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Assessment of High Frequency Vibrations

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- High frequency motions
- Cut-Off procedure
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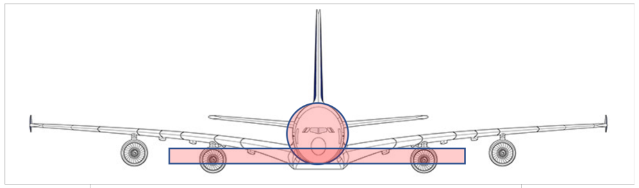
- Conclusion

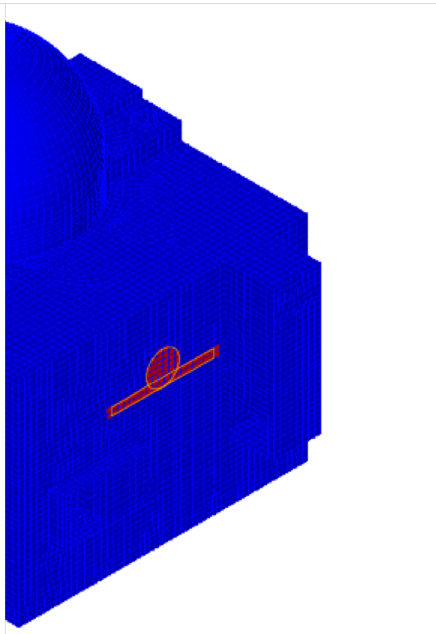
Introduction

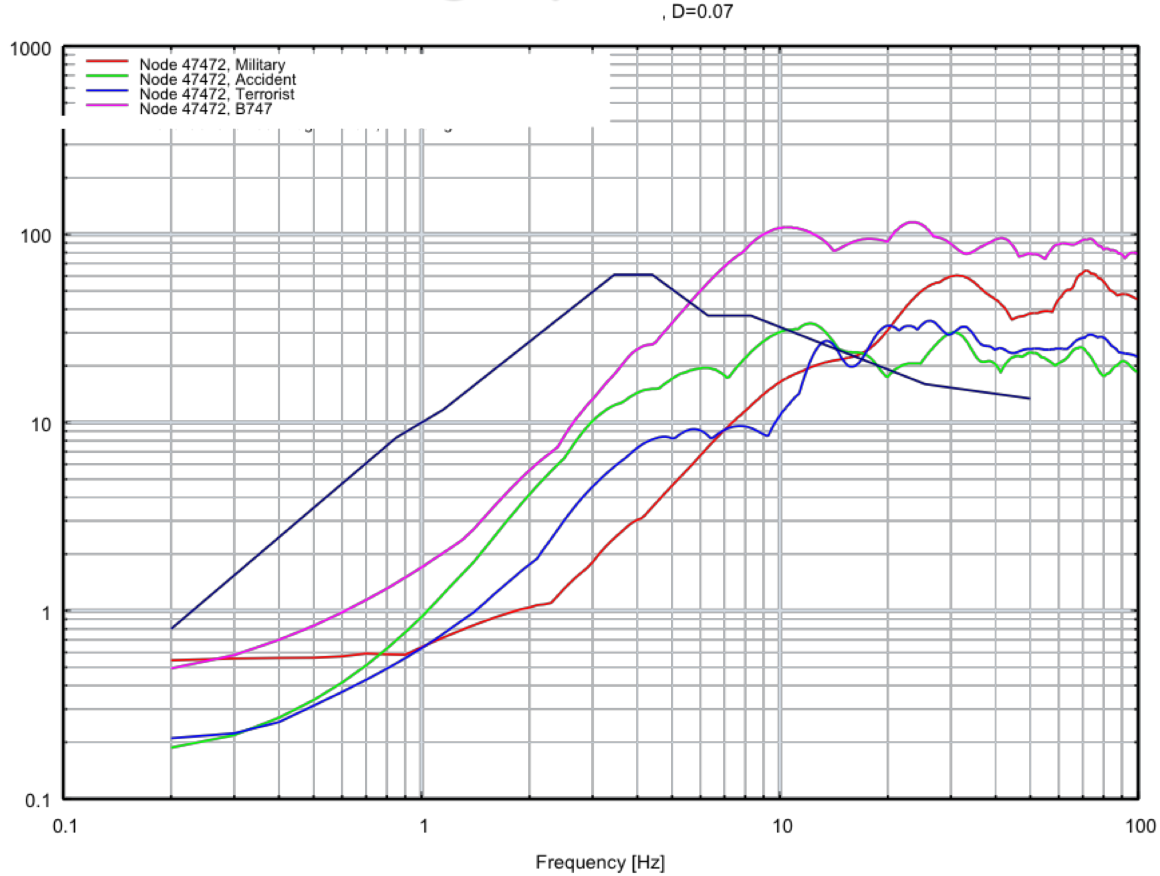
- The design of nuclear facilities is performed on the basis of the load case earthquake using design response spectra
- Short durating excitations like airplane crash, military weapon impact and explosions can result in design spectra exceeding the earthquake design spectra in the high frequency range
- The question arises - How is it possible that excitations with much less energy than the design basis earthquake can lead to higher design requirements ?

Comparison of DBE and APC design spectra

Response spectra calculated out of APC induced vibrations show high exceedance of the DBE design spectra







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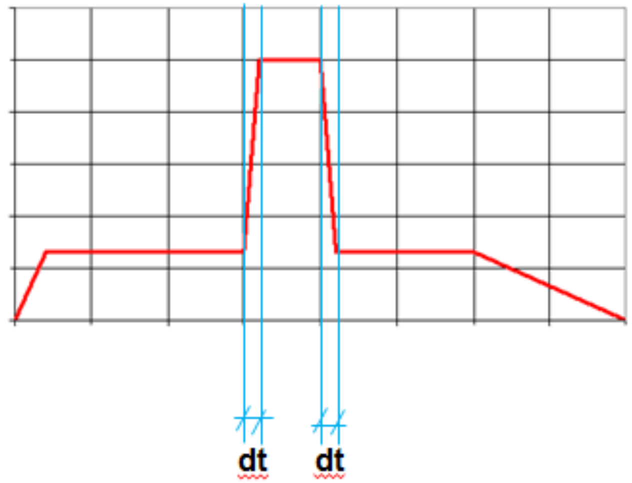
High frequency motions

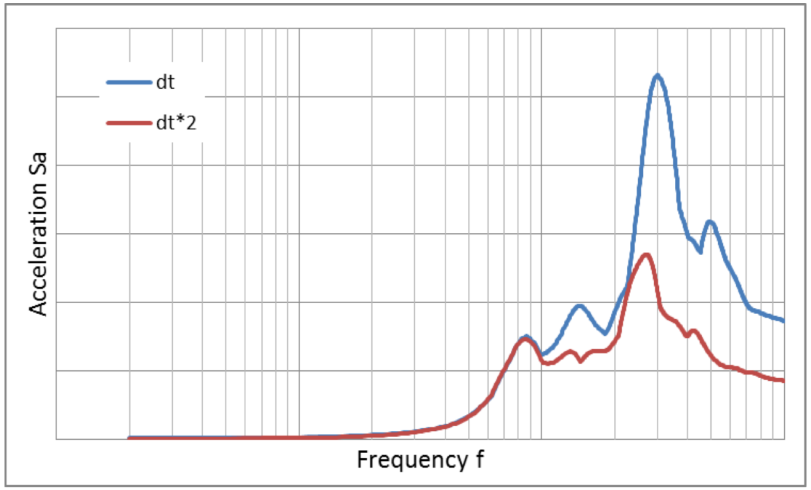
- EPRI Report 1015108, June, 2007:
  Structures and equipment systems have been subjected to high frequency motions from a variety of different sources. Structures and mounted systems have sustained base input motions induced by following sources without damage:
  - mining
  - quarry
  - construction blasting operations
- NRC Regulatory Guide 1.166, March, 1999:
  Frequencies over 10 Hz do not need to be considered in the determination of whether shutdown is warranted following a felt earthquake

Source of high frequency content of induced vibrations

- The inclination of the load curve has significant influence on the vibrations in the HFR.

