SCB-SSPS_0.1.0

Project Design Files

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Exported by

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1 Overview

Quality Assurance:

- General: @ Malte Rosskamp
- Hardware: @ Malte Rosskamp
- Software: @ Max Streicher
- Testing: @ Malte Rosskamp

Objectives

- The objective of this project is to develop a development board that includes the following technologies/systems:
  - Siemens SIMATIC S7 with TIA
  - IO-Link
  - OPC UA
  - CANopen
- The board shall be open to modifications in the future and well documented to enable easy testing of different use cases

Reference

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2 Getting Started

1. Connect the computer, the IO-Link Master and the PLC to a network switch
2. Download the attached software package (only the first time)
3. Run `docker compose up -d` in the folder of the `docker-compose.yml` file on the machine that has the IP Address `10.0.0.241`.
    a. You can check whether this was successful by trying to connect any MQTT-CLient to `localhost:1883`
4. Power up the electrics on the board
5. Make sure the light-barrier is not obstructed, the distancer is in an allowed position and the On/Off switch is in “1“ state
6. The motor should spin now.

Testing out other functions:

- Interrupt the photoelectric barrier to stop the motor
- Activate the inductive sensor via the screw to set the motor to an 2 seconds on-off state
- Move the distance slider to influence the motor RPM

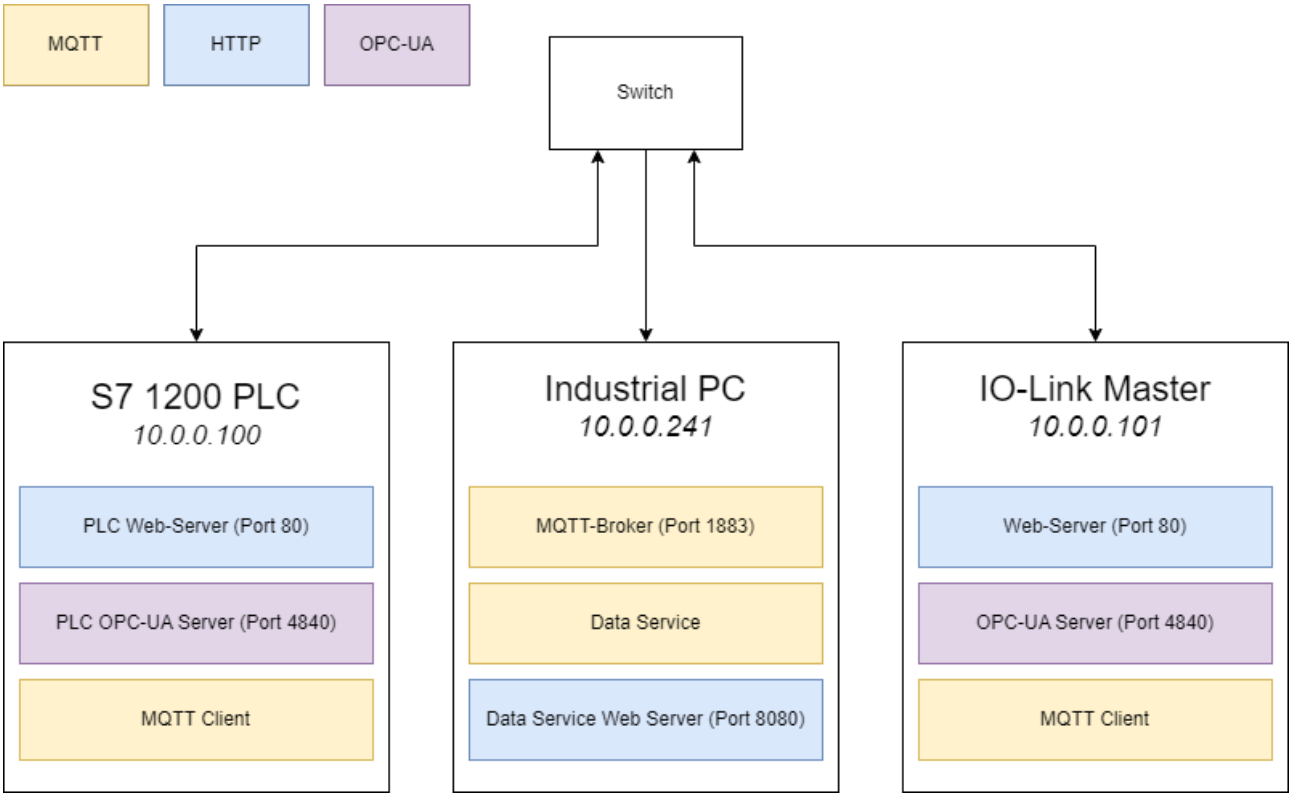
Reading OCP UA Values:

1. Install UA Expert
2. Add the S7 PLC Server by searching the network or entering the IP address `10.0.0.100`
3. Add the IO Link Master Server by searching the network or entering the IPaddress `10.0.0.101`

3 Software

Network:

- 10.0.0.100 - Siemens S7 1200 SPS
- 10.0.0.101 - IO-Link Master
- 10.0.0.241 - MQTT Broker



IO-Link Master

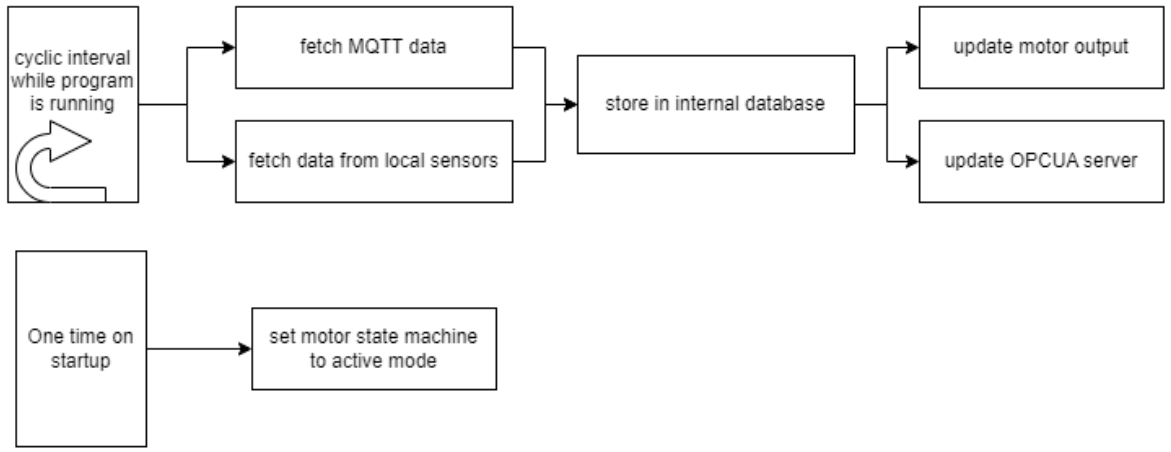
- The IO-Link Master publishes the observations from the temperature sensor, distance sensor, and inductive sensor over MQTT and makes them available via an OPC-UA interface.
  - MQTT-Topics for sensors:
    - `io-link/port/1/#` - Inductive sensor
    - `io-link/port/2/#` - Distance sensor
    - `io-link/port/3/#` - Signal lamp
    - `io-link/port/7/#` - Temperature sensor
  - For OPCUA, the anonymous login is activated
  - Settings can be changed by visiting `http://10.0.0.101` in the browser

S7 1200 SPS

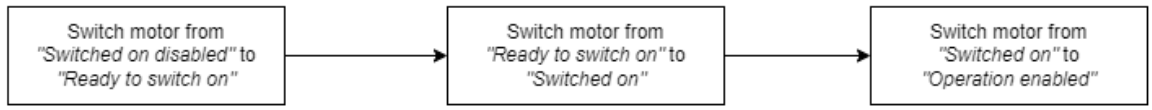
- The S7 1200 SPS uses an `ixxat CM CANopen` module to communicate with the encoder motor
- The SPS is configured and programmed using `TIA Portal V18`

Software state diagrams of the whole SPS, the motor booting sequence and the motor update sequence:

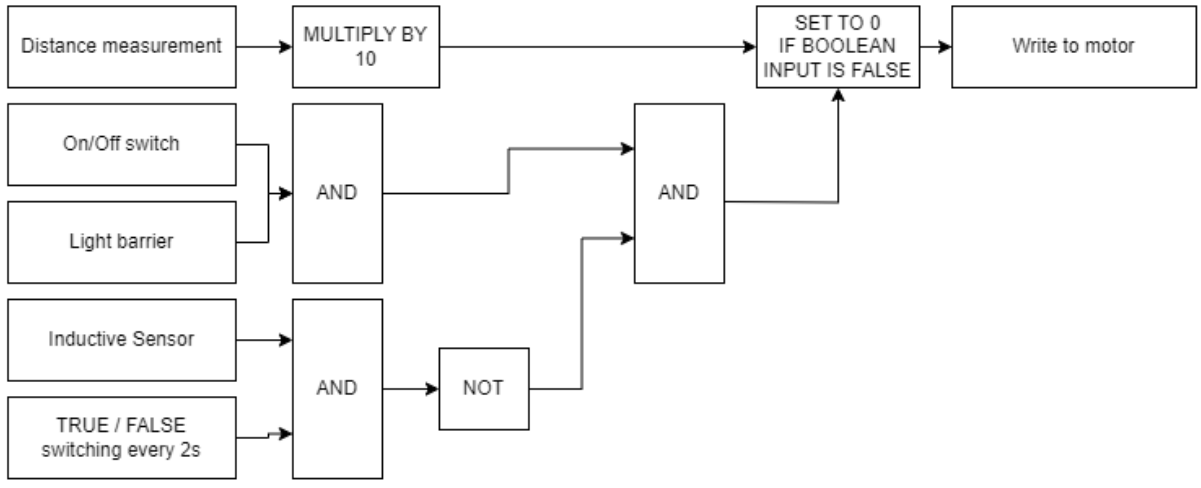
SPS



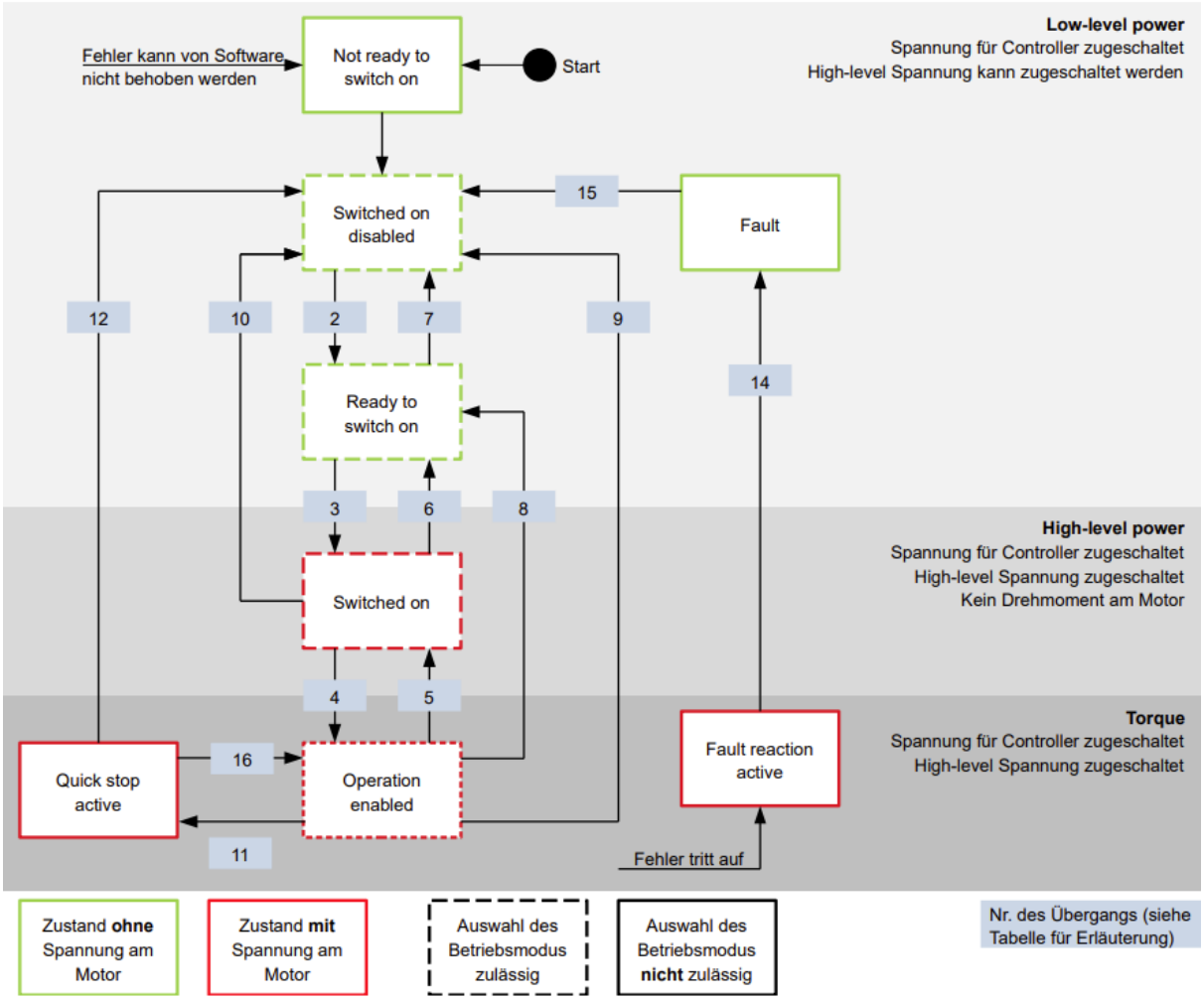
set motor state machine to active mode



update motor output



- Motor state diagram:



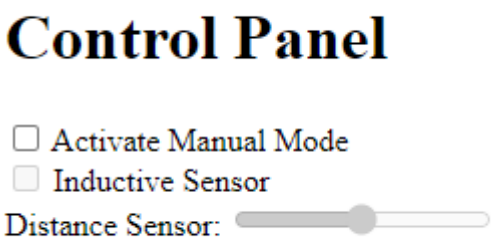
- Motor output control:
  - The motor is running in the operating mode “velocity“, which allows to input the desired rotations per minute. The motor itself is in charge of holding the entered velocity.
  - When the light barrier is blocked or the on/off switch is tuned off, the motor-rotations are set to 0.
  - In all other cases, the velocity of the motor will be set to 10 * (input from distance sensor in cm)
- OPC-UA
  - The OPC-UA Server on the IO-Link Master is configured with username: admin, password: admin
  - The OPC-UA Server on the PLC is configured to allow “anonymous“ login, the relevant data can be found in the “ServerInterfaces“ Node.
  - These are the available properties in th OPC-UA Server

#	Server	Node Id	Display Name	Value	Datatype	Source Timestamp	Server Timestamp	Statuscode
1	SIMATIC.S7-1200.OPC-UA.Application:PLC_1@10.0.0.100	NS4|Numeric|4	inductiveSensor	false	Boolean	05:13:24.985	05:13:24.985	Good
2	SIMATIC.S7-1200.OPC-UA.Application:PLC_1@10.0.0.100	NS4|Numeric|2	isMotorActive	false	Boolean	05:20:49.987	05:20:49.987	Good
3	SIMATIC.S7-1200.OPC-UA.Application:PLC_1@10.0.0.100	NS4|Numeric|5	lightBarrier	true	Boolean	05:20:50.990	05:20:50.990	Good
4	SIMATIC.S7-1200.OPC-UA.Application:PLC_1@10.0.0.100	NS4|Numeric|7	motorRpm	0	Int16	05:20:49.994	05:20:49.994	Good
5	SIMATIC.S7-1200.OPC-UA.Application:PLC_1@10.0.0.100	NS4|Numeric|8	onOffSwitch	false	Boolean	05:20:49.994	05:20:49.994	Good

Name	Description	Data-Type
inductiveSensor	Whether the inductive Sensor senses an object.	Boolean
isMotorActive	Whether the motor is commanded to spin.	Boolean
lightBarrier	Whether the light barrier is not obstructed “true“ or if the light is blocked by an object “false“.	Boolean
motorRpm	RPM target that is set by the PLC and communicated to the encoder motor.	Int16
onOffSwitch	Whether the On/Off Switch is in the Position “On“	Boolean

Data service on Industrial-PC

- To pre-process the JSON-Data emmitted by the IO-Link Master, there is a leighweight service in between the IO-Link master and the PLC. It pre-processes the events sent from the IO-Link master in an easy to read format and re-publishes the data for the PLC to consume.
- On 10.0.0.241:8080, it is possible to override the input coming from the distance and inductive sensor.



  - Use “Active Manula Mode“ to override the real sensor values with the provided ones from the “Inductive Sensor“ Checkbox and the “Distance Sensor“ Slider

Software internals on PLC

- Used Libraries:
  - Hardware Support Package for ixxat CM CANopen module
  - Function Blocks for ixxat CM CANopen module
  - Function Blocks from Siemens for MQTT Communication
- Data Blocks:

Name	Used for	Provided by
CANopenProcessImage	Internal use for CANopen	CANopen Library
LMQTT_Client_DB	Internal use for MQTT	LMQTT Library

Name	Used for	Provided by
Mqtt	Internal use for MQTT	rosslight
Database	Single source of truth for Actuator output and OPC-UA	rosslight
ReadSDO_DB	Internal use for CANopen	CANopen Library
WriteSDO_DB_1-6	Internal use for CANopen	CANopen Library

Main “Database“ Datablock:

Name	Datatype	Description
DemoBoard.isMotorActive	Bool	Whether the motor is active (All DemoBoard.xx values are directly connected to the OPC-UA output)
DemoBoard.inductiveSensor	Bool	Whether the inductive Sensor is triggered
DemoBoard.lightBarrier	Bool	Whether the light Barrier is not obstructed
DemoBoard.motorRpm	Int	The RPM of the motor
DemoBoard.onOffSwitch	Bool	Whether the ON/OFF switch is in status ON
Const60xx	SDO_WriteData	Internal use: Data that needs to be written to the nanotec motor in order to get it started
StartMotor	Bool	Is true when the motor needs to be started after the PLC finished booting

CANopen

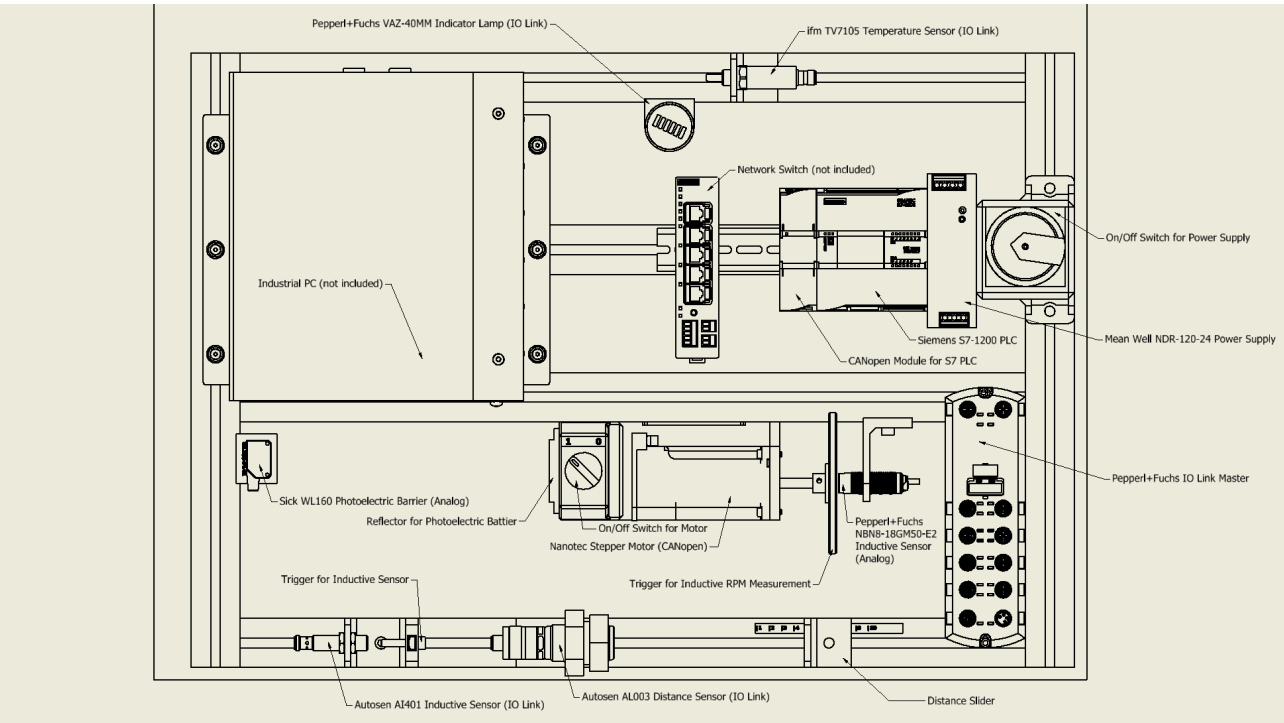
- There is one master (S7-1200) and one slave (nanotec servo motor https://de.nanotec.com/produkte/1609-pd4-c6018l4204-e-08).
- Baudrate: 1M
- S7-1200 Node-ID: 0xFF
- nanotec Node-ID: 0x02 (The address of the motor is adjustable via the rotary switch at the back of the motor)

4 Hardware - Drawing and structural overview

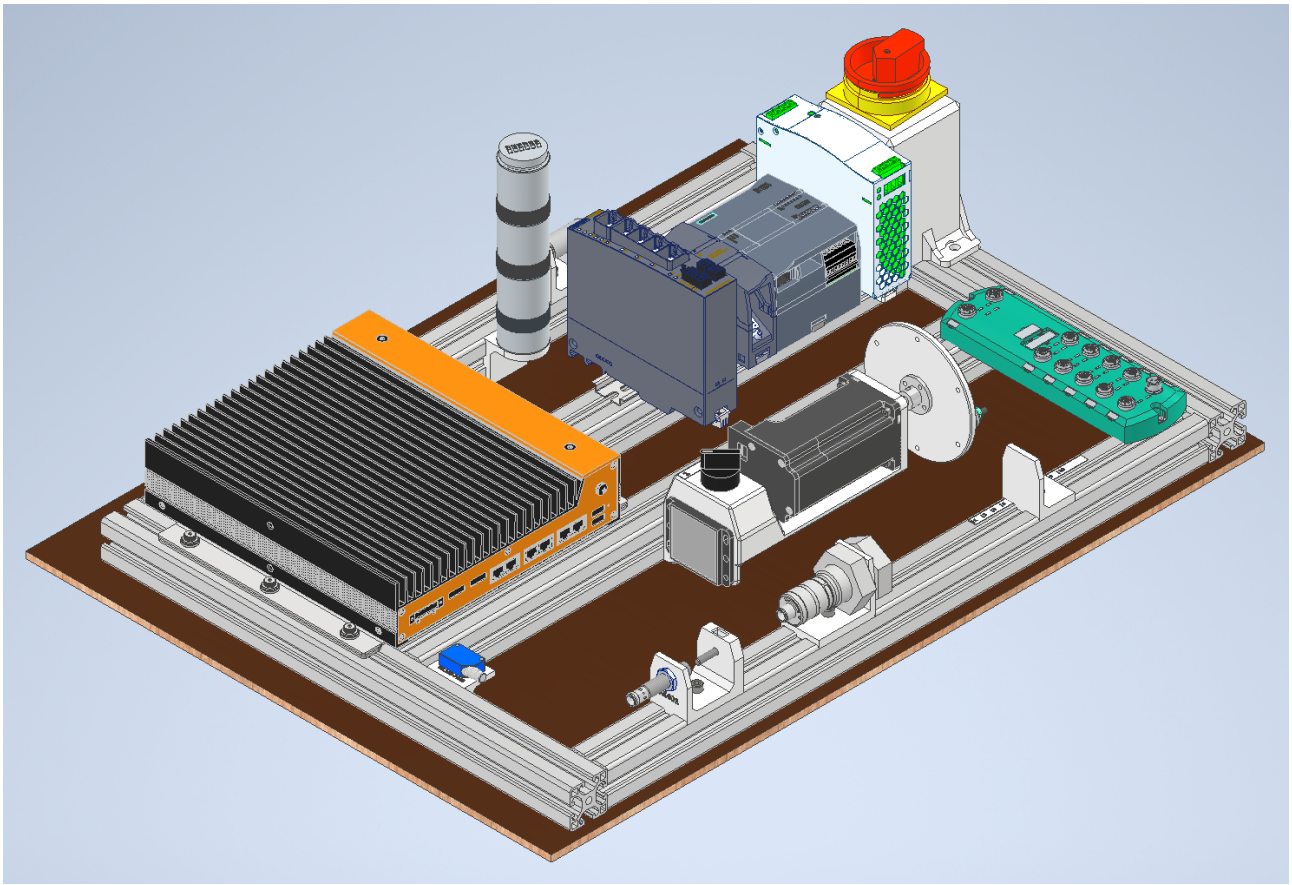
⚠ The electrical connections are only intended for test use by authorized personell. Do not keep the board unattended while plugged in. If you intend to use the board outside of testing purposes, it is required to get a DGUV 3 testing.

The resistance of the distance slider can be adjusted by turning the screw. The marked stages represent relative stages linked to a fixed distance of the sensor. If replacing the marks, please check that the stages are placed at positions where the sensor has a fixed output.

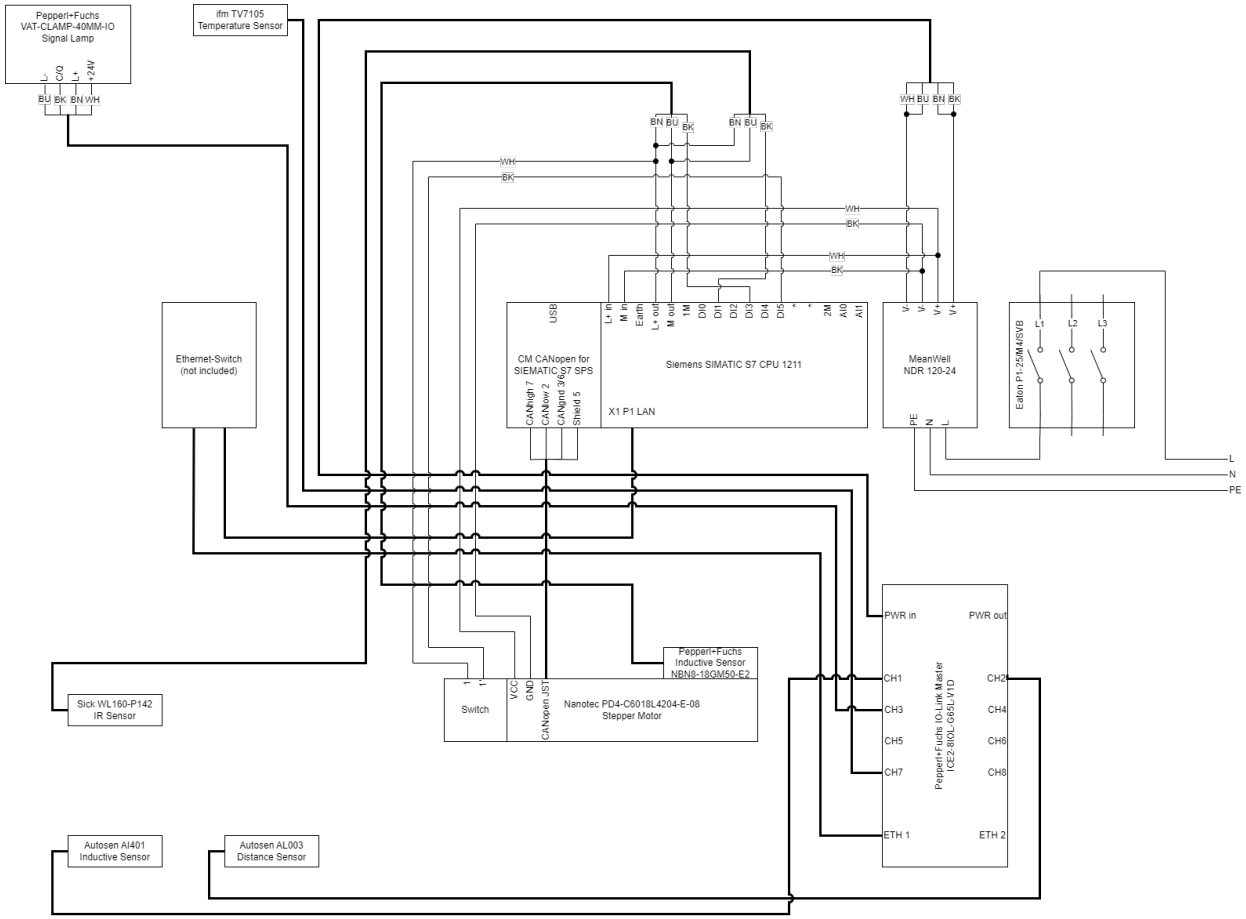
The boards initial hardware setup will look like the drawing below:



ⓘ To change the position of the items please use an allen key.



5 Hardware - Electrical drawing



6 Hardware - Export Part list

	Description	Order Link (opt)	Amount
1	Aluminium Profile 40x40x640mm I-Type, 8mm Groove		4
2	Aluminium Profile 40x40x500mm I-Type, 8mm Groove		2
3	Thread and form connector set I-Type, 8mm Groove		8
4	M6x16mm Cylinder Head Screw DIN912		3
5	M6x30mm Cylinder Head Screw DIN912		1
6	M6 groove slot nut 8mm		3
7	M8x16mm Cylinder Head Screw DIN912		9
8	M8 groove slot nut 8mm		9
9	M4x16mm Cylinder Head Screw DIN912		10
10	M4x10mm Cylinder Head Screw DIN912		8
11	M4x6mm Cylinder Head Screw DIN912		6

	Description	Order Link (opt)	Amount
12	M4 square nut DIN557		16
13	M4 groove slot nut 8mm		6
14	M3x10mm Cylinder Head Screw DIN912		2
15	Siemens SIMATIC S7 CPU 1211		1
16	Siemens SIMATIC CM CANopen 021620-B		1
17	Mean Well NDR-120-24 Power Supply		1
18	Pepperl+Fuchs ICE2-8IOL-G65L-V1D IO Link Master	https://www.pepperl-fuchs.com/global/de/classid_4996.htm?view=productdetails&prodid=96749	1
19	Sick WL160-P142 Photoelectric Reflex Switch		1
20	SCB-SSPS_0.1.0_WL160-P142-Mount	3d printed part	1
21	Schneider Electric XUZC50 Reflektor		1
22	Autosen AI401 Inductive Sensor		1

	Description	Order Link (opt)	Amount
23	SCB-SSPS_0.1.0_AI401-Mount	3d printed part	1
24	Autosen AL003 Distance Sensor		1
25	SCB-SSPS_0.1.0_AI003-Mount	3d printed part	1
26	SCB-SSPS_0.1.0_Distance-Slider	3d printed part	1
27	Pepperl+Fuchs NBN8-18GM50-E2 Inductive Sensor		1
28	SCB-SSPS_0.1.0_NBN8-18GM50-E2-Mount	3d printed part	1
29	Nanotec PD4-C6018L4204-E-08 stepper		1
30	Nanotec Cable ZK-PD4-C-CAN-4-500-S		1
31	SCB-SSPS_0.1.0_Stepper-Mount	3d printed part	1
32	SCB-SSPS_0.1.0_RPM-Measurement-Plate	3d printed part	1
33	Flange Coupling for 8mm Shaft		1

	Description	Order Link (opt)	Amount
34	RS PRO Switch 265-7657		1
35	DIN Rail 250mm		2
36	Eaton P1-25/M4/SVB		1
37	SCB-SSPS_0.1.0_P1-Mount	3d printed part	1
38	ifm TV7105 Temperature Sensor		1
39	SCB-SSPS_0.1.0_TV7105-Mount	3d printed part	1
40	Pepperl+Fuchs VAZ-CLAMP-40MM-IO		1
41	Pepperl+Fuchs VAZ-LED-40MM-CLD-RD		1
42	Pepperl+Fuchs VAZ-LED-40MM-CLD-GN		1
43	SCB-SSPS_0.1.0_VAZ-Mount	3d printed part	1
44	Cable Mount for 8mm groove		18

	Description	Order Link (opt)	Amount
45	Thomann Case 765x555x310mm		1