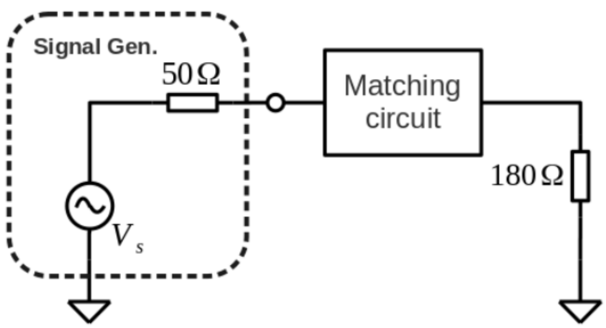
EEE 202 CIRCUIT THEORY LAB 3

Part 1 Software Implementation

Introduction:

The main aim of the experiment is to study the maximum power transfer theory with two different circuits. The circuit contains 180 ohm load resistance and the signal generator acts like there is 50 ohm resistance in the source. L section model and the T section model used for transferring maximum power to the 180 ohm load resistor.

Analysis:



The power equation for the given circuit can be found as ($R_s = 5\ ohm,\ R_L = 180\ ohm$)**:**

$$I = \frac{V_s}{Z_s+Z_L} \text{ (eq. 1.1)}$$

$$P_L = Re\{ \frac{V_L}{2} \cdot I^* \} = Re\{ \frac{|V_s|^2}{2|Z_s+Z_L|^2} \cdot Z_L \} = \frac{|V_s|^2}{2(R_S+R_L)^2+(X_s+X_L)^2} R_L \text{(eq. 1.2)}$$

For the real part if we take the derivative with respect to R_L and make it zero to find the maxima point:

$$\frac{|V_s|^2 \cdot (R_s^2-R_L^2)}{2(R_S+R_L)^4} = 0 \text{ (eq. 1.3)}$$

From the eq. 1.3 we can say that choosing $R_L = R_s$ maximizes $Re\{P_L\}$.

As seen in the eq. 1.2 and 1.3 for maximizing P_L, we should choose $X_s = - X_L$ and $R_L = R_S$.

Therefore making $Z_S = Z^*_L$ gives the maximum power transfer for the load.

$$P_{L\,max} = \frac{|V_s|^2}{8\,R_S} \text{ (eq. 1.4)}$$

In order to achieve maximum power transfer we should transform 180 ohm to 50 ohm. For this purpose impedance matching circuits are used.

L Section impedance matching:

Around the impedance frequency w_0 The circuit acts like a parallel tuned circuit.

$$R_s = 50,\ R_P = 180,\ w_0 = 50.2 \times 10^6$$

(Frequency is chosen for the inductor value, inductors values are limited in the lab)

$$R_p = (Q^2 + 1)R_s \text{ (eq. 2.1)}$$

$$C = C_p = C_L \text{ (eq. 2.2)}$$

$$L_p = (1 + \frac{1}{Q^2})L_s \text{ (eq. 2.3)}$$

$$w_0 = \frac{1}{\sqrt{C\,L_p}} \text{ (eq. 2.4)}$$

$$Q = \frac{W_0 L_s}{R_s} \text{ (eq. 2.5)}$$

We will use this equations to calculate corresponding L, C values for the circuit.

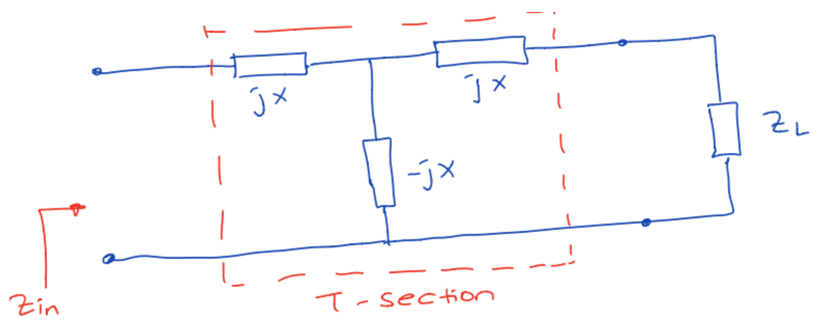
$$50 = (Q^2 + 1)180$$

Q = 1.61

$$L_S = \frac{QR_s}{w_0} = 1.6 \times 10^{-6} H$$

$$C = \frac{1}{W_0^{\ 2} L_p} = 152 \times 10^{-12} F$$

T Section impedance matching:



$$Z_{in} = jX + (-jX)//(jX + Z_L)\text{(eq. 3.1)}$$

$$X = \sqrt{Z_{in} Z_L}\ \text{(3.2)}$$

$$L = X W^{-1},\ C = (X W)^{-1}\ \text{(eq. 3.3)}$$

In our circuit $Z_{in} = 50,\ Z_l = 180, W = 59 \times 10^6$ so:

$$X = -94.87,\ \ + 94.87\ \text{(Chose the minus one)}$$

$$L = 1.6 \times 10^6 H\ ,\ C = 178 \times 10^{-12} F$$

Simulations:

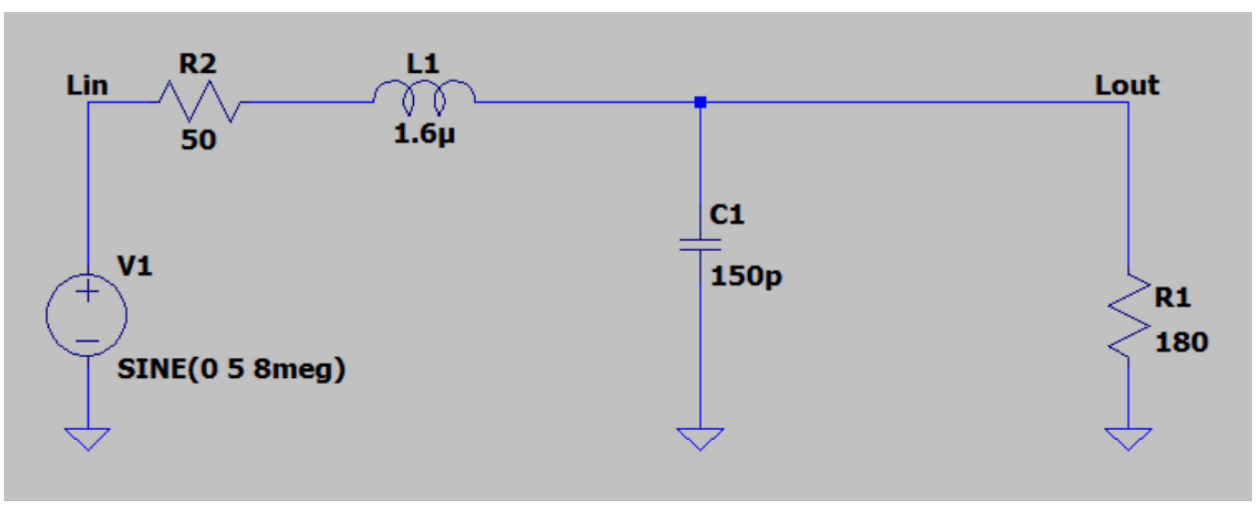


Photo 1: The L section Model

