Course Project
Presentation

Quadrature Down Converter

ANALOG ELECTRONICS AND CIRCUITS

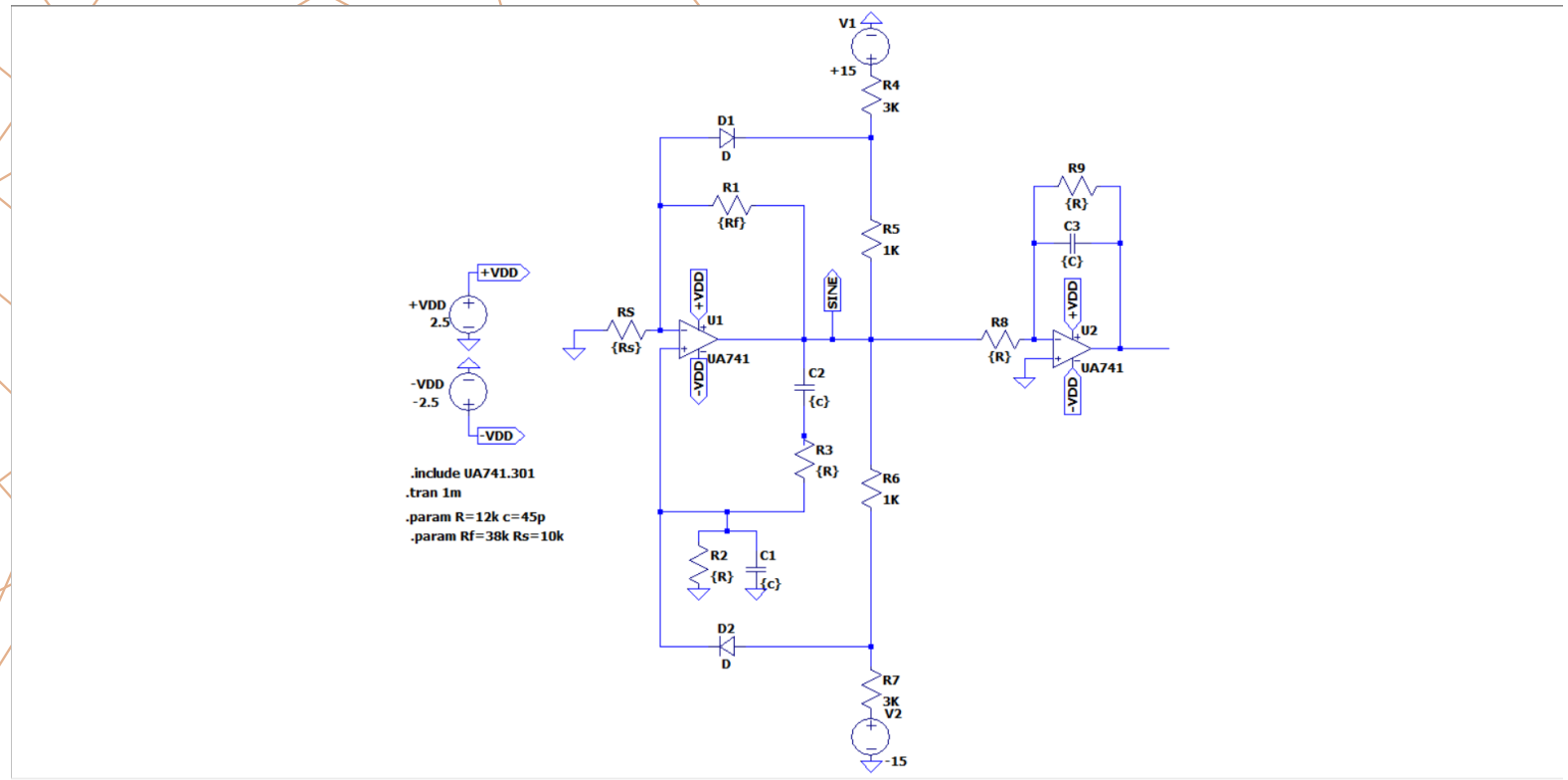
PROJECT REQUIREMENTS

To build a prototype of a Quadrature Down Converter :

- Part 1 – Wein Bridge Oscillator Design
- Part 2 – Switch(Mixer) Design
- Part 3 – Low Pass Filter Design
- Part 4 – Complete Circuit Prototype

