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Modified power controller with Arduino for cerebral palsy electric wheelchair control

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This paper presents a simple motion controller of an electric wheelchair by using a push button panel, Arduino platform and a VR2 modified power electronic drive. The aim of this paper its to replace joystick controller by a push button panel, this solution is easy to use it by the cerebral palsy patient who has problems with coordination in their upper extremities(head and hands) and dystonia states. The speed control of the wheels and change the direction is implemented through a digital pulse-width modulation technique, which is varying with the reference generated, by incremented or decremented push button action. Experimental results demonstrate that the proposed solution meets the user requirements in terms of reliability and good driving.

Keywords : Electric wheelchair EWC, ARDUINO, VR2, push button, Pulse width modulation.

1. Introduction

Cerebral palsy (CP) is a group of permanent movement disorders that appear in early childhood. Cerebral palsy is caused by abnormal development or damage to the parts of the brain that control movement, balance and posture [1]. Its symptoms may include muscle spasms, involuntary movements, dystonia, disturbance in gait and mobility. The condition usually originates before birth or during infancy, often due to trauma or lack of oxygen to the brain.

Fig1. Some Cases of Cerebral palsy patients

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The aim of this paper based on the open-loop control of an electric wheelchair in which it is intended for individuals carrying the Cerebral palsy patients. Electric wheelchairs (EWC) allow the patient to move quickly as they are powered by electric motors and controlled using a small switch called a joystick [2]. These types of wheelchairs are easily handled by patients who have coordination problems in their lower extremities only and do not have with their upper extremities (head and hands). To this end, we started to develop and control an electric wheelchair simply with simple push buttons without using the joystick for two main reasons:

The first, the patient who has coordination problems in the upper part (his head and his hands) shown on Fig 1, cannot handle the joystick correctly and consequently a disturbance of the orientation of the electric wheelchair (EWC).

Second, in terms of cost, the joystick is very expensive as a solution compared to an Arduino board.

The methodology was based on constructing and testing an electronic prototype type VR2 frame using Arduino for electric wheelchair control. Therefore, two DC motors (coupled to the speed reducer for the propulsion) are fitted with the wheels of the wheelchair [3].

2. Design of the Electric Wheelchair System

2.1 Hardware design:

Fig. 2 shows the general diagram of the hardware developed to drive a EWC motor. It was based on push button panel for direction used for the man-machine interface, tow H-bridge and an open-source electronic development with Arduino model UNO R3 platform clocked at 16 KHz.

A DC motor with permanent magnet connected field was used since the application range of this motor includes the electric wheelchair because of its high torque, power density and good efficiency [4]. The model of motor is EC82M244645ALGBLOQ (Motion TECH control) and it has 24V, 15.5A and 450W (nominal power), 4600 rpm (32:1). The power source supply was two lead acid batteries 24V 55AH.

Arduino executes the control algorithm that is responsible for generating the PWM signals (pulse-width modulation) and the signals digital for the direction and speed control of the EWC. Voltage regulator circuits into the VR2 frame is responsible for supplying power to power and control devices [5].

Fig. 2. Schematic diagram of the developed system

2.2 Working principle

The speed of rotation is dependent on the supply voltage, which in turn will be directly proportional to the duty cycle with which we command the driver. In this case, we used a specific integrated circuit for the control of power MOSFETs that is named IRS2184. The IC IRS2184 is specifically designed to handle the two MOSFETs from each of the H-bridge branch, introducing also a short delay when switching between the MOSFETs. The management of the MOSFET above takes place in floating mode with a technique called bootstrap [6]. The chosen MOSFET (IRF 1404Z) support voltages up to 40volt with currents over 200 amperes, more than sufficient. With two IRS2184 IC and four MOSFETs a full H-bridge is made that is suitable for the management of an engine in the four quadrants; a driver is directly controlled by the PWM signal while the other is driven with the opposite signal. The two transistors are placed on the inputs of the driver precisely serve to obtain the inversion of the PWM input signal, as required in locked antiphase mode. With only two PWM signals we manage both the drivers and consequently the two engines, a third signal indicated by shutdown (SD) is used to disable the driver when Electric wheelchair is in standby. By activating two particular MOSFETs at the same time the direction of the current flow can be changed, thus changing the rotation direction of the motor [7].

When the button is pushed for direction, the Arduino UNO board through the digital data pin count the number of the button push. If the person continues to push one of direction button, the system reads the signals and decides to increase or decrease smoothly the duty cycle and consequently the speed of rotation of each motor wheel.

