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E344 Assignment 1

Henry Louw
23837217

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.

July 31, 2022

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forward together
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23837217 Studentenommer / *Student number*	 Handtekening / *Signature*
HC. Louw Voorletters en van / *Initials and surname*	July 31, 2022 Datum / *Date*

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Nomenclature

Variables and functions

Acronyms and abbreviations

Op amp	operational amplifier
A	ampere

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.

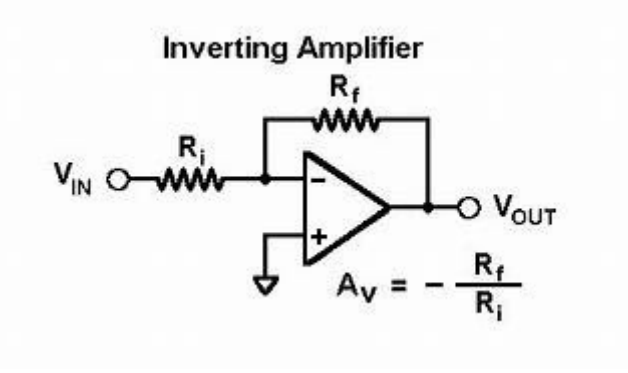
1.1. Operational amplifiers

Operational amplifiers: limitations and considerations

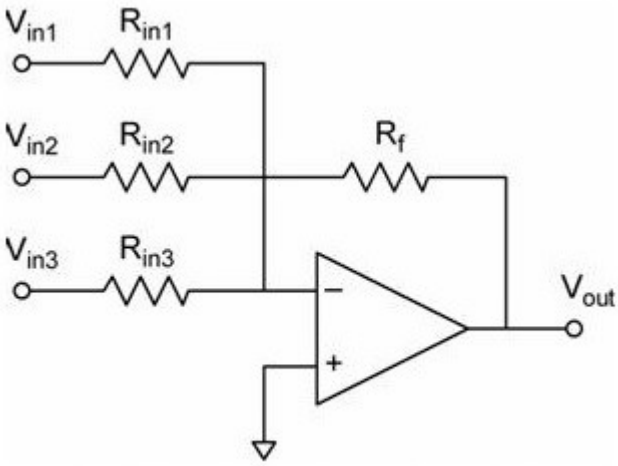
Operational amplifier configurations

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.

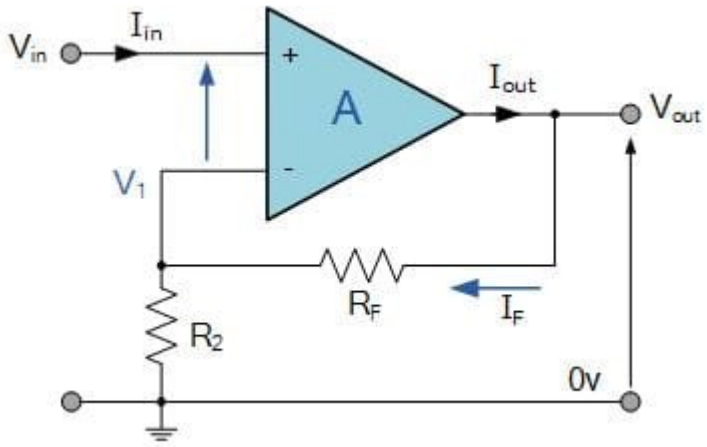


An inverting summing amplifier will be an amplifier that has two resistor that will be added parallel to one another.These two resistors will then be connected to the inverting pin.

