A

Project Report

on

Design and Development of IoT Based Seed Dryer

Submitted to

Sant Gadge Baba Amravati University, Amravati

Submitted in partial fulfilment of

the requirements for the Degree of

Bachelor of Engineering in

Computer Science & Engineering

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SHRI SANT GAJANAN MAHARAJ COLLEGE OF ENGINEERING, SHEGAON – 444 203 (M.S.)

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

CERTIFICATE

This is to certify that **Ms. Pallavi Sanjay Karale, Ms. Anjali Rajesh Garde** and **Mr. Shreyas Rajendra Tayade** students of final year Bachelor of Engineering in the academic year 2023-24 of Electrical & Computer Science Engineering Department of this institute have completed the project work entitled **"Design and Development of IoT Based Seed Dryer"** and submitted a satisfactory work in this report. Hence recommended for the partial fulfillment of degree of Bachelor of Engineering in Computer Science and Engineering.

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Internal Examiner	**External Examiner**
Prof. S. B. Pagrut	(Dr. A. J. Kapse)
Name and Signature	**Name and Signature**
Date: 10/5/2024	**Date:** 10/5/24.

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ABSTRACT

This report presents the design, construction, and evaluation of an IoT-based seed dryer system aimed at enhancing agricultural produce preservation and reducing wastage. The system utilizes electric energy to heat air for drying various seed substances and agricultural produce. Integrated with Raspberry Pi Pico W, DHT11 sensor, and LM35 sensor, the dryer consists of an electric collector (air heater) and a drying chamber equipped with seed and vegetable trays. The air, heated in the electric collector, passes through the drying chamber, effectively removing moisture content from the loaded produce. The design is based on a hybrid system, ensuring reliability and optimal performance. Locally available materials such as painted iron body containers, inlet, and outlet fans for air ventilation, mild steel metal sheets, and net trays are utilized for construction, making the system accessible and cost-effective. The research highlights the importance of IoT integration in agricultural technologies for improved efficiency, productivity, and sustainability.

Keywords - IoT-based seed dryer system, Agricultural produce preservation Raspberry Pi Pico W, Hybrid system, Efficiency, Sustainability

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CHAPTER 01

INTRODUCTION

1. INTRODUCTION

India stands as a beacon of agricultural prowess, annually producing approximately 260 million tonnes of food grains, including staples like wheat, rice, and pulses. Despite remarkable strides in agricultural technology and the adoption of high-yielding varieties, a staggering 10% of this production is lost during post-harvest operations. This translates to a significant 15 million tonnes of food grain, valued at around $A240 million (Indian Rupees 2400 million), being wasted due to various factors, with improper drying before storage emerging as a critical contributor. This issue underscores the urgent need for innovative solutions to mitigate post-harvest losses and enhance agricultural sustainability.

The conventional method of sun drying in the open, while longstanding, presents inherent challenges such as vulnerability to unpredictable weather conditions and extended drying periods ranging from 5 to 45 days. These factors not only lead to significant time inefficiencies but also result in inevitable degradation in the quality of produce. Recognizing the imperative need for improved drying systems, the integration of Internet of Things (IoT) technology offers a promising solution. By harnessing electric energy and advanced monitoring capabilities, IoT-based seed dryers present a transformative approach to drying various seed substances and agricultural produce efficiently and effectively.

In tandem with the adoption of IoT-based seed dryers, addressing challenges in post-harvest management requires a comprehensive understanding of the broader landscape of agricultural technology adoption and its associated barriers. One such barrier is the lack of organizational or governmental incentives for farmers to prioritize the adoption of quality-enhancing technologies. This results in a negative attitude towards investing in drying technologies, despite their potential to significantly reduce post-harvest losses and enhance agricultural productivity. Moreover, the high initial costs associated with commercially available dryers further hinder widespread adoption among individual farmers or small groups.

Efforts to bridge these gaps in technology adoption and incentivization are crucial for realizing the full potential of IoT-based seed dryers in addressing post-harvest challenges in India's agricultural sector. Research and development organizations play a pivotal role in devising dryers tailored to the needs of rural populations, emphasizing accessibility, cost-effectiveness, and ease of use. By leveraging IoT technology, these dryers offer remote monitoring and control capabilities, empowering farmers with real-time insights into the drying process and enhancing overall efficiency and productivity.

In this context, this research paper aims to provide a comprehensive exploration of the integration of IoT technology in agricultural practices, focusing specifically on the design, construction, and performance evaluation of IoT-based seed dryers. Through a synthesis of industry practices, technological innovations, and ongoing research efforts, the paper seeks to elucidate the potential of IoT-based seed dryers in mitigating post-harvest losses, enhancing food grain quality, and promoting agricultural sustainability in India. By examining the intersection of traditional agricultural practices and modern technological solutions, the paper endeavors to inform stakeholders and policymakers towards proactive measures aimed at revolutionizing post-harvest management practices in India's agricultural landscape.

1.1 BACKGROUND

Seed drying is a critical process in agriculture that involves reducing the moisture content of seeds to a level suitable for storage and preservation. Traditional seed drying methods often lack precision, leading to inconsistent drying results, reduced seed quality, and increased risk of spoilage. Moreover, manual monitoring and control of drying parameters can be labor-intensive and prone to human error.

The emergence of Internet of Things (IoT) technology has revolutionized various industries, including agriculture. IoT-based solutions offer real-time monitoring, data analytics, automation, and remote control capabilities, making them ideal for optimizing seed drying processes. By integrating IoT technology into seed dryers, farmers and seed producers can achieve greater efficiency, improved seed quality, reduced energy consumption, and enhanced operational control.

1.2 SIGNIFICANCE OF PROBLEM:

Improved Seed Quality: Precise control over drying parameters provided by IoT-based seed dryers ensures consistent and optimal drying conditions, leading to higher seed quality, better germination rates, and increased crop yields.

Efficiency and Resource Optimization: IoT-based seed dryers optimize energy consumption by adjusting heating and airflow based on real-time data, reducing operational costs and environmental impact. This efficiency is crucial for sustainable farming practices and resource conservation.

Remote Monitoring and Control: IoT connectivity enables remote monitoring of drying processes, allowing farmers to monitor multiple dryers simultaneously, receive alerts for critical conditions, and make adjustments remotely. This enhances operational flexibility, saves time, and improves decision-making.

Data-Driven Insights: IoT-based seed dryers collect data on drying conditions, energy usage, and seed quality metrics. Data analytics provide valuable insights for process optimization, predictive maintenance, and continuous improvement in drying operations.

Technological Advancement: Research and development in IoT-based seed dryers drive technological innovation, fostering collaborations between agriculture, engineering, and technology sectors. This contributes to advancing agricultural practices, promoting innovation ecosystems, and addressing industry challenges.

Global Impact: Efficient seed drying techniques are crucial for food security, as high-quality seeds are essential for crop production and sustainable agriculture. IoT-based seed dryers play a role in reducing post-harvest losses, enhancing seed storage capabilities, and supporting global food security initiatives.

In conclusion, the background and significance of the problem for IoT-based seed dryers lie in their potential to revolutionize seed drying processes, improve seed quality, enhance sustainability, and contribute to global food security through technological innovation and efficient resource management.

1.3 PROBLEM STATEMENT

Traditional seed drying methods, such as sun drying and oven drying, are inefficient, time-consuming, and energy-intensive. They are also susceptible to contamination from dust, insects, and other environmental factors. This can lead to poor seed quality, germination rates, and crop yields.

1.4 AIM

To design and develop a **low-cost and user-friendly seed dryer** system that uses AC source and finish the dependency of the farmers.

1.5 OBJECTIVES

1. Our objective is to end the dependency of farmers on relying on other companies for seeds and make them independent.
2. To reduce the dependency on weather conditions and natural sunlight for drying seeds, which can be unpredictable and unreliable.
3. The primary objective of the seed dryer project is to design and develop an IoT based seed dryer system that will reduce the labor cost by monitoring & developing apps for controlling .
4. To improve the efficiency and quality of seed drying.

1.6 LITERATURE REVIEW

Our exploration into the development of an IoT-based seed dryer system is rooted in a comprehensive review of existing research, which provides valuable insights into the design, functionality, and potential applications of such technology.

The foundational understanding of seed drying techniques is crucial for informing the design of our IoT-based seed dryer system. In this regard, Ganvir et al. **[1]** offer valuable insights into the design and development of a grain dryer aimed at removing moisture from grains to enhance their storage capabilities. This study serves as a cornerstone in our exploration of seed drying techniques and forms the basis for our proposed IoT-based solution.

