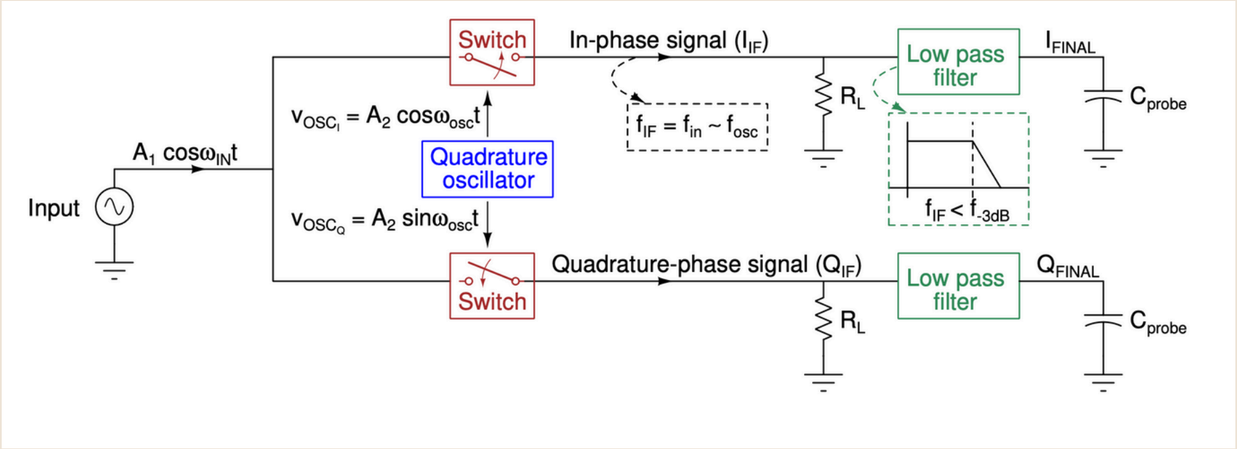
EC2.103 AEC
PROJECT

BOMBASTIC BABOONS

QUADRATURE DOWN CONVERTER

INTRODUCTION

A Quadrature Down Converter (QDC) is an essential block in modern wireless receivers like Bluetooth and Wi-Fi. It converts a high-frequency input signal into two lower-frequency signals—the in-phase (I) and quadrature-phase (Q) components—using a quadrature oscillator. These components have a 90° phase difference and are obtained by mixing the input with cosine and sine oscillator signals. This downconversion technique improves interference rejection and enhances signal clarity. The mixed signals are passed through low-pass filters to extract the intermediate frequency (IF). Our project involves designing and implementing a prototype of the QDC using LTSpice as per given specifications.

