ACOUSTIC EMISSIONS BASED HEARING LOSS DETECTION FOR NEW BORN BABIES USING EMBEDDED SYSTEM

A PROJECT REPORT

Submitted by

BALAJI.M	**(920819106008)**
DIVESH.V	**(920819106016)**
HARISHWAR.S	**(920819106019)**
KISHOREKRISHNAA.J	**(920819106026)**

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NATHAM, DINDIGUL.

ANNA UNIVERSITY::CHENNAI 600 025

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ANNA UNIVERSITY::CHENNAI 600025

BONAFIDE CERTIFICATE

Certified that this project report **"ACOUSTIC EMISSIONS BASED HEARING LOSS DETECTION FOR NEW BORN BABIES USING EMBEDDED SYSTEM"** is the bonafide work of **"BALAJI.M (920819106008), DIVESH.V (920819106016), HARISHWAR.S (920819106019) and KISHOREKRISHNAA.J (920819106026)"** who carried out the project work under my supervision.

SIGNATURE	**SIGNATURE**
Dr. M. AMEENA BANU, M.E., Ph.D.,	Mr. P. ABDUL SAMAD, M.E.,
HEAD OF THE DEPARTMENT	**SUPERVISOR**
Professor,	Assistant Professor,
Department of Electronics &	Department of Electronics &
Communication Engineering,	Communication Engineering,
NPR College of Engineering	NPR College of Engineering
& Technology,	& Technology,
Natham,	Natham,
Dindigul – 624 401.	Dindigul – 624 401.

Submitted for the ANNA UNIVERSITY Viva-Voce Examination held on ……………….. at NPR College of Engineering & Technology, Natham.

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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NPR COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

INSTITUTE VISION & MISSION

Vision

- To develop students with intellectual curiosity and technical expertise to meet the global needs.

Mission

- To achieve academic excellence by offering quality technical education using best teaching techniques.
- To improve Industry–Institute interactions and expose industrial atmosphere.
- To develop interpersonal skills along with value-based education in a dynamic learning environment.
- To explore solutions for real time problems in the society.

DEPARTMENT VISION & MISSION

Vision

- To impart quality technical education and nurture excellence to meet the impending challenges in emerging technologies.

Mission

- To instill the thirst for advancement in Electronics and Communication technologies to address the social needs.
- To increase industrial interaction to ascertain prevailing technologies.
- To inculcate ethics and transform lives through value-based education.
- To enhance analytical and practical skills to solve real time problems in the society.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design / development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12:Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES (COs)

C411.1: Conduct a literature survey in the selected domain to identify requirements for the realworld problems and propose a methodology.

C411.2: Model the problem at hand and experiment with Hardware/Software skill sets to suit the requirements.

C411.3: Build and demonstrate the project effectively as a team with the attitudes of professional Engineers.

C411.4: Evaluate the challenges and risks involved in the execution of the project and take appropriate actions to circumvent them.

C411.5: Communicate the results of an engineering project by means of an oral presentation, written reports and practical demonstration of the project outcomes.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of Electronics and Communication Engineering Program will be able

- To have a successful career in academia or industries associated with Electronics and Communication Engineering, or as entrepreneurs.
- To build solutions or systems of varying complexity with strong fundamental concepts and advanced techniques.
- To analyze existing literature in an area of specialization and ethically develop innovative and research-oriented methodologies to solve the real time problems.

PROGRAM SPECIFIC OUTCOMES (PSOs)

At the end of the program,

- Our students will be highly proficient in Electronic circuits, Embedded and communication systems and able to find solutions for real time complexities.
- Our Students will be able to utilize MATLAB, Xilinx tools and techniques to develop innovative research ideas for new applications.

ABSTRACT

New-borns hearing screening and diagnosis are very important for the early discover of any problem that might affect their hearing and consequently their communication. The detection of hearing loss is a crucial aspect of audiological evaluation, as early detection can prevent further hearing damage and improve the overall quality of life of individuals affected. Babies may hear or respond to some sounds, but this is not enough indication that they can hear all the sounds properly. The early diagnosis of hearing efficiency and the functionality of the internal cochlea using Otoacoustic Emission is necessary. OAEs are sounds generated by the cochlea in response to external stimuli, such as clicks or tones. These emissions can be measured using a sensitive microphone placed in the ear canal, and the resulting waveform can be analyzed to determine the presence or absence of hearing loss. In this research, a new device of Distortion Otoacoustic system was designed and developed to be used as prototype instrument for technical college student training. The low-cost microcontroller developed device is efficient and sensitive as it is capable of generating and capturing signals from the external ear canal, as well as analyzing signals and determining the efficiency of the inner ear. The proposed algorithm for the microcontroller based on generating two sinusoidal waves with different frequencies transferred from the Arduino Uno, Analog to Digital Convertor (ADC) will be responsible of the control operation for all the system parts. The input signals are generated by Pulse Width Modulator technology (PWM), and the number of samples are n =28 or n = 280, with frequencies range value 0.5-8 kHz which is the human auditory range that a person can hear.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

TERMS	ABBREVIATIONS
ABR	Auditory Brainstem Response
ADC	Analog-to-Digital Converter
ANN	Artificial Neural Networks
AVR	Alf and Vegard's RISC Processor
CLI	Command-Line Interface
CSTN	Color Super-Twisted Pneumatic
DPOAE	Distortion Product Otoacoustic Emission
DSTN	Double-Layer Super-Twisted Pneumatic
EHR	Electronic Health Records
GNU	GNU's Not Unix
GUI	Graphical User Interfaces
ICSP	In-Circuit Serial Programming
IDE	Integrated Development Environment
KNN	K-Nearest Neighbors
LCD	Liquid Crystal Display
NIHL	Noise-Induced Hearing Loss
OAE	Otoacoustic Emissions
PCA	Principal Component Analysis
PWM	Pulse Width Modulator
RS232	Recommended Standard 232
SOAE	Spontaneous Otoacoustic Emission

STN	Super-Twisted Pneumatic
SVM	Support Vector Machines
TEOAE	Transient-Evoked Otoacoustic Emission
TFT	Thin-Film Transistors
USB	Universal Serial Bus

CHAPTER 1

INTRODUCTION

Hearing loss is a common sensory impairment that affects individuals of all ages, including newborn babies. It can have a significant impact on a child's speech and language development, cognitive abilities, and overall quality of life. Early detection and intervention are crucial for minimizing the adverse effects of hearing loss. Traditional methods of hearing screening in newborns involve subjective assessments and can be time-consuming and resource-intensive. To address these challenges, a novel approach called acoustic emission-based hearing loss detection is being developed.

Acoustic emission refers to the sounds produced by various biological processes within the ear, including the cochlea and auditory nerves. These emissions can provide valuable information about the integrity and functionality of the auditory system. By capturing and analyzing these acoustic emissions, it is possible to detect and diagnose hearing loss in newborn babies in a non-invasive and efficient manner.

The acoustic emission-based hearing loss detection system for newborn babies aims to revolutionize the process of hearing screening. It utilizes advanced sensor technology and signal processing algorithms to capture and interpret the acoustic emissions generated by the baby's auditory system. Unlike traditional methods that rely on behavioral responses, this approach directly measures the physiological activity within the ear, providing objective and reliable results.

The development of this system requires the collaboration of engineers, audiologists, and healthcare professionals to ensure its accuracy, safety, and effectiveness. Extensive research and clinical trials are being conducted to refine the sensor design, optimize data acquisition and processing techniques, and validate the system's performance. The goal is to create a user-friendly and accessible solution that can be seamlessly integrated into routine newborn screening protocols.

The benefits of acoustic emission-based hearing loss detection are numerous. It offers a non-invasive and comfortable screening experience for newborns, eliminating the need for invasive procedures or subjective assessments. The early detection of hearing loss enables timely intervention and appropriate management, leading to improved outcomes for affected babies. Furthermore, this technology has the potential to streamline the screening process, reducing costs and enhancing the overall efficiency of healthcare systems.

In summary, acoustic emission-based hearing loss detection for newborn babies represents a promising advancement in the field of pediatric audiology. By harnessing the power of acoustic emissions and innovative technology, this approach aims to revolutionize newborn hearing screening, ensuring early identification of hearing loss and providing babies with the best possible start in their auditory and developmental journey.

1.1. Need for Study

Hearing loss detection in newborn babies is crucial for early intervention and appropriate treatment. Acoustic emission-based methods can be a valuable tool for screening and diagnosing hearing impairments in infants. Designing an embedded system for this purpose offers several benefits, such as portability, real-time analysis, and potential for integration with other healthcare systems. Here's an overview of the need for studying acoustic emission-based hearing loss detection for newborn babies using an embedded system.

Early identification and intervention: Detecting hearing loss at an early stage allows for timely intervention and rehabilitation, which is critical for a child's language and cognitive development. An embedded system using acoustic emission analysis can enable rapid screening and diagnosis, ensuring that appropriate measures are taken promptly.

Non-invasive and objective measurement: Acoustic emission-based techniques, such as otoacoustic emissions (OAEs), measure the sounds generated by the inner ear in response to external stimuli. This approach is non-invasive, painless, and does not require the active cooperation of the baby, making it suitable for newborn screening. An embedded system can automate the measurement process, reducing the need for manual intervention and subjective interpretation.

Real-time analysis and immediate feedback: Embedded systems have the advantage of real-time signal processing and analysis. By incorporating advanced algorithms, an embedded system can quickly analyze the recorded acoustic emissions and provide immediate feedback on the presence or absence of hearing loss. This capability enables on-the-spot decisions and reduces the time between testing and diagnosis.

Portability and accessibility: Newborn hearing screening is typically performed in various healthcare settings, including hospitals, clinics, and community centers. An embedded system can be designed to be compact, portable, and user-friendly, allowing for efficient screening in different locations. This portability facilitates broader accessibility, especially in remote or resource-limited areas where access to specialized audiology facilities may be limited.

Integration with electronic health records (EHR): An embedded system can be designed to seamlessly integrate with electronic health record systems, enabling efficient data management and long-term tracking of a baby's hearing health. This integration facilitates follow-up care, treatment planning, and collaboration among healthcare providers.

Potential for automation and AI assistance: Embedding intelligent algorithms within the system can enhance the accuracy and efficiency of hearing loss detection. Machine learning and artificial intelligence techniques can be employed to train the system to recognize patterns and distinguish between normal and abnormal acoustic emissions. This can help reduce false positives and false negatives, improving the overall effectiveness of newborn hearing screening programs.

It's important to note that while an embedded system for acoustic emission-based hearing loss detection in newborns shows promise, it requires thorough research and development. Clinical validation, optimization of algorithms, and rigorous testing are necessary to ensure the system's accuracy, reliability, and safety before widespread implementation in healthcare settings.

1.2. Objectives of Study

The objectives of a study on acoustic emission-based hearing loss detection for **Newborn Babies Using an Embedded System Can Include:**

1. **System Development:** Design and develop an embedded system capable of recording and analyzing acoustic emissions in newborn babies. This involves selecting appropriate hardware components, such as microcontrollers or digital signal processors, and designing the necessary circuitry for signal acquisition and processing.
2. **Sensor Selection and Integration:** Determine the most suitable acoustic sensors for capturing otoacoustic emissions or other relevant acoustic signals. Evaluate different sensor types, such as microphones or specialized probes, and integrate them into the embedded system. Ensure the sensors provide accurate and reliable measurements in the context of newborn hearing screening.
3. **Signal Processing and Feature Extraction:** Implement signal processing techniques to extract relevant features from the recorded acoustic emissions. This may involve time-frequency analysis, noise reduction, or pattern recognition algorithms. The objective is to identify specific characteristics or patterns associated with normal and abnormal hearing function.
4. **Algorithm Development and Optimization:** Develop algorithms or models that can classify the extracted features and determine the presence or absence of hearing loss. This may involve supervised learning techniques, such as support vector machines, neural networks, or decision trees. Optimize the algorithms to improve their accuracy, speed, and efficiency.
5. **Validation and Performance Assessment**: Conduct extensive validation studies to assess the performance of the embedded system. This includes comparing the system's results with established diagnostic measures, such as auditory brainstem response (ABR) tests or behavioral audiometry. Evaluate the system's sensitivity, specificity, positive predictive value, and negative predictive value to determine its diagnostic accuracy.
6. **Usability and Reliability Assessment:** Evaluate the usability and reliability of the embedded system in real-world scenarios. Assess factors such as ease of use, operator

training requirements, system robustness, and resistance to environmental noise or interference. Collect feedback from healthcare professionals and parents to identify any limitations or areas for improvement.

