# DESIGN AND FABRICATION OF LOW-COST HMI TESTER

**A PROJECT REPORT**

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**IN**

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**KUMARAGURU COLLEGE OF TECHNOLOGY,**

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**(An Autonomous Institution Affiliated to Anna University, Chennai)**


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# KUMARAGURU COLLEGE OF TECHNOLOGY,

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## BONAFIDE CERTIFICATE

Certified that this project report **"DESIGN AND FABRICATION OF LOW-COST HMI TESTER"** is the bonafide work of **"KISHORE K, THIRUNAVUKKARASU P, ARUNPRASANTH D, ESWAR K"** who carried out the project work under my supervision.

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

# ABSTRACT

Nowadays every business looks to optimize production cost. Automation at low cost is beneficial in two ways.  It eliminates or reduces labour cost and it brings down overall production cost. HMIs play an important role in industries. The HMI's needs to be manufactured/deployed in large numbers. At the same time, the importance of HMI testing is also increased. Industries looks for a cost-effective life cycle that is suitable for automation in design, production, operation, maintenance, refitting or recycling. In our current world, though there are new technologies budding daily, PLC is One Giant which make Automation in Industry. It is essentially an industrial computer.

Human machine Interface (HMI) available in the industry uses different types of inputs for different Human Machine Interface (HMI) to work. At present there are only limited ways that are confined to test a specific type of input method HMI's. This has led to an increase in manpower for testing each type of HMI's. Manual testing has accuracy and quality being compromised for various reasons. The generations of HMI's from 1.0 to 3.0 (at present) had technology supporting methodologies in manufacturing them. At present the three generation HMI's namely the Button based, Panel based, and Touch based are being tested with three individual infrastructures which involves manual labour and is time consuming. This project aims to increase productivity by automating the testing process which reduces the testing time.



**Keywords:** HMI testing, automation, time consuming,

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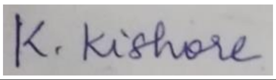
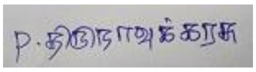
| 1 | KISHORE K | 17BMC001 |  |
| 2 | THIRUNAVUKKARASU P | 17BMC004 |  |
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# NOMENCLATURE

| | |
|---|---|
| PLC | Programmable Logic Controller |
| HMI | Human Machine Interface |
| DOF | Degrees of freedom |
| HRA | Human Reliability Analysis |

# CHAPTER 1

# INTRODUCTION

## 1.1 GENERAL

A Human-Machine Interface (HMI) is a user interface or dashboard that connects a person to a machine, system, or device. While the term can technically be applied to any screen that allows a user to interact with a device, HMI is most commonly used in the context of an industrial process. In industrial settings, HMIs can be used to:

- Visually display data
- Track production time, trends, and tags
- Oversee KPIs
- Monitor machine inputs and outputs

## 1.2 NEED FOR THE STUDY

The current method of testing was developed by a startup called Sastra Robotics. They have developed an HMI tester that would test the interfaces and give its performance results. So, the team decided to co-create with the startup sastra robotics. The adoption barrier that we need to consider before deciding the solution for this problem is the Error threshold percentage and the cost effectiveness of the solution.

## 1.3 OBJECTIVES AND SCOPE OF WORK

The objective of the project is testing touch-based HMI's using two link planar Robot. On considering the adoption barriers We have now come up with an idea of saving an average of 42 hours per month in the process of testing and also minimizing the investment cost in every separate test bed. The Minimal Usable Prototype Concept is to test the HMI's with a smart automatic tester that mimics a CNC Router which uses the Android Debug Bridge (ADB) to analyze the performance of the Machine interface and give the real time data.

