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HALL PROBE MAGNETIC MEASUREMENT OF 50 mm PERIOD PPM UNDULATOR

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Abstract

In this paper, we present theHall Probe magnetic measurement of the integrated multipoles of 50 mm period undulator.The ongoing activity on asymmetric undulator is discussed.

INTRODUCTION

The Hall probe is the most versatile magnetic measurement system for the undulators. The field integral and phase error [1,2] of the undulator are directly computed from the field mapping. The field integrals compute the angle and position offset of the electron at the undulator end. The phase error indicates the undulator quality through reduction of photon flux and small signal free electron gain. The multipole components of the undulator indicate the effects of the undulator on the propagating electron beam [3].

HALL PROBE MEASUREMENT BENCH

The schematic of the Hall probe bench is illustrated in Fig. 1. The Hall probe measurement bench uses a F.W. Bell make, Model No- 8030 Tesla meter and F.W. Bell make 3-axis probe Model No- ZOA83-3208-10. The cylindrical 3-axis probe stem is 205 mm in length and have 8 mm diameter. The probe is attached in specially designed indigenously made probe holder having measurable angle adjustment. The probe is fixed in a cylindrical tube of 20 mm inner diameter having 5 mm thickness attached inside the probe mount with the help of a coaxial cylinder, both the cylinders are covered with the mount case fixed with Allen screws. There is a knob in the bottom of probe mount for coarse adjustment and micrometer given on the side for fine adjustment of the angle of hall probe. The design of the hall probe holder presented in Fig. 2. The probe holder having M6 slot is mounted on a xy-stage; 50 mm travel distance each and moves on a motorized z-linear translation stage of 2000 mm length. A stepper motor with a single axis motion controller drives the hall probe assembly unit on the z-linear translation stage capable to move forward and backward. The motion controller operated with control software capable to record multiple Teslameter channels is programmed to control the speed and direction of the travel, delay time and step length of measurement defined by the user. The control software allow the linear translation stage to move distance range from 2 µm to 2000 mm both in forward and reverse directions with allowed speed ranging up to 20 mm/s and a delay time between the data capture range from 0ms to 9999 ms can be given to measurement system.

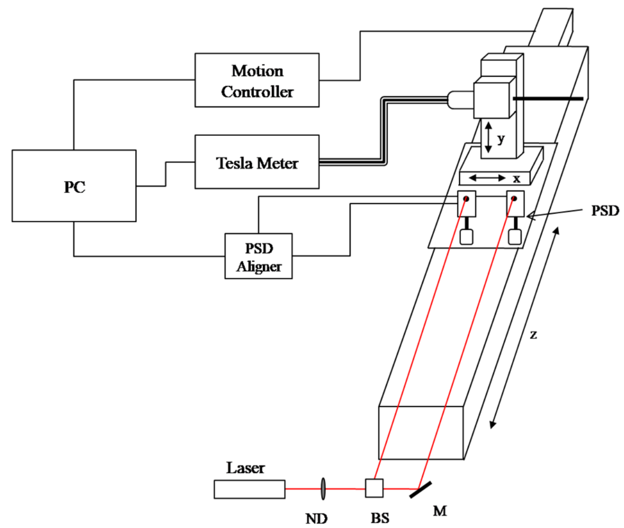

Figure 1: Hall probe bench.

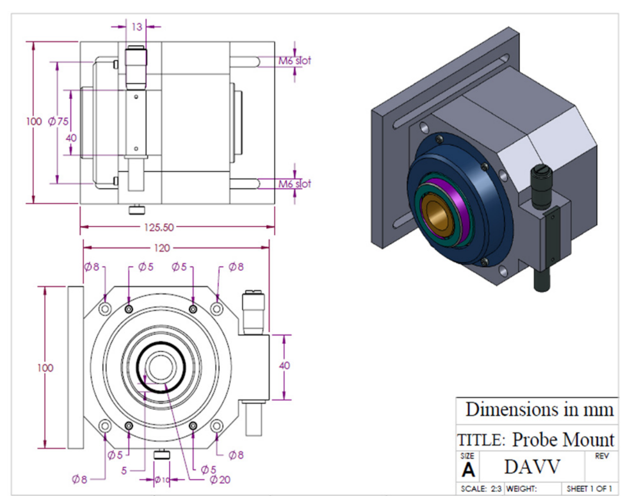

Figure 2: Design of Hall probe mount.

