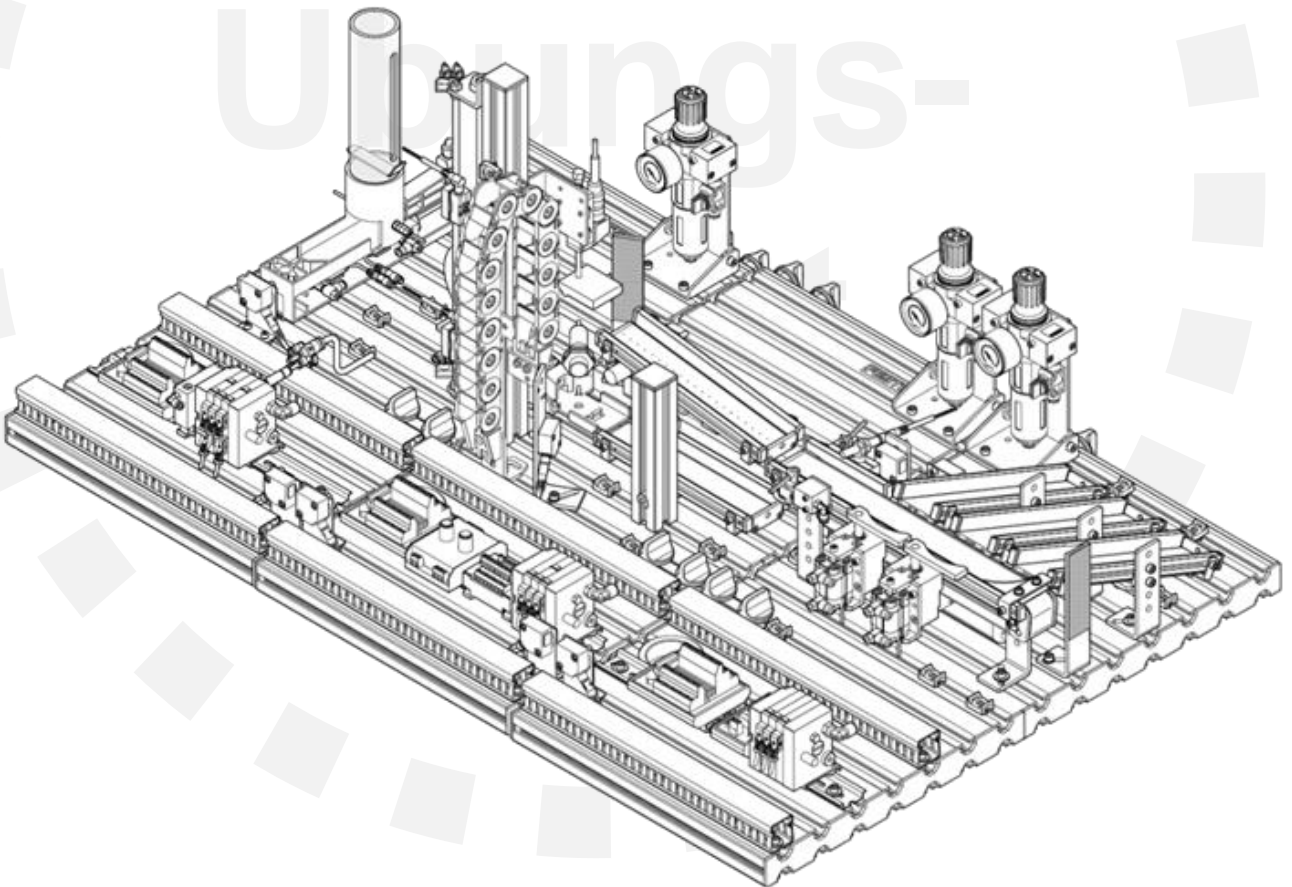


Plant exercise script

Development of intelligent distributed embedded systems in mechatronics



Station description & task definition

Introduction

This document should help you to perform the practical course "Development of Intelligent Distributed Embedded Systems in Mechatronics: Day 2 - IEC 61131-3" in the best possible way. It should also clarify as many questions and uncertainties as possible regarding the practical course in advance.

How to Start the Virtual Machine

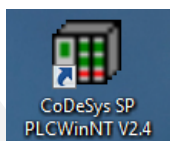
To log in on your computer use the following login data:

Username	<i>eivesim</i>
password	<i>PWD4ais!</i>

Then please start the virtual machine (VM): Open the *VMware Player* via the icon on the desktop and then open the VM "EiveSiM Internship". Accept all instructions of the *VMware Player* if necessary. When asked about "Moved or Copied" please click on "I copied".

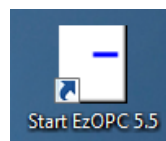
You should create your program in structured text. You will find templates for working on the tasks on days 2 and 4 of the internship within the virtual machine (folder "Templates") from which you can choose the one suitable for your station and open it in **CoDeSys V2.3**. Please note the labels on the stations and computers: All computers are identified by a sticker (e.g. "pru22") which correlates with the labels on the stations (e.g. "an pru22"). Now save the program under a different name (preferably in the folder "PraktikumWS1415" on the desktop) so that the template is not changed.

The template provides some security features and helps you to simplify hardware access. Within the template you will find two function blocks: "PLC_PRG" and "Control". **Implement your control program in the function block "Control" and do not change anything in the other parts of the template!** The created program must be loaded onto a software PLC for execution on the system. To do this, first start the **Soft PLC ("CoDeSys SP PLCWinNT")** and the **OPC server ("EzOPC")** and **let them run in the background**. If *EzOPC* reports that the connection to the *EasyPort* could not be established, please contact one of the tutors or employees.



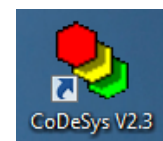
Soft PLC

Executes program in real-time environment



OPC server

Connects Soft PLC to EasyPort (and thus to the system)



Programming environment

Establishment and monitoring of the programme

After you have created a program, you must go through the following steps:

Upload and start program: You can now upload programs from **CoDeSys** to the **Soft PLC** via "Online" -> "Log in" (Alt-F8) and then start them via "Online" -> "Start" (F5). Please note that previously stopped programs may still have set values. It is therefore recommended to reset the controller via "Online" -> "Reset" before starting a program.

Monitor the program: By double-clicking on the control block -> Instances -> OK, you can monitor the set variables and thus draw conclusions about errors.

Change program: If you want to modify a running program, you should stop it via "Online" -> "Stop" (Shift+F8) and then log out via "Online" -> "Log out" (Ctrl+F8). Now the program can be modified and uploaded and started again (see above).

Notes on the control panel

Via the **start button** on the station's control panel, your control program is enabled and executed, which can be recognized by the green dot within the start button.

Using the **stop button** on the control panel of the station, the control program is not stopped, but the output signals of the program are no longer forwarded to the system, **the outputs are all switched "false"**. In the event of an unforeseen error in the program, you can thus stop all effects of your program.

The **key switch** can be used at some stations to "imitate" the release signals of the next station. In this way a fully functional program can be created, even though, for example, the next station is not programmed and therefore does not give a signal. If the release signal is given by the key switch, lamp Q2 on the control panel lights up.

Wichtig:

- Die Soft-SPS muss aus Lizenzgründen alle 2 Stunden neu gestartet werden.
- Rechner **nicht** ausschalten!
 - Beim Verlassen des Raumes „sperren“
 - Am Ende des Tages „abmelden“
- Beachten Sie die Sicherheitshinweise in Ihrem Aufgabenskript!

Task

Program your station! First create a flow chart with the sensors and actuators required for each step and think about a program structure. Then implement the complete sequence shown in the description.

Tips and advice:

- Despite the template, make sure that the working area of the system modules is free.
- Your system can only move if you have previously pressed the start button.
- All outputs are immediately set to zero as soon as the stop button on the station control panel is pressed (emergency stop).
- Test the correct functionality of your module not only at the end but already during programming. Program step by step and test each of the steps individually, before you check the entire process at the end. In this way, you will notice at an early stage whether, for example, you have a thought error in your implementation, and you may save yourself a long and frustrating search for errors at the end of the programming.
- If you need a timer, use the function block *TON*. As soon as the input *IN* of the function block is *TRUE*, the timer starts running until it reaches the value of input *PT* (time value). At this point, the output *Q* of the block becomes *TRUE*. To be able to use the timer again, it has to be reset. This is done by setting input *IN* to *FALSE* at least and executing it once.
- The time is given in the format *T#ab*, where *a* is an integer and *b* is the unit (e.g. s, ms), for example *T#250ms*.

```
VAR
  Timer : TON; (*definition of the timer block*)
END_VAR

Timer(IN := TRUE, PT := T#350ms); (*Execute*)
IF Timer.Q THEN (*Request the status of the timer*)
  Timer(IN := FALSE); (*Reset the timer*)
  ...;
END_IF
```

(If "IN" is TRUE, the timer starts counting with the "PT" (Process Time) time and outputs TRUE at "Q" if the time has expired and "IN" is also TRUE. "ET" is Elapsed Time and is not used in this programming.

