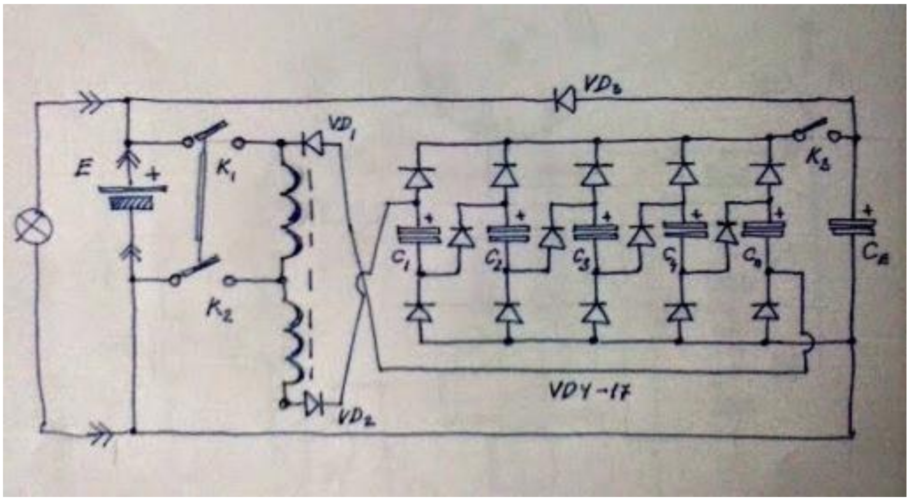
Thursday, Fall 17, 2022

Rotary Pulse Charger (RIZU)

I have previously tried to design and build a similar device. But in that version, I tried to increase the self-induction pulse in voltage and convert it through a capacitor buck converter. LINK



The idea was unsuccessful, due to the high ohmic losses in the circuit. In this case, the reverse pulse was short in time, compared with the excitation pulse. Currently, there are two variants of this design, with permanent magnets and valve-reactive format. Let's start with a description of an interesting design of generators.

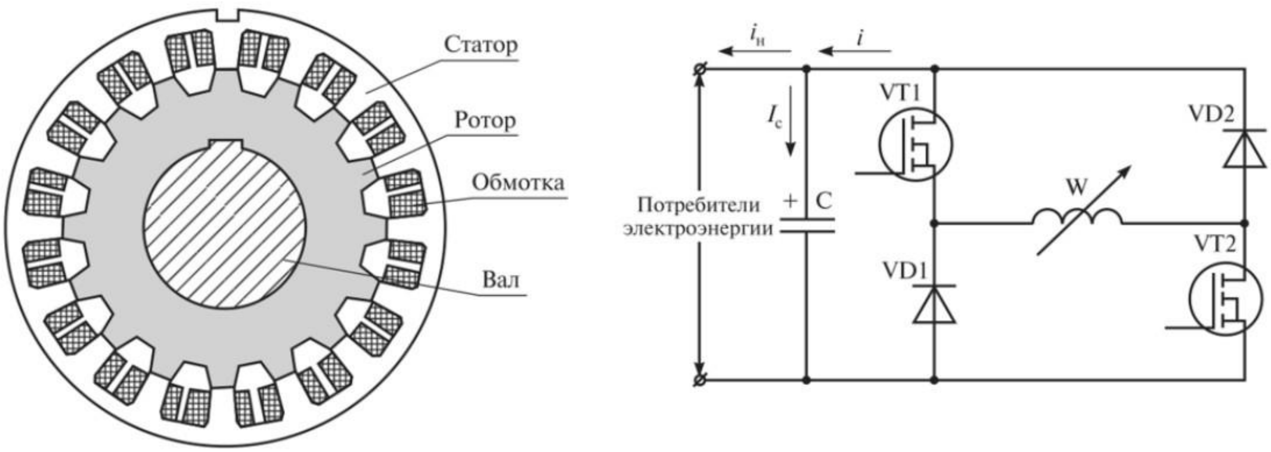
VALVE INDUCTION GENERATORS

Currently, work is underway to use switched reluctance generators (RIG) as an autonomous source of energy for passenger cars, which allow increasing power, have better specific performance and improve reliability and maintainability, as well as reduce the consumption of non-ferrous metals and structural materials.

TIG refers to parametric electric machines, the principle of its operation is based on a periodic change in the inductance of the stator winding depending on the angular position of the rotor . *The magnetic circuits of the stator and rotor have protruding poles - teeth. In the stator slots there is a lumped type winding, the rotor teeth are not covered by the winding and serve to close the magnetic flux. With this design, the stator winding inductance changes from the maximum value when the axes of the stator and rotor teeth coincide (tooth-tooth position) to the minimum value when the tooth-groove position. The shape of the winding inductance curve, in addition to the angular position of the rotor, is affected by the degree of saturation of the magnetic circuit.*

The configuration of the teeth and cavities is chosen in such a way that the difference between the maximum and minimum winding inductances, depending on the angle of rotation of the rotor, is as large as possible. This contributes to efficient electromechanical energy conversion, since the electromagnetic torque and, ultimately, the energy supplied to the electromagnetic circuit of the generator depend on the rate of change of the inductance.

