SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY,KARUKUTTY

Grants received from Government and non-governmental agencies for research projects / endowments in the institution during 2020-2021

SL NO:	Faculty Name	Department	Sanctioned by	Sanctioned for	Sanctioned amount	Current Status
1	Vinoj P G	ECE	GYTI- BIRAC SRISTI	Research work	1500000	Completed
2	R.Ajith Kumar	ME	National Physical and oceanography laboratory	Research work	928000	Completed
TOTAL SANCTIONED AMOUNT SANCTIONED FOR RESEARCH WORK BY GOVERNMENT AND NON-GOVERNMENT AGENCIES 2020-2021					**2428000**	

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY * KARUKUTTY ERNAKULAM 683 576

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

Society for Research & Initiatives for
Sustainable Technologies & Institutions

A Voice of Creative Grassroots Innovators and Traditional Knowledge Holders

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

SRISTI
AES Boys Hostel Campus,
Near Gujarat University Library & SBI bank,
Navrangpura, Ahmedabad - 380 009

SRISTI

સૃષ્ટિ
એઈએસ બૉયઝ હોસ્ટેલ કેમ્પસમાં,
ગુજરાત યુનિવર્સિટી લાઇબ્રેરી અને SBI બેંક નજીક,
નવરંગપુરા, અમદાવાદ-૩૮૦ ૦૦૯

Ph No: 079-2791 3293, 2791 2792, web: www.sristi.org, Email: info@sristi.org, honeybee@sristi.org
"SRISTI" Trust Regd.No. F/3538/AHMEDABAD (BOMBAY PUBLIC TRUST ACT1950)

GRANT AWARD LETTER AGREEMENT

THIS AGREEMENT made on this ....4th..... day of DECEMBER..... 2020 at SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY,KARUKUTTY,KERALA (TIME:11:30 AM)....by and between...**Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)**... hereinafter called as **SITARE Partner** (which expression shall wherever the context so admits include its successors and assignees), a non-profit organization having its office at ...AES Boys Hostel Campus, Near Gujarat University Library & SBI, Navrangpura, Ahmedabad-380009, Gujarat, India of the **First Part**

And

Shri.__VINOJ P G_____S/D/o __P P GEORGE_____ resident of _ERNAKULAM,KERALA_____ ,studying at ___ SCMS SCHOOL OF ENGINEERING ANDTECHNOLOGY,KARUKUTTY,KERALA (Institute/University)and having the Project:" Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed";hereinafter called **AWARDEE** of the **Second** Part:

WHEREAS all the parts are hereinafter referred to as "Parties";

Whereas,SITARE Partner is an organization set up with the objective ofstrengthening the capacity of grassroots and student, inventors, innovators and ecopreneurs in the area of conserving biodiversity and developing eco-friendly solution to local problems; is engaged *inter alia* in the area search, documentation, experimentation, development, diffusion of sustainable technologies and Techpedia, a Sristi initiative aims at putting the problems of micro, small and medium enterprises, informal sector, grassroots innovators and other social sectors on the agenda of the young technology students across the country.

WHEREAS, BIRAC has entrusted the SITARE Partner with implementation of the SITARE Scheme including necessary processing of the proposals, organizing various meetings and training programs, execution of the decisions taken, disbursement of funds, monitoring the physical and financial progress of the Project and to obtain reports and returns and clarifications as required from time to time from the Awardee.

Whereas to promote and encourage young students for embracing translational research to develop innovative products and technologies addressing unmet needs, SITARE Partner under the SITARE Scheme has established two components of the

GYTI) and Residentialworkshops called as Biotech Innovation Ignition School (BIIS) administered through the Project Management Unit at SITARE Partner.

WHEREAS Awardee has been selected for SITARE-Gandhian Young Technological Innovation Award for the research Project entitled "Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed" , hereinafter referred to as PROJECT and Appended herein as Annexure-1

WHEREAS all the Annexures to this Agreement shall be read as integral part of the Agreement.

NOW THEREFORE the Parties on valid consideration and mutual covenants enter into this GRANT AWARD LETTER AGREEMENT, hereinafter referred to as "GALA" as provided hereunder:

1. RESPONSIBILITIES OF THE AWARDEE

(a) The Awardee shall:

i. Carry out the activities of the Project and confirm to the specified objectives, outputs, milestones, and targets;

ii. Meet the resources on the Project activities to the extent as agreed to, as per details given in **Annexure 1**;

iii. Submit a utilization certificate and statement of accounts duly audited and/or certified by a chartered accountant for the expenditure incurred on the Project for the half year, ending 30th September and 31st March, to SITARE Partner, within a month of 30th September and 31st March for respective half year, in the format provided by SITARE Partner;

iv. Submit a milestones progress report to SITARE Partner as per the timeline and participate in the meetings organized by SITARE Partner to review the progress of the Project, as and when called for;

v. Obtain all the necessary requisite approvals, clearance certificates, permissions and licenses from the Government/local authorities for conducting its operations in connection with the Project;

vi. Keep the drawls from the grant assistance ina separate no-lien account in the name of the Awardeewith a scheduled bank, the payments from which account shall be subject to verification by SITARE Partner. It shall also obtain and furnish to SITARE Partner a letter from the said bank foregoing the right of set off or lien in respect of such account.

vii. Utilize the amounts sanctioned by SITARE Partner for the Project only for the purposes as specified in the Project and shall not entrust the implementation of the Project to another agency or divert the grant-in-aid assistance;

viii. Abide by the decision of SITARE Partner to modify the objectives, outputs, milestones, targets, funding as also the foreclosure of the Project or of its components after mutual discussion;

ix. Acknowledge the assistance of Scheme of BIRAC while publishing or presenting in any manner the details of the Project, its progress or its success.

x. In the case of any ambiguity or conflict or inconsistency between this Agreement and any other associated agreement(s) entered into between Awardee and SITARE Partner on the same subject matter, the provisions of this Agreement shall take precedence.

(b) The Awardee warrants that:

i. It shall obtain prior consent of SITARE Partner in writing before entering into any agreement or arrangement with any other party, national or international, on the Project having overlapping objectives or having impact on Intellectual Propertyfor the Project duration;

ii. It is under no contractual restrictions or legal disqualifications or other obligations which will prohibit the Awardee from entering into this agreement or which will interfere with the execution of this agreement; and

iii. Each and every one of the statement and particulars herein contained in this agreement and in the relevant and supporting documents to this agreement are correct;

(c) The Awardee acknowledges and agrees that:

i. The duties, responsibilities and functions assigned or entrusted to it as specified in the Project document shall be deemed to be the duties, responsibilities and functions assigned and entrusted under this Agreement and unless for reasons beyond control under normal circumstances any undue delay, failure or default in performance of the duties, responsibilities and functions as specified in the Project shall be deemed to be a default under this Agreement;

ii. It shall, at all times, indemnify and keep indemnified SITARE Partner against any claims or suits in respect of any losses, damages or compensation payable in consequences of any accident, death or injury sustained by any other third party resulting from or by any act, omission or operation conducted by or on its behalf;

iii. It shall, at all times, indemnify and keep indemnified SITARE Partner against all claims/damages etc. by any infringement of any Intellectual Property Rights (IPR) while -undertaking its responsibilities/work under the Project and this Agreement; and

iv. It shall notify SITARE Partner of any material change in its status and/or shareholding, in particular where such change would have an impact on performance of the obligations under the Project and this Agreement. SITARE Partner shall reserve the right to reconsider further funding assistance in such circumstances of change of control.