The features of the single bed tester, are

1. Saves time
2. Cost effective
3. Less manual lab
4. More accuracy

## 1.4 EXECUTION

The HMI Tester is composed of different components which works by two link planar robot using HMI Testing Bed. Each link has separate motors for moving. The Motors are provided with encoders for accurate position and orientation. At end effector the electromechanical actuator along with capacitive touch stick is providing for touching the HMI. The Two Link Planar robot and HMI are all controlled by PLC.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 VARIOUS RESEARCH WORKS IN HMI

### Advancing Display System for Universal Testing Machine Using Human Machine Interface (HMI)

Patil et al. (2015) published the “Advancing display system for Universal testing machine using Human Machine Interface (HMI)”. This paper explains the details about the advancing of display & data acquisition system for universal testing machine (UTM) using Human Machine Interfaces (HMI). In old days the data acquisition system is based on simple keypad & LCD based panel in such case operator is facing lot of problems while handling such type of systems. Also hardware space taken by the devices is much more wide which can be replaced by using Human Machine Interface (HMI). Also referred to as user Interface, provides a means of Controlling, monitoring, managing or visualizing device processes. operator panel which allows an industrial machine operator to interact with a machine in a graphical, visual way So here we can interface HMI for getting excellent results & enhancing the definitions of data acquisitions.

### The influence of study design on results in HMI testing for active safety

Mikael Ljung et al. (2007) studied “the influence of study design on results in HMI testing for active safety”. Active safety systems show great potential in preventing a large number of accidents. However, unless the system is completely autonomous, its actual effect will depend on how well it interacts with the driver. Therefore, Human-Machine-Interface (HMI) testing for active safety systems has become central in their development. For reasons of reproducibility and safety, HMI testing is usually carried out in a driving simulator or test track environment. These environments are different from real life driving. Unless the study design accurately reflects the conditions under which the system will be used, results will have low validity. Hence, study design becomes very important. study design becomes very important.

The influence of study design was shown in two HMI-studies of Forward Collision Warning (FCW) modalities carried out by Volvo Cars and Ford Motor Company in VIRTTEX, Ford's motion-based driving simulator. In each study subjects were exposed to a surprise FCW event, with most subjects receiving an FCW. Results show that distracted drivers' reactions to the warning correlated to their degree of previous exposure to warnings as well as the type of warning. Drivers who had received other warnings in the vehicle prior to the surprise FCW event responded as intended to all warning types. Drivers who neither trained with nor were informed about any vehicle warnings prior to the surprise FCW event responded partially as intended to the warnings, with an interesting exception for verbal warnings. The results show that to achieve high validity in HMI evaluations, the study design can benefit from exposing drivers to warnings in a way that reflects their normal awareness of warnings in real life driving. It also suggests that developers could tailor HMI design to frequency of use, as well as benefit from keeping drivers adequately aware of the warning types a vehicle can provide.

# CHAPTER 3

# MATERIALS AND METHODS

## 3.1 GENERAL

The materials are chosen by keeping the cost, affordability, reliability and performance in consideration as it is intended to test the HMI for a long time without any problem in between the operation.

## 3.2 MATERIALS USED

| S.No | Material | Specification | Quantity |
|---|---|---|---|
| 1. | Aluminum Rod | 20cm×5cm×1cm | 2 |
| 2 | Capacitive Mobile Touch stick | 1.6 cm×10cm | 1 |
| 3 | Coupling | Jaw link connecting | 2 |
| 4. | Hybrid Servo Motor | 29.5Nm,12V | 2 |
| 5. | Hybrid Servo Motor Driver | 50V 7A RS485 | 2 |
| 6. | PLC Controller | Delta PLC-Dvp14Ss211T | 1 |
| 7. | Touch Screen Display | 7'' inch capacitive touch screen LCD | 1 |
| 8. | Limit switches | ME-8108 rotary adjustable | 2 |
| 9. | Motor Clampers and Screws | Guard type | 2 |
| 10. | Magnetic Linear Actuators (JF-0630B) | JF-0630B | 1 |
| 11. | Programmable Cable | UC-PRG020-12A | 1 |
| 12. | Regulated Power Supply | 30V,10A | 1 |

**Table 3.1 Materials Used**

### 3.2.1 Aluminum Rod

**Figure 3.1 Aluminium Rod**

Aluminum is a very light metal with a specific weight of 2.7 g/cm$^3$, about a third of that of steel. This cuts the costs of manufacturing with aluminum. Its strength can be adapted to the application required by modifying the composition of its alloys. Aluminum naturally generates a protective thin oxide coating which keeps the metal from making further contact with the environment.

