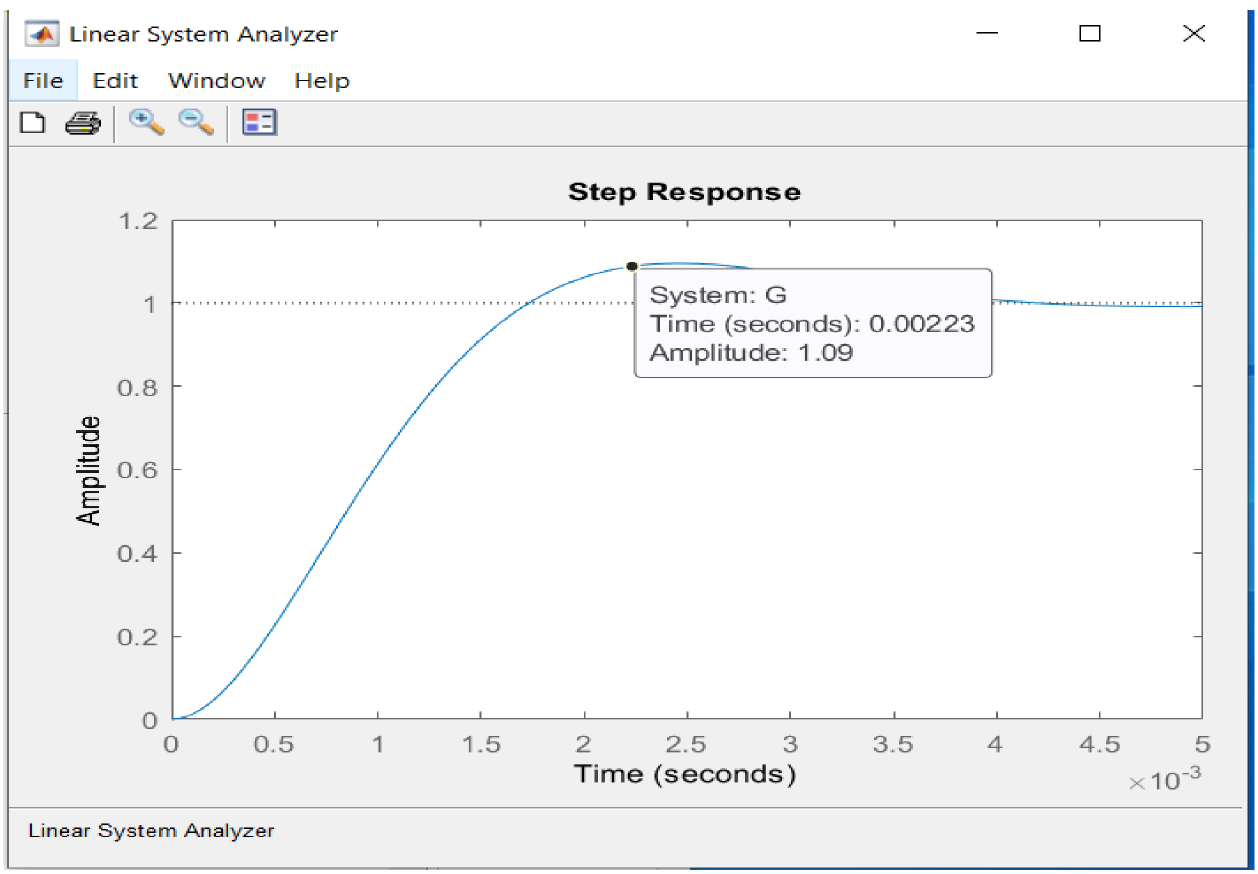
$$\frac{w}{w_n} \leq 0.59$$

$$\frac{942.5}{w_n} \leq 0.59$$

$$w_n \geq 1597.46$$

```
Untitled.m
%Anas Nimer 1180180
z=input('enter the damping ratio');
Wn=input('enter Wn');
num=[Wn^2];
d=[1 2*z*Wn Wn^2];
G= tf(num,d)
ltiview(G)
```

```
Command Window
>> Untitled
enter the damping ratio 0.6
enter Wn 1597.46

G =

           2.552e06
  -----------------------
  s^2 + 1917 s + 2.552e06

Continuous-time transfer function.

>>
```



