INDUSTRIAL GRADE MICROSCALE AUTO-TITRATOR

A PROJECT REPORT

Submitted in partial fulfillment of the requirement for the course of

ECE3003 – Microcontroller and it's applications

of the Degree of

BACHELOR OF TECHNOLOGY
IN
ELECTRONICS AND COMMUNICATION ENGINEERING

by

Thirumalai Srinivasan G (20BEC1155)

Under the Guidance of

DR. A. SIVASUBRAMANIAN

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Vellore Institute of Technology
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SCHOOL OF ELECTRONICS ENGINEERING
VELLORE INSTITUTE OF TECHNOLOGY
CHENNAI - 600127

May 2022

CERTIFICATE

This is to certify that the Project work titled "**INDUSTRIAL GRADE MICROSCALE AUTO-TITRATOR**" that is being submitted by ***Thirumalai Srinivasan G (20BEC1155),*** is in partial fulfillment of the requirements for the course of ECE3003 – Microcontroller and it's applications of **Bachelor of Technology in Electronics and Communication Engineering**, is a record of bonafide work done under my guidance. The contents of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

Guide

The Project Report is satisfactory / unsatisfactory

Internal Examiner **External Examiner**

Approved by

Head of the Department
B. Tech. (ECE)

DEAN
School of Electronics Engineering

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Thirumalai Srinivasan G
20BEC1155

Abstract

Chemists are now looking again at automation to reduce the monotonous process of synthesis. For example, flow chemistry is a promising technique in which the reaction is not in a single container, but in a channel where a constant flow of reactants is pumped. Automating reactions designed to work on a small scale makes them "large and fully reproducible."

A culture-dependent approach to the study of prokaryotic species significantly underestimates the diversity of bacterial communities, as most prokaryotic species cannot be easily cultured in the laboratory. Culture-independent approaches such as sequencing have been used to analyze non-culturable microorganisms without isolation.

Our device is going to be a solution for all the problems in chemical laboratory including culturing new type of bacteria.

Basically, our device is a device that can be used for titration, cell culture, bacterial growth and suspension, staining and washing procedures. Suppose everything is scaled small. This type has low-speed to high-speed circular shaking motion with less vibration and is ideal for culturing microorganisms. An automatic titrator that can be used as a shaking incubator with temperature control and edge computing monitoring system.

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1. INTRODUCTION

Chemists are now again turning to automation to reduce the monotonous process of synthesis. Flow chemistry, for example, is a promising technology in which reactions take place in channels with a constant flow of reactants pumped through them rather than in a single vessel.

When you automate a reaction that was designed to operate on a small scale, it becomes "completely repeatable on a huge scale."

The goal is not to create a mindless worker bee, Cooper says. The robot has an algorithm that will instantaneously determine its next step or action, on the basis of an iterative process that relates chemical composition to the catalytic activity, thus allowing the prediction of material compositions that are better than any studied so far. This, he says, is very different from how a human would approach the problem. “It’s selection, it’s not design.”

Culture-dependent approaches to research prokaryotic species drastically underestimate the variety of bacterial communities since the vast majority of prokaryotic species cannot be easily cultivated in the laboratory. Culture-independent approaches such as sequencing have been used to analyses unculturable microorganisms without isolating them. Recently, next-generation sequencing tools have made it possible to identify and describe whole bacterial populations in a single sequencing run.

Basically, our device is an equipment which can be used for , titration, cell culture, bacterial growth and suspension, staining and washing procedures. Provided everything is scaled small. Our equipment has a circular shaking motion with low to high speed with less vibrations, ideal for culturing microbes.

It is an Auto-titrator which can be used as shaking incubators with temperature control and Edge computing monitoring system.

1.1 MOTIVATION

Due to the unanticipated COVID-19 epidemic, educational institutions were obliged to switch to a remote or distance-learning mode. As a result, lessons were given online, which posed significant obstacles, particularly in the teaching of laboratory courses. Automated chemistry has risen in importance for many businesses since the outbreak began. From automating reaction conditions to deploying robots to manipulate reagents and carry out whole reactions, automation may be used in practically any form of chemistry at any scale.

The ultimate goal for medicinal chemists is to automate the whole workflow, from design to synthesis to assaying and analysis - also known as the DMTA cycle (design, make, test and analyze).

Automation has other benefits besides speed. ‘ Increased productivity, yields, product purity, rejections, waste, and disposal costs are all advantages.

By enabling more control over response circumstances, automating reactions can improve safety. Processes that are automated are also more repeatable. 'In the pharmaceutical sector, that is really crucial. It allows them to scale up their operations more easily.'

We were already working in an NDA signed project involving chemical reactions and we needed such product for our working.

1.2 LITERATURE REVIEW

1.2.1 Orbital shaker technology for the cultivation of mammalian cells in suspension

Authors : Natalie Muller,Philippe Girard,David L. Hacker,Martin Jordan,Florian M. Wurm

First published: 23 December 2004

For large-scale applications in biotechnology, cultivation of mammalian cells in suspension is an essential prerequisite. Typically, suspension cultures are grown in glass spinner flasks filled to less than 50% of the nominal volume. We propose a superior system for suspension cultures of mammalian cells based on orbital shaker technology. We found that "square-shaped" bottles (square bottles) provide an inexpensive but efficient means to grow HEK-293 EBNA and CHO-DG44 cells to high density. Cultures in agitated 1-L square bottles exceeded the performance of cultures in spinner flasks, reaching densities up to 7×10^6 cells/mL for HEK-293 EBNA cells and 5×10^6 cells/mL for CHO-DG44 cells in comparison to $(2.5–4) \times 10^6$ cells/mL for cultures of the same cells grown in spinner flasks. For 1-L square bottles, optimal cell growth and viability were observed with a filling volume of 30–40% of the nominal volume and an agitation speed of 130 rpm at a rotational diameter of 2.5 cm. Transient reporter gene expression following gene delivery by calcium phosphate–DNA co-precipitation was the same or slightly better for HEK-293 EBNA cells grown in square bottles as compared to spinner flasks. Reductions in cost, simplified handling, and better performance in cell growth and viability make the agitated square bottle a new and very promising tool for the cultivation of mammalian cells in suspension.

