MAGNETIC AND MECHANICAL CHARACTERIZATION OF VARIABLE POLARIZATION UNDULATOR FOR THE ALBA PROJECT

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Abstract

Two variable polarization undulators (EU62 and EU71) have been designed and constructed in collaboration between CELLS and Sincrotrone Trieste [1]. EU62 (figures 1 and 2) has been completely assembled and tested while EU71 is now under final magnetic assembling. In this paper the magnetic (EU62) and mechanical performances (EU62, EU72) are summarized. The main characteristics of the control system are also presented. Field optimization techniques are described, showing the achieved performance (EU62) in terms of phase, trajectory and field integral errors.

MECHANICAL DESIGN AND PERFORMANCE

The mechanical design was developed taking into account the forces, the maximum overall dimensions and the total weight of the structure [1]. Special attention was given to the anti-parallel mode, which generates a strong longitudinal force on the upper/lower beams. The mechanical design is based on the similar design proposed for the Soleil-France undulators [2]. Main mechanical components were manufactured by local companies under Sincrotrone Trieste supervision. The size of the stainless steel beams, the dimensions of the supporting brackets and of the frame truss elements were calculated by 3D FEM calculations taking into account a safety margin of about 20% with respect to the estimated magnetic forces.

To test the transverse deformation and validate the design of the phase shifting mechanism, a dedicated tool equipped with load cells and gauges was designed and constructed (see figure 3). This device is able to simulate positive and negative magnetic transverse forces distributed along the beam structure and measure the transverse deformation as a function of the applied force. All the measurements carried out with an applied load of 20% larger than the estimated magnetic forces showed deformations of less than 20 μm.

Magnet blocks are clamped on individual holders and grouped in modules containing either three or five magnets by means of small aluminium bars. The modules are precisely positioned on a base-plate acting as an interface with the stainless steel beams. By interposition of calibrated brass shims, small horizontal and/or vertical displacement of each block is allowed in order to compensate magnetic field imperfections.

After magnet assembly, detailed mechanical measurements were carried out with the final magnetic load applied (EU62), at minimum gap (15.5mm) and in both parallel and antiparallel modes.

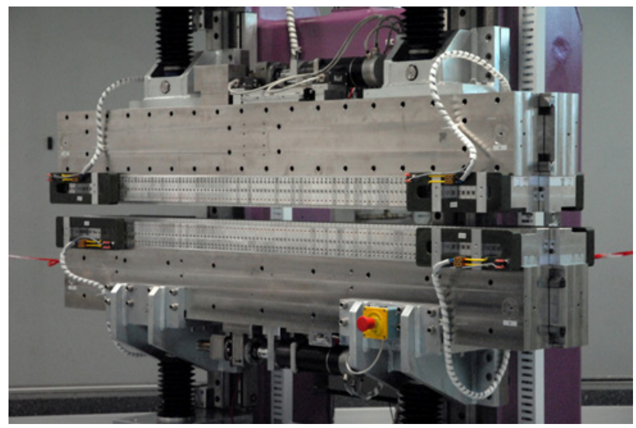

Figure 1: EU62 undulator.

The measurements performed in parallel (antiparallel) mode showed transverse/longitudinal deformations of the stainless steel beams supporting the magnetic arrays of less than 20/20 (20/75) μm. All the measured deformations were in agreement with the FEM 3D calculation.

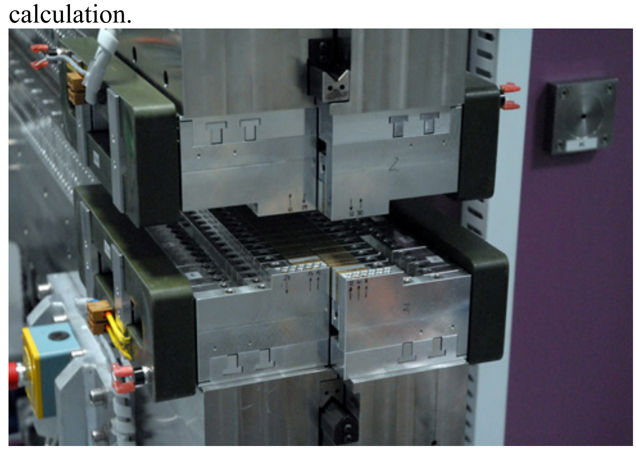

Figure 2: EU62 in antiparallel mode.