The operation of the generator is carried out as follows (Fig. 1). Mechanical energy is supplied from the wheel pair to the generator shaft. When the power source (excitation) is connected, at a moment close to the coincidence of the teeth *of the stator and the rotor of the excited phase, the current begins to flow in the stator winding along the circuit: C - VT 1 - W - VT 2 - C. Energy is used as a source of excitation.*

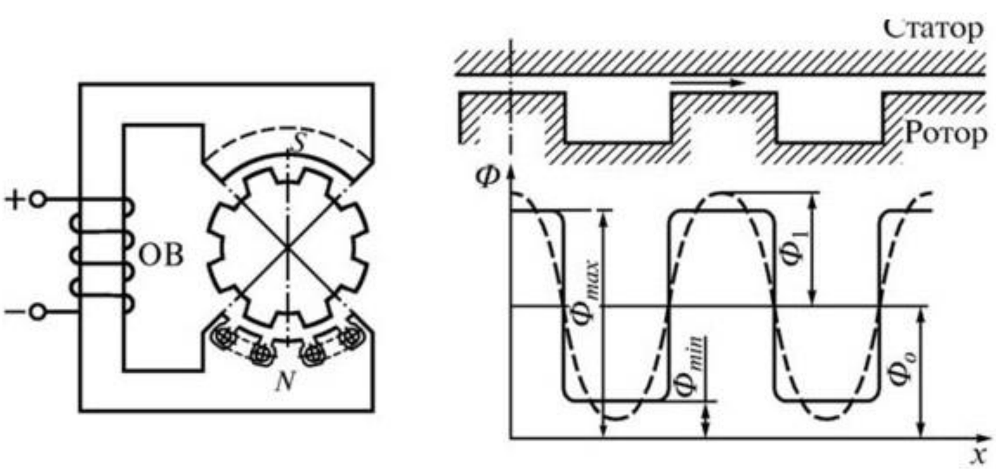


Rice. one

Rice. 1. The principle of operation of the switched reluctance generator accumulated in the capacitor C. Under the action of a mechanical moment applied to the TIG shaft, the rotor teeth move away from the stator teeth. In this case, the inductance of the winding decreases, which is accompanied by the induction of EMF in the stator winding in the direction coinciding with the current in the winding. The current flowing in the winding under the action of the induced EMF is added to the excitation current, increasing the supply of electromagnetic energy in the TIG circuits.

When the rotor, moving under the influence of external forces, reaches a position close to the tooth-groove position, the semiconductor keys VT 1 and VT 2 are closed by a signal from the rotor position sensor. , enters the external circuit: C - VD 1 - W - VD 2 - C. The closed state of power semiconductor switches (VT , VT 2) falls on a strictly defined region of the angular position of the rotor relative to the stator - the region of the generator mode. This area is determined by the rotor position sensor, the signal of which is fed into the control system.

Let's look at real designs, such similar valve inductor generators , they also have an excitation winding and a generator winding in the stator, and the rotor is moving cores:



Alternator 2GV.13.U1 *is installed on cars with electrical equipment system EV44.03.3 as part of RGA - 4 and RGA - 5 generator sets*

Таблица 3.6

Технические данные генератора 2ГВ.13.У1

Параметры	*Значения параметров*
Мощность, кВА	34
Напряжение, В	116
Ток, А	170
Частота вращения, об/мин	950-3400
Частота, Гц	158-566
Напряжение возбуждения, В	142
Ток возбуждения, А	5

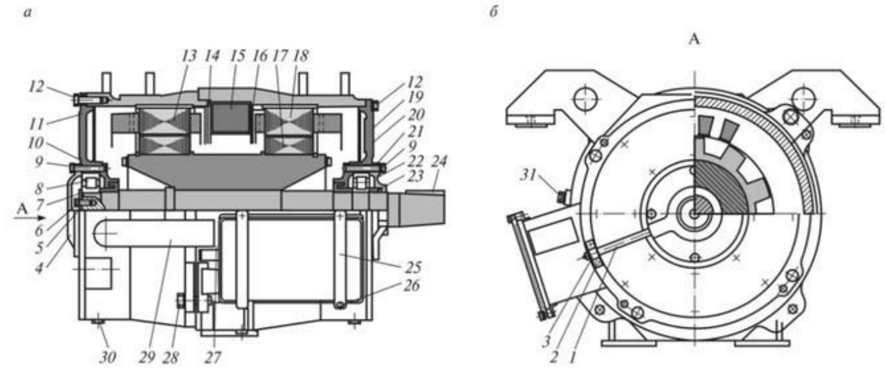


Рис. 3.23. **Конструкция генератора 2ГВ.13У1:**

Rice. 2

Source: https://studref.com/552936/tehnika/konstruktsii_mashin_peremennogo_toka

We go further in the description of the principle of operation of such a generator it is said: " ***TIG refers to parametric electric machines, the principle of its operation is based on a periodic change in the inductance of the stator winding depending on the angular position of the rotor*** ." To change the inductance parameter, there are few controls in the circuit (Fig. 1). When the core is saturated, the inductance will change anyway, in fact, the inductance is a parameter of interaction with the reactance parameter. With a decrease in reactance, the parameter of the magnetic permeability of the core also decreases, and the magnetic field in the core increases. But the length of the wire in the coil and its ohmic resistance does not change in any way. You can't call it a parametric change.

I remembered a very interesting device, a " nonlinear" inductance converter . This device also has an inductance parameter control element, which consisted in excluding part of the coil winding during the reverse pulse.

