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TESLA SWITCH OF 4 BATTERIES BASED ON THE ARDUINO UNO BOARD

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Abstract. *The paper considered the theoretical information of generators for several power sources, schematic their solutions, and the main disadvantages and advantages. A generator for 4 batteries based on field-effect transistors with optical galvanic isolation and a clock generator built on the basis of the Atmega328 microcontroller, which is part of the Arduino Uno device, was studied. The result of the study was the confirmation of the existence of the "Tesla-switch" effect. A program code was developed for the alternate switching of six transistor switches of the optical decoupling. The structural diagram of the device was studied, and the influence of the generator frequency and the consumed power of the load on the output parameters of the device were determined. The considered idea of energy saving and environmental friendliness of power supply systems is relevant, in particular in cases of blackouts.*

Keywords: generator, batteries, transistor, microcontroller

PRZEŁĄCZNIK TESLI DLA 4 AKUMULATORÓW OPARTY NA MODULE ARDUINO UNO

Streszczenie. *W artykule rozważono informacje teoretyczne dotyczące generatorów dla kilku źródeł zasilania, schematy ich rozwiązań oraz główne wady i zalety. Zbadano generator dla 4 baterii oparty na tranzystorach polowych z optyczną izolacją galwaniczną oraz generator zegara zbudowany na bazie mikrokontrolera Atmega328, który jest częścią urządzenia Arduino Uno. Wynikiem badań było potwierdzenie istnienia efektu "Tesla-switch". Opracowano kod programu do naprzemiennego przełączania sześciu przełączników tranzystorowych odsprzęgacza optycznego. Zbadano schemat strukturalny urządzenia oraz określono wpływ częstotliwości generatora i mocy pobieranej przez obciążenie na parametry wyjściowe urządzenia. Rozważana idea oszczędzania energii i przyjazności dla środowiska systemów zasilania jest istotna, w szczególności w przypadku awarii zasilania.*

Słowa kluczowe: generator; baterie; tranzystor; mikrokontroler

Introduction

One of the biggest challenges in the renewable energy field is the electricity production that depends on natural resources that humans cannot control. For example, solar power is only generated when sunlight is available and shuts off at night; Wind energy also depends on the wind presence, so if the wind speed is very low, the turbine does not turn, resulting in zero electricity flow to the grid. On the other hand, too much wind can damage the generator, so a delicate balance must be maintained to maintain constant energy production. Uncertainties in energy production in renewable energy technologies make integration difficult [10].

Constantly high-quality electricity is necessary to ensure stability and network high efficiency. The power supply quality allows the system to work well with high reliability and lower costs. On the other hand, poor power quality can have serious negative consequences for the power grid and industrial processes. This can lead to high costs and equipment failure. Power quality issues include frequency disturbance, voltage/current harmonics, low power factor, voltage fluctuations, and transmission line transients [14].

Most renewable energy installations that share their energy with the grid require large areas. In most cases, renewable energy sources depend on location, which can turn off users. First, some renewable energy sources are simply not available in different regions. Second, the distance between the renewable energy source and the grid is a major consideration in cost and efficiency terms. In addition, renewable energy sources depend on weather, climate, and geographical location, so one type of energy production is not suitable for a region. Although the field is improving, there is a lack of information and awareness about renewable energy benefits and needs. Investments and capital incentives were available for the renewable energy sources implementation. There is a clear need for government agencies to assist and advise applicants and potential recipients on how to apply for renewable energy incentives. The high initial installation cost is one of the main obstacles to the development of renewable energy. While the coal-fired power plant development requires about $6 per megawatt, wind and solar power plants are known to have required large investments as well. In addition to this, the storage systems of the produced energy are expensive and present a real challenge in megawatt production terms [7].

1. Literature review

Elektrodine Corporation tested the Tesla circuit with 4 batteries for 3 years [9]. They found that at the end of testing the battery showed no signs of any wear and tear, while using conventional lead-acid batteries. The systems were powered by lighting, heaters, televisions, small engines, and a 30 hp electric motor. If the batteries were discharged to the lowest value and then connected with a load, the batteries recharged in less than 1 min. Left without intervention, each of the batteries received a up to 36 V charge. When using mechanical switches, it was concluded that with a switching frequency of less than 100 Hz, the scheme is ineffective, and more than 800 Hz can be dangerous. The charging process is illustrated in Fig. 1 and Fig. 2 [15].

