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Department of Electronic Engineering

Infrared receiver simulation report
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Subject: Project 1
Project title: Infrared receiver

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Declaration

This project entitled “Infrared receiver” is my original work and has not been submitted for any other purpose to any other institute.

Signed

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Acknowledgements

I would like to acknowledge Brian Keogh for his support and assistance during this project.

Contents

1 Simulation

1.1 Introduction

This chapter is about simulating the infrared receiver. In specific the photodiode amplifier, as this is one of the most crucial circuits. Here, the current that the photodiode outputs is converted and amplified to a useful voltage and has the noise filtered out.

The simulation circuit is drawn and simulated using *OrCAD Capture CIS – Lite*.

1.2 Design

1.2.1 Input

This circuit has a photodiode for the input signal. As a photodiode is a component that converts light into an electrical current using the photoelectric effect, it is hard to simulate using standard software. As alternative signal sources there are three options, a *voltage* source, a *current* source and a variable *resistor*. Of these the current source acts the most similar to a photodiode, and it is good enough for this simulation model.

The chosen value was from a graph from an old textbook of mine “Vermogenelektronica (op AC gebied)”, written by Bart Huyskens.

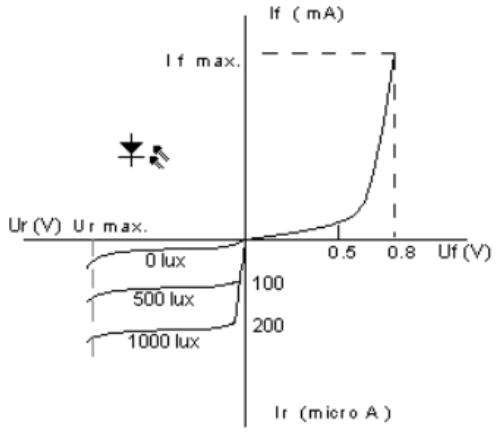

Figure 1.1: Current VS Illuminance "Vermogenelektronica (op AC gebied)"

Here a current of 100µA seems about right. More details about this can be found in the “Infrared Receiver design” report.

1.2.2 Circuit

In this chapter, both amplifier circuits described in the “Infrared Receiver design” report are simulated and analysed. In short, the first circuit is the one suggested by Brian Keogh, where the second one is an improved version for this application.

1.2.2.1 Original

The first circuit comprises a two-stage active high-pass amplifier and a coupling capacitor (C13) at the signal. Again, more details can be found in the aforementioned report. It also has two biasing resistors R28 and R29. The measurement points are indicated with this ≪ v ≫ probe icon, with V indicating that we measure the voltage.

Please note that I2, the current source, has two values. The one on top is the magnitude, this means that the signal will have a peak-to-peak voltage of $100\mu A\ (= 2 * AC_{mag})$. The second value is the DC offset current. This is also $50\mu A$, which results in a current source that alternates between $0A$ and $100\mu A$.

