# DESIGN AND DEVELOPMENT OF A TWIN STATION NRV TESTING RIG

**PHASE II REPORT**

***Submitted by***


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# BONAFIDE CERTIFICATE

Certified that this Report titled **"DESIGN AND DEVELOPMENT OF TWIN STATION NRV TESTING RIG''** is the bonafide work of **ROHINDH P (201201043), KHALID SHAJAHAN (2116201201057) and ASWINI KUMAR S (2116201201060)** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.


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This **MT19811-Project Work Phase-II** report is submitted for the **VIVA- VOCE Examination** held on.....at Rajalakshmi Engineering College (Autonomous), Chennai.

**INTERNAL EXAMINER** **EXTERNAL EXAMINER**

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# COMPANY DESCRIPTION

## BRAKES INDIA PVT LTD

Established in 1962, Brakes India stands as a prominent supplier of braking systems in the Indian market and a global provider of ferrous castings, catering to passenger vehicles, light commercial vehicles, heavy commercial vehicles, and tractors. Affiliated with the TSF Group, tracing its roots back to 1936, the company boasts robust in-house research and development capabilities, including cutting-edge test facilities and an international standard high-speed test track. Recognized for world class manufacturing, Brakes India has earned a reputation for delivering top-quality products through an extensive supply chain, serving renowned original equipment manufacturers worldwide. The renowned iron foundry, operating in India and Oman, produces over 200,000 tons of safety-critical castings. Trusted brands such as TVS-Girling, TVS Apache, and TVS-Sprinter dominate the spare parts segment. With revenues exceeding INR 6,500 crores, Brakes India has earned accolades like National Awards for Energy Conservation, Leadership and Excellence Award in Safety, Health & Environment, TPM Excellence Award, and the prestigious Deming Application Prize.

Throughout our enriching internship at Brakes India Pvt Ltd, we were privileged to be part of the Technology Development Department, guided by the astute leadership of Mr. G.M. Kumaravel, General Senior Manager of the Technology Development department. Our initial interaction with him provided invaluable insights into the trajectory of our project-centric journey at Brakes India. Engaging in discussions with Mr. Kumaravel not only offered clarity on our objectives but also emphasized the company's unwavering commitment to cultivating a culture of continuous learning and innovation within the realm of automotive technology.

# ABSTRACT

In automotive hydraulic braking systems, the brake booster assembly plays a critical role in augmenting the force exerted by the driver on the brake pedal, utilizing engine vacuum pressure. Central to its functionality is the Non-Return Valve (NRV), which maintains optimal vacuum levels within the booster chamber. However, NRV malfunctions can compromise braking efficiency and safety.

Our project introduces the "Twin Station Non-Return Valve Leak Test Rig," a pioneering automated method for testing NRVs within brake boosters. This innovative approach aims to enhance testing efficiency and accuracy in assessing NRV performance. By simulating real-world conditions, the test rig provides a comprehensive evaluation of NRV integrity. It detects potential leaks and assesses the valve's ability to maintain vacuum levels within the booster chamber. This ensures consistent and reliable brake performance.

The rig's dual-station design allows simultaneous testing of multiple NRVs, streamlining the evaluation process. Its automation minimizes human error and ensures precise results, enhancing testing reliability. Furthermore, the rig's adaptability enables compatibility with various brake booster models, making it a versatile solution for automotive manufacturers and service providers. Ultimately, this project aims to contribute to safer driving experiences by optimizing brake system performance through robust NRV testing methodologies.

Keywords: automotive; brake booster; Non-Return Valve (NRV); hydraulic braking system; vacuum pressure; testing rig; automation; efficiency; reliability; safety; performance evaluation; leak detection; brake pedal feel; automotive industry.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| 1. Pulse-width modulation | PWM |
| 2. In-circuit serial programming | ICSP |
| 3. Universal serial bus | USB |
| 4. Communication device class | CDC |
| 5. Communication port | COM PORT |
| 6. Microcontroller | MCU |
| 7. Analog to digital convertor | ADC |
| 8. Forward voltage | IF |
| 9. Reverse current | IR |
| 10. Breakdown voltage | V(BR) |
| 11. Diode capacitance | CD |
| 12. Electronic design automation | EDA |
| 13. Printed circuit board | PCB |
| 14. Integrated development environment | IDE |
| 15. Computer-aided design | CAD |
| 16. Finite element analysis | FEA |
| 17. Acrylonitrile butadiene styrene | ABS |
| 18. Polybutylene terephthalate | PBT |

# CHAPTER 1

# INTRODUCTION

## 1.1. OVERVIEW

In a car's hydraulic braking system, the brake booster assembly plays a vital role in amplifying the driver's applied force on the brake pedal. It achieves this by utilizing the engine's vacuum pressure. The assembly typically consists of a sealed chamber separated by a diaphragm. One side of the diaphragm is exposed to engine vacuum, while the other interacts with atmospheric pressure. When the driver presses the brake pedal, a rod connected to the pedal pushes on the diaphragm. This creates a pressure differential across the diaphragm, effectively multiplying the driver's leg force.

However, for the brake booster to function optimally, a crucial element called the Non- Return Valve (NRV) is integrated into the vacuum line leading to the booster. This small valve acts as a one-way gate, allowing engine vacuum to flow into the booster chamber and maintain the necessary pressure differential. Conversely, the NRV prevents air from leaking back out of the chamber, ensuring consistent operation.

The proper functioning of the NRV is essential for maintaining safe and effective braking performance. A faulty NRV can manifest in several ways. Leakage through the valve can cause a significant decrease in vacuum within the booster chamber. This translates to a stiff and unresponsive brake pedal, requiring the driver to exert considerably more force to achieve the desired braking effect.

In some scenarios, a malfunctioning NRV might allow unmetered air into the booster, effectively negating the vacuum assist and drastically reducing braking efficiency. This poses a serious safety risk. Additionally, a compromised NRV can lead to inconsistencies in brake pedal feel, making it challenging for the driver to modulate braking force precisely. Regular testing of the NRV is therefore imperative to ensure the integrity of the entire brake booster assembly and, consequently, safe and predictable braking performance.

Our project “Twin Station Non- Return Valve Leak Test Rig” proposes a novel method in automated testing of the NRV present in the brake booster present in a vehicle. The method proposed helps in improving the testing efficiency and also is an accurate method to assess the performance of the NRV.

## 1.2 NEED FOR STUDY

The "NRV Leak Test Rig" project tackles a critical gap in ensuring safe and reliable braking performance for modern vehicles. The brake booster assembly, an important part of modern braking systems, utilizes engine vacuum generated from intake manifold pressure to amplify driver input on the brake pedal. This crucial component relies on a Non-Return Valve (NRV) to maintain the necessary vacuum pressure for optimal operation. However, current testing methods for optimal NRV presents limitations that this project aims to address.

The primary motivation for the "Twin station NRV Leak Test Rig" project stems from safety concerns associated with a faulty NRV. A compromised NRV can significantly reduce vacuum within the brake booster, leading to a stiff brake pedal that requires excessive driver force for braking. This scenario can drastically increase stopping distances, especially in emergency situations. Additionally, a faulty NRV can introduce inconsistencies in brake pedal feel, hindering precise modulation by drivers

and potentially compromising vehicle control. These issues highlight the importance of reliable NRV performance and the need for effective testing methods.

Existing testing procedures might not comprehensively assess NRV performance under various operating conditions and over extended periods. Data on how NRV performance degrades due to wear and tear is also scarce. This lack of knowledge hinders the development of proactive maintenance strategies to identify potential issues before they escalate into critical failures. Finally, the absence of standardized testing protocols creates inconsistencies in evaluating NRV performance across different vehicles. This makes it difficult to accurately compare data and identify potential trends.

By developing a dedicated testing platform, the "NRV Leak Test Rig" project aims to bridge these knowledge gaps. The rig can replicate various engine vacuum levels and pressure fluctuations experienced by the NRV during normal driving. By subjecting the NRV to simulated operation over extended periods, the rig can provide valuable data on wear and tear effects on leak rates. The development of a dedicated test rig can pave the way for establishing standardized protocols for NRV evaluation across the automotive industry.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1. INTRODUCTION

The literature review for the Twin Station NRV Testing Rig project report will provide an overview of the existing research and developments in the field of pneumatic braking systems, focusing on their design, fabrication, and development. The review will cover various aspects of pneumatic braking systems, including their components, working principles, and applications in different industries.

One of the key studies reviewed is the development of an automatic pneumatic braking system using Arduino, relays, IR transmitter, and IR receiver for effective braking control in vehicles [18]. The study highlights the importance of automatic braking systems in reducing accidents caused by human error, such as delayed brake pedal application or rash driving. The system is designed to activate the brakes automatically when an obstacle is detected by the IR sensor, ensuring a timely and effective braking response.

Another study reviewed is the advancement of pneumatic braking systems in heavy vehicles, such as buses, trucks, and trains, to improve safety and efficiency [8]. The study discusses the use of pneumatic systems in automation, such as automatic braking systems, and their benefits, including high force application, variable speeds and forces, and simple and free resource nature. The study also suggests potential improvements, such as high bandwidth and bioactivated valves, to further enhance the performance of pneumatic braking systems.

The literature review will also cover the design and development of a single car test rig for pneumatic air brake testing in railways [27]. The study discusses the importance of brake testing in ensuring safety and efficiency in railway operations and

the limitations of manual testing methods. The test rig is designed to be fully automatic, with software-based command, execution, and data capture capabilities, providing accurate and reliable testing results.

In addition, the literature review will explore the use of pneumatic braking systems in different industries, such as automotive, aerospace, and industrial machinery, and their advantages over other braking systems. The review will also discuss the challenges and limitations of pneumatic braking systems, such as air leakage, compressor noise, and maintenance requirements, and the potential solutions and improvements to address these issues. Overall, the literature review will provide a comprehensive understanding of the current state of research and development in pneumatic braking systems, highlighting their importance, advantages, and challenges, and providing insights into the potential improvements and applications for the Twin Station NRV Testing Rig project.

## 2.2. A PRACTICAL GUIDELINE FOR ESTABLISHING NON-RETURN VALVE SPECIFICATION AND PERFORMANCE CRITERIA (2007)

The research paper "A Practical Guideline for Establishing Non-Return Valve Specification and Performance Criteria" by Eric W. Dawkins delves into the critical yet often overlooked component of non-return valves in the injection molding industry. The study addresses the lack of uniformity in valve specifications, the impact of wear on valve performance, and the economic considerations of valve replacement. The methodology involved three key phases: the Discovery Phase to establish variable effects, Test Development and In-Plant Experimentation to optimize valve

performance, and an In-Plant Wear Study to track valve life in a production environment.

Findings revealed insights into valve wear, machine monitoring variables, and the economic justification for valve replacement. Recommendations included guidelines for specifying valves, design criteria considerations, and significant process variables affecting valve performance. The study utilized statistically designed experiments to quantify the effects on part weight mean and variance, providing valuable insights for molders to optimize valve performance and maintenance. By focusing on predictive maintenance and understanding the factors influencing valve wear, this research aims to enhance the injection molding process, reduce variation, and optimize economic conditions for non-return valve replacement.

## 2.6. DESIGN AND CONTROL OF HARDWARE-IN-THE-LOOP SIMULATIONS FOR TESTING NON-RETURN VALVE VIBRATIONS IN AIR SYSTEMS (2012)

This research paper presents the design and control of a Hardware-in-the-Loop (HWIL) simulation for testing Non-Return-Valve (NRV) vibrations in air systems. The study aims to replicate the original system behavior with sufficient fidelity, ensuring the stability of the overall system when simulated on the HWIL simulator and assessing the level of performance of the overall system. The HWIL simulator is designed to couple a numerical model of an air system with a real NRV in the real air-flow, applicable to any type of flow control devices.

The HWIL simulator consists of an inner loop for controlling a motorized control valve and an outer loop based on the internal model of the rig, relying only on the input/output measurements of the device under test. The controller design is

independent of the component under test, treating the component as a black box flow control device with measurable inputs and outputs.

The simulator performance is evaluated in the time domain by comparing its response with that of several corresponding real system configurations. The results show that the simulator preserves the stability of the overall system when simulated on the HWIL simulator and provides a performance index or an upper bound on the simulation error.

The implications of this study are significant, as it demonstrates the potential of HWIL simulations for integrated system qualification testing of passive components like NRVs, poppet valves, check valves, and others in the aerospace industry. By reducing the cost of full system tests, HWIL simulations can help minimize the likelihood of component failure in service, contributing to safer and more reliable systems.

## 2.4. STRUCTURE ANALYSIS OF NON-RETURN CONTROL VALVE USING FINITE ELEMENT ANALYSIS (2015)

The research paper "Structural Analysis of Non-Return Control Valve using Finite Element Analysis" focuses on the structural analysis of the body or housing of a check valve, a critical component of the valve prone to internal fluid pressure. The study aims to optimize the shell thickness of the check valve housing, which significantly affects the valve's life and cost implications. The research employs Finite Element Analysis (FEA) using ANSYS v14.5 to analyze the structure of the check valve body. The results of the FEA are validated through stress analysis using classical theory of mechanics, comparing numerically calculated stresses with the FEA results. The study concludes that FEA is an extremely powerful tool when used

correctly, providing valuable insights into the design and optimization of check valve housings. The research highlights the importance of considering the check valve as a pressure vessel and the need for regular inspections and maintenance to ensure optimal performance and safety.

