Lab 2

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Section: 2

Purpose:

The aim of this lab is to design a passive linear circuit that generates high voltage spikes from a 10V peak-to-peak square wave with a source resistance of 50 Ohm and a frequency less than 5MHz. In simulation part, it is learnt how to simulate designed circuit by transformer and in hardware part, design was implemented.

Methodology:

When the primary side of a transformer is turned off, inductive kick causes a voltage spike on the secondary side, which can damage insulation and attached loads. Therefore, a simple transformer is used for to create a spike.

Simulation Part:

First, a pulse with a frequency of 1 MHz and an amplitude of 10 Vpp was sent to obtain a square wave as input. Then, a 50 Ω source resistor was connected in series to the voltage source as given in the lab instruction. In order to create a transformer, inductors with values of 1 µH and 9 µH, which are reverse to each other, were connected as primary and secondary parts. The values of the L1 and L2 inductors were chosen considering the input and output

values of the transformer and the winding ratio. As can be seen in the formula (1), a direct relationship is observed between these two values.

$$\frac{Vin}{Vout} = \frac{n1}{n2} \qquad (1)$$

By using the first equation and the inductance formula which is L= n^2. A, it can be obtain formula (2) :

$$\frac{L1}{L2} = \frac{n1^2}{n2^2} \qquad (2)$$

Then, combining the first and the second equations, can reach a relationship between voltage and inductance (3).

$$\frac{Vin}{Vout} = \sqrt{\frac{L1}{L2}} \qquad (3)$$

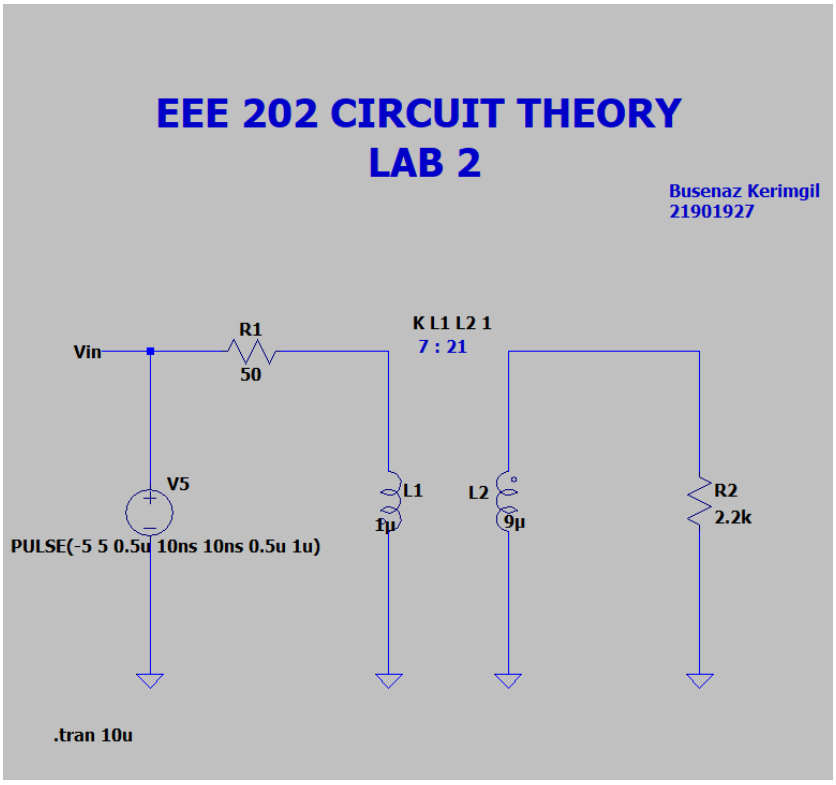
Since the voltage spikes must be 15V ≤ Vspike ≤ 20V. It is known that input voltage is 10Vpp therefore the input voltage – output voltage ratio must be between $\frac{1}{3}$ to $\frac{1}{4}$ as mathematically. 1 µH and 9 µH values satisfies the equation (3) with $\frac{1}{3}$ ratio.

