Process Report | Math & Analog Electronics

Introduction

In this report, I will summarize the key concepts I've learned in my Mathematics & Analog Electronics course. I will cover both theoretical foundations and practical applications, highlighting areas for improvement and potential future explorations.

Mathematics

What is the course about?

In mathematics, the course focused on complex numbers, their representation in the complex plane, and complex exponential functions. These concepts are fundamental for understanding signal behavior in different domains, such as time and frequency. The course covered basic operations on complex numbers, their geometric interpretations, and the relationship between complex exponentials and sinusoidal signals. It also emphasized the importance of understanding signals in both the time domain and the frequency domain, and introduced the Fourier transform as a tool to convert between these domains.

What I have learned?

- Through this course, I have gained a solid understanding of complex numbers and their representation in the complex plane. This involved learning how to perform basic operations like addition, subtraction, multiplication, and division with complex numbers, and understanding their geometric interpretations.
- I have also developed a strong grasp of complex exponentials and their relationship to sinusoidal signals, a concept that is crucial for frequency domain analysis. This knowledge has equipped me with the ability to analyze signals in both the time and frequency domains, providing a more comprehensive understanding of their behavior.

- Furthermore, I have learned about the Fourier transform, a powerful mathematical tool that allows for the conversion of signals between the time and frequency domains. This understanding has opened up new avenues for analyzing and manipulating signals, enabling me to extract valuable information about their frequency content.

Challenges

During this part of the course, I followed one of the provided textbooks, "Wat? Nog meer getallen!" (What? Even More Numbers!), which focused on working with complex numbers and their applications. The book covered a wide range of topics, including the history of complex numbers, their algebraic and geometric representations, operations with complex numbers, complex exponentials, and their applications in geometry and fractals. It also introduced the concept of Gaussian integers and their properties, as well as quaternions, an extension of complex numbers. The book provided numerous mathematical problems to be solved, and I have included photos of some of my solutions in my portfolio, demonstrating my ability to apply the concepts learned in the course.

Math: Complex numbers

1.1.a) $3+2\alpha-3\alpha^3 = 2\alpha^{1-1}+3(-3)\alpha^{3-1} = 2\alpha^0-9\alpha^2 = 2-9\alpha^2 =$
$= 2-9\times2 = 2-18 = -16$

$3+2\alpha-3\alpha^3 = 3+\alpha(2-3\alpha^2) = 3+\alpha(2-3\times2) = 3+\alpha(-4) = 3-4\alpha$

1.1.b) $(5+\alpha)(1-\alpha) = 5-5\alpha+\alpha-\alpha^2 = 5-4\alpha-\alpha^2 = 5-4\alpha-2 = 3-4\alpha$

