

2221114

by Kai White

Submission date: 06-Feb-2023 05:45PM (UTC+0000)

Submission ID: 196809310

File name: 17313_Kai_White_2221114_180886_546965300.pdf (858.03K)

Word count: 2679

Character count: 14062

71%

Course: HNC Electrical and Electronic Engineering

Module: SGEE4003- Electronics I

Assignment Title: Analogue Circuit Design

Name: Kai White

University number: 2221114

Date Submitted: 06/02/2023

Word count: 2500

- ① VERY GOOD RESEARCH AND CITATION LIST.
 - ② DESIGN METHOD WAS EXPLAINED IN DETAIL.
 - ③ EACH STAGE WAS TESTED AND RESULTS SHOWN.
 - ④ ANALYSIS AND CONCLUSIONS COULD HAVE BEEN MORE SPECIFIC.
 - ⑤ GOOD EVALUATION.
 - ⑥ AVOID PERSONAL PRONOUNS AND HANDWRITING MORE.
- 65 - 75.

Course: HNC Electrical and Electronic
Engineering
Module: SGEE4003- Electronics I
Assignment Title: Analogue Circuit Design
Name: Kai White
University number: 2221114
Date Submitted: 06/02/2023
Word count: 2500

Contents

Planning and reflection	3
Research into amplifiers, oscillators and feedback (800)	4
Amplifier configurations and choice of transistor	4
Op-amp configurations	5
Negative and positive feedback	7
Oscillator types with reference to frequency, accuracy and stability	8
Tuned amplifiers	8
Design method, calculations and testing (600)	9
Dc conditions	9
AC conditions	10
Refining the design for gain	13
Designing an oscilloscope	14
Build the final system	15
Results (200)	17
Comparison of results table	17
Calculations	17
Bandwidth	20
Analysis (300)	22
Evaluation (300)	23
Conclusion (300)	24
Executive Summary	25
Bibliography	26

Planning and reflection

I am going to complete "Design method, calculations and testing" section by 09/01/23 with all screenshots and completed working circuit. Adding the oscillator, op amp and amplifier together to create a finalised complete circuit.

"Research into amplifiers, oscillators and feedback" I will be completing this section as I go through my circuit and when I feel it will be relevant for me to research the topics, to get a better understanding of my results and to see if the results I'm getting are reasonable. Complete by 16/01/23.

"Results" will be worked on while going through "Design method, calculations and testing" to ensure that the results I'm getting are correct and this will stop me from making mistakes which will affect me long term. Complete by 23/01/23.

"Analysis" will be completed after the results section because all the main body of my assignment will be completed and I feel like that is the best time to comment on the accuracy of results. Complete by 30/01/23.

My "Evaluation" and "Conclusion" will be started on after I have finished all the headings above so I will know what went well and what could have gone better throughout the assignment. Complete by 3/02/23.

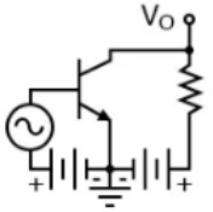
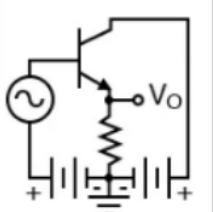
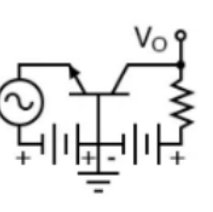
As I am going through my whole assignment, I will be refencing what is needed and being used and all the links will be in the "Citations".

Final look over assignment for any correction or additions will be by 5/02/23.

Research into amplifiers, oscillators and feedback (800)

Amplifier configurations and choice of transistor

There are three types of configurations for transistors; common emitter, common base and common collector (emitter follower). Each configuration of transistor is used for different outcomes so you would choose the transistor depending on the circuit. (electronicsnotes, 2023)

Basic circuit	Common emitter	Common collector	Common base
			
Voltage gain	high	less than unity	high, same as CE
Current gain	high	high	less than unity
Power gain	high	moderate	moderate
Phase inversion	yes	no	no
Input impedance	moderate $\approx 1k$	highest $\approx 300k$	low $\approx 50\Omega$
Output Impedance	moderate $\approx 50k$	low $\approx 300\Omega$	highest $\approx 1Meg$

(circuits, 2023) The table above shows the differences between each configuration with diagrams.

Common emitter – The voltage is common to both the collector and base. The input signal is placed into the base and the output is from the collector. (Sparkfun, 2023) This emitter is used a lot more than others because of its features. And it performs well all around and a good voltage gain. (electronicsnotes, 2023)

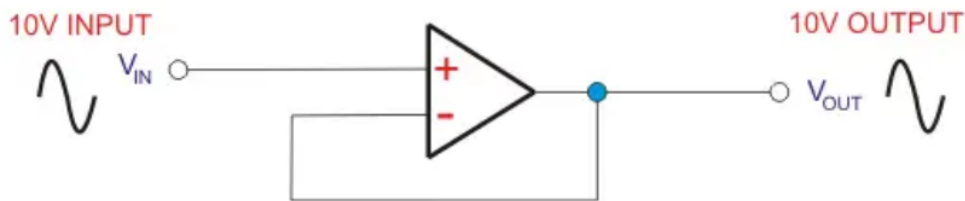
Common collector – is known as a bipolar junction transistor. The input signal is connected to the base and the output comes from the emitter. This transistor is the opposite to the common emitter. The collector is common to both the base and emitter. This type of transistor is connected to ground through the PSU. (Electronicstutorials, 2023)

Common base – The base is the common terminal, whereas the input is the emitter and the output is the collector. The collector is “capacitively coupled” to the collector. The common base

is commonly used for a voltage amplifier or buffer in high frequency applications. The input impedance is low but the output impedance is high. Normally it has a high voltage gain with a current gain less than or equal to 1. (Electronicshub, 2023)

