CREMLIN
St. Petersburg

ELECTRONIC DESIGN
IN NEUTRON INSTRUMENTATION JCNS

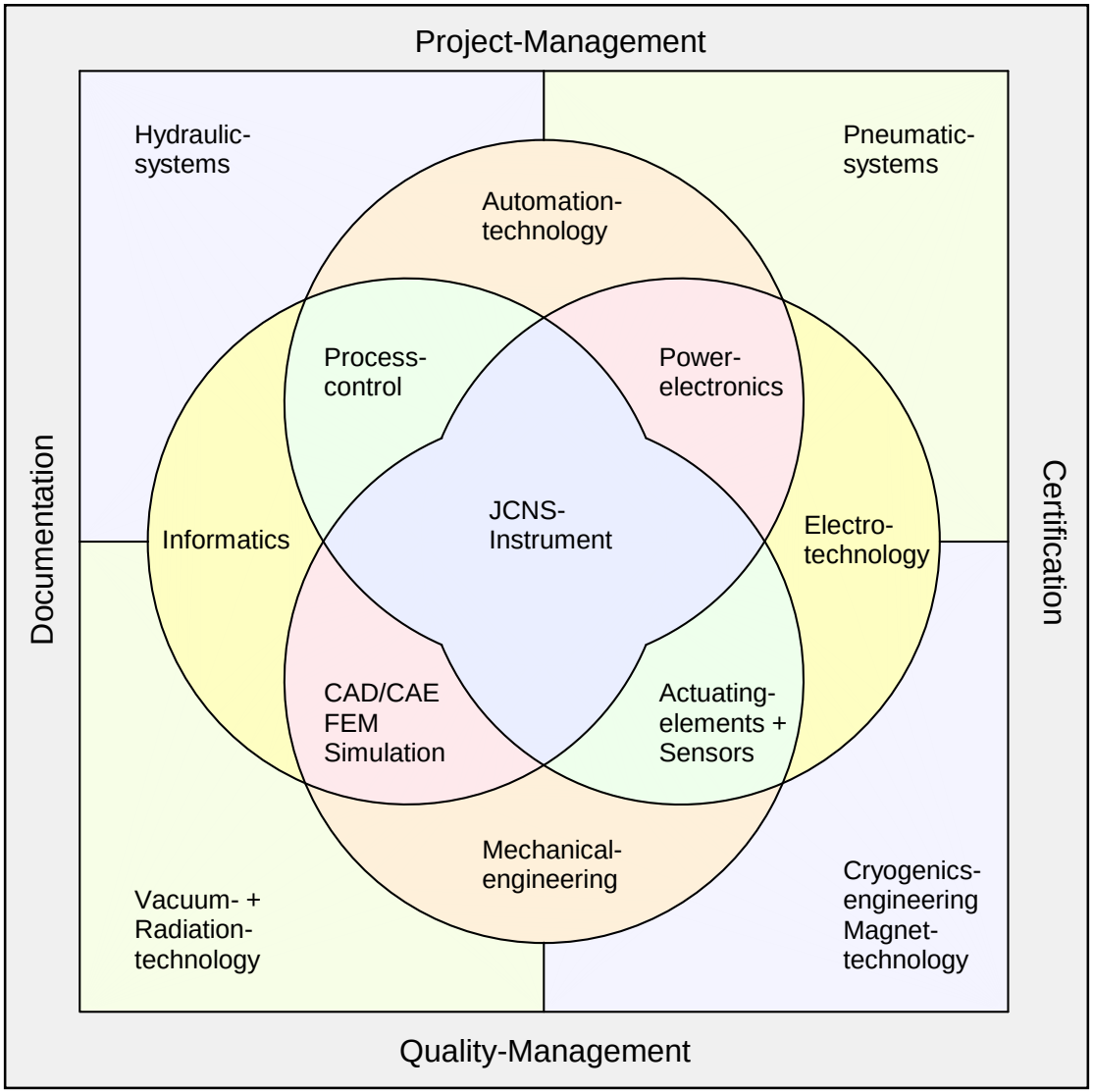
MAY 15TH, 2018 KLAUS BUSSMANN

OVERVIEW

... Technical Competences
... Support partner
... Workflow
... First idea to device
... E-CAD
... Workshop cabinets
... Control systems
... Drive systems and motortypes
... Feedback systems
... Example vacuum control TOPAS
... Interesting products, alternatives
... Example feasibility project FAN-chopper

TECHNICAL COMPETENCES

General overview



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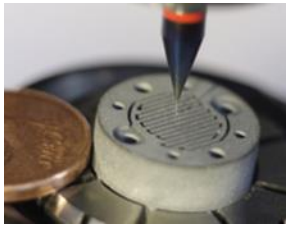
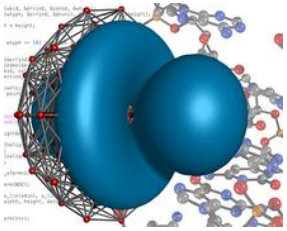
JCNS IN-HOUSE-SUPPORT (JCNS-PGI-TA, TECHNICAL ADMINISTRATION)

Administration


Engineering & design


Mechanical workshop

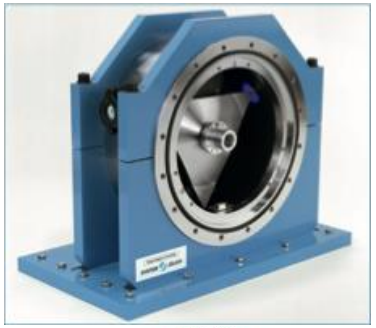
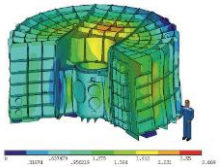

