# SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY,KARUKUTTY

## Grants received from Government and non-governmental agencies for research projects / endowments in the institution during the last five years (INR in Lakhs)

## ACADEMIC YEAR MAY 2020-JUNE 2021

| SL NO: | Code | Faculty Name | Department | Sanctioned by | Sanctioned amount |
|---|---|---|---|---|---|
| 1 | GEC20-2101 | Vinoj P G | ECE | GYTI- BIRAC SRISTI | 1500000 |
| 2 | GCSE20-2101 | Deepasree Varma | CSE | RajCOMP Info Services Ltd | 755,000 |
| 3 | GCSE20-2102 | Susmi Jacob | CSE | CERD-KTU | 75,000 |
| 4 | GME20-2101 | R.Ajith Kumar | ME | National Physical and oceanography laboratory | 928000 |
| **TOTAL SANCTIONED AMOUNT 2020-2021** | | | | | **3258000** |

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY KARUKUTTY ERNAKULAM 683 576

PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY
VIDYANAGAR, PALLISSERY, KARUKUTTY
ERNAKULAM, KERALA-683 576

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
CET campus, Thiruvananthapuram - 695 016
Ph: 0471 2598122; Fax: 2598522 www.ktu.edu.in Email: university@ktu.edu.in

No. KTU/RESEARCH 2/4643/2020 Dated: 02.09.2021

From

The DEAN (Research)

To

The Principal
SCMS School of Engineering and Technology

Sir,

Sub:- APJAKTU - CERD - Research Seed Money Scheme - Projects Selected for funding - reg:-

I am glad to inform you that the project proposals as listed in Annexure I are provisionally selected for funding under Research Seed Money (RSM) scheme of KTU.

The expenditure should be incurred as per the sanctioned budget heads and in accordance with terms and conditions given in Annexure II. Format of MOU to be furnished by the college is given as Annexure III.

The Principal Investigators may please be directed to forward request (in Annexure II) for releasing the fund with Bank Account details. The fund will be released only after settling pending accounts of the principal investigator in CERD, if any. Any request received after three months from the date of this letter will not be considered.

Yours faithfully
Dr. Shalij P.R *
DEAN (Research)

Copy To

1. Vinoj P. G, Assistant Professor in ECE.
2. Y. K. Remya, Assistant Professor in Civil Engineering.
3. Susmi Jacob, Assistant Professor in Computer Science.

* This is a computer system (Digital File) generated letter. Hence there is no need for a physical signature.

Annexure II

# APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
## Centre for Engineering Research and Development
## Request for releasing RSM grant

Title of Project:

Date of sanction:

Amount sanctioned:

Account No and bank details:

Terms & Conditions for Research Seed Money Scheme

1. The amount sanctioned for the project shall be deposited in a separate Joint A/c of Principal Investigator and Head of the institution where the Principal Investigator works. (Name of A/c: CERD Research Seed Money - File No.)

2. The maximum duration of the project will be three years from the date of start of the project

3. The amount has to be utilized as per budget provision under each head. It is the discretion of the University to settle amount towards the purchase of those items not clearly mentioned, if any, in the project proposal.

4. The purchase of equipments shall be in accordance with the store purchase rules. All equipment purchased will be the property of CERD and the stock entry of the items purchased shall be maintained in the College signed by the Investigator, Lab in charge and Principal. Purchase of computers/peripherals is not allowed unless specifically mentioned in the sanction order.

5. For Private self financing Colleges, 50% of the actual Equipment cost subjected to the maximum of sanctioned amount will be reimbursed by KTU if and only if the proof of remittance of other 50% is produced by the college.

6. The stock entries of consumables purchased shall also be done in the consumables stock register of College. Purchase of stationery shall be for project purpose only.

7. Books and literature purchased should be taken into the Stock Register of Central Library or Department library and then distributed to the investigators.

8. The interest accrued will also be accounted in the project.

9. On completion of the project, detailed report of the research work (hard and soft copies), audited statement of accounts and Utilization Certificate in the prescribed format duly attested by the head of the Institution shall be submitted within one month on completion of the project for settlement of accounts.

10. If the project is not completed within the time limit, the grant amount should be reimbursed along with the interest accrued.

11. The CERD reserves the right to terminate the project at any stage if it is convinced that the grant has not been properly utilized or appropriate progress is not being made. In addition, the CERD may designate Scientist/Specialist or an Expert Panel to periodically review the work done. The Principal Investigator has to appear for the periodic review meetings.

12. If the PI to whom the project has been sanctioned, leaves the Institution, the Head of Institution/PI shall inform the same to the CERD and in consultation with the CERD, evolve steps to ensure successful completion of the project, before relieving the PI.

13. Investigators must acknowledge the CERD in reports and technical/scientific papers published based on the research work done under the project. Investigators are requested to publish some of the research papers emerging out of the project work in leading journals.

14. If the results of research are to be legally protected by way of patent/copy rights etc. the results should not be published without action being taken to secure legal protection for the research results.

15. The knowledge generated from the project will be the property of the CERD and should be properly acknowledged. Transfer of technology generated shall be done in consultation with the CERD.

We agree to the terms and conditions stated above. Please transfer the amount to the above bank account.

Signature of Principal Investigator:

Name:

Designation:

Signature of Head of Institution:

Name:

Office Address:

Seal

## Annexure III

**(Stamp paper Rs 200)**

**MEMORANDUM OF UNDERSTANDING [MOU]**

BETWEEN

**-Name of Self Financing Engineering College-**

AND

**APJ Abdul Kalam Technological University (KTU), THIRUVANANTHAPURAM**

This Memorandum of Understanding is entered into at Thiruvananthapuram on this --- Day of Month Year

BETWEEN

**-Name of Self Financing Engineering College- affiliated to APJ Abdul Kalam Technological University (herein after referred to as COLLEGE) which expression shall unless it be repugnant to the context or meaning thereof to be deemed to mean and include its successors and assigns, represented by The Principal, ---Name of college- place of college -, of the ONE PART.**

AND

**APJ Abdul Kalam Technological University, CET campus, Thiruvananthapuram-695016 (herein after referred to as KTU) which expression shall, unless it be repugnant to or inconsistent with subject or context thereof, include and be deemed to include their heirs, successors and assigns, represented by The Dean (Research), APJ Abdul Kalam Technological University, Thiruvananthapuram 695016 of the OTHER PART.**

### 1. TERMS OF UNDERSTANDING

1.1. This memorandum of understanding lists out the terms of releasing and utilization of CERD research seed money fund sanctioned to a faculty of COLLEGE for the year ---------------.

1.2. The scheme is constituted for the purpose of providing assistance in the form of grants to initiate research work in Engineering and Technology with particular relevance to the State of Kerala in the economic and industrial development.

1.3. Grant will be released to the principal investigator of the project through the Head of the Institution.

1.4. The maximum duration of the project will be three years from the date of start of the project

1.5. On completion of the project, one copy of the final project report on the work done should be sent to the CERD along with the utilization certificate (UC) and statement of expenditure (SE).

1.6. The institute will maintain separate audited accounts for the project.

1.7. The institute will not entrust the implementation of the work for which the grant is being sanctioned to another institution nor will it divert the grant receipts to other institute as assistance.

1.8. The CERD reserves the right to terminate the project at any stage if it is convinced that the grant has not been properly utilized or appropriate progress is not being made. In additon, the CERD may designate a Scientist/Specialist or an Expert Panel to review the work done.

1.9. If the PI to whom the project has been sanctioned leaves the Institution, the Head of Institution/PI will inform the same to the CERD and in consultation with the CERD, evolve steps to ensure successful completion of the project, before relieving the PI.

1.10. Investigators must acknowledge the CERD in reports and technical/scientific papers published based on the research work done under the project. Investigators are requested to publish some of the research papers emerging out of the project work in leading journals.

1. 11. If the results of research are to be legally protected by way of patent/copy rights etc. the results should not be published without action being taken to secure legal protection for the research results.

1.12. The knowledge generated from the project will be the property of the CERD and should be properly acknowledged. Transfer of technology generated shall be done in consultation with the CERD.

1.13. For Private self financing Colleges, 50% of the actual Equipment cost subjected to the maximum of sanctioned amount will be reimbursed by KTU if and only if the proof of remittance of other 50% is produced by the COLLEGE.

1.14. The equipment details must be entered in the stock register of the college and signed by the Investigator, Lab in charge and Principal.

1.15. The college should submit annually the status and details of earlier grants received from KTU with pending statement if any.

1.16. The grant amount should be deposited in a separate bank account in the name of the Principal investigator and Head of Institution jointly.

1.17. The interest accrued shall also be accounted in the project.

1.18. If the project is not completed within the time limit, the grant amount should be reimbursed along with interest accrued.

We agree to the terms and conditions stated above.

## 2. SCOPE OF MOU

Nothing in this Memorandum is intended to or shall be deemed to establish an exclusive relationship between the parties or to restrict any activities that either party would otherwise be able to undertake. Nothing in this Memorandum is intended to or shall be deemed to establish any partnership or joint venture between the parties or constitute any activities that either party would otherwise be able to undertake.

## 3. PERIOD

This MOU shall be perpetual. This agreement will be amended or modified by the University at any time.

## 4. DISPUTE RESOLUTION AND ARBITRATION

This memorandum of understanding shall be governed by the laws of Union of India and State of Kerala. Any dispute arising with this MOU shall be brought to the notice of the Vice-chancellors of the parties who shall try to resolve them, failing which legal reasoning be taken in the jurisdiction of court in Thiruvananthapuram.

The terms and conditions of this memorandum of understanding shall not be disclosed to any third parties by any party of this memorandum of understanding without the prior written consent of both parties.

## 5. FORCE MAJEURE

Without prejudice to accrued liabilities and rights, no party shall have any liability whatsoever to the other Party or be deemed to be in default by reason of delay or failure in performance under this memorandum of understanding to the extent that such delay or failure is caused by or arises from acts or circumstance or events beyond the reasonable control of that party, including but not limited to acts of god, acts or regulations of any governmental authority, war or national emergency, accident, fire, riot, strikes, lock-outs, industrial disputes, natural catastrophes or epidemics.

Each Party shall bear its own losses arising from such force majeure event(s), if any.

## 6. INTELLECTUAL PROPERTY

All prior Information, design and data existing with either party before the signing of this MoU (pre-existing IP) shall be the sole property of the concerned party. All Intellectual Property including design information, designs, source codes and data generated through the collaboration under this MOU shall be as mutually agreed in writing and also as per the guide line of the funding agency, if such an agency is involved. Any IPR arising specifically out of this collaboration will be owned by both parties, except when mutually agreed in writing otherwise.

**IN WITNESS WHEREOF**, the parties hereto have caused this memorandum of understanding to be executed in duplicate, through their representatives at Thiruvananthapuram in the day and year first above written:

Now the memorandum of understanding witnesses as follows.

| | |
|---|---|
| **Principal** | **Dean (Research)** |
| **Name of College** | **APJ Abdul Kalam Technological University** |
| **Place** | **Thiruvananthapuram 695016** |

| | |
|---|---|
| **Witness: 1** | **Witness: 1** |
| Signature : | Signature : |
| Name : | Name : |
| **Witness: 2** | **Witness: 2** |
| Signature : | Signature : |

SCMS School of Engineering and Technology

| Sl.No | Name of Principal Investigator | Branch | Title of the Project | Amount sanctioned | First Installment | Second Installment | Consumables | Equipments | Travel | Contingency |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VINOJ P G<br>Assistant Professor | ECE | Brain Actuated Assistive Technology for the paralyzed | 75,000 | 50,000 | 25,000 | 15,000 | 40,000 | 10,000 | 10,000 |
| 2 | Y K Remya<br>Assistant Professor | Civil | Geometric design consistency evaluation criteria for two lane rural combined curves | 1,20,000 | 60,000 | 60,000 | 55,000 | | 5000 | 60,000 |
| 3 | Susmi Jacob<br>Assistant Professor | CSE | ContextAuth – An implicit Authentication system for Smartphones | 75,000 | 55,000 | 20,000 | 20,000 | 50,000 | | 5,000 |

Ref. No. BIRAC SRISTI PMU – 2020/007

December 31, 2020

**Subject: Sanction Letter of SITARE GYTI Award**

To,

**Awardee:** Vinoj P.G

**Supervisor Dr. Sunil Jacob**

**Institute Name:** SCMS School of Engineering & Technology, Kerala

You have been granted a sum of Rs. 15,00,000/- to further work on Project **"Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralysed"**.

You need to sign an agreement called Grant Award Letter Agreement (GALA) which must contain the relevant Annexures for Specific objective, Plan of work (Activities, Time Period & Milestones) and Output. The GALA had already been sent to you. The budget utilization in all phases must be as per the signed GALA and in all cases GALA guidelines will be followed.

**Project Period:** 2 Years (3 Semester; 1 Semester = 8 months)

**Release of The Grant:** In three instalments

vii. 33% (Rs. 5,00. 000/-) after the signing of GALA

viii. Next 67% (Rs. 10, 00, 000/-) in other two instalments of around 33% each after every eight months on completion of at least 80% of that semester's work as per milestones.

**You are required to submit the following:**

xiii. Progress Report after every eight months.

xiv. Audited Expenses Report (Utilization Certificate – UC & Statement of Expenditure - SOE) after every eight months and at the end of the project period.

xv. Compiled Project Report along with compiled UC of all phases at the end of the project period.

xvi. The next phase will be released after the approval of review committee meeting.

You are also required to return the unutilized grant at the end of the project period. The budget utilization will be done under GALA guidelines.

