SDD -
SYSTEM DESIGN DESCRIPTION
NIK5.3#5 IN-Kind – Project
Test Package for Linear Motion Technology

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Document status

Revision	Reason for revision/ Description of amendment	Date
1.0	Initial version	17. May 2018

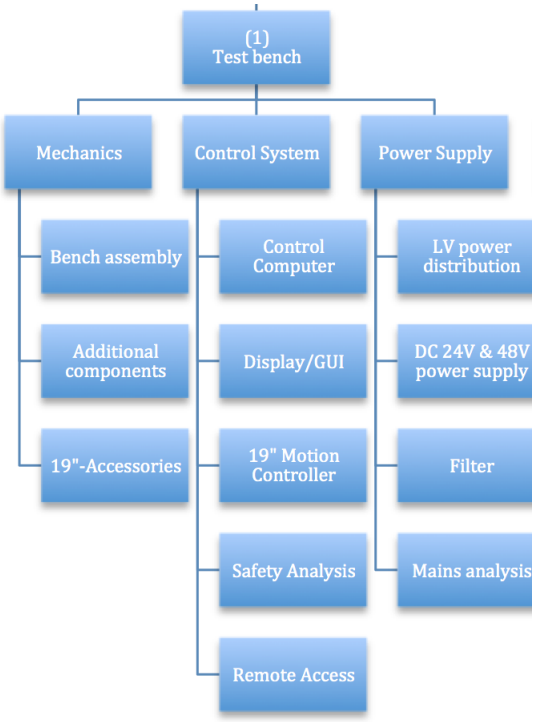
Content

1 Product Breakdown Structure (PBS) and System Requirements

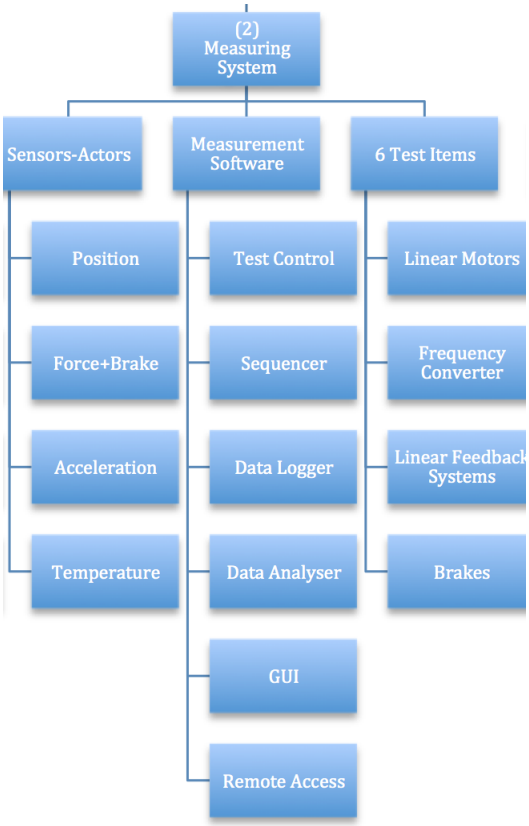
PBS

The deliverable item consists of three parts, as laid out in the Product Breakdown Structures below:

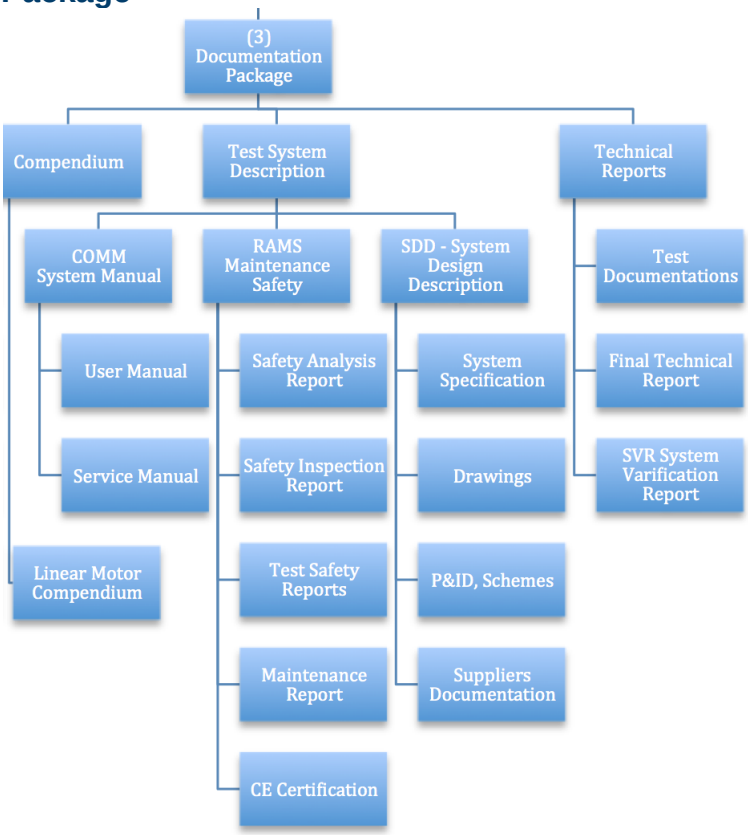
Motor Control Test Bench



Measuring System and Test Items



Documentation Package



System Requirements

The JCNS at the end of the project shall deliver a total of three test bench mechanics with installed power supply. One test bench shall be further equipped with the control system consisting of a control computer with monitor, a motion controller and a system to safely integrate the test items. The test benches shall be built according to ESS ERIC standards documentation.

The measuring system will be installed on one of the test benches. It consists of the sensors and actors necessary to perform the test, the measurement software to control the tests and of the 6 test item sets to perform the tests with. The different packages of the measurement software will run on the control computer of the test bench. Each test item set consists of a linear motor, frequency converter, linear feedback system, and brakes if applicable.

The documentation package contains all system and test item performance information. It consists of a general compendium about linear motors, the Test System Description and the Technical Reports. The test system is documented with the manuals compiled to the COMM, the safety + maintenance reports compiled in the RAMS and the actual systems documentation in the SDD. The main result of the in-kind project, the performance tests of the 6 test item sets, is compiled in the test documentation as part of the Technical Reports. The whole deliverable item will be CE certified.

2 Procurement List

Pos.	Quantity	Product	Manufacturer	Type
1	3	Test Bench - mechanical construction		
2	1, 4	Linear Motor + 4 x magnet yoke - ironless and vacuum	Tecnotion	UM12SV + UMX150V
3	1	Linear Motor stage + absolute linear Encoder (Hiperface) - iron-core in classic form	HIWIN	HT150LA12N0320SANAR
4	1	Linear Motor + guidance rail - iron-core in tubular form (Slider + Stator)	LinMot	Stator: PS10-70x80U-BL-QJ-D01 Slider: PL10-28x390/340 Guidance rail: H10-70x80/170
5	1	Linear Motor + Weight compensation for 1.5 to 2 kg - flexible and modular system	Jenny Science	ELAX EX 110F20
6	1	Linear stepper stage + absolute linear Encoder (BiSS-C) - 2-phase linear Stepper	H2W-Technologies	LSS-016-04-006-01A-ME
7	1	Linear Positioner Stage + integrated nano sensor - Piezo Technology and high vacuum	SmarAct	SLLV42-600-S-HV/1-S
8	1	Linear absolute Encoder - BiSS-C, 36 Bit + Ultra high Vacuum, Scale total length = 630 mm	Renishaw	Scanning Head: RL36BVS001C50V Scale: RSLA Single-Track
9	1	Linear absolute Encoder - BiSS-C, 32 Bit, Scale total length = 700 mm	AMO	Scanning Head: LMKA2010S.1612..NN-20-5,0-16S15 Scale: LMTA4010C 3-700-MF-LT01-..16S15
10	1	Linear absolute Encoder - BiSS-C, 32 Bit, Scale total length = 695 mm	NUMERIK JENA	Scanning Head: LAKI4-710A-TO Scale: MA14-310P 00650
11	1	Interferometer + Sensor Heads + Fibers - BiSS-C, Fiber-based, radiation hard	Attocube	Interferometer: IDS3010 Sensor heads: 1) IDSH/M12/C7.6/RAD + FAP retroreflector 2) IDSH/M12/F40/RAD 3) IDSH/D4/F17/RAD
12	1	Inductive linear position sensor + locator - SSI, 25 Bit Gray Code	Turck	Position sensor: LI700P0-Q25LM0-HESG25X3-H1181 Locator: P1-LI-Q25L
13	1	Inductive position measuring system + cylindric electronic unit - SSI, 13 Bit	TWK Elektronik	Cylindric electronic unit: IE25/150-E02 Linear transducer: IW120/150-025-RK5-A44
14	1	Carrier amplifier module for LVDT + Bus coupler for EtherCAT	Gantner Instruments	Amplifier module: Q.blocc-EC A106 Bus coupler: Q.bloxx-EC BC
15	1	LVDT	TE Connectivity Sensors	

