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.

July 24, 2022

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1. Plagiaat is die oorneem en gebruik van die idees, materiaal en ander intellektuele eiendom van ander persone asof dit jou eie werk is.
   Plagiarism is the use of ideas, material and other intellectual property of another's work and to present is as my own.

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   I agree that plagiarism is a punishable offence because it constitutes theft.

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5. Ek verklaar dat die werk in hierdie skryfstuk vervat, behalwe waar anders aangedui, my eie oorspronklike werk is en dat ek dit nie vantevore in die geheel of gedeeltelik ingehandig het vir bepunting in hierdie module/werkstuk of 'n ander module/werkstuk nie.
   I declare that the work contained in this assignment, except where otherwise stated, is my original work and that I have not previously (in its entirety or in part) submitted it for grading in this module/assignment or another module/assignment.

00024601 Studentenommer / *Student number*	 Handtekening / *Signature*
E. Stewdent Voorletters en van / *Initials and surname*	July 24, 2022 Datum / *Date*

Contents

List of Figures

List of Tables

Nomenclature

Update these lists to make it applicable to your project. It is in `/frontmatter/nomenclature.tex`

Variables and functions

Update this list to make it applicable to your project.

$p(x)$	Probability density function with respect to variable x.
$P(A)$	Probability of event A occurring.

Acronyms and abbreviations

Update this list to make it applicable to your project.

AE	Afrikaans English
AID	accent identification

Example chapter - remove

You can remove this chapter by deleteting the "\include{Chapter0}" line in the e344_A1_report.tex file.

The document you submit must not have ANY red text in - the text in red in this template is for information only. Introduce the reader to what you want to present in this chapter. Think carefully of what you want to convey. You want the reader (e.g. another student) to understand the main concepts – they need to understand enough to safely and efficiently **use** and **design for** a chassis car, but abstract enough to not get caught up in the minutiae of electrons. The person assessing your report will consider whether you have demonstrated that you were able to find, integrate (absorb), and effectively convey knowledge on this topic. So, write a short summary of information you gathered from literature (papers, web sites, datasheets). Include any references to literature you feel is needed. Be sure to cite all the references, which you can add in the References.bib file, using the \{cite} command.

Some examples of how to cite (all of these have been added in the References.bib file): It was stated by [1] that ... . Subsequently, he changed his mind and said in [2] that ... . While [3] claims it to be ... . Figure 1 shows a figure, which could paint a thousand words (if it does not, rather use words)! Table 1 could capture some of your datasheet and/or measured results.

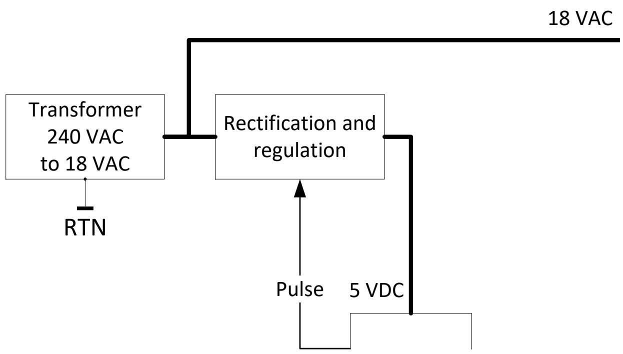


Figure 1: This is my caption, make me descriptive! And cite if you borrow figures [3].

Table 1: Example of a simple table.

	V_{OC} [V]	I_{CC} [A]	V_{pmax} [V]
Theroretical per cell	1.0	1.0	1.0
Datasheet per module	1.0	1.0	1.0
Measured dark 1.0	1.0	1.0	
Measured upside-down 1.0	1.0	1.0	
Measured oblique 1.0	1.0	1.0	
Measured facing 1.0	1.0	1.0	

Chapter 1

Literature survey

This chapter will cover a review on the different methods for current sensing and the limitations, considerations and configurations for operational amplifier design for current sensing.

1.1. Operational amplifiers

Operational amplifiers: limitations and considerations

Operational amplifier configurations

1.2. Current sensing

There are many different techniques to measure current. Both invasive and non invasive methods each with their own advantages and disadvantages that make them suitable for different situations. An invasive current sensor negatively affect the system and decreases performance whereas a non-invasive current sensor doesn't affect the operation of the system at a meaningful level.

Hall effect

The Hall effect current sensor is a non invasive method of current sensing that uses the magnetic field generated around a current carrying conductor [4]. This magnetic field creates a voltage across the material of the sensor. Hall effect sensors measure this voltage to determine the current flowing in a conductor [5]. There are many advantages to using a Hall effect sensor however, besides the amplifier circuit additional circuits are required and is more costly than other measurement methods [4].

