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Project Folder

Werkschulheim Felbertal Mechatronics

Service Robot Symposion

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1 Brief description

Symposion is a versatile transport robot that can maneuver autonomously through spaces, detect obstacles, and avoid collisions. Using a height-adjustable platform, it can pick up objects from a wide variety of processing stations and transport them further.

Transport robots play a crucial role in Industry 4.0. - Robots are suitable for all areas that are considered too dangerous, too dirty, or simply too monotonous for human workers. Given the ongoing shortage of skilled workers in many business areas, it is essential to automate monotonous and repetitive tasks so that human workers can focus their full attention on more creative and innovative tasks.

Conveyor belts may have contributed to the second industrial revolution, but they are simply too inflexible for today's fast-paced industry. The autonomous flexibility of Industry 4.0 promotes batch sizes of 1, which is why it is necessary to move away from rigid assembly line production and make both the processing stations and the transport between them as adaptable as possible. This is where transport robots come into play.

1.1 Intended use

As a universal transport robot with a height-adjustable platform, Symposion offers an extremely wide range of applications. However, special attention is paid to its didactic use.

On the one hand, Symposion enables the implementation of programming tasks in which a fully automated factory can be simulated together with other processing stations.

On the other hand, a special purpose is presentation at events and trade fairs. In conjunction with a robot gripping system, it can autonomously deliver drinks or flyers to visitors. In this way, it conveys the values of mechatronics and robotics in a playful manner and is a real eye-catcher at any event.

1.2 Technical data

Electrical specifications	
Supply voltage AC	220 - 240 V
Charging voltage DC	10.8 - 18 V
Power consumption DC (peak)	144 W
Operating voltage DC	24 V
Battery voltage	18 V
Battery capacity	5.2 Ah
Number of batteries	min. 1 max. 4
Battery technology	Li-ion
Dimensions	
Dimensions retracted (L x W x H)	450 x 450 x 970 mm ~ 17.7 x 17.7 x 38 in
Dimensions extended (L x W x H)	450 x 450 x 1250 mm ~ 17.7 x 17.7 x 49 in
Weight (unloaded)	30 kg / ~ 66 lbs
Platform specifications	
Platform load capacity	20 kg / ~ 44 lbs
Maximum platform travel speed	17.5 mm/s 0.7 in/s
Platform stroke	280 mm / 11 in
Driving behavior	
Distance detection on all sides	40 cm / ~ 15.7 in
Frontal distance detection	4 m / 13 ft
Maximum speed	200 mm/s ~ 7.9 in/s

1 : Technical data table

1.3 Cost estimate

Component / Assembly	**Cost**
Festo Robotino	€20,000
Sensors	€3,000
Platform and housing	€1,200
Linear axis	€500
Screen	€200
Sound system	€200
Basic electrical components (cables, plugs, emergency stop, lighting, etc.)	€150
Fastening materials	€50
Total	€25,300 (~ $29,700)

2 : Cost estimate

2 Operating instructions

2.1 Requirements for installation and operation

Before installation, ensure that all the components defined in sections 5.1 and 6.1 are present. Pay particular attention to safety components such as protective covers and distance sensors.

The robot is designed for use in event halls or laboratories. It should therefore only be used at standard room temperatures (10 to 30 °C / 50 to 86 °F). Any exposure to weather conditions such as rain or excessive heat should be avoided under all circumstances. The technical limits specified in section 1.2 must be strictly observed.

Contact with laypersons is permitted provided that the device does not show any damage or defects. However, it is essential that a qualified electrician checks the robot's safety compliance before any interaction with laypersons. Particular attention must be paid to the proper functioning of the protective covers and safety-related sensors.

The safety of the robot and all persons involved depends on careful compliance with these requirements and regular inspections by qualified personnel.

2.2 Device commissioning and use

1. Charging Symposion batteries

1 : Battery

Via Festool charging station; slide the batteries out of the slot and onto the charger.

2 : Robotino charging station

Via Robotino charging station; lift Robotino onto the charging station and ensure that the charging pins located in the lower front area of the robot are touching the contact surfaces of the charging station.

2. Pull out the emergency stop switch and press the on/off button for several seconds.

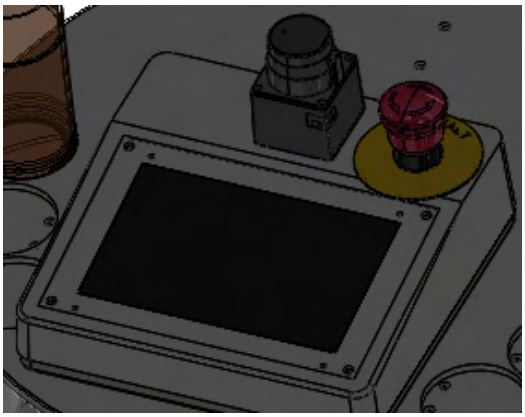


Figure3 : Touch panel

3. Select the desired operating mode via the touchscreen. Operating modes are listed in section 7.
   For a preview, see:
   https://www.figma.com/proto/IWKD7D1jYPG5CRBXiXjNHM/Symposion--EN-

4. Alternatively, log in to Symposion's Wi-Fi via an external device and open the web interface.

2.3 Equipment maintenance and cleaning

All safety-related equipment such as emergency stop switches, distance sensors, or protective covers should be checked weekly. A simple visual inspection of the housing and cables is sufficient for the weekly check.

The linear axis should be checked every six months and worn parts replaced as necessary. Particular attention should be paid to the spindle, nut, coupling, and drive platforms.

A complete mechanical and electrical inspection of the robot system should be carried out at least once a year. The above-mentioned inspection instructions should be followed, but a complete I/O check should also be carried out. Such an I/O check is available via the web interface in the "Debug" menu.

To maintain and clean the device, it is necessary to remove the protective covers of the robot. If possible, the platform should be moved to the highest possible position so that the inner covers can be removed without removing the outer cover. However, if this is not possible, the outer cover can be unscrewed and the robot lifted over the cover. The covers are mounted all around with hexagon socket screws. The inner cover consists of two parts, the outer cover of only one.

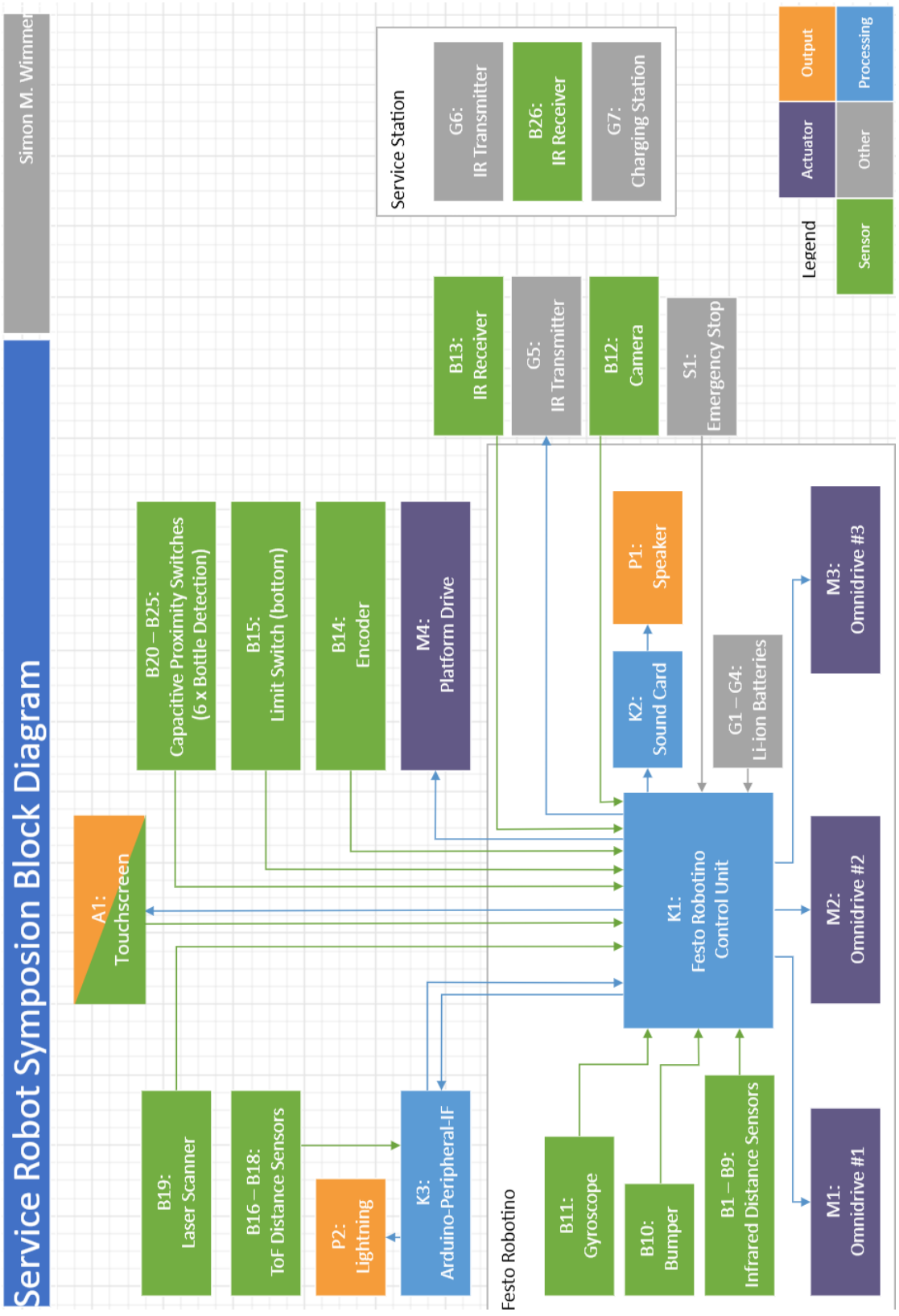
2.4 Possible errors and troubleshooting

Error	Cause	Potential Fix
Robot system does not start	Emergency stop activated Battery voltage too low	Check emergency stop switch Charge batteries
Platform height cannot be changed	Platform has been moved beyond its limits	Place platform back on spindle (thread of the spindle is cut at the limits)
Robotino does not recognize obstacles	The sensors' view is obstructed or cables are loose	Clean the sensors and check the cables
Communication with service station is not working	Infrared transmitter is dirty or receiver sensitivity is too low	Clean the transmitter and increase the sensitivity of the receiver.
Sensor signal cannot be received	Cable is loose	Check the cable guides inside Symposion

3 : Possible errors

3 Technical description

3.1 Block Diagram



4 illustration: Technical block diagram

3.1.1 Description of the components and their interaction

BMK	Component	Description
K1	Festo Robotino control unit	Central processing unit of the robot system. All other components are connected to it. It has a wide variety of inputs and outputs (DI, DO, relays, analog inputs, USB, etc.). Logical voltage 24V.
K2	Sound card	Connected to K1 via USB. Features a sound driver and an AUX input and output.
K3	Arduino peripheral IF	Interface board with Arduino Nano. The IF board is used to control 5V sensors (B16 – B18) and lighting (P2). The Arduino communicates with K1.
M1 – M3	Omnidrive	Integrated drive motors of the Robotino for omnidirectional movement of the robot.
M4	Platform drive	Drive motor for the height-adjustable platform.
S1	Emergency stop	Emergency stop switch that deactivates the motor outputs.
G1 – G4	Li-ion batteries	Power supply for K1. 18 V
G5 – G6	Infrared transmitter	For simple communication (1 bit) with the service station.
G4	Charging station	Station to which the robot can dock for autonomous charging. Equipped with a marker for precise positioning via an RGBD camera.
B1 – B9	Infrared distance sensors	Attached to the robot in a ring shape at floor level to detect obstacles at short distances (< 40 cm / 15.7 in). Permanently integrated into Robotino.
B10	Bumper	Detects collisions in the event of a malfunction of the distance sensors. Permanently integrated into Robotino.
B11	Gyroscope	For precise positioning of the robot. Factory-installed into Robotino.
B12	Camera	RGBD camera for transmitting live images and for obstacle and object detection.
B13, B26	Infrared receiver	In combination with the infrared transmitters (G2 and G3), they are used for easy communication with a service station.
B14	Encoder	For measuring the angular position of the platform drive (M4) and thus determining the height of the platform. Connected to the encoder input of K1.
B15	Limit switch	For referencing the platform's linear axis.
B16 – B18	ToF distance sensors	For long-range obstacle detection (4 m / 13 ft) in the front area. The ToF sensor operates with logical 5V signals, which is why it is processed by the Arduino (K3) and the signal is forwarded to K1.
B19	Laser scanner	Mounted on the height-adjustable platform for comprehensive obstacle detection in the room.
B20 – B25	Capacitive proximity switches	Mounted under the bottle storage positions on the platform to check for the presence of bottles.
P	Speaker	For acoustic transmission of information messages (e.g., to service personnel). Connected to the sound card (K2).
P2	Light	RGB lighting for better visibility of the robot. Controlled via the Arduino (K3).
A1	Touch	A touchscreen is mounted on the platform to allow interaction with the robot and to display information.

4 Table: Description of components

3.2 Technical dimensions of key components

3.2.1 K1: Festo Robotino v4 control unit

Number	Interface	Detailed information
1	RJ-45	
2	USB 2.0	
4	USB 3.0	
2	12V WAGO	max. 2 A total
2	PCI Express slots	Limited installation space
8	Digital input	Logic voltage 24 V Protected against overload
8	Digital output	24 V short-circuit proof max 1 A per output max. 2 A total
8	Analog input	0–10 V, 50 Hz
13	Power supply	total max. 3 A 24 V
2	Relay	24 V
1	Motor power connector	with H-bridge and PWM control 24 V max 5 A
1	Encoder input	5V 2-channel

5 table: Technical dimensions Robotino v4

Parameters	Value
Operating system	Linux Ubuntu
Processor	Intel i5 8th Gen 2.5–4.2 GHz clock speed 4 physical cores with hyperthreading
Memory	8 GB RAM
Hard drive	64 GB SSD
Motor control	32-bit microcontroller

6 : Robotino v4 Control Specifications

3.2.2 K3: Arduino Peripheral IF

Param	Value
Processor	ATmega328P 16 MHz clock rate
Logic voltage	5V
Flash memory	32 KB
Working memory	2 KB SRAM
Power consumption	19 mA

7 : Arduino Nano Specifications

Number	Interface	Detailed information
14	Digital Input/Output	6 x PWM capable (8-bit) 20 mA per I/O pin Total max. 200 mA UART: D0 (RX) D1 (TX) SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK) I2C: A4 (SDA) A5 (SCL)
8	Analog input	0–5 V, 10-bit resolution
1	Power supply	5 V max. 400 mA during USB operation

8 : Arduino Nano Pinout

3.2.3 M4 – Platform drive

Performance specifications: Speed (v) at least 5 mm/s.

Platform load capacity max. 20 kg + platform approx. 2 kg corresponds to approx. 220 N.

Critical buckling force of the spindle (approximation):

Physical Quantity	Symbol	Value
Force	F	220 N
Safety factor	γ	3
Length	L	670 mm
Modulus of elasticity	E	$210{,}000 N/mm^2$ (C15 steel)

Table9 : Buckling force calculation

$$I\ [mm^4] = \frac{F[N] \times \gamma[1] \times (L[mm] \times 2)^2}{\pi^2 \times E[N/mm^2]} = \frac{220 \times 3 \times (670 \times 2)^2}{\pi^2 \times 210.000} \approx 572 mm^4$$

$$d[mm] = \sqrt[4]{\frac{I[mm^4] \times 64}{\pi}} = \sqrt[4]{\frac{572 \times 64}{\pi}} \approx 10{,}4\ mm$$

Rotational frequency:

Trapezoidal thread spindle 12 mm diameter with a pitch (p) of 3 mm

$$n = \frac{v}{p} = \frac{5\ mm/s}{3\ mm} = 1{,}\dot{6}\ rps \times 60 = 100\ rpm$$

Torque:

$$M = \frac{F\ [kN] \times P\ [mm]}{2 \times \pi \times \eta_{thread}} = \frac{0{,}22\ kN\ \times 3\ mm}{2 \times \pi \times 0{,}7} \approx 0{,}15\ Nm$$

Safety factor 3 approx. 0.45 Nm

Result:

Speed at least 100 rpm and torque at least 0.45 Nm.

Igus MOT-DC-43-J-H-H has a rated speed of 350 rpm and a rated torque of 0.75 Nm. No-load current 0.7 A. Rated current 1.9 A.

3.2.4 B15: Limit switch

Inductive proximity switch with PNP output NO
12 to 24 V operating voltage
Detection range 30 mm

3.2.5 B16 – B18: ToF distance sensors

5V logic voltage – communication via I²C
27° field of view divided into 4x4 zones
Max. 400 cm detection range
50 Hz maximum sampling frequency

3.2.6 B20 – B25: Capacitive proximity switches

10–30 V operating voltage with overvoltage and reverse polarity protection
8 mm detection range with adjustment range from 0 to 6.48 mm
PNP NO output
Hysteresis 3 to 20%

4 Project management

4.1 Goal definition

Objectives		
1	Technically correct execution.	☐
2	Compliance with safety regulations in accordance with Machinery Directive 2006/42/EC.	☐
3	The parking platform is electrically height-adjustable and can be used in a height range from a minimum height of at least 85 cm to a maximum height of at least 110 cm (~ 33.5 to 43 in).	☐
4	The parking platform extends and retracts at a speed of at least 5 mm/s (~ 0.2 in).	☐
5	The robot can autonomously travel a route through a room using programmable reference points.	☐
6	The robot detects obstacles within a radius of at least 0.3 meters (~ 12 in) around it and takes steps to avoid a collision.	☐
7	The robot detects obstacles in front of it within a radius of at least 0.6 m (~ 23.6 in).	☐
8	The robot autonomously finds its way back to its base station from its route. It approaches the designated base station with an accuracy of at least +- 1 cm (0.4 in).	☐
9	The robot can hold at least six Vichy bottles (standard 0.33 l beverage bottles).	☐
10	The robot detects the presence of bottles on its designated bottle storage positions.	☐
11	When the robot detects that it no longer has any bottles loaded, it automatically returns to its base station.	☐
12	The robot can emit acoustic messages to inform staff about service requirements, for example.	☐
13	The robot is illuminated to draw attention to its presence.	☐
14	Information such as welcome messages or logos can be displayed on a screen.	☐
15	The robot has a bidirectional communication interface (transmission rate of at least 1 bit) that it can use to exchange data with another station.	☐
Optional targets		
1	The Vichy bottles can be automatically picked up by a pick-up system at the base station.	☐
2	Different types of beverages can be picked up depending on the software selection.	☐

3	Beverage selection can also be made via a mobile phone application.	☐
4	In addition to the basic beverage service mode, in which the robot travels along a defined route and passersby can take beverages from it, there is also a second mode in which the robot delivers beverages to a fixed location upon request.	☐
5	The beverage selection can also be made via voice control.	☐
6	Empty beverage bottles can be placed on the robot, where they are autonomously removed by the bottle collection system.	☐
7	The robot's lighting is multicolored and can play light scenarios for aesthetic enhancement.	☐
8	The robot can distinguish between people and objects as obstacles and decide accordingly whether to stop for a person or drive around an object.	☐
Not-in-scope		
1	The robot cools the drinks it picks up.	
2	The robot can handle inclines of more than three degrees.	

Table10 : Goals

4.2 Description of work packages

Date	PSP	Title	Content	Result
9/19/2023	1.1.2	Controlling	Ongoing controlling of project work.	The technically correct, scheduled, and high-quality implementation of the project is ensured.
9/20/2023	1.2.1	Draft description	Brief description of the project result.	Description that explains the project and can be published.
09/20/2023	1.2.2	Define areas of application	Define the areas of application for the robot system.	A clearly defined area of application for the robot is defined.
09/20/2023	1.2.3	Define objectives	Creation of all relevant objectives for the project.	A list of mandatory, optional, and non-goals that can be used to evaluate the success of the project.
09/20/2023	1.2.4	Calculate cost estimate	Rough total cost estimate for the project, based on non-binding quotes and planned components.	A cost estimate for the project and all its components.
10/3/2023	1.3.1	Draw a block diagram	Define all assemblies in a block diagram.	Block diagram that can be used to start further technical planning of the project.
10/10/2023	1.1.3	Coordination	Creation of the project management plan: 1. Definition of work packages 2. Scheduling of work packages 3. Project environment analysis 4. Defining milestones	The project structure plan is available and sufficiently detailed to ensure successful implementation of the project.
10/11/2023	1.3.2	Define electrical components	Specific electrical components are selected based on the objectives and the block diagram.	A list of specific components and suppliers for all components defined in the block diagram.
10/18/2023	1.3.3	Creating electrical plans	Drawing of the electrical documentation for the project: 1. Circuit diagram 2. Cable diagram 3. Circuit board design	Standard-compliant execution of: 1. Circuit diagram 2. Cable diagram 3. Circuit board design
11/7/2023	1.3.4	Designing electrical components	CAD files for all electrical components are obtained from suppliers or designed in-house.	All CAD files for the defined electrical components are available.
11/08/2023	1.3.5	Designing the linear axis	The assembly of the linear drive for the height-adjustable platform is designed.	A CAD assembly that can be used to build the linear drive system.

11/21/2023	1.3.6	Creating a software concept	1. Description of the software functions 2. Create flowchart and/or state diagram 3. Define the design of the graphical user interface	Document with concept information about the software, including flowchart and/or state diagram, as well as a prototype of the graphical user interface.
11/28/2023	1.3.7	Set up test structures	1. Evaluate sensors 2. Test setup of the linear drive	All existing sensor and actuator components are functional and test programs for control exist.
12/6/2023	1.3.8	Designing the housing	The outer covers of the robot system are being designed.	CAD file with which the housing can be produced.
12/11/2023	1.3.9	Designing the overall assembly	Design of a complete assembly containing all sub-systems of the robot structure.	CAD assembly of the entire robot system is available.
12/12/2023	1.3.10	Prepare technical drawings	1. Assembly drawing of the entire robot system 2. Assembly drawing of the platform drive 3. Workshop drawing of motor console	The assembly and workshop drawings are produced in accordance with standards.
12/13/2023	1.3.11	Write operating instructions	The operating instructions for the transport robot are being written.	The operating manual includes sections on: 1. Installation and operation 2. Maintenance and cleaning 3. Possible errors and troubleshooting
12/14/2023	1.3.12	Complete project folder	All remaining sections of the project folder are completed in accordance with the requirements.	The project folder is completed and all information relevant to the implementation of the project is available.
2/20/2024	1.4.1	Manufacture the engine console	1. Milling out the motor console 2. Bend sheet metal 3. Mount on Robotino	The platform drive motor is mounted on Robotino.
2/20/2024	1.5.1	Assemble Arduino peripheral IF	1. Check components 2. Assemble circuit board 3. Visual inspection 4. Continuity test 5. Function test	The lighting control system is functional and ready for installation on the Robotino.
2/20/2024	1.4.2	Manufacture controller platform	1. Milling the controller platform 2. Bend sheet metal 3. Mount on Robotino	The controller platform is mounted on Robotino.
2/23/2024	1.6.1	Controlling the linear axis	Code a control script for Robotino.	The linear axis can be controlled via software on the Robotino.
2/28/2024	1.4.3	Manufacturing the ELS mount	1. Milling the ELS bracket 2. Bend sheet metal 3. Mount on Robotino	ELS bracket is mounted on Robotino.

2/28/2024	1.4.4	Manufacture connection brackets	1. Milling connection brackets 2. Bend sheet metal 3. Mounting the lower bracket on Robotino	Both connection brackets have been produced and the lower one has been attached to Robotino.
3/4/2024	1.5.2	Wiring the distance sensor	Wire additional distance sensors to Robotino electronics.	The additional distance sensors are ready for use.
3/4/2024	1.5.3	Wiring the communication interface	Wiring the communication interface.	The communication interface between Robotino and another station is ready for use.
3/4/2024	1.4.5	Manufacturing the sensor housing	1. 3D printing of distance sensor housing 2. Dual-sensor housing 3D printing 3. Attaching to the controller platform	The sensor housings are attached to Robotino's controller platform.
3/6/2024	1.5.4	Wire the linear axis	Wire the motor and position encoder to the Robotino electronics.	The linear axis is ready for use.
3/6/2024	1.4.6	Milling the driver platforms	1. Mill out the lower carrier platform 2. Milling out the upper driver platform	The driver platforms have been milled out.
3/11/2024	1.4.7	Cut aluminum profiles to size	1. Cutting camera stands to size 2. Cutting the lifting profiles to size 3. Cut the required threads 4. Attach camera stand to controller platform	The aluminum profiles required for the camera stand and linear axis have been cut to size and the camera stand has been assembled.
3/13/2024	1.4.9	Assemble the linear axis	1. Install spindle 2. Assemble guide 3. Attach linear axis	Linear axis is attached to the Robotino.
3/13/2024	1.4.8	Cut off the threads the spindle ends	Cut off the thread of the spindle at the planned points.	Spindle is ready for installation.
3/20/2024	1.5.5	Wire the platform	1. Emergency stop switch 2. On/off switch 3. Capacitive proximity switches 4. Touchscreen	All components located on the platform are wired.
3/20/2024	1.4.10	Attaching the platform	1. Milling out the platform 2. Attach platform to linear axis 3. Attach sensors to platform	Platform is fixed on linear axis.
3/23/2024	1.6.2	Evaluate distance sensor	Code script to retrieve distance sensor measurements.	The distance sensors' measurements can be retrieved by the Robotino.
4/10/2024	1.4.11	Mounting the control panel	1. Milling the front panel 2. Mounting the components of the	Control panel is mounted on platform and fully equipped.

			control panel 3. Mounting the control panel on the platform	
4/17/2024	1.5.6	Installing the sound module	Install sound module.	Sound module is ready for use.
4/17/2024	1.4.12	Mounting the speaker and LED strip	1. Mounting the speaker 2. Mounting the LED strip	The speaker and LED strips are attached to the Robotino.
4/22/2024	1.5.7	Wiring the speaker	1. Wiring the speaker to the sound output 2. Testing the sound system	Robotino's sound system is usable.
4/22/2024	1.5.8	Wire the LED strip	Wire the LED strip to K3	LED strip is ready for use.
4/23/2024	1.6.3	Programming the communication interface	Programming communication exchange between Robotino and an external station.	Data communication between Robotino and an external system can take place.
4/30/2024	1.6.4	Programming the autonomous route driving mode	1. Approaching positions 2. Option to program positions 3. Alignment at the base station	Positions in the room can be programmed into the robot, to which it can then navigate autonomously. Once it has completed its route, it finds its way back to its base station.
5/22/2024	1.6.5	Programming the graphical user interface	1. Program development in accordance with program design 2. Installation 3. Testing	The graphical user interface of the Robotino is displayed on a screen.
6/9/2024	1.6.6	Installing sound files	Install the required sound files on Robotino.	The Robotino's sound system is fully operational.
6/21/2024	1.7.1	I/O tests	All inputs and outputs of the various control units (K1, K2, and K3) are thoroughly tested. Cables are checked for functionality.	The robot is fully functional electrically.
6/23/2024	1.7.2	Assemble housing	Assembly of the outer housing.	The outer housing is mounted on the Robotino.
6/25/2024	1.7.3	Installing and preparing the software	Installing the route driving mode and the graphical user interface.	All programs necessary for using the robot system are installed on the Robotino.
6/27/2024	1.7.4	Create test program	Create a test program to demonstrate the autonomous route driving mode.	A test program for testing the desired goals is available.

Table11 : Work packages

4.3 Gantt chart

Bar chart (GANNT)

		19. 9.	26. 9.	3. 10.	10. 10.	17. 10.	24. 10.	31. 10.	7. 11.	14. 11.	21. 11.	28. 11.	5. 12.	12. 12.	19. 12.	26. 12.	2. 1.	9. 1.	16. 1.	23. 1.	30. 1.	6. 2.	13. 2.	20. 2.	27. 2.	5. 3.	12. 3.	19. 3.	26. 3.	2. 4.	9. 4.	16. 4.	23. 4.	30. 4.	7. 5.	14. 5.	21. 5.	28. 5.	4. 6.	11. 6.	18. 6.	25. 6.
1	**Service robot Sy...**																																								
1.1	**Project management**																																								
1.1.1	Project started																																								
1.1.2	Controlling																																								
1.1.3	Coordination																																								
1.1.4	Completion of all...																																								
1.1.5	Project completed...																																								
1.2	**Definition phase**																																								
1.2.1	Description available...																																								
1.2.2	Areas of application...																																								
1.2.3	Defining goals																																								
1.2.4	Cost estimate...																																								
1.2.5	Project approval																																								
1.3	**Concept phase**																																								
1.3.1	Block diagram z...																																								
1.3.2	Electrical components...																																								
1.3.3	Electrical plans...																																								
1.3.4	Electrical components...																																								
1.3.5	Linear axis const...																																								
1.3.6	Software concept...																																								
1.3.7	Test setups on...																																								
1.3.8	Designing the housing																																								
1.3.9	Complete assembly k...																																								
1.3.10	Technical drawing...																																								
1.3.11	Operating instructions...																																								
1.3.12	Project folder complete...																																								
1.3.13	Submission of project folder																																								
1.4	**Mechanical preparation...**																																								
1.4.1	Motor console...																																								
1.4.2	Controller platform...																																								

1.4.3	ELS mount...	
1.4.4	Connection bracket...	
1.4.5	Sensor housing here...	
1.4.6	Drive platform...	
1.4.7	Cut aluminum profiles...	
1.4.8	Spindle turning	
1.4.9	Assemble linear axis...	
1.4.10	Attaching the platform	
1.4.11	Mounting the control panel	
1.4.12	Speakers and ...	
1.4.13	Mechanical connection...	
1.5	**Electrical preparations...**	
1.5.1	Arduino peripherals...	
1.5.2	Distance sensor ve...	
1.5.3	Communication...	
1.5.4	Linear axis sold...	
1.5.5	Platform wiring...	
1.5.6	Install sound module	
1.5.7	Connecting the speakers...	
1.5.8	Wiring the LED strip	
1.5.9	Electrical connection...	
1.6	**Software preparation**	
1.6.1	Connecting the linear axis...	
1.6.2	Distance sensor off...	
1.6.3	Communication chip...	
1.6.4	Autonomous routing...	
1.6.5	Graphical interface...	
1.6.6	Sound files inst...	
1.6.7	Completing the software...	
1.7	**Examination papers**	
1.7.1	I/O tests	
1.7.2	Mounting the housing	
1.7.3	Installing software...	
1.7.4	Test program first...	
1.7.5	Project completed...	

4.4 Project environment analysis

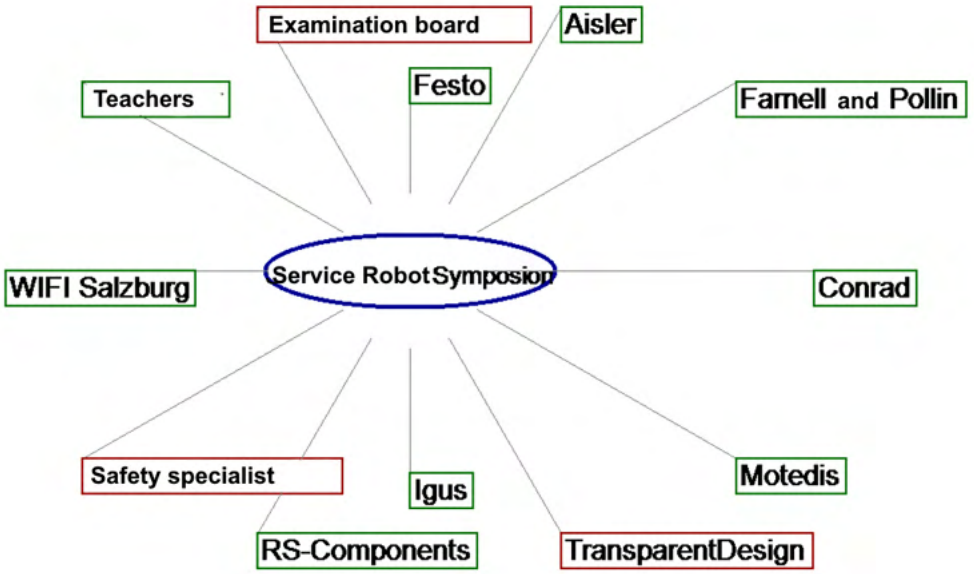


Figure5 : Project environment

Environment	Evaluation	Relationship	Action
WIFI Salzburg	supportive	Project client	satisfy
Teaching staff	supportive	Project controlling and support	exchange information
Examination board	critical	Evaluated Project implementation	satisfy
Safety specialist	critical	Monitors compliance with safety measures	satisfy
Aisler	neutral	Supplier	control
Conrad	neutral	Supplier	control
Farnell	neutral	Supplier	control
Festo	neutral	Supplier	control
Igus	neutral	Supplier	control
Motedis	neutral	Supplier	control
TransparentDesign	critical	Supplier which is difficult to replace	control
Pollin	Neutral	Supplier	control
RS Components	neutral	Supplier	control

12 table: Project environment

4.5 Risk

Risk analysis for all work packages. The work packages can be found by referring to the entries in section 4.2.

