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Converter design for DC motor control

[1]Jozef PAJTÁŠ, [2]Irena KOVÁČOVÁ

[1,2] Department of Theoretical and Industrial Electrical Engineering, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Slovak Republic

[1]jozef.pajtas@student.tuke.sk [2]irena.kovacova@tuke.sk

***Abstract* — The paper describes the design of the DC – DC converter for control of two independent DC motors. The control strategy is based on the signals obtained from four pressure sensors. The motors are powered from 12V battery.**

***Keywords* — Arduino, converter, PWM, sensors**

I. Introduction

In automation, the problem of automated product sorting often occurs. In the case of products with different weights, one of the options that can be addressed is the use of pressure sensors.

In our case, we will analyze the possibility of designing a drive to drive two unidirectional motors to provide movement of the sorting platform, depending on the signals obtained from the four pressure sensors.

II. Design of sorting platform

The implementation of the sorting platform is illustrated in figure Fig 1. Pressure resistive pressure sensors FSR400 were used for pressure sensing (Fig.2).

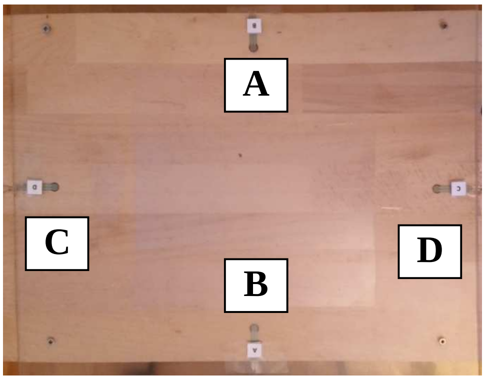

Fig. 1 Sorting platform

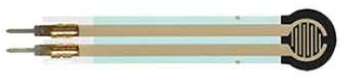

Fig.2 Pressure sensor FSR400

The resistance of the sensor depends on the pressure applied to the surface of the sensor. As the force increases on the sensor surface, sensor resistance decreases, as shown in Fig. 3. Sensor sensitivity is optimized for human touch so that electronic devices such as automobile electronics, medical systems, industrial and robotic applications, can easily control it.

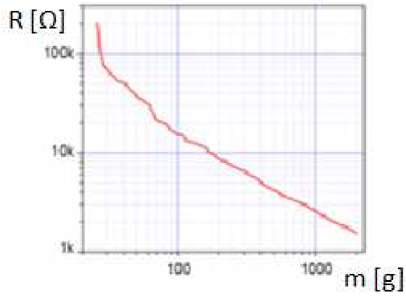

Fig. 3 Dependence of sensor resistance on applied force

In order to measure and subsequently evaluate the signal from the sensor, it is necessary to connect another R_M resistor to the sensor represented by the R_{FSR} resistor to create a voltage divider (Fig. 4). By changing the resistor R_M it is possible to set the desired sensitivity range of the sensor and it is also possible to limit the current flowing through the sensor.

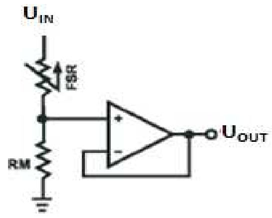

Fig. 4 FSR400 connected as voltage divider

By creating a voltage divider, we will ensure that the change in pressure is reflected by the change in voltage. Then the output voltage can be calculated from the following equation

$$U_{OUT} = \frac{R_M}{R_M + R_{FSR}} . U_{IN} \tag{1}$$

Based on the equation (1) and the graph (Fig. 3) it is clear that with the increasing force acting on the sensor, the resistance of the sensor decreases and the voltage will increase.

III. Design of a motor controller using a relay

Two control signals were selected for the control design. The PWM signal will control the speed of the motor speed and the second signal, acquiring logic 0 or logic 1, will control the relay contacts. The relay enables the mechanical contacts of the motor to be switched to control the direction of rotation of the motor.

Two twin-switch 12V relay switches are used to control the direction of rotation of the motor. The principal scheme of the relay connection as well as the actual relay we use is in Fig. 5.

Fig. 5 12V DC relay

Relay contacts, indicated by numbers 86 and 85, are coil contacts, contact 30 is an input contact, and contacts 87a, 87 are switching contacts. By passing the current through the coil, the coil is switched off and the input contact 30 is switched from position 87a to position 87. By using two switching relays, we can simultaneously mechanically switch the positive and negative poles on the DC motor as shown on the main circuit diagram (Fig. 6). Since we use a 12V relay and a 5V arduin signal amplitude is 5V, we use two more transistors to control the relay coil to amplify the signal. We need to use a pair of transistors to avoid inverting the original signal. By passing current in the relay coil there is an accumulation of energy thereon, and therefore a protective diode needs to be connected to the circuit in parallel to the relay coils.

