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PULSE POWER

Ph. M. Kanarev
E-mail: kanphil@mail.ru **http://Kanarev.innoplaza.net**

INTRODUCTION

There is an American scientist among the laureates of the first Russian prize "Global Energy" of the year of 2003. He was awarded the prize, because (as it was informed) he managed in his laboratory to form an electric pulse, which power is equal to power of all power stations of the world. Let us show that a mistake during the pulse power calculation is a result of this experiment. For this purpose, let us analyze energetics of pulses of voltage, current and power being obtained by us while determining electric energy consumed by the cell of water electric generator of heat [1].

ANALYSIS

The oscillograms of pulses of voltage, current and power being obtained with the help of PCS500A oscilloscope are given in Figs 1, 2 and 3. Horizontal scale is 50 μs per division. [1].

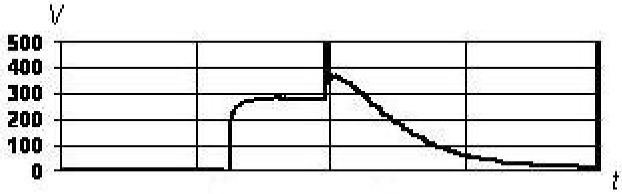


Fig. 1. Voltage pulse

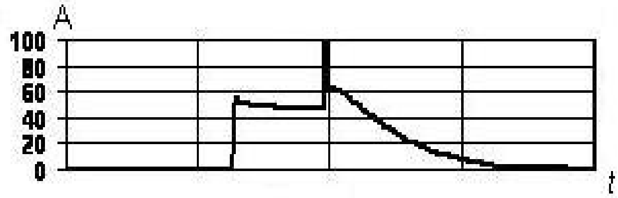


Fig 2. Current pulse

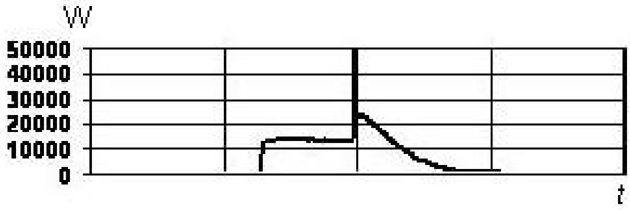


Fig. 3. Power pulse

It is clearly seen (Figs 1, 2 and 3) that a form of pulses of voltage, current and power can be reduced to a rectangular form. Pulse duration will be equal to 0.00007 s, pulse repetition period is 0.00725 s, pulse frequency is f =1000/7.25=137.9. Duty ratio is equal to S=0.00725/0.00007 =103.6. If the pulse form is considered to be a rectangular one, duty factor will be equal to Z=1/103.6=0.0096. Voltage pulse amplitude is U_{IC} =300 V, current pulse amplitude is I_{IC} =50 A and power pulse amplitude is P_{IC} =300x50= 15 kW. Taking it into consideration, average voltage value will be $U_C = U_{IC} \cdot Z$ = 300x0.0096=2.88 V, average current value will be $I_C = I_{IC} \cdot Z$ = 50x0.0096=0.48 A, average power value will be $P_C = P_{IC} \cdot Z$ =15000x0.0096=144 W.

Let us put a question: has power pulse (Fig. 3) 15 kW actually, and is average value of pulse power equal to 144 W? Is the calculation carried out correctly? [1]

In accordance with Si-system, if one voltage pulse with amplitude of U_{IC} and with assigned duration τ is supplied per second and one current pulse with amplitude of I_{IC} and with duration τ, the above-mentioned values of voltage and current can be used for power calculation **only in the case** when their duration corresponds to one second. Such requirement originates from the power unit definition by Watt. Watt is work done per second by current and voltage **continuously**. Consequently, pulse action of voltage and current should be prolonged till one second. Naturally, an oblong rectangle is obtained instead of a pulse in this case. Height of this rectangle multiplied by a pulse form factor k (k=1 if the pulse form is reduced to a rectangular form and k=0.5 if the pulse form is reduced to a triangular form), and it will be an average value of voltage U_C if voltage pulse U_{IC} is spread, an average value of current I_C if current pulse I_{IC} is spread, and an average value of power P_C if power pulse P_{IC} is spread.