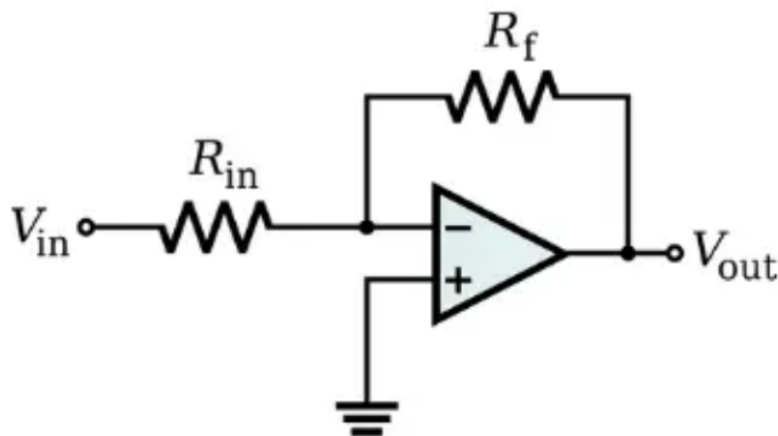
Op-amp configurations

Voltage follower: is an op-amp where the output voltage is the same as the input voltage. All this op-amp provides is buffering. Also, this particular op amp has a very high impedance and is normally used in circuits that need isolation between the input and output signal. (Electrical4u, 2023)



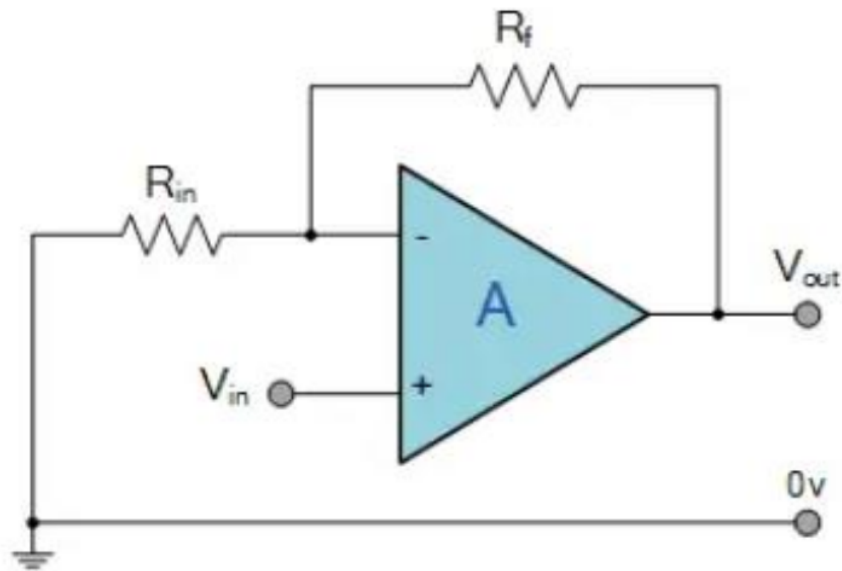
(Electrical4u, 2023) this is a diagram of how the voltage follower works

Inverting op-amp: is an op-amp which makes the output 180 degrees out of phase to the input. The input is opposite to the output, for example if the input was negative then the output would be positive. (Electrical4u, 2023)



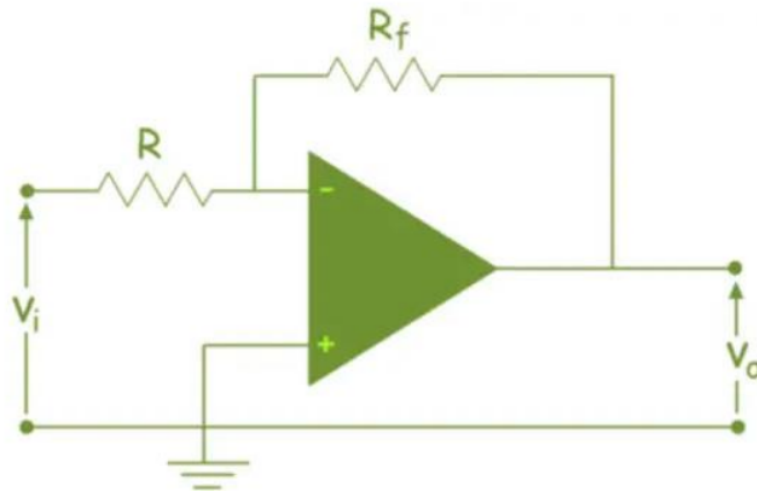
(Electrical4u, 2023) this is a diagram of how the inverting op-amp works.

Non-inverting op-amp: This is an op-amp with a positive voltage gain. (Electrical4u, 2023)



(Electrical4u, 2023) this is a diagram showing the non-inverting amplifier.

Integrator: is an inverting amplifier, and is like a capacitor replacing the feedback resistor. The output is proportional to the integral of the input. (Electrical4u, 2023)



(Electrical4u, 2023) this is a diagram of an integrator.

Negative and positive feedback

This table shows the difference between positive and negative feedback, comparing their key features.

Basis for Comparison	Positive Feedback	Negative Feedback
Also called as	Regenerative feedback	Degenerative feedback
Relation between input and output	In phase	Out of phase
Overall gain	Greater than the gain of the system where feedback is not present.	Smaller than the gain of the system where feedback is absent.
Effective input	Sum of applied input and fed back signal.	Difference of applied input and fed back signal
Transfer function of system with respective feedback	$\frac{G}{1 - GH}$	$\frac{G}{1 + GH}$
Stability	Less	Comparatively more
Phase shift	0° or 360°	180°
Feedback is taken from	Non-inverting terminal of op-amp	Inverting Terminal of op-amp
Sensitivity	Low	High
Use	In oscillators.	In amplifiers.