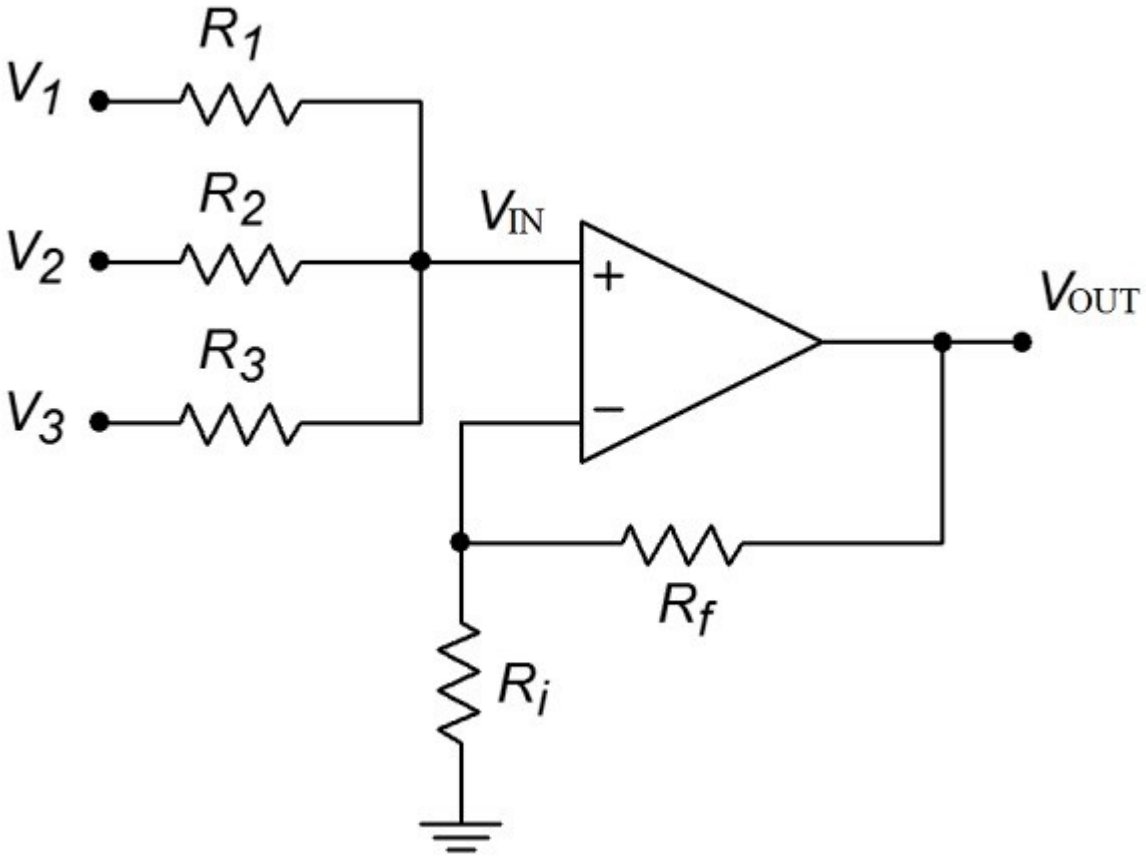


The Summing Amplifier Circuit Diagram

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.



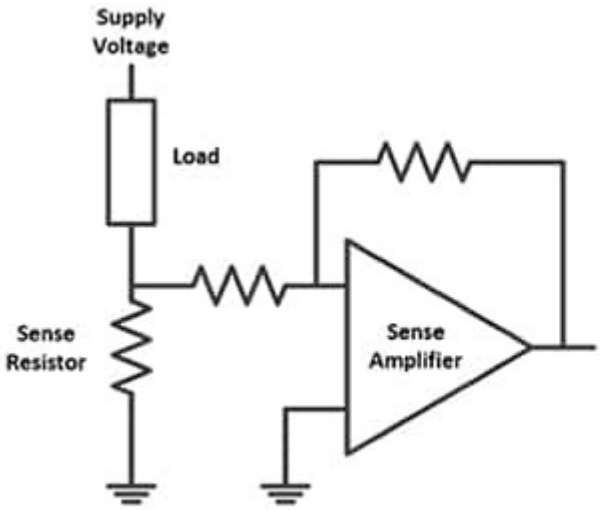
A non-inverting summing amplifier will be an amplifier that has two resistor that will be added parallel to one another.These two resistors will then be connected to the inverting pin.