- When using timers, it is recommended to assume longer waiting times (e.g. 5 seconds) to be able to check the correct function in peace. Once the program is fully functional, the times can be optimized for faster operation.
- The workpieces have the following colours and heights:

Colour	Height	Height with cover
Black	22 mm	25 mm
Silver	25 mm	28 mm
Red	25 mm	28 mm

- Make sure that all sensors, especially those in the *Check Station*, *Measure module* and *Disconnect Station*, *Distinguish module*, provide correct results before testing your program.
- Please do not adjust / "adjust" any sensors!
- If you finish your task well before the time limit, you can extend your program with additional functionalities. Please contact us for this.

Work pieces

Each of the stations processes so-called workpieces. These are cylindrical plastic parts with an opening on one side to which a cover can be screwed. The workpieces have the following colours and heights:



Colour	Height	Height with cover
Black	22 mm	25 mm
Silver	25 mm	28 mm
Red	25 mm	28 mm

Silver workpieces have metallic properties and can be detected as such by induction sensors.

Note

Workpieces without a cover must be inserted into the stations with the opening facing downwards. If a lid is screwed onto the workpiece, the system combination is decisive for the insertion orientation. If it is the combination "Distribute, check, sort", the workpiece must be inserted with the lid facing upwards. In the combination "Distribute, handle, separate", the workpiece is to be inserted with the lid facing downwards. These orientations are important to ensure the correct functioning of the stations. Otherwise, the workpiece may be handled in the station or may be cornered at the test station during transfer, as the lid is slightly larger than the base body.

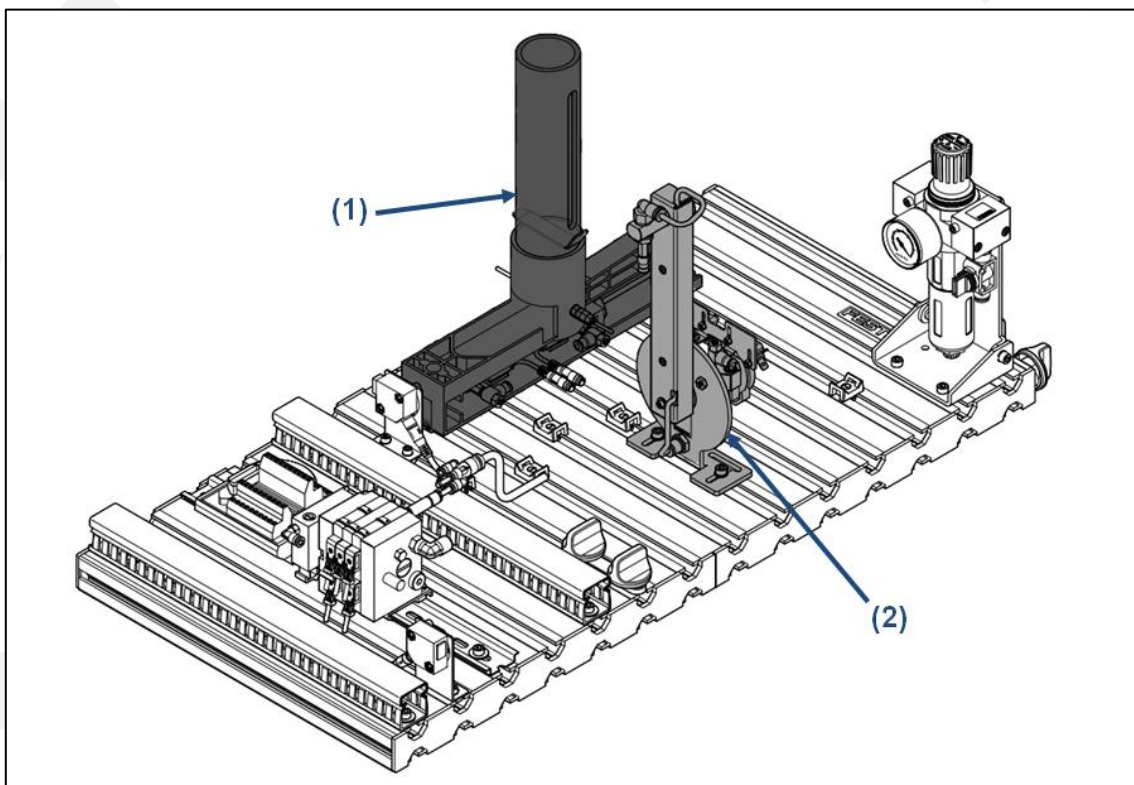
Station description

In the following, the individual stations are described, one of which you should program within the system practical course. The plant will be assigned to you at random. The systems are integrated into two different system combinations, each consisting of three stations. These two combinations are "Distribute, check, sort" and "Distribute, handle, separate".

Important: For the simulation part only the information for 2st Station Testing is used.

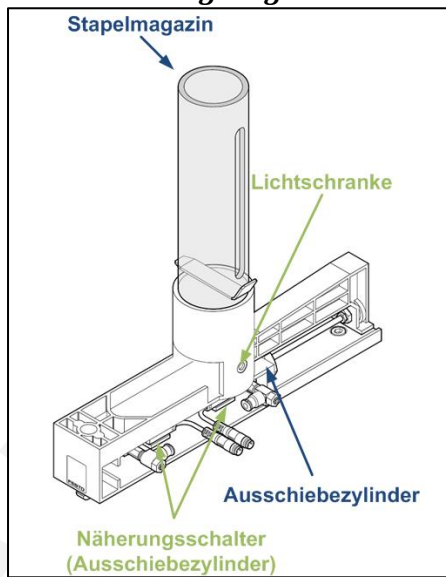
1st station "Distribute"

The station Distribute separates workpieces. The *stacking magazine* (1) holds up to eight workpieces, which can be ejected individually via a single-acting cylinder. The *swivel arm* (2) then grips the workpieces by means of a vacuum suction cup and transports them to the next station.



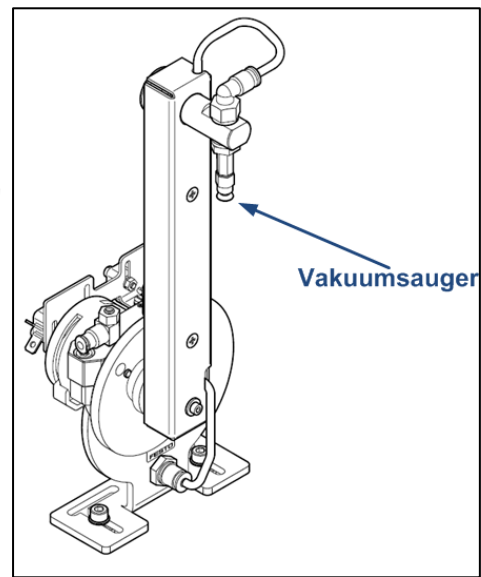
Modules

Stacking magazine



The module is used to store workpieces until they are used. For this purpose, the module has a stacking magazine that can hold up to eight workpieces. The presence of a workpiece can be detected by a light barrier. In order to push a workpiece out of the magazine, a self-resetting ejector cylinder exists, whose end positions can be queried via sensors.

Converter



The module serves to bring the workpieces to the next station. For this purpose, the module has a pneumatic transfer unit, at the end of which a vacuum suction cup is installed. Both end positions of the transfer unit can be monitored by sensors, as can the successful suction of a workpiece. In addition, a repulsion pulse can be given to release a workpiece.

