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08:30-12:00, October 15, 2016. No.4 Lecture Hall

Session Chairs:

Yong Yang (Jiangxi University of Finance and Economics, China)

Hanggeun Jeong (Chonbuk National University, Korea)

Multistage Voltage Booster for Wastewater Treatment System Using Plasma

Boram An, Seungho Joeng, Seonyoung Lee and Yongchae Jeong
Division of Electronic and Information Engineering
Chonbuk National University
Jeonju-si, Republic of Korea
work0265@naver.com

***Abstract*—This paper presents a design of multistage voltage booster for a wastewater treatment system using plasma. The proposed voltage booster consists of a harmonics pulse generator, transformer, and the multistage voltage doubler. To improve stability of system, a metal oxide silicon field effect transistor (MOSFET) switch and the snubber structure are applied in the pulse generator instead of an astable multi-vibrator. From the measurement results, the system operation was stable for 48 hours and the output voltage is obtained about 8 kV when the input voltage is 12 V. Also, the proposed booster shows a glow discharge forms which is used in wastewater treatment system.**

***Keywords*—** *Glow discharge, multi-stage booster, snuber, wastewater treatment system.*

I. INTRODUCTION

Globally, a sense of crisis for environmental problems such as the air, water, waste, marine pollution are spreading and the amount of waste is increasing due to urbanization, industrialization, population, and fuel consumption growth, etc. Especially, the water pollution is one of the primary causes of environmental pollution. Therefore, there are various waste water treatment methods to resolve the water pollution problem [1]-[4]. Recently, the wastewater treatment system using plasma processing method which electrically decompose the mixture, has been researched. The plasma processing method has various advantages such as excellent in treatment efficiency of wastewater, no fear of generating secondary contamination, easy maintenance and completely decomposing non-destructive material [5]-[7].

However, despite these advantages, the plasma processing method cannot be generalized to the actual process in terms of economic efficiency and the operating durability for a long time. In the wastewater treatment system using plasma, the electron generating device is used to generate radicals and ions which produce free electrons through the corona discharge. This process mainly causes a durability problem for electron generating devices and requires a voltage booster that steps-up voltage from low input DC voltage to several kV output DC voltage. In the conventional the electron generating device, astable multi-vibrator is used to transform DC voltage to AC voltage using transformer. The complementary state difference of the two bipolar junction transistor (BJT) generates a harmonic pulse output. However, this structure has a disadvantage of weak durability for stable operation of system because the BJT is the current driving device. In order to resolve a durability problem, this work proposes a harmonics pulse generator consisting of MOSFET switch and snubber instead of the astable multi-vibrator. Furthermore, multistage

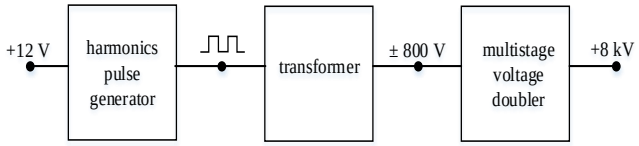
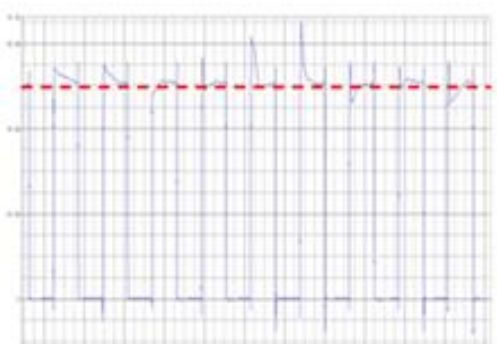
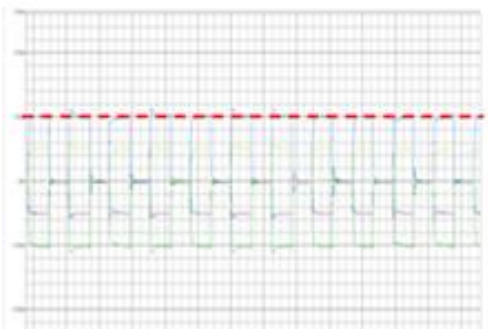


Fig. 1. Block diagram of the desinged multistage voltage booster.