Scientific IT Systems

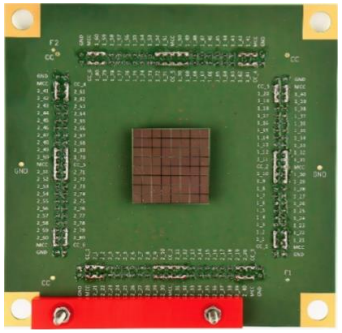

Industrial safety & radiation protection

Teamwork

JCNS PARTNER SUPPORT BY CENTER FACILITIES AND MANAGEMENT


G-ELI
Facility management-
Instrumentation -
Process control



ZEA-1
Central Institute for
Engineering & Technology


ZEA-2
Central Institute
for Electronics


External
technology-
providers

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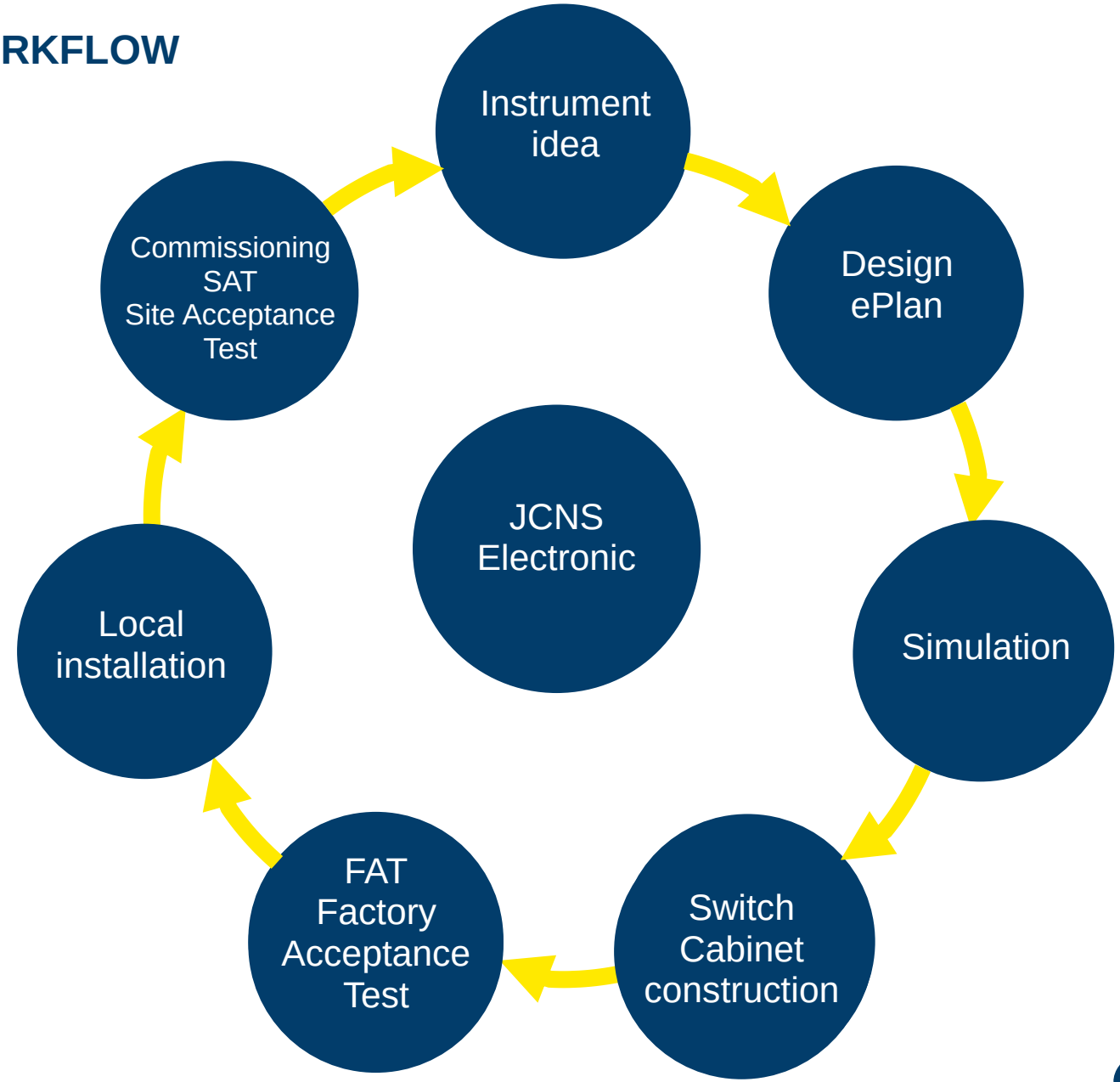
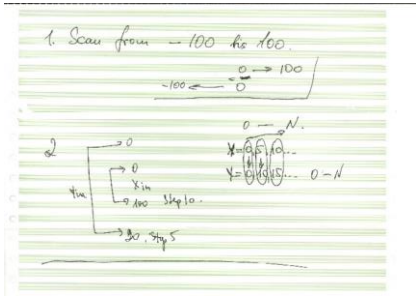
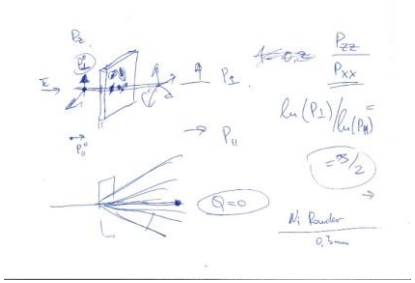
WORKFLOW


Instrument idea
Design ePlan
Simulation
Switch Cabinet construction
FAT Factory Acceptance Test
Local installation
Commissioning SAT Site Acceptance Test
JCNS Electronic

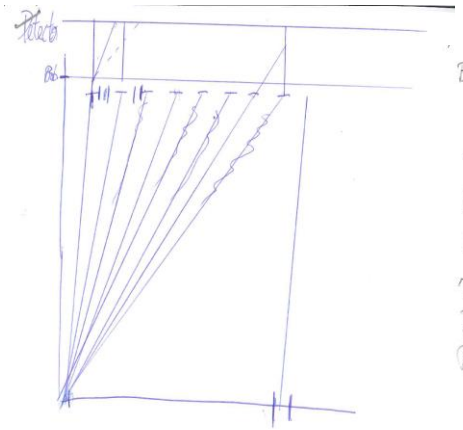
FROM THE FIRST IDEA TO THE DEVICE

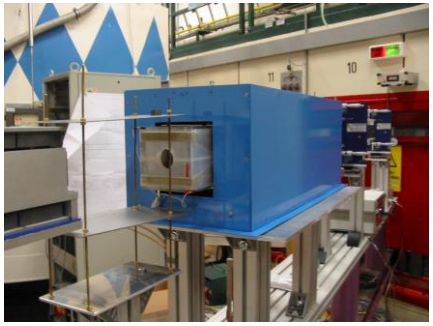
Larmor Phase labelling and Neutron Depolarization (LAP-ND)
Vector Polarization Analysis – Jülich 2002

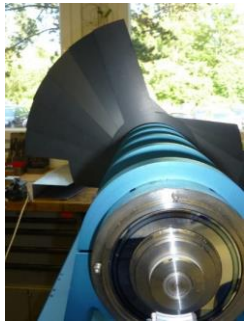


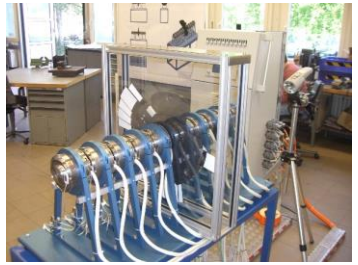


Novel Chopper-system for a Long-puls-neutronsource (FAN-Chopper) – Jülich 2014









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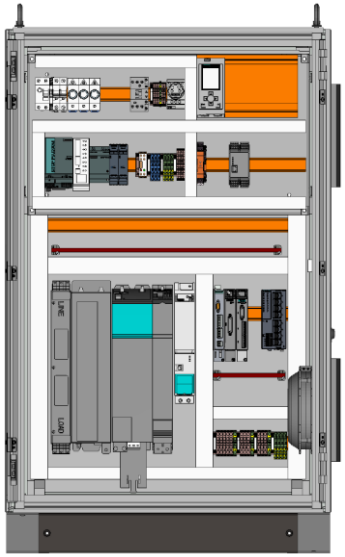
E-CAD - SYSTEM EPLAN

