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STAND FOR TESTING EXPERIMENTAL TOTAL HIP PROSTHESIS - electrical control circuits -

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Abstract: *This paper presents a variation circuit for controlling an electric motor with brushes 24 VDC. Motor is used to drive a device that is attached to a stem total hip prosthesis. The device is part of an experimental test stand total hip prostheses made in Transilvania University of Brasov, Department of Advanced Mechatronic Systems-D04 for a doctoral thesis. Electric circuit reliability has been demonstrated for a long enough period that about a year ago, when the stand has been tested a number of prostheses. This control circuit is based on the principle of H bridge is presented in detail in the paper.*
Keywords : *experimental stand, H bridge, brushless DC motor, transistor, MOSFET*

1. INTRODUCTION

For the testing of total hip with femoral head removable was designed, made and calibrated a stand of experimental tests. The design of the stand have had regard to the following aspects:

- On the stand must simulate all the movements of the hip joint namely: flexion-extension, abduction-adduction and internal – external rotation [1],[2];
- Compression force acting on the femoral head of the prosthesis should be amended (50-380 kg);
- The stand must offer the possibility of testing a wide range of hip prostheses made of different materials with different diameters of femoral head and acetabular Cup (22, ..., 56 mm);
- The choice can be simulated a single motion of articulation;
- Possibility of automatic metering the number of cycles performed
- Can change the amplitude of movements of articulation;
- Can record the angular velocities and accelerations on the three directions;
- The possibility of a very large number of cycles (in the order of 10^7);
- The stand must offer the possibility of joint prosthesis surface lubrication;
- The stand must have a simple construction and low cost price.

In reference [1] and [2] is presented in detail the pneumatic circuit of this stand, being presented and the methodology of calculation of the force developed by the Pistons and simulate the operation using a specialized software. In reference [3] is presented in detail the automatic metering device of cycles run on stand. The main device is based on an application developed in LabVIEW, a acquisition board LabJack U12 and a series of micro-switch. Therefore, this paper presents only the electrical circuit which controls the electric motor 24 VDC.
The main components of this stand are (see Figure 1) [2]:

- two pneumatic pistons (at the top of the stand) to provide compressive force necessary to simulate the loading of a hip joint. The pistons are mounted on a laminated profile type INP 100 through 8 M8 threaded rods. Piston rods are fixed in a fork at the top;
- force transducer (comprising a full bridge strain gauge) type Kaliber 7972;
- an intermediate piece acetabular cup fixation transducer;
- acetabular cup- prosthetic head attached to the stem prosthesis;
- an intermediate support assembly mounting plate prosthesis head + rod worm mechanism;
- worm gear mechanism is driven by an electric motor 24 VDC;
- pinion-rack gear mechanism (driven by two pneumatic pistons). Experimental stand provides a loading artificial hip joint and the three movements: flexion-extension, internal-external rotation and abduction-adduction. Movements are provided by the mechanism of the piston rack and worm.

The aim is to study the behavior of the hip prosthesis to requests from an artificial hip joint (it takes into account the tribology aspect). This has been tested: a total hip prosthesis made by the company Biotechni (France) in the head and

UHMWPE cup is made of stainless steel prosthesis (Co-Cr-Mo) and produced a total prosthesis SULZER company (Germany) where prosthetic head is alloy Co-Cr-Mo (Protasul) and cup of UHMWPE and Co-Cr alloy.

