REMOTE-CONTROLLED CROSS-COUNTRY FOUR-WHEELER

Radim Kejzlar

Bachelor Degree Programme (3.), FEEC BUT

E-mail: xkejzl00@stud.feec.vutbr.cz

Supervised by: Jiří Háze

E-mail: haze@vutbr.cz

Abstract: The thesis deals with a complete design of a remote controlled cross-country four-wheeler for FEEC BUT „Elektrikarium“. Vehicle can be controlled using the Android smart phone app. The vehicle uses a BLDC motor with a regulator and control unit in the form of a microcontroller from the AVR family. The thesis describes the selection of components and the actual solution of communication between the HC-05 module, application and microcontroller with regulator. Part of the thesis is also a practical demonstration of the model.

Keywords: RC vehicle, BLDC, Regulator, HC-05, AVR, ATMEGA, Bluetooth,

MIT App Inventor 2

1 INTRODUCTION

RC vehicle models are an important part of hobbies and military and space technology today. This time allows construction of different types of RC models for specific applications. In this text, there is design of a remotely controlled cross-country four-wheeler suitable for the BUT FEKT interactive room with the ability to overcome larger obstacles with solid speed.

2 CHASSIS

Great demands were placed on the chassis, including space for electronics, good suspension and durability. The original variant has been a chassis printed on a 3D printer. Due to lack of time, this concept was rejected and a commercially available variant was decided. The most advantageous variants were damaged RC vehicles due to very low price. These broken RC vehicles usually have only damaged electronics and the chassis is intact. The RC Truggy in 1/16 scale in aluminum-plastic design with 4x4 drive was therefore chosen as the chassis. This chassis comes from the leading manufacturer of RC models HIMOTO with the possibility of replacing individual parts (Fig. 1).

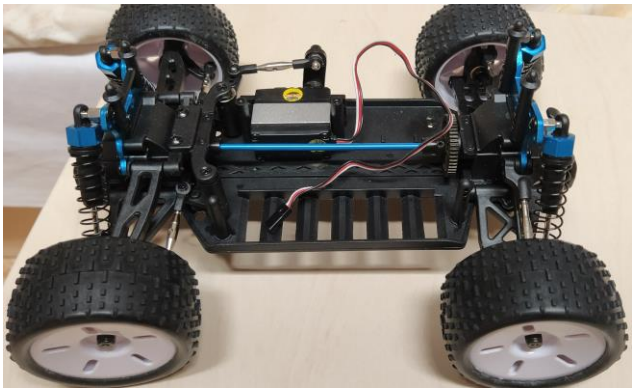

Figure 1: Chassis of RC Truggy 1/16 HIMOTO

3 CONCEPT OF CONTROL ELECTRONICS

The concept of the control electronics is shown in a functional block diagram (Fig. 2). The heart of the whole control is the AVR ATMEGA 328P microcontroller, which receives data from the Bluetooth module, processes it and sends it in the form of a PWM signal to the BLDC motor controller, turn servomotor and sets the lights switched on and off. The communication module takes information via Bluetooth from a mobile phone with the installed application. The controller is directly powered by the battery and disconnects these batteries in the event of a discharged battery. For this reason, all electronics are powered by the controller.

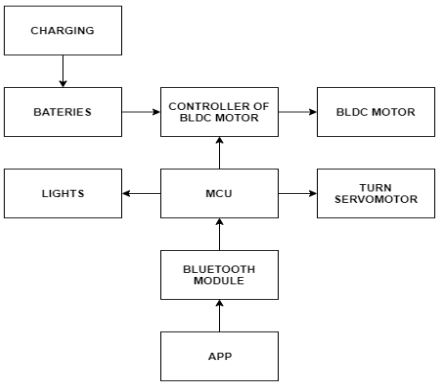

Figure 2: Block diagram of control Electronics

4 BLDC MOTOR, CONTROLLER AND SERVOMOTOR

In the past, DC motors were very often used. However, these motors do not have good efficiency and over time the commutator carbons wear out. The BLDC motor (Brushless DC) is a synchronous type of motor. Therefore, there is no slip. It means, that control frequency is synchronous with the speed. It is clear from the name that the motor does not contain a commutator. The problem of this commutation is solved in modern BLDC motors by electronic commutation. This is not a solution of classical commutation by electronic systems, but an integral part of the BLDC motor is an electronic unit, best integrated into the motor structure, which controls the supply of individual stator windings. [1] In this case, the electronic commutation is solved by a controller, which regulates the motor speed by PWM control signal with a changing duty between 1 and 2 ms (500 and 1000 Hz). The advantage of these motors is high endurance due to the absence of a commutator and the possibility of precise regulation. For the needs of a four-wheeled vehicle, a combo (combination of motor and controller) without sensors motor BH POWER 2430 and controller 25 A was chosen. This controller also includes a programming card for the initial settings of the speed control and braking. The already integrated servo in the chassis was chosen for turning. This servo is also from HIMOTO with a force of 6 Kg/cm for a sufficiently smooth turn.

Figure 3: Selected BLDC motor with regulator and servomotor

5 BATTERY SYSTEM AND CHARGING

The vehicle is powered by one two-cell battery of Li-Pol technology. The battery has a capacity of 5500 mAh. This ensures high endurance of the vehicle with time up to 30 minutes. Li-Pol batteries have very high discharge currents and very good capacity stability. The battery is protected against complete discharge by a protective function of the regulator, which disconnects it in case of low voltage. Charging is realized by an external Li-Pol charger, which ensures balancing of individual cells in real time. The user must interfere with the vehicle electronics to recharge the battery.

