



UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

E344 Assignment 1

Abraham Albertus Cilliers
23252162

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.

August 10, 2021



UNIVERSITEIT • STELLENBOSCH • UNIVERSITY
jou kennisvennoot • your knowledge partner

Plagiaatverklaring / *Plagiarism Declaration*

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 it as my own.

2. Ek erken dat die pleeg van plagiaat 'n strafbare oortreding is aangesien dit 'n vorm van diefstal is.

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

3. Ek verstaan ook dat direkte vertalings plagiaat is.


I also understand that direct translations are plagiarism.

4. Dienooreenkomstig is alle aanhalings en bydraes vanuit enige bron (ingesluit die internet) volledig verwys (erken). Ek erken dat die woordelike aanhaal van teks sonder aanhalingstekens (selfs al word die bron volledig erken) plagiaat is.

Accordingly all quotations and contributions from any source whatsoever (including the internet) have been cited fully. I understand that the reproduction of text without quotation marks (even when the source is cited) is plagiarism

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.

23252162	
Studentenommer / <i>Student number</i>	Handtekening / <i>Signature</i>
AA. Cilliers	August 10, 2021
Voorletters en van / <i>Initials and surname</i>	Datum / <i>Date</i>

Contents

Declaration	i
List of Figures	iii
List of Tables	iv
Nomenclature	v
1. Solar photovoltaic cells and solar modules	1
2. Lead acid batteries	4
3. High-side switching circuit	5
3.1. Intro	5
3.2. Design	5
3.3. Results	6
3.4. Summary	8
Bibliography	9
A. Social contract	10
B. GitHub Activity Heatmap	11
C. Stuff you want to include	12

List of Figures

1.1. OC Voltage of Solar Cell [1]	2
1.2. SC Current of Solar Cell [2]	2
1.3. Relationship between Current and Voltage Characteristics [3]	2
1.4. This is my caption, make me descriptive! And cite if you borrow figures [4]. . .	3
3.1. Circuit diagrams of the two voltage regulators, and another irrelevant one . . .	6
3.2. I am the short caption that appears in the List of Figures list	7

List of Tables

1.1. Example of a simple table.	3
3.1. Example of a simple table.	8
3.2. Example of another table.	8

Nomenclature

Update this list to make it applicable to your project.

Variables and functions

$p(x)$	Probability density function with respect to variable x .
$P(A)$	Probability of event A occurring.
ε	The Bayes error.
ε_u	The Bhattacharyya bound.
B	The Bhattacharyya distance.
s	An HMM state. A subscript is used to refer to a particular state, e.g. s_i refers to the i^{th} state of an HMM.
\mathbf{S}	A set of HMM states.
\mathbf{F}	A set of frames.
\mathbf{o}_f	Observation (feature) vector associated with frame f .
$\gamma_s(\mathbf{o}_f)$	A posteriori probability of the observation vector \mathbf{o}_f being generated by HMM state s .
μ	Statistical mean vector.
Σ	Statistical covariance matrix.
$L(\mathbf{S})$	Log likelihood of the set of HMM states \mathbf{S} generating the training set observation vectors assigned to the states in that set.
$\mathcal{N}(\mathbf{x} \mu, \Sigma)$	Multivariate Gaussian PDF with mean μ and covariance matrix Σ .
a_{ij}	The probability of a transition from HMM state s_i to state s_j .
N	Total number of frames or number of tokens, depending on the context.
D	Number of deletion errors.
I	Number of insertion errors.
S	Number of substitution errors.

Acronyms and abbreviations

Update this list to make it applicable to your project.

PV	Photovoltaic
OC	Open Circuit
NEC	National Electrical Code

Chapter 1

Solar photovoltaic cells and solar modules

Photovoltaic (PV) technology uses a natural source of energy in the form of sunlight and converts the sunlight into electrical energy. One PV device is called a cell, and are made from semiconductor materials such as silicon. These cells are quite small and only produce around 1-2 watts. In order to increase the power output several cells are connected together to form a module. **more detail?** <https://www.energy.gov/eere/solar/solar-photovoltaic-technology-basics> <https://www.energy.gov/eere/solar/solar-photovoltaic-cell-basics>

10.8% https://www.bio-conferences.org/articles/bioconf/fullhtml/2018/01/bioconf_wipie2018020
13-16% range

