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Power supply of the electric vehicle by photovoltaic solar energy source

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***Abstract*—The development of electric vehicle projects can be explained first and foremost by the environmental objectives set in the global frameworks to combat climate change, with a particular focus on reducing CO_2 emissions. The scarcity of natural hydrocarbon resources and current global warming poses the problem of energy transition. In the present situation, solar energy appears to man as an inexhaustible, renewable energy is above all, as a clean energy. It is therefore in response to a crucial problem of humanity that we decided to design a prototype miniature solar vehicle. In this article, the contribution envisaged with this research work is to realize an electric vehicle powered and charged by a photovoltaic solar panel (PV), from where the management and the optimization of the electrical energy is ensured by a card Arduino whose which two-wheel drive vehicle to control by a Bluetooth embedded, in order to ensure proper control, thus, the instructions are sent according to a Smartphone via a wireless local network.**

Keywords— electric vehicle; greenhouse gas (GHG); battery; solar panel; Arduino card; Bluetoot; Smartphone.

1. INTRODUCTION

A century later, the global car fleet has become gigantic, stabilizing in the industrialized countries but exploding in emerging countries (China, India, etc.). This very significant growth in the car fleet has forced the government to take measures to reduce pollutant emissions. At the dawn of the 1970s, the first anti-pollution standards appeared and forced car manufacturers and tankers to find technical solutions to reduce harmful emissions [1]. The scientists' warning on global warming will lead the governments of many industrialized countries to sign the Kyoto Protocol in 1997. Entered into force in 2005, this international treaty commits the signatory countries to reduce greenhouse gas emissions, which are responsible for global warming. To date, CO_2 emissions remain the major concern of international governments. Although it does not have the largest GWP (Global Warming Potential), it is a real threat to humans and the environment [2]. The release of CO_2 into the atmosphere increases every year by 2%. In case nothing is done, we would see by 2050 the doubling of these discharges... The consequences would be dramatic and irreversible for man and the environment: climate disruption, ecosystem changes... [1].

Therefore, the objective of this work of the electric traction system is to exploit the renewable energy sources and especially the photovoltaic solar energy for a goal to realize an electric vehicle (prototype) remotely controlled by an embedded Arduino microcontroller in the vehicle. The management and optimization of the system is ensured by the Mega Arduino control card. This achievement requires a power source, capacity converters, a direct current electric motor and a simulation display system and an algorithm that allows power management between the solar panel, the motor and batteries that are affected by climatic factors.

2. TRANSPORT GHG EMISSIONS IN ALGERIA

The CO_2 emissions, mainly due to the burning of energy, today account for more than three-quarters of global emissions [4].

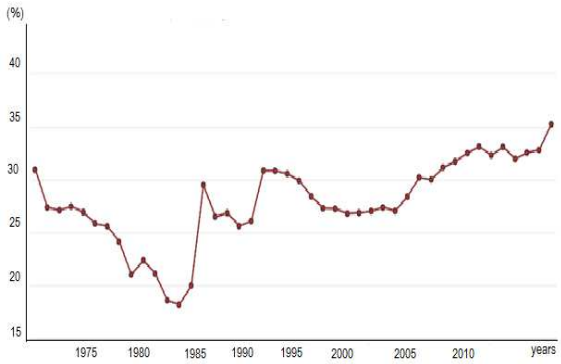


Figure 1.
CO_2 emissions from transport in Algeria (%)

The imperative need to reduce CO_2 emissions globally, combined with the rise in the price of oil, requires decisions

advocated by new political commitments. New commitments that lay the groundwork for a new global direction in terms of energy management. The objective is to enable the research and the marketing of new solutions, which imply:

- The optimization of thermal motors.
- The use of new energies.

3. ELECTRIC VEHICLE DESIGN AND REALIZATION

As we have previously pointed out, the objective of our study is the design and realization of an electric vehicle prototype which is controlled by the Arduino card [5].

