E344 Assignment 1

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Report submitted in partial fulfilment of the requirements of the module Design (E) 344 for the degree Baccalaureus in Engineering in the Department of Electrical and Electronic Engineering at Stellenbosch University.

October 2, 2022

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Nomenclature

Variables and functions

Acronyms and abbreviations

PWM - Pulse Width modulation
DAC -Digital analogue converter
Op amp -operational amplifier

A	ampere
s	seconds
ms	milliseconds
V	Voltage

Chapter 1

Literature survey

For the first assignment we had to design a current sensing circuit.A current sensing circuit is a circuit that can measure the current as the current is flowing through the circuit.We also had to use a circuit that can cancel all the noise,which is caused by an AC input.We had to amplify a certain signal by designing a circuit which consist of a operational amplifier,low current sensing circuit and a filter,which will be able to filter out all the noise of the signal.

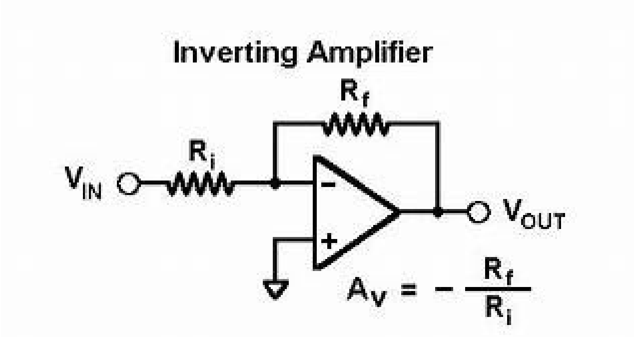
1.1. Operational amplifiers

Operational amplifiers: limitations and considerations

Operational amplifier configurations

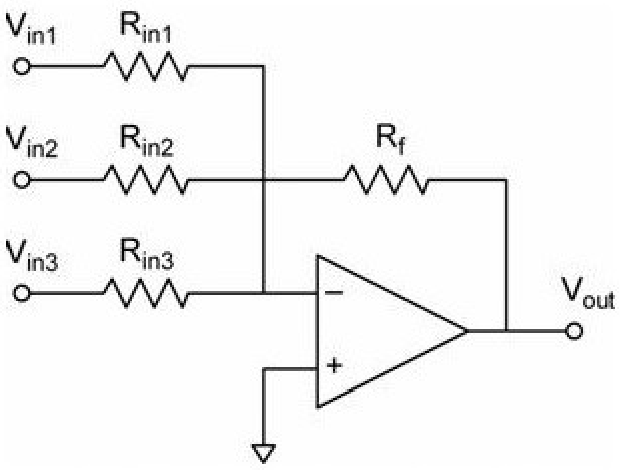
There are two main operational amplifiers that can be used to amplify signals.These two amplifiers are called: inverting amplifier and non-inverting amplifier.

Inverting amplifiers are used to amplify a signal where the output signal is fed back to the inverting input through a resistor R2.The input signal flow through R1 to the the inverting input.The positive pin is connected to ground.The gain of the circuit will be negative,because of the input being applied to the negative pin.This means that the output signal and the



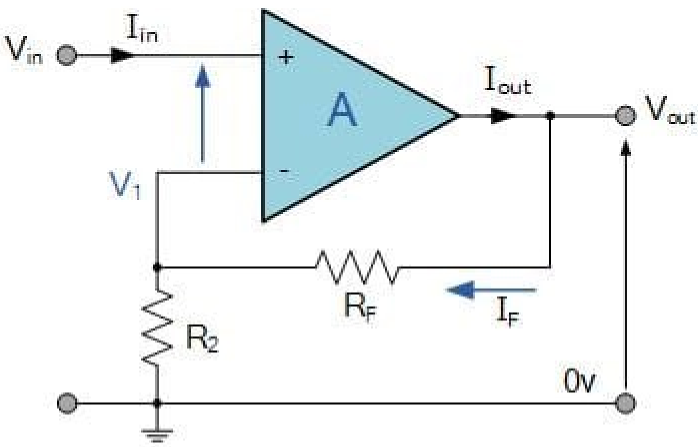
input signal will be out of phase.

An inverting summing amplifier will be an amplifier that has two resistor that will be added parallel to one another.These two resistors will then be connected to the inverting pin.

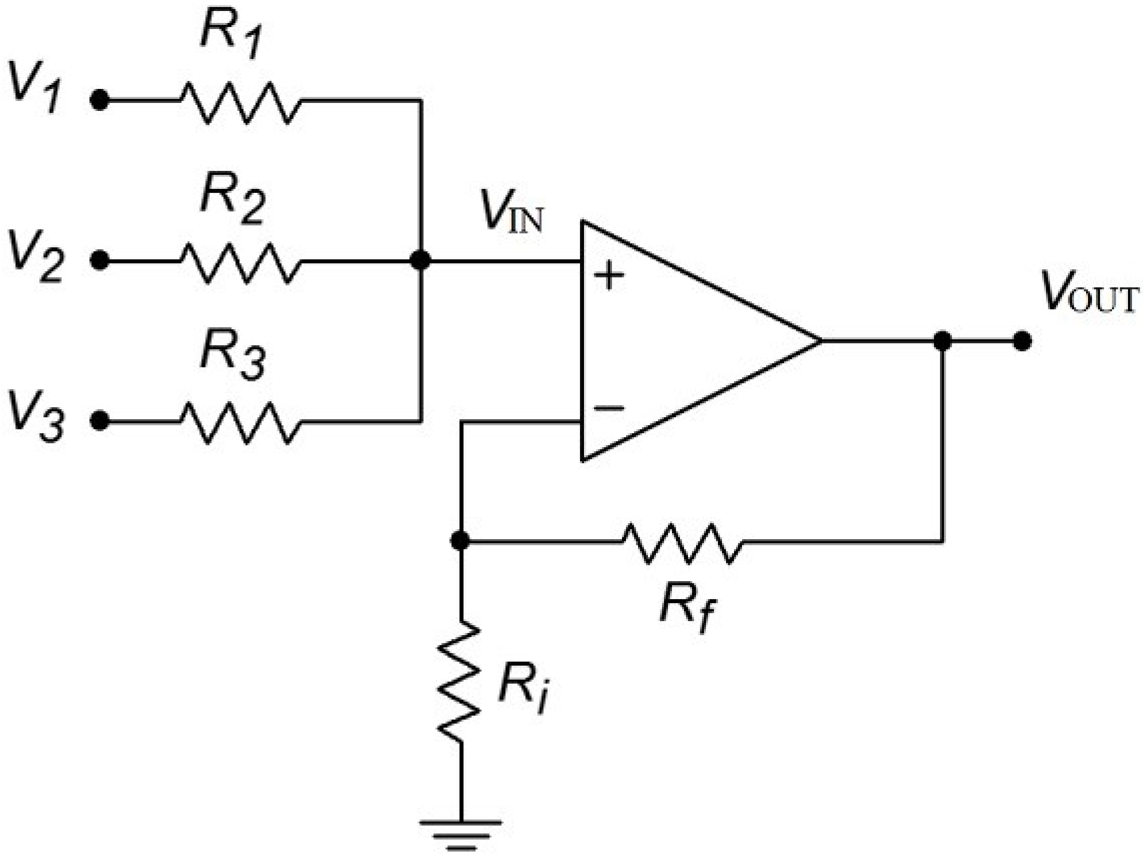


The Summing Amplifier Circuit Diagram

Non Inverting amplifier is very similar to the Inverting amplifier.The only main difference is that the voltage input will be connected to the non-inverting pin.The gain will be positive and the output signal and the input signal will be phase and therefore we will be using a non-inverting amplifier.



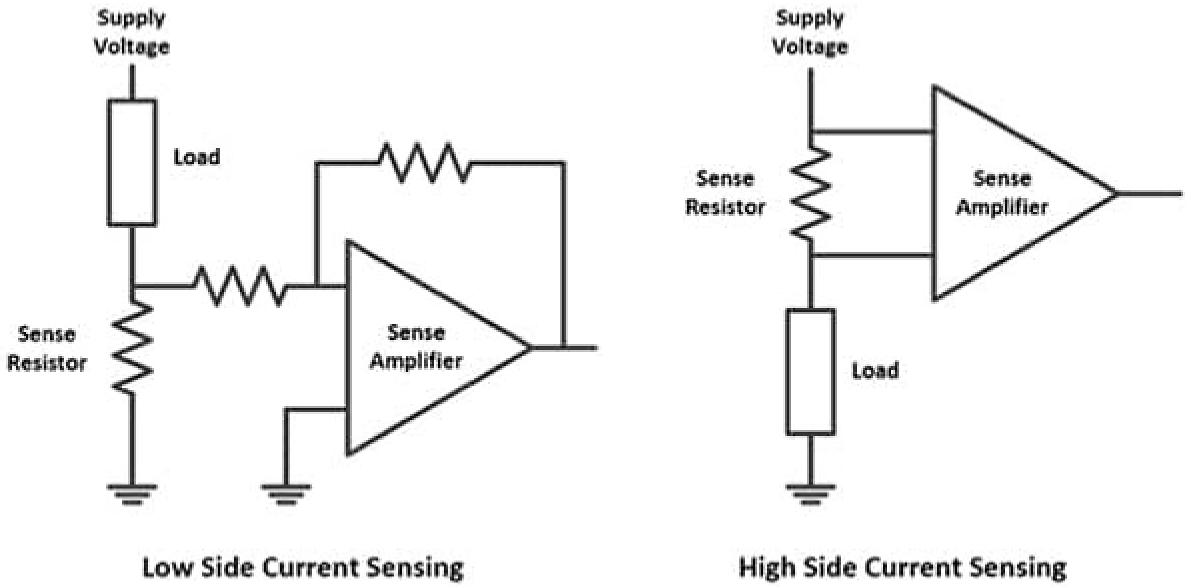
A non-inverting summing amplifier will be an amplifier that has two resistor that will be added parallel to one another.These two resistors will then be connected to the inverting pin.



An amplifier consist of a inverting input(-) ,a non inverting input,a voltage supply(+) and a negative voltage supply and a output.These components are then used to amplify a signal. The amplifier we will be using is the non-inverting amplifier.We don't want the input signal and the output signal to be out of phase. The gain we will be calculating will be Av=(1+Rf/R2). We will be using an LTC6079 op amp.This op amp doesn't have any range of common mode voltage.This op amp works with PMOS and NMOS pairs.A transition will happen when the common mode voltage is 0.9-1.3V.

1.2. Current sensing

A current sensing circuit is a circuit which is used to measure current.There are two different current sensing circuit called invasive and non invasive current sensing.A non invasive current senor can be placed around a supply line where it will be able to tell you how much current is present.Ac current sensor use a non invasive current sensor to measure alternative current.Dc current sensor would only be able to measure DC current.You will also find that there are two current sensing called high side current sensing and low side current sensing.Low side current sensing is when Rshunt is connected to ground and to the power supply. High side current sensing is when Rshunt is connected to the power supply and the load.



The maximum current flowing through the motor will be 1A.The voltage over the 10m ohm will be 10mV.The power over this particular resistor will then be p=IV,which is 10mW.

1.3. Ultrasonic sensors

Ultrasonic sensor are devices that measures distance by sending out ultrasonic signals and converts the reflected signals to electrical signals.Ultrasonic sensors has two main components namely:the transmitter and the receiver.The reason why the ultrasonic sensors send ultrasonic waves is mainly because ultrasonic waves travels faster than audible sound.

To calculate the distance the ultrasonic sensor takes the time the signal travels form the transmitter until the reflected signal is received by the receiver.The formula that is used is:

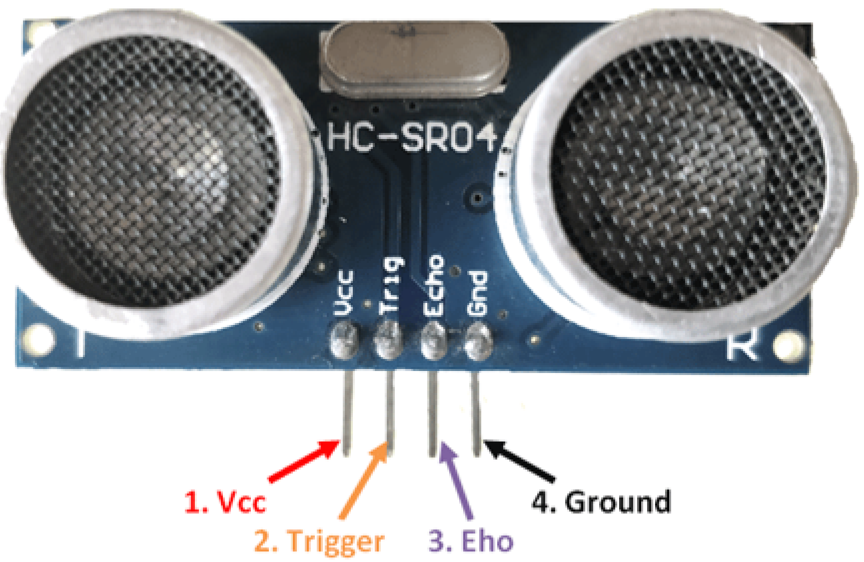
D=0.5T+C

D=Distance.

T=Time

C=Speed of sound(343 meters per second) The power specification of the ultrasonic sensor is the following:

Operating Voltage	Min range	Max range	Operating current	Raging accuracy
5V DC	3cm	4m	15mA	3mm



1.The Vcc pin will be supplied with 5V.

2.The trigger pin is used to trigger ultrasonic sound pulses.When this pin is set to HIGH for 10us, the system initiates an ultrasonic burst.

3.The echo pin goes High when ultrasonic burst is transmitted and remain HIGH until it receives an echo.It then goes low.The distance can then be calculated by looking at the time for which the the echo pin stays HIGH.

4.Is just connected to ground.

