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## PWM Control of a DC Motor Used to Drive a Conveyor Belt

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### Abstract

This work presents an experimental stand for the PWM control of a DC motor used for driving a conveyor belt. For supplying the DC motor an H-bridge has been used that allows the reversal of the motor rotation wise. The PWM signal is generated by an ARDUINO UNO board, equipped with an Atmega 328 microcontroller. For controlling the ARDUINO UNO board, a program has been issued in the LabVIEW 2013 programming environment. The purpose of the experimental stand consists of studying the running characteristics of the conveyor belts under laboratory conditions, so that, further on, such driving systems can be implemented to industrial applications as well. Unlike other driving systems of conveyor belts, this system allows the optimization, by trials, of their running duties. The running duty of a conveyor belt may be modified by modifying the duty-cycle value of the PWM signals that controls the transistors of the H-bridge that supplies the DC motor. The PWM control of the DC motor provides the performances settled at the designing stage.

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*Keywords:* PWM control; DC motor; Arduino board; LabVIEW; conveyor belt

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### 1. Introduction

The most usual control method of a Dc motor rpm consists of the control through pulse width modulation (PWM) [1], [2]. The motor rpm variation is performed by increasing or decreasing the time interval when the control signal has the logic value 1 ( $t_{ON}$ ). Thus, at a duty-cycle of 100%, the motor will have the maximum rpm,  $t_{ON}$  will be maximal and  $t_{OFF}$  will be zero. At a duty-cycle of 50 %, the motor will have half the rated rpm, so  $t_{ON} = t_{OFF}$ .

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In case of a duty-cycle of 0%, the motor will be stopped, so  $t_{OFF}$  will be maximal whilst  $t_{ON}$  will be zero. The duty-cycle is noted by  $f$  and can be calculated through the relation:

$$f = \frac{t_{ON}}{t_{ON}+t_{OFF}} \cdot 100 \text{ [%]} \tag{1}$$

In general, PWM signals are generated by microcontrollers, [3]. In an electric drive system micro-controllers form the logic control or decision part and DC motors form the acting part. The control part operates with voltage levels of 5V and low power and the acting part operates with higher voltage and power rates. For this reason an interface is necessary between the two parts of the system. Such an interface is composed of an amplifier that frequently has the role of galvanic separation between the two parts of the electric drive system. The block diagram of the DC motor control by means of the H-bridge is shown at Fig. 1, [4].

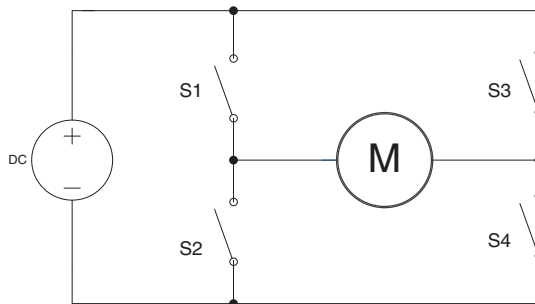


Fig. 1. Block diagram of the H-bridge.

The electric drive diagram presented above is made on the basis of several transistor type circuit breakers, GTO etc. The bridge is built of four circuit breakers, actuated diagonally. When the circuit breakers S1 and S4 are switched on (and S2 and S3 are switched off), Fig. 2.a, a positive voltage will be applied to the DC motor that will rotate clockwise. By switching off the circuit breakers S1 and S4 and switching on S2 and S3, Fig. 2.b, the voltage polarity is reversed, thus making possible the motor rotation counterclockwise.

