Design of Speed Control Circuit for Adams Motor

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Abstract. This paper is focused on two variants of speed control circuit for non-conventional electric motor-generator named after its inventor Robert Adams. The paper is divided into three parts. The principle of the Adams motor is described in the first part of the paper. The second part deals with a structure of realized Adams motor. Two variants of electrical speed control circuit for Adams motor are described in the third part.

Keywords: Adams motor; motor-generator; speed control; anisotropic electrical steel

1 Introduction

Adams motor is an electric motor working is switching mode like reluctance motor. The principle was described by Robert Adams and Harold Aspden´s patent in 1993. [1][2]

A similar principle of the machine is described in Tom Bearden publication. [3]

The motor is composed of salient rotor poles made of electrical steel and uses permanent magnets in rotor like a source of magnetic flux. Permanent magnets are often used in electric motors for reach their efficiency. There are a several differences between common synchronous motor or BLDC motors with permanent magnets and construction of Adams motor. [4]

2 Description of the Adams motor principle

The rotor is spun by the following force contributions:

a) The rotor pole is attracted to the magnetic stator cores by magnetic forces produced by permanent magnets protruding into the air gap and closed over the stator cores.

b) Once aligned with the rotor salient pole, the rotor is further spun by repulsive forces between rotor poles and the stator core. Coils in stator cores are supplied with electric pulses depending on the position of rotor with respect to the stator. The magnetic field within the air gap will reach its maximum intensity once the poles of both rotor and stator have been aligned.

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In Fig. 1 (a) is the pole of rotor R1 right in between the stator poles S1 and S2.

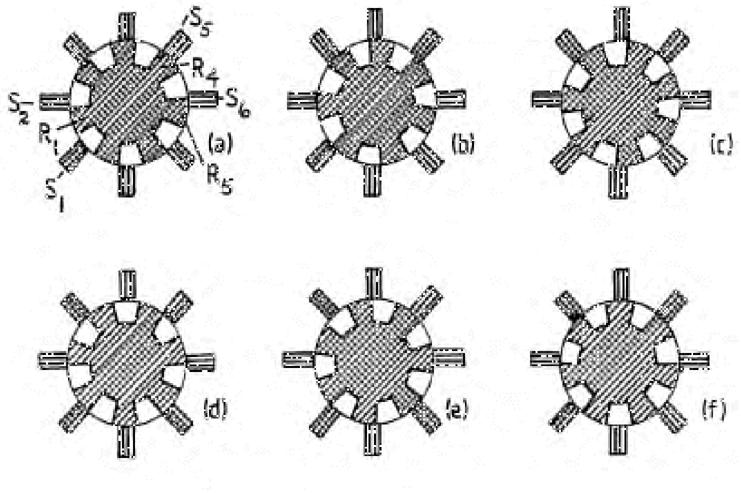

Fig. 1. Mutual positions of rotor and stator poles during rotation of the rotor.

Imagine that it inclines towards S2, being attracted to the latter until setting at the position indicated in Fig. 1. (c). It is aligned with the stator core now, current beginning to pass through its coils with such polarity to induce repulsion of the rotor pole from the position with aligned axes of the rotor salient pole and the stator core. It is therefore accelerated pursuant to strong interaction of magnetic fields of the rotor. The current will keep entering the stator coils until the stator has reached the position shown in Fig. 1. (e). The opposite stator core will be aligned with the rotor salient pole now.

Let us look what happens on the opposite side of the rotor during this process.

Rotor pole R4 in Fig. 1. (a) is currently aligned with the stator core S5. That is why the winding in core S5 is supplied with electric current the effects of which induce potential repulsion of the pole R4. The current is passing through winding of the core S5 till the moment illustrated by the Fig. 1. (c), when the core of stator S2 is de-magnetised.

2 Realization of the Adams motor

Fig. 2. shows the front view of the implemented machine. When working as an electric motor, the machine is supplied with direct current impulses depending on the position of the rotor salient poles with respect to the stator poles. The ratio between rotor and stator poles is 7:8. This ratio always helps the rotating rotor align axes of rotor poles and stator cores at a single salient pole of the rotor and one magnetic core of the stator. The axis of stator core is situated in the middle of the gap between the rotor salient poles on the opposite side.

