The next step was testing the voltage generated at the terminals of the fan by the passing steam. The maximum peak voltage obtained was 2.5V. The series made with a 500Ω resistor and two LEDs in parallel was connected to the terminals of the fan. The resistor was required to limit the current in LEDs.

The power plant has a very poor efficiency. In fact, the current required to heat the water is 6A, resulting in a 1320W input power.

When the tests phase concluded, the construction of the structure was initiated. First, the walls of the miniature were constructed and painted with spray. Then, the boiler was fixed in the wooden base. The next step was the construction and painting of the roofs and the chimney (this latter that was painted in white and red). Finally, the ejector and the fan were fixed inside the chimney.

Part of the water steam used in the energy generation turns back into water inside the chimney and returns to the water tank.

4. Conclusions

A miniature steam thermoelectric power plant was presented. It was built using old starch iron parts and a computer cooling fan. Construction and operation details were explained. The voltage generated by the power plant is enough to lighten two LEDs. Despite of its very poor efficiency, the device is eye-catching and very suitable for science fair events.

5. References

[1] Brandão, Diogo de Paiva Leite. Electrotecnia Geral. Fundação Calouste Gulbenkian, 1987.
[2] Matias, José Vagos Carreira. Tecnologias da Electricidade – Vol. I (6th ed.). Didáctica Editora, 2003.

Microcontroller-Driven Hydrogen Car

Hugo Queirós, Antonio Lafuente and João Sena Estevez
Dept. of Industrial Electronics. University of Minho.
Campus of Azurém. 4800-058 GUIMARÃES Portugal.
hugoqueiros@netcabo.pt; dookei@netcabo.pt;sena@dei.uminho.pt

Abstract. This paper presents a hydrogen-powered car with 8 minutes autonomy. The hydrogen is produced by electrolysis, which requires an external power supply. The gas is retained on an isolated compartment in the car. Then, it goes to the fuel cell, which produces the energy for the car motor. The car follows a white line on a black track using five infrared sensors that detect white and black colors. A servomotor controls its direction. Guidelines to the servomotor are given by a system based on an 8051 microcontroller, according to the information it receives from the infrared sensors.

Keywords. Fuel Cell, Infrared Sensors, 8051 Microcontroller, Hydrogen, Electrolysis.

1. Introduction

The project described in this paper applies fuel cell technology [1, 2] to a model car.

Figure 1. Hydrogen powered car

To control the vehicle, more conventional technologies were used. Infrared sensors and an 8051 microcontroller are some of the components integrated in the control system.

Figure 2. Car track

Since the hydrogen car (Fig. 1) is very suitable for science fair events – its appearance at *Robótica 2006* festival was a success – an oval track (Fig. 2) was built for exhibition purposes.

Over the black surface of the track, a white line was drawn. The car follows this line using its infrared sensors.

2. Key aspects of the project

These are the key aspects of the project, which will be emphasized:

- The use of fuel cells;
- The use of infrared sensors;
- The use of an 8051 microcontroller.

2.1. Fuel cell

The primary objective of the project was to create an autonomous car running on water, capable of circulating on a track. To power its electric motor, a fuel cell (Fig. 3) was used.

Figure 3. Fuel cell, between the hydrogen and oxygen tanks (on the left) and the servomotor (on the right)

This fuel cell can work in *electrolyzer mode* or in *fuel cell mode* [2]. Since it is the most important part of the project, these modes will be described with more detail.

2.1.1. Electrolyzer mode

In this mode, the fuel cell “produces” hydrogen and oxygen from water. This is a very useful capability, since it avoids the use of a refilling station.

The fuel cell needs an external power supply to do the electrolysis of the water, which separates the hydrogen from the oxygen. The chemical reactions are the following:

$$2H_2O \rightarrow 4H^+ + 4e^- + O_2 \qquad \text{(cathode side)}$$

$$4H^+ + 4e^- \rightarrow 2H_2 \qquad \text{(anode side)}$$

2.1.2. Fuel cell mode

The terminals of the external electric circuit to be powered are connected to the anode and the cathode of the fuel cell. The car has two separate and isolated tanks. Both tanks are partially filled with water. Through water electrolysis, one of the tanks is filled with hydrogen (H) and the other is filled with oxygen (O). Then, hydrogen flows to the anode and oxygen flows to the cathode. On the anode side of the cell, a platinum catalyst separates the hydrogen into electrons and protons. The protons flow towards the cathode through a Proton Exchange Membrane (PEM). However, the electrons cannot pass this membrane. Instead, they go to the cathode through the external electric circuit, establishing an electric current in this circuit. On the cathode side of the cell, the electrons are combined with the protons and oxygen, with the help of a platinum catalyst. The chemical reactions are the following:

$$2H_2 \rightarrow 4H^+ + 4e^- \qquad \text{(anode side)}$$

$$4H^+ + 4e^- + O_2 \rightarrow 2H_2O \qquad \text{(cathode side)}$$

2.2. Infrared sensors

Five infrared sensors are placed in the front of the car, facing down (Fig. 4). They allow distinguishing white surfaces from black surfaces, so the car can follow a white line drawn on a black track.

