USAGE OF THE ARDUINO MICROCONTROLLER ON THE STUDENT HYBRID VEHICLE HERMES

UPOTREBA ARDUINO MIKROKONTROLERA NA STUDENTSKOM HIBRIDNOM VOZILU HERMES

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REZIME

Na Univerzitetu u Novom Sadu, na Fakultetu tehničkih nauka, Republika Srbija, odvija se studentski projekat lakog paralelnog hibridnog vozila. Cilj projekta je da pruži studentima mogućnost da primene stečeno teorijsko znanje u praksi. Projekat omogućava studentima ne samo da unaprede inženjerske sposobnosti, već i da unaprede timski rad, komunikacij, organizacione sposobnosti itd. U ovom radu su opisane glavne konstrukcione odlike vozila u trenutnoj fazi. Nabrojani su zadaci Arduino mikrokontrolera. Opisano je kako se uz pomoć Arduino mikrokontrolera meri brzina vozila. Takođe, opisano je kako se meri broj obrtaja motora SUS, kako se meri nivo baterija i kako se utvrđuje pozicija menjača. Na kraju, dat je pregled korišćenog materijala sa pripadajućim cenama.

Professional paper

SUMMARY

At the University of Novi Sad, Faculty of Technical Sciences, Republic of Serbia, there is an ongoing student project of a light parallel hybrid vehicle. The purpose of the project is to provide students an opportunity to use their theoretical knowledge in praxis. The project enables students not only to improve their engineering skills, it enables them to improve their teamwork, communication, organization capabilities etc. In this paper, main design features of the vehicle in its current shape are described. Tasks of the Arduino microcontroller on the vehicle are listed. It is described how by the usage of Arduino for measurement of the vehicle speed is done. Also, it is described how the IC-engine rpm is measured, how the battery level is measured and how the determent of the gear position is done. Finally, a list of used material for measurements is shown with corresponding prices.

1. INTRODUCTION

Hermes hybrid vehicle is a student project of the Department of Mechanization and Design Engineering, Faculty of Technical Sciences, University of Novi Sad, Republic of Serbia. Vehicle design process was carried out taking into account general rules of automotive engineering (e.g. [1]), and considering main features and requirements for hybrid-electric vehicles, e.g. [2, 3]. Practical aspects of project realization are described on the internet page of the Department for Mechanization and Design Engineering [4]. Informal name of the vehicle given by the student team is “H.E.R.M.E.S.”, which in this case stands for “Hybrid Educational Recuperative Moto-Electric Special vehicle”. It is conceived that this project will be under long term development, so that numerous steps of design improvement and optimization may be carried out by next generation of students, enlarging impact of the project [5]. Subsequently, current stage of vehicle design is described.

Current appearance of the vehicle is shown in Fig. 1.

Powertrain is realized as in-parallel hybrid drive, so that the front wheels are driven by two in-wheel electric motors shown in Fig. 2, and for the rear axle conventional mechanical transmission is provided with the IC-engine as power source shown in Fig. 3. Thereby front and rear drive can be used together or independently of each other.

IC-engine is one-cylinder, four-stroke 250 cm^3-volume gasoline engine originating from all-terrain vehicle Loncin. Fuel system is based on carburetor. Maximum power according to available data [6] is 12 kW and maximum torque is 17 Nm. Mechanical gearbox is of the same origin, having four forward and one reverse gear.

***Figure 1** Current appearance of the vehicle*

Shifting pattern of the gears is sequential. Differential drive at the rear axle is from passenger vehicle Zastava Yugo, slightly modified to accommodate chain drive by which the power is transmitted from the gearbox to the axle. Chain drive is custom made for this application.

***Figure 2** Front axle with in-wheel electric motors and batteries*

***Figure 3** Rear axle with conventional passenger-car final drive, driven by IC engine*

At the front axle there are two in-wheel 48V BLDC-electric motors, each one for left and right wheel. According to available data [7], each motor has power of approximately 1 kW. Motors were produced in China. Manufacturer and exact specifications are not known. Power supply is obtained through 4 12V semi-traction batteries connected in series, via motor controllers.

Structure of the vehicle is made from steel tubes of Ø 21.3 mm diameter, with 2.6 mm wall thickness. Appearance of the frame in early stage of development is shown in Fig. 4. It was subsequently modified in several stages, including shortening of the wheelbase.