2. FINANCIAL ARRANGEMENTS

The financial arrangements under this Agreement are as here under

i. The total fund approved by BIRAC and granted by SITARE Partner on behalf of BIRAC towards the Project is Rs. __15___ lakhs (Rupees _Fifteen lakhs only___) only on the terms and conditions detailed in this Agreement.

ii. The detailed breakup of the financial assistance is given in **Annexure 2.**

iii. All financial assistance by SITARE Partner will be released as grant award. SITARE Partner shall release the first instalment after signing of the Agreement and subject to the fulfilment of the terms and conditions for such release. Further release of funds shall be subject to satisfactory progress against the objectives, outputs, milestones and targets specified in the Project as determined by SITARE Partner and on submission of statement of accounts/ audited statement of accounts and utilization certificates

iv. The Awardee shall ensure that the funds of the Project are actually utilized only for the Project and as expressly provided in this Agreement. Re-appropriation of funds from one budget head to another shall not be effected without the specific written approval of SITARE Partner;

v. The Awardee shall refund immediately any funds out of grant disbursed to it for the Project remaining unutilized with it on completion of the Project to SITARE PARTNER along with detailed accounts of funds received, utilized and unutilized;

vi. The capital assets acquired for the Project through SITARE Partner's grant shall not be disposed of without the specific prior written permission of the SITARE Partner. The Awardee shall take adequate care towards custody, safekeeping, and insurance and utilization access of such property at its own cost.

vii. The Methods of controlling the disposal/ granting access/resuming possession of such capital assets acquired for the Project will be at the discretion of the SITARE Partner in the event of completion, foreclosure or termination; and

viii. The manpower engaged in the Project are not the employees of SITARE partner and provision of grant-in-aid does not create any liability, explicit or implicit, on SITARE Partner in respect of the manpower engaged in the Project.

3. SITARE STEERING COMMITTEE (SSC)

SITARE Partner will constitute a SITARE STEERING COMMITTEE (SSC) comprising of eminent expert(s) from the relevant field based on specific aspects of the Project. SSC will assess the progress of the Project in conformity with the outputs, milestones, targets and objectives as contained in the Agreement will make recommendations accordingly and will provide mentorship and handholding services.

4. RESULTS OF THE PROJECT

i. The deliverables from the Project are defined and are included in the Project details at **Annexure 1.**

ii. Intellectual Property (IP) shall be the property of the Awardee. It is the responsibility of the Awardee to protect any IP generated during the conduct of the Project. It shall bear the expenditure involved in protecting such IP. During the Project Duration, the Awardee shall not assign or transfer the IP to any third party directly or indirectly without prior written consent from SITARE Partner.

5. PROJECT DURATION

The Awardee shall complete the Project within the stipulated period of___24____months after the date of execution of this Agreement or as per the corresponding order(s) issued by SITARE Partner from time to time.

6. CONFIDENTIALITY

i. During the tenure of the Agreement, both the Parties, undertake to maintain strict confidentiality and refrain from disclosure thereof, of all or any part of the information and data exchanged/generated from the Project under this Agreement for any purpose other than in accordance with this Agreement. It shall be the responsibility of both the Parties to ensure maintenance of such confidentiality in respect of their behalf and on behalf of their employees, representatives and associates involved in the Project.

ii. The Parties shall not have any obligation of confidentiality with respect to any information that:
   a. is in the public domain by use and/or publication at the time of its disclosure by the disclosing party; or
   b. was already in possession of the recipient prior to receipt from the disclosing party; or
   c. is properly obtained by the recipient from a third party with a valid right to disclose such information and such third party is not under confidentiality obligation to the disclosing party; or
   d. was disclosed to any third party on a non-confidential basis prior to commencement of the Project; or
   e. is required by public authority, by law or decree.

7. FORECLOSURE AND TERMINATION

i. In case, during the tenure of the Project, it is found that the Project or any Project component is not likely to lead to successful completion, SITARE Partner may decide to foreclose the Project or the Project component as warranted. The decision of the SITARE Partner shall be final in all respects. TheGrantee shall immediately refund any funds unutilized out of SITARE Partners disbursements, after deducting the legally committed expenses to third party vendors, to SITARE Partner, along with detailed accounts of funds received, utilized and unutilized. The entire outstanding amount as on the date of foreclosure will become due and payable immediately.

ii. The Granteemay, before the completion of the Project, terminate this Agreement by giving three months' notice in writing to SITARE Partner. SITARE Partnermay also terminate this Agreement by written notice for committing breach of any term of this Agreement and either not rectifying it to the satisfaction of SITARE Partner or not satisfying SITARE Partner about its inevitability within a reasonable period. In the event of termination of the Agreement, no further disbursement shall be made by SITARE Partner and the Awardeeshall be liable to return immediately the amount of grantalready availed of from SITARE Partner with simple interest at the rate of 12 (twelve) per cent per annum within 30 (thirty) days of termination of the Agreement.

In case of failure to repay, without prejudice to any other rights under this agreement, the amount can be recovered by initiating any procedure available in Law.

8. *FORCE MAJEURE*

The Parties shall not be held responsible for non-fulfillment of their respective obligations in successful completion of the Project under this Agreement due to the exigency of one or more of the *force majeure* events such as but not limited to acts of God, war, flood, earthquakes, strikes not confined to the premises of the Party, lockouts beyond the control of the Party claiming *force majeure*, epidemics, riots, civil commotion etc. lying beyond the reasonable control of and not brought about at the instance of the Party claiming to be affected by such event and which has caused the non-performance or delay in performance; provided on the occurrence and cessation of any such event the Party affected has given a notice in writing to the other Party within one month of such occurrence or cessation. If the *force majeure* conditions continue beyond six months, the Parties shall jointly decide about the future course of action on the Project. The validity of the claim of *force majeure*shall be determined by SITARE Partner after due enquiry and the decision in this regard shall be final.

9. DISPUTE RESOLUTION

In the event of any dispute or difference between the Parties hereto upon or in relation to or in connection with this Agreement, such dispute or difference shall be resolved amicably by mutual consultation. If the dispute is not resolved, then shall be referred to (Please insert the standard Arbitration clause of SITARE Partner as applicable)

10. EFFECTIVE DATE AND TENURE OF THE AGREEMENT

i. The Agreement shall be effective from the date of its signing by both the Parties. The Agreement shall be valid for till _24___ months or till full utilization/refund of the Grant award, whichever is later. It can be extended if agreed to by both the Parties.

ii. Two copies of the Agreement shall be signed by both the Parties and one copy each shall remain in the custody of each Party.

iii. Any failure or delay on the part of SITARE Partner to exercise the right or power under the Agreement shall not operate as waiver thereof.

11. AMENDMENTS TO THE AGREEMENT

No amendment or modification of this Agreement shall be valid unless the same is made in writing by both the Parties or their authorized representatives and specifically stating the same to be an amendment of this Agreement. The modifications / changes shall be effective from the date on which they are made / executed unless otherwise agreed to.

12. SEVERABILITY

In case any one or more of the provisions or parts of a provision contained in this Agreement shall, for any reason, be held to be invalid, illegal or unenforceable in any respect, such invalidity, illegality or unenforceability shall not affect any other provision or part of a provision of this Agreement; and this Agreement shall, to the fullest extent lawful, be reformed and construed as if such invalid or illegal or unenforceable provision, or part of a provision, had never been contained herein.

13. NOTICES AND JURISDICTION

i. All notices and other communications required to be served on the SITARE PARTNERincluding for violation of the terms of this Agreement shall be considered to be duly served if the same shall have been delivered by registered mail at its address as below.

ii. Similarly, any notice to be given to Awardee shall be considered as duly served if the same shall have been delivered by registered mail at its address as below:

Subject to the provisions of **Clause 10** hereof, the Courts at shall have exclusive jurisdiction in all matters concerning this Agreement including any matter arising therein.

