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Section-02

EEE202 CIRCUIT THEORY LAB2 REPORT

Purpose:

In this lab assignment, it is aimed to obtain voltage spikes with an amplitude between 15V and 25V.In addition, full width at half maximum(FWHM) of the voltage spikes are desired to be les than 80ns.These voltage spikes are obtained from a input signal which has 5V amplitude,50Ω serial internal resistence,2MHz and 10ns rise-fall times.

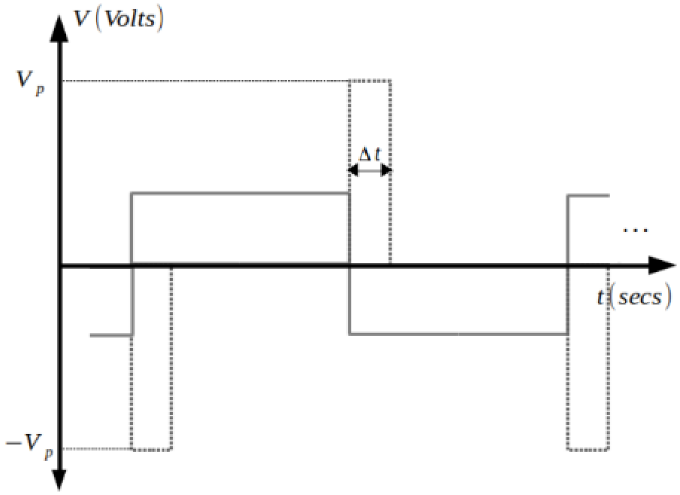

Fig1.1 rough image of desired output waveform ,Δt refers to FWHM.

Methadology:

There are many ways to generate voltage spikes.The most convenient way to generate desired voltage spikes in this lab assignment is called “inductor kickback”.This method can be demonstrated with a simple RL circuit.

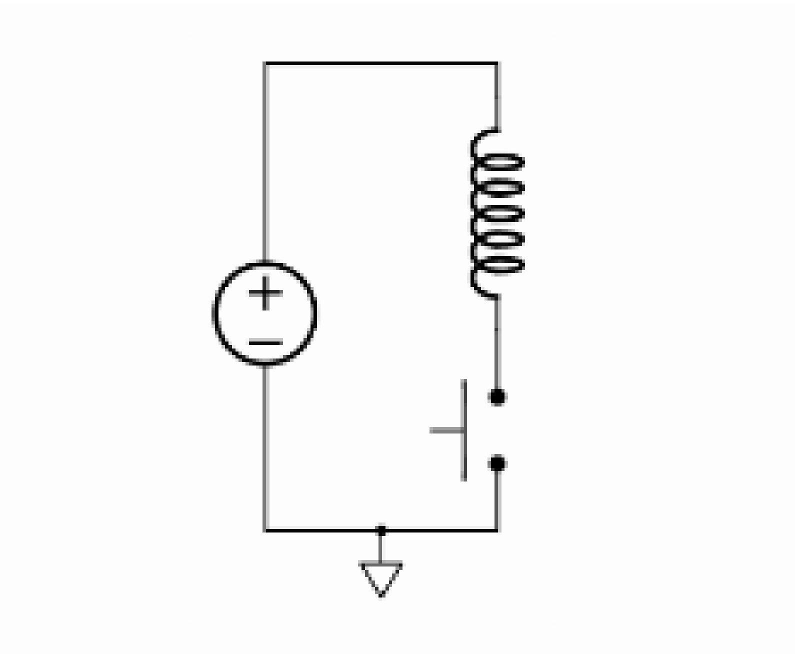

Fig2.1 the RL circuit for the demonstration of inductor kickback.

Let voltage supply (V)has 5V amplitude and inductor (L) is $10mH$.These voltage spikes occur due to instantenous accumulation or release of electromagnetic energy inside the inductor which results in reverse current.This characteristic behaviour of inductors is the reason of voltage spikes.

