I. V. Pyslar

REMOTE ENERGY RENEWAL OF RADIOELECTRONIC DEVICES INDEPENDENT SUPPLY SOURCES

Methods of energy renewal of radioengineering devices independent supply sources are considered. Method of obtaining electric energy as a result of raindrops kinetic energy is described. Experimental results of electromagnetic waves transmission efficiency without the increase of transmission side power while voltage multiplier usage are presented. Possibility of light energy usage of artificial sources of light is analyzed.

Key words: *alternative energy, electromagnetic energy, solar energy.*

Introduction

A great number of radioengineering devices, such as security systems, measuring sensors, requires independent supply, that would support the operation of the device in locations where there is no access to stationary 220 V electric grid. Application of storage batteries partially solves the problem of independent supply, but storage batteries must be constantly replaced or recharged. Usage of remote methods of storage batteries charging has the advantage over the wire – based method, as a result of reliability and the possibility of hiding the operating unit of the device.

Application of raindrops kinetic energy

The demand for the usage of the alternative energy grows all over the world [1]. In this connection, the search of new alternative sources of renewable energy becomes more intensive.

Kinetic energy of raindrops along with the solar energy or wind energy, is renewable source of energy. Nowadays raindrops are the least used source of energy. Annually hundreds of thousands cubic kilometers of water in the form of rain fall on the surface of the Earth. Each drop has kinetic energy that depends on the size of the drop and its speed.

Operation of such energy converter is ecologically safe, without any emissions into atmosphere and it is harmless for the environment. Unlike windmills, there is no limitations, regarding the usage of such installations in populated areas, because additional acoustic noise is not created. Besides, the device does not possess moving mechanical parts, that reduce considerably the time of failure – free operation.

In the absence of the sun (cloudy weather, night) usage of solar cells is not efficient. Conversion of raindrops kinetic energy in electric one could serve as a supplement (additional source) to photocells.

For the first time the experiments, aimed at obtaining electric energy from raindrops were carried out by French scientists [2, 3].The results of their research prove the possibility of rain energy usage.

The essence of the method of electric energy production is when raindrop reaches piezoelectric crystal plate-generator elastic mechanical deformation takes place, it generates electric voltage (direct piezoeffect) on the electrodes of piezo generator).

French scientists used PVDF plate of 25 μm of thickness as piezoelectric converters. It is revealed, that the energy, carried by one statistically average raindrop has the value of 2 μmJ ÷ 1mJ, depending on the diameter of the raindrop. Almost 1Wt/hr falls on 1 m^2 of the Earth surface.

It is quite natural, that with such values of raindrops energy, it would not be possible to construct industrial power plants that could supply even one residential house, because this energy would not be sufficient., although it would be enough to supply small power consumers, for instance, LED – based sources of light, radioreceivers, etc.

Modified variant of the device for using raindrops kinetic energy is developed, it operates in the following manner: when raindrops fall on the surface of piezoelectric-crystal plate, mechanical

deformation is developed in it, deformation causes the generation of voltage as a result of direct piezoelectric effect. Due to thin isolating material, piezoelectric crystal plate is covered, the possibility of short-circuiting of piezoelectric plate electrodes by water film is eliminated. To perform more efficiently the conversion of kinetic energy from the following raindrops piezoelectric crystal plate-generator is located under the angle of approximately ten degrees to the horizon. As a result the raindrops drip from the certain point of the given piezoelectric crystal plate--genertor on the other plate, located below. That is why, raindrops will not absorb kinetic energy of the next falling drop and will transfer the kinetic energy, obtained in the process of falling to the next piezoelectric crystal plate-generator. Electric circuit diagram is shown in Fig. 1.

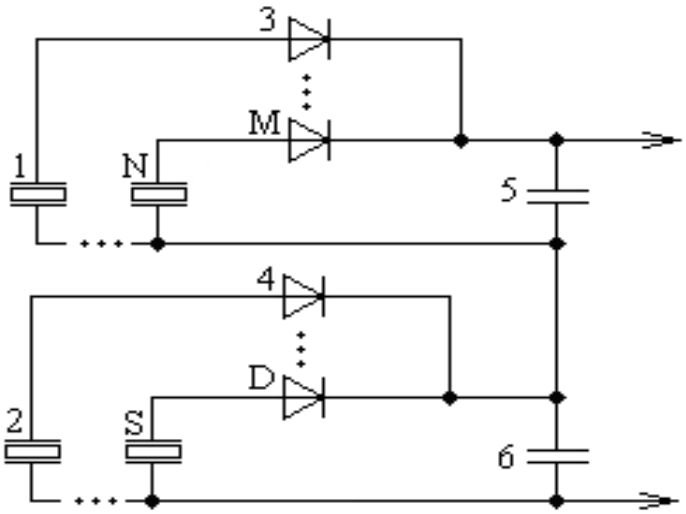

Fig. 1. Electric circuit diagram of piezo-electric converter of raindrops kinetic energy

