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The development and test results of a sun sensor for solar photometers

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Purpose and objectives

Purpose – development and testing of a sun sensor, for the automated operation of solar photometers in variable cloud conditions and automatic determination of the sunshine duration

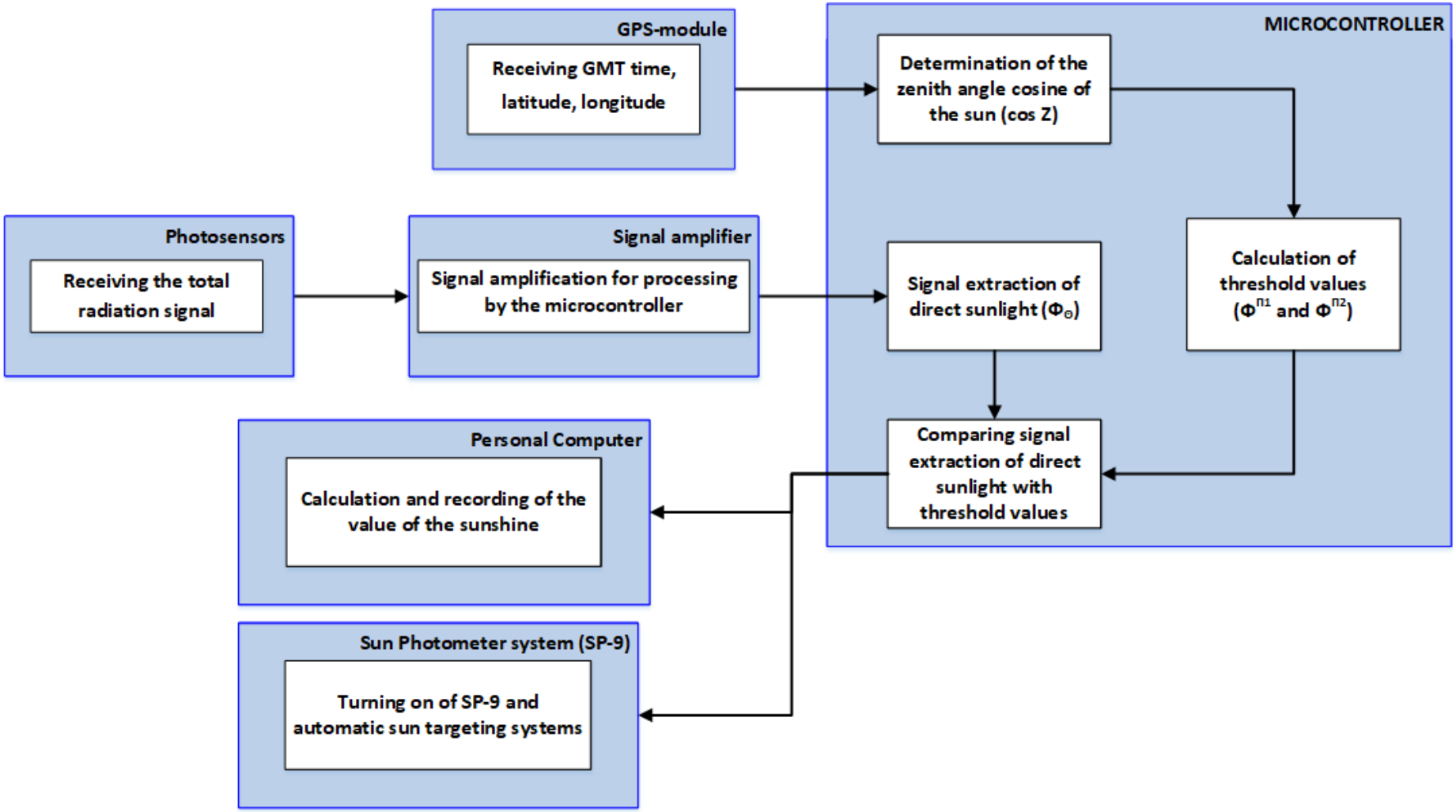
Objectives :

- To verify an experimental model with requirements;
- To verify and calibrate a photosensor;
- To select a diffuser;
- To select the schematic diagram and components of the sun sensor;
- To implement the microcontroller operation algorithm;
- To test the experimental model;
- To integrate the sun sensor into the SP-9 system.