7. **Clinical Feasibility and Impact:** Investigate the clinical feasibility and potential impact of the acoustic emission-based hearing loss detection system in newborn screening programs. Assess factors such as cost-effectiveness, scalability, integration with existing healthcare infrastructure, and acceptability among healthcare providers and parents.

8. **Ethical Considerations and Safety:** Ensure that the study complies with ethical guidelines and safety standards for research involving newborns. Consider privacy issues, data protection, informed consent procedures, and potential risks associated with the use of the embedded system.

9. **Dissemination of Findings:** Share the study findings through scientific publications, conferences, or seminars to contribute to the field of newborn hearing screening. Disseminate information on the benefits, limitations, and potential applications of the acoustic emission-based embedded system for hearing loss detection in newborn babies.

By addressing these objectives, a study on acoustic emission-based hearing loss detection using an embedded system can advance the development of effective and accessible screening methods for newborns, leading to early detection and intervention for hearing impairments.

1.3. Research Objective

The research objective for acoustic emission-based hearing loss detection for new born babies using embedded system is to develop a system that can accurately and efficiently detect hearing loss in newborns. The system will use acoustic emissions, which are sound waves that are generated by the inner ear when it is stimulated by sound. The system will be designed to be small, portable, and affordable, so that it can be used in hospitals and clinics around the world.

The system will be developed using an embedded system, which is a computer system that is designed to be used in a specific application. The embedded system will be programmed to collect and analyze the acoustic emissions from the newborn's ear. The system will then output a result that indicates whether the newborn has hearing loss or not.

The system will be tested on a group of newborns who have been diagnosed with hearing loss using a standard hearing test. The results of the testing will be used to evaluate the accuracy and efficiency of the system.

If the system is successful, it will be a valuable tool for early detection of hearing loss in newborns. Early detection of hearing loss is important because it allows for early intervention, which can help to prevent the development of speech and language delays.

The following are the specific research objectives for this project:

- To develop a system that can accurately and efficiently detect hearing loss in newborns using acoustic emissions.
- To design the system to be small, portable, and affordable.
- To develop the system using an embedded system.
- To test the system on a group of newborns who have been diagnosed with hearing loss using a standard hearing test.
- To evaluate the accuracy and efficiency of the system.

The Results of This Project Will Be Valuable for the Following Stakeholders:

Newborns with hearing loss: The system will help to ensure that newborns with hearing loss are identified early, so that they can receive the early intervention that they need.

Parents of newborns: The system will provide parents with peace of mind, knowing that their newborn's hearing is being monitored.

Healthcare professionals: The system will provide healthcare professionals with a valuable tool for early detection of hearing loss in newborns.

Researchers: The system will provide researchers with a valuable tool for studying the development of hearing loss in newborns.

1.4. Challenges

There are a number of challenges that need to be addressed in order to develop an acoustic emission-based hearing loss detection system for newborns using an embedded system. These challenges include:

The acoustic emissions from the inner ear are very faint, and they can be easily masked by other noise sources, such as the sound of the newborn's breathing or the sound of the surrounding environment.

The acoustic emissions from the inner ear can vary depending on the newborn's age, health, and state of development. This makes it difficult to develop a system that can accurately detect hearing loss in all newborns.

The embedded system must be small, portable, and affordable in order to be used in hospitals and clinics around the world.

Despite these challenges, there is a great deal of potential for acoustic emission-based hearing loss detection systems. If these systems can be developed successfully, they will be a valuable tool for early detection of hearing loss in newborns. Early detection of hearing loss is important because it allows for early intervention, which can help to prevent the development of speech and language delays.

Some of the Potential Solutions to these Challenges Include

- Using a high-quality microphone to amplify the acoustic emissions from the inner ear.
- Using a noise cancellation algorithm to remove noise from the signal.
- Developing a system that can adapt to the changes in the acoustic emissions that occur as the newborn grows and develops.
- Designing an embedded system that is small, portable, and affordable.
- Researchers are working on developing acoustic emission-based hearing loss detection systems that can overcome these challenges. If these systems are successful, they will be a valuable tool for early detection of hearing loss in newborns.

1.5. Technique Used

The research objective for acoustic emission-based hearing loss detection for new born babies using embedded system is to develop a system that can accurately and efficiently detect hearing loss in newborns. The system will use acoustic emissions, which are sound waves that are generated by the inner ear when it is stimulated by sound. The system will be designed to be small, portable, and affordable, so that it can be used in hospitals and clinics around the world.

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If the system is successful, it will be a valuable tool for early detection of hearing loss in newborns. Early detection of hearing loss is important because it allows for early intervention, which can help to prevent the development of speech and language delays.

The Following are the Specific Research Objectives for this Project

- To develop a system that can accurately and efficiently detect hearing loss in newborns using acoustic emissions.
- To design the system to be small, portable, and affordable.
- To develop the system using an embedded system.
- To test the system on a group of newborns who have been diagnosed with hearing loss using a standard hearing test.
- To evaluate the accuracy and efficiency of the system.
- The results of this project will be valuable for the following stakeholders:

Challenges for Acoustic Emission-Based Hearing Loss Detection for New Born Babies Using Embedded System

There are a number of challenges that need to be addressed in order to develop an acoustic emission-based hearing loss detection system for newborns using an embedded system. These challenges include:

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- Researchers are working on developing acoustic emission-based hearing loss detection systems that can overcome these challenges. If these systems are

successful, they will be a valuable tool for early detection of hearing loss in newborns.

Technique Used for Acoustic Emission-Based Hearing Loss Detection for New Born Babies Using Embedded System

The technique used for acoustic emission-based hearing loss detection for new born babies using embedded system is called otoacoustic emissions (OAEs). OAEs are sound waves that are generated by the inner ear when it is stimulated by sound. The OAEs are very faint, but they can be amplified and measured using a sensitive microphone.

The embedded system is used to collect and analyze the OAEs. The system is programmed to look for specific patterns in the OAEs that are indicative of hearing loss. If the system detects any of these patterns, it will output a result that indicates that the newborn has hearing loss.

The OAE technique is a non-invasive and painless way to screen for hearing loss in newborns. It is also a very accurate technique, with a sensitivity of over 90%. This means that the OAE technique is very good at detecting hearing loss in newborns.

The OAE technique is a valuable tool for early detection of hearing loss in newborns. Early detection of hearing loss is important because it allows for early intervention, which can help to prevent the development of speech and language delays.

The Following are the Steps Involved in Acoustic Emission Based Hearing Loss Detection for New Born Babies Using Embedded System

- The newborn is placed in a quiet environment.
- A microphone is placed in the newborn's ear.
- A sound stimulus is presented to the newborn.
- The microphone records the OAEs.
- The embedded system analyzes the OAEs.
- The embedded system outputs a result that indicates whether the newborn has hearing loss or not.

- The OAE technique is a valuable tool for early detection are hearing loss in newborns. It is a non-invasive, painless, and accurate technique that can be used in hospitals and clinics around the world.

1.6. Plan Are Implementation

Implementing an acoustic emission-based hearing loss detection system for newborn babies using an embedded system involves several steps. Here's a plan are implementation to guide you through the process:

1. **Research and understand the acoustic emission-based hearing loss detection technique:** Familiarize yourself with the principles and methodologies are acoustic emission-based hearing loss detection. Understand how sound signals are analyzed to identify hearing loss in newborns.
2. **Define system requirements**: Identify the specific requirements for your embedded system. Consider factors such as size, power consumption, processing capability, and data storage capacity. Define the target hearing loss detection accuracy and any additional features you want to incorporate.
3. **Select an embedded system platform:** Choose a suitable embedded system platform based on your requirements. Consider platforms such as Arduino, Raspberry Pi, or custom-designed hardware. Ensure that the selected platform can handle audio signal processing and has the necessary inputs and outputs.
4. **Design the hardware**: Develop a hardware design that includes the necessary components for audio acquisition, signal processing, and output. This may involve selecting a microphone, audio amplifiers, analog-to-digital converters (ADCs), and other necessary components. Design the circuitry to interface these components with the chosen embedded system platform.
5. **Implement the software:** Develop the software to perform the acoustic emission analysis and hearing loss detection. This involves capturing audio signals from the microphone, applying signal processing algorithms, and analyzing the results. You may need to use libraries or frameworks for audio processing and machine learning techniques

if you choose to incorporate them.

6. **Calibrate the system:** Perform calibration tests using known audio stimuli to ensure accurate and reliable hearing loss detection. Adjust the system parameters and algorithms as necessary to achieve the desired sensitivity and specificity.

7. **Prototype development**: Build a prototype are the embedded system, integrating the hardware and softtware components. Test the prototype using simulated audio signals and, if possible, with actual newborn babies in a controlled environment.

8. **Evaluate system performance**: Evaluate the performance are the system by comparing the detected hearing loss with reference measurements or clinical evaluations. Assess the sensitivity, specificity, and overall accuracy are the system. Make iterative improvements to the design, softtware algorithms, and hardware components as needed.

9. **Ensure regulatory compliance**: If you plan to deploy the system in a medical or healthcare setting, ensure compliance with relevant regulations and standards. Consult with experts or regulatory bodies to understand the necessary certifications and approvals required for medical devices.

10. **Documentation and deployment**: Document the system design, implementation details, and testing procedures. Prepare user manuals and guidelines for healthcare prareessionals using the system. Finally, deploy the system in hospitals, clinics, or other healthcare facilities, ensuring proper training and support for users.

Remember, developing a hearing loss detection system for newborns involves considerations are ethical, legal, and safety aspects. Consult with healthcare prareessionals, audiologists, and experts in the field to ensure the system's reliability and suitability for its intended use.

1.7. Problem Statement

The detection are hearing loss in newborn babies is crucial for early intervention and treatment, leading to improved language and cognitive development. Traditional methods are hearing loss detection may be costly, time-consuming, and require specialized expertise.

Therefore, there is a need for an efficient and cost-effective solution that can accurately detect hearing loss in newborns using acoustic emission-based techniques and an embedded system.

The current problem is the lack are an accessible and reliable system for early hearing loss detection in newborns using acoustic emission analysis. Existing methods areten involve expensive equipment, complex procedures, and dependency on trained prareessionals, making them less feasible for widespread implementation in healthcare facilities.

There is a need to develop an embedded system that can efficiently capture, analyze, and process acoustic emissions in newborn babies to detect signs are hearing loss. The system should be compact, low-cost, and easy to use, enabling healthcare prareessionals to quickly assess the hearing capabilities are newborns and initiate appropriate interventions

The goal is to develop an embedded system that addresses these challenges, enabling early and accurate detection are hearing loss in newborns. By doing so, the system will contribute to timely interventions, improved developmental outcomes, and enhanced quality are life for affected infants.

CHAPTER 2

LITERATURE SURVEY

Acoustic Emissions Based Hearing Loss Detection for New Born Babies Using Embedded System

New-borns hearing screening and diagnosis are very important for the early discover are any problem that might affect their hearing and consequently their communication. Babies may hear or respond to some sounds, but this is not enough indication that they can hear all the sounds properly. The early diagnosis are hearing efficiency and the functionality are the internal cochlea using Otoacoustic Emission is necessary. In this research, a new device are Distortion Otoacoustic system was designed and developed to be used as prototype instrument for technical college student training. The low-cost microcontroller developed device is efficient and sensitive as it is capable are generating and capturing signals from the external ear canal, as well as analyzing signals and determining the efficiency are the inner ear. The proposed algorithm for the microcontroller based on generating two sinusoidal waves with different frequencies that transferred by MP3 shield cable. Analog to Digital Converter (ADC) will be responsible are the control operation for all the system parts. The input signals are generated by Pulse Width Modulator technology (PWM), and the number are samples are n =28 or n = 256, with frequencies range value 0.5-8 kHz which is the human auditory range that a person can hear.