1.2.2 Understanding mechanobiology in cultured endothelium: A review of the orbital shaker method

Author Christina M.Warboys[1]MeanGhim[1]Peter D.Weinberg

A striking feature of atherosclerosis is its highly non-uniform distribution within the arterial tree. This has been attributed to variation in the haemodynamic wall shear stress (WSS) experienced by endothelial cells, but the WSS characteristics that are important and the mechanisms by which they lead to disease remain subjects of intensive investigation despite decades of research. *In vivo* evidence suggests that multidirectional WSS is highly atherogenic. This possibility is increasingly being studied by culturing endothelial cells in wells that are swirled on an orbital shaker. The method is simple and cost effective, has high throughput and permits chronic exposure, but interpretation of the results can be difficult because the fluid mechanics are complex; hitherto, their description has largely been restricted to the engineering literature. Here we review the findings of such studies, which indicate that putatively atherogenic flow characteristics occur at the center of the well whilst atheroprotective ones occur towards the edge, and we describe simple mathematical methods for choosing experimental variables that avoid resonance, wave breaking and uncovering of the cells. We additionally summarize a large number of studies showing that endothelium cultured at the center of the well expresses more pro-inflammatory and fewer homeostatic genes, has higher permeability, proliferation, apoptosis and senescence, and shows more endothelial-to-mesenchymal transition than endothelium at the edge. This simple method, when correctly interpreted, has the potential to greatly increase our understanding of the homeostatic and pathogenic mechanobiology of endothelial cells and may help identify new therapeutic targets in vascular disease.

1.2.3 Shaker Agitation Rate and Orbit Affect Growth of Cultured Bacteria

Authors: Mary Kay Bates; David S. Phillips and Janet O'Bryan, Thermo Fisher Scientific

Bacteria are grown in flasks on rotating shakers for many reasons, including production of non-native proteins and genetic material for research applications. The microbial growth can be affected by many variables, chief among these being temperature and aeration controlled by the mechanical orbital shaker. This article focuses on the shaking parameters and how to modify them for different shaker characteristics, including orbit diameter and rotation speed. We provide a conversion formula that allows convenient transition from one shaker with a specific orbit and speed to another shaker with a different orbit and speed.

1.3 OBJECTIVE

To Build an Auto-titrating equipment with inbuilt thermal incubator that can be used for titration, cell culture, bacterial growth and suspension, staining and washing procedures . We call it AT051

Our gadget should be a laboratory equipment that may be used for titration, cell culture, bacterial growth and suspension, staining, and washing. Assuming that everything is scaled down. Our equipment offers a low to high-speed circular shaking action with low vibrations, which is suitable for growing bacteria.
It's an auto-titrator with temperature control and an Edge computing monitoring system that may be used as shaking incubators.

1.4 NEED AND IMPACT.

To analyze the need and impact we need to see the impact of its objectives.

1.4.1 The Importance of Cultivating Unculturable Bacteria

Bacteria create a large number of new compounds, and bacteria-derived natural products account for half of all commercially accessible medications. As a result, unculturable bacteria represent a mostly untapped source of chemicals like antibiotics. Many bacteria species, including those found in the gut and those that are harmful, have yet to be cultivated in the laboratory. Isolation of unculturable bacteria will pave the path for their biotechnological potential to be realized, as well as a better understanding of their environmental functions.

1.4.2 Why Can't Most Bacteria Be Cultivated?

Although it may appear that cultured unculturable bacteria is an oxymoron, it is realistic to believe that they may be retrieved from the environment under growth-promoting circumstances...once these conditions are understood. In reality, "yet to be cultured bacteria" is a better term for unculturable bacteria. Bacteria cannot be cultivated using traditional procedures for a variety of reasons. Because certain bacteria are rare and grow slowly, they may be overlooked during routine microbiological cultivation. Others are picky, with precise growth conditions that must be fulfilled to the letter. Microbial competition and chemicals generated by other bacteria can also hinder bacterial development.

In short, most difficult task is either the time taken and Manual analysis or process activation as it may go for hours. And even if manual analysis or process is carried out , it is vulnerable to many humanly errors due to tiredness or mental saturation.
Application

The AT051 shakes in a circular motion at a modest pace (25-500 rpm). It's great for cultivating bacteria, washing blots, and mixing in general. Its features include the absence of vibrations and minimal heat production when compared to other types of shakers, making it excellent for growing bacteria. Due of its low temperature and vibrations, it may also be changed by placing it in an incubator to produce an incubator shaker.

The AT051 is a hybrid of an incubator and a shaker. It has the ability to shake while maintaining ideal incubation conditions for bacteria or DNA replication. This apparatus is extremely beneficial since, in order for a cell to thrive, it requires oxygen and nutrients, both of which require shaking in order to be distributed equally throughout the culture.
An orbital shaker is suited for general-purpose shaking applications such as cell culture, bacterial growth and suspension, staining, and washing. This sort of

shaker has a circular motion with low to high speed and low vibrations, making it suitable for growing bacteria.

An orbital shaker produces a gradual, circular shaking action. It's great for cultivating bacteria, washing blots, and mixing in general. What is the throw of an orbital shaker?

When it comes to cell culture, orbital shakers are utilized in a variety of ways. The major goal is to increase the culture's aeration. The settings, like centrifuges, have a significant influence on the performance and, ultimately, the quality of your samples. The shaker orbit, in addition to the shaking speed, is a crucial influencing element.

Anyone utilizing an Auto-titrator in the lab to grow yeast or bacteria should be aware that the pace at which oxygen diffuses from the gaseous phase into the shaken liquid phase is too sluggish to keep up with the rate at which oxygen is utilized by E. coli dividing every half hour or S cerevisiae dividing every hour, for example. If the investigator measures the oxygen in the shake flask on the shaker — polarographically, for example — at mid-exponential phase of development, the dissolved oxygen concentration in the shake flask on the shaker will be zero.