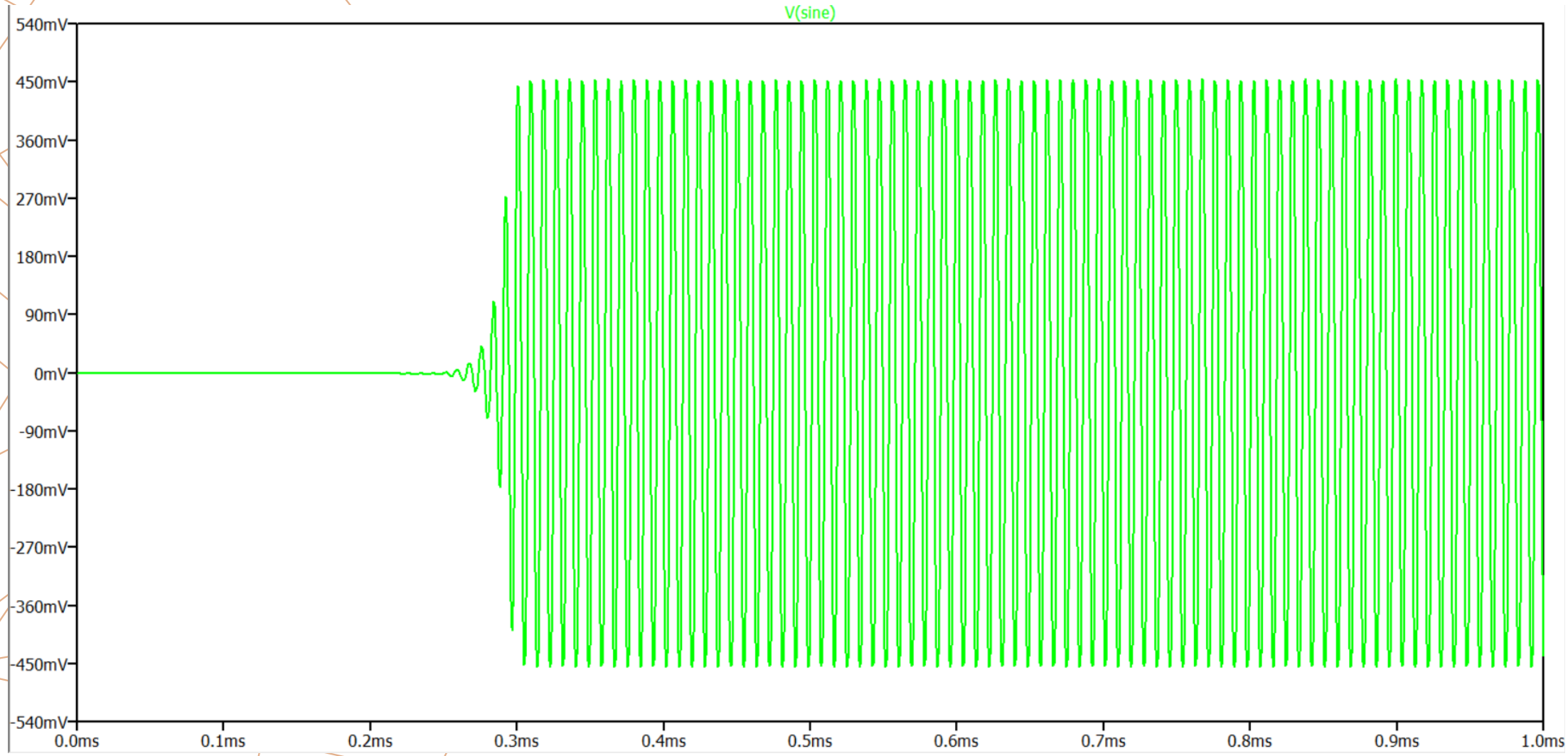
PART - 1

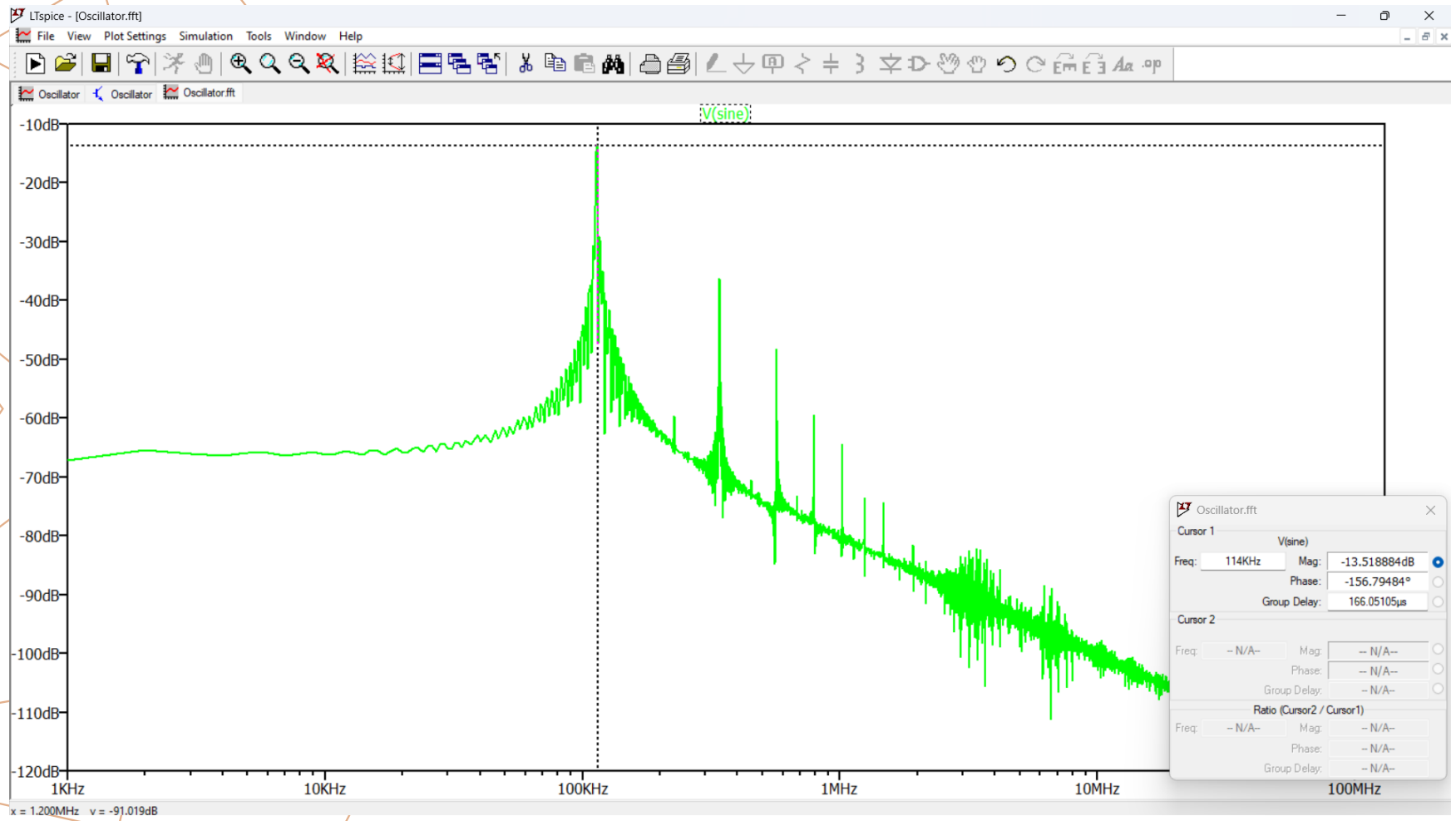
Wein Bridge Oscillator Design

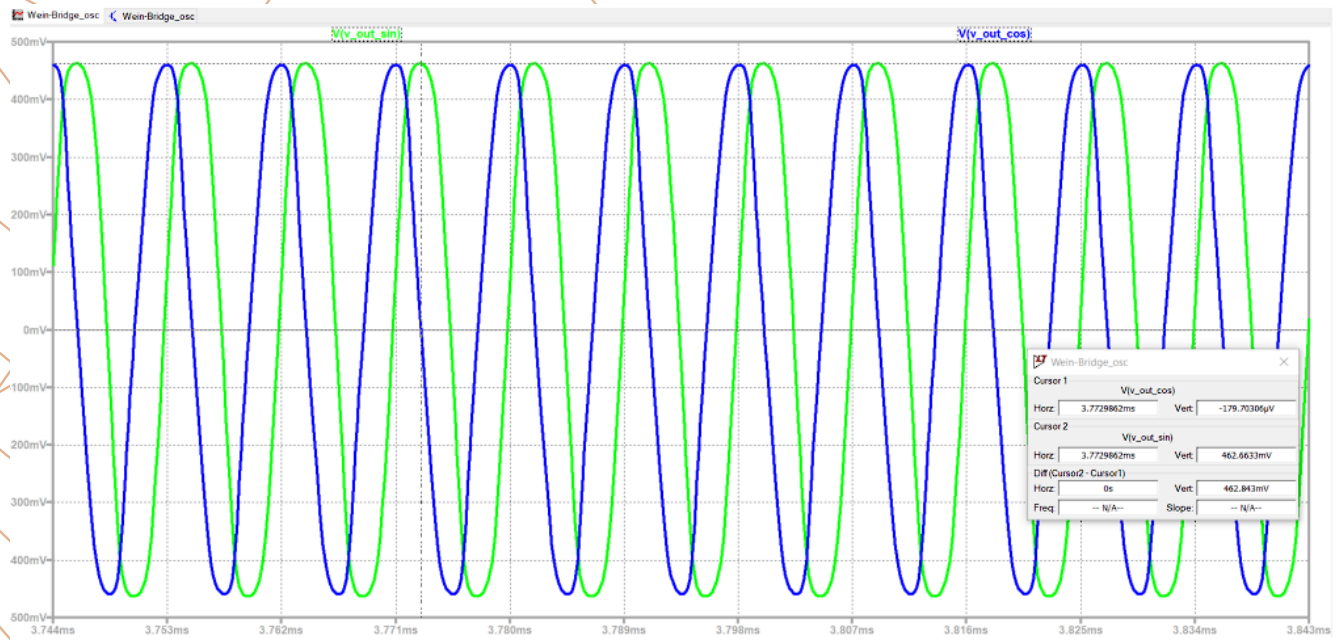


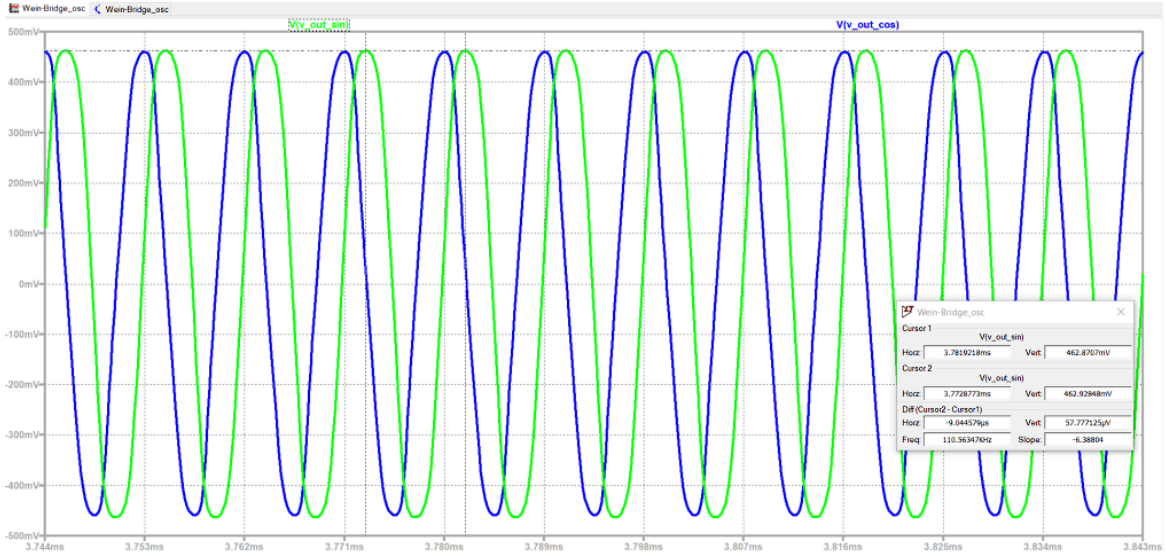
Circuit for generating a SINE wave of 100KHz frequency

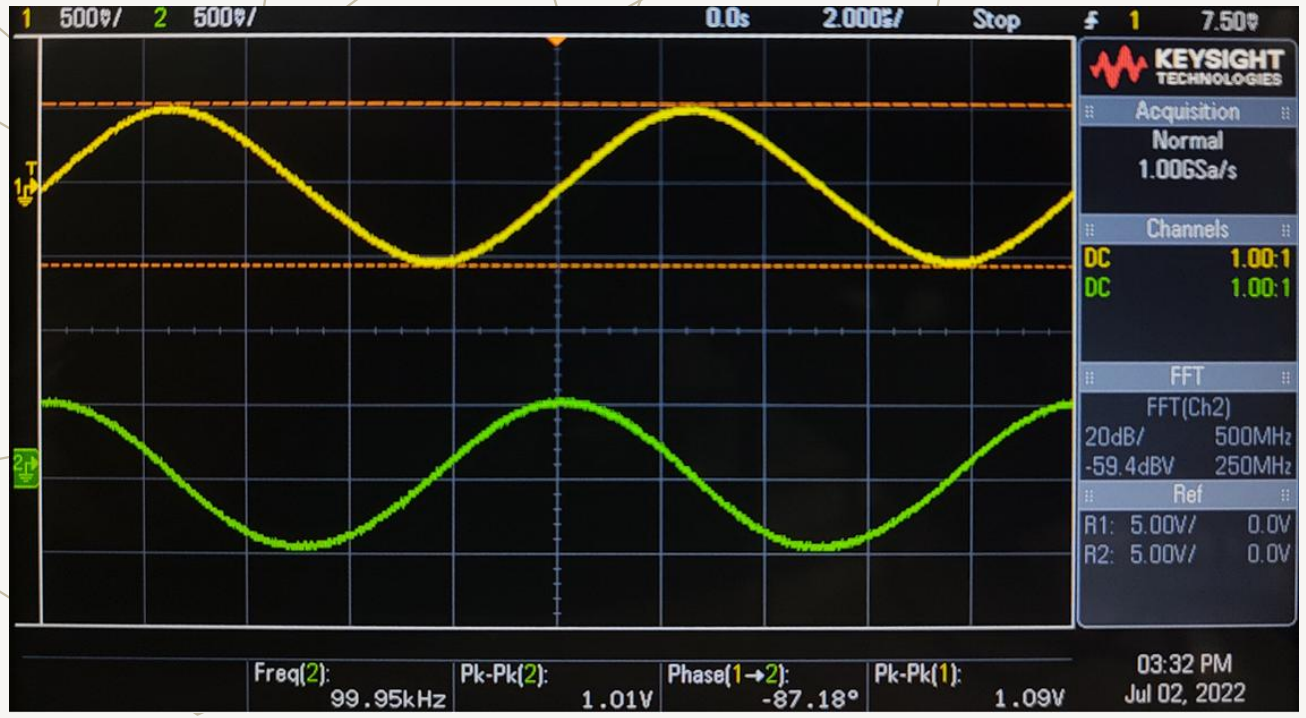
The basic idea of our Oscillator Circuit is to use a Wien-Bridge Oscillator to generate a Sine wave of required Frequency and convert it into a Cosine wave using known methods.


