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

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NATIONAL SYNCHROTRON LIGHT SOURCE II

ABSTRACT

The purpose of this project is to demonstrate the effective improvements on insertion device performance via upgrades on the motion control software. The insertion devices installed inside the National Synchrotron Light Source II (NSLS-II) storage ring are currently operating at sub/ micron resolution with slow speeds, which can limit the scope of user experimentation preferences. We can manipulate the devices with adaptive tuning algorithms to compensate for varying electromagnetic forces throughout motion scans. By correcting positional feedback with encoder compensation and redefining motion programs, we can safely increase the speed to run the same motion trajectories in less time.

BACKGROUND

- Issues with insertion devices

  3PW motors move slowly due to loose ballscrews. We had to reduce gain and speed.

  Linear position encoder feedback does not match rotary encoder feedback on U42 motors.

  Mechanical gearbox and springs on IVUs. Virtual IOC server too slow.

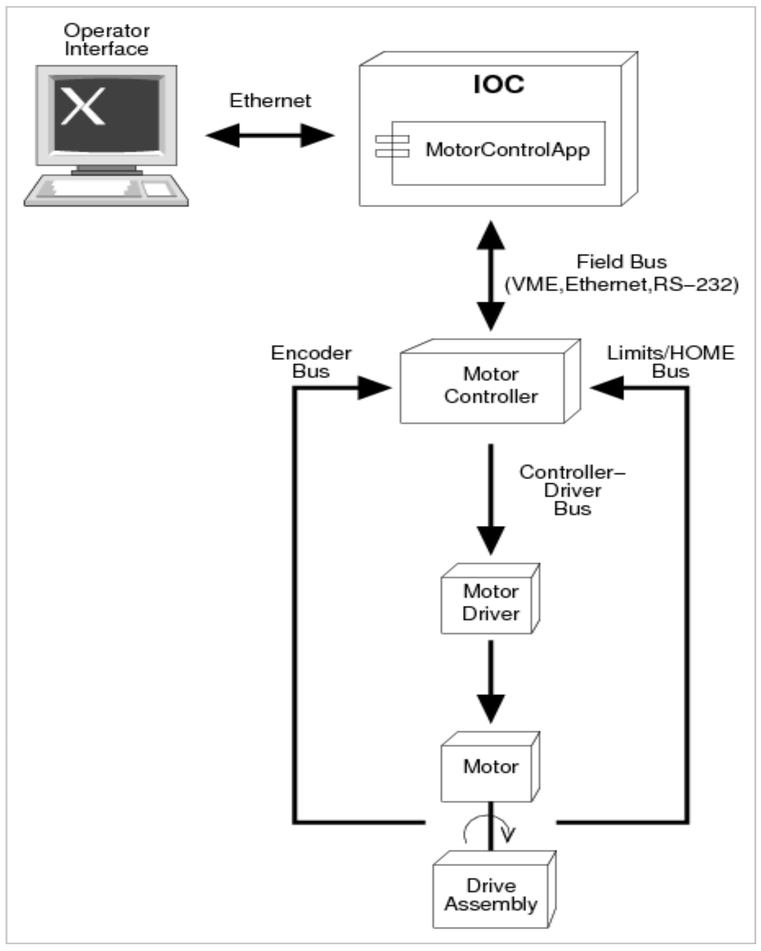
- Solutions for insertion devices

  Retune PID gains, migrate softiocs to new machine server, redesign tpmac code for IVUs.

  Mechanical repairs on IDs: 3PW ballscrews adjusted, IVU motors re-bolted and greased.