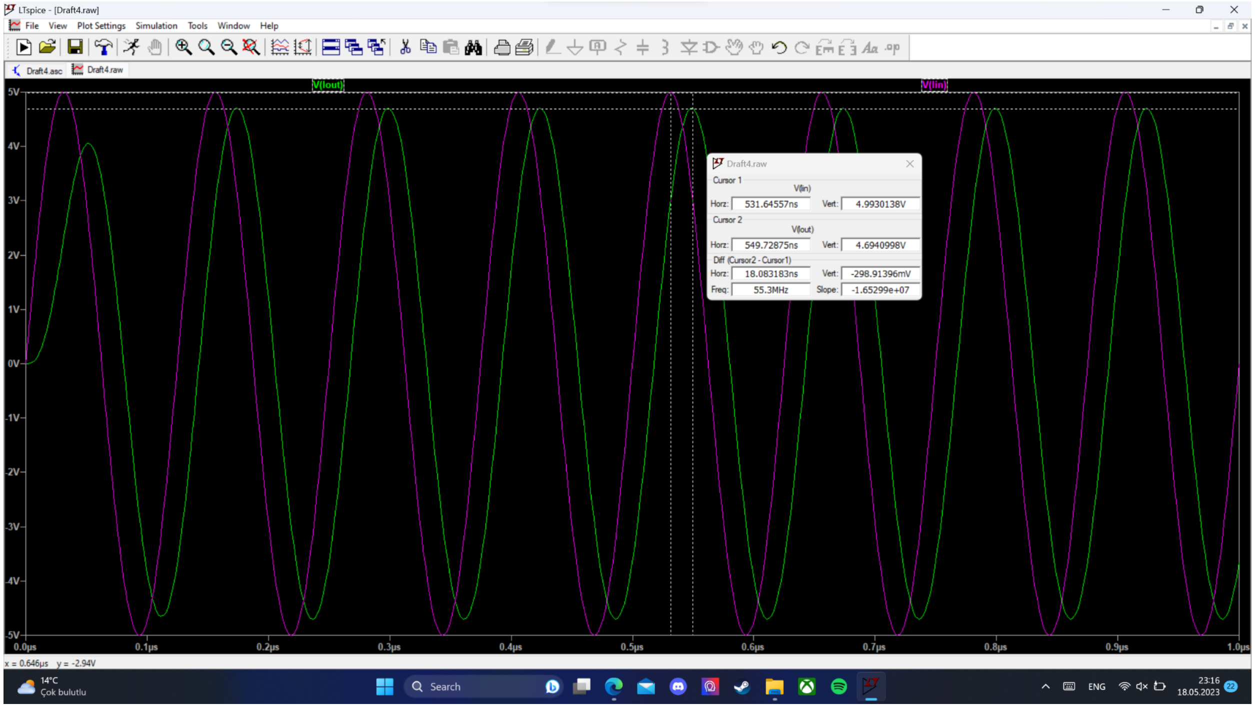


Photo 2: The L section Model Voltage comparison

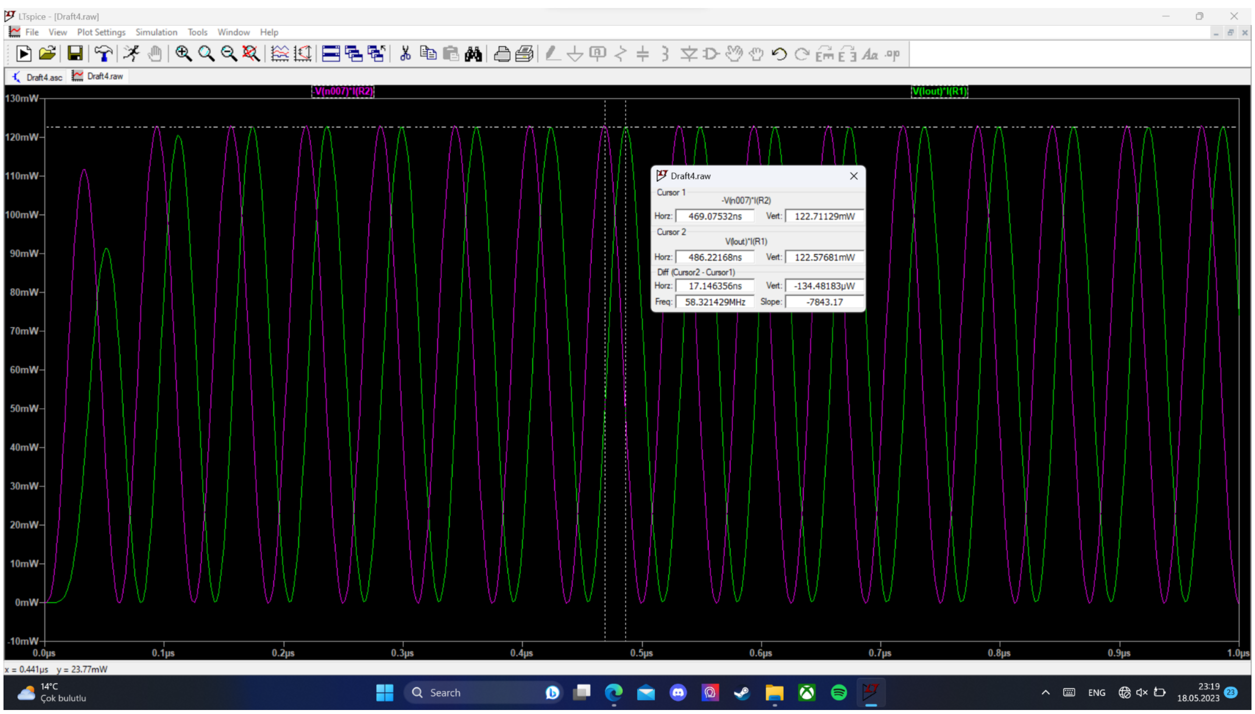


Photo 3: The L section Model power comparison

As seen in the plots the power transfer compared in Load and in the source is almost identical and the error is %0.16. The available power is around 250mW and it is disturbed half and half. The simulation results follow the equations.