V(sine)
540mV
450mV
360mV
270mV
180mV
90mV
0mV
-90mV
-180mV
-270mV
-360mV
-450mV
-540mV
0.0ms
0.1ms
0.2ms
0.3ms
0.4ms
0.5ms
0.6ms
0.7ms
0.8ms
0.9ms
1.0ms


LTspice - [Oscillator.fft]
File View Plot Settings Simulation Tools Window Help
Oscillator
Oscillator
Oscillator.fft
V(sine)
-10dB
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
-110dB
-120dB
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz
x = 1.200MHz v = -91.019dB
Oscillator.fft
Cursor 1
V(sine)
Freq: 114KHz
Mag: -13.518884dB
Phase: -156.79484°
Group Delay: 166.05105µs
Cursor 2
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--
Ratio (Cursor2 / Cursor1)
Freq: -- N/A--
Mag: -- N/A--
Phase: -- N/A--
Group Delay: -- N/A--


Wein-Bridge_osc
Wein-Bridge_osc
V(v_out_sin)
V(v_out_cos)
500mV
400mV
300mV
200mV
100mV
0mV
-100mV
-200mV
-300mV
-400mV
-500mV
3.744ms
3.753ms
3.762ms
3.771ms
3.780ms
3.789ms
3.798ms
3.807ms
3.816ms
3.825ms
3.834ms
3.843ms
Wein-Bridge_osc
Cursor 1
V(v_out_cos)
Horz: 3.7729862ms
Vert: -179.70306µV
Cursor 2
V(v_out_sin)
Horz: 3.7729862ms
Vert: 462.6633mV
Diff (Cursor2 - Cursor1)
Horz: 0s
Vert: 462.843mV
Freq: -- N/A--
Slope: -- N/A--


Wein-Bridge_osc
Wein-Bridge_osc
V(v_out_sin)
V(v_out_cos)
500mV
400mV
300mV
200mV
100mV
0mV
-100mV
-200mV
-300mV
-400mV
-500mV
3.744ms
3.753ms
3.762ms
3.771ms
3.780ms
3.789ms
3.798ms
3.807ms
3.816ms
3.825ms
3.834ms
3.843ms
Wein-Bridge_osc
Cursor 1
V(v_out_sin)
Horz: 3.7819218ms
Vert: 462.8707mV
Cursor 2
V(v_out_sin)
Horz: 3.7728773ms
Vert: 462.92848mV
Diff (Cursor2 - Cursor1)
Horz: -9.044579µs
Vert: 57.777125µV
Freq: 110.56347KHz
Slope: -6.38804


1 500mV/ 2 500mV/
0.0s
2.000s/
Stop
1 7.50V
KEYSIGHT TECHNOLOGIES
Acquisition
Normal
1.00GSa/s
Channels
DC 1.00:1
DC 1.00:1
FFT
FFT(Ch2)
20dB/ 500MHz
-59.4dBV 250MHz
Ref
R1: 5.00V/ 0.0V
R2: 5.00V/ 0.0V
Freq(2):
99.95kHz
Pk-Pk(2):
1.01V
Phase(1→2):
-87.18°
Pk-Pk(1):
1.09V
03:32 PM
Jul 02, 2022

Different Methods to convert the SINE wave generated by the Wien-Bridge Oscillator into COSINE WAVE:

- Using RC Phase Shifters
- Using a MOSFET as a buffer to prevent the attenuation of the signal while using RC Phase Shifters
- Using an Integrator block built using an Op- Amp

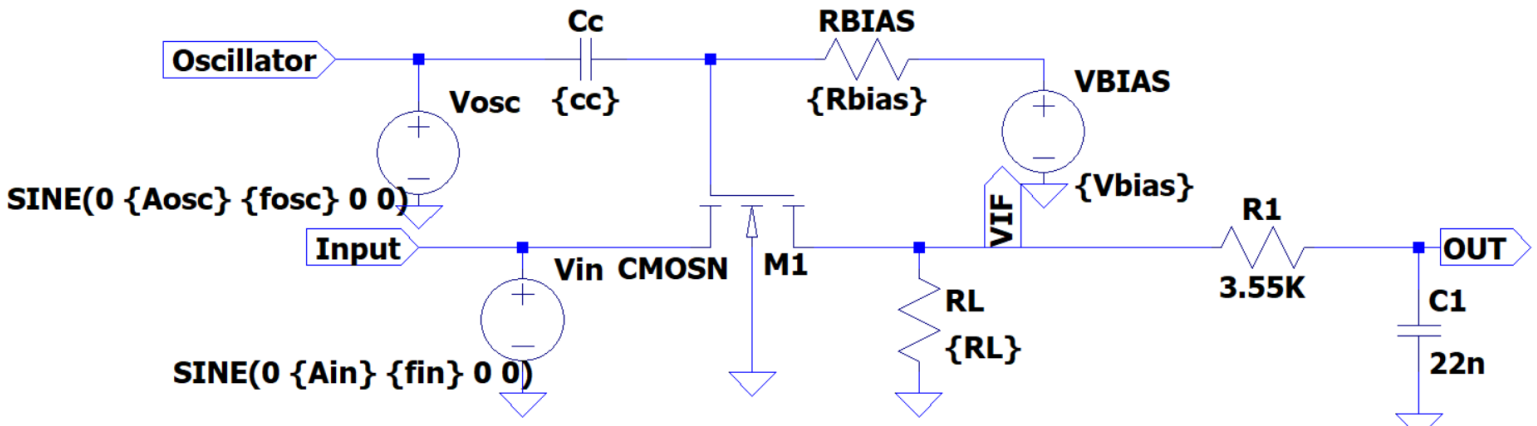
We have chosen a integrator block.

Reasons:

1. More reliable
2. Attenuation issues with RC phase shiftor and incorrect phase shift values
3. Not reliable on MOSFETs

PART - 2

Switch [Mixer]

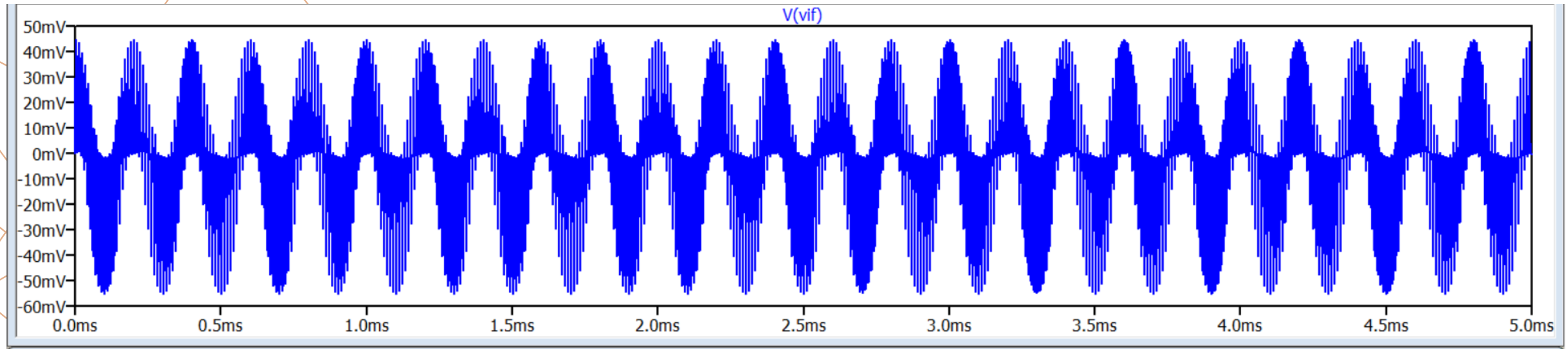


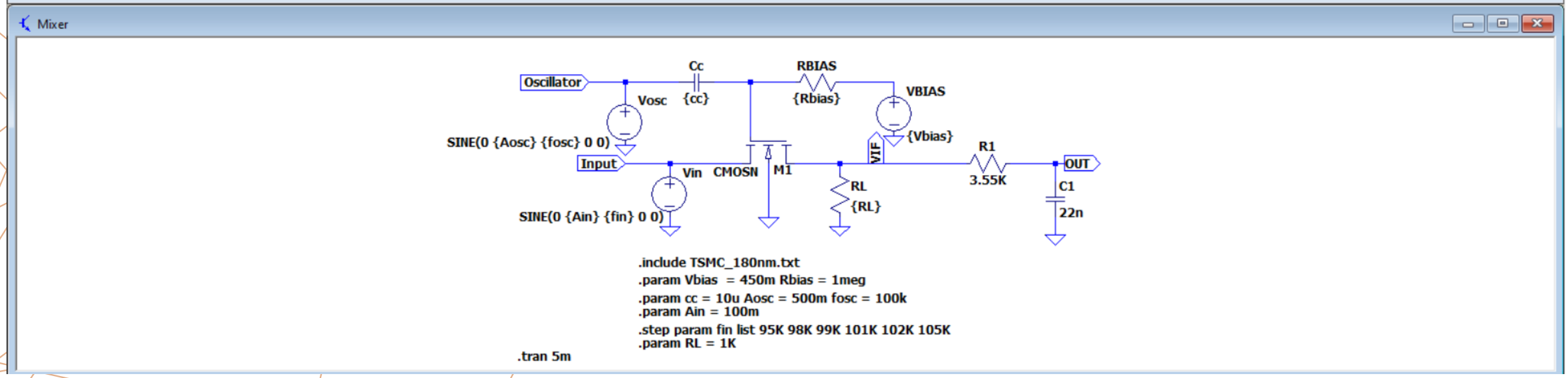

```
.include TSMC_180nm.txt
.param Vbias  = 450m Rbias = 1meg
.param cc = 10u Aosc = 500m fosc = 100k
.param Ain = 100m
.step param fin list 95K 98K 99K 101K 102K 105K
.param RL = 1K

.tran 1m
```

