

DESIGN AND DEVELOPMENT OF BRACES FOR CHRONIC LOWER BACK PAIN

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Technology degree in Biomedical Engineering

By

KISHORE R (39240021)

KEERTHIVASAN V (39240020)



**DEPARTMENT OF BIOMEDICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

APRIL – 2023



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF BIOMEDICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **KISHORE R (39240021)** and **KEERTHIVASAN V (39240020)** who carried out the final year project entitled **DESIGN AND DEVELOPMENT OF BRACES FOR CHRONIC LOWER BACK PAIN** under our supervision from October 2022 to April 2023.

Dr. BETHANNEY JANNEY, M.E., Ph.D

Guide

HEAD OF THE DEPARTMENT
DEPARTMENT OF BIOMEDICAL ENGINEERING
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Tondiar Nagar Rajiv Gandhi Salai
Chennai 600 095

Dr. T. SUDHAKAR, M.Sc., Ph.D

Head of the Department

Submitted for Viva -voce Examination held on 18th April 2023

Internal Examiner

External Examiner

DECLARATION

We, KISHORE R (39240021) and KEERTHIVASAN V (39240020), hereby declare that the Project Report entitled “ DESIGN AND DEVELOPMENT OF BRACES FOR CHRONIC LOWER BACK PAIN” done by us under the guidance of Dr. BETHANNEY JANNEY, M.E., Ph.D., is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in B.Tech Biomedical Engineering.

DATE: 18.04.2023

PLACE: CHENNAI

1. R. Kishore
2. Keerthivasan

SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this report and for completing it successfully. I am grateful to them.

We convey my thanks to **Dr.T.Sudhakar, Head of the Department, Dept. of Biomedical Engineering** and **Dr. Bethanne Janney, Dept. of Biomedical Engineering** for providing me necessary support and details at the right time during the progressive reviews suggestions and constant encouragement paved way for the successful completion of my report work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Bio Medical Engineering who were helpful in many ways for the completion of the project.

We would also like to express our gratitude towards our parents for supporting us in the successful completion of our project.

ABSTRACT

The ever-increasing sophistication of the world's technologies is drastically altering the way people live. The rise of the sedentary lifestyle in the modern world is directly attributable to the spread of industrialization and urbanisation. Indulging in technology often results in people neglecting their posture and spending long periods of time hunched over. Back pain is reportedly the third most common reason people go to the doctor, making good posture all the more critical to a healthy lifestyle. Yet, whether intentionally or not, humans downgrade one of the defining characteristics of being human: the capacity for upright locomotion. Finding effective methods for posture detection and correction is the focus of this paper. Every human spends most of their time remain seated especially students. A good posture during seated is important to determine the human health, while a bad posture during seated posture can lead to numerous diseases. This project explained the design and development of wearable posture identification system using accelerometers to determine the good human posture in a seated position. Electrodermal activity (EDA) is a sensitive index of sympathetic nervous system activity. Due to the lack of sensors that can be worn comfortably during normal daily activity and over extensive periods of time, research in this area is limited to laboratory settings or artificial clinical environments. We also evaluated the choice of electrode material by comparing conductive fabric with Ag/AgCl electrodes and discuss the limitations found. Our device offers the unprecedented ability to perform comfortable, long-term, and in situ assessment of EDA. This project opens up opportunities for future investigations that were previously not feasible, and could have far-reaching implications for diagnosis and understanding of psychological or neurological conditions.

Key words: IOT, Detection, Correction, Posture, Arduino, IMU MPU, Android, Circuit, Accelerometer, EDA

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	i
	LIST OF FIGURES	iv
	LIST OF ABBREVIATIONS	v
1	INTRODUCTION	1
2	LITERATURE REVIEW	3
3	AIM AND SCOPE	9
	3.1 AIM	9
	3.2 SCOPE	9
4	MATERIALS AND METHODS	10
	4.1 METHODOLGY	10
	<i>4.1.1 Block Diagram</i>	11
	<i>4.1.2 Control Unit</i>	11
	4.2 HARDWARE USED	12
	<i>4.2.1 EDA Sensor</i>	12
	<i>4.2.2 MEMS Sensor</i>	13
	<i>4.2.3 Node MCU</i>	14
	<i>4.2.4 Wi-Fi Module</i>	15
	<i>4.2.5 L293D</i>	16
	<i>4.2.6 SPI Protocol</i>	17

	<i>4.2.7 Power Supply</i>	19
	<i>4.2.8 Buzzer</i>	19
	<i>4.2.9 GSM Module</i>	20
	4.3 SOFTWARE USED	21
	<i>4.3.1 Arduino IDE</i>	21
	<i>4.3.2 Embedded C</i>	22
	<i>4.3.3 Java</i>	23
	<i>4.3.4 ThingSpeak</i>	24
5	RESULTS AND DISCUSSION	26
6	SUMMARY AND CONCLUSION	32
	6.1 SUMMARY	32
	6.2 CONCLUSION	32
	REFERENCES	33
	PROOF OF ACCEPTANCE	36
	APPENDIX	37

LIST OF FIGURES

FIGURE NO	TITLE	PAGE NO
4.1.1	Block Diagram	11
4.1.2	Control Unit	11
4.2.1	EDA Sensor	13
4.2.2	MEMS Sensor	14
4.2.3	Node MCU	15
4.2.4	Wi-Fi Module	15
4.2.5	L293D	17
4.2.6	SPI Protocol	18
4.2.7	Power Supply	19
4.2.8	Buzzer	20
4.2.9	GSM Module	21
4.3.1	ARDUINO IDE	22
4.3.4	ThingSpeak	25
5	Prototype	26
5.1	Front view	27
5.2	Back view	27
5.3	Detection of bad posture	28
5.4	Detection of abnormalities using EDA	29
5.5	Generation of heat	30
5.6	Output obtained on Thing Speak	31

LIST OF ABBREVIATIONS

ABBREVIATIONS

EXPANSION

EDA	Electro Dermal Activity
GSM	Global System for Mobile Communication
IMU	Inertial Measurement Unit
IOT	Internet of Things
LAN	Local Area Network
MCU	Micro controller Unit
MEMS	Microelectro Mechanical System
SPI	Serial Peripheral Interface
WIFI	Wireless Fidelity

CHAPTER 1

INTRODUCTION

The new industry is experiencing an enormous growth, thanks to the use of techniques that include advanced manufacturing and industrial design. Moreover, the optimization of the process, the development of new materials by manufacturers, or the decrease of environmental costs are some achievements that make it possible to expand these technics further than the industrial area. Nowadays, these techniques are being transferred to medicine areas, by applications known as bioengineering. Among all emerging technologies in the area of bioengineering, the implementation of additive manufacturing (AM) in the healthcare industry has led to several benefits. The design freedom allows customization of surgical equipment, medical devices, and implants. In fact, anatomy for pedagogical objectives, craniomaxillofacial surgery, oral appliance therapy for snoring and obstructive sleep apnea (OSA), orthopedics surgery, and rehabilitation are some examples in which the benefits of fused filament fabrication (FFF) technology could improve the clinical course of patients. These new techniques allow to improve wearing comfort and better hygiene due to the bio-compatible and sterilizable properties. Over this fields, many developments have been carried out in recent years, like exoskeletons, prosthesis, or assistive devices. These specialties are in demand in developed countries, but a level of maturity and technological development is necessary to promote a change in the actual model. Moreover, both orthopedics and rehabilitation are specialties of medicine very conducive and receptive to all kinds of technological developments or applications in the field of research, development, and innovation (R&D&I). Thanks to the use of different methods of industrial three-dimensional digitization and reverse engineering, advanced manufacturing has generated a recent emergence of solutions. Based on additive manufacturing it has allowed a great advance in products of mass use such as splints, braces, prostheses, or assistive devices. Moreover, these techniques, combined with new sensors and actuators, have revolutionized the applications of exoskeletons by the hand of robotics . Products such as splints made by additive manufacturing offer great advantages over classical methods of permanent and splinting (splinting) or commercial immobilization (braces, corsets, etc.). Some of these advantages are

adaptation, personalization, hygiene, materials used, or environmental impact, among others. The incursion of these new 3D techniques in medical processes allows to include smart systems to analyze different states of the medical evolution process. This project proposes to combine 3D techniques with electronic systems to develop a new era of splints that have not been achieved before. The use of these kind of systems, which include small electronic boards, programming systems, and data communication, would make possible to monitor parameters as temperature and pressure. These parameters would be sent to an application running on a portable device and compared in a database with other similar treatments data or sent to the doctor to see if the process is evolving correctly. This way, it is possible to include the smart splints into the use of big data in healthcare and the Internet of Things (IoT) movement.