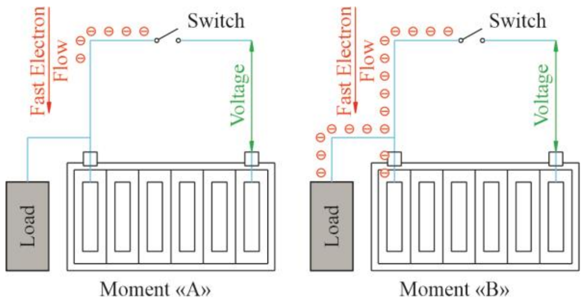

Fig. 1. Connecting the charger to the battery and the load. Moment «A» – the beginning of the electrons movement. Moment «B» – the stop of electrons at the entrance to the battery and the electrons movement into the load [9, 17]

At moment «A», the switch is closed, connecting the current source (battery, charged capacitor, other) with the lead-acid battery. Electrons begin to move outside the connecting conductor. Being very light, and not encountering significant resistance, they move very quickly (inside the conductor, electrons move very slowly, because movement through the conductor is difficult). All goes well until the «B» moment, when the electrons reach the lead plates inside the battery. Here they face a problem, because the current movement through the plates is carried out by lead ions. The latter perfectly cope with their task, but due to their great weight, they have a fraction of a second to start moving. This fraction of a second is very important. In that split second, the electrons pile up as they continue to come down the connecting conductor at tremendous speed. Therefore, at the moment «C» a significant amount of them accumulates [17].

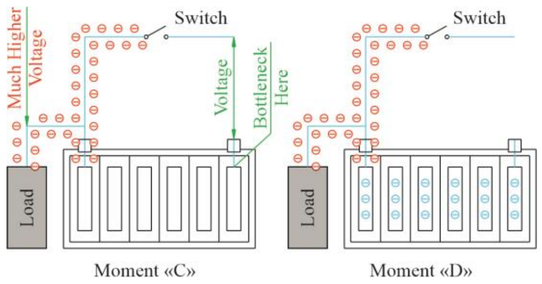

Fig. 2. Connecting the charger to the battery and the load. Moment «C» – increase in voltage at the inputs to the battery and load. Moment «D» – the beginning of the electrolyte ions movement in the battery – the charging beginning [9, 17]

The electron's large number accumulation is similar to the sudden connection of much higher voltage sources, giving capable a much larger current. This situation is very short-lived but has several very important consequences. First, at the moment «D» the battery receives a current that is much higher than the expected value from the source [13].

Second, excess energy enters the battery, charging it more than expected, and at the same time, some of the excess energy moves into the load, doing useful work. By load, we mean a lamp, a motor, an inverter, a pump, a drill, or whatever [1].

Therefore, excess energy is collected and used to perform useful work and simultaneously charge the batteries. Instead of being discharged by powering the load, the battery is charged by powering the load! That is why this scheme allows you to rotate the motor even from a discharged battery. This is made possible by the fact that the battery plates are lead composed, which creates an «electron plug» (a electrons plug), forcing the battery to charge and power the load at the same time. In principle, the more the battery is discharged, the faster it charges. John Bedini, who is an undisputed expert in this field, set up experiments in which the motors rotated continuously for three years or more, while the batteries did not discharge at all, despite the motors performing useful work [4].

2. Researches methodology

In order to ensure the necessary electrons accumulation, the switch closing must be very clear and instantaneous. A thyristor or field-effect transistor is suitable for these purposes, since, when turned on, it switches sharply and completely. There is an assumption that the Tesla candle with 4 batteries is based on this principle, and worked in the frequency range of 100…800 Hz [8].

This scheme can be improved by sharply disconnecting the electron flow from the output voltage source before the electron accumulation process is completed. This, in turn, causes a sudden (very short) increase in additional power, which increases the voltage and, as a result, allows you to increase the return of useful power to the load and accelerate the battery charge [2].

