

## Reading-up-time

For reviewing purposes of the problem statements, there is a “reading-up-time” of **10 minutes** prior to the official examination time. During this period it is **not** allowed to start solving the problems. This means explicitly that during the entire “reading-up-time” no writing utensils, e.g. pen, pencil, etc. at all are allowed to be kept on the table. Furthermore the use of carried documents, e.g. books, (electronic) translator, (electronic) dictionaries, etc. is strictly forbidden. When the supervisor refers to the end of the “reading-up-time” and thus the beginning of the official examination time, you are allowed to take your utensils and documents. Please **then**, begin with filling in the **complete** information on the titlepage and on page 3.

*Good Luck!*

NAME	
VORNAME	
MATRIKEL-NR.	
TISCH-NR.	

## Klausurunterlagen

Ich versichere hiermit, dass ich sämtliche für die Durchführung der Klausur vorgesehenen Unterlagen erhalten, und dass ich meine Arbeit ohne fremde Hilfe und ohne Verwendung unerlaubter Hilfsmittel und sonstiger unlauterer Mittel angefertigt habe. Ich weiß, dass ein Bekanntwerden solcher Umstände auch nachträglich zum Ausschluss von der Prüfung führt. Ich versichere weiter, dass ich sämtliche mir überlassenen Arbeitsunterlagen sowie meine Lösung vollständig zurück gegeben habe. Die Abgabe meiner Arbeit wurde in der Teilnehmerliste von Aufsichtsführenden schriftlich vermerkt. **Durch die Teilnahme versichere ich, dass ich prüfungsfähig bin. Bei Krankheit werde ich die Klausur vorzeitig beenden und unmittelbar eine Ärztin/einen Arzt aufsuchen.**

THE ABOVE REQUIRED STATEMENTS AS WELL AS THE SIGNATURE ARE MANDATORY AT THE BEGINNING OF THE EXAM.

Duisburg, _____ (Date)	_____ (Unterschrift der/des Studierenden)
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Falls Klausurunterlagen vorzeitig abgegeben: \_\_\_\_\_ Uhr

# Bewertungstabelle

Aufgabe 1	
Aufgabe 2	
Aufgabe 3	
Aufgabe 4	
Aufgabe 5	
Aufgabe 6	
Die Bewertung gem. PO in Ziffern ist der xls-Tabelle bzw. dem Papierausdruck zu entnehmen.	

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(Datum und Unterschrift 1. Prüfer, Lina Owino, M.Sc.)

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(Datum und Unterschrift 2. Prüfer, Univ.-Prof. Dr.-Ing. Dirk Söffker)

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(Datum und Unterschrift des für die Prüfung verantwortlichen Prüfers, Owino)

Fachnote gemäß Prüfungsordnung: (alternativ: siehe xls-Tabelle bzw. beigefügter Papierausdruck)

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1,0	1,3	1,7	2,0	2,3	2,7	3,0	3,3	3,7	4,0	5,0
sehr gut		gut			befriedigend			ausreichend		mangelhaft

Bemerkung: \_\_\_\_\_

**Attention:** Give your answers to ALL problems directly below the questions in the exam question sheet.

You are NOT allowed to use a pencil and also NOT red color (red color is used for corrections).

This exam is taken by me as a

mandatory (Pflichtfach)

elective (Wahlfach)

prerequisite (Auflage)

subject (cross ONE option according to your own situation).

Maximum achievable points:	<b>65</b>
Minimum points for the grade 1.0:	<b>95%</b>
Minimum points for the grade 4.0:	<b>50%</b>

### General hints:

- 1) For the multiple choice questions and multiple-choice-similar tasks, the following rules apply:
  - i) For tasks with individual evaluation of subtasks, the following applies:  
Only correct answers will be awarded the indicated number of points
  - ii) Points achieved in subtasks will be summed up.
  - iii) Unless explicitly stated otherwise, only ONE of the given solution options is correct.
  - iv) If subtasks contain more than two answer options and only one solution exists: The marking of multiple options is interpreted as a non-response due to the unclear declaration of intention. As a result no points can be awarded in this case.
- 2) Where no information is given for the valid range of numbers for time constants of masses etc., assume time constants (in sec.) and masses (in kg) to be positive numbers.
- 3) Where no information is given for application of negative or positive feedback, use the usual negative feedback.

**Problem 1** (15 Points)

1a) ( $5 \times 1$  Point, 5 Points)

Mark the correct solution in the following statements.

1) (1 Point)

- A pulse timer
- An on-delay timer
- An off-delay timer
- A reversible timer

is started by an increasing edge, and only runs when the input is true and the time has not expired. At expiry of the set time, the output is switched true. The timer is reset when the input is false.

