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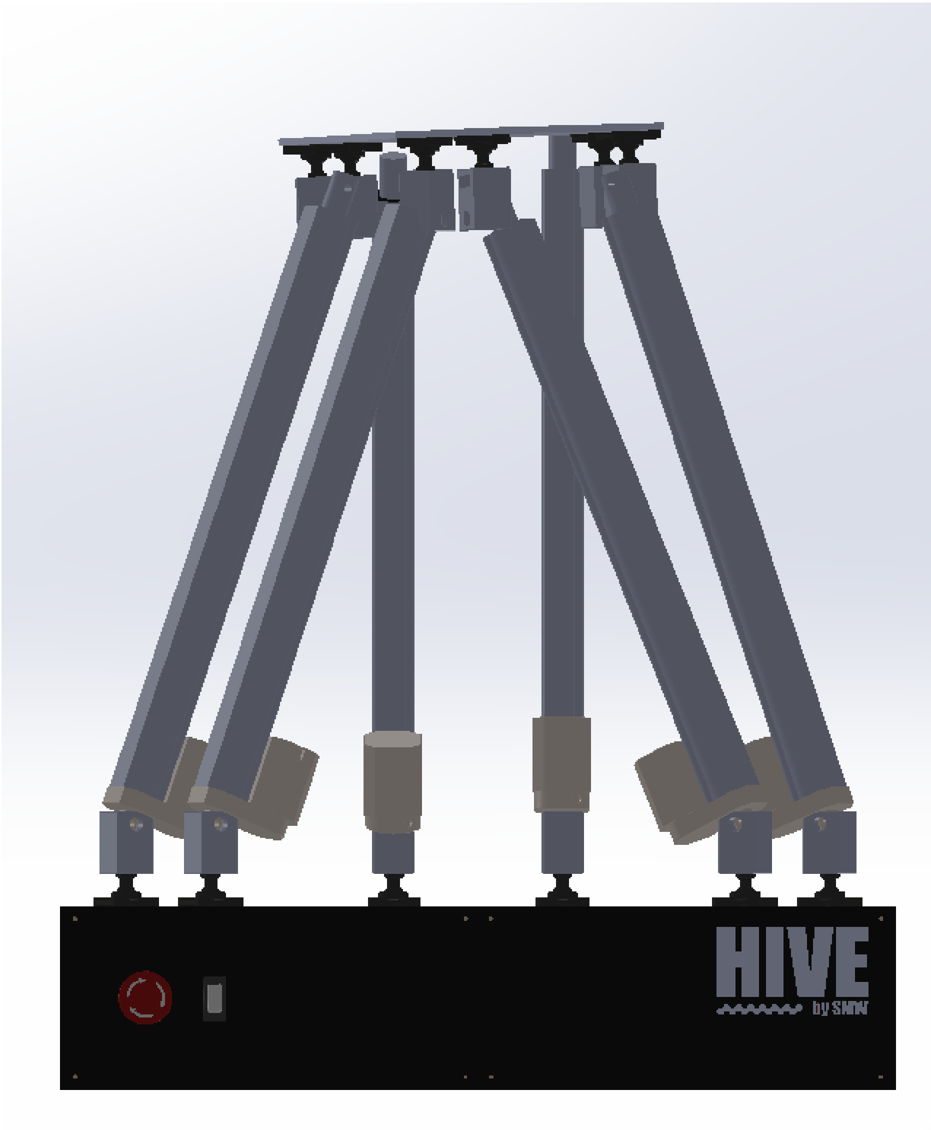
Project Folder

Werkschulheim Felbertal Mechatronics

Stewart Platform HIVE



Simon M. Wimmer

Class 7b (11th grade)

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1 Overview

1.1 General working principles

A platform can be moved in all six degrees of freedom using six linear drive units. The platform is freely mounted on the linear drive units, and the linear drive units are in turn freely mounted on the base housing.

1.2 Intended use case

The platform is universally applicable and a wide variety of modules can be attached to it. One intended use is the alignment of telescopes and satellite receivers.

1.3 Technical data

Physical quantity	**Value**
Supply voltage AC	230 V
Power consumption	50 W
Operating voltage DC	12 V
Dimensions (L x W x H)	600*600*700 mm
Weight	25 kg (55 lbs)
Axis speeds (no load)	35 mm/s
Load capacity per axis	150 N
Platform load capacity	15 kg (33 lbs)

Table 1: Technical data

1.4 Cost estimates

Component	**Cost [€]**
Linear drive units	250
Flange bearings	70
Microcontroller	60
Power supply	30
PCB interface board	15
Motor driver	15
Base and platform	10
Gyroscope	10
Switches	10
3D-printed clevis heads	5
Cables	5
Plastic covers	5
Fan	5
Total	490