Pos.	Quantity	Product	Manufacturer	Type
16	1	Servo Controller with EtherCAT Bus-Module for linear motor (Jenny Science)	Jenny Science	XENAX Xvi 75V8
17	1	Step-Direction Control System for linear positioner (SmarAct)	SmarAct	SDC2-1C-OEM
18	1	2-channel Frequency Converter for Linear Motors (Tecnotion, HIWIN, LinMot)	Beckhoff	AX5206-0000-0202
19	1	Encoder Option-Card for AX5000 (BiSS-C / EnDat 2.2)	Beckhoff	AX5722-0000
20	1	Braking Resistor for AX5000	Beckhoff	AX2090-BW50-0300
21	1	Braking Module for connecting external brake resistor	Beckhoff	AX5021-0000-0000
22	1	PLC / Embedded PC - Windows 10 IoT Enterprise, TwinCAT 3 Runtime + 30 GB CFast Card	Beckhoff	CX5130-0155
23	1	Stepper motor terminal for H2W linear stepper stage - EtherCAT	Beckhoff	EL7047
24	1	Pulse Train Output terminal for SmarAct linear positioner - EtherCAT	Beckhoff	EL2522
25	1	Brake chopper terminal for stepper motor - EtherCAT	Beckhoff	EL9576
26	1	External braking resistor for stepper motor terminal - EtherCAT	Beckhoff	ZB8110
27	1	2-channel SSI encoder interface terminal - EtherCAT	Beckhoff	EL5002
28	1	2-channel BiSS-C encoder interface terminal - EtherCAT	Beckhoff	EL5042
29	2	8-channel digital input terminal, 24V DC - EtherCAT	Beckhoff	EL1808
30	1	16-channel digital output terminal, 24V DC - EtherCAT	Beckhoff	EL2819
31	1	16-channel potential distribution, 0 V - EtherCAT	Beckhoff	EL9189
32	1	EtherCAT extension and end terminal	Beckhoff	EK1110
33	1	Control Computer - Linux	Intel Corporation	NUC
34	1	Signal Converter RS422 output to 5V TTL for SmarAct, SDC2 control unit	LEG	SU3-2

3 System Specification

Test Bench

Selection of a mobile test bench with rollers and a separate test chamber, which is the upper part of the test bench. The lower part of the test bench is equipped with drawers on one side and swing doors on the other side. Rittal profile rails are inside of the lower part of the test bench, which can be used for the connection of electrical components. The test chamber can be completely closed with a suitable and transparent hood. Therefore, there are grips on the top and sides of the hood. A cable bushing with strips is located between the test chamber and the lower part of the test bench, where electrical components could be installed. There is also a cable bushing and a cable holder on the side plate of the test bench to enable power supply through the electricity network. Furthermore, an emergency stopping button will integrated to the test bench.

Important technical specifications:

Total length Test Bench:	*1136 mm;*
Total width Test Bench:	*640 mm;*
Total height Test Bench:	*1143 mm;*
Total height without roller:	*1010 mm;*
Total height test chamber:	*305 mm;*
Total height of the layer with drawers and swing doors:	*705 mm;*
Total weight without Racks:	*100 kg;*
Total weight of the hood:	*20 kg;*

More information can be found in the corresponding technical data sheets.

Measuring System

Linear Motors

Tecnotion

Ironless Forcer (UVM12, s-type) with typical U-shaped magnet yoke (UMX150). Coil unit and yoke are completely vacuum compatible because Tecnotion is specialized in vacuum linear motors. A big advantage of ironless linear motors compared to iron-core motors is the missing "cogging" effect, what means that the coil part is not attracted by permanent magnets. This results in reduced weight and reduced inductivity of the coil parts. Because of that, this series is ideal for positioning in high dynamic or lightweight applications that require extreme accuracy. Selection of the s-winding type to reach higher speeds and four times magnet yoke to reach a total length of 600 mm.

Important technical specifications:

Power supply:	*3-phases, 230 V AC;*
Peak force / current:	*400 N / 20 A;*
Continuous force / current (passive cooled):	*20 N / 1 A;*
Maximum speed:	*16 m/s;*
Temperature sensor:	*PTC*
Vacuum compatibility:	*down to 10^{-8} mBar;*
Total length coil unit:	*260 mm;*
Total length of one magnet yoke:	*150 mm;*
Total length of four magnet yokes:	*600 mm;*
Total weight Coil unit:	*0.33 kg;*

Total weight of one magnet yoke:	*1.005 kg;*

More information can be found in the corresponding technical data sheets.

HIWIN

Complete linear stage (HT150-L) with integrated HIWIN double guide, iron-core linear motor, carriages, absolute positioning measuring system, energy chain and axis limit switches (PNP, NC- switches). HIWIN is one of the supplier who are specialized in linear motor technology. Selection of this linear motor stage because, disregarding from a motion controller, it provides a complete system that can be controlled via the Beckhoff frequency converter (AX5000 series), which uses a classic linear motor with an iron core coil unit. Therefor this linear stage offers an ideal comparison to an ironless forcer to investigate the various advantages and disadvantages between iron-core- and ironless forcers. Selection of the variant without cover to realize a smaller Forcer length and a larger stroke.

Important technical specifications:

Linear motor:	*LMSA12, iron-core;*
Power supply:	*3-phases;*
Peak force / current:	*579 N / 21 A;*
Continuous force / current:	*205 N / 4.2 A;*
Maximum speed:	*5 m/s;*
Maximum acceleration:	*50 m/s^2*
Linear Encoder:	*Absolute, TTK70 (Sick), HIPERFACE, 17 Bit;*
Repeatability:	*± 0,005 mm;*
Temperature sensor:	*PTC*
Total length Forcer:	*162 mm;*
Total length linear stage:	*700 mm;*
Stroke:	*320 mm;*
Total weight Forcer:	*3.87 kg;*

More information can be found in the corresponding technical data sheets.

LinMot

The remarkable thing about the LinMot motors is their design in tubular form. The linear motor consists of just two parts: the slider (PL10-28x390/340) and the stator (PS10-70x80U-BL-QJ-D01). The stator contains the motor windings, bearings for the slider, position capture sensors, and a microprocessor circuit for monitoring the motor. The internal position sensor measures and monitors the current position of the linear motor (Hall sensors). The P10-70 series of motors are the most powerful drives that LinMot offers and they are available with various encoder interfaces and can therefore be controlled by third-party servo drives (AX5000 series) without any difficulties. LinMot is also a manufacturer with extensive experience in linear motor technology. Selection of the version with the shortest stator length because of the limited space within the test chamber of the test bench.

