Innovation and Design through Industry Partnership

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Abstract

The benefits of university-industry partnerships and collaborations (UIPC) are many. The strength of university programs depends on staying relevant to innovative technology and current market trends, not only regionally but globally. Having strong industry partnerships allows students and university stakeholders to learn about current and future technology. The collaboration between LinMot Inc. USA and Purdue University Northwest (PNW), driven by support from the Packaging Machinery Manufacturers Institute (PMMI) Foundation and the "PMMI U Skills Fund" exemplifies that unity. Using industry-standard software, equipment, and resources, like that provided by LinMot USA, allows students and workforce trainees to learn about the newest equipment, learn about emerging technologies in packaging and processing, and provides a pipeline of workforce-ready talent. In this paper, the author explains the steps to design, fabricate, and build a testbed trainer to be used with the existing trainers in the hands-on activity laboratories, student/industry projects, and capstone design. This project is a good tool for students to practice innovative technology hands-on skills using an electromagnetic linear actuator made by LinMot. The results of this project also are also demonstrated and explained. All necessary steps that are needed for programming and testing will be discussed.

Introduction

There are many types of linear actuators used today in industry and university. The most common actuator types are electro/mechanical, pneumatic, and hydraulic. Electro/mechanical linear actuators or electrical linear actuators are usually converting rotary motion into linear motion. Hydraulic linear actuators use pressurized hydraulic fluid or oil. Hydraulic actuators have been used for many decades and are particularly useful for many difficult applications where high force, high power per unit weight and volume, mechanical stiffness, and high dynamic response are desired [1]. Pneumatic linear actuators use pressurized air or gas. Their basic design has been for many years and is usually powered in modern times by an electric compressor. They are used in applications typically requiring 100 PSI or less, or when high speeds are needed ranging from a couple of inches per second to over 60 inches of travel per second [2].

Recently, in the late twentieth century, a new type of actuator called an electromagnetic linear actuator was invented. LinMot motors are electromagnetic direct drives in tubular form. The linear movement is generated entirely electrically and wear-free without the use of mechanical gears, spindles, or belts. The electromagnetic actuator element and cross-section are shown in Figure 1. These actuators are replacing conventional pneumatic cylinders in more and more applications. The main reasons to replace pneumatic actuators include poor efficiency, high costs for commissioning, reconfiguration, service, and maintenance, and the limited control capabilities of pneumatic systems. Another huge benefit of electromagnetic actuators is significant carbon footprint reduction. In addition, they provide greater flexibility in the design of production processes and production monitoring systems. LinMot actuator applications are packaging Machines, assembly & handling systems, food productions, semiconductors, electronics, and CD/DVD. An example of LinMot actuator's real-world applications is shown in Figure 2.