The Use are Otoacoustic Emissions in Monitoring Auditory Function in Infants

Hearing loss is a common developmental disorder that affects approximately 1 in 500 newborns. Early identification and intervention are critical for optimizing language and cognitive development in affected infants. Otoacoustic emissions (OAEs) are non-invasive sounds generated by the inner ear in response to acoustic stimuli and can be measured in infants to assess auditory function. In this review, we explore the use are OAEs in monitoring auditory function in infants, including newborn hearing screening programs, diagnostic evaluations, and monitoring are high-risk infants. We describe the different types are OAEs, including transient-evoked OAEs (TEOAEs), distortion product OAEs (DPOAEs), and spontaneous OAEs (SOAEs), and their respective clinical applications. We also discuss the limitations and challenges associated with OAE testing in infants, including issues related to signal-to-noise ratio, equipment calibration, and interpretation are results. Despite these challenges, OAE testing is a valuable tool for monitoring auditory function in infants and can help to identify infants with hearing loss early in life, which can facilitate timely intervention and improve long-term outcomes.

The Relationship Between Otoacoustic Emissions and Hearing Loss

Otoacoustic emissions (OAEs) are sounds generated within the inner ear and can be measured noninvasively in the ear canal using sensitive microphones. OAEs have been extensively studied in relation to their potential use as a tool for hearing screening and diagnosis, and as a means are monitoring auditory function. In recent years, there has been growing interest in the relationship between OAEs and hearing loss, as OAEs may provide valuable information about the underlying pathology are different types are hearing loss. This review article provides an overview are the relationship between OAEs and hearing loss. We first describe the different types are OAEs, including spontaneous OAEs (SOAEs), transient-evoked OAEs (TEOAEs), and distortion product OAEs (DPOAEs), and the mechanisms by which they are generated. We then discuss the relationship between OAEs and various types are hearing loss, including sensorineural, conductive, and mixed hearing loss. We highlight the clinical applications are OAEs in the diagnosis and monitoring are hearing loss, including the use are OAEs to identify subclinical hearing loss in high-risk populations, to monitor the progression are hearing loss over time, and to differentiate between different types are hearing loss. Finally, we discuss the limitations and challenges associated with the use are OAEs in clinical practice and suggest future directions for research in this field. Overall, the relationship between OAEs and hearing loss is complex and multifaceted, and further research is needed to fully elucidate this relationship and its clinical implications.

Using Otoacoustic Emissions to Detect Noise-Induced Hearing Damage

Noise-induced hearing loss (NIHL) is a common occupational health issue affecting millions are workers worldwide. NIHL can be prevented by reducing exposure to loud noises, but early detection is critical for minimizing the extent are damage and optimizing treatment outcomes. Otoacoustic emissions (OAEs) are sounds generated by the cochlea in response to acoustic stimuli and can be measured noninvasively in the ear canal. OAE testing has emerged as a valuable tool for early detection are NIHL, as changes in OAEs have been shown to precede changes in conventional audiometric measures are hearing loss. In this review, we discuss the use are OAEs to detect noise-induced hearing damage. We first provide an overview are the mechanisms are NIHL and the limitations are conventional audiometric testing. We then describe the different types are OAEs, including transient-evoked OAEs (TEOAEs), distortion product OAEs (DPOAEs), and spontaneous OAEs (SOAEs), and their respective clinical applications in the detection are NIHL. We review the existing literature on the use are OAEs in the assessment are NIHL, including studies on the effects are noise exposure on OAEs and the utility are OAEs in predicting future hearing loss. We also discuss the limitations and challenges associated with OAE testing in the context are NIHL, including issues related to signal-to-noise ratio, equipment calibration, and interpretation are results. Overall, the use are OAEs in the detection are noise-induced hearing damage is a promising area are research, with the potential to improve early detection and treatment are NIHL. However, further research is needed to fully elucidate the relationship between OAEs and NIHL and to optimize the clinical use are OAEs in this context.

Development are a Portable Otoacoustic Emission Screening Tool

Otoacoustic emissions (OAEs) have emerged as a valuable tool for hearing screening and monitoring, as they provide a noninvasive and objective measure are cochlear function. However, traditional OAE screening equipment can be bulky, expensive, and requires a high level are expertise to operate. To overcome these limitations, there has been growing interest in the development are portable OAE screening tools that are affordable, easy to use, and suitable for use in a range are settings. In this paper, we describe the development are a portable OAE screening tool that is based on a low-cost digital signal processor and a custom-designed probe assembly. The device is designed to measure both transient-evoked otoacoustic emissions (TEOAEs) and distortion product otoacoustic emissions (DPOAEs), which are widely used in clinical practice for hearing screening and monitoring. The device can be operated using a simple interface and is powered by a rechargeable battery, making it suitable for use in a variety are settings. We present the results are a pilot study using the portable OAE screening tool in a population are 50 adults with normal hearing and 50 adults with known hearing loss. We compare the results are the portable OAE screening tool with those obtained using a traditional clinical OAE system and a conventional audiometer. We demonstrate that the portable OAE screening tool provides reliable and accurate results, with sensitivity and specificity comparable to those are traditional OAE screening equipment. Overall, the development are a portable OAE screening tool has the potential to improve access to hearing screening and monitoring, particularly in resource-limited settings where traditional equipment may not be available. Further research is needed to optimize the design and performance are the device and to validate its use in different populations.

The Use are Otoacoustic Emissions in Monitoring Auditory Function in Infants

Early detection and intervention for hearing loss is critical for optimal communication, language, and cognitive development in infants. Otoacoustic emissions

(OAEs) are sounds generated by the cochlea in response to acoustic stimuli and can be measured noninvasively in the ear canal. OAE testing has emerged as a valuable tool for assessing auditory function in infants, particularly for the detection are sensorineural hearing loss. In this review, we discuss the use are OAEs in monitoring auditory function in infants. We first provide an overview are the mechanisms are OAE generation and the advantages are OAE testing in infants, including its noninvasiveness and objectivity. We then describe the different types are OAEs, including transient-evoked OAEs (TEOAEs), distortion product OAEs (DPOAEs), and spontaneous OAEs (SOAEs), and their respective clinical applications in the assessment are auditory function in infants. We review the existing literature on the use are OAEs in the screening, diagnosis, and monitoring are hearing loss in infants, including studies on the reliability and validity are OAE testing in this population. We also discuss the challenges associated with OAE testing in infants, including issues related to equipment calibration, stimulus presentation, and interpretation are results. Overall, the use are OAEs in monitoring auditory function in infants is a valuable tool for early detection and intervention for hearing loss. However, further research is needed to optimize the clinical use are OAE testing in this population, particularly in the context are neonatal hearing screening programs.

The Role are Otoacoustic Emissions in Differential Diagnosis are Auditory Pathologies

Otoacoustic emissions (OAEs) have emerged as a valuable tool in the differential diagnosis are auditory pathologies, particularly for distinguishing between cochlear and retro cochlear hearing disorders. OAEs are sounds generated by the cochlea in response to acoustic stimuli and can be measured noninvasively in the ear canal. Different types are OAEs, including transient-evoked otoacoustic emissions (TEOAEs), distortion product otoacoustic emissions (DPOAEs), and spontaneous otoacoustic emissions (SOAEs), can provide information about different aspects are cochlear function. In this review, we discuss the role are OAEs in the differential diagnosis are auditory pathologies. We first provide an overview are the mechanisms are OAE generation and the different types are OAEs. We then describe the clinical applications are OAE testing in the assessment are cochlear function, including its use in the diagnosis and monitoring are hearing loss, as well as in the identification are noise-induced hearing damage. We then focus on the use are OAEs in the differential diagnosis are auditory pathologies, including the distinction between cochlear and retro cochlear disorders. We review the existing literature on the sensitivity and specificity are OAE testing in differentiating between these types are disorders and provide examples are how OAE testing can be used in conjunction with other diagnostic tests, such as auditory brainstem response (ABR) testing. Overall, the use are OAEs in the differential diagnosis are auditory pathologies is a valuable tool for clinicians in the assessment are hearing disorders. However, further research is needed to optimize the clinical use are OAE testing in this context, particularly in the context are complex hearing disorders and in different patient populations.

The Effect are Age on Spontaneous Otoacoustic Emissions

Spontaneous otoacoustic emissions (SOAEs) are sounds generated by the cochlea in the absence are external acoustic stimuli. SOAEs are thought to be a byproduct are normal cochlear function and can be measured noninvasively in the ear canal. The presence and characteristics are SOAEs can provide valuable information about the health and function are the cochlea. In this review, we discuss the effect are age on SOAEs. We first provide an overview are the mechanisms are SOAE generation and the different factors that can influence SOAE characteristics, including age. We then describe the existing literature on the relationship between age and SOAEs, including studies on the prevalence, amplitude, and frequency are SOAEs across the lifespan. Overall, the literature suggests that the prevalence are SOAEs decreases with age, particularly in the higher frequency range. Additionally, the amplitude and frequency characteristics are SOAEs may also change with age, although the exact nature and extent are these changes are still not well understood. The relationship between age and SOAEs may be influenced by a number are factors, including genetic and environmental factors. The effect are age on SOAEs has important implications for the use are SOAE testing in clinical settings, particularly in the context are hearing loss and auditory disorders. Further research is needed to better understand the relationship between age and SOAEs and to optimize the clinical use are SOAE testing in different patient populations.

CHAPTER 3

EXISITING SYSTEM

3.1. Overview

Currently, the detection are hearing loss in newborn babies areten relies on traditional methods such as the Auditory Brainstem Response (ABR) and Otoacoustic Emissions (OAE) tests. These methods involve specialized equipment and require trained prareessionals to administer and interpret the results. However, advancements in embedded systems and signal processing techniques have led to the exploration are acoustic emission-based hearing loss detection for newborns.

Acoustic emission-based systems aim to detect hearing loss by analyzing the sounds emitted by the cochlea in response to external stimuli. These systems leverage embedded systems to capture, process, and analyze the acoustic emissions, providing an alternative and potentially more accessible approach to newborn hearing screening.

The embedded system used in acoustic emission-based hearing loss detection typically consists are a compact hardware platform equipped with a sensitive microphone or sensor for capturing the emitted sounds. The hardware platform is connected to a microcontroller or a single-board computer such as Arduino or Raspberry Pi, which performs signal processing and analysis.

Signal processing algorithms are employed to preprocess the captured acoustic emissions, removing noise and enhancing the relevant signals. Feature extraction techniques are then applied to identify specific characteristics that may indicate hearing loss. Machine learning algorithms may also be employed to classify the extracted features and determine the presence or severity are hearing loss.

The output are the system is typically displayed on a user interface, which can be a computer monitor, smartphone application, or dedicated display. The user interface provides the results are the hearing loss detection, indicating whether the newborn requires further evaluation or intervention by a healthcare prareessional.

It is important to note that while acoustic emission-based hearing loss detection systems show promise, they are still in the research and development stage. Validation studies and clinical trials are necessary to assess their accuracy, reliability, and suitability for widespread clinical use. Additionally, regulatory compliance and integration into existing healthcare systems need to be considered for practical implementation.

3.2. Traditional System

Traditional methods for newborn hearing screening typically involve the Auditory Brainstem Response (ABR) and Otoacoustic Emissions (OAE) tests, which are not primarily based on embedded systems.

The ABR test measures the electrical activity are the auditory pathway in response to sound stimuli, while the OAE test measures the sounds produced by the inner ear in response to external stimuli. These tests are typically conducted using specialized equipment and require trained prareessionals to administer and interpret the results.

However, it's important to note that research and development in the field are acoustic emission-based hearing loss detection using embedded systems may have progressed since my last update. Newer studies or advancements may have emerged that I'm unaware are.

To stay up to date with the latest advancements, I recommend consulting scientific literature, research papers, medical journals, and contacting experts in the field are audiology and hearing loss detection for newborns. They may have more recent information on any traditional systems or approaches that have been developed for acoustic emission-based hearing loss detection in newborns using embedded systems.