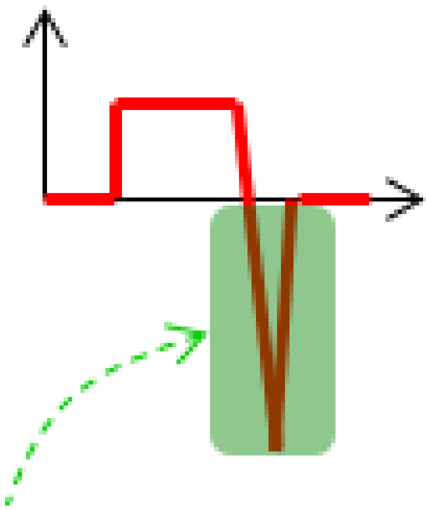

Fig2.2 the voltage spike obtained due to reverse current which is a consequence of electromagnetic energy release.

In order to provide a better understanding the logic of voltage spikes is further investigated mathematically.The relation of current and voltage among the inductor for this RL circuit is as following:

$$V = \frac{di}{dt} L$$

Function of current with respect to time can be expressed as following:

$$i(t) = \frac{1}{L}\int_0^t V(x)\,dx + i(0)$$

At t=0, i=0 therefore $\frac{di}{dt} = 0$.So, $i(0) = 0$. Here t represents the time when switch is opened.At t voltage across the inductor is equal to input voltage so equals to 5V.Substituting the values $V(t)$, L and $i(0)$ to the equation i(t) is obtained as:

$$i(t) = \frac{5V}{10mH} t = 500 amps/second$$

Assume that switch is opened at t=2ms:

$$i(2ms) = 1000mA$$

$$V = \frac{-1000mA}{0} L = -\infty$$

As it can be seen mathematically due to instantenous changes voltage goes to infinity which is consedered to be a voltage spike.Although there is no such thing as infinity voltage in real life,still abrupt voltage spikes can be observed with inductor kickback.

Software Part:

In software part of the lab, a transformer circuit is established in order to use inductor kickback method for voltage spikes and obtain desired value of the output voltage.The established circuit can be seen in Fig3.1.

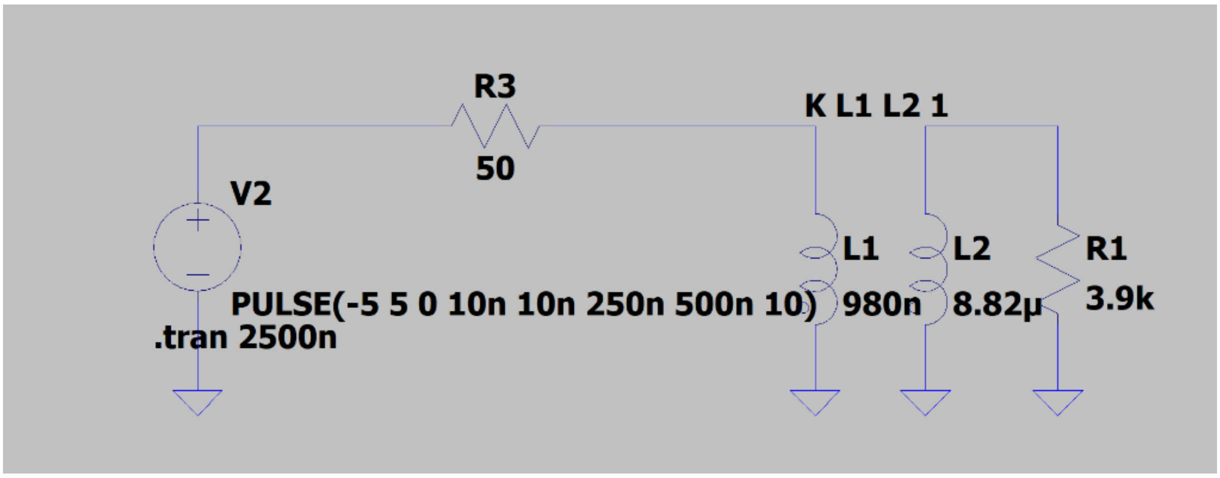

Fig3.1 demonstration of transformer circuit.