Q5:

1. the concept of coriolis force is used in Gyrocope in this sensor to measure the angular rate, the rotation rate of the sensor is converted in to an electrical signal

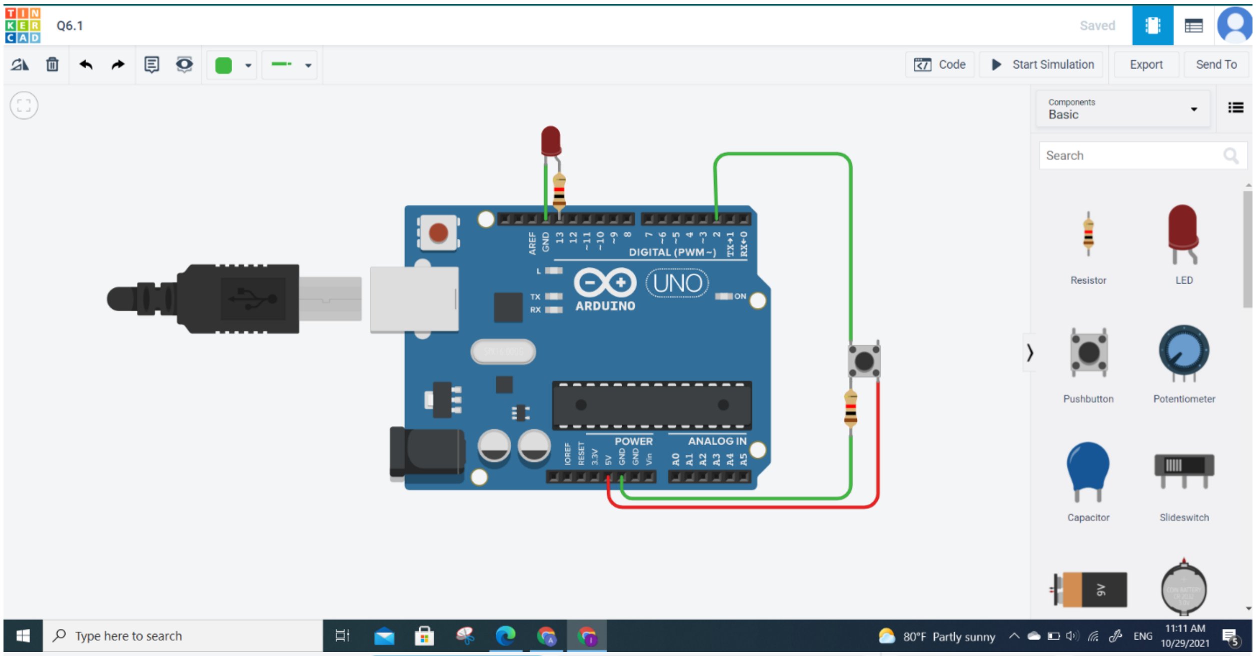
2. 3D MEMS technology and highly integrated electronic are technologies in manufacturing the sensors

3. As per the defination static Characteristic of sensor is that where the performance Criteria for the measurement of quantites that remain constant or vary in small amount eristics. Whereas, that for a Dynamic ~~ek~~ Characteristic shows the relationship between the system input and system output when the measured quantity is varying rapidly

4. For sensor to give output and for any digital interface connect 5v to 5v lines and 3.3v to 3.3v lines. Also, gyros with digital interfaces can have low power and sleep modes that allow them to be used in battery powered applications.

Q6)

1-




```
int buttonState = 0;

void setup()
{
pinMode(2, INPUT);
pinMode(LED_BUILTIN, OUTPUT);
}

void loop()
{
// read the state of the pushbutton value
buttonState = digitalRead(2);
// check if pushbutton is pressed. if it is, the
// buttonState is HIGH
if (buttonState == HIGH) {
// turn LED on
digitalWrite(LED_BUILTIN, HIGH);
} else {
// turn LED off
digitalWrite(LED_BUILTIN, LOW);
}
delay(10); // Delay a little bit to improve simulation performance
}
```

In this circuit push button used to turn on the LED and when we push it again the LED will turn off as representation for pullup/pulldown resistor.