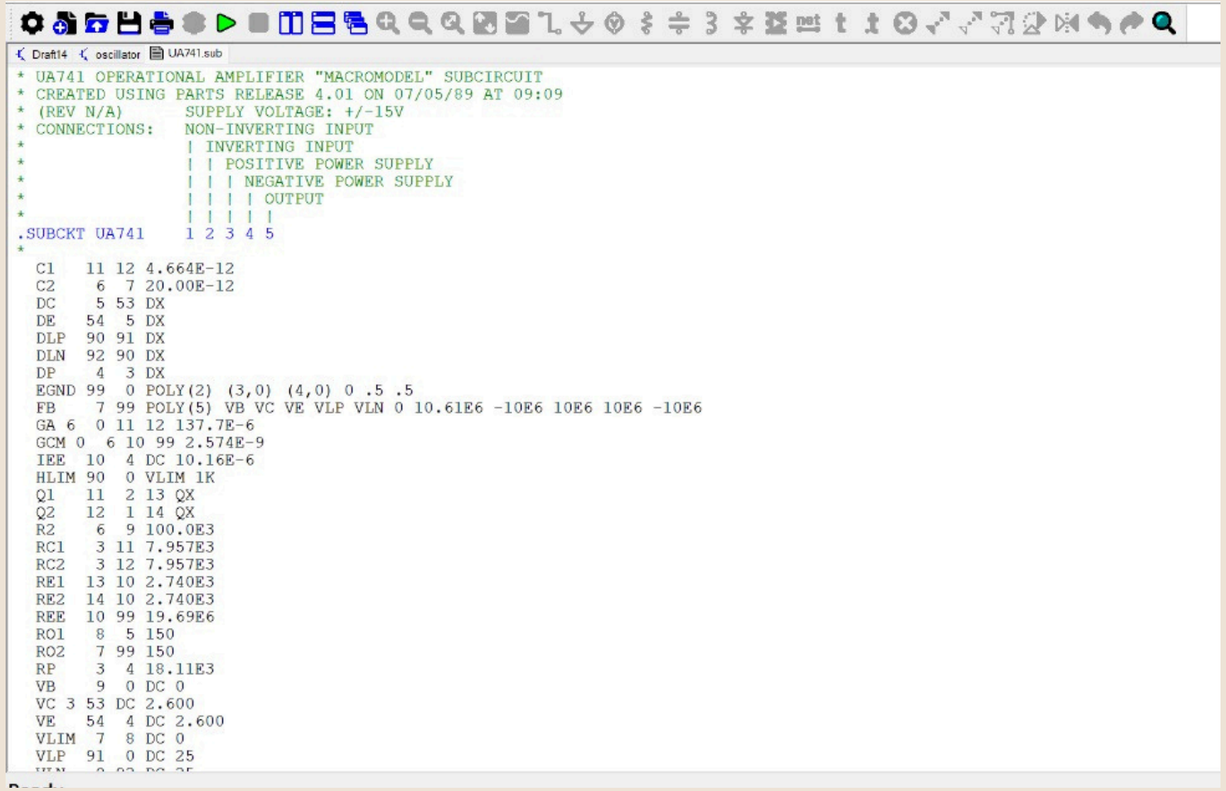


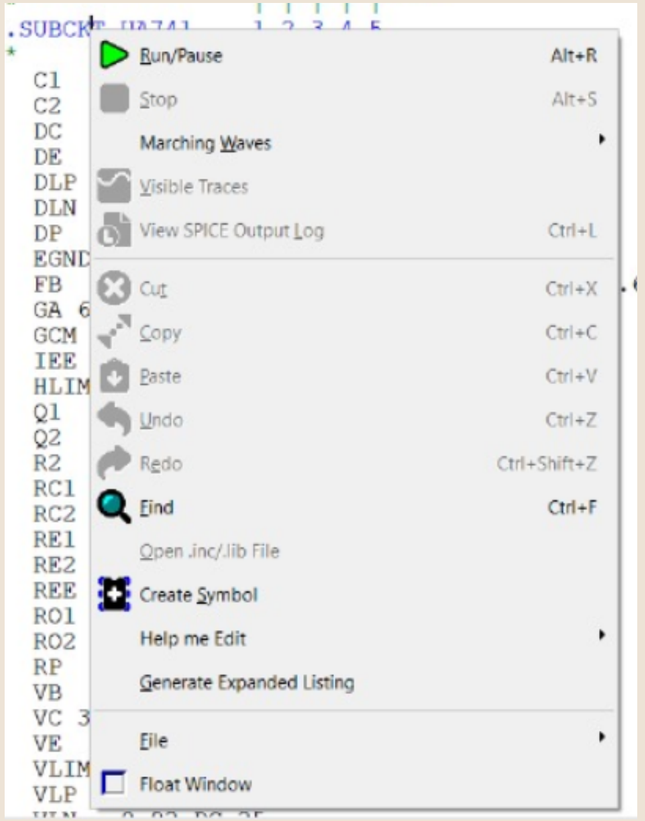
EC2.103 AEC
PROJECT

OSCILLATOR

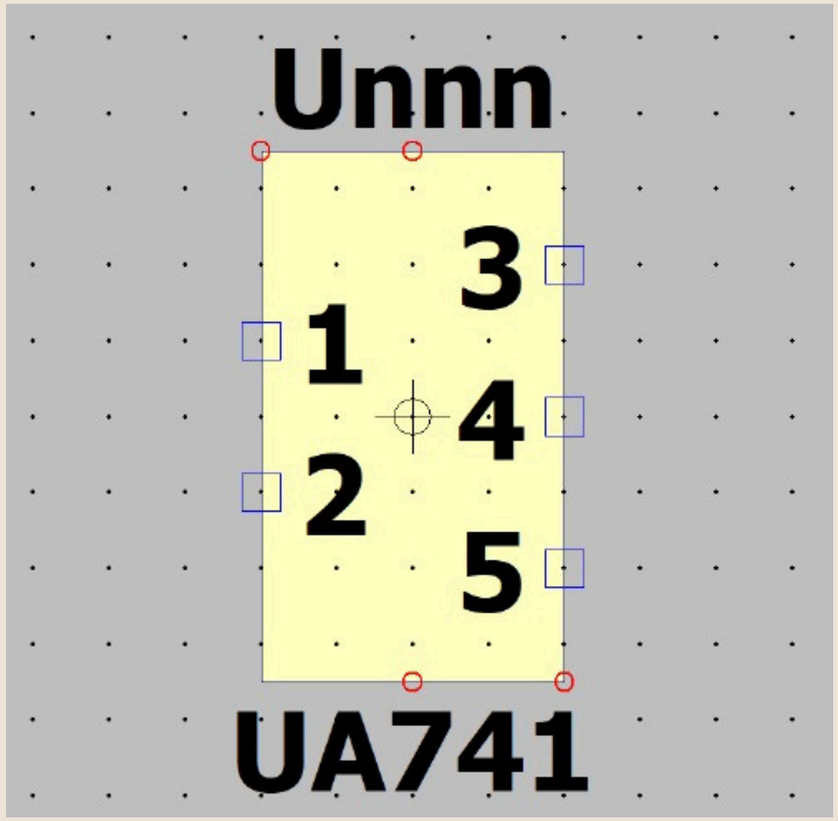
EC2.103 AEC
PROJECT

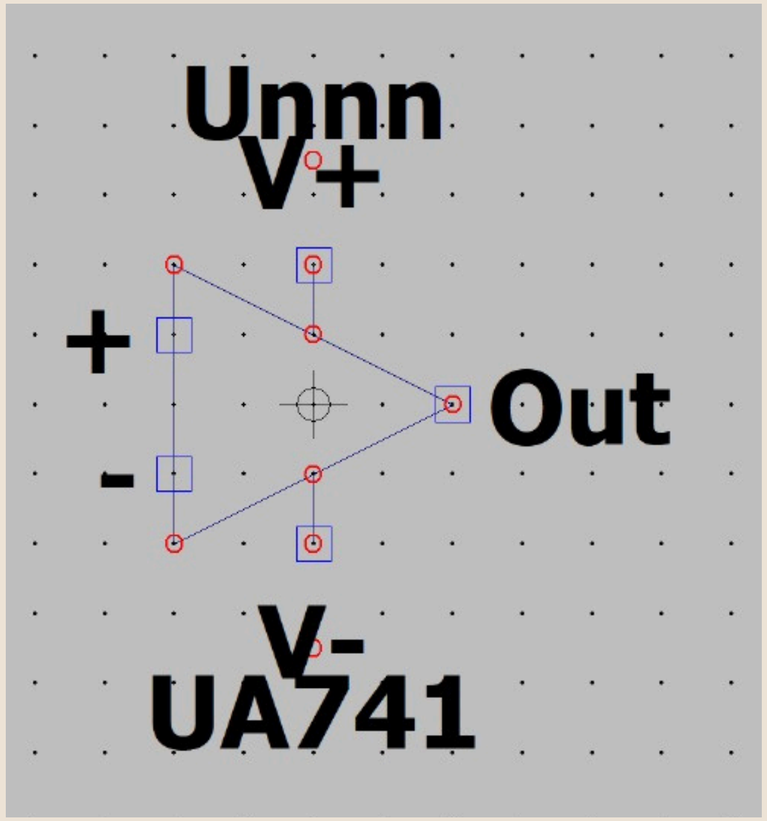
OPAMP SYMBOL



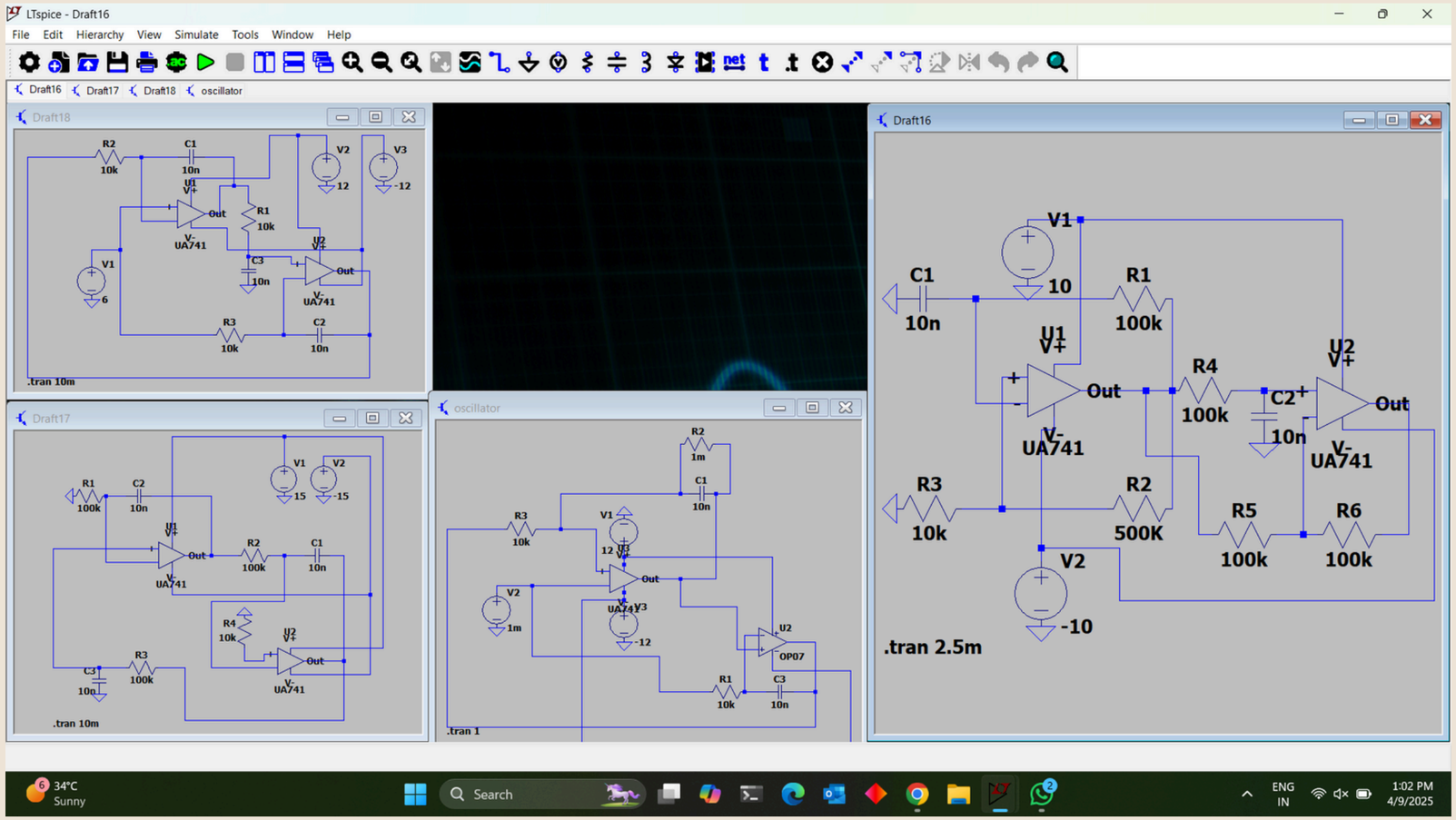


OPAMP SYMBOL

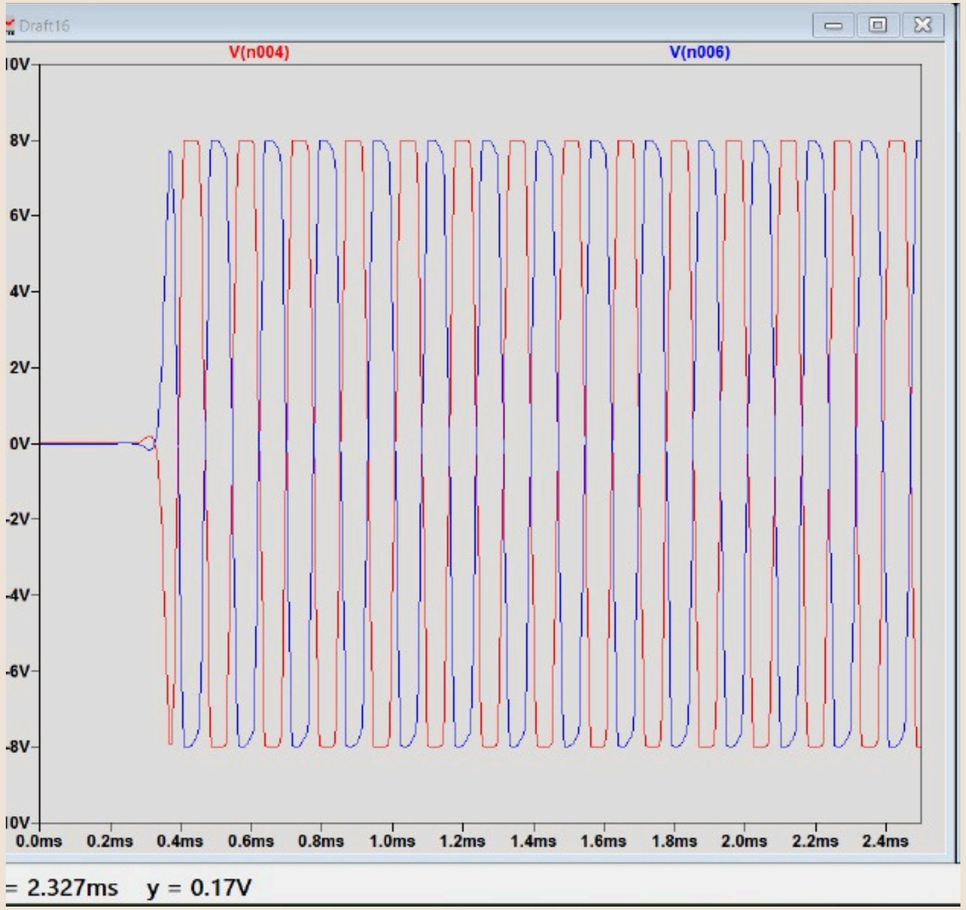


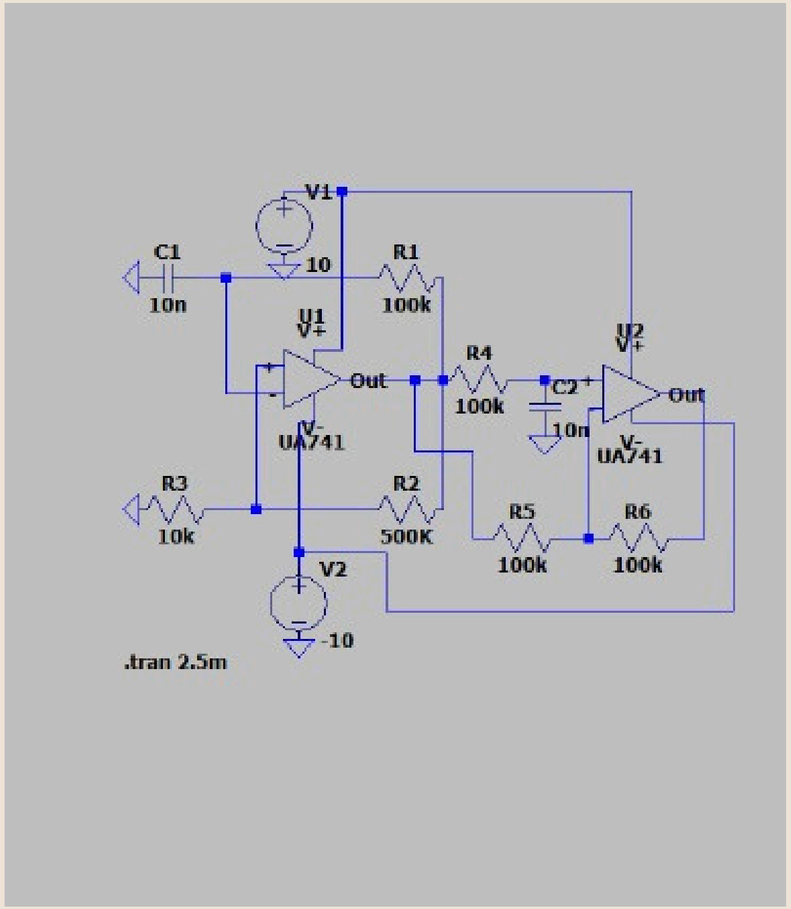


CIRCUITS TRIED



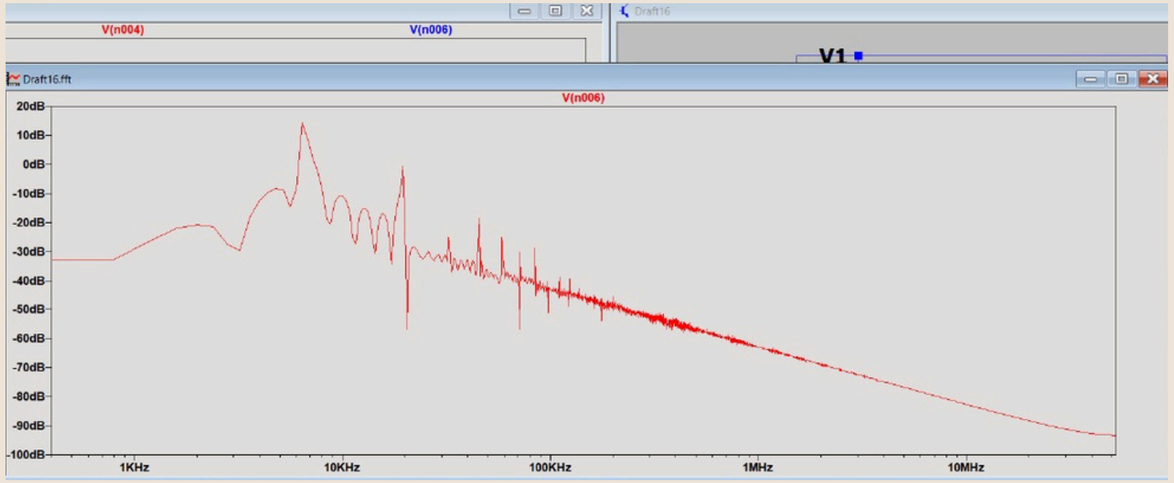
OUTPUT FORM

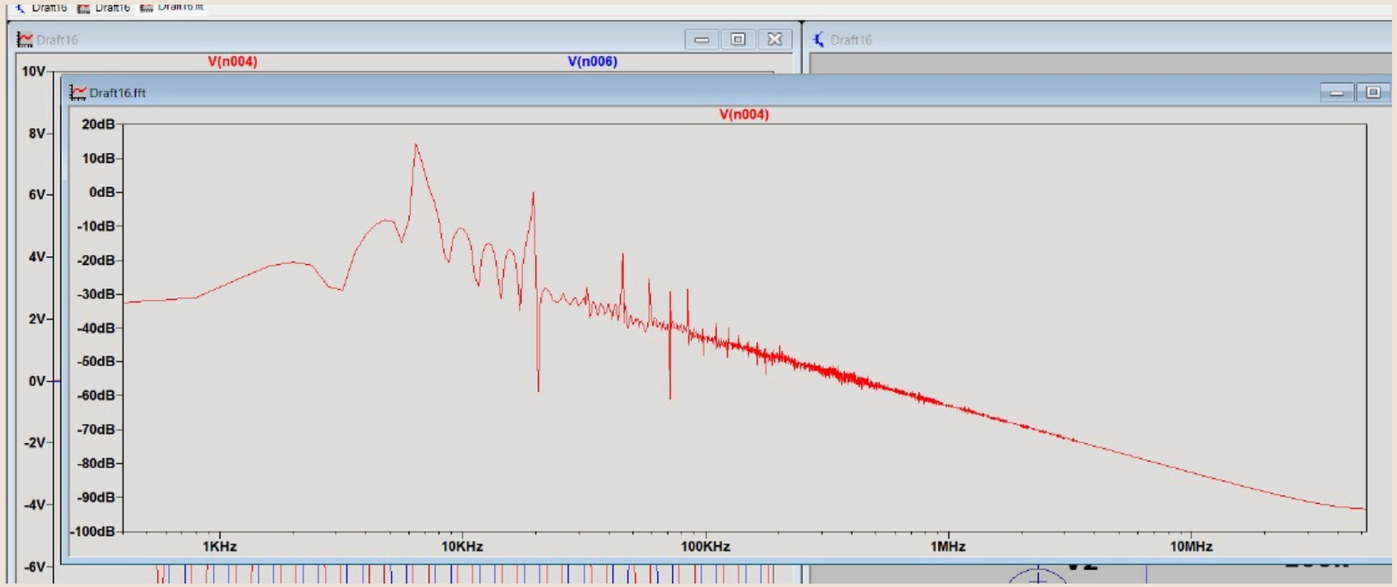

Draft16
V(n004)
V(n006)
10V
8V
6V
4V
2V
0V
-2V
-4V
-6V
-8V
-10V
0.0ms
0.2ms
0.4ms
0.6ms
0.8ms
1.0ms
1.2ms
1.4ms
1.6ms
1.8ms
2.0ms
2.2ms
2.4ms
= 2.327ms y = 0.17V


V1
10
C1
10n
R1
100k
U1
V+
Out
V-
UA741
R4
100k
C2
10n
U2
V+
Out
V-
UA741
R3
10k
R2
500K
R5
100k
R6
100k
V2
-10
.tran 2.5m