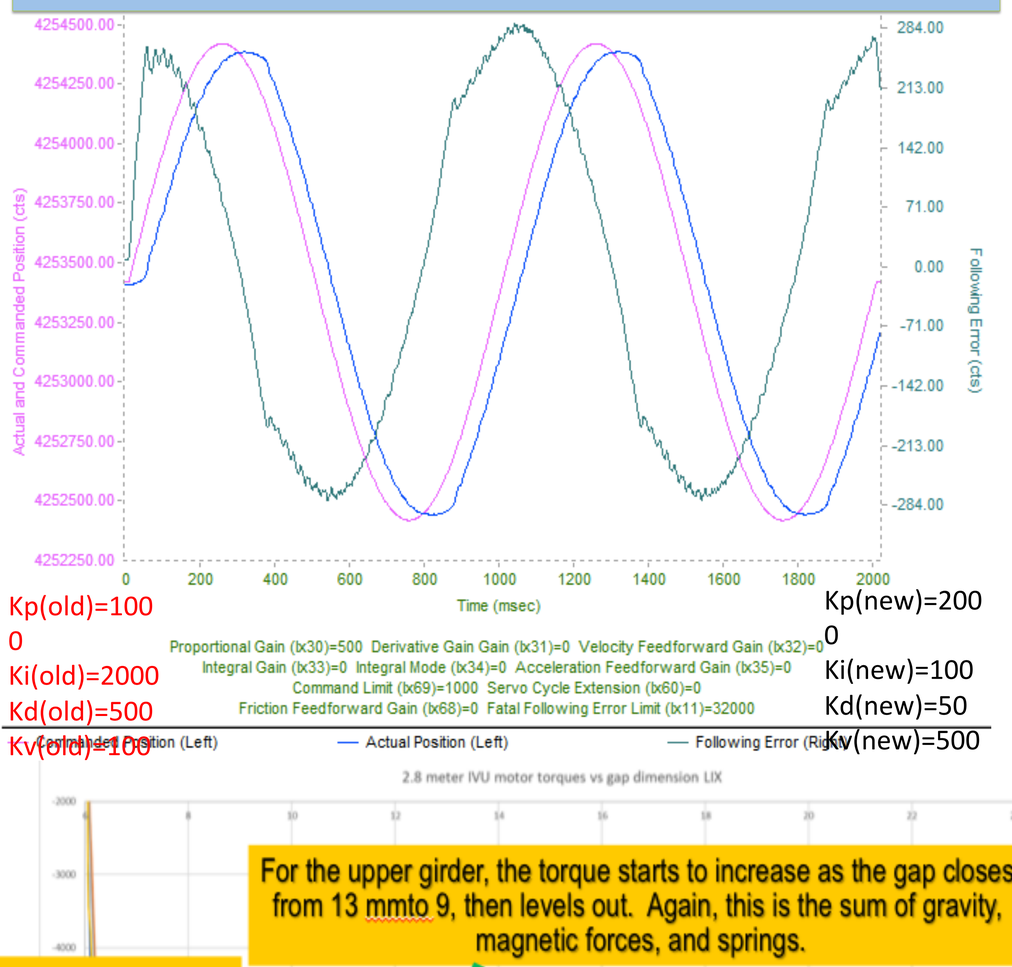
  Developed motion control diagnostic software for IVUs using Python to run a full range scan motion program and collect actual linear and rotary encoder feedback on all motors.

