Simple Designed of High Voltage Pulsed Electric Field Generator Based on Fly-back Transformer

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Abstract. The high pulse voltage low power supply can be built with fly-back transformer as a converter. Generation by using fly-back converter is a significant method which can be improved the circuits of the device to make it simpler, and occupies a smaller space, and cheaper. The study aimed to study and develop a device that will obtain a high pulse voltage low power supply. The results of the study obtained are, the high pulse voltage has reached 50 kV at the frequency of 100 kHz. In addition, when the high pulse voltage is fed to the plane parallel, then at the distance of 50 cm there is a spark, which means it is can generate high pulsed electric fields, it was 50kV/cm.

1. Introduction
The solution for power supply design with the low cost, the simplicity of design and intrinsic efficiency is the fly-back transformer. The fly-back transformer over circuits with similar topology include isolation between primary and secondary and the ability to provide multiple outputs and a choice of positive or negative voltage for the output. The most commonly used circuit for low output power applications is fly-back converter. The commonly use a fly-back converter requires a single controllable switch like, MOSFET and usual switching frequency is in the range of 100 kHz [1]. One of the newest non-thermal methods that are reliable in the process of processing food-drinks is a pulsed electric field, PEF [2-3]. To generate PEF, a Direct Current High Voltage Pulse (HVP-DC) is needed. We need for HVP-DC lately is very vital because it can be used as a trigger energy in various physical and chemical processes. These energy sources can be converted to various needs in the field of engineering technology such as x-rays, electric fields, microbial sterilization, biotechnology, and so on. For producing a pulsed electric field, an HVP-DC source is needed which is fed a pair of electrodes with a certain distance. Based on the theory of electric fields, if between two parallel plate electrodes is given voltage, then between the electrodes there will be an electric field E. The PEF method is known that the process does not cause heat, non-thermal [4–7].

The availability of high power is difficult to get, better than low power and it will need the expensive to produce it. In this case, the supply of high power is important to solve the research innovation. In this research, we developed and designed the high voltage pulsed the 50 kVolt using Fly-back Transformer to increase the pulsed generator electric magnetic with the parallel plate electrode. This study aims to study and develop a device that will obtain a high pulse voltage low power supply.
2. Method
The research method is conducted electronically as experimental in Figure 1 is a block diagram. The measurement sample is prepared in the Laboratory of Electronics, FMIPA, Universitas Sumatra Utara (USU). The research methods in making the supply of 50 kV Pulse Voltage uses a flyback transformer[8], [9] as amplification to increase high voltage.

![Figure 1. Modification of electronic circuits.](image)

We used the instruments to measurement by a digital/analog multimeter, High Voltage Probe (HV-40), and Oscilloscope (GW in stock GDS-2204). Generally, pulse forming circuits can be made with various series and supporting components, including the use of AT-mega microcontroller components, IC Timer 555, IC MC 44603A, and so on. The generator of pulses is known as an oscillator. The oscillator of the component is easy to adjust the duty cycle and frequency. theoretically, it can reach a ratio of 10:90%.

In this case, we use the fly-back transformer. The transformer is a passive electronic component that can transform magnetic energy with the principle of induction. This is in accordance with the law of electromagnetic induction, Faraday's Law, based on the law, the transformer can function as an increase or decrease in voltage [10]. The basic principle of a transformer is joint induction, mutual induction, between two sets of coils connected by magnetic flux. If a high voltage is needed, the number of turns in the primary part is less than the second part of the coil, and the reverse.

2.1 Material
The material in this research, consist of two-part, we use low and high voltage. In the low voltage, the power supply used Travo with 12 Volt 5 Ampere, Rectifier 5 A, the MC44603 A oscillator, driver or switching and using MOSFET IGBT 20N60. The power supply of high voltage using the 300 V, DD HS-05 150 WY for the fly-back transformer, stainless steel for plate electrodes, a diode with 1N4407.

Manufacturing Method of Supply Pulse Voltage 50 kV using a Fly-back Transformer consists of several steps, including the following, by create an experimental setup, make the power supply module, Oscillator, Driver, connector to FB, Test and retrieve data from the database, make the plate electrode parallel and Test the voltage between the electrodes and the strong electric field pulses [11-12].

3. Result and Discussions
The results of this study are accordance and represented of the electronically as figure 2 which consists of a power supply using 12V5A and 300 V transformer (top left). The oscillator with IC MC44603A (under the power supply), driver or switching, is the MOSFET IGBT 20N60 (middle rank). While the high part is a fly-back transformer (DD HS-05 150 WY, series) [3]. At the fly-back output which connected in series to the cascade fed to the plate electrode (stainless steel) parallel to the size of cm for generating electric field pulses.
The result of design of the high voltage generator and electric field pulse generator are show in figure 3 below.

In Table 1, showed the test data for the supply of pulsed voltage at electrodes, with duty cycle 50:50 %, input voltage 300 volt, oscilloscope GW INSTEK GDS-2204 and high voltage Probe is HV-40.
Table 1. Test data for supply of Pulse Voltage at Electrodes.

| Frequency, kHz | Average Pulsed Voltage , (kV) | The pulsed strength of electric field on , kV/cm |
|----------------|-------------------------------|-----------------------------------------------|
| 20             | 39,2                          | 39,2                                          |
| 40             | 38,6                          | 38,6                                          |
| 60             | 45,2                          | 45,2                                          |
| 80             | 48,8                          | 48,8                                          |
| 100            | 52,5                          | 52,5 (Spark)                                  |

Based on the occurrence of spark events, in this study, when the voltage between the electrodes has reached the air dielectric strength is about 3 MV/m. The results of the experimental data obtained the maximum voltage pulsed $V_{\text{max}}$ measured by HyProbe is 52.5 kV.

And the relationship between voltage $V$, the electric field strength $E$ to the distance between electrodes, then the electric field pulsed at the time of the condition is 52.5 kV/cm. In this case, the result can be applied as the source of PEF in the electroporation process which generally ranges from 20 – 80 kV/cm [11–13]. Based on the data in Table 1, the relationship of fractionation to the strong pulses of the electric field, PEF satisfies the relationship shown in figure 4.

![Figure 4](image_url)  
**Figure 4.** Frequency relationship vs pulsed of electric fields (PEF).

4. Conclusions

Based on the results obtained in the study, the design of high voltage pulse generator has yielded a significant result, namely the frequency of the oscillator reaches 100 kHz and the maximum voltage $V_{\text{max}}$ pulse is approximately 52.5 kV. The pulsed strength of the electric field under the condition of 52.5 kV electrode voltage is obtained at 50 kV/cm.

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