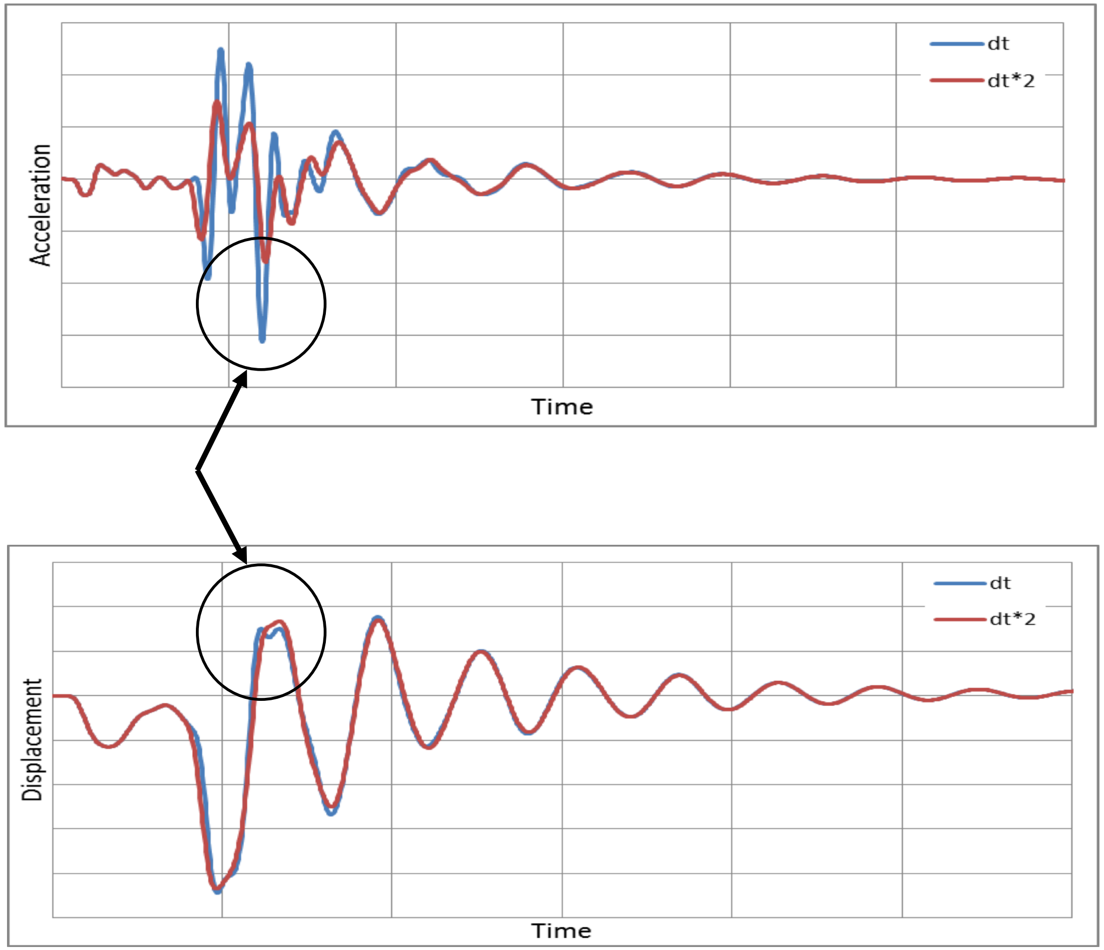


- The comparison of two load curves with the same magnitude but different inclinations defined by dt and 2*dt results in huge differences in the HFR.



Source of high frequency content of induced vibrations

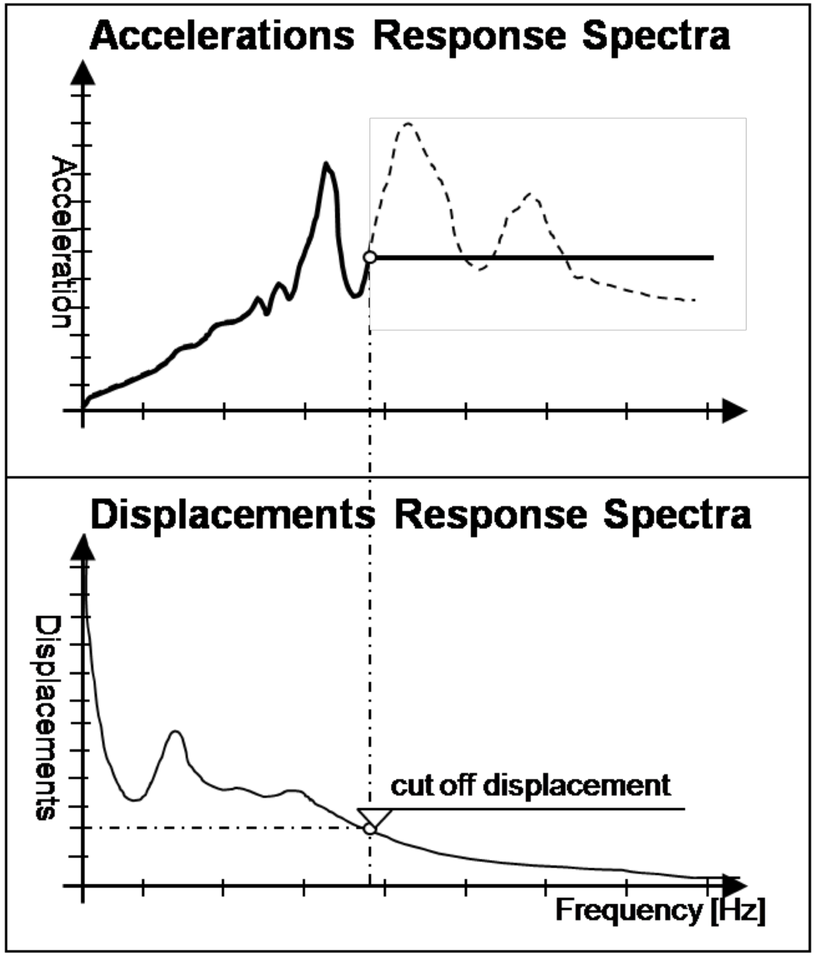
- Acceleration time history for case dt is much higher than for case 2*dt (Needs explanation).
- Displacement time histories for both cases dt and 2*dt are almost the same.
- The differences of the acceleration time histories are results of small local deformations.