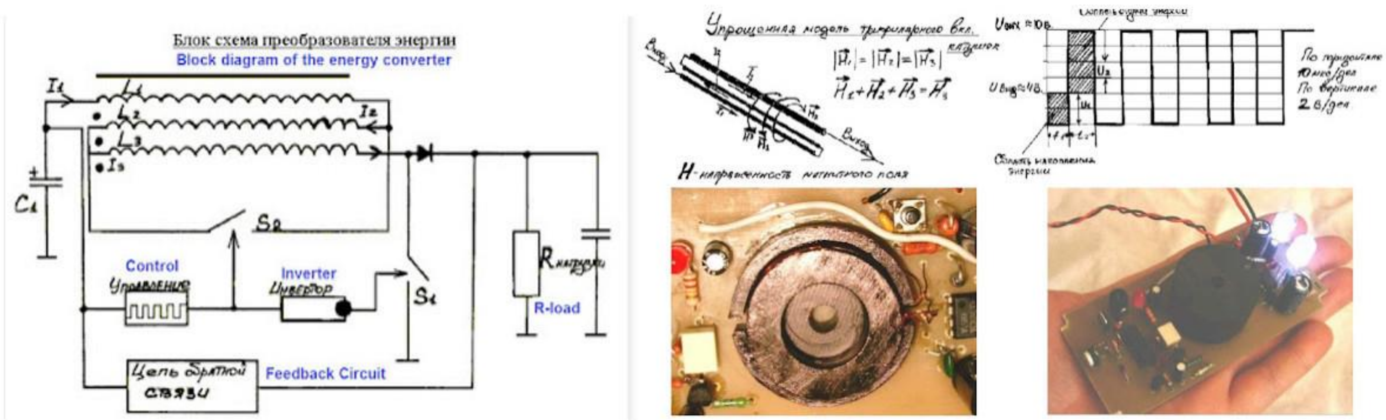
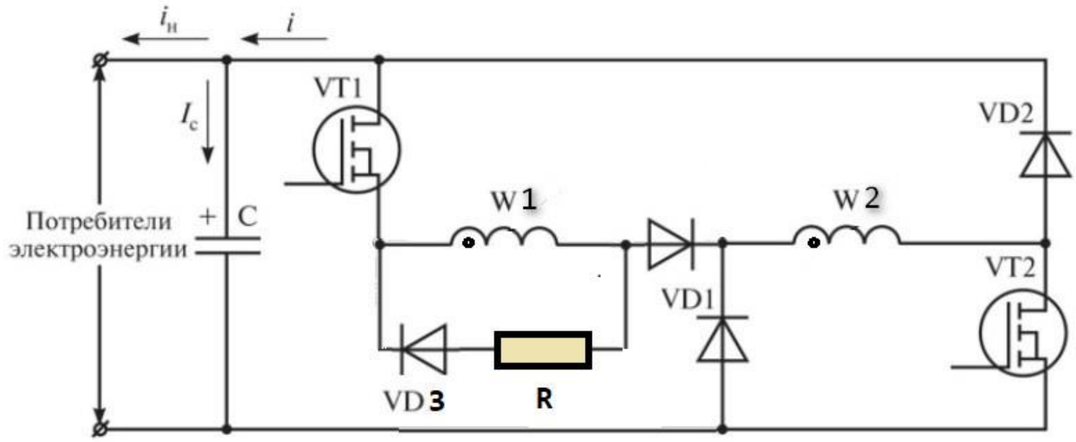


Fig.3

What do we see in this device? We see two periods: excitation (all three parts of the inductor winding are involved), reverse motion - generation / transformation (only two parts of the winding are involved, one is shorted). This is a clear sign of "inductance" control, and the principle of the flyback action, which is just right for us.

After a little thought, the following scheme was born in my head (Fig. 4):



Rice. four

Winding W2 is wound first on the core with a thicker wire. The second winding W1 is wound over W2 with 1.618-2 times more turns than W2. The connection of the windings in series, through a diode (without marking on the diagram). For winding W1, a shunt circuit is organized (VD3; R), for winding W2, a shunt reverse circuit is organized using diodes (VD1; VD2).

The excitation of the field occurs through the keys (transistors VT1; VT2) and series-connected windings. Thus, the field strength of the solenoid ***H*** is formed by all the turns of the two windings. ***H = In/l***

In this case, the magnetic field will be formed in the dynamics of closing the magnetic circuit into a ring, increasing the total inductance of the coil, up to the maximum value of the magnetic field in the coil core:

$$B = \mu_0 \mu H$$

On the way to achieve axial alignment, in the course of rotation of the rotor in the stator (*a segment of the closure of the teeth of the poles of the rotor and stator into a magnetic circuit*), a magnetic field of attraction will appear between the teeth, imparting an acceleration vector to the shaft (motor effect).

After reaching the axial alignment, the excitation is turned off. The magnetic field of the coil core is discharged through the winding W2 and diodes VD1; VD2. Winding W1 through the shunt circuit VD3; R (1-5 kOhm) will reduce the current flow parameter with a 1-5 kOhm resistor. In this case, the OEMF voltage will increase in the circuit, which will also have a beneficial effect on the discharge voltage of the OEMF winding W2. In fact , a falling half-cycle of the generator-type EMF occurs in the winding W2. The shape of the electromagnetic force between the teeth of the rotor-stator will be decreasing. The opening movement will allow the field to decrease in the core, to make the rotation speed uniform.

With the correct calculation of the OEMF / EMF voltage and the cross section of the winding wire W2, we will receive a current pulse sufficient to maintain the voltage in the capacitor C to excite and load the corresponding power.

One feature of the operation of such a generator is a pulsed mode focused on the common battery ballast and capacitor. In principle, the same task that stood when creating RIZU.

