Design and Development of Fatigue Testing Machine for Rubber Components

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I certify that this research work titled "Design and development of fatigue testing machine for rubber components" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

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I am thankful to my Creator Allah Subhana-Watala to have guided me throughout this work at every step and for every new thought which you setup in my mind to improve it. Indeed, I could have done nothing without Your priceless help and guidance. Whosoever helped me throughout the course of my thesis, whether my parents or any other individual was Your will, so indeed none be worthy of praise but You.

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Abstract

Mechanical Fatigue testing and life evolution is very important in design and development procedure to make sure the safety, reliability of part to be used. Structures, manufactured parts, and prototypes always need fatigue testing prior to deployment into the practical applications more likely in industries. This fatigue testing required a mechanical loading setup which predicts the lifetime of component. In this work design and development of low cost and high frequency pneumatic operated rubber fatigue testing system is presented. Cyclic load is applied through pneumatic system over number of cycles to test the rubber specimen and corresponding displacement and applied force is measured.

This testing system consists of two portions namely mechanical and electrical setup. The whole system includes mechanical structure, pneumatic actuator, air compressor, proportional valve, load cell, signal generator and DAQ card for data acquisition. The measured parameters are then logged into computer system using LAB VIEW.

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CHAPTER 1: INTRODUCTION

Background:

Fatigue is the phenomenon in which material fails when subjected to cyclic load. Once fatigue crack is initiated in material it will grow with continuous load cycles until it reaches to critical limit where material fails completely. Commonly the fatigue of rubber is shown by S-N curve which shows stress applied at related number of cycles cause material failure [1]. According to Goodman statement, a component could have an infinite life if stress applied (σ_a) remain below the endurance limit (σ_m) for mean stress ($\sigma_m = 0$).

Problem Statement:

The existing pneumatic fatigue systems in the industry are very expensive and they become more expensive when someone need a customised design. So, to cater this it was necessary to develop this system indigenously which is reliable and less expensive.

Objective:

To design and develop a pneumatic fatigue system for rubber components which comprises of a strong mechanical structure which can stand high force is developed and coupled with electric setup. A sine wave of amplitude 0-10 V and pressure 8-bar is applied to operate pneumatic actuator for the rubber specimen fatigue test. Proportional valve of high flow and high frequency is used for testing. Load cell with amplifier is assembled below the rubber specimen to measure the force of actuator. Finally, the load cell signal is interpreted by Lab view data acquisition system.

Designing:

This part includes designing of mechanical structure using the knowledge of mechanical engineering which includes the concepts of machine design. The 3D model was completed on solidworks and model run through simulation.

Manufacturing:

After completing the modelling of system, the required system is manufactured. All the parts were manufactured locally. Parts were then assembled into single unit.

CHAPTER 2: LITERATURE REVIEW

A high frequency and low-cost pneumatic operated fatigue testing machine capable of producing 3 kN force is desired to developed. This structure is developed for fatigue testing of rubber materials with varying dimensions.

Reference system:

LiTeM single column machine developed in Italy for fatigue testing of rubber. System consists of pneumatic actuator, proportional valve, air compressor load cell and supporting assembly. Pneumatic actuator with the load range of 2 kN. And stroke up to 500 mm. Desired load is applied by pneumatic actuator with the integrated contactless displacement sensor. [2]

A bidirectional proportional valve is used to operate the pneumatic cylinder. This valve can be operated at different pressure and flow ranges as per requirements.

Load cell is mounted with vertical assembly to calculate the load applied on specimen. The load cell and displacement reading are measured and shown by graphs. [3]

Figure 1: Reference System, LiTem fatigue testing machine

Pneumatic Actuator:

Pneumatic actuator is a device which uses compressed air from compressor and convert it into motion. It usually consists of regular air, a pressurized gas or can be mixture of two is contained and allowed to expand. When this gas expands the pressure difference between the cylinder and outer atmosphere causes the compressed gas to build up required amount of energy. Afterwards this compressed gas is allowed to leave the cylinder in a controlled manner so that it will be directed towards the cylinder's piston or the mechanical device attached. Then this piston is used to do required work.

They are of various design of actuator according to the application required. Electric compressor is used to generate the linear and rotatory motion from the actuator. [7]

Pneumatic actuator is very effective in producing the directional push with quick reaction. Frictional loss is very minimum overall and when used in one specific application. Frictional loses usually are of range 0-5 % with cylinder in great condition. Temperature range for pneumatic actuator for industrial applications lies in 0-250 C.

The main and very important factor that makes it working unsatisfactory at high load is pressure losses and air compressibility. Pneumatic actuators should be sizes or designed properly for specific application.

- **Classification of Pneumatic Actuators:**
    - Pneumatic actuator converts energy of compressed air into required motion. On the basis of motion type following are the basic types,
        - Linear Actuator
        - Rotatory Actuator
        - Limited angle Actuator
        - Rodless Actuators
    - Based on cylinder design:
        - Diaphragm Cylinder
        - Rolling diaphragm cylinder
        - Spring return single acting return cylinder
        - Gravity return single acting cylinder.
    - Based on action of cylinder
        - Single Acting cylinder
        - Double acting cylinder

Proportional Valve:

Proportional valves operate on small forces than solenoid and rely on deflection of spool. Electro Pneumatic control incorporates pneumatic and electrical advancement, and it is widely used in industrial applications. In electro pneumatic system working fluid is air and signal AC/DC source is used to operate.

There are two control methods for proportional technology,

- Open loop control system
- Close loop control system

In **Open loop system** we do not have a feedback, we specify the target for the required result.

In **closed loop system** actual valve and set point value is constantly compared and deviations are rectified.

Proportional valves are best solution to complex circuits. Both force -controlled and stroke-controlled are used foe get infinite spool positioning. They provide infinite positioning of spool, resultantly providing infinitely adjustable flow volumes.

For direction and speed control variable positioning spool is designed in a manner to control both the flow/speed and direction function. So, there should be need of separate valve for flow and direction control. These proportional valves are usually operated at DC signal. Required speed can be achieved by varying the electric signal to deliver the required speed/flow. [4]

Proportional valve offers wide range of machine cycles, safe operation at higher speeds and controlled start and stop signalling.

Closed loop proportional valve which functions as servo valve are widely available. Usage of high force, continuous action solenoid with low or minimum frictional moving parts and fast response electronics, proportional valve have servo valve-like performance with the pressure drop and high pressure drop as conventional valves. [6]

Proportional valve control, actuator position, flow, velocity, torque, and they can synchronize the action of many different cylinders. Common application of such systems are moulding machines, press systems, flight simulators and air frame testing.

Proportional valve requires precise manufacturing but still its cheaper than servo designs.

Classification of Proportional Valves:

- Based on regulating target:
  - Proportional directional control valve
  - Proportional Flow control valve
  - Proportional Pressure regulator

- Based on control principle:
  - Direct Control Proportional Valves
  - Pilot Control Proportional Valves

Air Compressor:

Pneumatic device that converts power (by using electrical motor, gasoline, or diesel engine) into potential energy stored in the pressurized air. Air compressor force more and more air into a storage tank, increasing the pressure.

Inlet discharge valves are controlled by the head of valve that is present right above the cylinder. Inlet valve is mounted below, and discharge valve is assembled with direction above the plate of valve. When piston move downwards, vacuum is created in upper portion. This allows the air from outside which is at atmospheric pressure to rush open the inlet valve and fill the area above the piston. During piston upward movement it compresses air present in upper portion, which closes the valve inlet and open ups the valve at discharge port. The air moves into the tank from the opening of the discharge port. Pressure rises when air enter the tank during operation.

Commonly one- or 2-cylinder version compressor are available according to requirement and application they used to power. For domestic and medium level operation 2-cylinder compressor just works the same as 1-cylinder compressor except there are two strokes per revolution instead of one. Pressure switch is available on compressor to stop the motion of the motor when the tank of compressor touches its limit. when the compressor tank reaches its maximum limit. Air lines have regulator which is set to match the pressure requirement to need in specific application. A pressure gauge before and after the regulator monitors airline pressure. If pressure malfunctions the tank have safety valve that opens up.

- **Classification of Air compressors**:

- Main two classes of compressors are:
  - Positive displacement
  - Dynamic
  - Hermetically sealed and open

- Positive Displacement includes,
  - Reciprocating compressor
  - Rotary vane compressor
  - Rolling piston compressor
  - Diaphragm compressor
  - Scroll compressor
  - Ionic liquid piston compressor
  - Rotary screw compressor

- Dynamic type includes,
  - Axial Compressor
  - Air bubble compressor
  - Centrifugal compressor
  - Diagonal and mixed flow compressor

Compressor Power:

One of many factors to check compressor power is motor horsepower. Other important factor which should be known is amount of compressed air that can compressor delivers at specific pressure. The rate at which a compressor delivers an air is calculated in cubic feet per minute (cfm). How fast an air is coming in the cylinder depends on the atmospheric pressure. Cfm vary with the atmosphere pressure. Temperature and humidity also effect the quantity of air entering the cylinder. For the best result calculate standard cubic feet per minute (Scfm) as cfm at sea level with air temperature 68 degrees and humidity level 36%.

The cfm and pressure rating are because they make sure that compressor can run the required system. So, it's very necessary to check all the specifications and ratings of the compressor before buying it for practical applications.

Load Cell:

Load cell is a transducer that takes weight as input and converts it into a measurable electric signal as an output. There are many types of load cell available, but mostly the strain gauge type is used.

- **Measurement principle**:

Load cell is made of a strain gauge and spring material. This spring element develops a strain directly proportional to the applied force. Stain gauge then changes its resistance corresponding to the strain caused by spring element. This change in resistance is then calibrated to use the load cell to measure weights.

- **Classification of load cell**:

Various factors count for the classification of load cell are,

- Based on sensor type
  - Resistive
  - Capacitive

- Based on loading:
    - Tension
    - Compression
    - Universal/Alternating
    - Bending

- Based on outer Shaped:
    - Beam type
    - Canister Type
    - S Type
    - Diaphragm Type

- Based on Shape of Spring:
    - Column Type Spring Type
    - Ring Type
    - Roberval Type

- Based on Air tightness:
    - Hermetically sealed
    - Open
    - Explosion Proof

- Based on precision:
    - Ultra-precision
    - Standard
    - General Purpose

- Other Classification:
    - Single and Multi-point Type
    - Miniature Type
    - Ring Torsion Load Cell

Signal generator:

An electronic instrument which generates signals in the form of waves. Signal generators are commonly found applications in the electronic equipments. Operation like electronic circuit design, electronic devices/components tests and faulty equipment repairment.

Signal generators available can be categorised as:

- RF and microwave signal generators
- Function generators
- Arbitrary wave form generator
- Digital pattern generator
- Pitch generator
- Frequency generators

Function generator:

Electronic device that produces simple repetitive waveforms. Function generators have electronic circuit which have capacity to produce repetitive waveforms. When system's oscillator operates above audible frequency range (.20 kHz), the generator will often have functions like,

- Amplitude Modulation
- Phase Modulation
- Frequency Modulation
- Off set Modulation

Different types of wave that are produced by signal generator are,

- Square wave
- Sine wave
- Triangular wave
- Saw tooth.
- Step waveform

Buck Module:

Buck Module or buck convertor is an electronic device that is used for DC-DC voltage conversion. It efficiently converts the high DC voltages to low DC voltages.

Buck Module have inductor which in controlled by two switches usually a diode and transistor.

- During ON condition, zero voltage drop at diode and the switch.
- During OFF condition, no current flows, Series resistance is zero for conductor.

CHAPTER 3: METHODOLOGY

Phase-01 (Proof of concept):

Air cylinder of 25 mm diameter with stroke length of 80 mm is used to develop a fatigue testing system.

Solenoid valve with pressure range of 0.15~0.8 MPa and 24V DC operated, is used to operate a pneumatic cylinder.

Mechanical switch is used to switch the direction of pneumatic cylinder. Whenever the cylinder rod touches the switch, its give the signal to solenoid to alter the direction.

Solenoid valve is operated by air compressor at the pressure range of 0-8 MPa, which in turn operate the pneumatic actuator. The to and fro motion, displacement and operating direction of pneumatic cylinder is control by mechanical switch which is mounted in front of pneumatic cylinder.

The whole system is mounted on the table with supporting assemblies. The motion, frequency and force applied by pneumatic actuator is observed.