To eliminate the inverse piezo-optical effect, that could emerge as a result of parallel connection of two and more piezo-electric crystal plates-generators (1) between themselves, it is necessary to use the diode (2). Number of diodes M equals the number of used piezo-electric crystal plates-generators N, i. e., $M = N$. Rate of capacitor charging (5) depends of the value of piezo-electric crystal plates-generators deformation and, as a result, on kinetic energy of raindrops and their amount during time unit and, therefore, on the number of charging electric pulses. Amount of electric pulses, charging the capacitor, can be considerably increased if the given capacitor is charged from numerous piezo-electric crystal plates-generators, connected in parallel. Serial connection of two capacitors (5) and (6), connected to sections $1 \div N$ and $2 \div S$ correspondingly of piezo-electric crystal plates-generators across diodes $3 \div M$ and $4 \div D$, enables to obtain two times greater level of output voltage. Fig. 2 shows the raindrops concentrator (7) that collects and concentrates the falling drops, dripping on piezo-electric crystal plate-generator. Waterprool box (8) fixed to frame-housing (9) contains necessary quantity of radioelements (diodes, capacitors), reliably protected from raindrops. Piezo-electric crystal plate-generator is fixed on the console (10), from the other side this console is fixed to frame-housing.

In case of cascade-type arrangement of piezo-electric crystal plates-generators (one over another) at the distance of approximately 1.5 m practically two times greater electric energy could be obtained from one raindrop. If the distance between piezo-electric crystal plates-generators increases, the velocity of drop falling reaches the values, at which gravitation is balanced by the force of air resistance.

Experimental results [4, 5] showed, that from one raindrop, on condition, that the raindrop falls from the height of 1.5 m voltage of capacitor charge on the level of 0.8 V from one section (one piezoelectric-crystal plate-generator, one diode and capacitor) can be obtained. Chaotic nature of raindrops falling does not allow to use efficiently the given method for producing electric energy.

The problem could be solved, collecting drops and directing them by means of concentrator. Raindrops concentrator is manufactured in the form of cone (Fig. 2) with groves in the middle of each section for directing the dripping drops in the centre of piezoelectric-crystal plate-generator.

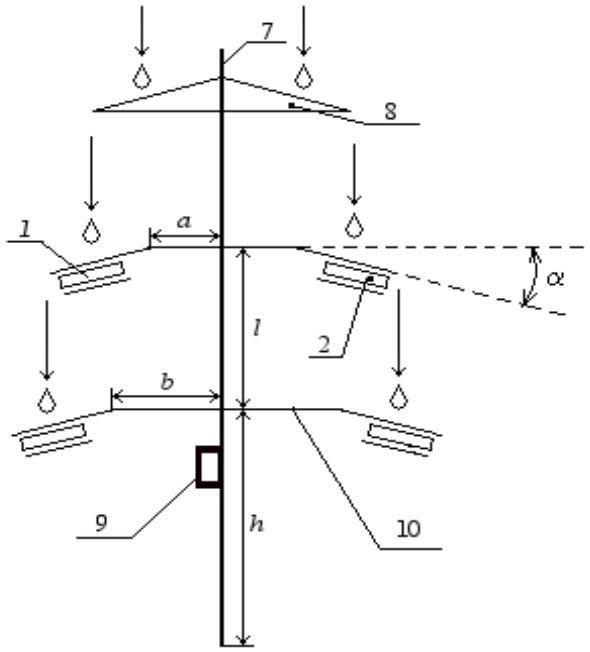

Fig. 2. Piezoelectric converter of raindrops kinetic energy

In the process of the experiment average value of kinetic energy of one raindrop – 0.96 mJ was determined. The results of the experiment prove the possibility of using the raindrops for obtaining electric energy and allow to recommend the application of piezo-electric converter of raindrops kinetic energy in power industry due to such advantages:

- absolutely ecological and safe operation of the device;
- lack of moving mechanical parts (rotors) – acoustic noise is not created;
- device can serve as the supplement to solar, wind power plants, hydro installations for electric energy generation.