Finally, a load resistor 2.2 K Ω connected series next to the secondary inductor. The load resistor was approximated using impedance matching (4). It will be use 2.2 K Ω in order for our spike values to be between 15V and 20V and is also a standard number that can be conveniently utilized in the hardware section of the lab assignment.

$$\frac{Rsource}{Rload} = \left(\frac{L1}{L2}^2\right) \qquad (4)$$

$$Rload = 81\ x\ 50 = 4.050\ \text{K}\Omega \approx 2.2\ \text{K}\Omega \qquad (4)$$

The final result of simulation can be seen as below *(Figure 1)*

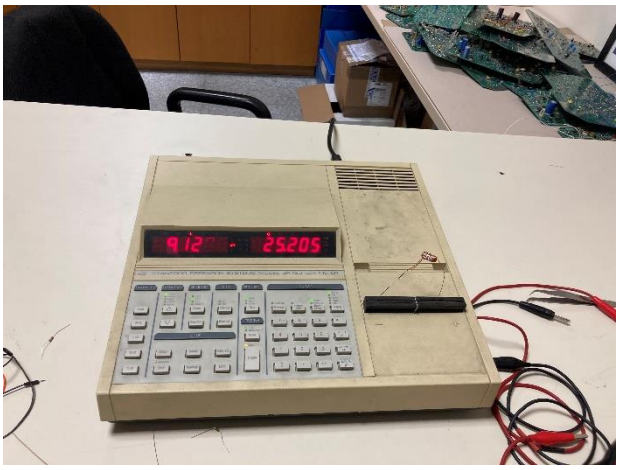


(Figure 1) – Schematic of design

Hardware Part:

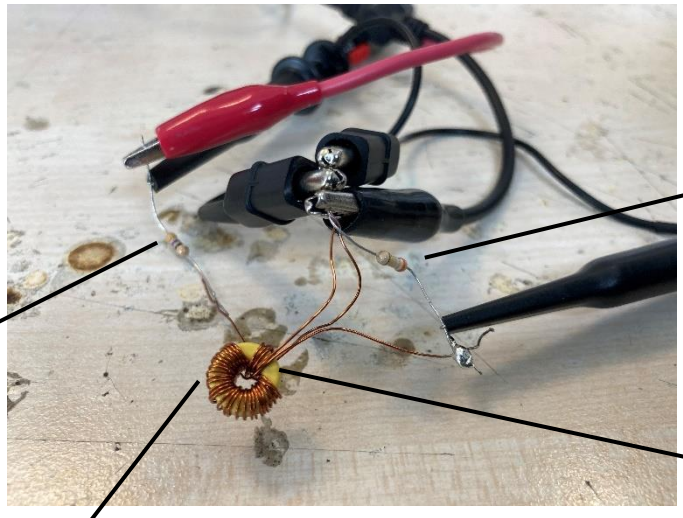
In the hardware part, transformer was made by winding a toroid. Using the formula (3), L1 and L2 was calculate. T38-8 toroid was wounded 7 times for the primary part and 21 times for the secondary part *(Figure 2)* and *(Figure 3)*. Then, 47 Ω as a source resistor and 2.2 KΩ as a load resistor were connected in series. The frequency was set to 100 kHz and the signal generator was set to 10Vpp. Finally, the input was given from the primary part and observed the results.