#### 3.2.1.1 Properties

- High thermal conductivity
- Excellent Corrosion Resistance
- Easy machinability

### 3.2.2 Capacitive Mobile Stick


**Figure 3.2 Capacitive Mobile Stick**

#### 3.2.2.1 Introduction

Capacitive (also called passive) styluses emulate a finger by using a tip made of rubber or conductive foam; or metal such as copper. They do not need to be powered and can be used on any multi touch surface that a finger can be used, capacitive screens that are common in smart phones and multi touch surfaces. Stylus tips made of rubber or foam are often large so it's difficult to get precise notes or drawings.

#### 3.2.2.2 Capacitive Mobile Stick Working

Capacitive styluses are made of a conductive material (typically as a metal rod or barrel) to transmit electrical charge between your hand and a rubber, foam or metal tip such as copper. Capacitive styluses work by distorting the screen’s electrostatic field. Screens that receive input from a capacitive stylus (as well as human fingers) can't register pressure applied by the pen; tilting of the pen; and can't distinguish between a capacitive stylus, your finger, or a resting palm as input - it will register all of these touches as marks on the screen.

### 3.2.3 Coupling

**Figure 3.3 Coupling**

#### 3.2.3.1 Introduction

Coupling link manufacturer Peerless Chain makes coupling links used for attaching chain to master links on a chain sling or attaching hooks or other components to the legs of a chain sling. Link coupling links are strong, dependable and easy to use in overhead lifting applications.

#### 3.2.3.2 Usage

The primary purpose of couplings is to join two pieces of rotating equipment while permitting some degree of misalignment or end movement or both.

Other common uses:

- To alter the vibration characteristics of rotating units
- To connect driving and the driven part
- To introduce protection
- To reduce the transmission of shock loads from one shaft to another
- To slip when overload occurs

### 3.2.4 Hybrid Servo Motor


**Figure 3.4 Hybrid Servo Motor**

#### 3.2.4.1 Introduction

A servomotor is a rotary linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servo motors are not a specific class of motor, although the term servomotor is often used to refer to a motor suitable for use in a closed loop control system.

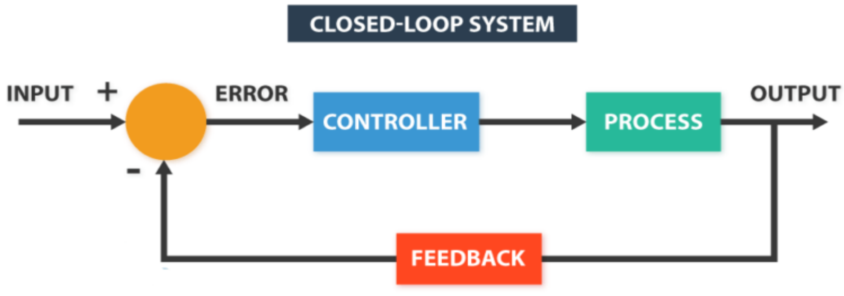


**Figure 3.5 Closed-loop System**

### 3.2.4.2 Working

The motor is paired with some type of position encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

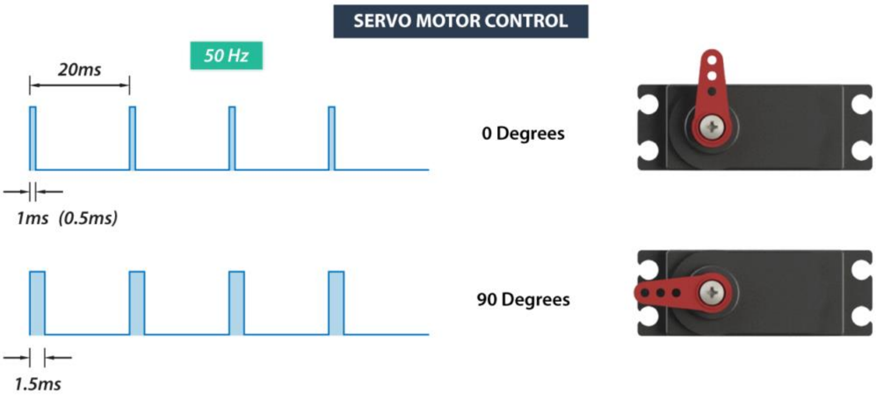


**Figure 3.6 Servo Motor Control**

### 3.2.4.3 Applications

- The servo motor is used in robotics to activate movements, giving the arm to its precise angle.
- The Servo motor is used to start, move and stop conveyor belts carrying the product along with many stages. For instance, product labeling, bottling and packaging
- The servo motor is built into the camera to correct a lens of the camera to improve out of focus images.
- The servo motor is used in robotic vehicle to control the robot wheels, producing plenty torque to move, start and stop the vehicle and control its speed.

