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Behavior simulation of the liquid droplet injection device according to the multi-actuator

マルチアクチュエータによる液滴噴射素子の動作シミュレーション

Yoshihiro Ono[1†] Michitaka Yosino[1] Akira Yasuda[1] Chiaki Tanuma[1]
([1]Hosei. Univ.;)
大野 貴大[1†], 吉野 理貴[1], 安田 彰[1], 田沼千秋[1]([1]法政大学)

1. Introduction

The inkjet printer has established its position as a personal printer and has expanded into high-speed printing markets such as digital printing. In addition, as the use of innovative manufacturing by the inkjet spreads, further technological advancement is demanded. To respond to various types of ink, an inkjet head is required to stably control the ejection of ink droplets in a high speed [1~3]. In particular, as the ink becoming high viscosity is closely related to the higher speed, higher quality, and higher stability of printing, enhancement of the inkjet adequacy has become a big challenge. Therefore, various actions have been taken. However, an example of successful approaches that exceeds the range of low viscosity due to warming of the ink has not yet been found [4].

We developed a hypothesis to achieve the ejection of high viscosity ink by pressure control. To begin with, we tried the pressure control by using multiple sources of pressure generation. First, we devised an equivalent circuit model of an inkjet head to evaluate the generation of micro-droplets using multi-actuator [5~10]. With the circuit analysis software, we then examined the possibility of the operating simulation. Using the equivalent circuit method, a long-time operating analysis and an operating simulation by the general-purpose software can be performed. As a result of the simulation, we found a constant relation between the drive and the pressure of the actuator. In this report, we describe an equivalent circuit model of an operating simulation and the possibility of an adequacy of a multi-actuator system to micro-droplet-ejection device.

E-mail: 10x2024@stu.hosei.ac.jp

2. Equivalent circuit of the proposed droplet element

Figure 1 shows the structure of the liquid droplet ejection device using a multi-actuator. In addition, an equivalent circuit is shown in Figure 2. Multiple piezoelectric elements are attached in a pressure chamber to synthesize the pressure generated in the pressure chamber. Here, the external vibratory force F is generated when given an input Vin as Eq. (1).

$$\left.\begin{aligned} F &= -2\frac{Z_1}{Z_1+Z_2}\phi V \\ Z_1 &= -j2Z_o\cot\left(\frac{\omega l}{2v}\right) \\ Z_2 &= j2Z_o c\tan\left(\frac{\omega l}{2v}\right) \end{aligned}\right\} \quad (1)$$

G in Figure 2 is the figure conductance of the gyrator and the load is the impedance of the pressure chamber and the nozzle passage. Using the multi-actuator, the piezoelectric element can be regarded as a load and thus, the gyrator converts current to voltage [11]. In addition, the current I is calculated from Eq. (2).

$$\begin{aligned} I &= i_1 + i_2 + i_3 \\ &= -G\left(F_1 + F_2 + F_3\right) \\ &\begin{cases} i_1 = -GF_1 \\ i_2 = -GF_2 \\ i_3 = -GF_3 \end{cases} \end{aligned} \quad (2)$$

3. Simulation results

Figure 3 and 4 shows the simulation results using MATLAB/Simulink. Figure 3 is the changes in the output with the changes in the drive number of the piezoelectric element. The output in proportion to the number of actuators to be driven

can be seen, which is 1-3 times bigger. Figure 4 is a comparison with the single actuator. Because the piezoelectric element itself becomes a load, it is not possible to obtain a three-fold amplitude. However, the output waveform is almost the same.

4. Conclusion

We have proposed an equivalent circuit model of the liquid droplet injection device using a multi-actuator. Using the proposed liquid droplet ejection elements, we can simulate multiple output levels by selecting the number of piezoelectric elements to drive. In addition, as the pressure generated itself is synthesized, it is possible to lower the voltage per piezoelectric element to be applied. Ejection of high viscosity ink and reduction of power consumption can be achieved by using a liquid droplet ejecting device using the multi-actuator.

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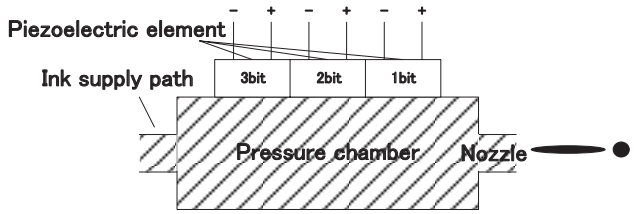

Fig. 1 Configuration of the inkjet head using multiple piezoelectric elements (3bit)

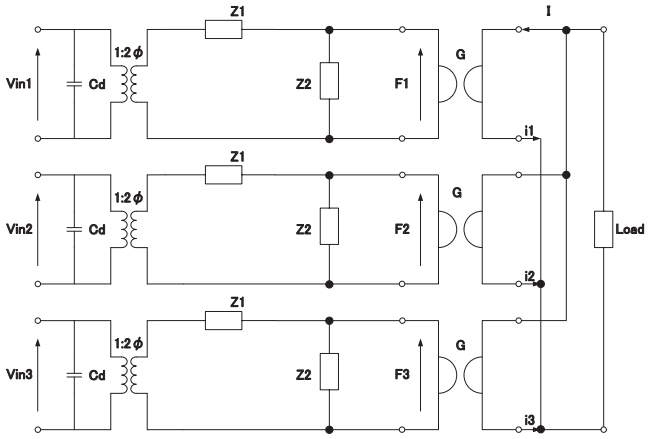

Fig. 2 Equivalent circuit of the inkjet head using multiple piezoelectric elements (3bit)

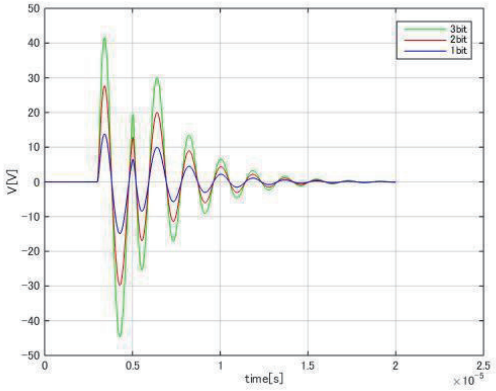

Fig. 3 The output waveform of the droplet jetting device using multiple piezoelectric elements (green: 3bit, red: 2bit, blue: 1bit)

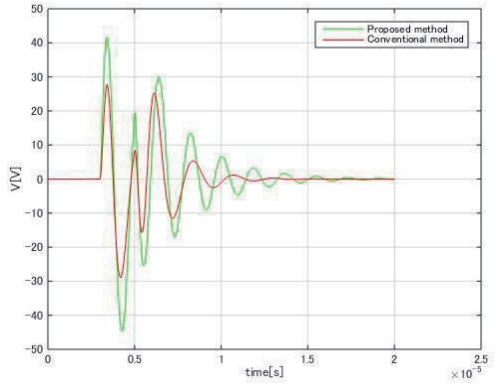

Fig. 4 Comparison with the single actuator