

## Design specification of a new intelligent air purification device based on ion air technology

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### Abstract

With the continuous expansion of the scale of breeding production in China, a large number of harmful gases produced in the poultry house cause great harm to the health of poultry and feeding personnel. In view of the above problems, the team has developed a new type of intelligent air purification device. The ion wind generated by high voltage electrode is used to kill harmful bacteria in the air, condense particulate matter, purify a variety of harmful gases, and photovoltaic power generation energy storage realizes energy self-supply, which improves the air quality in the poultry house. At the same time, the new intelligent air purification device based on ion wind technology truly realizes the collaborative purification of compound air pollution, realizes the new revolution of air purification in greenhouse breeding, and creates a very clean life for breeding farmers.

### Keywords

Ion wind; high voltage electrode; sterilization and dust removal; photovoltaic power generation.

### 1. Introduction

The new intelligent air purification device applies the ion air without mechanical movement to the air purification, and the whole system sets dust removal (PM<sub>2.5</sub>), sterilization, odor removal gas (NH<sub>3</sub>、H<sub>2</sub>S) and other functions as one, creating a new mode of air collaborative purification with low noise, low power consumption and fast response.

The whole system adopts photovoltaic energy storage integration, using high-voltage power supply for tip discharge, generating a large number of positive ions attached to the dust or air molecules. Under the action of the powerful electric field between the emitter and the receiving pole, the charged particles move to the receiving pole, thus forming the ion wind. During the movement of the ion wind, on the one hand, the electric particles carried by the ion wind react with the harmful gas in the air and convert them into N<sub>2</sub> Such as harmless gas, can effectively remove the toxic gas in the shed; On the one hand, the kinetic energy produced in the air charged dust and air molecules under the action of the electric field can achieve the effect of absorbing dust and killing bacteria, which can achieve a good efficiency in air purification.

The microcontroller of the system processes the data information collected by the peripherals, and transmits it to the cloud data terminal remotely by using the 5G network. Users can remotely obtain and adjust the parameters of air purification through the cloud visualization platform or mobile APP to improve air quality.

## 2. Core operating principle and analysis of ion wind system

### 2.1. Core operating principle of ion wind system

After the fan of the system rotates, a negative pressure is formed to inhale various harmful substances in the indoor air and filter them through the initial filter screen. And adopt the integration of photovoltaic energy storage, On the solar panels by the lights in the greenhouses, The electricity generated goes through a rectified filter, Design ultracapacitors to store excess electricity, High voltage power supply by DC-DC conversion, Allowing the solid particles to be charged, After charged, particles can be adsorbed to the dust collecting plate, Through the combined action of the photocatalyst filter and the ultraviolet UV lamp, Disrupt the molecular structure of the microorganisms, Finally, the charged particles generated by the tip discharge of the high-voltage electrostatic field collide with the molecules in the air for energy exchange, Ionizing air forms ions, High-energy electrons generated by the gas discharge push the neutral particle in motion, Air flow out to the surface, Eventually forming an ionic wind.