On successful completion of the project work, you will be issued a Project Completion Certificate from SRISTI.

Thanking you

BIRAC SRISTI PMU

# SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

Accredited by NAAC, Affiliated to APJ Abdul Kalam Technological University, Kerala and Approved by AICTE, Govt. of India
An ISO 9001:2015 Certified Institution

CAMPUS: VIDYA NAGAR, KARUKUTTY, ERNAKULAM-683576 PHONE: 0484-2882900, 2450330
E-mail: sset@scmsgroup.org • Website: www.scmsgroup.org/sset


## STATEMENT OF EXPENDITURE

**Project Title: "Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For paralysed"**
**Name of Institution: SCMS School of Engineering & Technology, Karukutty,Kerala**

| | Receipts | Amount (Rs) | | Payments | Amount (Rs) |
|---|---|---|---|---|---|
| 1 | Amount sanctioned from BIRAC SRISTI | 500000/- | 1 | Development of Prototype | 389483 |
| 2 | Interest | 5036 | 2 | Travel | 12620 |
| 3 | Others | 65 | 3 | Incubator Rentals | 60000 |
| | | | 4 | Man Power | NIL |
| | | | 5 | Consumables | 24166 |
| | | | 6 | Contingencies | 18832 |
| | Total | 505101 (Five Lakh Five Thousand One Hundred and One) | | Total | 505101 (Five Lakh Five Thousand One hundred and one) |

Certified that I have exercised all kinds of checks to see that the grant has been utilized for the purpose for which it was sanctioned by BIRAC SRISTI (Ref. No. BIRAC SRISTI PMU - 2020/007).

VINOJ P.G

Name & Signature of the Awardee

Name & Signature of Head of the Institution

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

Office Seal

UDIN:22207419AGQASA9799

Name & Signature of Accounts Officer/ Chartered Accountant

P.K. THOMAS,FCA,DISA (ICA)
CHARTERED ACCOUNTANT
SOUTH JUNCTION
CHALAKUDY - TCR - 680 307
MNO: 207419, Ph:0480-2707989

Project Report

ON

# Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed

**BIRAC- SITARE**

**SRISTI-GYTI Awards**

**Proposal Reference No.: BT/BIRAC/SITARE-GYTI-0144/01/19**


PHD Scholar: VINOJ P.G

Research Guide: Dr. Sunil Jacob

Institute: SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

UNIVERSITY: APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, KERALA

Table of Contents

**Abstract:** Due to partial or full paralysis due to stroke, the majority of patients are compelled to rely upon parental figures and caregivers in residual life. With post-stroke rehabilitation, different types of assistive technologies have been proposed to offer developments to the influenced body parts of the incapacitated. In a large portion of these devices, the clients neither have control over the tasks nor can get feedback concerning the status of the exoskeleton. Additionally, there is no arrangement to detect user movements or accidental fall. Rehabilitation is the natural remedy for recovering from paralysis and enhancing the quality of life. Brain Computer Interface (BCI) controlled assistive technology is the new paradigm, providing assistance and rehabilitation for the paralysed. But, most of these devices are error prone and also hard to get continuous control because of the dynamic nature of the brain signals. Moreover, existing devices like exoskeletons bring additional burden on the patient and the caregivers and also results in mental fatigue and frustration. In Phase1 the proposed framework tackles these issues utilizing a Brain-Controlled lower limb exoskeleton (BCLLE) in which the exoskeleton movements are controlled based on user intentions. An adaptive mechanism based on sensory feedback is integrated to reduce the system false rate. The BCLLE uses a flexible design which can be customized according to the degree of disability. The exoskeleton is modelled according to the human body anatomy, which makes it a perfect fit for the affected body part. The BCLLE system also automatically identifies the status of the paralyzed person and transmits information securely using Novel-T Symmetric Encryption Algorithm NTSA to caregivers in case of emergencies. The exoskeleton is fitted with motors which are controlled by the brain waves of the user with an electroencephalogram EEG headset. The EEG headset captures the human intentions based on the signals acquired from the brain. The brain-computer interface converts these signals into digital data and is interfaced with the motors via a microcontroller. The microcontroller controls the high torque motors connected to the exoskeleton joints based on user intentions. Classification accuracy of more than 80 is obtained with our proposed method which is much higher compared with all existing solutions. In phase 2 of our work we created Artificial Muscle Intelligence with Deep Learning (AMIDL) system. AMIDL integrates user intentions with artificial muscle movements in an efficient way to improve the performance. Human thoughts captured using Electroencephalogram EEG sensors are transformed into body movements, by utilising microcontroller and Transcutaneous Electrical Nerve Stimulation (TENS) device. EEG signals are subjected to pre-processing, feature extraction and classification, before being passed on to the affected body part. The received EEG signal is correlated with the recorded artificial muscle movements. If the captured EEG signal falls below the desired level, the affected body part will be stimulated by the recorded artificial muscle movements. The system also provides a feature for communicating human intentions as an alert message to caregivers, in case of emergency situations. This is achieved by offline training of specific gesture and online gesture recognition algorithm. The recognised gesture is transformed into speech, thus enabling the paralysed to express their feelings to relatives or friends. Experiments were carried out with the aid of healthy and paralysed subjects. The AMIDL system helped to reduce mental fatigue, miss-operation, frustration, and provided continuous control. The thrust of lifting the exoskeleton is also reduced by using lightweight wireless electrodes. The proposed system will be a great communication aid for the paralysed to express their thoughts and feelings with dear and near ones, thereby enhancing the quality of life.

**INDEX TERMS** Artificial Muscle Intelligence, Assistive technologies, BCI, EEG, Exoskeleton, Healthcare, Intelligent solutions, Deep Learning System, Paralyzed, Stroke.

# 1. Introduction

The recent survey by reeve foundation revealed the impact of paralysis on world population, affecting approximately 5.4 million people [1, 2]. The survey also identified stroke (33.7%) as the major cause for paralysis. Paralysis is the increasing interest and involvement in the field of post stroke rehabilitation. Exoskeleton-assisted technologies have emerged as a reliable means for rehabilitation of the affected upper and lower limbs [3]. Exoskeleton movements were controlled using sensors like gyroscopes, accelerometers, and potentiometers. Recently the focus is on controlling exoskeleton using Brain Computer Interface (BCI) [4]. Javier et al. demonstrated upper limb movement of the paralyzed using EEG signals [5]. A closed loop is established between human thought and movement of paralyzed limbs using non-invasive BCI [6]. Android feedback based BCI training is employed to enhance brain rhythms during motor imagery task. The realistic feedback is realized in training sessions using humanoid robots [7]. Humanoid robot is navigated in a real-time indoor environment based on human intentions. The asynchronous BCI system was designed using two level classifiers [8]. Co-operation and coordination of dual robotic arm is demonstrated using an EEG based system. SSVEP (Steady-State Visual Evoked Potentials) are utilized to improve the user concentration level [9]. Electromyography (EMG) sensors are also used to control exoskeleton movements, EMG returns the information regarding human muscular activity [10]. The motor adaptability of the upper limb is predicted using resting state functional connectivity. The system could identify effectiveness of robotic upper limb rehabilitation in different patients [11]. However, the system does not investigate real time human behaviours and thoughts. The clinical trials to investigate the effectiveness of BCI training sessions on stroke patients with upper limb paralysis are carried out. The results of the trial indicate that BCI based assistive devices are effective for post stroke rehabilitation [12]. Human intentions measured through cortical potentials were used to control upper-limb exoskeleton movements. The BMI system eliminated the need for recalibration but resulted in large false positive rates [13]. The Grasping feature is incorporated into the assistive device for amputees using non-invasive EEG control. The participants were able to grasp the objects, but resulted in low success rate without sufficient training [14]. Brain activity is modulated to control robotic arm with multiple degrees of freedom. The system demonstrated the effective control of robotic arm with few training sessions, but increased the latency periods during certain operations [15]. Hybrid BMI system based on sensorimotor cortical desynchronization (ERD) and electromyography (EMG) activity was designed to control upper limb movements. The integration of BMI, NMES and exoskeleton improved the system accuracy, but increased the system complexity [16]. The linear control of upper limb is demonstrated using motor imagery based BCI and Functional Electrical Stimulation (FES), support is provided to the arm using passive exoskeleton. The generated limb movement is evaluated to identify the precise positioning [17]. The self-induced EEG variations based on ERD/ERS is utilized for controlling upper limb movements. Distinguishable patterns are obtained for left and right-hand movements in both motor imagery and motor execution experiments [18]. Online robot control using motor imagery based BCI is designed with high classification accuracy. The mental imagination of hand movement is detected for controlling the robot movements [19]. An integrated platform consisting of BCI controlled exoskeleton, functional electrical stimulation (FES) with proprioceptive feedback is developed. Goal directed motor task is used for training and subjects could complete the task with minimum latency period [20]. In our previous works [21-23], we have demonstrated an alternative technology to exoskeletons using non-invasive brain signals. Also, exoskeletons with feedback mechanisms have also been implemented by us [22]. The paralyzed body part is stimulated using Transcutaneous Electrical Nerve Stimulation (TENS) device and Microcontroller [24]. Because of the dynamic and uncertain nature of brain signals, most of the BCI systems result in miss-operation, mental fatigue and it is hard to produce continuous control. The proposed system is designed to address the above gaps in research.

In the phase 1 of the proposed work, we use a gyroscope in the BCI headset to control the directions along with only two mental commands. This reduces the load on the system and increases the speed of the exoskeleton. The exoskeleton interfaced with the brain is controlled based on the decoded brain signals. In correspondence to the mental commands recognized, the high torque motors connected to the joints of the exoskeleton are activated. The exoskeleton is made using carbon fibre which makes it light and hence user-friendly. The exoskeleton replicates the movement of a healthy functioning leg using all the joints. Sensory feedback is introduced to reduce the system false rate. The user intentions given to the system are converted to motor actions. If the produced motor action is not sufficient to trigger the actual limb movement, an adaptive algorithm is used to make the corrective action. The status of the paralyzed and emergency rescue information is transmitted wirelessly to the corresponding caregivers. NTSA encryption and decryption algorithm is used to transmit the information securely to the intended user without interference. Walsh– Hadamard transform is used for feature extraction of brain signals. The extracted features along with Hadamard coefficients are transmitted wirelessly from brain to the lower limb via Bluetooth. At the receiver side using the Hadamard coefficients, the original brain signals are reconstructed. The feature extraction and reconstruction is implemented for all five different user intentions. The Brain-Controlled Lower Limb Exoskeleton (BCLLE) analyses the human thoughts and transforms it into different movements on a unique lower limb structure. The contributions of our phase1 research are,

- A Brain-Controlled Lower-Limb Exoskeleton (BCLLE) in which the exoskeleton movements are controlled based on user intentions.
- An adaptive mechanism based on sensory feedback integrated with the exoskeleton to reduce the system false rate.
- A flexible design for the exoskeleton which can be customized according to the degree of disability.
- Artificial skin incorporated with sensors which can provide a sense of touch to the body parts of users.
- Automatic identification of the status of the paralyzed person and secure transmission of information to caregivers in case of emergencies

In the phase2 of the research, AMIDL is designed to reduce miss-operation, user fatigue and to enhance user capabilities. In the proposed work, human intentions are monitored in real-time employing 16 channel EEG sensors. TENS machine is integrated with Muscle Inspired Algorithm (MIA) to produce movements on the upper limb. Subjects are relieved from the task of carrying exoskeleton structure. The system is designed to perform six different movements on the affected upper limb. The different hand postures used to trigger the rehabilitation process are Release, Grasp, Rollup, Roll down, Rollup Release and Rollup grab. In the offline phase, Artificial Muscle movements corresponding to each posture are recorded to create the database. The decoded EEG signals are transformed into muscle activation signals in a real-time environment. The captured EEG signal is converted into frequency domain using Walsh Hadamard Transform (WHT) for feature extraction. The extracted features along with WHT coefficients are utilized for the classification of different limb movements. The activation signal is then correlated with the recorded muscle movements. The signal with superior characteristics is passed on to the upper limb electrodes for inducing motion. In case of ambiguity or inadequate EEG signal, the periodic activation of the affected body part will be taken care of by the artificial muscle movements. If the activation is executed by brain signal, the produced gesture is recognized and passed on to the caregiver as voice command. Thus, AMIDL transforms human thoughts into different movements on the unique upper limb structure. The EEG activated movements are utilized for communicating paralyzed person's emergency needs to the caregivers. The contributions of our research are,

• An Artificial Muscle Intelligence with Deep Learning (AMIDL) system without exoskeleton structure, in which movements of paralyzed body parts are controlled based on user intentions.

• An adaptive mechanism based on recorded muscle movements is integrated with the system to enhance continuous control and facilitate rehabilitation.

• Designed flexible assembly, which can be customized according to the degree of disability.