2.3 Modified schematic circuit:

Fig .3 shows the button box, this last consists of an on / off switch and five pushbuttons: front, rear, left, right and stop. Therefore, Arduino Uno is connected. An additional circuit shown in fig 4 has been added in order to control separately the two MOSFETs from each of the H-bridge branch (ex: T3 and T4). Fig .5a and Fig. 5b show the VR2 power controller original board before and after modification respectively.

In this case, we will control the electric wheelchair with the MCU of the ARDUINO card and not with that of the VR2 power controller. The modified schematic circuit was presented by fig 6.

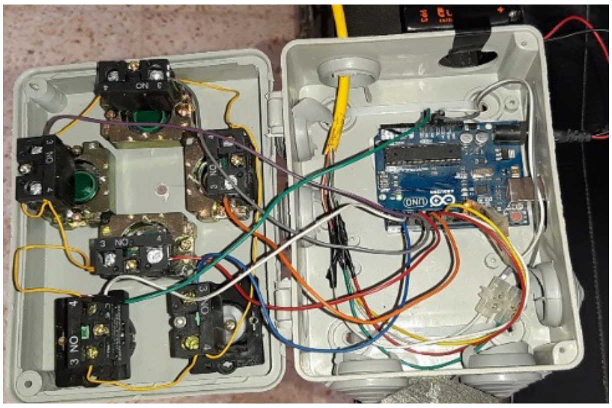

Fig.3. Push button panel inside with Arduino Platform

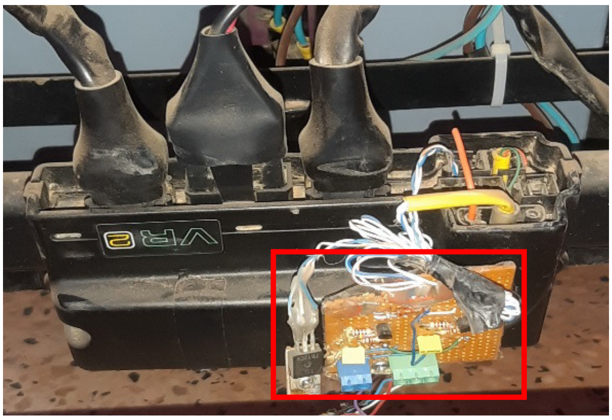

Fig.4. Additional circuit to control the H-bridge branch

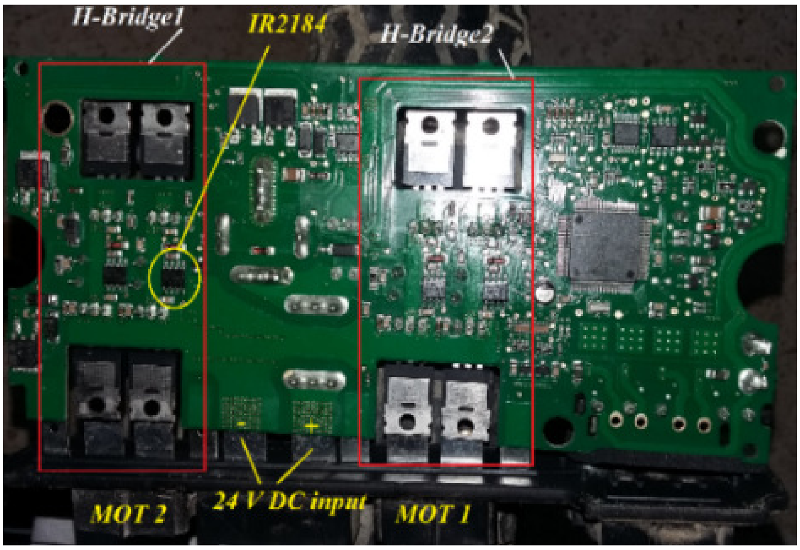

Fig.5 a. VR2 power controller original board

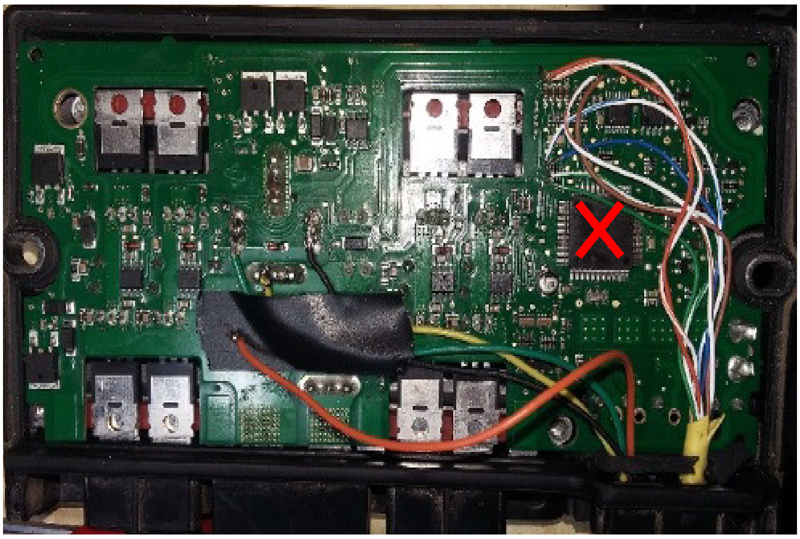

Fig.5 b. Modified VR2 power controller

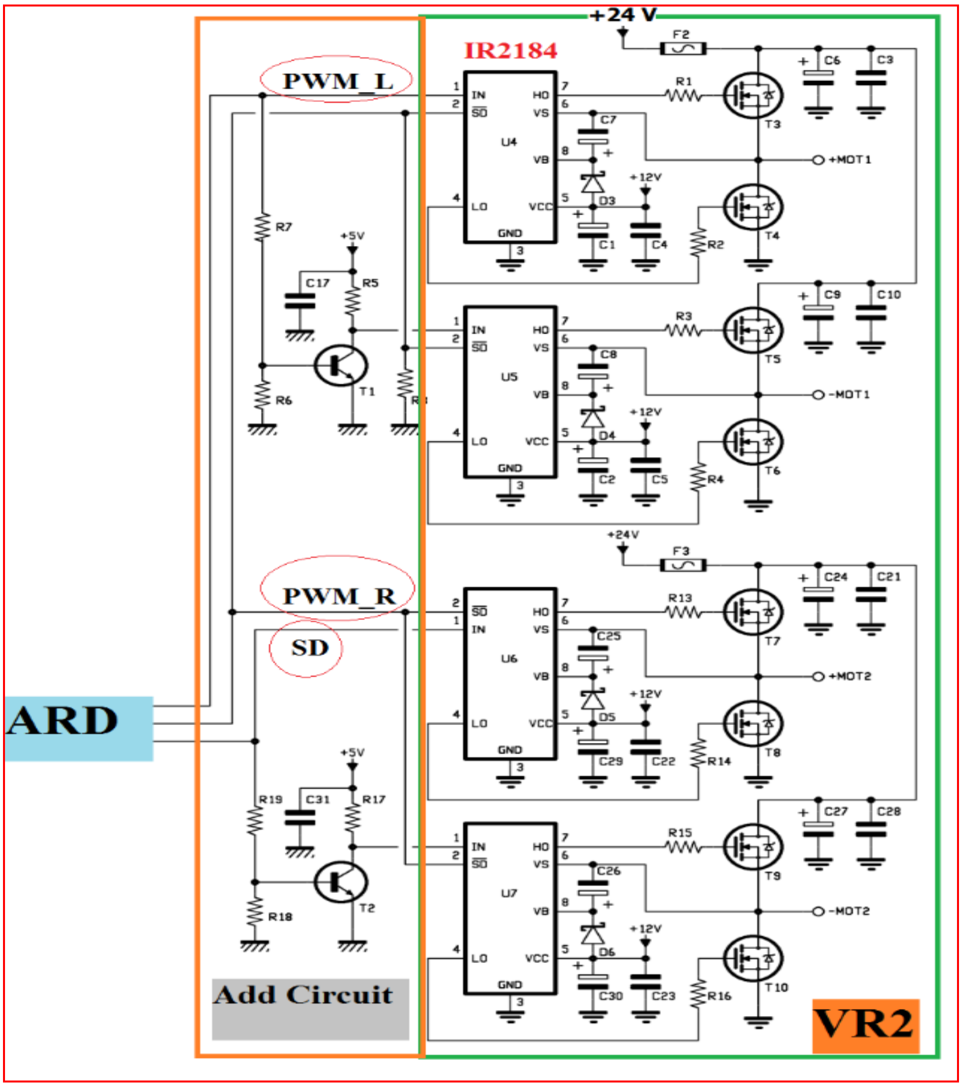

Fig.6 The modified schematic circuit

2.4 Code for modified EWC controller:

This code has been developed to generate the two PWM left and right to control the two DC motor of the EWC [8].

```
void loop() {
 status=digitalRead(PStart_pin);
 digitalWrite(ShutDown_pin, status);
  if (digitalRead(P1_pin)==0) {
     if (drive>-stallMotor) drive-=1.0;
     SetMotor();  }
 if (digitalRead(P2_pin)==0) {
```

```
    if (drive<stallMotor) drive+=1.0;
    SetMotor();  }
