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Brain Control And Gesture Recognition Robot

M.Devi , G.Devaraj

Abstract— In this paper, an EEG Electrode and Flex sensors are employed for controlling the Robot mobility. The existing system is entirely based on EEG Electrode-Brain control Technique.

Primary Objective: To improve the mobility for the disabled people and senior citizens in a cost effective way. We are planning to develop a system which is not entirely based on EEG Electrode (Costlier to measure more sensitive signals).

Improvement: Improvement is where Artificial Intelligence (EEG Electrode) in combination with human motions mapping method(Flex sensor) are used to control the Robot. Flex sensors are used to determine the current state of the system with great degree of accuracy in a cost effective way.

Research Design and Methods/Analysis: My proposed work is designed in Protheus software using Arduino programming language. Artificial Intelligence(AI) based on Brain computer Interface(BCI) Technique with ERD/ERS Component is used with respect to EEG Electrode. Human motions mapping method is used with respect to Flex sensors.

Results and conclusions: EEG Sensors based on ERS/ERD component can make the robot to function based on the imagination made by the user. In addition flex sensors are used which controls robot more efficiently than the EEG Sensors. The system is partitioned into two parts. The first part has the EEG Sensor(ON/OFF), cannot be used fullfledgely so we have used Flex sensors for performing some major functions(Left, Right, Forward and Reverse). In this case a switch can be used to select the part needed as per the convenience. Map building, Path planning, voice information production and obstacle/collision avoidance can be made as future enhancements in the Autonomous Navigation System(ANS). Thus the Artificial Intelligence in combination with Autonomous Navigation System(ANS) can be used to form shared control.

Keywords— AI, ANS, Arduino, BCI, EEG Sensor, ERD/ERS and Flex sensor.

I. INTRODUCTION

Brain Computer Interface (BCI) technology is a new and fast evolving field that seeks direct interaction between the human neural system and machines. BCI is aiming to augment human capabilities by enabling people (especially Disabled) to communicate and control devices by mere “thinking” or expressing intent.The increasing success of BCI systems is partially due to a better understanding of the dynamics of brain oscillations that generate EEG signals. In the brain, networks of neurons form feedback loops responsible for the oscillatory activity recorded in the EEG.

Non Invasive BCI Technique, EEG electrodes are weared as cap. The EEG electrodes are used for capturing the words imagined. Beta waves ranging from 14-25 Hz are chosen which is related with thinking, active attention, and focus on outside world or solving concrete problems found in normal adults but due to the high cost involved in purchasing EEG Electrode we have planned to do the major part with Flex Sensors. The flex sensor achieves great form-factor on a thin flexible substrate which produces output when it is bent.

EEG Signals can be used for controlling the Robots by using Intelligent Techniques[5]. P300 BCIs are more suitable for individuals with severe motor disabilities to select a destination from predefined ones but it does not suit all people[3]. SSVEP BCI-based vehicle control is currently not accurate or reliable[2]. P300 Signals are used for selecting the destination and SSVEP Signals are used for confirming the selected destination but it does not suit all people[4]. ERD/ERS is typically induced by mental tasks, such as motor imagery, mental arithmetic, or mental rotation[1]. Flex Sensors can be used to control the Robotic operation efficiently using microcontroller[6].

II. PROPOSED METHODOLOGY

A. Existing system:

The Existing system is based on BCI with P300 & SSVEP (Visual stimulus) components used for selecting the Autonomous Navigation System for driving the 4-wheeler.

B. Proposed system:

In the proposed system, Flex sensors are used in addition to EEG Electrodes where the control can be achieved more accurately and in a cost effective manner. As the EEG Sensor measuring sensitive signals are costlier to purchase we have used an low budget EEG Sensor but as a standalone device. Here we are using motor imagery component based on imagination. LCD screen is used for displaying the information.

M.Devi, PG Scholar, Department of Mechatronics Engineering, Jeppiaar Engineering college, Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai-119. (e-mail: devimani9@gmail.com).
G.Devraj, Assistant Professor, Department of Mechanical Engineering, Jeppiaar Engineering college, Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai-119. (e-mail: devmecz@gmail.com).

