



## DEVELOPMENT OF TOUCH SCREEN OPERATED ELECTRIC WHEELCHAIR FOR DWARFISM COMMUNITY

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### ABSTRACT

Current mass production Electric Powered Vehicle (EPW) only caters for X-axis and Y-axis movement only. A Z-axis EPW available in the market is used to provide a stand-up position function and does not cater for elevation in a sitting position. The sitting position elevation function in an EPW is needed for a dwarfism student to access common table in a classroom. This paper will detail out the development of a sitting position elevation function EPW which will be known as ZUMP 4. A development of EPW for the X-axis, Y-axis and Z-axis movement are modelled through 16 I/O PLC system applications. This ZUMP 4 is developed for the dwarfism community with body height weakness suitable for in house and outdoor usage. For this reasoning, a capability of 24V BLDC motor with reduction gear and in order to support forward, backward, turning right or turning left. For this buggy, AC Asynchronous Machine (0.5HP) supplied with single phase voltage and ball screw concepts have been applied to support the elevation function. More specifically, the application of touch screen as medium concept for an input signal of the system to move the wheelchair in this multi direction is an added function to provide ease of manoeuvring. The integration and fabrication process of mechanical system, electrical and control system are done to get the best design that can suit the actual application for Zull Hanif Abdul Halim, a dwarfism student in UMP. As far as the author's knowledge, this type of EPW has not been developed yet.

**Keywords:** electric powered wheelchair, dwarfism, BLDC motor, ball screw, AC asynchronous machine, touch screen.

### INTRODUCTION

Based on medical research "Dwarfism" is classified an abnormally small person, a condition characterized by short stature or even "midget" and features a typically proportioned or formed. According to the definition of the advocacy group Little People of America (LPA), a dwarfism is a person of abnormally small stature owing to a pathological condition. Especially one suffering from cretinism or some other disease that produces disproportion or deformation of features and limbs. Most types of dwarfism as skeletal dysplasia, which are conditions of abnormal bone growth. Dwarfism symptom can be caused by any one of more than 200 conditions, most of which are genetic.

Defects in a society of dwarfs have a negative impact, low self-esteem compared with usual persons. Based on that dwarf society should be encouraged to continue living where they are suitable for the same respect like a normal people.

The vision of the paper is to enhance the lifestyle and dignity of the disabling community. Also, to make sure the disable sit and speak equally with normal people and to change to public facilities to support a better living environment.

The ability persons that cannot manage the use of conventional joystick electric chair in perfect to move independently. Some input signal for current available wheelchair are a voice command, body motion attraction, yaw head angle, EEG signal, attention and eye blinking signal, Tongue Drive System (TDS). New intuitive control interface are described through a Bluetooth interface, wireless interface and electrical interface in EPW. For this

reason, the localised powertrain product of this mission idea is started with to introduce reasonable cost with a touchscreen control for practical commercialization for both local and overseas market.

Improper of a manual wheelchair designed to be a chance of injuries after long anxious difficulties. The constraint on ecological difficulties amplifies an MWC's initial and needs greater cardio-respiratory and muscular effort on behalf of persons in about their physical abilities [1]. It means during manual wheelchair propulsion users have a high prevalence of shoulder impingement. This is related to musculoskeletal pain [2], wrist carpal tunnel syndrome [3] and upper limb pain.

The occupational omission or no arrangement for peoples with mobility is a one of travelling difficulties for indoors or outdoors manual wheelchair [4]. Thus the hand rim wheelchair propulsion and wheelchair setting is a highly constraining task and repetitive especially effects on the upper limb kinematics, shoulder, and the wrist [5]. This is proved through previous research mentioned that hand rim wheelchair propulsion [5, 6, 7]. It is related to a musculoskeletal structure or musculoskeletal syndromes and high physical strain cause by mechanical loading [5, 6].

Also the hand rim wheelchair propulsion is an inefficient mode of human movement such as Hemiplegic Stroke patients [7]. This type of disability is physically able to use only one arm and leg and unaffected to propel and steer a manual wheelchair. Also a high strain on the cardiorespiratory and musculoskeletal systems, which leads to high energy consumption [7]. Also a high heart



rate and in the long term, complaints of pain in the upper limbs.

