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Note that all files are attached.

Internet Phone Filter Splitter

Main concepts:

ADSL phone splitters are mainly used to separate voice signals and internet signals. Our ADSL phone splitter consists of two passive filters: lowpass filter and (highpass filter or band-pass filter) depending on the requirements, so in our case we will use lowpass filter and band-pass filter. Lowpass filter is used to pass voice signals duo to its low frequency comparing to internet signals, on the other side the band-pass filter will be used to pass internet signals as we want to pass a restricted frequency for the internet.

The lowpass filter:

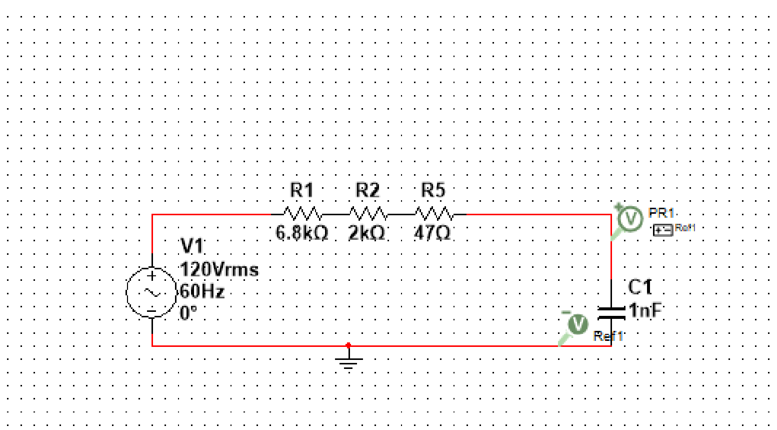


Figure 1lowpass filter circuit

As shown in figure 1, our lowpass filter consists of a 1 nF capacitor and a total resistance of 8842 Ω. Voltage out is the voltage red across the capacitor. At this case we need the filter to pass from zero to 18K Hz. $\omega_c = \frac{1}{RC}$ $2\pi * 18000 = \frac{1}{10^{-9} * 8842}$

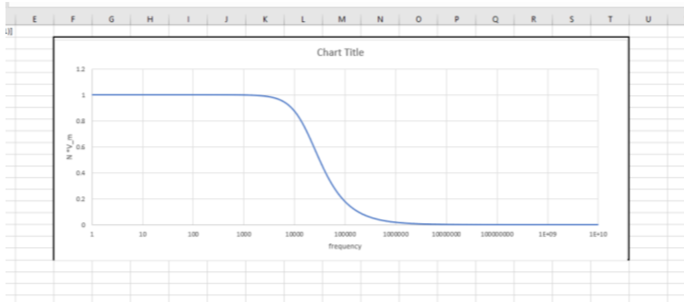


Figure 2 simulation result

Figure 2 represents the simulation of the circuit of the lowpass filter. As we can see it starts from the maximum H and starts to decay at the cur of frequency -18 KHz this case- and reaches zero.

$$\mathbf{X_C} = \frac{\mathbf{1}}{\mathbf{j\omega C}}$$

$$\boldsymbol{H}(\boldsymbol{\omega}) = \frac{\mathbf{V_0}}{\mathbf{V_s}} = \frac{\mathbf{1}}{\mathbf{1} + \boldsymbol{j\omega}\mathbf{CR}}$$

For $\boldsymbol{\omega = 0}$, $|\mathbf{H}| = \mathbf{1}$, **capacitor is open circuit and** $\mathbf{V_0} = \boldsymbol{V_s}$

And for $\boldsymbol{\omega = \infty}$, $|\mathbf{H}| = \mathbf{0}$ **capacitor is a short circuit and** $\mathbf{V_0} = \mathbf{0}$

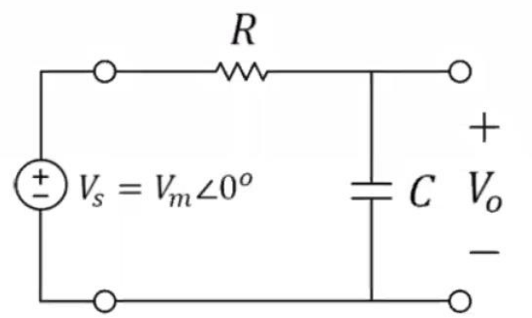
Low pass filter		
f(Hz)	H(ω)	V_0
16595.9	0.735007	8.820084
16982.4	0.727171	8.726052
17378	0.719229	8.630748
17782.8	0.711185	8.53422
18197	0.703044	8.436528
18620.9	0.694813	8.337756
19054.6	0.686496	8.237952

Figure 3 a snapshot from the graph values

The cutoff frequency is 18000 Hz. At the cut of frequency, $|\boldsymbol{H}| = \frac{\mathbf{1}}{\sqrt{\mathbf{2}}}$ which is shown in figure 3 (this figure is a snip from the graph points which will be attached). There is some inaccuracy because of some in the resistance value (5 ohms).

Some analysis for lowpass filter:

$$V_o = V_s \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}}$$



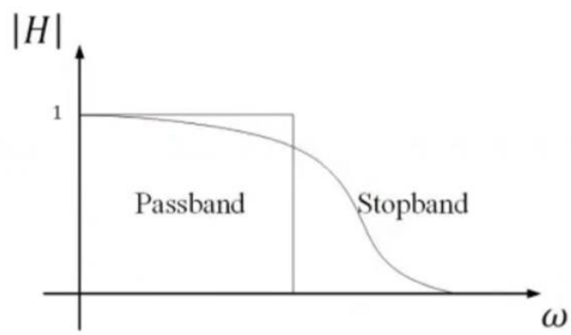
$$V_o = V_s \frac{1}{1 + j\omega CR}$$

$$H(\omega) = \frac{V_o}{V_s} = \frac{1}{1 + j\omega CR}$$

$H(\omega)$ is called Transfer Function

$$H(\omega) = \frac{V_o}{V_s} = \frac{1}{1 + j\omega CR}$$

$$= \frac{1}{\sqrt{1 + (\omega CR)^2}} \angle - tan^{-1}(\omega CR)$$



At $\omega = 0 \quad \rightarrow \quad |H| = 1 \quad \rightarrow \quad V_o = V_s$

At $\omega = \infty \quad \rightarrow \quad |H| = 0 \quad \rightarrow \quad V_o = 0$

Band-pass filter:

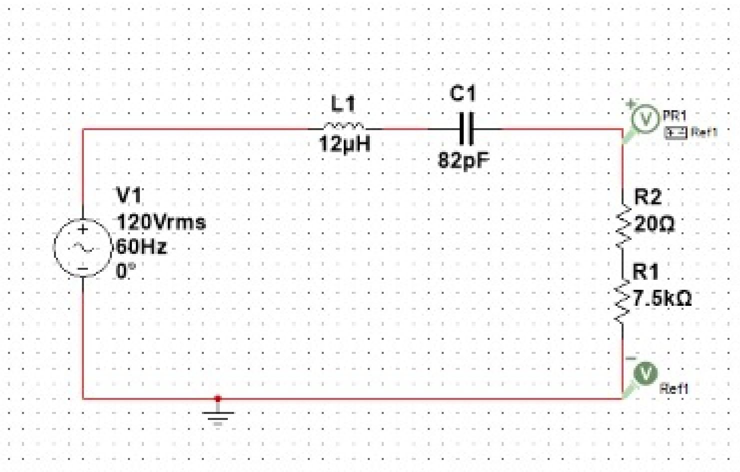


Figure 4 band-pass RLC circuit

For the band-pass filter $\boldsymbol{\omega_1 = 256\ \mathrm{KHz}, \omega_2 = 100\mathrm{MHz}}$ (as we require).

