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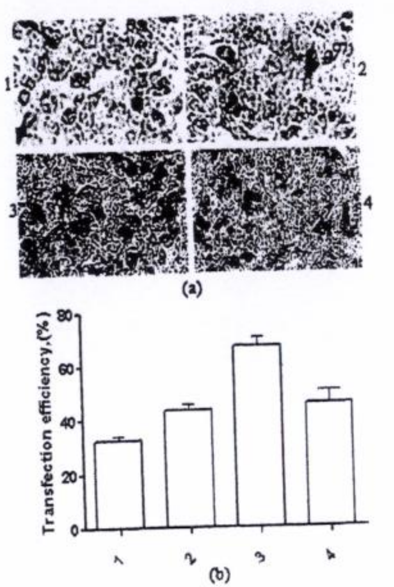


Fig. 5 Effect of magnets' rotation frequencies on expression of ß-galactosidase. (a) Representative data showing ß-galactosidase expression in HepG2 cells at 24 h folowing liposomal magnetofection under dynamic magnetic field with magnets' rotation frequency 5 (1), 25 (2), 50 (3) and 100 (4) rpm; (B) Bar chart showing the proportion of transfected cells at 24 h following liposomal magnetofection under dynamic magnetic field with magnets' rotation frequency 5 (1), 25 (2), 50 (3) and 100 (4) rpm. Data represent the mean values of three independent experiments.

## IV. Conclusion

We have described the construction and principle of work of the new device for the enhancement of liposomal magnetofection efficiency under dynamic magnetic field, named by authors the "DynaFECTOR",. We have also considered the forces governing particle motion under influence of applied field of dynafector and suggested possible mechanism of the increase of the magnetofection efficiency. *In vitro* magnetofection studies in hard-to-transfect HepG2 cell line carried out with gene reporter plasmid pcDNA3.1/LacZ on the "DynaFECTOR" device showed that the magnetofection efficiency was the incubation time and the magnet rotation frequency depended. The magnetofection efficiency obtained by using "DynaFECTOR", was higher than that of lipofection and standard magnetofection in all performed experiments. More cell lines should be tested to show the universality of use of the "DynaFECTOR" for the enhancement of magnetofection efficiency. In the future, the use of "DynaFECTOR" for such bioapplication as shRNA coding plasmid screening for the drug therapy can undoubtedly have the advantage for successful results.

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# Wheelchair Stabilizing by Controlling the Speed Control of its DC Motor

M. Dechrit, M. Benchalak and S. Petrus

*Abstract*—The aim of this paper is to design and control of electric powered wheelchair (EPW). The model of a DC motor is considered as a speed control by selection of a PID parameters using genetic algorithm. The simulation experiment is performed using MATLAB. An experimental set-up constructed, which consists of microcontroller PIC16F877 as controller, a DC motor driven EPW and feedback elements. And this paper is tuning methods of parameter for a pulse width modulation (PWM) control system. A speed controller has been designed successfully for closed loop of the DC motor so that the motor runs very closed to the reference speed. The result shows that, EPW can provide to the higher system also.

*Keywords*—rehabilitation, wheelchair, PID control, speed control

## I. Introduction

According to Wheelchairs, Wheelchairs give mobility to people who cannot walk. Knowing basic information about the types, accessibility, leans and safe use of wheelchairs is important [1]. Many prototypes of wheelchairs were developed in the research laboratories. Thus, EPW make up a significant portion of the mobility assistive devices in use today for the motor disabled and patients in recovery. While standard wheelchairs are mainly used by those who have the necessary upper-body strength to propel and manoeuvre it, EPW are destined for those who cannot: people with excessive body weight, poor health, weak upper limbs, and those long-time living with the disability [2].

To approach the motion control problem of an EPW with DC motor control. The DC motor has been widely used in industry. As a result, speed control of DC motor has attracted considerable research and several methods have evolved. Proportional-Integral Derivative (PID) controllers have been widely used for speed control of DC motor [4],[7].

Some of the most significant developments in wheelchairs are in the speed control. The actual speed sometimes can not follow the instruction speed as given from the joy stick. As the same time, right or left wheel usually do not run in the same speed. It may cause disorientation of the wheelchair [5]. The purpose of this paper is to discuss on how to achieve the best control performance of a wheelchair. In section 2, the discussion focuses on mathematical model and the conceptual design of a PID controller.

