EEE- 202 Circuit Theory
Lab-2

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Section - 2
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I. Software Implementation

1) Introduction

In this lab, we are asked to generate high voltage spikes from a 10V peak-to-peak square wave with a 50 ohm source resistor at a frequency less than 5MHz, peak-to-peak value between 15 and 20V and Full width at half maximum must be less than 90ns.

2) Analysis

voltage, turn count equation of transformers;

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

And inductance calculation of the transformers ($A_L = 20\frac{nH}{turns^2}$ and inductance is in terms of nH);

$$L = A_L * n^2 = 20 * n^2$$

I chose the turn values $\frac{n_p}{n_s} = \frac{1}{4}$, so that the 5V value will reach close to 20 volts. Also we now that $\tau = \frac{L}{R}$ so in order to satisfies FWHM, assuming that after 4τ voltage spike will disappear, then;

$$4\tau < 90ns$$

$$\tau < 22.5ns$$

$$\frac{L_1}{R} < 22.5ns$$

$$\frac{L_1}{50} < 22.5ns$$

$$L_1 < 1125ns$$

Therefore, as soon as L_1 taken less then 1125, FWHM conditions satisfies. So, while the 1st inductor value was taken 320nH, second one is 5120nH. R_2 chosen a 10KΩ.

So the following values were selected;

Component	Value
R1	50Ω
R2	10KΩ
L1	320nH
L2	5120nH
n1	4 turn
n2	16 turn

TABLE I: Selected component values of the circuit

3) Simulations

In LTSpice, the circuit was designed by entering the values calculated in the analysis part (Green indicates the input voltage, while blue indicating output voltage.).

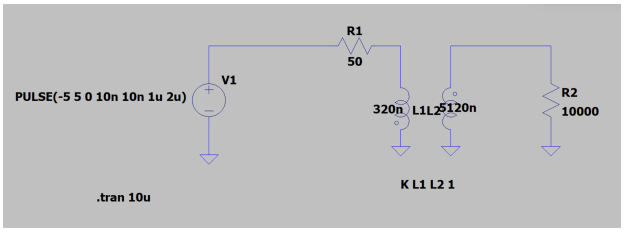

Fig. 1: Circuit built with specified circuit values

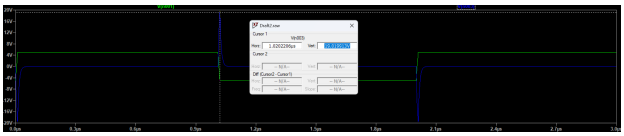

Fig. 2: Simulation of the circuit

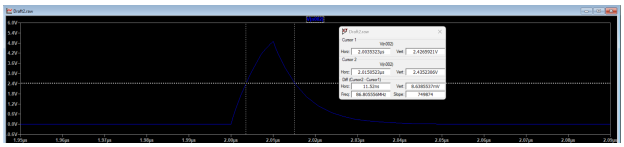

Fig. 3: Fall time of Circuit

As expected, $\Delta t < 90$ and V_{out} is 19 voltage.

II. Hardwire Implementation

In reality, We need to consider leakage when thinking about the number of turns. Leakage formula ($L_{Leakage}$ is close to 0.55 in reality);

$$Vs = \frac{n_s}{n_p} * v_p * (1 - L_{Leakage})$$

$$V_s = \frac{n_s}{4} * v_p * (1 - 0.55)$$

For $n_s = 34$, $V_s = 19.125V$.

Note: Since sufficient voltage could not be obtained in the experiment, the number of windings was increased to 37.

