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DEVELOPMENT OF SOLAR POWERED FEEDING SCHEME FOR WIRELESS SENSOR NETWORKS IN LOW SOLAR DENSITY CONDITIONS

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In the recent years, there has been significant research focus on the safety and reliability of data harvesting and optimal energy consuming by wireless sensor network nodes. If external electrical power fails, the node needs to be able to send notifications to the utility demanding the use of backup energy strategies. The authors of the research offer an approach that can help to use PV panels as an alternative power source for WSN nodes in particular irradiation conditions. Survey and testing of the main types of PV panels offered on the market in conditions closed to real ones, in which WSN nodes are maintained, have been implemented. Based on the test results, maximum power control module parameters can be calculated in order to achieve the best effectiveness of the power control system for a selected type of PV panel or panel group. The novelty of the research is an approach that includes an original test bed design for PV testing, PV testing method and selection of design and MPP control module parameters, which ensure maximum effectiveness of WSN node power feeding.

Keywords: *maximum power point, PV panels, smart meters, wireless sensor networks.*

1. INTRODUCTION

The impressive growth of the solar energy generation industry has created a large variety of PV modules. However, there are issues, which still are needed for the research. For example, it is not well known how long these modules will last. Manufacturer warranties often guarantee 80 % maximum power for 25 years; however, relatively few PV modules have been in use for such a long time. As a result, there is a limited amount of data on PV module lifetime. Several studies provided by the Tucson Electric Power (TEP) Solar Test Yard can serve as an example. This test yard supports many projects, such as irradiance forecasting using cloud imaging [1], [2], degradation studies using historical AC power data [3], degradation studies using I-V curves, partial shading studies, performance studies using AC and DC power data and studies of novel PV modules.

Due to smart approach introduction, wireless sensor networks (WSNs) for service monitoring, in particular water distribution, heating gas and other utility networks, the reliability becomes critical, as now data from WSNs are used for real time control. For this purpose, WSN node feeding and renewable energy harvesting mechanisms should be taken into account to ensure a long operational life. The solar energy is most promising in outdoor deployments due to its relatively high power density. Wireless sensor nodes, being mostly planned for outdoor long-time operations, only seldom rely on external energy supply sources that, in turn, require the node to consider solar energy harvesting mechanisms. In the paper, the authors [4] propose a low-power maximum power point tracker (MPPT) circuit specially designed for wireless sensor nodes.

Solar harvesting circuits have been proposed in [5] to increase the autonomy of embedded systems with the task to optimise the efficiency of solar energy collection under non-stationary light conditions. Paper [5] proposes a scavenger that exploits miniaturised photovoltaic modules to perform automatic maximum power point tracking by providing power to ensure the minimum calculated operation time constraint for a particular WSN application.

The purpose of the research described in this paper is the creation of power supply management module to provide the operating voltage of 5 V for autonomous operations of radio signal repeaters, sensors or gateways of WSN. The power supply management module is composed of a solar panel storage solution, a lithium battery or its equivalent and a power management module. The research was conducted within the framework of project NR.1.21 "Photovoltaic Module Energy Storage and Management Independent Studies of Electronics Equipment – Repeater Development".

The power supply management module has to ensure a sufficient working cycle for collecting metering data from distributed sensor nodes by receiving or repeating sensor-metering telegrams. These telegrams contain temperature, pressure, moisture, electricity, and water usage data. An example of the wireless network sensors tested for the photovoltaic power system within the framework of the project can be seen in Fig. 1.

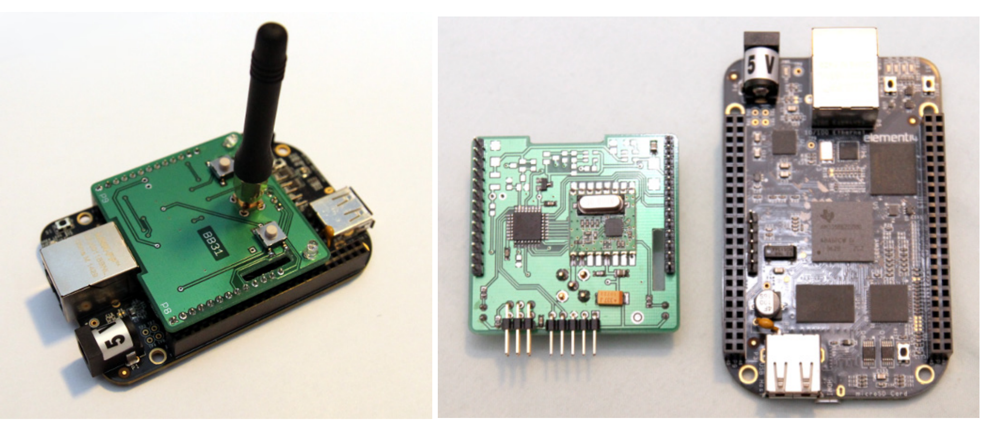


Fig. 1. Gateway node of wireless sensor network [6].