A PV module's performance is judged by its current-voltage (I-V) characteristic curve. As seen in figure 1.1 and figure 1.2 a few interesting points can be seen on the figures, namely the Open Circuit (OC) voltage and the Short Circuit (SC) Current (**insert fig here + reference**). The open circuit voltage can be defined as the maximum available voltage from one solar cell when no load is connected (this occurs at 0 current). The OC voltage is useful when you want to calculate how many solar modules(panels) you can connect in series which will connect to your inverter or charge controller. SC Current is how much current the solar cell is pulling when the voltage across the cell is 0, this can be measured when the positive and negative terminals are connected directly to each other. This SC current will be the maximum amount of amps that the solar cell will produce and can be used to determine how many amps connected devices can handle by multiplying with a 1.25 times scaling factor according to National Electrical Code (NEC) 80% requirements [5]. Typically a single PV cell has an OC voltage of around 0.5V to 0.6V at room temperature (25°C). <https://www.alternative-energy-tutorials.com/photovoltaics/photovoltaic-panel.html>

6. <https://www.victronenergy.com/blog/2020/02/20/pv-panel-output-voltage-shadow-effect/> <https://www.alternative-energy-tutorials.com/photovoltaics/solar-cell-i-v-characteristic.html> As voltage increases current stays the same until a certain point.

7. The maximum power point is where the product of volts x amps gives the highest wattage possible. $P_{mpp} = V_{mpp}I_{mpp}$

"The point on a power (I-V) curve that has the highest value of the product of its corresponding voltage and current, or the highest power output"re phrase

citing fine as is or must say fig obtained from...?

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

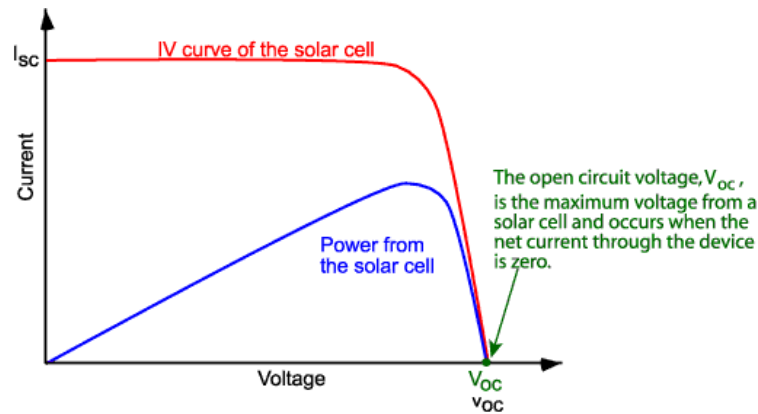


Figure 1.1: OC Voltage of Solar Cell [1]

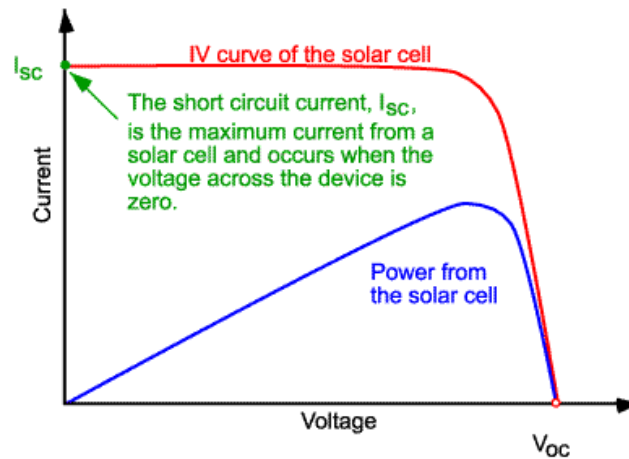


Figure 1.2: SC Current of Solar Cell [2]

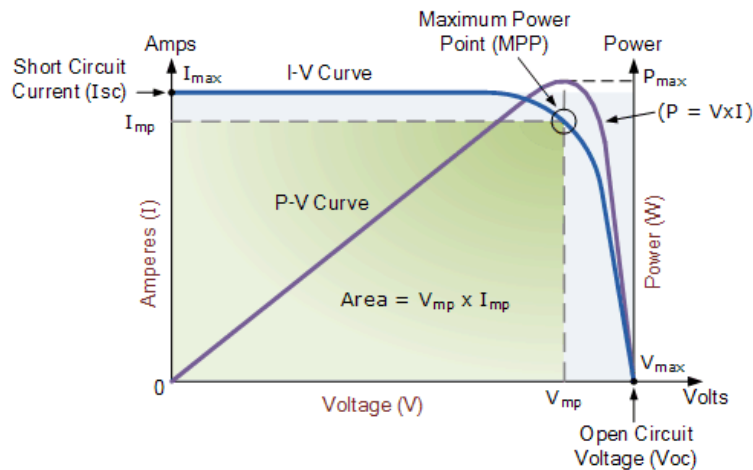


Figure 1.3: Relationship between Current and Voltage Characteristics [3]

