PROGRESS IN DEVELOPMENT AND MEASUREMENT OF AN ASYMMETRIC MAGNET POLE UNDULATOR

G. Mishra*, Chilukamarri Bindua, Devi Ahilya Vishwa Vidyalaya (DAVV), Indore, India, Mona Gehlot, DESY, Hamburg, Germany, Roma Khullar, Holker Science Collège, Indore, India

Abstract

A new prototype undulator known as Asymmetric magnet pole with upper and lower structure having different period lengths will be designed and fabricated.

INTRODUCTION

There are interests in asymmetric magnet pole undulators for quasi periodic systems and emission of both linearly polarized and circularly polarized radiation[1,2]. Asymmetric magnet pole undulator has a special demand for reducing on axis heat load from radiation. A prototype asymmetric magnet pole undulator is under development at Laser and Insertion Device Application (LIDA) laboratory of DAVV. The undulator will be a variable gap undulator with upper structure consist of 25mm period having NdFeB magnets of rectangular cross section 6.25 mm, 6.25 mm and 50mm and lower structure will be with 50mm period length with the same magnet material but having rectangular cross section of 12.5mm, 12.5mm and 50mm. In this paper the design details for an asymmetric magnet pole undulator is presented along with magnetic measurement systems of the LIDA laboratory.

Table 1: Undulator Parameters

<table>
<thead>
<tr>
<th>Undulator</th>
<th>Pure Permanent asymmetric magnet pole</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet Material</td>
<td>NdFeB</td>
</tr>
<tr>
<td>Remanent Magnetic Field</td>
<td>1.12T</td>
</tr>
<tr>
<td>Period Length</td>
<td>25 mm</td>
</tr>
<tr>
<td>Magnet Dimension Upper Half</td>
<td>6.25×6.25×50mm</td>
</tr>
<tr>
<td>End Magnet</td>
<td>3.125 mm</td>
</tr>
<tr>
<td>Period Length</td>
<td>50 mm</td>
</tr>
<tr>
<td>Magnet Dimension Lower half</td>
<td>12.5×12.5×50mm</td>
</tr>
<tr>
<td>End Magnet</td>
<td>6.25 mm</td>
</tr>
<tr>
<td>Length of Undulator</td>
<td>1500mm</td>
</tr>
<tr>
<td>Gap</td>
<td>8 mm to 40 mm, uniform and tapered</td>
</tr>
<tr>
<td>Maximum Phase Shift</td>
<td>Pi/2 for upper array</td>
</tr>
</tbody>
</table>

Magnetic Field Simulations

The magnetic field of an asymmetric undulator is described by

\[ B = B_1 \sin(k_{u1}z + \varphi) + B_2 \sin(k_{u2}z) \]  

Where \( B_1 \) and \( B_2 \) are the on-axis amplitudes of magnetic field of the upper and lower magnet rows and the upper and lower magnet arrays, respectively, \( k_{u1} = \frac{2\pi}{\lambda_{u1}} \) and \( k_{u2} = \frac{2\pi}{\lambda_{u2}} \) are the corresponding wave numbers, \( \lambda_{u1} \) and \( \lambda_{u2} \) are the period lengths, \( \varphi \) is the phase shift between the upper and lower rows of magnets. The Radia[3] software for the simulation studies of asymmetric undulator has been used and compared with analytical magnetic field. Figure 1. Shows the Radia model for asymmetric undulator. The upper half row of the undulator is having period of \( \lambda_{u1} = 25 \text{mm} \) and period length of lower half row is \( \lambda_{u2} = 50 \text{mm} \). The length of the undulator length is 1.5m. Figure 2 shown the magnetic field from Radia for 50mm period length planar undulator for the geometrical gap of 8mm. The peak magnetic field is 0.9T. Figure 3 is the plot of magnetic field for 25mm period length of planar undulator having peak magnetic field of 0.56T for 8mm of undulator gap. For comparison of theoretical field and Radia simulation the peak field for asymmetric undulator are \( B_1=0.28 \text{T} \) and \( B_2=0.55 \text{T} \) for upper and lower row respectively has been fixed to get asymmetric magnetic field at \( \varphi = \frac{k_{u1}\lambda_{u1}}{4} \). In the Radia modelling end magnets at extremities having \( \frac{1}{2}: \frac{1}{2} \) configuration are included for both the rows of asymmetric undulator.

Figure 1: Asymmetric Undulator from Radia

* gmishra_dauniv@yahoo.co.in
Figure 2: Magnetic Field for gap=8mm for 50mm Period Undulator.

In Radia, undulator is built with a phase shift of $\varphi$ for upper row of asymmetric undulator. Figure 4 is the plot for the comparison of magnetic field from theory and Radia for 8mm undulator gap. Figure 5 and Figure 6 are the first and second field integral obtained from Radia for 8mm gap and $\varphi = k_{u1}\lambda_{u1}/4$ for asymmetric undulator.

Figure 3: Magnetic Field for gap=8mm for 25mm Period Undulator.

Figure 4: Theoretical pPot (Red) of the Asymmetric Magnet Pole Undulator from Eq1. For $B_1=0.28T$ and $B_2=0.55T$ and Radia Simulation (Blue)

Figure 5: First field integral for $\varphi = k_{u1}\lambda_{u1}/4$

Figure 6: second field integral for $\varphi = k_{u1}\lambda_{u1}$

MECHANICAL DESIGN DESCRIPTION

Figure 7: Girder Design a: Front View
A new Girder system of the asymmetric magnet pole undulator has been designed as shown in Figure 7. In the present case, the previous design [4] has been modified to include the provision of longitudinal phase shift between the arrays. There will be hand driven knob on the upper array which will be used to provide a variable phase shift. Figure 7a presents the front view of the design. Figure 7b and Figure 7c gives the side view and back view with dimensions. All the dimensions are in mm. The gap will be varied manually. Four independent ball screws of the upper and lower rows will permit tapered gap measurement.

**LIDA MAGNETIC MEASUREMENT SYSTEMS**

The LIDA-DAVV Laboratory is equipped with Hall probe magnetic measurement bench [5]. The LIDA Hall probe system has Wollaston prism interferometer and position sensitive detectors for probe alignment. The Michelson interferometer measures the longitudinal accuracy of the measurement. In the Hall probe measurement method, a specially designed carriage on the bench carries the probe through the undulator at a given speed and delay while the measurements are being performed. We use F.W. Bell make Hall probes and Tesla meters. The pulsed wire magnetic bench has been set up as an alternate method for field integral measurements [6]. It has the advantages of measuring the field integrals directly. Cu-Be wire under tension is stretched along the undulator axis with a sensor located near the end but outside the undulator magnet. When a current flows through the wire, the Lorentz force set up a travelling wave in the wire and picked up by the sensor. The sensor output versus time is the field integral versus position along the length of the wire. The LIDA Laboratory has developed a stretched wire system to measure the field integrals and the field harmonics as well. In the method the field integral and second field integral are measured from the induced voltage at appropriate wire translation inside the undulator [6]. The undulator will be measured by Hall probe and wire method to compare the results.

**CONCLUSION**

An asymmetric magnet pole undulator with 25mm ,50 mm period lengths is under development. The prototype undulator will be measured in the Hall probe, pulsed wire and stretched wire magnetic bench. There is a further plan to design asymmetric type undulators with 20 mm ,25 mm periods and 20 mm ,50 mm periods to measure the field mapping, field integrals and phase error of the devices.

**ACKNOWLEDGMENT**

This work is supported by Science & Engineering Research Board (SERB) New Delhi, Govt of India through the project grant No. CRG/2022/001007.

**REFERENCES**