If not one, but several pulses are generated during one second, the above-mentioned average values of pulses of voltage, current and power, **as it is considered now**, should be multiplied by frequency of pulse f. This operation is equivalent to a division of amplitude values of voltage U_{IC}, current I_{IC} and power P_{IC} by duty ratio S. If we take into account that $S = 1/k \cdot \tau \cdot f$, average values of voltage and current will be equal to:

$$U_C = U_{IC} \cdot k \cdot \tau \cdot f = \frac{U_{IC}}{S} = 300 \cdot 1 \cdot 0.00007 \cdot 137.9 = 2.88B \quad (1)$$

$$I_C = I_{IC} \cdot k \cdot \tau \cdot f = \frac{I_{IC}}{S} = 50 \cdot 1 \cdot 0.00007 \cdot 137.9 = 0.48A. \quad (2)$$

If we pay attention to the formulas (1) and (2), we'll see that the amplitude values of voltage U_{IC} and current I_{IC} are reduced to a duration of one second; that's why their values are in strict correspondence with Si-system. It is a vivid example of the fact that average power of the pulse should be determined according to the formulas:

$$P_C = U_C \cdot I_C = 2.88 \cdot 0.48 = 1.38Bm \quad (3)$$

$$P_C = \frac{U_{IC} \cdot I_{IC}}{S^2} = \frac{300 \cdot 50}{103.6^2} = 1.39Bm \quad (4)$$

But this result is considered to be erroneous, because voltage and current are changed simultaneously and synchronously, and their duty ratios are united in one duty ratio in power pulse; that's why, **as it is considered now**, average pulse power should be determined according to the formula [3], [4]

$$P_C = \frac{U_{IC} \cdot I_{IC}}{S} = \frac{300 \cdot 50}{103.6} = 144.80Bm \quad (5)$$

This value of average power will be obtained if we use the formula

$$P_C = P_{IC} \cdot k \cdot \tau \cdot f = 15000 \cdot 1 \cdot 0.00007 \cdot 137.9 = 144.80Bm. \quad (6)$$

Later on, we'll prove experimentally that power pulse (Fig. 3) has not 15000 W and 144.80 W, but only 1.40 W. That's why a question emerges: where does the essence of the mistake lie?

A single division by duty ratio of a product of the amplitude values of voltage U_{IC} and current I_{IC} (formula 5) is equivalent to stretching till duration of one second of power pulse. It appears from this that either voltage pulse, or current pulse (i.e. one of two pulses) is stretched to duration of one second in the formula (5). This process can be shown graphically (Fig. 4) if it is supposed that the experiment has lasted 300 s.

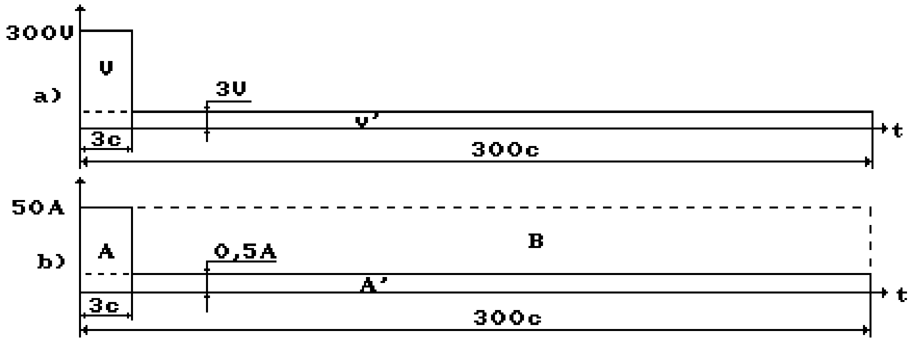


Fig. 4. Diagram of duration of maximal (300 V, 50A) and average (3.0 V, 0.5A) values of voltage and current

