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Determination of the natural frequencies of vibration of geodetic pillars with a COTS seismometer

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Introduction

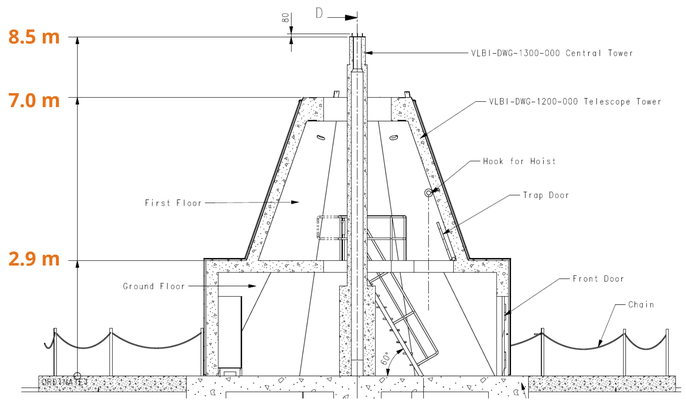
The stability of geodetic monumentation is critical for the ultimate performance of the associated instrumentation. In the case of large pillars supporting heavy telescopes, attention must be given to the study of their natural frequencies of vibration. The presence of resonance conditions might adversely affect the mount control loop, compromising its performance.

COTS seismometer

At Yebes Observatory, we have developed a seismometer based on COTS 3-axis MEMS (microelectromechanical systems) accelerometers [1].

- ±2g/±4g/±8g dynamically selectable full-scale
- 400 Hz sampling rate (max. 1 KHz), 12-bits resolution
- Triple redundancy for averaging and filtering
- Raspberry Pi controlled
- Low-cost addition to the regular seismometer network

The pillar



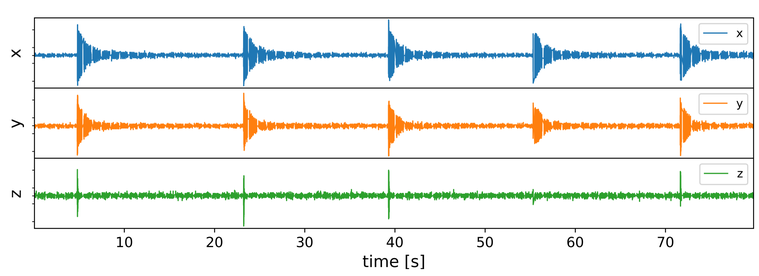
Pillar inside the VGOS radiotelescope at Yebes Observatory. Used for testing the method.

Method

Measure the impulse response of the pillar, exciting it with impacts at different heights.

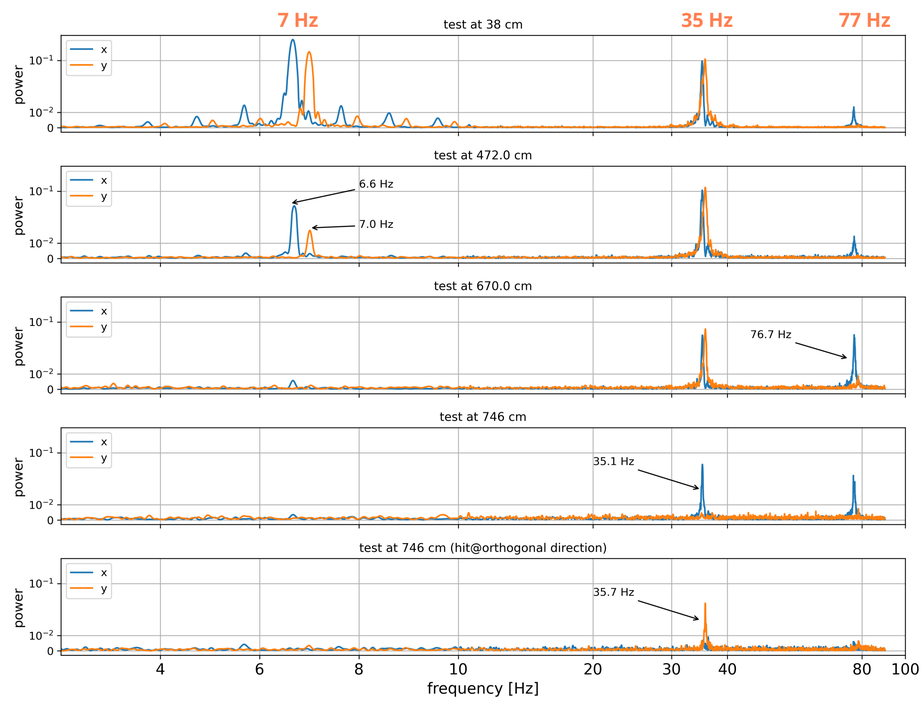
After a short period, the structure vibrates according to its natural modes, and the time series are captured by the accelerometer.

Signal to noise is improved by averaging in the frequency domain.



Time series of one experiment, with impacts at ~15 s intervals.

Results



Periodograms obtained exciting the pillar at different heights and orientations.

The frequencies obtained correspond to the lowest horizontal modes of vibration of the pillar (7, 35, 77 Hz)

These agree reasonably well with those expected for a simple structure, for which simple mathematical expressions are available [2].

Conclusions & Future Work

A. Inexpensive accelerometers are suitable for the determination of the vibrational behaviour of geodetic monumentation.

B. We have characterised the normal modes of a large geodetic pillar.

C. We plan to determine the frequencies of vibration of the **SLR** pillar at the new station in Yebes, to ascertain that no problems can arise during operations.

D. The empirical determination of the normal modes of these structures is advisable: the disparities between model predictions and the measurements can some times be considerable.

[1] M. Patino Esteban et al. *Diseño del circuito impreso prototipo para un acelerómetro basado en tecnología MEMS*. Yebes Observatory Technical Reports, IT-CDT 2013-5

[2] Young & Budynas. *Roark's Formulas for Stress and Strain*, McGraw-Hill, 2002