Table 2: Cost estimates

2 Technical Description

2.1 Block diagram

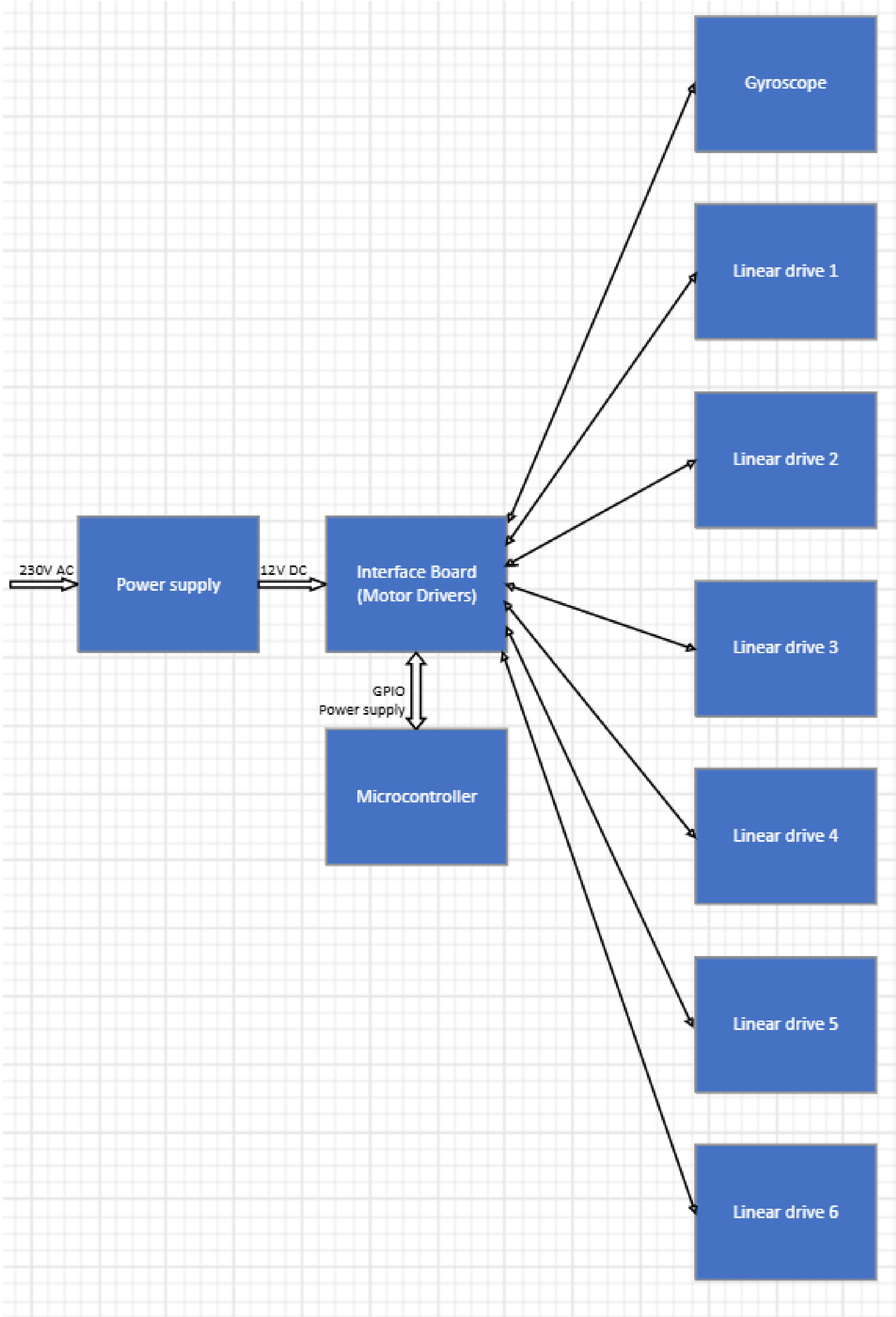


Figure 1: Block diagram

2.1.1 Description of the components and their interaction

Block diagram	Component	Function
Power supply	Meanwell LRS 100-12	Provides 12 V operating voltage for the microcontroller and linear drives
Interface Board	Own design	Houses the motor drives to control the linear axes via the microcontroller
Microcontroller	Raspberry Pi 3B	Runs the control software and gives hardware outputs
Gyroscope	MPU-9250	Captures platform alignment data
Linear drives	HF-TGA-SC-400-12-35	Actuators; move the platform

Table 3: Component descriptions

2.2 Technical dimensions of key components

Block diagram	Components	Values
Power supply	Meanwell LRS 100-12	Input 100-240V AC max. 2.1A 50/60Hz Output 12V DC max. 8.5A
Interface Board	Own design	132*90*1,6 mm
Microcontroller	Raspberry Pi 3B	5V 1.5A – logic voltage 3.3V 26 GPIOs
Gyroscope	MPU-9250	3.3V – Data transmission via I^2C 9-axis acceleration and orientation sensor
Linear drives	HF-TGA-SC-400-12-35	Stepper motor – 12V 300mA 35 mm/s feed rate 150 N load capacity 15.179 steps