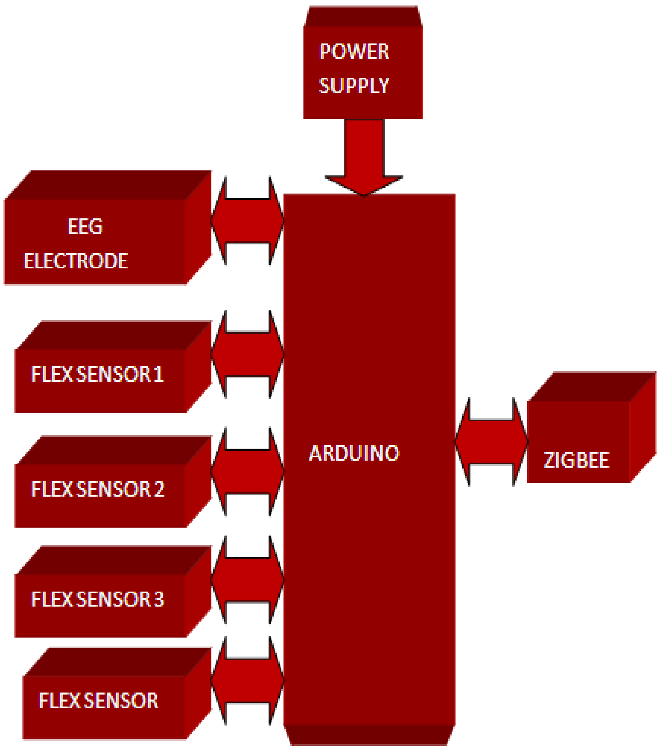


Fig.1 Block diagram – Transmitter section

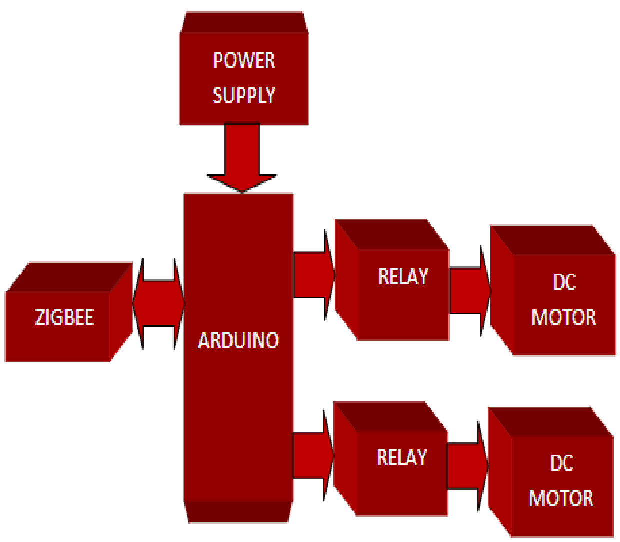


Fig.2 Block diagram – Receiver section

Let us discuss the brain anatomy before starting with component description and its functions.

C. Brain anatomy:

Human brain, three pound organ controls all body functions including receiving and interpreting information from the outside world, and expressing the essence of the mind and soul. Intelligence, creativity, emotion and memories are a few of the many things governed by the brain. The brain receives information through different sensors such as sight, smell, touch, taste, and hearing.

The brain constructs the received data from the different sensors and form a meaningful message. The brain controls our body movement of the arms and legs, thoughts, memory and speech. It also determines how a human respond to different situations such as stress by regulating our heart and breathing rate.

Anatomically five basic parts of the brain can be distinguished including Cerebrum, Diencephalon, Cerebellum, Mesencephalon, and Medulla oblongata as shown in Fig 3. The cerebrum, located directly under the skull surface, is the largest part of the brain.

