Preliminary Design Review

MISCE project

Mechatronics for Improving and Standardizing Competences in Engineering

Competence: Automation Technology

Workgroup: University of Cagliari

University of Cassino and Southern Latio

This document is the Preliminary Design Review of the technical competence ‘Automation Technology’. Its briefly contains the experimental platform analysed in MISCE project, to be designed and standardised for improving the acquisition level of this competence on engineering degrees.

Version: 2.5

Date: May 12th, 2025

Visit https://misceproject.eu/ for more information.

Index of contents

Index of figures

Index of tables

1 Competence and skills

The conceptual design presented in this document is referred to the technical competence:

C1. Automation Technology

which related skills are (see Table I):

Table I. Skills of Automation Technology

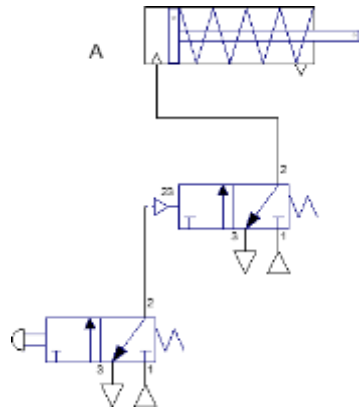
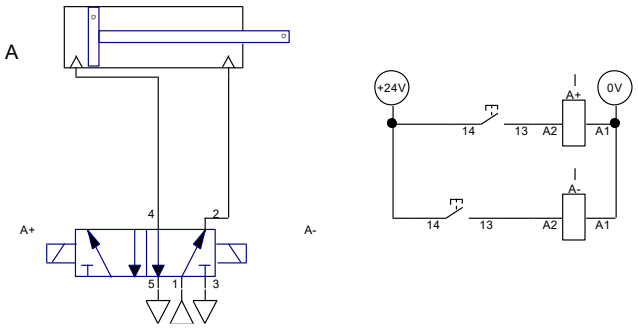
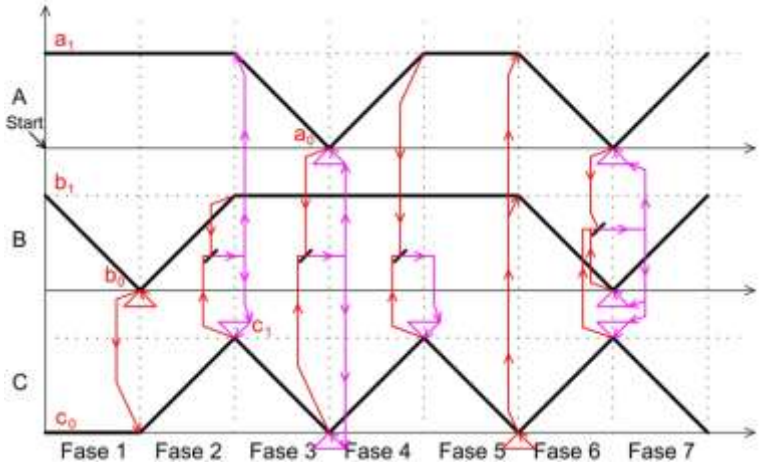
S1.1.	To know the main electric/pneumatic and hydraulics elements
S1.2.	To be able to design the functional behavior of the system
S1.3.	To be able to understand the technical documentation of a project/product
S1.4.	To program the functional behavior of the device
S1.5.	To debug the final planned behaviour of the system

The different conceptual designs presented in this document have been analysed to ensure that can improve the acquisition level of the aforementioned competence.

2 Experimental proposals

For this competence, MISCE project proposes the joint use of the devices in Table II, together with their corresponding teaching materials.

Table II. Proposed devices for 'automation technology' competence

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Actuation of a single effect pneumatic cylinder</td><td>Actuation of a double effect pneumatic cylinder</td></tr>
<tr><td colspan="2"> 
</td></tr>
<tr><td colspan="2">Diagram of Movement-Phase</td></tr>
</table>

In the following sections each device is detailed explained.

2.1 Actuation of a single effect pneumatic cylinder

This experimental platform has been widely analysed for teaching purposes (e.g. [1-3]). It consists on a single effect pneumatic cylinder, a 5/2 (five ways, two positions) pneumatic valve with pneumatic actuation a 3/2 (three ways/two positions) pneumatic valve with mechanical actuation to visually note the one way movement of the cylinder (see Figure 1).

