3. Green M.A. Solar cell efficiency tables (version 47) / M.A. Green, K. Emery, Y. Hishikawa, W. Warta, E.D. Dunlop // Progress in Photovoltaics: Research and Applications, 2015. 24(1): pp. 3-11.

4. Ritenour A.J. "Towards high-efficiency GaAs thin-film solar cells grown via close space vapor transport from a solid source," / A.J. Ritenour; S.W. Boettcher // Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE, vol., no., pp.000913, 000917, 3-8 June 2012

5. Sater B.L. The development of high intensity silicon vertical multi-junction solar cells / B.L. Sater // Final report grant DEFG36-00GO10523. – 2003.

UDC 621.472:629.78

HIGH-VOLTAGE POWER TAKE-OFF SYSTEM FOR PHOTOVOLTAIC STATION

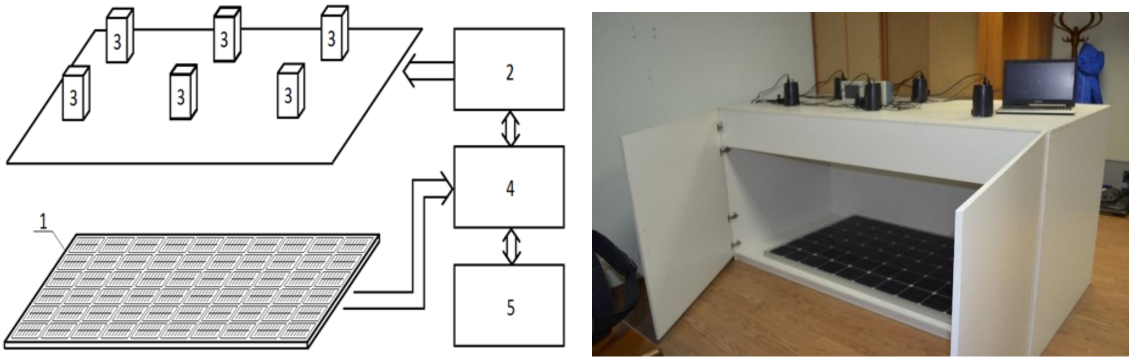
Zaitsev R.V., Kirichenko M.V., Khrypunov G.S., Prokopenko D.S.
National Technical University «Kharkiv Polytechnic Institute»
E-mail: zaitsev.poman@gmail.com

To generate a maximum electric power by photovoltaic station (PVS), besides the use of the developed high-performance liquid-cooled photovoltaic modules (PVM), equipped with solar radiation concentrators, high-performance power take-off system (PTOS) should be used [1]. Upconverter (UC) is the most important part of PTOS that provides increasing a constant voltage generated during PVM operation, for its further efficient transfer and transformation [2, 3]. Since, electric power generated by the PVM depends on daily solar radiation changes, the optimization UC and PTOS constructive and technological solutions should be carried out taking into account the full range of converted electric power. Optimization of constructive and technological solutions of all components of solar energy conversion into commercial frequency system will increase the PVS effectiveness and achieve its competitiveness in the domestic and global market due to energy and economic indicators.

Based on the above, the creating a highly efficient and cost-effective PTOS was carried out by three steps. In the first step the dependence of the electric power from the intensity of the incident solar radiation was studied. Based on these data, in the second stage electrical schematic diagram of UC was developed, and calculation of the resonant circuit and converter operating parameters of UC were carried out. In the third stage, the PTOS work using the UC was analyzed.

Measurements of short circuit current (I_{SC}), open-circuit voltage (U_{OC}), work (P_W) and maximum (P_{MAX}) electrical power and the efficiency of standard industrial PVM were carried out at intensive of solar insolation from 1000 to 2000 W/m^2, to simulate their performance when using concentrators. These measurements were conducted by load light current-voltage characteristics with the help of developed stand, block diagram and design of which are shown in Figure 1.