## 3.2.5 Hybrid Servo Motor Driver

### 3.2.5.1 Introduction

A servo drive is an electronic amplifier used to power electric servomechanisms. A servo drive monitors the feedback signal from the servomechanism and continually adjusts for deviation from expected behavior.


**Figure 3.7 Hybrid Servo Motor Driver**

### 3.2.5.2 Mechanism

A servo drive receives a command signal from a control system, amplifies the signal, and transmits electric current to a Servo motor in order to produce motion proportional to the command signal. Typically, the command signal represents a desired velocity, but can also represent a desired torque or position. A sensor attached to the servo motor reports the motor's actual status back to the servo drive. The servo drive then compares the actual motor status with the commanded motor status. It then alters the voltage, frequency or pulse width to the motor so as to correct for any deviation from the commanded status.

### 3.2.6 PLC Controller


**Figure 3.8 PLC Controller**

#### 3.2.6.1 Introduction

A programmable logic controller (PLC) is an industrial digital computer that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis. PLCs can range from small modular devices with tens of inputs and outputs in a housing integral with the processor, to large rack-mounted modular devices with thousands of I/O, and which are often networked to other PLC and SCADA systems.

#### 3.2.6.2 How does a PLC Work

The PLC receives information from connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters. Depending on the inputs and outputs, a PLC can monitor and record run-time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms if a machine malfunction, and more. Programmable Logic Controllers are a flexible and robust control solution, adaptable to almost any application.