Sun Sensor Requirements

- The field of view of the sun sensor should cover the entire trajectory of the sun
- From the total radiation entering the sensor a component of direct solar radiation should be distinguished;
- The solar sensor must recalculate the threshold level based on the position of the sun;

Functional diagram



Formulas

Calculation of the zenith angle cosine based on data received from the GPS module:

$$\cos Z = \sin\varphi \cdot \sin\delta + \sin\varphi \cdot \sin\delta \cdot \sin t,$$

$$\varphi - latitude\ value;\ \delta - declination\ by\ date;\ t - solar\ time.$$

Recalculation of the set threshold value for determining sunshine duration:

$$\Phi^{П1}{}_{\perp} - assigned\ threshold\ value\ for\ a\ photodetector\ located\ perpendicular\ to\ the\ direction\ of\ the\ sun\ ;$$

$$\Phi^{П1} = \cos Z \cdot \Phi^{П1}{}_{\perp};$$

Calculation of a threshold value based on atmospheric transparency:

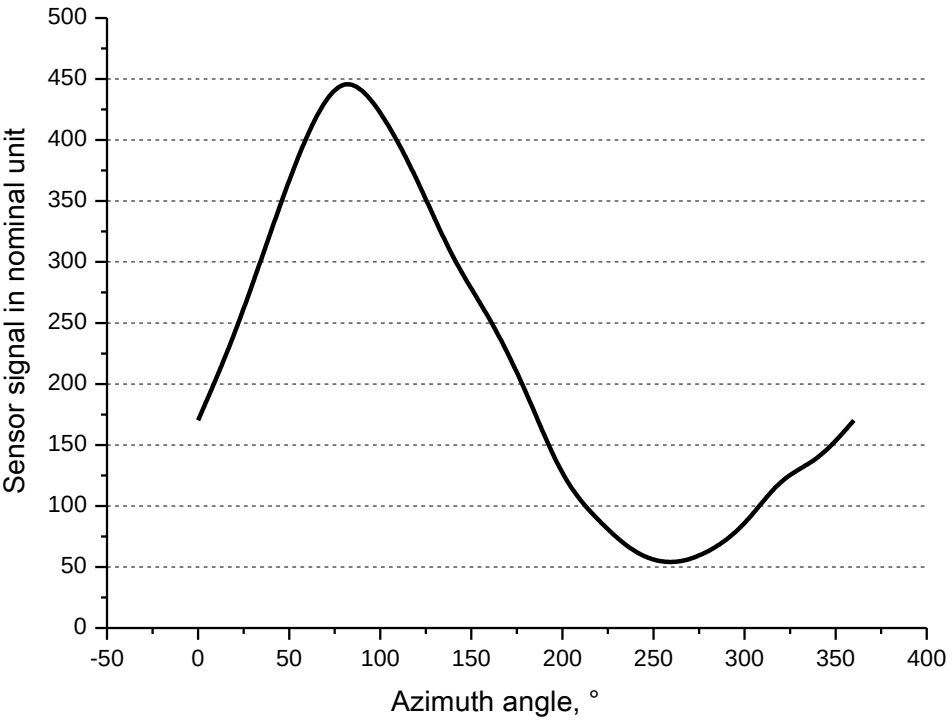
$$\Phi^{П2}{}_{\perp} = \Phi_0 \cdot e^{-\tau_П / \cos Z};$$

