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This issue of Scientific Collection «InterConf» contains the International Scientific and Practical Conference. The conference provides an interdisciplinary forum for researchers, practitioners and scholars to present and discuss the most recent innovations and developments in modern science. The aim of conference is to enable academics, researchers, practitioners and college students to publish their research findings, ideas, developments, and innovations.

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PULSE POWER SUPPLY FOR 3D PRINTER

Abstract. *The work is devoted to the design of a pulse power supply for a 3D printer. A functional diagram of the power supply has been developed. Based on the functional diagram, a schematic diagram of the power supply was built, a circuit board was made and the power supply was assembled. The transformer was also calculated and modeled using MATLAB.*
Keywords: *3D printer, control system, power supply, feedback.*

The 3D printer is a peripheral device that performs 3D printing by layer-by-

layer formation of a physical object according to a given digital 3D model. 3D printers are used for both household and professional prototyping of objects. Today, in addition to conditionally "standard" equipment, there are developments and designs that print food, printers are used in medicine, and printers are capable of printing low-rise buildings and small structures.

The 3D printer power supply, which is used to power the extruder heating, table heating, stepper motors and electronics, needs special attention.

The purpose of the work is the design and manufacture of a power supply for a 3D printer [1]. To achieve this goal, the following tasks were identified in the work:

– make a functional diagram of the power supply

– develop a 3D printer power supply circuit and justify the choice of its elements

– calculate and manufacture a pulse transformer

– make a power supply and explore the dynamics of its work

Among the many existing circuits of switching power supplies, reciprocating ones are considered to be the most common. Network reciprocating voltage converters with a power of up to 150 W can be assembled using three output microcircuits of the TOP22x series from Power Integrations.

The proposed power supply can be used to power the power circuits of 3-D printers, industrial robots, CNC machines, as well as in other technical devices of electromechanical systems.

The aim of the work is to create a 12 V 12 A power supply for power circuits of 3D printers [2, 3, 4], which has voltage stabilization and current limiting.

To solve this problem, a functional diagram of the power supply was constructed, which is shown in Fig.1.

Any switching power supply creates radio interference, and as a result, the main problem is to ensure electromagnetic compatibility with other electronic equipment. Due to the principle of operation, switching power supplies are a source of various electromagnetic defects and flaws. To prevent this, an input filter was assembled, assembled on elements L1, C1 and C2 (Fig. 2), it protects the power supply and the network from mutual high-frequency and impulse defects.

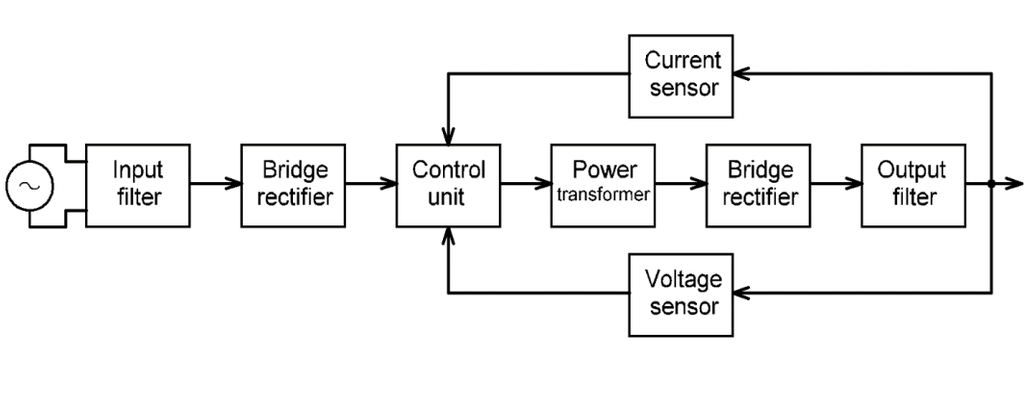

Fig.1. **Functional diagram of the power supply:**
1 - input filter; 2 - bridge rectifier; 3 - control unit; 4 - power transformer; 5-bridge rectifier; 6 - output filter; 7 - current sensor; 8 - voltage sensor

Almost all switching power supplies and rectifiers with capacitor filters have one significant drawback. When the power is on, the filter capacitor is in a discharged state, and its time is charged. During this time, a current is supplied that can exceed the operating parameters by several times (in some cases even tens of times). This is detrimental to many circuit elements inside the power supply, as well as to connected circuits. There are many different solutions for limiting current surges, but they all have advantages and disadvantages. The easiest way to deal with such current pulses is to include an NTC (inversely coupled) thermistor in the circuit.