## 2.5. DESIGN, FABRICATION AND DEVELOPMENT OF SINGLE CAR TEST RIG FOR PNEUMATIC AIR BRAKE TESTING IN RAILWAYS (2019)

The research paper titled "Design, Fabrication and Development of Single Car Test Rig for Pneumatic Air Brake Testing in Railways" focuses on the development of a test rig for pneumatic air brake testing in railways. The study was conducted by a group of students under the guidance of Prof. Amruta Karve from the Department of Mechanical Engineering at Anjuman-I-Islam’s Kalsekar Technical Campus in Navi Mumbai, India.

The paper provides an overview of the Indian Railways and the importance of brake testing in ensuring safety and efficiency. The authors also discuss the limitations of manual testing methods and the benefits of automated testing.

The methodology section describes the design and fabrication process of the test rig, including the selection of components such as ITV valves, solenoid valves, relay cards, and multi-span indicators. The test rig is designed to be fully automatic, with software-based command, execution, and data capture capabilities.

The results section presents the testing procedure and the various tests conducted, including air pressure tests, brake application and release tests, emergency brake application and release tests, passenger emergency valve tests, and guard's emergency van valve tests.

The paper concludes that the computerized single car test rig has several advantages over manual testing methods, including increased accuracy, reduced testing time, and the ability to store and retrieve data for future reference. The authors also suggest potential future improvements, such as the integration of the test rig into a centralized data system for faster and more efficient processing.

In summary, this research paper presents the design, fabrication, and development of a single car test rig for pneumatic air brake testing in railways. The study highlights the importance of brake testing in ensuring safety and efficiency in railway operations and demonstrates the advantages of automated testing methods over manual testing. The authors also provide suggestions for future improvements to further enhance the efficiency and effectiveness of the test rig.

## 2.3. DEVELOPMENT OF BRAKING SYSTEM IN AUTOMOBILES (2020)

The research paper "DEVELOPMENT OF BRAKING SYSTEM IN AUTOMOBILES" focuses on the evolution and advancements in automotive braking systems, emphasizing safety and performance enhancement. The study explores various types of braking systems, including mechanical, hydraulic, and power brakes, such as air, air hydraulic, vacuum, and electric brakes. The research highlights the importance of optimizing braking systems to meet safety standards and driver expectations. The methodology includes experimental testing, data analysis, and performance evaluations of various braking components. Findings reveal significant improvements in braking system technology, with design modifications impacting braking performance and safety features. The research

emphasizes the need for regular inspections and maintenance of braking systems to ensure optimal performance and safety. Advancements in braking technology can lead to enhanced vehicle control, reduced stopping distances, and improved overall safety on the roads.

## 2.7. ADVANCEMENT OF PNEUMATIC BRAKING SYSTEM (2021)

The research paper "Advancement of Pneumatic Braking System" discusses the development of an automatic pneumatic braking system to reduce accidents and improve safety in vehicles. The authors propose the use of an IR sensor attached to the front of the vehicle to detect obstacles and trigger the braking system. The system is designed to be controlled electronically and activated when the vehicle is traveling at a speed of 30-50 km per hour.The study highlights the importance of pneumatic braking systems in heavy vehicles and the need for advancements in this area. The authors suggest that the use of pneumatic braking systems in mini cars and auto vehicles can improve safety and reduce accidents.

They propose a design that includes an air filter, compressor, reservoir, and solenoid valve, all controlled by a board with stored coding. The paper also includes a literature review of pneumatic braking systems, discussing their advantages and applications. The authors note that pneumatic braking systems are widely used in heavy vehicles, such as buses, trucks, and trains, as well as in pneumatically powered vehicles and tools. They also highlight the benefits of pneumatic braking systems, including their ability to apply a lot of force from a small and light package, their variable speeds and forces, and their simple and free resource nature.

The study concludes that the proposed automatic pneumatic braking system can improve safety and reduce accidents in mini cars and auto vehicles. The authors suggest that further research is needed to optimize the design and improve the system's performance. Overall, the paper highlights the potential of pneumatic braking systems to enhance safety and reduce accidents in various types of vehicles.

## 2.8. PROBLEM STATEMENT

Individuals with a single arm often encounter challenges when it comes to typing certain characters and navigating the keyboard and mouse simultaneously. The struggle to seamlessly switch between these devices not only poses practical difficulties but also leads to fatigue, particularly in professional settings. Surprisingly, despite advancements in technology, there is a notable absence of specialized computer input devices tailored to the unique needs of one-armed individuals. This deficiency in support significantly hampers their typing speed, reducing it to almost half of what their two-handed counterparts can achieve. Recognizing the urgency of this issue, there is a compelling need for the development of a distinctive input device that caters specifically to the requirements of one- armed users, thereby enhancing their overall computing experience and productivity.

## 2.9. OBJECTIVE

To design and develop a Twin Station Non-Return Valve Leak Test Rig for automated testing of the Non-Return Valve (NRV) within automotive brake booster assemblies. By creating a versatile and efficient testing rig, we aim to enhance the accuracy and reliability of NRV evaluations, ensuring optimal performance levels and consistent braking performance. Through automation, the rig will minimize human error and streamline the testing process, enabling simultaneous assessment of multiple NRVs. Ultimately, this project seeks to contribute to improved safety and reliability in automotive braking systems by facilitating thorough and precise NRV testing methodologies.

# CHAPTER 3

# METHODOLOGY

## 3.1 PROPOSED WORK

The method used to design and develop the project “Twin Station NRV Leak Test Rig” is shown in the various stages of the proposed method are

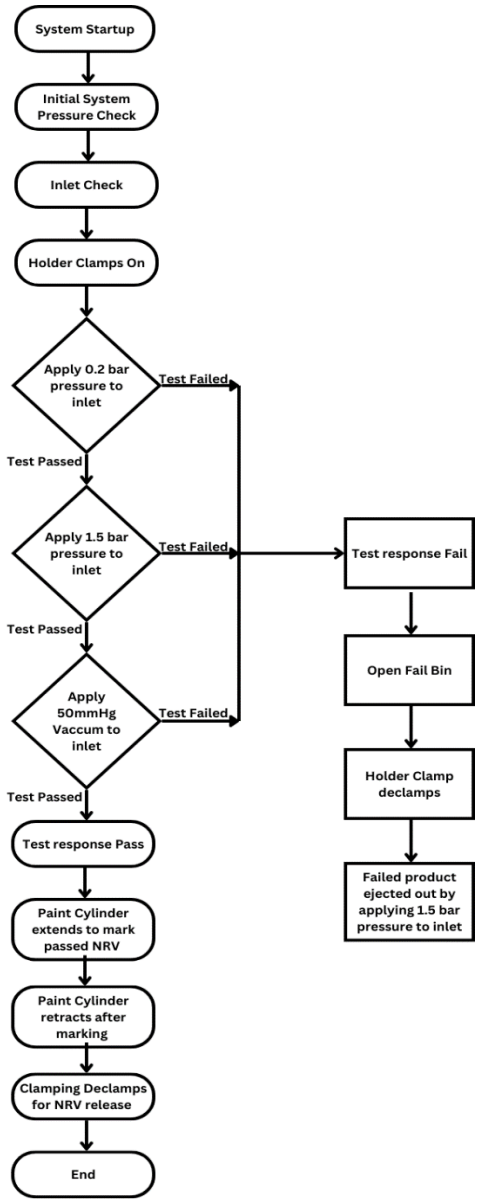


*Fig 3.1 Flow chart of the proposed solution*

## 3.2 SYSTEM STARTUP

The test rig is switched on by the operator and then the connections are verified so that there are no errors/ stoppage of the machine during operation.

## 3.3 INITIAL SYSTEM PRESSURE CHECK

The above picture depicts the 3D design of Cylinders divided into six cylinders and flow gas through each of them. There is a nostril present where gas flow will be regulated one after the other cylinder. An automatic check is initiated when the rig is powered on to determine whether the pneumatic pressure coming from the supply line is sufficient to ensure smooth operations. If this pressure is insufficient, an error message informs the user right away so that the deficiency can be quickly fixed. Such insufficiency could indicate a leak in the system, necessitating a careful inspection of pneumatic equipment for possible issues. This methodical procedure guarantees early identification and resolution of any possible problems that could jeopardize performance or safety in addition to optimizing operating efficiency. Through timely resolution of pressure-related issues and thorough inspections, the system is kept reliable and functional, reducing downtime.

## 3.4 0.2 BAR LEAK TEST

The 0.2 bar leak test method is a crucial step in the Non-Return Valve (NRV) assessment process that guarantees the dependability and integrity of the valve assembly's seal. Through a carefully calibrated application of low pressure (0.2 bar), operators are able to measure the likelihood of diaphragm leakage a crucial sign of the seal's health.

It is essential to exactly deliver the appropriate pressure to the NRV's intake manifold end in order to do this evaluation. This stage guarantees uniform testing circumstances for every unit under review. Additionally, the maximum allowable leakage rate cannot be higher than 0.025 ml/s. For the NRV in the brake booster assembly to function as best it can, this threshold provides a critical reference point for evaluating how well the seal stops the loss of gas or fluid.

When test results show a leakage rate higher than the predetermined threshold, the system immediately initiates the Fail Bin mechanism. This automated response streamlines the quality control procedure and reduces the possibility that subpar units will continue down the manufacturing line by making it easier to identify and separate defective items. Manufacturers can reduce any negative effects on product performance and quality by quickly identifying and isolating defective components. Conversely, when the 0.2 bar leak test yields favorable outcomes within acceptable parameters, the NRV is subjected to the next test seamlessly. This ensures the continued production of NRV assemblies that adhere to predefined quality standards, thereby upholding the reputation for precision and reliability synonymous with the brand.

## 3.5 1.5 BAR LEAK TEST

The modelling of incremental pressure up to 1.5 bar is an essential assessment stage that mimics the severe operating circumstances that the Non-Return Valve (NRV) faces in practical applications. This exacting examination is accomplished by precisely pressing on the intake manifold end, methodically examining the quality of the welding joints in freshly produced NRV components. Manufacturers can detect possible leaks from welding seams, which are a common source of worry in valve assembly fabrication, by putting the NRV under high pressure. This thorough

inspection guarantees that the NRV will continue to function and be dependable even in the most difficult operating circumstances, protecting against fluid or gas leaks that can jeopardize system performance or safety.

The severe criteria require that any identified leakage after applying 1.5 bar of pressure to the intake manifold end during the test not exceed 0.25 ml/s, emphasizing the importance of maintaining high quality standards throughout the production process. When a test fails and the leakage rate exceeds the specified threshold, the system immediately activates the Fail Bin procedure. This automated response allows for the prompt elimination of defective units from the production line, preventing their incorporation into finished goods and avoiding potential quality issues downstream. In contrast, successful completion of the pressure simulation test indicates that the NRV meets the defined quality criteria, confirming its fitness for deployment in brake booster assemblies. In such cases, the rig easily transitions to the next test, guaranteeing that the NRV has no weld leaks and fulfills the manufacturer's quality criteria.

## 3.6 DIFFERENTIAL VACUUM TEST

The differential vacuum test is an important step in determining the Non-Return Valve's (NRV) ability to prevent unwanted reversal of fluid or gas flow, which is required in a wide range of industrial situations. During this examination, the NRV is subjected to regulated vacuum conditions, with roughly 50 mmHg of vacuum delivered to the manifold end. This arrangement simulates events similar to the release of a brake pedal, mimicking real-world settings where backflow prevention is crucial. Manufacturers can learn about the NRV's performance under pressure differentials and vacuum environments by subjecting it to these simulated operational circumstances. The vacuum drop seen during the test is a key measure,

with a rigorous threshold of 20 mmHg. This restriction ensures that the NRV's seal integrity and operational efficiency remain intact even when pressure fluctuates abruptly. After the test, if the vacuum drop remains within the required limit, indicating successful backflow prevention, the product moves forward and passes the examination.

However, if the test findings surpass the required threshold, indicating an ineffective backflow prevention system, the Fail Bin process is initiated. This automated response quickly identifies and removes defective products from the manufacturing process, preventing them from being included in completed goods and maintaining high quality requirements. The rigorous execution of the backflow prevention test determines whether the NRV is of the accepted quality standard of the manufacturer.

# CHAPTER 4
# MATHEMATICAL CALCULATIONS

The choice of a 45x45 mm Aluminum Profile as the skeletal body for the Twin Station NRV Testing Rig consisting of pneumatic circuits, an electrical panel and a fixture was made within it is strategic and beneficial for several reasons.

## 4.1 STRUCTURAL INTEGRITY AND STABILITY

The Aluminum Profile's robust construction provides excellent structural integrity, ensuring stability and durability for the testing rig. Its lightweight yet sturdy nature makes it ideal for supporting the weight of pneumatic components, electrical panels, and other equipment without compromising on stability.

## 4.2 MODULAR DESIGN AND FLEXIBILITY

The modular design of the Aluminum Profile allows for easy assembly and customization of the testing rig. With T-slot grooves for mounting various components, it offers flexibility in configuring the layout of pneumatic circuits, electrical panels, and other elements within the rig. This adaptability facilitates efficient modifications and upgrades as needed.

## 4.3 COMPATIBILITY WITH PNEUMATIC CIRCUITS

Aluminum Profiles not only offer structural integrity but also integrate seamlessly with pneumatic components and systems, providing an ideal framework for incorporating pneumatic circuits within the testing rig. The profile's design enables the secure installation of pneumatic valves, actuators, and tubing, ensuring reliable functionality and connectivity of the pneumatic system.

## 4.4 ELECTRICAL PANEL MOUNTING

The Aluminum Profile's versatility extends to accommodating electrical panels within the testing rig. Its T-slot grooves enable the easy installation of mounting brackets for securing the electrical panel, control units, and wiring components. This organized setup ensures a neat and efficient arrangement of electrical elements for effective testing operations.