$$L = n^2.A \qquad (3)$$



(Figure 2)- secondary inductor value

(Figure 3)- primary inductor value

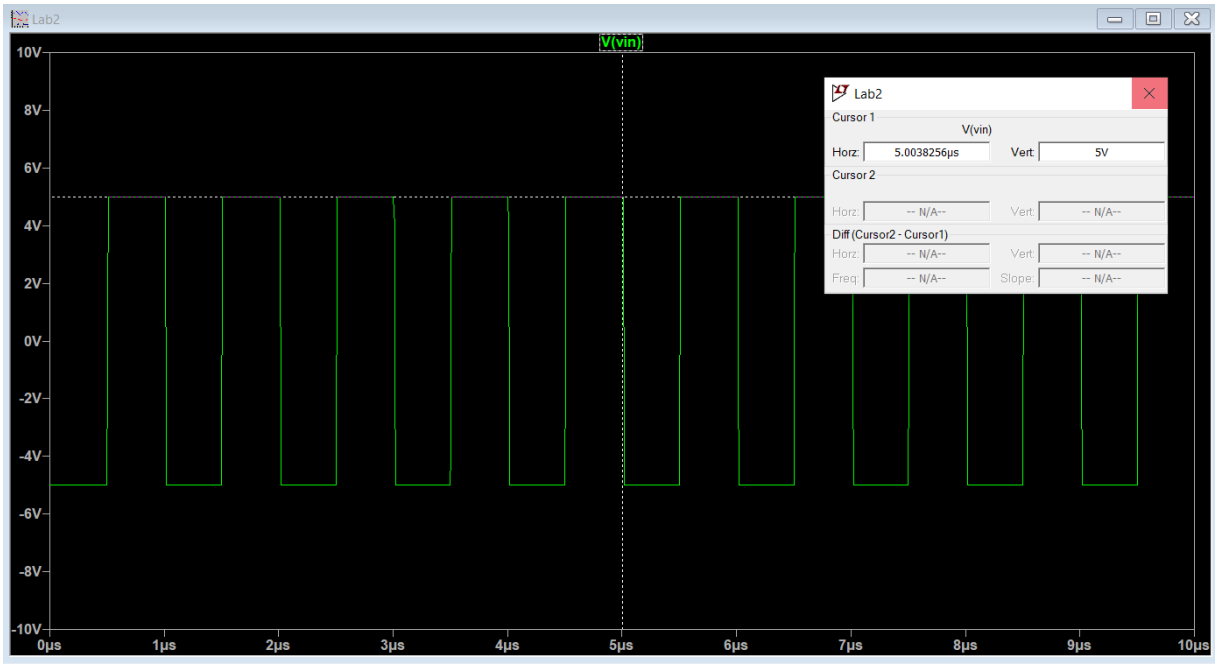


(Figure 4) – Hardware implementation

Results:

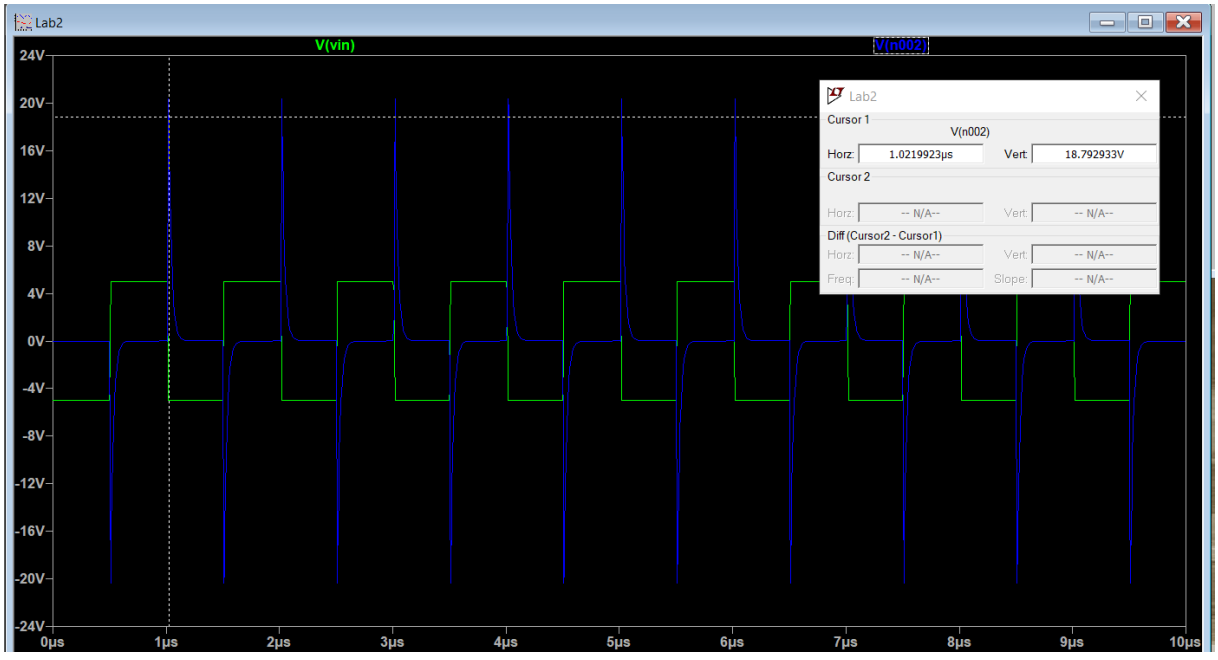
Simulation part:

10 V peak-peak square wave input voltage



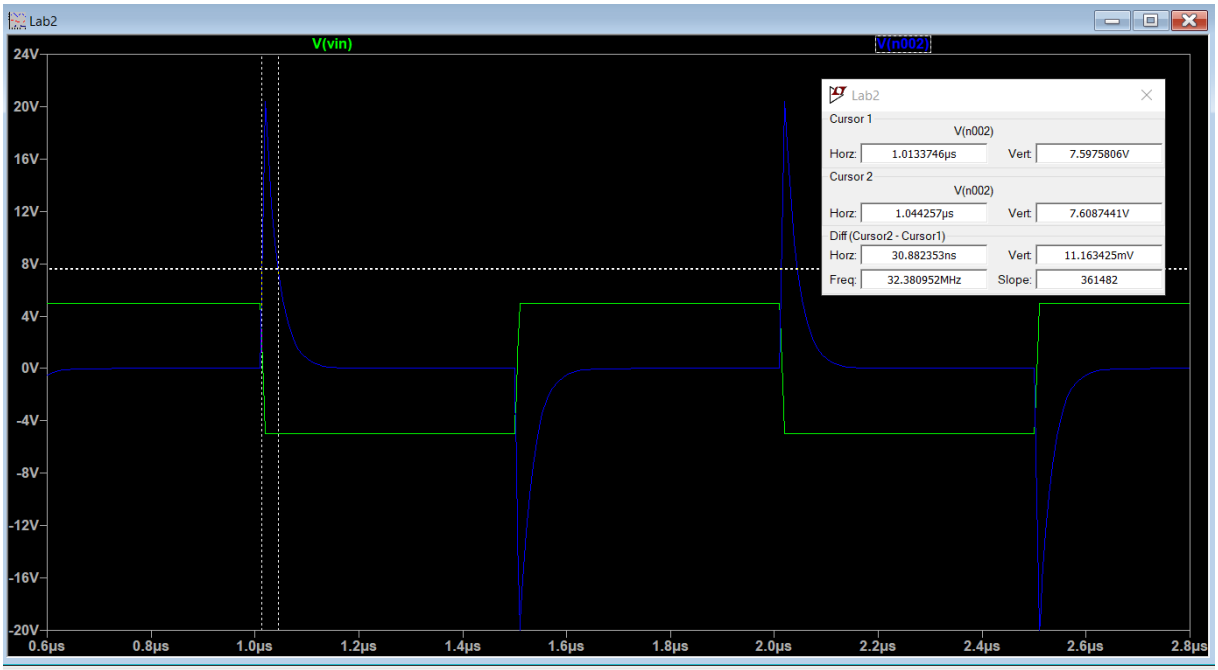
(Figure 5) – Input Voltage

The output voltage with 18.79V spike.