CONTROL SYSTEM

The control system is based on Tango software. Tango has first been developed at ESRF and now it is a collaboration between five institutes: CELLS, Elettra, ESRF, Soleil and Desy [3].

The control of the motors is carried out via the Icepap motor controller, a new device developed at ESRF implementing a wide range of capabilities [4]. CELLS has selected Icepap as a standard for motor controller for beamlines as well as accelerators and its application to IDs control has been done for the first time in the EU62 device with excellent results.

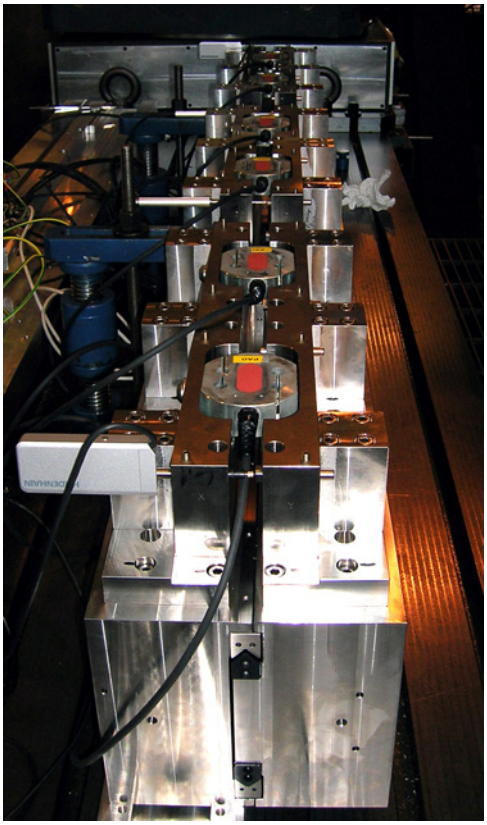

Figure 3: Stainless steel beams, phase shifting mechanism and the mechanical system used to simulate the transverse magnetic load.

In the this application, six Phytron ZSH88 stepper motors, with 200 steps/revolution and six absolute encoders LT-140-S from TR electronics, with a resolution of 0.1 microns, are controlled. Each motor has also attached an incremental rotary encoder that can be read if necessary. Motors are provided with brakes, acting as safety actuators to prevent any accidental movement.

The control is done via an industrial PC running Tango over a Suse Linux platform, acting as input-output controller (IOC). Communication between IOC and the Icepap is made via Ethernet. The IOC also controls the four power supplies of the eight correction coils installed at the ends of the stainless steel beams. Power supplies come from OCEM and are capable to deliver up to 10 A at 10 kHz with an accuracy of 10 ppm.

Twelve limit switches, managed by the Icepap controller, stop the movement in one direction and they allow the movement in the opposite direction. Twelve additional limit switches (kill switches) are controlled via a PLC. They act as safety interlocks, and disable the power of the Icepap if they are activated.

In order to avoid dangerous taper angles, two inclinometers are also managed by the PLC. Motors have Pt1000 thermal sensors implemented in order to monitor the motor temperature and connected to PLC able to disable the Icepap in case an overtemperature is detected in each motor. The PLC also reads the thermal switches of the eight corrector coils and can produce an interlock disabling the power supplies. ALBA is using as standard a B&R PLC units composed of a CPU and input cards for reading thermal sensors and digital signals.