## 4.5 THERMAL CONDUCTIVITY AND CORROSION RESISTANCE

Aluminum's excellent thermal conductivity helps dissipate heat generated by electrical components, maintaining optimal operating conditions within the testing rig. Additionally, aluminum profiles are corrosion-resistant, ensuring longevity and reliability in diverse environmental conditions, making them suitable for long-term use in testing environments. Its lightweight nature contributes to ease of handling and installation within the testing rig.

## 4.6 DESIGN CALCULATIONS

**Aluminum Profile Specification:**

Mass = 1.63 kg/m

Tensile Strength = 230 MPa Modulus of Elasticity = 700 N/mm

Limit of Elasticity = 145 N/mm

Yield strength = 200 N/mm

**Given:**

load = 15 kg

**Calculation:**

Square cross-section of length = 45mm

Area of cross section, A = 45mm x 45mm = 2025 = 0.002025 $m^2$

Weight = load x gravity

= 15 kg x 9.81

= 147.15 N

Stress Developed = Force / Area

= 147.15 N / 0.002025

= 72666.67 $N/m^2$

Yield Strength = 230MPa

= 230 x 106 $N/m^2$

**Assume**: Factor of Safety (FOS) = 2

Yield Strength can be varied due to factor like manufacturing process, material imperfection and environmental condition. Factor of safety helps to account for uncertainties in material.

Stress Allowable = Yield Strength / Factor of safety

= (230 x $N/m^2$) / 2

**= 115 x 106 MPa**

**∴ Stress Developed < Stress Allowable**

**i.e., 72666.67 N/m2 < 115 x 106 N/m2**

Since the calculated stress is much smaller than the allowable, the aluminum profile should be able to withstand the load without permanent deformation.

In conclusion, the choice of a 45x45 mm Aluminum Profile as the skeletal body for a testing rig with pneumatic circuits and an electrical panel provides a harmonious combination of attributes. Its structural strength ensures stability, while flexibility allows for easy customization. Compatibility with pneumatic and electrical components, coupled with excellent thermal conductivity and corrosion resistance, ensures durability and efficiency, making it the optimal choice for a robust testing setup that meets diverse requirements.

## 4.7 SOFTWARE ANALYSIS

### 4.7.1 DESIGN OF THE PROTOTYPE (FRONT VIEW)

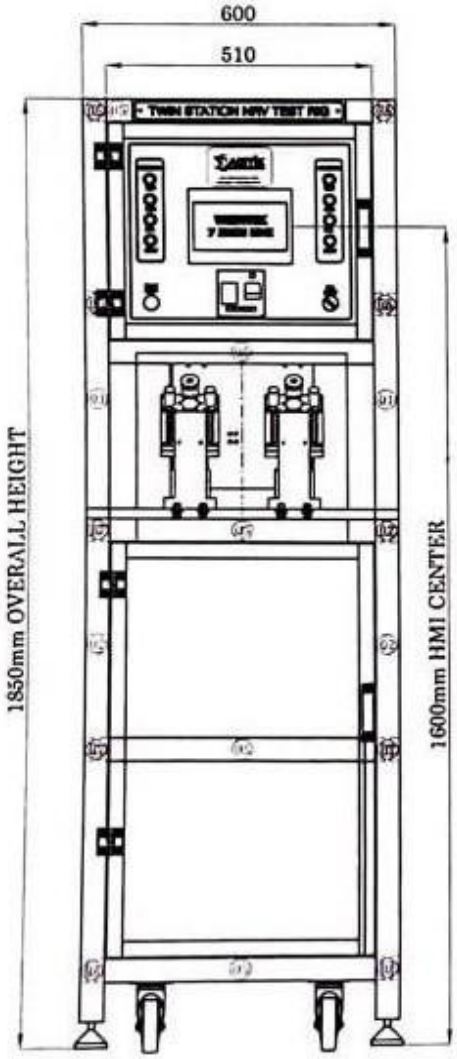


*Fig 4.7.1 Design of the prototype (Front View)*

The above figure shows us the anticipated design of the Twin Station NRV Testing Rig, giving us the broader view of the design with the dimensions of the structure and the dimensions of the Electrical Panel that is to be installed for automating the rig.

## 4.7.2 DESIGN OF THE PROTOTYPE (SIDE VIEW)

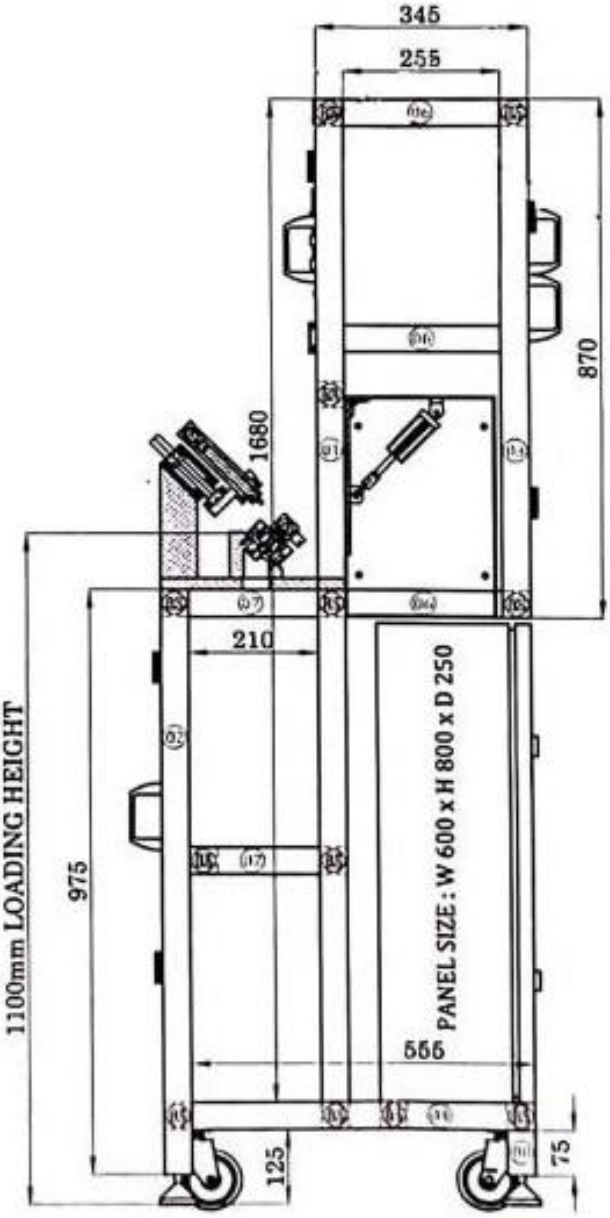


*fig 4.7.2: Design of the testing rig (side view)*

## 4.7.3 DESIGN OF THE PROTOTYPE (ISOMETRIC VIEW)

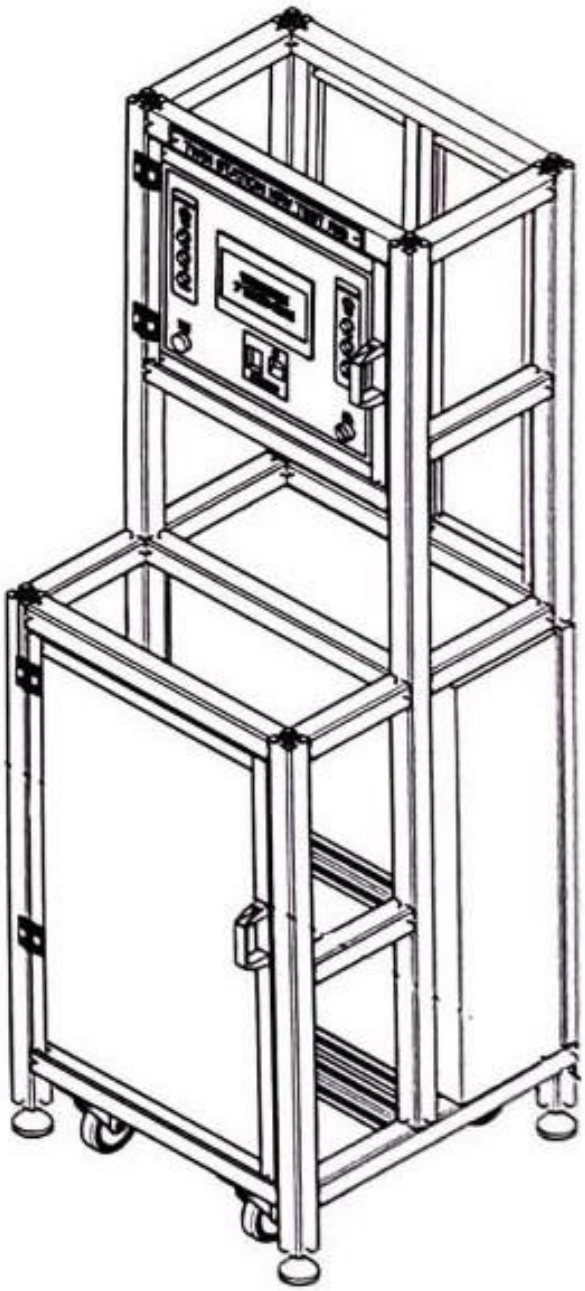

*Fig 4.7.3: Design of the testing rig (isometric view)*

## 4.7.4 DESIGN ANALYSIS OF PNEUMATIC CIRCUIT – 1

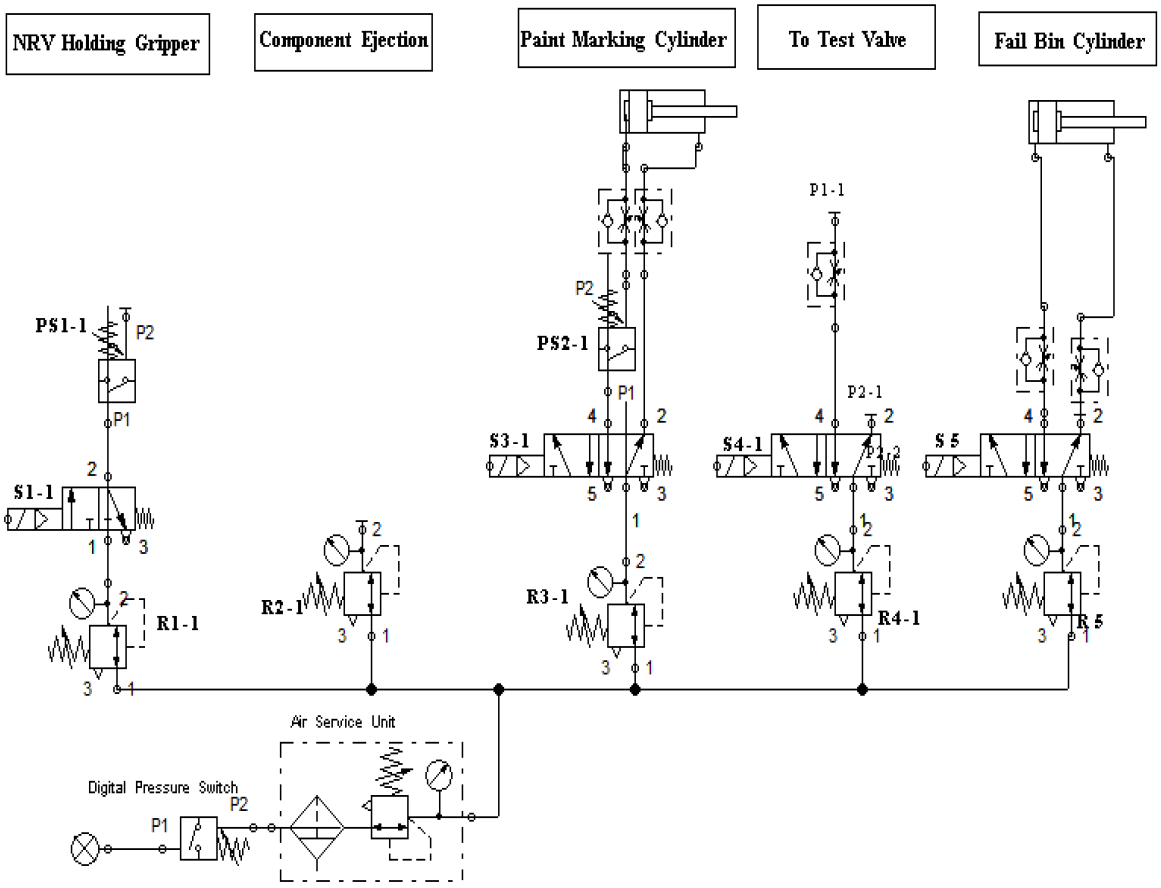


*Fig 4.7.4: Design of pneumatic circuit - 1*

The above figure represents the Pneumatic circuit for the Actuation of Process initialization for one of the two stations in the Twin Station NRV Testing Rig. It represents the fluid flow from the reservoir to the Gripper, Paint marking cylinder, Test Valve and Fail Bin Cylinder

