Modal Analysis of the Pre-isolator Support

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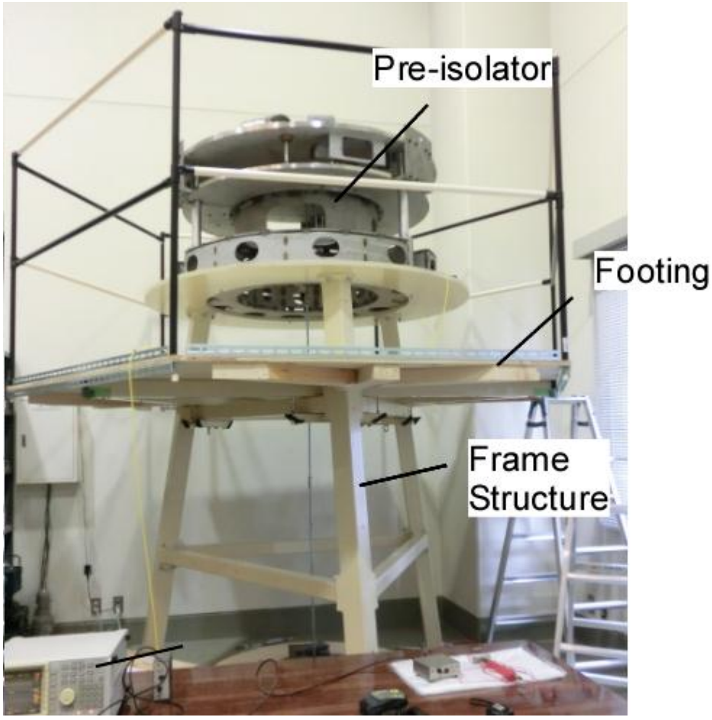
System Overview



Setup

Modal hammer (Endevco 2302-5, S/N 2613) with an amplifier TEAC SA-610

FET: ~99.9, Current: 3 mA, Sensitivity: 115 mV/G – pc/G

LPF (1 kHz): ON, CAL: OFF

Accelerometer (TEAC 710, A274) with an amplifier TEAC SA-610H

FET: ~9.9, Current: 0.5 mA, Sensitivity: 270 mV/G – pc/G

LPF (1 kHz): ON, CAL: OFF

FFT servo analyzer (ADVANTEST R9211C)

Mode: FRT, f-Range: 100Hz, CHA→Hammer, CHB→Accelerometer

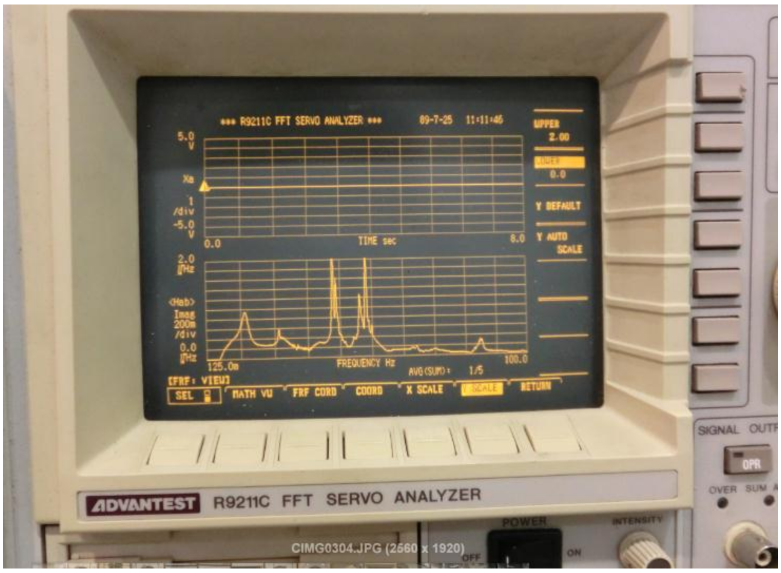
CHA Sensitivity: +10dB, CHB Sensitivity: -5 dB

Coupling: AC, Filter (anti-aliasing): ON, ICP: OFF

Trigger: CHA, slope (+), level=314.44 mV, hysteresis=34.93 mV, delay=-3.9 msec

CHA Window: Force Window (2 ~ 102 msec)