Important technical specifications:

Power supply:	*1-phase, 230 V AC / 3-phases, 400 V AC;*
Peak force / current:	*561 N / 10.9 A;*
Continuous force / current (passive cooled):	*67 N / 1.3 A;*
Maximum speed:	*3.5 m/s (230 V AC) / 6.1 m/s (400 V AC);*
Internal position sensor:	*Sin/Cos 1 Vpp;*
Repeatability:	*± 0,05 mm;*

Temperature sensor:	*KTY84*
Total length Stator:	*180 mm;*
Total diameter Stator:	*70 mm;*
Total weight Stator:	*2.85 kg;*
Total length Slider:	*390 mm;*
Total diameter Stator:	*28 mm;*
Maximal Stroke:	*170 mm;*

More information can be found in the corresponding technical data sheets.

Jenny Science

The ELAX series integrates the linear motor directly into the slider case with a flexible one-cable connection. The components are equipped with direct screw connections which is why several ELAX linear motors are linked together in order to realize travel paths in X, Y and Z directions quickly and compactly. Jenny science is specialized in compact and flexible linear motors as an alternative to pneumatic systems. In 2015, they won the Swiss innovation award by the chamber of industry and commerce with the ELAX series. Selection of the ELAX EX 110F20 series, as it allows both weight compensation in vertical applications for 1.5 to 2 kg and the maximum stroke of 110 mm. The whole system is maintenance free for more than 350 million cycles. Additionally an incremental linear magnetic Encoder is already included inside the slider case. Fully automatic calculation of absolute positioning after reference drive. Homing to stopper necessary when switching on or restarting the system.

Important technical specifications:

Power supply:	*12 – 75 V DC;*
Peak force:	*60 N;*
Continuous force:	*20 N;*
Maximum speed:	*2.6 m/s;*
Maximum acceleration:	*65 m/s^2*
Resolution:	*1 µm;*
Repeatability:	*± 10 µm;*
Total length max:	*318 mm;*
Total length min:	*208 mm;*
Total width:	*58 mm;*
Total height:	*28 mm;*
Total weight:	*945 g;*
Total weight Slider:	*415 g;*
Maximal Stroke:	*110 mm;*

More information can be found in the corresponding technical data sheets.

H2W Technologies

The linear stepper stage (LSS), manufactured by H2W Technologies, unlike many other axes, does not use a classic linear motor as a drive section, but a stepper motor that moves on a linear stage with the help of roller bearings. The linear stepper stage is a complete, compact, small footprint, positioning stage. It uses a 2 phases H2W linear stepper motor STS-0620-R to generate a force of 26.7 N with a total stroke length of 406mm. Furthermore a 1-micron resolution absolute encoder is already integrated (BiSS-C). A corresponding EtherCAT stepper module (e.g. EL7047) will be added for control of the linear stepper motor.

Important technical specifications:

Continuous force:	*26.7 N;*
Rated Current:	*2 A;*
Bearing Type:	*Roller Bearing;*
Linear Encoder:	*BiSS-C Interface;*
Encoder Resolution:	*1 µm;*
Total length stage:	*522.4 mm;*
Total length motor:	*87.5 mm;*
Total width motor:	*74.2 mm;*
Total height motor:	*61.3 mm;*
Total weight motor:	*279 g;*
Maximal Stroke:	*406 mm;*

More information can be found in the corresponding technical data sheets.

SmarAct

Linear Positioner manufactured by SmarAct based on piezo driving technology for very precise long range positioning with the help of recirculating ball slides. The SLLV42-600-S-HV stage represents a complete linear positioner system with guidance, drive unit and incremental positioning sensor. In cooperation with the SmarAct SDC2 control system, the linear positioners can be controlled via differential signals like a stepper motor. The SDC2 serves both the supply of the the positioner and the position evaluation. The SDC2 can interpret and execute simple step and direct signals of a conventional stepper motor controller. This could be solved with an EtherCAT pulse-train output terminal (e.g. EL2522) manufactured by Beckhoff. Furthermore, the SLL linear positioner systems are suitable for use in high vacuum. For precise positioning, a nano sensor is already included to the system.

Important technical specifications:

Continuous force:	*30 N;*
Maximum speed:	*> 0,02 m/s;*
Internal position sensor Resolution:	*1 nm;*
Repeatability:	*± 70 .. 450 nm;*
Vacuum compatibility:	*down to 10^{-6} mBar;*
Total length rail:	*600 mm;*
Total length Positioner:	*54.8 mm;*
Travel range:	*538 mm;*

More information can be found in the corresponding technical data sheets.

Feedback Systems – Commutation and Positioning

In the feedback systems, we differentiate between systems that provide both for positioning and for commutation (only for direct linear motors, like Tecnotion, HIWIN or LinMot) and systems that could be used as additional position control. This section first describes the feedback systems for commutation and positioning.

Renishaw

RESOLUTE UHV true-absolute 30 µm encoder system with RSLA high accuracy linear stainless steel scale for measuring lengths up to five meter, manufactured by Renishaw. The absolute position is determined immediately upon switch-on. Renishaw supports the high-speed serial protocol BiSS-C (36-Bit position word) for absolute encoders. Another reason for selecting this linear position measuring system is, in addition to the absolute value detection, the compatibility for ultra-high vacuum. Furthermore, the RSLA scale will be fixed with the help of mechanical clips.

Important technical specifications:

Power supply:	*5 V DC;*
Maximum current:	*250 mA;*
Maximum speed:	*up to 100 m/s;*
Maximum acceleration:	*65 m/s^2*
Resolution:	*1 nm;*
Accuracy grade:	*± 1.5 µm;*
Length of positon word:	*36-Bit;*
Total length scanning head:	*36 mm;*
Total width scanning head:	*16.5 mm;*
Total height scanning head:	*14.8 mm;*
Total length scale (L):	*630 mm;*
Maximal measuring length (ML):	*620 mm; (ML = L – 10)*

More information can be found in the corresponding technical data sheets.

AMO

LMKA-2010S (.1612..NN-20-5,0-16S15) absolute length measuring system with LMTA-4010C (3-700-MF-LT01..16S15) stainless steel scale for measuring lengths up to 32 meter, manufactured by AMO. The absolute position is determined immediately upon switch-on. AMO supports the high-speed serial protocol BiSS-C (32-Bit position word) for absolute encoders.

Important technical specifications:

Power supply:	*3.6 - 14 V DC;*
Continuous current:	*0.3 A; (at 5 V DC)*
Maximum speed:	*up to 20 m/s;*
Measuring step:	*0.25 µm;*
Position deviation per grating pitch:	*± 2 µm;*
Accuracy grade:	*± 3 µm/m;*
Length of positon word:	*36-Bit;*
Total length scanning head:	*50 mm;*
Total width scanning head:	*26 mm;*
Total height scanning head:	*22.1 mm;*
Total length scale (GL):	*700 mm;*

Maximal measuring length (ML):	*630 mm; (ML = GL – 70)*

More information can be found in the corresponding technical data sheets.

NUMERIK JENA

LAK (14-710A-TO) absolute length measuring system with Quick Guide stainless steel measuring scale for measuring lengths up to 1.2 meter (following version up to 3.8 meter), manufactured by NUMERIK JENA. Non-contact optical scanning of the scale tape by the scanning head. The fusion of incremental and absolute technology. The combination of incremental and absolute encoder enables high speed measuring with high resolution while still maintaining very small dimensions. The absolute position is determined immediately upon switch-on. NUMERIK JENA supports the high-speed serial protocol BiSS-C (32-Bit position word) for absolute encoders.

Important technical specifications:

Power supply:	*3.5 – 5.5 V DC;*
Continuous current:	*0.1 A; (at 5 V DC)*
Maximum speed:	*up to 10 m/s;*
Maximum acceleration:	*65 m/s^2*
Measuring step:	*78.125 nm;*
Accuracy class:	*± 3 µm;*
Grating period of the incremental track:	*20 µm;*
Length of positon word:	*36-Bit;*
Total length scanning head:	*33.5 mm;*
Total width scanning head:	*11.5 mm;*
Total height scanning head:	*10.5 mm;*
Total weight scanning head:	*≤ 5.5 g;*
Total length system:	*695 mm;*
Maximal measuring length:	*650 mm;*

More information can be found in the corresponding technical data sheets.