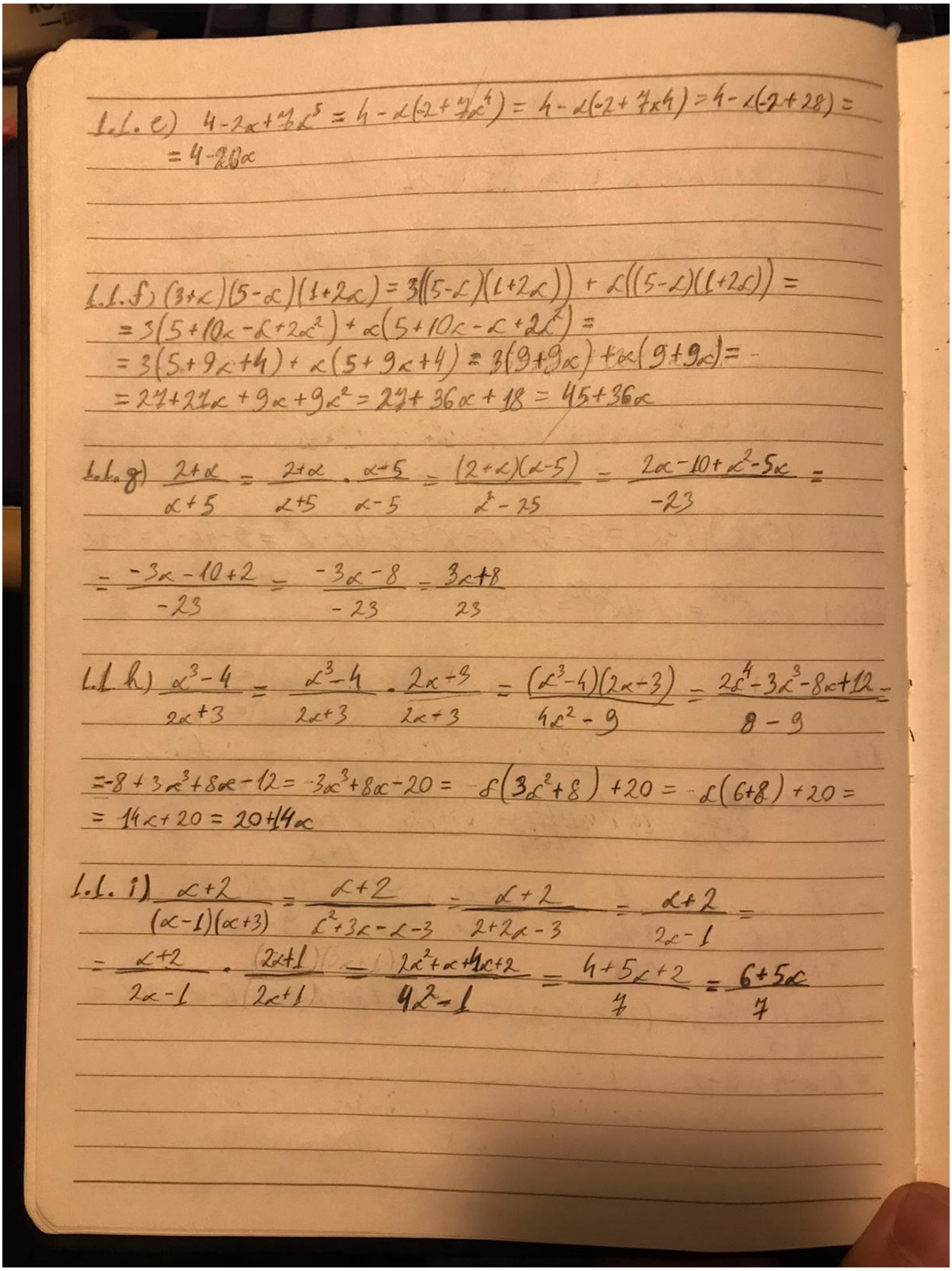
1.1.c) $1-\alpha^{100} = 1-(\alpha^2)^{50} = 1-2^{50}$

1.1.d) $\frac{1}{1+\frac{1}{1+\frac{1}{1+\alpha}}} = \frac{1}{1+\frac{1}{\frac{1+1+\alpha}{1+\alpha}}} = \frac{1}{1+\frac{1}{\frac{2+\alpha}{1+\alpha}}} = \frac{1}{1+\frac{1+\alpha}{2+\alpha}} =$

$= \frac{1}{\frac{2+\alpha+1+\alpha}{2+\alpha}} = \frac{1}{\frac{3+2\alpha}{2+\alpha}} = \frac{2+\alpha}{3+2\alpha}\cdot\frac{3-2\alpha}{3-2\alpha} = \frac{(2+\alpha)(3-2\alpha)}{9-4\alpha^2} =$

$= \frac{(2+\alpha)(3-2\alpha)}{9-8} = (2+\alpha)(3-2\alpha) = 6-4\alpha+3\alpha-2\alpha^2 = 6-\alpha-2\alpha^2 =$

$= 6-\alpha-4 = 2-\alpha$



What can I improve?

- To further enhance my understanding of complex analysis, I aim to delve deeper into its applications in signal transformations and filter design. This will involve exploring more advanced mathematical techniques used in signal processing, such as Fourier transforms and Laplace transforms, which are essential for analyzing and manipulating signals in the frequency domain. By strengthening my grasp of these concepts, I can expand my capabilities in signal analysis and processing.

Analog Electronics

What is the course about?

In analog electronics, the course covered fundamental principles and components of analog electronic circuits. It introduced essential circuit analysis techniques, such as Kirchhoff's laws and Ohm's law, and explored the properties and applications of passive components (resistors, capacitors, inductors) and active components (op-amps). The course also emphasized the importance of analyzing circuits in both the time and frequency domains and introduced the concept of signal filtering, including the design of simple analog low-pass filters.

