Investigation of Wireless Data Transmission between Hearing Aids

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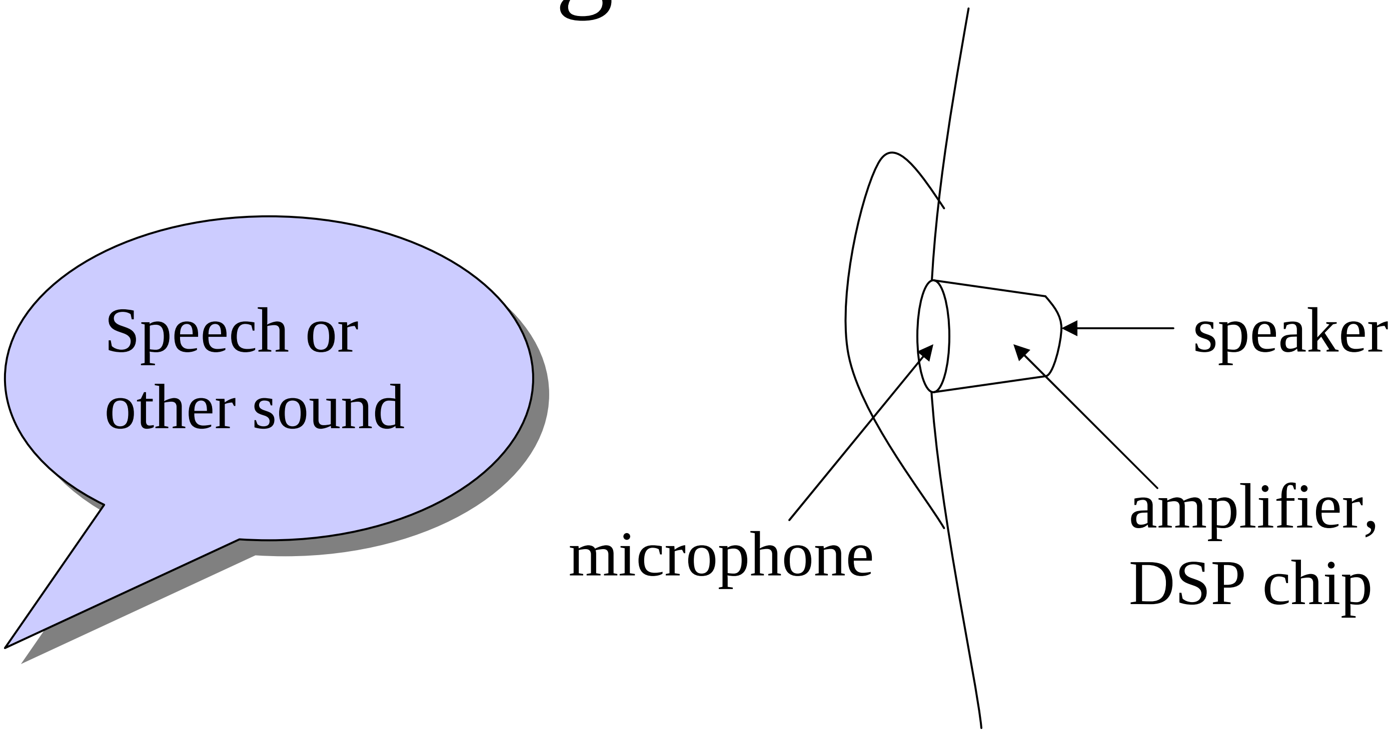
Wireless Hearing Aid Development

- Existing technology
- Electrode placement
- Measurement techniques
- Gains across test subjects’ heads

Hearing Aid Overview



- Several algorithms[1,2,3,4] exist that allow users to localize sound and hear in ‘cocktail party’ situations.
- All algorithms require the comparison of information from at least two microphones.

