DRIVING MECHANISM OF AN APPLE-2 TYPE VARIABLE POLARIZING UNDULATOR FOR THE GAP AND PHASE VARIATION

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Abstract

This report presents a function and structure of a driving girder of an APPLE-2 type variable polarizing undulator for SPring-8.

1 INTRODUCTION

A variable polarizing undulator (ID23)[1,2] as the light source of the soft X-rays beamline (BL23SU)[3] for SPring-8 was constructed. The magnetic structure of the ID23 is APPLE-2 type[4-6]. The ID23 can generate a linearly (horizontal or vertical plane), an elliptically or a circularly polarized radiation by providing the phase position shifts to the magnet rows. The most important performance of the ID23 is switching of right and left circularly polarized radiation at 0.5Hz by successful phase shift driving of the magnet rows. This feature is expected to promote a study of circular dichroism in spectroscopic research fields. Main parameters of the ID23 are shown in Table 1. The ID23 consists of the four magnet row and the supporting system; we call driving girder.

Table 1: Main parameters of the ID23

Device type	APPLE-2
Period length	120 mm
Period number	16
Available gap range	20~300 mm
Available phase shift range	-120~+120 mm
Switching rate (right~left~right)	0.5 Hz
Peak field for horizontal polarization	By=0.55 T
Peak field for vertical polarization	Bx=0.55 T
Peak field for circular polarization	By=Bx=0.39 T

2 FUNCTION AND STRUCTURE

The function of the driving girder is to support the magnetic structure and to provide gap motion and phase shift motion. The girder is able to make a the phase shift motion at 0.5Hz in cycles.

The magnetic force between the magnet pieces varies with the gap motion and the phase shift motion. The maximum force between the magnet rows is as follows:

vertical attraction:	1200 kgf/row
vertical repulsion:	900 kgf/row
horizontal attraction:	1100 kgf/row
horizontal repulsion:	900 kgf/row

The maximum longitudinal driving force for phase shift motion is 500 kgf/row except for force of inertia. The girder must rigid enough against these forces.

Figure 1 shows the conceptual design of the driving girder. Each magnet row is fixed to the supporting beam. The beam is connected with the up-down bed through linear guides for the phase shift motion of magnet rows. The up-down bed is connected with the main structure of the girder through linear guides.

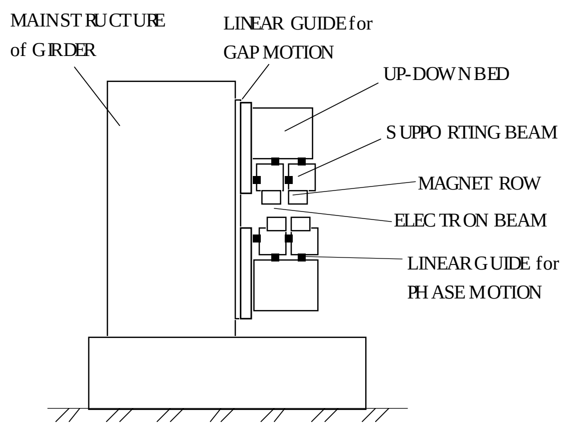


Figure 1: Concept of driving girder

The gap driving system consists of one stepping motor, gears and ball screws to move the up-down beds. See Figure 2. A self-lock function on the gap motion is available regardless of the motor on or off to use worm-wheel gears. The gap position is measured by both an optical rotary encoder and a magnetic linear scale. We have shielded the encoder by lead to protect against high level radiation. We have installed limit switches and mechanical gap motion stopper between the upper up-down bed and the lower one to avoid destroy the vacuum chamber of the storage ring in the case of lose of driving control. Parameters of the gap driving system are shown in Table 2.

Table 2: Parameters of the gap driving system

Available gap range	20~300 mm
Maximum speed of gap motion	>30 mm/min
Resolution of setting gap	10 µm
Error between set and actual values of gap	5 µm
During gap motion	
horizontal variation of magnet rows	<20 µm
variation of median plane	<20 µm
rotation of median plane around s-axis	<0.5 mrad
Variation of gap by motor on/off	5< µm

The phase driving system consists of two AC servo motor and ball screws to move the supporting beams. See

Figure 3. Each AC servo motor drives a pair of magnet rows to the opposite direction. The Upper motor and the lower one are exactly controlled for the phase shift motion of APPLE-2 type. In order to reduce the vibration of the girder with phase driving, we control the motion of the rows to be free from changing the centre of the mass of moving parts, and we smooth the pattern of the motion. The phase position is measured by both an optical rotary encoder and a magnetic linear scale to be fail-safe. We have installed limit switches to limit the phase shift range. Since the phase driving system has no self-lock mechanism, the ID23 has two methods to hold the phase position system, one is a servo motor holding and another is an built-in electromagnetic break system of the motor. Parameters of the phase driving system are shown in Table 3.