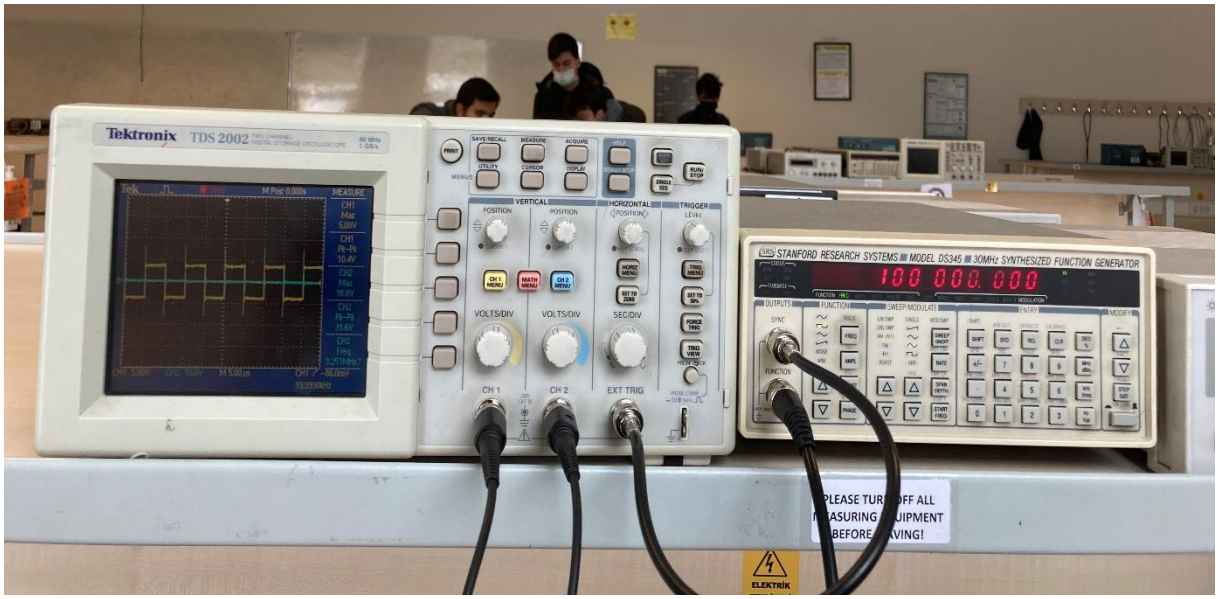
(Figure 6)- Output and Input Voltage

The time difference is equal to 30.88 ns, which is way lower than the expected result 90 ns.



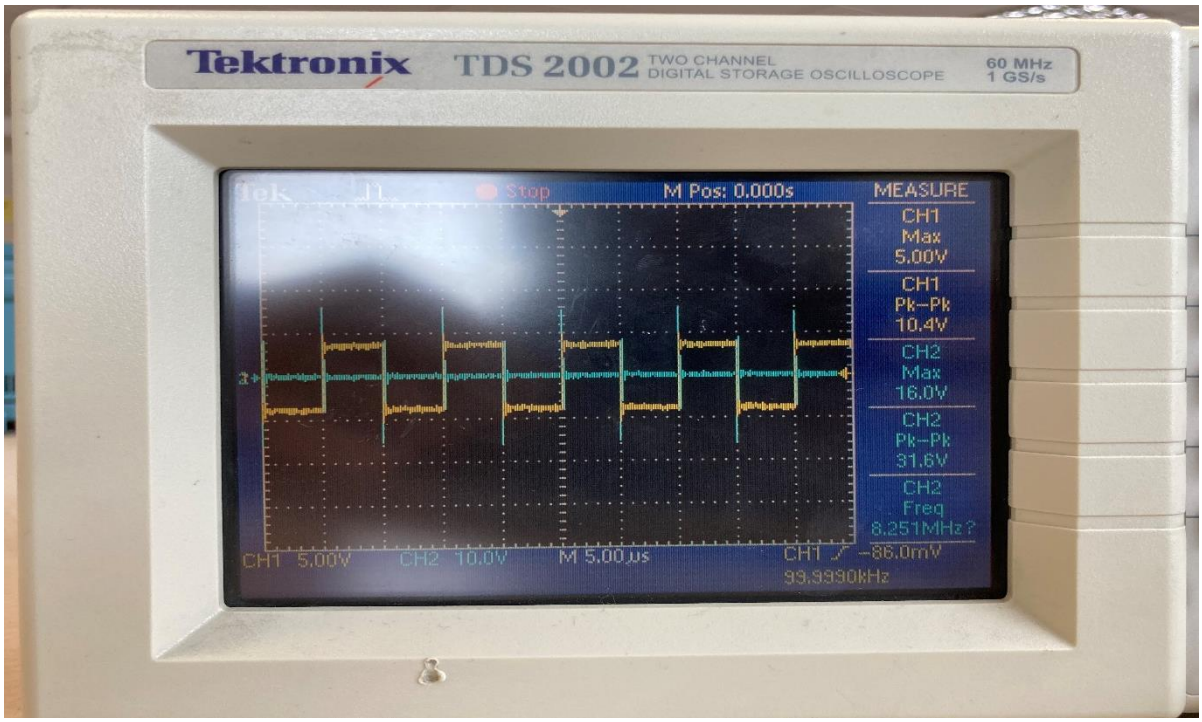
(Figure 7)- Time difference

Hardware part:



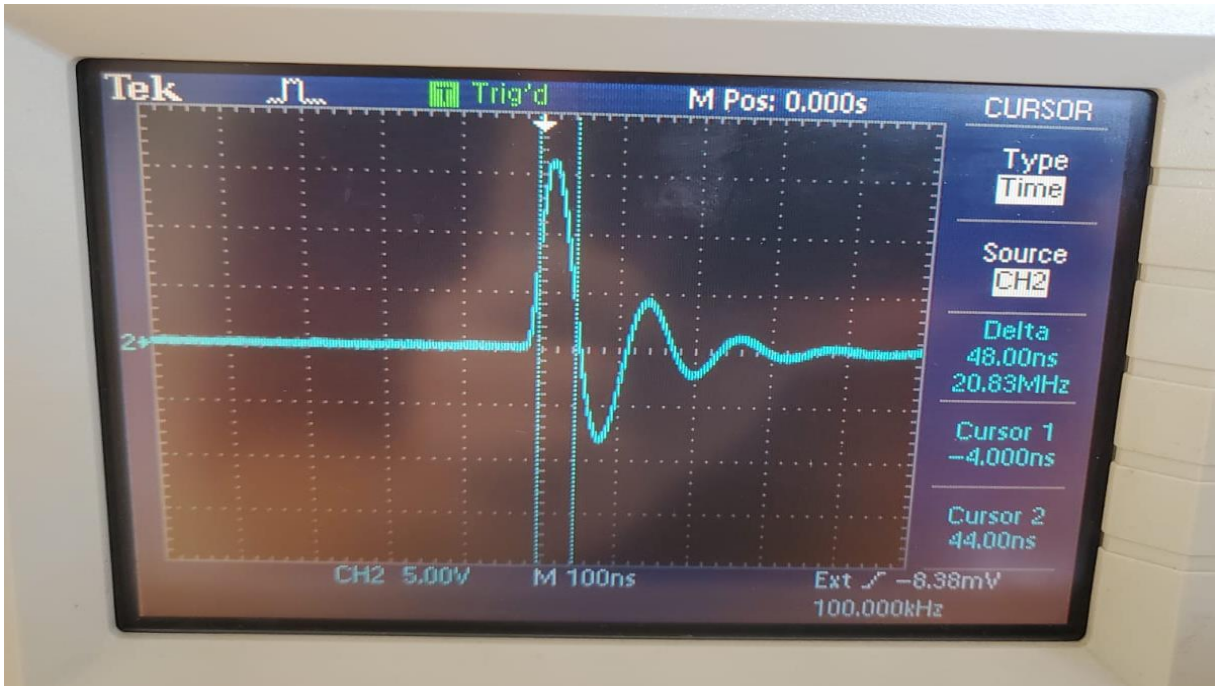
(Figure 8) – Oscilloscope Values

In the hardware part, the output voltage is exactly 16v at 100 kHz.



(Figure 9)

The time difference is 48.00 ns



(Figure 10)

Conclusion:

The goal of this experiment to create voltage spikes between 15V – 20V and with under 90 ns of width less than 5Mhz frequency which we successfully accomplished. We learned that simple transformer can be used for creating voltage spikes. As the results shown that in hardware part, we obtained 16V peak voltage with 48 ns of width. In order to ensure that this value fully coincides with the simulation value, we can increase the voltage by playing with the winding frequency and spacing. In addition to that when we tried to do the experiment with 1 MHz the square wave began to deteriorate and spike voltage deviated excessively so we tried to keep our frequency range in kHz units. When we look the error, the inner resistance is the source of a mistake. The signal generator has an internal resistance in real life. However, the inner resistance of a resistor was not taken into account while computing the findings. Another error is caused from the mutual inductance of the toroidal transformer which may result in some deviation in the peak voltages. To sum up in general the error results variate between 10-20 percentage.