Existing Data-Sharing Technology

- Wired arrays of microphones[5,6]
- Low-power transceiver system specifically for hearing aid applications[7]
- Various wireless systems for Personal Area Network (PAN)[8,9,10,11]
- Electrodes forming a capacitor for hearing aid remote control[12]

Among these, there is no antenna system suitable for communication between hearing aids.

Antenna Design for Near-Body Communication

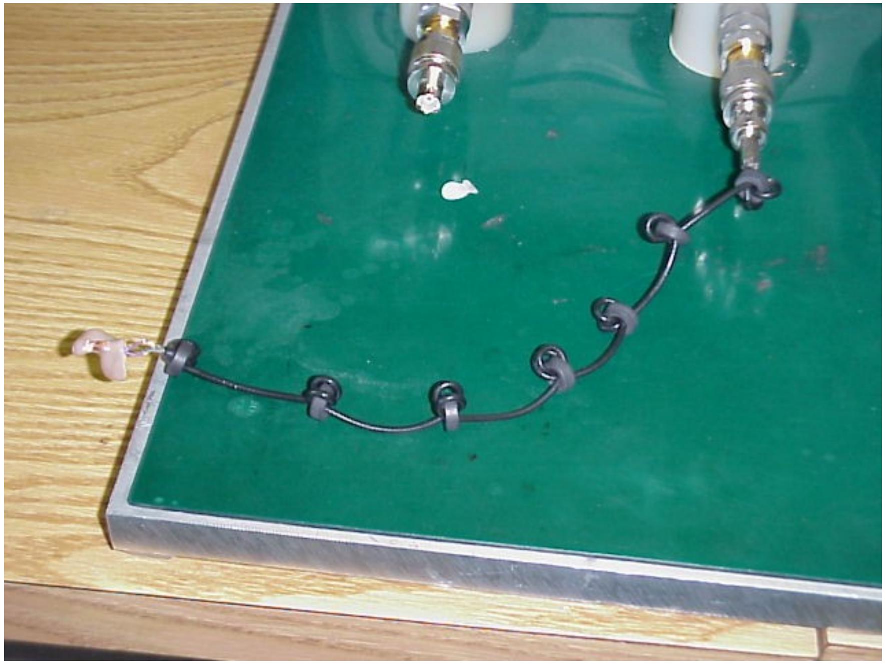
- Antenna design is crucial for link efficiency and reliability
  - Hearing-aids demand very low power
- Body becomes part of the antenna/channel
- May behave very differently from free-field

Electrode placement for stable and reproducible impedances

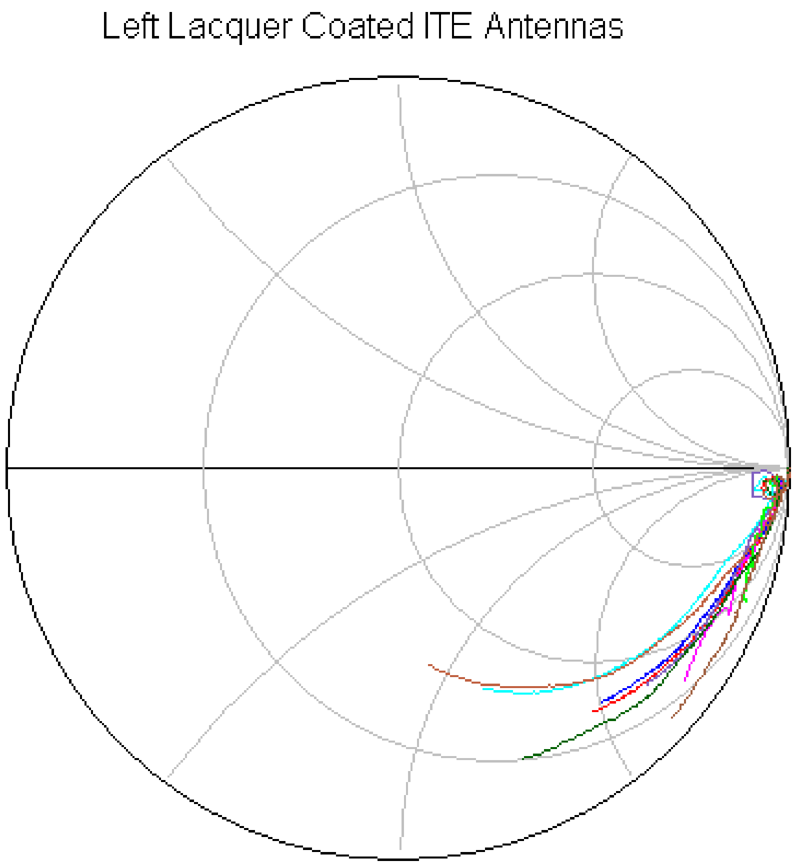
- Tried different locations, sizes, and coatings of electrodes
- The impedance of electrodes placed on the top and bottom of the shells was stable and reproducible in the frequency range of interest.