An even greater effect can be achieved if the next pulse reaches the battery and loads before the effect of the previous pulse dissipates. Suppose that this is what was found to be "unsafe" during experiments at Electrodyne Corporation at frequencies above 800 Hz. Maybe it's not that the battery or the load is "not ready" to accept excess energy, but rather that the components used are not designed for high currents and voltages. When the frequency is further increased, some circuit components are guaranteed to fail because they are not designed to work with high currents and voltages (note that the used output capacitors were designed for 100 V, which is eight times the nominal batteries voltage). This can hardly be called a problem, considering that they have a 12-volt battery, if necessary, they could perfectly withstand a 36 V charge voltage of [6, 11].

The Tesla candle from 4 batteries demonstrated the seemingly impossible thanks to:

- intercepting the current from the load and directing it to charge the second battery, instead of letting it dissipate;
- using the inertia of heavy lead ions with the help of short, sharp pulses (switching) [12].

John Bedini showed that the electric effect of Tesla with 4 batteries can be realized with three batteries (Fig. 3) [3, 9].

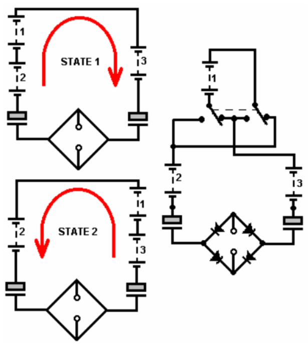

Fig. 3. Bedini generator for 3 batteries: operating cycles and connection method with mechanical switches [9]

In this circuit, the current in battery "1" never changes. This may not matter, since the energy supplied is taken from the zero-oscillation energy domain, not batteries. The flowchart used by John when he designed it is in Fig. 4.

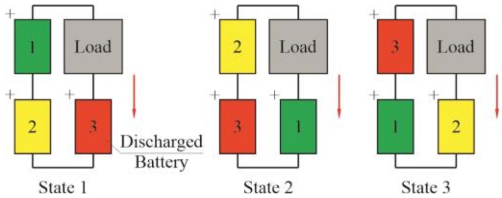

Fig. 4. Block diagram for a three-stroke Bedini generator [9]

This is a more difficult version of switches to implement. One battery "3" in the diagram is never charged. If mechanical switches were used (but they are not suitable because they are too slow), then the block diagram would look like this (Fig. 5).

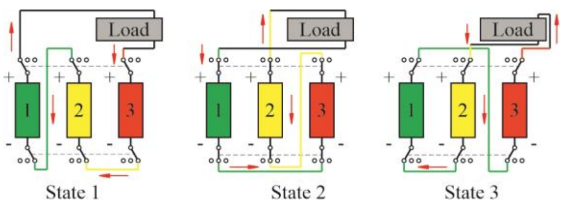

Fig. 5. The three-stroke generator with mechanical switches connection diagram [4]

The problem is to implement this scheme in an electronic version. Bedini said his device produces excess energy by creating resonance in the batteries, which are treated as capacitors. He warns that sometimes batteries explode – probably due to exceeding the limit frequency. He also noted that if the battery is used as a capacitor in a resonant circuit, it releases energy many times more than in normal mode (Fig. 6).

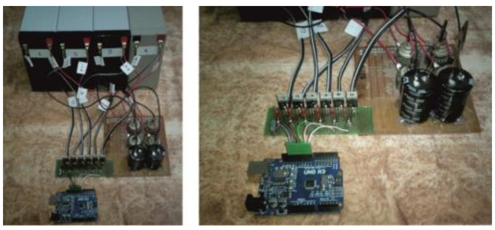

Fig. 6. Scheme of the installation for experiments (constructed by the authors)

Bedini was invited to participate in a symposium on the Tesla's centenary occasion in Colorado Springs on August 11, 1984. The symposium was dedicated to the Nikola Tesla's centenary arrival in the USA. It was organized by the Tesla Committee, Institute of Electronics and Electrical Engineers, Pikes Peak Section, and Ford Aerospace & Communications Corporation, Colorado Springs Operation. At the symposium, Bedini unexpectedly demonstrated a Tesla-type converter, the cigarettes pack size, that he had recently been building. During all demonstrations, which lasted 24 years, in the symposium framework, constant loads were connected to the working system. Despite this, the converter kept the nickel-cadmium battery fully charged [5, 16].

