# Loudspeaker Response Optimization with the Aid of Impulse Response

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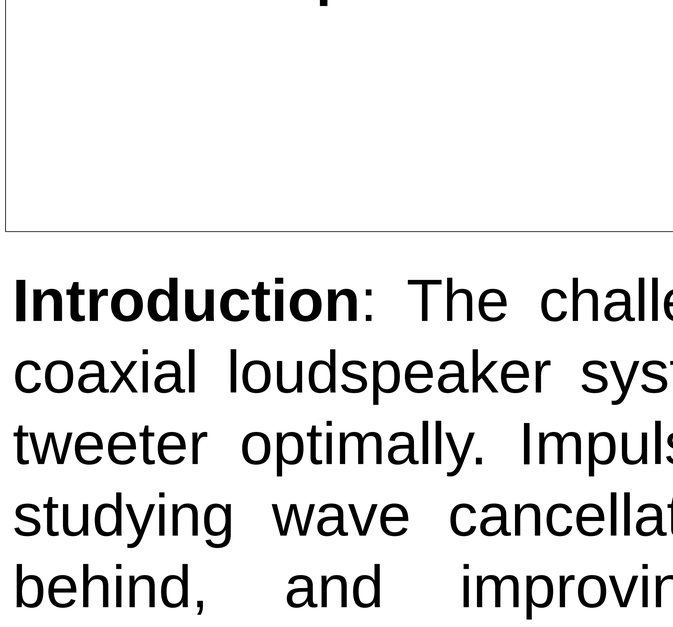
**Introduction**: The challenge with designing coaxial loudspeaker systems is locating the tweeter optimally. Impulse response helped studying wave cancellation with the cavity behind, and improving coverage and response for better sound reproduction.




By courtesy of Klipsch

**Figure 1**. Tweeter Model and early prototype

**Computational Methods**: The model was analyzed in Pressure Acoustics physics interface. Firstly solved in Transient, aided with FFT, then, in order to analyze the far field properties, results were mapped to the Frequency Domain from Eq.1 monopole domain source $Q_m$, into Eq. 2 where *k* represents the wave number.

$$\frac{1}{\rho c^2}\frac{\partial^2 p}{\partial t^2} + \nabla \cdot \left(-\frac{1}{\rho}\left(\nabla p_t - \mathbf{q_d}\right)\right) = Q_m$$

**Equation 1**. Scalar Wave Equation Transient

$$\nabla \cdot \left(-\frac{1}{\rho_c}\left(\nabla p_t - \mathbf{q_d}\right)\right) - \frac{k_{eq}^2 p_t}{\rho_c} = Q_m$$

**Equation 2**. Scalar Wave Equation Frequency Domain

**Results**: There was correlation between the results from studies of impulse response to fully fledged simulation. Gain in processing time is possible allowing to eyeball the design quicker with multiple iterations within the Transient study in the Acoustics Module.