3.1. SOLAR ELECTRIC VEHICLE PROTOTYPE DATA

TABLE 1.
GENERAL DESCRIPTION OF PROTOTYPE SOLAR ELECTRIC VEHICLE

Specifications General of the vehicle		➢ Electrical specifications ➢ Motor :
Length	41 cm	Permanent magnet DC motor reversible so electrical regeneration can be decelerated) Operating voltage: 3V to 12V DC
Width	21 cm	➢ Controller of the Motor :
Height	25 cm	L298 Dual H-Bridge Motor Driver, allowed us to control the machine in the four quadrants. This Double H control module can drive two DC motors.
Mass	1.5kg	➢ Batteries:
Speed	15 km/h	4 lithium-ion batteries, voltage of each battery 4.2V each two serial battery consisting of a 8.4 V (voltage required by L298 Dual H-Bridge).
chassis	Carbon Fibers	➢ Weight of batteries:
Energy		Battery 0.044 Kg (total = 0.176 Kg)
Engine operating voltage	3V à 12V DC	➢ Solar panel:
Battery	Lithium-ion battery	Dimensions (mm) 250*200, maximum supply voltage 9.0V, maximum supply current 0.56A
CO_2 rejected	0g per kilometer traveled	

3.2. DESCRIPTION OF PROTOTYPE COMPONENTS

3.2.1 ARDUINO MEGA 2560

The Arduino module is a printed circuit in free hardware (control platform) whose plans of the card itself are published under free license including certain components of the card: like the microcontroller and the complementary components which are not in free license. Arduino is used in many applications such as industrial and embedded electrical engineering [6],[7].

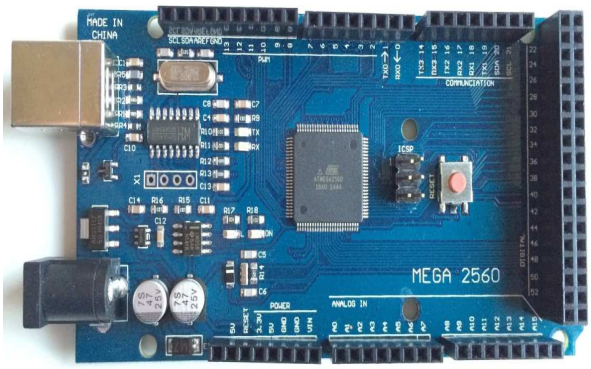


Figure 2.
Arduino Mega 2560

3.2.2 L298N MOTOR CONTROLLER

This component is a double bridge-H for continuous motor control (H-Bridge Motor Driver). It is based on the L298N component which is a double bridge-H designed specifically for this use case [6].

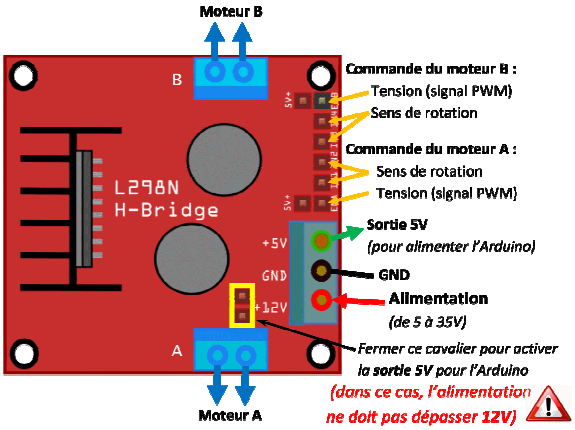


Figure 3.
Description of a L298N module

3.2.3 BATTERY

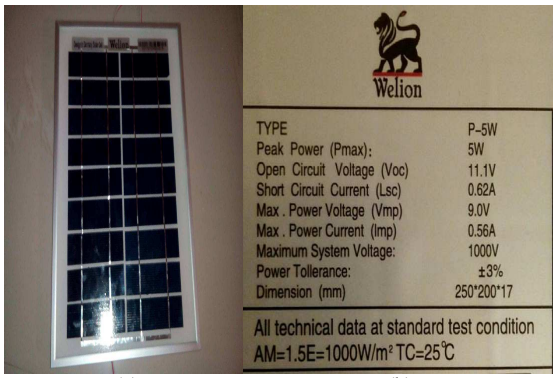
We used four batteries (Lithium-ion) voltage of 4.2 V, Current: 6800 mAh, power: 9.6 Wh each two battery connected in series compose a battery of 8.4 V, [8],[9].
A 9 V voltage battery to power the Arduino.