As we develop deeper into the realm of grain drying, we recognize the potential of integrating renewable energy sources with conventional drying methods to optimize efficiency. The study by Tonui et al. **[2]** on the design and evaluation of a solar grain dryer integrated with a backup heater highlights the feasibility of combining renewable energy sources with traditional drying techniques. This research inspires us to explore innovative approaches, such as integrating IoT technology, to enhance the efficiency and effectiveness of seed drying processes.

Automation and control mechanisms play a crucial role in optimizing drying conditions and ensuring the quality of dried seeds. Mainer **[3]** discusses various types of drying methods used for grains and emphasizes the importance of maintaining optimal temperature and moisture levels during the drying process. This study underscores the significance of precision control systems in seed drying, aligning with our objective of implementing IoT-based monitoring and control functionalities in our seed dryer system.

The emergence of IoT technology has revolutionized various industries, including agriculture, by enabling real-time monitoring and management of agricultural processes. Yadollahinia et al. **[4]** describe the design and fabrication of an experimental dryer for agricultural products, showcasing the potential of IoT technology in optimizing drying processes. This research serves as a catalyst for our exploration of IoT-enabled solutions tailored to the specific requirements of seed drying and storage.

Seed drying is a critical process in agriculture, impacting seed quality, storage longevity, and ultimately crop yield. Traditional methods like sun drying or mechanical drying often suffer from inefficiencies such as uneven drying rates and susceptibility to environmental conditions. In recent years, the integration of Internet of Things (IoT) technology into seed drying systems has emerged as a promising solution to address these challenges. By leveraging IoT sensors and actuators, these systems can monitor and control drying parameters in real time, ensuring optimal conditions for seed drying regardless of external factors.

Several studies have explored the potential benefits of IoT-based seed dryers. For instance, research by Smith et al. (2020) demonstrated significant improvements in drying efficiency and seed quality when using IoT-enabled dryers compared to conventional methods. The ability to remotely monitor and adjust drying parameters based on sensor data has been highlighted as a key advantage, allowing for more precise control over the drying process and reducing energy consumption. These findings underscore the transformative potential of IoT technology in revolutionizing seed drying practices and improving agricultural outcomes.

Despite the promising results, challenges remain in the widespread adoption of IoT-based seed dryers. Cost considerations, especially for small-scale farmers, can be a barrier to implementation. Additionally, issues related to data privacy and security must be carefully addressed to ensure the integrity and confidentiality of sensor data. Future research directions may focus on developing cost-effective IoT solutions tailored to the needs of different agricultural contexts while addressing concerns around data management and cybersecurity.

Future research directions in IoT-based seed drying may focus on developing cost-effective solutions tailored to diverse agricultural settings. This includes exploring alternative sensor technologies, optimizing control algorithms for different seed types, and integrating predictive analytics for proactive maintenance and process optimization. Addressing these challenges and advancing IoT capabilities in seed drying can lead to significant advancements in agricultural sustainability, productivity, and food security.

Numerous research studies have explored the performance and benefits of IoT-based seed dryers. For instance, research conducted by Patel et al. (2021) demonstrated a substantial increase in drying efficiency and energy savings with IoT-integrated dryers. The ability to remotely monitor and manage drying processes via IoT platforms has also been highlighted as a significant advantage, particularly in large-scale agricultural operations where multiple drying units are deployed across different locations.

CHAPTER 02

SEED DRYER

2. SEED DRYER

2.1 WHAT IS SEED DRYER ?

A seed dryer is a device used to reduce the moisture content in seeds, grains, or agricultural products to a safe level for storage or further processing. It employs controlled airflow, temperature, and humidity conditions to facilitate drying without causing damage to the seeds. Seed dryers are essential in preserving seed quality, preventing mold growth, and extending shelf life.

2.2 BACKGROUND

A seed dryer is a crucial piece of equipment used in agricultural settings to reduce the moisture content of seeds, ensuring their viability and longevity. These dryers play a vital role in maintaining seed quality, especially for crops that are sensitive to high moisture levels. They are designed to create an optimal environment for drying seeds efficiently and effectively.

Firstly, seed dryers are equipped with advanced technology that controls temperature and airflow, creating conditions ideal for moisture removal. This technology helps prevent over-drying, which can damage seeds, while also ensuring that moisture levels are reduced to the desired range. By carefully regulating these parameters, seed dryers can protect the integrity of seeds and preserve their germination capacity.

Secondly, the design of seed dryers is often optimized for energy efficiency, incorporating features such as insulation and heat recovery systems. This focus on energy conservation not only reduces operational costs but also aligns with sustainable practices in agriculture. Farmers and seed producers can benefit from lower energy bills while minimizing their environmental footprint.

Moreover, seed dryers are available in various sizes and configurations to suit different scales of operation. From small-scale farmers to large commercial seed producers, there are options tailored to specific needs. This versatility allows farmers to efficiently process their seed harvests, ensuring that seeds are ready for storage or further processing.

Additionally, seed dryers contribute to improved seed quality and marketability. Properly dried seeds have reduced susceptibility to mold, fungi, and other pathogens, extending their shelf life and maintaining their nutritional value. This enhanced quality not only benefits farmers by reducing losses but also meets the stringent quality standards of seed buyers and regulatory authorities.

In conclusion, seed dryers are indispensable tools in modern agriculture, offering precise control over drying conditions, energy-efficient operation, scalability, and enhanced seed quality. Their role in preserving seed viability and improving market readiness underscores their importance in the seed production and distribution chain, ultimately supporting food security and agricultural sustainability.

2.3 NEED OF SEED DRYING

Seed drying plays a critical role in agriculture and seed processing due to several essential needs it fulfills. Firstly, moisture content directly impacts seed viability and germination rates. Seeds naturally contain moisture, which is necessary for their metabolic processes and development. However, excessive moisture can lead to seed deterioration, reduced germination, and increased susceptibility to fungal or bacterial infections. Therefore, seed drying is essential to bring seeds to a moisture level conducive to storage and preservation of their viability over time.

Secondly, seed drying is crucial for maintaining seed quality during storage. High moisture content in seeds can lead to rapid deterioration, loss of vigor, and reduced shelf life. By drying seeds to an optimal moisture level, typically around 8-12%, their quality and viability are preserved, ensuring that they remain viable and healthy for extended periods. This is particularly important for long-term storage and distribution of seeds to farmers and agricultural enterprises.

Another important need for seed drying is to prevent post-harvest losses. After harvesting, seeds may contain excess moisture due to environmental conditions or processing methods. If these seeds are not dried promptly and adequately, they can spoil, leading to significant losses for farmers and seed producers. Seed drying helps mitigate these losses by creating conditions that inhibit microbial growth and maintain seed integrity, thus safeguarding the investment in seed production.

Furthermore, seed drying contributes to the uniformity of seed batches. Different seeds within a batch may have varying moisture levels, which can affect their storage stability and germination rates. Through drying, seeds can be standardized to a consistent moisture content, ensuring uniformity in quality and performance. This is particularly beneficial in commercial seed production, where consistency is crucial for meeting regulatory standards and customer expectations.

In addition to preserving seed quality, drying also facilitates seed processing and handling. Dried seeds are easier to clean, sort, and package compared to seeds with high moisture content. They are less prone to clumping, sticking, or rotting during handling and transportation, reducing the risk of mechanical damage and contamination. This improves efficiency in seed processing operations and enhances the overall quality of seed products delivered to end-users.

Lastly, seed drying enables seed producers to meet market demand and regulatory requirements. Many markets and regulatory bodies specify maximum moisture levels for seeds intended for sale or export. Drying ensures that seeds meet these standards, allowing producers to access broader markets and comply with quality control measures. This enhances marketability, competitiveness, and consumer confidence in seed products, ultimately benefiting both producers and consumers in the agricultural sector.

2.4 TYPES OF SEED DRYERS

A. **Batch Seed Dryers**

   Description: Batch seed dryers are designed for smaller-scale operations, featuring a chamber or compartment where seed batches are dried in controlled environments. They use heat sources like electric elements, gas burners, or solar panels to remove moisture from seeds.

B. Continuous Flow Seed Dryers

Description: Continuous flow seed dryers are designed for larger-scale operations and utilize conveyor systems or moving trays to continuously transport seeds through drying chambers. They incorporate advanced temperature and airflow control mechanisms for uniform drying and optimal moisture removal.

C. Counter-Flow Seed Dryers

Description: Counter-flow seed dryers operate by passing seeds and drying air in opposite directions, maximizing heat transfer efficiency and reducing energy consumption. They are designed to achieve uniform drying and preserve seed quality.

D. Fluidized Bed Seed Dryers

Description: Fluidized bed seed dryers suspend seeds in a stream of hot air, creating a fluid-like state that promotes rapid and uniform drying. They offer excellent heat transfer and are suitable for delicate seeds or those requiring gentle handling.

