Data analysis for mechanical system identification

FRF - impulse

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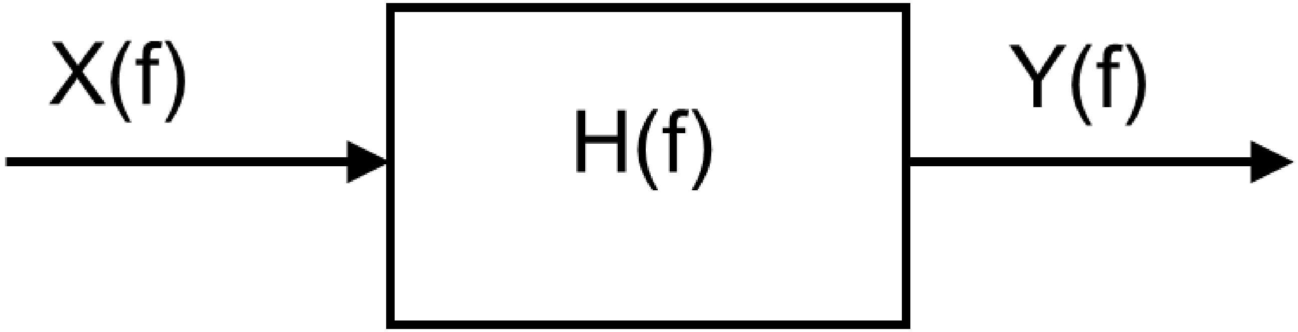
The experimental evaluation of the dynamic response or of the frequency response function (FRF) of any mechanical system requires the application of some dynamic forces to the system itself.
There is no theoretical restriction on waveform, or on how the excitation is implemented.

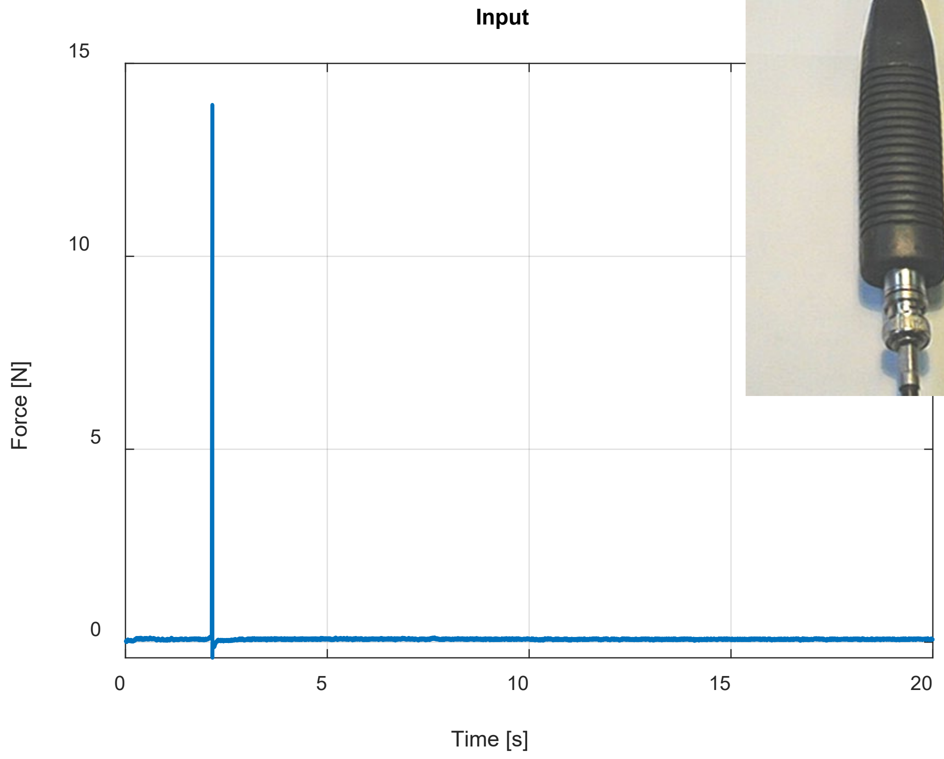


- X(f) = F(f): input force
- Y(f) = system response

Impact hammer

Advantages

- speed - only a few averages are needed;
- no elaborate fixtures are required;
- there is no variable mass loading of the structure;
- it is portable and very suitable for measurements in the field;
- it is relatively inexpensive.