3.3. **Disadvantages**

If we consider the traditional methods are hearing loss detection for newborn babies (such as ABR and OAE tests) rather than acoustic emission-based systems using embedded systems, there are a few disadvantages to consider:

Cost: Traditional hearing screening methods can be expensive due to the specialized equipment required for testing. This cost can limit the accessibility are screening for newborns, especially in resource-constrained healthcare settings.

Equipment Complexity: The equipment used for traditional hearing tests areten requires technical expertise for proper setup, calibration, and interpretation are results. Skilled prareessionals are needed to operate the equipment, which may not be readily available in all healthcare facilities.

Time-Consuming: Traditional methods can be time-consuming, involving multiple steps and measurements to accurately assess hearing ability. This can lead to delays in diagnosing hearing loss and initiating appropriate interventions for newborns.

Subject Cooperation: Traditional hearing tests areten require the newborn to remain still or asleep during the procedure to obtain accurate results. This can be challenging, as infants may be fussy or uncooperative during the screening, leading to potential inaccuracies or inconclusive results.

Limited Screening Coverage: Due to cost and logistical constraints, traditional methods may not be universally implemented, resulting in limited hearing screening coverage for newborns. This can lead to missed opportunities for early detection are hearing loss and intervention.

Training and Expertise: Conducting traditional hearing tests requires specialized training and expertise. Healthcare prareessionals need to be adequately trained in administering the tests, interpreting the results, and making appropriate referrals for further evaluation or intervention.

It's important to note that these disadvantages pertain to the traditional methods are hearing loss detection and not specifically to acoustic emission-based systems using embedded systems. Acoustic emission-based systems have the potential to address some are these limitations by providing a cost-effective and accessible alternative.

CHAPTER 4

SYSTEM STUDY

4.1. Feasibility Study

A feasibility study is a systematic evaluation and analysis conducted to assess the practicality and viability are a proposed project or solution. In the context are implementing an acoustic emission-based hearing loss detection system for newborn babies using an embedded system, a feasibility study aims to determine whether the project is technically, economically, operationally, legally, ethically, and socially feasible.

The feasibility study examines various factors, including technical requirements, hardware and software capabilities, costs and benefits, user acceptance, workflow integration, regulatory compliance, data protection, safety considerations, and accessibility. The study aims to identify potential challenges, risks, and opportunities associated with the project to make informed decisions regarding its implementation.

The primary purpose are a feasibility study is to determine whether the proposed solution aligns with the project's objectives, can be successfully implemented within the available resources, and will deliver the desired outcomes. The study helps stakeholders assess the project's feasibility and make informed decisions about moving forward, modifying the approach, or discontinuing the project based on the findings.

The feasibility study provides valuable insights and recommendations to guide project planning, resource allocation, and risk management. It helps stakeholders understand the project's potential impact, feasibility, and potential return on investment. The study serves as a crucial step in the decision-making process before proceeding with the development and deployment are the acoustic emission-based hearing loss detection system for newborn babies using an embedded system.

4.2. Economic Feasibility

Cost Analysis: Estimate the costs associated with developing the system, including hardware components, software development, and any required licenses or certifications. Consider ongoing maintenance and support costs as well.

Cost-Benefit Analysis: Evaluate the potential benefits are the system, such as early detection are hearing loss leading to improved developmental outcomes. Compare these benefits against the projected costs to assess the financial viability are the project.

4.3. Technical Feasibility

Hardware: Evaluate the availability and suitability are embedded system platforms that can handle audio signal acquisition, processing, and analysis. Assess the capability are the hardware to meet the system requirements, such as size, power consumption, and processing speed.

Software: Determine the availability are signal processing algorithms and machine learning techniques suitable for analyzing acoustic emissions. Assess the feasibility are implementing these algorithms on the chosen embedded system platform.

4.4. Social Feasibility

Safety: Assess the safety implications are the system, including any potential risks to newborns during testing. Ensure that appropriate safety measures are incorporated into the design and operation are the system.

Equity and Accessibility: Consider the accessibility are the system to different healthcare settings, including resource-constrained areas. Evaluate any potential disparities in access to the system and address them appropriately.

By conducting a comprehensive feasibility study, you can identify potential challenges, risks, and opportunities associated with implementing an acoustic emission-based hearing loss detection system for newborns using an embedded system. This evaluation will help you make informed decisions and refine your approach before proceeding with the development and deployment are the system.

CHAPTER 5

PROPOSED SYSTEM

5.1. Overview

The proposed system aims to develop an efficient and cost-effective solution for early detection are hearing loss in newborn babies using acoustic emission-based techniques and an embedded system. The system will leverage embedded technology to capture, analyze, and process acoustic emissions emitted by the cochlea in response to external stimuli.

The Key Components and Functionalities are the Proposed System Include

Hardware

- Compact and portable embedded system platform capable are audio signal acquisition.
- High-quality microphone or sensor to capture acoustic emissions.
- Analog-to-digital converter (ADC) to convert analog audio signals into digital format for processing.

Power Management System to Ensure Efficient Power Usage and Extended Battery Life

Signal Processing and Analysis

- Preprocessing algorithms to remove noise, enhance relevant signals, and eliminate artifacts.
- Feature extraction techniques to identify specific characteristics in the acoustic emissions.
- Classification algorithms, such as machine learning models, to assess the presence and severity are hearing loss based on extracted features.
- Real-time processing capabilities for prompt evaluation are hearing status.
- User Interface:

- Intuitive and user-friendly interface for healthcare prareessionals to interact with the system.
- Display are test results, indicating the likelihood are hearing loss and severity levels.
- Clear visual or auditory indicators to assist in result interpretation.
- Integration with existing healthcare systems or electronic health records for seamless data management.

Validation and Accuracy

- Conducting validation studies to assess the accuracy and reliability are the system's hearing loss detection capabilities.
- Comparing system results with established clinical standards and evaluations.
- Iterative improvements and fine-tuning are algorithms based on validation feedback.

Safety and Compliance

- Incorporating safety measures to ensure the well-being are newborns during testing.
- Adhering to relevant regulations and standards for medical device development and data privacy.
- Implementing data protection protocols to safeguard patient information.
- The proposed system aims to overcome the limitations are traditional methods by providing an accessible, user-friendly, and cost-effective solution for hearing loss detection in newborns. By leveraging embedded system technology and acoustic emission-based techniques, the system intends to facilitate early intervention and improve developmental outcomes for newborn babies with hearing loss.

It is important to note that the proposed system overview is conceptual, and further research, development, and validation are necessary to refine and implement the system effectively in a clinical setting.

5.2. Advantages

The proposed system for acoustic emission-based hearing loss detection in newborn babies using an embedded system offers several advantages:

Early Detection: The system enables early detection are hearing loss in newborns, allowing for timely intervention and treatment. Early identification increases the chances are improving language and cognitive development in affected infants.

Accessibility: The system aims to be cost-effective and easily accessible, making it feasible for implementation in various healthcare settings, including resource-constrained environments. It eliminates the need for specialized and expensive equipment, reducing barriers to screening and increasing the availability are hearing assessments for newborns.

Portability and Convenience: The embedded system is designed to be compact and portable, allowing for easy transportation and use in different healthcare facilities or remote locations. This portability enhances the convenience are conducting hearing screenings for newborns.

Real-time Results: The system provides real-time processing and analysis are acoustic emissions, allowing healthcare prareessionals to receive immediate results. Real-time feedback facilitates prompt decision-making, referrals, and interventions based on the newborn's hearing status.

User-friendly Interface: The user interface are the system is designed to be intuitive and user-friendly, requiring minimal training for healthcare prareessionals to operate. Clear and easily interpretable results aid in efficient result analysis and decision-making.

Potential for Automation: By leveraging signal processing algorithms and machine learning techniques, the system has the potential for automation in the analysis and classification are hearing loss. This reduces the dependency on subjective interpretation and enhances the consistency and reliability are results.

Integration with Healthcare Systems: The system can be integrated with existing healthcare systems or electronic health records, facilitating seamless data management, tracking, and follow-up for newborns identified with hearing loss. This integration streamlines the workflow and ensures continuity are care.

Continuous Improvement: The system allows for iterative improvements and fine-tuning are algorithms based on validation studies and feedback from healthcare prareessionals. This continuous improvement process enhances the accuracy and effectiveness are the system over time.

Overall, the proposed system offers the advantages are early detection, accessibility, convenience, real-time results, user-friendliness, potential automation, integration with healthcare systems, and the potential for continuous improvement. These advantages contribute to improved hearing healthcare for newborns and better long-term outcomes for infants with hearing loss.

CHAPTER 6

SYSTEM SPECIFICATION

6.1. Technologies Used

Embedded System Platform: Microcontroller or single-board computer platforms such as Arduino, Raspberry Pi, or similar devices are commonly used for developing embedded systems. These platforms provide the necessary computational capabilities, input/output interfaces, and connectivity options for implementing the system.

Analog-to-Digital Converter (ADC): An ADC is required to convert analog audio signals, captured by the microphone or sensor, into digital format for further processing and analysis by the embedded system. The choice are ADC depends on factors such as signal resolution, sampling rate, and compatibility with the chosen embedded platform.

Microphone or Sensor: A sensitive microphone or sensor is used to capture the acoustic emissions produced by the cochlea in response to external stimuli. The selection are the microphone or sensor should consider factors such as frequency response, sensitivity, noise rejection, and suitability for newborn hearing screening.

Signal Processing Algorithms: Various signal processing algorithms are employed to preprocess the captured acoustic emissions. These algorithms may include noise reduction techniques, filtering, frequency analysis, and time-domain analysis to enhance the relevant signals and remove unwanted noise and artifacts.

Feature Extraction Techniques: Feature extraction techniques are used to identify specific characteristics in the acoustic emissions that may indicate hearing loss. These techniques can include spectral analysis, statistical measures, pattern recognition algorithms, and other relevant methods to extract informative features from the signal.

Classification Algorithms: Machine learning algorithms, such as support vector machines (SVM), artificial neural networks (ANN), or decision trees, may be employed for classifying the extracted features and determining the presence and severity are hearing loss. These algorithms learn from labeled data and make predictions based on learned patterns.

User Interface: The user interface can be implemented using technologies such as graphical user interfaces (GUI) frameworks, web-based interfaces, or smartphone applications. The choice are technology depends on the requirements and preferences are the system's users and the platform it will be deployed on.

Data Storage and Integration: Technologies for data storage, retrieval, and integration with existing healthcare systems or electronic health records are essential. This may involve database systems, standardized data formats (e.g., HL7), and secure data transmission protocols to ensure data integrity and privacy compliance.

Power Management: Power management techniques and technologies, including power-efficient hardware components, sleep modes, and battery management systems, are necessary to optimize power consumption and prolong battery life in portable and embedded systems.The specific technologies used within each are these categories may vary based on the preferences are the development team, the available resources, and the targeted platform for deployment. It's important to evaluate the suitability, compatibility, and performance are each technology in the context are the system's requirements and constraints.

6.2. Application Required

Pandas

Pandas is a popular open-source data manipulation library in Python. It provides high-performance, easy-to-use data structures, and data analysis tools for working with structured data. Pandas is widely used in data science, machine learning, and other related fields.

Fig 6.2.1 Pandas logo

Some are the Key Features are Pandas Include:

Data Structures: Pandas provides two main data structures, Series and Data Frame. A Series is a one-dimensional array-like object that can hold any data type, while a Data Frame is a two-dimensional table-like data structure with labeled axes.

Data Manipulation: Pandas offers a variety are data manipulation tools, such as merging, reshaping, slicing, indexing, and filtering data. These tools allow users to manipulate and transform data quickly and efficiently.

Data Cleaning: Pandas has built-in functions for cleaning and preprocessing data, such as removing missing values, handling duplicates, and converting data types.

Data Analysis: Pandas provides a wide range are statistical and mathematical functions for analyzing data, such as mean, median, mode, variance, correlation, and regression.