(a) (b)

Figure 4.
(a)- Battery Lithium-ion 4.6V
(b)- Pile 9V

3.2.4 PHOTOVOLTAIC SOLAR PANEL

The panel used is a solar photovoltaic voltage max panel: 11.6 V and current 0.62 A, [7].



(a) (b)

Figure 5.
(a)- Actual photo of used panel
(b)- Used panel characteristics

3.3.5 DC MOTOR

This DC electric wheel motor is ideal for robotics and model vehicles. It has a gear ratio of 1:48 and a maximum torque of 800 g/cm, has a minimum of 3 V. Load current 70mA, Length: 65 mm, Width: 37 mm, Height: 22 mm[7].

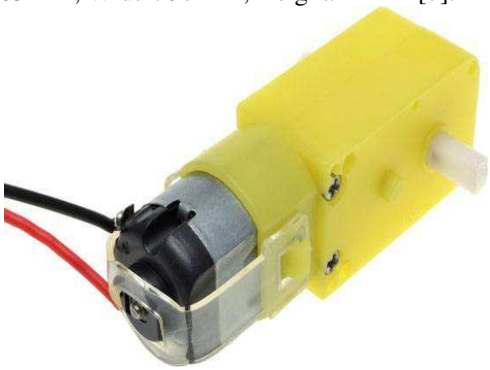


Figure 6.
DC wheel motor

3.2.6 SERVOMOTOR

The servomotor in this vehicle used to rotate the solar panel for an ideal reflection angle of the sun on the panel [7].

Figure 7.
Servomotor works with the Arduino

3.2.7 VOLTAGE SENSORS

We use three model voltage sensors (F031-06) 25 V for 5 V microcontroller [7]:

- The first to measure the output voltage of photovoltaic solar panel.
- The second to measure the level battery charge 1.
- The second to measure the level battery charge 2.

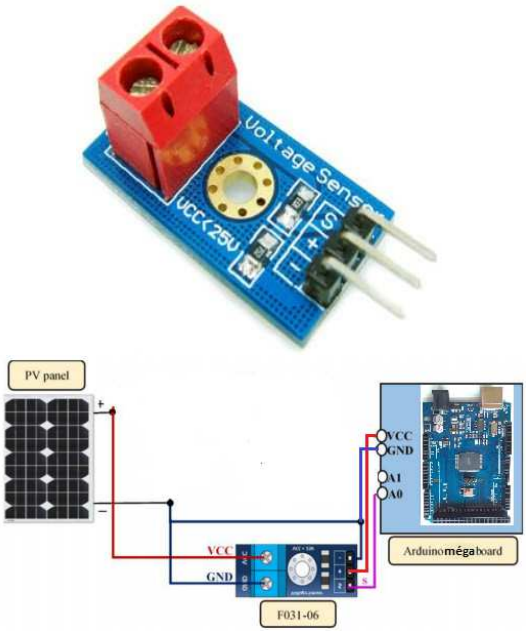


Figure 8.
Model voltage sensor operation (F031-06)

3.3 DESIGN OF THE ELECTRIC VEHICLE

The principle of our realization is shown schematically in “Fig.9”, it is a two-wheel drive electric vehicle driven by two permanent-current DC motors, a DC motor operated as a

generator for the recovery of electricity connected with the rear wheels of the vehicle. The control system is an Arduino placed in the vehicle, the control implemented in the Arduino has two control loops (voltage and speed), the power part is provided by three chopper model L298N, [7].

