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Dust Sensors for Cotton Processing Plants and Their Use

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Abstract

The article discusses the calculation of pulses left by dust particles in a given unit of time, the range of detection of dust particles, graphs of changes in sensor values under the influence of a certain temperature, the results of error evaluation.

Keywords: *dust concentration, photo sensor, infrared diode, photo sensor output voltage, optic lens, concentration, error, sensor working area, analog output.*

Emissions of harmful substances into the atmosphere have a negative impact on the state of atmospheric air, which is a vital component of nature. The process is hampered by industrial emissions and the spread of dust particles. In order to limit their negative impact on the atmosphere, emission standards are set and state environmental monitoring is carried out. Atmospheric pollution control stations regularly measure the concentration of various substances in the air. The level of air pollution is assessed by comparing these concentrations with the MPC - the maximum allowable concentration. The Nova PM SDS011 sensor provides information on ambient air quality by measuring dust concentration. The level of dust particles in the air (PM level) is measured by calculating the pulses (LPO time) left by the dust particles within a given unit of time. The LPO time is proportional to the PM concentration. This sensor allows the detection of a PM with a diameter of 1 μm for air purification systems. The sensor is a six-pin analog output optical dust sensor that is designed to detect dust particles in the air. Works on the principle of laser scattering. Inside the sensor module, an infrared diode and a photosensor are placed at the ends of a rectangle. The air inlet is opened perpendicular to the photosensor.(Figure1)

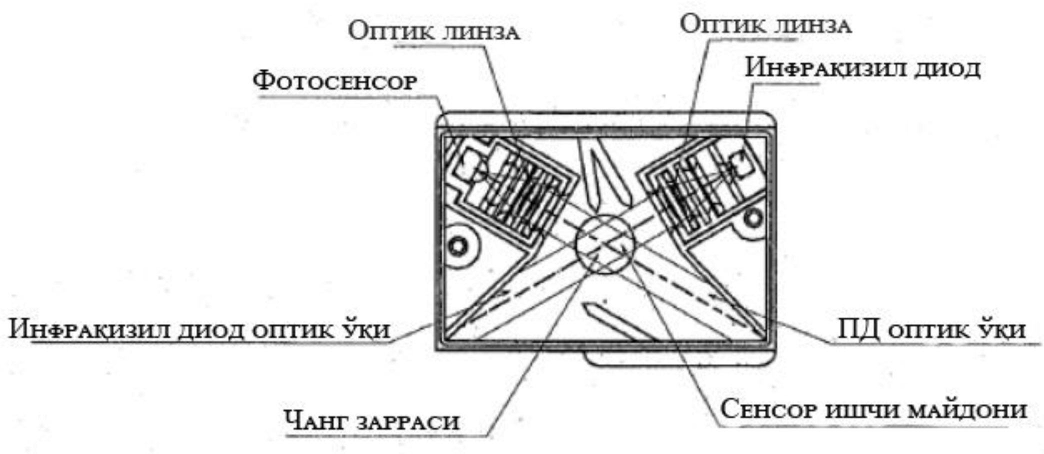

Figure 1. Nova PM SDS011 sensor principle schematic.

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There is a constant voltage on the sensor (in working condition). The light flux allows current to flow through the photosensor. The dust particle enters through the slit and forms a shadow at the intersection of the optical axes of the photosensor and the infrared diode. This shadow causes the voltage across the photosensor to change. The output voltage of the sensor is in the range of 0..5 volts. Using an optical lens, shadows are reflected and amplified. When air with dust particles enters the sensor chamber, the dust particles are directed by the infrared LED light towards the photodetector. The intensity of the scattered light depends on the dust particles. The more dust particles in the air, the higher the light intensity. The output voltage at the V-OUT pin of the sensor varies depending on the intensity of the scattered light. The sensor operates under a current of 20 mA and a voltage of 4.5-5.5 volts. Dust particle detection range up to 0.5 microns. It can detect the density of dust particles up to 580 ug / m3. Sensor start-up and particle detection time is less than 1 second.

The connection diagram of the sensor internal modules is shown in Figure 2.