EC2.103 AEC
PROJECT

FFT FOR V1, V2





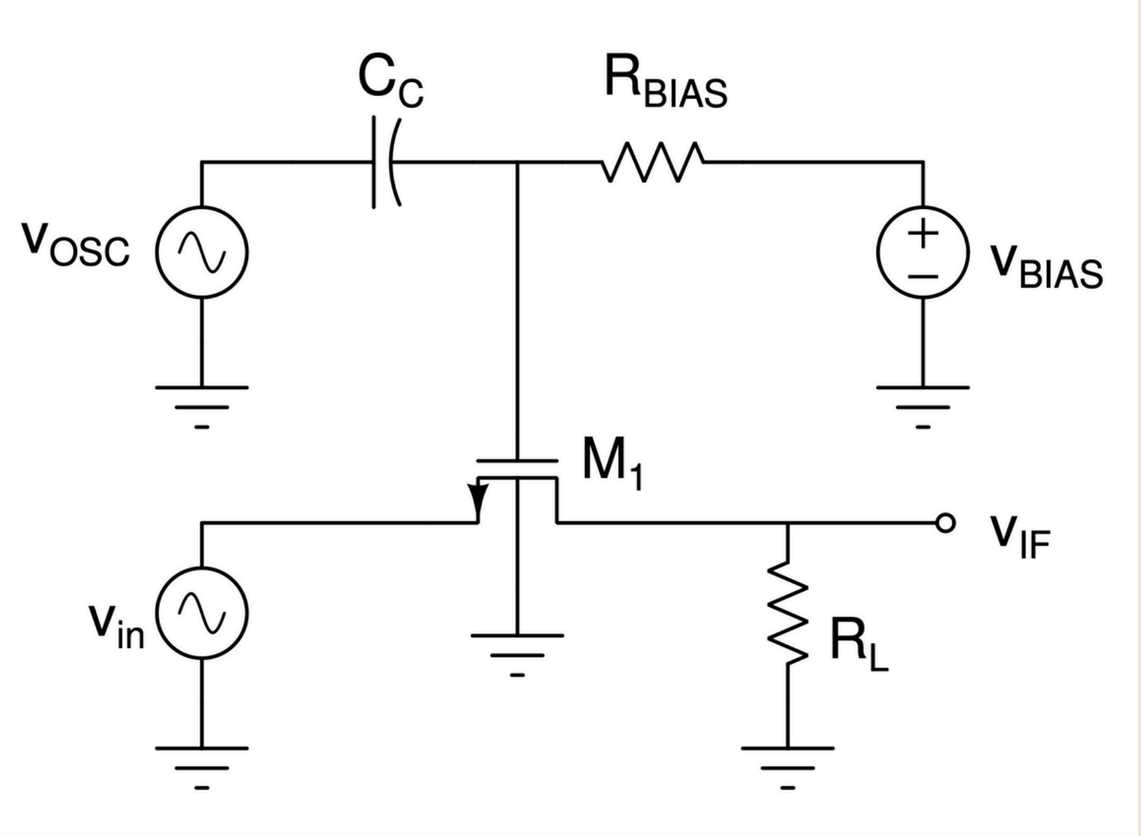
EC2.103 AEC
PROJECT

SWITCH (MIXER) DESIGN

EC2.103 AEC
PROJECT

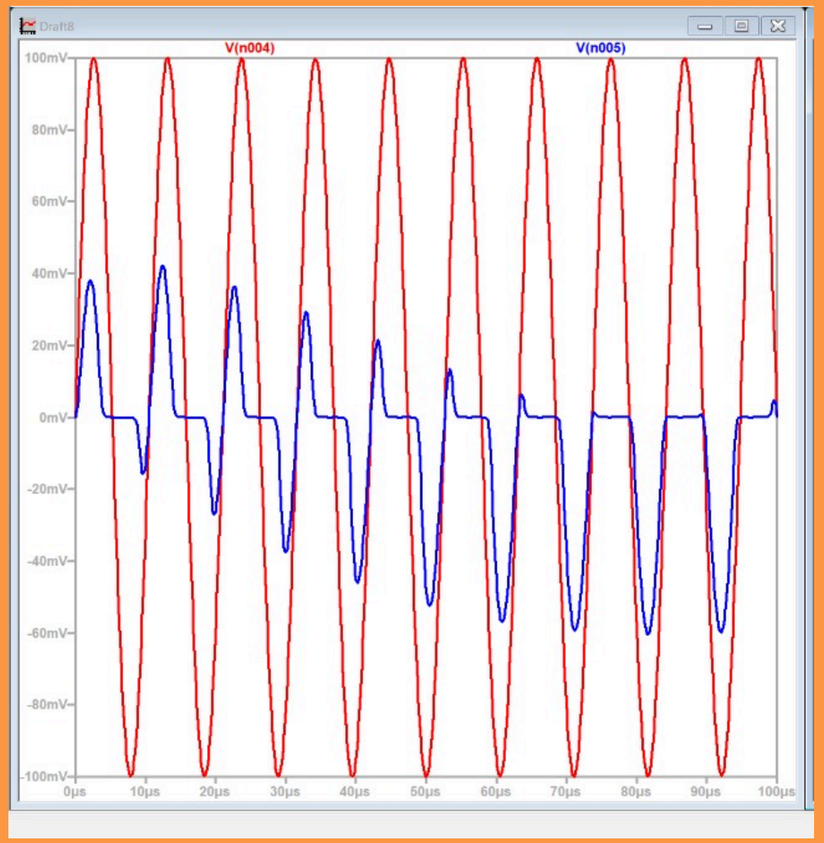
SWITCH (MIXER) DESIGN

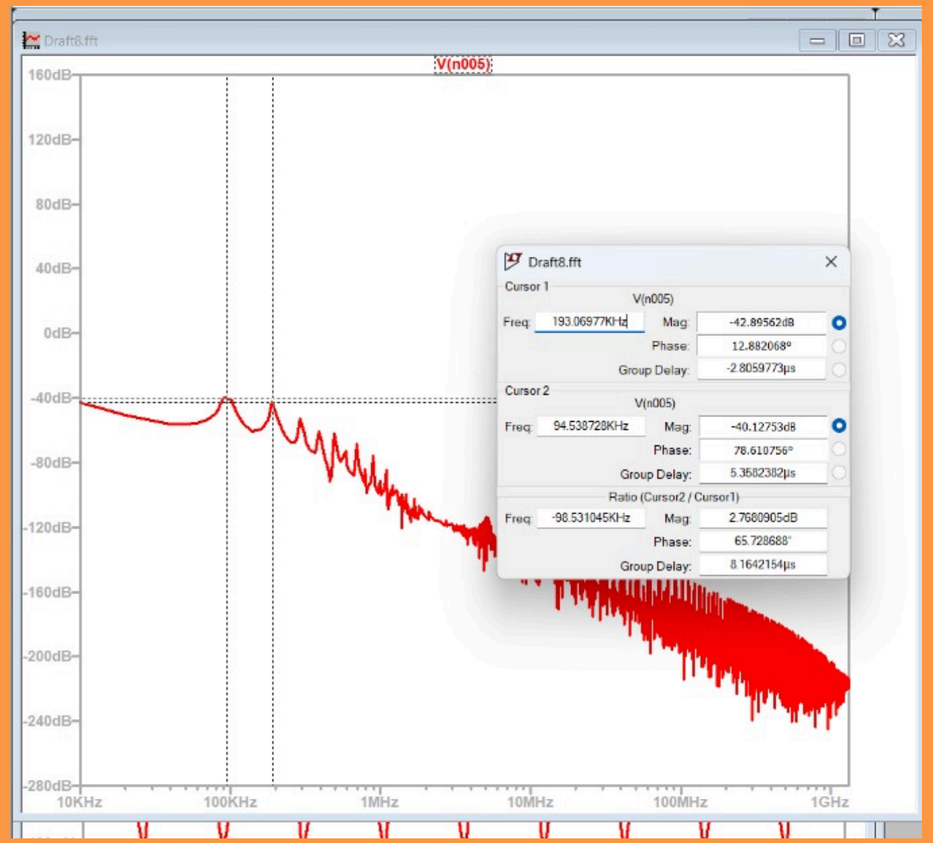
In this section, we design a mixer using an NMOS transistor acting as a switch. The oscillator signal is applied at the gate, the input signal at the source, and the intermediate frequency (IF) output is taken from the drain. The mixer multiplies the input with the oscillator signal, producing sum and difference frequency components. A low-pass filter is later used to extract the desired IF signal. This simple yet effective design is implemented and analyzed using LTSpice simulations (for now).