		Mechanical preliminary work (1.4.x)			
Probability	frequent				
	probable				
	occasional				
	remotely conceivable				
	unlikely				2
	unimaginable	12	11	1, 3, 4, 5	6, 7, 8, 9, 10
		insignificant	minor	critical	catastrophic
		Impact			

		Electrical preparatory work (1.5.x)			
Probability	frequent				
	probable				
	occasional				
	remotely conceivable				
	unlikely				
	unimaginable	6, 7, 8	3	1, 2	4, 5
		insignificant	minor	critical	catastrophic
		Impact			

		Software preparatory work (1.6.x)			
Probability	frequent				
	probable				
	occasional				
	remotely conceivable				4
	unlikely				5
	inconceivable	6	3	2	1
		insignificant	minor	critical	catastrophic
		Impact			

		Examination papers (1.7.x)			
Probability	frequent				
	probable				
	occasional				
	remotely conceivable				2
	unlikely				4
	inconceivable				1, 3
		insignificant	minor	critical	catastrophic
		Impact			

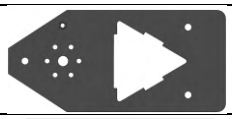
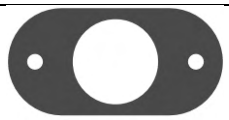
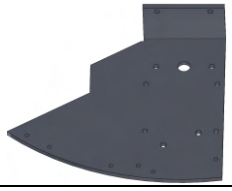
Table13 : Risk analyses

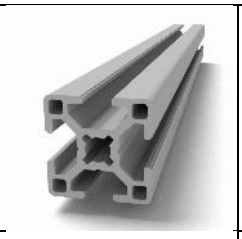
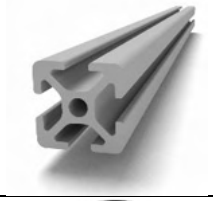
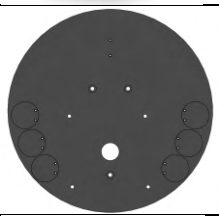
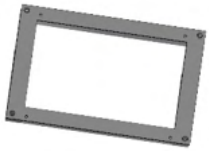
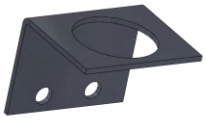
AP	Title	Prevention
1.4.2	Manufacture controller platform	Consultation with machine builders to evaluate the mechanical design.
1.6.4	Programming the autonomous route driving mode	Consultation and regular feedback loops with robotics experts (Lukas Födinger).
1.6.5	Programming the graphical user interface	Consult software experts (Robert Mutter).
1.7.2	Assemble housing	Outsourcing housing production to an external service provider.
1.7.4	Creating test program	Consultation and regular feedback loops with software and robotics experts (Lukas Födinger and Robert Mutter).

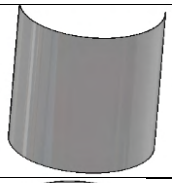
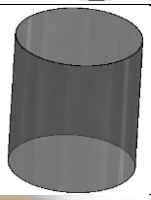
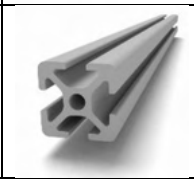
Table14 : Risk mitigation measures

5 Technical description of mechanics

5.1 Bill of materials for mechanical components

Item no.	Part name	Illustration	Qty.	Description	Supplier Order no.	Total price [€]
101	Spindle		1	Trapezoidal thread Diameter: 12 mm Pitch: 3 mm Length: 670 mm Material: C15 steel	Igus; PTGSG-12X3-01-R	11.22
102	Lead screw nut		1	with flange max. 2,309 N static 48 mm outer diameter	Igus; JFRM-2835TR12X3	15.18
103	Carrier platform (bottom)		1	Milling part POM 9 mm 120x260x9 mm	In-house production	21.84
104	Carrier platform (top)		1	Milled part POM 9 mm 120x260x9 mm	In-house production	21.84
105	Motor console		1	Aluminum bent part 60x106x2 mm	In-house production	1.89
106	Thrust bearing			Static 200 N Dynamic 250 N Maximum 600 rpm Inner: 10 mm Outer: 24 mm Height: 9 mm	Igus; BB-51100-B180-ES	9.42
107	Bearing flange		1	Milled part POM 9 – 60x30 mm Bore 23.8 mm	In-house production	0.48
108	Shaft coupling		1	Claw coupling vibration-damping pluggable max. 15,000 rpm Inner: 8 / 10 mm Outside: 25 mm Height: 26 mm	Igus; COU-AR-K-080-100-25-26-B-AAAA	41
109	Motor shaft		1	Pluggable motor shaft DIN 5481 7x8	Igus; NOR-22301	16.73
110	Controller platform		1	Bending part Aluminum 4 mm 200x200 mm	In-house production	16.02

111	Lift profile			Aluminum profile 30x30 B-type Length 470 mm	Motedis; 30x30 B-type groove 8	11.67
112	Cable drag chain		75	3D energy chain Diameter: 60 mm Cables: 3x20.5 mm Bending radius 87 mm Cables are pressed in	Igus; TRL.60.087.0	103.50
113	Distance sensor housing		2	3D printed part 30x12x40 mm	In-house production	2
114	Communicator combo housing		1	3D printed part 60x12x40 mm	In-house production	1.50
115	Camera stand		1	Aluminum profile 20x20 I-type Length 100 mm	Motedis; 20x20 I-type groove 5	0.51
116	Platform		1	Milled part Black MDF 19 mm Diameter 470 mm	In-house production	15.00
117	Display housing		1	Combination console housing ABS (UL 94 HB) 228x216x76	Farnell; 775113	70.72
118	Front panel		1	Milled part Polystyrene 1.5 mm 130x200 mm	In-house production	2.94
119	ELS mount		1	Bending part Aluminum 2 mm 74.8x47.2 mm	In-house production	1.11
120	Connection element energy chain (bottom)		1	85x80x37 mm with short strain relief	Igus; TL.60.01.Z1	9.83

121	Connection element energy chain (top)		1	85x80x37 mm without strain relief	Igus; TL.60.01.Z0	9.47
122	Connection bracket (bottom)		1	Bend piece Aluminum 2 mm 220x65 mm	In-house production	4.35
123	Connection angle		4	Galvanized aluminum angle bracket 30x30x30 mm M6	Motedis; BR30STS	4.96
124	Inner front cover		1	Silver polystyrene 1.5 mm 810x500 mm Radius 225 mm	In-house production	40.50
125	Inner rear cover		1	Silver polystyrene 1.5 mm 710x500 mm Radius 225 mm Height 500 mm	In-house production	35.50
126	Outer cover		1	Acrylic glass 3 mm Cylinder Outer diameter 460 mm Height 570 mm	Transparent Design; custom-made	610
127	Felt glides		1	Can be cut to any size Thickness 3 mm	Pollin; 490029	2.28
128	T-Slot nut		4	for 30x30 B-type with spring M6	Motedis; S8BSSNM6	2.00
129	Platform stabilizer		1	Aluminum profile 20x20 I-type Length 90.5 mm	Motedis; 20x20 I-type groove 5	0.46
Total (including VAT):						1,084.02

15 table: Parts list of all mechanical components

5.2 General Arrangement Drawing

001_Overall assembly_ZUS

SYM-001-03

5.3 Assembly drawing: Mechanical axis

002_Linear_axis_assembly_ZUS

SYM-002-03

5.4 Assembly drawing: Control panel

003_Control_panel_assembly_ZUS

SYM-003-02

5.5 Assembly drawing: Controller platform

004_Controller platform assembly_ZUS

SYM-004-03

5.6 Assembly drawing: Platform

005_Platform assembly_ZUS

SYM-005-01

5.7 Assembly drawing: Carriage

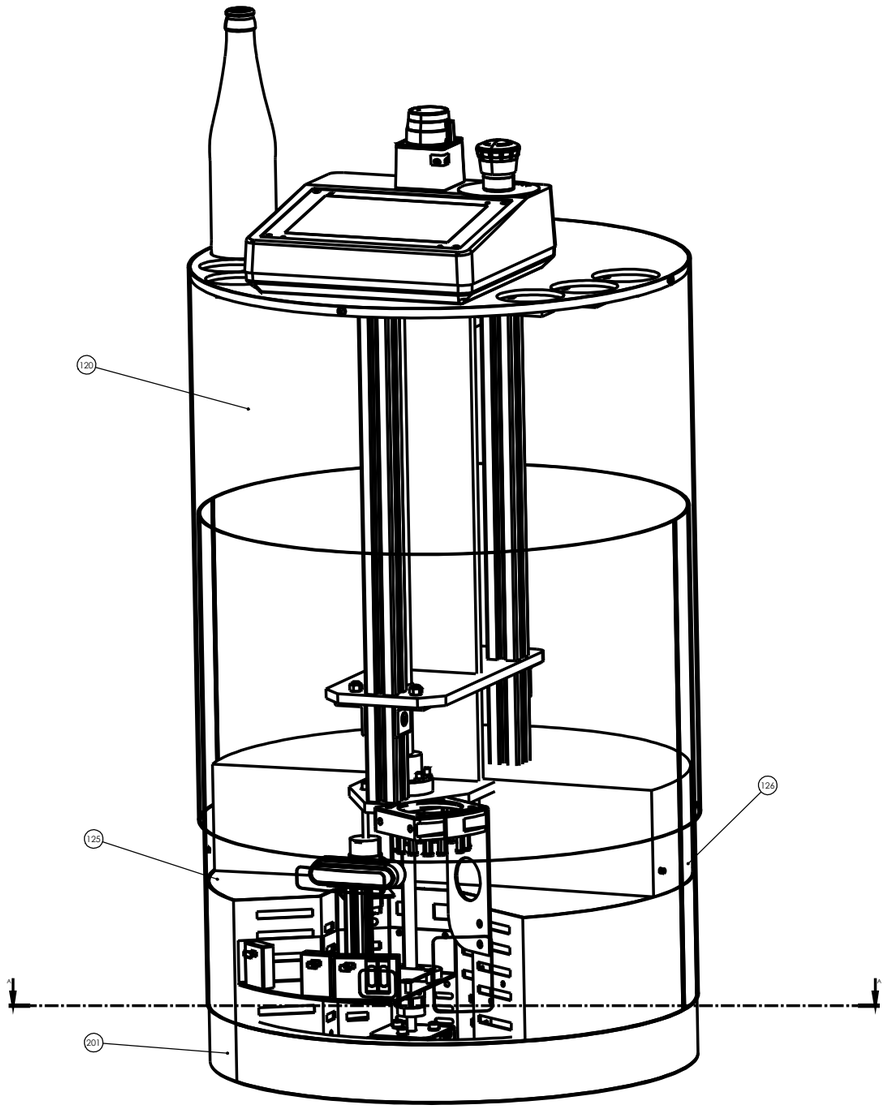
006_Carriage_ZUS

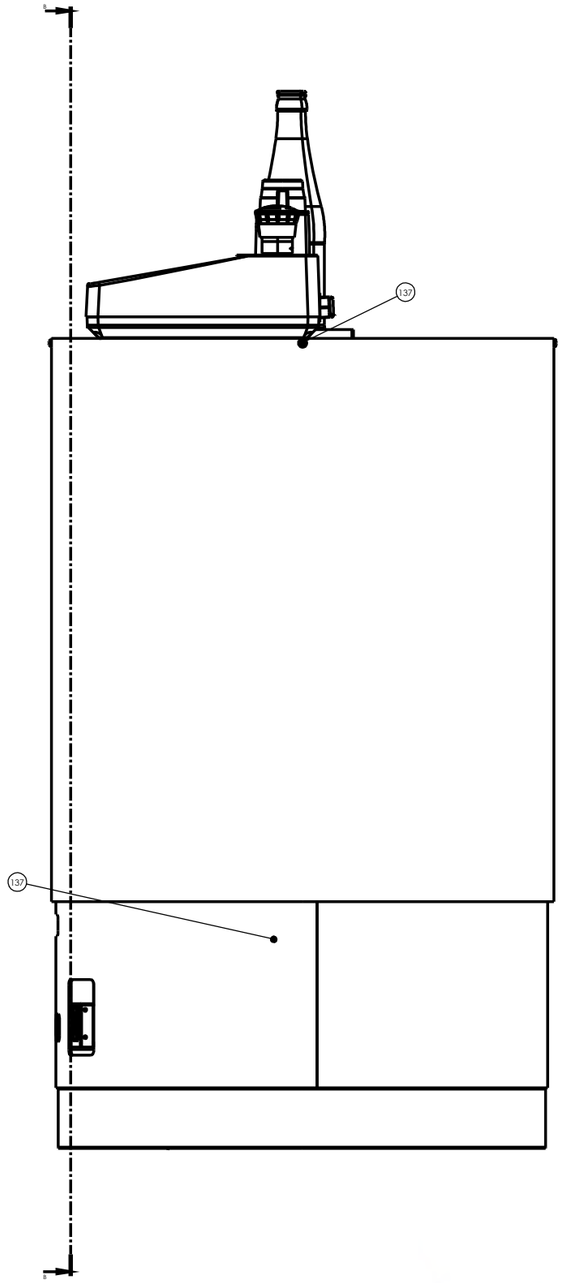
SYM-006-02

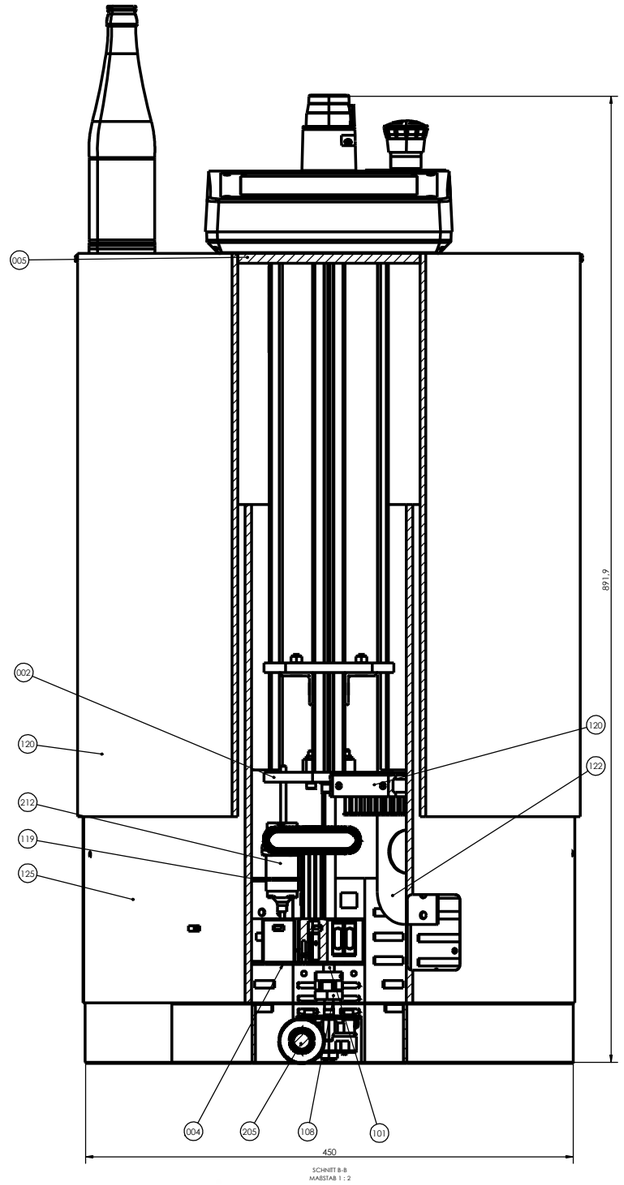
5.8 Production drawing: Motor console

105_Engine console_WZ

SYM-105-02







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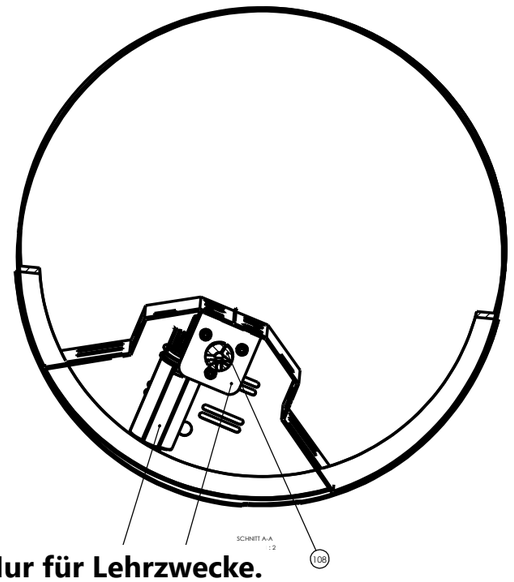

SCHNITT A-A
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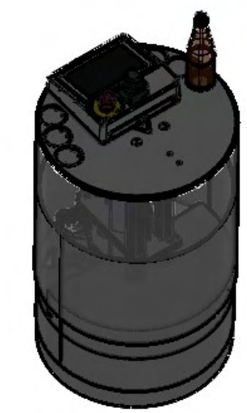

POS-NR.	BENENNUNG	BESCHREIBUNG	MENGE
002	Linearachse	SYM-002-xx	1
004	Controller-Plattform	SYM-004-xx	1
005	Plattform	SYM-005-xx	1
101	Spindel	Igus: PTGSG-12X3-01-R	1
105	Motorkonsole	Biegeteil Aluminium 2 mm	1
108	Wellenkupplung	Igus: COU-AR-K-080-100-25-26-B-AAAA	1
109	Motorwelle	DIN 5481 7x8	1
119	ELS-Halterung	Aluminium Biegeteil 2 mm	1
120	Anschlusselement Energiekette unten	Igus: TL.60.01.Z1	1
121	Anschlusselement Energiekette oben	Igus: TL.60.01.Z0	1
122	Anschlusshalterung unten	Biegeteil Aluminium 2 mm	1
123	Anschlusshalterung oben	Biegeteil Aluminium 2 mm	1
125	Innenabdeckung vorne	PETG Opal 2 mm Radius 225 mm	1
126	Innenabdeckung hinten	PETG Opal 2 mm Radius 225 mm	1
120	Außenabdeckung	PETG Opal 2 mm Durchmesser 264 mm	1
201	Festo Robotino Steuerungseinheit	Festo: 8101344	1
205	Plattformantrieb	Igus: MOT-DC-42-J-H-H	1
212	Endlagenschalter	RS-Components: 805-4888	1

	Datum	Name	Klasse:	Abteilung:	Schuljahr:	Werkschulheim Felbertal Ebenau
Gezeichnet	2024-2024	simon	BB	Mechatronik	2023/2024	
Geprüft:			Name:			
Kompetenz:			Simon M. Wimmer			
Maßstab: 1:2	Benennung: Symposion					Zeichnungsnummer: SYM-001-03
DIN EN ISO 2768 mittel						Ausgabedatum: Dienstag, 20. Februar 2024 19:02:38
						Ersatz für:
						Ersetzt durch:

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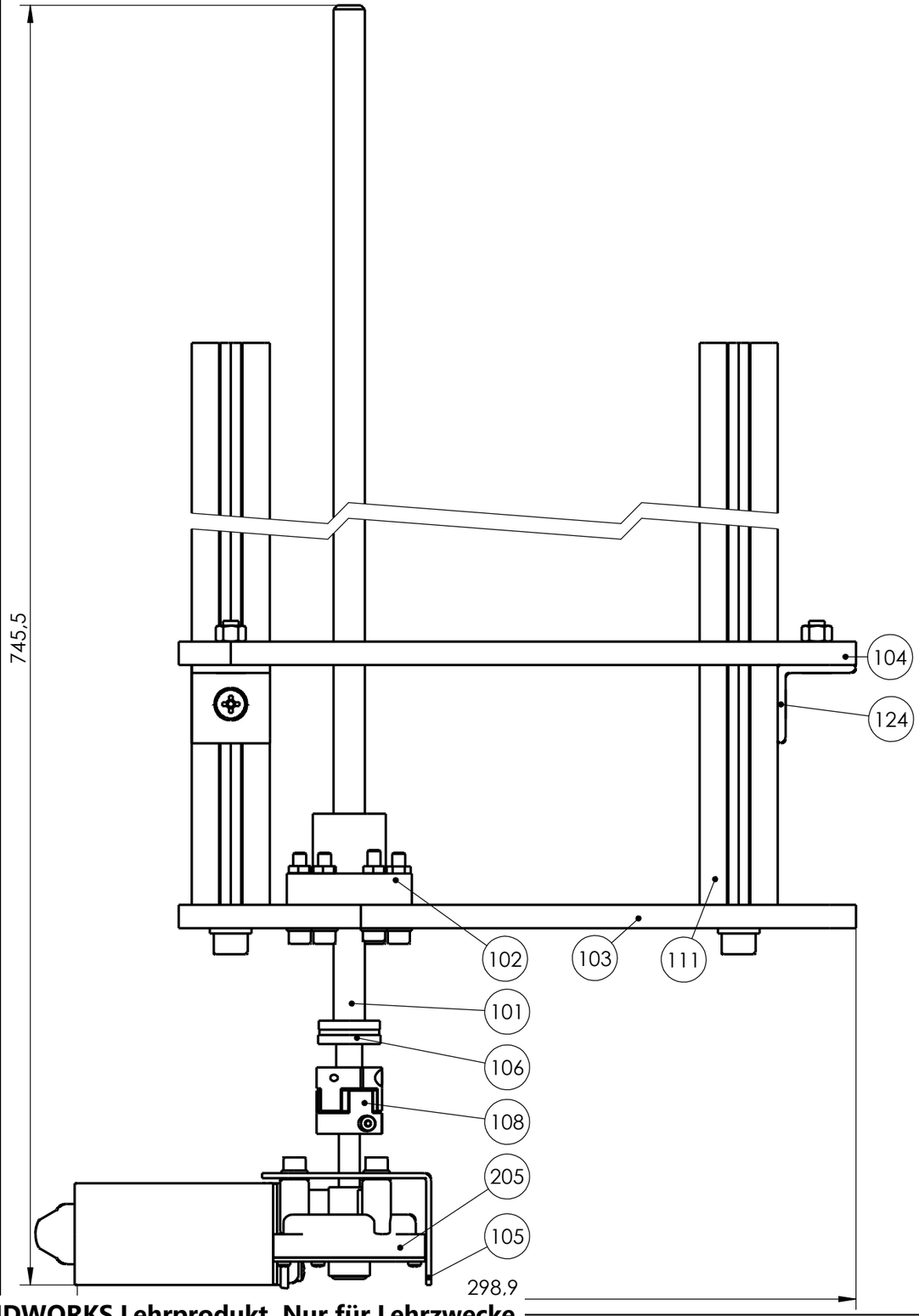

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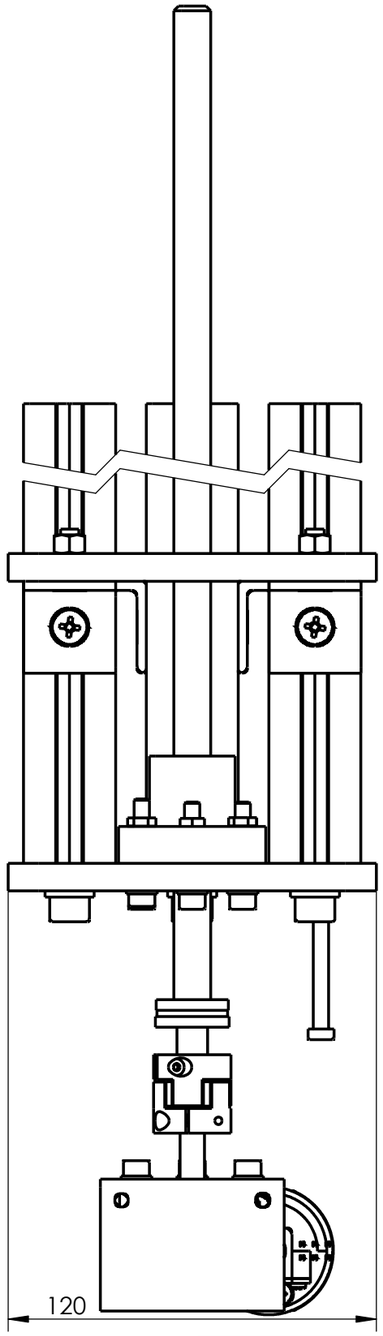

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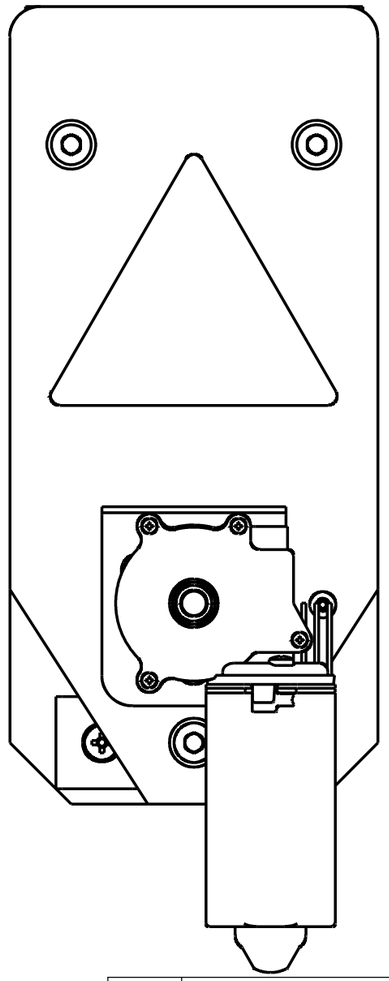

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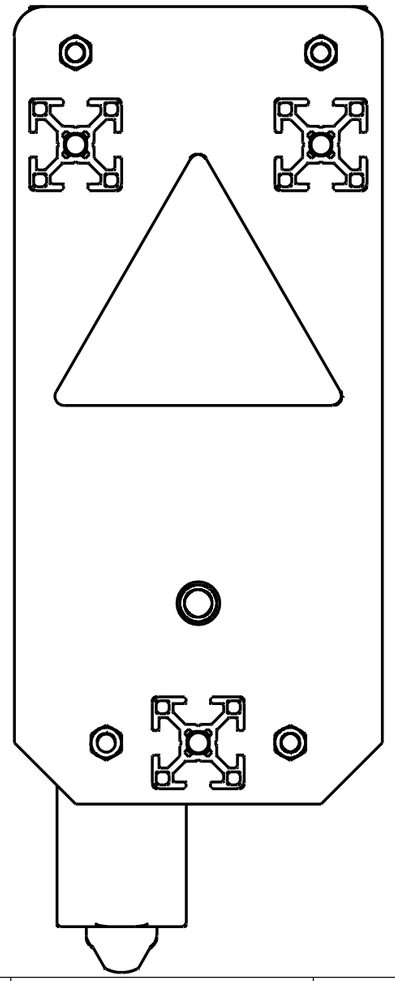


POS-NR.	BENENNUNG	BESCHREIBUNG	MENGE
101	Spindel	Igus: PTGSG-12X3-01-R	1
102	Mitnehmermutter	Igus: PTGSG-12X3-01-R	1
103	Mitnehmerplattform unten	Frästeil POM 9 mm	1
104	Mitnehmerplattform oben	Frästeil POM 9 mm	1
105	Motorkonsole	Biegeteil Aluminium 2 mm	1
106	Axiallager	Igus: BB-51100-B180-ES	1
108	Wellenkupplung	Igus: COU-AR-K-080-100-25-26-B-AAAA	1
111	Hubprofil	Motedis: 30x30 B-Typ Nut 8	3
124	Profilwinkel	Motedis: 30x30 B-Typ Nut 8	4
205	Plattformantrieb	Igus: MOT-DC-42-J-H-H	1

	Datum	Name
bearbeitet	20.02.2024	simon
geprüft:		
normgepr.:		

Klasse: 8B
Abteilung: Mechatronik
Schuljahr: 2023/2024
Name: Simon M. Wimmer

Werkschulheim Felbertal Ebenau

Maßstab: 1:2

Freimaßtoleranz ON EN 22768 mittel

Benennung:

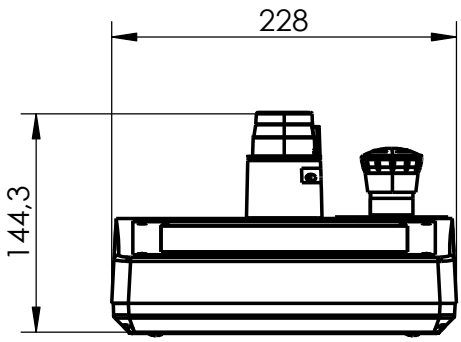
Linearachse

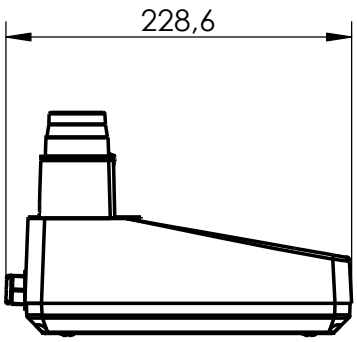
Zeichnungsnummer: SYM-002-03

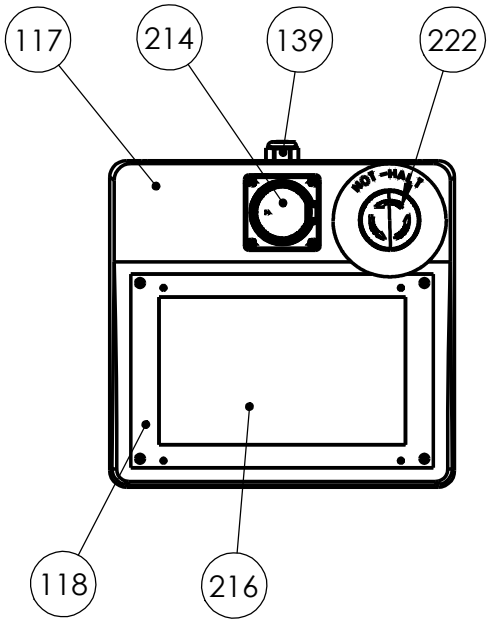
Ausgabedatum: Dienstag, 20. Februar 2024 19:07:18

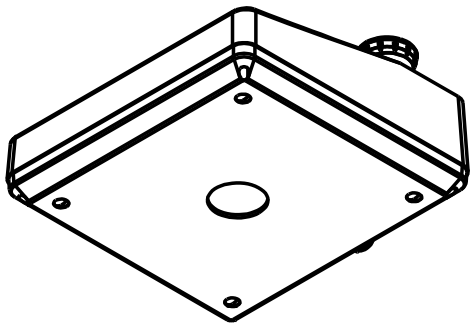
Ersatz für:

Ersetzt durch:









POS-NR.	BENENNUNG	BESCHREIBUNG	MENGE
117	Displaygehäuse	Farnell: 775113	1
118	Gehäusefrontplatte	Frästeil Aluminium 2 mm	1
139	Kabelverschraubung	PG9	1
214	Laserscanner	Festo: 8029454	1
216	Touchscreen	Conrad: 1543962	1
222	Not-Aus	RS-Components: 193-2789	1

	Datum	Name
bearbeitet	20.02.2024	simon
geprüft:		
normgepr.:		

Klasse: 8B
Abteilung: Mechatronik
Schuljahr: 2023/2024
Name: Simon M. Wimmer

Werkschulheim Felbertal
Ebenau

Maßstab: 1:5

Benennung:

Bedienpult

Zeichnungsnummer:

SYM-003-02

Freimaßtoleranz ON EN 22768 mittel

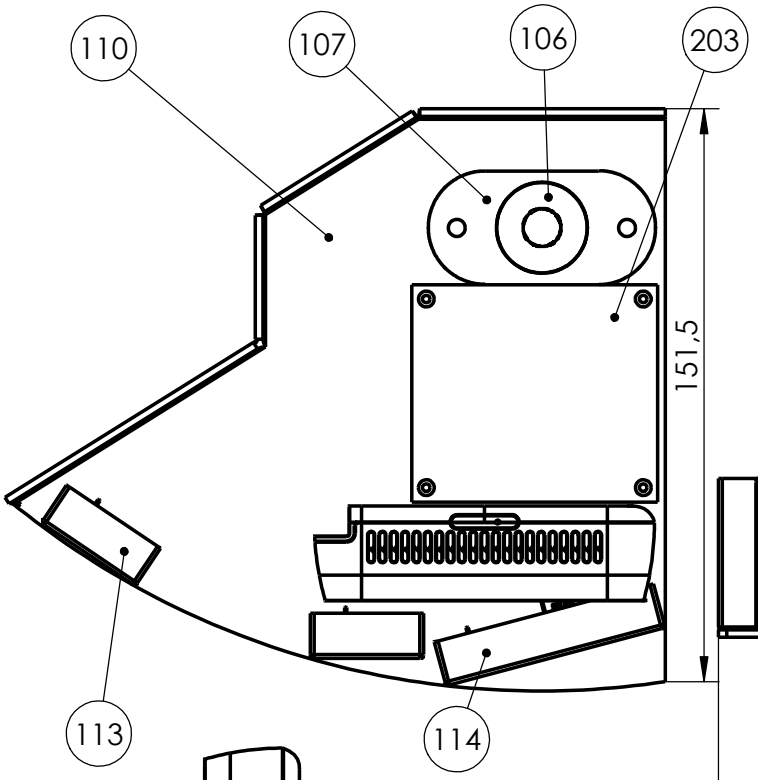
Ausgabedatum: Dienstag, 20. Februar 2024 19:09:38

Ersatz für:

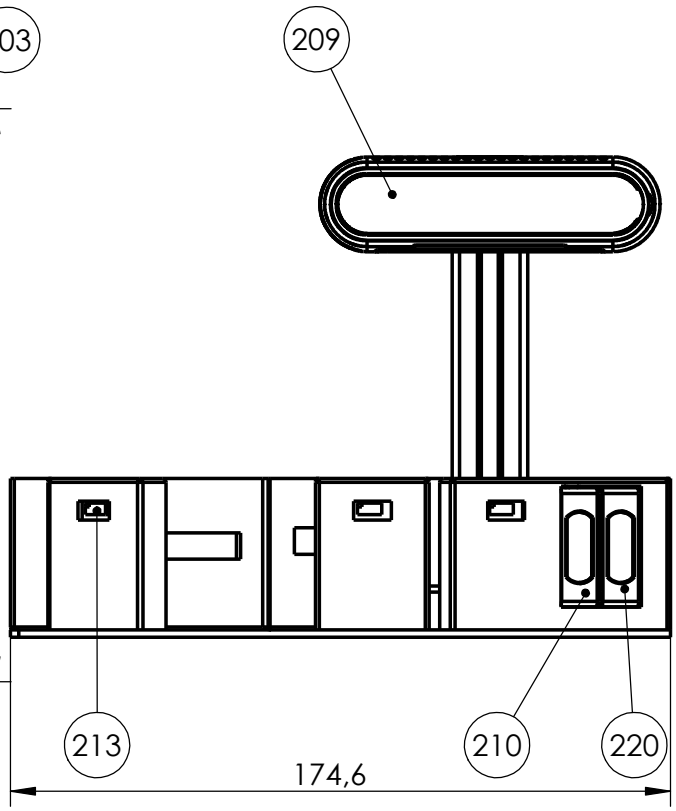
Ersetzt durch:

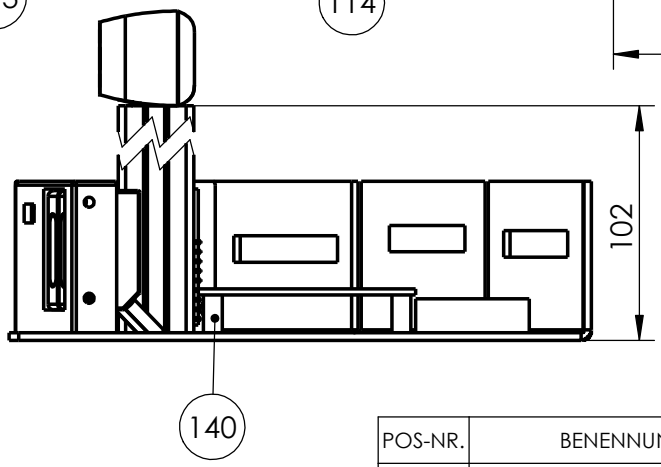
D C B A

Draufsicht



Vorderansicht





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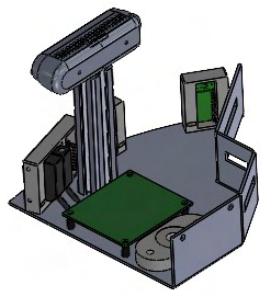


POS-NR.	BENENNUNG	BESCHREIBUNG	MENGE
106	Axiallager	Igus: BB-51100-B180-ES	1
107	Lagerflansch	Frästeil POM 9 mm	1
110	Controller-Plattform	Biegeteil Aluminium 2 mm	1
113	Abstandssensorgehäuse	3D-Druckteil	2
114	Kommunikatorkombigehäuse	3D-Druckteil	1
115	Kameraständer	Aluminiumprofil 20x20x100 I-Typ	1
140	Abstandshülse	Höhe 5 mm, Kerndurchmesser 4,2 mm	4
203	Arduino-Peripherie-IF	Board 65x57,5 mm	1
209	Kamera	Intel RealSense	1
210	Infrarotempfänger	Conrad: 182202 - VQ	1
213	ToF-Abstandssensoren	Farnell: 3772972	3
220	Infrarotsender	Conrad: 282202 - VQ	1

	Datum	Name
bearbeitet	20.02.2024	simon
geprüft:		
normgepr.:		

Klasse: 8B | Abteilung: Mechatronik | Schuljahr: 2023/2024

Name: Simon M. Wimmer

Werkschulheim Felbertal Ebenau

Maßstab: 1:1

Benennung:

Controller-Plattform

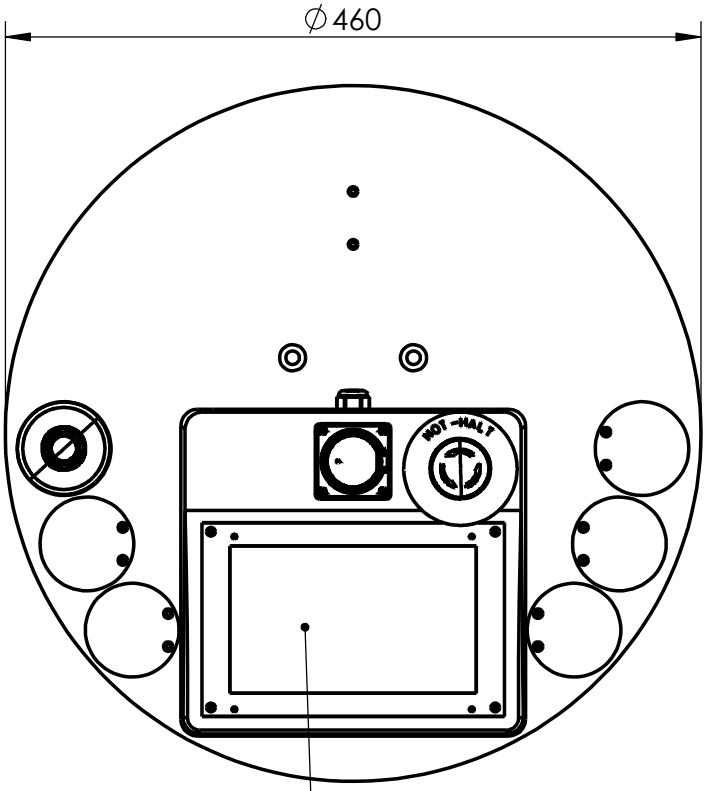
Zeichnungsnummer: SYM-004-03

Freimaßtoleranz ON EN 22768 mittel

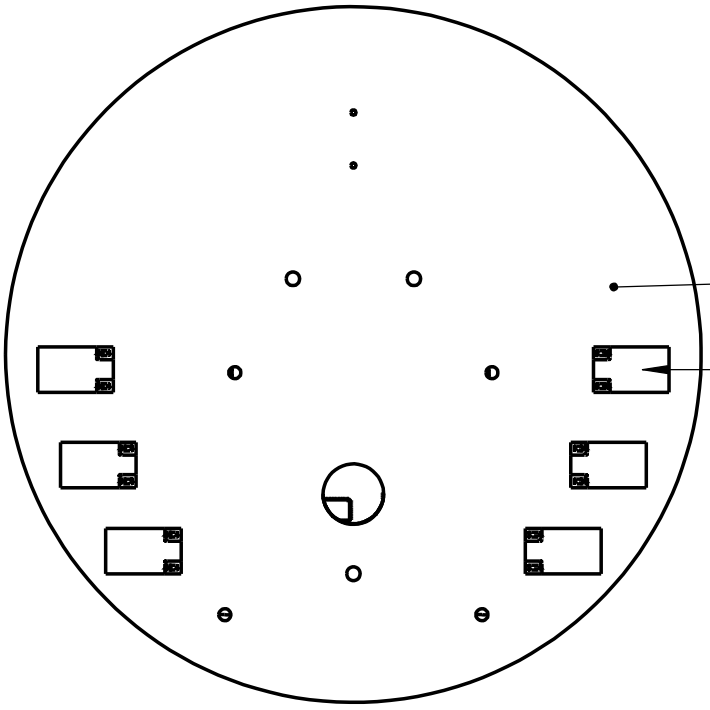
Ausgabedatum: Dienstag, 20. Februar 2024 19:11:20

Ersatz für:

Ersetzt durch:



Draufsicht



Untersicht

POS-NR.	BENENNUNG	BESCHREIBUNG	MENGE
116	Plattform	Frästeil POM 9 mm Durchmesser 450 mm	1
215	Kapazitiver Näherungsschalter	RS-Components: 896-7282	6
003	Bedienpultbaugruppe	SYM-003-xx	1

	Datum	Name
bearbeitet	15.12.2023	wims
geprüft:		
normgepr.:		

Klasse: 8B
Abteilung: Mechatronik
Schuljahr: 2023/2024
Name: Simon M. Wimmer

Werkschulheim Felbertal
Ebenau

Maßstab: 1:5

Freimaßtoleranz ON EN 22768 mittel

Benennung:

Plattformbaugruppe

Zeichnungsnummer:

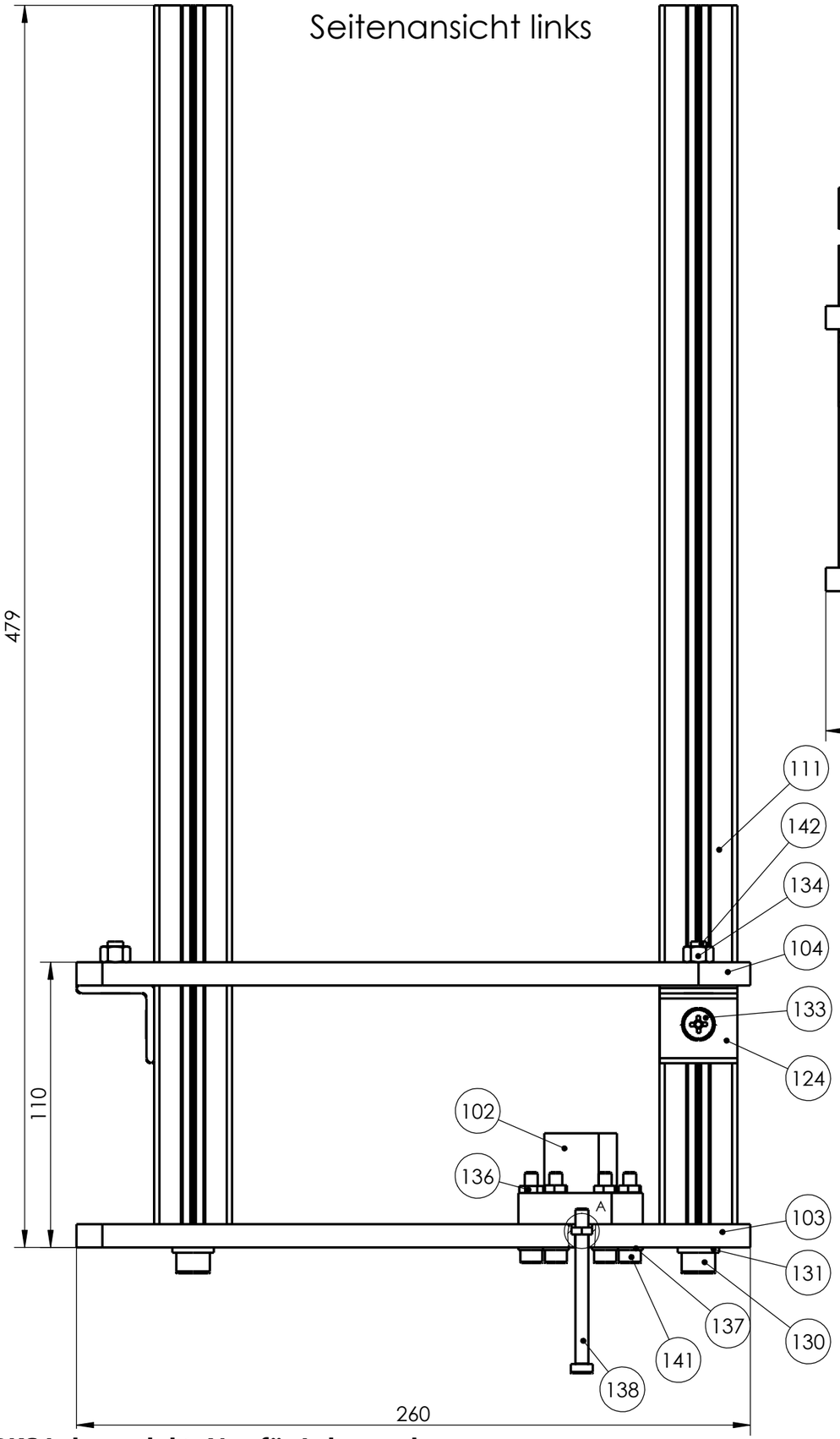
SYM-005-01

Ausgabedatum: Freitag, 15. Dezember 2023 11:35:38

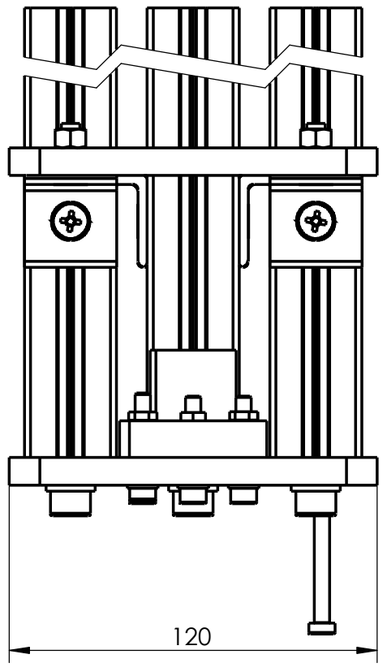
Ersatz für:

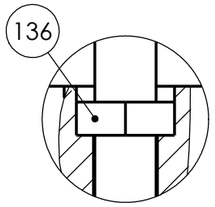
Ersetzt durch:

Seitenansicht links



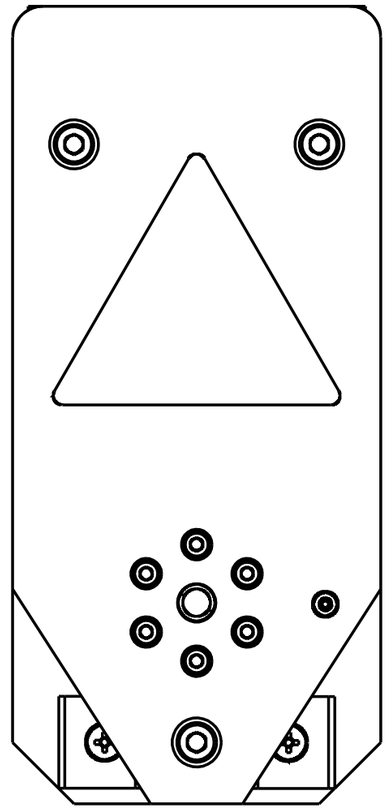
Rückansicht



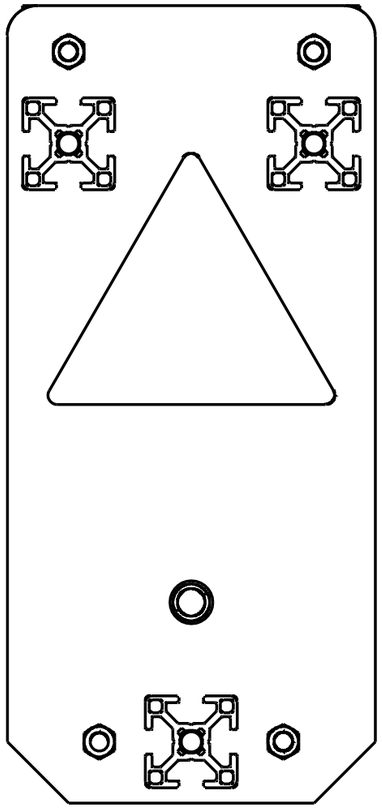


DETAIL A
MAßSTAB 2 : 1

Untersicht



Draufsicht



POS-NR.	BENENNUNG	Beschreibung	MENGE
102	Mitnehmermutter	Igus: PTGSG-12X3-01-R	1
103	Mitnehmerplattform unten	Frästeil POM 9 mm	1
104	Mitnehmerplattform oben	Frästeil POM 9 mm	1
111	Hubprofil	Motedis: 30x30 B-Typ Nut 8	3
124	Profilwinkel	Motedis: BR30STS	4
129	Nutenstein	Motedis: S8BSSNM6	4
130	Innensechskantschraube M8 30 mm	WSH-Vorrat	3
131	Beilagscheibe M8	WSH-Vorrat	3
133	Senkkopfschraube M6 10 mm	WSH-Vorrat	4
134	Mutter M6	WSH-Vorrat	4
136	Mutter M5	WSH-Vorrat	7
137	Beilagscheibe M5	WSH-Vorrat	6
138	Senkkopfschraube M5 70 mm	WSH-Vorrat	1
141	Innensechskantschraube M5 20 mm	WSH-Vorrat	6
142	Innensechskantschraube M6 20 mm	WSH-Vorrat	4

	Datum	Name
bearbeitet	20.02.2024	simon
geprüft:		
normgepr.:		

Klasse: 8B
Abteilung: Mechatronik
Schuljahr: 2023/2024
Name: Simon M. Wimmer

Werkschulheim Felbertal Ebenau

Maßstab: 1:2

Freimaßtoleranz ON EN 22768 mittel

Benennung:

Linearachse Schlitten Detail

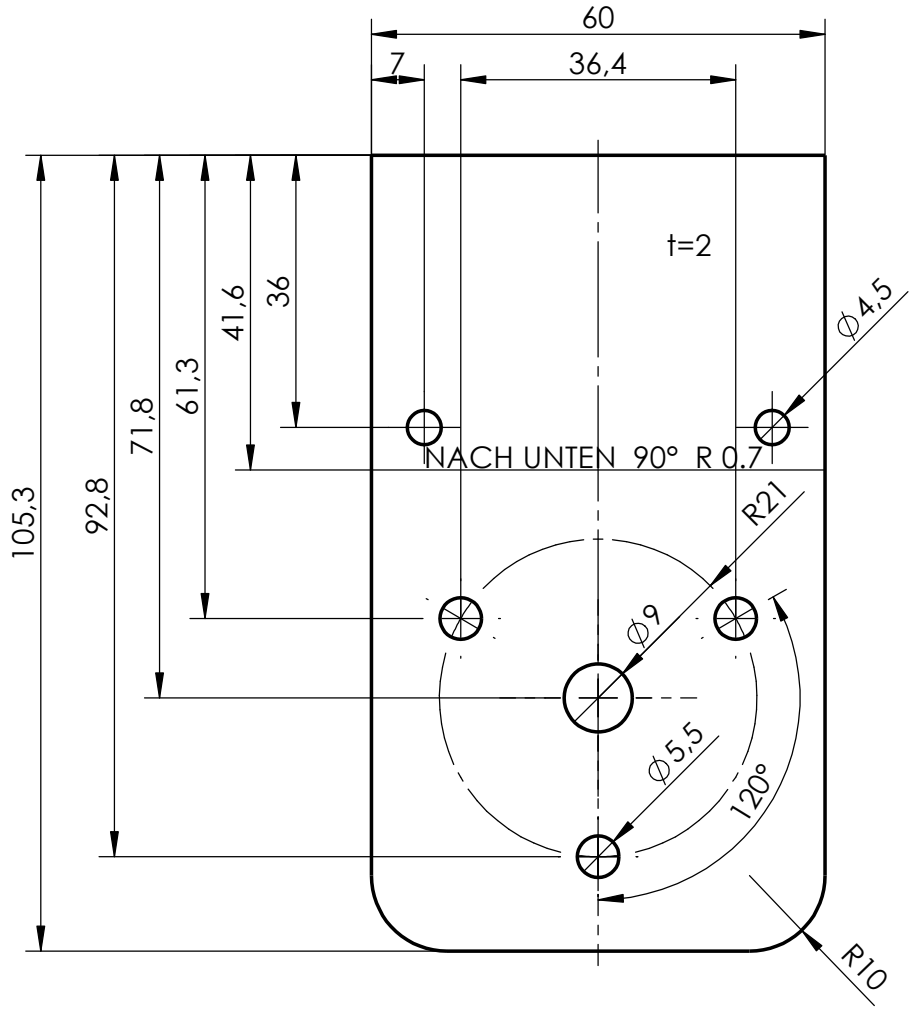
Zeichnungsnummer: SYM-006-02

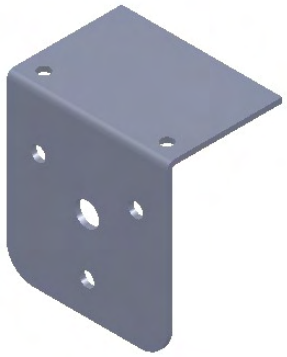
Ausgabedatum: Dienstag, 20. Februar 2024 19:18:12

Ersatz für:

Ersetzt durch:

Ra 3,2 Alle Kanten entgratet





	Datum	Name
bearbeitet	14.01.2024	wims
geprüft:		
normgepr.:		

Klasse: 8B | Abteilung: Mechatronik | Schuljahr: 2023/2024

Name: Simon M. Wimmer

Werkschulheim Felbertal Ebenau

Maßstab: 1:1

Benennung:

Motorkonsole

Zeichnungsnummer: SYM-105-02

Freimaßtoleranz ON EN 22768 mittel

Ausgabedatum: Sonntag, 14. Januar 2024 21:03:57

Ersatz für:

Ersetzt durch:

5.9 Mechanical commissioning

First, the motor is attached to the robot's inner housing using the motor console.

Then the controller platform is assembled. The controller platform includes the Arduino peripheral IF, the additional distance sensors, the communication interface, and the camera. The exact design can be found in the assembly drawing SYM-004. The fully equipped controller platform is now attached above the motor console, on the robot's inner housing.

Next, the capacitive limit switch and the drag chain connection element are attached to the inner housing using the corresponding consoles.

Now the spindle can be inserted and secured using the shaft coupling and thrust bearing.

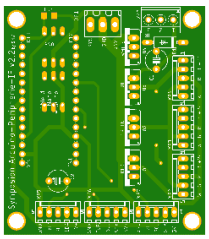
The assembly of the linear axis can then begin. First, the lower driver platform is attached to the lifting profile. Then the driver nut is placed on the spindle. The linear axis is completed by the upper platform. First, the specified guide distance must be measured, after which the driver nut can be screwed onto the driver platform. The exact structure can be seen in SYM-002 and SYM-006 respectively.

The platform is screwed onto the linear axis. The capacitive proximity switches are mounted underneath the platform. The control panel is located on the top. Kindly refer to the assembly drawings SYM-003 and SYM-005 for this.

Finally, the two inner covers are first attached to the outer housing and then the outer cover is screwed onto the side of the upper platform.

6 Technical description Electrical engineering / electronics

6.1 Parts list of main electrical components

Item no.	BMK	Part name	Illustration	Qty.	Description	Supplier Order no.	Total price [€]
201	K1	Festo Robotino control unit v4		1	Input 18V (Li-ion) Logic 24 V Intel i5 1xEthernet 6xUSB 2x12V 2xPCIe 1xHDMI 8xDI; 8xDO 8xAI; 13x24V 2xRelays 1xMotor OUT 1xEncoder IN 450x450x325 mm 20 kg	Festo; 8101344	16,943.53
20	K2	Sound card		1	USB to AUX IN and OUT	Conrad; 1406215 - 62	8.49
203	K3	Arduino Peripheral IF		1	Includes Arduino Nano 3xRGBW OUT for LED strips 3xI^2C connection for ToF 2 layers Assembled on both sides 65x57.5 mm	In-house development	29.97
204	M1 – M3	Integrated Omnidrive		3	DC motor max. 3,600 rpm Gear ratio 32:1 Omni-directional wheels 120 mm diameter	K1 integrated	-
205	M4	Platform drive		1	24 V DC motor with worm gear 350 rpm 0.75 Nm 1.9 A	Igus; MOT-DC-42-J-H-H	79.20

206	B1-B9	Integrated infrared distance sensors		9	4–30 cm 5V Vcc Analog signal Voltage decreases with increasing distance	K1 integrated	-
207	B10	Integrated bumper		1	IP40 max 24 V Switch	K1 integrated	-
208	B11	Integrated gyroscope		1	9-axis Gyroscope Acceleration Angle I²C and UART	K1 integrated	-
209	B12	Camera		1	RGBD Webcam + Depth measurement system	K1 integrated	-
210	B13, B26	Infrared receiver		2	12 – 24 V PNP NO	Conrad; 182202 – VQ	89.99
211	B14	Encoder (integrated into motor)		1	5 – 24 V 2-channel Hall 5 pulses/motor revolution 70 pulses / output rotation	M4 integrated	-
212	B15	End position switch		1	Inductive 12 – 24 V PNP NO 0 – 30 mm 100 Hz Scanning M30	RS Components: 805-4888	36.28
213	B16–B18	ToF distance sensors		3	5V, I²C 27° field of view divided into 4x4 50 Hz sampling rate 40–4,000 mm Resolution 1 mm	WSH	22.50
214	B19	Laser scanner		1	5V; USB (SCIP2.0) 240° field of view 20–4,000 mm 683 steps	Festo: 8029454	2,206.32

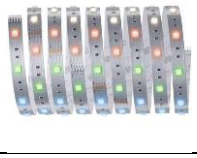
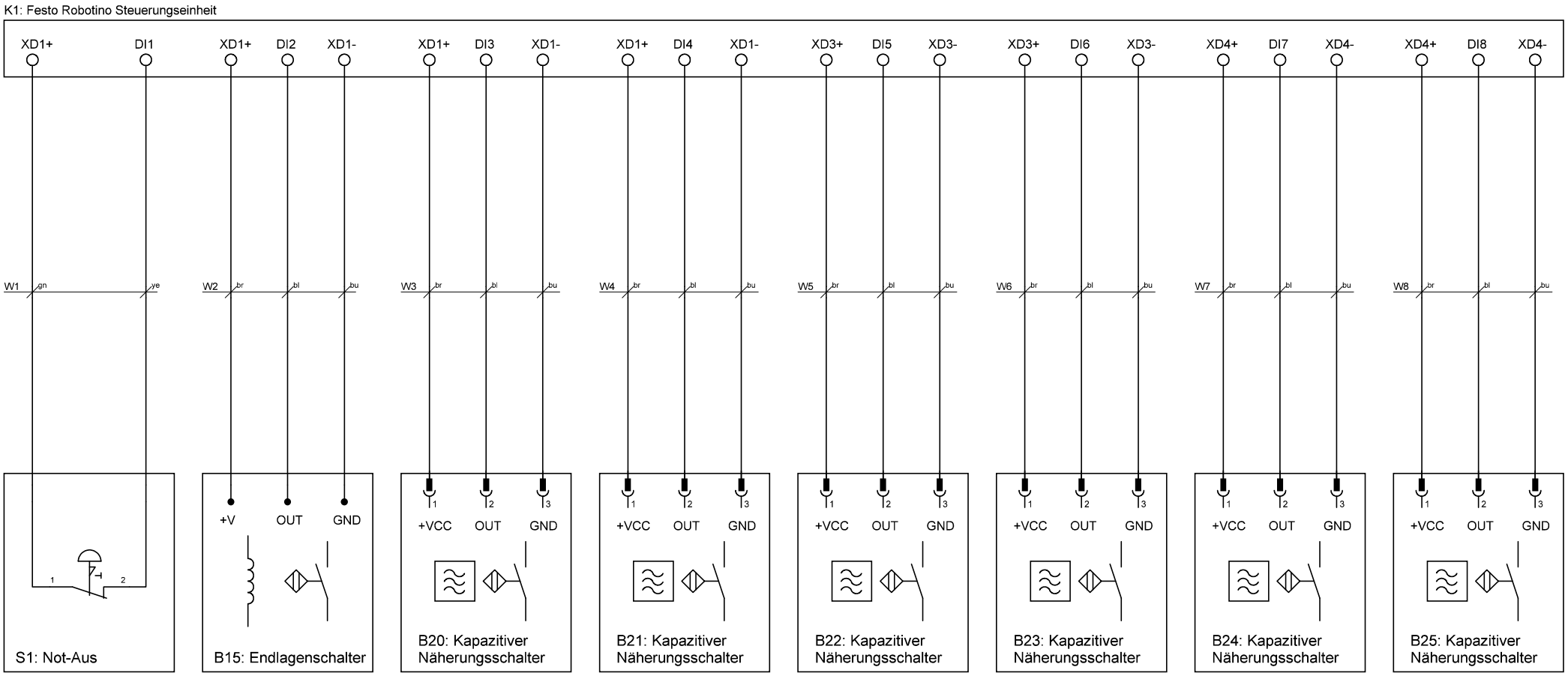
215	B20-B25	Capacitive proximity switches		6	10 – 30 V Detection range 0–8 mm Adjustment range 0 – 6.48 mm PNP NO	RS Components: 896-7282	33
216	A1	Touchscreen		1	7" 1024x600 px Power and image via HDMI Touch via MicroUSB Capacitive touch (5 multi-touch)	Conrad: 1543962 – VQ	89
217	P1	Speaker		2	Power via USB Audio via AUX 140Hz – 20kHz 120mW	Conrad: 1681257 - 62	13.99
218	P2	Lighting		1	24 V RGBW Common anode 2.5 m	Conrad: 2345002 – 62	25.60
219	G1 – G4	Li-ion batteries		1	18V Li-ion 5.2 Ah	Festo: 8100249	- €
220	G5 – G6	Infrared transmitter		2	12 – 24 V 15 mA max 10 m (adjustable)	Conrad: 282202 – VQ	89.99
221	G7	Charging station		1	24V max 10 A 14 kg 535x212x152 mm	Festo: 8134659	2,695.03
222	S1	Emergency stop		1	2xnormally closed max 500 V max 10 A 300,000 switching cycles	RS Components: 193-2789	69
Total (including VAT):							€22,686.50

Table16 : Parts list of all electrical components

6.2 Circuit diagram *(German)*



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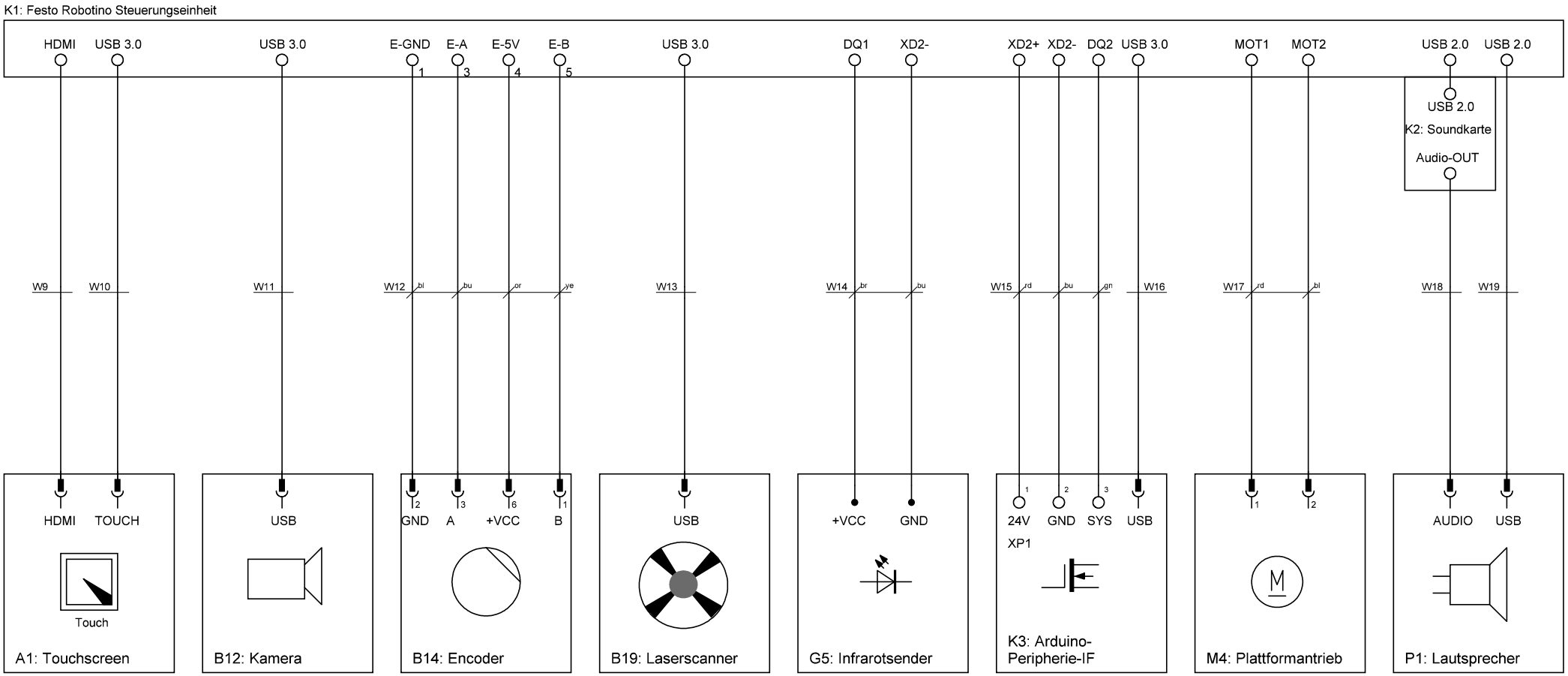
15.01.24	wims				Zeichnungs-Nr.: SYM-SLP-05	
13.03.24	wims					