14. NO JOINT VENTURE

Nothing contained in this Agreement will be construed as creating a joint venture, agency, partnership or employment relationship between the Parties hereto, nor will any party have the right, power or authority to create any obligation or duty, express or implied, on behalf of the other Party.

15. GOVERNING LAW

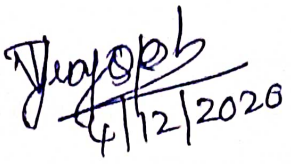
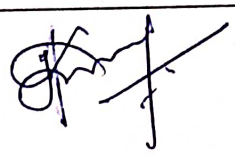
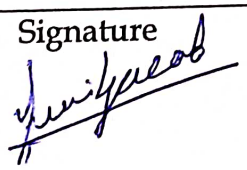
This Agreement shall be governed and interpreted in accordance with the laws of India.

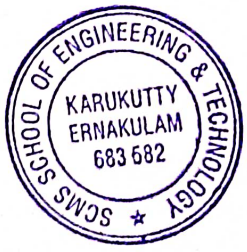
IN WITNESS WHEREOF the Parties hereto through its duly authorized representatives have signed this Agreement on the day, month and year mentioned hereinbefore.

Parties

For and on behalf of the SITARE PARTNER	
Signature	
Name:	
Designation:	
Seal	
Witnesses	
Signature Place Date Name Address	Signature Place Date Name Address

For and on behalf of "Awardee"

Signature  4/12/2020	
Name VINOJ P.G	
Designation Research Scholar, SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY, KARUKUTTY, ANGAMALY	
Witnesses	
Signature 	Signature 
Place: KARUKUTTY	Place: KARUKUTTY
Date: 04/12/2020	Date: 4-12-2026
Name Dr. PRAVEENSAL C.J.	Name Dr Sunil Jacob
Address DR. PRAVEENSAL C.J. PRINCIPAL SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY	Address Director SCMS Centre for Robotics SCMS School of Engineering & Technology
Seal of the Institute with Name	**Seal**



Complete Project document after amendments (as mutually agreed between BIRAC, SITARE PARTNER and Awardee) including work programme, milestones, timelines and corresponding budget shall have to be specifically mentioned.

(This document should be bound as part of the Agreement and labeled as Annexure 1 bearing continuous pagination and should not be submitted as a separate document.)

Key Milestones:

1. Completion of Design of EEG sensor , Muscle stimulation Unit, Mechanical and Electronic prototyping activities
2. Completion of Phase 1 BCLLE working Prototype,Mechanical,Electronic prototyping and integration activities
3. Completion of Phase 2 AMIDL Prototype, Deep-learning Model development, Electronic prototyping and integration activities
4. Usability Testing of the integrated prototype device on paralyzed patients

Work Program:

1. **Milestone 1:**

    1. Design of Mechanical structure of the EEG sensor and the placement of electrodes in the structure
    2. Testing and signal analysis of the designed sensor
    3. Muscle stimulation unit design using Multichannel TENS device
    4. Integrating medical electrodes with the stimulation unit and its testing
    5. Integrated Prototype testing on the Upper limb

2. **Milestone 2:**

    1. Design of mechanical structure of exoskeleton and integrating electronic components
    2. Establishing communication between EEG Sensors and the exoskeleton
    3. Closed loop controller design for different Muscle movements
    4. Integrated system testing on Lower Limb

3. **Milestone 3:**

1. EMG sensor design and Data recording
2. Real time EEG data acquisition
3. Deep learning model development and Training
4. Integrating electronic and mechanical subsystems and testing the model
5. System stability and accuracy testing and incorporating aesthetics and ergonomics to the device

4. **Milestone 4:**

1. Usability test on 10 different paralyzed patients
2. Incorporating user and Medical Practitioner feedback
3. Product compliance with India's medical device regulations

Timeline:

1. Milestone 1 (5 months):

- 1-5 months

2. Milestone 2 (7 months):

- 6-12 months

3. Milestone 3 (7 months):

- 13-20 months

4. Milestone 4 (5 months):

- 21-24 months

Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed - Project Plan

Activity	Plan Start (months)	Plan Duration (months)	Period in Months
			1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Milestone 1: Completion of Design of EEG sensor , Muscle stimulation Unit,Mechanical and Electronic prototyping activities	1	5	
Milestone 2: Completion of Phase 1 BCLLE working Prototype,Mechanical,Electronic prototyping and integration activities	6	7	
Milestone 3: Completion of Phase 2 AMIDL Prototype,Deep-learning Model development, Electronic prototyping and integration activities	13	7	
Milestone 4: Usability Testing of the integrated prototype device on paralyzed patients	20	5	

BUDGET DETAILS

Budget Heads:

Head	Amount (in lakhs)
Development of Prototype (including outsourcing activity)	5
Travel	2
Incubator Rentals	2.20
Manpower	2.16
Consumables	2
Training and conferences	1.14
Contingency	0.50

Budget Justification:

1. Development of Prototype (including outsourcing activity) : 5 Lakhs

- EEG/EMG, Pressure, Accelerometer and gyroscope sensors,cables,Controller boards,shields,Actuators,Motors and Other electronic Components: **3 Lakhs**
- Design and Manufacture of Exoskeleton,EEG headset,PCB fabrication: **2 Lakhs**

2. Travel, Total: 2 Lakhs

- Travel Budget will be utilized for meeting doctors, patients and subject experts

3. Incubator Rentals: 2.20 Lakhs

- Incubator rental for SSET, Karukutty: 5000 Rupees per month for 24 Months:1.20 lakhs
- Utilization of Fab Lab at SSET, Karukutty for facilities like 3D printer, CNC machine, Laser cutter, Electronics Test bench: 1 lakh

4. Manpower: 2.16 Lakhs

- The manpower budget is utilized by recruiting Technical assistant, having proficiency in hardware and software design and prototyping. Salary for the technical assistant(18,000 Rupees per month for 12 months =2.16 Lakhs)

5. **Consumables: 2 Lakhs**

- Medical grade Components like EEG-EMG electrode pads, skin preparation spray, silicon rubber: 1 lakh
- carbon fiber,3D printing material, Acrylic sheets,batteries,Drill bits etc.: 1 lakh

6. Training and Conferences: 1.14 Lakhs

- Training and Conferences budget will be utilized for attending Training and Conferences related to Biomedical Assistive Technologies

7. Contingency: 0.50 Lakhs

- Contingency Fund is utilized for patent filing, medical committee approval, to cover unforeseen risks during patient usability testing.

