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ON THE ISSUE OF RECHARGING THE BATTERY OF AN UNMANNED AERIAL VEHICLE

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Abstract

This paper examines the issue related to recharging the battery of an unmanned aerial vehicle (UAV) in flight mode. By attaching a neodymium magnet with a propeller, a magnetic flux F is generated, which, crossing the coils of the coil wound on the beams of the unmanned aerial vehicle, generates an induction current. The work shows that it is with this induction current that it is possible to recharge the battery of an unmanned aerial vehicle.

Keywords: *Charging, magnet, propeller, magnetic flux, battery, induction current*

Introduction

UAV – is an abbreviation for "unmanned aerial vehicles". These devices have been widely used by civilians relatively recently. They are used in many fields, including military, civilian and scientific. As is known, unmanned aerial vehicles are used to solve a wide range of civil and military tasks (monitoring, surveying and mapping the area for scientific or other purposes, delivery of mail and other goods, assistance in emergency situations) in various sectors of the economy (agriculture, construction, energy). The main advantage of an unmanned aerial vehicle is the significantly lower cost of their creation and operation.

The principle of operation of the drone is based on a combination of sensor systems, autopilot and software. Sensors such as cameras, radars, lidars and a navigation system collect information about the environment and the position of the device. This data is transmitted to the autopilot, which processes the information and makes decisions about the further movement and behavior of the drone, controlling the rotation of the engines and the deviation of the device from a given trajectory.

Today, the most vulnerable part of an unmanned aerial vehicle is recharging the battery in flight mode. The solution to this problem is relevant.

The aim of the work is to develop a system for recharging an unmanned aerial vehicle in flight mode.

The solution method. Today, there are many methods of charging the battery of an unmanned aerial vehicle (Zhukov D. R., Mikhailov V. A., 2024; Drone History Timeline From 1849, To 2019). Today, an unmanned aerial vehicle is a very practical and necessary device, but they have several main disadvantages: 1) fast battery discharge, 2) long charging, 3) constant human involvement when working with units. In the 21st century, humanity solved two out of three problems by creating a charging station for drones, and software for an unmanned aerial vehicle was written along with this. The high energy consumption of the engines of an unmanned aerial vehicle forces the use of batteries of rather large capacity, which most often have a lot of weight and do not allow you to spend a long time in flight. Thus, with an increase in the duration of flight missions, the use of a reliable and sufficiently distributed system of charging stations represents one of the main roles in ensuring autonomous operation of an unmanned aerial vehicle, the widespread use of unmanned aircraft is significantly limited by the need to charge batteries directly at the research facility, for which serial mobile power plants are used. In practice, there is an urgent problem of developing a reliable battery charging system for an unmanned aerial vehicle. Below is one of the possible solutions to this problem. The idea of the proposed method is as follows. A neodymium magnet is attached to the propellers of an unmanned aerial vehicle, preferably, under this magnet, an inductance coil is wrapped around the beams. When the propeller starts to rotate, a downward magnetic flux is generated. This flow, crossing the windings of the induction coil, creates an induction current I. This current is directed to the battery of the unmanned aerial vehicle (Rustamov N. T., Meirbekov A. T., Kibishev A. T.). In Fig. 1. A mock-up of the proposed battery charging system for an unmanned aerial vehicle is shown.

Figure 1. *A mock-up of an unmanned aerial vehicle that is being recharged.the charge from electromagnetic induction in coils*