***Figure 4** Tubular frame consisting of 3 modules in early stage of development*

It was completely developed and realized by student team. Structure consists of front, middle and rear module that are connected to each other by using bolt connections. Main idea of using this modular approach is to enlighten future design modifications, above all regarding powertrain or suspension system [5].

Suspension system on the front axle is McPherson. It was mostly taken from the small electric vehicle originating from China, of unknown manufacturer, from which also front powertrain is used (integrated with other components of the front axle). Steering system is made by combining parts from this donor vehicle and components of the steering system of Zastava Yugo passenger car. 13” diameter wheels are used front.

For the rear axle, almost complete McPherson axle from Zastava Yugo is used, though it is originally placed at the front end of the donor car. The only modification is substitution of steering rods by control arms with inner joints of fixed position, in order to disable steering movements of rear-axle wheels. One of the future plans is, though, to utilize this configuration by introducing electronically controlled rear-wheel steering. Rear wheels have diameter of 14”.

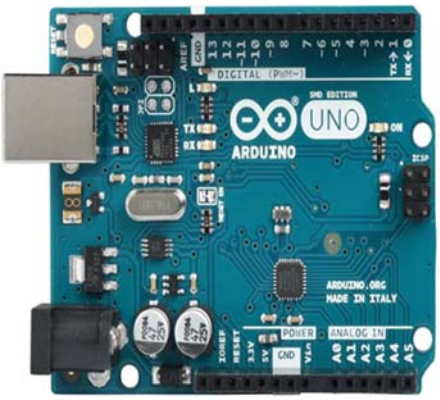
Braking system also consists of elements already present on both front and rear axle from donor vehicles, and the master cylinder is also from Zastava Yugo.

Mass of the vehicle: 500 kg. Mass distribution front/rear: approximately 50/50%. Wheelbase: 2500 mm [5].

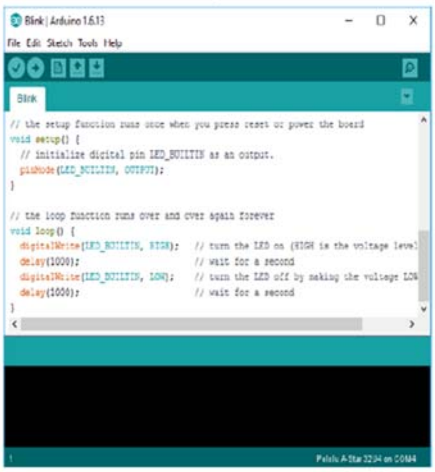
2. THE USAGE OF THE ARDUINO MICROCONTROLLER FOR THE CONTROL OF THE MEASURING DEVICES

To obtain the full potential of the Hermes vehicle, it was necessary to make possible to measure speed of the vehicle, rpm of the IC-engine, the battery level etc. Sensors and other devices had to be used with a control unit. For that purpose, the microcontroller Arduino was chosen. There are several types of the Arduino microcontroller. The basic one, Arduino Uno Rev3, is shown in Fig. 5. a.

Arduino enables data processing from various types of sensors. Also, it provides the possibility to control devices which are connected to it. To accomplish this, programming of the Arduino has to be done. The programming takes place in a software package called Arduino IDE, shown in Fig. 5. b. The software has a large data base from which various code lines can be taken and implemented. For this occasion, Arduino Pro Mini was chosen.



a)



b)

Figure 5 *Microcontroller Arduino Uno Rev3 a) Arduino UNO, b) Software Arduino IDE*

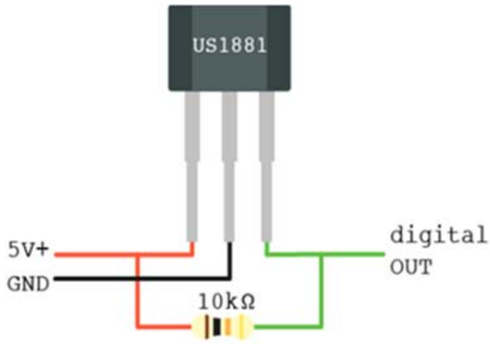
3. TASKS OF THE ARDUINO MICROCONTROLLER

Arduino PRO mini was used for next operations:

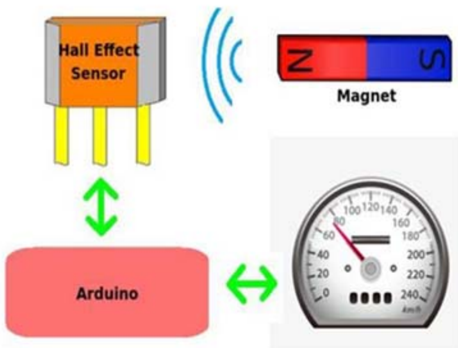
- Measurement of the vehicle speed;
- Measurement of the IC-engine rpm;
- Measurement of the battery level;
- Determent of the gear position.