(Circuitglobe, 2023)

Negative feedback – the input signal is opposite in phase to the feedback signal. Making a net decrease from the input, making a reduction in gain. Another name for negative feedback is

“degenerative or inverse feedback”. Negative feedback is used in amplifiers to “improve the stability of gain, reduce distortion, transform input and output impedances and improve frequency response”. (Physicwave, 2023)

Positive feedback – The input signal is in phase with the feedback signal. Another name for positive feedback is regenerative or direct feedback. One of the reasons for using this is for increased gain and it also enlarges the distortion and this makes it so it has a lower quality of stability. (Physicwave, 2023)

Oscillator types with reference to frequency, accuracy and stability

The Colpitts oscillator changes the input DC signal to an AC output signal. This circuit is made two capacitors in series and an inductor is connected in parallel, by changing the values of these components of the “tank circuit” to adapt the frequency of the oscillator. (CUS, 2023)

$$f_r = \frac{1}{2\pi\sqrt{LC_T}}$$

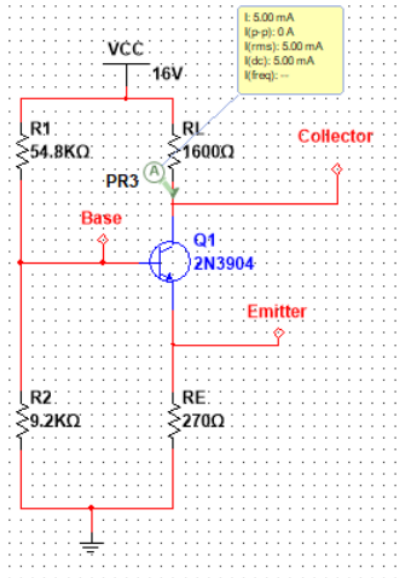
Colpitts oscillator calculates the oscillation frequency by using the “resonant frequency of the LC tank” (ElectronicsTutorials, 2023)

Tuned amplifiers

Tuned amplifiers are made by replacing the load on an amplifier by a tuned circuit. Tuned amplifiers are good because you can select which frequencies you want and which ones you want to block out. Selection is picking out frequencies that are desired using this amplifier. Reactive components like coils and capacitors decrease the amount of power usage making tuned amplifiers efficient. (tutorialspoint, 2023)

Design method, calculations and testing (600)

Dc conditions

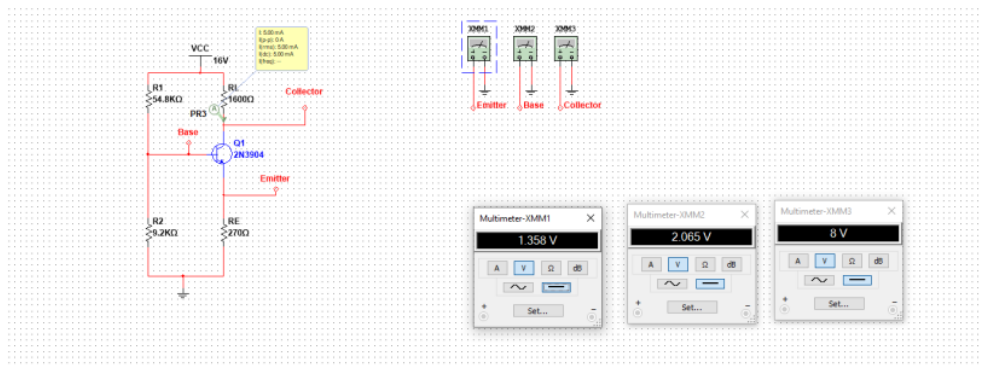


To start off VCC is 16V

Secondly, I decided on what transistor was most suitable for the circuit and I went with “2N3904”. I needed to work out the current needed for the collector so I looked at the given range which is 10 – 20 % but I changed this so I could keep the resistor values as a better value so I used a smaller percentage and got a value of 5mA.

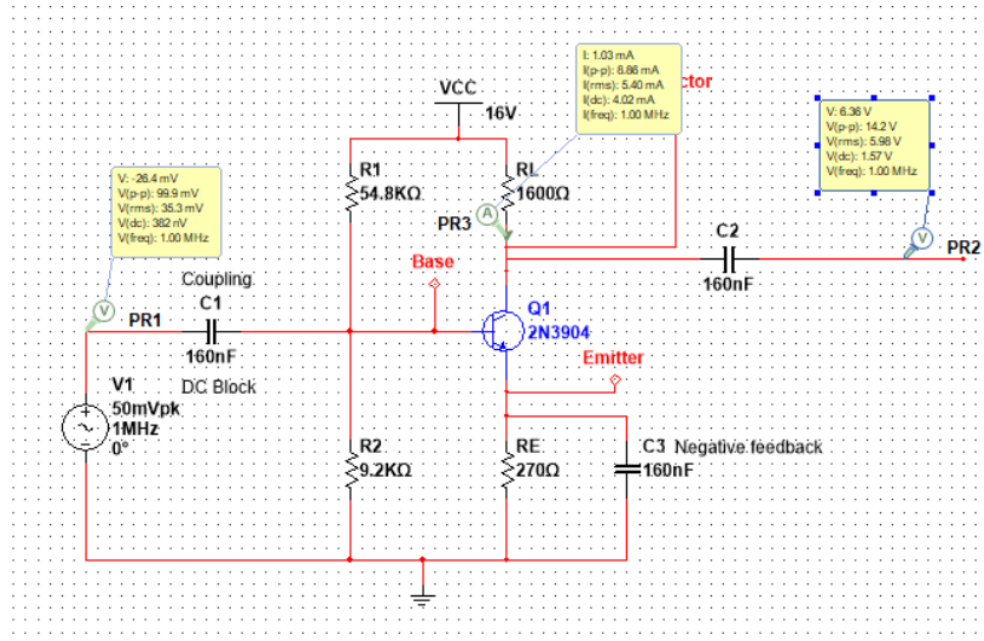
Next, I worked out the Vc, Re, Ib, Vb, IR1. R1 and R2. I changed my Re value to ensure that it was half of the VCC so that I can amplify equally higher and lower this was because of how inaccurate capacitors values are because of their HFE.

