Prathap et al. 2018. *Int. J. Vehicle Structures & Systems*, 10(5), 313-317
ISSN: 0975-3060 (Print), 0975-3540 (Online)
doi: 10.4273/ijvss.10.5.01

International Journal of
Vehicle Structures & Systems
Available online at www.maftree.org/eja

Novel Approach of Implementing Effortless Manoeuvrability in Vehicle for Physically Challenged

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ABSTRACT:

Automobile is a comprehensive invention which became a basic need for every human. But some modifications were necessary in automobile design in case of differently abled person. The existing vehicle comprises with usual hand twist acceleration, hand lever braking and handlebar steer control. Conventionally, three wheeled rear axles are used by physically challenged person. If the physically challenged person is about to park his/her vehicle then he/she should get down for moving the vehicle. Hence a reverse drive feature is proposed for vehicle which can help them to move in reverse direction when they are in seating position. In our proposed vehicle, the acceleration can be controlled either by right hand twist accelerator in handlebar or by foot pedal. The acceleration switch determines the working of accelerators. For left hand impairment, they can switch to foot pedal acceleration. Here the rear braking is applied by left hand brake lever or foot brake pedal (to apply rear brake if they are left hand impaired).

KEYWORDS:

Automobile; Reverse drive; Acceleration; Foot pedal; Mobility vehicle

CITATION:

P. Prathap, K. Mujiburrahman, P.M. Krishnan, S. Sreemaan, U.A. Sai and S.N. Kannan. 2018. Novel Approach of Implementing Effortless Manoeuvrability in Vehicle for Physically Challenged *Int. J. Vehicle Structures & Systems*, 10(5), 313-317. doi:10.4273/ijvss.10.5.01

1. Introduction

Disability is an impairment that may be cognitive, developmental, intellectual, mental, physical, sensory, or some combination of these. It substantially affects a person's life activities and may be present from birth or occur during a person's lifetime. Disability is thus not just a health problem. It is a complex phenomenon, reflecting the interaction between features of a person’s body and features of the society in which he or she lives. The International Classification of Functioning, Disability and Health (ICF), founded by the World Health Organization, distinguish between body functions (physiological or psychological, such as vision) and body structures (anatomical parts, such as the eye and related structures). The data released by the Census Commissioner of India shows that the number of total households having disabled persons has shown an increase of 20.5 lakhs from 187.3 lakhs in 2001 to 207.8 lakhs in 2011. Of these, 6.2 lakhs are in rural and 14.3 lakhs in urban areas.

Transportation is an extremely important policy issue for those with disabilities. People with disabilities have consistently described how transportation barriers affect their lives in important ways. Over the last two decades the National Organization on Disability (NOD) has sponsored three successive Harris polls for people with disabilities, and respondents in each survey have reported that transportation issues are a crucial concern. In the last survey, undertaken in 2004, just under a third of those with disabilities reported that inadequate transportation was a problem for them; of those individuals, over half said it was a major problem. The more severe the disability of the respondent tends the more serious were the reported transportation problems. Moreover, barriers to mobility have complicated causes. The 2004 NOD-Harris Interactive poll found that almost two-thirds of all the people with disabilities who reported major transportation problems had annual incomes below $35,000. For those with higher incomes, reported transportation problems dropped markedly, as did the differences in transportation problems between those with and without disabilities.

2. Study of existing vehicles

2.1. Mobility scooters

A mobility scooter is a mobility aid equivalent to a wheelchair but configured like a motor scooter. It is often referred to as a power-operated vehicle/scooter or electric scooter as well. A mobility scooter has a seat over three, four or now five wheels, a flat area or foot plates for the feet, and handlebars or a delta-style steering arrangement in front to turn one, two or three steerable wheels. The seat may swivel to allow access when the front is blocked by the handlebars. Mobility scooters are usually battery powered. A battery or two is stored on board the scooter and is charged via an on-board or separate battery charger unit from standard electric power. Gasoline-powered scooters may also be available in some countries, though they are rapidly being replaced by electric models. User powered propelled by a lever used in a push-pull rowing motion to provide exercise and mobility at the same time.