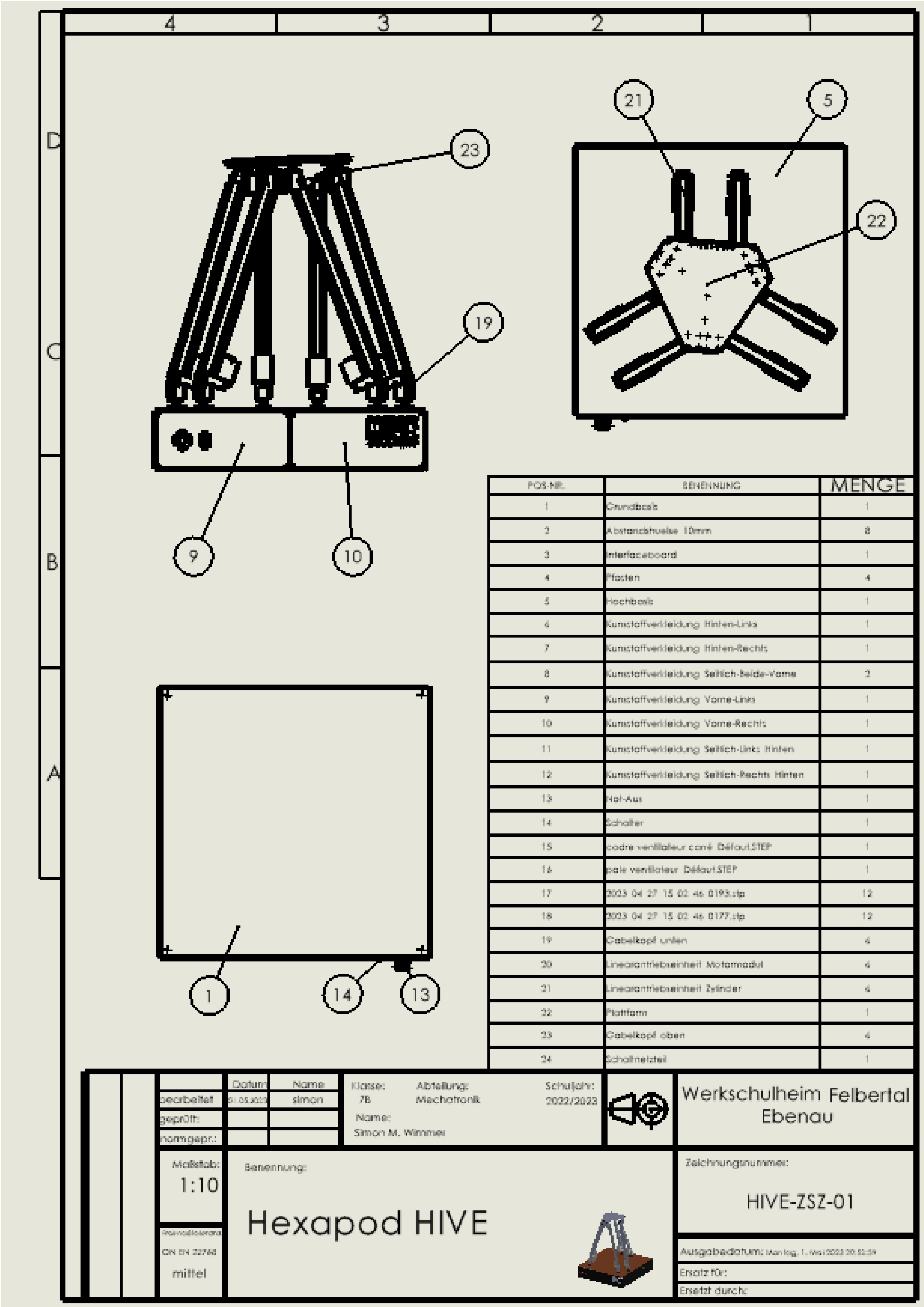
Table 4: Component dimensions

3 Project Management

Mechanics	**hrs**	**Electronics**	**hrs**	**Software**	**hrs**
3D printing of clevis heads	3	Design the interface board	6	Motor control	2
Mill plastic covers	3	Wire the power supply	2	Motor referencing	2
Cut out base	3	Wire the actuators	3	Motor control via graphical user interface	10
Assemble the housing	3	Wire the sensors	2	Visual output of gyroscope data	5
Mount linear drive untis	3				

Table 5: List of work packages

4 Assembly Drawing



POS-NR.	BENENNUNG	MENGE
1	Grundbasis	1
2	Abstandshuelse 10mm	8
3	Interfaceboard	1
4	Pfosten	4
5	Hochbasis	1
6	Kunstoffverkleidung Hinten-Links	1
7	Kunstoffverkleidung Hinten-Rechts	1
8	Kunstoffverkleidung Seitlich-Beide-Vorne	2
9	Kunstoffverkleidung Vorne-Links	1
10	Kunstoffverkleidung Vorne-Rechts	1
11	Kunstoffverkleidung Seitlich-Links Hinten	1
12	Kunstoffverkleidung Seitlich-Rechts Hinten	1
13	Not-Aus	1
14	Schalter	1
15	cadre ventilateur carré Défaut.STEP	1
16	pale ventilateur Défaut.STEP	1
17	2023 04 27 15 02 46 0193.stp	12
18	2023 04 27 15 02 46 0177.stp	12
19	Gabelkopf unten	6
20	Linearantriebseinheit Motormodul	6
21	Linearantriebseinheit Zylinder	6
22	Plattform	1
23	Gabelkopf oben	6
24	Schaltnetzteil	1