If we follow the logic and consider the conversion power of the railway car generator under consideration, we have:

Output power: **Pg** = 116V*170A= 19720W (**19.7KW**)

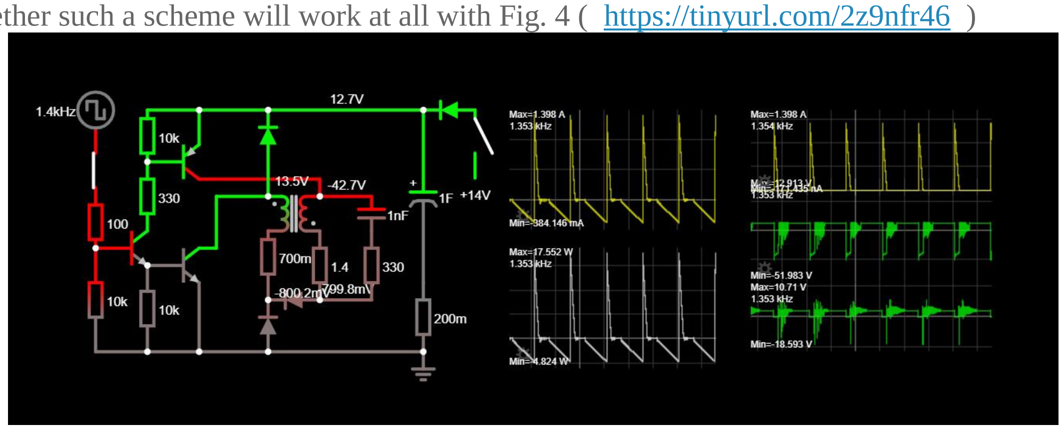
Excitation power: **Pm** = 142V * 5A = 710 W (**0.7 kW**)

Conversion COP = 19.7 / 0.7= 28 (2800%) without taking into account the mechanical moment on the shaft.

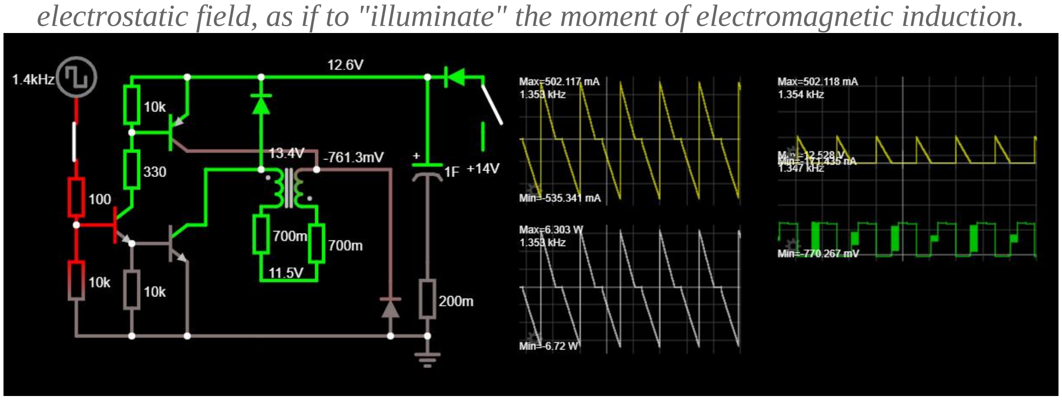
Many people cannot accept this arithmetic, but these are the data from Table 3.6 of a real generator, shown in Figure 2. Just do not claim that the mechanical energy expended from the drive of the wheelset is not taken into account here. In contrast, I will ask how the mechanical force (power) is converted in the mechanism for converting excitation power into electrical generation power, in addition to the actual physical movement of the poles of the rotor rods past the poles of the stator rods with the coil. The field source and the generator winding are stationary relative to each other. In this case, the movement of the rotor in the segment of the circuit is not braking, but the motor vector is acceleration, see the figure below

We are interested in positions ***a*** and ***b*** . In any textbook for designers of electromechanical devices and devices, this is chewed up to the point of being impossible.

Let's check whether such a scheme will work at all with Fig. 4 (https://tinyurl.com/2z9nfr46)



Plot from the simulator screen. Please note that the diagram shows the moment of reverse motion. In the first winding with a damper (C, R), an electric field strength is formed (look at the orientation of the windings). If you put a shunt diode instead of a damper, the reverse power in the secondary winding disappears. If we make the classic version without changing the inductance, the reverse stroke comes with a loss of power. The task is to create a large magnetic field with low power, which is then discharged through a circuit with low ohmic resistance, plus an additional electrostatic field, as if to "illuminate" the moment of electromagnetic induction.



The simulator cannot mathematically calculate the smooth change in magnetic flux when the magnetic circuit is opened. We see that the reverse stroke has a greater current strength than the excitation pulse.
Thus, it seems to me that there is not enough information in the public domain about flyback generators. There is indeed information about them.

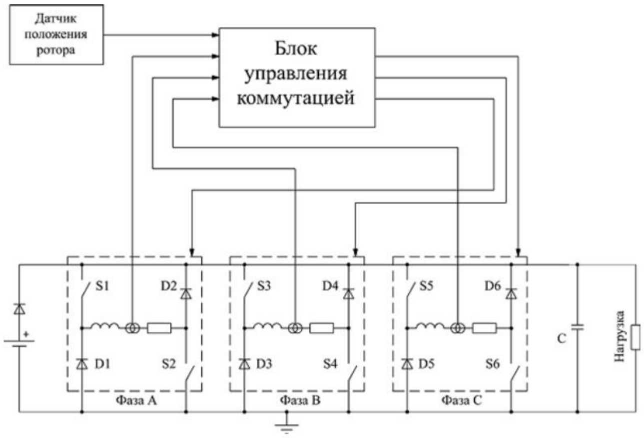


Рисунок 1. Блок-схема вентильно-индукторного генератора.