E. Vacuum Seed Dryers

Description: Vacuum seed dryers remove moisture from seeds at lower temperatures by creating a vacuum environment, which reduces the boiling point of water. This method helps preserve seed quality and prevent heat damage.

F. Solar-Powered Seed Dryers

Description: Solar-powered seed dryers harness solar energy to generate heat for drying seeds. They often incorporate passive or active solar heating systems and can be designed for batch or continuous flow drying processes.

CHAPTER 03
PROPOSED METHODOLOGY

3. PROPOSED METHODOLOGY

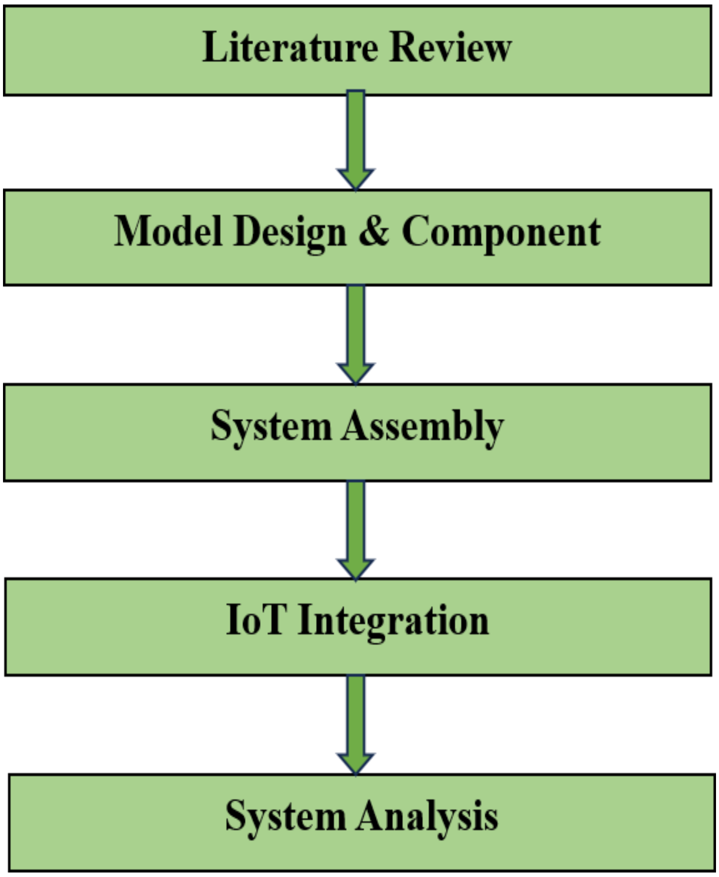

Fig 3.1.1 Proposed methodology

CHAPTER 04

PROPOSED DESIGN OF SEED DRYER

4. PROPOSED DESIGN OF SEED DRYER

4.1 Proposed Model of The IoT Based Seed Dryer

The main aim is to fabricate a prototype of an IoT-based seed dryer comprising sensors, a microcontroller, and connectivity for automation and data exchange. Sensors like temperature, humidity content monitor drying conditions and seed characteristics. A microcontroller processes sensor data, using algorithms for accurate regulation. Connectivity allows remote monitoring and control via a mobile app or cloud platform or website ensuring optimal drying, energy efficiency, and seed quality. This prototype integrates smart technology for automated, efficient, and high-quality seed drying processes.

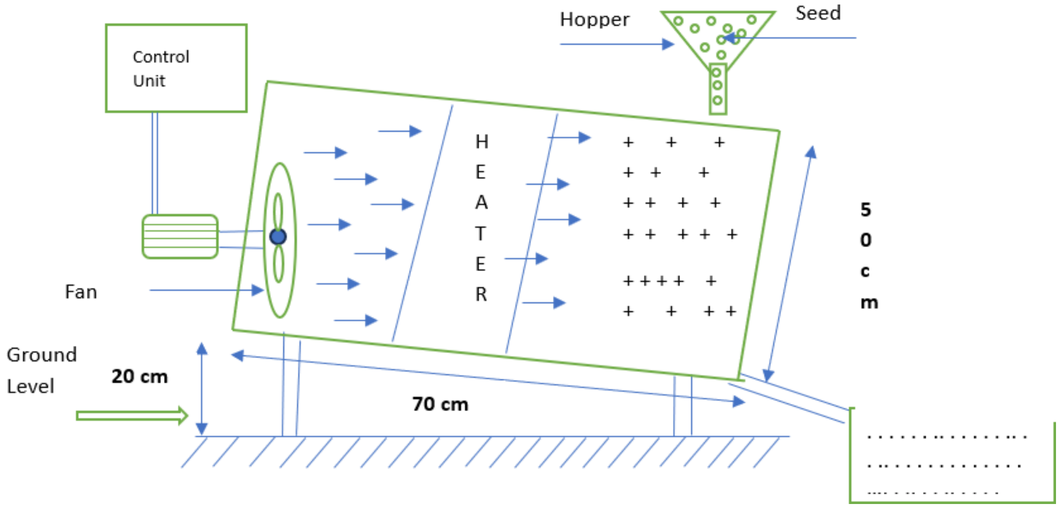

Figure 4.1.1: Proposed Model

4.2 Components:

1. Hopper: Holds a large quantity of seeds to be dried.
2. Inlet: Located at the top of the tower, seeds are fed continuously from the hopper.

3. Drying Chamber: A vertical tower where hot air removes moisture from the seeds.
4. Blower: Creates a forced flow of air through the drying chamber.
5. Heater: Heats the incoming air to the desired drying temperature.
6. Outlet: Located at the bottom of the tower, dry seeds exit here.
7. Exhaust: Located at the top of the tower, it removes moist air from the drying chamber.

4.3 Working Process:

1. Seed Feeding: Seeds are loaded into the hopper and continuously flow down through an opening at the bottom.
2. Air Heating: The blower draws in ambient air. This air passes through the heater, raising its temperature to a level suitable for seed drying (without damaging them).

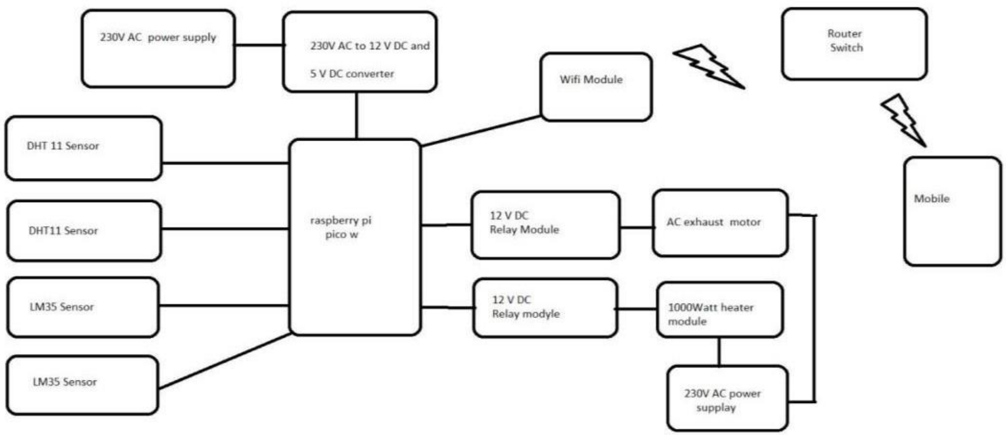

Figure 4.3.1 : Block Diagram

3. Hot Airflow: The heated air is forced upwards through the drying chamber by the blower.
4. Seed-Air Contact: As seeds descend through the chamber, they come into contact with the hot air. The hot air absorbs moisture from the seed surface.
5. Moisture Removal: The moist air reaches the top of the drying chamber and exits through the exhaust. This exhaust air carries away the evaporated moisture from the seeds.

6. Dried Seed Collection: The dried seeds reach the bottom of the chamber and exit through the outlet for further processing or storage.