3.1. Measurement of the vehicle speed

For For the measurement of the vehicle speed, two Hall effect sensors, two neodymium magnets, a servomotor and a speedometer were used. The schematic of sensor connection is shown in Fig 6.



a)



b)

Figure 6 *The schematic of the Hall effect sensor (a) and the schematic of the velocity measurement (b)*

The speedometer was reconstructed in order to make it compatible with the Arduino microcontroller. A little servomotor was placed in the speedometer and a pointer needle was attached to the servomotor. The principled schematic is shown in Fig. 7.

On the inner side of the rear rims, neodymium magnets were placed. Near them, on the chassis, Hall effect sensor were placed so that the gap between the magnet and the sensor is few millimeters. On each full revolution of the wheel, the sensor detects the passing magnet and it sends the signal to the microcontroller. The microcontroller counts the number of these signals in a specified time period and uses that data in the equation which contains the radius of the wheel to get the velocity of the vehicle. After that, the microcontroller sends a signal to the speedometer to place the pointer needle at the correct position.

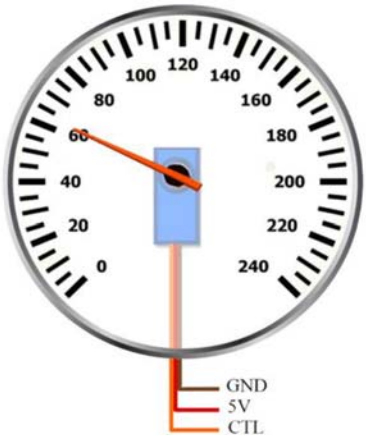


***Figure** 7 The principled schematic of the speedometer with a servomotor*

The reason for the usage of the double Hall effect sensor and the double neodymium magnet is the need for precise velocity measurement. If the vehicle is moving in a road curve, the wheel of the inner side will rotate slower than the wheel of the outer side and in that case their rotation speed is different. The doubled sensor system provides the mean rotation speed which enables a more precise velocity calculation. This system functions in the normal road conditions. By modification of this system, ABS (Automatic Braking System) can be achieved. For road conditions which include slippery surfaces it is necessary to apply additional means of velocity calculation.

3.2. Measurement of the IC-engine rpm

For the measurement of the IC-engine rpm, a Hall effect sensor, a servomotor and a rpm meter were used. As the IC-engine, which is used for the drive of the rear wheels, is a spark ignition engine, the measurement of the rpm can be achieved by counting when sparks occur. In other words, the Hall effect sensor detects the electromagnetic field which is created around the spark plugs conductor when electricity flow occurs. The servomotor was embedded into the rpm meter.
The principled schematic of the measurement of the IC-engine rpm is shown in Fig. 8.

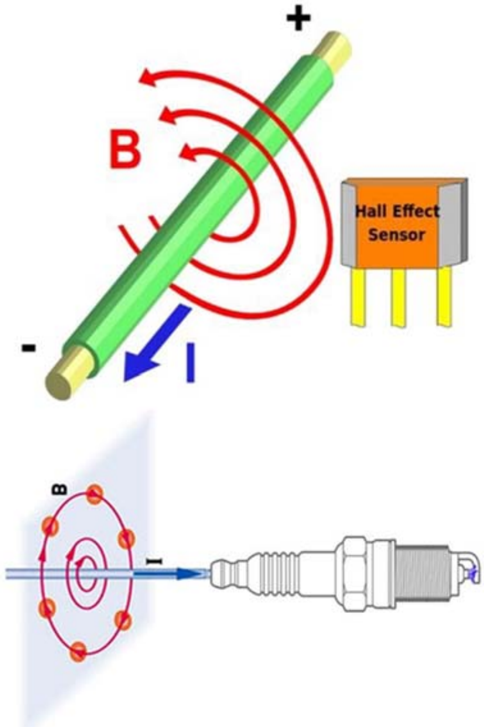


***Figure 8** Detection of the electromagnetic filed around the conductor of the spark plug during its ignition*

3.3. Measurement of the battery level

For the measurement of the battery level, a voltage distributor was used. The voltage of the battery was lowered to the voltage of the Arduino microcontroller so it could be directly measured. By knowing the capacity of the battery and with the amperage measurement, remaining time of battery usage can be calculated and the percentage of battery charge can be shown. Schematic is shown in Fig. 9.

