

A New Technique for Measuring the Charge-to-Mass Ratio of Toner Particles

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Abstract

In this paper, we show the measurement of the values of Σq/Σm by an improved technique when the charged toner particles are transported on the sheet with periodic array-conductors driven by the four phase rectangular pulses. On the way of transportation of toner particles, the parallel electrodes are set up for sensing the signal of Σq / Σm. The sense electrodes are connected to the sense amplifier whose output is sent to the analog input of the A-D conversion board in a personal computer. Analyzing the sensed signal, we can obtain the value of Σq / Σm of the toner particles more precisely.

Introduction

As shown in references [1-3] we have developed the method for the measurement of Σq/Σm up to this time.

The major points of our previous research are as follows:

1. The techniques for decreasing the adhesion force acting on the toner particles placed on the surface of the electrode, for example; by using the piezo electric element.
2. The utilization of the movement of toner particles near the center of the gap between parallel electrodes. In this case, forces act on toner particles are both the Coulomb force and the gravity one.

In the same situation mentioned above, we use the toner particles which are transported by means of traveling waves of the electric field generated by the four-phase rectangular waves.

In this paper, we will present a new technique to calculate the value of q/m by analyzing the signal in the toner transportation system.[4-7]

Theory

Figure 1 illustrates the relationship between a toner particle on the sheet printed periodic array-conductors driven by the four phase rectangular pulses and parallel electrodes.

As described in the reference [4], we have already presented the movement of toner particles driven by the same type of generators in detail. In Figure 1, the toner particles are moved toward the sense electrodes placed to the left end of the sheet printed periodic array-conductors.

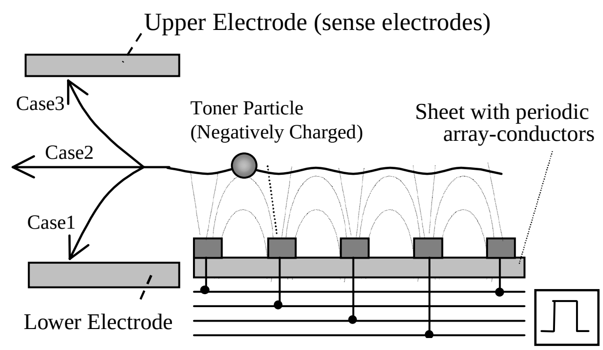

Figure 1. Movement of toner particles on the periodic array-conductors

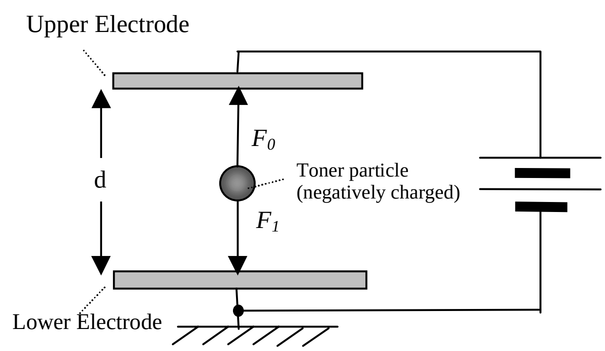

Figure 2. Movement of toner particles between two electrodes.

In the air gap of the sense electrodes shown in Figure 2, the following forces may act on the toner particle:

1. The Coulomb force F_0 due to the electric field is given as follows:

$$F_0 = q(V/d) \tag{1}$$

where

q : the charge of the toner particle
V: the voltage applied across the parallel electrodes
d: the air gap distance between parallel electrodes

2. The gravity force F_1 is given as follows:

$$F_1 = mg \tag{2}$$

where

m : The mass of the toner particle
g : The acceleration of gravity

From the relationships between F_0 and F_1, there are three major cases of the toner particle, as shown in Figure 1.

Case 1:

$$F_0 < F_1 \tag{3}$$

In this case, the charged toner particle moves from the center of the air gap between parallel electrodes toward the lower electrode.

Case 2:

$$F_0 = F_1 \tag{4}$$

In this case, the charged toner particle passes through the center of the air gap between two electrodes.

