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DEVELOPING OF SYSTEM FOR FAST EMERGENCY EVACUATION THE PILOT OF ELECTROMOBILE DTT-3

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Abstract: *The article shows the development of a system to improve the pilot`s safety in electric car DTT-3 at emergency situations. This system consists of actuators and sensors controlled by microcontroller control - Arduino Nano. The sensors monitor the fulfillment of all requirements that would ensure unimpeded and safe get off of the electric car from the pilot. The system offers reduced time for evacuation of the pilot in critical situations that may occurr on the track during the Shell Eco-marathon.*

Keywords: *Evacuation, Electromobile, Pilot, Arduino*

INTRODUCTION

The Shell Eco-marathon aim is to create innovative solutions to cover the maximum distance with a minimum amount of energy (Mitev, E .; Iliev, S. & Gunev, D., 2019) (Iliev, S; Gunev, D . & Mitev, E. 2019). Also, the organizers put the safety of their participants first and foremost. For this reason, before a team is allowed on the track, it must pass several technical inspections; Electrical inspection and Safety inspection (Tuzharov, K .; Iliev, S. & Gunev, D., 2018). Like any inspection, it monitors compliance with rules that seek to ensure the complete safety of participants. There is a section in the Safety inspection that checks the readiness of pilots to leave the vehicle in less than 10 seconds. Every year the organizers reward the teams not only for their performance on the track, but also off it. The so-called "Off-track awards" encourage innovations that are made in areas other than ecology. The awards are divided into five separate categories: "Safety Award", "Circular Economy Award", "Technical innovation Award", "Communications Award" and "Vehicle Design Award" (Iliev, S., Gunev D., Dobrev V., 2017) (Shell, 2020).

Through the innovation that will be discussed in this article, the team "Avtomobilist" of the University of Ruse, Bulgaria, will take part in the category "Safety Award". This system will ensure faster exit of the pilot from the vehicle in the event of emergency situation.

EXPOSITION

Establishment of a logical block diagram for the implementation of the algorithm

Creating of a logical block diagram for the execution of the algorithm is an important part of the trouble-free construction of the system at a later stage. It presents the image of the logical path that must be followed in order to achieve a predetermined end result.

The logic block diagram is an algorithm that follows precisely defined conditions and according to them a decision is made on how algorithm continues. As for performing the emergency evacuation cycle of the pilot from the electric car, DTT-3 consists of 5 conditions and 3 actions (Fig. 1).

The algorithm which is set to the microcontroller control recreates the logical block diagram of the system. The microcontroller used to create this system is the Arduino Nano.

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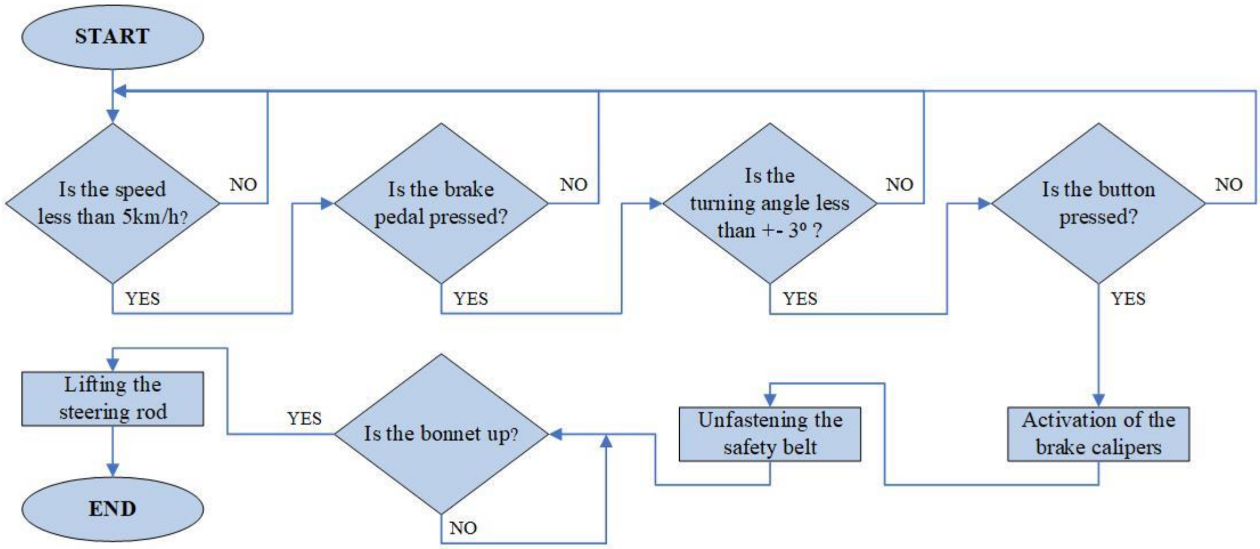

Fig. 1. Logical block diagram of the system for emergency evacuation of the pilot from electric car DTT-3

Via sensors, the control board receives input signals, after the processing of which, checks whether the preset conditions are met, which are uploaded in the microcontroller in the form of a code. Due to their interdependence, in case of non-fulfillment of even one condition from the first 4, the system will not be activated. As the first 2 conditions ensure the safety of the pilot, and the next two prevent accidental activation of the system.