3. Results

The idea of a generator for 4 batteries is not new and arose long before the semiconductor radio electronic components appearance. Mechanical relays and contactors were used in the first generators for rapid battery switching. However, they could not provide stable contact, switching frequency and no distortion. It was also difficult to avoid contact losses.

With the element base development, it became easier to perform the creating task new schematic solutions. Semiconductor transistors have become an excellent substitute for mechanical switches when building circuits with high-speed switching. However, at high frequencies, the stabilizing problem the switching frequency remained. Control generators circuits with a quartz resonator successfully cope with this type complexity.

As a rule, circuits of arithmetic and logical devices are built with frequency stabilization on the basis of quartz. A microcontroller, like nothing else, will be suitable for the Tesla generator control device. When building the device, the microcontroller use will allow:

- configure system parameters;
- get a stable frequency at the output;
- connect additional sensors to monitor system operation;
- enter control elements into the device, which will be controlled by the microcontroller.

The relatively high voltages that will be operating in the system, there is a damaging high risk the control circuit and the microcontroller. On the other hand, the microcontroller itself is not designed to control power systems. In this situation, an optoelectric conversion device – an optocoupler or an optocoupler – will come in handy. It will allow stable and high-speed microcontroller controlled generator power circuits. The generator circuit and the control unit galvanic isolation will also be carried out, which will protect the microcontroller from damage by high voltage.

Considering all of the above, the Bedini-Tesla generator scheme was chosen with the following modifications:

- bipolar transistors were replaced by field ones;
- optocouplers were used for galvanic decoupling;
- a programmable microcontroller was chosen as the control device.

The generator power part is shown in Fig. 7

Figure 7 schematically shows the optocouplers parts, after they are all connected to the microcontroller according to the same scheme and it does not matter how they are physically connected, after the controlled output of the microcontroller (Fig. 8) they are freely programmable.

To carry out research, we need to alternately switch 6 transistor switches using galvanic (optocoupler) decoupling. Since the connection in the scheme and optocoupler control is no different from the connection and light diode control, the program code for the microcontroller will be very similar to the code for controlling 6 LEDs. The trios of LEDs (optocouplers) will alternately turn on and off at equal time intervals.

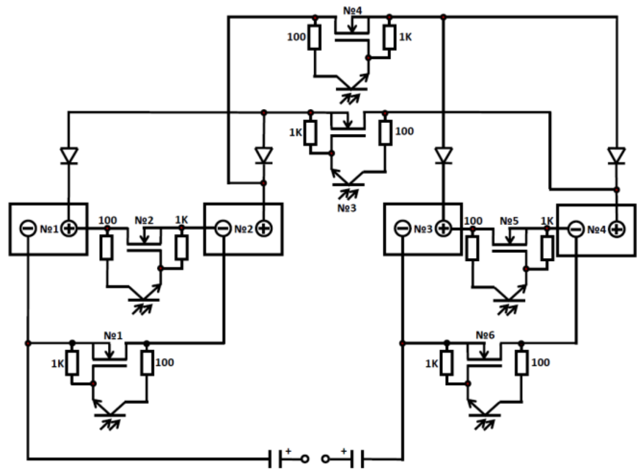

Fig. 7. The generator power part scheme (constructed by the authors)

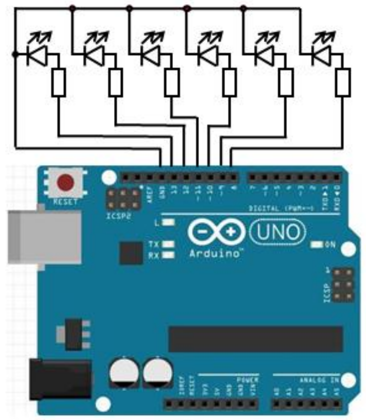

Fig. 8. The generator control part scheme (constructed by the authors)