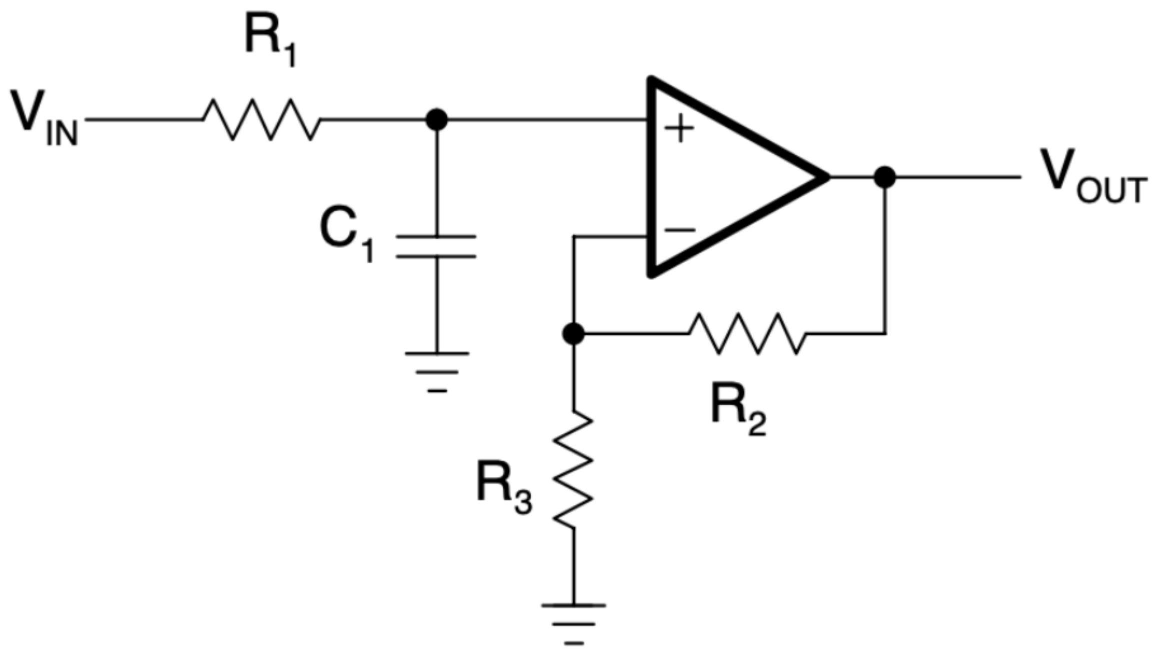
What I have learned?

- In the realm of analog electronics, I have developed a strong foundation in circuit analysis. I am now proficient in applying techniques such as Kirchhoff's laws, Ohm's law, and the concepts of voltage dividers and Thévenin/Norton equivalents to understand the behavior of electrical circuits and calculate key parameters like voltage, current, and power.
- I have also gained a deep understanding of the properties and applications of various passive components, including resistors, capacitors, and inductors. This knowledge has enabled me to design and analyze circuits that control the flow of electrical current and shape signal responses.
- Additionally, I have learned about operational amplifiers (op-amps) and their role in building amplifier circuits. I understand the basic operating principles of op-amps and can apply this knowledge to design and analyze different circuit configurations, such as inverting and non-inverting amplifiers.
- Finally, I have explored the concept of filtering and learned how to design simple analog low-pass filters to attenuate high-frequency components of a signal. This knowledge is essential for signal processing applications,

