The Cochlea Modeling

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Cochlear Duct

Cross-section through the cochlea



The fluid in the duct is the series mass

Organ Of Corti

The Organ of Corti is treated as a shunt mass-spring system



First Model of the Cochlea

The Wegel and Lane model is a dispersive transmission line



1D (transmission line) cochlear model

- The series mass is due to scalae fluid
- The shunt stiffness is due to the cochlear partition



• The shunt mass is a 1st-order 2D effect, with $M_p \approx \rho H/3$

Traditional modeling approach

 Expand using a lumped parameters, in the frequency domain

(1)
$$\begin{bmatrix} P_1 \\ V_1 \end{bmatrix} = \begin{pmatrix} A(s) & B(s) \\ C(s) & D(s) \end{pmatrix} \begin{bmatrix} P_2 \\ V_2 \end{bmatrix},$$

A 2-port is called *reciprocal* if

$$AD - BC = 1.$$

It is said to obey *parity* if the system remains invariant to a change in direction

$$x \to -x$$

Series impedance

Series inductance



Shunt capacitance

Shunt capacitance



Traditional modeling approach

Mathematical formulation of a model section

$$\begin{bmatrix} P_1 \\ V_1 \end{bmatrix} = \begin{bmatrix} 1 & Z_s/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1/Z_p & 1 \end{bmatrix} \begin{bmatrix} 1 & Z_p/2 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} P_2 \\ V_2 \end{bmatrix},$$