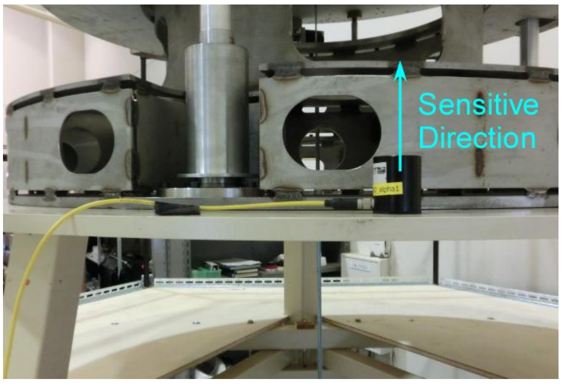
CHB Window: Response Window (2 msec start, damping=2000 msec)



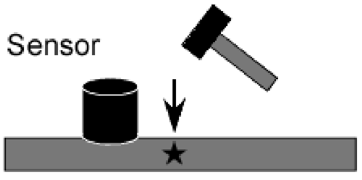
Measurement Sequence

1. Put the accelerometer on the frame structure.
2. Hit somewhere on the frame by the modal hammer.
3. Signals from the sensor and hammer are collected to the servo analyzer.
4. Transfer functions (from the force signal to the sensor signal) are calculated.
5. See the imaginary part of the transfer function and read out the frequencies and amplitudes of the peaks.

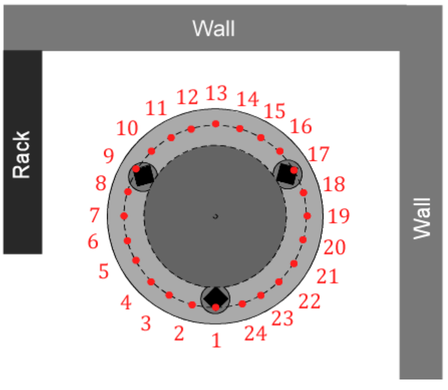
Investigation on vertical modes of the top frame:



1st Step: Put the accelerometer on the top frame, and hammer nearby the sensor.



Change the sensor position and see the frequencies & amplitude of the resonant modes

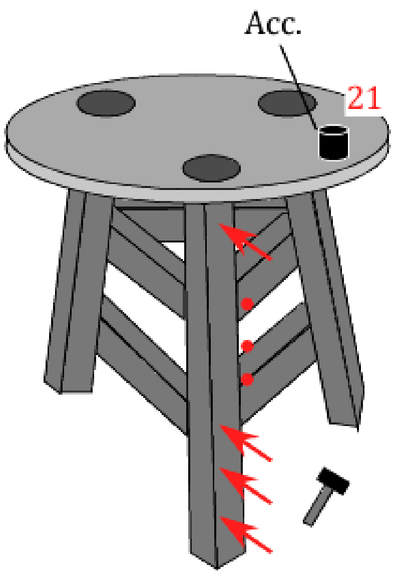


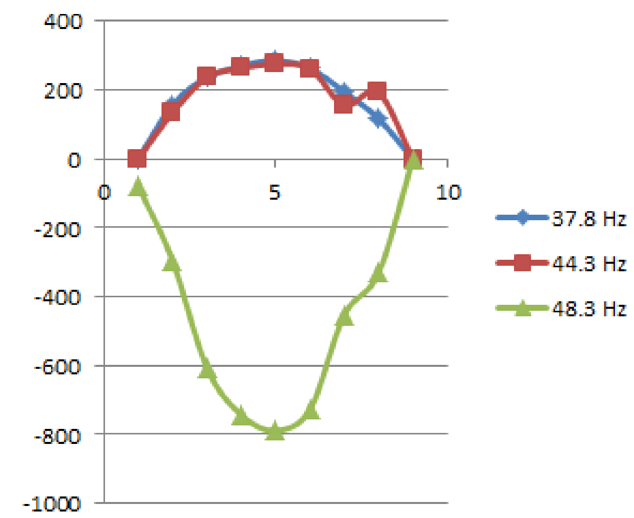
Here are the resonant frequencies (and the place where the amplitude becomes the largest) found by this measurement.