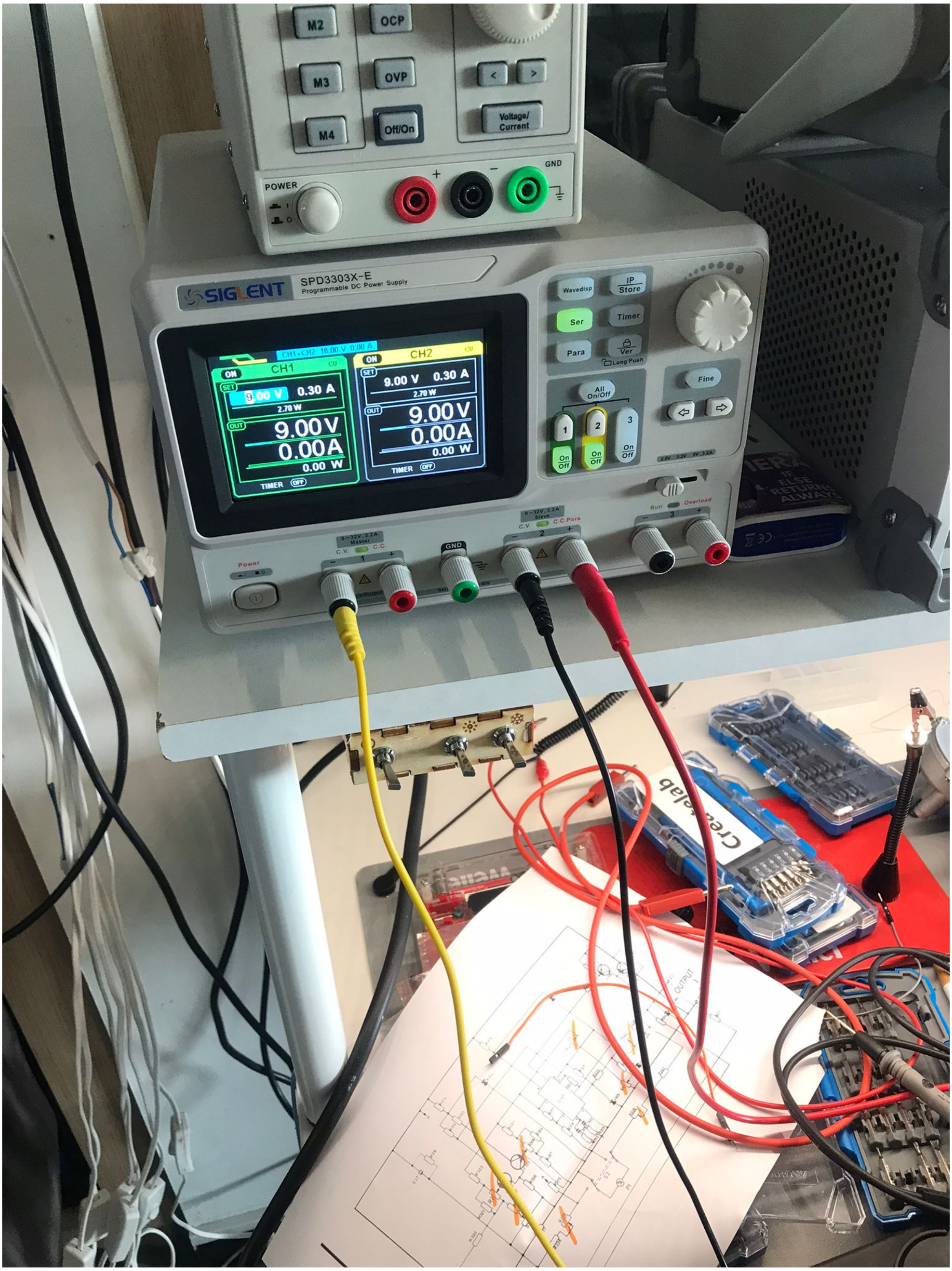
where it is often necessary to remove unwanted noise or isolate specific frequency bands.

