IOT ENABLED LIVESTOCK HEALTH MONITORING DATA LOGGER

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Certification

This is to certify that **Muhammad Hassan Fazil (BEEP/F19/1353)**, **Muhammad Bilal Khan (BEEP/F19/1057)** and **Bilal Hussain (BEEP/F19/1316)** have successfully completed the final project **IOT Enabled Live Stock Health Monitoring Data Logger,** at the **Hamdard University**, to fulfill the partial requirement of the degree **Bachelors of Engineering in Electrical Engineering.**

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IOT Enabled Livestock Health Monitoring Data Logger

Sustainable Development Goals

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1	No Poverty	SDG 9	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals

Range of Complex Problem Solving			
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	
Range of Complex Problem Activities			
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	

Abstract

This project aims to create a comprehensive IoT-based platform for cattle monitoring in agriculture and livestock management. The system employs a variety of sensors, including motion sensors, pulse oximeters, heart-rate sensors, force sensors, and humidity/temperature sensors, strategically placed on cattle for early disease detection and real-time health monitoring. The gathered data is securely stored in a cloud-based database, ensuring easy accessibility for farmers and stakeholders. The IoT framework facilitates 24/7 monitoring capabilities. The compact monitoring device integrates these sensors, compiling health metrics into a cloud database for continuous monitoring. Keywords: IoT framework, cattle monitoring, sensors, agriculture, livestock management, real-time monitoring, disease detection, cloud-based database, 24/7 monitoring, health parameters, dairy animals, innovation, productivity, decision-making, efficiency.

Keywords: IoT framework, cattle monitoring, sensors, agriculture, livestock management, real-time monitoring, disease detection.

Undertaking

I certify that the project **IOT Enabled Livestock Health Monitoring Data Logger** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

Muhammad Hassan Fazil

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Chapter 1 Project Introduction

1.1 Introduction

This project is designed to present an automated, IoT-based compact monitoring system designed to monitor the vital health parameters of dairy cows. The system is composed of hardware devices, a cloud system, an end-user application, and innovative techniques of data measurements and analysis algorithms. This project proposes the design and development of a compact device for monitoring of vital health parameters of cow. Device will make use of sensor technology to monitor the health parameters such as body temperature, humidity, pulse rate, respiration rate, position, and rumination of the cow. The data will be transmitted to a central server where it will be stored in a database on cloud storage. This will make the data easily accessible to dairy cattle farmers and for industrial purpose with 24/7 monitoring. The device will also have an alert system which will send an alert to the farmer in case of any anomalies in the data. This system will help in early detection of any potential health issues in the cows which will help in timely interventions and prevention of major health problems. The compact size of the device will make it easy to install and use. This device will help in improving the overall health of the cows, reduce the mortality rate due to diseases and ensure better productivity of the livestock.

1.2 Statement of the problem

The problem at hand pertains to the pressing issue of animal welfare, specifically focusing on cows in Pakistan, exacerbated by the country's heavy reliance on physical labor in the agricultural sector and the absence of comprehensive animal care regulations. This problem highlights the necessity for technological interventions, particularly in the form of an Internet of Things (IoT) based cow health monitoring device, to address challenges related to illness management and the early detection of diseases. In Pakistan, where physical labor is widely used in many sectors, including agriculture, cows are essential as milk producers, providers of animal-based labor, and drivers of regional economies. However, the absence of clear animal care laws and a sufficient healthcare system makes these animals susceptible to diseases brought on by viruses, germs, and parasites. These illnesses have a significant detrimental impact on the health and wellbeing of the cows as well as important factors including milk production, animal growth, and reproduction. This strategy intends to tackle the problems brought on by restricted access to veterinary treatment and the damaging effects of undiagnosed illnesses on cow health, milk output, and regional economy. This technology aims to improve early disease detection, optimize resource allocation, and promote the general well-being of cows by utilizing real-time data collection, analysis, and remote monitoring. This encourages sustainable agricultural practices and protects the livelihoods of people who depend on bovine-related activities.

1.3 Goals/Aims & Objectives

- To design and develop real time health monitoring system for diary animals.
- To make a system that predicts health values.
- To design the system that measures the vital health parameters.
- To make an indigenous, convenient and cost-efficient system which will contribute to revive Pakistan's economy.

1.4 Motivation

In a rapidly evolving world where technological advancements touch every facet of our lives, it's imperative that we turn our attention to the very foundation of our sustenance - agriculture, livestock, and farming. The motivation driving our cattle monitoring project is deeply rooted in our unwavering commitment to revolutionize how we care for and manage our invaluable livestock.

1.5 Assumption and Dependencies

Likely other systems this system also have few limitations and challenges. The initial cost of purchasing and installation can be significant and may pose barrier to adoption for smaller farms with limited budget. The batteries require periodical maintenance which includes replacement, recharging to ensure the system works properly. The controllers used in this system esp32 can be used for data logging but handling and managing large amount of data can be difficult task. Data privacy and security can also be a challenging task as may contain sensitive information. It can create false alarm or inaccurate raw readings which may lead to unnecessary misconceptions. The system have limitations in terms of signal range and network coverage, it can affect its effectiveness in remote areas especially. The workforce or labor require training to fetch useful outcomes or predictions from the reading and it will be difficult if there is resistance in the adoption of a new technology. Harsh environmental conditions like thunderstorms, increase in humidity, extreme heat can impact the overall performance of the system. Compliance with local regulations and standards related to animal welfare and data privacy can be complex and may vary by region. Implementing this technology on farms with larger scale can lead to complexities and may require additional infrastructure and resources.

1.6 Methodology

1.6.1 Research Design:

In general, the system involves a controller some sensors supporting I2C communication protocol a power bank with an additional analog sensor, the controller basically programmed to give readings for the parameters i.e. Rumination, Heart Rate, Breathing Rate, Position/Movement, and Temperature. All the mentioned are the vital parameters for a cow's health.

In this case the equipment used is ESP32 Microcontroller for the interfacing of the sensors, MAX30102 for Heart rate and Oxygen Level Indication, MPU6050 for Movement and Temperature, FSR402 pressure sensor for Rumination along with power bank of 10,000 mAh capacity. The following shows the conceptual block diagram and schematics of the system.

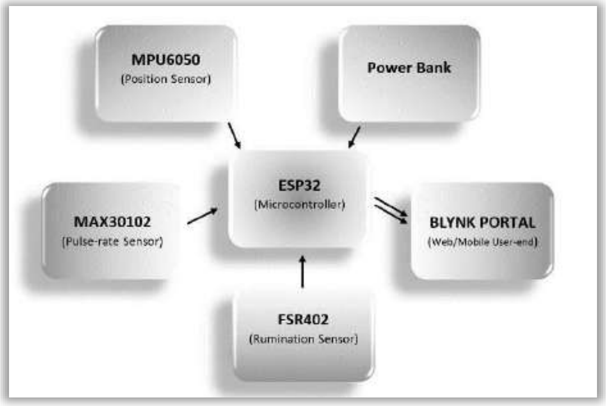


Figure 3.10

1.7 Report Overview

The project's overarching goal is to design and develop a real-time health monitoring system for dairy animals, emphasizing the prediction and measurement of vital health parameters. Motivated by a commitment to revolutionize livestock care and contribute to Pakistan's economic revival, the IoT-enabled Livestock Health Monitoring Data logger represents a significant advancement in agriculture.

The device comprehensively monitors parameters such as rumination, heart rate, breathing rate, movement, and temperature, crucial for assessing a cow's health. Leveraging the ESP32 Microcontroller, MAX30102, MPU6050, and FSR402 pressure sensor, the system offers a cost-efficient and user-friendly solution accessible to a broad range of farmers.

Currently utilizing Google Spread-sheet for monitoring, the project envisions a dedicated web portal and a multifunctional application for comprehensive monitoring. The roadmap includes integrating direct connections to medical professionals, expanding sensor capabilities, and enhancing communication through Bluetooth and 4G-enabled SIM connections.

In conclusion, the Livestock Health Monitoring Data logger empowers farmers with real-time health data, promoting informed decision-making, improving animal welfare, enhancing agricultural productivity, and contributing to industry sustainability. The project signifies a transformative step towards a more sustainable and prosperous agricultural future.

Chapter 2 Literature Review

2.1 LITERATURE SURVEY

KEYWORDS: Agriculture 4.0, Smart farming, Precision livestock farming, Cow health monitoring
Problem Statement:

ANALYSIS: Due to the fact that cows are used to supply the world's demand for milk and meat, tracking and monitoring cows using current technologies is a subject of intense research. In this context, numerous solutions for effective management of dairy farms and live monitoring of cows' health-related indicators have been suggested in the literature. The Internet of things (IoT) is also playing its important role in collecting the real time data about multiple factors which have a serious effect on cow health. Early detection of disease is a crucial task in cow health monitoring.

2.1.1 IOT-BASED DISEASE DETECTION IN COWS FOR FMD AND MASTITIS

[1] In their study, Vyas et al. (2019) proposed an IoT-driven approach for the detection of Foot mouth Disease (FMD) and Mastitis in cows. The researchers recognized the significance of real-time data collection and analysis in identifying disease symptoms at an early stage, thereby preventing potential outbreaks and minimizing economic losses. The study involved the utilization of sensor nodes to collect real-time values of crucial cow health parameters such as temperature, motion, and rumination. The data collected from these sensor nodes were subsequently transmitted to the cloud for storage and analysis. By monitoring the variations in temperature, motion, and

Rumination patterns, the system aimed to identify potential cases of FMD and Mastitis. The authors argued that these variations could serve as indicators of the presence of these diseases, allowing for timely intervention and treatment. The implementation of machine-based analysis in the cloud played a pivotal role in disease detection. By processing the collected data, the system could identify patterns that were indicative of FMD and Mastitis. This automated analysis not only expedited the detection process but also alleviated the burden on farm personnel and veterinarians, who would otherwise need to manually examine each cow. The significance of this study extends beyond disease detection. It highlights the potential of IoT technology in revolutionizing disease management practices in the dairy industry. The real-time nature of data collection, coupled with cloud-based analysis, offers a proactive approach to cow health monitoring. Moreover, the system's reliance on sensor nodes underscores the feasibility of implementing cost-effective IoT solutions even in resource-constrained settings.

In conclusion, the study conducted by Vyas et al. (2019) exemplifies the transformative impact of IoT technology on disease detection and management in cows. By leveraging real-time data collection and cloud-based analysis, the system offers a promising solution to the challenges posed by diseases like FMD and Mastitis. This research paves the way for further exploration and implementation of IoT-based approaches in precision livestock farming, ultimately contributing to improved cow health, increased productivity, and sustainable dairy practices.

