DESIGN AND DEVELOPMENT OF HEAD MOTION CONTROLLED WHEELCHAIR

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ABSTRACT
The aim of the project is to design a wheelchair tilt communicator system that could operate the wheelchair of the handicapped person with the help of tilt of head movements. This system could be used by physically disable persons who cannot move their hands or legs but make head and eye motions. This wheelchair could be operated in any direction using head tilt movements by the handicapped person. Design and development of Head motion controlled wheelchair has been achieved using tilt sensors and wireless modules. The system is implemented practically and works well with a person sitting on it and has a weight bearing capacity of upto 100 kg. This wheelchair is aimed to be designed at a lower cost as compared to the other versions available in the market. The head motion controlled wheelchair designed using tilt communicator system turns out to be a great use for quadriplegic patients and disabled people having more than 45% or more disability as this could be operated easily through head gestures.

INDEX TERMS— *Tilt sensors, Wireless control, Gesture based control, Gear Ratio.*

I. INTRODUCTION

Mobility has become very important for a good quality of life. Loss of mobility due to an injury is usually accompanied by a loss of self-confidence. Designing a system with independent mobility for such disabled people is our aim in this project. Statistics show us that 43 million are disabled, about 17% of 250 million; almost 1 out of 5 persons are disabled. 52% of spinal cord injured individuals are considered paraplegic and 47% quadriplegic [1]. The idea behind this project is to design a handicapped tilt communicator system for a Handicapped person who is suffering from spinal cord injury those who could not move their hands as well as legs. Quadriplegics are limited in their motion and need some device to communicate with their wheel chair for mobility without others assistance [2]. Providing the quadriplegics with movement and help them to be more independent is the main goal of the project. The idea is to design a new human-machine interface for controlling a wheelchair by head movements. It has been found that this project can be used by not only the Quadriplegics but also by all those who are mobility impaired. This system is an automatic head tilt movement controlled wheelchair that could operate in any direction using head movements, i.e. Forward, Backward, Left and Right. It stops when the person does not tilt his head in any direction. Various types of research groups at a world level have begun to set up cooperation projects, projects to aid communication and mobility of elderly and/or disabled persons with the aim of increasing their quality of life and allowing them a more autonomous and independent lifestyle and greater chances of social integration [3], [4]. One of the most potentially useful applications for increasing the mobility of disabled and/or elderly persons is wheelchair implementation.

There has been a significant increase since last years in the development of assistive technology for people with disabilities, improving the traditional systems. Other than this, the growing use of computers has led to PC based control of wheelchairs. Also, a lot of automatic wheelchairs are now in trend and available in the market that could be controlled by the disabled person by controlling a joystick. But such wheelchairs are quite expensive and are not affordable by a general public. Also, a quadriplegic patient could not control such switch or joystick controlled wheelchairs due to impaired movement of hands. A standard motorized wheelchair aids the mobility of disabled people who

cannot walk, always providing that their disability allows them to control the joystick safely. Persons with a serious disability or handicap, however, may find it difficult or impossible to use them because it requires fine control [5].

So, our main design focus was to reduce the cost by including lower cost components, making the design simple by avoiding the use of highly complex programmable IC's and making more effective gesture based control by head tilt movements for physically impaired persons. The available designs for automatic and gesture based wheelchairs are designed using microcontrollers and their programming, but our design incorporates very basic analog and digital circuits to avoid the complexity and cost issue. Also, we have employed tilt sensors in place of accelerometers to make the design simple and robust.

Paper Organization:

This paper is organised in VII sections where basic working of electronic circuit used in the Head motion controlled wheelchair has been presented in section II. Section III and IV present the proposed block diagram and Circuit diagram along with the hardware design details with description of components used. Section V discusses the mechanical design of the automated wheelchair. Finally, the results obtained and conclusions from the designed system is presented in section VI and VII respectively.

II. BASIC WORKING OF ELECTRONIC SECTION

The position of the head is determined by use of tilt sensors as a small circuit board attached to the head of the user. This wheel chair would be very simple as compared to other designs and would involve no programming, but only digital logic for designing the control system between the tilt communicator and the wheel chair motors. Also, reducing the use of microcontroller and processors would make the design more economical.

This circuit is fitted on the top of a hat that the disabled person could wear. Tilt sensors are used to provide Forward, Backward, left and right movements of the wheel chair by the respective movements of the head. When the head is in normal position, wheel chair stops. The placement of the tilt sensors are on the top of the head of the user, so that the proper signals are generated by tilting of head of the user. For severe disabled persons one way of controlling a wheelchair is by use of head movements. There exists such devices today called head controlled joystick or head movement interface, both mechanical, camera based, accelerometer based and based on infrared light. The HMI proposed here is based on tilt sensors that are more efficient and easy to implement as compared to mechanical and camera based interface.

The tilt sensor used is presented in the following figure:

Figure 1: Tilt Sensor

A tilt sensor can measure the tilting in two axes. It usually consists of a free mass rolling ball inside it and a conductive plate at the bottom that opens or closes connection with the circuit.