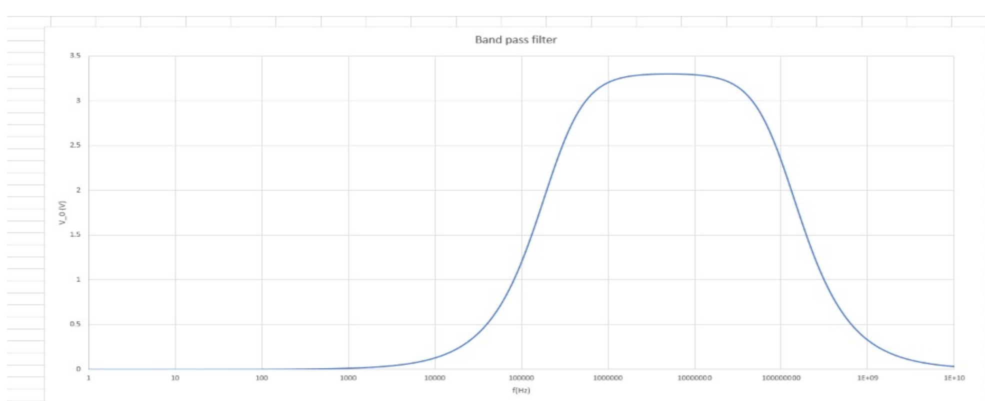
$$Bw = (\boldsymbol{\omega_2 - \omega_1}) * \mathbf{2\pi = 626710035}\ \textbf{rad/s}$$

$$\boldsymbol{\omega_s = \sqrt{}(\omega_1 * \omega_{2)} = \sqrt{256 * 10^3 * 2 * \pi * 100 * 10^6 * 2\pi} = 31790682.5\,\frac{rad}{s}}$$

$$\boldsymbol{\omega_s = \frac{1}{\sqrt{LC}}}$$

By using $\boldsymbol{C = 82\ pF}$ then it leads to $\boldsymbol{L = 12\ \mu H}$

$$\boldsymbol{Bw = \frac{R}{L}\ then\ R = L *\ Bw = 12 * 10^{-6} * 929710035 = 7520\Omega}$$



$\boldsymbol{X_l =}$ $\boldsymbol{j\omega L,}$ $\boldsymbol{X_c = \frac{1}{j\omega C}}$

Figure 5 simulation of band-pass circuit

at $\omega = 0, X_l = 0$ **and** V_0 **and** $|H|$ **will equal zero as well**

at $\omega = \infty, X_C = 0$ **and** V_0 **and** $|H|$ **will equal zero as well**

Band Pass filter		
f(Hz)	H(ω)	V_0
245471	0.690004	2.28E+00
251189	0.698325	2.30E+00
257040	0.706559	2.33E+00
263027	0.714701	2.36E+00
269153	0.722745	2.39E+00
275423	0.730687	2.41E+00
281838	0.73852	2.44E+00

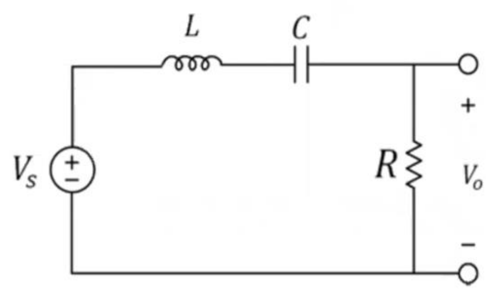
Band Pass filter		
f(Hz)	H(ω)	V_0
9.33E+07	0.731196	2.41E+00
9.55E+07	0.723261	2.39E+00
9.77E+07	0.715223	2.36E+00
1.00E+08	0.707087	2.33E+00
1.02E+08	0.698859	2.31E+00
1.05E+08	0.690543	2.28E+00

Figure 6 two snapshot for the graph values: the first is for the rising side and the second is for the falling side.

The two cutoff frequencies we use are 256 KHz and 100 MHz. As shown in charts, the value of |H| is equal to $\frac{1}{\sqrt{2}}$ when corresponding to the cutoff values.

Some analysis for band-pass filter:

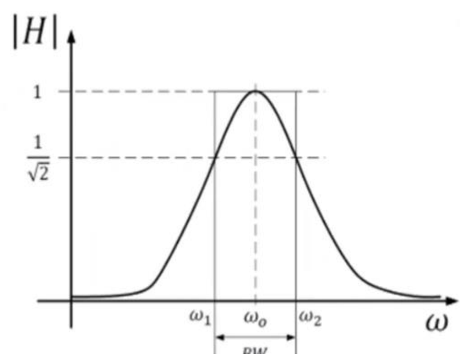
$$H(\omega) = \frac{V_o}{V_s} = \frac{R}{R + j(\omega L - 1/\omega C)} = \frac{1}{1 + jQ_s\Omega}$$



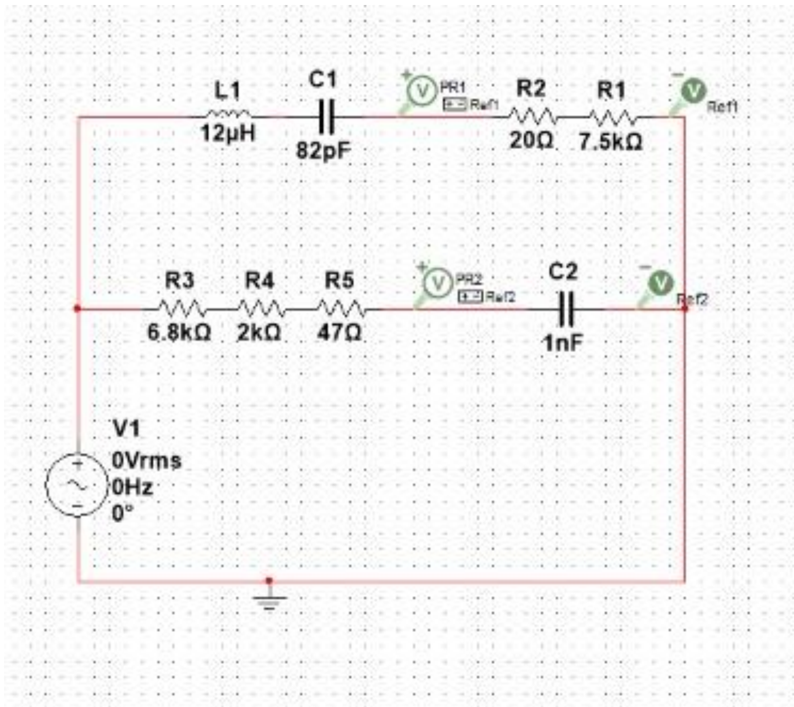
$$\omega_o = \omega_s = \frac{1}{\sqrt{LC}}, \qquad Q_s = \frac{X_L}{R}$$

$$\omega_{1,2} = \omega_o \left[\pm \frac{1}{2Q_s} + \sqrt{\left(\frac{1}{2Q_s}\right)^2 + 1} \right]$$

