DESIGN AND DEVELOPMENT OF AN IOT-INTEGRATED LEAD SCREW DRIVEN SCISSOR LIFT MECHANISM

Mohan Arumugam, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, Tamil Nadu, India – 641004 (amn.mech@psgtech.ac.in)* ,
Bharath. V, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, Tamil Nadu, India - 641004
Naveen S, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, Tamil Nadu, India - 641004
Vimalan. JK, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, Tamil Nadu, India - 641004

ABSTRACT:
The impedance tube test setup is widely used to analyse the acoustic properties of materials, particularly sound absorption and transmission loss. However, present methods for resonator placement and testing are time-intensive and inefficient, requiring manual adjustments by inserting blocks. To address this limitation, a scissor lift mechanism-based fixture has been developed to streamline the testing process by reducing setup time and enhancing flexibility for accommodating various resonators. The proposed fixture features adjustable height control, ensuring precise and airtight placement of specimens within the impedance tube. The system employs a lead screw-based actuation mechanism, enabling controlled movement with minimal effort. The structure, fabricated from mild steel, provides durability while maintaining ease of operation. The implementation of this fixture optimizes testing efficiency by significantly reducing specimen installation time. Additionally, it supports a broader range of resonator dimensions, overcoming the limitations of previous placing methods. By incorporating IoT-enabled automation, this system enhances efficiency.
Keywords
Impedance tube, Acoustic testing, Scissor lift fixture, Lead screw mechanism, IoT-based automation, Sound absorption, Transmission loss.

INTRODUCTION:
Impedance tube testing is a standard method for determining the acoustic properties of materials, including sound absorption coefficients and transmission loss. Current setups require manual placement and adjustment of resonators, which are time-consuming and can lead to inconsistent test conditions. The demand for automated and efficient solutions has led to the development of an IoT-enabled scissor lift mechanism-based fixture, designed to reduce the setup time. This study proposes an automated fixture with a lead screw-based scissor lift mechanism, which provides controlled height adjustment for precise resonator positioning. The integration of IoT-based monitoring and control further enhances usability by enabling remote adjustments and real-time data acquisition. The fixture design aims to increase testing efficiency, minimize human work, and improve repeatability in measurements.

DEFINITION OF SCISSOR LIFT MECHANISM:
The scissor lift is a mobile aerial work platform that uses a series of linked, folding supports (scissor arms) to raise and lower a platform. This mechanism provides vertical movement, allowing workers and materials to reach elevated areas.

Method of Actuation of Mechanisms:
- Hydraulic Scissor lift
- Pneumatic scissor lift
- Electric Scissor lift

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.2, April : 2025

- Diesel Scissor Lift.

Based on the method of actuation, weight handling capacity & number of, the mechanisms were applied in various industries & Purposes.

- Construction & Renovation Industry-HVAC installation & finishing works
- Warehouses & logistics: Loading & unloading of goods from warehouses
- Facility Maintenance etc.

Sensors:

A sensor is a device that detects and measures physical, chemical, or environmental changes and converts them into electrical signals for processing. Sensors are used in various applications, including automation, monitoring, and control systems.

Types of sensors:

1)Motion Sensor & Position sensors

2)Force & load sensor

3)Temperature sensor

4)Distance sensor

5)Electrical sensor

Microcontrollers: A microcontroller (MCU) is a compact integrated circuit that contains a central processing unit (CPU), memory (both RAM and ROM), and input/output (I/O) peripherals.

Functions of Microcontrollers:

1. Controlling
2. Data acquisition
3. Data Processing
4. Automation
5. Real-Time Operations

In modern industrial and commercial applications, scissor lifts play a crucial role in lifting and positioning loads with stability and precision. This study focuses on the development of a scissor lift mechanism actuated by a mechanical screw rod, integrated with IoT sensors for automation and monitoring. The system consists of interconnected scissor links that expand and contract to achieve vertical motion. A lead screw, driven by a DC wiper gear motor, provides controlled linear motion, eliminating the need for hydraulic or pneumatic systems, making it more efficient and maintenance-friendly. The incorporation of IoT-based sensors enhances the functionality and safety of the system. Proximity sensors monitor the platform's position, while limit switches prevent overextension or over-retraction. An ESP32 microcontroller controls the motor operation and processes sensor data, enabling remote monitoring and automation. A relay circuit manages power distribution, and an SMPS (Switched-Mode Power Supply) ensures stable operation.