Rogowski coil

The Rogowski coil is a non invasive current sensing method that uses a helical shaped coil that is wrapped around the conductor that you want to measure current in. The coil outputs a voltage depending on the rate of change of current through the conductor, this requires an integrator circuit to create an output voltage that is proportional to the current. The Rogowski coil is very useful for high frequency currents and does not require complex temperature compensation. However this method is only suitable for AC current [4].

Shunt Resistor

The shunt resistor is the most common current sensing technique and uses a resistor in series with the current to be measured. This is a invasive current measuring method. The shunt resistor produces a voltage drop proportional to the current, however the resistance and hence the voltage must be kept low in order to reduce the power consumption. This requires a high gain amplifier circuit to increase the small voltages to meaningful levels. The shunt resistor is a very cost effective solution that works on both AC and DC however it creates a decrease in system efficiency and can't handle high currents due to power dissipation across the resistor. Thermal drift also results in error [4].

High-side vs low-side current sensing is only applicable for invasive methods like the shunt resistor. Low-side has the advantages of being simple and low cost and low input common mode voltage however it can't detect high current due to a short [6]. High-side current sensing removes the ground disturbance and can detect accidental shorts however it has a higher complexity and cost because the gain circuit must be able to handle high common mode voltages [6].

Chapter 2

Detail design

In this section, you need to capture your design, which should include the following:

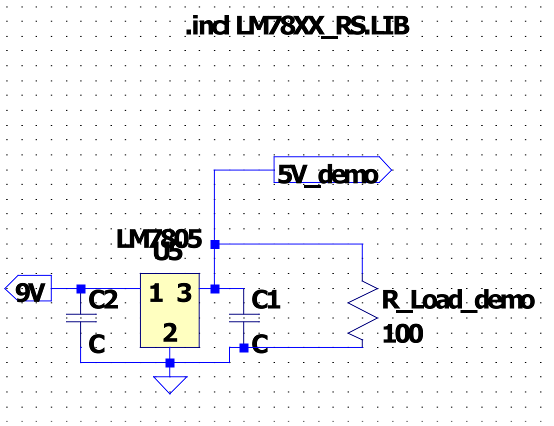
- Design rationale, i.e. what your thinking was behind the design.
- References to literature/sources as appropriate [3], but preferably in the intro above.
- You can assume the reader is in their third year of their E&E engineering degree, and that they will not need detailed explanations of trivial information (e.g. what a resistor is, or what Ohm's law is).
- Design calculations, for example to determine resistor values and capacitor values, or to check for allowed voltage and current ranges and levels. These calculations should also give expected outputs, which hopefully matches the simulated values.
- Analysis of given or expected input conditions.
- Expected values and ranges based on your design.
- Explain your choice of supply by referring to the advantages and disadvantages of each.
- Circuit diagram like the one in Figure 2.1. I used "print to PDF" from LTSpice, but feel free to use a cropped screengrab if you are PDF-challenged and do not have a PDF printer (there are some free PDF creators online). Also have a look at the demo video on SUNLearn.

For your benefit, here is how to write values with units: 150 mΩ or 199 myUnits, and this is how we write ranges: from 2 to 5 kV.

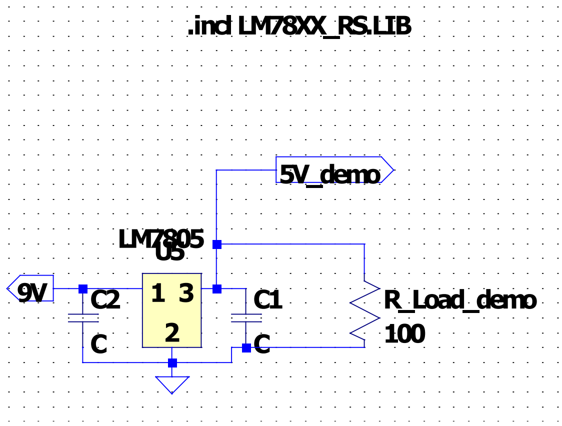
Here is an inline equation $\frac{55}{45+3}$.
Here is a numbered equation in Eq. 2.1.

$$a = \frac{55}{45+3}. \tag{2.1}$$

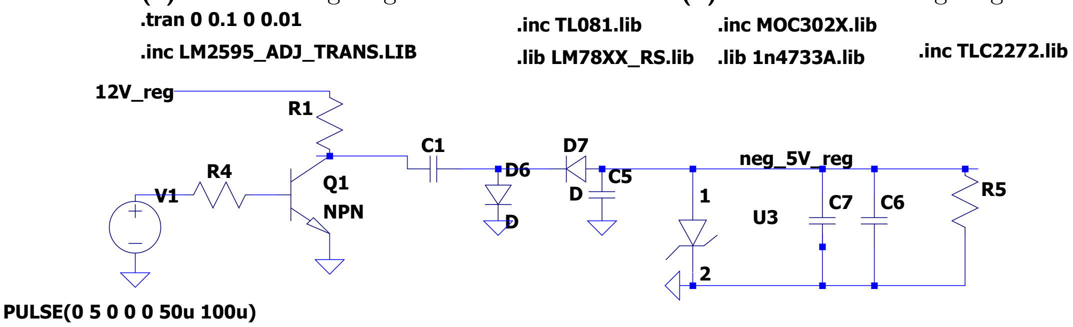
.