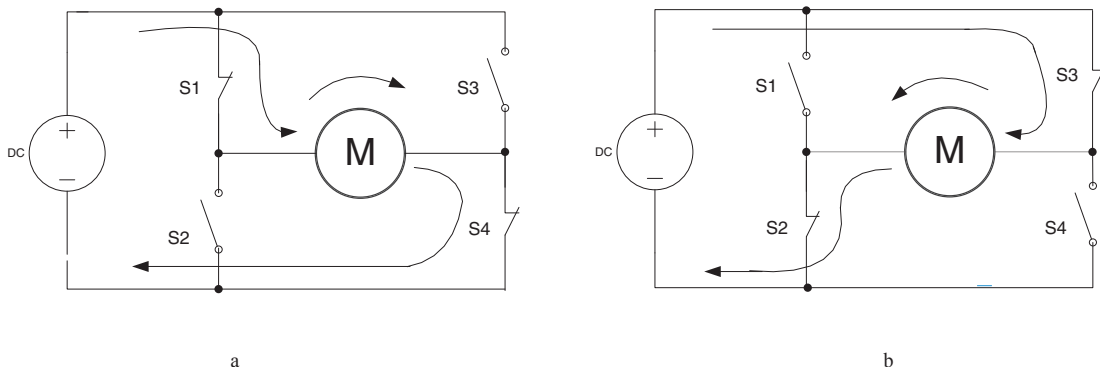


Fig. 2. H-bridge functioning diagram.

The H-bridge is generally used for reversing the polarity of the motor supply voltage but it may be also used for braking the motor (the motor stops suddenly because of short-circuiting its terminals) or for allowing the motor to freely rotate until still. This work presents an experimental stand for the PWM control of a DC motor used for driving a conveyor belt. For the supply of the DC motor an H-bridge has been used that allows the reversal of the rotation wise of the motor. The PWM signal is generated by an ARDUINO UNO board, built with an Atmega 328 microcontroller, [5], [6]. For controlling the ARDUINO UNO board a program has been issued in LabVIEW 2013 programming environment, [7]. The experimental stand aims at studying the running characteristics of the conveyor

belts under laboratory conditions and, further on, such driving systems to be implemented to industrial appliances as well. Unlike other driving systems of conveyor belts, this system allows the optimization, through tests, of the conveyor belt running duties. The running duty of a conveyor belt can be modified by changing the value of the filling factor of the PWM signal that controls the transistors in the structure of the H-bridge that supplies the DC motor.

## 2. Construction of the experimental stand

The block diagram of the experimental stand is shown at Fig. 3.

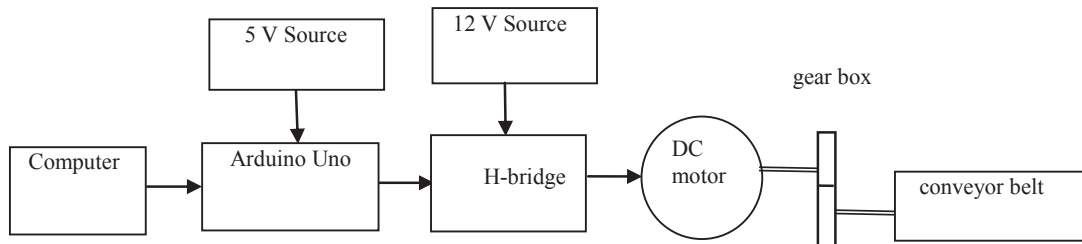


Fig. 3. Block diagram of the experimental stand.

A picture of the experimental stand is shown at Fig. 4. The experimental stand is composed of: DC-motor (1), gear box (2), H-bridge (3), ARDUINO UNO board (4), portable computer (5), conveyor belt (6), oscilloscope (7), tachometer (8).