CHAPTER 2

LITERATURE SURVEY

Slavomir Matuska et al., (2020) proposed a Smart System for Sitting Posture Detection Based on Force Sensors and Mobile Application. The employees' health and well-being are an actual topic in our fast-moving world. Employers lose money when their employees suffer from different health problems and cannot work. The major problem is the spinal pain caused by the poor sitting posture on the office chair. This paper deals with the proposal and realization of the system for the detection of incorrect sitting positions. The smart chair has six flexible force sensors. The Internet of things (IOT) node based on Arduino connects these sensors into the system. The system detects wrong seating positions and notifies the users. In advance, we develop a mobile application to receive those notifications. The user gets feedback about sitting posture and additional statistical data. We defined simple rules for processing the sensor data for recognizing wrong sitting postures. The data from smart chairs are collected by a private cloud solution from QNAP and are stored in the MongoDB database. We used the Node-RED application for the whole logic implementation.

S.Unnathi Annapurna et al., (2022) proposed the Alert System for Posture Correction : a review. Millions of people across the globe are suffering from back pain. The main reason behind is bad posture of back. We always tend to ignore these little symptoms of back pain, which would lead to serious deformities in the future. In the present, computers, laptops, electronic gadgets have been an important routine. So as prevention, we require a bio-electronic device which could give the inference on his posture and help maintain a better posture, hence maintaining a good spine health. The main focus of this paper is about the construction, working, testing of the posture alert system device developed using Arduino Uno and flex sensors. This device being developed is low cost, reliable and user friendly for most ages.

M. Suresh Anand et al., (2019) proposed a Human Posture Detection System using real time Self Calibrating Algorithm. In order to detect and correct the posture we developed a wearable garment integrated device to sense the posture of the user and analyze the posture within the device to alert the user remotely. Further the posture data are sends to the server to analyze the data in detail. Device contains the accelerometer sensor to detect the angle of the user. From the angle the 12 posture is calculated using the micro controller in the device. The posture is analyzed and if bad posture is detected then the buzzer sensor present in the device alert the user to correct the posture. The bad posture data are sends to server through the WiFi module present in the device. The data are stored in the database along with time, date and device id. The month wise statistical graph is developed from the data in the database. Daily analyzes of the posture data is done to provide the average posture of the user and worst posture of the user.

Swapnali Dhulap et al., (2021) proposed an IOT Based Smart Wearable Posture Detection & Alert System. Low back pain treatment costs a billion dollars every year. One of the most common causes for doctor visits is low back pain. Lower back pain is frequently caused by poor posture, which affects the transverses abdominal muscle. Regularly altering postures and maintaining excellent posture are supposed to help enhance and to maintain one's fitness. A wide range of smart monitoring systems have been built around the world to assist people in improving their lives enhancing one's quality of life by delivering a variety of services a helping hand. Wearable smart technology has become the standard the century's main focus, especially in the medical sector, where breakthroughs range from pulse to Hearing aids to monitors The procedure for creating, developing and testing a small wearable interface uses a variety of sensors to keep track of a user's back posture in real-time and notify them when their posture is bad identified is described in this article.

C. J. A. M. Willemse et al., (2016) proposed a Wearable intervention for Posture improvement : a review. Incorrect posture is a problem that becomes increasingly wide-spread in today's world. It can lead to short and long term pain in

the back and neck areas, and has further been linked to depression. Modern lifestyle facilitates poor posture, especially because of the increasing amount of time people spend sitting. Even individuals that are considered physically active often still spend a considerable amount of time in sedentary behaviors. Seated posture is therefore critically important and deserves more attention. Typically, people reside in unhealthy hunched-over or slouching positions, especially when interacting with screens. A poor seated posture can also affect a person's posture while standing and walking. Muscle memory plays an important role in this, as the body gets used to being incorrectly positioned. Therefore, to correct one's posture and avoid the aforementioned risks, a correct sitting and standing position has to be established and trained. Wearable technology can be a means to achieve this aim by constantly measuring the wearer's body posture and giving feedback on correct or incorrect posture. In the course of this project, a concept for a smart garment that can detect incorrect posture and communicate it to the user, who then can correct her posture, is developed. Overall, the design can be considered to achieve Wearability Level 2: "System is wearable, but changes may be necessary, further investigation is needed". In conclusion, the developed design shows potential, but leaves room for further improvements.

Franz Landauer et al., (2021) proposed an Indication-Based Concept for Stepwise Spinal Orthosis in Low Back Pain According to the Current Literature. The 30 highest-rated literature citations (Pub Med: best match, 30 December 2021) dealing with low back pain and spine orthosis were included in the study. Excluded were all articles related to Kinesio Taping, scoliosis, physical exercise, or dealing with side effects and unrelated to treatment effect. Thus, the literature list refers only to "low back pain and spine orthoses". These articles were analyzed according to the PRISMA criteria and divided according to "specific diagnosis", when the cause of pain was explained (group A), or when "specific diagnosis is not given" (group B). The articles were also distinguished by the information about the orthosis. Articles with bio mechanical information about the function of the orthoses were called "diagnosis-based orthosis" (group C). The results were compared to each other in terms of effectiveness. According to anatomical causes, a concept of orthosis selection depending on diagnosis of low back pain for clinical practice was developed. The risk of bias lies in the choice of the MESH terms. The synthesis of

the results was a clinical treatment concept based on findings from the current literature. In all review articles where specific diagnosis was not given, no effect with spine orthoses could be found. Using this knowledge, we created a clinical treatment concept. The structure was based on diagnosis and standardized orthoses. According to pain location and pathology (muscle, inter vertebral disc, bone, statics, postoperative) the orthoses were classified to anatomical extent and the mechanical limitation (bandage, bodice, corset, orthosis with shoulder straps and erecting orthosis). Conclusion: The effectiveness of spinal orthoses could not be deduced from the current literature. The most serious limitation was the inconsistency of the complaint and the imprecise designation of the orthoses.

Petra Jellema et al., (2008) proposed the Lumbar Supports for Prevention and Treatment of Low Back Pain. Lumbar supports are used in the treatment of low back pain, but also to prevent the onset (primary prevention) or recurrences of a low back pain episode (secondary prevention). To assess the effects of lumbar supports for prevention and treatment of non specific low back pain. The Medline, Cinahl, and Current Contents databases; the Cochrane Controlled Trials Register up to September 1999; and the Embase database up to September 1998 were all searched. References of identified trials and systematic reviews were 14 reviewed and the Science Citation Index used to identify additional trials. Methodological quality assessment and data extraction were performed by two reviewers independently. A quantitative analysis was performed in which the strength of evidence was classified as strong, moderate, limited or conflicting, and no evidence. Five randomized and two non randomized preventive trials and six randomized therapeutic trials were included in the review. Only 4 of the 13 studies were of high quality. There was moderate evidence that lumbar supports are not effective for primary prevention. No evidence was found on the effectiveness of lumbar supports for secondary prevention. The systematic review of therapeutic trials showed that there is limited evidence that lumbar supports are more effective than no treatment, whereas it is still unclear whether lumbar supports are more effective than other interventions for treatment of low back pain.