student) to understand the main concepts – they need to understand enough to safely and efficiently **use** and **design for** a solar module, 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 [6] that Subsequently, he changed his mind and said in [7] that While [4] claims it to be Figure 1.4 shows a figure, which could paint a thousand words (if it does not, rather use words)! Table 1.1 could capture some of your datasheet and/or measured results.

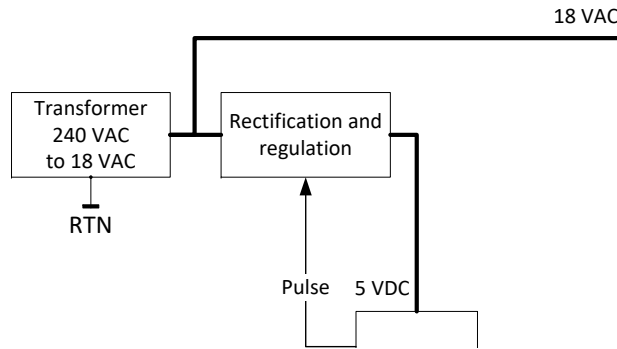


Figure 1.4: This is my caption, make me descriptive! And cite if you borrow figures [4].

Table 1.1: 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 2

Lead acid batteries

Chapter 3

High-side switching circuit

3.1. Intro

Introduce the reader to **what you want to present** in this chapter (i.e. what are you trying to achieve by initiating this communication?). Try to put yourself in the readers' shoes - what would you like need to see to be convinced that the author (1) knew what they were doing and understood what they had to do (2) properly designed for the requirements, (3) simulation-tested their design, and (4) correctly and critically assessed the outcome.

Include any references to literature you feel is needed. In this section, you put a very short summary of information you gathered from literature (papers, web sites, datasheets) that you used to do the design. Be sure to cite the references, which you can add in the `References.bib` file.

3.2. 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 [4], 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 3.1. 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 m Ω or 199mUnits, and this is how we write ranges: 2 to 5 kV.

Here is an inline equation $\frac{55}{45+3}$. Here is a numbered equation in Eq. 3.1.