Each sensor has an emitter and a receiver. The emitter sends to the track infrared radiation that is reflected back to the receiver if the white line is detected.

If the leftmost sensors detect the white line, the car turns left; if the rightmost sensors detect the white line, the car turns right. This way, the car follows the white line.

2.3. The 8051 microcontroller circuit

A circuit that contains an 8051 microcontroller (Fig. 5) was designed to receive and process the information sent by the infrared sensors [3] and then send the correct information to the servomotor that controls the direction of the car.

© 2006 H-Sci ISBN 989 9509 50 7

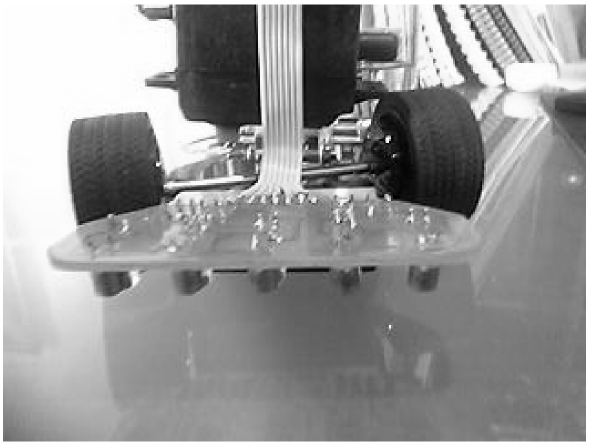

Figure 4. Five infrared sensors are placed in the front of the car, facing down

The program installed on the 8051 microcontroller [4, 5] has two functions: controlling the direction of the car and switching on and off the car motor. The source code was written on C [5]. This task offered the authors the opportunity to practice this programming language.

The microcontroller requires a 5V power supply. This is provided by a 9V battery, which also supplies the servomotor and the infrared sensors.

3. Car operation

To start the car, the fuel cell must first be filled with water into the tanks located in the middle of the car. Then, an external power supply is attached to the anode and cathode of the fuel cell, so it can produce hydrogen and oxygen.

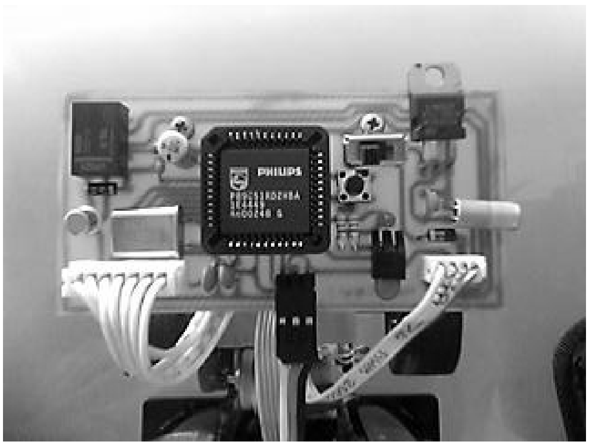

Figure 5. The 8051 microcontroller circuit

The second step is starting the car: a switch most be turned on and a key must be pressed. After this, the car will automatically run on the track, following the white line.

When a horizontal line appears, the car stops for a few minutes to refill. This only takes place after the car completes three or four laps.

The autonomy of the car is up to 8 minutes with the compartments initially filled with hydrogen and oxygen.

4. Conclusions

A hydrogen-powered car with 8 minutes autonomy has been presented.

The hydrogen, produced by electrolysis, is used by a fuel cell to generate the electric current supplied to the car motor.

The car follows a white line on a black track using infrared sensors that detect white and black colors.

A system based on an 8051 microcontroller has been developed. It receives information from the infrared sensors, controls a servomotor that steers the car and switches on and off the car motor.

The car is very suitable for science fair events. Seeing a fuel cell working arouses the interest for this technology. The project offered the authors the opportunity of learning more about fuel cells, practicing electronics and improving programming skills.

5. References

[1] Voight, C., Hoeller, S., Kueter, U., Fuel Cell Technology for Classroom Instruction, Books on Demand GmBh, Norderstedt, 2005.

[2] FuelCellStore www.fuelcellstore.com

[3] Rocha, José Gerardo Vieira, MOSFETS e Amplificadores Operacionais, Netmove Comunicação Global, Lda Editora, 2005.

[4] Nicolosi, Denys E.C., Microcontrolador 8051 Detalhado (6th ed.), Érica, 2005.

[5] Nicolosi, Denys E.C., Rodrigo B. Bronzery Microcontrolador com Limguagem C, Érica, 2005.