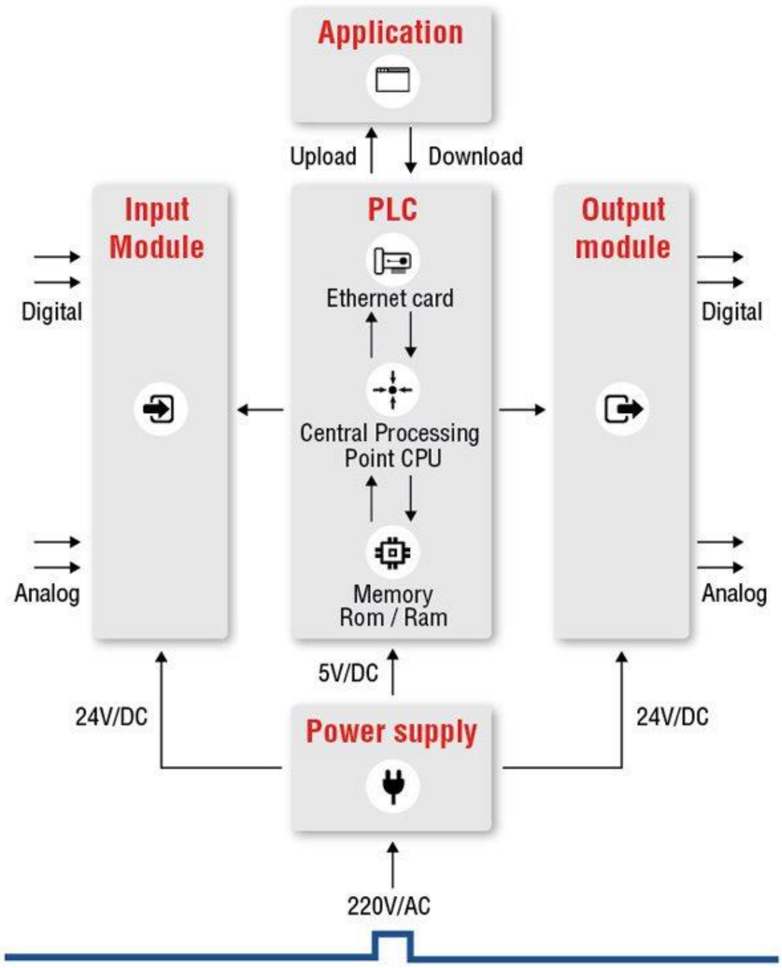


**Figure 3.9 Working of a PLC**

### 3.2.7 Touch Screen Display


**Figure 3.10 Touch Screen Display**

### 3.2.7.1 Introduction

A touchscreen is both an input and output device and normally layered on the top of an electronic visual display of an information processing system. The display is often an LCD or OLED display while the system is usually a laptop, tablet, or smartphone. A user can give input or control the information processing system through simple or multi touch gestures by touching the screen with a special stylus or one or more fingers. Some touchscreens use ordinary or specially coated gloves to work while others may only work using a special stylus or pen.

### 3.2.7.2 Components and Working

There are three components that work together to create the magic of touch screen capability: the touch sensor, the controller, and the software. The touch sensor can be one of three types: resistive, surface acoustic wave, or capacitive. Resistive and capacitive are the most common and are quite ingenious.

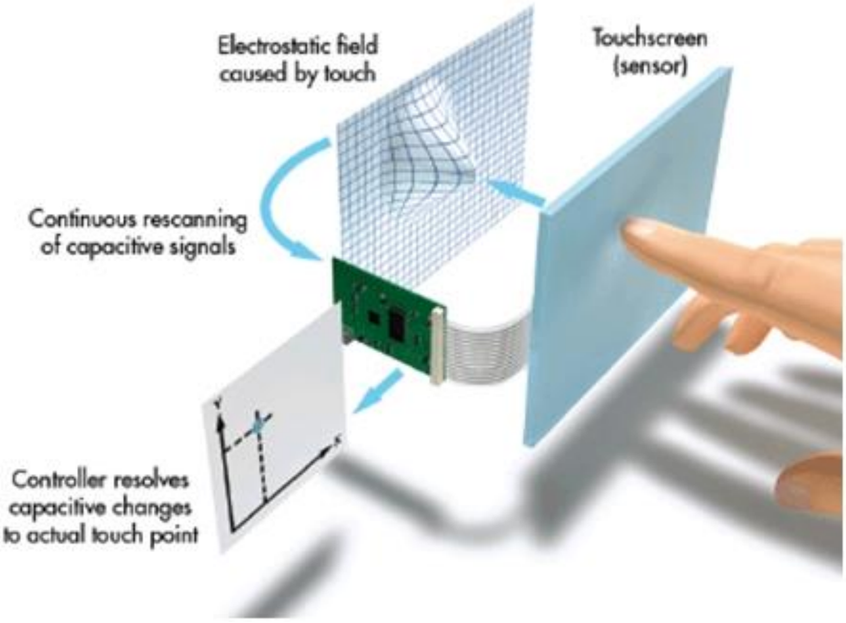


**Figure 3.11 Working of Touch Screen Display**

### 3.2.8 Limit Switches


**Figure 3.12 Limit Switches**

#### 3.2.8.1 Introduction

Limit switch is a switch operated by the motion of a machine part or presence of an object. They are used for controlling machinery as part of a control systems, as a safety interlocks, or to count objects passing a point. A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

#### 3.2.8.2 Types of Limit switch

Various types of limit switches exist, including:

- Snap switches
- Heavy duty oil-tight switches
- Gravity return switches
- Safety locking and unlocking switches

### 3.2.9 Motor Clampers and Screws

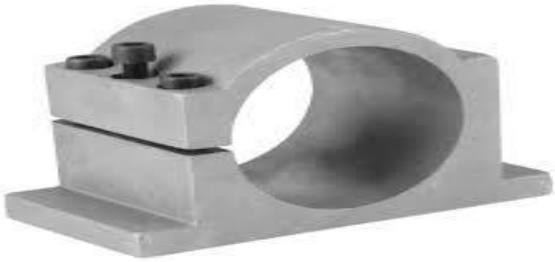

**Figure 3.13 Motor Clampers and Screws**

#### 3.2.9.1 Introduction

A clamp is a fastening device used to hold or secure objects tightly together to prevent movement or separation through the application of inward pressure. Clamps are versatile tools that serve to temporarily hold work securely in place. They are used for many applications including carpentry, woodworking, furniture making, welding, construction and metal working.