So, the optocoupler control program will look like this (after the double slash, comments for each line are given):

```
                 // the setup block is executed once at startup
                 // reboots
voidsetup() {
pinMode(8, OUTPUT);     // digital pin 8 is triggered as an output
pinMode(9, OUTPUT);     // digital pin 9 is triggered as an output
pinMode(10, OUTPUT);   // digital pin 10 is triggered as an output
pinMode(11, OUTPUT);   // digital pin 11 is triggered as an output
pinMode(12, OUTPUT);   // digital pin 12 is triggered as an output
pinMode(13, OUTPUT);   // digital pin 13 is triggered as an output
}
                 // the loop block executes in a circle over and
over
voidloop() {
digitalWrite(8, LOW);    // on output 8 sets the potential LOW
digitalWrite(9, LOW);    // on output 9 sets the potential LOW
digitalWrite(10, LOW);   // on output 10 sets the potential LOW
digitalWrite(11, HIGH);  // on output 11 sets the potential HIGH
digitalWrite(12, HIGH);  // on output 12 sets the potential HIGH
digitalWrite(13, HIGH);  // on output 13 sets the potential HIGH
delay(5);               // delay in milliseconds
digitalWrite(13, LOW);   // on output 13 sets the potential LOW
digitalWrite(12, LOW);   // on output 12 sets the potential LOW
digitalWrite(11, LOW);   // on output 11 sets the potential LOW
digitalWrite(10, HIGH);  // on output 10 sets the potential HIGH
digitalWrite(9, HIGH);   // on output 9 sets the potential HIGH
digitalWrite(8, HIGH);   // on output 8 sets the potential HIGH
delay(5);               // delay in milliseconds
}
```

During the research, the program will not change except for the delay line (5). The number in parentheses is the delay in milliseconds between generator switches. By changing this number in both lines, you can change the generator frequency.

Battery parameters were measured at a 20 W load and a generator 100 Hz frequency. Measurements were made every 15 minutes, during 3 hours. Zero point measurements were performed with the generator turned off. After 3 hours of measurements, each battery was charged for one hour.

After measuring the voltage on the batteries in the generator mode at different frequencies, the generator was turned off, and the batteries were disconnected from the electronic keys. A load was connected to each battery in turn and measurements were made similar to the measurements of the generator (table 6).

According to the received data (table 1–5), graphs of the voltage change depending on the generator frequency and over a certain time period were drawn, Fig. 9 – Fig. 13.

Table 1. Results of voltage measurements on batteries at frequency 100 Hz

Battery number	Timestamps in minute												
	0	15	30	45	60	75	90	105	120	135	150	165	180
1	12.72	12.62	12.61	12.61	12.61	12.61	12.61	12.61	12.61	12.61	12.61	12.61	12.61
2	12.72	12.41	12.41	12.40	12.39	12.38	12.36	12.35	12.33	12.31	12.30	12.28	12.26
3	12.70	12.62	12.62	12.62	12.61	12.61	12.61	12.61	12.61	12.61	12.61	12.61	12.61
4	12.96	12.55	12.55	12.55	12.55	12.54	12.52	12.51	12.49	12.48	12.47	12.46	12.44

Table 2. Results of voltage measurements on batteries at frequency 200 Hz

Battery number	Timestamps in minute												
	0	15	30	45	60	75	90	105	120	135	150	165	180
1	12.71	12.50	12.49	12.48	12.47	12.46	12.45	12.44	12.43	12.42	12.41	12.36	12.35
2	12.52	12.19	12.16	12.12	12.08	12.05	12.00	11.95	11.90	11.82	11.69	9.39	9.51
3	12.69	12.51	12.50	12.49	12.48	12.48	12.48	12.47	12.46	12.45	12.45	12.43	12.42
4	12.73	12.39	12.36	12.34	12.31	12.29	12.26	12.24	12.22	12.20	12.17	12.17	12.17

Table 3. Results of voltage measurements on batteries at frequency 300 Hz

Battery number	Timestamps in minute												
	0	15	30	45	60	75	90	105	120	135	150	165	180
1	12.60	12.25	12.15	12.12	12.05	12.02	11.96	11.89	11.80	11.72	11.53	11.18	9.77
2	12.21	9.35	8.79	8.76	8.25	8.19	8.14	8.11	8.07	8.00	7.89	7.78	7.17
3	12.62	12.35	12.29	12.28	12.26	12.25	12.24	12.22	12.20	12.18	12.16	12.14	12.12
4	12.45	12.16	12.12	12.11	12.08	12.07	12.05	12.02	12.01	11.98	11.96	11.95	11.94

