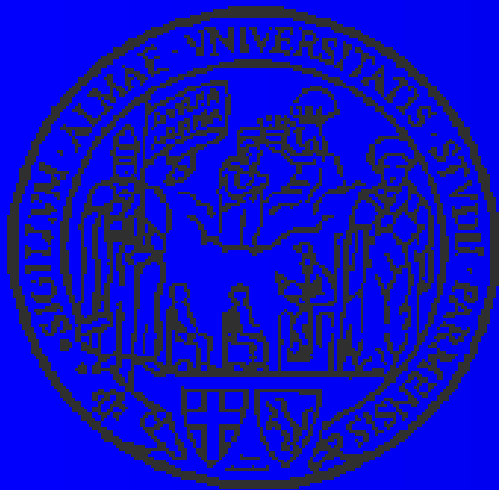


Non-linear Digital Processor for dedicated loudspeaker systems

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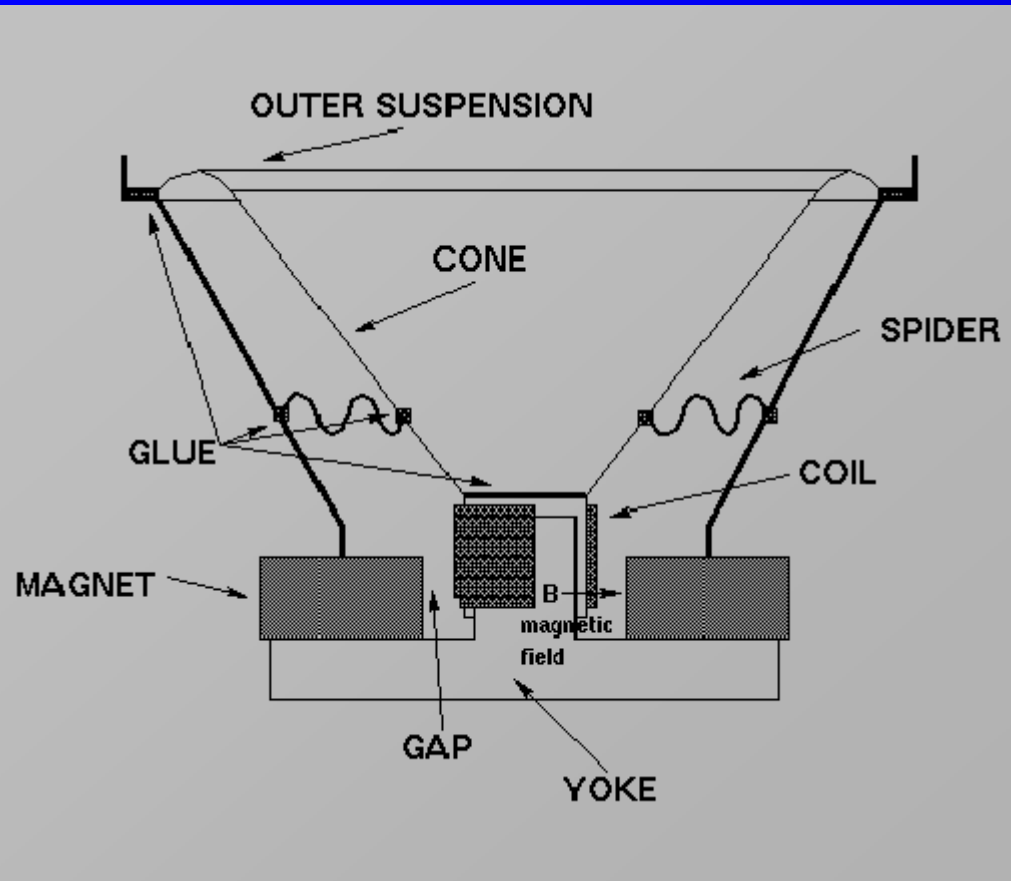


Outline

- Loudspeaker physical conformation;
- Loudspeaker non-linear modeling;
- Digital audio Processor for distortion compensation;
- DSP implementation;
- Measured distortion results;