This study aims to design a compact, cost-effective, and automated fixture that can be applied in a testing setup shown in figure2 and 3. By integrating IoT technology, the scissor lift can be remotely controlled, monitored, and optimized for real-time applications, enhancing safety, efficiency, and reliability.

METHODOLOGY :

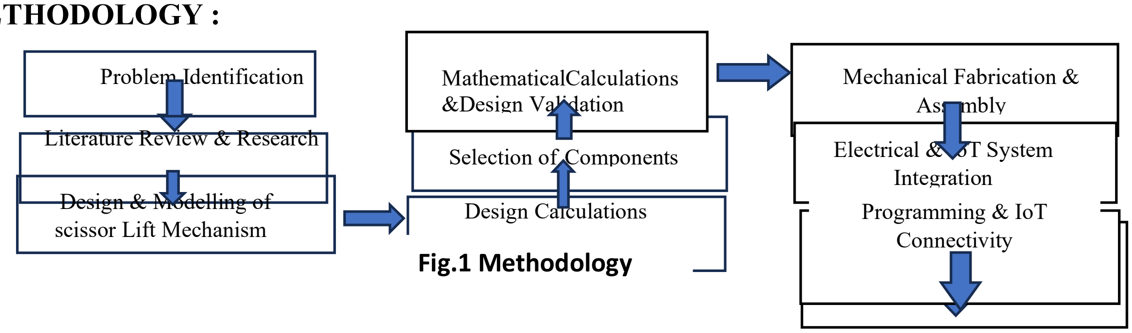

Fig.1 Methodology

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.2, April : 2025

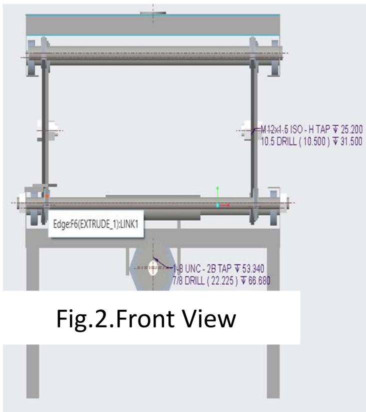

Fig.2.Front View

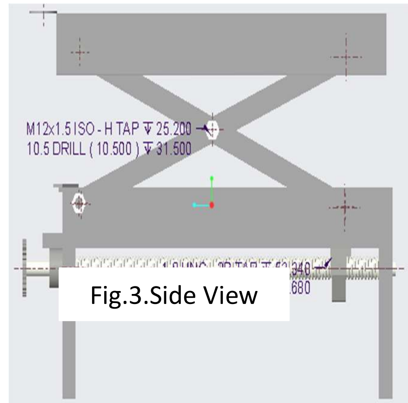

Fig.3.Side View

DESIGN CALCULATION & SELECTION OF COMPONENTS:

Material Selection for Links, Top Plates, and Frames:

Mild Steel (MS) has been chosen as the primary material for the scissor links, base frame, top platform, and shafts due to its excellent mechanical properties, cost-effectiveness, and ease of fabrication. Mild steel is selected due to its high strength-to-weight ratio, which allows it to withstand operational loads and forces while maintaining a manageable weight. Additionally, good weldability and machinability make it ideal for fabrication, as the scissor lift components, including the links and supporting structures, require welding and machining, both of which are easily performed on mild steel. Furthermore, durability and wear resistance ensure that the material maintains its structural integrity under repeated load cycles, increasing the lifespan of the mechanism. Another key factor in choosing mild steel is its cost-effectiveness and availability. Compared to alternative materials like stainless steel or aluminium, mild steel is widely available at a lower cost, making it an economical choice for fabrication. Additionally, its adequate stiffness ensures that the lift mechanism remains stable under loading conditions without excessive deflection or deformation. To further enhance its longevity, mild steel is compatible with surface treatments such as painting or coating, which help improve corrosion resistance and suitability for different environments. In this scissor lift application, scissor links are designed to bear bending and shear forces while maintaining structural stability. Top and bottom plates provide support to the load and efficiently transfer forces, whereas shafts serve as rotational axes for the scissor links, requiring sufficient toughness and strength to resist bending and torsional loads.

