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ROTATION LESS DEVICE OF MEASUREMENT OF WIND FORCE AND DIRECTION

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ABSTRACT
LABI- Laboratories of Integrated Automation at the TBU in Zlin are going to be extended to a new model of photovoltaic processes. There will be measured a wind force and a wind direction too. Our solving is using a rotation less device. There is elected a principle of stain gauges as sensors. The base of measuring element is deformation effect of small beam according to wind flow. The beam has plastic binding of couple strain circuits. The couple strain circuits has a special Wheatstone bridge connection. The strain elements are against connected together in Wheatstone bridges. There are two output signals to calculation of wind power and wind direction in the next unit. The mathematical formulas use a vector analysis. The all measuring device is constructed for outdoor environment. The range of wind force or better flow is from 0,1 to 50 m/s. The wind direction is +/- 180 ° for north-, east- , south- and west-ward.
Keywords: measurement, wind speed, wind direction, photovoltaic system

1. INTRODUCTION
System LABI [1] is enlarging some new models in this year. It is according to our plan and strategy. There is a new model realize in every year. It is planning model DE10 – Photovoltaic system. The DE10 is preparing with access via the Internet as other models up DE1 to DE9.

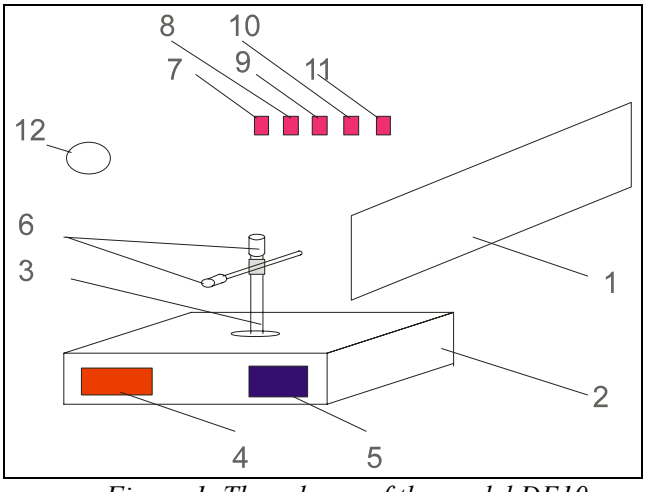

Figure 1. The scheme of the model DE10

The goal of the DE10 is for students to know photovoltaic system, the basic of principle of photovoltaic. The special function is the solar panel to control of its position according to sun position. The position is controlling according to measuring specific solar energy or according to calculating the position. The solar position is calculated according to mathematical model. The

outputs of control are signals for two motors. The application of the position control is important to ensure the stability of model base by a big wind flow. Therefore there is reason to solve a new equipment for measurement of force and direction of wind. The scheme of DE10 is on figure 1.
On the figure 1 are: 1-photovoltaic panel, 2-base of model, 3-two axis rotation, 4-batery , 5-automation system, 6-motors, 7-11-sensors. The sensors are for temperature, position, sun radiant energy, forse and direction of wind, other meteorological values.

2. AUTOMATION SYSTEM

The DE10 has projected an automation system with function of control, visualizing, archiving and communication on the Internet. The scheme of the system is on figure 2.

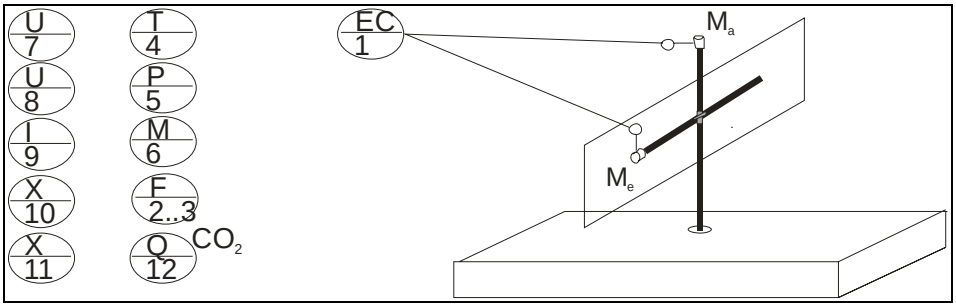

Figure 2. The scheme of the automation system

The automation system has planed measurement and control parameters according to table 1.