2.2. Limitations in mobility scooter

While a mobility scooter eliminates much of the manual strength problems of an unpowered wheelchair, its tiller steering mechanism still requires upright posture, shoulder and hand strength, and some upper-body mobility and strength. The arm-rest mounted controller typical of power chair designs may be more suitable for many users. Scooters also have fewer options for body support, such as head or leg rests. They are rarely designed for ease of patient transfer from seat to bed.

2.3. E-bikes

An electric bicycle, also known as an e-bike, power bike or booster bike, is a bicycle with an integrated electric motor which can be used for propulsion. Many kinds of e-bikes are available worldwide, from e-bikes that only have a small motor to assist the rider's pedal-power (i.e., pedelec) to somewhat more powerful e-bikes which tend closer to moped-style functionality: all, however, retain the ability to be pedalled by the rider and are therefore not electric motorcycles. E-bikes use rechargeable batteries and the lighter varieties can travel up to 25 to 32 km/h (16 to 20 mph), depending on the laws of the country in which they are sold, while the more high-powered varieties can often do in excess of 45 km/h (28 mph). The terms e-bike, power bike, "pedelec", pedal-assisted, and power-assisted bicycle were commonly used to refer to e-bikes. The terms "electric motorbike" or "e-motorbike" refer to more powerful models that attain up to 80 km/h (50 mph). In a parallel hybrid motorized bicycle, such as the aforementioned 1897 invention by Hosea W. Libbey, human and motor inputs are mechanically coupled either in the bottom bracket, the rear wheel, or the front wheel, whereas in a (mechanical) series hybrid cycle, the human and motor inputs are coupled through differential gearing. In an (electronic) series hybrid cycle, human power is converted into electricity and is fed directly into the motor and mostly additional electricity is supplied from a battery.

2.4. Limitations in E-bikes

Comparing with normal bicycles these e-bikes are complex when it is dismantled and assembled. E-bikes are usually lesser in weight but when it is peddled, due to the battery weight it becomes harder to pedal. Electric bicycle batteries don't last forever, a Lithium Ion Battery will last 2-5 years and an SLA battery will last 1-2 years before the cells have to be replaced.

3. Methodology

With the advent of technology, standard scooters have given way to electric scooters. It runs on rechargeable batteries and is usually accepted as environment friendly. The endurance of these batteries is good enough for you to travel within a range of 10 to 40 miles. The motor of the electric scooter is mounted on the frame. The electricity that is produced in the battery is transmitted back to the motor through a network of wires. Depending on the type and model of the scooter, the motor might either make the front wheel or both the wheels to rotate to push the scooter forward. However, because of the constraints of the motor, electric scooters seldom cross 25 to 30 kmph. The battery and motor combination only allows for top speeds of about 20 miles per hour, but safety is still a concern at these speeds on what your definition of a long drive is. The limitations of electric scooters currently available in the market are as below: Electric scooters are not powerful enough. It takes 6 to 8 hrs for fully charging the battery. Charging stations for electric scooters are very few. The battery pack has to be replaced once every two years or so which costs considerably. Electric scooters cover only 70 km at the maximum after a full charge of the battery. Level roads only are suitable for electric scooters as they are unable to manage steep ascents. Electric scooters cannot attain high speeds. A 250W scooter can attain a maximum speed of just 25kmph. In spite of all these limitations electric scooters are very costly. It may be concluded that electric scooters are suitable for those who have to travel only some 10 km daily. The specifications of Hero electric maxi vehicle is given in Table 1.

Table 1: Chassis and suspension

Parameter	Value
Chassis/Frame	Reinforced High Strength Steel
Suspension	Fork at front Dual Telescopic
Starting	Self-Start Only
Maximum Speed	40 kmph
Gear Box	Automatic/No gear Shifting
Ground Clearance	160 mm
Kerb Weight	75 kg
Weight Carrying Capacity	90 kg
Wheel Size Front	16 inch
Wheel Size Rear	16 inch
Wheel Type	Alloy
Tyre Size Front	3.00 - 16
Tyre Size Rear	3.00 - 16
Tyre Type	Tube
Radial Tyres	Yes
Battery Type	VRLA Battery
Battery Capacity	48 V / 24 Ah
Motor type	250 W BLDC Motor
Tail Lamp	Bulb
Turn Signal Lamp	Bulb
Front Brake	Drum
Rear Brake	Drum

