A study on Reactor Parameter of Atmosphere Plasma Power Supply

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ABSTRACT

This paper proposes an extraction method for reactor parameters in atmosphere plasma power supplies. This method is performed by detecting phase difference between inverter voltage and current, and extracting the reactance through reactive power. The validity of the proposed scheme is investigated through simulation results and experimental results.

1. Introduction

In the field of process equipments, the electrode of the atmosphere plasma equipment is a protected know-how of the equipment makers and is treated as a trade secret. Fig.1 shows the atmosphere plasma reactor which applies high electric fields to neutral gas which divide a portion of the neutral gas into proton and electron and generates mixed plasma with the energy of the electrical field energy[1]. Such plasma has high energy and is unstable, and is in the chemical active state, which is used to effectively remove the minute organic pollutant or oxides from polymer or metal surface[1]. However, only when electrode parameter is fully understood and the parameter of atmosphere plasma power supply is properly adjusted, the plasma equipment can operate with high quality and high efficiency. Here, voltage and current change the state of inner reactor (inflow gas and gas element, electrode change), which makes it hard to stably supply voltage[1]. Thus, the power supply needs to be designed to perform normal operation even in case of reactance change in the plasma reactor. To facilitate such matching by the operators, this study guides how to intelligently extract parameters of plasma electrode and proposes Display Windows of power supply for simple operation. The proposed system consists of Phase Shift Full-Bridge inverter of switching frequency 30Khz as the main power circuit, high voltage transformer and output device. The stable output voltage was validated in the variety of conditions such as changes of electrode and reactance through the simulation and experiment.

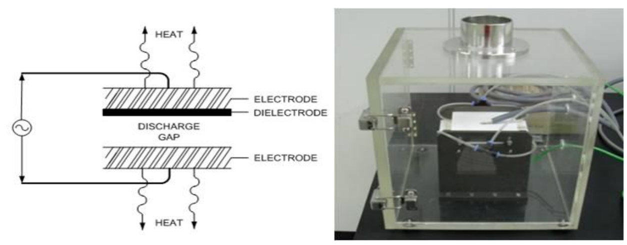


Fig.1 Diagram of plasma reactor, Plasma reactor

2. Power circuit and Reactor modeling

As shown in Fig.2, the output terminal of Phase Shift Full-Bridge inverter has L, C, and transformer, where L, C and transformer represent inductor (L1) for resonance, capacitor for DC cut-off(C3), transformer for boosting voltage, respectively. Fig.3 shows the block diagram of the Atmosphere plasma power supply.

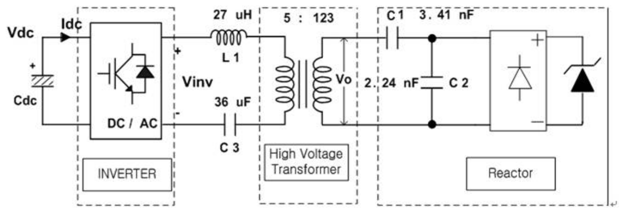


Fig.2 The inverter and reactor modeling

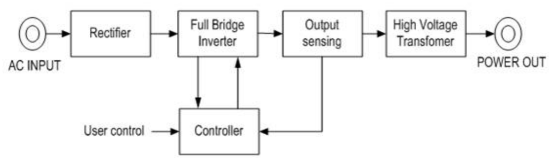


Fig.3 Block diagram of AP Power Supply

A corona is characterized by a low-current electrical discharge across a gas-filled gap. During insulation breakdown(electrical discharge), the gas becomes partially ionized and a characteristic, diffused bluish glow results. Kilovolt voltages and milliampere-to-ampere currents are typical within a corona[1]. Fig.2 shows the model of the electric device for reactor simulation. Electrode(c1) and discharge gap(c2) were modeled with capacitor and gap sparking potential with zener diode[2-3]. The discharge voltage wave-form of reactor should be identical to the gas gap voltage shown in Fig.4[1-2].

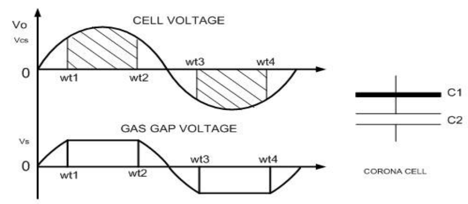


Fig.4 Discharge voltage(Gas gap voltage)

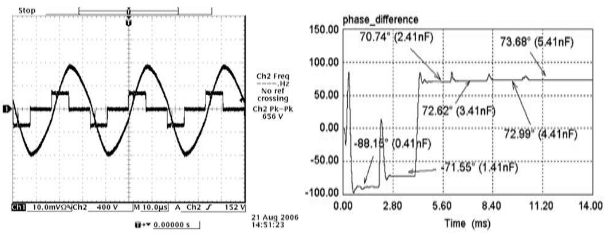
3. Simulation and Experimental

Table 1 System specification and Parameters

Input Voltage, Tr Turns ratio	285V[dc], 5 : 123
Switching Frequency, Duty ratio	30k[Hz], 0.5
L1,C3	27uH, 3.6uF
Simulation Parameter	
C1, C2	0.41uF~5.41nF, 2.24nF
Zener diode	2.28k[V]

The power circuit consists of a Phase Shift Full-Bridge PWM Inverter , 4 IGBTs which operate with ZVS(Zero Voltage Switching)[4-6]. CTs and the voltage divider circuits were used for the output detection circuit[7]. EPLD was used for controlling PWM. DSP TMS320C32 was used for controlling microscopic partial discharge, restraining arc, extracting intelligent parameters, matching and controlling rated voltage and rated current. Through PSIM, simulation was performed to extract parameters as well as matching. The parameters which were used in the experiment and simulation are shown in Table II.

Fig. 5(a) shows the phase difference can be obtained with the voltage and current of inverter. Fig. 5(b) shows the changes of the phase difference as C1 increases. PSIM increases C1 by increasing per 1ms from 0.41nF to 5.41nF.



(a)   (b)

Fig.5 Experimental & Simulation results

(a)Voltage and current of inverter output, (b)The changes of the phase difference as C1 increases

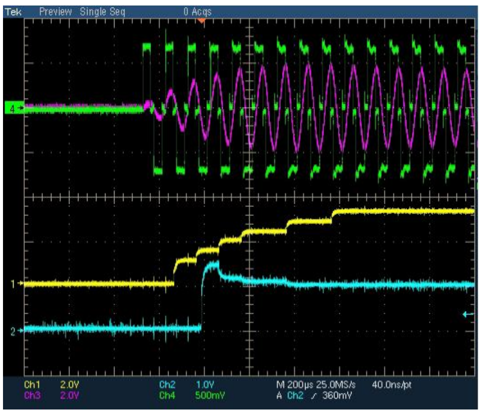


Fig. 6 Experimental result of parameter extraction from the proposed algorithm

(a) ch1: phase difference (20°/div), (b) ch2: reactor parameter (1uF/div), (c) ch3: Inverter current(100A/div), (d) ch4: Inverter voltage(250V/div)

Fig. 6 shows Experimental result of parameter extraction from the proposed algorithm at initial starting.

4. Conclusion

This study deals with matching by extracting reactor parameters of an atmosphere plasma power supply. It solves reactor parameter matching problems which were the stumbling block and hereby making it an easier counter-move to handle conditions such as reactor changes and operating conditions. The proposed method doesn't require an impedance matching device, which causes the reduction of initial purchasing cost, maintenance and repair costs since it doesn't need the new power equipment for the reactor change. The proposed method was validated with simulation and experiments. In the future, the proposed method will be validated through experiments at various load conditions.

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