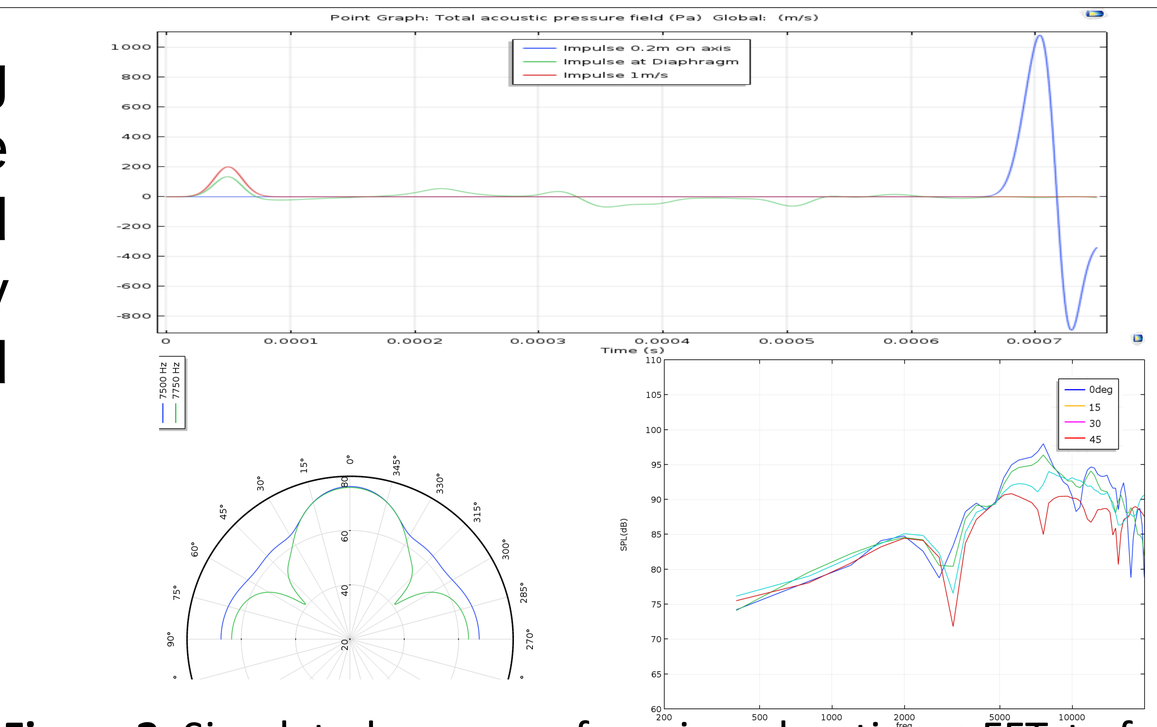



**Figure 2**. Simulated response from impulse, time->FFT, to freq.

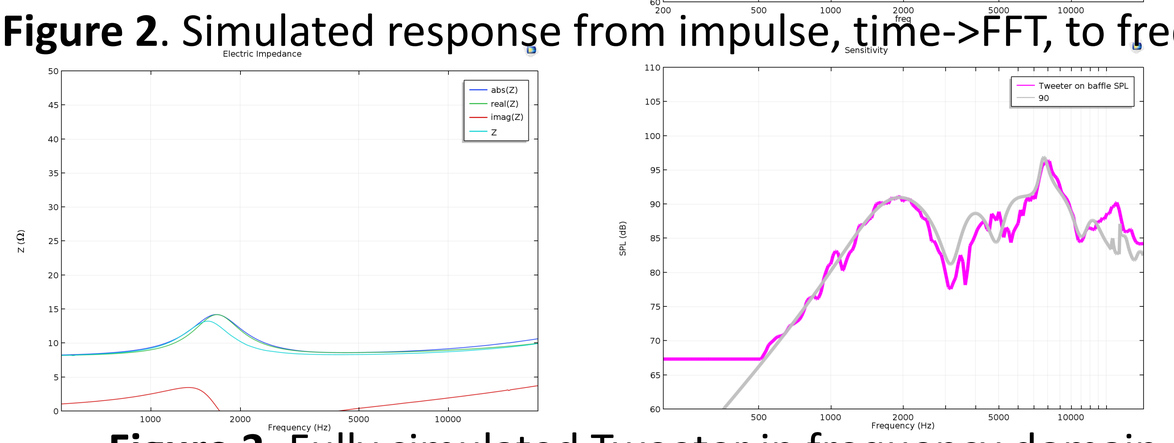



**Figure 3**. Fully simulated Tweeter in frequency domain

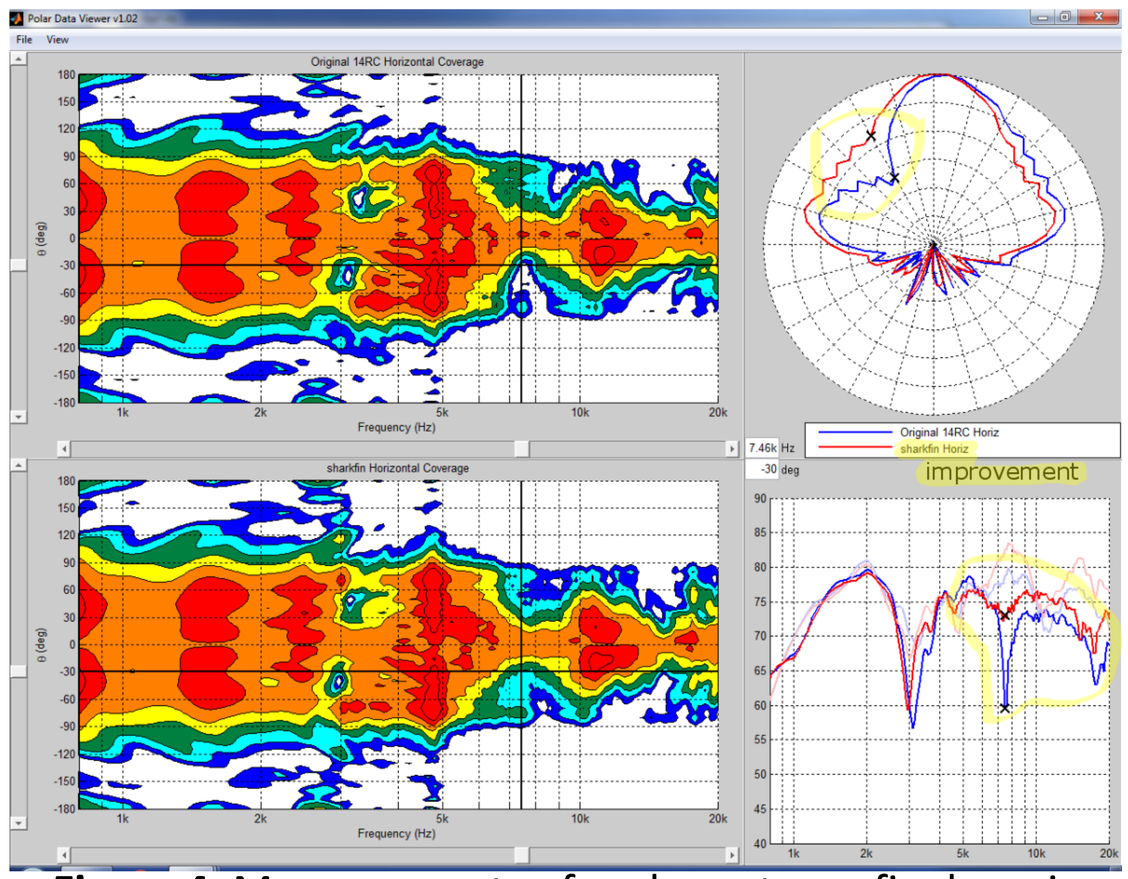



**Figure 4**. Measurements of early proto vs. final version

**Conclusions**: This methodology is perhaps at its infancy, however, it has great potential to become an essential tool as the impulse response measurements are now in the loudspeaker industry.

**References**:

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