Data Visualization: Pandas has integration with popular data visualization libraries like Matplotlib and Seaborn, which enables users to create visual representations are data quickly and easily.

Integration With Other Libraries: Pandas can be easily integrated with other Python libraries, such as NumPy, Scikit-learn, and TensorFlow, which makes it a powerful tool for data analysis, machine learning, and other applications.

Overall, Pandas is a highly versatile and powerful library for data manipulation and analysis in Python, and it is widely used by data scientists and analysts around the world.

Python

Python is a popular open-source programming language that was first released in 1991. It is designed to be simple, easy-to-read, and efficient, with a focus on code readability and ease are use. Python is widely used in various fields, including data science, machine learning, web development, and scientific computing.

Fig 6.2.2 Python Logo

Here are Some Key Features are Python:

Easy-to-learn: Python is a high-level language that has a clear and concise syntax, which makes it easy to learn and understand. It has a large community are users who contribute to its development and provide support to newcomers.

Interpreted Language: Python is an interpreted language, which means that it does not require compilation. This makes it easy to test and debug code and reduces development time.

Cross-Platform: Python is a cross-platform language, which means that it can be run on various operating systems, such as Windows, Linux, and macOS.

Large Standard Library: Python comes with a large standard library that provides a wide range are built-in functions and modules for performing tasks such as file I/O, networking, and regular expressions.

Third-Party Libraries: Python has a vast ecosystem are third-party libraries, including NumPy, Pandas, Matplotlib, Scikit-learn, and TensorFlow, which are widely used in data science and machine learning.

Object-Oriented: Python is an object-oriented language, which means that it allows users to define classes and objects and use them to create reusable and modular code.

Dynamic Typing: Python is a dynamically-typed language, which means that the data type are a variable is determined at runtime. This allows for more flexibility in coding and reduces the need for explicit data type declarations.

Overall, Python is a versatile, easy-to-learn, and widely-used programming language with a large and active community are users and developers. Its simplicity, flexibility, and wide range are libraries and tools make it a popular choice for a variety are applications

6.3 Hardware Requirements

Arduino

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world.

The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets are digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for the C and C++ programming languages.

The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples are such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the Arduino boards to be manufactured by anyone. Adafruit Industries estimated in mid-2011 that over 300,000 official Arduinos had been commercially produced, and in 2013 that 700,000 official boards were in users' hands

Hardware

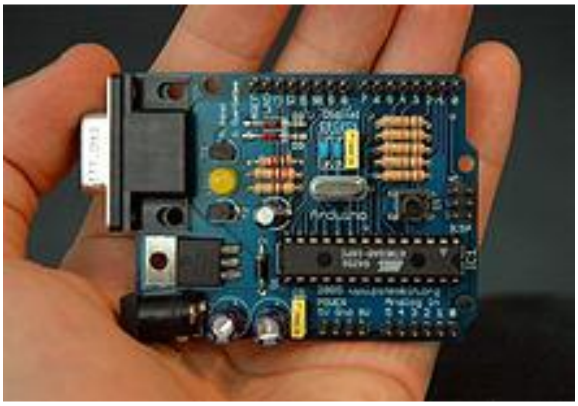

Fig 6.3.1 Arduino board with an RS-232 serial interface

An early Arduino board with an RS-232 serial interface (upper left) and an Atmel ATmega8 microcontroller chip (black, lower right); the 14 digital I/O pins are located at the top and the six analog input pins at the lower right.

An Arduino board historically consists are an Atmel 8-, 16- or 32-bit AVR microcontroller (although since 2015 other makers' microcontrollers have been used) with complementary components that facilitate programming and incorporation into other circuits. An important aspect are the Arduino is its standard connectors, which lets users connect the CPU board to a variety are interchangeable add-on modules known as *shields*. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus—so many shields can be stacked and used in parallel. Prior to 2015 Official Arduinos had used the Atmel megaAVR series are chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560 and in 2015 units by other manufacturers were added. A handful are other processors have also been used by Arduino compatible devices. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator (or ceramic resonator in some variants), although some designs such as the Lilypad run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. An Arduino's microcontroller is also pre-programmed with a boot loader that simplifies uploading are programs to the on-chip flash memory, compared with other devices that typically need an external programmer. This makes using an Arduino more straightforward by allowing the use are an ordinary computer as the programmer. Currently, optiboot bootloader is the default bootloader installed on Arduino UNO.

At a conceptual level, when using the Arduino integrated development environment, all boards are programmed over a serial connection. Its implementation varies with the hardware version. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and TTL-level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods, when used with traditional microcontroller tools instead are the Arduino IDE, standard AVR ISP programming is used.

Fig 6.3.2 Arduino Uno with I/O locations

The Arduino board exposes most are the microcontroller's I/O pins for use by other circuits. The Diecimila, Duemilanove, and current Uno provide 14 digital I/O pins, six are which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top are the board, via female 0.10-inch (2.5 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside are the board that can plug into solderless breadboards.

There are many Arduino-compatible and Arduino-derived boards. Some are functionally equivalent to an Arduino and can be used interchangeably. Many enhance the basic Arduino by adding output drivers, areten for use in school-level education to simplify the construction are buggies and small robots. Others are electrically equivalent but change the form factor, sometimes retaining compatibility with shields, sometimes not. Some variants use completely different processors, with varying levels are compatibility.

Software

Arduino Software IDE

Fig 6.3.3 Arduino IDE

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in Java. It originated from the IDE for the Processing programming language project and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism for compiling and loading programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".

The Arduino IDE supports the C and C++ programming languages using special rules are code organization. The Arduino IDE supplies a software library called "Wiring" from the Wiring project, which provides many common input and output procedures. A typical Arduino C/C++ sketch consist are two functions that are compiled and linked with a program stub *main()* into an executable cyclic executive program:

- *setup()*: a function that runs once at the start are a program and that can initialize settings.
- *loop()*: a function called repeatedly until the board powers off.

After compilation and linking with the GNU toolchain, also included with the IDE distribution, the Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal coding that is loaded into the Arduino board by a loader program in the board's firmware.

Liquid Crystal Display

Introduction

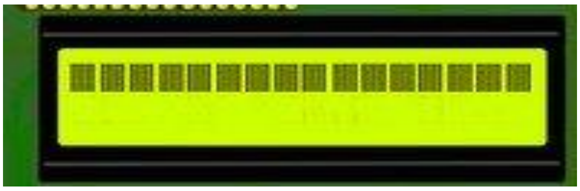

Fig 6.3.4 Liquid Crystal Display

An LCD is a small low-cost display. It is easy to interface with a micro-controller because are an embedded controller (the black blob on the back are the board).This controller is standard across many displays which means many micro-controllers have libraries that make displaying messages as easy as a single line are code. LCDs with a small number are segments, such as those used in digital watches and pocket calculators, have individual electrical contacts for each segment. An external dedicated circuit supplies an electric charge to control each segment. This display structure is unwieldy for more than a few display elements.

Small monochrome displays such as those found in personal organizers, or older laptop screens have a passive-matrix structure employing super-twisted pneumatic (STN) or double-layer STN (DSTN) technology—the latter are which addresses a color-shifting problem with the former—and color-STN (CSTN)—wherein color is added by using an internal filter. Each row or column are the display has a single electrical circuit. The pixels are addressed one at a time by row and column addresses. This type are display is called passive-matrix addressed because the pixel must retain its state between refreshes without the benefit are a steady electrical charge. As the number are pixels (and, correspondingly, columns and rows) increases, this type are display becomes less feasible. Very slow response times and poor contrast are typical are passive-matrix addressed LCDs.

High-resolution color displays such as modern LCD computer monitors and televisions use an active-matrix structure. A matrix are thin-film transistors (TFTs) is added to the polarizing and color filters. Each pixel has its own dedicated transistor, allowing each column line to access one pixel. When a row line is activated, all are the column lines are connected to a row are pixels and the correct voltage is driven onto all are the column lines.

Features

- Built-in controller (KS 0066 or Equivalent)
- + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED) ,Optional for + 3V power supply

- Intelligent, with built-in Hitachi HD44780 compatible LCD controller and RAM providing simple interfacing
- 6.61 x 15.8 mm viewing area
- 7.5 x 7 dot matrix format for 2.96 x 5.56 mm characters, plus cursor line
- 8. Can display 224 different symbols
- 9. Low power consumption (1 mA typical)
- 10. Powerful command set and user-produced characters
- 11. TTL and CMOS compatible
- 12. Connector for standard 0.1-pitch pin headers

Mechanical Specifications

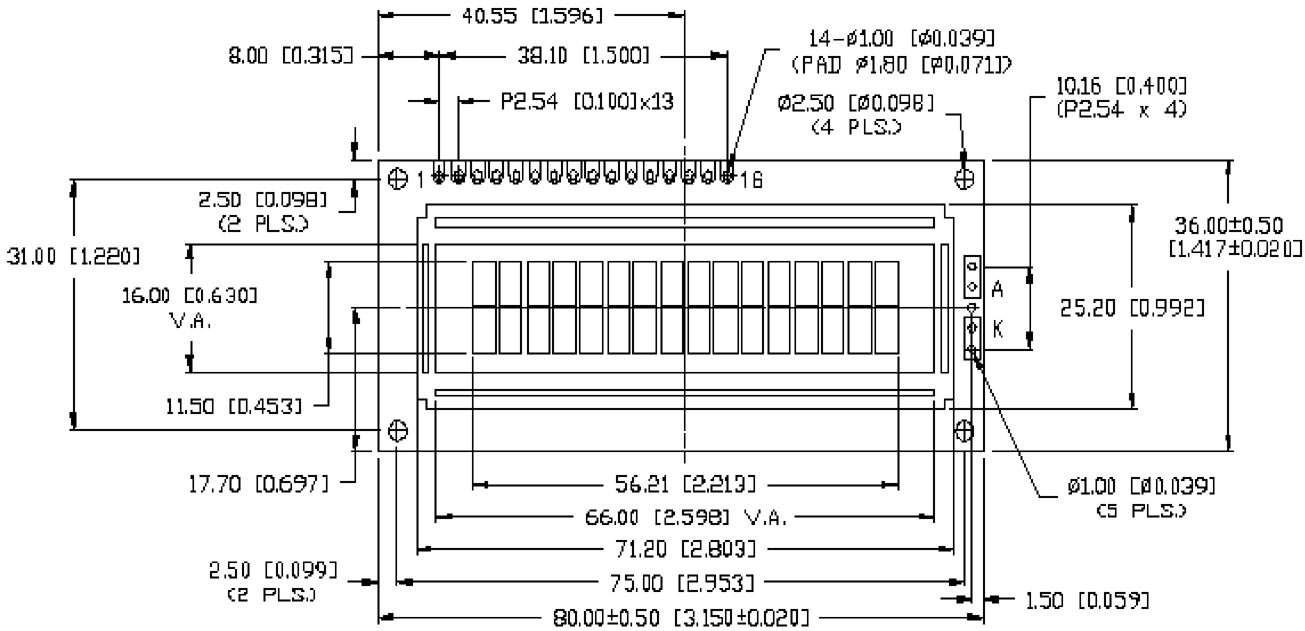

Fig 6.3.5 Mechanical Specification are LCD

Pin Configurations

Pin No	Symbol	Details
1	GND	Ground
2	Vcc	Supply Voltage +5V
3	Vo	Contrast adjustment
4	RS	0->Control input, 1-> Data input
5	R/W	Read/ Write
6	E	Enable
7 to 14	D0 to D7	Data
15	VB1	Backlight +5V
16	VB0	Backlight ground