At rest (power off), the thermistor is at ambient temperature and has a high resistance.

At the moment of switching on, the current pulse is extinguished by the high resistance of the "cold" NTC thermistor. In the process of further exposure to current, the thermistor heats up and switches to an operating mode in which it has a low resistance, which means that it will have almost no effect on the operation of the entire power supply circuit.

The thermistor resistance is calculated based on the amount of current we plan to limit:

$$R_{NTC1} = \frac{(U \cdot \sqrt{2})}{I}$$

Power is supplied through a diode bridge assembled on diodes VD1, VD2,

VD3, VD4. The diodes must have a reverse voltage of at least 400 V. In addition, the diodes must withstand the surge current when the power supply is turned on.

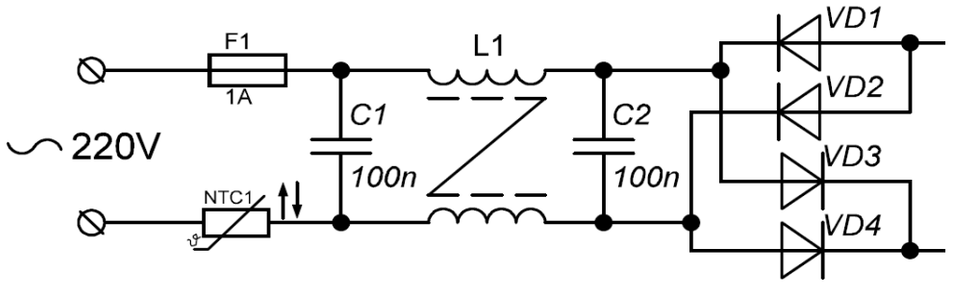

Fig. 2 – **Input filter with diode bridge**

The TOP22x microcircuit includes a powerful high-voltage transistor and all the necessary control circuits for it (Fig. 3). This is, first of all, a master oscillator operating at a fixed frequency of 100 kHz, from the three outputs of which signals of the required shape are taken. The signal from output 1, fed to the input of the AND-NOT element, determines the maximum possible duty cycle D_MAX. Short pulses on output 2 set the flip-flop to a single state, turning on the output transistor.