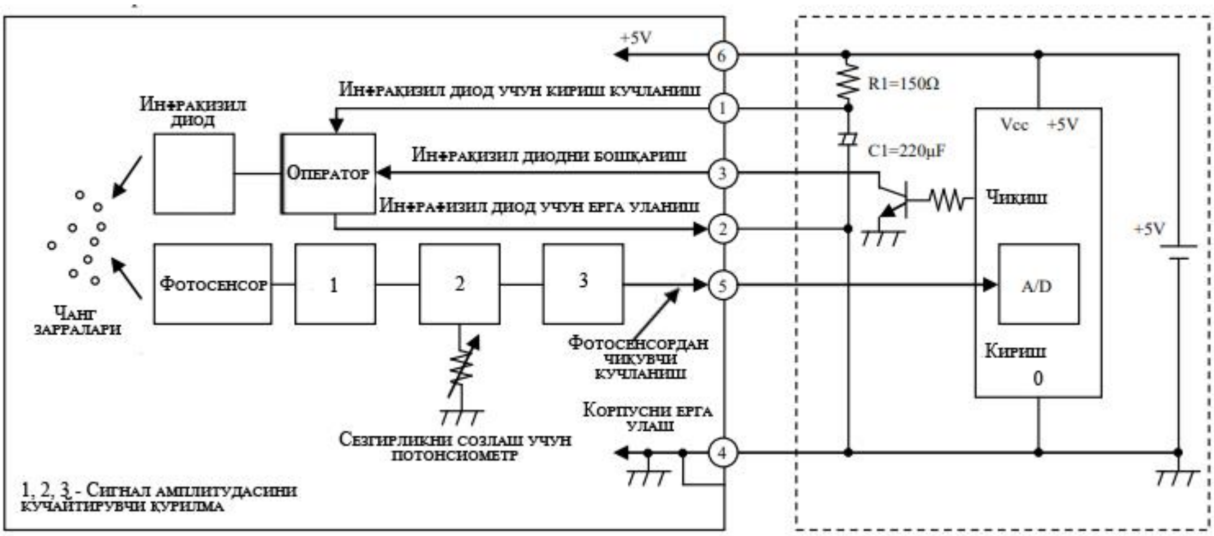

Figure 2. Wiring diagram of Nova PM SDS011 sensor modules

A resistor R1 = 150 Ohm and a capacitor C1 = 220μF were used to generate pulses in the infrared diode. The sensor can be thought of as three interconnected modules. Photosensor, Infrared diode and control microprocessor. The control microprocessor allows the infrared diode to heat up at the desired interval and generate a pulse. Calculates the voltage value from the photosensor based on the pulse generation time, forming the concentration values of the dust particles over time. The accuracy of the sensor depends on the characteristics of the infrared diode, and the technical characteristics of the diode are shown in Table 1.

Table 1

Parametrs	Designation	Defined condition	Recommended condition	Unity
Pulse return	T	10	10±1	ms
Pulse width	Pw	0.32	0.32±0.02	ms

The infrared diode emits pulsed light. The detected signal is amplified in the amplifier mode and turns off when the output is synchronized with the pulse mission of the diode. The specified output

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value is the value measured 0.28 ms after the diode is turned on. Therefore, it is recommended that the microcomputer read the output from 0.28 ms even after infrared diode emission.

Figure 3.

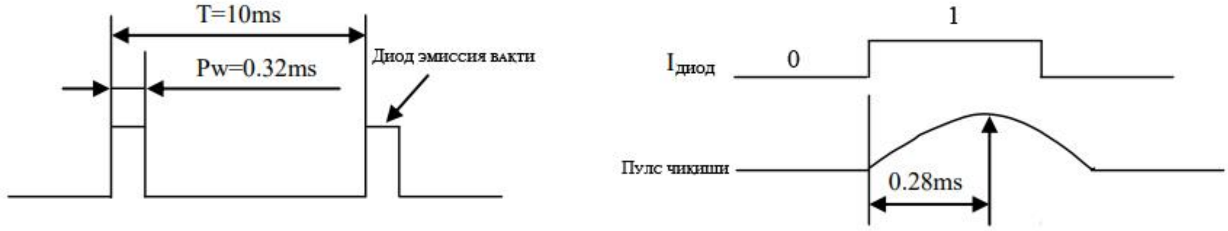

Figure 3. Infrared diode output pulse time graph.

The Vo output voltage of this sensor is the difference of the Voc output voltage in the absence of dust, forming a voltage value equal to the dust density DV. 3.1 - expression.