Tatiana Ortegon-Sarmiento et al., (2020) proposed the Low Back Pain Attenuation Employing Virtual Reality Physiotherapy. Pain can negatively impact the quality of life and affect daily activities that can lead to work absenteeism and depression. According to the World Health Organization, lower back pain is one of the most common musculoskeletal disorders requiring physical and/or pharmacological treatment in chronic conditions. The effectiveness of such treatments is negatively affected by the lack of compliance. For physical activity, common challenges include discomfort, lack of feedback when unsupervised, or boredom caused by the repetitive and monotonous nature of exercising. An approach that has gained popularity in physical therapy employs games to boost engagement and adherence by taking advantage of natural pain attenuators including deep breaths, listening to music, or playing video games. This paper presents the evaluation of three virtual environments designed to modulate lower back pain by means of the visual analog scale (VAS) to assess pain perception, and the System Usability Scale (SUS) to evaluate the systems. The results indicate that two of the three environments showed a positive impact on pain perception. The VAS reported by the participants for the second and the third environment was the same or lower when using the virtual environment, the first environment represented better results for the 60 % of the participants meanwhile, the other 40% perceived higher pain. Finally, the participants found the scenarios usable with a SUS score average of 83, 78.5, and 88.5 for each environment.

Wenjing Du et al., (2018) proposed the Recognition of Chronic Low Back Pain During Lumbar Spine Movements Based on Surface Electromyography Signals. Chronic low back pain (CLBP) is a common musculoskeletal disorder and a major source of disability in adults. The assessment of lumbar muscle functioning has proven as an appropriate approach for early identification of CLBP when significant pathological signs and symptoms are absent. Thus, earlier therapy or rehabilitation can be administered to prevent further deterioration, such as spinal stenosis or disk herniation. In this paper, surface electromyography (sEMG) signal analysis was explored for the recognition of low back pain in subjects with non-specific symptoms; 88 CLBP subjects and a control group of 83 subjects were recruited for sEMG data acquisition. Subjects were asked to

perform four specific movements, namely forward bending, backward bending, right lateral flexion, and left lateral flexion. While performing each movement, sEMG signals from three pairs of lumbar muscles were captured, and 31 features from both the time and frequency domains were extracted from the signal. Finally, the main feature group and four subsets, derived from it, were explored. The suggested method allowed to achieve CLBP recognition accuracy of 98.04% based on subset C for forward bending, followed by 96.15% based on subset E for right lateral flexion, 93.33% based on subset E for left lateral flexion, and 91.30% based on subset B for backward bending. A combination of support vector machine classifiers and optimal feature selection allowed for improved classification performance. The main aim of this paper is to recognize CLBP in subjects with non-specific pathology during the four types of movement. The major steps carried out to achieve this are pre-processing, feature selection, and classification of the sEMG signals acquired from 171 subjects. Results suggest CLBP recognition based on sEMG as a promising alternative to the conventional methods. Therefore, this paper could inspire the design of appropriate programs that can ensure effective rehabilitation of CLBP patients.

Alyazyah Alsuwaidi et al., (2018) proposed a Wearable Posture Monitoring System with Vibrational Feedback. Around 50 billion dollars is spent yearly on therapy for low back pain in the United States alone. Low back pain is one of the most common reasons for doctor visits. Having poor posture has been found to be a main cause of lower back pain as it impacts the transverses abdominis muscle. Maintaining a good posture and changing one's position from time to time is considered to significantly improve and maintain one's health. The world has witnessed a vast amount of smart monitoring devices that are used to enhance the quality of life by providing different types of support. Smart wearable technology has been the main focus of this century, specifically in the medical field, where the advances range from heartbeat monitors to hearing aids. This report highlights the design, development and validation process of a compact wearable device that uses multiple sensors to measure the back posture of a user in real time and notify them once poor posture is detected.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

For certain musculoskeletal complex rupture injuries, the only treatment available is the use of immobilization splints. This type of treatment usually causes discomfort and certain setbacks in patients. In addition, other complications are usually generated at the vascular, muscular, or articular level. Currently, there is a really possible alternative that would solve these problems and even allows a faster and better recovery.

3.2 SCOPE

The main scope of this work was the project, design, and manufacture of a smart and immobilization splint to monitor different parameters about the real evolution of an injury. This makes it possible to have real-time data to diagnose any kind of problem that is not possible to detect with traditional splints.

CHAPTER 4

MATERIALS AND METHOD

4.1 METHODOLOGY

This project proposes the implementation of a series of sensors to detect possible problems during the whole time of the treatment. The duration of the treatment does not interfere with the data collection and interpretation. In fact, the collection may be carried out periodically, depending on the specialized doctor necessities and on the injury evolution. For this reason, the data collection is carried out as a sign that the system works.

The current state of the technology allows the realization of particular and individualized immobilization splints by using advanced manufacturing, based on fused deposition modeling (EDD Device), 3D digitalization (MEMS), and reverse engineering (Therapy). Moreover, the knowledge of these parameters, might reduce the curing time as some treatments can be applied in this kind of splint but not in traditional splints. In this project it is shown an interesting and really possible evolution of the traditional splints, to provide them with the term “intelligent”. The great possibilities that it offers by this kind of splint is fully demonstrated. However, there are some improvements that are proposed to be carried out in this studies:

- Implementation of a sensor to detect color changes of the skin: This would make it possible to detect bruising and redness, which would allow to get more data for the diagnostic.
- Sending these data to a Bluetooth device that allows remote medical monitoring of the treatment applied and the application of an alarm system in the event of complications, as well as the generation of the data dump in a database for project.
- Integration into functional splints based on rehabilitation techniques in the immobilization phase. This would make it necessary to incorporate a battery to get a full autonomous system.

To finish this project, the main objective is considered to have been achieved, by the incorporation of these sensors and demonstrated that it is possible to detect complications in the treatment of injuries using immobilization splints.