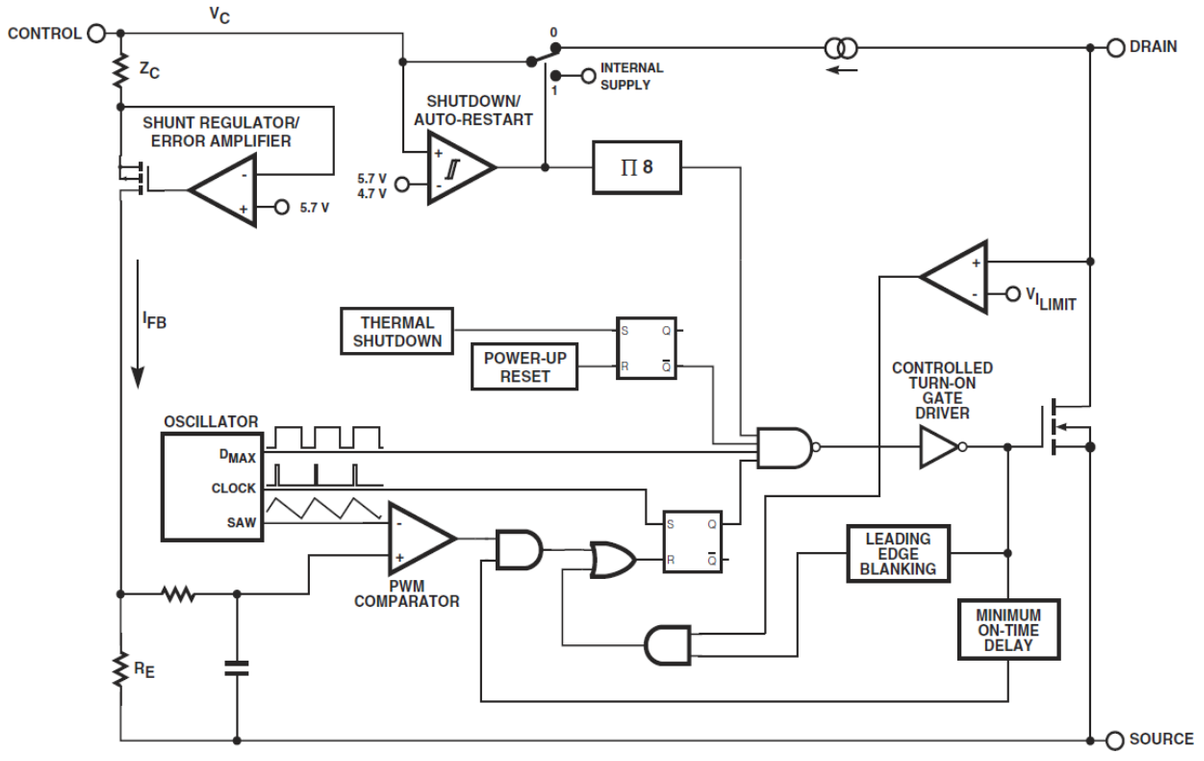

Fig. 3 – **The structure of the TOR227 chip**

In normal operation, the trigger is reset by an inconsistency signal at the output of the PWM comparator. A triangular voltage is supplied to one of its inputs from the output of the generator 3, to the other - a voltage proportional to the excess voltage at the control input "Control" of the 5.7 V level microcircuit, which implements pulse-width modulation (PWM). The field-effect transistor at the input of the operational amplifier and the resistors Z_C1 and R_E provide a stable rated transfer coefficient exceeding the signal level of 5.7 V to the input of the comparator.

TOP22x microcircuits are available in DIP packages with eight pins, of which six are combined (P suffix), this is a leakage pin, and in a TO-220 package with three pins (Y suffix)

The calculation of the converter on microcircuits of the TOP22x series is simple. It begins with the selection of the required microcircuit. On fig. 4 and 5 show curves facilitating this choice; 4 for the output voltage of the converter 12 V. The required output power P_OUT=U_OUT I_OUT is plotted along the horizontal axis on the graphs. The solid lines of the graphs correspond to different microcircuits of this series.

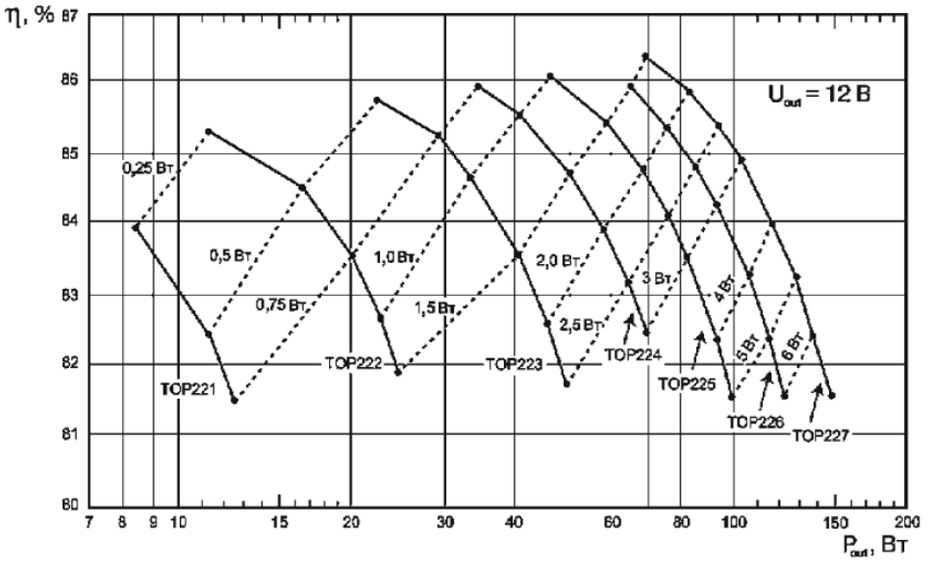

Fig. 3 – **Types of curves for output voltage 12V**

All calculations of the converter are carried out for a heavier version, and it (with one exception) takes place at a low input voltage. Graphs fig. 3 are built for a

mains voltage of 230 V - 15%, i.e. for 195 V AC. In the domestic network of 220 V with a tolerance of 20%, the minimum voltage is 176 V and the calculation must be carried out specifically for him. With such a voltage on a particular microcircuit, it is possible to build a converter with a slightly lower output power than at 195 V. The correction factor $К_П$, which determines the decrease in permissible power, is found from the graph in Fig. 5. For a mains voltage of 176 V, it is about 0.94. This means that it is necessary to choose a microcircuit that provides output power in excess of the required one by a factor of 1/0.94=1.06.