Table 3: Parameters of the phase driving system

Available phase shift range	-60~+60 mm
Switching rate (right~left~right)	0.5 Hz
Resolution of phase set value	50 µm
Error between set and actual values of phase	25 µm
During phase motion	
transverse variation of magnet rows	<20 µm
variation of median plane	<20 µm
rotation of median plane around s-axis	<0.5 mrad
vibration amplitude on the girder	<40 µmpp
Variation during holding phase	<20 µm
Phase position error between the rows	<20 µm
Variation of phase position	
from servo holding into break holding	<20 µm

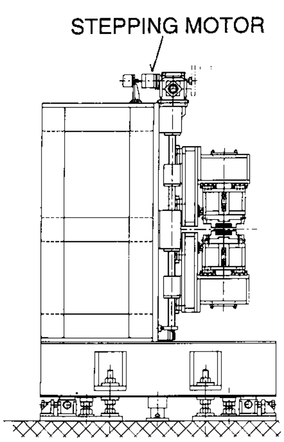


Figure 2: Side view of the ID23

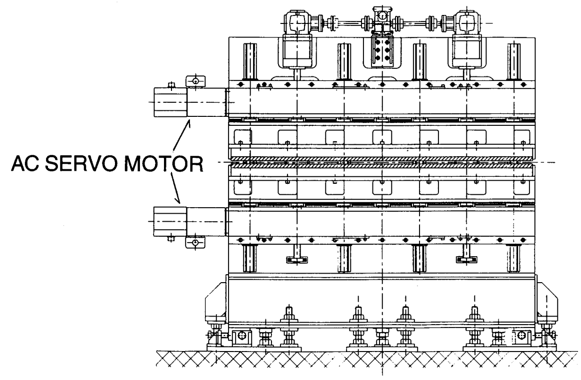


Figure 3: Front view of the ID23

The ID23 was installed in the storage ring of SPring-8 and have been under operation without any troubles. See Figure 4. The increment of the amplitude of the vibration with 0.5Hz phase driving is less than 1 nm on the floor near the ID23 shown in Figure 5.

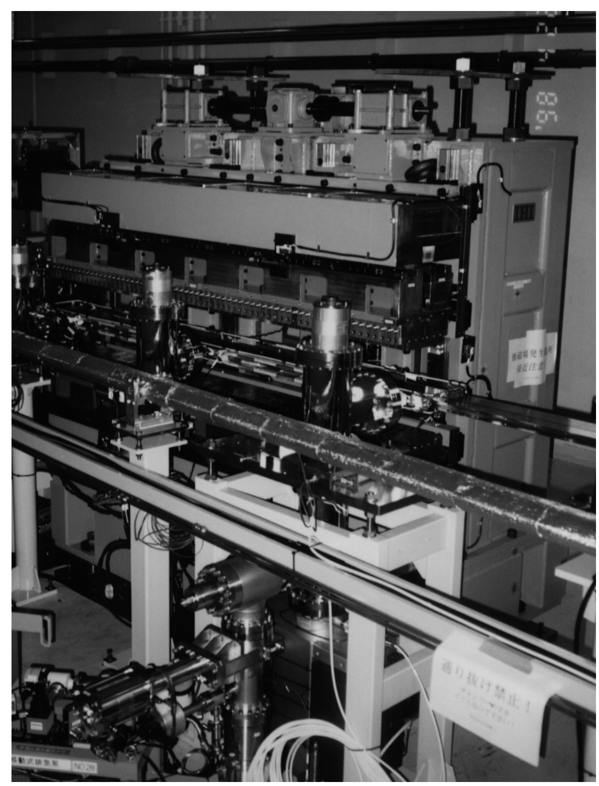
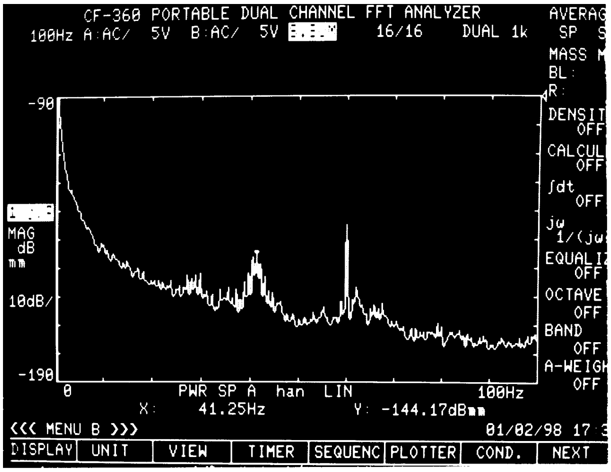


Figure 4: ID23 installed.



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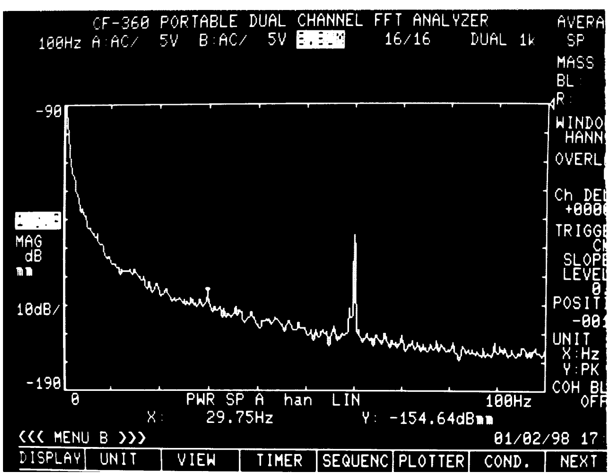

Figure 5: The upper photo is a spectrum of vibration with the cyclic phase shift motion on the floor near the ID23. The lower one is in all motor-off of the ID23. The peak at 41.25 Hz is caused by the phase motion in the upper photo. Its amplitude is 0.62 nm.

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