2.1.2 IOT-BASED COW HEALTH MONITORING SYSTEM

[2] Unold et al. (2020) presented a comprehensive IoT-based cow health monitoring system. This study addresses the need for a sophisticated solution that offers real-time insights into various health parameters of cows. The authors recognized that the early detection of health issues can have far-reaching implications for both animal welfare and farm productivity. The IoT-based system described in the study relies on a network of sensor nodes strategically placed on cows. These sensors collect a diverse range of data including temperature, motion, and even rumination patterns. By analyzing this data, the system aims to detect anomalies and deviations from normal behavior. An innovative aspect of this system is the incorporation of advanced analytics, which allow for the early detection of potential health problems. A key feature of this IoT solution is its ability to provide continuous monitoring. Traditional methods of cow health monitoring often involve manual observations that are time-consuming and susceptible to human error. The IoT-based approach, on the other hand, provides a real-time stream of data that can be accessed remotely. This enables farmers and veterinarians to intervene promptly in case of any detected abnormalities. Furthermore, Unold et al. (2020) highlight the scalability and adaptability of their IoT-based system. This is particularly relevant for large-scale dairy farms where individualized attention to each cow might be challenging. The system's ability to handle multiple data streams and provide actionable insights aligns well with the requirements of modern dairy farm management. The study also underscores the significance of data analysis

in the cloud. By centralizing data storage and analysis, the system minimizes the burden on individual farms while also facilitating more advanced analytics that can identify patterns and trends over time. This cloud-based approach transforms raw sensor data into actionable information, ultimately contributing to better decision-making. Monitoring systems in modern dairy farming. By combining sensor data, real-time monitoring, advanced In conclusion, the research conducted by Unold et al. (2020) showcases the potential of IoT-based cow health analytics, and cloud-based processing, and this approach offers a comprehensive solution to management. This study serves as an important contribution to the field, paving the way for further innovations in precision livestock farming.

2.1.3 WSN-BASED ELECTRONIC LIVESTOCK MONITORING FOR DAIRY CATTLE

[3] The integration of Wireless Sensor Networks (WSNs) with livestock management has emerged as a transformative technology in modern agriculture. This review delves into the study by Priya and Jayaram (2019), which focuses on the application of WSNs in monitoring dairy cattle and their physical parameters, contributing to improved farm management practices. Priya and Jayaram (2019) present a study that harnesses WSNs for real-time monitoring of dairy cattle and their physical well-being [3]. In the context of dairy farming, where the health and productivity of cattle are paramount, this study addresses the need for efficient and reliable monitoring systems. The research revolves around the deployment of WSNs consisting of sensor nodes placed strategically on the cattle. These sensor nodes continuously collect data related to various physical parameters, including body temperature, activity level, and other relevant metrics. The authors emphasize the significance of these parameters as they directly correlate with the overall health and well-being of the cattle. One of the noteworthy aspects of the study is the utilization of WSNs to enable continuous and remote monitoring. Traditionally, obtaining such data involved labor-intensive manual procedures. However, the WSN-based approach offers real-time data streams that can be accessed remotely by farmers and veterinarians. This not only reduces the need for constant physical presence but also facilitates prompt intervention in case of any detected anomalies.

The study underscores the potential of data-driven insights. By collecting and analyzing data over time, the system can identify patterns and trends that might go unnoticed through manual observation alone. This provides a holistic view of cattle health and aids in the early detection of any deviations from normal behavior, which is crucial for preventive care. Furthermore, Priya and Jayaram (2019) highlight

The scalability of their approach. WSNs can be easily deployed on a large scale, making them suitable for both small and large dairy farms. This scalability is essential in meeting the diverse needs of the agricultural sector while maintaining efficiency.

In conclusion, the study by Priya and Jayaram (2019) contributes significantly to the field of precision livestock farming by leveraging WSNs for dairy cattle monitoring. The utilization of WSNs, continuous monitoring, data analytics, and remote accessibility collectively offer an innovative solution for enhancing cattle health and farm management. This research marks an important step forward in the application of IoT technology in agriculture.

2.1.4 REAL-TIME MONITORING OF DAIRY CATTLE'S CORE BODY TEMPERATURE USING IMPLANTABLE BIOSENSORS AND WEARABLE SCANNERS

[4] The integration of cutting-edge technologies in livestock management is reshaping the dairy farming landscape. This review focuses on the study by Chung et al. (2020), which explores the innovative use of implantable biosensors and wearable scanners to monitor the core body temperature of dairy cattle in real-time, thereby advancing precision farming practices. Chung et al. (2020) present a pioneering study that employs implantable biosensors and wearable scanners to monitor dairy cattle's core body temperature with unparalleled precision. Acknowledging the direct impact of body temperature on animal health and productivity, the study addresses the need for sophisticated monitoring techniques that offer real-time insights. Central to this research is the deployment of implantable biosensors within the cattle. These biosensors provide continuous, internal temperature readings, enabling researchers and farmers to monitor core body temperature accurately. The use of implantable technology highlights the commitment to non-invasive monitoring, minimizing discomfort and disruption to the cattle's

routine. In parallel, wearable scanners play a vital role in this ecosystem. These scanners are designed to interact with the implantable biosensors, wirelessly retrieving temperature data. This real-time data transmission enables prompt detection of any deviations from normal temperature ranges, which can be indicative of health issues or stress. The study underscores the potential of data synchronization and analysis. By integrating the data collected by wearable scanners with additional factors such as environmental conditions, researchers can gain deeper insights into cattle health. This holistic approach to data analysis enhances the accuracy of health assessments and contributes to the overall well-being of the cattle. Chung et al. (2020) emphasize the significance of real-time monitoring. The ability to

Access core body temperature data in real-time allows for immediate intervention in case of abnormal readings. This proactive approach to cattle health management can prevent potential health issues from escalating, leading to improved animal welfare and enhanced farm productivity. Furthermore, the study's findings highlight the practicality and scalability of the proposed system. The integration of implantable biosensors and wearable scanners showcases the feasibility of applying advanced technology even in dynamic farming environments. This scalability is crucial for catering to diverse farm sizes and operational requirements.

In conclusion, the study by Chung et al. (2020) epitomizes the potential of advanced technologies in precision dairy farming. By leveraging implantable biosensors and wearable scanners for real-time core body temperature monitoring, the research contributes to enhanced cattle health management

2.1.5 CLOUD IOT-BASED LIVESTOCK MONITORING AND IDENTIFICATION SYSTEM USING UID

[5] The integration of Cloud-based Internet of Things (IoT) technology has propelled livestock monitoring into a new era of precision and efficiency. This review centers on the study conducted by Saravanan and Saraniya (2018), which introduces a novel approach to livestock monitoring and identification through the utilization of Cloud IoT technology and Unique Identification (UID) mechanisms. Saravanan and Saraniya (2018) present a significant contribution to the field of precision livestock farming by leveraging Cloud IoT technology and UID for monitoring and identifying livestock. The study recognizes the challenges

associated with traditional livestock management practices and aims to provide a streamlined and automated solution that caters to modern agricultural demands. At the core of this research is the utilization of UID mechanisms. These unique identification codes enable the individual tagging of livestock, allowing for accurate and efficient tracking. This approach is instrumental in streamlining record-keeping, ensuring accurate data collection, and facilitating the management of individual animals within a larger herd. Central to the proposed system is the integration of Cloud IoT technology. The study capitalizes on the ubiquity of Cloud computing and the seamless connectivity enabled by IoT devices. By utilizing IoT-enabled devices and sensors, livestock-related data such as location, health parameters, and behavior can be continuously collected and transmitted to Cloud-based servers in real-time. The Cloud IoT-based approach revolutionizes the accessibility of data. Farmers, veterinarians, and other stakeholders can remotely access the collected data from their preferred devices. This real-time accessibility enhances decision-making, facilitates prompt intervention, and contributes to proactive

Livestock management strategies. Furthermore, Saravanan and Saraniya (2018) highlight the scalability of their system. The UID-based identification and Cloud IoT technology can be seamlessly extended to accommodate larger livestock populations. This scalability is pivotal in addressing the diverse needs of farms, irrespective of their size. The study also underscores the significance of data security and privacy in Cloud-based systems. As the system relies on Cloud storage, ensuring the confidentiality and integrity of livestock-related data becomes paramount. Implementing robust security measures becomes essential to protect sensitive information.

In conclusion, the study by Saravanan and Saraniya (2018) offers a novel approach to livestock monitoring and identification, leveraging Cloud IoT technology and UID mechanisms. This research aligns with the evolving demands of precision livestock farming by introducing automation, scalability, and real-time accessibility. By integrating UID and Cloud IoT, this approach offers a comprehensive solution to modern livestock management challenges and contributes to sustainable agricultural practices.

2.1.6 REAL-TIME VITAL SIGNS MONITORING SYSTEM FOR LIVESTOCK HEALTH ENHANCEMENT

[6] Advancements in technology are revolutionizing livestock management, and one key area of innovation is real-time vital signs monitoring. This review focuses on the study conducted by Reigones and Gaspar (2021), which introduces a real-time vital signs monitoring system aimed at advancing livestock health management practices. Reigones and Gaspar (2021) present a study that addresses the critical need for continuous health monitoring in livestock through the development of a real-time vital signs monitoring system. Recognizing that timely intervention is crucial for livestock health, this research seeks to provide farmers and veterinarians with a reliable tool for monitoring the well-being of animals. Central to this research is the creation of a system that can capture and transmit vital signs data in real-time. The authors emphasize the significance of parameters such as heart rate, respiratory rate, and temperature, as these indicators directly reflect the overall health status of the livestock. The system relies on sensor technologies to gather these vital signs data. These sensors, strategically placed on the animals, provide a continuous stream of information. The real-time nature of data collection ensures that any deviations from normal values are promptly detected, enabling timely intervention in case of health issues. One of the novel aspects of the study is the integration of wireless data transmission. The captured vital signs data are wirelessly transmitted to a central monitoring station, enabling remote access

And analysis. This real-time accessibility empowers farmers and veterinarians to make informed decisions based on the latest health information. Furthermore, Reigones and Gaspar (2021) highlight the potential of

Data analytics in enhancing livestock health management. By aggregating and analyzing data from multiple animals, trends and patterns can be identified. This proactive approach aids in disease prevention and supports evidence-based health management strategies. The study underscores the practicality and scalability of the proposed system. The utilization of sensor technology and wireless data transmission showcases the feasibility of implementing real-time vital signs monitoring on a larger scale, catering to the diverse needs of livestock operations.

In conclusion, the study by Reigones and Gaspar (2021) contributes to the advancement of livestock health management by introducing a real-time vital signs monitoring system. By harnessing sensor technology, wireless data transmission, and data analytics, the research offers a reliable tool for farmers and veterinarians to proactively manage livestock health. This innovation aligns well with the evolving demands of precision livestock farming and marks a significant step towards more efficient and sustainable livestock management practices.

2.1.7 IOT-BASED CATTLE HEALTH MONITORING SYSTEM AND CHALLENGES IN SMART AGRICULTURE

[7] The advent of Internet of Things (IoT) technology has ushered in transformative changes across various sectors, including agriculture. This review focuses on the study conducted by Thakur and Sheetlani (2021), which critically examines an IoT-based cattle health monitoring system and sheds light on the challenges encountered in the realm of smart agriculture. Thakur and Sheetlani (2021) present a study that delves into the intricate landscape of cattle health monitoring utilizing IoT technology. Recognizing the potential of IoT in revolutionizing livestock management, this research aims to offer insights into the workings of a cattle health monitoring system and the associated challenges that arise in the context of smart agriculture. The core of this study lies in the analysis of an IoT-based cattle health monitoring system. The authors emphasize the critical role that real-time data collection and transmission play in efficient livestock management. By deploying sensor nodes on cattle, various health parameters such as temperature, activity, and movement can be monitored continuously. The authors delve into the intricacies of data transmission and cloud storage within the IoT ecosystem. They discuss the significance of seamless connectivity and data accessibility for effective cattle health management. The study highlights how real-time data insights can empower farmers and veterinarians to make informed decisions promptly. In addition to expounding on the advantages, Thakur and Sheetlani (2021) delve into the challenges faced in the implementation of IoT in smart agriculture. The authors address concerns related to data security, privacy, and the reliability of IoT devices. They also explore the Potential issues of sensor calibration and data accuracy, underlining the importance of robust calibration methods to ensure the validity of collected data. Furthermore, the study underscores the broader implications of IoT in smart agriculture. The authors highlight the need for robust infrastructure, connectivity, and skilled human resources to maximize the potential benefits of IoT-based systems. They emphasize that

while the benefits are substantial, the challenges require careful consideration for successful integration.