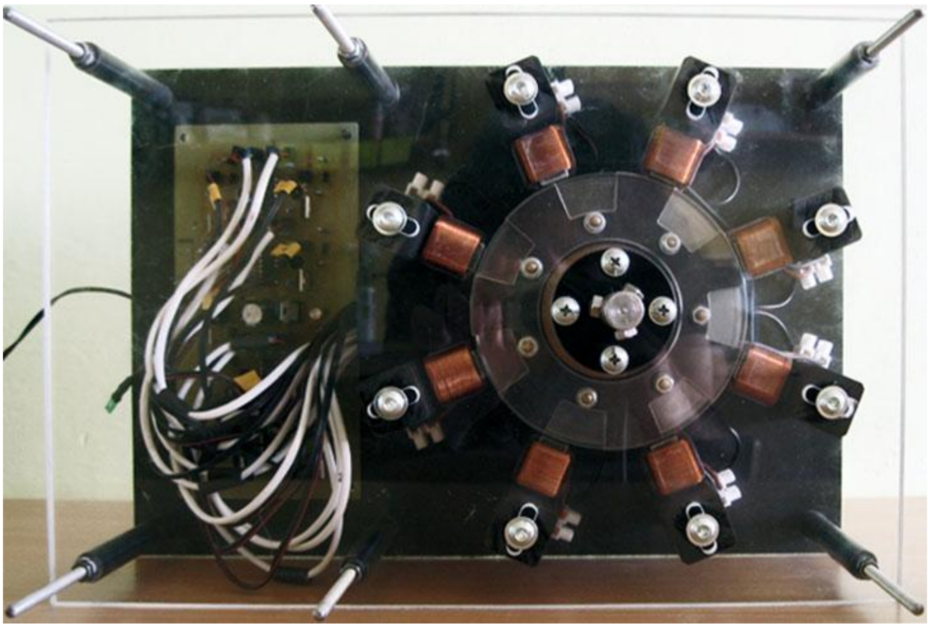

Fig. 2. Front view of the finished model of the implemented Adams' motor-generator.

The rotor is fitted with 7 permanent magnets NdFeB with magnetisation rating of N38 and 15 mm in diameter and 13 mm in height. These magnets are situated between two sections made of stratified metal laminations made of steel M600-50. These laminations are cut with a water jet into a gear shape with alternating 7 gaps and 7 teeth forming salient poles supported by magnetising of magnets. The Fig. 3. shows an assembled rotor.

Fig. 3. View of a rotor comprising a shaft, fixing flanges, a magnet enclosure, rotor sections and stratified laminations and side perspex panels with brass bolts to tighten the rotor body

Foundation for the rigid stator structure is made of two 8 mm thick perspex pads fitted with ball bearings and wooden holders for attachment of magnetic cores of the stator containing the cores glued in with epoxy resin. The magnetic circuit of stator comprises 8 soft C-shaped magnetic cores coiled from the material M150-30 S and provided with a pair of excitation coils connected in series. The cores are spaced evenly around the rotor circumference and they were originally designed for core-type transformers.

Fig. 4. shows the commutator comprises a transparent foil printed with a pattern of alternating black and transparent spots. When the optocoupler beam passes through the transparent foil, electric current supply will be actuated for the relevant pair of coils on one of the eight stator cores. Location of eight optocouplers around the circumference of the black commutating foil is evident from Fig. 9. The foil can be tilted within the range between -12.85° and 12.85° with respect to its default position to achieve the optimal moment of current switching for the relevant coils.

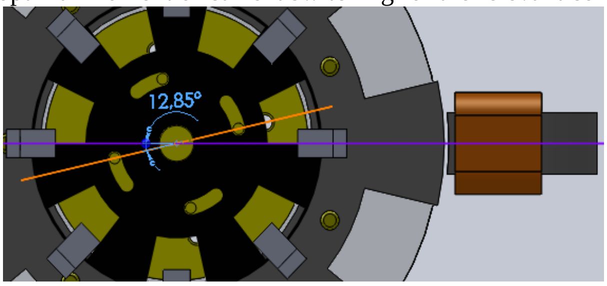

Fig. 4. Setting the lead angle of commutating foil to -12.85° with respect to the default position.

2 Electronic control circuits

The machine was initially connected as a motor benefiting from the wiring shown in the Fig. 5. The performance section is actuated upon interruption of an infrared beam landing on the phototransistor in the optocoupler. The beam passes through the transparent foil part at the moment, when the rotor salient poles are in the front position together with stator cores with the magnetic induction flow initiated by coils; this flow is opposite to the power flow coming out of the rotor poles. The rotor is spun by forces acting between magnetic fields of the rotor and the stator.