Now find the values for my capacitors so I will reformulate the Xc formula and for a low Xc at 1Mhz, I will assume $X_c = 1 \text{ Ohm}$



I tested these values with multimeters on my circuit

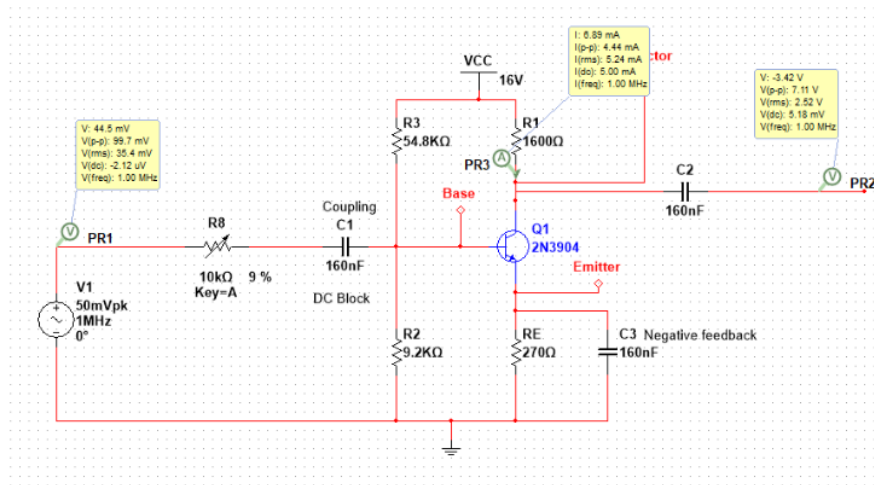
AC conditions



By here I added an AC supply, C1 (coupling capacitor) which is used to stop any sort of interference given from the transistor's bias voltage by AC signals (Anon., 2022), C2 is for coupling as well and it separates transistors for each other by giving off different voltages acting as a DC block and C3 for negative feedback so that the amplifier gives us a 180 degrees phase shift.

Adding the capacitors isolates the circuit because it's all DC, the values cant gets changed by any of the other components/values on the other side of the capacitors. Where as if it was AC, the values could be adapted by other values/components on the other sides of the coupling capacitors.

Zin



Next a 10K ohm variable resistor was added to calculate input impedance I used trial and error and it turned out it needed to be 9%. Then I did 9% of 10k = 900 Ohms

By using a variable resistor, it allows adjustments to the voltage by editing the resistance without the current getting changed

Included C4 and changed C2

$$\begin{aligned} v_{pp} &= 14.2 \\ V_{out}/2 &= 7.1 \\ VR1 &= Z_{in} \\ Z_{in} &= 900 \text{ Ohms} \end{aligned}$$

These are my calculations for C4 and the changes for C2

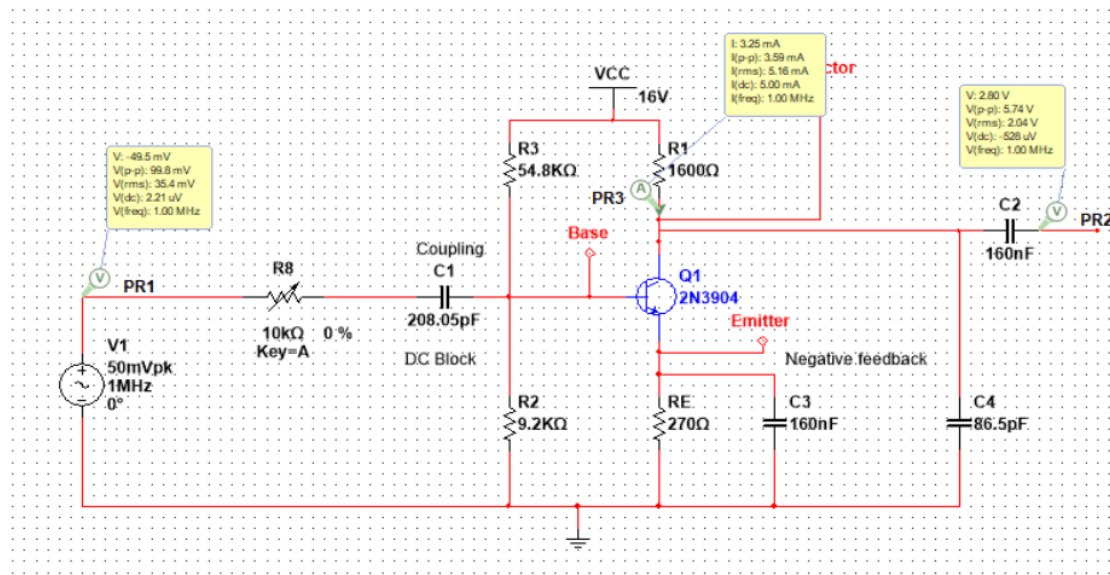
$$\begin{aligned} C &= 1/(2 \pi \times f \times X_C) \\ &= 1/(2 \pi \times 1 \times 10^6 \times 1) \\ &= 160 \text{ nF} \end{aligned}$$

C4 is used to lower the upper bandwidth

$$\begin{aligned} C2 &= 1/(2 \pi \times f_{lower} \times Z_{in}) \\ &= 1/(2 \pi \times 850 \times 10^3 \times 900) \\ &= 208.05 \text{ pf} \end{aligned}$$