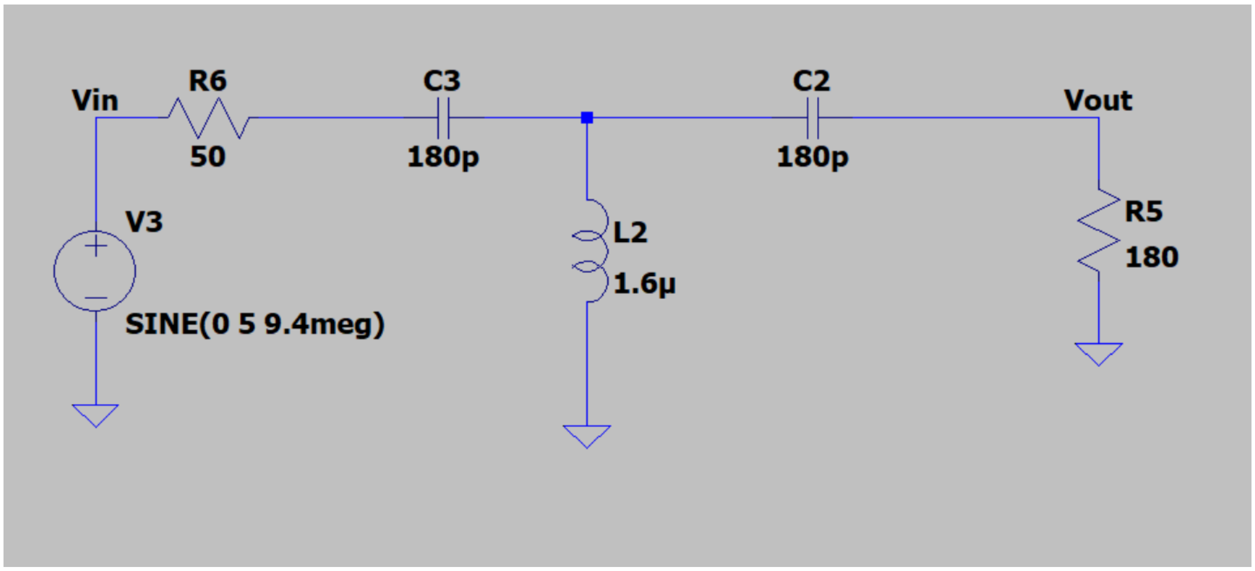


Photo 4: The T section Model

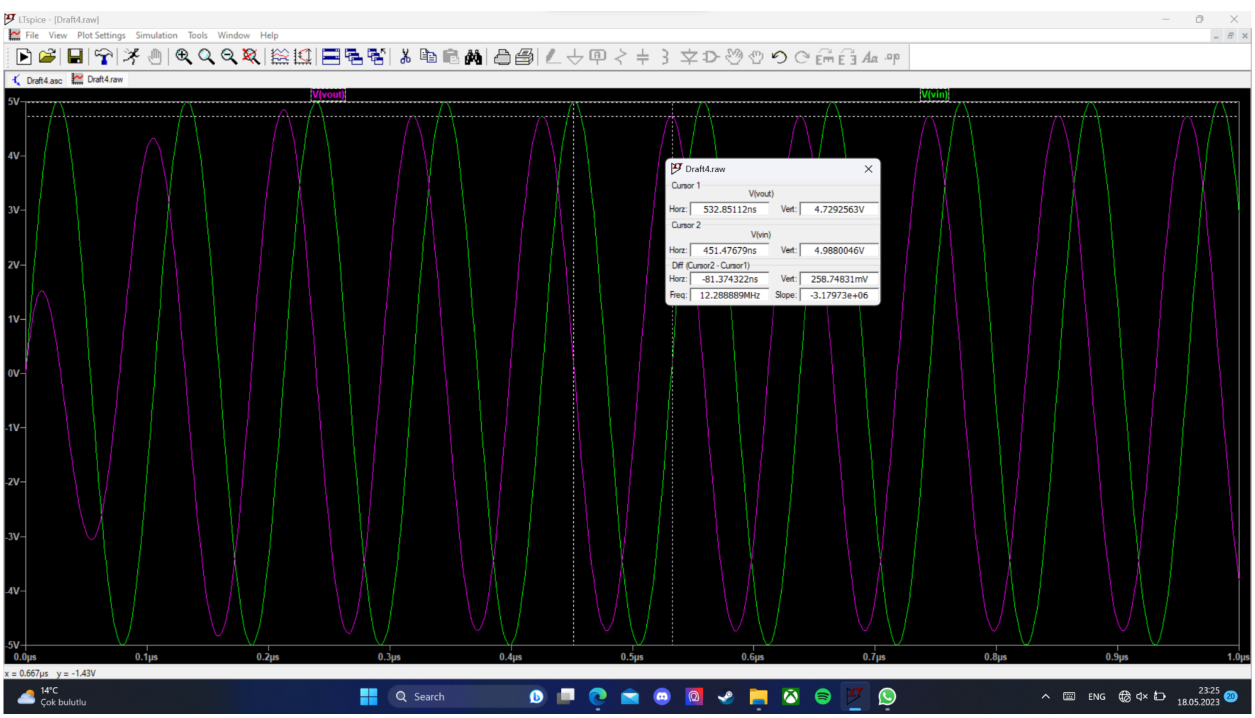


Photo 5: The T section voltage comparison

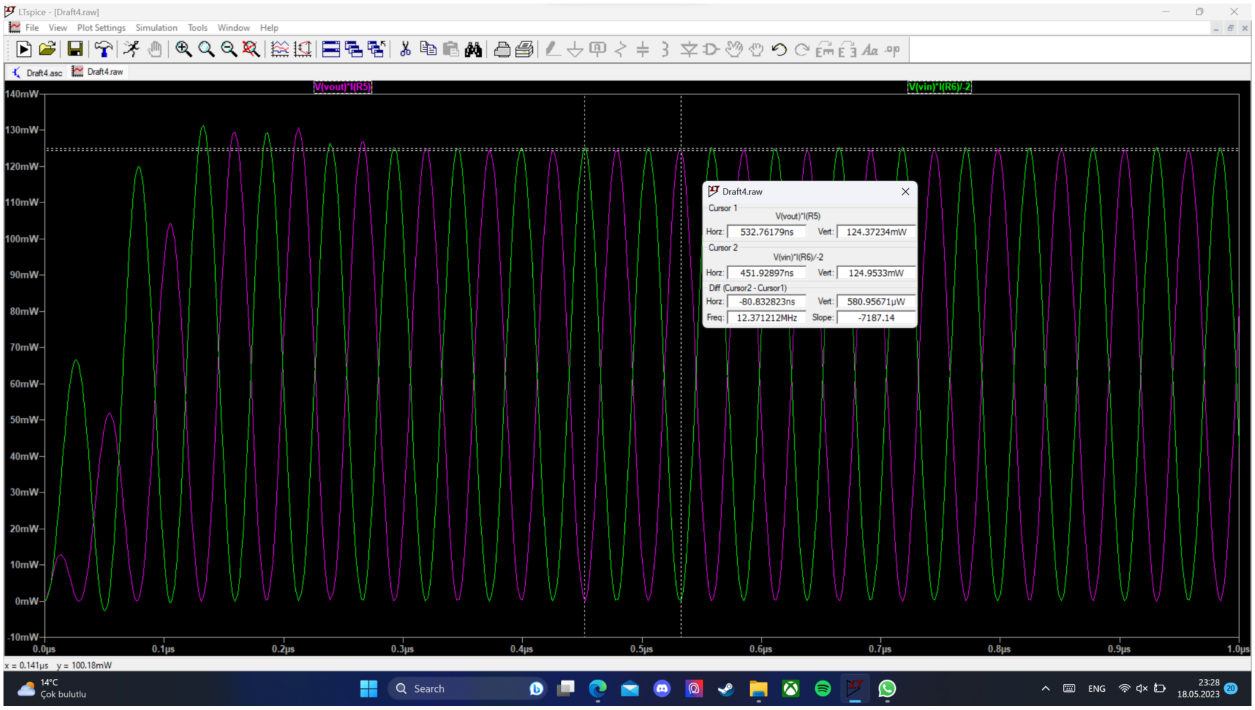


Photo 6: The T section power comparison

As seen in the plots the power transfer compared in Load and in the source is almost identical and the error is %0.4. The available power is around 250mW and it is disturbed half and half. The simulation results follow the equations.

