UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

ANALOG ELECTRONICS ENE310

PRACTICAL 3 LECTURE

Colpitts, Hartley and Clapp Oscillators

Wednesday, 25 May 2020

Introduction

In this practical students need to

1) design and simulate an LC oscillator. *Two approaches are required*. Students are assigned a Hartley, Colpitts or Clapp oscillator, and

2) design and simulate to any opamp based multivibrator, triangular wave or sawtooth wave generator of their choice.

A document that provides the assignments is given on ClickUp

Part 1: LC OSCILLATORS
- Engineering Problem Statement (1)

The LC oscillators should be designed according to the following requirements.

- An op-amp should be used.
- Power supply rails of $\pm 5V$ should be used.
- A close to full-swing output is expected.
- A “pure” sinusoidal output.

Part 1: LC OSCILLATORS
- Engineering Problem Statement (2)

- Every student will be given a frequency between 50 kHz and 300 kHz:
- There is no limit on the number of components.
- The use of oscillator support circuits (filters, etc.) are encouraged.
- No oscillator crystals or IC oscillators are allowed.

Part 1: LC OSCILLATORS - Engineering Problem Statement (3)

- Part 1: Follow the preparation steps (slides 6, 7 and 8) for a standard inverting amplifier based oscillator. An example circuit diagram is given in the final slide of the lecture slides, and on slide using *your* assigned Pi network.
- Part 1: Repeat all the steps of the standard oscillator above for the modified network of slide 9.
- Part 2: Follow the steps of slide 10.

Part 1: LC OSCILLATORS
- Design and simulation implementation

- Derive an expression for the resonant frequency in terms of the LC components of the Pi network configuration.
- Determine the component values that will give the specified resonant frequency.
- Derive the feedback factor (β) for the chosen oscillator configuration.
- Determine the amplifier gain which will satisfy the Barkhausen criteria.
- Simulate the oscillator.

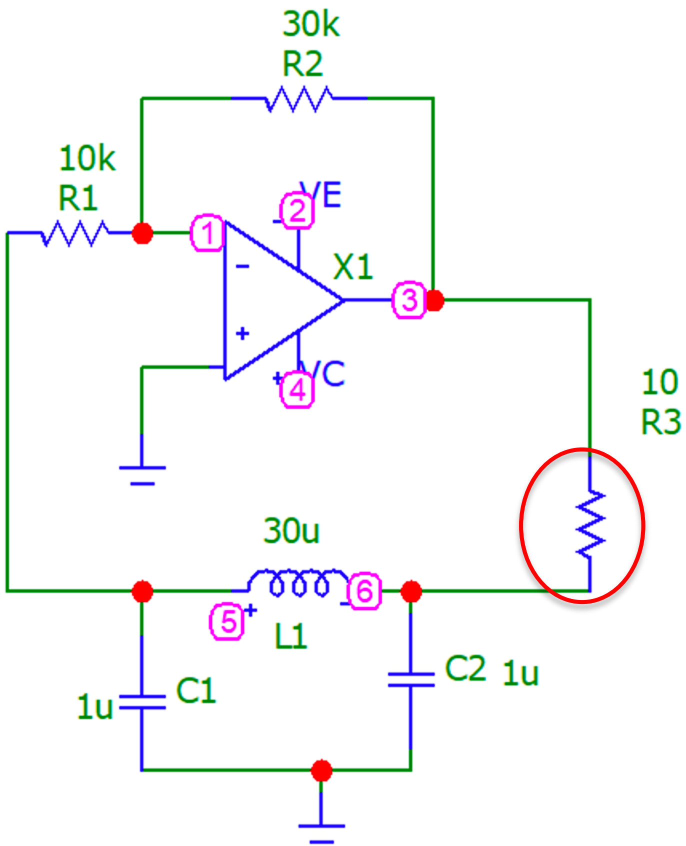
Part 1: LC OSCILLATORS
- Simulation results

- Do a transient analysis. What is the frequency of the signal?
- Do an FFT analysis to see if there are any other harmonics in the output.
- Determine the total harmonic distortion (THD) of the circuit. What happens when the gain is increased?
- Use simulations to investigate the effects of component tolerances. Simulate a version of your circuit that uses E6 resistors and E12 capacitors and discuss the effect on the resonant frequency.

Part 1: LC OSCILLATORS
- Analysis of results

- Compare your theoretical and simulation data. Discuss.
- Calculate the effects that component tolerances have on the resonant frequency (% change in C → % change in fp), which was measured in simulation.
- Discuss the relationship between Barkhausen's criterion and the amplifier gain.
- Discuss the relationship between clipping, distortion and feedback/gain.

Part 1: LC OSCILLATORS
-Investigating the output amplitude



Investigate your output amplitude when adding a resistor in the feedback path. How does the output change? Does if affect the oscillating frequency?