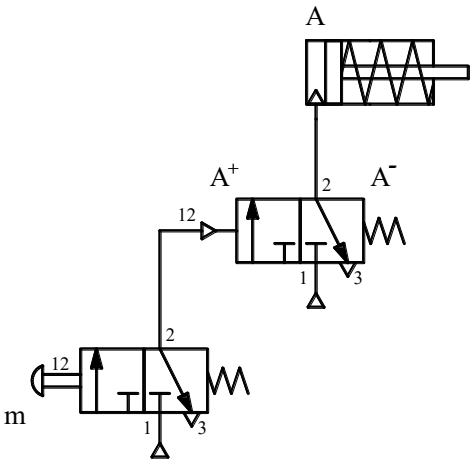


Figure 1. Actuation of a Single effect (SE) pneumatic cylinder

This proposal requires the realized test bed or the simulation with the software (in this case Autosim-200 that allows the simulation of the behaviour of the movement

The main advantage of this test bed is related to the possibility to be used widely in different academic activities. In addition, the behaviour of the cylinder is well-know and easy to be achieved and offers a very illustrative way to introduce in all the skills of automation technology.

On the contrary, the main drawback is that some important aspect cannot be considered because this is a basic actuation system, and movement back of the cylinder is obtained by means of the spring return.

2.2 Actuation of a double effect pneumatic cylinder

The actuation of the double effect pneumatic cylinder is well-known on teaching activities related to automation technology (e.g. [4-6]). It consists of a double effect pneumatic cylinder, a 5/2 (five ways, two positions) electro-pneumatic valve with electric actuation and a two electric push button. The movement of the pneumatic cylinder can be controlled by means of two button or via a PLC. Additionally, the control objective of this platform is to control the velocity of the pneumatic cylinder (see Figure 2).

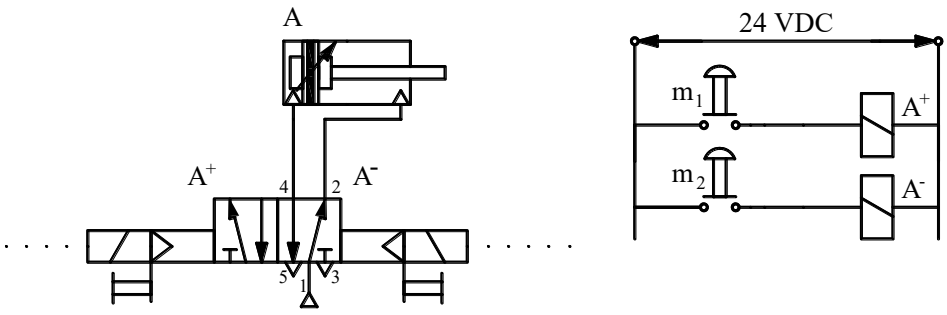


Figure 2. Double effect pneumatic cylinder

This device shall also include the electronics part and the control equipment to command the behaviour of the cylinder by means of electronic board (e. g. Arduino, Raspberry, PLC etc.).

This exercises complements the pneumatic/electropneumatic test bed adding a more functionality in a basic control approach.

2.3 Diagram of Movement-Phase

In order to create a suitable “Movement-Phase” displacement, by using the previous reported experimental platform, will be possible to create all typo of required/desired movement/phase diagram. The control objective is to create all possible combination of movement of the cylinder by mean of the experimental/Numerical (digital Twin) Platform (see Figure 3).

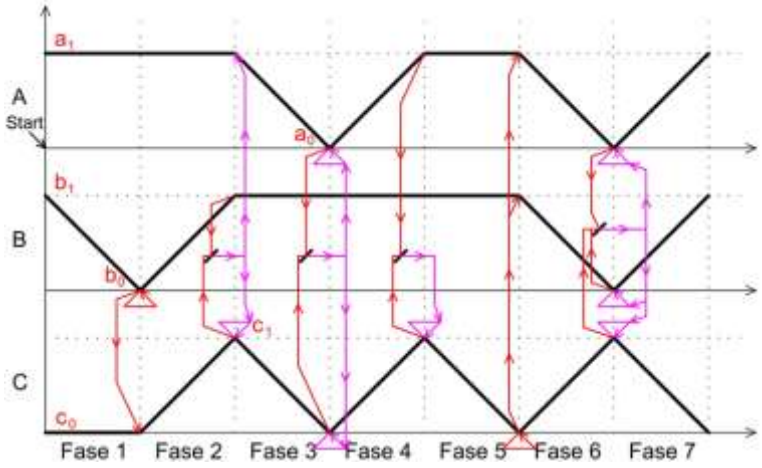


Figure 3. Generation of a suitable “Movement-Phase” displacement

This experimental platform complements the aforementioned by adding a more complex capability.

3 Competence and skills analyses

Table III summarises the competence and skills analyses of the proposed experimental platform attending to the contribution of acquisition of the technical competence ‘automation technology’ and their corresponding skills in Table I.