Feedback Systems – Additional Positioning

In this chapter, the additional feedback systems for positioning will be described in more detail.

Attocube

IDS3010 fiber-based displacement sensor for measuring ranges of up to five meters, which uses the interferometric measuring principle and is manufactured by Attocube. The laser based technology enables contactless measurements directly at the target. Fiber-based sensor heads enable the operation in extreme environments, such as ultra-high vacuum (UHV version), or even hard radiation (RAD version: γ- and β-rays with a total dose of 10 MGy/MSv) because the sensor heads are electronic-free. The IDS sensors are compatible with a variety of optical targets. Up to three sensor heads can be connected to the basic unit for which reason the IDS3010 can simultaneously track targets in up to three axes at velocities of 2 m/s. Selection of the IDS3010 basic unit with the standard industrial high-speed BiSS-C interface because the version with the BISS-C interface is the quickest and cheapest solution and well tested by Attocube. Furthermore, selection of three different sensor heads with different benefits to test and get to know a broad portfolio of the available sensor heads. The IDSH/M12/C7.6/RAD long-range sensor head with necessary FAP3 mounted retroreflector, the IDSH/M12/F40/RAD standard sensor head for a broad variety of applications and the IDSH/D4/F17/RAD miniature sensor head with lower surface quality. Selection of the RAD version for all sensor heads and corresponding fibers, for applications under radiation or in high vacuum. Due to an integrated webserver, the sensor can be aligned, initialized and (re-) configured remotely at any time.

Important technical specifications:

Power supply:	*12 V DC;*
Power consumption:	*8 W;*
Laser source:	*DFBlaser (class1);*
Laser output power:	*max. 400 µW;*
Laser wavelength:	*1530 nm;*
No. sensor axes:	*3;*
Max. target velocity:	*2 m/s;*
Interface:	*BiSS-C, 32-Bit;*
Sensor resolution:	*1 pm;*
Sensor repeatability:	*2 nm;*
Compatible environments:	*RAD = up to 10 MGy radiation dose;*
Total length basic unit:	*195 mm;*
Total width basic unit:	*55 mm;*
Total height basic unit:	*52 mm;*
Maximal measuring length:	*5 m; (depending on sensor head)*

More information can be found in the corresponding technical data sheets

Turck

Li-Q25L, inductive linear position sensor with the standard industrial SSI interface (25-Bit gray coding) for measuring lengths up to one meter, manufactured by Turck. The measuring principle of the new linear position sensors is based on RLC coupling. The sensor system consists of a powered stator with emitter and receiver coil systems that are manufactured as printed circuit coils and a passive target (positioning element/resonator). The measuring system works contactless and wear-free. The PCB on which the sensor element is positioned is located directly under the active face and the electronic circuit for signal evaluation is housed one level below it. The measuring principle of the new encoders is based on an inductive resonance coupling circuit. The emitter coils are excited with a high-frequency AC field and form with the positioning element (resonator) an inductive resonance coupling circuit. The geometry of the receiver coils is designed so that different voltages are induced in the coils depending on the position of the positioning element, and thus determine the sensor signal. To increase the flexibility and speed of measurement, the sensor operates with two coil systems. One for rough and on for precise position detection of the resonator. The innovative technology ensures a high immunity to electromagnetic DC and AC fields. Selection of Li-7000P0-Q25LM0(-HESG25X3-H1181) position sensor and the corresponding P1-LI-Q25L guided locator because of the maximal measuring length of 700 mm, the SSI interface and the high speed H-series with the high sampling rate.

Important technical specifications:

Power supply:	*15 – 30 V DC;*
Resolution:	*12-Bit / 0.001 mm;*
Reproducibility:	*≤ 36 µm;*
Interface:	*SSI, 25-Bit, gray-code, synchronous;*
Sampling Rate:	*5 kHz;*
Total length:	*758 mm;*
Total width:	*35 mm;*
Total height:	*25 mm;*
Maximal measuring length:	*700 mm;*

More information can be found in the corresponding technical data sheets

TWK Elektronik

The system comprises an inductive linear displacement transducer (IW120/150-025-RK5-A44, standard design form) and a cylindrical electronic module (IE25/150-E02), both with a measuring length of 150 mm (the system is available with a measuring length of up to 200 mm). The cylindrical housing in stainless steel contains the excitation circuit for the inductive transducer (oscillator and demodulator) as well as the conditioning electronics along with the standard industrial SSI-interface. The linear transducers operate according to the classic differential throttle principle (inductive half-bridges). They consist of two coils which are impermeably cast into a Mu-metal cylinder. On displacement through the hollow coil body, a Mu-metal plunger leads to a change in the induction direction in both coils. Selection of these components because they provide a coordinated system based on the classic inductive measurement principle for displacement transducers with an inductive half-bridge. Furthermore, it is equipped with a standard industrial SSI protocol and it is by way of comparison low-cost.

Important technical specifications:

Power supply:	*21.5 – 30 V DC;*
Current consumption:	*60 mA / max. 80 mA;*
Resolution:	*12-Bit;*
Linearity:	*0.25 %;*
Interface:	*SSI, 13-Bit, synchronous;*
Total length:	*115 mm;*
Total diameter:	*25 mm;*
Maximal measuring length:	*150 mm;*

More information can be found in the corresponding technical data sheets

Gantner Instruments

The Q.bloxx EC A106 product line manufactured by Gantner Instruments represents a universal EterCAT module for measuring bridges, like LVDTs or inductive half and full bridges. This module can be used as a carrier frequency amplifier for different LVDTs. Carrier frequency measuring amplifiers for inductive sensors in half or full bridge circuits (LVDT) produce an AC voltage for supplying the measuring bridge. They evaluate the voltage picked up on the bridge and provide the measurement value, for example via a standardized interface. It is possible to connect the Q.bloxx EC A106 module to an EtherCAT Master via an separate EtherCAT bus coupler (Q.bloxx EC BC). In that case, the Q.bloxx EC A106 module will be handled like an EtherCAT slave. The EC version of the Q.bloxx modules are specially designed for use with a higher-level Beckhoff (EtherCAT) control system. For configuration they support CoE (CAN application protocol over EtherCAT), and FoE (File access over EtherCAT) protocols.

Important technical specifications:

Power supply:	*10 – 30 V DC;*
Power consumption	*2.5 W;*
Analog input channels:	*2, galvanic isolated;*
Analog output channels:	*2, voltage ± 10 V, 10 kHz;*
Digitalization:	*24-Bit ADC, 10 kHz sample rate per channel;*
Mode for LVDT:	*4.8 kHz Carrier Mode(AC);*
Permitted sensor cable length:	*< 100 m;*
Total width case:	*35.6 mm;*
Total height case:	*118.8 mm;*

Total deepness case:	*124 mm;*
Total weight case:	*400 g;*

More information can be found in the corresponding technical data sheets

TE Connectivity Sensors
Waiting for response.

Motion Controller / Frequency Converter
At this point necessary servo drives (frequency converters) and corresponding motion terminals will be described in more detail.

Beckhoff AX5206
The AX5206-0000-0202 digital compact servo drive is equipped with two channels, which offers the possibility of operating two motors synchronously or independently of each other on this device. In addition, this frequency converter manufactured by Beckhoff is equipped with an EtherCAT interface, which offers the possibility to integrate the device and the connected linear motor directly into a higher-level Beckhoff (EtherCAT) control system. This servo drive is equipped with the necessary characteristics for the operation of the selected linear motors. In addition an encoder option card (AX5722-0000), exclusively made for the servo drives of the AX5000 series, had to be selected. This option card offers two additional feedback channels with which the servo drive can also evaluate BiSS-C or EnDat 2.2 encoders for commutation and positioning of the linear motors. As this servo drive does not support an SSI protocol, encoders with BiSS-C interfaces have been selected for the linear feedback systems. It is necessary to use an encoder whose protocol can also be processed by the servo drive, since otherwise the encoder can only be used for positioning, but not additionally for commutation.

