New design of high performance ionizing bar

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Abstract. This paper introduces a new design of DC-pulse ionizing bar to solve the problem of imbalance offset voltage for the AC ionizing bar, which is easily affected by the environment, as well as indicate the final tests. The new design mainly includes five parts: power supply circuit, main control unit, logic circuit, high frequency transformer unit, and feedback unit. The ionizing bar can automatically adjust the discharge voltage, pulse frequency and pulse width to balance the positive and negative ions. The final test results indicate that the DC ionizing bar owns good effect in electrostatic elimination.

1. Introduction

In the electronic industries, the products always carry on the positive and negative charges due to the relative motion such as friction, contact and separation. The static charge can cause problems in production, for example, the surfaces of the products adsorb tiny dust particles, plastic film products bind hard to separation in the process, accumulated charges cause electronic components breakdown for electrostatic discharge [1]. In order to minimize or eliminate static electricity damage, the best way is to build up electrostatic protected areas (short for EPA) as a systematic project [2]. In this project, the effective protection requires the trinity measures of environment, human body and manufacturing process control. For the performance of electrostatic eliminator, offset voltage, decay time, stability and durability is considered the important parameters [3-4]. As the advantage of installation convenience, size extensibility, environment adaptability and good performance, the ionizing bars is applied in industrial production widely. This paper introduces a new design of ionizing bar which can achieve the desired effect to remove static electricity, and makes analysis of the performance combining with measured data. It employs DC pulse discharge and closed-loop feedback system to adjust high voltage output to guarantee stability of the offset voltage.

2. New design of ionizing bar

2.1 Principle of DC pulse discharge

The DC pulse-discharge is different from the other AC-discharge products in the market. The discharge mode is showed in figure 1. The core is control circuit of high-voltage generator which employs closed-loop feedback system. Figure 2 (A) shows the positive and negative pulse voltage is same value in one period, and figure 2 (B) shows the adjustment of pulse frequency, amplitude and width. This technique can guarantee the ion balance in multiple environment conditions.

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2.2 Design of Control Circuit
The circuit mainly includes five parts: power supply circuit, main control unit, logic circuit, high frequency transformer unit, and feedback unit. The specific design principle is shown in figure 3.

Power supply circuit includes HV+ & HV- amplitude adjustment circuit. It cooperates with feedback unit to supply the power of high frequency transformer unit.

With the help of good performance MCU, the main control circuit realizes the feedback signal collection and related control. The A/D converter samples the human-setting and environment information and sends them to MCU. MCU analyzes and contrasts with the inner database to generate the appropriate pulse wave. This wave includes two frequencies: 1-60 Hz (adjustable) and 50 kHz signal. 50 kHz signal is the work signal of the high-frequency transformer unit. 1-60 Hz (adjustable) signal is the discharge wave frequency. Logic circuit synthesizes the 1-60 Hz (adjustable) signal and 50 kHz signal and convert them to one signal as seen in figure 4. High frequency transformer unit receive the signal which generated by logic circuit and power supply which generate by power supply unit, and then transform to corresponding high voltage pulse output. The high voltage pulse output transmits to the electrode for corona discharge to release positive and negative ions.
Figure 4. High voltage square-wave pulse.

The feedback unit installed near the electrode can detect the balance of positive and negative ions, and sends the detected signal to the main control unit as the conference of next adjustment. The main control unit bases on the detected signal to make appropriate adjustment of frequency, amplitude and pulse width, thus ensuring the offset voltage is near 0 V. The whole process performs the function of the closed-loop feedback and control.

The new design makes the EPA voltage control within the secure range effectively, and it greatly improves the stability, anti-interference and dust-resistant performance of the ionizing bar.

3. Performance test
The performance of the ionizing bar consists of two aspects: one is Electrical performance, including offset voltage and decay time; the other is stability and anti-interference. The standards IEC61340 and ANSI/ESD STM 3.1 provide electrical performance test method [6-7]. The test equipment is the charged plate monitor (CPM), which has installed continuous sample and analysis software, and it can show and remember the real-time offset voltage in the computer.

The test operates in a class 10,000 cleanroom which control temperature & humidity. The temperature is 23±2°C and the humidity is 40%~60%. The stability and anti-interference is the capabilities that the ionizing bars worked in a period time within the voltage range. The test time can be set as necessary, for example, 12 hours. Test diagram as shown in figure 5, the ionizing bar hangs in 60 cm above the work surface. The CPM is placed just below the middle of the ionizing bars and the electrode is perpendicular to the work surface.

Figure 5. Test diagram.
4. Test data analysis
The test included the decay time test, offset voltage test, stability and anti-interference test. The result of the ionizing bars decay time was less than 3s. The offset voltage of the continuous work in 15 hours was showed in figure 6. The offset voltage was controlled within 10 V. It validated the ionizing bar owned high stability and anti-interference performance. At the same time, it shows the continuous test method is better than the points measure. Setting voltage range ±30 V (the high-performance ionizing bars requirements value), the process capability index was 6.6. It showed the work operation was very stable, and the result was showed in figure 7.

Figure 6. Offset voltage test.

Figure 7. CPK result.

5. Conclusion
This paper introduces the design of new type ionizing bar using DC pulsed high-voltage discharge. The control circuit can adjust frequency, amplitude and pulse width according to the environment changing. Compare with existing AC transformer discharge, the new design has many advantages, such as, high discharge efficiency, good electrical performance, excellent stability and anti-interference under various working condition.
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