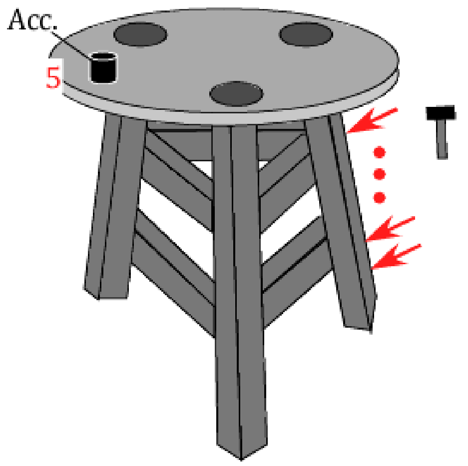
37.8 Hz (21), 39.6 Hz (5), 44.3 Hz (23), 46.3 Hz (5), 48.3 Hz (21),
54.0 Hz (13), 55.9 Hz (13), 56.5 Hz (13), 63.6 Hz (13), 65.5 Hz: (13)

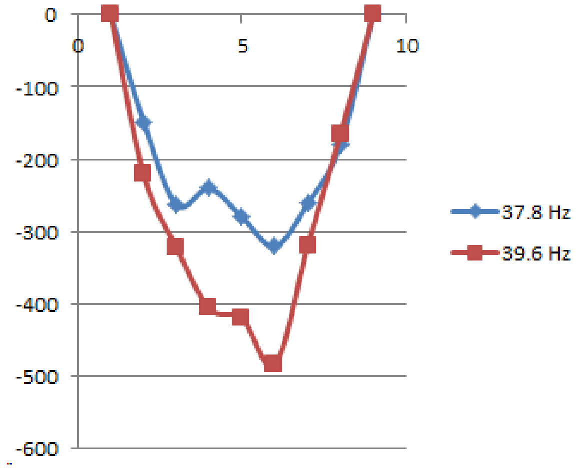
Blue ones, which are mostly found around No. 13, are associated with the resonances of the footing. These modes are strongly excited when you hammer the footing board. Other 5 resonances are associated with the bending modes of the legs.

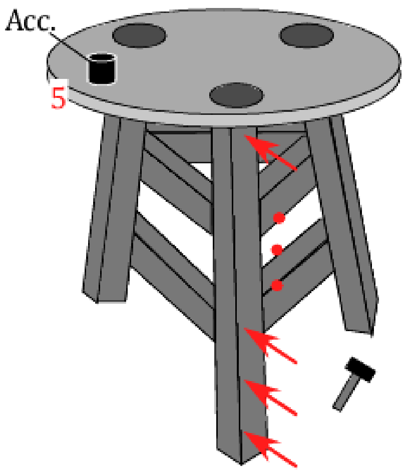
2nd Step: Put the accelerometer where the bending modes are excited (No. 5 for 39.6, 46.3 Hz and No. 21 for 37.8, 44.3, 48.3 Hz). Hammer the legs of the structure, changing the height of the hit position (from bottom to the top).

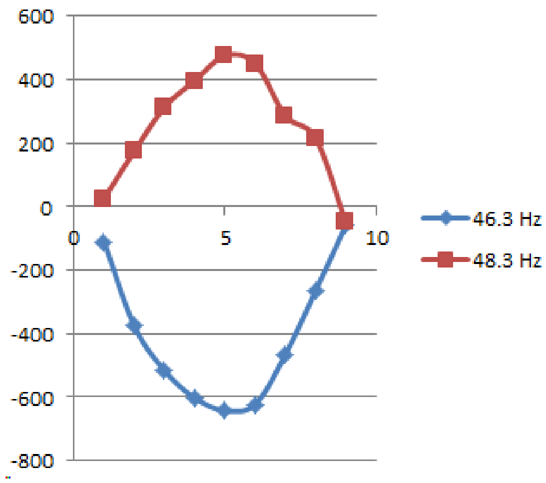




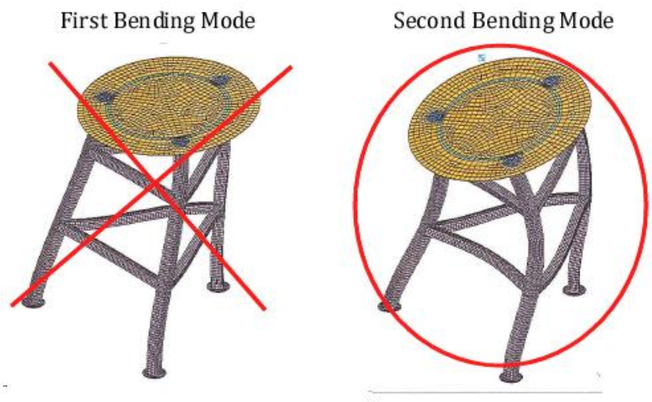




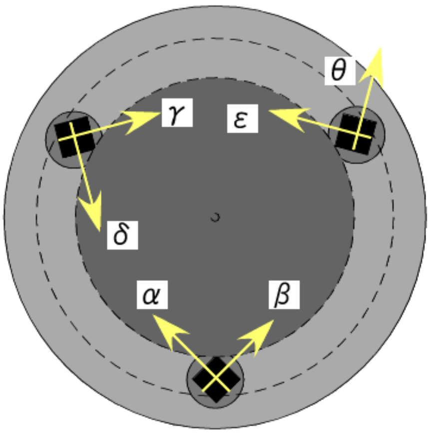




We found nodes at the both ends of the leg. It indicates that these are not the primary bending modes, but the second bending modes of the structure.

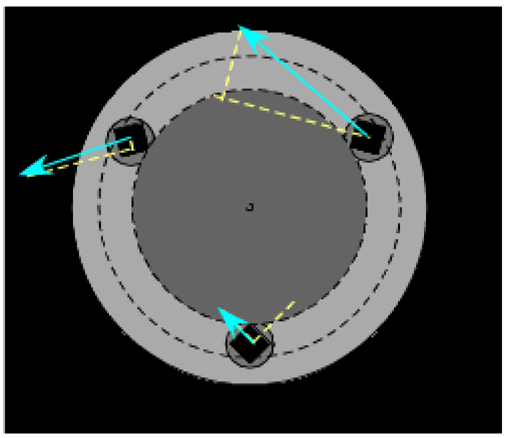


3rd Step: Put the accelerometer where the bending modes are excited. Hammer the middle of each leg in two directions. From the ratio of the amplitude of the peaks in two directions, determine the directions of the leg displacement in each resonance.

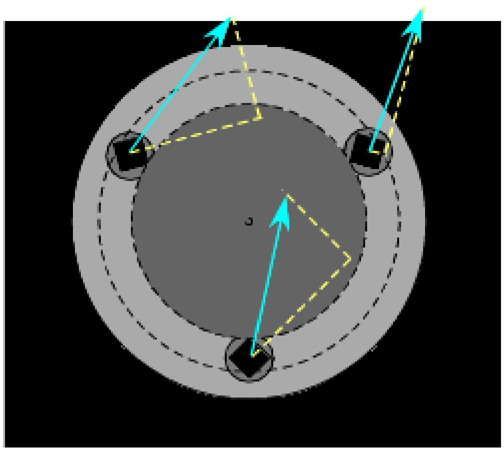


Here are the direction and amplitude of the leg displacement in each resonant mode.