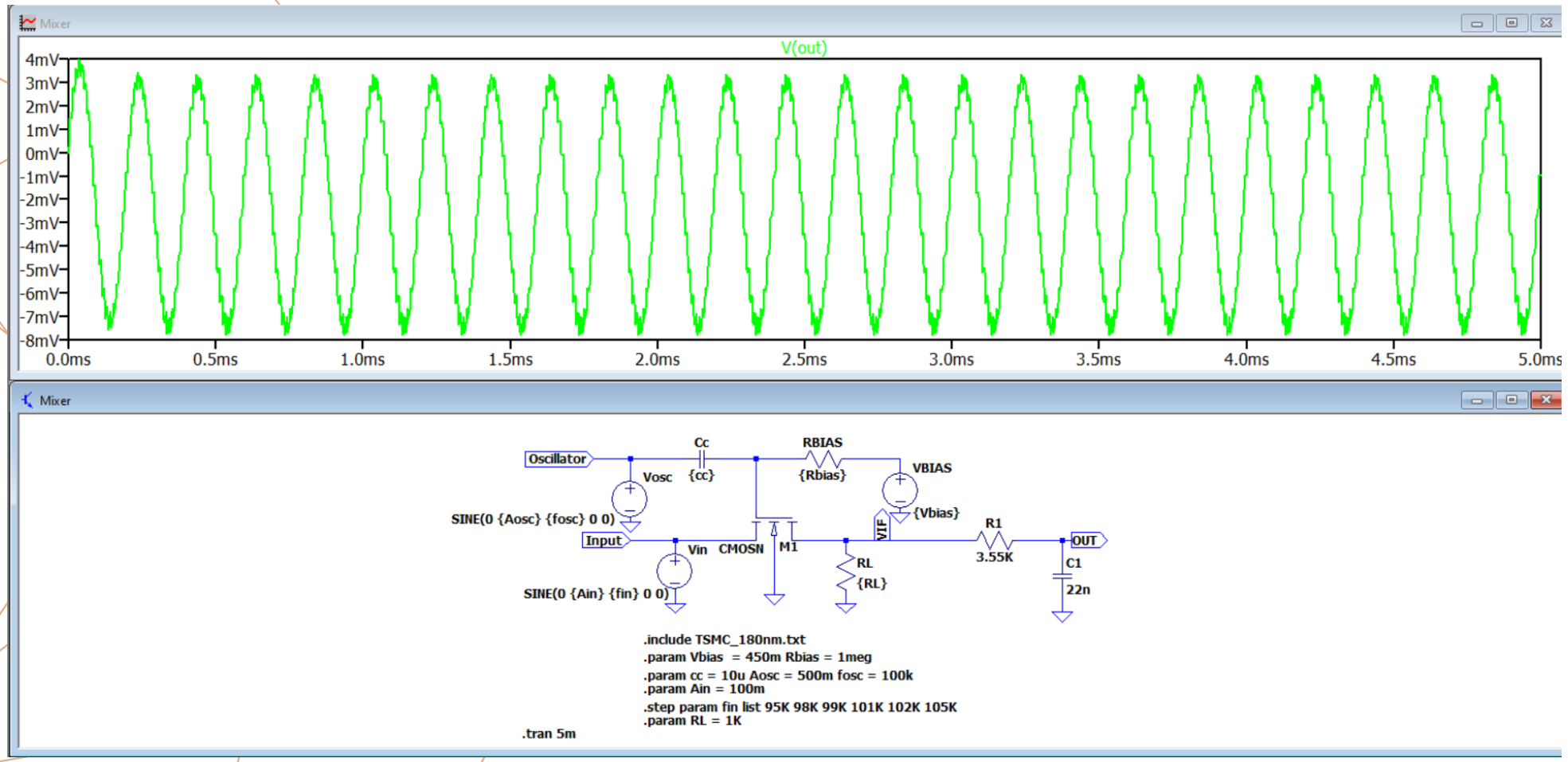
Here is the circuit design of our Switch / Mixer

This design uses a nMOS of 180nm technology to perform the mixing of the Input and the Oscillator signals.