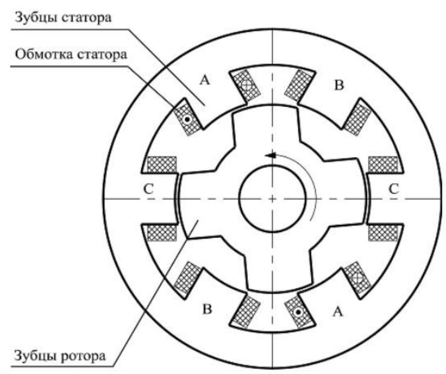
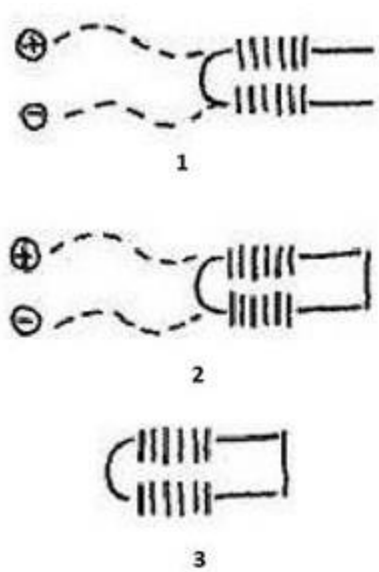


Рисунок 2. 3-х фазный вентильно-индукторного генератора в разрезе.

Calling this generator variable does not work, rather a pulse one. Three phases provide reverse pulses from the coils of different phases at different time intervals during the rotation of the rotor.

How it works, we can consider the simplest example of the design of an EDA magnetic keeper . The electromagnet creates a magnetic field and two parts of the ferromagnetic core are attracted, closing the magnetic flux into a ring in the U-shaped core and core.



Создание магнитного хранителя.

If you apply physical force and open the core from the U-core, an EMF will appear in the winding, and when the winding is closed with the resistance of the consumer device (for example, a light bulb), there is also a current strength. The light bulb will flicker. The energy that arises in this reverse impulse can be called reactive. The core accumulates it during the excitation period of the winding, in the form of a magnetic flux, then gives it away when the core is demagnetized by inducing an EMF in the winding. For a circuit, the coil is a reactive load. A very large class of flyback converters work on a similar principle. Basically, these are boost converters. The flyback buck converter already has a separate output winding. My idea, the circuit that is shown in Figure 4, can just be attributed to a flyback "down" converter. The difference is that the field in the core will not be completely static, and the mechanical opening with an OEMF/EMF pulse must be longer in time. We plan that in this leapfrog of transformations, the win should be in the dimension of CURRENT POWER.

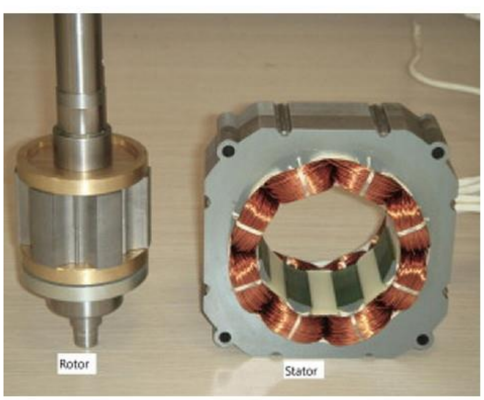
The question arises, can the self-induction impulse be greater than the excitation impulse? Everyone knows that the law of conservation of energy is triggered in this action, and at the output we will get no more than we invested. A very good question, to which there is a second question: why do engineers design this type of power generators? What is not written in textbooks, what do design engineers know about?

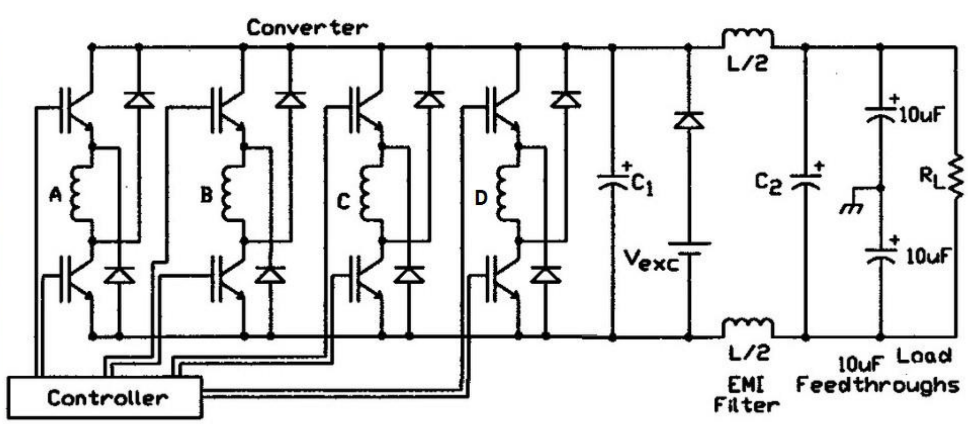
For example, this one: VALVE-INDUCTOR GENERATOR (RU2179779C2)

I think that the simplicity and the modern level of power electronics make it possible to make such a device **Switched Reluctance Motors / Generators** https://kaskod.ru/srm_article01/

Switched Reluctance Generators | kaskod.ee

As you can see, I didn’t discover anything new, engineering thought has worked out everything for a long time to the technologies that are being produced. The electromagnetic moment of such a generator has a tricky calculation formula (Controlling a Switched Resistance Generator in a Wind Power System for Applying Variable Speeds - ScienceDirect).





It has been observed that the graph of the SRG output voltage supplied at 15V, 25V and 30V, obtained from simulation and experimental results, overlaps with each other.