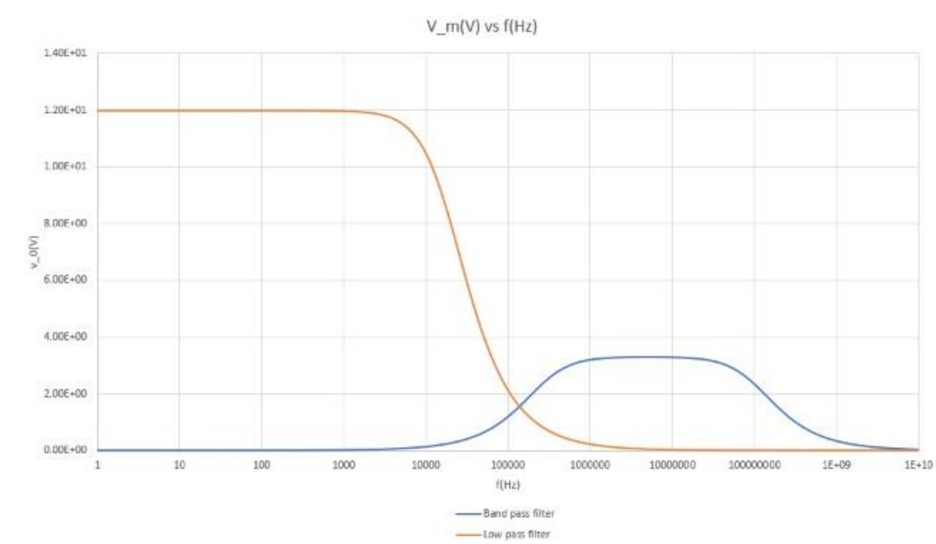
$$\text{If } Q_s \geq 10 \rightarrow \omega_{1,2} = \omega_o \pm \frac{BW}{2}$$



Total splitter circuit:



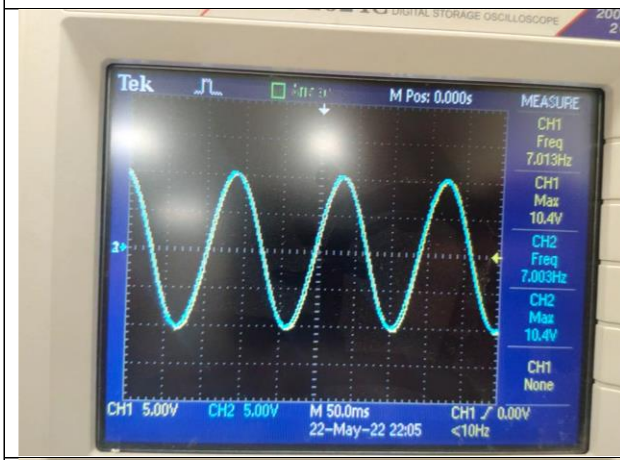
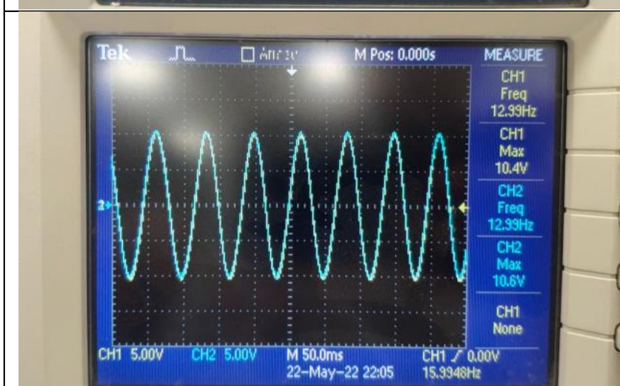
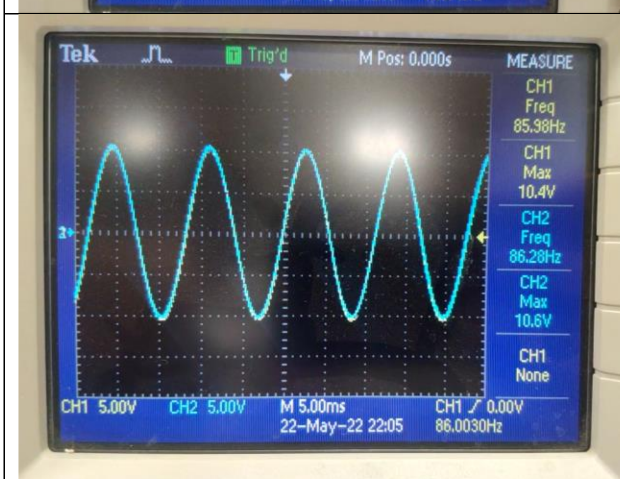
Simulation for total circuit:

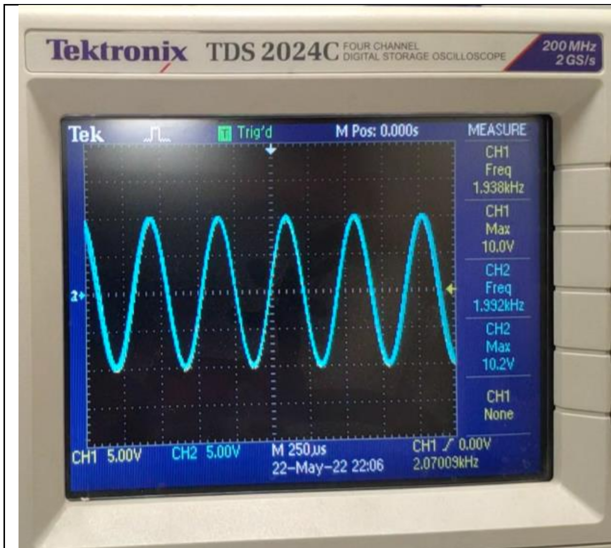
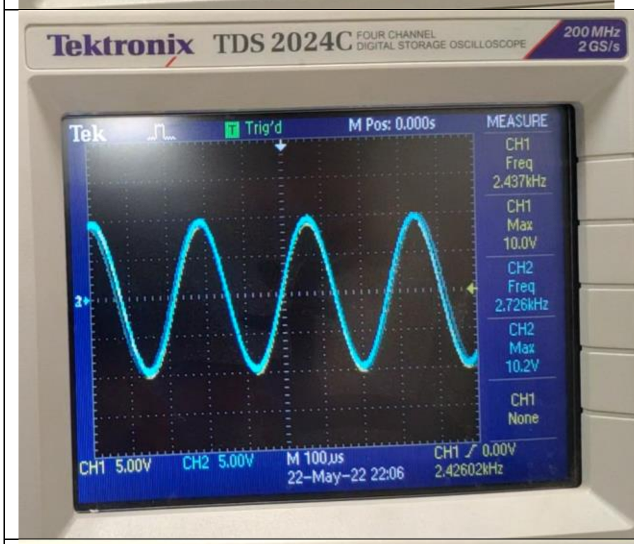
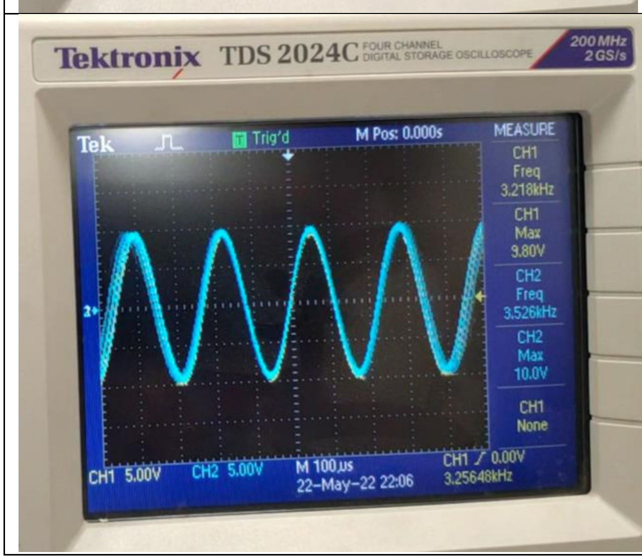