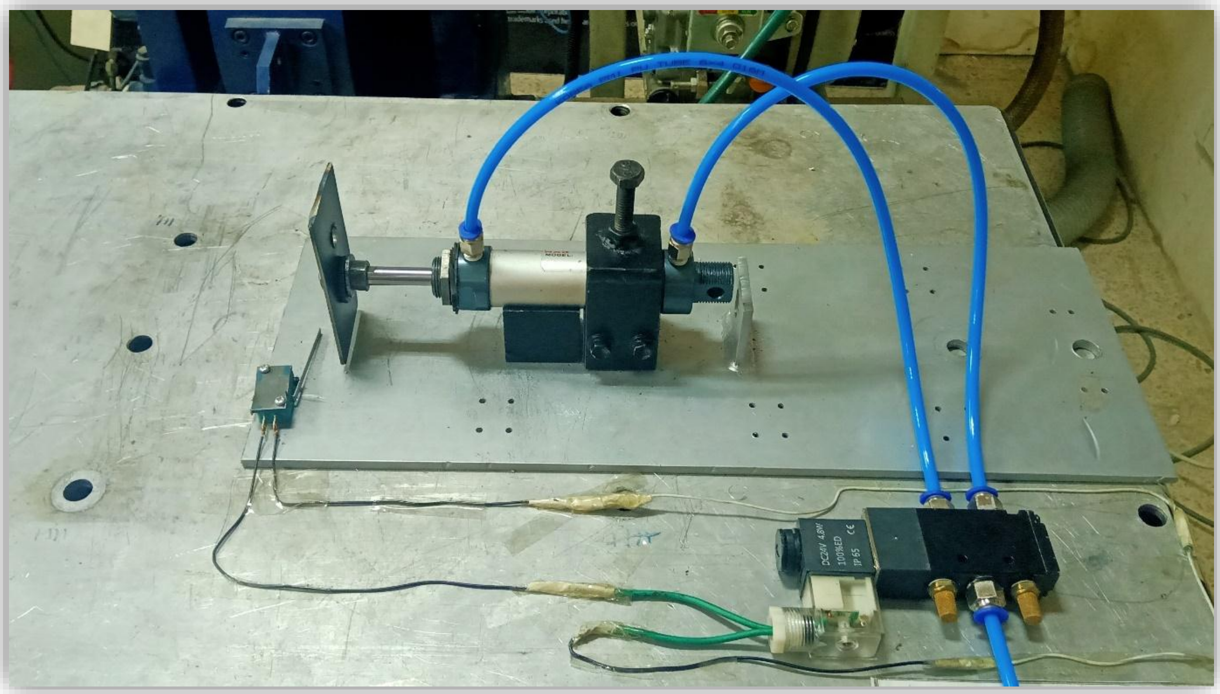


Figure 2: Proof of concept - I

Working of solenoid at different air flows and pressure is checked. Also, the switching of pneumatic cylinder at different pressures and displacement and corresponding behaviour is observed.

Phase-II (Proof of concept):

Solenoid valve is replaced by proportional valve and metal proximity detector switch is used along with mechanical switch.

When metal comes in sensing ranges of detector, the detector gives the signal to valve to operate in reverse direction. In this way position is controlled.

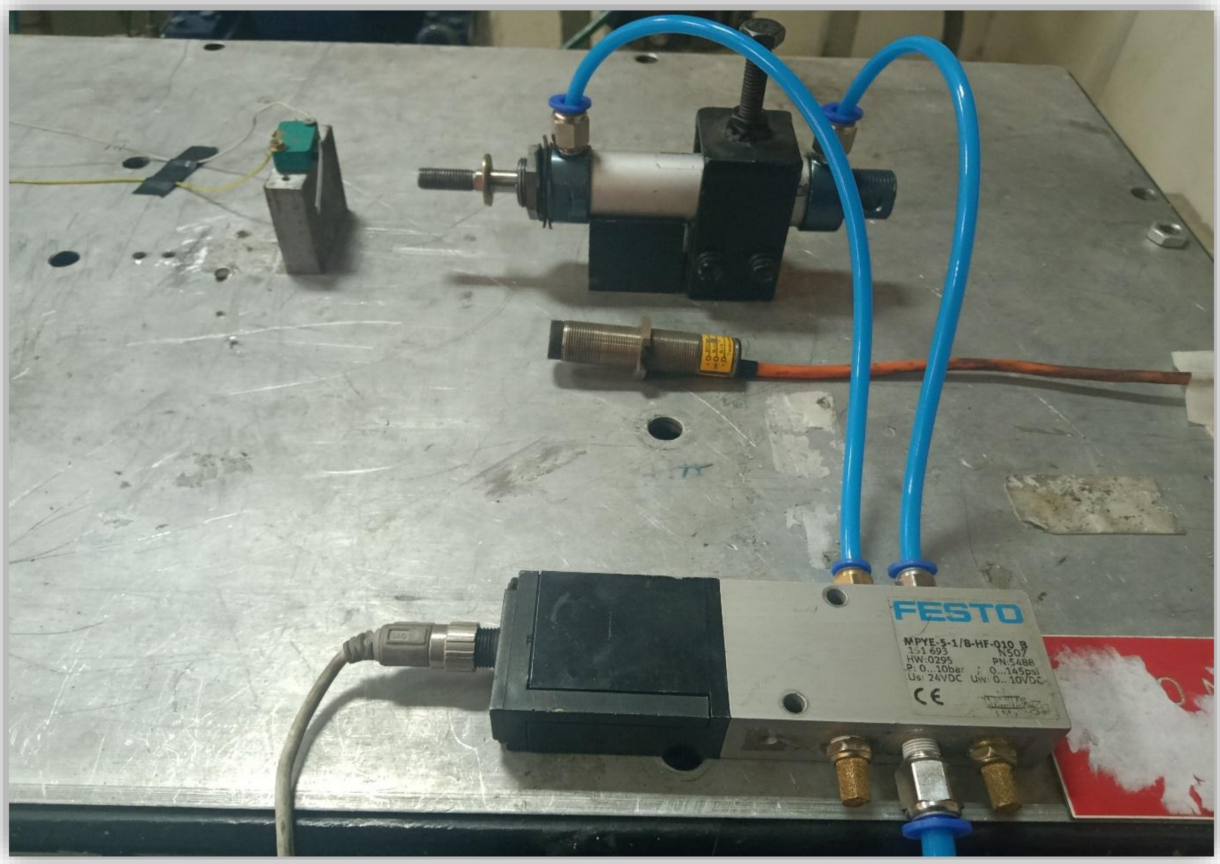


Figure 3 Proof of concept-II

Proportional valve operation at different air flows, pressure range and switching of cylinder is observed through metal transducer.

Phase-III (Proof of concept):

In this stage the mechanical switch is replaced totally by metal detector to control the motion. Calibrated load cell with load range of 500 kg is mounted in front of the pneumatic actuator and motion of actuator is controlled by metal detector. The data of load cell is then sent to amplifier to get the load signal. Amplifier is tuned to give the voltage signal in range of 5-10V.

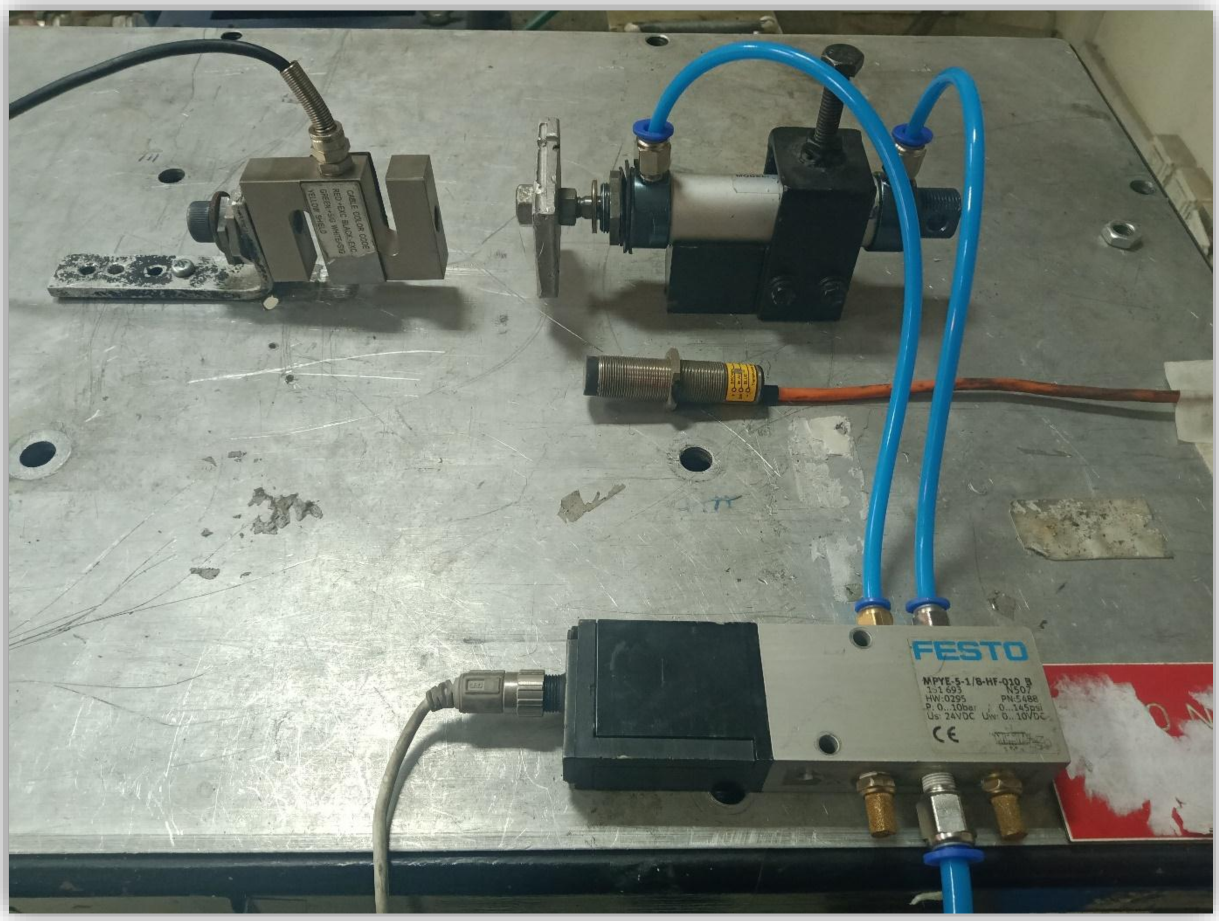


Figure 4: Figure 4: Proof of concept-III

Working of proportional valve, metal transducer at different pressures is checked and load is calculated by the load cell mounted.

Final setup:

The final assembly divided to two parts,

- Fixe Part
- Moving Part

Fixed Part

Fixed part contain:

- Mechanical Structure
- Load cell
- Proportional valve
- Amplifier

Moving Part

Moving Part contains:

- Pneumatic actuator

Mechanical Structure:

Mechanical Structure consists of:

- Base plate

  Area = 450 x 450 mm

  Width = 20 mm:

  - With mounting of load cell and small U-shaped table

- Top plate

  Area = 250 x 250 mm

  Width = 15 mm

  - With Pneumatic Actuator and proportional valve are mounted on top plate.