In addition, changes in the SRG phase current depending on the excitation angles are shown in Fig.18 . It has been found that choosing the turn-off angle after the rotor misalignment and the angle of rotation before the rotor pole alignment and **positive torque** increases the phase current SRG

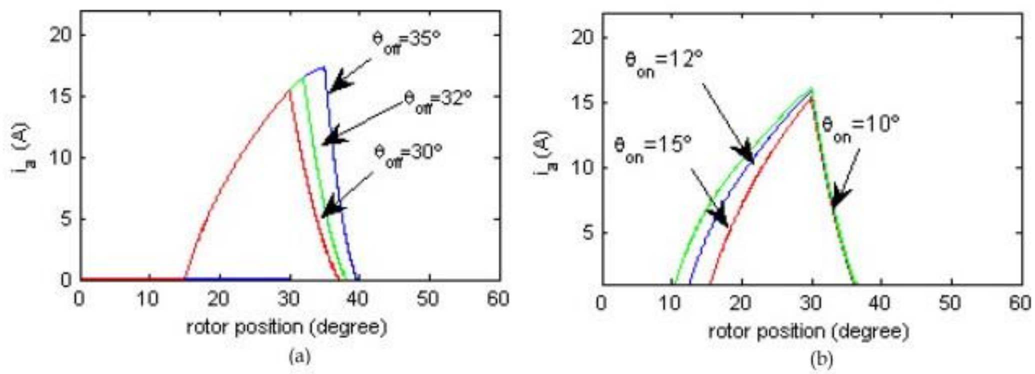


Figure 18 . Phase A current graph for different (a) turn-off angles (θ) at = 15°), (b) turn-on angles (θ from = 30°).

Positive and negative torque. One position is braking and the other is accelerating. It is difficult to say what the authors have behind these designations. One thing is definitely written that the generator generates negative torque (clockwise) and the maximum phase current pulse at positive torque (counterclockwise) though there is a misunderstanding what this means.

Because the SRG operates in a range where the inductance value decreases ($dL/d\theta < 0$), the resulting torque is negative.

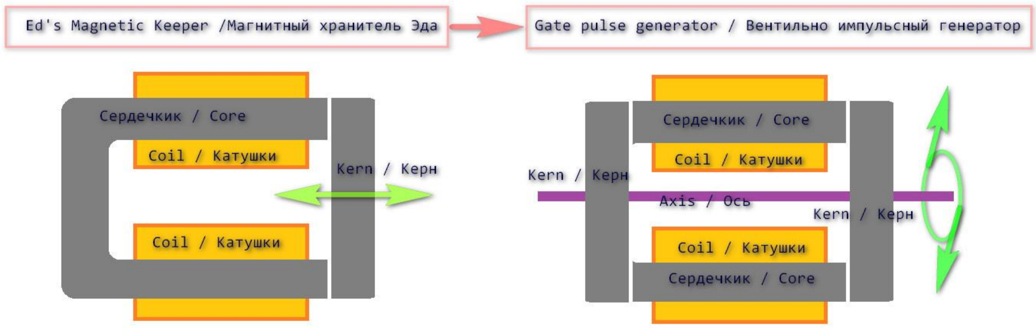
Thus, if you follow the logic, the negative moment is the one that is directed against the shaft rotation vector, and the positive moment is the one that coincides with the rotation vector. The resulting torque must always be positive. Based on this conclusion, the maximum current output from the generator phases when the generator "does not brake rotation" has a positive torque. It sounds strong and deafening, in fact, with such an indicator, this is an electromechanical OU generator in mechanical form. In theory, when the rotor tooth disengages from the stator tooth. there is a forced break in the magnetic flux between them - this is a negative torque. If this moment is compensated by neighboring positive attraction moments of retraction,

In fairness, you can see that information about this type of generator is very scarce. Secondly, this type of generator does not work by issuing a sinusoidal AC signal from the phases, it requires a serious control controller. In any case, if we set the task of minimizing the electromagnetic torque on the shaft to the minimum possible value, such a task is possible if the phases are separated into separate rotor-stators, on the same shaft with an offset. It turns out that the task of compactness and cost in general is more important than reducing the electromagnetic torque of the generator. The question is not in **impossibility** , but in **commercial expediency** .

***

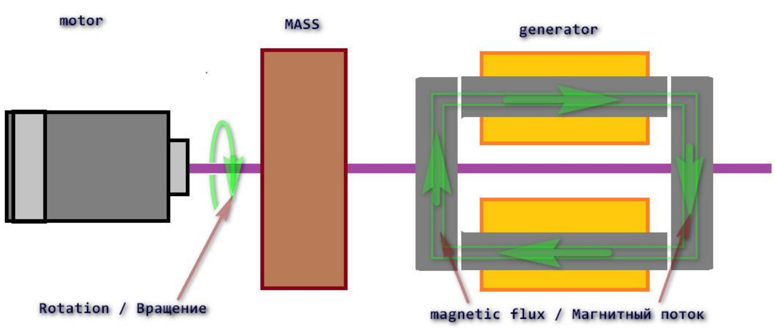
I was asked how to make a simple desktop model. Good question even for me. The first such generators are technologies. It will not work to use anything from used donors of electromechanical motors and generators. Let's return to our task - RIZU.

A simple model, say! We take the design of Ed's Magnetic Guardian, and transform it into a generator. For ease of manufacture in a system with rotating cores on the axis.



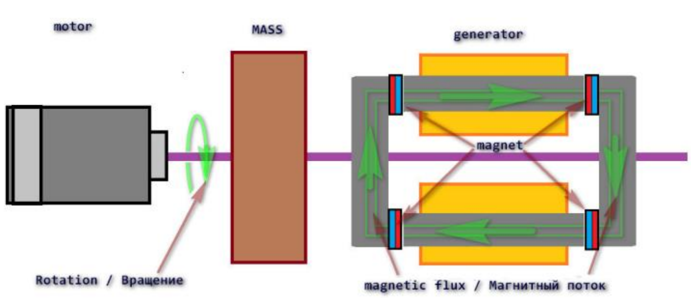
Rice. 5

An electric motor is required for rotation. Our valve pulse generator will have a variable mechanical acceleration / deceleration torque on the shaft. A flywheel is needed to smooth out these episodes. We get the following construction on one axis:

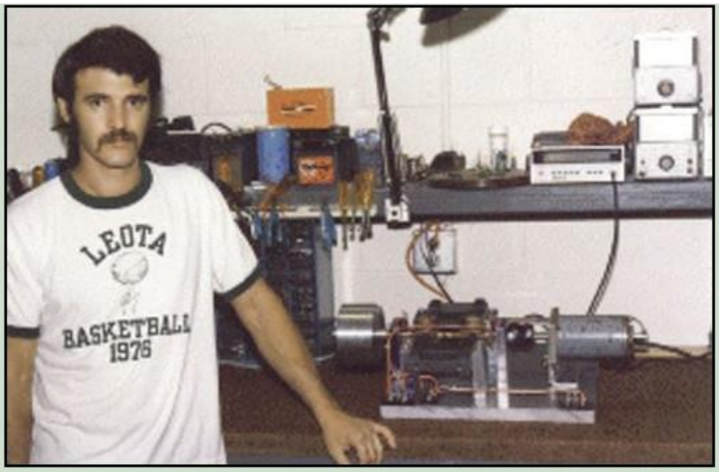


Rice. 6

This model is structurally similar to John Bedini's system, which he presented at an exhibition in Colorado Springs (1984). The difference is only in the design of the generator. But a similar type of generator on two coils with cores and two cores with magnets. We also have such a design with magnets.



Rice. 7



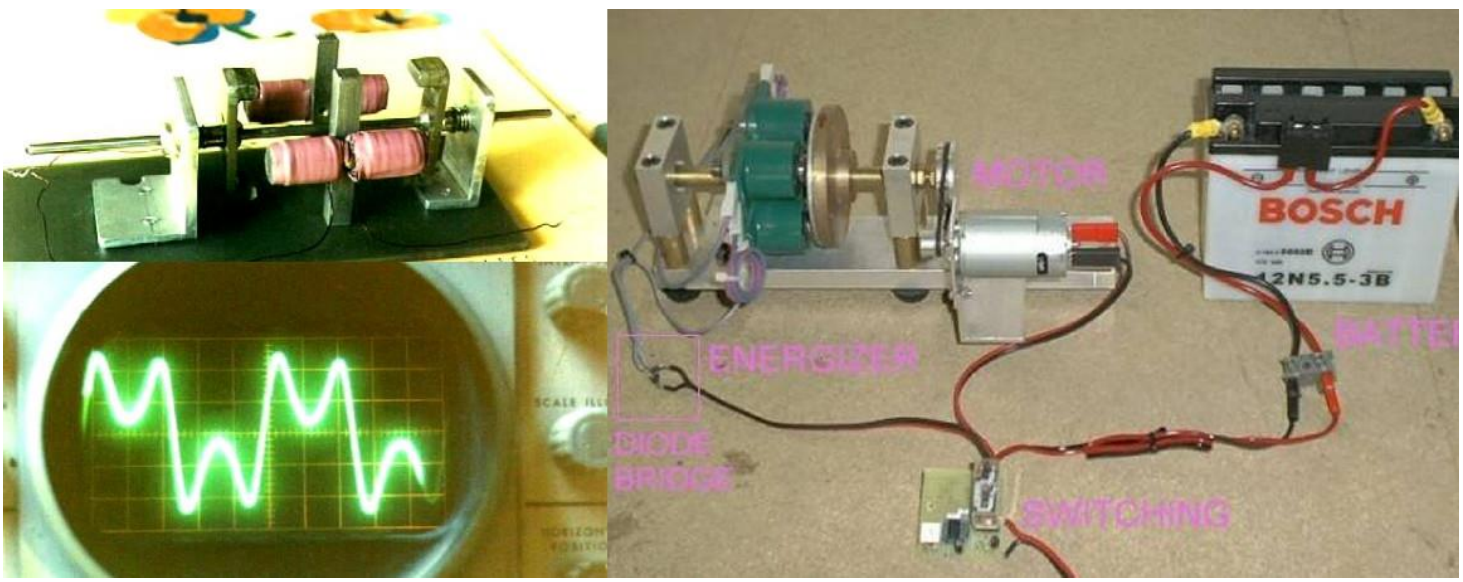
Джон Бедини со своим первым G-Field генератором в 1984 году.

Другой опыт с маленьким G-Field генратором.

Photographs of the referenced installations by John Bedini.

For both options, the electrical circuit will be the same. We will follow the adopted decision, controlling the winding inductance during excitation and reverse motion of the generated pulse.

Other Device Examples Fig.8



Rice. eight

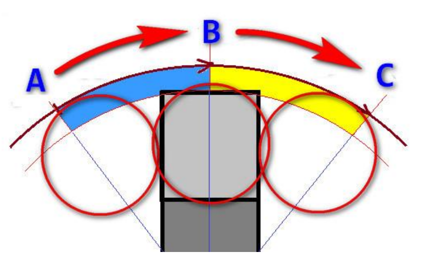
All devices are valve and magnetic flux switching devices. We are interested in a device with parametric control of inductance, for flyback devices.

If you were careful, in the description of the principle of operation of the valve induction generator, excitation occurs when the rotor tooth is disengaged from the stator tooth. The discharge occurs when the tooth of the rotor is in the groove of the stator. Thus, the electromagnetic moment of the generator is always negative (opposite to the shaft rotation vector). There are gaps in the kinetic moment on the shaft, but this is, as it were, a weakening, and not the opposite position of the torque rotation vector.

We are interested in obtaining an EMF pulse and an induction current of the reverse stroke of the pulse, at the moment of opening the magnetic circuit - the rotor / stator, when the magnetic coil in the coil core is maximum.