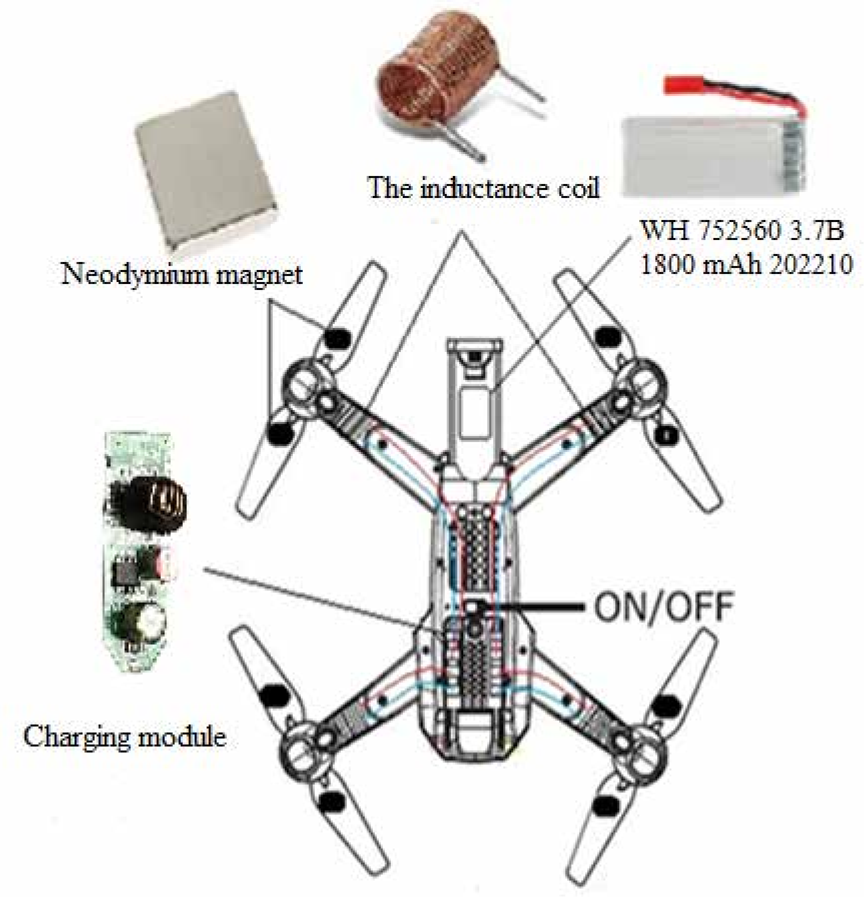


Figure 2. *Block diagram: additional power supply for recharging the drone's battery: 1–4 – motor generator; 5–8 – LED lamps; 9 – rechargeable battery; 10–13 – DC motors*

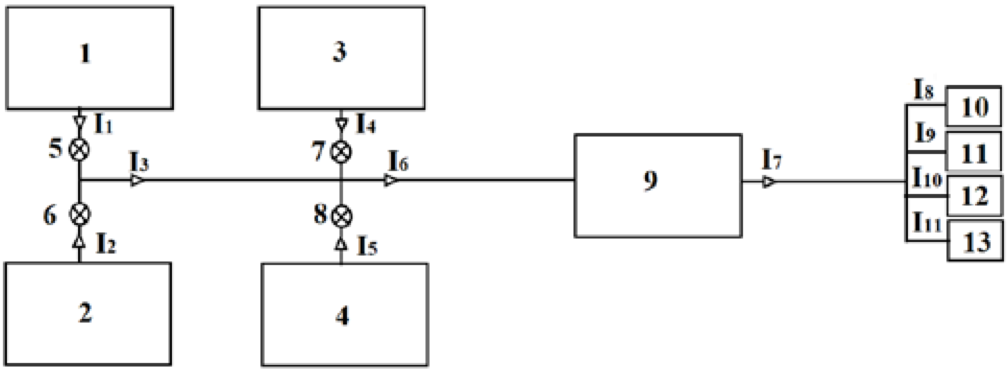
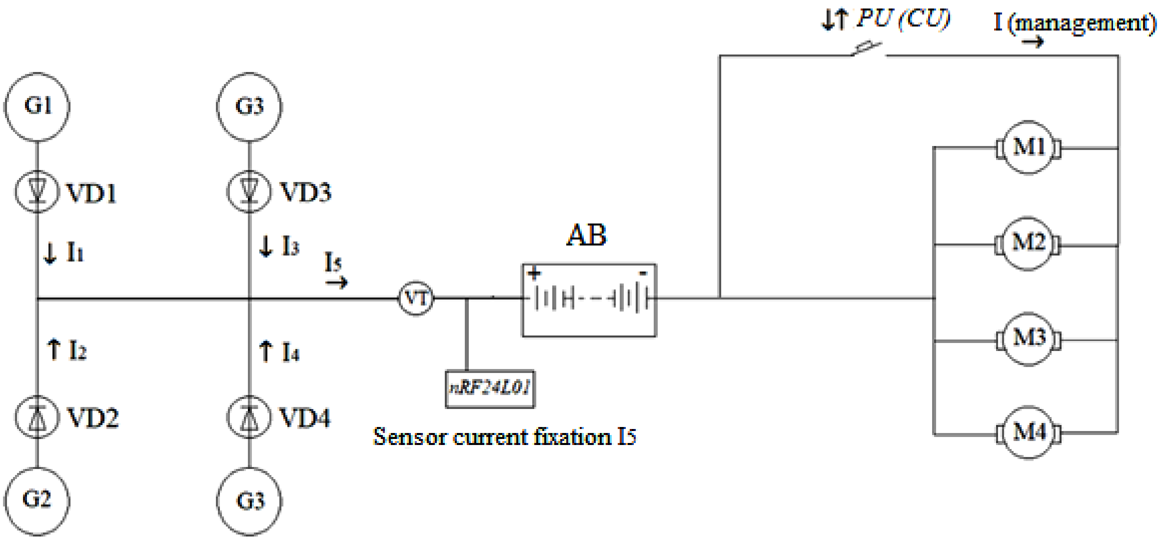


