International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08, Special Issue | Oct 2021 www.irjet.net p-ISSN: 2395-0072

International Conference on Recent Trends in Science & Technology-2021 (ICRTST - 2021)
Organised by: ATME College of Engineering, Mysuru, INDIA

Design of Motorised Wheelchair for Paraplegic

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ABSTRACT: The Wheel Chair is a mobility vehicle intended for moving patients, disabled, matured individuals, aged who experience issues and can't stroll starting with one spot then onto the next with the assistance of participant or by methods for self- pushing. First wheelchair model advanced long back in eighteenth century, yet fast improvement right now since mid of twentieth century. From that point forward, numerous assortments of models had been structured, reaching out into expansive scope of items. The wheel seat is partitioned into two distinct sorts dependent on the force utilized for portability i.e. Manually controlled wheelchairs and Electric propelled wheelchairs. Manual controlled wheelchairs are driven by manual force which are again arranged into foldable and non - foldable with or without cabinet structure

Mobility impairing disorders causes a person to use the wheel chair. The paper presents an ergonomically designed low cost Motorised wheelchair for Paraplegic patients who have both lower limbs paralyzed and have upper body strength to propel the wheelchair. The model designed has been customized as per the standard design and suggestions of doctor. Joystick is used for controlling the motion and the results for smooth and inclined surface is tabulated.

Keywords: DC Motor, Load, Manual, Motorised, Paraplegic, Wheelchair

1. INTRODUCTION

An Electric-Powered Wheelchair (EPW) is a wheelchair that works utilizing electric engine as opposed to manual force. Motorised/Mechanized wheelchairs are valuable for those incapable to impel a manual wheelchair or who may need to utilize a wheelchair for separations or over landscape which would be exhausting in a manual wheelchair. They may likewise be utilized by individuals with 'conventional' versatility hindrances, yet additionally by individuals with cardiovascular and exhaustion based conditions. The wheelchair is predominantly an indoor vehicle which is used to move around inside homes. But this does not negate its possibility to be transported and taken to another location and moved around in public spaces like shopping malls, local bazaar or cinema halls. The structure and advancement of electric-controlled wheelchairs has pulled in expanding consideration in ongoing decades [1].

A Motorised wheelchair/Mechanized wheelchair is a portable mobility device that is controlled by a battery permitting the client to utilize a joystick to impel the seat around. The principal electric wheelchair was created by Canadian creator, George Klein and his group of designers while working for the National Research Council of Canada in a program to help the harmed veterans returning after World War II. Everest and Jennings, from a similar organization whose authors made the collapsing wheelchair were the first to fabricate the electric wheelchair on a mass scale starting in 1956. There are different variants of wheelchairs which includes Manual Wheelchair, Electric Powered, Sports variant, All terrain [2].

Future interest of manual wheelchair in composed portion is required to clock a CAGR (Compound Annual Growth Rate) of 10 percent to reach $5 million business. Future interest of motorised wheelchair in composed portion is relied upon to clock a CAGR of 5 percent to reach $4 million business [3]. The wheelchair market in India is currently dominated by wholesalers. Paraplegic means both the lower limbs are paralyzed. The Injury/infection to the spinal cord is caused by infection/accidents. As per the disabled population census of 2011, the statistics is as shown in Table 1. 1.

Table 1.1: Incapacitated Population Census of 2011

SL.No.	Disability Types	Persons	Males	Females
1	Total	26,810,557	14,986,202	11,824,355
2	In Movement	5,436,604	3,370,374	2,066,230
3	Multiple Disability	2,116,487	1,162,604	953,883

Wheelchair comes in many variations like self-propelled, propelled by the motor or with the help of an attendee to push. The various components of motorised wheelchair are shown in Fig. 1.1

Fig.1.1: Components of Motorised Wheelchair

2. DESIGN AND DEVELOPMENT

Individuals with loss of motion have a high hazard for pressure bruises and subsequently for the most part require cushions in wheelchairs and seating frameworks to give some alleviation. Paraplegic people with strength in the top portion of the body regularly utilize a manual chair and move it with their arms on the edges of the wheels. Hence to minimize the strain on upper body we propose to design an ergonomic Motorised wheelchair. In light of the problem definition, the objectives of the proposed paper are, To plan an ergonomic model of mechanized wheelchair for paraplegic dependent on broad actuality discoveries and research on existing models, innovation utilized, advertise utilized situation and client prerequisites. The subsequent target, to alter the model for indoor and open air developments according to standard structure particulars. To accomplish the destinations following calculations were performed to choose the fitting segments.

A. Load Calculation

In the presented work, The maximum load weight was taken as 80 kg and the overall weight was taken to be as 130 kg. A spring balance test was carried out which involved moving a normal 4 wheeled chair by using a spring a balance. Therefore, the spring balance reading by carrying out from the above test = 11kgs for Smooth Surface was achieved.

