VIBRATION MEASUREMENTS OF SUPER-CONDUCTING UNDULATOR AT SSRF *

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Abstract

A Super-Conducting Undulator (SCU) is being built at SSRF. Mechanical stability of SCU is critical to beam stability since the central load is supported by special strings in SCU and the vibration of load will cause directly the vibration of beam. Vibration results of several key components including central load, cold head, frame support, etc, are studied under different working mode of compressors in this paper. The ground vibrations near SCU are also compared to get the influence of compressors to SCU. Useful suggestions and possible measures are described to mitigate the vibration and improve SCU stability.

INTRODUCTION

A Super-Conducting Undulator (SCU) is being built at SSRF [1]. For SCU, the mechanical stability problem deserves more attention larger than other undulators. Vibration measurements have been performed on the SCU to investigate the mechanical stability. Comparisons have been made on different key parts of SCU with compressors open and closed.

For measurement instruments, we use a DHDAS5927 data acquisition system and DH610 seismometers from Donghua Testing Technology Co., LTD, China. The displacement power spectrum density (PSD) and integrated root-mean-square (RMS) displacement are derived based on the data analysis techniques [2].The range of the RMS displacement is between 1 Hz to 100 Hz, which is within the effective frequency band of the DH610 seismometer.

LAYOUT OF SCU MEASUREMENTS

The measurement points of SCU are shown in Figs. 1(a) to (d). There are totally 5 points from P1 to P5 shown in Figure 1(a), (c) and (d). Figure 1(b) shows the four compressors name 1# to 4# used for SCU. The numbers of cold head from 1# to 4# in Fig. 1(a) correspond to the four compressors in Fig. 1(b), P1 is the measurement point for cold head atop. Vertical seismometer of P1 is placed on the top of motor for cold head 1# and west-east seismometer of P1 is placed on the top of motor for cold head 2#. There is no north-south seismometer of P1 because there are only two cold heads atop and no space for the third seismometer. P2 locates on the top of SCU frame. P3 locates on central load in south while P4 locates on central load in north. P5 locates on the ground just near SCU.

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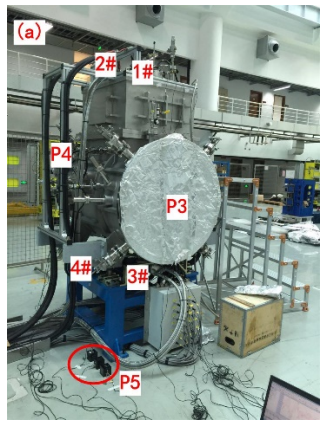

Figure 1(a): SCU measurements.

Figure 1(b): SCU compressors.

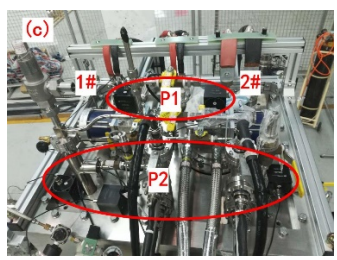

Figure 1(c): SCU measurements atop.

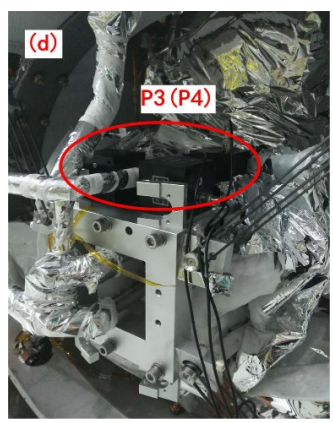

Figure 1(d): SCU measurements on central load.

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MEASUREMENT RESULTS

Measurement Results Of Vibration With Compressors Fully Open

The contrast of PSD and RMS curves of measurement points at SCU in vertical direction, west-east (W-E) direction and north-south (N-S) direction during 1 to 100Hz are shown individually in Fig.2 – Fig.7. We can see that when the four compressors are all open, there are many spikes on PSD curves of measurement points, whether in vertical direction, W-E direction or N-S direction, especially on SCU machine. Vibrations on SCU machine are much larger than that on ground.