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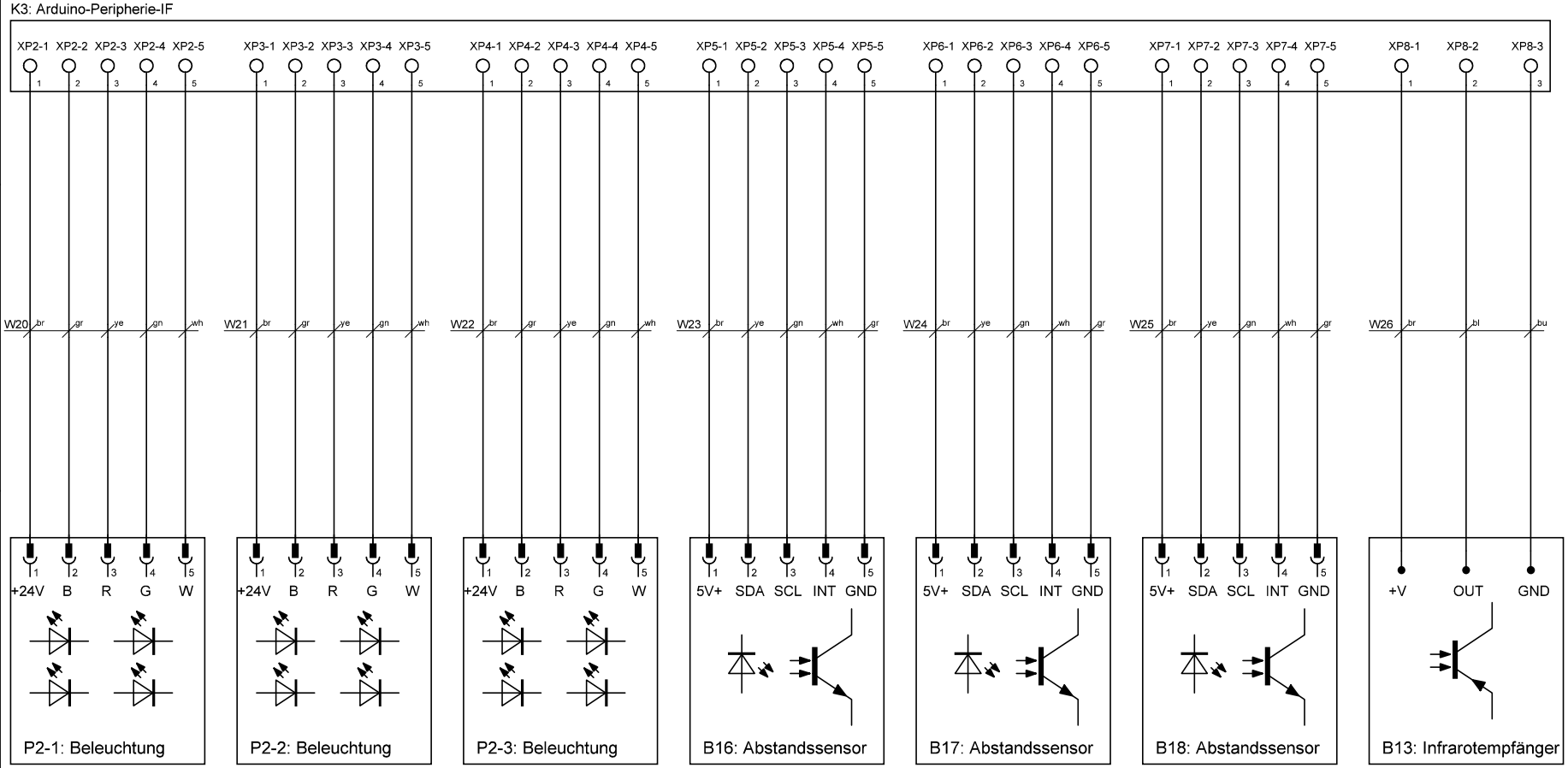

Änderungen			Datum	Name	Bezeichnung: Symposion Stromlaufplan	Blattzahl: 4
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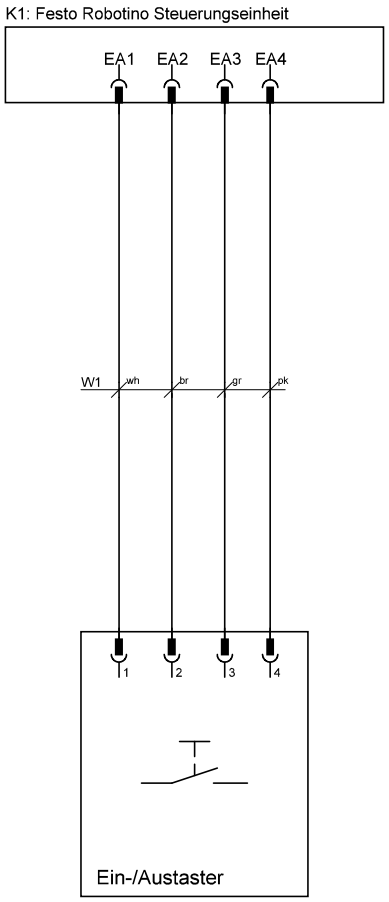
15.01.24	wims				Zeichnungs-Nr.: SYM-SLP-04	
13.03.24	wims					



Änderungen			Datum	Name	Bezeichnung: Symposion Stromlaufplan	Blattzahl: 4
Datum	Name	gez.:	28.10.23	wims		
13.12.23	wims	gepr.:				Blatt-Nr.: 4
15.01.24	wims				Zeichnungs-Nr.: SYM-SLP-04	
13.03.24	wims					

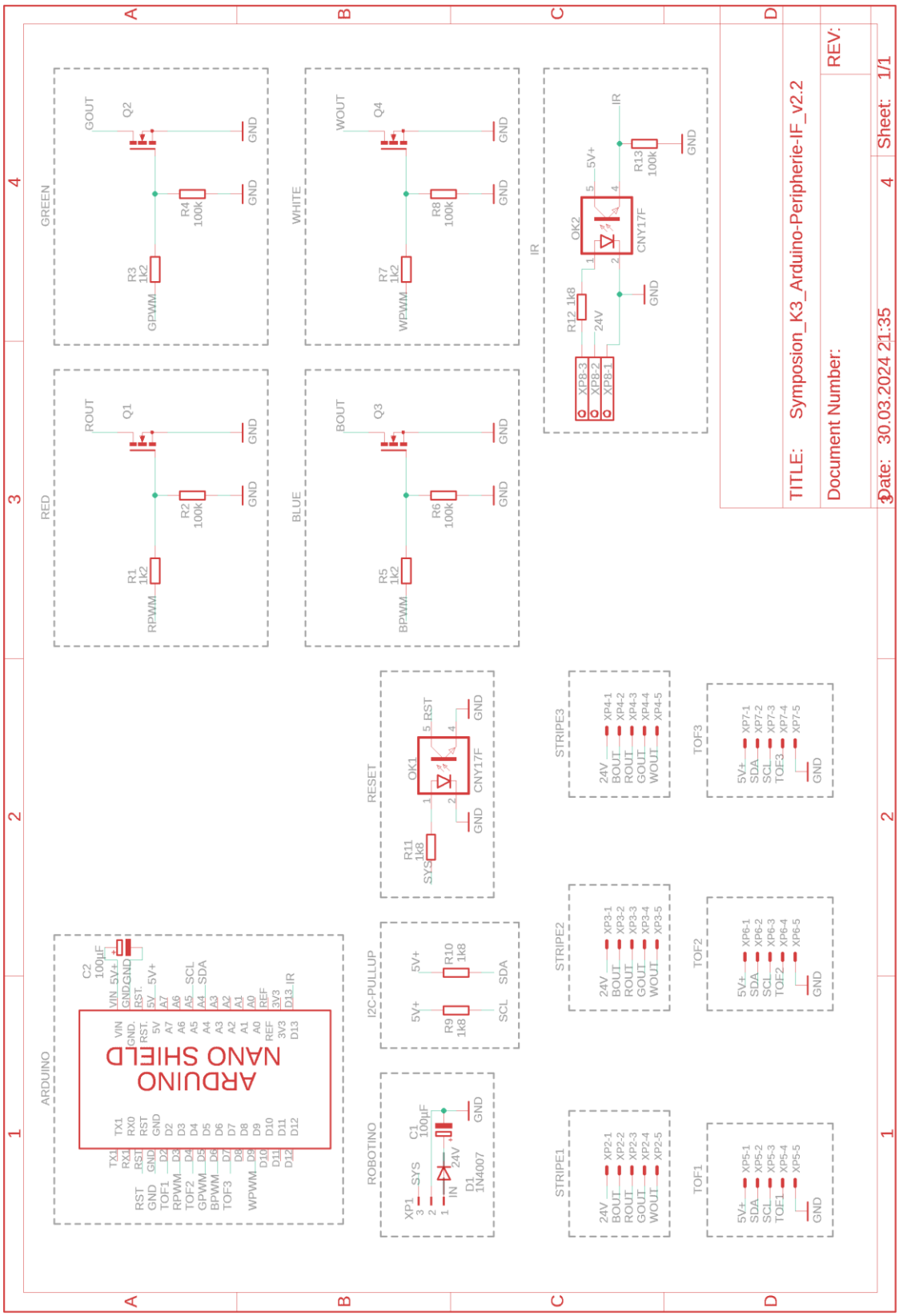
6.3 Description of the connecting cables

BMK	Designation	Length	Connection type 1	Connection type 2
W1	Round cable, stranded, 7 x 0.25 mm², twistable	1,800 mm	Spring-loaded terminal and solder point	Spring-loaded terminal
W	Round cable, stranded, 3 x 0.33 mm²	250 mm	Spring-loaded terminal	Solder point
W3 - W8	Round cable, stranded wire, 3 x 0.33 mm²	1,000 mm	Spring-loaded terminal	Solder point
W9	HDMI-A to HDMI-A	2,000 mm	HDMI	HDMI
W10	USB-A to MicroUSB, shielded	200 mm	USB	MicroUSB
W11	USB-A to USB-C, shielded	500	USB-A	USB-C
W12	Flat ribbon cable, 6-pin, AWG 28	150 mm	MPE RM 2.54 2x3-pin	Solder point
W13	USB-A to USB-A, shielded	300 mm	USB-A	USB-A
W14	Round cable, stranded, 2 x 0.5 mm²	200 mm	Spring-loaded terminal	Solder point
W15	Round cable, stranded wire, 3 x 0.33 mm²	350 mm	Spring-loaded terminal	Screw terminal
W16	USB-A to USB-C, shielded	500 mm	USB-A	USB-C
W17	Twin strand, 2 x 1 mm²	150 mm	Wago 721-462 2-pin	Solder point
W18	Jack cable integrated into device with 3.5 mm plug	300 mm	Jack socket 3.5 mm	Solder point
W19	USB-A cable integrated into device	300 mm	USB-A	Solder point
W20 - W22	Round cable, stranded, 5 x 0.5 mm²	400 mm	Molex socket housing, 5-pin.	DuPont plug housing, 5-pin.
W23 - W25	Round cable, stranded, 5 x 0.25 mm²	100 mm	Molex female connector housing, 5-pin.	DuPont socket housing, 6-pin.
W26	Round cable, stranded, 3 x 0.33 mm²	300 mm	Molex socket housing, 3-pin	Solder point
W27	Flat ribbon cable, 6-pin, AWG 28	100 mm	MPE RM 2.54 2x3-pin	Solder point
W28	Round cable, stranded, 4 x 0.33 mm²	300 mm	Spring-loaded terminal	Solder point
W29	Round cable, stranded wire, 2 x 0.5 mm²	300 mm	Spring-loaded terminal	Spring-loaded terminal
W30	USB-A to USB-A, shielded	1,800 mm	USB-A	USB-A

17 : Connection cables

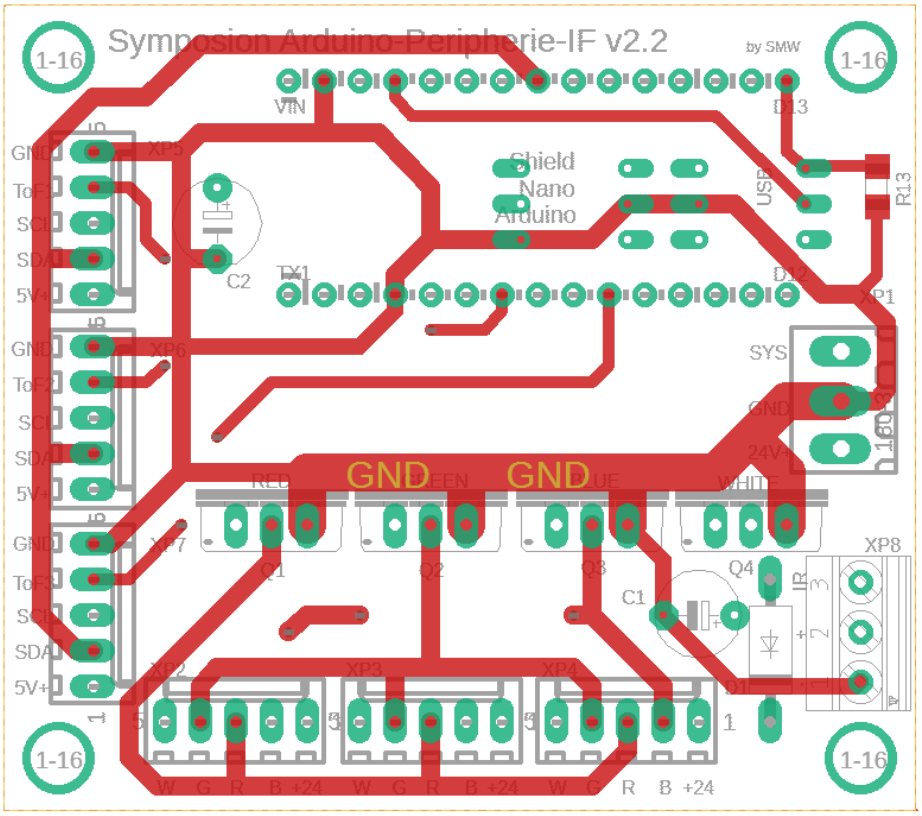
6.4 Documentation Printed circuit board

6.4.1 Circuit diagram

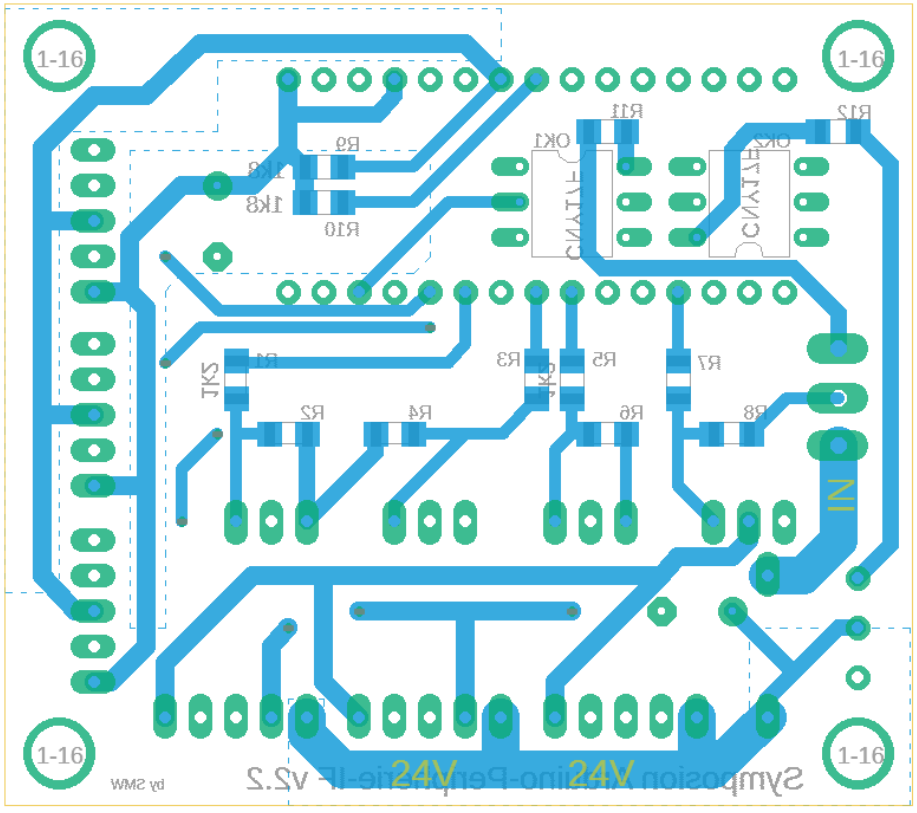


6 : Circuit diagram for interface circuit board

6.4.2 Layout

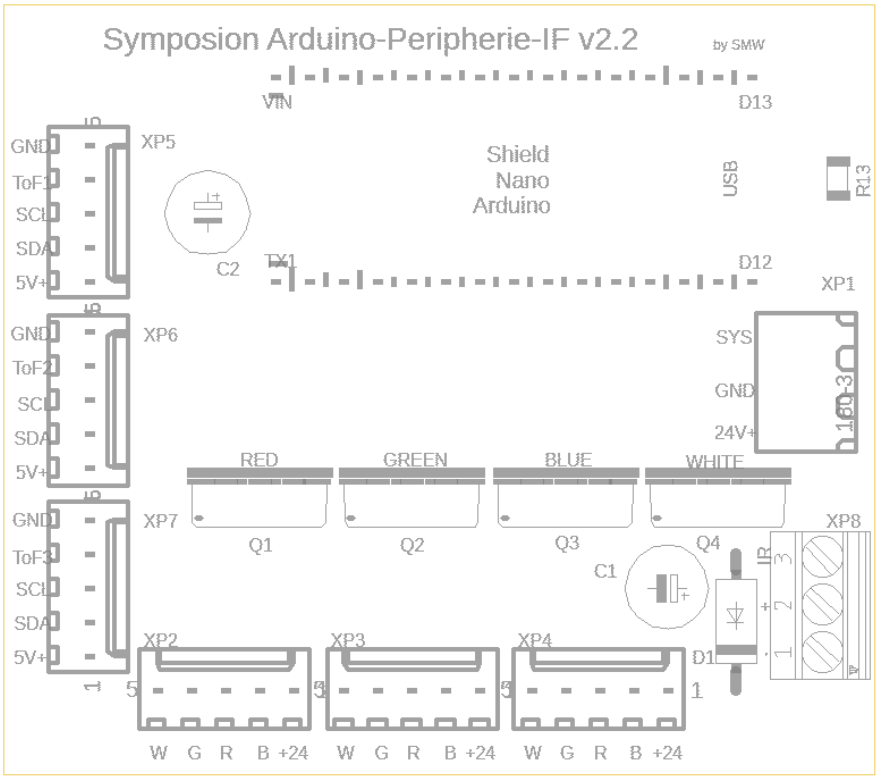


7 : Interface board layout TOP

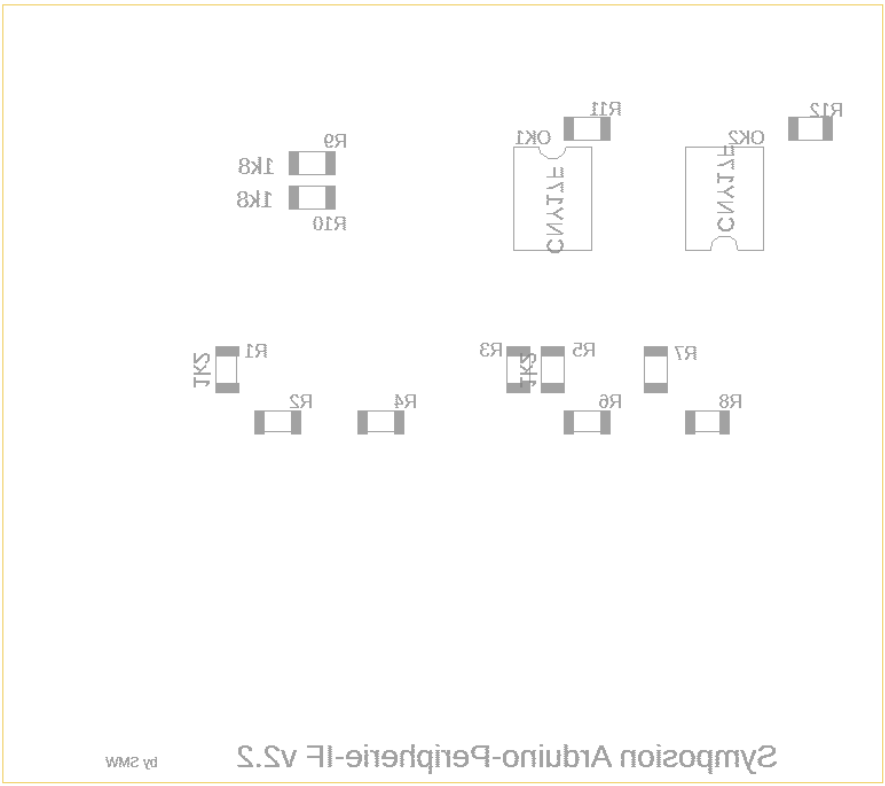


8 : Interface board layout BOTTOM

6.4.3 Assembly plan



9 : Interface board assembly plan top



10 : Interface board assembly plan bottom

6.4.4 Bill of materials

Bill of materials **K3 - Arduino Peripheral IF**

Total cost:	**€29.97**
WSH parts:	$10.90

All prices include VAT.

Quantity	Unit	Reference code	Description	Additional description	Value / Manufacturer part number	Supplier	Order no.	Single price [€]	Total price [€]
1	Piece	K3	Circuit board	2 layers, 1.6 mm, HASL	Beautiful Board Simple	Aisler	UMCVKSHQ – Rev. 6	19.07	19.07
1	Piece	D1	Universal diode	1000 V, 1 A	1N4007	RS Components	917-5386	0.15	0.15
7	Pcs	XP2, XP3, XP4, XP5, XP6, XP7, XP8	Molex pin header	straight, 5-pin, single row, RM 2.54	22-27-2051	RS Components	170-7104	0.29	2.03
2	Pcs	OK1, OK2	Optocoupler	6-pin, phototransistor output	CNY17F	RS Components	178-0898	0.37	0.74
2	Pcs	PCB1	Socket strip	20-pin, single row, RM 2.54, straight	SPL 20	Reichelt Electronics	SPL 20	0.40	0.80
4	Pcs	Q1, Q2, Q3, Q4	MOSFET N-channel	TO-220AB, 50V, 35A	BUZ 11	Reichelt Electronics	BUZ 11	1	4.00
4	Pcs	R1, R3, R5, R7	SMD chip resistor	Type 1206; tolerance 1%	1k2	RS Components	223-2271	0.05	0.20
5	Pcs	R2, R4, R6, R8, R13	SMD chip resistor	Type 1206; tolerance 1%	100k	RS Components	223-2524	0.05	0.25
4	Pcs	R9, R10, R11, R12	SMD chip resistor	Type 1206; tolerance 1%	1k8	RS Components	223-2293	0.06	0.23
1	Piece	XP1	Pin strip	3-pin, RM 3.5, 90°	180-3	Reichelt Electronics	CTB932HD-3	0.29	0.29
1	Piece	XP1	Pluggable screw terminal	3-pin, RM 3.5, 0°	180-3	Reichelt Electronics	CTB922HD-3	0.63	0.63
2	Pcs	C1, C2	Al-e-cap	Radial, RM 5, 35V	100 µF	Farnell	2466947	0.79	1.58

18 table: Interface board parts list

6.5 Commissioning electronics

Interface board	
1	Visual inspection for correct solder joints, correct component use, and obvious damages.
2	Continuity test of connected and unconnected cables.
3	Connect to 24VDC supply voltage. Current limitation 40 mA.
4	Check 24VDC and GND lines using an oscilloscope.
5	Check the Vcc and GND pins of the Arduino pin header and the MOSFETs.
6	Attach the Arduino Nano.
7	Apply 5VDC to data inputs and evaluate via Arduino code pins.
8	Set Arduino outputs to high and check the outputs on the interface board using an oscilloscope.
Linear drive	
1	Connect the encoder to the corresponding socket on the robot.
2	Connect the DC motor to the corresponding socket on the robot.
3	Connect the limit switch to the corresponding terminal on the robot.
4	Disconnect the motor from the shaft.
5	Run the platform referencing program and check whether the motor stops when the limit switch is activated.
6	Use the test program to check the stored directions of rotation (run the motor up and down, checking at the same time that the encoder is counting correctly).
Sensors	
1	For binary sensors, functionality can be determined using a laboratory power supply and oscilloscope. Voltage and current limitation according to data sheet (usually 24VDC 150 mA).
2	Test other sensors using the existing test programs.
3	Each software module should be controlled and tested individually.

Table19 : Commissioning electronics

7 Technical description of firmware/software

7.1 General information

7.1.1 Software modules

Module	Description	Language	Dependency	Execution location
GUI	Web interface hosted locally on Robotino. It is used to select the desired programs.	HTML, CSS, Python	Open localhost	K1
Debug	The Python web framework, in conjunction with the REST API, communicates directly with Robotino to display hardware states in the GUI.	Python, XML (REST API)	Accessible via GUI	K1
Billboard	Option to play an audio file and open an image file in the graphical user interface, which is displayed continuously on the Symposion screen.	Python	Accessible via GUI	K1
Teaching	Symposion can be moved manually around the room using a joystick controller. When the controller button is pressed, Symposion saves the positions it has moved to.	Python, XML (REST API)	Accessible via GUI	K1
Route_Following	Symposion autonomously travels to the stored positions.	RobotinoView, Python	Accessible via GUI	K1
Platform_Referencing	The platform references itself.	Python, XML (REST API)	Accessible via GUI	K1
Height_Adjustment	The platform height can be adjusted.	RobotinoView, Python, XML (REST API)	Accessible via GUI	K1
Bottle_Detection	Evaluation of capacitive proximity sensors for bottle detection.	RobotinoView, Python, XML (REST API)	Accessible via GUI Can be called from Route_Following	K1
Docking	Symposion autonomously docks at its charging station by positioning itself at a marker using an RGBD camera.	RobotinoView	Can be called from Route_Following	K1

Dodge	Symposion avoids an obstacle.	RobotinoView	Can be called from Route_Following	K1
Station_Communication	Symposion performs a three-way handshake with an external service station.	RobotinoView	Can be called from Route_Following	K1
Distance_Measurement	Evaluation of the distance sensors.	RobotinoView	Can be called from Route_Following	K1
Distance_Measurement_K3	Evaluation of the ToF distance sensors by the Arduino.	Arduino C	Runs continuously on K3	K3
Light_Control	Sending the RGB code to the Arduino.	Python	Accessible via GUI	K1
Light_Control_K3	PWM output of the RGB code to the LED strips.	Arduino C	Runs continuously on K3	K3

20 : Software modules

7.1.2 Libraries

Library	Language	Usage
subprocess	Python	Opening the RobotinoView programs via the graphical user interface
flask	Python	Python web framework
requests	Python	Communication with Robotino's REST API
serial	Python	Serial communication with Arduino
time	Python	Serial communication with Arduino
csv	Python	Saving and reading routes in a csv file
pydub	Python	Sound output
Wire	Arduino C	I^2C Communication with the ToF distance sensors
VL531LX	Arduino C	Evaluation of the ToF distance sensors

21 table: Software libraries

7.1.3 General information

Symposion is controlled via a graphical web interface that can be accessed either directly from the device over the integrated display or externally via a device connected to the robot's Wi-Fi network.

The graphical interface is implemented using HTML and CSS. Python is used in the backend to execute robot commands. Complex hardware processes are implemented using Robotino's own programming language, "RobotinoView." These programs are then called up by Python. However, Python also has direct hardware access via Robotino's REST API, which is used to visualize hardware states in the graphical interface and pass on small commands.

The PWM control of the LED lighting and the evaluation of the 5V ToF distance sensors are outsourced to the K3 control board, which has an Arduino Nano on it. Python on K1 and Arduino C on K3 communicate with each other via an USB connection.

Programming language	Programming environment
RobotinoView	RobotinoView Editor
Python	Visual Studio Code
Arduino C	Arduino IDE

22 Table: Programming Languages and Environments

7.2 Signal list

7.2.1 K1: Festo Robotino control unit

Signal name Circuit diagram	I/O pin Control unit	Variable name in the program	Data type	Description
S1: Emergency stop	DI1 (XD1.1)	s1_safety_stop	bool	0: All motors off
B15: Limit switch	DI2 (XD1.2)	b15_limit_switch	bool	1: Lower limit switch reached
B20: Capacitive proximity switch	DI3 (XD1.3)	b20_bottle	bool	1: Object at bottle position 1
B21: Capacitive proximity switch	DI4 (XD1.4)	b21_bottle	bool	1: Object on bottle position 2
B22: Capacitive proximity switch	DI5 (XD1.5)	b22_bottle	bool	1: Object on bottle position 3
B23: Capacitive proximity switch	DI6 (XD1.6)	b23_bottle	bool	1: Object on bottle position 4
B24: Capacitive proximity switch	DI7 (XD1.7)	b24_bottle	bool	1: Object on bottle position 5
B25: Capacitive proximity switch	DI8 (XD1.8)	b25_bottle	bool	1: Object on bottle position 6
G2: Infrared transmitter	DQ1 (XD2.1)	g2_infrared_out	bool	1: Activate infrared transmitter
K3: Arduino peripheral IF SYS	DQ2 (XD2.2)	k3_res	bool	1: Restart Arduino
K3: Arduino peripheral IF USB	USB 3.0	k3_com	Serial communication	K1 -> K3 (xxx, xxx, xxx) RGB array K3 -> K1 (xxxx, xxxx, xxxx) in mm Spacing array
M4: Platform drive	MOT1 / MOT2	m4_platform_motor	int	(-)100 to 0: PWM direction of rotation right 0 to 100: PWM rotation direction left
B14: Encoder	Encoder	b14_encoder	int	(-)1: One-fifth turn clockwise drive shaft +1: One-fifth turn left drive shaft 98 pulses per revolution of output shaft
B12: Camera	USB 3.0	b12_cam	Serial communication	Intel RealSense SDK
A1: Touchscreen HDMI	HDMI	NONE (outside program boundary)	Serial communication	Video
A1: Touchscreen TOUCH	USB	NONE (outside program limits)	Serial communication	Touch position
B19: Laser scanner	USB 3.0	NONE (outside program limits)	Serial communication	SCIP 2.0 communication

K2: Sound card	USB 3.0	NONE (outside program limits)	Serial communication	Audio

23 : Signal list K1

7.2.2 K2: Sound card

Signal name Circuit diagram	I/O pin Control unit	Variable name in program	Data type	Description
P1: Loudspeaker	Out	NONE (outside the program boundary)	Analog	Audio

24 table: Signal list K2

7.2.3 K3: Arduino peripheral IF

Signal name Circuit diagram	I/O pin Control unit	Variable name in program	Data type	Description
P2: Lighting B	DO6	p2_blue	int	0-255: PWM blue light
P2: Lighting R	DO3	p2_red	int	0-255: PWM red light
P2: Lighting G	DO5	p2_green	int	0-255: PWM green light
P2: Lighting W	DO9	p2_white	int	0-255: PWM white light
B16-18: Distance sensor SDA	A4	SDA	Serial communication	Communication with distance sensors via predefined commands
B16-18: Distance sensor SCL	A5	SCL	bool	Clock
B16: Distance sensor INT 1	DO2	b16_tof	bool	0: Disables I2C communication; for resetting and assigning addresses to individual sensors
B17: Distance sensor INT 2	DO4	b17_tof	bool	0: Disables I2C communication; for resetting and assigning addresses to individual sensors
B18: Distance sensor INT 3	DO7	b18_tof	bool	0: Disables I2C communication; for resetting and assigning addresses to individual sensors
B13: Infrared receiver	DI13	b13_ir_in	bool	1: Infrared light beam is received

25 table: K3 signal list

7.3 SW planning and description

7.3.1 Note

The following software diagrams serve only as simple models and do not represent detailed programming instructions. For reasons of clarity, ramp controls for the motors have not been included in the visualization, for example, but this does not mean that they are not present in the final program.

