POLITECNICO DI MILANO

MEASUREMENTS

Signal processing: time domain analysis

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Course website

- Measurements on Beep

Vibration measurement – Disturbance to people

Problem

After the end of the maintenance work on the railway tracks aimed at strengthening the ballast (foundation), some inhabitants began to complain about the disturbance caused by the passage of trains.

Survey and analysis have been performed basing on the Italian standard UNI 9614 *“Misura delle vibrazioni negli edifici e criteri di valutazione del disturbo”. (Vibration Measurements in buldings and criteria for the disturbance analysis)*

Vibration measurement – Disturbance to people

Measurements layout: characteristics

• 1 measurement point for each floor of the building

• for each mesaurement point the measurement have to be recorded in 3 directions, following the main axes of the building;

• the measurement points have to be chosen in correspondence of the yielding parts of the stucture (e.g. The centre of the slab)

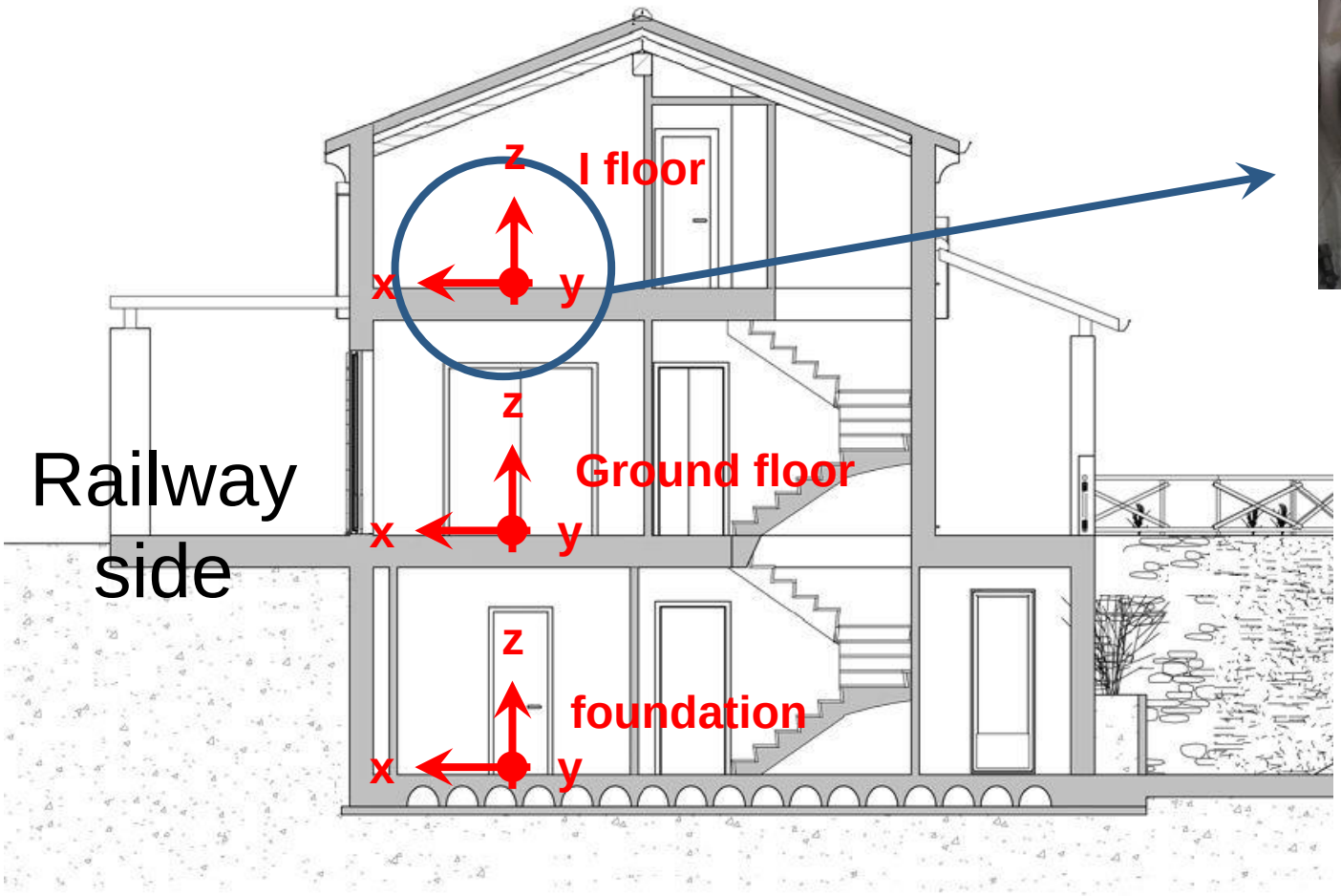
Instruments:

• servo-accelerometers

• 16 bit acquisition system, sampling frequency 1024 Hz, anti-aliasing filter 340Hz

Vibration measurement – Disturbance to people

Measurements Layout



Vibration measurement – Disturbance to people

The analisys include:

For each accelerometer point:

1. Calculate the root mean square value of the signal of a 60s record;

2. Calculate the signal crest factor;

3. If the crest factor value is less than 6 compare the root mean square of point 1 with the UNI 9614 limit;

4. If the crest factor is higher than 6 calculate the RMS on a travelling window of 1 s and compare the maximum RMS value with the limit of the standard;

Vertical Limit	[dB]	89
Horizontal Limit	[dB]	87

Vibration measurement – Disturbance to people

5. Evaluate the signal to noise ratio of the given signal and check that it is higher than 10 dB

$$S2N = 20\log_{10}\left(\frac{rms(S+N)}{rms(N)}\right)$$

You can handly select 2 different parts of the signal:

- one when the train is in transit
- one in a quite moment (the train is not passing near the building)

(Matlab: ginput)

Vibration measurement – Disturbance to people

RMS

Root mean square of a signal

$$rms = \sqrt{\frac{1}{N}\sum_{i=1}^{N} y_i^2} = \sqrt{\mu^2 + \sigma^2}$$

It represents the average power of the signal in the considered time window

CREST FACTOR

$$CF = \frac{\max|y - \mu|}{rms(y)}$$

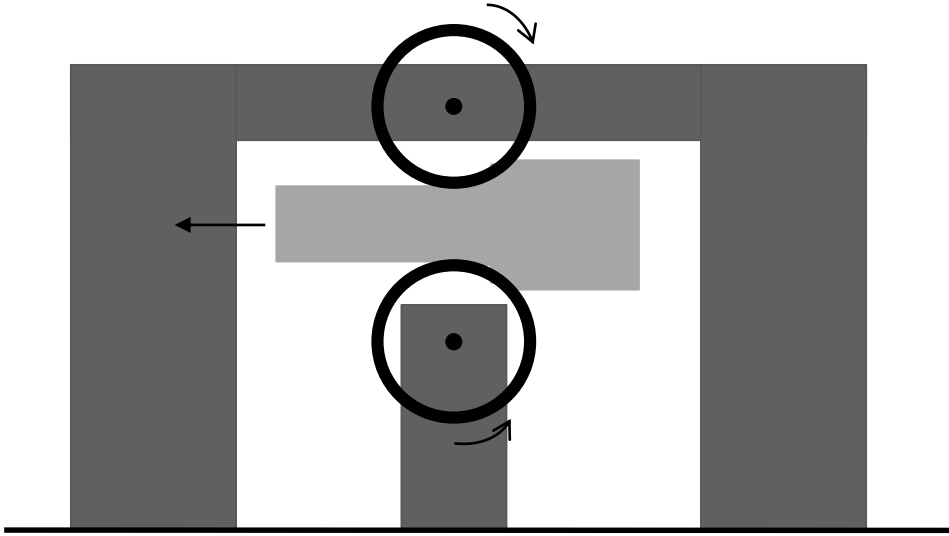
It can highlight the presence of impulses in the signal

DECIBEL

$$rms_{dB} = 20 \cdot \log\left(\frac{rms}{a_{ref}}\right) \qquad a_{ref} = 1 \times 10^{-6}\ m/s^2$$

Minnum vibration level that can be percieved by the human body

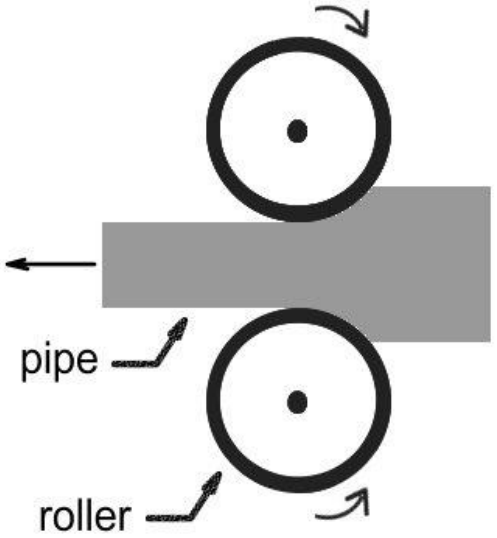
Strain gauge measurements on a rolling mill