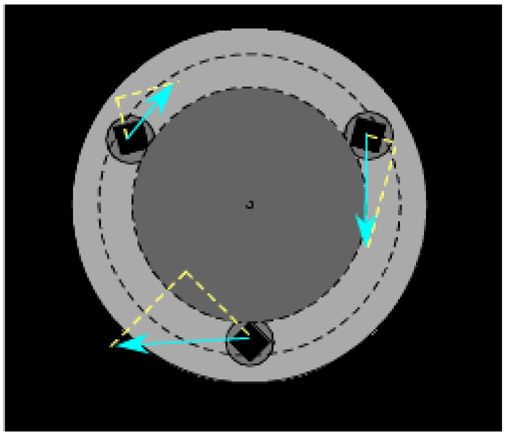
37.8 Hz



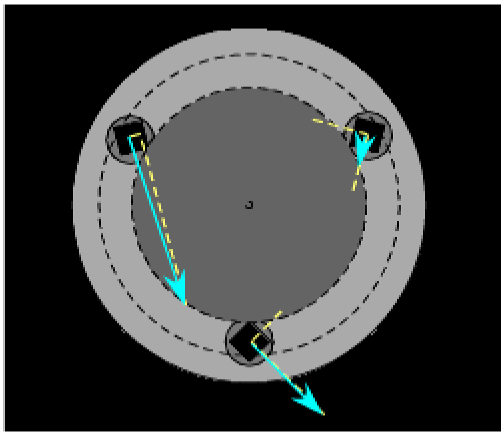
39.6 Hz



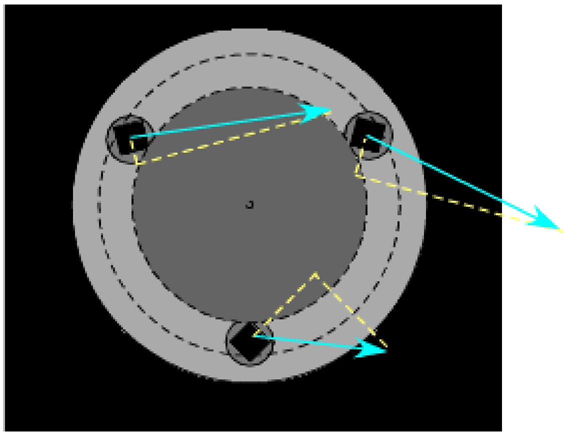
44.3 Hz



46.3 Hz

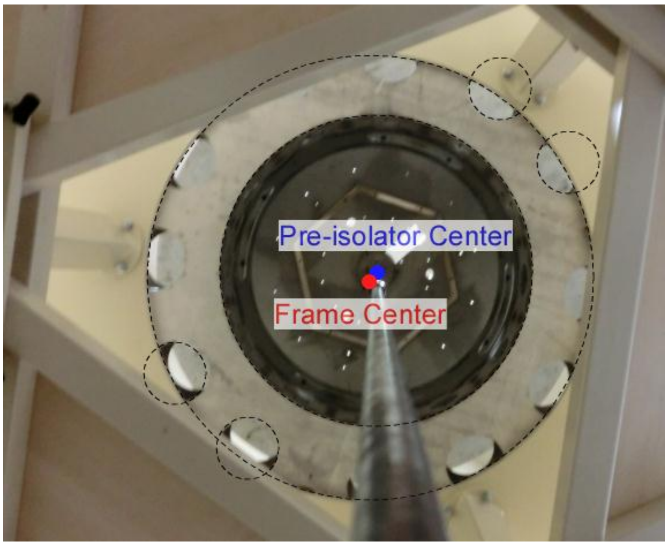


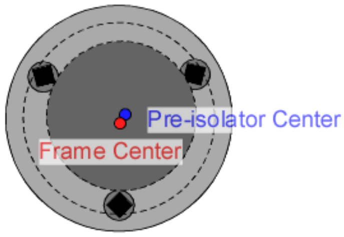
48.5 Hz



39.6 and 48.3 Hz are the 2nd bending modes. 44.3 Hz is the 2nd torsion mode. 37.8 and 46.3 Hz are funny modes: two legs move, but one leg does not move largely.

Two bending modes are split largely in frequencies (39.6 and 48.3 Hz), because the pre-isolator is not perfectly centered on the frame structure (see the picture below) and the system is not symmetric. The funny modes (37.8 and 46.3 Hz) may come from this asymmetry.





4th Step: In order to see the deformation of the top frame,

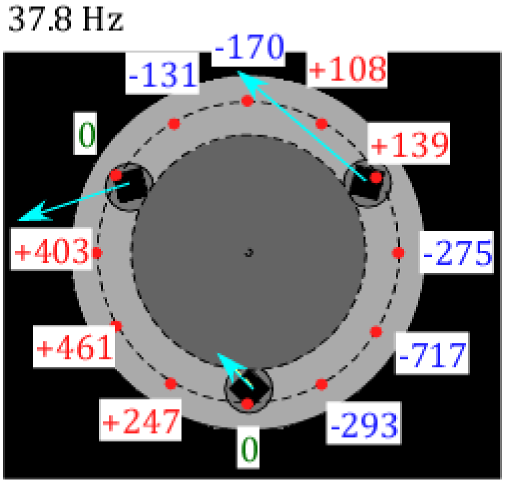
1. Hammer the same position of one leg, changing the sensor position on the top frame.

OR

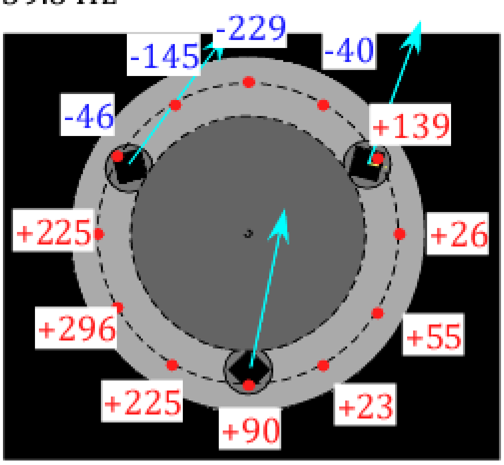
2. Put the accelerometer in the same position, and hammer the top frame at various points.