From equation (4), q/m can be written in the following form.

$$q/m = g\,d/V \tag{5}$$

Case 3:

$$F_0 > F_1 \tag{6}$$

In this case, the charged toner particle moves from the center of the air gap between parallel sense electrodes toward the upper electrode. The output signal due to the movement of toner particles is picked up from the sense electrodes. After amplification of its signal, this output signal is sent to the analog input of the A-D converter in the computer.

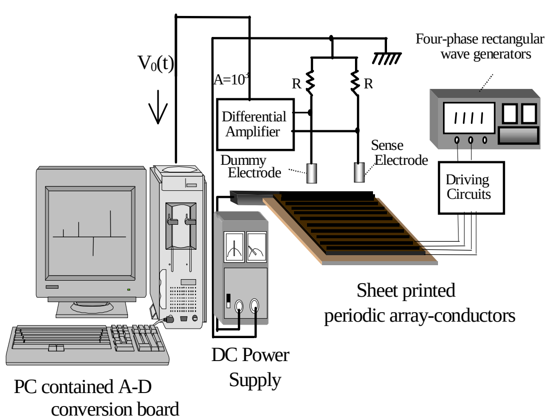

Figure 3. Schematic diagram of the experimental system

Experimental System

The schematic diagram of the experimental system for sensing Σq / Σm is shown in Figure 2. This system consists of the following parts: the four-phase rectangular wave generator, the sheet printed periodic array-conductors for transporting charged toner particles, the DC power supply for giving the voltage to the parallel electrodes and the PC for analyzing the output voltage. The air gap between parallel electrodes is about 1000μm.

By the electric curtain made on periodic array-conductors, toner particles are moved toward the center of the air gap between parallel electrodes.

If $F_0 \geq F_1$ is satisfied, toner particles are lifted toward the upper electrode of the sensor. As a result, the induced voltage is generated across the resister R for sensing the signal caused by toner's potential and is amplified by the differential amplifier. The output voltage $V_0(t)$ is sent to the analog input of the A-D conversion board in the personal computer.

Experimental Results

Spherical toner particles with silica coating process are used for this experiment. The values of voltage and frequency generated by four-phase rectangular wave generators are 100(V) and 100(Hz), respectively.

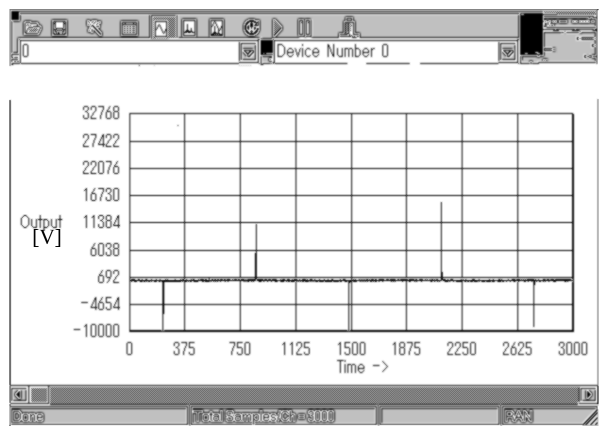

Figure 5. Output voltage waveform without toner particles

Figure 5 shows the output voltage waveform of the sense amplifier in the case that the toner particle is not transported. In this figure, the induced noise voltage waveforms are only seen at the output of the sense amplifier. Figure 6 shows the output voltage waveforms obtained from sense amplifier in the case that the voltage applied across the sense electrodes is 0 (V). Then, the toner particles may fall toward the lower electrode. The voltage applied across parallel electrodes is increased by the step of 0.1(V) from 0 (V) until 3 (V). Figure 7 shows the output voltage waveforms of the sense amplifier in the case that the voltage applied across the sense electrodes is 1.9 (V). In the case that the voltage V applied across the sense electrodes has more than 1.9 (V), most of toner particles in the vicinity of the center of the sense electrodes may be lifted to the upper electrode. The output voltage waveform of the sense amplifier is also presented in Figure 7. The information for electrical states of toner particles may be included in this waveforms. From equation (5), we can calculate the value of q/m as the approximate average value of 5.15 (μC/g).