(a) Linear voltage regulator.



(b) Switchmode voltage regulator.



(c) Chargepump voltage regulator.

Figure 2.1: Circuit diagrams of the two voltage regulators, and another irrelevant one
.

2.1. Current sensor

Chapter 3

Results

In this section, you want to demonstrate, by means of referring to simulation results, using the designed circuit, how your circuit behaves as you designed it in Section 2.1. Present and report on your simulated results in Figure 3.1. Be absolutely sure that the text and information in your report are readable.

You can use screengrabs or photos of the oscilloscope, or download the CSVs and plot them as PDFs using Matlab, Excel or similar. You can also use tables, example of which are presented in Tables 3.1 and 3.2.

Table 3.1: Example of a simple table.

	2017	2018	Δ_{Abs}	Δ_{DiD}
A	9,868	10,399	+5	-11
B	10,191	10,590	+4	-12

Table 3.2: Example of another table.

Schools	Total energy used		Change	
	2017 [kWh]	2018 [kWh]	Δ_{Abs} [%]	Δ_{DiD} [%]
A	9,868	10,399	+5	-11
B	10,191	10,590	+4	-12

3.1. Current sensor

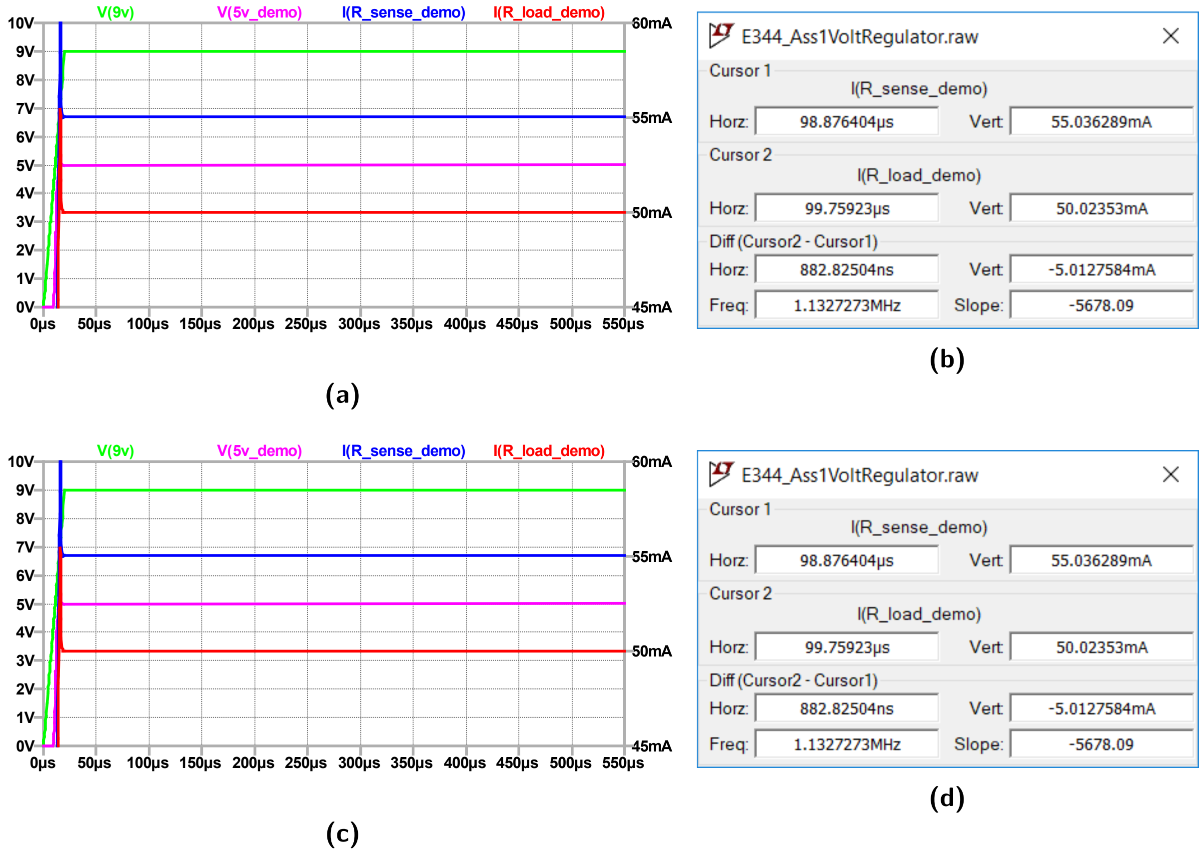


Figure 3.1: Voltage regulation, comparing the linear and switchmode regulators... (a) Blah blah. (b) Blah blah. (c) Blah blah. (d) Blah blah. As far as possible, please put input(s) and output(s) on the same plot rather than on separate plots. Based on the datasheet of XXXX in [3].