In section 3, hardware design and experimental results separated by PWM, and PID control. Finally, the paper is concluded in Section 4.

## II. DC Motor Mathematics Model And The Control Theory

### A. DC Motor mathematics model

Please We consider a DC shunt motors as is shown in Fig.1. DC shunt motors have the field coil in parallel (shunt) with the armature. The current in the field coil and the armature are independent of one another. As a result, these motors have excellent speed and position control. Hence DC shunt motors are typically used applications that require five or more horse power. The equations describing the dynamic behavior of the DC motor are given below.

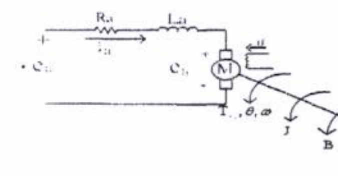


Fig. 1 DC motor using the armature voltage control method

Where, $R_a$: the armature resistance, $L_a$ : the armature inductance, $i_a$ : the armature current, $i_f$ : the field current, $e_a$ : the input voltage, $e_b$ : the back electromotive force (EMF), $T_m$: the motor torque, $\omega$ : an angular velocity of rotor, $J$ : rotating inertial measurement of motor bearing, $B$ : a damping coefficient. Because the back EMF eb is proportional to speed ω directly, then

$$e_b(t) = K_b\frac{d\theta(t)}{dt} = K_b\omega(t) \tag{1}$$

Making use of the KCL voltage law can get

$$e_a(t) = R_a i_a(t) + L_a\frac{di_a(t)}{dt} + e_b(t) \tag{2}$$

From Newton law, the motor torque can obtain

$$T_m(t) = J\frac{d^2\theta(t)}{dt^2} + B\frac{d\theta}{dt} = K_T i_a(t) \tag{3}$$

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Take (1), (2), and (3) into Laplace transform respectively, the equations can be formulated as follows:

$$E_a(s) = (R_a + L_a s) I_a(s) + E_b(s) \quad (4)$$

$$E_b(s) = K_b \Omega(s) \quad (5)$$

$$T_m(s) = B\Omega(s) + Js\Omega(s) = K_T I_a(s) \quad (6)$$

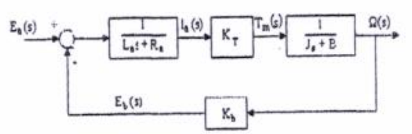



Fig. 2 Function block diagram of DC motor

The transfer function of DC motor speed with respect to the input voltage can be written as follows:

$$G(s) = \frac{\Omega(s)}{E_a(s)} = \frac{K_t}{(L_a s + R_a)(Js + B) + K_b K_t} \quad (7)$$

From Equation (7) the armature inductance is very small in practices, hence, the transfer function of DC motor speed to the input voltage can be simplified as follows.

$$\frac{\Omega(s)}{E_a(s)} = \frac{K_m}{\tau s + 1} \quad (8)$$

Where $K_m = \dfrac{K_T}{R_a B + K_b K_T}$ is a motor gain

$\tau = \dfrac{R_a J}{R_a B + K_b K_T}$ is the motor time constant

From Equation (8), the transfer function can be drawn the DC motor system block diagram which is shown in Fig. 3.

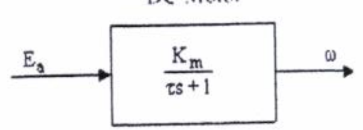



Fig. 3 Simplified block diagram of DC motor

*B. PID Control*

The PID controller includes a proportional term, integral term and derivative term, where the proportional term is to adjust the output of controller according to all of the magnitude of error, the integral term is used to remove the steady state error of control system and improve the steady state response, the derivative term is used to predict a trend of error and improve the transient response of the system. These functions have been enough to the most control processes. Because the structure of PID controller is simple, it is the most extensive control method to be used in industry so far. The PID controller is mainly to adjust an appropriate proportional gain $(KP)$, integral gain $(KI)$, and differential gain $(KD)$ to achieve the optimal control performance. The PID controller system block diagram of this paper is shown in Fig. 4.