Electrical Planing and engineering	Electric P8
Virtual enclosure layout in 3D	Pro Panel
Technical preplaning of machines/plants	Preplaning
Fluid power engineering (pneumatic & hydraulic)	Fluid

Standards



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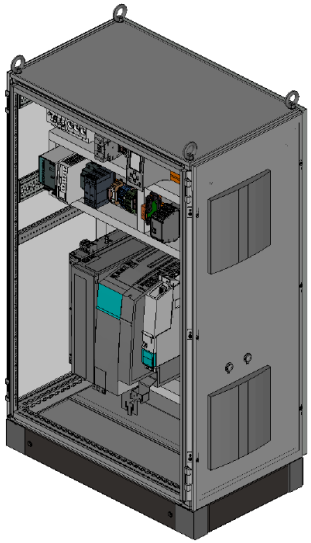
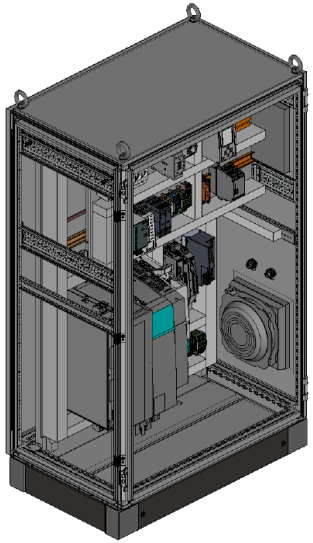
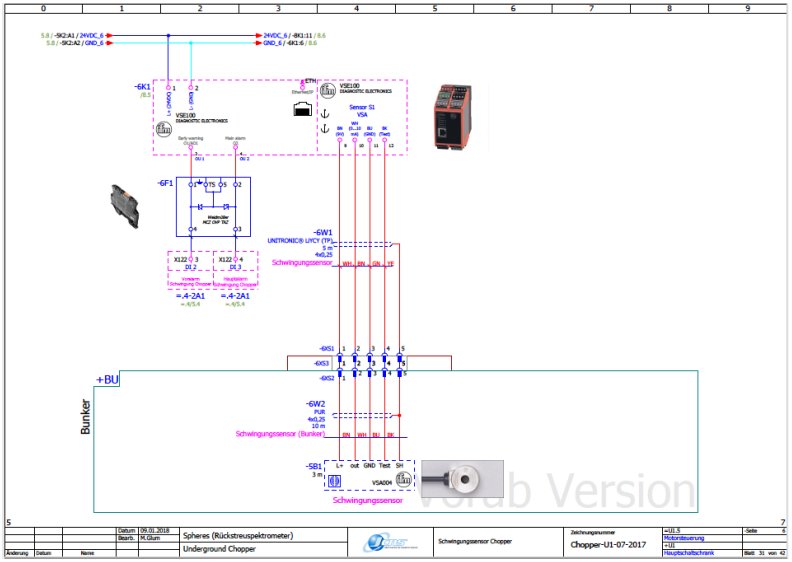




Simulation



MANUFACTURING CONTROL CABINETS

maintenance and operational supervision

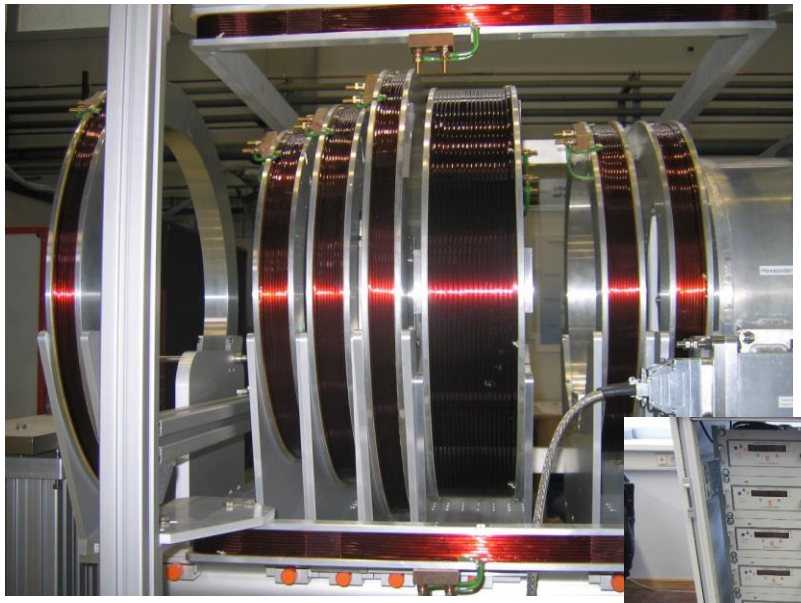



Current/voltage monitoring

FAT – Factory Acceptance Test
SAT – Site Acceptance Test

careful attention of current EMC and Installation standards
multifunctional power quality analyser with residual current monitoring
frame size: 1800mm ... 2000mm with base/plinth system
middleware, servers, network components and detector-electronics in 19“-enclosures

ASSEMBLY OF COILS AND MAGNETIC SYSTEMS



Magnetic coils – Neutron Spin Echo Instrument

power supplies for control

Magnetic coil – Neutron Spin Echo Intrument

Exotic shapes

Cooled inside

Separate from the carrier

CONTROL-SYSTEMS

The simple, hand-adjustable devices of the first hour in the fifties have evolved into fully automatic, computer-driven instruments with error analysis today supported by PLC‘s in the field level.

PLC-Standard EN 61131-3 -> TIA-Portal Siemens, TwinCat 3 Beckhoff
PLCopen, Profidrive , uniform PLC- platform of several companies

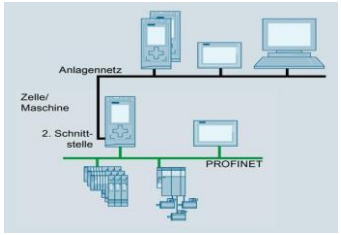
The choice of the PLC system is a philosophical question.

