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Wireless Control of Powered Wheelchairs with Tongue Motion Using Hall Effect Sensors

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Abstract: **We introduce a new system for the physically challenged, an automatic wheelchair that can be controlled by the relative tongue movement of the patient. An automatic wheelchair has been undoubtedly one of the most useful inventions ever made in history. Even though wheelchairs are considered very useful for the quadriplegics, they still find it difficult to maneuver it without the help of someone else. They always need someone to push the chair on uphill roads and other difficult places. So, an automatic wheelchair came as a boon to them and has been the favorite among them for long time now. The biggest advantage of automatic wheelchair is that they give the physically challenged person a sense of freedom and comfort like he has never felt before. Particularly elders find it very easier to move across and do things on their own. We use Hall Effect sensors to detect the position of the tongue. This intelligent wheelchair is a microcontroller based system, the movement of wheelchair is controlled by the MCU through proper DC motor driving mechanisms which are used to control the rotation of the DC geared motors which are connected to the tires of the chair. Obstacle sensors are also attached to the wheelchair.**

Keywords: **Wheelchair, quadriplegics, maneuver, Hall Effect sensor, microcontroller, DC geared motor, obstacle sensors**

I. INTRODUCTION

Persons with severe disabilities as a result of various causes like traumatic brain and spinal cord injuries find it very difficult to carry out tasks without an external help. They are completely dependent on wheeled mobility for transportation. Electrically powered wheelchairs had been widely used as they provided greater independence. However this required certain level of physical movement ability as it required a joystick for its operation. This was difficult for people with severe disabilities. Several other assistive technologies have been developed to provide an alternative means for these wheelchairs. Technologies based on electrooclugraphy electromyography, electroencephalography etc. were developed. However these have their own drawbacks and hence a thought of introducing tongue controlled wheelchair came up. Tongue is capable of controlling sophisticated manipulation tasks. It is noninvasively accessible and hence not influenced by position of rest of body. The tongue is connected to brain via hypoglossal cranial nerve which escapes severe damages in case spinal cord injuries.

Here we introduce a new system for the physically challenged people, an automatic wheelchair that can be controlled by the relative tongue movement of the patient. Hall Effect sensors are used to detect the position of the tongue on which magnet is placed. We have four Hall Effect sensors denoting four different directions. : Forward, Reverse, Left and Right. An additional feature is the presence obstacle sensors that we are attaching to the wheel chair.

II. TONGUE WHEELCHAIR

HALL EFFECT SENSOR ARRAY: Hall Effect Sensors are devices which are activated by an external magnetic field. A magnetic field has two important characteristics flux density and polarity (North and South Poles).

Fig.1 : hall effect sensor array

The output signal from a Hall Effect sensor is the function of magnetic field density around the device. When the magnetic flux density around the sensor exceeds a certain

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preset threshold, the sensor detects it and generates an output voltage. Here magnet is placed on the tongue and four Hall Effect sensors are connected in the mouth corresponds to the four directions of movement, forward, backward, left and right.

MULTIPLEXER: Multiplexer is a device that selects one of several analog or digital input signals and forwards the selected input into a single line. They are mainly used to increase the amount of data that can be sent over the network. Here it is used to multiplex the analog output from the Hall Effect sensor to out the selected one.

ADC (ANALOG-TO-DIGITAL CONVERTER): An analog-to-digital converter (abbreviated ADC, A/D or A to D) is a device that converts a continuous quantity to a discrete digital number. The reverse operation is performed by a digital- to-analog converter (DAC). Typically, an ADC is an electronic device that converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current. Here it is used to covert the analog output signal from the Hall Effect sensor into digital data.

MCU (MICROCONTROLLER UNIT): MCU is the microcontroller unit, which controls all the functions of other blocks explained here. MCU takes or read data from the Hall Effect sensor and controls all the functions of the whole system by manipulating these data**.** Microcontroller analysis signal from the ADC and determined the movement of the wheel chair with respect to the program. The movement of motors is controlled by the microcontroller corresponding to the tongue movement of the patient as per his need.

Fig.2 : pic microcontroller

MCU cannot drive a motor directly, so a motor interface is used here. The motor drive section accepts the low level logical signal from the controller and to provide necessary voltage and current excitation to the motor.MCU also checks the condition of the obstacle sensor also, if any obstacle is present behind the wheel chair, MCU will provide signal to the LED and it becomes turned ON.