C2 was used to increase the lower bandwidth

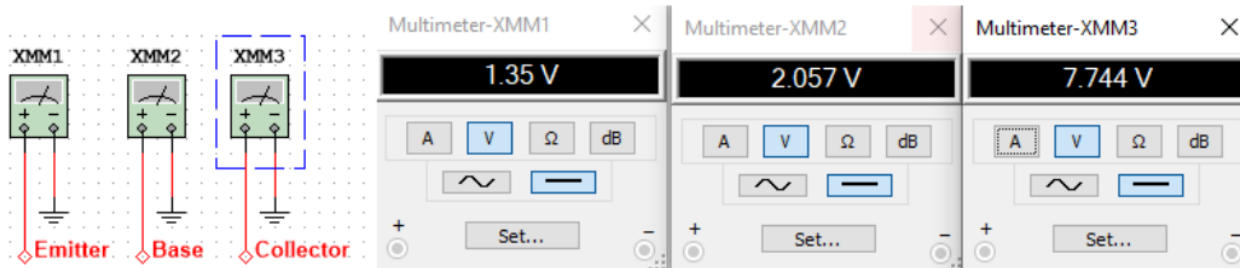
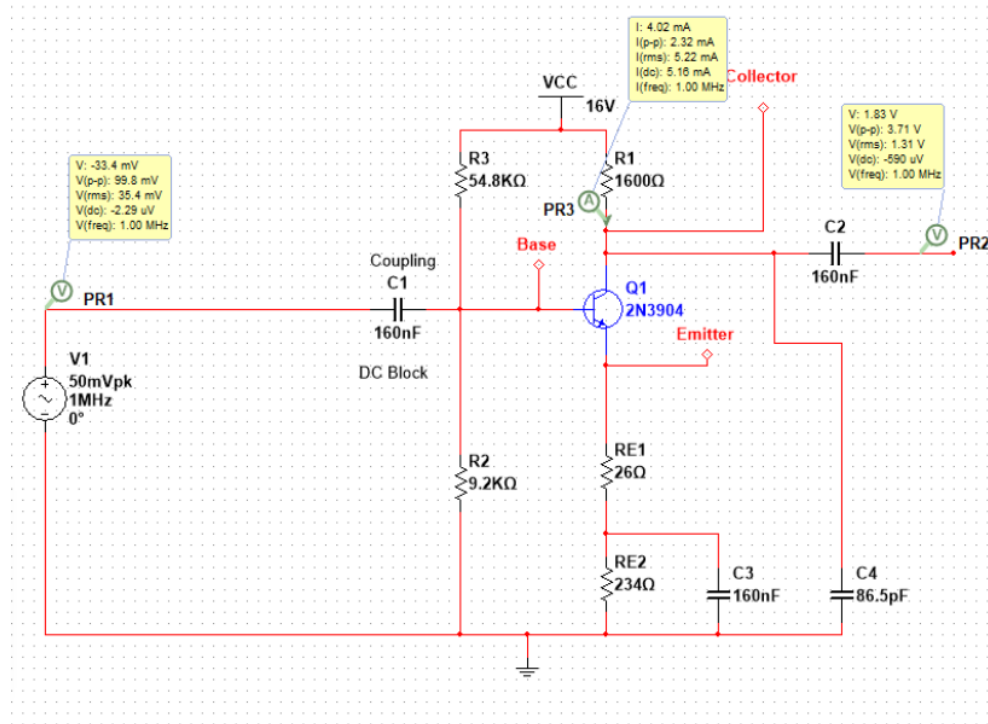
$$\begin{aligned} C4 &= 1/(2 \pi \times f_{upper} \times Z_{out}) \\ &= 1/(2 \pi \times 1150 \times 10^3 \times 1600) \\ &= 86.50 \text{ pf} \end{aligned}$$



This was done to decrease the bandwidth range as you can see in the “AC sweep” below.

Refining the design for gain

RE gain

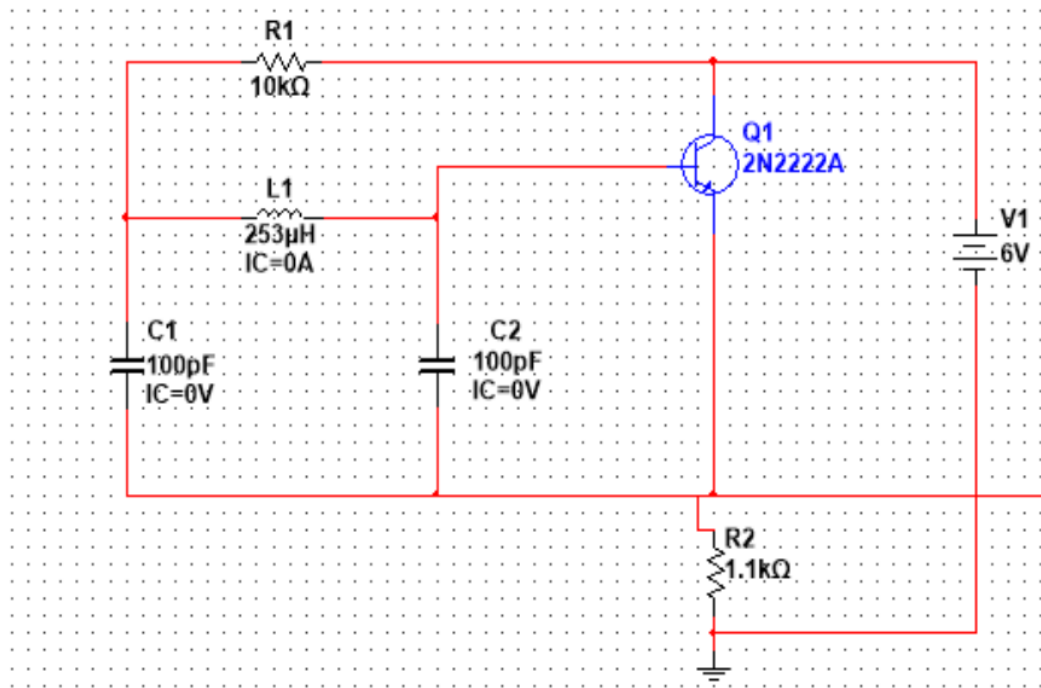


Gain = 37 – reduced from 170 gain

I brought my gain down by adding another resistor but both the resistors will need to equal the resistance of the one resistor that was there previously. I kept adjusting these until I found the gain I was looking for. – RE1 needs to be around 10% of RE2.