An example of the WSN node, which needs to be equipped with alternative power source, is the WSN gateway node developed in the project [6]. The gateway consists of BeagleBone Black platform that provides base functions and main computational resources. A daughterboard contains controller and radio module interfaces with the exposed BeagleBone connections (see Fig. 1).

The radio module of the daughterboard uses an average of 20 mA at the voltage of 5 V in a receiving mode. The current used by BeagleBone can be varied depending on the selected clock rate and power saving modes, where the minimum of 275 MHz is sufficient for the particular application at the current state of design. At this frequency, the average current is 350 mA. It is not required to ensure an uninterrupted operation of the receiver (gateway, repeater) for the reception of the metering data from the WSN nodes, so a minimum operation time window is estimated where the harvested solar energy is used to feed the equipment aiming to process metering data.

2. POWER SUPPLY MANAGEMENT MODULE DEVELOPMENT

A. Approach Applied

Solar modules are initially assigned their nameplate ratings by the manufacturer, which are determined under standard test conditions (STCs), which are 25 °C, 1000 W/m2, and air mass of 1.5. These standard testing conditions are rarely the same as the operating conditions when modules are deployed outdoors, which results in temporary (reversible) degradation of module performance. However, we do not know the real characteristics in particular geographical and environment conditions. Moreover, the current standard test conditions are not relevant indoors. However, indoor light sources can also be used for feeding WSN power constrained devices. In the Baltic States, solar conditions differ significantly from standard testing ones by a lower level of irradiation (see Fig. 2). The situation worsens even more due to dust and precipitation that lower the PV power output.

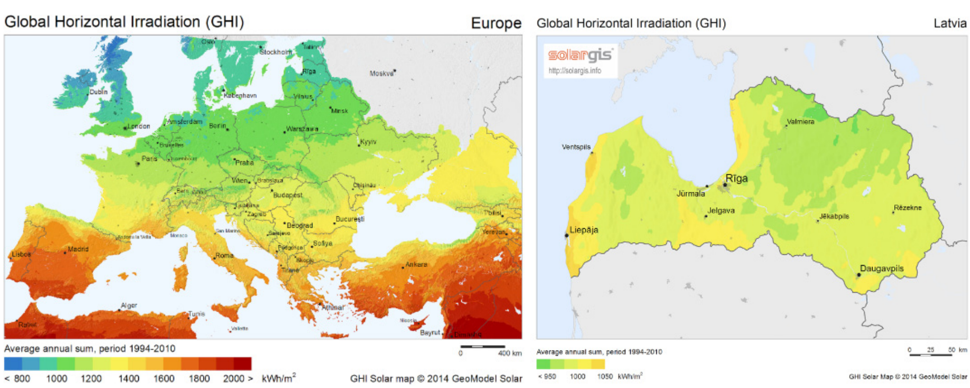


Fig. 2. Global horizontal irradiation: a) European territory; b) Latvian territory [7].

The problem to be resolved in the research is related to the selection of PV panel or group of panels to ensure sufficient power supply for WSN devices. Therefore, the authors of the research offer an approach and guidelines for engineers and equipment installers, who are willing to use PV panels as an alternative power source for WSN nodes in particular irradiation conditions.

The approach comprises two parts:

1. Survey and testing of the main types of PV panels offered on the market in conditions closed to real ones, in which WSN nodes are maintained. An original test bed has been designed. The conclusions have been made based on the test results.
2. Based on the test results, optimal power control module parameters can be calculated in order to achieve the best effectiveness of the power control system.

Therefore, the novelty of the research is an approach that includes the original test bed design for PV testing, PV testing method and selection of design and MPP control module parameters, which ensure maximum effectiveness of WSN node power feeding.

B. Maximum Power Point Tracker Application

The PV cell output is both limited by the cell current and by the cell voltage, and it can only produce a power with any combinations of current and voltage on the I-V curve. As shown in Fig. 3, if the P-V curve shifts with different irradiance, the maximum power point (MPP) also shifts. As the I-V curve of a PV cell changes with different irradiance, it reveals that the amount of power produced by the PV module varies greatly depending on its irradiance. It is important to operate the system at the MPP of PV module in order to exploit the maximum power from the module.

The foremost way to increase the efficiency of a solar panel is to use a Maximum Power Point Tracker (MPPT), a power electronic device that significantly increases the system efficiency. By using it, the system operates at the MPP and produces its maximum power output for a given irradiance. Thus, the MPPT maximises the array efficiency, thereby reducing the overall system costs. Therefore, the purpose is to maximise the power output of a selected photovoltaic module by varying the current of the load and battery charging.