2. INDUSTRIAL GRADE MICROSCALE AUTO-TITRATOR

2.1 METHODOLOGY :

The AT051 is a mix of a shaker and an incubator. It has the capacity to shake while maintaining appropriate bacteria incubation conditions. This equipment is incredibly useful since a cell requires oxygen and nutrients, both of which must be shaken evenly throughout the culture in order for them to be dispersed evenly.

Cell culture, bacterial growth and suspension, staining, and washing are among applications that can benefit from an orbital shaker. This type of shaker has a circular motion, low to high speed, and low vibrations, which makes it ideal for bacteria growth.

- First, we designed CPU architecture of the device:
- Then we designed the Casing and enclosure
- Then we Designed the Software, IOT computation.

2.1.1 FLOW OF WORK

- Fixing up the Hardware
- Once there are no issues with proposed Hardware with the subject norms, we are good to go
- Preparing the STL files STL files will be sliced for building the prototype
- Building Electronics of Prototype to be built using Dot board or breadboard

2.2 HARDWARE SPECIFICATIONS:

We have used:

- **8051 - Microcontroller**
- **Motor driver IC - L293D**
- **Temperature monitoring Module**
    - **Temperature Module w1209**
- **Display interface –**
- **LCD**
- **Stepper Motor – 1.7 A – 4.2KG**
- **Custom Built 3d Body**
- **Ball bearings and Screws**
- **IOT engine**
- **7805 5v regulator**

2.3 SOFTWARE USED:

- Keil :

  Keil development tools for the 8051 Microcontroller Architecture support every level of software developer from the professional applications engineer to the student just learning about embedded software development.
- AutoCAD
- SolidWorks
- Fusion 360

2.4 WORKING

First, the data pins of the LCD are connected to the PORT0 Pins of 8051. Since PORT0 doesn't have any internal pullup, a resistor pack is used to pull the PORT0 up. The RS and E Pins of LCD are connected to P2.0 and P2.1 of 8051. The RST Pin is pulled do wn using a 10KΩ resistor. The combination of a Push Button and a 10μF Capacitor will be used to reset the microcontroller. Also, the EA Pin is pulled a 10KΩ resistor. Next, the oscillator. It consists of two 33pF Capacitors and an 11.0592 MHz Cry connected between XTAL1 and XTAL2 Pins of 8051.up using stal Coming to the Motor Driver, the two enable pins and two supply pins are connected to +5V supply. The four inputs are connected to PORT1 pins of 8051: P1.0, P1.1, P1.2 and P1.3. The four pins of the Bipolar Stepper Motor are connected to the four out pins of L293D. Three buttons are connected to PORT3 pins i.e., P3.0, P3.1 and P3.2. To control the direction of the Stepper Motor.

We have employed a H-Bridge. To avoid difficulties caused by back emf, freewheeling or clamp diodes should be employed. As a result, transistors, diodes, and resistors are required, potentially making our circuit big and complex to put together.

The L293D driver IC is utilized to solve this problem. It's a Quadruple Half H-Bridge driver, and it entirely addresses the problem. There are no transistors, resistors, or diodes to connect. Using a microcontroller, we can simply control the switching of L293D. In this category, there are two ICs: L293D and L293. From 4.5V to 36V, the L239D can deliver a maximum current of 600mA, whereas the L293 can deliver up to 1A under the same circumstances.

The L293D driver IC is utilized. It's a Quadruple Half H-Bridge driver that entirely resolves the issue. Transistors, resistors, and diodes do not need to be

connected. Using a microcontroller, we can simply control the L293D's switching. L293D and L293 are the two ICs that fall within this group. From 4.5V to 36V, the L239D can deliver up to 600mA, whereas the L293 can deliver up to 1A.

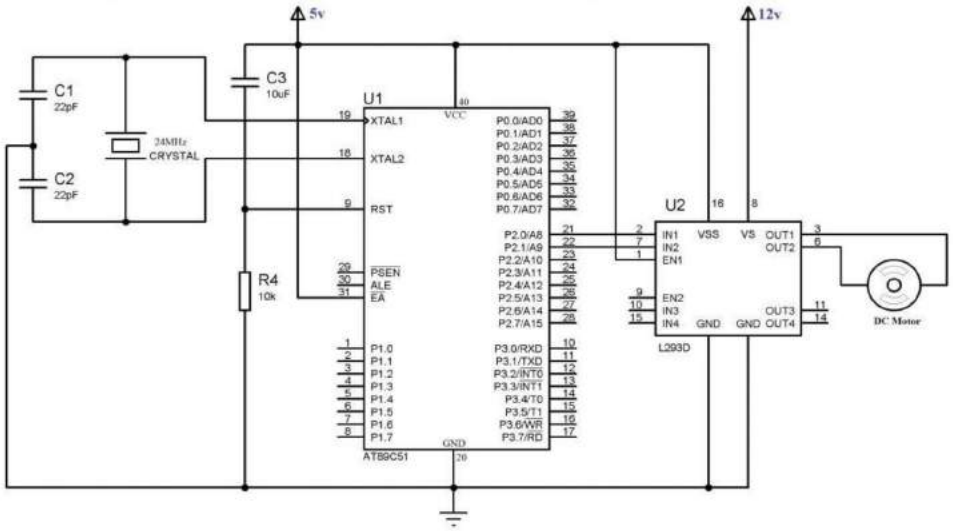


Fig 2.4 1 – Reference Circuit

2.4.1 Temperature Incubation:

W1209 Temperature Controller Module XH-W1209 Red Digital Display Thermostat Cooling/Heating Module DC 12V with 30cm Waterproof -50~110°C NTC Probe

- MCU controller The W1209 thermostat module has a MCU controller, a sensor input, keys, LED display and a relay. It can be reprogrammed for control, timing, or counting.
- Heating / Cooling Work Mode Heating: Startup Temperature < Desired Temperature; Cooling: Startup Temperature > Desired Temperature. Range from -50°C to 110°C. Temperature control precision is 0.1°C.
- High brightness digital display - 3-digit display with high brightness, highly recognizable and easily control equipment and devices.

