

DESIGN AND REALIZATION OF WIND DIRECTION AND WIND SPEED SENSOR

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Abstract

The paper deals with the design and realization of the wind direction and wind speed sensor (anemometer), which works by optoelectronic principle and measure frequency of impulses from the wind fan of the anemometer. In the present work were used methods and materials conformable with the modern electronic and informatics as well as mathematic – statistic methods of the linear regression which were used in the process of the calibration characteristic. Results from analyses are, that the anemometer works from 0 to 150 km.h⁻¹ with the errors of measurement to 1% to 90 km.h⁻¹ and over 90 km.h⁻¹ to 3% of measured value. The prime area application of the wind direction and the wind speed sensors is in the automatic weather–stations, in the agricultural (microclimatic weather–stations) in the field conditions and in the industry for the other technological operations where is need to monitor air speed circulation. This function sensor will be used as model for the education system on the lesson of the biometeorology and climatology.

Key words: anemometer, wind direction sensor, optoelectronic principle

1. INTRODUCTION

Weather information has become an integral part of our everyday life. One of the most important meteorological elements and phenomena, such as temperature, air pressure, precipitation, etc. is the wind direction and speed. Wind effects can be favorable or unfavorable.

The beneficial effects is mainly air exchange in stands of vegetation and soil, where is the fresh air constantly brings to plants, which by its composition corresponds best to the requirements of plants, especially in photosynthetic assimilation [4], [5]. On the airflow is directly dependent the existence of wind-pollinated (anemophily) plants [1]. Wind transmits the pollen over long distances, which fall on their ways on the flowers female organs and pollinate them. In higher latitudes, where there are few insects, wind pollinate up to 38% of plants.

In terms of hygiene is air exchange very important in the areas of industrial buildings and settlements [6].

Harmful effects of wind are most often associated with the reduction of the bioclimatic country total value [7]. Wind significantly increases evaporation and transpiration, thereby drying the soil and plants wither and dry up [2]. Even at wind speeds of 0.5 ms⁻¹ were observed an increasing of transpiration about 100% in leaves of beech. Very dangerous are winds, which occurred at the same time with low relative humidity, where the wind causes wind erosion, especially in the drier areas, in which one part stripped off the plant roots and elsewhere plants being buried by dust or sand [3], [9].

The presented paper deals with own proposal and the actual realization of direction and wind speed sensor, which works on optoelectronic principle, which is based on measuring the impulses frequentation of the proposed vanes of anemometer.

2. MATERIAL AND METHODS

Anemometers analysis (wind speed sensors analysis)

The most commonly used measurement principles of anemometers are:

1. Electrical principle (remote electrical anemometer)
2. Inductive principle (induction anemometer)
3. Mechanical principle (cup counter anemometer)
4. Electronic principles (electromagnetic, optoelectric)

Currently, come to the forefront electronic anemometers, which operate on the principle of pulse rate measuring with using electromagnetic or photoelectric elements.

2.1 Description of electromagnetic anemometer working principle

Sensor which works on the electromagnetic principle functions such that vanes are attached to the shaft which rotates and at the other end are fixed two magnets. These magnets switch reed contact (e.g. reed relay). The accrued pulses are fed to a serial or parallel (LPT) entry PC or data logger, where with help of software are further processed.

2.2 Description of proposed optoelectronic anemometer working principle

The proposed type of anemometer is working on optoelectronic principle by using phototransistor, illuminating LED (Light Emitted Diode) and aperture on the shaft. As in the previous case, also in this case are the resulting pulses impressed to the further processing and subsequent evaluation to the PC. The main task of the evaluation software is the ability to load generated impulses ("0" and "1") for a certain time unit and assign them to the correct value of the measured quantity on the basis of calibration with other measuring device. The advantage of working on optoelectronic principle against sensors sensor based on electromagnetic principle is the smaller geometric dimensions, less failure, higher reliability, and greater compactness.

The problem is the mechanical construction of these sensors, on which will also depend on their total accuracy.

2.3 Analysis of wind direction sensor

For measure of the wind direction are used various types of direction indicators. The most often work on electrical principles (electric direction indicator) or mechanical principle (registration direction indicator (so called Stružková)).

2.4 Working principle description of proposed optoelectronic sensor of wind direction

The proposed wind direction sensor works as well on optoelectronic principle using three phototransistors, three LED lighting and a specially designed shade on shaft. As in the previous case of the wind speed sensor, also in this one are the resulting pulses impressed to the further processing and subsequent evaluation to the PC. The main task of the evaluation software is also the ability to retrieve generated impulses ("0" and "1") for a certain time unit and assign them to the correct value of the measured quantity on the basis of calibration with other measuring device. Also in this sensor realization is very important to properly manage the mechanical construction, on which will depend the total accuracy.

