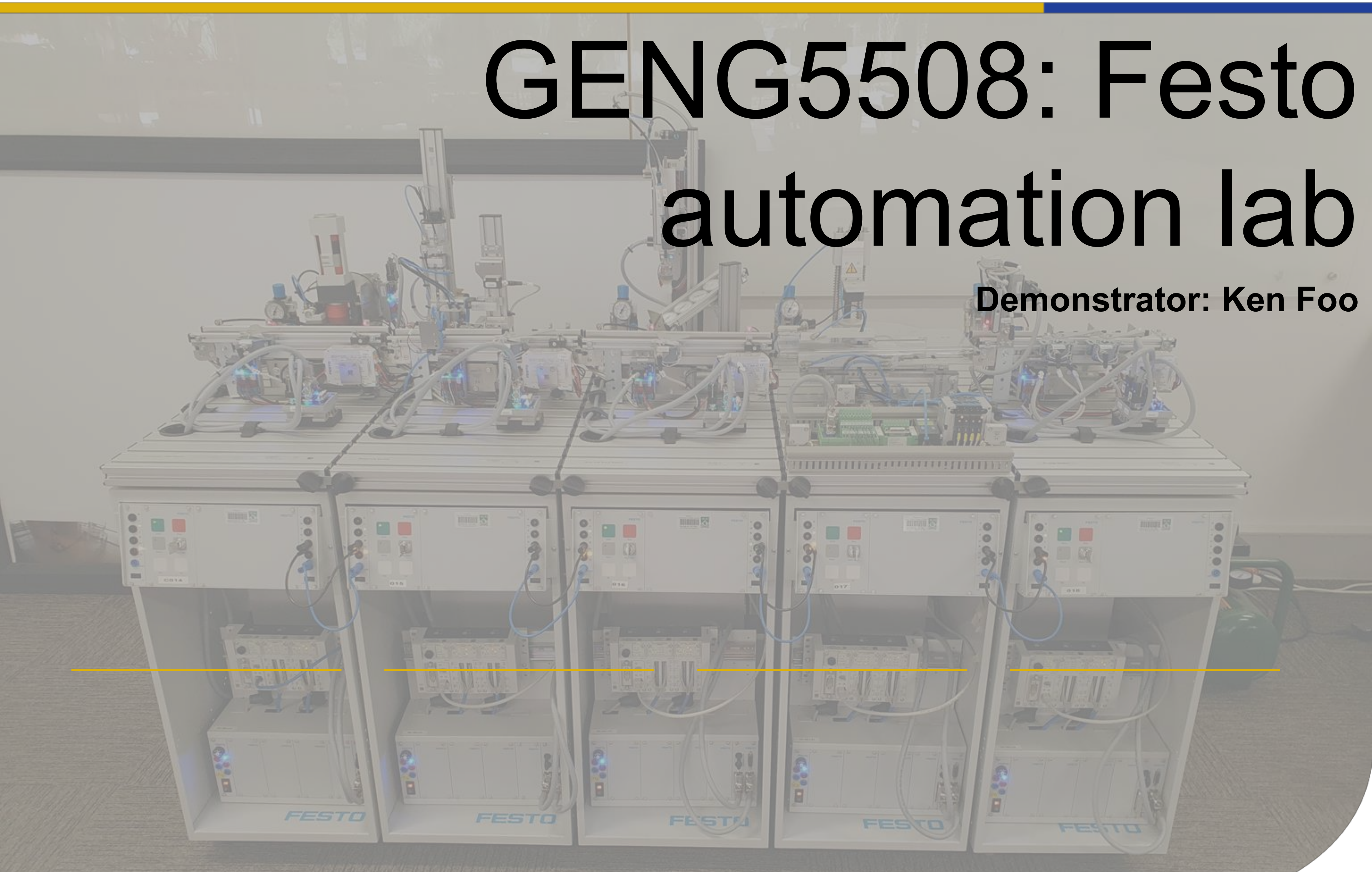
GENG5508: Festo automation lab

Demonstrator: Ken Foo

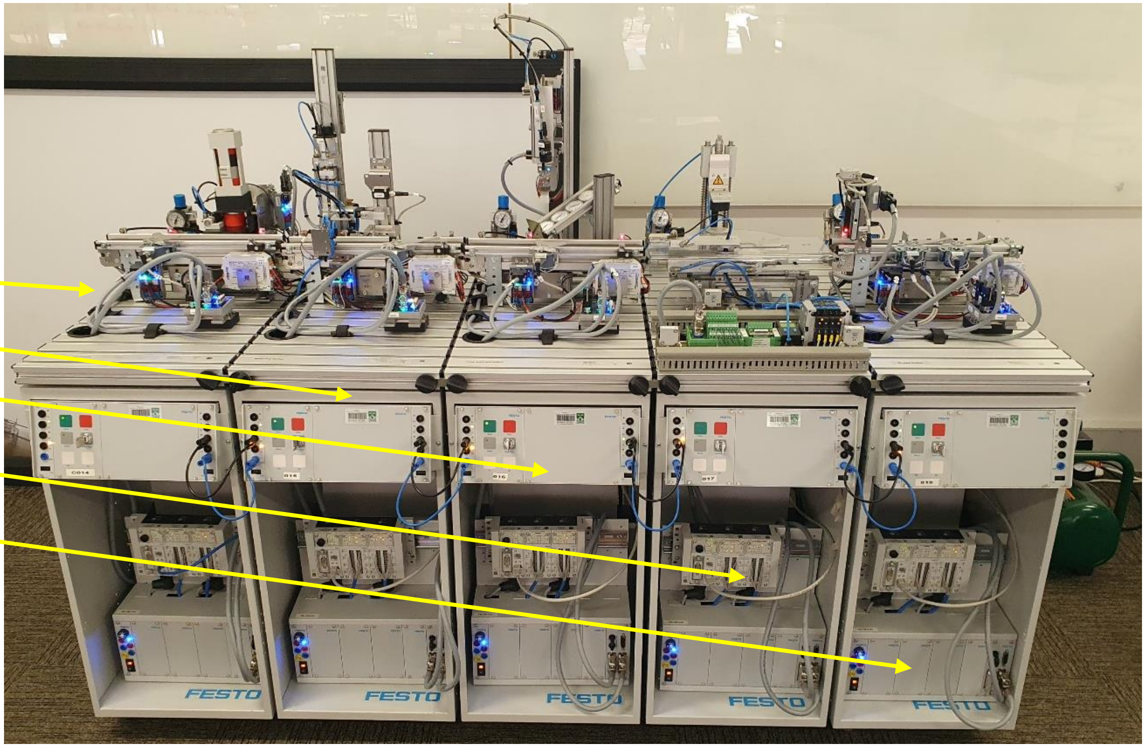


Contents

- Introduction to Festo
- Description of lab project
- Introduction to CODESYS
- Sequential Flow Chart (SFC) example
- Practical details and lab preparation

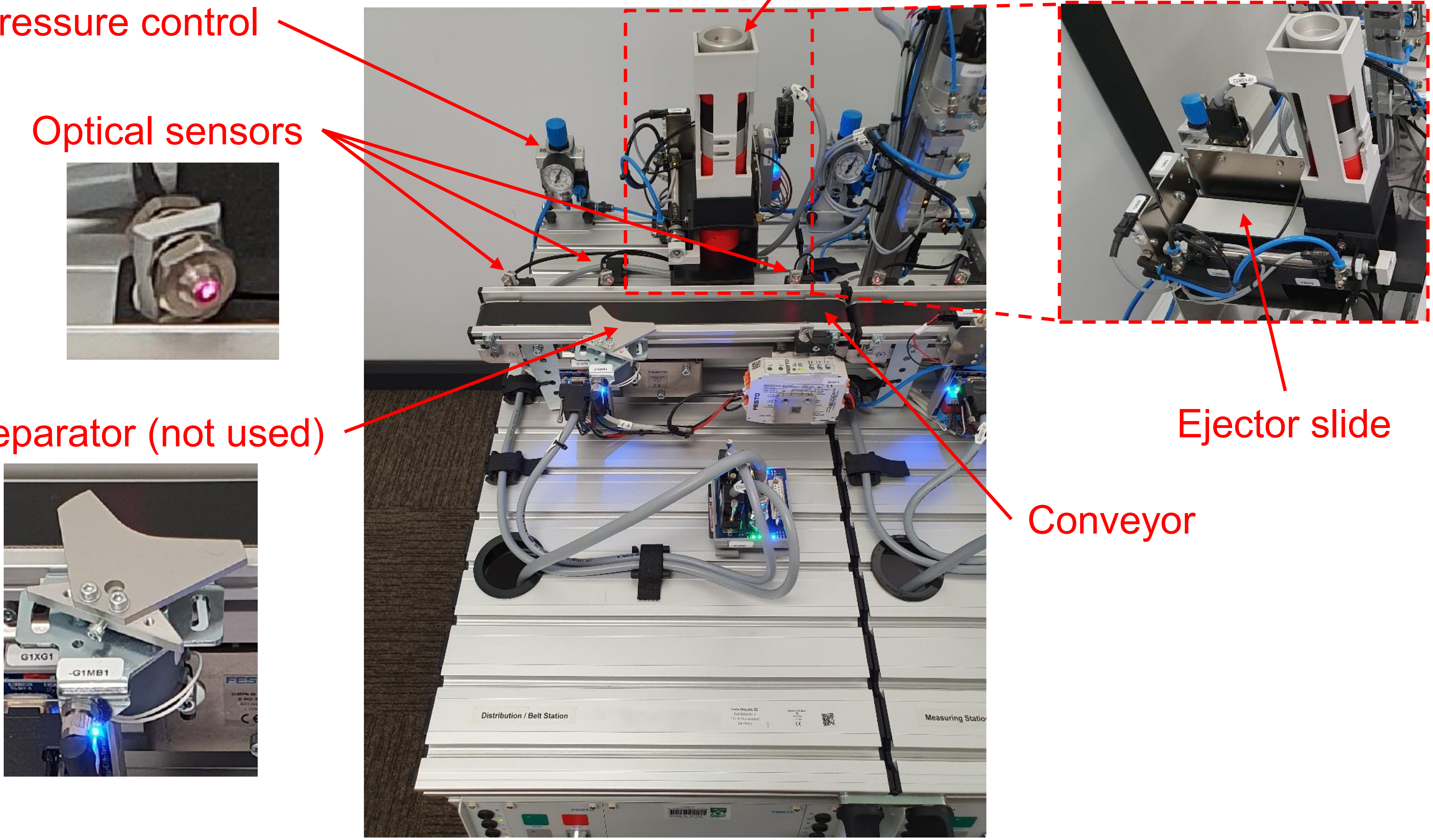
Festo introduction

- Festo is a German industrial control and automation company
  - Festo Didactic: provides educational and consultation services
- Festo Modular Production System (MPS): miniaturised production line used for educational purposes
- Simulates production of humidity (hygrometer) sensors
- Comprised of both electrical and pneumatic systems
- Composed of 5 stations:
  - Distribution station
  - Measuring station
  - Pick and place station
  - Pressing station
  - Sorting station