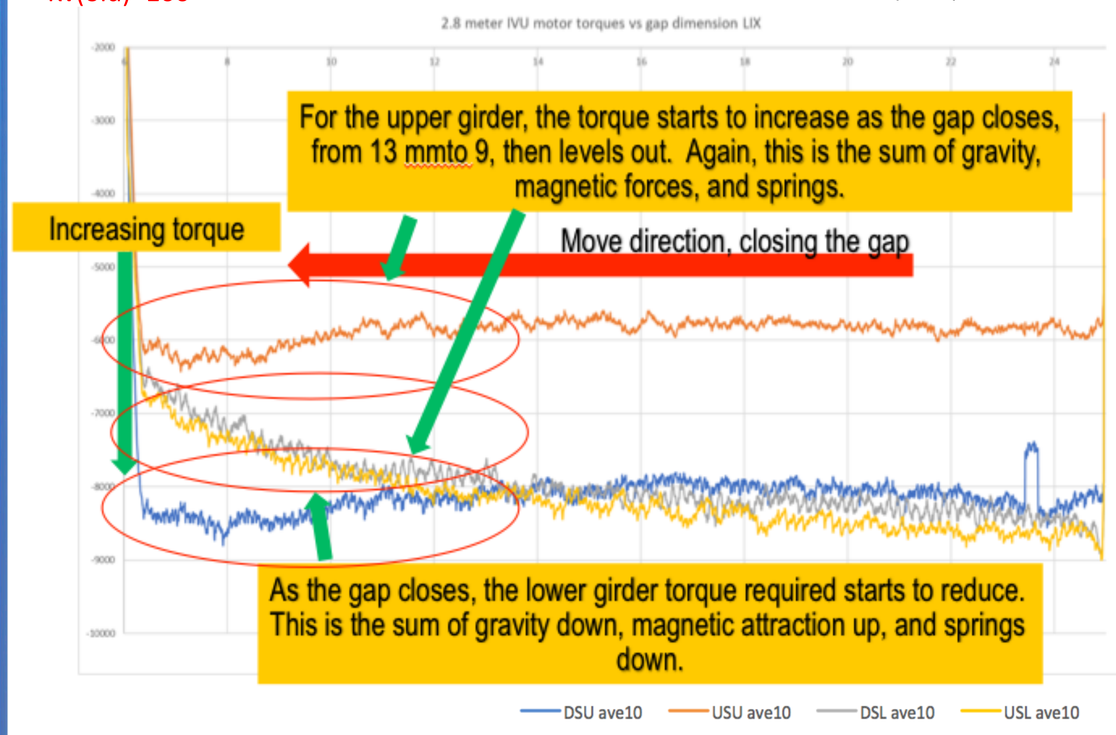
Motion Control System Template



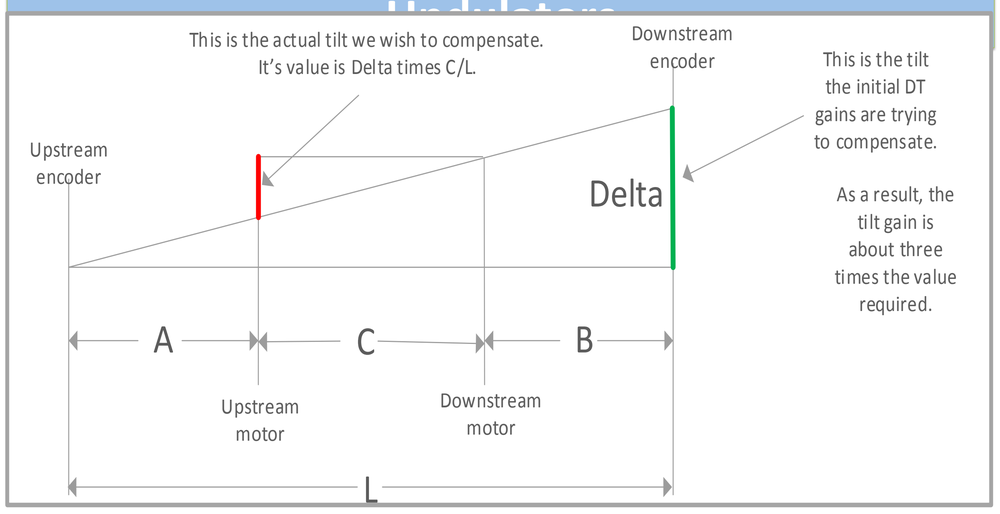
https://ps.bnl.gov/acc/controls/Shared%20Documents/ID%20Control/id-notes.html

3PW Sinusoidal Motion Plot with loose Ballscrew





Geometry Cantilever Correction for Undulators



Encoder Math

- Gives true ballscrew locations
- Removes positional error from cross couple gantry algorithm
- Allows higher proportional gain to reduce following error
- Eliminates need to install encoder directly on ballscrews

IVU Torque Results

- Downstream motor torque appears 1/3 larger than upstream motor torque
- Torque ripples due to spring compensations and phase jumping from magnetic forces
- Period of torque ripple is 80 micron movement, which corresponds to a shaft rotation of exactly 1 revolution. This is consistent with a bent shaft undergoing cyclic fatigue
- Results of torque and encoder data from diagnostic test repeatable for every IVU (2.8m devices at cells 4, 12, 16; 1.5m devices at cells 5 and 17)

IVU Torque Plots

CONCLUSIONS

- 3PW motors were running at 0.2 mm/sec (15-20mins for full motion ~190 mm), now running at 2mm/sec.
- Updating IVU motion control software from vendors (2008-2010) to current NSLS-II software standards.
- Reduce network/operational error by migrating ID softiocs from virtual machine server to physical server.
- Diagnostic software for IVU TPMAC: https://github.com/dhidas/IVUTests

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