MAIN FUNCTIONS OF BRAIN:

1. The initiation of complex movement.
2. Speech and language understanding and production.
3. Memory.
4. Reasoning.

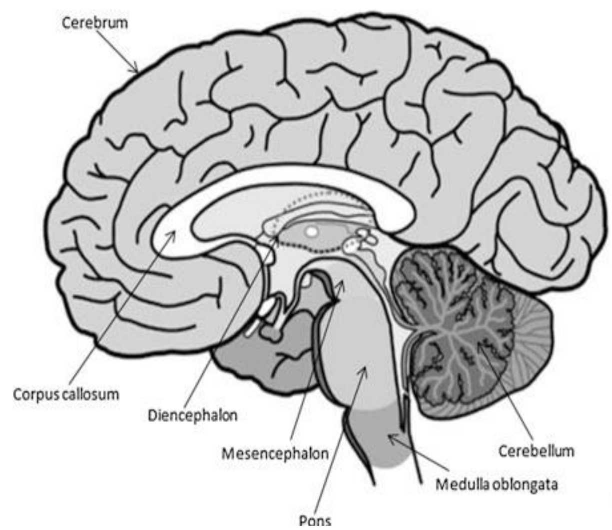


Fig.3 Brain Anatomy

Brain monitoring techniques which make use of sensors placed on the scalp mainly record activities from the outermost part of the cerebrum which is called as Cortex. The Cortex consists of two hemispheres, connected via a beam called corpus callosum. Each hemisphere is dominant for specific abilities. For right handed persons, the right hemisphere is activated more during the recognition of geometric patterns, spatial orientation, the use nonverbal memory and the recognition of non-verbal noises. More activity in the left hemisphere can be observed during the recognition of letters and words, the use verbal memory and auditory perception of words and language. Each hemisphere is partitioned into five anatomically well-defined regions, the so called lobes as given in Fig.4. For occurring ERD BCIs, the EEG electrodes can be located at frontal, central, and parietal regions to acquire EEG signals (e.g., F3, F4, C3, Cz, C4, P3, Pz, and P4).

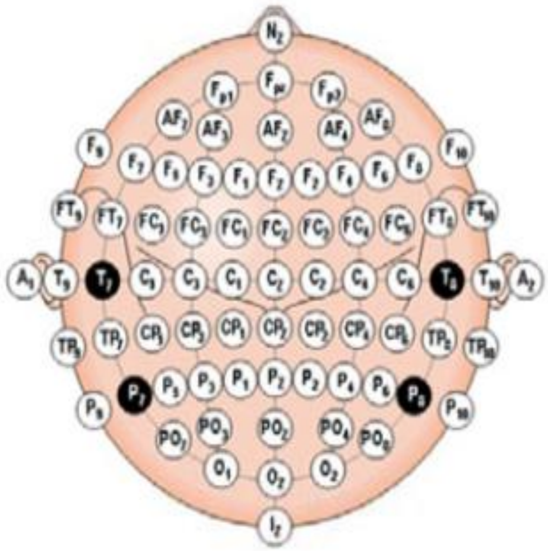


Fig.4 Brain Lobe positions

D. Event related synchro-nization/(de) syn-chronization

A particular type of Event Related Potential (ERP) is characterized by the occurrence of an event-related desynchronization (ERD)and an event-related synchronization (ERS). A decrease in the synchronization of neurons causes decrease of power in specific frequency bands. This phenomenon is defined as an ERD and can be identified by a decrease in signal amplitude. ERS is characterized by an increase of power in specific frequency bands that is generated by an increase in the synchronization of neurons and/or in signal amplitude.

E. Power supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU.

F. Linear power supply

AC powered linear power supply usually uses a transformer to convert the voltage from the wall outlet (mains) to a different, usually a lower voltage. If it is used to produce DC, a rectifier is used. A capacitor is used to smooth the pulsating current from the rectifier. Some small periodic deviations from smooth direct current will remain, which is known as ripple. These pulsations occur at a frequency related to the AC power frequency (for example, a multiple of 50 or 60 Hz).

The voltage produced by an unregulated power supply will vary depending on the load and on variations in the AC supply voltage. For critical electronics applications a linear regulator will be used to stabilize and adjust the voltage. This regulator will also greatly reduce the ripple and noise in the output direct current. Linear regulators often provide current limiting, protecting the power supply and attached circuit from over current.