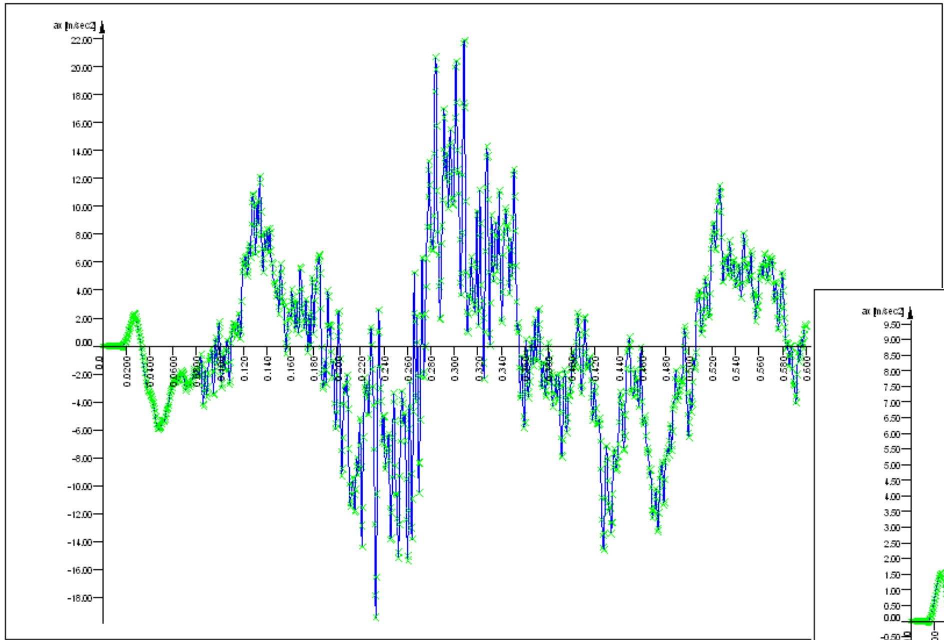
Cut-off procedure

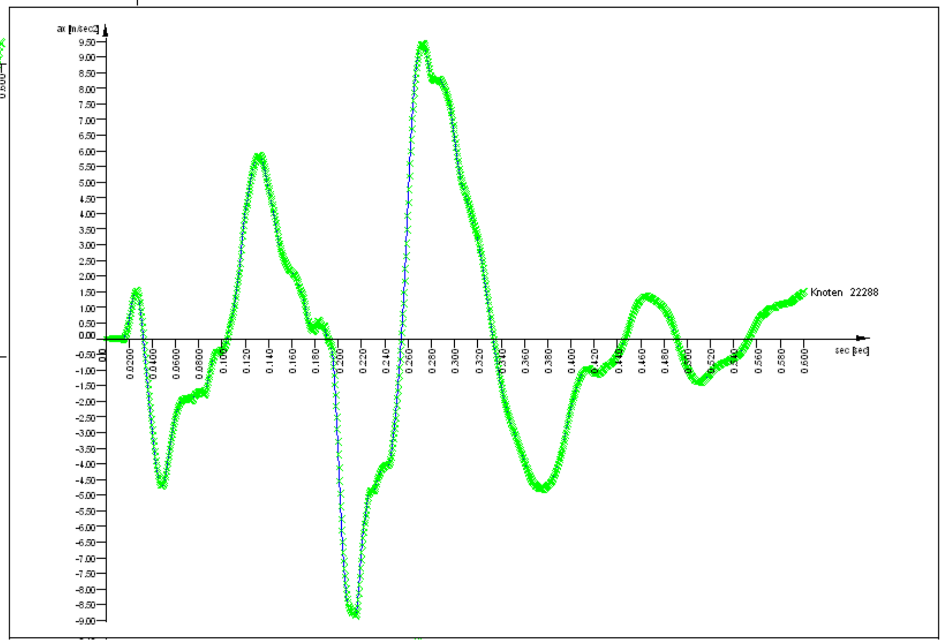
- A discrete fourier transformation is used to filter out the high frequency content of accelerations.

- The number of coeffcients used to describe the functions is determined based on a defined spectral displacement e.g. 1mm or 0.1mm or cumulative power value e.g. 90%.



