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A Motorized and Detachable Driving Module for Generic Wheelchair

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ABSTRACT: It's a known fact that a large portion of the world's population is physically disabled. Recently, electric wheelchairs have become common because they provide more mobility to persons with disabilities. Further, intelligent functions have now been applied to enhance their functionality, making them useful for daily activities that are performed by persons with disabilities. A driving module that can be attached to a wheelchair with an easy attaching system is designed to upgrade generic manual wheelchairs. It consists of a battery powered BLDC motor drive, a controlling circuitry, and an easy attaching procedure, which together upgrades a generic manual wheelchair to an electrical wheelchair driven using a steering handle. The easy attaching mechanism enables the driving module to be attached in front of a generic wheelchair and firmly fixed on the wheelchair frame. A brushless DC motor is used to mobilize the wheelchair.

KEYWORDS: Wheelchair Attachment, Driving Module, BLDC Motor, Motorized Wheelchair.

I.INTRODUCTION

Most commonly used assisting devices for enhancing personal mobility is the wheelchair. There are many varieties of wheelchairs are available in the market. The major ones are the generic manual wheelchairs and powered wheelchairs. Manual wheelchairs are the most commonly used and preferred wheelchairs, due to their low cost, lightweight, little maintenance and manoeuvring easily. But it comes with its fair share of disadvantages as well. The use of manual wheelchairs is crude and tiresome. To hurdle these problems posed by manual wheelchairs we seek the assistance of power-assisted wheelchairs. Electric wheelchairs have become popular because they increase the mobility of persons with disabilities. Electric wheelchairs can reduce the energy required for exertion and pain even when navigating long distances. But the cost of said wheelchairs are too high for common people to afford, they are significantly heavy than normal wheelchairs, very difficult to transport, the requirement of regular maintenance etc.

So, it is required to find an equilibrium between manual and electric wheelchairs to squeeze out the maximum advantages of both sets. This is where we introduce a Motorised and Easy-docking wheelchair drive which is essentially a semi-automatic wheelchair as shown in figure 1. Here the motorising part can be easily attached or detached according to the user's needs. That is instead of fully automating the manual wheelchairs we are using this drive as an add-on. Only the attaching drive is fully automatic. It is highly versatile since we can connect it to any normal wheelchairs. By using these facilities, it helps to reduce the cost of electric wheelchairs and provide user-friendly operation.

Fig. 1 Motorized and detachable driving module with a generic manual wheelchair

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II.OPERATION OF DRIVING MODULE

Figure 2 shows the basic block diagram of the driving module. The user can select forward motion or reverse motion by flipping a switch. Then analog input from the throttle is given to the microcontroller. This then gives the command to the motor driver circuit to enable the drive motor. To steer left or right, the user can turn the handle provided. As the throttle input decrease, the speed of the motor decreases and manual brakes can also be used to slow the wheel.The input from the brake sensor is also given to the microcontroller. Flowchart of the driving module is given in figure 3.

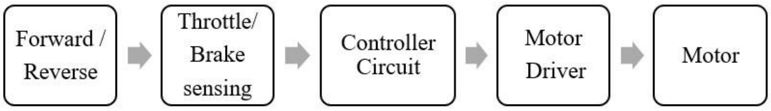

Fig. 2 Block diagram ofdriving module.

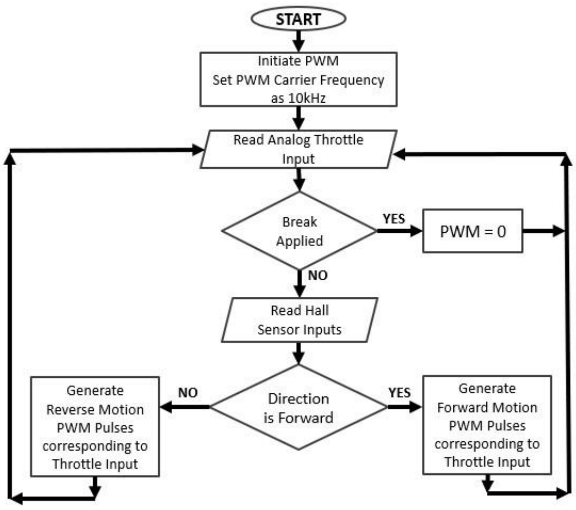

Fig. 3 Flowchart of the driving module.