- Waterproof Insulated Prob - With 30CM NTC10K waterproof probe is equipped for convenient usage. The NTC probe is allows to control the temperature even of fluids, allowing the controlled heated or cooling.

Fig 2.4.2 – W1209 -Circuit

We use this Temperature module for maintaining Incubation temperature which switches the device ON only when sensed with set temperature width.

We use DHT11 for chamber and vial temperature sensing and send to IOT.

We plan to collect temperature and humidity data from the surrounding area with this weather station. We utilize a DHT11 sensor module to measure those two parameters for this purpose. The sensor's output data should be sent into a microcontroller with a WIFI adapter to connect to the internet. The DHT11 sensor module connects to the Esp32 development board with ease, WIFI connection is already built-in to connect to the Internet. We upload the sensor data to the cloud platform after obtaining it to the microcontroller, where we may develop a customized interface to see the data. The Blynk application is used for this purpose.

Blynk is an Internet of Things platform with a free cloud, applications, and digital dashboard where you can drag and drop widgets to create a graphic interface for your project. It also works with a variety of processors, including Arduino, Esp32, and others

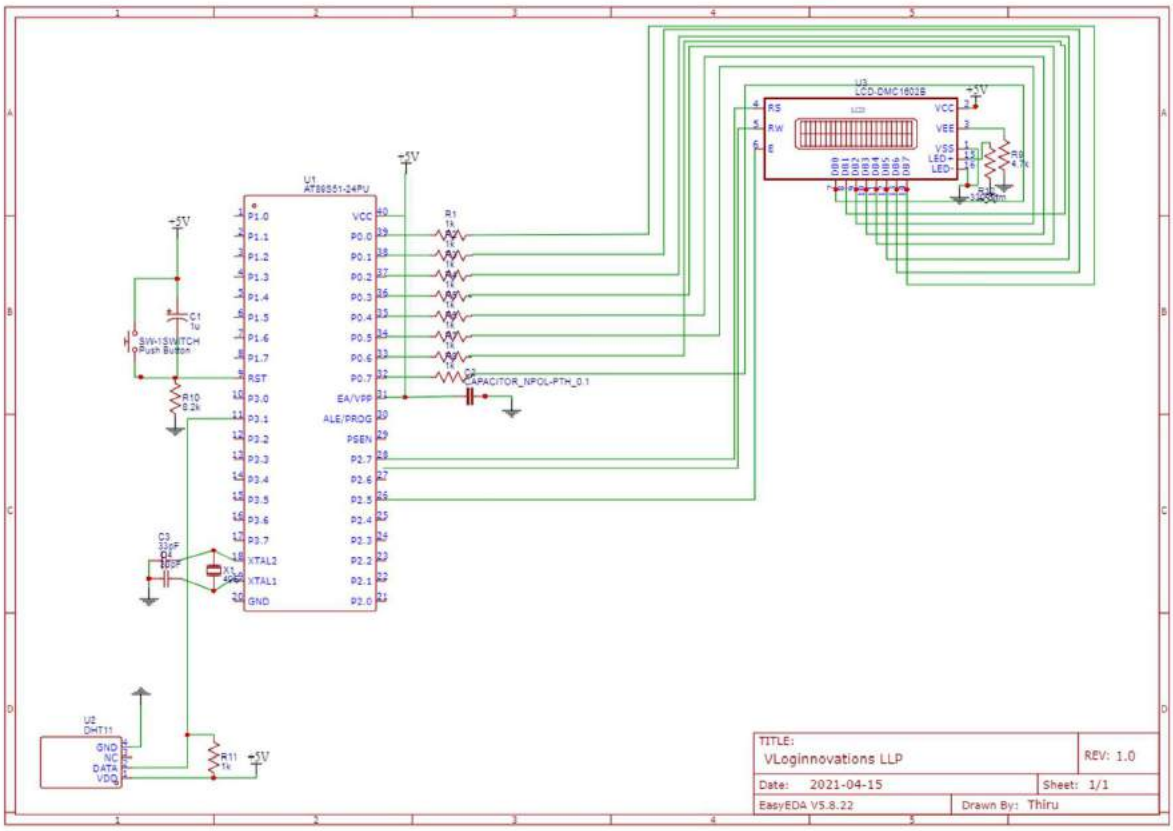
DHT11 or DHT22

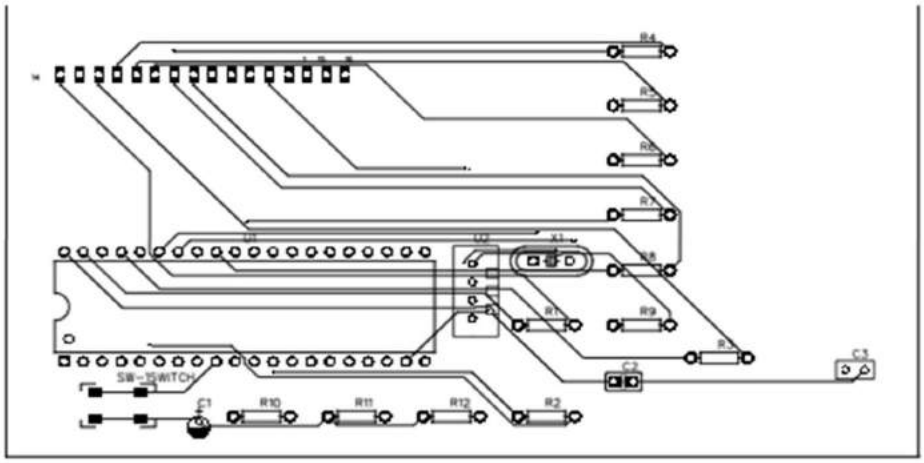
DS18b20

ESP32

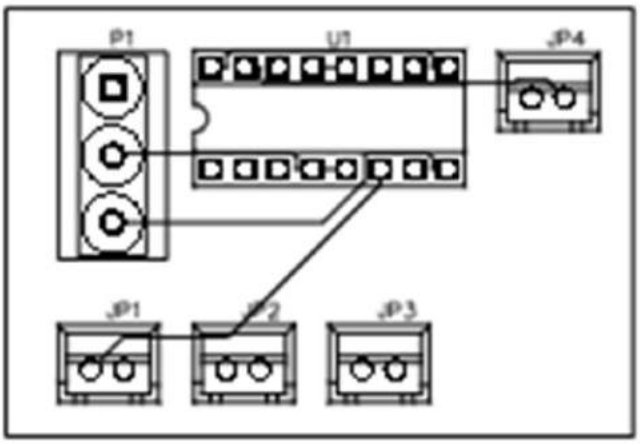
Blynk App

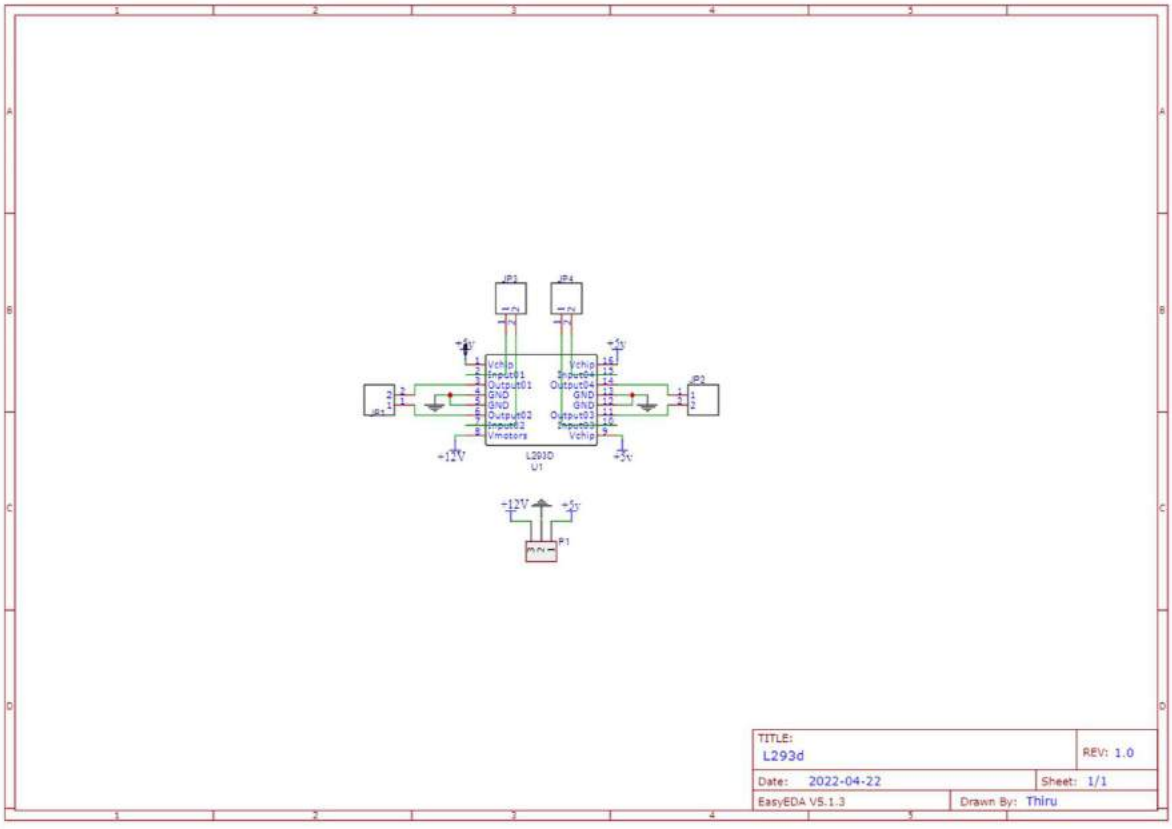
2.5 Circuit Diagrams and PCB designs





8051 with LCD





Motor Driver -L293d

3. IMPLEMENTATION

In our project, the functioning is going to be based on 8051. The power input to 8051 is going to be controlled by W2019 Temperature module being safety guard technology as every degree Celsius temperature makes huge difference. The information about functioning of the Device can be inferred through an LCD display.

We use Stepper motor for the orbital motion of the device and which is integrated through L293d as mentioned before. Here we integrate ESP8266-01 with our device so that we can implement IOT based communication and inference tracking.

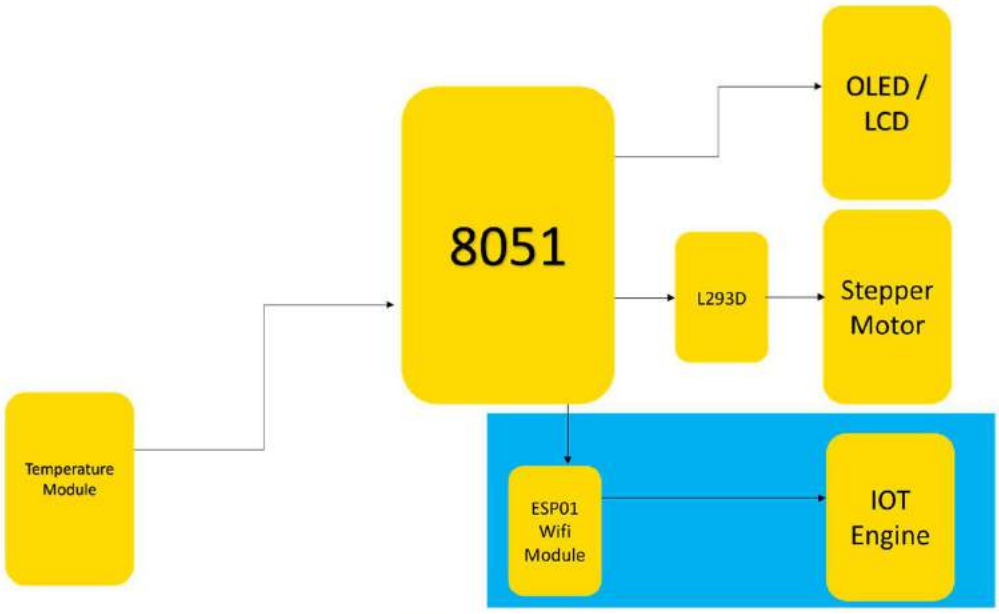


Fig 3 1 Block Diagram

The AT051 is a device that combines the functions of a shaker and an incubator. It may shake while keeping the bacteria incubation conditions correct. This piece of equipment is extremely essential since a cell requires oxygen and nutrients, all of which must be shaken uniformly throughout the culture in order to be evenly spread.

