EPFL

Course «Industrial Automation»

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Industrial Automation - Exam 2025

Conditions

The exam comprises the course as it is downloadable as power point slides and/or PDF on Moodle on May 31th, 2025. There will be no change to the slides after that date.

The exam lasts 15 minutes per candidate; it consists of three questions taken from this list. There is no preparation time at the exam. The exam is conducted in English.

You are allowed to bring two hand-written A4 sheets to the exam, but no electronic, photocopied or printed material. You can write on both sides of the two sheets, so you can fill four pages in total. The list of questions (see next 4 pages) will be available as a printout during the exam.

2025.05.27 P. Sommer and J.C. Tournier

1. What are the two principal kinds of plants, the way of modelling them and of controlling them?
2. What are the principal categories of industrial processes? Give examples.
3. To which category do the following applications belong: production of cement, chocolate packaging, traffic lights of crossroads, waste water, bottle-filling, power plant, pulp&paper and which effect does the plant have on the operation of the automation system?
4. List the layers in an automation system and their functions. How are the response time and the complexity of the decisions related to each other?
5. Draw the hierarchy of an automation system with its communication networks and characterize the traffic.
6. What is the difference between a centralized and a distributed automation system? What are their advantages and disadvantages?
7. What is a controller and what is its purpose? What has to be taken into account when designing it?
8. How is a plant modelled? What is a process variable? What is the control output?
9. What are the differences between modelling for continuous and discrete processes?
10. What is plant identification? How is it carried out? Explain a step response.
11. How does a two-point regulator operate?
12. How does a PID regulator work? What is the influence of each coefficient?
13. What are nested controllers and what is the influence of nesting on their time response?
14. What is feed-forward control used for?
15. What characterizes a PLC, which kinds exist and what is their application field?
16. What criteria need to be evaluated when selecting PLCs for an application?
17. Describe the chain of signal processing from the sensor input to the actor output in a PLC.
18. Which programming languages are specified in IEC 61131-3 and what are they used for?
19. Program a simple sequence in LAD (e.g. combining two buttons with AND/OR logic and a LED as output).
20. How is a program executed on a PLC and how does it ensure its real time behavior?
21. What is a fieldbus, what distinguishes it from an office network connecting PCs?
22. What are the criteria for selecting a fieldbus for a given application?
23. Which information must be transmitted for each process variable?

24. How does a sensor device connected to the 4-to-20 mA loop operate?
25. What is the HART protocol?
26. What are the (dis-)advantages of datasets?
27. Explain how a traffic memory works.
28. Explain the advantages and respective disadvantages of cyclic and event-driven transmission.
29. Explain the operation of a cyclic bus with source address broadcast (publisher/subscriber).
30. Where and how does non-determinism influence industrial communication networks?
31. Why should a fieldbus provide at the same time a cyclic and event-driven transmission and what is the corresponding application interface for each traffic type?
32. How are control system devices synchronized to a reference clock?
33. Explain the differences between OT and IT.
34. What is the difference between a bridge/switch and a router? At which layers in the OSI model do they operate?
35. Which is the goal of OPC UA? How is the communication network organized?
36. Which services does OPC UA Data Access offer and how are variables organized on the client and on the server side?
37. Explain the OPC UA Information Model. How can we discover services provided by a device?
38. What is OPC Historical Access used for and what are the services it offers?
39. Explain what the role of a broker is in the MQTT protocol.
40. What are the main functionalities of a SCADA?
41. What is a process database and what is the difference with an historical database?
42. What are the typical pitfalls to avoid when designing synoptic views?
43. Which is the difference between an alarm and an event?
44. What properties should always be assigned to an alarm?
45. What are the different types of alarms?
46. How alarms on levels are defined?
47. What is an Historian for SCADA and what is its purpose?
48. What is the difference between precision and accuracy for sensors?

49. Explain the principle of a capacitive angular sensor.
50. Explain the principles of strain gauges.
51. Explain the measurement principle of a thermo-element (thermocouple).
52. What is a P&ID?
53. What are the different types of alarms and what are their properties?
54. What are SBOM and why are they useful in the context of cyber-security?
55. What is the difference between a fault, a failure and an error?
56. What is the difference between a physical fault and a design fault?
57. What is the difference between cold, warm and hot redundancy?
58. What is the difference between reliability, availability and safety?
59. What is the difference between safety and availability and why do they conflict?
60. What is the difference between stationary and punctual availability?
61. What is the difference between corrective, preventive and predictive maintenance?
62. How can availability of a system be improved?
63. Explain why it is a valid assumption to consider the failure rate being constant for reliability calculations.
64. How can infant mortality be avoided in industrial systems?
65. Explain the notion of failure rate and its relation to the MTTF.
66. Calculate the reliability of a system that depends on a set of N elements.
67. Calculate the reliability of a system that depends on K out of N elements.
68. How does the reliability of a 2oo3 (TMR, voter) compare with a simplex (1oo1) system?
69. Calculate the reliability of a system that has a 2oo3 redundancy with repair.
70. Calculate the reliability of a 1oo2 redundant system (different failure rates).
71. Calculate the availability of a 1oo2 redundant system (different failure rates and different repair rates).
72. Set up the equations for calculating the MTTF of a redundant system with repair.
73. What is the Markov model to compute the MTTF of a 1oo2 architecture when imperfect coverage is considered?
74. How is the availability of a system that has a 2oo3 structure with repair calculated?
75. Set up the calculation for the availability of a system given its Markov Diagram.

76. What is the Markov model to compute the availability of a 1oo2 architecture when imperfect coverage is considered?
77. What does hamming distance, coverage and latency mean in the context of error detection?
78. What is the difference between persistent and integer fault tolerant architectures?
79. How can an architecture be both persistent and integer?
80. Explain/describe the following dependable computer architectures: integer, persistent, integer & persistent.
81. Present a classification of the different error detection methods.
82. How does a watchdog error detection work?
83. What are the main error detection mechanisms implemented for data transmission? For memory elements? For processing elements?
84. Illustrate the principles of workby and standby redundancy approaches in the case of a network protocol.
85. What are the main issues of workby redundant architectures? How are they solved?
86. What are the main issues of standby redundant architectures? How are they solved?
87. What are byzantine faults?
88. Why are input matching and consensus needed in the context of work-by architecture?
89. Explain the main principles of FMEA and FTA.
90. What is the difference between FMEA and FMECA?
91. In the context of safety function, what does SIL mean? What is the highest level?
92. What is the difference between validation and verification in the context of software development?