Important technical specifications:

Power supply:	*100 – 240 V AC, single-phase connection;*
	100 – 480 V AC, three-phase connection;
Max. DC link voltage:	*875 V DC;*
Rated output current / channel:	*6 A;*
Max. peak output current / channel:	*13 A;*
Rated apparent power (S1 operation):	*230 V AC = 4.8 kVA;*
	400 V AC = 8.3 kVA;
	480 V AC = 10 kVA;
Power loss:	*160 W;*
Max. continuous braking power:	*90 W; (internal brake resistor)*
Max. braking power:	*14 kW; (internal brake resistor)*
Min. brake resistance:	*47 Ω; (external brake resistor)*
Max. braking power:	*15 kW; (external brake resistor)*
DC link capacity:	*470 µF;*
Total width:	*283 mm;*
Total height:	*540 mm; (without plugs)*
Total deepness:	*232 mm; (without connectors / accessories)*
Total weight:	*approx. 6 kg;*

More information can be found in the corresponding system manual.

Beckhoff EL7047

For the supply and control of the selected linear stepper motor, manufactured by H2W technologies, a suitable stepper motor controller has to be selected. Selection of the EtherCAT EL7047 stepper motor terminal (1-channel) manufactured by Beckhoff. This terminal is equipped with the necessary characteristics for the operation of the selected linear stepper motor, it can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and it is already on the standardization list of the ESS. The EL7047 EtherCAT Terminal is intended for stepper motors with medium performance range. The PWM output stages cover a wide range of voltages and currents. Together with two inputs for limit switches, they are located in the EtherCAT Terminal. The terminal can be adjusted to the motor and the application by changing just a few parameters. 64-foldmicro-stepping ensures particularly quiet and precise motor operation.

Important technical specifications:

Power supply:	*24 V DC via the E-Bus;*
	encoder/driver stage: via the power contacts;
Current consumption from the E-Bus:	*typ. 140 mA;*
Number of outputs:	*1 stepper motor, 2 phases;*
Number of digital inputs:	*2 limit position, 4 for an encoder system;*
Number of digital outputs:	*1 configurable for brake (0.5 A);*
Motor supply voltage:	*8 - 50 V DC; (via terminal contacts)*
Output current:	*5 A; (6.5 A with fan cartridge ZB8610)*
Max. step frequency:	*1000, 2000, 4000, 8000 or 16000 full steps/s;*
Step pattern:	*up to 64-fold micro stepping;*
Total width:	*27 mm; (connected width: 24 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 105 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL2522

In order to be able to control and operate the linear positioner manufactured by SmarAct and its associated SDC2 control system like a stepper motor, it is necessary to use a terminal that can output a predefined sequence of pulses via differential outputs. Selection of the EtherCAT EL2522-0000 pulse train output terminal (2-channel) manufactured by Beckhoff. This terminal can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS. The EL2522 pulse train terminal outputs a frequency-modulable signal on two channels with four outputs. The signal can be used to control motor drivers or other signal receivers, which are controlled by single cycles. The pulse sequence and pulse number can be specified directly via the process data in the frequency. Alternatively, the integrated travel distance control can be used. In addition, the EL2522 can control three output channels in the ABC encoder simulation (incremental).

Important technical specifications:

Power supply:	*24 V DC via the E-Bus;*
Current consumption from the E-Bus:	*typ. 120 mA;*
Digital outputs:	*2 channel (2 differential outputs A/A, B/B);*
Alternatively:	*1 channel (3 differential outputs);*
Signal voltage:	*RS422 level;*
Output current max. (per channel):	*50 mA, RS422 specification;*

Resolution:	*max. 15-Bit;*
Step size:	*min. 10 ns (internal);*
Total width:	*15 mm;*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 50 g;*

More information can be found in the corresponding system documentation.

SmarAct SDC2

With the Step-Direction Control SDC2-MAX SmarAct offers a low level control system to use the selected SmarAct linear positioners like stepper motors. The standard inputs of the SDC controller are step and direction signals (TTL). For every step a closed-loop controlled position increment is performed in the specified direction. In order to get a position signal, the SDC2 supports a quadrature signal feedback (RS422). The selected EtherCAT EL2522 pulse train terminal with the differential signal outputs can provide the step-direction signals to drive the linear positioners. The position change in the linear positioner then leads to a sinus / cosinus signal of the integrated optical sensor. This signal is then digitized and transmitted with a serial RS485 data stream to the SDC 2 controller. Based on this position feedback the SDC 2 controller performs a closed-loop position control and outputs quadrature signals. Optionally, these quadrature signals could be evaluated via a corresponding EtherCAT encoder terminal (eg EL5101) which is capable of processing RS422 signals. Otherwise, for example to minimize cost and effort, the linear positioner could also be controlled and positioned by steps / pulses. Selection of the MAX version of the SDC2 adapter board because inputs and outputs of the SDC2-MAX operate with a maximum voltage of 28 V. The alternative EUR version of the adapter board typically operates with 5V signals at the inputs and outputs, which makes it less flexible.

Important technical specifications:

Power supply:	*12 V DC;*
Voltage range in- and outputs:	*up to 28 V;*
Control Interface:	*Step / DIR, 5 V TTL;*
Signal Level quadrature signal output:	*RS422;*
Housing:	*Single control board (OEM);*

More information can be found in the corresponding system documentation.

Jenny Science Xenax Xvi 75V8

The XENAX Xvi 75V8 Ethernet servo controller controls all series of the ELAX electric slide product family. Jenny Science manufactures both products, the XENAX servo controller and the ELAX linear motor series what means that they are ideally coordinated. Additionally the force calibration function is a nice feature by using the XENAX Xvi 75V8 servo controller in cooperation with the ELAX linear motor. The force calibration function allows controlling, limiting and monitoring forces without an additional force sensor. Furthermore, this servo controller will be equipped with an EtherCAT bus module, for the integration into the EtherCAT control system. The integrated webserver allows a setup and parameterization over web browser. Since both products are ideally coordinated to each other, configuration and commissioning via the web browser can be implemented quickly.

Important technical specifications:

Power supply:	*12 - 75 V DC; (typical 24 V DC)*
Number of digital inputs:	*12 x 24 V DC;*
Number of digital outputs:	*8 x 24 V DC, 100 mA;*
Motor supply voltage:	*12 - 75 V DC;*

Logic supply:	*24 V DC, max. 1.3 A;*
Nominal current:	*0 - 8 A;*
Peak current:	*18 A;*
Continuous power / power dissipation:	*Typical 150 W (48 V, 3 A) / 22 W;*
Index:	*50 motion moves (accl. / speed / distance);*
Total width:	*30 mm;*
Total height:	*140 mm;*
Total deepness:	*183 mm;*
Total weight:	*approx. 105 g;*

More information can be found in the corresponding instruction manual.

Control Computer – TAROX ECO 44 G5

The next computer generation is conquering the working world. In spite of the small dimensions, the smartly designed mini-computer TAROX ECO combines high performance and best connectivity on the level of a high-tower PC. The advantages are a compact housing, low noise level and high-energy efficiency.

Important technical specifications:

Manufacturer:	*TAROX;*
Body housing:	*TAROX ECO 44 G5;*
Power supply:	*65 W;*
Processor:	*Intel Core i5-5250U, 1.6 GHz, dual-core; (Turbo-frequency: 2.7 GHz)*
Main memory:	*4096 MB DDR3 PC1600;*
Hard disk:	*120 GB SSD; (enlargement possible)*
Operating system:	*LINUX;*
Interfaces:	*2 x USB 3.0, 1 x mini-HDMI,*
	1 x mini-Displayport, 1 x RJ45;
Total width:	*115 mm;*
Total height:	*33 mm;*
Total deepness:	*111 mm;*

More information can be found in the corresponding system documentation.

