POLITECNICO DI MILANO

Measurements

Power spectrum and PSD

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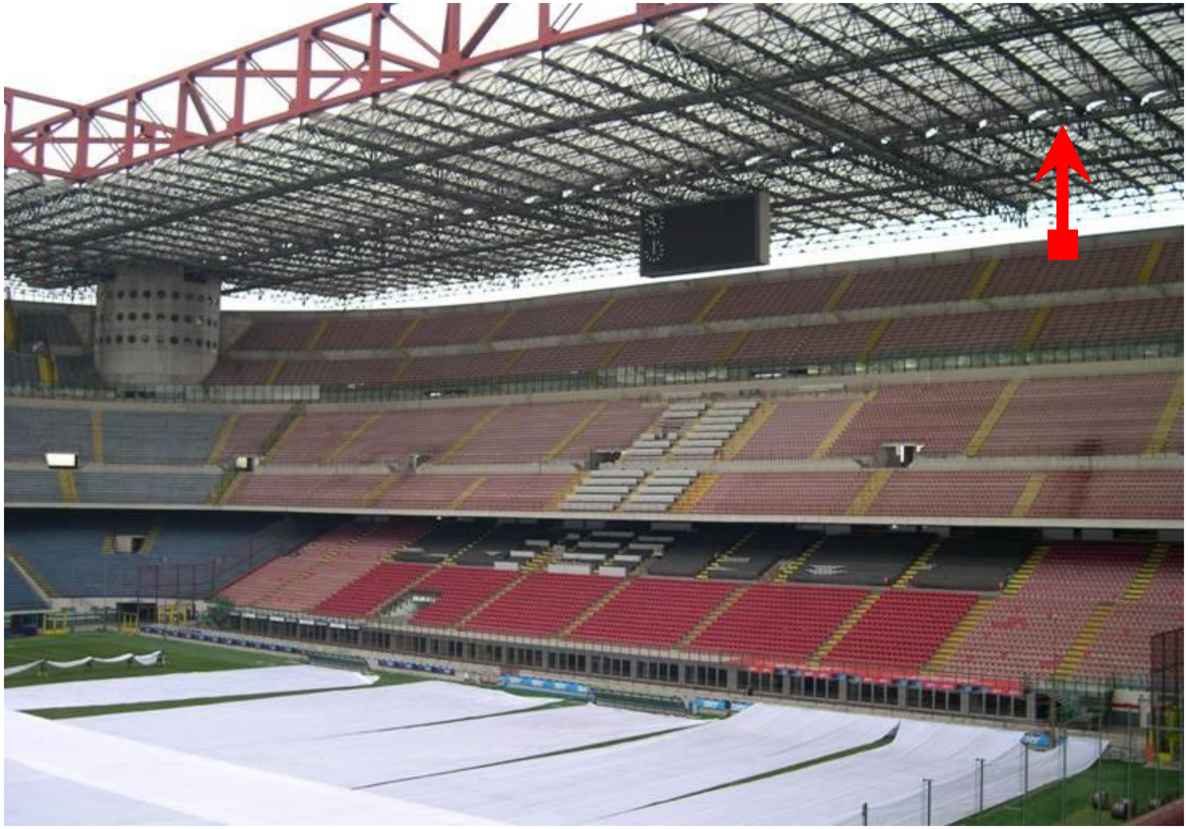
Course website

- Measurements on Beep

Vibration measurements – Meazza stadium

The S. Siro stadium in Milan is equipped with a permanent monitoring system that measures the vibrations of the structure h24.

We will analyse the vertical vibrations of a stand of the third ring, measured by the monitoring system.



Problem

We will work on a **time history coming form an accelerometer** used to monitor the vibration of the Meazza stadium

The structure is **forced by ambient vibrations** like wind, traffic, people…, thus **the forcing term can be considered random**

Therefore also the measured **response** of the structure to this kind of excitation can be considered **random**

How is it possible to have information on the main frequencies that characterize the response signal (natural frequencies)?

Problem: the spectrum of the signal cannot be easily interpreted as it is

It is possible to perform an **average** process on several sub-records of the original signal.

There are **3 different ways** to do the average process on the signal:

- ✓ ~~in the time domain~~
- ✓ in the frequency domain in terms of **complex numbers**
- ✓ in the frequency domain in terms of **power spectrum**

Power spectrum:

$$S_{AA}(f_k) = E\left[\hat{A}_j^*(f_k)\hat{A}_j(f_k)\right] =$$

$$= \lim_{n_d \to \infty} \frac{1}{n_d} \sum_{i=1}^{n_d} \hat{A}_i^*(f_k)\hat{A}_i(f_k)$$

PSD:

$$PSD_{AA} = \frac{S_{AA}(f)}{\Delta f} = \frac{A^*(f)A(f)}{\Delta f} \qquad \Delta f = \frac{1}{T}$$

Laboratory 06

- Load the data file and plot the time history
- Plot (semilogy) the modulus of the spectrum, the power spectrum (conj) and the PSD applying the DFT to the whole record.
  Limit the plot to the frequency range 0.5 - 10 Hz. (xlim)
- Apply the average process:
  - ✓ in the frequency domain in terms of **complex numbers**, then calculate the power spectrum
  - ✓ in the frequency domain in terms of **power spectrum**
- Plot the power spectra calculated in the previous point for different frequency resolutions (for example 0.1 Hz and 0.05 Hz)
- Calculate the PSD for different frequency resolutions

Laboratory 06 - Questions

- Do you think the use of a **window** on the original signal is needed before calculating its Fourier transform?

- What is it possible to notice by comparing the **power spectrum obtained by an average process on the spectra** and **the average power spectrum**? Which is the right approach considering that the signal under analysis is **random**?

- What can be noticed by comparing the **power spectrum** and the **PSD** with varying the frequency resolution? Which is the right approach to follow considering the signal under analysis?

- If the signal were **periodic** the conclusions would be the same?