Total: 15 Lakhs

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

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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	63.8%
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 extension/flexion	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

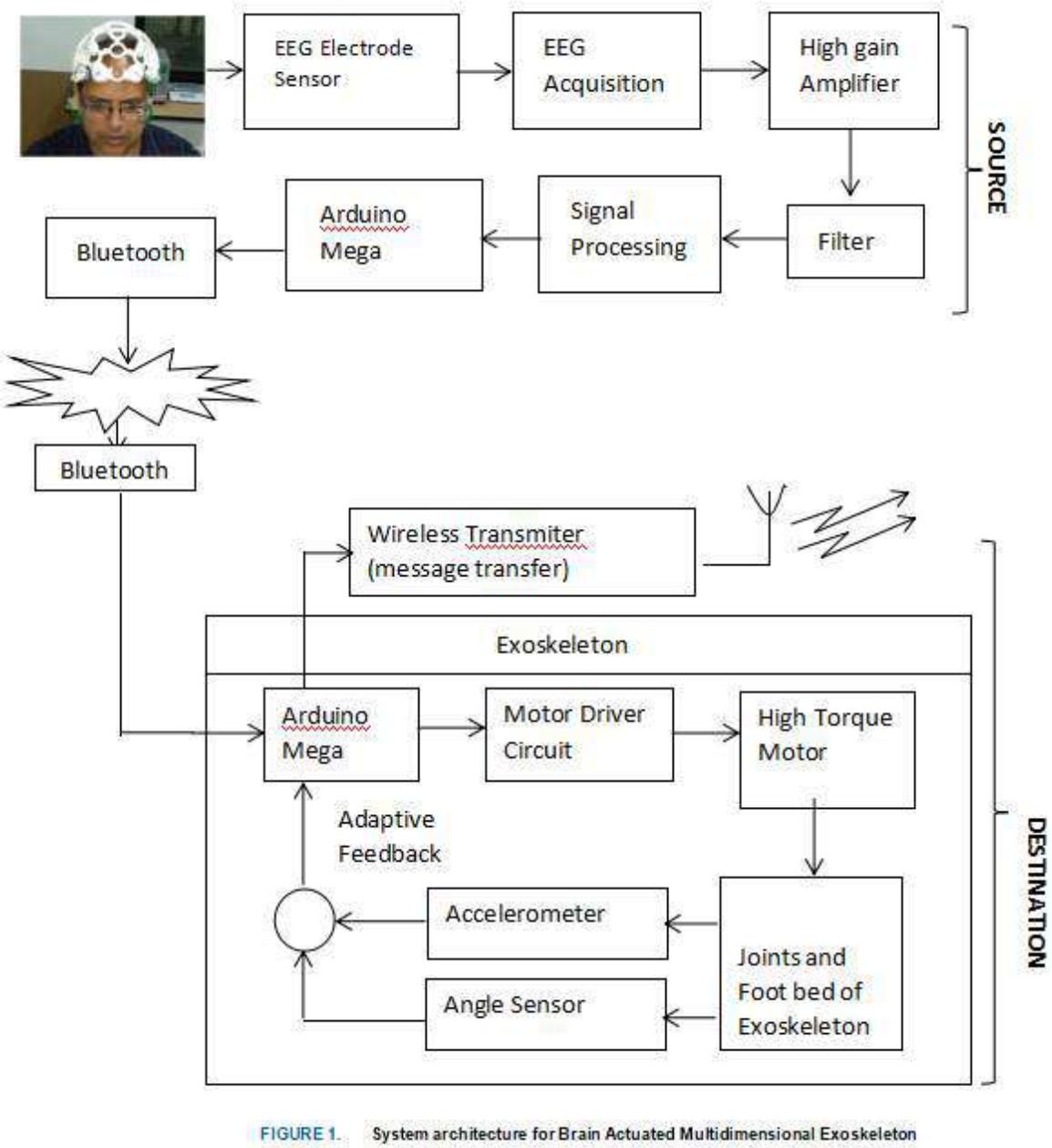

FIGURE 1. System architecture for Brain Actuated Multidimensional Exoskeleton

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.

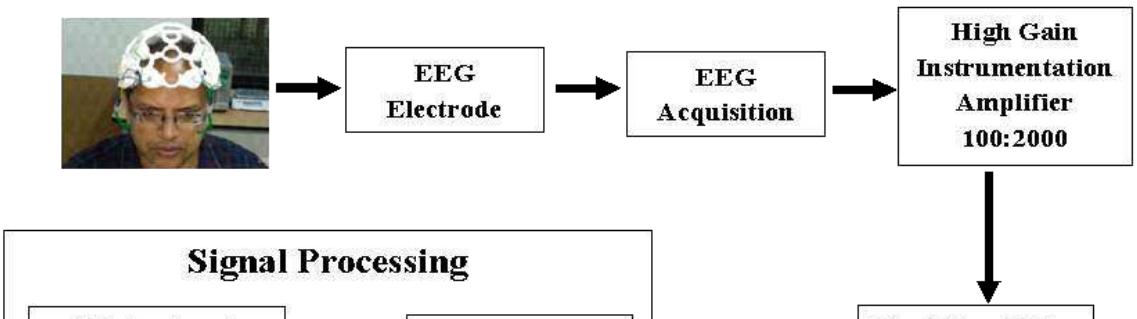

Figure 2. AMIDL EEG Acquisition and Muscle Stimulation Modules

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.