❖ Pullup Resistor: -

Pull-up resistors are defined as resistors which are used to ensure that a wire is pulled to a high logical level in the absence of an input signal.

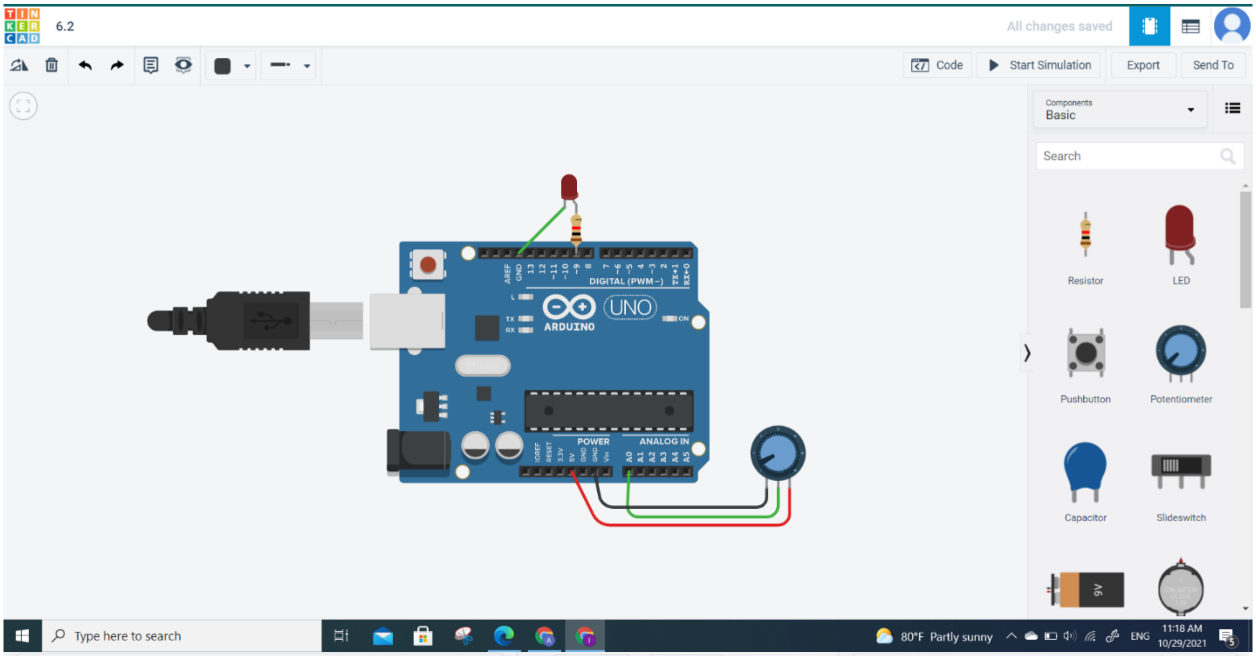
This means that pull-up resistors are connected between the voltage supply and the particular pin, they are also commonly found in digital logic circuits.

❖ Pulldown Resistor: -

Pull-down resistors are connected between ground and the appropriate pin on a device. Though they are less common than pull-up resistors, they work the same way as pull-up resistors.

One thing to note about pull-down resistors, it must have a larger resistance than the impedance of the logic circuit, or else it might pull the overall voltage down by too much.

2-



Text | 1 (Arduino Uno R3)