It was established experimentally that the use of the test samples PVM in a low-concentration solar radiation is justified, because investigated PVM achieve maximum efficiency of 16.9% exactly at the radiation power 1700 W/m^2. An additional advantage of using low-concentration radiation is increasing the maximum power generated by the PVM to 420 watts, which is 1.7 times greater than for classical PVM. The use of low-concentration solar radiation as well is an additional argument in favor of equipping each PVM with UP in PTOS, because the operating current of the PVM at radiation power 1700 W/m^2 reaches 13 A that almost twice greater than for 1000 W/m^{2}radiation power, which for is traditional PTOS performing will cause additional losses in the connecting wires, or lead to significant investment for equipping the photovoltaic plant with increased cross-section cables.



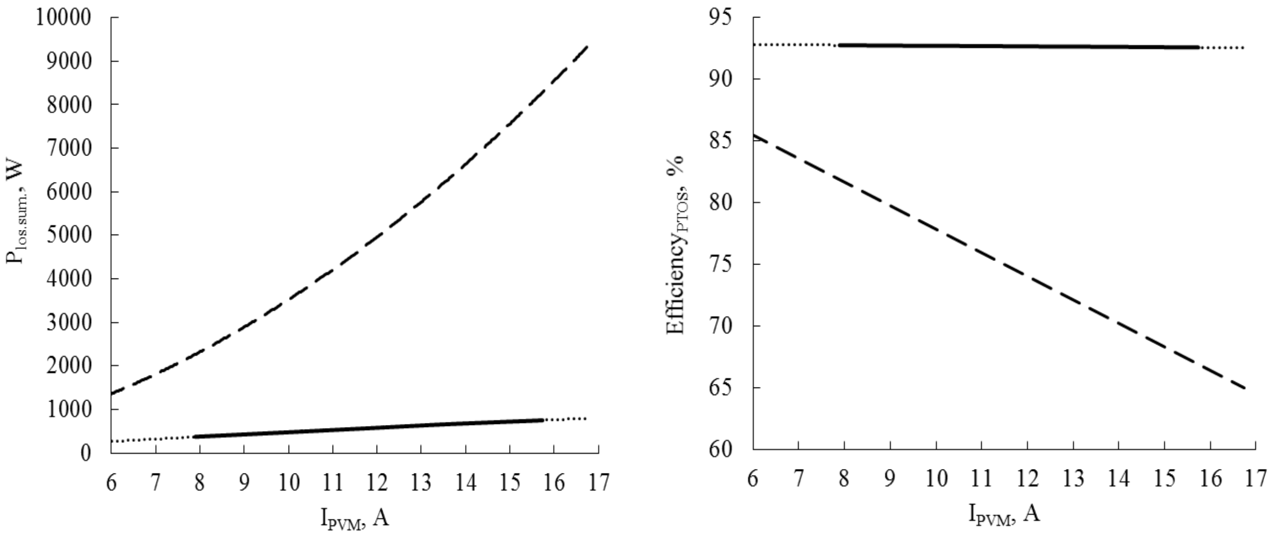
a) b)

Figure 1 - Block diagram of (a) and design (b) of stand for the study of the PVM

It was established experimentally that the use of the test samples PVM in a low-concentration solar radiation is justified, because investigated PVM achieve maximum efficiency of 16.9% exactly at the radiation power 1700 W/m^2. An additional advantage of using low-concentration radiation is increasing the maximum power generated by the PVM to 420 watts, which is 1.7 times greater than for classical PVM. The use of low-concentration solar radiation as well is an additional argument in favor of equipping each PVM with UP in PTOS, because the operating current of the PVM at radiation power 1700 W/m^2 reaches 13 A that almost twice greater than for 1000 W/m^{2}radiation power, which for is traditional PTOS performing will cause additional losses in the connecting wires, or lead to significant investment for equipping the photovoltaic plant with increased cross-section cables.

To optimize the power take-off system adjustable bridge resonant UC [3, 4], which allows to achieve high conversion efficiency values up to 95.8% was developed. A high efficiency is achieved by digital control inverter and opens up opportunities for flexible control algorithms that ensure reliability and conversion efficiency, fast and accurate determination of maximum power point [6].