Simatic S7-300

Simatic S7-1500

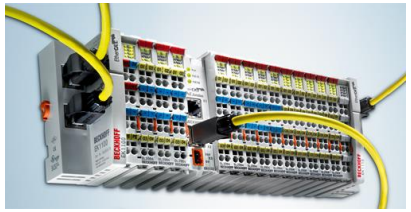
Simatic ET200S

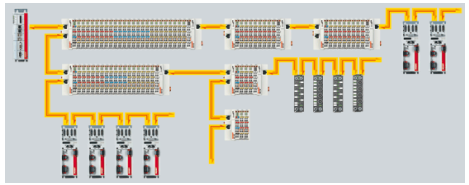
Simatic ET200SP



Beckhoff IPC-Control-System

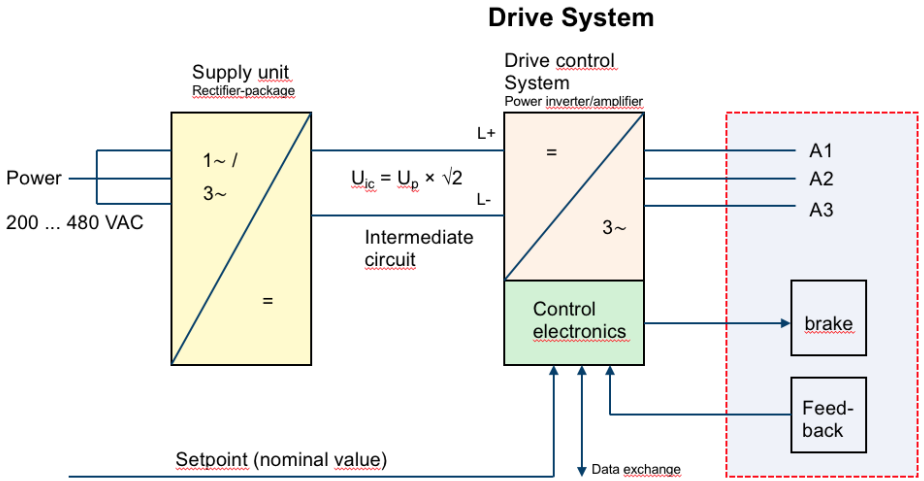
Beckhoff EtherCAT fieldbus-components

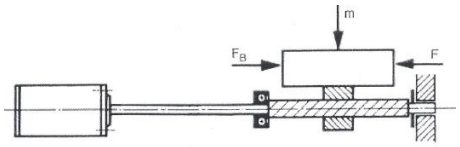


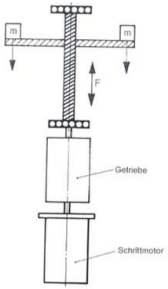


DRIVE SYSTEMS

Powerful drives are tailored to their tasks.
Circa 350 motors are in use at JCNS instruments.
The motor types are: stepper motors, synchron-/ asynchronous motors, DC motors and piezo motors.
The engine parameters are defined by the usual mathematical calculation methods. Depending on the application and systems, power supplies of 200 VAC ... 400 VAC and 5VDC ... 48VDC are required.
In composite systems, real and virtual masters are used with the support of PLC‘s with technology objects (e.g., S7-1500T) for electronic gear, cam control, etc.







Distributed system

DRIVE-SYSTEMS AND COMPONENTS
USED MOTOR TECHNOLOGIES

Steppermotor

mostly used
on all instruments

precision positioning

Asynchron motor

pumps,
lifting equipments

chopper

Synchron motor

vertical movements

chopper

special tasks
high power

Direct current motor

used in older systems
new BLDC motor for
probe-movement

Linear actuator
(Piezo/Servo)

slit systems

vacuum, magnet fields

high end precision positioning

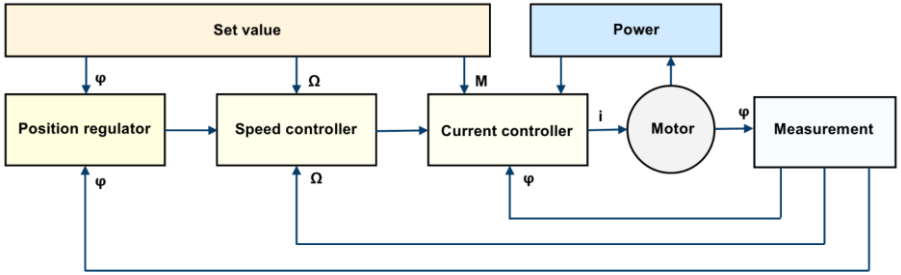
Requirements for modern drive technology for neutron scattering:

powerful drives with high performance and sustainability
link of motion and plc-technology
pre-assembled modules in hardware and software
standardization, generic systems

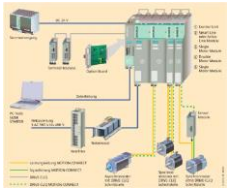
DREHSTROM ASYNCHRON MOTOR

DREHSTROM SYNCHRON MOTOR

Asynchronous and synchronous motors are used when high performance and dynamic precise tasks have to be solved.
Both are rotating induction maschines.



Typical loop controller for a drive system



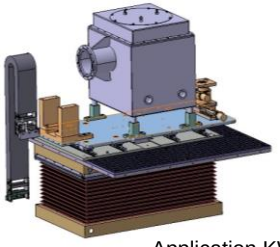
Asynchronous motore needs to be controlled
because the rotor speed trails behind the rotating field speed
more fault tolerant
the problem is the iron saturation with the result of the increasing current
Software complex, high starting current and torque, high speeds possible
low price

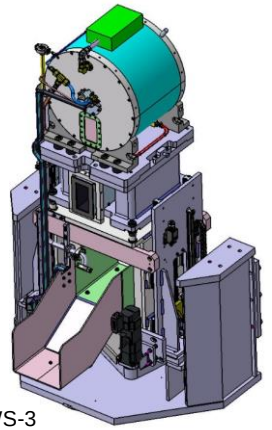
motors move synchronously to the rotating field without relative movement
Interesting to 30 Nm,
efficiency better at nominal load
lightweight compact design
high acceleration capacity
rare earth metals needed


Sinamics S120

Sinamics S110


Siemens servo


Application KWS-3




High frequency spindle


Sinumerik 840D


Sinamics S120


Ax500x Beckhoff


Indradrive Bosch-Rexroth


nano servo controller

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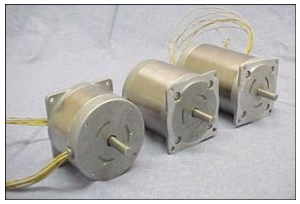
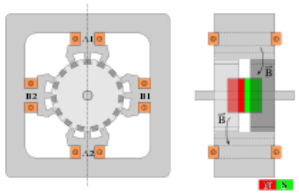
STEPPERMOTOR

up to 1 kw economical, robust, durable,
easy installation, maintenance free, brushless
Keywords:
construction and characteristic
torque, max step frequency
acceleration / deceleration
limit switch positioning
homing
safety aspects