Festo: Distributing station

- Task: store and feed workpiece housings



Workpiece housings

Stacking magazine

Pressure control

Optical sensors

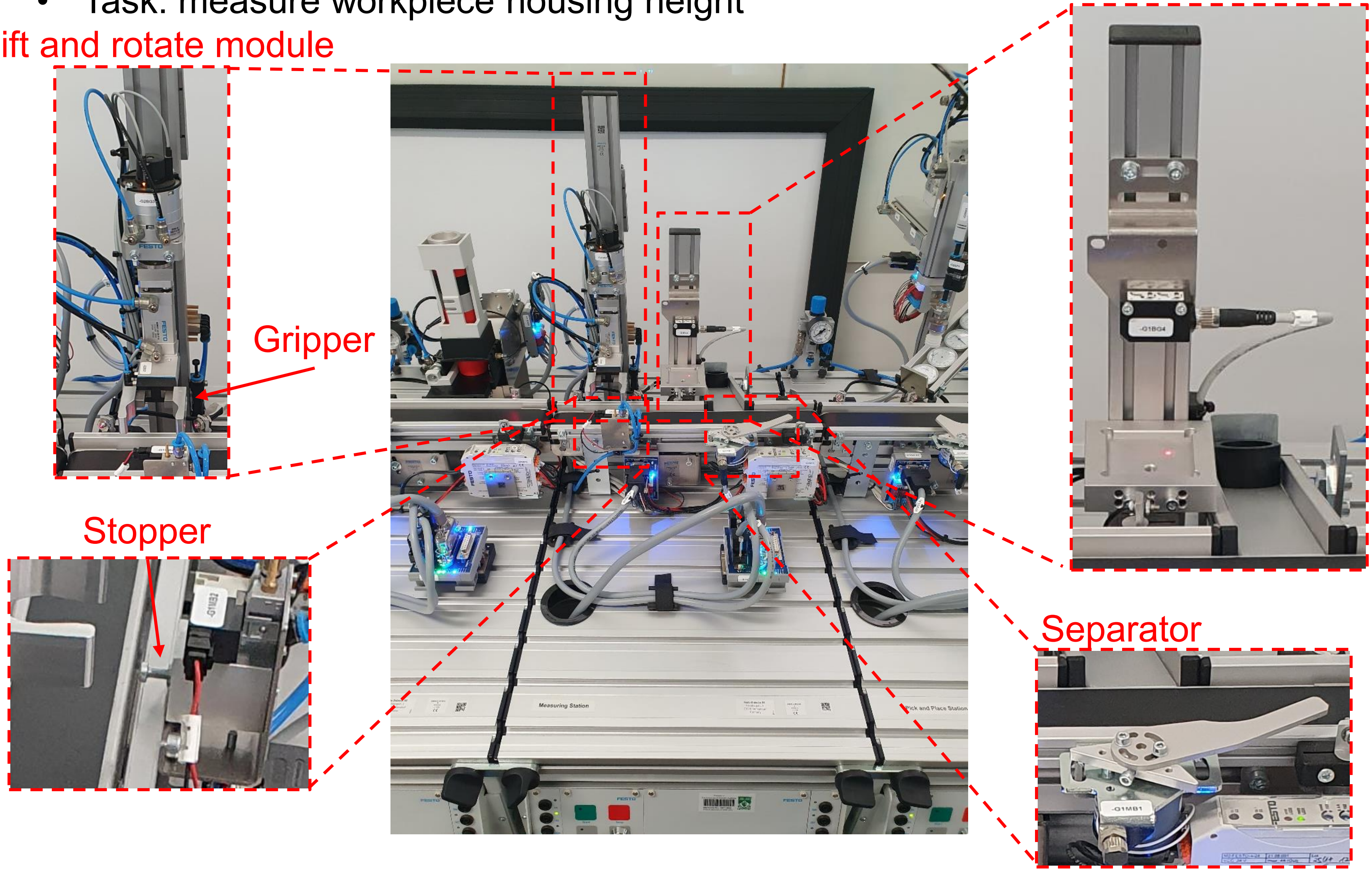
Separator (not used)