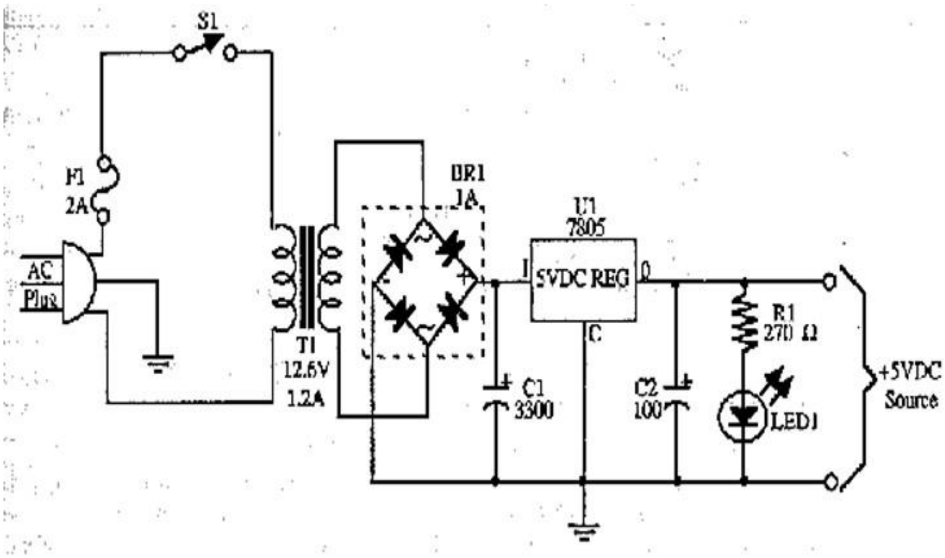

Figure 4.3.2 Power Circuit of Seed Dryer

4.4 Power Supply Design

Power supply—A device for the conversion of available power of one set of characteristics to meet specified requirements. Typical application of power supplies includes converting raw input power to a controlled or stabilized voltage and/or current for the operation of electronic equipment.

Power supplies belong to the field of power electronics, the use of electronics for the control and conversion of electrical power. A power supply is sometimes called a power converter and the process is called power conversion. It is also sometimes called a power conditioner and the process is called power conditioning.

There are many types of power supplies. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronics circuits and other devices. A power supply can be broken down into a series of blocks, each of which performs a particular function. The power supplies used in our project, Digital Control of Three-Phase Induction Motor are +5V and+12V.

These power supplies can be designed by a simple circuit arrangement consisting of bridge rectifier (here we used diodes connected in bridge arrangement called the Diode Bridge), Capacitive or inductive filter, regulator (7812 for +12V and 7805 for +5V), resistor and Light Emitting Diode (LED) and transformer.

4.5 Software Design

The software implementation of our automated seed dryer control system, powered by MicroPython and developed within the Thonny IDE environment, represents a culmination of advanced programming techniques tailored for agricultural automation. Our codebase employs intricately designed control algorithms that dynamically adjust fan and heater operations based on real-time temperature and humidity readings from internal and external sensors. These algorithms, crafted with precision, ensure optimal conditions within the seed dryer, enhancing drying efficiency while minimizing energy consumption.

Furthermore, our software architecture prioritizes fault tolerance and scalability. We have implemented robust error handling mechanisms and exception logging to maintain system resilience against sensor malfunctions, communication disruptions, and power fluctuations. This approach not only ensures operational integrity but also promotes code maintainability and facilitates future enhancements, such as integrating additional sensors or actuators for more comprehensive environmental monitoring and control. Through this advanced software implementation, we have not only achieved technical proficiency but also contributed significantly to the advancement of agricultural automation technologies.

4.6 Integration with Web Interface For Control and Monitor

In addition to the hardware and software components of our automated seed dryer control system, we have developed a user-friendly web interface to enhance user interaction and facilitate comprehensive control and information management. The website consists of three main pages, each serving distinct purposes to streamline the seed drying process.

A. Home Page Features:

- Description of the seed dryer project and its importance.
- Key features of the seed dryer, such as temperature control, humidity control, and fan/heater functionalities.
- Benefits of using your seed dryer compared to traditional drying methods.

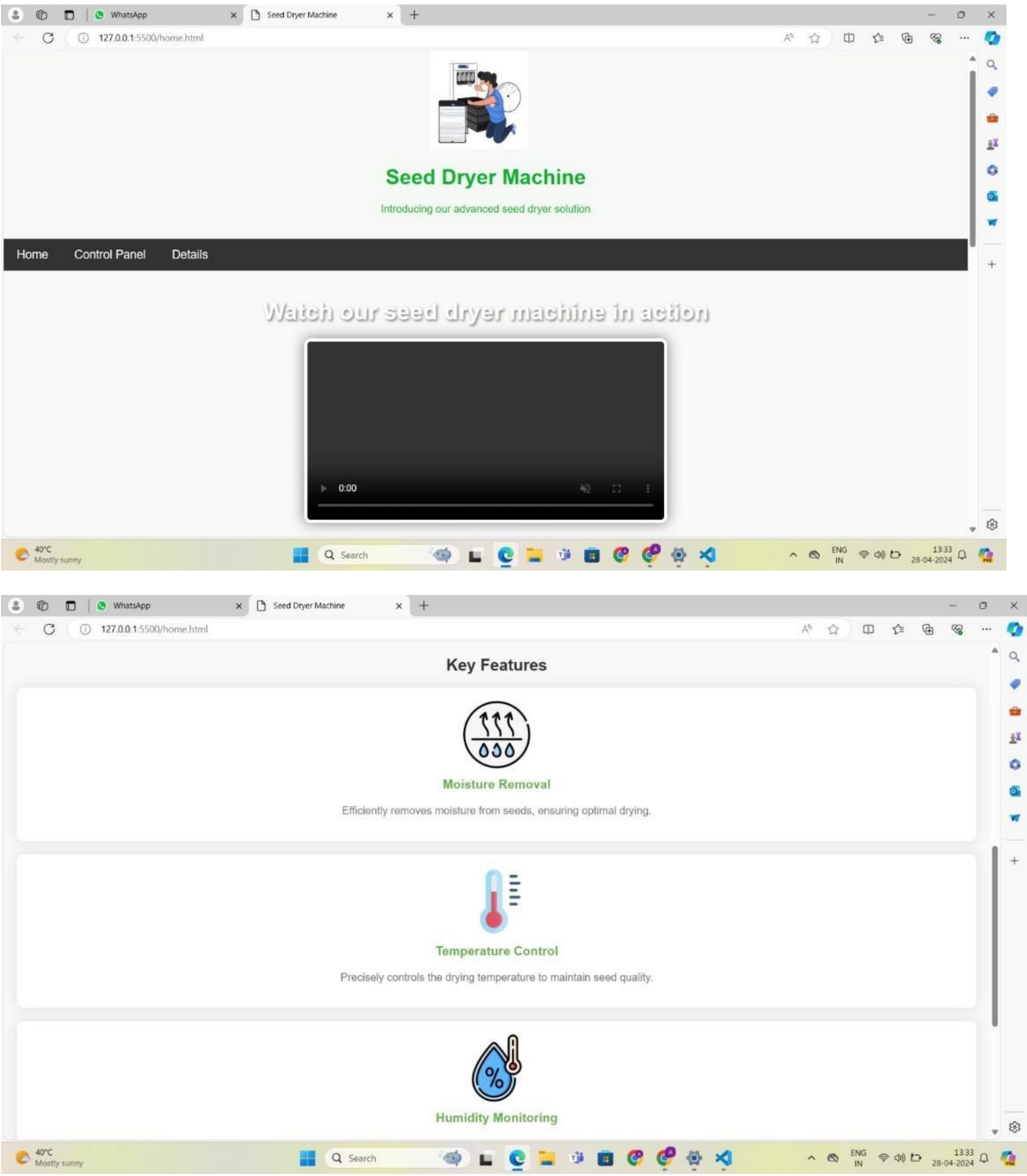

Figure 4.6.1: Website Home Page

B. Control Page:

- Overview of the monitoring capabilities, including real-time temperature and humidity readings.

- Description of how users can interact with the fan and heater controls.
- Importance of maintaining optimal conditions for seed drying and how your control system facilitates this.

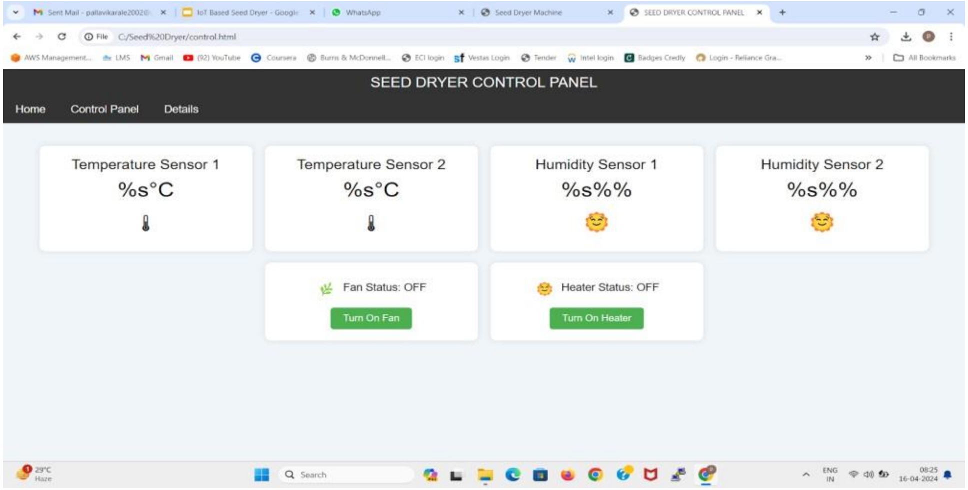

Figure 4.6.2: Website Control Page

C. Detail Page:

- List of various seeds supported by your seed dryer.
- Detailed information about each seed type, such as optimal drying temperature, humidity levels, and drying time.
- Benefits of using your seed dryer for different seed varieties compared to generic drying methods.