4.1.1 Block Diagram

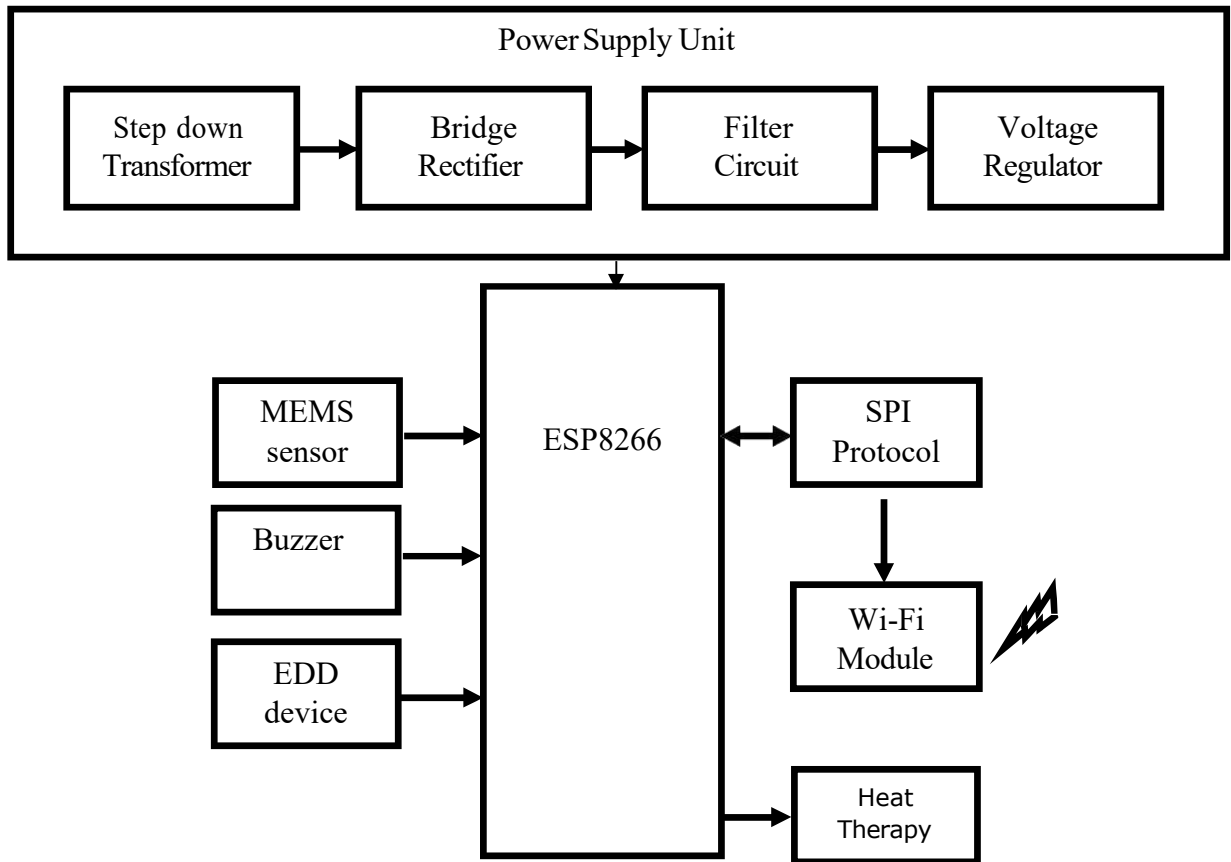


Fig 4.1.1 Block Diagram

4.1.2 Control Unit



Fig 4.1.2 Control Unit

4.2 HARDWARE USED

4.2.1 EDA Sensor

EDA, standing for galvanic skin response, is a method of measuring the electrical conductance of the skin. Strong emotion can cause stimulus to your sympathetic nervous system, resulting more sweat being secreted by the sweat glands. EDA allows you to spot such strong emotions by simple attaching two electrodes to two fingers on one hand, an interesting gear to create emotion related projects, like sleep quality monitor. The EDA sensor is measuring arousal, basically how much you are sweating. Two electrodes are strapped usually in two fingers. In the case of the microcontroller, one was connected to the 5V and the other to one of the analog output/Input and to the GND. The concept of the EDA sensor is based on the fact that our body is used as a resistor. According to what you are measuring the data that you get, show how easy (conductance) or how difficult (resistance) it is for the current to pass through your body. Of course it is understandable that since conductance and resistance are opposite, when the resistance data are transformed into conductance data and then visualized the two graphs for resistance and conductance will show opposite trends. EDA is a sensitive psycho physiological index of changes in autonomic sympathetic arousal that are integrated with emotional and cognitive states." Many biofeedback therapy devices utilize EDA as an indicator of the user's stress response with the goal of helping the user to control anxiety. EDA monitoring is combined with the recording of heart rate, respiratory rate, and blood pressure, because they are all autonomically dependent variables. EDA measurement is one component of modern polygraph devices, which are often used as lie detectors. The E-meter used by the Church of Scientology as part of its practice of auditing and security is checking is a custom EDA measurement device. An ongoing European center study, driven by the research company Emotra, in cooperation with the European Psychiatric Association - Suicide Section, EPASS, is testing to what extent ElectroDermal Hyperactivity can be an indicator of increased risk for suicide among depressed patients. Galvanic Skin Response originates from the autonomic activation of sweat glands in the skin. The sweating on hands and feet is triggered by emotional stimulation: Whenever we are emotionally aroused,

the EDA data shows distinctive patterns that are visible with bare eyes and that can be quantified statistically.

SPECIFICATIONS

- Input Voltage: 5V/3.3V
- Sensitivity adjustable via a potentiometer
- External measuring finger cots



Fig 4.2.1 EDA Sensor

4.2.2 MEMS Sensor

MEMS is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements that are made using the techniques of micro fabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move. The term used to define MEMS varies in different parts of the world.

While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable elements are the microsensors and microactuators. Microsensors and microactuators are appropriately categorized as “transducers”, which are defined as devices that convert energy from one form to another. In the case of microsensors, the device typically converts a measured mechanical signal into an electrical signal. More recently, the MEMS research and development community has demonstrated a number of micro actuators including: micro valves for control of gas and liquid flows; optical switches and mirrors to redirect or modulate light beams; independently controlled micro mirror arrays for displays, micro resonators for a number of different applications, micro pumps to develop positive fluid pressures, micro flaps to modulate airstreams on airfoils as well as many others.

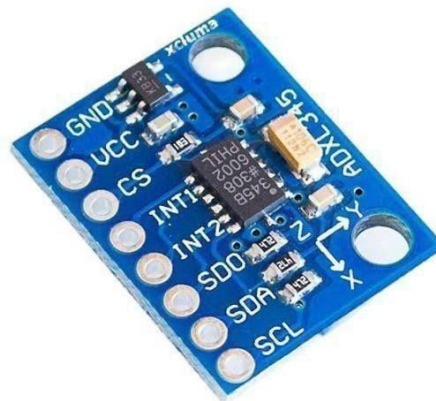


Fig 4.2.2 MEMS Sensor

4.2.3 Node MCU

Node MCU is an open source IOT platform. It includes firmware which runs on the ESP8266 Wi-Fi SOC from Espressif Systems, and hardware, which is based on the ESP-12 module. The term “Node MCU” by default refers to the firmware rather than the dev kits. The firmware uses the Lua scripting language. It is based on the eLua project and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as Lua-cjson and spiffs. LUA based interactive firmware for Espressif ESP8622 Wi-Fi SOC, as well as an open source hardware board that contrary to the \$3 ESP8266 Wi-Fi modules includes a CP2102 TTL to USB chip for programming and debugging, is breadboard-friendly, and can simply be powered via its micro USB port.

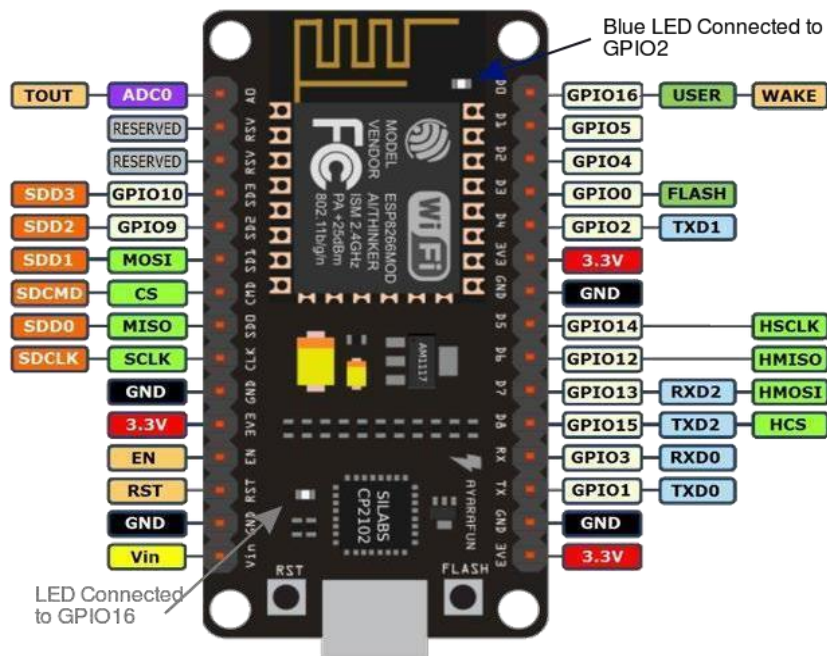


Fig 4.2.3 Node MCU

4.2.4 Wi-Fi Module

Wi-Fi is a popular wireless networking technology. Wi-Fi stands for “wireless fidelity”. The Wi-Fi was invented by NCR corporation/AT&T in Netherlands in 1991. By using this technology we can exchange the information between two or more devices. Wi-Fi has been developed for mobile computing devices, such as laptops, but it is now extensively using for mobile applications and consumer electronics like televisions, DVD players and digital cameras. There should be two possibilities in communicating with the Wi-Fi connection that may be through access point to the client connection or client to client connection. Wi-Fi is a one type of wireless technology.