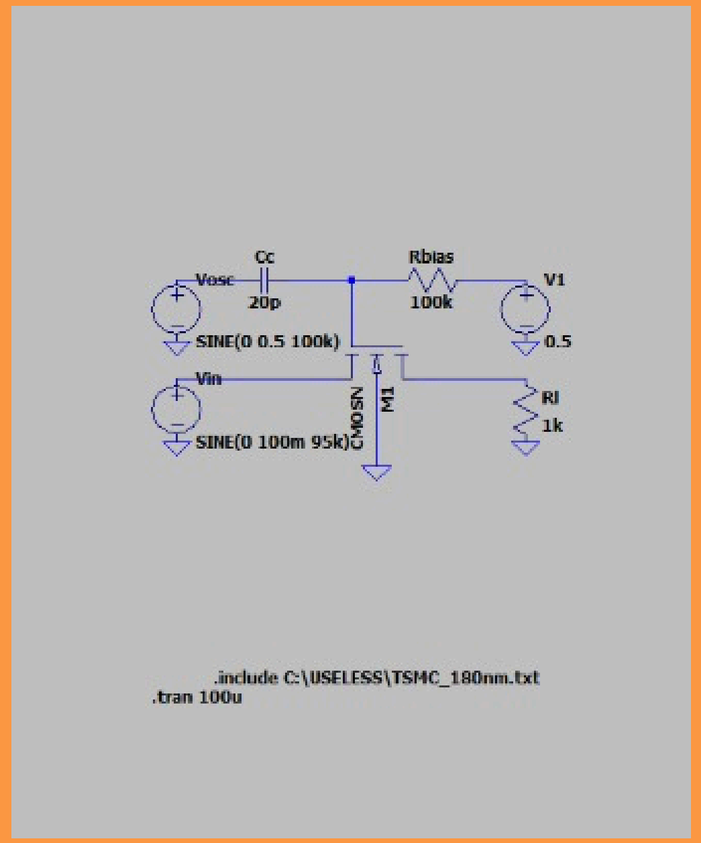


EC2.103 AEC
PROJECT

F_{IN} = 95K

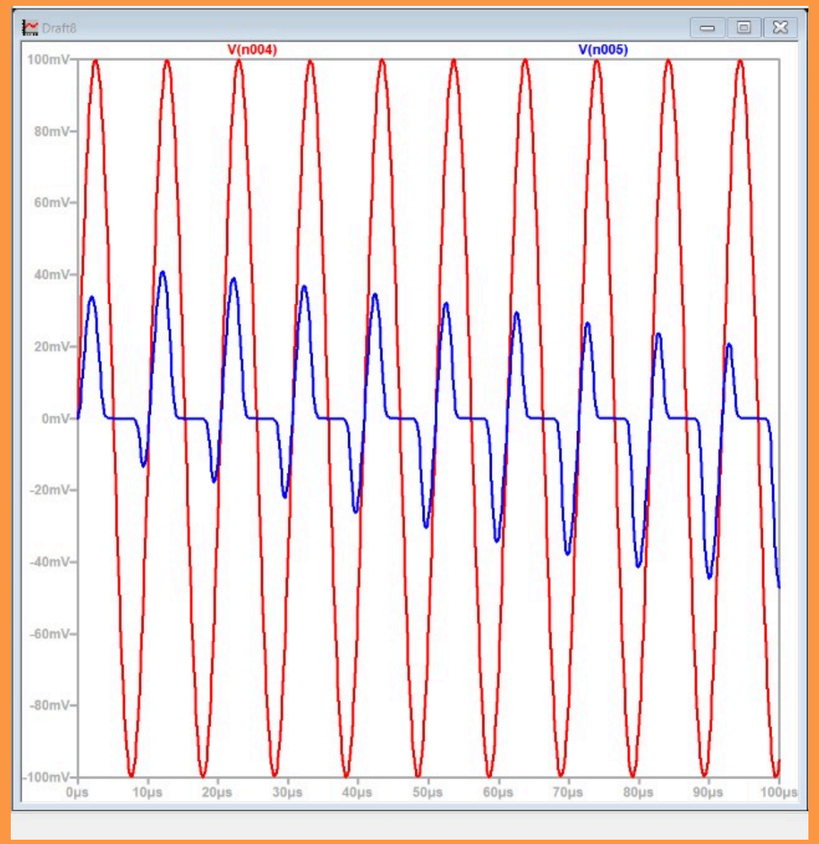


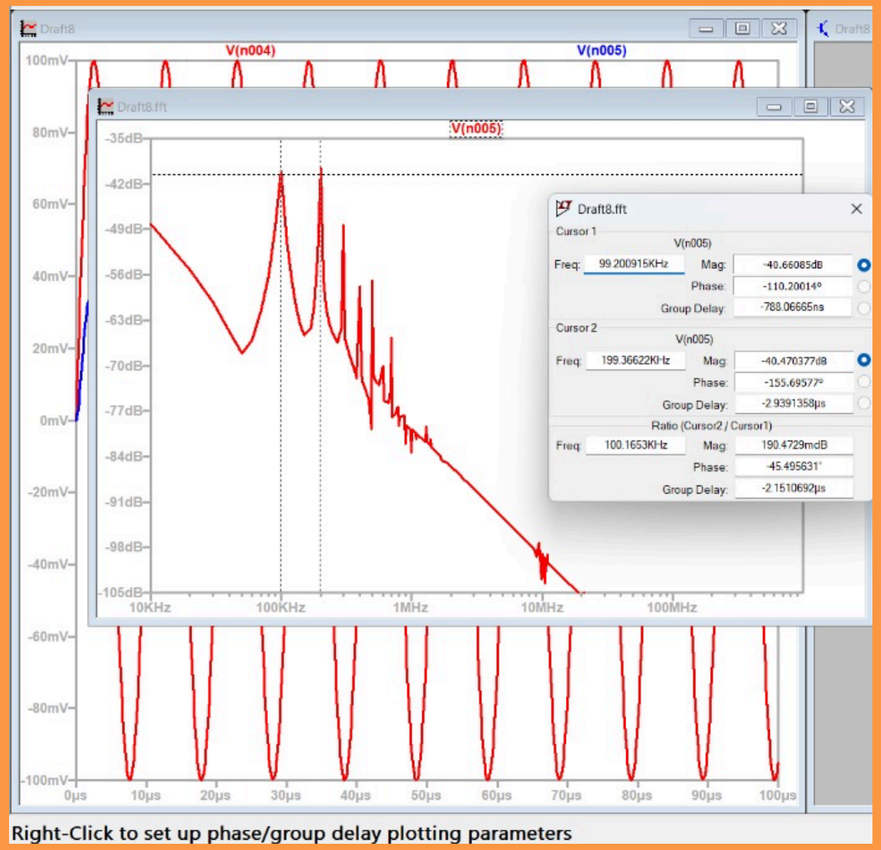


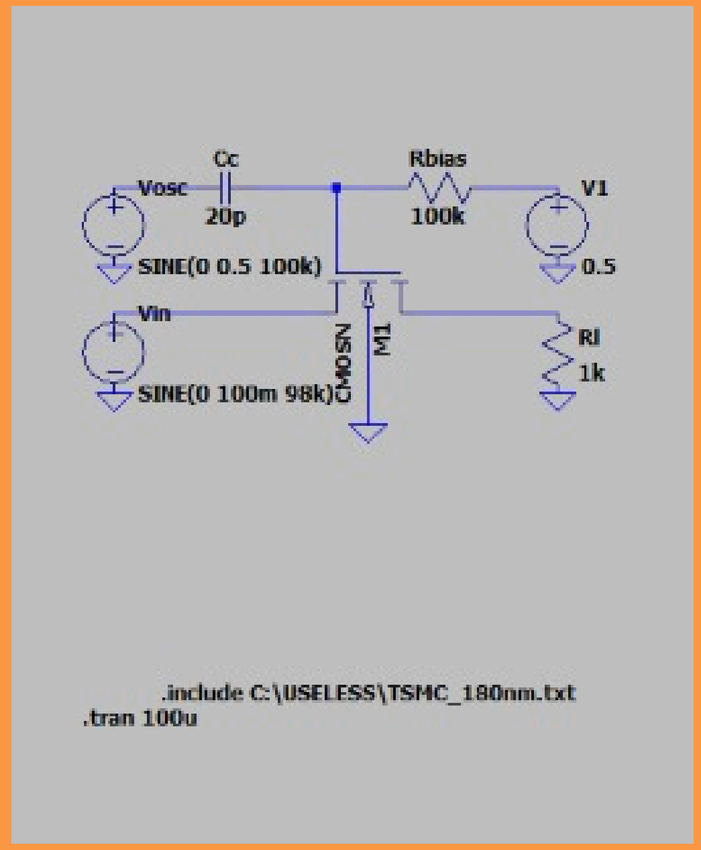


EC2.103 AEC
PROJECT

F_{IN} = 98K

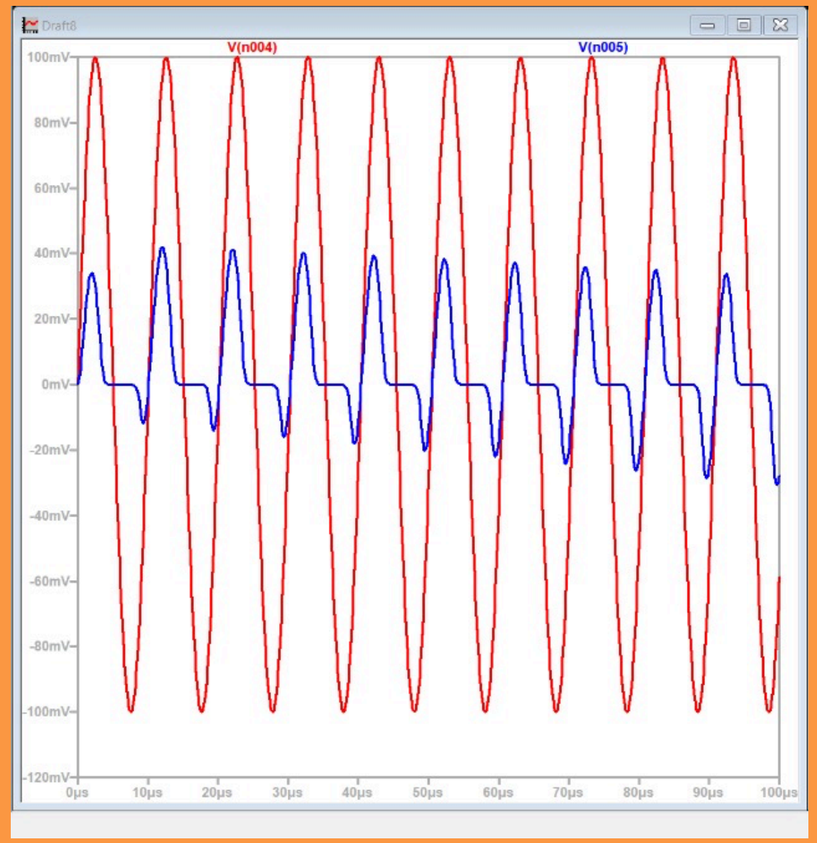


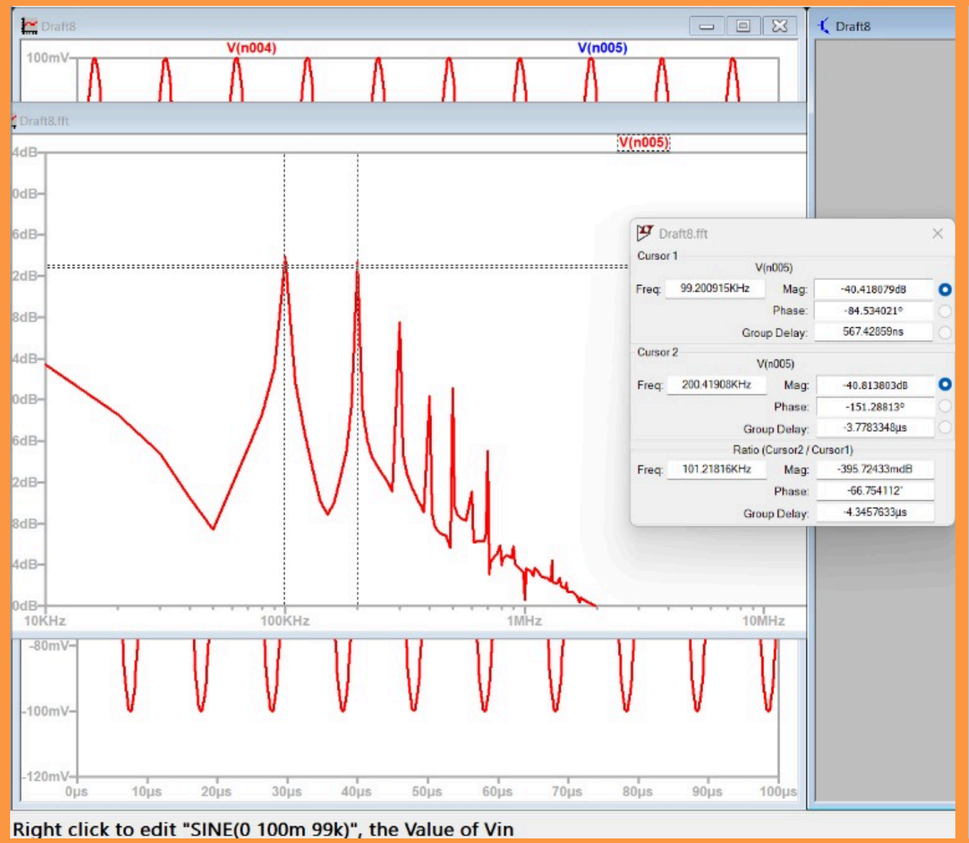


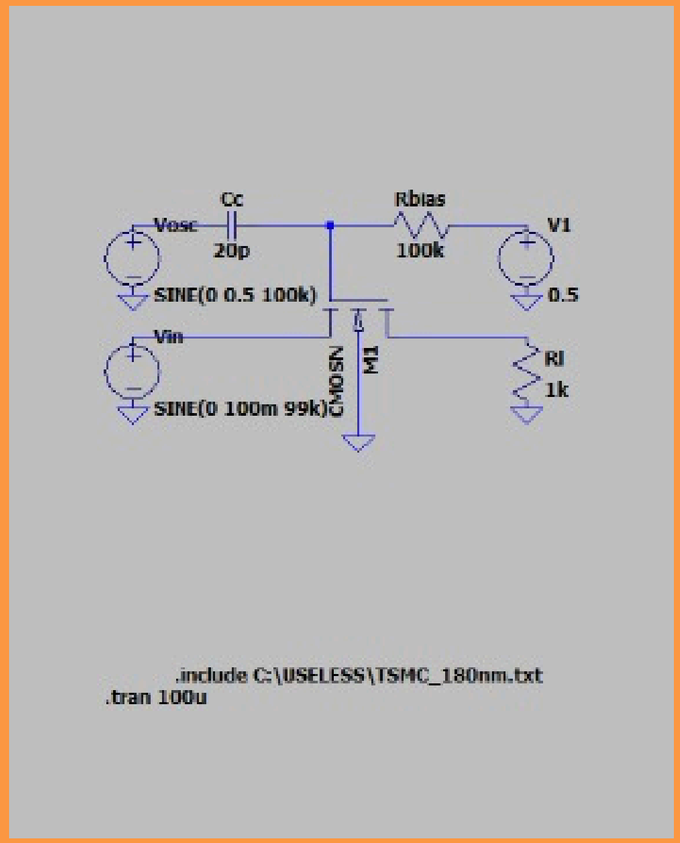


EC2.103 AEC
PROJECT

F_{IN} = 99K

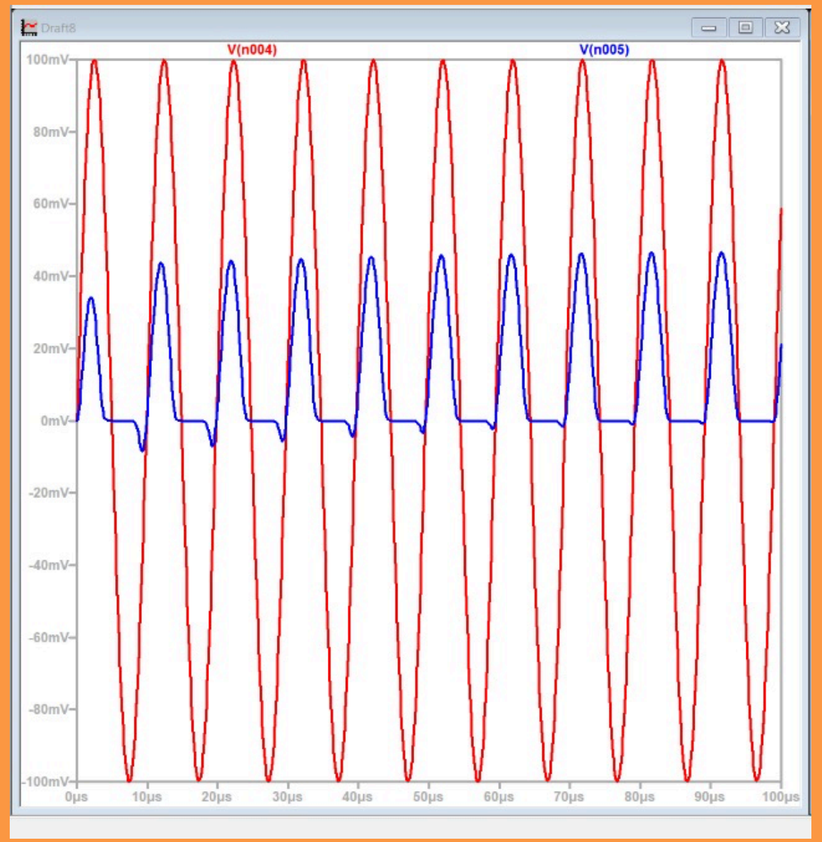


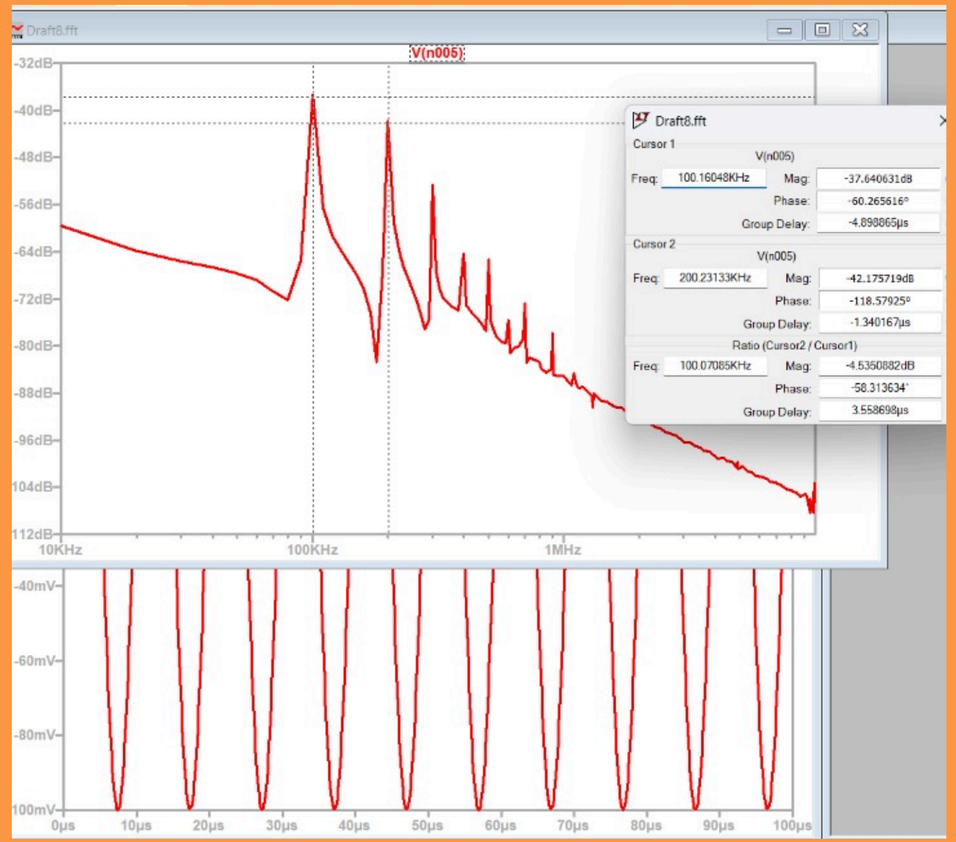