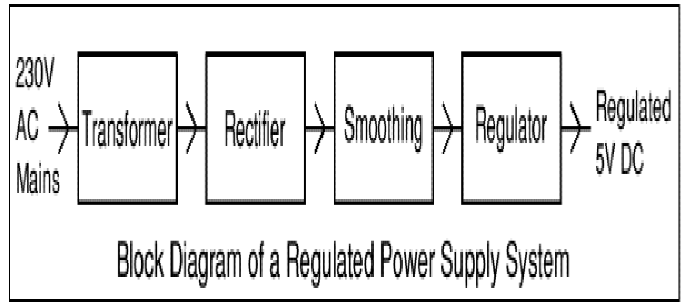


Fig.5 Regulated Power supply.

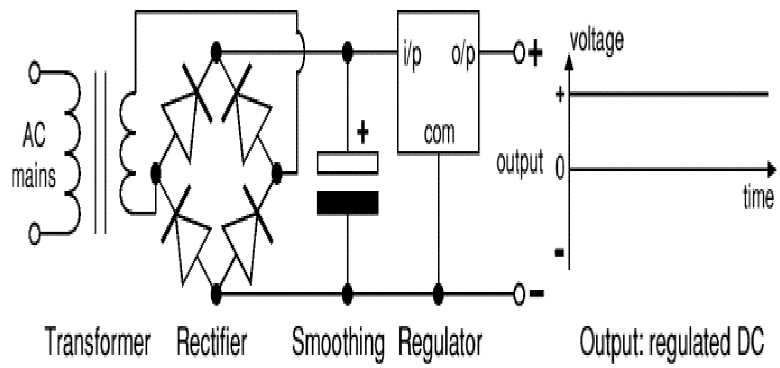


Fig 6 Circuit diagram of RPS.

G. Brain activity monitoring using eeg:

The activity of the potential generators could be measured directly by:

1. A superposition of potentials generated in different areas of the cortex is measured using scalp electrodes since brain tissue and the liquor are conductive.
2. The amplitude of the originally generated potential differences is attenuated because of the resistive properties of the tissue between the potential generators and the electrode (e.g. liquor, skin, bone of the skull).
3. Capacities caused by cell membranes and other inhomogeneities (e.g. liquorskull, skull-skin) between potential generators and electrodes influence the amplitude of the EEG signals as a function of their frequency.

Table 1

EEG electrode properties

Specifications	Features	Transfer functions	Physical characteristics	Applications
Gain: 40000db.	Single-channel differential sensor	[-37.5μV, 37.5μV] $EEG(V)$ =$(ADC/2$-1/2).VCC/G	**W1 x L1 x H1:** 1.0x1.8x0.4cm	Evoked potentials analysis
Consumption: 3mA	Discrete elastic head band	EEG (μV) = EEG (V) . 1×10^6	**W2 x L2 x H2:** 1.5x2.3x0.4cm	Neuro-feedback
Range: ±37.5µV (with VCC = 3V)	Pre-conditioned analog output	VCC = 3V (operating voltage)	**A1:** 105.0±0.5cm **A2:** 2.5±0.5cm	Sleep studies
Bandwidth: 0.8-49Hz	High signal-to-noise ratio	G= 40000	**A3:** 10.0±0.5cm	Human-Computer Interaction
Input Impedance: 100GOhm	Shielded miniaturized cables	$EEG(V)$ – EEG value in Volt V EEG (μV)– EEG value in microvolt .	**D:** 0.4cm	Neurophysiology studies
CMRR: 100Db	Medical-grade raw data output with Ready-to-use form factor	ADC – Value sampled from the channel n – Number of bits of the channel	**S:** White, Black, Blue, Green, Red, Yellow, Gray, or Brown	Psychophysiology

H.EEG electrode positions:

EEG Sensor has two measurement electrodes, detects the electrical potentials and one reference electrode. The resulting signal is the amplified difference between these two signals, eliminating the common unwanted signals detected by the surfaces. EEG Signal acquisition must be performed in a low electromagnetic noise environment.