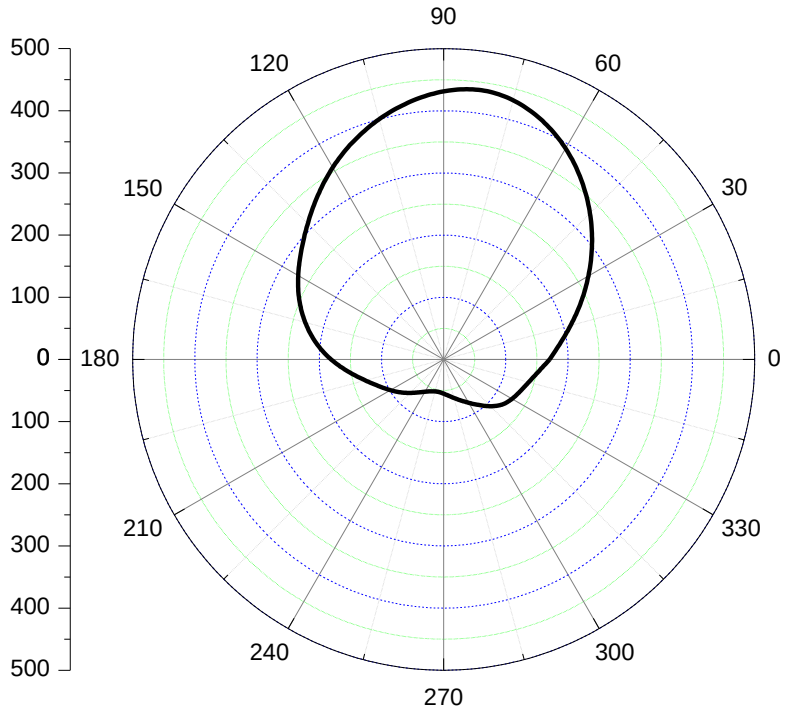
$$\Phi_0 - value\ of\ the\ flux\ outside\ the\ atmosphere;$$