The results of the calculations of the PTOS can be concluded that the use in such system UC can significantly reduce power losses in the PTOS and therefore improve efficiency PVS [7]. The above will result in an additional increase of usable power given to the consumer through an invert er.



a) b)

Figure 2 - The dependence of the calculated power losses (a) and efficiency (b) using PTOS PVS upconverters (solid line) compared to PVS without such converters (dashed line)

According to Figure 2, a the total loss of power in a PTOS ($P_{loss.sum.}$) with output power 1700 W/m^2 and a current of the PVM (I_{PVM}) at 13 A was 644.6 watts, which is much less than 6180.8 watts typical for a system without such converters. This will increase the efficiency of the PTOS from 71.0% to a value of 92.5% (Figure 2, b).

It should also be noted that the efficiency of the PTOS remains almost unchanged at wide range of PVM illumination, which changes depending on weather and seasonal conditions.

References

1. *Kriukov Yu.A., Zaitsev A.Ye., Feshchenko A.A., Gorshkov A.V. Influence of operating temperature on efficiency of silicon photovoltaic devices. International Journal of Applied Engineering Research, 2015, vol.10, no.15, p.35446-35450.*
2. *Rozanov Yu.K., Baranov N.N., Antonov B.M., Efimov E.N., Solomatin A.V. Silovaya electronika v sistemah s netradicionnymi istochnikami electroenergii [Power electronics in non-traditional sources of electricity systems] // Elektrichestvo - Electricity, 2002, no.3, p.20-28. (Rus)*
3. *Melyoshin V., Ovchinikov D. Upravlenie tranzistornymi preobrazovatelyami elektroenergii [Management transistor power converters]. Moscow, Technosfera Publ., 2011. 576 p. (Rus)*
4. *Gu Yi., Hang L., Chen H., Lu Z. A simple structure of LLC resonant DC-DC converter for multi-output applications. Applied Power Electronics Conference and Exposition, 2005, vol.3, p.1485-1490.*
5. *Abdel-Rahman S. Resonant LLC converter: Operation and Design 250W 33Vin 400Vout Design Example. Infineon Technologies Application Note AN 2012-09 V1.0, 2012.*
6. *Freeman D. Introduction to photovoltaic systems maximum power point tracking. Texas Instruments Application Report SLVA446, 2010.*
7. *Bogatyirev N.I., Grigorash O.V., Kurzin N.N., Strelkov Yu.I., Telnov G.V., Tropin V.V. Preobrazovateli elektricheskoy energii: osnovyi teorii, rascheta i proektirovaniya. ucheb. posob. dlya vuzov. pod red. N.I. Bogatyireva [Converters of electric power: the basic theory, calculation and design. Proc. allowance for schools]. Krasnodar, 2002, 358 p.*

УДК 535.331

ВПЛИВ ГРАФЕНУ НА ОПТИЧНІ ВЛАСТИВОСТІ СИСТЕМИ Cu-HfO_2, НАНЕСЕНОЇ НА СКЛЯНУ ПІДКЛАДКУ

Негруб М.М.[1*], Кравець В.Г.[2], Лопатинська О.Г.[1], Юргелевич І.В.[1], Поперенко Л.В.[1]
[1] Київськй національний університет імені Тараса Шевченка, просп. Глушкова, 4, Київ, 03022, Україна;
[2] Інститут проблем реєстрації інформації, вул. М. Шпака, 2, Київ, 03113, Україна
**E-mail: maryana1423@gmail.com*

В останній час підвищена увага приділяється вивченню нового матеріалу в нанотехнологіях – графену. За допомогою спектроскопічної еліпсометрії виявлено, що при нанесенні графену на золоту підкладку, змінюються його оптичні властивості [1]. Плівки оксиду гафнію є необхідним матеріалом для використання в різних галузях науки і техніки. Нанесення тонкої плівки HfO_2 в системі $Cu/HfO_2/TiO_2/Pt$ обмежує міграцію атомів Cu, тим самим підвищуючи надійність та узгодженість перемикачів в елементах пам’яті [2], а при використанні їх в багатошарових тонкоплівкових структурах, досягаючи високих значень показника заломлення, дозволяє застосовувати такі шари в пристроях вимірювання за допомогою високих рівнів потужності лазерів від ближньої ІЧ області спектра до ближньої УФ області спектра [3]. Тонкі плівки HfO_2, отримані із гідролізованих розчинів, є прозорими для УФ та видимої