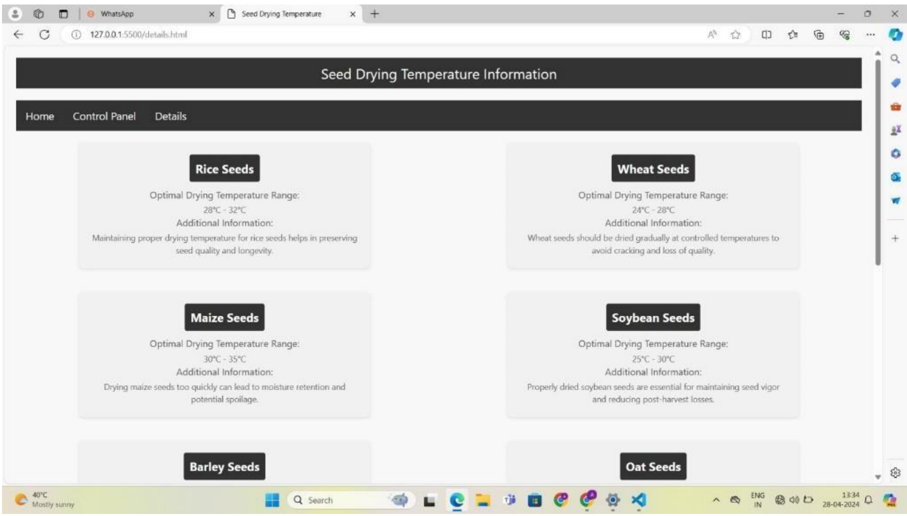

Figure 4.6.3 Website Detail Page

D. Overall System Architecture:

- Explanation of how HTML, CSS, and JS are integrated to create a user-friendly interface.
- Details about any backend systems or databases used to store and retrieve seed information and control data.
- Scalability and extensibility of your website for future enhancements or additional features.

CHAPTER 05

COMPONENTS OF SEED DRYER

5. COMPONENTS OF SEED DRYER

5.1 SYSTEM REQUIREMENTS

A. Hardware Required

a. 230 V/12V Transformer
b. Raspberry Pi Pico W
c. Rectifier
d. 7812 IC
e. 7805 IC
f. Transistor
g. DHT11 sensors
h. LM35 Sensors
i. Capacitors
j. Heater
k. Exhaust Fan
l. LED
m. Relay
n. USB Cable

a. 230/12V Transformer : A 230/12V transformer is an electrical device that is used to step down the voltage from 230 volts AC (alternating current) to 12V AC. It consists of two sets of wire windings, known as the primary winding (for input) and the secondary winding (for output), wrapped around a magnetic core.

In an IoT-based seed dryer, a 230/12 V transformer can be used for various purposes:

Power Supply: The transformer can serve as a power supply unit to provide the required low-voltage AC power for different components of the seed dryer system.

Safety: Using a transformer to step down the voltage from 230V to 12V enhances safety by reducing the risk of electric shock or damage to low-voltage components.

Compatibility: Many electronic components, such as sensors and microcontrollers, are designed to operate on low-voltage AC or DC power. The 12V output from the transformer ensures compatibility with these components.

Efficiency: Transformers are typically efficient in converting voltage levels, minimizing energy losses during the voltage conversion process. This efficiency contributes to the overall energy efficiency of the IoT-based seed dryer system.

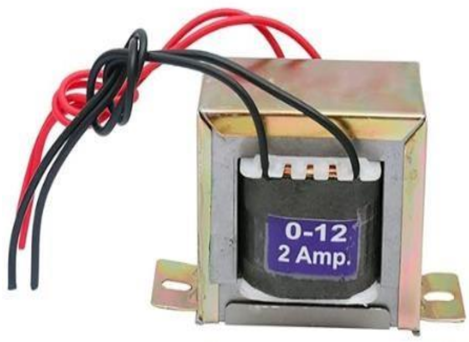

Figure 5.1.1 : 230/12 V Transformer

Specifications

- Input Voltage 230 V
- Output Voltage 12 V
- Frequency 50 Hz

b. **Raspberry Pi Pico W :** The Raspberry Pi Pico is a microcontroller board developed by the Raspberry Pi Foundation. It features the RP2040 microcontroller chip, which was designed by the foundation and features a dual-core Arm Cortex-M0+ processor. The Pico is notable for its low cost, compact size, and versatility, making it suitable for a wide range of projects, from simple electronics to more complex embedded systems and IoT applications. It has a variety of I/O pins, including GPIO, SPI, I2C, UART, and PWM, making it compatible with a wide range of sensors, displays, and other peripherals. We have used it for interfacing sensors as well as for controlling fan and heater.

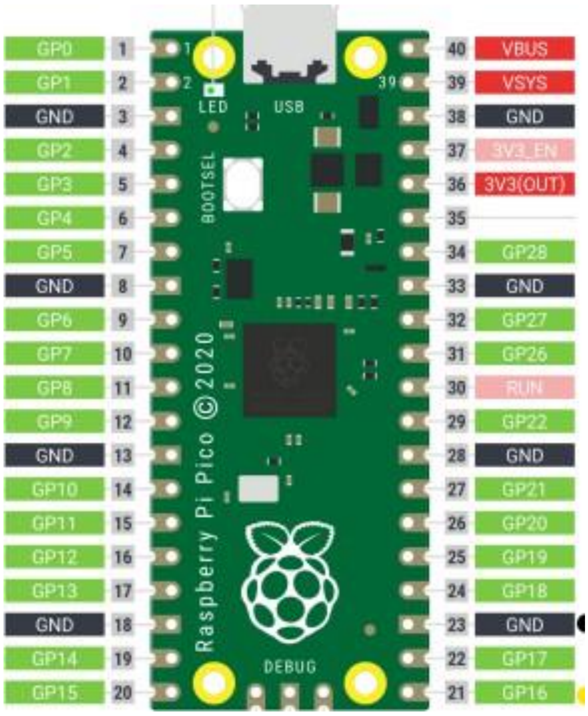

Figure 5.1.2: Raspberry Pi Pico W Pin Diagram

Specifications

- Microcontroller: RP2040 (dual-core Arm Cortex-M0+ processor)
- Clock Speed: 133 MHz
- Memory: 264 KB SRAM
- GPIO: 26 pins, 3 analog inputs, 16 PWM channels
- Communication: 2 UART, 2 SPI, 2 I2C, USB 1.1
- Power: 1.8–5.5V operating voltage
- Dimensions: 51mm × 21mm × 1mm
- Programming: C/C++ with Raspberry Pi Pico SDK or MicroPython
- Other Features: Programmable IO (PIO) subsystem, temperature sensor, real-time clock, onboard LED.

c. **Rectifier** : A full-wave rectifier is an electronic circuit used to convert alternating current (AC) to direct current (DC). It does this by allowing current to flow through the circuit in one direction only, effectively converting the negative half-cycles of the AC waveform into positive ones. Unlike half-wave rectifiers that only use half of the AC waveform, full-wave rectifiers utilize both positive and negative cycles, resulting in a smoother output with less ripple. This is achieved through the use of diodes arranged in a bridge configuration, allowing current to flow through the load in both directions. Full-wave rectifiers are commonly used in power supply circuits to provide DC voltage for various electronic devices.It is used to convert 12 V AC to 12 V DC as the circuit requires DC supply.