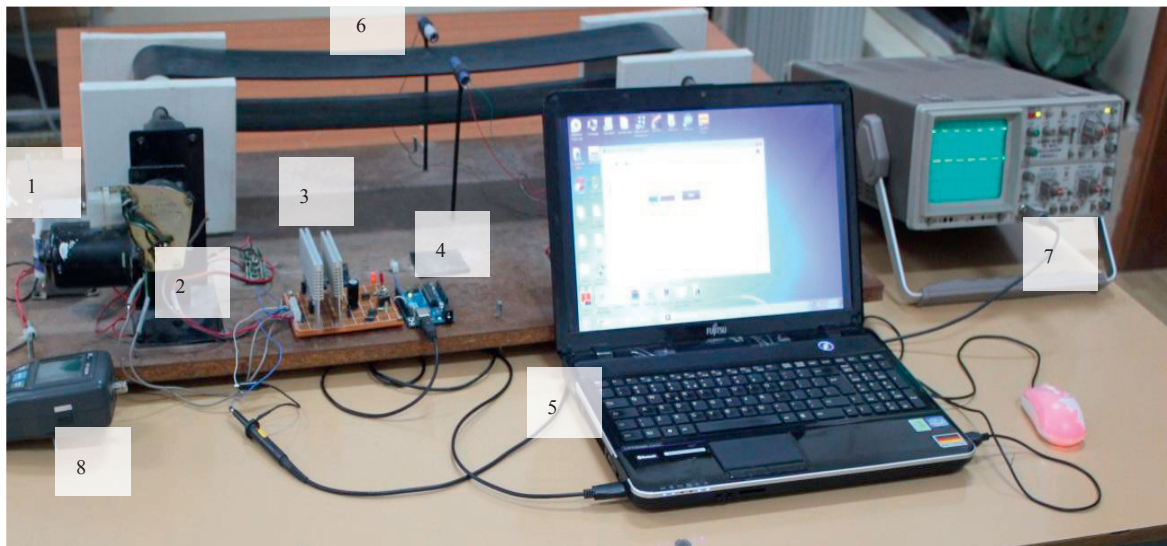


Fig. 4. Picture of the experimental stand.

### 2.1. Description of the experimental stand

The conveyor belt has been designed for the following dimensions: length = 63.5 cm, width = 10 cm, drum diameter = 4.5 cm. For driving the conveyor belt a DC motor has been used. Its characteristics are: the rated voltage  $U_N = 12 \text{ V.c.c.}$ , the nominal power  $P_N = 60 \text{ W}$ . The DC motor drives the conveyor belt by means of a gear box

(reducer) that has the role to increase the driving torque of the conveyor belt. In function of the motor power, the H-bridge has been sized. For the H-bridge field effect transistors of the following type have been used: IRF 4095, IRFZ 44.

**3. Functioning of the experimental stand**

The electric diagram of the experimental stand is shown at Fig. 5. The H-bridge is supplied from the DC voltage source of 12 V.D.C., of 100 W power, and the board ARDUINO UNO is supplied at 5V.D.C. through the USB port, from the portable computer used for its control.