From the above analysis and working principle of sensor for wind direction and wind speed can be deduct the following conclusions:

1. When designing real sensor for direction and wind speed should be appropriately design and analyze physical principle by which the sensor will operate.
2. Since most of the system parameters can be changed only to a very limited extent, the main influencing requirements of the proposed model are the sensitivity and accuracy of the sensor for direction and wind speed, but also the correctness of each auxiliary electronic circuit.
3. When designing real measuring unit for sensing the direction and speed of wind should place great emphasis on motion and the actual implementation of mechanical construction, from which will depend on the overall accuracy of the proposed encoder.
4. Finally, the overall accuracy will depend not only on the parameters referred above, but also by the proposed software.

2.5 Design of motion sensing unit for measuring of wind speed and wind direction

This measure seems to be very simple in principle; it is measures the pulse frequency from wind cup crown. But the problem is its mechanical design.

For the evaluation of the wind speed was designed and fabricated sensor working on the optoelectronic principle with using electro optical transistor, LED lighting and the diaphragm shaft. According to the shape of the output pulses it is necessary to add shaping comparator that pulses have not been evaluated incorrectly. The Fig.1 shows the layout coding wheels for measuring of wind speed.

For the evaluation of wind direction was designed and fabricated scanning sensor, which uses a resolution of eight wind directions, which for making common observation in agrometeorology is completely sufficient. Sensor with higher resolution will be more complex and more difficult to produce. If necessary, it is possible to rewrite control program, and use three sense wires used for serial data transmission from the sensor. The program evaluates the direction according to the following protocol:

NORTH = 0 degrees

Direction	N	NE	E	SE	S	SW	W	NW
°	0	45	90	135	180	225	270	315
Bit A	0	0	0	0	1	1	1	1
Bit B	0	0	1	1	1	1	0	0
Bit C	0	1	1	0	0	1	1	0

Table 1 Protocol for evaluation of side direction

Abbreviation	Wind direction	Azimuth
N	North	360°
NE	North-east	45°
E	East	90°
SE	South-east	135°
S	South	180°
SW	South-west	225°
W	West	270°
NW	North-west	315°

Table 2 Eightfold scale of wind direction

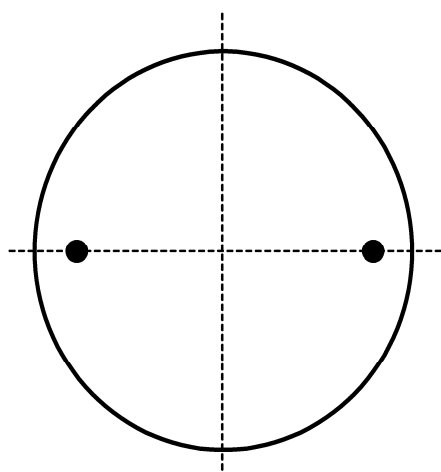


Fig.1 Shade of wind speed

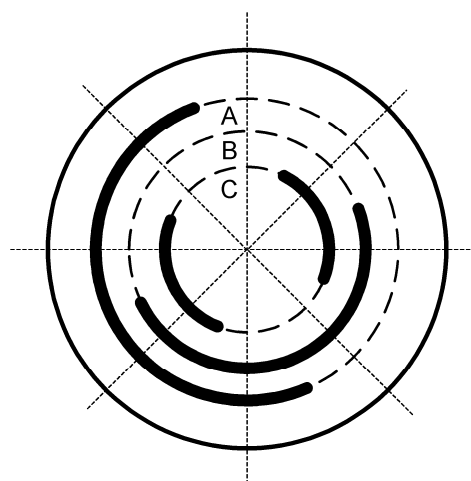


Fig.2: Shade of wind direction

To determine the wind direction in this coding is preferable to use optoelectronics. Shade will have shape of wheels with milled holes so that the mask and pass the light on the phototransistor under the protocol are showed in tab. 1. Formatting of sensor again depends on the possibilities of each constructor (see Figure 2). Thick lines are marked milled holes.