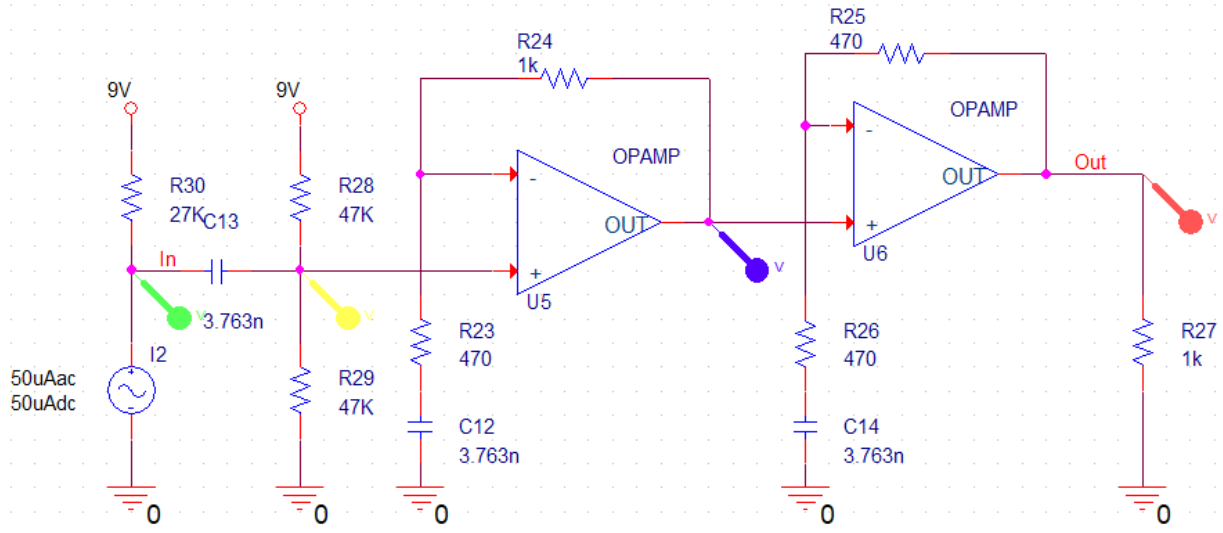

Figure 1.2: Original circuit, based on schematic from Brian Keogh

1.2.2.2 Modified

The modified version adds C8 and C9 to the design. These two capacitors create a low-pass filter. Which allows us to filter the high frequency noise we pick up. In the IR spectrum this is an immense problem, as even the sunlight will give a lot of high frequency noise in the system. The reason for choosing two high-pass filter stages is described in the "Infrared Receiver design" report. For the other components, the resistor values were lowered in the feedback loops to allow for larger capacitor values, to lessen the effect of stray capacitance in the PCB design.

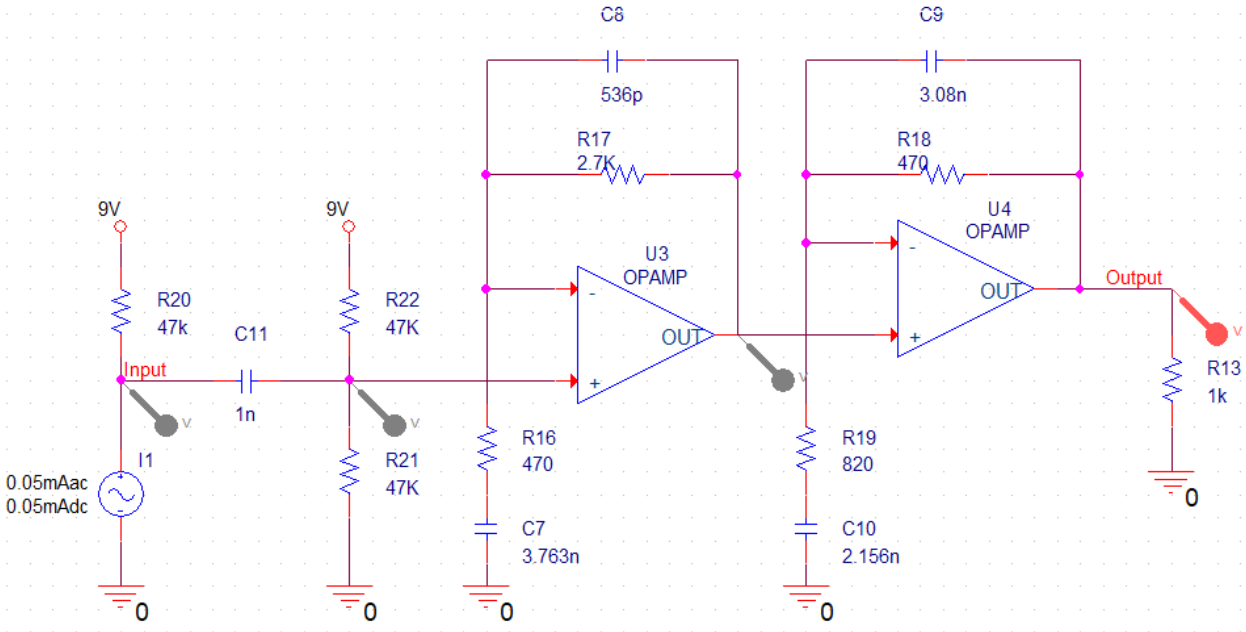

Figure 1.3: Modified circuit

1.3 Results

1.3.1 Original

The results of the original amplifier shows two critical points. The first is the cut-off frequency at $1.8KHz$. This is caused by the coupling capacitor blocking the lower frequencies. The second cut-off frequency at $90KHz$ is caused by the active high-pass filter.

