PWM BASED ANDROID CONTROLLED WHEELCHAIR

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ABSTRACT

Most of the physically disable individual satisfies their movement through motorized wheelchair. The scenario is unusual for the disables of developing countries because of their economic conditions. Moreover traditional powered wheelchair is not comfortable to all segments of the disable society because of their complexity. Several researchers have used sophisticated technologies to operate wheelchair such as voice controlled, head gesture controlled, remote controlled wheelchair for providing better flexibility. For being sophisticated technology Android is being used in mobile, TV or in smart watches.An app with mitigating required controlling facilities is implemented here that may provide a flexible movement of the certain disable community. This paper focuses on the system of PWM based Android Controlled Wheelchair.

KEYWORDS

Wheelchair, Microcontroller, Android phone, Bluetooth, Assistive Technologies and PWM.

1. INTRODUCTION

“World report on disability” and “World Health Organization (WHO)” say approximately 70 million people in the world are disabled [1].These large numbers of people depend entirely or partly on different types of assistive technologies. The type of disability is not the same. So the need for assistive technology will be different. Although the manual wheelchair is the most common assistive technology for disabled person, which is used to improve the user's social participation and personal mobility but the manual wheelchair is hard for running long-term [2].Most wheelchair user claims that wheelchair is the main factor limiting their social community participation [3].So the improvement of manual wheelchair to a motorized one may reduce this limiting factor. If a sophisticated control technology is applied in motorized wheelchairs, then the freedom of the disabled and the quality of life can be ensured. Generally disabled people use joystick controllers to run motorized wheelchairs. A severely disabled person may experience many problems using joystick controllers, because they may require smooth or remote control[4]. Therefore, a PWM-based Android-controlled smart wheelchair can be a well-developed technology for those who have lost their dynamic power due to significant amount of paralysis, accident or due to old age. Moreover, it is possible to replace the traditional joystick controller by a PWM based Android controller for better flexibility.

Usually Android-based wheelchair is a device where DC motors and Android mobile applications are used to control the wheelchair speed. The Wheelchair movement includes left, right, stop, forward and reverse functionality [5].Where an Android operating wheelchair can give a specific speed towards the forward, a PWM-based Android-controlled wheelchair can provide different speeds for forward directions. The wheelchair operation involves two customized DC gear motor of 180 RPM and separate motor driver module for each. A PIC16F877A microcontroller is working as the processor or brain of the wheelchair. Data sharing between the Android device and the control box is done through Bluetooth serial communication [6].HC-05 is being used for reception of Bluetooth data and we programmed PIC microcontroller by embedded C programming language.

2. HARDWARE INTERFACE METHODOLOGY

In terms of speed control, you can use a current limited resistor in series with DC motors, but this mode of motion control leads to a lot of energy loss and produces plenty of heat. Using microcontroller or by designing some specific system a practical implementation can be done to solve this problem. The most common implementation technique at present is Pulse-Width Modulation (PWM) [7] [8]. This technique offers energy efficiency, flexibility, control accuracy and good dynamic responses of DC motor control. Following Figure1illustrates PWM scenario by frequency and amplitude. Where the speed is controlled by duty cycle and the motor only runs for "ON Time".

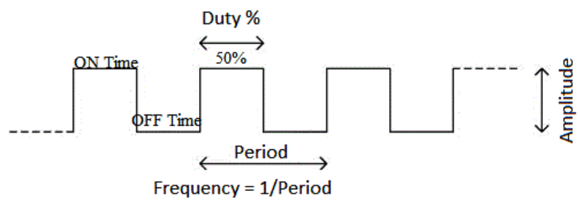

Figure 1. Principle of Pulse Width Modulation (PWM)

Our research is based on a PWM controlled wheelchair. PWM stands for Pulse Width Modulation technique. This technique can also be called as Pulse Duration Modulation (PDM). PWM is the technique of getting analog results in digital means. A square wave generates through the process by switching the voltage between 5v and 0v. The mathematical representation of the duty cycle is given below-

$$\text{Duty cycle} = \frac{T_{on}}{T_{on} + T_{off}} \times 100\%$$

$$= \frac{T_{on}}{T_{total}} \times 100\%$$

Where,

T_{on}= Time period when the signal is high.

T_{off}= Time period when the signal is low.

$T_{total} = T_{on} + T_{off}$

This technique is used for permissible power. Another factor is PWM frequency. It determines how fast switching between high and low states. Some application uses this technique, where is necessary to reduce power by balancing torque or intensity. Here we used this technique for controlling the speed of our motor. Instead of fixed speed movement speed variation is done. Here a full cycle means 100% PWM, where on time or 5 volt continues for full cycle. This on time can also be termed as duty cycle. Similarly half duty cycle means 50% PWM. To get variation in analog value we need to change the duty cycle [9]. Thus we accomplish the motor control.