Procedure

At the beginning the transfer device is turned to the magazine and no workpiece is sucked in. The push-out cylinder is retracted, i.e. at the "magazine" position. When the initial state is established, the system starts the following routine:

Only when a workpiece is detected and an enable signal from the following station is present does the transfer unit turn to the following station to clear the way for the ejector cylinder. The push-out cylinder now pushes out a workpiece, which the transfer unit picks up. To do this, it turns back in the direction of the magazine and, once there, switches on the vacuum after a short waiting period and retracts the cylinder again (workpiece otherwise jammed). As soon as the vacuum is built up, the release signal of the next station is checked. If the release signal is given, the transfer unit then turns there and pushes the workpiece off. After the workpiece has been ejected, another workpiece, if present, can be pushed out and the sequence repeated. If not, the transfer unit should be returned to its original position at the magazine to avoid damage by the next station.

Notes

- Place the workpieces without cover with the opening facing down into the stacking magazine.
- If a lid is screwed onto the workpiece, place the workpiece with the lid facing upwards in the stacking magazine if the next station is the "Check" station.
- If the next station is "Handling", insert the workpiece with the lid facing down.
- The converter does not move if both travel signals are set.

- Always take collision situations into account when moving the transfer unit or the extension cylinder!
- Please note that the enable signal of the following station is hardware-bound and given by default (following_station_occupied = 0), even if the following station is not running or programmed.
- Check the enable signal only when the converter is really ready for transfer (vacuum built up). Also make sure that the enable signal can be cancelled during the transfer!

Important variables:

Inputs (feedback from the system)

Bit	Variable name	Description
1	e_cylinder_retracted	Cylinder in the magazine is retracted (workpieces can fall down)
2	e_cylinder_extended	Cylinder in magazine is extended
3	e_converter_vacuum	Negative pressure is built up at the suction cup of the converter
4	e_converter_magazine	Transfer device at the pickup position of the stacking magazine
5	e_converter_following_station	Converter at the next station
6	e_magazine_empty	No workpiece in light barrier in drop magazine
7	e_follow_station_free	The next station is ready for receiving workpieces

Note: The enable signal can also be simulated in this station by the key switch on the control panel, for example if the next station is not programmed or if a system acceptance test is to be carried out independently of the next station.

Outputs (commands from user to system)

Bit	Variable name	Description
0	a_cylinder_extend	Extend the cylinder, i.e. push the workpiece to the pick-up position. If this value is not set, the cylinder moves back to the starting position.
1	a_converter_vacuum	Switching on the vacuum for sucking a workpiece
2	a_converter_reject	Reject workpiece
3	a_converter_magazine	Move the transfer unit to the pickup position at the magazine
4	a_converter_following_station	Move the transfer unit to the next station

Safety functions

The setting of some output variables in certain states is prevented by the main program to prevent damage to the plant:

1. If the transfer unit is at the magazine, the extension cylinder cannot be extended.
2. If no enable signal has been given to the next station, the converter is prevented from travelling to this station.

If safety functions are active, lamp Q1 on the control panel lights up.

Approval

For acceptance of the station the following characteristics must be fulfilled:

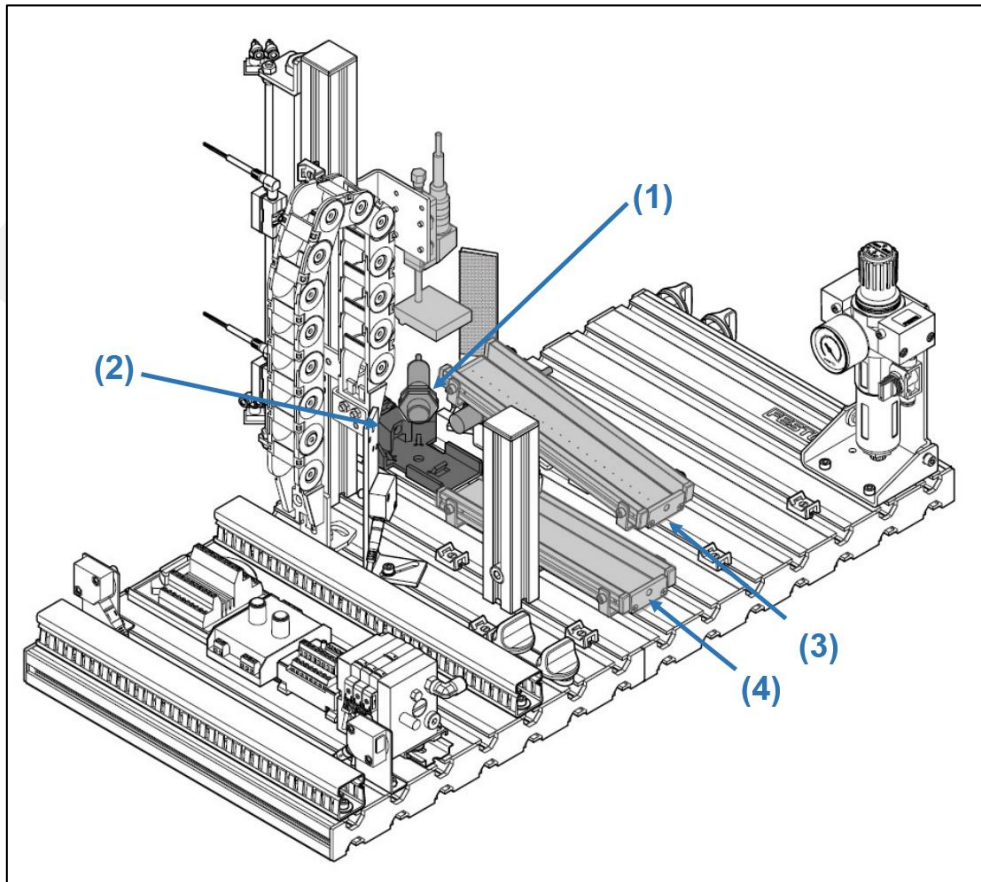
- Initial situation according to process description.
- Converter may only move to the next station if an enable signal has been given.
- The transfer unit does not remain at the next station unnecessarily long, but moves back to its starting position regardless of whether the stacking magazine is full or empty.

Two workpieces (black without lid, red/silver with lid) are placed together in random order in the stacking magazine, which must be successfully transported to the next station. After transport, the transfer unit moves to the starting position.

Übungs-
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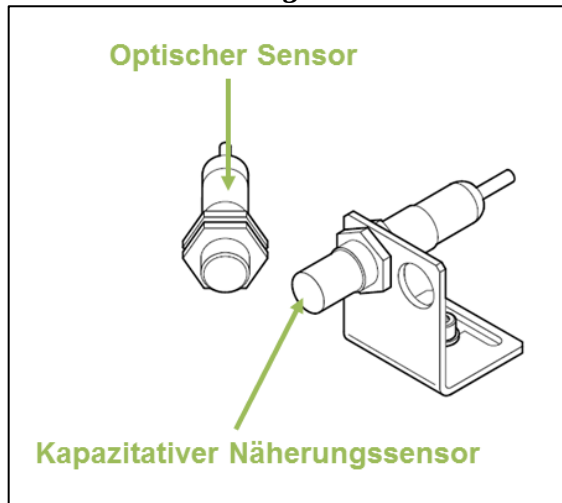
2nd station Testing

The station "Testing" sorts out workpieces without lids. For this purpose, the workpiece is lifted via a *lifting platform* (2) and its height is measured. At the same time, the colour of the workpieces (black/non-black) is distinguished at the *detection module* (1). Depending on the result, the workpiece is either guided to the next station on the *air-cushion slide* (3) or lowered again by the lifting platform and conveyed to the *reject slide* (4).