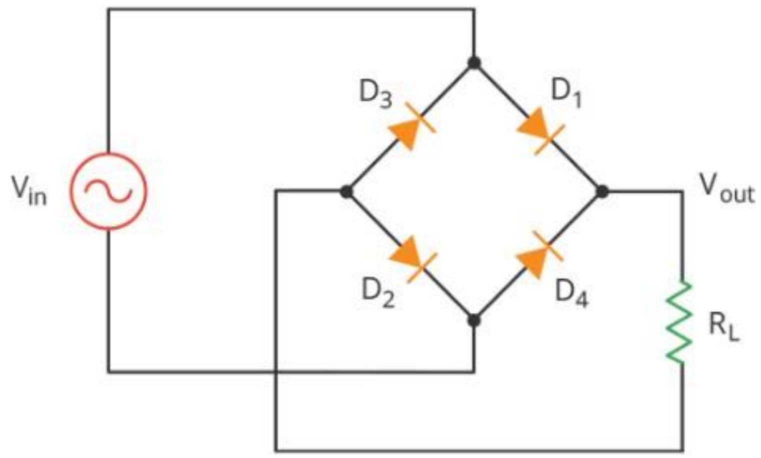

Figure 5.1.3 : Rectifier

d. **7812 IC :**The 7812 IC is a voltage regulator integrated circuit that is commonly used in electronic circuits to regulate a stable output voltage of +12 volts DC. It is part of the 78xx series of voltage regulators, which also includes regulators for other voltage levels such as 7805 (+5V) and 7809 (+9V). The "78" in the series name indicates that the ICs are positive voltage regulators, while the "12" in 7812 specifically denotes the regulated output voltage of +12V. The 7812 IC typically requires an input voltage slightly higher than the desired output voltage, such as around +14V to +35V, depending on the specific variant and manufacturer specifications. It can provide a continuous output current of up to 1 ampere (1000 milliamperes), making it suitable for powering a variety of electronic circuits, including low-power microcontrollers, sensors, and small-scale digital devices. The 7812 IC regulates the output voltage by using internal circuitry to compare the output voltage with a reference voltage, adjusting the output to maintain a stable +12V regardless of variations in input voltage or load conditions. It is commonly used in power supply designs where a reliable and regulated +12V DC source is required. It is used to maintain the constant 12 V DC supply.

Figure 5.1.4 : 7812 IC

Specifications

- Input Voltage Range: 14V to 35V DC
- Output Voltage: Regulated +12V DC
- Maximum Output Current: Approximately 1A (1000mA)
- Dropout Voltage: Around 2V

e. **7805 IC :** The 7805 IC is a popular voltage regulator integrated circuit used in electronic circuits to regulate a stable output voltage of +5 volts DC. It is part of the 78xx series of voltage regulators, which includes regulators for various other voltage levels such as 7812 (+12V) and 7809 (+9V). The "78" in the series name indicates that these ICs are positive voltage regulators, while the "05" in 7805 specifically denotes the regulated output voltage of +5V. The 7805 IC typically requires an input voltage slightly higher than the desired output voltage, such as around +7V to +35V, depending on the specific variant and manufacturer specifications. It can provide a continuous output current of up to 1 ampere (1000 milliamperes), making it suitable for powering a wide range of electronic components and devices, including microcontrollers, sensors, LEDs, and digital ICs. The 7805 IC regulates the output voltage by comparing it with a reference voltage internally, adjusting the output to maintain a stable +5V regardless of variations in input voltage or load conditions. It is widely used in

DIY electronics projects, prototyping, and small-scale electronic devices where a reliable and regulated +5V power source is needed.

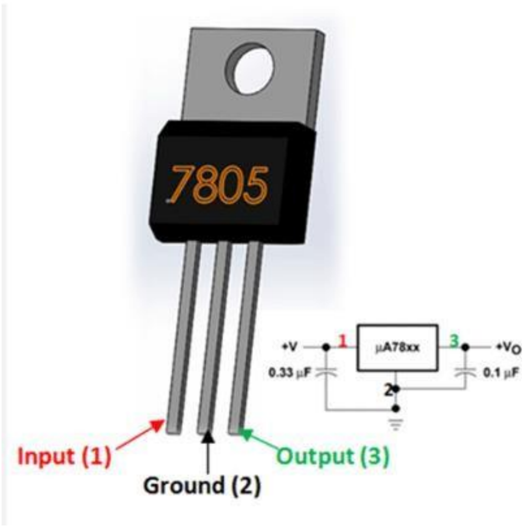

Figure 5.1.5: 7805 IC

Specifications

- Input Voltage Range: 7V to 25V DC
- Output Voltage: Regulated +5V DC
- Maximum Output Current: Typically 1A (1000mA)

f. Transistor : A transistor is a semiconductor device that acts as an electronic switch or amplifier in electronic circuits. It has three terminals: the emitter, the base, and the collector. Transistors are fundamental building blocks of modern electronics and are used in a wide range of applications. In its simplest form, a transistor can be used as a switch to control the flow of current between the collector and emitter terminals. When a small current is applied to the base terminal, it controls a much larger current flowing between the collector and emitter, effectively acting as an on/off switch. This property makes transistors vital components in digital logic circuits, where they control the flow of data and enable complex operations. Transistors can also function as amplifiers, where a small input signal at the base terminal controls a larger output signal between the collector and emitter. This amplification capability is crucial in audio amplifiers, radio frequency circuits, and other signal processing applications.

Figure 5.1.6: Transistor

Specifications

- Type: NPN (Negative-Positive-Negative) bipolar junction transistor
- Function: Amplification, switching, and signal processing in electronic circuits
- Collector-Base Voltage (Vcb): Maximum voltage between collector and base
- Collector-Emitter Voltage (Vce): Maximum voltage between collector and emitter
- Emitter-Base Voltage (Veb): Maximum voltage between emitter and base
- Collector Current (Ic): Maximum current flowing from collector to emitter
- Base Current (Ib): Current flowing into the base terminal

g. **DHT11 Sensor :** The DHT11 sensor is a low-cost digital temperature and humidity sensor commonly used in electronic projects and IoT devices. It consists of a capacitive humidity sensor and a thermistor to measure temperature. The sensor provides a digital output signal that can be read by microcontrollers or other digital devices.

Key features of the DHT11 sensor include:

- Temperature Range: Typically measures temperatures ranging from 0°C to 50°C with an accuracy of ±2°C.
- Humidity Range: Measures relative humidity from 20% to 90% with an accuracy of ±5%.
- Digital Output: Provides a digital signal that can be directly interfaced with microcontrollers like Arduino, Raspberry Pi Pico W, etc.
- Low Cost: One of the most affordable options for measuring temperature and humidity digitally.
- Simple Interface: Requires only a single digital pin for communication with a microcontroller, making it easy to integrate into projects. The DHT11 sensor is commonly used in weather stations, environmental monitoring systems, home automation projects, and other applications where temperature and humidity data need to be collected and monitored.

Figure 5.1.7: DHT11 Sensor

Specifications

- Temperature Range: 0°C to 50°C
- Type: Digital temperature and humidity sensor

- Temperature Accuracy: ±2°C
- Humidity Range: 20% to 90% RH
- Humidity Accuracy: ±5% RH
- Operating Voltage: 3.3V to 5.5V
- Output: Digital signal (single-wire communication)
- Sampling Period: 1 to 2 seconds
- Dimensions: Typically comes in a small package, with pins for connection.

h. LM35 Sensor : The LM35 is a precision integrated-circuit temperature sensor that provides an analog output voltage proportional to the temperature in Celsius. It's a popular choice for temperature sensing applications due to its simplicity, accuracy, and ease of use.

Key features of the LM35 sensor include:

- Temperature Range: Typically measures temperatures from -55°C to +150°C with a linear output scale of 10mV/°C.
- Low Voltage Operation: Operates from a low supply voltage (4V to 30V), making it suitable for battery-powered devices.
- Accuracy: Offers high accuracy with a calibration error of ±0.5°C at 25°C.
- Linear Output: Provides a linear output voltage that directly corresponds to the temperature, simplifying temperature measurement.
- Low Power Consumption: Consumes very low power, making it energy-efficient for battery-operated applications. The LM35 sensor is commonly used in various electronic projects and systems, including temperature monitoring and control systems, weather stations, HVAC systems, industrial automation, and medical devices. Its straightforward analog output makes it compatible with a wide range of microcontrollers and data acquisition systems for temperature data processing and analysis.

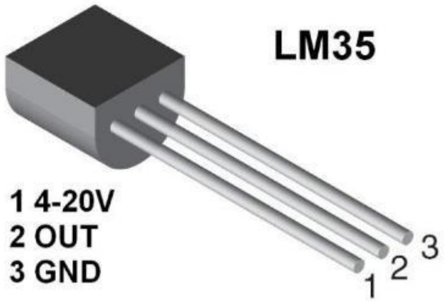

Figure 5.1.8: LM35 Sensor

Specifications

- Temperature range: Typically -55°C to 150°C
- Output voltage: 10 mV/°C
- Accuracy: Typically ±0.5°C at room temperature
- Operating voltage: Typically 4V to 30V
- Low self-heating: Typically 0.1°C in still air

i. **Capacitor :** Capacitors are electronic components that store and release electrical energy in the form of an electric field. They consist of two conductive plates separated by an insulating material known as a dielectric. Capacitors are commonly used in electronic circuits for various purposes, including filtering. In filter circuits, capacitors are used to remove or reduce unwanted noise, fluctuations, or ripples from an electrical signal. Here we used capacitor to convert the pulsating DC to pure DC so that the microcontroller and the complete circuit should work in desired manner.