In conclusion, the study by Thakur and Sheetlani (2021) offers valuable insights into IoT-based cattle health monitoring and the challenges it presents in the context of smart agriculture. By discussing the intricacies of data collection, transmission, and storage, as well as addressing challenges in implementation, this research provides a comprehensive view of the potential and complexities of adopting IoT technology in precision livestock farming. This contributes to the ongoing dialogue on the transformative role of IoT in shaping the future of agriculture.

2.1.8 SENSOR NETWORK FOR MONITORING LIVESTOCK BEHAVIOR

[8] In the realm of modern livestock management, the integration of advanced technologies, such as sensor networks, has emerged as a game-changer. This review centers on the study by Luo et al. (2020), which explores the application of sensor networks for monitoring livestock behavior, thereby enhancing precision farming practices. Luo et al. (2020) contribute to the evolution of livestock management by introducing a sensor network designed to monitor livestock behavior. The study acknowledges the critical role that behavior plays in assessing the health and well-being of livestock. This research seeks to provide an innovative solution that offers real-time insights into the behavior patterns of animals. Central to this study is the establishment of a sensor network that captures and analyzes livestock behavior data. The authors emphasize the significance of behavior as a reflection of animal health and stress levels. By utilizing sensor nodes strategically placed in livestock environments, the system gathers data related to movement, activity levels, and other behavior-related parameters. The study highlights the significance of real-time data collection and analysis. The continuous stream of behavior data enables the system to identify deviations from normal patterns promptly. This real-time accessibility to behavior insights empowers farmers and veterinarians to detect health issues, assess stress levels, and make informed decisions for intervention. One of the notable Aspects of the research is the potential for data-driven insights. The authors discuss the implementation of data analytics to identify behavioral trends and patterns over time. This proactive approach to livestock management aids in disease prevention, supports evidence-

based decision-making, and contributes to overall animal welfare. Furthermore, Luo et al. (2020) emphasize the potential for scalability and applicability. The utilization of sensor networks offers versatility in monitoring various livestock species and settings. This scalability is essential in catering to the diverse needs of different farming operations.

In conclusion, the study by Luo et al. (2020) underscores the potential of sensor networks in monitoring livestock behavior. By harnessing sensor technology, real-time data collection, and data analytics, this research introduces an innovative solution for enhancing livestock management practices. The ability to monitor behavior patterns offers a deeper understanding of animal health, stress levels, and overall well-being, contributing to the pursuit of sustainable and efficient livestock farming practices.

2.1.9 REAL TIME EXTENSIVE LIVESTOCK MONITORING USING LPWAN SMART WEARABLE AND INFRASTRUCTURE

[9] In the landscape of modern livestock management, the integration of Low Power Wide Area Network (LPWAN) technology has ushered in transformative capabilities for real-time monitoring. This review centers on the study conducted by Casas et al. (2021), which presents a novel approach to extensive livestock monitoring through the utilization of LPWAN smart wearable and infrastructure. Casas et al. (2021) contribute significantly to the field of precision livestock farming by introducing a real-time extensive livestock monitoring system empowered by LPWAN technology. Recognizing the need for efficient, scalable, and cost-effective solutions in livestock management, this research endeavors to harness the potential of LPWAN technology to monitor livestock remotely and comprehensively. Central to this research is the

implementation of LPWAN smart wearable for livestock. The authors emphasize the practicality and scalability of LPWAN technology in enabling long-range communication with minimal power consumption. By deploying smart wearable on livestock, various data points, including location, activity levels, and health parameters, can be continuously collected and transmitted in real-time. The study underscores the significance of infrastructure in facilitating LPWAN technology. The establishment of LPWAN networks enables seamless connectivity and communication between smart wearable and central monitoring stations. This infrastructure lays the foundation for remote data retrieval and actionable insights. The authors emphasize the real-time nature of data transmission and accessibility. LPWAN technology's long-range capabilities empower farmers and livestock managers to remotely access crucial data without the need for constant physical presence. This

Real-time accessibility enhances decision-making and enables prompt intervention when necessary. Furthermore, Casas et al. (2021) discuss the implications of data analysis and interpretation in extensive

Livestock monitoring. By aggregating data from multiple smart wearable, they highlight the potential for identifying trends, patterns, and abnormal behavior. This proactive approach aids in disease prevention, enhances animal welfare, and supports evidence-based management strategies.

In conclusion, the study by Casas et al. (2021) presents a pioneering approach to extensive livestock monitoring through the integration of LPWAN smart wearable and infrastructure. By harnessing LPWAN technology's long-range communication and low power consumption characteristics, this research contributes to the evolution of precision livestock farming. The real-time data collection, remote accessibility, and potential for data-driven insights collectively offer a comprehensive solution to modern livestock management challenges, marking a significant advancement in the pursuit of sustainable and efficient livestock farming practices

2.1.10 DEEP LEARNING-BASED CATTLE VOCAL CLASSIFICATION MODEL AND REAL-TIME LIVESTOCK MONITORING SYSTEM WITH NOISE FILTERING

[10] The integration of deep learning techniques in livestock management has opened new avenues for real-time monitoring and assessment. This review focuses on the study conducted by Jung et al. (2021), which introduces a novel approach to cattle vocal classification using deep learning, leading to the development of a real-time livestock monitoring system equipped with noise filtering. Jung et al. (2021) make a significant contribution to precision livestock farming by introducing a deep learning-based cattle vocal classification model and real-time monitoring system. They recognize that vocalizations are a valuable source of information in assessing cattle behavior and health. This research aims to harness the power of deep learning to classify cattle vocalizations and develop a system for continuous monitoring. At the core of this study is the creation of a deep learning-based classification model. The authors emphasize the potential of deep neural networks in identifying and classifying cattle vocalizations. By training the model on a diverse dataset of cattle sounds, it becomes capable of recognizing specific vocal patterns associated with different behaviors or conditions. The study underscores the importance of real-time monitoring enabled by the deep learning model. Once deployed, the system continuously records and analyzes cattle vocalizations in real-time. This immediate analysis allows for the prompt identification of specific vocal patterns, which may indicate stress, distress, or other behavioral

Cues. One of the remarkable aspects of this research is the incorporation of noise filtering techniques. The authors acknowledge that livestock environments can be noisy, and background noise can interfere with

Vocalization analysis. To address this challenge, they implement noise filtering algorithms to enhance the accuracy of vocal pattern recognition. Furthermore, Jung et al. (2021) discuss the implications of data-driven insights. By analyzing cattle vocalizations over time, the system can identify trends and patterns in behavior and health. This proactive approach supports early disease detection, stress assessment, and evidence-based decision-making in livestock management.

In conclusion, the study by Jung et al. (2021) introduces a pioneering approach to cattle vocal classification using deep learning, leading to the development of a real-time livestock monitoring system equipped with noise filtering capabilities. By harnessing the power of deep neural networks, this research contributes to the evolution of precision livestock farming. The real-time vocalization analysis, noise filtering, and potential for data-driven insights offer a comprehensive solution for modern livestock management, marking a significant step towards efficient and sustainable livestock farming practices.

2.1.11 SMART FARM MONITORING VIA THE BLYNK IOT PLATFORM: CASE STUDY: HUMIDITY MONITORING AND DATA RECORDING

[11] The Internet of Things is a network of smart sensors that can control and monitor things from anywhere over the Internet. This smart system can be used to improve the productivity and quality of modern farming. Therefore, the present research aimed to propose a smart farming application powered by the Internet of Things. In this research, the prototype of a smart capsule was developed to measure the humidity in paddy bags stored in various locations within a warehouse. This smart capsule used Node MCU ESP8266 microcontroller and the SHT21 humidity sensor to send data to the Blynk server over a Wi-Fi network. Arduino IDE was used to write a C++ code for the microcontroller. The Blynk mobile application was used to monitor and display real-time humidity data through the digital dashboard. The collected humidity data were further analyzed and used to develop a paddy storage system for the future. In addition, when the smart capsule lost contact with the Blynk server, a notification was sent to responsible persons in a timely manner. The research results indicated that the developed smart capsules and Blynk application can effectively work together and are deemed suitable for use in smart farming.

2.1.12 SMART AUTOMATED HOME APPLICATION USING IOT WITH BLYNK APP

[12] By the virtue of blooming automation industry and wireless connectivity, all the devices within the home can be connected. Today's World is moving to digitalization where everything is made easy and comfortable for people i.e. Young youth as well as senior citizen. Smart Automated House Application using IOT (Internet of Thing)is a system where basic house facility can be handled by device from any place such as ON and Off of Light, Fan, AC, Water pump, Gardening of Water. One can handle all this things with help of device NodeMCU ESP8266, Android Application, Internet Connection. This paper include functionality of node esp8266 are connected with either of above given house application like fan, light, water pump, gardening with help of coding and hosting online with web server. All the functionality is handled by Mobile App created in android application, from which house application are controlled with help of internet. This paper is clarifying that monitoring of circuit devices through wireless using Node MCU and controlling using App Blynk. According to requirement of need one can connect multiple device like sensors, appliance and many more till 8.

Chapter 3 Method, Experimental Setup & Procedure:

3.1 MATERIALS LIST:

Following is kit of materials which are used in hardware design.

- ESP32
- MAX30102
- MPU6050
- FSR402
- DS18B20
- Cow Halter
- Wires

For the software purpose following items are used.

- Arduino IDE
- Google Spreadsheet
- KiCAD 6.0

3.1.1.1 ESP32-WROOM-32 (MICROCONTROLLER)

The ESP32-WROOM-32 microcontroller module, a well-known member of the ESP32 series, has a deep and extensive feature set, making it a pillar of the IoT and embedded systems environment. It uses a dual-core Tensilica Xtensa LX6 microprocessor with a maximum clock speed of 240 MHz for its processing power. This CPU power enables smooth and effective wireless connection for a variety of IoT applications, in addition to integrated Wi-Fi and dual-mode Bluetooth (Classic and BLE). The ESP32-WROOM-32's sophisticated RF (Radio Frequency) capabilities are what really set it apart. Built-in antenna switches for signal routing, RF baluns for impedance matching, power amplifiers for signal strength, low-noise receive amplifiers for sensitivity, and filters for noise reduction are just a few of the crucial RF components that are included. The microcontroller can enhance wireless performance, increase signal range, and guarantee reliable connectivity thanks to an RF ensemble. A key component of the ESP32-WROOM-32's design is power management. It is perfect for battery-operated applications needing a longer battery life since it contains power-management modules that offer fine-grained control over energy consumption. The superior 40 nm process technology used by TSMC to create this microcontroller achieves the ideal combination between performance and energy economy. The ESP32-WROOM-32 is the progression of the well-known ESP8266 microcontroller and was created by the creative minds at Espressif Systems, a Shanghai-based business with an outstanding reputation for IoT development. Significant improvements in processing power, networking possibilities, and general versatility are brought about by this succession. Widespread user acceptance and a thriving, helpful developer community support the ESP32 platform. The ESP32-WROOM-32 has a wide range of uses, including wearable technology, smart appliances, robotics, and home and industrial automation. To design creative solutions for various IoT applications, developers can use the Arduino IDE, Espressif IDF (IoT Development Framework), or comparable development platforms. The ESP32-WROOM-32, with its impressive capabilities and ecosystem driven by the community, is essentially a personification of cutting-edge technology that is poised to influence the direction of embedded systems and the Internet of Things.