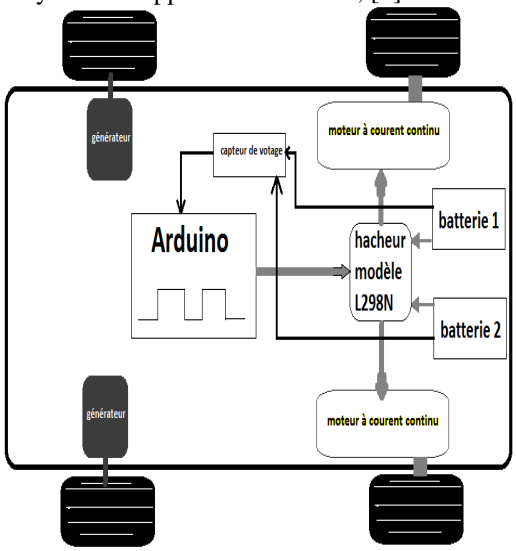


Figure 9.
Electric vehicle design diagram

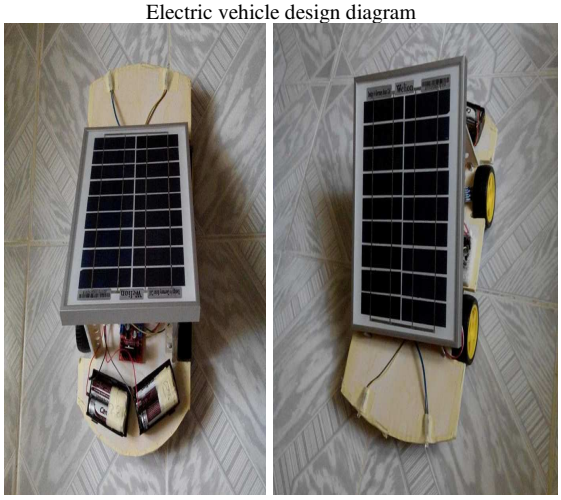


Figure 10.
Initial image of the vehicle after installing the solar panel front and rear face

4. ENERGY MANAGEMENT ALGORITHM

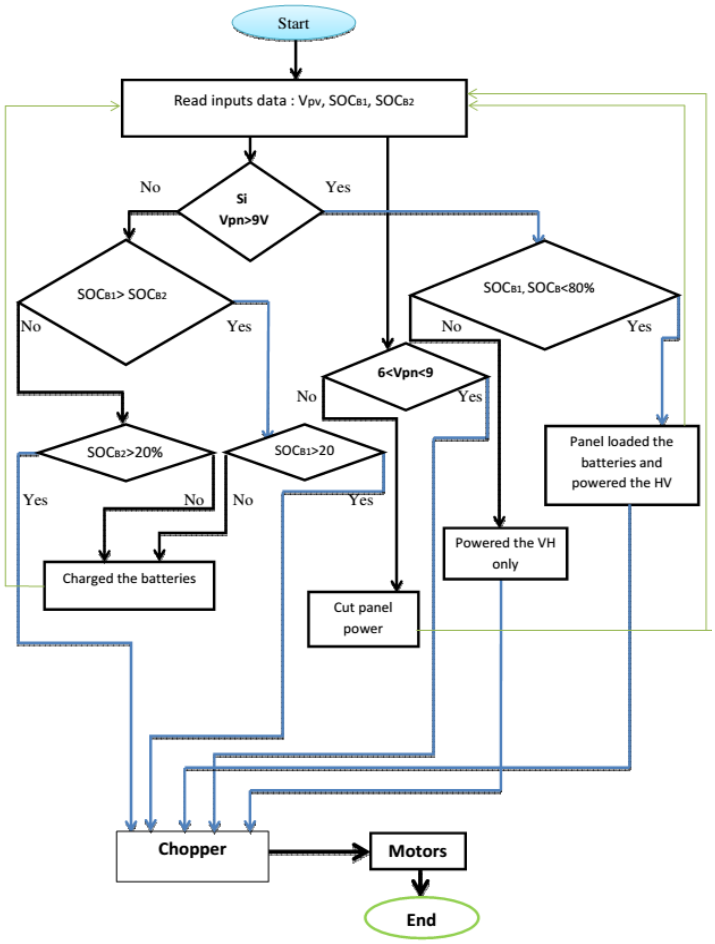


Figure 11.
Flowchart of energy management

5. SIMULATION AND RESULTS

5.1 COMMAND TWO MCC BY L298N AND ARDUINO

The following figure shows the schematic of the control system two motors (speed, direction of rotation) by Proteus software [6].