• Communication aid is incorporated in the system using gesture recognition

• The subject concentration is improved by using multimedia feedback

## 2. Literature Survey

In this section, we discuss a few existing devices controlled by Brain-Computer Interface designed specifically for paralyzed people. But the problem with most of them is that the users are unable to get continuous control over the device. The users are required to have a high level of concentration to get sufficient control on the device, which results in mental fatigue and frustration. Additionally, there is no arrangement to take care of the miss-operations. The subjects are also burdened with the task of carrying the load of exoskeleton on the affected body parts. Our research focuses on overcoming these major problems and provides an efficient and flexible solution, which can enhance the post stroke recovery process. Our system also provides a communication aid for the paralyzed to express their feelings. The assistive rehabilitation devices and its EEG control techniques are systematically reviewed and the major gaps are identified [25]. Three-dimensional robotic assistance using motor imagery task for upper limb rehabilitation is demonstrated with multi-joint exoskeleton. Desynchronization of sensorimotor oscillations in the β-band is measured to control the different robotic hand movements [26]. Different upper limb exoskeletons like Track hold [27] and Armeospring [28] are employed to track upper limb movements. Both these devices have integrated passive robots with virtual reality environments to help patients carry out their daily routine activities. Control of assistive robots are improved by integrating electroencephalography (EEG) and electrooculography (EOG). This hybrid approach called brain/neural-computer interaction (BNCI) is adopted to control grasping movements of a hand exoskeleton [29]. Multimodal signal approach is further used to enhance the control system for external devices connected to the upper limb. EEG and EMG signals are integrated to improve the classification accuracy and to reduce the false positive rate [30]. Upper limb robotic orthosis, FES, and wireless BCI are combined in an efficient way on account of EEG signals. EMOTIV EEG device is employed to measure EEG signal, which is used to control grasp/release of an object [31]. An integrated passive robotic system is developed for assisting the paralyzed. The system employs a robotic device which compensates gravitational effects to allow exercise, virtual engines to facilitate interaction and EEG to monitor brain activities. The three components are coordinated in real-time to enhance the rehabilitation process [32]. The effects of BCI therapy on post stroke rehabilitation is analysed based on motor imagery tasks. The analysis is performed by measuring coherence of EEG in different regions of the brain and the best result for motor recovery is obtained for the activation of lesion hemisphere [33]. The online BCI coupled with hand exoskeleton is employed to address the issues related to proprioceptive feedback on the regulation of cortical oscillations. The results show an enhancement in SMR desynchronization with proprioceptive feedback during flexing and extending fingers of the exoskeleton [34]. Multimodal architecture based on BCI, exoskeleton and an active vision system is proposed to enhance BCI control and rehabilitation process. The VR environment coupled with biofeedback helps to reduce mental fatigue and improve user interactions [35]. Few studies have also been conducted in related areas recently [36-42] Feng et al proposed another interesting system using optimal haptic communications [43]. Baoguo Xu et al. [44] proposed a three-dimensional animation to guide upper limb movements using EEG signals. Feature extraction is carried out by Harmonic Wavelet Transform (HWT) and linear discriminant analysis (LDA) classifier was utilized to classify the patterns for controlling the upper limb movements. MR-compatible robotic glove operates pneumatically and doesn't cause any disturbance to functional Magnetic Resonance imaging (fMRI) images during rehabilitation process [45]. The resistance to mechanically actuated movements in an exoskeleton robot is measured based on spasticity. The relevant guidelines for practical neuro-rehabilitation robot design based on degree of spasticity and resistance is established [46]. In most of the design it is hard to get continuous control on the exoskeleton due to the nonstationary nature of the EEG signal. Moreover, the subjects experience metal fatigue and frustration due to lack of superior control. None of the devices in the literature focused on providing communication aid for the paralyzed. Our research focuses on solving these issues in an efficient manner using the AMIDL system proposed in this paper. Table 1 shows the comparisons between AMIDL and existing systems in the literature

| METHOD REFERENCE NO., YEAR | NO. OF SUBJECTS | TYPE OF CONTROL | TYPE OF EEG SIGNAL | DEVICE ASSIGNED | TASK | ACCURACY/ SUCCESS RATE |
|---|---|---|---|---|---|---|
| Ref [14], 2016 | 2 amputees | EEG -based control | Motor imagery Low frequency-time domain feature | Prosthetic hand | Grasping objects | 63.6% |
| Ref [15], 2016 | 13 healthy subjects | EEG-based control | ERD/ERS | Arm exoskeleton | Reach and grasp tasks | 77.8% |
| Ref [12], 2017 | 64 stroke patients | EEG-based control | Motor imagery 5–30 Hz EEG signal | Hand exoskeleton | Hand open/closed | 79.4% |
| Ref [17], 2016 | 7 healthy subjects | EEG-based control | 7–30 Hz EEG signal | ArmeoSpring and FES | left hand, right hand, and feet | 79.6% |
| Ref [16], 2016 | 7 stroke patients | EEG-based control | ERD | ArmeoSpring exoskeleton | Wrist extensor/flexor | 80.7% |
| Ref [13], 2016 | 3 chronic stroke patients | EEG-based control | MRCPs | MAHI exoskeleton | Elbow flexion/extension | 81.3% |
| Ref [11], 2018 | 19 healthy subjects | EEG-based control | 15–25 Hz EEG signals | Robotic Arm | Upper limb movement/reaching | 83.5% |
| Ref [18], 2016 | 4 healthy subjects | EEG-based control | ERD/ERS | Custom upper limb exoskeleton | Left/right hand and left hand versus both feet | 84.29% |
| Proposed System, AMIDL | 20 subjects | EEG and EMG based control | Motor Imagery ERD/ERS with multimedia feed back | TENS device with EMG Electrodes | left or right hand movements | 87% |

**Table 1. Proposed system comparisons with existing system (Sorted by success rate)**

# 3. Methodology

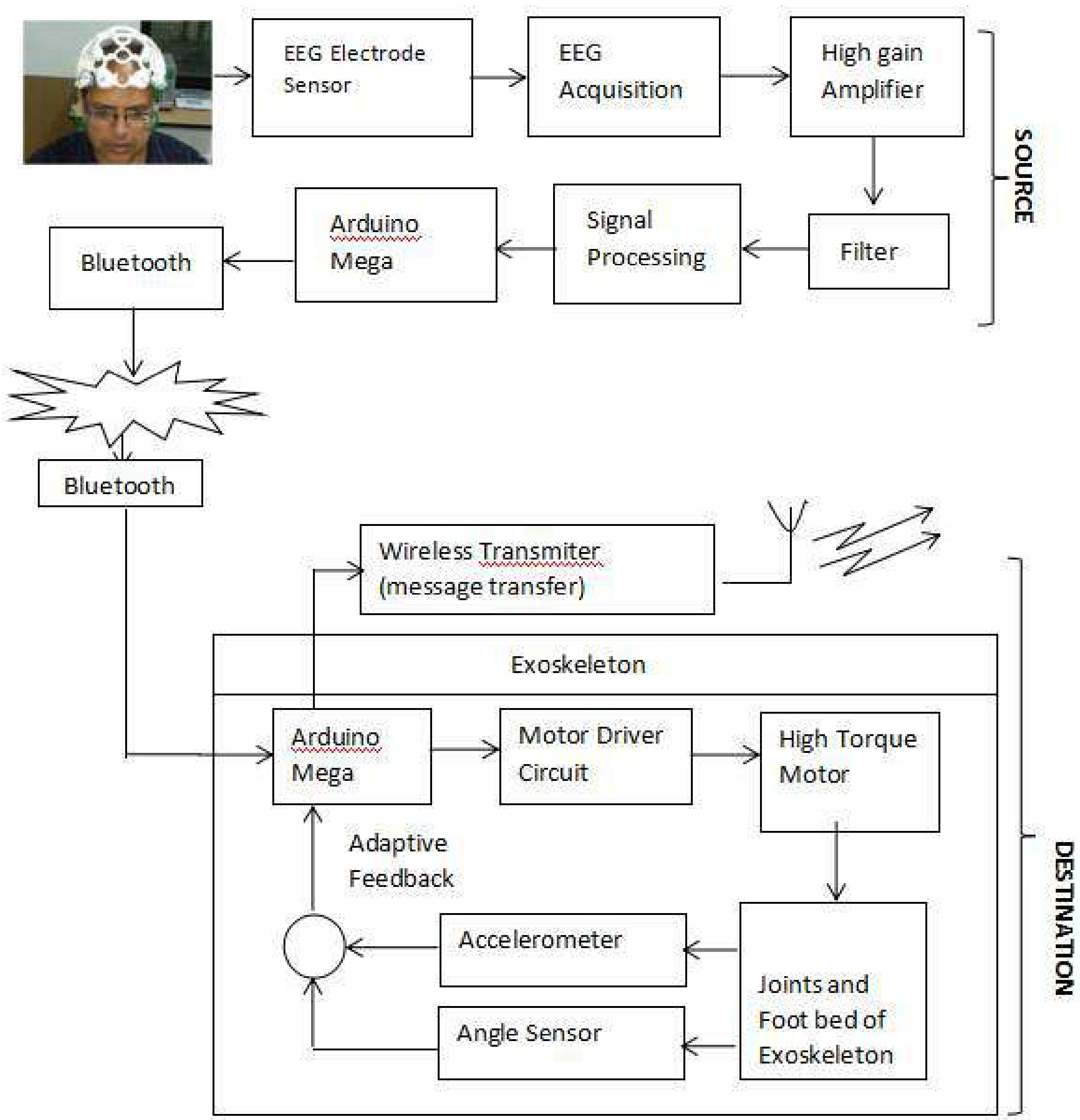


FIGURE 1. System architecture for Brain Actuated Multidimensional Exoskeleton

The architecture of the proposed system is presented in figure 1. The system design comprises an exoskeleton that replicates a lower limb, which is made using carbon fiber. The exoskeleton has total six degrees of freedom including both legs, one on each side of the pelvic bone, one on each knee and one on each ankle. Thus three degrees of freedom on each leg making it total of six degrees of freedom on the entire exoskeleton. Each joint of the lower limb is actuated using high torque motors. The movement of the exoskeleton is facilitated by controlling the degree of rotation of the motors. This exoskeleton is strapped onto the abdomen as well as foot region for improving the stability and balance of the person. Support is also provided on the back side of the ankle region. The angle sensors are placed on the joints to provide feedback regarding the status of exoskeleton. This sensor is also used to validate whether the applied force is sufficient to stabilize the exoskeleton. The fall detection mechanism is implemented by placing an accelerometer on the back side of the lower limb to measure the tilt. If the measured sensor value crosses the threshold, a message will be given to the caregivers for emergency rescue. The exoskeleton is controlled through human intentions. Electroencephalograph (EEG) sensors use non-invasive methods to collect the brain signals from the scalp of the person. EEG sensor has 16 electrodes incorporated in structure, where two electrodes act as the reference for measurement. The conductivity of the electrodes is improved by using gold plating. The signals collected are amplified using a high gain amplifier and a band pass filter is used for filtering high-frequency noise. In the signal processing stage, the signal undergoes further pre-processing and filtering. The suitable pattern based on the mental command is selected by using windowing technique. The signal is converted into digital data which is given as input to the microcontroller. The microcontroller does the classification of each mental command based on the feature extraction. In the training phase, users will be trained for five basic commands (sitting, standing, forward movement, right turn, left turn). The recorded patterns during the training phase will be used by the microcontroller for decision making. The recognized thought patterns will be mapped to five different commands. During the testing phase, the controller makes use of machine learning to recognize and match patterns in the input data along with the training data that is already stored in the system to make the necessary decision regarding the action to be performed. The activation command to the exoskeleton is given by the controller through the Bluetooth module. At the receiver side the microcontroller converts this command into motor action which in turn moves the desired parts of the exoskeleton. Using a three-level sensing mechanism, feedback is given to the microcontroller regarding the status of the exoskeleton. Based on this feedback the microcontroller makes the desired corrections on the activation signals. The sensory feedback gives more stability to the system, and moreover rescue messaging systems are also implemented in case of emergencies.

The secured communication between the paralyzed person and caregiver is achieved using Novel-T symmetric algorithm (NTSA). This algorithm ensures that the data is securely transmitted to the intended caregiver. NTSA is a symmetric algorithm that uses a single 128-bit symmetric key that is agreed upon by sender and receiver for performing encryption and decryption. The 128-bit key is divided into four partial keys k0, k1, k2 and k3. There are 64 rounds with partial keys k0, k1 applied for odd rounds and k2, k3 applied for even rounds. Multiple XOR and shift operations are performed in each round of encryption. The message from the paralyzed person is encrypted using NTSA encryption algorithm to produce ciphertext. The cipher text is transmitted to the caregiver either through the internet or wireless module. The NTSA decryption algorithm decrypts the cipher text using the key and the original message is retrieved at the receiver-end by the caregiver. The NTSA algorithm introduces key confusions in each round of encryption that makes the algorithm safe and secure from possible attacks. This algorithm uses minimum system memory and provides faster response.

## 3.1 system architecture of AMIDL

***AMIDL EEG Acquisition Module***

The system architecture is designed using a modular approach, it consists of three main modules. They are 1) EEG Acquisition Module, 2) Muscle Stimulation Module and 3) Gesture to Voice Conversion Module. Figure 1 indicates the two main modules of the system. The system captures brain signals using an EEG sensor module, which has 14 electrodes to make measurement and two acts as reference. The acquired signal undergoes pre-processing, feature extraction and classification. The low amplitude EEG signal is amplified using a high gain instrumentation amplifier with a gain of approximately 1000-2000 db. The signal is band limited by employing a band pass filter having a pass band frequency of 5-50Hz.Windowing and pattern selection is utilized for getting finite response. Feature coefficients of the signal are extracted using Walsh Hadamard Transform (WHT). These extracted features are used to classify the thoughts into six different movements. The actual brain pattern is reconstructed using the transmitter Hadamard coefficients. The decoded brain pattern is given to the TENS device, which transforms the thought into muscular actions. The muscle inspired algorithm stored in the controller facilitates the process of conversion. In the offline phase, muscle movements corresponding to the six different predefined hand postures are recorded to create the database. The hand postures are recorded using 7 Electromyography (EMG) sensors on the different hand muscles. Five EMG electrodes are placed on the finger muscles to record finger activity. Two electrodes are placed on either side of the elbow to identify roll movements. In the online phase, brain signals based on human thought are acquired and transformed into muscle movement. This transformed muscle movement is then correlated with the recorded muscle movements. The signal with superior characteristics is selected by the controller for producing movements on the affected body part. If the brain signal fails to provide sufficient activation, periodic movements in the upper limb will be triggered by artificial muscle.

