## Real experiences of pilot operation of the photovoltaic system

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*Abstract:* The system LABI is extended a experiment DE10 – photovoltaic system. The experiment DE10 offers remote access for students and a professional community studying and testing the photovoltaic specifics without time, financial and other regression. At the moment the system consists a photovoltaic panel of monocrystal semiconductor, a system of measurement and control and a system of remote date transfer via the Internet. During a pilot operation there are confirmed functions and practicing of the system. There were achieved positive experiences.

Key-Words : photovoltaic, photovoltaic system, track system, measurement, automatic control

#### **1** Introduction

The laboratory system LABI with remote access [1,2] was extended the real laboratory experiment DE10 – photovoltaic system [3,4,5]. There were utilized all priority and advantages of the system LABI: its openness, extending, remote accessing for students and people of professional community.

The experiment DE10 consists a modern and actual photovoltaic system. There are solved the specific problems of photovoltaic: automated tracking of the panel and changing the its position according to position of the sun during the day and year, manual setting of position for studying and testing the global radiation and efficiency of transfer sun irradiation on the electric energy. The using of the system is via the remote access over the Internet and manual processing.



Fig. 1. Scheme of DE10 - photovoltaic system

The scheme of the all system DE10 is in the fig. 1. The one contents : a track device for two axis, a set of end switches for azimuth and elevation position, two potentiometric sensors of position, a sensor of sun irradiation, measurement of voltage and current of photovoltaic panel, sensors of temperature. moisture and other ambient parameters. The input system is connected to switch box. The switch box has located all transmitters, supplies and controlling computer accordant with protection. The main output is connected to the Internet.

The system DE10 is have been opening and testing according to technology and system at the moment. Its installation is on the roof a building of Faculty, see in fig. 2. The switch-box is connected to AC power lines 230V/50 Hz and to the LAN of faculty.



Fig. 2 Photograph of installation of DE10

### 2 Specific points of system structure

Over development and projecting of system there were solving some specific points of structure. The first point is track subsystem. Literature search offered information in current solving in the world. Their analysis gave results with some restriction. Financial problem and application were reason of negative results. There was choice technical clean solving with high accuracy and sensitivity. It was the solving with step motors and big number of steps. The motors are combined with robust gears. The track system has high quality and function parameters. Real view on one is in fig. 3.



Fig. 3 Photograph of track system DE10

The control and informatics system was projecting with goals of conflict less connection to current system LABI with older experiments and of compatibility between mechanical and electrical system. Main hardware parts are photovoltaic panel, the track system and measurement and control system. A signification part of DE10 is software application. There is used the programmable system Control-WEB. The its application makes: data acquisition, its evaluation, control of panel position according to calculated values of azimuth and elevation, data archiving and remote system communication of type client-server via the Internet.

## 3 Main parameters

Experiment equipment DE10 contents:

 Photovoltaic panel, Type STR 36-55, 55W, Voltage/optimal 21,6/17,6 V, Current short circuit/optimal 3,42/3,13 A, size 991x451x34 mm, weight 5,5 kg, monocrystal technology, protection IP54, process temperature -35°až +85°C, resistance again hail storm, frost and snow.

- Track system, 2 pieces of step motors a gears with 20Nm power unit of control impulses, range of azimuth position: 90°až 270°; range of elevation position: from 0°(vertical position to surface of earth) up to 90° (horizontal position to surface of earth).
- Measuring sensors:
  - Temperature and moisture of ambient (range -25 up to 50°C, 10-98% relative .moisture, output 4-20 mA)
  - irradiation(up to 100 klux, output 4-20 mA),
  - position of azimuth a elevation with potentiometers, range up to 270°, output 0-100  $\Box$ ,
  - DC voltage and current from panels, range U=0-25V, I=0-3,5A.
- Switch box with equipment:
  - Industrial PC, type DataLab/PC with interface: mouse, keyboard, USB, TCP/IP\_RJ45,
  - Unit of inputs and outputs, type Datalab\_I/O
  - Line power 230VAC, Supply 24V DC

# 4 Results of pilot operation

Pilot operation of DE10 have run from August of 2010 and is finishing on end of March. The current results are positive. There were obtained the experience:

- Mechanical part: is satisfactory, it is robust, resistance to outdoor condition, operation can run from -25°C, good protection again rain, temperature and moisture.
- Electrical part: function of step motors is without any problems, the end switch needed to change at the test beginning (the old ones have problems with water).
- System part:
- The central unit has been running without any collision, only some problem after drop-out of power (it has to restart sometimes manually)
- Measuring sensors show out 100% functionality, all tests of accuracy were positive.
- The software of local application DE10 has been working with full functionality, without mistakes. There was set up newly the part of position control of elevation according to results of testing. The application of server of LABI has been got processed intermediate after the

start of function and hasn't been had any problems during pilot operation.