On average, the fallout of atmospheric precipitations in Chernivtsi is 621 mm annually [6]. Area of Chernivtsi Region is 153 km^2. Thus, during the year, almost 95 million liters of water per year get on the surface of Chernivtsi Region, in energy equivalent, taking into account average value of one rain drop (0.96 mJ), is 1.8 milliard of joules or 3.3 Wt/hr, that is three times more than gets on the whole Earth surface (1 Wt / hr.). Let us assume that the area of of piezo-electric converter of kinetic energy is 1 m^2. In this case average energy that could be obtained annually from such converter in Chernivtsi Region is 0.16 mW|hr.

Usage of the energy of electromagnetic waves

In modern world no one could be surprised by the information about contactless charging devices, by means of which storage batteries of various gadgets could be charged remotely. Nowaday such basic principles of wireless transmission of electric energy are known: inductive (at small distances and relatively small powers), resonance (used in contactless smart-cards and RFID chips); directed electromagnetic for relatively large distances and powers (in the range from microwaves and practically to visible part of the spectrum).

The example of induction phenomenon usage for electric energy transmission and devices for

contactless charging of storage battery are electric toothbrushes, implanted electric devices [7], built-in modules for wireless charging of mobile devices in ultrabooks, monoblocks that charge storage batteries of peripheral devices [8]. In medicine contactless systems of energy transmission charge storage batteries of the devices, that were implanted in human body in the process of surgical intervention.

Increase of the distance of the device for transmission of electric energy is possible at the expense of corresponding increase of the power of electric energy transmitter. Such an approach to problem solution may worsen the principles of electromagnetic compatibility of radioelectronic devices. For the solution of the given problem contactless device for electric energy transmission, where resonance circuits and voltage-multiplier rectifier [9, 10] is suggested.

The device for electric energy transmission consists of transmitting and receiving units (Fig. 3).

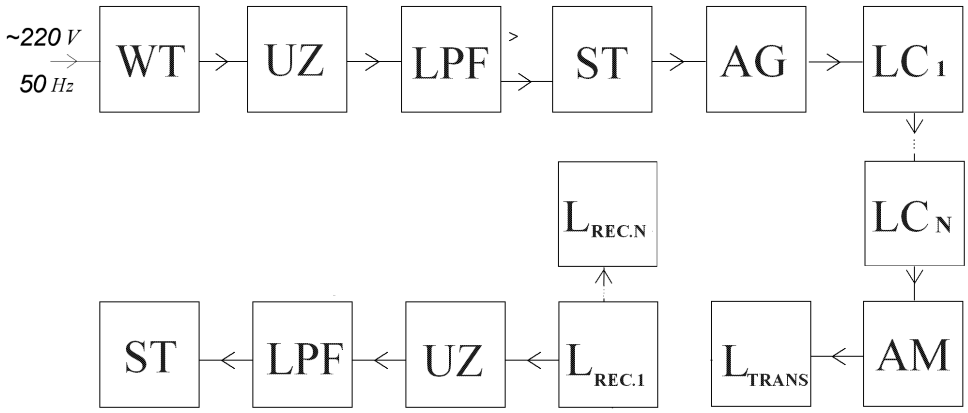

Fig. 3. Block-diagram of the device for wireless transmission of electric energy

Transmitting unit of contactless charging device contains transformer (WT), alternative voltage rectifier (UZ), low-pass filter (LPF), stabilizer (ST), clock generator (AG), series-oscillating circuit (LC), power amplifier (AM) and transmission coil (L transmition). Transmitter circuit is supplied from 220 V grid. Receiving coil (L-receiving), voltage-multiplier rectivier (UZ), filter (LPF) and stabilizer (ST) are connected to receiving unit. For energy transmission induction method is used. The given method of transmission uses the effect of electromagnetic induction.