Both Base plate and top plate are connected by the 4-shafts

- Shafts

  Length = 650 mm

  Diameter = 30 mm

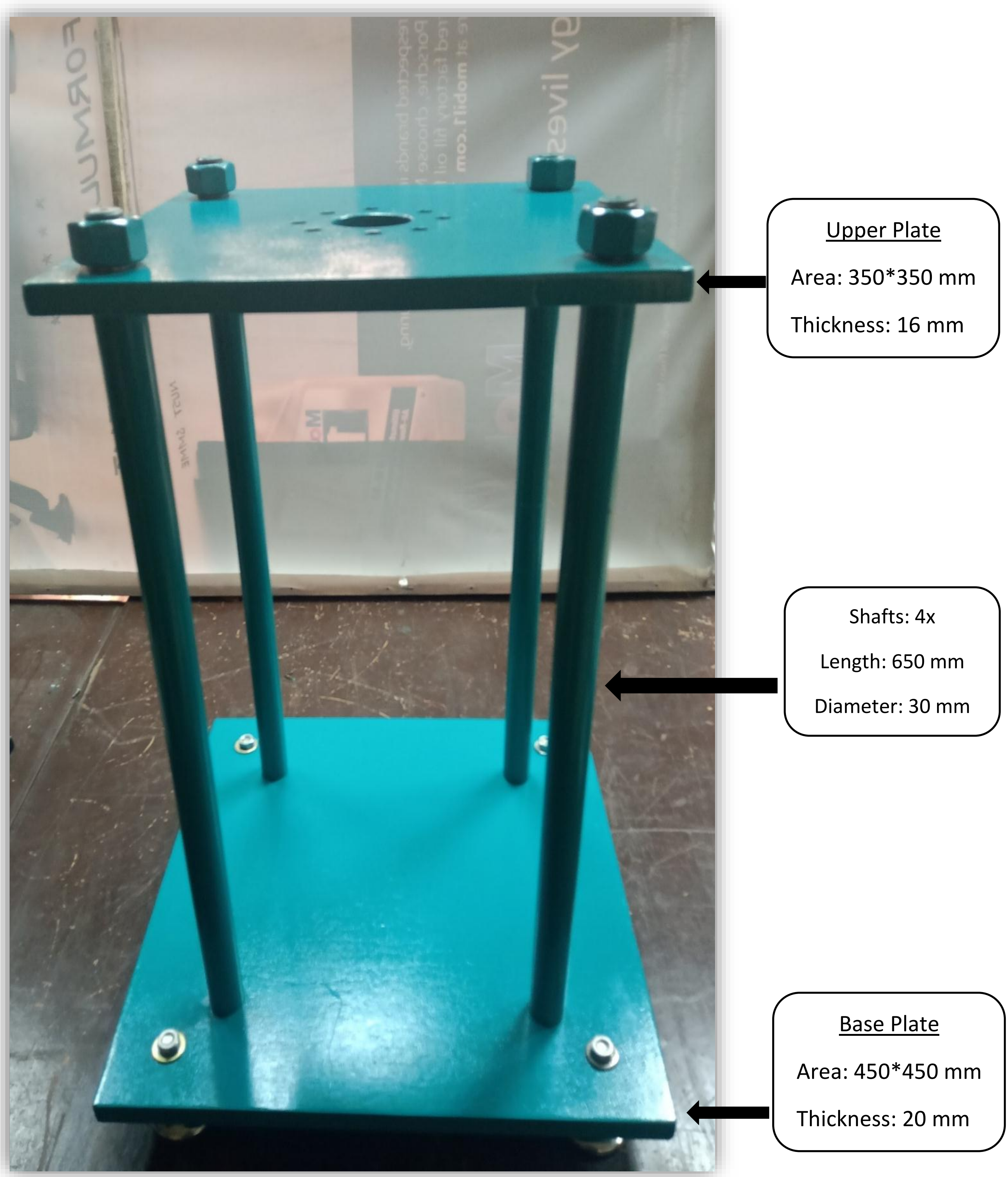


Figure 5:Final structure

Selection of Pneumatic Actuator:

According to the force requirement, A force of 3000N is required for fatigue testing of rubber specimen. This force is dependent on diameter of actuator and the pressure applied to the actuator.

Force Calculation:

- **Bore** = 80mm
- **Radius** = $\frac{Bore}{2}$ x *1000 (m)*

  = $\frac{80}{2}$ *x 1000*

  = *0.04 m*
- **Area** = πr^2

  = 3.14 x $(0.04)^2$

  = 0.005024 m
- **Pressure**: Standard Pressure Applied is 8 bar.

  As, 1 bar = 100000 Pa

  8 bar = 800000 Pa

Force:

F = P x A

= 800000 x 0.005024

F= 4021.4 N

So, the force generated by a pneumatic actuator at above mentioned values is required. It is calculated by keeping in mind the factor of safety and compressibility factor of air.

Pressure applied can be vary from compressor controls to get any value of force from pneumatic actuator.

Figure 6 Pneumatic Actuator

Selection of Proportional Value:

A high frequency operating valve is required for fatigue testing of rubber specimen. A 5/3-way proportional directional valve is selected, which has position control spool. [5]

This proportional valve transforms analogue input signal into a corresponding opening cross section at valve output. In combination with

Figure 7: 5/3 Proportional control valve

external position controller and displacement encoder, a precise pneumatic positioning system can be created.

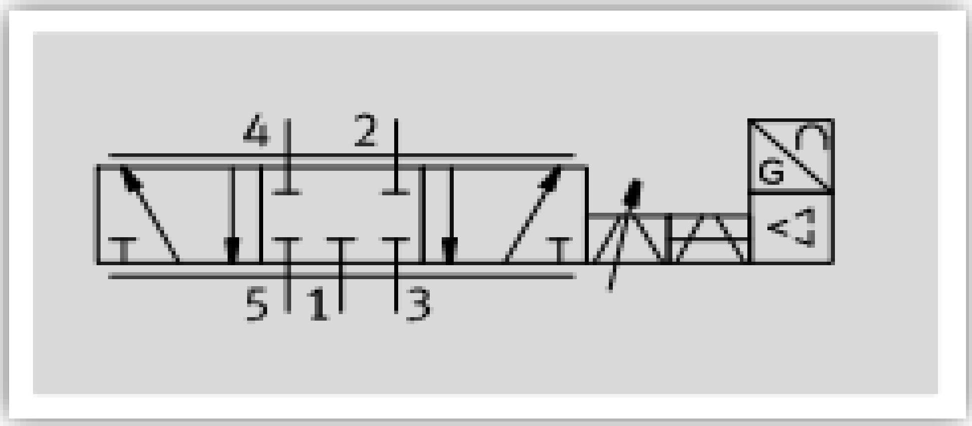


Figure 8: Schematic of proportional control valve

Table 1: Valve specification

Valve Function	5/3-way, normally closed
Construction design	Piston Spool directly actuated.
Power Supply	17-30 V
Response time	4.8 ms
Set Point value (Voltage)	0-10 V
Critical Frequency	95 Hz
Standard Nominal flow	350 l/min

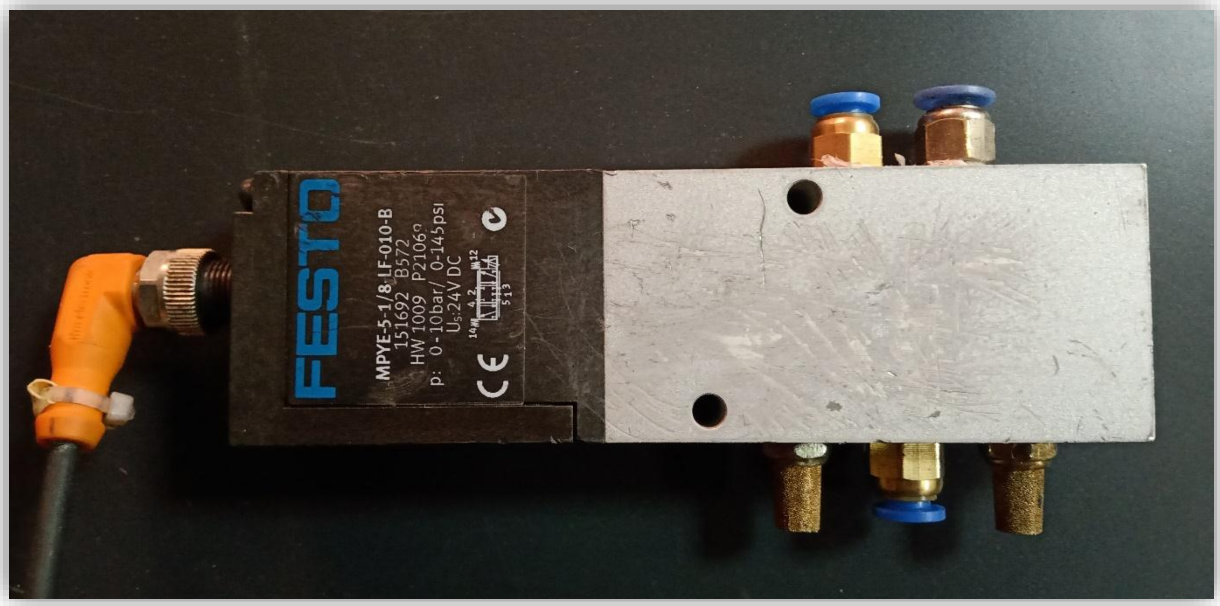


Figure 9: FESTO Low flow Proportional Valve

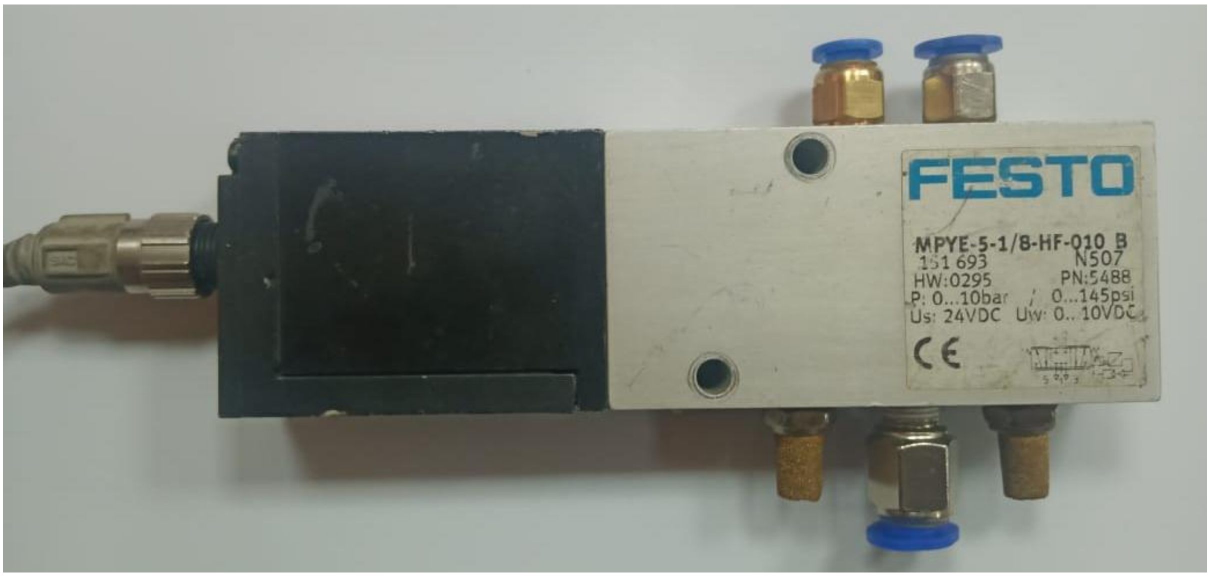


Figure 10:FESTO High flow proportional Valve

Experiment was performed using both the high and low flow proportional valve. The difference was only in the air flow through the proportional valve.

Low flow valve has capacity of 350 l/min and high flow valve have capacity of 700 l/min. This air flow is provided to actuator for fatigue operation.

Valve Actuation:

Proportional Directional Valve need an analogue signal voltage from 0-10 V to operate.