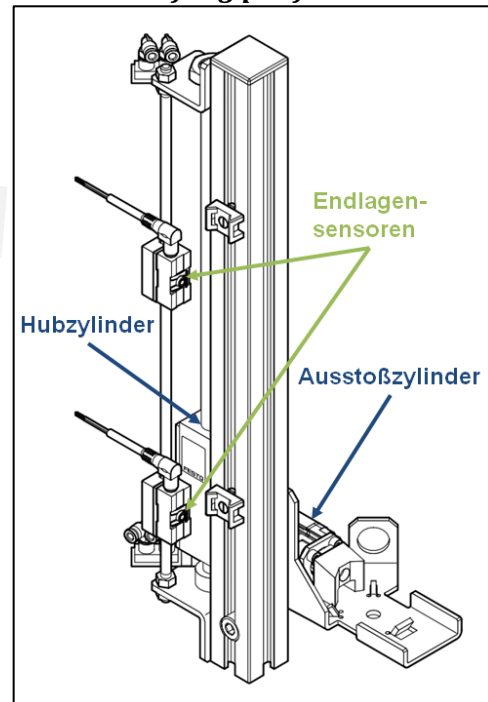
Modules

Recognize



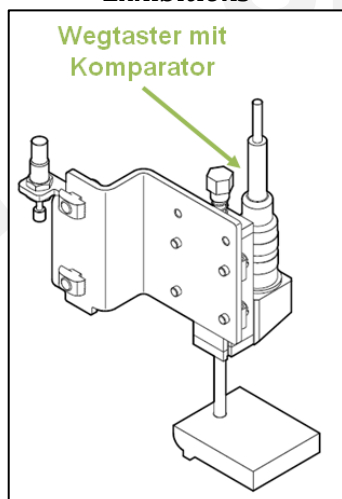
The module is used to distinguish black from non-black workpieces. An optical sensor is installed for this purpose. A capacitive proximity sensor is also available to check the presence of a workpiece - regardless of its color.

Lifting platform



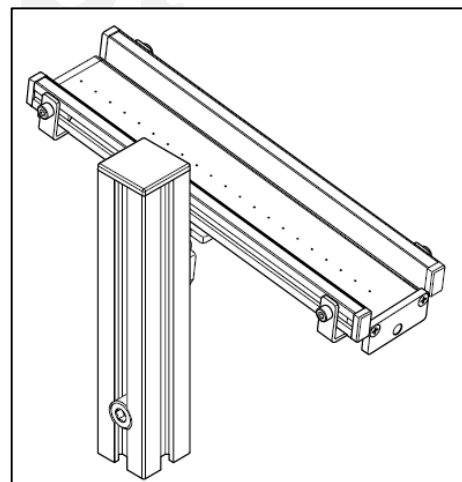
The module is used to lift workpieces for height testing to the *Measuring* module and to eject workpieces onto one of the two chutes. For lifting, there is a lifting cylinder whose end positions can be queried. A self-resetting ejection cylinder is used for ejection.

Exhibitions



The module can measure the height of the workpiece using a displacement sensor. A potentiometer can be used to set a height interval to be checked, e.g. to determine whether the height of the workpiece is within the correct range.

Air cushion slide



The module conveys a workpiece to the connected downstream station when compressed air is switched on.

Procedure

At the beginning the elevator is at the lower position, the ejection cylinder is retracted, there is no workpiece there and the air slide is switched off. Furthermore, no enable signal ("actuators.Station_frei") is sent. When the initial state is established, the system starts the following routine:

In this state (no workpiece present) the release signal ("actuators.Station_frei") is given to the previous station, which then delivers a workpiece. As soon as a workpiece is detected, the enable signal is cancelled. If the work area is free (sensors.Arbeitsraum_frei), after a short waiting period (approx. 0.5 seconds) the workpiece is lifted with the lifting platform (Actuators.Aufzug_abwaerts, and Actuators.Aufzug_aufwaerts). If the lifting is up (Sensors.Aufzug_oben) the height of work piece is checked by the resulting pressure on the measuring module. Before measuring the height, a short wait is necessary to prevent the spring from oscillating. At the same time, the optical sensor can be used to determine whether the component is black or not.

Workpieces with lids (sensors.Hoehe_ok, sensors.Werkstuck_nicht_Schwartz) are ejected onto the air-cushion chute (Luft_an) as soon as the release signal of the following station is available (Sensors.Folgestation_belegt). For this purpose the ejection cylinder (Actuators.zylinder_ausscheiben) is used and the air-cushion chute is switched on. After a waiting time of approx. 2 seconds the air supply is switched off.

If, on the other hand, it is a workpiece without a lid, the workpiece is only ejected onto the reject chute at the lower lifting platform position (Actuators.Aufzug_abwaerts, and Actuators.Aufzug_aufwaerts). Black workpieces with lids provide a positive height check and a negative brightness check. Workpieces with a different colour provide a negative height check and a positive brightness check. Thus, for workpieces with a lid, the operation "sensors.height_ok" != "sensors.workpiece_not_black" is always true and for workpieces without a lid it is always false. This is summarized in the Fig 2-21. After ejection (Actuators.zylinder_ausscheiben), the system is returned to its initial state and the process starts over again.

Notes

- During measurements, the workpiece should be at rest for a short time (e.g. three seconds) at the sensor before the value is queried.
- There is no sensor to check whether the ejection cylinder is fully extended. Use a suitable control structure instead.
- When moving the lift, always ensure that the working area is free!
- For processes whose end position cannot be checked by end position sensors, you must perform time measurements to assume that the end position has been reached. First assume sufficiently large values (e.g. five seconds) before optimizing the times later.
- If necessary, adjust the mass comparator to determine the inspection interval of the height sensor. Rotary knob 1 (Level 1) sets the lower limit of the interval, rotary knob 2 (Level 2) the upper limit. If the measured value is within the interval, a 1 is returned. If the sensor is correctly adjusted, it should return the values in the table below. (If you are not sure, contact a tutor before making changes).
- Refer to the following table to identify workpieces with lids with the given sensors:

	With lid		Without lid	
	<i>height_ok</i>	<i>height_ok</i> != <i>work-piece_not_black</i>	<i>height_ok</i>	<i>height_ok</i> != <i>work-piece_not_black</i>
	<i>work-piece_not_black</i>		<i>work-piece_not_black</i>	
black	1	1	0	0
	0		0	
red or metallic	0	1	1	0
	1		1	

Übungs-
skript

Important variables

Inputs (feedback from the system)

Bit	Variable name	Description
0	e_workpiece_available (e_werkstueck_vorhanden)	A workpiece has been detected on the elevator (sensor only supplies correct data at the lower elevator position)
1	e_workpiece_not_black (e_werkstueck_nicht_schwarz)	Work piece on the elevator is not black (sensor moves with elevator)
2	e_workspace_free (e_arbeitsraum_frei)	The working area is free, the transfer unit of the previous station is in the starting position (at the magazine)
3	e_hoehe_ok (e_hoehe_ok)	The measured height is within the set interval
4	e_elevator_up (e_aufzug_oben)	The elevator is up
5	e_elevator_down (e_aufzug_unten)	The elevator is down
6	e_cylinder_retracted (e_zylinder_eingefahren)	The extension cylinder is retracted (does not eject)
7	e_follow_station_free (e_folgestation_frei)	The following station can pick up a workpiece

Outputs (commands from user to system)

Bit	Variable name	Description
0	a_elevator_down (a_aufzug_abwaerts)	Lower the elevator
1	a_elevator_upward (a_aufzug_aufwaerts)	Move the elevator up
2	a_cylinder_extend (a_zylinder_ausschieben)	Extend the extension cylinder, push the workpiece onto one of the slides (cylinder moves back if value not set)
3	a_air_on	Switch on the air cushion on the upper chute

	(a_luft_an)	
4	a_station_free (a_station_frei)	Give enable signal to previous station

Safety functions

The setting of an output variable in certain states is prevented by the main program to prevent damage to the plant:

- If the converter is not in the lower position and its cylinder is not retracted, no release signal can be given.

If safety functions are active, lamp Q1 on the control panel lights up.