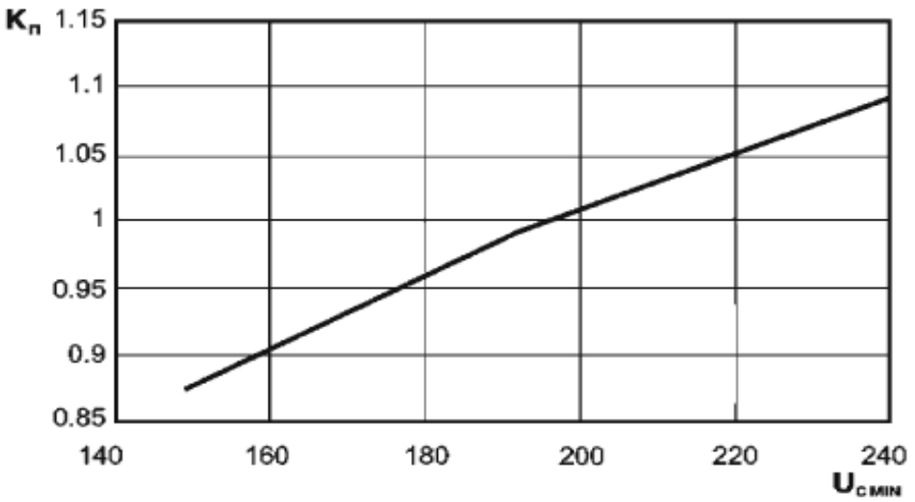

Fig. 5 – **Graph for determining the correction factor**

Then you can proceed to the calculation of the power transformer, so below we present some calculation parameters [5].

The switching frequency *f* determines the pulse period *T*:

$$T = \frac{1}{f}$$

The period together with the duty cycle determines the duration of the pulse of the open state of the key

$$t_i = qT$$

The maximum output power of the converter is equal to the product of the load current and the voltage on it:

$$P_{OUT\_max} = V_{OUT\_max} I_{OUT\_max}$$

The maximum converter power consumption P_{IN_max} is given by the maximum output power divided by the efficiency:

$$P_{IN\_max} = \frac{P_{OUT\_max}}{\eta}$$

where P_{OUT_max} *maximum inverter output power*

The inductance L_1 of the primary winding is determined by the ratio:

$$L_1 - \eta \frac{(V_{IN\_min} q_{max})}{2 P_{OUT\_max} f}$$

where f *– operating frequency*

V_{IN_min} *– input voltage*

q_{max} *– the maximum value of the fill factor of the converter controller*

P_{OUT_max} *– the maximum value of the fill factor of the converter controller*

η *– efficiency*

The maximum current through the primary winding is determined by the formula:

$$I_{w1\_max} = \sqrt{\frac{2 P_{OUT\_max}}{f \eta L_1}}$$

The inductance of the secondary winding is determined by the ratio:

$$L_2 = \frac{(1 - q_{max})^2 (V_{OUT\_max} + V_{VD})^2}{{q_{max}}^2 {V_{IN\_min}}^2} \frac{L_1}{\eta}$$

where V_{OUT} *– output voltage;*

V_{VD} *– voltage drop on the open diode.*

The ratio of the number of turns of the secondary and primary winding is calculated by the ratio:

$$k = \frac{N_1}{N_2} = \frac{q_{max} V_{IN\_min}}{(1 - q_{max})(V_{OUT\_max} + V_{VD})} \frac{\sqrt{\eta}}{1}$$

The maximum current through the secondary winding is calculated by the formula:

$$I_{w2\_max} = kI_{w1\_max}$$

If the gap is planned to perform independently, the value of the inductance per turn can be calculated by the following formula:

$$A_E = \frac{A_{E(0)} \cdot L_E}{\mu_E \cdot g}$$

where $A_{E(0)}$ *– value of coil inductance for core without gap (from specification)*

L_E *– the length of the midline of the core*

μ_E *– initial core magnetic permeability*

g *– introduced gap*

Consider the formula for the effective magnetic permeability of the core:

$$\mu_E = \frac{l_E}{g}$$

Substituting the values obtained in the calculation part in the substitution scheme, which is shown in Figure 6, we obtain the values of the transient characteristics of the power supply.