Fig.7 EEG Electrode

I. Flex sensor2.2:

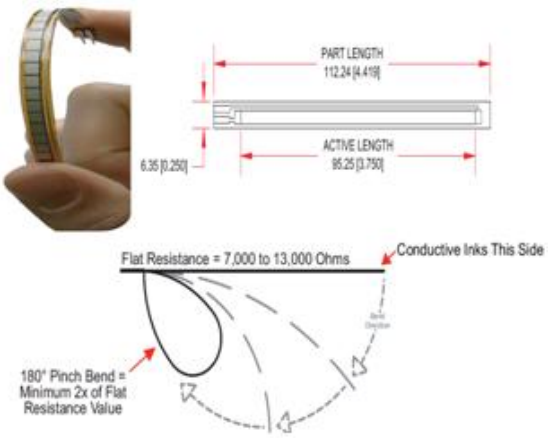


Fig 9 Flex sensor

Table 2

Flex sensor properties

J. Circuit diagram of flex sensor:

Features	Electrical specifications	Mechanical specifications
Angle Displacement Measurement.	Flat Resistance: 10K Ohms ±30%	Life Cycle: >1 million
Bends and Flexes physically with motion device.	Bend Resistance: minimum 2 times greater than the flat resistance at 180° pinch bend	Height: 0.43mm (0.017").
Robotics, Gaming, Medical Devices, Computer Peripherals, Musical Instruments, Physical Therapy.	Power Rating : 0.5 Watts continuous; 1 Watt Peak	Temperature Range: -35°C to +80°
Simple Construction and low cost.		

1. The impedance buffer in the Flex Sensor Circuit is a single sided operational amplifier, connected with the sensors as its low bias current reduces error due to source impedance of the flex sensor as voltage divider.
2. Op amps used are the LM358 or LM324.

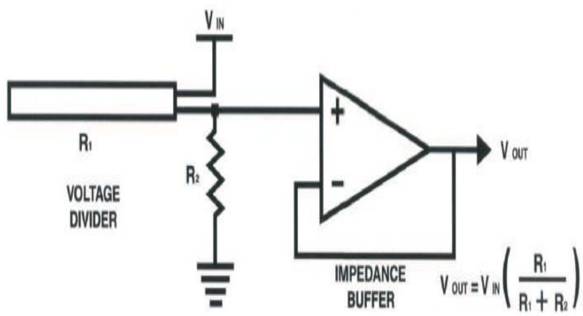


Fig.10 Circuit diagram of flex sensor.

K. Arduino:

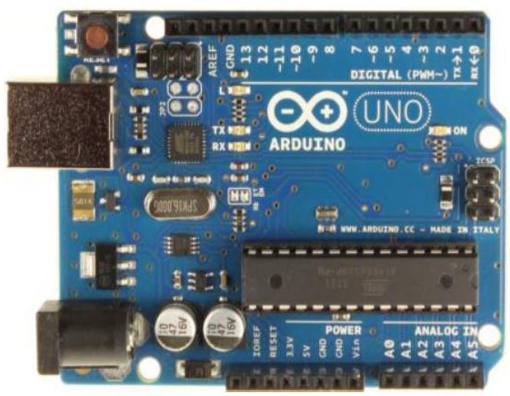


Fig.11 Arduino

The Arduino Uno is a micro-controller board based on the ATmega328. Arduino has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack and a reset button. Arduino can be connected to a computer with a USB cable or power it with a AC-to-DC adapter or battery.

L. Arduino specifications :

Input Voltage (limits): 6-20V
Digital I/O Pins: 14 (of which 6 provide PWM output)
Analog Input Pins: 6
DC Current per I/O Pin: 40 mA
DC Current for 3.3V Pin: 50 mA
Flash Memory: 32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM: 2 KB (ATmega328)
EEPROM: 1 KB (ATmega328)
Clock Speed: 16 MHz.

M. Zigbee:

1. Zigbee is a technological standard designed for control and sensor networks.
2. Zigbee based on the IEEE 802.15.4 Standard Created by the Zigbee Alliance and in Personal Area Networks (PAN's) and device-to-device networks Connectivity between small packet devices Control.
3. Development started 1998, when many engineers realized that Wi-Fi and Bluetooth were going to be unsuitable for many applications. IEEE 802.15.4 standard was completed in May 2003.
4. Organization defining global standards for reliable, cost effective, low power wireless applications.

