Control System for Helical Insertion Device UE56

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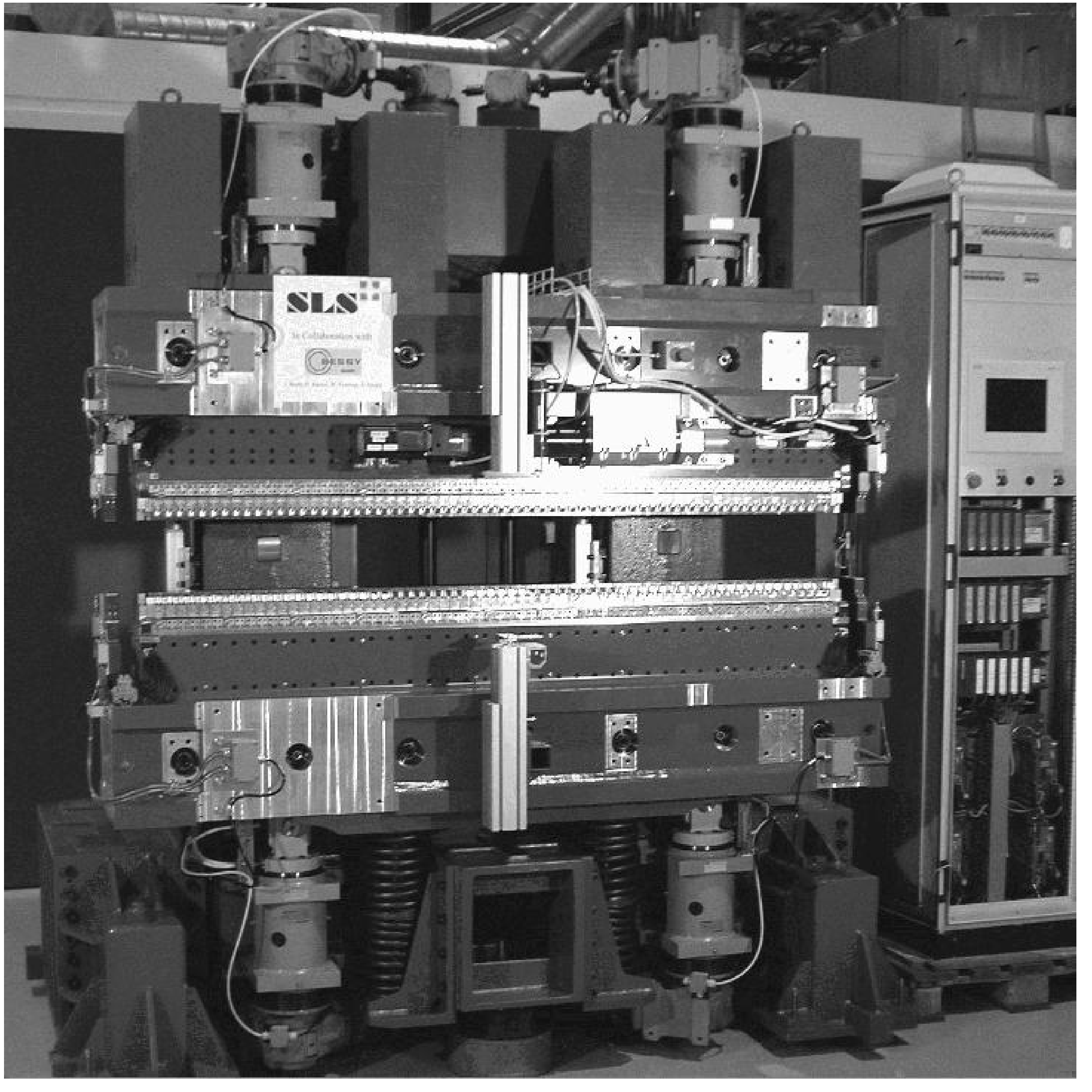
- The basic system structure
- Operational requirements
- Implementation
- Performance

UE56 undulator



UE56 undulator and control system requirements

UE56 undulator: the top and bottom magnet arrays are split into two halves for generating photons with different polarization states (linear or vertical) by shifting the arrays.

Servo motor control 4 axes per ID (2 for gap, 2 for shift) 8 axes in total for 2 devices in synchronous use. Compensation (feedback control) for gap due to nonlinear forces when shift is changed.