  if (digitalRead(P3_pin)==0) {
    drive=0.0; SetMotor();
 }
}
void initMotor()
{
 pinMode(ShutDown_pin, OUTPUT);
 digitalWrite(ShutDown_pin, LOW);
 pinMode(PWMLeft_pin, OUTPUT);
 pinMode(PWMRight_pin, OUTPUT);
 TCCR1A = _BV(COM1A1) | _BV(COM1B1);
 TCCR1B = _BV(WGM13) | _BV(CS10);
 ICR1=500;
 maxPWM = float(ICR1)*0.95/2;
 stallMotor=ICR1/2;
 OCR1A = stallMotor;  //ICR1/2=50%
 OCR1B = stallMotor;
}
 void SetMotor()
{
  drivePWM = int(drive);
  drivePWM = constrain(drivePWM, -maxPWM, maxPWM);
  dutyCycleLeft = stallMotor + drivePWM;
  dutyCycleRight = stallMotor + drivePWM;
  dutyCycleLeft = constrain(dutyCycleLeft, stallMotor-maxPWM, stallMotor+maxPWM);
  dutyCycleRight = constrain(dutyCycleRight, stallMotor-maxPWM,
stallMotor+maxPWM);
  OCR1A = dutyCycleLeft;  //set PWM
  OCR1B = dutyCycleRight;  //set PWM
}
```

3. Results

The programming is done in Arduino environment and loaded to the board. The push button panel ensures precise control of the developed system. After connecting of all, the system provides accurate input and output signals, which ensure the desired algorithm performance from Arduino Code.

Fig.7 presents the electric wheelchair EWC with the push button panel and modified VR2 power controller. The digital PWM signal is sent to the motor driving IC via digital data input pin. This PWM duty cycle determines the speed of the two DC motors driving the wheelchair. When the push button is fully pressed, the expected speed of movement is approximately 7km/h.

