

# High voltage designed and pulsed electric field circuit using standard sphere-gap method

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**Abstract.** The circuits designed of the high voltage pulsed source using the sphere-gap as switching and will be used as generating of the high voltage pulsed electric field (PEF). Based on the experiment testing that the high voltage source can produce 80 kV with the efficiency of high voltage DC source is 81.70% and the operating voltage of sphere-gap is 18.5 kV. Therefore, the intensity of the pulsed electric field of the design can be reached at 80 kV/cm. Based on this ranges that design can be used for electroporation process. Furthermore, this tool was tested into a sample, Nematode. For Nematode sample testing, the electric fields strength is  $E = 37.33 \text{ kV/cm}$  on the voltage of between the electrode is 6.7 kV. Thus, the design of the pulsed electric field source using a sphere-gap has functioned.

## 1. Introduction

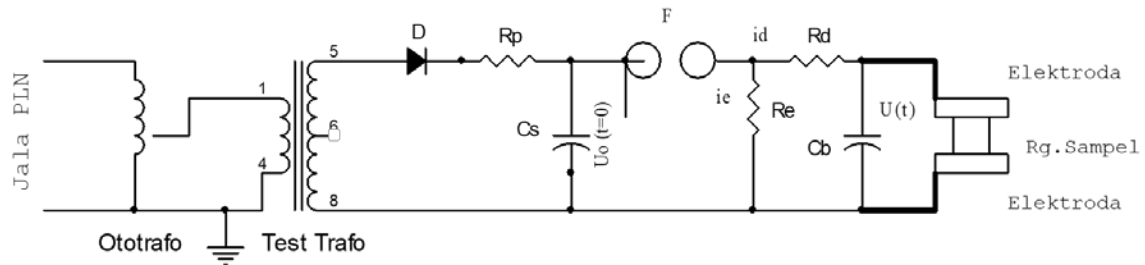
The design and construction of a high voltage source can be done by several techniques such as the construction of Cockroft-Walton multiplication, Van Der Graaff circuits [1]. High voltage can be divided into various AC, DC high voltage and impulse voltage. In the high voltage source can be done by using transformation which as functioned as a step-up transformer [2][3]. The simpler, easier and cheaper to make of the transient voltage pulse is RC circuits. In this experiment, high voltage pulse designed in such a way that can produce high voltage pulses are generated by the RC circuit from the release of the capacitor or discharged by sphere-gap. Then, the pulse has been raised inside to a pair of electrodes inside the chamber. The chamber is filled with water and a Nematode as a sample. When the source of the voltage is turned on that pulse electric field will appear on both electrodes. Consequently, pulses of the electric field will induce them membrane cell inside the chamber and electroporation will occur. The design of high voltage pulse source equipment consists of a DC high voltage, rectifier diode, capacitor storage, sphere-gap, and pulse forming circuit. The objectives of this paper are to design a tool of the high voltage pulses and tested for electroporation process, for obtain a tool of high voltage pulsed using sphere gap as switching and testing of the equipment. The tool's application can be used as microbial sterilization on food products.

## 2. Data and Method

### 2.1 Data

The research method is conducted electronically as in Figure 1. The materials in this study are the high voltage generator type YHIG-100KV, 5KVA, Capacitors, 6000pF-140KV, Sphere release electrical energy gaps F, and RC pulse shaper and pathogen nematode sample is prepared in the Laboratory of Microbiology of Universitas Sumatra Utara (USU). V voltage

relationship and Medan E in Chamber Based on the law of electrostatics in the space field chamber, as shown in Figure 4, the relationship Velek field E and the flux, D is obtained by [4][5].

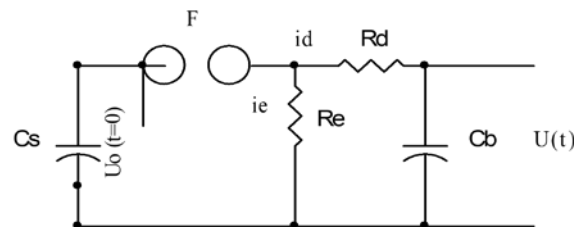


**Figure 1.** Modification of electronic circuits

The high voltage source is assembled together with the Test Transformer. The source of the test transformer is supplied from out otrafo and connected to 220 V/50 Hz which used to controlled the input voltages. The generator used is YHIG 100kV- 5kA and the storage capasitor of 6000 PF- 140 kV. In order to obtain DC high voltage, generally used diode rectifier Villardtype, Greienacher or Cockroft-Walton, and Zimmermann-Wittka[6]. Among the serectifier the best is the Greienachertype. However, the output voltage of the diode is still in a half-wavestate so that it is flattened with a capasitor which also function as a storage of electrical charge energy. The principles work of the sphere-gap as follows. The sphere-gap operation process is basically dependent on the magnitude of the trigger voltage. Firstly, given a second electrode voltage  $V$ , so that the resulting electric field  $E$  between the two electrodes, 3 MV/m [7][8]. Secondly, the trigger is operated at 50-10 kV voltage pulse [9], and forwarded to the metal needle in between the spark that resulted in silt, 1mm, which resulted in distance between the main conductive to be reduced, and electric breakdown will occur that behave as high-speed switching. To determine the voltage of sphere gaps, can be done in two ways, namely by looking at Table and practice. Practically apply the relationship between the voltage electrodes ball,  $U$  and the trigger voltage[10].