## 4.7.5 DESIGN ANALYSIS OF PNEUMATIC CIRCUIT – 2

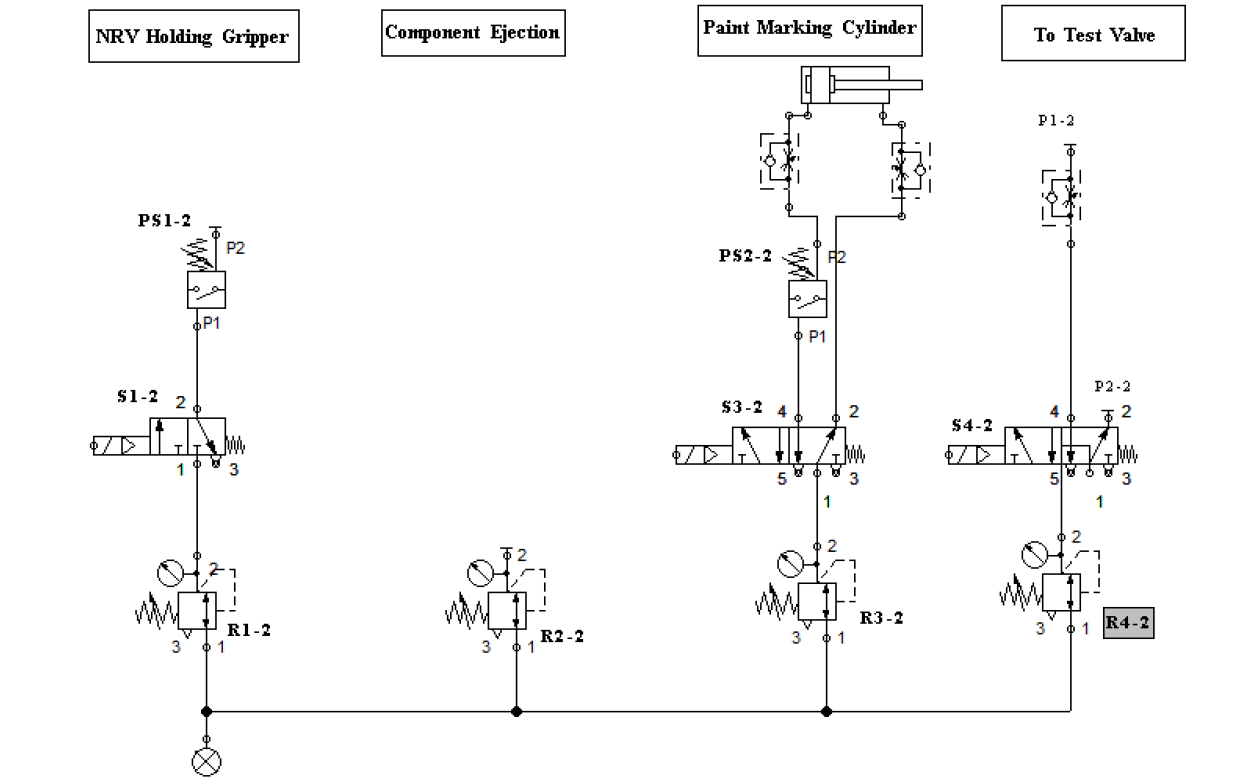


*Fig 4.7.5: Design of pneumatic circuit – 2*

The above figure represents the Pneumatic circuit for the Actuation of Process initialization for the other station in the Twin Station NRV Testing Rig. It represents the fluid flow from the reservoir to the Gripper, Paint marking cylinder, Test Valve and Fail Bin Cylinder.

## 4.7.6 DESIGN ANALYSIS OF PNEUMATIC CIRCUIT – 3

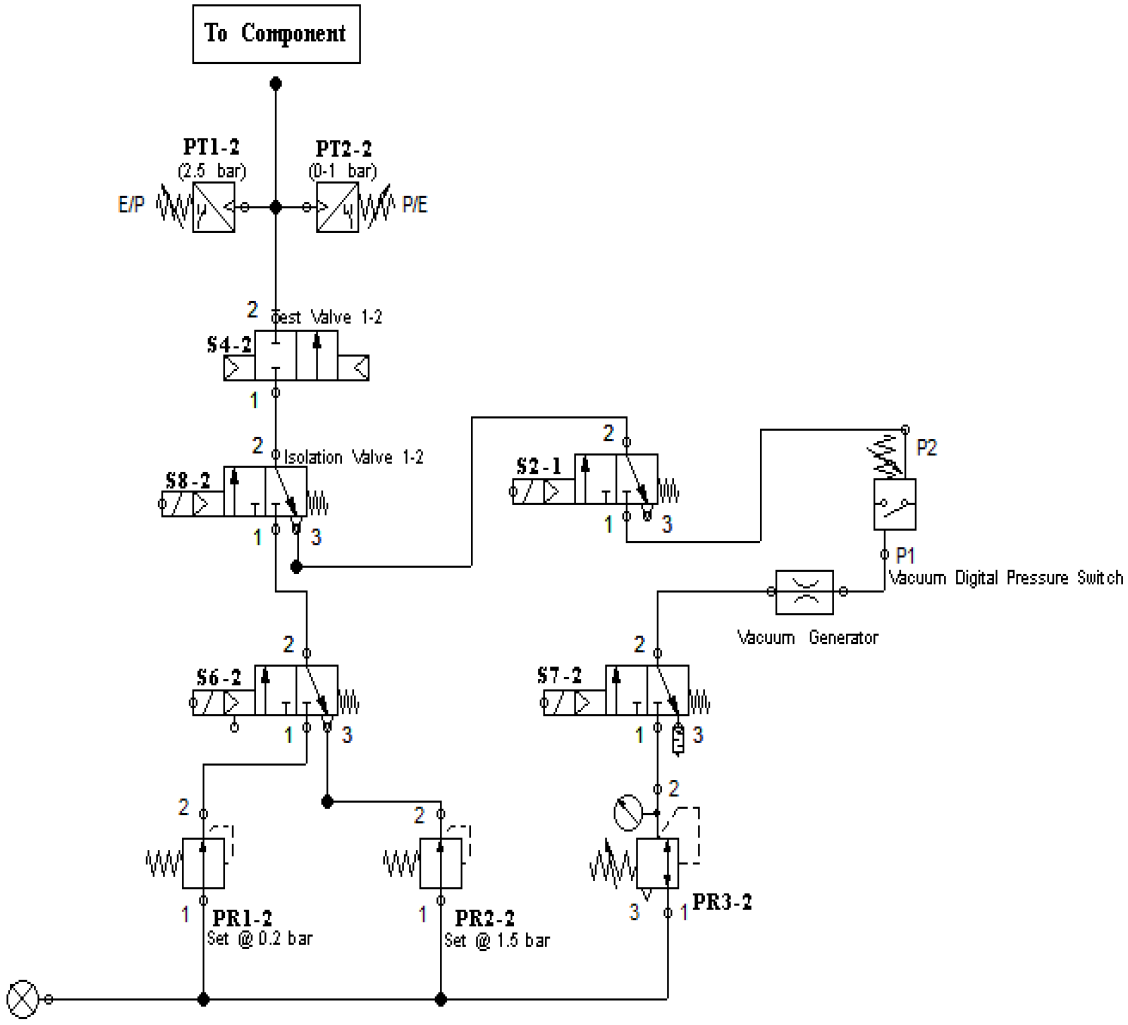


*Fig 4.7.6: Design of pneumatic circuit - 3*

The above figure represents the Pneumatic circuit for the Testing Process of every test with different pressures that is 0.2 Bar, 1.5 Bar and the Differential Vacuum test to be conducted on the NRV. It includes the Pressure regulators and the Vacuum generator for each test.

# CHAPTER 5
# HARDWARE/SOFTWARE COMPONENTS USED

## 5.1. ALLEN BRADLEY L306 PLC

Allen-Bradley, a subsidiary of Rockwell Automation, developed the AB L306 PLC, a compact and versatile programmable logic controller (PLC). It's excellent for a variety of industrial automation applications due to its user-friendly interface and durable build. Here's a quick summary of its specifications:

**1.Processor:** The AB L306 PLC is equipped with a strong processor that can perform difficult automation jobs efficiently.

**2.Memory:** It has enough memory to store programmed logic, data, and configurations.

**3.I/O Modules:** The PLC supports a variety of input and output modules, providing flexibility in system configuration and extension.

**4.Communication Ports:** It includes several communication ports for connecting to other devices, networks, and supervisory systems.

**5.Programming:** The PLC can be programmed using Rockwell Automation's software suite, which includes ladder logic, structured text, and other programming languages for a variety of application requirements.

**6.Environmental Ratings:** Designed for use in difficult industrial environments, it typically meets industry standards for temperature, humidity, vibration, and electrical noise resistance.

**7.Safety Features:** Includes built-in safety features and adheres to safety regulations to provide dependable operation and protection for persons and equipment.

**8.Mounting choices:** Available in a variety of form factors and mounting choices to meet varied installation needs.

The Microcontroller, an advanced hardware device meticulously crafted in collaboration with Adafruit, is ingeniously built around the ATmega32U4 (refer to the comprehensive datasheet for detailed specifications). The board boasts a versatile array of features, including 20 digital input/output pins. Among these, 7 pins are thoughtfully designated for pulse-width modulation (PWM) outputs, while 12 serve as analog inputs, adding a layer of flexibility to its functionality. Furthermore, a precision-engineered 16 MHz crystal oscillator ensures reliable performance, complemented by a micro-USB connection, an In-Circuit Serial Programming (ICSP) header, and a strategically positioned reset button.

A noteworthy convenience lies in the comprehensive integration of components that support the microcontroller's seamless operation. To kickstart its functionality, one simply needs to establish a connection with a computer using a standard micro-USB cable. This straightforward initiation process aligns with the user-friendly design, which includes a form factor facilitating effortless placement on a breadboard for rapid prototyping and experimentation.

The Micro board, in its architectural elegance, draws parallels with the acclaimed Arduino Leonardo. This similarity stems from the inherent USB communication capabilities of the ATmega32U4, effectively eliminating the need for an auxiliary processor. This intrinsic feature empowers the Micro to emulate, upon connection to a computer, the diverse functionalities of both a mouse and a keyboard. Additionally, it seamlessly presents itself as a virtual (Communication Device Class) CDC serial / Communication Port (COM port), widening its applications in various contexts. The

nuanced engineering behind the Micro not only enhances its utility but also positions it as a versatile tool in the realm of microcontroller development.


*Fig 5.1: AB L306 PLC*

**Specifications and values:**

| SPECIFICATIONS | VALUE |
|---|---|
| ● MCU | 8-bit ATmega328p |
| ● Frequency | 16 MHz |
| ● Input/Output | 14xDIO |
| ● ADC Pin | 6x10 Bit |
| ● Operating Voltage | 5V |
| ● IO Current | 40 mA |
| ● Program Memory | 32kB |

## 5.2. WEINTEK HMI

Weintek, a prominent company specializing in Human-Machine Interface (HMI) products and industrial automation solutions, is renowned for its innovative offerings tailored to meet the evolving demands of industrial control systems. Among its array of solutions, Weintek's EasyBuilder Pro software stands out as a cornerstone for programming Weintek HMIs. However, recent attention has been drawn to a vulnerability associated with hard-coded credentials in versions preceding v6.07.02, v6.08.01.592, and v6.08.02.470. Mitigations, such as updating EasyBuilder Pro to v6.08.01.614 or v6.08.02.500 and implementing defensive measures like network segmentation and secure remote access methods such as Virtual Private Networks (VPNs), have been recommended to address this concern.

Additionally, Weintek's commitment to security is evident in its response to security advisories highlighting vulnerabilities like code injection, improper access control, and cross-site scripting in its products. These vulnerabilities have prompted recommendations from organizations like CISA to apply OS upgrades, minimize network exposure, and employ firewalls and VPNs for secure remote access.

Weintek's MT8070iE HMI, a stalwart in industrial human-machine interface (HMI) solutions, parallels the Microcontroller's meticulous design and versatility. Here's a succinct overview of its key specifications:

**1.Processor:** Anchored by a robust 32-bit RISC 600MHz processor, the MT8070iE adeptly handles diverse industrial control tasks with precision.

**2.Memory:** With 128 MB of flash memory and 128 MB of RAM, the HMI offers ample space for storing configurations, data, and program logic.

**3.Communication Interfaces:** Featuring USB 2.0, Ethernet 10/100 Base-T, and COM ports (COM1: RS-232/RS-485 2W/4W, COM3: RS-485 2W), the MT8070iE facilitates seamless connectivity with peripheral devices and networks.

**4.Programming**: Utilizing the intuitive EasyBuilder Pro software, programming the MT8070iE is a seamless endeavor, empowering users with customization capabilities tailored to their industrial automation needs.

**5.Environmental Resilience:** Built to withstand industrial rigors, the MT8070iE boasts NEMA4 / IP65 compliance, ensuring durability in diverse operating environments.

**6.Physical Attributes:** Encased in a sturdy plastic enclosure, the MT8070iE's compact dimensions of 200.3 x 146.3 x 34 mm and lightweight design (approximately 0.6 kg) facilitate effortless panel mounting, meeting UL Type 4X, NEMA4, and IP65 standards.


*Fig 5.2: WEINTEK HMI*

**7.Operating Parameters:** Operating within a temperature range of 0° to 50°C and offering a storage temperature range of -20° to 60°C, the MT8070iE guarantees reliable performance across varying industrial settings.

Weintek's offerings extend to cloud-based monitoring solutions like Weincloud. Powered by a robust Cortex A8 1GHz CPU, Weincloud delivers real-time data visualization and synchronization in the cloud, bolstered by features such as customizable dashboards, historical data analysis, and SSL/TLS encryption for secure data transmission. Catering to the needs of machine builders, system integrators, and users seeking efficient monitoring and maintenance solutions, Weincloud exemplifies Weintek's commitment to innovation and customer satisfaction.

The MT8070iE HMI by Weintek offers a comprehensive set of features tailored for industrial control and monitoring applications, including a robust processor, ample memory, versatile communication interfaces, and durable construction meeting NEMA4 and IP65 standards.