Basic loudspeaker conformation

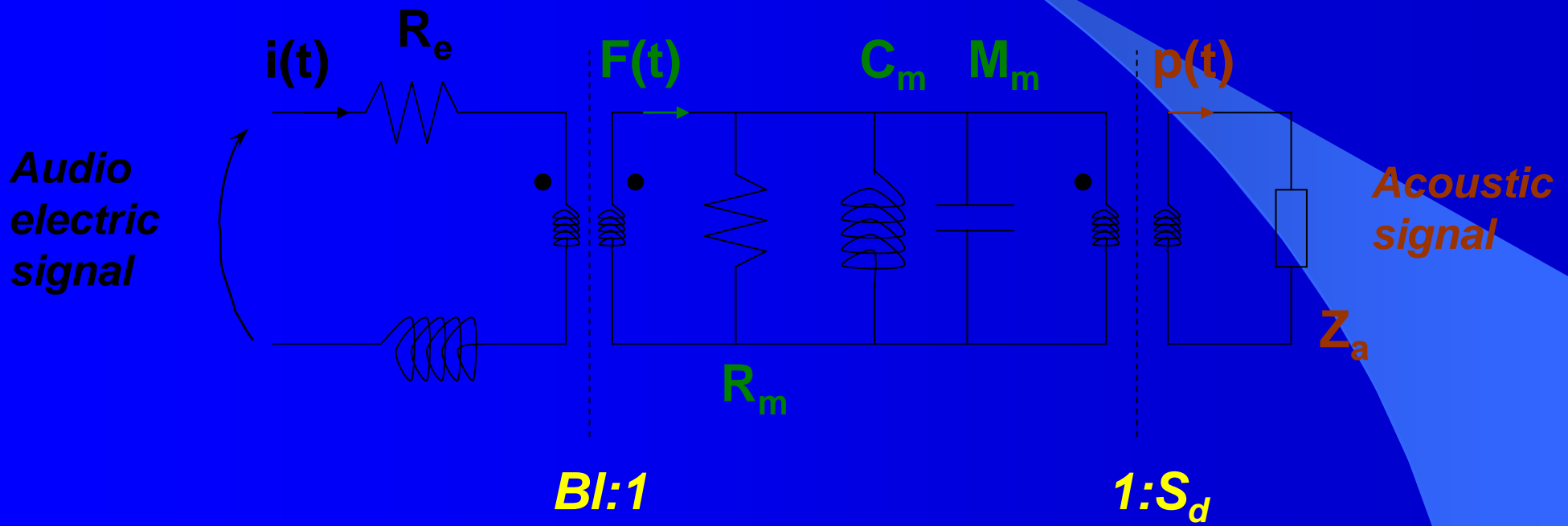


- Electric- mechano-acoustic transducers:
 - $p(t) = k e(t)$
- Non-linear behavior:
 - The magnetic induction B is not constant with displacement
 - non ideal suspension stiffness
 - $R = R(T)$