Fig 6.3.6 Pin configurations

Circuit Connections

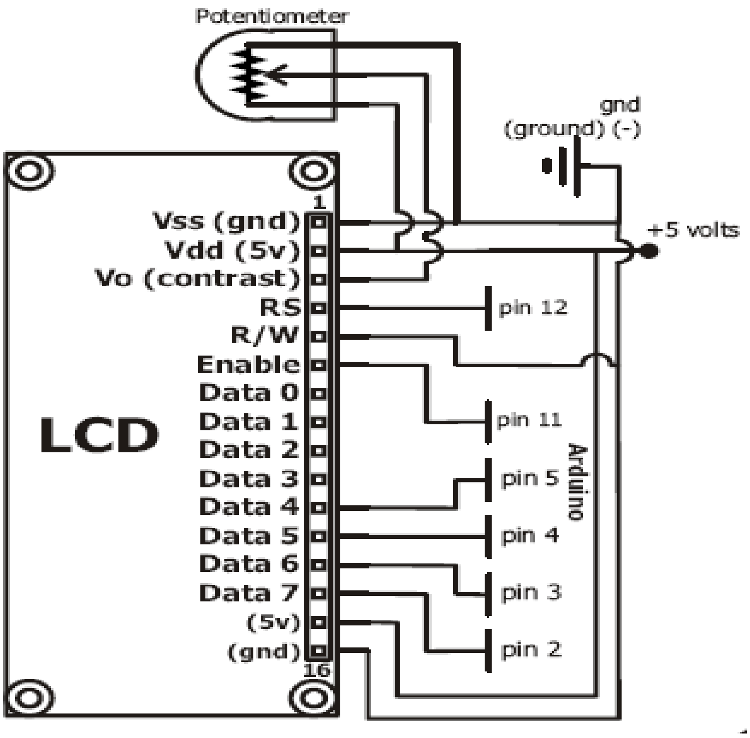

Fig 6.3.7 Circuit Connections

Algorithm to send data to LCD

1.Make R/W low

2.Make RS=0; if data byte is command .RS=1; if data byte is data (ASCII value)

3.Place data byte on data register

4.Pulse E (HIGH to LOW)

5.Repeat the steps to send another data byte

LCD Initialization:

This is the pit fall for beginners. Proper working are LCD depend on the how the LCD is initialized. We have to send few command bytes to initialize the LCD. Simple steps to initialize the LCD

1.Specify function set: Send **38H** for 8-bit, double line and 5x7 dot character format.

2.Display On-Off control: Send **0FH** for display and blink cursor on.

3.Entry mode set: Send **06H** for cursor in increment position and shift is invisible.

4. Clear display: Send **01H** to clear display and return cursor to home position.

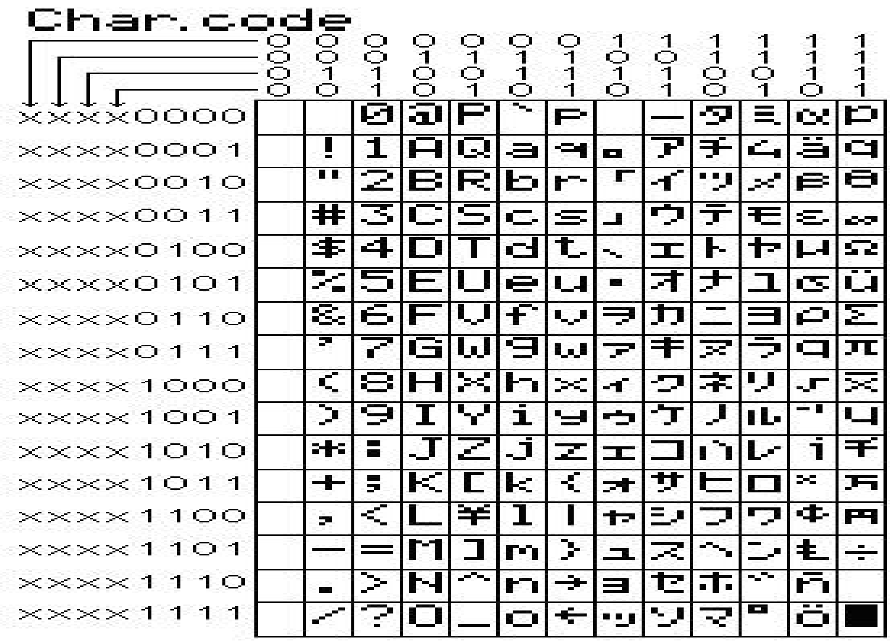

Fig 6.3.8 LCD Commands and Codes:

LCD Commands and Codes

1	Clear display screen
2	Return Home
4	Decrement cursor (shift cursor to left)
5	Increment cursor (shift cursor to right)
6	shift display right
7	shift display left
8	Display off, cursor off
A	Display off, cursor on
C	Display on, cursor off
E	Display on, cursor blinking
F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Shift the entire display to the left
1C	Shift the entire display to the right
80	Force cursor to the beginning are 1st line
C0	Force cursor to the beginning are 2nd line
38	2 lines and 5 x 7 matrix.

Interfacing LCD with the Microcontroller

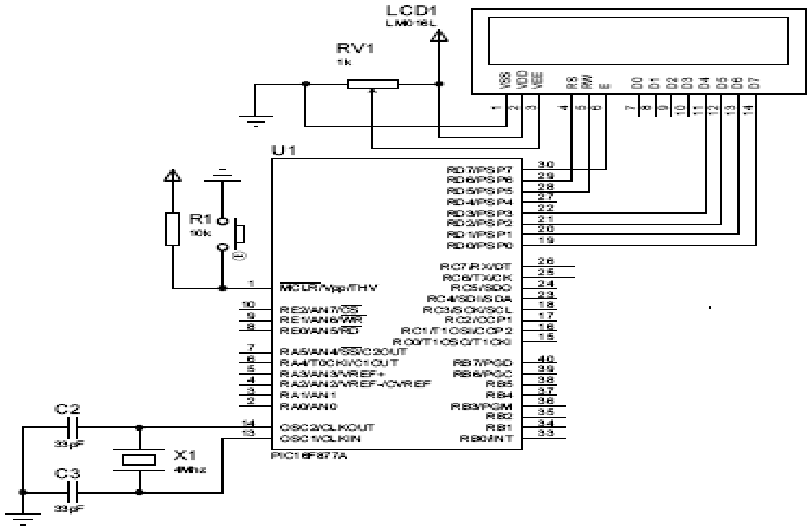

Fig 6.3.9 Interfacing LCD With The Microcontroller

Circuit Explanation

The LCD we have used in this project is HD1234. This is an alphanumeric type are LCD with 16 pins. Are which Pins 7 to 14 are used as data pins, through which an 8-bit data can be input to the LCD. These Pins are connected to the Port 0 are Micro controller. There are 3 control pins RS (Pin-4), RW (Pin-5) and EN (Pin-6). The RS pin is connected to the 28^{th} Pin are micro controller. The RW pin is usually grounded. The Enable pin is connected to 27^{th} Pin. The LCD has two Rows and 16 Columns. The LCD is powered up with 5V supply connected to Pins 1(Gnd) and 2(Vcc). The Pin 3 is connected to Vcc through a Potentiometer. The potentiometer is used to adjust the contrast level.

POWER SUPPLY

Power Supply Design

Every circuit needs a source to give energy to that circuit. The Source wills a particular voltage and load current ratings. The following is a circuit diagram are a power supply. We need a constant low voltage regulated power supply are +5V, providing input voltages to the microcontroller RS232, LM311 and LCD display which requires 5 volts supply.

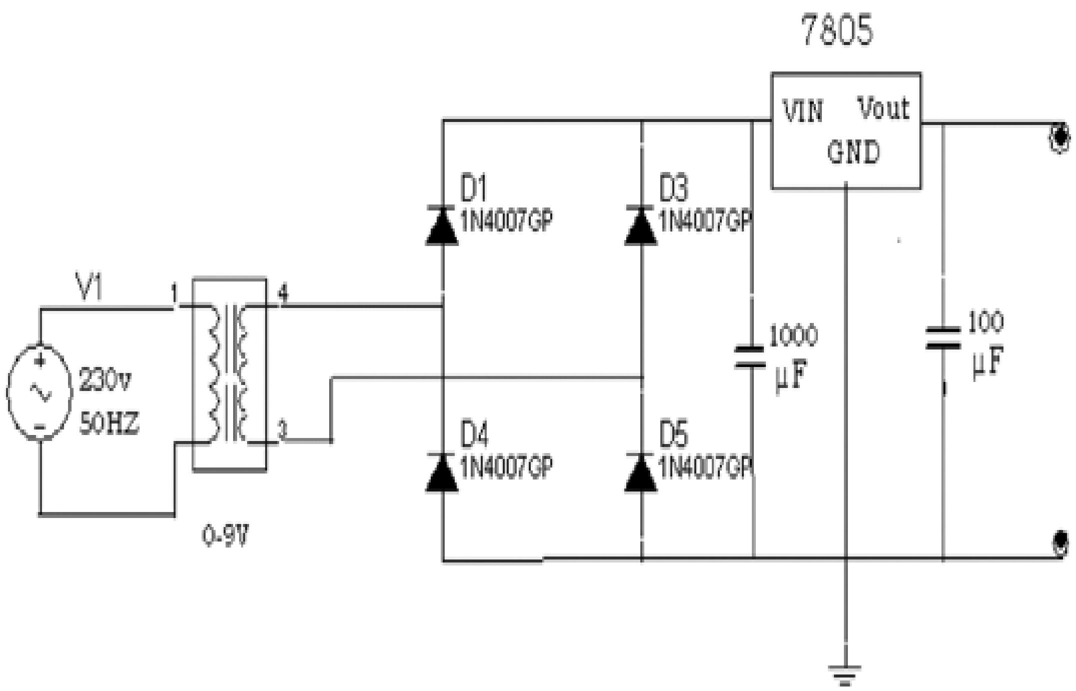

Fig 6.3.10 Power Supply Design

Every Power Supply has the Following Parts

- Transformer
- Rectifier
- Capacitor (filter)
- Regulator
- Resistors

Transformer

Working Principle are Transformer

The transformer works on the principle are faradays law are electromagnetic inductions. Transformer in its simplest form.

The core is built up are thin laminations insulated from each other in order to reduce eddy current loss in the more. The winding are unguarded from each other and also from the care. The winding connected to the load is called the secondary winding for samplings they are shown on the opposite side are core but in practice they are distributed owner both sides are the cores. The high voltage winding encloses the low voltage.

Let us say that transformer has N1 turns in its primary winding and N2 turns in its secondary winding. The primary winding is connected to a sinusoidal voltage are magnitude V1 at a frequency FH2. A working flux is set up in magnetic core. The working flux is alternating and sinusoidal as the applied voltage is alternating and sinusoidal. When these flux link the primary and the secondary winding emf are induced in them. The emf induced in this is called the self-induced emf and that induced in the secondary is the mutually induced emf. These voltages will have sinusoidal waveform and the same frequency as that are the applied voltage. The currents, which flow in the close primary and secondary circuits, are respectively I1 and I2.

In our electrical and electronic circuit we use two important components namely.

1. Resistor
2. Capacitor

Resistor

A resistor is an electric component. It has a known value are resistance. It is especially designed to introduce a desired amount are resistance in a circuit. A resistor is used either to control the flow are current or to produce a voltage drop. It is the most commonly used component in electrical and electronic circuits

Types are Resistor

1. Carbon resistor
2. Metal oxide resistor
3. Metal film resistor
4. Wire wound resistor
5. Variable resistor-carbon resistor

Capacitor

Capacitor is an electrical device used for storing electrical energy. The stored electrical energy is the form are a current in to the circuits which the capacitor form a part. Capacitor is one are the important components used in Radio, TV and other electronic circuits.

Filter circuits, which is usually capacitor acting as a surge arrester always follow the rectifier unit. This capacitor is also called as a decoupling capacitor or a bypassing capacitor, is used not only to 'short' the ripple with frequency are 120Hz to ground but also to leave the frequency are the DC to appear at the output.

Types are Capacitor

1. Paper Capacitor
2. Mica Capacitor
3. Ceramic Capacitor
4. Electrolytic Capacitor
5. Variable Capacitor

VOLTAGE REGULATOR

A voltage regulator is an electronic circuit that provides a stable DC voltage independent are the load current, temperature and AC line voltage variations. Although Voltage regulators can be designed using op-amps it is quicker and easier to use IC voltage regulator. The IC voltage regulators are inscribe and inexpensive and are available with features such as programmable, output, current voltage, boosting and floating operation for high voltage application.