For a better understanding of this circuit Faraday's Law of Induction should be investigated:

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

The relation between inductance and winding is as following:

$$L = A_l * n^2$$

Faraday's Law of Induction can be written as:

$$\frac{{V_p}^2}{{V_s}^2} = \frac{L_p}{L_s}$$

For this lab assignment T38-8 toroidal core is selected which is $20nH/n^2$. n_p is selected as 7 turns and n_s is selected as 21 turns.

$$L_p = 20 * 7^2 = 980nH$$

$$L_s = 20 * 21^2 = 8.82\mu H$$

Since $\frac{V_p}{V_s} = \frac{n_p}{n_s} = \frac{1}{3}$, the desired magnitude for output voltage is obtained.The magnitude and waveform of output signal is observed in simulation results.

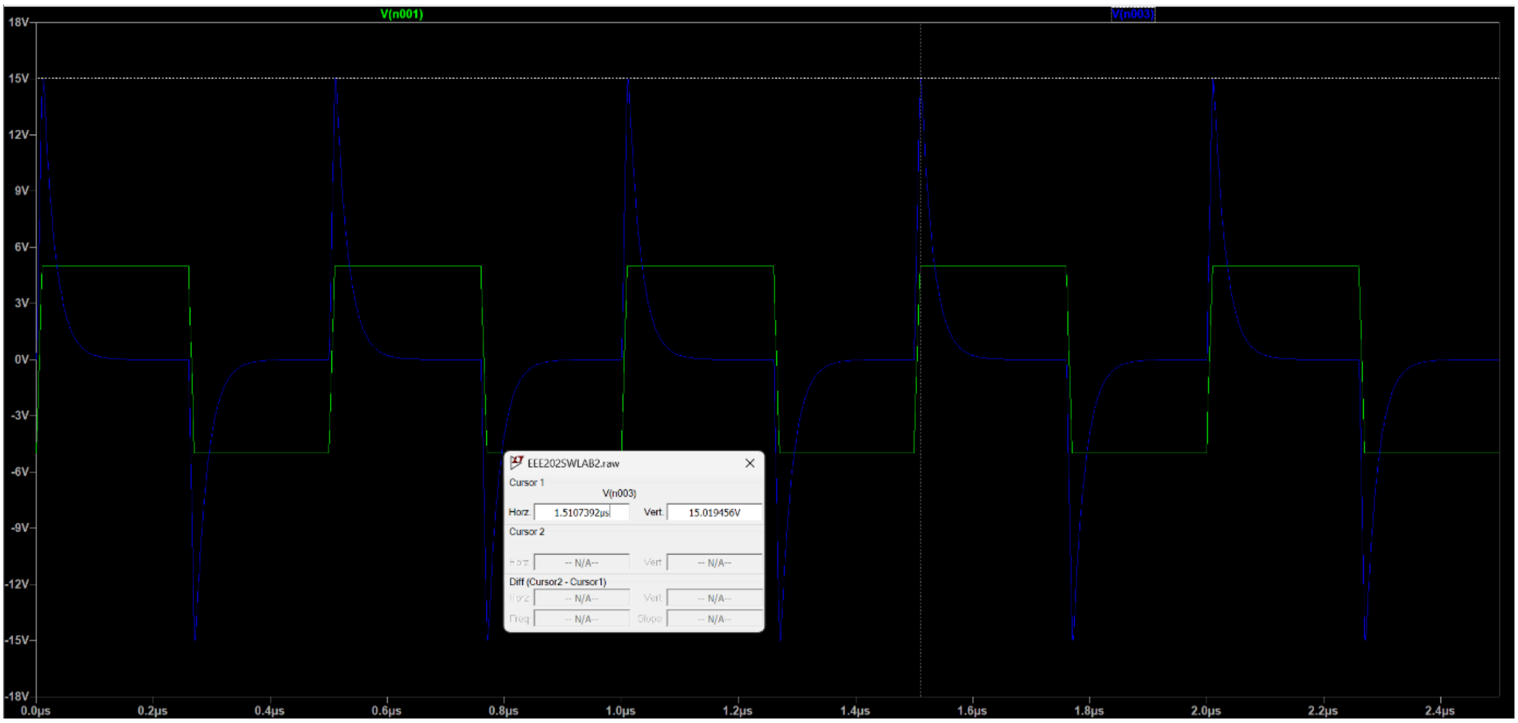

Fig3.2 demonstration of the waveform and magnitude of output.