The 2D position sensing detector based position measuring system previously used for different setup [4] to align the Hall probe in both vertical and horizontal directions implemented on new 2000 mm long translation stage.

MAGNETIC MEASUREMENTS

Straightness and flatness of the travel of Hall probe measurement assembly shown in Fig. 3. The undulator is 1m long having 20 periods, each period is 50 mm in length. The motion of Hall probe is observed throughout

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the length of undulator considering it as z-axis and it stay on axis of the undulator within the range of ±10 μm along x-axis and ±30 μm along the y-axis.

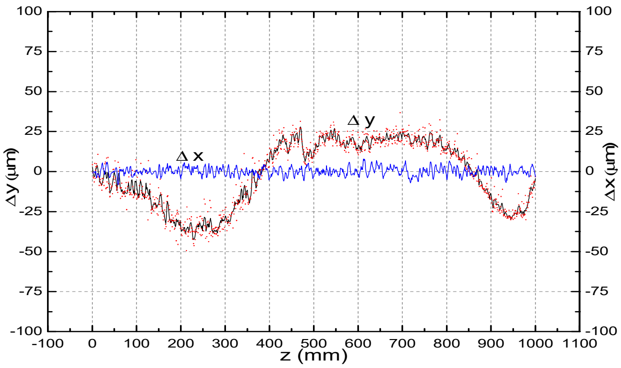

Figure 3: Horizontal and vertical alignment.

The magnetic field mapping of the undulator from the Hall probe within the range of gap from 14 mm to 21 mm is presented in Fig. 4(a) and Fig. 4(b). The measurement is recorded at the step length of 1mm with delay of 3000 ms between each reading. The magnetic field integrals are calculated with a new user friendly MATLAB-code.

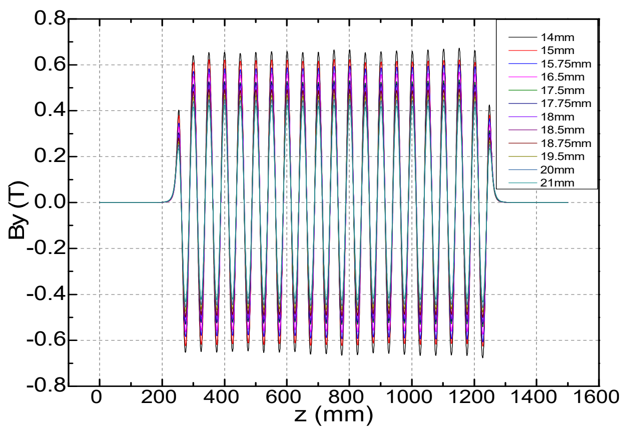

Figure 4(a): Normal magnetic flux density.

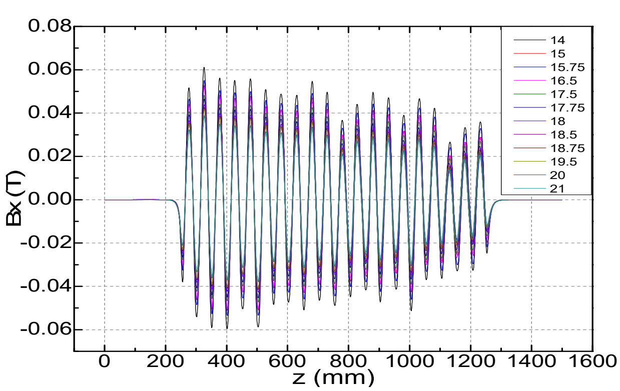

Figure 4(b): Skew magnetic flux density.