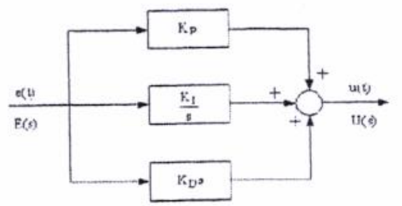



Fig. 4 PID controller system block diagram

The relationship between the input $e(t)$ and output $u(t)$ can be formulated in the following.

$$u(t) = K_P.e(t) + K_I.\int_0^t e(t)dt + K_D \frac{de(t)}{dt} \quad (9)$$

The transfer function is expressed as follows.

$$C(s) = \frac{U(s)}{E(s)} = K_P + \frac{K_I}{s} + K_D s \quad (10)$$

The controlled plant in this paper is a DC motor. The PID DC motor speed control system block diagram is shown in Fig .5.

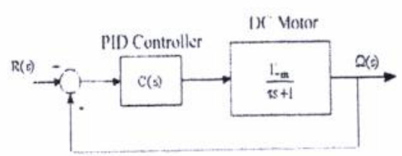



Fig. 5 PID DC motor speed control system block diagram





The closed loop transfer function of DC motor speed control system expresses as follows,

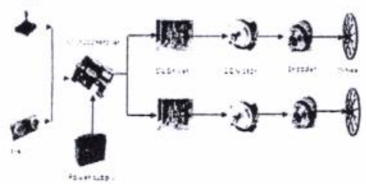
$$G(s) = \frac{\Omega(s)}{R(s)} = \frac{\left(K_P + \frac{K_I}{s} K_D s\right)\frac{K_m}{1+\tau s}}{1+\left(K_P + \frac{K_I}{s} + K_D s\right)\frac{K_m}{1+\tau s}}$$

$$\frac{(K_D s^2 + K_P s + K_I)K_m}{(K_D K_m + \tau)s^2 + (1 + K_P K_m)s + K_I K_m} \quad (11)$$

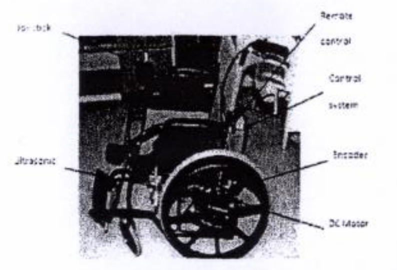
## III. Hardware Design and Experimental Results

*A. System Design*

In this research designed the control system of an EPW for the disabled. The system composes of 24 volt and 250 watt DC motor. The former one controlled by Pulse Width Modulation (PWM) generated from a Microcontroller PIC 16F877 through the H-Bridge functions on forward-backward movement of electric wheelchair. Microcontroller used as the controller is PIC16F877 microcontroller. This microcontroller circuit is designed as a single chip circuit. A personal computer (PC) is connected to this microcontroller for data acquisition process. The microcontroller will read the speed and then control the speed of a wheelchair by using PID control algorithm. Two DC motors are used as the pulley and belt for moving links of the wheel. Because we need to control the speed and direction of the DC motor, H Bridge driver circuit is used in this system. PID controller applied in this research is a parallel PID controller. PWM is a switching technique in which the supply voltage is full applied to the load and then removed the on and off times being precisely controlled. An integrated circuit PWM controller. A H bridge contains four switching power devices (power mosfets were used in this application) and the motor load is placed across the central arms, then execute the parameter adjustment of the PID controller through the designed program under the Microcontroller control. The system design is shown in Fig. 6.



(a)




(b)

Fig. 6 (a) Schematic Diagram and (b) Electric Power Wheelchair

Software of PWM is designed by using PIC code vision program. Fig 7. shows flowchart of the designed software.

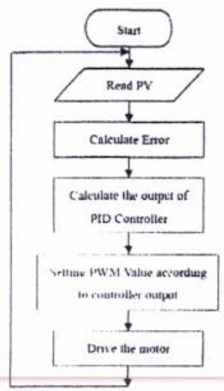



Fig. 7 Flowchart of the designed software

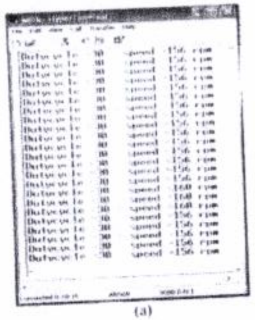
*B. Experimental Results*

In this section, we test that examined 21 patients referred to be assessed for the provision of an EPW by compared with weight and duty cycle at 15 meters are provided in Table 1. The purpose of this EPW demo track is to familiarize the students with power converters and their functions as used in power electronics applications. To allow the students are perfectly as working in the laboratory the DC motor bus voltage and the control signals are allow bellow 30 volt.