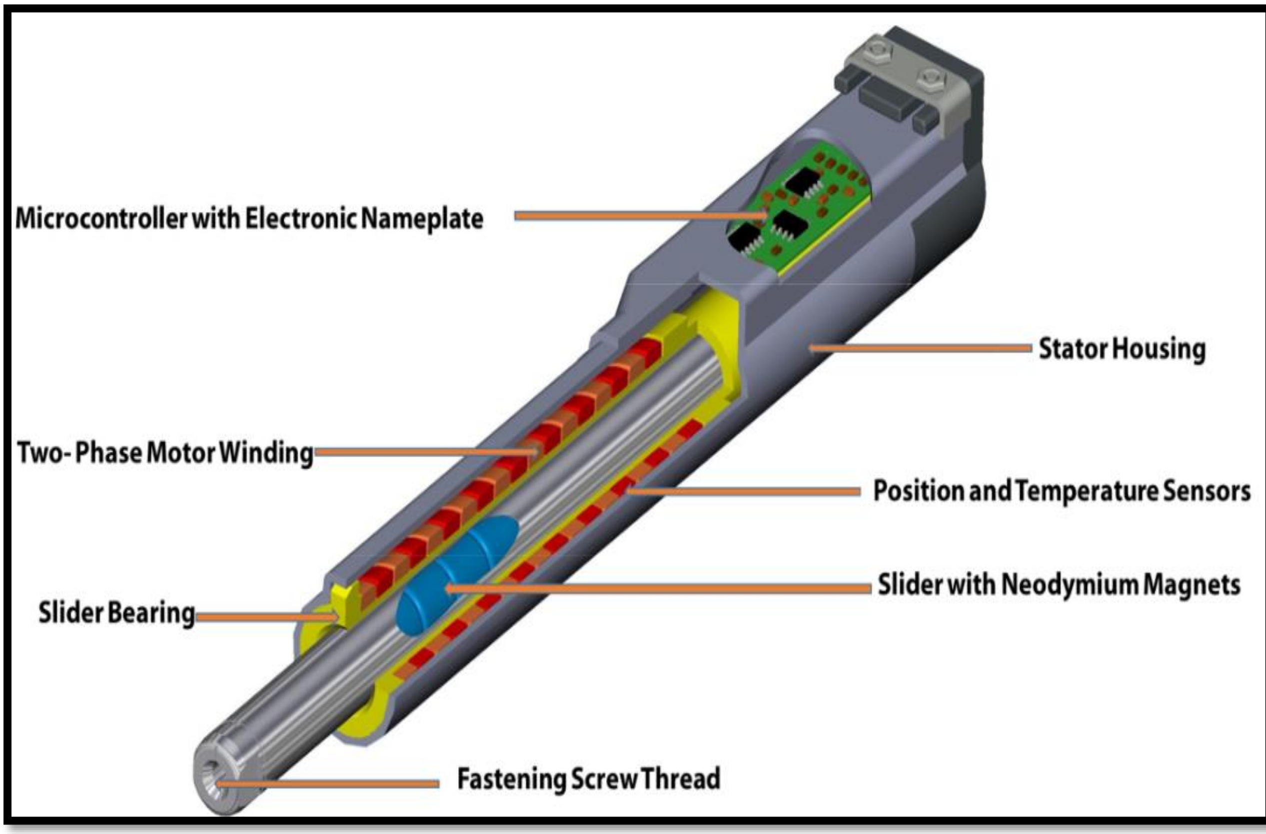


Fig.1. LinMot Linear Motor cross section [3].

Furthermore, LinMot electromagnetic linear actuators provide better flexibility in the design of production processes and production monitoring systems.