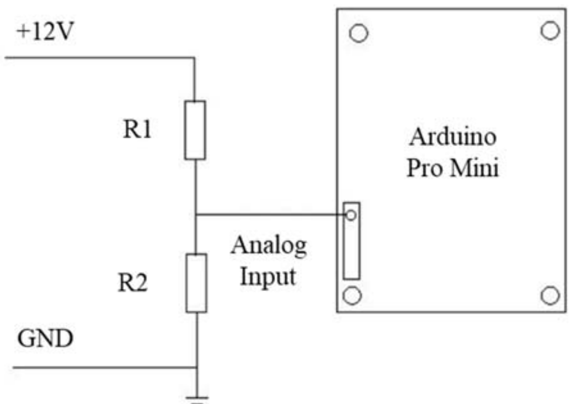


***Figure 9** The schematic of the battery level measurement*

3.4. Determining of the gear position

For determining gear position, two neodymium magnets, two magnetic Reed switches and one seven-segment display were used. The functioning principle of this system is very simple. Two Reed switches were positioned near the shaft of the gear lever according to the Fig. 10.

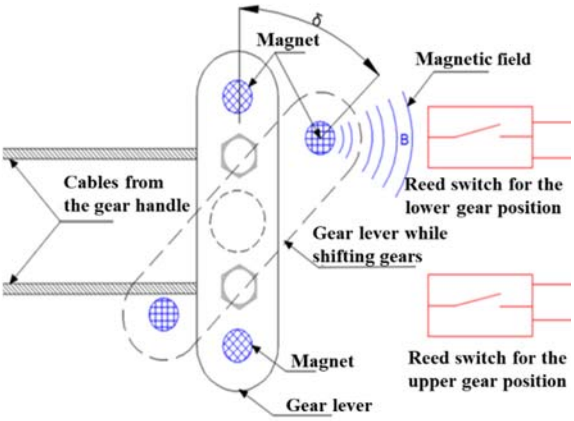


Figure 10 *The schematic of the gear position determent system*

On the gear lever, two neodymium magnets were positioned and, on the chassis near the lever, two Reed switches were positioned.
By shifting gears, the shaft of the gearbox is rotated in one or the other direction. The magnet gets near the switch which activates the switch and sends a signal to the microcontroller to change the value on the display according to the selected gear. The gearbox possesses a sensor which gives a signal when the gearbox is set in the neutral position. By using that signal, the microcontroller is capable to be precise when sending data to the display. In the case of gear position skipping, it is necessary to shift the gearbox to the neutral position to reset the display. After that the display continues to display the proper gear.

4. CALIBRATION METHOD

Calibration was done for the measurement of the vehicle speed. It was done in three ways. First, the calibration was done by simple calculation of travelled distance and the time needed for it. The vehicle travelled 200 m straight at a constant speed rate and the distance was divided with the spent time.
For the second calibration method, an Android application called Speedbot was used. Speedbot is a GPS speedometer with high precision that allows to visualize the speed of the vehicle [8].
The third method for calibration was done by the usage of police radar equipment which was lent by the local police station.
All the measurements matched the value that was on the control table with slight differences of 1% which was acceptable.
The reading of the IC-engine measurement was checked when the vehicle speed measurement was calibrated. Because the transmission rates of all systems are known, it was calculated what the RPM should be when the gearbox was in second gear at constant speed rate of the vehicle. The calculation matched the readings on the control table.
The system for determining gear position did not needed to be calibrated separately because the gearbox possesses a sensor which gives a signal when the gearbox is set in the neutral position.
Finally, the measurement of the battery level was checked using a 4 ½-digit digital multimeter, the Fluke 87V. The result matched the readings on the control table.
The final look of the control table is given in Fig. 11.

Figure 11 *The control table with the speedometer, rpm meter, battery voltage display and gear position display (H as in Serbian Cyrillic neutral)*

5. CONCLUSION

The possibility of the usage of the microcontroller Arduino for data processing is given in this paper. Also, a brief introduction to the vehicle's design and development is introduced. According to experience with this project gained so far, it was concluded that this project-based learning activity gives significant contribution to engineering education process, and widens and improves learning outcomes as well. It was also stated that this project provides numerous opportunities for the scientific and research work.

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