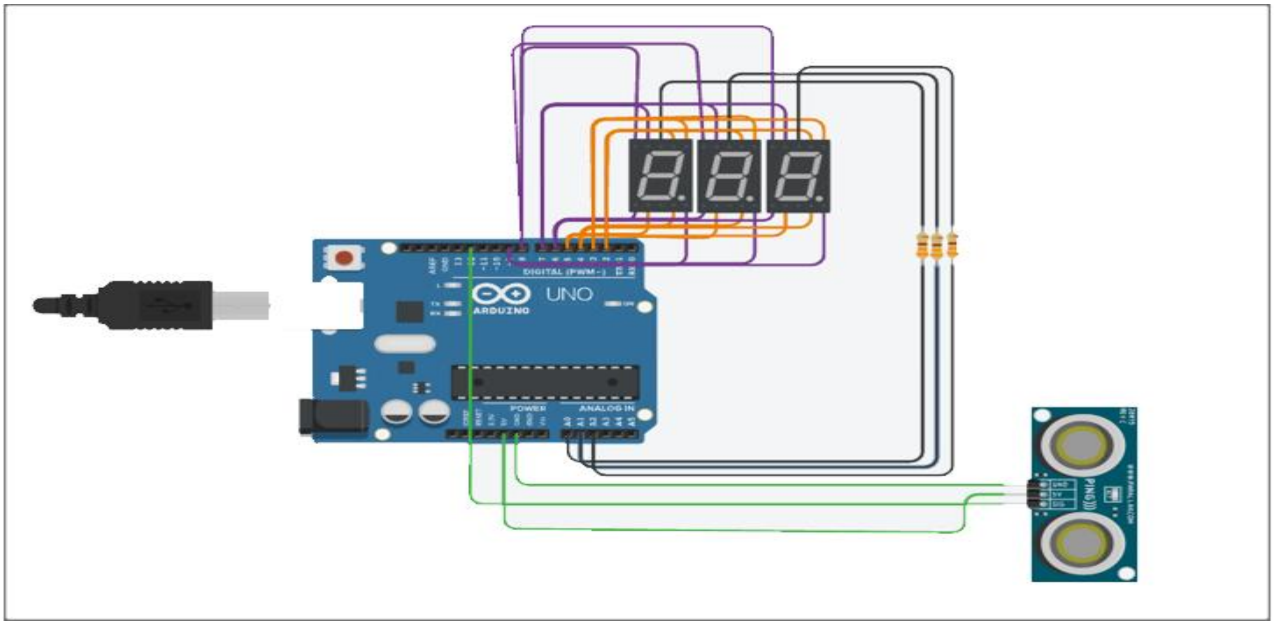
```


int sensorValue = 0;

int outputValue = 0;

void setup()
{
pinMode(A0, INPUT);
pinMode(9, OUTPUT);
Serial.begin(9600);

}

void loop()
{
// read the analog in value:
sensorValue = analogRead(A0);
// map it to the range of the analog out:
outputValue = map(sensorValue, 0, 1023, 0, 255);
// change the analog out value:
analogWrite(9, outputValue);
// print the results to the serial monitor:
Serial.print("sensor = ");
Serial.print(sensorValue);
Serial.print("\t output = ");
Serial.println(outputValue);
// wait 2 milliseconds before the next loop for the
// analog-to-digital converter to settle after the
// last reading:
delay(2); // Wait for 2 millisecond(s)
}
```

Serial Monitor

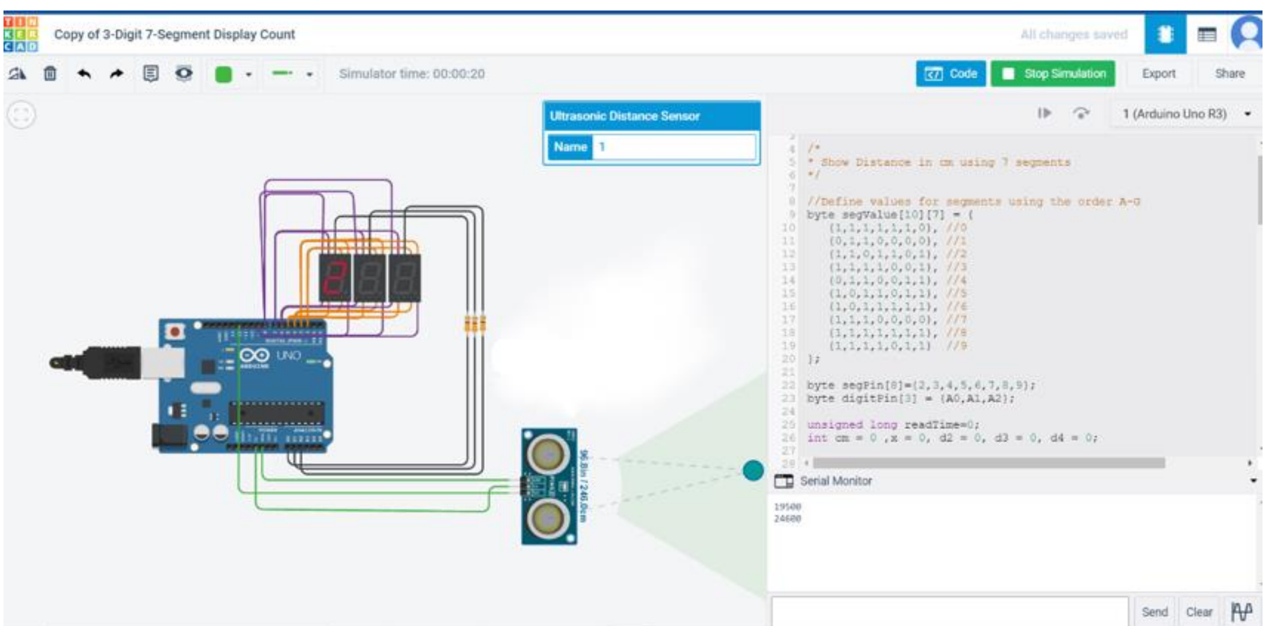
80°F Partly sunny ENG 11:18 AM 10/29/2021