$$\tau_П - assigned\ threshold\ optical\ depth.$$

$$\Phi^{П2} = \cos Z \cdot \Phi^{П2}{}_{\perp};$$

Azimuthal dependences of the photosensor

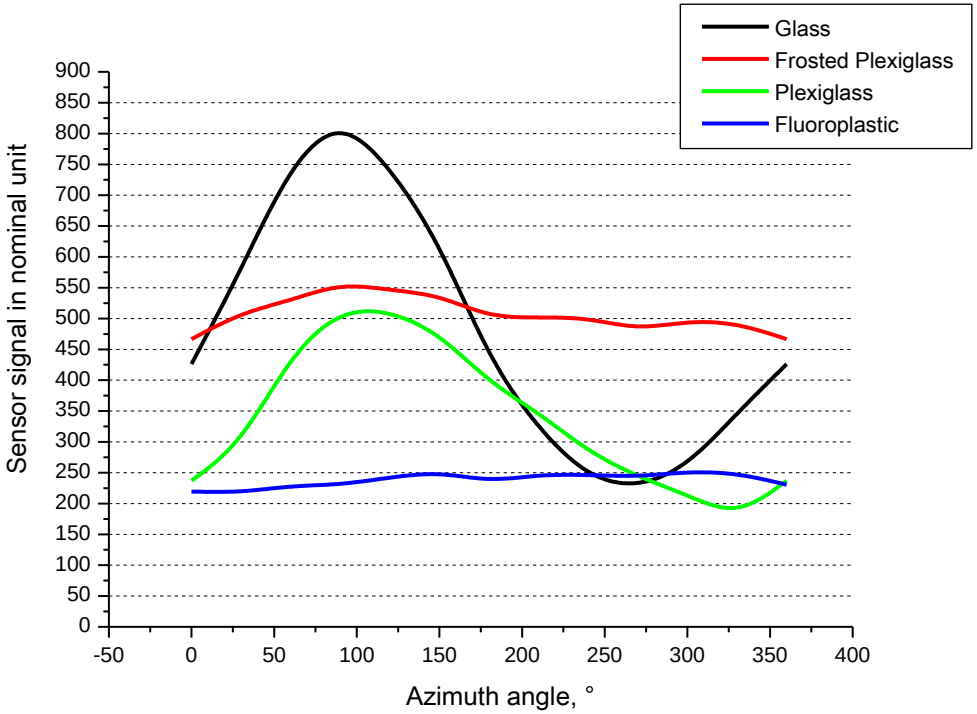


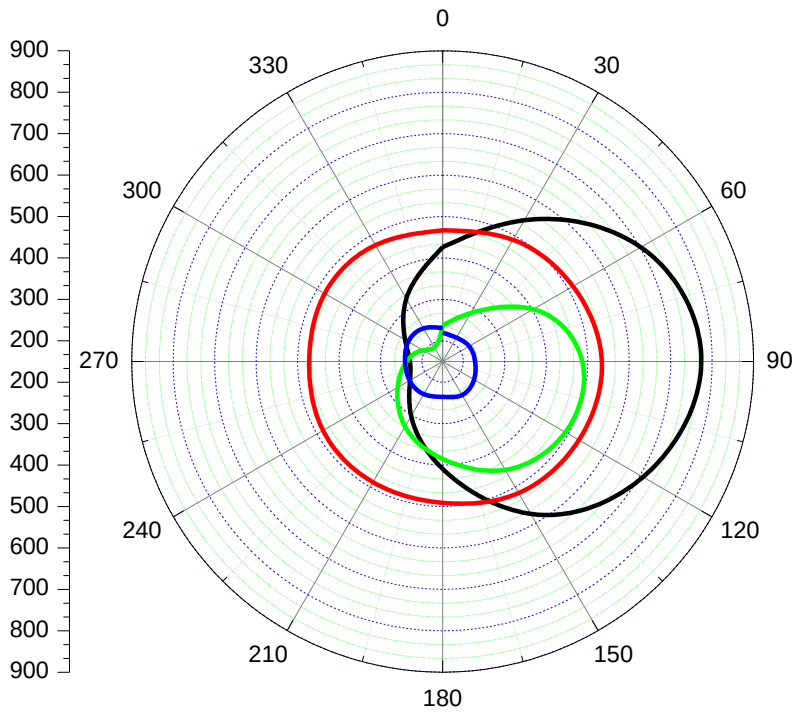


The azimuthal dependence is the dependence of the signal magnitude on the azimuthal angle of the radiation source with its constant zenith angle.

Sensor imperfection is the reason for this dependence.