Approval

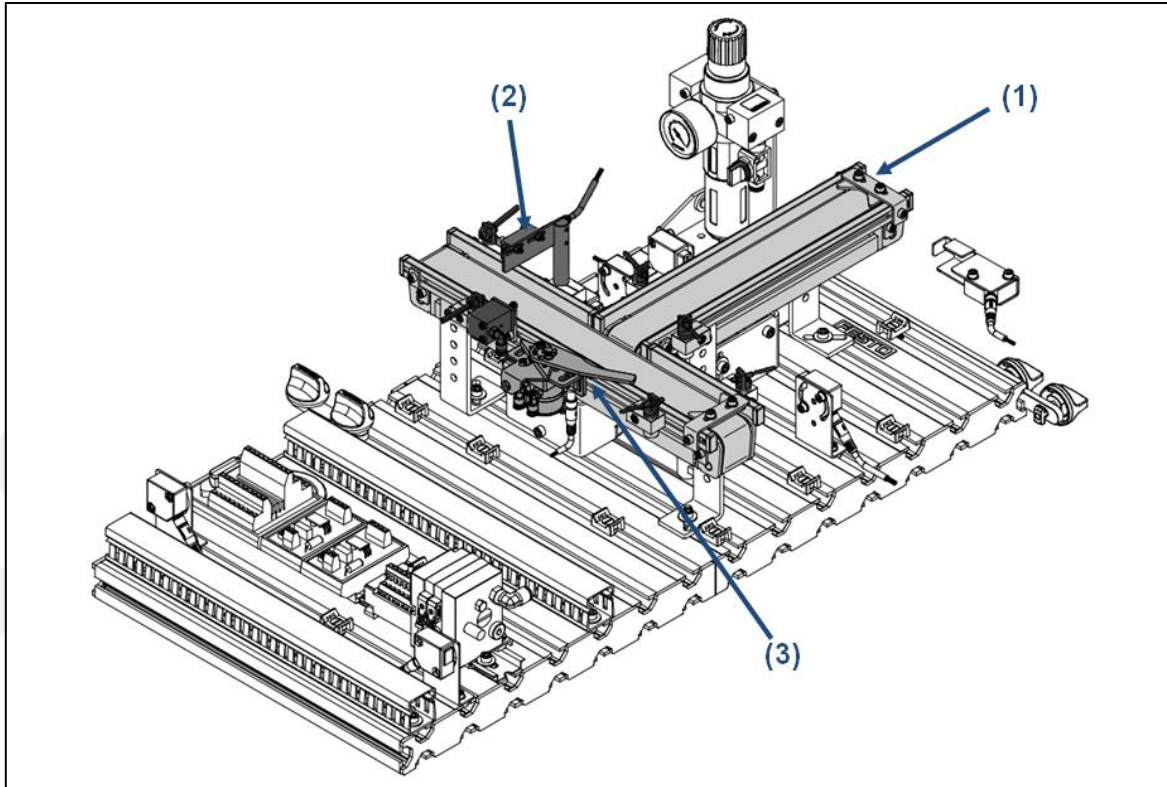
For acceptance of the station the following characteristics must be fulfilled:

- Initial state according to process description.
- All workpieces are sorted so that workpieces with lids are transported on the air chute and workpieces without lids are transported on the reject chute.
- The air slide is only switched on as long as necessary.

Four workpieces (black without lid, red/silver without lid, red/silver with lid, black with lid) are placed individually in random order in the holder. New workpieces are only placed on the holder when the release signal has been given to the preceding station.

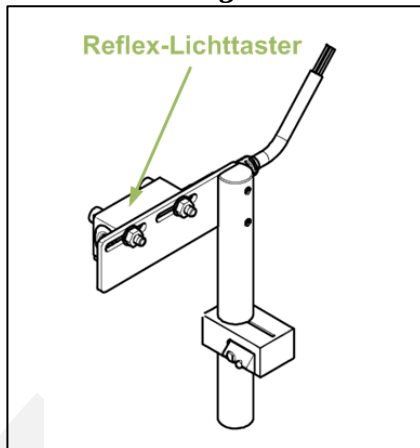
3rd station "Disconnect"

The station "Cutting" can distinguish between different workpieces and transfer those that are no longer required to a *reject belt* (1). The workpieces are differentiated by means of a *height measurement* (2). Depending on the evaluation, a *switch* (3) transports the workpieces to the reject belt.



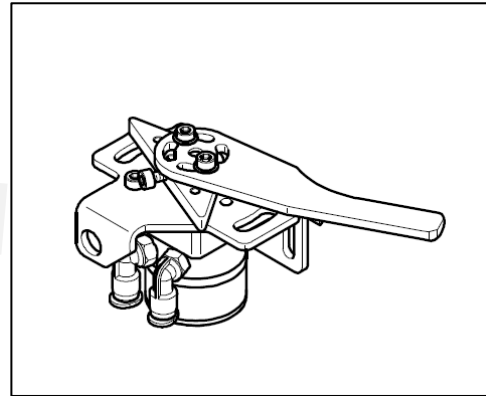
Modules

Distinguish



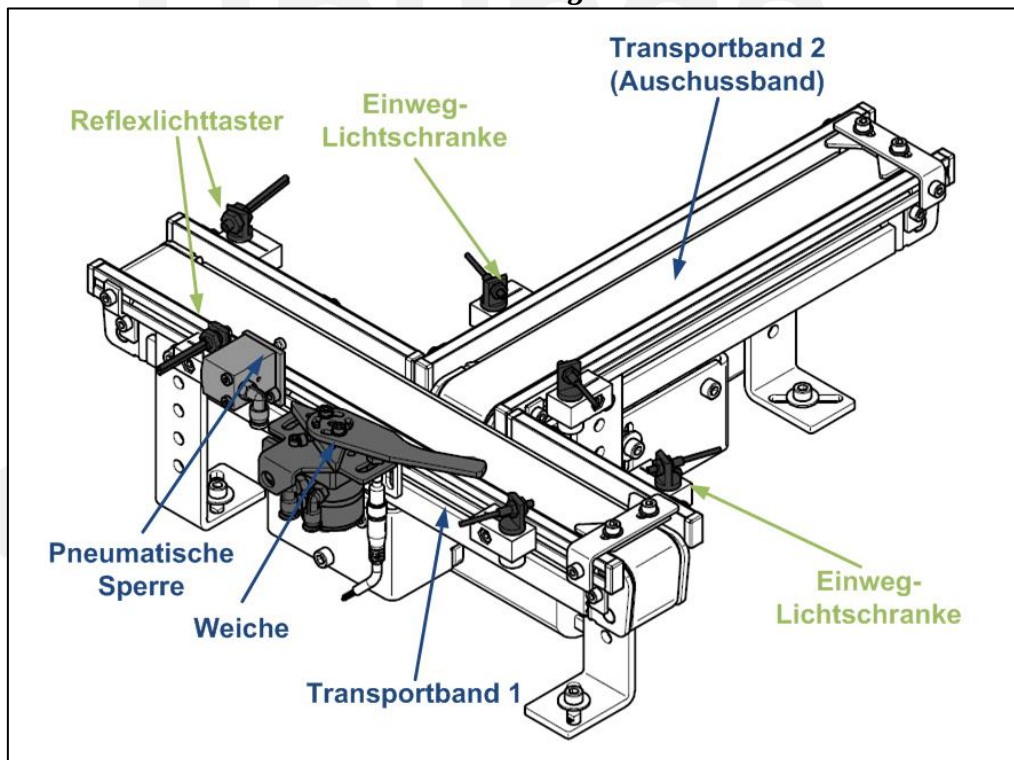
The module serves to classify workpieces according to their height. The sensor returns a positive value (true) in a certain interval ($>25\text{mm}$: red+silver with cover), which is determined by the hardware.

Turnout



The module is used to divert or let workpieces pass. In the starting position, workpieces can pass unhindered. Both end positions of the switch can be detected by sensors.

Branching



The module serves to forward the workpieces via two conveyor belts according to their previous classification. Several photoelectric proximity switches and light barriers are installed to detect workpieces. In order to simplify the classification of the workpieces by the *differentiation* module, a pneumatic lock is also installed.

Procedure

At the beginning there is no workpiece in the station and both the lock and the switch are in their initial position (lock pushed out, switch not deflecting). Both belts are switched off. In addition, no release signal is given. When the initial state is established, the system starts the following routine:

First, an enable signal must be given to the previous station so that workpieces can enter the station. If a workpiece is detected in the first light barrier, the enable signal is immediately cancelled. After a short waiting period, the main belt is switched on. After the workpiece has arrived at the barrier, the belt is switched off and the height of the workpiece is measured. Red and silver workpieces with cover should remain on the main belt. Based on this information the switch is switched accordingly and if necessary the reject belt is switched on. If the switch is in the correct position, the lock is retracted and the main belt is switched on again.

The case that one or both bands become full is not considered further here.

Notes

- All workpieces without a cover must be inserted with the opening facing downwards so that the height measurement can be carried out correctly.
- During measurements, the workpiece should be at rest for a short time (e.g. three seconds) at the sensor before the value is queried.
- For processes whose end position cannot be checked by end position sensors, you must perform time measurements to assume that the end position has been reached. First assume sufficiently large values (e.g. five to ten seconds) before optimizing the times later.
- Due to the (in this case) unreliable height sensor, silver workpieces without lids are not used for the individual acceptance of this station.