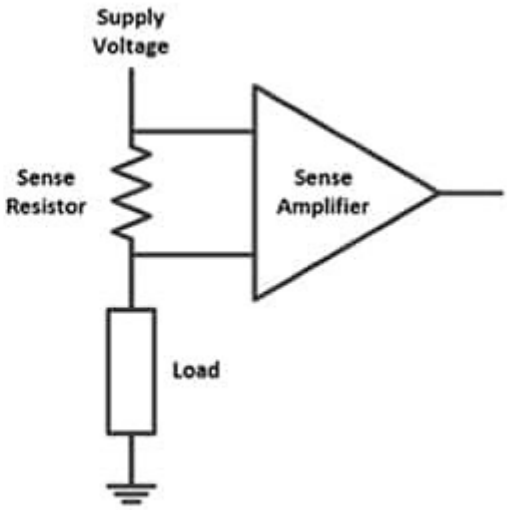
An amplifier consist of a inverting input(-) ,a non inverting input,a voltage supply(+) and a negative voltage supply and a output.These components are then used to amplify a signal. The amplifier we will be using is the non-inverting amplifier.We don't want the input signal and the output signal to 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.



Low Side Current Sensing



High Side Current Sensing

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.

Chapter 2

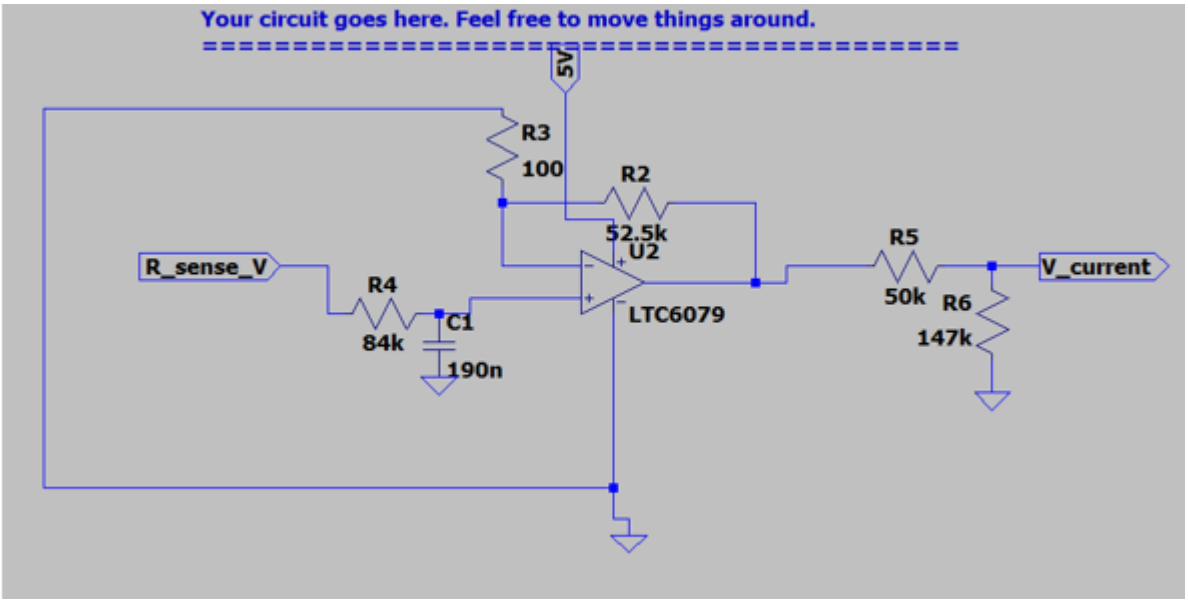
Detail design

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. 2.3.