N. Zigbee Transreceiver:

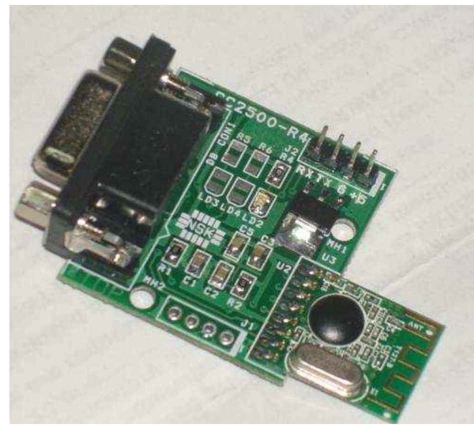


Fig.12 zigee transceiver

CC2500 RF Module is a transreceiver module which provides easy to use RF communication at 2.4Ghz. It can be used to transmit and receive data at 9600 baud rates from any standard CMOS/TTLsource. This module is a direct line in replacement for your serial communication it requires noextra hardware and no extra coding and works in Half Duplex mode.

Table 3
Zigbee specifications

Features:	Specifications:
Supports Multiple Baud rates (9600)	Input Voltage - 5Volts DC.
Works on ISM band (2.4 GHz)	Baud Rate – 9600.
No complex wireless connection software or intimate knowledge of RF is required to connect our serial devices.	RS 232 Interface & TTL Interface.
Designed to be as easy to use as cables.	Range – Max 30 Mtrs - Line of Sight.
No external Antenna required.	Channels - 3 Ch - JP1 & JP2 - Ch 1 On – On.
Plug and play device.	
Works on 5 DC supply.	

O. Relays:

1. Relays are remote control electrical switches that are controlled by another switch which allow a small current flow circuit to control a higher current circuit.
2. Relays have control circuit switches and load circuit switches.

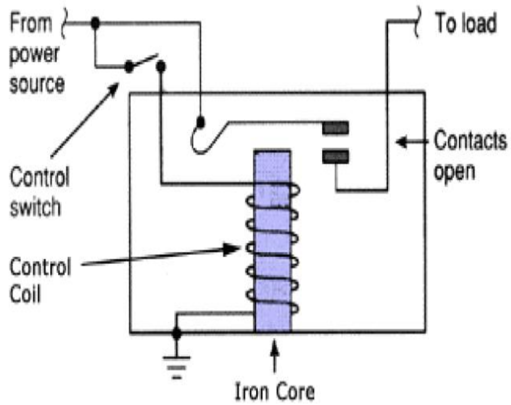


Fig.13 Relay

3. Relays are energised by passing current through the control circuit. Thus the control circuit creates a small magnetic field which causes the load circuit switches to close.
4. Relays are de-energised when the current through the control circuit is stopped.

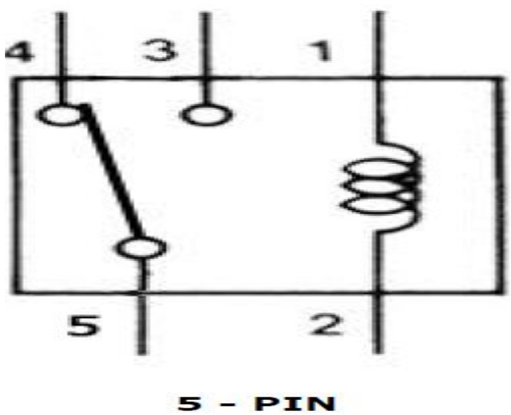


Fig.14 5-pin Relay

P. DC MOTOR:

Geared motors with 60RPM, 12V are used for robotics applications. Very easy to use and available in standard size. Nut and threads on shaft to easily connect and internal threaded shaft for easily connecting it to wheel.