Additional Accessories (PLC, EtherCAT Terminals, Braking resistor etc.)

Beckhoff CX5130-0155

With the Embedded PCs of the CX series, Beckhoff has combined PC technology and modular I/O level on a DIN rail unit in the control cabinet. The Embedded PC CX5130-0155 is a full-fledged PC that can be equipped with the various Windows operating systems. To realize a future-oriented application, the selection has fallen on a Microsoft Windows 10 IoT Enterprise LTSB operating system. In combination with the TwinCAT automation software, the CX5130 Embedded PC becomes a powerful PLC with up to four user tasks. Additionally, Motion Control tasks can also be executed. The modular system of the CX series can be configured to match the task in hand: by adding or omitting units and interfaces, only those components that the system actually requires are installed on the DIN rail in the control cabinet or terminal box. Installation space and costs are reduced. The power supply terminal for the Embedded PC is located on the right-hand side. Several EtherCAT terminals (E-bus) can be attached on the right-hand side of the power

supply unit. Selection of this PLC because this is the basic unit of the higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Power supply:	*24 V DC via power supply terminal;*
Max. power loss:	*12 W;*
Power supply for I/O terminals:	*max. 2 A;*
Current load of the power contacts:	*max. 10 A;*
Max. number of E-terminals:	*up to 65534 terminals;*
Processor:	*Intel Atom E3827 1.75 GHz, dual-core;*
Main memory:	*4 GB DDR3-RAM;*
Flash memory:	*30 GB CFast-Card;*
Operating system:	*Microsoft Windows 10 IoT Enterprise LTSB;*
Control Software:	*TwinCAT 3;*
Interfaces:	*2 x RJ 45 (optionally EtherCAT), 4 x USB, DVI-I for external monitor;*
Total width:	*142 mm;*
Total height:	*100 mm;*
Total deepness:	*91 mm;*
Total weight:	*approx. 1095 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL1808

The 8-channel EL1808 digital input terminal acquires the binary control signals from the process level and transmits them, in an electrically isolated form, to the higher-level automation device. The EtherCAT Terminal contains eight channels, consisting of signal input and 24 VDC, whose signal state is indicated by LEDs. The power contacts are connected through. Selection of this this terminal because it can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Power supply:	*24 V DC via the power contacts;*
Current consumption from the E-Bus:	*typ. 100 mA;*
Nominal voltage of the inputs:	*24 V DC;*
Input current:	*typ. 3 mA;*
Number of digital inputs:	*8*
Number of power contacts:	*8 (8 x 24 V DC, connected through);*
Signal voltage “0”:	*- 3 … 5 V;*
Signal voltage “1”:	*11 V … 30 V;*
Bit width in the process image:	*8 input bits;*
Total width:	*15 mm; (connected width: 12 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 60 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL2819

The 16-channel EL2819 digital output terminal connects the binary control signals from the automation device on to the actuators at the process level with electrical isolation. The integrated diagnosis can be evaluated in the controller and is indicated by the LEDs. Overtemperature and the lack of a voltage supply to the terminal are supplied as diagnostic information. Beyond that each channel can among other things signal a short circuit individually. The output behavior of the channels in the case of a bus error can be parameterized. The outputs are fed via the 24 V power contact in the EL2819. Selection of this this terminal because it can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Power supply:	*24 V DC via the power contacts;*
Current consumption from the E-Bus:	*typ. 90 mA;*
Rated load voltage:	*24 V DC;*
Current consumption power contacts:	*typ. 30 mA + load;*
Number of digital outputs:	*16*
Load types:	*ohmic, inductive, lamp load;*
Max. output current:	*0.5 A per channel;*
Bit width in the process image:	*16-Bit output and 68-Bit diagnostic;*
Total width:	*15 mm; (connected width: 12 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 70 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL9189

The potential distribution terminals EL9188 and EL9189 provide 16 terminal points with a potential and enable the voltage to be picked up without further bus terminal blocks or wiring. 16 x 0V to match the 16 digital outputs (EL2819) of 24 V DC. Selection of this this terminal because it can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Outputs:	*16 x 0 V contact;*
Bit width in the process image:	*0;*
Total width:	*15 mm; (connected width: 12 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 60 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL5002

The 2-channel EL5002 SSI interface EtherCAT terminal is for the direct connection of two SSI encoders. In this application, the EL5002 terminal possibly can be used for the data processing of the displacement transducers (TWK) and the inductive linear position sensor (Turck) because both are equipped with an SSI interface. Selection of this this terminal because it can be

integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Power supply:	*24 V DC via the power contacts;*
Current consumption from the E-Bus:	*typ. 130 mA;*
Current consumption power contacts:	*typ. 20 mA; (without sensor load current)*
Data direction:	*Read;*
Signal output:	*Differential signal (RS422);*
Signal input:	*Differential signal (RS422);*
Max. output current:	*0.5 A per channel;*
Bit width in the process image:	*Inputs 1 x 32-Bit data, 1 x 8-Bit status;*
Total width:	*15 mm; (connected width: 12 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 55 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL5042

The 2-channel EL5042 BiSS-C interface can be used for direct connection of BiSS-C encoders. In this application, the EL5042 terminal possibly can be used for the data processing of the IDS3010 fiber-based displacement sensor (Attocube) or alternatively for the several selected feedback systems that are equipped with a BiSS-C interface. As a master, the EL5042 sends the clock signal to the BiSS-C slave (encoder), which transmits the position data. Here a position value can be represented in the process image with up to 64 bits, depending on the resolution of the connected sensor. Selection of this this terminal because it can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Power supply:	*24 V DC via the power contacts;*
Current consumption from the E-Bus:	*typ. 120 mA;*
Current consumption power contacts:	*typ. 150 mA;*
Encoder connections:	*D+, D-, C+, C-;*
Encoder operating voltage:	*optionally 5V DC or 9 V DC;*
Encoder output current:	*max. 0.5 A for both channels;*
Resolution:	*max. 64-Bit position, 2-Bit status, 8-Bit CRC;*
Data transfer rates:	*up to 10 MHz, variable;*
Total width:	*15 mm; (connected width: 12 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 50 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL5101

The EL5101 EtherCAT Terminal is an interface for the direct connection of incremental encoders with differential inputs (RS422). A 32/16 bit counter with a quadrature decoder and a 32/16 bit

latch for the zero pulse can be read, set or enabled. This terminal can be used for the evaluation of the quadrature position feedback signal (RS422) of the SmarAct linear positioners provided by the SDC2 control system. Selection of this this terminal because it can be integrated directly into a higher-level Beckhoff (EtherCAT) control system and additionally it is already on the standardization list of the ESS.

Important technical specifications:

Power supply:	*24 V DC via the power contacts;*
Current consumption from the E-Bus:	*typ. 130 mA;*
Current consumption power contacts:	*typ. 100 mA;*
Encoder connections:	*A, ¬A, B, ¬B, C, ¬C (RS422 diff. inputs);*
Encoder supply:	*5V DC;*
Encoder output current:	*0.5 A;*
Counter:	*16 bit, 16/32 bit switchable;*
Zero pulse latch:	*16 bit, 16/32 bit switchable;*
Limit frequency:	*1 MHz, equals 4 million increments with 4-fold evaluation;*
Quadrature decoder:	*4-fold evaluation;*
Bit width in the process image:	*up to 6 bytes outputs, 22 bytes inputs;*
Total width:	*27 mm; (connected width: 24 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 100 g;*

More information can be found in the corresponding system documentation.