Previous research has pointed out that the people without disabilities seamlessly control devices with their hands and can execute fine and rough control. Implementing smooth control of wheelchair for the computerized system is not straightforward and most of the time it is not intuitive either [8].

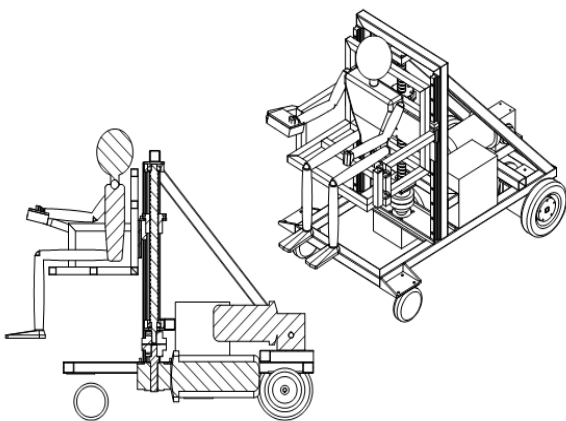
One of the most major problems in manual wheelchair industry they cannot easily move vertically without an extra assistance such as a wheelchair lift, an elevator, or a ramp in building or bus arrivals. Ramp type of vertical movement is a basic type assistive device of the user [9].

To solve the problem, touch screen operated electric wheelchair for dwarfism community is developed and researched on. The development includes the use of touch screen as a way to operate the EPW. Besides that the EPW which is named ZUMP 4 by the developer is also equipped with the ability to vertically shift the EPW. This paper details out the working prototype.

### EPW DEVELOPEMENT

Since ZUMP 4 was developed for Zull Hanif, the EPW will need to have a normal height, maximum height and width of 950mm, 1200mm and 400mm respectively. The EPW will move in forward, reverse, right, left, up or down according the button on the touch screen as long as the button is not released. The passenger seat designed with a height of 300mm was meant it to be used safely in any position.

The concept modeling for ZUMP 4 mostly depends on the ball screw that is designed to move the wheelchair UP/DOWN parallel to the floor. The main drive shaft that connects to the front wheel is extendable and the rear wheels are mounted on the frame as shown in Figure-1.

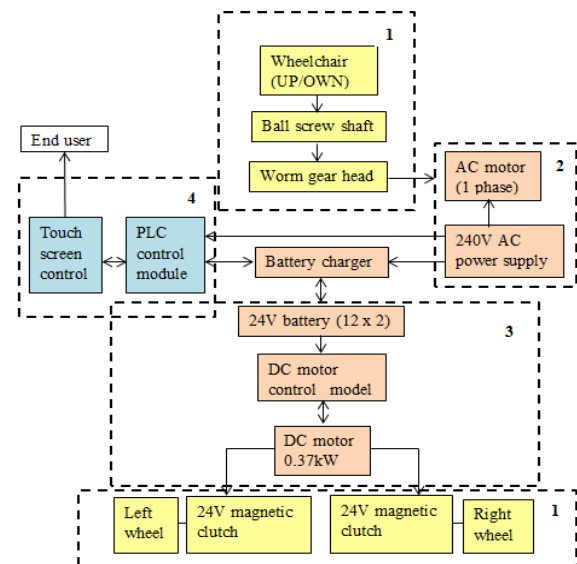


**Figure-1.** Overall 3D design Of ZUMP 4 project with driver loaded.

Referring to Figure-2, the overall design and construction of the EPW developed could be considering the end-user height, age and also the environment. Based on that this prototype wheelchair have assembled the 2

pieces of the motor with different power input. Also, motor drive, from electric to electronic control via small touch screen operated in multi-direction mounted on the armrest with all the advantages that it can offer in programming.

AC 230 V power supply is utilized in the design because the application of ZUMP 4 will only be limited in the classroom area. A single AC motor needs to push the end-user together with all vertical components motion as required to control UP and DOWN movement.