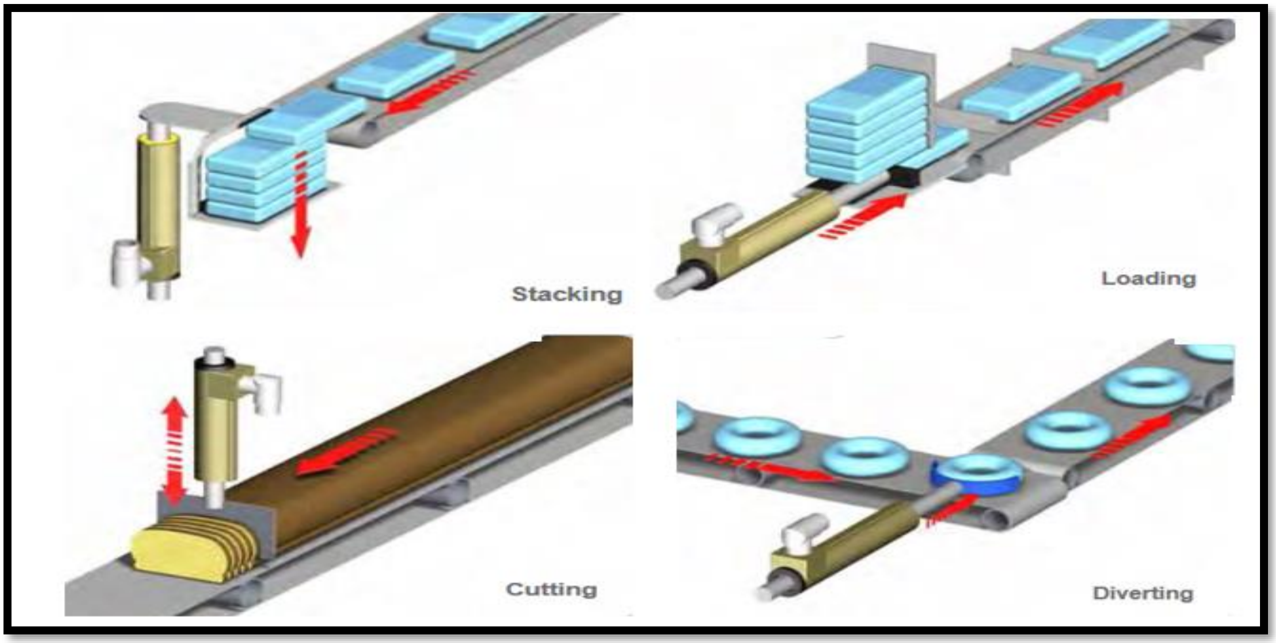


Fig. 2. LinMot Actuator applications [4].

Some of the LinMot actuator's characteristics are [5]:

- Speeds > 10m per second
- High accelerations up to 100g
- Forces 2700 N
- Repeatability of .002" standard, and .0004" with external encoder
- Very long lifespan – Tested out to 3 B cycles
- Energy savings compared to air cylinders (high cycle rate can provide a 1-year payback)
- Low maintenance required.

Project Overview

The main goal of the Mechatronics Engineering Technology program at Purdue University Northwest and The PMMI U Skills Fund grant is to help bridge the manufacturing skills gap by engaging PMMI industry members and educational institutions with current workforce technology thereby increasing the development of educational programs regionally.

Using the PMMI U Skills Fund grant model, LinMot USA gifted Purdue University Northwest College of Technology (COT) a linear actuator system that includes hardware, software, and basic set-up and user manuals to support the COT Mechatronics Engineering Technology program. The linear system is state of the art and is used in many applications, recently used in

COVID-19 test kit manufacturing. The matched cash funds can be used towards curriculum/lab development and equipment consumables.

System Details

LinMot motors systems are electromagnetic direct drives in tabular form. Linear motor electrically independent units. The commissioning of the linear motor can therefore be performed sequentially or simultaneously. It does not matter which motor (linear motor or rotary motor) is commissioned first. The motion is produced purely electrically and wear-free, without any intermediate coupling of mechanical gearboxes, spindles, or belts. The linear motor stator contains the motor windings, bearings for the linear movement, position capture sensors, motor winding temperature sensors, and a microprocessor circuit for monitoring the motor.

System Advantages and Technical Aspects

This system will be integrated with existing hardware equipment in the lab. This will give students more advantages in learning and practicing system integration using innovative technology. This type of system is currently not available in our engineering technology labs and will add another avenue to our students and our curriculum. This system has many technical advantages over the conventional ones currently in use. These advantages include being positioned freely, extremely dynamic, long service life, adjustable speed, monitored motions, adjustable acceleration, gentle motions, programmable force, and synchronization to other motors.

Project Tasks

During the summer of 2020, the following objectives will be accomplished for new equipment integration for the fall 2023 semester:

- *System assembly*
  The system will be assembled using all components, including the motor-driver-Power supply. The assembled system will be programmed and tested.

- *Programming*
  Writing a set of programs to connect the assembled system with the conveyor belt.

- *Write lab manual*
  Write a set of labs using the new system to help students and incorporate the new system with the Mechatronics engineering technology curriculum.

- *Integration with PLC and HMI*
  Writing clear steps and programs for integrating the system with PLC and HMI

System Design

A) CAD Drawing

The first step of the design is the design system layout using SOLIDWORKS software. All components' measurements used in this design were taken from the bill of materials sheet for accurate design. Many of the components have a CAD model and were added to the solid works for better design. One of the constrain in the design is the whole system should fit in the Pelican 1200 Case including a foam. The metal plates to build the internal encasement from the bottom right and an isometric view of the system housed within the hard-shell casing, taken from the bottom right are shown in Figure [3].

