SETUP AND DIAGNOSTICS OF MOTION CONTROL AT ANKA BEAMLINES

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Abstract

The precise motion control in high resolution [1] is one of the necessary conditions for making high quality measurements at beam line experiments.

At a common ANKA beam line, up to one hundred actuator axes are working together to align and shape beam, to select beam Energy and to position probes. Some Experiments need additional motion axes supported by transportable controllers plugged temporary to a local beam line control system.

In terms of process control all the analogue and digital signals from different sources have to be verified, levelled and interfaced to the motion controller. They have to be matched and calibrated in the control systems configuration file to physical quantities which give the input for further data processing. A set of hard- and software tools and methods developed at ANKA over the years is presented in this paper.

INTRODUCTION

Building a new beam line, the motion control setup is accompanied by ANKA-IT from an early stage of the design phase, the factory acceptance tests of components and systems at manufacturer site and the final tests at ANKA site.

Therefore ANKA-IT proposes to the beam line designer a catalogue of up to date ANKA-proven specifications for hardware components and control software environment.

The suggestion defines objects of hardware with a range of preferred attributes which describe the components manufacturer independently. This gives a flexible response to upgrade obsolete components over years of operation or setup new systems equipped with not ‘ANKA-standard’ compatible components.

On the software site versatility in intermediate layer, concepts enables the embedding of OEM controllers in the ANKA control system without giving preference to the operating system they were primarily designed for.

A design guideline was created by ANKA-IT to minimize the effort to select communication software and define interface specifications. The preferences for key elements are described in the chapters below

ANKA DESIGN GUIDELINES

- The manufacturer/supplier should clearly state the proposed scope of supply for the control system and associated electronics.
- The beam line control software concept will be provided by ANKA-IT.
- Network Interfaces are preferred for beam lines but alternatively an ANKA-standard hardware Interface, s. Figure 3 is accepted.
- The motion beam line components, use VME-bus as well as various bus protocols working over Ethernet TCP/IP.
- For the system realisation, a Tango-interface is preferred, in case of not availability spec*[2] can be used. The libraries and component software drivers for setting up motion control should be documented and supplied to ANKA-IT.

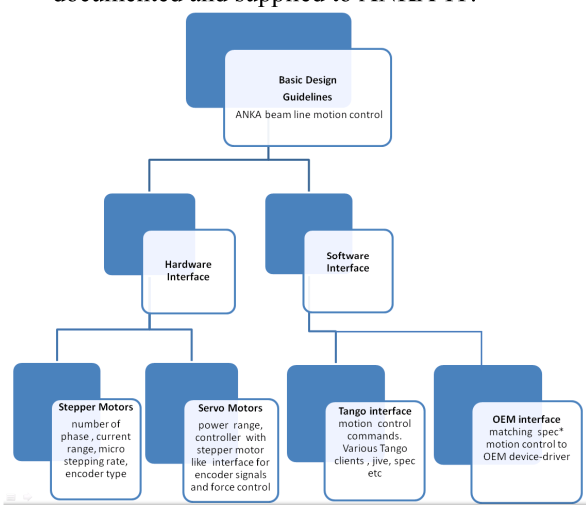

Figure 1: Overview hard- and software design guidelines for ANKA-motion control.

Since ANKA is migrating to Tango [3] for beam line control the communication between spec* and WinCCOA*[4] is fully Tango-based and all new implemented devices are controlled via Tango device servers.

DESIGN REPORT

A Tango interface and a set of geometry parameters for setup of the motor configuration should be supplied by the manufacturer in his design report. During the factory acceptance test these attributes and parameters are verified by test. The Tango interface is defined by the five device attributes: position, velocity, offset, limit switch negative direction, limit switch positive direction. The motor device is addressed by a set of specific commands given in Table 1.

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Table 1: ANKA Tango device control commands

Argum. Input	*Argum.Output*	*Tango Name*	*Description*
DEV_VOID	DEV_VOID	Init	initialize motor
DEV_VOID	DEV_VOID	Forward	move motor + to limit switch
DEV_VOID	DEV_VOID	Backwart	move motor - to limit switch
DEV_VOID	DEV_VOID	MotorON	init motor driver
DEV_VOID	DEV_VOID	MotorOFF	switch off motor driver
DEV_DOUBL	DEV_VOID	DefinePosition	new position in encoder units(dial)
DEV_DOUBL	DEV_VOID	ComputerNew-Offset	'is' position user, user-dial deviation. is calculated
DEV_DOUBL	DEV_VOID	MoveRelPosition	move position in user coordinates
DEV_VOID	DEV_VOID	Stop	stop motor
DEV_VOID	DEV_VOID	InitializeReferencePosition	starts homing
DEV_VOID	CONST_DEV_STRING	status string: ON,AL,FLT,MOV,OFF,STBY,UNK	states string
DEV_VOID	DEV_STATE	status integer: 0,11,8,6,1,7,13	states integer

MOTION CONTROL TEST SYSTEM

Having collected all parameters from manufacturers design report a test system is configured. The test system includes an OMS-MAXnet* [5] controller with TCP/IP interface for PC-controlled motion.

This allows different options for communication with the beam line components under test (Spec* native, Tango client or user defined clients, communicating with Tango) using the basic control software concept defined in the ANKA design guidelines described.

The System is completed by a test stepper motor/limit-reference-switch/encoder combination with ANKA-standard pin out. The test motor is used for

- The verification of a component test software configuration prepared for Factory Acceptance Test (FAT).
- At ANKA it is used complementary for the verification of the installed motion control pinout. The motor then replaces a beam line hardware component.
- The correct setting of the coordinate system for the component motion.
- The choice of geometrical parameters like gear ratios, encoder ratios, acceleration/deceleration intervals, motor backlash and homing procedure.