	Available Power	Power Dissipated in the source resistance	Power delivered to the Load	% error
L-Section	250 mW	122.7 mW	122.5 mW	0.16
T-Section	250 mW	124.9 mW	124.3 mW	0.4

Table 1: Simulation Results

Part 2 Hardware Implementation

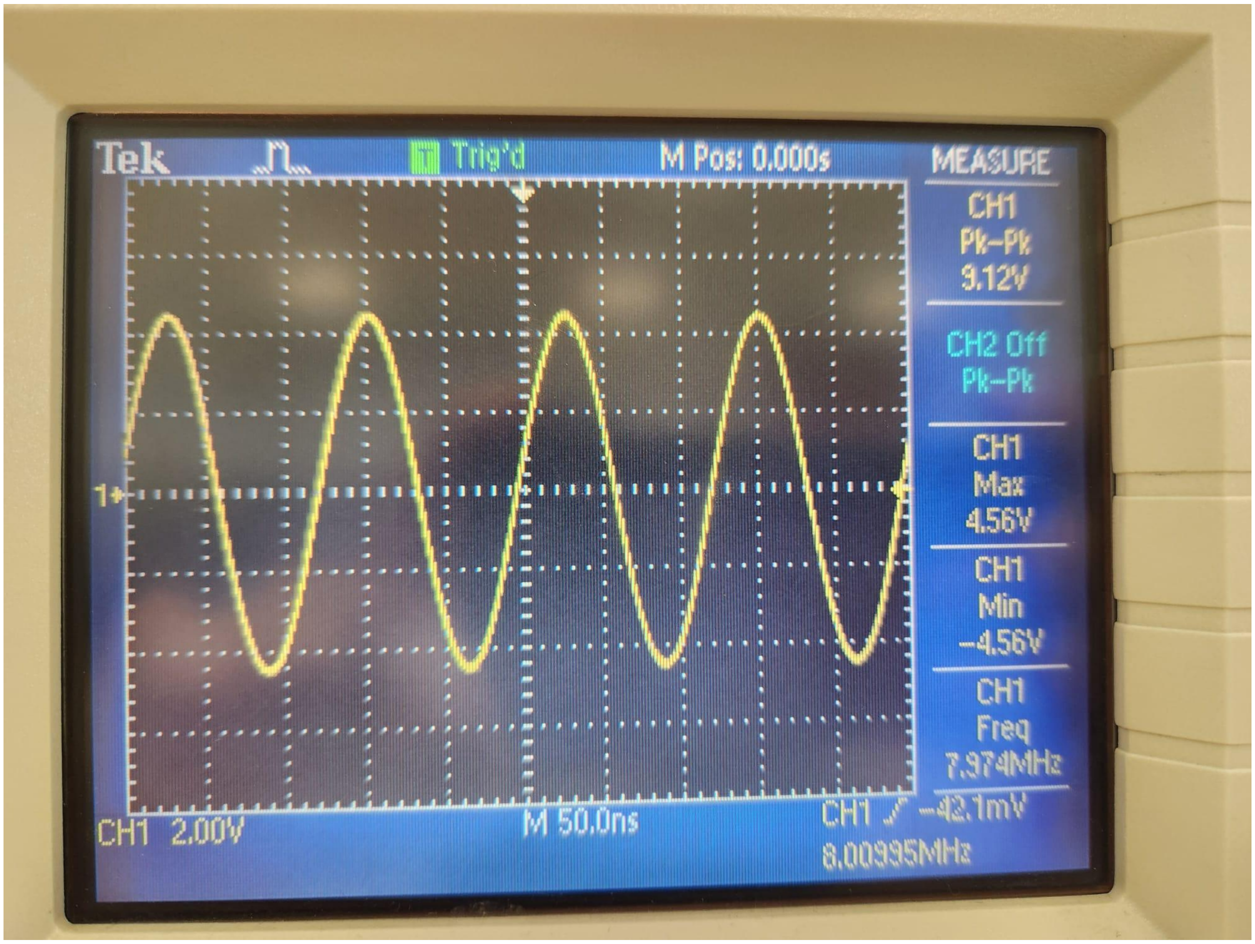


Photo 7: The L section output voltage

In the hardware lab the delivered power is 115.7 mW wich is only %5.7 lower than the simulations.