As described in the design report, the coupling capacitor will block any DC offset we get. This is confirmed by the measured loss of $-65.1dB$ at $1Hz$ [Figure 1.5].

It can also be noted that, as by design, this schematic will not filter higher frequencies, but instead amplify them the same way it does with the intended frequency range. This issue is addressed in the modified version.

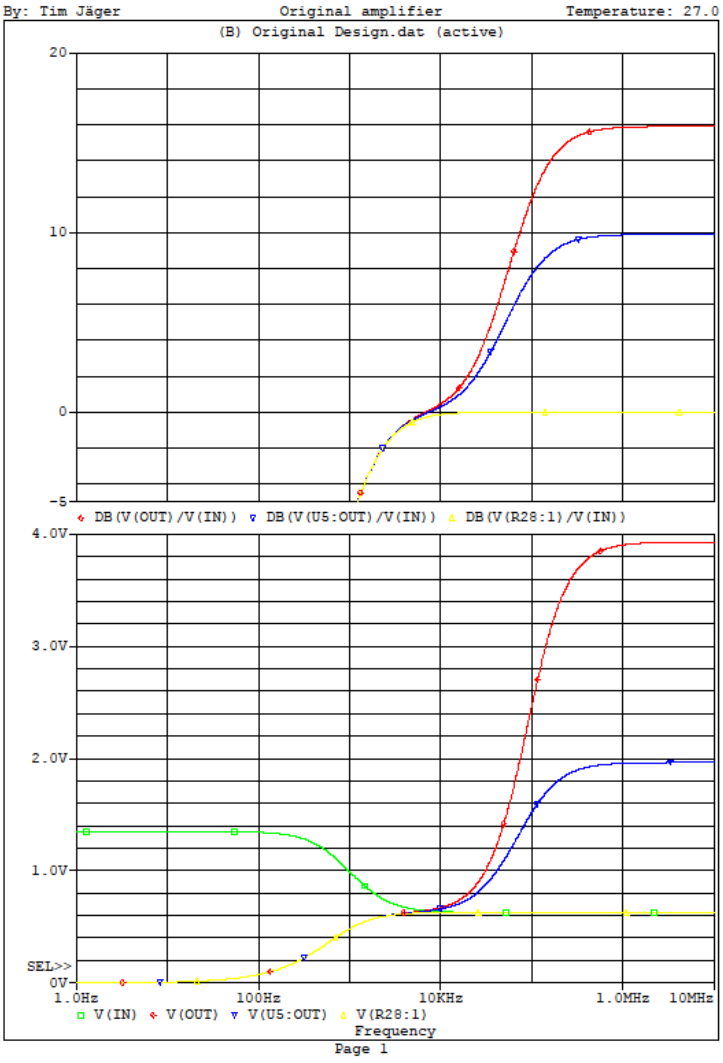

Figure 1.4: Simulation results original schematic

Trace Name	Y1
X Values	1.0000
DB(V(OUT)/V(IN))	-65.104

Figure 1.5: Original schematic measurement 1Hz

Zoomed in to an area between $80KHz$ and $140KHz$, it becomes clear that there is a large voltage deviation. At $90KHz$ there is a gain of $11.15dB$ and at $110KHz$ it is $12.17dB$. The difference in gain is over 10% or $0.3V$. In this application, this shouldn't be an issue, but it can definitely be improved.

When looking at these graphs, please pay attention to the scale. Fig. 1.4 is logarithmic and fig. 1.6 is linear.