3.1 3D DESIGNING AND EXECUTION

Prototypes may now readily come to life on a computer screen thanks to developments in design and 3D CAD software. Modern workflows have brought in a new breed of deeply featured apps, redefining what can be created in a given amount of time. Many flaws connected with outmoded techniques have been addressed by 3D modelling, which has boosted functionality across design teams. Let's look at some of the ways that 3D modelling and 3D CAD tools have revolutionized the design process.

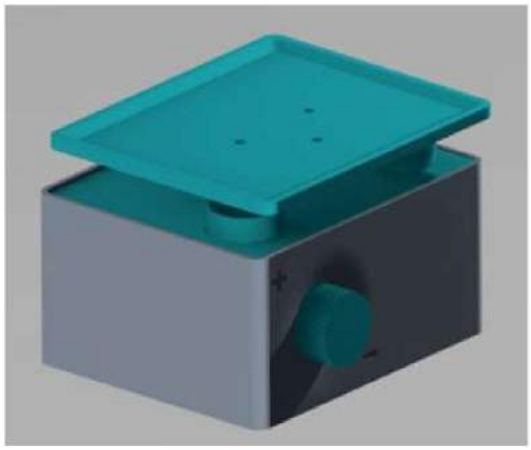


Fig 3.1 1 - Rendered image of the assembly

3.1.1 WHY 3D PRINTING?

Concepts come to life thanks to modern 3D modelling. Designers may alter and study their models from all angles. I am no longer limited to "flat" design, making it much easier to test changes without investing time and money. Simpler Detection of Flaws

When I can apply extra layers (and tests) to ideas, detecting design flaws becomes considerably easier.

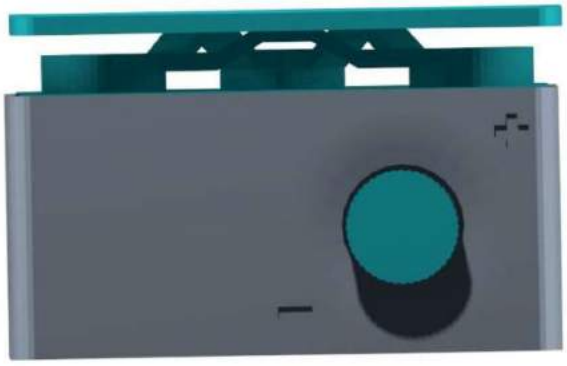


Fig 3.1 2-Frontal view

3.1.2 EASE OF USE AND PRODUCTIVITY

Digital design makes it simple to make a variety of modifications to each iteration with only a few clicks, selections, or toggles. The enhanced visibility provided by 3D modelling allows the user to see these modifications from all angles, making it simple to check physical changes, functional adjustments, and aesthetic refinements. Traditional designs are inconvenient and time-consuming to create, while 3D modelling allows for the creation of updated versions in less than 15 minutes. Leading 3D design systems' great user-friendliness minimizes the software learning curve, keeping teams nimble and saving training time.

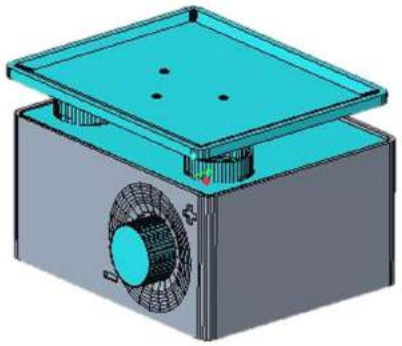


Fig 3.1 3 – Sketch of the whole assembly design

3.1.3 UNPRECEDENTED ACCURACY AND DETAIL

3D models allow teams to create any form they want while yet maintaining manufacturing capacity, allowing concepts to come together quickly. Modern 3D modelling allows for design depth that is not possible with crude drawings or 2D designs, such as enhanced detail control. It also allows engineers to investigate the physical characteristics of a design without being bound by physical constraints.

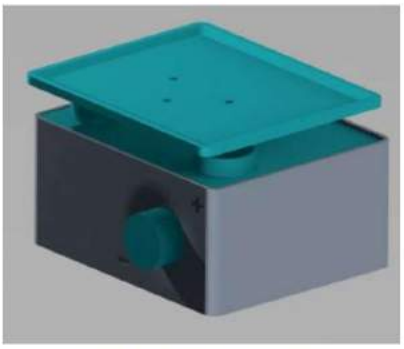


Fig 3.1 5- Rendered Image 2

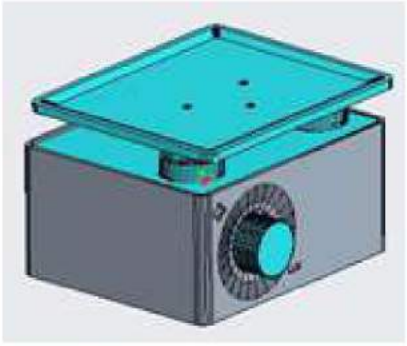


Fig 3.1 4 – Sketch Diagram 2

3.2 TECHNICAL SPECIFICATIONS

- **8051 – Microcontroller**

  Intel created the 8051 microcontrollers in 1981. It's a microcontroller with an 8-bit resolution. It has a 40-pin DIP (dual inline package) with 4KB of ROM and 128 bytes of RAM and two 16-bit timers. It has four parallel 8-bit ports that may be programmed and addressed to meet the needs of the user. The microcontroller has an on-chip crystal oscillator with a crystal frequency of 12 MHz

- **Motor driver IC - L293D**

  Quadruple Half-H Drivers

  The L293D is **a 16-pin Motor Driver IC which can control a set of two DC motors simultaneously in any direction**. The L293D is designed to provide bidirectional drive currents of up to 600 mA (per channel) at voltages from 4.5 V to 36 V (at pin 8!). You can use it to control small dc motors - toy motors.