Corrector magnet control to compensate for orbit changes due to the ID ("feedforward")

BPM subsystem for monitoring (and interlock)

synchronization with other beamline & accelerator components (e.g. Scans)

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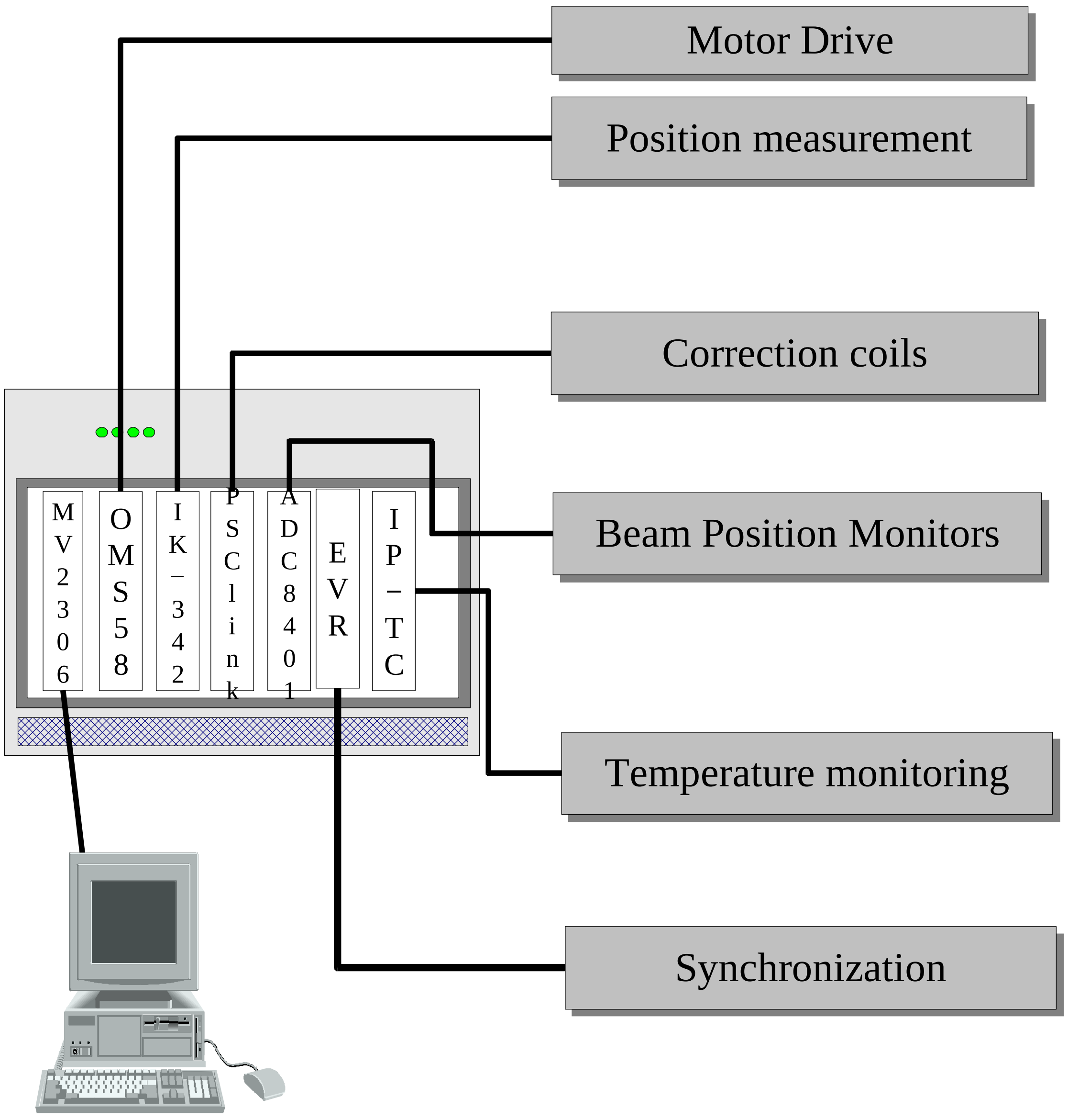
UE56 ID Control System Structure



Motor drive system:
controller: OMS58 (Oregon Micro Systems)
up to 8 axes (with one card) in closed loop control with servo motors (UE56)
Position encoders: Heidenhain linear encoder, direct feedback to OMS controller. Rotary encoders as optional backup.

Power Supplies: SLS standard digital power supplies & controller

BPM readout: ADC 8401 16−bit, 100 kHz ADC

Temperature: SBS−Greenspring thermocouple card.
(not used for UE56 at the moment.)