With respect to the software, Tango defines pseudo-motors in such a way that the user can directly drive the gap, the taper and the phase positions of the system, with a synchronous and symmetric movement of the six motors, despite each one of the six motors and encoders are totally independent from the hardware point of view. Deviations of parallelism and symmetry of no more than 10 microns have been observed during movements.

IOC, motor controller, power supplies and the PLC are connected to the network via ethernet, acting in fact as a fieldbus. Graphical user interface (figure 4) can run in the control room or in the beamline hall.

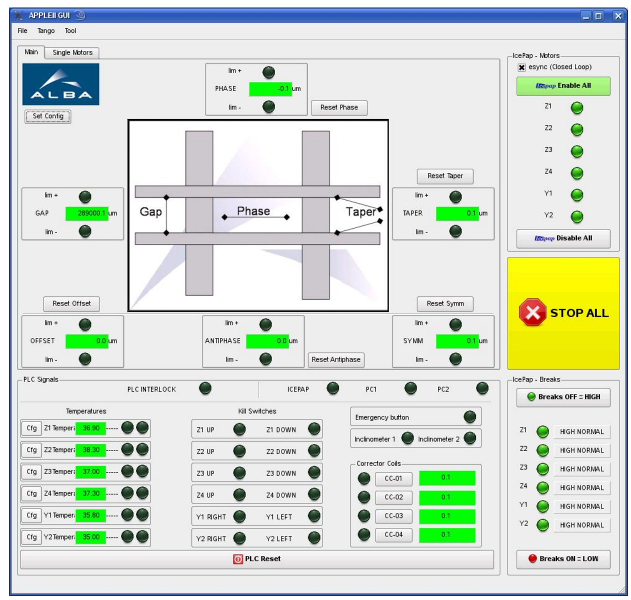

Figure 4: EU62 Graphical user interface.

EU62 OPTIMIZATION AND RESULTS

Based on previous work, a "modular" approach was adopted for field optimization. The magnet arrays were segmented in 3-block and 5-block units, individually characterized using a stretched wire system. The method is described in some detail in Ref. [5]. Figure 5 shows EU62 during the magnet array assembling phase.

Figure 6 shows the trajectory and phase error of the device after initial assembly. The method demonstrated a good control over the trajectory straightness and the optical phase error in the central periodic region, without requiring explicit phase shimming. The vertical kicks observed at the extremities are due to non-optimized end modules. This second integral error, however, was easily removed by the application of only four 0.25 mm shims. Fig. 7 shows the improvement obtained in this way.

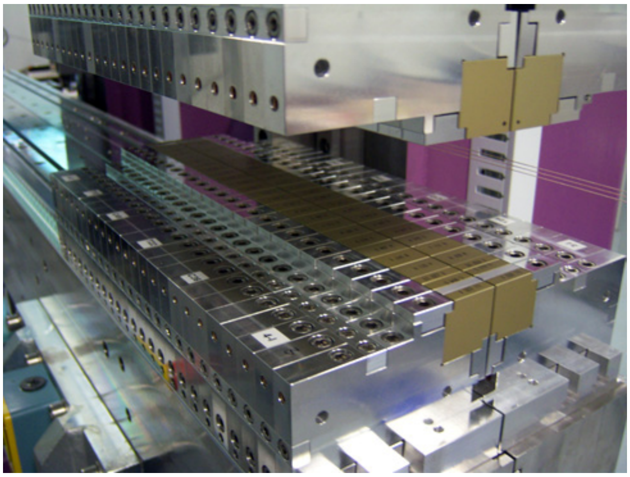

Figure 5: Partially assembled magnetic structure during the measurement/optimization process.