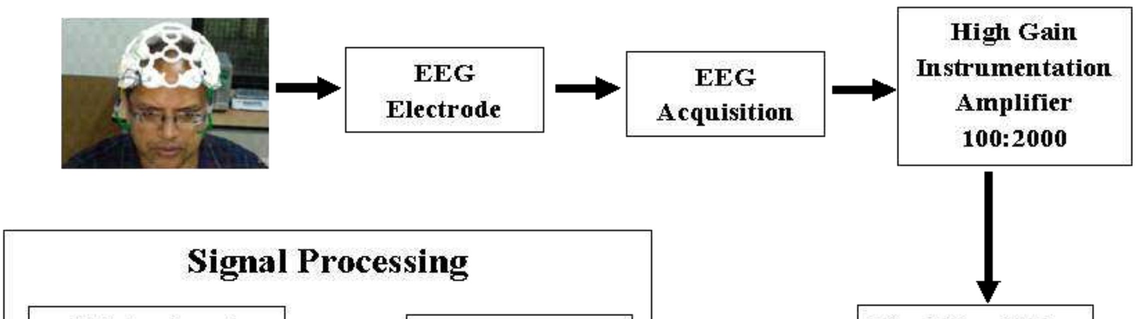

**Figure 2. AMIDL EEG Acquisition and Muscle Stimulation Modules**

### *AMIDL Gesture to Voice Conversion Module*

If the brain signal with superior features activate the upper limb, the created gesture will be captured. Flex sensors placed on each finger is used for acquiring the gesture. The captured gesture will be recognized by the algorithm and transforms it into voice commands for the care givers. Figure 3 depicts the AMIDL gesture to voice conversion module. This module is used to give emergency alert messages to the caregivers or relatives.

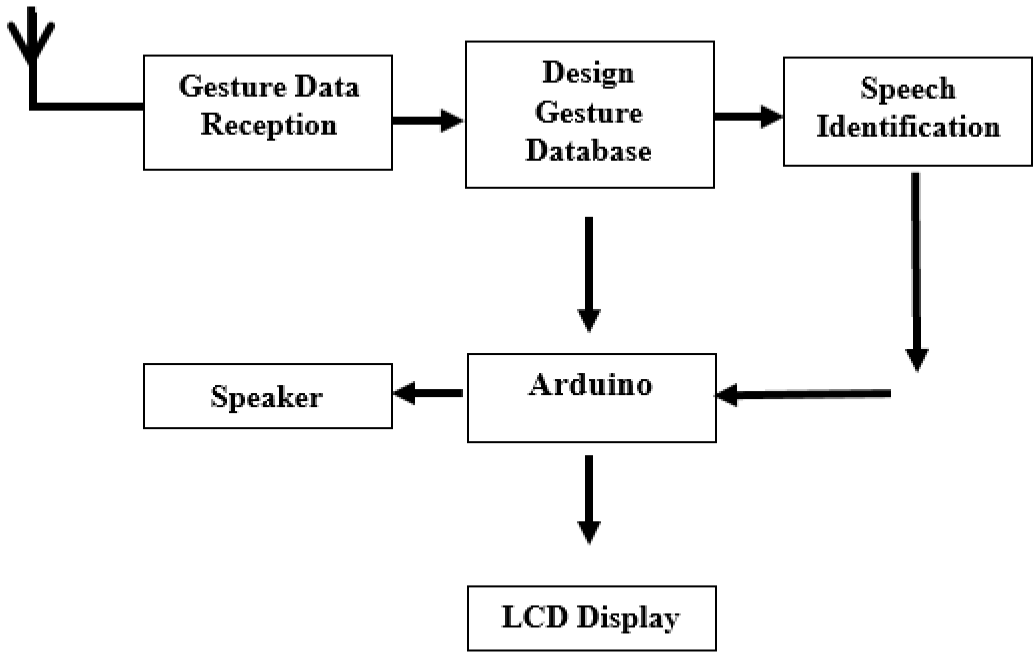


**Figure 3. AMIDL Gesture to Voice Conversion**

# 4. Results and Implementations

### 4.1 Sensor Design

In the initial stages, brain signals are monitored using Emotive EPOC mobile EEG headset. Emotive uses 14 channels to access the raw EEG data and the analysis of acquired data is carried out using integrated software tools. Figure 4 exhibits the Emotive EEG headset deployed in brain signal monitoring. In the latter stages of experimentation Emotive headset is replaced by the designed EEG Sensor. The EEG sensor is manufactured using 3D printer Technology. It has a total of 16 electrodes in which 14 are used for tapping the brain signals and two electrodes act as reference. Figure 5 shows the designed EEG sensor and its electrodes


**Figure 4. Emotive EPOC mobile EEG headset**

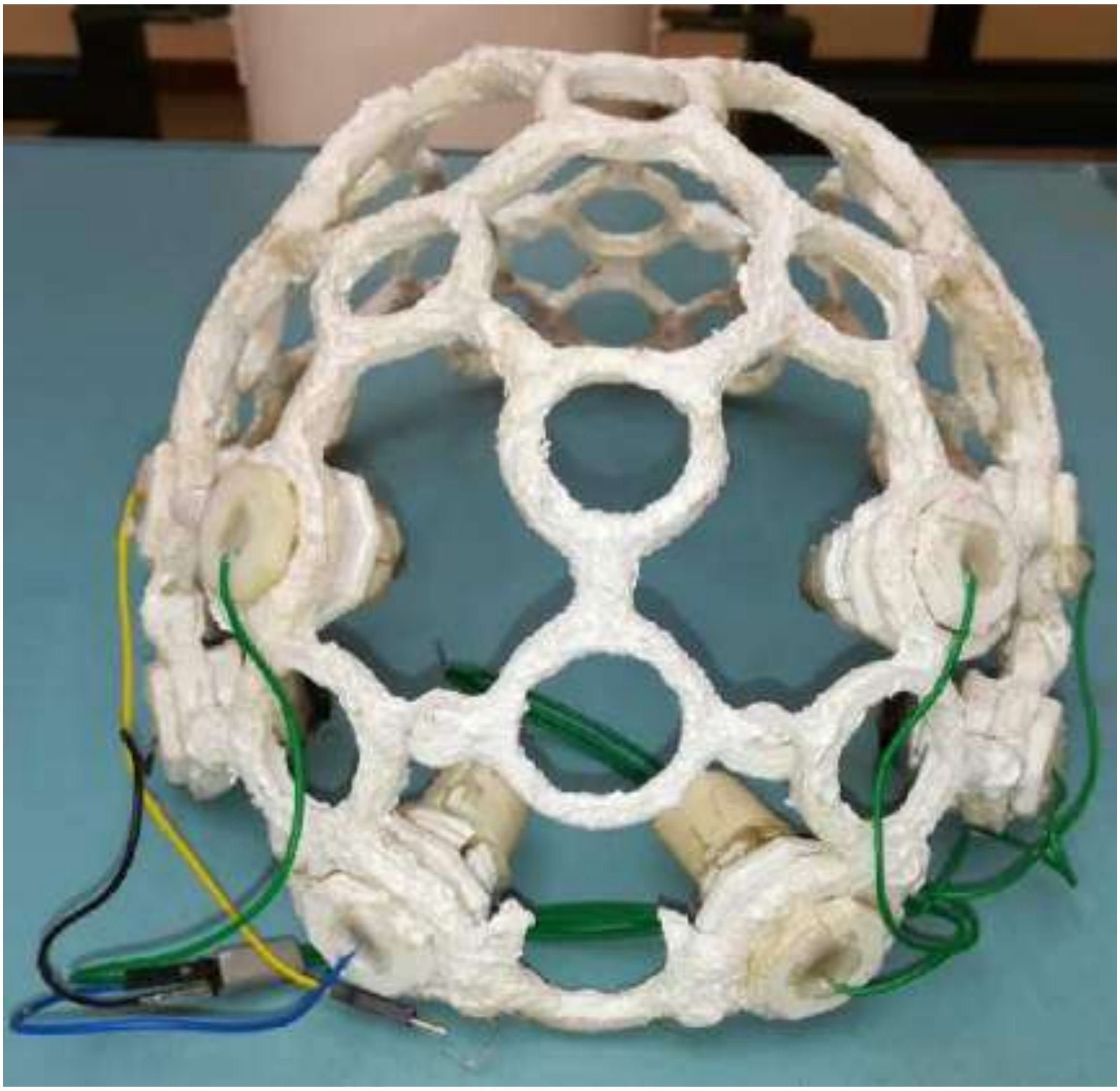

**Figure 5. Designed EEG Sensor with electrodes**

### 4.2 *Exoskeleton Design*

The Lower limb exoskeleton is designed matching the characteristics of the human anatomy. Figure 6 depicts the complete lower body exoskeleton designed using 3D software. The important parts of the exoskeleton are labelled as below

A Gluteal Region
B Hip joint
C Thigh Region
D Knee Joint
E Leg Region
H Ankle Joint
G Foot Region

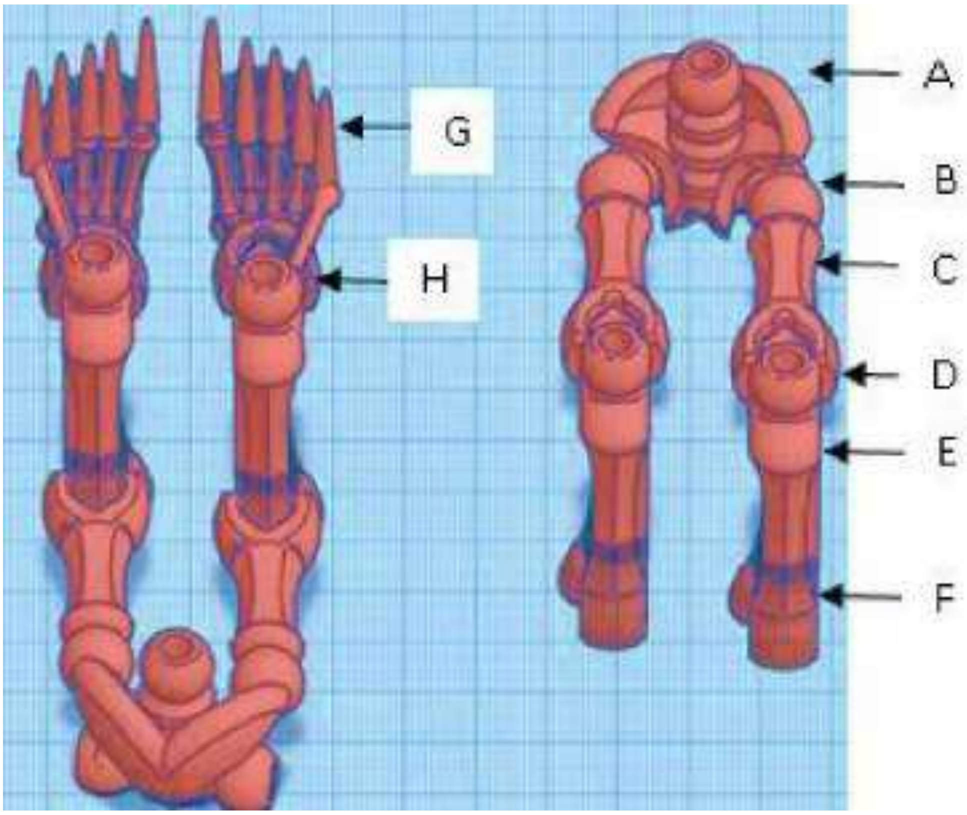


**Figure 6: Complete Lower body part exoskeleton**

These parts are flexible and allow easy attachment and detachment. For the fully paralyzed, the complete exoskeleton will be used. In case of partial paralysis, we can detach the complete assembly into separate parts. The carbon fiber material is used for the construction of exoskeleton. This provides the exoskeleton, easier mobility and light weight. To get better adhesion to the exoskeleton two supports are designed: one over the foot region and other on the back side of the ankle joint

### 4.3 Artificial Skin Preparation

The sensor circuit is incorporated in the artificial skin to get the sense of touch or feeling for the exoskeleton. The skin will be placed over the designed exoskeleton model with all the essential circuits. This gives the exoskeleton the functionality and aesthetics similar to the human body parts. Silicon rubber is the material used for constructing the artificial skin. The artificial skin acts as a protective coating and binds together the entire exoskeleton structure. Figure 7 illustrates the developed artificial skin along with its SMD components. ATtiny45 microcontroller is used for capturing vibrations and sense of touch using different sensors integrated into the circuit. The PCB design of the circuit is done using Fritzing software which is an open source tool for PCB design. The design is optimized for compactness by appropriate placement of components and reducing the line width.