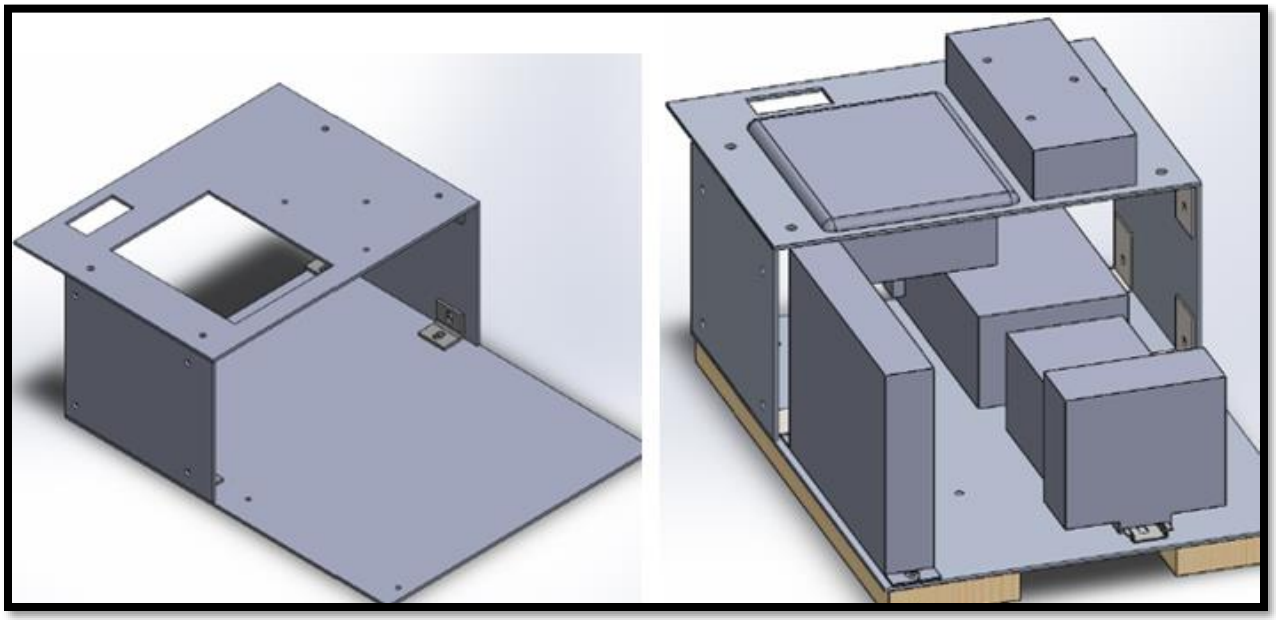


Fig. 3. CAD model for the internal encasement from the bottom right.

The CAD drawing was very helpful in including all component details before assembly processing started. The programmable logic controller (PLC) and its components such as Allen Bradley MicroLogix 1100 and the power supply are also included in the CAD system drawing. The final CAD drawing of the system is shown in Figure 4.