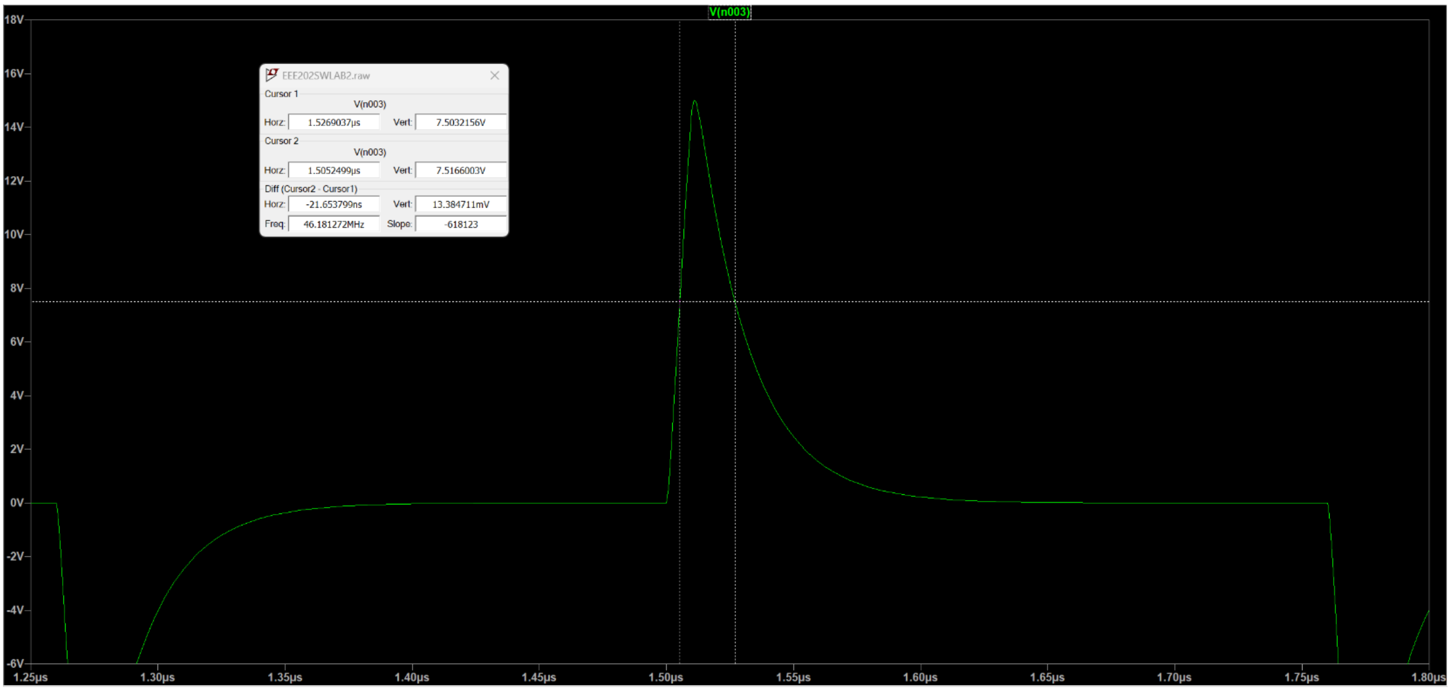

Fig3.3 Demonstration of FWHM

In Fig3.2 voltage spike waveform is clearly observed and it can be seen that 5.0V voltage input is amplified to 15.0V successfully.In Fig3.3 it is observed that FWHM,Δt=21.65ns<80ns.Since the values meet the requirements the circuit works properly.