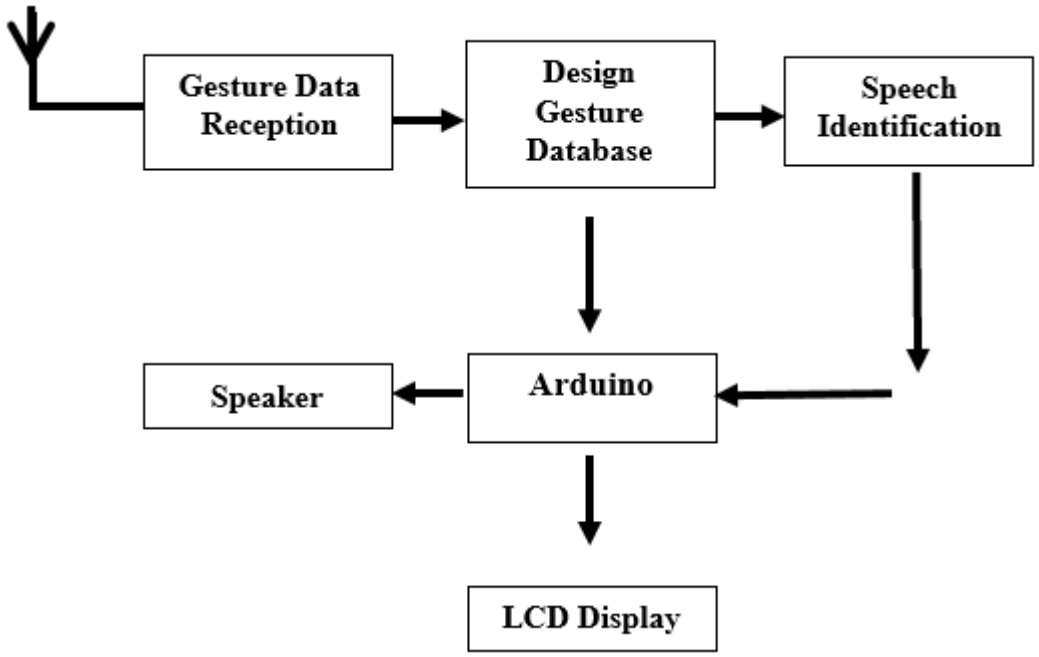

Figure 3. AMIDL Gesture to Voice Conversion

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

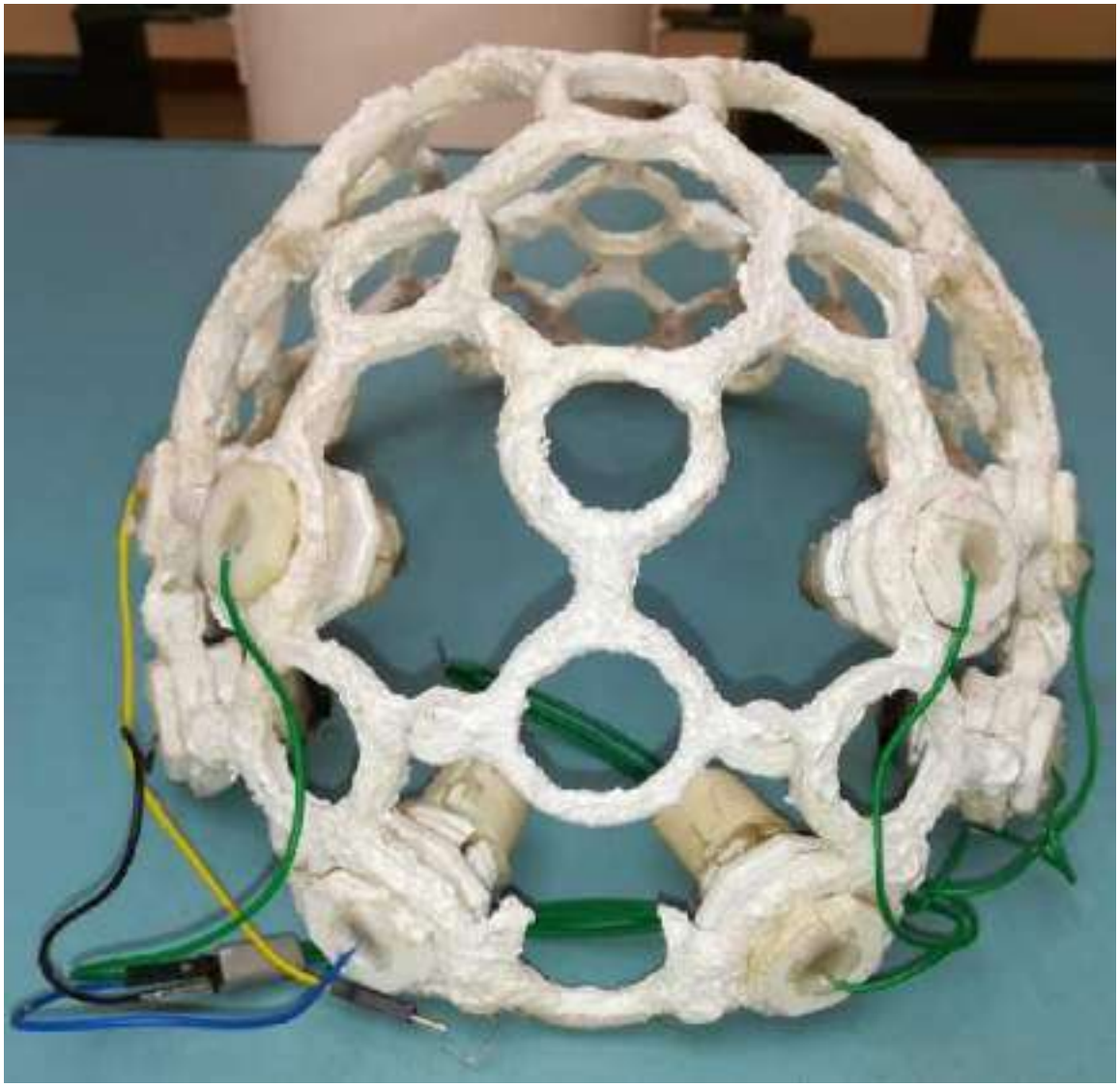

Figure 5. Designed EEG Sensor with electrodes

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

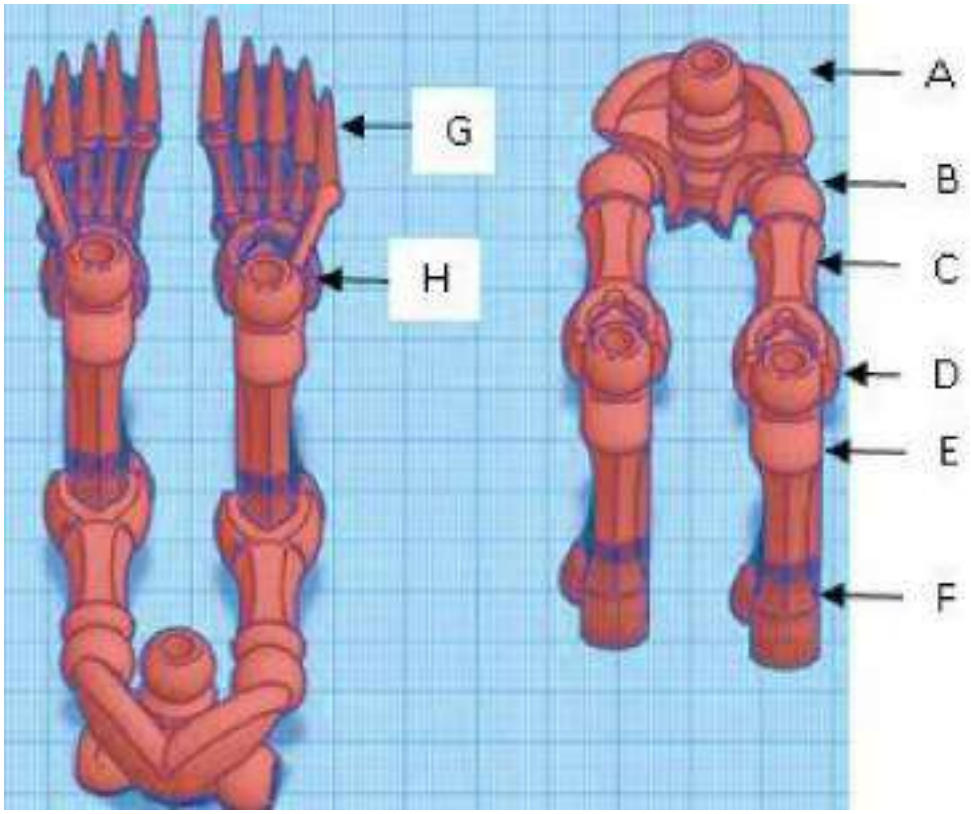

Figure 6: Complete Lower body part exoskeleton

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.