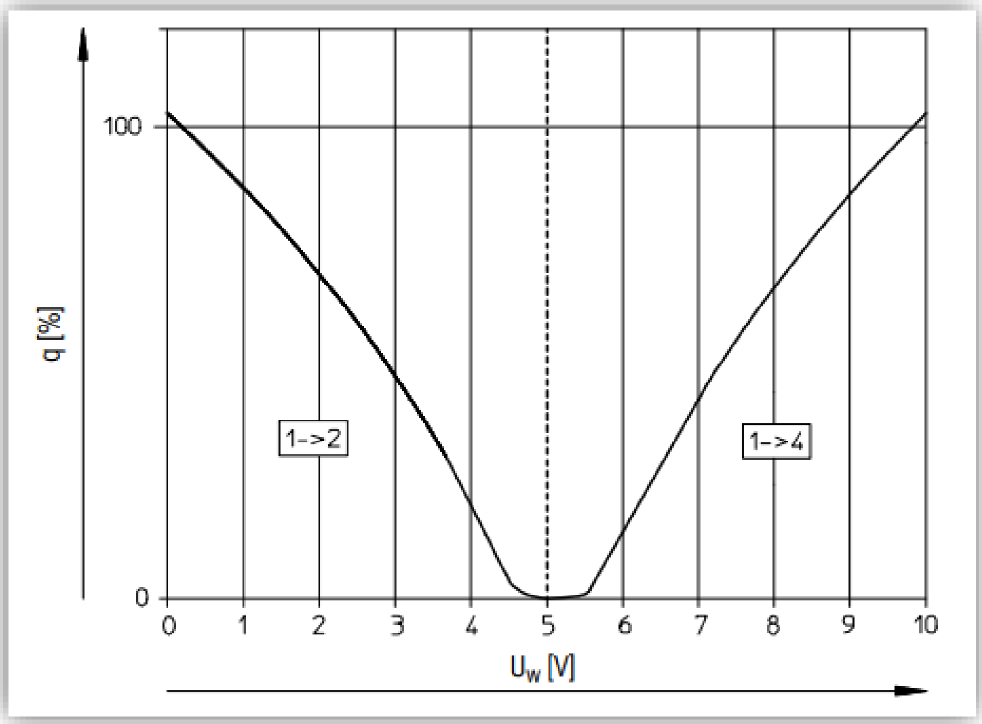


Figure 11: Valve Actuation

When valve is actuated, the spool changes its position and allow the cylinder the cylinder to operate in forward direction and when valve is in un-actuated form, it allows the spool to return to its original position, by air removal through outlet port.

<u>Selection of Load Cell</u>:

To ensure all required values being measured to be exactly measured by load cell, the specific load condition had to be calculated by measuring the force acting on the load cell.

Force to be measured = 3000 N= = 300 Kg

Figure 12: S Type load cell

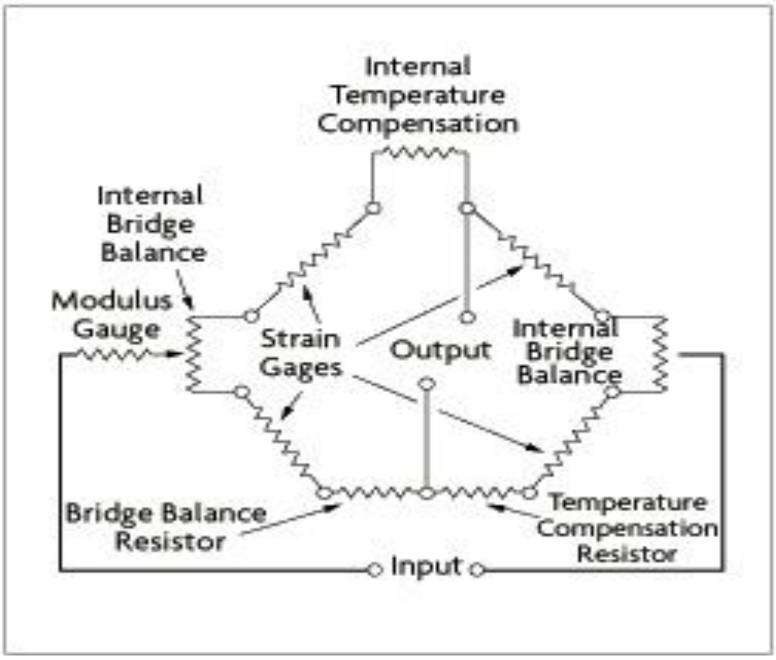


Figure 13: Lad cell schematic

Table 2: Load cell specification

Model	LCS-1
Type	S-type
Load Measurement	500 Kg
Sensitivity	2mv/V

- **Load cell Calibration**

Procedure:

Different value weights were added at different intervals and reading on load cell amplifier is noted.

The loading curve was followed by unloading curve in which weights were removed gradually. This is to check any hysteresis. Result show there was not much difference in values during loading and unloading, which show no hysteresis in measurement.

A graph was then plotted between weight added and load cell amplifier reading. A straight line shows the linear relationship of both variables.

Table 3: Load Cell-Calibration Data

Weight (Kg)	Voltage (V)
0.03	3.9
0.11	12.3
0.17	20.5
0.26	31.6
0.39	50.6
1.02	135.7
1.4	182.1
1.73	225
2.08	270.5
2.3	300.3

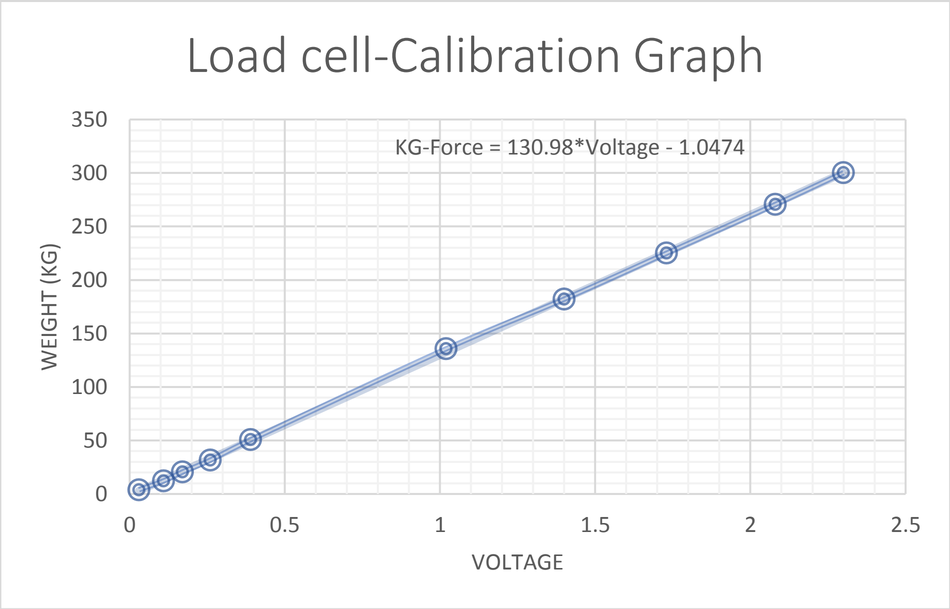


Figure 14:Load Cell-Calibration Graph

Placement of load cell

Load cell is mounted on bench type structure which is place on base on mechanical structure. This structure holds the load cell in vertical position.

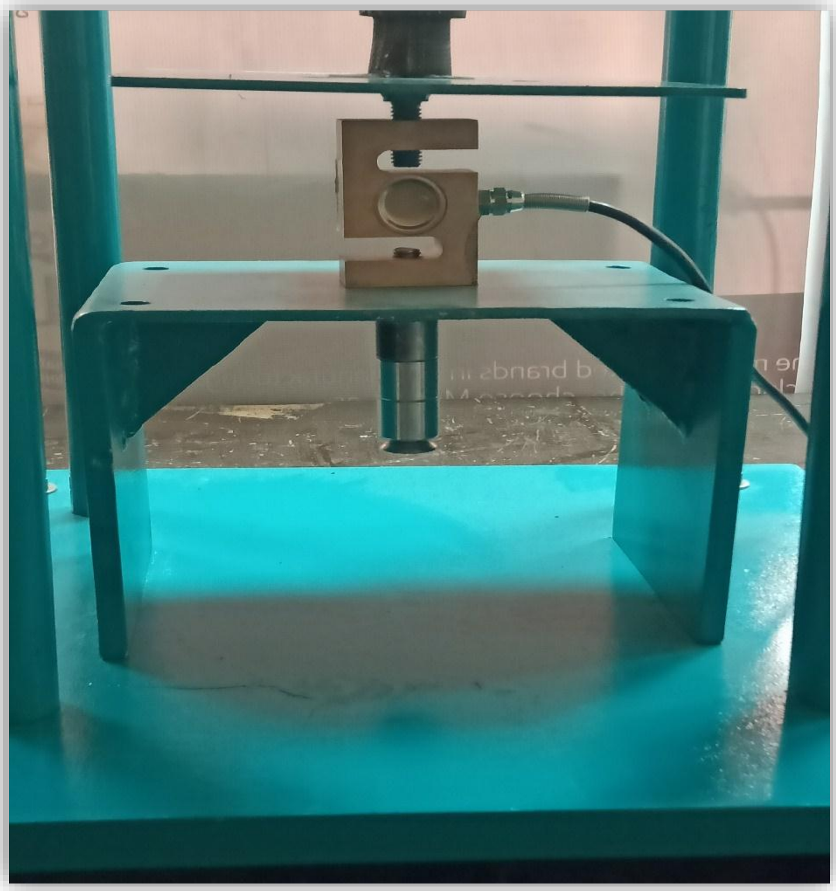


Figure 15: Load cell placement

Load Cell Amplifier:

As the output value of load cell comes into millivolts (mV). Load cell amplifier RW-T01A is used. It filters, adjust, and amplify electrical signal from the load cell and gives out output of 0-5V and 4-20 mA. Which can be use in measuring control system acquisition.

Figure 16: Amplifier

Table 4: Load cell Amplifier

Terminal	Definitions
1	Power supply (+24V)
2	Ground (0V)
3	Current Output
4	Voltage Output (V+)
5	Output Common
6	Excitation Voltage (E+)
7	Signal (S+)
8	Signal (S-)
9	Excitation Voltage(E-)
10	Shield

Signal Generator:

Signal generator is used to operate the proportional valve which operate on 0-10 V. A sine wave is generated by signal generated and is fed to valve to operate the pneumatic cylinder.

Table 5: Function Generator Specifications

Parameters	Specifications
Model	ICL8038
Supply Voltage	12~15 V
Frequency Range	5Hz to 400 kHz
Duty Cycle	2~95 %
Output Amplitude Range	0.1~11 Vpp
Wave output form	Sine/triangle/square

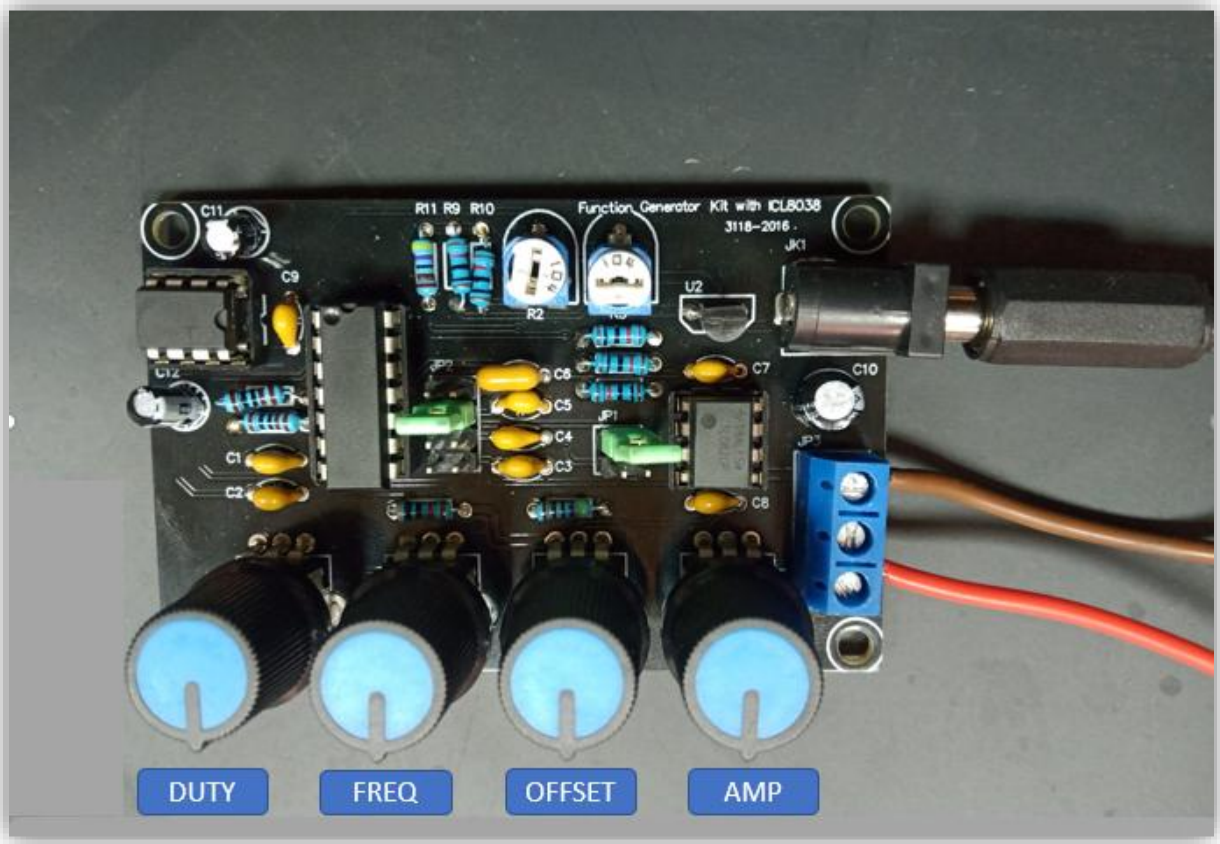


Figure 17: Function Generator

<u>Measurement and Instrumentation</u>:

National Instrumentation USB-6009 is used to get the load cell reading. It provides 8-Signle ended analog input (AI) channel, 2-Analog output (AO) channels, 12 DIO channels and 32-bit counter with full speed USB interface.