1.4. Converting PWM signals to analogue

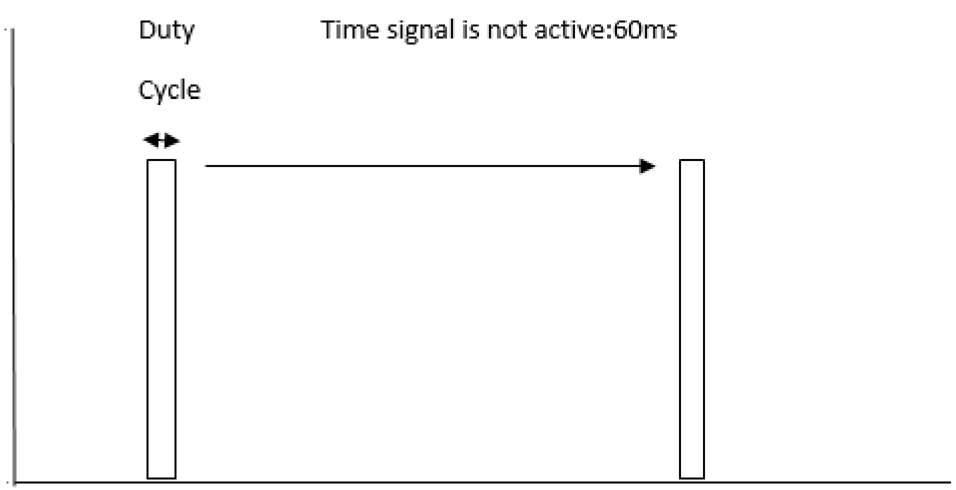


Figure 1: Duty cycle

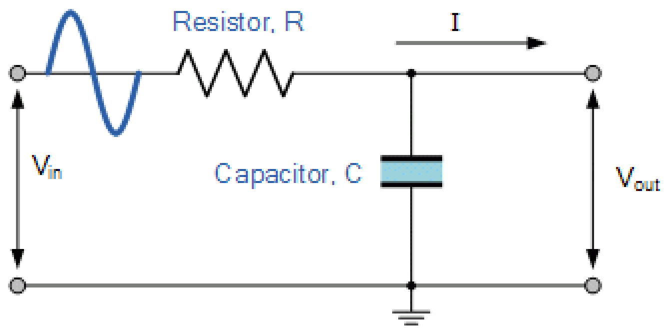
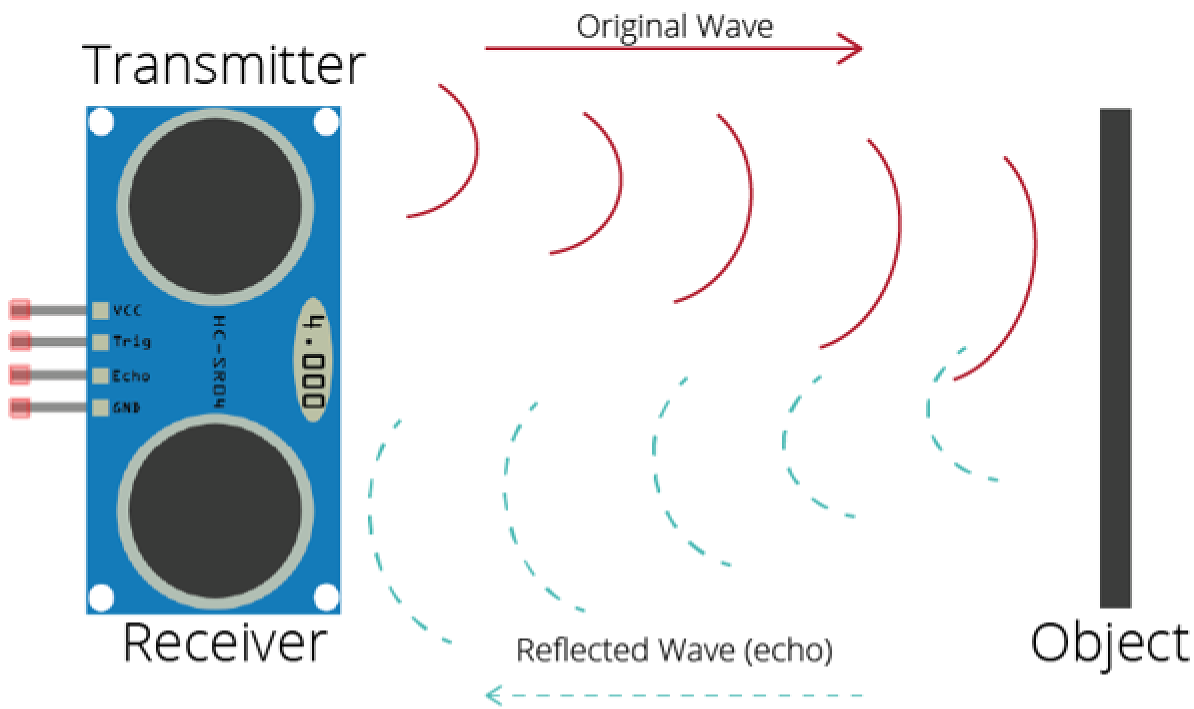


Figure 2: Low pass Filter

PWM signal is a modulation technique to generate different width wave pulses to represent the amplitude of an analog signal.

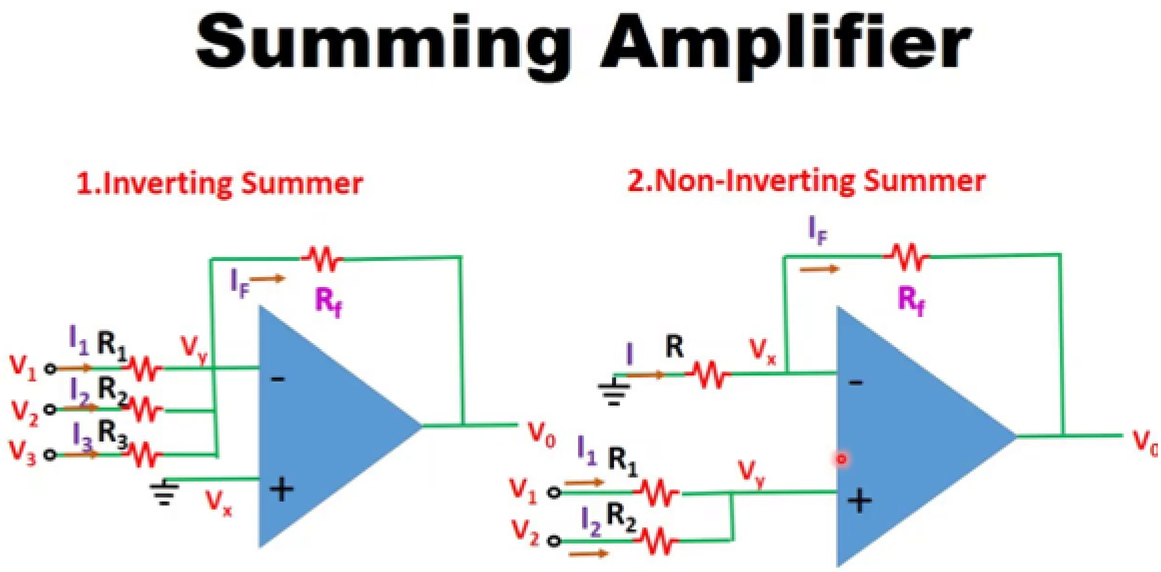
PWM signals can be transformed by only using a low-pass RC filter(Figure 2).This RC filter will then be directly proportional to the duty cycle of PWM.We want to get rid of the frequency where the signal is not active.In this case the frequency of the signal is 16Hz.The duty cycle of this wave is 0.017 percent.We can then use the time where the signal is not active and with that we can calculated our cut off frequency.We will also need to add an amplifier to amplify signal,because a low pass filter might lower the voltage.Only 0.707 of the voltage gain is able to pass the through the low pass filter.

1.5. Fundamental operation of the range sensor



The ultrasonic sensor consists of four pins.One of the pins,the trigger pin, is used to trigger a ultrasonic sound wave.This wave will then travel and the pin will stay be set on HIGH for 10us.This will then cause an ultrasonic burst of eight pulses at 40kHz.When this ultrasonic sound wave hits an object it will reflect a signal .This signal will then be received by the ultrasonic sensor which will set the echo pin back to LOW.After the reflected signal has been received the echo pin will then echo a pulse from 25us to 50ms dependent on the time it took for the signal to be received..The time it takes for the echo pin to stay high will then be used to determine the distance between the ultrasonic sensor and the object.

1.6. Converting digital values to analogue equivalents



We are going to look at a way to use a operational amplifier as an adder.We will be using a summing amplifier.There are two types of summing amplifiers namely an inverting and a non inverting amplifier. With a non inverting amplifier the amplifier will have a positive gain that an be calculated by this formula:

Vout=Vin(1+Rf/Rin)

All the inputs of the summing amplifier can bee added together to get the value of Vin.A inverting amplifier will work the same ,but the amplifier will have a negative gain.We will calculate the output with the following formula:

Vout=-Vin(1+Rf/Rin)

The output voltage of each channel can be calculated individually and then be added together to get your voltage input.I will be using an inverting amplifier,because I want the voltage to subtract from a DC offset,which will give me lower output for a higher input and visa versa. The common mode voltage will now also be equal to the non-inverting node of the operational amplifier.The output impedance for the operational will be dependent on the voltage input of the binary signals and the input resistances of the channels.The formula that will be used is the following:

Vout=-Vin(Rf/R1 +Rf/R2 +Rf/R3 +Rf/R4). Your Rf will be your gain resistor.This resistor value will be dependent on the inverting node voltage and what you want your output to be. Your input impedances will be a ladder of values which all differs from R to 2R to 4R to 8R.There are four bits which means there will be 2 to the power of 4 possibilities.So to counter that we will be using a 8,4,2,1 ratio of resistors.

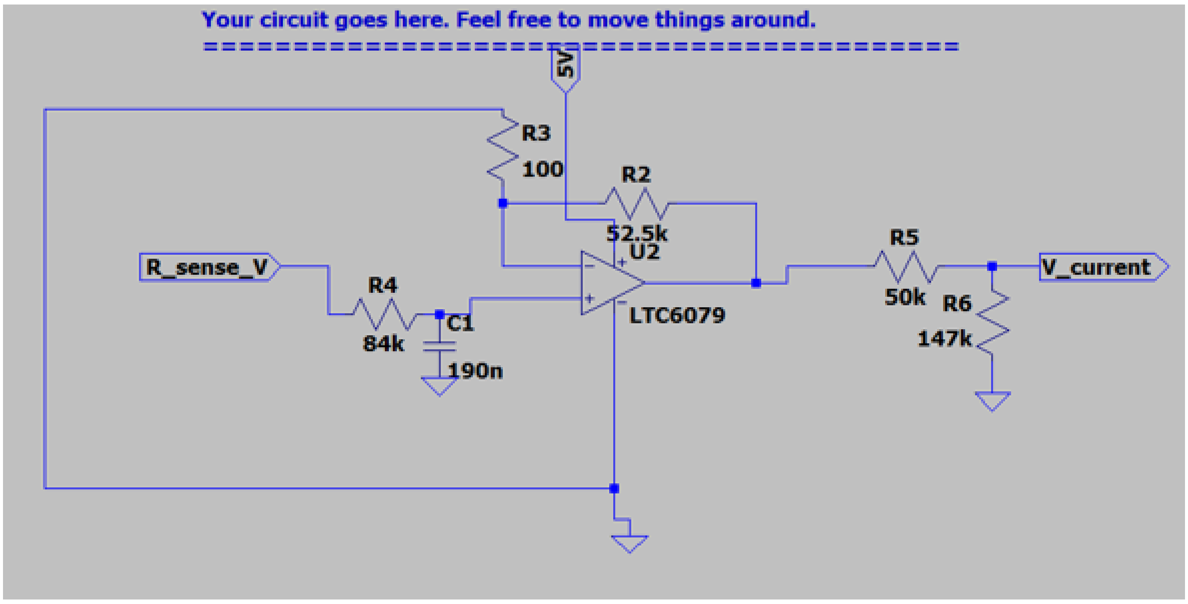
Chapter 2

Detail design

I had to design an small signal amplifying op-amp,and a low current sensor with a lowpass filter which will then filter all the noise with a cut off frequency of 1kHz.

I used a cut off frequency of 10Hz to cancel all the noise bigger than 10Hz.I used 10HZ.because I said that f=1/T and then calculated the frequency to be 10hz.The lower your frequency is how lower your amount of noise will be.I will then use this frequency to create a low pass filter.I the used the following equation to calculate the resistance and the value of the capacitor. numbered equation in Eq. 2.8.

$$fc = \frac{1}{2piCR}. \tag{2.1}$$



.

The max current measured over the motor at 6V is 1A.I chose to choose my max current 0.95A.The max voltage that will be entering the op amp will then be 10m ohm multiplied by the max current.The max voltage will be then 9.5mV.I also chose the output voltage to be 5V at max current .This will then enable me to use voltage division to get my output 3.3V. The Gain will be calculated by this formula:

$$Av = 1 + \frac{R2}{R3}. \tag{2.2}$$

This table will show you the characteristics I needed to consider before designing the op amp

Common mode voltage	Rail voltage	Differential Mode voltage	Expected input voltage	Maximum allowable voltage
0-5V	5.5V	-	10mV	2.7-5.5V

$$Av = 1 + \frac{R2}{R3}. \tag{2.3}$$

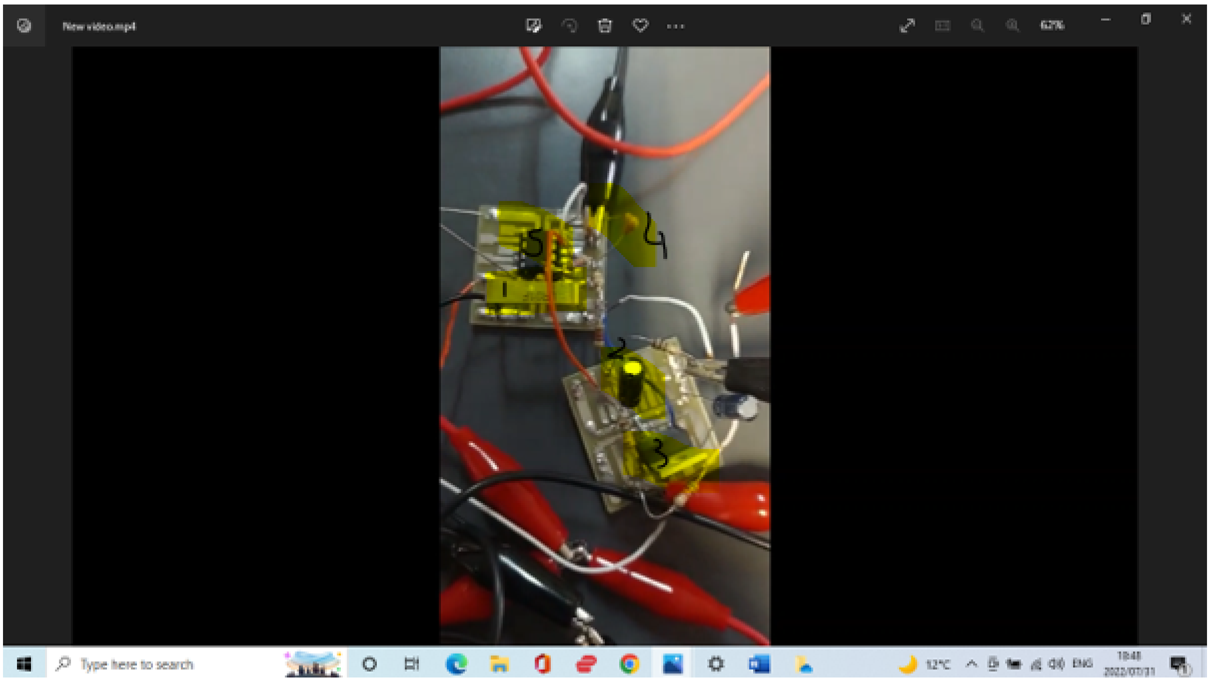
This table will show you the characteristics I needed to consider before designing the op amp

Common mode voltage	Rail voltage	Differential Mode voltage	Expected input voltage	Maximum allowable voltage
0-5V	5.5V	-	10mV	2.7-5.5V

The voltage input of the operational amplifier is 10mV.My rail voltage is 5V and ground which meets the specifications.My output voltage between 3V and 3.6V for that is the only voltages my microprocessor would be able to handle and that is why I made my out put voltage to be 3.3V. I used voltage division and calculated the voltage division in the following way:

$$3.3V = 5V(\frac{R6}{R5 + R6}). \tag{2.4}$$

. I used the following resistors: R4=84Kohm R3=100ohm R2=52.5kohm R5=50kohm R6=147kohm



1-Rsense(0.1 ohm)

2-Capacitors to help with oscillation.Make the voltage stable

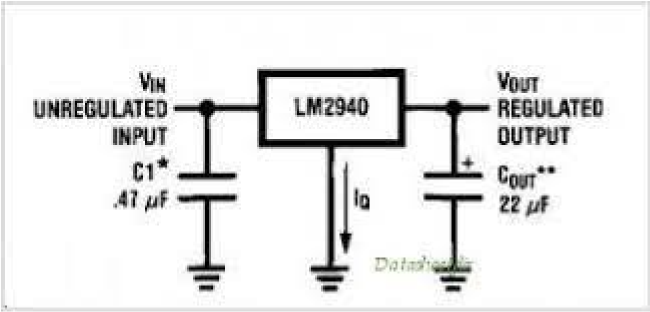
3-Voltage regulator(7.2V-5V)

4-Capacitor for low pass filter.