Hardware Part:

In this part,22 windings are done instead of 21 windings in order to obtain more accurate results.7 and 22 windings are done on T38-8 torodial core.Afterwards,transformer is connected with 3.9kΩ resistor, signal generator and probe as demonstrated in Fig4.1.

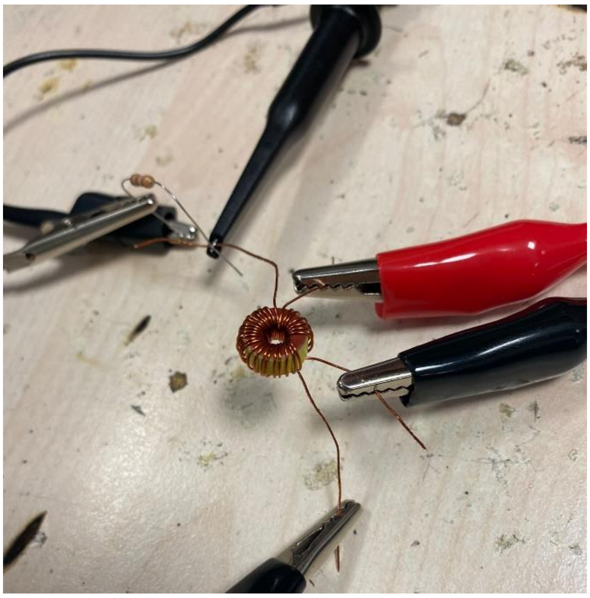

Fig4.1 Hardware circuit.

After establishing the circuit,hardware results of amplitude of output voltage and FWHM is tested.

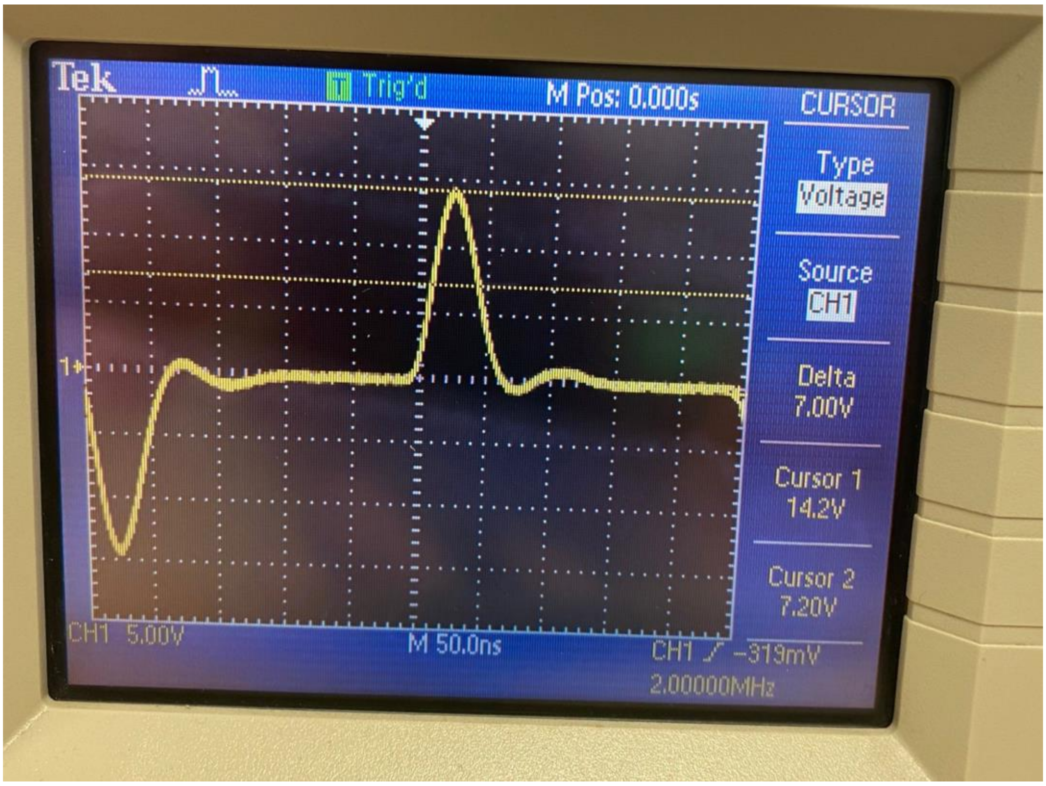

Fig4.2 hardware result of amplitude

	Software result	Hardware Result
Peak Voltage	15.0V	14.2V

Table1.1 results of peak voltages in software and hardware part.