1) Mechanical system, 2) Lifting system, 3) Manoeuvring system & 4) User Control System

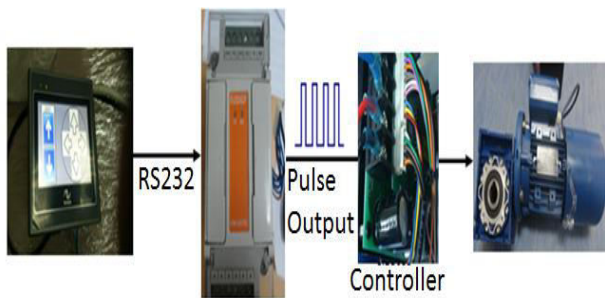
**Figure-2.** Block diagram of ZUMP 4.

For reach turning left and right and moving in forward and backward direction, 370W DC motor would be enough to integrate with the main mechanical components. An electromagnetic clutches, electromagnetic brakes, and mini gearbox are mechanical components needs for this purpose design.

To support a DC source system two pieces of lead acid batteries in series connection come with battery charger and DC motor controller is used to control the speed of the 24V DC motor. Also, the PLC controller and 230V contactor is used to control the motors rotating direction when the cursor pressed.

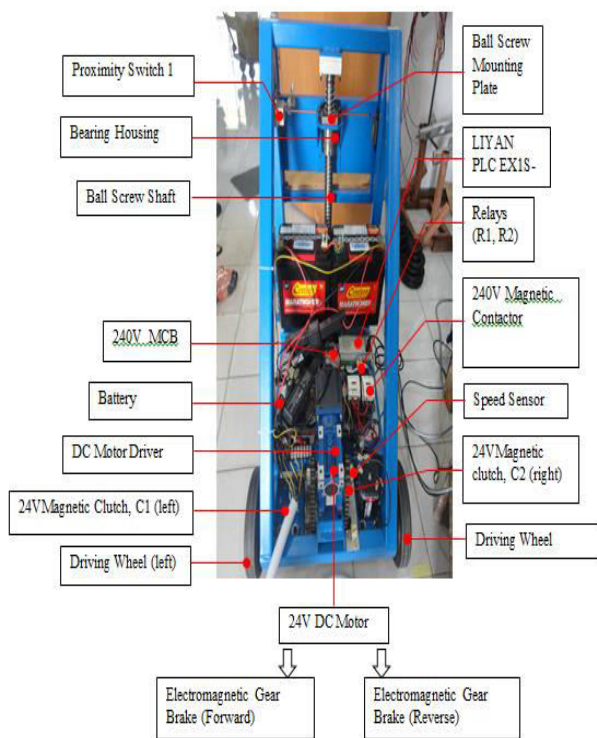
The safety issue considered through assembling two pieces of limit switch and integrated the PLC to ensure the AC motor stop and lock when reach the position.

Testing was carried out during and after the installation of all parts to ensure safety, reliability and functionality of ZUMP 4. To against corrosion on the aluminum and steel components, the whole main frame was sprayed with multi-coated paint.



**Figure-3.** PLC interaction and devices connection.

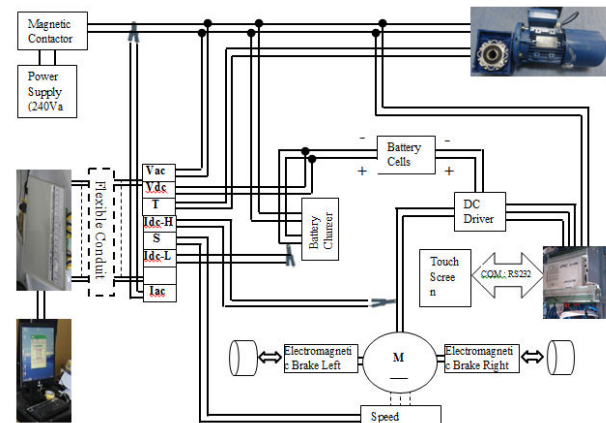
To control the ZUMP 4, EX1S-32MR PLC is used. The interaction between the touch screen to the motor driver can be seen in Figure-3.