5-Operational amplifier.

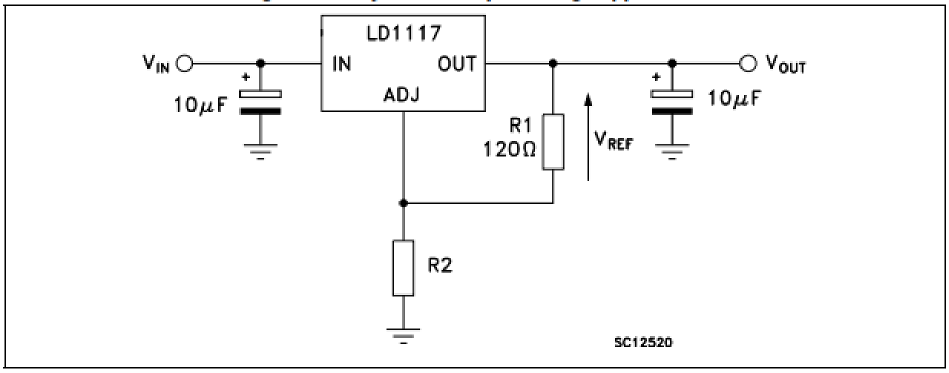
2.1. Voltage regulator

My design is according to the datasheet.The Datasheet of the LM2940CT.This design is used to regulate the voltage form 7.2V to 5V.



To regulate the voltage from 7.2V to 5V I had to use the LM117D regulator.With this regulator I had to use the following design.

Figure 10. Adjustable output voltage application



I used 1.25V as the VREF and the calculated R2 with the formula:

Vout=Vref(1+R2/R1)

I then calculated my R2 to be 360 ohm's.

2.2. Design for ultrasonic sensor

The first thing I had to do was to remove the unwanted signal in the PWM signal.The time where the signal was not active was 60ms.I had to cut out 60ms of the signal where it was not active.I used the following formula to calculate the cut off frequency.The op-amp I will be using in my design is MCP6242.This op-amp uses a common mode input voltage with the range of Vdd+350mV,Vss-300mV.

fc=1/(2 x pi x 60ms)

=2.653Hz

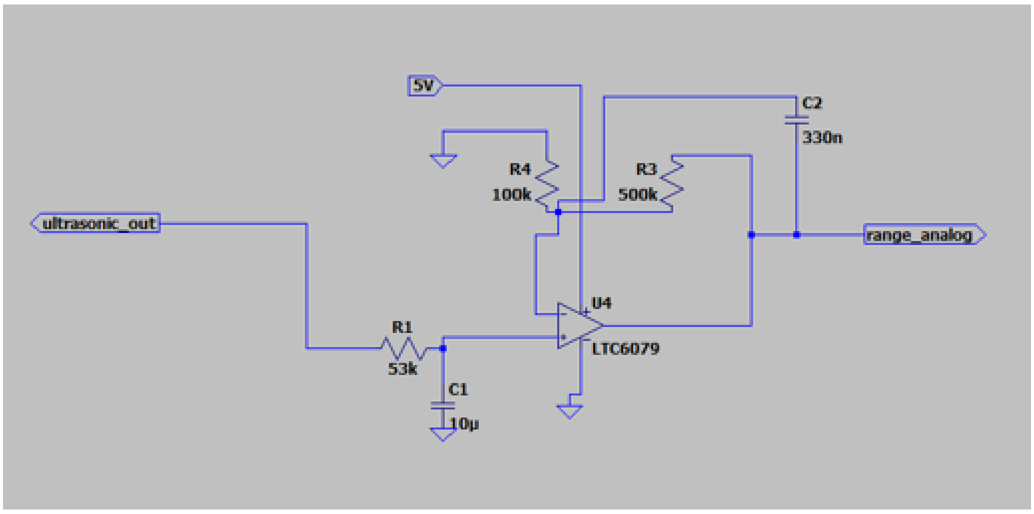
The cut off frequency had to be lower than 2.653Hz.When using this frequency ,my signal still had a lot of noise.I lowered my cut off frequency till I reached less noise.The cut off frequency I chose was 0.3Hz.I also chose resistance to be 53kohm. I calculated the capacitance by using the following formula:

fc=1/(2 x pi x R x C)

I calculated the capacitance to be 10uF.I then had to amplify the signal.The output of this signal was equal to 600mV and I wanted it to be 3.3V.To calculate the gain I used the following formula:

Av=R2/R1

I chose R1 to be equal to 100kohm.I then calculated the R2 to be 500kohm.To smooth out the noise on the signal even more I picked a 330nF capacitor.I used this capacitor to lower the noise on the signal down to 70mV peak to peak.In the building of my circuit I will be using 3.3V to power my op-amp,because when my distance measured on my ultrasonic sensor is more than 1 meter, my output voltage is more than 3.3V.


5V
C2
330n
R4
100k
R3
500k
ultrasonic_out
range_analog
U4
R1
53k
LTC6079
C1
10μ

2.3. : Digital to analogue converter design

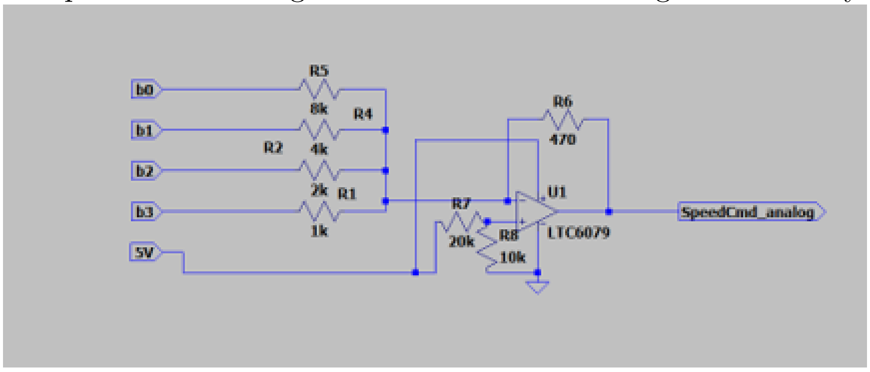
For my design I have decided to use a summing inverting amplifier.I will also be using a Dc offset that will be connected to my non-inverting node.With this offset I will be able to subtract my voltages from my offset.I will then be able to get lower outputs form higher inputs and visa versa.I will be using a gain of 0.5.With this gain I will use a voltage divider to get my 5V down to 1.67V.With a gain of 0.5 I will then be able to get a voltage of 3.2V for my output.

the output impedance of a DAC is a Thevenin equivalent circuit resistance.The higher the output resistance of the circuit the higher the output impedance of the DAC.The lower the output resistance the higher the current draw from the buffers and it will be inefficient in power.

Your Rf will be your gain resistor.This resistor value will be dependent on the inverting node voltage and what you want your output to be. Your input impedances will be a ladder of values which all differs from R to 2R to 4R to 8R.There are four bits which means there will be 2 to the power of 4 possibilities.So to counter that we will be using a 8,4,2,1 ratio of resistors.

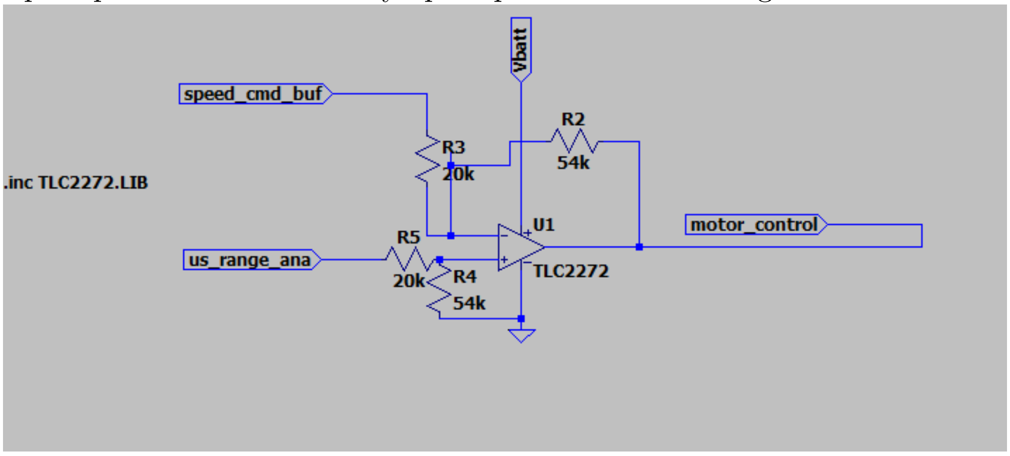
The expected voltages from the source will be 3.3V.We can expect the following input voltages depending on the binary code: if binary code is 0001: Vin=3.3(0*1/R1+0*1/R2+0*/R3+1*1/R4)

The maximum allowable output of this circuit will be over 3V,but not higher than 3.3V. The output needs to range form 0 to 3.3V according to the binary signal that was send.

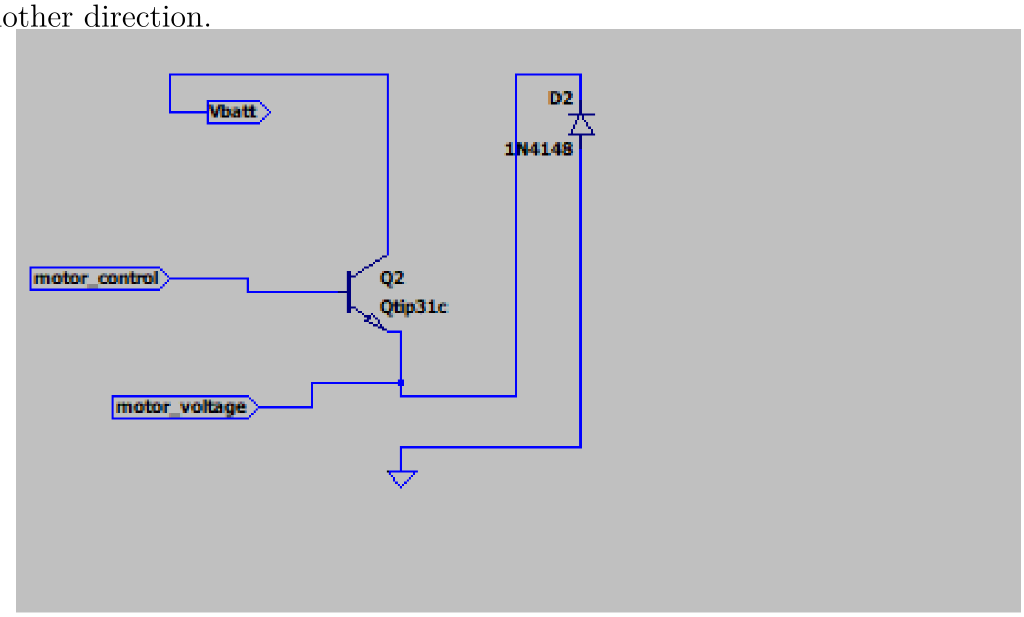


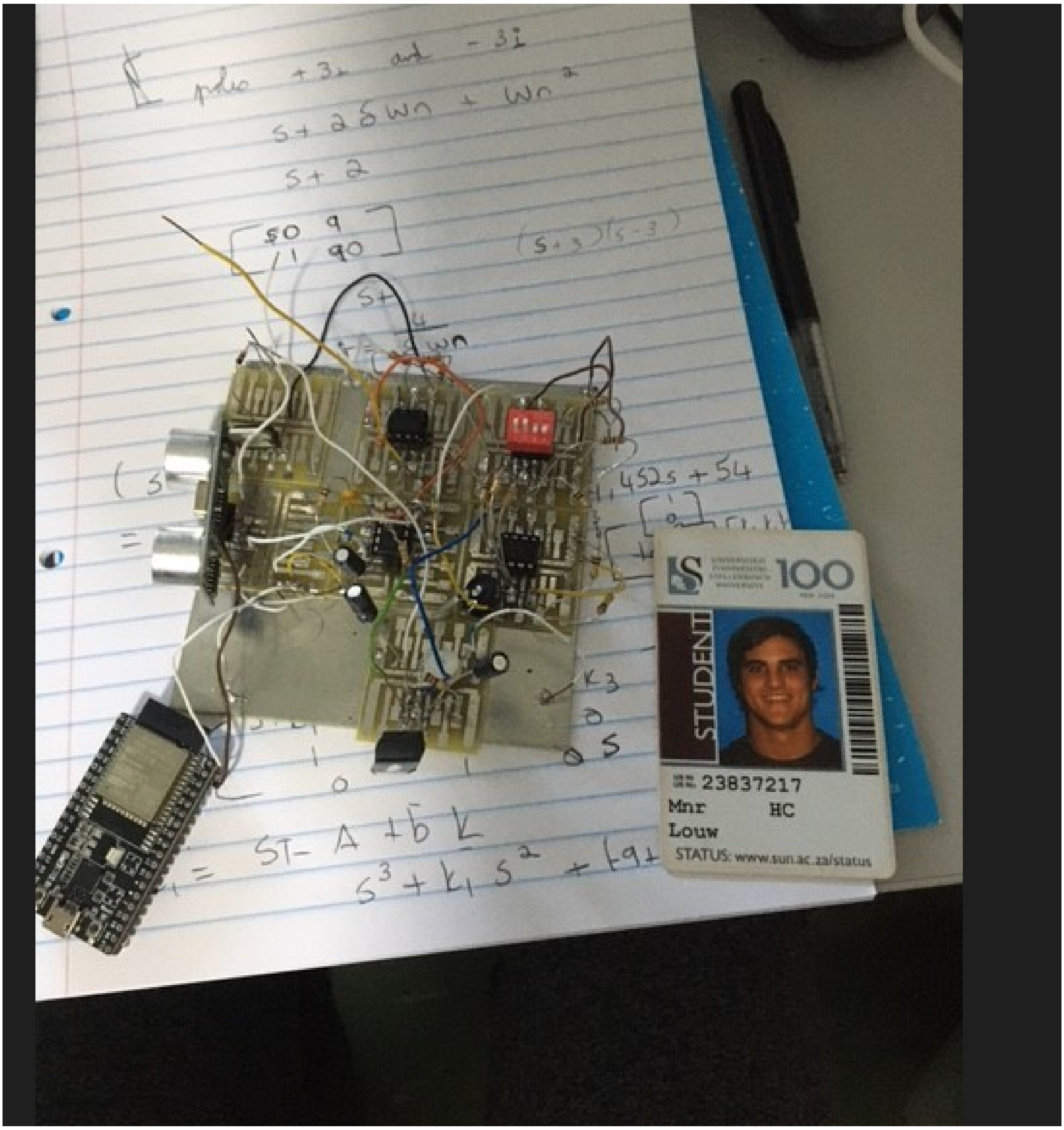
2.4. : Motor control signal and driver

We want the signals from the DAC and the ultrasonic sensor to subtract from one another.When the DAC signal is low and the ultrasonic sensor is HIGH we want the output to be above 6V.Therefore our gain would have to be 6.4/(3-0.5) .We used 0.5 in this formula ,because that is the minimum voltage of the DAC.We have to build a differential amplifier and we also want our two signals subtract from one another to be equal to zero,when the signals are equal to one another.I chose R1 to be equal to 20k ohm.We chose our gain to be 2.5.We then calculated our R2 to be 50k ohm.It was important to use the same resistances in my voltage divider ,otherwise my reaction time would've been slower and it would've taken my op-amp an extra 5ms for my op-amp to subtract the signals.