Important variables

Inputs (feedback from the system)

Bit	Variable name	Description
0	e_workpiece_at_the_beginning	Diffuse sensor at the beginning of the strip detects a workpiece
1	e_workpiece_at_lock	Diffuse sensor on the pneumatic lock detects a workpiece
2	e_he_ok	Workpiece height lies within a certain interval
3	e_soft_non_distracting	Switch lets workpieces pass
4	e_reject_band_not_full	The reject belt is not full (light barrier not broken)
5	e_workpiece_at_end	Light barrier at the main band end is broken

Outputs (commands from user to system)

Bit	Variable name	Description
0	a_main_band_an	Switch on main band
1	a_reject_band_at	Switch on the reject conveyor
2	a_lock_engage	Retract pneumatic lock (let the workpieces pass through)
3	a_soft_steer_down	Switch the switch so that the workpieces are directed onto the reject belt
7	a_station_free	Send enable signal to predecessor station

Safety functions

The setting of an output variable in a certain state is prevented by the main program to prevent damage to the plant:

- If a workpiece is detected at the beginning of the belt, no release signal can be given to the preceding station.

If safety functions are active, lamp Q1 on the control panel lights up.

Approval

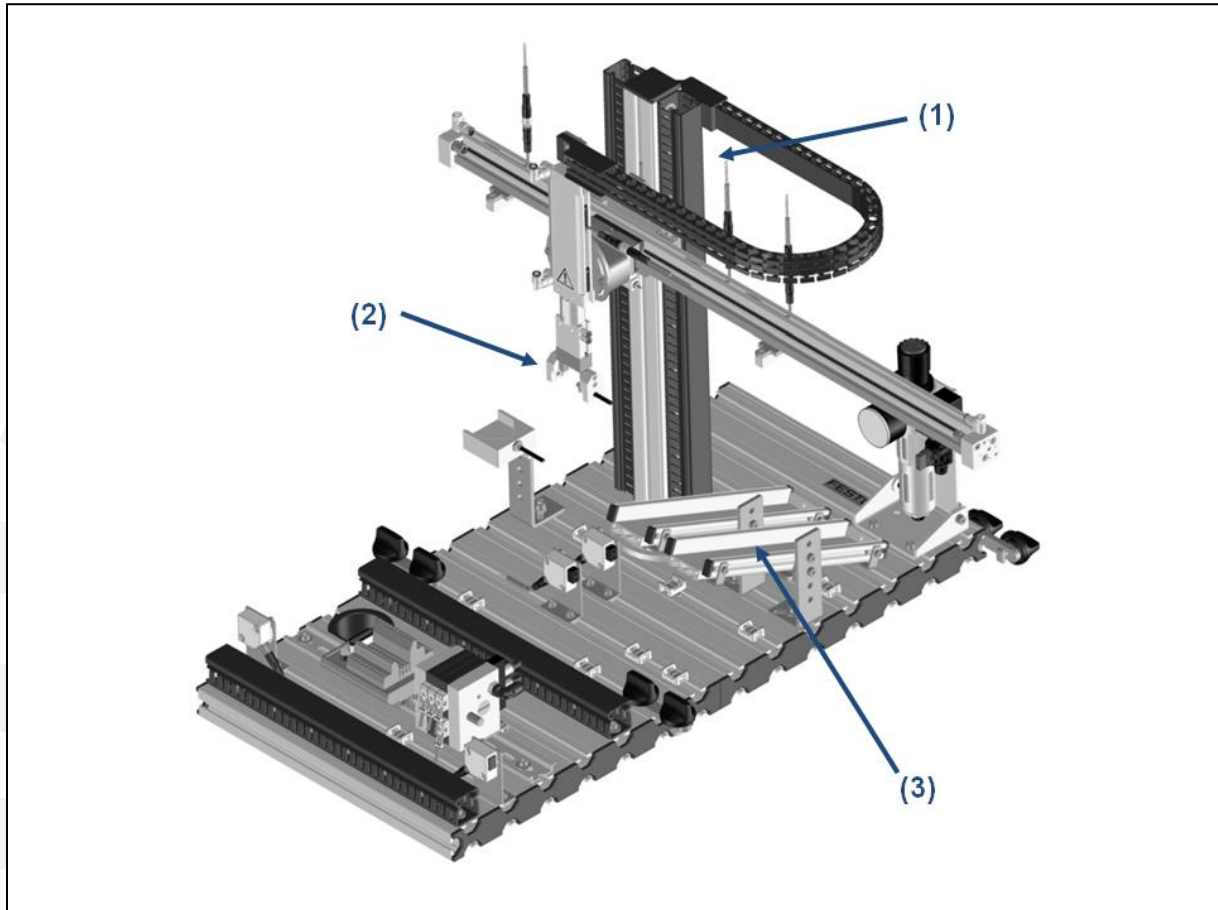
For acceptance of the station the following characteristics must be fulfilled:

- Initial situation according to process description.
- Workpieces are sorted so that all black (with or without lid) and red (and silver) workpieces without lid are transported onto the reject belt, all others are transported further onto the main belt. Please note the different heights of the workpieces of different colours!
- Release signal may only be given if the parking space at the beginning of the conveyor is not occupied.

Four workpieces (black without cover, red without cover, red with cover, black with cover) are placed individually on the belt in random order. New workpieces are not placed on the belt until the release signal is given to the preceding station. Silver workpieces are not used because the height sensor does not work correctly in some cases.

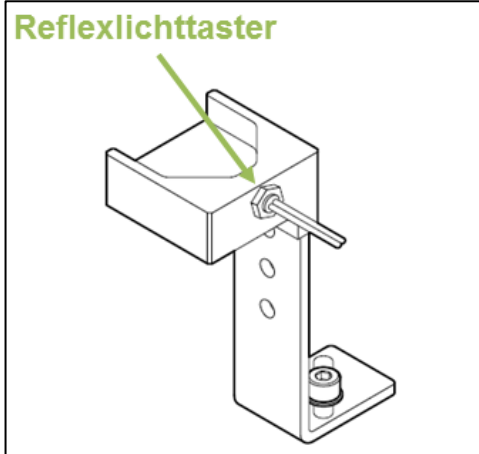
4th station Handling

The heart of this station is a *two-axis crane (PicAlfa)* (1), which can pick up workpieces from the pick-up by means of a *pneumatic gripper* (2) and then deposit them on one of the two *chutes* (3) or the following station. An optical sensor is mounted in the gripper, which can differentiate between "black" and "non-black" workpieces.



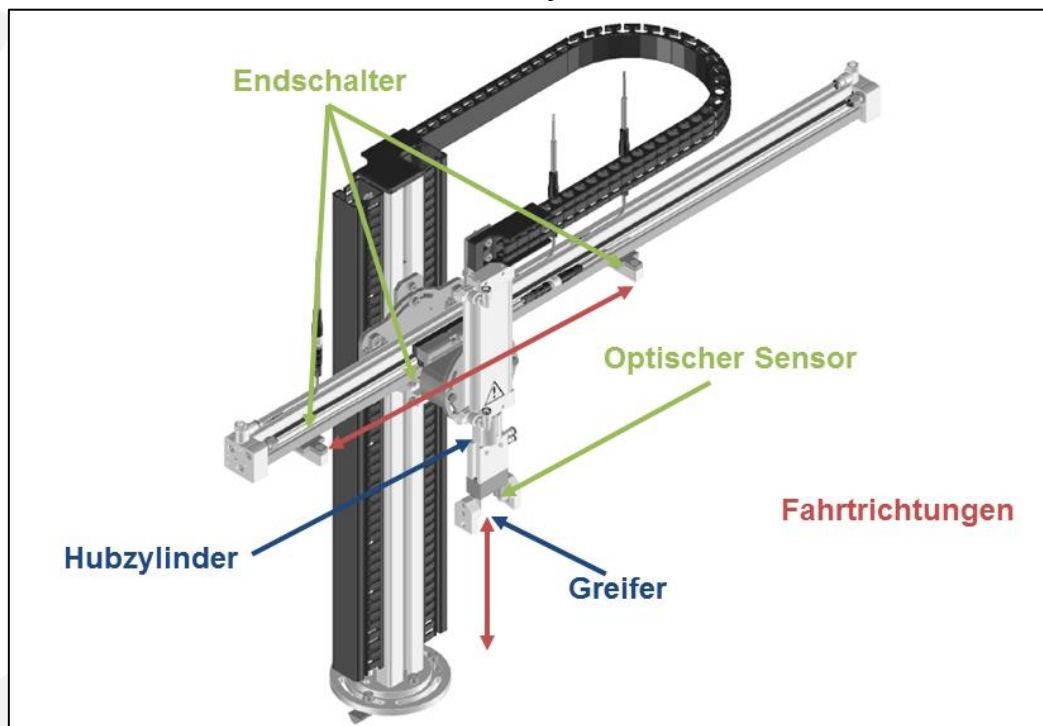
Modules

Recording



The module serves to hold the workpieces in a defined position so that they can be picked up by the crane or its gripper. The presence of a workpiece can be detected via a light sensor. To avoid collision with the previous station, workpieces are only detected when the transfer unit of the previous station is in the starting position.