Average values of voltage of 2.88≈3.0 V and current 0,48 ≈0.50 A have been obtained in consequence of division of their maximal values of 300 V and 50 A by duty ratio of 103.6 ≈100. If we divide only voltage $U_{IC} = 300$ V by duty ratio, and we'll not divide current $I_{IC} = 50$ A, it will mean that current value during 300 s with average voltage value of 3.0 V will be equal to 50 A (Fig. 4, b). It is a vivid contradiction, which results in the mistake in the formulas (5 and 6).

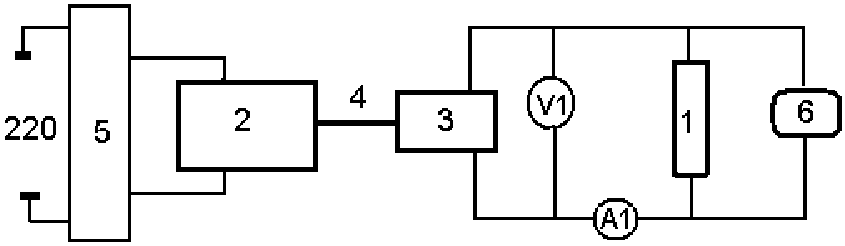
As two values (voltage and current) are changed, it is necessary to determine average power during pulse consumption of energy according to the formulas (3 and 4). The formulas (5 and 6) take into account a change of one value, which forms power, voltage or current. That's why they should give an incorrect result. **How can it be checked?**

It is necessary to carry out such an experiment where not the electronic pulse generator connected with the whole grid galvanically has been used, but a rotating magnetic generator, like a magnetic inductor. Power pulses being generated by the magnetic inductor and sent to the consumer will be on the same shaft of the magnetic inductor and the electric motor, which rotates the magnetic inductor. Galvanic coupling between the general grid and the grid of the magnetic inductor is absent in this case. Electric energy of pulses of the magnetic inductor is converted into mechanical energy of the jointly rotating shafts of the magnetic inductor and the electric motor.

As the electric motor is connected in the general grid, an electric motor will show in general the energy being consumed by the electric motor, the magnetic inductor and the consumer connected to the grid of the magnetic inductor. If we write energy consumption by the electric motor, the magnetic inductor and the consumer and subtract electric energy consumption of the electric motor and the magnetic inductor from the obtained value, we'll get energy being generated by the magnetic inductor and consumed by the consumer [5], [6].

Thus, as we have the readings of the electric energy meter and the pulses of voltage and current being written with the help of the oscilloscope, we can see, which formula (3 and 4) or (5 and 6) is correct and which one is erroneous. A diagram of such experiment is shown in Fig. 5. An oscillogram of pulses of voltage and current is shown in Fig. 6.

The cell of the water electric generator of heat has been used as a consumer of electric energy generated by the magnetic inductor (Fig. 7).



Fig, 5. Electrical diagram of the system: 1 - cell; 2 - electric motor; 3 - magnetic inductor; 4 - the coupling connecting the motor shaft with the generator shaft; 5 - electric meter; 6- Nektronix TDS 2014 oscilloscope