My emitter follower was a basic design.This emitter follower will be used as an buffer amplifier to provide a lower output impedance to the circuit and also the decreasing loading in the previous circuits.I used my QTIP31c transistor and then I connected my motor to my emitter.I also used a diode connected parallel to my motor to block any current flowing into another direction.





2.5. : Current sensing left wheel

For my current sensor design for my left wheel I used the same cut off frequency as for my right wheel ,which was 10Hz.I then also used the same current sensing circuit as the one I used on my right wheel.I calculated the capicator and resistor values by using the following formulas: numbered equation in Eq. 2.8.

$$fc = \frac{1}{2piCR}. \tag{2.5}$$

. The max current measured over the motor at 6V is 1A.I chose to choose my max current 0.95A.The max voltage that will be entering the op amp will then be 10m ohm multiplied by the max current.The max voltage will be then 9.5mV.I also chose the output voltage to be 5V at max current .This will then enable me to use voltage division to get my output 3.3V. The Gain will be calculated by this formula:

$$Av = 1 + \frac{R2}{R3}. \tag{2.6}$$

This table will show you the characteristics I needed to consider before designing the op amp

Common mode voltage	Rail voltage	Differential Mode voltage	Expected input voltage	Maximum allowable voltage
0-5V	5.5V	-	10mV	2.7-5.5V

$$Av = 1 + \frac{R2}{R3}. \tag{2.7}$$

This table will show you the characteristics I needed to consider before designing the op amp

Common mode voltage	Rail voltage	Differential Mode voltage	Expected input voltage	Maximum allowable voltage
0-5V	5.5V	-	10mV	2.7-5.5V

The voltage input of the operational amplifier is 10mV.My rail voltage is 5V and ground which meets the specifications.My output voltage between 3V and 3.6V for that is the only voltages my microprocessor would be able to handle and that is why I made my out put voltage to be 3.3V. I used voltage division and calculated the voltage division in the following way:

$$3.3V = 5V(\frac{R6}{R5 + R6}). \tag{2.8}$$

. I used the following resistors: R4=84Kohm R3=100ohm R2=52.5kohm R5=50kohm

R6=147kohm.

2.6. Firmware (range sensor and PWM control)

To measure the distance from an object to an ultrasonic sensor I will set the trigpin to HIGH for 10ms.I will then measure the time it takes for the echoPin to return a value by using the function pulesIn(echopin,High).This time I will the multiply by the sound of speed divided by 2 to calculate the distance between the object and the ultrasonic sensor.The reason why I divided by 2 is ,because the wave travels to the object and reflect back to the ultrasonic sensor.So to know how far the object is from the ultrasonic sensor we need to divide by 2. I will then calculate my first duty cycle which will then be used as a percentage to control my output voltage.The lower the distance between the object and the ultrasonic sensor the lower the output voltage. You can see my my method in the following code:

// Reads the echoPin, returns the sound wave travel time in
microseconds duration = pulseIn(echoPin, HIGH);
// Calculate the distance
distanceCm = duration * SOUND$_{S}PEED/2$;
$x = 1 - distanceCm/100$;
$dutycycle1 = x * 65536$; ”

I will then also implement a code using my DIP switch.The combination of 4 bits will determine the speed of my wheels.Therefore I will use the combination of these 4 bits to calculate the percentage of my duty cycle .The duty cycle will be used to control the output voltage of my output pin.I will add the 4 bits input according to the ratio 1,2,4 and 8.I will then count the bits as a sum according to it’s input ratio.I will then put the sum of the inputs and divided it by the sum of all the bits added together,which is 16.I will then get a percentage of the duty cycle I will be using. The following code will be used:
if(digitalRead(32)==HIGH)
x2=1000;
elsex2=0;

if(digitalRead(35)==HIGH)
x3=100;
elsex3=0;

if(digitalRead(4)==HIGH)
x4=10;
elsex4=0;

```
if(digitalRead(25)==HIGH)
x5=1;
elsex5=0;

x1=x2+x3+x4+x5;
if(x1==11)
dutycycle2=(3/16)*65536;

if(x1=111)
dutycycle2=(7/16)*65536;
    dutycycle1=dutycycle1-(65536-dutycy
cle2);
if(dutycycle1¡0)
dutycycle1=0;
```

I will minus the duty cycle I have calculated at the distance from the duty cycle of the speed(DIP switch) This will then give me duty cycle which I can send to my mosfet.

2.7. Low side switch)

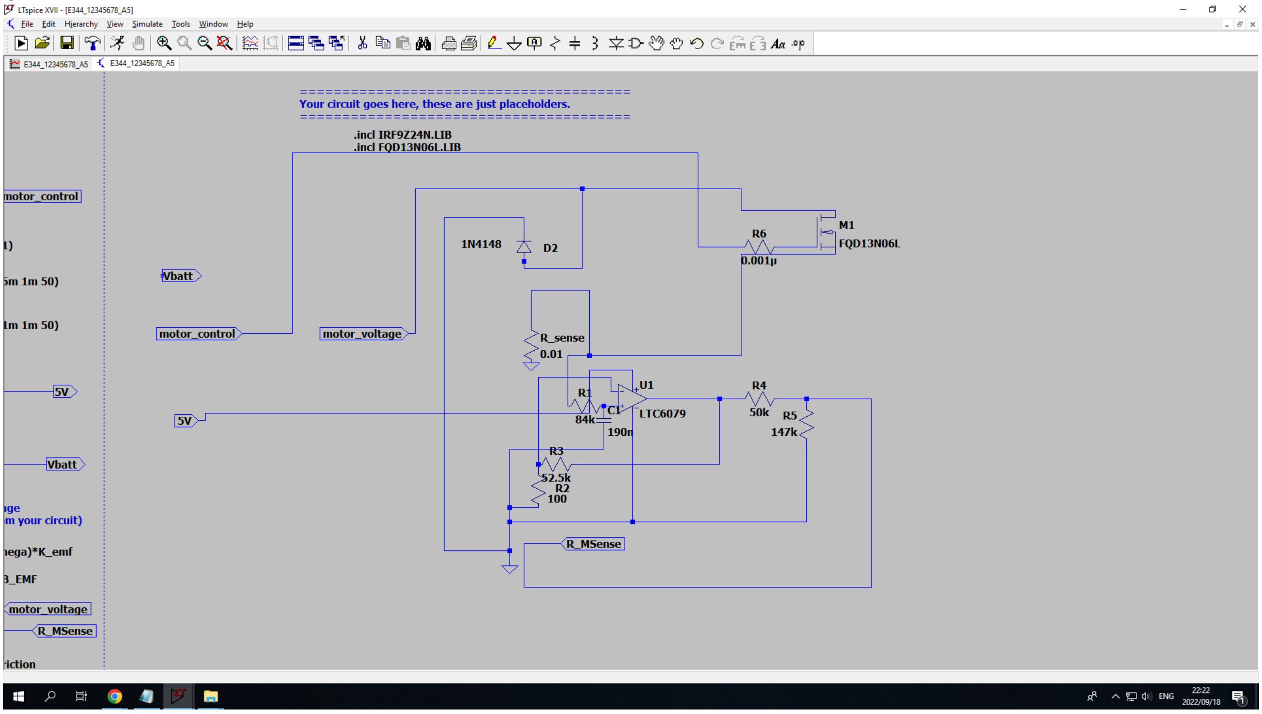
For my low side switch I needed to figure out which mosfet I was going to use.I needed to make sure mosfet can use 6.5V and had to switch on at 3.3V.The mosfet that I was able to use and met all my requirements was the PQD13N06L.My circuit was using 220mA and I needed to make sure that my mosfet would be able to take that amount of current. The following table describes the characteristics of the PQD13N06L.

Table 2.1: Characteristics of PQD13N06L.

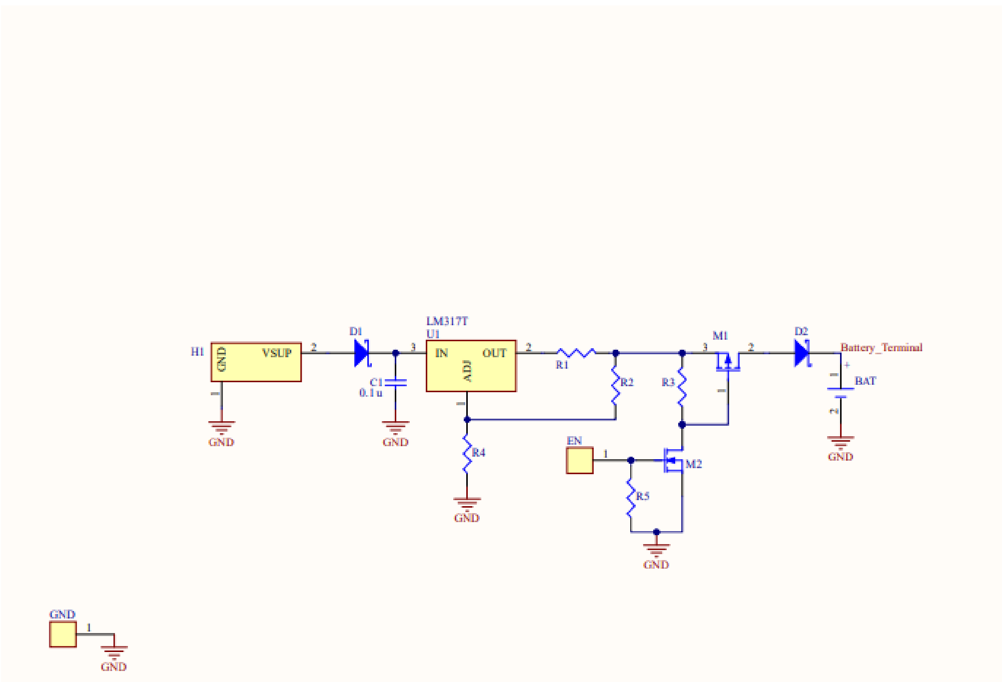
max equivalent series resistance	VGS-Threshold	max voltage	max current	minimum DS current
115m(ohm)	1-2.5V	60V	11A	250uA

This means that this mosfet can sustain a lot of power and won't get warm and blow very easily . For the mosfet to turn on the incoming voltage,which is 3.3V,need to be a lot higher than the rated gate threshold voltage .As you can see in the table,it is.The highest current the mosfet could take through the DS is 11A.The required Drain to Source current required is 250uA.The question is how much current do we have?My current from my drain to source is equal to 6mA,which meets the requirement.The mosfet will turn on.The maximum Rds is 115m(ohm).

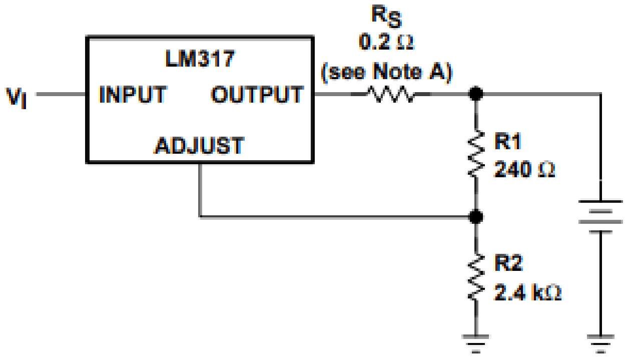
A small pull down resistor needs to be included at the mosfet ,because the mosfet is highly capacitive and can draw a large amount of instantaneous current.We will also use a diode to prevent current flowing back to the motor.This diode will be connected form the motor to ground.



2.8. Battery charger design)



We will be using the LM317T voltage regulator to regulate the voltage at 7.2V.Therefore we will be using some of the equations from the LM317T datasheet to complete the circuit.For this battery charger we want the battery to charge at a constant current.When the load increases the charger will increase the voltage. To calculate Rs,R1 and R2 ,I will use the following diagram from the datasheet of the voltage regulator,LM317T.



I used the following formula to calculate value of Rs and R2.I selected my R1 to be a random value of 240 ohm.Vout will be equal to the 7.2V ,which we would use to charge the battery .According to the datasheet of the LM317T the current IADJ will be equal to 100uA.VREF will also be equal to 1.25V according to the datasheet of the LM317T voltage regulator.With the following formula,I will then be able to calculate the values for R2 and Rs:

Vout=VREF(1+R2/R1)+IADJ.

I then calculate the R2 value to be 1047.2ohm.I then used A KVL circuit to calculate RS.We know that the output of the circuit has to be 400mA and with that knowledge we will be able to calculate the value of RS.

(V1-1.25)/R1 +400mA-1.25/Rs=0
Rs=0.5.

2.9. High side switch)

With that knowledge we need to be able to calculate the resistance values from the mosfets.Question is what voltages and currents can the mosfets handle and why are they even used for.The mosfet will be used as an active switch.If the current is too low the mosfet will not be turned on .If the mosfet is turned off,the mosfet will act as an open circuit and won't allow any current to pass.We will use the 2N2007 Nmos mosfet and the IRF9Z24N mosfet.