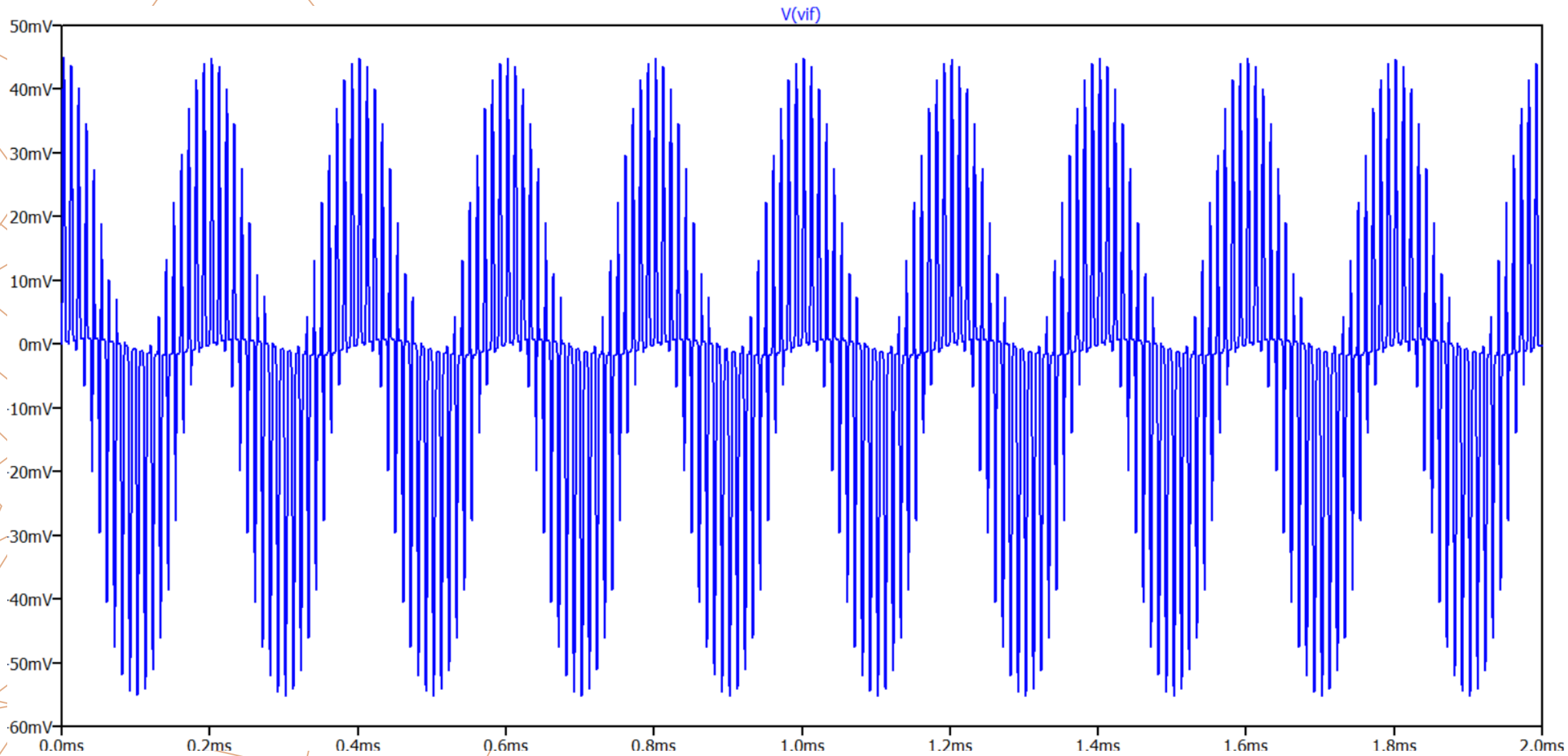




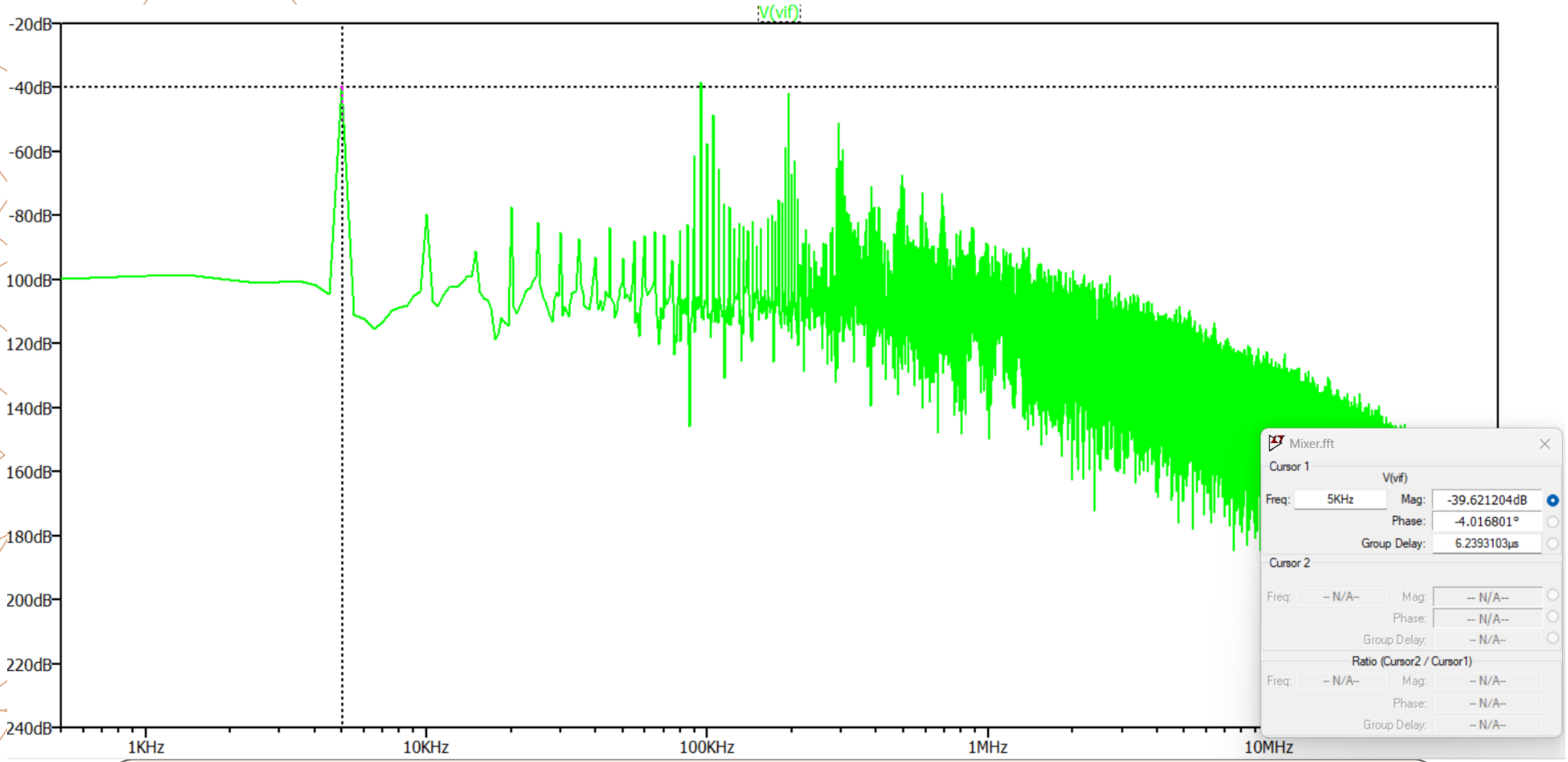
Input(Single Frequency (95 KHz)) and Oscillator Signals to the Mixer



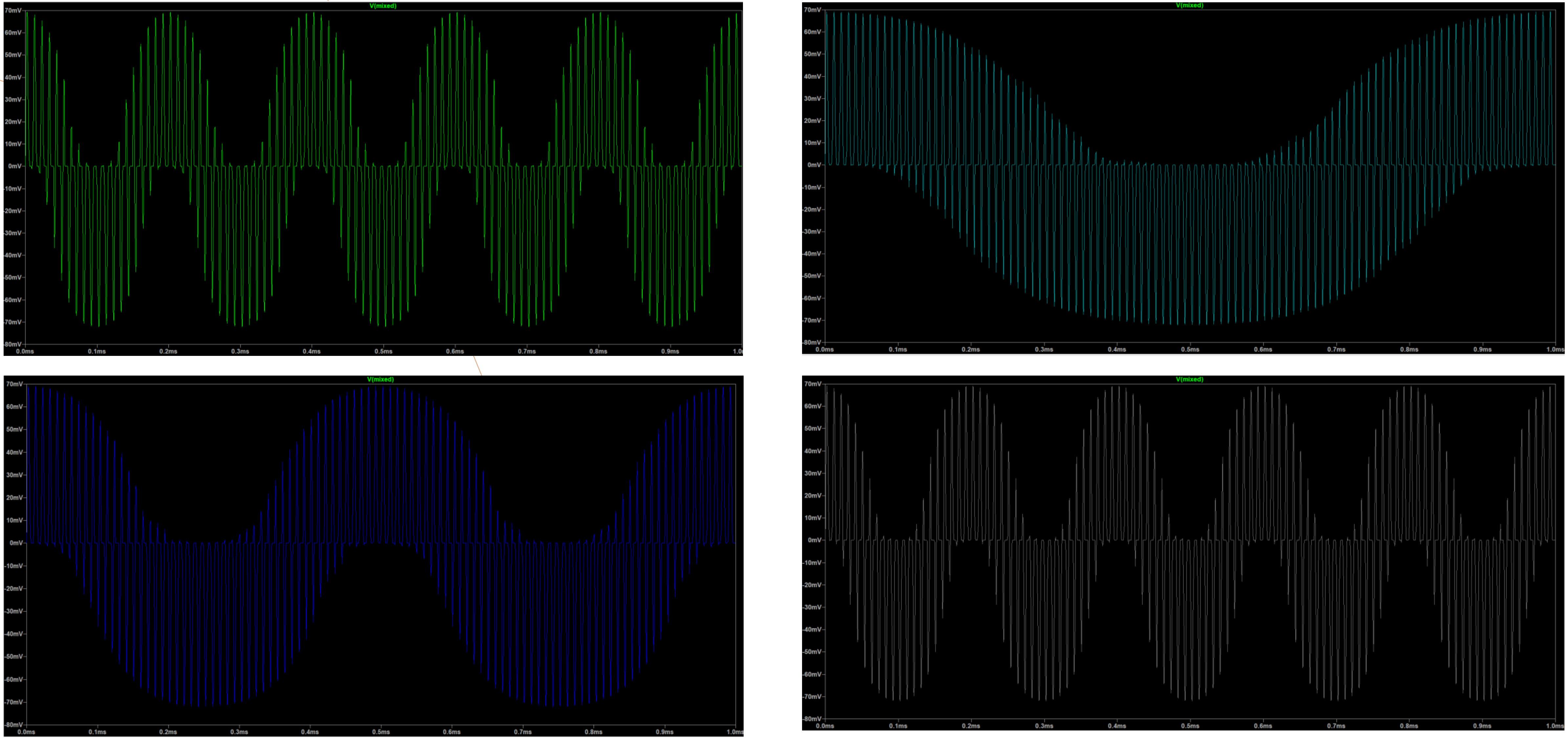
Output from the Mixer + LPF for the Input signal of 95KHz



Output of the Mixer for a single frequency of Input

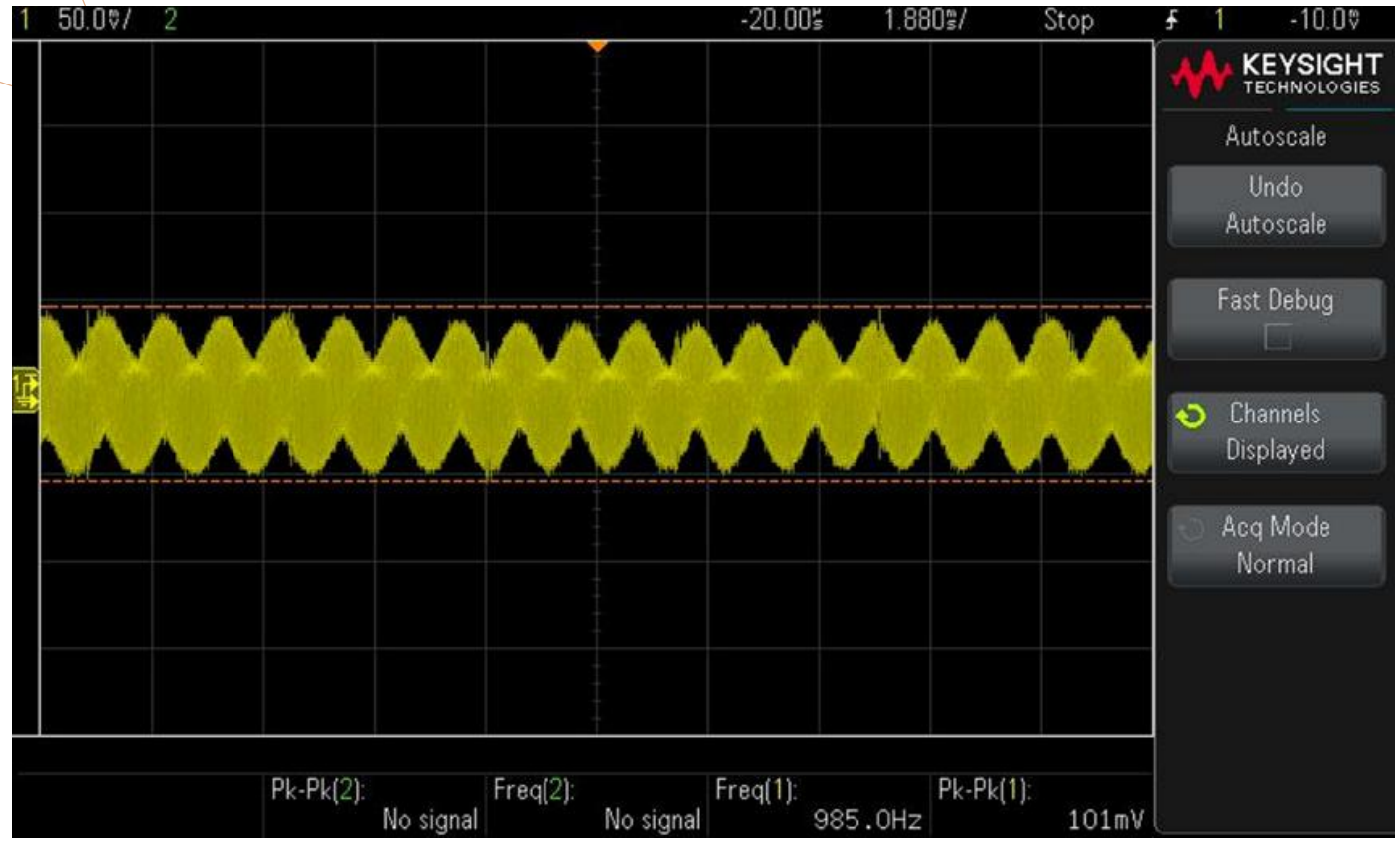


FFT of the Output V(IF) Signal for an Input Signal of 95KHz and Oscillator Signal of 100KHz