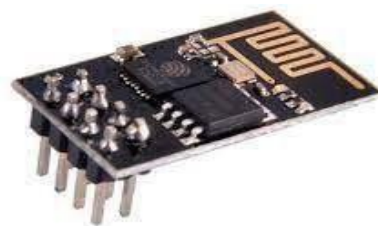


Fig 4.2.4 Wi-Fi Module

It is commonly called as wireless LAN (local area network). Wi-Fi allows local area networks to operate without cable and wiring. It is making popular choice for home and business networks. A computer's wireless adaptor transfers the data into a radio signal and transfers the data into antenna for users.



4.2.5 L293D

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge Motor Driver integrated circuit (IC). It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller. There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high.

TIP: you can simply connect the pin16 VCC (5v) to pin 1 and pin 9 to make them high.

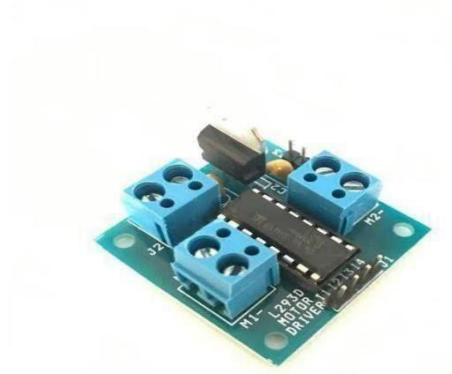


Fig 4.2.5 L293D

4.2.5 SPI Protocol

The Serial Peripheral Interface (SPI) bus is a synchronous serial communication interface specification used for short distance communication, primarily in embedded systems. The interface was developed by Motorola and has become a de facto standard. Typical applications include Secure Digital cards and liquid crystal displays. SPI devices communicate in full duplex mode using a master-slave architecture with a single master. The master device originates the frame for reading and writing. Multiple slave devices are supported through selection with individual slave select (SS) lines. Sometimes SPI is called a four-wire serial bus, contrasting with three-, two-, and one-wire serial buses. The SPI may be accurately described as a synchronous serial interface,[1] but it is different from the Synchronous (SSI) protocol, which is also a four-wire synchronous serial communication protocol, but employs differential signalling and provides only a single communication channel. The SPI bus, which operates at full duplex (means, signals carrying data can go in both directions simultaneously), is a synchronous type.

SINGLE MASTER, SINGLE SLAVE SPI IMPLEMENTATION

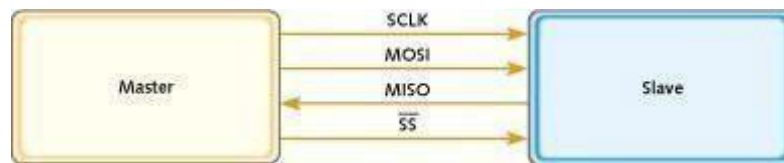
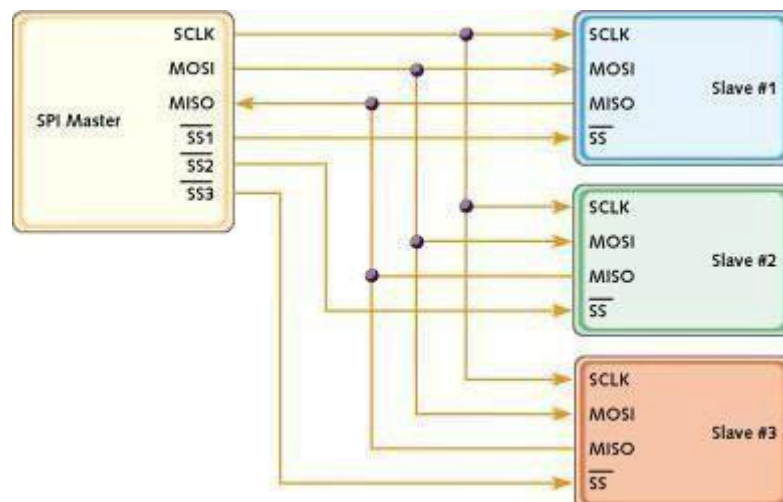


Fig4.2.6 SPI Protocol

SPI specifies four signals: clock (SCLK); master data output, slave data input (MOSI); master data input, slave data output (MISO); and slave select ($\overline{CS}$). Figure 1 shows these signals in a single-slave configuration. SCLK is generated by the master and input to all slaves. MOSI carries data from master to slave. MISO carries data from slave back to master. A slave device is selected when the master asserts its $\overline{CS}$ signal.

SINGLE MASTER, MULTIPLE SLAVE SPI IMPLEMENTATIONS



The master generates slave select signals using general-purpose discrete input/output pins or other logic. This consists of old-fashioned bit banging and can be pretty sensitive. You have to time it relative to the other signals and ensure, for example, that you don't toggle a select line in the middle of a frame. While SPI doesn't describe a specific way to implement multi-master systems, some SPI devices support additional signals that make such implementations possible. Each of the two parameters has two possible states, which allows for four possible combinations, all of which are incompatible with one another component.

So a master/slave pair must use the same parameter pair values to communicate. If multiple slaves are used that are fixed in different configurations, the master will have to reconfigure itself each time it needs to communicate with a different slave.

4.2.7 Power Supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. Basic power supply the input power transformer has its primary winding connected to the mains (line) supply. A secondary winding, electro-magnetically coupled but electrically isolated from the primary is used to obtain an AC voltage of suitable amplitude, and after further processing by the PSU, to drive the electronics circuit it is to supply.

The transformer stage must be able to supply the current needed. If too small a transformer is used, it is likely that the power supply's ability to maintain full output voltage at full output current will be impaired. With too small a transformer, the losses will increase dramatically as full load is placed on the transformer.

As the transformer is likely to be the most costly item in the power supply unit, careful consideration must be given to balancing cost with likely current requirement. There may also be a need for safety devices such as thermal fuses to disconnect the transformer if overheating occurs, and electrical isolation between primary and secondary windings, for electrical safety.



Fig 4.2.7 Power Supply

4.2.8 Buzzer

A Buzzer is an audio signalling device. There are many types of buzzer and here 5V passive Buzzer is used, which is used to create the sound and it may be

mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. The passive buzzer is an electromagnetic

squeaker used to generate sound signals of different frequencies. It requires an AC signal to make a sound, where a changing input signal produces the sound, rather than producing a tone automatically. To use this 5v buzzer, connect one pin to ground and the other to a micro controller programmed to output a square wave or a timer IC.



Fig 4.2.8 Buzzer

4.2.9 GSM Module

GSM/GPRS module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer. The MODEM is the soul of such modules. Wireless MODEMs are the MODEM devices that generate, transmit or decode data from a cellular network, for establishing communication between the cellular network and the computer. These are manufactured for specific cellular network (GSM/UMTS/CDMA) or specific cellular data standard.

communication to interface with and need Hayes compatible AT commands for communication with the computer (any microprocessor or micro controller system). A GSM/GPRS module assembles a GSM/GPRS modem with standard communication interfaces like RS-232 (Serial Port), USB etc., so that it can be easily interfaced with a computer or a microprocessor / micro controller based system. The power supply circuit is also built in the module that can be activated by using a suitable adaptor.



Fig 4.2.9 GSM Module

4.3 SOFTWARE USED

4.3.1 Arduino IDE

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino.

The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information.

The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

NB: Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.



Fig 4.3.1 Arduino IDE

4.3.2 Embedded C

Embedded C is the most popular embedded software language in the world. Most embedded software is written in Embedded C. It is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems.

Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

Most C programmers are spoiled because they program in environments where not only there is a standard library implementation, but there are frequently a number of other libraries available for use. The cold fact is, that in embedded systems, there rarely are many of the libraries that programmers have grown used to, but occasionally an embedded system might not have a complete standard library, if there is a standard library at all. Few embedded systems have capability for dynamic linking, so if standard library functions are to be available at all, they often need to be directly linked into the executable. Oftentimes, because of space concerns, it is not possible to link in an entire library file, and programmers are often forced to "brew their own" standard c library implementations if they want to use them at all. While some libraries are bulky and not well suited for use on micro controllers, many development systems still include the standard libraries which are the most common for C programmers.