Table 4. Results of voltage measurements on batteries at frequency 400 Hz

Battery number	Timestamps in minute												
	0	15	30	45	60	75	90	105	120	135	150	165	180
1	12.43	12.16	12.10	12.05	11.98	11.90	11.81	11.64	9.35	8.52	7.48	7.38	7.33
2	12.43	12.06	11.96	11.83	9.32	8.22	7.93	7.35	7.18	5.91	5.31	4.00	3.93
3	12.31	12.01	11.98	11.94	11.88	11.67	11.45	9.76	9.55	9.24	8.44	7.31	7.26
4	12.16	11.82	11.77	11.72	11.73	11.70	11.68	11.67	11.61	11.62	11.60	11.60	11.60

Table 5. Results of voltage measurements on batteries at frequency 500 Hz

Battery number	Timestamps in minute												
	0	15	30	45	60	75	90	105	120	135	150	165	180
1	12.38	12.12	12.07	11.99	11.93	11.90	11.60	10.41	9.29	9.29	8.27	7.88	7.18
2	12.45	12.07	12.01	11.92	11.78	11.52	8.18	7.42	7.39	7.17	5.40	5.08	3.95
3	12.28	12.10	12.07	12.02	11.98	11.96	11.86	11.79	11.68	9.46	9.13	7.55	7.34
4	12.21	11.95	11.89	11.82	11.75	11.72	11.72	11.70	11.67	11.62	11.63	11.62	11.64

Table 6. The measurements results when connected are loaded to each battery separately when the generator is turned off

Battery number	Timestamps in minute												
	0	15	30	45	60	75	90	105	120	135	150	165	180
1	12.18	1.96	0										
2	12.26	4.35	0.58	0									
3	12.19	2.83	0										
4	12.18	11.68	11.46	11.08	5.13	2.34	0.36	0					