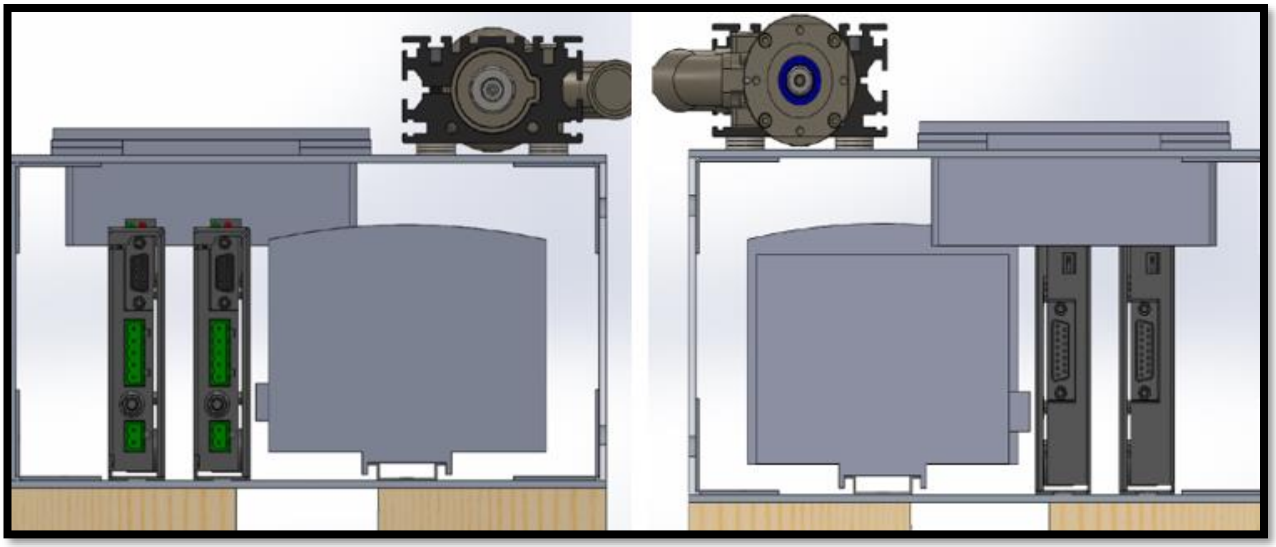


Fig. 4. The right-left sides of the mounting encasement.

B) Assembly

The assembly process started with gathering all materials needed together in order and sorting for proper sequence. Some of the steps are listed below:

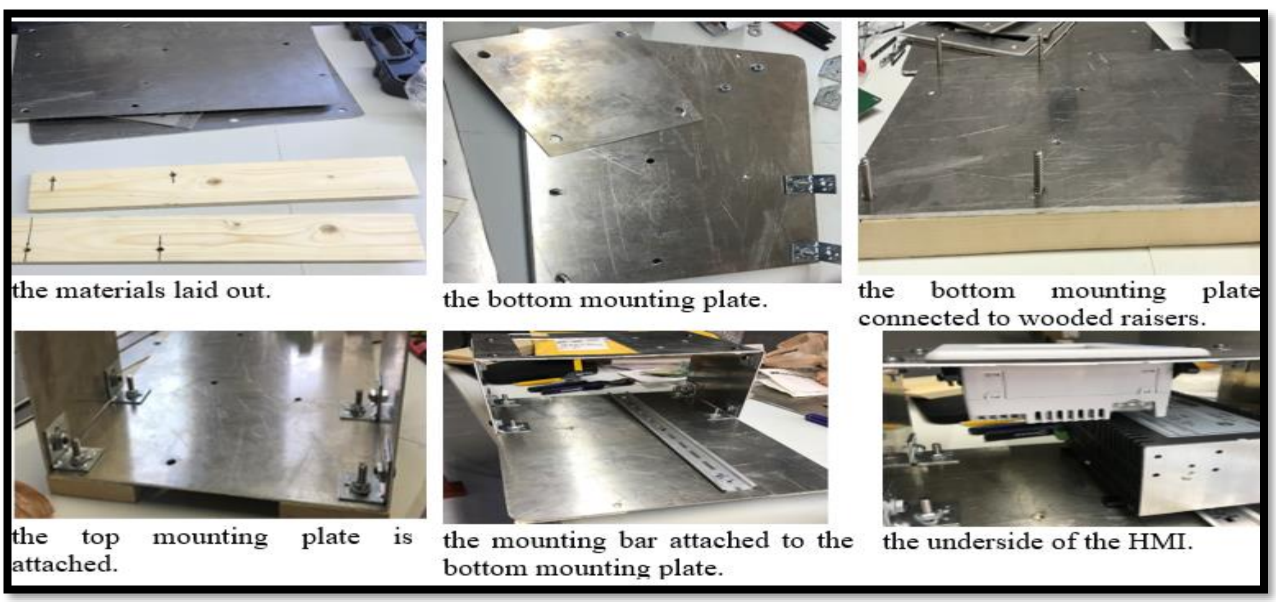


Fig. 5. Assembly steps.