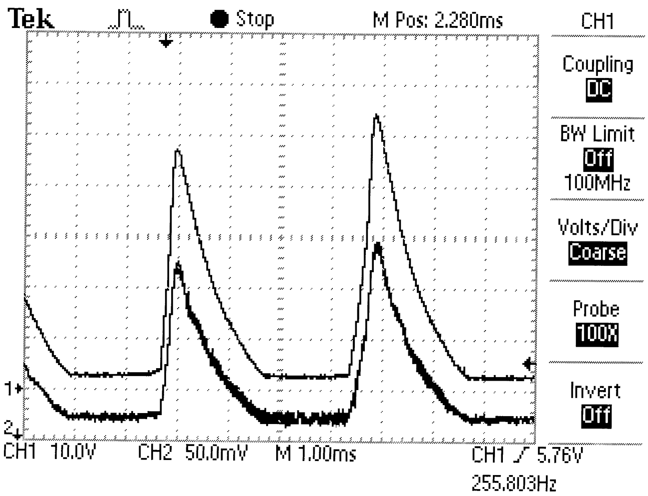


Fig. 6. Sample of an oscillogram of voltage and current being generated by the magnetic inductor

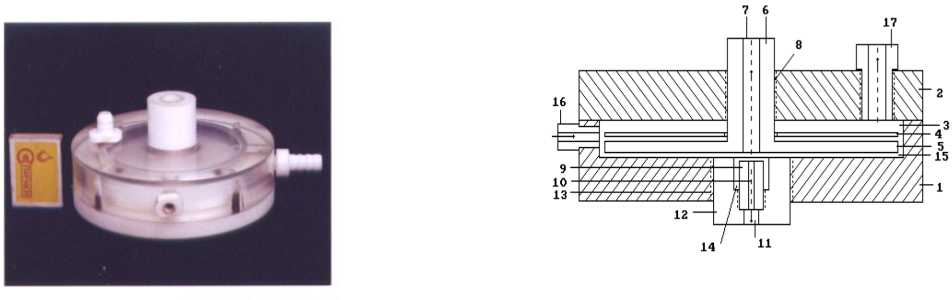


Fig. 7. Photo and diagram of the cell of the water electric generator of heat (patent No. 2258098)

Voltage pulses were rectified and corrected; the magnetic inductor was driven with the help of a single-phase electric motor from the grid (Fig. 5). In order to determine energy consumed by the electric motor, a domestic electric meter was used. The readings of the electric meter 5 were duplicated by the readings of voltmeter V_1 and ammeter A_1 being arranged before the cell 1 as well as by the readings of the oscilloscope 6 (Fig. 5). Heated solution energy was determined in a standard way.

The experimental results are given in Table 1. Here ΔP is power consumed by the cell from the mains. It is equal to a difference between the readings of the electric power meter when the load (the cell) is energized and de-energized. P_1 is heat power of the heated solution. P_2 is power being indicated by the voltmeter and the ammeter arranged before the cell. P_3 is power being indicated by the oscilloscope and determined according to the formula (10). P_3^0 is power indicated by the oscilloscope and determined according to the formula (11). $\eta = P_1 / \Delta P$ is an index of efficiency of the solution heating process.

Table 1. Indices of the direct experiment

Experiment No.	P_1, W	ΔP, W	P_2, W	P_3, W	P_3^0, W	$\eta = P_1/\Delta P$
1	2	3	4	5	6	7
1	9.40	3.10	4.32	3.80	17.10	3.10
2	9.80	3.53	4.45	3.41	15.35	2.77
3	10.20	3.10	4.40	4.30	19.35	3.34
4	11.30	4.80	5.10	4.80	21.60	2.35
5	13.28	4.00	5.00	5.30	23.85	3.32

We managed to adjust the magnetic inductor in such a way that it generated voltage pulses; its average amplitude was equal to $U_{IC} \approx 46V$. Average amplitude of current pulse $I_{IC} \approx 1.5A$ was equal to. Pulse duration was $\tau \approx 0.0018s$. Pulse frequency was f = 255.8 Hz. Pulse duty ratio was $S \approx 4.5$. It is natural that such pulse form is easily reduced to a triangular form; then, $k = 0.5$. As a result, the formulas (1) and (2) give such average values of voltage and current.