OBSTACLE SENSOR TRANSMITTER: IR based wireless communication technology is used here. IR transmitter receiver pair is placed behind the wheel chair in order to detect whether any object is present at the back side of the chair. For detecting obstacle we use IR reflection method. The obstacle sensor transmitter emits IR radiation continuously.

Fig. 3: ir led

Usually IR signal have the reflective range of 1 to 2 meters. The very common method for generating IR radiation is IR diode. The source should be excited by a voltage or current to get maximum reflective radiation in the area of interest. When the exciting current increases, the intensity of IR radiation also increases. IRED is an LED that emits a wavelength of light below red in the color spectrum.

OBSTACLE SENSOR RECEIVER: The IR receiver or sensor is placed at the back side of the wheel chair for detecting the obstacle. It is directly interfaced with the MCU. If any obstacle is present behind the wheelchair, the emitted rays from IRED strikes on it and will reflect back, which is detected by IR receiver or sensor placed in the direction of reflecting radiation, is fed to the MCU. Any light sensor can be used for this purpose, but should have the capability of avoiding ambient light effect.

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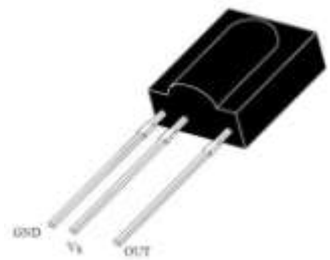


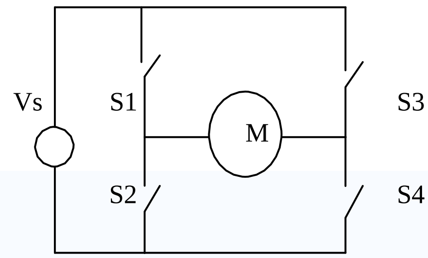
Fig.3 : TSOP

The receiver should have the sensitivity to detect the radiation from the detective object. Usually photo sensors having maximum sensitivity at IR region is used for this purpose. Besides ambient light there are several IR sources is present to make noises in the sensor circuit. To prevent this noise, sensors are always attached with optical and electrical filters with the detecting element. Optical filters give the protection from the unwanted light frequencies exposure to the sensor. Electrical filters are used to avoid the electrical noises present.

MOTOR INTERFACE: Motor driver circuit is required to provide an interface between the 5V logic signal from the microcontroller & the high current / high voltage power side to drive the motor, because motor is an electromechanical device, which convert electrical energy to rotation/ mechanical energy. For this energy conversion large current excitation is required. These much energy cannot be provided by the logical signal pins from the microcontroller. So a motor interface is used here.

The motor drive section should have the capability for accepting the low level logical signal from the controller and to provide necessary voltage and current excitation to the motor. Usually high current transistor switches or relays or ICs with motor drive packages are used for this purpose. Here bidirectional motor drive is required so an H-bridge based circuitry is used. An H-bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards.

H- BRIDGE



Fig, 4 : H bridge

S1	**S2**	**S3**	**S4**	**Result**
1	0	0	1	Motor moves right
0	1	1	0	Motor moves left
0	0	0	0	Motor free runs
0	1	0	1	Motor brakes
1	0	1	0	Motor brakes

Table 1

Two motors are used in this system. The movement of the machine with respect to motor and respective H Bridge is as drown below.

LEFT MOTOR **S1 S2 S3 S4**				**RIGHT MOTOR** **S1 S2 S3 S4**				**RESULT**
1	0	0	1	1	0	0	1	FORWARD
0	1	1	0	0	1	1	0	REVERSE
0	0	0	0	1	0	0	1	LEFT
1	0	0	1	0	0	0	0	RIGHT

Table 2

The H-bridge (or "full bridge") is so named because it has four switching elements at the "corners" of the H and the motor forms the cross bar. The basic bridge is shown in the figure to the right.