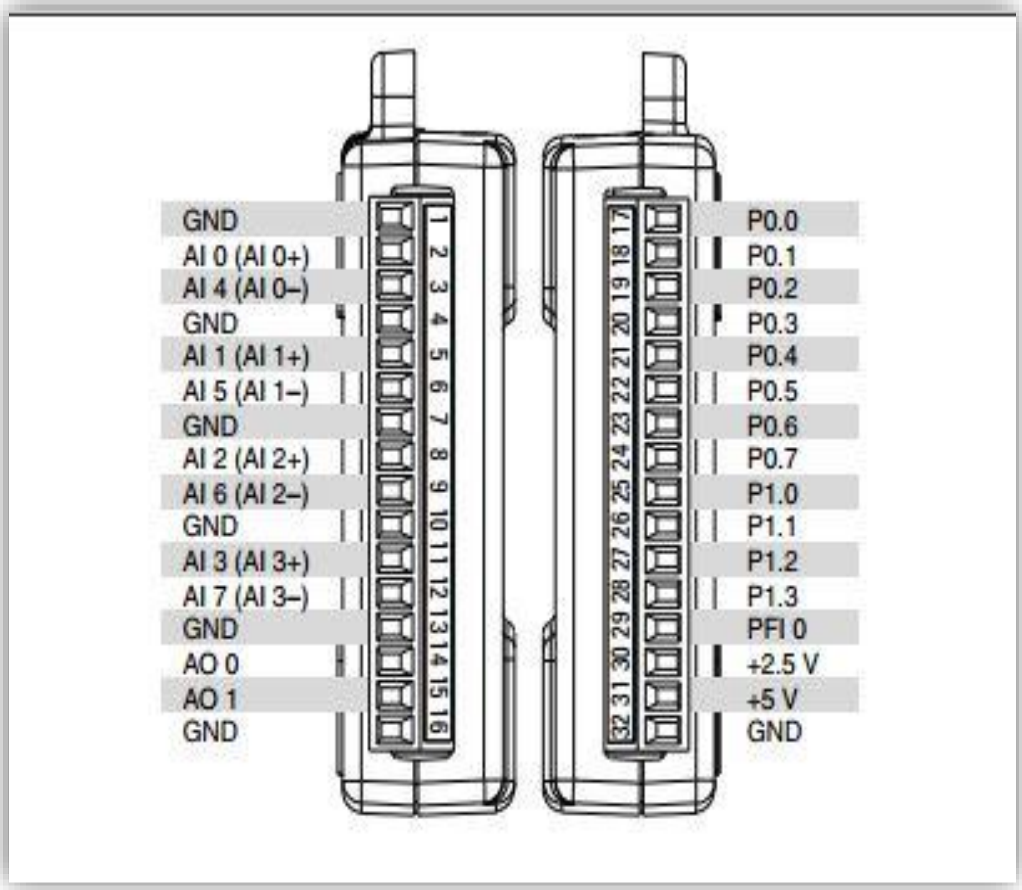


Figure 18: NI USB 6009

Analog Pin terminal 0 and 1 are used for data acquisition.

- Pin 0 is used for getting the output from signal generator.
- Pin 1 is used for getting the output of load cell.

LAB View Interface:

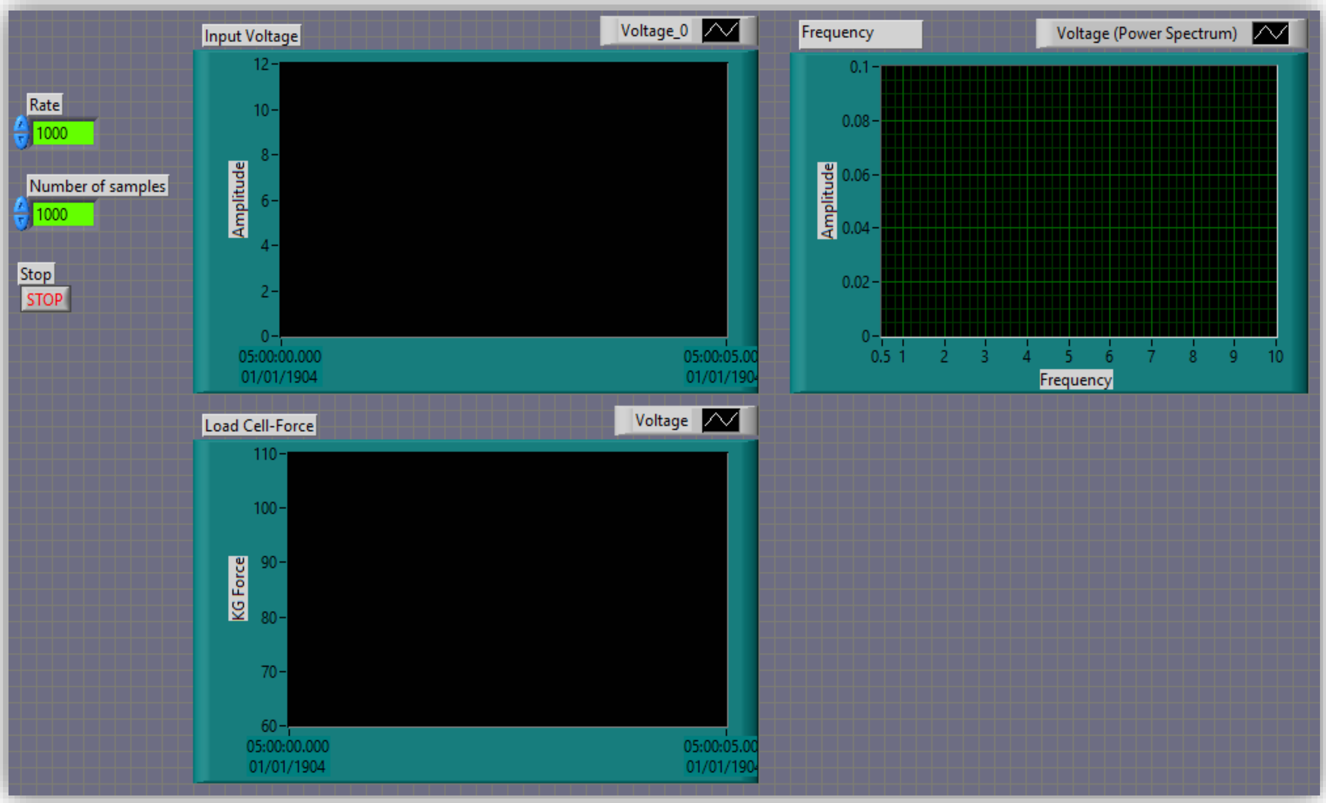


Figure 19: LabView Interface

Rubber specimen is tested under different pressure ranges (0-8 bar). Operating frequency ranges from 1-60 Hz. Rubber specimen behaviour is observed under these conditions and data from load cell is then interpreted through NI DAQ 6009 through LabView.

CHAPTER 4: RESULT AND DISCUSSION

Final Assembly CAD Model:

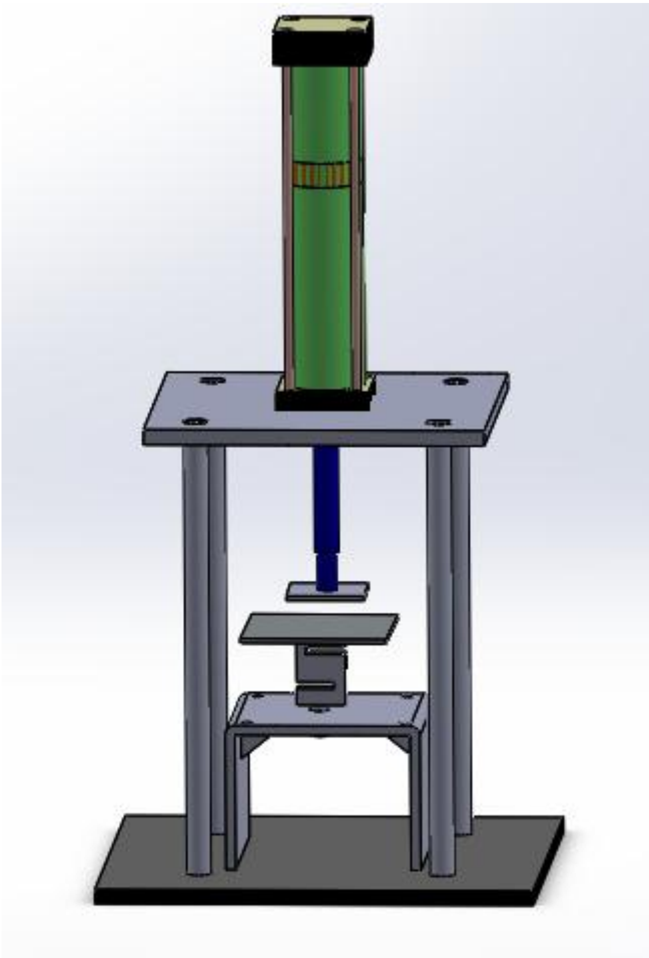


Figure 20: Final assembly CAD Model

Final Assembly:

Figure 21: Final Setup

System Layout:

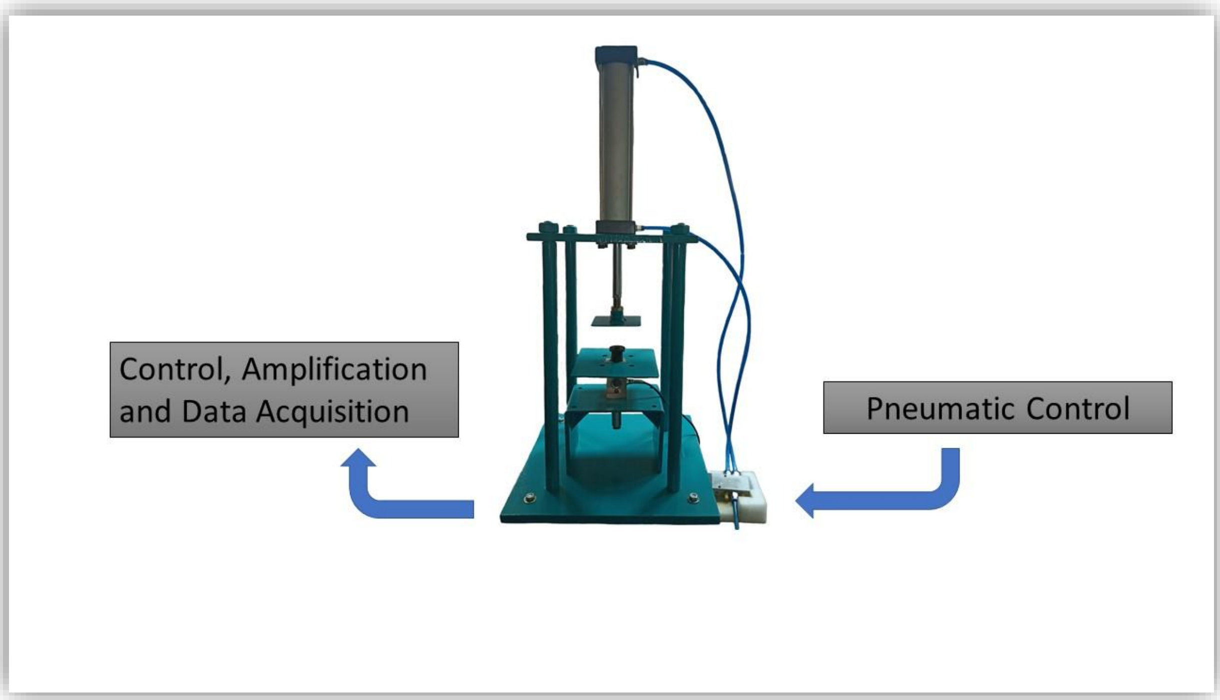


Figure 22: System Layout

Applied set point voltage waveform:

Set point Voltage 0~10 is applied to proportional valve by the signal generator. Which was measured by NI DAQ device.