Diagram of the electronics located within the meter of wind direction and speed is shown in Figure 3. As mentioned earlier, this sensor uses optoelectronics. As a light source is used infrared LED, that shines through the shade to the phototransistor sensitive to infrared light. Due to the small area within the meter are designed and used phototransistors Φ 3 mm. The output is taken from the collector resistor and the inverter formed by a Schmitt trigger circuit.

Due to the high variability in production of mechanics of wind direction and wind speed meter, is the proposal board with printed circuit design adapts to sensor.

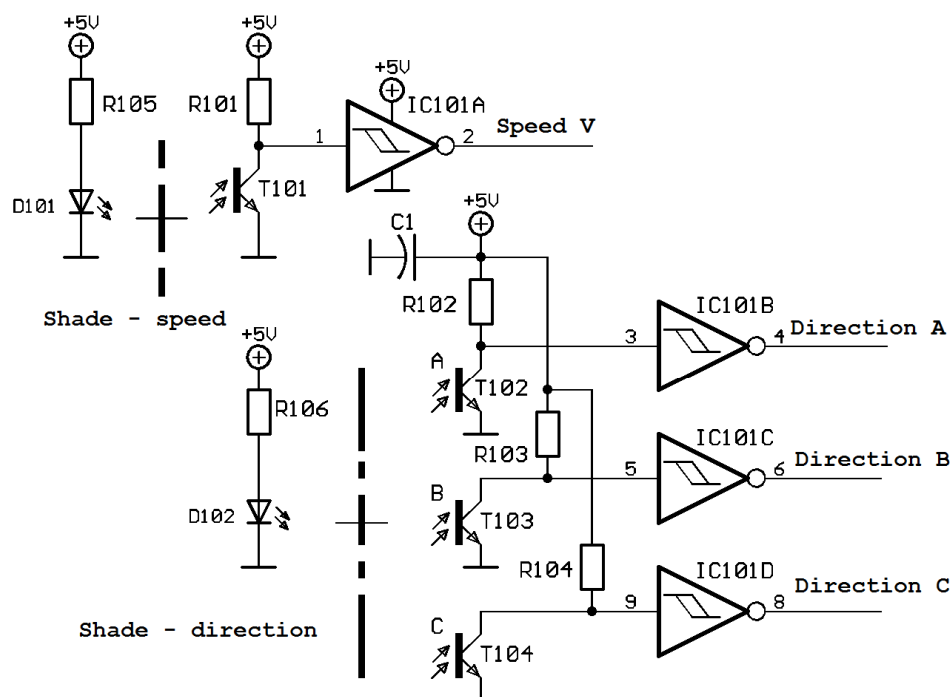


Fig. 3 Connection scheme of wind speed and wind direction sensor

2.6 Calibration of wind speed sensor

Calibration of the wind speed sensor is very difficult tasks which it has much in common with electronics. The number of pulses is greatly dependent on the mechanical design. For calibration we need to know the actual number of pulses per measurement period. The actual measurement was made on, so that the speedometer was placed on the roof of the car and there was watched the number of pulses with using a digital multimeter Metex M - 3850D, depending on the speed of the car set (Table 2). An important condition for wind speed calibration is to be performed to done the calibration itself of dead calm, when is avoiding any error of measurement and calibration accuracy will depend only on the accuracy and precision of the vehicle tachometer (digital multimeter Metex), which determines the frequency. For calibration has been used car Octavia, where the manufacturer specifies an error of tachometer to 90 km.h⁻¹ about 1% and over 90 km.h⁻¹ about 3%. From the measured data was a used mathematical - statistical method of linear regression (Fig.4), established a standard curve, which is incorporated into the program Meteostation.

Speed (km/h)	0	5	10	15	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Frequency(Hz)	0	1	2	3	5	7	11	13	16	19	22	24	28	31	36	38	41	43