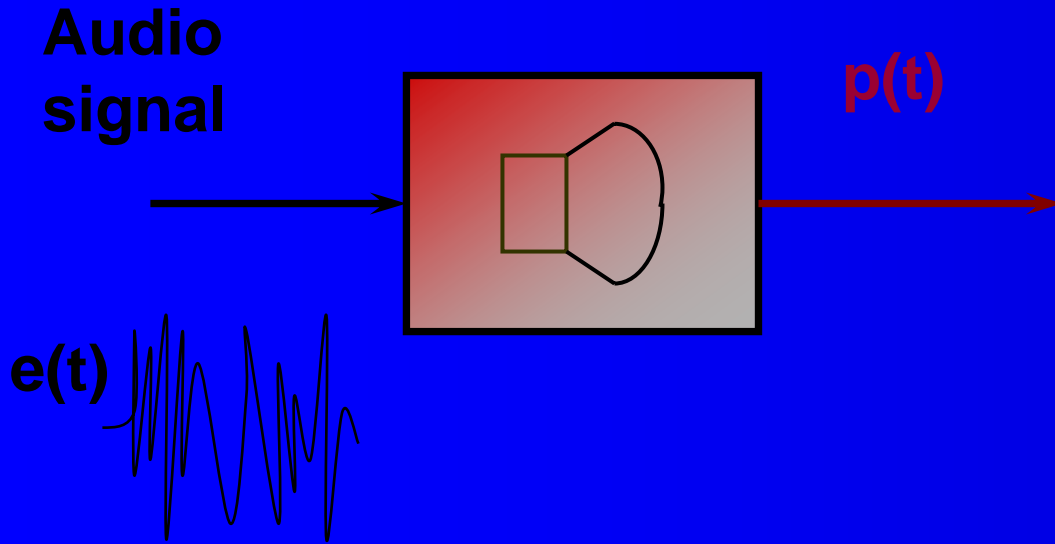


Loudspeaker modeling





Loudspeaker modeling



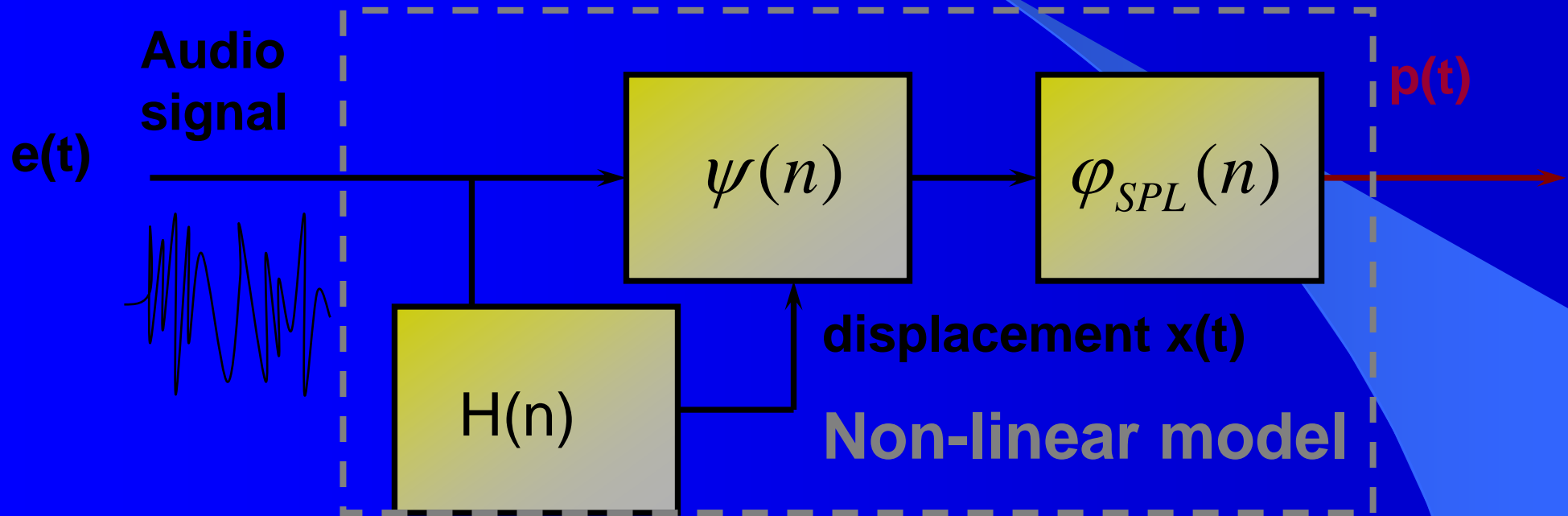
- Non-linear loudspeaker I/O relation is linearized around fixed displacements x_n
- ψ_{x_n} accounts only for non-linear behavior

$$\varphi_{\hat{x}_n}(s) = \frac{p(s)}{e(s)}$$

$$\psi_{\hat{x}_n}(s) = \frac{\varphi_{\hat{x}_n}(s)}{\varphi_0(s)}$$



Loudspeaker non-linear modeling



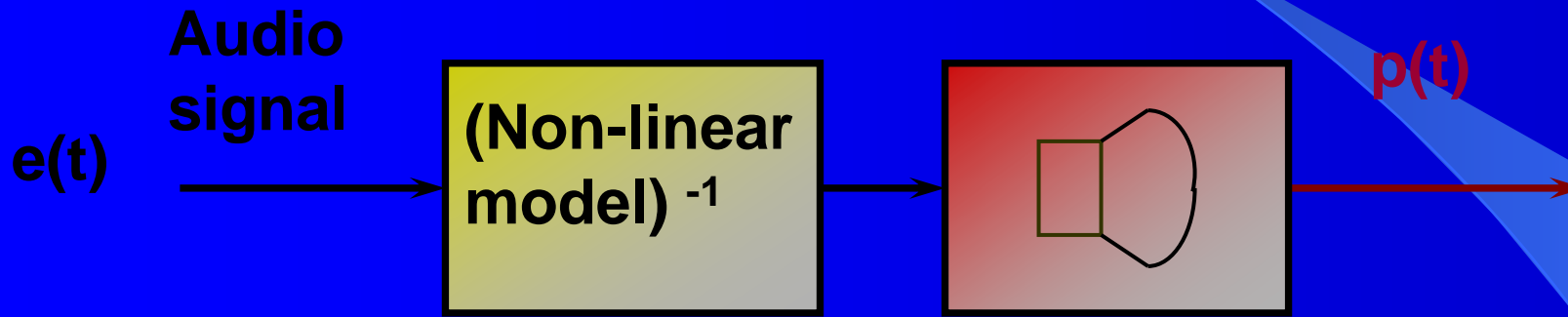
- $\varphi_0(s) = \frac{p(s)}{e(s)} \rightarrow \varphi_{SPL}(n)$