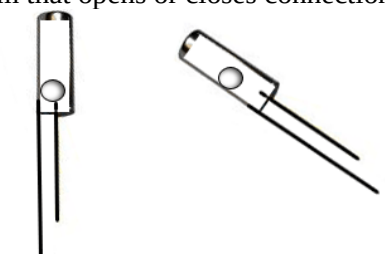

Figure 2: Schematic diagram of tilt sensor with open and closed circuit

The tilt sensors are connected in a potential divider circuit that generates appropriate voltage signals. These signals are fed to a diode logic circuit that converts these signals into desired signals required to move the motors in the wheelchair in appropriate directions. The diode logic is simple and easy to implement and replaces the use of complex and costly microcontrollers for generating the same logic. These signals are then given to a wireless transmitter fitted onto the top of the hat itself and sends the head tilt signals wirelessly to the wheelchair.

Finally, at the receiver end, a wireless receiver receives and decodes these signals back to the desired ones and drives a ULN2003 amplifier. The ULN2003 IC drives the SPDT relays used in the receiver section that controls the motors. DC geared motors are used to drive the wheelchair. As the idea for designing intelligent wheel chair can be easily implemented, this product could prove to be a great application for market and for assisting many handicapped persons in economical ways.

III. BLOCK DIAGRAM

1. Transmitter section

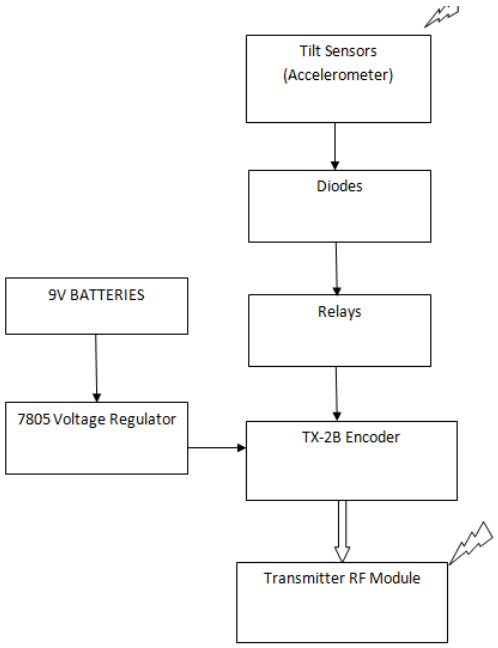

Figure 3: Block Diagram of Transmitter section of Head Motion Controlled Wheelchair