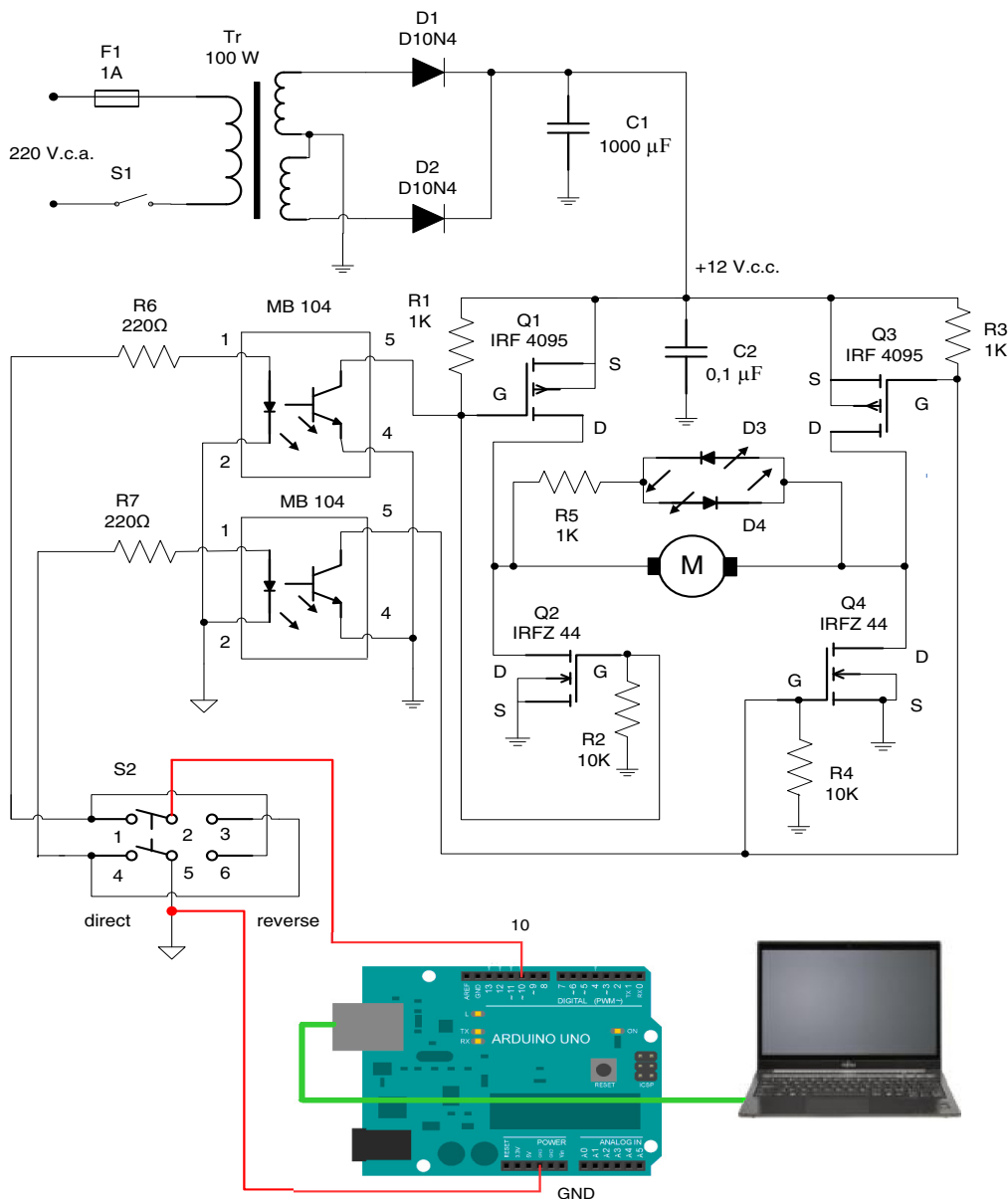


Fig. 5. Electric diagram of the experimental stand.

The PWM signal generated by ARDUINO UNO board is amplified through the amplifying steps built with the optocouplers MB 104 in function of the moving direction of the conveyor belt, selected through the switch S2. The program issued in LabVIEW 2013 for controlling the board ARDUINO UNO has the block diagram shown at Fig. 6 and the related front panel is shown at Fig. 7. The duty-cycle of the PWM signal may be modified through the Slide 2 located on the front panel of the program issued in LabVIEW 2013. The board ARDUINO UNO is controlled from the computer, through the USB port. The PWM signal of the ARDUINO UNO board is transmitted through its output, pin No. 10.

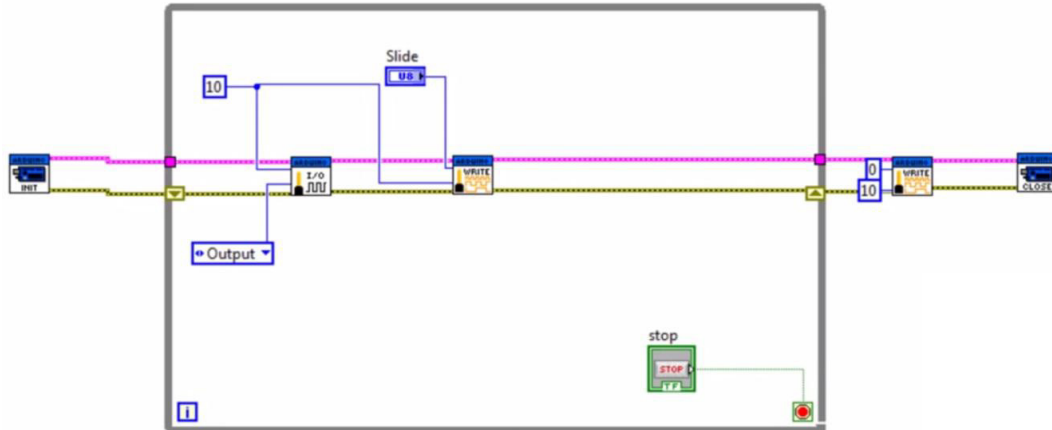


Fig. 6. Block diagram.

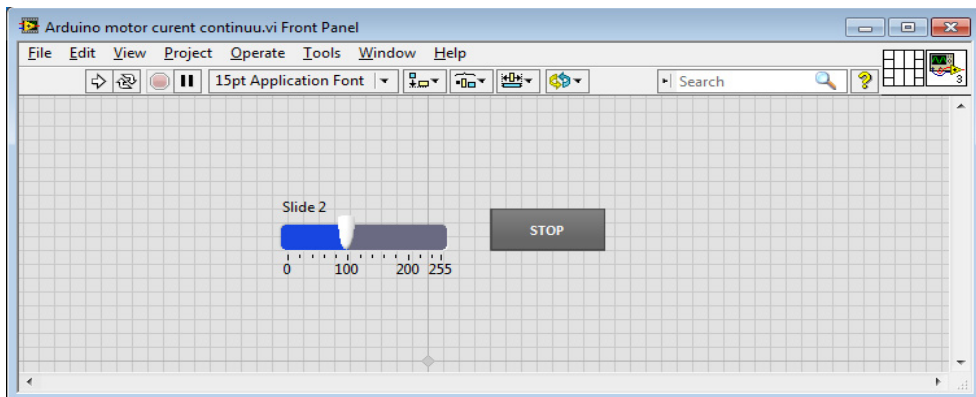


Fig. 7. Front panel.