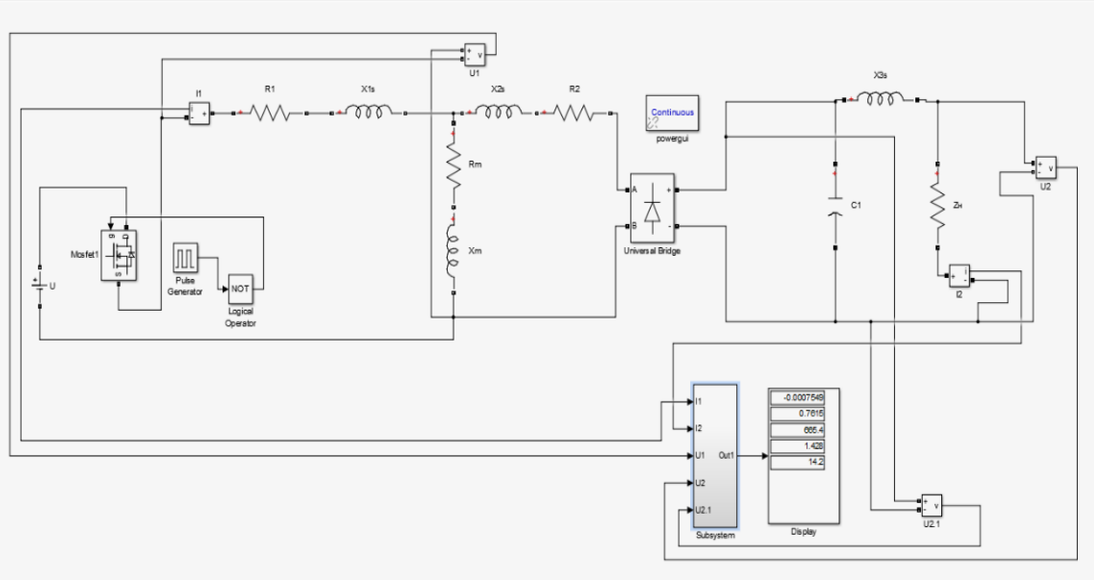

Fig. 6. **Transformer replacement scheme in the power supply**

After modeling the system, we obtained graphs of transients, which are shown in Figure 7.

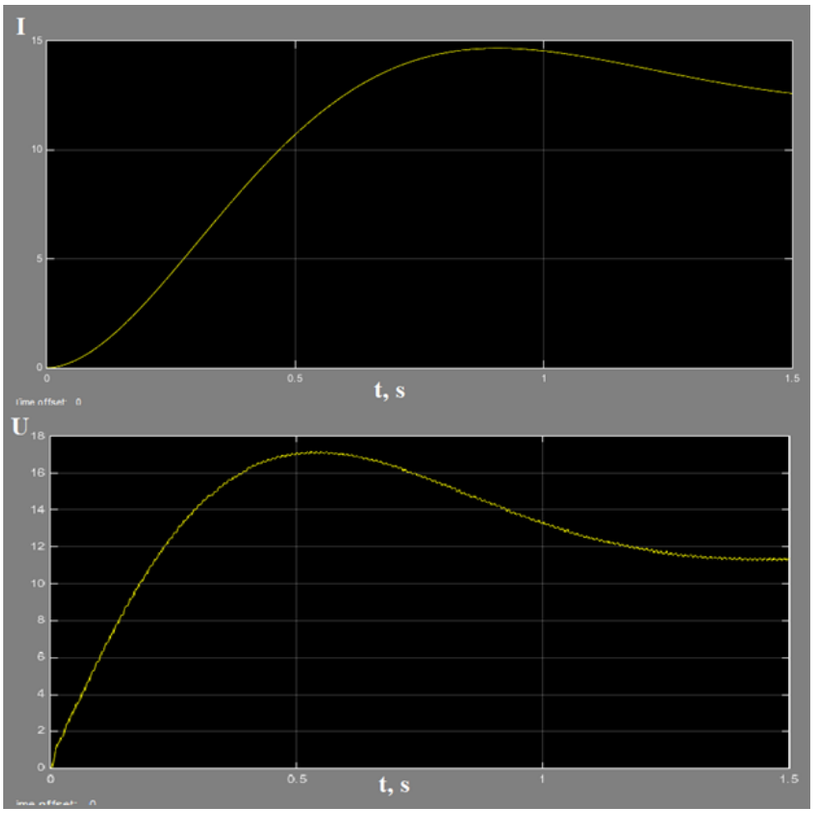

Fig. 7. **Current and voltage at the output of the power supply at a load of 90%**

From the above characteristics was built a schematic diagram of the viewing unit 3-D printer, which is shown in Fig.8.