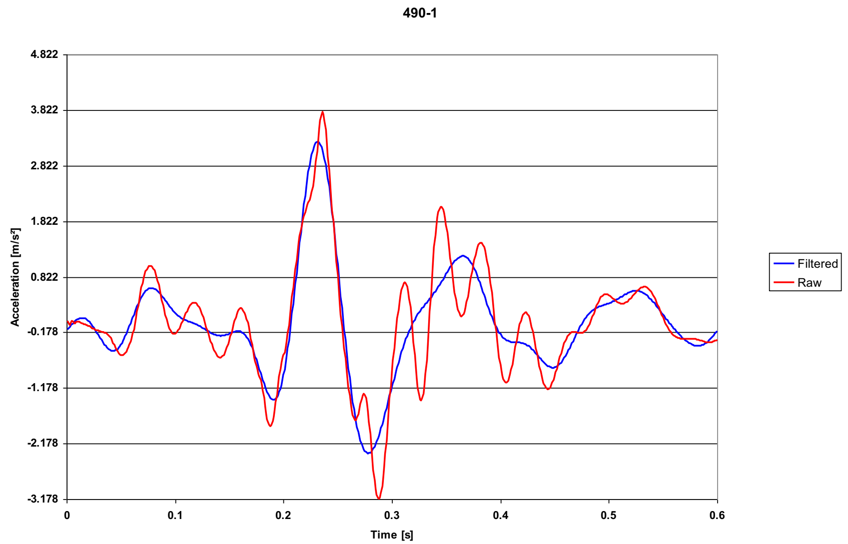
Effect of filtering

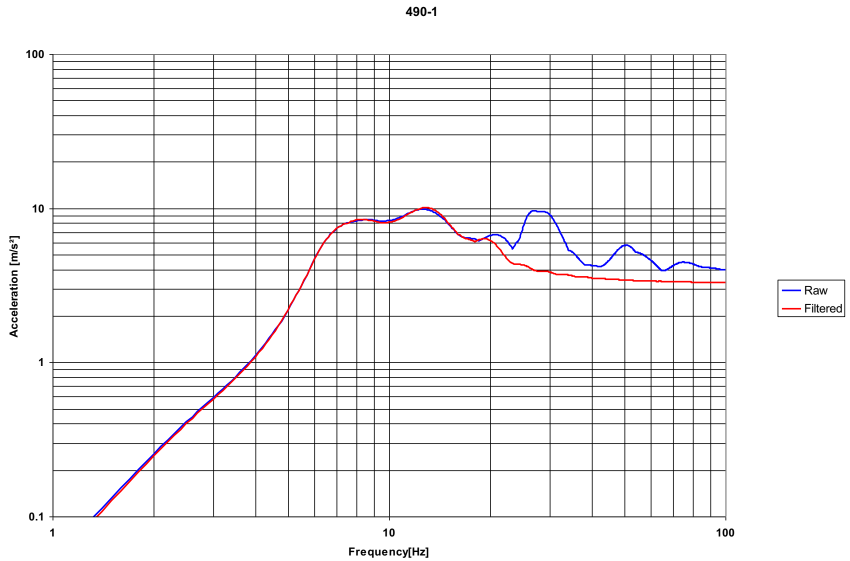




Scope of experiment

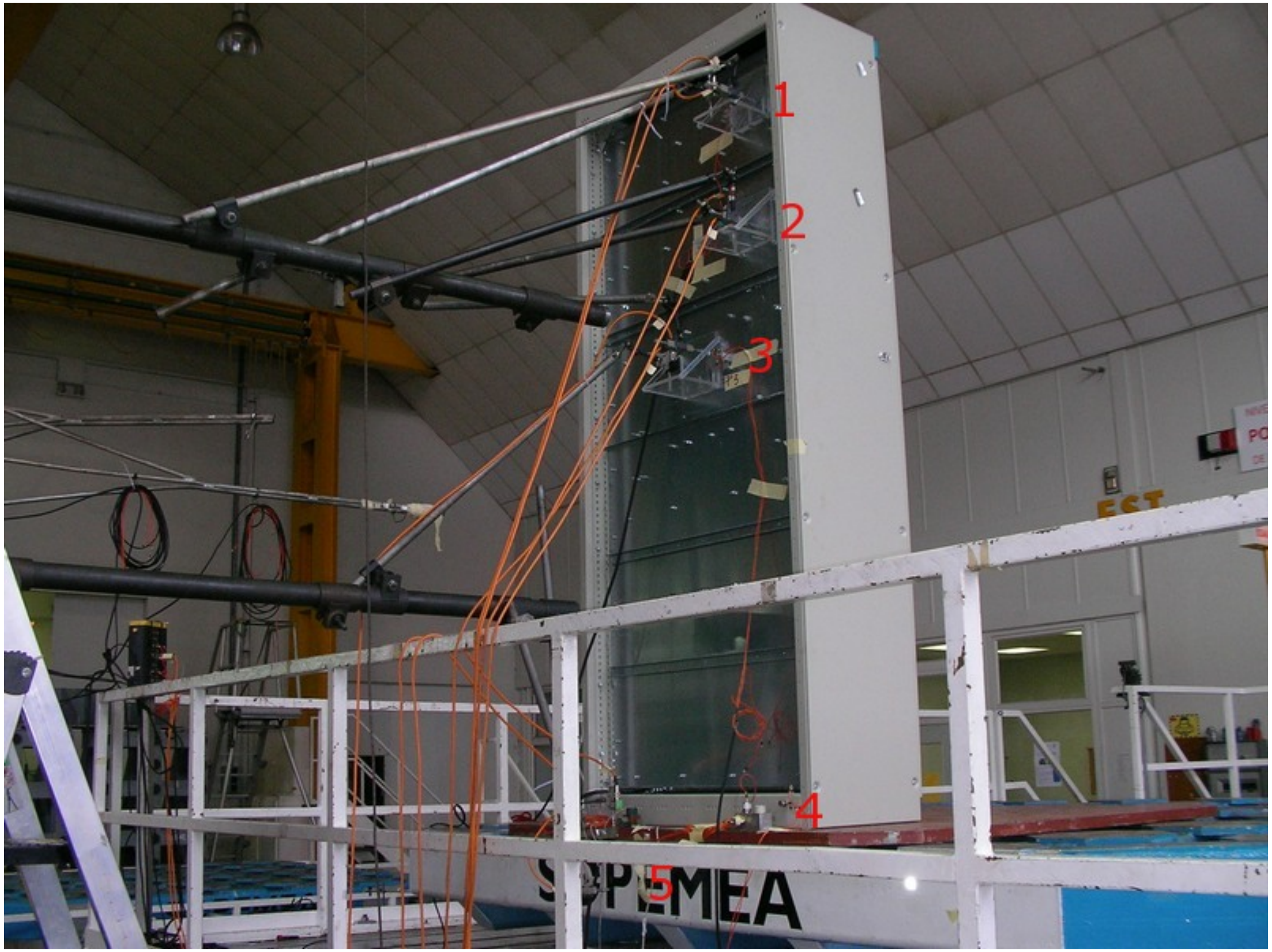
- Application both of raw and filtered acceleration time history
- If filter methodology is correct, the response of both excitations should be compatible
- Applied excitations:
  - 9 horizontal
  - 9 vertical
  - 9 horizontal & 9 vertical at the same time