## 2.2Method

Transient pulsed voltage generators using RCcircuits that combined with the sphere gap as shown in figure 2 below. Based on the circuit in Figure 3 above, and in accordance with the laws of Kirch-off voltage, then the output voltage,  $U(t)$ .



**Figure 2.** RC Transient Pulse Generator

## 3. Result and Discussions

### 3.1 Testing data sphere gap

In this study for air translucent stress testing data in Figure 4, we use standard ball electrode diameter,  $D = 5$  cm; the distance to the second electrode,  $S = 0.5$  cm,  $T = 23^\circ \text{C}$ ,  $P$

= 760 mm Hg; inertia absolute air = 11 g / m<sup>3</sup>; N = 10 times (picuan), t = 50 us. Then, the transient test data generator in Table 1, with T = 23 C, P = 760 mm Hg, t impulse (50%) = 50 μs. N = 10 times.

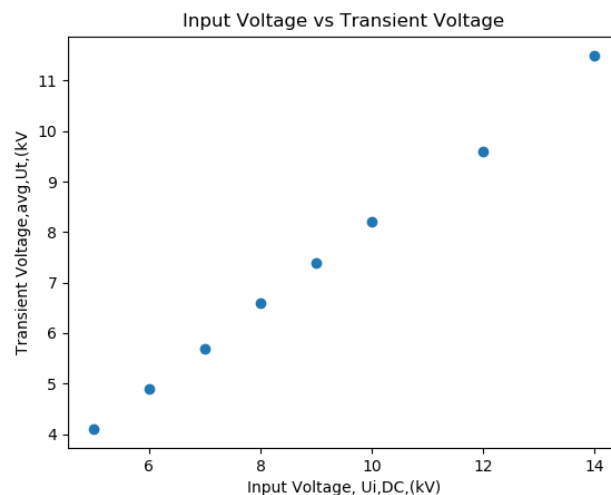
The term of the machine learning model on decision tree represent entire sample of TB divided into more homogeneous set. The splitting was process of deviding anode into more sub-nodes of TB and making strategics split heavily affects a tree's accuracy.

**Table 1.** Test data generator

No	Input Voltage, (Ui), DC, (kV)	Transient Voltage, avg., (Ut), (kV)
1	5	4,1
2	6	4,9
3	7	5,7
4	8	6,6
5	9	7,4
6	10	8,2
7	12	9,6
8	14	11,5

### 3.2 Discussion

In accordance with the data first, then gained V elec sg = 18.5 kV. Thus, the sphere gap can be used as a switching transistor that expensive to replace. Based on measured data in Table 2, the relationship between voltage input voltage, output voltage transients and Ui, Ut, and graphics then obtained as in Figure 3.

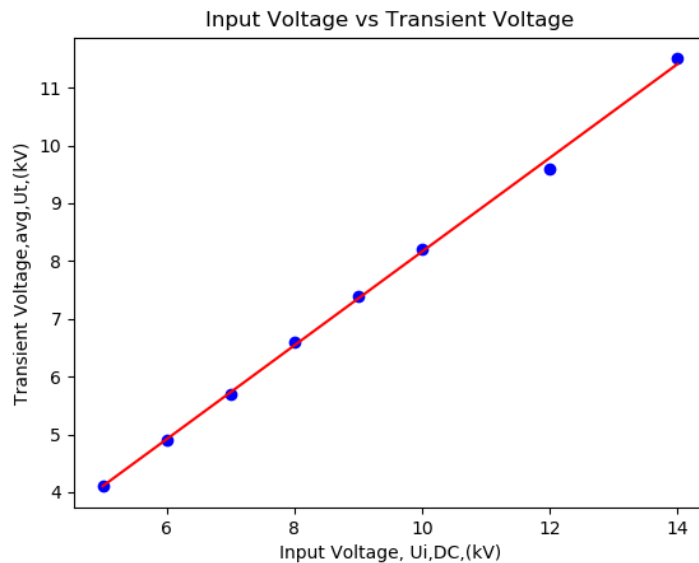


**Figure 3.** Input vs. Output voltage relationship of transient.

Then, with the Least Square method, the obtained equation, namely:

$$U(t) = 0.812U_i - 0.047 \text{ Volt} \quad (1)$$

In accordance with equation (7), the transient voltage generator efficiency = 81.7% at peak price, while according to the theory is obtained: = 83.30%, difference 1.6%. The waveform-shaped output voltage transients, such as Figure 4.



**Figure 4.** Form of transient voltage,  $U(t)$  versus time.

### 3.3 Electric Field Intensity and Applications

According to the result of modifications such as in Figure 4, and the electrode voltage as in equation 9, then by substituting the data in Table 1 and 2, then obtain the maximum electric field intensity inside the chamber is equal to 80 kV / cm. As a test sample containing the nematode, apparently on the electrode voltage, 6.7 kV V electrode,  $t = 50 \mu s$  to produce  $E = 37.33 \text{ kV / cm}$ , which resulted in the cell membrane rupture, nematode death.

### 4. Conclusions

The PEF modification had been obtained in sphere gap operating voltage of 18.5 kV. While the intensity of the electric field  $E$  of transient maximum in the chamber is 80 kV / cm, and the conditions  $V_{elec} = 6.7 \text{ kV}$  or  $E = 37.33 \text{ kV / cm}$ , leading to nematode death, non-active.

### Acknowledgment

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