Drawbacks

- high crest factor (non-linear behaviour)
- Not suitable for large structures
- Coherence function does not show leakage or non-linear behaviour
- the spectrum can only be controlled at the upper frequency limit.

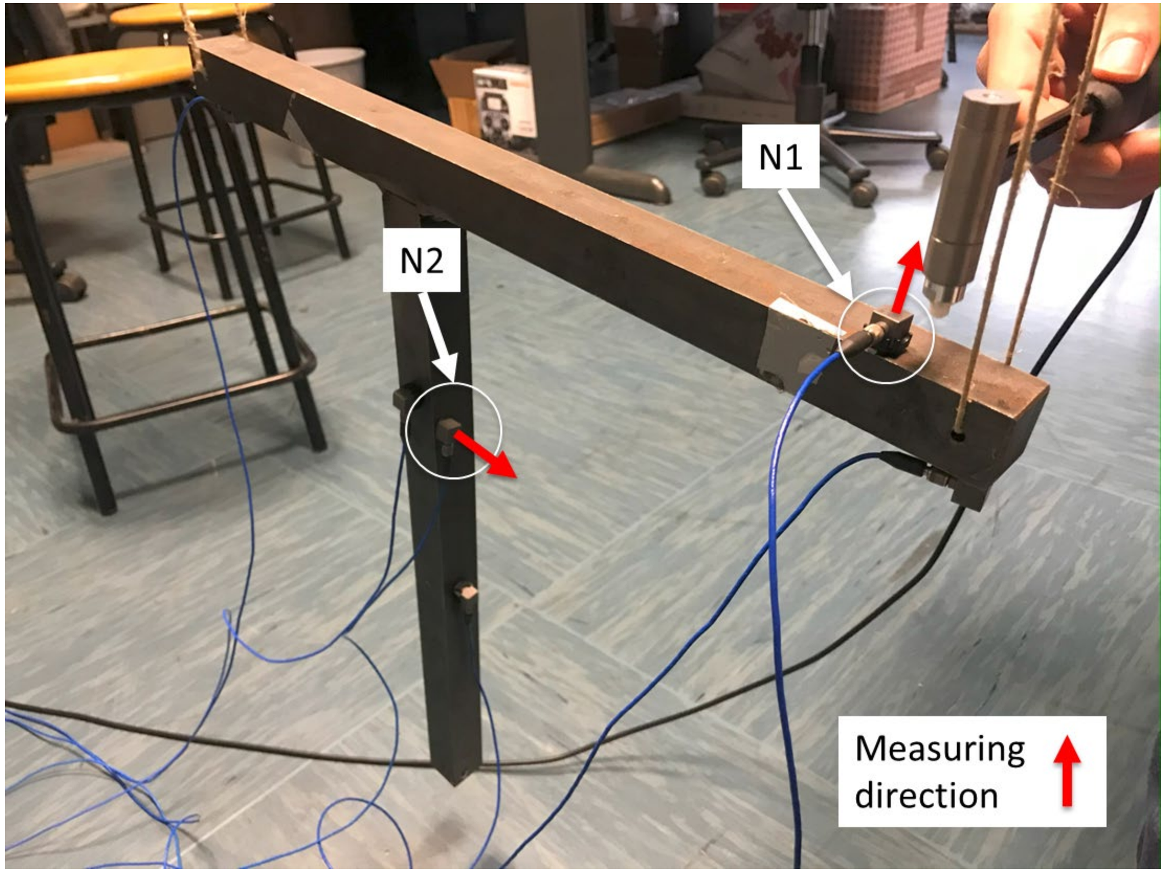
Sensors, actuator and acquisition system

Sensors
6 x piezo-electric accelerometers (PCB 333B30)
Type: uniaxial
Measurement Range= 490 m/s^2 pk
Frequency range: 0.5 to 3000 Hz
Sensitivity: 1.02e-2 $V/[m/s^2]$

Actuator
Impact hammer (PCB 086C03)
Sensitivity: 2.40e-3 V/N

Acquisition system
2 x NI 9234 board with anti-aliasing filter
Sampling frequency: 5120 Hz

The experimental set-up
Impulse location and measuring direction



The impulse is provided in proximity of <u>node N1</u>. The test was repeated <u>10 times.</u>

To do list

1. Build a MATLAB script that allows the analysis of data collected during an impact-hammer test.

   The **input** of the script are multiple .mat files, each containing the data related to every single test.