$$a = \frac{55}{45 + 3}. \quad (3.1)$$

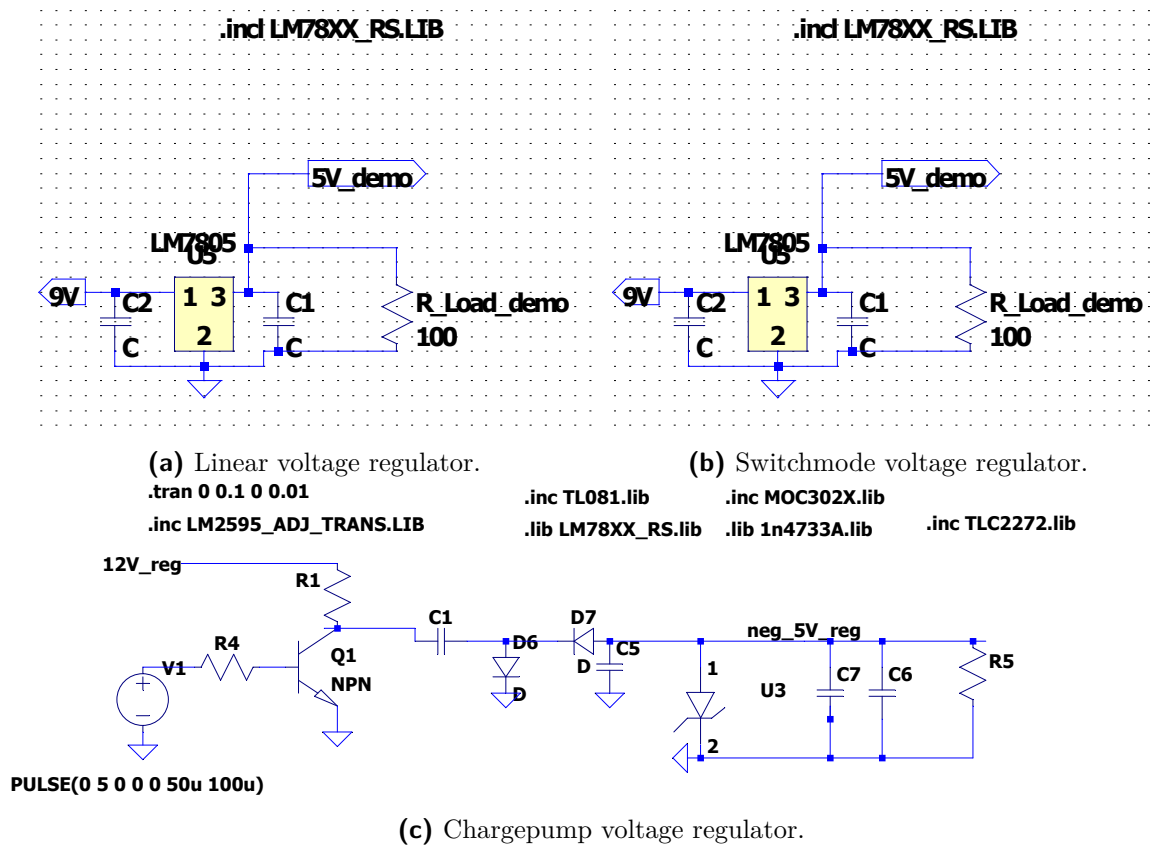
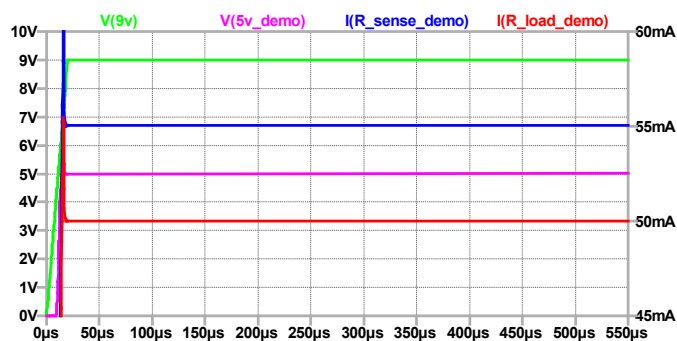


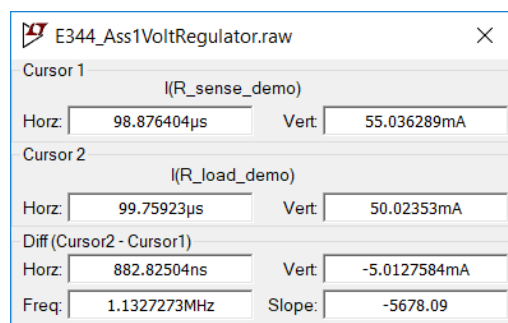
Figure 3.1: Circuit diagrams of the two voltage regulators, and another irrelevant one

3.3. Results

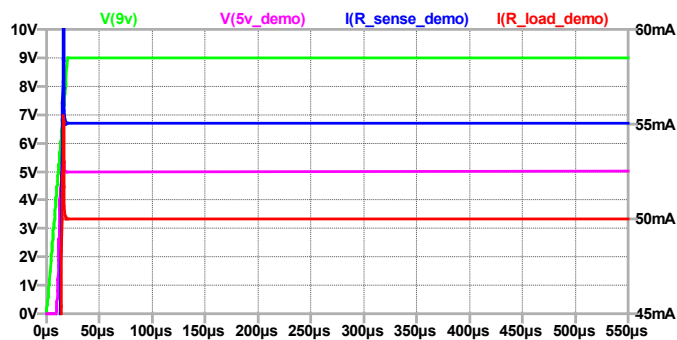
In this section, you want to demonstrate, by means of referring to simulation results, using the designed circuit, how your circuit behaves as you designed it in Section 3.2. Present and report on your simulated results in Figure 3.2. Be absolutely sure that the text and information in your report are readable.



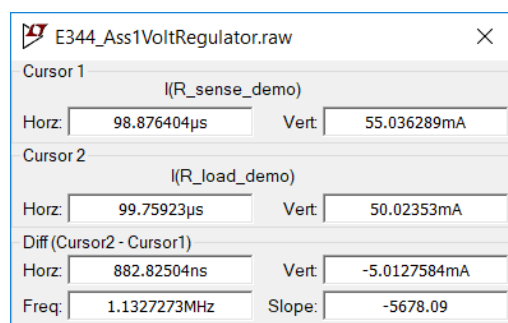
(a)



(b)



(c)



(d)

Figure 3.2: 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 [4].