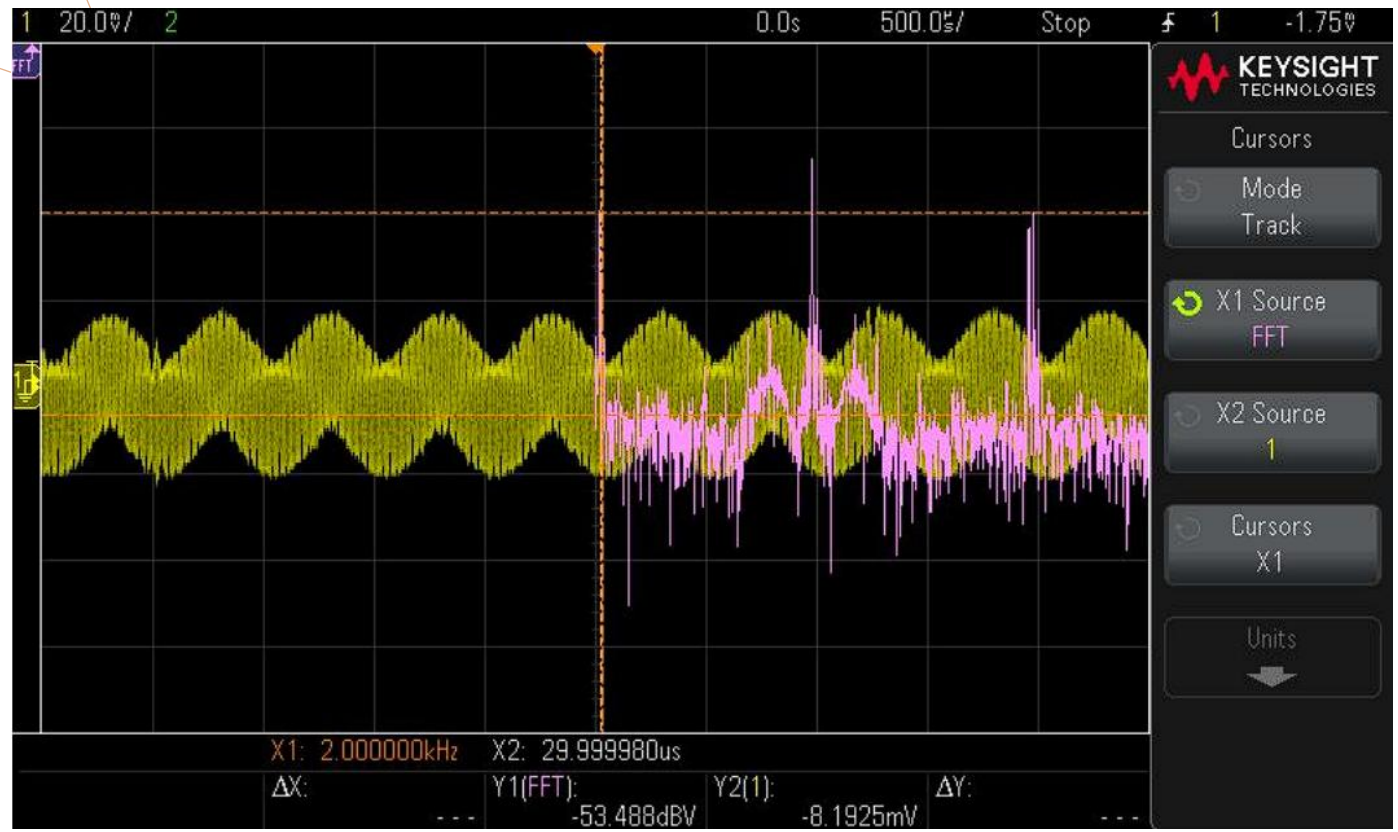


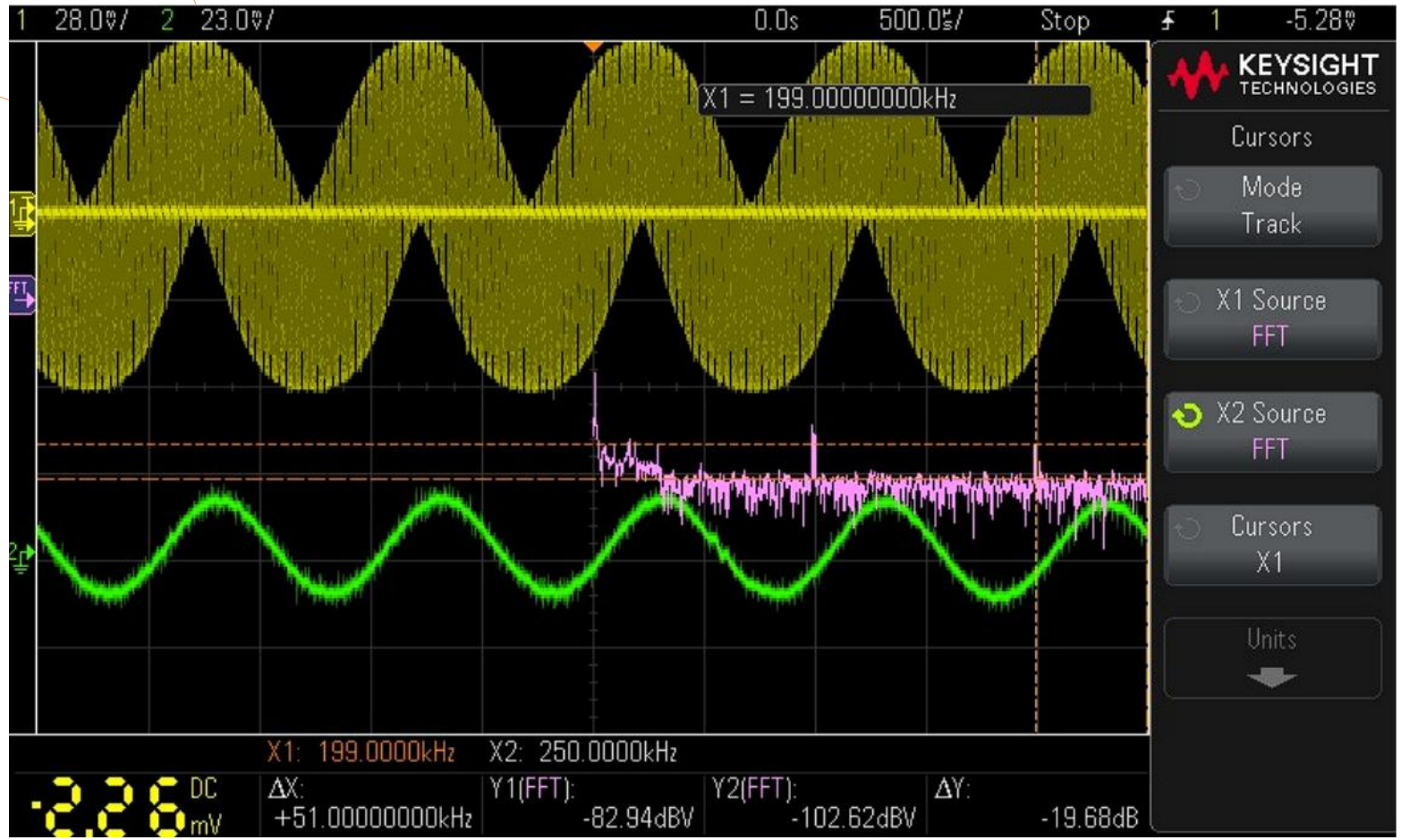
Output of the Mixer for a different frequencies of Input Signal