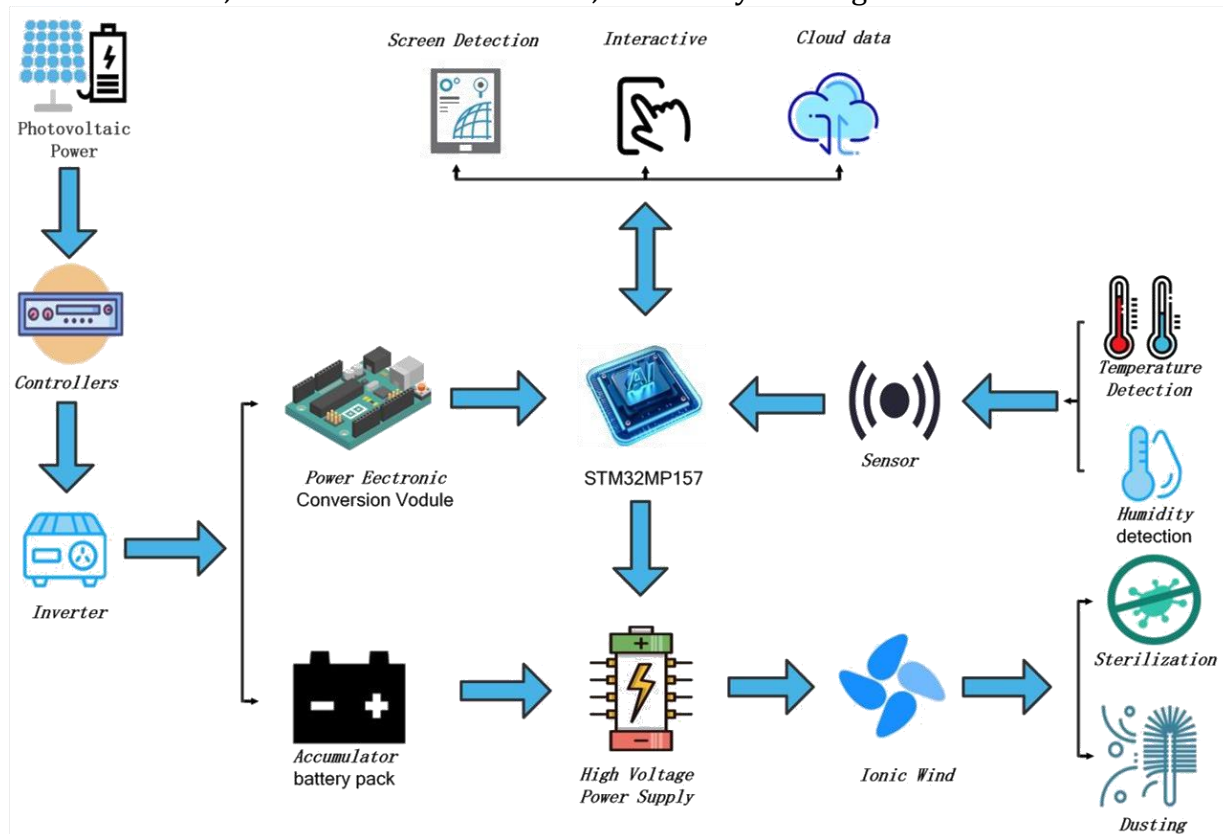


Fig. 1 System structure block diagram

### 2.2. Core control

The new intelligent air purifier plans to choose STM32MP157 as the control core of the system, and realize the closed-loop control of high voltage output and sampling of each sensor. It can remotely visually regulate the parameters and indicators of the purifier, support gigabit network communication and network operation, and facilitate the remote update and upgrading of the system.

### 3. Design of the ion wind air purification system

#### 3.1. Ion wind design proposal

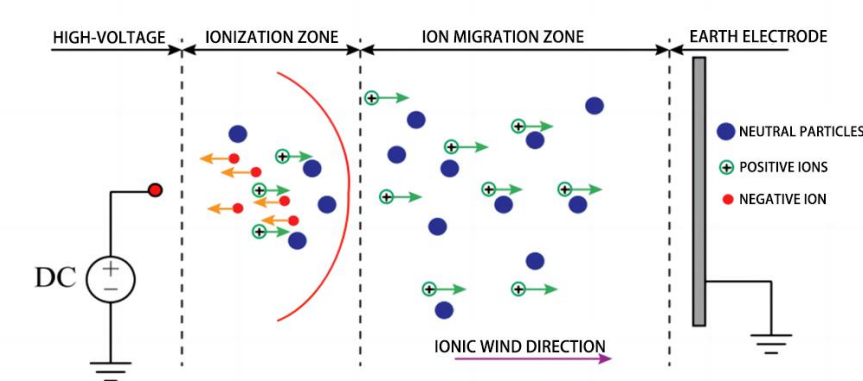


Fig. 2 A Schematic of the ionic wind generation

Ionic ionization unit in the high voltage device under the action of high voltage, form a stable high voltage electric field, charged particles under the action of the electric field collision with air molecules for momentum exchange, ionizing air form ions, gas discharge of high-energy electron push neutral particles, by the air out to the surface, eventually form the ionic wind.