Synchronization with other beamline components & the machine: (channel access + Event receiver)

UE56 ID Local controller

PLC for low−level safety/interlocks
−axis monitoring to avoid excessive taper and motor failures
−interlocks (motor end stage failure, brake air pressure failure, etc.)
−local operation
−binary input/output to IOC

Binary I/O modules for status and control exchange

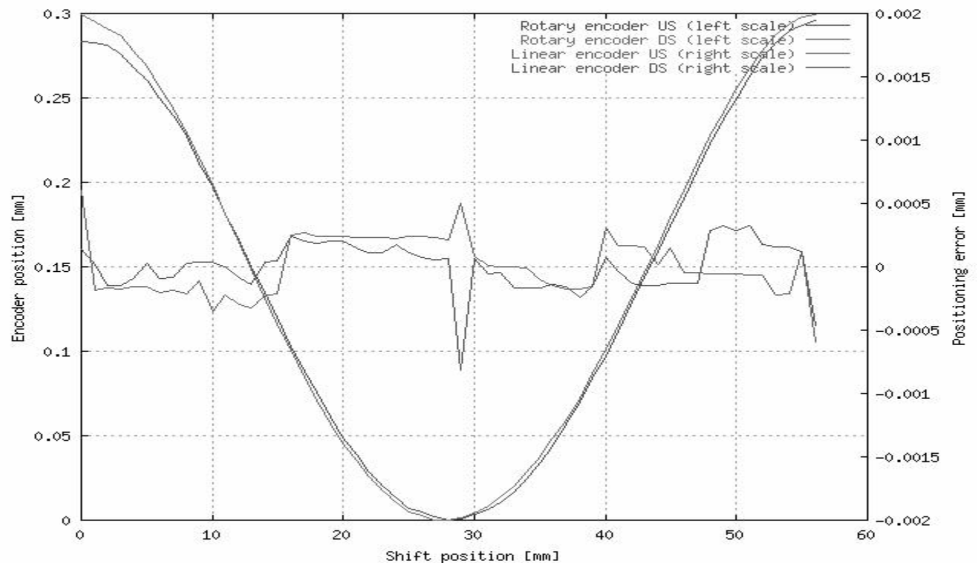
Motor endstages (4)

Gap drive principle & performance

Position directly measured at the gap with Heidenhain incremental encoders (ULS300) and directly fed to the servo controller (OMS58)

- Position error from bending due to the magnetic forces eliminated
  - Requires careful handling at startup and servo loop tuning

Encoders provide reference marks to get the absolute position.



Accuracy measurement:

- Linear and rotary encoders recorded simultaneously while moving the shift arrays.
- Rotary encoders show how much the motors regulate: corresponds to 300 um while the gap stays at constant setting.

Gap can be controlled to the level achieved with the encoder (1 um in this case)

Magnet control & feedforward

Horizontal and vertical corrector magnets are used to reduce the orbit distortion due the ID.

The SLS standard digital power supplies are used: fiberoptic link connection from VME to power supplies. Used in SLS machine for (practically) all power supplies. EPICS software (driver, dev support, **templates**) copied from the machine, providing all the required low−level functionality.

ID−specific controls implemented on top of the basic structure: corrector currents are set according to the gap & shift setting.

Current feedforward is implemented as a set of formulas. Formulas are fits to data obtained from measurements with the beam (to minimize distortion.)

2.5 dimensional correction: gap, shift (symmetric and antisymmetric.)

Reduces distortion by a factor of ~10, rest is taken care by the orbit feedback.

Insertion device modes

Polarization mode: linear or circular

- Symmetric or antisymmetric shift: arrays are moved equal amounts to same (circular polarization) or different (linear polarization) directions
  - Nicely handled by transform record (synApps/T.Mooney): always consistent state
  - In linear mode, polarization vector can be rotated by changing the amount of shift
- Operation: set polarization mode & photon energy (and harmonic)
  - In circular mode, the shift positions depend on the set photon energy
  - Gap and shift are calculated from energy and propagated to motors
- Energy to gap formula validity range depends on the mode and degree of polarization
  - Outside of validity range formula produces invalid values (NAN, INF). IVOA (Invalid Value Output Action) is used to prevent these to be propagated further (can freeze records or even completely stop the OMS58 card.)

Status & conclusions

- ID operated from beamline with minimal disturbance to other beamlines, energy scans in routine operation.
- Local control (PLC) has been very useful. Servo motors are sensitive to programming/operation errors; low−level interlock is important.
- Reliability has been good, despite the high complexity
- Present operation: moving to fixed positions, velocity is not critical. Future option for on−the −fly scans: velocity profiles. The gap/shift velocity has to be changed according to a pre−defined table when moving. (to keep dE/dt constant.)