Fig. 1 describes the basic layout the proposed system. The frame is made up of reinforced high strength steel whose property is given in Table 2. They are low carbon steels, with high yield strengths, excellent weldability and formability, and good toughness. As-rolled pearlite steels often include carbon-manganese steels, but they may also have small additions of other alloying elements to provide enhanced strength, formability, weldability, and toughness. Chassis with different structures are designed to handle large amounts of stress or need a good strength-to-weight ratio. HSLA steel cross-sections and structures are usually 20 to 30% lighter than carbon steel with the same strength. HSLA steels are also more resistant to rust than most carbon steels because of their lack of pearlite - the fine layers of ferrite (almost pure iron) and cementite in pearlite. HSLA steels usually have densities of around 7800 kg/m³. Due to their construction, the gel and absorbent glass mat (AGM) types of valve-regulated lead-acid battery (VRLA) can be mounted in any orientation, and do not require constant maintenance. The basic two wheeler structure is shown in Fig. 2.

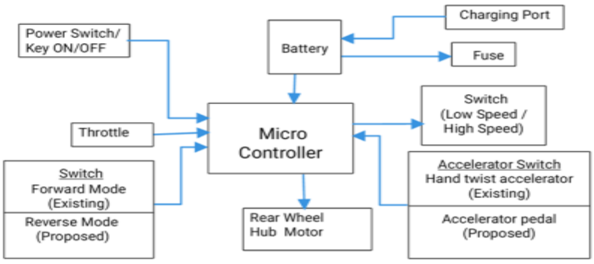

Fig. 1: Layout of proposed vehicle

Table 2: Materials used

Material	Composition in %
Carbon(C)	0.05–0.25%
Copper(Cu), Nickel(Ni), Vanadium(V), Chromium(Cr), Molybdenum(Mb), Titanium(Ti), calcium(Ca) and zirconium(Zr)	2.00-4.00%
Silicon (Si)	0.20%

Fig. 2: Two wheeler body

A rechargeable lithium-ion battery is made of one or more power-generating compartments called cells. Each cell has essentially three components: a positive electrode (connected to the battery's positive or + terminal), a negative electrode (connected to the negative or - terminal), and a chemical called an electrolyte in between them. BLDC motor controller provides efficient, smooth and quite control for electric vehicles which operate 48V battery system. The BLDC motor controller is shown in Fig. 3. Double pole Double throw (DPDT) switches with 12 leg/pin are classified into direction and accelerator control switch. Fig. 4 shows the hand accelerator used in regular vehicle. Accelerator pedal is obtained by using an AC motor pedal which has been changed according to our requirements. The front brake lever is as usual. We have used a combo brake technology for the rear brake. This means if we apply brake lever or brake pedal the rear brake applies. Fig. 5 describes the basic working principle of Hall effect sensor. The rear brake lever rooting is as usual but we have welded an extra piece in the cam and an L clamp so that we can root the brake pedal in it. Hall effect is the production of a voltage difference across an electrical conductor, transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current.