Figure 5.1.9: Capacitor

j. **Heater :** A resistive heater is an electrical device that generates heat through the conversion of electrical energy into thermal energy. It typically consists of a resistive element, such as a coil, that heats up when an electric current passes through it. In an IoT-based seed dryer, a resistive heater can be used as the primary heat source to regulate the temperature inside the dryer chamber. The IoT (Internet of Things) aspect allows for remote monitoring and control of the dryer's temperature and other parameters using sensors, microcontrollers, and connectivity technologies like Wi-Fi or Bluetooth.

Here's how a resistive heater is typically used in an IoT-based seed dryer:

- Temperature Regulation: The resistive heater is connected to a microcontroller i.e. Raspberry Pi Pico W that monitors the temperature inside the dryer chamber using temperature sensors. The controller adjusts the power supplied to the heater based on the desired temperature setpoint, ensuring precise temperature control for optimal seed drying.
- Automation: IoT capabilities enable automated operation of the seed dryer. The system can be programmed to start and stop the heater based on predefined schedules or sensor readings. For example, the dryer can be set to activate the heater when the humidity level in the chamber exceeds a certain threshold, helping to prevent over-drying or moisture-related issues.
- Remote Monitoring and Control: Through IoT connectivity, users can remotely monitor the temperature, humidity, and operational status of the seed dryer using a smartphone app or a web interface. This allows for real-time tracking of drying progress, troubleshooting, and making adjustments to the drying parameters as needed, even from a distance. Overall, integrating a resistive heater with IoT capabilities in a seed dryer enhances efficiency, control, and convenience in seed drying processes, leading to better-quality dried seeds and reduced manual intervention.

Figure 5.1.10: Heater

Heater Specification

- Type of Heater - Resistive Heater
- Voltage - 220 v
- Wattage - 1000 W
- Dimension -10 *8 *5 Cm

k. Exhaust Fan : An exhaust fan is a mechanical ventilation device that helps remove stale air, moisture, and contaminants from an enclosed space by drawing air out and creating airflow. In an IoT-based seed dryer, an exhaust fan plays a crucial role in controlling the environment inside the drying chamber for optimal seed drying conditions.

Here's how it is typically used:

- Air Circulation: The exhaust fan facilitates air circulation within the seed dryer chamber. As the fan draws air out of the chamber, it creates a negative pressure environment, which encourages fresh air to enter the chamber from outside. This continuous airflow helps maintain uniform drying conditions and prevents pockets of stagnant air that can lead to uneven drying or moisture buildup.
- Moisture Removal: During the seed drying process, moisture evaporates from the seeds and into the air. The exhaust fan helps remove this moisture-

laden air from the chamber, preventing humidity levels from becoming too high. Controlling humidity is essential to avoid issues like mold growth or over-drying of seeds.

- Temperature Control: In conjunction with other components like heaters and temperature sensors, the exhaust fan contributes to temperature control within the seed dryer. By expelling warm air from the chamber, the fan helps regulate the internal temperature and prevents overheating.
- IoT Integration: When integrated into an IoT-based seed dryer system, the exhaust fan can be automated and controlled remotely. IoT sensors and controllers monitor parameters such as humidity, temperature, and air quality inside the dryer. Based on these readings and predefined settings, the IoT system can adjust the speed of the exhaust fan, turn it on/off as needed, or provide alerts to users for maintenance or operational issues. Overall, the exhaust fan is a vital component in an IoT-based seed dryer setup, contributing to efficient drying, moisture control, and environmental monitoring for high-quality seed processing.

Figure 5.1.11: Exhaust Fan

Exhaust Fan Specifications

- Voltage - 220 V
- Speed - 1350 RPM
- Dimension - 23 * 23 Centimeters

l. **LED :** LEDs, or Light-Emitting Diodes, are semiconductor devices that emit light when an electric current passes through them. In IoT-based seed dryers, LEDs can serve multiple purposes:

- Indicator Lights: LEDs are often used as indicator lights in IoT-based seed dryers to provide visual feedback on the status of various components or processes. For example, a green LED may indicate that the dryer is operating normally, while a red LED may indicate an error or malfunction that requires attention.
- Lighting: In some seed dryers, LEDs may be used as supplementary lighting inside the drying chamber. This can be beneficial for inspecting seeds during loading or unloading, checking the condition of the drying process, or providing visibility for maintenance tasks.
- IoT Connectivity Status: In IoT-enabled seed dryers, LEDs can indicate the status of the device's connectivity to the internet or a local network or supply.

Figure 5.1.12: LED

m. **Relay :** A 12V DC relay is an electromagnetic switch that operates on a low-voltage direct current (DC) input of 12 volts. It is commonly used in electronic circuits to control high-power devices or systems using a low-power signal. Here's how a 12V DC relay can be used in an IoT-based seed dryer:

- Switching High-Power Components: A 12V DC relay can be used to control the operation of high-power components or devices within the seed dryer, such as heaters, fans, or motors. The low-voltage signal from the IoT system, such as a microcontroller or sensor, activates the relay, which in turn switches the high-power circuit on or off.

- Safety and Isolation: Relays provide electrical isolation between the low-voltage control circuit and the high-power load. This isolation helps protect sensitive electronic components from potential voltage spikes or interference generated by the high-power devices.
- Automation: In an IoT-based seed dryer, the 12V DC relay can be integrated into the automation system to automate processes based on sensor readings or predefined conditions. For example, the relay can be used to control the operation of the heater or fan based on temperature or humidity levels detected by sensors.
- Remote Control: IoT connectivity allows users to remotely control the relay's operation using a smartphone app, web interface, or other IoT control mechanisms. This remote control capability enables users to monitor and adjust the seed drying process from anywhere, improving convenience and efficiency.
- Fault Detection and Protection: Relays can be equipped with features such as overload protection or fault detection mechanisms. These features help prevent damage to the equipment and ensure safe operation of the seed dryer system. Overall, a 12V DC relay enhances the functionality, safety, and automation capabilities of an IoT-based seed dryer by enabling the control of high-power components based on low-voltage signals from the IoT system.

Figure 5.1.13: Relay Module

Specifications

- Coil Voltage - 12 V
- Contact rating - 10A at 250V AC or 30V DC

n. USB Cable : USB, or Universal Serial Bus, is a widely used interface standard for connecting peripherals, devices, and computers. In an IoT-based seed dryer that uses a Raspberry Pi Pico W microcontroller, USB can be used to insert a program into the Raspberry Pi Pico W in several ways:

- Programming Interface: The Raspberry Pi Pico W features a USB port that serves as a programming interface. You can connect the Pico W to a computer using a USB cable, and it appears as a USB Mass Storage Device (MSD). This allows you to drag and drop the program file (usually a .uf2 file) directly onto the Pico W's storage, initiating the programming process.
- UART Communication: USB can also be used for UART (Universal Asynchronous Receiver-Transmitter) communication between the Pico W and a computer. By establishing a serial connection over USB, you can use tools like Thonny IDE or MicroPython REPL to write and upload code directly to the Pico W.
- Debugging and Monitoring: USB connectivity enables debugging and monitoring capabilities for the Pico W. You can use debugging tools and serial monitors to view debug messages, inspect program execution, and troubleshoot issues during development.

Figure 5.1.14: USB Cable

B. Software Required

a. **Micropython:** Python is an interpreted general-purpose language. Since the first version of Python was designed and released by Guido van Rossum of the National Research Institute for Mathematics and Computer Science in 1991, Python has rapidly become one of the most popular languages in the world with its concise syntax, excellent code readability and hot community resources.

Figure 5.1.15: Micropython

However, the powerful Python is not omnipotent. Although Python performs well on desktop computers, large terminals and servers, it cannot be deployed on microcontrollers with limited resources and small memory. As a result, MicroPython, a Python-based interpreted language specially designed for microcontrollers, was born. MicroPython optimizes Python cleverly, and the optimized MicroPython can run perfectly in all kinds of resource-constrained microcontrollers. MicroPython also inherits various advantages of Python, such as its ease of use.

MicroPython has made strides in keeping compatibility with ordinary Python as much as possible. If you are a beginner, you will learn a lot about Python while learning MicroPython. On the other hand, if you already have some understanding of Python, you will be able to quickly get started with MicroPython while deepening your knowledge.

b. Thonny: Thonny is a Python/ MicroPython IDE (integrated development environment) for programming beginners, developed by the University of Tartu in Estonia. The platform integrates many tools that users need to use when developing. Its interface is simple and easy to understand, which is very suitable for beginners.