Design Calculation for Shaft

Given Data: Length of plate = 500 mm

Width of the plate =400 mm

Thickness= 1mm

Density = 7850 Kg/m^3

Volume = $(0.0002)m^3$

W= 0.0002× 7850

Weight of the Plate = 1.57 kg,

Weight of component to be placed (Assume)= 8 kg

Weight of square frame 1.46 kg,

Total Weight acting on the component,

Total weight = $w_{component} + w_{frame} + w_{plate}$

=78.48 + 14.33 + 15.4

Force = 108.21 N

The mechanism Consists of 4 links, Load is distributed in 4 links,

Force Acting on each link.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.2, April : 2025

$F_{links=}{}^{108.21}/_{4}$

$= \mathbf{27.0525\ N}$

Design of Shaft :

Each shaft consists of two connected links,
From the PSG design data book, material C308 yields tensile strength,

$\sigma_{y=250\ N/mm^2}$

Factor of safety (n) = 3

$\sigma_{allowable} = \frac{250}{3}$

$\tau = Shear\ Stress$

$\tau = 0.5 \times (\sigma)$………….. (1)

= 0.5 × 83.33

= 41.655 $^{N}/_{mm^2}$

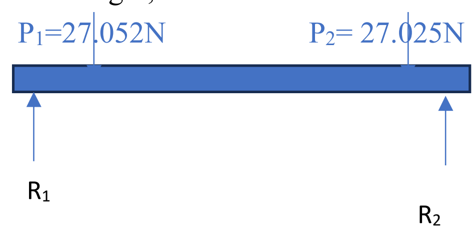

Fig.4 Reaction forces diagram

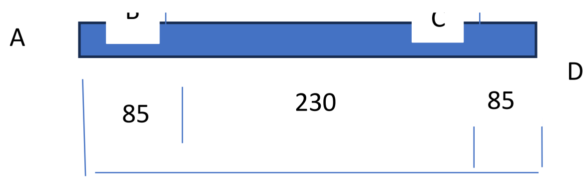

Fig.5 Reaction forces diagram

Calculation of Reaction Forces from Figure12,
Moment About Point A,

$(27.52 \times 85) + (27.52 \times 315) = (R_2 \times 400)$

$2339.2 + 8668.8 = R_2 \times 400$

$11008 = R_2 \times 400\ ,\ R_2 = 27.5$

Moment about D,

$(27.52)(315) + (27.52 \times 85) = (R_2 \times 400)$

$\frac{11008}{400} = R1$

R1= 27.52 N

We know that,

$T_{eq} = \sqrt{(M)^2 + (T)^2}$………………… (2)

The bending moment at A & D =0
The bending moment at B

$R_{AV} = 27.52 \times 85$

The bending moment at C = 2339.2 N

Point $R_{Dv} = 27.52 \times 85$

= 2339.2 N

Resultant bending moment,

$M_b = \sqrt{((M_{BH^2}) + (M_{BV^2}))}$ ………………………… (3)

$M_B = \sqrt{((O)^2 + (2339.2)^2)}$

= **2339.2 Nmm**

$M_c = \sqrt{((M_{CH^2}) + M_{CV^2}))}$……………………… (4)

$M_c = \sqrt{((O)^2 + (2339.2)^2)}$

= **2339.2 Nmm**

Equivalent torque = $\sqrt{(M^2 + T^2)}$…………………… (5)

M – Bending Moment
T - Twisting moment

Twisting Momentum is Acting by the moment of the lead screw,
From the lead screw, the link experiences a twisting moment,
Total load required for lead screw

W total = $W\ frame + W\ plate + W\ link + W\ component$

Thickness of link =5 mm
Length of the link = 460 mm
Width of link = 25 mm
Volume of link = $(0.46 \times 0.025 \times 0.005)$
$= 5.75 \times 10^{-5} m^3$
$\rho = Density$ of mild steel
V=Volume of the link,
Mass of link =ρV ………………… (6)
Mass of link = (7850) (5.75×10^{-5})
= 0.451 kg
Weight of 4 link = (0.451× 4) =1.804 N
Force = 1.804× 9.81
= 17.69 N
W_{TOTAL}=78.48 + 14.33 + 15.4 + 17.68
= 125. 89 N
The torque required for the lead screw to move the lead screw,
$= \frac{F \times dm}{2} \times (\frac{l+\pi}{\pi dm-})$……………………. (7)
$D_m = \frac{D-pitch}{2}$……………………………. (8)

