UPGRADE OF THE INSERTION DEVICE MAGNETIC MEASUREMENT FACILITY AT SINCROTRONE TRIESTE

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Abstract

The performance of a new 5.5 m 3-axis insertion device measuring bench is presented, including the specified and measured mechanical accuracy as well as the reproducibility and accuracy of field measurements using a Hall plate sensor. The performance of the new integrated flipping coil system with a 4.2 m wire length is also discussed and compared with that of a previous system.

1 INTRODUCTION

The ELETTRA storage ring is a 2 GeV third generation synchrotron radiation source, designed for the inclusion of up 11 insertion devices, each up to 4.8 m long. Up to last year, each insertion device (ID) consisted of up to 3 separate and independent sections, based on a standard 1.5 m support structure. At the beginning of this year a new Electromagnetic Elliptical Wiggler (EEW) [1] of 3.3 m has been installed in the storage ring. In addition the construction of a series of new Elliptical Undulators [2] (EU) is under way and the first of this series will be installed this year. Each of these new devices will have a length up to 2.2 m.

In order to perform accurate magnetic measurements of these new devices, including the fringe fields, we had to substitute our Hall plate bench [3] that had a travel range of only 2.5 m, with a new one with a larger travel range. Given the relatively small additional cost we took the opportunity to increase the length to 5.5 m, in order to be able to measure IDs with a length up to the maximum possible for ELETTRA straight sections.

Accurate field integral measurements are performed by our stretched wire bench [4]. The length of this also had to be increased to 4.2 m. in order to measure the EEW, compared to its previous length of 2.5 m. However this operation did not require the complete substitution of the bench, but only a quite simple modification.

2 HALL PLATE BENCH

2.1 Description

The new Hall plate bench, supplied by Microcontrole-Newport (France), was installed in November of last year. It is based on long granite beams of 6.5 m. The bench lies on 12 leveling devices, regulated during the bench installation in order to meet the specified angle tolerances. A carriage moves (Z-axis) on air-bearing along the upper beam, driven by a belt system and a dc-motor (UE512CC). The length of travel of Z axis is 5.5 m. This carriage supports the X (horizontal) and Y (vertical) stages, each with 200 mm of travel, driven by stepping motors (MTL200P1). The total moving mass is about 225 Kg. and the max. Z speed is 60 mm/sec. The mass of the complete system is about 3.5 tons. The X and Y positions are measured by a rotary encoder, with a sensitivity of 1 µm, the Z position is read by a linear encoder (Heidenhain, model Lida 105 + Exe), having a sensitivity of 1 µm.

All axes are driven by a standard MM4005 Newport integrated motion/controller connected to a PC via RS232 (or GPIB). This controller has the possibility to make in-flight measurements: during a Z-scan it is able to generate TTL signals (trigger) to 2 voltmeters (HP-3458) at predefined and equispaced measuring positions.

Data taking is performed at 20 mm/sec; the data are stored in the voltmeter buffer and read at the end of the scan. The Hall plates used are described in [4].

2.2 Mechanical Specifications and Measured Accuracy

The mechanical new bench specifications were:

- Main axis (Z) : Pitch, roll and yaw ≤ 20 µrad. Straightness and flatness ≤ 50 µm, measured at a distance of 0.5 m. vertically and 0.5 m. horizontally from the carriage surface i.e. at the position of the Hall plate sensors.
- Positioning accuracy : ≤ 50 µm.
- Origin repeatability : ≤ 1 µm. (for all 3 axes)
- Subsidiary axes: X (hor.) and Y (vert.), mounted at 90 deg. with an ortogonality of all three axes of ± 50 µrad.

The X,Y axes are commercial Microcontrole (MTM) motorized stages.

Fig. 1 shows the pitch, roll and yaw errors, measured at Trieste after the installation of the bench, using an electronic level (roll) and an autocollimator (pitch and yaw). It can be seen that the angle errors are within the tolerances specified, apart from a pitch value (24 µrad) measured at the limit of the range (5.4 m.). For the old Hall plate bench we measured angle errors about twice larger, along the 2.5 m. Z axis.

Fig. 2 shows the difference between the true displacement measured with a HP interferometer and the value given by the motion controller (Heidenhain encoder) as a function of the Z position. The positioning accuracy measured is about 2 times better than specifications (and 4 times the specification for the old bench).

The squareness between the 3 axes has been measured by a reference granite cube and was better than 50 µrad.

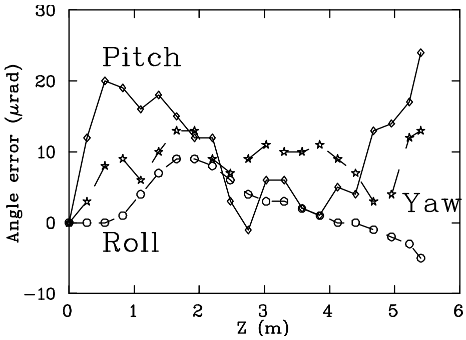

Figure 1: Pitch,Yaw, Roll angle error as a function of Z position.