Designing an oscilloscope

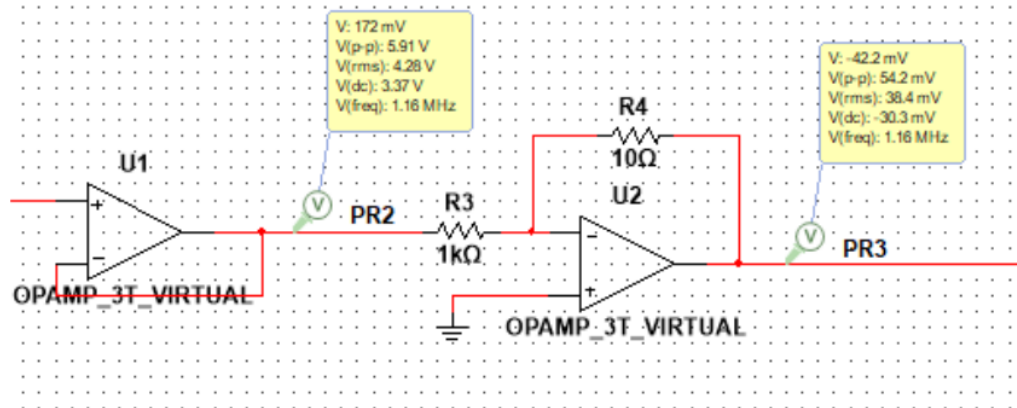
Oscillator

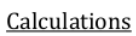


Values of L1, C1, C2 need to be adjusted for the frequency.

Build the final system

OP AMP





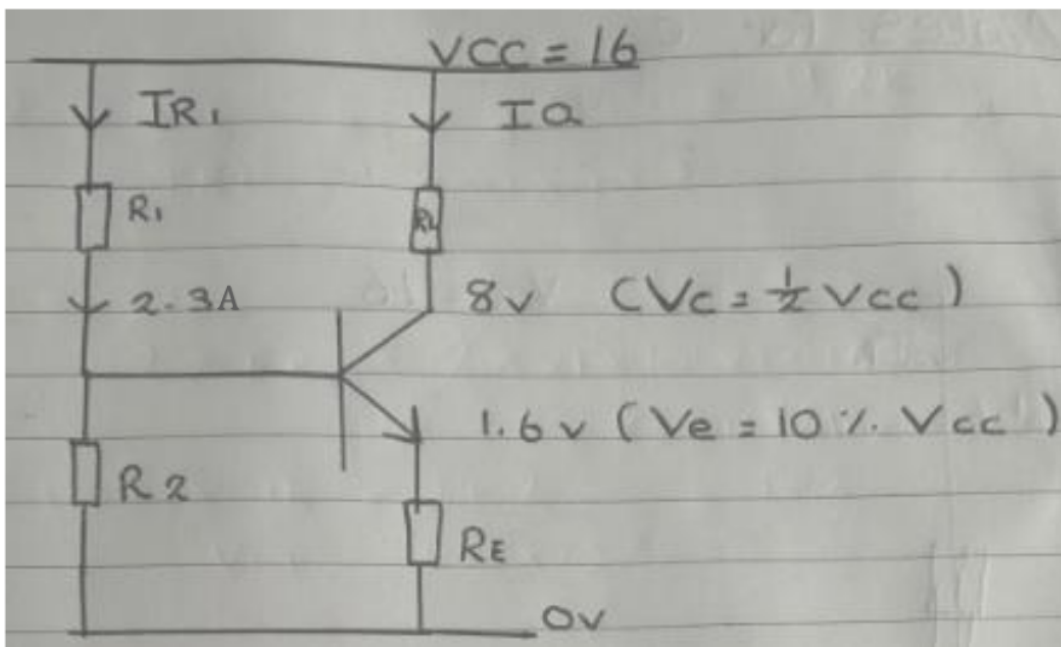
$$\therefore R_f = 100 \times 0.10 = 10 \text{ ohms}$$

Results (200)

Comparison of results table

	Calculated	Simulated
I	5mA	5.27mA
V _e (emitter)	1.6V	1.358V
V _b (base)	2.3V	2.065V
V _c (collector)	8V	8V
I _b	25uA	30.8uA

Calculations



$$I_q (A_v) \Rightarrow I_c (max) \\ 200mA$$

$$10 - 20 \% \text{ OF } I_c (max) \\ 20 - 40$$

$$\text{But use } < 10 \% \text{ (1 - 10 mA) } 5mA$$

$$V_c = \frac{1}{2} V_{cc} = 8$$

$$R_L = \frac{V_{cc} - V_c}{I_Q} = \frac{8}{5 \times 10^{-3}} = 1600 \Omega$$

$$10\% \text{ OF } V_{cc} = 1.6V$$

$$R_E = \frac{V_E}{I} = \frac{1.6}{5 \times 10^{-3}} = 320 \Omega$$

$$I_E = I_c + I_B \quad I_B = \frac{I_Q}{HFE} = \frac{5 \times 10^{-3}}{25} = 25 \mu A$$

$$HFE = \frac{I_c}{I_B}$$

$$I_B = \frac{I_Q}{HFE} = 5mA = 25mA$$

$$V_B = V_E + 0.7 = 2.3V$$

$$I_{R1} = I_B \times 10 = 250 \mu$$

$$R_1 = \frac{V_{cc} - V_B}{I_{R1}} = \frac{16 - 2.3}{250 \times 10^{-6}} = 54.8K \Omega$$