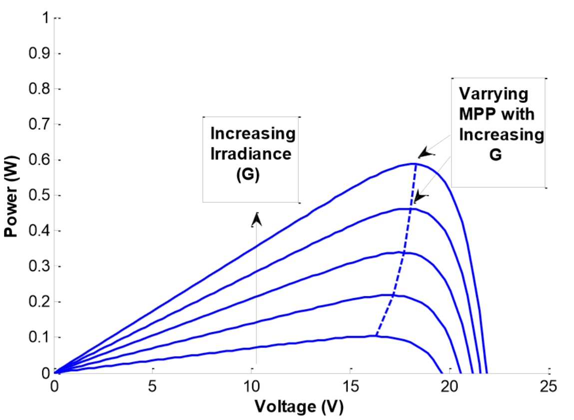


Fig. 3. P-V curve with different irradiance [8].

C. The Photovoltaic Module Test Bench Structure

The most fundamental technique of solar cell characterisation is the measurement of cell efficiency. Standardised testing allows comparing devices manufactured at different companies and laboratories with different technologies to be compared [9]. The standards for cell testing are as follows:

- Air mass 1.5 spectrum (AM1.5) for terrestrial cells and Air Mass 0 (AM0) for space cells;
- Intensity of 100 mW/cm^2 (1 kW/m^2, one-sun of illumination);
- Cell temperature of 25 °C (not 300 K);
- Four-point probe to remove the effect of probe/cell contact resistance.

For the purpose of the evaluation and measurements of the selected photovoltaic cells, a test bench has been designed with controllable illumination and solar power. Light control has been done with a three-phase 12-channel 4 KW (total 48 kW) dimming controller. To isolate from the surrounding environment, the test bench has a possibility for a full closing with outputs of the measurement devices and video surveillance for process monitoring (see Fig. 4).

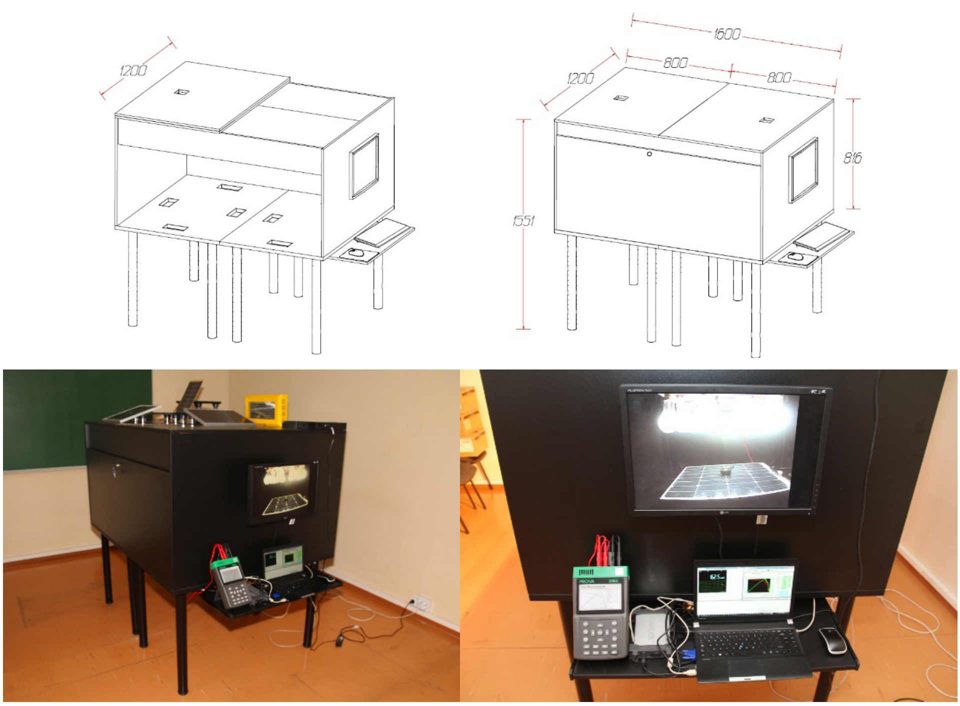


Fig. 4. Solar panel test bench drawings.

To perform the tests and process the results, the following measurement devices have been used:

- Hantek 365A: used as a current and voltage logging tool. Device functions: voltage measurements, current measurements, resistance measurements, capacitance measurements, real time data visualisation, trend curve visualisation.

- Prova 200 solar panel analyser has been used for professional testing and maintenance of solar panels and modules. The solar panel analyser provides the user with current and voltage (I-V) test curves, maximum solar power, as well as current and voltage. Test results have been saved and downloaded to a PC for the analysis using application software supplied with the portable solar panel analyser (see Fig. 5a).
- TM-208 - UVA Meter, Solar power meter and illumination measurement meter. TM-208 is a "three in one" meter; it measures the following sources: UVA, solar power features and illumination features (see Fig. 5b).

Fig. 5. Test measurement equipment: a) Prova 200 solar panel analyser; b) TM-208.