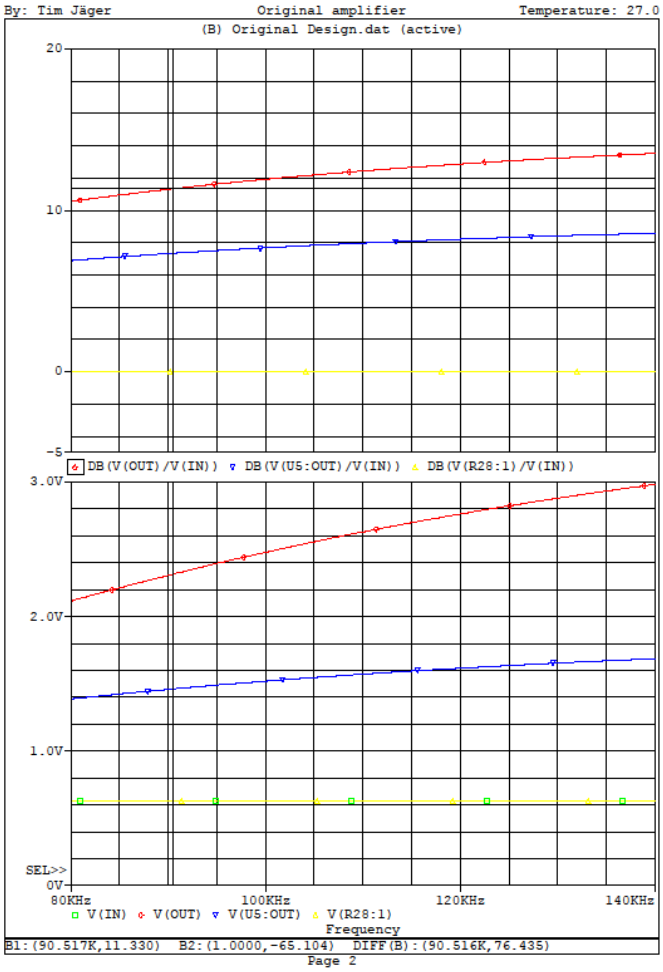

Figure 1.6: Simulation results original schematic [80KHz-140KHz]

1.3.2 Modified

In the modified schematic, the first cut-off frequency is at $6.8KHz$. The change in frequency is due to a different input resistor value (R20). Here the cut-off point is also due to the coupling capacitor blocking lower frequencies. With a loss of $-76.6dB$ at $1Hz$[Figure 1.8].

Now, at the peak there are two cut-off frequencies from the active band-pass filter. These frequencies are respectively $90KHz$ and $110KHz$.

In this modified schematic, any high frequency noise will not be amplified. This makes it low enough compared to the $14.74dB$ peak gain to be irrelevant for the application.