is similar to SPL measurements





Audio processor



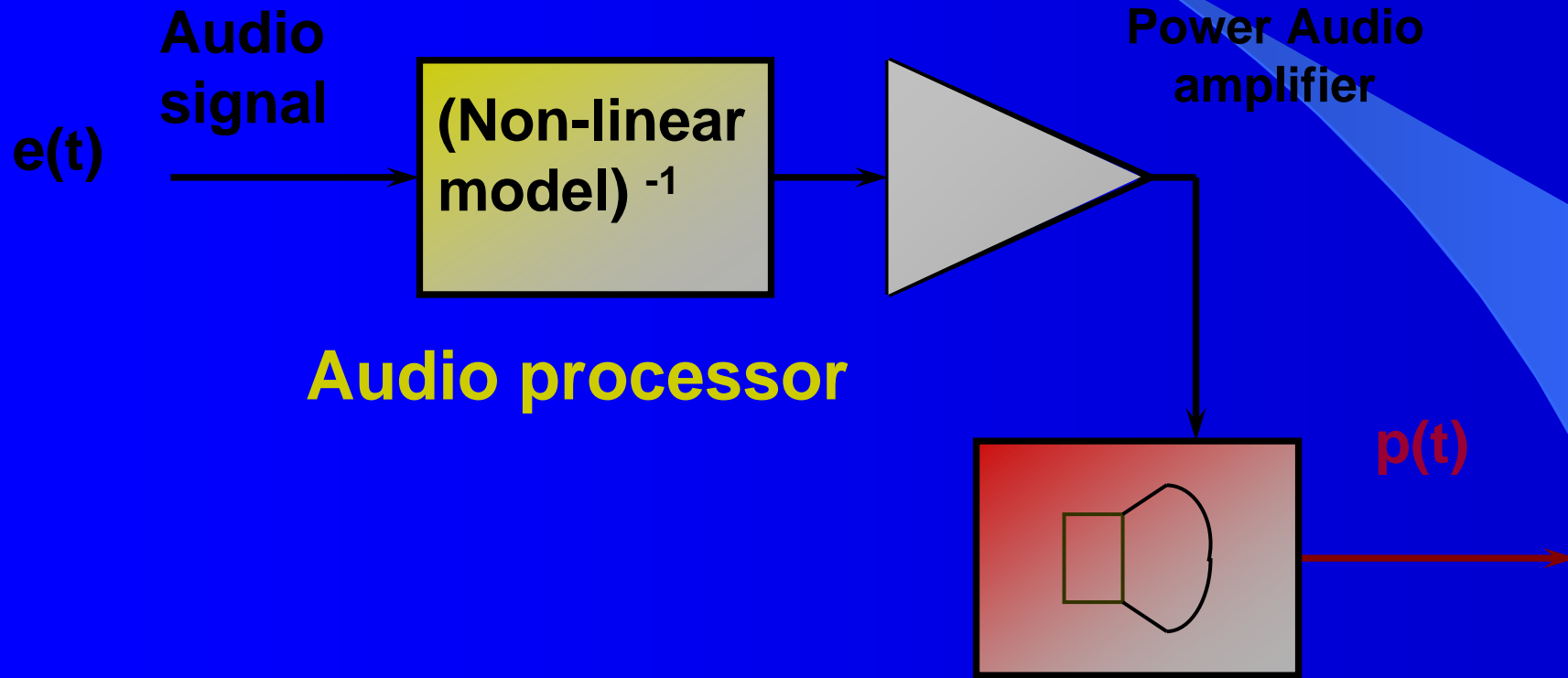
Audio processor

- The more critical part is the synthesis of the $H(n)$ filter





DSP implementation