2. Receiver section

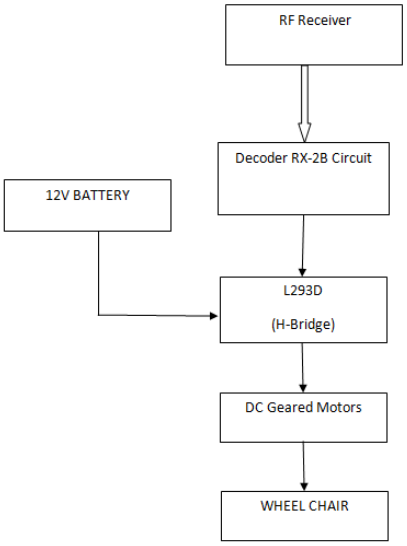

Figure 4: Block Diagram of Receiver section of Head Motion Controlled Wheelchair

IV. CIRCUIT DIAGRAM

1. Transmitter Circuit Diagram (Remote Fitted On Head)

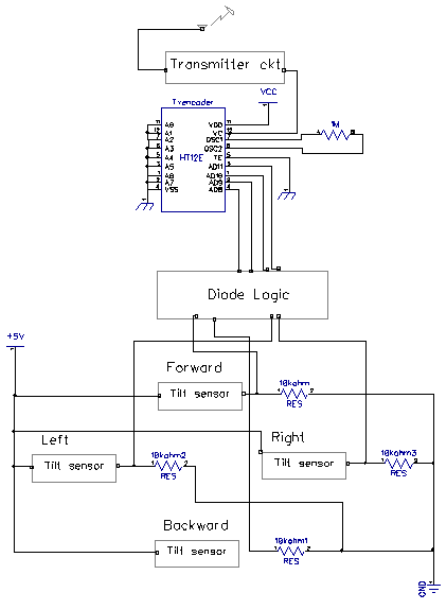

Figure 5: Circuit Diagram of Transmitter Section

2. Receiver Circuit Diagram

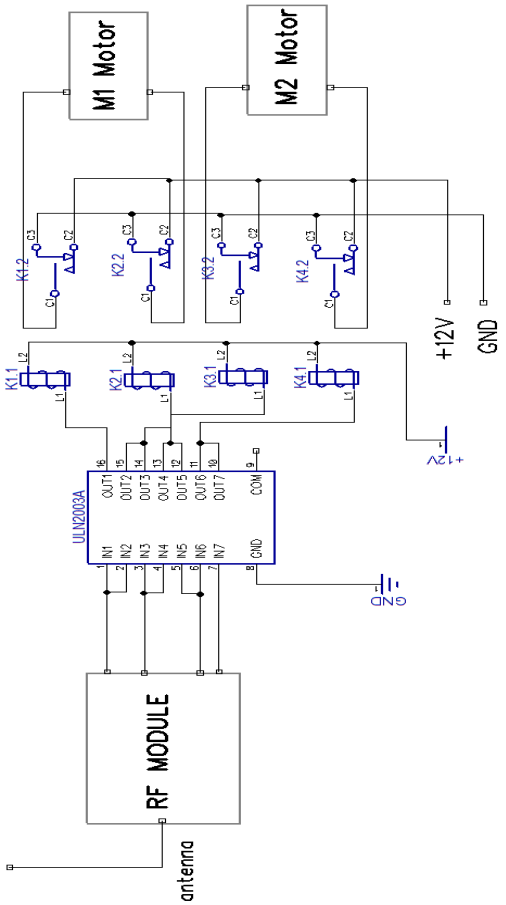

Figure 6: Circuit Diagram of Receiver Section

Description of components used:

Various components used in this project are described below:

i. Tilt Sensors:

As discussed earlier, tilt sensor is used to detect the direction of head tilt by means of a free mass rolling ball inside that either closes or opens a contact between its pins. Each tilt sensor is connected in series with a 10k resistor to make a potential divider circuit and generate 0 V when tilted in a particular direction and 5 V when no tilt is made as it is clear from figure 4.

ii. Diode Logic

A diode is a device that allows unidirectional current flow through a circuit. We have used 1N4007 diodes to provide the desired logic indicated in Table 1 for moving the wheelchair in four directions. With the use of diode logic, we have avoided the use of microcontrollers in the circuit.

Table 1: Digital Logic for moving wheelchair in different directions

S.No.	Digital Logic	Direction of Motion
1.	1010	Forward
2.	0101	Backward
3.	1001	Left
4.	0110	Right
5.	1111	Stop

iii. ULN2003: It consists of 7 independent Darlington pairs that generate a high current output of upto 1 Ampere. This IC is used to drive 4 Relays that operate the motors in the wheelchair.

Figure7: ULN2003 IC used in our project

iv. Relays: A **relay** is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. In our project, we have used 4 SPDT relays in order to operate the two DC motors of the wheelchair.

v. DC Motor:

DC geared motors are used in our wheelchair to drive the system in forward, backward, left and right directions as indicated in table 1. 12 V DC motors have been used powered by a rechargeable battery of 12 V, 7 Ah.

Figure 8: DC Geared motor used in our project

V. MECHANICAL DESIGN

We have deigned the wheelchair chassis considering the cost effective features. The Mechanical design has been made using a chassis of Mild Steel that is a rectangular frame supported by from two castor wheels and rear drive wheels. The power is provided to the rear wheels using the DC geared motor shown in the figure 7. Castor wheels act as free wheels to allow easy rotation of the wheelchair. The drive shaft includes custom designed Hubs for mounting the motor onto the shaft of wheels through a gear transmission system. A gear reduction using two spur gears with the gear ratio of 1:10 is used to drive the rear wheel. This is done in order to reduce the load on the motor shaft while a person sitting on the wheelchair and operating it.

Complete chassis's made using welding and lathe machining. A chair is fitted on the top of the chassis for sitting and again fitted using welding joints on the base. Circuit board of the receiver unit is placed on the back of the chair using nut-bolts.

The complete assembled wheelchair operated by head movements is presented in the following figure.

Figure 9: Head Motion controlled wheelchair

VI. RESULTS AND DISCUSSION

After the completion of our project, Head motion controlled wheelchair for handicapped, we have tested it for various cases and the wheelchair is working successfully for all the conditions. The remote with tilt sensors is also working well. We could easily operate the wheelchair in forward, backward, left or right directions using head motions and stop the wheelchair as and when desired by the user.

The wireless module also works well in sending the signals from head motions to the wheelchair chassis in the receiver circuit. However, we could use high range ASF, FSK transmission modules based on 434 MHz frequency for a higher range and accuracy for the operation of the wheelchair.
Finally, the complete cost of our wheelchair operated by head tilt movements is coming upto 30,000 INR that is quite economical as compared to other automatic wheelchairs coming in the market. So, we have made this product cost effective and reliable.

VII. CONCLUSION

With the completion of our wheelchair, we have concluded that it works well for head tilt motions and it proves to be an effective solution for quadriplegic patients with more than 45 % disability or for the patients with spinal cord injury who could not move their hands and legs for driving a manual or automatic wheelchair. This system proves better than automatic joystick powered wheelchairs in terms of ease of operation and head tilt control. Also, the project comes out to be economical as compared to other available wheelchairs in the market.

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