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



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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:

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

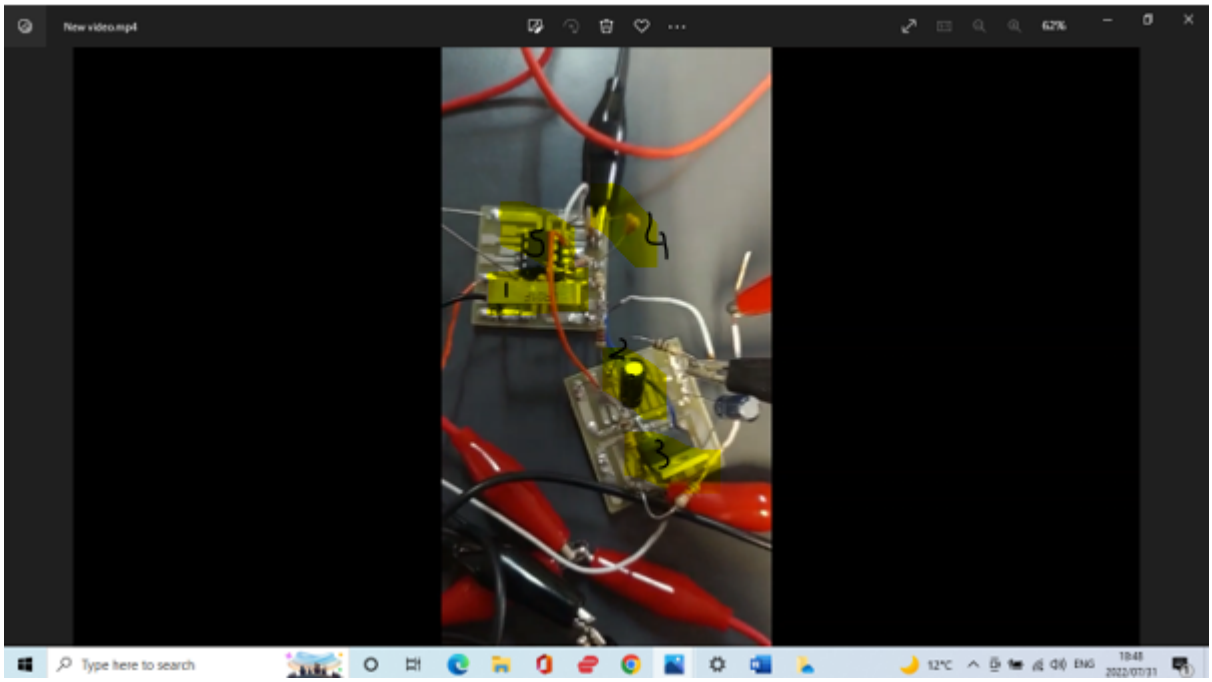
This table will show you the characteristics I needed to consider before designing the op amp

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

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:

$$3.3V = 5V(\frac{R6}{R5 + R6}). \tag{2.3}$$

. 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

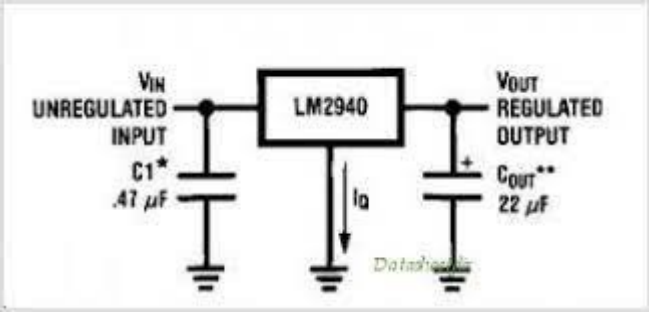
3-Voltage regulator(7.2V-5V)

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.