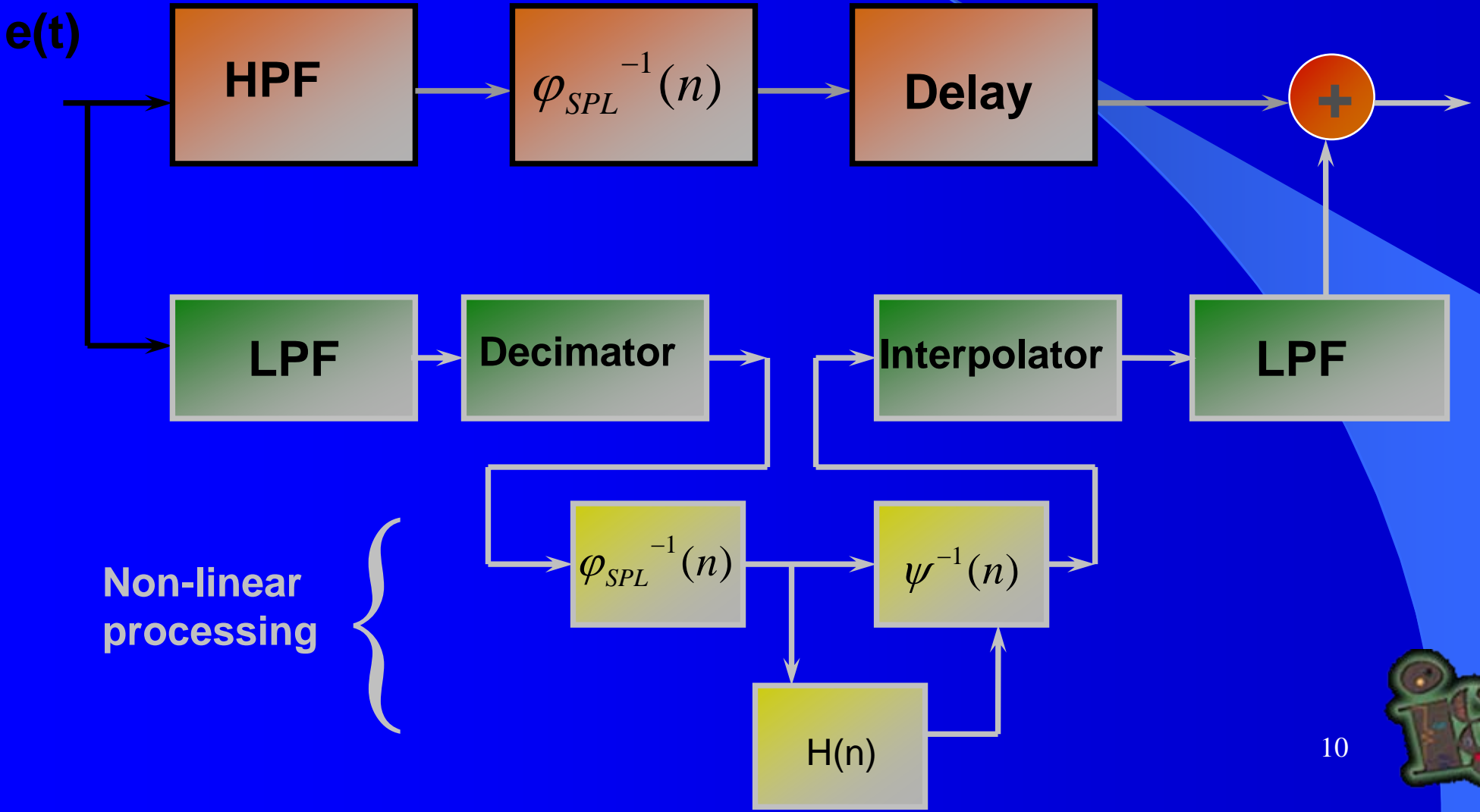
DSP implementation

- Audio processor implemented with a 320C54x DSK;
- 40 MIPS, 10Kword Dual Access RAM;
- Sampling frequency 23148 Hz;
- Converter resolution 14 bit.