As conclusion, the 3 experimental activity and a digital twin numerical activity has been developed, starting with the basic movement of a single acting pneumatic cylinder up to arrive to a complex movement of a systems.

Table III. Contribution of each proposed platform to automation technology competence and its corresponding skills

Platform	S1.1	S1.2	S1.3	S1.4	S1.5	**Overall competence contribution**
Actuation of a single acting pneumatic cylinder	 Know the main electric/pneumatic and hydraulics elements	 To be able to design the functional behaviour of the system.	 Ability to understand the technical documentation of a project/product.	 Ability to program the functional behaviour of the device	 Capability to debug the final planned behaviour of the system	 4.2
Actuation of a double acting pneumatic cylinder	 Know the main electric/pneumatic and hydraulics elements.	 To be able to design the functional behaviour of the system.	 Ability to understand the technical documentation of a project/product.	 Ability to program the functional behaviour of the device	 Capability to debug the final planned behaviour of the system.	 3.6
Movement-Phase" displacement	 Know the main electric/pneumatic and hydraulics elements	 To be able to design the functional behaviour of the system	 Ability to understand the technical documentation of a project/product.	 Ability to program the functional behaviour of the device	 Capability to debug the final planned behaviour of the system	 4.0

References

[1] Marin, L., Vargas, H., Heradio, R., de La Torre, L., Diaz, J. M., & Dormido, S. (2020). Evidence-based control engineering education: Evaluating the LCSD simulation tool. IEEE Access, 8, 170183-170194.

[2] Hamed, B. (2010). Application of a LabVIEW for real-time control of ball and beam system. IACSIT International Journal of Engineering and Technology, 2(4), 401-407.

[3] Israilov, S., Fu, L., Sánchez-Rodríguez, J., Fusco, F., Allibert, G., Raufaste, C., & Argentina, M. (2023). Reinforcement learning approach to control an inverted pendulum: A general framework for educational purposes. Plos one, 18(2), e0280071.

[4] Boubaker, O. (2012, July). The inverted pendulum: A fundamental benchmark in control theory and robotics. In International conference on education and e-learning innovations (pp. 1-6). IEEE.

[5] Iishiba, Y., Sugaya, J., & Yajima, K. (2015, October). The development of fundamental teaching materials and the inverted pendulum system as advanced sequence control. In 2015 7th International Conference on Information Technology and Electrical Engineering (ICITEE) (pp. 156-161). IEEE.

[6] FOIT, K.; BANAŚ, W.; ĆWIKŁA, G. The pneumatic and electropneumatic systems in the context of 4th industrial revolution. In: *IOP Conference Series: Materials Science and Engineering*. IOP Publishing, 2018. p. 022024.

[7] OLIVER, Mario Oscar Ordaz, et al. Design Algorithm For Sequential Pneumatic And Electropneumatic Systems. *International Journal of Combinatorial Optimization Problems and Informatics*, 2023, 14.3: 157.

[8] Gonzalez-Rodriguez A.G., Ottaviano E. Rea P., “Evaluation of Two Tension Sensors for Cable-Driven Parallel Manipulators”, Journal of Field Robotics, 2024, Volume 12, Issue 1 Article number 33, DOI:10.3390/act11010014.

[9] Gonzalez-Rodriguez A.G., , Ottaviano E., Rea P., (2024) Libraries and Tools for the Design of a GUI on a Touch Screen Controlled by ESP32. 16th Congreso de Tecnologia, Aprendizaje y Ensenanza de la Electronica, TAEE.

[10] Chao K.-M., James A.E., Nanos A.G.,Chen J.-H., Stan S.-D., Muntean I., Figliolini G., Rea P., Bouzgarrou C.B., Vitliemov P., Cooper J., Van Capelle J. “Cloud E-learning for Mechatronics: CLEM” Future Generation Computer Systems, Vol. 48, July 2015, pp. 46-59. **ISSN:** 0167739X, **DOI:** 10.1016/j.future.2014.10.033.

[11] James, A.E., Chao, K.-M., Li, W., Matei, A., Nanos, A.G., Stan, S.-D., Figliolini, G., Rea, P., Bouzgarrou, C.B., Bratanov, D., Cooper, J., Wenzel, A., Van Capelle, J., Struckmeier, K., .(2013), “An ecosystem for E-learning in mechatronics: The CLEM project”, 2013 IEEE 10th International Conference on e-Business Engineering, ICEBE 2013; Coventry; United Kingdom; 11 September 2013 through 13 September 2013; Category numberE5111; Code 102388.

[12] Figliolini G. and Rea P., “Design and test of pneumatic systems for production automation”, CD Proceedings of the Inaugural Conference of the Canadian Design Engineering Network (CDEN’04), Montreal (Canada), 2004.