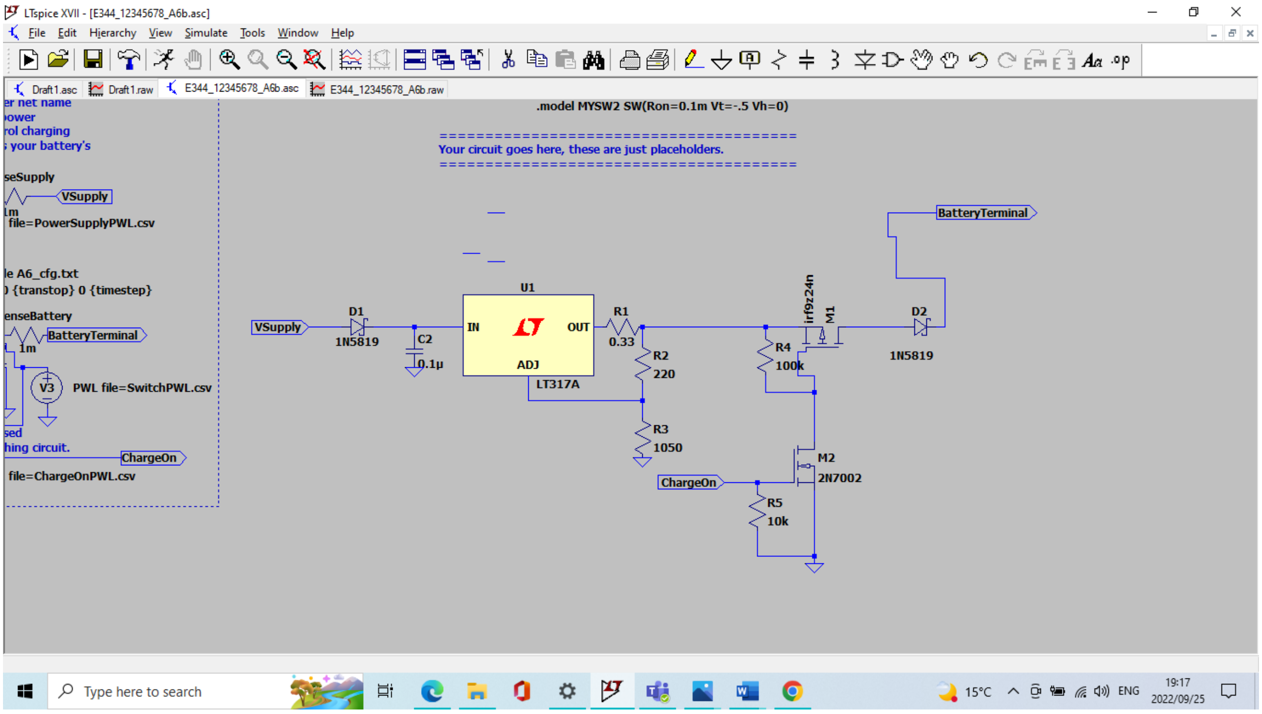
I will be picking the IRF9Z24N as my high side switch,because it can handle a lot more current.We will be needing a negative Vgs for the mosfet,therefore we will be using the 27N002 mosfet and connect it to ground. I will be picking my R3 and R4 as 100k and 10k ohm.R3 will be used to keep the mosfet off at some unknown voltages

Table 2.2: Characteristics of IRF9Z24N mosfet.

VGS-Threshold	max voltage	max current	max equivalent series resistance
-2 to -4V	-55V	-11A	0.175(ohm)

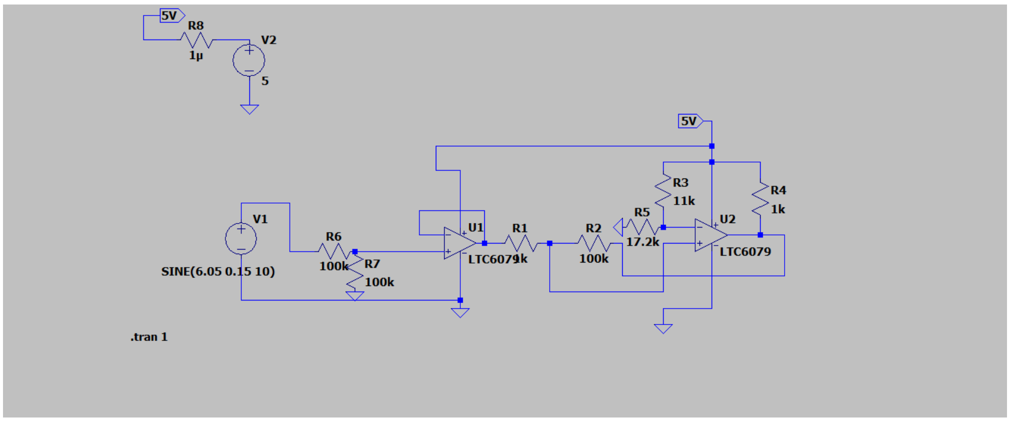
Table 2.3: Characteristics of 27N002 mosfet.

VGS-Threshold	max voltage	minimum DS current required	max equivalent series resistance
1V-2.5V	60V	0.5A	0.175(ohm)



2.10. Schmitts trigger circuit)

Schmitts trigger .The Schmidt trigger is to trigger the mosfet only with a certain voltage threshold .The mosfet will be able to turn on when the voltage ,that is fed into the circuit, is above 6.2V.When the voltage is lower than 5.9V the mosfet will turn off and there will be low output voltage.This low output voltage would not be able to turn on the motor.For this design we calculate the resistance values.We will firstly use an differential amplifier to half the voltage going into the first op-amp.This will make the output voltage of the first op-amp 3.6V..This output will then travel to the non inverting node of the op amp.My design looks the following way:



2.11. Bluetooth design)

For the following design we want the esp and the computer to connect via bluetooth , so that we can send commands to esp without any serial wires connected to the esp.To enable the bluetooth we will need to implement the following code:

```
” Serial.begin(115200);
SerialBT.begin(”ThinusSeKar”); //Bluetooth device name
Serial.println(”The device started, now you can pair it with bluetooth!”);
```

This code will enable the bluetooth of the esp and we will be able to connect to the esp throught the computer.This will enable us to send commands to the esp.This commands will tell the car to go full speed,to turn hard left,to turn hard right and to stop.

I will send commands to the esp through python ,where the commands will then be interpreted through the esp .The following code is the python code ,where I asked the user which command he would like to send to the esp.

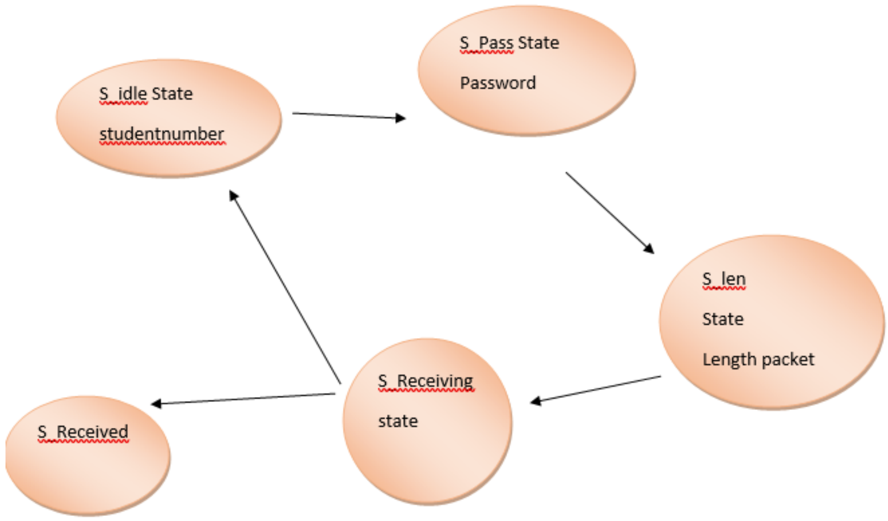
```
while True:
choice = menu()
if choice == 1:
fullspeed(52) ;
if choice == 2:
Hardturnleft(53);
if choice == 3:
Hardturnright(54);
if choice == 4:
stop(55) ;
Do stuff
if choice == 5: Or whatever
```

end condition;
break;
print(arduino.read())
arduino.close()
This command will then be read by the arduino code you uploaded on the esp32.That command will be received by the arduino by using the following code;

define cmd set FS 52;
define cmd set HL 53;
define cmd set HR 54;
define cmd set ST 55;

if(buffer[2]==52)
Rightwheelspeed=100;
Leftwheelspeed=100;
if(buffer[2]==53)
Rightwheelspeed=100;
Leftwheelspeed=0;

When the This code will then determine the speed of the car and in which direction you want your car to turn.When the car is in full speed mode,we will set the binary output pin all to HIGH,which will make the car turn faster.We would also use the output of the left wheel of the current sensor and use it as an input to one of the esp32 pins.The distance of the object we will be able to measure by using the code that was mentioned in the ”firmware(range sensor and PWM control” section.This will enable us to then display the distance of an object away from the vehicle. There is also a state machine,regarding the bluetooth connection of the esp32.


S_idle State
studentnumber
S_Pass State
Password
S_len
State
Length packet
S_Receiving
state
S_Received

Chapter 3

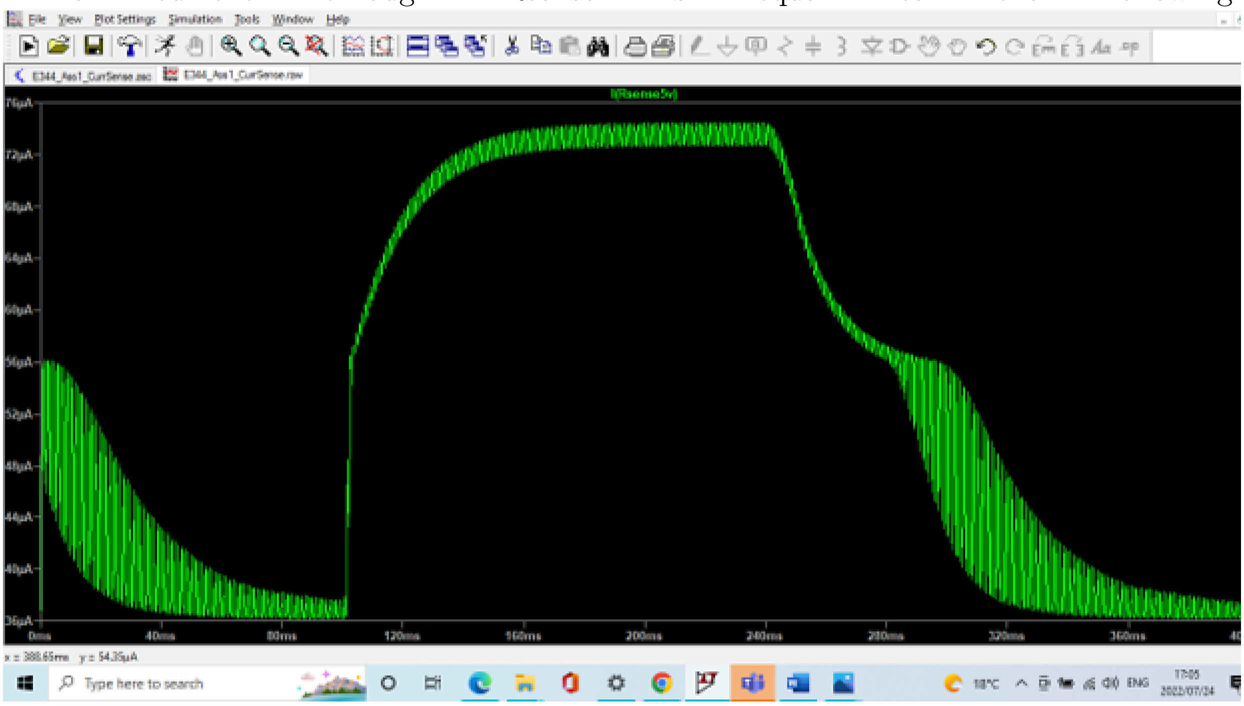
Results

In this section I will be showing my results by referring to my simulation results and will be showing how my designed circuit behaves.I will also be showing the current use of the DC motor according to it's condition.

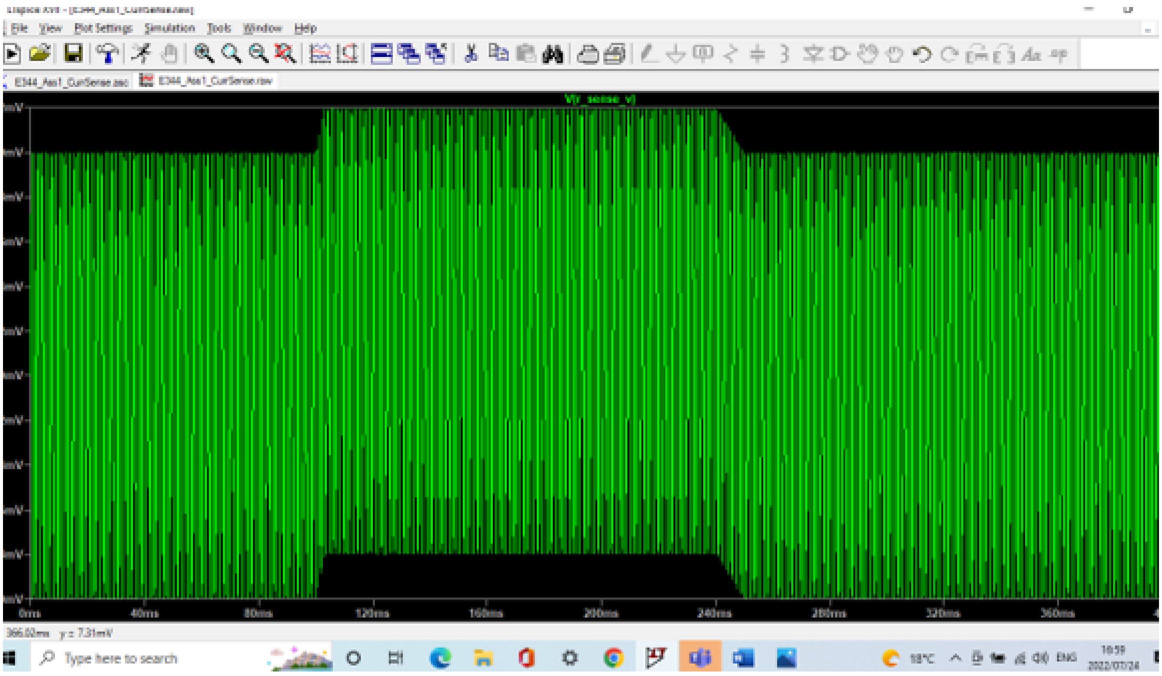
Table 3.1: voltage use of circuit when motor:.