Chapter 3

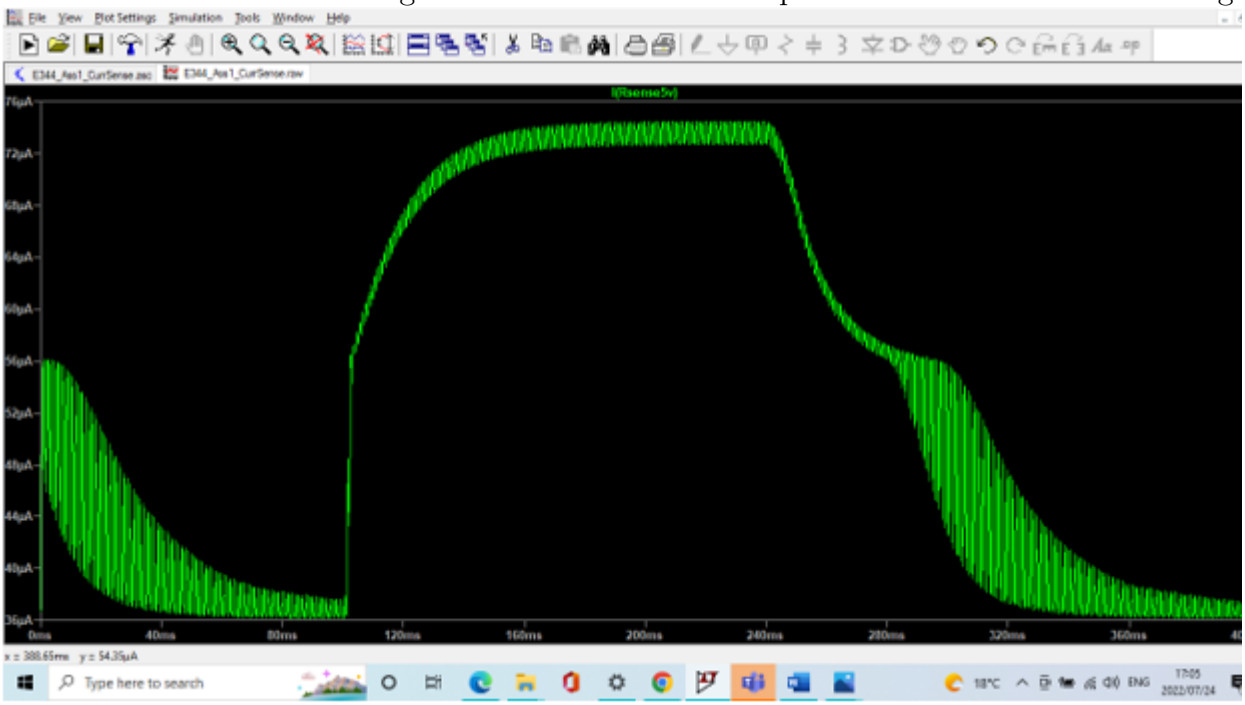
Results

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.

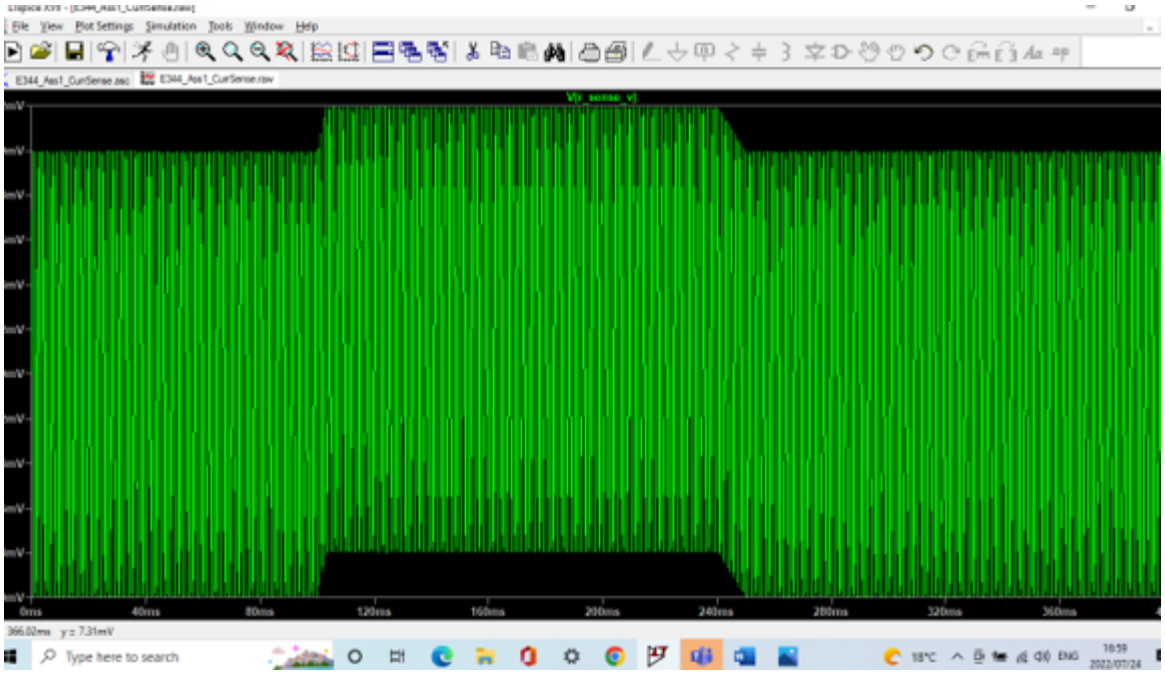
Table 3.1: voltage use of circuit when motor:.