Ejector slide

Conveyor

Festo: Measuring station

- Task: measure workpiece housing height



Measurement module

Lift and rotate module

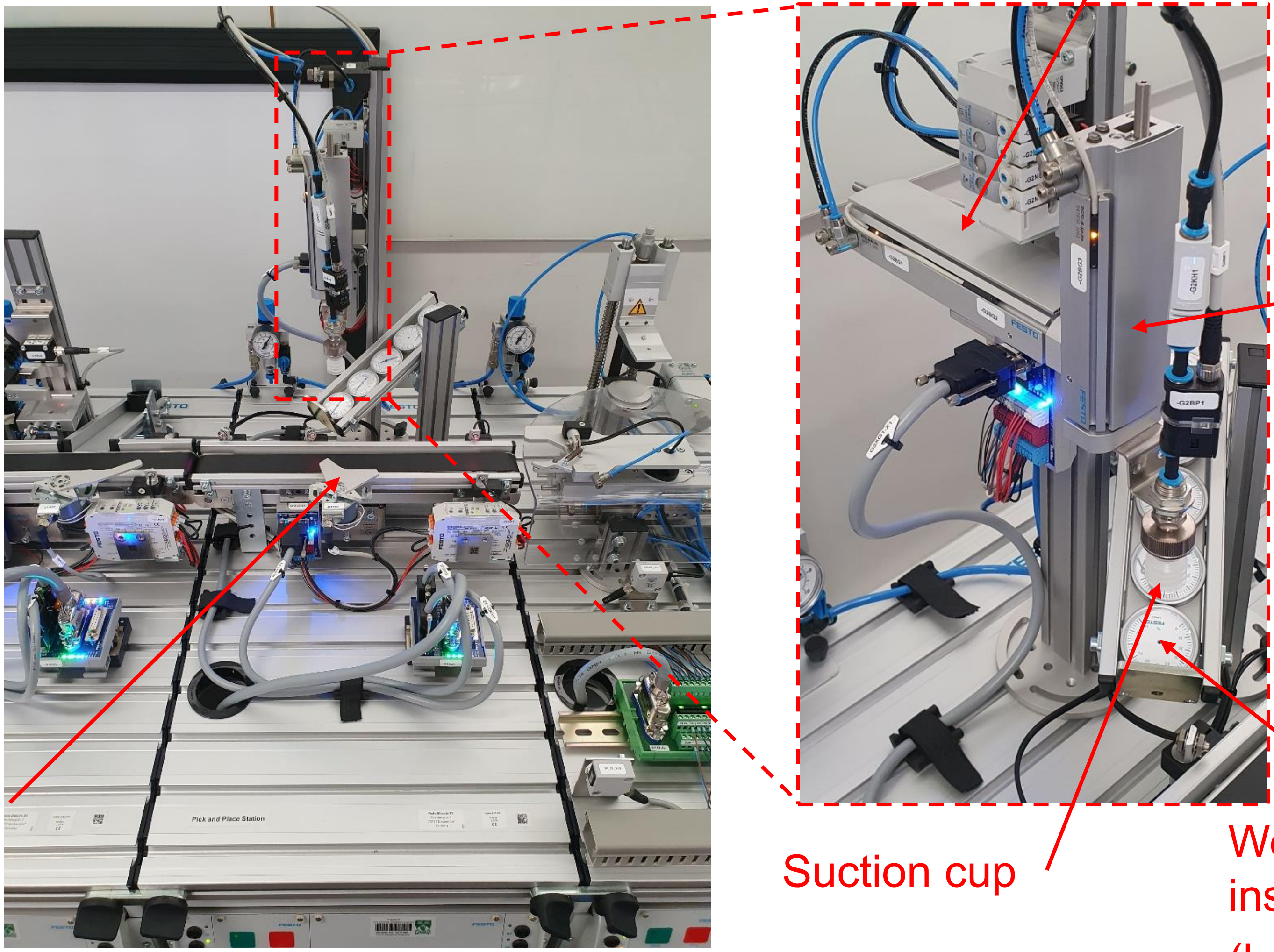
Gripper

Stopper

Separator

Festo: Pick and place station

- Task: insert workpiece insert into workpiece housing



Horizontal slide

Vertical slide

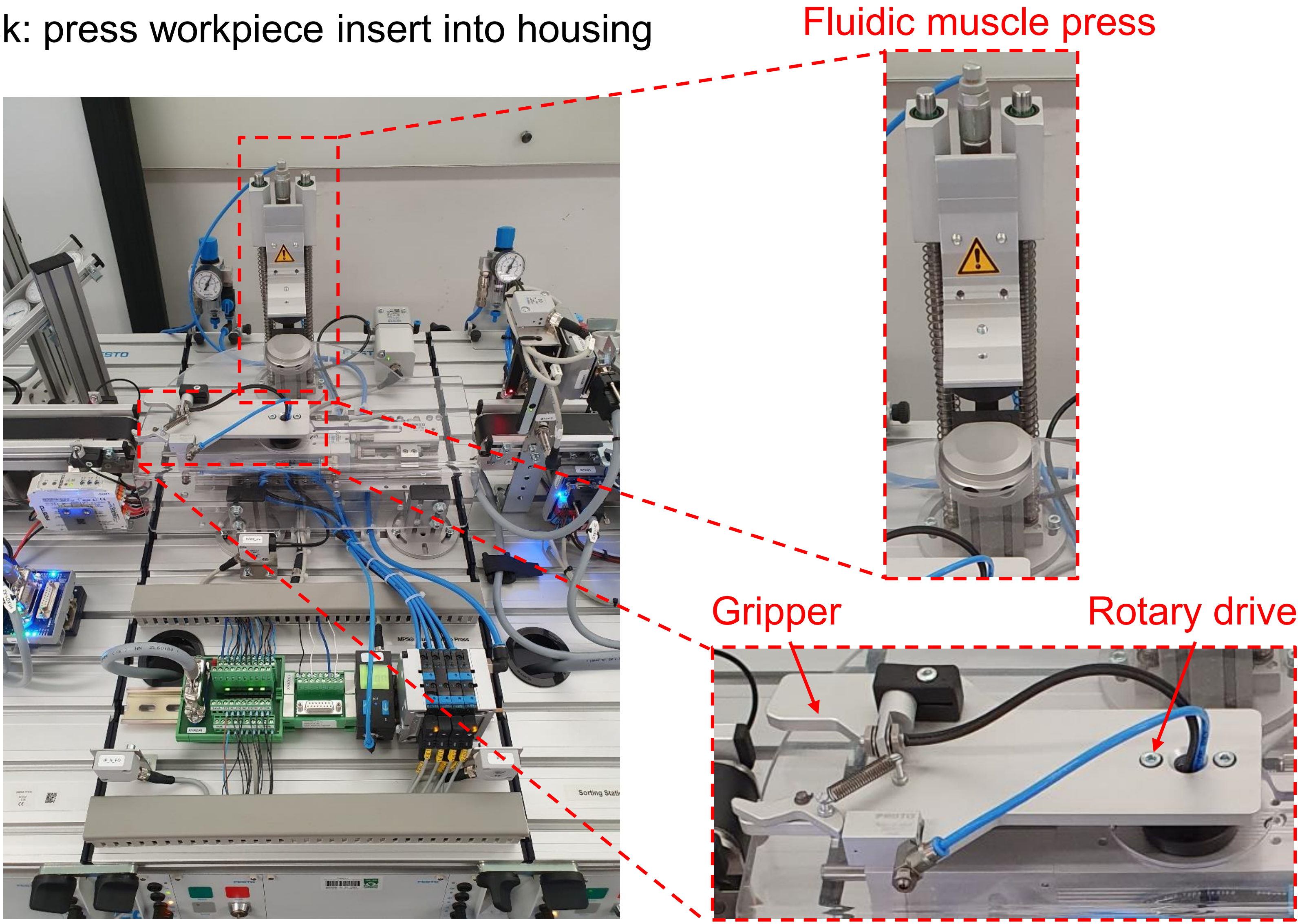
Separator

Suction cup

Workpiece insert (hygrometer)

