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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.

August 13, 2020



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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

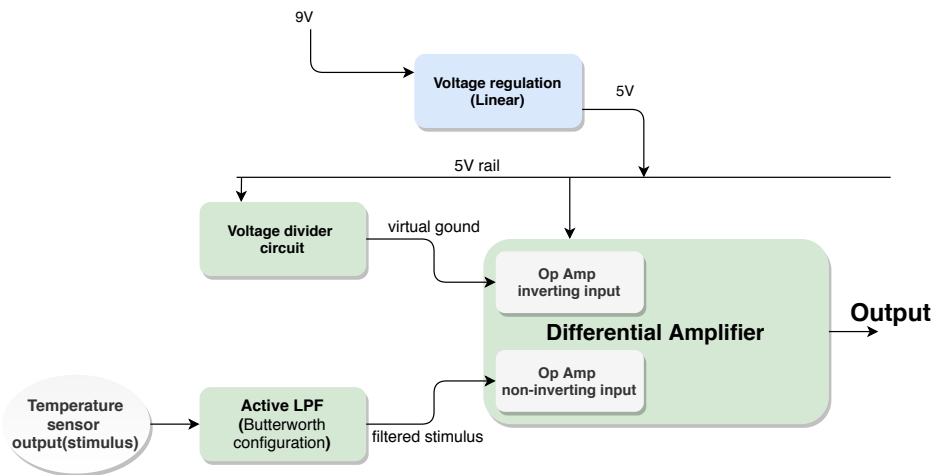


Figure 1.1: System diagram

The purpose of this design is to implement a signal conditioning circuit for an analogue temperature sensor. The **voltage regulator** shall provide a regulated 5V supply to the circuit from a nominal 9V power. An Op Amp circuit in a **differential amplifier** configuration is used: It provides a gain and removes a dc offset from the sensor output(stimulus) and thus, amplifies it from millivolts to volts while staying in the recommended output voltage range. In order to remove the dc offset from the stimulus and establish a virtual ground, given that only a positive voltage rail shall be used to power the Op Amp, a **voltage divider**(a resistors circuit) is used. Before feeding the stimulus to the amplifier, an **active low-pass filter** in the Butterworth configuration is used. The filter shall suppress noise from the stimulus by attenuating components at 50Hz and above.

1.2. Rationale

A linear regulator was chosen over a switching mode regulator due to the low noise levels on its output despite the switching regulator being more power efficient than the linear one. A second order Butterworth low-pass filter has high accuracy, low noise levels, relatively short settling time and a sharp drop-off gradient after the cut-off frequency(approximately 40db/dec): these characteristics make it an ideal choice for a filter given that noise need to be suppressed from the stimulus at 50Hz without attenuating the dc components.

Chapter 2

Voltage regulation

2.1. Introduction

This section deals with the power conditioning of the circuit. Two alternatives were available; namely a linear voltage regulator, the LM7805 or a switching mode regulator, the LM2595. The linear regulator's resistance varies according to the load and results in a constant output voltage. Conversely, switching regulators rapidly switch a series element(FETs) on and off. These devices store the input energy temporarily and then release that energy to the output at a different voltage level. [1]

The following subsection documents the rationale followed in the choice of the regulator.

2.2. Design

In order to pick which one of the regulators in the design, both the linear and switching mode regulators were implemented with additional circuitry and their respective performances were compared.

- **Linear regulation**

The circuit diagram is illustrated in figure 2.1 bellow. Capacitors C1 and C2 are used to smooth out noise on the 9V input supply and the 5V regulated output, respectively.