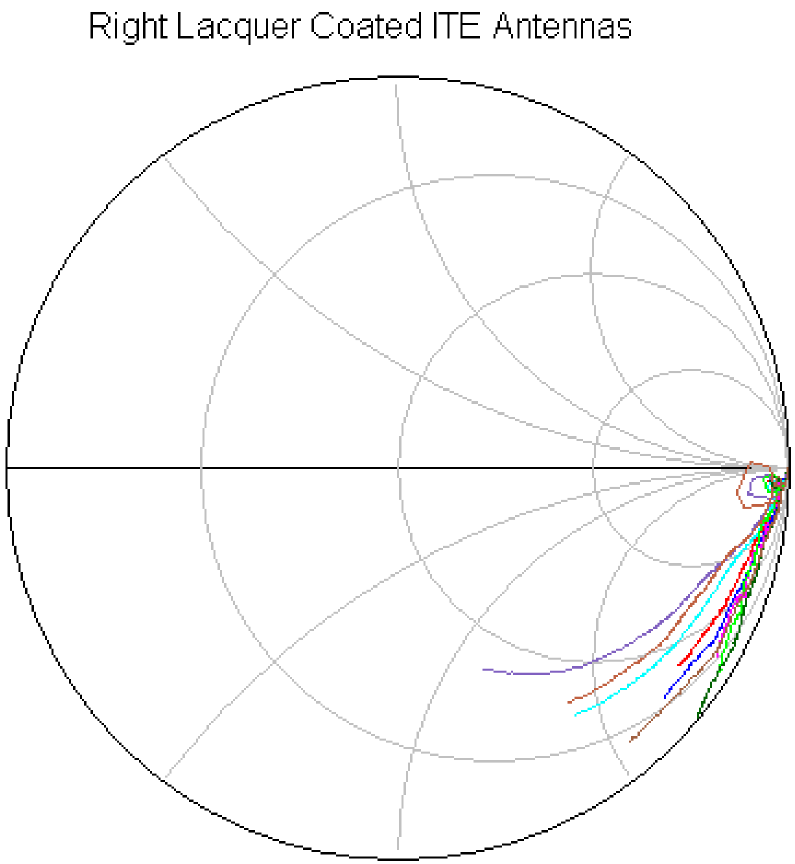
Impedance measurements

- Hearing-aid shell must fit in subject’s ear during measurement, hence the 100 cm length of coax.
- 7 chokes eliminate coupling in the frequency range of interest.
- Calibration was performed with a 50 Ω chip resistor at the end of the coax.