stall	running	
3.2	0.45	V

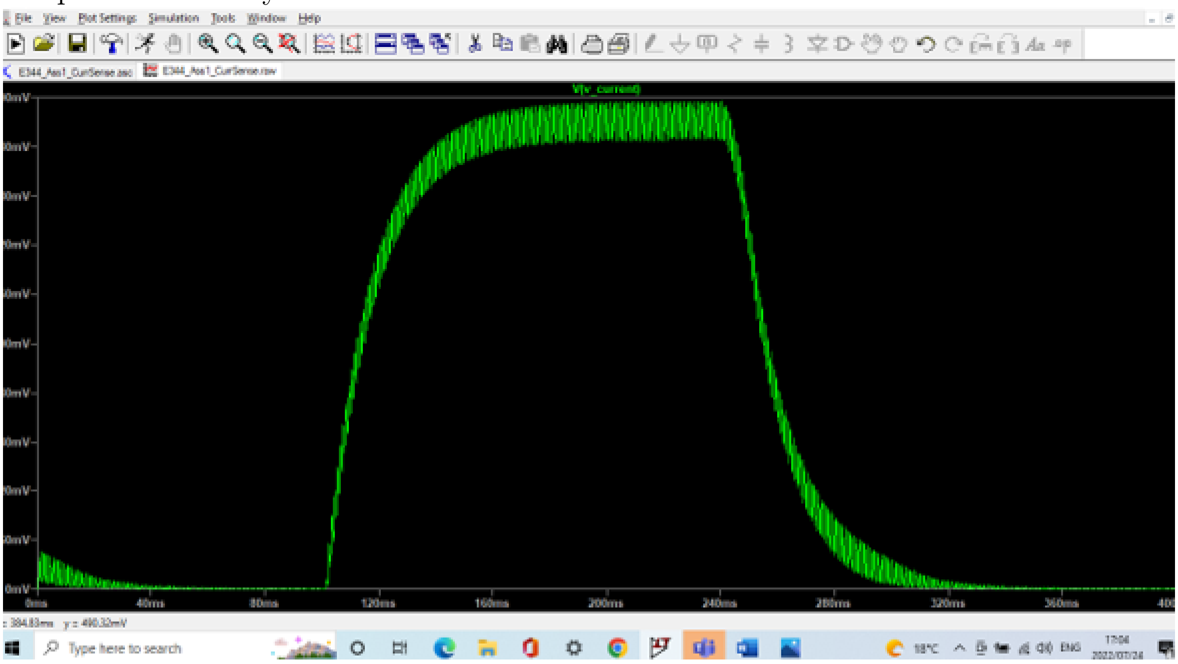
The current through Rsense is equal to the following:



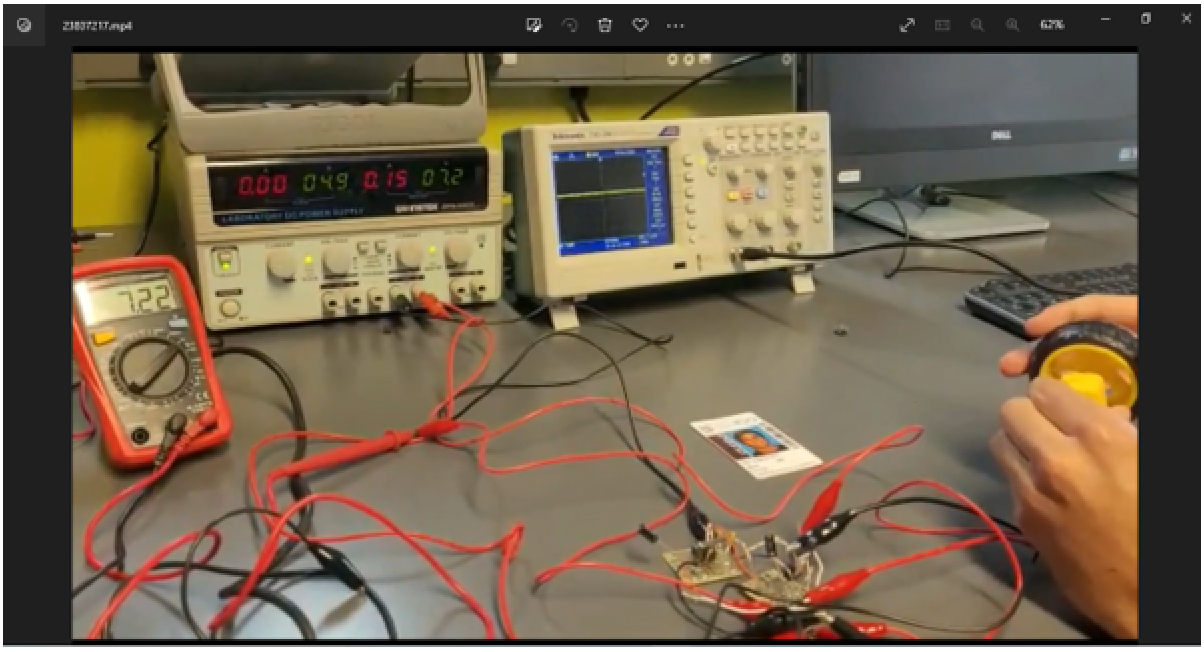
The input with the noise is :



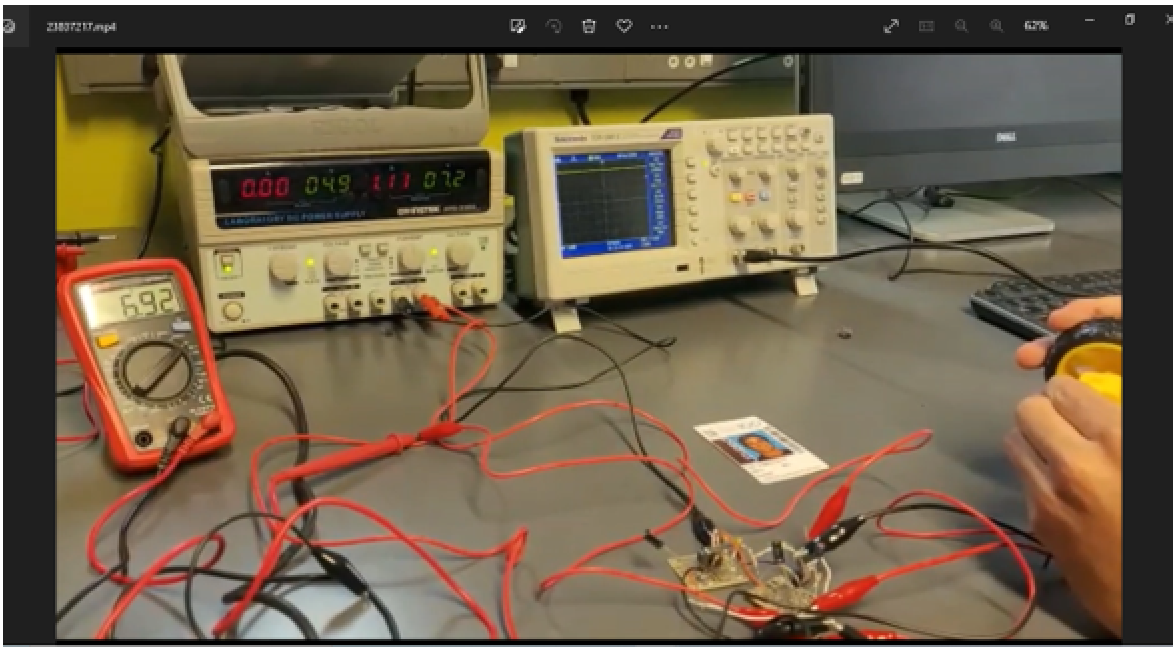
Output without any noise:



Results when 1.5A input and wheel is running:

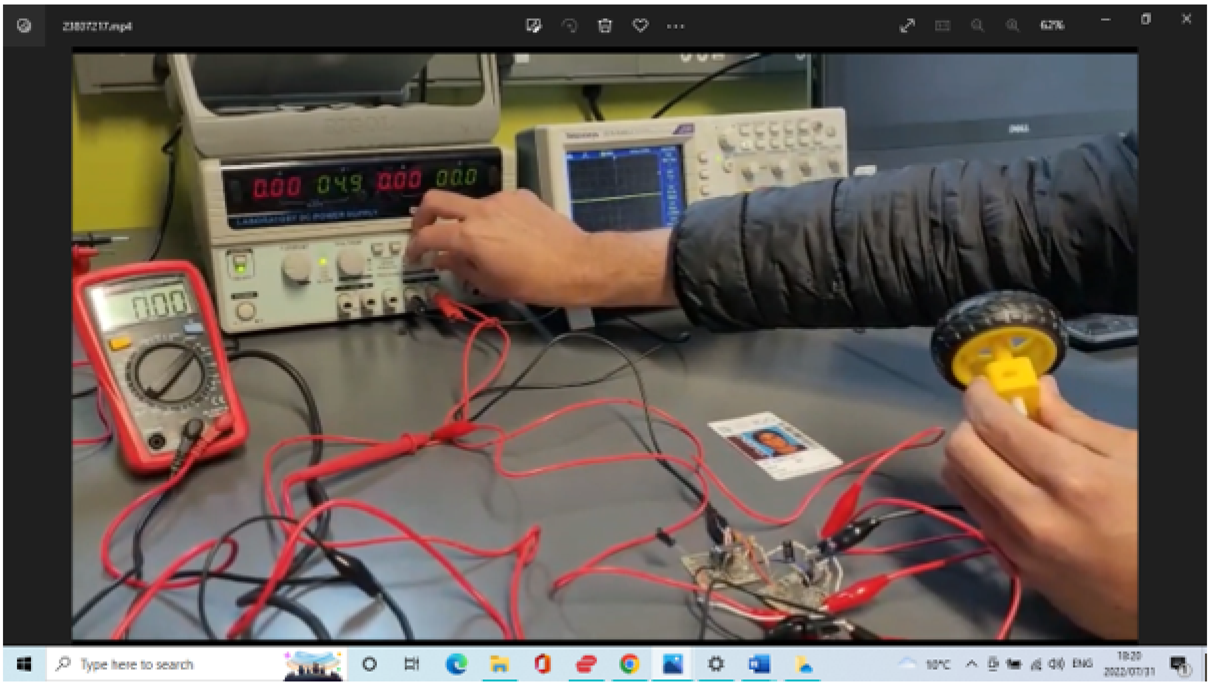


Results when 1.5A input and wheel is stalled:



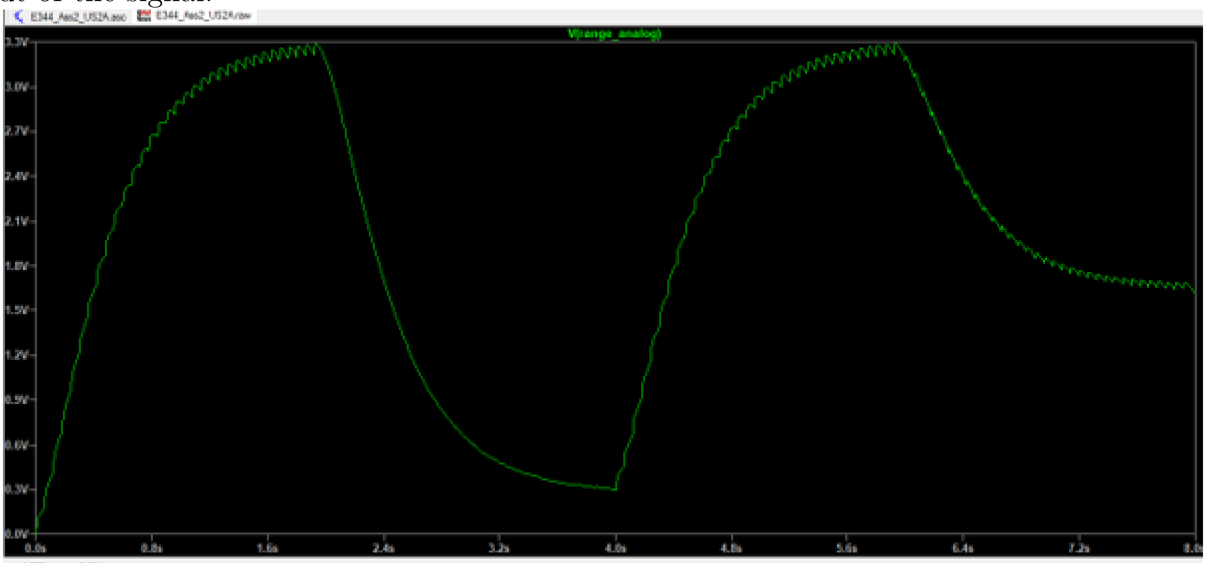
When the input current is 1.5A, the output voltage, when the wheel is stalled, is 3.2V.When current is 0.25A the results remain the same,but when the wheel is stalled the voltage go down to 0V.

When 0A or 0.05A is input:

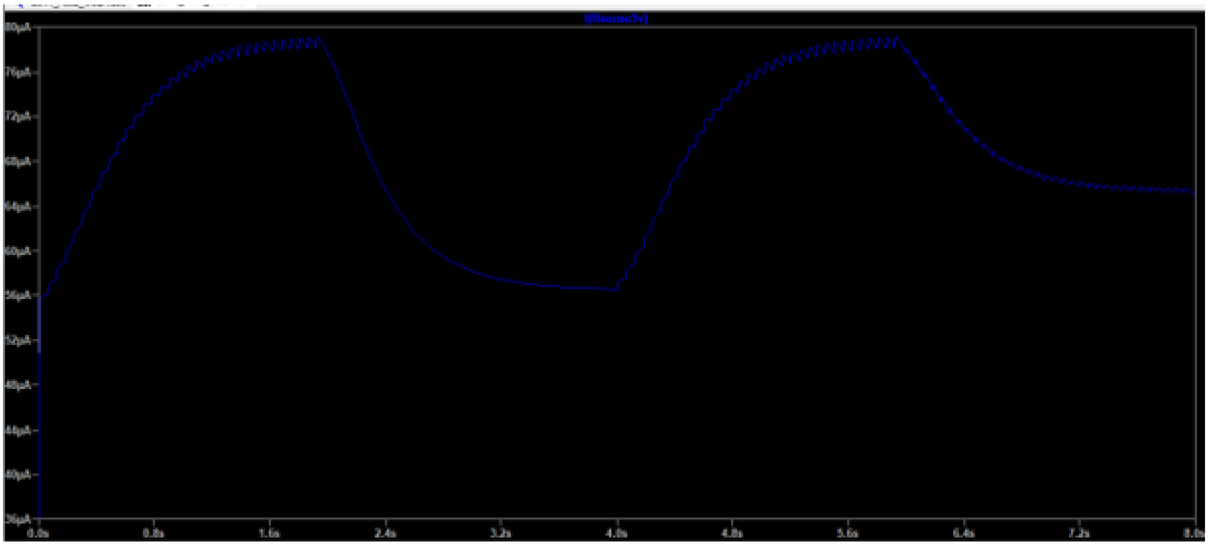


3.1. Ultrasonic sensor design

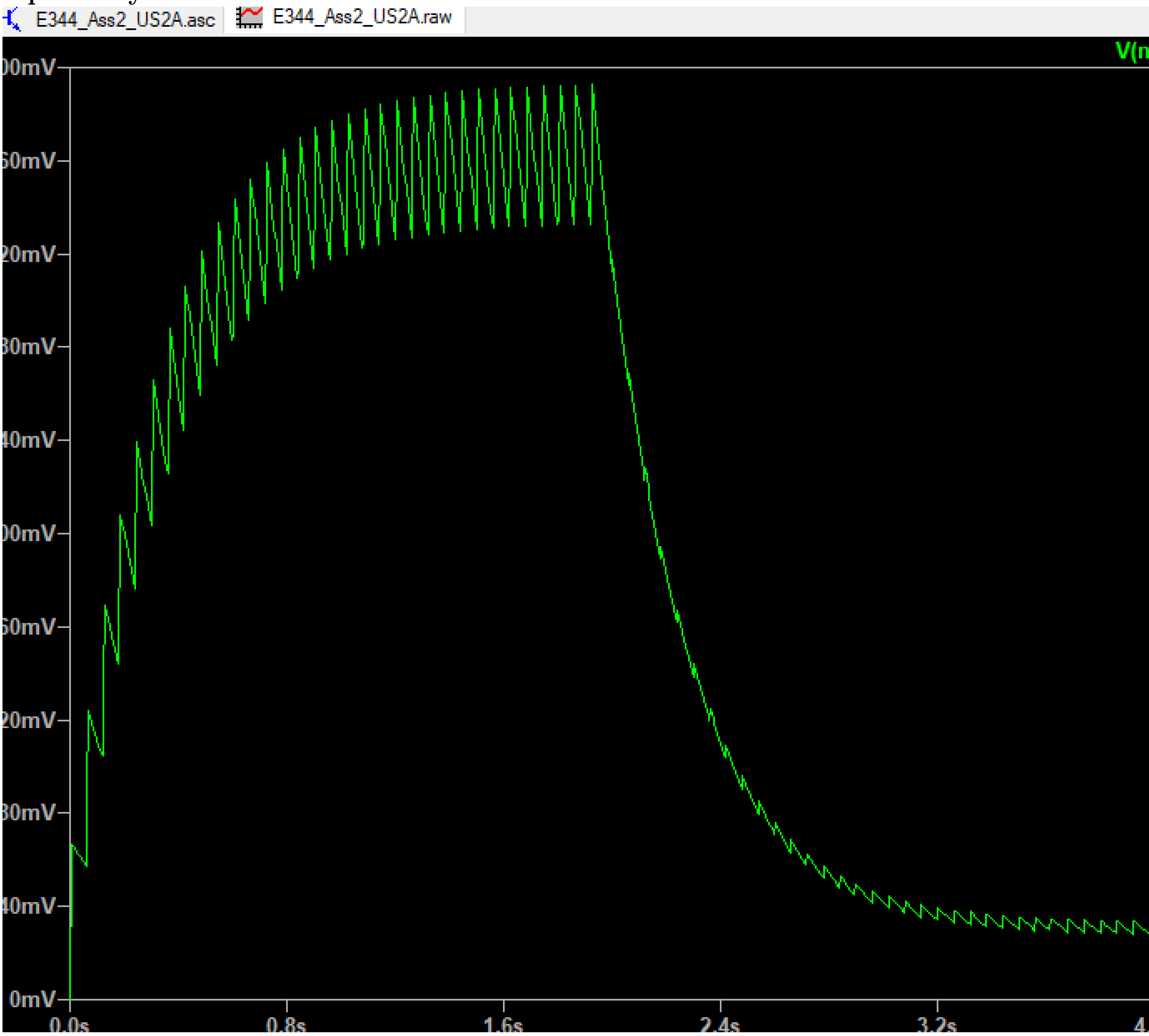
Output of the signal:



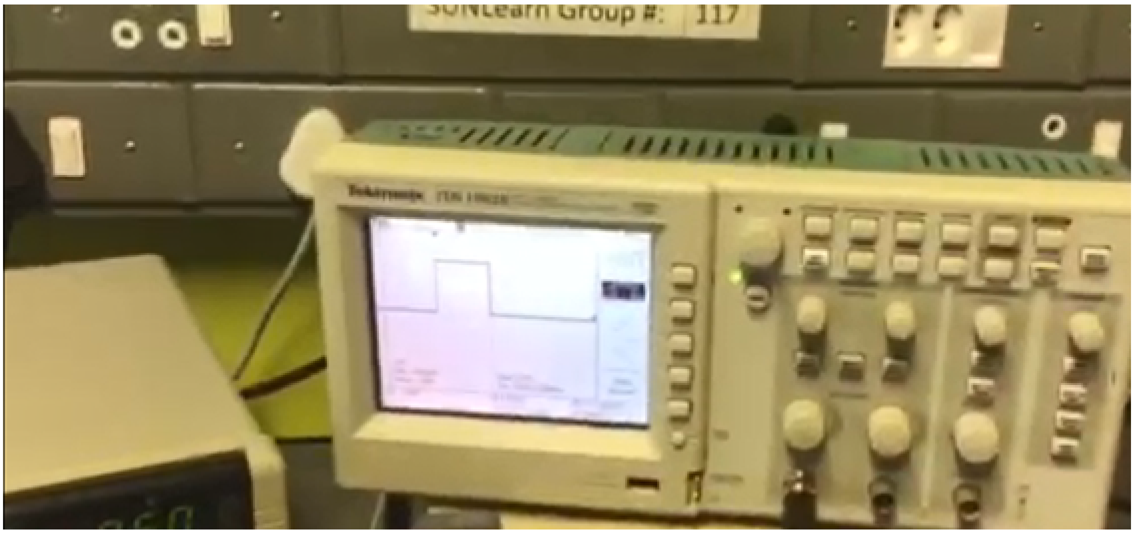
The amount of current going through Rsense:

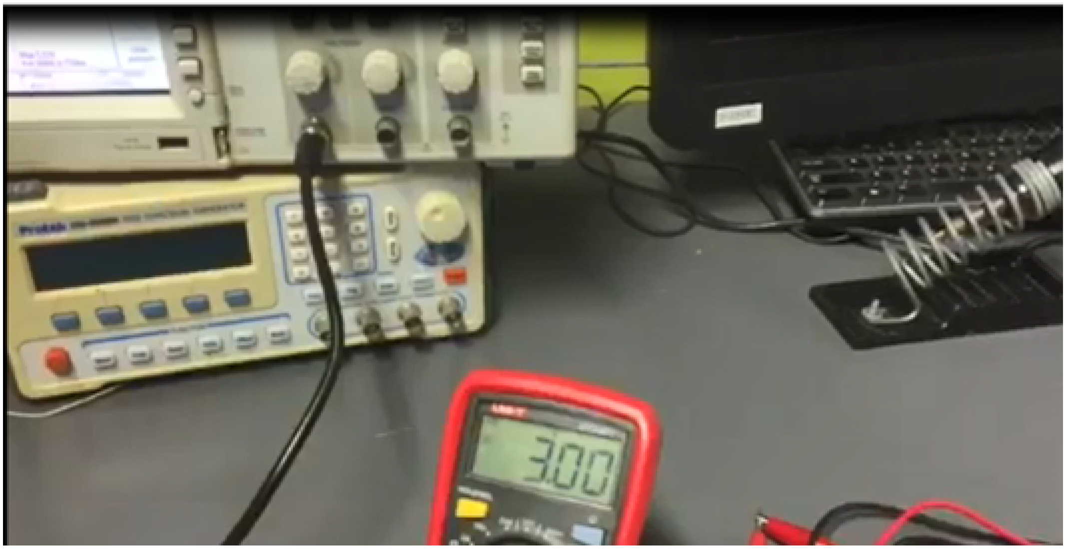


input of system

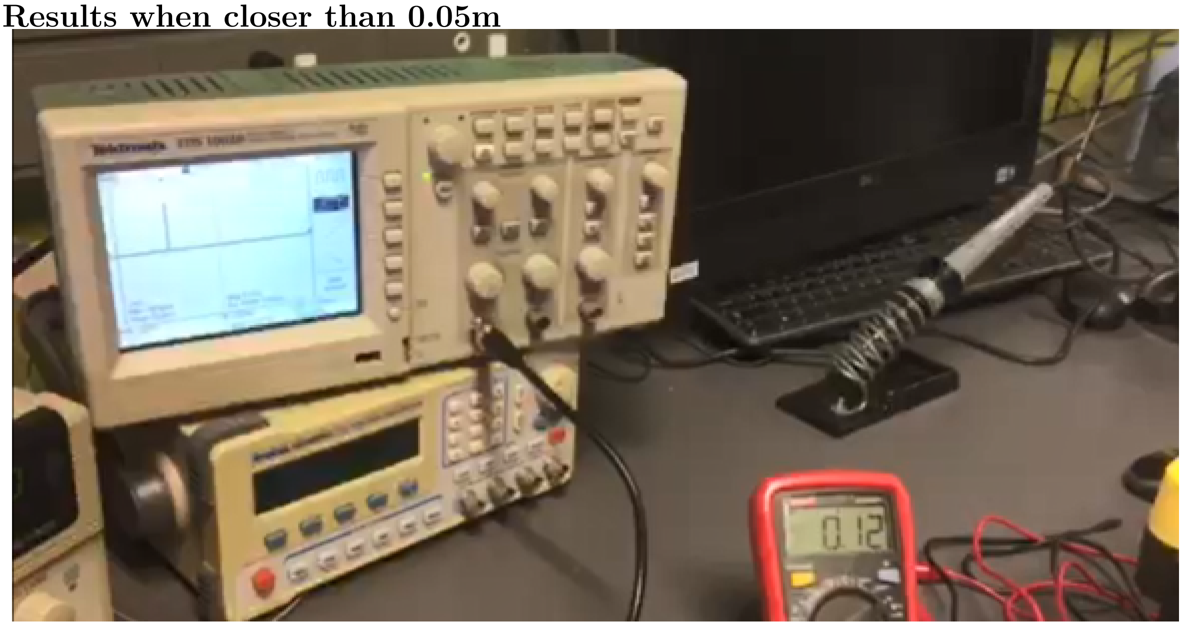


Results of practical circuit: Results when 1m away:



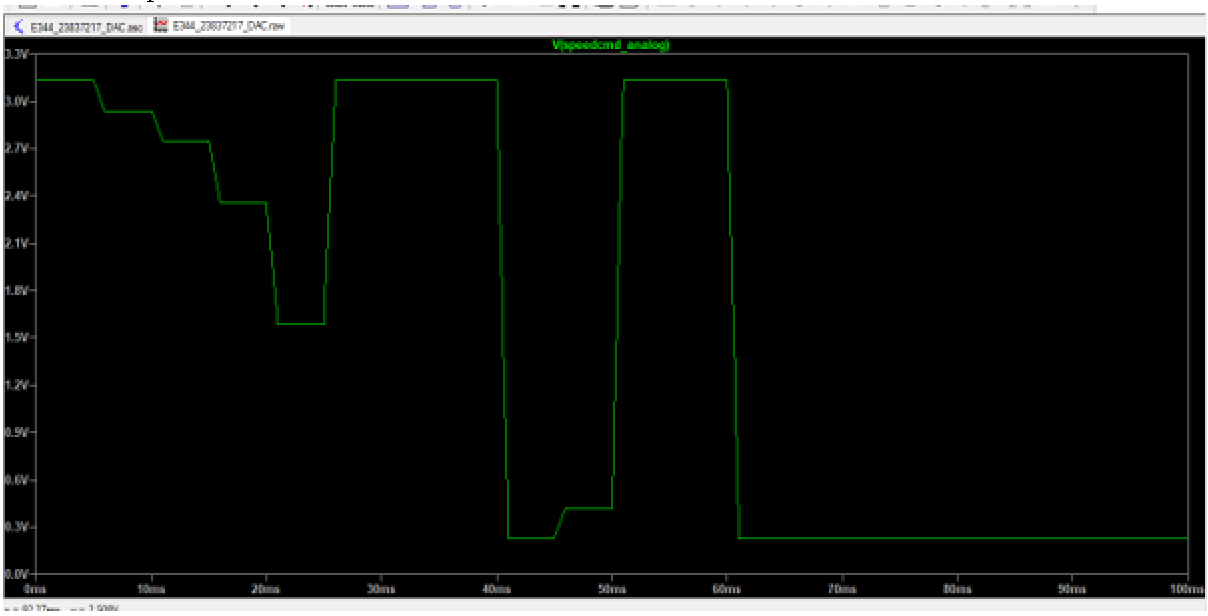


Results when closer than 0.05m

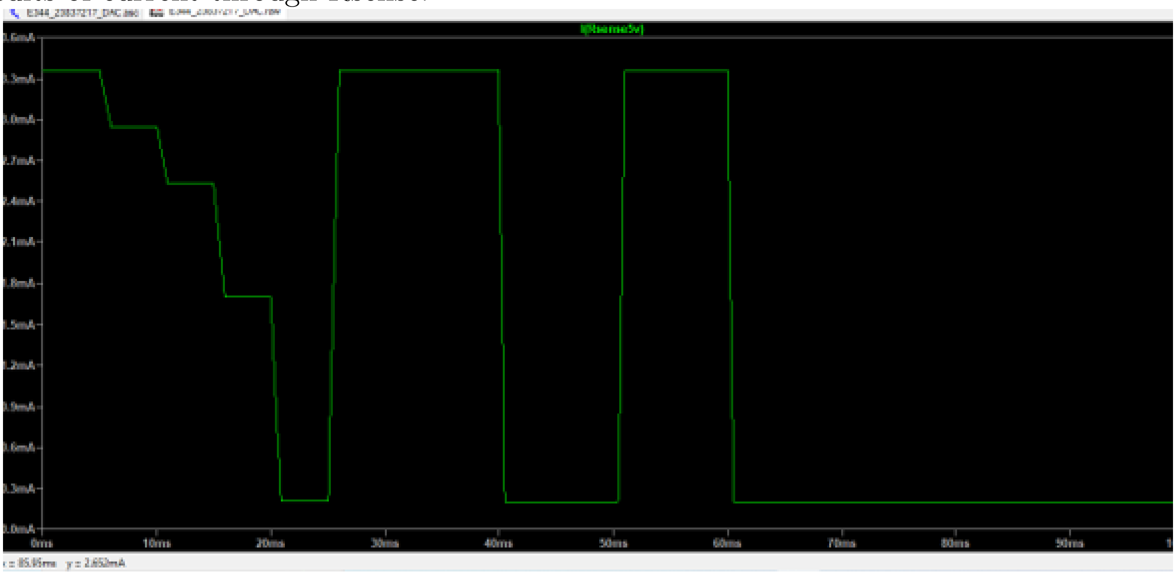


3.2. binary to analogue design

Results of Lt spice:



Results of current through Rsense:



Measurement for 0000:

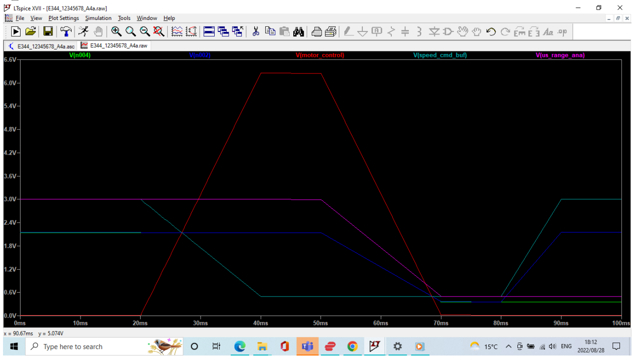
measurement for 0001:

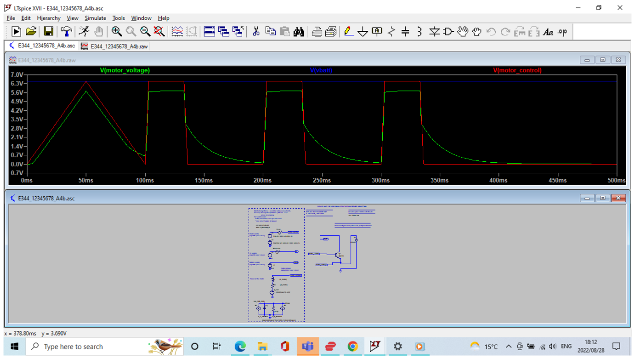
measurement for 1110:

measurement for 1111: 

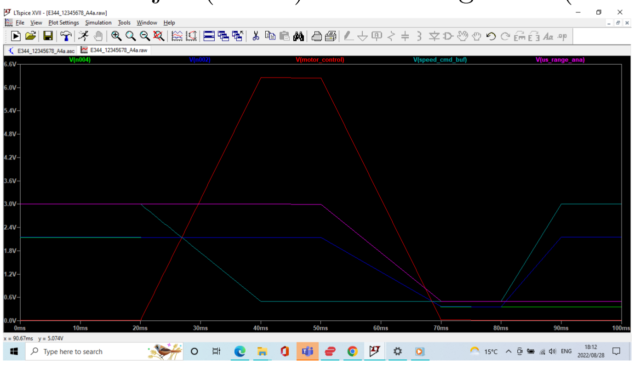
3.3. Motor design

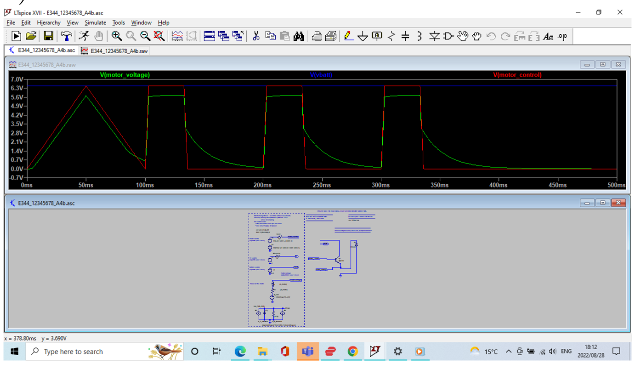
Lt spice:



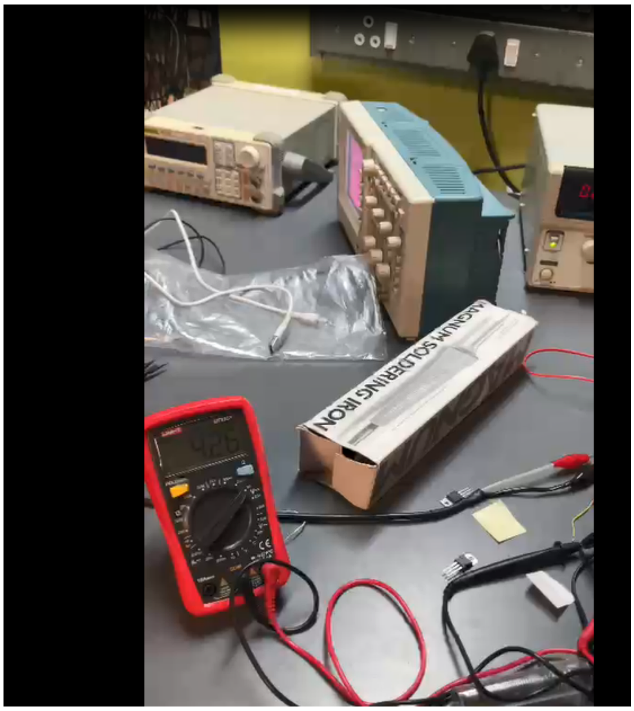


1000 no object(3.37V) and coming closer(2.47V):



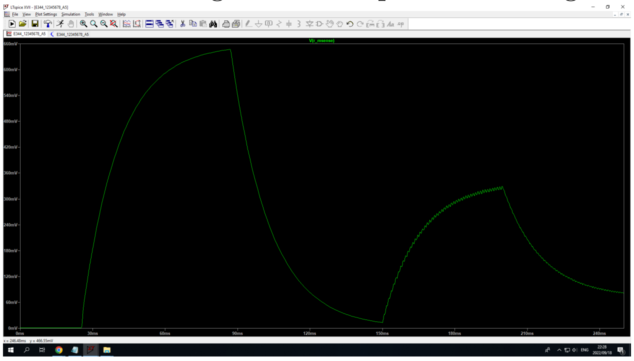


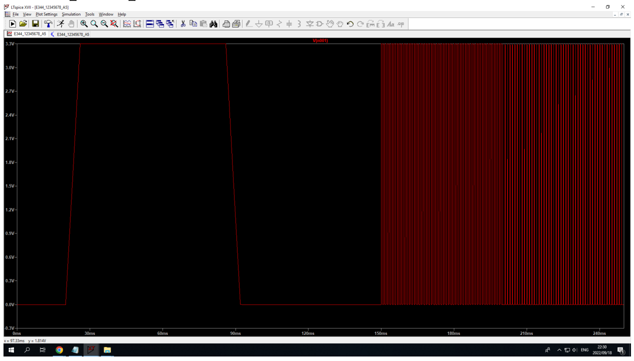
1100 near(2.47) and far away(4.26):



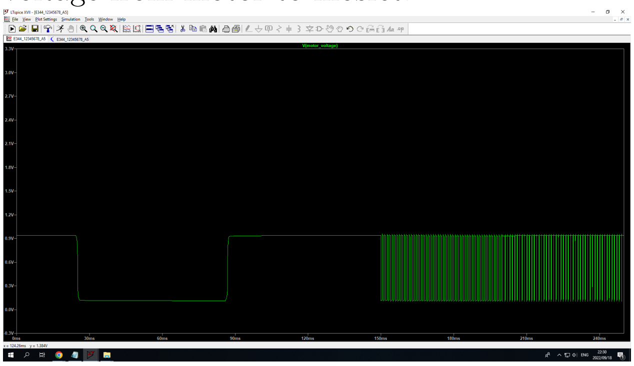
3.4. left side wheel control

The current sensing circuit output and voltage from esp32 pin:



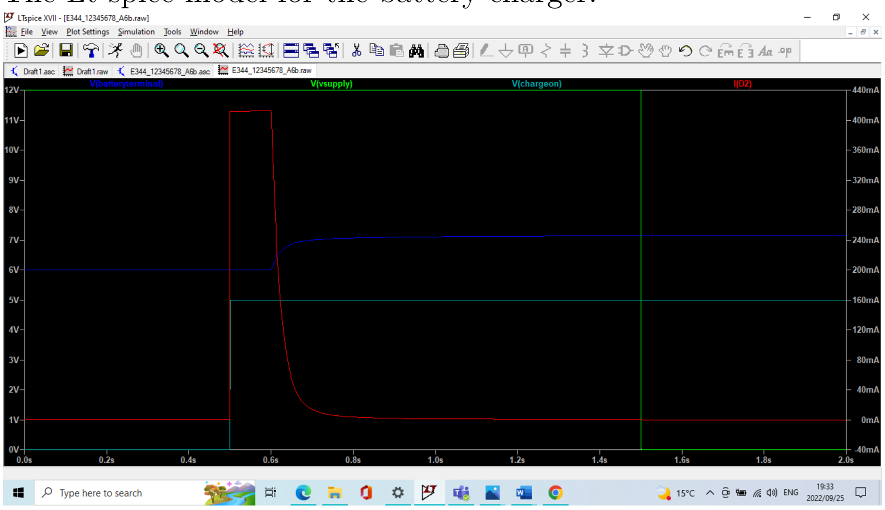


voltage from motor to mosfet:

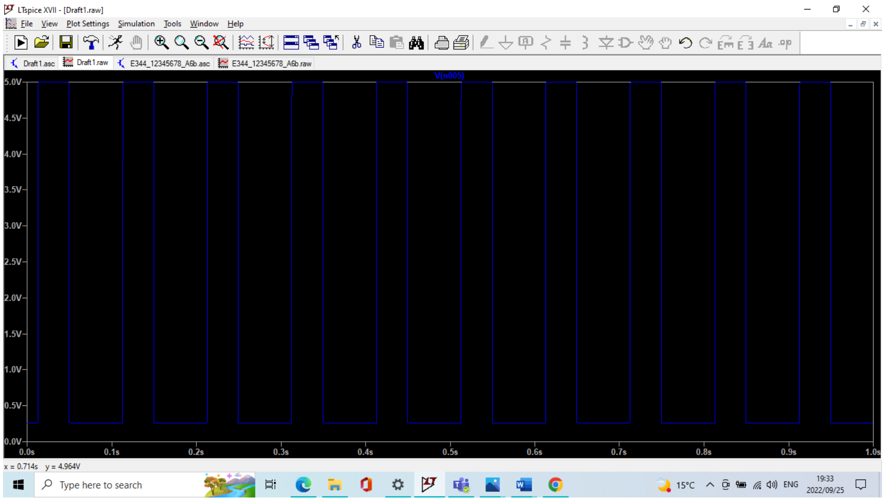


3.5. Charger design

The Lt spice model for the battery charger:

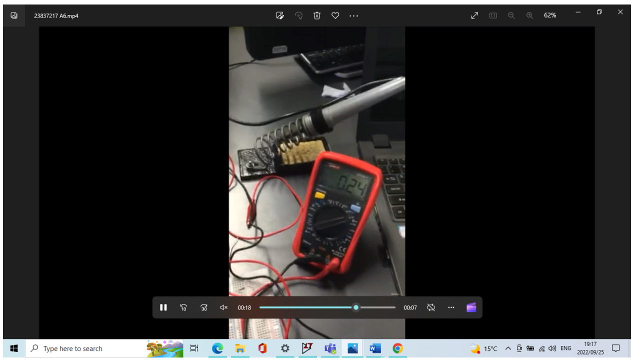


Lt spice model for the schmitt trigger circuit:



Battery charger over 50 ohm and 1k ohm:

Schmitt trigger at 5.9V and at 6.2V:



Schmitt trigger circuit:

Batter charger circuit:

3.6. Bluetooth measurement

The results of the current at the current sensor and the distance measured between an object and the car was sampled through code.Commands was also sent to the car to do certain function.The results of these measurements and commands are as follow:
Car at full speed:

LEFT WHEEL INSTRUCTION:	21
LEFT WHEEL CURRENT:	135.30mA
LEFT SENSOR RANGE:	1m
RIGHT WHEEL INSTRUCTION:	21
RIGHT WHEEL CURRENT:	145.65mA
RIGHT SENSOR RANGE:	1m
BATTERY VOLTAGE:	7.2V

Range measurements left and right :

LEFT WHEEL INSTRUCTION:	15
LEFT WHEEL CURRENT:	67.80mA
LEFT SENSOR RANGE:	0.68m
RIGHT WHEEL INSTRUCTION:	15
RIGHT WHEEL CURRENT:	148.7mA
RIGHT SENSOR RANGE:	1m
BATTERY VOLTAGE:	7.2V

LEFT WHEEL INSTRUCTION:	15
LEFT WHEEL CURRENT:	166.80mA
LEFT SENSOR RANGE:	1m
RIGHT WHEEL INSTRUCTION:	15
RIGHT WHEEL CURRENT:	35.7mA
RIGHT SENSOR RANGE:	0.35m
BATTERY VOLTAGE:	7.2V

measurements when commands at hard left and hard right turn:

LEFT WHEEL INSTRUCTION:	19
LEFT WHEEL CURRENT:	3.30mA
LEFT SENSOR RANGE:	1m
RIGHT WHEEL INSTRUCTION:	19
RIGHT WHEEL CURRENT:	157.3mA
RIGHT SENSOR RANGE:	1m
BATTERY VOLTAGE:	7.2V

LEFT WHEEL INSTRUCTION:	17
LEFT WHEEL CURRENT:	135.30mA
LEFT SENSOR RANGE:	1m
RIGHT WHEEL INSTRUCTION:	17
RIGHT WHEEL CURRENT:	5.3mA
RIGHT SENSOR RANGE:	1m
BATTERY VOLTAGE:	7.2V

Measurements when left and right wheel stopped:

LEFT WHEEL INSTRUCTION:	15
LEFT WHEEL CURRENT:	362.80mA
LEFT SENSOR RANGE:	1m
RIGHT WHEEL INSTRUCTION:	15
RIGHT WHEEL CURRENT:	133.7mA
RIGHT SENSOR RANGE:	1m
BATTERY VOLTAGE:	7.2V

LEFT WHEEL INSTRUCTION:	15
LEFT WHEEL CURRENT:	145.80mA
LEFT SENSOR RANGE:	1m
RIGHT WHEEL INSTRUCTION:	15
RIGHT WHEEL CURRENT:	365.7mA
RIGHT SENSOR RANGE:	1m
BATTERY VOLTAGE:	7.2V

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Appendix A

Social contract

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E-design 344 Social Contract

2022

The purpose of this document is to establish commitment between the student and the organisers of E344. Beyond the commitment made here, it is not binding.

In the months preceeding the term, the lecturer (Thinus Booysen) and a few paid helpers (Rita van der Walt, Keegan Hull, and Michael Ritchie) spent countless hours to prepare for E344 to ensure that you get your money's worth, that you are enabled to learn from the module, and demonstrate and be assessed on your skills. We commit to prepare the assignments, to set the assessments fairly, to be reasonably available, and to provide feedback and support as best and fast we can. We will work hard to give you the best opportunity to learn from and pass analogue electronic design E344.

I, ...Henry Charles Louw...................... have registered for E344 of my own volition with the intention to learn of and be assessed on the principals of analogue electronic design. Despite the potential publication online of supplementary videos on specific topics, I acknowledge that I am expected to attend the scheduled lectures to make the most of these appointments and learning opportunities. Moreover, I realise I am expected to spend the additional requisite number of hours on E344 as specified in the yearbook.

I acknowledge that E344 is an important part of my journey to becoming a professional engineer, and that my conduct should be reflective thereof. This includes doing and submitting my own work, working hard, starting on time, and assimilating as much information as possible. It also includes showing respect towards the University's equipment, staff, and their time.

Prof. MJ (Thinus) Booysen   Student number: ....23837217....................

Signature: .... Signature: .... Date: ....

Date: ....22/07/24...........................

1

Appendix B

GitHub Activity Heatmap