Part 2
- Implement a multivibrator, triangular wave or sawtooth wave generator

- You can choose any design from the textbook or from other sources.
- The oscillating frequency should be the same as the frequency you are given for the LC oscillator.
- Simulate and show the output in the time and frequency domain.
- You do not have to investigate component tolerances.
- What is the THD of your output signal? Explain the difference compared to that of your LC Oscillator.

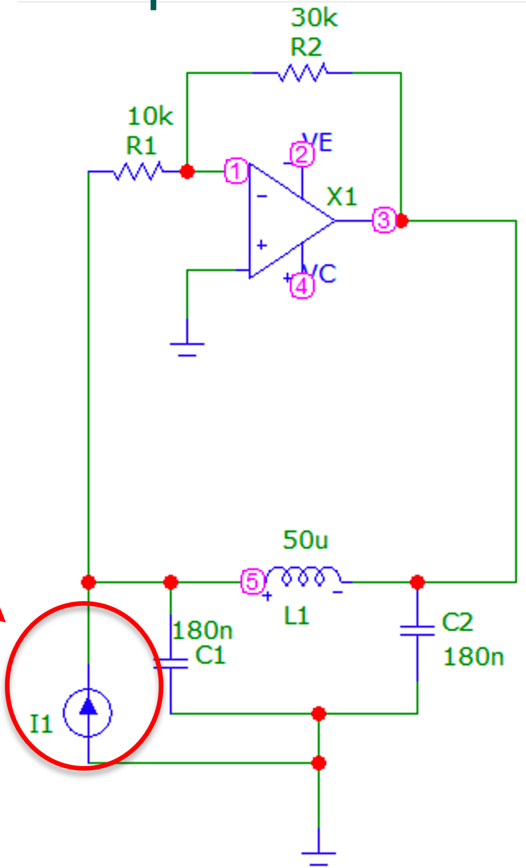
LC OSCILLATORS

- Simulating an Oscillator

Tips and tricks: In real life oscillators start up on their own due to a non-zero output voltage caused by thermal noise. In simulation there is no noise source causing the oscillation to start up. To overcome this one might need to add a disturbance into the simulation. This can be done by using a pulsed source in the simulation. Just ensure that after the disturbance is off that it no longer affect the circuit.

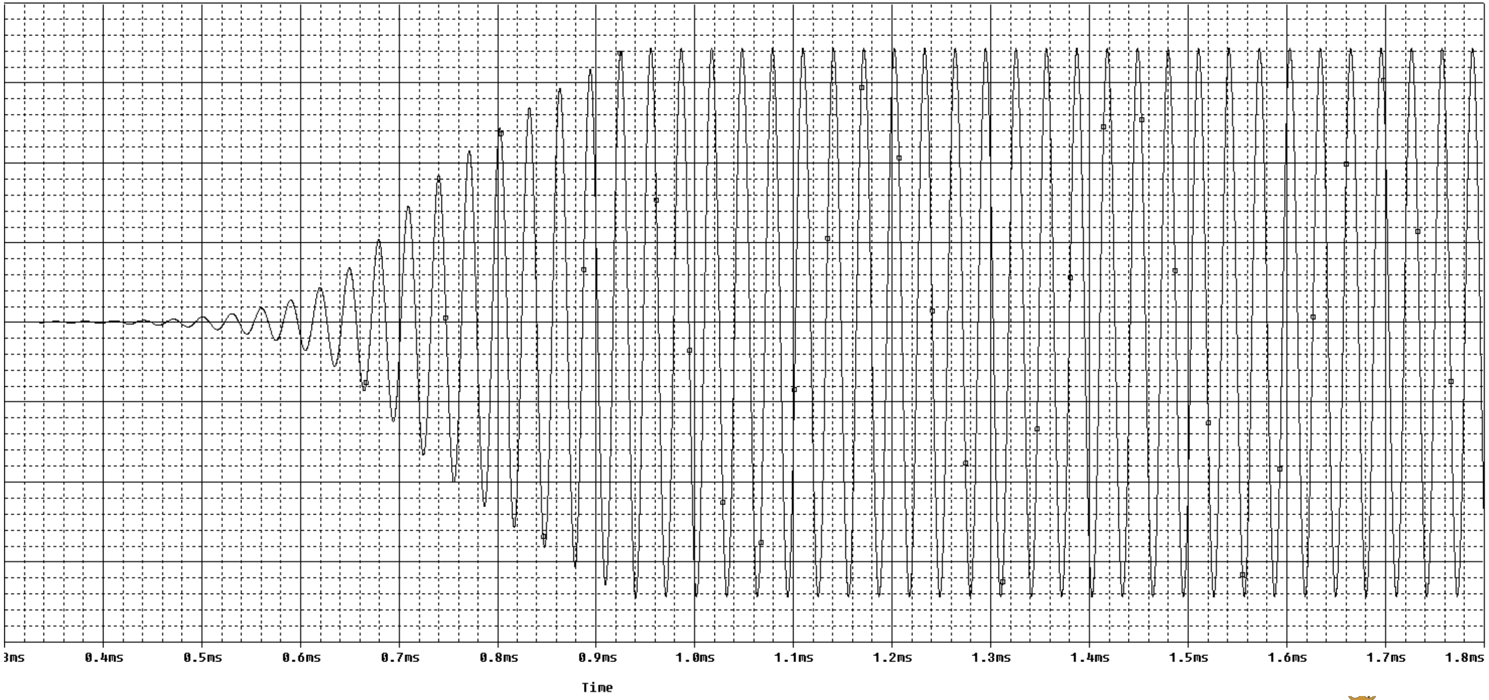
LC OSCILLATORS
- Oscillator with a start up disturbance