Material selection for diffuser

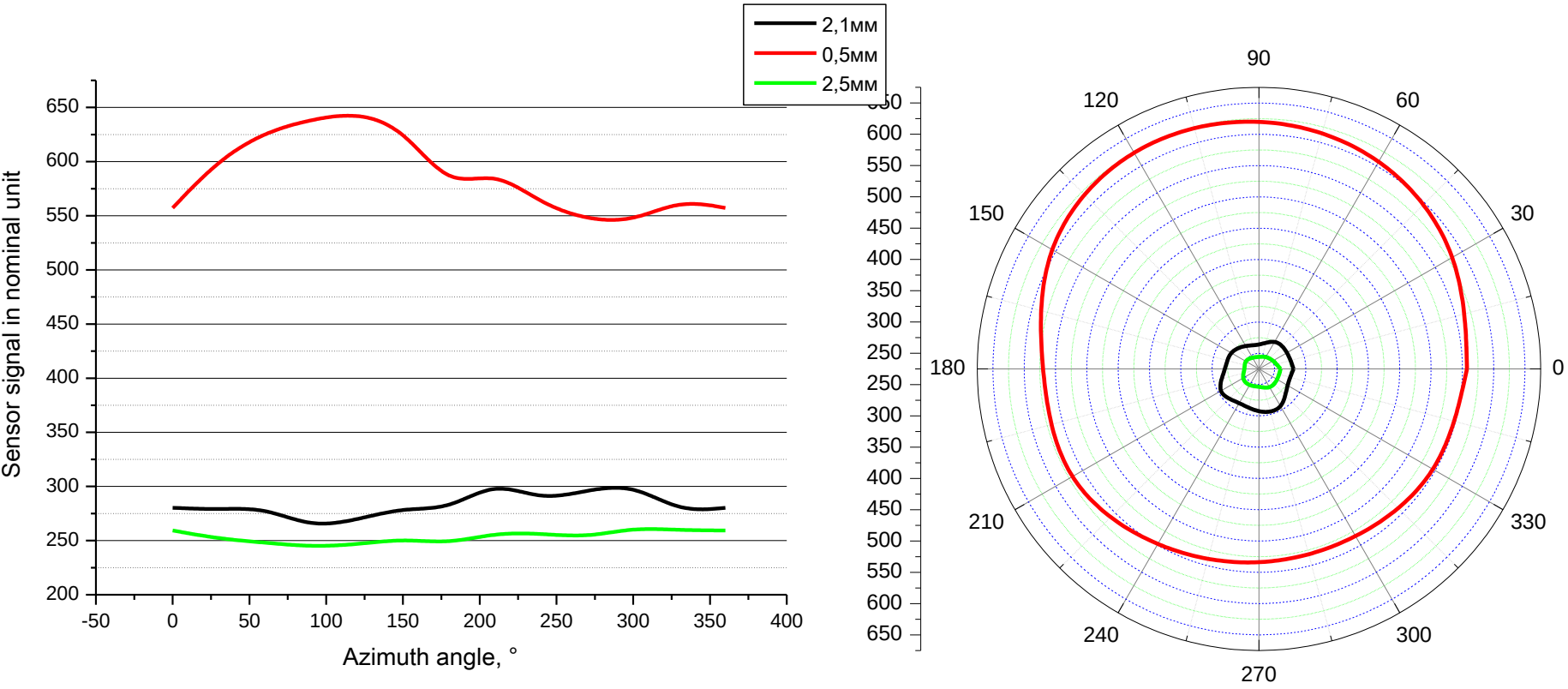




Based on the data obtained, it was decided to use fluoroplastic as a material for the diffuser.

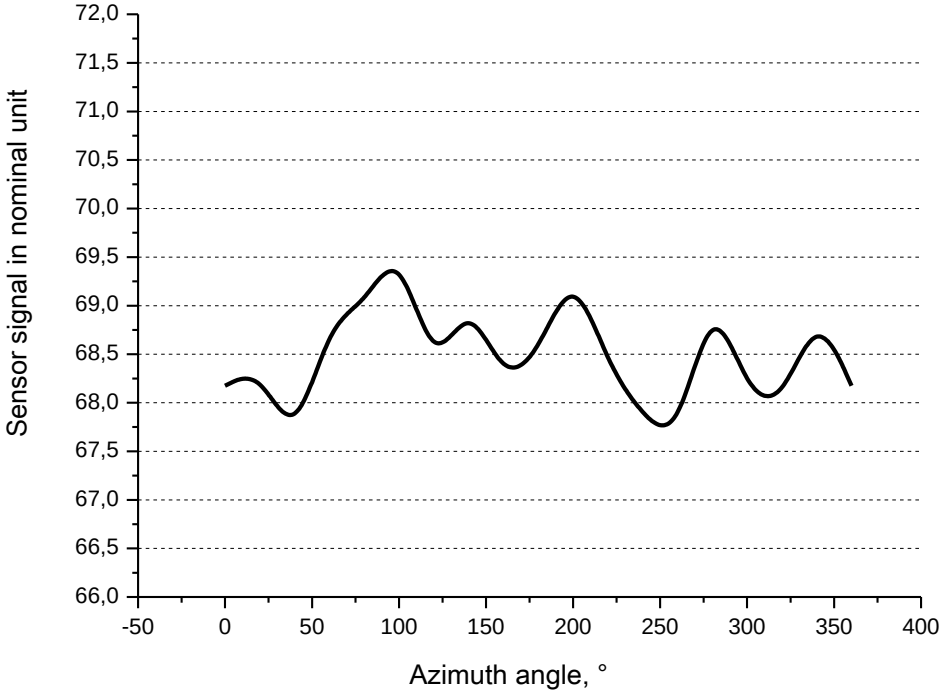
This material has a small own azimuth dependence, is easy to process, and quite durable.