The key fact to note is that there are, in theory four switching elements within the bridge. These four elements are often called, high side left, high side right,
low side right, and low side left (when traversing in clockwise order). The switches are turned on in pairs, either high left and lower right, or lower left and high right, but never both switches on the same "side" of the bridge. If both switches on one side of a bridge are turned on it creates a short circuit between the battery plus and battery minus terminals. This phenomenon is called shoot through in the Switch-Mode Power Supply (SMPS) literature. If the bridge is sufficiently powerful it will absorb that load and your batteries will simply drain quickly. Usually however the switches in question melt.To power the motor, you turn on two switches that are diagonally opposed. In the picture to the right, imagine that the high side left and low side right switches are turned on. The current flow is shown in green. The current flows and the motor begins to turn in a "positive" direction. If the polarity changed current flows the other direction through the motor and the motor turns in the opposite direction

MOTOR DRIVER (L293D)

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high- voltage loads in positive-supply applications. All inputs are TTL compatible.

Fig. 5 : L293D

Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by
1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable
input become high, the associated drivers will get enabled, and their outputs will become active. These outputs are in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoidor motor applications.

DC GEARED MOTOR: Motor is used to drive the wheel chair. The motor should have torque and rpm to meet the requirement like move the wheel chair by carrying battery and circuit load. DC motors are the best choice for this purpose. But DC motors are always comes with high rpm 2000 to 3000, and with lesser torque.

Fig. 6 : DC geared motor

So usually geared DC motors are used. Geared DC motors are well suitable because which have lesser rpm like 30 or 45 and have sufficient torque to drive the all mechanical load. A 12V motor is preferable because which can be easily connected to
12V battery. Hence we use geared dc motor for drive the wheel chair.

VISUAL INDICATIONS: Different colored LEDs are used here as the visual indicators. RED and GREEN LEDs are used here, if any obstacle is present in the path of IR radiation RED LED becomes ON. A light-emitting diode (LED) is a semiconductor light source.

Fig. 7 : LED

LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across thevisible, ultraviolet and infrared wavelengths, with very high brightness.

III. WORKING

Hall Effect sensors are activated by a magnetic field and here the direction of movement of wheel chair can be

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decided by using four Hall Effect sensors and a single permanent magnet placed on the tongue. Here the four Hall Effect sensors will be connected in the mouth represents four directions. Depending upon the relative motion of the tongue one of the sensors produces appropriate voltages. These analog voltages will be converted to digital format for the processing purpose of the microcontroller.

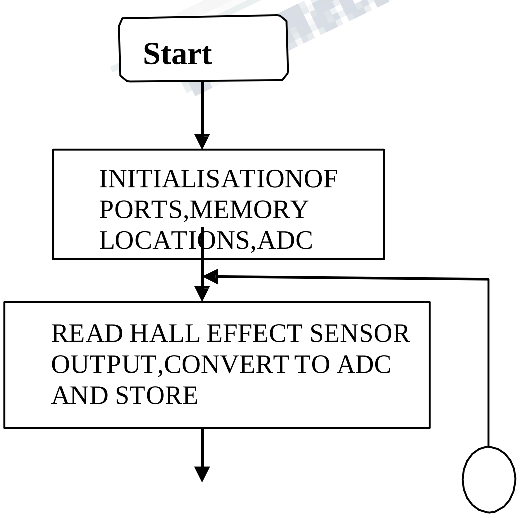
The Hall Effect sensor is connected to the MCU through an ADC. The MCU is programmed in such a way that the data coming from the sensor controls the function of wheel chair. An obstacle detector is also interfaced in this system in order to detect whether any object is present at the back side of the chair. For detecting obstacle we use IR reflection method. By this we will transmit IR radiation to the obstacle. If any obstacle is present in the range of IR radiation it will reflect back, which is detected by IR receiver or sensor placed in the direction of reflecting radiation. Output from the IR receiver is also fed to the MCU.