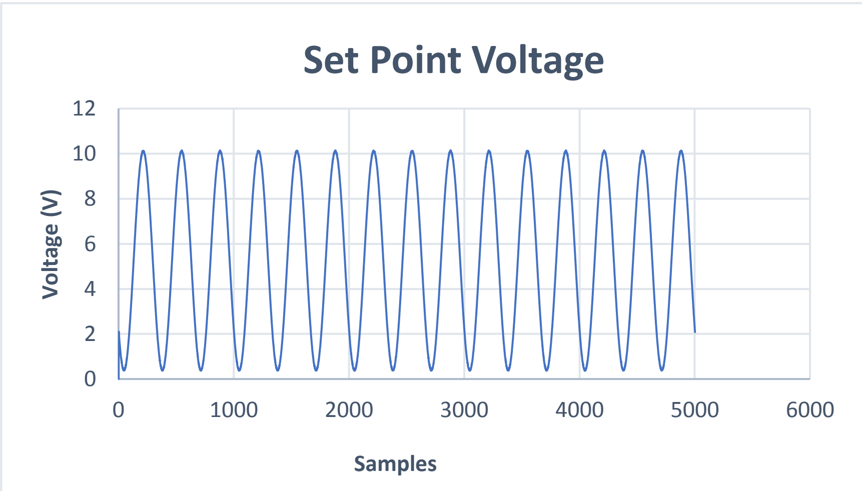


Figure 23: Set Point Voltage

For Analog input terminal 1 of the NI DAQ is selected. Voltage by function generator is given to the valve to operate and at the same time it is measured by the DAQ device. After getting the data it is then plotted into graphical form.

Compressor Power:

Compressor provides air flow of 50 l/min at the pressure of 0-6 Bar. This pressure is used to run the proportional valve which in turn runs the pneumatic actuator.

Force Measurement:

Force generated by pneumatic actuator at applied pressure is measured on different frequencies. Corresponding value of force is then measured by load cell and fed to NI DAQ 6009 to get wave form.

At high frequencies, the actuator keeps the rubber specimen in loaded condition and does not give enough time to actuator to retract back. By changing the offset, the position of actuator rod can be adjusted as per requirements.

- At frequency = 03 Hz

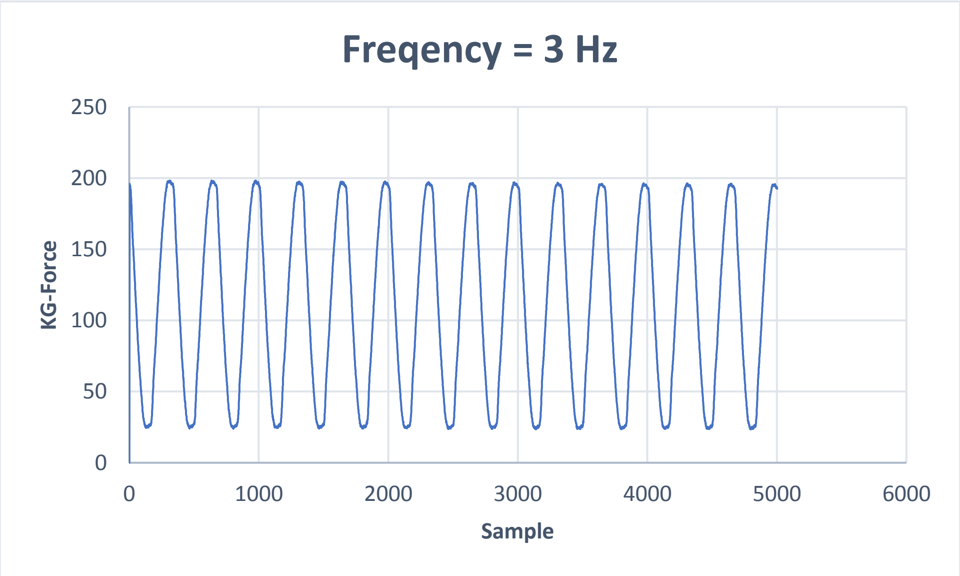


Figure 24: Force measurement graph

Graph the force that is generated by the pneumatic cylinder. At higher frequencies, the valve actuation operation become so fast that is seems that system is applying static force on the specimen.

Frequency measurement graph:

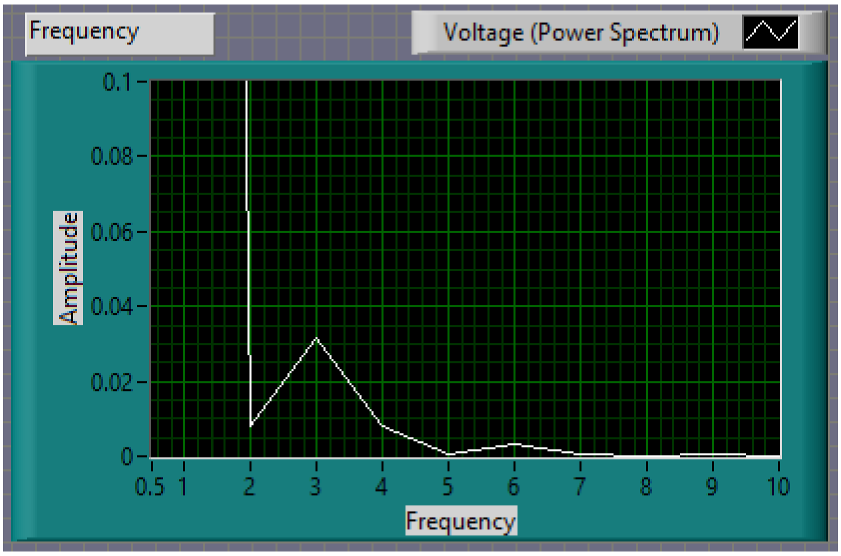


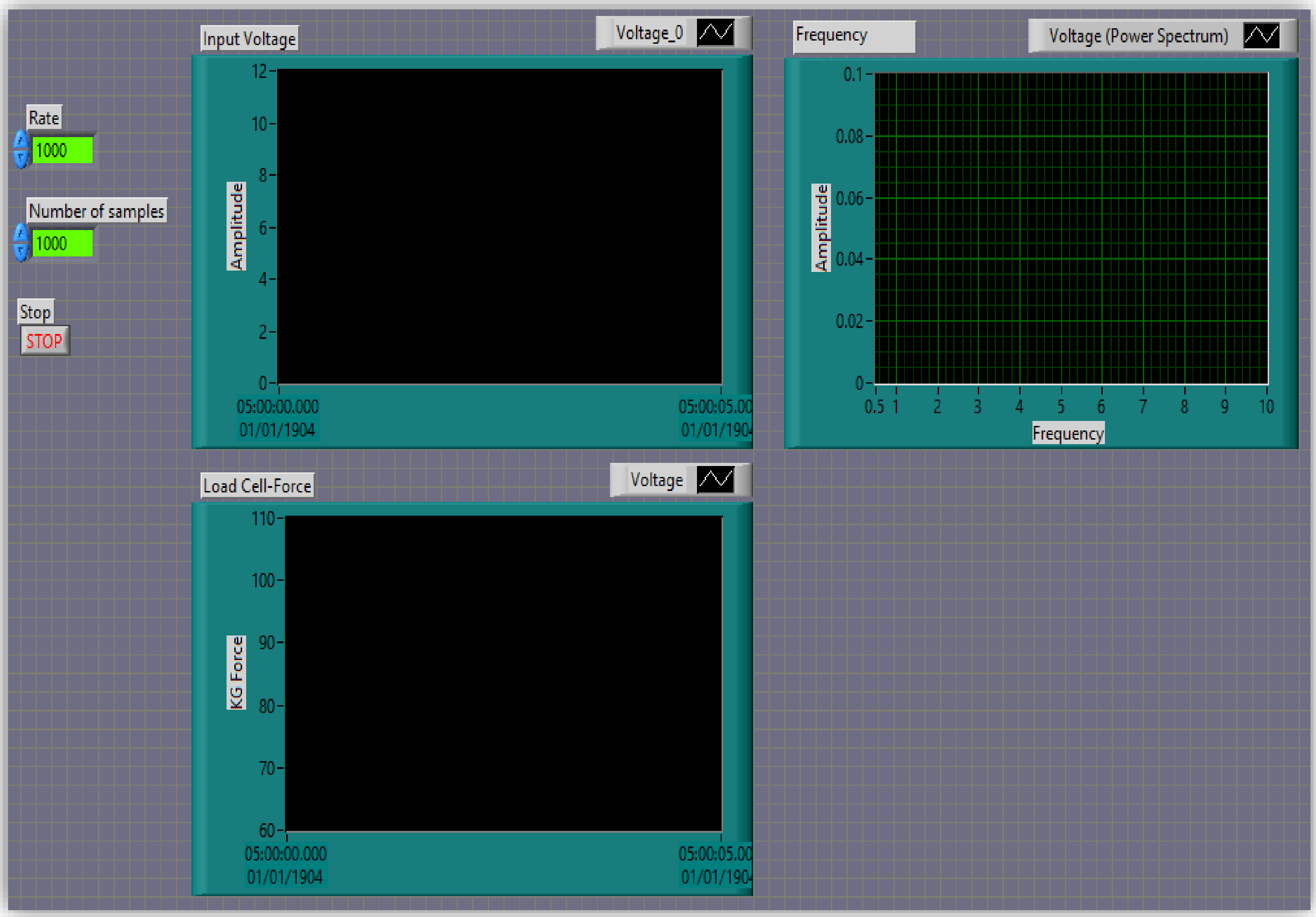
Figure 25: Frequency measurement

Pneumatic system was operated on different frequencies. To get the desired frequency operation a calculated compressed air flow and pressure is provide to the pneumatic proportional valve. Which in actuate the pneumatic cylinder at different frequencies.

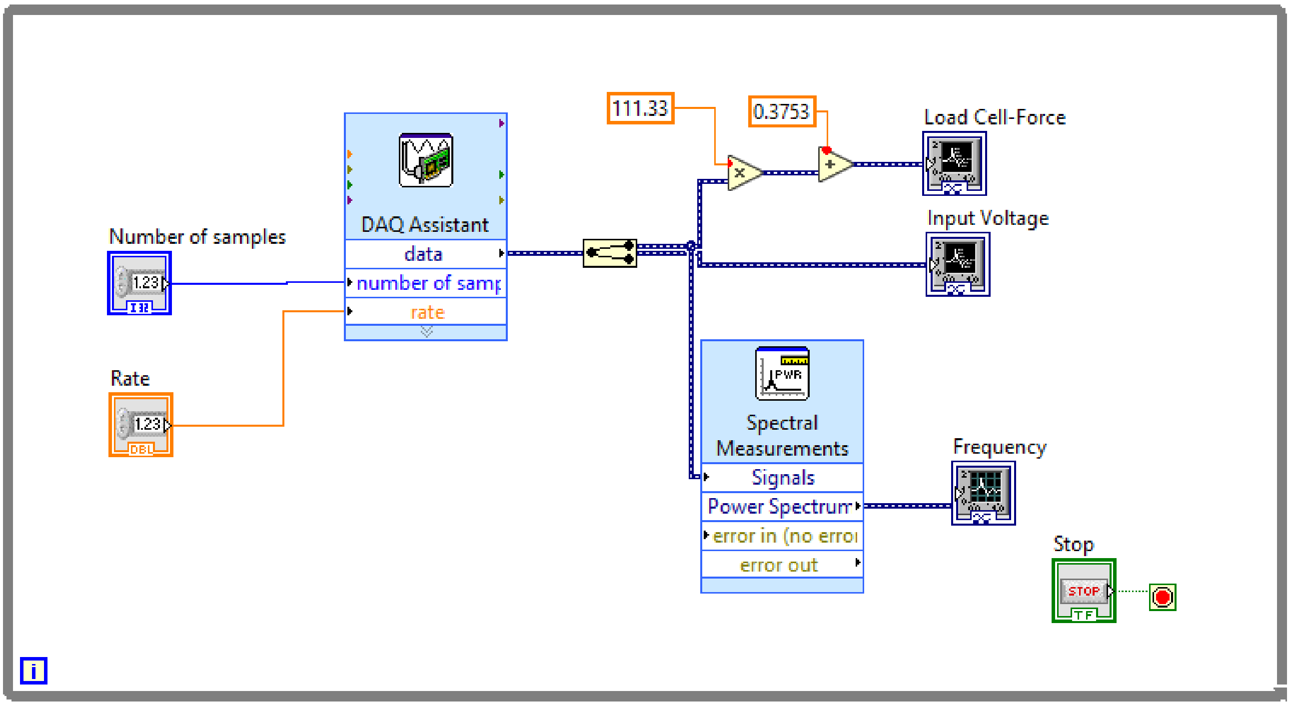
Data was then interpreted in the LabVIEW program using NI DAQ system.