$$U_C = U_{IC} \cdot k \cdot \tau \cdot f = \frac{U_{IC}}{S} = 46 \cdot 0.5 \cdot 0.0018 \cdot 255.8 = 10.60B \tag{7}$$

$$I_C = I_{IC} \cdot k \cdot \tau \cdot f = \frac{I_{IC}}{S} = 1.5 \cdot 0.5 \cdot 0.0018 \cdot 255.8 = 0.345A. \tag{8}$$

A calculation according to the formulas (3 and 4) gives a result P_3, which is close (9 and 10) to the readings of the meter ΔP (Table 1, experience 2) and the readings P_2 of voltmeter V_1 and ammeter A_1 (Fig. 5).

$$P_C = P_3 = U_C \cdot I_C = 10.60 \cdot 0.345 = 3.66Bm \tag{9}$$

$$P_C = P_3 = \frac{U_{IC} \cdot I_{IC}}{S^2} = \frac{46 \cdot 1.5}{4.5^2} = 3.41Bm \tag{10}$$

Then according to formula (5), average power will be equal to (Table 1, experiment 2)

$$P_C = P_3^0 = \frac{U_{IC} \cdot I_{IC}}{S} = \frac{46 \cdot 1.5}{4.5} = 15.35Bm \tag{11}$$

It is an explicitly wrong result, because the electric power meter has shown that in this case the cell has consumed ΔP=3.53 W (Table 1, experience 2).

When we compare the calculation results according to the formulas (10 and 11) with the experimental results (Table 1, experiment 2), we see that when determining average power according to the oscillogram the amplitude values of voltage and current should be divided by duty ratio **not once** (11) as it is stipulated in the manuals [3], [4], **but twice** (10) as it is shown in the formulas (4 and 10). Only this power value will agree with the reality. It appears from this that the formulas (3, 4, 9 and 10) are correct and the formulas (5, 6 and 11) are erroneous.

Thus, the power pulse shown in Fig. 3 has not 15 kW and not 144.8 W, but only $P = U_C \cdot I_C = 2.88 \cdot 0.48 = 1.40W$.

Let us see what the results are when motor 2 and magnetic inductor 3 (Fig. 5) are replaced by the electronic pulse generator (Figs 8, 9). The oscillograms of the experiment are shown in Figs 1, 2 and 3.

As it is shown in Fig. 1, an average amplitude of voltage pulses is 300 V when an average value of voltage is 3.0 V (Fig. 9); an average amplitude of current pulses (Fig. 2) was 50 A when an average value current is 0.5 A (Fig. 9). Pulse duration is τ =0,00007 when duty ratio is S=100 and duty factor is $Z = 0.01$.

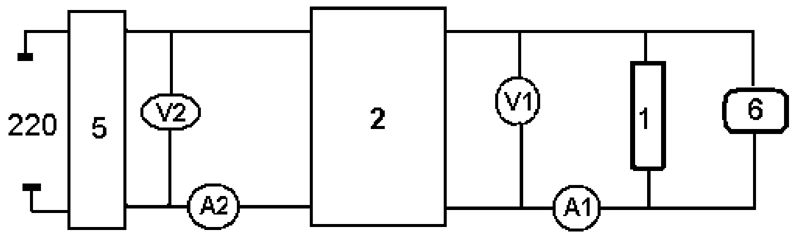


Fig. 8. Electrical diagram of the system: 1 - cell: 2- electronic pulse generator; 5 - electric power meter; 6- PCS500A oscilloscope