#### 3.2. Ion wind appearance and structure design

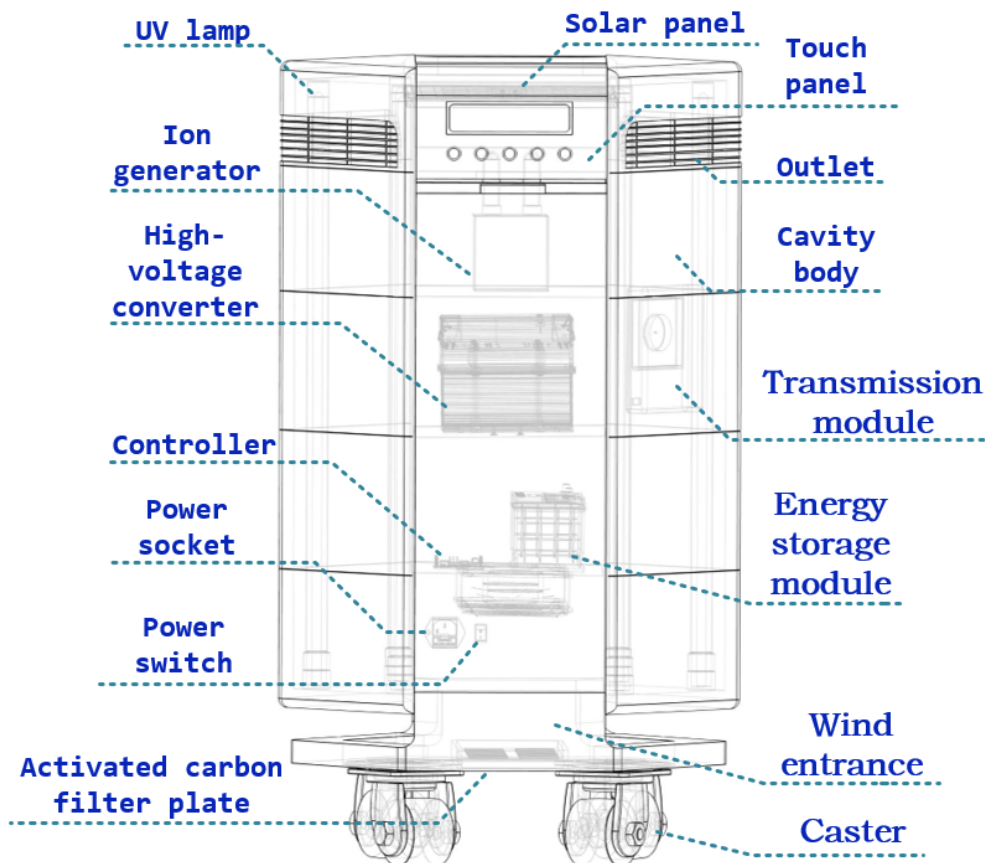


Fig. 3 Appearance structure design

The whole chassis device includes the inner chamber and outer wall, and the inner chamber is equipped with main control components. The main control components include ion wind generating unit, control unit, high pressure generating unit, communication unit and energy supply unit. The outer wall of the cabinet is equipped with touch panel for the recording and adjustment of the equipment and environmental parameters. Solar panels are placed on the top

of the case to absorb the energy consumption of the solar energy supply unit. The upper part is equipped with air inlet and air outlet, and the lower part is equipped with air suction device, which is connected to the high pressure generated by the high voltage generating unit. In the ion wind generating device, the ionized air, ionized air has positive electric ions and negative electric ions, and flow to form a fluid and then produce ion wind. The whole device is also equipped with a loose air channel, which enters from the bottom and is issued by the upper air duct. At the same time, the inner wall of the box is equipped with ultraviolet light, which effectively solves the secondary pollution problem caused by ozone during high voltage ionization.

### 3.3. Ion wind Internet of Things and Display

The device uses a 6.86-inch display screen to display the air temperature and humidity of the equipment environment collected by the microprocessor, and the dynamic parameters of harmful gases such as NH<sub>3</sub>, H<sub>2</sub>S, so that farmers can observe the air quality in the greenhouse in real time. The ion wind speed can also be set dynamically according to the air quality, with various functions such as one-key start, air prediction and mode adjustment. At the same time, the 5G module is used to transmit the data to the Internet cloud platform, so that farmers can also remotely view the operation of the device by using the mobile APP.