Classical 2-phase steppermotor

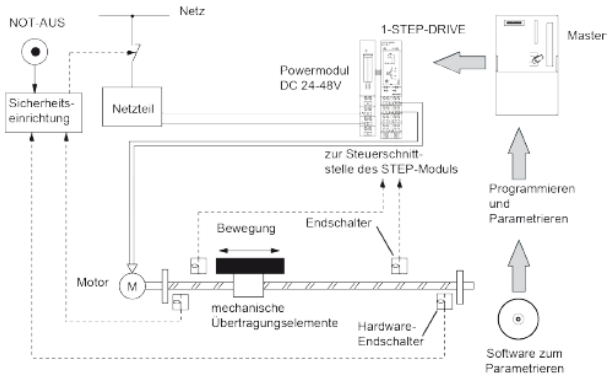


Radiation hard steppermotor



Two-phase hybrid stepper motor
with 4 windings

Flat steppermotor



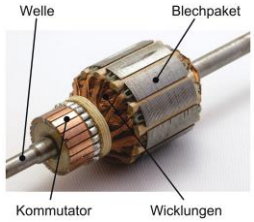
Stepping motor end phase Phytron

DC MOTOR

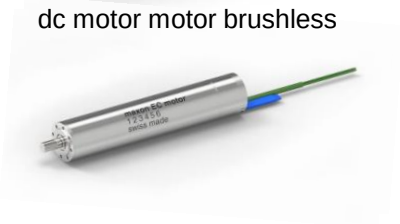
BLDC MOTOR brushless dc motor
EC Motor electronically commutated motor

BLDC's replace the old DC motors in the future
compact, dynamic, powerful
commutation electronics necessary
cabling and operating costs more
no sliding contacts (Wear brushes)
higher speeds up to 100000rpm
suitable for Ultra-high vacuum and sample movements
adjustments easier
better lifetime

dc motor motor



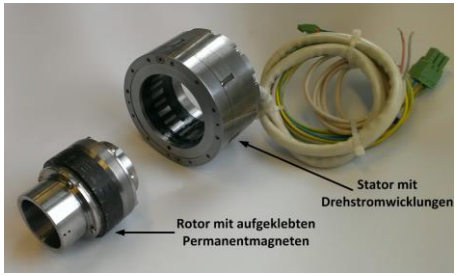
dc motor motor brushless



TORQUEMOTOR

Torque motors permanent-magnet direct drive motors that rotate along an axis. They can be used as an alternative for conventional servo drives.

Characteristics:
very compact
stiff drive train
maintenance free
inner diameter enables cable feedthrough
easy to integrate
high torque density
no bearings and clutches
own construction with bearings
limited in max. speed



Assembly motor kit

New narrow design

1.2 KW
2500 rpm
4.5 Nm

Complete mounted motor

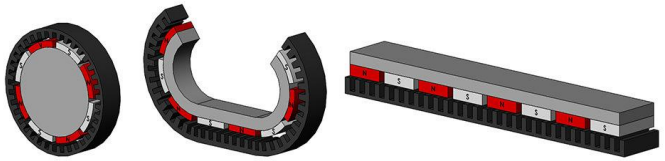
Example FAN-chopper

DIRECT DRIVE

LINEARMOTOR

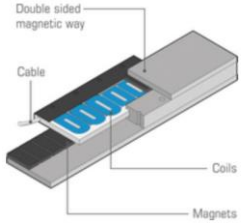
A linear motor is an unfolded rotary permanent-magnet direct drive motor.

An evaluation of the suitability for neutron scattering experiments and a feasibility study are carried out for the ESS (Lund) as part of an inkind project.



free from backlash
free from wear
direct coupling of the payload
large power and speed range,
enclosures, bearings and measuring systems must be designed by the user
dynamic movement

Ironless linear motor



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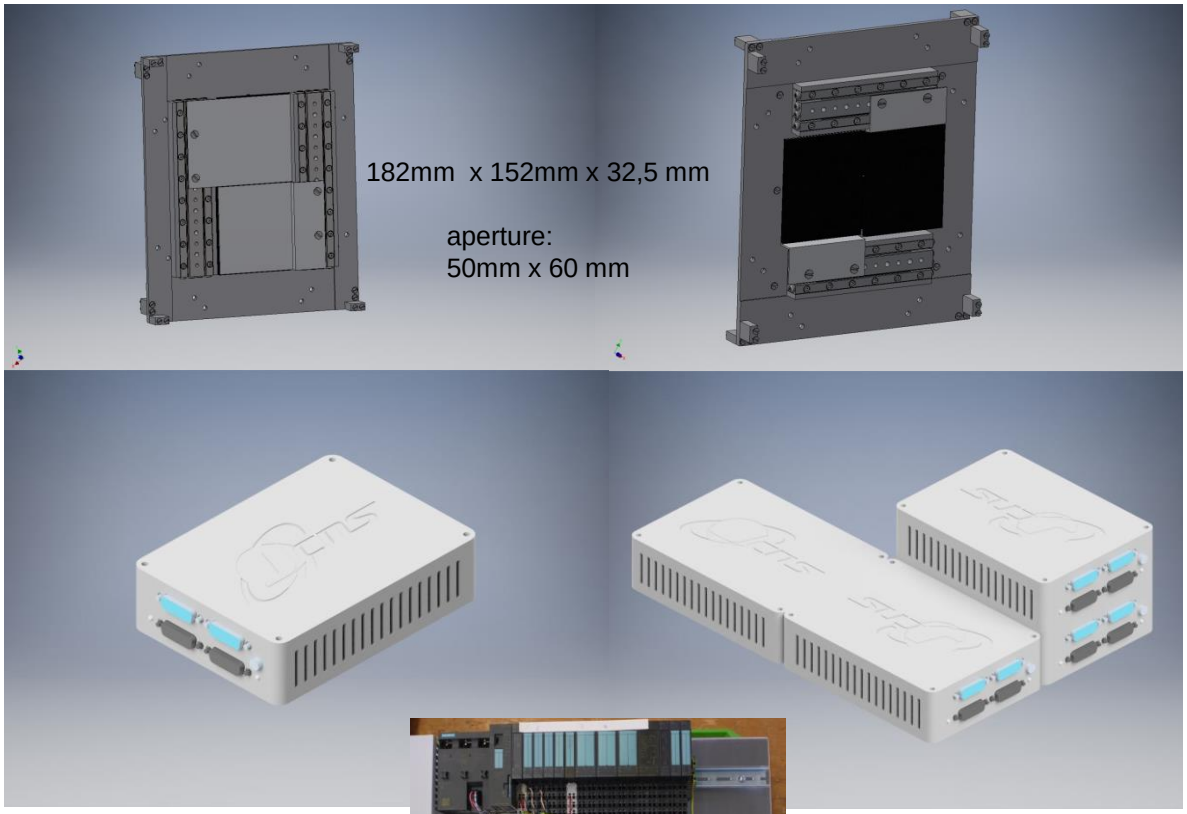
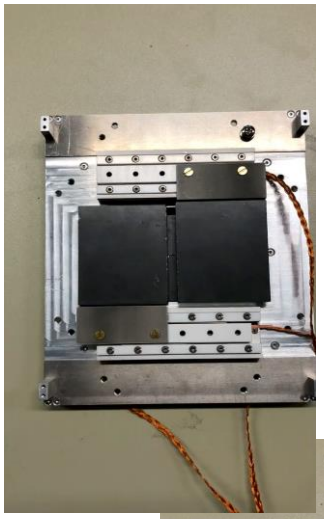
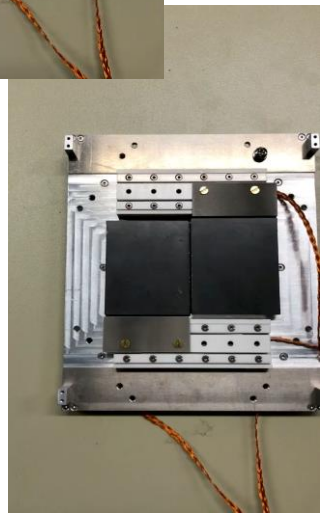
PIEZO DRIVE (DIRECT DRIVE)