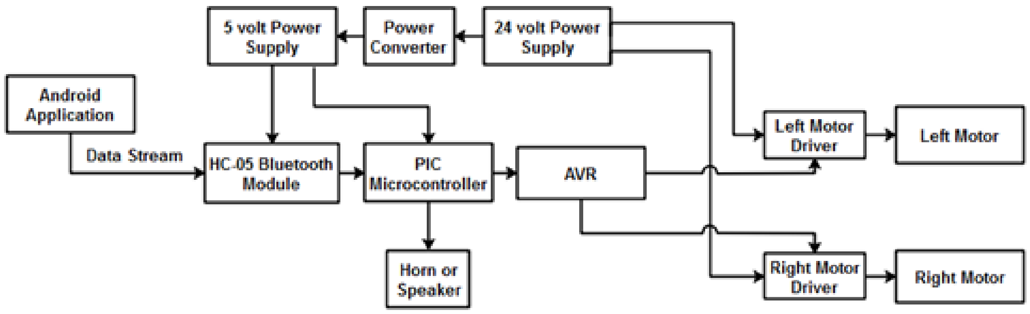

Figure 2.Block diagram of the system.

The above block diagram shows system architecture at a glance. An android app through android device is connected to HC-05 Bluetooth module and the app transmits data stream to Bluetooth module. The process uses Bluetooth communication. We choose this communication protocol for secure communication, low power consumption and android availability. The next block follows a PIC16F877A microcontroller. Receiving the data from Bluetooth module and translate those data by switching are microcontroller's responsibility. So it is the brain of the system. HC-05 Bluetooth shield and PIC microcontroller require a power of Vcc that comes from main power supply by a buck converter. Since the 7805 and 7812 linear IC produces a lot of heat, in this case a buck converter will conserve more energy. Another important processing section is PWM system that includes an AVR (Automatic Voltage Regulator)and Motor drivers. The AVR provides required voltage to the MOSFET of two separate motor drivers through timer. Later sections will describe the whole circuit. Here, PIC switches the regulator in different position for the generation of PWM and then the corresponding motor will start to run at the defined speed. The only power supply of the whole system is battery. These motors drive power from the battery which is of 2pcs 12v and 30A/h.

3. TRANSMITTING UNIT ARCHITECTURE

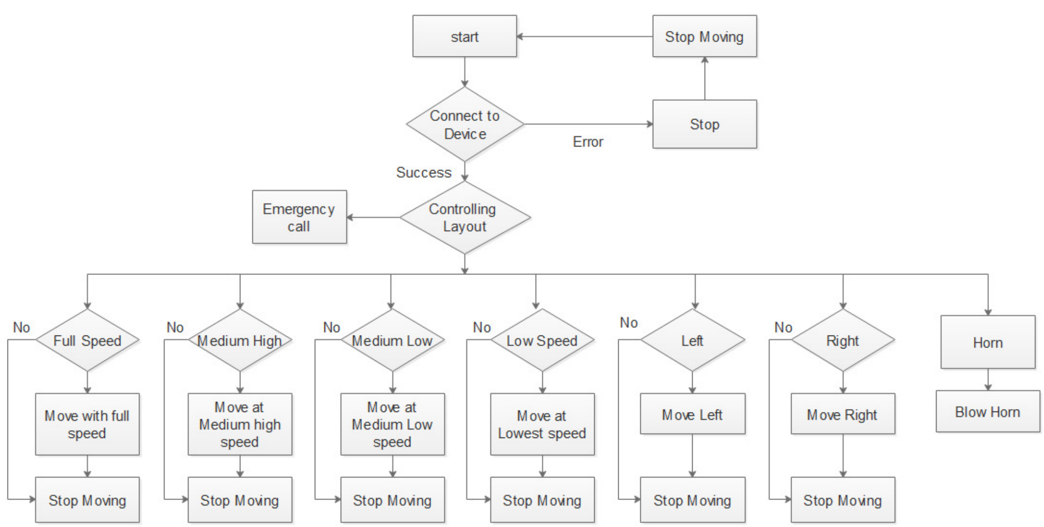

Figure 3.Flow chart of Android Mobile Application.

Only the Android mobile application works as a transmitting and control device. The Android application uses the Android mobile phone to take full control of the wheelchair. The application software is designed to be considered suitable for all versions of Android. For example, Marshmallow, Kit Kat, Lollipop, Jelly Bean are different versions of Android. This mobile application is designed in such a way that it can be run in any Android version. In the transmission unit architecture, data is created by a flow chart and algorithm. The mobile application controls an error handling process for raw data transmission. If there is a problem connecting to the Android Bluetooth module, then the app will try it again as per user's wish. If a successful connection is established, the application will automatically be sent to the control screen. Here the user will have two choice of SOS dial or main operation layout.