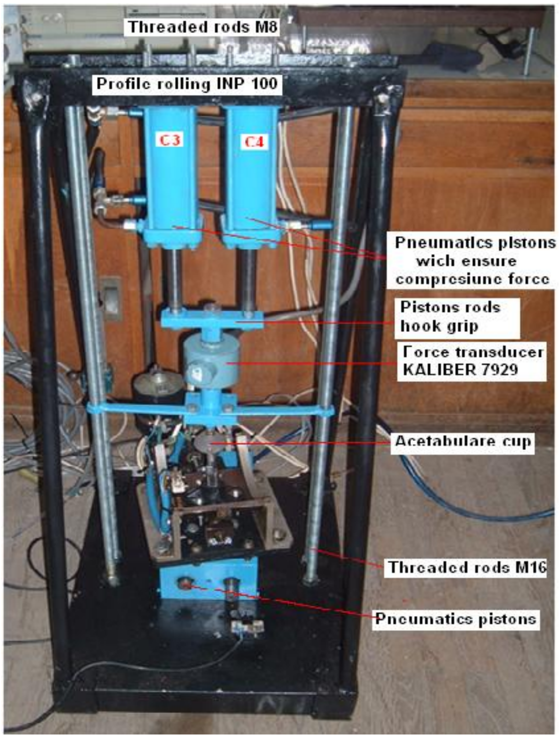

Figure 1: Experimental stand for the hip prosthesis behavior

2. THE CONTROL CIRCUIT OF THE ELECTRIC MOTOR

2.1. Constructive and operation principle

An electric motor is a device that converts electrical energy (from a voltage source) into mechanical energy. Most of them operate on the electromagnetic forces acting on a current-carrying wire conductor located in a magnetic field. Brush DC motors are widely used in various applications such as in toys, the constant speed drives in spin systems and ventilators, pumps and industrial processes.

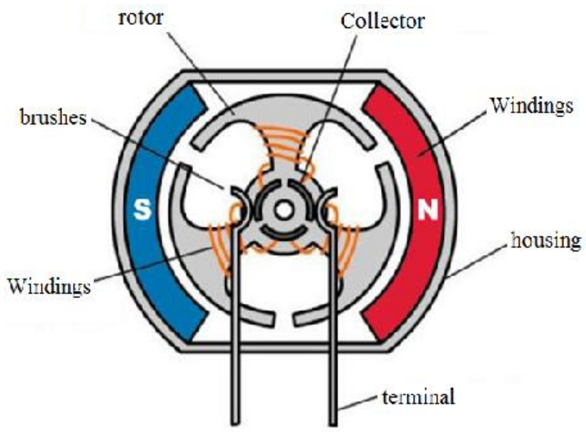

Figure 2: The structure of electric motor brushes

These electric motors are not expensive, are easily ordered (acted) and are available in a large range of shapes and sizes. Elements of a DC motor are: stator, rotor, brushes and collector -Figure 2. The stator generates the magnetic field around the rotor. This field can be generated in two ways: by means of permanent magnets or with the help of the helix of electromagnets. The rotor, and the armor is made of one or more windings. When these windings are supplied with voltage they produce a magnetic field. Poles of the rotor will be attracted to the opposite poles of the stator generate, producing rotating impeller. As long as the motor rotates, the windings are supplied continuously in different sequences, so that poles generate by the rotor will not overcome the poles generate in stator.

This disruption (changing) of the field in the rotor windings is called switching. Switching windings of such an motor is achieved mechanically. A segment (semi-ring) of copper called switch (collector) make the body together with the spindle motor. During rotation, graphite brushes glides over the switch, coming in contact with the various segments of it. Segments of the switch are attached to the different windings of the rotor, thus a dynamic magnetic field is generated in the inside of the motor when the voltage is applied to the ends of the brushes. For electric drives of small and medium powers, or for drives that require no magnetic field excitation variable stator windings in place using permanent magnets.

The motor speed is proportional to the voltage applied to the winding of rotor and is regulated by varying the voltage applied to the motor up to the nominal value of blood. The torque developed by the motor is directly proportional to the electric current through the rotor. Changing the direction of rotation is done either by changing the polarity of the supply voltage.