**Figure-4.** Full assembled hardware.

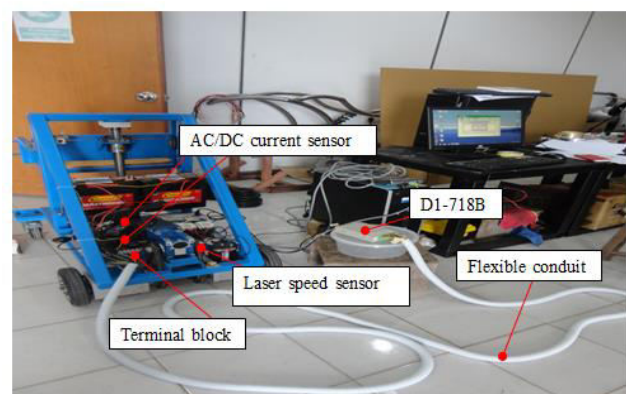
## RESULT AND DISCUSSION

In this experiment, the motor drives are operated in various angles to perform the external command and match their combined performance with the electrical machine. Figure-5 shows the AC/DC probe for measuring  $I_{dc-H}$  and  $I_{dc-L}$  connected to the life wire of input supply to the DC machine and life wire of batteries. Also, the AC power was measured through the connection of input life wire to the Asynchronous machine. The DC voltage of batteries input capacity was measured during charging process through connection to a module of DAQ.



**Figure-5.** The entire apparatus mounted in a separate area to collect the test data.

Referring in Figure-6 the power battery cell during charging is measured by sensors SL-206 connected to channel 2 ( $\pm 60V_{dc}$ ) and channel 6 ( $\pm 5V_{DC}$ ) using 1.5mm signal cable. A speed laser sensor with a frequency of 10 kHz TTL installed near the machine shaft NMRV 040. It purposes to capture the readings of shaft speed through the laser light reflection from the transparent tape attached to the shaft of the machine. The terminal block attached to one side of EPW for easy connection of flexible conduit and the D1-718B DAQ-module to the points test. The input current to AC asynchronous motor capacitor start /run is measured using a clamp meter of 1 kHz frequency no. Model DAQ-D1-718B at terminal 8. Changes in temperature in Celsius units in the body measured using Teflon wire (T3) through a thermocouple type K at terminal 3. Power input to the DC motor and the battery capacity data in discharging mode also can be displayed on the screen through the installation of AC / DC probe ( $\pm 1V_{dc}$ ) on channel 4.



**Figure-6.** Test bed.

Figure-7 through 9 shows the test result for battery cells consumption in forward and reverse mode. The purpose of the test of the electric wheelchair to examine the:



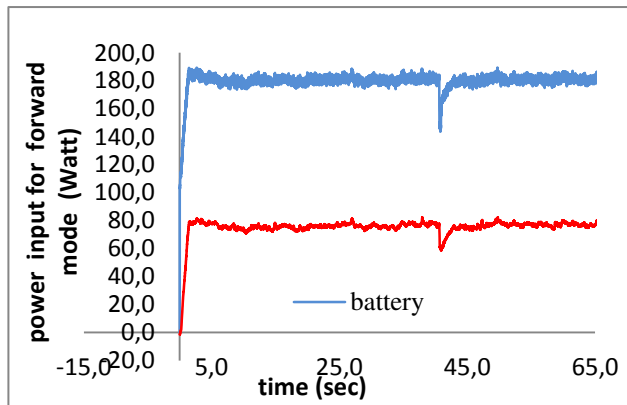


- power input for battery and DC machine in forward and reverse mode
- the speed of wheelchair in forward and reverse mode

Table-1 shows time duration for EPW to move in 6 m distance from 5 laps testing. Duration of testing for each laps not much different in two forward and backward movements.

**Table-1.** Result of 5 laps for epw in forward and backward direction testing.

Laps	1	2	3	4	5
Forward (minutes)	1:04.04	1:03.08	1:05.05	1:04.06	1:05.03
Reverse (minutes)	1:05.02	1:04.04	1:03.07	1:04.09	1:05.03



