WAI Mathematical Relationships

Commercial equipment allows one to measure the Thévenin impedance, Z_{TH}, and the Thévenin pressure, P_{TH}, of a sound source and microphone. With Z_{TH} and P_{TH} and a measurement of pressure in the ear canal, P_{ear}, one can compute any of the WAI quantities below. Note: all quantities are functions of frequency. Also, the characteristic impedance $Z_o = \frac{\rho c}{A}$, where A is the cross sectional area of the ear canal.

- Acoustic Impedance (complex): $Z_{ear} = \frac{Z_{TH} P_{ear}}{P_{TH} - P_{ear}}$
- Acoustic Admittance (complex): $Y_{ear} = \frac{1}{Z_{ear}}$
- Pressure Reflectance (complex): $\Gamma = \frac{Z_{ear} - Z_o}{Z_{ear} + Z_o}, \quad Z_o = \frac{\rho c}{A}$
- Power Reflectance (scaler): $\mathcal{R} = |\Gamma|^2$
- Absorbance (scaler): $A = 1 - \mathcal{R}$
- Group delay (scaler): $\tau = \frac{d}{df} \angle \Gamma$

- Reflectance $= \Gamma = \frac{\text{Reflected Pressure Wave}}{\text{Incident Pressure Wave}}$
- Γ has a complex ratio with magnitude between 0 and 1.
- Power Reflectance $= \mathcal{R} = |\Gamma|^2$ and is between 0 and 1.