C remains a very popular language for micro-controller developers due to the code efficiency and reduced overhead and development time. C offers low-level control and is considered more readable than assembly. Many free C compilers are available for a wide variety of development platforms. The compilers are part of an IDEs with ICD support, breakpoints, single-stepping and an assembly window. The performance of C compilers has improved considerably in recent years, and they are claimed to be more or less as good as assembly, depending on who you ask. Most tools now offer options for customizing the compiler optimization. Additionally, using C increases portability, since C code can be compiled for different types of processors.

4.3.3 Java

Java is a high-level, object-oriented programming language that was developed by Sun Microsystems in the mid-1990s. It is a general-purpose language that is designed to be portable, robust, and secure, and is widely used for developing web applications, mobile apps, desktop applications, and enterprise software. One of the key features of Java is its "write once, run anywhere" philosophy, which means that Java code can be compiled into platform-independent byte code that can run on any platform that has a Java Virtual Machine (JVM) installed. This makes Java a popular choice for developing applications that need to run on multiple platforms.

Java is also known for its strong emphasis on object-oriented programming (OOP) principles, such as encapsulation, inheritance, and polymorphism. It provides a rich set of libraries and frameworks that support OOP, making it easy for developers to create complex applications with reusable code. Java is used in a wide variety of applications, including web development, mobile development, gaming, data analysis, and scientific computing. It is also widely used in enterprise software development, such as customer relationship management (CRM) systems, supply chain management systems, and financial management systems. To develop Java applications, developers typically use an Integrated Development Environment (IDE) such as Eclipse, NetBeans, or IntelliJ IDEA. These IDEs provide tools for writing, testing, and debugging Java code, as well as tools for managing dependencies and building applications.

4.3.4 ThingSpeak

ThingSpeak is a platform providing various services exclusively targeted for building IOT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs. We will consider each of these features in detail below. The core element of ThingSpeak is a 'ThingSpeak Channel'. A channel stores the data that we send to ThingSpeak and comprises of the below elements:

8 fields for storing data of any type - These can be used to store the data from a sensor or from an embedded device.

3 location fields - Can be used to store the latitude, longitude and the elevation. These are very useful for tracking a moving device.

1 status field - A short message to describe the data stored in the channel.

To use ThingSpeak, we need to sign up and create a channel. Once we have a channel, we can send the data, allow ThingSpeak to process it and also retrieve the same. Let us start exploring ThingSpeak by signing up and setting up a channel.

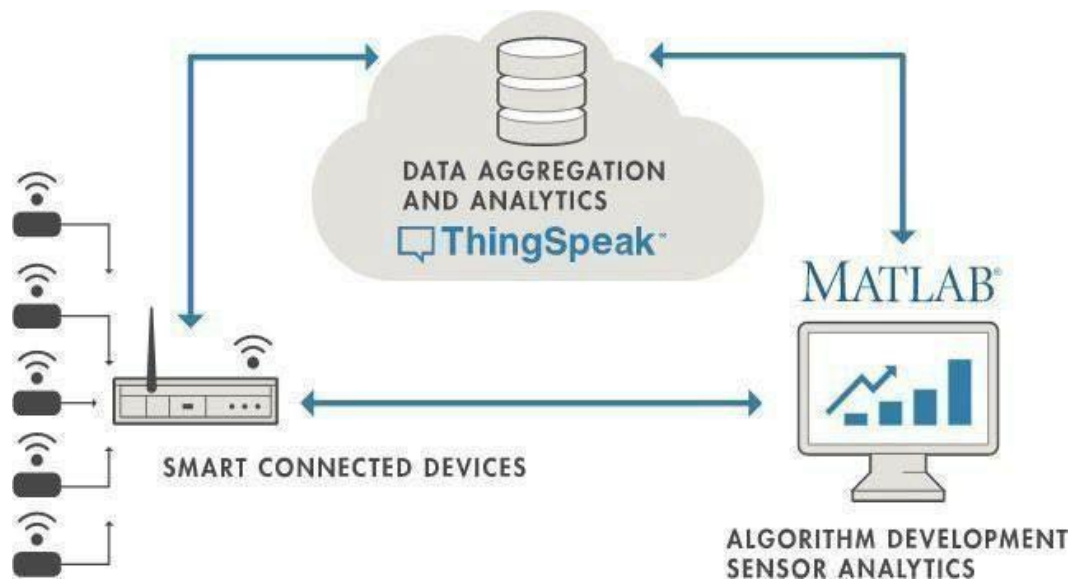


Fig 4.3.4 ThingSpea

CHAPTER 5

RESULTS AND DISCUSSION



Fig 5 Prototype



Fig 5.1 Front view



Fig 5.2 Back view

The smart back brace system that is being developed here the capacity to identify the bad back posture , which could lead to one of the main reason for back pain.The MEMS sensor (accelerometer) which detects the position of the person and alerts the person by giving beep sound and notification through SMS.This brace consists of various other sensors and modules such as micro-controller,EDA sensor (Electro dermal activity), GSM module and power supply unit includes transformer,filter,rectifier and voltage regulator as seen in Fig. 5.These sensors are fixed and fabricated in the belt as seen in Fig.5.1 and Fig.5.2.Moreover the abnormalities of pulse rate can be monitored consistently through EDA sensor and it alerts the person by sending emergency message through SMS with the help of GSM.By passing high voltage in the transformer,up to 10V heat can be produced which is further used as a therapy in the painful area.

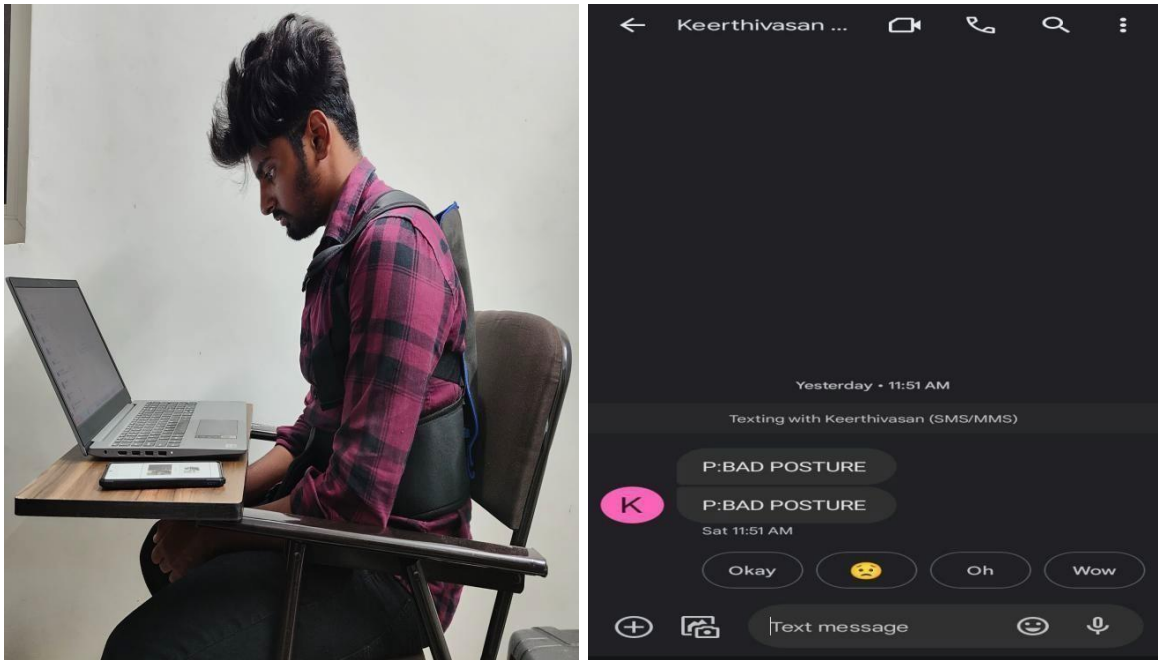


Fig5.3 Detection of badposture

The brace which comprise the accelerometer which detects the position of posture and the mechanism on the back brace also enables the person to alert about bad posture position by sending notification as seen in Fig.5.3 and beep sounds.