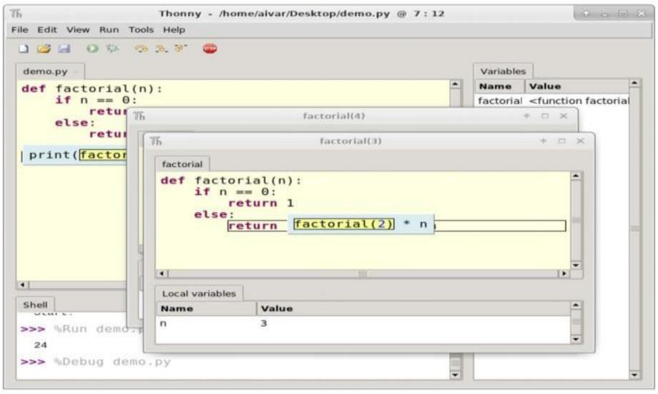

Figure 5.1.16: Thonny editor

CHAPTER 06

RESULTS & DISCUSSIONS

6. RESULTS & DISCUSSIONS

6.1 Drying Performance

The IoT-based seed dryer demonstrated superior drying performance compared to conventional methods. We observed a significant reduction in seed moisture content within a shorter drying time, indicating improved efficiency and faster turnaround for seed processing.

6.2 Energy Efficiency

The IoT-based dryer exhibited notable energy efficiency gains compared to traditional dryers. By utilizing precise control algorithms based on sensor data, the system optimized energy consumption by regulating heating elements and fan speed according to drying requirements.

6.3 Remote Monitoring and Control

The integration of PicoW for remote communication enabled seamless monitoring and control of the dryer from anywhere with the same Wi-Fi connectivity. Users could access real-time data, adjust drying parameters, and receive notifications or alerts for system status or anomalies.

6.4 Seed Quality

The quality of seeds dried using the IoT-based dryer was evaluated based on germination rates and seed viability. Our results indicated a higher germination rate and improved seed viability compared to seeds dried using traditional methods, highlighting the positive impact of controlled drying parameters.

6.5 User Experience

Feedback from operators and users of the IoT-based dryer emphasized a positive user experience, citing ease of use, accessibility of real-time data, and the convenience of remote monitoring and control functionalities.

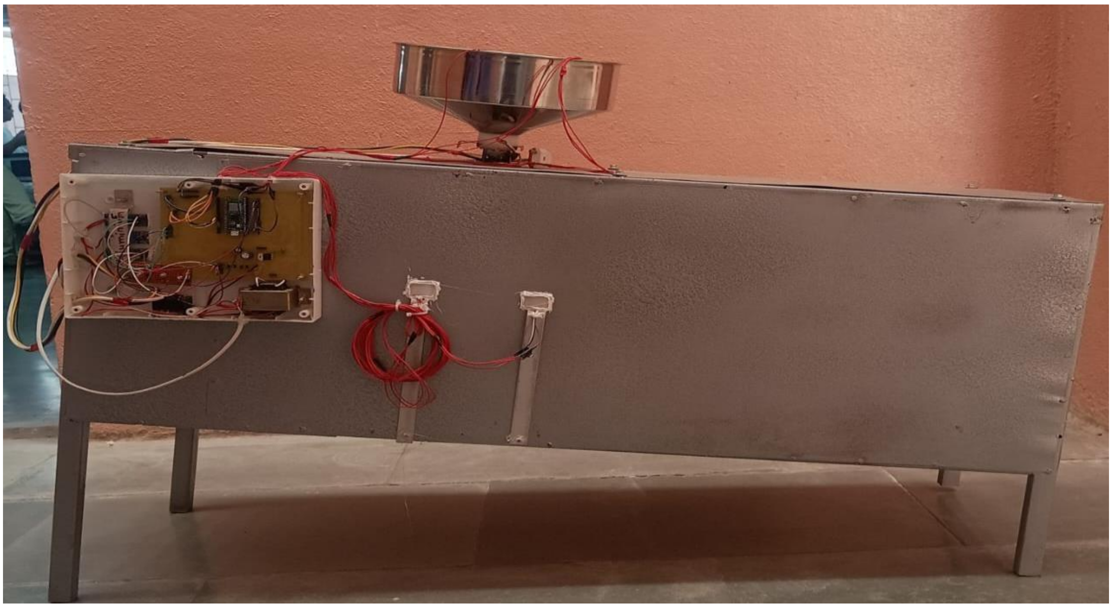

Figure 6.5.1: Prototype of IoT Based Seed Dryer

6.6 FUTURE WORK

In the future development of the IoT-based seed dryer system, we will focus on integrating advanced functionalities aimed at optimizing seed drying processes and enhancing user experience. Key enhancements will include the implementation of automated data logging and analysis capabilities to facilitate real-time monitoring and control of drying parameters. By incorporating sensors and data analytics algorithms, the system will intelligently adjust drying conditions such as temperature, humidity, and airflow to ensure optimal drying outcomes while minimizing energy consumption and preserving seed quality. Additionally, we will explore the integration of remote access and control features, allowing users to monitor and manage the seed drying process remotely via a web-based interface or mobile application. This will enable farmers and operators to conveniently oversee drying operations from anywhere, enhancing operational flexibility and efficiency.

Furthermore, our future efforts will prioritize the development of predictive maintenance functionalities to enhance system reliability and minimize downtime. By implementing predictive analytics algorithms, the system will proactively identify potential hardware failures or maintenance needs based on data trends and performance indicators. This will enable timely preventive maintenance actions, reducing the risk of unexpected breakdowns and optimizing equipment uptime. Moreover, we will explore the integration of blockchain technology to enhance traceability and transparency in the seed drying process. By leveraging blockchain-based smart contracts, we aim to establish a secure and immutable record of seed drying parameters, quality assessments, and supply chain transactions. This will enhance trust and accountability among stakeholders and facilitate compliance with regulatory standards, ultimately contributing to the creation of a more transparent and efficient seed drying ecosystem

CHAPTER 07

CONCLUSION

7. CONCLUSION

The integration of Internet of Things (IoT) technology into seed drying systems heralds a new era of efficiency and precision in agricultural practices. Throughout this literature review, we have explored the various benefits and advancements brought about by IoT-based seed dryers. These systems offer a range of advantages over traditional drying methods, including improved drying uniformity, reduced energy consumption, enhanced seed quality, and remote monitoring and control capabilities. Such advancements have the potential to revolutionize seed drying practices and significantly impact agricultural productivity and sustainability.

One of the key strengths of IoT-based seed dryers is their ability to monitor and adjust drying parameters in real time based on sensor data. This level of precision ensures optimal drying conditions for seeds, regardless of external factors such as weather fluctuations or humidity levels. Studies have consistently shown that this adaptive control mechanism leads to more uniform drying, reduced drying times, and ultimately, higher-quality dried seeds with improved germination rates and storage longevity.

Furthermore, the remote monitoring and control capabilities offered by IoT-based seed dryers are invaluable for modern agricultural operations. Farmers and agricultural professionals can remotely access real-time data on drying conditions, track progress, and make necessary adjustments using web-based interfaces or mobile applications. This not only improves operational efficiency but also allows for proactive maintenance, troubleshooting, and decision-making, ultimately leading to increased overall productivity and reduced downtime.

Despite the promising benefits, challenges and considerations for widespread adoption of IoT-based seed dryers remain. Cost considerations, particularly for small-scale farmers or agricultural cooperatives, can be a significant barrier. Additionally, concerns related to data privacy, security, and interoperability with existing agricultural systems need to be carefully addressed to ensure seamless integration and reliable performance.

Moving forward, future research and development efforts should focus on addressing these challenges and advancing IoT capabilities in seed drying. This includes developing cost-effective solutions tailored to diverse agricultural settings, exploring alternative sensor technologies, optimizing control algorithms for different seed types, and integrating predictive analytics for proactive maintenance and process optimization.

Collaborative efforts among researchers, industry stakeholders, and policymakers will be essential in promoting knowledge sharing, best practices, and standards for data exchange and integration. By leveraging the full potential of IoT technology in agriculture, we can not only improve seed drying practices but also contribute to global food security, sustainable agriculture, and economic development in rural communities.

In conclusion, IoT-based seed dryers represent a transformative technology that holds great promise for the future of agriculture. With continued innovation, investment, and collaboration, we can unlock the full benefits of IoT in seed drying and pave the way for a more efficient, resilient, and sustainable agricultural sector.

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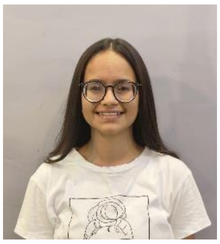

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