B. Electrical Parameters

The force is given by Eqn. 2.1,

$$F = mxa \text{ -- Eq.2.1}$$

Where, F = Required Force, M = mass obtained from spring balance reading, a = acceleration due to gravitation in $m/s^2 = 9.81\ m/s^2$. Substituting the value of mass as 11kgs and acceleration due to gravitation we get F=**107.91N.**

The torque required is given by Eqn. 2.2,

$$T = Fxr \text{--} Eq.2.2$$

Where, T = torque required, r = radius of the wheel. The force calculated as per Eqn.2.1 is 107.91 N and r= 0.3 m (standard value). Therefore, the torque is calculated as, T=41.202N-m. Consider the walking speed of a human being to be 4 km/hr and converting it into m/s,

$$4 \times \frac{5}{18} = 1.11\ m/s$$

$$Power \text{ needed to move the load } = \frac{Forcexdistance}{time}$$

$$= \frac{107.91 \times 1.11}{1} = 119.78W$$

Assuming 25% rotational losses and we get the power as, 119.78W X 1.25 = **149.72 W**

We assumed a standard inclination of the surface to be 7.1° θ.

Therefore, total load on inclined surface,

$$\frac{M}{Cos\theta} \text{--} Eq.2.4$$

Substituting the value of mass as 11kgs and standard inclination of the surface as 7.1° =11.08kgAssume

5% losses, $load$ = 11.08 × 1.05 = **11.64 *kg***

Now to calculate the power at an inclined surface, From Eqn. 2.3, we get **126. 68 W**

Assume 20% rotational losses and 10% additional power, the power required now is, 126.68 x1.3= **164W**

As we are using 2 motors for driving the wheelchair, the total power is shared by the 2 motors. Therefore, the power needed for a single motor is, **82.3W.**

The current rating of the motor is determined using Eqn.2.5

$$\text{Current } \frac{= Powerratingofthesinglemotor}{Voltageacrossthemotorterminals} \text{---------} Eq.2.5$$

Therefore, from Eqn.2.5 the current is obtained as 82.3/12

= 6.8Amps The Peripheral velocity is calculated as,

$$Ve = \frac{\Pi Dn}{60} \text{------------------------------------} Eq.2.6$$

Considering Peripheral velocity as 1.11m/s, and diameter as 0.6 we get, Speed as **36RPM**

Assuming 1-hour continuous running per day, we require a battery rating of 12x1 = **12AH**.

C. Gear Mechanism

To reduce the rated speed of the motor from 200 RPM to around 40 RPM, we used an external speed reduction kit (gear mechanism). The formula of the gear ratio is given by Eqn.1.4

$$\text{Gear ratio} = \frac{Speedofdrivegear}{Speedofdrivengear} \text{--------------} Eq.2.7$$

The gear ratio thus is obtained as 5: 1. The total teeth in the drive gear are 14 and the total teeth in the driven gear is 72.

3. MOTOR DRIVE CIRCUIT

In this presented work, we have used 2 circuits namely:

A. Motor Drive Circuit

In the model we have utilized drive circuit to drive the 2 motors which are introduced at the back wheel of the wheelchair in 2 opposite directions: Forward and Backward Direction. The same circuit is used to drive the motor which is installed in the front for right and left direction. The Motor drive circuit is as shown in Fig 3.1

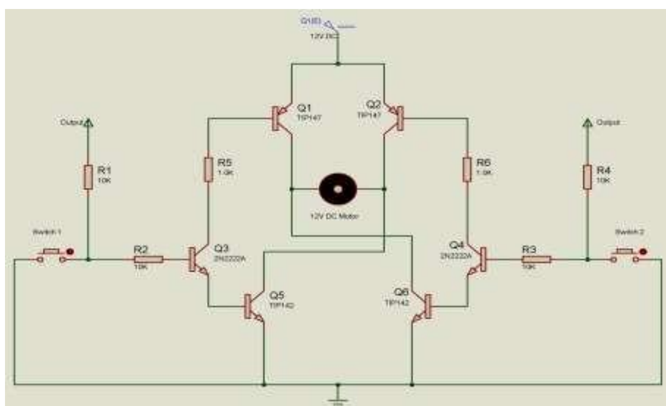

Fig 3.1: Motor Drive Circuit / Direction Control Circuit (H-Bridge Circuit)

Here we have utilized 2 TIP 142 and TIP 147 Transistors. These transistor sets are high force (125 Watt) and high current (10A) darlington pair transistors. One is a NPN transistor (TIP 142), the other is PNP transistor (TIP 147). They are made to fit together explicitly for H-Bridge setups. Next, 2N2222A.Transistors are utilized as cradles between the digital on/off side and the simple motor control side of the circuits. A digital signal into the 2N2222A advises the H-Bridge to go ahead or in reverse. The 10kΩ resistors are utilized as current constraining cradles between the digitalized and simple parts of this circuit. They will help ensure against potential harm to any computerized circuits controlling the H-Bridge. The 1kΩ resistors are additionally current constraining resistors with the goal that the 2N2222A doesn't get harmed when it is turned on.