In summary, Weintek's reputation as a reputable provider of HMI products, software solutions, and cloud-based monitoring services underscores its dedication to advancing industrial automation technologies, albeit with a keen awareness of the imperative to address security vulnerabilities to ensure the integrity and reliability of industrial operations.

**Specifications and values:**

| SPECIFICATIONS | VALUE |
|---|---|
| ● Processor | 32-bit RISC 600MHz |
| ● Memory | Flash: 128 MB, RAM: 128 MB |
| ● Com Interfaces | USB 2.0, Ethernet 10/100 Base-T, COM ports (COM1: RS-232/RS-485 2W/4W, COM3: RS-485 2W) |
| ● Programming | EasyBuilder Pro software |
| ● Physical Attributes | Dimensions: 200.3 x 146.3 x 34 mm |
| ● Operating Parameters | Operating Temperature: 0°C to 50°C, Storage Temperature: -20°C to 60°C |

## 5.3. FESTO VACUUM GENERATOR VN-30-H

Festo, a leading global manufacturer of automation technology, known for its wide range of high-quality pneumatic and electrical automation components and solutions, was founded in 1925 and is headquartered in Esslingen, Germany. The company operates in over 176 countries worldwide, with a global network of subsidiaries and sales partners, employing over 20,000 people globally. Festo has established a strong reputation for innovation, reliability, and a customer-centric approach. Festo's product portfolio encompasses a wide range of automation components, including pneumatic and electric actuators, valves, sensors, controllers, and software solutions. The company is particularly known for its innovative vacuum technology, which includes a diverse range of vacuum generators, such as the VN-30-H model.

Festo's automation solutions are widely used across various industries, including automotive, packaging, food and beverage, and pharmaceutical, among others. Festo is recognized for its customer-centric approach, offering comprehensive technical support, customization services, and tailored solutions to meet the specific needs of its clients. The company's global presence and extensive distribution network allow it to provide localized support and quick delivery of products to customers worldwide. The Vacuum Generator VN- 30-H, a versatile component designed for various industrial applications requiring vacuum handling, gripping, and lifting of objects. Here's a concise overview of its specifications:

**1.Performance:** The VN-30-H boasts a maximum suction flow rate of 30 Nl/min and achieves a maximum vacuum level of -85 kPa, ensuring efficient operation for a wide range of vacuum-based tasks.

**2.Compact Design:** With its compact and lightweight design, the VN-30-H offers easy integration into machinery and equipment, providing a space-saving solution for industrial automation setups.

**3.Versatile Connections:** Flexible connection options are facilitated by a G1/8 female thread for the vacuum connection and another G1/8 female thread for the compressed air supply, ensuring adaptability to various system configurations.

**4.Materials and Construction:** Constructed with high-quality materials, including a die-cast aluminum body, the VN-30-H ensures durability and reliability in challenging industrial environments.

**5.Customization:** Festo offers various configuration options for the VN-30-H, allowing users to tailor the vacuum generator to specific application requirements, enhancing its versatility and effectiveness.

**6.Application:** Industrial automation, Automotive, packaging, food and beverage, pharmaceutical, among others.

**7.Additional Features:** vacuum switch, Integrated ejector pulse, Electrical control for vacuum ON/ OFF, Combination of ejector pulse and actuation.

The Vacuum Generator VN-30-H is a versatile component in Festo's vacuum technology product line, designed for various industrial applications such as handling, gripping, and lifting of objects. Featuring a maximum suction flow rate of 30 Nl/min and a maximum vacuum level of -85 kPa, the VN-30-H excels in vacuum-based tasks. Its compact and lightweight design allows for easy integration into machinery and equipment, providing a space-saving solution. The vacuum generator offers flexible connection options with a G1/8 female thread for the vacuum connection and a G1/8 female thread for the compressed air supply. Constructed with high-quality materials, including a die-cast aluminum body, the VN-30-H ensures durability and reliability in industrial environments. Festo offers various configuration options for the VN-30-H, allowing customers to tailor the vacuum generator to their specific application requirements.

*Fig 5.3: FESTO Vacuum Generator VN-30-H*

**Specifications and values:**

| SPECIFICATIONS | VALUE |
|---|---|
| ● Nominal Size, Laval Nozzle | 3 mm |
| ● Grid Dimension | 24 mm |
| ● Design | T-shape |
| ● Operating Pressure (Max. Suction Flow Rate) | 3 bar |
| ● Operating Pressure (Max. Vacuum) | 3.7 bar |
| ● Maximum Vacuum | 93% |
| ● Nominal Operating Pressure | 6 bar |
| ● Air Supply Time (at Nominal Operating Pressure) | 0.1 s |
| ● Operating Medium | Compressed air |
| ● Ambient Temperature | 0°C to 60°C |
| ● Product Weight | 182 g |

In summary, Festo's Vacuum Generator VN-30-H embodies the company's commitment to providing innovative and high-quality automation solutions, while also meeting our requirements, offering reliability, versatility, and performance to meet the diverse needs of industrial customers worldwide.

## 5.4. SOLIDWORKS

SolidWorks, a robust and feature-rich computer-aided design (CAD) software, takes center stage as the primary tool for the mechanical design aspects of this project, providing an unparalleled environment for creating and refining intricate 3D models.

At the core of SolidWorks' appeal lies its comprehensive suite of modelling and simulation tools, empowering designers to transform conceptual ideas into precise and visually compelling 3D representations. The software's parametric modelling capabilities enable the creation of intelligent designs, allowing for efficient modification and adaptation as the project evolves.

SolidWorks' user-friendly interface ensures a smooth design process, catering to both novice and experienced designers. The intuitive sketching tools, coupled with robust parametric controls, facilitate the creation of detailed and accurate models. The software's assembly features enable the seamless integration of various components, offering a holistic view of the project's mechanical structure.

The software's simulation capabilities are instrumental in validating and optimizing designs before physical prototyping. SolidWorks' finite element analysis (FEA) tools enable engineers to assess the structural integrity and performance of components, ensuring that the final design meets the project's specifications and requirements.

SolidWorks' compatibility with industry-standard file formats enhances collaboration within the design team. The ability to import and export files in various formats ensures smooth communication with other tools and stakeholders involved in the project.

The software's extensive library of pre-built components and materials streamlines the design process, saving valuable time and ensuring that the project adheres to industry standards. SolidWorks' photorealistic rendering capabilities allow

for the creation of lifelike visualizations, aiding in the communication of design concepts to stakeholders.

Moreover, SolidWorks' commitment to continuous improvement, backed by a dedicated user community and regular software updates, ensures that designers have access to cutting-edge features and enhancements. This commitment, combined with comprehensive training resources, empowers designers to maximize their proficiency and leverage the full potential of the software.

In essence, SolidWorks emerges as the software of choice for the mechanical design aspects of this project, offering a powerful and versatile platform that seamlessly integrates modelling, simulation, and validation. Its user-friendly interface, parametric modelling capabilities, simulation tools, and commitment to innovation collectively position it as an indispensable tool for bringing the project's mechanical components to life.

## 5.5. FLUIDSIM

For more than 25 years, FluidSIM has been the world's leading simulation software for creating and simulating circuit diagrams in pneumatics, hydraulics, and electrical engineering. FluidSIM enables valuable technical skills to be acquired by designing circuits, bringing them to life through simulation and optimizing them through interaction. The simulation of control systems and processes has long been an industrial standard that ensures errors are prevented, and efficiency and quality are increased.

FluidSIM 6 Pneumatics, the premier software for designing and simulating pneumatic circuit diagrams, revolutionizes the field with its comprehensive features and intuitive interface.

At the heart of FluidSIM 6 Pneumatics lies its interactive simulation in high definition, enabling the creation and simulation of pneumatic circuit diagrams with unparalleled precision and realism. The software is tailored for lesson preparation, classroom use, and self-learning, offering a robust platform for understanding automation technology principles.

The software application provides a practical way for students to develop their skills in automation technology and to master complex tasks. The learning objectives of FluidSIM include: Learning Goals: Creation of circuit diagrams, Error identification and prevention, Simulation and optimization of solution circuit diagrams, understanding of solution development in automation technology and learning the effects of technical changes through real-time simulation.

With these learning goals, it benefits the users in many ways which include: Interactive simulation in high definition, Virtual and real measuring devices, Extensive component library, Intuitive operation, Complete didactic material included.

FluidSIM 6 Pneumatics facilitates the creation of electro pneumatic circuits and their interactive simulation. Realistic changes of state and switching processes are accurately calculated, with interactive interventions possible through switches or valves. The software also supports signal transmission via connected hardware or other programs, along with virtual measuring devices.

With this technology, FluidSIM covers topics such as: Pneumatics/electro pneumatics, Closed-loop pneumatics, Vacuum technology, Electrical controls, Digital technology and GRAFCET (EN 60848).

FluidSIM 6 incorporates a novel diagnostic concept, storing fault models for various components to depict typical defects. Thus, emerging as a go-to solution for designing and simulating with a user-friendly interface, extensive component library, and robust simulation core.

## 5.6 EASYBUILDER PRO

Weintek's EasyBuilder Pro software stands out as a powerful tool for programming Human-Machine Interface (HMI) devices, offering a user-friendly interface and advanced features for efficient automation control. This software plays a crucial role in configuring and customizing Weintek HMIs, enabling seamless integration with various electronic and pneumatic systems.

EasyBuilder Pro simplifies the process of HMI modeling by providing intuitive tools and a drag-and-drop interface for designing interactive and visually appealing user interfaces. Users can create dynamic screens, incorporate graphics, animations, and interactive elements, and configure data display formats with ease. The software allows for the creation of multi- page projects, enabling comprehensive visualization of control processes and system status.

EasyBuilder Pro facilitates seamless interfacing with electronics and pneumatics, enhancing the functionality and control capabilities of Weintek HMIs. The software supports communication protocols for connecting to a wide range of electronic devices, such as PLCs, sensors, and actuators, enabling real-time data exchange and control. This integration allows for monitoring and controlling pneumatic systems, adjusting parameters, and responding to feedback efficiently.

EasyBuilder Pro, from Weintek, facilitates customized HMI screen design for industrial applications, enhancing flexibility. It provides real-time data visualization, including alarms and trends, for informed decision-making. The software supports scripting functions for advanced logic control and event handling, empowering customization of HMI behavior. Its compatibility with diverse Weintek HMI models ensures adaptability and scalability in automation projects.

In conclusion, Weintek's EasyBuilder Pro software provides a comprehensive solution for HMI programming, offering advanced features for HMI modeling and seamless interfacing with electronics and pneumatics. Its user-friendly design, robust functionality, and compatibility with various devices make it a valuable tool for optimizing automation processes and enhancing operational efficiency in industrial settings

# CHAPTER 6

# PROTOTYPE IMAGES

## 6.1 FRONT VIEW OF THE PROTOTYPE

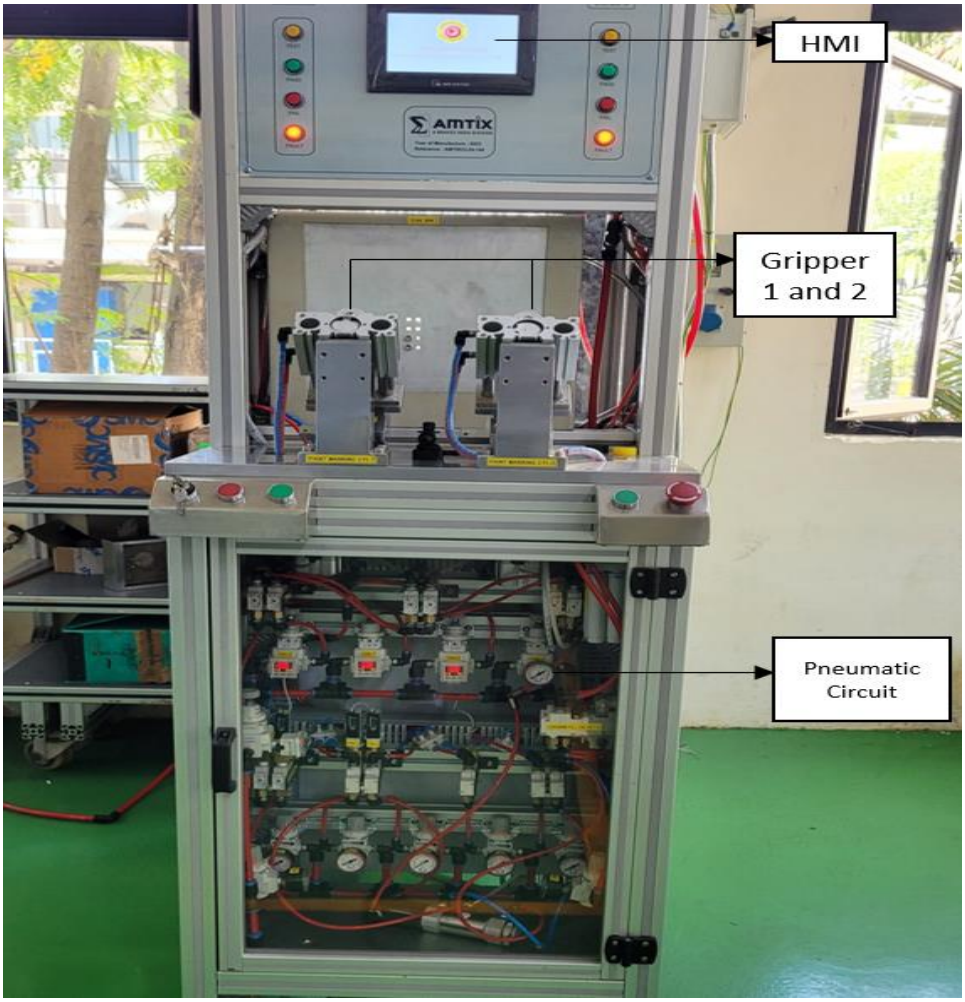


*Fig 6.1: Front view of the prototype*

The above figure shows the actual image of the prototype and labels out the components of the rig shown in the image which includes the HMI, The Pain marking cylinders 1 and 2 and a glimpse of the Pneumatic Circuit and its connections.