Table 3 determined values of frequency for sensor calibration

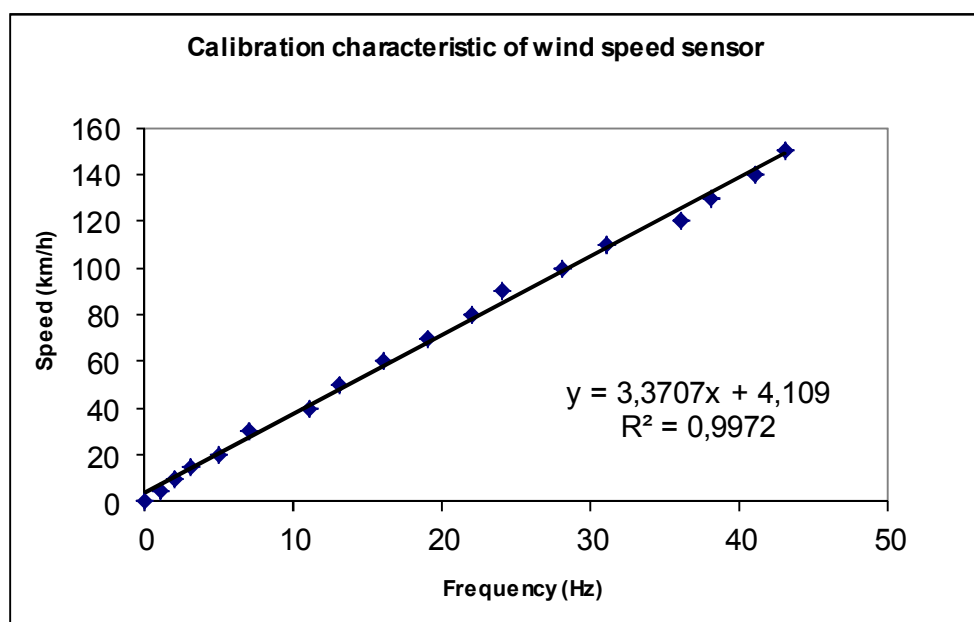


Fig. 4 Calibration curve of wind speed sensor

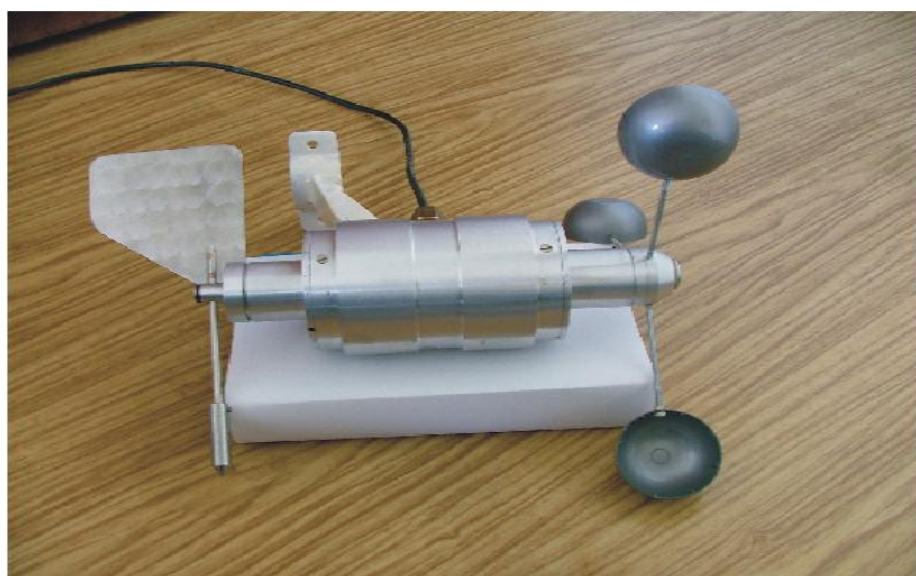


Fig. 5 Detailed view on sensor of wind speed and wind direction

2.7 Calibration of wind direction sensor

For proper operation of the wind direction sensor is sufficient to direct the rudder to the north, and set proper coding ring. Weather Station allows you, to recalibrate this direction, and it is not necessary to climb the mast and rudder turn.

2.8 The mechanical design of the direction and wind speed sensor

Mechanical design of direction and wind speed sensor are proposed in the program MechanicalDesktop and AutoCAD.

3. RESULT AND DISCUSSION

From the analyzes and the results can be finally conclude that the proposed sensor operates in the range 0-150 km.h⁻¹ with a measuring error up to 1% when speed is 90 km.h⁻¹, and over 90 km.h⁻¹ about 3% of value. If we want to achieve greater accuracy of sensor and thus reduce the measurement error to 1%, it is necessary to done anemometer calibration performed in the calibration chamber of Slovak Hydrometeorological Institute, which would minimize errors.

4. CONCLUSION

The proposed machine finds wide application in various areas, especially where it is necessary to monitor and store individual data on wind direction and wind speed for a variety areas of agricultural and non-agricultural purposes.

The main application area of wind direction and wind speed sensor (anemometer) is the automatic weather stations, also in agriculture, as part of agro-meteorological stations and microclimate stations under field conditions, in the industry, in various technological operations, where it is necessary to monitor air speed, and not least as a guide for the teaching hours on Biometeorology and Climatology.

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