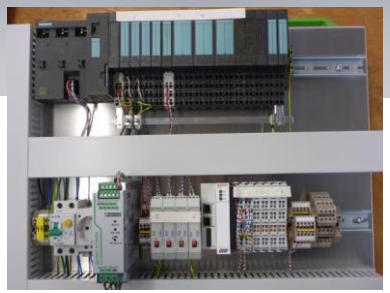
New slit-system with linear-piezo-drives (4 degreeses of freedom) SmarAct







Variable box for electronics



Participants:
PGI-JCNS-TA-construktion
G-ELI
JCNS-2

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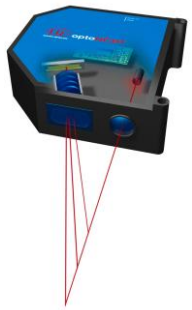
FEEDBACK SYSTEMS

Distance measurement rotational, translational

Digital drive systems as well as position control loops with feedback systems for data acquisition demand fast data transmission from the measuring devices with high transmission reliability. In addition, further data, such as drive-specific characteristics, correction tables, etc., must be available. For high system security, the feedback systems must be integrated into error detection routines and offer diagnostic options.



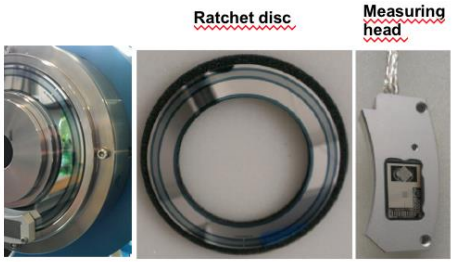


Most common interfaces:

SSI	**EnDat**	**magnetistrictive**	**BISS-C**	**potentiometry**	**Resolver**	**ProfiNet /EtherCAT**
incrementally	**RS232/485**	**analogous**				

Rugged absolute feedback systems are preferred, in rotary applications as a single or multi-turn version, for translational tasks in the form of optical or magnetostrictive linear position sensors.
Special sensors like lasers, ultrasonic sensors or potentiometers are used as needed.



Numerik Jena encoder disc and record sensor

Lenord + Bauer MINIcoder

Vacuum suitability and radiation resistance are important selection criteria.

FEEDBACK SYSTEMS
CONDITION MONITORING TO INCREASE SAFETY AND MACHINE EFFICIENCY

With special sensors the condition monitoring is carried out.

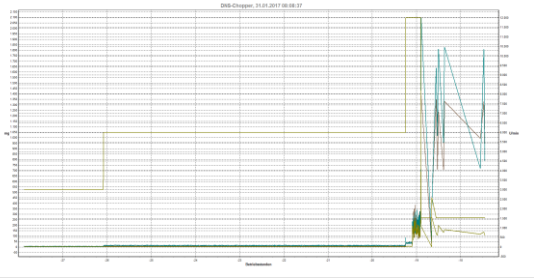
The voltage and current quality is checked by multifunction power analyzer. Important in this case is the continuous monitoring of power quality and analysis of electrical interference in the event of network problems.

A special vibration measuring system is used for regular acquisition and analysis of machine data such as unbalance and bearing conditions (Fourier transformation).
For collision avoidance, ultrasound, laser or photoelectric sensors are used.

AC / DC Analyser

Vibration analyser

Vibration sensors



Vibration histogram

Examples:
Current and voltage quality control

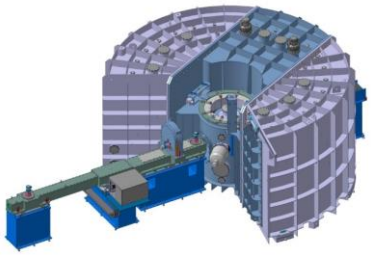
vibration sensor	- unbalance, bearing condition
ultrasonic sensor / photocells	- collision access control area controlling
push button (switch)	- position
temperature sensors	- overheating errors