Beckhoff EL9576

The EL9576 EtherCAT brake chopper terminal contains high-performance capacitors for stabilizing supply voltages. The EL9576 can be used, for example, in conjunction with the EL7047 stepper motor terminal. Return currents are stored, particularly in the context of drive applications, thereby preventing overvoltages. If the recovery energy exceeds the capacity of the capacitors, energy can be dissipated via an external ballast resistor (e.g. Beckhoff ZB8110). Furthermore this terminal can be integrated directly into a higher-level Beckhoff (EtherCAT) control system.

Important technical specifications:

Rated voltage:	*up to 72 V;*
Current consumption from the E-Bus:	*typ. 80 mA;*
Current consumption power contacts:	*0 mA;*
Capacitance:	*155 µF;*
Overvoltage protection:	*Standard 50 V, configuration via CoE;*
Recommended ballast resistor:	*ZB8110, Beckhoff, 10 Ω, 100 W;*
Total width:	*15 mm; (connected width: 12 mm)*
Total height:	*100 mm;*
Total deepness:	*70 mm;*
Total weight:	*approx. 90 g;*

More information can be found in the corresponding system documentation.

Beckhoff ZB8110

During the acceleration phase, a motor needs energy supply, whereas during braking a motor can be used as a generator, feeding energy back into the DC-Link, which raises the voltage in the DC-Link. If the voltage exceeds the adjustable threshold value, a ballast resistor is activated. The external ZB8110 ballast resistor is available as an accessory to the EL9576 brake chopper terminal. It regulates the DC-Link voltage as soon as more braking power is needed. The ZB8110 is connected directly to the EL9576.

Important technical specifications:

Rated output:	*100 W;*
Resistance value:	*10 Ω;*
Cable length:	*1000 mm;*
Special features:	*incl. mounting plate;*
Total width:	*110 mm;*
Total width mounting plate:	*110 mm;*
Total height:	*80 mm;*
Total height mounting plate:	*31 mm;*
Total deepness:	*15 mm;*
Total deepness mounting plate:	*28.5 mm;*
Total weight:	*approx. 280 g;*

More information can be found in the corresponding system documentation.

Beckhoff EK1110

Like the E-bus end terminal, the EK1110 EtherCAT extension is connected to the end of the EtherCAT Terminal Block. The terminal offers the option of connecting an Ethernet cable with RJ 45 or rather M8 connector, thereby extending the EtherCAT strand electrically isolated by up to 100 m. Selection of this terminal because it terminates the EtherCAT bus and additionally it offers the possibility to extend the E-bus if desired. Furthermore, it is already on the standardization list of the ESS.

Important technical specifications:

Power supply::	*from E-bus;*
Current consumption from the E-Bus:	*typ. 130 mA;*
Transmission medium:	*Ethernet CAT 5 cable (shielded);*
Cable length between two bus couplers:	*max. 100 m;*
Bus connection:	*1 x RJ45;*
Total width:	*44 mm;*
Total height:	*100 mm;*
Total deepness:	*68 mm;*
Total weight:	*approx. 50 g;*

More information can be found in the corresponding system documentation.

LEG SU3-2

The signal converter SU3-2 manufactured by LEG, converts RS422 signals to 5VDC (TTL) signals. This signal conversion is necessary for the operation of the SmarAct linear positioner because the Step-Direction control SDC2-MAX (SmarAct) processes TTL signals, but the corresponding EL 2522 pulse-train output terminal supplies only differential signals (RS422). There are three separate channels available.

Important technical specifications:

Supply voltage:	*19.2 - 30 V DC;*
Current consumption:	*> 1.5 A + load;*
Inputs:	*3-channels, RS422;*
Voltage output:	*5 V DC (TTL);*
Current:	*3 x 50 mA;*
Total width:	*17.5 mm;*
Total height:	*85 mm;*
Total deepness:	*70.4 mm;*
Total weight:	*approx. 64 g;*

More information can be found in the corresponding system documentation.

4 Control Software Description

Control System and Measurement software

The control system as well as the Measurement software are main work packages for the test bench and the measurements system. It includes the control hardware and the software, both described in more detail in the following chapters.

Control Hardware

All linear actuators have to be controlled, accordingly. Therefore, certain control hardware will be necessary and shall be determined, including motion controllers, servo drive modules and a control computer as well as linear feedback systems.

Control Computer

In order to communicate commands belonging to the linear test stages, a central control PC (Linux) shall be installed. It is supposed to run EPICS, further software to program the motion controllers and additional software providing a graphical user interface (GUI). A suitable Computer (e.g. Intel NUC) with enough CPU power has to be chosen.

Motion Controller

The motion controller shall be integrated into a 19” control cabinet with exception of great servo drive modules and in-house controllers. Main purpose of the motion controller is to control and evaluate the movements of the linear motors. A Beckhoff-PLC (e.g. CX5130) serves as a control system to execute the corresponding control software and to control and evaluate feedback signals. Thus, it needs to provide enough I/O interfaces (digital). Further modules have to be added for application specific purposes, so that all sensors and actuators being part of the test bench or the measurement system can be controlled. Furthermore, the motion controller serves as a communication unit, sending and receiving commands from a control PC. Besides the mechanical integration into the 19”-control cabinet, also cabling, especially the interconnection with the PLC shall be achieved.

Servo drive modules

Much that applies to the motion controller is also true for the servo drives. In contrast to the motion controllers, which can be integrated in a 19" control cabinet, the servo drives are large frequency inverters which have to be mounted separately. They are necessary for the control of the large linear test motors.

