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E344 Assignment 2

Daniel von Eschwege
21785155

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.

September 21, 2020

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3. Ek verstaan ook dat direkte vertalings plagiaat is.
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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.

21785155 Studentenommer / *Student number*	DHEschwege Handtekening / *Signature*
D.H. von Eschwege Voorletters en van / *Initials and surname*	September 21, 2020 Datum / *Date*

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Nomenclature

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

AE	Afrikaans English
AID	accent identification
ASR	automatic speech recognition
AST	African Speech Technology
CE	Cape Flats English
DCD	dialect-context-dependent
DNN	deep neural network
G2P	grapheme-to-phoneme
GMM	Gaussian mixture model
HMM	hidden Markov model
HTK	Hidden Markov Model Toolkit
IE	Indian South African English
IPA	International Phonetic Alphabet
LM	language model
LMS	language model scaling factor
MFCC	Mel-frequency cepstral coefficient
MLLR	maximum likelihood linear regression
OOV	out-of-vocabulary
PD	pronunciation dictionary
PDF	probability density function
SAE	South African English
SAMPA	Speech Assessment Methods Phonetic Alphabet

Chapter 1

System design

1.1. System overview

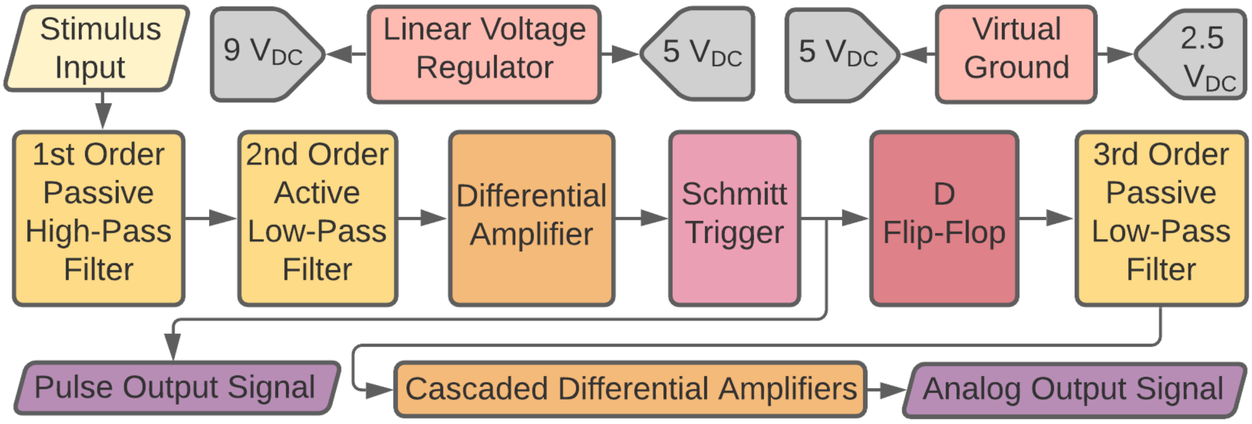


Figure 1.1: System Diagram

Creating a health monitoring system requires the design and implementation of a heart-rate sensor. This sensor obtains an input signal, from which pulses, corresponding to heart-beats are generated, as well as analogue values which represent the heart-rate. The aforementioned is achieved by means of various subcircuits, respectively responsible for voltage regulation, signal conditioning, pulse generation and conversion to analogue, which proceeds as can be seen in figure 1.1 - explanation follows hereafter. A voltage regulator generates 5 V which powers the circuit. See **??** old report for the design. The stimulus input signal, obtained from the heart-rate sensor, is to be converted to a pulse output signal, but has an amplitude of insufficient magnitude, and is subject to high levels of noise. This necessitates signal conditioning: the input signal is fed into a first order passive high-pass filter and a second-order active low-pass filter consecutively, thereby attenuating both high- and low-frequency noise. The filters were chosen with maximal simplicity in mind, as to reduce cost and complexity, while still performing adequately. After filtering, the signal is amplified by means of a differential amplifier, resulting in a signal with a large amplitude and little noise. This allows for pulse generation by means of a Schmitt Trigger comparator, which produces an output pulse signal, where the frequency corresponds to the heart-rate. The Schmitt Trigger was preferred above alternatives as it provides a a noise margin by means of hysteresis, thereby eliminating heart-beat misdetections that otherwise arise. Further, an analogue voltage is required, where the voltage level represents the heart-rate. Filtering and peak detection using diodes was considered, but ultimately discarded, as diodes are non-linear, resulting in extremely slow simulation. Rather, the pulse output signal was converted to a pulse-width modulated signal, where the frequency of the former determined the duty cycle of the latter. This was done as PWM signals lend themselves to conversion-to-analogue by simple filtering. The PWM signal was obtained by using a D Flip-Flop in conjunction with a RC-circuit (see section **??** for more detail), and was then filtered by a fourth-order passive RC filter. Passive components were selected as to reduce current usage and simulation time. The filter is of high order as to greatly minimize noise, as the settling time requirement for the analog signal was easily met.