2) (1 Point)

A variable has been declared within a function block and designated as PERSISTENT. This variable will be reinitialized after

- cold reset
- application download
- reset origin
- cold reset, reset origin or application download

3) (1 Point)

One advantage of a PC-based PLC is

- the ability to realize absolute hard real-time behavior.
- suitability for unlimited range of pure control applications.
- higher interface quality.
- higher reliability of PC hardware.

4) (1 Point)

A step in a sequential function chart is labelled with the execution type SD. This action

- will be activated after a certain time and will be active till a reset.
- will be activated after a certain time as long as the step is active, and remains active as long as the step is active.
- will be deactivated after a certain time and remain deactivated as long as the step is active.
- will be active for a certain time.

5) (1 Point)

- Instruction List
- Structured Text
- Assembly Language
- Sequential Function Chart

is a high-level programming language that provides a compact formulation of the program task with a syntax similar to Pascal. It also incorporates constructs for control of program flow.



1b) ( $5 \times 1$  point, 5 Points)

Mark the correct solution in the following statements.

1) (1 Point) A threshold monitoring alarm block, LIMITALARM, has the inputs IN, HIGH, and LOW and the outputs O, U, and IL.

When  $IN < LOW$ ,

- O = TRUE AND IL = FALSE.
- U = TRUE.
- U = TRUE AND IL = TRUE.
- U = FALSE.

2) (1 Point)

The tree bus structure

- is a combination of ring and star structures.
- experiences failure of network communication upon failure of a single point-to-point connection.
- consists of a central unit whose failure leads to communication failure in the network.
- requires devices in different branches to communicate via the root.

3) (1 Point)

The SET signal in an SR block is set to TRUE. 5 seconds later, the RESET signal is set to TRUE. After a further 3 seconds, the SET signal is set to FALSE. The output from the SR block

- changes from TRUE to FALSE immediately the RESET signal is set to TRUE.
- changes from TRUE to FALSE when the SET signal is set to FALSE.
- remains TRUE until both the SET and RESET signal are FALSE.
- alternates every 5 seconds between TRUE and FALSE.

4) (1 Point)

Control Area Network systems

- allow a maximum of 256 nodes without a repeater
- are well suited to real-time applications
- use a tree topology for communication
- allow message objects with maximum size of 8 bytes

5) (1 Point)

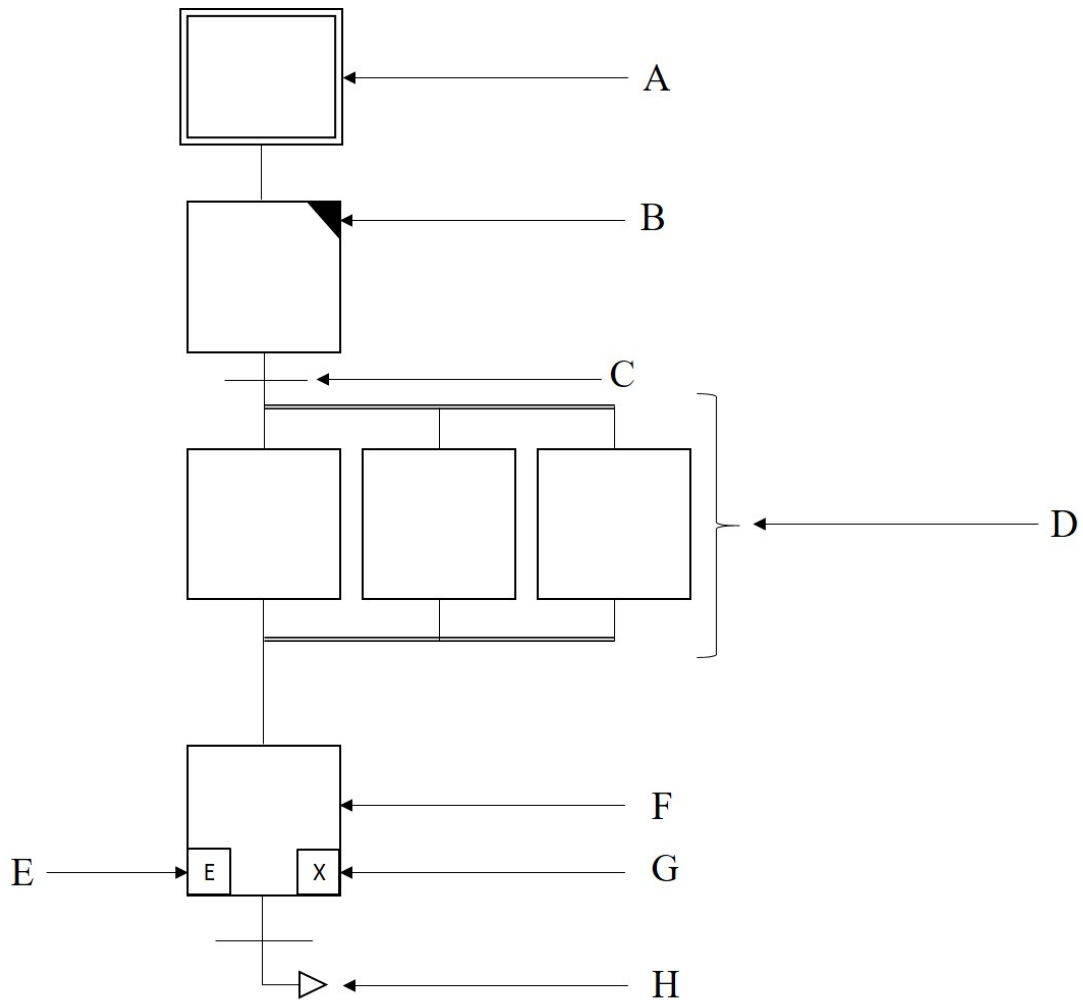
- A mechanical line shaft
- An electronic line shaft
- A mechatronic line shaft
- An intelligent line shaft