- **Temperature monitoring Module**
  - **Temperature Module w1209**

  The W1209 is an incredibly low cost yet highly functional thermostat controller. With this module you can intelligently control power to most types of electrical device based on the temperature sensed by the included high accuracy NTC temperature sensor. Although this module has an embedded microcontroller no programming knowledge is required. 3 tactile switches allow for configuring various parameters including on & off trigger temperatures. The on-board relay can switch up to a maximum of 240V AC at 5A or 14V DC at 10A. The current

temperature is displayed in degrees Centigrade via its 3-digit seven segment display and the current relay state by an on-board LED.

- **Display interface –**
  - **LCD**
- **Stepper Motor – 1.7 A – 4.2KG**
- **NEMA17 4.2 kg-cm Single Shaft Stepper Motor**

  Nema17 4.2 kg-cm Single Shaft Stepper motor can provide 4.2 kg-cm of torque at 1.7A current per phase. The stepper motors move in precisely repeatable steps; hence they are the motors of choice for the machines requiring precise position control.

The motor's position can be commanded to move or hold at one position with the help of Stepper Motor Drivers. The Nema17 4.2 kg-cm Stepper motor provides excellent response to starting, stopping and reversing pulses from stepper motor driver.

They are very useful in the various application, especially which demands low speed with high precision. Many machines such as 3D Printers, CNC Router and Mills, Camera Platforms, XYZ Plotters etc.

It is a brushless DC motor, so the life of this motor is dependent upon life of the bearings. The position control is achieved by a simple Open Loop control mechanism so doesn't require complex electronic control circuitry.

The motor's shaft has been machined for good grip with a pulley, drive gear etc. and especially avoiding stall or slip.

Single Shaft Nema17 4.2 kg-cm at 1.7A current per phase, a stepper motor may provide 4.2 kg-cm of torque. Because stepper motors travel in exactly repeatable steps, they are ideal for devices that require precise position control.

With the use of Stepper Motor Drivers, the position of the motor may be ordered to move or stay in one place. The Nema17 4.2 kg-cm Stepper motor responds quickly to stepper motor driver pulses for starting, halting, and reversing.

They are extremely helpful in a variety of applications, particularly those that need low speed and great precision. Many devices are available, including 3D printers, CNC routers and mills, camera platforms, and XYZ plotters, among others.

- **Custom Built 3d Body**

  We have Built our own 3D model for each physical section , casing and connecters.

  I used An Ender creality Printer and a custom-built 3D printer running on marlin firmware for this project.

  Inspiration design is from open-sourced website, reference provided.

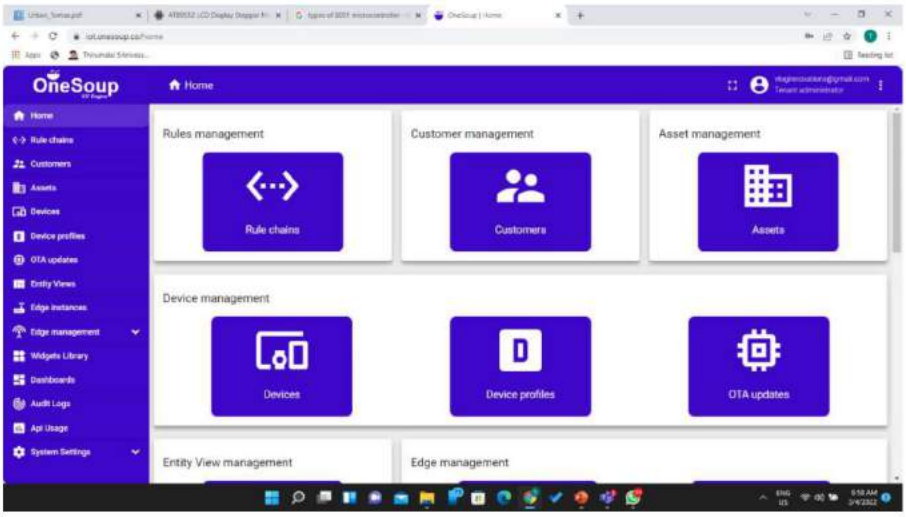
- **Ball bearings and Screws**

608ZZ	bearings	(x5)
3mm	bolts	(x3)
3mm	nuts	(x3)
3mm screws		(x3)

- **IOT engine**

  We have used Custom built IOT engine of VLoginnovations LLP.

  For prototyping we worked on Blynk.cc platform.



4. CONCLUSION

Our device is a laboratory instrument capable of titration, cell culture, bacterial growth and suspension, staining, and cleaning. Assuming that everything has been reduced in size. Our equipment has a low-to-high-speed circular shaking motion with mild vibrations that is ideal for bacteria growth.