Bibliography

[1] M. J. Booysen, S. J. Andersen, and A. S. Zeeman, "Informal public transport in Sub-Saharan Africa as a vessel for novel Intelligent Transport Systems," in *16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013)*, Oct 2013, pp. 767–772.

[2] S. Gerber, A. J. Rix, and M. J. Booysen, "Combining grid-tied PV and intelligent water heater control to reduce the energy costs at schools in South Africa," *Energy for Sustainable Development*, vol. 50, pp. 117 – 125, 2019.

[3] BBC, "How to make opamps amp op," 2018. [Online]. Available: www.electronics-tutorials.ws

[4] Current Sensing Techniques using Different Current Sensors, "How to make opamps amp op," 2019. [Online]. Available: https://circuitdigest.com/article/how-to-measure-current-in-a-circuit-with-different-current-sensing-techniques

[5] RS Electronics, "The guide to hall effect sensors." [Online]. Available: https://za.rs-online.com/web/generalDisplay.html?id=ideas-and-advice/hall-effect-sensors-guide

[6] Preeti Jain, "Current sensors." [Online]. Available: https://www.engineersgarage.com/current-sensors/

Appendix A

Social contract

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

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E-design 344 Social Contract

2021

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 the Teaching Assistant (Kurt Coetzer) spent countless hours to prepare for E344 to ensure that you get your money's worth and 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 tests and 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, ... 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.

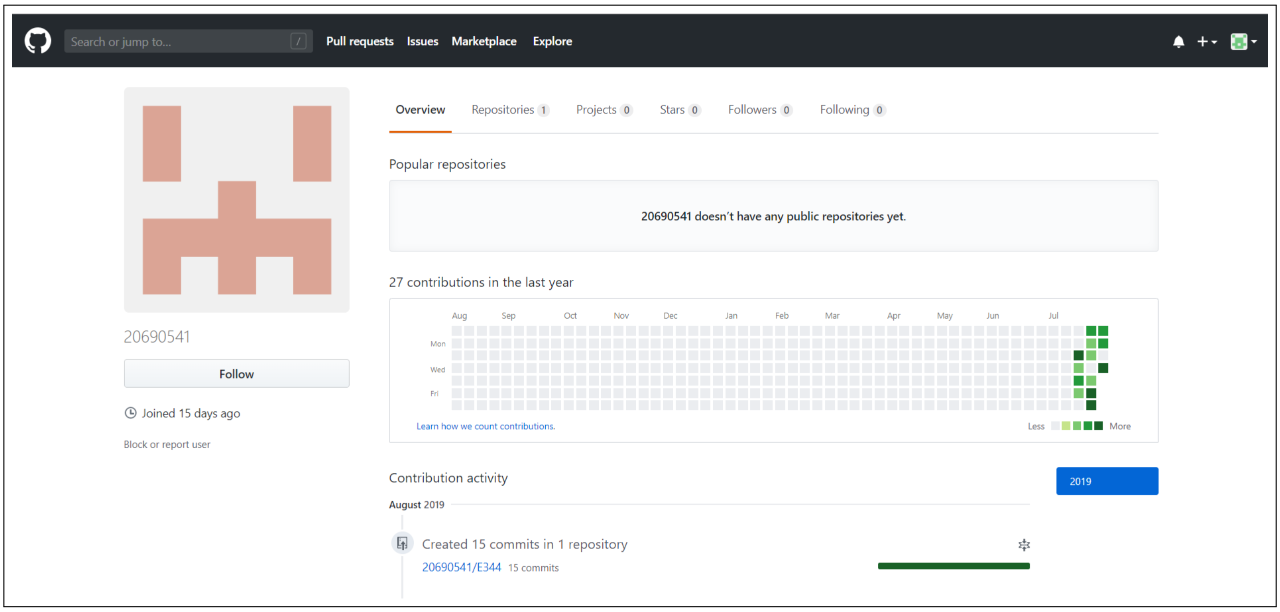
Prof. MJ Booysen	Student number: ....
Signature:	Signature: ....
Date: 29 July 2021	Date: ....

1

Appendix B

GitHub Activity Heatmap

Take a screenshot of your github version control activity heatmap and insert here.



Appendix C

Stuff you want to include

remove this if not needed!!

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