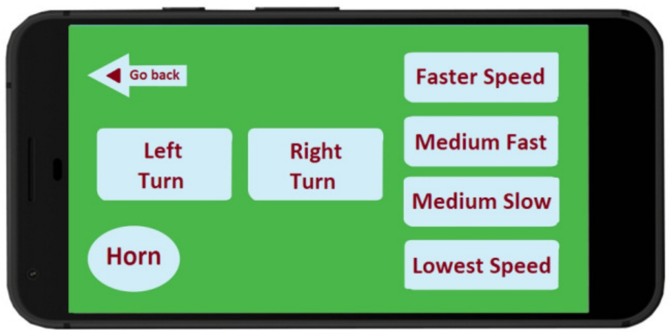

Figure 4. Android application layout.

A user can use "Go Back" option for SOS dial layout. SOS stands for Save Our Soul, which generally implies instant contact at any emergency. In SOS dial layout he/she will find 3 buttons for emergency dial. Here in controlling layout, for speed selection in forward he/she can choose either button shown on right side. If necessary user can go left or right by using "Left Turn" of "Right Turn" button. All the buttons shown in the layout are tap and hold type. This express, one button will send a particular data as long as the user hold the area of the button on the screen. As well as that button will send a different data when the user pull out his hand from that area. This type of button has been chosen for smooth controlling mechanism and safety issue. In addition user has an option to blow horn if required. So the app provides a horn blowing option. Here different codes are assigned for different option. For example, FS, MF, MS & LO are assigned for Faster speed, Medium fast, Medium slow and Slower speed respectively.

4. Receiving Unit Architecture

Table 1.Data represents corresponding functionality

Raw Data	System Function	Left Motor Rotation	Right Motor Rotation	PWM
FS	Move at Faster Speed	CW	CW	100%
MF	Move at Medium Fast Speed	CW	CW	80%
MS	Move at Medium Slow Speed	CW	CW	60%
LO	Move at Lowest Speed	CW	CW	40%
L	Turn Left	CW	CCW	40%
R	Turn Right	CCW	CW	40%
H	Horn	------	------	-----

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Receiving unit architecture from the table can be interpreted. Columns three and four respectively explain the direction of the rotation of the left and right motor. In addition, the corresponding

PWM duties cycle has been shown. Here are some raw data which are predefined to Android by coding. This information is adopted by the HC-05 Bluetooth Shield at the next processing stage. Later, USART was established through a HR-05 and PIC 16F8777A.Bluetooth shield to PIC microcontroller uses simplex communication protocol mode. At the next level, PIC understands the microcontroller code and creates related ports for the corresponding PWM generation. These PWM signal has been created by designing a corresponding circuit using NE-555 timer IC. PIC's CCP module programming is another way to create PWM signals but we designed an electronics circuit to avoid system risk and system's break down.

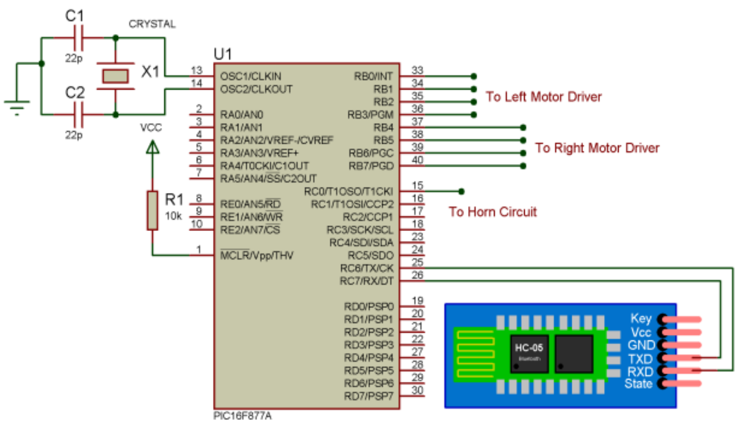

Figure 5.Receiving system unit.

From above circuit you can understand the pin defined for the left motor and right motor. The left motor uses pin number 33 to 36 and the right motor uses pin number 37 to 40. Another pin is allocated to switching a horn.