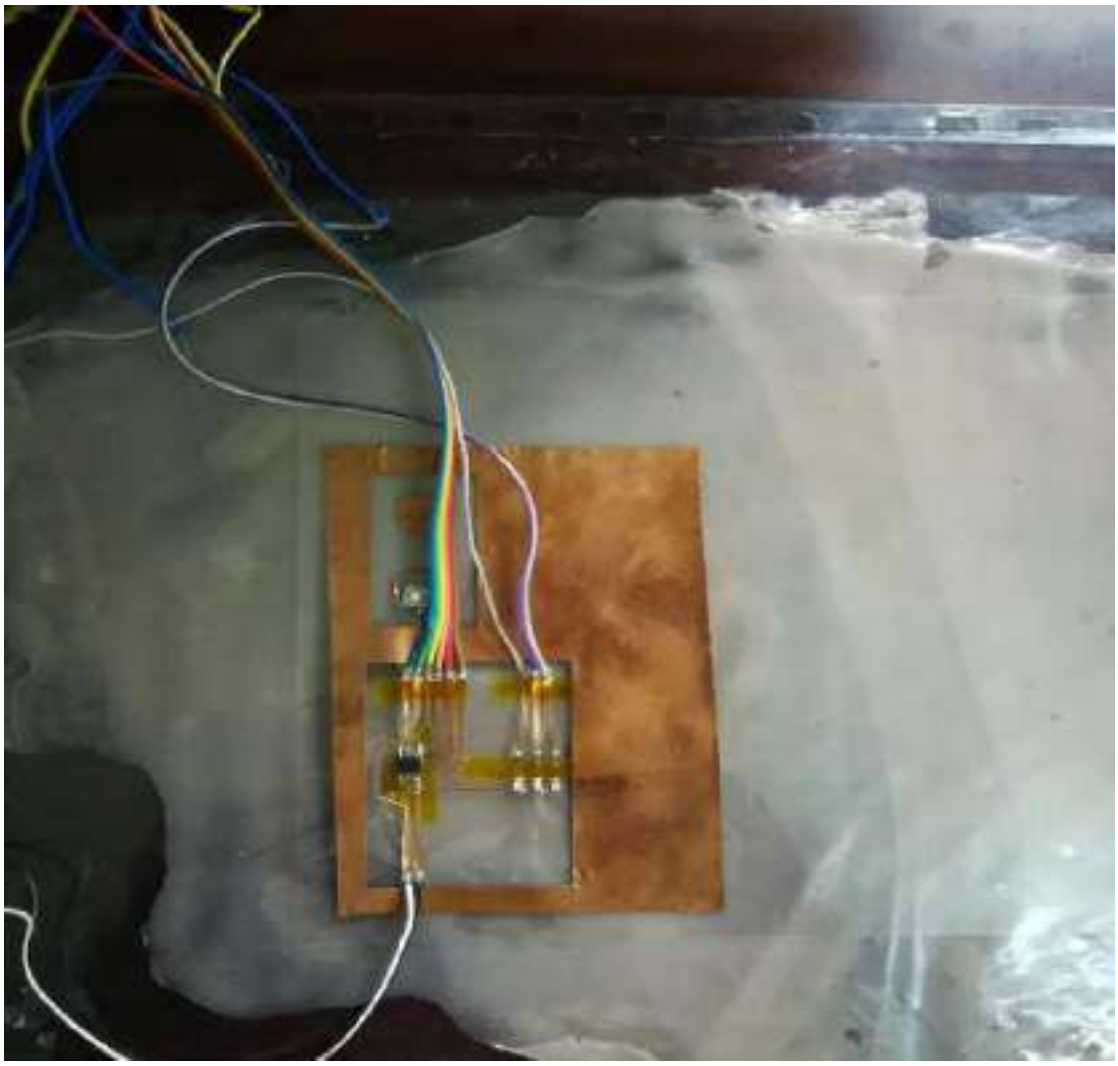

FIGURE 7. Artificial Skin along with processor and sensor circuit

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

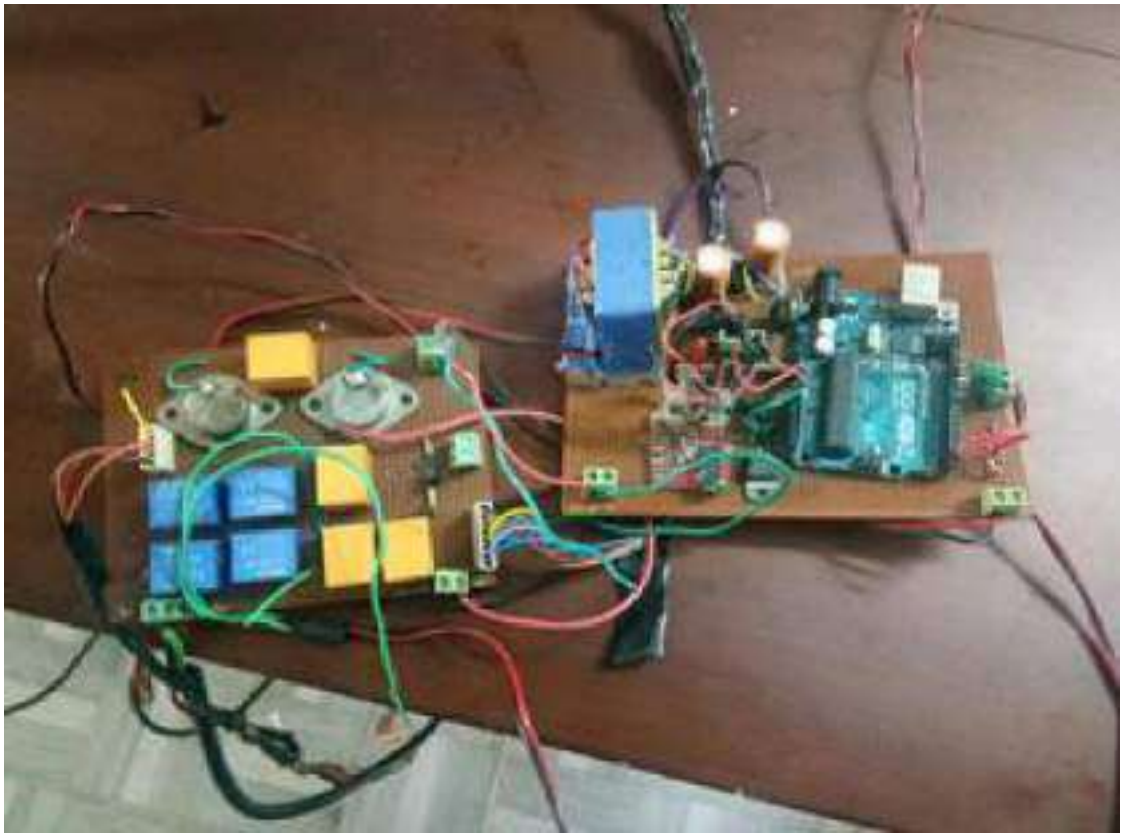

FIGURE 9.PCB of microcontroller and its associated driver

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

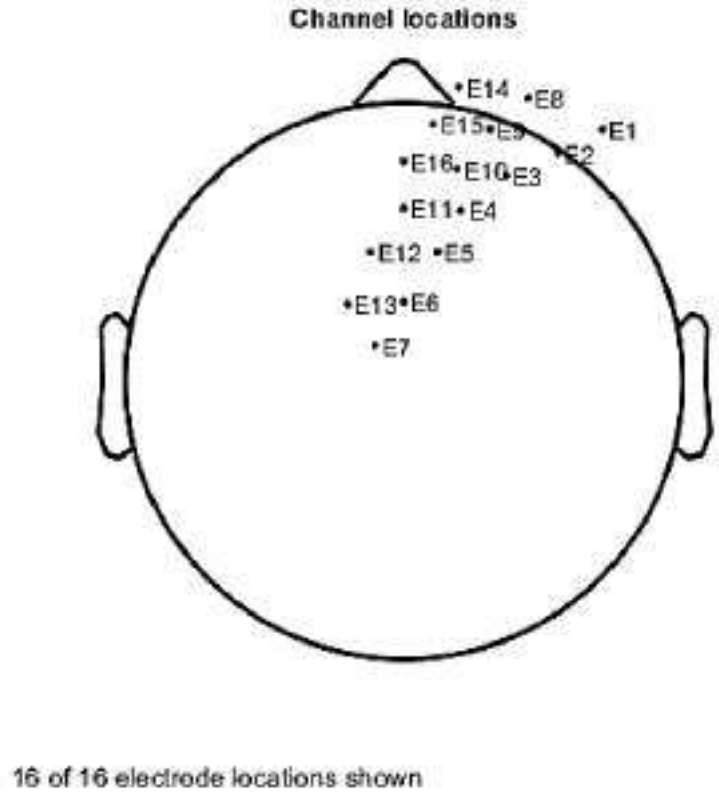

FIGURE 10. Location of 16 different electrodes

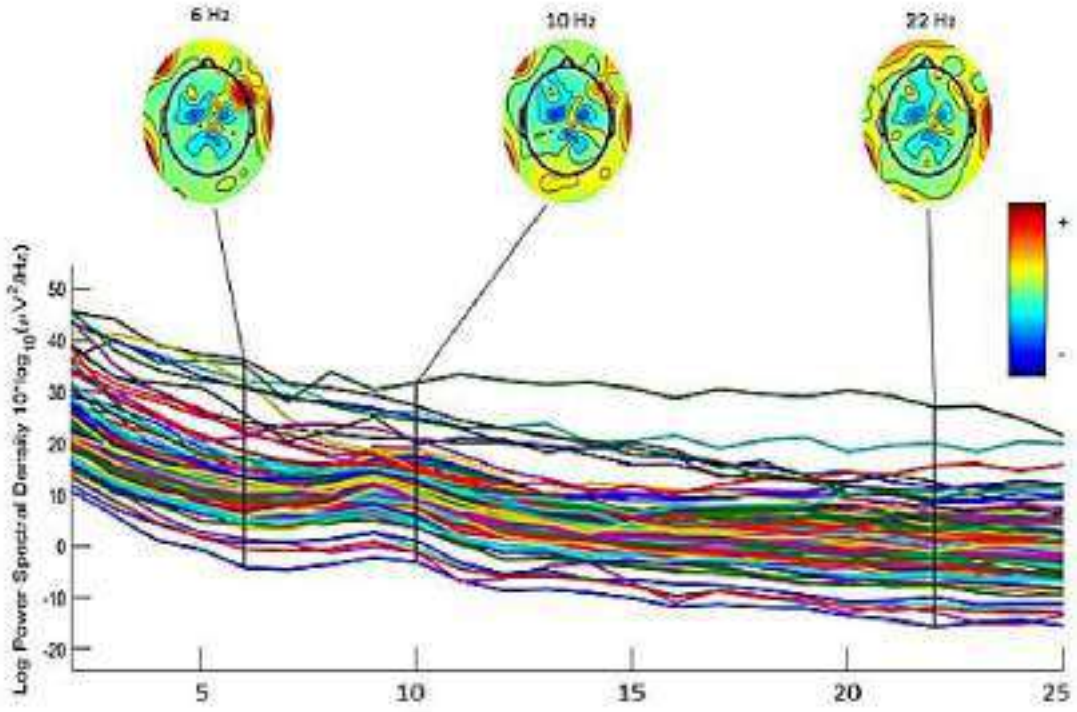