   The **output** of the script are the following plots (for each node input/node out combination):
   - H1 (modulus and phase)
   - H2 (modulus and phase)
   - Coherence

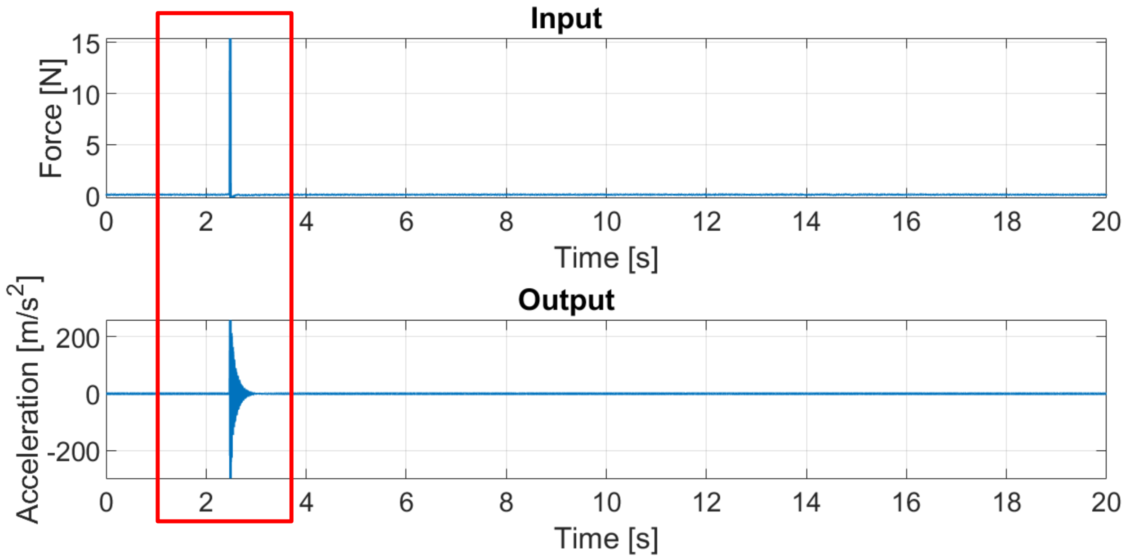
   as function of the frequency.

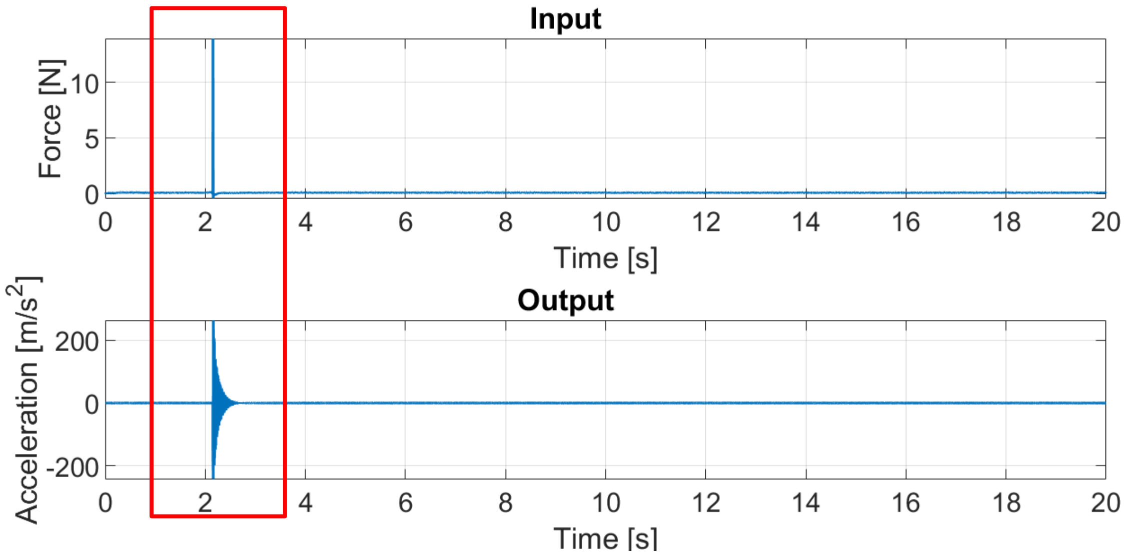
2. Use the script on the provided data: interpret the results by comparing the FRFs related to different output nodes.

