Maintenance and Optimization of Insertion Devices at NSLS-II using Motion Controls

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Outline

1. Preface on motion controls at NSLS-II
2. Accelerator motion controls
   1. Insertion devices (3PW, IVU, EPU, etc.)
   2. ID Issues
   3. ID Improvements
3. Q&A
Motion control hardware

- 64-bit Linux computers
- Delta Tau Programmable Multi Axis Controller (PMAC-2) and power supply modules
- Stepper/servo motors (and brakes where needed)
- Optical glass linear encoders
- Embedded rotary positional encoders (for some IDs)
- Ethernet, motor, encoder cables, etc.
Motion control software

- 3 Levels of software: controller configuration, IOC, and operator interface via EPICS communication
- Delta Tau Turbo PMAC GeoBrick LV is the standard motor controller at NSLS-II
- IOC has EPICS applications to channel access interface with motor controller
- User interfaces are OPI screens on CSS
Insertion device issues

- 3PW motor moves too slow
- Undulator controls geometric issues
- EPU phase jumping
- Mechanical gear box/assemblies
- IOC server too slow

Proposed Solutions: cross couple gantry, retune PID/adaptive tuning, ESA, migrate ID IOCs to new physical machine servers
Loose 3PW Ballscrew

Only small PID gains would drive motor with 2A.

\[ \begin{align*}
K_p(\text{old}) &= 1000 \\
K_i(\text{old}) &= 2000 \\
K_d(\text{old}) &= 500 \\
K_vff(\text{old}) &= 100 \\

K_p(\text{new}) &= 2000 \\
K_i(\text{new}) &= 100 \\
K_d(\text{new}) &= 50 \\
K_vff(\text{new}) &= 5000
\end{align*} \]
3PW Motion plot with loose ballscrew

Motor #8 Sinusoidal Move Plot Result: Executed at 3:02:29 PM 2/6/18

Proportional Gain (x30)=500  Derivative Gain Gain (x31)=0  Velocity Feedforward Gain (x32)=0
Integral Gain (x33)=0  Integral Mode (x34)=0  Acceleration Feedforward Gain (x35)=0
Command Limit (x69)=1000  Servo Cycle Extension (x60)=0
Friction Feedforward Gain (x68)=0  Fatal Following Error Limit (x11)=32000

- Commanded Position (Left)
- Actual Position (Left)
- Following Error (Right)
Was running at 0.2 mm/sec (15-20mins for full motion), now running at 2mm/sec
Undulator Cross-Coupled Gantry

This is where you want to measure

Encoder A

Encoder B
Undulator Cross-Coupled Gantry

This is where you ARE measuring

Encoder A

Encoder B

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Geometry Cantilever Correction

- Give true ballscrew locations
- Remove positional error from cross couple gantry algorithm
- Allow higher proportional gain to reduce following error
- Eliminate need to install encoders directly on ballscrews

This is the actual tilt we wish to compensate. It’s value is \( \Delta \times \frac{C}{L} \).

This is the tilt the initial DT gains are trying to compensate.

As a result, the tilt gain is about three times the value required.
16-ID 3m IVU linear encoder data

Moving gap position from 24mm to 23 mm, 15 servo cycle gather period

Takes ~450 ms before responding to motion

Upstream Lower Raw Linear Encoder

Commanded gap position
LIX torque from 25 to 21mm

LIX torque from 25 to 21+ mm motor bolted back down centered horizontally.
Repeatability of IVU motion

Starting gap at 25mm ending at 24mm
Currently under development

• Redesign of TPMAC source code for Neomax IVU at cells 4, 12, and 16
• Mechanical repairs on undulators drive train
• EPU Phasing
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Any Questions?