Elettra Sincrotrone Trieste

Elettra 2.0
Engineering requirements document (ERD)

Elettra stability principles and guidelines

Revisions

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1.0	21/11/2023	Document creation
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1 INTRODUCTION

Stability is an essential topic for the fourth generation, low-emittance storage rings. The dynamic characteristics of the stands, supports, stages and holders are crucial to avoid resonance phenomena and decrease the vibrational displacements.

The vibration sensitivity is specifically important in the beamlines optical elements and experimental chambers, with special regards to beamlines that perform focusing to the nano-scale level, where the vibration tolerances are very tight and must be properly checked.

2 VIBRATION MEASUREMENTS

Vibration environmental measurements have been performed during the shutdown periods in the Elettra experimental hall and storage ring. The measurements were done using a triaxial PCB accelerometer (TLD356B18) and Dewesoft Sirius Mini as acquisition system. The acquisition system was powered via a laptop, disconnected from the electrical mains. The sampling frequency was set to 5000 Hz.
In the post processing, the RMS values (0 to peak) measured between (0-2500 Hz) have been analysed.

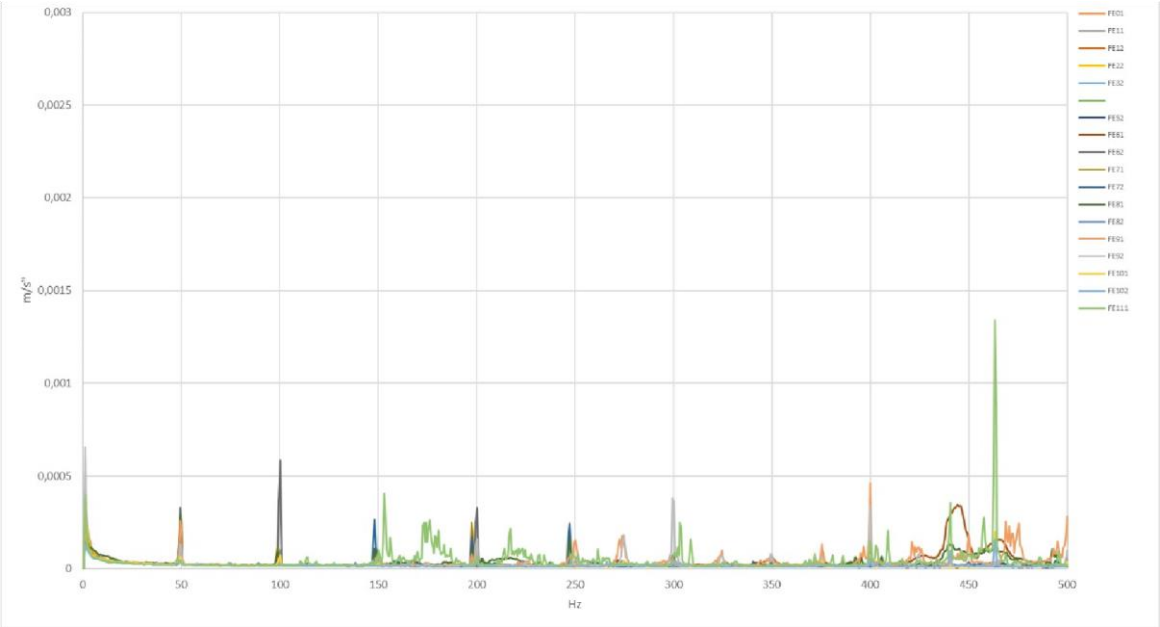

Fig.1 FFT of the accelerometric signal in the Elettra experimental hall without cooling water circulating.

Two conditions have been measured: with and without water circulating in the cooling system. The measurements showed that the two profiles become markedly different above 300 Hz.

The FFTs were doubly integrated to obtain the corresponding displacement values (µm).