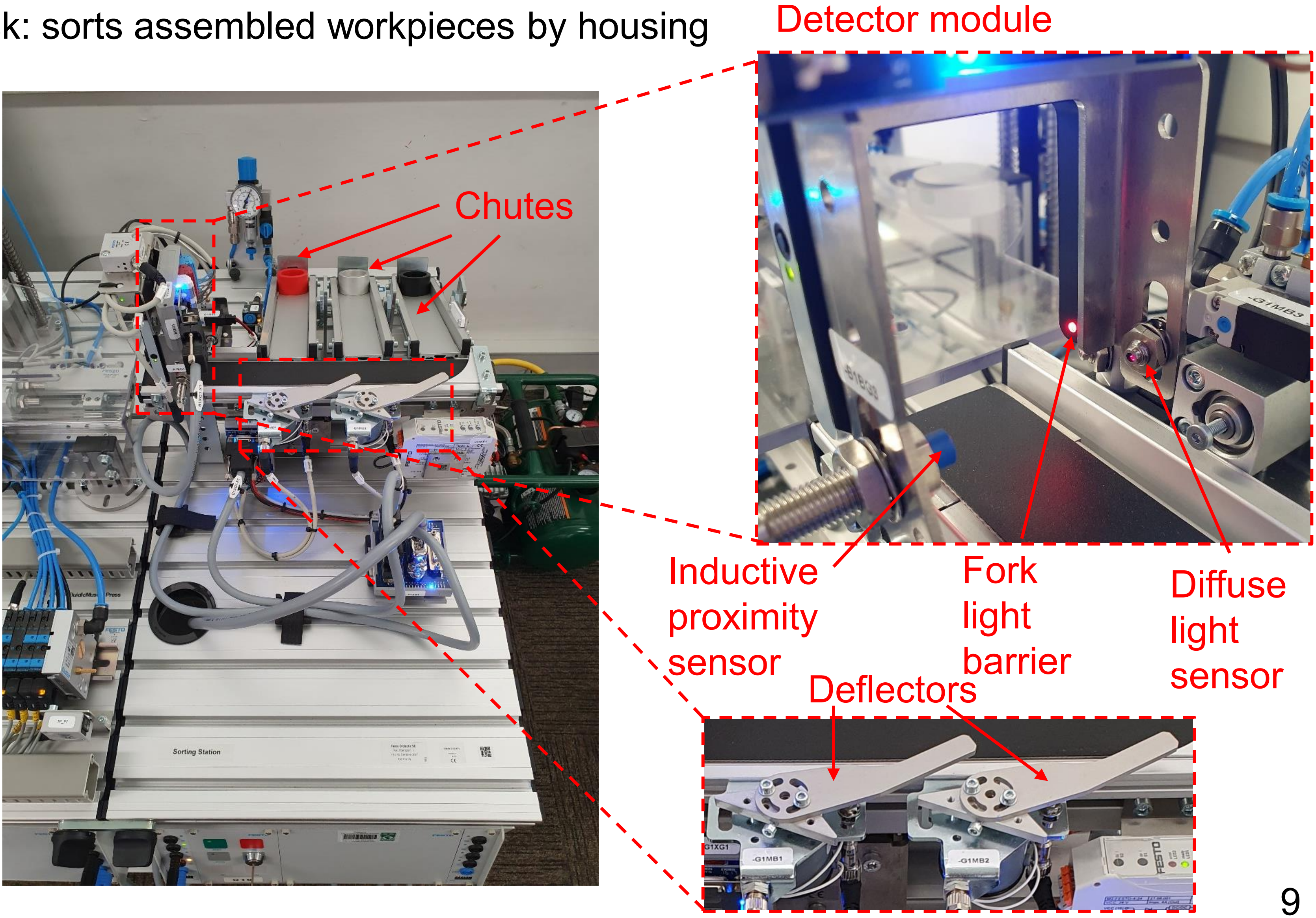
Festo: Pressing station

- Task: press workpiece insert into housing



Festo: Sorting station

- Task: sorts assembled workpieces by housing



Detector module

Chutes

Inductive proximity sensor

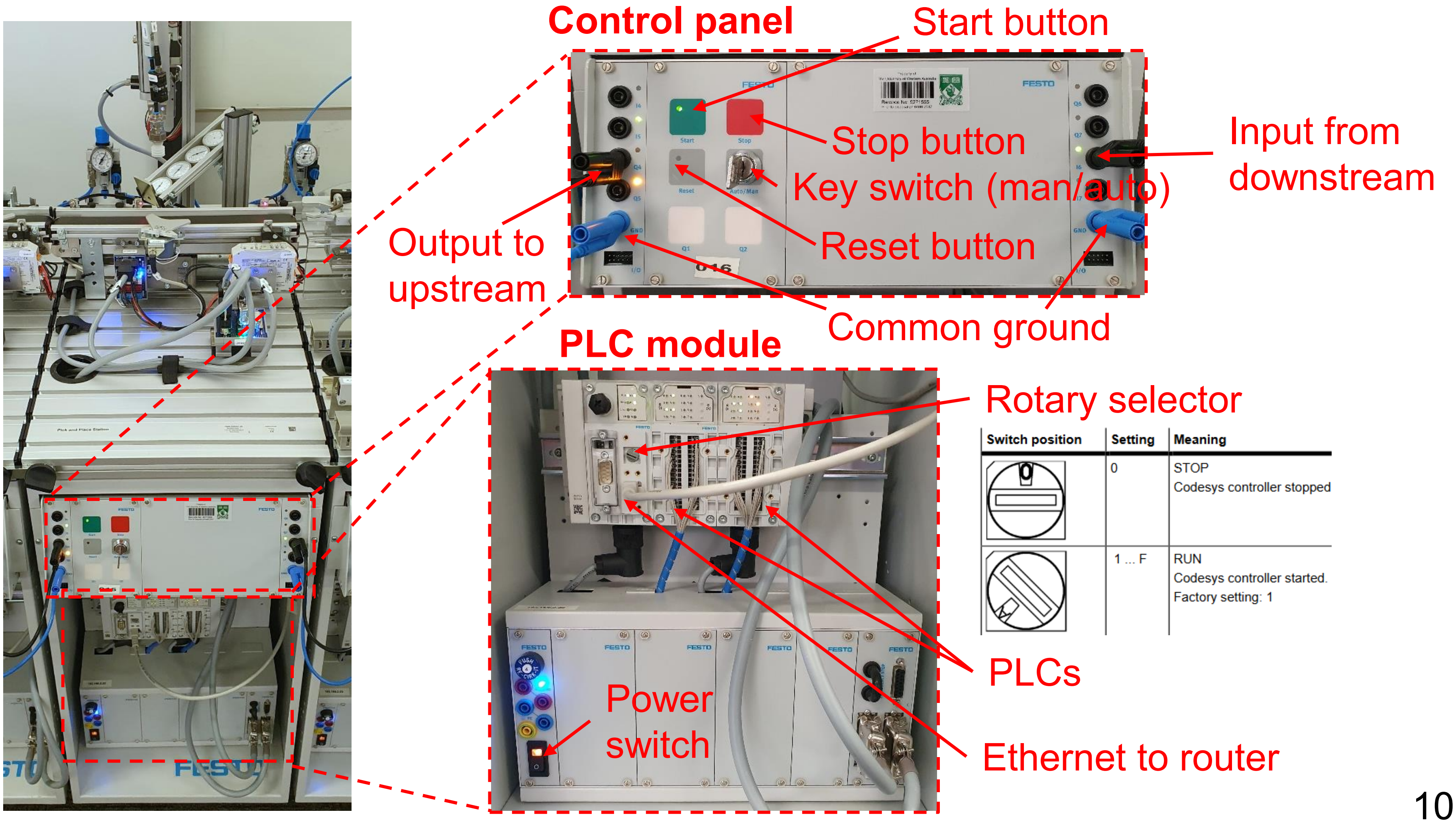
Fork light barrier

Diffuse light sensor

Deflectors

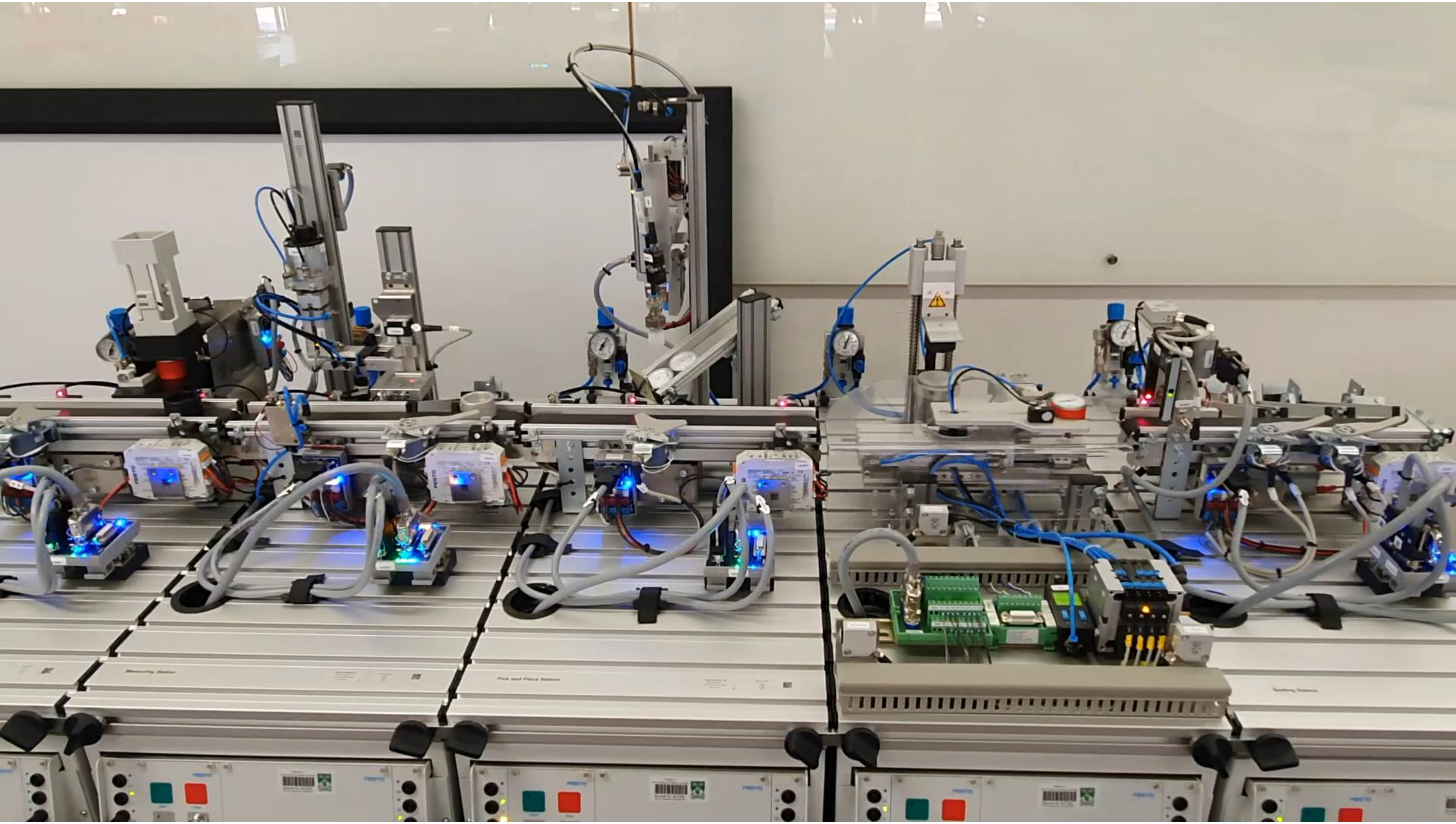
Festo: PLCs and control panels

- Each station is programmed by a programmable logic controller (PLC) module and manually controlled from the control panel



Switch position	Setting	Meaning
0	0	STOP Codesys controller stopped
	1 ... F	RUN Codesys controller started. Factory setting: 1

Festo: Video demonstration



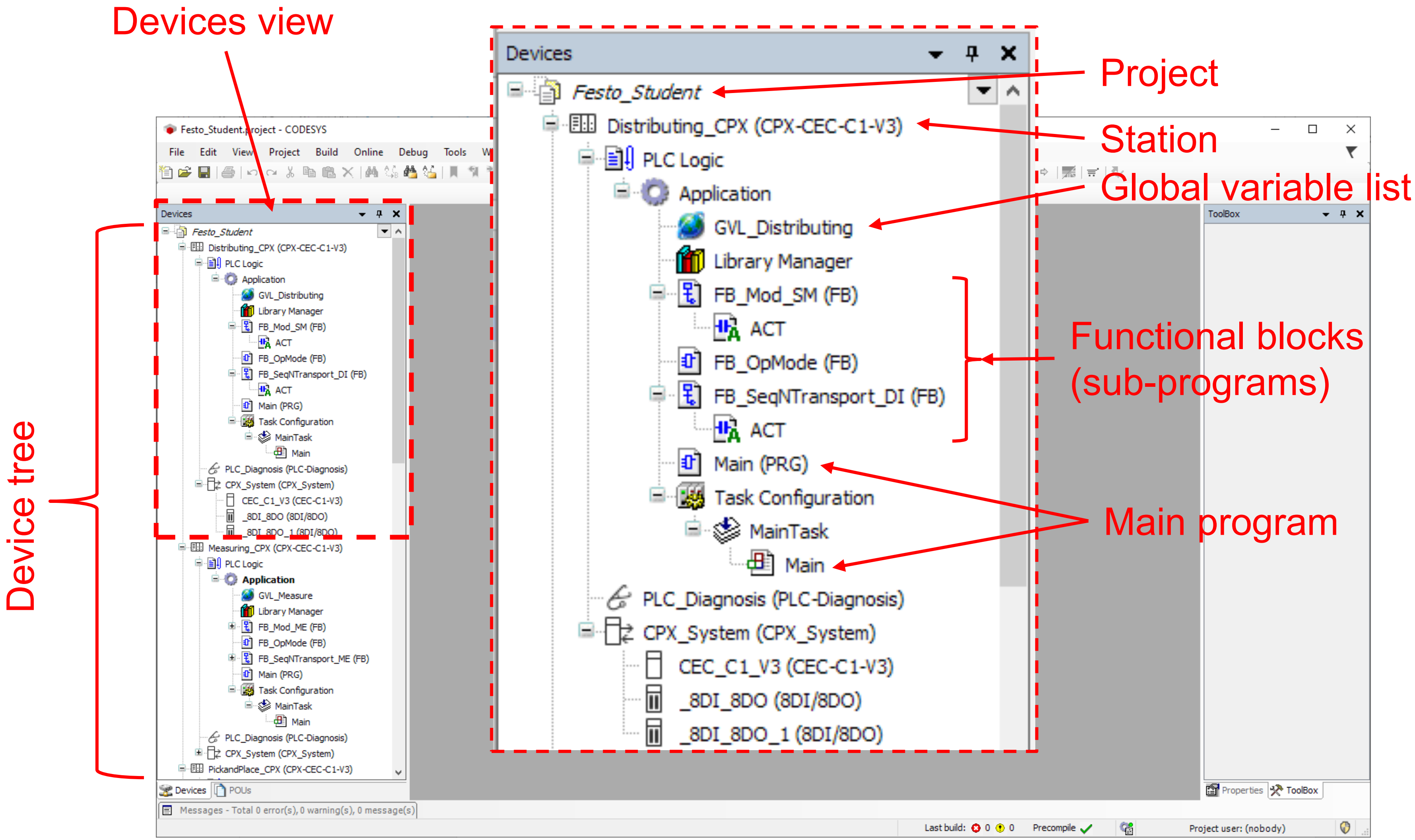
Project description

- The aim of the project is to program one Festo MPS station to complete the tasks previously outlined
- Students will work in groups of 3–4
- The stations will be programmed using CODESYS
- Partially complete code will be provided – students are required to complete the missing sections
- The lab consists of three parts:
  - Prelab: Read provided documentation and complete prelab questions
  - First lab (Week 3): Match variables defined in CODESYS with the corresponding PLC input, and describe the physical action associated with it
  - Second lab (Week 4): Each group in a session will be assigned one station and complete the code for that station. The code will then be uploaded to the station to demonstrate functionality.

CODESYS overview

- CODESYS (COntroller DEvelopment SYStem) is a development environment for PLCs
- **Windows required – not available for MAC!**
- Programming is implemented in the open international standard IEC61131-3
- This includes three graphical and two textual languages:
  - Ladder diagram (LD, graphical)
  - Functional block diagram (FBD, graphical)
  - Structured text (ST, textual)
  - Instruction list (IL, textual, deprecated)
  - Sequential function chart (SFC, graphical)

CODESYS Main interface



Devices view

Device tree

Project

Station

Global variable list

Functional blocks (sub-programs)