III.CONTROLLING CIRCUIT

The main controlling circuit of the system consists of three sections as shown in figure4. The microcontroller circuit, MOSFET driving circuit and the three-phase inverter.

The microcontroller used is a dsPIC30F4011 microcontroller. The six PWM output pins are connected to six individual driving circuits to drive the MOSFETs of the three-phase inverter. The three hall sensor outputs from the motor, which is used to detect the position of the rotor and hence to determine the sequence pulse requires, is HA, HB and HC. Analog input from the throttle/accelerator that controls the speed is given to the microcontroller. An additional forward or reverse switch and a brake indicator pulse are also connected.

The driver circuit uses photocouplers to drive the MOSFETs in the three-phase inverter circuit. We use the TLP250 as a non-inverting low side MOSFET driver. A GaAlAs LED is present at its input side. The output signal is driven by an integrated photodetector. Therefore, there is electrical isolation between low and high-power circuits.

For the three-phase inverter circuit, we use six MOSFET P60 as the switches. Speed control of the BLDC motor is achieved through this inverter circuit. At a time two switches are kept closed. The sequence of activating the switches is selected according to the hall sensor outputs. There are six sequences for the rotation of the rotor, each providing a rotation angle of 60 degrees. In each arm of the inverter, two inverter switches get closed and complete the circuit in each sequence.

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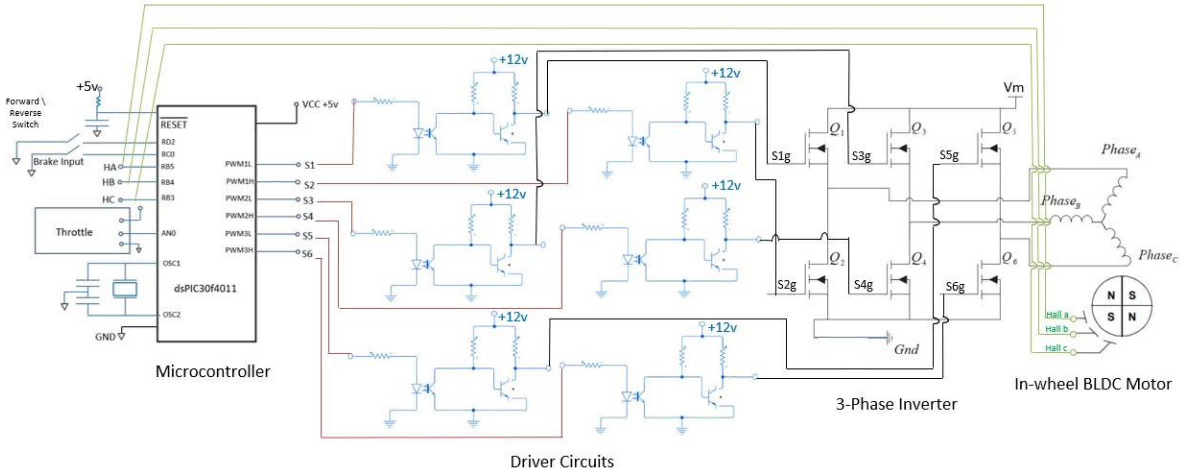

Fig. 4 Controlling circuit of the driving module

IV.SIMULATION USING MATLAB/SIMULINK

The three-phase inverter is simulated in MATLAB Simulink by providing the required data and the Simulink model of the inverter is as shown below.