PicAlfa



The module consists of a 2-axis crane, which is equipped with a gripper to pick up workpieces. Sensors exist for three positions of the crane. In addition, a sensor is installed in the gripper to distinguish between black and non-black workpieces. The vertical position of the gripper can also be queried via sensors.

Procedure

At the beginning there is no workpiece in the pick-up, the gripper is open in its upper end position and the crane is at the next station. When the initial state is established, the system starts the following routine:

An enable signal is given to request workpieces. As soon as a workpiece is detected in the fixture, the enable signal to the previous station is immediately cancelled. Please note that workpieces are only detected when the transfer unit of the previous station is also in its initial position (at the magazine). The crane now travels to the pick-up, the gripper is lowered, the workpiece is gripped and the gripper is raised again. Then it is checked whether the workpiece is black or not. If the workpiece is black, the crane moves to the chute and deposits it there. Otherwise the crane moves to the next station and deposits the workpiece there (release signal of the next station necessary!). Afterwards, it moves back to its starting position and again gives the release signal to the previous station.

Notes

- When both pneumatic valves for the crane are switched on, the crane does not move.
- Pneumatic cylinders are used to lower and open the gripper. Lifting and closing of the gripper is done by means of return springs.
- During measurements, the workpiece should be at rest for a short time (e.g. one second) at the sensor before the value is queried.
- For processes whose end position cannot be checked by end position sensors, you must perform time measurements to assume that the end position has been reached. First assume sufficiently large values (e.g. five seconds) before optimizing the times later.
- Please note that the enable signal of the following station is hardware-bound and given by default (following_station_occupied = 0), even if the following station is not running or programmed.

Important variables

Inputs (feedback from the system)

Bit	Variable name	Description
0	e_workpiece_available	A workpiece is located in the workpiece holder and the transfer device of the station "Distribute" is located at magazine
1	e_crane_at_a_thrust	The crane is at the reception
2	e_crane_at_follow_station	The crane is at the front sensor (1.chute)
3	e_crane_on_slide	The crane is at the rear sensor (following station)
4	e_gripper_down	The grab is down
5	e_gripper_up	The gripper is up
6	e_workpiece_not_black	The sensor in the open gripper detects a non-black workpiece
7	e_follow_station_free	The next station is free

Note: The enable signal can also be simulated in this station by the key switch on the control console, for example if the next station is not programmed.

Outputs (commands from user to system)

Bit	Variable name	Description
0	a_crane_to_take	Move the crane in the direction of the intake (previous station)
1	a_crane_to_following_station	Move the crane in the direction of the next station
2	a_gripper_down	Move gripper down (cylinder moves back if value not set)
3	a_gripper_open	Open gripper
7	a_station_free	Give an enable signal to the predecessor station

Safety functions

The setting of some output variables in certain states is prevented by the main program to prevent damage to the plant:

1. If the grab is at the lower end position, it is prevented that the crane can be moved to the left or right.
2. If the crane is at the position of the pick-up (previous station) or is moving straight towards the pick-up, it is prevented from giving an enable signal to the previous station.

If safety functions are active, lamp Q1 on the control panel lights up.

Approval

For acceptance of the station the following characteristics must be fulfilled:

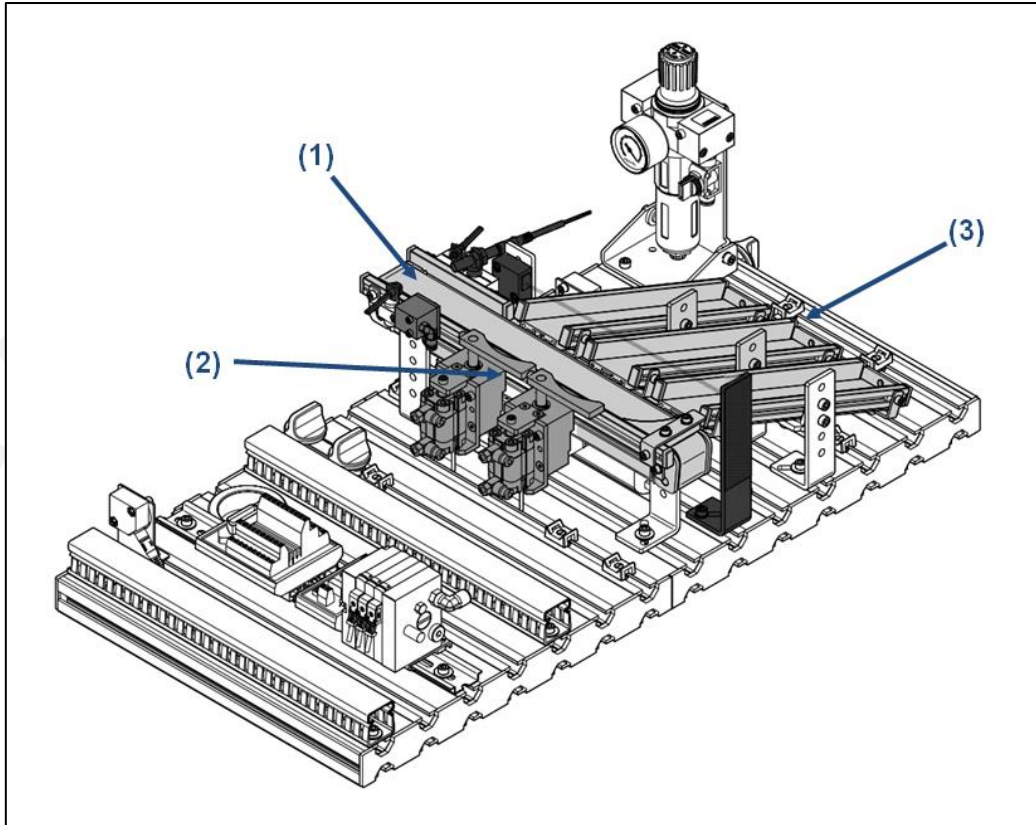
- Initial situation according to process description.
- The enable signal for the previous station is cancelled as soon as the workpiece is on the pick-up and the previous station is in the starting position (at the magazine).
- Crane does not move in the direction of the next station if the release signal of the next station has not been given.
- The crane transports one black workpiece to the reject chute and all others to the next station (test with black workpiece may be repeated as sensor is not very reliable).

Four workpieces (black without lid, red/silver without lid, red/silver with lid, black with lid) are placed individually in random order in the holder. New workpieces are only placed on the holder when the release signal has been given to the preceding station.

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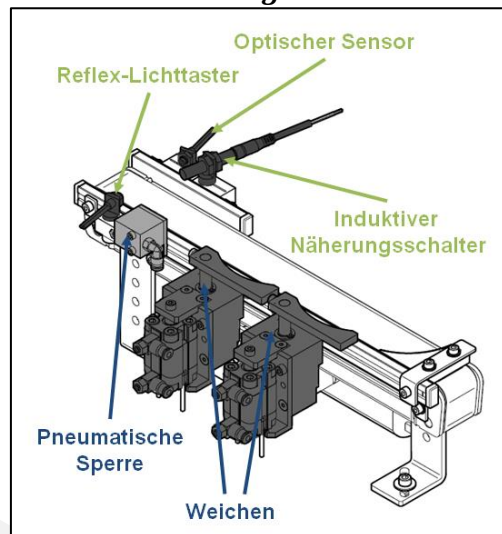
5th station Sort

When reaching the "Sorting" station, the workpiece is first stopped at the *detection module (1)* and uniquely identified. It is then sorted into one of the three *chutes (3)* using the two *switches (2)* according to the specifications.