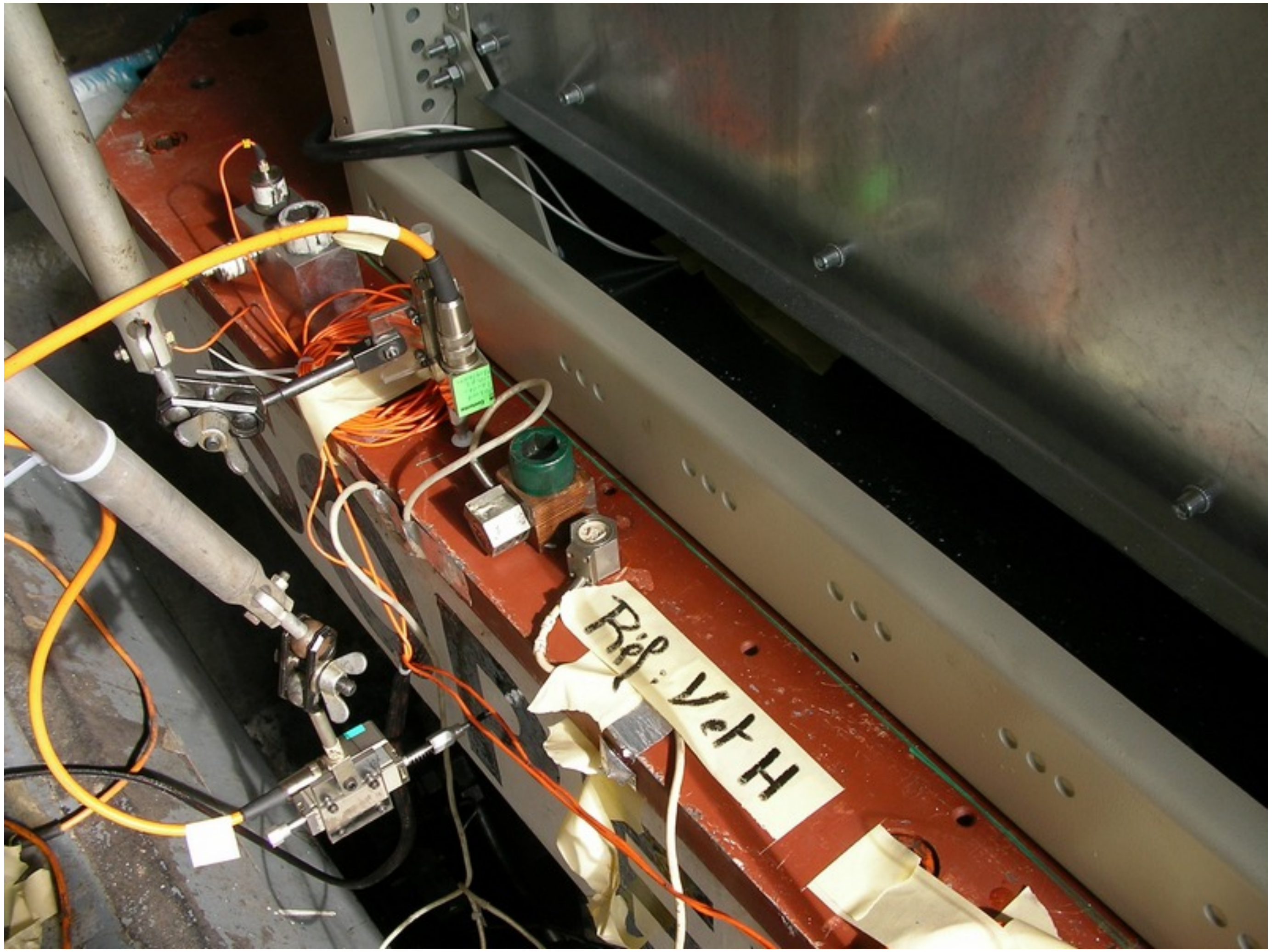


Tested cabinet

Measuring points



Measuring devices – accelerometer



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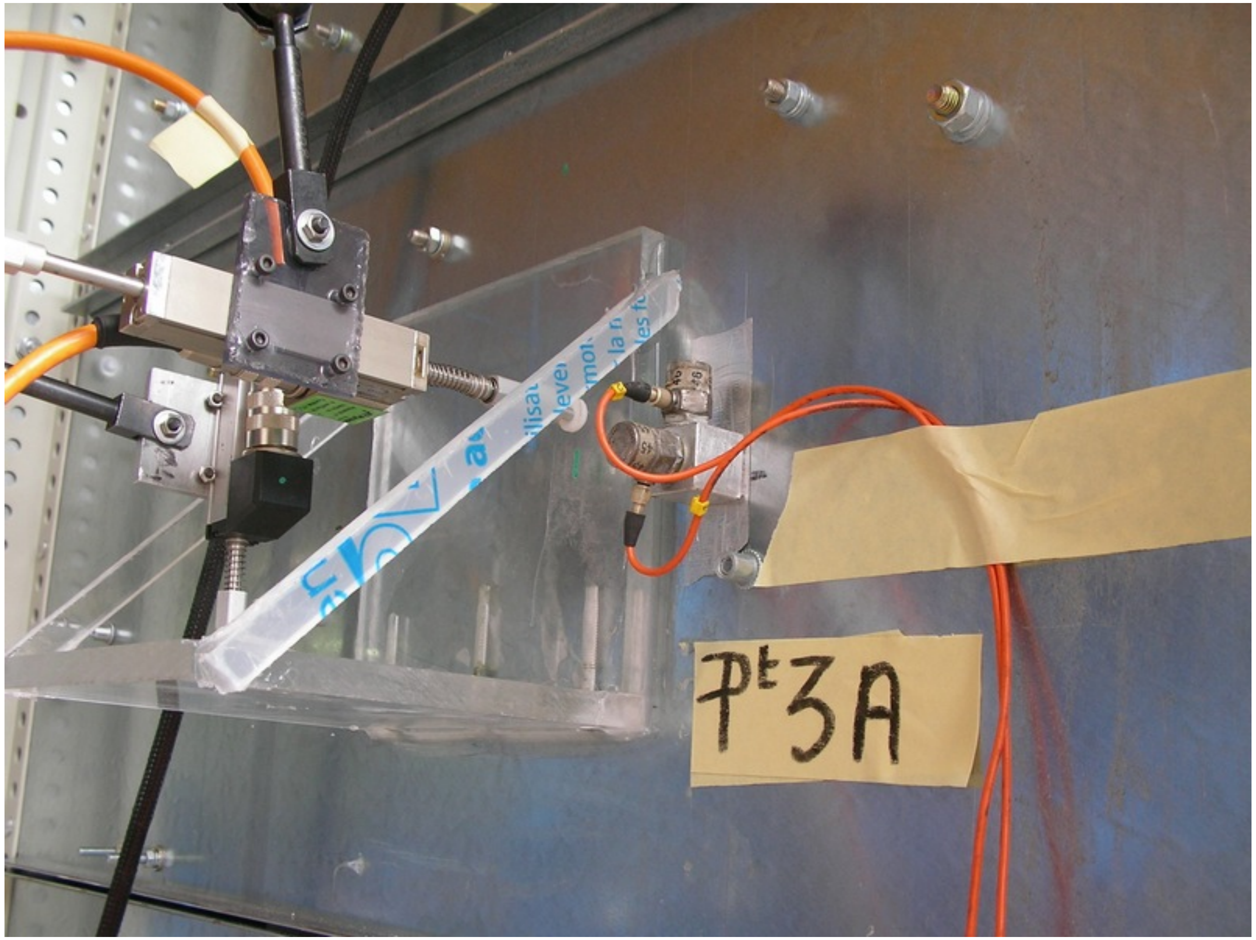
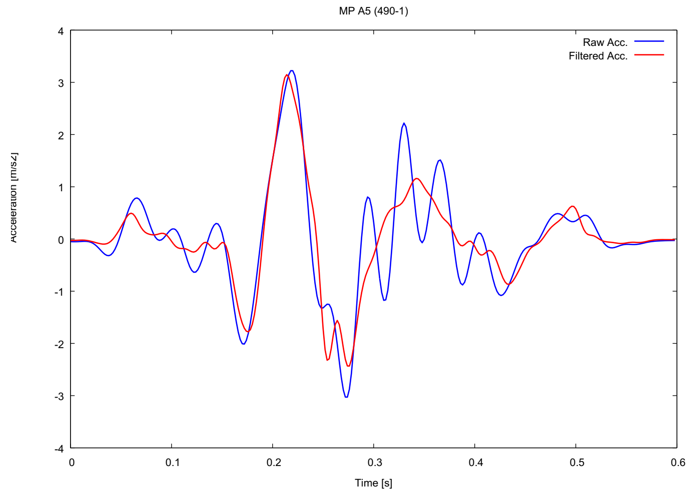
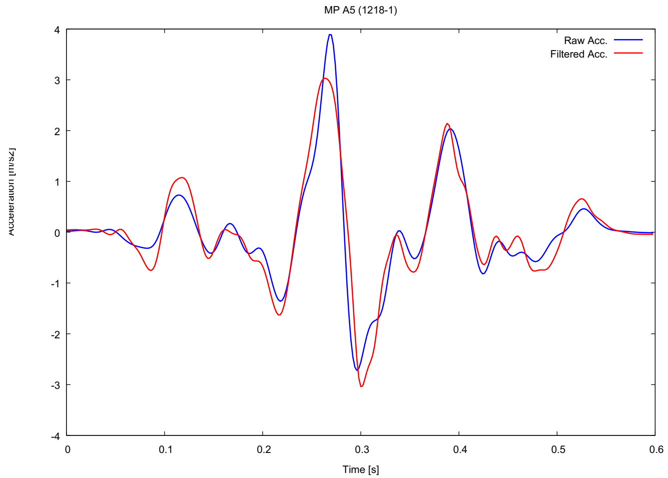
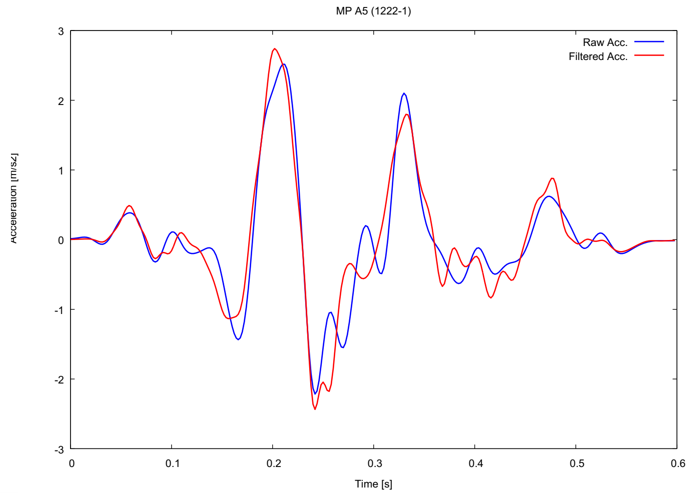
Measuring devices – displacement transducer