3.1.1.2 INTEGRATED DEVELOPMENT ENVIRONMENTAL OF ESP32

The Arduino Integrated Development Environment (IDE), recognized for its accessibility and broad community support, is a powerful and popular platform for programming and developing applications for ESP32 micro controllers. Installing the ESP32 board support package is the first step in starting to develop for the ESP32 using the Arduino IDE. This package mainly consists of a collection of necessary programs, libraries, and board definitions for interacting with ESP32-based gadgets. Installing requires going to the "Preferences" menu of the Arduino IDE, where you may add the URL for the ESP32 board package made available by Espressif Systems. After completing this, use the "Boards Manager" to access and install the ESP32 package. You can choose your individual ESP32 development board from the "Tools" menu after installing the ESP32 board package, which supports a variety of models and configurations. The IDE gives you the ability to create code that is compatible with Arduino and gives you access to the extensive ESP32 API and libraries, making it easier to work with hardware parts, sensors, and wireless connectivity. It's easy to upload code to the ESP32. Select the appropriate COM port on your computer, connect your ESP32 board using USB, and then click "Upload" in the Arduino IDE. The IDE's serial monitor, which shows important output and assists with debugging and real-time communication with the ESP32. The vast library selection of the Arduino ecosystem is one of its assets. Libraries are easily accessible for a wide range of sensors, communication protocols, and capabilities, greatly decreasing the time and effort required for development. Additionally, the Arduino community is renowned for its strong support, including thorough documentation, tutorials, and forums where developers may exchange information. It's crucial to remember that while the Arduino IDE provides a user-friendly and accessible starting point into ESP32 development, more experienced developers may want to consider PlatformIO or the Espressif IoT Development Framework (ESP-IDF). These choices offer more customization and flexibility, but they could necessitate a deeper comprehension of the underlying technology and software. The selection of an IDE ultimately depends on the requirements of the project in question and the developer's expertise with the development environment, with the Arduino IDE standing out as an excellent starting point for ESP32 enthusiasts of all skill levels.

3.1.1.3 DRIVE CIRCUIT

The ESP32, a flexible microcontroller module well-known for its IoT features, is frequently used for GPIO pin-based external device interface. One must first understand the GPIO pin arrangement and operations in order to fully utilize the capabilities of this microcontroller. When integrating external devices like sensors or motors, the power supply compatibility and connection setup must be carefully considered, frequently requiring the addition of resistors or transistors. Writing code for the ESP32 in languages like C/C++ or Micro Python enables the manipulation of GPIO pins through operations like setting them as HIGH or LOW, watching their status, and creating custom logic to control external devices based on sensor input or particular circumstances. The dynamic pairing of hardware and software enables programmers to produce creative and adaptable.

- **MICROCONTROLLER:** ESP32-WROOM-32 is built around the ESP32 dual-core microcontroller chip, which features a 32-bit Tensilica Xtensa LX6 CPU.
- **WI-FI**: The module supports 2.4 GHz Wi-Fi connectivity and can be used for both station (client) and access point (AP) modes.
- **BLUETOOTH**: It also includes Bluetooth Low Energy (BLE) capabilities for wireless communication.
- **OPERATING CURRENT:** The operating current can vary depending on the power mode and the specific application, but it typically ranges from around 80 mA to 260 mA during active Wi-Fi and Bluetooth communication.
- **DEEP SLEEP CURRENT:** In deep sleep mode, the ESP32-WROOM-32 can consume as little as a few microamperes (μA). The actual current consumption depends on the sleep mode configuration.
- **SUPPLY VOLTAGE**: The module typically operates from a supply voltage of 3.3V. It is important to note that supplying voltage above 3.6V can damage the module.
- **IO VOLTAGE**: The ESP32-WROOM-32 supports both 3.3V and 5V tolerant I/O pins, which means it can interface with 5V devices without the need for level shifting.

3.1.1.4 PIN CONFIGURATION

Figure 3.1: ESP32

3.1.2 MAX 30102 PULSE SENSOR (HEART-BEAT SENSOR).

The module features the MAX30102 – a modern (the successor to the MAX30100), integrated pulse oximeter and heart rate sensor IC, from Analog Devices. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry (SpO2) and heart rate (HR) signals. Behind the window on one side, the MAX30102 has two LEDs – a RED and an IR LED. On the other side is a very sensitive photodetector. The idea is that you shine a single LED at a time, detecting the amount of light shining back at the detector, and, based on the signature, you can measure blood oxygen level and heart rate.

3.1.2.1 DRIVE CIRCUIT

The MAX30102 is a highly integrated pulse oximeter and heart-rate sensor module, and it requires a specific drive circuit for proper operation. The drive circuit ensures that the sensor receives power, communicates with a microcontroller or other control system, and processes the optical signals generated by the sensor to measure oxygen saturation and heart rate. Here's a basic overview of the drive circuit for the MAX30102:

- Power Supply: Provide a stable power supply voltage (typically 3.3V or 5V) to the MAX30102 module. The power supply should be capable of delivering sufficient current to meet the module's requirements.
- I2C Communication: The MAX30102 communicates with a microcontroller or host system using the I2C (Inter-Integrated Circuit) protocol. Connect the SDA (serial data) and SCL (serial clock) pins of the MAX30102 to the corresponding pins on your microcontroller.
- Interrupt Output: The MAX30102 can generate interrupt signals to alert the microcontroller when new data is available. Connect the INT (interrupt) pin to an interrupt-capable GPIO pin on the microcontroller.
- LED Drive Current: The MAX30102 uses LEDs to emit light into the skin and measures the reflected light to calculate oxygen saturation and heart rate. You may need to adjust the LED drive current to achieve the desired intensity. This can be done through register settings.
- Signal Processing: The MAX30102 performs signal processing on the received optical signals to extract heart rate and oxygen saturation data. This processing is typically handled by the built-in digital signal processing (DSP) circuitry of the MAX30102.
- Data Output: The MAX30102 provides heart rate and oxygen saturation data to the microcontroller through the I2C interface. The microcontroller can read and process this data as needed for display or further analysis.
- Grounding and Decoupling: Proper grounding and decoupling capacitors should be used to minimize noise and ensure the stability of the sensor module.
- Data Logging or Display: Once the microcontroller receives and processes data from the MAX30102, it can be logged, displayed on a screen, or transmitted to another device for further analysis.

Please note that the specific drive circuit design may vary depending on the application and the microcontroller or platform you are using. It's essential to refer to the MAX30102 datasheet and application notes provided by the manufacturer for detailed guidance on connecting and configuring the sensor module in your particular setup.

3.1.2.2 ENVIRONMENTAL IMPACT

Assessing the environmental impact of a specific electronic component like the MAX30102 involves considering various factors throughout its life cycle. Here are some considerations related to the environmental impact of the MAX30102:

- Energy Consumption: The manufacturing process of the MAX30102 and its components typically involves significant energy consumption, including processes like wafer fabrication, assembly, and testing. The environmental impact depends on the energy sources used.
- Resource Extraction**: The production of semiconductors and electronic components relies on the extraction of raw materials, including silicon, metals, and plastics. This extraction can have environmental effects, such as habitat disruption and resource depletion.
- Transportation: The transportation of MAX30102 modules and related components to manufacturers and end-users involves energy use and emissions. The environmental impact depends on factors like transportation mode and distance.
- End-of-Life Considerations: Manufacturers often provide guidelines for the disposal of their products. Proper disposal, recycling, or refurbishing can help reduce the environmental impact of electronic components like the MAX30102.
- Medical Waste Considerations: In medical applications, the disposal of devices containing the MAX30102 should adhere to healthcare industry regulations for medical waste disposal to ensure safety and environmental responsibility.

It's important to note that the environmental impact of a specific component like the MAX30102 is just one part of the overall environmental impact of the devices and systems in which it is used. To assess the full environmental impact of a product or system, a life cycle assessment (LCA) is typically conducted, considering all stages from raw material extraction to disposal.

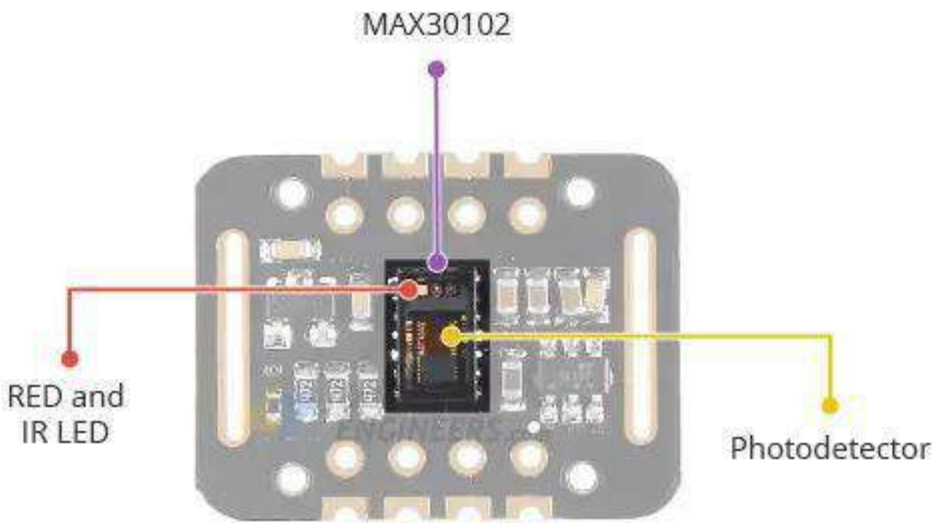


Figure 3.2: MAX30102

3.1.3 MPU-6050 ACCELEROMETER AND GYROSCOPE (POSITION SENSOR).

The MPU6050 IMU has both 3-Axis accelerometer and 3-Axis gyroscope integrated on a single chip. The gyroscope measures rotational velocity or rate of change of the angular position over time, along the X, Y and Z axis. It uses MEMS technology and the Coriolis Effect for measuring, but for more details on it you can check my particular How MEMS Sensors Work tutorial. The outputs of the gyroscope are in degrees per second, so in order to get the angular position we just need to integrate the angular velocity. The MPU-6050 is a multipurpose sensor module that combines a gyroscope and an accelerometer to create a potent and widely-used position sensor. The MEMS (Micro-Electro-Mechanical Systems) accelerometer and gyroscope in this little module work together to deliver accurate readings of motion and orientation in three dimensions. The MPU-6050's accelerometer records changes in velocity and detects linear acceleration along three axes (X, Y, and Z), which enables it to identify the sensor's position in relation to gravity. Applications like tilt detection, motion tracking, and gesture recognition all depend on this capacity. The gyroscope, on the other hand, calculates angular velocity and reports the speed at which the sensor rotates around its axes. This information is necessary to monitor the direction or The MPU-6050's capability to combine data from the accelerometer and gyroscope using sensor fusion methods like the complementing filter or Kalan filter is one of its standout characteristics. The constraints of each individual sensor are reduced and total positioning accuracy is improved as a result of the fusion process' production of more precise and stable orientation estimates. The MPU-6050 may interface through I2C (Inter-Integrated Circuit) or SPI (Serial Peripheral Interface) communication with a variety of microcontroller platforms and communication protocols. It is a well-liked option for projects involving motion tracking, navigation, and control systems due to its adaptability and precision. The MPU-6050's capability to give real-time, high-resolution motion and orientation data plays a critical role, whether it's utilized in quad copters to maintain stable flight or in wearable devices to detect human motions.