### 3.2.10 Magnetic Linear Actuators (JF-0630B)

#### 3.2.10.1 Introduction

A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery, in computer peripherals such as disk drives and printers, in valves and dampers, and in many other places where linear motion is required.


**Figure 3.14 Magnetic Linear Actuator**

#### 3.2.10.2 Operation

Magnetic Actuators use magnetic effects to generate forces which impact on the motion of a part in the actuator placed between two magnet poles, a mobile permanent magnet can be switched from one pole to the other using coils. Such moving magnet actuators are bi-stable. They present high forces but are not so controllable.

### 3.2.11 PLC Programmable Cable

**Figure 3.15 PLC Programming Cable**

#### 3.2.11.1 Introduction

Serial communication is when data is transmitted one bit at a time. A data word has to be separated into its constituent bits for transmission and then reassembled into the word when received. Serial communication is used for transmitting data over long distances. Might be used for the connection between a computer and a PLC**.**

#### 3.2.11.2 Serial Standards

RS-232 communications is the most popular method of PLC to external device communications. RS 232 is a communication interface included under SCADA applications.

Other standards such as RS422 and RS423 are similar to RS232 although they permit higher transmission rates and longer cable distances.

### 3.2.12 Regulated Power Supply

### 3.2.12.1 Introduction


**Figure 3.16 Regulated Power Supply**

A regulated power supply is an embedded circuit; it converts unregulated AC into a constant DC. With the help of a rectifier, it converts AC supply into DC. Its function is to supply a stable voltage, to a circuit or device that must be operated within certain power supply limits.

### 3.2.12.2 Working Principle

Its function is to supply a stable voltage (or less often current), to a circuit or device that must be operated within certain power supply limits. The output from the regulated power supply may be alternating or unidirectional but is nearly always DC (Direct Current).

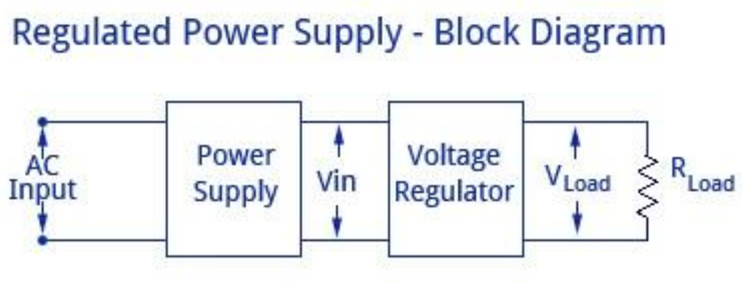


**Figure 3.17 Regulated Power Supply – Block Diagram**

The basic building blocks of a regulated DC power supply are as follows:

1. A step-down transformer
2. A rectifier
3. A DC filter
4. A regulator

# CHAPTER 4

# SOFTWARE USAGE

## 4.1 Autodesk Fusion 360

**Figure 4.1 Autodesk Fusion 360**

### 4.1.1 Introduction

Unlike any other tool of its kind, Autodesk Fusion 360 connects CAD, CAM, and CAE in a single cloud-based platform that works on both Mac and PC. Fusion 360 connects the entire product development process by using the first 3D design, manufacturing, and engineering tool of its kind.

### 4.1.2 Modelling Technique

Fusion 360 supports direct modelling, both in history based and non-history based modes. History free direct modelling is great when working with single CAD files from other CAD systems. Simple edits can be made by pushing and pulling or deleting faces. Ideal for preparing files for CAM or Simulation. Even the most complex organic shapes can be quickly iterated using Fusion 360’s T-Splines modelling tools. T-Splines are a powerful take on subdivision modelling.