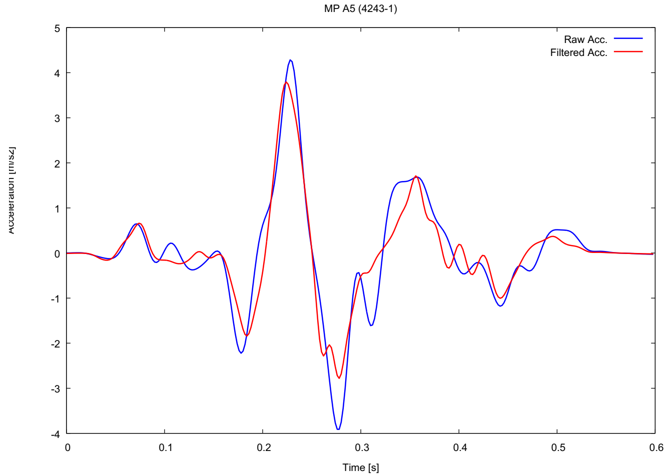


Examples of excitations

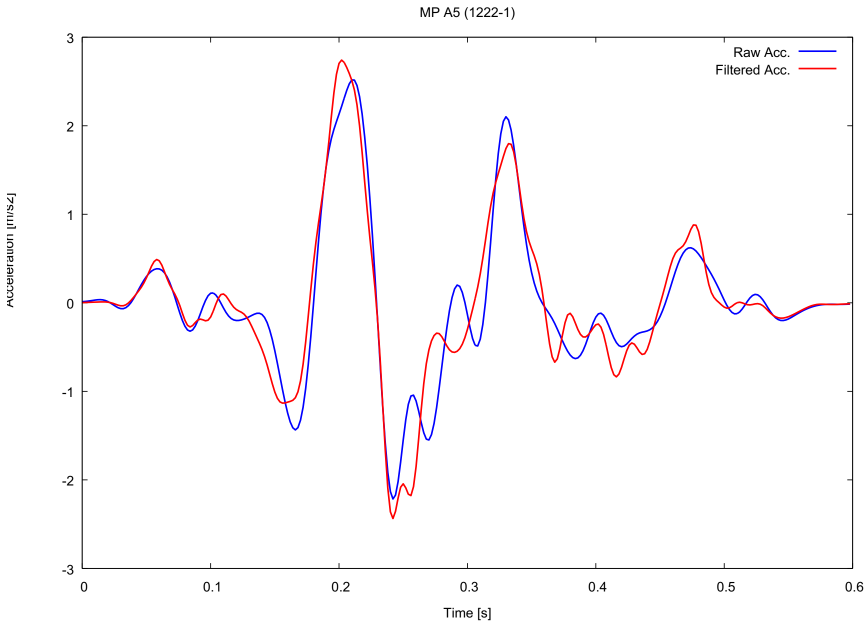




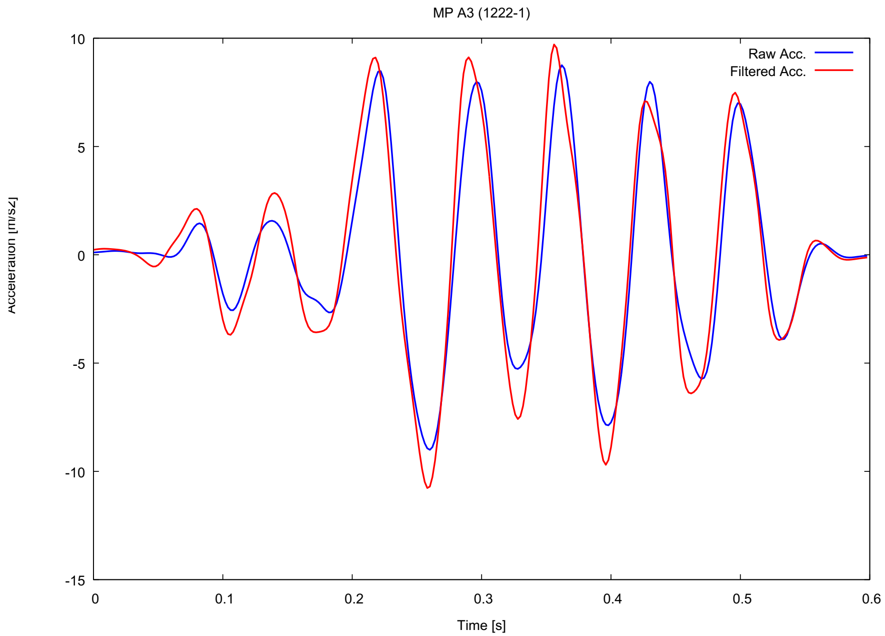




Applied and measured data

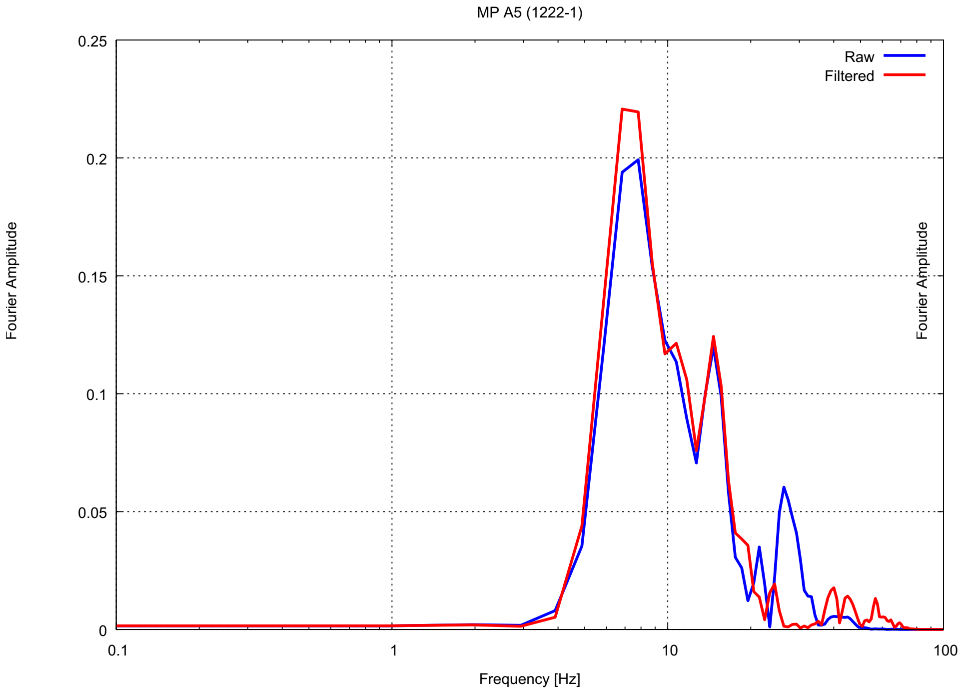


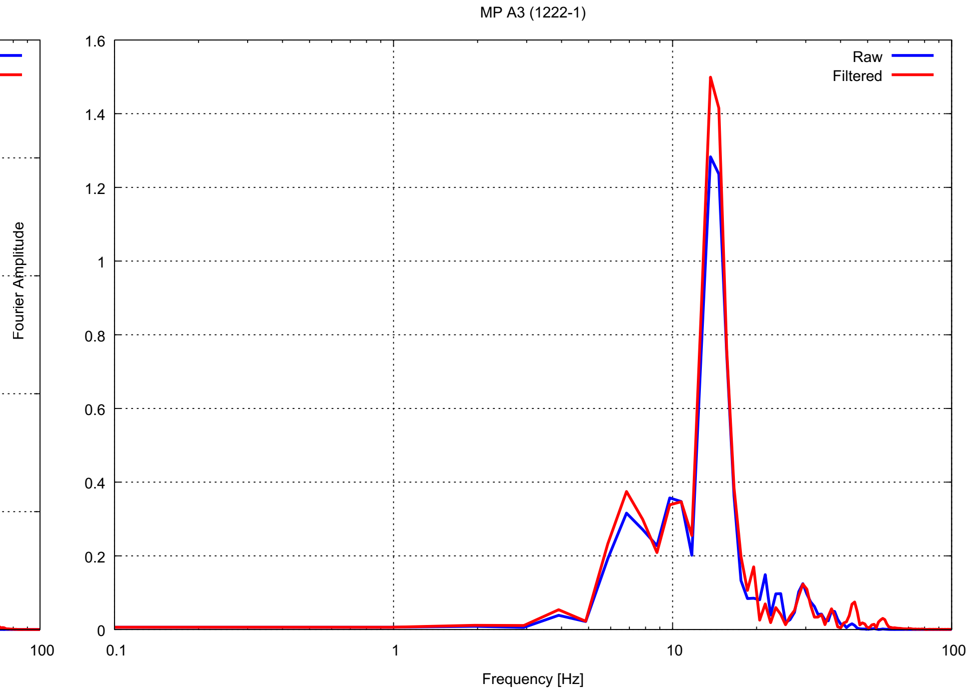
Excitation – Applied acceleration time histories