Strain gauge measurements on a rolling mill

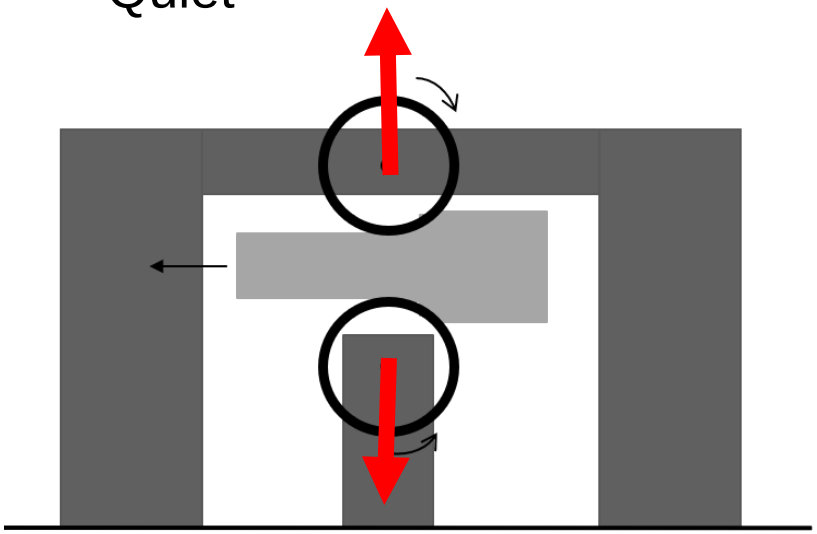
Problem

measure the force that the pipe transmits to the rollers



Phases of the phenomenon

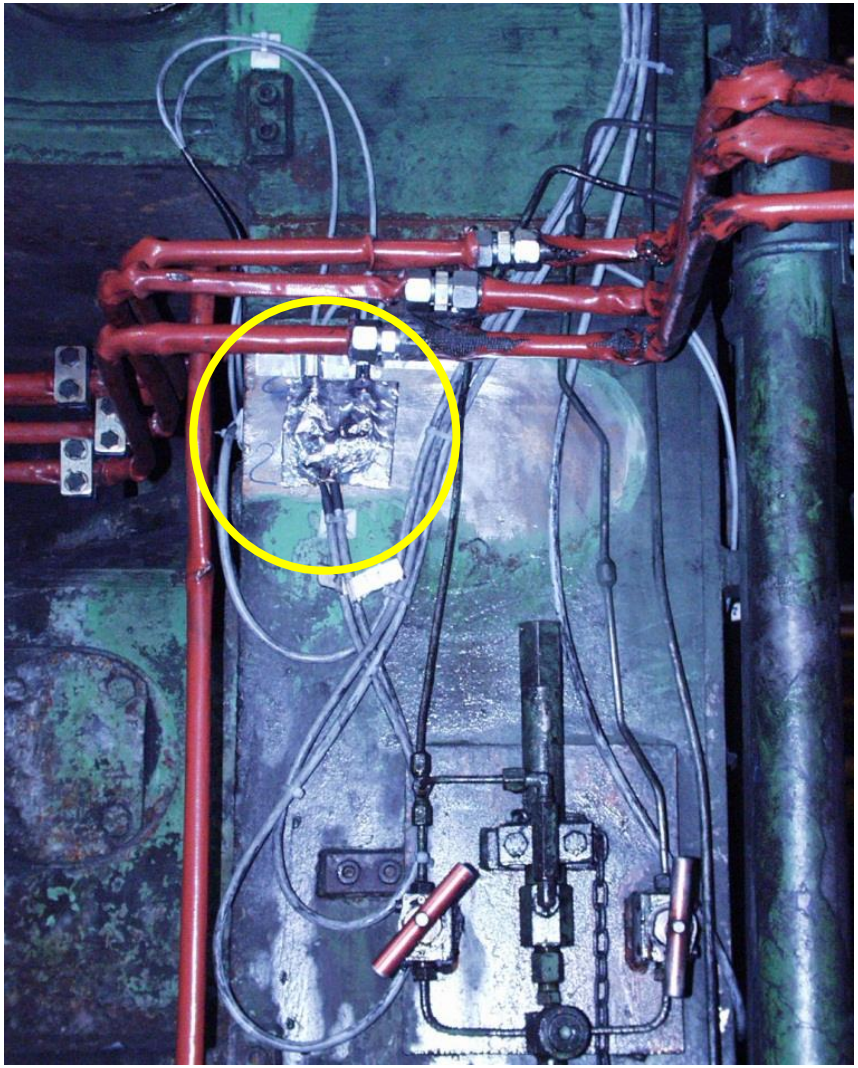
- Quiet
- The pipe enters in the rolling mill (entering transient)
- The pipe is in grip condition (steady state condition)
- The pipe exit from the rolling mill (exit transient)
- Quiet



- The lower roller transmits the force to the ground
- The higher roller transmits the force to the frame; therefore the columns are subjected to traction

Strain gauge measurements on a rolling mill

A strain gauge bridge is installed on each of the four columns



Strain gauge bridge

Strain gauge measurements on a rolling mill

The relatioship between the outuput of the strain gauge bridge and the force is known by means of a calibration procedure

System calibration by using an hydraulic jack

In operating conditions, the force on each of the four columns is measured by means of the strain gauge bridges using the calibration curve

Rolling mill
Signal processing in the time domain

1. Plot the time histories of the traction forces on the 4 columns of the rolling mill frame.
2. Calculate the mean, the standatd deviation and the RMS of the whole signal for 1 of the columns.
3. Evaluate the mean, the standard deviation and the RMS on travelling windows of 1 s of the same channel.

- Relating to this application does it make sense to compute the average on the whole signal?
- What should I look at if I am interested in estimating the average force?
- What does the travelling RMS represent in this application?
- How can I only represent the dynamic part of the phenomenon?