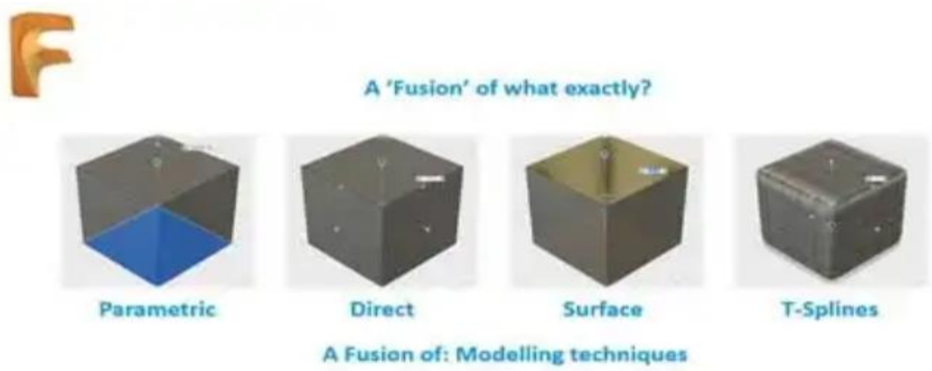


**Figure 4.2 Modelling Techniques**

## 4.2 MIT App Inventor

**Figure 4.3 MIT App Inventor**

### 4.2.1 Introduction

MIT App Inventor is an online platform designed to teach computational thinking concepts through development of mobile applications. Students create applications by dragging and dropping components into a design view and using a visual blocks language to program application behavior.

### 4.2.2 Basic Working

It uses graphical user interface (GUI) very similar to the programming languages Scratch (programming language) and the StarLogo, which allows users to drag and drop visual objects to create an application that can run on android devices, while a App-Inventor Companion (The program that allows the app to run and debug on) that works on iOS running devices are still under development. In creating App Inventor, Google drew upon significant prior research in educational computing, and work done within Google on online development

## 4.3 Logix Pro 500 for PLC Simulator


**Figure 4.4 LogixPro 500 for PLC Simulator**

### 4.3.1 Introduction

LogixPro is a PLC simulator that is particularly geared toward Rockwell's RSLogix 500 software. There is no need for any PLC hardware when using the simulator. The keyed edition of LogixPro, that is part of the course materials, provides animated process simulations, including an I/O simulator with changeable switch types, output indicators, thumbwheel switches and a BCD digital readout. Several process animations are also included and we will be working with several of them in future homework labs.

### 4.3.2 The LogixPro Interface

1.The LogixPro interface is very similar to the RSLogix 500 interface, so now that you have successfully completed the introduction to RSLogix 500 lab, you should quickly be able to become comfortable in the LogixPro environment.

2.Note the similarities and differences to RSLogix 500. The first obvious difference is that there is a simulation where the project window should be and that there is an animated help wizard on the screen. If you would like to hide the animated help wizard, right click on him and select Hide.

3. The Online/Offline toolbox has no functionality except for the Online/Offline dropdown box and this dropdown box is not really needed.

4. The menu bar is different because there are some functions in the RSLogix 500 software that are not needed in the LogixPro software, and some options in the LogixPro software that are needed for it to function properly. One such menu is the Simulations menu.

5. The instruction tool bar is the same as RSLogix 500 except that not all the instructions are available in LogixPro and there is an additional button in the upper right corner.