Figure 2: Newest version of ANKA-compact motor test system with display and stand-alone operator pulse control, which is used for direct verification of component compatibility to ANKA-Interface pinout, s. Figure 3. It is completed by power supplies for limit switches, encoder, two booster stages and a test stepper motor with limit/reference stop buttons and rotary encoder.

At FAT, the test system is used for fine tuning the kinematics of not visible components which are later enclosed in a vacuum container. This is of special interest due to define anti-collision stop and position recovery procedures for sensible and expensive motion components like a Bragg-crystals of a monochromator.

HARDWARE FOR MOTION CONTROL

Some of the standard ANKA beam line control hardware was designed by ANKA-IT. So a four channel I/O Interface for beam line motion component sensors, which is used universally at ANKA beam lines.

- Signal inputs levels are guarded by opto-couplers.
- Power supply outputs are generated for different kinds of limit- and reference switches (mechanical or electronic open collector).
- LED state indicators for limit switches, reference switch/encoder input signals. The power supply can be adapted for ohmic loss and routed to the Beamline component motion sensors.

In addition a signal conditioning terminal box (SCTB) for beam line components was developed. This SCTB (one per motion axis) is supplied to the component manufacturer with a detailed terminal diagram of the ANKA-standard pinout and preinstalled at his site before FAT.

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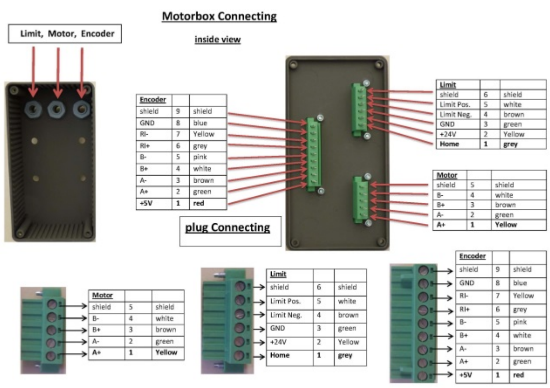

Figure 3: The SCTB box pin-out interface between the motion control signals generated by the beam line component and ANKA control system standard I/O. The signal levels can be reversed on the SCTB board due to positive or negative logic, referenced to Gnd/ Vcc.

The advantage of ANKA motion control is based on the open loop concept. The actuators are moved in high speed mode without overshot or oscillations to a measurement setpoint of interest.

The disadvantage will be that there is no direct automatic feedback to control absolute actuator positioning as with the 'closed loop' approach. When there is a controller power loss, the position of the motor steps may disagree with the encoder readings and a 'homing' procedure may be necessary. In case of a predefined deviation between the calculated, relative position (by motor pulse counts) and the monitored encoder value, a warning message is generated.

A choice is offered, the user can now agree to the spec* calculated position or when knowing the reason for discrepancy use the indicated encoder position or in case of doubt, test with the 'check' macros and initiate a homing procedure to regain absolute position.

SOFTWARE FOR MOTION CONTROL

At home a first setup of the motion parameters is given by the spec* motor configuration established at the Factory Acceptance Test.

The fine tuning of the motion behaviour is done using ANKA- software diagnostic tools

- A spec* macro set to test the functionality of the limit and reference switches of a component.
- A set to test absolute and relative positioning of the component under investigation
- A test for repetition accuracy doing various runs to gain statistics of motor-pulse calculated position and component final position indicated by encoder.
- Test of correct component motion in two directions and function of its limit switches.
- Test of encoder-gear ratio parameter set and motion repetition accuracy.
- Homing procedure with reference switch.
- Encoder homing with encoder reference mark.

CONCLUSION

At the beginning of 2014 more than ninety percent of ANKA motion control is based on PCs and low cost proven standard industry components:

PCI-VME*-bus, OMS-MAXv* controllers for response in the µsec range and the OMS-MAXnet*-TCP/IP controller, making VME bus obsolete for applications with response time in the msec range.

Seven types of pin-compatible boosters with different electric current characteristic are driving a variety of stepper motor types in high resolution micro stepping mode and a fast open loop configuration.

With the introduction of OMS-MAXnet TCP/IP capable controllers, VME-based hardware communication for motion control will be on the decline at ANKA beam lines.

The last ten percent of ANKA motion control are closed loop controlled OEM systems with power in the kW range. This are mostly servo motors for heavy load applications like undulator gap mechanics or double crystal monochromators.

To avoid nested controllers, servo motors at ANKA are used in connection with special matching controllers [6] which accept the same feedback sensor input as used for stepper motor based motion control.

REFERENCES

[1] B.Borovic *et al* 2005 *J. Micromech.-Microeng.* "Open loop versus closed-loop control of MEMS devices: choices and issues" in Journal of Micromechanics and Micro-engineering Volume 15 Number 10

[2] spec, certified scientific software, http://www.certif.com/

[3] Tango, Source forge, http://www.tango-controls.org/

[3] Tango, Source forge, http://www.tango-controls.org/

[4] WinCCOA, http://w3.siemens.com/mcms/human-machine-interface/en/visualization-software/simatic-wincc-openarchitecture/Pages /Default.aspx

[5] MAXnet manual, http://www.omsmotion.com/

[6] Danaher motion, "S700 Digital Servo Amplifier S701...S724" Product Manual Translation of the original manual edition 12/2008. Valid for Hardware Revision

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