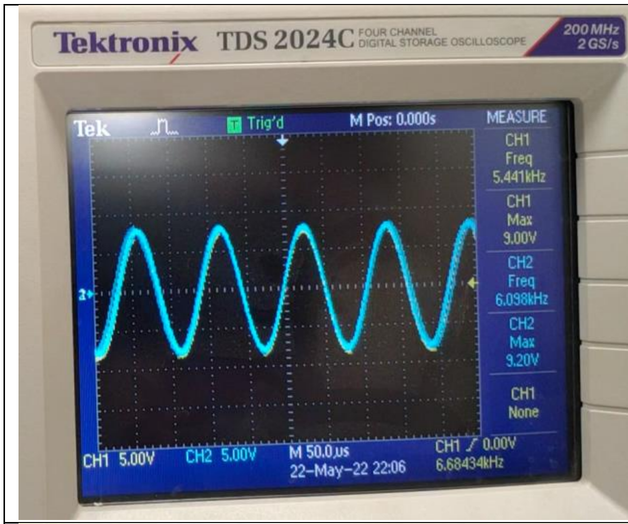
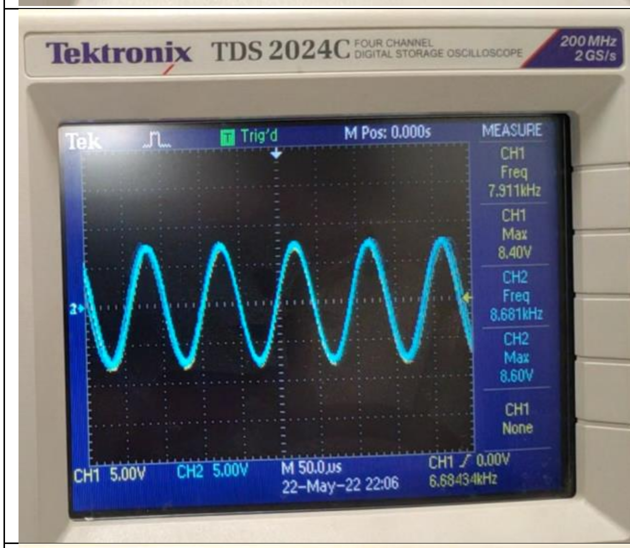
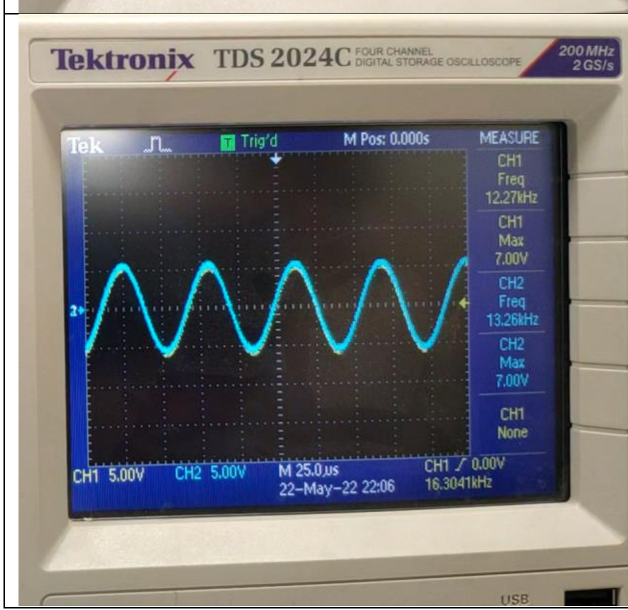
low pass filter (Experimental results):

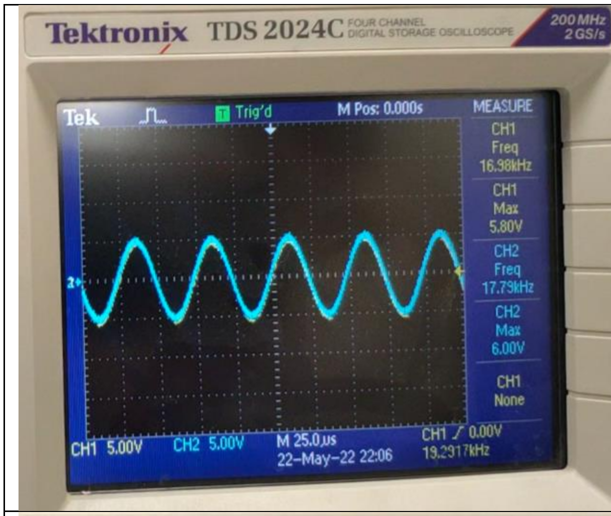
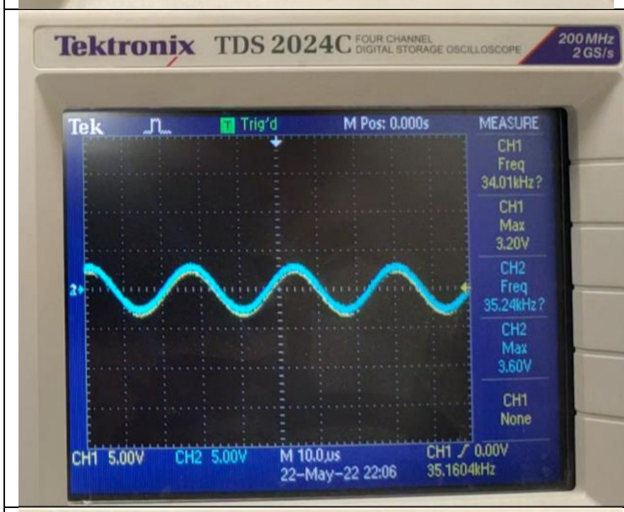
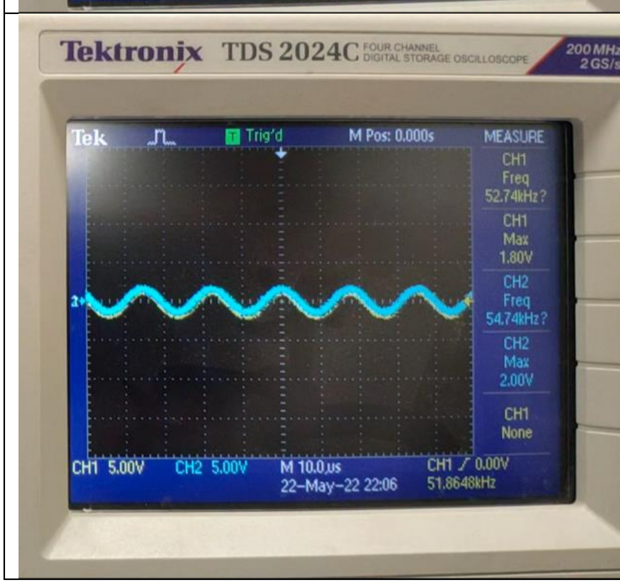
Note that the function generator was providing the circuit with maximum voltage 10V not (12V) so we will consider our maximum voltage as 10 V