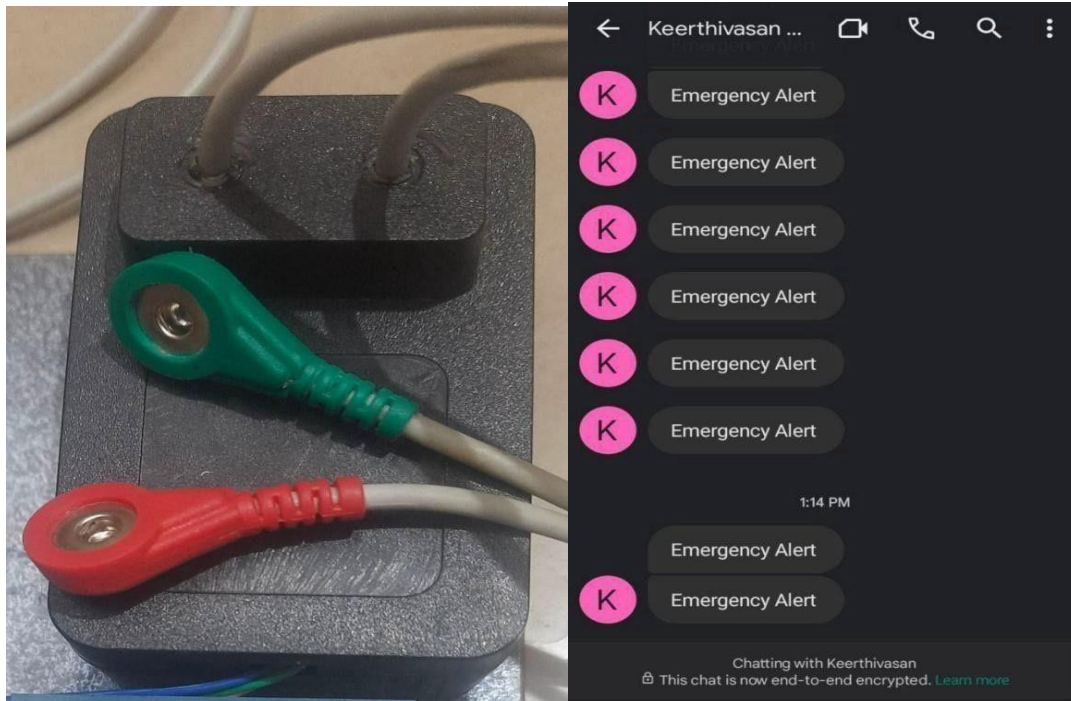


Fig5.4 Detection of abnormalities using EDA

The back brace also includes a EDA sensor that assists in monitoring the person's pulse rate consistently and if any abnormalities detected by the two electrodes (red and green colour) through skin conductance it will alert the person by sending emergency message as seen in Fig.5.4 with the help of GSM module.

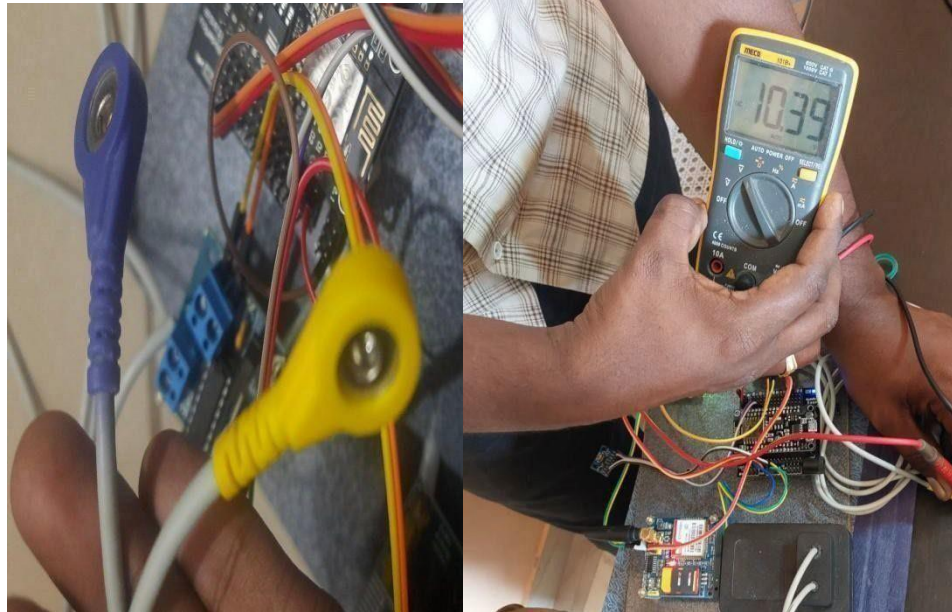


Fig 5.5 Generation of heat

By passing high pass voltage in the transformer, it generates heat up to 10.39V as seen in Fig.5.5 which will be used for pain relief in the abnormality area. The obtained heat can be observed in these two electrodes (Blue and yellow colour).





Fig 5.6 Output obtained on Thing Speak

The graphical output at the Thing Speak cloud is seen in Fig.5.6 and can be used only after logging in to the Thing Speak website with the username and password generated and the cloud provides a stable output.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The proposed smart brace system can provide valuable assistance in detecting the bad posture using MEMS sensor (accelerometer) and also helps to monitor abnormality of pulse rate through skin conductance with the help of EDD. Similarly, these detection and abnormalities can be indicated by sending SMS with the help of GSM module. These monitoring data can be monitored and stored in a ThingSpeak website, which will be helpful for the medical physician to observe and give appropriate treatment to person. By passing high voltage in the transformer, it can produce heat (up to 10.39V) which is further used as a therapy in the painful area. The use of ESP8266 provides a powerful and versatile platform for integrating multiple sensors and wireless networks. The proposed design can significantly improve the quality of back posture and reduce the back pain, healthcare costs by promoting preventive care and home-based care.

6.2 CONCLUSION

However, further research and development are required to address the limitations and challenges of developing such a smart brace. These challenges include the adding additional features which includes measuring water level, temperature, ensuring reliability and accuracy of the monitoring and alert systems. Nevertheless, the potential benefits of this technology for the back pain people make it a worthwhile investment for healthcare providers and technology companies alike. In conclusion, the proposed smart brace can make a significant contribution to improving the good back posture and promoting better healthcare outcomes, especially as the back pain problems continue to rise.

REFERENCES

1. Alyazyah Alsuwaidi, Aisha Alzarouni, Dana Bazazeh. Wearable Posture Monitoring system with Vibrational Feedback. (2016)
2. Chen, Duo and Zhang, Haihong and Kavitha, "Scalp EEG-Based Pain Detection Using Convolutional Neural Network," IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 30, pp. 274-285, 2022.
3. Crane A B, Doppalapudi S K, O'Leary J, Ozarek P and Wagner C T, "Wearable posture detection system," 2014 40th Annual Northeast Bioengineering Conference (NEBEC), pp. 1-2, doi: 10.1109/NEBEC.2014.6972764, 2014.
4. Feradov, Firgan, Valentina Markova, and Todor Ganchev, "Automated Detection of Improper Sitting Postures in Computer Users Based on Motion Capture Sensors," Computers, Vol. 11(7), pp. 116-125, 2022, <https://doi.org/10.3390/computers11070116>.
5. Franz Landauer, Klemens Trieb. An Indication-Based Concept for Stepwise Spinal Orthosis in Low Back Pain According to the Current Literature. Landauer, F.; Trieb, K. An Indication-Based Concept for Stepwise Spinal Orthosis in Low Back Pain According to the Current Literature. J. Clin. Med. 2022, 11, 510. <https://doi.org/10.3390/jcm11030510>
6. Gálvez-Goicura J, Pagán J, Gago-Veiga A B, Moya J M and Ayala J L, "Cluster-Then-Classify Methodology for the Identification of Pain Episodes in Chronic Diseases," IEEE Journal of Biomedical and Health Informatics, vol. 26(5), pp. 2339-2350, 2022.
7. Huang Y R y X.-F. Ouyang, "Sitting Posture Detecting And Recognition Using Force Sensor," International Conference on BioMedical Engineering and Informatics, Chongqing, 2012.