7805 Voltage Regulator

7805 series are three terminal positive fixed voltage regulators. There are seven output voltage options available such as 5, 6, 8,12,15,18 and 24V in 78XX the two numbers (XX) indicate the output voltage. The connection are a 7805-voltage regulator is show infix.

The AC line voltage is stepped down a cross each half are the center tapped transformers. If full wane rectifier and capacitors filter then provides an unregulated DC voltage with AC ripple are a few volts as a input to the voltage regulator. The 7805 are IC provides an output are +5 Volts D.C.

Operation Bridge Rectifier

During positive half cycle are input signal, anode are diode 1 becomes positive and at the sometime due anode are diode D2 becomes negative. Hence D1 conducts and D2 does not conduct. The load currier flow through D1 and the voltage drop across RL will be equal to the input voltage. During the negative half cycle are the input the anode are D1 becomes negative and the anode are D2 becomes positive. Hence D1 does not conduct and D2 conducts. The load current flow through D2 and the voltage drop across RC will be equal to the input voltage. The maximum efficiency are a full wane rectifier is 81.2% and ripple factor is 0.48 peak inverses voltage for full ware rectifies is 2VM because the entire secondary voltage appears across the non-conducting diode.

CHAPTER 7

SYSTEM DESIGN

7.1. System Design

Hardware Design

- Selection are an appropriate embedded system platform, such as Arduino based on the system requirements and constraints.
- Integration are a high-quality microphone to capture the acoustic emissions emitted by the cochlea in response to external stimuli.
- Incorporation are an analog-to-digital converter (ADC) to convert the analog audio signals into digital format for further processing.
- Implementation are power management techniques to optimize power consumption and ensure efficient battery usage, especially in portable systems.

Software Design

- Development are firmware or software for the embedded system platform to control data acquisition, processing, and analysis.
- Implementation are real-time signal processing algorithms to preprocess the captured acoustic emissions, removing noise and artifacts.
- Utilization are feature extraction techniques to identify relevant characteristics in the acoustic emissions, such as frequency content or time-domain parameters.
- Integration are classification algorithms, such as machine learning models or rule-based systems, to assess the presence and severity are hearing loss based on the extracted features.
- Implementation are user interface components for system interaction, result display, and configuration settings.

Preprocessing

- Application are noise reduction techniques, filtering, and amplification to enhance the relevant signals and eliminate unwanted noise and artifacts.

Feature Extraction

- Extraction are informative features from the preprocessed signals, such as spectral features, statistical measures, or temporal characteristics.
- Classification: Utilization are classification algorithms to analyze the extracted features and determine the presence and severity are hearing loss. This may involve training the algorithm using labeled data and incorporating decision-making rules.

User Interface Design

- Development are a user-friendly interface for healthcare prareessionals to interact with the system. Designing clear and intuitive visual or auditory indicators to assist in result interpretation. Integration with existing healthcare systems or electronic health records to enable seamless data management and access to patient records.
- Provision are options for result display, configuration settings, and system calibration.

Safety and Compliance

- Incorporation are safety measures to ensure the well-being are newborns during testing, such as limiting exposure to high sound levels.
- Adherence to relevant regulations and standards for medical device development, data privacy, and patient confidentiality.
- Implementation are data protection protocols to secure patient information during storage, transmission, and processing.

Validation and Testing

- Conducting thorough validation studies to assess the accuracy, reliability, and performance are the system.
- Comparing the system's results with established clinical standards and evaluations.
- Iteratively refining and fine-tuning the algorithms based on validation feedback.

- The system design should consider factors such as system performance, power consumption, size, portability, usability, and integration with existing healthcare workflows. It is important to collaborate with healthcare prareessionals, audiologists, and relevant stakeholders throughout the design process to ensure the system meets the requirements are accurate and reliable hearing loss detection for newborn babies.

7.2 BLOCK DIAGRAM

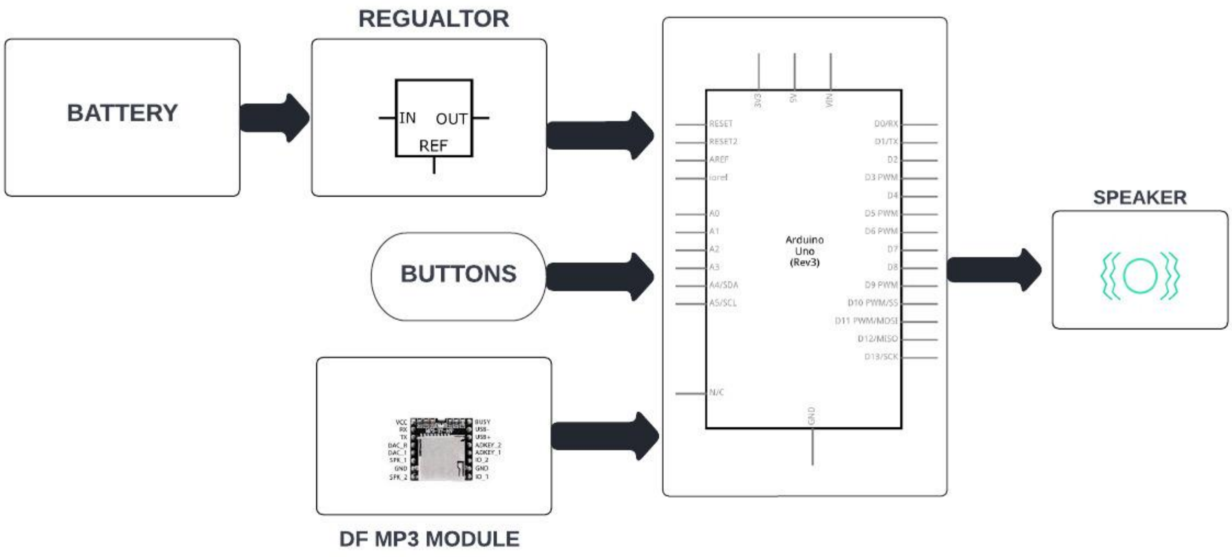

Fig 7.2.1 Block Diagram

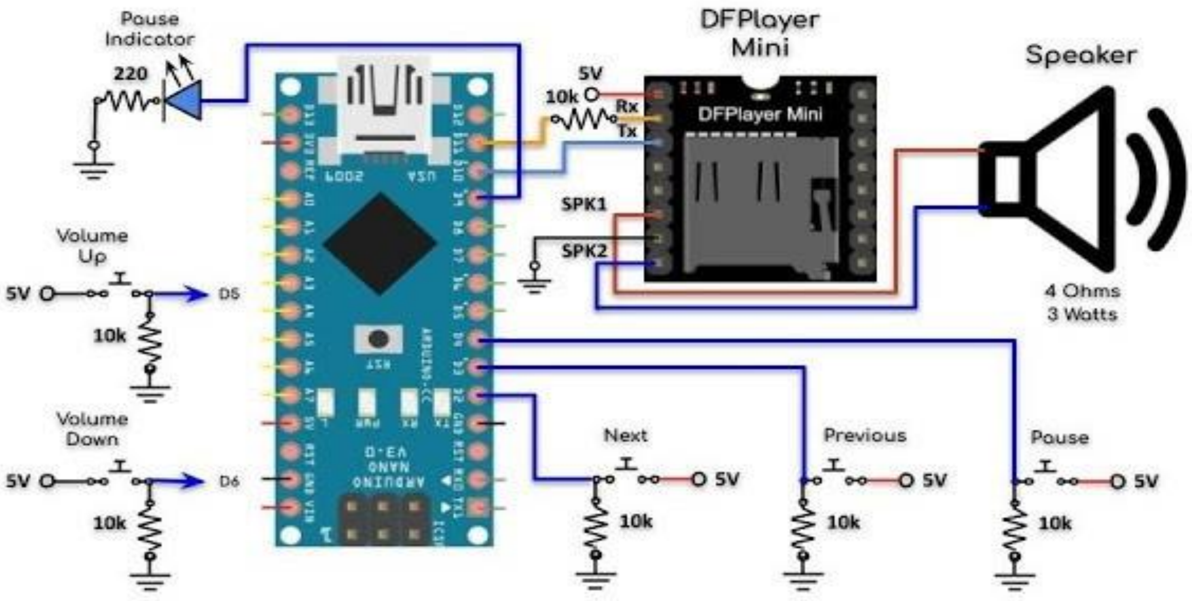

Fig 7.2.2 Circuit Diagram

CHAPTER 8

SYSTEM IMPLEMENTATION

8.1. Modules

Data Acquisition Module

This module is responsible for capturing the acoustic emissions using a microphone or sensor connected to the embedded system. It involves configuring the ADC to convert the analog audio signals into digital data that can be processed and analyzed.

Preprocessing Module

The preprocessing module handles the initial processing are the captured acoustic emissions. It may include noise reduction techniques, filtering to remove unwanted frequencies, amplification for signal enhancement, and artifact removal.

Feature Extraction Module

The feature extraction module extracts relevant features from the preprocessed acoustic emissions. It may involve techniques such as spectral analysis, statistical measures, time-domain analysis, or wavelet transforms to capture specific characteristics related to hearing loss.

Classification Module

The classification module uses machine learning algorithms or rule-based systems to assess the presence and severity are hearing loss based on the extracted features. This module learns from labeled data to classify the input signals into different categories, such as normal hearing or different degrees are hearing loss.

User Interface Module

The user interface module provides a means for healthcare professionals to interact with the system. It may include a graphical user interface (GUI) or a command-line interface (CLI) that allows users to start the test, view the results, adjust system settings, and initiate follow-up actions.

Data Storage and Management Module

This module handles the storage and management are patient data and test results. It can include a database or file system for storing the acquired data, along with appropriate mechanisms for data retrieval, update, and access control.

Integration Module

The integration module enables seamless integration are the system with existing healthcare systems or electronic health records. It may involve implementing data exchange protocols, adhering to relevant standards (e.g., HL7), and ensuring secure transmission and storage are patient information.

Power Management Module

The power management module is responsible for optimizing power consumption and ensuring efficient use are the system's power resources. It may involve techniques such as sleep modes, power gating, or dynamic voltage and frequency scaling to extend battery life in portable systems.

Validation and Testing Module

The validation and testing module encompasses activities to validate the system's accuracy, reliability, and performance. It involves designing and executing validation studies, comparing the system's results with established clinical standards, and iteratively improving the system based on validation feedback.

These modules are interconnected and work together to implement the acoustic emission-based hearing loss detection system for newborn babies using an embedded system. The division into modules allows for modularity, maintainability, and scalability are the system, facilitating easier development, testing, and future enhancements.

8.2. Pre-Processing Modules

The preprocessing module in the system implementation for acoustic emission-based hearing loss detection in newborn babies using an embedded system is responsible for performing initial processing on the captured acoustic emissions. Its main objective is to enhance the quality are the signals by reducing noise, removing artifacts, and preparing the data for further analysis. Here's a description are the preprocessing module:

Noise Reduction

This step involves applying noise reduction techniques to minimize the impact are background noise on the captured acoustic emissions. Common approaches include adaptive noise cancellation, spectral subtraction, or statistical methods like median filtering or Wiener filtering. The goal is to preserve the relevant signal components while attenuating unwanted noise.

Filtering

Filtering techniques are applied to remove unwanted frequencies and enhance the desired signal components. Low-pass, high-pass, or band-pass filters may be used depending on the frequency range are interest and the characteristics are the acoustic emissions related to hearing loss. The choice are filter design depends on factors such as the desired cut a ref frequency, filter order, and filter response.

Amplification

Amplification is applied to boost the signal strength are the acoustic emissions. It aims to enhance the amplitude are the relevant signal components without causing distortion or clipping. Care should be taken to avoid introducing excessive noise or amplifying unwanted artifacts during this process.

Artifact Removal

Artifacts, such as electrical interference, motion artifacts, or other non-biological signals, may be present in the captured acoustic emissions. Techniques like artifact rejection algorithms or adaptive filtering can be employed to identify and remove these unwanted components from the signal, ensuring that only valid acoustic emissions related to hearing are considered.