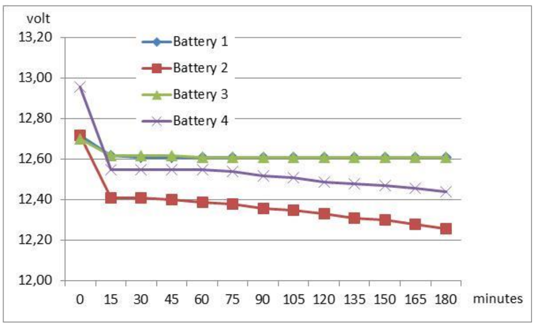

Fig. 9. The generator operation at the frequency 100 Hz, load 20 W

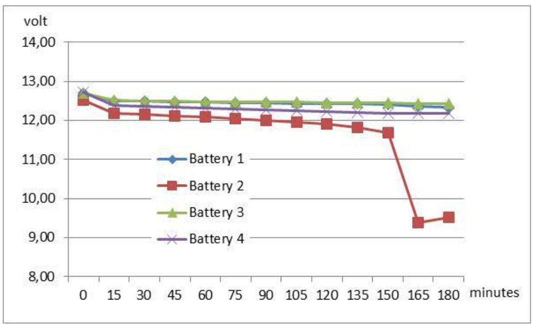

Fig. 10. The generator operation at the frequency 200 Hz, load 20 W

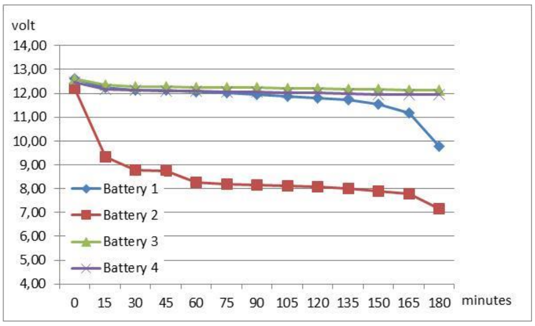

Fig. 11. The generator operation at the frequency 300 Hz, load 20 W

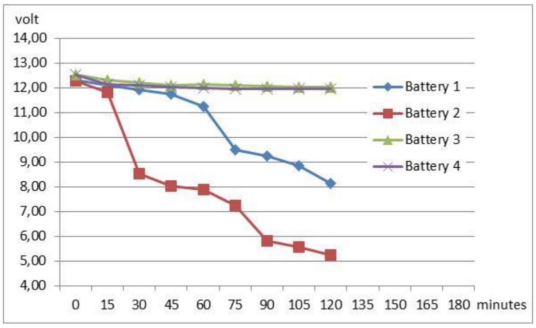

Fig. 12. The generator operation at the frequency 400 Hz, load 20 W

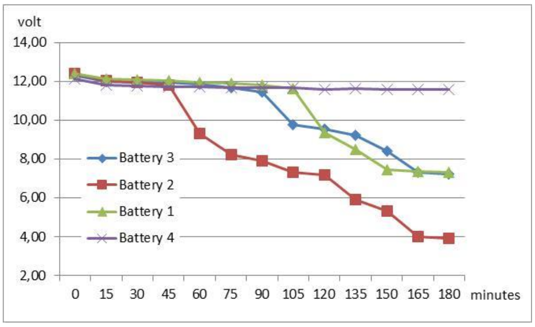

Fig. 13. The generator operation at the frequency 500 Hz, load 20 W

Since in the generator mode, 4 batteries worked on the load, and in the control measurement mode, each battery was connected to the same load separately, it would be wrong to compare the results without adjusting the time intervals. If when measuring the voltage, the battery has a certain voltage, then in the generator mode – 4 batteries – the same voltage should be obtained in a time period that is 4 times greater.

Thus, it is logical to compare voltage measurements on the battery, for example, at the 15th minute in mono mode with measurements on the same battery in the generator mode at the 60th minute of operation. Table 7 and Fig. 14 displays the time-corrected measurement results of each battery when the load is directly connected.

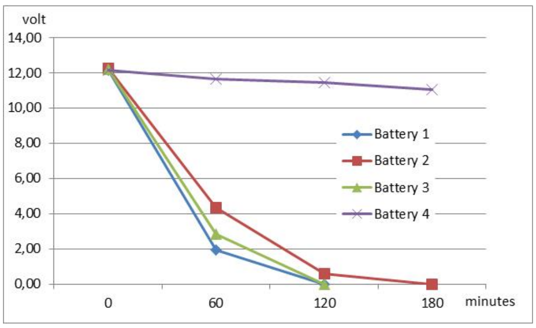

Fig. 14. The battery parameters measurements in mono mode

Table 7. The measurements results when connected are loaded to each battery separately when the generator is turned off

Battery number	Timestamps in minute			
	0	60	120	180
1	12.18	1.96	0	
2	12.26	4.35	0.58	0
3	12.19	2.83	0	
4	12.18	11.68	11.46	11.08

Analyzing figure 14, we can conclude that charging the batteries in mono mode is performed by discharging batteries 1, 2, and 3. In this way, the use of the proposed circuit 4 of the Tesla battery generator makes it possible to distribute the charge between the batteries and increase the time of their effective operation by approximately 30%.

4. Conclusions

In the research course, a device based on Nikola Tesla's 4-battery generator was created.

After analyzing the existing options for building similar systems, a structural scheme was determined. This device has a construction structure that allows you to fully define the requirements for the problems solved by the device, as well as the specified technical requirements. Also, in the performing work process, appropriate technical indicators were achieved that meet the technical task requirements. And also the product quality level is ensured, which, thanks to its simplicity and flexibility, allows for further development, changes in schematic and technical implementation and conducting research in the future.

Advantages:

- the scheme simplicity
- ease of programming the microcontroller
- possibility to change the frequency
- the control system protection due to the galvanic separation between the generator and the field transistors
- longer battery life within one charge and discharge cycle.

In the future, it is possible to improve this device, namely to change the frequency by changing the microcontroller software code. It is also possible to additionally connect various sensors, executing devices and information display devices. It is also possible to reconfigure the generator power part to reduce the temperature of the transistor keys and, as a result, increase the device efficiency.

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