D. Photovoltaic Cell Practical Testing and Verification Using Simulated Environmental Effects

Eight types of the PV panels have been tested in the test bench (see Table 1).

Table 1

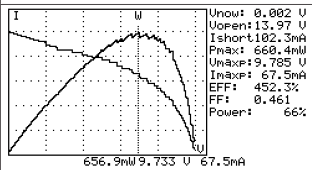
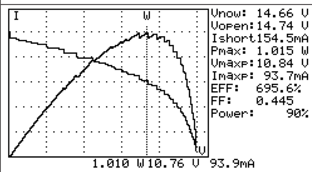
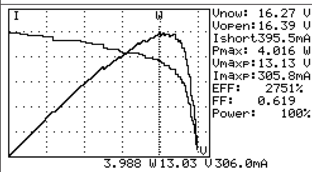
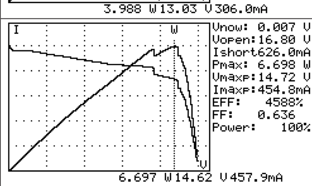
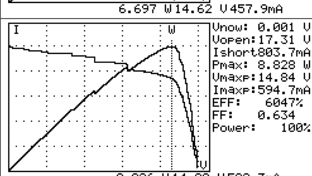
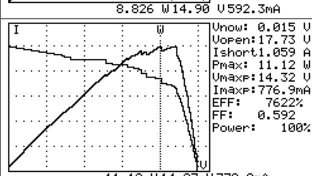
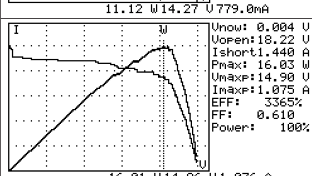
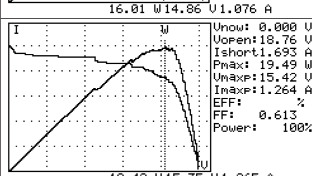
Tested PV Panel Specification

Panel A:	Panel A:	Panel B:	Panel C:	Panel D:	Panel E:	Panel F:	Panel G:
Model Number or Type	SN-H50W	ECO-sources	ECO-sources	MONO or POLY: POLY	ECO-sources	ECO-sources	MONO or POLY: POLY
Brand Name:	SHINE	-	-	-	-	PG	-
Max. Power:	50 W	10 W	10 W	20 W	18 W	5 W	20 W
Nominal Capacity:	50 W	10 W	10 W	20 W	15 W	5 W	20 W
Number of Cells:	32	36	36	36	36	32.00	36
Size:	0.291 m^2	0.0861 m^2	0.0861 m^2	0.1394 m^2	0.1225 m^2	0.12397 m^2	0.1394 m^2
Material:	Monocrystalline silicon	Monocrystalline silicon	Monocrystalline silicon	Polycrystalline silicon	Monocrystalline silicon	Amorphous silicon	Polycrystalline silicon
Working Voltage:	17.6 V	18.2 V	18.2 V	17.3 V	18.0 V	27 V	17.3 V

In Table 2, one can see the test results of panel A. The power of artificial irradiation has been selected in 8 steps taking into account also low power per m^2 that characterises Latvian conditions.

Table 2

The Test Results of Panel A

Artificial W/m^2	Lux	uW/ cm^2	Measurement	FF	Vmax (V)	Imax (mA)	Pmax (mW)	mW/ m^2
76	1200	2.8		0.461	9.78	67.5	660.4	2269.4
151	2731	6.1		0.445	10.84	93.7	1015	3487.9
325	7150	12.5		0.619	13.13	305.8	4016	13800.6
530	9500	15.3		0.636	14.72	454.8	6698	23017.1
733	12000	18.3		0.634	14.84	594.7	8828	30336.7
950	14610	24.8		0.592	14.32	776.9	11120	38213.1
1239	19230	29.4		0.610	14.90	1075	16030	55085.9
1480	22720	31		0.613	15.42	1264	19490	66975.9

Due to the lack of space, only test results of Panel A are depicted in this paper. The results of the test of all eight panels are summarised in Table 3. As the panels have different size and space, all the results have been normalised and calculated as mW/m^2 (see Table 3).