The rms values of normal and skew measurement of the field and the first field integral with the variation of gap is presented in the Fig. 5(a), 5(b) respectively. The normal and skew magnetic field integrals at the end 250 mm away from end of the undulator is presented in Fig. 6(a) and Fig. 6(b).

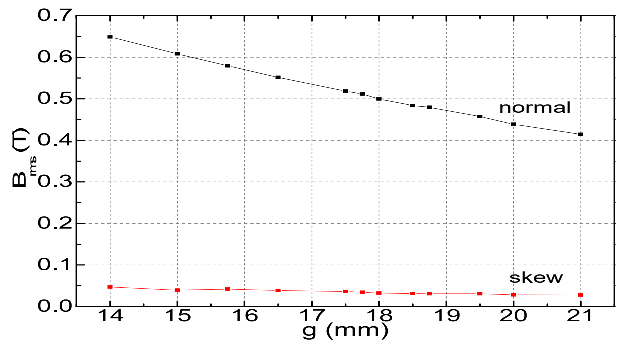

Figure 5(a): rms magnetic flux density.

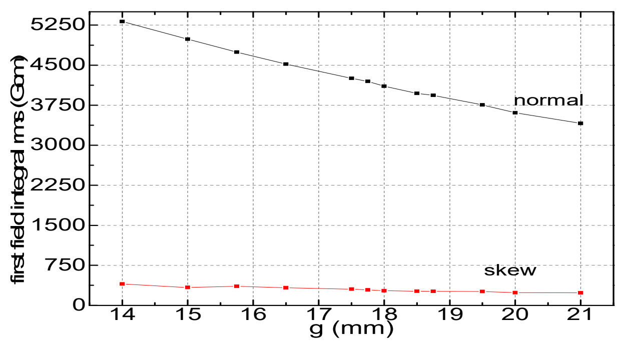

Figure 5(b): rms first field integral.

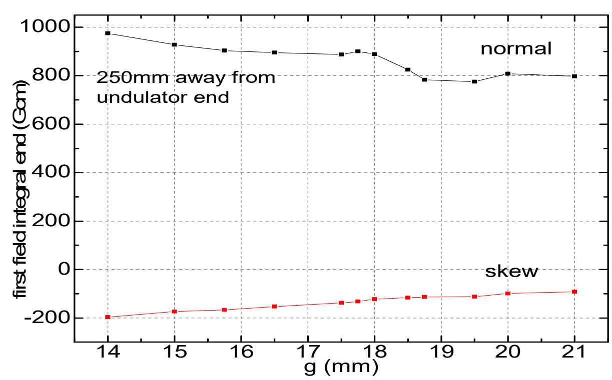

Figure 6(a): First field integral at the end.

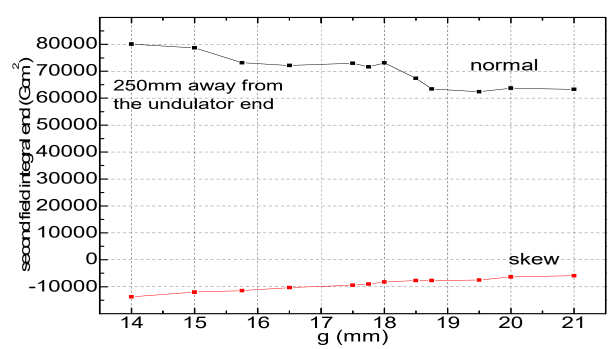

Figure 6(b): Second field integral at the end.

The integrated multipole components canbe derived from the following equation [5],

$$\int_{-\infty}^{\infty} \left(By + iBx\right)dz = \sum_{n=0}^{\infty} \left(b_n + ia_n\right)\left(x + iy\right)^n \qquad (1)$$

Where By and Bx are real and these can be obtained by the imaginary and real part of the right-hand side of the

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given equation. Here index n which is an integer denotes the order of the multipole field component. n=1 denotes the dipole field, n=2 is for quadrupole field, n=3 for sextupole field component and so on.

The multipole component can be computed by fitting a polynomial to the data set of field; extending the Eq. (1) upto few indices gives,

$$\int_{-\infty}^{\infty} (By+iBx)dz = (b_0+ia_0)+(b_1+ia_1)(x+iy) + (b_2+ia_2)(x+iy)^2 \tag{2}$$

Considering only vertical multipole field along x-axis,

$$\int_{-\infty}^{\infty} (By+iBx)dz = b_0+b_1x+b_2x^2+i\left(a_0+a_1x+a_2x^2\right) \tag{3}$$

where b_0, b_1 and b_2 are the normal component of the field and a_0, a_1 and a_2 are the skew components of field.

The numerical data of the field from the measurement of the undulator magnet is obtained within the range from -4mm to +4mm. The data set is then plotted and fitted with the polynomial function; in our case second order polynomial from eq. (3) and the corresponding normal and skew multipole field are computed. Fig. 7 shows the plot and the fitted polynomial on the data set of skew measurement at 18mm gap.

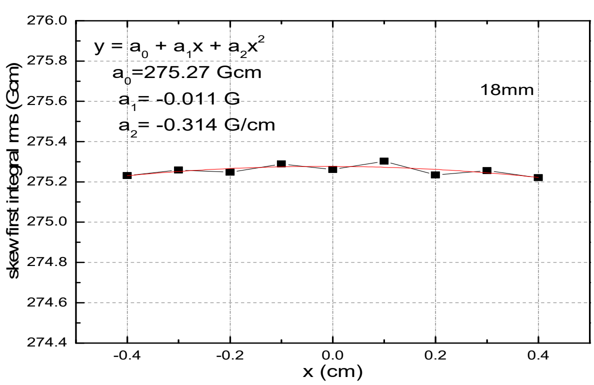

Figure 7: Skew first field integral distribution.

The variation of both normal and skew of the quadrupole component and sextupole component are presented in the Fig. 8(a) and Fig. 8(b) and summary in Table 1 for the 18 mm gap.

An asymmetric undulator with 25mm and 50mm period has been designed and measurement ready shown in Fig. 9. Both the Hall probe system and the Pulsed wire magnetic measurement system will be used to field map the undulator.

Table1: Magnetic Measurement Results

(n)	Measurement
(0)Normal Dipole	4105Gcm
(0)Skew Dipole	275Gcm
(1)Normal Quadrupole	-0.164G
(1)Skew Quadrupole	-0.011G
(2)Normal Sextupole	-4.4682 G/cm
(2)Skew Sextupole	-0.3139 G/cm

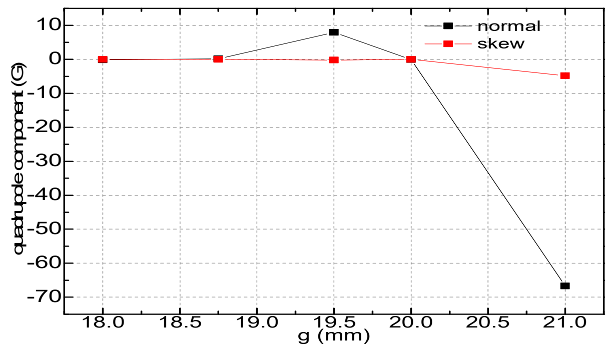

Figure 8(a): Quadrupole components of field versus gap

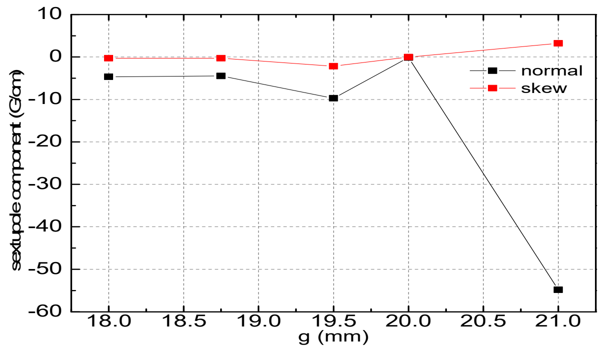

Figure 8(b): Sextupole component of field versus gap.

Figure 9: 300 mm length asymmetric undulator.

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