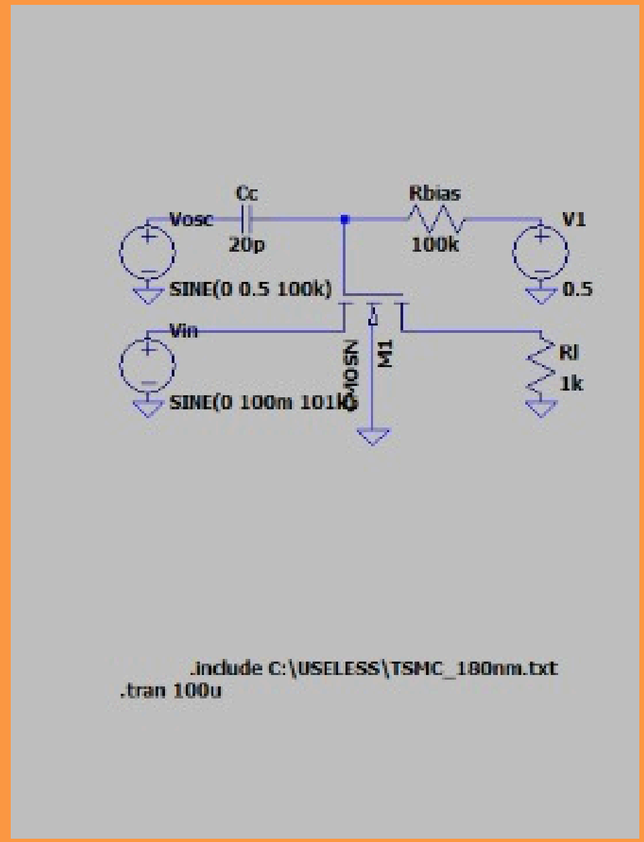


EC2.103 AEC
PROJECT

F_{IN} = 101K

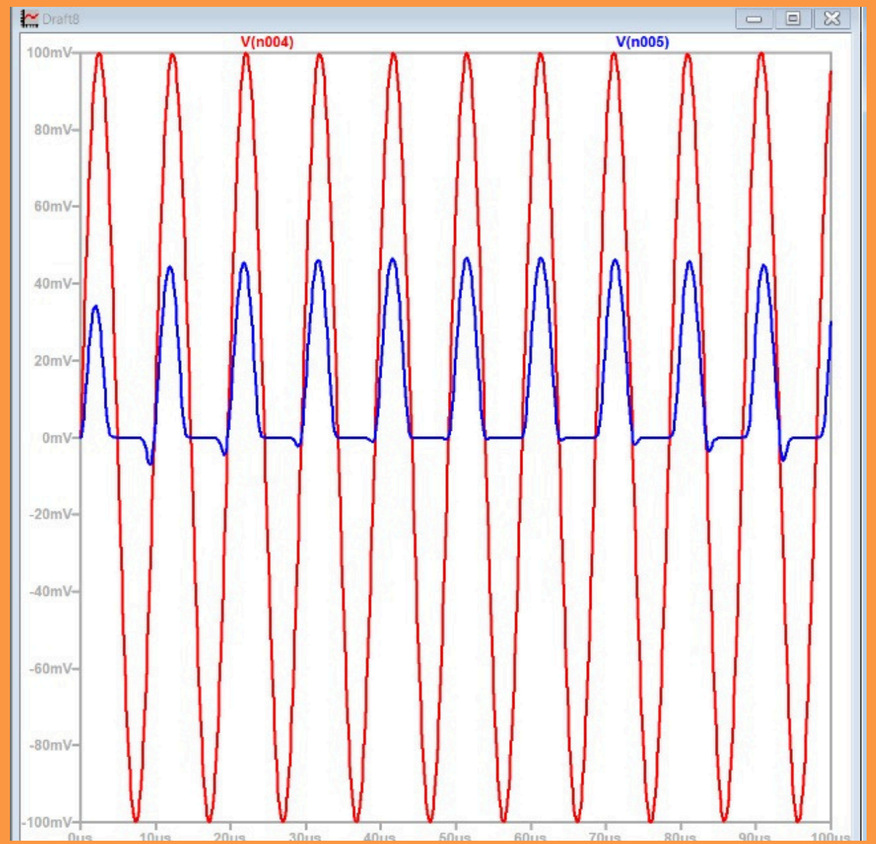


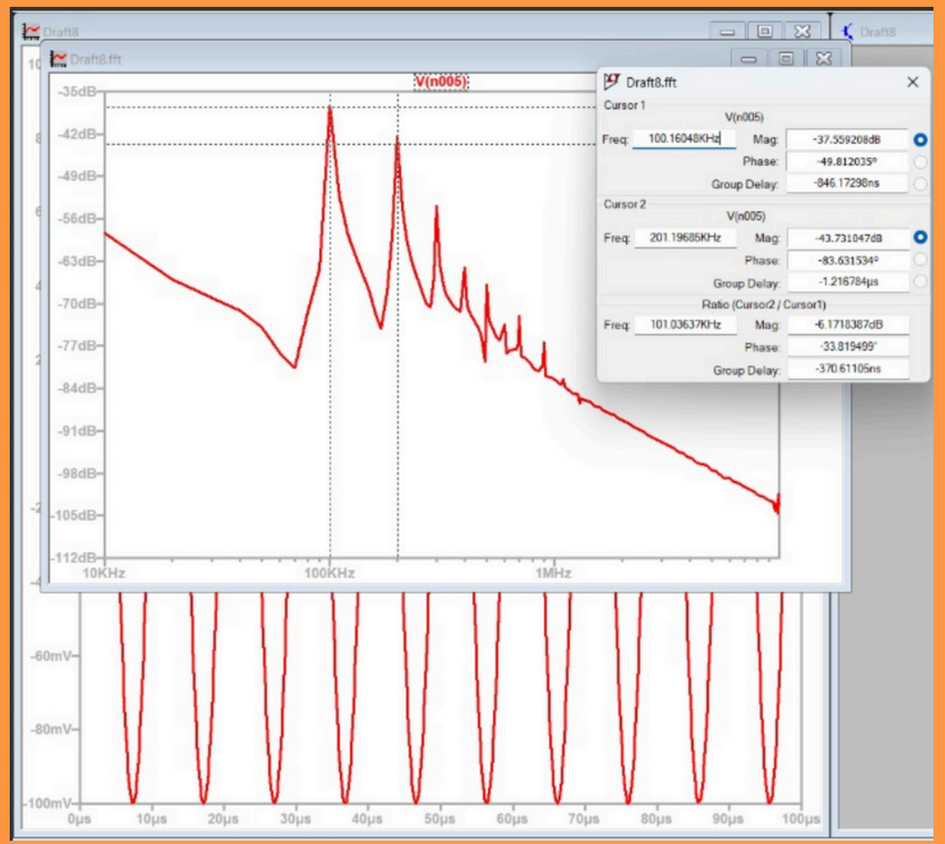


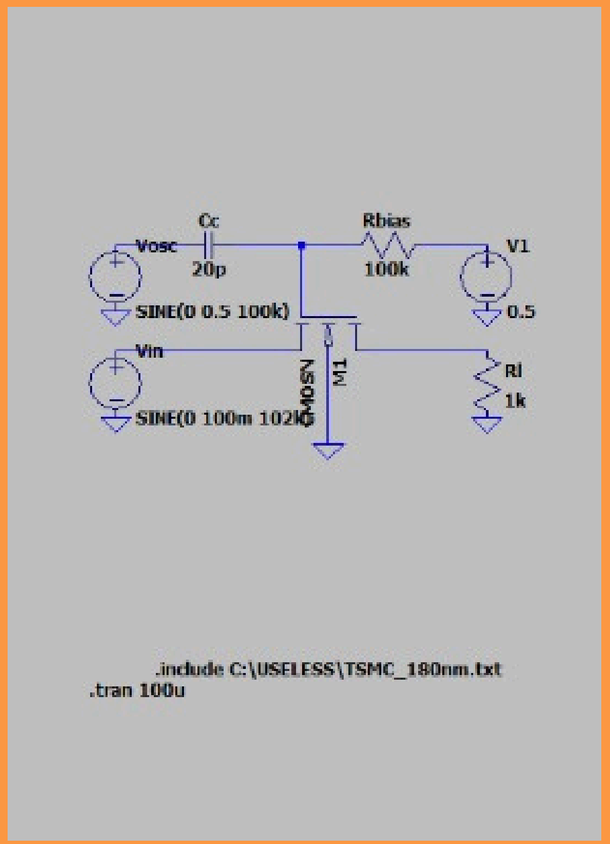


EC2.103 AEC
PROJECT

F_{IN} = 102K

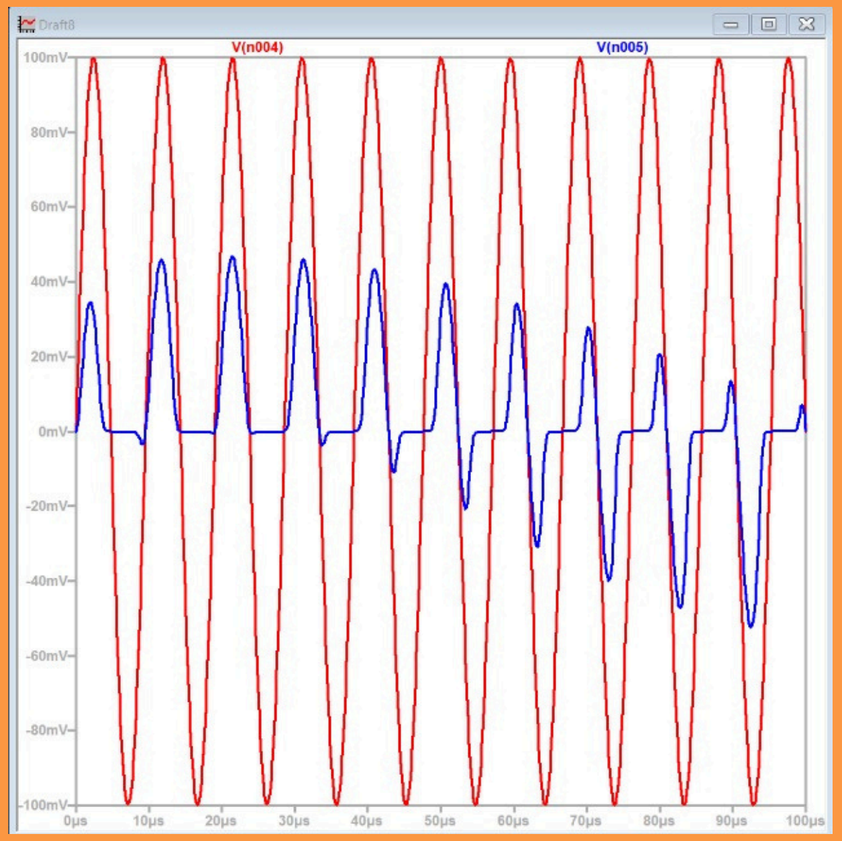


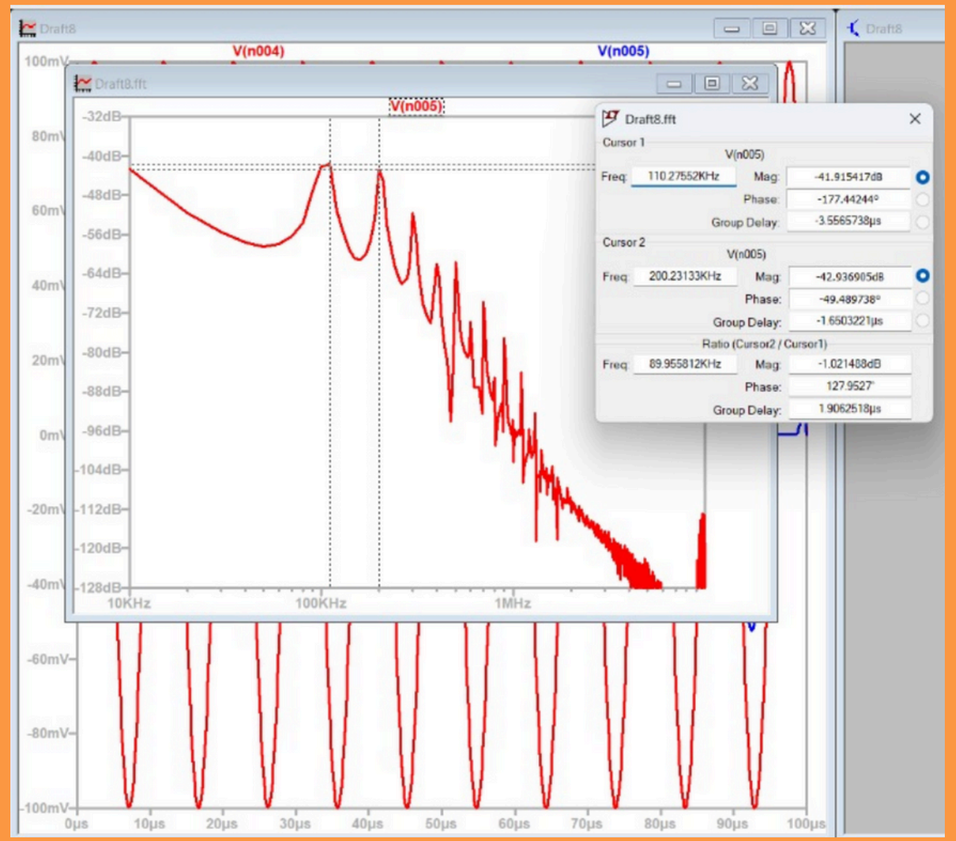


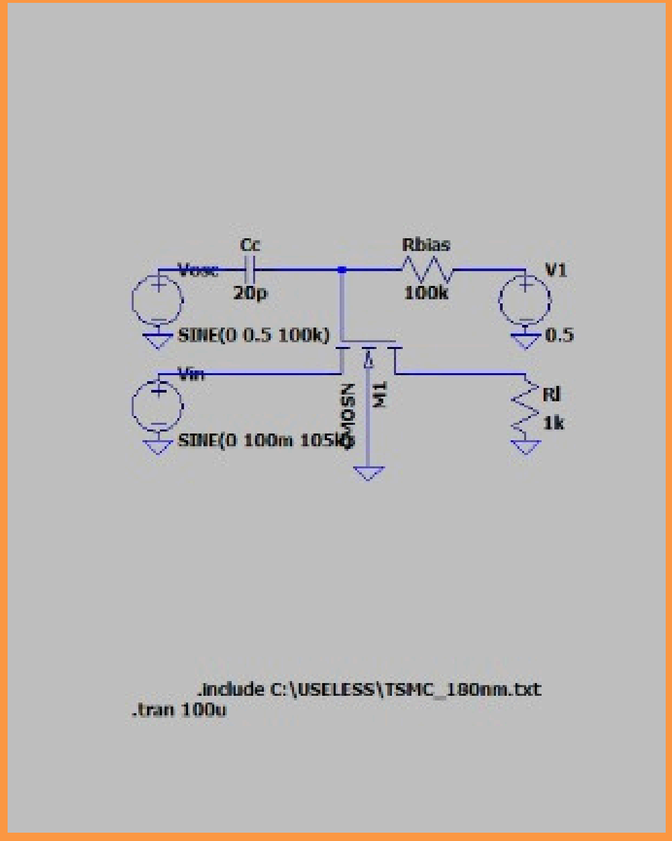


EC2.103 AEC
PROJECT

F_{IN} = 105K







EC2.103 AEC
PROJECT

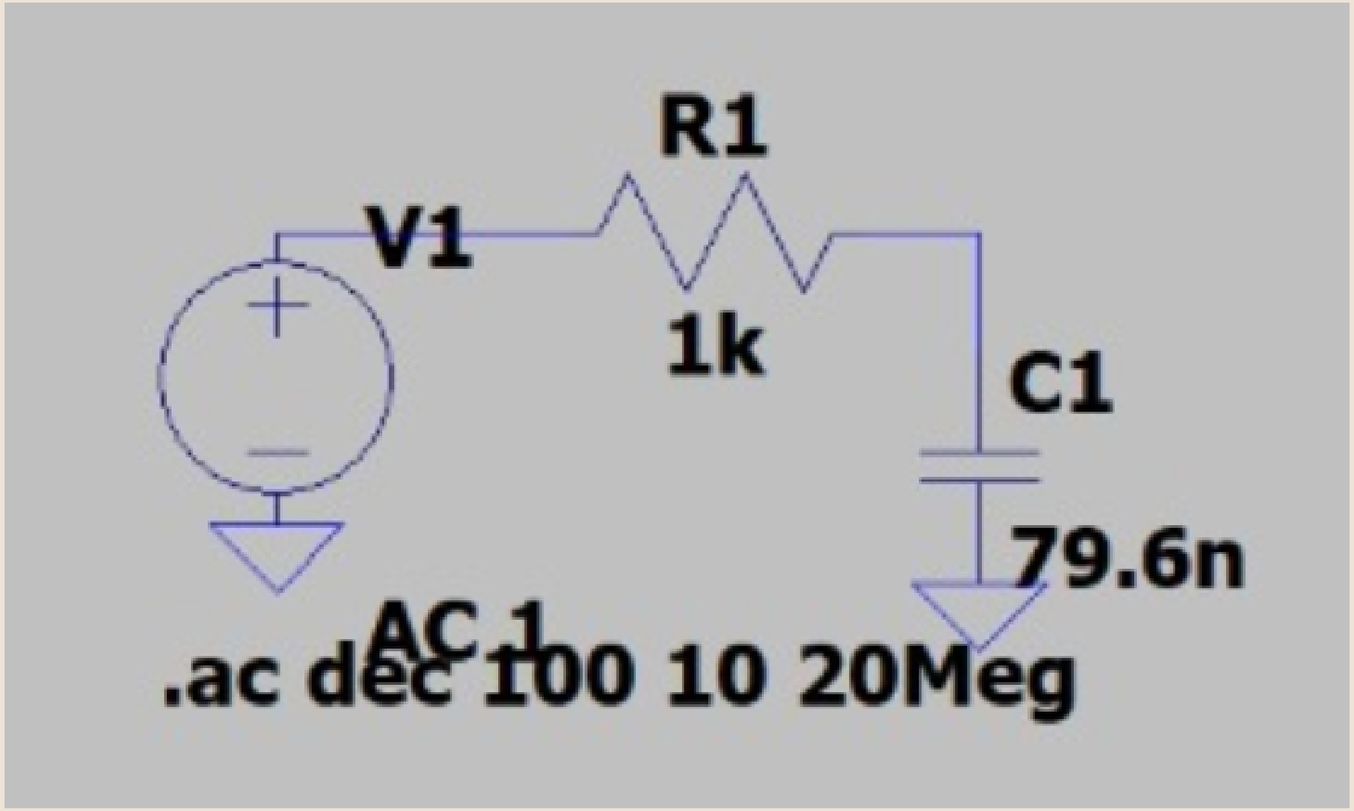
LOW-PASS FILTER

LOW PASS FILTER