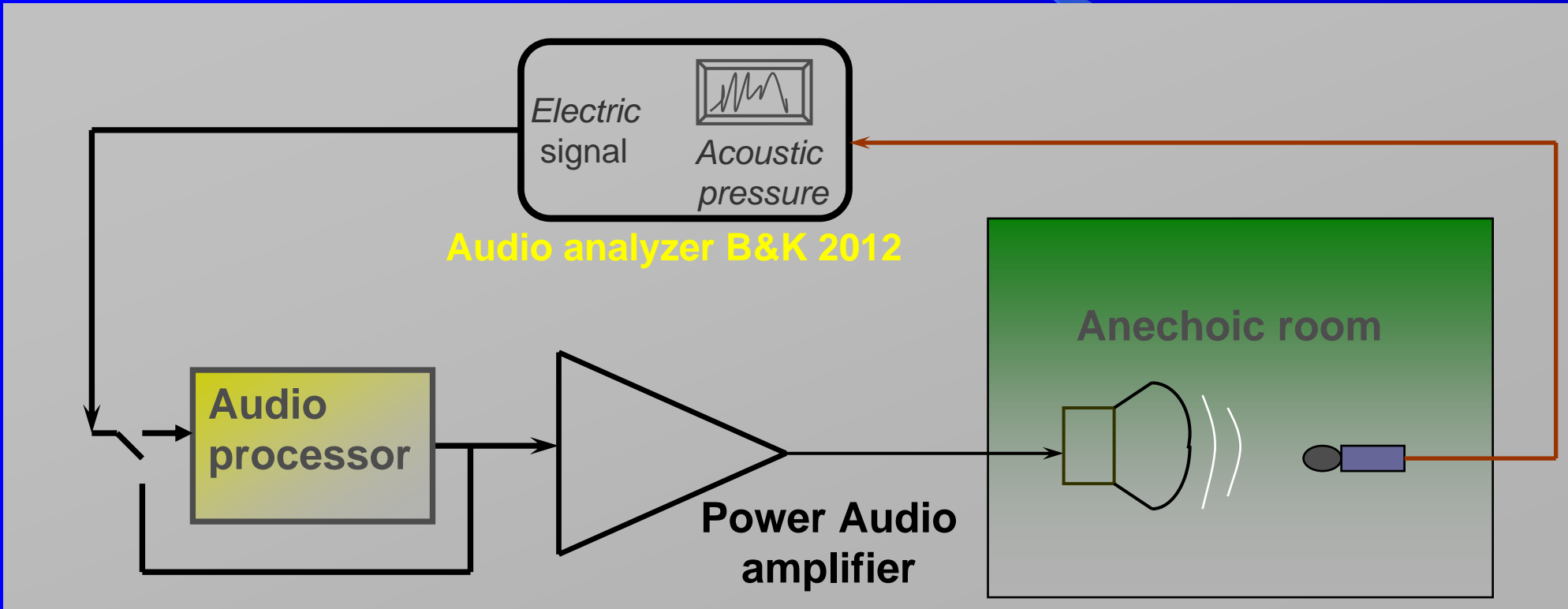


Multirate Audio processor



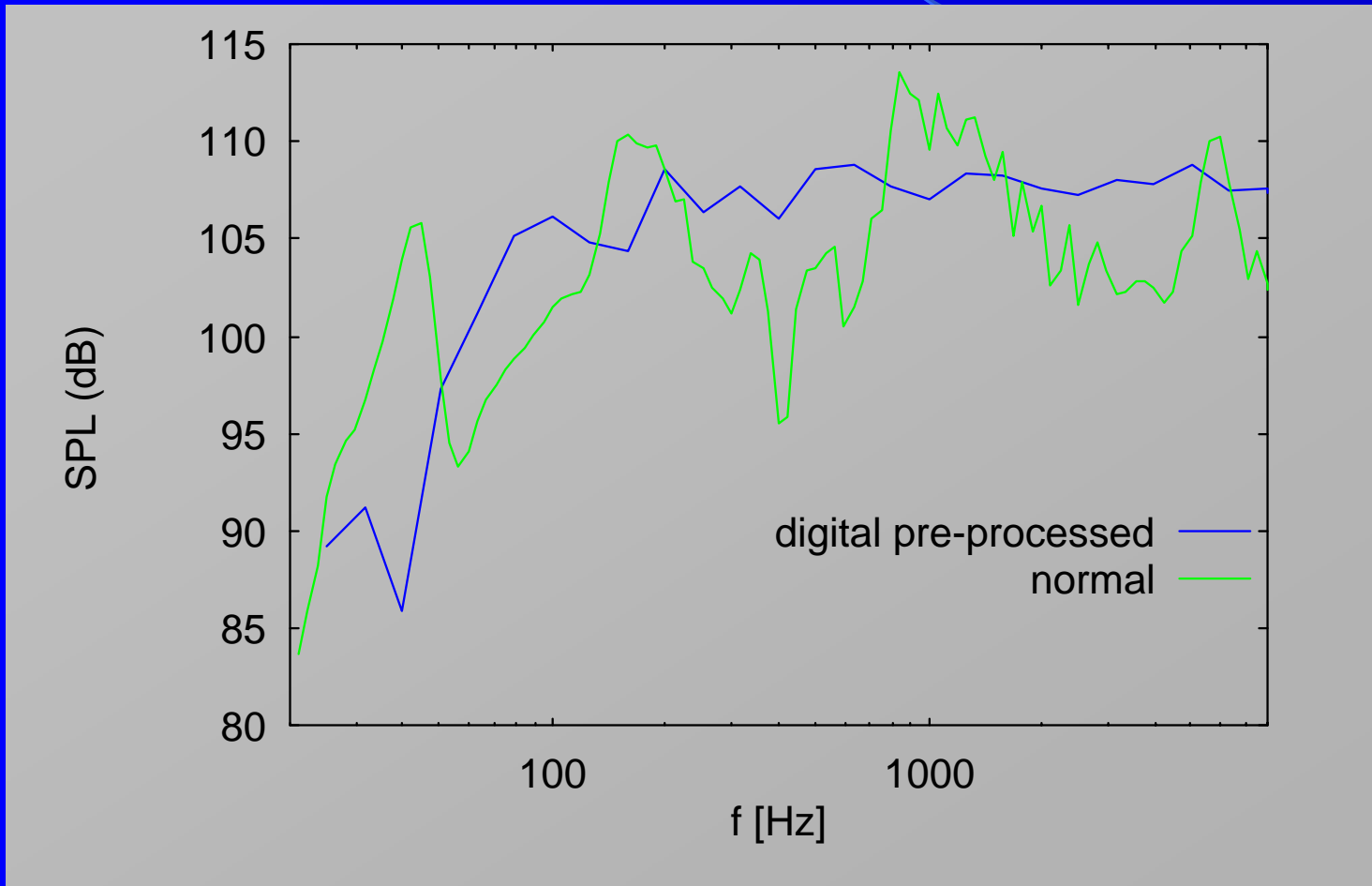


Audio processor measurements



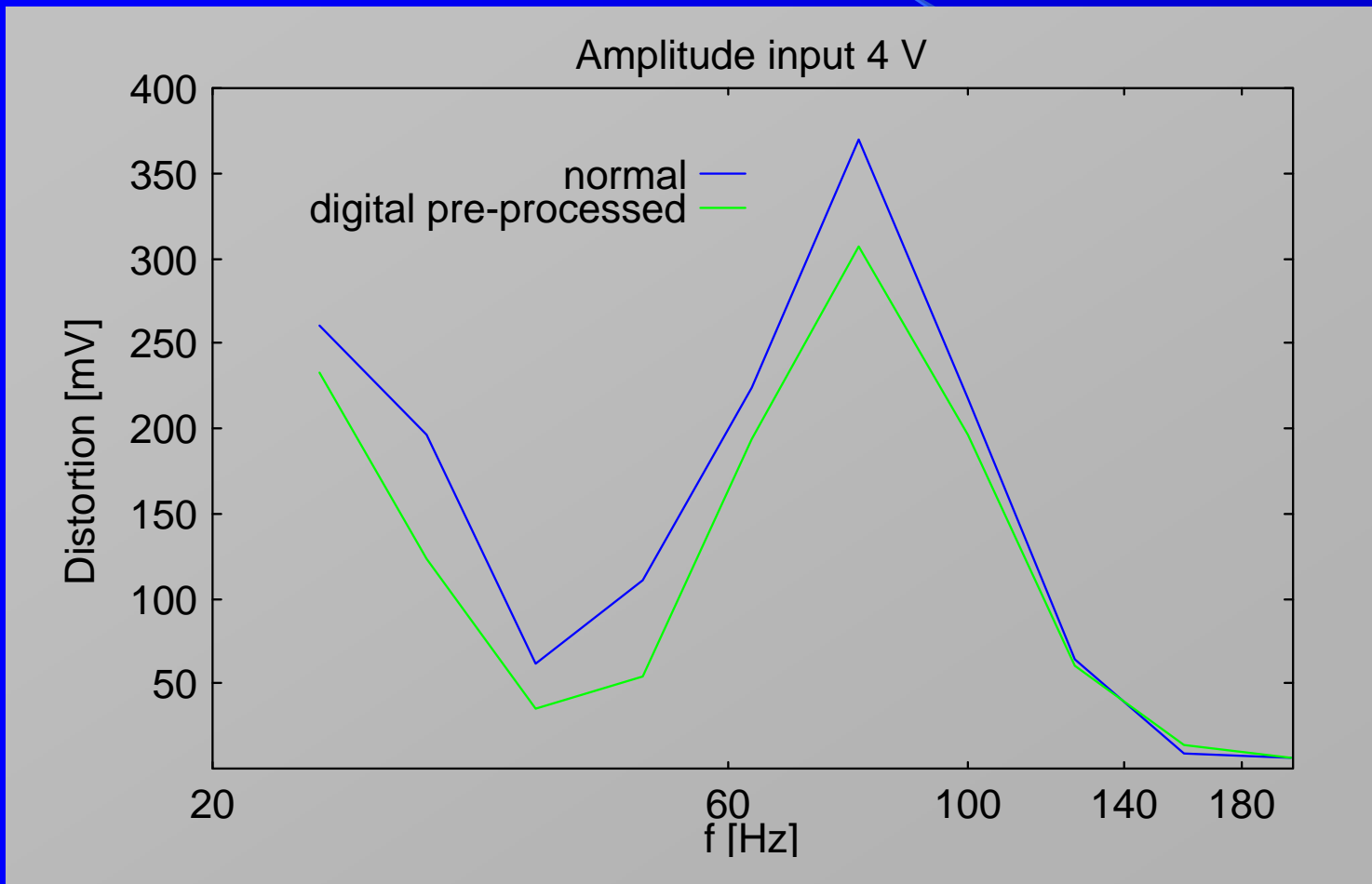


SPL Results