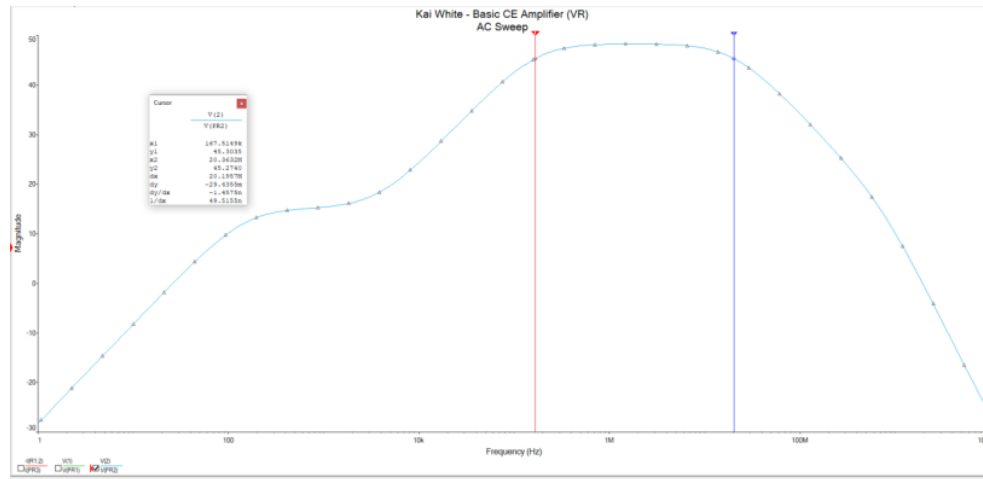
$$R_2 = \frac{V_B}{I_{R1}} = \frac{2.3}{250 \times 10^{-3}} = 9.2 \text{ k}\Omega$$

$$C = \frac{1}{2\pi f X_C} = 2\pi \times 1 \times 10^6 \times 1 = 160 \text{ nF}$$

(for low X_C at 1 Mhz assume $X_C = 1 \Omega$)

$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{14.2}{100 \times 10^{-3}} = 142$$

Bandwidth



From this "AC sweep" I calculated my bandwidth by Voltage out / Voltage in

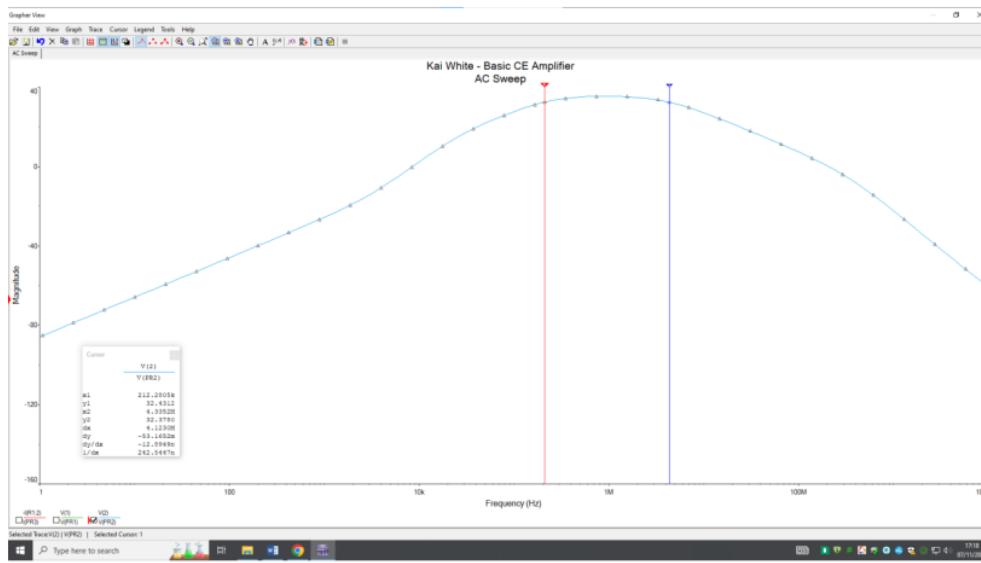
The problem with the bandwidth is that it's too wide of a scale, this can cause quite a lot of noise.

$$Dx = 20.196 \text{ M}$$

Cursor			
		V(2)	
		V(PR2)	
x1	167.5149k		
y1	45.3035		
x2	20.3632M		
y2	45.2740		
dx	20.1957M		
dy	-29.4355m		
dy/dx	-1.4575n		
1/dx	49.5155n		

This supports my calculations

But as you can see the frequency range is incredibly high so below this will be a way to decrease the range of frequency by a large amount.



Cursor	
	V(2)
	V(PR2)
x1	212.2805k
y1	32.4312
x2	4.3352M
y2	32.3780
dx	4.1230M
dy	-53.1652m
dy/dx	-12.8949n
1/dx	242.5447n

Reduced the 20MHz to 1MHz. Reducing the bandwidth stops any noise that is coming up. This is a better accuracy of readings, range and sensitivity.

You can see that the results have gone from 20M to 4M showing that reducing the bandwidth has working and give me a more accurate result.

Analysis (300)

It was successful in reducing the gain because it went from 170 to 37.

The voltage output began at 6 volts and was drastically decreased to 2.65 pV in the final circuit.

When comparing the reduced bandwidth to the bandwidth before the reduction, the results are better since the range reduction is around 5 times smaller than it was, which reduces noise.

The "comparison of results" table indicates that the transistor is simulating with the appropriate parameters. Additionally, the current is as predicted.

Still, the bandwidth is excessive.

Evaluation (300)

The main strength of this project is that the calculations were done first, so when building the circuit if the simulation calculations weren't similar to the calculations there would be something wrong with the circuit. And by seeing what calculation is wrong is good because it will help show what value/component is wrong in the circuit.

If I was to do this again I would match the labelling of components from my diagrams to multi-sim to make it easier for someone to else to understand it and make it easier to make changes in the future if needed to be.

The reduced bandwidth which was wanted was 300khz but it is 4Mhz making an inaccuracy in the readings as it is a lot larger. This was done by changing the value of c1 and adding c4. Reducing the bandwidth lowers the circuit performance so going to 300khz would damage the performance running the results. Also reducing the bandwidth means that you can use less higher frequencies.

Recommendation for if this project was to happen again is to change the values of the supply and components do see what would happen to the results and how they differ and use a tunes circuit. Also, then comparisons between the both can be drawn finding out trends about the components and values. Another recommendation could be trying to lower the bandwidth closer to 300khz.

Mainly next time it could be done in person (practically) to see what results can be obtained and how they compare.