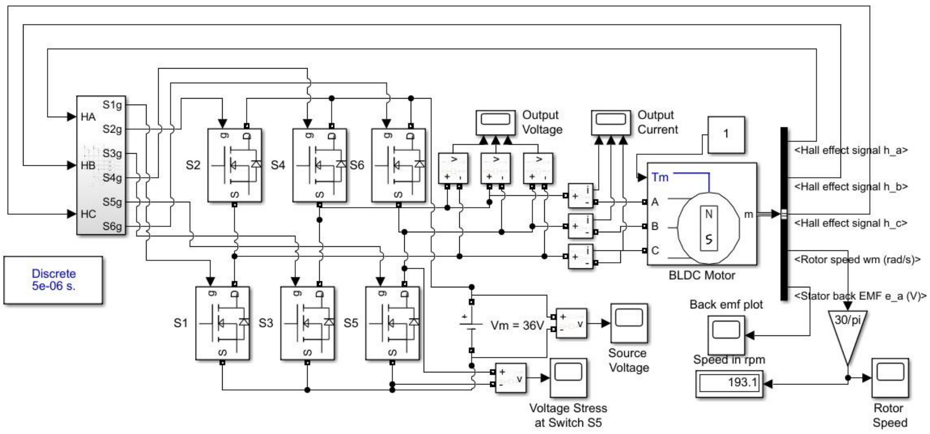

Fig. 5Simulink model of the three-phase inverter

The gate pulse is generated by using electronic commutation by the sequence data provided from the truth table for hall sensor outputs and activation of corresponding switches for clockwise rotation of the BLDC motor. Speed control is achieved by integrating pulse width modulation (PWM) pulses with the control logic. Output from the three hall sensors in the motor is taken as the input parameter to determine the signal that has to be sent out to the switches of the inverter.

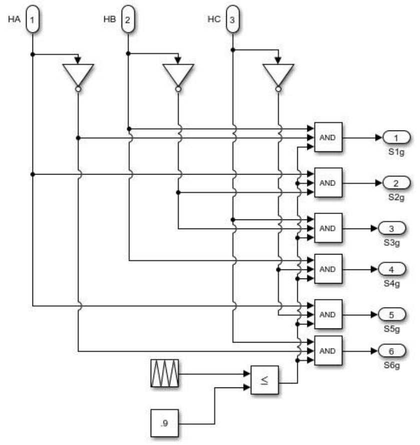

Fig. 6 Electronic commutation control logic subsystem

V. SIMULATION RESULTS

The simulation results of the inverter are shown in the following figures.

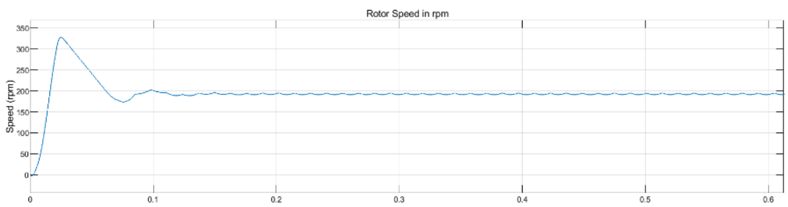

Fig. 7Speed of rotor in rpm vs time

Figure 7, shows the graph of the speed of the rotor obtained at the application of 90% of the PWM duty ratio to the switches of the three-phase inverter.

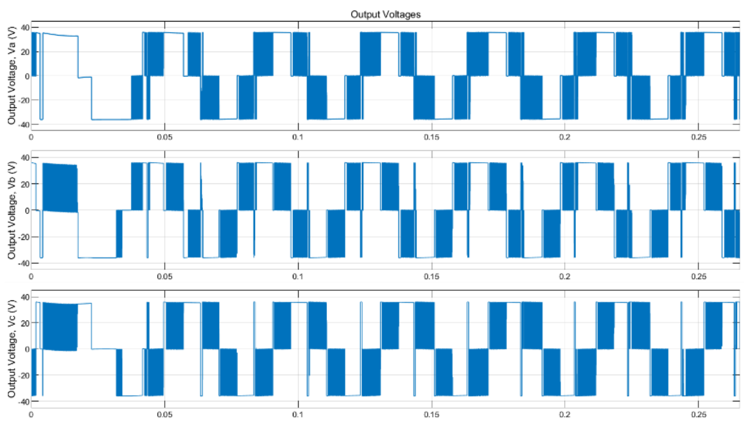

Fig .8 Output voltages of the three phases of the inverter

In figure 8, the voltage output of the three arms of the inverter is shown. This is obtained when the switches are given switching pulses with a PWM duty ratio of 90% along with the control sequence pulses. The three voltages are in a phase difference of 120 degrees.

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We found the Simulink model was able to produce acceptable results required for the smooth working of the driving module. The results showed that speed control of the BLDC motor is possible with the sequence logic applied along with generated PWM pulses.

VI.CONCLUSION

A driving module that can easily be attached to a generic manual wheelchair to help persons with lower-limb disabilities is developed. A controller circuit is used to drive the BLDC motor considering the various inputs that are given by the user through the throttle. The MOSFET driving circuit, the three-phase inverter circuit are the main components of the controlling circuit. The speed control of the motor is achieved with the help of a PWM signal produced by the controller. The operating logic was constructed considering safety factors and was embedded into MCUs. Comparing to the normal manual wheelchairs and fully electric wheelchairs, this was able to bring about many of the main features from both sides within an affordable price range.

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