4.1 Result and Outcome

Fig 4.1 1 – 8051 based Orbital rotation mechanism checked at VIT Microcontrollers Laboratory

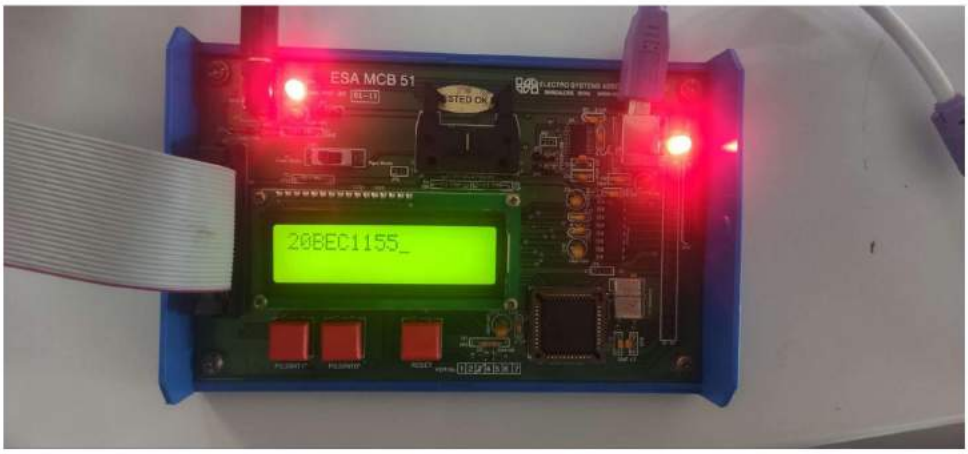


Fig 4.1 2 – LCD interfacing and testing

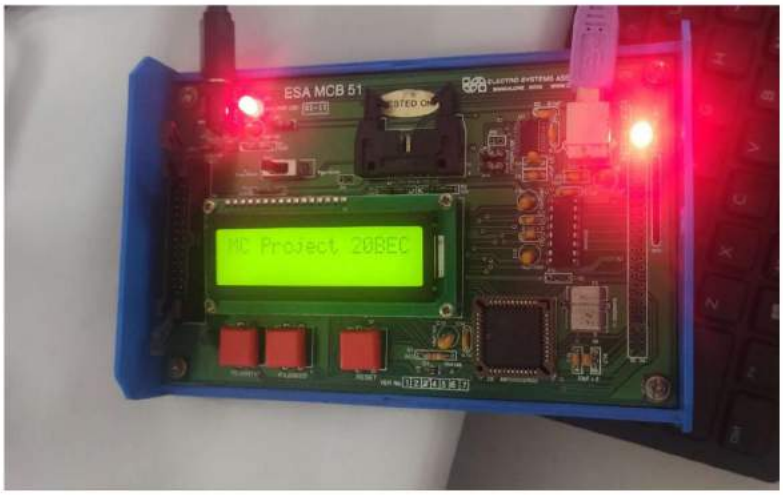


Fig 4.1 3 - LCD interfacing

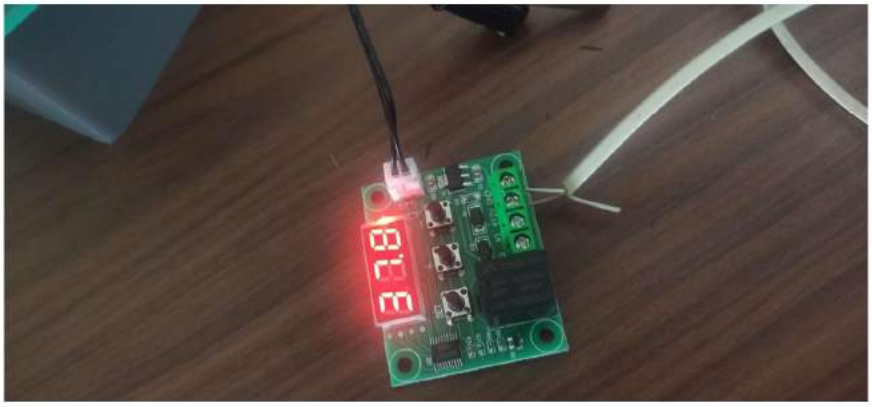


Fig 4.1 4 – Incubation Temperature - Mode -2 (Above Threshold)

Condition – Threshold set at 36.5

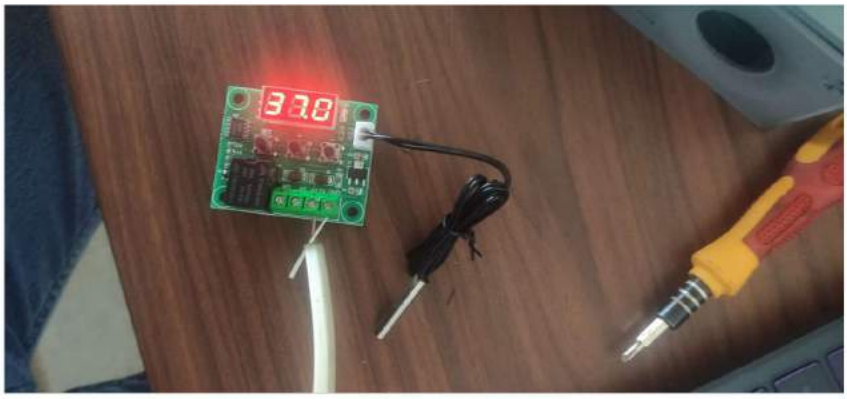


Fig 4.1 5 - Incubation Temperature - Mode -2 (Above Threshold)

Condition – Threshold set at 38.5

Fig 4.1 6 – IOT output Dashboard

4.2 Future Scope

Orbital Shakers market provides industry size estimation with top manufacturers data, production and supply, consumption and demand it also includes key raw materials analysis, industry trends, future opportunities

Market Analysis and Insights: Global Orbital Shakers Market. The global Orbital Shakers market was valued at USD million in 2020 and it is expected to reach USD million by the end of 2027, growing at a CAGR during 2021-2027.

An orbital shaker is ideal for a variety of general-purpose shaking applications in cell culture, bacterial growth and suspension, staining and washing procedures. This type has a circular shaking motion with low to high speed with less vibrations, ideal for culturing microbes.

This can be further built over with real time tracking system using data driven robotics. Ex. We can analyze the samples kept for many hours and get values of every factor like temperature, turbidity, viscosity etc.

We have now completed the project making taking only temperature into consideration.

This device can be used for complex Bio chemical application which can be improvised in every other factor including speed or dimension analysis providing the best suitable factors.

This product is now used for testing as a part a project w, in a project with NDA signed.

5. REFERENCES

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