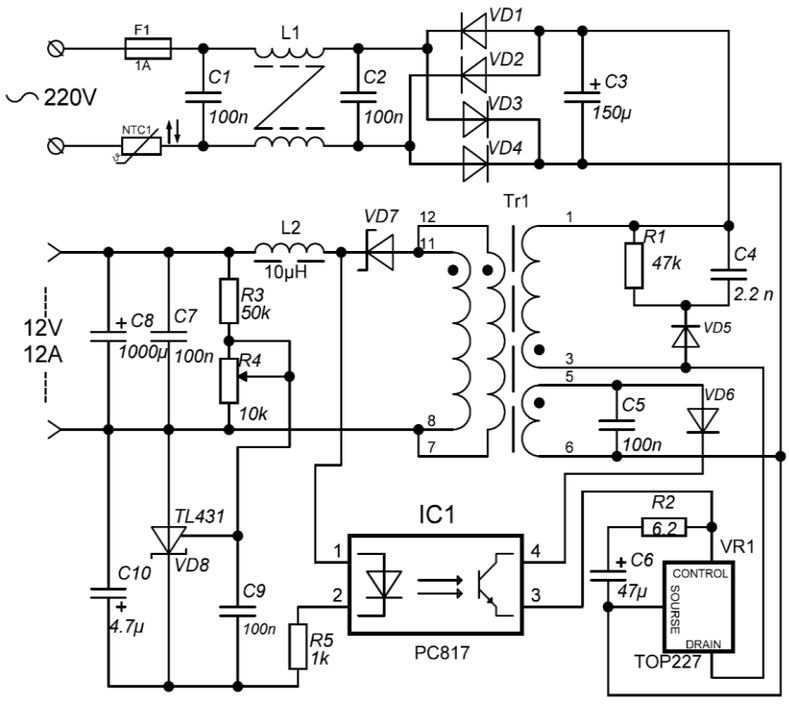

Fig. 8. **Schematic diagram of the power supply**

The wiring diagram is shown in Figure 9.

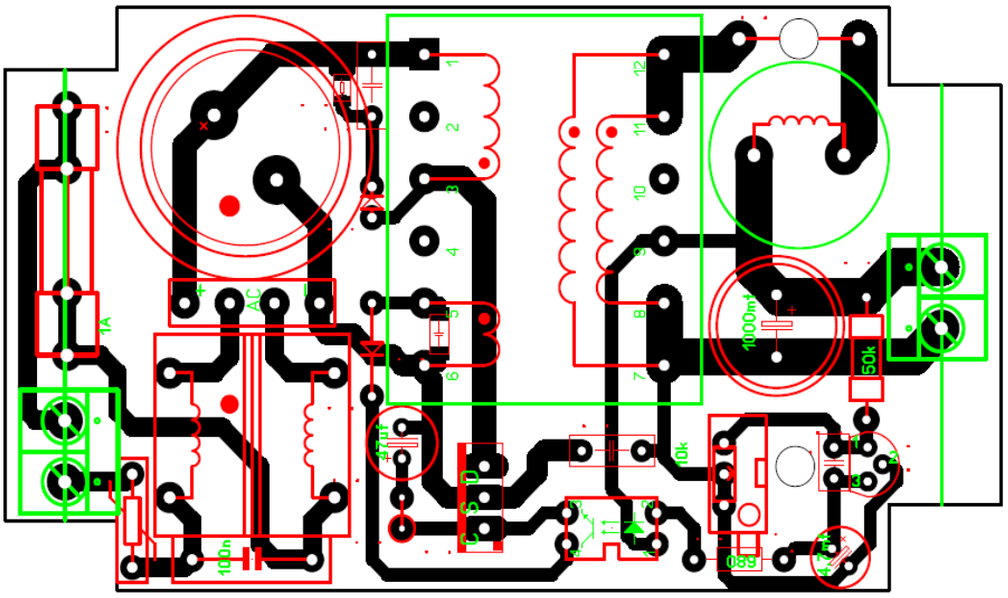

Fig. 9. **Wiring diagram of the power supply**

The completed power supply is shown in figure 10.

