POLYTECHNIC UNIVERSITY OF PUERTO RICO
MECHANICAL ENGINEERING DEPARTMENT

EXPERIMENT #4: Electro-Hydraulics

Prof. Daniel Lozada Perez
MECHATRONICS LAB (ME-4011-22)

GROUP #2
Daniel Rodriguez Medina #120123
Adrian Marrero Pagán #135950
Gilmarcos Vázquez Díaz #98317

Date of experiment: September 19 , 2024
Date of submission: October 1 , 2024

Abstract:

This electro-hydraulic laboratory experiment aims to explore the functionality and applications of pressure switches, as well as the setup and operation of electro-hydraulic circuits. The primary objectives are to identify and operate pressure switches, interpret electro-hydraulic schematics, and examine the behavior of hydraulic circuits with electrical control elements. Through hands-on activities, such as testing a pressure switch and sequencing hydraulic cylinders, we will gain practical experience in building and analyzing electro-hydraulic systems. The experiment highlights the advantages of electro-hydraulics, including precise control, efficiency, and high power density. By integrating electrical and hydraulic components, the lab showcases how modern industrial systems can enhance automation and reliability in processes requiring force and accuracy.

Table of contents:

Experiment Objective:

- Identify a Pressure Switch and its possible applications.
- Setup and operate electro-hydraulic circuits using input elements, controller elements and actuating mechanisms.
- Interpret an electro-hydraulic schematic circuit and explain its behavior.

Theory:

D.1 Why Electro-Hydraulic?

Electro-hydraulic systems are favored in industrial applications due to their ability to meet the demands for fast, cost-effective production with improved quality, reduced waste, and enhanced power. These systems offer fine control in a compact size, making them suitable for processes where both high force and precision are critical. In a hydraulic system, fluid power acts as the "muscle" that performs work, while the control mechanism serves as the "brain," directing the operation of the system. Control can range from simple start-stop actions to more complex tasks like the controlled movement of multiple cylinders in an automated process. The combination of electrical control and hydraulic power allows for precise operation, higher efficiency, and flexibility.

D.2 System Components:

In electro-hydraulic systems, electrical signals control hydraulic actuators, such as cylinders or motors, through valves, making use of the power density of hydraulics. The electrical control setup in these systems is similar to electro-pneumatic systems, involving input elements, controllers, and actuating mechanisms. Input elements, as explained in F.1.1, are commonly used, while hydraulic solenoids are utilized as output elements. The integration of electronics with hydraulics enhances system feedback, automation, and energy efficiency, leading to widespread use in industrial machinery, automotive systems, and aerospace, where precision and high force are needed.

Procedure:

Material:

Lab-Volt pneumatics trainer :

- Work surface
- Conditioning unit
- Directional control valves
- Actuators
- Tubing
- Limit switches
- Pushbuttons
- Relays
- Pressure Switch
- Hydraulic pressure gages
- Notes from the Mechatronics class

Activity #1: “Test the Operation of a Pressure Switch:

1. Locate and mount the hydraulic components of the circuit shown in Figure 4-1. Close the Pressure relief valve so the pressure in the system is the minimum.
2. Locate and mount the electrical components of the circuit shown in Figure 4-2. Use the LabVolt power supply and lights.
3. Open the pressure relief valve very slowly until the light is turned ON. Close again the relief valve very slowly to obtain the reset pressure, which is when the light turns OFF again. Write your results in Table 4-1
4. Turn off and disconnect the system.