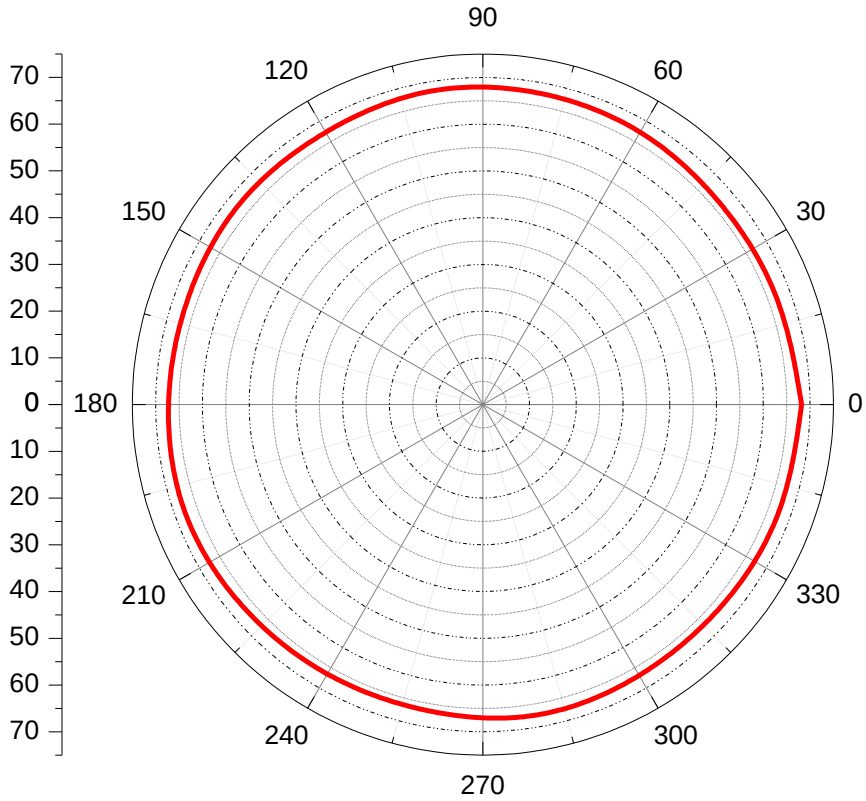
Diffuser thickness selection



A fluoroplastic diffuser 2.5 mm thick was chosen. It completely suppresses the dependence of the photosensor, reduces the illumination of the photosensor, which will not allow you to get too large a signal in bright sun.

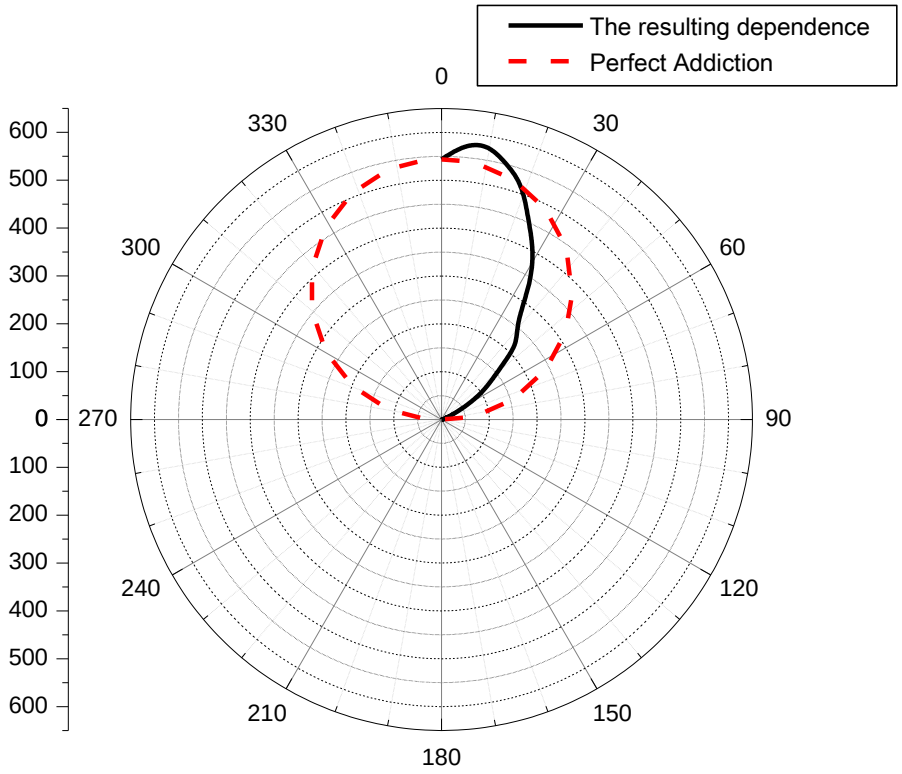
Azimuthal characteristic in actual environment