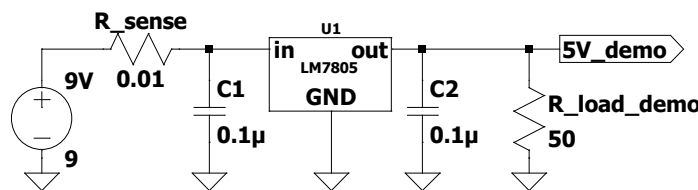


Figure 2.1: Linear regulator circuit diagram

Capacitors C1 and C2 values, 0.1 μ F each, were selected as suggested in the LM7805 data sheet specifications for typical applications circuits for a minimal noise linear regulation. [2]

- **Switch mode regulation**

The circuit diagram as derived from the LM2595 data sheet [3]. is illustrated in figure 2.2 bellow.

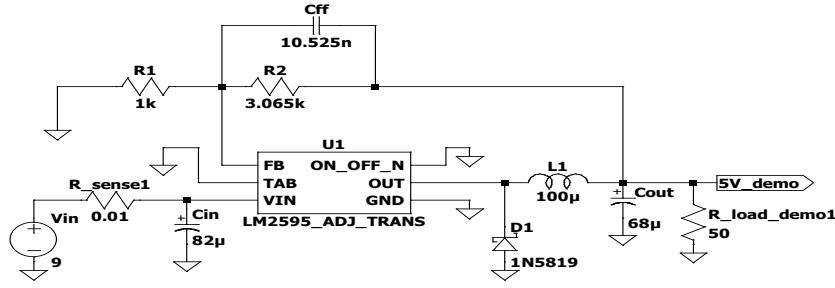


Figure 2.2: Switchmode regulator circuit diagram

The configuration is for an adjustable output voltage and it was preferred to a fixed output voltage for more flexibility.

In both the linear and switching regulator evaluations, a resistive load, R_{load_demo} was used to draw 100mA from the 5VDC side. Hence, $R_{load_demo} = \frac{5V}{100mA} = 50\Omega$

- R_1 and R_2 :

$$R_1 = 1k\Omega, R_2 = R_1 \left(\frac{V_{OUT}}{V_{REF}} - 1 \right), \text{ where } V_{REF} = 1.23V.$$

$$\therefore R_2 = 3,065k\Omega$$

These 2 resistors set the output voltage value to the required 5V.

- Catch Diode D1: A Schottky diode, the 1N5819 was picked due to its fast switching speed and low forward voltage drop.

- Capacitors C_{in} and C_{out} values were selected following the quick design table for a 5VDC output [3].

- FeedFoward Capacitor C_{ff} : Although this capacitor is only required for an output voltage greater than 10V, adding it substantially reduces noise levels at the regulator output, hence it was retained in the design. $C_{ff} = \frac{1}{31 \times 10^3 \times R_2}$

$$\therefore C_{ff} = 10.5nF$$

- L1: from the given formula $E \cdot T = (V_{IN} - V_{OUT} - V_{SAT}) \cdot \frac{V_{OUT} + V_D}{V_{IN} - V_{SAT} + V_D} \cdot \frac{1000}{150kHz} (V \cdot \mu s)$, where $V_{SAT} = 1V$ and table 30 in the data sheet [3], L1 value was chosen to be 100 μF . With the linear and switchmode regulators designed as above, a 5VDC regulated output was expected through simulations. The following subsection documents the obtained results.

2.3. Results

To select the adequate regulator(linear or switchmode), simulations were performed on the above two designs in order to asses their conformity to the expected results as well as the output noise levels and efficiencies of the regulators. Figure 2.3 bellow illustrates the simulation results:

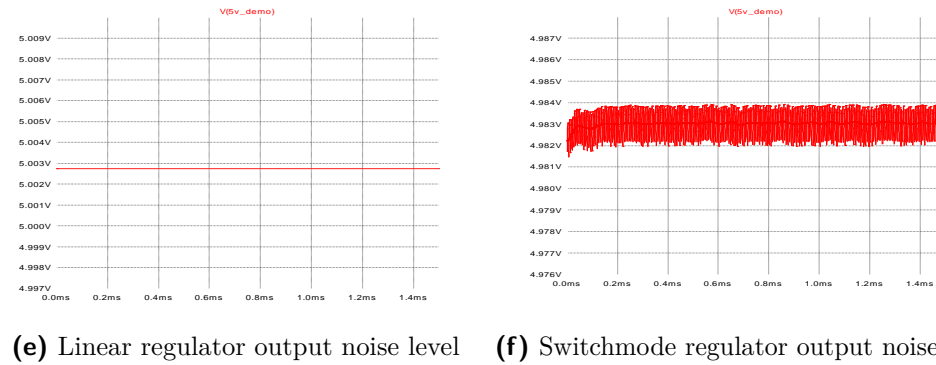
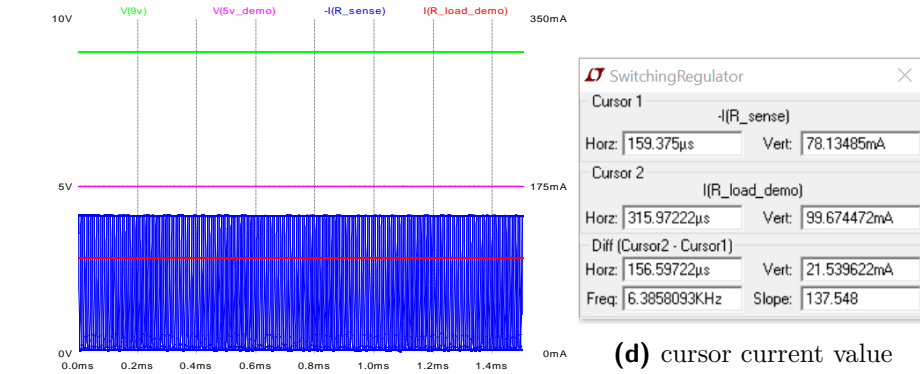
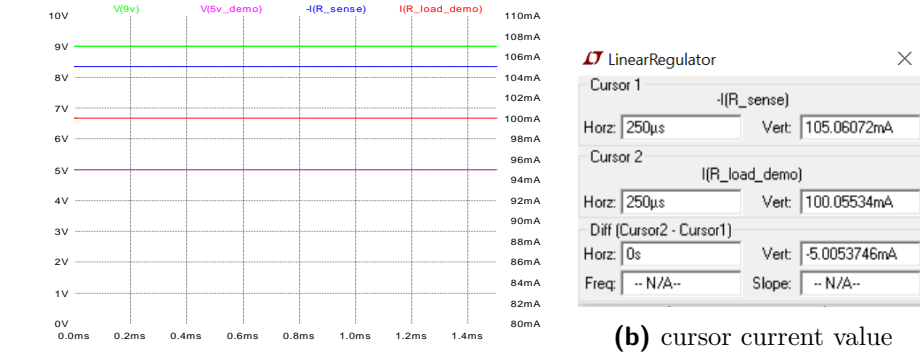


Figure 2.3: Voltage regulation, comparing the linear and Switchmode regulators

In addition, the difference between the input and output currents vary between the two regulator, which causes their power efficiency to differ. Efficiency and power calculation is illustrated in 2.1 bellow.

Regulator	Input Voltage	Input Current	Input Power	Output Voltage	Output Current	Output Power	Efficiency	Dropout Voltage
Linear	9VDC	105.06mA	945.547mW	5.003VDC	100mA	500.3mW	52.91%	2V
Switchmode	9VDC	60.23mA(rms)	560.03mW	5.00VDC	100.01mA	501.5mW	89.55%	

Table 2.1: Efficiency and power calculation

2.4. Summary

The switching mechanism in a switching mode regulator introduces lots of noise on its output despite the regulator's high efficiency(typically 85 to 90%) and very low voltage drop. Inversely, a linear regulator has very low output noise levels but with low efficiency and relatively high drop out voltages. State whether your design performs as expected and what the limitations are or things to keep in mind are.

