CHAPTER 4

HF-HV CIRCUIT TO ENHANCE OZONE CONCENTRATION AND OZONE YIELD

4.1 INTRODUCTION

So for researches have mainly focused on the concentration levels on ozone through the corona discharge or dielectric barrier discharges (DBDs), have for a long time been exclusively related to ozone generation (Valdivia-Barrientos et al 2006). DBDs are often applied at atmospheric oxygen or air. There are usually electrode configurations and choosing very high voltage power supply method that have been employed for most of the applications (Rahuls et al 1995). Therefore the choice of high voltage sources and frequency play an important role in producing ozone concentration as well as energy efficiency.

4.2 SIMULATION METHODS

4.2.1 Circuit Model and Frequency Measurement

The power supply circuit consists of a single-phase full bridge diode rectifier with a DC smoothing capacitor which provides 5V. The power supply of 5V is supplied to the oscillator circuit. The RESET circuit is used to reset the operation of the circuit and the noise filter eliminates the noise produced by the capacitor. The opto coupler is used to provide the isolation between the MOSFET device and the microcontroller circuit (PIC16F877). The microcontroller is capable of measuring frequency of range 5 kHz - 20 MHz. The MOSFET is adjusted for the switching frequency of
25 kHz. The LCD monitor is used to display the frequency which was obtained. The design developed using proteus7.6 for individual circuits, frequency measurement using microcontroller and schematic diagram of HV-HF circuit are shown Figure 4.1, 4.2 and 4.3 respectively.

Figure 4.1 Simulation Models of Individual Circuits
Figure 4.2 Simulation of Frequency Measurement
Figure 4.3 The Schematic diagram of HF-HV Circuit
4.3 DESIGN OF HF-HV SWITCHING POWER SUPPLY

The high-frequency, high-voltage, (HF-HV) switching power supply of high-ripple voltage is controlled by IC LM555. Switching devices, power MOSFETs IRFP460, are used in the fly back converter controlled by the PWM strategy from IC LM555 (National Semiconductor, 2006). The switching frequencies range from 5 kHz to 25 kHz. The energy from the converter is transferred through the HF-HV transformer to produce the HF-HV high-ripple voltage supplying the electrode tube (Siseerot Ketkaew 2007). The structure and the circuit of this supply are shown in Figure 4.4 and Figure 4.5 shows the HF-HV converter circuit with fly back Transformer.

Figure 4.4 The HF-HV Converter Circuit
FLY BACK TRANSFORMER

The high frequency is supplied to the primary winding of the fly back transformer with a supply voltage of 15V. The high voltage of 10 kV is obtained by making necessary changes in the fly back transformer (Kim et al 2007). The main function of this circuit is to simulate a square-wave, high frequency input for the fly back transformer (Kim et al 2006), which allows for working the transformer. The square wave generated typically has a frequency between 25-100 kHz. Fly back transformers are high frequency transformers, and their low output power and small size make them very useful in generating high output voltages with low current (Oksuz et al 2005). Rale design software is used to calculate the parameters of
flyback transformer (http://www.rale.ch/aspnet_client/Examles/ CAL0010e/ cal0010e.htm). The transformer specifications are shown in Table 4.1.

Table 4.1 Fly Back Transformer Specifications

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Frequency</td>
<td>20 – 50 (kHz)</td>
</tr>
<tr>
<td>Time</td>
<td>20 µs</td>
</tr>
<tr>
<td>Efficiency</td>
<td>80%</td>
</tr>
<tr>
<td>Diode voltage drop</td>
<td>0.7 V</td>
</tr>
<tr>
<td>Voltage primary (V&lt;sub&gt;in&lt;/sub&gt;)</td>
<td>15 V</td>
</tr>
<tr>
<td>Voltage out (V&lt;sub&gt;out&lt;/sub&gt;)</td>
<td>10 kV</td>
</tr>
<tr>
<td>Current out</td>
<td>180 mA</td>
</tr>
<tr>
<td>Primary inductance</td>
<td>0.915 µH</td>
</tr>
</tbody>
</table>

The design setup is developed for generating high voltage using Proteus software. The fly back transformer and simulated setup for flyback transformer is shown in Figures 4.6 and 4.7.

Figure 4.6 Fly back Transformer
4.5 RESULTS FOR FREQUENCY MEASUREMENT BY PWM TECHNIQUE

The waveform of frequency 20 kHz generated by oscillator circuit is shown in Figure 4.8.
The voltage waveform generated by the fly back transformer is shown in Figure 4.9.

4.6 BLOCK DIAGRAM OF POWER CIRCUIT FOR OZONE GENERATOR

Figure 4.10 shows the ozone gas generator, which is constructed with the use of the high-voltage, high-frequency, switching power supply. The AC input voltage is 180 V, 50 Hz, needed by the rectifier circuit to produce the dc voltage of 18 V. The dc voltage signal is delivered to the inverter controlled by Pulse-Width Modulation (PWM) in order to obtain the operational frequencies within the range 5 kHz – 25 kHz. The low voltage signal of the inverter of the primary circuit is amplified to the 10 kV High-Frequency High-Voltage (HF-HV) signal of the secondary circuit which is fed into the electrode tube for the generation of the ozone gas (Dalarat et al 2004).
4.7 HIGH VOLTAGE AND HIGH FREQUENCY EFFECTS

4.7.1 Effect of Frequency

The effect of frequency on ozone generation is shown in Figure 4.11. With increase in frequency, the generation rate was increased. Although higher frequency is desirable for high capacity generator, the operating frequency is limited by the heating of electrodes and control circuit chokes.
4.7.2 Effect of Voltage

The effect of voltage on ozone concentration and yield are shown in Figure 4.13, 4.14 respectively. With increase in voltage, the generation rate was increased. Although higher voltage is desirable for high capacity generator, the operating voltage is limited by the insulation of transformer.
Figure 4.13  Effect of voltage Vs Ozone Concentration

Figure 4.14  Effect of voltage Vs Ozone yield
From the experiments, the effect of changing the switching frequency, one can evaluate the process of ozone gas concentration and yield. The experimental results demonstrate the relationship between the switching frequency and the quantity of ozone gas parameters. With the increase of the switching frequency, increased ozone concentrated gas are generated because the shifting of the frequency level in the converter circuit has an effect on the production resonance at the ozone tube. Also, the yield of generated ozone gas changes accordingly. The operation of the ozone generator with the high-frequency fly back source allows an increase in the efficiency due to low losses and a reduction in the prototype size. This results in the reduction of the costs of ozonation system totally. These advantages considerably facilitate the design of an appropriate HV power supply for DBD applications.