Modules

Sorting belt



The module is used to classify workpieces and forward them accordingly. To classify workpieces, the module has an inductive sensor that can distinguish metallic from non-metallic workpieces; and an optical sensor that can distinguish black from non-black workpieces. For classification, the workpieces can be stopped by means of a pneumatic lock. The workpieces are sorted into the appropriate chutes by two switches, whose end positions are also detected. Workpieces at the beginning of the module are additionally detected by a light sensor.

Procedure

At the beginning there is no workpiece on the station, the belt is off and both the lock and the switches are in their initial position (lock pushed out, switches not deflecting). In addition, no release signal is given. When the initial state is established, the system starts the following routine:

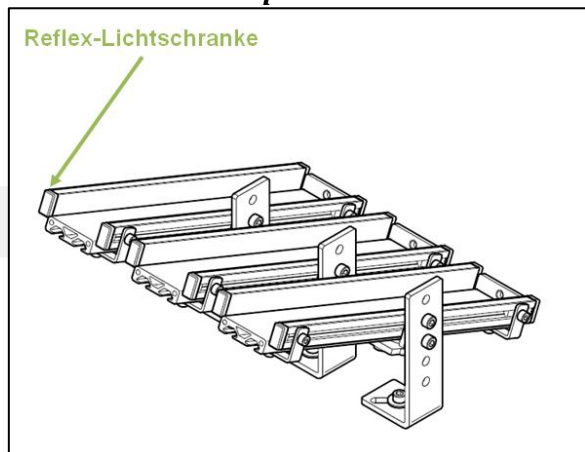
An enable signal is transmitted to the preceding station to request a workpiece. As soon as a part is detected by the first light barrier, the enable signal is cancelled and the main belt is switched on. After a short time the workpiece has arrived at the barrier. There the sensors check the properties of the workpiece. Meanwhile, the main band should be switched off so that the workpiece is at rest during measurement. In the following the switches are switched according to the sorting decision made. As soon as the switches are in the correct position, the barrier is retracted to let the workpiece pass. After a few seconds, the station is returned to its initial state.

The case that the slides become full does not need to be considered further here.

Notes

- For processes whose end position cannot be checked by end position sensors, you must perform time measurements to assume that the end position has been reached. First assume sufficiently large values (e.g. five seconds) before optimizing the times later.
- The light barrier does not check the working area directly before the first stopper.

Triple slide



The module has three chutes into which the workpieces are sorted. A full chute is detected by a light barrier.

- The workpieces should be sorted according to the following table:

Workpiece	Red	Black	Metallic
Slide	First (turnout 1)	Middle (turnout 2)	Last

Important variables

Inputs (feedback from the system)

Bit	Variable name	Description
0	e_workpiece_at_the_beginning	Workpiece detected at the beginning of the strip
1	e_workpiece_metallic	Workpiece on lock is metallic
2	e_workpiece_not_black	Workpiece on lock is not black
3	e_slide_full	One of the three slides is full
4	e_soft1_non_distracting	Switch 1 is not switched (does not deflect)
5	e_soft1_deflecting	Switch 1 is switched (deflects)
6	e_soft2_non_distracting	Turnout 2 is not switched (does not deflect)
7	e_soft2_deflecting	Switch 2 is switched (deflects)

Outputs (commands from user to system)

Bit	Variable name	Description
0	a_band_an	Switch on tape
1	a_switch1_steering_down	Switch the first switch so that the workpieces are directed to the first chute
2	a_switch2_steer_down	Switch the second switch so that the workpieces are directed to the second chute
3	a_lock_engage	Retract pneumatic lock, i.e. allow workpieces to pass
7	a_station_free	Send enable signal to predecessor station

Safety Instructions

If the light barrier at one of the three chutes should be broken (e_rutschen_voll = TRUE), then no further workpiece should be allowed to pass through the barrier at the beginning of the belt.

Approval

For acceptance of the station the following characteristics must be fulfilled:

- Initial state according to process description.
- Belt is switched off again after the sorting process.
- station sorts black, red and metallic components (with or without lids) into the three different chutes (which chute is used for which colour corresponds to the specification).
- The release signal is sent to the previous station when the station is ready to receive new workpieces.

Six workpieces (two red, two black and two silver) are placed individually on the belt in random order. New workpieces are not placed on the belt until the release signal is given to the preceding station.

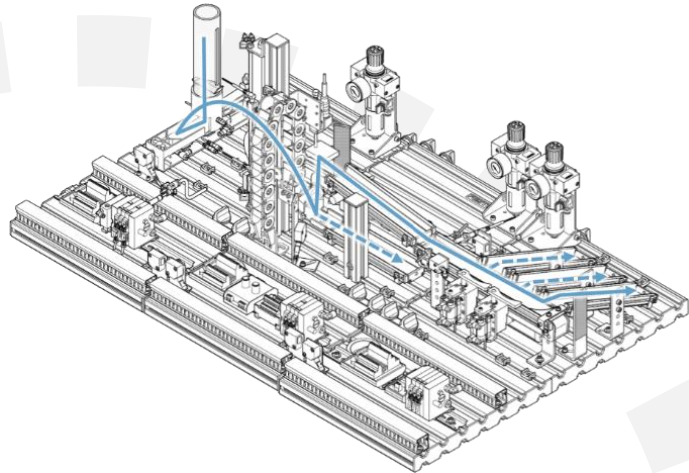
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Facility description

There are two different plant combinations in the plant internship, each consisting of three stations. In order to obtain the team bonus points, depending on the system combination, certain characteristics must be fulfilled when performing a specified test case.

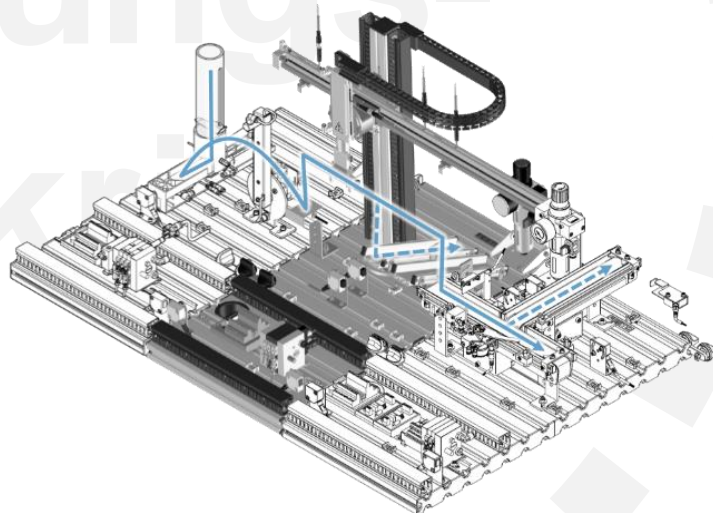
Combination 1: Distribute - Check - Sort

In order to receive the team bonus for this system, all four randomly selected workpieces must be correctly sorted **after acceptance of the individual systems**. Among the inserted workpieces, there must be at least one workpiece that is to go into the sorting chutes of the last station. It is irrelevant for the selection which sorting chutes the work piece gets into. There must be no collisions between the stations.

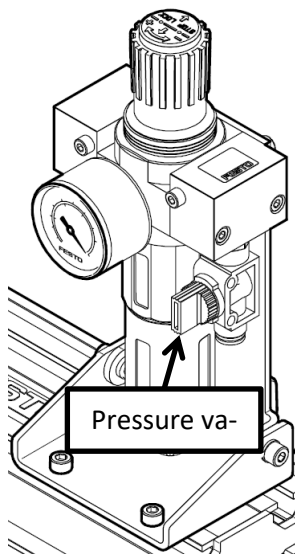


Combination 2: Distribute - handle - separate

In order to obtain the team bonus for this system, all four inserted workpieces must be sorted correctly **after acceptance of the individual systems**. No silver workpieces are used. There must be no collisions between the stations.



Safety Instructions



- If manual intervention is necessary, close the pressure valve in any case and only open it if there are no workpieces or body parts in the danger zone. Please note that actuators can hardly be moved even when the valve is closed.
- In particular, try not to move the lift of the "Check" station by force!
- Keep your hands away from all moving parts during operation of the system.
- If parts of the system jam, press the Stop button on the control panel and reset the program (Stop button in PIT).
- To avoid collisions with other stations, only give the enable signal by key if the partner of the following station is informed or is not programmed at the following station. Furthermore, an enable signal should only be given if the system is ready to pick up a workpiece.

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