Main program

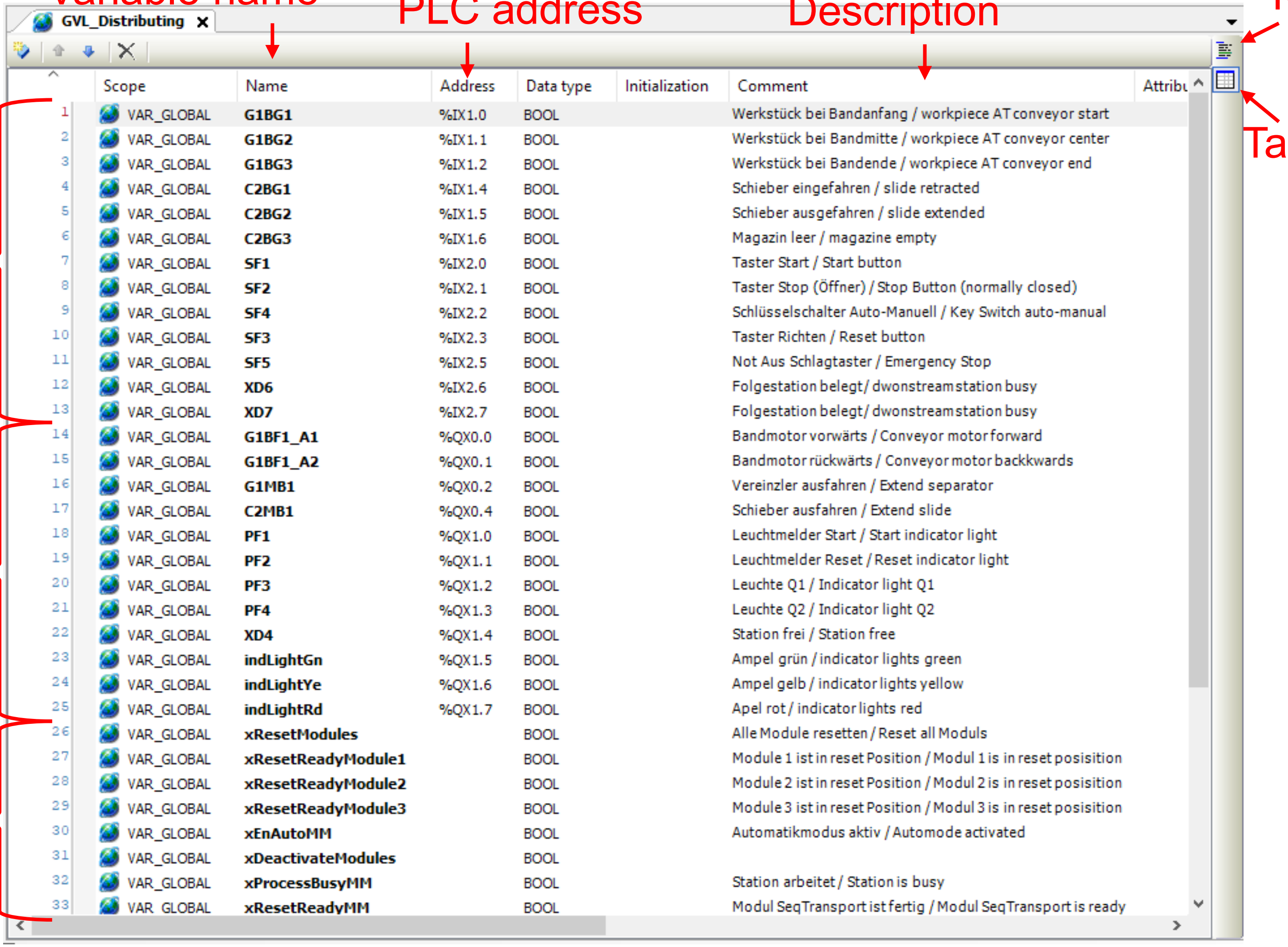
```
Festo_Student
  Distributing_CPX (CPX-CEC-C1-V3)
    PLC Logic
      Application
        GVL_Distributing
        Library Manager
        FB_Mod_SM (FB)
          ACT
        FB_OpMode (FB)
        FB_SeqNTransport_DI (FB)
          ACT
        Main (PRG)
        Task Configuration
          MainTask
            Main
    PLC_Diagnosis (PLC-Diagnosis)
    CPX_System (CPX_System)
      CEC_C1_V3 (CEC-C1-V3)
      _8DI_8DO (8DI/8DO)
      _8DI_8DO_1 (8DI/8DO)
  Measuring_CPX (CPX-CEC-C1-V3)
    PLC Logic
      Application
        GVL_Measure
        Library Manager
        FB_Mod_ME (FB)
        FB_OpMode (FB)
        FB_SeqNTransport_ME (FB)
        Main (PRG)
        Task Configuration
          MainTask
            Main
    PLC_Diagnosis (PLC-Diagnosis)
    CPX_System (CPX_System)
  PickandPlace_CPX (CPX-CEC-C1-V3)
```

Messages - Total 0 error(s), 0 warning(s), 0 message(s)

Last build: 0 0 Precompile ✓ Project user: (nobody)

Global variable list (Distributing station)

- Defines/declares global variables (i.e., variables available in all sub-programs)



Variable name

PLC address

Description

Text view

Table view

PLC inputs

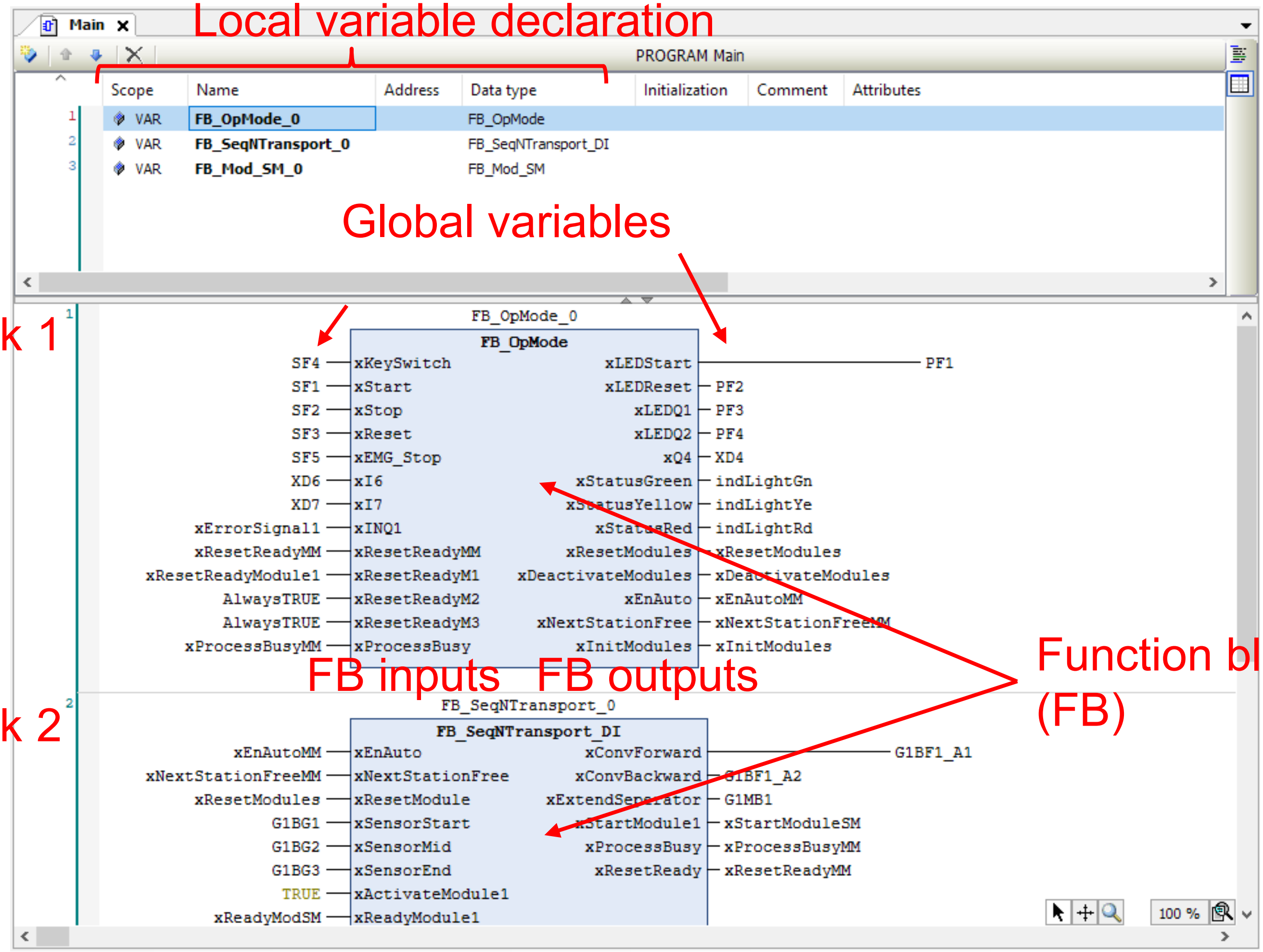
PLC outputs

Other variables

	Scope	Name	Address	Data type	Initialization	Comment	Attribu
1	VAR_GLOBAL	G1BG1	%IX1.0	BOOL		Werkstück bei Bandanfang / workpiece AT conveyor start	
2	VAR_GLOBAL	G1BG2	%IX1.1	BOOL		Werkstück bei Bandmitte / workpiece AT conveyor center	
3	VAR_GLOBAL	G1BG3	%IX1.2	BOOL		Werkstück bei Bandende / workpiece AT conveyor end	
4	VAR_GLOBAL	C2BG1	%IX1.4	BOOL		Schieber eingefahren / slide retracted	
5	VAR_GLOBAL	C2BG2	%IX1.5	BOOL		Schieber ausgefahren / slide extended	
6	VAR_GLOBAL	C2BG3	%IX1.6	BOOL		Magazin leer / magazine empty	
7	VAR_GLOBAL	SF1	%IX2.0	BOOL		Taster Start / Start button	
8	VAR_GLOBAL	SF2	%IX2.1	BOOL		Taster Stop (Öffner) / Stop Button (normally closed)	
9	VAR_GLOBAL	SF4	%IX2.2	BOOL		Schlüsselschalter Auto-Manuell / Key Switch auto-manual	
10	VAR_GLOBAL	SF3	%IX2.3	BOOL		Taster Richten / Reset button	
11	VAR_GLOBAL	SF5	%IX2.5	BOOL		Not Aus Schlagtaster / Emergency Stop	
12	VAR_GLOBAL	XD6	%IX2.6	BOOL		Folgestation belegt/ dwonstreamstation busy	
13	VAR_GLOBAL	XD7	%IX2.7	BOOL		Folgestation belegt/ dwonstreamstation busy	
14	VAR_GLOBAL	G1BF1_A1	%QX0.0	BOOL		Bandmotor vorwärts / Conveyor motor forward	
15	VAR_GLOBAL	G1BF1_A2	%QX0.1	BOOL		Bandmotor rückwärts / Conveyor motor backkwards	
16	VAR_GLOBAL	G1MB1	%QX0.2	BOOL		Vereinzler ausfahren / Extend separator	
17	VAR_GLOBAL	C2MB1	%QX0.4	BOOL		Schieber ausfahren / Extend slide	
18	VAR_GLOBAL	PF1	%QX1.0	BOOL		Leuchtmelder Start / Start indicator light	
19	VAR_GLOBAL	PF2	%QX1.1	BOOL		Leuchtmelder Reset / Reset indicator light	
20	VAR_GLOBAL	PF3	%QX1.2	BOOL		Leuchte Q1 / Indicator light Q1	
21	VAR_GLOBAL	PF4	%QX1.3	BOOL		Leuchte Q2 / Indicator light Q2	
22	VAR_GLOBAL	XD4	%QX1.4	BOOL		Station frei / Station free	
23	VAR_GLOBAL	indLightGn	%QX1.5	BOOL		Ampel grün / indicator lights green	
24	VAR_GLOBAL	indLightYe	%QX1.6	BOOL		Ampel gelb / indicator lights yellow	
25	VAR_GLOBAL	indLightRd	%QX1.7	BOOL		Apel rot / indicator lights red	
26	VAR_GLOBAL	xResetModules		BOOL		Alle Module resetten / Reset all Moduls	
27	VAR_GLOBAL	xResetReadyModule1		BOOL		Module 1 ist in reset Position / Modul 1 is in reset posisition	
28	VAR_GLOBAL	xResetReadyModule2		BOOL		Module 2 ist in reset Position / Modul 2 is in reset posisition	
29	VAR_GLOBAL	xResetReadyModule3		BOOL		Module 3 ist in reset Position / Modul 3 is in reset posisition	
30	VAR_GLOBAL	xEnAutoMM		BOOL		Automatikmodus aktiv / Automode activated	
31	VAR_GLOBAL	xDeactivateModules		BOOL			
32	VAR_GLOBAL	xProcessBusyMM		BOOL		Station arbeitet / Station is busy	
33	VAR_GLOBAL	xResetReadyMM		BOOL		Modul SeqTransport ist fertig / Modul SeqTransport is ready	