Oscillations, formed by the generator, are far from being harmonic by its form. Taking into account relatively large input capacitance of field-effect transistor, and taking into consideration the necessity to provide the operation of the device at certain fixed frequency, series LC-circuit with corresponding resonance frequency is connected between generator and transistor. Powerful field-effect transistor amplifies the power of electric oscillations and sends them on the transmitting coil, thus alternating current of high frequency is created in the winding, this current forms around the circuit electromagnetic field As a result, in the second coil alternating voltage is formed, it is rectified, then smoothed by means of LC-filter. For voltage stabilization voltage regulator is used. Regulator is selected, taking into consideration the voltage, necessary for storage battery charging.

Experimental data show (Fig. 4), that at the output of receiving unit at the distance of 5 cm the voltage of 2.5 V could be obtained, using the rectifier with multiplier, factor of which is 5, voltage of 5 V could also be obtained, using the multiplier with factor 10 - 7 V.

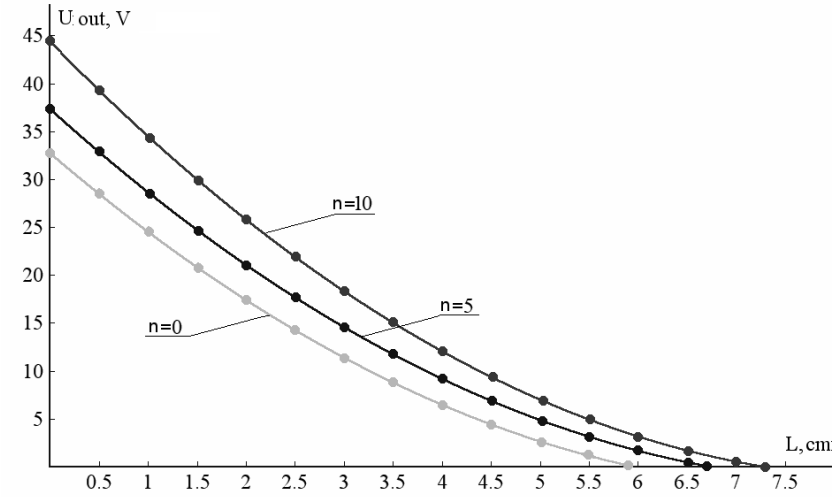

Fig. 4. Efficiency of voltage multiplier usage

In our case, non-symmetric voltage multiplier was used, its number of stages provides necessary voltage at the output [11]:

$$U_{out} = 2nU_{inp.} \tag{1}$$

More accurate calculations could be obtained, using the formula

$$U_{out} = 2nU_{inp} - (I_l * (4n^3 + 3n^2 - n) / (6fC)). \tag{2}$$

where I_l – load current; n – multiplicity; f – frequency of input voltage; C – capacitor capacitance.

Usage of light energy of the Sun and artificial sources of energy

Greater part of radioengineering devices can charge their storage batteries by means of semiconductor solar cells; these cells convert solar energy into electric energy, however at night, due to the lack of sunshine, the usage of such type of charging is not possible but there exist devices [12], that radiate artificial light, for instance, lamps, light emitting diodes. Theoretically, the radiated artificial light also could be converted into electric energy.

Experimental research showed that the efficiency factor by the power of artificial energy of light conversion (in our case LED with rated power 10 Wt) in electric energy did not exceed 0.002%. Number of semiconductor solar cells is limited only by area of coning angle of the radiated light from artificial sources of light.

Increase of efficiency factor of the sources of artificial light is possible if modern semiconductor solar cells are used, where efficiency factor is up to 31% [13], or with the increase of the area of semiconductor solar cell crystal.

Conclusion

The given paper considered experimental methods of charging the sources of independent supply of radioelectronic devices. The most suitable from the considered methods was the method of solar energy usage along with artificial sources of light. But in conditions of the lack of sunshine or artificial illumination there appears the need in searching of another method to provide independent supply. Using such method, the transmission of electromagnetic energy could be realized or kinetic energy of raindrops could be used. The latter, in its turn, is a good supplement to solar elements. Application of the device for conversion of kinetic energy of raindrops is very efficient in the regions

where it often rains (mountains, tropics). Possible locations, suitable for device application in populated area are – on the roofs of houses, under water gutters, etc. Unlike burning fossil fuel (coal, oil, gas), energy of raindrops is practically inexhaustible.