$\Delta V = V_0 - V_{oc}$ (3.1)

here

ΔV- dust density,

Vo – photosensor output voltage

V_{oc} the value of the photosensor when the infrared diode is not activated.

There are two options for digital output: passive and active. Passive mode is activated when the power is turned on. In this mode, the sensor automatically sends serial data to the microprocessor. Active mode is divided into two sub-modes: steady mode and fast mode. If the concentration change is small, the sensor operates in steady mode with an actual interval of 2.3 seconds. If the change is large, the sensor will automatically switch to fast mode at intervals of 00 ~ 800 ms, the higher the concentration, the shorter the interval.

The sensor faults were tested in a test room at different temperatures and humidity. The test results can be seen in Figures 4a, b, c, d, e.

Y axis: PM2.5 concentration, unit: µg / m³,

X axis: number of samples, unit: hours.

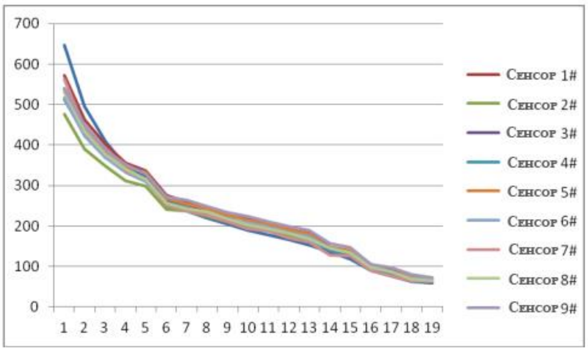

Figure 4 a. Graph of change of sensor values at 20 ^{0}C

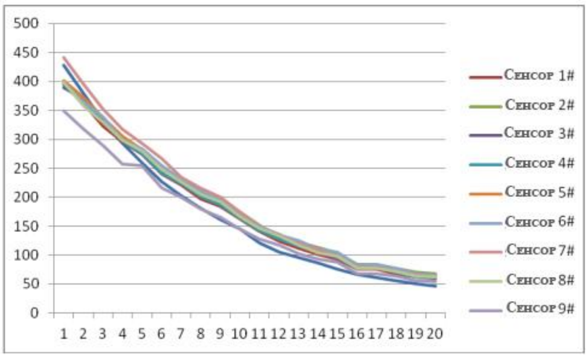

Figure 4 b. Graph of change of sensor values at 43 ^{0}C

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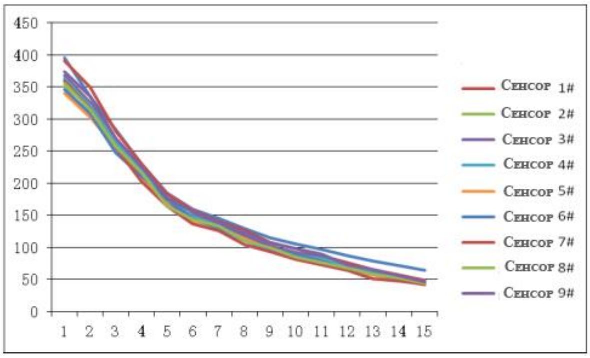

Fig. 4 s. Graph of sensor values change at -5 ^{0}C

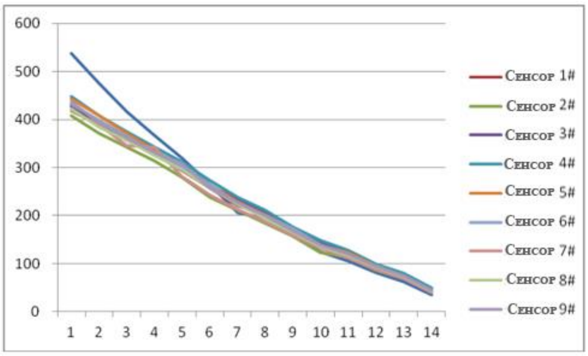

Figure 4 a. Graph of sensor values change in 30 days

Temperature changes and sensor errors were detected after 30 days of experiments. The results of the error assessment can be seen in Table 2.

Table 2.