FIGURE 11. Brain pattern variations at different frequencies

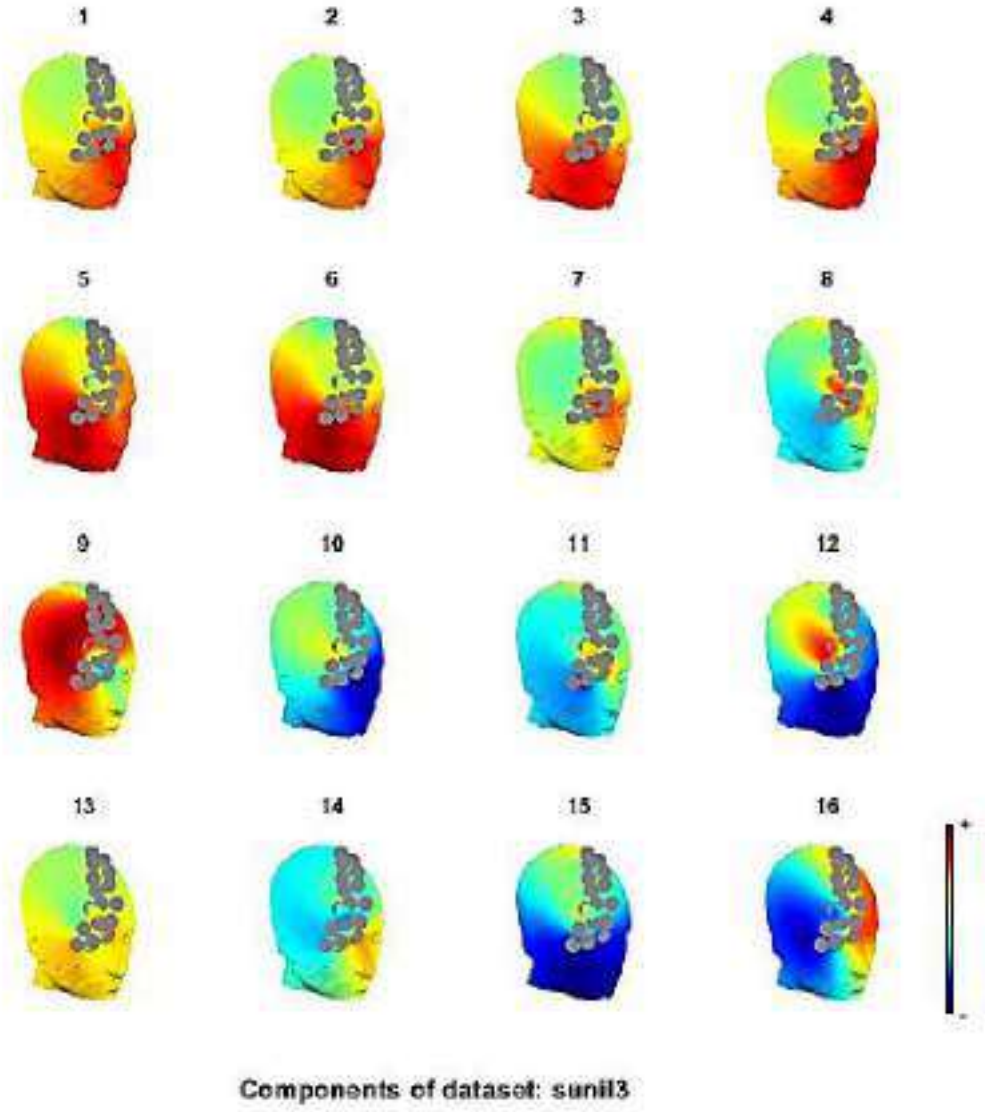

FIGURE 12. Realistic head model with active region

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

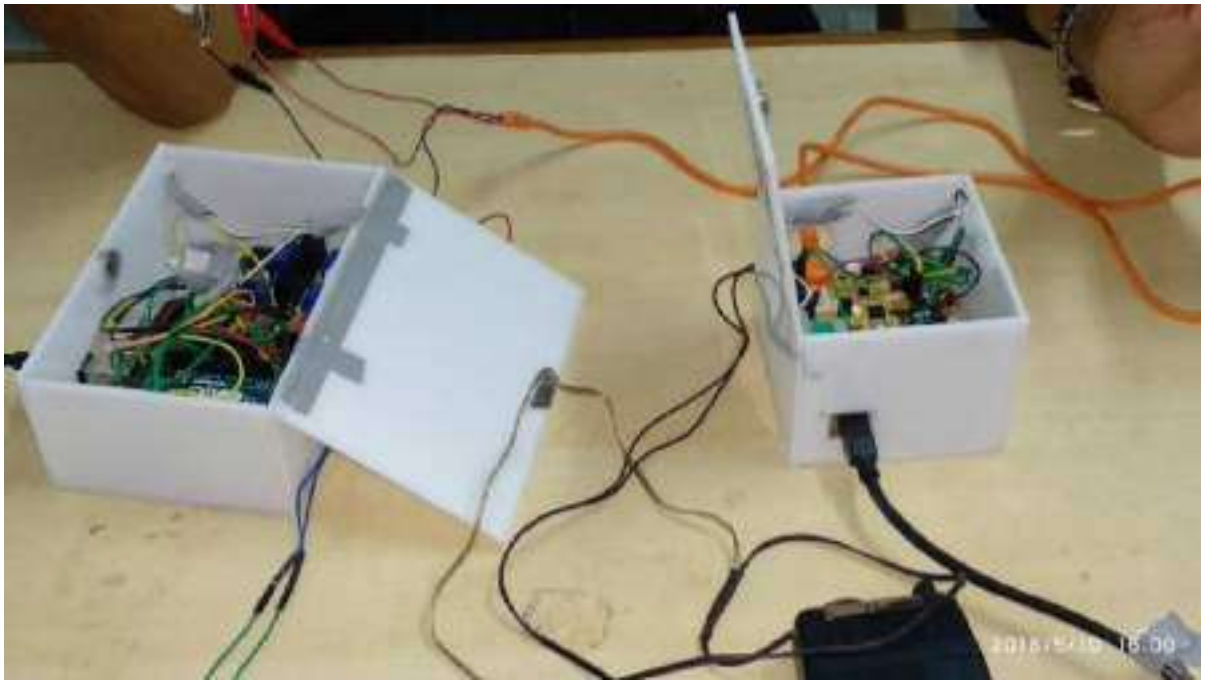

Figure 4. PCB designed for the experimentation

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

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).