Regarding the transmission of electric energy by means of electromagnetic waves, the introduction of such technologies and their integration in modern devices will decrease the need in wired systems, this considerably increase the reliability of usage and safety of devices with self-contained supply.

REFERENCES

1. Kasich A.O. Alternative Energy : foreign and domestic experience / A. O. Kasich, Я. O. J.O. Litvinenko, P.S. Melnychuk // Proceedings of National University "Ostrozka Academy", series "Economics". – Ostrog, 2014. – №23. – P. 43 – 47. (Ukr).

2. Harvesting raindrop energy: theory [Electronic resource] / Romain Guigon, Jean-Jacques Chaillout, Thomas Jager, Ghislain Despesse // Smart Materials and Structures. – 2008. Vol. 17, №1. – Access mode to the journal : http://iopscience.iop.org/article/10.1088/0964-1726/17/01/015038/pdf.

3. Harvesting raindrop energy: experimental study [Electronic resource] / Romain Guigon, Jean-Jacques Chaillout, Thomas Jager, Ghislain Despesse // Smart Materials and Structures. – 2008. Vol. 17, №1. – Access mode to the journal : http://iopscience.iop.org/article/10.1088/0964-1726/17/01/015039/pdf.

4. Brailovskiy V. V. Usage of raindrop energy / V. V. Brailovskiy, I. V. Pyslar // Proceedings of Scientific Information Center "Knowledge" on the materials of IV International Scientific-Practical Conference: "Development of science in XXI century", Kharkov. – 2015. – P. 12 – 15. (Ukr).

5. Pat. 104441 Ukraine, IPC H 02 N 2/18, H01L 41/113. Piezoelectric converter of raindrops kinetic energy / Brailovskiy V. V., Pyslar I. V., Rozhdestvenska M. G. ; Patent applicant and holder of patent Yu. Fedkovych Chernivtsi National University. – № u 2015 08490 ; pending 31.08.2015, published 25.01.2016, Bul. № 2. (Ukr).

6. Climate of Chernivtsi, Pogodaiklimat.ru [Electronic resource] / «Weather and Climate». – Access mode : – http://www.pogodaiklimat.ru/climate/33658.htm. (Rus).

7. Pat. 31659 Ukraine, TPC A 61 N 1/362, H 04 B 10/10. Device for contactless charging of the storage batteries of implanted electrostimulators / Pentegov I. V., Volkov I. V., Prystupa A. L., Sheikovskiy D. O., Stemkovskiy E. P.; Patent applicant and holder of patent Chernigiv State Technological University. – № a 200602349 ; pending 03.03.2006; published 25.04.2008, Bul. № 8. (Ukr).

8. Wireless charging devices: innovations, principles of operation and good news [Electronic resource] / Habrahabr, Company Intel // Access mode : http://habrahabr.ru/company/intel/blog/147970/. (Rus).

9. Brailovskiy V. V. Contactless charging device / V. V. Brailovskiy, I. V. Pyslar, O. V. Typa // Conference abstracts "Measuring and computing engineering in technological processes", Odesa. – 2014. – № 13. – P. 145. (Ukr).

10. Pat. 95963 Ukraine, TPC (2015.01) H 02 J 17/00. Device for wireless transmission of electric energy / Brailovskiy V. V., Pyslar I. V., Rozhdestvenska M. G. ; Patent applicant and holder of patent Yu. Fedkovych Chernivtsi National University. – № u 2014 08701 ; pending 31.07.2014, published 12.01.2015, Bul. №1. (Ukr).

11. Cockroft-Walton Optimun Design guide v.2.0, Blazelabs.com [Electronic resource] / Blazes labs research. - Access mode : http://www.blazelabs.com/e-exp15.asp.

12. Brailovskiy V. V. Noise immune information system on light rays / V. V. Brailovskiy, I. V. Pyslar, M. G. Rozhdestvenska // International Scientific-Engineering Journal "Measuring and computing engineering in technological processes", Khmelnitski. – 2013. – P. 157 – 160. (Ukr).

13. Solar Cell Efficiency Tables / M. E. Green, K. Emery, D. L. King [et al] // Progress in photovoltaics: research and applications. – 2002. – №10 (355). – P. 355 – 360.

Pyslar Ivan – Post-Graduate with the Department of Radioengineering and Information Security, i.pyslar@chnu.edu.ua.

Yuri Fedkovych Chernivtsi National University.