Main program (Distributing station)

- PLC loops over Main program every 20ms
- In each cycle, networks in Main are executed sequentially



Main ×

PROGRAM Main

	Scope	Name	Address	Data type	Initialization	Comment	Attributes
1	VAR	FB_OpMode_0		FB_OpMode			
2	VAR	FB_SeqNTransport_0		FB_SeqNTransport_DI			
3	VAR	FB_Mod_SM_0		FB_Mod_SM			

```
1
                              FB_OpMode_0
                 FB_OpMode
SF4               —xKeySwitch                 xLEDStart—          PF1
SF1               —xStart                     xLEDReset— PF2
SF2               —xStop                       xLEDQ1— PF3
SF3               —xReset                      xLEDQ2— PF4
SF5               —xEMG_Stop                     xQ4— XD4
XD6               —xI6                   xStatusGreen— indLightGn
XD7               —xI7                  xStatusYellow— indLightYe
xErrorSignal1     —xINQ1                   xStatusRed— indLightRd
xResetReadyMM     —xResetReadyMM        xResetModules— xResetModules
xResetReadyModule1—xResetReadyM1   xDeactivateModules— xDeactivateModules
AlwaysTRUE        —xResetReadyM2              xEnAuto— xEnAutoMM
AlwaysTRUE        —xResetReadyM3     xNextStationFree— xNextStationFreeMM
xProcessBusyMM    —xProcessBusy          xInitModules— xInitModules

2
                              FB_SeqNTransport_0
                 FB_SeqNTransport_DI
xEnAutoMM         —xEnAuto                 xConvForward—          G1BF1_A1
xNextStationFreeMM—xNextStationFree       xConvBackward— G1BF1_A2
xResetModules     —xResetModule       xExtendSeperator— G1MB1
G1BG1             —xSensorStart          xStartModule1— xStartModuleSM
G1BG2             —xSensorMid             xProcessBusy— xProcessBusyMM
G1BG3             —xSensorEnd              xResetReady— xResetReadyMM
TRUE              —xActivateModule1
xReadyModSM       —xReadyModule1
```

Local variable declaration

Global variables

Network 1

Network 2

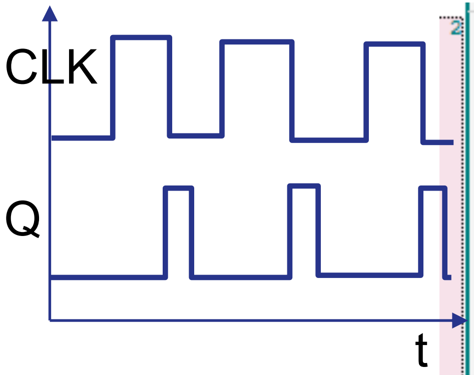
FB inputs

FB outputs

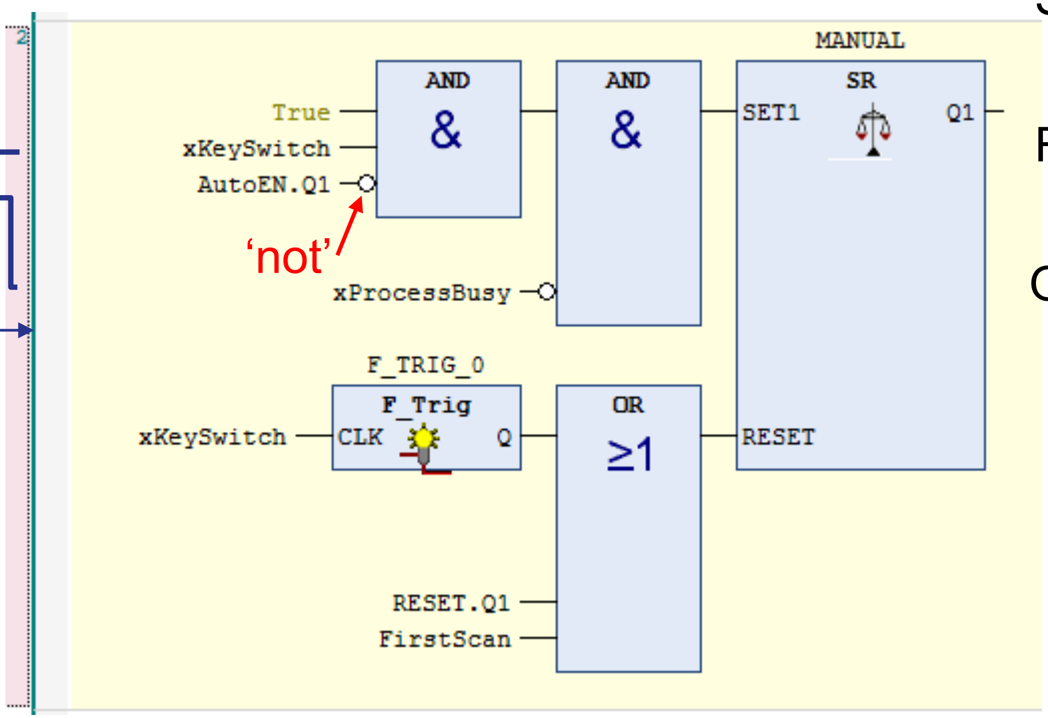
Function blocks (FB)

Functional block diagram (FBD) example

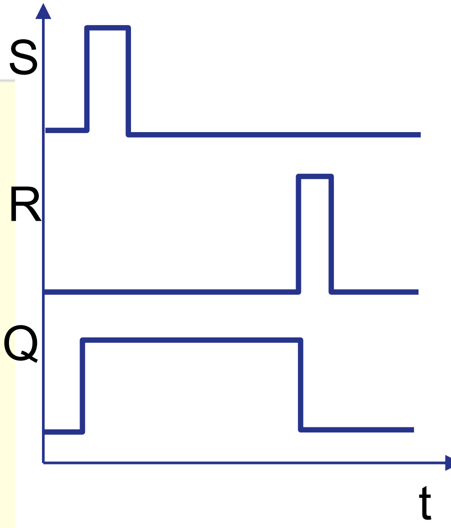
- Denoted by 🗎 in Device tree
- Networks executed sequentially
- Each network executed left-to-right (inputs on left, outputs on right)
- Common functions (AND, OR) and function blocks (SR latch, falling trigger) included in base library



Falling trigger: Set Q=1 when CLK transitions 1->0 for one cycle, then reset Q=0



‘not’

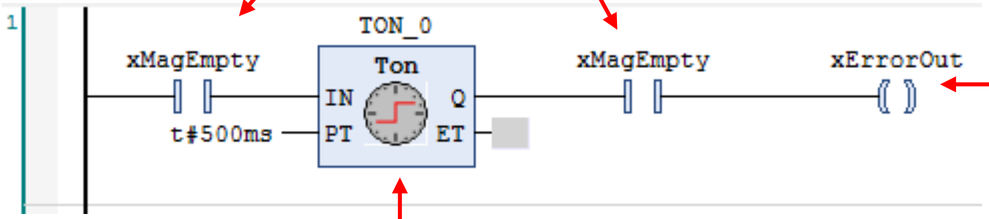


SR latch: Set Q=1 on rising edge of S, reset Q=0 on rising edge of R

Ladder diagram (LD) example

- Denoted by in Device tree
- Networks executed sequentially
- Each network executed left-to-right
- Each network consists of ‘contacts’, ‘blocks’, and ‘coils’:
  - Contacts: analogous to switches. Denoted | | (normally open) or | \ | (normally closed)
  - Blocks: implements higher-level functions
  - Coils: analogous to devices, e.g. lightbulb. Denoted ( ) (normally off) or (\ ) (normally on)

Contacts
(normally open)

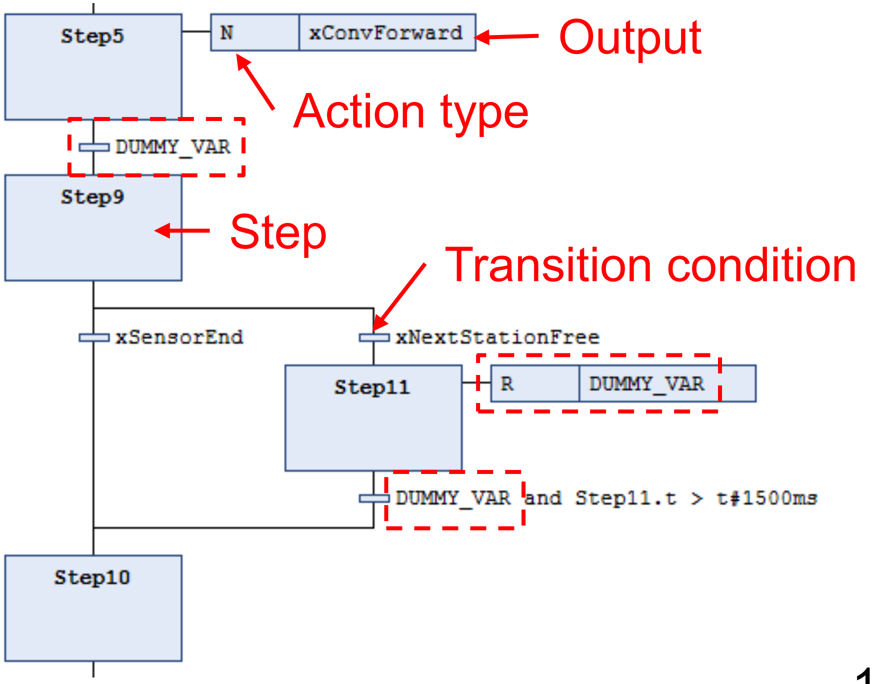


Coil
(normally off)

Block (on after
time delay)

Sequential Flow Chart (SFC) example

- Denoted by in Device tree
- Flows from top to bottom, and consists of steps, actions and transitions
- A step may be **active** or **inactive**.
  - A step becomes active when it is the first step, or when all immediately preceding steps are active and the transition condition is True.
  - A step becomes inactive when the succeeding transition is true
- Actions associated with steps are only executed when the step is active.
- Actions have an output and type. Types include:
  - S: Set output to 1
  - R: Reset output to 0
  - N: Set output to 1 while step is active, then reset to 0 when step is inactive