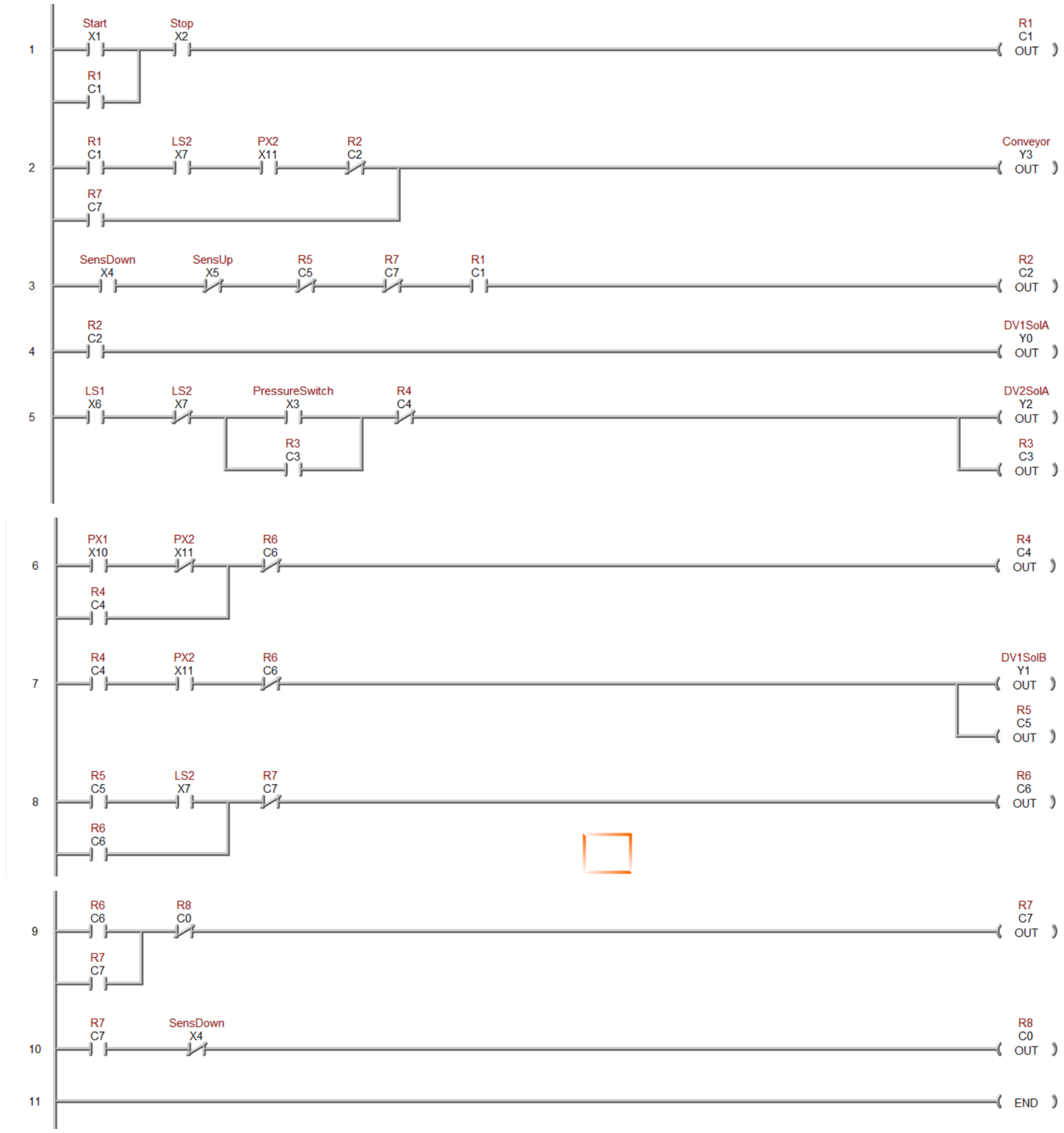
Activity #2: “Hydraulic Cylinder Sequencing”

1. Locate and mount the hydraulic components of the circuit shown in Figure 4-3. Be sure both cylinders are retracted before connecting them in your circuit.
2. Locate the electrical components of the circuit. Use the LabVolt power supply. Program the PLC with the ladder provided by the instructor.
3. Connect the electrical components according to Appendix F.

4. Test and operate the circuit. Compare it with a Hydraulic system with no electrical control.
5. Turn off and disconnect the circuit. Clean and store each component and the LabVolt trainer.

Results:

Ladder Code: Activity #2



List of Inputs & Outputs:

INPUTS	
START	X1
STOP	X2
PRESSURE SWITCH	X3
SENSOR 4	X4
SENSOR 5	X5
SENSOR 6	X6
SENSOR 7	X7
SENSOR 10	X10
SENSOR 11	X11

OUTPUTS	
DV1SolA	Y0
DV1SolB	Y1
DV2SolA	Y2
CONVEYOR	Y3

Verbal Description:

To start the program we have the inputs of X1 and X2 normally open to be able to start or pause the program as much as necessary. Once the start button is pressed, the conveyor belt starts running until sensor #4 gets activated. Once that and once the box is detected on sensor #4 it will start the protocol for which it was programmed. Right after detecting the box, it will deactivate the conveyor belt and it will verify the state of the clamp. In our case, since the clamp is retracted from the beginning, it will make us use that first sensor to activate the clamp and the solenoid will turn on until it reaches the activation of its second sensor, which would be the one that determines that it is in an extension state. When the sensor that determines the retraction state is turned off and when the extension one is activated then the program continues verifying the state of the piston and in our case this is also in the retraction state. Then we wait until the pressure switch has reached its set point so that its sensor activates and activates a relay in charge of keeping the piston on until the sensor of the extension state is activated. It is important to note that since the pressure switch is only activated for an instant in order to keep the current running it was necessary to implement a bridge under its signal to keep it running actively. Once the activation of the sensor is detected, indicating that it has been extended, then we cut the current to turn off the solenoid that activates the piston so that it can begin its retraction process. When the sensor that indicates that the piston is completely retracted is activated again, we send a signal that closes the part of the solenoid in charge of expanding the clamp and activates the part of the solenoid in charge of retracting it completely. Once the code is retracted, it cuts all its signals and starts running the conveyor belt again until sensor #4 is detected again.

Analysis of the Results:

After an extensive amount of trying and long hours programming the PLC the system worked as described in the manual. Once the code was correctly programmed there were no interruptions in its overall performance. At first the team struggled with how to process the data from the cylinders using the physical sensors. We had difficulty because for a period of time none of the sensors would be detected, so we had to be more careful how we would activate and deactivate the solenoids. The most essential discovery of this lab was to understand how to program and connect a PLC taking into consideration the physical sensors. With more time better improvements can be made to avoid possible errors due to how the components work and capture information.

Conclusion:

In conclusion for this laboratory report, the program effectively utilizes inputs from normally open buttons X1 and X2 to start and manage the conveyor belt system. Upon pressing the start button, the conveyor operates until sensor #4 detects a box, triggering a series of programmed protocols. The system checks the state of the clamp, activating it as needed, and relies on pressure switches to control the piston mechanisms for extension and retraction. After successfully programming the PLC, the system performed reliably according to the manual, demonstrating the importance of accurately processing data from physical sensors. Although initial challenges were faced with sensor detection and solenoid activation, the team's experience highlighted the critical learning involved in programming and integrating a PLC with physical components. Further small improvements could be implemented to optimize the system and enhance performance reliability.

References:

- HAWE Hydraulik. (n.d.). *Electro-hydraulic systems*. Retrieved September 29, 2024, from https://www.hawe.com/fluid-lexicon/electro-hydraulic-systems/
- HydraForce. (n.d.). *Introduction to electro-hydraulic control technology*. Retrieved September 29, 2024, from https://www.hydraforce.com/resources/technical-reference/introduction-to-electro-hydraulic-control-technology/
- Sun Hydraulics. (n.d.). *EH solutions library* (Doc. No. 999902104). Retrieved September 7, 2024, from https://www.sunhydraulics.com/sites/default/files/media_library/tech_resources/EH-SolutionsLibrary_999902104_1.pdf

REPORT EVALUATION SHEET

EXPERIMENT: ____________________

Section: ______ Trimester: __________ Date: __________

Group: ______ Instructor: __________

Outcome Indicator	Weight	Points	Score		Comments
1) Abstract composition (outcome g)	**10%**				
Propose (What?)		4			
Importance (Why?)		4			
Method (How?)		4			
Results and main conclusion		4			
2) Interpretation of experimental data graphically. (Outcome b-1)	**10%**				
Recognize a data treat (free calculation errors)		4			
Interpret the data graphically (Present in correct format the results figures or tables).		4			
3) Analysis of experimental data (Outcome b-3)	**40%**				
Identify the variables involved in the experiment		2			
Select the mathematical equations applicable to the procedure		2			
Apply the equation correctly in order to obtain correct results		4			
Discuses all tables and graphs presented as results		4			
Analyze the results obtained agree with the expected results present in theory section.		4			
4) Presentation of theory and results	**10%**				
Explain in own words the theory required in the experiment (no copy & paste manual theory).		4			
Introduce to the results with a description text in own words		4			
5) Mechanical organization of the written report (Report contains the following ordered sections) (outcome g)	**10%**				
Title Page, Abstract, Table of Contents, Introduction, Theory, Experimental Procedure		4			
Results introduction, Discussion of Results,		4			
Conclusions and Recommendations,		4			
References, Appendixes (sample experiment calculation)		4			
6) Grammar	**10%**				
Spelling		4			
Meaning and/or Semantic rules		4			
7) Format	**10%**				
Plan of organization of report		4			
Total	**100%**	Final Score			
Correct Experimental Data Acquisition*	[ ]	* The report is invalid if this sheet is missing.			
Original Experimental Data Sheet*	[ ]				
Signed Share Workgroup Sheet *	[ ]				

Instructor's sign: ____________________