Fig. 4 Data in a real-time display panel

## 4. Theoretical design calculation

### 4.1. Photovoltaic power generation and energy storage management

In order to ensure the production performance of poultry, it is necessary to timely replenish the light, stabilize the light intensity in the house, and ensure the stability of chicken feeding and egg production. So the device installed photovoltaic panels on the top to make full use of solar energy.

$$L = Q * W * \eta \quad (1)$$

L is the daily solar energy generation, Q is the daily light time, W is the total power of the photovoltaic array, and  $\eta$  is the power generation efficiency.

According to the actual volume of the device, each equipment carry each piece of single crystal photovoltaic panel power can be up to 50W, under the sunshine and normal light, sunny total

power of up to 50W, power efficiency of 70%, in Beijing, for example, the average daily light hours 7.2h considering loss, nearly  $252W \cdot h$  a day, can meet the entire power, including the basic power supply requirements of the core system.

#### 4.2. Output calculation of the excitation circuit

The system adopts the excitation circuit topology and the excitation high voltage transformer to realize energy transfer, and the output voltage is calculated as follows:

$$\frac{U_0}{U_1} = \frac{N_2}{N_1} * \frac{T_{on}}{T_{off}} \quad (2)$$

The rectifier filter sampling is carried out on the secondary side resistance of the high voltage transformer, the sampling circuit is designed through the single-phase half-wave uncontrolled rectification and transport circuit, the voltage sampling of the high voltage side is realized by dividing the voltage of the resistance tower, and the high voltage of 10~20kV is output on the high voltage side of the reverse excitation transformer to meet the demand of ionic wind generation. In order to facilitate high voltage regulation, the original side winding of the excitation transformer adopts 12V DC input. By setting the high voltage output, the duty ratio  $D$  of the PWM drive signal is automatically adjusted to change the high voltage output, and then change the strength of the ion wind.

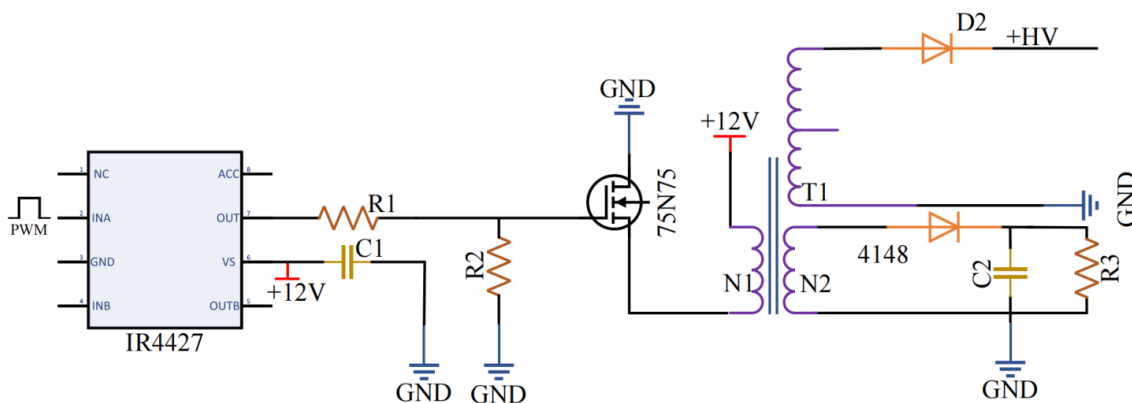


Fig. 5 Schematic diagram of the excitation circuit

#### 4.3. Ion wind speed

After reviewing relevant literature, we found that the wind speed of the ion wind is closely related to the spacing between the electrodes and the voltage level., the higher the voltage level, the higher, the higher the ion wind speed. The device achieves the purpose of adjusting the ion wind speed by adjusting the high voltage output.