Some shots from the oscilloscope:

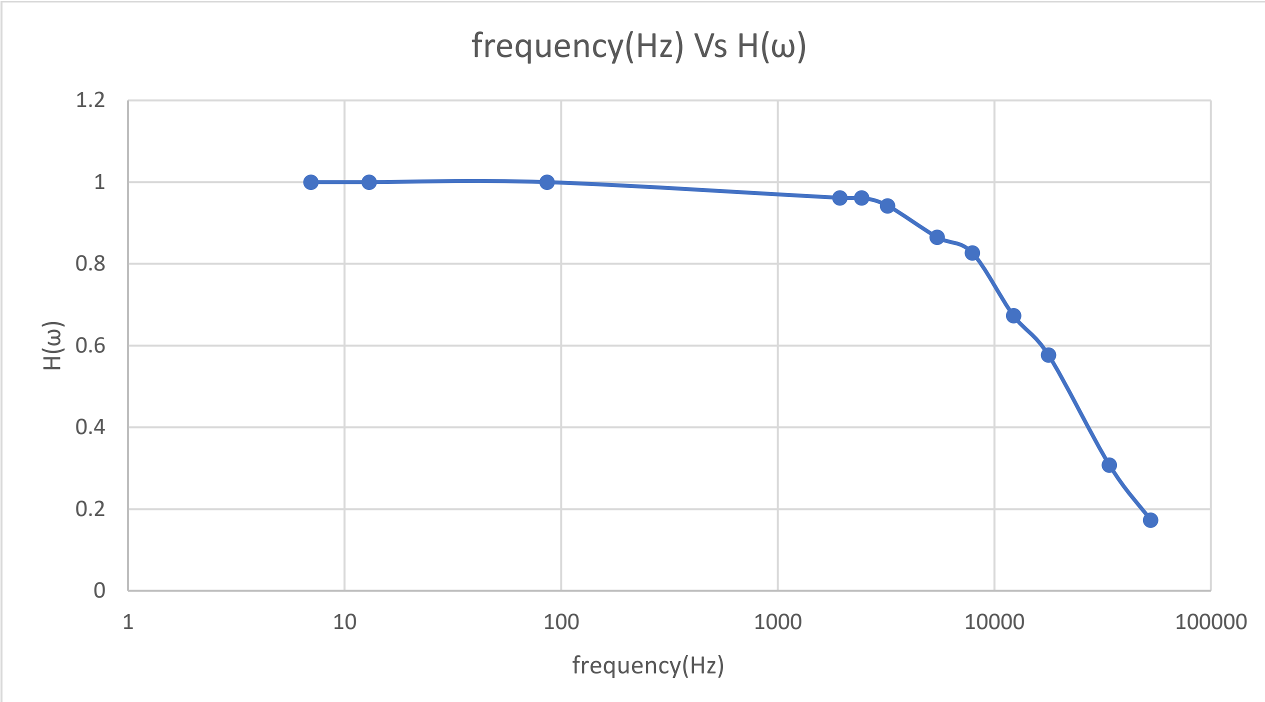
<table>
<tr><th>Oscilloscope shot</th><th>Input frequency (Hz)</th><th>Output voltage(V)</th><th>H((ω)</th></tr>
<tr><td>
</td><td>7</td><td>10.4</td><td>1</td></tr>
<tr><td>
</td><td>13</td><td>10.4</td><td>1</td></tr>
<tr><td>
</td><td>86</td><td>10.4</td><td>1</td></tr>
</table>

<table>
<tr><td>
</td><td>1938</td><td>10</td><td>0.961538</td></tr>
<tr><td>
</td><td>2437</td><td>10</td><td>0.961538</td></tr>
<tr><td>
</td><td>3218</td><td>9.8</td><td>0.942308</td></tr>
</table>

	5441	9	0.865385
	7911	8.6	0.826923
	12270	7	0.673077

	17790	6	0.576923
	34010	3.2	0.307692
	52740	1.8	0.173077

Hardware graph:



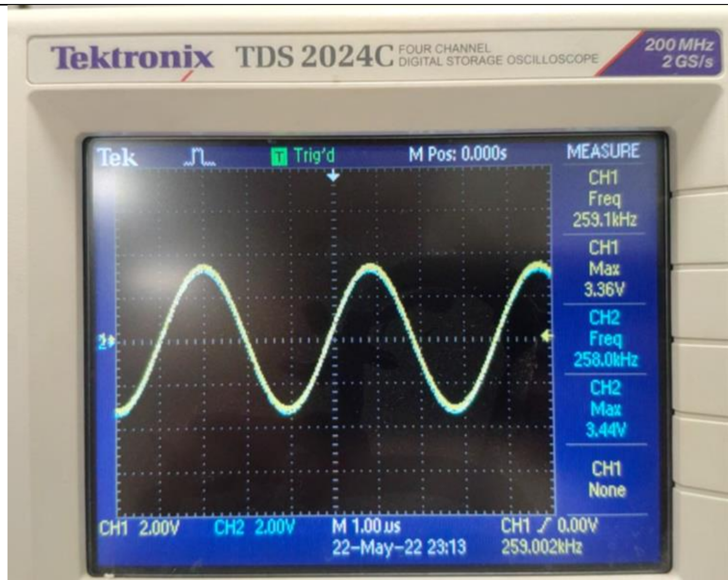
Band pass filter:

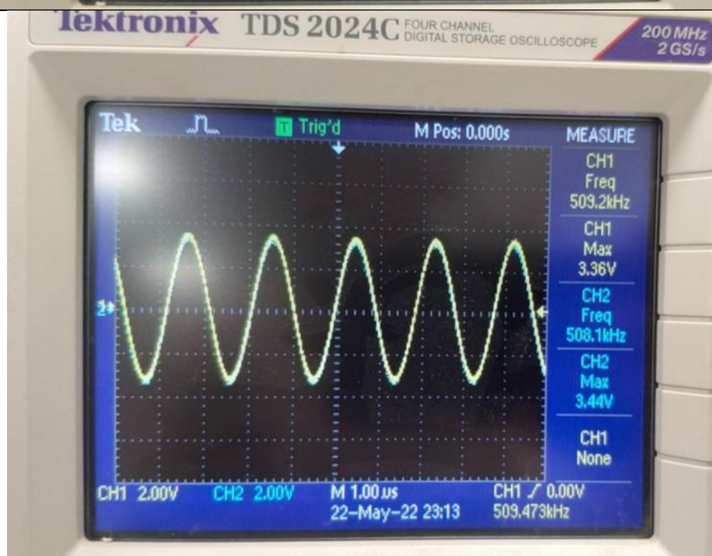
Notes:

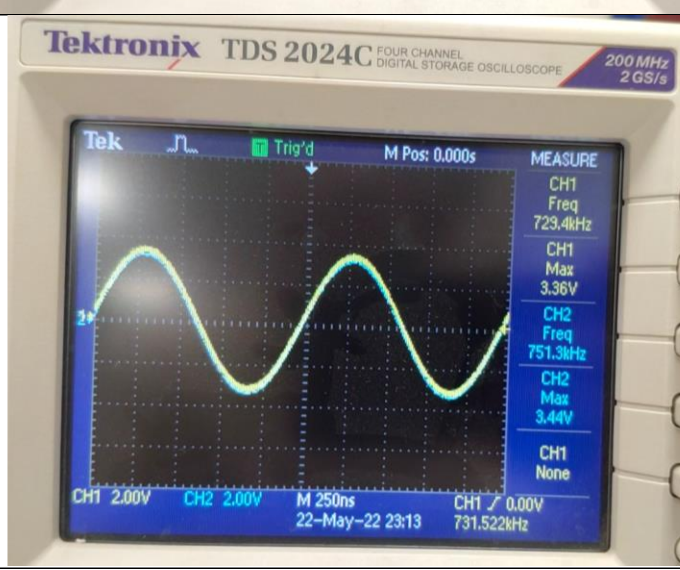
The function generator was not able to deliver frequency more than 25M H so that we were not able to test all cases.

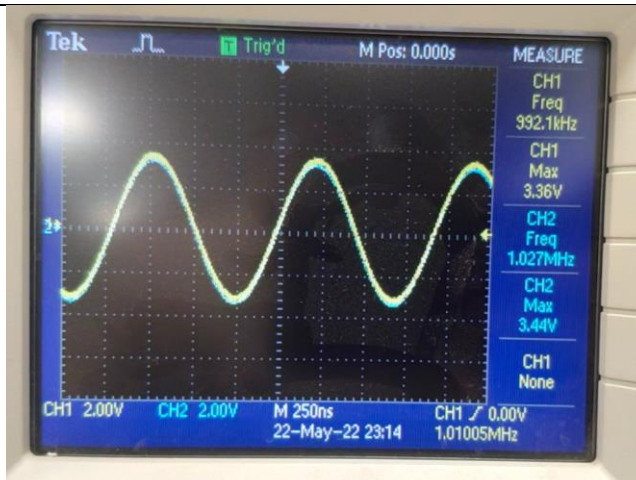
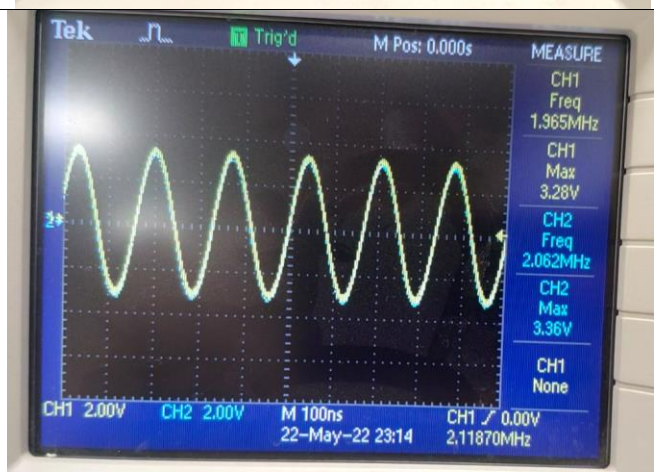
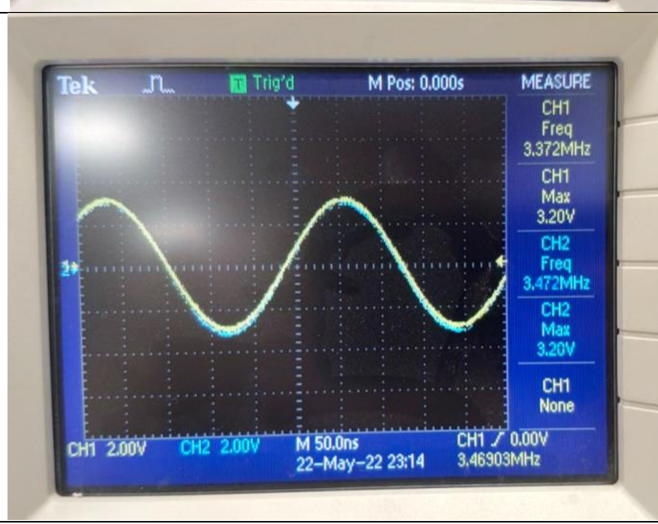
Also, it was lagging in higher frequencies so that the shots are limited in narrow range of frequencies

Some shots from the oscilloscope:

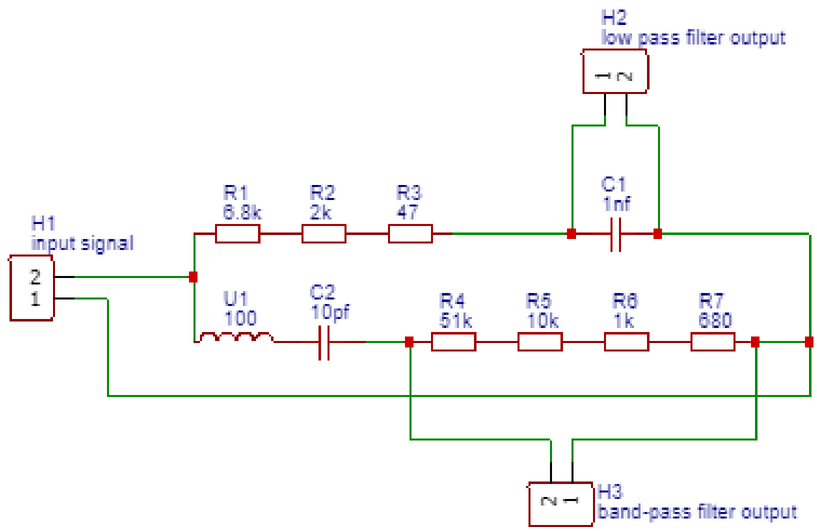

Tektronix
TDS 2024C FOUR CHANNEL DIGITAL STORAGE OSCILLOSCOPE
200 MHz 2 GS/s
Tek
Trig'd
M Pos: 0.000s
MEASURE
CH1 Freq 259.1kHz
CH1 Max 3.36V
CH2 Freq 258.0kHz
CH2 Max 3.44V
CH1 None
CH1 2.00V
CH2 2.00V
M 1.00µs
22-May-22 23:13
CH1 / 0.00V
259.002kHz


Tektronix
TDS 2024C FOUR CHANNEL DIGITAL STORAGE OSCILLOSCOPE
200 MHz 2 GS/s
Tek
Trig'd
M Pos: 0.000s
MEASURE
CH1 Freq 509.2kHz
CH1 Max 3.36V
CH2 Freq 508.1kHz
CH2 Max 3.44V
CH1 None
CH1 2.00V
CH2 2.00V
M 1.00µs
22-May-22 23:13
CH1 / 0.00V
509.473kHz