To do list

Pay attention: each .mat contains data characterized by the same duration (in this case, equal to 20 s). However, the impulse starts at different time for each .mat file.

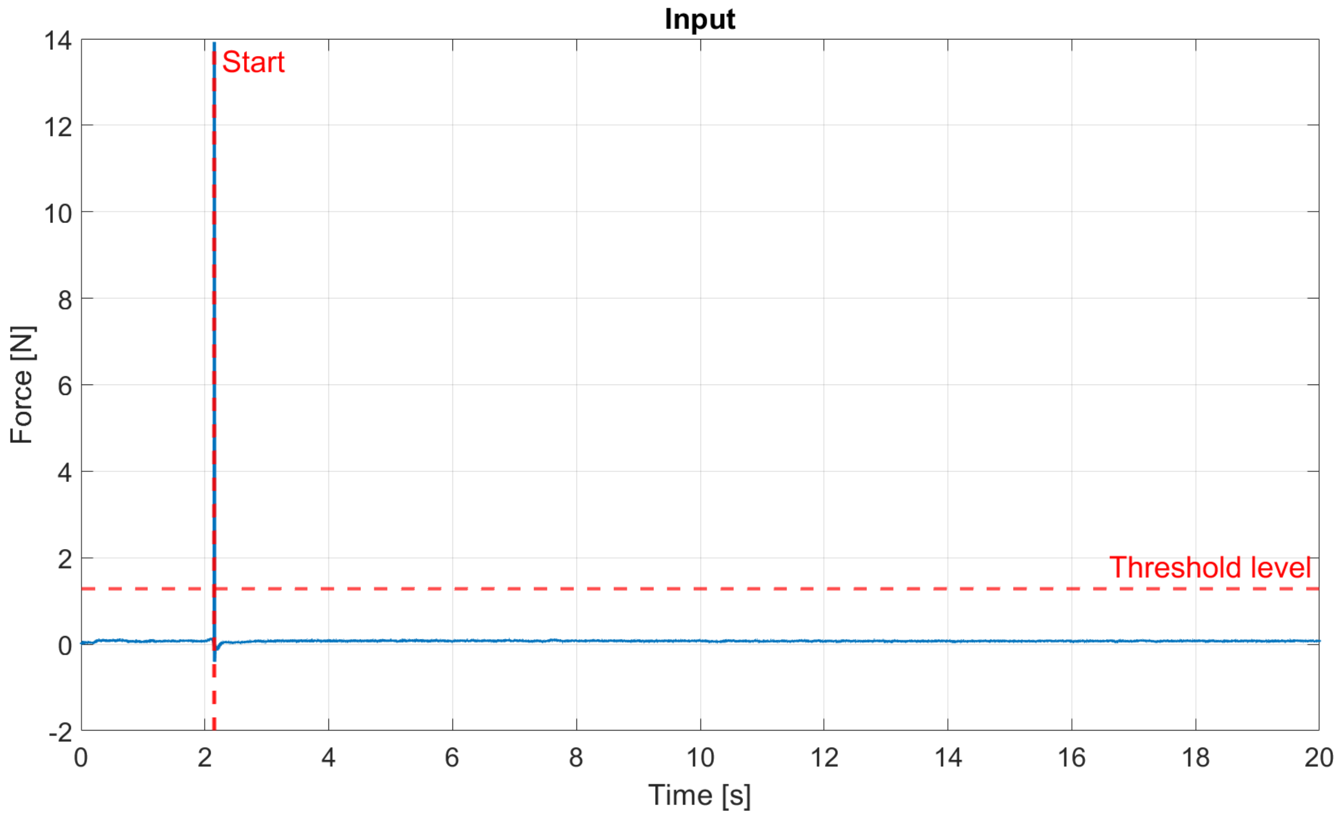
Example:





To do list

Therefore, develop a post-processing strategy that mimics the adoption of a trigger to automatically detect the beginning of the event on the force signal (define a **threshold level** and a pre-trigger time)



To do list

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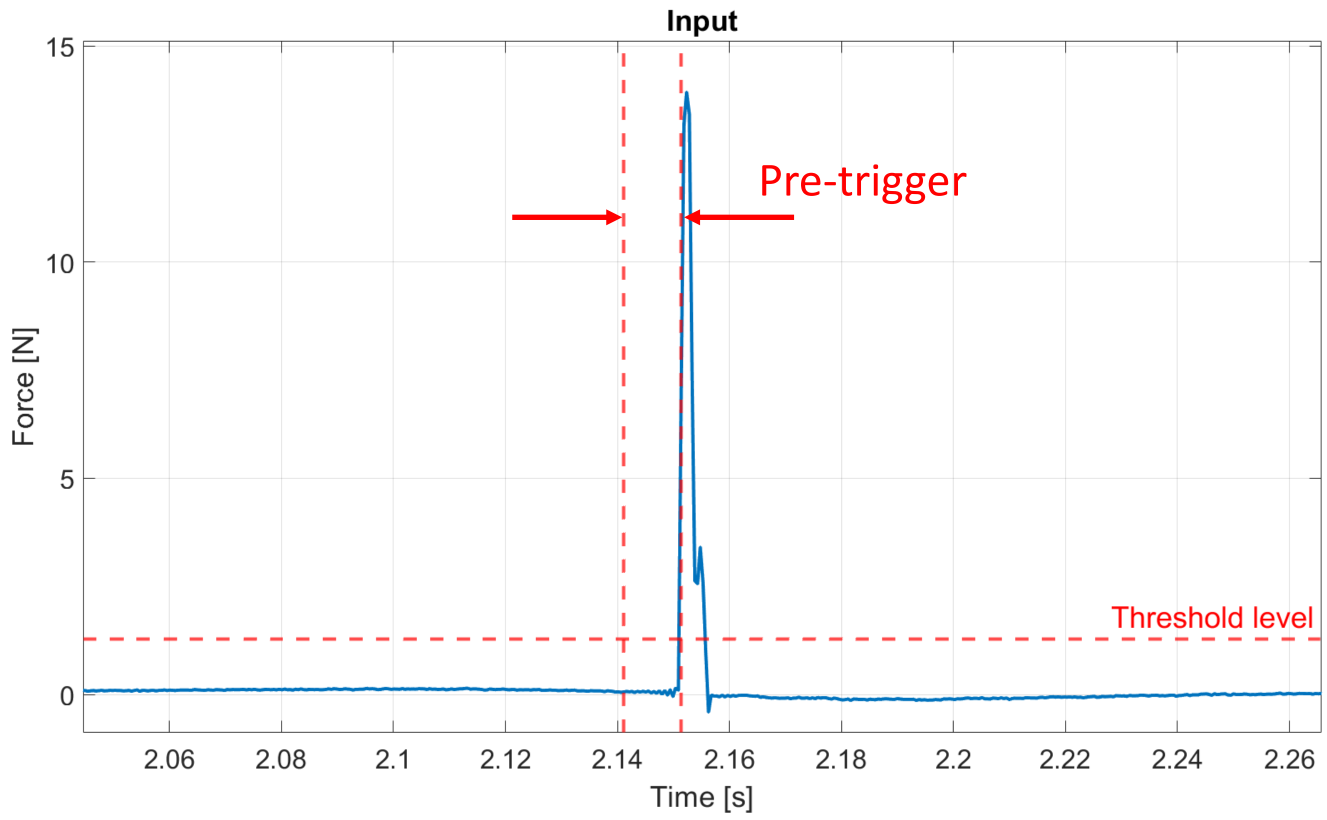
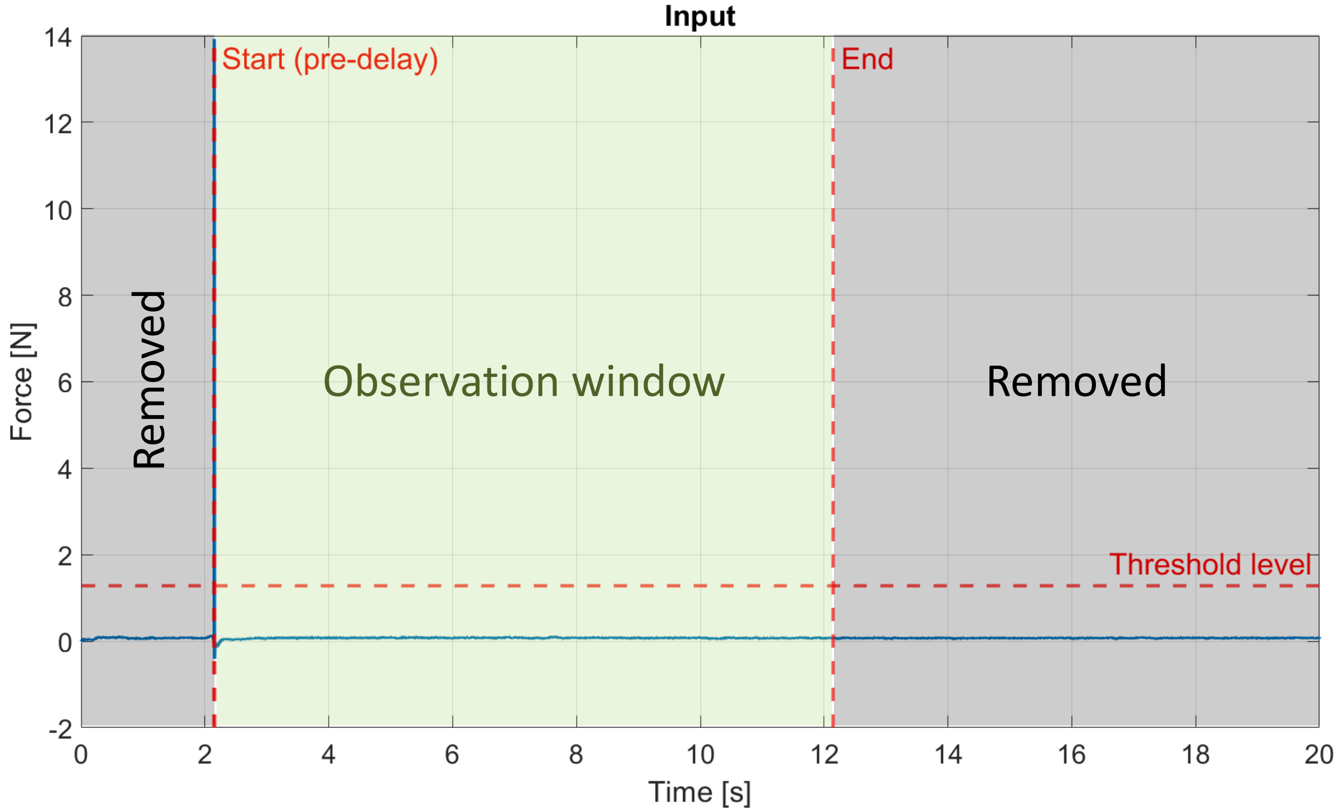
Zoom