Technical characteristics of c. c motor (24 V) with permanent magnets used at this stand are: supply voltage: 24V/30A; stator with permanent magnets; two speed of manufacture; presents a worm reducer $90^0$and rated power 180W. Output shaft has a diameter of 10 mm, a length of 19 mm and has a threaded portion (M8) on a length of 8 mm. The centering bushing reducer shaft has a diameter of 19 mm and is made of bronze. The motor features a clamping flange steel of 2 mm which has charged three holes (located at 1200) with diameter 6,5 mm allowing an assembly with screws M6.

2.2. Controlling the direction of rotation of DC motors

All engines require circuits that control the current through the windings. This includes the direction and size of the current. The simplest type of engine in terms of the order is the DC motor with brushes. Control circuits for this type of motor are given below. If we want to start a DC motor in one direction, then we can achieve this by using a MOSFET transistor, according to installation shown in Figure 3.

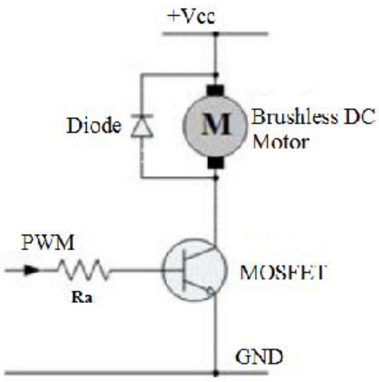

Figure 3: Electrical scheme for one-way meaning control of a DC motor

Command of the transistor can be given by a control circuit such as a microcontroller. The transistor, if receiving a signal based 5V (3.3V) from microcontroller, then will lead and the motor will be powered, rotating in one sense. If upon entering this amplifier circuit (also called "driver"), on the basis of the transistor, will attend a 0V signal, then the engine will stop.

Technique PWM-*Pulse Width Modulation* - may be used to perform a variety of tasks, from changing the intensity of the LEDs to the speed control of a DC electric motor or temperature control from electric ovens because the inertia effect of mediation devices blood. The modulated signal can build an analogue signal, if filter with a low-pass filter. In essence, the PWM technique is a way to encode digital signals to analog. The fundamental principle of this technique is that with increasing fill factor of a rectangular signal, the power and the voltage average supplied grows in linear fashion, while signal frequency remains constant. With such a circuit, usually achieved with a microcontroller, is present and amplifying circuit with a transistor, it can order the engine only in one sense it is the most economical technique for DC motors with brushes due to the simplicity of the command with the transistors MOSFET [2].

Usually in practical applications, it is necessary to order an motor in both directions what can be done using a H bridge as a booster. The H has the name derived from the usual way of drawing of the circuit and is basically a circuit with four switches, two time acting diagonally, to change the direction of rotation of the engine (Figure 4). These switches or switches are usually carried out with MOSFET or Darlington transistors. Simulation stand consists of a control circuit 24 V brushless DC motor, which drives a worm gear that is mounted rod holder (stem) hip prosthesis (Figure 1). The main components of this circuit with a simple construction, a small number of components and a low cost price, are (Figure 5): two 220VAC/24VAC transformer (TR1 and TR2); two rectifier bridge (20PM1, 10MP1); an auxiliary relay RI-13 (Figure 5); a variable voltage circuit; 24 V brushless DC motor (which drives gear mechanism); terminal block for the connections; two micro-switches K1 and K2, which limits travel gear mechanism and electric relay command determines reversing movement (Figure 5); a digital multimeter and metering device operating hours of the facility.

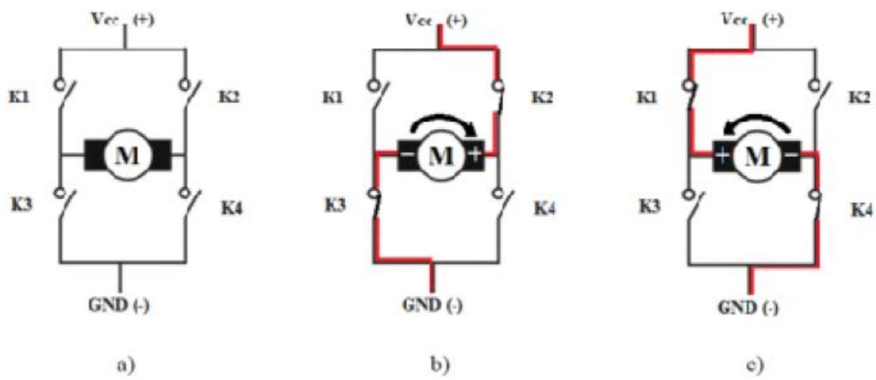

Figure 4: The operating principle of the bridge H [2]