#### 4. Experimental results

By means of the experimental stand the following experimental findings have been done: For various rates of the PWM signals, visualized with the help of an oscilloscope, the rpm values of the DC motor have been measured through a tachometer, for each moving direction of the conveyor belt. These values are shown at Table 1 for the direct motion direction and for the reverse motion direction of the conveyor belt and the diagrams of these characteristics are shown at Fig. 8. Through experimental trials, the running duty of the conveyor belt may be optimized, in function of the materials to be transported on the belt and technological conditions of use. After determining the optimal running duty, the program issued in LabVIEW may be implemented into the memory of the microcontroller ATMEGA 328 of the control board ARDUINO UNO. Thus, the cost of the automation equipment

used for controlling the DC motor of the conveyor belt system will be decreased.

Table 1. Resulting values of speed DC motor and duty-cycle for the direct and reverse motion direction.

Duty-cycle		50	100	150	200	255
Speed DC motor (rpm)	Direct	13	30	47	67	91
	Reverse	11.8	25.3	36.2	44.5	55.9

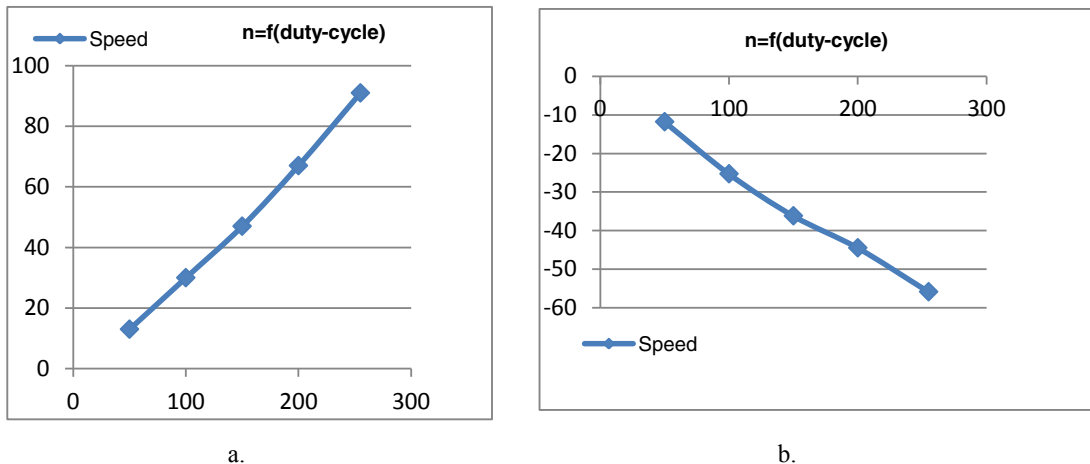


Fig. 8 Diagram of speed of the DC –motor a.- direct motion direction, b.- reverse motion direction.

## Conclusions

In this work was presented an experimental stand for the PWM control of the DC motor used for driving a conveyor belt. This experimental stand has been built at Electric machinery Laboratory of the University “Vasile Alecsandri” in Bacau. For supplying the DC motor an H-bridge has been used that allows the reversal of the motor rotation wise. The PWM signal is generated by an ARDUINO UNO board, equipped with an Atmega 328 microcontroller. For controlling the ARDUINO UNO board, a program has been issued in the LabVIEW 2013 programming environment. The running duty of a conveyor belt may be modified by modifying the duty-cycle value of the PWM signals that controls the transistors of the H-bridge that supplies the DC motor. With this experimental stand were studied the running characteristics of the conveyor belts under laboratory conditions, so that, further on, such driving systems can be implemented to industrial applications as well.

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- [7] \*\*\*\* program LabVIEW 2013 trial.