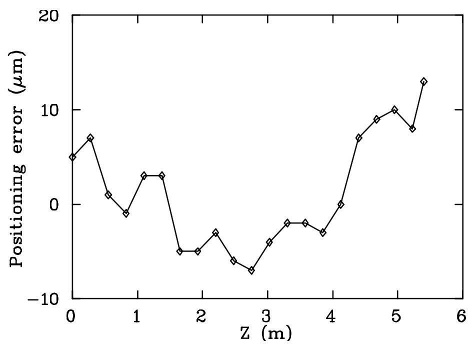

Figure 2: Longitudinal positioning error

2.3 System performance

The new bench has been used to measure the EEW [1], the prototype Elliptical Undulator [2], and the magnetic arrays (1 m long, 0.76 T. of peak field, period 200 mm.) of the 2T wigglers presently being constructed for CLRC-Daresbury [5].

Table 2 shows the reproducibility of the first and second field integrals (rms) obtained measuring one of the CLRC arrays (at a distance of 10 mm, from the poles) and the EEW at max. horizontal and vertical current, corresponding to a peak field of 0.1 (hor.) and 0.6 T (vert.).

Table 1: First and second field integral reproducibility for a CLRC array and the EEW (in brackets)

RMS Field Integ.	**Hor. (Gm)**	**Vert. (Gm^2)**
First	0.019 (0.041)	0.034 (0.129)
Second	0.002 (0.010)	0.016 (0.037)

In fig. 3 is shown the calculated horizontal trajectory (E=2 GeV), for 8 different scans in the EEW at maximum current, without any field error compensation. The maximum peak to peak position variation at the exit of the wiggler is 10 μm, with an integration performed on a distance of 3.8 m.

Even though the length of the scans is now doubled, the overall reproducibility is improved with respect the values obtained with our old bench [4], and in some cases (I_x) seems to be one order of magnitude better.

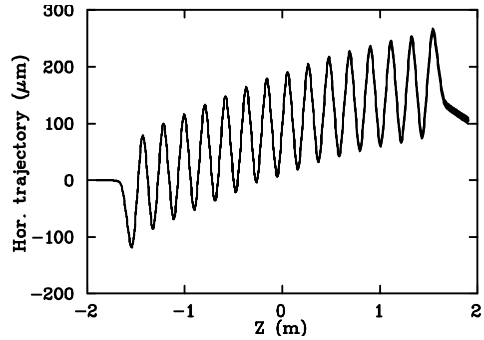

Figure 3: 8 trajectories calculated from magnetic measurements in the EEW.

3 STRETCHED WIRE BENCH

3.1 Description

The stretched wire bench is now positioned in the front of the Hall plate bench, in order to be able to perform magnetic measurements with both benches, without having to move the magnetic devices. The 3.2 m. long granite beam has been eliminated [4], and the motorized stages are now supported by two independent tables. In fig.4 is shown the Hall plate bench and the stretched wire system, during the CLRC array measurements.

Another advantage of 2 separate supports is the possibility to vary the wire length i.e. the distance between the stages up to 6 m. (limited by the lab dimensions).

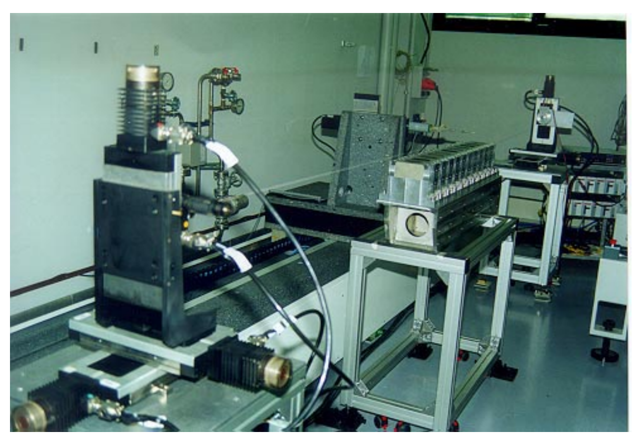

Fig.4 The stretched wire and hall plate benches.

We mounted a litz wire (made up of 19 strands) having a length of 4.2 m., sufficient to measure the EEW (3.3 m). The motorized stages and the acquisition system are the same as that described in [4] and [6].

As reference, to align the 2 separate 3-axis stretched wire stages, the Hall plate bench has been used.

The flipping coil technique has been chosen although the stretched wire system has given better results [6], because we had to perform dynamic measurements (up to 100 Hz) of field integral variation. i.e. we needed to measure the voltage induced in the static coil by magnetic flux variation, by varying the current in the EEW.

