ELECTRONIC DESIGN
IN NEUTRON INSTRUMENTATION JCNS
MAY 15TH, 2018  KLAUS BUSSMANN

CREMLIN
St. Petersburg
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

- Pneumatic systems
- Hydraulic systems
- Cryogenics engineering
- Magnet technology
- Vacuum + Radiation technology
- Automation technology
- Power electronics
- Electro technology
- Actuating elements + Sensors
- Mechanical engineering
- CAD/CAE Simulation
- JCNS Instrument
- Informatics
- Process control
- Certification
- Documentation
- Project Management
- Quality Management
JCNS IN-HOUSE-SUPPORT (JCNS-PGI-TA, TECHNICAL ADMINISTRATION)

Teamwork

Administration  Engineering & design  Mechanical workshop  Scientific IT Systems  Industrial safety & radiation protection

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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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-neutrons source
(FAN-Chopper) – Jülich 2014
E-CAD - SYSTEM EPLAN

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

Electric P8
Pro Panel
Preplaning
Fluid

Simultation

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MANUFACTURING CONTROL CABINETS

maintenance and operational supervision

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

Current/voltage monitoring
Exotic shapes

Cooled inside

Separate from the carrier

Magnetic coils – Neutron Spin Echo Instrument

Power supplies for control

Magnetic coil – Neutron Spin Echo Instrument

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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
DRIVE SYSTEMS

Powerful drives are tailored to their tasks. Circa 350 motors are in use at JCNS instruments. The motor types are: stepper motors, synchronous-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.
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

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

Asynchronous motors need 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

DREHSTROM SYNCHRON MOTOR

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
STEPPER MOTOR

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

Two-phase hybrid stepper motor with 4 windings

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

Histology images

dc motor motor brushless

Keywords:
construction and characteristic torque, max step frequency acceleration / deceleration limit switch positioning homing safety aspects
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

Complete mounted motor

1.2 KW
2500 rpm
4.5 Nm

DIRECT DRIVE

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.

New narrow design

Example FAN-chopper

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.

Ironless linear motor

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

Double sided magnetic way
Cable
Coils
Magnets
New slit-system with linear-piezo-drives (4 degrees of freedom) SmarAct

Participants:
PPI-JCNS-TA-construktion
G-ELI
JCNS-2
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.

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.

Vacuum suitability and radiation resistance are important selection criteria.
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.

Examples:
Current and voltage quality control
vibration sensor - unbalance, bearing condition
ultrasonic sensor / photocells - collision
push button (switch) - area controlling
temperature sensors - position

Overheating errors

AC / DC Analyser
Vibration analyser
Vibration sensors
Vibration histogram
Light barrier
End switches
Ultasonic sensor
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.
Product:
IO-LINK, Single-drop digital communication interface 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

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

Test conditions:
Motor DM70 coil B
Driver: ID640
Current: 6 A
Mode: Open loop

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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 length, suitable for drag chains
highly dynamic applications

Beckhoff: Siemens: up to 630 VAC
Motor series AM58xx Sinamics S210 with S7-1500 (T)
150 ... 10000 W 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
KEYWORDS FOR FURTHER ACTIVITIES
FOR MAXIMUM AVAILABILITY AND RELIABILITY OF THE MAINTENANCE CONDITION

Project management and controlling
Quality management incl. risk analysis
Condition monitoring
Service management
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
Thank you for your attention

Большое спасибо