Table 3

Dependence between Power of Irradiation and MPP for A–G Types of PV

Source W/m^2	A: mW/m^2	B: mW/m^2	C: mW/m^2	D: mW/m^2	E: mW/m^2	F: mW/m^2	G: mW/m^2
76.00	2269.42	3229.97	1637.63	2449.07	3257.14	591.03	2666.43
151.00	3487.97	5950.06	3479.67	5599.00	6652.24	1276.92	5769.01
325.00	13800.69	19012.78	12764.23	18163.56	18742.86	2094.06	14863.70
530.00	23017.18	26085.95	19686.41	26355.81	27004.08	3395.98	21470.59
733.00	30336.77	33124.27	24181.18	35337.16	34440.82	4320.40	25997.13
950.00	38213.06	43565.62	32462.25	44813.49	45600.00	5654.59	35243.90
1239.00	55085.91	56295.01	39837.40	61793.40	59681.63	7387.27	47367.29
1480.00	66975.95	63554.01	45772.36	78263.99	77346.94	9349.04	61571.02

The test results demonstrate that the PV panel produced from amorphous silicon (F type panels in the test) is less suitable for usage in a weak irradiation environment, since its dimension and power output ratio are relatively small. To achieve higher power output, it would be necessary to increase PV panel size or its number that is not desirable because of the limited installation space and installation complexity of outdoor WSN equipment.

To measure the quality of the solar cell, the Fill Factor (FF) is essential. It is calculated by comparing the maximum power (P_{MAX}) to the theoretical power (P_T) that would be output at both the open-circuit voltage and short-circuit current together.

$$FF = \frac{P_{MAX}}{P_T} = \frac{V_{MP} \cdot I_{MP}}{V_{OC} \cdot I_{SC}} , \qquad (1)$$

where:

V_{MP} – the maximum power point voltage;

I_{MP} – the maximum power point current;

V_{OC} – the cell open-circuit voltage;

I_{SC} – the cell short-circuit current.

Comparison of FF of the panels does not give us a clear indication as to which type of the tested panels is better for operation in low irradiation conditions; therefore, efficiency indicator η is evaluated. It is also noted that the quality of each panel has to be verified as cell defects are not instantly notable and the manufacturers' I-V curves can deviate from the real values – as observed during the research.

Efficiency is the ratio of electrical power output P_{out} compared to solar power input P_{in} into the PV cell. P_{out} can be taken to be P_{MAX} since the solar cell can be operated up to its maximum power output to get the maximum efficiency.

$$\eta = \frac{P_{out}}{P_{in}} \Rightarrow \eta_{\max} \frac{P_{MAX}}{P_{in}} . \tag{2}$$

P_{in} is taken as the product of irradiance of the incident light, measured in W/m^2 (or 1000 W/m^2), with the surface area of the solar cell [m^2]. The maximum efficiency (η_{MAX}) found from a light test is not only an indication of the performance of the device under test, but, like all of I-V parameters, can also be affected by ambient conditions, such as temperature and the intensity and spectrum of the incident light [10].

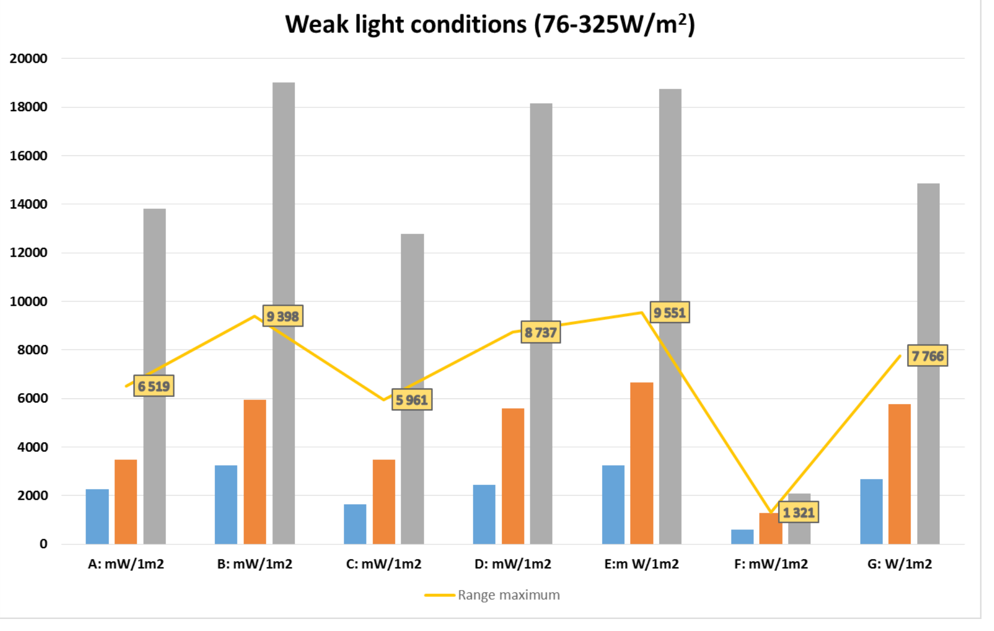


Fig. 6. Dependence between power on the irradiation and MPP for A–G types of PV for low power inputs.

As the test ensured similar lighting and temperature conditions for PV cells, the results in Table 3 and Fig. 6 can be used for evaluation of the efficiency of the panels. As P_{in} is the same for all panels, P_{out} indicates which panels are most efficient for operation in low irradiation conditions. In fact, A and E panels appeared to be more efficient for the conditions set in the test.