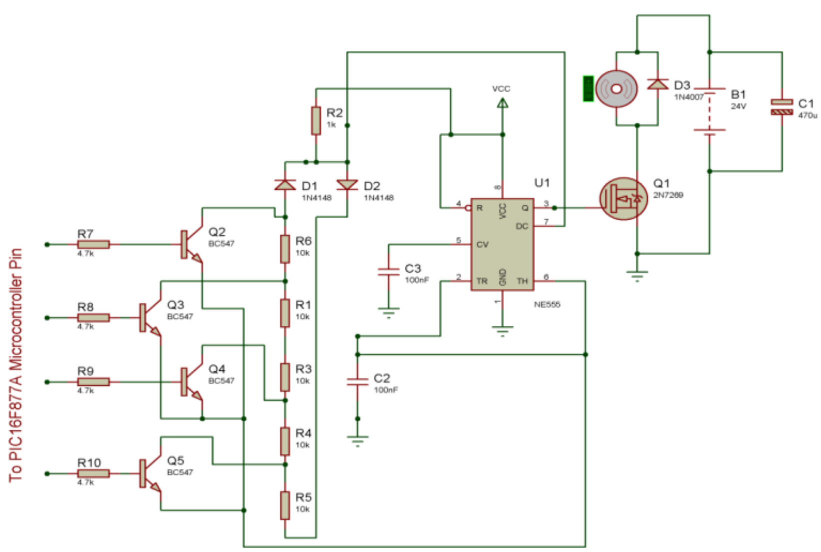

Figure 6.Single motor driver circuit diagram.

Figure 7.PWM based android controlled wheelchair.

At the next level, motor driver circuits are followed, which are controlled by the PIC microcontroller activating the associated pins. Here a 555 timer IC creates and controls PWM signals. High current rated MOSFET is driving the required current for the motor. [10] In the driver circuit a protection diode is used with each motor in reverse biased. This is also called fly back or spike suppressor diode. When current goes through an inductive component like motor, a voltage spike is created. A very large negative spike is generated. The fly back diode ensures a safe path to discharge the negative voltage signal. As it controls reverse current flow in the circuit and thus protect the electronics component of the system.

5. RESULT AND DISCUSSION

After completing the research, we developed a PWM based android controlled wheelchair model. Transmitting and receiving units are working properly. To understand the performance of the chair we can compare the system with an android controlled wheelchair which is not based on PWM [11]. We did the test to summarize the performance analysis. For this reason, we have tested our system on several surfaces and as a result of the data analysis, the following performance curve is summarized.

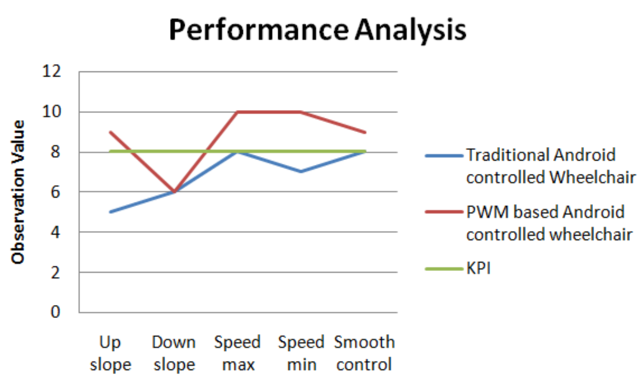

Figure 8.Performance analysis and comparison between android controller and PWM based android controller.

The value of observation is comparing two systems based on KPI. The KPI (Key Performance Indicator) indicates all parameters should be above or equal to 8 out of 10. Several disable people has tested the model of our wheelchair. After experimental session they were given a choice form to provide performance value. Finally the performance analysis curve is generated based on climbing up slope, maximum speed, and minimum speed and for smooth controlling. Our wheelchair shows a greater performance and each value is larger than the KPI. To move on a down slope, the system shows a performance value which is below the KPI. We have used manual break system to solve this issue. As a result the performance of moving on a slope to downward becomes more smooth and comfortable. As a result, a PWM based android controlled wheelchair can be more comfortable than an Android-controlled wheelchair [12]. Contrary to cost analysis, the total cost of the system is approximately 440 USD, which is more economic than any motorized wheelchair.

6. CONCLUSIONS

The disability cannot be explained in some words. This scenario becomes more pathetic for the disables of a developing country, because of their poverty. In some cases, they cannot even think of buying a powered motor driven wheelchair. To reduce these all sufferings we have worked on the entitled research. Our main goal was to design a new control technology and develop a new cost-saving motorized wheelchair for the disabled. Through this paper we have explained, the whole control technology and the system mechanism from top to bottom. All mechanisms have been explained clearly from transmitting unit to receiving unit. In summarize, transmitting unit produces controlling data by algorithm. Receiving section generates PWM to run the motor. PWM-based wheelchairs provide more flexibility than an Android-controlled wheelchair. To improve the quality, we've used stainless steel materials, solid rear tire and DC customized gear motors. In addition, the mobile-based wireless controller system provides remote control facilities. The future speed-based or accelerometer sensor-based wheelchair design can be redesigned, because such a sensor is a common part of Android mobile. This feature can improve the quality of the system without any cost.

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