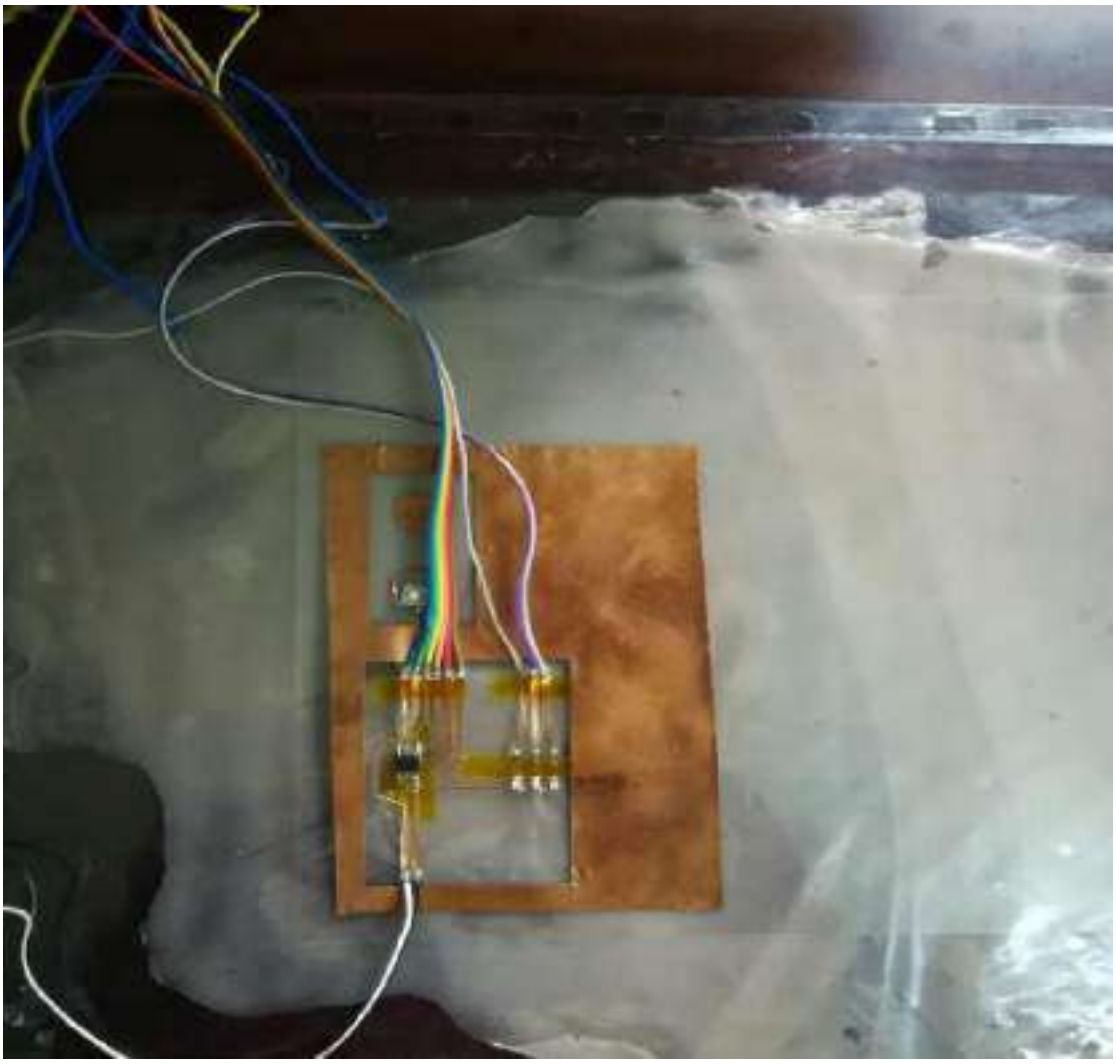

**FIGURE 7**. **Artificial Skin along with processor and sensor circuit**

**4.4 Mechanical structure and hardware design of Exoskeleton**

The mechanical structure of the exoskeleton is designed using high torque motors with geared mechanisms. Figure 8 shows the subject controlling the internal part of the exoskeleton using his thoughts. This part of the exoskeleton will be encapsulated inside the designed 3D model. The 3D model along with artificial skin gives the exoskeleton the aesthetics and functionality similar to the human body part. Figure 9 displays the PCB of the control unit and associated circuits which control all the movements of exoskeleton. Driver circuits are designed to provide enough current to activate the high torque motors and actuators. The output of the sensors integrated in the artificial skin is connected to the control unit. The PCB of the control unit, driver circuits and sensor circuit will be embedded inside the exoskeleton module. After powering up, the microcontroller waits for human command, based on the detected posture, the microcontroller activates the corresponding motor rotations. Then the microcontroller scans the sensor value to validate if the applied activation signal is sufficient to make the exoskeleton stable. According to the sensor value, alterations will be made on the excitation signal. Thus using an adaptive mechanism, the system improves the stability and reduces the errors. The sensors are also utilized for providing a sense of touch. The pressure sensors accept the external force on the skin surface, converting it into vibrations with the aid of a control unit. The vibrations produced on the affected body part are proportional to the applied force. These vibrations or sense of touch also assist in the rehabilitation process. Testing and validation of the hardware design are done using different human controlled movements in the online and offline phase.

**FIGURE 8.Controlling the outer structure of exoskeleton using EEG headset**

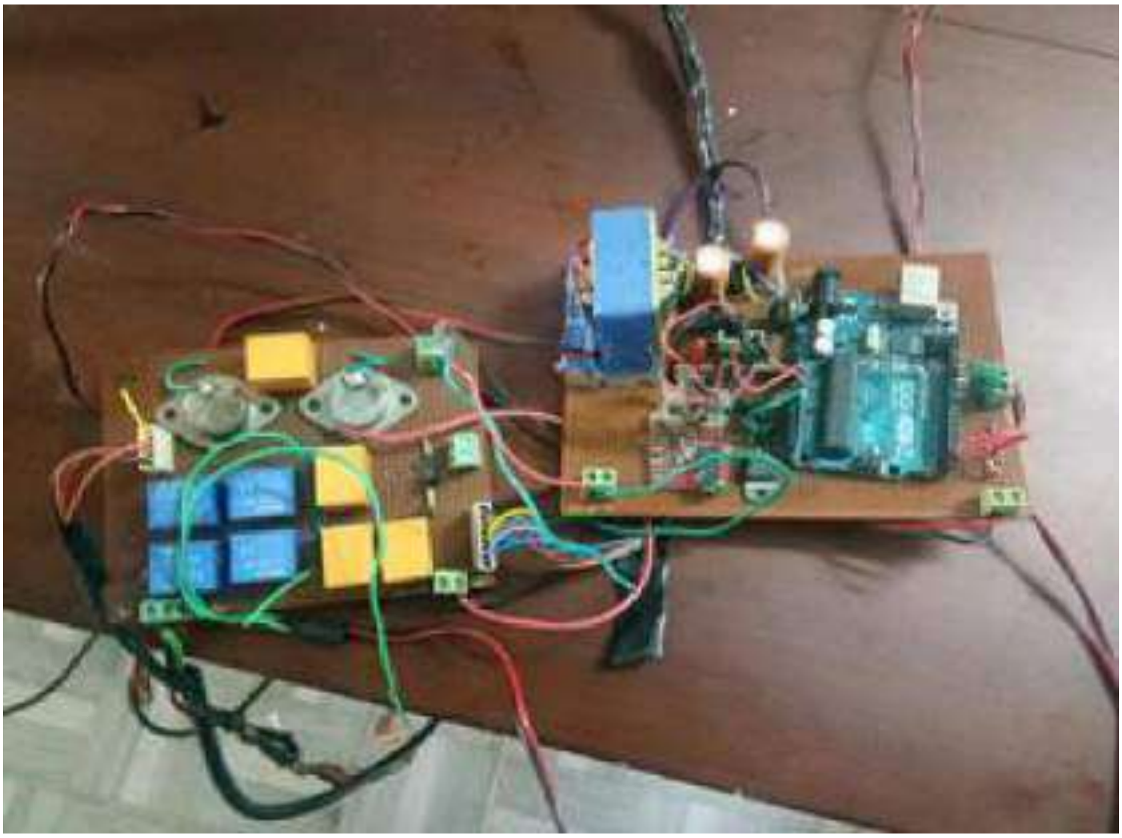

**FIGURE 9.PCB of microcontroller and its associated driver**

### 4.4 Results of EEG patterns using Realistic Head models

EEG analysis is carried out using realistic Head models to identify the unique EEG signal features and to validate the brain network connectivity. EEG signal is acquired by 16 electrodes placed in the frontal and parietal regions of the Brain. Figure 10 indicates the electrode placement scheme followed in the experimentation. The electrodes E12, E5, E13, E6, and E7 are placed in the parietal region and remaining in the frontal region, as shown in Figure 10. The power spectral analysis is carried out for each electrode used in the signal acquisition, Figure 11 indicates the brain patterns variations at different frequencies based on power spectral density. The brain signal analysis using realistic head models is carried out for different human intentions and on a variety of healthy and unhealthy subjects with repeated trials. Figure 12 depicts the realistic head models with active and non-active region variations