3.2 System Performance in DC Mode

The typical reproducibility for measuring the EEW and for the CLRC arrays was about 0.02 Gm, about the same value obtained with the stretched wire of 2.5 m (0.03 Gm). The typical peak to peak field integral variation as a function of the longitudinal coil position [4] was for the hor. (vert.) plane equal to 0.75 Gm (0.5 Gm) i.e. about the same value obtained with the old system (0.6 Gm horiz. and 0.3 Gm vert.).

In fig. 5 is shown a comparison of the vertical transverse field integral distribution for the CLRC array measured with the flipping coil (fc) and the hall plate (hp) (at a distance of 10 mm from the poles, Z-scan length equal to 1.8 m.). In this case there is a difference, that does not depend on the transverse position, of about 2.2 Gm. However, this difference depends on the vertical distance between the hp and the poles: at 15 (50) mm it is equal to 1.6 (0.512) Gm. Similarly in the horizontal plane there is a constant difference of -1.8 Gm.

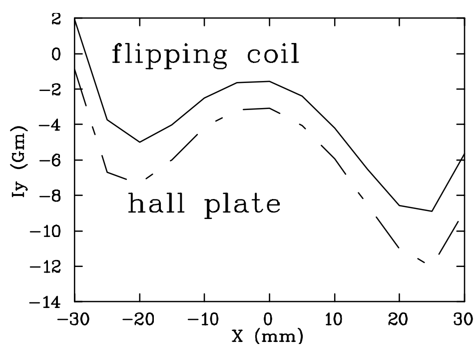

Fig.5 Field integral variation at a distance of 10 mm from the poles, measured with the flipping coil and hall plate.

The vertical field integral difference between the Hall plate and flipping coil measurements observed in the EU6 prototype (seven periods, about the same peak field, but with a hp scan of about 1 m.) was at a level of 0.4 Gm. In [4] we measured differences between the two benches that were about an order of magnitude smaller. These change could be due to a variation of calibration since the Hall plates were calibrated 4 years ago.

We performed also some measurements of the EEW second field integral. The method closely followed that used at APS (Argonne) [7], but in this case the reproducibility obtained was very poor, with variations larger than 100% for second field integral of $\approx$ 1 G m^2. The reason for this large variation is unknown.

3.3 System Performance in AC Mode

In order to measure the field integral variation of the EEW in AC mode (max. 100 Hz) [1], we connected the long stretched wire coil to the HP 3458 voltmeter. The voltmeter read (at constant time interval) the voltage induced in the coil while the hor. current in the wiggler was varying. The data were then stored in the HP internal buffer. The integration time (aperture) was set in the range 0.4 - 1 mSec; the acquisition frequency was up to 2 kHz, depending on the EEW current frequency. In fig. 6 is shown a typical hor. field integral variation measurement at 10 Hz for a current variation of ±275 A. as a function of the time (aperture 0.8 mSec).

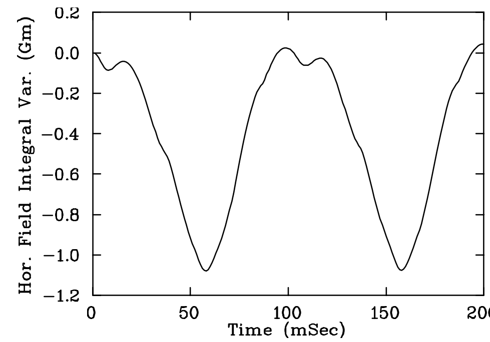

Fig.6 Hor. field integral variation in the EEW at 10 Hz.

Table 2 shows the reproducibility (rms) as a function of the aperture time of the HP voltmeter, measured for different scans with the EEW hor. current frequency set at 10 and 100 Hz.

Table 2: Peak to peak field integral variation and rms reproducibility as a function of the integrating time (aperture) of the voltmeter.

Freq. (Hz)	**Apert. (mSec)**	**ΔIx (Gm)**	**Ix,rms (Gm)**
10	0.4	1.153	0.070
10	0.8	1.160	0.029
10	1.5	1.186	0.006
100	0.4	1.104	0.098
100	0.8	1.013	0.037

5 ACKNOWLEDGMENTS

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REFERENCES

[1] R.P.Walker et al, “Construction and Testing of an Electromagnetic Elliptical Wiggler for ELETTRA”, this conference.
[2] B.Diviacco et al, “Construction of Elliptical Undulator for Elettra”, this conference.
[3] D.Zangrando and R.P.Walker, “Magnetic Measurement Systems for the ELETTRA Insertion Devices”, EPAC’90, Nice, June 1990.
[4] D.Zangrando and R.P.Walker, “Magnetic Measurements Facility for the ELETTRA Insertion Devices”, EPAC’92, Berlin, March 1992.
[5] J.A.Clarke, “The Magnetic Design of High Field Permanent Magnet Multipole Wiggler for the SRS”, Proc. PAC 1997, Vancouver, to be published
[6] D.Zangrando and R.P.Walker, NIM, A 376 (1996) p.275-282
[7] D.Frachon et al, ANL/APS/TB-22, Argonne, March 1995