The logical sequence of conditions and actions performed by the microcontroller are:

- **Is the speed less than 5 km/h? -** to check this condition, a light sensor emitting light in the infrared spectrum is used. Via four evenly spaced reflective markers along the diameter of the wheel. They return the emitted light from the infrared diod to the infrared phototransistor, as a result of which it is on and voltage flows to a precisely defined input pin of the microcontroller. Due to the low operating frequency of 16MHz on the Arduino Nano (Arduino.cc), the speed reading is done per second. To calculate the speed of rotation of the wheel of the microcontroller it is necessary to determine the perimeter of the wheel. The perimeter is calculated by the following formula:

$$P = \frac{2\pi r}{10^6} \quad ,[km] \tag{1}$$

***r**- outer wheel radius, [mm]*

Using a continuously repeating cycle, the Arduino Nano counts the number of logical units read (passed reflective markers), which are zeroed every second:

$$n = n + 1 \tag{2}$$

After the perimeter of the wheel, the number of reflective markers and the number of logical units read are determined, an equation can be drawn up to calculate the speed of rotation of the wheel:

$$V = \frac{3600.Pn}{m} \quad ,[km/h] \tag{3}$$

***m**- the number of reflective markers placed on the diameter of the wheel.*

After calculating the wheel speed, the microcontroller checks the numerical value of the speed. If it is greater than 5, then the check of this condition continues to be repeated in an infinitely repeating cycle until the condition is met. If the speed is less than 5, proceed to the next condition.

- **Is the brake pedal pressed?** – a contact switch mounted on the brake pedal is used to check this condition. By means of it, as with the car brake pedal, when it is pressed, the signal is interrupted and the input pin of the microcontroller control receives a logic zero. If this condition is met, the third condition is passed, otherwise the check starts from the first condition.

- **Is the turning angle less than ± 3˚? –** this condition arises mainly for design reasons. Because the design of the steering rod allows it to be raised, with the steering wheel turning less than ± 3˚. This design feature is due to the desire to make it easier and problem free for pilot to leave the electric car.

Monitoring of the turning angle is performed by means of a rotary potentiometer with a value of 10kOhm, which has the ability to rotate 270˚(Arduinogetstarted.com). Therefore, with each 1˚ rotation of the rotary potentiometer, the resistance increases by 37Ohm. The maximum full rotation of the front wheels in one direction or another is done by turning the steering wheel +15˚ or -15˚or a total rotation of 30˚. The rotary potentiometer is placed in a way so that at maximum rotation in the left direction, the resistance has a value of 0 Ohm. With the wheels fully upright, the steering wheel is in the 0˚position and the resistance created is approximately 555 Ohm. By turning the steering wheel to the full right position, the potentiometer reaches a value of approximately 1110 Ohm.

Since the rotary potentiometer works as a voltage divider, the left pin is connected to the power supply with a voltage of 5V, and the right is connected to GND. The middle pin of the rotary potentiometer is connected to one of the analog inputs of the microcontroller.

The reading of the value from the analog input pin is performed by a multi-channel 10-bit analog-to-digital converter, which is built into the Arduino Nano. This means that it will convert the input voltages between 0 and the operating voltage (5V) into integer values between 0 and 1023. On the Arduino Nano, this gives a resolution between the readings of: 5V / 1024 units or, 0.0049V (4.9 mV) Per unit. This allows the following table 1 to be made.

Table 1. Determining the values relative to the steering angle

Steering wheel position	Resistance	Voltage	Units
maximum left rotation (+15˚)	0 Ohm	5V	1023
upright position of the steering wheel (0˚)	555 Ohm	4,73V	969
maximum right rotation (-15˚)	1110 Ohm	4,45V	911

Now it is now possible to check the condition for the steering angle, which must not be greater than or less than ± 3˚. This in units corresponds to values between 956 and 978. If this condition is met, then the microcontroller control passes to the last condition before the system is activated.

- **Is the button pressed?** – за ценлата се използва бутон, който е разположен на лесно достъпно, но и същевременно защитено от неволно натискане място на волана. Той по подразбиране е с отворен контур. При затварянето си той затваря контура, който свързва 5V пин с дигитален pull up пин. Посредством това действие се потвърждава желанието на пилота да активира системата за бърза евакуация. При изпълнение и на четирите условия системата извършва две действия преди следващото условие.