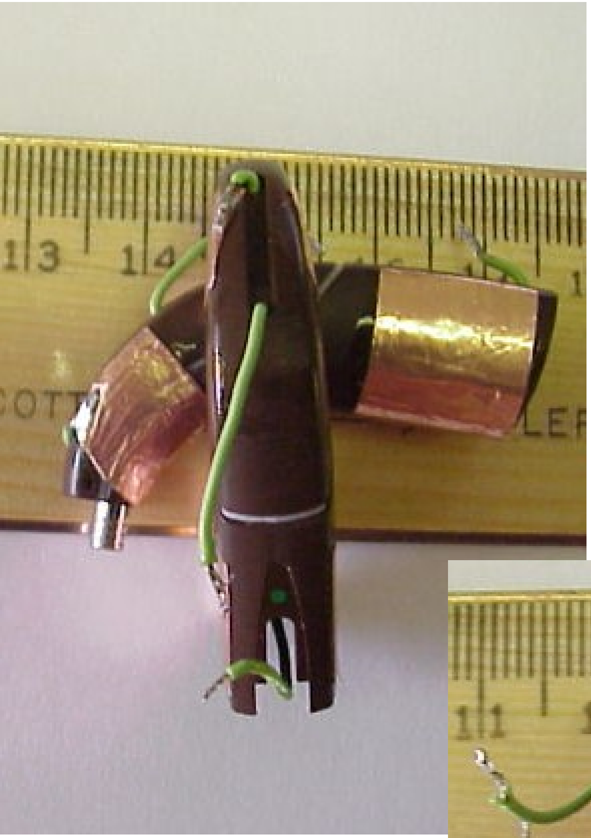


Examples of antenna impedances: 1 to 500 MHz

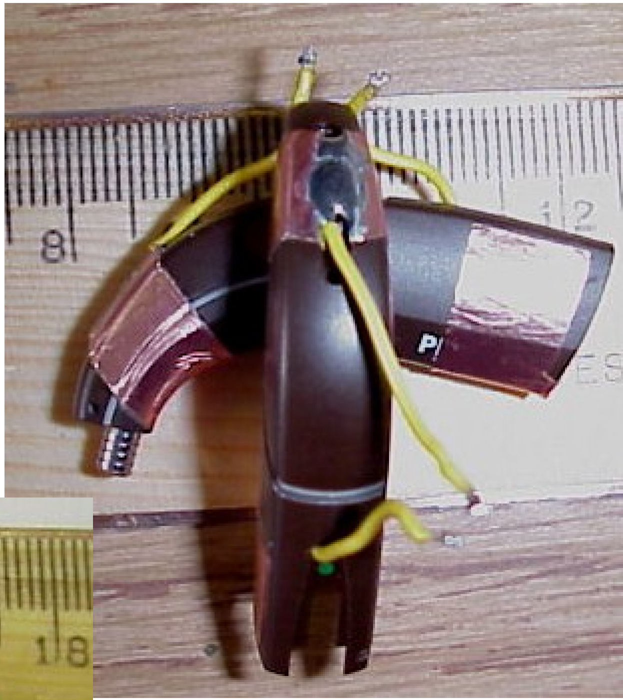


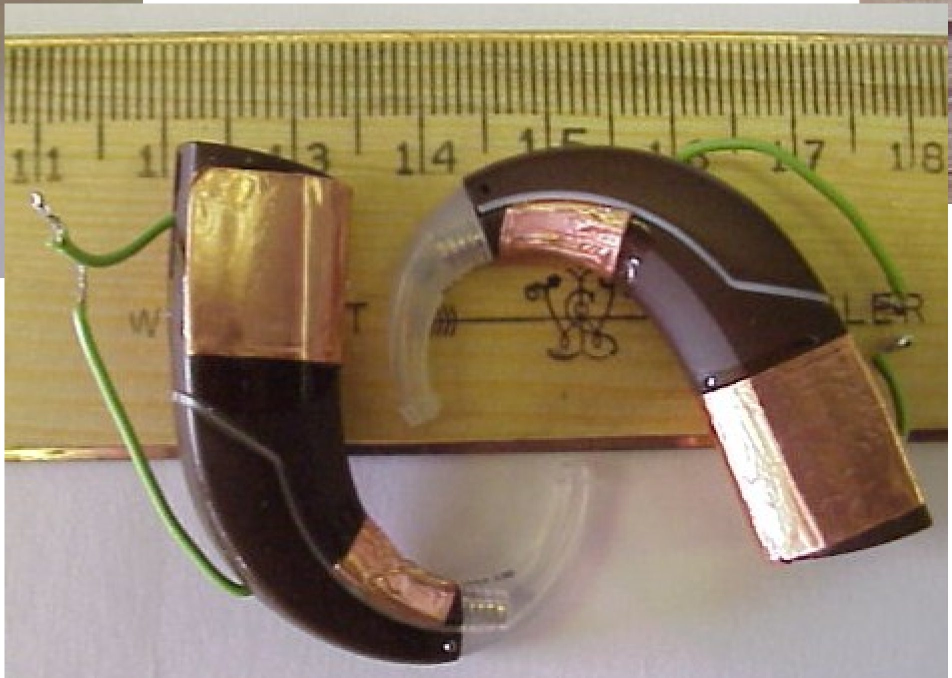


Antenna Types and Coatings: BTEs



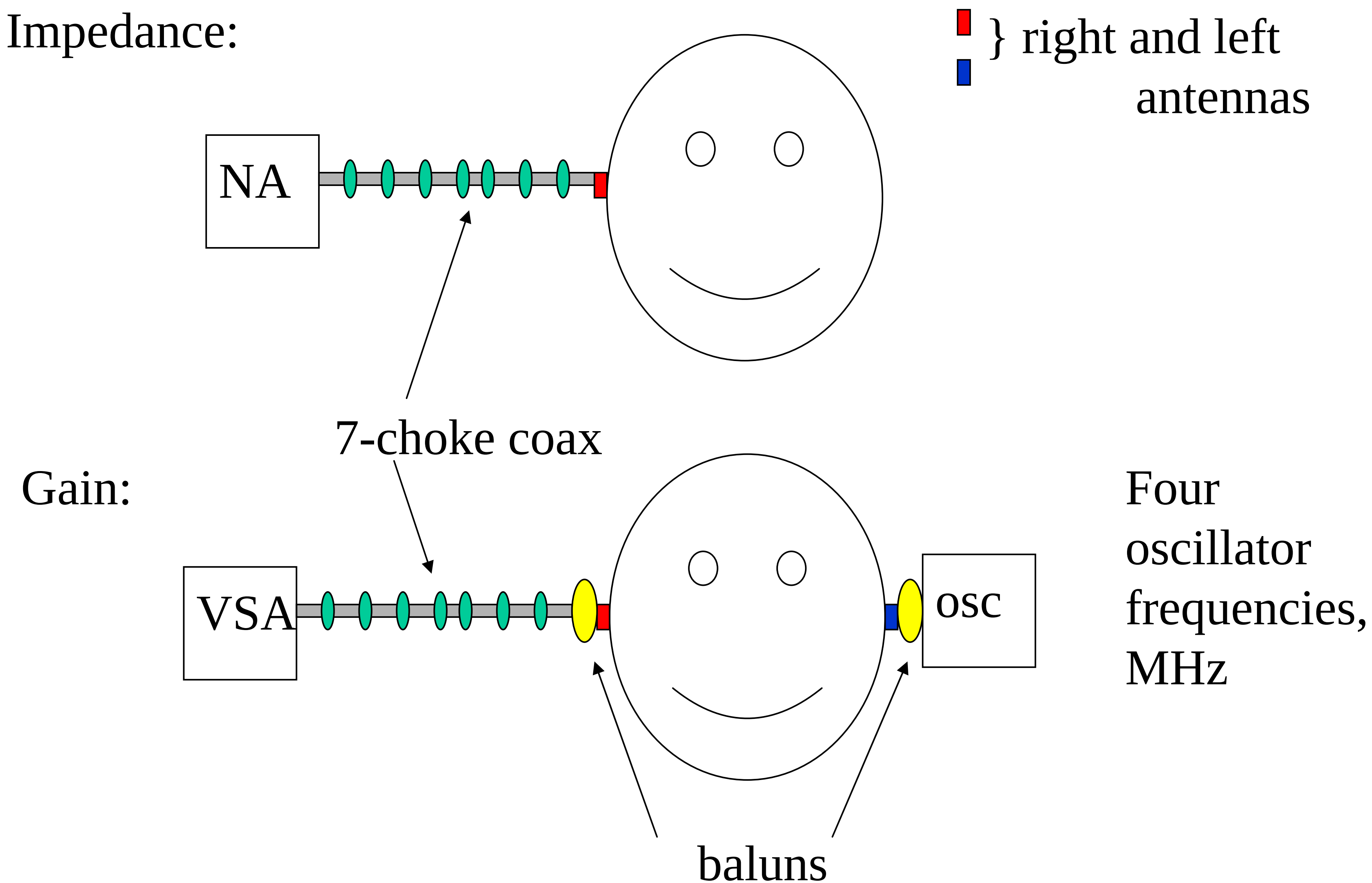
Galxyl coated antennas





2 sizes of lacquer coated antennas