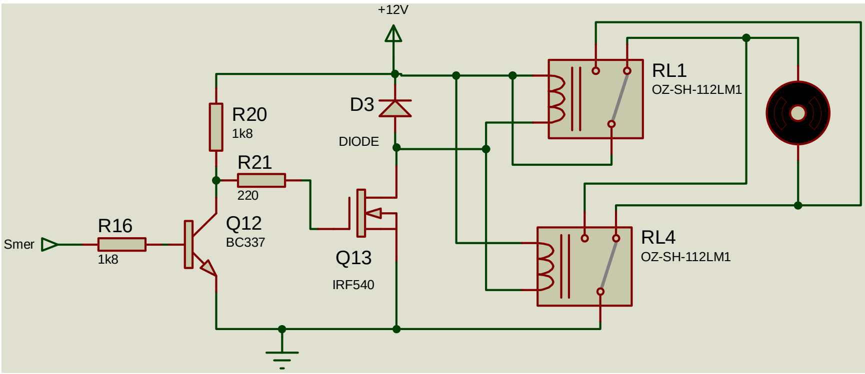

Fig.6 Main circuit diagram of 12V relay and motor connection

Due to the fact that Arduino, as a control member, provides a 490 Hz PWM signal which is insufficient, because we need a frequency of at least 10 kHz to generate a continuous control signal, so we need to use an external generator. We produce a PWM signal with sufficient frequency by comparing the birthing signal and the one-way signal. The linear saw signal can be obtained by using the NE555 integrated circuit in the circuit where the timing capacitor is charged by the current from the transistor according to the scheme in Fig. 7. A signal with the desired frequency and amplitude in the range of 4 V to 8 V provides output "TRESHOLD" as indicated by the manufacturer.

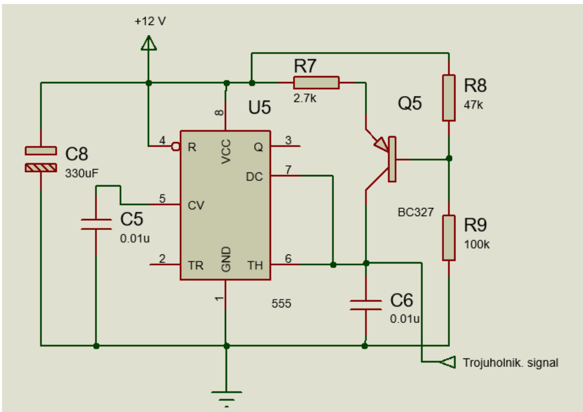

Fig 7 Wiring diagram NE555

PWM signal from Arduin must be filtered using RC filter to get a one-way component. In Fig. 8 is an orange color showing the PWM signal from Arduino and the blue color shows the DC component measured by the RC filter. This signal is subsequently amplified by two parallel transistors. At the base of both transistors a potentiometer is connected. By changing the base resistor value, it is possible to set the lower and upper level of the one-way signal that is compared in the comparator with the signal in the shape and thus we can associate the PWM signal from Arduin with the different PWM signals obtained from the comparator. In this way, we can adapt the PWM signal to our needs.

The amplified DC signal behind the RC filter enters the inverting input of the operational amplifier connected as a comparator where it is compared with the saw signal from the NE555 circuit. The

Fig. 8 PWM signal from Arduin before and after the filter

output from the comparator is an inverted PWM signal with a frequency of 35kHz and an amplitude of 12V (Fig. 9). Such signal is sufficient for impulse control of the switching power transistor by which we control the speed of the motor speed.

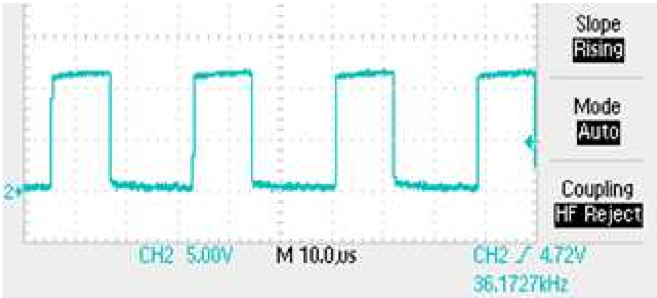

Fig. 9 Inverted PWM signal from the comparator

The MOSFET transistor is connected behind the comparator, which inverts the PWM signal from the comparator. The output signal from this transistor (Fig. 10), switching the power transistor, then has the same logic as the Arduino PWM signal. If we do not want to invert the PWM signal from the comparator, it is necessary to change the comparator input signals. However, in this case, it would be necessary to connect another transistor in the common emitter circuit to the circuit diagram (Fig. 12), behind the comparator to obtain a PWM signal of the same logic as the PWM signal from Arduino.