First, the software modules are described individually, followed by the corresponding flowcharts.

7.3.2 GUI

The GUI software module includes the backend logic via Python, which runs HTML and CSS-based graphics. This module description refers only to the backend logic. The design of the graphical part of the GUI can be found in section 7.4. When a button is pressed on the website, Python calls up the corresponding program.

7.3.3 Debug

Python can call up the states of the digital inputs and outputs via the REST API. These are converted into an array, which is being visualized in the frontend.

7.3.4 Teaching

Symposion is manually maneuvered using the joystick of the supplied controller. The current x, y, and rotation values are tracked in Robotino's own map, and when the joystick button is pressed, the current point is saved and added to the autonomous route. The service station should always serve as the starting point for the stored movement pattern. A zero point shift occurs from the global home point to the first defined point.

7.3.5 Route_Following

Symposion calls up Robotino's own map, which was generated in teaching mode, and travels to the stored points. If an obstacle is detected, the robot stops. If the battery capacity falls below 20%, the docking module is called up, in which Symposion moves to its charging station. The "Bottle_Detection" submodule continuously checks for the presence of bottles. If it detects that it no longer has any bottles in storage, it returns to the service station, where it can be reloaded. Once it is reloaded, it continues on its route.

7.3.6 Docking

Robotino uses its own map to navigate back to its home point. Precise calibration is achieved by a marker that is read by the RGBD camera. Successful docking is confirmed when charging begins.

7.3.7 Platform_Referencing

The motor rotates clockwise (right-hand thread) until the capacitive limit switch is triggered. The height value of the platform is reset. This module can be called up at any time in the GUI.

7.3.8 Height_Adjustment

When the button on the graphical user interface is pressed, the platform is moved either up or down by one output rotation (3 mm). The current height is displayed on the graphical user interface.

7.3.9 Bottle_Detection

Python reads the values of the digital inputs reserved for the capacitive proximity switches and returns an array with the values accordingly.

7.3.10 Dodge

Symposion retrieves the distance sensor values. If the distance is too small, it moves in the direction with the greatest distance.

7.3.11 Station_Communication

Symposion performs a three-way handshake.

7.3.12 Distance_Measurement

Symposion reads its own distance sensors and queries the values of the ToF sensors from the Arduino.

7.3.13 Distance_Measurement_K3

The Arduino queries the values of the ToF distance sensors and forwards an array to the Robotino via USB.

7.3.14 Light Control

An RGBW value is selected using a color picker in the graphical user interface and then forwarded to the Arduino via USB.

7.3.15 Light Control_K3

Arduino outputs the RGBW values sent to it as an array as PWM signals to the corresponding light strip outputs.

7.4 User interface / GUI design

Prototype can be accessed online:

https://www.figma.com/proto/IWKD7D1jYPG5CRBXiXjNHM/Symposion--EN-

Figure11 : GUI StartUp

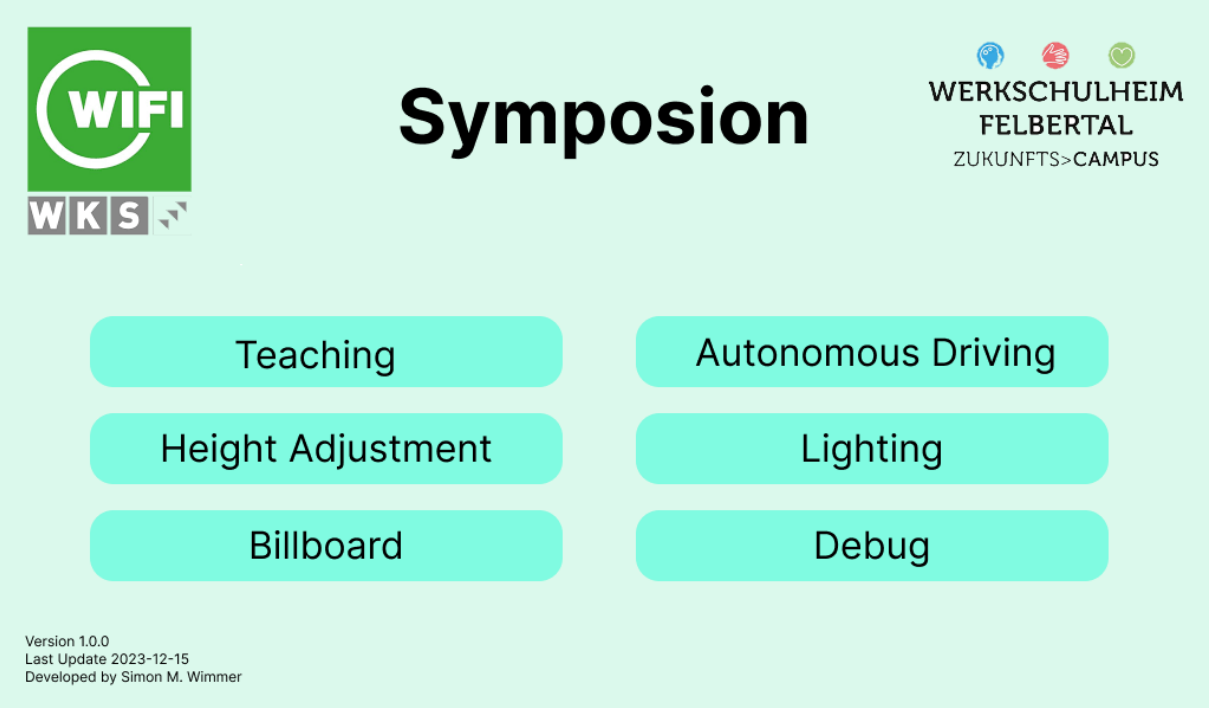


Figure12 : GUI Home

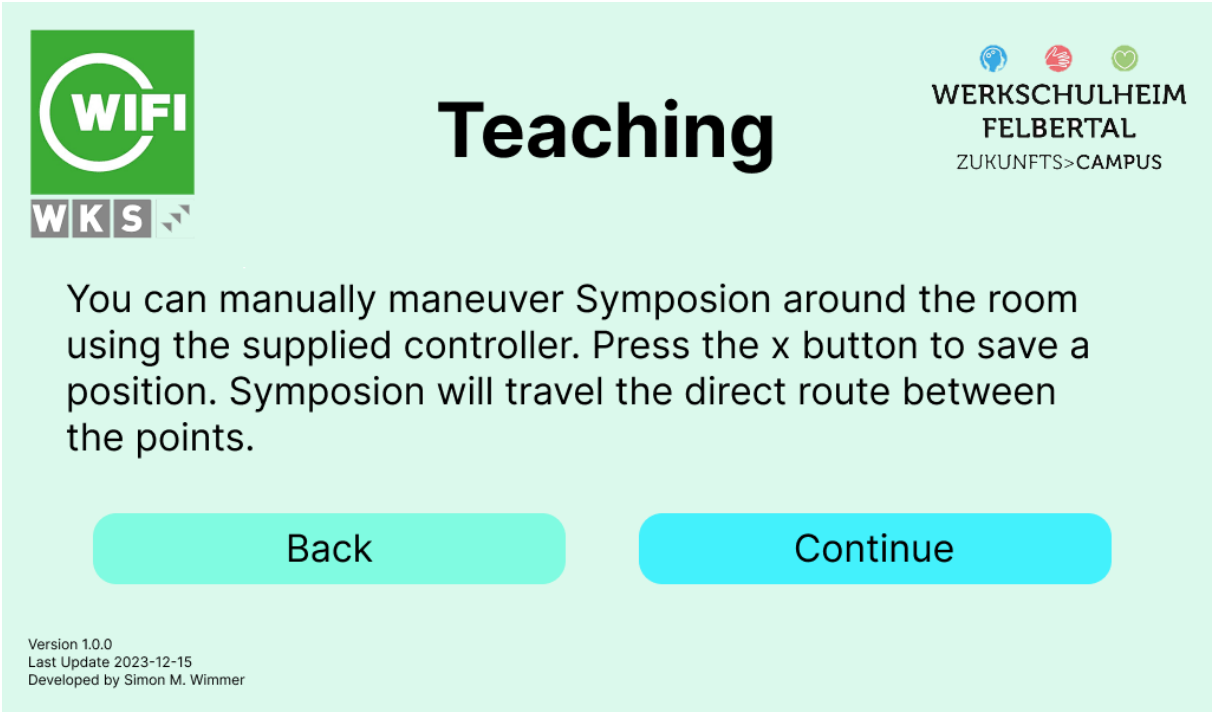
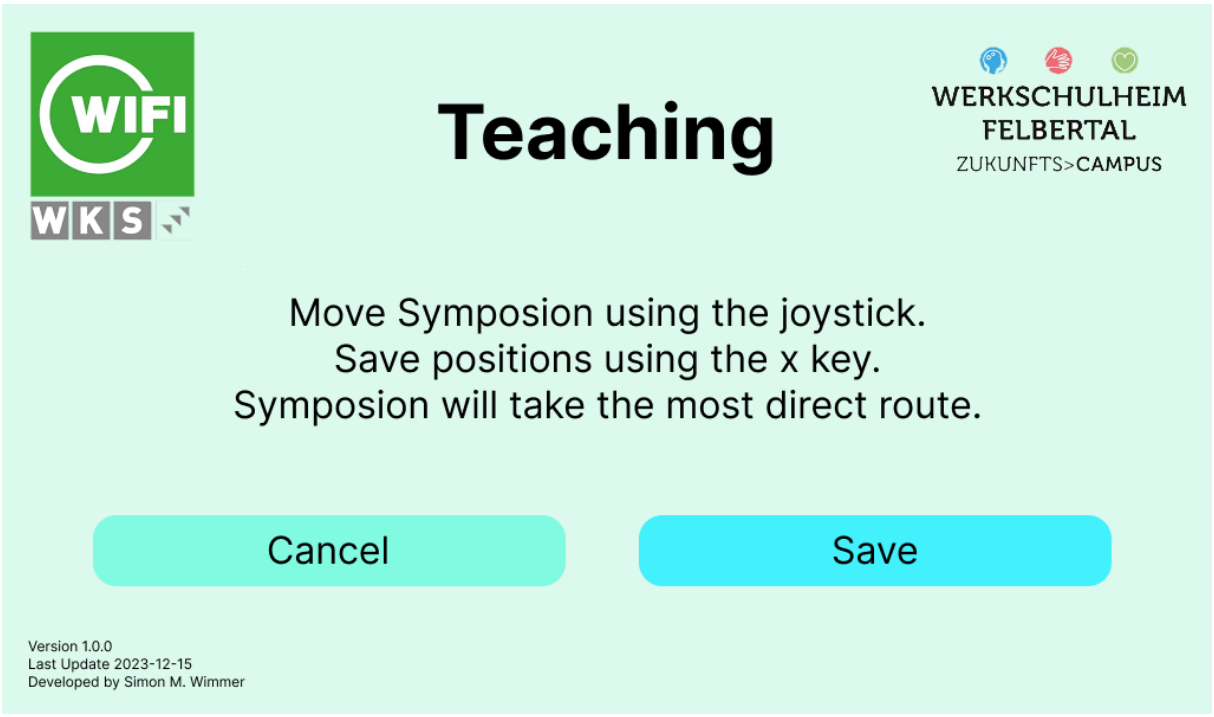
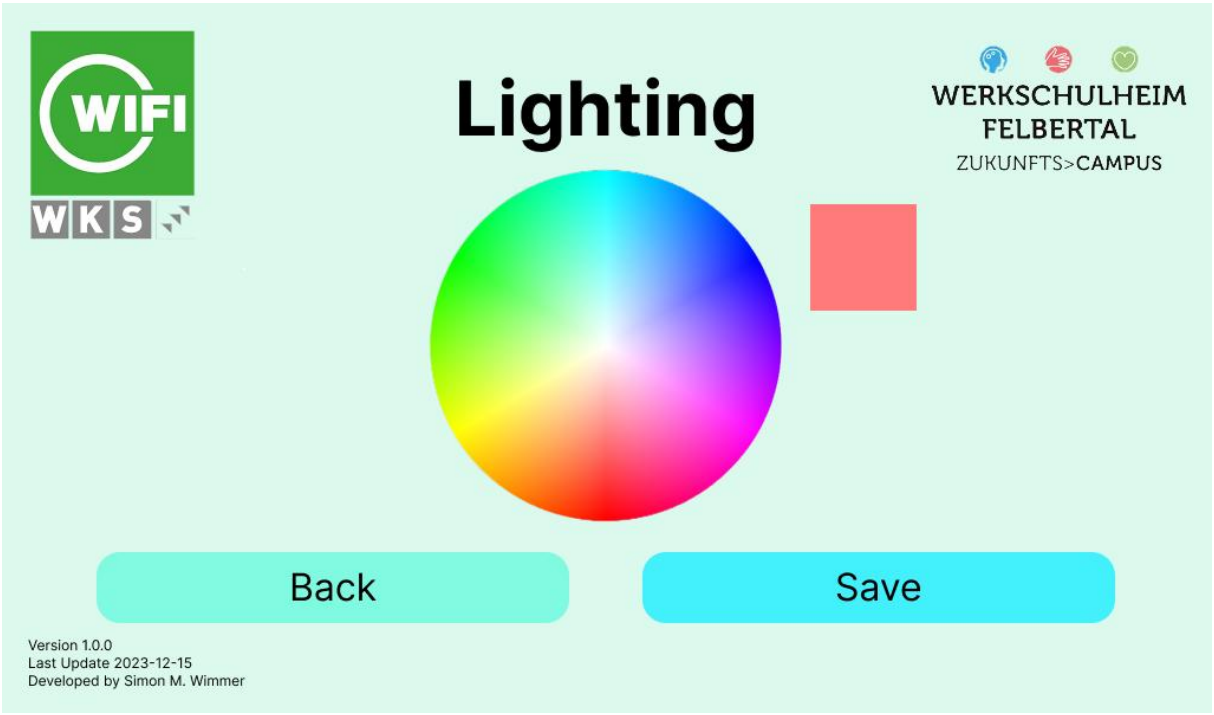


Figure13 : GUI Teaching Explanation



14 : GUI Teaching

Figure15 : GUI Height Adjustment



16 : GUI lighting control

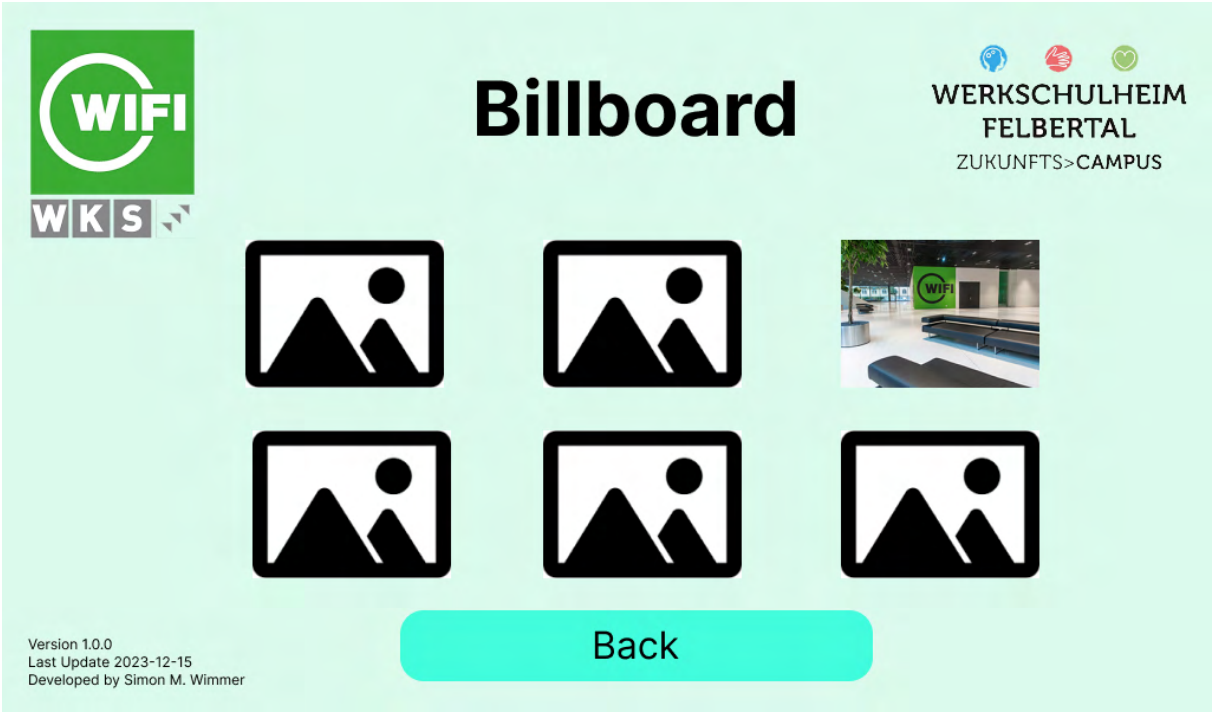


Figure17 : GUI Presentation

Images should be saved to the "static/images" folder, and audio files to "audio/music" in the main directory of the graphical user interface.

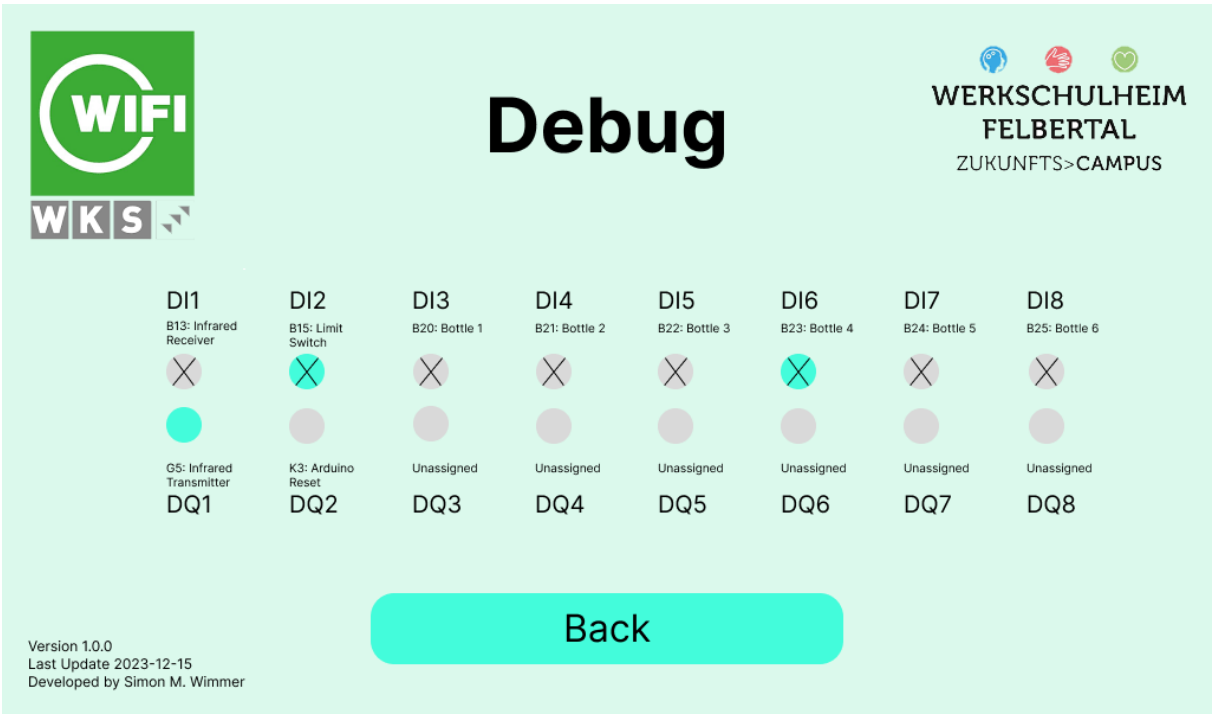


Figure18 : GUI debug

Output buttons can be triggered. The Python web framework will execute them via the ROS library.

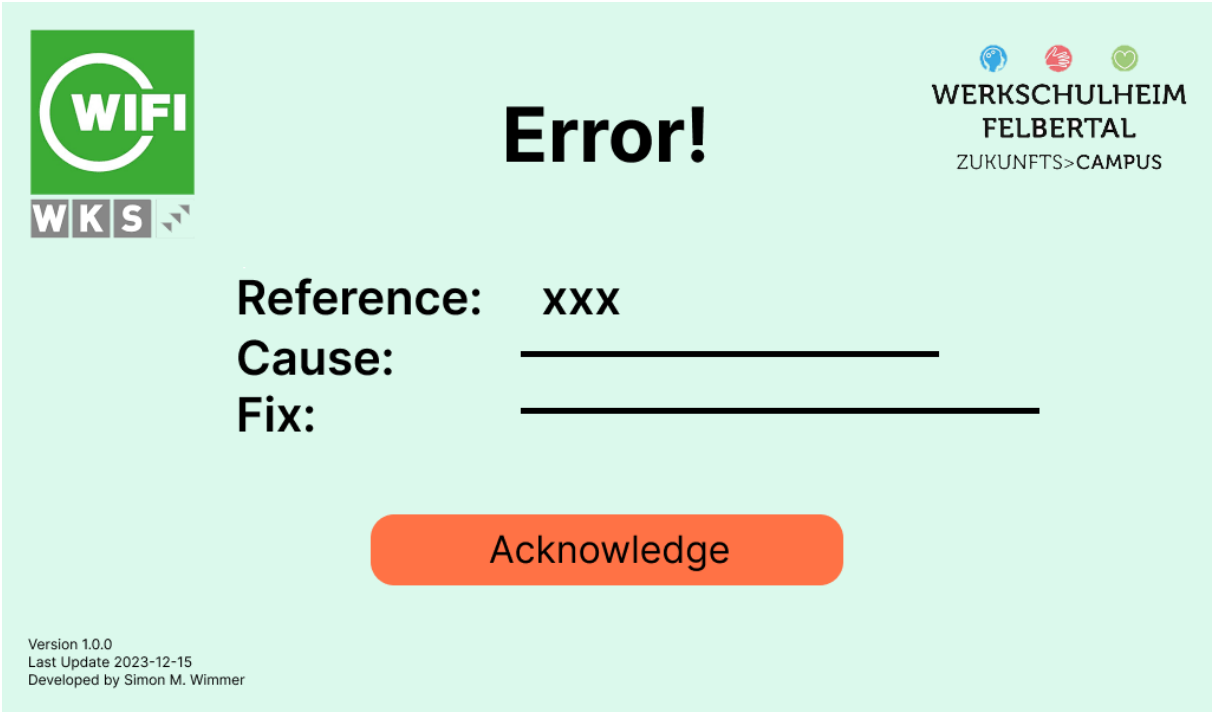


Figure19 : GUI Error

7.5 Error handling

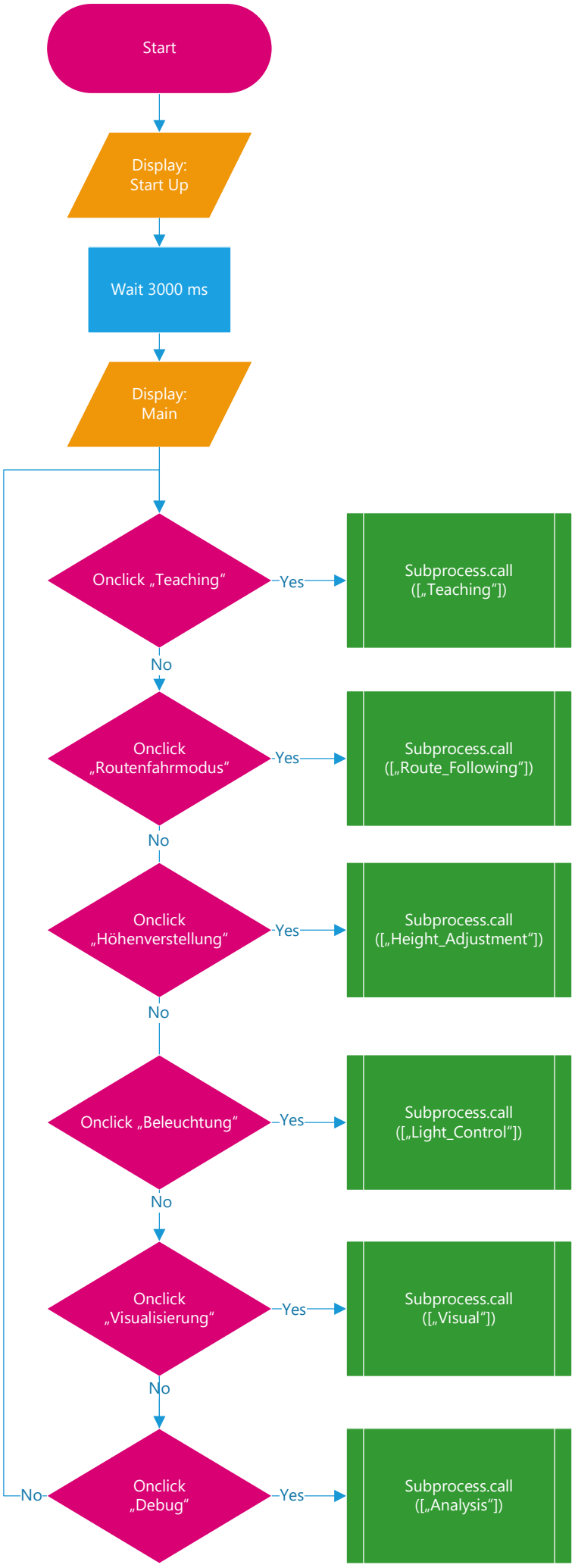
Error	Cause	Remedy
100	Limit switch was not reached within the defined time	Check whether the platform has been moved beyond its limits. If the platform exceeds a limit, it will fall off the spindle. In this case, place the carrier platform back on the spindle.
101	Motor is activated but encoder value does not change	Check whether the motor is still turning. If it is turning, there is a problem with the encoder; if not, there is a problem with the motor. First check the supply cables and then the sensor/actuator itself.
200	USB communication with Arduino could not be established	Check the Arduino's power and data cables. Try restarting the Arduino using the "Reset" button.
201	Arduino is not receiving any feedback from the ToF distance sensors	Check the power and data cables of the distance sensors. Try restarting the Arduino using the "Reset" button.
300	Handshake with service station failed multiple times	Check whether the infrared transmitters are dirty or whether the sensitivity of the receivers is set too low.
301	Communication with Robotino hardware interface failed	Check whether the access point is activated. Restart the robot if necessary.
302	Robotino subroutine cannot be executed	Restart the web application. Restart Symposion if necessary.
400	Battery voltage too low	Charge Symposion’s batteries.

26 : Software error

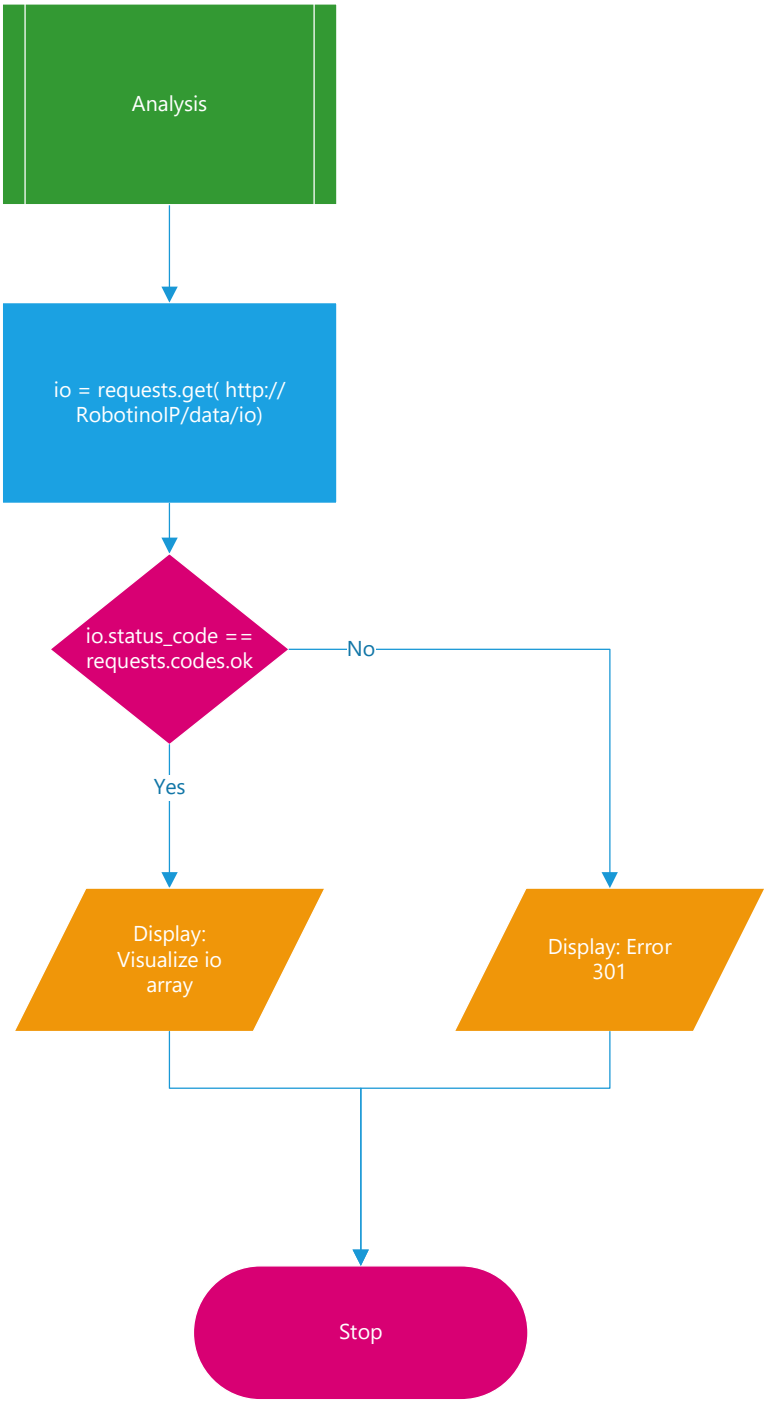
7.6 Commissioning module software

1. GUI: Test whether the web server starts and the graphical user interface can be accessed.
2. Debug: Test whether the digital inputs display the current state and the outputs can be set when debug mode is opened.
3. Presentation: Open the billboard program and test whether a locally stored image can be displayed and audio can be played.
4. Bottle_Detection: Open RobotinoView and check variable values for correctness.
5. Distance_Measurement_K3: Log distance sensor values via SerialWrite and check them for correctness.
6. Distance_Measurement: Open RobotinoView and check distance values for correctness.
7. Light_Control_K3: Insert test values into the Arduino code and check whether the correct PWM signals are output.
8. Light_Control: Select a color via the graphical user interface and test whether communication with the Arduino is successful.
9. Station_Communication: Connect the infrared transmitter to a laboratory power supply and the infrared receiver to an oscilloscope, simultaneously open debug mode in Symposion and check whether the handshake is working.
10. Platform_Referencing: Disconnect the motor and ensure that the motor switches off when the inductive limit switch is activated.
11. Height_Adjustment: Adjust the height using the graphical user interface and check the height values achieved with a tape measure.
12. Teaching: Teach Symposion a route and use RobotinoView to check whether the values have been stored correctly.
13. Route_Following: Have Symposion follow the programmed route and check whether the actual route matches the programmed route.
14. Docking: Place Symposion in front of its charging station and test whether it reaches it autonomously.