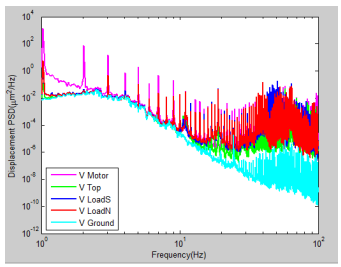

Figure 2: PSD curves of vibration on different parts of SCU in vertical direction with compressors fully open.

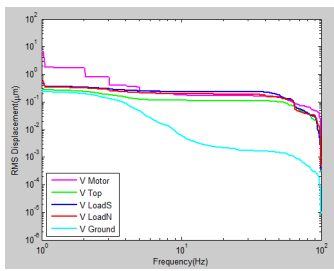

Figure 3: RMS curves of vibration on different parts of SCU in vertical direction with compressors fully open.

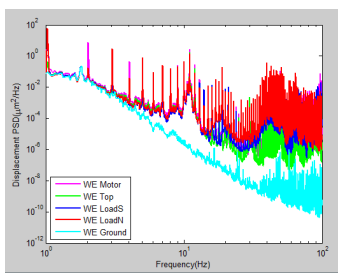

Figure 4: PSD curves of vibration on different parts of SCU in W-E direction with compressors fully open.

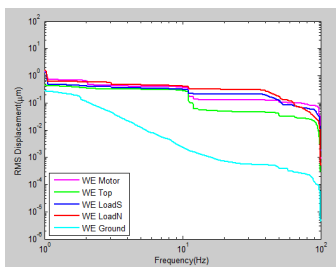

Figure 5: RMS curves of vibration on different parts of SCU in W-E direction with compressors fully open.

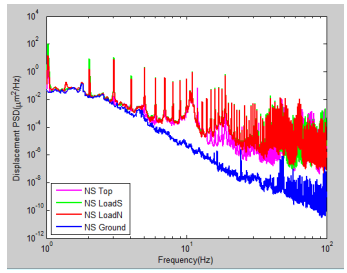

Figure 6: PSD curves of vibration on different parts of SCU in N-S direction with compressors fully open.

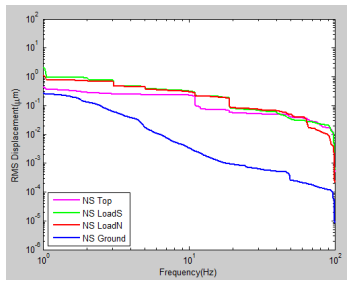

Figure 7: RMS curves of vibration on different parts of SCU in N-S direction with compressors fully open.

Contrast Of Vibration On Central Load With Compressors Fully Open And Fully Closed

The contrast of PSD curves of central load at SCU in vertical direction, west-east (W-E) direction and north-south (N-S) direction during 1 to 100Hz are shown individually in Fig.8 – Fig.10. The central load is affected during the whole frequency band from 1 to 100Hz when the four compressors are all open, whether in vertical direction, W-E direction or N-S direction.

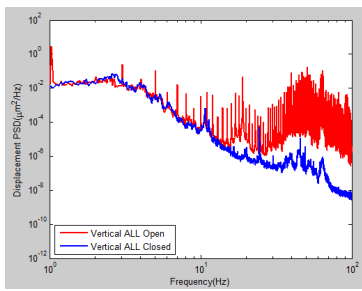

Figure 8: PSD curves of vibration on central load in vertical direction with compressors fully open and fully closed.

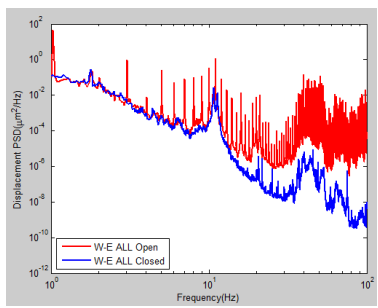

Figure 9: PSD curves of vibration on central load in W-E direction with compressors fully open and fully closed.