FEATURES:

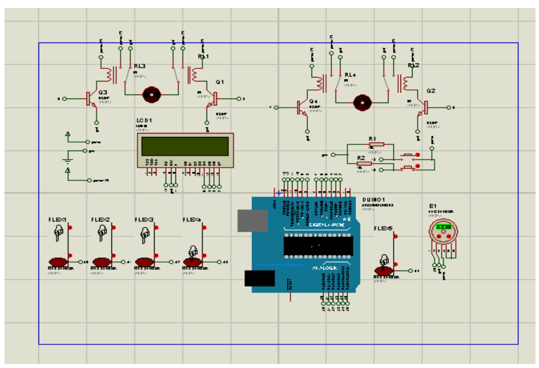
1. Model=RKI-1036.
2. 60RPM 12V DC motors with Gearbox
3. 3000RPM base motor
4. 6mm shaft diameter with internal hole
5. 125gm weight
6. Same size motor available in various rpm
7. 2kgcm torque
8. No-load current = 60 mA(Max), Load current = 300 mA(Max).

Fig.15 DC Motor

III. PIN CONFIGURATIONS:

The button for EEG is connected to pin number “A5”and similarly Flex sensor is connected to pin number “A4” of Arduino. Then the first part with EEG sensor along with the Flex sensor 1, Flex sensor 2, Flex sensor 3 and Flex sensor 4 are connected to pin numbers “A0”, “A1”, “A2” and “A4”. Thus above mentioned are the input pins and now comes the output pins. Arduino’s pin number “11” is connected to LCD’S “6” pin which when enabled displays the information on display via the connection of “12” to “4”. Each time when particular direction is chosen, the information passes LCD through the pins “2”, “3”, “4” and “5” to “14”, “15”, “16” and “17”. Motor 1 runs in clockwise direction whenever relay connected with the transistor having pin configuration “6” is activated. Similarly, Motor 1 runs in clockwise direction whenever relay connected with the transistor having pin configuration “8” is activated. Motor 2 runs in clockwise direction whenever relay connected with the transistor having pin configuration “7” is activated. Similarly, Motor 2 runs in anti-clockwise direction whenever relay connected with the transistor having pin configuration “9” is activated.

IV. SIMULATION AND INTERFACING:



EEG Electrode,Flex sensors, Arduino, Relay,Motors,LCD, Transistors, Resistors, Buttons and connecting wires are used to build the Proposed system in Protheus software using Arduino Programming. As we said earlier the proposed system consists of 2 parts. First part makes use of EEG Electrode and Flex sensors. Second part is fully based on Flex sensors. Buttons are used for selecting the required system as per user convenience.

With respect to the first part, have placed EEG Electrode in the right hand side of the Arduino, activates when it reaches the required limit and displays “MIND CONTROL ROBOT” in the LCD screen. Then we can make use of the Flex sensors in the left hand side. Flex sensor 1 is activated, LCD screen displays as “LEFT”.Flex sensor 2 is activated, LCD screen displays as “RIGHT”. Flex sensor 3 is activated, LCD screen displays as “FORWARD”. Flex sensor 4 is activated, LCD screen displays as “REVERSE”. The second part makes use of the Flex sensor in the right side of Arduino for initializing/Halting. Similarly, Flex sensors in the left side are used for other operations.

Meanwhile the motor rotates as per the direction selected. Motors rotates in clockwise direction when FORWARD flex sensor is strained. Similarly motors rotates in anticlockwise direction when REVERSE Flex sensor is strained. Now for accomplishing LEFT direction, Motor1 rotates anticlockwise and Motor2 rotates in anticlockwise. Contrastly for accomplishing RIGHT direction, Motor1 rotates clockwise and Motor2 rotates anticlockwise direction.

V. FUTURE WORK & CONCLUSIONS

EEG Sensors based on ERS/ERD component can make the robot to function based on the imagination made by the user. In addition flex sensors are used which controls robot more efficiently than the EEG Sensors. The system is partitioned into two parts. The first part has the EEG Sensor(ON/OFF), cannot be used fullfledgely so we have used Flex sensors for performing some major functions(Left, Right, Forward and Reverse). In this case a switch can be used to select the part needed as per the convenience. Map building, Path planning, voice information production and obstacle/collision avoidance can be made as future enhancements in the Autonomous Navigation System(ANS). Thus the Artificial Intelligence in combination with Autonomous Navigation System(ANS) can be used to form shared control.

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