3.1.3.1 DRIVE CIRCUIT

In order to fully utilize the MPU-6050 accelerometer and gyroscope sensor module's capabilities for precise motion detection and orientation tracking, the drive circuit is crucial. Before designing this circuit, one must take the power requirements into account. Depending on the voltage selected, the MPU-6050 can function at 3.3V or 5V, hence a reliable power supply must be offered. If the sensor's voltage tolerance is greater than that of the microcontroller or development board, this can be accomplished using a voltage regulator. The chosen protocol for communication between the MPU-6050 and the microcontroller is I2C (Inter-Integrated Circuit). The microcontroller's equivalent pins must be linked to the sensor's SDA (Serial Data) and SCL (Serial Clock) pins. Include pull-up resistors, which are typically 4.7 k in value. The INT (Interrupt) pin must be connected to an interrupt-capable pin on the microcontroller in order to use the MPU-6050's interrupt feature, which is particularly useful for triggering operations upon certain sensor events like motion detection. The microcontroller must be configured to communicate with the MPU-6050 over the I2C bus after the hardware connections have been made. Particularly for well-known platforms like Arduino, there are a ton of libraries and example scripts readily available, which makes configuring and reading data much easier. Users can access accelerometer and gyroscope data by installing the MPU-6050 drive circuit and uploading the necessary code to the microcontroller. The sensor's orientation, velocity, and changes in position can then be precisely determined by using this data to perform sensor fusion calculations. The INT (Interrupt) pin must be connected to an interrupt-capable pin on the microcontroller in order to use the MPU-6050's interrupt feature, which is particularly useful for triggering operations upon certain sensor events like motion detection. The microcontroller must be configured to communicate with the MPU-6050 over the I2C bus after the hardware connections have been made. Particularly for well-known platforms like Arduino, there are a ton of libraries and example scripts readily available, which makes configuring and reading data much easier. Users can access accelerometer and gyroscope data by installing the MPU-6050 drive circuit and uploading the necessary code to the microcontroller. The sensor's orientation, velocity, and changes in position can then be precisely determined by using this data to perform sensor fusion calculations.

3.1.3.2 ENVIRONMENTAL IMPACT

The MPU-6050 is a widely used sensor module that combines an accelerometer and a gyroscope. In terms of its environmental impact, it's essential to consider both the manufacturing and disposal aspects of this electronic component.

- **MANUFACTURING IMPACT:**
  - **RESOURCE USAGE:** The manufacturing process of electronic components like the MPU-6050 involves the extraction and processing of raw materials, including metals like copper, silicon, and various other materials for packaging. This consumes energy and resources.
  - **ENERGY CONSUMPTION:** The manufacturing of semiconductor components like the MPU-6050 can be energy-intensive, especially in the fabrication of integrated circuits.
  - **CHEMICAL USAGE:** The semiconductor manufacturing process may involve the use of chemicals, some of which can have environmental impacts if not handled properly.
- **USAGE IMPACT:**
  - **POWER CONSUMPTION:** While in use, the MPU-6050 will consume power. The environmental impact of this power usage depends on the energy source. If it's powered by fossil fuels, it contributes to greenhouse gas emissions.

- **LONGEVITY:** The lifespan of the MPU-6050 and the devices it's integrated into can affect its overall environmental impact. Devices with a longer lifespan tend to have a lower per-year environmental impact.

- **DISPOSAL IMPACT:**
  - **ELECTRONIC WASTE (E-WASTE):** When the MPU-6050 or devices containing it reach the end of their useful life, they can contribute to the growing problem of e-waste. Proper disposal and recycling of electronic components are essential to mitigate this impact.
  - **HAZARDOUS MATERIALS:** Electronic components often contain small amounts of hazardous materials, such as lead in solder. Proper disposal and recycling are crucial to prevent the release of these materials into the environment.

To reduce the environmental impact of components like the MPU-6050, it's important to:

- **OPTIMIZE MANUFACTURING:** Manufacturers can work to reduce energy and resource consumption during production and adopt more sustainable manufacturing practices.
- **EFFICIENT DESIGN:** Device designers can optimize power usage and device longevity to reduce the overall impact during usage.
- **RECYCLING:** Encourage recycling and proper disposal practices to ensure that electronic components are disposed of in an environmentally responsible manner.
- **GREEN ENERGY:** Consider using devices like the MPU-6050 in applications powered by renewable energy sources to reduce the carbon footprint during usage.

Ultimately, the environmental impact of the MPU-6050, like any electronic component, is influenced by various factors, from manufacturing processes to usage patterns and disposal practices. Efforts to minimize this impact should be a consideration in both the development and use of such technologies.

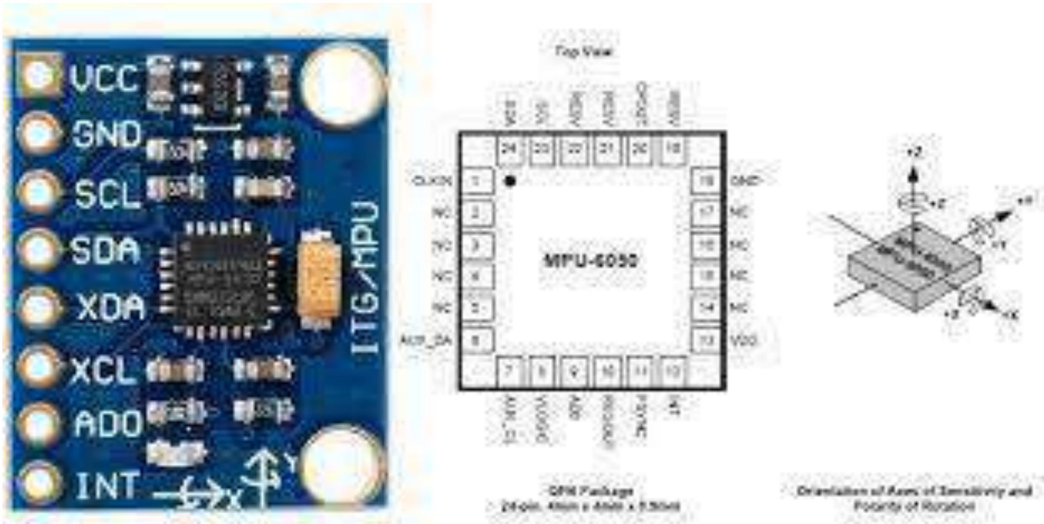


Figure 3.3: MPU6050

3.1.4 DS18B20 TEMPERATURE SENSOR

The DS18B20 is a popular and versatile digital temperature sensor known for its accuracy and ease of use. Manufactured by Maxim Integrated, this sensor is widely used in various applications, including industrial, automotive, and consumer electronics. One notable feature of the DS18B20 is its one-wire interface, allowing multiple sensors to be connected in series to a single microcontroller pin, simplifying wiring and reducing the number of required input pins.

The DS18B20 operates in a temperature range of -55°C to +125°C, with a resolution of 9 to 12 bits, providing precise temperature measurements. Its digital output eliminates the need for analog-to-digital conversion, streamlining integration with microcontrollers and digital systems. The sensor also features non-volatile memory that stores the unique 64-bit serial code, enabling identification and differentiation between multiple sensors on the same bus.

With its robust design, low power consumption, and high accuracy, the DS18B20 has become a go-to choice for temperature sensing in a wide range of applications, from climate monitoring to industrial automation and beyond. Its simplicity and reliability make it an excellent solution for projects requiring accurate and digital temperature measurements.

Figure 3.4 Temperature Sensor

3.1.5 FSR402 Force-Sensitive Resistor (FSR)

The Force-Sensitive Resistor (FSR) sensor designed to detect and measure the force or pressure applied to its surface. It is commonly used in various applications, including touch-sensitive interfaces, force-sensitive applications, and human-machine interaction. Here are some basic details about the FSR402 sensor, including its current and voltage ratings: A specialized sensor that is a member of the resistive-based force sensor family is the FSR402 Force-Sensitive Resistor (FSR). These sensors are made to recognize and quantify the pressure or force that has been applied at a particular point of contact. The FSR402 is a desirable component in numerous applications because of its small size, dependability, and simplicity of integration. The FSR402's operating system depends on modifications in electrical resistance in reaction to mechanical pressure. It is made up of a thin, pliable layer of semi-conductive polymer that demonstrates a reduction in resistance with increasing stress. The conductive particles within the polymer matrix of the sensor's active area move closer to one another when pressure is applied to it, which lowers resistance. This shift in resistance is directly proportional to the applied force, enabling precise force measurement.

3.1.5.1 DRIVE CIRCUIT:

In order to convert applied force into a quantifiable voltage signal, the FSR402 Force-Sensitive Resistor is efficiently interfaced with a voltage divider circuit. Variations in force result in matching changes in resistance by grounding the junction between the resistor and sensor and connecting one end of the FSR402 to the supply voltage (Vcc) and the other to a resistor. The resultant voltage is then read by a microcontroller or analog-to-digital converter (ADC) after being tapped from the junction point. Since the relationship between voltage readings and specific force levels can differ between different FSR402 sensors, calibration is essential. This configuration enables accurate and responsive force readings, making the FSR402 a versatile and affordable force or pressure sensor that finds applications in human-machine interfaces, robotics, medical devices, and beyond.

- **FUNCTIONALITY:** The FSR402 is a type of resistive sensor that changes its resistance in response to the applied force or pressure. It relies on the variation in electrical resistance to detect and measure force.
- **CONSTRUCTION:** FSR sensors consist of a conductive polymer material embedded between two conductive layers. When force is applied to the sensor, it causes a change in the resistance of the material, which can be measured and correlated with the applied force.
- **SENSITIVITY:** The sensitivity of an FSR402 sensor can vary based on its design and characteristics. It can be calibrated to provide a specific response to different levels of force or pressure.

3.1.5.2 5.2 ENVIRONMENTAL IMPACT:

The force-sensitive resistor sensor, or FSR402, has distinct environmental effects throughout its lifecycle and is a flexible component used in applications including touch detection and pressure sensing. In terms of production, the creation of FSR402 sensors requires the use of raw materials, such as substrates, conducting substances, and packaging materials. While the manufacturing process itself uses energy, especially when sensitive materials are created and conductive patterns are applied to substrates, the extraction and processing of these materials has the potential to deplete resources. The use of FSR402 sensors has a variety of environmental effects. Despite the fact that these sensors are very low-power gadgets, their overall effect depends on how much power the gadgets or systems they are incorporated into use. Additionally, the durability of gadgets containing FSR402 sensors plays a pivotal role; devices engineered for durability and extended use tend to exhibit a reduced per-year environmental footprint. When devices incorporating FSR402 sensors reach the end of their useful lives, they, like other electronic components, may contribute to the growing problem of electronic waste (e-waste). Recycling and disposal methods that are responsible are essential to reducing the environmental impact in this case. Furthermore, it is important to handle electronic components carefully during recycling and disposal to prevent the release of dangerous elements into the environment. A comprehensive approach is required to reduce the environmental impact of FSR402 sensors, including effective manufacturing procedures, the optimization of device design for durability, the promotion of recycling and responsible disposal, and investigation of sustainable materials for sensor construction. It's critical to understand that FSR402 sensors can have a negative overall environmental impact vary considerably depending on their specific application and usage scenario, emphasizing the need for a holistic approach to environmental sustainability throughout their lifecycle.