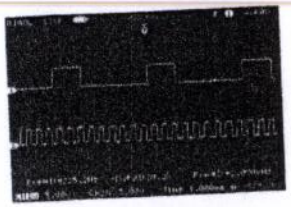
TABLE I
EXPERIMENTAL RESULTS FOR PWM

| Duty cycle | 30% (m/s) | 50% (m/s) | 70% (m/s) | 90% (m/s) |
|---|---|---|---|---|
| Weight (kg) | | | | |
| 45 | 0 | 1.15 | 1.63 | 1.89 |
| 50 | 0 | 1.04 | 1.34 | 1.85 |
| 55 | 0 | 0.97 | 1.20 | 1.84 |
| 63 | 0 | 0.82 | 1.C4 | 1.71 |
| 73 | 0 | 0 | 0.57 | 1.36 |
| 85 | 0 | 0 | 0.85 | 1.24 |
| 95 | 0 | 0 | 0.57 | 1.03 |

In order to illustrate that the PWM is functioning the DAC was set to 126 out of 255. The result can be observed on Figs 8, 9.

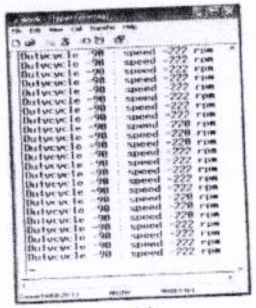


(a)

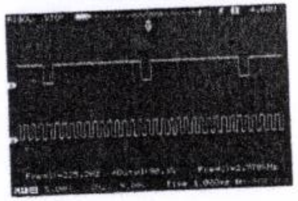


(b)

Fig. 8 (a) Speed control, (b) 30% PWM and Encoder signal



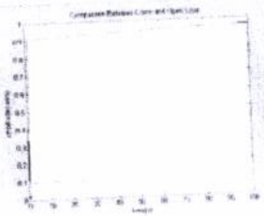
(a)



(b)

Fig. 9 (a) Speed control, (b) 90% PWM and Encoder signal

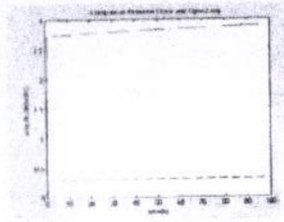
In the following, apply the real gain of PID control parameters $K_P$, $K_i$, $K_d$ with MATLAB simulink, simulate the PID control of DC motor speed control system according to the hardware connected wire and the system function block diagram is to draw the PID speed control system and verify with the actual system response. The simulation results of the response of PID speed control in DC motor are shown in Fig 10.



(a)







(b)

Fig. 10 Comparative response of open and closed loop with (a) and (b)

## IV. CONCLUSION

From the experimental results, we can conclude that the PID controller can control the speed of an EPW well. The simulation of the DC motor was done using the software package MATLAB/SIMULINK. But this is depended on the setting value of PID parameters. By setting the PID parameters with proper value, we can get good system response. At the same time, PWM designed has been simulated and observed to have good performance. In the decrement test of the four levels of speed, percent duty cycle of PWM and average voltage supplied to 24 volt motor are investigated. The lowest speed (Level 1) of wheelchair has the percent duty cycle of 30% and the average voltage of 16.2 volt, consequently the maximum weight be able to load on the chair at 40 kg. and the maximum weight be able to load on the chair at 100 kg as much as Level 4 which has the percent duty cycle of 90% and the average voltage of 22 volt. Overall, a speed controller has been designed successfully for closed loop operation of the DC motor and the motor runs very closed to the reference speed.

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# INVITATION LETTER

July 18, 2011

Dr. Dechrit Maneetham
Rajamangala University Of Technology Thanyaburi
Thailand

To Whom It May Concern,

We are pleased to inform you that your peer-reviewed & refereed full paper entitled "Wheelchair Stabilizing By Controlling The Speed Control Of Its Dc Motor" is accepted for oral presentation at the ICMIBE 2011 : International Conference on Medical Informatics and Biomedical Engineering to be held in Bali, Indonesia during October 26-28, 2011.
This letter serves as confirmation of your participation in the conference.
We would greatly appreciate if you could facilitate granting the conference delegate the necessary visa.

Sincerely Yours,

C. Ardil,
Conference Secretariat
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