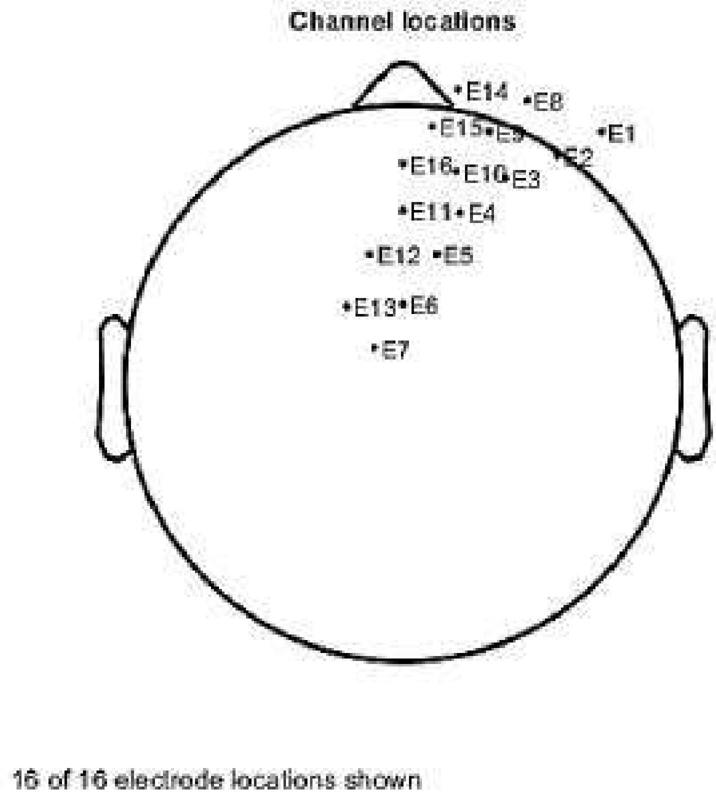


**FIGURE 10. Location of 16 different electrodes**

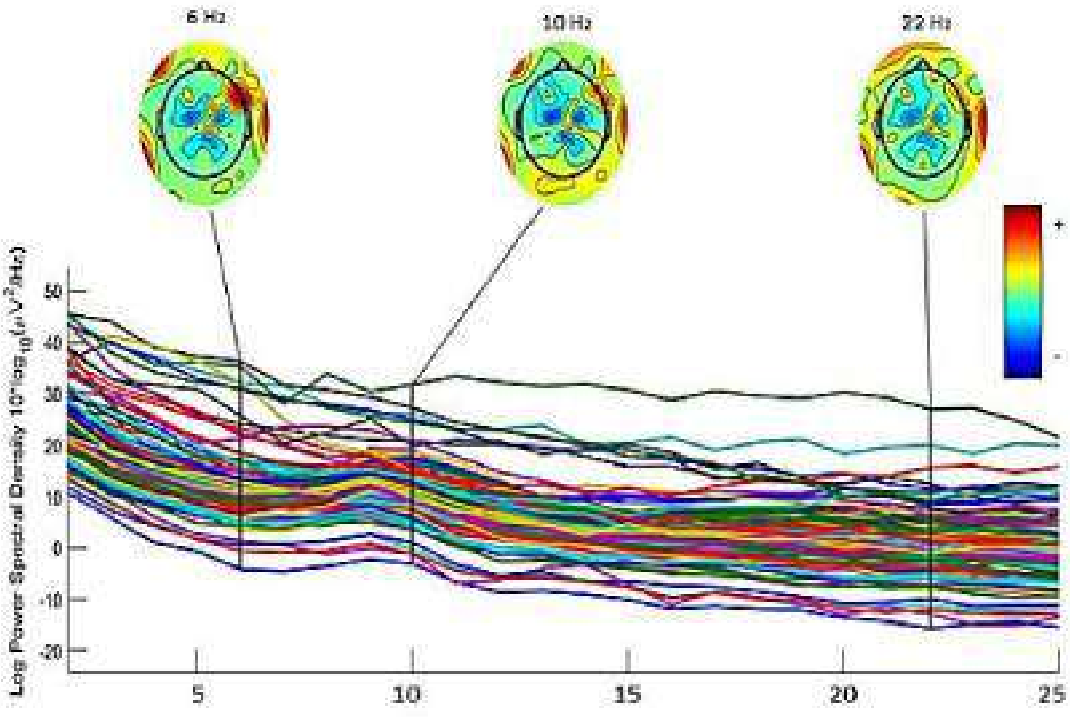


**FIGURE 11. Brain pattern variations at different frequencies**

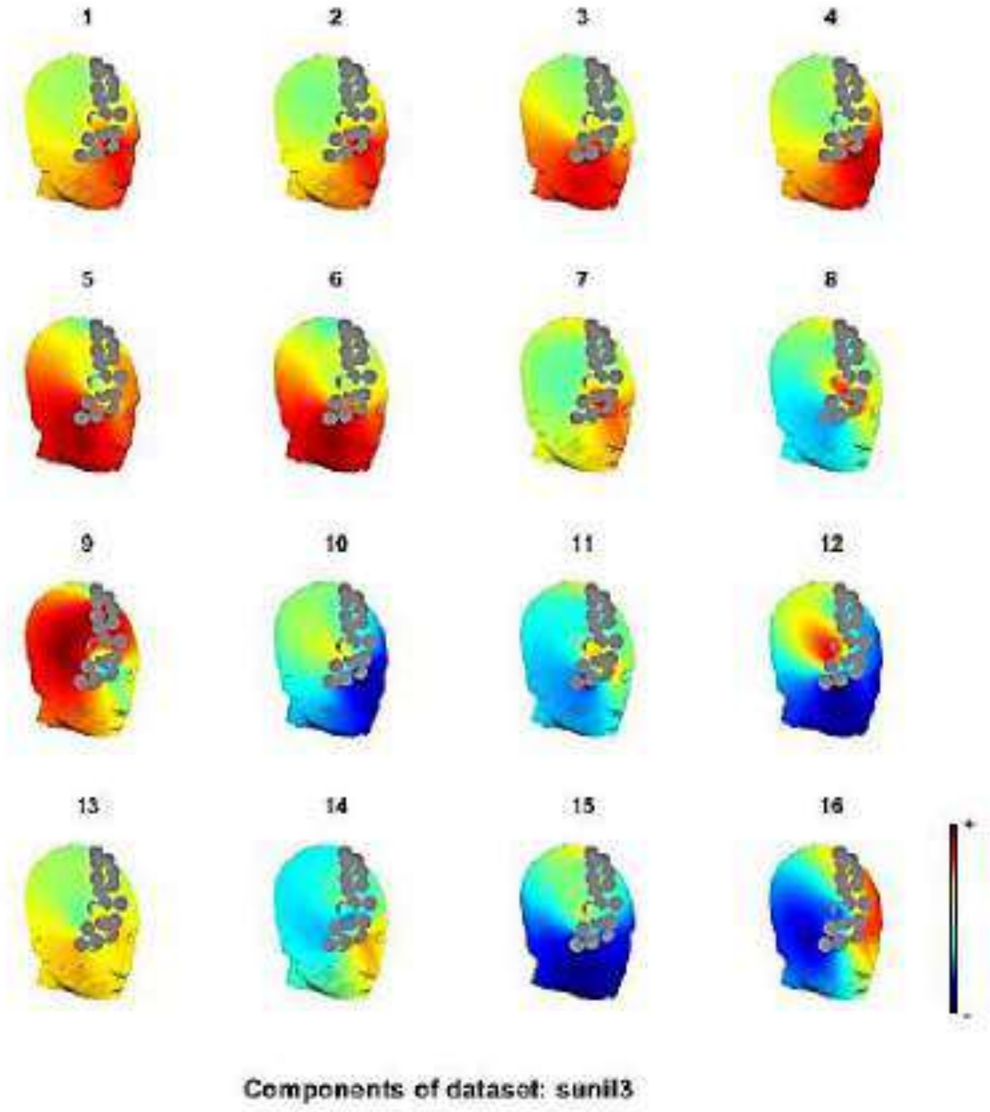


**FIGURE 12. Realistic head model with active region**

### 4.5 AMIDL Acquisition and stimulation process

The muscle stimulation module receives the data using a wireless module. The received data is converted into muscle movements or stimulation using muscle inspired algorithms stored in Arduino along with the TENS device interfaced to it. The output of the TENS is connected to the EMG electrode through EMG shield to activate the affected upper limb movements. The EMG shield helps to customize the stimuli produced by the TENS device. The entire assembly used for acquisition and stimulation is depicted in figure 13. Signal undergoes further pre-processing and filtering to reduce the high frequency noise. Frequency domain conversion of the signal is done by using WHT transform and a finite sample is selected using window technique. The design uses a microcontroller in the acquisition and muscle stimulation module. The microcontrollers communicate with each other using Bluetooth technology. Bluetooth is selected because the short distance between modules and data rate required is less than 1mbps. EEG sensors and other electronic circuits are interfaced to the microcontroller to design the PCB. Figure 14 shows the electronic assembly used in our experimentation.

**Figure 13. Acquisition and stimulation process**

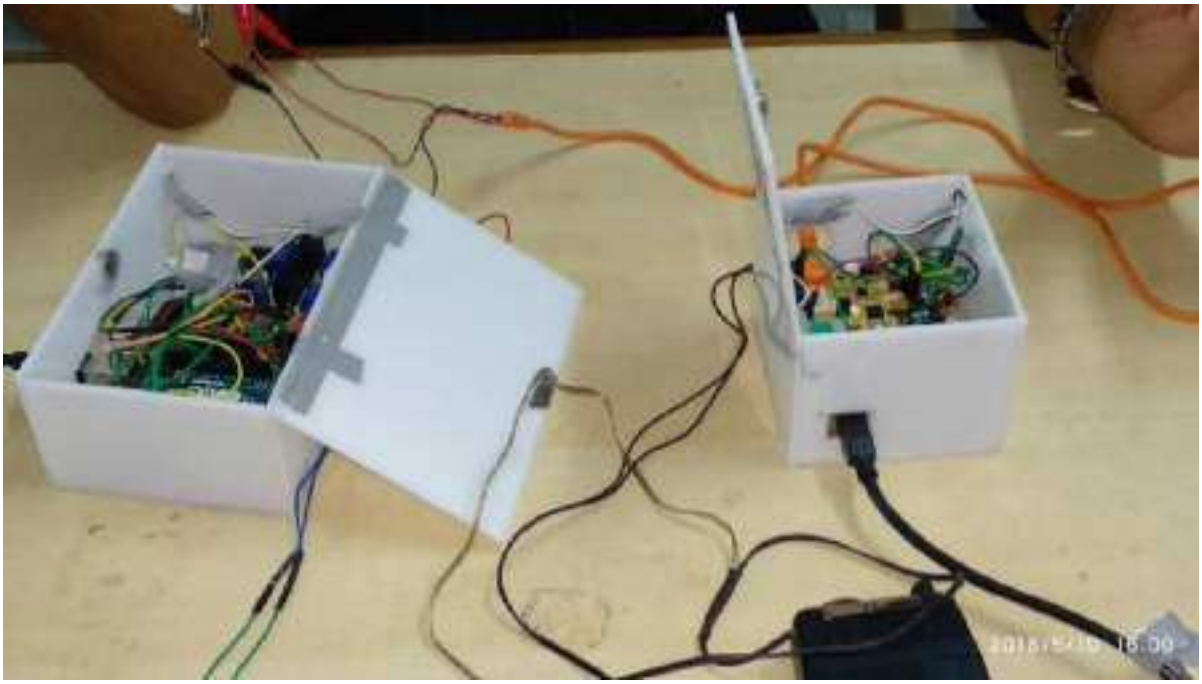

**Figure 4. PCB designed for the experimentation**

# 5. Publications

The publications in refereed journals are:

1) Artificial Muscle Intelligence System with Deep Learning for Post-Stroke Assistance and Rehabilitation, published in IEEE Access Journal, ISSN: 2169-3536, DOI: 10.1109/ACCESS.2019.2941491, Page(s): 133463 – 133473, https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8839118 - Impact Factor – 4.098 indexed with SCIE & Scopus Clarivate Analytics

2) Artificial Intelligence Powered EEG-EMG Electrodes for Assisting the Paralyzed, published in IEEE Future Directions, published on September 2019, https://cmte.ieee.org/futuredirections/tech-policy-ethics/september-2019/artificialintelligence-powered-eeg-emg-electrodes-for-assisting-paralyzed/

3) Brain-Controlled Adaptive Lower Limb Exoskeleton for Rehabilitation of Post-Stroke Paralyzed, published in IEEE Access Journal, ISSN: 2169-3536, DOI: 10.1109/ACCESS.2019.2921375 , Page(s): 132628 – 132648, https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8732331 - Impact Factor – 4.098 indexed with SCIE & Scopus Clarivate Analytics

4) Secure thought transfer and processing using Novel-T algorithm, Basic & Clinical Pharmacology & Toxicology (ISSN: 1742-7843),Volume 123, Issue S3, 2018, https://onlinelibrary.wiley.com/doi/full/10.1111/bcpt.13100 No.6

5) Hybrid brain actuated muscle interface for the physically disabled, Basic & Clinical Pharmacology & Toxicology (ISSN: 1742-7843),Volume 123, Issue S3, 2018, https://onlinelibrary.wiley.com/doi/full/10.1111/bcpt.13100 No.10

6) Secure Brain to Brain Communication with Edge Computing for Assisting Post-Stroke Paralyzed Patients, IEEE Internet of Things Journal ( Early Access ), DOI: 10.1109/JIOT.2019.2951405, 05 November 2019, https://ieeexplore.ieee.org/document/8891712

# 6. Patents

Patents published

1) The patent published in the version and application of the concept I am attaching the link http://ipindiaservices.gov.in/PatentSearch/PatentSearch//ViewApplicationStatus Application No: 201841042113

2)http://ipindiaservices.gov.in/PatentSearch/PatentSearch//ViewApplicationStatus Application No: 201841042115

# 7. Conclusions/Project Status

As per the timeline of the project,we have completed the implementation of BCCLE.Online and offline testing of the BCLLE on six different subjects was carried out.WH Transform is utilized for feature extraction and reconstruction. The results obtained indicate that it produces good classification accuracy. The SSVEP method is incorporated using a visual interface, which improves human concentration. The healthy and paralyzed subjects were able to control the exoskeleton for different movements such as backward movement, forward movement, Sitting, Standing, Turn Left and Turn Right. The sensory feedback was implemented using angle sensors and rescue assistance is provided using accelerometers. The adaptive mechanism used helped to reduce the false rate of the system. The secure message transmission is established using NTSA encryption, which helps the caregiver to know the status of the paralyzed. In phase 2 of the work we will be integrating artificial muscle intelligence to the system. The timeline of the project implementations are listed in the Gantt chart below

RajCOMP Info Services Ltd.
(A Government of Rajasthan undertaking)
RISL
email: info.risl@rajasthan.gov.in
website: www.risl.rajasthan.gov.in
CIN : U72200RJ2010SGC033185

F1.9(139)/RISL/MISC/2015/8802

Date: 31/03/2

**The Indian Institute of Information Technology,**
**2nd Floor, Prabha Bhawan, MNIT Campus,**
**JLN Marg, Jaipur - 302017**

Sub: Contribution for research and development of project "Social media analysis using explainable artificial intelligence (AI) based techniques for less-resourced languages" under Corporate Social Responsibility (CSR) head of RISL.

We wish to inform you that a research project titled "Social media analysis using explainable artificial intelligence (AI) based techniques for less-resourced languages" (the "Project"), has been approved for contribution of Rs. 7,55,000/- by RISL (A Government of Rajasthan Undertaking) under its CSR head for the financial year 2021-22 to Indian Institute of Information Technology, Kota ('IIIT Kota') having following project investigators:

| S. No. | Name of Investigators | Designation | Role |
|---|---|---|---|
| 1. | Dr.Basant Agarwal | Assistant Professor, Department of Computer Science and Engineering, Indian Institute of Information Technology Kota (IIIT Kota), MNIT Campus, Jaipur -302017, India | Principal Investigator |
| 2. | Dr.Vinod P. | Professor, Department of Computer Applications, Cochin University of Science & Technology, Cochin, Kerala, India, University Road, South Kalamassery, Kalamassery, Kochi, Kerala 682022 | Co-Principal Investigator-I |
| 3. | Deepasree Varma | Assistant Professor, Department of Computer Science, SCMS School of Engineering and Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576, Kerala | Co-Principal Investigator-II |

The fund has been transferred to the account of IIIT Kota.

RajCOMP Info Services Ltd
C-Block Ist Floor, Yojna Bha
Tilak Marg, C-Sheme
Jaipur-302 005

RISL

# RajCOMP Info Services Ltd.

(A Government of Rajasthan undertaking)

email: info.risl@rajasthan.gov.in
website: www.risl.rajasthan.gov.in
CIN : U72200RJ2010SGC033185

The sanction is subject to the Terms and Conditions as mentioned below:

1. IIIT Kota should acknowledge the contribution under CSR received from the RISL in all the outcomes of the project.
2. The contribution shall be spent within the duration of the project.
3. The Intellectual property rights associated with the project shall vest with IIIT Kota and RISL.
4. The Project Investigators will be in-charge to take the decisions regarding all the matters related to the project as per IIIT Kota Norms.
5. IIIT Kota shall submit the Utilisation Certificates along with status reports from time to time till completion of the Project Implementation.

31/03

(Sandesh Nayak)
**Managing Director**

RajCOMP Info Services Ltd.
...ck Ist Floor, Yojna Bha...
Tilak Marg, C-Sheme
Jaipur-302 005

## Annexure II

# APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
## Centre for Engineering Research and Development
### Request for releasing RSM grant

Title of Project: ContextAuth : An implicit Authentication System for smartphones

Date of sanction: 2.09.2021

Amount sanctioned: 75,000/-

Account No and bank details: 588802010007680, UNION BANK OF INDIA, PALLISER[illegible]
IFSC code: UBIN0558885
A/c name: CERD RESEARCH SEED MONEY 2464320200[illegible]

### Terms & Conditions for Research Seed Money Scheme

1. The amount sanctioned for the project shall be deposited in a separate joint A/c of Principal Investigator and Head of the institution where the Principal Investigator works. (Name of A/c: CERD Research Seed Money - File No.)

2. The maximum duration of the project will be three years from the date of start of the project

3. The amount has to be utilized as per budget provision under each head. It is the discretion of the University to settle amount towards the purchase of those items not clearly mentioned, if any, in the project proposal.