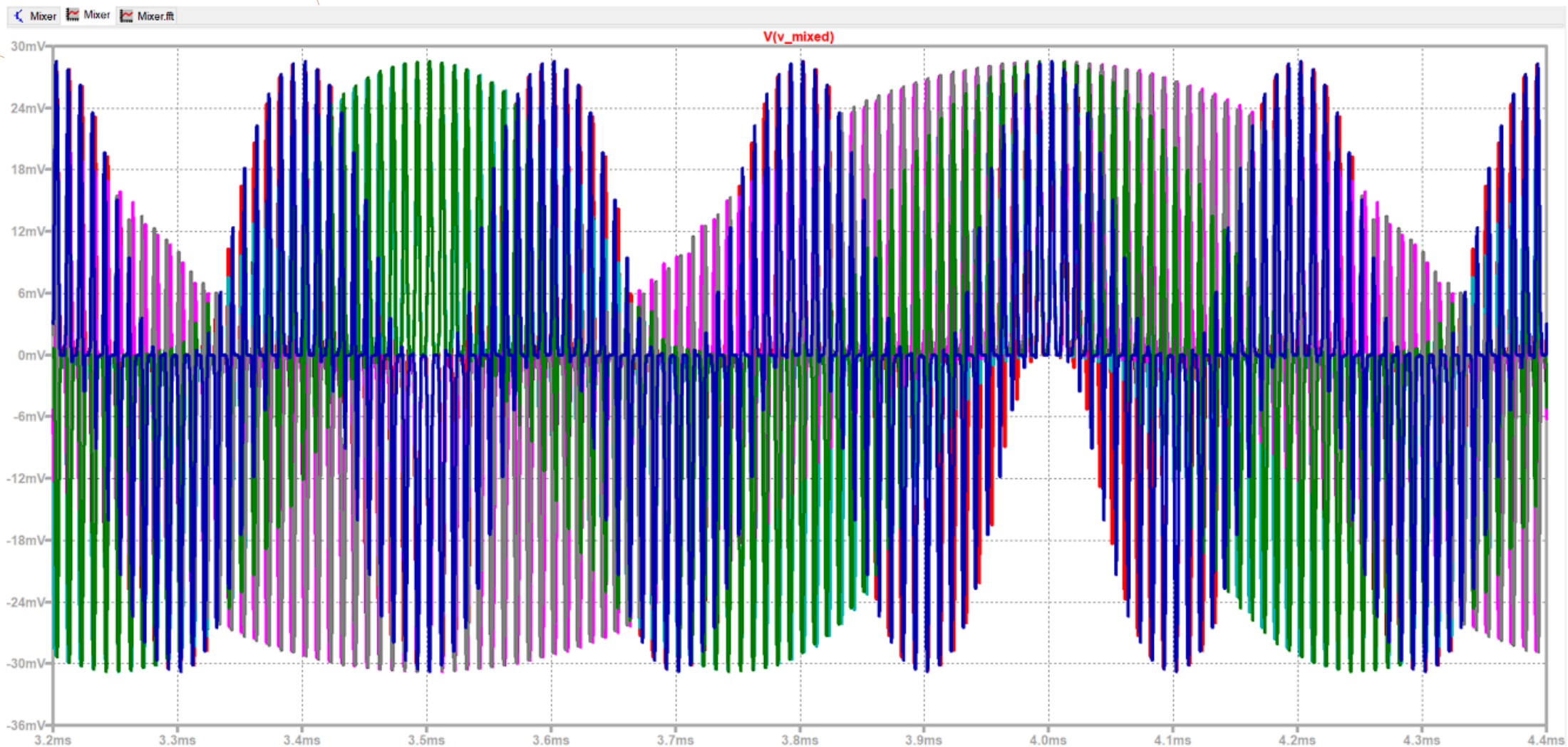
Practical Circuit built in the Lab



Outputs of the DSO

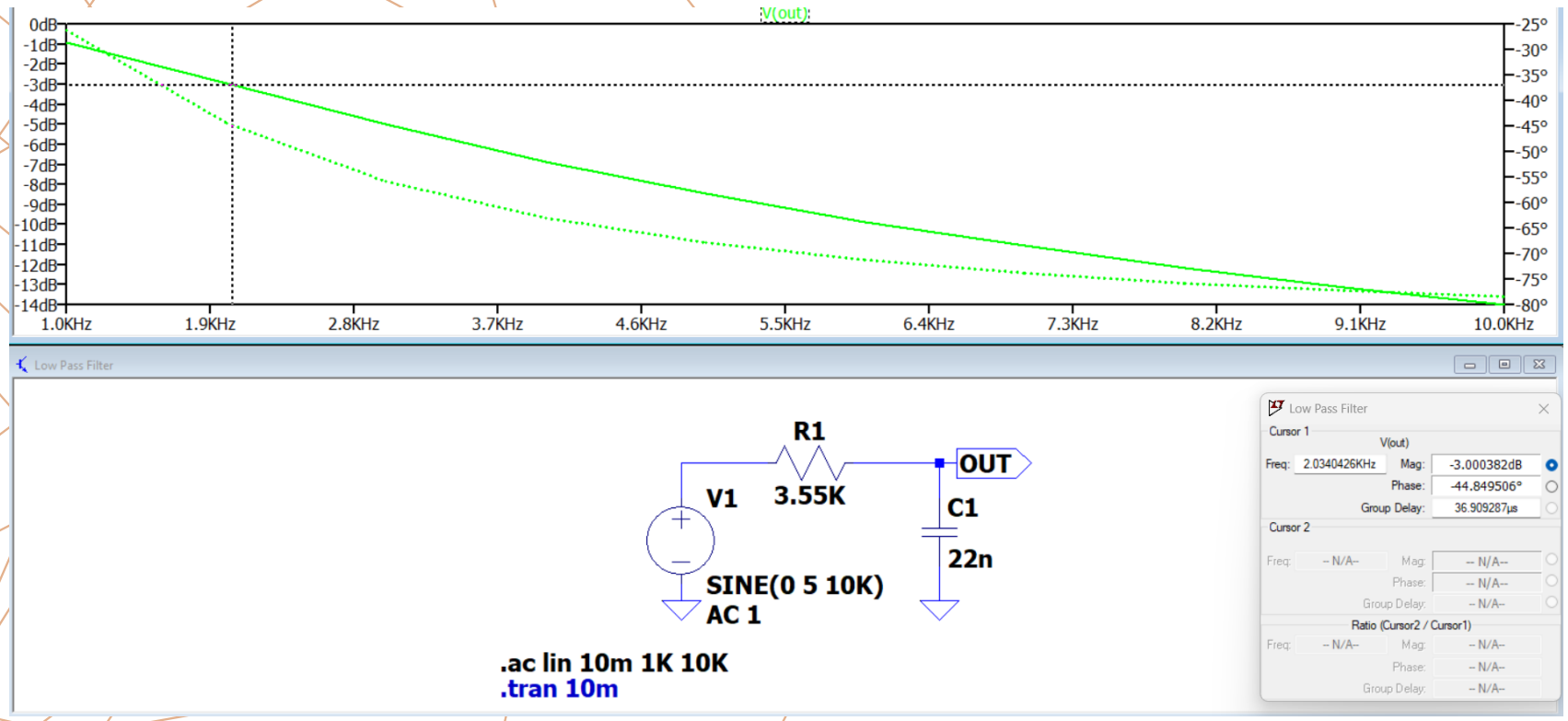



1 28.0mV/ 2 23.0mV/
0.0s
500.0µs/
Stop
1 -5.28mV
X1 = 199.00000000kHz
KEYSIGHT TECHNOLOGIES
Cursors
Mode
Track
X1 Source
FFT
X2 Source
FFT
Cursors
X1
Units
X1: 199.0000kHz
X2: 250.0000kHz
-2.26 DC mV
ΔX:
+51.00000000kHz
Y1(FFT):
-82.94dBV
Y2(FFT):
-102.62dBV
ΔY:
-19.68dB


Mixer
Mixer
Mixer.fft
V(v_mixed)
30mV
24mV
18mV
12mV
6mV
0mV
-6mV
-12mV
-18mV
-24mV
-30mV
-36mV
3.2ms
3.3ms
3.4ms
3.5ms
3.6ms
3.7ms
3.8ms
3.9ms
4.0ms
4.1ms
4.2ms
4.3ms
4.4ms

PART –3

Low Pass Filter (LPF)

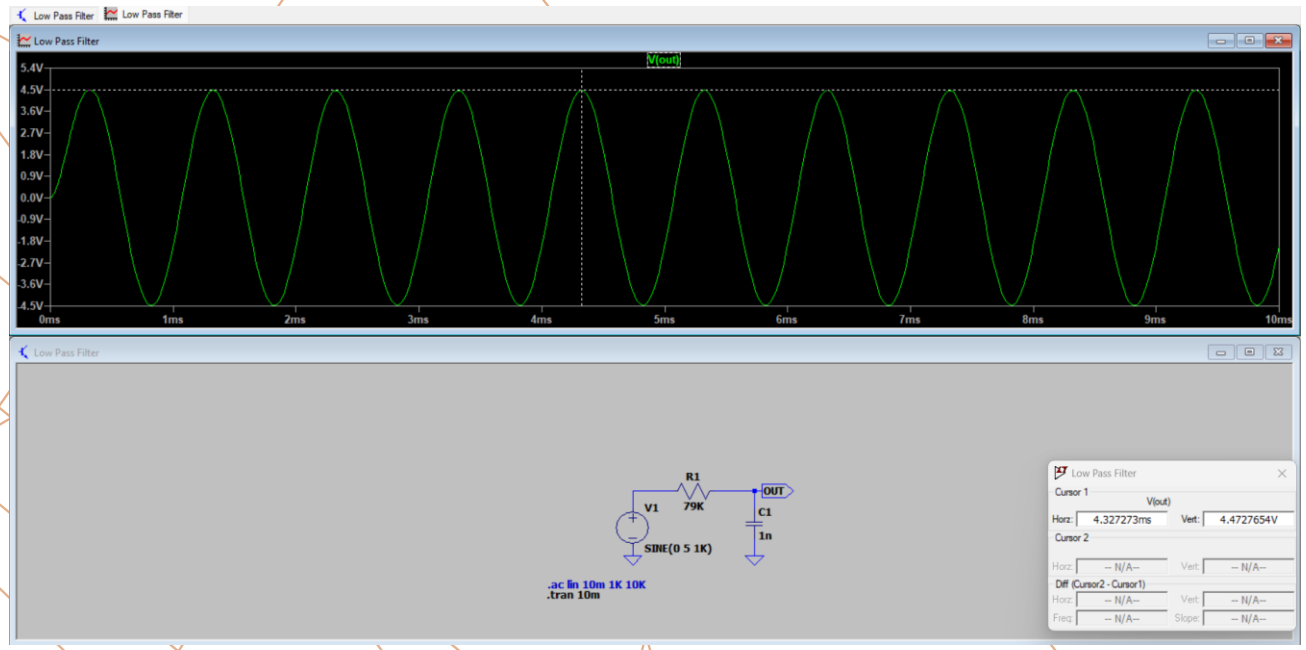


Frequency Response of the LPF from AC Analysis in LTSpice

Here is the circuit design for the required LPF.