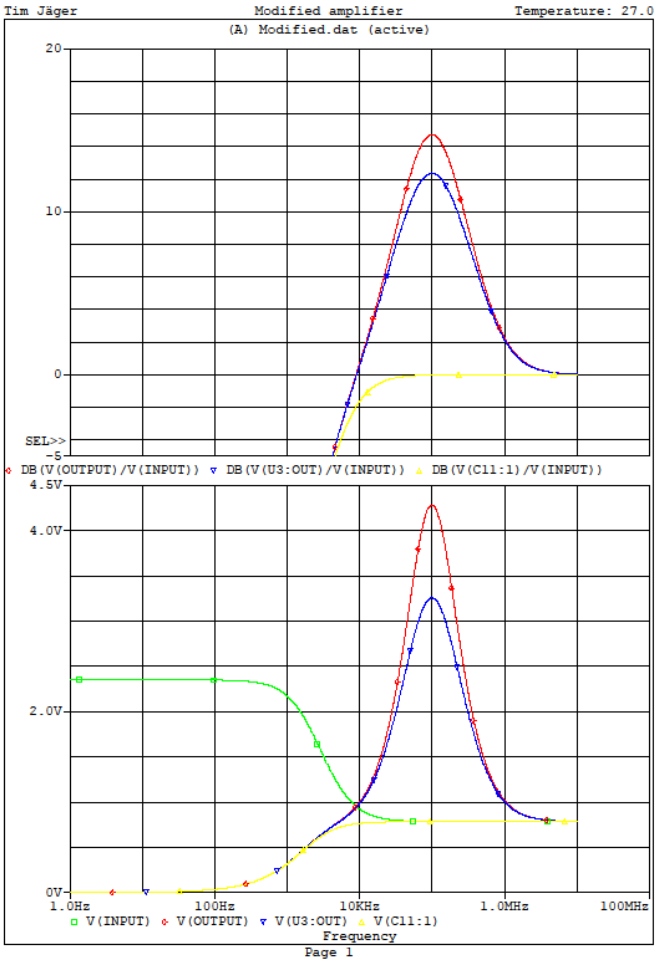

Figure 1.7: Simulation results modified schematic

Trace Name	Y1
X Values	1.0000
DB(V(OUTPUT)/V(INPUT))	-76.615

Figure 1.8: Modified schematic measurement 1Hz

When zooming in to a span between $80KHz$ and $140KHz$, it can be noted that the difference in amplification at the target frequency range is relatively small. Namely, $0.046dB$ which is about 0.32% or $29.4mV$[Figure 1.10].

When looking at these graphs, please pay attention to the scale. Fig. 1.7 is logarithmic and fig. 1.9 is linear.

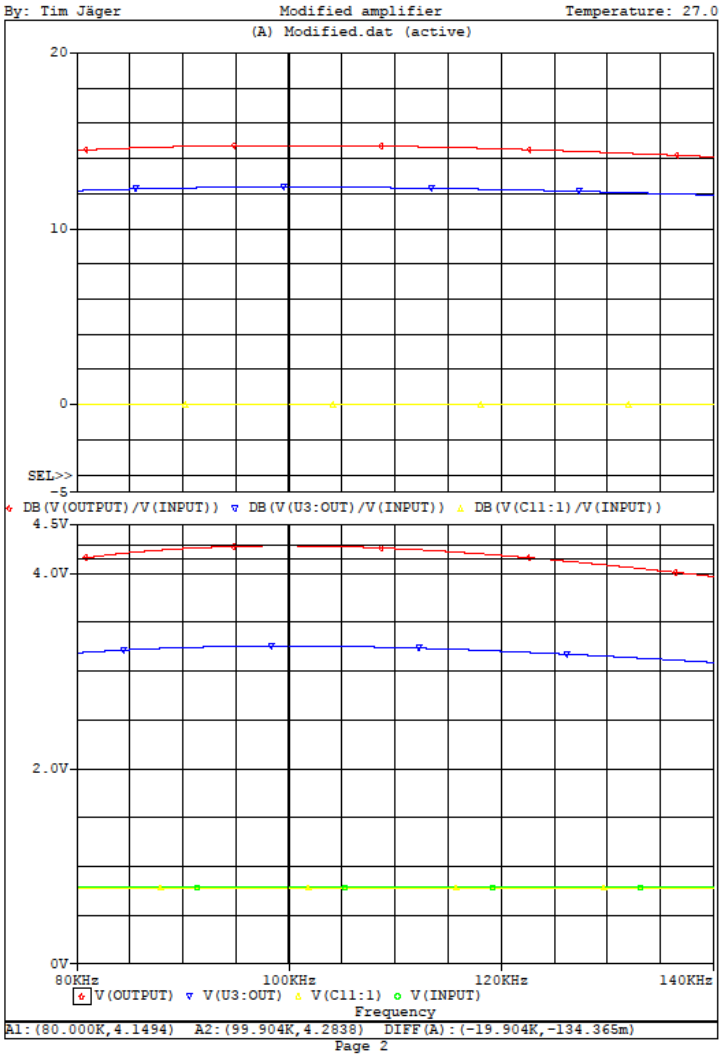

Figure 1.9: Simulation results modified schematic [80KHz-140KHz]

Trace Name	Y1	Y2	Y1 - Y2
X Values	99.999K	90.000K	9.999K
V(OUTPUT)	4.2838	4.2544	29.424m
DB(V(OUTPUT)/V(INPUT))	14.740	14.693	46.583m

Figure 1.10: Simulation modified schematic ΔA

2 Conclusion

During the simulation it became apparent that the input coupling capacitor has more influence than estimated. Luckily, it does not have any consequences for the design, moreover it actually helps more than expected (see the “Infrared Receiver design” report for the original expectations).

In the end it is clearly worth upgrading to from the original design to the modified version, given the extra stability and noise reduction for the cost of two capacitors.

3 Sources and software

All used files can be found at https://github.com/Jaeger-Tim/project-2-IR-receiver.

Software:
Simulation and simulation schematic design software: OrCAD Capture CIS - Lite