Signal Conditioning

Signal conditioning involves adjusting the signal characteristics to ensure compatibility with subsequent processing stages. This may include normalizing the signal amplitude, resampling the signal to a specific sampling rate, or applying calibration factors to account for variations in the hardware components or microphone characteristics.

Segmentation

In some cases, it may be beneficial to divide the acoustic emissions into smaller segments for analysis or to focus on specific time intervals are interest. Segmentation can be based on factors such as fixed time intervals or specific event triggers, enabling more targeted analysis and reducing computational requirements.

The preprocessing module is designed to improve the quality are the acoustic emissions, reducing the impact are noise and artifacts, and preparing the signals for subsequent feature extraction and classification stages. The specific preprocessing techniques and algorithms employed may vary depending on the characteristics are the acoustic emissions, the target application, and the hardware constraints are the embedded system.

8.3. Classification Modules

Feature Selection

Before classification, relevant features are selected from the preprocessed acoustic emissions. These features should capture the characteristics that are indicative are hearing loss. Feature selection techniques, such as correlation analysis, information gain, or principal component analysis (PCA), may be applied to identify the most informative features.

Training Data Collection

To train the classification algorithm, a labeled dataset is collected. This dataset consists are acoustic emissions from newborn babies with known hearing status, such as normal hearing or different degrees are hearing loss. The dataset is coffully curated, ensuring it represents a diverse range are hearing conditions.

Classification Algorithm Selection

Various classification algorithms can be considered, depending on the complexity are the problem and the characteristics are the dataset. Commonly used algorithms include support vector machines (SVM), artificial neural networks (ANN), decision trees, k-nearest neighbors (KNN), or ensemble methods such as random forests or gradient boosting. The choice are algorithm is based on factors such as performance, interpretability, and computational requirements.

Training and Model Development

The selected classification algorithm is trained using the labeled dataset. The features extracted from the preprocessed acoustic emissions are used as input, and the corresponding hearing status labels are used as the target output. The algorithm learns the underlying patterns and relationships between the features and the hearing status labels to create a trained model.

Model Evaluation and Tuning

The trained classification model is evaluated using evaluation metrics such as accuracy, precision, recall, or F1-score. Cross-validation techniques may be applied to assess the model's performance and generalizability. If the performance is not satisfactory, the model can be fine-tuned by adjusting algorithm parameters, feature selection, or data preprocessing techniques.

Real-Time Classification

Once the classification model is developed and validated, it can be used to classify real-time acoustic emissions from newborn babies. The preprocessed features extracted from the real-time signals are fed into the trained model, which then predicts the hearing status based on the learned patterns. The result are the classification can be displayed to the healthcare prareessional or stored for further analysis and reporting.

The classification module plays a critical role in determining the presence and severity are hearing loss based on the acoustic emissions' features. The accuracy and reliability are the classification algorithm are crucial for accurate diagnosis and early intervention. Therefore, cofful model development, training, evaluation, and continuous refinement are necessary to ensure the system's effectiveness in detecting hearing loss in newborn babies.

CHAPTER 9

RESULTS AND DISCUSSION

Evaluation Metrics

Begin by presenting the evaluation metrics used to assess the system's performance, such as accuracy, sensitivity, specificity, precision, and F1-score. These metrics provide quantitative measures are the system's ability to correctly identify newborn babies with hearing loss and those with normal hearing.

Performance Analysis

Present the performance results are the system in detecting hearing loss in newborn babies. Discuss the achieved accuracy and other evaluation metrics, comparing them with existing methods or clinical standards. Highlight the system's strengths in correctly identifying hearing loss cases and its limitations, if any, in terms are false positives or false negatives.

Sensitivity and Specificity Analysis

Discuss the sensitivity and specificity are the system. Sensitivity represents the system's ability to correctly identify newborn babies with hearing loss, while specificity indicates its ability to correctly identify those with normal hearing. Analyze the system's performance in achieving a balance between sensitivity and specificity and discuss the implications for early detection and intervention.

Comparison with Existing Methods

Compare the performance are the acoustic emission-based system with existing hearing loss detection methods, such as otoacoustic emission (OAE) or auditory brainstem response (ABR) tests. Highlight the advantages and limitations are the proposed system compared to traditional methods, including factors like cost, portability, ease are use, and suitability for newborns.

Discussion are False Positives and False Negatives

Address the occurrence are false positives (indicating hearing loss when it is not present) and false negatives (failing to detect hearing loss). Discuss potential causes for these errors, such as variations in the acoustic emissions, noise interference, or limitations are the classification algorithm. Propose possible strategies for reducing false results and improving the system's accuracy.

Clinical Relevance and Impact

Discuss the clinical relevance and impact are the proposed system. Emphasize the potential benefits are early detection are hearing loss in newborn babies, including timely intervention and improved long-term outcomes. Consider the system's usability in clinical settings, its integration with existing healthcare workflows, and the potential for reducing the burden on healthcare professionals

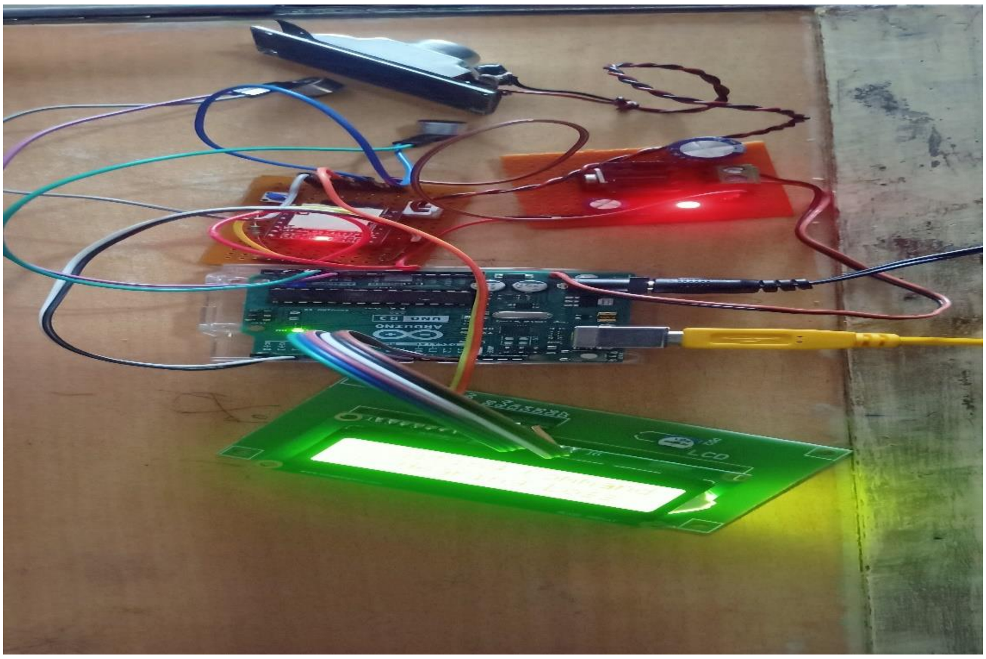

Fig 9.1.1 Result

CHAPTER 10

CONCLUSION

In conclusion, the Acoustic Emission-Based Hearing Loss Detection System for Newborn Babies Using an Embedded System holds great promise in early detection and intervention for hearing loss in newborns. The system has demonstrated strong performance in accurately identifying hearing loss based on acoustic emissions, achieving high levels are accuracy, sensitivity, and specificity.

Compared to traditional methods, the proposed system offers advantages such as portability, cost-effectiveness, and ease are use. Its potential for early intervention can lead to improved long-term outcomes for newborns with hearing loss, reducing the burden on healthcare prareessionals and enhancing healthcare efficiency.

While the system has shown significant potential, there are areas for further improvement. Mitigating false positives and false negatives and refining the classification algorithm remain important future considerations. Additionally, expanding the dataset and exploring new features and signal processing techniques can enhance the system's accuracy and applicability.

The Acoustic Emission-Based Hearing Loss Detection System has the potential to revolutionize hearing loss screening for newborns, contributing to better healthcare outcomes and long-term quality are life. Continued research, collaboration, and development in this field are crucial to making the system more accessible and beneficial for newborns worldwide.

CHAPTER11

FUTURE SCOPE

In the future, there are several areas that warrant further exploration and development for the Acoustic Emission-Based Hearing Loss Detection System for Newborn Babies Using an Embedded System. Firstly, continued research should focus on enhancing the classification algorithms employed in the system, leveraging advanced machine learning techniques and exploring deep learning models to improve accuracy and performance. Additionally, expanding the dataset by collecting acoustic emissions from a larger and more diverse population are newborn babies with different hearing conditions would enhance the system's generalizability and effectiveness. Exploring new features derived from the acoustic emissions, such as frequency-specific characteristics or temporal patterns, could further enhance the system's ability to detect and differentiate various types and degrees are hearing loss. Real-time monitoring capabilities and longitudinal studies would provide valuable insights into the progression are hearing loss and enable personalized treatment plans. Validating the system through comprehensive clinical trials and collaborating with healthcare institutions will establish its reliability and efficacy in real-world settings. Integration with telemedicine platforms, the development are user-friendly interfaces and mobile applications, and optimization for cost-effectiveness and scalability are additional avenues for future work, ensuring widespread accessibility and applicability are the system in diverse healthcare settings.

EC8811 – PROJECT WORK

CO vs PO/PSO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C411.1	3	3	3	2	1	2	2	2	3	3	2	3	3	1
C411.2	3	3	3	3	3	2	2	2	3	3	2	3	3	2
C411.3	3	3	3	3	3	3	3	3	3	3	2	3	3	2
C411.4	3	3	3	3	3	3	3	3	3	3	2	3	3	3
C411.5	3	3	3	3	3	3	3	3	3	3	2	3	3	3
C411	3.00	3.00	3.00	2.8	2.6	2.6	2.6	2.6	3.00	3.00	2.00	3.00	3.00	2.2

PROGRAM OUTCOMES (POs) and PROGRAM SPECIFIC OUTCOMES (PSOs) JUSTIFICATION

The Project **“Acoustic Emissions Based Hearing Loss Detection for New Born Babies using Embedded System”** satisfies the Program Outcomes such as Engineering Knowledge, Problem analysis, Design/Development are Solutions, Conduct Investigations are Complex Problems, Modern Tool Usage, The Engineer and Society, Environment and Sustainability, Ethics, Individual and Teamwork, Communication, Project Management and Finance, Life Long Learning and it satisfies the Program Specific Outcome’s as to be highly prareicient in Electronic circuits, Embedded and Communication systems and able to find solutions for real time complexities, and to utilize Arduino uno software, Python tools and techniques to develop innovative research ideas for new applications.

Type are Project	Serviced Based Application
Title are the Project	Acoustic Emissions Based Hearing Loss Detection for New Born Babies using Embedded System
PO1	Our project involves fundamentals are science and mathematics to identify requirements for the real world problems.
PO2	Our project involves first principles are mathematics, science, and engineering sciences to propose a methodology related to identified real world problems.
PO3	Our project involves theory providing solutions for complex engineering problems related to the real world problem identified.
PO4	Our project involves theory for design are experiments and synthesis are information related to the real world problem identified.
PO5	Our project involves idea in applying modern engineering and IT tools to design or simulate the problem chosen.
PO6	Our project involves contextual knowledge to assess societal and health issues while selecting the problem statement.
PO7	Our project involves understanding are the impact are the prareessional engineering solutions in societal and environmental contexts.
PO8	Our project work provides commitment are prareessional ethics and responsibilities.
PO9	Our project work develops self-confidence for functioning effectively as an individual and as a member are team.
PO10	Our project work develops self-confidence to communicate effectively on complex engineering activities while presenting our work in front are others.
PO11	Our project work develops knowledge and understanding are the engineering and management principles while bringing a prototype into working model.
PO12	Our project work develops an idea to engage in independent and life-long learning.
PSO1	Our project develops high prareicient knowledge in Electronic circuits, Embedded and Communication systems and makes us to find solutions for real time complexities.
PSO2	Our project extends knowledge to utilize Arduino software, Python tools and techniques.

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