4. The purchase of equipments shall be in accordance with the store purchase rules. All equipment purchased will be the property of CERD and the stock entry of the items purchased shall be maintained in the College signed by the Investigator, Lab in charge and Principal. Purchase of computers/peripherals is not allowed unless specifically mentioned in the sanction order.

5. For Private self financing Colleges, 50% of the actual Equipment cost subjected to the maximum of sanctioned amount will be reimbursed by KTU if and only if the proof of remittance of other 50% is produced by the college.

6. The stock entries of consumables purchased shall also be done in the consumables stock register of College. Purchase of stationery shall be for project purpose only.

7. Books and literature purchased should be taken into the Stock Register of Central Library or Department library and then distributed to the investigators.

memorandum of understanding to the extent that such delay or failure is caused by or arises from acts or circumstance or events beyond the reasonable control of that party, including not limited to acts of god, acts or regulations of any governmental authority, war or national emergency, accident, fire, riot, strikes, lock-outs, industrial disputes, natural catastrophes or epidemics.

Each Party shall bear its own losses arising from such force majeure event(s), if any.

## 6. INTELLECTUAL PROPERTY

All prior information, design and data existing with either party before the signing of this MoU (pre-existing IP) shall be the sole property of the concerned party. All Intellectual Property including design information, designs, source codes and data generated through the collaboration under this MOU shall be as mutually agreed in writing and also as per the guide line of the funding agency, if such an agency is involved. Any IPR arising specifically out of this collaboration will be owned by both parties, except when mutually agreed in writing otherwise.

**IN WITNESS WHEREOF,** the parties hereto have caused this memorandum of understanding to be executed in duplicate, through their representatives at Thiruvananthapuram in the day and year first above written:

Now the memorandum of understanding witnesses as follows.

Principal

SCMS School of Engineering and Technology
APJ Abdul Kalam Technological University

DR. PRAVEENSAL C.J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

Dean (Research)

APJ Abdul Kalam Technological University
Thiruvananthapuram 695016

Witness: 1
Signature: 13.10.2021
Name: DR. ANITHA G PILLAI

Witness: 1
Signature:
Name:

Witness: 2
Signature: 13/10/2021
Name: DR. MINI TOM

Witness: 2
Signature:
Name:

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY
KARUKUTTY
ERNAKULAM
683 576

Name: DR. PRAVEENSAL C J

Office Address: PRINCIPAL
SCMS School of Engineering
& Technology
683576.

Seal

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY
KARUKUTTY
ERNAKULAM
683 576
*

Annexure II

# APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

## Centre for Engineering Research and Development

## Request for releasing RSM grant

Title of Project: ContextAuth : An implicit Authentication systems for smartphones

Date of sanction: 2.09.2021

Amount sanctioned: 75,000/-

Account No and bank details: 588802010007680, UNION BANK OF INDIA, PALISER
IFSC code: UBIN0558885
A/c name: CERD RESEARCH SEED MONEY 2464320200

### Terms & Conditions for Research Seed Money Scheme

1. The amount sanctioned for the project shall be deposited in a separate joint A/c of Principal Investigator and Head of the institution where the Principal Investigator works. (Name of A/c: CERD Research Seed Money - File No.)

2. The maximum duration of the project will be three years from the date of start of the project

3. The amount has to be utilized as per budget provision under each head. It is the discretion of the University to settle amount towards the purchase of those items not clearly mentioned, if any, in the project proposal.

4. The purchase of equipments shall be in accordance with the store purchase rules. All equipment purchased will be the property of CERD and the stock entry of the items purchased shall be maintained in the College signed by the Investigator, Lab in charge and Principal. Purchase of computers/peripherals is not allowed unless specifically mentioned in the sanction order.

5. For Private self financing Colleges, 50% of the actual Equipment cost subjected to the maximum of sanctioned amount will be reimbursed by KTU if and only if the proof of remittance of other 50% is produced by the college.

6. The stock entries of consumables purchased shall also be done in the consumables stock register of College. Purchase of stationery shall be for project purpose only.

7. Books and literature purchased should be taken into the Stock Register of Central Library or Department library and then distributed to the investigators.

## COMPUTER SCIENCE & ENGINEERING

| Sl.No | Name of Principal Investigator | Title of the Project | Name of College | Amount Sanctioned | First Installment | Second Installment | Consumables | Equipments | Travel | Contingency |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poorna B R<br>Assistant Professor | Healthcare recommender system using hybrid filtering technique | Mar Baselios College of Engineering and Technology Trivandrum | 100,000 | 75,000 | 25,000 | 20,000 | 70,000 | | 10,000 |
| 2 | Vidya K R<br>Assistant Professor | Development of an Advanced Image Forgery Detection System for supporting Cyber Forensics in Kerala | Saintgits college of Engineering, Kottayam. | 90,000 | 70,000 | 20,000 | 15,000 | 70,000 | | 5,000 |
| 3 | Jestin Joy<br>Assistant Professor | Investigating the effectiveness of gesture based learning framework for deaf students | Federal Institute of Science And Technology (FISAT) | 80,000 | 55,000 | 25,000 | 15,000 | 50,000 | 5,000 | 10,000 |
| 4 | Susmi Jacob<br>Assistant Professor | ContextAuth – An implicit Authentication system for Smartphones | SCMS School of Engineering & Technology | 75,000 | 55,000 | 20,000 | 20,000 | 50,000 | | 5,000 |
| 5 | Dr. Deepika M P<br>Associate Professor | Two in One System for Baby Diaper and Sanitary Napkin Disposal. | Adi Shankara Institute of Engineering and Technology | 95,000 | 70,000 | 25,000 | 30,000 | 46,000 | 4,000 | 15,000 |
| 6 | Dr.Lizy Abraham<br>Assistant Professor | WESAT - Development of a Payload for the Comparison of Solar Irradiance and UV Index Measurements at Space with respect to the Monitoring Station at LBSITW Campus in Thiruvananthapuram City | LBS Institute of Technology for Women | 200,000 | 150,000 | 50,000 | 30,000 | 150,000 | 10,000 | 10,000 |
| 7 | Rakhee M<br>Assistant Professor | Blockchain Based Framework for Enhancing Trust During Various Phases of Research Publication | Muthoot Institute of Technology and Science, | 50,000 | 30,000 | 20,000 | 8,000 | 30,000 | 4,000 | 8,000 |

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
CET campus, Thiruvananthapuram - 695 016
Ph: 0471 2598122; Fax: 2598522 www.ktu.edu.in Email: university@ktu.edu.in

Dated: 02.09.2021

No. KTU/RESEARCH 2/4643/2020

From
The DEAN (Research)

To
The Principal
SCMS School of Engineering and Technology

Sir,

Sub:- APJAKTU - CERD - Research Seed Money Scheme - Projects Selected for funding - reg:-

I am glad to inform you that the project proposals as listed in Annexure I are provisionally selected for funding under Research Seed Money (RSM) scheme of KTU.

The expenditure should be incurred as per the sanctioned budget heads and in accordance with terms and conditions given in Annexure II. Format of MOU to be furnished by the college is given as Annexure III.

The Principal Investigators may please be directed to forward request (in Annexure II) for releasing the fund with Bank Account details. The fund will be released only after settling pending accounts of the principal investigator in CERD, if any. Any request received after three months from the date of this letter will not be considered.

Yours faithfully
Dr. Shalij P.R *
DEAN (Research)

Copy To

1. Vinoj P. G, Assistant Professor in ECE.
2. Y. K. Remya, Assistant Professor in Civil Engineering.
3. Susmi Jacob, Assistant Professor in Computer Science.

* This is a computer system (Digital File) generated letter. Hence there is no need for a physical signature.

# Research Seed Money - CERD

Ms. Susmi Jacob, Assistant Professor, Department of CSE, SSET, has been awarded CERD RSM (Research Seed Money) fund of 75,000/- rupees for the project titled "ContextAuth – An implicit Authentication system for Smartphones".


**Abstract :**

A context-aware implicit and continuous multimodal authentication system is proposed to identify and validate a user. Different modalities include touch gestures and typing behaviour that leverages different built-in smartphone sensors while typing a password, head movements while user making calls or interacting with smartphone through voice and, finally different voice modalities which utilizes unique audio features of the user.


**Progress of work :**

The fund was approved on July 2021. And first instalment of rupees 55,000/- was released on March 2022. Withdrawal of rupees 45,000/- was requested and sanctioned in June 2022. Account statement till February 2023 is attached herewith.

**Purchase details**

The equipment purchased for the ongoing work include:

1. Adafruit Playground Bluefruit – Bluetooth Low Energy
2. MPU-6050 3-axis Accelerometer and Gyro Sensor
   Total Purchase cost – 3188/- (from ROBU.IN)

3. Kodenshi IR sensor – Infrared sensor
4. NordicSemi Embedded AI Dev board
   Total purchase cost – 3700/-

Head of Department
Dr Varun C. Menon

Principal Investigator
Susmi
24/2/23
Susmi Jacob

SCMS COLLEGE OF ENGG AND TECH

यूनियन बैंक ऑफ इंडिया Union Bank of India

KERALA INDIA

IFSC Code : UBIN0558885

Issue Date:24-09-2021

SI No: 1

शाखा BRANCH

शाखा का पता Branch Address :

शाखा का फोन नं/ Branch Phone No.:

खाता क्र. Account No.: 588802010007690 (SB GENERAL)

In the Name of : S CERD RESEARCH SEED MONEY 2 4643 2020 03

नाम Name i) 999,SCMS ENGG COLLEGE 888,VIDHYA NAGAR

ii) GENEV Pin : 683576 KERALA INDIA

iii) 20-09-2021

Branch Phone No : 0484-2439029

N

पेशा Occupation

पता Address

खाता खोलने की तारीख
Date of Opening A/c

नामांकन पंजीकृत / Nomination Registered : हाँ Y / नहीं N

लेखाकार Accountant

| दिनांक Date | विवरण Particulars | सोल आयडी SOL ID | चेक न. CHQ. No. | निकाली गयी राशी DEBIT | जमा की गयी राशी CREDIT | जमा कर्ता के खाते में शेष राशी BALANCE |
|---|---|---|---|---|---|---|
| 23-03-2022 | NEFT:Director of Treasuries account f47380 | | | | 55000.00 | 55000.00Cr |
| 07-04-2022 | 588802010007680:Int.Pd:01-01-2022 to 31-03-2022 | | | | 127.00 | 55127.00Cr |
| 13-04-2022 | SUSMI JACOB | | 144195 | 45000.00 | | 10127.00Cr |
| 06-07-2022 | 588802010007680:Int.Pd:01-04-2022 to 30-06-2022 | | | | 331.00 | 10458.00Cr |
| 06-10-2022 | 588802010007680:Int.Pd:01-07-2022 to 30-09-2022 | | | | 72.00 | 10530.00Cr |
| 03-01-2023 | 588802010007680:Int.Pd:01-10-2022 to 31-12-2022 | | | | 73.00 | 10603.00Cr |

**SCMS SCHOOL OF ENGINEERING & TECHNOLOGY**

VIDYA NAGAR, KARUKUTTY, ERNAKULAM - 683 582

**DEPARTMENT OF MECHANICAL ENGINEERING**

File No: P-14 Index No : P-14.1 SSET/NBA/ME/P-14.1

**R and D details AY 2020-2021**

| S.No | Name | Topic of Research with summary | Funding Agency | Amount | Status of the project |
|---|---|---|---|---|---|
| 1 | Development of Hydrodynamic Depressor for Towed System | Design hydrodynamic depressor for improving the depth achieved by the underwater towed system. | National Physical and Oceanography Laboratory | 900,000 | On going |

**HOD**

दूरभाष/Phone : 0484-2571000
फैक्स/Fax : 0484-2424858
ई-मेल/E-mail : tso@npol.drdo.in
सभी पत्रादि निदेशक, एन पी ओ एल को सम्बोधित किया जाए / All correspondence should be addressed to Director NPOL

Certified ISO 9001:2015

FAX MESSAGE

भारत सरकार, रक्षा मंत्रालय
Government of India, Ministry of Defence
रक्षा अनुसंधान तथा विकास संगठन
Defence Research & Development Organisation
नौसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला
**Naval Physical & Oceanographic Laboratory**
तृक्काक्करा, कोच्चि – 682 021, भारत
Thrikkakara, Kochi -682 021, India

NPOL/E/GD/7100 04.09.2020

To

The Principal
(Kind Attn: Dr.P Venu, Head, Mechanical Engineering Department)
SCMS school of Engineering and Technology,
Ernakulam

Sub: Development of hydrodynamic depressor for NPOL project

Naval Physical and Oceanographic Laboratory (NPOL), Kochi is an establishment under Defence Research and Development Organization, Ministry of Defence, Government of India and is involved with the development of sonar systems for the Indian Navy. In one of the ship towed sonar projects, it is proposed to develop hydrodynamic depressor for the purpose of improving the depth performance of the towed system.

It is noted that Department of Mechanical Engineering, SCMS School of Engineering and Technology has done research work in the area of hydrodynamic depressors (Ref: "Analysis of Hydrodynamic Depressor for High Speed Naval Applications" by Sri.R Ajithkumar, ICTCEES, 2020) and also in related areas such as hydrodynamics of underwater vehicles. With this background, it is proposed to initiate a project with Department of Mechanical Engineering, SCMS School of Engineering and Technology with Sri. R. Ajithkumar as the Principal Investigator under the Contract for Acquisition of Research Services (CARS) scheme of DRDO.

Brief scope of work envisaged under the project is attached. Request to forward a project proposal on the same.