Figure 3.5: FSR402

S.No	Name Of Component	Component Nature	Operating Voltage	Current Rating	Competition	Priority Reason	Operating Range / Accuracy
1.	ESP32-Wroom-32	Micro-controller	5v	70-300mA	ESP8266	Multiple GPIOs	-
2.	MPU-6050	Sensor	$2.6v - 3.3v$	$3.9mA$	ADXL335	Accelerometer and gyroscope	$6\ DOF,$ $Higher\ accuracy$
3.	FSR-402	Sensor	$3.3v - 5v$	$\cong 0.1mA$	-	-	$Upto\ 10\ N$
4.	MAX30102	Sensor	$3.3v - 5v$	$4mA$	MAX30100	Easy to interface	$30\ to\ 180\ bpm$
5.	DS18B20	Sensor	$\cong 3.3v$	$1.5mA$	DHT22	Compatible under requirements	$-10℃\ to\ 85℃$

Table No. 1: Main components

3.1.6 COW HALTER:

A "cow halter" is a piece of gear used in livestock management and animal husbandry to lead, lead, and restrain cows. It is a form of headgear manufactured specifically for cows, usually consisting of straps, ropes, or other materials. The cow halter can be adjusted to fit around the cow's head and keep it in place. It frequently has a ring or other point of attachment where a lead line can be fastened, enabling the operator to direct the cow's movements.

1. *Control*: With the aid of the halter, handlers can direct the cow's motions in the direction they desire, such as into and out of a barn or down a certain path.

2. *Restraint*: A cow halter may be used in some circumstances to restrain a cow safely so that it can be groomed, had a veterinarian checkup, or had its hooves trimmed.

3. *Training*: Halter training, which helps young or untrained cows get used to handling and commands from humans, is a widespread practice.

4. *Identification*: To help identify specific cows in a herd, cow halters may have tags or labels.

Cow halters come in a variety of styles and materials, but they are normally created to be strong and cozy for the cow while giving the handler adequate control. For controlling cattle in a variety of agricultural contexts, cow halters are a crucial piece of equipment.

Figure 3.6: Cow Halters

(https://www.tackwholesale.com/cdn/shop/products/5Nylon_Cow_Halter_Lifestyle_Two_Cows_909050_700x.jpg?v=161981048)

3.1.7 JUMPER WIRE:

Jumper wires are essential components in electronics and electrical work. They consist of conductive wires typically made of copper or aluminum and are insulated to prevent short circuits. These wires often come with connectors at the ends, such as male/female header pins or alligator clips, making it easy to establish secure and temporary connections between various electronic components, like sensors, micro controllers, or circuit boards. Jumper wires are flexible, come in different lengths and colors, and are widely used in electronics prototyping and experimentation to create and modify electrical pathways for testing and development purposes.

Figure 3.7: Wire

(https://cityelectronics.pk/wp-content/uploads/2022/07/Jumper_Set3in1.jpg)

3.1.8 GOOGLE SPREADSHEET:

Google Sheets, a cloud-based spreadsheet application, plays a role in IoT systems by serving as a versatile platform for data storage, real-time monitoring, and integrates with IoT platforms through API gateway. With visualization tools, scripting capabilities and automation, it enables users to creates chart automate tasks and generate reports. The cloud-based nature supports easy sharing and collaboration, while export options enhance interoperability with other components of an IoT system. Overall, Google Sheets provides a user- friendly solution for managing, analyzing and visualizing data in IoT applications.

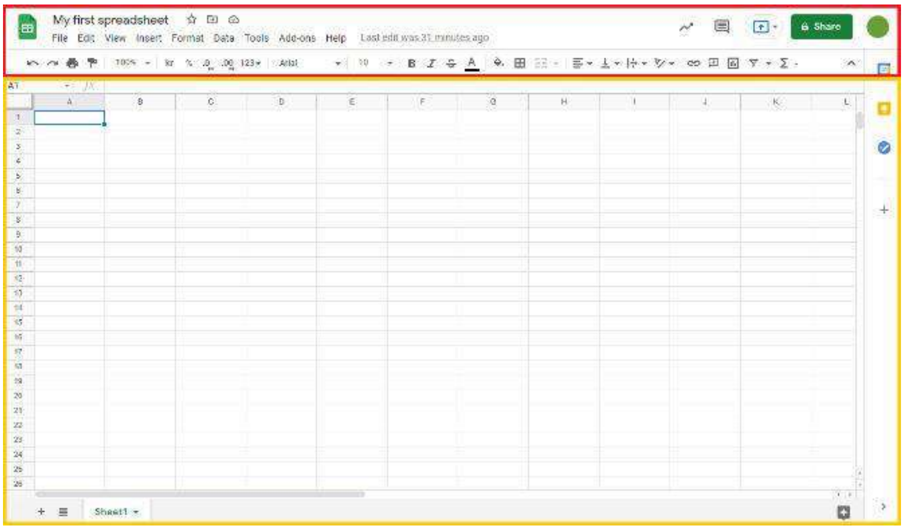


Figure 3.8: Google Spreadsheet

3.1.9 KiCAD:

KiCad is a free software suite for electronic design automation (EDA). It facilitates the design and simulation of electronic hardware. It features an integrated environment for schematic capture, PCB layout, manufacturing file viewing, ngspice-provided SPICE simulation, and engineering calculation. Tools exist within the package to create bill of materials, artwork, Gerber files, and 3D models of the PCB and its components.

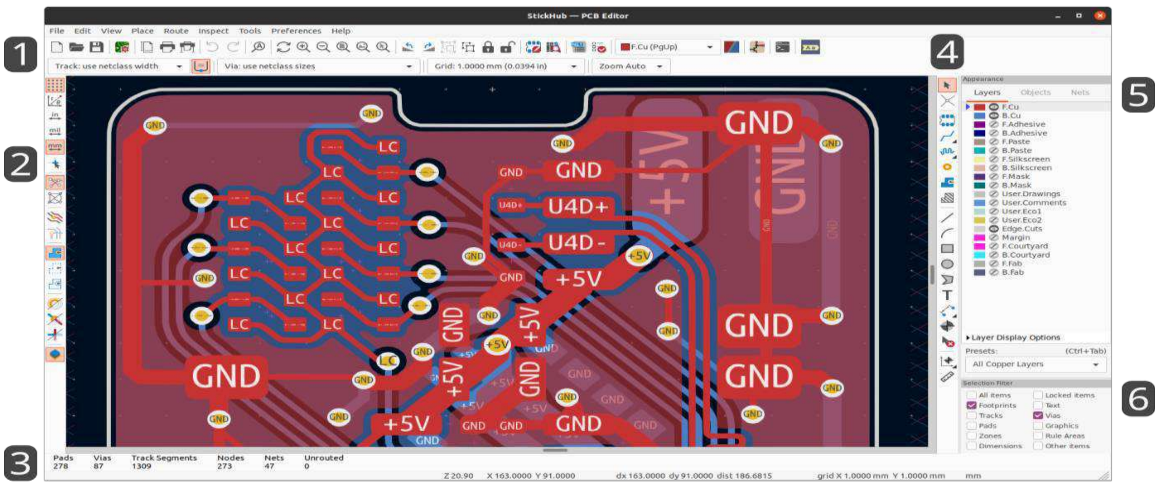


Figure 3.9: KiCAD-UI

(https://docs.kicad.org/master/en/pcbnew/images/pcbnew_user_interface.png)

3.2 METHODLOGY:

3.2.1 Research Design:

In general, the system involves a controller some sensors supporting I2C communication protocol a power bank with an additional analog sensor, the controller basically programmed to give readings for the parameters i.e. Rumination, Heart Rate, Breathing Rate, Position/Movement, and Temperature. All the mentioned are the vital parameters for a cow's health.

In this case the equipment used is ESP32 Microcontroller for the interfacing of the sensors, MAX30102 for Heart rate and Oxygen Level Indication, MPU6050 for Movement and Temperature, FSR402 pressure sensor for Rumination along with power bank of 10,000 mAh capacity. The following shows the conceptual block diagram and schematics of the system.

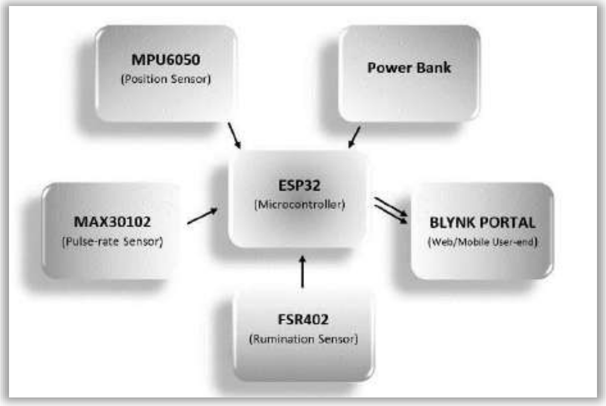


Figure 3.10: Block Diagram

3.2.2 Data Collection:

The controller used is a dual core processor which supports SPI, I2C, UART communication protocols with several general I/O pins. It has built-in Wi-Fi, BT and BLE functions that can be used to interface microcontroller to internet or other peripherals to display the output data. It has variants and is a successor of ESP8266 (Node-MCU). The variant used in this system is ESP32-WROOM-32D by ESPRESSIF systems.

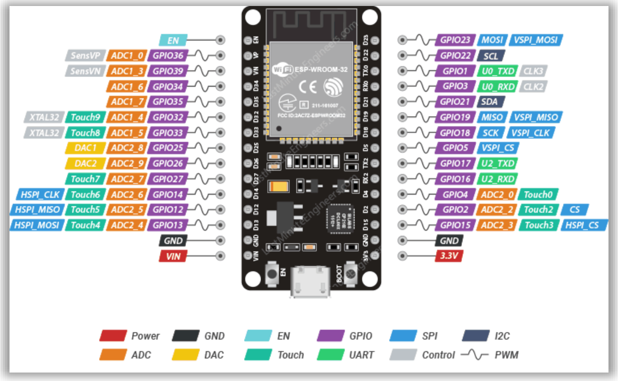


Figure 3.11: Controller

MAX30102 is I2C compatible sensor which can be easily interfaced with micro controllers like Arduino, ESP32, and STM32 to make a nearly accurate heart rate monitoring and oxygen level saturation device. It is used in this project for its benefits like nearly accurate readings and low power consumption of only 600μA and on stand-by mode it only consumes 0.7μA. The other sensors available in the market lack the benefits compared to MAX30102.