C) Wiring

The wiring process started after drawing an electrical wiring diagram. The wires used in this project were in proper size and gauge size and correct length. All wires and cables are secured close to connection points, with enough slack to avoid putting strain on connectors. Cables and wires are secured and all additional points are added to keep the wiring neat and clean. After finishing wiring and testing, all wires are zipped and tied to avoid electrical hazards or loosing. Some pictures are listed below during the warning process as shown in Figure 6.

Fig. 6. Wiring steps.

D) Programming

The programming started after connecting all wires between the PLC and the Motor's drive as shown in Figure 7. The main components are

- MicroLogix Rockwell PLC
- Allen Bradley HMI PanelView 600
- LinMot B1100 servo drive.

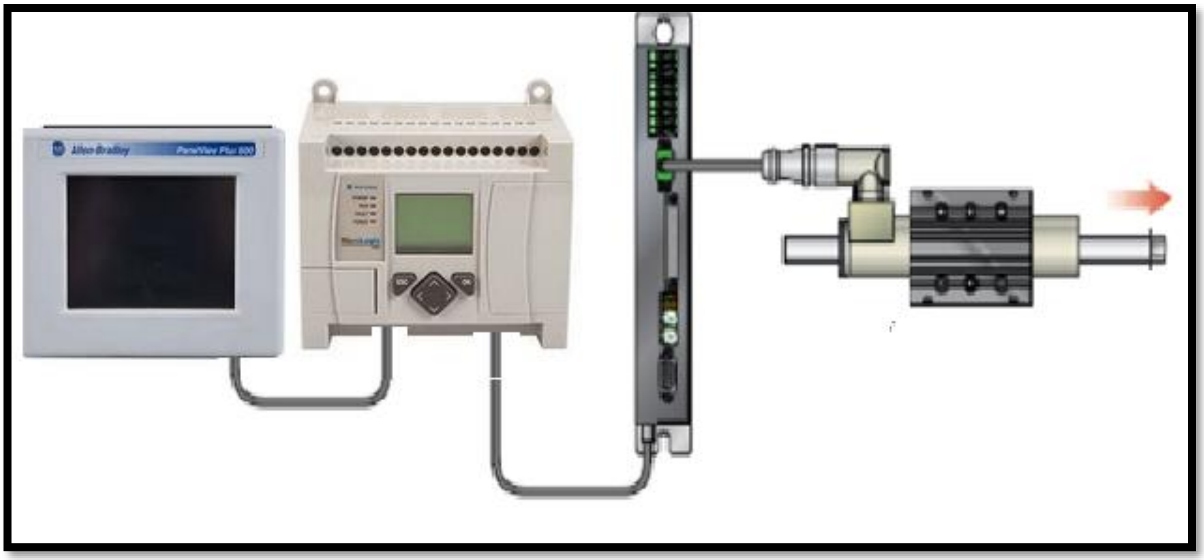


Fig. 7. System main components.

The software that has been used is RSlogix 500 along with RSlinx Classic and LinMot Talk 6.9. A screenshot of Rslogix 500 software is shown below in Figure 8.