3-

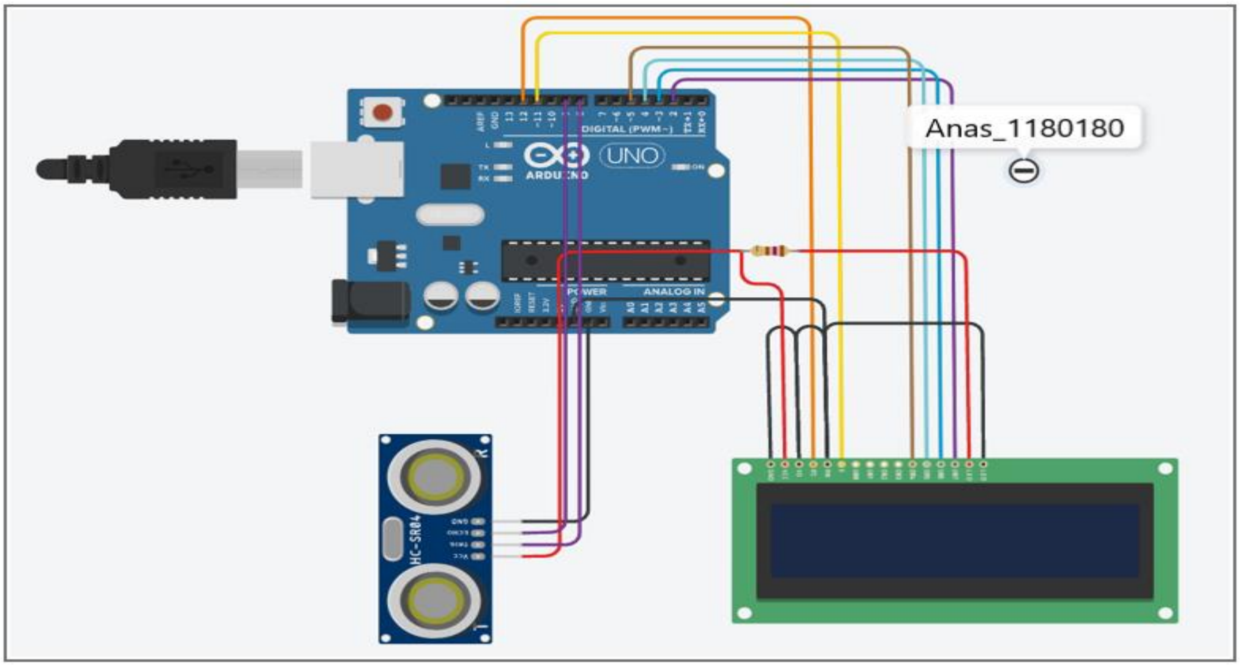
3.1.



The figure shown an Arduino circuit which sense if there's a body in distance from 3cm to 336cm using ultrasonic distance sensor then this value shown on 7 segment chips the code in appendix includes the required comments where the figures below show the running process:



3.2.



In this case the idea is the same as the previous requirement but instead of show the result on 7 segment chips the distance shown in cm on LCD as shown in the figures below: -