## 6.2 BACK VIEW OF THE PROTOTYPE

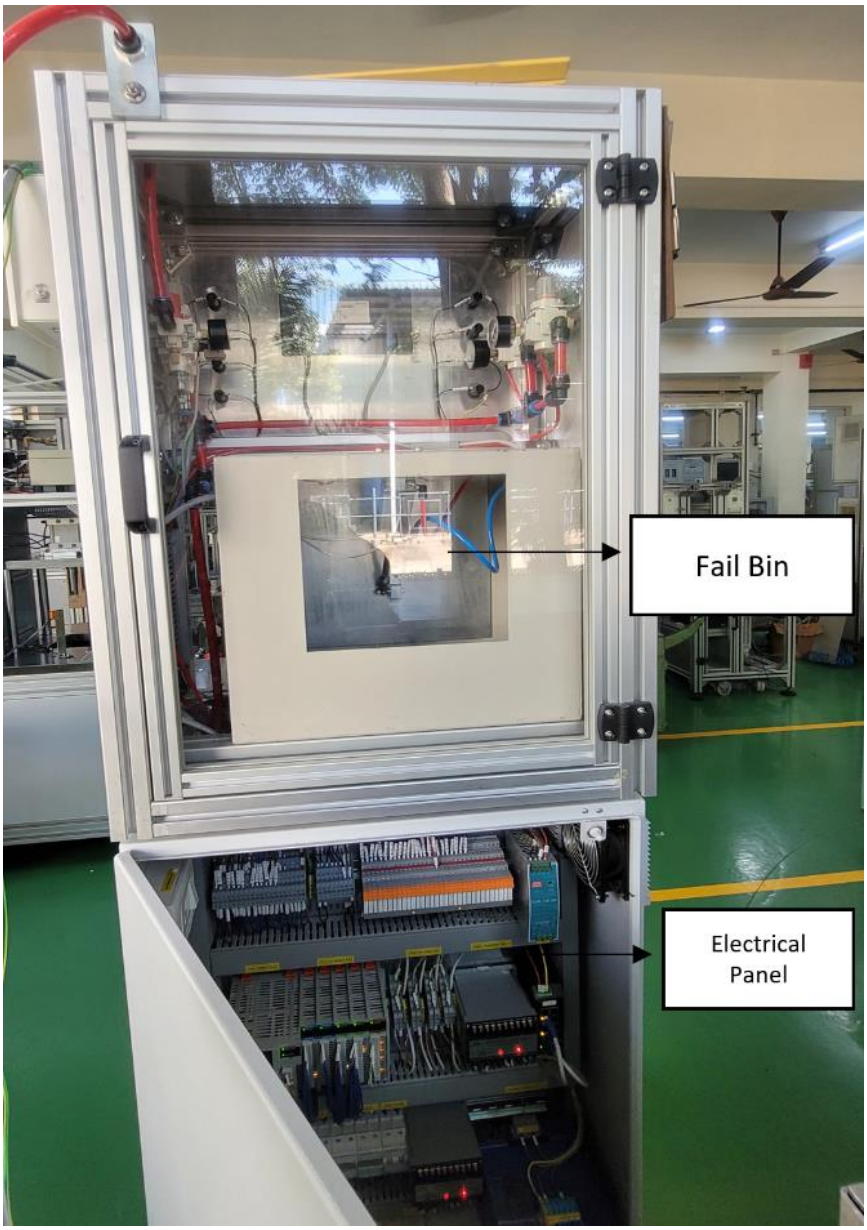


*Fig 6.2: Back view of the prototype*

The above figure shows the actual Back view image of the prototype and labels out the components of the rig shown in the image which includes the Fail Bin and a glimpse of the Electrical Panel used for the automation of the Rig.

## 6.3 PNEUMATIC CONNECTIONS OF THE PROTOTYPE

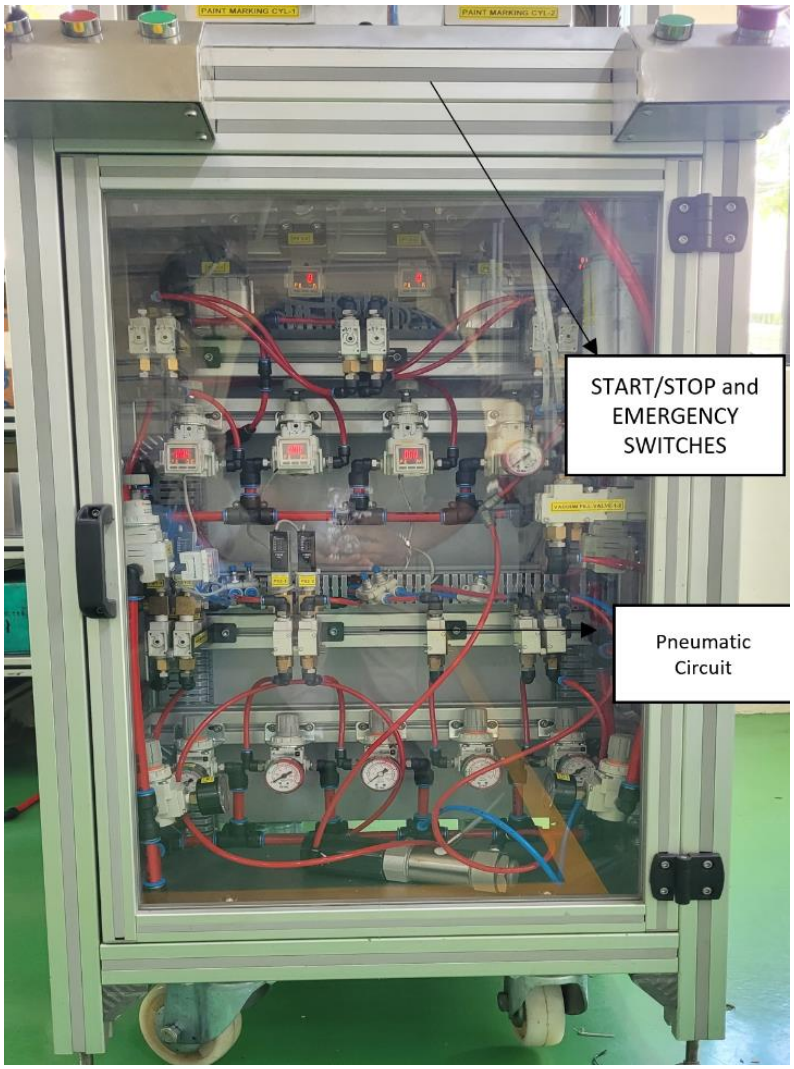


*Fig 6.3: Isometric view of the prototype*

The above figure shows the actual image and the pneumatic connections of the prototype, labelling out the components of the rig shown in the image which also includes the control switches.

# CHAPTER 7
# RESULT AND DISCUSSION

In conclusion, the Twin Station NRV Testing Rig represents a paradigm shift in Non-Return Valve (NRV) evaluation, offering a comprehensive solution for precise assessments through automated sequential leak tests and vacuum testing. This automation significantly enhances operational efficiency, leading to streamlined processes and reduced testing durations compared to manual methods. The rig's robust design and sophisticated data collection mechanisms provide invaluable insights into NRV performance and manufacturing processes, empowering continuous improvement initiatives within automotive brake system production. The integration of accurate sensors enables comprehensive data analysis, facilitating informed decision-making and driving continuous process enhancement.

Furthermore, the rig's adherence to rigorous testing protocols ensures the reliability and safety of automotive brake systems by preventing faulty NRVs from entering production lines. Designed to meet or exceed industry standards, the rig ensures compliance with regulatory requirements, guaranteeing alignment with automotive safety regulations. The user-friendly Human-Machine Interface (HMI) further enhances operational ease, enabling technicians to monitor and control testing seamlessly. Beyond operational efficiency, the rig's efficient testing processes and early defect detection contribute to reduced material wastage, thereby minimizing environmental impact and supporting sustainability objectives and corporate social responsibility initiatives. Moreover, the project provides valuable opportunities for training and skill development among technicians and engineers, fostering a culture of continuous learning and expertise within the organization.

This project experience equips team members with a diverse skill set and fosters a deep appreciation for the complexities and rewards inherent in real-world engineering projects. Ultimately, the Twin Station NRV Testing Rig plays a pivotal role in enhancing customer satisfaction by ensuring the delivery of reliable, high-performance brake systems, solidifying its significance in the automotive industry.

# 7.1 BILL OF MATERIALS

| Twin Station NRV Leak Test Rig -SPD | | | |
|---|---|---|---|
| Description | Qty | Unit Price | Amount |
| AB L306 | 1 | ₹15000 | ₹15000 |
| Weintek 7" HMI | 1 | ₹12000 | ₹12000 |
| AB Analog module -5069 -IF8 | 1 | ₹10000 | ₹10000 |
| AB OB 16 output moduie | 1 | ₹10000 | ₹10000 |
| AB Ig16 input module | 1 | ₹10000 | ₹10000 |
| Wika transmitter 0 to 2.5 bar ‘t | 2 | ₹10000 | ₹20000 |
| Wika transmitter 1 bar ABS | 2 | ₹11000 | ₹22000 |
| Electrical panel | 1 | ₹10000 | ₹10000 |
| Transformer | 1 | ₹6000 | ₹6000 |
| Ethernet switch | 1 | ₹8000 | ₹8000 |
| Tower lamp | 1 | ₹3500 | ₹3500 |
| Anjana power supply | 2 | ₹3500 | ₹7000 |
| Fail bin Contrinex proximity with cable | 1 | ₹1500 | ₹1500 |
| Electrical acc. | | ₹30000 | ₹30000 |
| **Electical and Electronic System** | | | ₹165000 |
| SMC FRL Unit | 1 | ₹9500 | ₹9500 |
| SMC 5/2 Single solenoid valve | 5 | ₹4000 | ₹20000 |
| SMC 3/2 solenoid valve | 6 | ₹3800 | ₹22800 |
| SMC regulator | 7 | ₹1500 | ₹10500 |
| SMC precision regulator | 6 | ₹6500 | ₹39000 |
| CKD pressure switch | 5 | ₹2000 | ₹10000 |
| DPS Vacuum | 2 | ₹3200 | ₹6400 |
| SS Reservoir 1,5 L/2L | 2 | ₹3500 | ₹7000 |
| Dps Air | 5 | ₹2800 | ₹14000 |
| Festo vacuum Generator VN 30 | 2 | ₹8000 | ₹16000 |
| Flow control valve | 10 | ₹1000 | ₹10000 |

| | | | |
|---|---|---|---|
| BI Test valve | 4 | ₹15000 | ₹60000 |
| SMC fitting, Quick exh. and tubing | 1 | ₹15000 | ₹15000 |
| Hardware accessories | 1 | ₹10000 | ₹10000 |
| **Fluid control system** | | | ₹2,50,200 |
| Main Fixture with base palte | 1 | ₹75000 | ₹75000 |
| Clamping cylinder | 2 | ₹6000 | ₹12000 |
| Stamping cylinder | 2 | ₹3250 | ₹6500 |
| Pass bin cylinder | 1 | ₹2500 | ₹2500 |
| Fail bin cylinder | 1 | ₹2500 | ₹2500 |
| Standard items ( sbc shaft) | 1 | ₹15000 | ₹15000 |
| **Fixture and Machine elements** | | | ₹1,13,500 |
| Aluminium Profile with acd, | 1 | ₹60000 | ₹60000 |
| Carry wheel with plate | 1 | ₹10000 | ₹10000 |
| MS'sheet & Name plates | 1 | ₹20000 | ₹20000 |
| **Profiles and Name plates** | | | ₹90000 |
| **Total Material Cost** | | | ₹618700 |
| Equipment Design Charges | 1 | ₹61870 | ₹61870 |
| PLC Programming Charges | 1 | ₹92805 | ₹92805 |
| Project Planning and Execution Charges | 1 | | ₹123740 |
| Overhead Charges | | ₹123740 | ₹278415 |
| Packing and Forwarding | 1 | ₹10000 | ₹10000 |
| Freight | 1 | ₹15000 | ₹15000 |
| Insurance | 1 | ₹5000 | ₹5000 |
| Documentation and Manual | 1 | ₹3510 | ₹3510 |
| **Freight and Insurance Charges** | | | |
| Installation & Commissioning | 1 | ₹9300 | ₹9300 |
| Training of your Engineers | 1 | ₹10075 | ₹10075 |
| Installation and Training charges | | | ₹19375 |
| | | **Total** | **₹9,50,000** |

# CHAPTER 8

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# CHAPTER 9
# CERTIFICATE / JOURNAL

## 9.1 BRAKES INDIA PROECT CERTIFICATE

Brakes India

13th March 2024

**CERTIFICATE**

This is to certify that Mr.Khalid Shajahan, 4th year B.E.(Mechatronics Engineering) of **Rajalakshmi Engineering College, Chennai** has done his **Project Work** in **"Technology Development Department"** from **5th January 2024 to 16th February 2024**.

His Project Work on **"Twin Station NRV Testing Rig"** was completed successfully.

We wish him success in all his future endeavours.