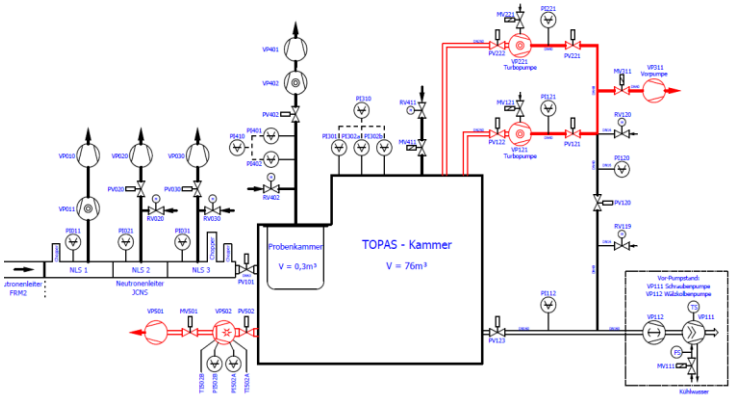
Light barrier

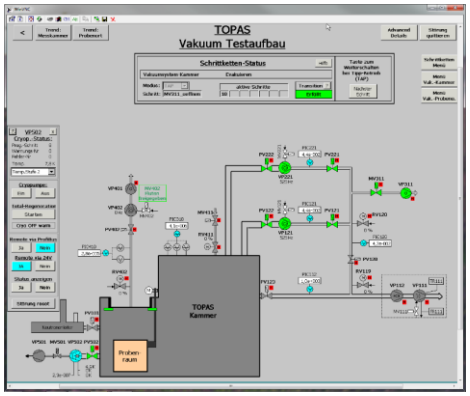
End switches

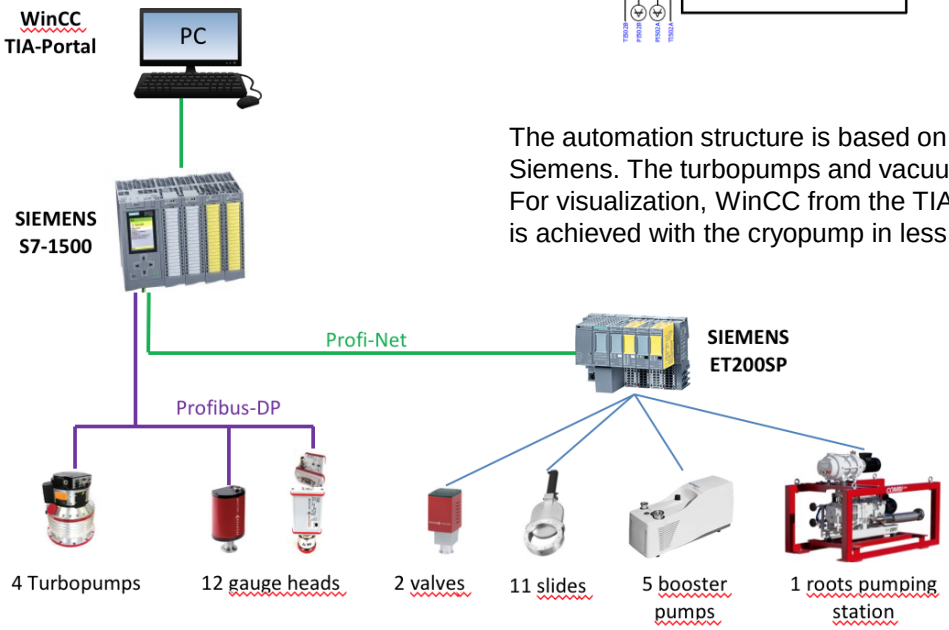
Ultasonic sensor

VACUUM ASSEMBLY
USING THE EXAMPLE OF TOPAS

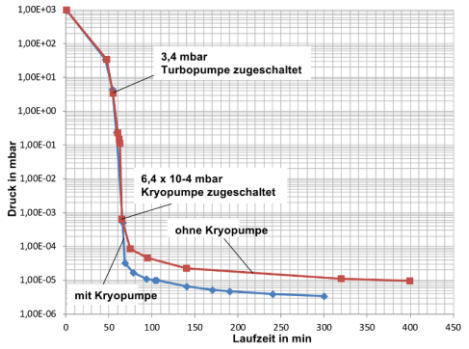








The automation structure is based on an S7-1500 controller with distributed I/O (ET200SP) from Siemens. The turbopumps and vacuum gauges communicate with the controller via Profibus-DP. For visualization, WinCC from the TIA Portal Siemens is used. The required vacuum of 10^{-5} mbar is achieved with the cryopump in less than 2 hours.



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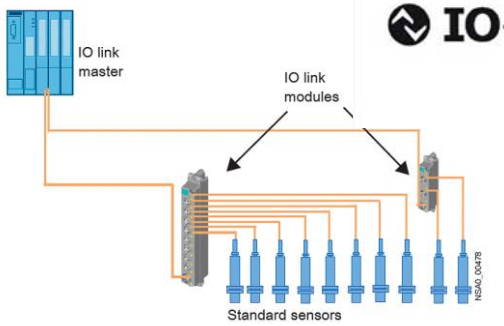
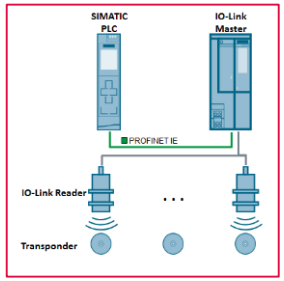
IO-LINK

Product:
IO-LINK, ***S**ingle-drop **d**igital **c**ommunication **i**nterface for small sensors and actuators* (SDCI)

Facts & figures:
fieldbus independent standard interface for automation and communication standard (currently available in 10 fieldbuses)
simple parametrization of sensors and actuators
point to point connection without addressing effort, less interface diversity
less wiring, no shielded lines, better diagnostics, more sensor data, reduced downtimes cost reduction
data can be read and written directly via plc input and output data
interference resistand transmission of 32byte per cycle
supports diagnostic concepts of industry 4.0
IO-LINK products are constantly increasing

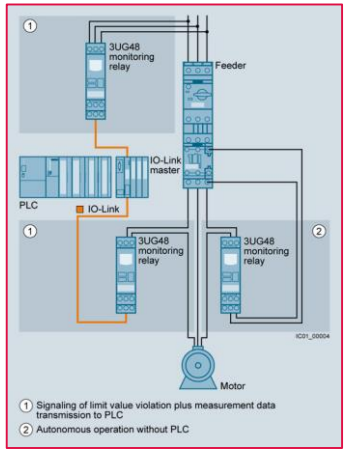




Flow sensor
with non-return valve
Precise detection of flow and medium temperature

Smart LED signal light

IO-LINK rotative encoder



Example:
monitoring of electrical and mechanical parameters
such as voltage, current,
cos phi and speed

ALTERNATING AND INTERESTING PRODUCTS

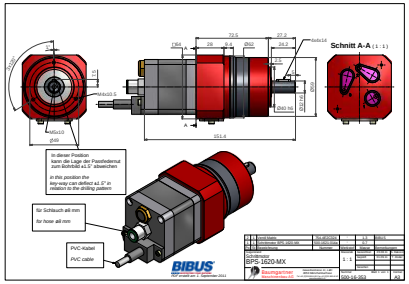
PNEUMATIC STEPPERMOTOR

Product:
Pneumatic steppermotor

Facts & figures:
Rotation, 3 step angle, ± 9 , tolerance
needs dry, filtered compressed air 4 ... 6 bar
Forward and reverse running, feedback sensors optional
simple control via PLC
torque 1.4 ... 7.6 Nm, Holding torque 7 ... 60 Nm, IP55

Advantages:
maintenance-free, compact, high torque with small size
no lubrication necessary
in case of energy failure position is held, self-locking
great force in relation to the size
Restriction. Max. 24 rpm, not spinning fast

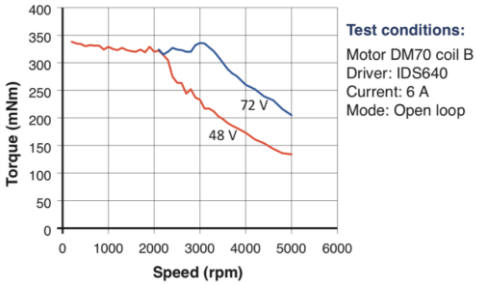
Application:
simple adjustment and positioning tasks, easy control, no electrics/electronics
Use in magnetic fields and difficult environments

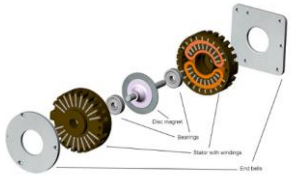


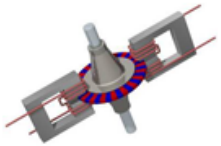
MAGNETIC DISC STEPPERMOTOR

Product:
Magnetic disc steppermotor (hybrid)