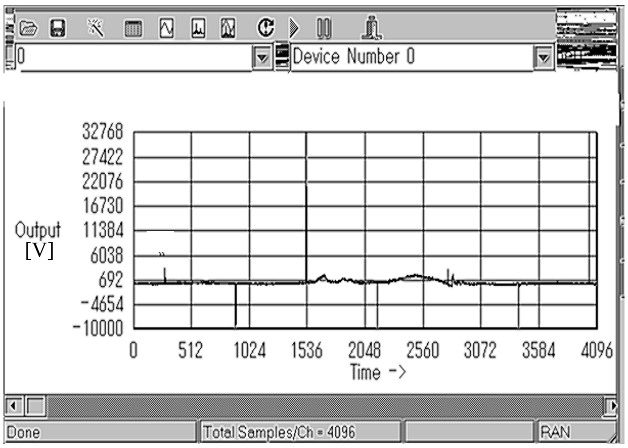

Figure 6. Output voltage waveform in the case that the voltage applied across the electrodes is 0V.

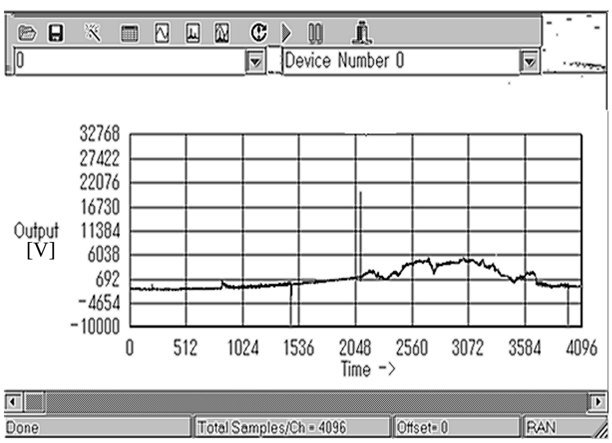

Figure 7. Output voltage waveform in the case that the voltage applied across the electrodes is 1.9V.

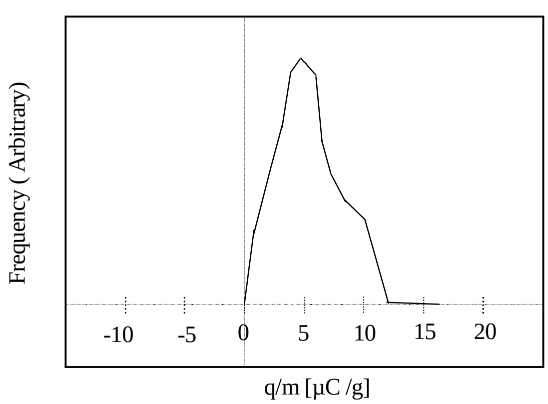

Figure 8. Distribution curve of the charge-to-mass ratio (q/m).

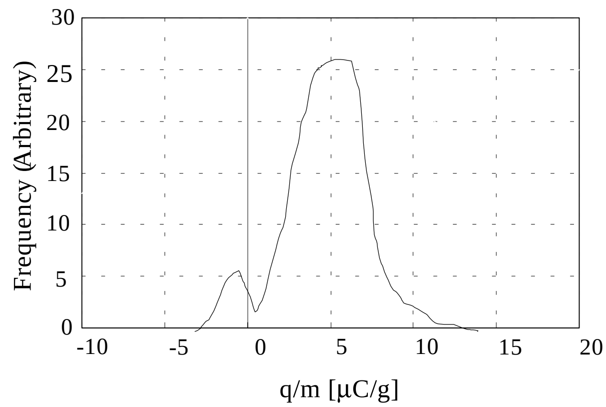

Figure 9. Distribution curve of q/m of the toner particles which is measured by using E-SPART method.

Figure 8 shows the distribution of the charge to mass ratio (q/m) of the toner particles. Figure 9 also shows the distribution of q/m of the toner particles which is measured by using E-SPART method.

Conclusion

A new measurement technique for the value of Σq / Σm of charged toner particles transported on the sheet with periodic array-conductors driven by the four phase rectangular pulses is presented in this paper. The parallel electrodes are placed on the way of transportation of toner particles for sensing the signal of Σq / Σm. The induced signal caused by toner particles is amplified by the differential amplifier. Analyzing this signal, we can obtain the value of Σq / Σm of the toner particles precisely.

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Biographies

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