6 PROGRAM SECTION

The main part of the program section is the already mentioned ATMEGA 328P microcontroller. It ensures communication between the Bluetooth module HC-05 and the controller with the servomotor. The Bluetooth module is connected via the USART serial interface and always sends 8-bit application status information in series. The received data in the 8-bit register looks as shown in Table 1 (the individual sections are color-coded).

value of bit	128	64	32	16	8	4	2	1
significance of bit	LIGHTS ON/OFF	DRIVE ON/OFF	DRIVE DIRECTION	SPEED		TURN DIRECTION	TURN POSITION	

Table 1: 8-bit communication with significance of each bit

Four bits were reserved for the needs of smooth driving, where two bits show whether the car should go and where and the other two at what speed (4 speeds). The speed can be adjusted in the application described below. A space of a total size of three bits was reserved for turning. One bit determines the direction of turning and the other two determine how much the wheels should be turned. The bit with the highest value (128) is reserved for information on whether the user wishes to switch on the lights.

The microcontroller only functions as a serial data receiver. It converts 8-bit information and converts it into a PWM signal for the controller and servomotor. The PWM signal is implemented by a counter / timer integrated in the microcontroller. Microcontroller also switches transistors to turn on the lights as needed. The micro-controller also operates the function of checking the connection between the mobile device and the Bluetooth module. This is done by another counter / timer, where it is monitored in the interrupt loop if data is still coming. If no data arrives for a while. The microcontroller switches off all controlled devices (controller and servomotor) to prevent the vehicle from escaping spontaneously.

7 APP FOR ANDROID OS

The RC four-wheel drive control application was created in the MIT APP INVENTOR 2 development environment. This environment offers intuitive work with mobile device peripherals.

Using the application, turning was tilted by the device. A gyroscope is used for this and the application directly recalculates the tilt values for 2-bit information (Table 1). The layout of the application is shown in Fig. 4. The buttons for the direction of ride are located on the sides of the application screen. It is ensured that both buttons are not pressed at the same time. There are two buttons in the middle of the application. One opens a list of Bluetooth devices to connect to. The user selects the Bluetooth module and the application automatically connects it with a text message above the button: Connected. It is necessary to have the module already paired in settings of the device. With the second button, the user switches the lights of the RC vehicle on and off. In the lower part of the center of the application, there is a slider which can be used to set the already mentioned 4 speeds. This status will be shown in the text box above the slider. The application sends data every 0.5 s to detect microcontroller disconnection and for low power consumption. The whole application is created to dark mode. This ensures low power consumption for today's smart device displays without disturbing the brightness.

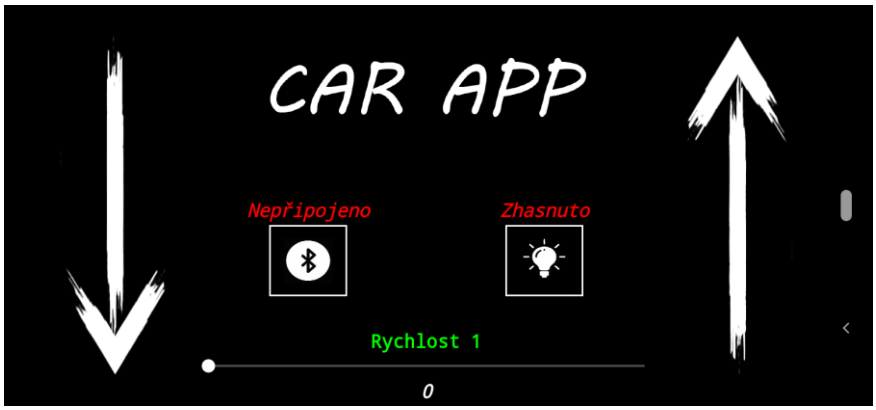

Figure 4: APP for Android OS

8 CONCLUSION

In this text, a remote-controlled cross-country four-wheeler was largely implemented for the needs of the BUT FEEC Elektrikarium. The model is in a state of complete completion now. As part of the assignment, all conditions for the completion of this work were met. A complete application for the Android OS with communication via Bluetooth was created, a sufficiently durable off-road chassis was ensured and high battery life compared to commercially available RC models. In the program part, all undesirable conditions (disconnection, etc.) were treated. In the future continuation of the work, it is necessary to optimize all parts (app, control electronics).

REFERENCE

[1] ŠIMON, Josef. *BLDC aneb DC motor s nulovými náklady na údržbu. ELEKTRO* [online]. *FCC PUBLIC*, 2011/10 [cit. 2020-03-09]. Dostupné z: http://www.odbornecasopisy.cz/elektro/casopis/tema/bldc-aneb-dc-motor-s-nulovymi-naklady-na-udrzbu--10016

[2] Big Hobby. *Big Hobby* [online]. 2020 [cit. 2020-03-09]. Dostupné z: https://www.bighobby.cz/

[3] DEJAN. *How Brushless Motor and ESC Work. How To Mechatronics* [online]. 2019 [cit. 2020-03-11]. Available from: https://howtomechatronics.com/how-it-works/how-brushless-motor-and-esc-work/

[4] ATMEL CORPORATION. *ATmega 328P: datasheet* [online]. San Jose, 2015 [cit. 2020-03-09]. Available from: http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf