Conditioning circuit for assessing the performance of renewable energy sources

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Abstract – **Developing power energy from renewable energy resources (photovoltaic, wind, etc.) must be prepared according with criteria of a good use in terms of efficiency. Paper proposes an evaluation system of efficiency taken in consideration as many as possible quantities who are involved. This is useful for example to evaluate hybrid photovoltaic panels, which produce not only electrical energy, but also thermal energy.**

Keywords – Hybrid Photovoltaic Panel, Hall Sensor, Efficiency

I.   INTRODUCTION

Today, many developed energy harvesting system, like photovoltaic, are built in different form, from different materials and with different characteristics, [1]. Their operation in different power supply systems may be affected by different external factors or by some incompatibility between the components.

In order to measure performance and some parameters, the performance rating system must globally characterize the renewable energy production system. The proposed system can be easily expanded to any size, the concrete examples for which were developed as a hybrid photovoltaic panel system or mirrors add-on, [1].

II.   RELATED RESULTS IN THE LITERATURE

Classical photovoltaic panels are used widely, and use of it increase along with rising performances and lowering the price. Less used, but with new features, are photovoltaic panels with additional components like cooling system or mirror add-on, [1], [2].

Today, these are at the beginning, many of them being used for demonstration purposes and still under evaluation, [3]. For the reason of additional components of system, the price is moderate. Modified photovoltaic panel basically is supposed to have characteristic a higher performance then simple photovoltaic panel. It is well know the photovoltaic panel increases the output energy with more lighting. But this can increase the temperature of photovoltaic panel. On the other hand, efficiency of photovoltaic panel increases when temperature is lower.

III.   DESCRIPTION OF THE METHOD

Because of different quantities an example of analyzed system is presented, Fig. 1. For the evaluation of the efficiency, the thermal transfer in the cooling liquid is also taken into account, so that both the balance of the electrical and thermal quantities will be achieved.
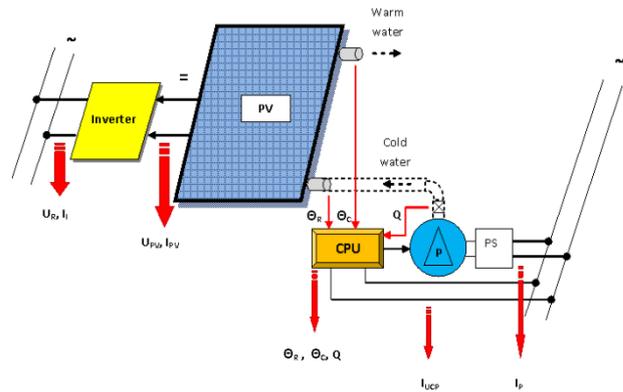

Fig. 1. Design of system analyzed

For this, the flow of liquid and the temperature difference of the liquid at the outlet of the photovoltaic panel and at its entrance must be known.

The presentation of the elements of the analyzed system, Fig. 1, is summarized in Table 1, together with explanations on role or functionality.

Table 1. Components of analyzed system.

	Symbol	Comments
1	~	Power network
2	Inverter	Ensures the conversion of the continuous voltage from the photovoltaic panel to the alternating voltage of the network
3	PV	Hybrid Photovoltaic Panel
4	P	Pump of cooling system
5	CPU	Central Processing Unit
6	PS	Power Supply (for CPU and pump)

Table 2. Quantities.

	Quantities	Comments
1	U_R	Power Voltage
2	I_I	Inverter Current
3	U_{PV}	Photovoltaic Voltage
4	I_{PV}	Photovoltaic Current
5	I_{UCP}	Control Unit Current
6	I_P	Pump Current

The quantities analyzed are summarized in Table 2 specifying the quantities type. The signals are picked up by some sensors. For electrical (voltage, current) sensors, Hall sensors (LEM type) are used, as they can be used for both continuous and alternate sizes (both quantities types exist in the system). The power supply can be used both for powering the pump and for feeding the central processing unit. Schematic isn't problematical, because of large scale integrated components, Fig. 3. Power supply is classical approach, having ±15V and +5V voltages.
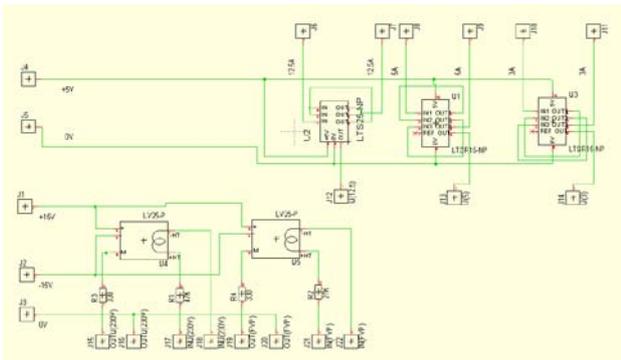

Fig. 3. Schematics of LEMs connections

For currents, their transformation into voltages accepted by the acquisition plate is achieved by means of LEM transducers and resistors. Voltage divider can be used for voltages, or for better galvanic isolation, LEM transducers. Were used LV20-P for voltages and LTSR15-NP, LTS25-NP and LTS6-NP for currents. All are closed loop transducer using Hall effect. Voltage sensors LV20-P have two resistances. First, in primary circuit have role to limit input current to ±14mA to highest limits. The output resistance have an interval between 100 and 350 ohms (to ±10mA), in established conditions.

Current sensors are powered supplying by 5V and from the datasheet it is observed that in the absence of current, we have the output voltage $V_{OUT} = 2.5$ [V], Fig. 4. Output voltages have a good linearity, according to datasheet specifications; I is the current and I_N is nominal current, (1).

$$V_{OUT} = 2.5 \pm 0.625 \cdot I/I_N \qquad (1)$$

Ratio between primary and secondary can be modifying by different numbers of primary turns. Embedded are predefined three modes: divided by one, by two and by three.
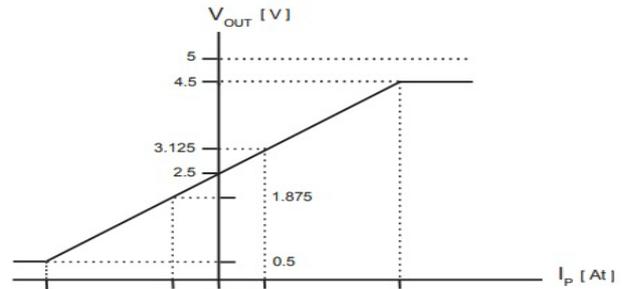

Fig. 4. Characteristic of LEM current sensors

Supplementary divider can be by four and five, using existing hole. Depending on the value and sense of the current, the voltage may increase or decrease (it works in a certain value range). LTSR vs. LTS has supplementary an adjustment of internal LEM reference voltages.

IV. RESULTS AND DISCUSSIONS

All data are summarized by a software application (virtual instrument), Fig. 5, [4]. That gives flexibility to reshape application according to necessities, Fig. 6. Application has possibility to save data into file. First, application prepare name of eventually save file, using local data and time. After data retrieved from data acquisition board, each interest quantity is selected. To avoid sudden jumps because of noise was used sliding average function, on last five values, for direct current quantities. In alternative current quantities was used a root mean square function. Blocks to adjustment of data are present and will be used in calibration stage. Mathematical operations are consistent with a linear variation of the entire measuring chain. Finally, are present some data conversion (number to string) blocks.

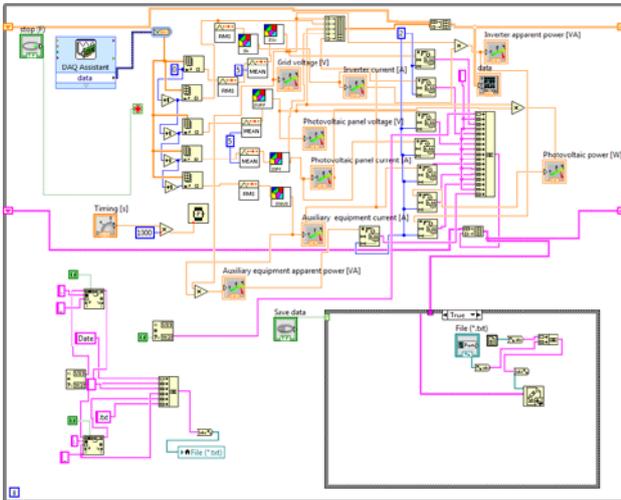*Fig. 5. Front panel of hybrid PV performance (not calibrated)*

Fig. 6. Diagram of application

In saved data file, near desired quantities, are present timestamp and computed quantities in different situation (cloudy or sunny moments of day), Fig. 7. No rigorous identity is required between the components on each analog input and the displayed value, because a program calibration can be performed in a first phase.

Calibration consists in finding influence coefficients for each size so that the displayed value matches the value of the measured size. For current type quantities, a 2.5 V offset correction is required due to the specific output presentation (2.5V output at 0A input). For voltage type quantities is only necessary a resistor to convert output current in voltage, without any offset.

Thickness of traces and distances between traces are important; PCB manufacturing of conditioning take in consideration data acquisition board voltage and current levels, Fig. 8. On the same single layer PCB have voltage supply stabilizers near LEM transducers and additional electronic components, Fig. 9.

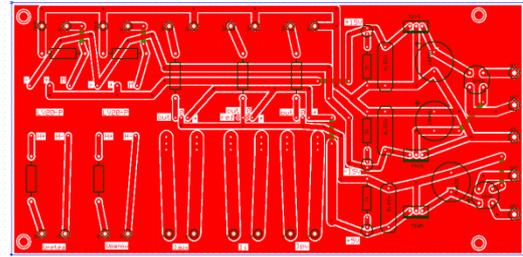*Fig. 7. Examples of data file (different situations)*

Fig. 8. General view of PCB and electronic components

Fig. 9. Assembled equipment

Output signals are connected to acquisition board through shielded cable. These cables are linked to analog input of data acquisition board.

During the experiments it was found that the current transducers are more stable than the voltage transducers, due to the fact that high immunity to external components (are some schematics different internal components between voltage and current LEM sensors).

When tested photovoltaic panel with mirrors an increase in efficiency of over 10% has been noted (for example this was revealed in maximum power point 15W with mirrors and 13W without mirror), but there are no known implications for the lifetime of the panel in the long run. This is due to the increased heating of the panel and aging of materials. A study about temperature influence on photovoltaic panel operation can be a future development.

In experiments photovoltaic panel has 500 mm x 340 mm and mirrors are two pieces of 492 mm x 195 mm, Fig. 10. Mirrors size was chosen in correlation with photovoltaic panel size and if experiments take long time, must adjust the position of mirrors according with position of the sun. Photovoltaic panel test was performed using a 1 kW and 47 ohm (maximum value) rheostat as load. Local condition of developing experiments was a sunny day, afternoon, little wind and a few clouds. This is reflected in some variability of acquisition data.

Developed system ensures a comfortable way to analyze efficiency of various power supplies.

Fig. 10. Experimental setup

It provides a real-time indication of the parameters required for performance appraisal. Entire system developed (hardware and software) is very flexible and versatile and can be setup in short time.

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