Lead screw Calculations:
Diameter of leadscrew = 25.4 mm
Pitch of lead screw = threads per inch
(Mean diameter) dm= 25.4 mm
The lead of the screw = 3.175mm
Coefficient of friction $(\mu) = 0.15$

$$T = \frac{125.89 \times 25.4}{2} (\frac{3.175 + \pi(0.15)(25.4)}{\pi(25.4) - (0.15)(3.175)})$$

T = 305.256 N/mm

$T_{eq} = \sqrt{(M)^2 + (T)^2}$………..,,,,,,,,,(10)

$= \sqrt{(2339.2)^2 + (305.256)^2}$

= 2359.033 N/mm

$T_{eq} = \frac{\pi}{16} \times (\tau) \times d^3$……………………………..(11)

$(2359.033) = \frac{\pi}{16} \times (41.665) \times d^3$

d^3=288.425

D= 6.607mm

Minimum diameter of shaft = 6.607 mm
Based on standard ranges,
The diameter of the shaft is considered 15 mm
[For machining purposes safety]

Design Calculation for Bearing:

Bearing calculation:
Given:
Diameter of shaft = 15mm
Forces consider for bearing calculation,
Reaction force on the shaft = 27.52 N
Consider it a radial load,
Pg no: 4.13

Size of bearing = 620 2, co=355, c= 610
F_r = 25.52
Pg no: 4.2
Equivalent load,
$P = (XFr + YFa)$………………………..(12)
X-radial factor
Y-thrust factor
P- Equivalent load, Kgf
F_a- Axial load in N
F_r -Radial load in N
S- service factor
From Data Book Page NO:4.2
Service factor = 1.3 to 1.9
S = 1.6
The axial load is Negligible in this case.
$P = [(1.6 \times 25.52\ ) + (0)]1.6$
P= 65.3312 N
Pg no: 4.6 from data book
For rpm =20,
Life of Hours = 200,
Ratio of C/p = 6.70
C =6.70 $\times$ 65.3312
C= 437.719 N
Actual capacity of bearing (C) = 6100 N
437.759 < 6100 N
The selected bearing is safe
The bearing selected is SKF 6202

Selection of Motor:

The selection of an appropriate motor is essential for the efficient operation of a scissor lift mechanism. A DC wiper gear motor has been chosen for this application due to its high torque output, compact size, and ability to provide controlled and smooth motion. This motor type is well-suited for applications requiring precise movement and load handling, making it an ideal choice for the scissor lift.

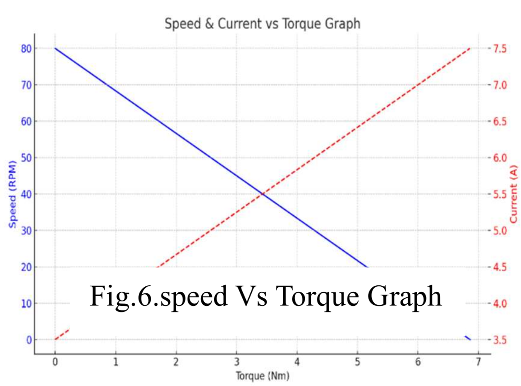

Fig.6.speed Vs Torque Graph

Secondary gear:

Spur Gear: the spur gear is a type of cylindrical gear with teeth that are parallel to the gear axis and mesh with another gear to transmit power and motion between parallel shafts. Spur gears are the most

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.2, April : 2025

common and simplest type of gear, known for their high efficiency, ease of manufacturing, and ability to handle high torque loads.

Table1.gear Parameters

No of Teeth	27
Type of Gear	Spur
Module	2

GEAR TOOTH CALCULATION:

Number of teeth in pinion=7
Number of teeth in Gear =27
The module of the gear =2mm
Pitch circle diameter of pinion= 2*7= 14 mm
Pitch circle Diameter of Gear= 2*27= 54 mm
Base Circle diameter of the Pinion (D_{B1}) = 14 * (cos 20) =18 mm.
Base Circle diameter of the Gear (D_{B2}) =54* (cos20) =58 mm.