Tektronix
TDS 2024C FOUR CHANNEL DIGITAL STORAGE OSCILLOSCOPE
200 MHz 2 GS/s
Tek
Trig'd
M Pos: 0.000s
MEASURE
CH1 Freq 729.4kHz
CH1 Max 3.36V
CH2 Freq 751.3kHz
CH2 Max 3.44V
CH1 None
CH1 2.00V
CH2 2.00V
M 250ns
22-May-22 23:13
CH1 / 0.00V
731.522kHz

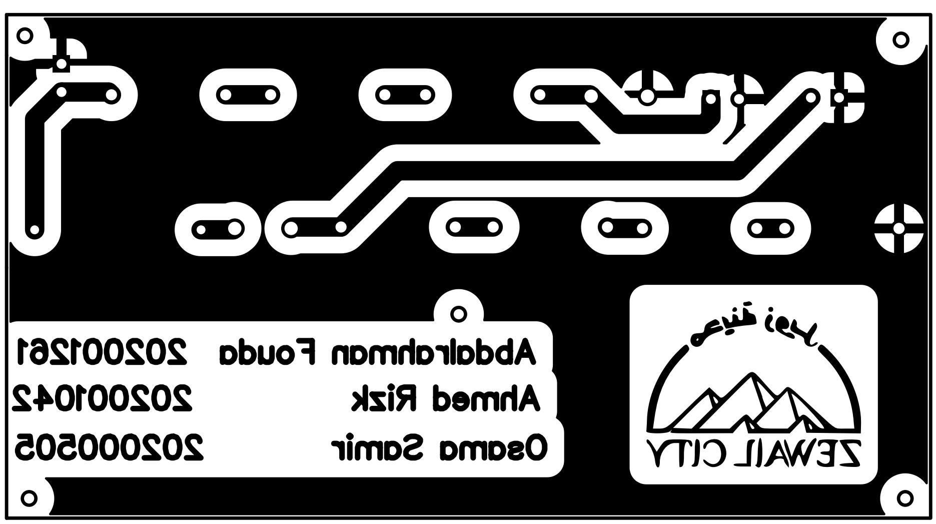
	Tek Trig'd M Pos: 0.000s MEASURE CH1 Freq 992.1kHz CH1 Max 3.36V CH2 Freq 1.027MHz CH2 Max 3.44V CH1 None CH1 2.00V CH2 2.00V M 250ns 22-May-22 23:14 CH1 ƒ 0.00V 1.01005MHz	
	Tek Trig'd M Pos: 0.000s MEASURE CH1 Freq 1.965MHz CH1 Max 3.28V CH2 Freq 2.062MHz CH2 Max 3.36V CH1 None CH1 2.00V CH2 2.00V M 100ns 22-May-22 23:14 CH1 ƒ 0.00V 2.11870MHz	
	Tek Trig'd M Pos: 0.000s MEASURE CH1 Freq 3.372MHz CH1 Max 3.20V CH2 Freq 3.472MHz CH2 Max 3.20V CH1 None CH1 2.00V CH2 2.00V M 50.0ns 22-May-22 23:14 CH1 ƒ 0.00V 3.46903MHz	

Schematic of the PCB design by EasyEDA:



Note that some Values are different in the final phase due to the availability of the components.

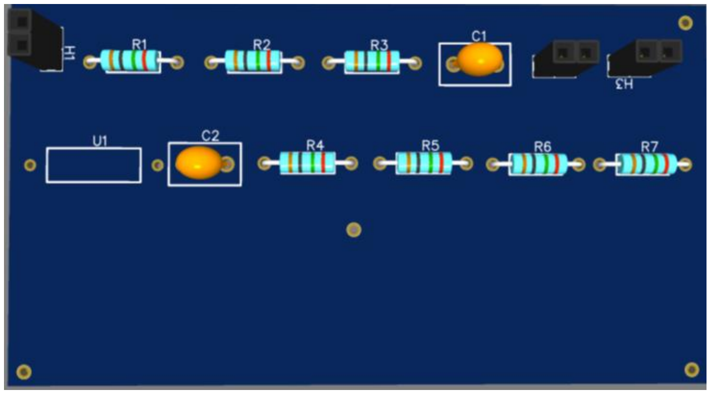
Virtual PCB design:



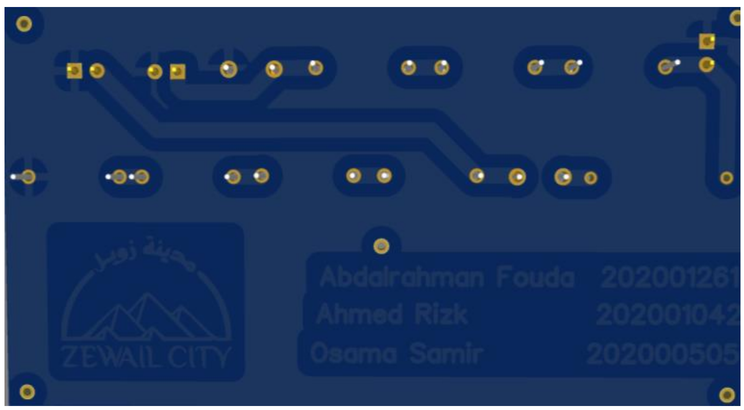
Note that the names and university logo are inverted as they are in the bottom layer of the PCB.

3D model of the PCB:

Front:

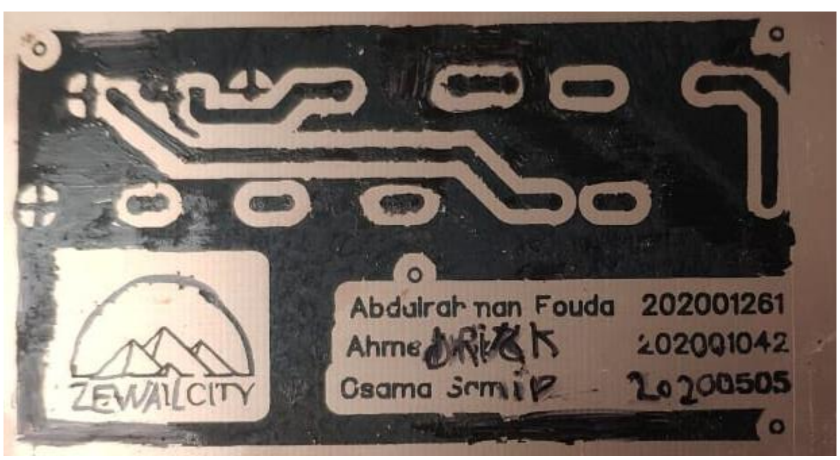


Back:



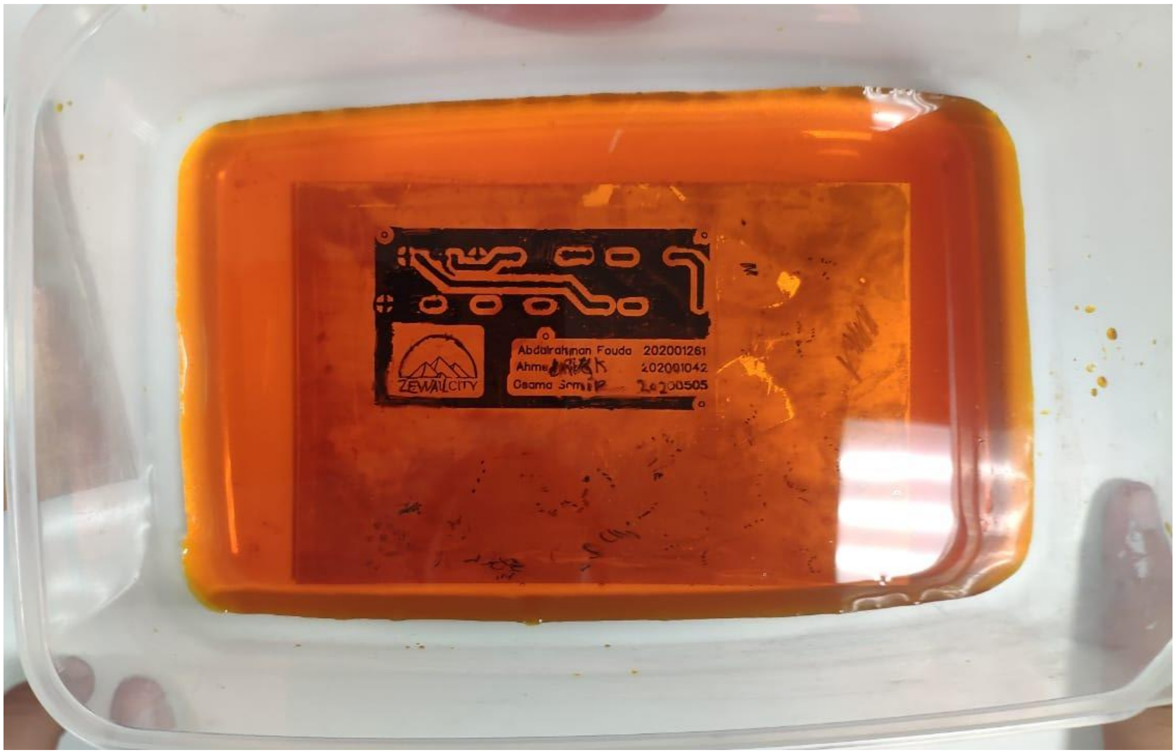
Note that the design is normal (Not inverted)

The design after transferred to the PCB:

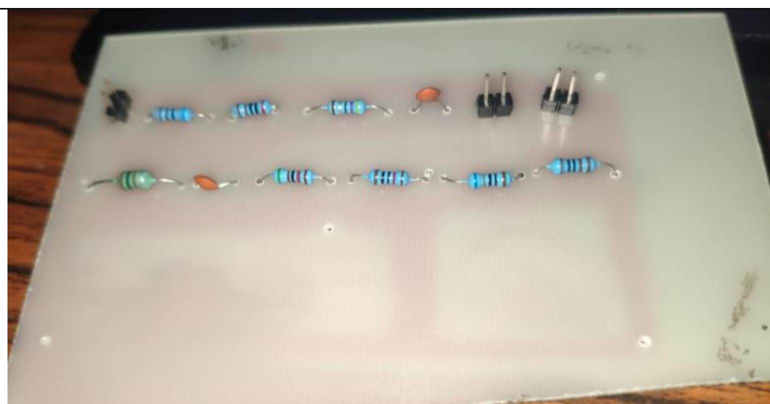


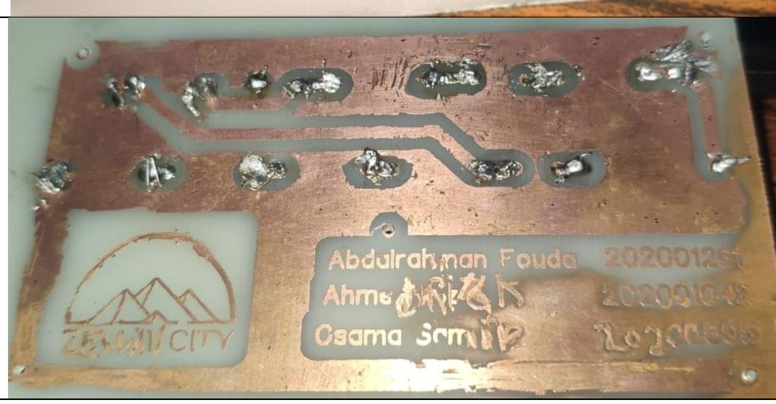
Some tracks were not transferred properly so we repaired the design using PCB pen.

After that we put the design in the Acid to be etched:



Using the acid, the uncovered area was removed. Then we drilled the holes to fit the component size and solder them as shown in figures below.



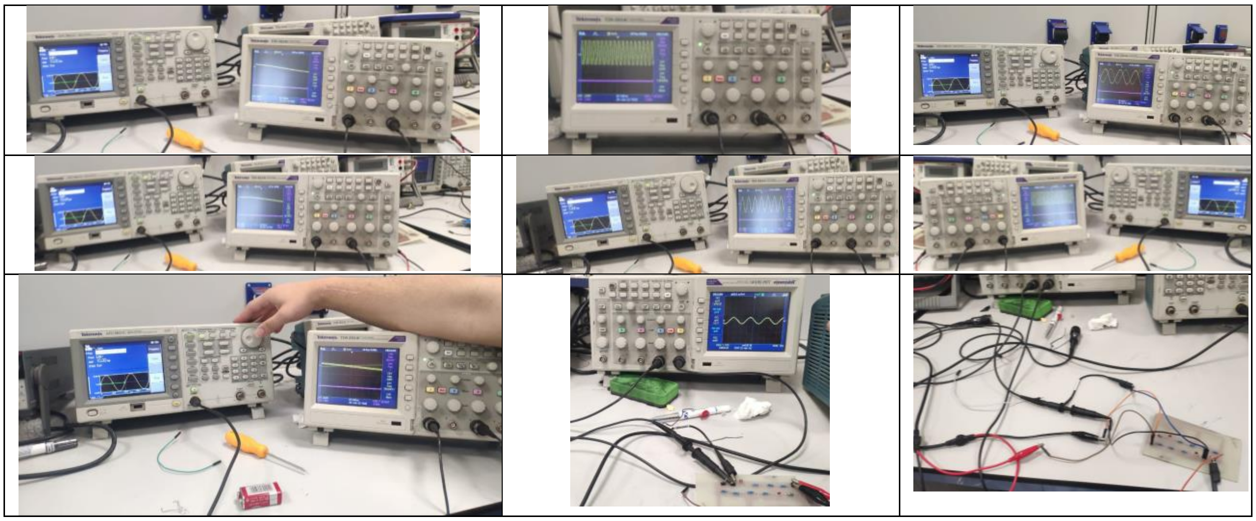


Testing the circuit after soldering:

Using battery, LEDs, and wires we checked that there are no short circuits or cuts in the PCB.

Testing the functionality of the circuit:

Some snap shots from the results:



Note that: The results were like the results in phase 2

The wires standard file that we used in the project implementation is attached.