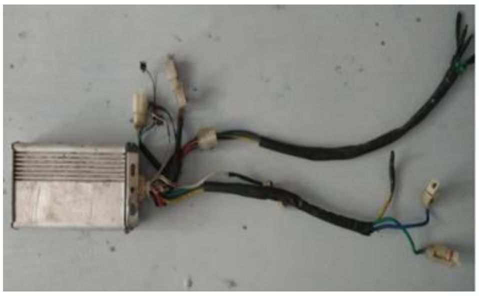

Fig. 3: BLDC motor controller

Fig. 4: Accelerator pedal

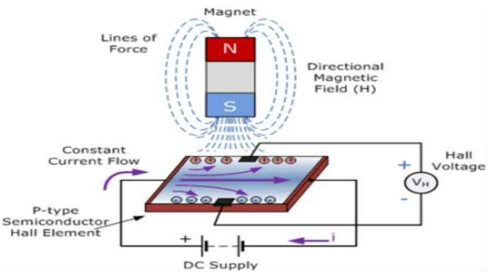

Fig. 5: Principle of Hall effect

4. Fabrication of three wheeled rear axle by arc welding

Arc welding is a process that is used to join metal to metal by using electricity to create enough heat to melt metal. The melted metals when cooled result in a binding of the metals. An external rod is connected to the rear powered wheel which transmits the power to the other dummy wheels. The fabrication of three wheels on rear side axle is the process of adding the two extra wheels to the rear side for the better balancing of vehicle. For fitting the extra side wheel on rear side axle the extra axle need to be welded. The axle is weld on the both side of chassis by the arc welding process. To reduce the shock and vibration and to with stand the stress acting on it the shock absorber needs to be attached. It is done by drilling and welding of clamps to fit the shock absorber. The axle is designed and welded into both sides of the chassis of the vehicle. The head of the shock absorber is attached to the clamp welded on chassis near to the seat and its bottom eye is fitted into the extra wheel to be attached. The extra wheel has no power train to drive it. Fig. 6 gives a clear view of the rear end of the proposed vehicle. The additional rear wheel brake is added to the vehicle for left hand impaired persons. It is controlled with a brake pedal on the right leg side of a driver which is parallel to the accelerator pedal. It is done by fixing the brake pedal on foot rest area by welding. The braking clamp is additionally attached to the existing one to connect the brake cable to the brake pedal. The one meter brake cable is connecting the brake pedal and brake clamp which helps to operate the brake successfully.

Fig. 6: Rear view of the vehicle

Fig. 7 shows the foot rest in the vehicle. As same as the rear wheel, the front wheel also been fixed in front axle without any wire connections. Then the brake connections were done using pliers and spanners. The newly added feature accelerator pedal had been mounted on foot rest area parallel to the brake pedal on left leg side of a driver. And its control connections have been done by using the wires. The head lamp and tail lamp is fixed to its place by using the screw drivers and spanners, their wires need to be connected by its connection plug provided on it. The body panels were fitted at the right place by using the ring spanner, T-box spanners and screw drivers. The vehicle operates with the help of:

- BLDC motor (brush less DC motor)
- Microcontroller
- DC to DC convertor
- Battery

Fig. 7: Foot rest of the vehicle

5. Working of BLDC motor & switches

Electric motors use a mechanical device called a commutator and two contacts called carbon brushes to reverse the electric current periodically and ensure the axle keeps turning in the same direction. Hub motors are typically brushless motors (sometimes called brushless direct current motors or BLDCs), which replace the commutator and brushes with half-a-dozen or more separate coils and an electronic circuit. The circuit switches the power on and off in the coils in turn creating forces in each one that make the motor spin. The electronic circuit sends power round the nine copper coils in turn, making the grey outer case (which is a magnet split into a number of sections, bent round into a circle) spin around the copper coils and circuit board (which remains static). The BLDC motor has battery wires and hall sensor wires. The BLDC motor is placed inside the rear wheel hub. We have taken four wire connections from BLDC motor to the direction control switch which helps to decide the motion of direction of the vehicle according to the requirement of the driver. Micro-controller or BLDC speed controller will control the BLDC motor depending upon the accelerator response by signals by varying the power supply from battery to hub motor. Fig. 8 describes the basic layout of electrical setup.