Conclusion (300)

In conclusion, I designed and tested a small signal class A voltage amplifier. And I designed and tested an oscillator and buffer circuit to provide the amplifier with an input. Started off by calculating the initial circuit parameters on the DC conditions. Testing of the transistor was then needed to see if they matched my calculated results. Moving on to the AC components, which I needed to calculate the values of the coupling and decoupling capacitors, and then find a suitable input signal to check the gain. Then I reduced the gain by adding negative feedback and repeated all the testing again and changed components. Furthermore, the impedance needed to be found and this was done by trial and error. I then used that value to change the circuit to get as close to the needed bandwidth as I could. Next, I designed and added an oscillator and op amp buffer and combined the circuit.

Executive Summary

I created and evaluated a class A voltage amplifier for tiny signals. And to provide the amplifier an input, I created and tested an oscillator and buffer circuit. first determined the initial circuit characteristics under DC circumstances. The transistor then needed to be tested to determine if the results agreed with my calculations. Moving on to the AC components, I had to determine the coupling and decoupling capacitor values before locating an appropriate input signal to assess the gain. Then I updated the components, did all the testing, and decreased the gain by include negative feedback. Additionally, the impedance had to be discovered, which required some trial and error. Then, I applied that value.

Bibliography

Circuitglobe, 2023. *Difference Between Positive and Negative Feedback*. [Online]

Available at: <https://circuitglobe.com/difference-between-positive-and-negative-feedback.html>

[Accessed 01 02 2023].

circuits, A. a., 2023. *Amplifier Impedances*. [Online]

Available at: <https://www.allaboutcircuits.com/textbook/semiconductors/chpt-4/amplifier-impedances/>

[Accessed 1 02 2023].

CUS, E. P., 2023. *Colpitts Oscillator: working and applications*. [Online]

Available at: <https://www.elprocus.com/colpitts-oscillator-circuit-working-and-applications/>

[Accessed 01 02 2023].

Electrical4u, 2023. *What is a non inverting amplifier?*. [Online]

Available at: <https://www.electrical4u.com/non-inverting-amplifier/>

[Accessed 01 02 2023].

Electrical4u, 2023. *What is a voltage follower*. [Online]

Available at: <https://www.electrical4u.com/voltage-follower/>

[Accessed 01 02 2022].

Electrical4u, 2023. *What is an integrator op amp?*. [Online]

Available at: <https://www.electrical4u.com/integrator/>

[Accessed 01 02 2023].

Electrical4u, 2023. *what is an inverting amplifier?*. [Online]

Available at: <https://www.electrical4u.com/inverting-amplifier/>

[Accessed 01 02 2023].

electronicsnotes, 2023. *Transistor Common Emitter Amplifier*. [Online]

Available at: https://www.electronics-notes.com/articles/analogue_circuits/transistor/transistor-common-emitter-configuration.php

[Accessed 01 02 2023].

Electronicshub, 2023. *common base amplifier*. [Online]

Available at: <https://www.electronicshub.org/common-base-amplifier/>

[Accessed 01 02 2023].

electronicsnotes, 2023. *Transistor Configurations: circuit configurations*. [Online]

Available at: https://www.electronics-notes.com/articles/analogue_circuits/transistor/transistor-circuit-configurations.php#:~:text=The%20three%20different%20transistor%20circuit,dependent%20upon%20what%20is%20required.

[Accessed 31 01 2023].

ElectronicsTutorials, 2023. *The Colpitts Oscillator*. [Online]

Available at: <https://www.electronics-tutorials.ws/oscillator/colpitts.html>

[Accessed 29 01 2023].

Electronicstutorials, 2023. *common collector amplifier*. [Online]

Available at: <https://www.electronics-tutorials.ws/amplifier/common-collector-amplifier.html>

[Accessed 01 02 2023].

Physicwave, 2023. *Positive and negative feedback amplifier*. [Online]

Available at: <https://physicswave.com/positive-and-negative-feedback-amplifier/>

[Accessed 03 02 2023].

Sparkfun, 2023. *Transistors*. [Online]

Available at: <https://learn.sparkfun.com/tutorials/transistors/applications-ii-amplifiers>

[Accessed 1 02 2023].

tutorialspoint, 2023. *Tuned Amplifiers*. [Online]

Available at:

https://www.tutorialspoint.com/amplifiers/tuned_amplifiers.htm#:~:text=What%20is%20a%20Tuned%20Amplifier,a%20process%20is%20called%20Selection.

[Accessed 01 02 2023].

FINAL GRADE

GENERAL COMMENTS

Instructor

71 /100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

GRADING FORM: CSG-RUBIC

KAI WHITE

14

RESEARCH-INFORMED LITERATURE



There was very good evidence of further reading and research from credible and reliable sources. Your interpretation and understanding of the additional research was good and demonstrated a very good underlying appreciation of the subject. Your references were appropriate to the task and applied with few errors or inconsistencies. Your reference list was of an appropriate length for this assignment.

15/20

KNOWLEDGE AND UNDERSTANDING



The knowledge and understanding of the subject demonstrated by this assignment was reasonably detailed and mainly accurate. There were very few gaps in your knowledge of the basic concepts and your understanding of the higher level concepts was demonstrated to a limited degree - you could have explained in more detail how the circuit evolved. Further work – Your explanations need to be more detailed and written with a greater emphasis on critical evaluation rather than description.

13/20

ANALYSIS



Your analysis of the task was generally very good, both in class and as shown in this assignment. You have demonstrated sound critical analysis skills and your approach to the task was logical. You carried out a detailed evaluation of the results and included a good conclusion relating the practical results to researched theory. The conclusions demonstrated very good cognitive skills and the ability to interpret quantitative and qualitative data without error.

14/20

PRACTICAL APPLICATION AND DEP.



Your application of practical skills for this task was generally good. You used the resources available appropriately when designing the circuit and you

15/20

used appropriate options for testing and evaluating the circuit performance. You managed to design an efficient circuit that functioned within the specification and achieved this by only asking for assistance when appropriate. Your results were comprehensive and allowed for a good conclusion to be attempted.

SKILLS FOR PROFESSIONAL PRAC.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was generally good and contained most of the required detail, it was also written in a coherent and logical way. The available word count was in the main effectively used. Avoid using personal pronouns in any section of the report.

14