Also point the reader to your first report for more information on the temperature sensing and voltage regulation, and use a citation to it (add it to your `References.bib` file and cite it here). Remember to state what your remaining power budget is, based on Assignment 1's results.

Chapter 2

Heart rate sensor

2.1. Introduction

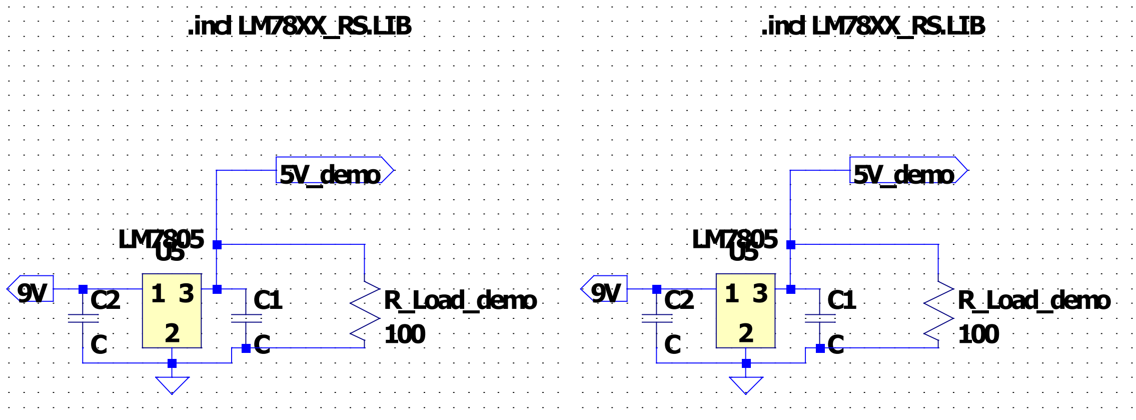
Introduce the reader to what you want to present in this chapter. Include any references to literature you feel is needed. In this section, you put a very short summary of infrormation you gatherered from literature (papers, web sites, datasheets) that you used to do the design. Be sure to include the references, which you can add in the `References.bib` file. Rather than just copy&pasting [1] from the datasheet, give your own circuit diagrams. Remember, it is important that someone who reads your report must be able to reproduce your results.
Some examples of how to cite (all in `References.bib`): It was stated by [?] that ... . Subsequently, he changed his mind and said in [?] that ... . While [?] claims it to be ... .

2.2. Design

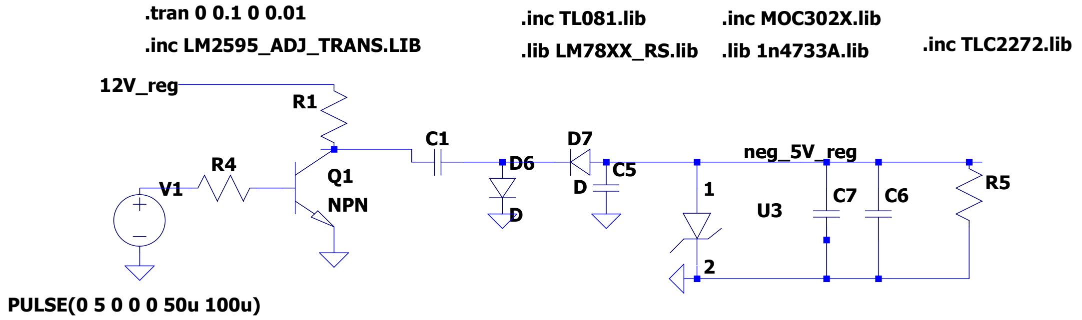
In this section, you need to capture your design, which should include the following:

- Design rationale, i.e. what your thinking was behind the design. For example, explain that you had to first analyse the heart beat signals before you could design the filtering.
- References to literature/sources as appropriate [?].
- You can assume the reader has an E&E degree, and will not need detail 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. Importantly, they are based on maths, and not on simulation - there is a difference.
- Analysis of given or expected input conditions.
- Expected values and ranges based on your design.
- Explain your choice of supply buy referring to the advantages and disadvantages of each.