Table 1: list of measurement inputs and control outputs

	Parameter	Range	In/Output
EC1	Radiant energy	0-100 W/m^2	0-10V
F2a	Wind force and direction	0-100 m/s	0-0,1V
F2b	Wind force and direction	0-100 m/s	0-0,1V
T4	Ambient temperature	"-50..+50°C	0-10V
P5	Atm pressure	75-150kPA	0-10V
M6	Air moisture	0-100% RM	0-10V
U7	Voltage from Panel	0-30V	0-10V
U8	Voltage on batery	0-30V	0-10V
I9	Output current	0- 5 A	0-10V
X10	Azimut position	0 +/- 90°	0-100 Ω
X11	Elevation position	0-100°	0-100 Ω
Q12	Concentration ofce CO2	0-5000 ppm	0-10V
AO1	Control M_a	0 .. +/-95°	0-10V
AO2	Control M_e	0..100°	0-10V

3. SPEED AND DIRECTION OF WIND

The wind is flow of air in the atmosphere. The reason is a pressure difference of air and rotation of the Earth. The flow of wind is described speed and horizontal direction. The speed of wind is not constant. It is a lot changed in the time. The speed and direction of wind is measured according to international standards. Therefore there is calculated a mean of speed. The high above land surface acts on the speed. The wind has a turbulent flow at all times.

3.1. Principles of measurement

The parameters of wind, speed and direction, is measured in different principles generally. There are methods: rotation anemometer and non rotation equipment using thermo electrical, ultra voice and force principles. The measuring equipment names anemometers generally.
The meteorological stations use rotating and mechanical equipments mainly. They have any preferences and problems too. It is e.g. useful live, accuracy.

For our application there is chosen a principle of evoked force from the speed of wind. There is knew the Newton law to describe a value of force according to speed of wind:

$$F = 1/2.kS\rho v^2 \quad (1)$$

where is F resistive force,
k coefficient
S resistive area
R density of air
v flow speed .

The coefficient *k* is constant and has value for circle disk *k=1,11*, for square disk *k=1,27*, for circle cylinder *k=1,2*.

3.2. Measuring element

The speed of air influences on the area of cylinder and evokes force F. The one performs on the measuring element. The element is stressed of force, it develops mechanical strain. The strain is measured by strain gauges. The scheme of mechanical measuring element is on figure 3.

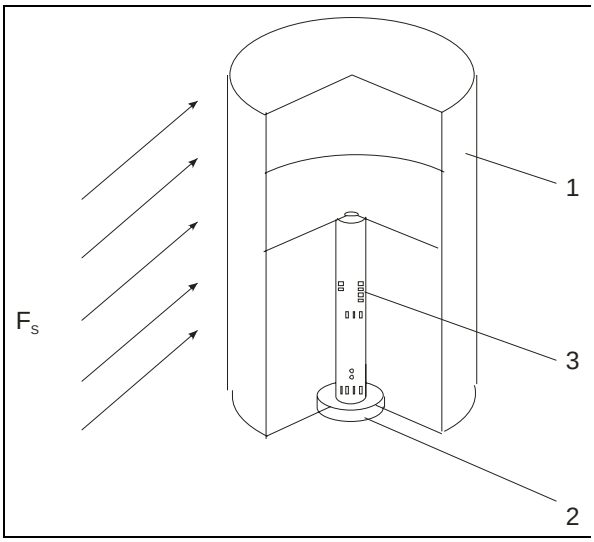

Figure 3. The scheme of the measurig element

The surface force from air speed stresses as force F_s on the cylinder (1). The result force generates on a spin (2). The spin has adhesive strain gauges (3). The measuring strain gauges are situated on the spin in four points placed in 90° (on figure 4). It is in directions *S, V, J,* and *Z*.