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- **Activation of the brake calipers –** this action ensures that the brake shoes are kept active. It is carried out by means of a servo motor, which holds the brake pedal already pressed by the pilot. This provides additional stability to the electric vehicle as the pilot stands up to leave the electric vehicle.
- **Unfastening of seat belt** – due to requirements set by the organizer of the competition, electric cars must be equipped with 5-point sports seat belts. To be released from them, the pilot must turn the unlocking mechanism. During an emergency, finding this mechanism and turning it takes time for the pilot. For this reason, this action is replaced by an actuator (servo motor), which is actuated by the microcontroller control. After performing both actions, the algorithm waits for the fulfillment of the next condition.
- **Is the hood of the electric car raised? -** this condition is intended to verify that the pilot has removed the hood of the electric vehicle, as this cannot be done by an automated actuator. The condition is important due to the fact that if the cover is not removed, then the subsequent action will lift the steering rod together with the steering wheel and will hit the cover in its path.

The verification of whether this condition is fulfilled is performed via a light sensor emitting light in the infrared spectrum, which is also used in the reading of the wheel speed. Thus, when lifting the bonnet, the luminous flux is disturbed, which leads to a logical zero of the digital pin to which the sensor is connected. Hence, the microcontroller accepts that the condition is met and proceeds to the last execution action.

- **Lifting the steering rod** – as mentioned above, the steering rod is only lifted at $\pm 3^\circ$ rotation. The action itself makes it easier for the pilot to leave the electric car. The action is performed by means of an actuator (servo motor).

Constructing a set of sensors and actuators.

The system consists of two parts - verification and executive. In figure 2, the two parts are considered as two separate circles, with the verification part shown in orange and the executive part in yellow. The location of the Arduino Nano microcontroller is shown in blue. The positions shown depict the location of the respective sensors and actuators, and the lines illustrate the shortest possible path of the wires.

Low resistance wires with a small cross-section of 0.2 mm2 or 24 AWG (American Wire Gauge) are used for wiring the system. At the same time, the wires are shielded due to the low operating voltages and high electromagnetic interference caused by the operation of the electric motor of the electric vehicle

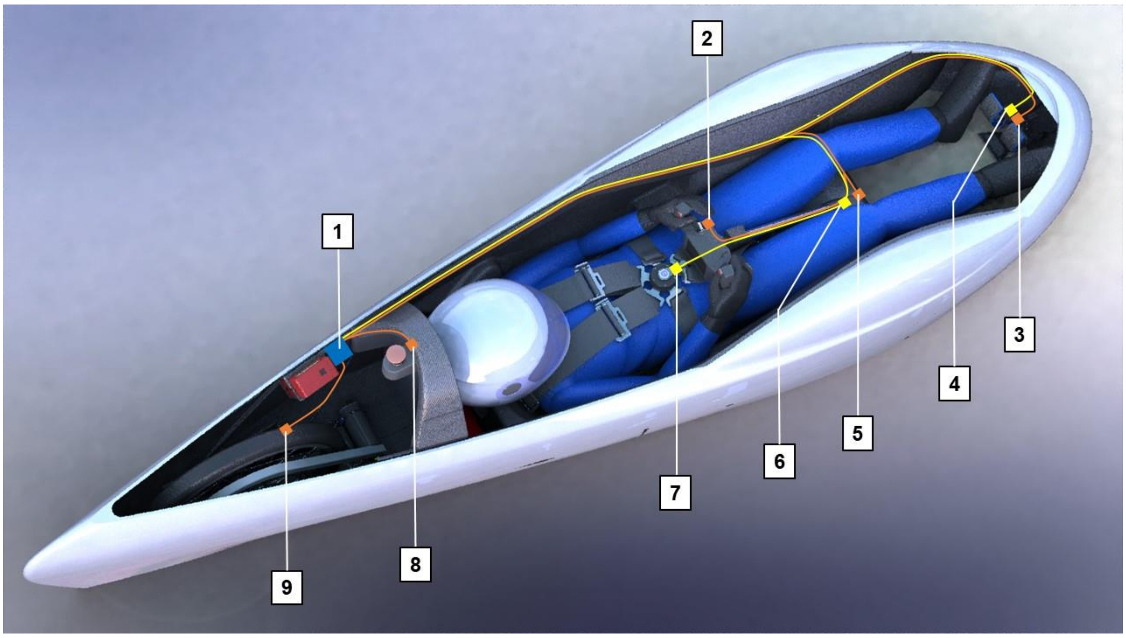

Fig. 2. View of the locations of the sensors and the actuators
1- Microcontroller Arduino Nano; 2- Activation button; 3, 6, 7- Servo motor; 4- Microswitch button; 5- Rotation potentiometer; 8, 9- IR proximity sensor

CONCLUSION

The introduction of new technical solutions in competitions such as the Shell Eco-marathon, lead to the development of technology in many areas. One of the most important ones is the protection of human life.

The conclusions we reached are:

- The system allows the pilot to leave the electric car with a minimum number of movements;
- The time required for the pilot to leave the electric car is decreased by 40%;
- Holding the brake apparatus, when the system is activated, helps the pilot to stand up without any problems.

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