Figure 3. *Schematic diagram of the electrical circuit: The scheme of recharging the battery of an unmanned aerial vehicle; G1\G4 – engine generators (coil and neodymium magnet); VD1\VD4 – LED lamps; PU (CU) – engine control panel (key); SF – circuit breaker; AB – battery; M1\M4 – drone engines*



Initially, when the PU is turned on, after receiving a battery charge, high-speed M1\M4 DC drones begin to rotate. Due to the thrust, the air rises into space. Drone direction through the friction of air in the horizontal direction, the screws of the generators of the G1\G4 engine (coil and neodymium magnet) begin to rotate. They produce DC power and transfer it to the battery pack (AB). The battery begins to charge and constantly (continuously) transfers energy to the M1\M4 traction motors. Thus, receiving an additional charge from the generators of the G1\G4 unmanned battery in flight prolongs its operation. And the drone can fly longer and longer.

The transfer function of induction coils.

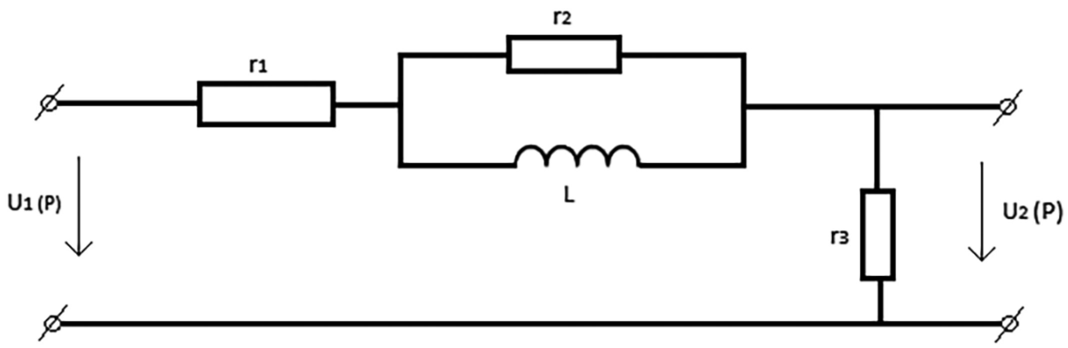
First, let's build a transfer function for one coil, since an unmanned aerial vehicle has four such coils, the transfer function of each coil is limited.

The procedure for constructing the transfer function of one induction coil will be shown by an example for the replacement shown in Fig. 4, for data:

$$r_1 = 1Ohm, r_2 = 1Ohm;\ r_3 = 2Ohm; L = 3H.$$

1. Here, the output valuey $= U_2(p)$ corresponds to the electrical energy of the generated coil, the input effect – $U_1(p)$ corresponds to the energy of the wind flow (Babakhan Shokhrukh, Kokanbay Yernar, Pernebaev Kuanysh. 2023).

Figure 4. *The replacement electrical circuit of the induction coil*



2. In this case, the equivalent resistance is: $Z_1(p) = r_1$, $Z_3(p) = r_3$, $Z_L(p) = pLZ_2(p)$ when the elements are connected in parallel:

$$\frac{1}{Z_2} = \frac{1}{r_2} + \frac{1}{pL} = \frac{r_2 + pL}{r_2 pL} = \frac{r_2 pL}{r_2 + pL} \quad (1)$$

Here $Z_{общ}(p)$ will be the resistance in the circuit, then $Z_1(p), Z_2(p), Z_3(p)$ we know:

$$Z_{общ}(p) = Z_1(p) + Z_2(p) + Z_3(p) =$$
$$= r_1 + \frac{r_2 pL}{r_2 + pL} + r_3 = \quad (2)$$
$$= \frac{r_1 r_2 + r_1 pL + r_2 pL + r_2 r_3 + r_3 pL}{r_2 + pL}$$

The current before branching according to Ohm's law is equal to:

$$I(p) = \frac{U_1(p)}{Z(p)} =$$
$$= U_1(p) \cdot \frac{r_2 + pL}{r_1 r_2 + r_1 pL + r_2 pL + r_2 r_3 + r_3 pL} \quad (3)$$