**CAD Model**

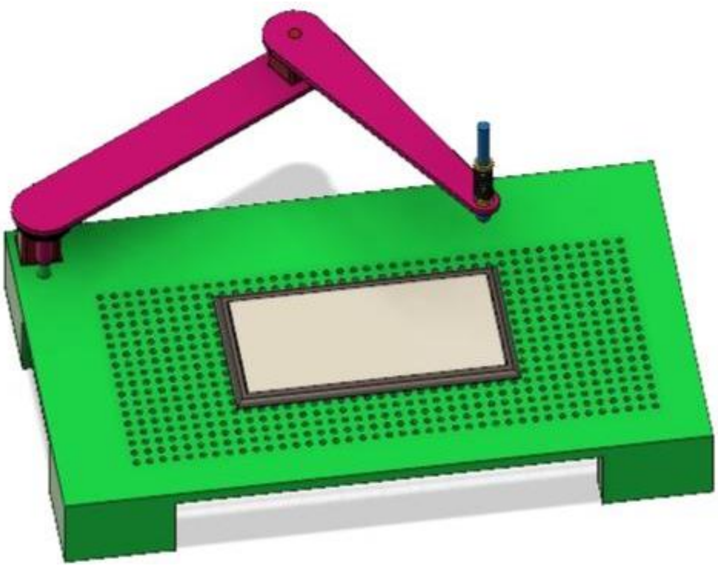

**Figure 4.5 Isometric View of HMI Tester**

## BLOCK DIAGRAM

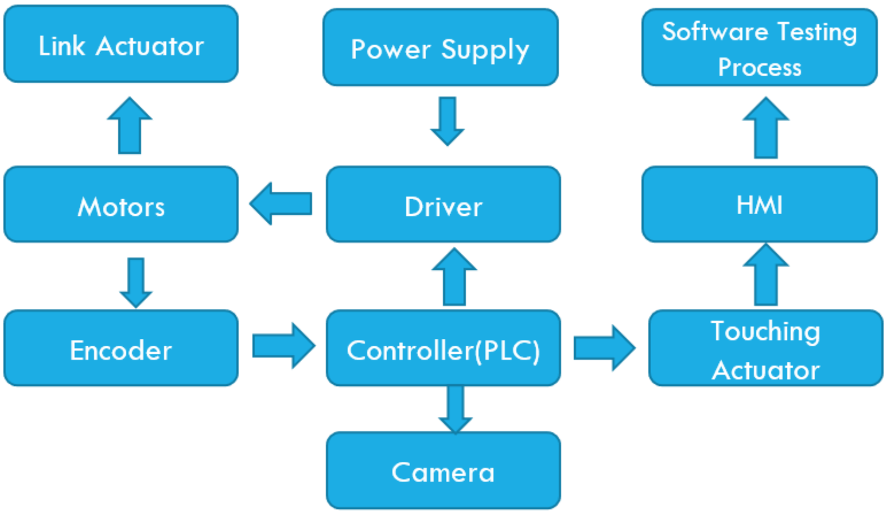


**Figure 4.6 Block Diagram**

## CONTROLLER PROGRAM – ALGORITHM

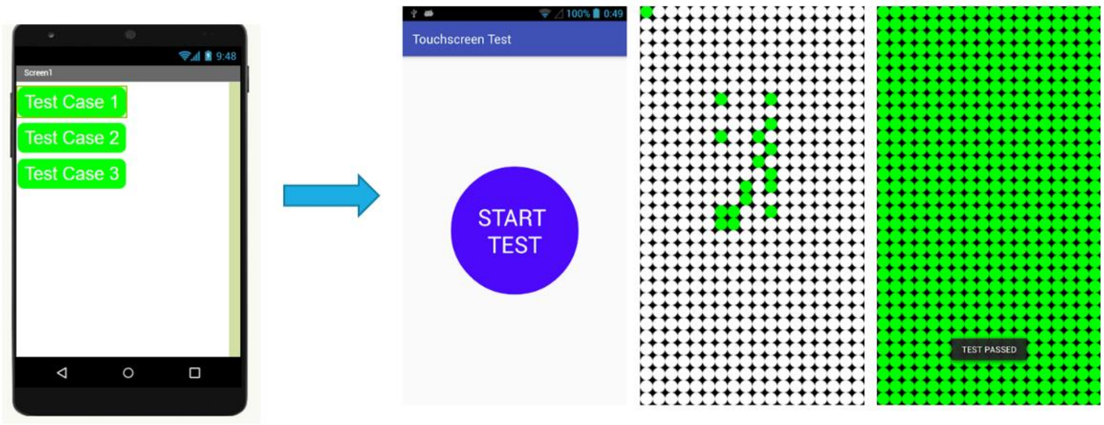


**Figure 4.7 Controller Program - Algorithm**

# CHAPTER 5

# RESULTS AND DISCUSSION

## 5.1 SUMMARY

On discussing various aspects on the working of the Human Machine Interface tester it can be seen that the robot can be accurate and quicker while testing the HMI. The data received from HMI is quick and hence the two link planar robot determines the correct position and orientation. The Actuators are controlled by perfect encoders and hence the motor cannot rotate further step.

## 5.2 CONCLUSION

A common test bed would enable industries check the efficiency and accuracy of HMI's precisely. Less manpower involved. Time for testing reduces. A common test bed for various input HMI's reduces the need for multiple and separate test beds. The real time monitoring of the testing process leads to manufacturing of advanced HMI's.

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