E. Maximum Power Point Tracker for WSN Nodes

Different existing MPPT algorithms have disadvantages in terms of flexibility for environmental conditions that produce uncertainty for the detection of the optimal operating point [11]. One of the typical problems is the inability to determine actual location of MPP. In this method, only the oscillation of point can be achieved in a region close to MPP. In order to reduce the volume of these oscillations, several studies have been conducted, for instance, the time intervals between voltage movements can be increased by adding a waiting period [12]. However, this application is successful under the constant or linear solar radiation conditions. Another method of reducing oscillations is called three-point weight comparisons (TPWCs) [13]. In the recent years, fuzzy logic, artificial neural networks, and genetic algorithm techniques have been used widely in the MPPT process. Under non-uniform and partially shading conditions, the power and current characteristics of PV cells are more complex, and it is more difficult to track MPP. Implementation of these algorithms makes the embedded applications for WSN more complex and decreases the efficiency of the PV array as it has to be compact to fulfil restrictions for deployment. Embedded MPPT control with the method described in this paper provides a feasible solution for a PV-based powering system used in compact and optimized sensor networks.

Maximum Power Point Tracker (MPPT) – a microcontroller based power electronic module that significantly increases the system efficiency – has been developed within the framework of the present research. It ensures the charging of a battery and a power to the connected equipment by optimising the solar panel maximum possible power rate under varying lightning conditions.

The module consists of:

- Uniting diodes to connect multiple solar panels;
- Step-down impulse converter;
- Lithium battery charging circuit;
- Circuit for uninterrupted switchover from the solar panel power to the battery and vice versa;
- Digital potentiometer and ADC;
- Load disconnection circuit;
- Microcontroller;
- Microcontroller software – control algorithm.

The authors of the paper focus only on the elements of the module, which are necessary to enable MPPT.

<u>Step-down impulse converter</u>

<u>LM22675</u> controller with an operating frequency of 500 kHz allows the inductor to reduce the cumulative nominal and dimensions. It operates in a pulse mode with the internal circuit-breaker transistor up to 1.8 A per pulse. Resistors R1 and R2 form a divider to compare the output voltage with the reference voltage of 1.28 V. The selected output voltage of 5 V is adapted for the electronic equipment in the particular application.

<u>Digital potentiometer</u>

<u>The digital potentiometer together</u> with resistor R5 enables the controller to change the battery charging current and adjust the optimal working point of solar cells – the used power is maximum provided by the solar panel. If the digital potentiometer mode is zero, then only resistor R5 limits the maximum charging current. When the potentiometer is switched on, the charging current decreases. The microcontroller ATTINY13A controls the potentiometer.