Challenges

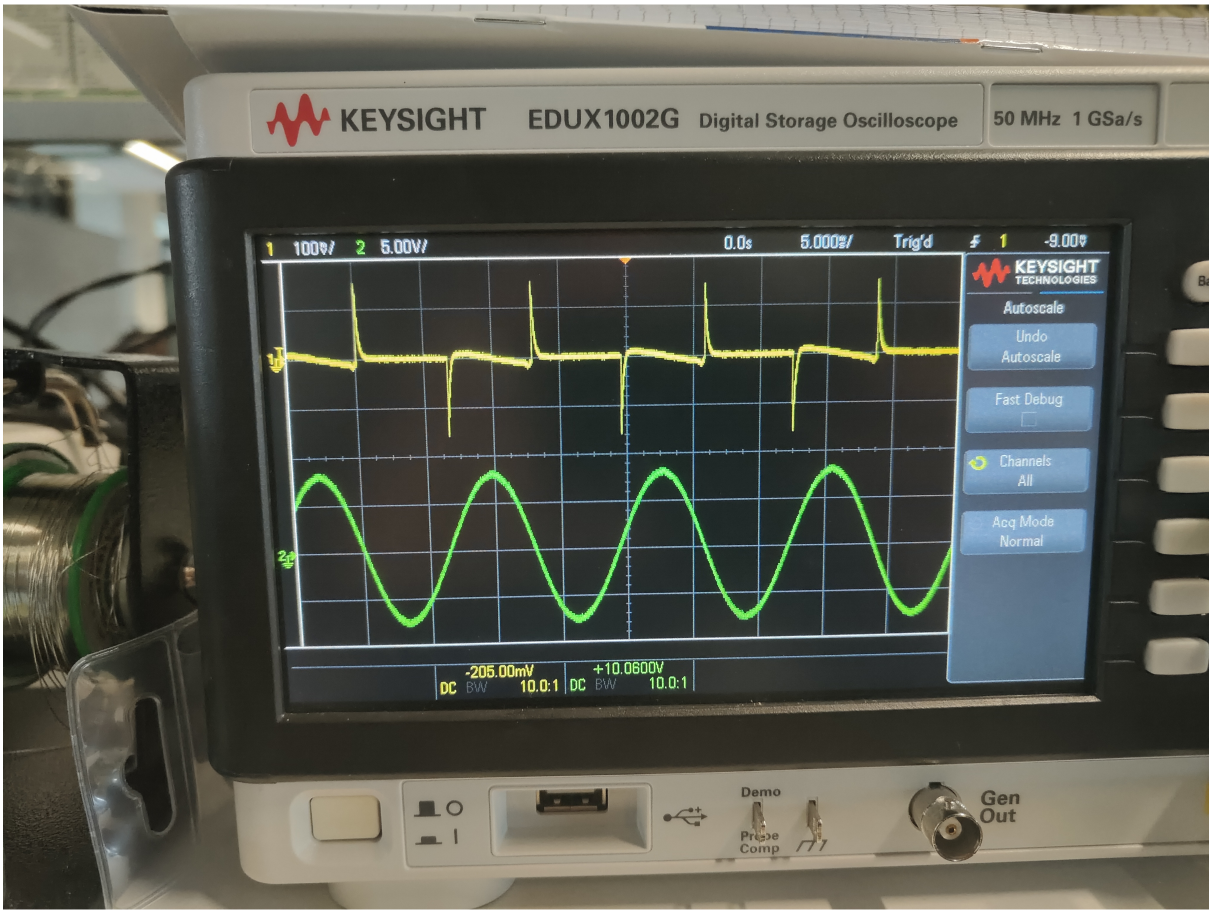
During the analog electronics portion of the course, one of the challenges presented was to design and build a simple analog low-pass filter using a combination of resistors, a capacitor, and an operational amplifier (op-amp). The specific challenge, as illustrated in the provided image, involved constructing an inverting op-amp configuration with specific component values (R1 = R2 = R3 = 10kΩ and C1 = 10nF) and using a symmetric power supply.