Chapter 3

Temperature sensor conditioning circuit

3.1. Intro

3.2. Design

3.3. Results

3.4. Summary

Chapter 4

System and conclusion

4.1. System

Report on the integration of the voltage regulator and temperature sensing circuitry. Report on noise levels and how the temperature 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).

4.2. Lessons learnt

Write down at least three of the most important things you have learnt in Assignment 1.

Bibliography

- [1] Renesas Electronics Corporation, “Linear vs. switching regulators,” 2021. [Online]. Available: <https://www.renesas.com/cn/en/products/power-management/linear-vs-switching-regulators.html>
- [2] *LM78XX, LM78XXA 3-Terminal 1 A Positive Voltage Regulator*, LM7805 datasheet, Fairchild, September 2014.
- [3] *LM2595 SIMPLE SWITCHER® Power Converter 150-kHz 1-A Step-Down Voltage Regulator*, LM2595 datasheet, Texas Instruments, May 2016.

Appendix A

Social contract

Sign and include.



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E-design 344 Social Contract

2020

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 (Michael Ritchie) 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 for the module, 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.

Signature:  Date: 13 July 2020

.....
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 of supplementary videos on specific topics, I acknowledge that I am expected to attend the lectures and lab sessions 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.

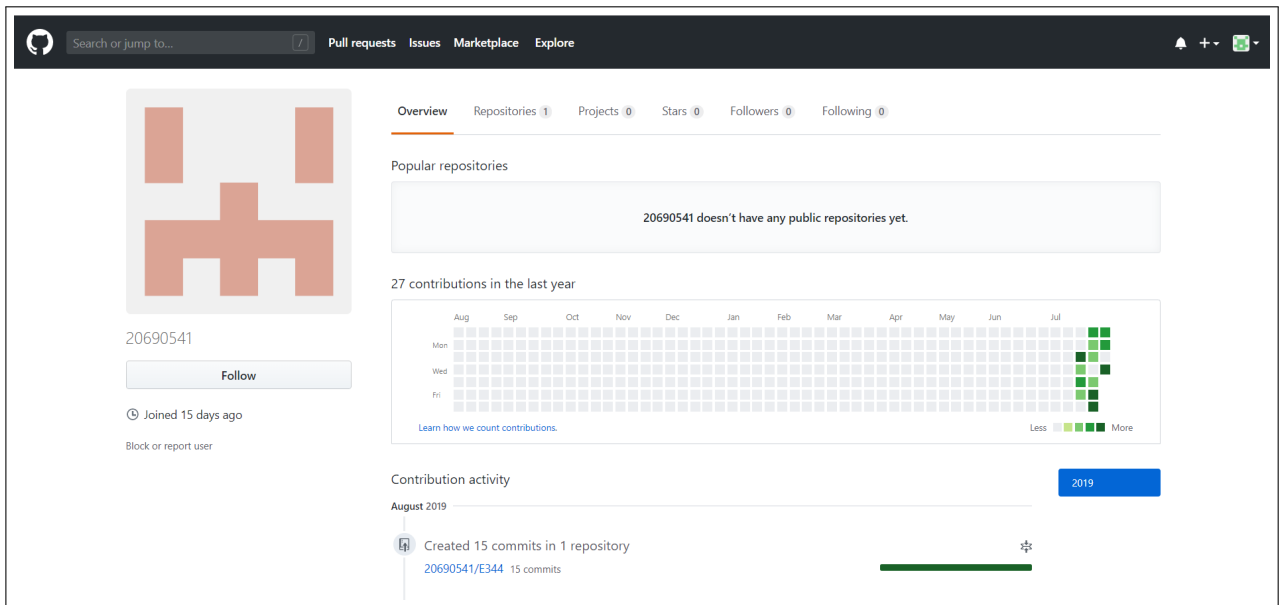
I acknowledge that E344 is an important part of my journey to becoming a professional engineer, and that my conduct should be reflective thereof. This includes doing and submitting my own work, working hard, starting on time, and assimilating as much information as possible. It also includes showing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

Signature: Date:

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

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