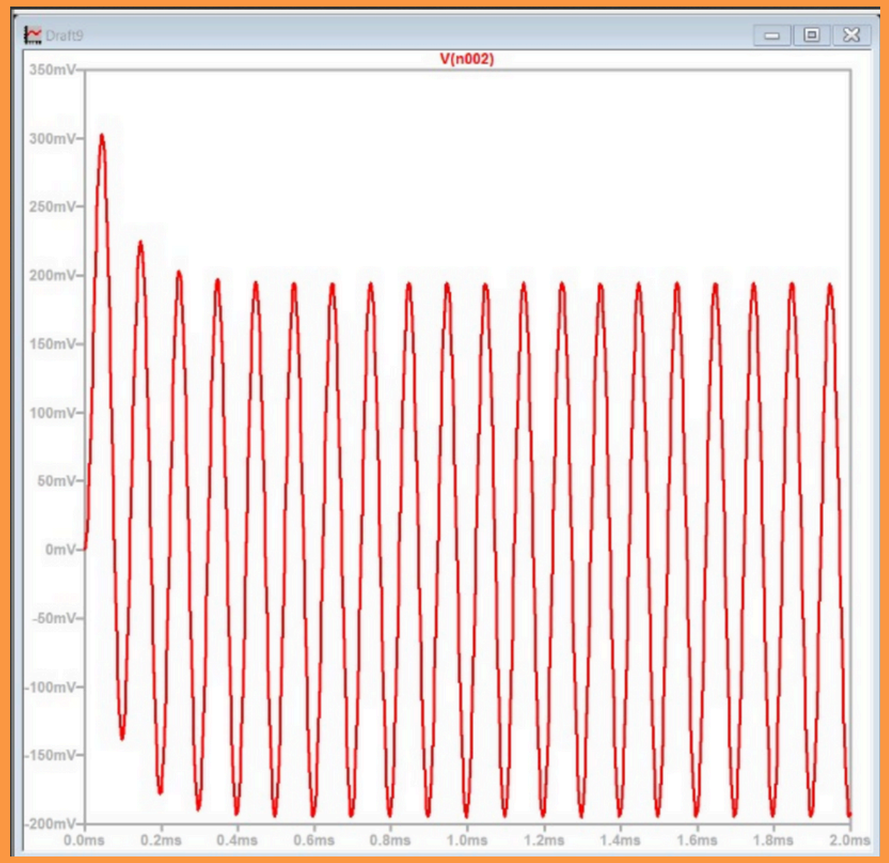
(Low pass filter of Cutoff Frequency 2kHz at -3dB)
To achieve this we first find the Vout at -3dB, which is Vin/$2^{1/2}$,
Then we use the following formula:

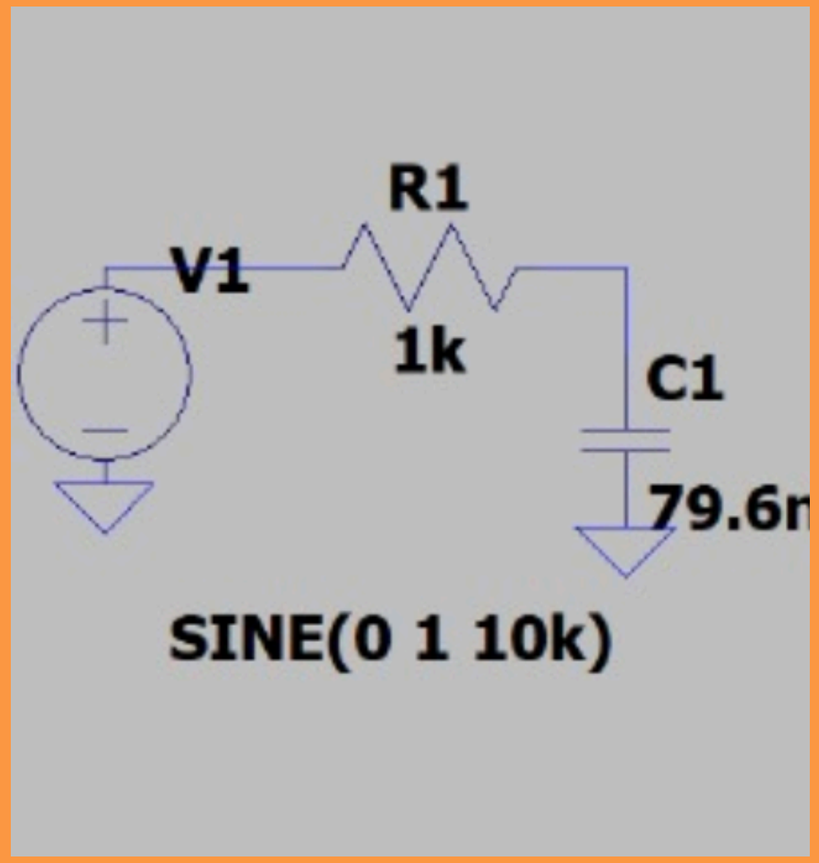
$$f_c = \frac{1}{2\pi RC}$$

(we take R as 1kOhm and calculate C with regard to that)
This low pass filter will allow signals of low (<2Khz) frequency through, and block higher frequency signals.
At exactly 2Khz, our output amplitude is about 70.7% of the input voltage.