is a standardized function block by PLCopen, composed of a virtual guidance axis and a real axis with an external encoder.



1c) (5 × 1 Point, 5 Points)

Below is a program written in SFC.



Indicate in the table which of the elements labelled A to H is described by the statement given. Where none of the elements is described indicate a dash (-).

i)	Exit action	
ii)	Branching and merging of a chain selection	
iii)	Transition requirement	
iv)	Chain end	
v)	Action	



Σ





**Problem 2** (8 Points)

a) (1 point)

Describe the difference between soft and hard real-time systems

b) (1 point)

Explain why function blocks have to be instantiated.

c) (1 point)

By means of an illustration, describe the minimum ('best case') and maximum ('worst case') reaction time of a PLC.



d) (2 points)

Declare a variable K32 of type REAL, assign it the memory address ID58 and initialize it with the value 30.819.

e) (3 points)

Generate a program in FBD to calculate:

$$Z := C - K * D$$

The value of  $Z$  must be limited between the values 0 and 10. Include a Boolean variable **Override** which when true, results in a value of 5 being given as the output instead of the result of the calculation.





**Problem 3** (10 Points)

The following logical expression

$$A = (E1 \wedge E2) \vee (E2 \wedge \overline{E3}) \vee (E2 \wedge E4 \wedge E5)$$

is given.

3 a) (4 points)

Generate the truth table relating to the logical expression.

E1	E2	E3	E4	E5	A



3 b) (2 points)

Describe the logic in LD.

3 c) (2 points)

Analyze and simplify the logic equation.

3 d) (2 points)

Describe the simplified logic as FBD.





**Problem 4** (10 points)

The following logic expression is given

$$\text{OUT} := \text{IN1 AND NOT IN2 OR IN2 AND IN3}$$

a) (3 points)

Generate a truth table to represent the expression.

b) (2 points)

Describe the logic expression using FBD.



c) (2 points)

Describe the logic expression in LD.

d) (3 points)

Describe the logic expression using IL.







**Problem 5** (10 Points)

In a carwash, the control action remains in step *Wait* until the light barrier **LightBarrier1 = False** is blocked by the arrival of a car. As soon as the light barrier **LightBarrier1 = False** is blocked, the next step *ConveyorBelt* gets active. As soon as both the second light barrier **Lightbarrier2 = False** and the first **Lightbarrier1 = False** are blocked, in the next step either *NormalRim* or *SpecialRim* is activated depending on the washing program **Normal = True** or **Special = True**. The action *SpecialClean* is executed exactly once, when the step *SpecialRim* is active. In both steps *NormalRim* and *SpecialRim* the action *RimScrub* is executed while the step is active. As soon as the next light barrier **Lightbarrier3 = False** is blocked, the step *Wash* gets active. The step is assigned two actions *Sides* and *Roof*. The action *Sides* is active as long as the step *Wash* is active. The action *Roof* gets active 15 seconds after activation of the corresponding step and remains active for the duration of the step *Wash*. When the washing operation is done **WashComplete=True**, the step *Dry* is activated. As soon as the car leaves the carwash area **Exit=True**, the control action switches from the step *Dry* to *Wait* and waits until a new car gets in.

a) (5 points)

Draw the sequence chain in SFC.

b) (5 points)

Assign the actions to the steps





**Problem 6** (12 Points)

When the button **START** is pressed and the key-operated switch **KEYSWITCH** is operated a motor is started with a delay of **5 s**. When the process signal **STOPP** is true, the motor stops running.

a) (4 points)

Draw for this task a function chart in FBD.



b) (8 points)

Create a function module **MOTORCONTROL** to solve the control tasks.

- i) State the declaration part of the function module.
- ii) Generate the body of the function module in IL.