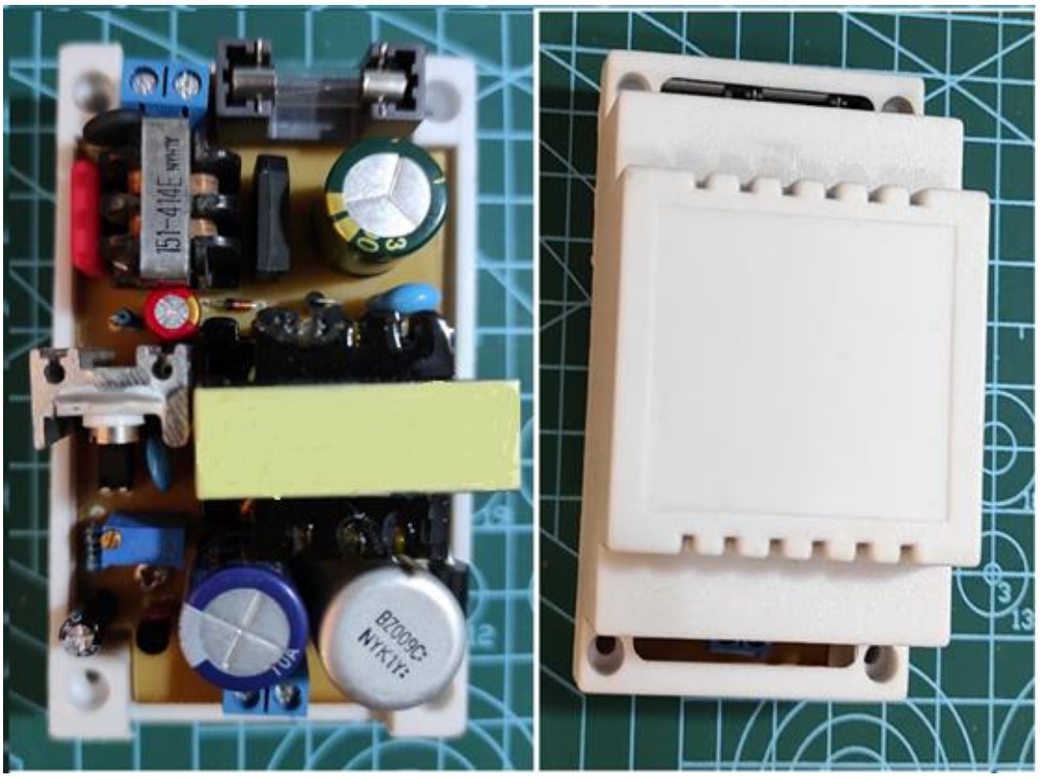

Fig. 10. **Completed power supply**

Conclusions:

In the work, a power supply circuit for the power circuits of a 3D printer designed for a current of 12 A and a voltage of 12 V was designed. Also, voltage stabilization and current limiting were added to the circuit.

To solve this problem, the TOR227 microcircuit was used in the power supply unit of the power circuits of ship equipment.

In the work, a transformer was calculated for a switching power supply. The equivalent circuit of the transformer was also simulated in the MATLAB 14 program, which showed the operability of the developed power supply.

After all calculations and simulations, a power supply was made.

The proposed scheme refers to the power supply of power circuits of 3D printers, laboratory stands for the study of elements of automation systems, industrial robots, CNC machines, as well as in other technical devices of electromechanical control systems for electric drives. It provides the necessary parameters of electrical energy and protection of automation systems.

References:

1. The 9 Different Types of 3D Printers// – link – https://3dinsider.com/3d-printer-types/
2. TOP221-227. TOPSwitch-II Family. Three-terminal Off-line PWM Switch.// – link www.powerint.com.
3. TOPSwitch-II Flyback. Design Methodology. Application Note AN-16. // – link www.powerint.com.
4. TOPSwitch-II Flyback. Quick Selection Curves. Application Note AN-21. // – link www.powerint.com.
5. Severns R., Blum G. Impulsnyie preobrazovateli postoyannogo napryazheniya dlya sistem vtorichnogo elektropitaniya. Per. s angl. pod red. L.E. Smolnikova. Moskva: Energoatomizdat, 1988

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