- User part generally was programmed after intensive discussing and analyzing of submission. There were applied the experience of operation of older experiments: DE01, DE05 too. Very high signification has the automatic regime which is running permanent and date is archived. The date bank is the date bank of sun irradiation for last days. The manual regime is fit for individual studying, for testing of panel for moment irradiation.

## 5 Examples of using DE10

Access to the system LABI and to the experiment DE10 is free. Calling of application is by URL: <u>labi.fai.utb.cz</u>. There is possibility to study system and open the experiment and use it. The first window of LABI is in fig. 4.

After the choosing the system DE10 – Solar panel in the main window is opening the its window (fig.5 and 6) The data of system can be showed in the table and in the graphs.

If the access is currently, there is necessary to registry. Then is opened the experiment an it can be started the experiment.



Fig.4 The first window of system LABI

The using has three regimes:

- 1. Export the archived data pro set date and time. The output is a date file of all measured date in the text format for next recalculation or study post mortem.
- 2. Hand regime for a short measurement for set the position of panel azimuth and elevation, the output is the date file with all measured date.

3. Automation regime for a short measurement for calculated position.



Obr.5 The windows of DE10 - the table



Obr.6 The windows of DE10 – the graphs

The measured date are archived in the files at the set name and the format is "csv". The next evaluation is possibly in EXCEL program very simply. Example of a file in the table 1. The evaluation can be for a form of next mathematical calculation, graphs.

# 6 Possibility of enlargement and improvement of function

Experiences of pilot operation of DE10 have showed some possibility and given ideas to enlargement and improvement of current functions. They are at the moment:

1. The construction of DE10 is prepared as open to enlargement the kinds and areas of panels. There are discussed the possibilities of expand on new plastics panels and on panels with contractors.

- The new project solves expanding on measurement of air quality in environment: (CO<sub>2</sub>, NO<sub>x</sub>, CO, eventual VOC).
- The new access to DE 10 and LABI will use new mobile phones. The application SW of DE10 and server's SW will have new html server program.

					· ·			
UTB LABI								
Experiment DE10								
Name hru304ruo		b						
Azimuth	150							
Elevation	42							
Period [m	2							
Time	(Lux)	air T °C	% moistur	Azimuth	Elevation	I solar (A)	U solar (V	Výkon
12:22:28	67310.3	12.13	38.33	183.05	37.99	1.5	17.75	26.56
12:22:32	68799.93	12.13	38.23	178.55	41.95	1.5	17.83	26.79
12:22:36	69381.1	12.15	38.18	174.14	41.95	1.5	17.84	26.83
12:22:40	69160.8	12.16	38.06	169.01	41.95	1.5	17.8	26.72
12:22:44	68606.91	12.17	38.03	165.59	41.95	1.5	17.75	26.55
12:22:48	67645.99	12.18	38.01	161.09	41.95	1.49	17.68	26.35
12:22:52	66855.01	12.18	37.82	156.68	41.95	1.48	17.59	26.06
12:22:56	64763.22	12.2	37.73	152.27	41.95	1.47	17.46	25.68
12:23:00	63424.64	12.2	37.61	150.02	41.95	1.46	17.29	25.18
12:23:04	62734.38	12.21	37.56	150.02	41.95	1.45	17.24	25.05
12:23:08	62694.51	12.2	37.55	150.02	41.95	1.45	17.24	25.05
12:23:12	62736.47	12.21	37.71	150.02	41.95	1.45	17.24	25.05
12:23:16	62639.96	12.21	37.78	150.02	41.95	1.45	17.24	25.05
12:23:20	62631.57	12.21	37.78	150.02	41.95	1.45	17.24	25.06
12:23:24	62595.9	12.21	37.88	150.02	41.95	1.45	17.24	25.04
12:23:28	62528.76	12.23	38.03	150.02	41.95	1.45	17.23	25.02
12:23:32	62497.29	12.24	38.06	150.02	41.95	1.45	17.23	25.01

Table 1 Part of file in EXCEL program

# 7 Conclusion

The experiences of pilot operation confirm operating, functionality and signification of system DE10 at the period 6 months. The equipment was in the outdoor environment with influences of winter environment (e.g. up to  $-22^{\circ}$ C.) and in the autumn up to  $+32^{\circ}$ C in the ambient. Parallel there were tested the all measuring loops. The results of pilot operation release the system DE10 to use in the full end-user operation.

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