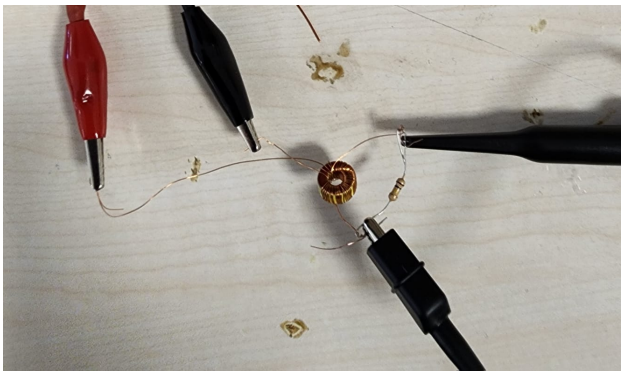

Fig. 4: Builded Circuit with a 4 turn and 37 turn

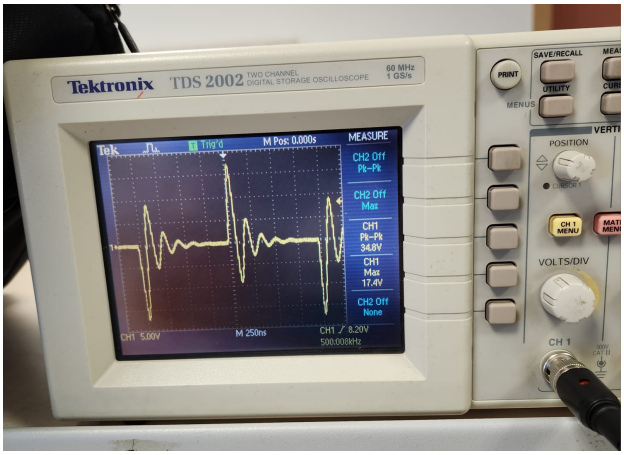

Fig. 5: spikes of circuit

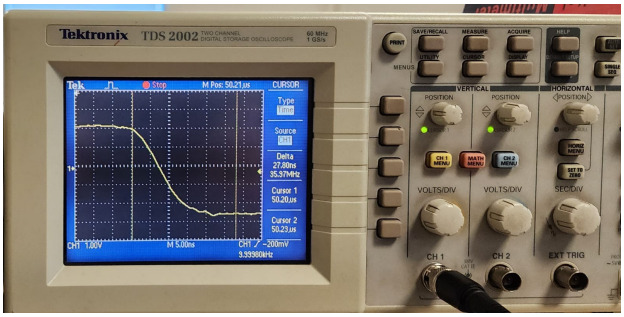

Fig. 6: Fall time of Circuit

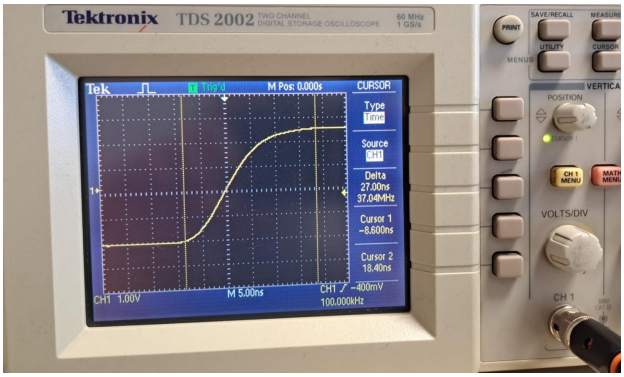

Fig. 7: rise time of Circuit

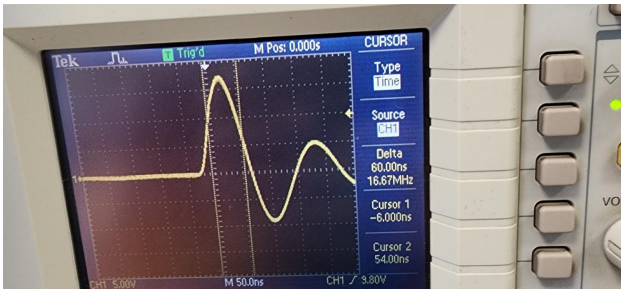

Fig. 8: FWHM of Circuit

	Simulation circuit	Harware circuit
Rising time	10ns	27ns
Falling time	10ns	27.8ns

TABLE II: Table of simulation and real circuit comparison for rising and falling time

	Simulation circuit	Harware circuit
FWHM	11.52ns	60ns
V_{out}	19.01V	17.4V

TABLE III: Table of simulation and real circuit comparison for FWHM and V_{out}

Conclusion

As a result, we entered the values we determined in the software and hardware and got results close to the expected values. As for the error rate, I can give the fact that the human-made inductor cannot reach the correct count numbers (Not reaching the exact number of 4 and 37 turns because of its hand-winded physical structure), problems arising from the copper cable chosen for the inductor, and the cables, signal generator and oscilloscope not being ideal.Additionally, an additional number of windings was added because of these errors. As a result, although the voltage and of the Hardware lab is lower than expected, the voltage and fall time are within the desired value range. Therefore the experiment is successful.

References

1) Atalar, A., and Köymen, H.(2023) *Analog Electronics*(4th ed.). Meteksan.
2) eepower.com. (2022, july, 07). *What is an Inductor?*. https://eepower.com/technical-articles/what-is-an-inductor/