**Figure-7.** Graph of battery cells and NMRV 040 DC machine power input in forward mode.

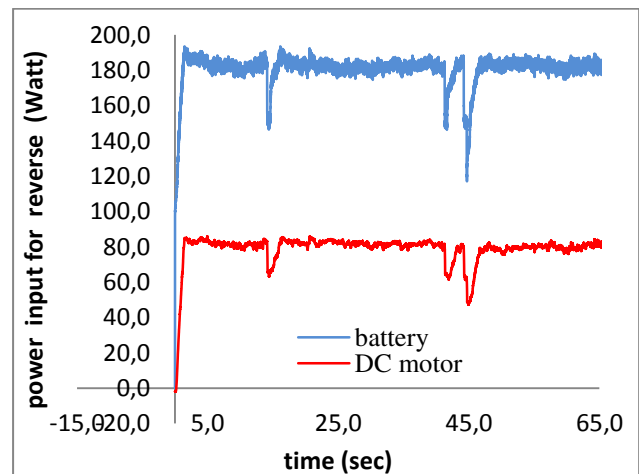
The overall power input of battery is larger than DC motor for forward and reverse movement of the wheelchair as shown in Figure-7. The input power of battery moving forward is higher than power input of DC motor. During initial the graph overshoot for about 5 seconds and stable at 180W. There is a slight drop off at 40 second and stable back at 45 seconds until the test end at 65 seconds where the power input from both battery and DC motor decrease nearly to 50W and 10W.

As shown in Figure-8, the range from 0s to a 60s power source of the battery is quite unstable closely 15s. An energy input is reduced during 45-second to 115W and back to 180W and 190 W before reaching the end of the experiment. At the same period power input of DC motor also experienced unstable reading at 45 seconds with minimum power at 48W.

Maximum battery power source in reverse motion is greater than forward motion in the same distance. Same goes for DC motor power input whereby the reverse motions consume more power than forward motion. However, the minimum power source for battery and DC motor during forward motion is larger than reverse motion. This statement can prove in Table-2 below.

**Table-2.** Minimum and maximum power input in forward and reverse motion.

	Batt power (max)	Power input - DC motor (max)	Batt power (min)	Power input - DC motor (min)	Power losses (max)	Power losses (min)
Forward	190	81	144	60	109	84
Reverse	194	117	85	48	77	37



**Figure-8.** Graph of battery cells and NMRV 040 DC machine power source in reverse mode.

From the result, it shows that more force from the DC motor is needed to overcome larger frictional force between the tire and the surface in the reverse motion than forward motion. This statement also has considered the electric devices that located at the back of build wheelchair.

As shown in Figure-9 the speed of the electric wheelchair in forward motion within 7.40 rpm (minimum) to 8.50 rpm (maximum) with the time 65 seconds. Also, the average speed is 7.4614 rpm in a same period of testing.

The highest rate speed of an electric wheelchair can achieve in reverse motion is 9.10 rpm, and the minimum is 7.50 rpm with duration of 65 seconds. The average speed in reverse motion is 7.888 rpm.

**Table-3.** The average speed in forward and backward motion.

	Forward direction	Reverse direction
Maximum speed (rpm)	8.50	9.10
Minimum speed (rpm)	7.50	7.50
Average speed	7.461	7.888

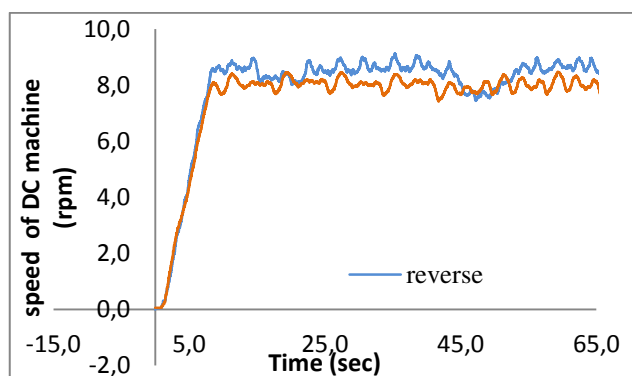
**Figure-9.** Speed of wheelchair in forward and reverse mode.

Table-3 shows the results of forward and reverse motion of the wheelchair with the distance of 1 meter, and the results collect from the origin point where the wheelchair is in stationary. The minimum speed for forward and reverse motion is same at 7.50 rpm. Due to critical fluctuation in reverse motion rather, this cause average speed in reverse motion is larger than forward motion or same.

## CONCLUSIONS

The main target of the project is to develop an electric-powered wheelchair with Z-axis movement. At the end of the project, the main objectives were achieved.

A complete system of a new electric wheelchair with a touch screen that able to move the wheelchair in X-axis, Y-axis and Z-axis direction was successfully designed and developed.

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