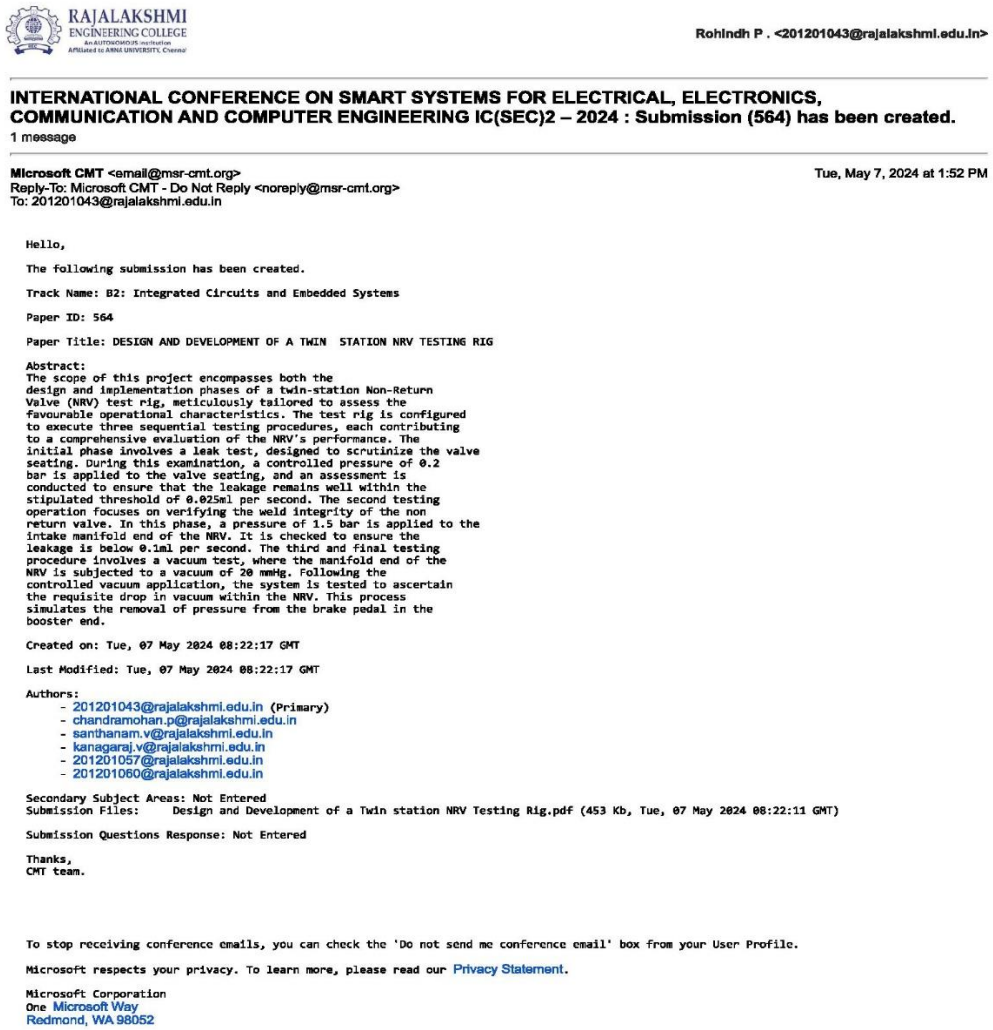
N Lakshminarasimhan
Senior General Manager (P& HR- LVBU)

BRAKES INDIA PRIVATE LIMITED PADI CHENNAI 600 050

Brakes India Private Limited
Corporate Office : M.T.H. Road, Padi, Chennai - 600 050. | Registered Office : No. 21, Patullos Road, Chennai - 600 002.
(044) 2625 8161 (044) 2625 7010 www.brakesindia.com sales@brakesindia.co.in CIN: U35999TN1962PTC004928

*Fig 9.1: Certificate provided by Brakes India for the project completion*

# 9.2 APPLIED FOR INTERNATIONAL CONFERENCE ON SMART SYSTEMS FOR ELECTRICAL, ELECTRONICS, COMMUNICATION AND COMPUTER ENGINEERING IC



RAJALAKSHMI ENGINEERING COLLEGE
An AUTONOMOUS institution
Affiliated to ANNA UNIVERSITY, Chennai

Rohindh P . <201201043@rajalakshmi.edu.in>

**INTERNATIONAL CONFERENCE ON SMART SYSTEMS FOR ELECTRICAL, ELECTRONICS, COMMUNICATION AND COMPUTER ENGINEERING IC(SEC)2 – 2024 : Submission (564) has been created.**

1 message

**Microsoft CMT** <email@msr-cmt.org> Tue, May 7, 2024 at 1:52 PM
Reply-To: Microsoft CMT - Do Not Reply <noreply@msr-cmt.org>
To: 201201043@rajalakshmi.edu.in

Hello,

The following submission has been created.

Track Name: B2: Integrated Circuits and Embedded Systems

Paper ID: 564

Paper Title: DESIGN AND DEVELOPMENT OF A TWIN STATION NRV TESTING RIG

Abstract:
The scope of this project encompasses both the design and implementation phases of a twin-station Non-Return Valve (NRV) test rig, meticulously tailored to assess the favourable operational characteristics. The test rig is configured to execute three sequential testing procedures, each contributing to a comprehensive evaluation of the NRV's performance. The initial phase involves a leak test, designed to scrutinize the valve seating. During this examination, a controlled pressure of 0.2 bar is applied to the valve seating, and an assessment is conducted to ensure that the leakage remains well within the stipulated threshold of 0.025ml per second. The second testing operation focuses on verifying the weld integrity of the non return valve. In this phase, a pressure of 1.5 bar is applied to the intake manifold end of the NRV. It is checked to ensure the leakage is below 0.1ml per second. The third and final testing procedure involves a vacuum test, where the manifold end of the NRV is subjected to a vacuum of 20 mmHg. Following the controlled vacuum application, the system is tested to ascertain the requisite drop in vacuum within the NRV. This process simulates the removal of pressure from the brake pedal in the booster end.

Created on: Tue, 07 May 2024 08:22:17 GMT

Last Modified: Tue, 07 May 2024 08:22:17 GMT

Authors:
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- chandramohan.p@rajalakshmi.edu.in
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- kanagaraj.v@rajalakshmi.edu.in
- 201201057@rajalakshmi.edu.in
- 201201060@rajalakshmi.edu.in

Secondary Subject Areas: Not Entered
Submission Files: Design and Development of a Twin station NRV Testing Rig.pdf (453 Kb, Tue, 07 May 2024 08:22:11 GMT)

Submission Questions Response: Not Entered

Thanks,
CMT team.

To stop receiving conference emails, you can check the 'Do not send me conference email' box from your User Profile.

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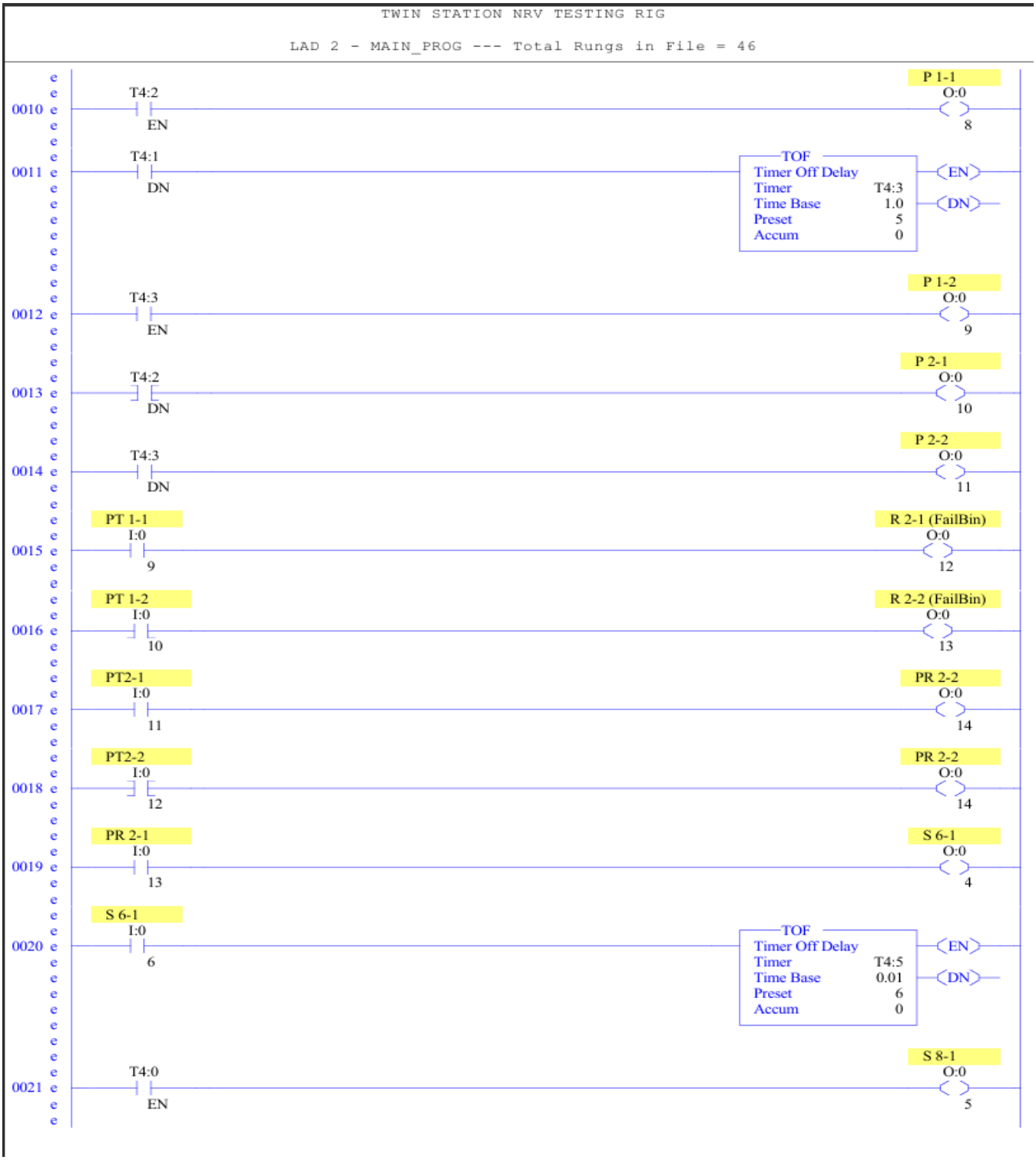
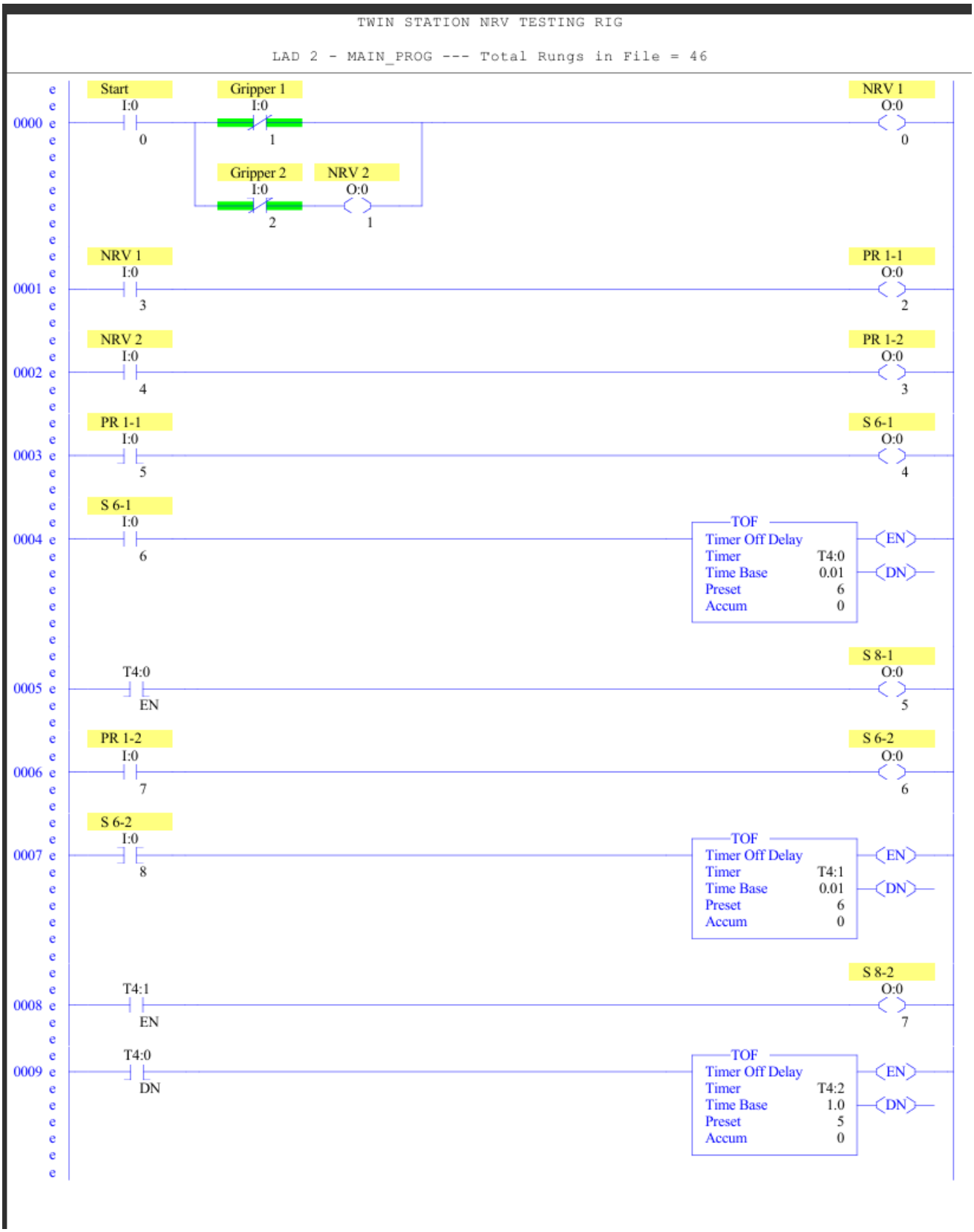
*Fig 9.2: Applied for ICSSEECC*