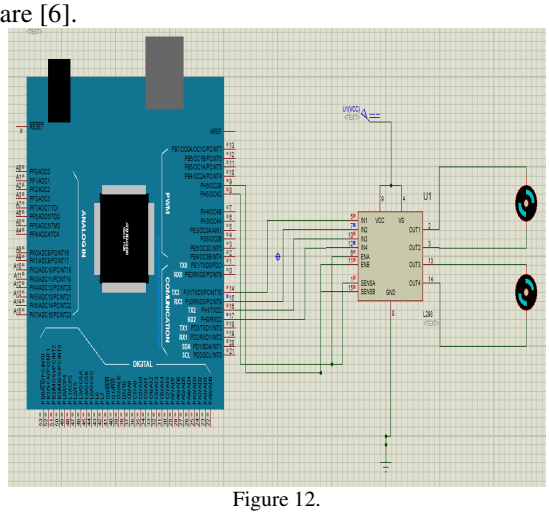


Figure 12.
Schematic of the control circuit two MCC by L298N and Arduino in Proteus program

"Fig. 13 and Fig. 14" represent the results of generation of PWM signal by the Arduino card:

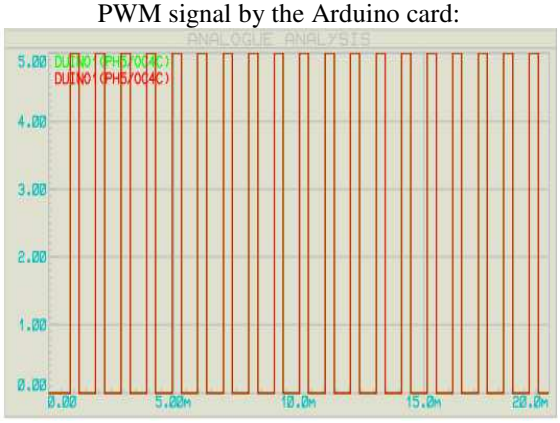


Figure 13.
Arduino output voltage with a cyclic ratio of 40%

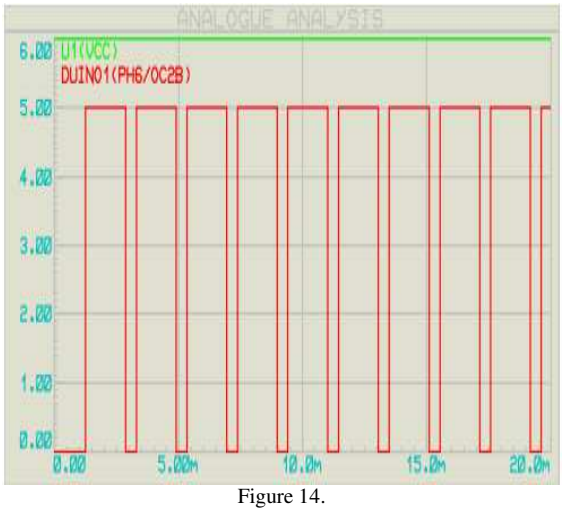


Figure 14.
Arduino output voltage with a cyclic ratio of 75%

5.2 ENERGY MANAGEMENT CONTROL SYSTEM SIMULATION

Energy management based on three cases is concerned with solar panel output voltage:

The first case: panel voltage and 9 volts higher open transistor 1 to power the chopper and transistor 4 and 5 to charge the batteries.

The second case: panel voltage (6V <Vpv <9V) opens transistor 1 to power the chopper through the panel.

The third case: the panel voltage (Vpv <6V) opens the transistor 2 or 3 to power the chopper by the batteries (in this case compared between the charge level and open the circuit of the upper battery charge).