№	Experiments	Sensor characteristics and errors
1	10 m^2 indoor experiment room, temperature: 20 ~ 25 0C, Humidity: 30% ~ 70%.	9 sensors, 0 ~ 500 µg / m³ The mean error at 0 ~ 100 µg / m³ is ± 15 µg / m³
2	10 m^2 indoor experiment room, temperature: 40 ~ 43 0C, Humidity: 70%.	9 pieces of sensor 100 ~ 500 mg / m³ Average error ≤ ± 15 µg / m³
3	10 m^2 indoor experiment room, temperature: -5 0C, Humidity: 30%.	9 pieces of sensor 100 ~ 500 mg / m³ Average error ≤ ± 8 µg / m³
4	10 m^2 indoor experiment room, temperature: consnt, Humidity: 90%.	9 pieces of sensor 100 ~ 500 mg / m³ The average error is ± 10 µg / m³

These experiments can be used to plot graphs of temperature and dust concentration. Based on the detected values, it can be said that the average error values of the sensor in the range of values of 10 ^{0}C and 40 ^{0}C are minimal. The low number of errors in this range and the fact that the working conditions of the workers are fully compatible with the temperature increase the possibility of using the sensor in the primary processing of cotton. The increase in humidity in the production area accelerates the extinction of dust particles, which is characterized by the weighting of dust particles, but more than 90% humidity in the production area has a negative impact on human health. The correlation graphs of the temperature and dust concentration determined in the experiments are shown in Figure 5.

Y axis: PM2.5 concentration errors, unit: µg / m³,

X axis: Temperature change, unit: ^{0}C.

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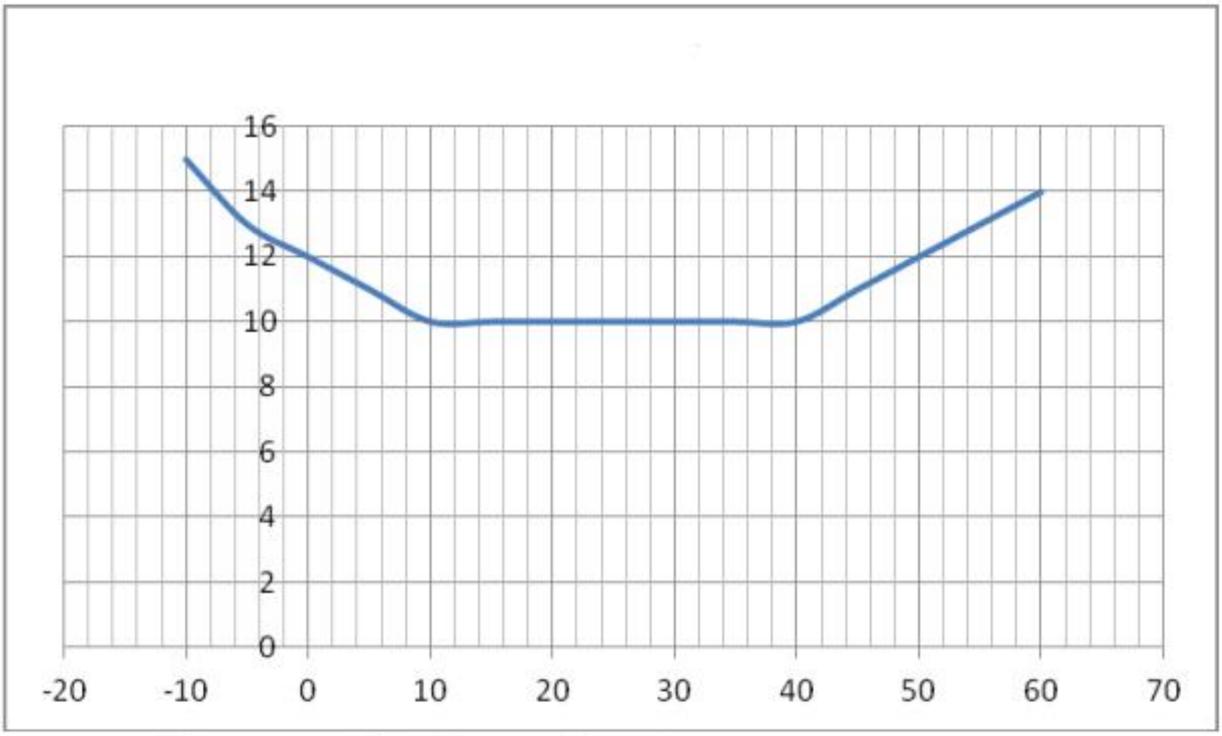

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