Table 1 Ionic wind wind speed under different conditions

Discharge form	Electrode structure	electrode gap /mm	the classification of voltage /kV	wind speed /(m/s)
corona discharge	Needle-board	8	16	6.08
		15	6-12	2.6
		15	17.2	3.5
		15	6	2.5

5. Performance analysis

5.1. Analysis of the dust removal by the ion wind

The ion wind dust removal technology improves the dust removal efficiency by 12% compared with the electrostatic precipitator without device. The needle electrode can produce bipolar ion wind, which can not only promote the full mixing of charged particles with air microorganisms and particles, but also accelerate the flooding speed of particles. The dust removal efficiency can reach 94%.

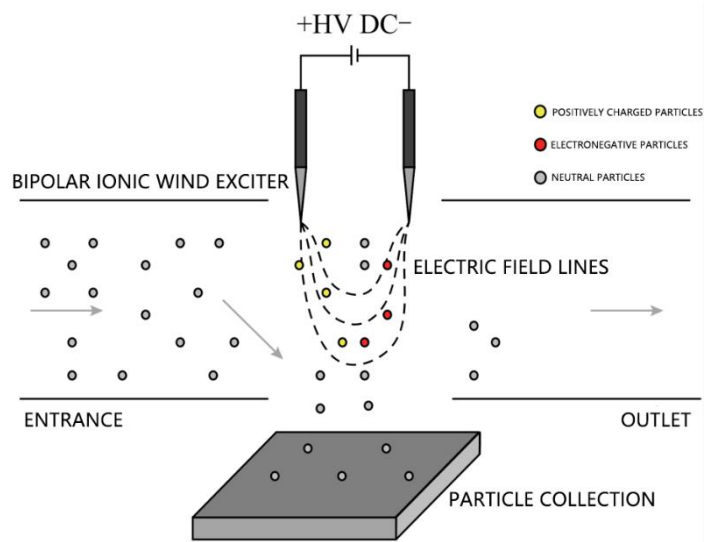


Fig. 6 Schematic diagram of the principle of ion wind dust removal

5.2. Ion wind air sterilizing analysis

Due to the small potential difference between the nucleus and the cell membrane of bacteria, the ion wind movement will be instantly killed by the energy released by the high pressure charge, so that the structural change of the bacteria leads to the loss of biological activity and be completely killed, achieving the sterilization effect.

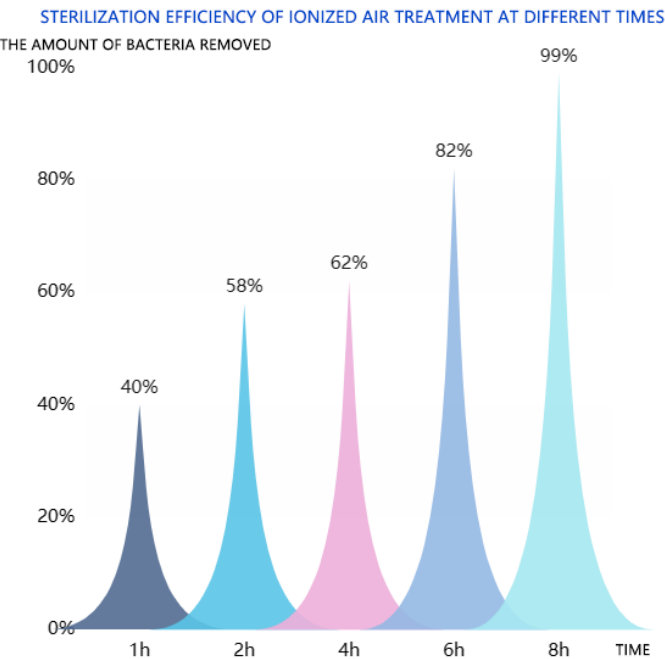


Fig. 7 Efficiency plot of ion wind sterilization at different times



5.3. Analysis of the ion air to purify the harmful gas

The high-energy electrons produced after discharge collide inelastic with various molecules and atoms in the air, which are excited, ionized and free, while the electrons generated by the electric field collide with the pollutant molecules, which break the chemical bonds of the pollutant molecules in the air, change their chemical properties and inactivate the pollutants.