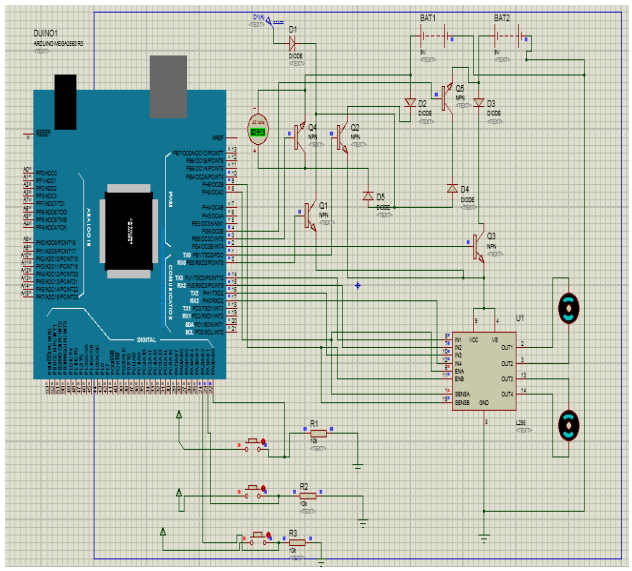


Figure 15.
Energy management control circuit schematic

5.3 SIMULATION OF A FOUR-QUADRANT CHOPPER CONTROLS TWO DC MOTOR

With the use of a four-quadrant chopper, the direction of rotation can be reversed.

5.3.1 SIMULATION BLOCK

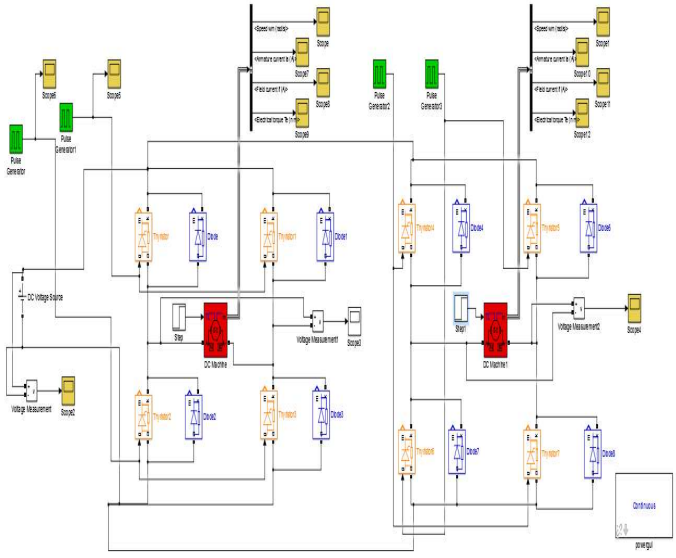


Figure 16.
Block diagram of the simulation of the four quadrant double bridge chopper H.

5.3.2 SIMULATION RESULTS:

- **Input voltage:**

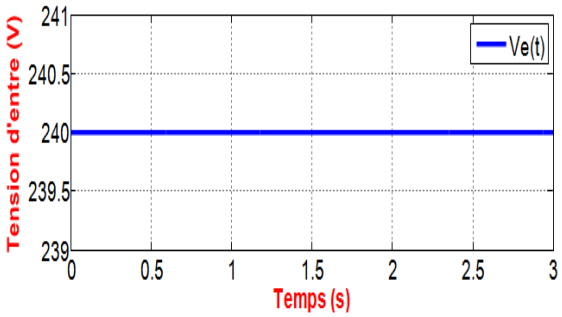


Figure 17.
Chopper input voltage

- **Output voltage:**

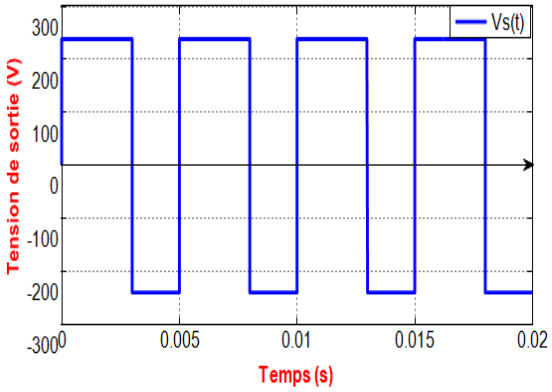


Figure 18.
Chopper output voltage with a cyclic ratio of 60%

- **Speed :**

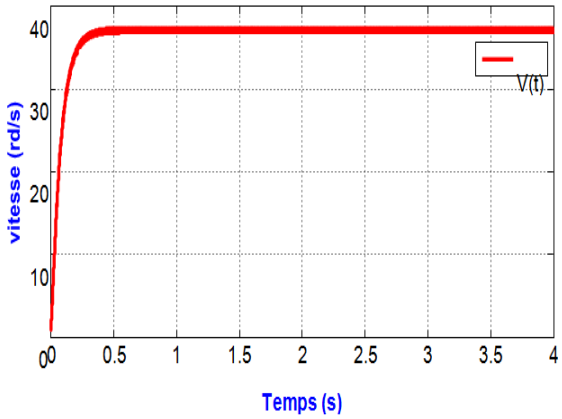


Figure 19.
Motor speed with a cyclic ratio of 60 %

Interpretation:

The speed starts from zero to stabilize at 37.3 rad / s, which is the steady state speed. The curve has an exponential shape, which corresponds to the presence of transient phenomena in the windings of the machine.

5.4 CONTROL PART

The control algorithm implemented in the Arduino has two parts:

The first to initiate the opening and closing of the vehicle power circuits according to the following voltage measurements: (panel, battery 1 and battery 2).

The second for speed control and vehicle steering (remote control via a Bluetooth wireless network by a smart phone) [6],[7].

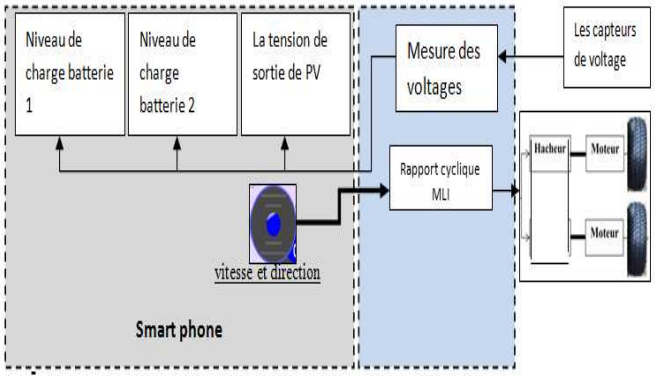


Figure 20.
Synoptic diagram of the control part

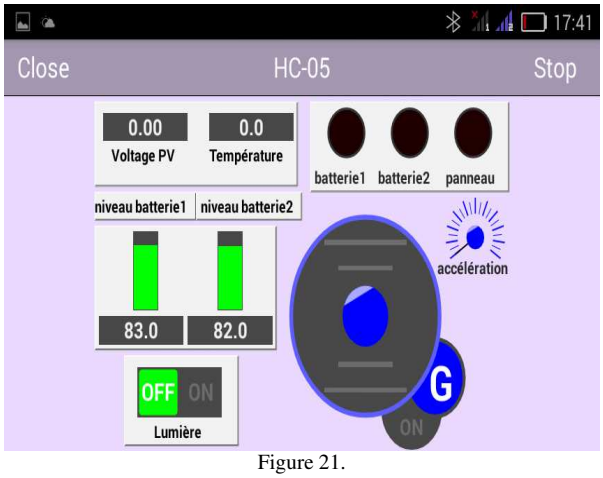


Figure 21.
The interface of the command application

For our project we have opted to make an Electric Vehicle according to the following specifications:

1. Two - wheel drive propulsion system.
2. The control provided by the microcontroller implanted in an embedded Arduino.
3. Remote control via a Bluetooth type wireless network.

To conclude, we can say that the design and optimization of the traction chain of an electric vehicle is a multidisciplinary problem that must take into consideration, as a minimum, the batteries, the mechanical transmission and the electronically powered electromagnetic actuator. Finally, the search for a minimum cost complements scientific and technological difficulties.

For future platforms they must meet new mobility specifications, significantly limiting their weight and dimensions to make the vehicle more modular. These

specificities in modularity, compactness and flexibility require a profound challenge to the vehicle architecture [10].

6. CONCLUSION

In our human society we consume a very high amount of energy to cover our daily activities, this energy is necessary to move, to heat, to enlighten, to heal ... But our energy resources are not eternal, in addition the majority of resources are contaminated, so we need to use new sources of renewable energy and at the same time clean such as solar energy, wind energy ... Until this moment the energy usable in the transport is not clean. In this work we used a clean and renewable energy that is solar energy with optimization in the context of an electric vehicle. The objective of this project was to create a solar electric vehicle prototype controlled in speed and direction, with optimization of the consumption of electrical energy.

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