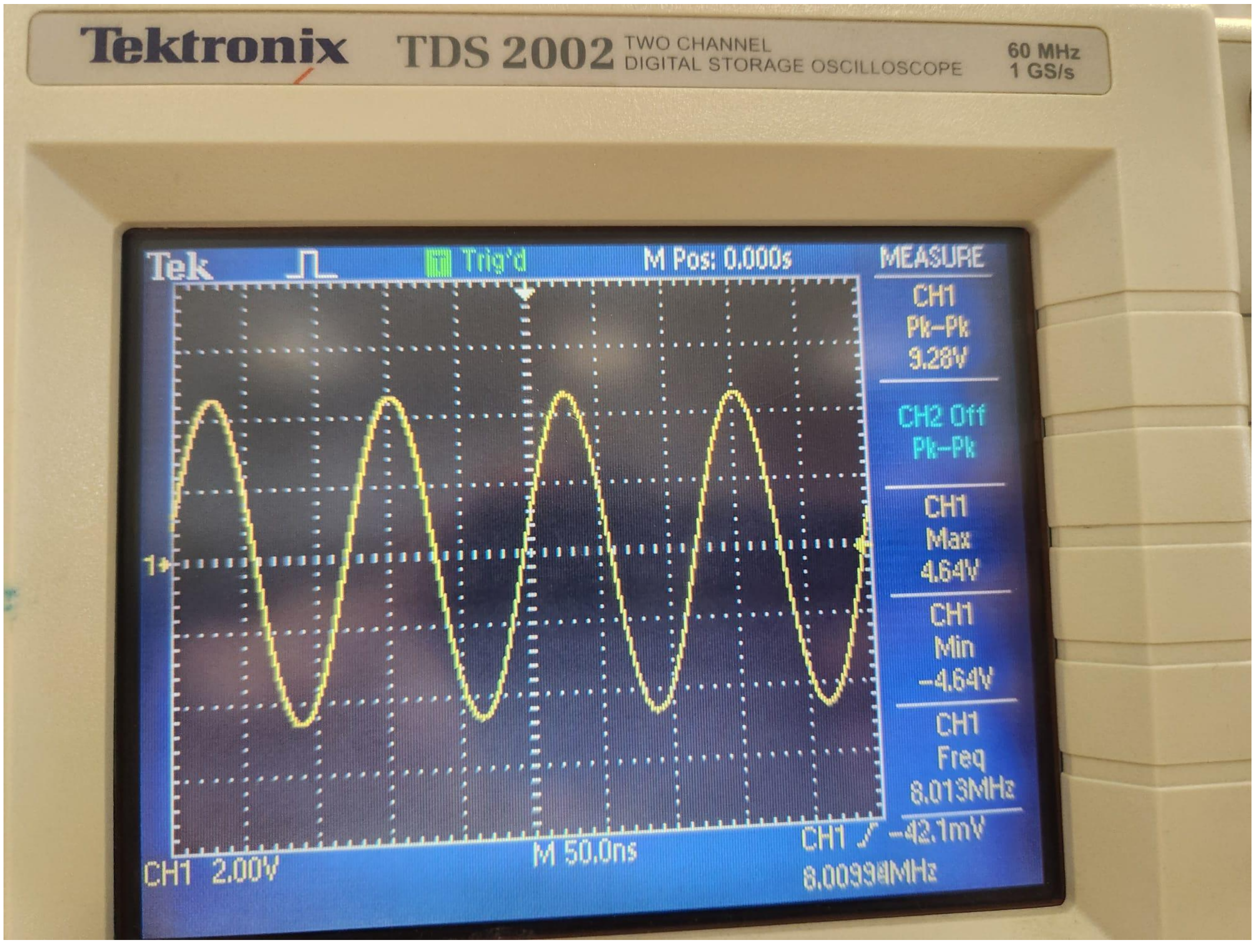


Photo 8: The T section voltage output

In the hardware lab the delivered power is 119.6 mW which is only %3.28 lower than the simulations.

	Power delivered to the Load in simulations	Power delivered to the Load in Hardware	% Power Transfer ratio	% error
L-Section	122.5 mW	115.7 mW	95.68	5.7
T-Section	124.3 mW	119.6 mW	92.48	3.28

Table 1: Hardware Results

Conclusion:

All of the results came as expected. They are matching with the theory. The results only differ so little from the simulation parts. Not using breadboard jumper cables etc significantly enhanced my results. Also the results showed that T section is more favorable in terms of delivering maximum power. Only errors came from the measurement errors they were not significant.