stall	running	
3.2	0.45	V

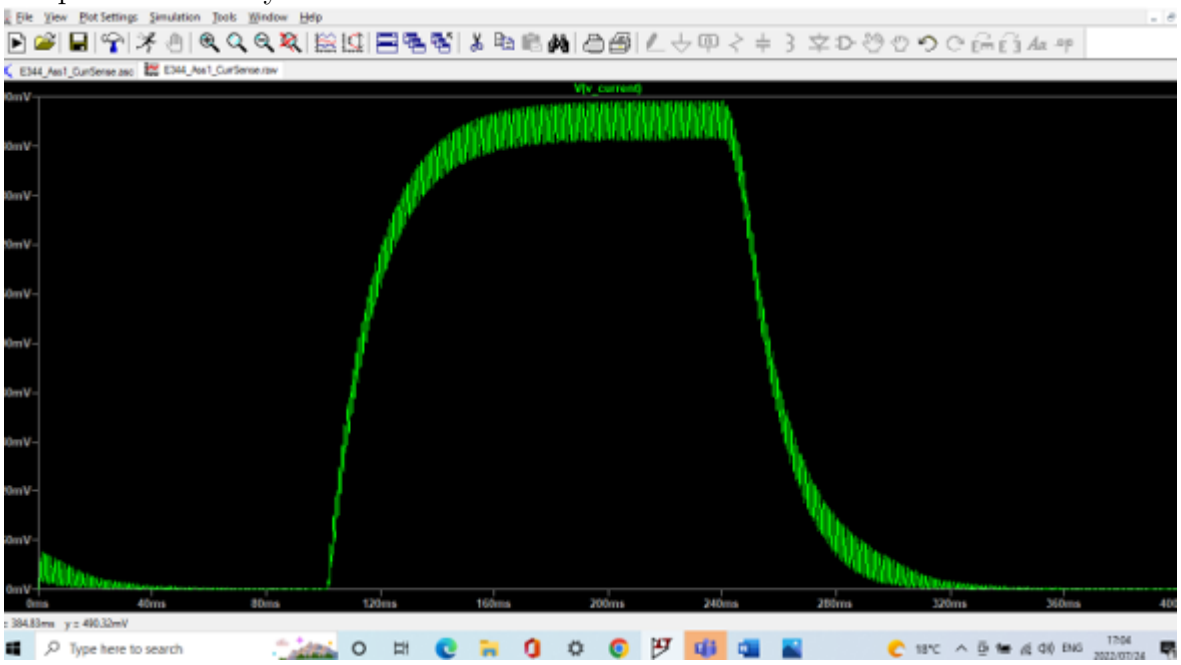
The current through Rsense is equal to the following:



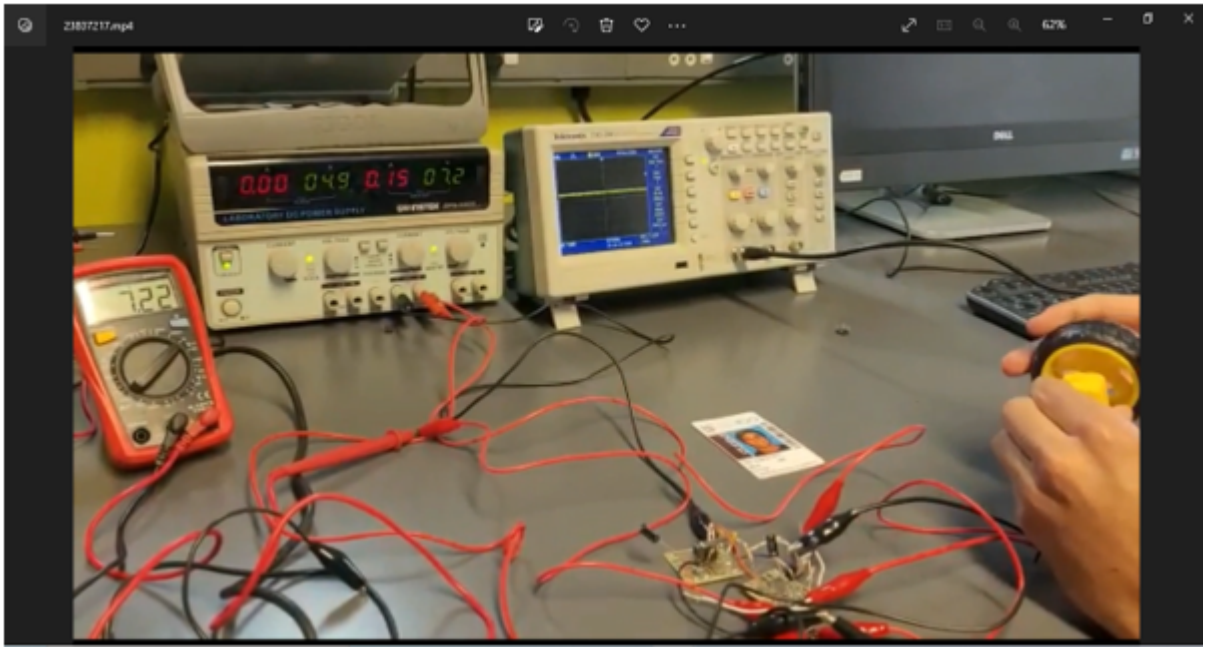
The input with the noise is :



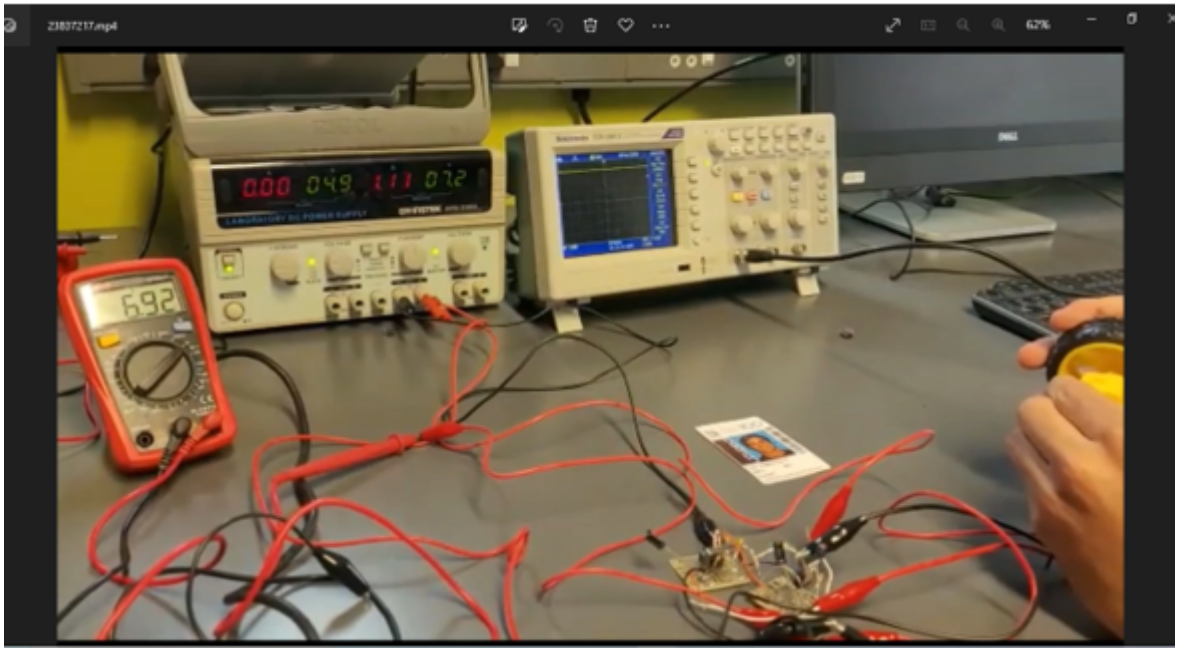
Output without any noise:



Results when 1.5A input and wheel is running:

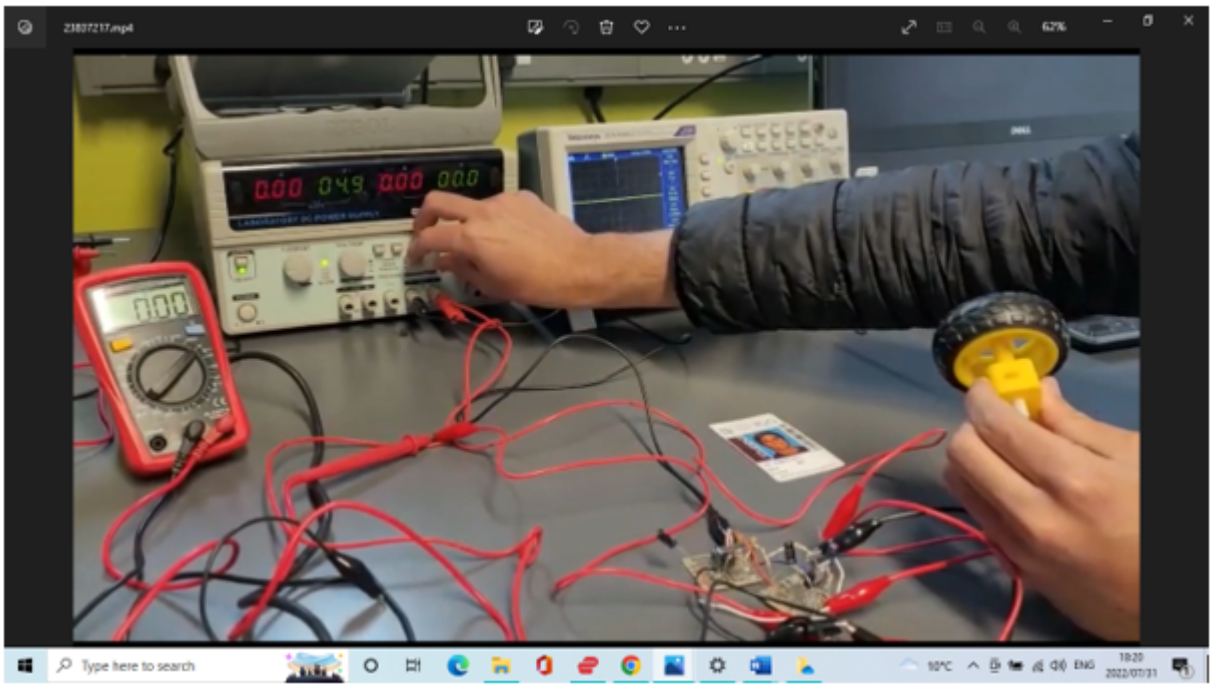


Results when 1.5A input and wheel is stalled:



When the input current is 1.5A the output voltgae 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. Current sensor

Bibliography

Appendix A

Social contract

Download copy from SUNLearn, sign and include here (replace this one).

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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.....

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Appendix B

GitHub Activity Heatmap