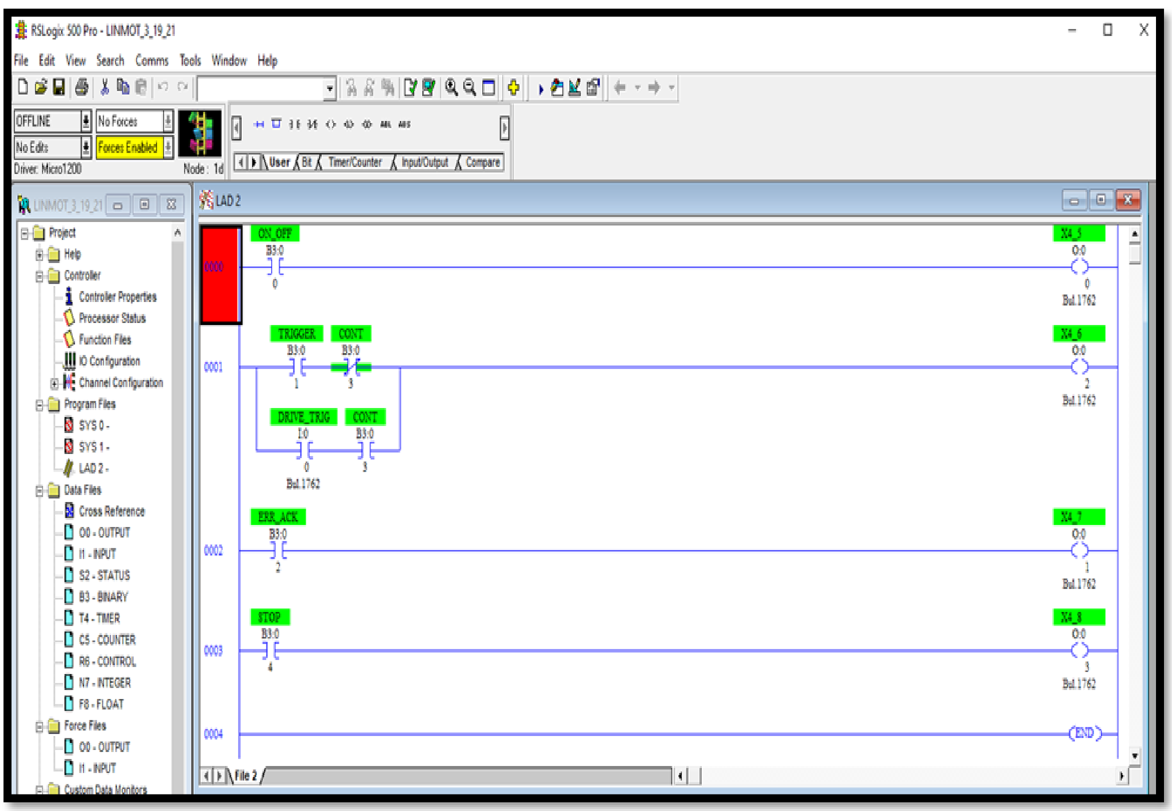


Fig. 8. PLC program for the LinMot system.

E) HMI Interface

The HMI programming was implemented using factory talk view studio machine edition software.

The main keys are on the screen:
ON/OFF: to start and stop the drive
Home: To trigger the drive go to the predetermined home position
ErrACK: to acknowledge the error and reset it.
Trigger: to send a pulse single for the drive to perform one action
Cont_Off: for ON/OFF continues movement.
Quick Stop: to stop the drive at any position
Home Pos: is the same as the Home button