[1] I have a little bee in my bonnet about people who say "cut&paste" - if it were cut, it would not be there anymore!



(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
.

- 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.

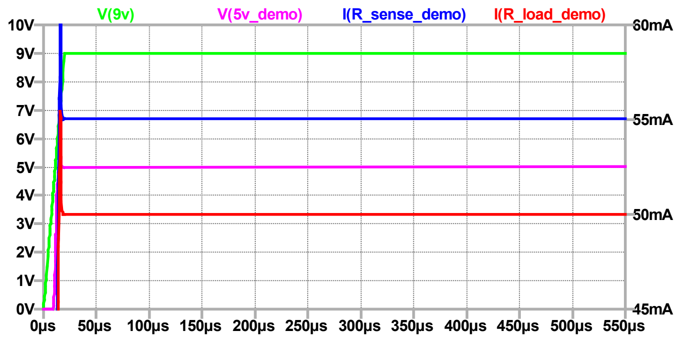
For your benefit, here is how to write values with units: 150 mΩ or 199 myUnits, and this is how we write ranges: 2 to 5 kV.
Here is an inline equation $\frac{55}{45+3}$. Here is a numbered equation in Eq. 2.1.

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

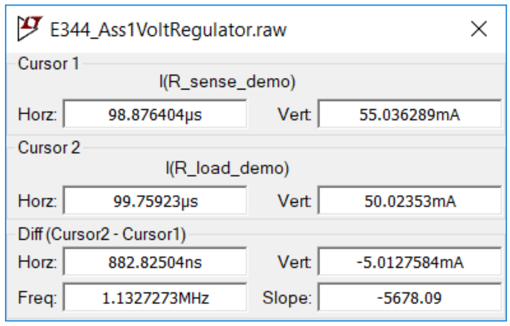
.

2.3. Results

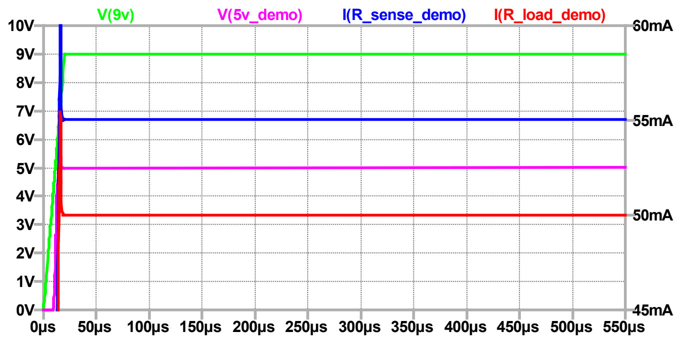
In this section, you want to demonstrate, by means of referring to simulation results, using the designed circuit, how your circuit behaves as you designed it in Section 2.2. Present and report on your simulated results in Figure 2.2. Be absolutely sure that the text and information in your report are readable.
You can use screengrabs or photos of the oscilloscope, or download the CSVs and plot them as



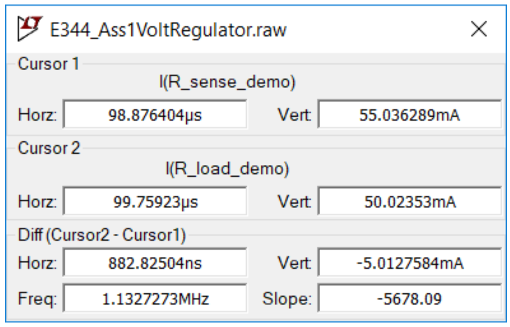
(a)



(b)



(c)



(d)

Figure 2.2: 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 [**?**]

Table 2.1: 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 2.2: 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

PDFs using Matlab, Excel or similar. You can also use tables, example of which are presented in Tables 2.1 and 2.2.

2.4. Summary

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

Chapter 3

System and conclusion

3.1. System

Report on the "so what" or the take-away of the ciruit you designed in this report. Report on noise levels and how the Heart rate sensor will fit into the system (E.g. what the calibration will look like and what the the measurement error will be given the range, quantisation error and noise).

3.2. Lessons learnt

Write down at least three of the most important things you have learnt in Assignment 2, and state what you would have done differently if you had another chance.

Appendix A

Social contract

Sign and inlcude.

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