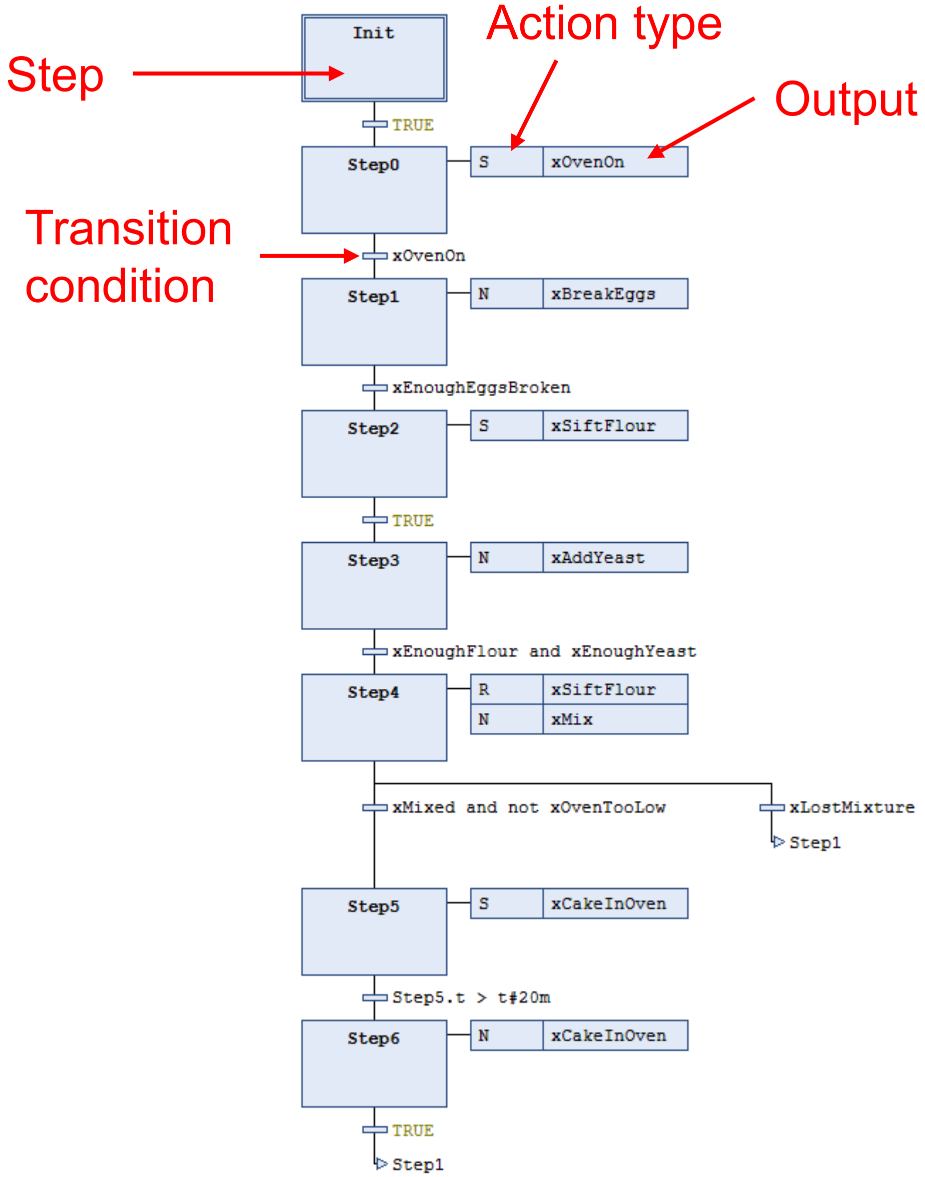
Output

Action type

Step

Transition condition

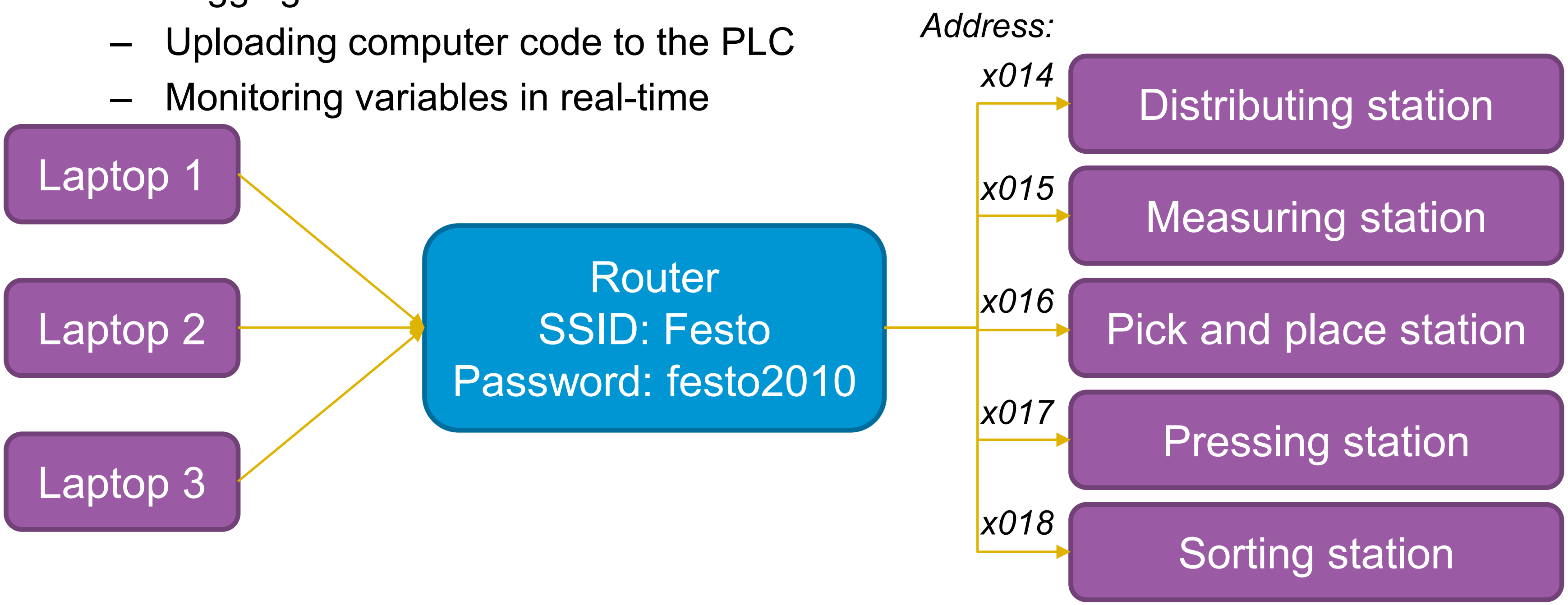
SFC example: Baking a cake



- Action types:
  - S: sets output high
  - N: sets output high while step is active
  - R: sets output low
- Step0: oven is set (S) to on and will stay on until it is reset (R)
- Step1: output *xBreakEggs* will remain on only while the condition *xEnoughEggsBroken* is not true (N)
- Step2-3: The Boolean *True* can be used to proceed immediately from Step 2 to 3
- Step3-4: Functions such as *and* and *not* can be used in the conditions
- Step4: Multiple actions can be associated with each step (executed sequentially)
- Step4-5: The branch implements *or*. Conditions are evaluated left-to-right until one is true.
- Step5-6: The time taken to complete a step can also be used as a condition

Connecting to Festo MPS

- The steps required to connect to Festo MPS are provided at the unit website in LabA-Festo_CODESYSBasics.pdf
- These steps included:
  - Connecting to the router:
    - All stations are connected to the same router
    - Note: no internet connection available through router
  - Assigning the station to a network address in CODESYS
  - Logging in to the station in CODESYS
  - Uploading computer code to the PLC
  - Monitoring variables in real-time



Laptop 1

Laptop 2

Laptop 3

Router
SSID: Festo
Password: festo2010

Address:

x014 Distributing station

x015 Measuring station

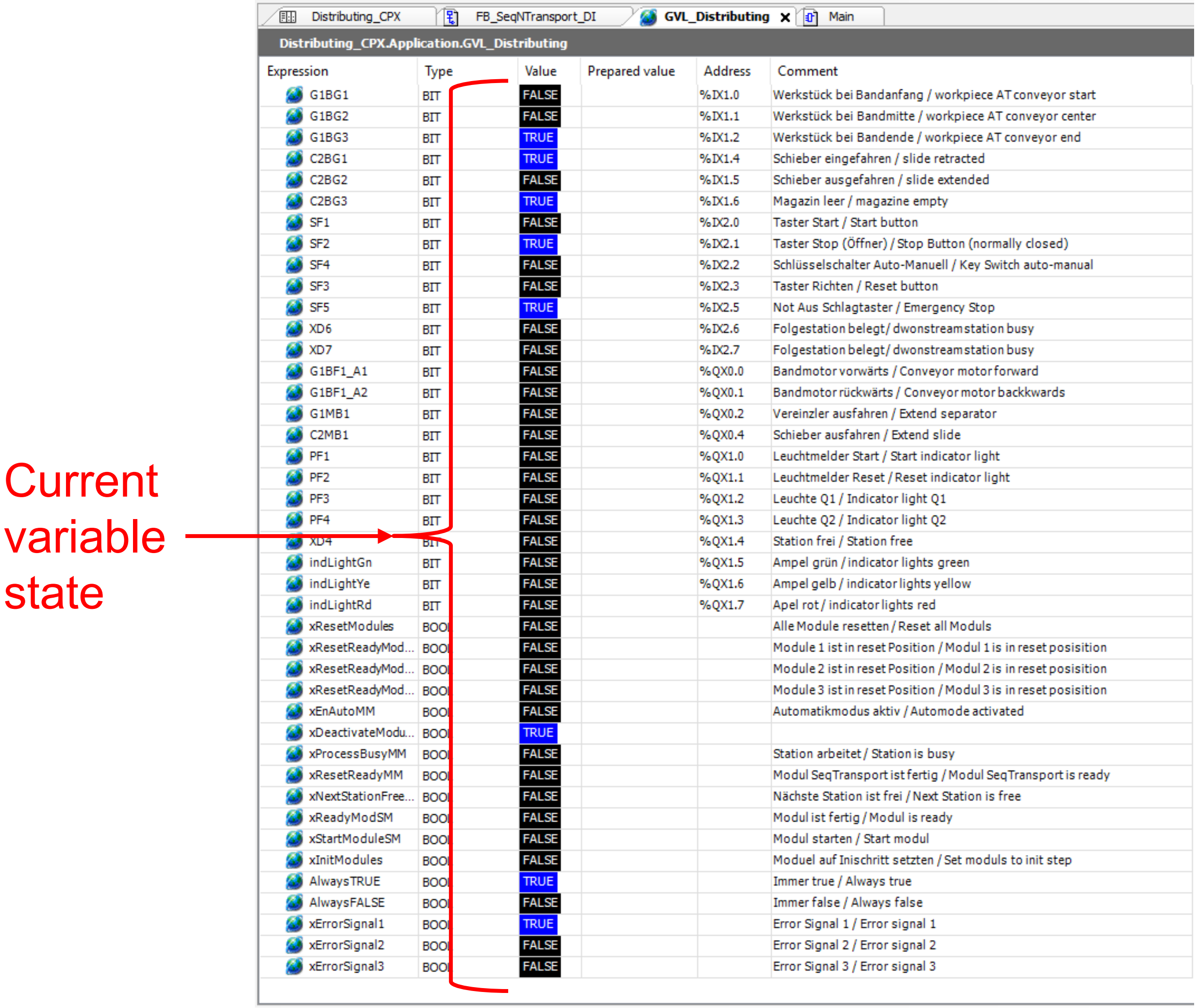
x016 Pick and place station

x017 Pressing station

x018 Sorting station

Monitoring variables in real-time

- Once connected to a Festo station, the state of variables can be monitored in real-time (this will be particularly useful for the first lab)



