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PROTOTYPE OF HIGH STABILITY MECHANICAL SUPPORT FOR SHINE PROJECT*

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Abstract

Quadrupole stability of undulator segment is key to the beam performance in SHINE project. Vibration stability requirement of quadrupole is not larger than 200 nm displacement RMS between 1 and 100 Hz, but the field test of SHINE tunnel shows that the tunnel vibration during the day time is greater than 200 nm. In this paper, a mechanical support including a marble base and an active vibration reduction platform is sophisticated designed. Vibration stability of the key quadrupole fixed on this support is expected to be improved and the performances of the quadrupole meet the demands.

INTRODUCTION

Shanghai HIgh repetition rate XFEL aNd Extreme light facility (SHINE) is under construction. In undulator segment, the position of quadrupole is key to the beam performance. The position accuracy and stability of quadrupole are both nms. Quadrupole is supported by girder and girder is fixed to the ground. The high stability of mechanical support for quadrupole is important to assure the quality of the beam therefore. In SPring-8 [1], it is the cordierite ceramic support because ceramic has a low thermal expansion rate. In addition, sand is filled in the support to increase heat capacity to insure good stability. Support in SLAC [2] is a Mild Steel girder, which has sand inside and thermal insulation outside to ensure stability. In SHINE, the technical requirements of quadrupole are shown in Table 1.

Table 1: Technical Requirements of Quadrupole

Item	Value	Unit
Adjustment range of quadrupole center (H/V)	≥ ± 0.5	mm
Adjustment step of quadrupole (H/V)	≤ 0.05	μm
Positioning accuracy of quadrupole (H/V)	≤ ± 0.1	μm
Stability of Magnetic Center Vibration of Quadrupole (H/V, RMS, > 1 Hz)	≤ 0.20	μm

Acceptance requires that over 80 % of the total vibration measurement data (all day) meet the above stability requirement.

STRUCTURAL DESIGN

The overall mechanical support, as shown in Fig. 1, includes two parts: a marble base and an upper support. The marble base is fixed to the ground by grouting with steel plate. The thickness of grouting is not less than 40 mm and a raised plate below the marble used for adjusting the height displacement changes in the initial and later stages. The upper girder directly supports the beam equipment. The active vibration reduction platform plays an important role in dynamic vibration reduction and precise positioning. Adjustment range of the base is ± 10 mm both in vertical and horizontal direction. Adjustment range of the upper support is ± 10 mm in vertical direction and ± 5 mm in horizontal direction.

The active vibration reduction platform is fixed to the quadrupole base plate, and the seismometers are fixed on top of the marble to monitor the background vibration. Based on the vibration signal of seismometers, the piezoelectric motors in the active vibration reduction platform feedback adverse displacements to attenuate the vibration transmitted from the surrounding environment of the support platform to the quadrupole. The control cabinet is placed on the near undulator frame, as shown in the following figure.

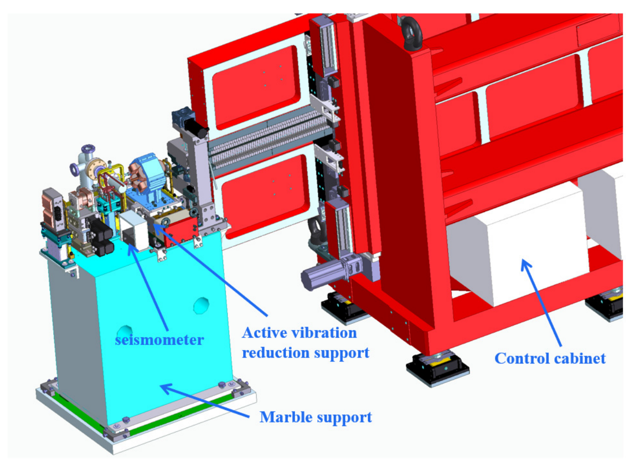

Figure 1: Mechanical support model.

The active vibration reduction platform is driven by piezoelectric motors, including 4 sets of vertical motors and 1 set of horizontal motors. A spring compensator is used to counteract gravity. A grating ruler is installed on the outer side to locate closed-loop feedback and facilitate the installation of lead plates for radiation protection. Considering a movement range of ± 0.5 mm, vertical and horizontal mechanical limits are designed internally, and vertical and

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horizontal electric shock switches are designed externally, as shown in Fig. 2, to facilitate precise adjustment of the protection range of the quadrupole according to the actual installation situation.

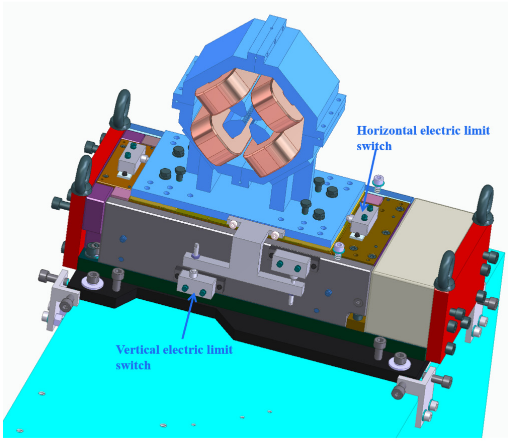

Figure 2: Limit switches in quadrupole support.

RESULTS

The quadrupole support is tested in lab at Shanghai Synchrotron Radiation Facility. Seismometers are placed on ground and top of dummy quadrupole at the same time. The contrasts of RMS value of vibration between ground and dummy quadrupole between 1 to 100 Hz are shown in Fig. 3 and Fig. 4. The vibration of dummy quadrupole is much less than ground vibration.

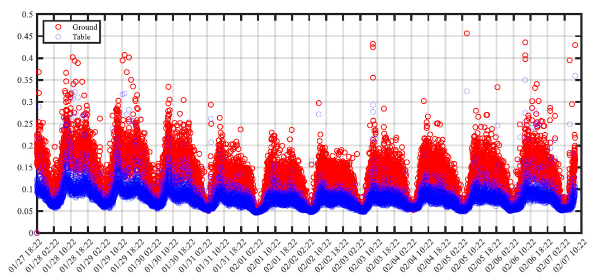

Figure 3: RMS contrasts between ground and dummy quadrupole in vertical direction.

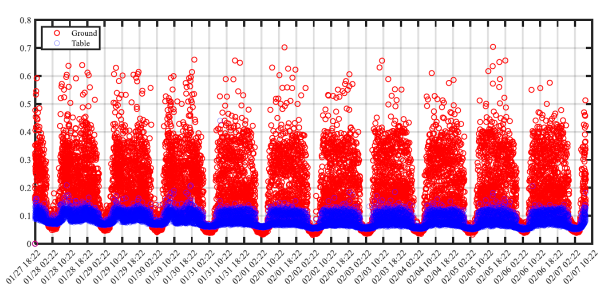

Figure 4: RMS contrasts between ground and dummy quadrupole in horizontal direction.

Capacitive Displacement Sensors are used to test the adjustment range, adjustment step and positioning accuracy of dummy quadrupole. The result of displacement step of dummy quadrupole as an example is shown in Fig. 5.

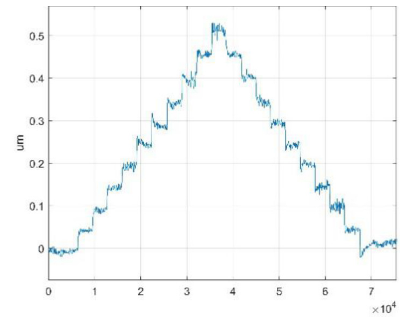

Figure 5: Adjustment step of dummy quadrupole.

CONCLUSIONS

An active vibration reduction platform fixed on a marble base is designed to meet SHINE requirements of precise positioning and high stability of quadruple. Prototype of the support works well and will be installed in tunnel of SHINE in the future.

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