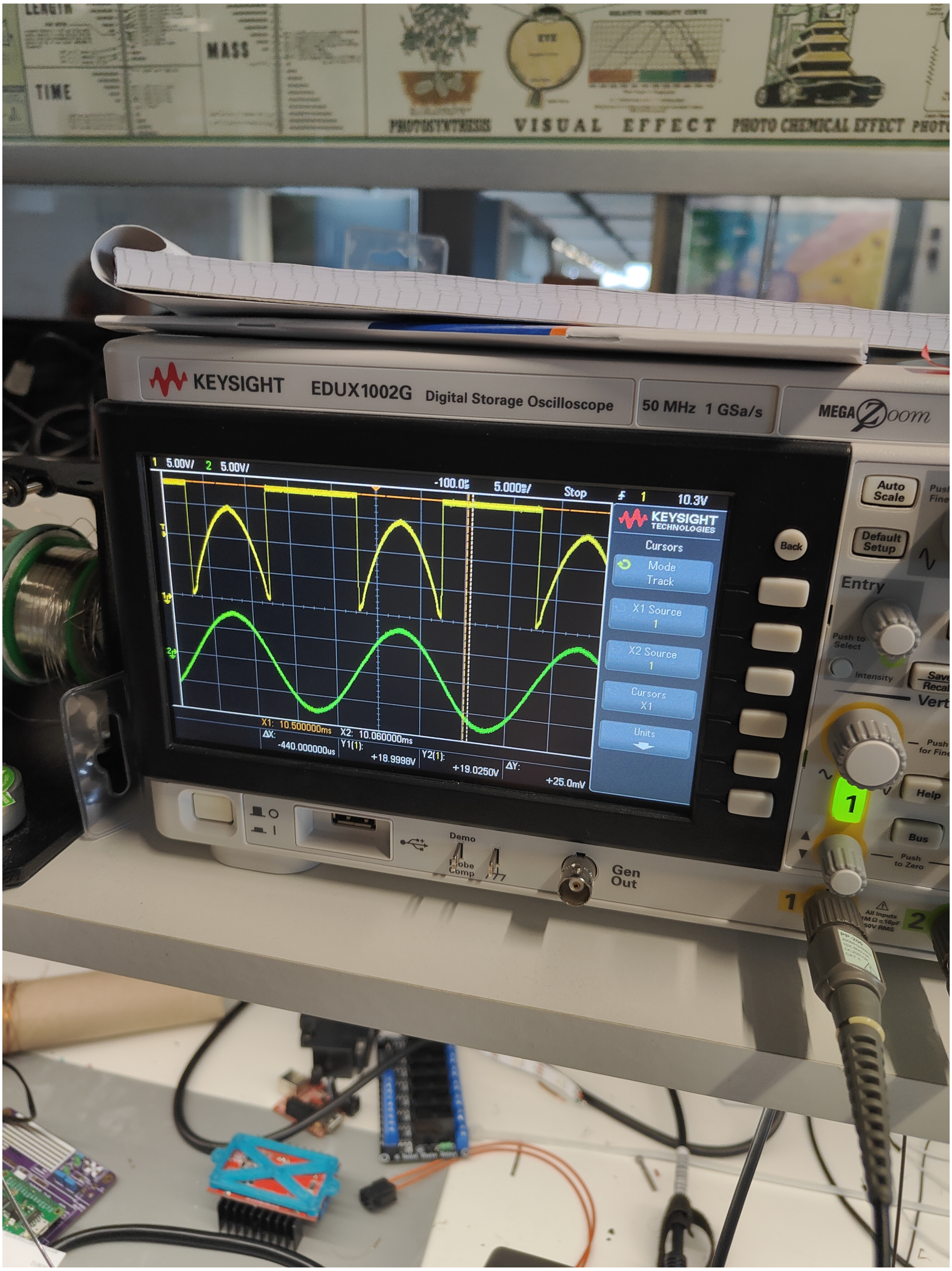


The goal of the challenge was to observe the filter's behavior by connecting a function generator to the input (Vin) and analyzing the output (Vout).