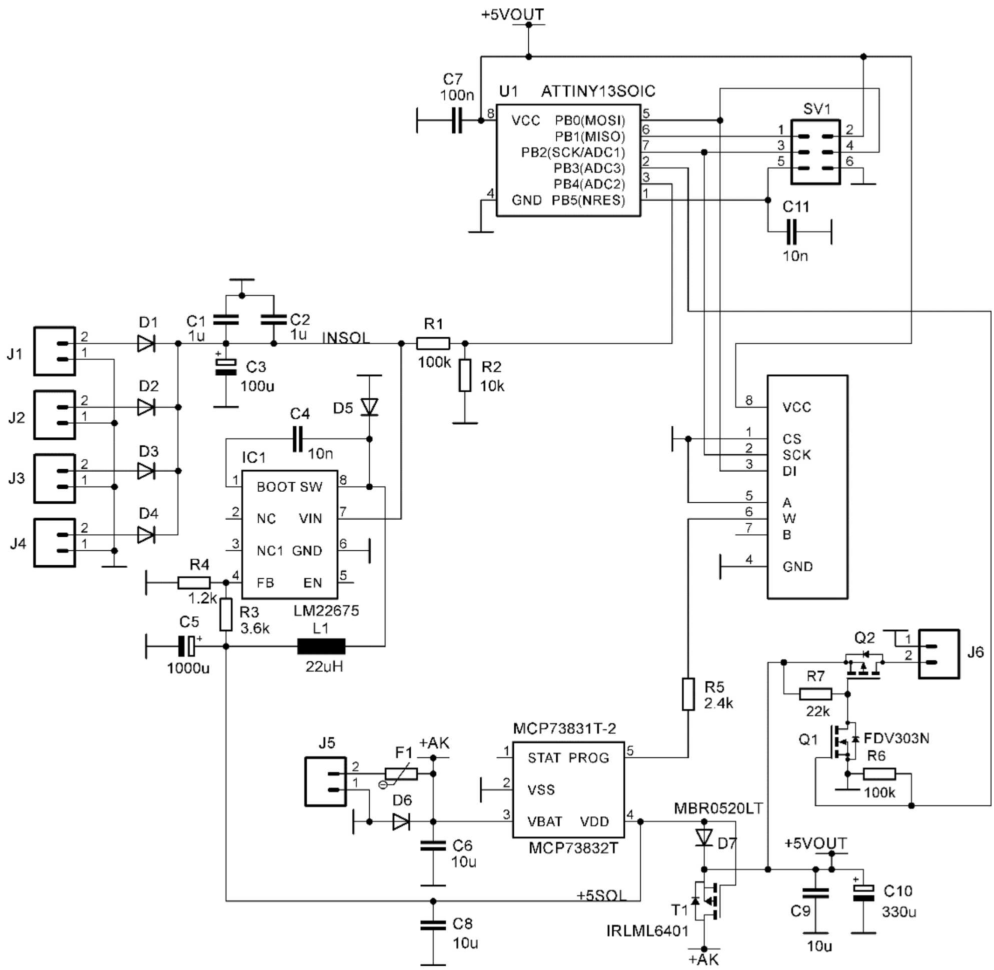


Fig. 8. Electrical schemes of the MPPT module.

<u>Microcontroller</u>

The tasks of ATTINY13A are to combine the solar panel voltage measurements with ADC, to drive the digital potentiometer by ensuring the optimal charging current selection and to control the load disconnection and connection. The interface of the digital potentiometer is SPI, where pin number 8 of the microcontroller is used.

<u>Microcontroller software – control algorithm</u>

The control software is modular: ADC, digital potentiometer driver, disconnection module and algorithm logical machine. ADC measures output voltage of the solar panel, for the selected panel it is in the range up to 20 V. The divisor reduces the voltage to a reference voltage and the software finds the current voltage value. This voltage is the starting point for the determination of the optimal power point for the selected solar panel. This point must be observed by monitoring the nominal voltage drops and adapting the charging current.

Here is a simple application of the research results. In Section 1 of the paper, it has been noted that the average current of the gateway developed at BeagleBone board is 350 mA. Imagine that for a particular WSN it is sufficient, if a gateway operates at least 8 hours in twenty-four hours. Therefore, 350 mA x 5 V x 8 hours = 14000 mAh.

The best solar plate, tested in the paper, theoretically has P_{out} of about 9000 mW/m^2 that is 9000 mW/m^2 x 0.25 m^2 = 2250 mW – P_{out} of one panel.

Thus, 14000 mWh : 2250 mW = 6.2 hours. It means that in Latvian conditions one solar panel is able to ensure feeding of the device in the summer during 8 hours, but in the winter, when the day light is much shorter and there are fewer solar days, one solar panel is not enough. To ensure the operation of a particular WSN, the decision can be made to use a lower power rating solution like a repeater node to compensate the insufficient solar irradiation levels. In any case, the evaluation of each individually deployed PV panel is vital to ensure critical data transmission. However, for a reliable result for real WSN it is also necessary to conduct field research on solar irradiation at different times of the day and the year.

3. CONCLUSIONS

The authors of the research have offered an approach that can help to use PV panels as an alternative power source for WSN nodes in particular irradiation conditions.

Survey and testing of the main types of PV panels offered on the market in conditions closed to real ones, in which WSN nodes are maintained, have been implemented.

Based on the test results, maximum power control module parameters can be calculated in order to achieve the best effectiveness of the power control system. The measurement procedure also provides a way of verification and evaluation of the PV panels whether of different or the same type.

The conclusions have been made that in Latvian conditions one solar panel is able to ensure feeding of the device in the summer during particular hours, but in the winter, when the day light is much shorter and there are fewer solar days, one solar panel is not enough. However, for a reliable result for real WSN it is also necessary to conduct field research on solar irradiation at different times of the day and the year. Moreover, the selection of lower power consuming WSN equipment (i.e., WSN repeater) can be considered.

The novelty of the research is the approach that includes the original test bed design for PV testing, PV testing method and selection of design and MPP control module parameters, which ensure maximum effectiveness of WSN node power feeding.