Pneumatic fatigue system was operated on different flow rates. Compressed air at pressure range of 0-6 bar was supplied from the compressor which operates the proportional valve which in turn operate the pneumatic actuator which different frequency ranges as per requirement.

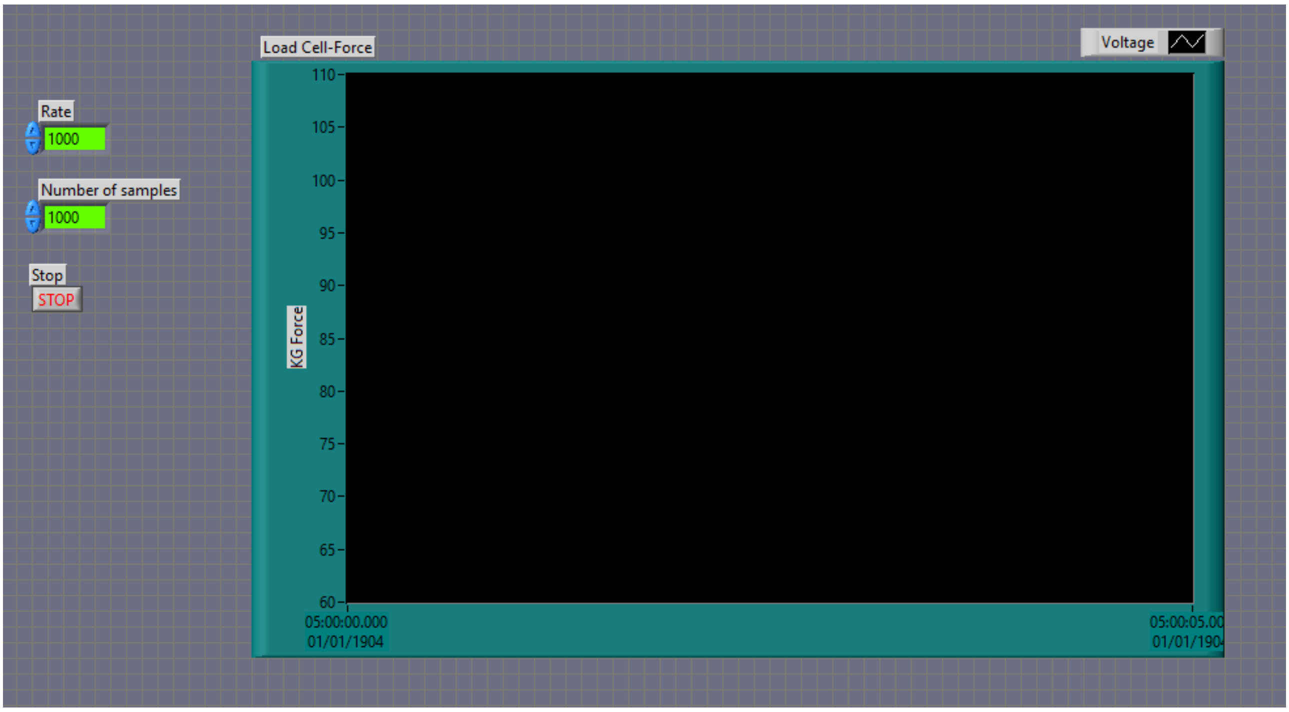
LABVIEW Interface Front Panel:



LABVIEW Block Diagram:

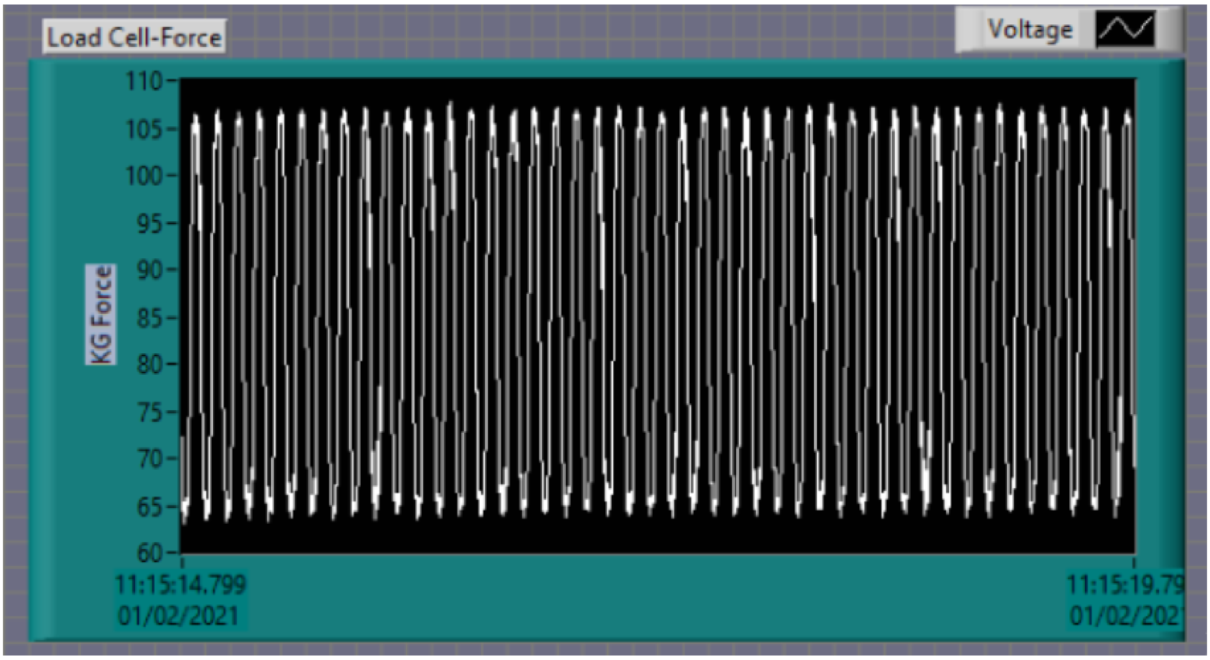


LABVIEW Interface-Load Cell force:



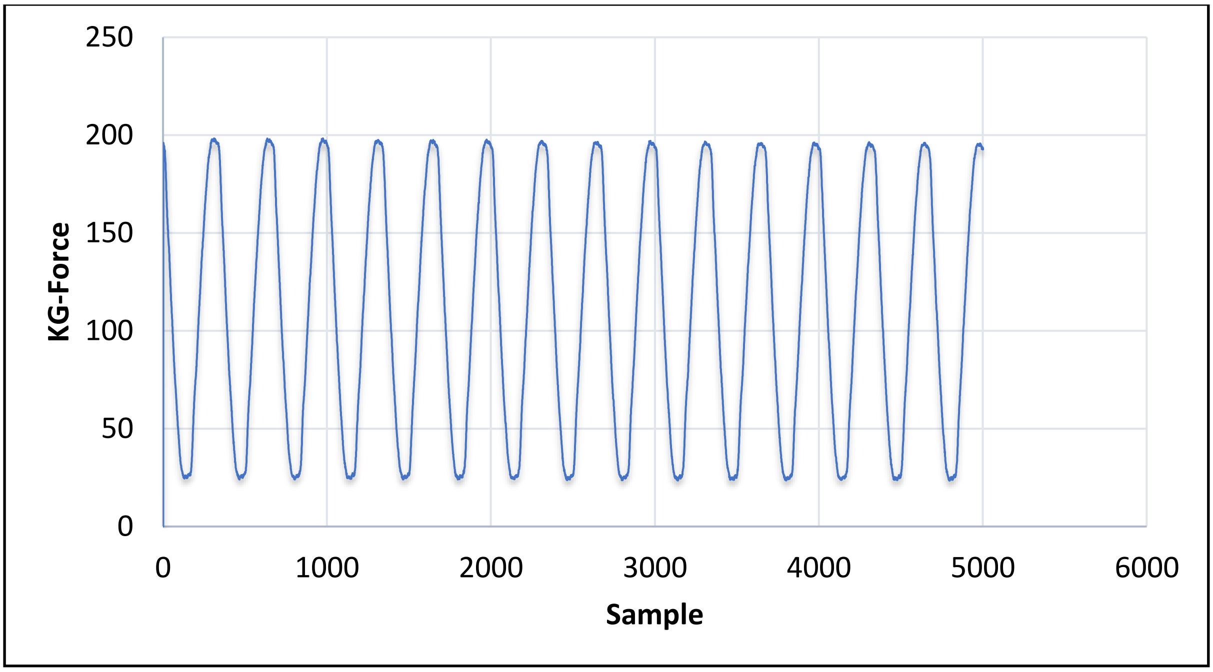
Force Measurement:

3 bar pressure:

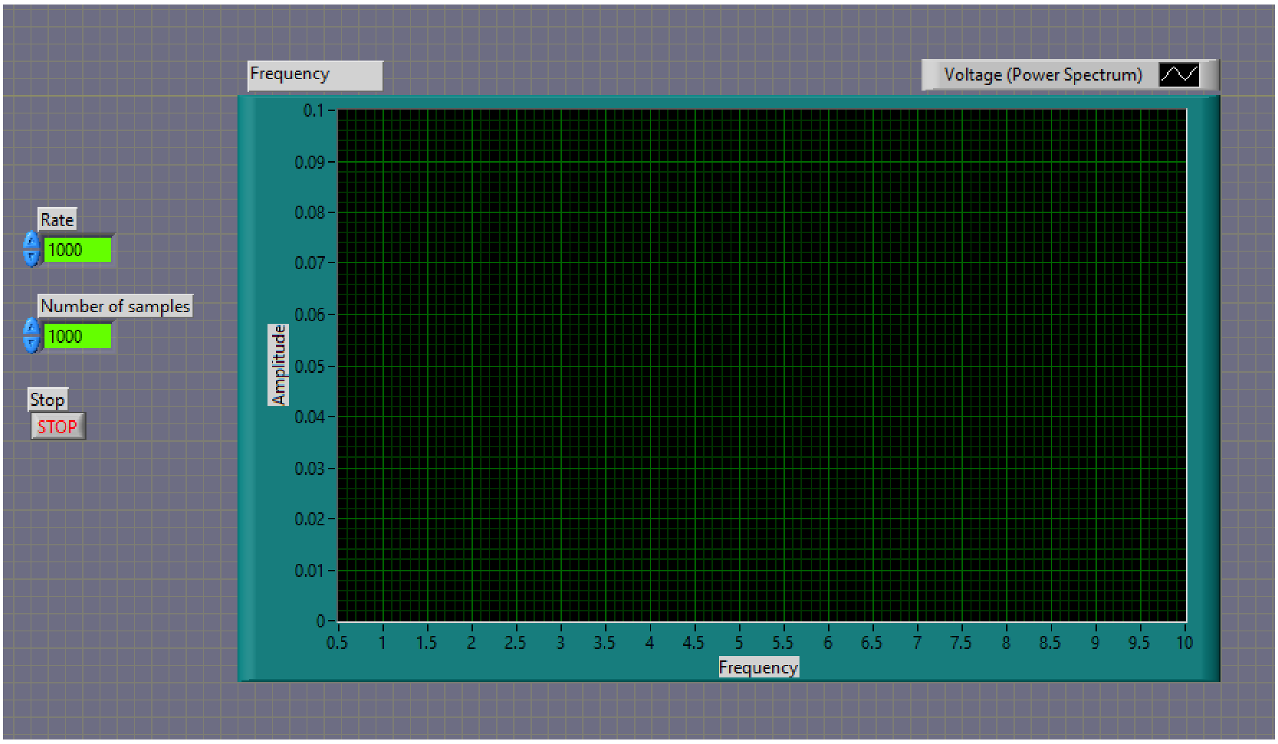


Force Measurement:

6 bar Pressure:

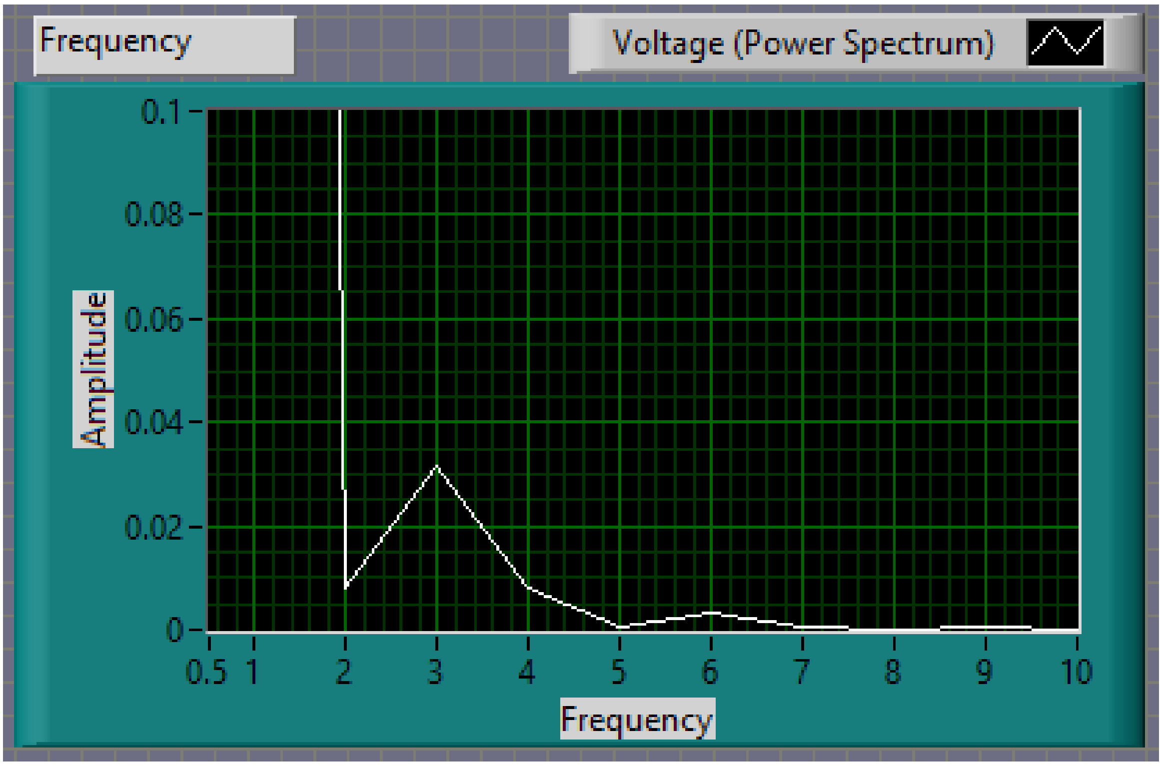


LABVIEW Interface-Frequency:

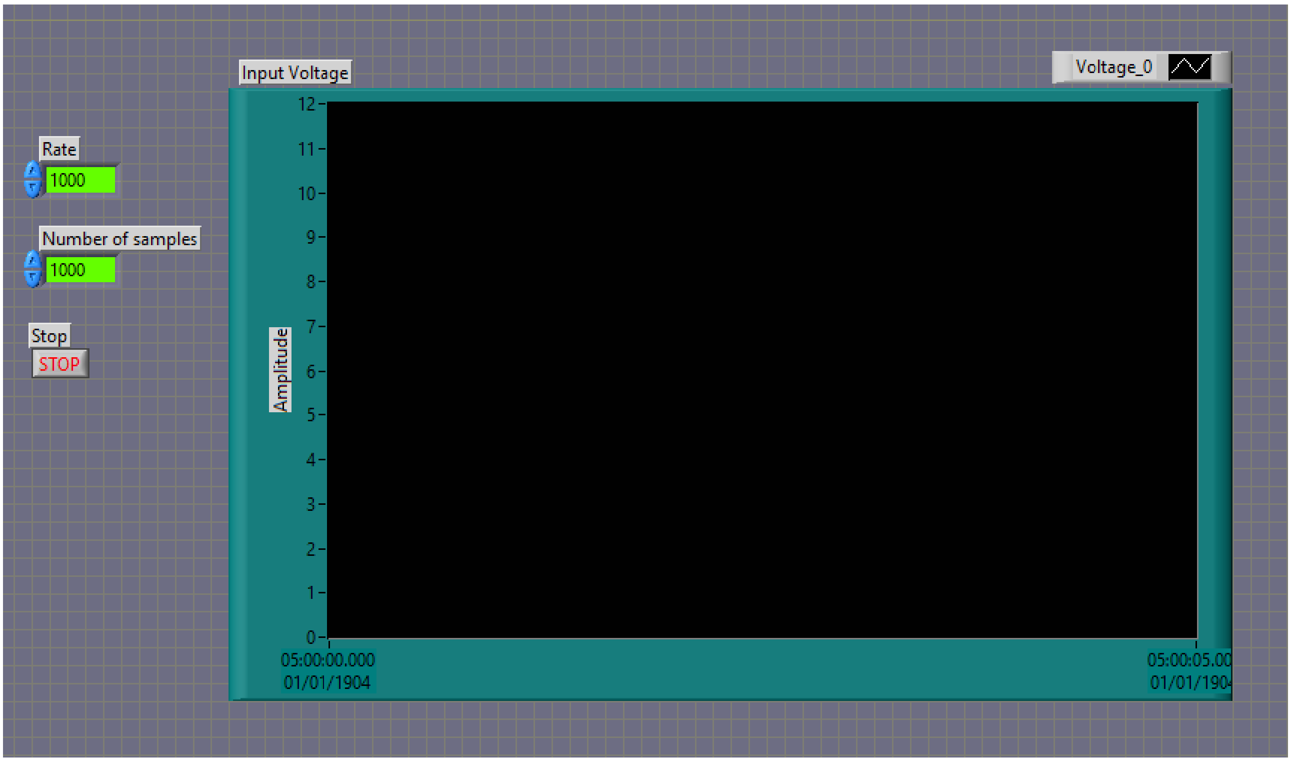


Frequency Measurement Graph:

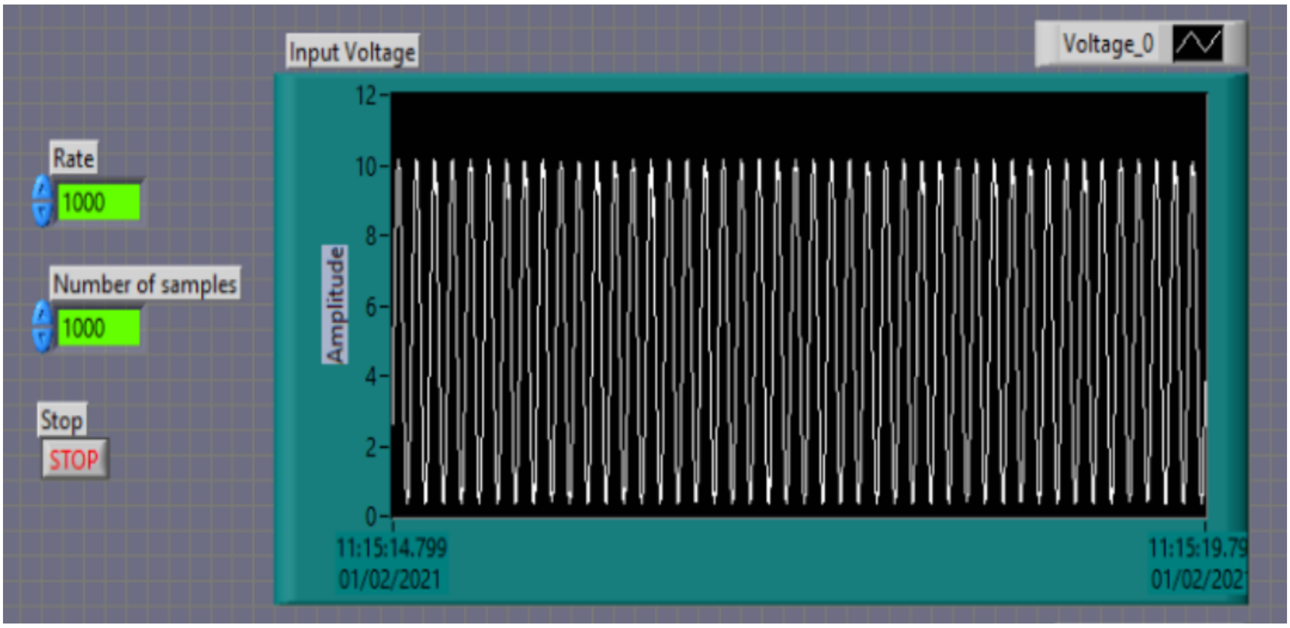
3 Hz



LABVIEW Interface- Input Voltage:



LABVIEW-Input Voltage



CHAP 5: CONCLUSION

Aim of project was to design and develop the pneumatic fatigue testing system for rubber components. In industries especially automobile industries different and customised designed rubber components are used. With automobile operations and working with time these rubber components are affected and they lose their compactness and original design specification. So, it become necessary to replace them over the time. It became necessary to know the fatigue life of the rubber components under used. This fatigue testing system provides the solution for checking the fatigue life of the rubber components. Careful calculation of required force that is required for fatigue testing operation is very necessary to control. Force then defines the behaviour of the rubber component behaviour under the continuous loaded and unloaded conditions.

The project was started with the research on different possible ways to develop this system which operates pneumatically and provide our desire force to test the rubber components. Different possibilities were checked practically under proof-of-concept phenomenon and final system was successfully develop under project requirements.

Fatigue testing system designed was designed to generate a force of 3 kN at higher frequencies. System was designed to use the pneumatic power. Compressed air source is used to operate the pneumatic cylinder that have stroke length of 650 mm and diameter of 80mm bore. This calculation of pneumatic cylinder provides the required force of 3 kN force for fatigue testing. Dynamic force of 3kN is then operated on rubber specimen to check fatigue life.

Fatigue testing system developed with mechanical and electronic setup provides the compact and reliable solution to the industries which require fatigue testing system for the rubber components. Firstly, the project model was designed on solidworks. Different components were designed separately and then assembled in one system.

Mechanical structure was designed to withstand the high forces that were generated during the pneumatic fatigues testing operation. Mechanical System has capacity to be modified and customised according to the requirement. The 650 mm stroke length of the pneumatic actuator provides the opportunity to use different types of rubber components whose fatigue testing is required. Stroke length can be adjusted by tunning the function generator. Function generator can be tuned at different values as per the rubber piece dimension and user required stroke length force.

Rubber components in industries specially in automotive industries are under constant load applications. This makes this development desirable to have a life testing system for the rubber components.

Pneumatic proportional valve provides the continuous actuation to the pneumatic cylinder for number of cycles. Valves have capacity to run at higher frequencies which make this possible to check the system at different frequencies. A low flow proportional valve runs the system at higher critical frequencies maximum flow rate of 350 l/min. Compressed air is provide at continuously to meet the flow rate required for value to operate at designed parameters.

With a high flow proportional valve was also used for fatigue testing. This high flow proportional valve operates at maximum flow rate of 750 l/min. Due to this it was possible to check the fatigue life operation at different frequencies, different pressure ranges and different flow rate specifications.

Force generated by pneumatic actuator is feed to load cell which was connected to DAQ system to get the force data from the system. Data was interpreted for the different number of the samples. Graphs were generated to check the behaviour of the force that was generated by pneumatic actuator. Data plotting was done for the pneumatic actuator generated force, the voltage required by the proportional valve and the operating frequency of the system.

This project provided the solution to different rubber industries and automobile industries for checking the fatigue life of the rubber components they manufacture or use. This customised was design on standard parameters for fatigue life evaluation of rubber specimens.

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