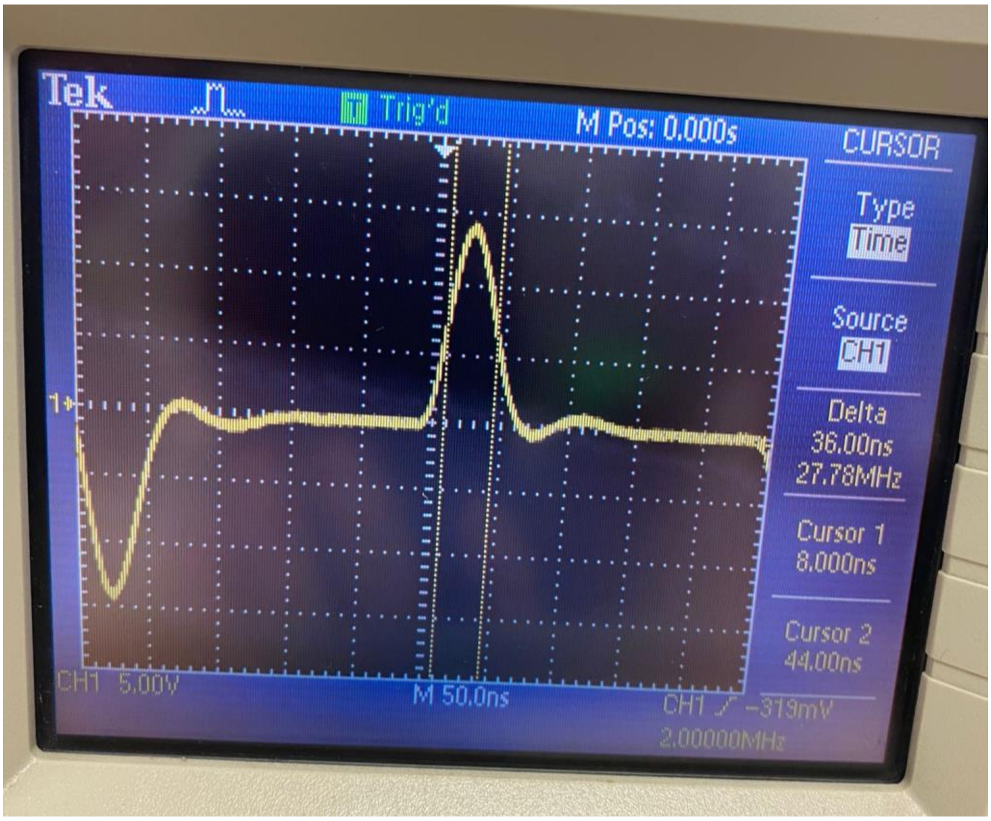

Fig4.3 demonstration of FWHM

	Software result	Hardware Result
FWHM	21.65ns	36.00ns

Table1.1 results of peak voltages in software and hardware part.

Even tough hardware and software results are similar there are slight differences.Since these differences are between the error range the hardware results are valid.Furthermore in the assignment testing of the rise and fall times of the power supply is desired by connected 47Ω resistor to the two ends of the power supply.The rise and fall times can be seen in the following figures:

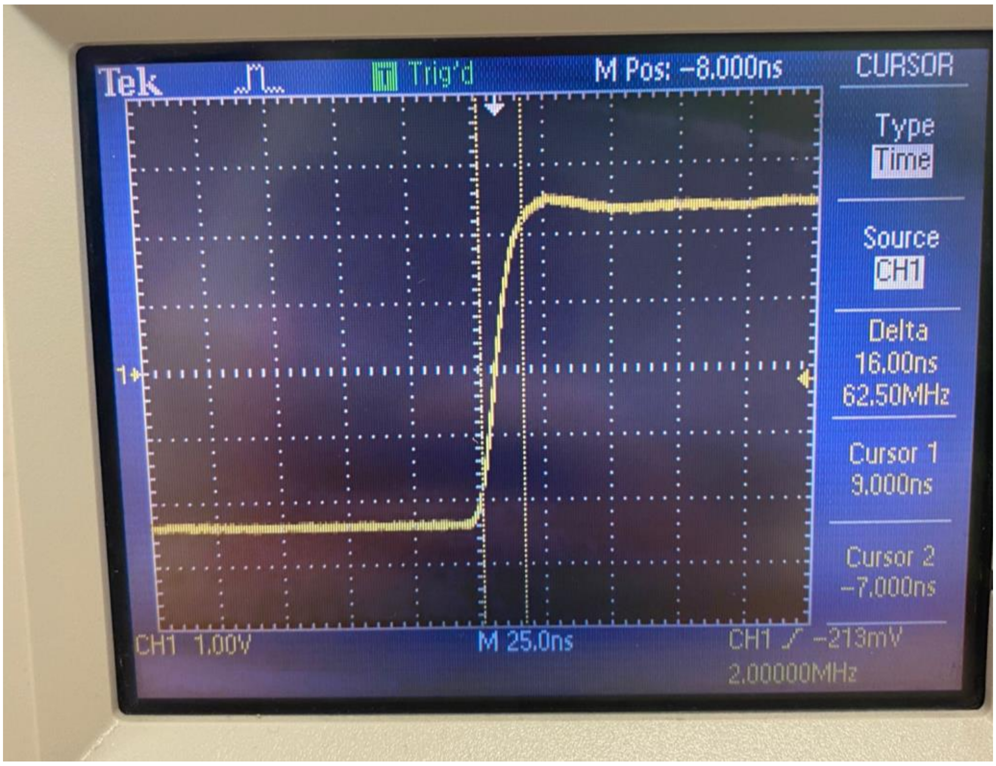

Fig4.4 demonstartion of rise time in hardware part

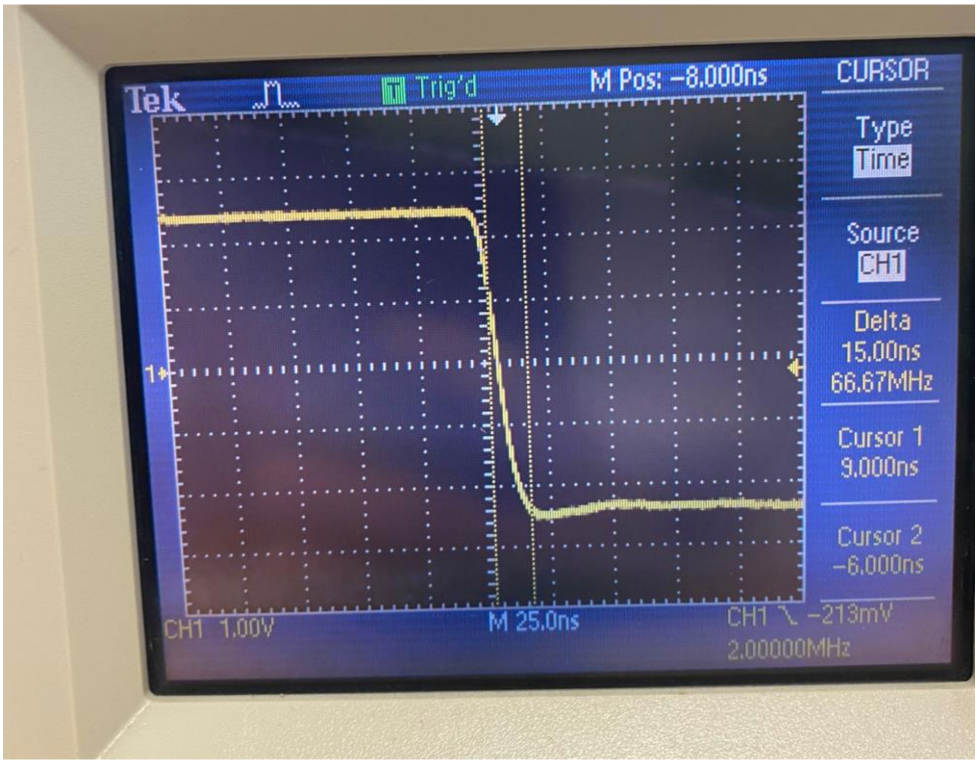

Fig4.5 demonstration of fall time in hardware part.