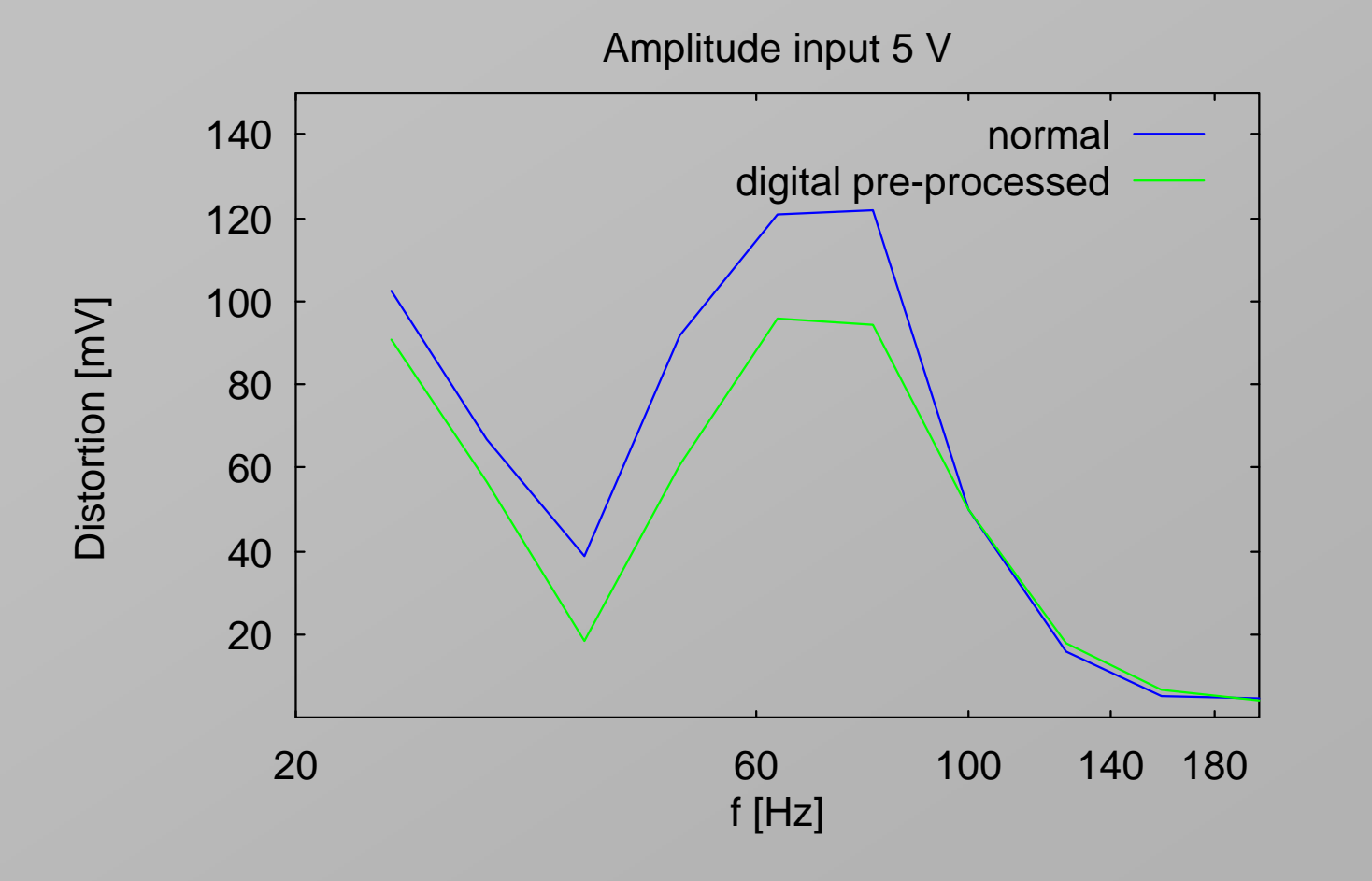


SPL Results





SPL Results





Conclusion

- Definition of a non-linear model for low frequency loudspeaker systems;
- Design of a parametric audio processor for the compensation of non-linear distortion of loudspeaker;
- Implementation of the audio processor with a low cost commercial DSP;
- Measured reduction of Distortion with the insertion of the audio processor;