# CHAPTER 10
# APPENDIX

## PLC PROGRAM




TWIN STATION NRV TESTING RIG
LAD 2 - MAIN_PROG --- Total Rungs in File = 46
0000
Start
I:0
0
Gripper 1
I:0
1
Gripper 2
I:0
2
NRV 2
O:0
1
NRV 1
O:0
0
0001
NRV 1
I:0
3
PR 1-1
O:0
2
0002
NRV 2
I:0
4
PR 1-2
O:0
3
0003
PR 1-1
I:0
5
S 6-1
O:0
4
0004
S 6-1
I:0
6
TOF
Timer Off Delay
Timer T4:0
Time Base 0.01
Preset 6
Accum 0
EN
DN
0005
T4:0
EN
S 8-1
O:0
5
0006
PR 1-2
I:0
7
S 6-2
O:0
6
0007
S 6-2
I:0
8
TOF
Timer Off Delay
Timer T4:1
Time Base 0.01
Preset 6
Accum 0
EN
DN
0008
T4:1
EN
S 8-2
O:0
7
0009
T4:0
DN
TOF
Timer Off Delay
Timer T4:2
Time Base 1.0
Preset 5
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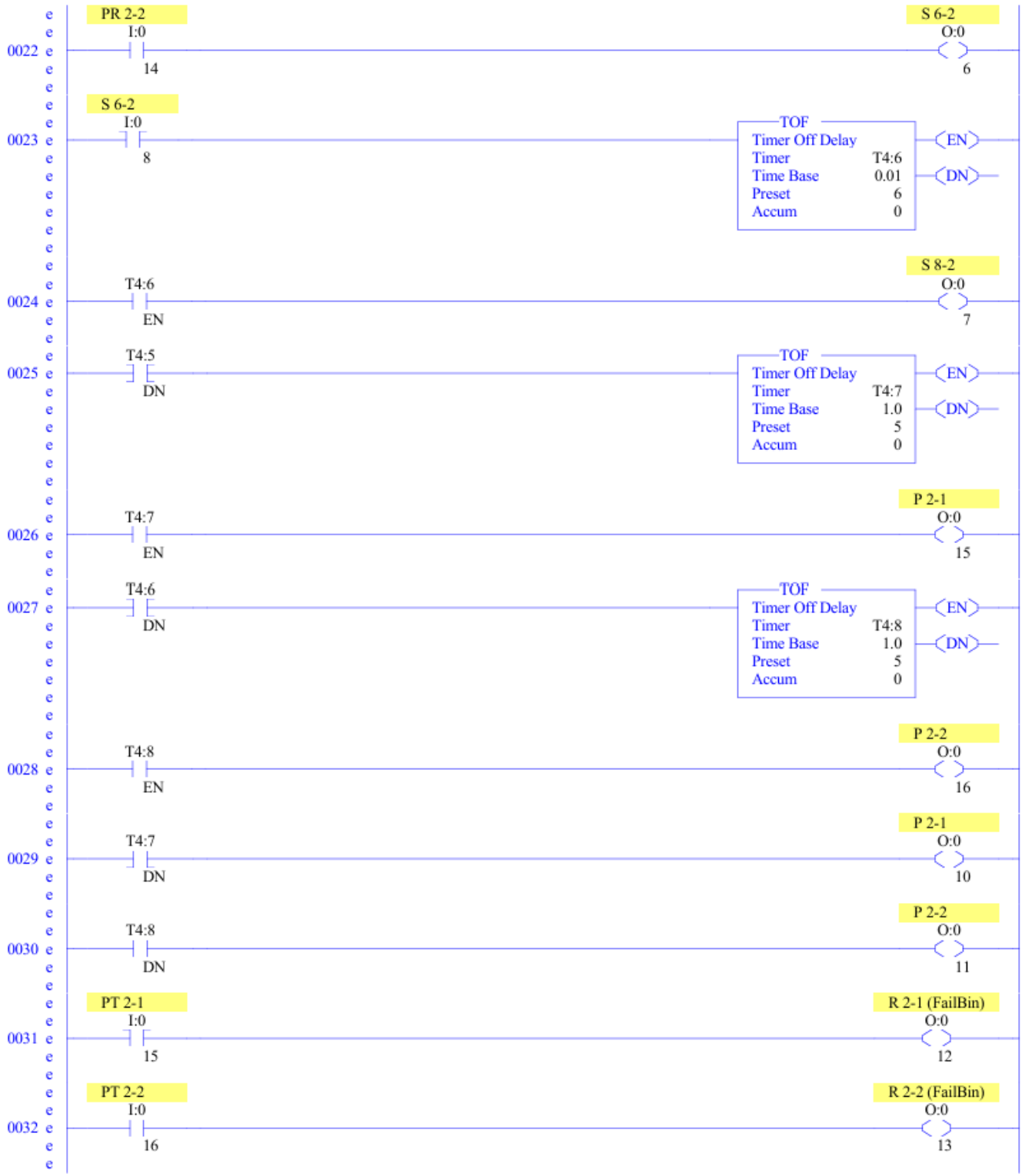
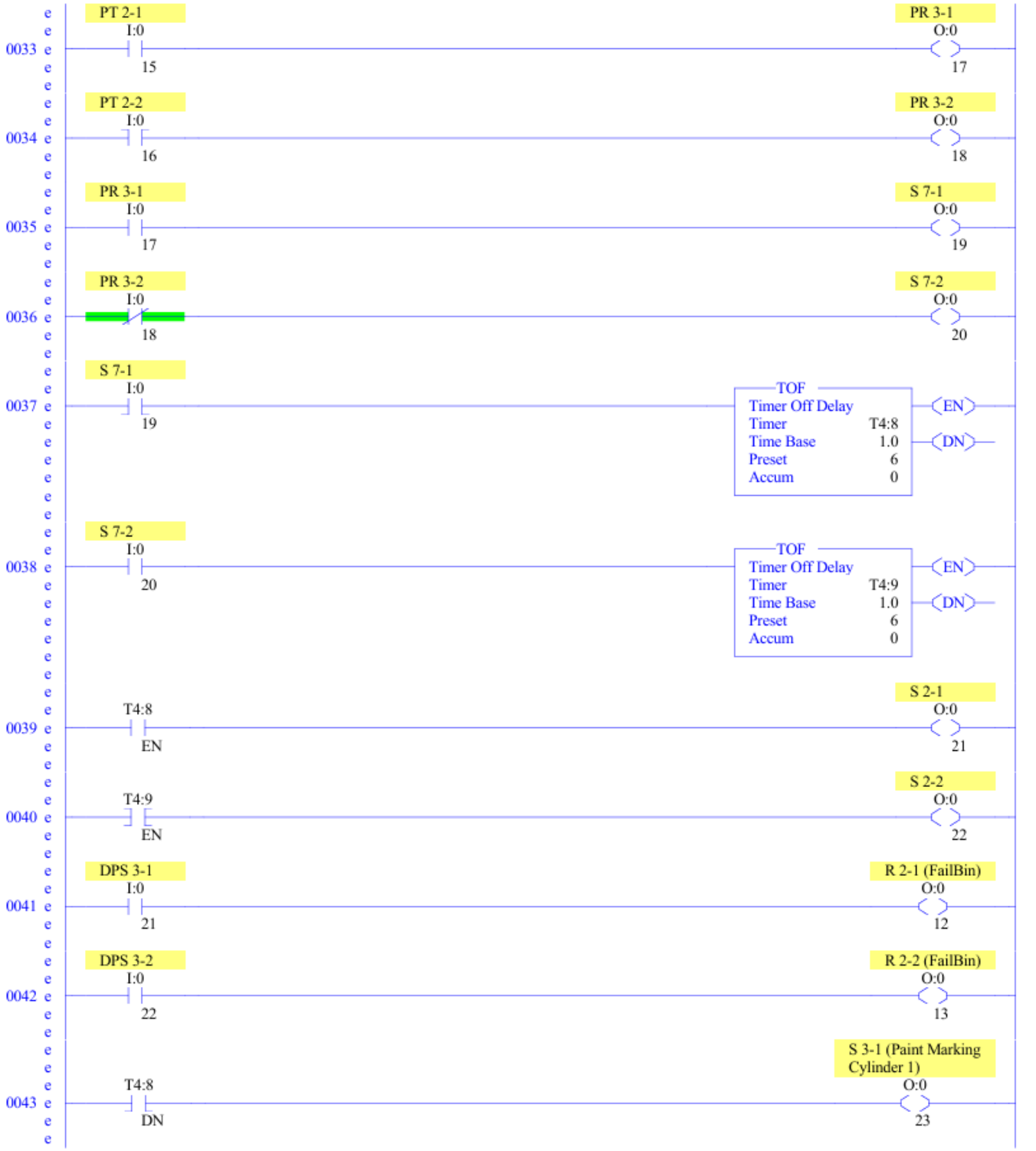
TWIN STATION NRV TESTING RIG

LAD 2 - MAIN_PROG --- Total Rungs in File = 46



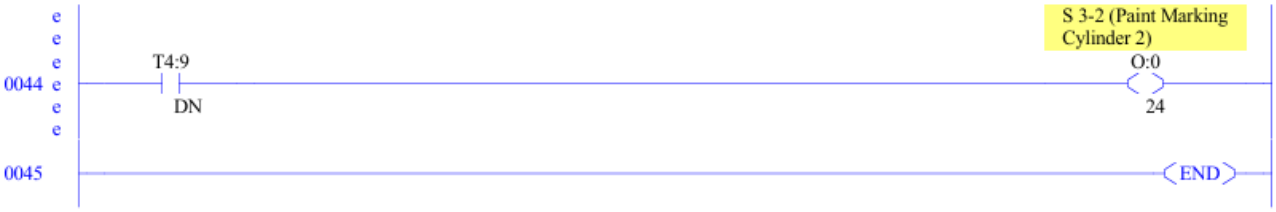
TWIN STATION NRV TESTING RIG

LAD 2 - MAIN_PROG --- Total Rungs in File = 46



TWIN STATION NRV TESTING RIG

LAD 2 - MAIN_PROG --- Total Rungs in File = 46



# RAJALAKSHMI ENGINEERING COLLEGE
## (An Autonomous Institution Affiliated to Anna University Chennai)

## DEPARTMENT OF MECHATRONICS ENGINEERING
## CURRICULUM AND SYLLABUS REGULATIONS – 2019
## B.E. MECHATRONICS ENGINEERING

**VISION:**

To attain excellence in academics, research and technological advancement in Mechatronics Engineering with a concern for society.

**MISSION:**

● To impart high quality professional education and produce Mechatronics Engineers with all round knowledge of multi-disciplinary branches of engineering and technology.

● To foster skill sets required to be a global professional in the areas of automation, intelligent systems, robotics, research for technology management and to fulfill the expectations of industry and needs of the society.

● To inculcate entrepreneurial qualities for creating, developing and managing global engineering ventures.

**Programme Educational Objectives (PEOs):**

**PEO I :**

Graduates will have comprehensive knowledge in the analytical, scientific and engineering fundamentals necessary to model, analyze and solve engineering problems and to prepare them for graduate studies and for successful careers in

industry.

**PEO II :**

Graduates will effectively design and develop products in areas such as automation, manufacturing, Internet of Things, machine vision, system simulation, intelligent systems and robotics.

**PEO III:**

Graduates will acquire technical expertise, Leadership skills, Ethical practices and Team spirit with a concern towards greener society.

**PROGRAM OUTCOMES (POs):**

Engineering Graduates will be able to:

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

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

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

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

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

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

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

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

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

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

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

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

**PROGRAM SPECIFIC OUTCOMES (PSOs)**

Engineering Graduates will be able:

**PSO 1**: To innovate a Mechatronics system to meet the requirements and specifications.

**PSO 2:** To analyze and improve the performance of a Mechatronics system and enhance the intellectual capabilities of the system

**PSO 3:** To lead a professional career in industries or an entrepreneur by applying Engineering and Management principles and practices**.**

| MT19811 | PROJECT WORK PHASE -II | EEC | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 0 | 0 | 16 | 0 |

| **Objectives:** This laboratory course enables students to | |
|---|---|
| • | To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same |
| • | To train the students in preparing project reports and to face reviews and viva voce examination |

| **Course Outcomes: On completion of the course, the student will be able to:** | |
|---|---|
| **CO1** | Ability to fabricate any components using appropriate manufacturing techniques |
| **CO2** | Use of design principles and develop conceptual and engineering design of any mechatronics component |
| **CO3** | Demonstrate the function of the fabricated model |
| **CO4** | Prepare the project as a technical report and deliver it in oral presentation |
| **CO5** | Exhibit their team work and technical Skills |

| PO/PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO | | | | | | | | | | | | | | | |
| C01 | | | | | | | | | | | | | | | |
| CO2 | | | | | | | | | | | | | | | |
| CO3 | | | | | | | | | | | | | | | |
| C04 | | | | | | | | | | | | | | | |
| C05 | | | | | | | | | | | | | | | |

CO - PO – PSO Matrices of Course

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

If there is no correlation, put “-“