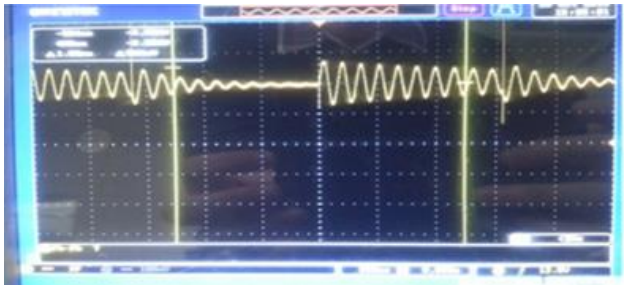


(a)

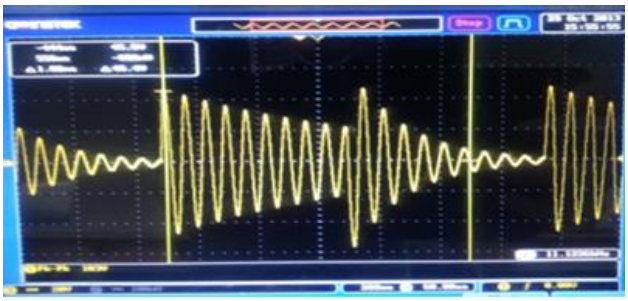


(b)

Fig. 2. Simulation of MOSFET drain current wave: (a) wihout snubber and (b) with snubber.



(a)



(b)

Fig. 3. Measurement results of transformer output voltage at: (a) front end and (b) back end.

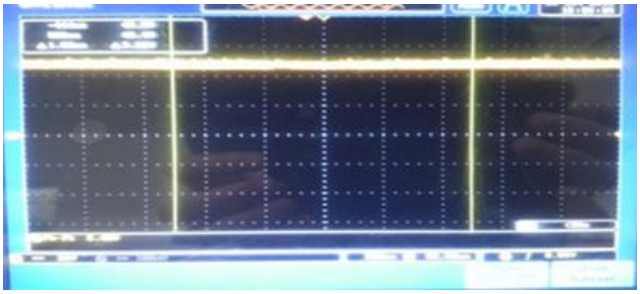


Fig. 4. Output voltage of designed multistage booster.

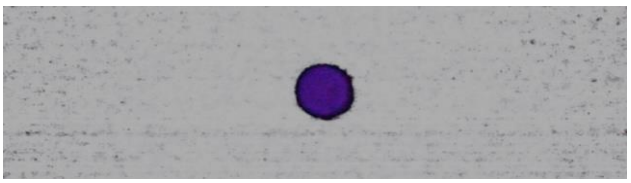


Fig. 5. Plasma discharge experiment.

booster is designed based on the proposed harmonic pulse generator for the wastewater treatment system using plasma.

II. DESIGN AND MEASUREMENT

Fig. 1 shows a block diagram of the designed multistage voltage booster which consists of the proposed harmonics pulse generator, transformer, and the multistage voltage doubler.

A. Proposed harmonics pulse generator

Considering the condition of the operating environment and a conventional transistor circuit, the harmonics pulse generator SE555 having relatively large temperature characteristic is used. In this case, the frequency of the pulse wave is designed and optimized for the resonance characteristic of the AC voltage transformer at 27 kHz. The MOSFET switch is used to control input of transformer by switching output of harmonic pulse generatorAlso, the snubber is added to prevent an over-current caused by the leakage inductance of transformer. When the MOSFET switch is off, the energy stored in the leakage inductance is discharged to capacitor. Similarly, when the switch is on, the energy is consumed in the resistor. Fig. 2 shows the simulation result of MOSFET switch with and without the snubber.

B. Transformer

The turns, inductance, and resistance ratios of the transformer are given as 23 : 256, 133 μH : 677 mH, and 0.35 Ω : 282 Ω, respectively. In this case, the optimum operating frequency transformation is determined as 27 kHz. Fig. 3 shows measurement result of transformer at front end and back end. These results show that the pulse of amplitude ±18 V is generated when the input voltage is 12 V and amplified up to ±800 V through the transformer.

C. Multistage voltage doubler

Each stage in the multistage voltage doubler is composed of Villard voltage doubler using diode and Mylar condenser that can withstand the internal pressure more than 2 kV. The multistage voltage doubler is half-wave rectifier and take an AC voltage as input and produces output DC voltage of 8 kV. In addition, the frequency characteristics can vary according to the number of stage because the capacitor and the diode are operated as series capacitor and resistor. Similarly, the variation of time constant according to the capacitance of condenser affects the discharge cycle. Therefore, a stage number of multistage voltage doubler should be optimized for the desired output voltage and discharge cycle. Fig. 4 shows the output voltage of designed multistage voltage booster. From the measurement, it is found that input voltage of 12 V is amplified up to 8 kV with designed multi-stage voltage booster. Fig. 5 shows a plasma and glow discharge forms experiment results and these discharges are used in wastewater treatment system. From the experimental results, the system shows stable operation for 48 hours in the laboratory operation.

III. CONCLUSION

In this paper, a highly stable multistage booster is designed to overcome the durability problem of the conventional one. Since the proposed voltage booster provides a stable output voltage and glow discharge, it can be applied to the electron generating device in wastewater treatment system using plasma. Moreover, the proposed circuit has a possibility to use in other systems which require high voltage output.

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