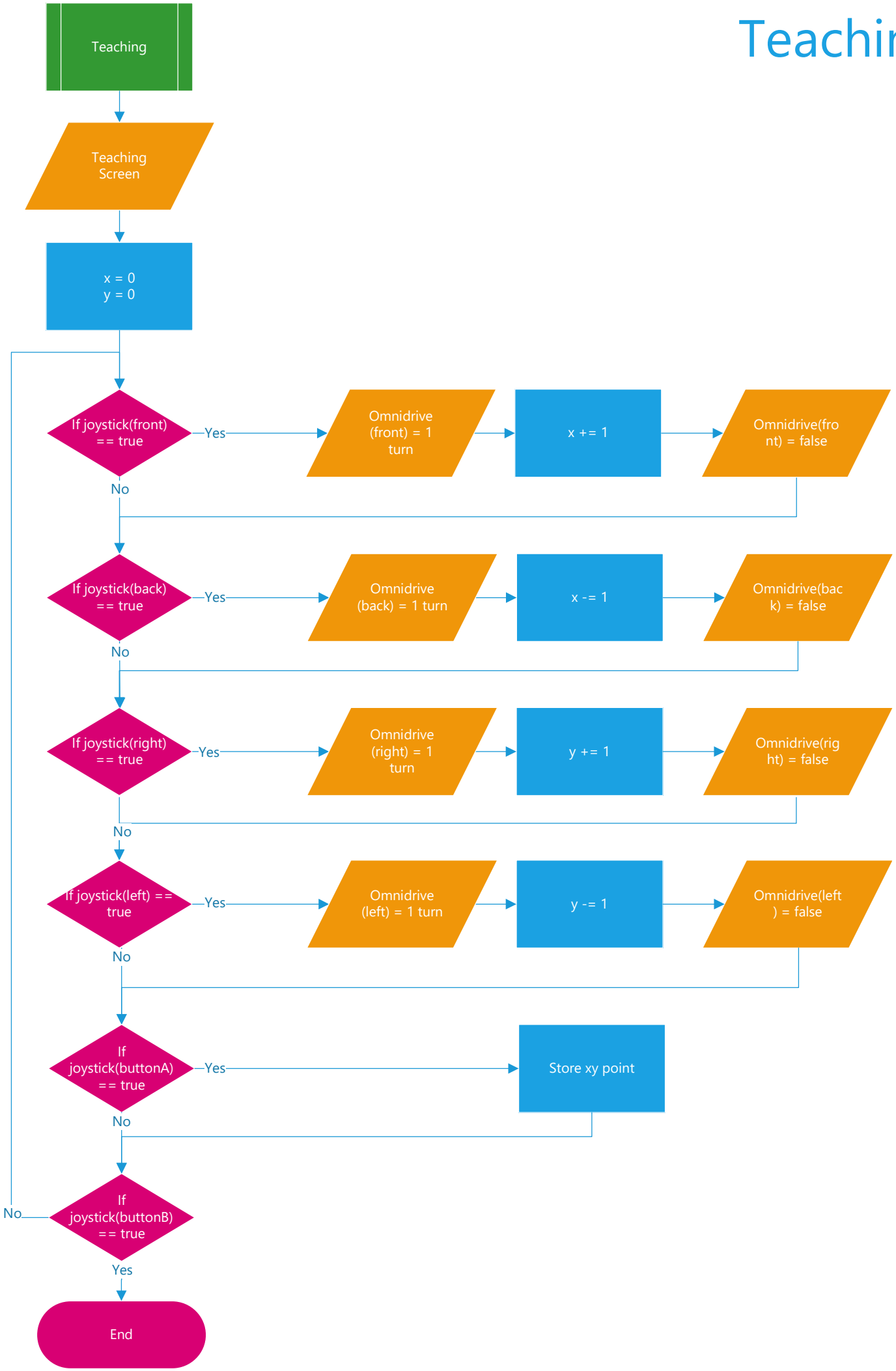
GUI


Start
Display:
Start Up
Wait 3000 ms
Display:
Main
Onclick „Teaching“
Yes
Subprocess.call
([„Teaching“])
No
Onclick
„Routenfahrmodus“
Yes
Subprocess.call
([„Route_Following“])
No
Onclick
„Höhenverstellung“
Yes
Subprocess.call
([„Height_Adjustment“])
No
Onclick „Beleuchtung“
Yes
Subprocess.call
([„Light_Control“])
No
Onclick
„Visualisierung“
Yes
Subprocess.call
([„Visual“])
No
Onclick
„Debug“
Yes
Subprocess.call
([„Analysis“])
No

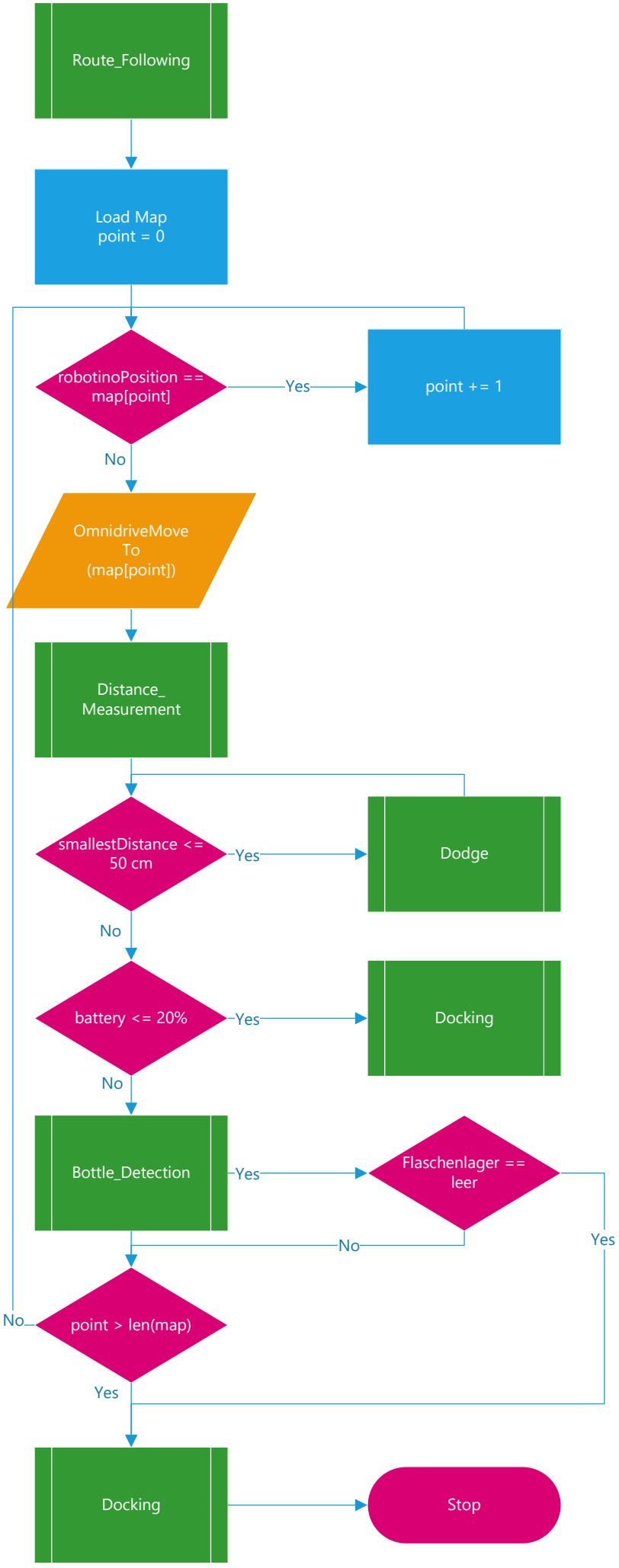
Analysis


Analysis
io = requests.get(http://
RobotinoIP/data/io)
io.status_code ==
requests.codes.ok
No
Yes
Display:
Visualize io
array
Display: Error
301
Stop

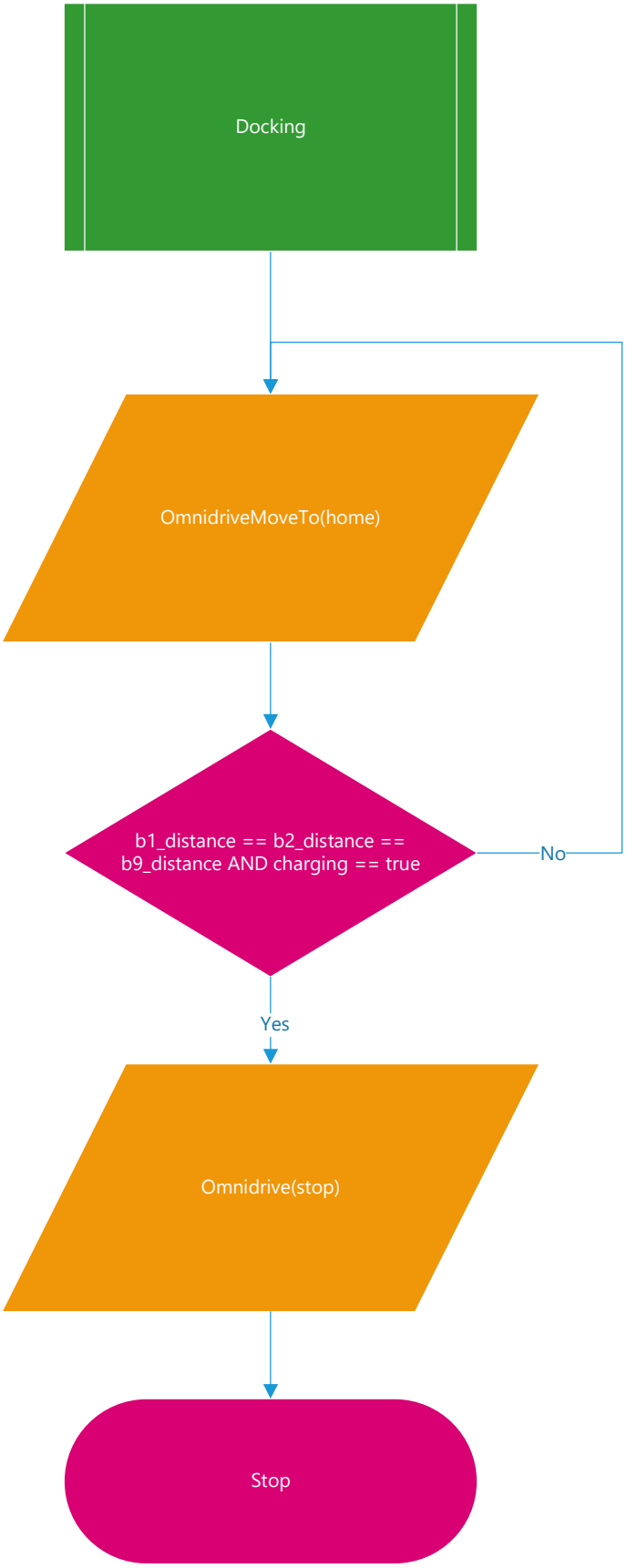
Teaching


Teaching
Teaching Screen
x = 0
y = 0
If joystick(front) == true
Yes
Omnidrive (front) = 1 turn
x += 1
Omnidrive(front) = false
No
If joystick(back) == true
Yes
Omnidrive (back) = 1 turn
x -= 1
Omnidrive(back) = false
No
If joystick(right) == true
Yes
Omnidrive (right) = 1 turn
y += 1
Omnidrive(right) = false
No
If joystick(left) == true
Yes
Omnidrive (left) = 1 turn
y -= 1
Omnidrive(left) = false
No
If joystick(buttonA) == true
Yes
Store xy point
No
If joystick(buttonB) == true
No
Yes
End

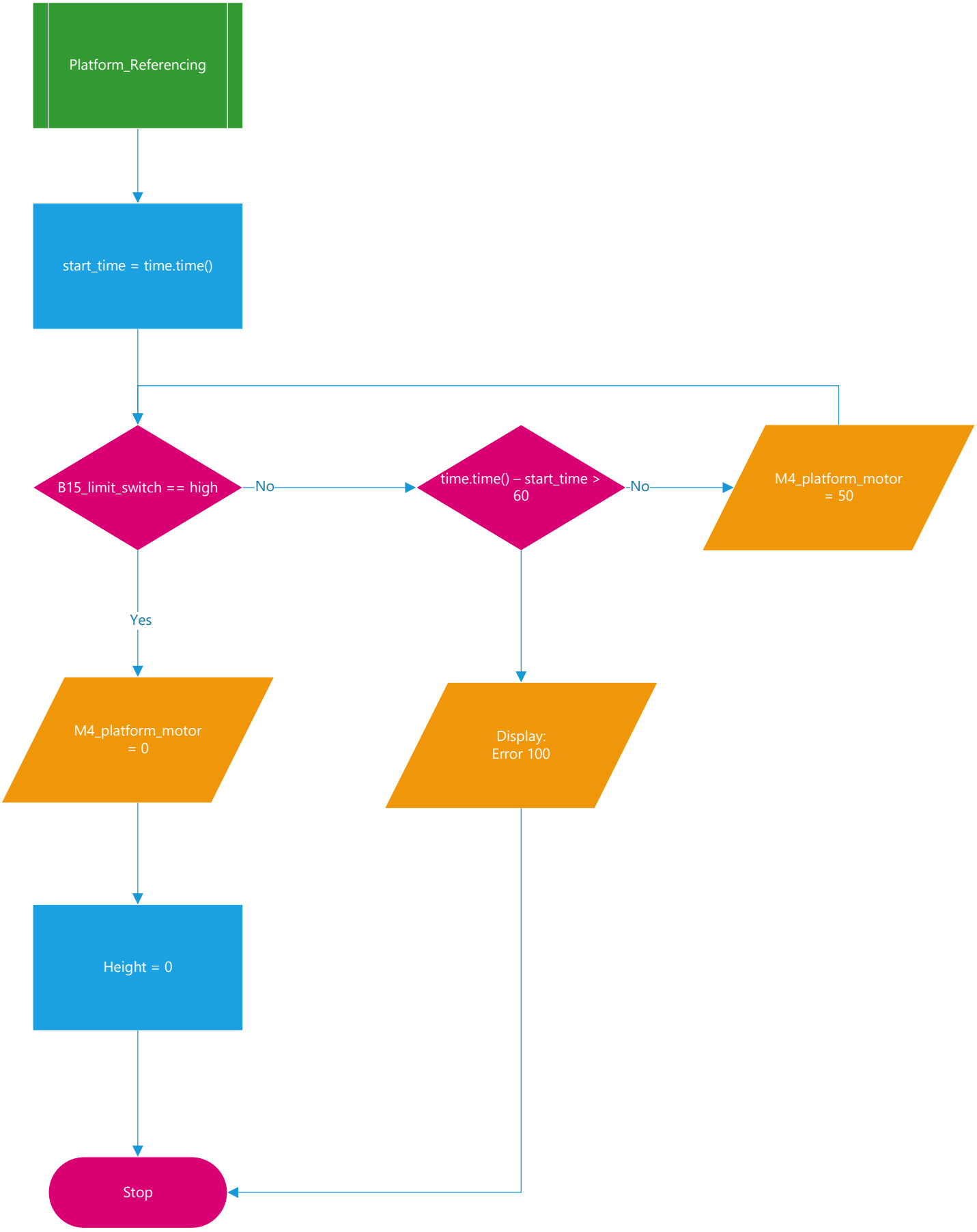
Route_ Following



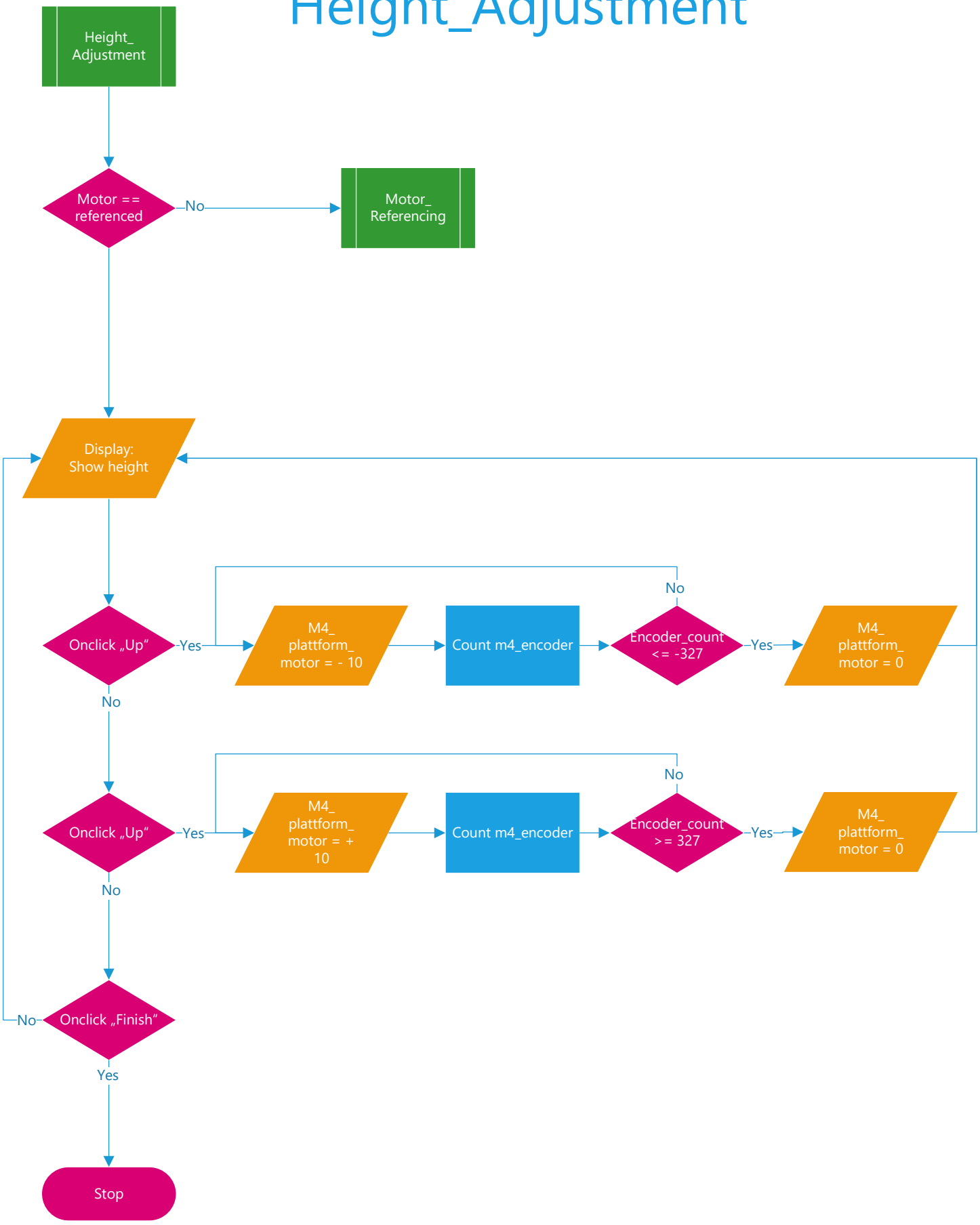
Docking


Docking
OmnidriveMoveTo(home)
b1_distance == b2_distance ==
b9_distance AND charging == true
No
Yes
Omnidrive(stop)
Stop

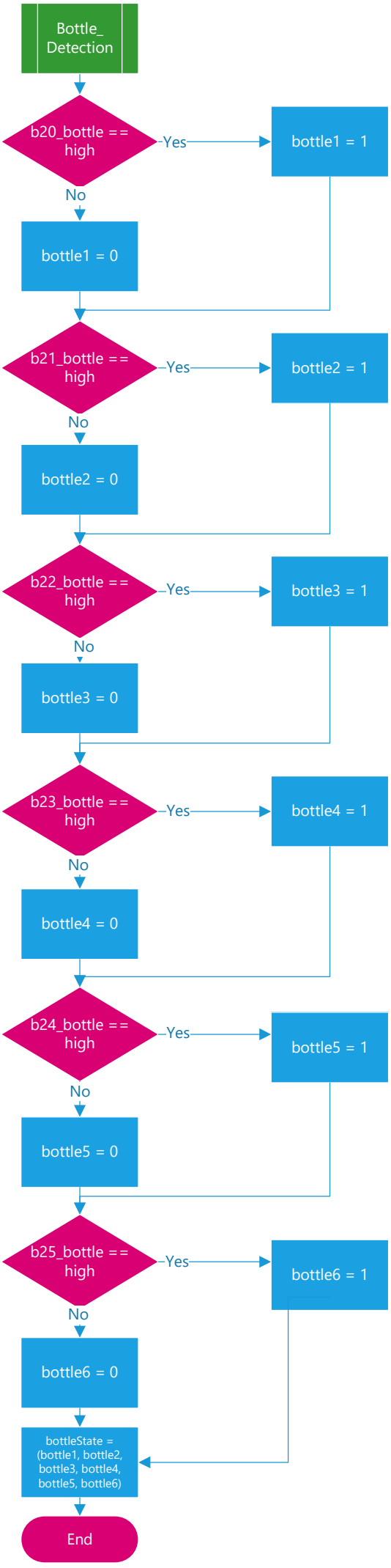
Platform_Referencing



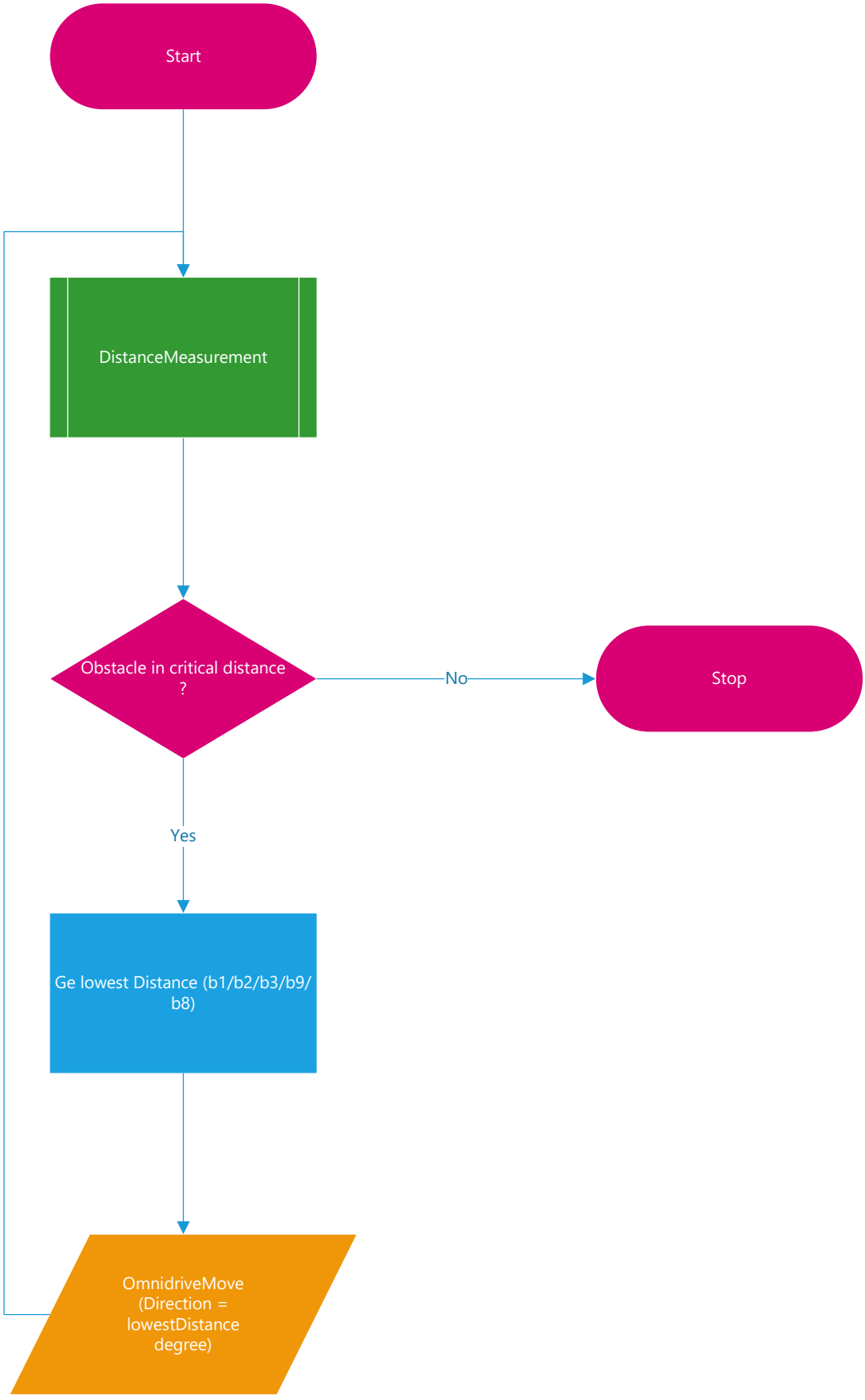
Height_Adjustment



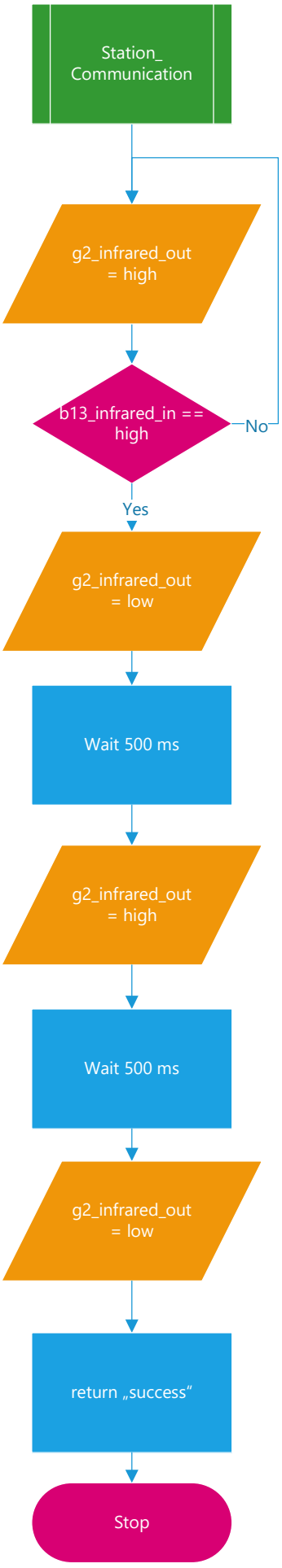
Bottle_Detection



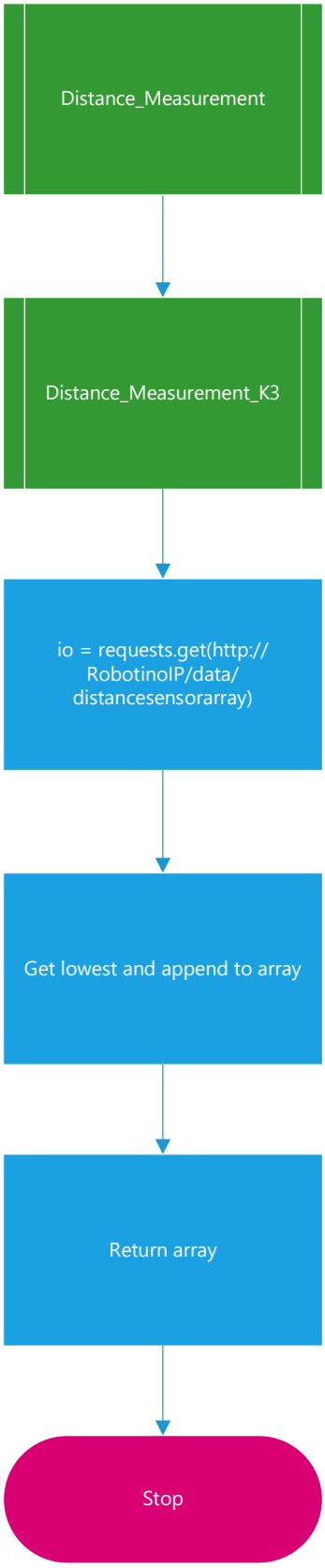
Dodge


Start
DistanceMeasurement
Obstacle in critical distance ?
No
Stop
Yes
Ge lowest Distance (b1/b2/b3/b9/ b8)
OmnidriveMove (Direction = lowestDistance degree)

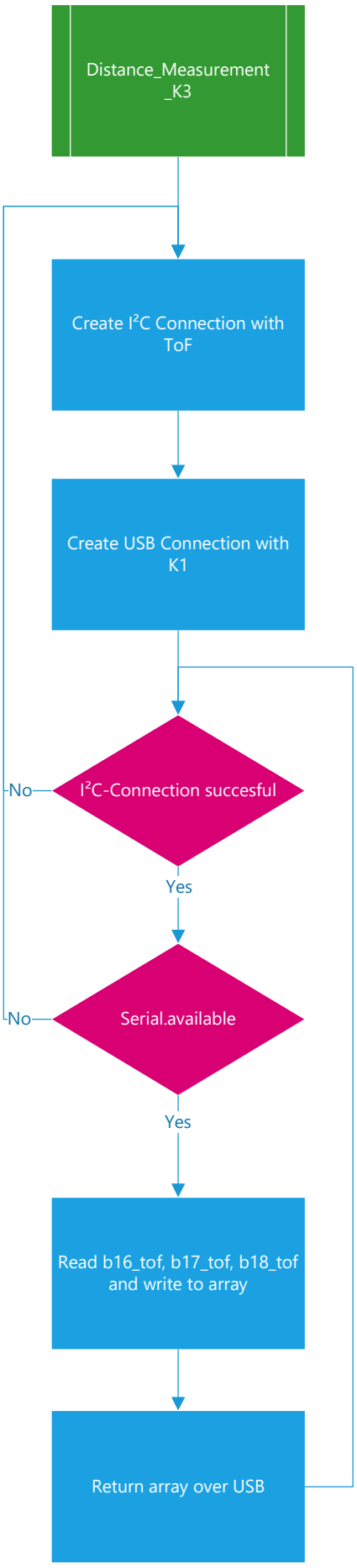
Station_Communication



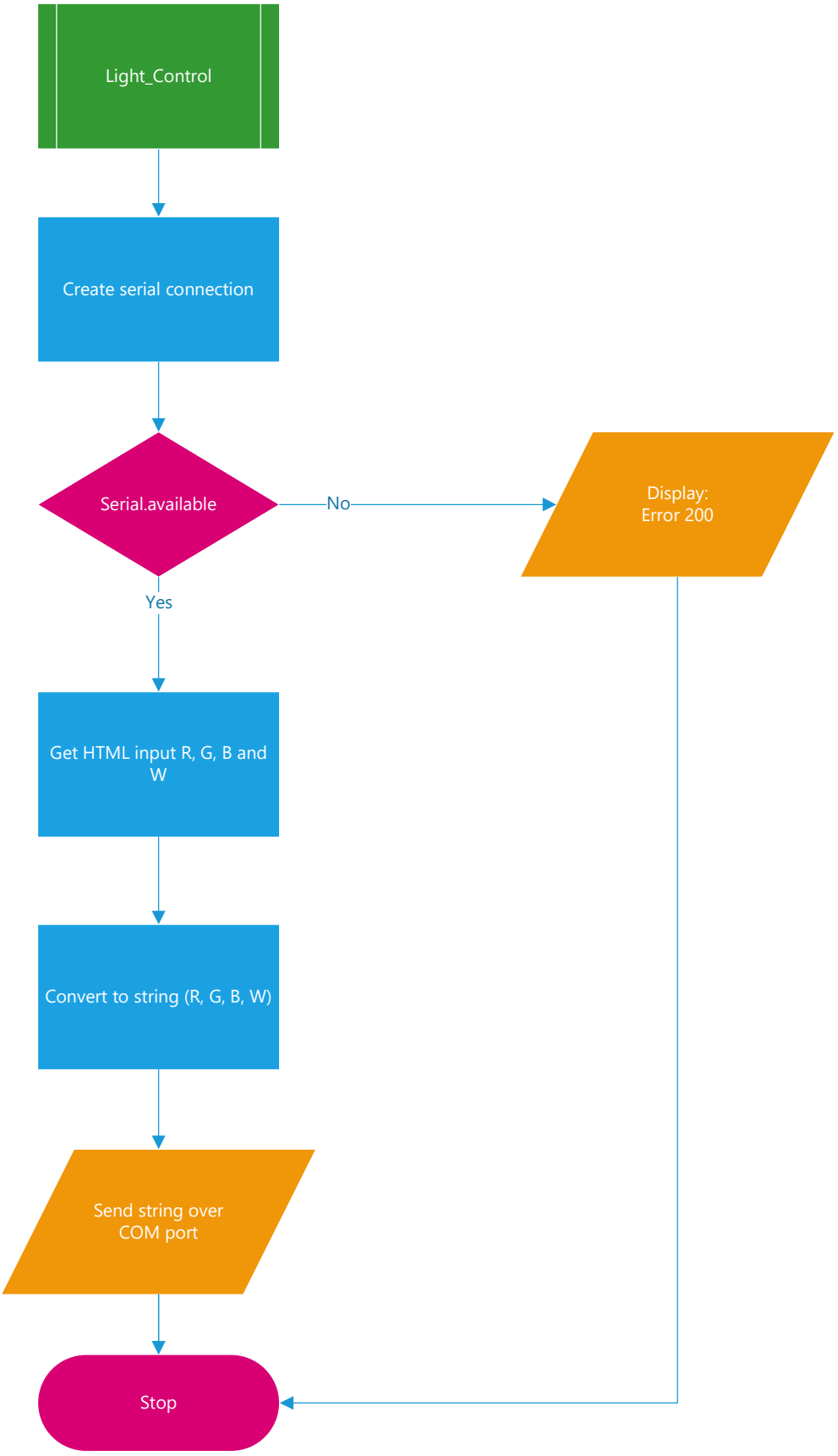
Distance_Measurement



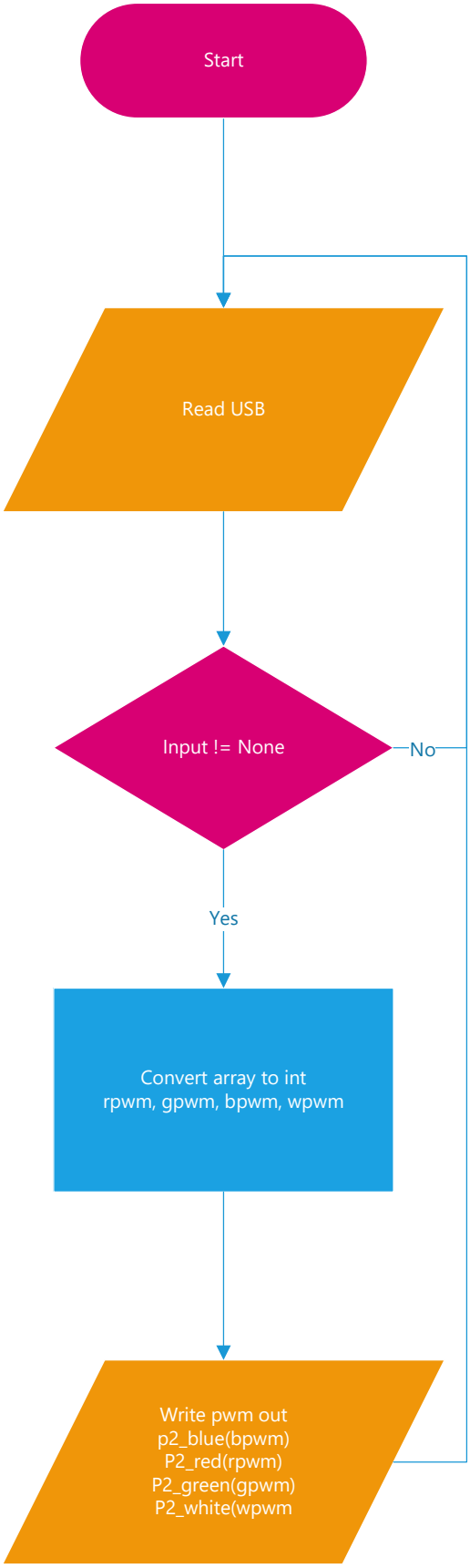
Distance_Measurement_K3



Light_Control



Light_Control_K3



Appendix A – Excerpts from data sheets

7 Technical data

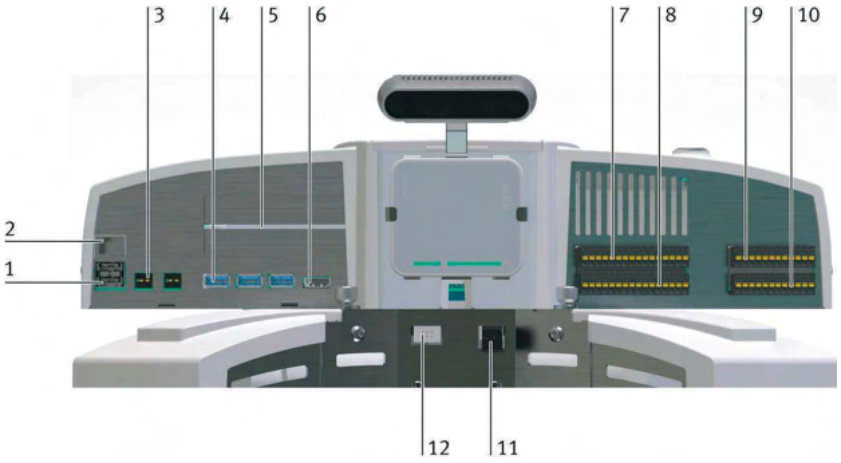
7.1 General data

Parameter	Value
Height	325 mm
Diameter	450 mm
Total weight (unladen weight)	20 kg
Total weight (including 4 rechargeable battery packs)	22.8 kg (approx. 700 g per rechargeable battery pack)
Payload	max. 30 kg (centered)
Degree of protection	IP 00
Battery voltage	18 V
Housing material	Stainless steel, PA6
Degrees of freedom	3 translational in x- and y-direction rotational about the z-axis
Subject to change	

7.2 Control and interfaces

Parameter	Value
Drive	
Wheels	3 x omnidirectional wheels with 120 mm diameter
Motors	3 x DC motors, maximum 3,600 rpm, with encoders and gear unit, gear ratio: 32:1
Controller	Embedded PC to COM Express specifications Intel i5, 8th generation, 2.5 GHz frequency, up to 4.2 GHz in turbo mode, 4 physical cores with hyperthreading Integrated UHD Graphics 630 Main memory: 8 GB RAM Hard disk: 64 GB SSD Operating system: Linux Ubuntu 18.04 LTS (64 bit) Motor control: microcontroller with 32-bit microprocessor and separate Ethernet interface
Subject to change	

7.2.1 Electrical connections



Parameter	Value	No. in fig.	Designation
Interfaces	2 x USB 2.0 (1 x occupied by Access point) 1 x RJ-45 (occupied by Access point) 2 x 12 V WAGO-734-162 (max. 2 A total) 4 x USB 3.0 (1 x occupied by camera) 2 x PCI express slots (Gen3 4 x, extensions) 1x HDMI 2 x Digital I/O connector 1 x analog input connector 1 x relay connector 1 x Wago 721-462 2-pole motor 4, power plug 1 x MPE RM 2.54 2x3-pole motor 4, encoder WLAN to specification, 5 GHz and 2.4 GHz as client or access point in bridge mode	1 2 3 4 5 6 7, 8 9 10 11 12 –	-XF2, -XF3 -XF1 -XD5-1, -XD5-2 -XF4, -XF5, -XF6, -XF9 – -XF7 -XD1, -XD2 -XD3 -XD4 – –
Subject to change			

Parameter	Value
Digital inputs/outputs Inputs: 8 Outputs: 8	 Max. 24 V DC Max. 2 A per output Max. 2 A total
Analog inputs	8
Relay toggle switch	2
Camera	USB 3.0 controlled stereo camera (Intel® RealSense ™ depth camera D435) with two color cameras (1080p resolution) Infrared projector and RGB depth-sensing camera architecture with on-board processing
Subject to change	

7.2.2 Motor 4 encoder pin allocation

Pin	Function
1	GND 0 V
2	I (30-3)
3	W
4	V_{CC} 5 V
5	B
6	n.c.
Subject to change	

7.2.3 Motor 4 power plug

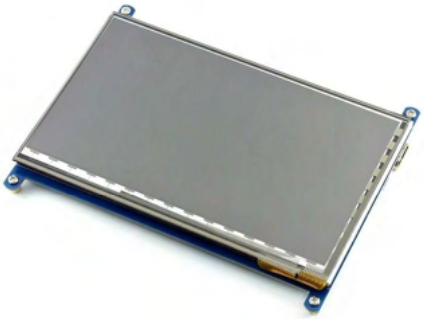
Pin	Function
Left (view of plug)	+(PWM 0-24 V)
Right (view of plug)	GND (PWM)
Subject to change	

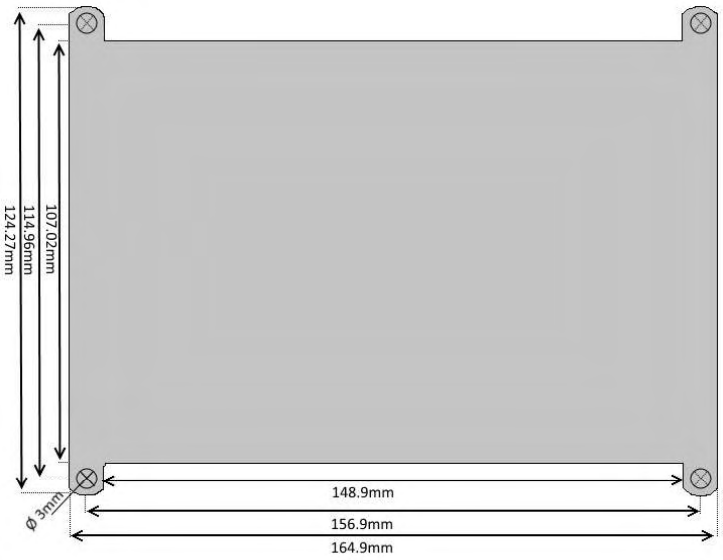
7.2.4 Access point specification

Parameter	Value
WLAN standards	5 GHz (IEEE802.11 ac/n/a) 2.4 GHz (IEEE802.11 b/g/n)
Transmission power	CE: max. 23 dBm (5 GHz) max. 20 dBm (2.4 GHz)
Interfaces	10/100 Mbps WAN/LAN port USB 2.0 port Micro USB port (power supply)
Power supply	5 V max. 2 A
Subject to change	

7Inch LCD Display

Technical specification





This 7 inch TFT display extends the Raspberry Pi or Banana Pi easily by an touchscreen display.
It can also be used on any Windows device and convinces by its high contrast and its true-color image.
With a maximum resolution of 1024x800 pixels, this display is suitable for every use case.

Model	RB-LCD7-2
Resolution	1024 x 600
Supported Devices	Raspberry Pi A+/ B+/ 2B / 3B, Banana Pi, Banana Pro, Windows-PCs
Special features	Can also be used as an independent HDMI-Display
LCD Type	TFT
Connections	HDMI, Micro-USB
Touch Controller	GT811
Touch-Panel Type	Capacitive (5 Multi-Touch)
Backlight	LED
Display-Size	154.21 x 85.92 (mm)
EAN	425023681499

Double sensing distance, DC 3-wire models

Item \ Size / Type		M18		M30	
		Shielded	Non-shielded	Shielded	Non-shielded
		E2B-M18KS08-__-B1 E2B-M18KS08-__-C1	E2B-M18KN16-__-B1 E2B-M18KN16-__-C1	E2B-M30KS15-__-B1 E2B-M30KS15-__-C1	E2B-M30LN30-__-B1 E2B-M30LN30-__-C1
Sensing distance		8 mm	16 mm	15 mm	30 mm
Differential travel		10% max. of sensing distance			
Target		Ferrous metal (The sensing distance decreases with non-ferrous metal.)			
Standard target (mild steel ST37)		24 × 24 × 1 mm	48 × 48 × 1 mm	45 × 45 × 1 mm	90 × 90 × 1 mm
Response frequency (See note 1.)		500 Hz	400 Hz	250 Hz	100 Hz
Power supply voltage (operating voltage range)		12 to 24 VDC. Ripple (p-p): 10% max. (10 to 32 VDC)			
Current consumption (DC 3-wire)		10 mA max.			
Output type		B models: PNP open collector, C models: NPN open collector			
Control output Load current		200 mA max. (30 VDC max.)			
Indicator		Round visible LED indicator for cable type semsors.			
Operation mode		B1/-C1 models: NO; B2/-C2 models: NC			
Protection circuit		Output reverse polarity protection, Power source circuit reverse polarity protection,			
Ambient air temperature		Operating & Storage: –25 to 70°C (with no icing or condensation)			
Temperature influence		±10% max. of sensing distance at 23°C within temperature range of –25 to 70°C			
Ambient humidity		Operating and Storage: 35% to 95%			
Voltage influence		±1% max. of sensing distance in rated voltage range ±15%			
Insulation resistance		50 MΩ min. (at 500 VDC) between current carry parts and case			
Dielectric strength		1,000 VAC at 50/60 Hz for 1 min between current carry parts and case			
Vibration resistance		10 to 55 Hz, 1.5-mm double amplitude for 2 hours each in X, Y and Z directions			
Shock resistance		M8: 500 m/s², 10 times each in X, Y and Z directions M12-M30: 1000 m/s², 10 times each in X, Y and Z directions			
Standards and listing		IP67 after IEC 60529 EMC after EN60947-5-2			
Connection method		(1) Pre-wired models (standard is dia 4.0 mm PVC with length = 2 m, 5 m) (2) Connector models (Head M8: M8-3pin, Head M12-M30: M12-4Pin)			
Material	Case	Brass-nickel plated			
	Sensing surface	PBT			
	Cable	Standard cable is PVC dia 4 mm.			
Weight (packaged)	Pre-wired models	Approx. 85 g			
	Connector models	Approx. 35 g			

Note 1. The response frequency is an average value. Measurement conditions are as follows: standard target, twice the standard target distance between targets, and a setting distance of half the sensing distance.

VL53L5CX-SATEL

Data brief

VL53L5CX breakout board Time-of-Flight 8x8 multizone ranging sensor with wide field of view

Features

- VL53L5CX Time-of-Flight 8x8 multizone ranging sensor with wide field of view
- Regulator: 5 to 3.3 V range input voltage (output voltage: 3.3 V)
- True distance measurement independent of target size and reflectance
- Divisible board enabling use as mini PCB breakout board, easy to integrate in customer device

Description

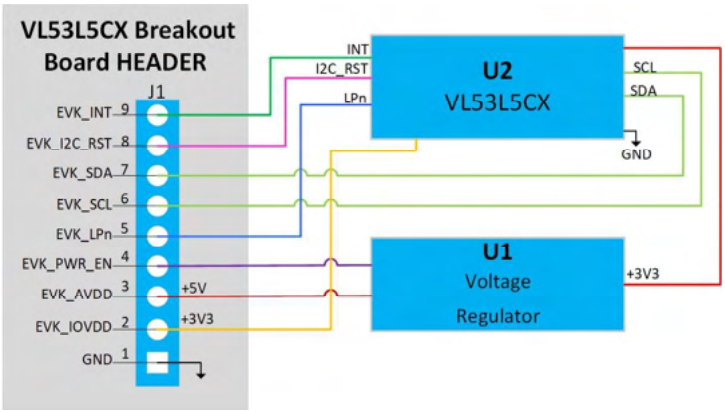
The VL53L5CX-SATEL breakout boards can be used for easy integration into customer devices.

The PCB section supporting the VL53L5CX module is perforated so that developers can break off the mini PCB for use in a 3.3 V supply application using flying wires. This makes it easier to integrate the VL53L5CX-SATEL breakout boards into development and evaluation devices due to their small size.

Product status link	
VL53L5CX-SATEL	Two VL53L5CX breakout boards

2 Schematic and list of materials

Figure 3. VL53L5CX-SATEL schematics



ENGLISH

Features

Mounting	Non-flush
Sensing range Sn	8mm
Setting distance	0...6.48mm
Housing Size	30mm*50mm*7mm
Output	PNP NO
Power supply	10…30VDC
Standard target	Fe 30*30*1t
Temperature drifts	≤±20%
Hysteresis	3…20%
Repeat accuracy	≤3%
Load current	≤200mA
Residual voltage	≤2.5VDC
Consumption current	≤15mA
Protection circuit	Surge and reverse polarity protection
Indicator	Yellow LED
Ambient temperature	-10…55℃
Ambient RH	35-95%RH
Frequency	60Hz
Dielectric strength	1000V/AC 50/60Hz 60s
Insulation resistance	≥50MΩ (500VDC)
Anti-vibration	1.5mm amplitude at 10 to 55Hz for 2hours each in x, y, z D-D
Protection degree	IP67
Housing material	PBT
Connection	PVC Cable 2m

DC motor with worm gear

technical data									
motor		MOT-DC-42-J-H-B	MOT-DC-42-J-H-D	MOT-DC-42-J-H-F	MOT-DC-42-J-H-H	MOT-DC-42-J-H-J	MOT-DC-42-J-H-L	MOT-DC-42-J-H-N	MOT-DC-42-J-H-P
nominal voltage	[VDC]	24	24	24	24	24	24	24	24
nominal torque	[Nm]	2,00	1,75	1,25	0,75	3,00	2,50	1,6	1,4
nominal speed	[1/min]	50	100	200	350	80,0	110	280	400
nominal current	[A]	1,5	2,8	1,9	1,9	4,0	4,0	5,0	4,0
no-load speed	[1/min]	60	125	230	400	100,0	135,0	350,0	500,0
no-load current	[A]	0,45	1,35	0,45	0,70	1,3	1,6	1,3	2,5
starting torque	[Nm]	10,0	8,0	7,5	5,0	18	13	7	9
starting current	[A]	5,0	10,0	9,0	10,0	16	16	18	36
max. shaft load axial	[N]	0	0	0	0	0	0	0	0
max. shaft load radial	[N]	0	0	0	0	0	0	0	0
gear ratio		62:1	62:1	59:3	56:4	62:1	62:1	59:3	59:3

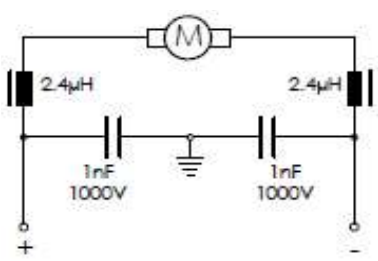
Hall sensor								
operating voltage	[VDC]	5-24V +/-25%						
current per channel max.	[A]	0,1						
impulse / turn (motor shaft)		5						
impulse / turn (drive shaft)		310	310	98	70	310	310	98	98
zero impulse / index		no						

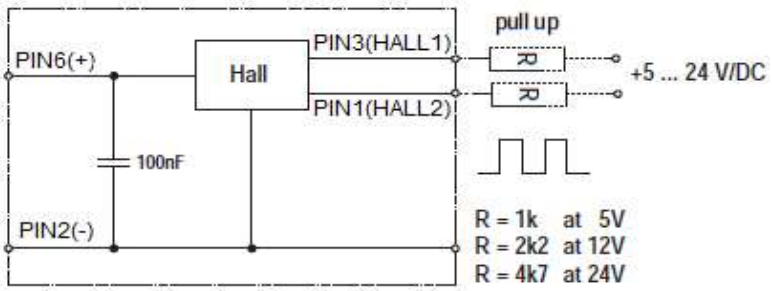
weight		
motor weight	[kg]	0,7

operating data		
ambient temperature	[°C]	-10 …+50
max temperature rise	[°C]	70
humidity (not condensing)	[%]	85
protection class		IP20
operation mode		S2 (short-time duty)

plug connection					
Molex serie Mini-Fit				Mini-Fit,4.2mm,6pol.,2row,stra.	
signal	PIN	color	wire typ	PIN	
Hall chanal 2	1	yellow	0,128mm² (26 AWG)	1	
Hall minus	2	black	0,128mm² (26 AWG)	2	
Hall chanal 1	3	blue	0,128mm² (26 AWG)	3	
motor +	4	red	0,128mm² (26 AWG)	4	
motor -	5	black	0,128mm² (26 AWG)	5	
Hall plus (5-24VDC)	6	orange	0,128mm² (26 AWG)	6	

suppressor	Hall sensor in motor	PullUp supplied by customer

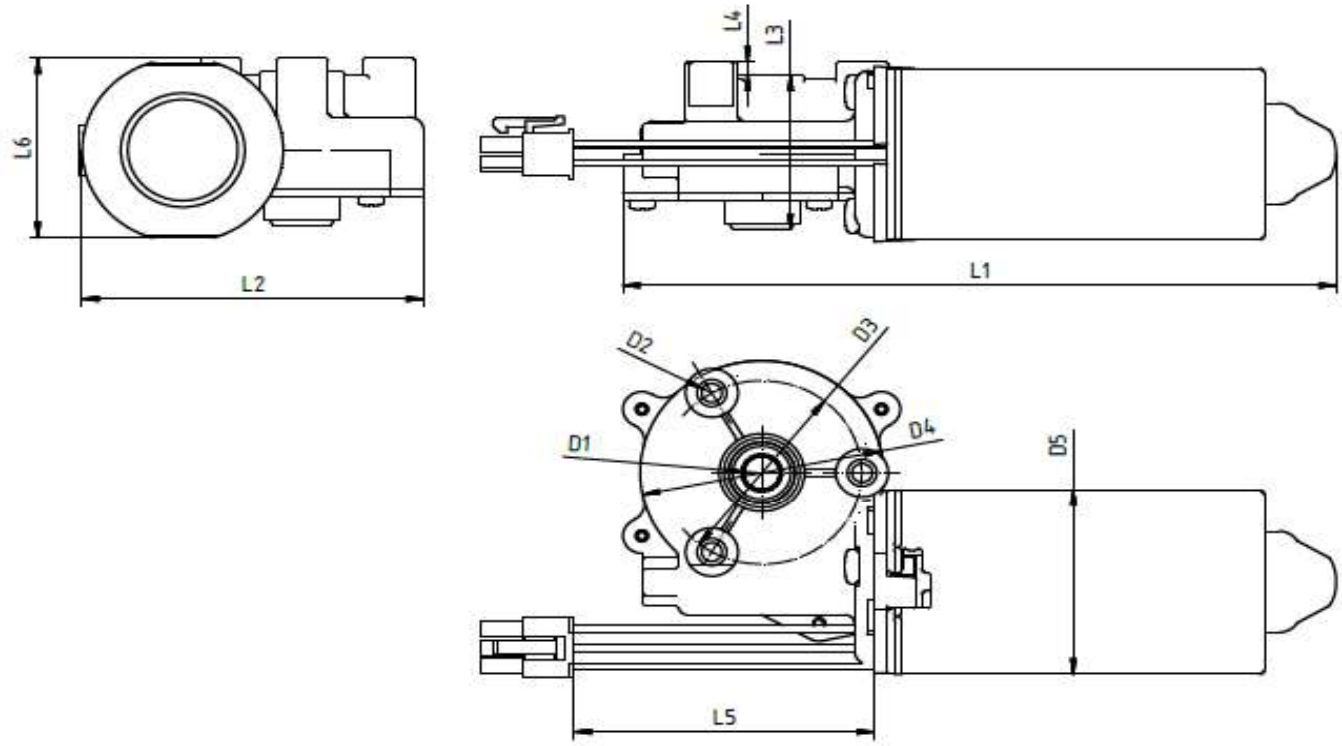




torque-, current- & roation speed datas are valid at cold motor. The tolerance of these values is 10%.

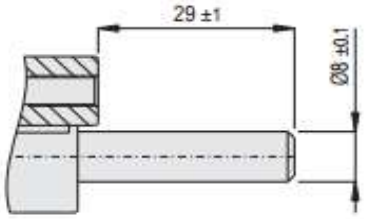
technical data

dimension



typ	D1 [mm]	D2 [mm]	D3 [mm]	D4 [mm]	D5 [mm]	L1 [mm] ±1	L2 [mm] ±2	L3 [mm]	L4 [mm]	L5 [mm]	L6 [mm] ±1
MOT-DC-42-J-H-... (valid for all motors)	7x8 DIN5481	M5	42 (3x120°)	51	42	150	72	35	3	75	41

motor shaft		
part number	description	parts per motor
NOR-22300	plug-in motor shaft (DIN 5481 7x8)	1
NOR-22301	plug-in motor shaft (DIN 5481 7x8) (D-Cut)	1
NOR-20507	lock ring	2



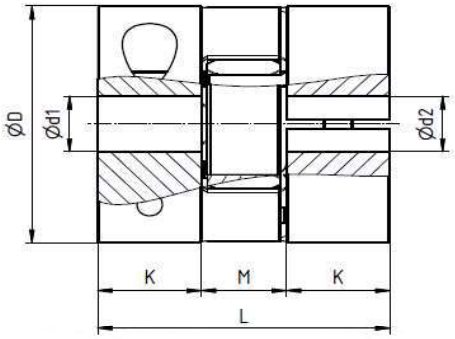
cables

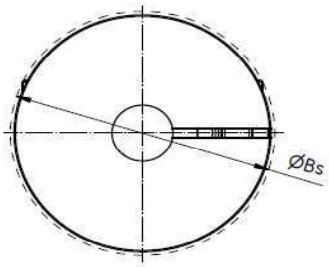
cable Ø: 7,5 mm / bending radius moved < 10 m travel distance: min. 7,5 x d				
part number	outer jacket	type	cable length [m]	connector
DLE904121463-3 (MAT904101539-3 old) (unshielded)	PVC	CF130	3	straight
DLE904121463-5 (MAT904101539-5 old) (unshielded)	PVC	CF130	5	straight
DLE904121463-10 (MAT904101539-10 old) (unshielded)	PVC	CF130	10	straight
cable Ø: 9,5 mm / bending radius moved < 10 m travel distance: min. 10 x d				
part number	outer jacket	type	cable length [m]	connector
DLE904121462-3 (MAT904106262-3 old) (shielded)	PVC	CF211	3	straight
DLE904121462-5 (MAT904106262-5 old) (shielded)	PVC	CF211	5	straight
DLE904121462-10 (MAT904106262-10 old) (shielded)	PVC	CF211	10	straight

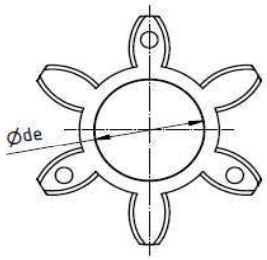
Accessories Coupling

Technical data					
general data					
manufactured size		**25**	**32**	**42**	
max. revolutions per minute	[min^{-1}]	15.000	13.000	12.500	
moment of inertia	[10^{-3} kgm^2]	0,002	0,003	0,01	
mounting screw		M3	M4	M5	
bolting torque mounting screw	[Nm]	2	4	6	
max. offset lateral	[mm]	0,08	0,1	0,1	
max. offset angular	[°]	1	1	1	
max. offset axial	[mm]	±1	±1	±2	
weight min. - max.	[g]	23 - 28	47 - 58	114 - 154	

material		
coupling hub		high-strength aluminium
elastomer annulus		wear-resistant high performance TPU
color		red
Shore hardness elastomer annulus	[Sh]	98
ambient temperature elastomer annulus	[°C]	-30 … +100







dimension							
manufactured size	L [mm]	K1 [mm]	M [mm]	D Ø [mm]	d1/d2 Ø [mm]	de Ø [mm]	-
25	26	8,0	10,0	25,0	4,0 - 12,7	10,2	-
32	32	10,3	11,4	32,0	4,0 - 16,0	14,2	-
42	50	17,0	16,0	42,0	8,0 - 25,0	19,2	-

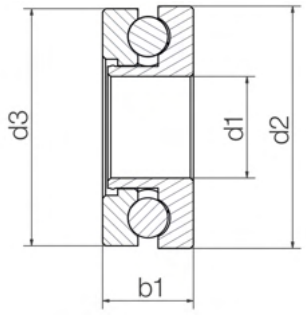
maximal transmittable torque of the coupling depending on the bore diameter																
	shaft diameter [mm]															
	5 [Nm]		6,35 [Nm]		8 [Nm]		10 [Nm]		11 [Nm]		12 [Nm]		14 [Nm]		20 [Nm]	
manufactured size	M_N	M_{max}	M_N	M_{max}	M_N	M_{max}	M_N	M_{max}	M_N	M_{max}	M_N	M_{max}	M_N	M_{max}	M_N	M_{max}
25	1	2	2,5	5	4	8	4,3	8,5	4,5	9	5	10	-	-	-	-
32	2	4	3,3	6,5	6	12	7	14	8,5	17	10	20	12,5	25	-	-
42	-	-	-	-	10	20	11	22	11,8	23,5	12,5	25	13,5	27	17	34

M_N: rated torque (permanent transmittable torque)

M_{max}: max. transmittable torque (short term application torque, for example max. acceleration torque, no permanent transmittable torque)

xiros® axial ball bearings, single row, xirodur® B180, stainless steel balls

BB-51100-B180-ES



xiros® axial ball bearings, single row, xirodur® B180, stainless steel balls

- For shafts Ø: 10, 20 mm
- Good chemical and seawater resistance
- Suitable for food contact
- Operating temperature: -40 °C to +80 °C
- Ring material: xirodur® B180
- Ball material: stainless steel
- Also available with glass balls

Product description

Discover the xiros axial ball bearings, designed for durability and efficiency. Made with xirodur B180 and stainless steel balls, these single-row bearings offer excellent corrosion resistance and are suitable for food contact. They operate smoothly in temperatures ranging from -40 to +80 °C, ensuring low-maintenance and quiet performance without the need for lubricating oil. Ideal for shafts with diameters of 10 or 20 mm, they outshine traditional metal bearings in reliability and longevity.

Thermal properties

Max. long-term application temperature	80 °C
Lower application temperature	-40 °C

Dimensions

size	51100
Ø d1	10 mm
Ø d2	23.5 mm
Ø d3 (Flange)	24 mm
b1	9 mm

General chemical resistance

Alcohol	+ resistant
Greases, oils without additives	+ resistant
Hydrocarbons	+ resistant
Fuels	+ resistant
Strong acids	– non-resistant
Strong alkalis	+ to 0 resistant to conditionally resistant
Diluted acids	0 to – conditionally to non-resistant
Diluted alkalis	+ resistant

General properties

Rings material	xirodur B180
Ball material	Stainless steel
Density	1.42 g/cm³
Colour	White
Max. moisture absorption	0.2 Wt.- %
Max. total moisture absorption	0.7 Wt.- %
Shipping weight (kg or kg/m)	0.006676

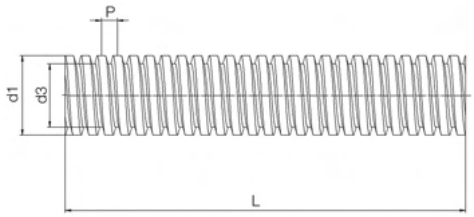
Mechanical properties

max. speed (rpm)	600.0000
Static load capacity	200 N
Dynamic load capacity	250 N
Modulus of elasticity	2500 MPa
Flexural strength (at 20°C/68°F)	68 MPa
Shore D hardness	77.0000

Certificates and standards

dryspin trapezoidal lead screw, right-hand thread, C15 steel AISI 1015

PTGSG-12X3-01-R



dryspin trapezoidal lead screw, right-hand thread, C15 steel AISI 1015

- Outer diameter: 8-50mm
- Pitch: 1.5-8mm
- Single start
- Self-locking

Product description

Introducing the drylin® trapezoidal lead screw, crafted from durable C15 steel AISI 1015. This right-hand thread lead screw transforms rotary motion into smooth linear movement, ensuring 100% maintenance-free dry running. Enjoy quiet and vibration-free operation, with resistance to dust and dirt. Its corrosion-free design and high efficiency make it a cost-effective choice for your projects. Experience fast delivery times and elevate your applications with this reliable lead screw solution.

General properties

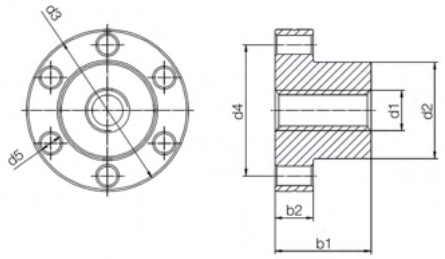
Thread direction	Right-hand thread
Thread type	Trapezoidal threads; absorption of larger axial forces

Dimensions

Thread size	TR12X3
Pitch P	3 mm
Pitch angle α	4.55 °
Outer diameter ø d1 min.	11.8 mm
Outer diameter Ø d1 max.	12 mm
Core diameter Ø d3 min.	7.7 mm
Core diameter Ø d3 max.	8.5 mm
max. length	3000 mm

drylin® trapezoidal lead screw nut with flange, JFRM

JFRM-2835TR12X3



drylin® trapezoidal lead screw nut with flange, JFRM

- Material: iglide® J
- Thread direction: Right-hand thread
- Thread type: Trapezoidal threads
- Design: Standard
- Cylindrical lead screw nut with flange

Product description

Introducing the drylin trapezoidal lead screw nut with flange, JFRM, crafted from high-performance iglidur J material. This versatile lead screw nut ensures high efficiency at all speeds, making it perfect for various applications. Enjoy a low coefficient of friction for reduced wear, and benefit from its durability in temperatures up to +90°C. With its lubrication-free and maintenance-free design, this nut is robust, chemical resistant, and provides quiet, vibration-free operation, ensuring long-term reliability.

Requirements

Mould-resistant according to DIN EN ISO 846 Procedure A	Yes

Thermal properties

Efficiency [η]	19-33

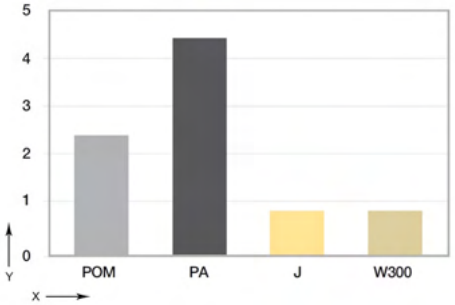
General properties

Thread direction	Right-hand thread
Thread type	Trapezoidal threads; absorption of larger axial forces
With spanner flat	No
Weight	45.625 g

Dimensions

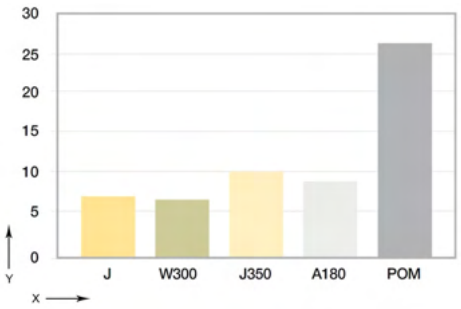
Thread size	TR12X3
Ø d1	12 mm
Ø d2	28 mm
Ø d3	48 mm
Ø d4	38 mm
Ø d5	6 mm
b2	12 mm

Additional information and diagrams



Wear test on a rolled trapezoidal lead screw

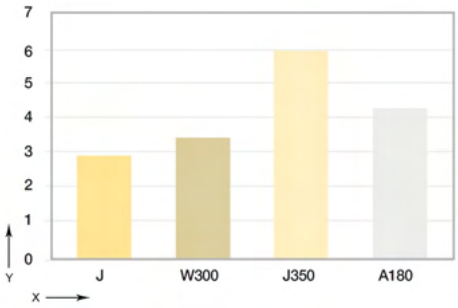
x = Different materials
y = Wear [mg/km]



Wear test on C15 lead screw drive

Stroke 140 mm, 50 N, lead screw C15 rolled, 450 rpm

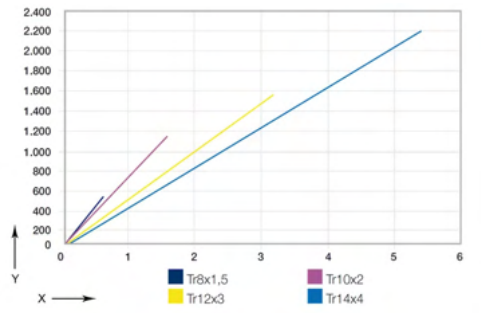
x = Different materials
y = Wear [mg/km]



Wear test on a VA lead screw

Stroke 140 mm, 50 N, lead screw VA rolled, 450 rpm

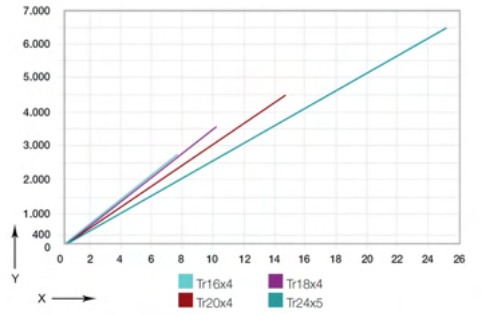
x = Different materials
y = Wear [mg/km]



Required drive torque lead screw modules Ø8 to Ø14

Assuming μ = 0.25, without considering the lead screw supports

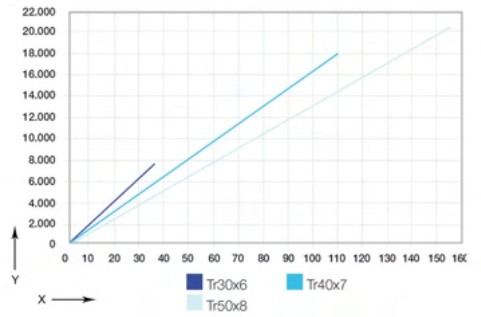
x = Torque [Nm]
y = Load [N]



Required drive torque lead screw modules Ø16 to Ø24

Assuming μ = 0.25, without considering the lead screw supports

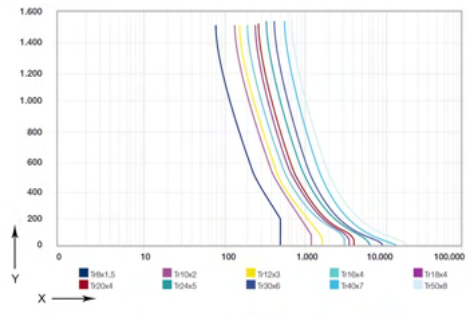
x = Torque [Nm]
y = Load [N]



Required drive torque lead screw modules Ø30 to Ø50

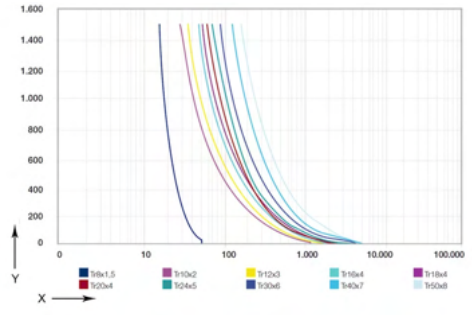
Assuming μ = 0.25, without considering the lead screw supports

x = Torque [Nm]
y = Load [N]



Maximum dynamic load for lead screw units with 10% ESD

x = load [N]
y = speed [rpm]



Maximum dynamic load for lead screw units with 100% ESD

x = load [N]
y = speed [rpm]

SA1E Miniature Photoelectric Switches

Key features:

- Seven sensing methods: through-beam, polarized retroreflective, small beam reflective, diffuse, background suppression, convergent, and transparent.
- 2m cable type and M8 connector.
- NPN output, PNP output, light ON, dark ON can be selected.
- Coaxial polarized retro-reflective type (SA1E-X) available for sensing transparent objects.
- Background suppression (SA1E-B) type detects objects only, ignoring the background.
- Red LED available for easy alignment in long distance applications (SA1E-T, -P, -N, and -B)
- Convergent reflective type (SA1E-G) is ideal for detecting objects at a short distance with a background.
- Also available without sensitivity adjustment (SA1E-T, -P)
- Air blower mounting block for installing an air blower to clean the lens surface. Ideal to maintain a clean lens surface and sensor performance.
- UL Listed and CE marked
- IP67

Part Numbers

Photoelectric Switches

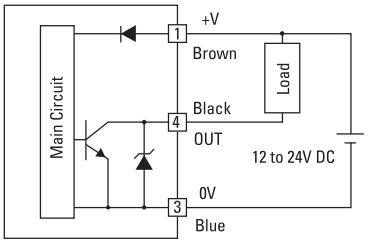
Sensing Method			Sensing Range	Connection	Cable Length	Operation Mode	Part No.	
							NPN Output	PNP Output
Through-beam	Infrared LED	w/Sensitivity Adjustment	10m	Cable	2m	Light ON	SA1E-TN1-2M	SA1E-TP1-2M
						Dark ON	SA1E-TN2-2M	SA1E-TP2-2M
				Connector	–	Light ON	SA1E-TN1C	SA1E-TP1C
						Dark ON	SA1E-TN2C	SA1E-TP2C
		w/o Sensitivity Adjustment	15m	Cable	2m	Light ON	SA1E-TN1-NA-2M	SA1E-TP1-NA-2M
						Dark ON	SA1E-TN2-NA-2M	SA1E-TP2-NA-2M
				Connector	–	Light ON	SA1E-TN1C-NA	SA1E-TP1C-NA
						Dark ON	SA1E-TN2C-NA	SA1E-TP2C-NA
	Red LED	w/Sensitivity Adjustment	10m	Cable	2m	Light ON	SA1E-TAN1-2M	SA1E-TAP1-2M
						Dark ON	SA1E-TAN2-2M	SA1E-TAP2-2M
				Connector	–	Light ON	SA1E-TAN1C	SA1E-TAP1C
						Dark ON	SA1E-TAN2C	SA1E-TAP2C
	Class 1 Laser	w/Sensitivity Adjustment	30m	Cable	2m	Light ON/ Dark ON	SA1E-LTN3-2M	SA1E-LTP3-2M
				Connector	–	Light ON/ Dark ON	SA1E-LTN3C	SA1E-LTP3C

Specifications

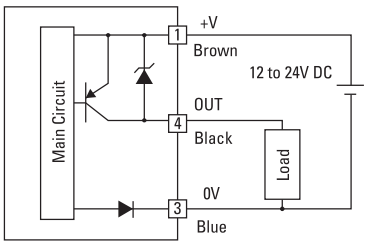
Sensing Method	Through-beam	Polarized Retroreflective	Diffuse-reflective	Small-beam Reflective	Background Suppression (BGS)	Convergent Reflective	Transparent
Part No.	SA1E-□T	SA1E-□P	SA1E-D	SA1E-N	SA1E-□B	SA1E-G	SA1E-X
Power Voltage	12 to 24V DC (Operating range: 10 to 30V DC) Equipped with reverse-polarity protection						
Current Draw	Projector: 15 mA Receiver: 20 mA Laser Receiver: 30 mA	30 mA with laser: 35 mA					20 mA maximum
Sensing Range	With sensitivity adjustment: 10m Laser models: 30m	With sensitivity adjustment: 2.5m (IAC-R5/R8) 1.5m (IAC-R6) 1.3m (IAC-RS2) 1.0m (IAC-RS1) 0.8m (IAC-R7□) [1] Laser models 0.3-10m	700 mm (using 200 × 200 mm white mat paper)	50 to 150 mm (using 100 × 100 mm white mat paper)	20 mm to preset (using 200 × 200 mm white mat paper) with laser: 20 - 300mm	5 to 35 mm (using 100 × 100 mm white mat paper)	2m (when using IAC-R9)
	Without sensitivity adjustment: 15m	Without sensitivity adjustment: 3.0m (IAC-R5/R8) 2.0m (IAC-R6) 1.4m (IAC-RS2) 1.1m (IAC-RS1) 1.0m (IAC-R7□) [1]					
Adjustable Sensing Range	—				40 to 200 mm with laser: 40-300mm	—	—
Detectable Object	Opaque		Opaque/Transparent		Opaque	Opaque/ Transparent	Opaque, transparent and mirror-like objects
Hysteresis	—		20% maximum		10% maximum	20% maximum	—
Response Time	1 ms maximum with laser: 250us						500 µs maximum
Sensitivity Adjustment	Adjustable using a potentiometer (approx. 260°) Through-beam type and polarized retroreflective type are also available without sensitivity adjustment. Laser models: 2 turn adjustment				—	Adjustable using a potentiometer (approx. 260°)	Adjustable using a potentiometer (approx. 240°)
Sensing Range Adjustment	—				6-turn control knob	—	—
Light Source Element	Infrared LED Red LED Red laser diode	Red LED Red laser diode	Infrared LED	Red LED	Red LED Red laser diode	Infrared LED	Red LED
Operation Mode	Light ON/Dark ON						
Control Output	NPN open collector or PNP open collector 30V DC, 100 mA maximum Voltage drop: 1.2V maximum (BGS type: 2V maximum) Short-circuit protection						
LED Indicators	Operation LED: Yellow Stable LED: Green Power LED: Green (Through-beam type projector)				Operation LED: Yellow Stable LED: None	Operation LED: Yellow Stable LED: Green	Operation LED: Yellow Stable LED: None
Interference Prevention	—	Two units can be mounted in close proximity.					
Degree of Protection	IP67 (IEC 60529)						
Extraneous Light Immunity	Sunlight: 10,000 lux maximum, Incandescent lamp: 5,000 lux maximum (at receiver)						
Operating Temperature	–25 to +55°C (no freezing)						
Operating Humidity	35 to 85% RH (no condensation)						
Storage Temperature	–40 to +70°C (no freezing)						
Insulation Resistance	Between live part and mounting bracket: 20 MΩ maximum (500V DC megger)						

Output Circuit & Wiring Diagram

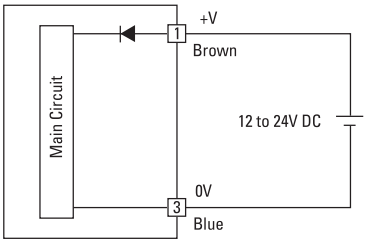
NPN Output



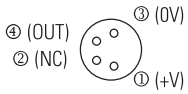
PNP Output



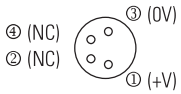
Through-beam Type Projector



(Connector Pin Assignment)

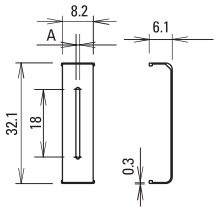


(Connector Pin Assignment)

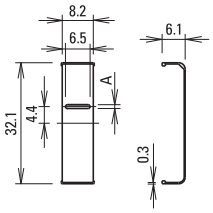


Dimensions (mm)

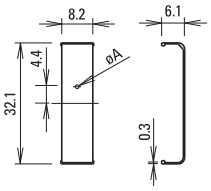
Vertical Slit
SA9Z-S06
SA9Z-S07
SA9Z-S08



Horizontal Slit
SA9Z-S09
SA9Z-S10
SA9Z-S11



Round Slit
SA9Z-S12
SA9Z-S13
SA9Z-S14



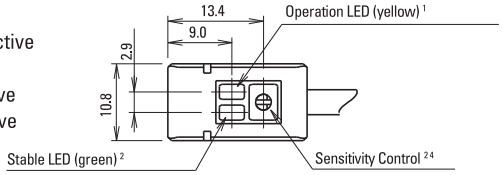
Material: Stainless Steel

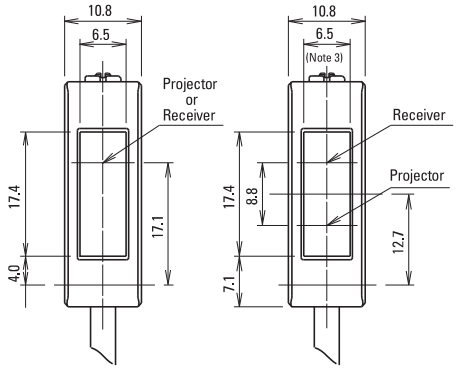
Cable Model

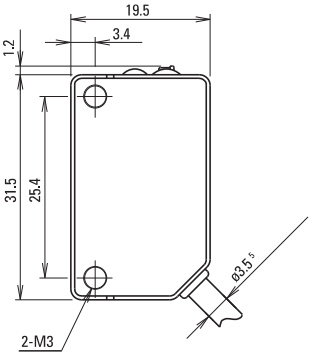
Through-beam

Polarized retroreflective
Diffuse-reflective
Small-beam reflective
Convergent reflective

- Through-beam
- Polarized retroreflective
- Diffuse-reflective
- Small-beam reflective
- Convergent Reflective





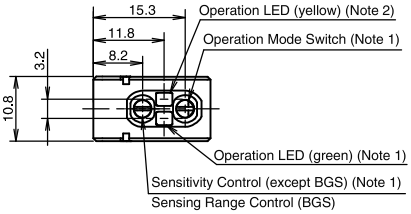


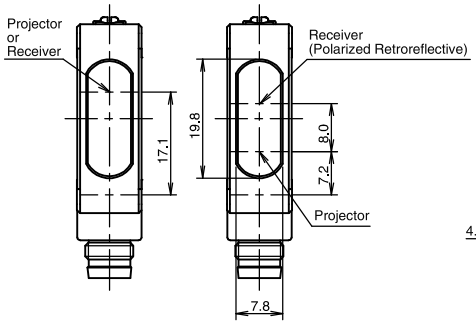
1. Power ON LED (green) for through-beam projector
2. No sensitivity control and stable LED are attached on the through-beam projector.
3. 5.2 mm for polarized retroreflective type
4. No sensitivity control is installed on the type without sensitivity adjustment.

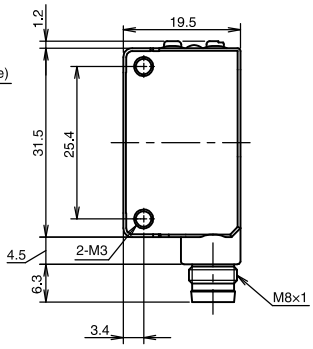
Connector Model (Laser)

Through-beam
Polarized Retroreflective
Background Suppression

1. Stable LED is not provided on the coaxial polarized retro-reflective type.

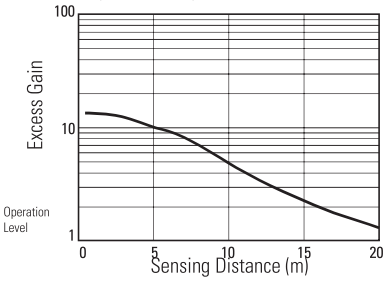




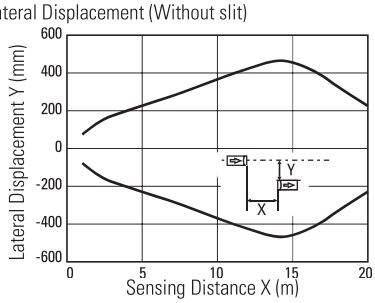


1-1. Through-beam SA1E-T (Infrared LED w/sensitivity adjustment)
SA1E-TA (Red LED) w/sensitivity adjustment)

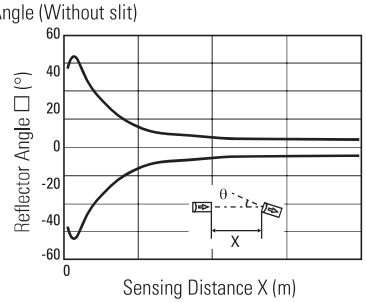
Excess Gain (Without slit)



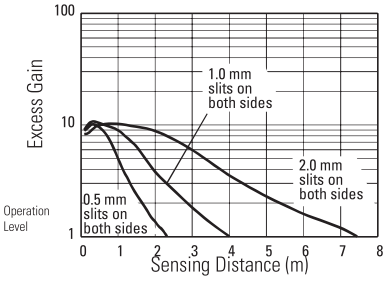
Lateral Displacement (Without slit)



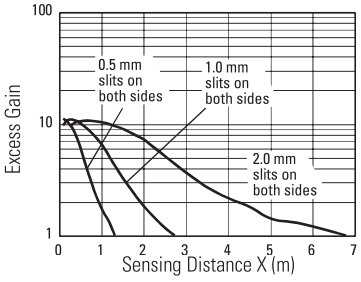
Angle (Without slit)



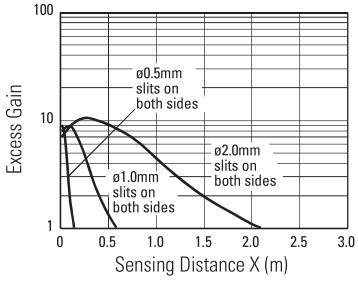
Excess Gain (With vertical slit)



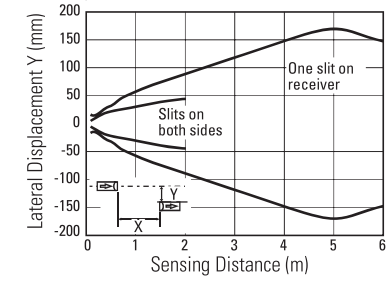
Excess Gain (With horizontal slit)



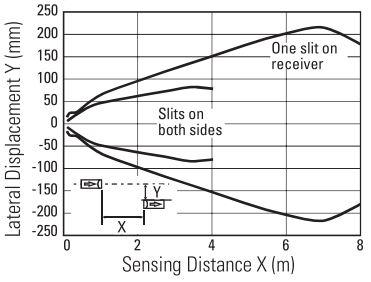
Excess Gain (With round slit)



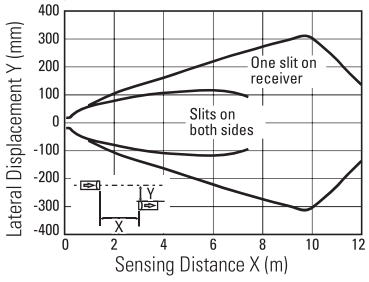
Lateral Displacement (With 0.5-mm vertical slit)



Lateral Displacement (With 1.0-mm vertical slit)

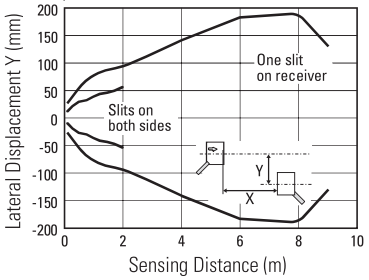


Lateral Displacement (With 2.0-mm vertical slit)

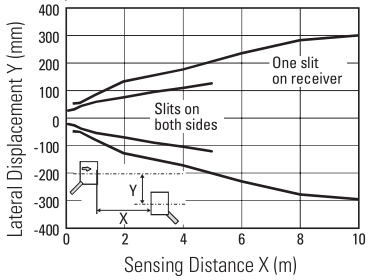


Characteristics (Typical)

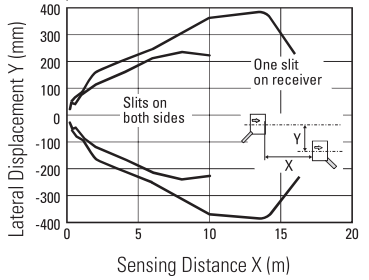
Lateral Displacement (With 0.5-mm horizontal slit)



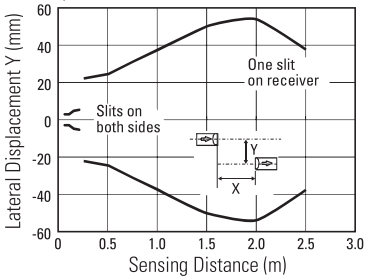
Lateral Displacement (With 1.0-mm horizontal slit)



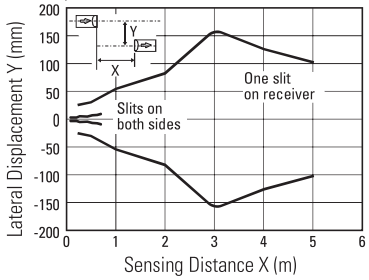
Lateral Displacement (With 2.0-mm horizontal slit)



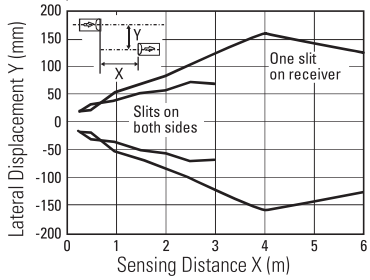
Lateral Displacement (With ø0.5-mm round slit)



Lateral Displacement (With ø1.0-mm round slit)

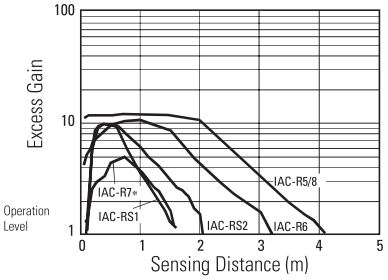


Lateral Displacement (With ø2.0-mm round slit)

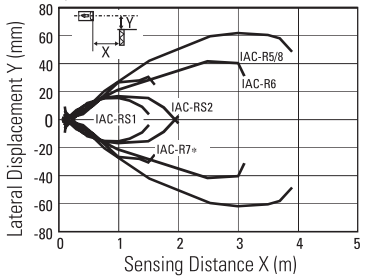


2-1. Polarized Retroreflective SA1E-P (Red LED w/sensitivity adjustment)

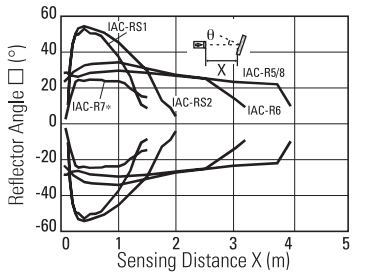
Excess Gain



Lateral Displacement

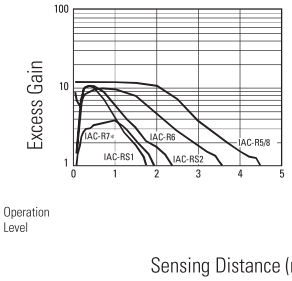


Angle (when using IAC-R5/-R8)

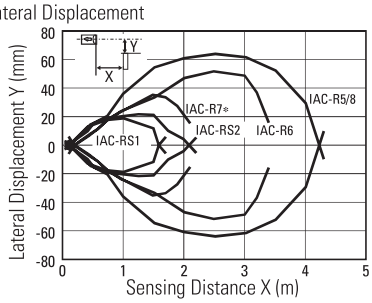


2-2. Polarized Retroreflective SA1E-P☐-NA (Red LED w/o sensitivity adjustment)

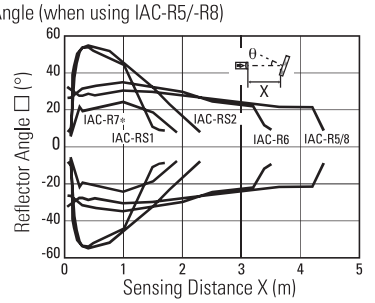
Excess Gain



Lateral Displacement



Angle (when using IAC-R5/-R8)



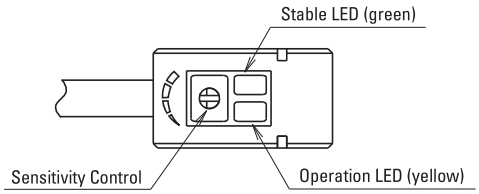
Safety Precautions

Turn off power to the SA1E Miniature Photoelectric Switches before installation, removal, wiring, maintenance, and inspection. Failure to turn power off may cause electrical shock or fire hazard.

Instructions

1. Indicator and Output Operation

(except for background suppression type)



Operation Level	1.2 and over	Stable Incident	ON	ON	OFF
	1.0	Unstable Incident	OFF		
		Unstable Interruption		OFF	ON
	0.8 and below	Stable Interruption	ON		

- The operation LED turns on (yellow) when the control output is on.
- The stable LED turns on (green) either at stable incident or stable interruption. Make sure to use the photoelectric switch after the stable operation is ensured.
- In the light ON operation, the output turns on when the receiving light intensity level is 1.0 or over as shown on the right.
- In the dark-ON operation, the output turns on when the receiving light intensity level is 1.0 or less as shown on the right.

2. Optical Axis Alignment (Light ON)

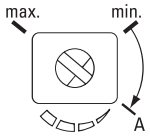
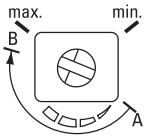
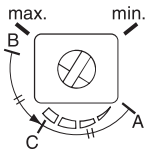
Through-beam
Fasten the receiver temporarily. Place the projector to face the receiver. Move the projector up, down, right and left to find the range where the operation LED turns on. Fasten the projector in the middle of the range. Next, move the receiver up, down, right and left in the same manner and fasten in the middle of the range where the operation LED turns on. Make sure that stable LED turns on at stable incident and stable interruption.

Polarized retroreflective
Install the reflector perpendicularly to the optical axis. Move the SA1E photoelectric switch up, down, right and left to find the range where the operation LED turns on. Fasten the switch in the middle of the range. Polarized retroreflective type can be installed also by finding the position where the reflection of projected red light is most intense, while observing the reflection on the reflector from behind the switch. Make sure that stable LED turns on at stable incident and stable interruption.

Diffuse-reflective/Small-beam reflective/Convergent reflective
Place the SA1E photoelectric switch where the switch can detect the object. Move the switch up, down, right and left to find the range where the operation LED tuns on. Fasten the switch in the middle of the range. Make sure that stable LED turns on at stable incident and stable interruption. Because the light source element of small-beam reflective type is a red LED, visual inspection is possible as well.

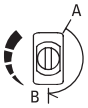
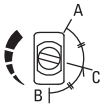
3. Sensitivity Adjustment

- Referring to the table to the right, adjust the sensitivity of the SA1E photoelectric switch when necessary, in such cases as the through-beam type is used to detect small or translucent objects or the reflective type is affected by background. The table explains the status of operation LED when the operation mode is set to light ON.
- After adjusting the sensitivity, make sure that stable LED turns on at stable incident and stable interruption. For detecting objects too small to turn on the stable LED, use an optional slit.
- Sensitivity is set to the maximum at the factory before shipment. When adjusting the sensitivity, use the screwdriver supplied with the SA1E photoelectric switch to turn the control as shown below, to a torque of 0.05 N·m maximum.

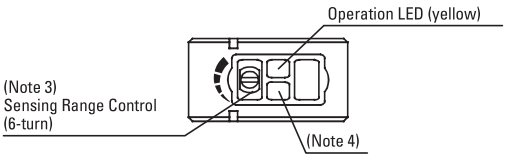
Step	Photoelectric Switch Status	Sensitivity Control	Adjusting Procedure
1	Receiving light • Through-beam, polarized reflective: No object detected • Diffuse reflective, small-beam reflective, convergent reflective: Object detected		Turn the control counter-clockwise to the minimum. Then turn clockwise until the operation LED turns on (turns off with dark ON type) (point A).
2	Light is interrupted • Through-beam, polarized reflective: Object detected • Diffuse reflective, small-beam reflective, convergent reflective: No object detected		At interruption status, turn the control clockwise from point A, until the operation LED turns on (turns off with dark ON type) (point B). If the operation LED does not turn on (turn off with dark ON type) even though the control has reached the maximum, set the maximum position as point B.
3	–		Set the middle point between point A and B as point C.

4. Adjustment of Sensing Range for Background Suppression (BGS) Type

- When adjusting the sensing range, follow the instructions below.

Step	Distance Control	Adjusting Procedure
1		Turn the control counter-clockwise to the minimum. Then turn clockwise until the operation LED turns on (turns off with dark ON type) (point A).
2		At interruption status, turn the control clockwise from point A, until the operation LED turns on (turns off with dark ON type) (point B). If the operation LED does not turn on (turn off with dark ON type) even though the control has reached the maximum, set the maximum position as point B.
3		Set the middle point between point A and B as point C.

1. When the background is far off and not detected, turn the control 360°, and set the point as point C.
2. Because the control is multi-turn, it may take more than one turn to move from point A to point B.



3. Turning the control clockwise lengthens the sensing distance.
4. Background suppression (BGS) type is not provided with a stable LED.

5. Power Supply and Wiring

- Do not use the SA1E photoelectric switch at the transient status immediately after turning on the power (approx. 100 ms, background suppression type: 200 ms). When the load and switch use different power supplies, make sure to power up the switch first.
- Use a power supply with little noise and inrush current, and use the photoelectric switch within the rated voltage range. Make sure that ripple factor is within the allowable limit. Do not apply AC voltage, otherwise the switch may blow out or burn.
- When using a switching power supply, make sure to ground the FG (frame ground) terminal, otherwise high-frequency noise may affect the photoelectric switch.
- Turn power off before inserting/removing the connector on photoelectric switch. Make sure that excessive mechanical force is not applied to the connector. Connect the connector cable to a tightening torque of 0.5 N·m maximum.
- To ensure the degree of protection, use the applicable connector cable for the connector type. Connector cables are ordered separately.
- Avoid parallel wiring with high-voltage or power lines in the same conduit, otherwise noise may cause malfunction and damage. When wiring is long, use a separate conduit for wiring.
- Use a cable of 0.3 mm^2 minimum core wires, then the cable can be extended up to 100m.

6. Installation

Installing the Photoelectric Switch

- Do not install the SA1E photoelectric switches in an area where the switches are subject to the following conditions, otherwise malfunction and damage may be caused.
  Inductive devices or heat source
  Extreme vibration or shock
  Large amount of dust
  Toxic gases
  Water, oil, chemicals
  Outdoor
- Make sure to prevent sunlight, fluorescent light, and especially the fluorescent light of inverters from entering the receiver of the photoelectric switch directly. Keep the through-beam type receiver away from intense extraneous light.
- Interference prevention allows two SA1E switches to be mounted in close proximity. However, the through-beam type is not equipped with interference prevention. Maintain appropriate distance between the switches referring to the lateral displacement characteristics on pages 218, 219, and 220.
- Because the SA1E photoelectric switches are IP67 waterproof, the SA1E can be exposed to water. However, wipe water drops and smears from the lens and slit using a soft cloth to make sure of the best detecting performance.
- Polycarbonate or acrylic resins are used for optical elements. Do not use ammonia or caustic soda for cleaning, otherwise optical elements will be dissolved. To remove dust and moisture build-up, use soft dry cloth.
- Tighten the mounting screws (M3) to a torque of 0.5 N·m. Do not tighten the mounting screws excessively or hit the switch with a hammer, otherwise the protection degree cannot be maintained.

Installing the Reflector

- Use M4 mounting screws for the IAC-R5 reflector and M5 mounting screws for the IAC-R6 reflector. Tighten the mounting screws to a tightening torque of 0.5 N·m maximum. Mounting screws are not supplied with the switch.
- Use the M3 self-tapping screw, flat washer, and spring washer to tighten the IAC-R7 reflector to a torque of 0.5 to 0.6 N·m.
- While optional reflector mounting bracket IAC-L2 is not supplied with mounting screws or nuts, the IAC-L3 and IAC-L5 are supplied with mounting screws for mounting the reflector on the bracket.
- Reflector IAC-RS1 and IAC-RS2 can be installed directly on a flat surface using the adhesive tape attached to the back of the reflector. Before attaching the reflector, clean the board surface to ensure secure attachment.

Installing the air blower mounting block SA9Z-A02

- When installing the SA9Z-A02 on the SA1E photoelectric switch, use the attached M3 × 20 mounting screws and tighten to a torque of 0.5 N·m maximum.
- Do not use the mounting screw (M3 × 12) supplied with the mounting bracket (SA9Z-K01) to mount the SA1E photoelectric switches.
- The SA9Z-A02 cannot be used with the through-beam slits (SA9Z-S06 to S14).
- The air tube fitting (M5) can be installed to either the top or side. The air tube is not supplied.
- Close the unused port using the supplied air supply port plugging screw and gasket to a tightening torque of 1 to 2 N·m maximum. The recommended air pressure is 0.1 to 0.3 MPa.

Installing the background suppression (BGS) type

- This sensor can detect objects correctly when the sensor head is installed perpendicular to the moving object. Install the sensor head as shown below to minimize sensing errors.