This is the disturbance added to cause the circuit to start. The disturbance can be applied anywhere. Think carefully about when it should be a voltage or a current source.



LC OSCILLATORS

This is was the start up of the oscillator looks like. Make sure the time span of your simulation is long enough so that you you see the full voltage swing of your amplifier.



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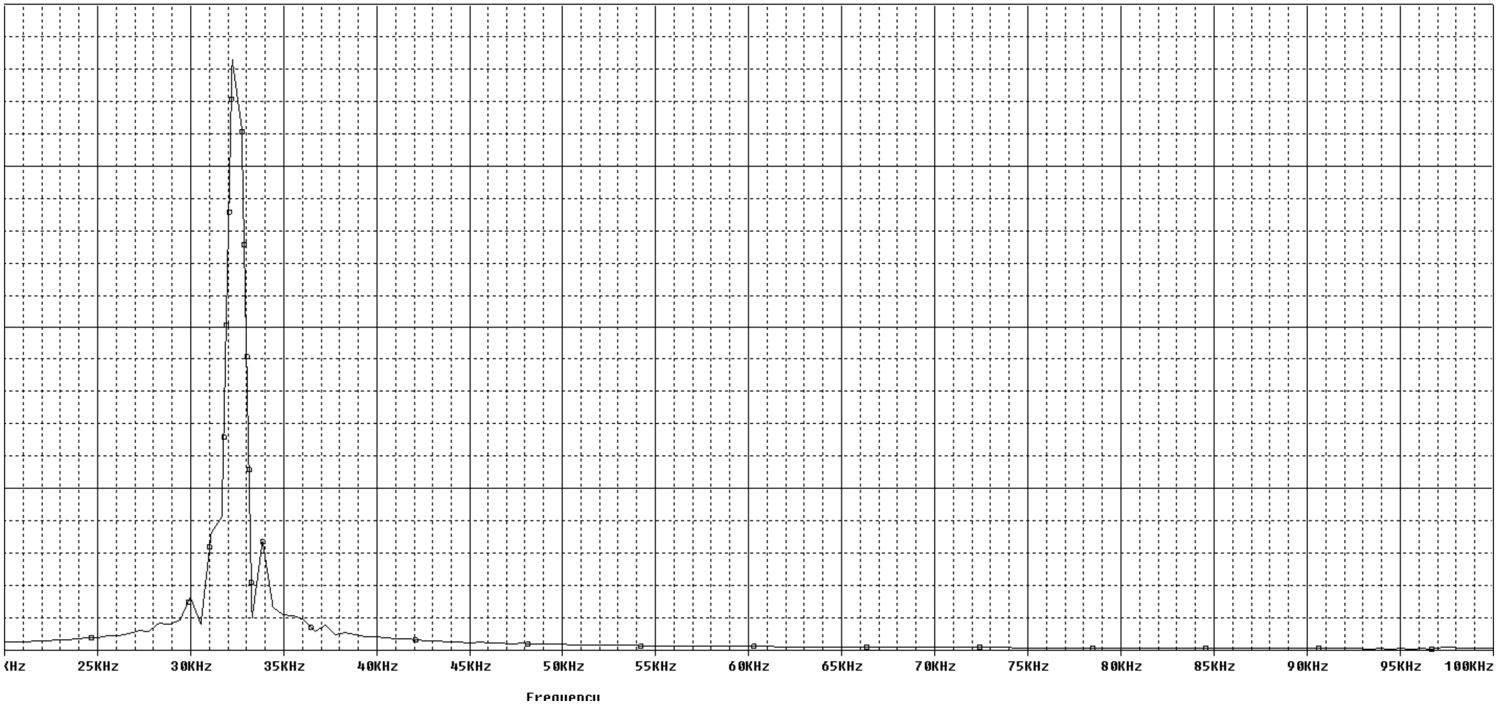
LC OSCILLATORS
- The output of the oscillator in the frequency domain



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LC OSCILLATORS
- Report (1)

- Title page
- Table of contents
- Abstract/Introduction
- Design objectives
- Detail design
- Results
- Discussion
- Conclusion
- References
- Appendix Questions

Due dates

The report is due on the15th of June.

Questions?

Post questions to the Lab 3 forum of the discussion board.