Figure 8 shows the EMF waveform of a Cromry-type magnetic flux switching generator. The failure of the sinusoid is just in the zone of complete closure of the magnetic circuit, when the coil core and the magnet pole are closed in area. When closing and opening, when the poles are conditionally closed by half, we see a surge in EMF. In these intervals, there is a sharp change in the rate of change of the magnetic flux, an increase at the input and a decrease at the output. With a complete closure, the rate of change of the flux tends to zero, which is immediately displayed on the guidance of the EMF in the conductor. Thus, the valve-driven design of the windings in Figure 6 is very viable. The only thing, three pairs of coils are needed (three positions for switching) and two cores i.e. (cross-shaped core) in this case we will get a denser current form and a smaller kinetic braking impulse on the shaft, which will require less mass of the stabilization flywheel. The reader is probably thinking that a drive motor might not be needed. Probably, but this would require a more complex system configuration. It is easier to make a drive motor with recuperation. Part of the momentum for rotation will be returned from the flywheel. In any case, these are our assumptions, a practical model is needed for accuracy. Part of the momentum for rotation will be returned from the flywheel. In any case, these are our assumptions, a practical model is needed for accuracy. Part of the momentum for rotation will be returned from the flywheel. In any case, these are our assumptions, a practical model is needed for accuracy.

Why do I not follow the algorithm when saturation is carried out at opening, but on the contrary, saturation at the moment on the closing interval. Everything is very simple. The maximum magnetic flux, with less excitation costs, is possible in the core when it is closed in a circuit. The level of the magnetic field in a core that does not have a closed magnetic circuit will require large powers for excitation. The reactance of the winding, at the moment (A), when the rotor tooth is not closed with the stator tooth, will be significantly less than at the moment of complete closure (B) Fig. 9.



Rice. 9

Thus, turning on the excitation at the moment (**A**) on the segment (**A - B**), the current in the coil turns will reach a much higher level than at the moment of switching on (**B**) on the segment (**B - C**). As a result, the closing moment of the circuit will occur with a large magnetic flux and with a large torque (motor) moment. The gap of the magnetic flux, at the moment the excitation is turned off at the point (**B**), will occur with a large indicator of the accumulated magnetic field **Bm** (*Tl*) of the possible maximum, when the excitation is turned off at the level of the circuit. Thus, the EMF will depend on this indicator, and the speed **V** (*m / s*) its decrease **.** As a result, we can reduce the length **L** (*m*) [*w2*] of the conductor. by increasing its cross section, reducing its resistance **r** , which will be displayed on the current strength indicator:

$$\mathbf{I = ((E}\ \boldsymbol{w2} = Bm*L*V\mathbf{) - U) / (Rz + r)}$$

where: **Rz** - load resistance; **U** is the voltage of the ballast storage, for example, a battery.

From here we see that the EMF (**E**) must be greater than the battery voltage (**U**) in order to provide the level of Current Strength (**I**) to the total resistance of the circuit: load + winding (**Rz + r**).

Taking into account the illumination by the electric field of the first winding, the formula will be as follows:

$$I = ((E\ w2 + E\ w1) - U) / (Rz + r)$$

In blue, the same increase

With the system formula, three pairs of coils and two cores, at the moment of breaking and generating one pair of coils, the next pair of coils will be activated to excite and attract the cores to their poles, a kind of switching relay race, which will be reflected in a decrease in the total electromagnetic moment of the generator on the shaft.

The excitation activation angle must be adjusted to the position when current saturation is reached just at the moment of turning off and activating the reverse generation pulse. It follows from this that such a generator requires a control controller, based on the position of the tooth of the rotor of the tooth in relation to the stator tooth. On the hall sensor system, it cannot be performed. It can be performed on a slotted optocoupler or at home using a line sensor for robotics.

How to wind a coil? The first is to provide for the ratio of the winding thickness to the cross section of the coil core. The winding thickness should not exceed the diameter of the core, unless special technologies are provided. Our technology is pulse generation, therefore, the reverse pulse pickup winding must be made with a thicker wire, wound tightly to the core, for example, with a diameter of 1.2 mm. Let's say we had a winding length of 1.5 meters, the number of turns w2 (Resistance: 0.015 Ohm / m * 1.5 m = 0.0225 Ohm).

Further, on top of this winding, we wind the next winding w1, with a wire 0.56 mm in diameter, 3 meters long (Resistance: 0.073 Ohm / m * 3 m = 0.219 Ohm).

The total resistance of the coil windings connected in series, excluding diodes and transistors, will be: 0.0225 Ohm + 0.219 Ohm = 0.250 Ohm. Two coils in series 0.5 ohm. The excitation current, excluding the reactive component, will be I \u003d U / R \u003d 12V / 0.5 Ohm \u003d 24A, which is very, very much. The carrying capacity of the current strength of the wire is 0.56 mm in diameter 2.5A. We need to calculate the excitation current, taking into account the reactive component of the starting turn-on current of not more than 2.5A. The reactive component will depend on the switching frequency, that is, on the rotational speed of the shaft and the core switch on the shaft. In this way we can increase the number of turns in both coils w1, w2. But again, the winding w2 during the reverse stroke should induce an EMF of the appropriate dimension. Again, we do not have enough initial data for the calculation. Why am I telling you all this? because the creation of such a generator is a complex creative design and engineering work. The main thing is to take into account the load, which you just can’t turn off at will. It is necessary to regulate the output with a complex system for adjusting the excitation voltage for each group of coils.

This is one of the reasons why such devices do not work for *amateurs* . The calculation technology is hidden from the sufferers, who lack the appropriate specification and experience.

The only way to find out is to start, make the first model by eye and use trial and error to find the right proportion of winding data.

Serge Rakarskiy

Glory to Ukraine!