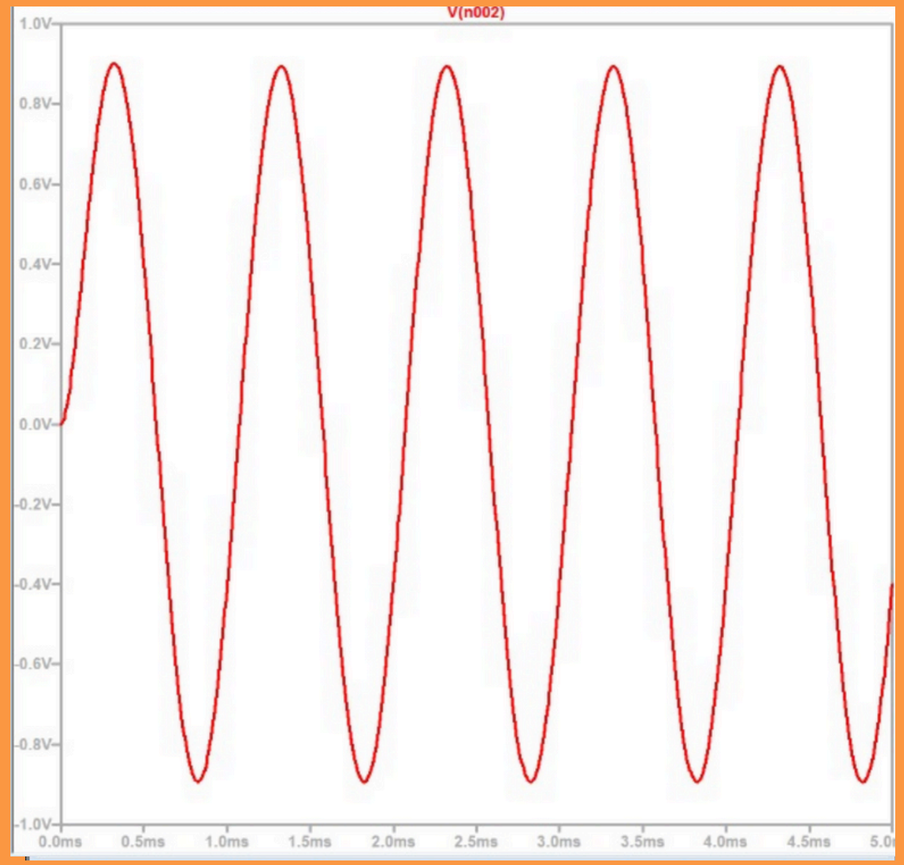


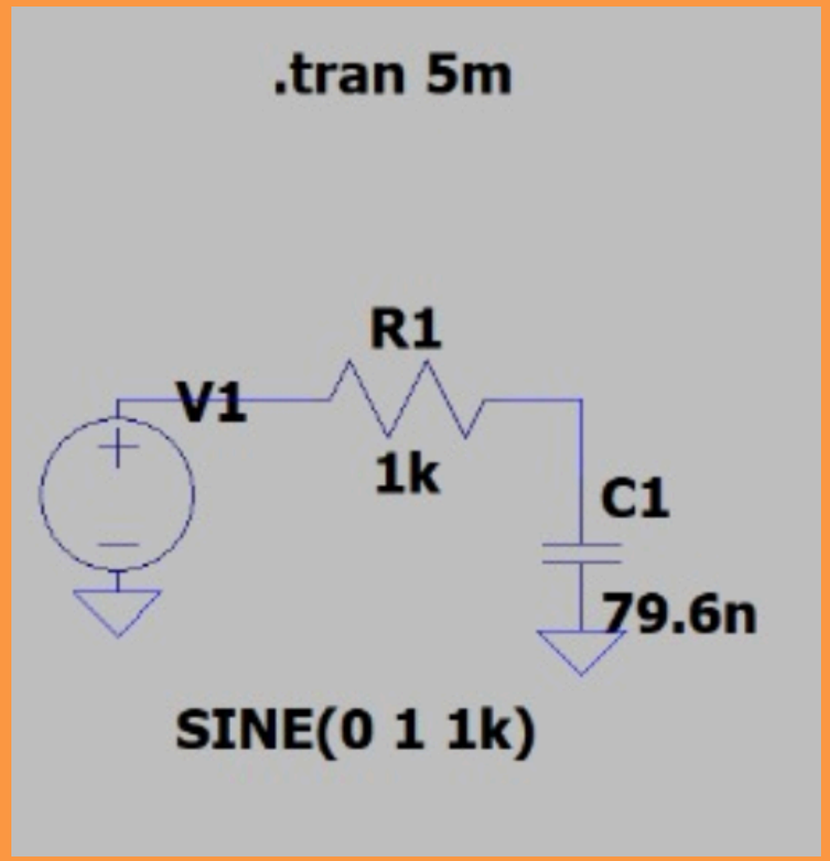
TRANSIENT RESPONSE PLOT FOR 10K



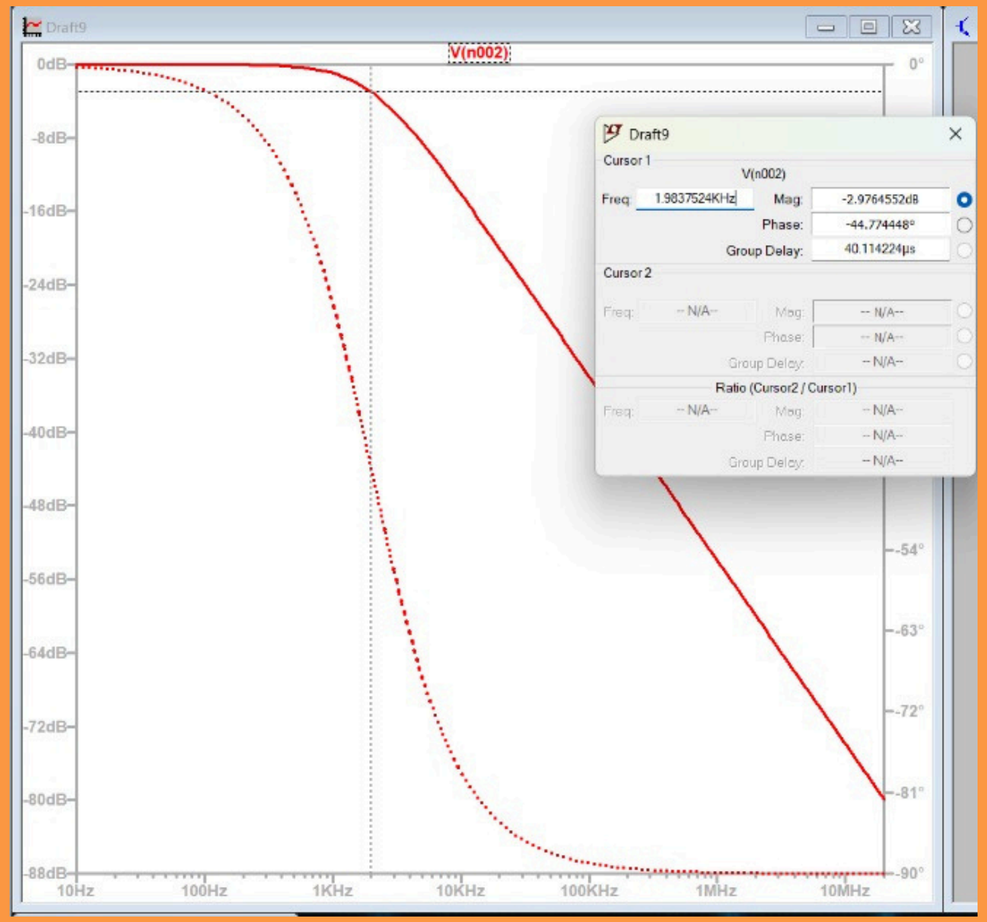


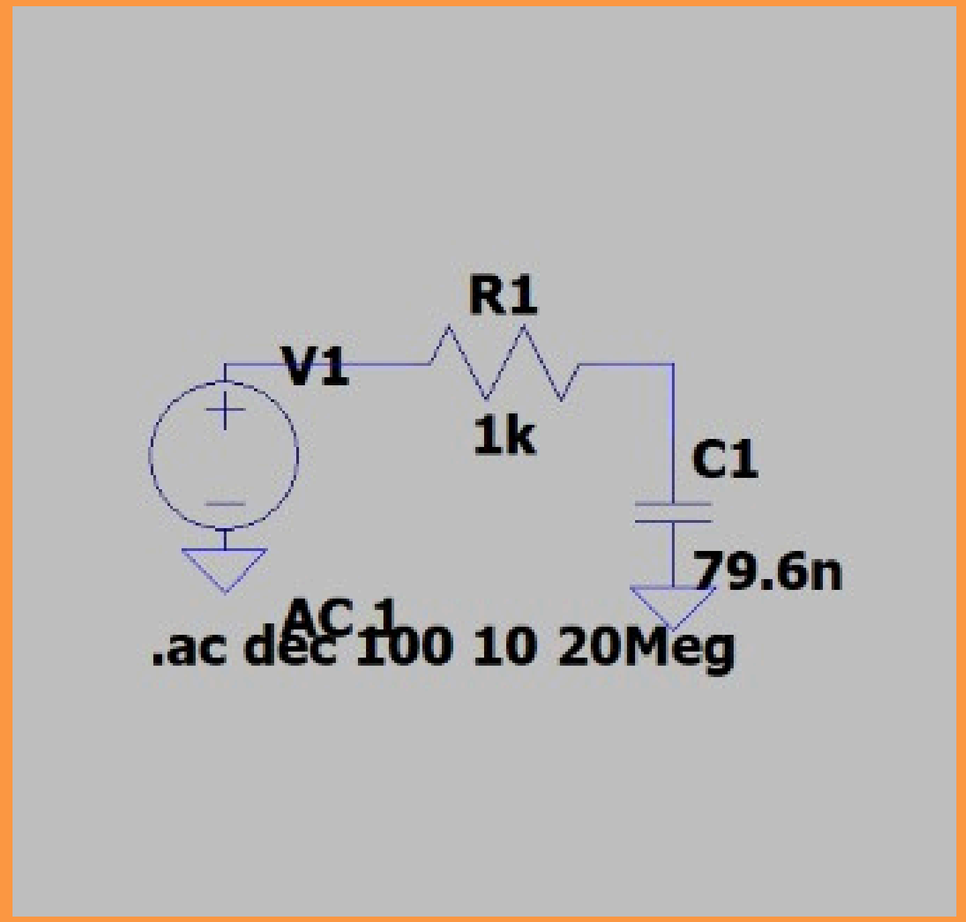
TRANSIENT RESPONSE PLOT FOR 1K





FREQUENCY RESPONSE FROM AC ANALYSIS





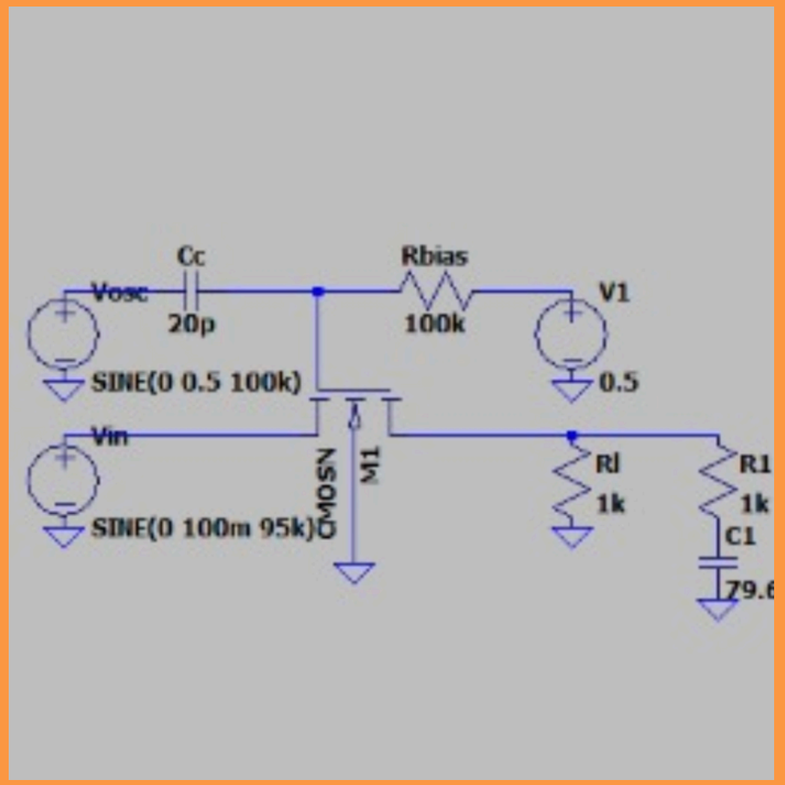
EC2.103 AEC
PROJECT

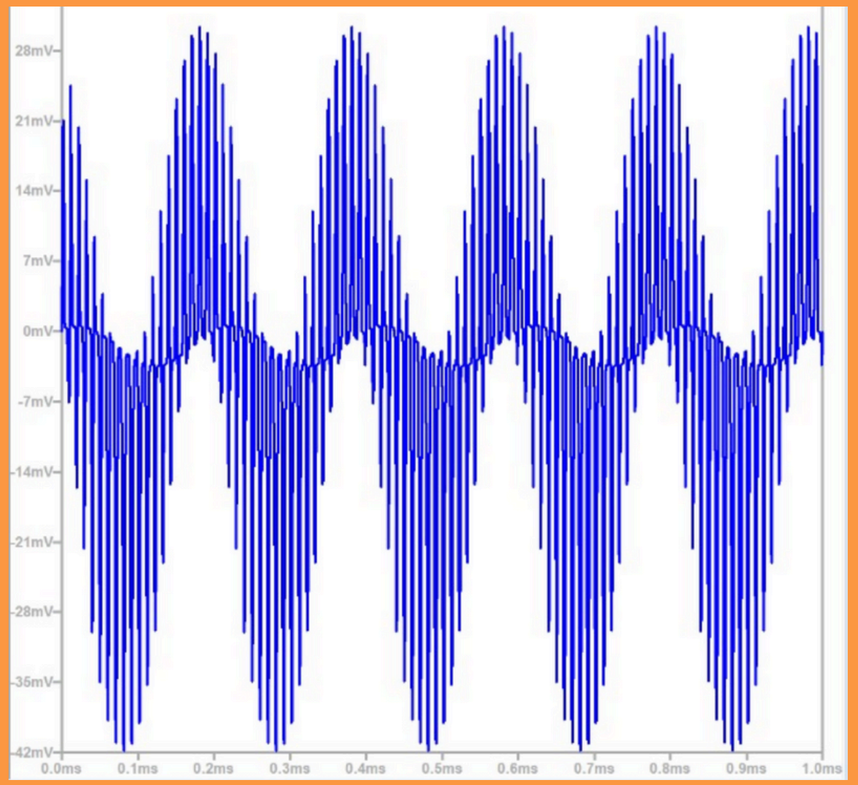
C O M B I N I N G

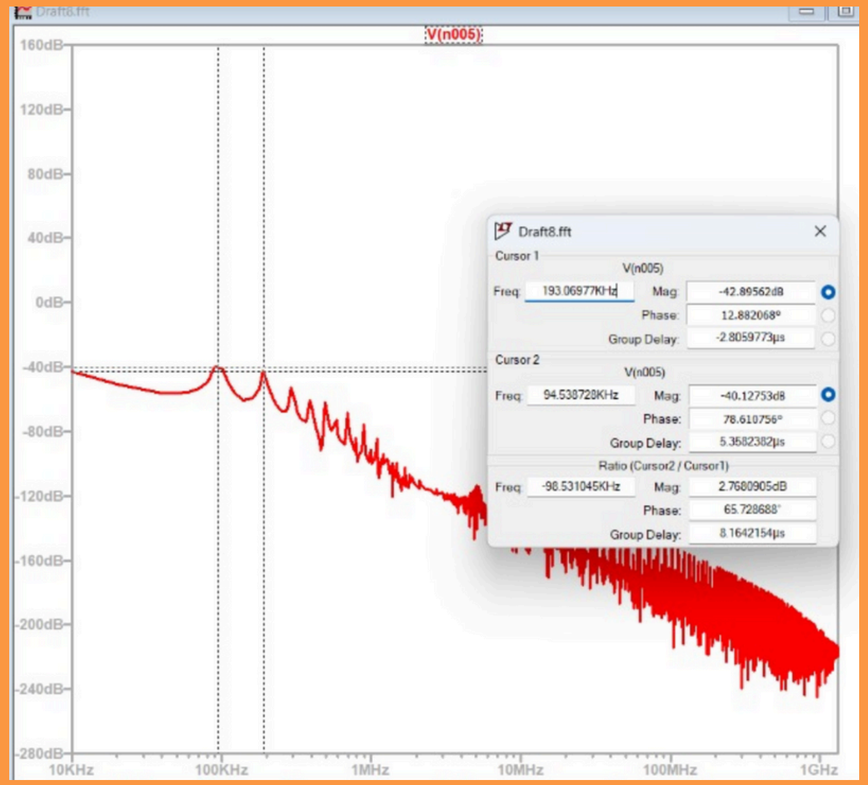
LOW-PASS FILTER AND MIXER

EC2.103 AEC
PROJECT

FIN = 95K

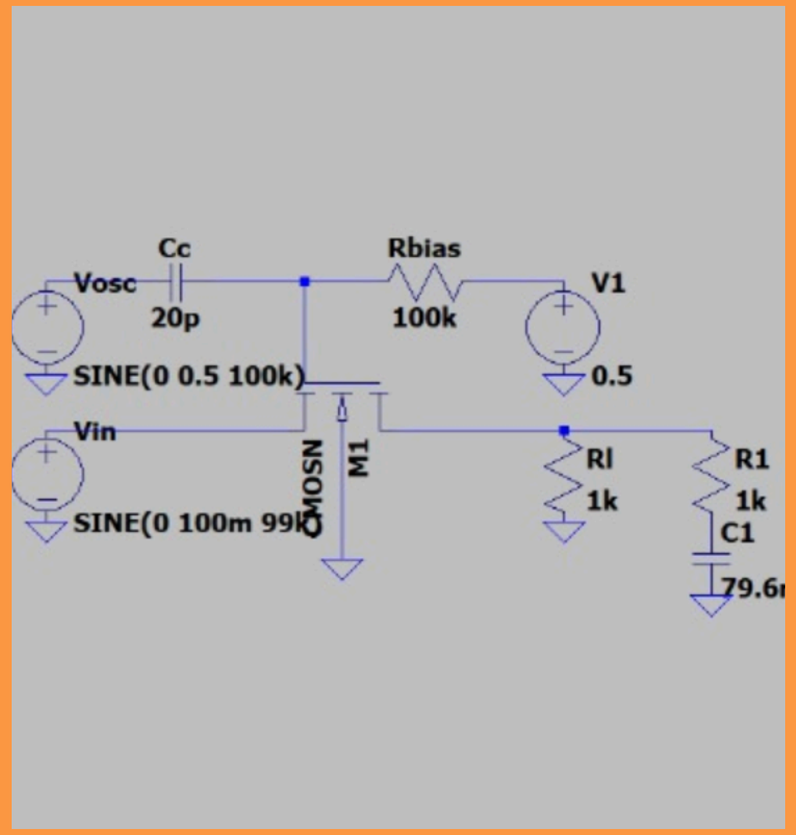


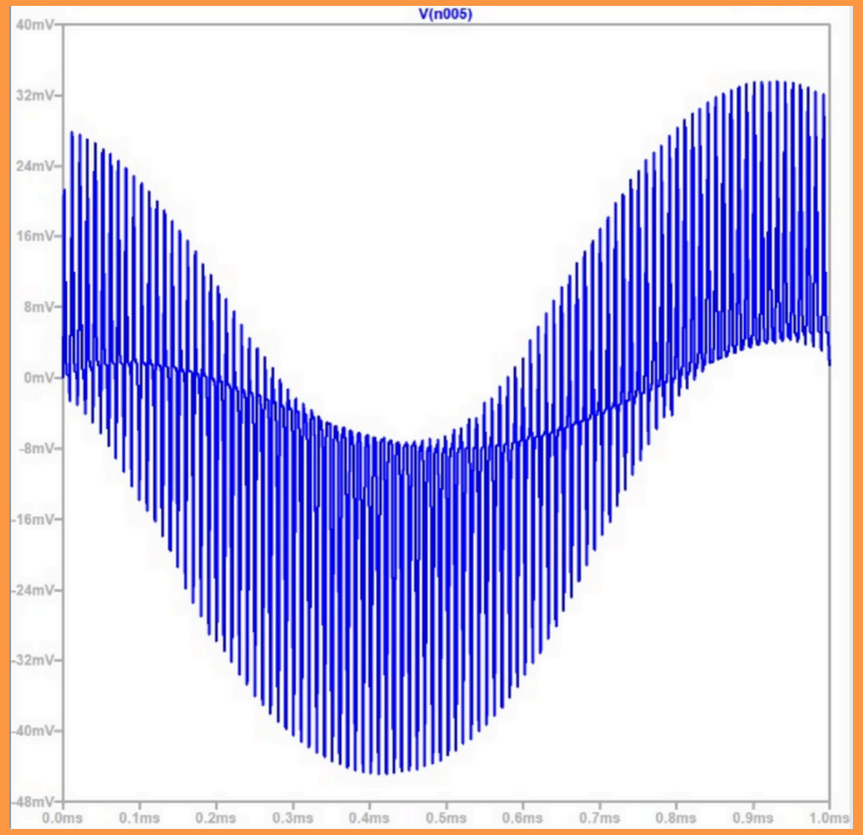


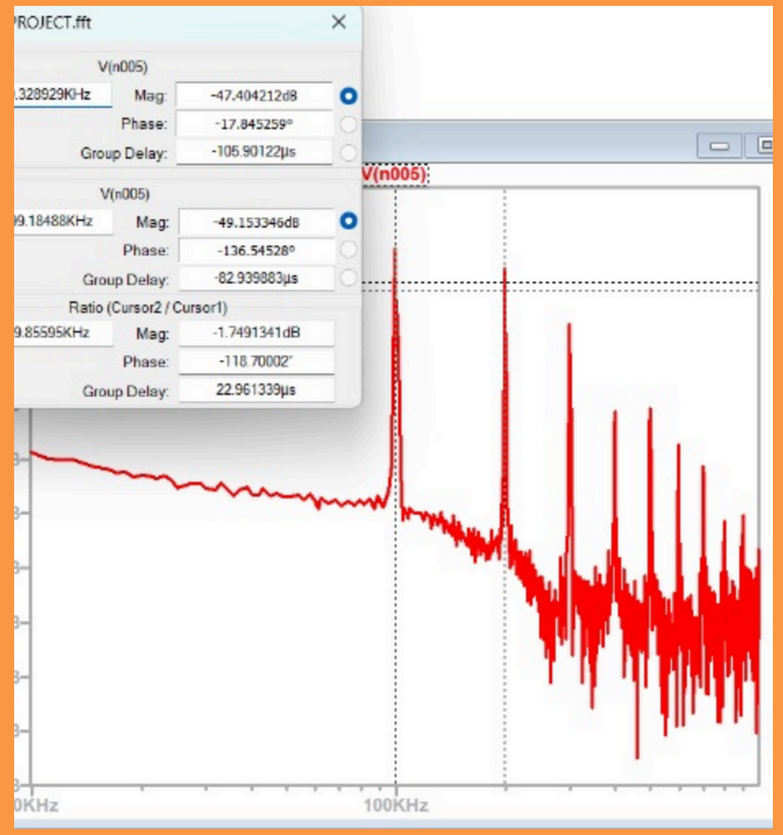


EC2.103 AEC
PROJECT

FIN = 99K

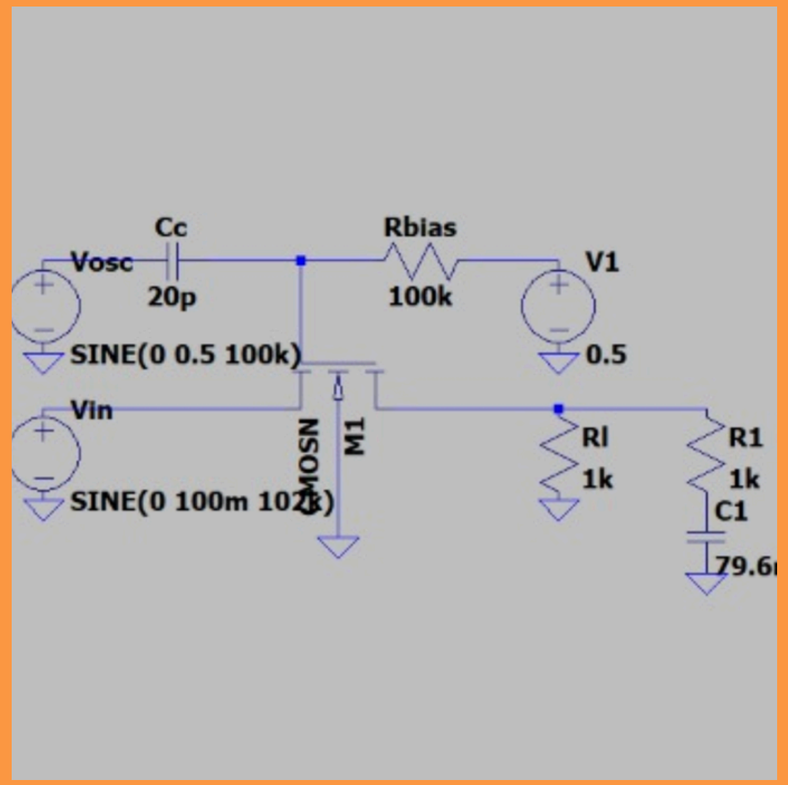


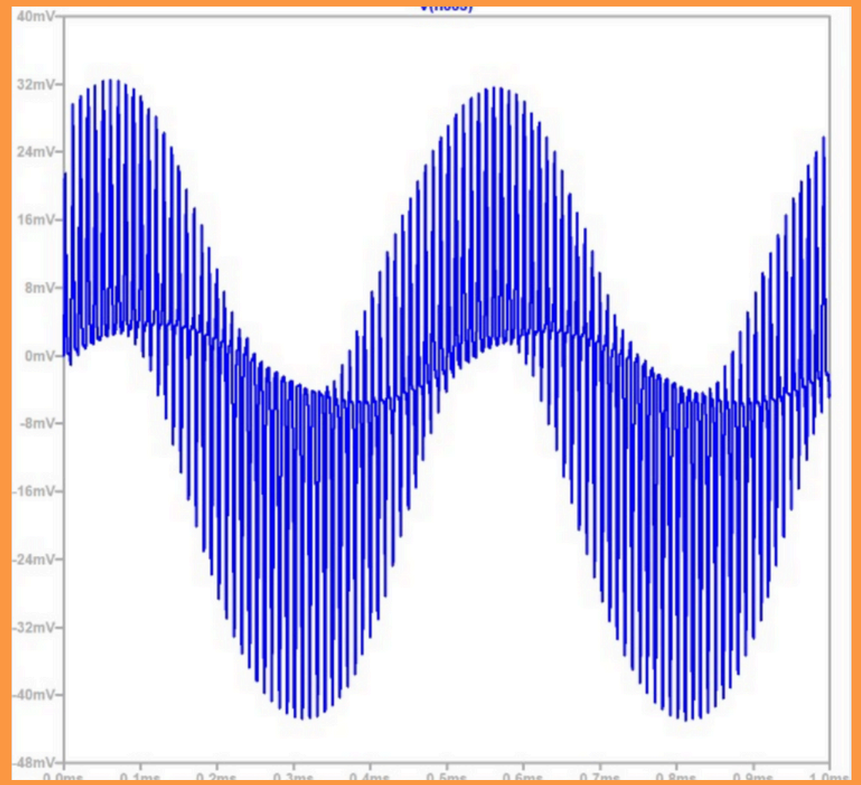


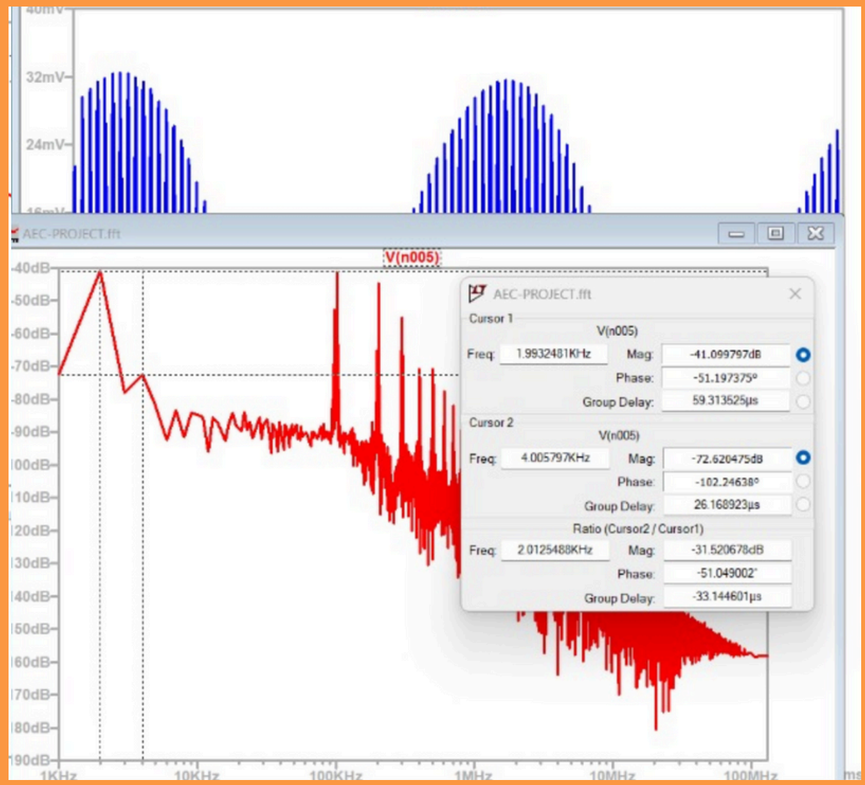


EC2.103 AEC
PROJECT

FIN = 102K

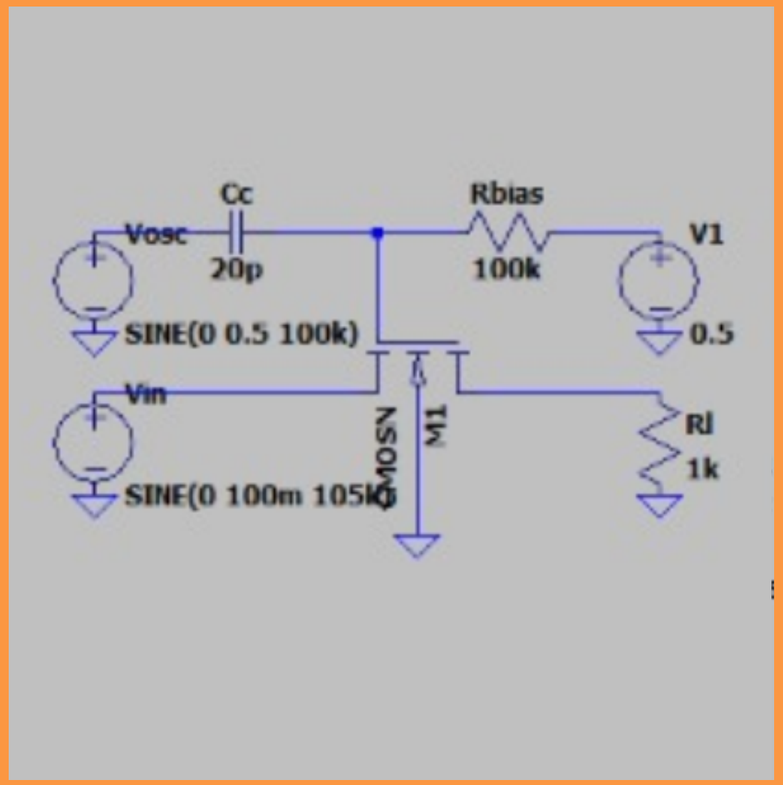


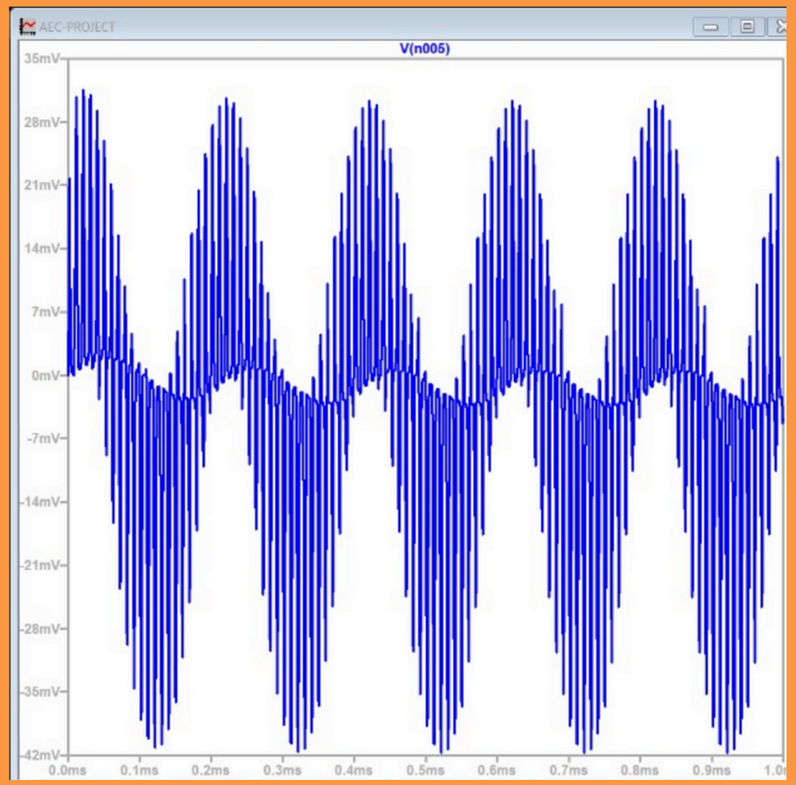


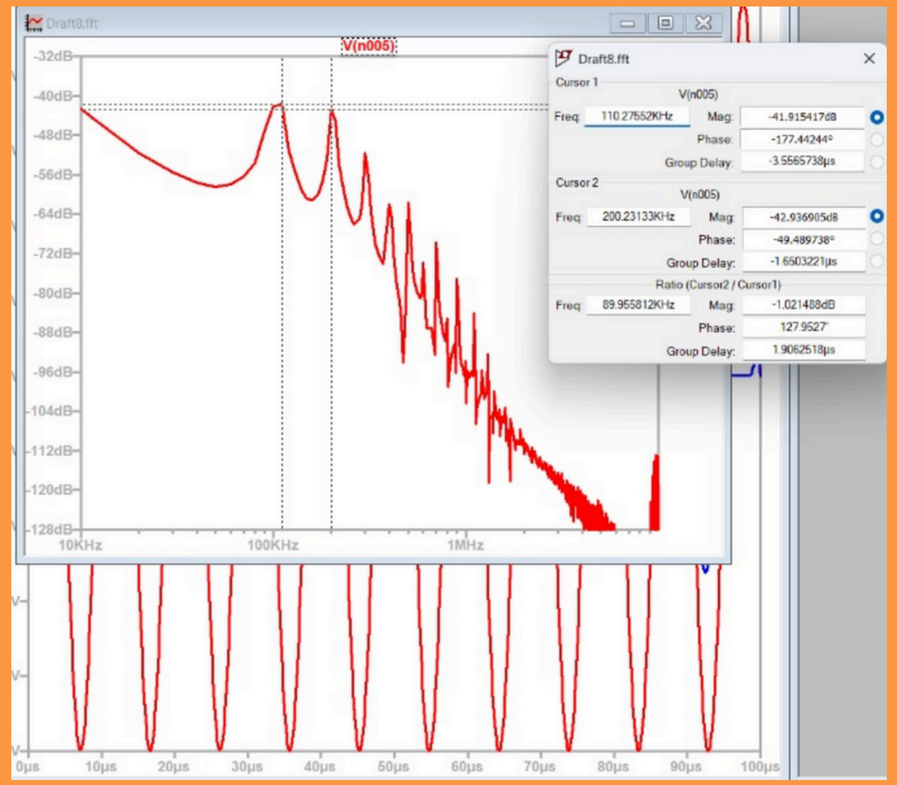


EC2.103 AEC
PROJECT

FIN = 105K







FUTURE PLANS

FUTURE PLANS

1

Continue work with the oscillator to get a 90 degree phase shift and understand the usage of op-amps and integrator circuits to make a furnished quadrature oscillator.

2

To infuse all the separate components into a working project that satisfies our problem statement. This involves fusing Low pass filters with switch (mixer) and adding them to the oscillator.

3

Understanding the usage of not just the entire project but also how each component is used in separate domains and brainstorming how the QDC can be further optimised.

DIVISION OF WORK

EC2.103 AEC
PROJECT

ADVAITH

- Making the Switch (Mixer) circuit
- Working with Samyak on the integration of LPF with Switch

UDHAV

- Made different circuits that could perform as the quad oscillator
- Working with Shriya on the usage of op-amps in LTSpice

SAMYAK

- worked on the low pass filter circuit and the analysis of the same
- Working with Advaith on the integration of LPF with Switch

SHRIYA

- Made the LTSpice usable op-amp symbol
- Working with Udhav on the usage of op-amps in LTSpice
- PPT making

THANK YOU