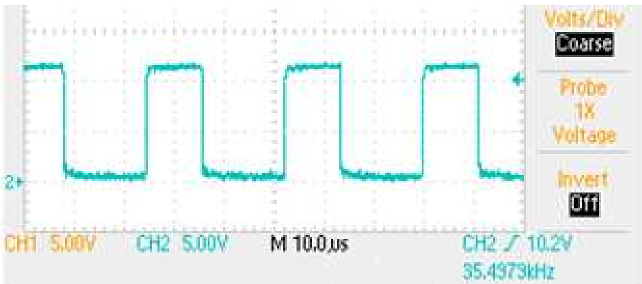

Fig. 10 Non-inverted PWM signal

Fig. 11 shows the voltage circuits on an IRF540 transistor with a connected load. The blue color shows the control signal of the power transistor and the orange color shows the voltage pattern of the u_{DS} of the power transistor used.

The overall circuit diagram for controlling the direction and speed of one motor is shown in Fig. 12. Since we need to control two motors independently of one another, the same wiring diagram will also be for the second motor. As you can see in the following diagram, we added two diodes to the circuit. Both perform a protective function. The D_1 diode is connected in parallel to the relay coil and the D_2 diode is connected between the motor contacts. The protective function is that the diode leads the current in only one direction. After changing the engine speed, by polarity of the motor contacts,

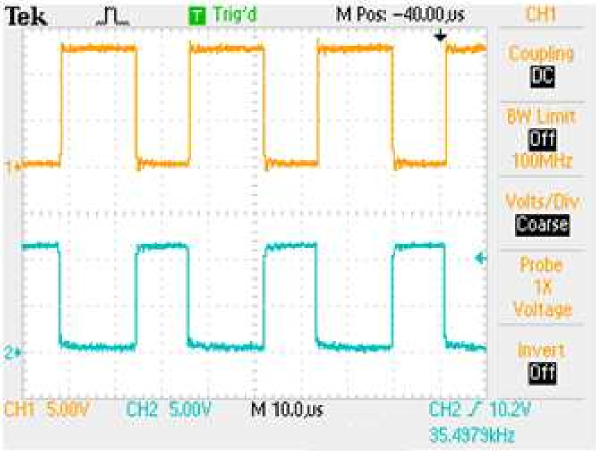

Fig. 11 Control signal and load signal

the current in the motor coil could be switched, as well as when the relay coil is switched on and off, which could ultimately result in the destruction of the switching power transistors.

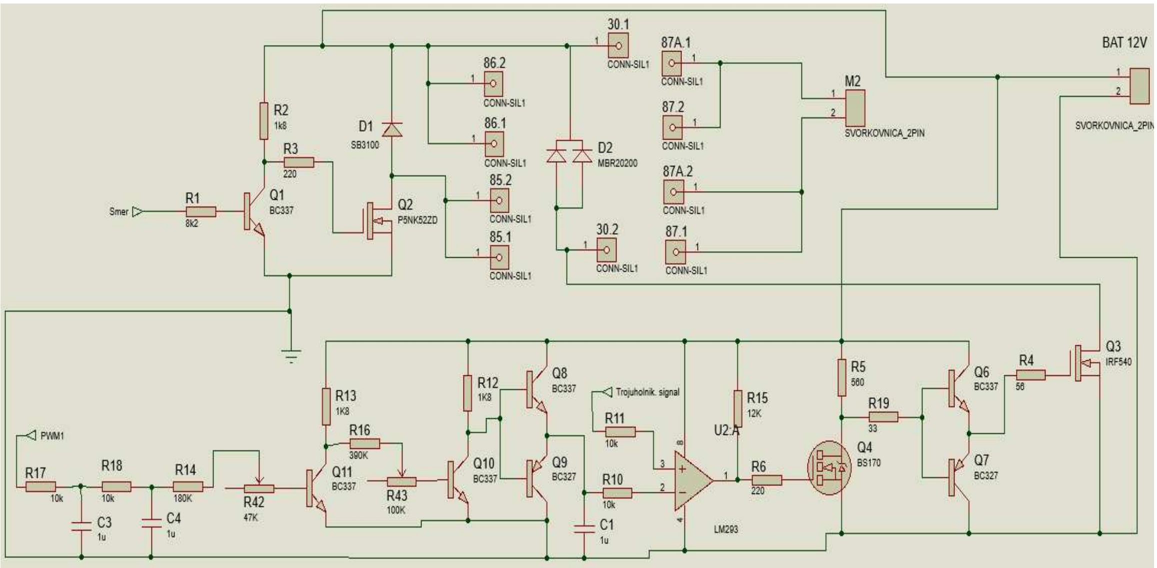

Fig. 12. Wiring diagram for direction and speed control of one motor

IV. CONCLUSION

The article describes the simplest possible solution of the problem of the connection of inverters for complete and reverse speed control of two motors, based on signals from four pressure transducers. This engagement, thanks to a small number of power components, also provides small losses and thus high efficiency. Such a way is possible to control DC motor effectively.

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