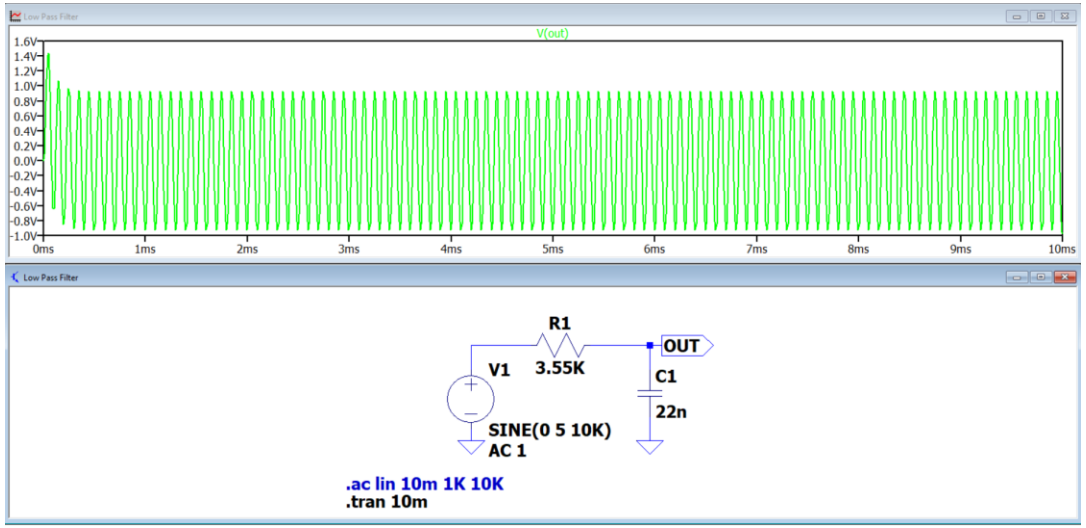
The required -3 dB cut – off frequency for the LPF is 2KHz.
Calculated values of the components are :

R = 3.55 KOhms
C = 22 nF



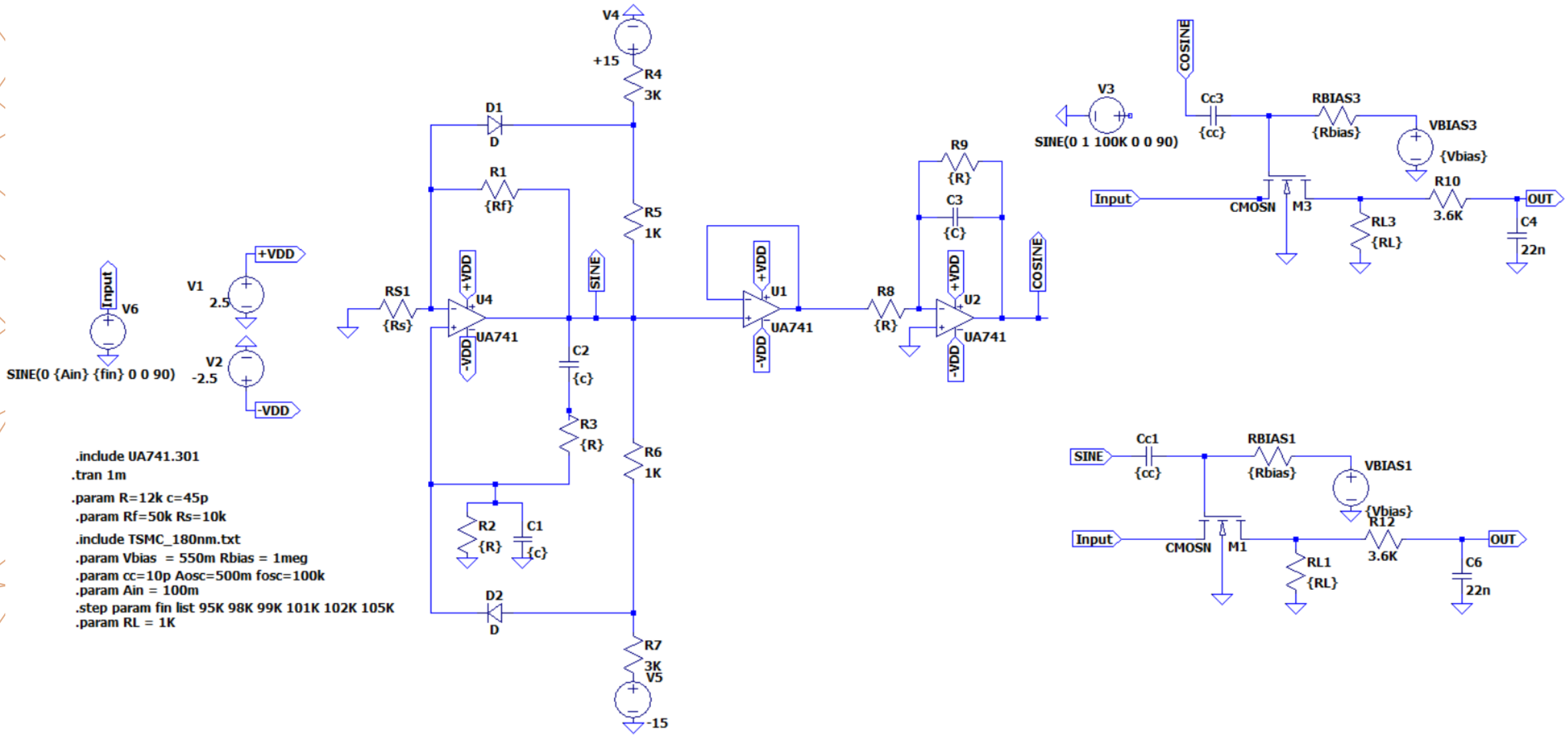
For a 1 KHz signal, (less than 2KHz cut-off) the output is almost same as the input, (although we can observe small attenuation in the signal)

For a 10KHz signal,(greater than 2 KHz cut-off) the output is attenuated .

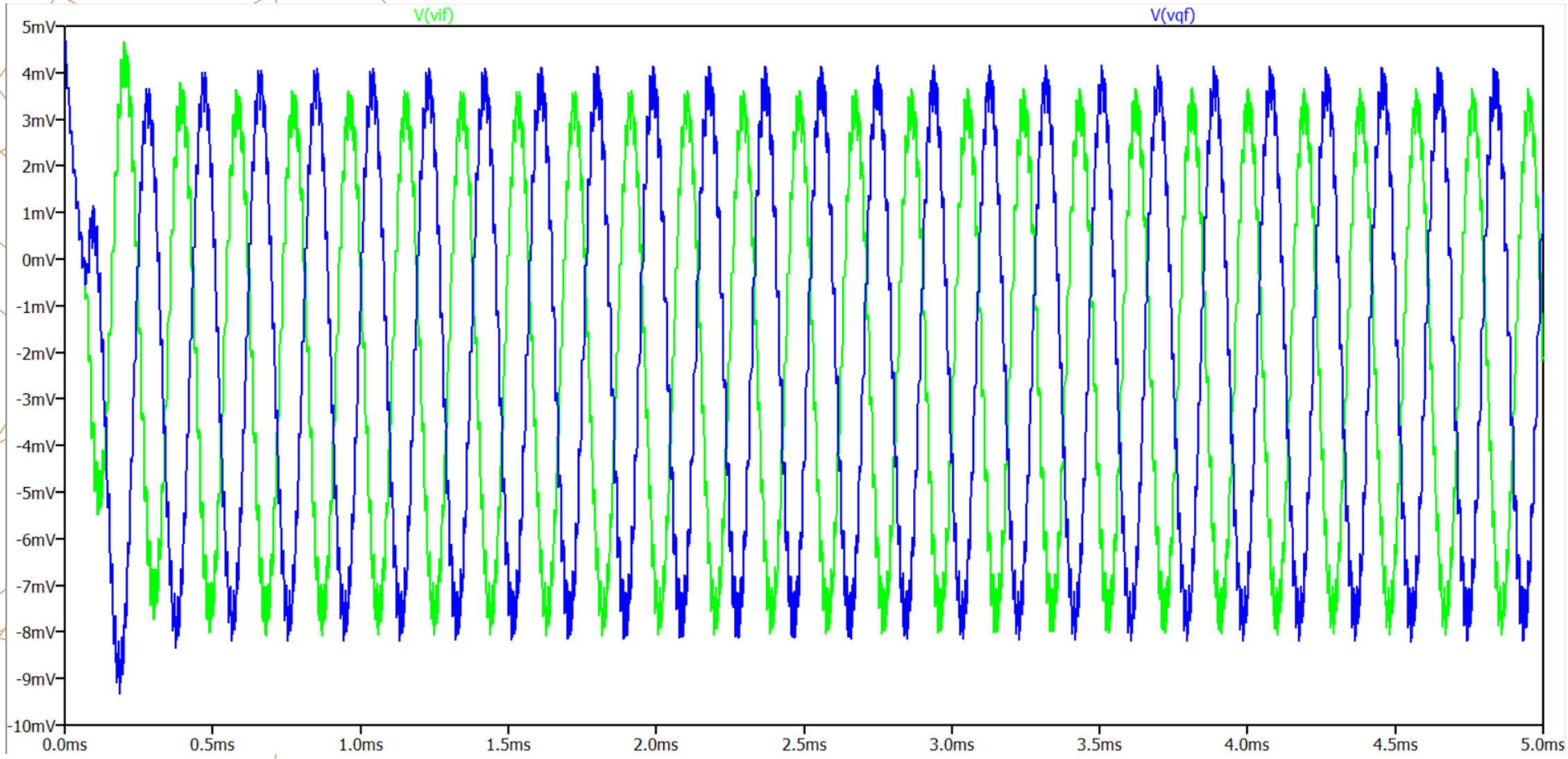


COMPLETE CIRCUIT PROTOTYPE

LTSpice Simulation



LT Spice simulations:



Hardware Implementation:

DSO Output:

THANK YOU

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