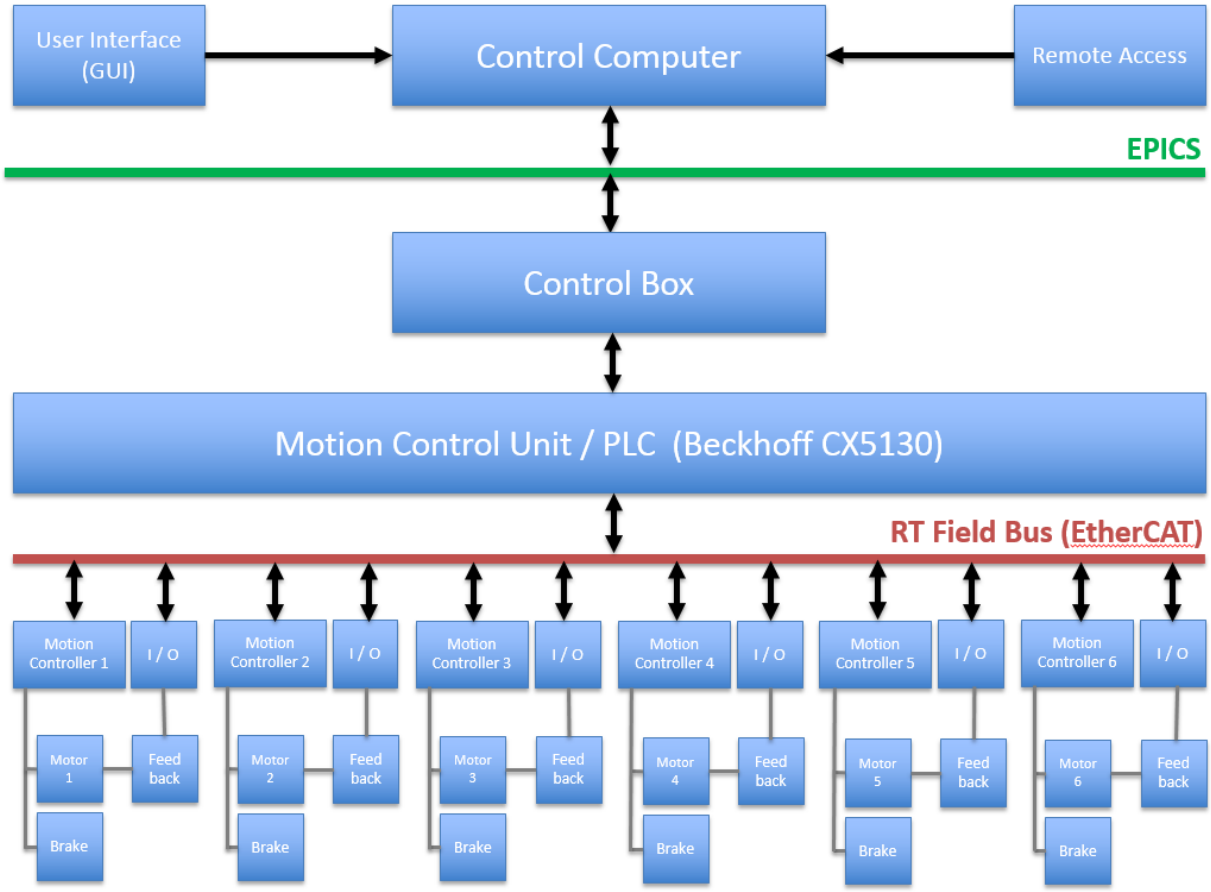
Remote Access

The possibility to access to the control and measurement system via remote access is requested. Therefore, it is necessary to define and conduct appropriate network settings. A solution can be the in-house remote desktop connection software from Windows. Otherwise, a corresponding remote software must be selected and installed on the control computer.

GUI

As already mentioned a software providing a graphical user interface (GUI) shall be installed on the test bench, to control processes related to the linear test stages. A solution can be a separate display with an integrated HMI.

Block diagram – Control system concept



Control Software

Control software shall be provided for PLC functionalities, linear motion positioning purposes and the measurement control. These different software packages are described in more detail in the following chapters.

Test Control

The measuring system will be installed on one of the test benches. It consists of the sensors and actors necessary to perform the test, the measurement software to control the tests and of the six test item sets to perform the tests with. The different packages of the measurement software will run on the control computer of the test bench. The test control is a package of the measuring software and is responsible for controlling and monitoring the test processes. This package will be implemented in the PLC.

Data Logger

The Data logger is part of the measuring software as well. The function of the data logger is to record, collect and transport the measured values to the corresponding target units. The data logger could be implemented in the PLC. In addition, this functionality could also be realized by additional hardware.

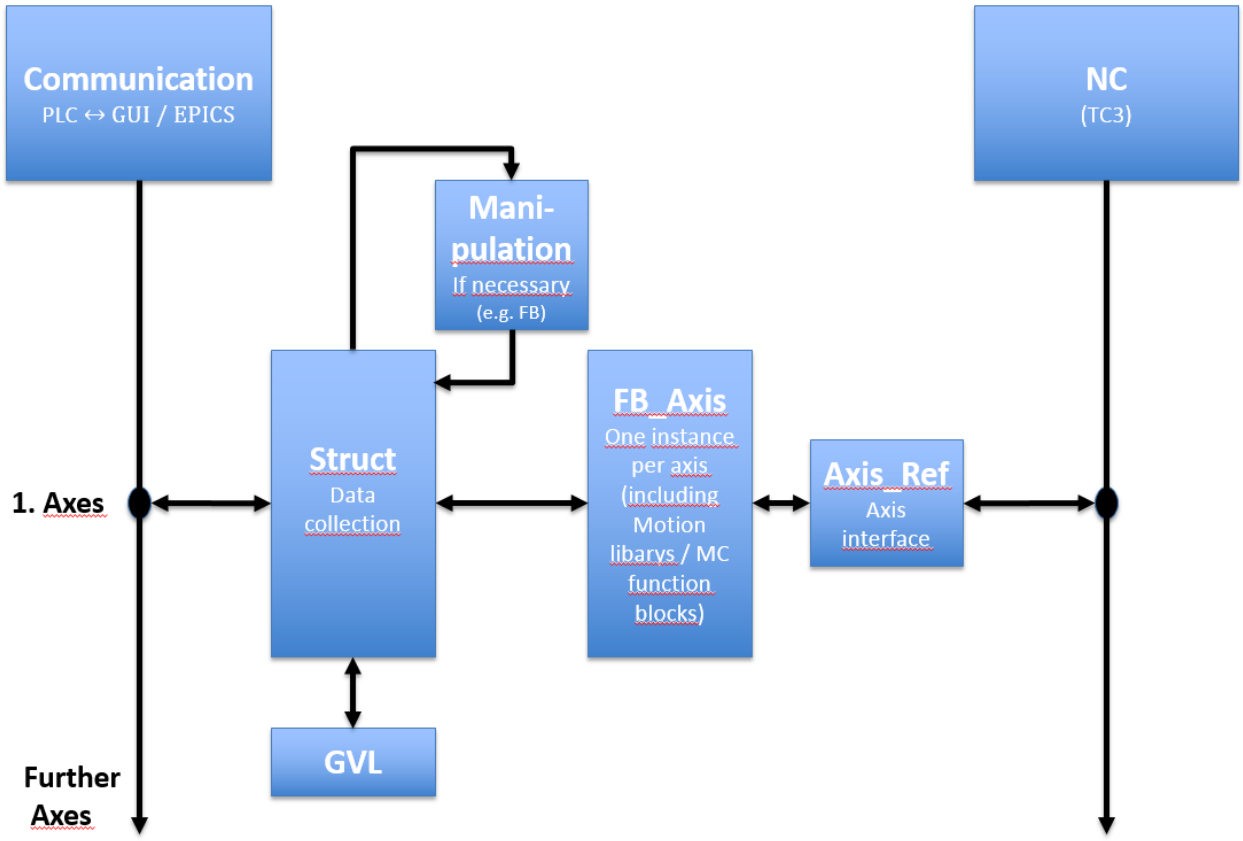
Sequencer

In order to collect and control a certain number of measured values under certain conditions (e.g. 1000 measuring steps within a defined time), the functionality of a sequencer makes sense. This functionality will be implemented in the PLC.

Data analyzer

The data analyzer is used to evaluate the collected measured values. It could be implemented in the PLC. Furthermore it is possible to realize this functionality graphically in form of scopes or graphs on the control computer or an additional computer with corresponding software. For this, an interface have to be defined, which determines how the measurement data is transferred to the computer and the corresponding analysis software.

Block diagram – Generally software concept for motion applications



Movement commands, position requests etc. could be transferred from the Control Computer (GUI / EPICS) to the PLC. This is represented by the block "Communication". The accumulation of all this data could takes place in the structure "Struct". For each standard axis there could be a main structure "Struct", a part within an entire - or possibly even a separate - global variable list “GVL”, an instance of the function block "FB-Axis" and with "Axis_Ref" an interface between the PLC and the NC. If necessary, for example by special treatments, where for example, several sequences are to be carried out or several axes have to cooperate, additionally the “manipulation” block could come into action. The structure "Struct" supplies the data to the “manipulation” block and this may influence the "Struct" before corresponding movement commands are transferred to the instance of the FB_Axis. There could be a function block “FB_Axis” for all axes, from which one instance per axis could be generated. Contents of the function block "FB_Axis" are the different movement commands (MC function blocks) from the various motion libraries (PTP, flying saw, etc.), which are based on the PLC-open specification. The Axis_Ref data type contains axis information and represents the interface between PLC and NC. TwinCAT “NC” is an assembly of function groups used for the control and regulation of axes. For each additional axis, a structure "Struct", a "Manipulation" block, an instance of the function block "FB_Axis", the axis interface "Axis_Ref" and, if necessary, a separate GVL could be created again. This approach keeps the program clear and simplifies commissioning, since this system makes it possible to uncouple the communication between the control computer and PLC during commissioning. This allows commissioning in two steps. First commissioning of the PLC program separately. In the second step, commissioning of the PLC program with the communication between the PLC and the control computer with corresponding instructions and movement commands being supplied from EPICS or the GUI.