Regards,

P Vinod
Scientist-G
Group Director (Engineering)
For Director

# नौसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला, कोच्चि -21

## NAVAL PHYSICAL & OCEANOGRAPHIC LABORATORY, KOCHI-21.

## ठेकेदार का बिल / CONTRACTOR'S BILL

* ठेका करार सं/Contract agreement No. NPOL121CR007 तारीख/Date 12/02/2021 सुपुर्दगी की तारीख/Delivery date

ठेकेदार का नाम तथा पूरा पता /Name of contractor with full postal address SCMS School of Engineering & Technology, Ernakulam, 683576

सुपुर्दगी चालान सं तथा तारीख /Delivery challen No. & Dates

| क्रम सं SI No. | आपूर्ति की गई वस्तुओं या दी गई सेवाओं का विवरण Description of articles supplied or service rendered | ए/यू A/U | स्वीकृत मात्रा या संख्या Qty. or No. accepted | दर (के हिसाब से) ए/यू Rate (Per) A/U रु./ Rs. | पैसे /Ps. | कुल लागत / Total cost रु./ Rs. | पैसे /Ps. | टिप्पणी Remarks |
|---|---|---|---|---|---|---|---|---|
| 1. | Initial Payment on Project Design and Analysis of Hydrodynamic Depressor | No | | 2,34,000 | 00 | 2,34,000 | 00 | |
| | | | | बि.क. तथा से.प्र. /ST & SC | | | | |
| | | | | उत्पाद/सीमा प्रभार /EXCISE / CUSTOMS DUTY | | | | |
| | | | | GST अन्य /OTHERS | | 42,120 | | |
| | | | | कुल /TOTAL | | | | |
| | | | | कटौतियां /DEDUCTIONS ..........% | | | | |
| | | | | कुल योग /GRAND TOTAL | | 2,76,120/- | | |

बिक्री कर, स्थानीय रजिस्ट्रेशन सं० /Sales Tax. Local registration No:

बिक्री कर, सेन्ट्रल रजिस्ट्रेशन सं० /Sales Tax Central registration No:

आर आर/एल आर/एडब्ल्यूबी/कूरियर सं० /R.R / LR/AWB/ Courier No:

बिक्री कर प्रमाण-पत्र की प्रति संलग्न /Copy of Sales Tax Certificate enclosed.

### प्रमाण-पत्र /CERTIFICATE & PRE-RECEIPT

प्रमाणित किया जाता है कि उपर्युक्त सूचनाएँ वास्तविक तथ्यों पर आधारित और सही है। वस्तुओं/सेवाओं के लिए अब लिए जा रहे प्रभार संबंधी बिल को प्रस्तुत नहीं किया गया है। यदि उपर्युक्त में से कोई भी सूचना गलत पाई जाती है तो आपके द्वारा की जाने वाली किसी भी कानूनी कार्रवाई का पूर्णतया पालन किया जाएगा। / Certified that the information given above is true and based on the actual facts. No bill has been rendered previously in respect of articles / services now charged for hereon. In case any of the information provided above is false, we agree to abide by for any legal action to be taken by you.

Received Rs. 2,76,120/- (In words Rupees Two Lakh Seventy Six Thousand One Hundred and Twenty)

स्थान /Station: Karukutty

दिनांक /Date: 30/10/2021

Revenue stamp

ठेकेदार के हस्ताक्षर /Signature of the Contractor
(मोहर /With seal)

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

# नौसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला, कोच्चि -21
# NAVAL PHYSICAL & OCEANOGRAPHIC LABORATORY, KOCHI-21.
## ठेकेदार का बिल / CONTRACTOR'S BILL

* ठेका करार सं०/Contract agreement No. NPOL/21CR007 तारीख/Date 12/03/2021 सुपुर्दगी की तारीख/Delivery date..........

ठेकेदार का नाम तथा पूरा पता /Name of contractor with full postal address SCMS School of Engineering and Technology, Ernakulam - 683576

सुपुर्दगी चालान सं० तथा तारीख /Delivery challan No. & Dates..........

| क्रम सं० Sl No. | आपूर्ति की गई वस्तुओं या दी गई सेवाओं का विवरण Description of articles supplied or service rendered | ए/यू A/U | स्वीकृत मात्रा या संख्या Qty. or No. accepted | दर (के हिसाब से) ए/यू Rate (Per) A/U रु./ Rs. | पैसे /Ps. | कुल लागत / Total cost रु./ Rs. | पैसे /Ps. | टिप्पणी Remarks |
|---|---|---|---|---|---|---|---|---|
| 1. | First Milestone Payment on Project Design and Analysis of Hydrodynamic Depressor | No | | 2,34,000 | 00 | 2,34,000 | 00 | |
| | | | बि.क. तथा से.प्र. /ST & SC | | | | | |
| | | | उत्पाद/सीमा प्रभार /EXCISE / CUSTOMS DUTY | | | | | |
| | | | GST अन्य /OTHERS | | | 42,120/- | | |
| | | | कुल /TOTAL | | | 276,120/- | | |
| | | | कटौतियां /DEDUCTIONS ..........% | | | 0 | | |
| | | | कुल योग /GRAND TOTAL | | | 2,76,120/- | | |

बिक्री कर, स्थानीय रजिस्ट्रेशन सं० /Sales Tax, Local registration No:..........
बिक्री कर, सेन्ट्रल रजिस्ट्रेशन सं० /Sales Tax Central registration No:..........
आर आर/एल आर/एडब्ल्यूबी/कूरियर सं० /R.R / LR/AWB/ Courier No:..........
बिक्री कर प्रमाण-पत्र की प्रति संलग्न /Copy of Sales Tax Certificate enclosed.

### प्रमाण-पत्र /CERTIFICATE & PRE-RECEIPT

प्रमाणित किया जाता है कि उपर्युक्त सूचनाएँ वास्तविक तथ्यों पर आधारित और सही है। वस्तुओं/सेवाओं के लिए अब लिए जा रहे प्रभार संबंधी बिल को प्रस्तुत नहीं किया गया है। यदि उपर्युक्त में से कोई भी सूचना गलत पाई जाती है तो आपके द्वारा की जाने वाली किसी भी कानूनी कार्रवाई का पूर्णतया पालन किया जाएगा। / Certified that the information given above is true and based on the actual facts. No bill has been rendered previously in respect of articles / services now charged for hereon. In case any of the information provided above is false, we agree to abide by for any legal action to be taken by you.

Received Rs. 276,120/- (In words Rupees Two Lakh Seventy Six Thousand One Hundred and Twenty)

स्थान /Station: Kaprukally
दिनांक /Date: 30/10/2021

Revenue stamp

ठेकेदार के हस्ताक्षर /Signature of the Contractor
(मोहर /With seal)

DR. PRAVEENSAL C.J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

# नौसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला, कोच्चि -21
# NAVAL PHYSICAL & OCEANOGRAPHIC LABORATORY, KOCHI-21.
## ठेकेदार का बिल / CONTRACTOR'S BILL

* ठेका करार सं/Contract agreement No. NPOL/21CR007 तारीख/Date. 18/09/2022 सुपुर्दगी की तारीख/Delivery date.........

ठेकेदार का नाम तथा पूरा पता /Name of contractor with full postal address. SCMS School of Engineering and Technology, Ernakulam - 683 576

सुपुर्दगी चालान सं तथा तारीख /Delivery challen No. & Dates.........

| क्रम सं Sl No. | आपूर्ति की गई वस्तुओं या दी गई सेवाओं का विवरण Description of articles supplied or service rendered | ए/यू A/U | स्वीकृत मात्रा या संख्या Qty. or No. accepted | दर (के हिसाब से) ए/यू Rate (Per) A/U रु./ Rs. | पैसे /Ps. | कुल लागत / Total cost रु./ Rs. | पैसे /Ps. | टिप्पणी Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Second Milestone Payment on Project Design and Analysis of Hydrodynamic Depressor | No. | | 2,34,000 | 00 | 2,34,000 | 00 | |
| | | | बि.क. तथा से.प्र. /ST & SC | | | | | |
| | | | उत्पाद/सीमा प्रभार /EXCISE / CUSTOMS DUTY | | | | | |
| | | | GST अन्य /OTHERS | | | 42,120/- | | |
| | | | कुल /TOTAL | | | 2,76,120/- | | |
| | | | कटौतियां /DEDUCTIONS ..........% | | | | | |
| | | | कुल योग /GRAND TOTAL | | | 2,76,120/- | | |

बिक्री कर, स्थानीय रजिस्ट्रेशन सं० /Sales Tax. Local registration No:.........
बिक्री कर, सेन्ट्रल रजिस्ट्रेशन सं० /Sales Tax Central registration No:.........
आर आर/एल आर/एडब्लूबी/कूरियर सं० /R.R / LR/AWB/ Courier No:.........
बिक्री कर प्रमाण-पत्र की प्रति संलग्न /Copy of Sales Tax Certificate enclosed.

### प्रमाण-पत्र /CERTIFICATE & PRE-RECEIPT

प्रमाणित किया जाता है कि उपर्युक्त सूचनाएँ वास्तविक तथ्यों पर आधारित और सही है । वस्तुओं/सेवाओं के लिए अब लिए जा रहे प्रभार संबंधी बिल को प्रस्तुत नहीं किया गया है । यदि उपर्युक्त में से कोई भी सूचना गलत पाई जाती है तो आपके द्वारा की जाने वाली किसी भी कानूनी कार्रवाई का पूर्णतया पालन किया जाएगा । / Certified that the information given above is true and based on the actual facts. No bill has been rendered previously in respect of articles / services now charged for hereon. In case any of the information provided above is false, we agree to abide by for any legal action to be taken by you.
Received Rs. 2,76,120/-.....(In words..... Rupees Two Lakh, Seventy Six Thousand One Hundred and Twenty

स्थान /Station: Karukutty
दिनांक /Date: 20/10/2021

Revenue stamp

ठेकेदार के हस्ताक्षर /Signature of the Contractor
(मोहर /With seal)

DR. PRAVEENSAL C.J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

# GST INVOICE

## SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

**Prathap Foundation ForEducation And Training**

Karukutty, Ernakulam, Kerala - 683576

GSTIN: 32AADCP1668B1ZV
Tax is payable on reverse charge: No
Invoice Serial Number: SCMGST001
Invoice Date: 24/11/2021

| **Details of Receiver (Billed To)** | **Details of Consignee (Delivered To)** |
|---|---|
| Name: Director NPOL<br>Address: Naval Physical and Oceanographic Laboratory, Kochi<br>Thrikkakara (PO) -682021<br>State: Kerala<br>State Code :32<br>GSTIN: Unregistered | Name: Director NPOL<br>Address: Naval Physical and Oceanographic Laboratory, Kochi<br>Thrikkakara (PO) -682021<br>State: Kerala<br>State Code :32<br>GSTIN: Unregistered |

| S.No. | Description of Goods/ Services | HSN/SAC Code (GST) | Qty. | UOM | Rate | Total | Discount | Taxable Value | CGST % | CGST Amount | SGST % | SGST Amount | IGST % | IGST Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Initial advance payment for Project "Design and Analysis of Hydrodynamic Depressor" CARS Project No. NPOL/21CR0007 dated 12.02.2021 | 9983 | 1 | Nos | 234000 | 234000 | 0.00 | 234000 | 9.00 | 21060.00 | 9.00 | 21060.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | 276120 |
| Rupees | | | | | | | | | | | | | | Two lakh seventy-six thousand and twenty only |

Category : Research and Development Services

For SCMS School of Engineering and Technology

Authorised Signatory

DR. PRAVEENSAL C J
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

# GST INVOICE

## SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

**Prathap Foundation For Education And Training**

Karukutty, Ernakulam, Kerala - 683576

GSTIN: 32AADCP1668B1ZV
Tax is payable on reverse charge: No
Invoice Serial Number: SCMGST002
Invoice Date: 24/11/2021

| **Details of Receiver (Billed To)** | **Details of Consignee (Delivered To)** |
|---|---|
| Name: Director NPOL<br>Address: Naval Physical and Oceanographic Laboratory, Kochi<br>Thrikkakara (PO) -682021<br>State: Kerala<br>State Code :32<br>GSTIN: Unregistered | Name: Director NPOL<br>Address: Naval Physical and Oceanographic Laboratory, Kochi<br>Thrikkakara (PO) -682021<br>State: Kerala<br>State Code :32<br>GSTIN: Unregistered |

| S.No. | Description of Goods/ Services | HSN/SAC Code (GST) | Qty. | UOM | Rate | Total | Discount | Taxable Value | CGST % | CGST Amount | SGST % | SGST Amount | IGST % | IGST Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | First Milestone payment for Project "Design and Analysis of Hydrodynamic Depressor" CARS Project No. NPOL/21CR0007 dated 12.02.2021 | 9981 | 1 | Nos | 234000 | 234000 | 0.00 | 234000 | 9.00 | 21060.00 | 9.00 | 21060.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | | | |

| | |
|---|---|
| Total | 276120 |
| Rupees | Two lakh seventy-six thousand and twenty only |

Category : Research and Development Services

For SCMS School of Engineering and Technology

Authorized Signatory

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Second Milestone payment for Project "Design and Analysis of Hydrodynamic Depressor" CARS Project No. NPOL/21CR0007 dated 12.02.2021 | 9981 | 1 | Nos | 234000 | 234000 | 0.00 | 234000 | 9.00 | 21060.00 | 9.00 | 21060.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | | | |
| | | | | | | Total | | | | | | | | 276120 |
| | | | | | | Rupees | | | | | | | | Two lakh seventy-six thousand and twenty only |

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