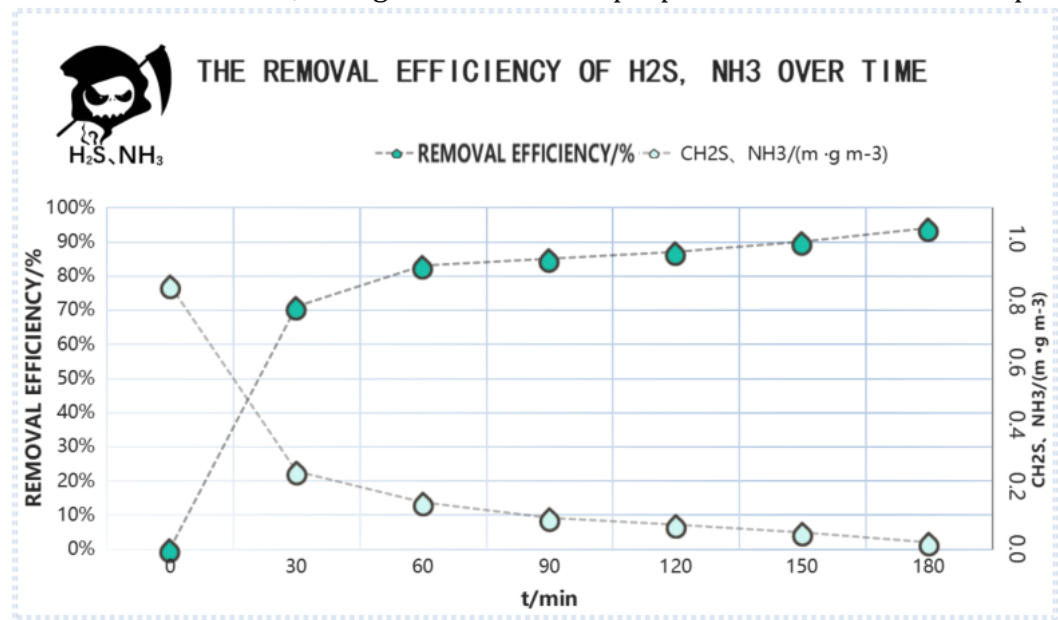


Fig. 8 Plots of H2S and NH3 content after ion wind action

6. Conclusion

With the improvement of the level of aquaculture, people pay more attention to the quality of life of poultry. Air purifier, as a small power equipment to improve the air quality of breeding greenhouses and efficiently sterilize effectively, has a broad market prospect. The general price of air purifiers on the market is about 5000 yuan, and multiple air purifiers are needed to work at the same time, which will consume a lot of financial and material resources; and the overall cost of this product can be controlled within 2000 yuan, with obvious price advantage, and due to the small power consumption of ion wind generator, it has obvious advantages such as low consumption, efficient sterilization and elimination. At the same time, this product does not need to replace the filter element, which greatly reduces the cost of later operation and maintenance. In summary, compared with the traditional air purifier, this device has obvious market competitiveness.

Table 2 Analysis of the advantages of ion wind and air purifier

air cleaner	Maintenance cost of filter element	power dissipation /W	secondary pollution	Price estimate / yuan
Traditional purifier	400 Yuan / time	100	Formaldehyde saturation	5000
Ion wind purifier	No filter element	50	no secondary pollution	2000

New energy is a very popular problem in contemporary society and also a problem concerned by people from all walks of life. Among them, the development and utilization of new energy is also a difficult problem. The system combines photovoltaic and energy storage to achieve the comprehensive utilization of renewable energy. Research on the air purifier based on ion wind technology, to achieve clean energy production and self-use, can complete high-performance,

high-standard, pollution-free air purification. The use of new air purifiers in the aquaculture industry will promote the development of the field of air purification and the new revolution in the aquaculture industry, and provide a new solution for realizing the real green environmental protection technology without raw material consumption and no secondary pollution. The whole set of devices can also reduce the amount of ozone, further improve the efficiency of air purification, committed to creating low consumption, low pollution, high efficiency, safe, stable air purification new technology, to contribute new strength to the greenhouse breeding industry.

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