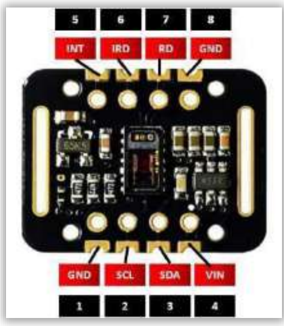


Figure 3.12: MAX30102

MPU6050 is a 6-axis Accelerometer and Gyroscope with compatibility of 9-axis motion reading upon the addition of magnetometer through auxiliary I2C ports. It has an additional on-chip temperature sensor and can easily interfaced with any microcontroller supporting I2C communication protocol. Other options were neglected due to low power consumption of 3.9mA of MPU6050.

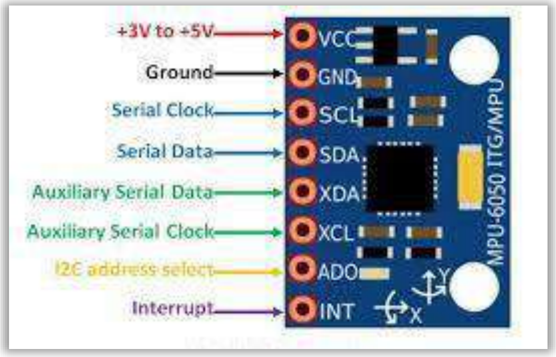


Figure 3.13: MPU6050

FSR402 is a 0.5in pressure sensor which decreases the ohmic value on the action of increased pressure. It is used in this project as alternate option of rumination sensors for two main reason i.e. it is indigenous and low cost option. It is a total engineering knowledge implementation because it is not used in any rumination sensors before.

Figure 3.14 FSR402

DS18B20 used in this project has a metal covering and used in various applications to measure ambient environment. In this project this is used to measure the neck temperature of the cow. The sensor can be seen in Figure 3.4.

3.3 HOW IT WORKS:

In this project the vital parameter for health condition of a cow are under concern. These parameters are temperature, heart rate, breathing, motion and rumination. For the temperature and motion purpose the sensor named MPU6050 is used which is a motion sensor which comes up with feature of accelerometer and gyroscope, with the help of these features the movement of the cow is being done. On addition to that this sensor also tells the temperature of a body now this feature help us to check the temperature of a cow. Now for the heart rate and breathing levels the sensor named max30102 is used which is specially used for heart rate and oxygen levels. As we already know that the breathing can either be done by mouth or nose so it is possible to place a sensor over there in order to get breathing level so instead of that oxygen level can be taken form the blood which can be detected by Max30102 easily then of there will be any hurdle in breathing then that will also affects the oxygen and that can be detected by this sensor. MAX30102 is positioned at the back of the ear of cow. At last for the rumination purpose the FSR402 is being used which is a force sensor. This sensor will work on count logic as when animal does the rumination then some force will applied to the jaws at that position this sensor is placed from there it can take value that will be generated by the pressure which will be exerting when an animal doing the process of rumination.

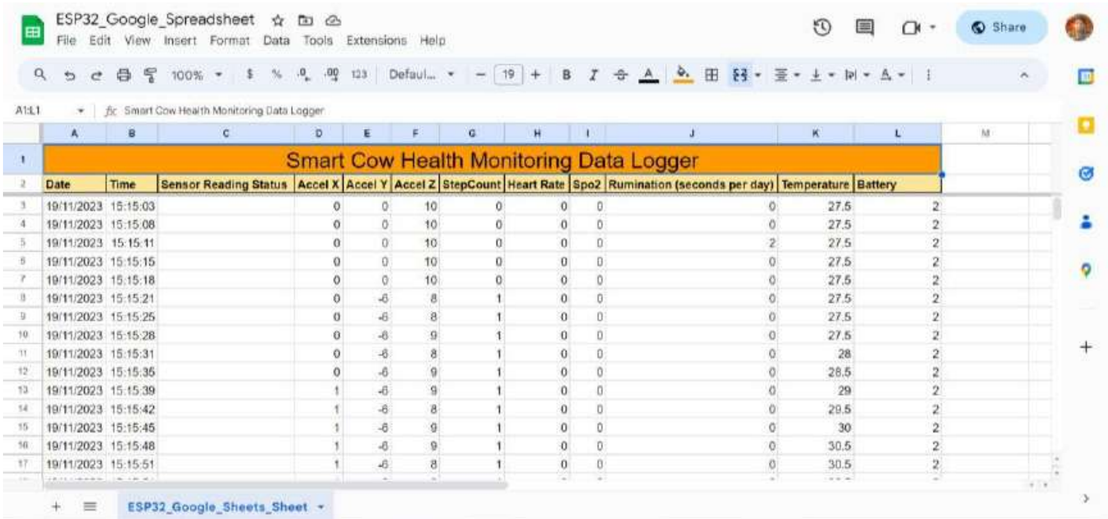
Figure 3.15: Data Logger

Chapter 4 Results & Discussion

In this chapter the results are concluded of the overall project and compared with literature previously mentioned. The results mentioned here are 90% to 95% accurate. The system was firstly tested on the routine basis human body and gives accuracy mentioned before.

4.1 Data Presentation:

The data will be logged into online Google spreadsheet and can be viewed as Figure 4.1. This raw data can be programmed to use google spreadsheet as a database and send the current and useful data to front-end web page.


ESP32_Google_Spreadsheet

Smart Cow Health Monitoring Data Logger

Date	Time	Sensor Reading Status	Accel X	Accel Y	Accel Z	StepCount	Heart Rate	Spo2	Rumination (seconds per day)	Temperature	Battery
19/11/2023	15:15:03		0	0	10	0	0	0	0	27.5	2
19/11/2023	15:15:08		0	0	10	0	0	0	0	27.5	2
19/11/2023	15:15:11		0	0	10	0	0	0	2	27.5	2
19/11/2023	15:15:15		0	0	10	0	0	0	0	27.5	2
19/11/2023	15:15:18		0	0	10	0	0	0	0	27.5	2
19/11/2023	15:15:21		0	-6	8	1	0	0	0	27.5	2
19/11/2023	15:15:25		0	-6	8	1	0	0	0	27.5	2
19/11/2023	15:15:28		0	-6	9	1	0	0	0	27.5	2
19/11/2023	15:15:31		0	-6	8	1	0	0	0	28	2
19/11/2023	15:15:35		0	-6	9	1	0	0	0	28.5	2
19/11/2023	15:15:39		1	-6	9	1	0	0	0	29	2
19/11/2023	15:15:42		1	-6	8	1	0	0	0	29.5	2
19/11/2023	15:15:45		1	-6	9	1	0	0	0	30	2
19/11/2023	15:15:48		1	-6	9	1	0	0	0	30.5	2
19/11/2023	15:15:51		1	-6	8	1	0	0	0	30.5	2

ESP32_Google_Sheets_Sheet

Figure 4.1 Data Representation

4.2 Analysis and Interpretation:

S.No.	Thermometer Reading	Temprature Sensor Reading	Difference	IF Difference < 0 then diff. x -1	Efficiency
1	27	27.5	0.5	0.5	99.98
2	38	36	-2	2	99.95
3	35	35.5	0.5	0.5	99.99
4	34.5	32	-2.5	2.5	99.93
Overall Efficiency					**99.96**

Table No. 2: Temperature Sensor Results

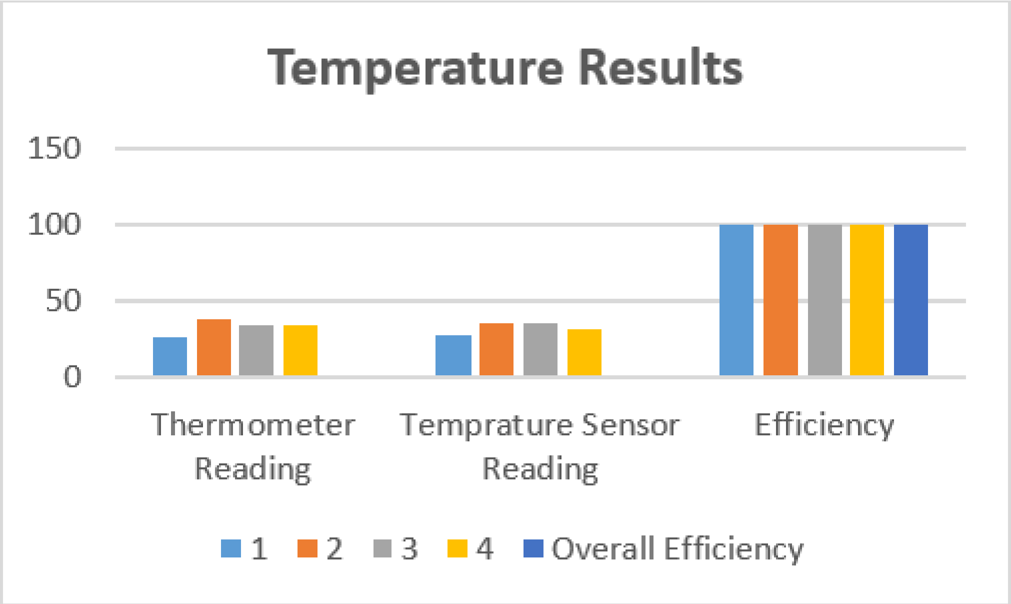


Chart 1: Temperature Sensor Results

S.No.	Steps Taken	Steps Showing	Difference	IF Difference < 0 then diff. x -1	Efficiency
1	10	8	-2	2	99.80
2	20	21	1	1	99.95
3	30	25	-5	5	99.83
4	40	40	0	0	100.00
Overall Efficiency (%)					**99.90**

Table No. 3: Motion Sensor Results

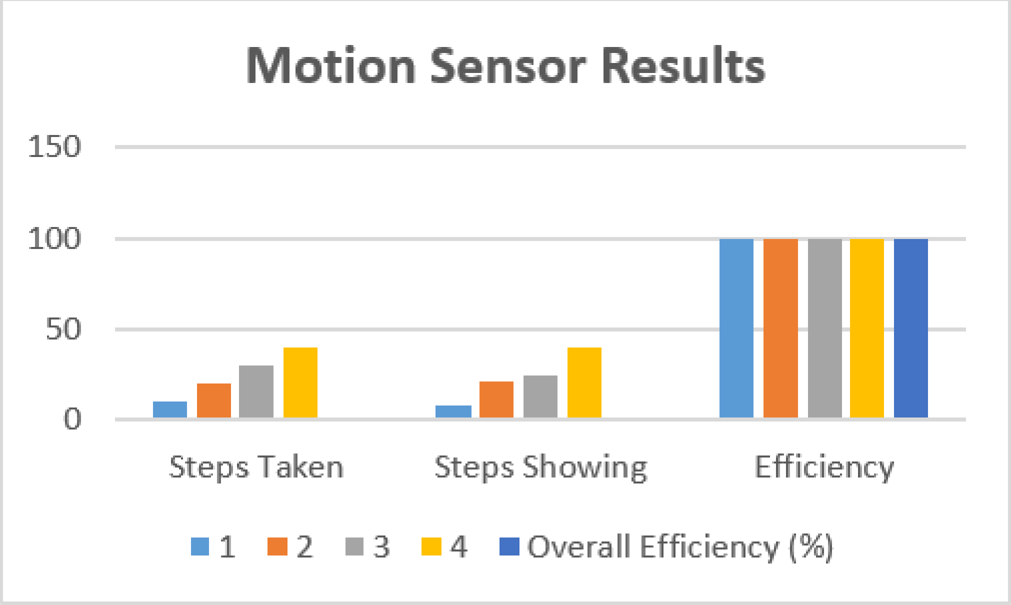


Chart 2: Motion Sensor Results

S.No.	FSR402	Presseing Interval (sec)	Difference	IF Difference < 0 then diff. x -1	Efficiency (%)
1	2	1	-1	1	50.00
2	3	3	0	0	100.00
3	9	10	1	1	90.00
4	12	11	-1	1	99.91
Overall Efficiency (%)					**8498%**