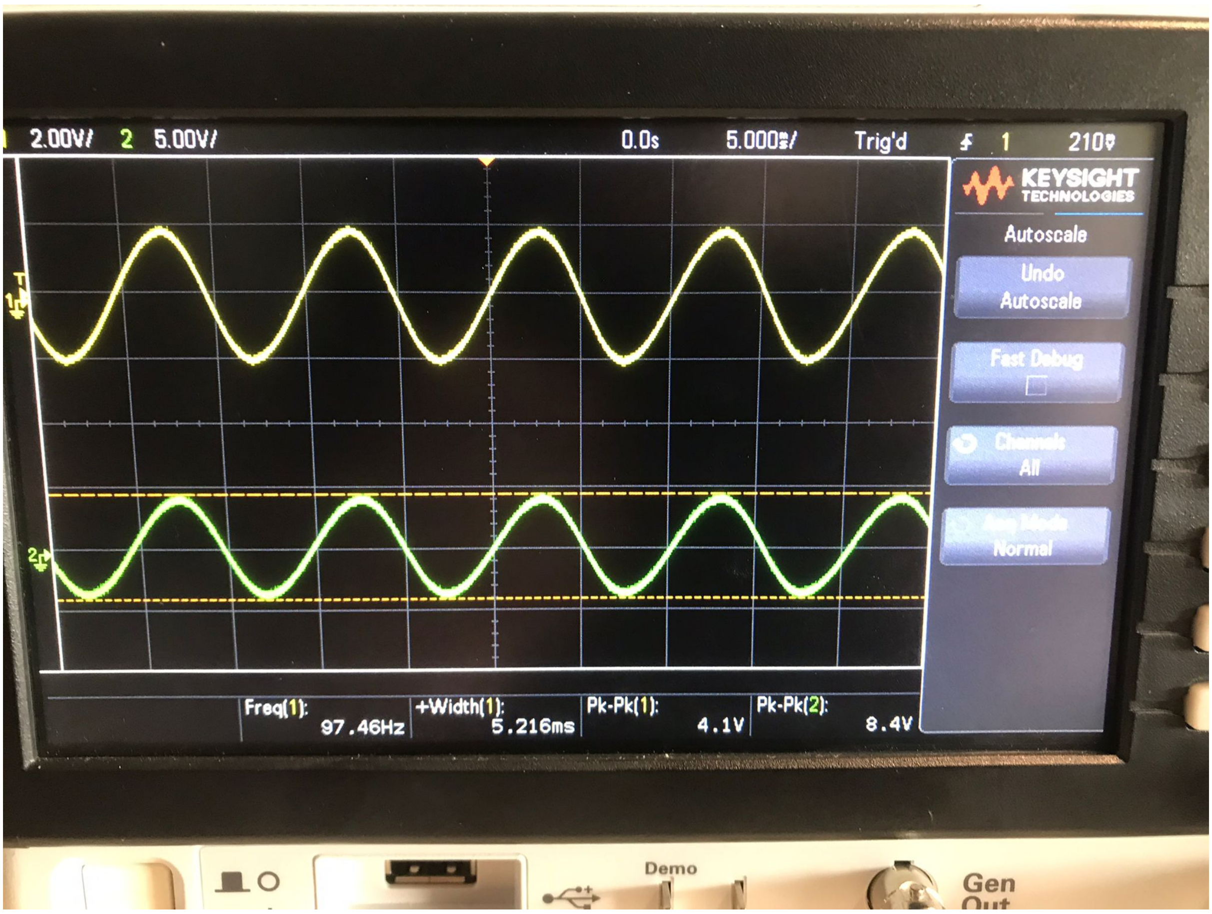


This practical exercise aimed to reinforce the theoretical concepts of filter design and operation, as well as to highlight potential real-world challenges and unexpected behaviors that may arise in circuit implementation. In the following pictures I have shown a few issues I encountered the first being incorrect wiring of the circuit and the second accidentally adding a constant DC offset to the the input (Vin).





After addressing these problems I was able to achieve the desired result of filtering higher frequency signals which resulted in amplitude reduction of the output (Vout) as depicted in the image bellow.



What can I improve?

- In the realm of analog electronics, I plan to broaden my knowledge of filter design by exploring different filter types beyond low-pass filters, such as high-pass, band-pass, and band-stop filters. Understanding the characteristics and applications of these various filter types will enable me to design circuits that can selectively attenuate or amplify specific frequency ranges, which is crucial in many signal processing applications.
- Additionally, I aim to delve into the design of more complex analog filters using active components like op-amps. This will involve learning about different filter topologies, such as Sallen-Key and multiple feedback filters, and understanding their advantages and limitations. By mastering the design of complex filters, I can create circuits that meet specific filtering requirements with greater precision and flexibility.

Conclusion

In conclusion, the Mathematics & Analog Electronics course has provided me with a valuable foundation in both theoretical concepts and practical skills. Through the study of complex numbers and analog circuits, I have gained a deeper understanding of the mathematical tools and engineering principles that underpin signal analysis and processing. While I acknowledge that there are areas where I can further develop my knowledge and expertise, I am confident in my ability to apply the fundamental concepts I have learned to real-world problems. I am eager to continue exploring the fascinating world of mathematics and analog electronics, and I am excited to see how I can leverage this knowledge in my future academic and professional pursuits.