It can be seen that rise and fall times in hardware and software parts are slightly differentdue to uncertainity of the oscilloscobe however this difference can be neglected.Furthermore when 47Ω is serialy connected, the total error can be observed .5V peak to peak is expected and 4.36V peak to peak is obtained as it can be seen in the following figure:

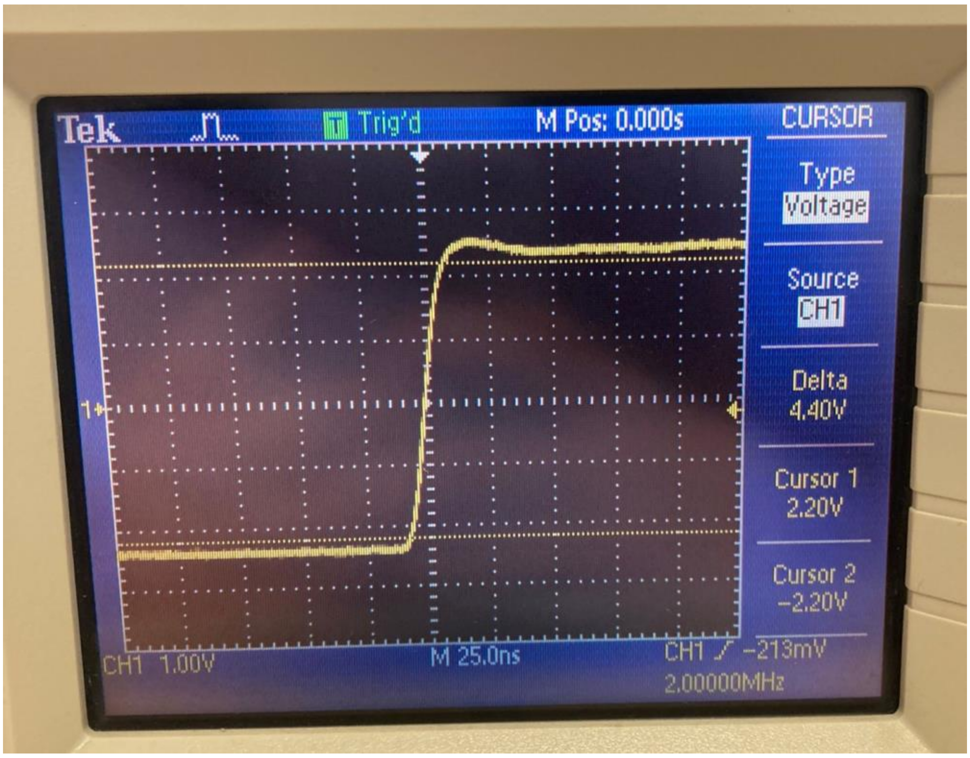

Fig4.6 demonstration of peak to peak value.

Conclusion:

This experiment is useful to provide a better understanding of ways to generate voltage spikes and passive linear curciuts.In order to generate desired voltage spikes that are given in the lab assignment a transformer circuit is used.”Inductor Kickback” method provided the necessary waveform and transformer amplified the amplitude of the input signal to the desired value.In hardware lab, the windings of the secondary inductor is incremented by one in order to obtain a better magnetic inductance.Later on, software lab result and hardware lab results are compared and it has been seen that there is a slight difference between the values however this is difference is acceptable since the difference is between the error range.The error is a result of uncertainity of oscilloscope, power supply, human errors possibly done in the process of winding and small resistence provided from crocodile cables.