Response – Measured acceleration time histories

Applied and measured data





Excitation
Fourier Amplitude Spectra

Response
Fourier Amplitude Spectra

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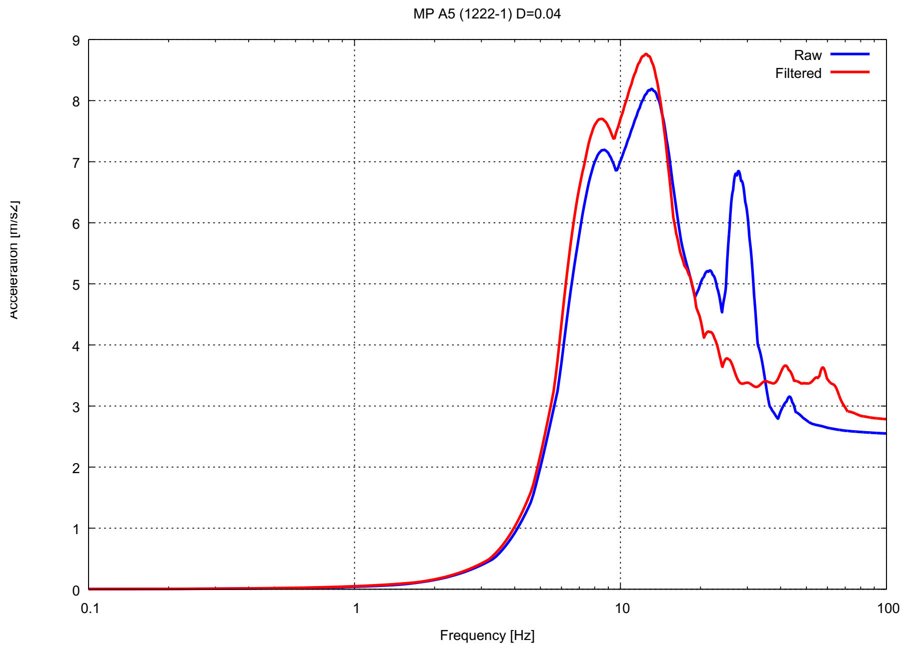
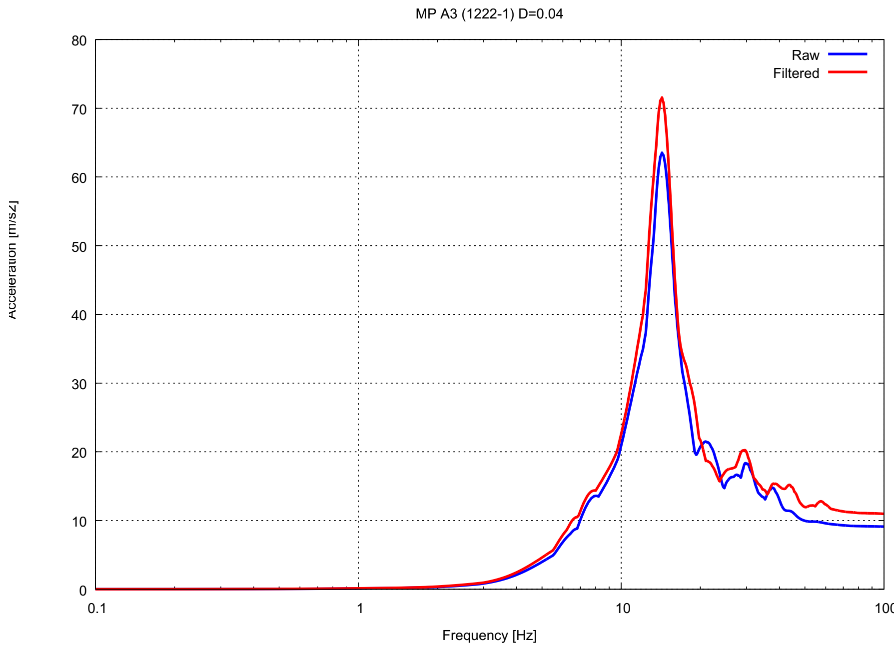
Applied and measured data