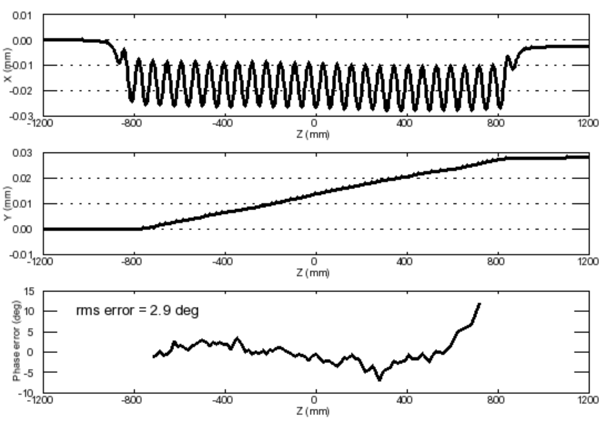

Figure 6: Trajectory and phase error at the minimum gap of 15.5 mm in horizontal polarization mode before shimming.

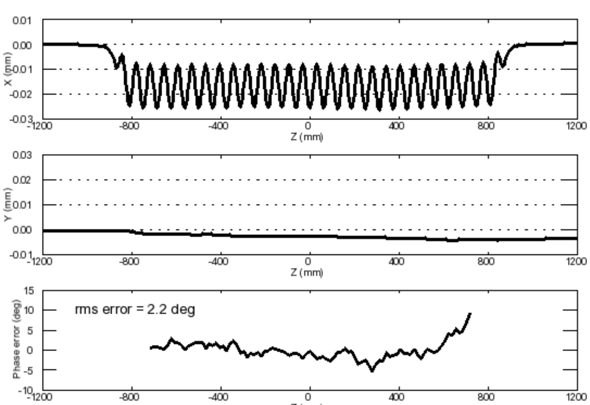

Figure 7: Same as figure 6, after shimming.

Residual field integral errors were corrected using arrays of small trim magnets attached at the end of the magnetic arrays [6]. Figure 8 shows the measured distributions before and after the process. As a result the quadrupole and sextupole errors were brought within the specifications (100 G and 100 G·cm respectively).

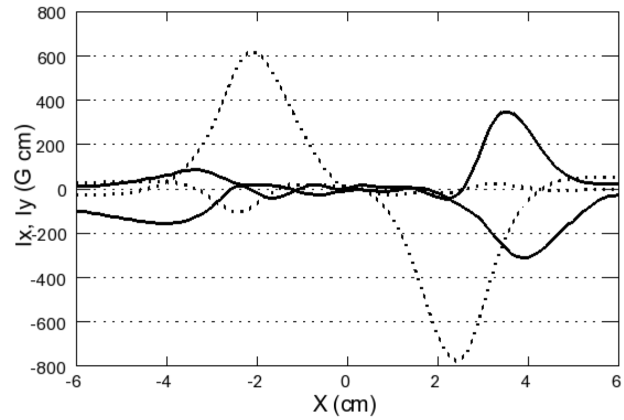

Figure 8: Field integrals at minimum gap before (dashed) and after (solid line) application of trim magnets.

The device showed good performance also at larger gaps and in the other polarization modes, with phase error always below 4° rms and central field integrals well within the capabilities of the dipole compensation coils. As an example fig. 9 illustrates the situation for linear-skew polarization.

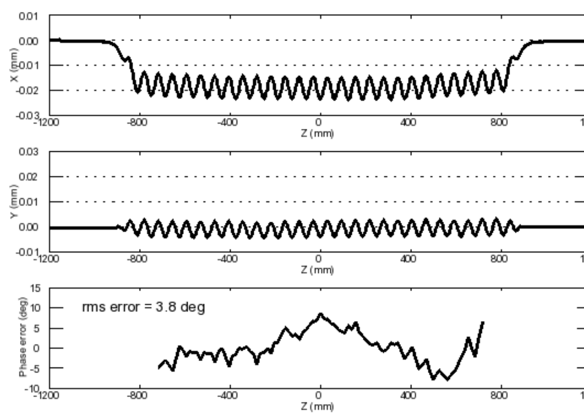

Figure 9: Trajectory and phase error in antiparallel mode at minimum gap.

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