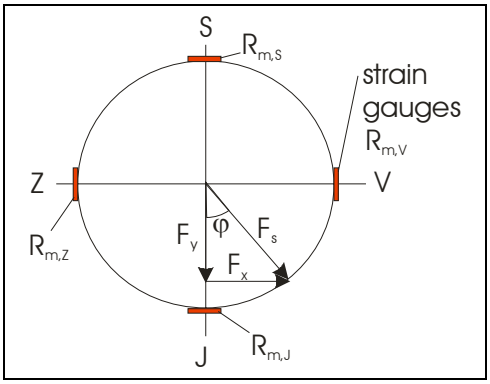

Figure 4. Position four measuring strain gauges and force effect

The air force evokes in the spin the mechanical strain and it is measured by four measuring strain gauges: $R_{m,S}$, $R_{m,V}$, $R_{m,J}$ and $R_{m,Z}$,. The resistance of strain gauges gives information about value of force effecting on the spin. There is possibility to write:

$$F_S^2 = F_x^2 + F_y^2 \tag{2}$$

and

$$tg\varphi = F_x / F_y \tag{3}$$

where is F_s total force from air speed
F_x partial force for axis x
F_y partial force for axis y
φ angle between vector of and axis y (of azimuth).

The measuring strain gauges are connected in the Wheatstone bridges, see figure 5. The change of strain gauges resistances $R_{m,S}$ and $R_{m,J}$ gives the output voltage $\Delta U_{N,X}$ and strain gauges resistances $R_{m,Z}$ and $R_{m,V}$ gives the output voltage $\Delta U_{N,Y}$.

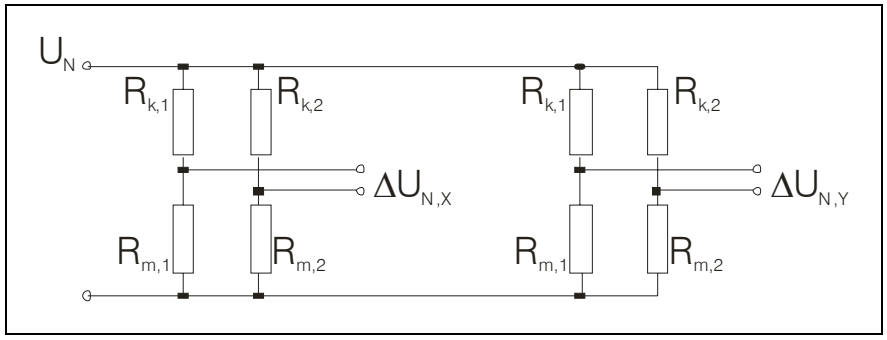

Figure 5. Connecting of measuring strain gauges in Wheatstone bridges ??označit Rm,x

The voltage outputs connect into other electronic unit to calculate speed and direction of wind as date for the automation system of experiment DE10. There is used as a central unit a industrial personal computer. Their inputs can be voltage only 0,1 V. It is positive

4. CONCLUSION

The paper gives information about development and solving the measuring equipment of speed and direction of wind. There is the force principle used with electronic circuits with strain gauges. The solving give positive results in view of measuring range and of measurement accuracy. There is described the experiment DE10 of system LABI, where the measuring equipment is applied.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Hruska F.: *Internet a laboratoře integrované automatizace* (The Internet and the Integrated Automation Laboratory). JEMNÁ MECHANIKA A OPTIKA, 2007, 2, pp.64-66. Prague: Fyzikální ústav Akademie věd České republiky, 2007. ISSN 0447-6441.

[2] Hruska F.: Laboratoře integrované automatizace na UTB ve Zlíně (The Integrated Automation Laboratory at the UTB in Zlin). AUTOMA, 51, 2007, 2, pp.43-46. Praha: FCC Public, 2007. ISSN 1210-9592.