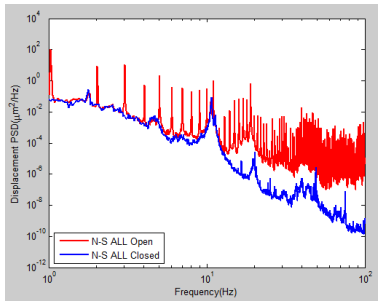

Figure 10: PSD curves of vibration on central load in N-S direction with compressors fully open and fully closed.

Contrast Of Vibration On Ground With Compressors Fully Open And Fully Closed

The contrast of PSD curves of ground vibration in vertical direction, west-east (W-E) direction and north-south (N-S) direction during 1 to 100Hz are shown individually in Fig.11 – Fig.13. The main affected frequency band of ground vibration concentrate on 30Hz above when the four compressors are all open, whether in vertical direction, W-E direction or N-S direction.

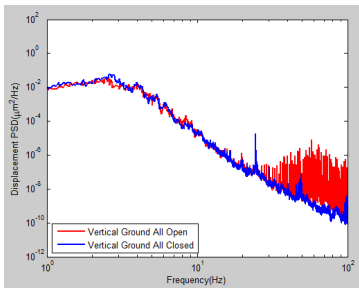

Figure 11: PSD curves of vibration on ground in vertical direction with compressors fully open and fully closed.

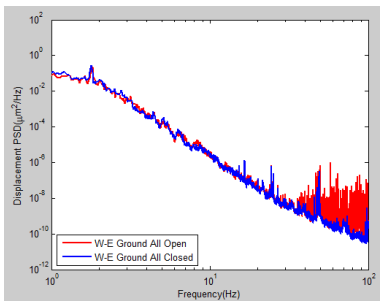

Figure 12: PSD curves of vibration on ground in W-E direction with compressors fully open and fully closed.

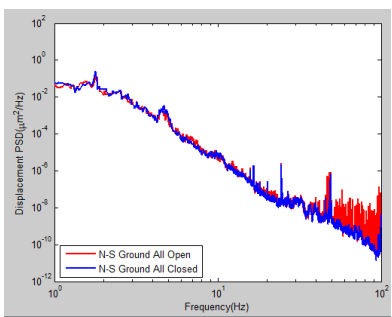

Figure 13: PSD curves of vibration on ground in N-S direction with compressors fully open and fully closed.

Contrast Of RMS Vibration Of SCU

RMS values of measurement points of SCU with compressors fully open and fully closed are listed in Table 1 and Table 2.

Table 1: RMS Values of Vibration With Compressors Fully Open (Micron)

SCU	Vertical	W-E	N-S
P1	6.7140	1.3774	
P2	0.2786	0.4488	0.4325
P3	0.4731	1.2906	1.9954
P4	0.5501	1.5273	1.0410
P5	0.2313	0.2757	0.2566

Table 2: RMS Values of Vibration With Compressors Fully Closed (Micron)

SCU	Vertical	W-E	N-S
P1	0.3211	0.3686	
P2	0.2828	0.3334	0.3192
P3	0.2908	0.3307	0.3135
P4	0.2832	0.3189	0.3091
P5	0.2681	0.3021	0.2687

CONCLUSIONS

Vibration of key parts of SCU have been measured to study mechanical stability of SCU. The following conclusions can be drawn from the present analysis.

(1) Vibrations of central load both in vertical and horizontal direction with compressors fully open are much more than vibrations with compressors fully closed. Support of central load should be strengthened to alleviate vibration to assure beam stability.

(2) There is high spark at 10Hz in vertical and horizontal directions with compressors full open and full closed, especially in horizontal direction. Damping or further reinforcement measures is suggested to increase the natural frequency in order to prevent disturbance of 10Hz.

(3) There is little difference of RMS value during 1 to 100Hz on ground vibration with compressors fully open and fully closed. But when the compressor is fully open, it has an influence on the 30Hz above vibration of ground.

REFERENCES

[1] Y. Y. Liu *et al.*, Design of Cold Mass Supports for a Superconducting Undulator Prototype at SINAP, *IEEE Trans. Appl.Supercond.*,vol.25,no.3,June 2015.

[2] D.B. Li and Q.H. Lu, *Analysis of Experiments in Engineering Vibration*. Beijing, China: Tsinghua University Press, 2011,pp.124-157.

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