For order reversing bidirectional DC motor has started to bridge principle H (shown above), but in this case instead of four transistor (MOSFET or Darlington) being taken by an auxiliary relay type RI-13 produced by Electromagnetic SA - Bucharest. Wiring diagram of the entire circuit (power and control) serving 24 V DC motor is shown in Figure 5.

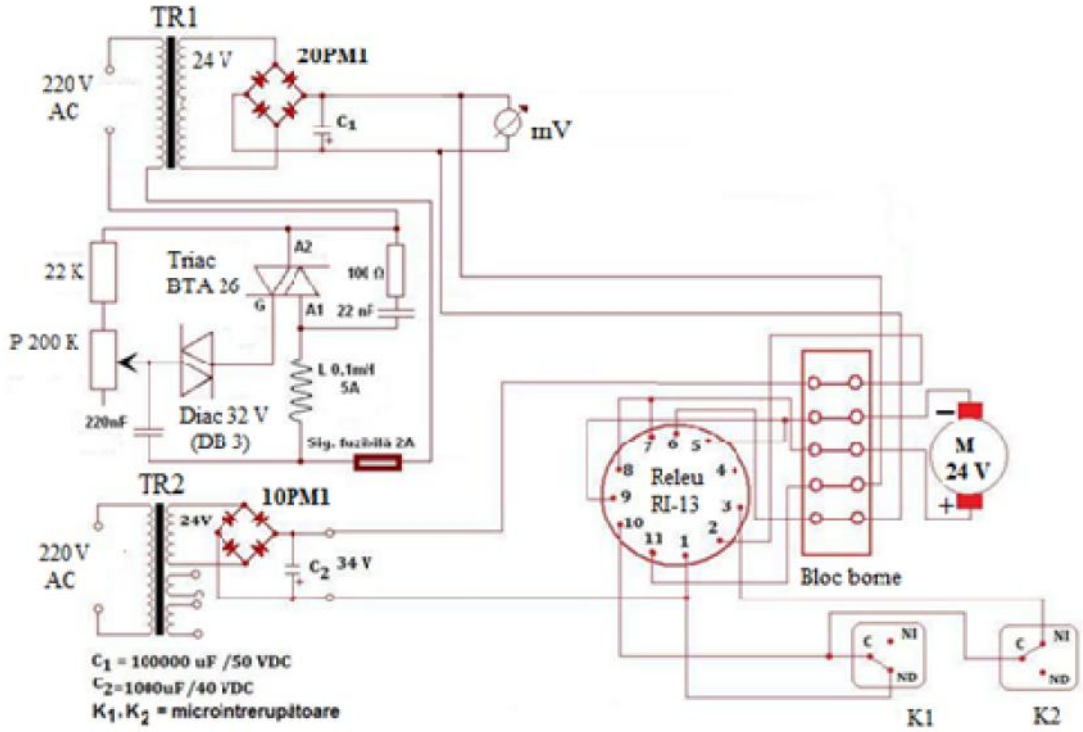

Figure 5: Electrical scheme of full control circuit of 24 V brushless DC motor [2]

3. CONCLUSION

Although electric control circuit 24 volt electric motor has a simple design has proven very effective for this stand. Low cost price component was still a criterion for choosing these circuits. Making electrical circuit was done in a very short period. Although the stand has conducted a large number of cycles (10^6) were problems regarding this circuit.

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