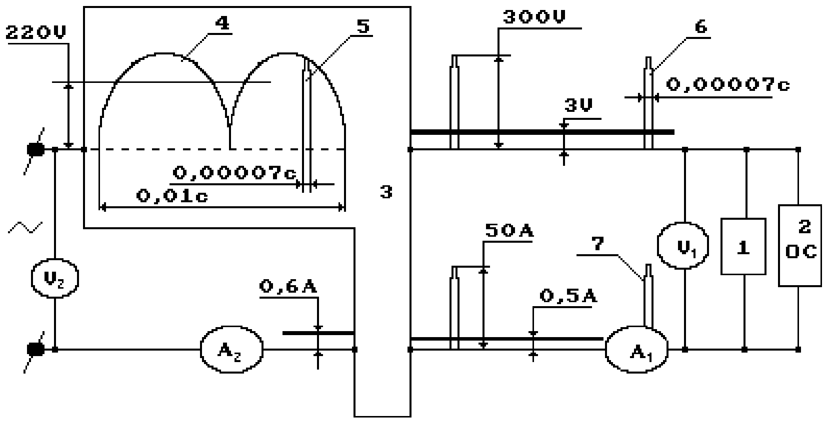


Fig. 9. Block diagram of electric value measurement: 1 - cell; 2 – PCS500A electronic oscilloscope; 3 - pulse generator

In accordance with the readings of voltmeter V_1, ammeter A_1 and oscilloscope (Figs 8, 9), power at the input into the cell of water electric generator of heat is P_C=3.0x0.5=1.50 W on average. A calculation according to the formulas (3 and 4) gives a near result of 1.40 W.

A question arises: what power will be indicated by the instruments: voltmeter V_2 and ammeter A_2 arranged before the pulse generator (Figs 8 and 9)? It is quite natural that the voltmeter will indicate mains voltage V_2= 220 V, current value is increased as well, because there are two loads before ammeter A_2: cell 1 and electronic pulse generator 3. I_2=0.65 A is in our experiment (Fig. 9). As a result, power implemented by pulse generator 3 and cell 1 is P_1=220x0.65=143 W; it is at variance with the result (P_C=1.4 W) being obtained according to the formulas (3 and 4). **Their correctness has been proved by us experimentally.**

Let us pay attention to the fact that the obtained result is P_1=143 W. It is near to the result P_C=144.8 being obtained during the calculation according to the incorrect formulas (5 and 6).

Now we know that actual energy consumed by the cell is indicated by the instruments (voltmeter V_1, ammeter A_1) arranged before it. The oscilloscope readings will correspond to actual consumption of energy by the cell if the formulas (3 and 4) are used. The formulas (5 and 6) distort a result in proportion to pulse duty ratio. When pulse duty ratio is equal 100, the formulas (5 and 6) increase an actual power consumption by the cell nearly 100fold. Such are the properties of electric circuits with the **electronic pulse generator**. It does not implement evident energy efficiency of the cell. Energy efficiency of the cell is implemented only in the case when energy source, which is similar to **magnetic inductor**, is used (Table 1) [5], [6].

Thus, we have eliminated the contradictions between the instrument readings and the calculations during pulse consumption of electric power. Now let us put such a question: according to what formula has the laureate of the prize "Global Energy" calculated pulse power? An answer is clear: according to the formula

$$P_{IC} = U_{IC} \cdot I_{IC} = P_{WORLD} \quad (12)$$

which (as it is supposed in modern physics) determines instantaneous power of a pulse and which (as we have already shown) is a fictitious value.

As power of one pulse is given in the formula (12), it is quite natural that U_{IC} and I_{IC} can have very large values. But in any case, their product gives the fictitious value, not the actual value. If we take pulse duty ratio, which has been used in our experiments ($S = 100$) and keep in mind that in order to get actual pulse power the right part of the formula (12) should be divided by a square of duty ratio (in the case being considered by $S^2 = 100 \cdot 100 = 10000$), actual power of pulse P_{WORLD} is 10000fold less than the value, for which the prize was awarded. If we take into account the fact that pulse duration being obtained by the laureate was considerably less than the one being obtained during our experiment and duty ratio was considerably greater than 100, the actual value of the power pulse will be millionfold less than the value, for which the prize was awarded.

CONCLUSION

Let us put the representatives of the committee "Global energy" at their ease. Their mistake is nothing as compared with the mistakes made by the Nobel prize [7].

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