Table No. 4: Rumination Sensor Results

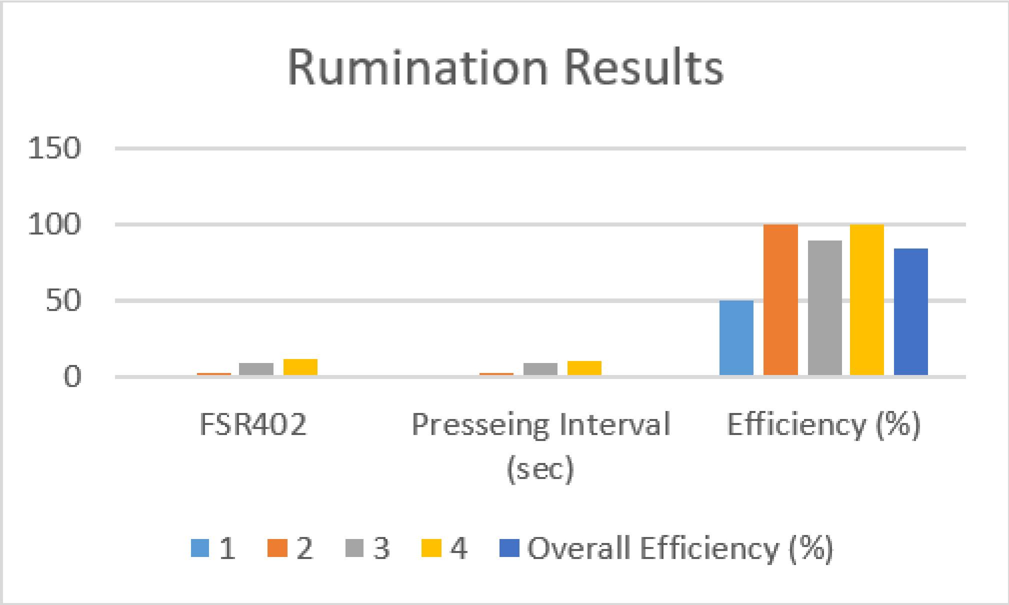


Chart 3: Rumination Sensor Results

S.No.	LH719 Smart Watch	MAX30100	State	Difference	IF Difference < 0 then diff. x -1	Efficiency (%)
1	74	75	Stationary	-1	1	99.99
2	106	102	Jogging	4	4	99.96
3	74	71	cool down	3	3	99.96
4	87	84	Exercise	3	3	99.97
Overall Efficiency compared to Smart Watch (%)						**99.97**

Table No. 5: Heart Rate Sensor Results

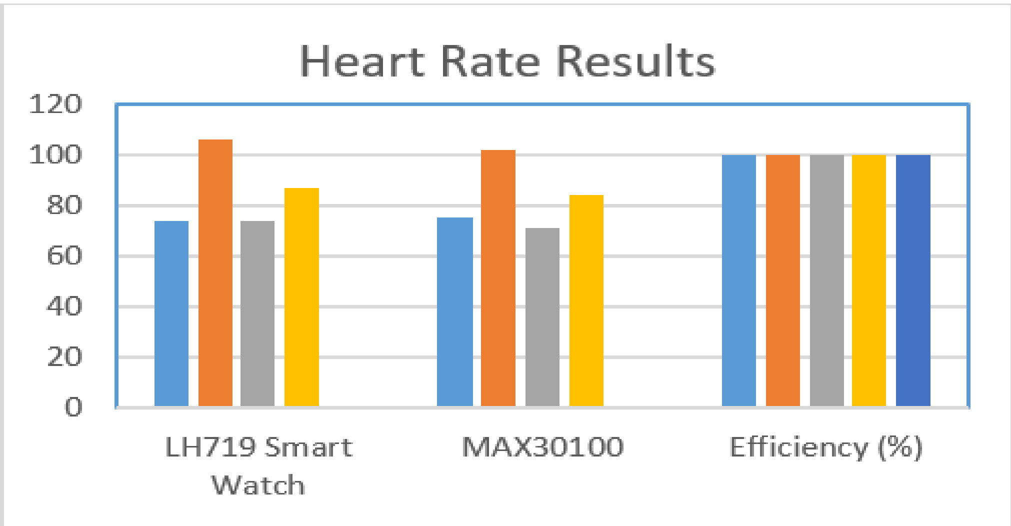


Chart 4: Heart Rate Sensor Results

The data shown here was a result of gathering useful information from the database and making it useful for research and anlytics. As mentioned in the limitations section as well the system seems to give raw or irrelevant data moreover online platforms with 4^{th} gen wifi speed takes minimum upto 4 seconds to receive the data which is the potential challenge and limitation to our project.

4.3 Implications and Applications:

This system is designed to be user friendly and to provide technological support to the main consumers i.e. farmers and cattle farm owners to study the behaviors of cow in different climatic, psychological or any other physical circumstances.

These iot based cow health monitoring systems provides the improved overall health status of cows as it can monitor the vital parameters i.e. movement, heart rate, rumination, temperature and breathing rate. The data obtained from the system can be used to analyze the early signs of illness or distress, the animal might be facing providing an improved animal welfare.

The data collected through this project can help farmers and veterinarians for anticipated research or solution to the distress of illness animal may face.

It can also increase the productivity as it provide the insights through the data collected on the iot portal. Into their reproduction cycles and allowing them for optimized breeding and milk production to meet the demand of meat and milk.

The data collected from the system can be used make useful decisions about herds to gain profit in a productive way.

It reduces the labor required for the herd management and allows to allocate the time in a useful and more productive patterns.

The data obtained from the system can be used for further research purposes and contributes to the betterment in livestock management and veterinary science.

Chapter 5 Summary & Future work

5.1 Summary:

The presented report details the development and implementation of an innovative real-time health monitoring system for dairy animals, with a focus on enhancing agricultural practices and contributing to the economic revitalization of Pakistan. The project's core objectives include designing a system capable of predicting and measuring vital health parameters in livestock. Leveraging an IoT framework, the resulting Livestock Health Monitoring Data logger represents a significant leap forward in agriculture, promising substantial benefits to farmers and global food security.

The system monitors essential parameters such as rumination, heart rate, breathing rate, movement, and temperature – all critical indicators of a cow's health. Utilizing advanced components like the ESP32 Microcontroller, MAX30102, MPU6050, and FSR402 pressure sensor, the design prioritizes cost-effectiveness and user-friendly integration, ensuring accessibility for a wide range of farmers.

Currently employing Google Spreadsheet for monitoring, the project envisions an ambitious roadmap for the future. Plans include the development of a dedicated web portal and a multifunctional application for comprehensive monitoring. This bespoke infrastructure aims to archive all collected data, featuring dual account classifications for master and user accounts. The project also anticipates integrating a unique feature – a direct connection to medical professionals, enabling prompt health assessments for livestock.

Looking ahead, the project aims to expand its sensor array and incorporate advanced programming logic to capture a broader range of vital health parameters. Communication capabilities are slated for enhancement, transitioning from Wi-Fi reliance to encompass Bluetooth and 4G-enabled SIM connections. This augmentation will significantly broaden the system's connectivity options, ensuring operational reliability in diverse agricultural settings.

In conclusion, the Livestock Health Monitoring Data logger not only empowers farmers with real-time health data but also aligns with Sustainable Development Goal 2 (Zero Hunger) by bolstering food security and livestock productivity. The project signifies a transformative step towards a more sustainable and prosperous agricultural future, where informed decision-making, improved animal welfare, and enhanced productivity contribute to the overall sustainability of the livestock industry.

5.2 Future Work:

Presently, our project leverages the Google Spread-sheet as a third-party solution for livestock health monitoring. In our forward-looking roadmap, we envisage the creation of a distinct web portal designed exclusively for comprehensive monitoring functionality. Concurrently, we aspire to develop a multifunctional application that ensures seamless access to system data, whether through mobile devices or computer interfaces. This bespoke monitoring infrastructure will be equipped with the capacity to archive all collected data and will offer dual account classifications: a master account and a user account.

Furthermore, our project's evolution includes the integration of an innovative feature—a direct connection to medical professionals. This will empower users to promptly summon a nearby healthcare provider for livestock health assessments.

Expanding the project's sensor array and implementing advanced programming logic is also on the horizon. This approach will enable us to capture an extended range of vital health parameters, responding to the evolving landscape of livestock management.

Moreover, our communication capabilities will undergo enhancement, transitioning from a current reliance on Wi-Fi and LED indicators on the livestock's belt to encompassing Bluetooth and 4G-enabled SIM connections. This augmentation will substantially broaden the system's connectivity options and operational reliability.

Chapter 6 Conclusion & Recommendation

6.1 Conclusion:

In conclusion, our IoT-enabled Livestock Health Monitoring Data logger represents a significant leap forward in agriculture, promising to benefit farmers, livestock, and global food security. Its adoption holds the potential to usher in a more sustainable and prosperous agricultural future.

Our device comprehensively monitors vital health parameters, enabling early disease detection and aligning with Sustainable Development Goal 2 (Zero Hunger) by bolstering food security and livestock productivity. Its user-friendly design ensures easy integration in common livestock environments, making it accessible to a wide range of farmers. The device's low cost and high accuracy enhance its practicality and affordability.

By providing real-time health data, our Livestock Health Monitoring Data logger empowers farmers to make informed decisions, improving animal welfare, enhancing agricultural productivity, and promoting industry sustainability.

6.2 Recommendations:

1. Development of Dedicated Monitoring Infrastructure:

The project should prioritize the development of a dedicated web portal designed exclusively for livestock health monitoring. This portal will provide comprehensive functionality and serve as a centralized platform for data analysis and visualization.

2. Multifunctional Application for Seamless Access:

A multifunctional application should be developed to ensure seamless access to the system's data. This application should be compatible with both mobile devices and computer interfaces, enhancing accessibility for a diverse user base.

3. Dual Account Classifications:

Implementing dual account classifications, including a master account and a user account, is recommended. This feature will facilitate varying levels of access and control, ensuring data security and user-specific functionalities.

4. Direct Connection to Medical Professionals:

The integration of a direct connection to medical professionals is a noteworthy recommendation. This innovative feature will empower users to promptly seek healthcare assistance for livestock health assessments, promoting timely interventions.

5. Expansion of Sensor Array and Advanced Programming Logic:

The project should focus on expanding the sensor array and incorporating advanced programming logic. This will enable the capture of an extended range of vital health parameters, ensuring that the system remains adaptable to the evolving landscape of livestock management.

6. Enhancement of Communication Capabilities:

Transitioning from the current reliance on Wi-Fi and LED indicators to encompass Bluetooth and 4G-enabled SIM connections is a crucial recommendation. This enhancement will substantially broaden the system's connectivity options, improving operational reliability, especially in remote or diverse agricultural settings.

These recommendations collectively aim to elevate the effectiveness and versatility of the Livestock Health Monitoring system, providing a more comprehensive and user-friendly solution for farmers and stakeholders in the livestock industry.

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