On Fig 8, the cerebral palsy patient presents a good interaction with the push button panel to conduct his EWC easily and independently. The study presented in this article only covers the movement of EWC in different directions, without describing the battery charging and the braking systems.

Fig 7. Modified Electric wheelchair (without joystick)

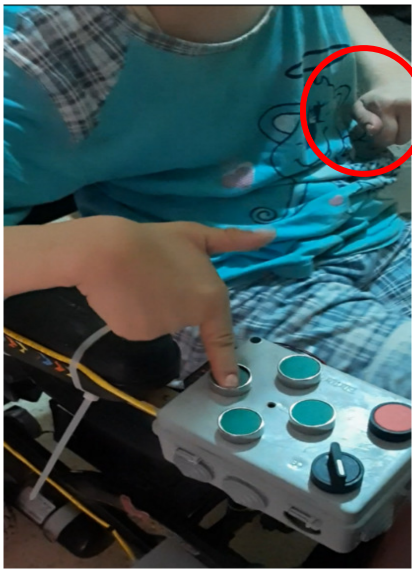

Fig. 8. Cerebral palsy patient has control the modified EWC

4. Conclusion

Tests and analysis of the results show that the proposed system for digital control of the EWC satisfies the requirements in terms of power ease of handling, cost and comfort. The design and implementation of the hardware and of software are the result of creativity and applied knowledge to solve a problem. The system responds perfectly under the conditions for the ones it was designed for.

As a future work, a new method can be added to the system by extracting the information from the patient's brain using the BCI (brain cerebral interface). The signals must be conditioned, filtered and amplified to be exploited. Moreover, it is possible to apply improvements in the software without increasing cost, for example implementing advanced motor control techniques, or add other user interfaces such as: speech recognition or the recognition of obstacles. The control can be also improved by neural based algorithm. Kinematic eye retina control of wheelchair using optical sensor also can be investigated

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