Facts & figures:
stepper motor with speed and acceleration of a brushless DC servo
Developed in Switzerland
better dynamics, high speed, almost a servo
smaller step angle compared to permanent magnet stepper motors
higher accelerations ... low mass inertia
high start-stop frequencies
excellent microstep performance







ALTERNATING AND INTERESTING PRODUCTS

ONE CABLE CONNECTION / TECHNOLOGY SIEMENS OCC, BECKHOFF OCT

Product:
servo motor with one cable connection

Facts & figures:
power wires, encoder signals, brake
simplifies configuration in mechanical engineering
compact design, easy construction
reducing costs and time
up to max. 50 m cable lenght, suitable for drag chains
highly dynamic applications

Beckhoff:
Motor series AM58xx
150 ... 10000 W

Siemens: up to 630 VAC
Sinamics S210 with S7-1500 (T)
50...750 W

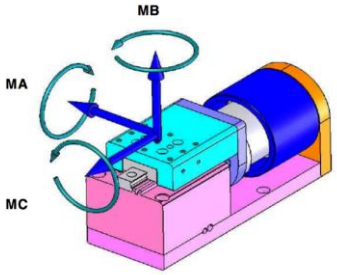
also in the portfolio from Kollmorgen, AMK Group, B&R, Parker, Harmonic Drive, Wittenstein, ...

VOICE COIL MOTOR

Product:
voice coil linear motor

Facts & figures:
linear direct drive with permanent magnet for moving
small masses with high stroke frequency
5x faster than conventional drive solutions
smallest space, voice coil with minimum mass
wear-free, backlash-free
dynamic oscillating short-stroke movements without abrasion
restless torque-free with high synchronization quality
short response times, very good acceleration capacity
no contact between coil and core

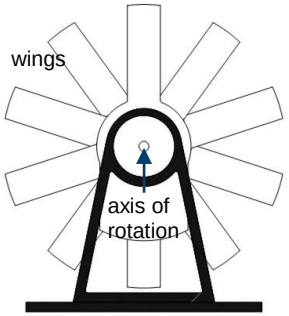
Example:
Stroke 2.5 ... 3.2 mm, 0.27 ... 1.35 N
5.0 ... 30 mm, 3.5 ... 315 N
stroke frequency up to 1000 Hz, differently optimized versions

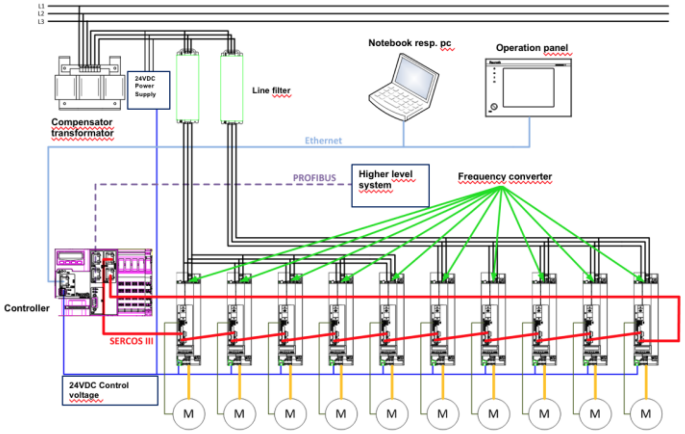


FEASIBILITY STUDY FAN-CHOPPER

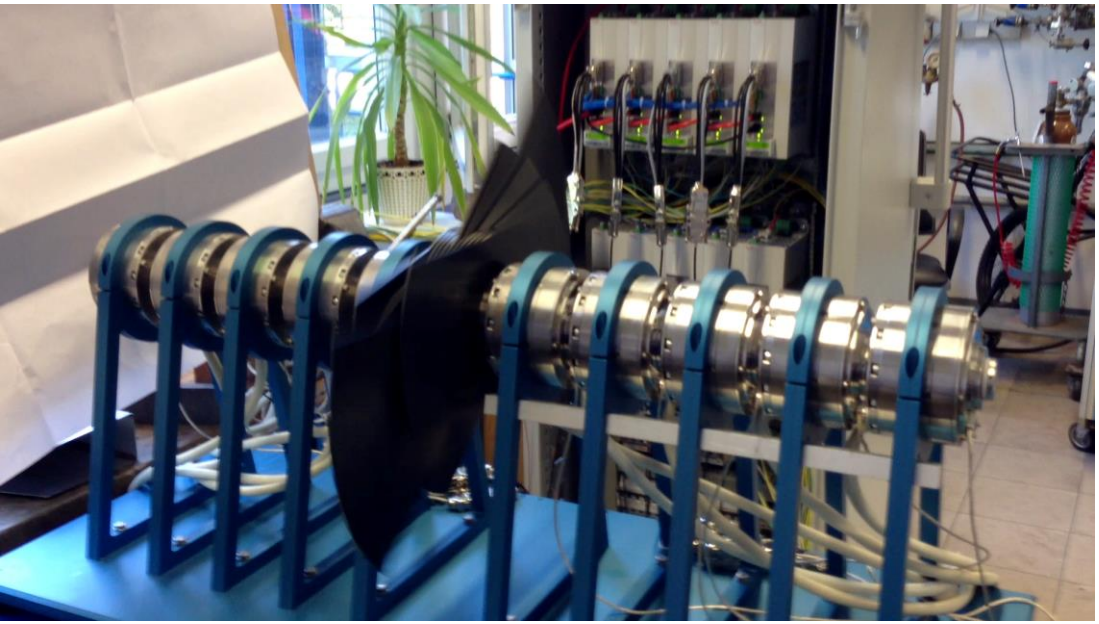
Functional prototyp

- 10 Servo-drives synchronized
- Frequency and phase controlled
- Design speed 840 Hz,
- 10^{-3} mbar vacuum, local/remote handling
- tested in neutron beam, low cost





Complete automation setup



Function example

Front view Cabinet

Back side Cabinet

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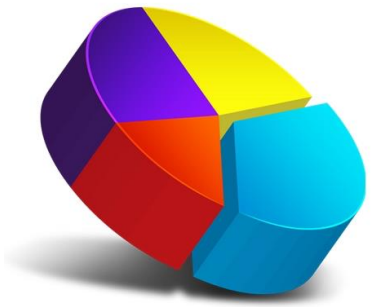
KEYWORDS FOR FURTHER ACTIVITIES
FOR MAXIMUM AVAILABILITY AND RELIABILITY OF THE MAINTENANCE CONDITION

Projectmanagement and -controlling
Qualitymanagement incl. riscanalysis
Condition monitoring
Servicemanagement
Professional and On-The-Job trainings, teaching, lectures
Waste management
Operation large scale facilities for external international users



Helpful background of JCNS:

- partners worldwide
- strong scientific basis
- technical infrastructure
- support by center facilities and management
- motivated staff
- prospective plans for the future
- interest in new techniques

END

JCNS – Jülich Centre for Neutron Science

Thank you for your attention
Большое спасибо