Then the voltage in the circuit will be equal to:

$$U_2(p) = I(p) \cdot Z_3(p) = U_1(p) \times$$
$$\times \frac{r_2 + pL}{r_1 r_2 + r_1 pL + r_2 pL + r_2 r_3 + r_3 pL} \times r_3 = \quad (4)$$
$$= U_1(p) \cdot \frac{r_2 r_3 + r_3 pL}{r_1 r_2 + r_1 pL + r_2 pL + r_2 r_3 + r_3 pL}$$

3. Write down the final transfer function as the ratio of input to output and open the brackets in the denominator:

$$\frac{U_2(p)}{U_1(p)} = \frac{r_2 r_3 + r_3 pL}{r_1 r_2 + r_1 pL + r_2 pL + r_2 r_3 + r_3 pL} \quad (5)$$

$$\frac{U_2(p)}{U_1(p)} = \frac{r_2 r_3 \left(1 + \frac{r_3 pL}{r_2 r_3}\right)}{r_2 r_3 \left(\frac{r_1 r_2}{r_2 r_3} + \frac{r_1 pL}{r_2 r_3} + \frac{r_2 pL}{r_2 r_3} + 1 + \frac{r_3 pL}{r_2 r_3}\right)} \quad (6)$$

$$\frac{U_2(p)}{U_1(p)} = \frac{1 + \frac{pL}{r_2}}{\frac{r_1}{r_3} + \frac{r_1 pL}{r_2 r_3} + \frac{pL}{r_3} + 1 + \frac{pL}{r_2}} \quad (7)$$

We have found the ratio of the output voltage to the input voltage. We have fulfilled all the specified conditions. But we have one more point that needs to be taken into account, and it is necessary to switch to a constant time chain.

$$[\tau] = [\frac{Гн}{Ом}]. \quad \frac{L}{r_2} = \tau_1, \quad \frac{L}{r_3} = \tau_2 .$$

$$\frac{U_2(p)}{U_1(p)} = \frac{1 + p\tau_1}{\frac{r_1}{r_3} + \frac{r_1}{r_2} p\tau_2 + p\tau_2 + 1 + p\tau_1} \quad (8)$$

4. Substituting numerical values, we get:

$$W(\kappa) = \frac{U_2(p)}{U_1(p)} =$$
$$= \frac{1 + \frac{pL}{r_2}}{\frac{r_1}{r_3} + \frac{r_1 pL}{r_2 r_3} + \frac{pL}{r_3} + 1 + \frac{pL}{r_2}} = \frac{2 + 3p}{3 + 12p} \quad (9)$$

The image shown in Fig. 5 is a single module charging system for an unmanned aerial vehicle created in Matlab Simulink.

Figure 5. *The model of the induction coil in the Simulink application of the Matlab program*

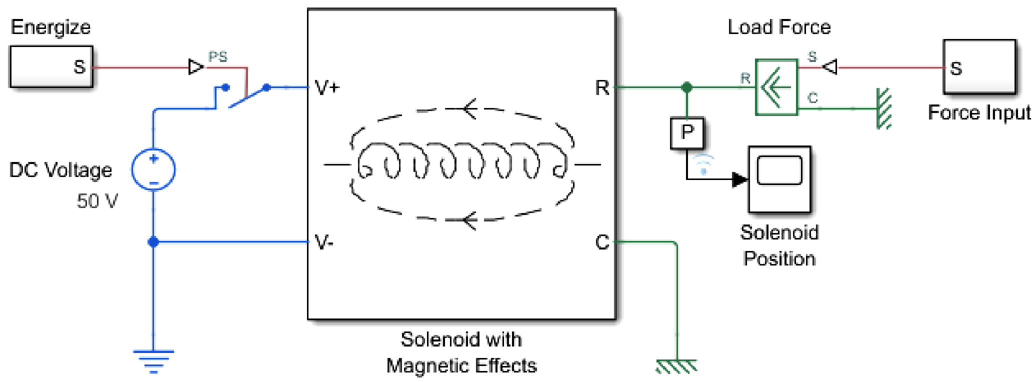
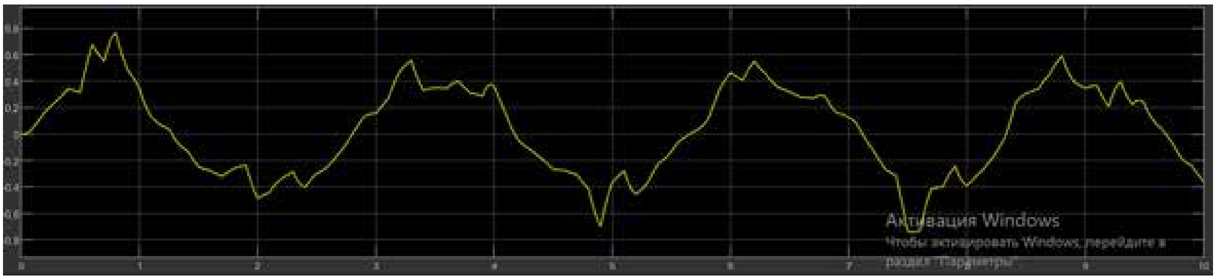