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REFERENCES

1. Jayadevan, V.T., Rodriguez, J., Lonij, V.P.A., and Cronin, A.D. (2012). Forecasting solar power intermittency using ground-based cloud imaging. In *Proceedings of American Solar Energy Society Meeting*.
2. Lonij, V.P., Jayadevan, V.T., Brooks, A.E., Koch, K., Leuthold, M., and Cronin, A.D. (2012). Improving forecasts of PV power output using real-time measurements of PV output of 100 residential PV installs. In *Proceedings of the 38th IEEE Photovoltaics Specialists Conference*.
3. Cronin, A., Pulver, S., Cormode, D., Jordan, D., Kurtz, S., and Smith, R. (2010). Measuring degradation rates without irradiance data. In *Proceedings of the 36th IEEE Photovoltaics Specialists Conference*, March 2010.
4. Alippi, C., and Galperti, C. (2008). An adaptive system for optimal solar energy harvesting in wireless sensor network nodes. *IEEE Transactions on Circuits and Systems—I. 55* (6).
5. Brunelli, D., Benini, L., Moser, C., and Thiele, L. (2008). An efficient solar energy harvester for wireless sensor nodes. In *DATE '08 Proceedings of the Conference on Design, Automation and Test in Europe*, (pp. 104–109).
6. Zabašta, A., Dambrauskas, V., Deksnis, J., Deksnis, V., Gudele, I., Kondratjevs, K., Kriaučeliūnas, A., Kuņicina, N., Navalinskaite, K., Nolendorfs, A., and Šeļmanovs-Plešs, V. (2013). Smart Metering. In *Project (LLIV-312) "Smart Metering"*, 2013 (pp. 1–110). Ventspils: Engineering Research Institute, Ventspils International Radio Astronomy Centre of Ventspils University College.
7. Global Horizontal Irradiation (GHI), GeoModel Solar, (2015). Retrieved 20 May 2015, from http://solargis.info/doc/free-solar-radiation-maps-GHI.
8. Nedumgatt, J. J., Jayakrishnan, K. B., Umashankar, S., Vijayakumar, D., and Kothari, D. P. (2011). Perturb and observe MPPT algorithm for solar PV systems-modelling and simulation. In *Annual IEEE India Conference (INDICON)*, Dec. 2011 (pp. 1–6).
9. Honsberg, C., and Bowden, S. (n.d.). *Measurement of solar cell efficiency*. Retrieved 20 May 2015, from http://www.pveducation.org/pvcdrom/characterisation/measurement-of-solar-cell-efficiency.
10. *Part II – Photovoltaic Cell I-V Characterization Theory and LabVIEW Analysis Code*. (2012). Retrieved 20 May 2015, from http://www.ni.com/white-paper/7230/en/.
11. Onat, N. (2010). Recent developments in maximum power point tracking technologies for photovoltaic systems. *International Journal of Photoenergy 2010* , Article ID 245316 (11 p.).
12. Chao, K. H., and Li, C. J. (2010). An intelligent maximum power point tracking method based on extension theory for PV systems. *Expert Systems with Applications 37* (2), 1050–1055.
13. *International Journal of Electrical and Electronic Engineering & Telecommunications 1.4* (1), January 2015 (23 p.). ISSN 2319 – 2518.

BEZVADU SENSORU TĪKLU ELEKTROAPGĀDES SISTĒMAS IZSTRĀDE, KAS IZMANTO SAULES PANEĻUS UN DARBOJAS PAZEMINĀTAS SAULES RADIĀCIJAS APSTĀKĻOS

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K o p s a v i l k u m s

Pēdējos gados vairāki pētījumi ir veltīti problēmām, kas ir saistītas ar enerģijas patēriņa mazināšanu un efektīvu izmantošanu bezvadu sensoru tīklu mezglos. Kad sensors mezgls ir izsmēlis enerģijas krājumu, tas vairs nefunkcionē un atslēdzas no kopēja tīkla, kas var būtiski ietekmēt visa tīkla veiktspēju.

Šī pētījuma mērķis ir izveidot barošanas vadības moduli, lai nodrošinātu stabilu elektroapgādes spriegumu autonomi strādājošiem radio signāla atkārtotājiem, sensoriem vai vārtejām, kas darbojas bezvadu sensoru tīklos. Pētījuma ietvaros izstrādāta metode saules paneļu kvalitatīvai salīdzināšanai starp tehnoloģijām vai savā starpā, izvērtējot to atbilstību mērķa pielietojumam. Izstrādātā metode sniedz iespēju veikt kontrolētus testus pie variējošiem, simulētiem gaismas apstākļiem, ļauj prognozēt enerģijas resursus kontekstā ar reģionālajiem apstākļiem un aprēķināt darba režīmus bezvadu tīkla komponentēm vai pieņemt lēmumus par to funkcionalitātes pielāgošanu. Izstrādātais vadības modulis sastāv no saules paneļa fotoelementu moduļa, uzglabāšanas risinājuma (litija vai līdzvērtīgas baterijas) un elektroapgādes pārvaldības moduļa.

Pētījuma novitāte ir elektroapgādes pārvaldības modulis, kas nodrošina stabilu un nepārtrauktu elektronisko iekārto darbību dažādos barošanas režīmos, dažādās situācijās, vienlaikus nodrošinot enerģijas saglabāšanu un moduļa sastāvdaļu ilgtspēju. Izstrādātais risinājums nodrošina nepārtrauktu 5V barošanu elektronikas shēmām bez strāvas pārtraukuma, kad notiek komutācija starp barošanas avotiem un enerģijas plūsmām dažādos virzienos. Elektroapgādes pārvaldības modulis nodrošina stabilu spriegumu mainīgos saules radiācijas apstākļos.

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