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

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.

3.4. Summary

State whether your design performs as expected and what the limitations or things to keep in mind are.

Bibliography

- [1] C. Honsberg and S. Bowden, “Open-circuit voltage,” pveducation.org/pvcdrom/solar-cell-operation/open-circuit-voltage, 2020.
- [2] —, “Short-circuit current,” <https://www.pveducation.org/pvcdrom/solar-cell-operation/short-circuit-current>, 2020.
- [3] A. E. Tutorials, “Solar cell i-v characteristic,” <https://www.alternative-energy-tutorials.com/photovoltaics/solar-cell-i-v-characteristic.html>, 2016.
- [4] BBC, “How to make opamps amp op,” 2018. [Online]. Available: www.electronics-tutorials.ws
- [5] A. Beaudet, “How do i read the solar panel specifications?” <https://www.altestore.com/blog/2016/04/how-do-i-read-specifications-of-my-solar-panel/>, Apr. 2016.
- [6] 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.
- [7] 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.

Appendix A

Social contract



UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvenoot • your knowledge partner

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.

Abraham Albertus Cilliers

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.

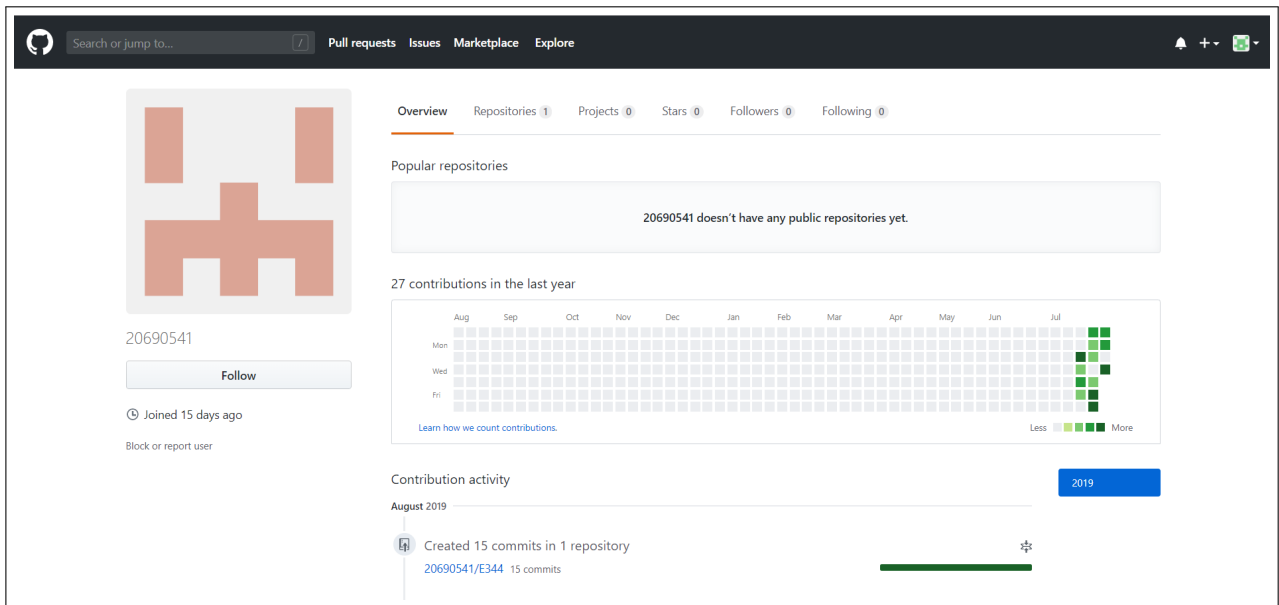
I acknowledge that E344 is an important part of my journey to becoming a professional engineer, and that my conduct should be reflective thereof. This includes doing and submitting my own work, working hard, starting on time, and assimilating as much information as possible. It also includes showing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

Prof. MJ Booysen	Student number: 23252162
Signature: 	Signature: 
Date: 4 Aug 2021	Date: 10 Aug 2021

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!!

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetur adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque,

augue quis sagittis posuere, turpis lacus congrue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilis. Sed a turpis eu lacus commodo facilis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetur.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congrue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.