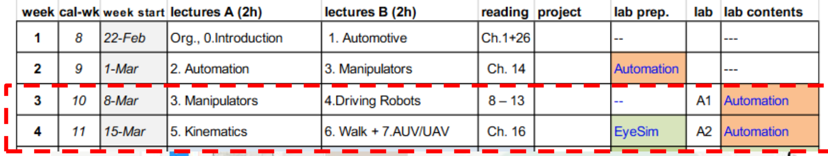
Current variable state

Distributing_CPX.Application.GVL_Distributing

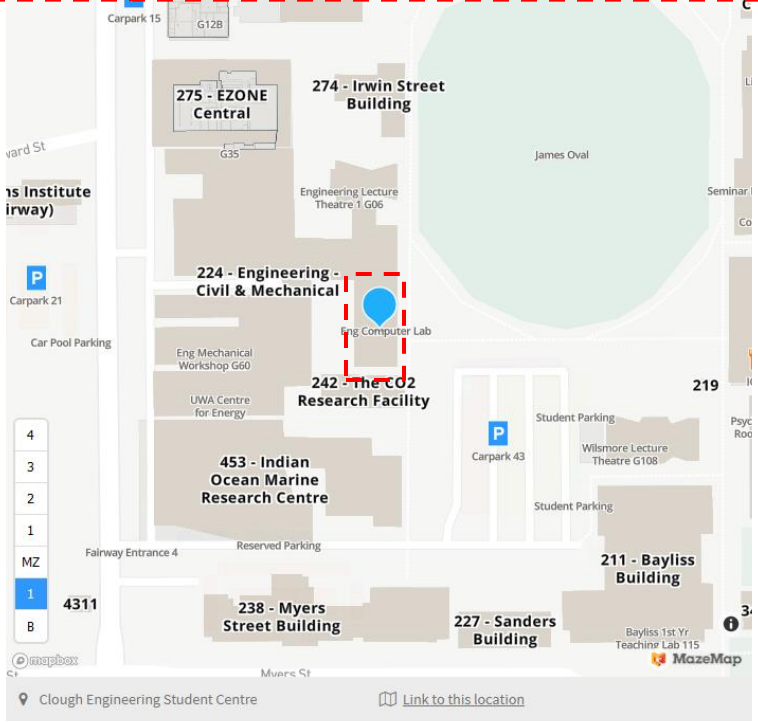
Expression	Type	Value	Prepared value	Address	Comment
G1BG1	BIT	FALSE		%IX1.0	Werkstück bei Bandanfang / workpiece AT conveyor start
G1BG2	BIT	FALSE		%IX1.1	Werkstück bei Bandmitte / workpiece AT conveyor center
G1BG3	BIT	TRUE		%IX1.2	Werkstück bei Bandende / workpiece AT conveyor end
C2BG1	BIT	TRUE		%IX1.4	Schieber eingefahren / slide retracted
C2BG2	BIT	FALSE		%IX1.5	Schieber ausgefahren / slide extended
C2BG3	BIT	TRUE		%IX1.6	Magazin leer / magazine empty
SF1	BIT	FALSE		%IX2.0	Taster Start / Start button
SF2	BIT	TRUE		%IX2.1	Taster Stop (Öffner) / Stop Button (normally closed)
SF4	BIT	FALSE		%IX2.2	Schlüsselschalter Auto-Manuell / Key Switch auto-manual
SF3	BIT	FALSE		%IX2.3	Taster Richten / Reset button
SF5	BIT	TRUE		%IX2.5	Not Aus Schlagtaster / Emergency Stop
XD6	BIT	FALSE		%IX2.6	Folgestation belegt/ dwonstreamstation busy
XD7	BIT	FALSE		%IX2.7	Folgestation belegt/ dwonstreamstation busy
G1BF1_A1	BIT	FALSE		%QX0.0	Bandmotor vorwärts / Conveyor motor forward
G1BF1_A2	BIT	FALSE		%QX0.1	Bandmotor rückwärts / Conveyor motor backkwards
G1MB1	BIT	FALSE		%QX0.2	Vereinzler ausfahren / Extend separator
C2MB1	BIT	FALSE		%QX0.4	Schieber ausfahren / Extend slide
PF1	BIT	FALSE		%QX1.0	Leuchtmelder Start / Start indicator light
PF2	BIT	FALSE		%QX1.1	Leuchtmelder Reset / Reset indicator light
PF3	BIT	FALSE		%QX1.2	Leuchte Q1 / Indicator light Q1
PF4	BIT	FALSE		%QX1.3	Leuchte Q2 / Indicator light Q2
XD4	BIT	FALSE		%QX1.4	Station frei / Station free
indLightGn	BIT	FALSE		%QX1.5	Ampel grün / indicator lights green
indLightYe	BIT	FALSE		%QX1.6	Ampel gelb / indicator lights yellow
indLightRd	BIT	FALSE		%QX1.7	Apel rot / indicator lights red
xResetModules	BOOL	FALSE			Alle Module resetten / Reset all Moduls
xResetReadyMod...	BOOL	FALSE			Module 1 ist in reset Position / Modul 1 is in reset posisition
xResetReadyMod...	BOOL	FALSE			Module 2 ist in reset Position / Modul 2 is in reset posisition
xResetReadyMod...	BOOL	FALSE			Module 3 ist in reset Position / Modul 3 is in reset posisition
xEnAutoMM	BOOL	FALSE			Automatikmodus aktiv / Automode activated
xDeactivateModu...	BOOL	TRUE			
xProcessBusyMM	BOOL	FALSE			Station arbeitet / Station is busy
xResetReadyMM	BOOL	FALSE			Modul SeqTransport ist fertig / Modul SeqTransport is ready
xNextStationFree...	BOOL	FALSE			Nächste Station ist frei / Next Station is free
xReadyModSM	BOOL	FALSE			Modul ist fertig / Modul is ready
xStartModuleSM	BOOL	FALSE			Modul starten / Start modul
xInitModules	BOOL	FALSE			Moduel auf Inischritt setzten / Set moduls to init step
AlwaysTRUE	BOOL	TRUE			Immer true / Always true
AlwaysFALSE	BOOL	FALSE			Immer false / Always false
xErrorSignal1	BOOL	TRUE			Error Signal 1 / Error signal 1
xErrorSignal2	BOOL	FALSE			Error Signal 2 / Error signal 2
xErrorSignal3	BOOL	FALSE			Error Signal 3 / Error signal 3

Practical details and preparation

- Schedule: 2x 3-hour (2 hours supervised) labs during Weeks 3–4
- Location: Clough Engineering Centre (Engineering building 224)
- Groups of 3–4
- Preparation:
  - Download lab worksheet (LabA-Festo_Prelab&Instructions.pdf [1]) and do prelab using Festo PrelabDocumentation/ [2]
  - Review LabA-Festo_CODESYSBasics.pdf [3]
  - If possible, form groups before lab
  - Download CODESYS3.5.13.0.exe [4] and source code (Festo_Student.projectarchive [5]) and install CODESYS (1 computer per group)
    - Charge your laptops! Not many power points available in venue



week	cal-wk	week start	lectures A (2h)	lectures B (2h)	reading	project	lab prep.	lab	lab contents
1	8	22-Feb	Org., 0.Introduction	1. Automotive	Ch.1+26		--		---
2	9	1-Mar	2. Automation	3. Manipulators	Ch. 14		Automation		---
3	10	8-Mar	3. Manipulators	4.Driving Robots	8 – 13		--	A1	Automation
4	11	15-Mar	5. Kinematics	6. Walk + 7.AUV/UAV	Ch. 16		EyeSim	A2	Automation


Carpark 15
G12B
275 - EZONE Central
274 - Irwin Street Building
G35
James Oval
ward St
ns Institute
irway)
Engineering Lecture Theatre 1 G06
Seminar
Carpark 21
224 - Engineering - Civil & Mechanical
Eng Computer Lab
Car Pool Parking
Eng Mechanical Workshop G60
UWA Centre for Energy
242 - The CO2 Research Facility
219
Student Parking
Carpark 43
Wilsmore Lecture Theatre G108
4
3
2
1
MZ
1
B
453 - Indian Ocean Marine Research Centre
Student Parking
Fairway Entrance 4
Reserved Parking
211 - Bayliss Building
4311
238 - Myers Street Building
227 - Sanders Building
Bayliss 1st Yr Teaching Lab 115
mapbox
MazeMap
Myers St
Clough Engineering Student Centre
Link to this location

[1] http://robotics.ee.uwa.edu.au/courses/robotics/project/festo/LabA-Festo/LabA-Festo_Prelab&Instructions.pdf

[2] http://robotics.ee.uwa.edu.au/courses/robotics/project/festo/LabA-Festo/PrelabDocumentation/

[3] http://robotics.ee.uwa.edu.au/courses/robotics/project/festo/LabA-Festo/LabA-Festo_CODESYSBasics.pdf

[4] http://robotics.ee.uwa.edu.au/courses/robotics/project/festo/LabA-Festo/CODESYS3.5.13.0.exe

[5] http://robotics.ee.uwa.edu.au/courses/robotics/project/festo/LabA-Festo/Festo_Student.projectarchive