VINOT P.G
Name & Signature of the Awardee

Name & Signature of Head of the Institution

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

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

CORPORATE OFFICE: SCMS CAMPUS, PRATHAP NAGAR, MUTTOM, ALUVA, COCHIN-683 106,
Phone: 91-484-2628000 • E-mail: scms@scmsgroup.org

Statement of Account

VINOJ P G
PARAMBALOTH HOUSE
KARTHEDOM MALIPURAM P O

City	ERNAKULAM
State	KERALA
Country	INDIA
Zip	682511
Mobile No	919446276238
E-mail	vinojpg@yahoo.co.in

Statement Date : 11/01/2023 14:02

Union Bank of India

Branch	PALISSERY
Customer Id	212635093
Account No	588802010007430
Account Currency	INR
Account Type	Saving Account
MICR Code	683026004
IFSC Code	UBIN0558885

Records from 1 to 8. No more records available.

Statement Period From -01/04/2022 To 31/12/2022

Date	Remarks	Tran Id	UTR Number	Instr. ID	Withdrawals	Deposits	Balance
07/04/2022	588802010007430:Int. Pd:01-01-2022 to 31-03-2022	S30743726	-			441.00	1,099.50
22/04/2022	NEFT:SRISTI-BIRAC PROJECT A/C AXIC221120774962	S517157	Sender No:AXIC221120774962			500,000.00	501,099.50
06/07/2022	588802010007430:Int. Pd:01-04-2022 to 30-06-2022	S7578279	-			2,727.00	503,826.50
29/07/2022	eTXN/To:345801010030000/Exoskeleton phase2	S77994936	-		265,000.00		238,826.50
29/07/2022	eTXN/To:345801010030000/Phase 2 2nd Payment	S78173949	-		200,000.00		38,826.50
06/10/2022	588802010007430:Int. Pd:01-07-2022 to 30-09-2022	S94076175	-			1,250.00	40,076.50
08/11/2022	NEFTO-KAMAL UPRETI 000710536815	S4467353	-		9,500.00		30,576.50
21/11/2022	MOBFT to: VINOJ P G/232523048718	S87239729	-		30,000.00		576.50

Statement of Account

VINOJ P G
PARAMBALOTH HOUSE
KARTHEDOM MALIPURAM P O

City	ERNAKULAM
State	KERALA
Country	INDIA
Zip	682511
Mobile No	919446276238
E-mail	vinojpg@yahoo.co.in

Statement Date : 07/02/2022 19:39

Union Bank of India

Branch	PALISSERY
Customer Id	212635093
Account No	588802010007430
Account Currency	INR
Account Type	Saving Account
MICR Code	
IFSC Code	UBIN0558885

Statement Period From -25/01/2021 To 07/01/2022

Records from 1 to 17. No more records available.

Date	Remarks	Tran Id	UTR Number	Instr. ID	Withdrawals	Deposits	Balance
25/01/2021	NEFT:SRISTI-BIRAC PROJECT A/C AXIC210252419020	S73603337	Sender No:AXIC210252419020			500,000.00	500,000.00
16/03/2021	eTXN/To:345801010030000/Gyti fund for purchase	S75750403	-		200,000.00		300,000.00
20/03/2021	eTXN/To:345801010030000/Gyti project fund	S27940834	-		295,000.00		5,000.00
05/04/2021	588802010007430:Int. Pd:01-01-2021 to 31-03-2021	S38599092	-			2,158.00	7,158.00
13/04/2021	PRINCIPAL SCMS	AA225319	-			243,000.00	250,158.00
15/04/2021	IMPSAR/110512453453/HDFC0001512/15121140005885	S81000006	-		68,450.00		181,708.00
12/05/2021	NEFTO-UPS EXPRESS PRIVATE LTD 000279775883	S17311805	-		28,015.00		153,693.00
16/05/2021	IMPSAR/113618814442/HDFC0001512/15121140005885	S70693574	-		4,200.00		149,493.00
08/06/2021	IMPSAR/115915707617/SBIN0020149/62423775910	S53268262	-		750.00		148,743.00
03/07/2021	588802010007430:Int. Pd:01-04-2021 to 30-06-2021	S99506500	-			1,066.00	149,809.00
10/07/2021	IMPSAR/119110234506/FDRL0001272/99980104180893	S11581035	-		19,150.00		130,659.00
20/07/2021	MOBFT to: VINOJ P G/120122372710	S72865166	-		11,200.00		119,459.00
02/10/2021	588802010007430:Int. Pd:01-07-2021 to 30-09-2021	S45903945	-			935.00	120,394.00
07/12/2021	MOBFT to: VINOJ P G/134123338052	S64557773	-		1,025.00		119,369.00
30/12/2021	MOBFT to: VINOJ P G/136414147306	S94662579	-		1,500.00		117,869.00
31/12/2021	MOBFT to: VINOJ P G/136514620927	S15135920	-		4,000.00		113,869.00
06/01/2022	588802010007430:Int. Pd:01-10-2021 to 31-12-2021	S37076477	-			877.00	114,746.00

NPOL
Certified ISO 9001:2015
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

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

FAX MESSAGE

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 सं०/Contract agreement No. NPOL/21CR007 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 सं० तथा तारीख /Delivery challen 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.	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: Kaukkanad

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

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. 12/02/2021 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		2,76,120/-		
				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/एस 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 कारेवाई 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: Kaviketty
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/DICR007 तारीख/Date 18/08/2021 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 - 683 576

सुपुर्दगी चालान सं० तथा तारीख /Delivery challen 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	Second Milestone Payment on Project Design and Analysis of Hydrodynamic Depressor	No.		234,000	00	2,34,000	00	
				बि.क. तथा ज.ज. /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/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: Kanjikkuzhy

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

GST INVOICE

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

Pratap 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 Address: Naval Physical and Oceanographic Laboratory, Kochi Thrikkakara (PO) -682021 State: Kerala State Code :32 GSTIN: Unregistered	Name: Director NPOL Address: Naval Physical and Oceanographic Laboratory, Kochi Thrikkakara (PO) -682021 State: Kerala State Code :32 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	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

Dr. PRAVEEN K.C. Signatory
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 Address: Naval Physical and Oceanographic Laboratory, Kochi Thrikkakara (PO) -682021 State: Kerala State Code :32 GSTIN: Unregistered	Name: Director NPOL Address: Naval Physical and Oceanographic Laboratory, Kochi Thrikkakara (PO) -682021 State: Kerala State Code :32 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

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: SCMGST003
Invoice Date: 24/11/2021

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

Category : Research and Development Services

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