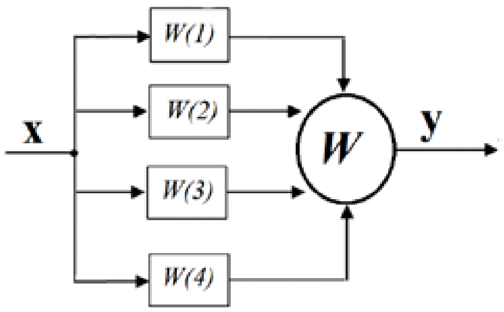
Figure 6 shows the production of an induction current of one coil

Figure 6. *Simulation results of the voltage at the output of the induction coil*



The transfer function of the accumulator battery charging system of an unmanned aerial vehicle is shown in Fig. 7:

Figure 7. *Transfer function of the battery charging system of an unmanned aerial vehicle*



From this scheme, you can write the transfer function of a magnetic coil mounted in an unmanned aerial vehicle.

$$W = W(1) + W(2) + W(3) + W(4) =$$

$$= \frac{2+3p}{3+12p} + \frac{2+3p}{3+12p} + \frac{2+3p}{3+12p} + \frac{2+3p}{3+12p} = \frac{8+12p}{3+12p}$$

$$W = \frac{12p+8}{12p+3} \qquad (10)$$

Thus, the mathematical model of the battery charging system of an unmanned aerial vehicle in the Simulink application of the Matlab program is shown in Fig. 8.

Figure 8. *Model of the battery charging system of an unmanned aerial vehicle in the Simulink application of the Matlab program*

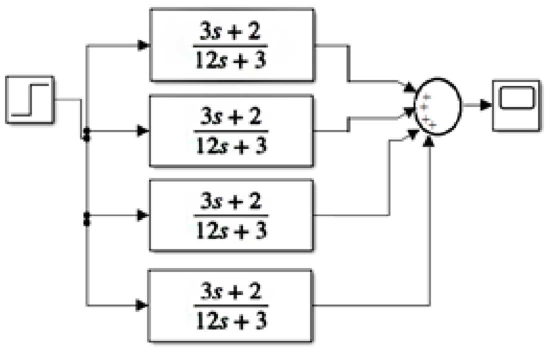
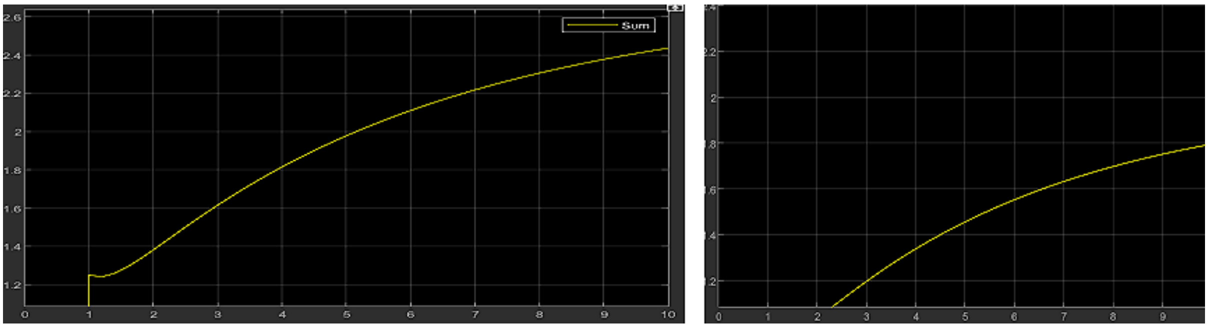


Figure 9 shows the output from the battery charging system of an unmanned aerial vehicle

Figure 9. *View of the output induction current from the battery charging system of an unmanned aerial vehicle in the Simulink application of the Matlab program*



Conclusions

The unmanned aerial vehicle is undergoing a period of active development, and its application is becoming more widespread and diverse. At the same time, there is a need to extend the flight mode of an unmanned aerial vehicle. On the other hand, this problem has become in demand today. The proposed method of recharging the battery of an unmanned aerial vehicle is one of the possible solutions to this problem, the advantage of the proposed method of recharging the accumulator battery is its prostate in design and efficiency in operation. The proposed method is patented (Patent of the Republic of Kazakhstan for invention No. 36987)

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