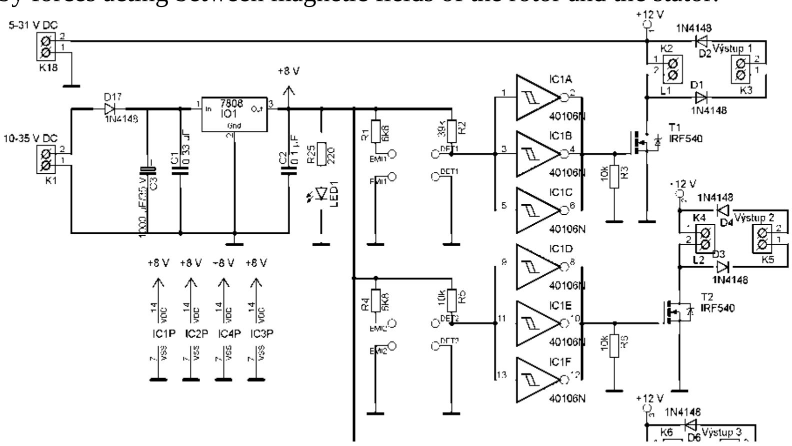

Fig. 5. The first version of the wiring diagram of the electric circuit for motor control. The circuit in the right side of the figures behind dashed line is repeated 4 times in total. The figure shows one quarter of the wiring only to save space.

The electric circuit can be divided into the output part separated from the low input power section by means of a control electrode MOSFET on IRF540N transistors. The left side of this diagram shows the connection points of supply voltage. The positive pole of 2-31 V direct current supply voltage is linked with stator coils via connectors L1 to L8. The voltage of 10 – 35 V DC is connected via the voltage regulator 7808. This diagram shows the optocoupler TCST 2103 represented by outlets marked EM1 and DET1. The resistance values are determined in order to limit the current in control circuit to the lowest value, while preserving correct operation of the circuit. The beam passes through transparent part of the commutator, as it is interrupted by the piece printed with black colour. Schmitt trigger circuits are connected behind detectors to invert the voltage at the input point. One enclosure of the integrated circuit 40106 includes 6 investing gates. The parallel connection of three gates in each batch helps reduce the gate resistance to one third of its initial value. That is followed by the N-MOSFET type output IRF560N transistor with low-resistance electrode transition DS in actuated state equal to 44 mΩ. Once the transistor opens, the current will be passing through the relevant winding linked with the connector. Connection of contacts K3 ensures engagement of the transistor overvoltage protection in terms of serial connection of rectifier diodes D1 and D2.

In Fig. 6, the second version of electronic circuit is showed. The second version of electronic control uses a microcontroller module Adrduino Nano with a microchip AT328P. Application of microcontroller lets as much friendly set the optimal switching angle than in the first version.

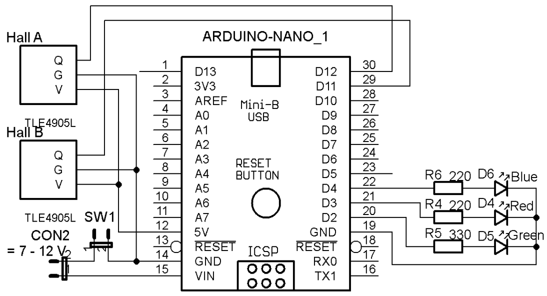

Fig. 6. The second version of the wiring diagram of the electric circuit for motor control.

Two hall sensors TLE 4905L are used. The Hall A serves for switch on the transistor T1-T8 and sensor Hall B control the position of the rotor for switch off these transistors. The Arduino Nano computing the right switching positions when all transistors are alternately switched on or off. The connection of the transistors with microchip is realized with Schmitte device 40106 connected to pins A0-A7. There are tree led diodes for inform you about the status of the motor. The red led means error in function, green signature means common mode and the blue means save mode for manipulating with the rotor by hand when the circuit is connected to the power supply voltage.

4 Conclusion

The implementation of microcontroller for speed control the Adams motor lets us set a right switching angle between stator and rotor poles much better than in first realization of control circuit uses a commutator foil where transparent and non-transparent sections are alternating. The motor can be easily regulated by next addition of buttons connected to free pins of microcontroller for instantaneous set the angle of switching position between stator and rotor poles.

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