At the point when we apply an 'on' +5v sign to the other side of the H-connect, the 2N2222A transistor initiates the two transistors (TIP142 and TIP147), permitting current to course through the motor and furthermore acts like a switch simultaneously. When there is no present to the base, practically no present streams between the collector and the emitter.

At the point when the Switch is shut there is a progression of current to the base terminal (base current) and huge current streams between the collector and emitter. This turns the engine one way. Also, when we initiate the contrary side with an 'on' +5v signal, the other two transistors are turned on and the DC motor turns the other way. Since there are 3 motors used in this work, the same circuit is developed for each motor. The 2 motors installed at the back wheel runs in forward and backward direction. And the motor installed at the front of the wheelchair results in right and left direction of the front wheel. This is obtained with the help of gear mechanisms.

B. Joystick with Arduino Uno Board

Joystick is used to command the motors to run in the desired direction. A program is uploaded in to the Arduino Uno board where desired output signal is given to the motor drive circuit based on the input command received with the help of joystick. The circuitry image of a joystick connected to Arduino Uno Board is as shown in the Fig 3.2.

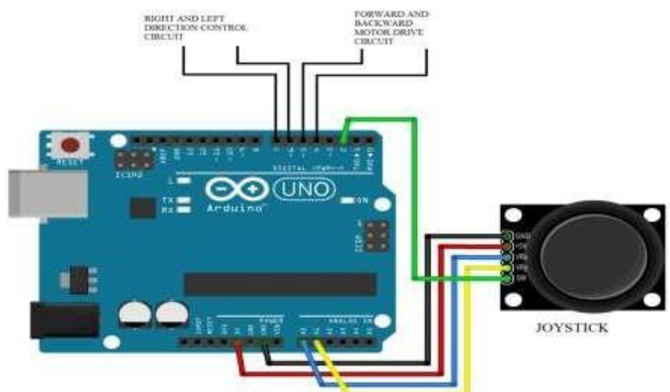

Fig 3.1: Joystick interface with Arduino Uno Board

The Analog Joystick is like two potentiometers associated together, one for the vertical development (Y-axis) and other for the even development (X-axis). The Arduino Uno board utilizes Atmega328 as the Microcontroller has ADC goals of 10 bits. Consequently, the values on every simple channel can shift from 0 to 1023. The home position for the stick is at x, y: 511,511. When the stick is proceeded onward X axis from one end to the next, the X values will change from 0 to 1023 and comparable thing happens when moved along the Y axis. On similar lines you can peruse position of the stick anyplace in upper half side of the equator from blend of these values.

4. RESULT AND DISCUSSION

As the work proceeded, the model went through various changes and improvements. The mechanical dimensions of our designed model are: **Wheelchair**: Height: 900mm, Length: 1010mm, Width: 480mm, Diameter of the wheel: 600mm, Seat: 550mm, Arm rest: 250mm, Back rest: 450mm. **Battery:** Height: 70mm, Length: 170mm

In the planned model, there are varieties in corresponding dimensional scaling. These are because of the various percentiles of anthropometric parameters considered in the plan of individual highlights of chair. These percentiles to be considered depend on emotional recognitions showed up at by abstract examinations. The system for commitment and separation of shaft to the rigging and the wheel transporter are to be grown further. The outcomes acquired are shown in Table 4.1.

Table 4.1: Results for Smooth and Inclined surface movement with wheelchair

	Smooth surface			Inclined surface $7.1°(\theta)$		
SL. No.	Load(kg)	Speed(RPM)	Current(Amps)	Load(kg)	Speed(RPM)	Current(Amps)
1	38	30	3	38	18	4.4
2	60	28	3.4	60	15	4.6

Fig .4.1: Final Model with specification

5. CONCLUSION

The team felt that we achieved the objectives set forth at the beginning of this design process. The designed electric wheelchair is for indoor applications. However, the extent of the work widened from examining wheelchair choices to incorporate social thought while endorsing wheelchairs, financing issues, administration and upkeep needs, the conveyance of help benefits inside these networks, just as natural factors that impact wheelchair portability and execution. A higher Ampere-Hour rating can be used to obtain a long duration of run. The travelling distance of the motorised wheelchair also increases. This can be done by replacing the present battery with a higher rating battery or connecting the higher rating battery in parallel to the present battery. Therefore, the motorised wheelchair can be used for outdoor applications. A lever mechanism should be employed in an electric wheelchair in such a way that whenever the battery of the motorised wheelchair gets exhausted, the lever should disengage all the gear mechanism and it should act as a manual wheelchair so that the paraplegic individual have a secondary option available.

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