Figure 2: Assembly drawing

5 Technical Description of Electronics

5.1 Bill of Materials

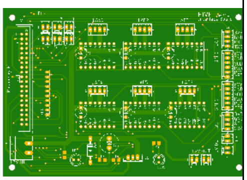
Ref.	Component	Illustration	Qty.	Technical data	Order no.
24	Power supply Meanwell LRS-100-12	 at.rs-online.com	1	Input: 90-260VAC Output: 12VDC / 2.1A Power: 25W	Pollin; 352181
25	Raspberry Pi 3B	 at.farnell.com	1	Input: 5VDC, 1.5A; 26 GPIOs; 4*USB; HDMI	Farnell; 2842228
3	PCB Interface Board HIVE-v1.0		1	PCB 2 Layers, 1,5mm Dim.: 132x90mm	Own stock
3	A4988	 twinschip.com	6	Stepper motor driver; 3.3V logic Power 12-36V 2A	Own stock
20	Linear drives	 alibaba.com	6	12 VDC 35 mm/s 150 N 2x limit switches	Own stock
13	Emergency stop	 conrad.at	1	5A NC	Conrad; 2304757 - 62
26	MPU-9250	 wolles-elektronikkiste.de	1	9-axis gyroscope and acceleration sensor I^2C	School
15	Fan	 conrad.at	1	70*70 mm 12 VDC	Own stock

Table 6: Bill of electronical Materials

5.2 Wiring diagram

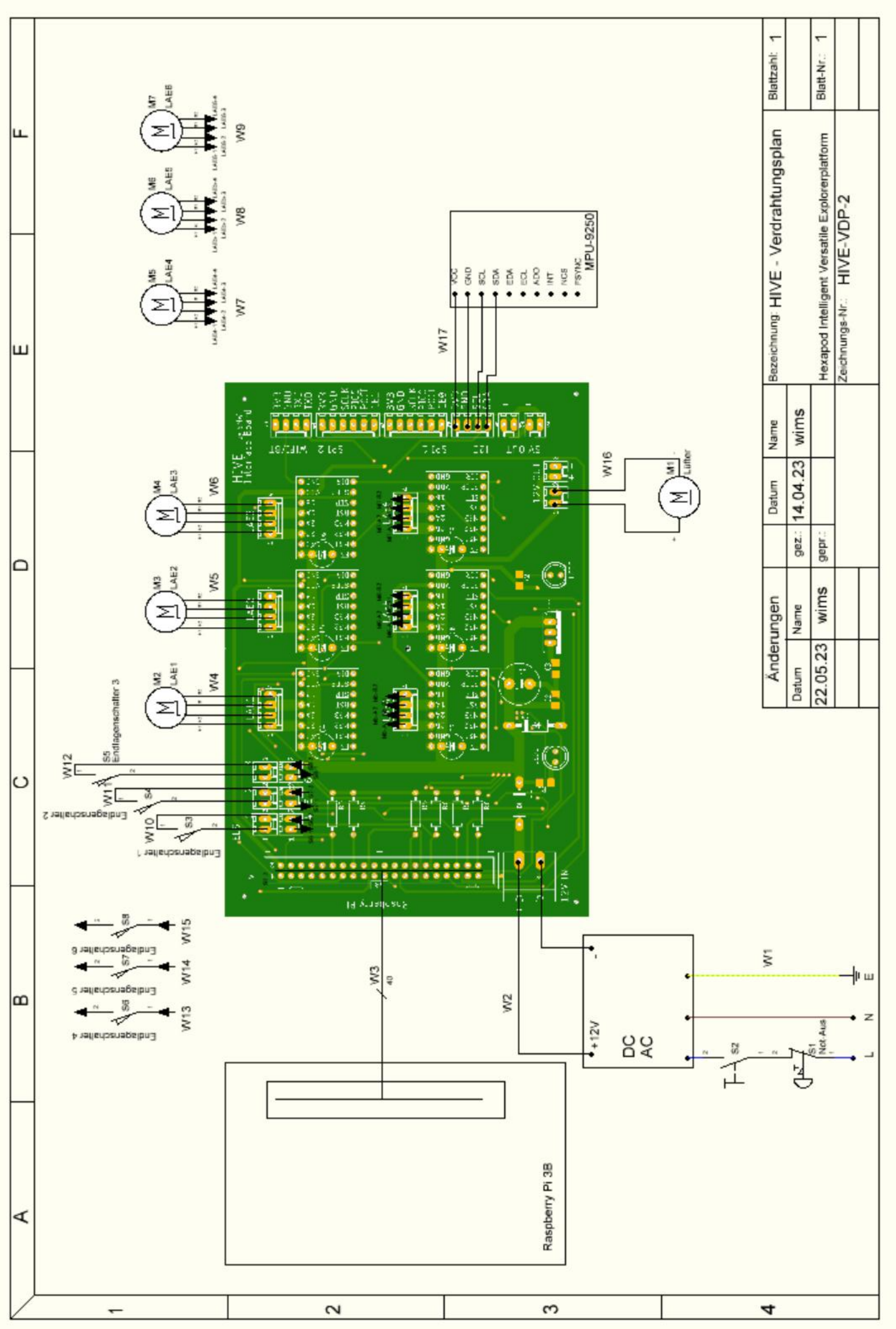


Figure 3: Wiring diagram

5.3 Description of connection cables

Reference	Type	Length [mm]	Connection type A	Connection type B
W1	Single wire 1,5mm²	50	Non-detachable	Wire end ferrules
W2	Single wire 1,5mm²	200	Wire end ferrules	Wire end ferrules
W3	Flat ribbon, 40-pol., 0,5mm²	300	Flat ribbon cable tray 40-pin	Flat ribbon connector 40-pin
W4	Molex 0,5mm	400	Molex connector 4-pin	Molex connector 4-pin
W5	Molex 0,5mm	400	Molex connector 4-pin	Molex connector 4-pin.
W6	Molex 0,5mm	400	Molex connector 4-pin	Molex connector 4-pin
W7	Molex 0,5mm	400	Molex connector 4-pin	Molex connector 4-pin
W8	Molex 0,5mm	400	Molex connector 4-pin	Molex connector 4-pin
W9	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W10	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W11	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W12	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W13	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W14	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W15	Molex 0,5mm²	400	Molex connector 4-pin	Molex connector 4-pin
W16	Molex 0,5mm²	300	Molex connector 4-pin	Non-detachable
W17	Molex - DuPont 0,5mm²	1000	Molex connector 4-pin	DuPont 4-pol.

Table 7: Connection cables

5.4 PCB documentation

5.4.1 Circuit diagram

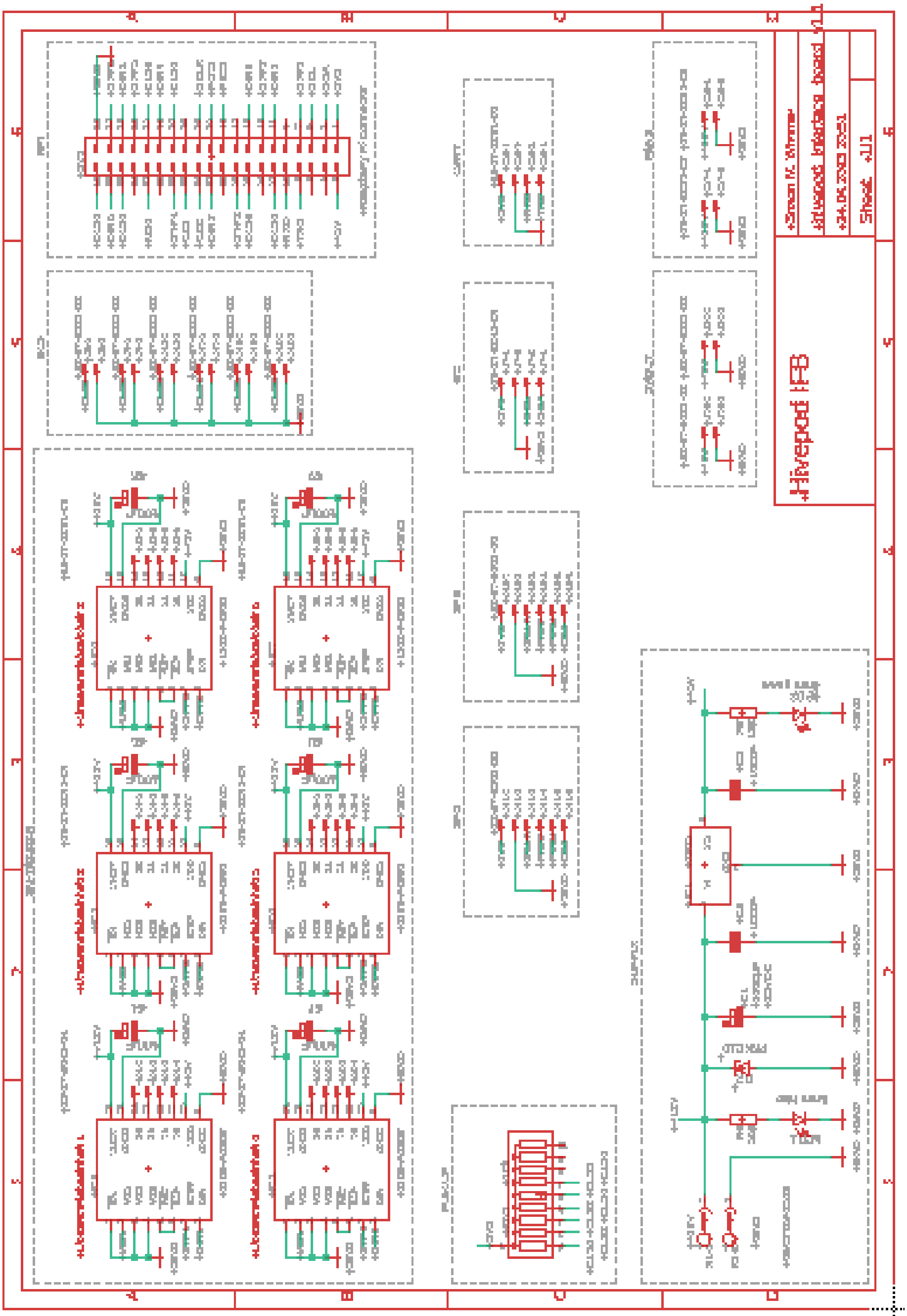


Figure 4: PCB circuit diagram

5.4.2 Layout

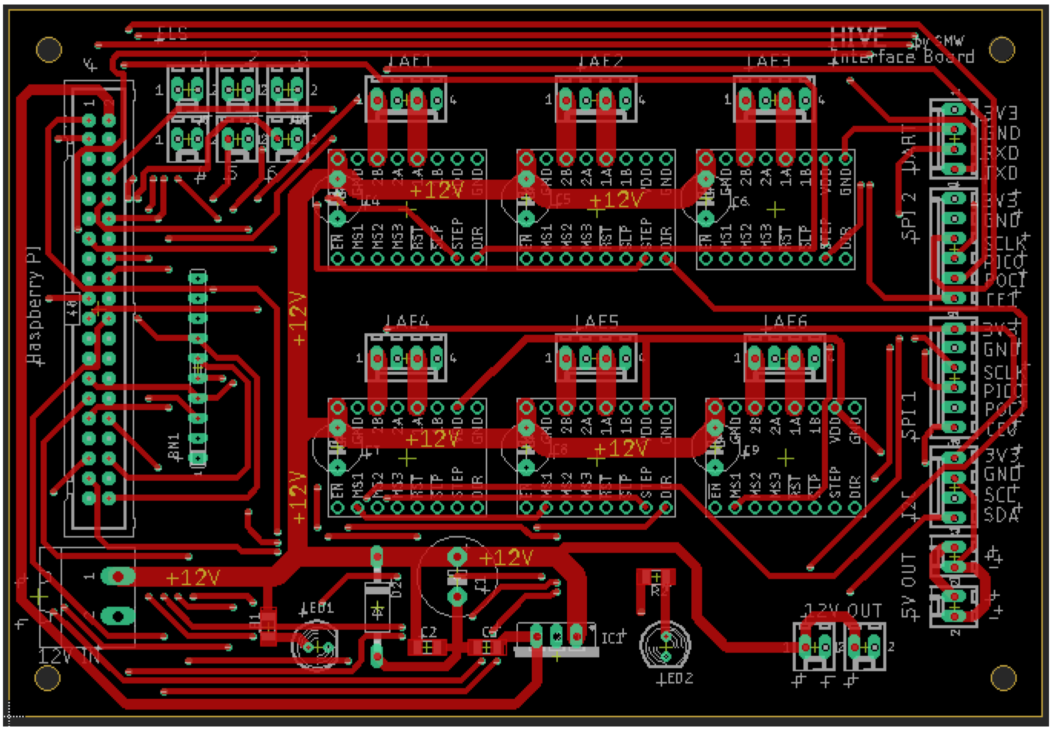


Figure 5: PCB Layout TOP

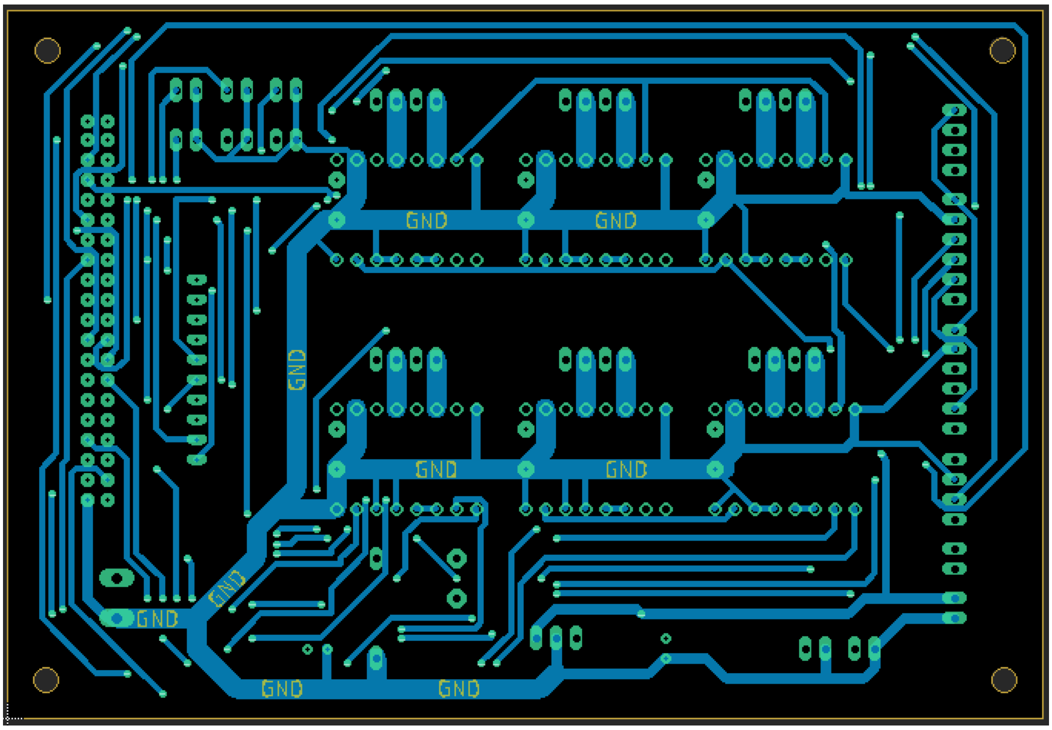


Figure 6: PCB Layout BOTTOM

5.4.3 Assembly plan

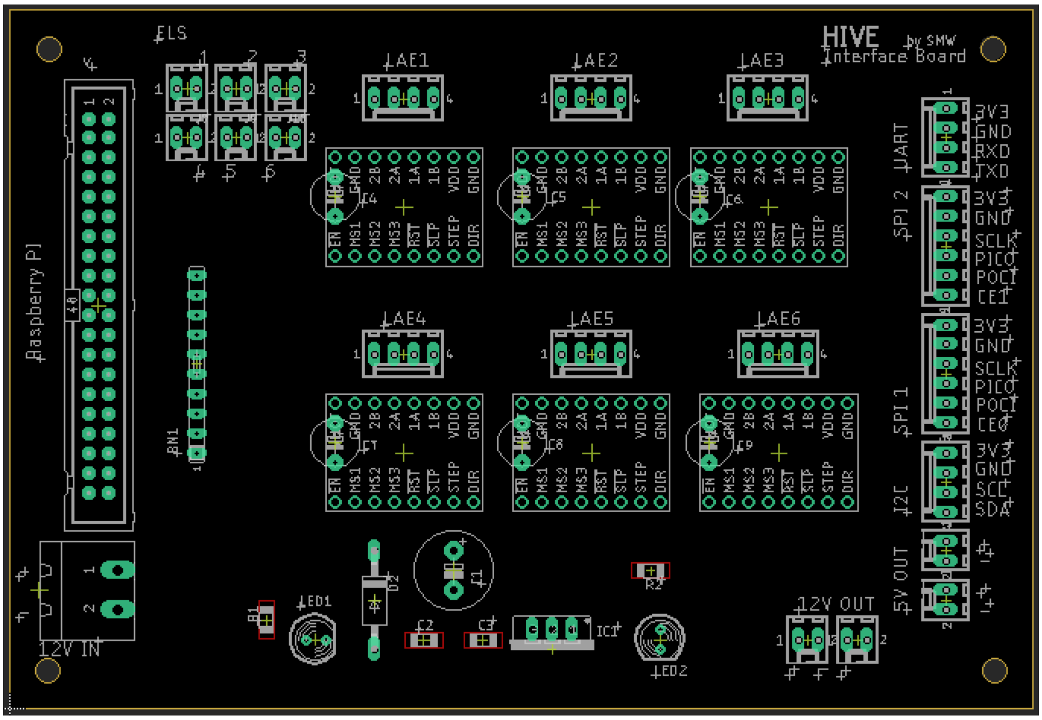


Figure 7: PCB assembly

5.4.4 Bill of Materials

Qty.	Value	Device	Package	Parts	Description
1	1000µF	CPOL-EUE5-10.5	E5-10,5	C1	POLARIZED CAPACITOR, European Symbol
2	100nF	C-EUC1206	C1206	C2, C3	CAPACITOR, European Symbol
6	100ÂµF	CPOL-EUE5-6	E5-6	C4, C5, C6, C7, C8, C9	POLARIZED CAPACITOR, European Symbol
1	10k	G09R	SIL10	RN1	SIL RESISTOR
6	1182-A4988	1182-A4988	A4988	IC2, IC3, IC4, IC5, IC6, IC7	A4988 Stepper Motor Driver Carrier
1	120	R-EU_R1206	R1206	R2	RESISTOR, European Symbol
10	22-27-2021-02	22-27-2021-02	6410-02	J8, J9, J10, J11, J12, J13, J17, J18, J19, J20	CONNECTOR
8	22-27-2041-04	22-27-2041-04	6410-04	J1, J2, J3, J4, J5, J6, J7, J16	CONNECTOR
2	22-27-2061-06	22-27-2061-06	6410-06	J14, J15	CONNECTOR
1	560	R-EU_R1206	R1206	R1	RESISTOR, European Symbol
1	5mm Blue	LED5MM	LED5MM	LED1	LED
1	5mm Green	LED5MM	LED5MM	LED2	LED
1	7805	78V	TO220V	IC1	Positive VOLTAGE REGULATOR
1	GMSTBA2508	GMSTBA2508	HOR-2	X1	PHOENIX
1	P6KE15	BZY97	F126Z12	D2	Z DIODE
1	Raspberry Pi Connector	ML40	ML40	SV1	HARTING