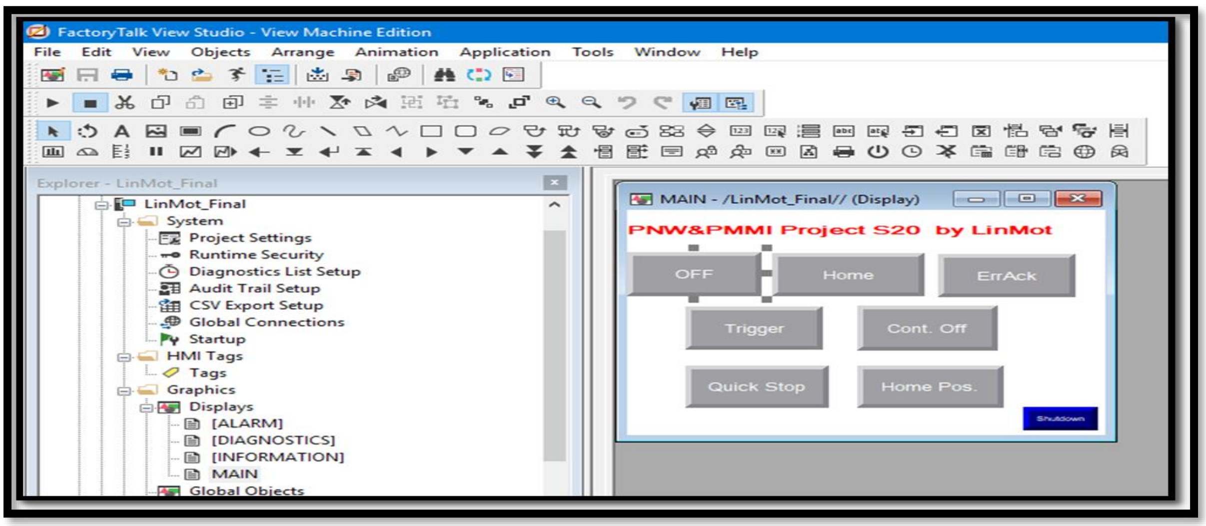


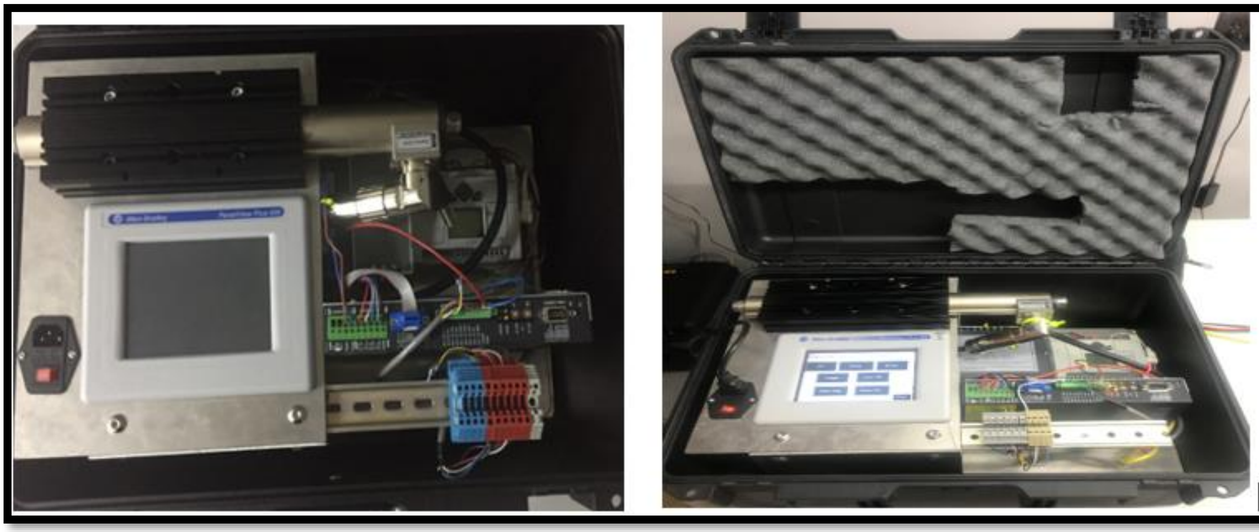
Fig. 9. HMI interface with the main buttons.

F) Testing, Running

The programming part of the LinMot was already set up to run the program. To run the program,

- Turn the device ON
- Select the LinMot program that is already highlighted
- Select downloaded to get a screen like the one in HMI programming
- Press ON
    - This should stay highlighted in red
- Press trigger
    - This will move the rod into its home position
- Press Cont. Config

G) Final Design and Delivery



Conclusion

The scope of the project was to create a simple system that can help demonstrate the capabilities of the LinMot linear motor systems to showcase how it can apply to multiple industries using automation. The system is contained inside a hard shell case for ease of transport, and while maintaining easy access to the PLC and motor drive I/O if the configuration was to be changed. The motor itself was easy to set up and integrate with the Allen Bradley MicroLogix 1100 PLC, with the motor drive being set up to respond to the PLC through the Linmot software. The motor was set up to turn on, home out, acknowledge errors, trigger, and continuously actuate in response to the commands received from the PLC. The software was found to be easy to use after watching a few of LinMots setup guide videos and also contained various research functions such as the built-in oscilloscope that allows the user to monitor various parameters of the motor such as actual position, demand position, and electrical current. The versatility built into the motor could easily be adapted to industries currently using pneumatic pistons in production lines, package sorting, etc. while maintaining high speed and accuracy over a longer lifespan and less maintenance compared to pneumatic pistons.

Acknowledgment

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Biography

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