Centre Distance between both of the gears (C)= $\frac{C_1+C_2}{2}$

$=\frac{14+54}{2}$

=34 mm

Gear Ratio=$\frac{27}{7}$ =3.86

4.8 Lead Screw: the lead screw (also known as a power screw or translation screw) is a screw used in machinery to convert rotary motion into linear motion.

Table.2. Lead screw parameters

Hexagonal Nut: A hexagonal nut is a fastener with a six-sided (hexagonal) shape, designed to be used in conjunction with a bolt to fasten multiple parts together

Table3.Hexagonal Nut Parameters

Parameters	Values
Diameter	One-inch Hex nut
Thread	1" – 8 threads per Inch
Height	22.2mm

Selection of Electrical Components

Infrared (IR) sensor: The IR sensors are designed to sense radiation within the infrared portion of the electromagnetic spectrum. This radiation is invisible to the human eye.

Limit switch: the limit switch is an electromechanical device that uses a mechanical actuator to trigger an electrical switch. When an object comes into contact with the actuator, it causes the switch to open or close an electrical circuit.

Microcontroller (ESP 32 Board): the ESP32 is a built-in WIFI + Bluetooth-enabled microcontroller that acts as the brain of the scissor lift mechanism. It controls the motor operations using relays and based on inputs from communication devices & controls the motor operation based on data from limit switches and proximity sensors.

Buck Converter: A Buck converter is a DC-DC step-down voltage regulator that reduces a higher input voltage to a

Parameters	Values
Diameter	1 inch
No threads per Inch	8

lower output voltage efficiently. In this application, a 12v DC power supply from the system is converted to a 5V power supply to power the relays, sensors, ESP 32boards etc.
Relays: the relay is an electrically operated switch used to control the 12V DC motor used to control the motor directions and position of motors
SMPS -A Switched-Mode Power Supply (SMPS) is used to efficiently convert 230 AC mains power to 12V DC required for the operation of a DC motor. It also provides a power supply for the other Controllers & Sensors.

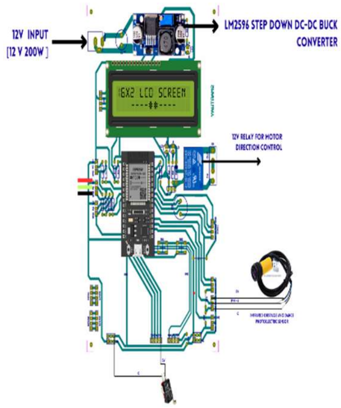

Fig:7 Circuit Diagram


Fig.8…Arduino Interface

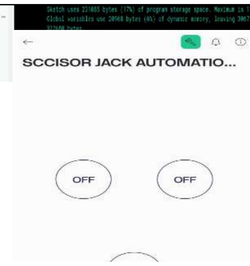

Fig.9. Blynk Interface

BLYNK Interface:
Blynk is an Internet of Things (IoT) platform that enables remote monitoring and control of connected devices via a smartphone or web interface. In the scissor lift mechanism, integrating Blynk enhances automation, efficiency, and user convenience.
Arduino IDE Software:
Arduino IDE Shown is used as the primary development platform to program the ESP32 microcontroller, which controls various components such as the DC wiper motor, sensors, relays, and IoT-based monitoring system. The software enables seamless integration of hardware and software, allowing efficient control and automation of the scissor lift mechanism.

V.FABRICATION & ASSEMBLY OF FIXTURE:

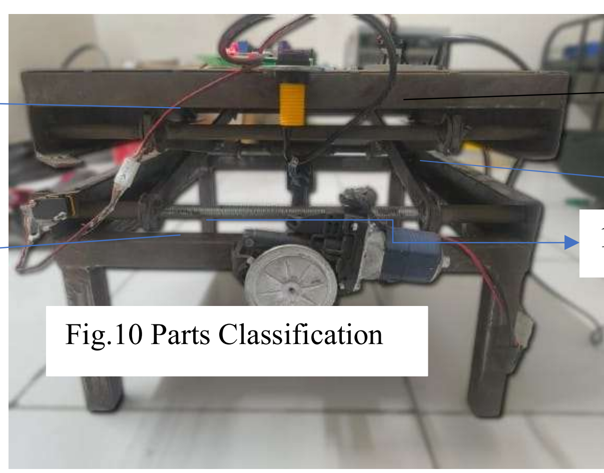

Fig.10 Parts Classification

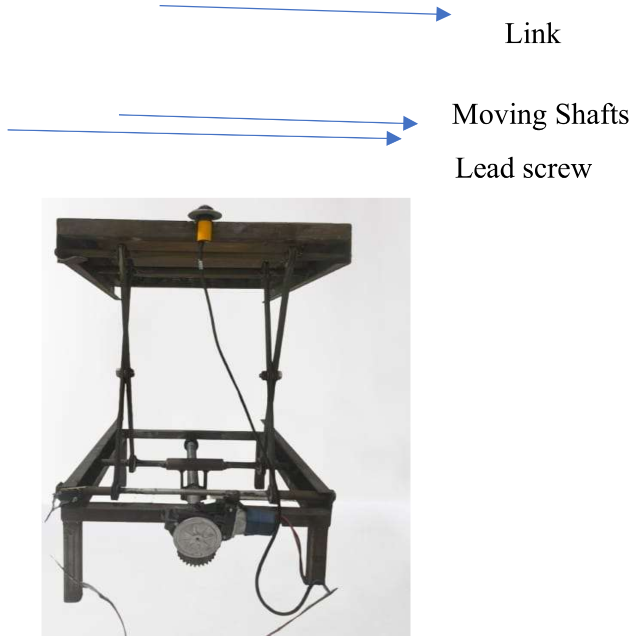

Fig.11. Lifted Position

The scissor lift mechanism integrated with a lead screw, ESP32, relays, IR sensors, and limit switches is a smart, precise, and automated lifting solution. The core mechanical structure relies on a scissor arm assembly, where pairs of metal links are connected in a criss-cross fashion. The vertical movement of the lift is achieved through a lead screw mechanism mounted at the base. When the screw is rotated by a DC gear motor, it translates rotary motion into linear motion, causing the arms to extend or contract, thereby raising or lowering the top platform. The lead screw provides precise control and stability, making it ideal for load handling and vertical motion systems.

At the heart of the control system is the ESP32 microcontroller, which manages all inputs and outputs. The ESP32 is responsible for processing signals from IR sensors and limit switches, and activating relays to control the motor's operation. Relays serve as electrically controlled switches that allow the low-power ESP32 to operate the higher-power motor. A two-relay configuration is commonly used—one relay controls the ON/OFF state, while the other manages the motor's direction by reversing polarity.

To enhance safety and automation, IR proximity sensors are deployed to detect objects or users around the lift. These sensors ensure that the lift only operates when conditions are safe, such as detecting whether a person is standing near the platform. Additionally, mechanical limit switches are installed at both the top and bottom ends of the lift's range of motion. When the platform reaches either extreme, the corresponding limit switch is triggered, signaling the ESP32 to stop the motor immediately. This prevents over-travel, mechanical stress, and ensures user safety.

The entire system is powered using a suitable SMPS (Switched Mode Power Supply), which supplies 12V or 24V to the motor, while the ESP32 operates at 3.3V, powered via USB or a buck converter. This setup offers a compact, reliable, and intelligent control mechanism for a scissor lift system.

Table. 5. Results

S.no	Opera[illegible]	[illegible]aken	Travelled Length
1	Lifti[illegible]	[illegible]ins	300 mm
2	Landing	3mins	300 mm

CONCLUSION:

The IoT-enabled scissor lift fixture successfully enhances impedance tube testing by automating height adjustment, reducing setup time, and ensuring accurate specimen alignment. The lead screw-driven mechanism provides smooth and controlled adjustments, while IoT connectivity enables control.

FUTURE SCOPE:

Battery backup systems can be introduced for uninterrupted operation during power failures. Improving the accuracy of IR sensors and limit switches will enhance safety and precision. Additionally, incorporating a simple LCD or OLED display can provide real-time feedback on lift height, system status, and fault alerts. These upgrades would make the system more user-friendly, reliable, and ready for light industrial and domestic applications

ACKNOLEDGEMENT:

We would like to express our sincere gratitude to Prototrial Engineering Solutions, Coimbatore for their invaluable guidance and technical support.

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