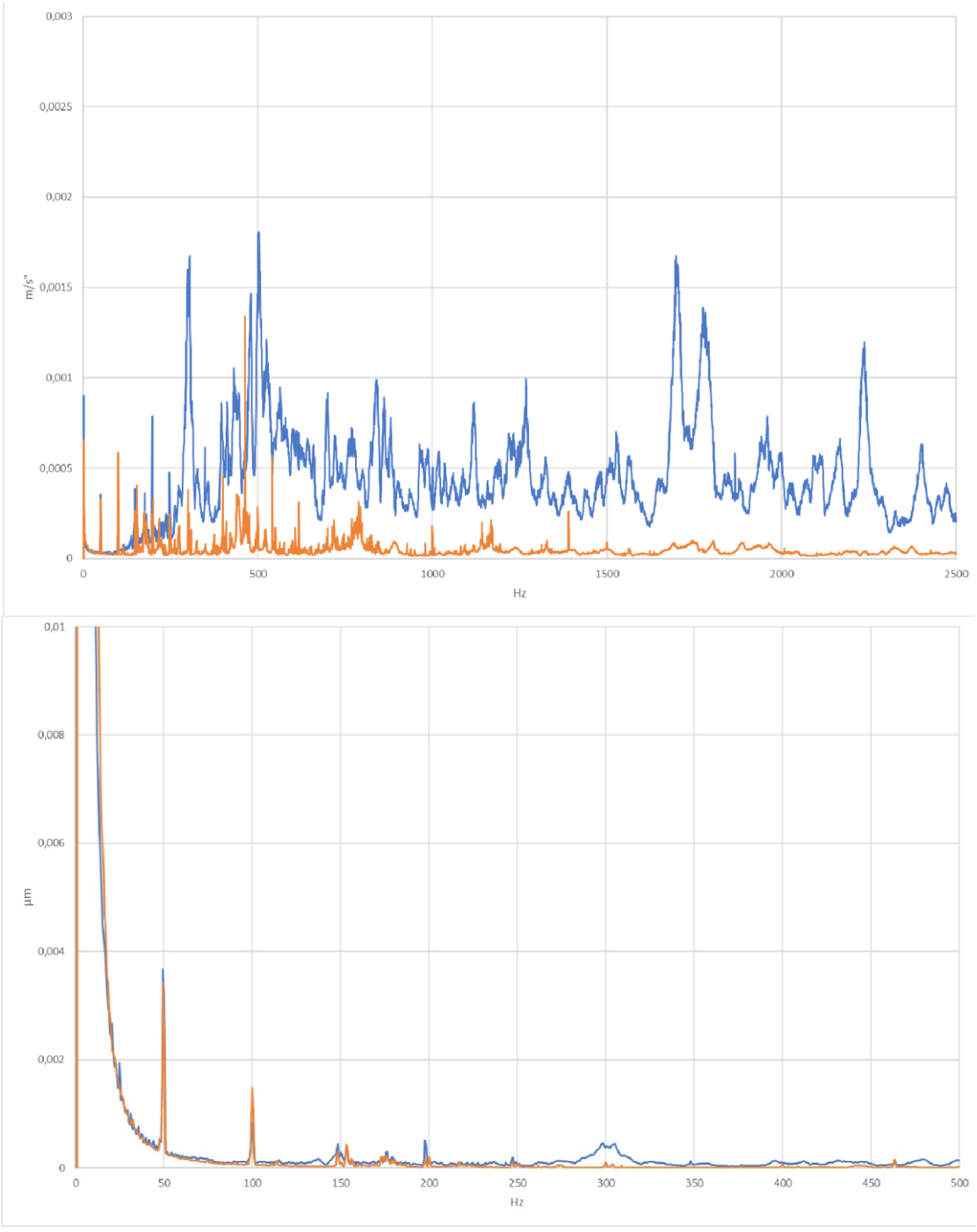

Fig.2 FFT accelerometric signal (above) and its double integration (below) in the Elettra experimental hall with (blue curve) and without (orange) cooling water circulating.

The high value of the displacement value for frequencies lower than 20-30 Hz is due to the double integration process of an accelerometer-type signal.

The frequency of 50Hz (European electrical mains frequency) and its harmonics are evident in the graphs as well as the frequencies due to the cooling system. Nonetheless, the measurements confirmed the weak ground vibrations at the Elettra site, thanks to its geological conformation.

3 VIBRATION ACCEPTANCE TESTS

As previously stated Elettra has equipment to measure natural frequencies of structures and their amplification factors.

A test of the dynamic response of all vibration sensitive components will be carried out in our laboratory. Examples of such components are: granite girders, that can lead to performance weakening and orbit deviations; optical elements, such as mirrors, that can deteriorate the photon beam properties at the sample.

4 STABILITY STRATEGIES AND GUIDELINES

The ambient vibrations are not a general issue, but floor motion, the flow of the cooling water, air conditioning, power supplies, mains disturbances and other sources excite the vibration modes of every single component [1].

To minimize the vibrational amplitudes of mechanical components, they must be stiff, in the sense that their natural frequencies must be far from the exciting frequencies, so the amplification factor remains low and the structure only follows and does not magnify the vibrations' amplitude. [2]

Every manufacturer must verify that the design of critical components has natural frequencies far from the peaks showed in Fig.2 by means of modal simulations and vibration measurements of the mechanical systems. All optical components, including stands, manipulators and holders must have high natural frequency for Eigen modes and above 55Hz. The optical components should be designed to work below 20 nm RMS for all frequencies higher than 10 Hz.
Stable supporting systems must reduce the impact of ambient and external sources of vibrations.

The connection to the floor is essential to have a good stability performance, and grouting must be properly executed. All the screws must be firmly tightened. The adjustment screws and kinematic systems must be 'oversized'. Disc springs must be preferred to others to push the aligned object back against the screws, and to counteract backlash in the kinematic chain. Integrated mechanical systems must be preferred to "Stacked Systems".

Ion and turbo pumps must be mechanically isolated from the chambers by bellows and with separated and dedicated supports.

[1] Philippe Marion, Loys Goirand, Jean-Claude Biasci, "The ESRF new storage ring project main features and mechanical design aspects", in Proc. MEDSI2014, Melbourne, Australia, Oct. 2014.

[2] L. Zhang, “Beam stability consideration for low emittance storage ring”, in Proc. Workshop on Ambient Ground Motion and Vibration Suppression for Low Emittance Storage Rings (GM 2017), Beijing, China. Dec.
2017. pp. 11-13