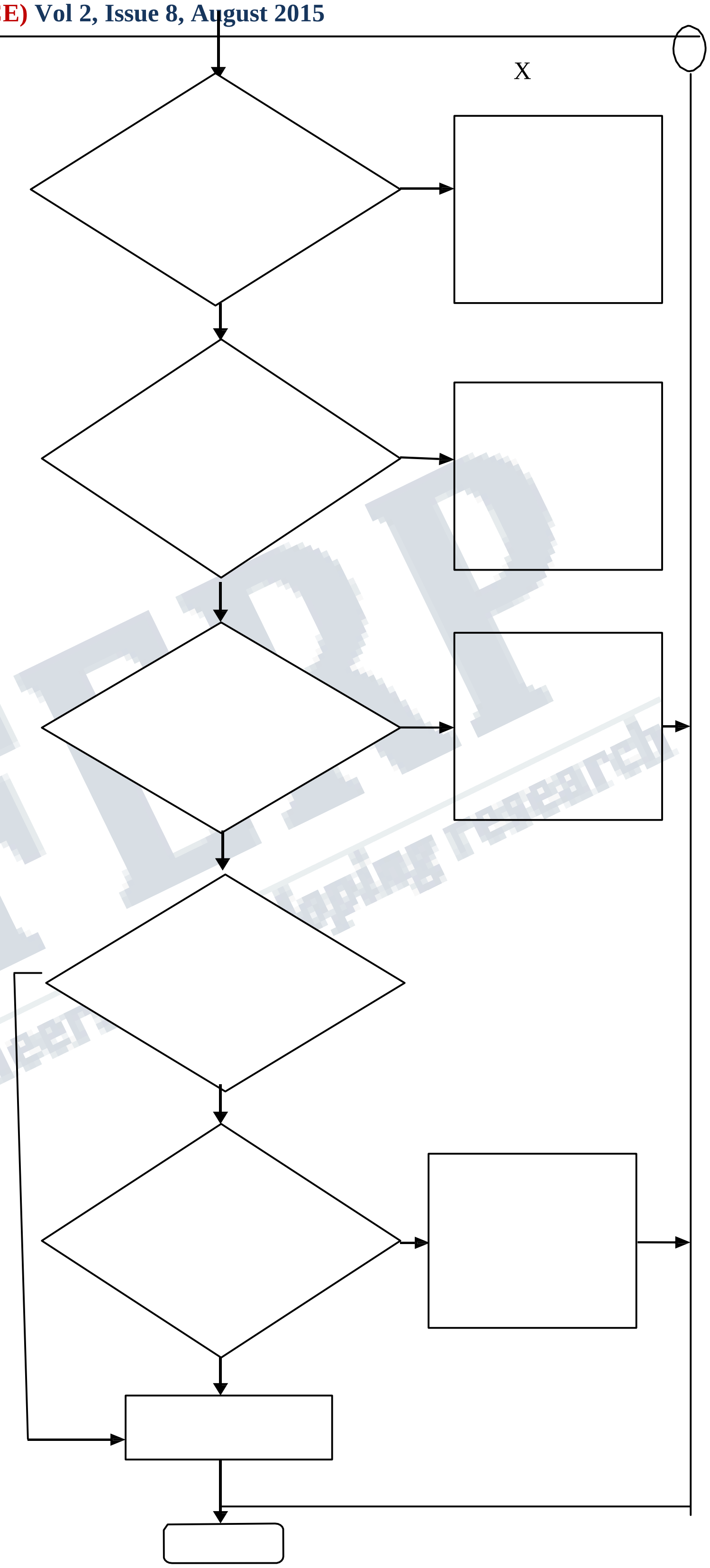
Our wheel chair contains 2 DC geared motors and a free rotating wheel. The DC motors move in both directions, if the polarity is reversed

Movement	motor right	motor left
Forward	Forward	Forward
Reverse	Reverse	Reverse
Left	Forward	Stop
Right	Stop	Forward

Here we use 12V DC motors. In order to interface these motors with MCU, we use H - bridge driver IC L293D. The H- Bridge driver controls the movement of each motor as per the instruction from MCU.

IV. FLOWCHART





YES

CHECK FOR

CHANGE IN OUTPUT FORWARD MOVEMENT (MOTOR1= FORWARD MOTOR2= FORWARD)

FOR SENSOR

1

V. CONCLUSION

Different types of electronics technologies are very much capable in biomedical areas such as wheelchair rour system helps the persons to control the action of the wheel chair with his own tongue movement. This newly introduced tongue controlled wheelchair can benefit people with severe disabilities. Here we have a magnet placed on the tongue. The Hall Effect sensors are used to detect the position of the tongue. The obstacle sensors avoid the accidents in backward movements.

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