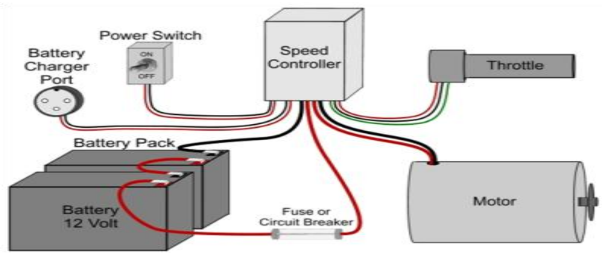

Fig. 8: Electrical setup

The metal-oxide-semiconductor field-effect transistor (MOSFET) is a type of field-effect transistor, most commonly fabricated by the controlled oxidation of silicon. It has an insulated gate, whose voltage determines the conductivity of the device. The working of brushless motor controller should control brushless motor phase, limit starting current, control speed, PWM control etc. MOSFET is an important part of controller. More MOSFET, controller is more expensive. Generally 6-MOSFET brushless controller is used to control 36V 250W BLDC hub motor. 36V 750W brushless motor should be controlled by 12-MOSFET controller. Now in existing vehicle we use 12-MOSFET to control 48V 250W brushless hub motor. Fig. 9 shows the board connection of BLDC. Programmable BLDC motor controller (programmable only by manufacturer by special software) provides efficient, smooth and quite control for electric vehicles which operate 48V battery system. Braking will release the motor from the controller as long as brake is applied over current protection to protect controller during faulty conditions or short circuit. Low voltage detection ensures battery life. Accelerator fault protection is to prevent runway provision for 120°/60° Selection (by default / manufacturer) speedometer output brake inputs with high active and low active provision.

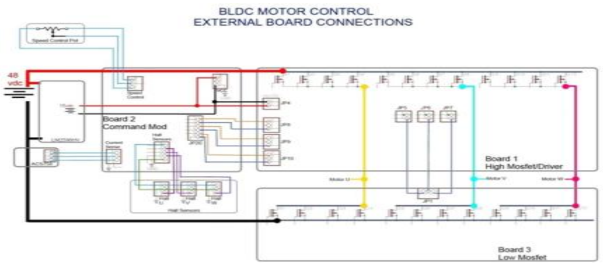

Fig. 9: PCB Diagram of existing vehicle's micro controller

We have used two DPDT switches one for direction control and other for accelerator control. Each switch has twelve legs. We have taken four wire connections from BLDC motor and eight wire connections from microcontroller for directions control switch. In accelerator control switch we have taken four wires connections from microcontroller and four wire connections from hand accelerator and four wire connections from accelerator pedal. These switches can be used according to the requirement of the driver (disabled persons). Forward and reverse mode control switch, accelerator functional switch (hand twist accelerator or leg pedal) combined braking system- application of rear brake is either by left hand lever or by foot brake pedal. User needs to switch over from OFF to any functionality mode in accelerator switch and also to forward or reverse mode, then only the vehicle moves. Formerly the vehicle's wheel tends to rotate when the key is turned ON. This act as engine kill switch used in conventional vehicles. Vehicles powered by hub motors are a lot simpler than normal ones. Supposedly you want to reverse, all you have to do is reverse the electric current instead of using elaborate arrangements of gears. The motor spins backward. Friction produced inside the hub is less compared to other motors. Hence wear produced is less. The output wires from micro-controller are connected with similar wires.

Fig. 10: Testing of vehicle by Hall Effect sensor

6. Testing of proposed vehicle

The whole system is tested by hall sensor tester from wheel hub wires for any riding difficulties hall sensor wires from hub motor is connected to hall sensor tester. Now the wheels rotate manually. If all the three light indicators of hall sensor tester glows then the hub motor and hall sensor is working properly. If any one of light does not glow then there is defect in hall sensor inside hub motor. The testing procedure is shown in Fig. 10. Now the vehicle is tested in road by one of our team member. The suggestions got from team members are closely analysed and corrected for good working conditions. After the road inspection, the vehicle is given for physically challenged person to ride in less traffic road conditions with our supervision and the reviews are collected from them.

7. Conclusions

Novel methodology is adapted and followed to acquire the reverse movement of the vehicle in such a manner to eliminate a drawback in physically challenged e-bike. This methodology allows the user to move vehicle in reverse direction with ease for parking purpose or other. Physically challenged people who rode our vehicle said the following remarks:

- The vehicle is lighter in weight.
- Reverse feature is useful for them and satisfactory.
- The time taken to full charging the battery is about 2 hours. Hence a fast battery charger is needed to be developed to solve this issue.
- For a right hand disabled person, there is an accelerator pedal to accelerate the vehicle.
- For a left hand disabled person, there is a brake pedal to apply rear brake.
- Usually after turning the key on, e-bike slowly tends to move accelerator switch off to prevent this movement in plain surface.
- Left leg disabled persons can use the brake lever placed on left side of the handle bar.
- Right leg disabled person can use the accelerator placed on the right side of the handle bar.
- No need of kick start.
- Cost per kilometre is only 45 paisa.

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