To do list

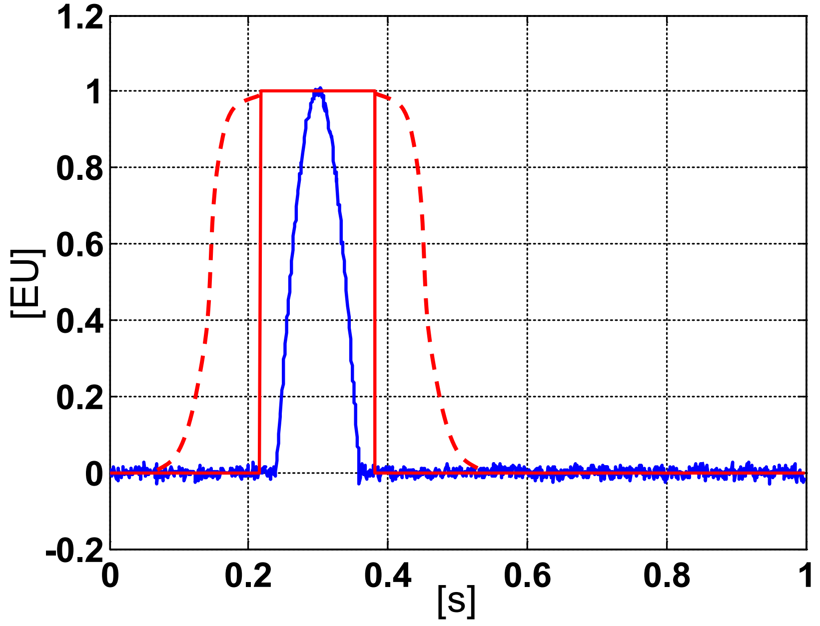
Once the beginning of the event is detected, cut all the signals (force and acceleration signals) by setting a **fixed duration** for the final observation window.



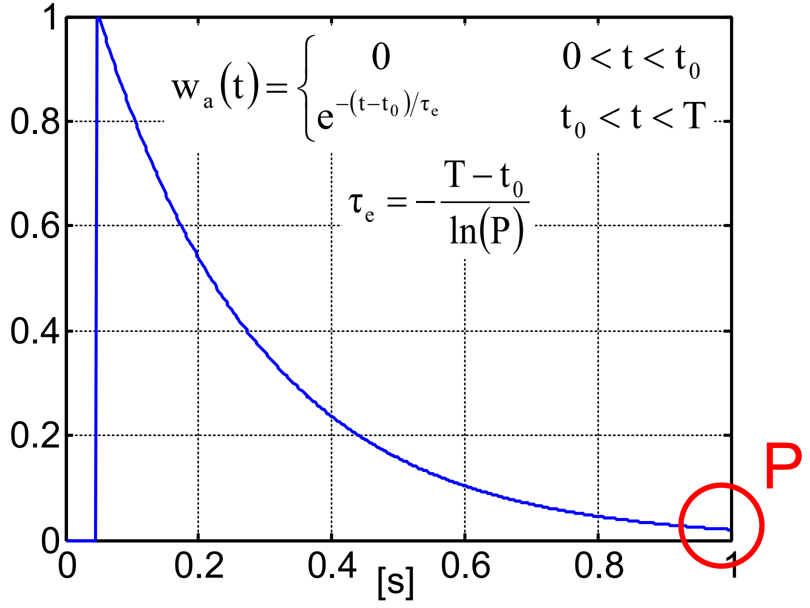
To do list

Remember to use appropriate windowing strategies to improve the quality of the results:

- use a force window (*tukeywin*) to preserve the impulse amplitude and eliminate the noise before/after the impulse.
- (use an exponential window on the acceleration signals.)



Tukey window



Exponential window

Data description

For each of the 10 tests, the acquisition software stored:

- A .mat file, containing a matrix “Dati”:
  - Dati (:,1) is the force signal (in V)
  - Dati (:,2) is the acceleration signal (in V) measured at node N1
  - Dati (:,3) is the acceleration signal (in V) measured at node N2

<u>Sensitivity values (for accelerometers and impact hammer) are reported in slide 4</u>

- A .inf file, which is a custom text file containing some info about the acquisition parameters, e.g.:

Sampling frequency

Number of channels

Measurement unit

Channel name

```
5120.000000
3
Hammer  1.000000          [V]
Acceleration_1  1.000000          [V]
Acceleration_2  1.000000          [V]
```