8. Kardash Kateryna, Koutras Christos, Otaduy Miguel A, "Design of personalized scoliosis braces based on differentiable biomechanics—Synthetic study," *Frontiers in Bioengineering and Biotechnology*, vol. 10, pp. 1-13, 2022.

9. Dr. Mader A H, Willemse C J A M, Neidlinger K, Klaassen B, Prof. Dr. Heylen D K J. A wearable intervention for posture improvement. Isabel Pfab: A Wearable Intervention for Posture Improvement, MSc. Thesis, 2016, January.

10. Oung Q W, Hariharan M, Lee H L, Basah S N, Sarillee M, and Lee C H, "Wearable multimodal sensors for evaluation of patients with Parkinson disease," *Proc. - 5th IEEE Int. Conf. Control Syst. Comput. Eng. ICCSCE*, pp. 269–274, 2016.

11. Petra Jellema, Maurits W. van Tulder, Mireille N. M. van Poppel, Alf L. Nachemson, Lex M. Bouter. Lumbar Supports for Prevention and Treatment of Low Back Pain. *SPINE* Volume 26, Number 4, pp 377–386 (2001), Lippincott Williams & Wilkins, Inc.

12. Pinero Fuentes, Enrique, Salvador Canas-Moreno, Antonio Rios-Navarro, Manuel Domínguez-Morales, José Luis Sevillano, and Alejandro Linares-Barranco, "A Deep-Learning Based Posture Detection System for Preventing Telework-Related Musculoskeletal Disorders," *Sensors* 21, vol. 15(5236), pp. 1-16, 2021.

13. Schmitz A, Ye M, Boggess G, Shapiro R, Yang R, and Noehren B, "44 measurement of in vivo joint angles during a squat using a single camera markerless motion capture system as compared to a marker-based system," *Gait Posture*, vol. 41(2), pp. 694– 698, 2015.

14. Slavomir Matuska , Martin Paralic, Robert Hudec. A Smart System for Sitting Posture Detection Based on Force Sensors and Mobile Application. Hindawi, Mobile Information Systems, Volume 2020, Article ID 6625797, 13 pages, <https://doi.org/10.1155/2020/6625797>
15. Suresh Anand M, Kumar R, Deepak Keshav K, Karthikeyan G, Vigneshwaran B. Human Posture Detection System using real time self calibrating algorithm. (2019) JETIR June 2019, Volume 6, Issue 6 www.jetir.org (ISSN-2349-5162)
16. Swapnali Dhulap, Ashwini Patil, Shriya Kamble, Sapana Gaikwad, Pranavi Mhatre. Iot Based Smart Wearable Posture Detection & Alert System. Swapnali Dhulap, et. al. International Journal of Engineering Research and Applications, www.ijera.com, ISSN: 2248-9622, Vol. 11, Issue 8, (Series-III) August 2021, pp. 01-06
17. Tatiana Ortegon-Sarmiento, Lina Penuela, Alvaro Uribe-Quevedo. Low Back Pain Attenuation Employing Virtual Reality Physiotherapy. 978-1-7281-9231-4/20/\$31.00 ©2020 IEEE DOI 10.1109/SVR51698.2020.00037
18. Unnathi Annapurna S, Adithi K.S, Meghala Murali, Syed Saqalain Quadri. Alert System for Posture Correction. International Journal of Engineering Applied Sciences and Technology, 2022, Vol. 6, Issue 11, ISSN No. 2455- 2143, Pages 95-101, Published Online March 2022 in IJEAST
19. Wenjing Du, Olatunji Mumini Omisore, Huihui Li, Kamen Ivanov, Shipeng Han, Lei Wang. Recognition of Chronic Low Back Pain During Lumbar Spine Movements Based on Surface Electromyography Signals (2018) Digital Object Identifier 10.1109/ACCESS.2018.2877254
20. Werner P, Lopez-Martinez D, Walter S, Al-Hamadi A, Gruss S and Picard R W, "Automatic Recognition Methods Supporting Pain Assessment: A Survey," IEEE Transactions on Affective Computing, vol. 13(1), pp. 530-552, 2022.

PROOF OF ACCEPTANCE



Acceptance Letter

Paper ID	Paper Title	Authors
ICBSII935	An analysis of the design and evolution of braces for lower back pain	Kishore R, Keerthivasan Keerthivasan V, Bethanney Janney, Ponni S, Meenatchi S and Saraswathi B

Dear Author[s],

Thank you for your submission to the 9th International Conference on Biosignals, Images and Instrumentation [ICBSII 2023]. The Article has been accepted after the double-blinded peer review process for the oral presentation at the International conference on Biosignals, Images and Instrumentation [ICBSII 2023] on 16 – 17 March 2023 organized by Department of Biomedical Engineering at Sri Sivasubramaniya Nadar College of Engineering, Chennai. Based on the recommendations of reviewers and technical program committee, your manuscript has been accepted for oral presentation and publication.

Please strictly adhere to the format specified in the conference template while preparing your final paper. The authors are instructed to submit the final version of the paper along with the required documents to schedule your presentation in the conference program by sending an email to icbsii@bme.ssn.edu.in.

This notification email serves as our formal acceptance to your manuscript as well as an invitation to present your work at 9th ICBSII 2023. Please note that this email will be sent to your co-author(s) (if any), as well.

For the most updated information on the conference, please check the conference website at <https://icbsii.in/>. Finally, we would like to further extend our congratulations to you!

Yours' Sincerely

Dr. L. Suganthi
Conference Chair
ICBSII-2023



APPENDIX

```
#include <ESP8266WiFi.h>;
#include <WiFiClient.h>;
#include <ThingSpeak.h>;
WiFiClient client;
const char* ssid = "IOT"; //Your Network SSID
const char* password = "IOT@123456789" ; //Your Network Password
unsigned long myChannelNumber = 2052165; //Your Channel Number (Without Brackets)
const char * myWriteAPIKey = "8MT6ABP80G7RMY2U"; //Your Write API Key
#include <string.h>
#include <ctype.h>
//int rxPin = 0; // RX PIN
// int txPin = 1; // TX TX
//GPS
int byteGPS=-1;
char linea[300] = "";
char comandoGPR[7] = "$GPRMC";
int cont=0;
int bien=0;
int conta=0;
int indices[13];
char flag,flag1;
void conditions();
void sendmsg();
void gps();

void setup()
{
  Serial.begin(9600);
```

```

WiFi.begin(ssid, password);
ThingSpeak.begin(client);
pinMode(16,INPUT);pinMode(5,INPUT);pinMode(4,INPUT);
    for (int i=0;i<300;i++)
    {
        linea[i]=' ';
    }

    Serial.begin(9600);
    //lan
    while (!Serial){
        ;
    }
}

void loop()
{

    int eda=analogRead(A0);Serial.println(eda);
    ThingSpeak.writeField(myChannelNumber, 1,eda, myWriteAPIKey);delay(1500);

}

void sendmsg()
{
    Serial.println("AT");
    delay(2000);
}

```

```
Serial.println("AT+CMGF=1");  
delay(2000);  
Serial.println("AT+CMGS=\"+ \"\r");  
delay(1000);
```

```
}
```

```
delay(2000);  
Serial.println((char)26);  
delay(4000)
```