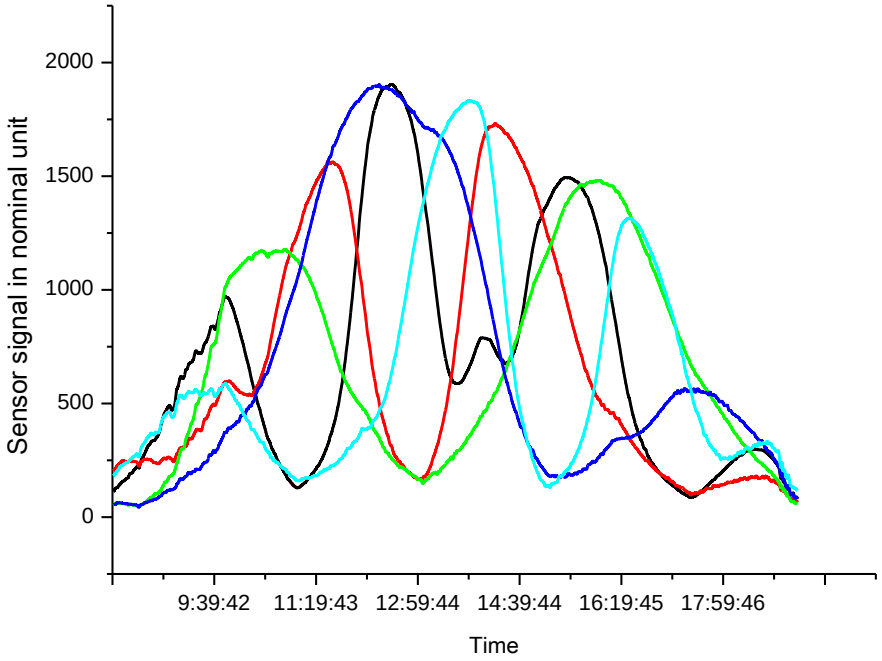
Deviations from the average value do not exceed 2%.

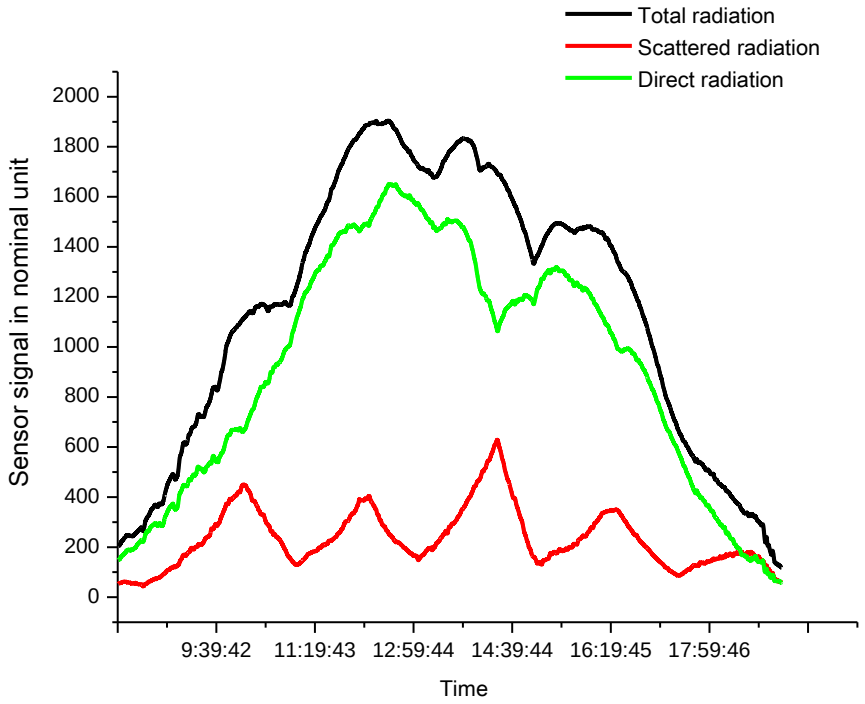
Zenith dependences



A more complete study of this parameter is needed.

Signal extraction of the direct sunlight





Conclusion

The experimental model of photosensor and amplifier was built. The algorithm of the device operation is developed and tested.

Electric circuit diagram of the entire device is under development. Also, the experimental model with a microcontroller will be assembled soon.

Thank you for your attention!