Table 8: PCB Bill of Materials

5.5 Commissioning of Electronics

Power supply	
1	Wire the 3-pin socket
2	Connect to 230 VAC
3	Measure the output voltage and fine-tune it using the potentiometer if necessary
PCB	
1	Connect to 12VDC supply voltage
2	Check 12VDC and 5VDC outputs
3	Check the Vcc and GND pins of the stepper motor drivers and the Raspberry Pi
4	Connect the Raspberry Pi
5	Apply 3.3 VDC to limit switch inputs and evaluate via Raspberry Pi code
6	Set all Raspberry Pi pins to high and check the outputs on the interface board using an oscilloscope
Linear drives	
1	Connect limit switch to the corresponding socket on the interface board
2	Connect the stepper motor to the corresponding socket on the interface board
3	Reference the linear drive unit via the Raspberry Pi program and then move it 100 steps
Gyroscope	
1	Connect to the interface board via I^2C
2	Evaluate sensor data using Raspberry Pi program

Table 9: Commissioning of Electronics

6 Technical Description Software

6.1 General information

The stewart platform is controlled via a web interface that runs on the Raspberry Pi. The web interface is implemented using simple HTML/CSS. A Python script handles the I/O output in the backend.

However, it should also be noted that the main task of this project is to verify the mechanical feasibility of a self-designed stewart platform construction and not to implement a highly responsive GUI design or mathematical calculations for the possible range of motion of the kinematics. These goals are purely optional and are expected to be carried out after the project is completed as part of the workshop lessons.

6.2 Signal list

Physical PIN	BCM PIN	I/O Type	Use
1	3V3 Power	Power supply	3V3 line on PCB board
2	5V Power	Power supply	Power supply Raspberry Pi
3	GPIO 2 (SDA)	Serial communication	I²C SDA
4	5V Power	x	x
5	GPIO 3 (SCL)	Serial communication	I²C SCL
6	Ground	x	x
7	GPIO 4 (GPCLK0)	Output	LE1 STP
8	GPIO 14 (TXD)	Output	TXD
9	Ground	x	x
10	GPIO 15 (RXD)	Input	RXD
11	GPIO 17	Output	LE1 DIR
12	GPIO 18 (PCM_CLK)	Input	LE1 ELS
13	GPIO 27	Output	LE2 STP
14	Ground	x	x
15	GPIO 22	Output	LE2 DIR
16	GPIO 23	Input	LE2 ELS
17	3V3 Power	x	x
18	GPIO 24	Output	LE3 STP
19	GPIO 10 (MOSI)	Output	SPI PICO
20	Ground	x	x
21	GPIO 9 (MISO)	Input	SPI POCI
22	GPIO 25	Output	LE3 DIR
23	GPIO 11 (SCLK)	Output	SPI SCLK
24	GPIO 8 (CE0)	Output	SPI CE0
25	Ground	x	x
26	GPIO 7 (CE1)	Output	SPI CE1
27	GPIO 0 (ID_SD)	Input	LE3 ELS
28	GPIO 1 (ID_SC)	Output	LE4 STP
29	GPIO 5	Output	LE4 DIR
30	Ground	x	x

31	GPIO 6	Input	LE4 ELS
32	GPIO 12 (PWM0)	Output	MS1
33	GPIO 12 (PWM1)	Output	LE5 STP
34	Ground	x	x
35	GPIO 19 (PCM_FS)	Output	LE5 DIR
36	GPIO 16	x	LE5 ELS
37	GPIO 26	Output	LE6 STP
38	GPIO 20 (PCM_DIN)	Output	LE6 DIR
39	Ground	Power supply	Power supply Raspberry Pi
40	GPIO 21 (PCM_DOUT)	Input	LE6 ELS

Table 10: Signal list

6.3 Software description

After switching on, all axes reference themselves by moving to the lower limit switch. Once this step has been completed without error, the web server with the graphical user interface opens automatically. The Python script controls the linear axes according to the entries in the graphical user interface; the feasibility of the entered axis positions may be checked during this process.

6.4 User interface

As mentioned at the outset, a highly functional GUI is not part of this project scope. The web interface should primarily be used to move to standard positions (positions whose mechanical accessibility has already been tested in advance) and to move the individual axes via input fields/controllers. It should be clearly stated that the test version of this project does not include any mathematical calculations for the kinematic accessibility of the entered values. Furthermore, the positions that have been moved to can also be saved in the program so that they can be easily moved to again at a later point in time.

6.5 Error handling

The software monitors the time required to move to a specific position. If this takes an unusually long time, the stewart platform is stopped and an error message is displayed.

Furthermore, it is not possible to enter position values that are above or below the number of steps of the linear drive units.

If time permits, a software function will be implemented that regulates the possible axis positions in relation to the other axis positions; "if axis A is extended by 10%, it is not possible to extend axis B by more than 15%, etc.".