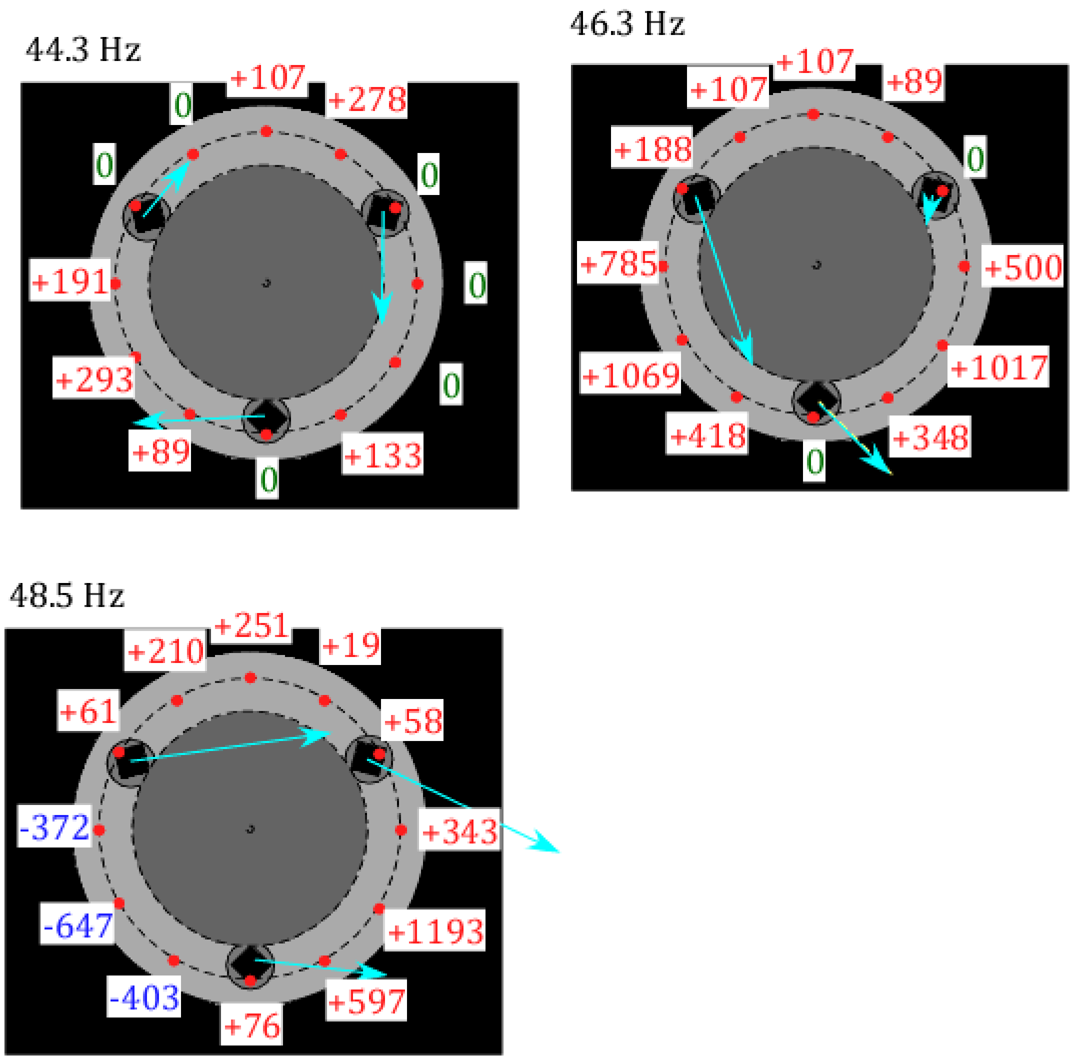
Here are the vertical displacements on the top frame in each mode, accompanied with the bending direction of the legs. (Positive: up, Negative: down)

37.8 Hz



39.6 Hz





In most cases, the vertical displacement in the leg position is ~zero.

Summary

We find 5 resonances associated with the bending modes of the legs, and several resonances associated with the bounce of the footing. The bending modes are not symmetric, because of the miscentering of the pre-isolator and the frame structure.