Excitation
Response spectra, D=4%

Response
Response spectra, D=4%

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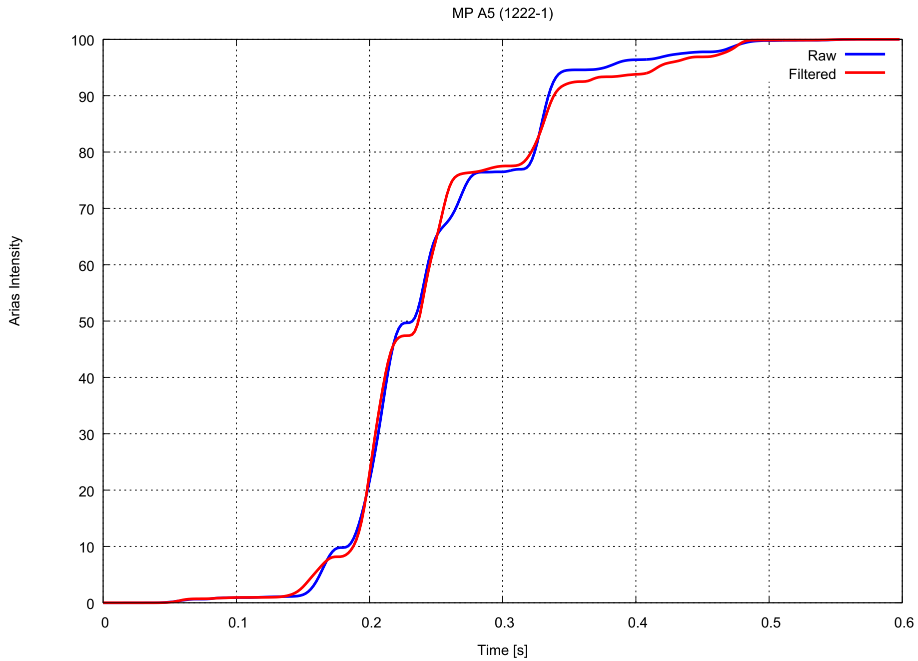
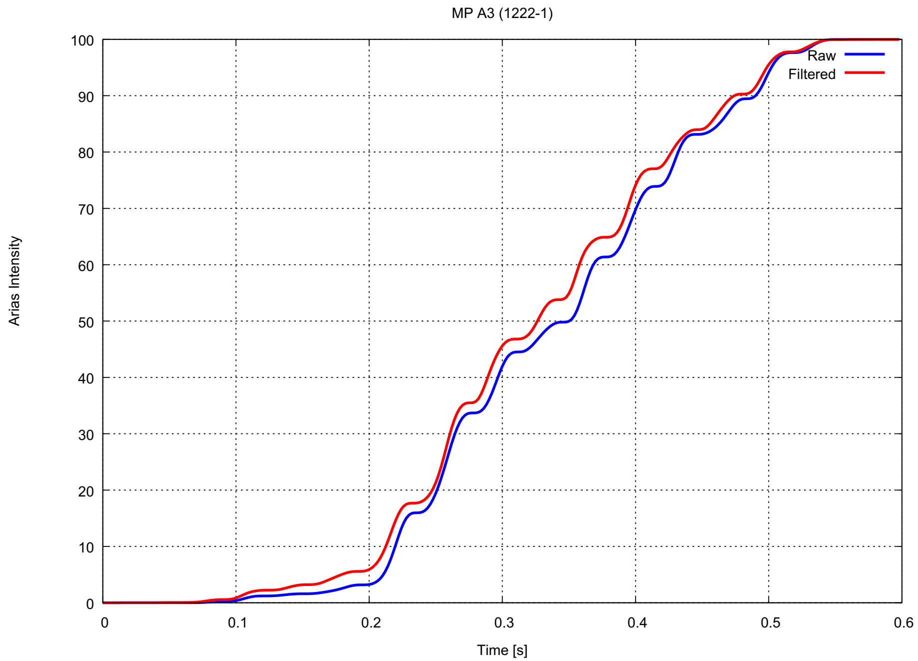
Applied and measured data



Excitation

Husid Plot



Response

Husid Plot

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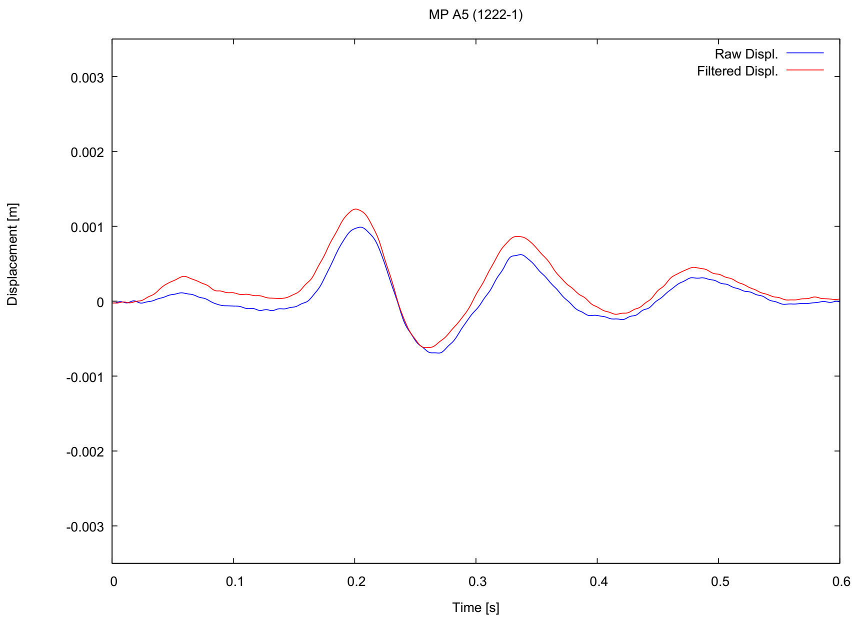
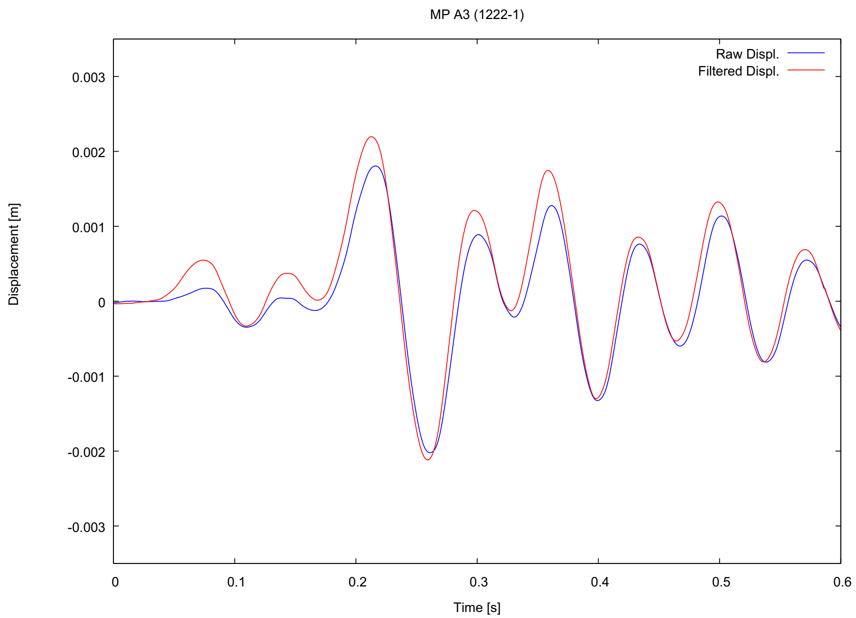
Applied and measured data





Excitation
Displacements time histories

Response
Displacements time histories

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Conclusion

- The response acceleration time histories both of the raw and of the filtered excitation are almost identic
- The peak of the raw acceleration time history at approximately 30 Hz almost disappeared
- The response spectra of the raw and filtered time histories are almost identic
- The energy distribution of the raw and filtered time histories are almost the same
- The measured displacements of the raw and filtered time histories are almost identic
- High frequency vibrations are absorbed and do not reach the component. They can be numerically filtered and neglected.

We would love to answer your questions.
Please contact us:

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Thank you for your attention

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