Measurements



Oscillator Side of Gain Measurement

Touching the battery on the oscillator changes the gain:

- 5 dB at 21.5 MHz
- 3 to 4 dB at 64.8 MHz
- 1 to 2 dB at 128.3 MHz
- not at all at 216 MHz

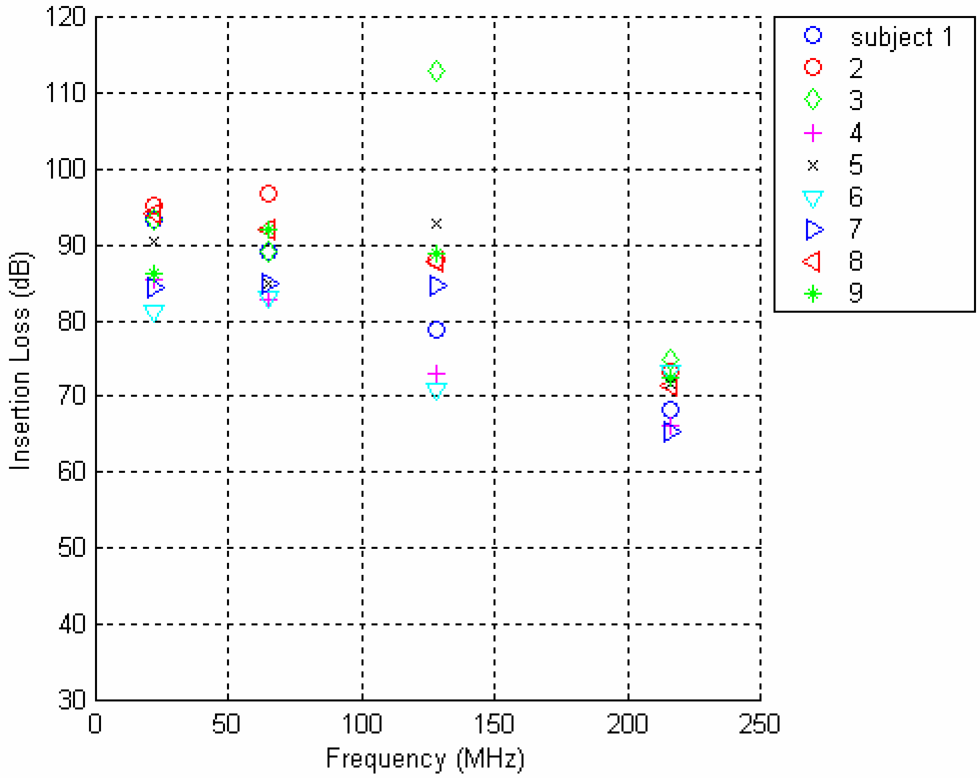
The ground plane was oriented away from the head.

Two Gains Reported

- **Insertion loss:** loss from inserting antennas-head combination between 50 Ω source and load.
- **Transducer loss:** loss expected in a real system. Instead of matching perfectly, match the source and load to the average impedance of the 9 subjects' antennas.

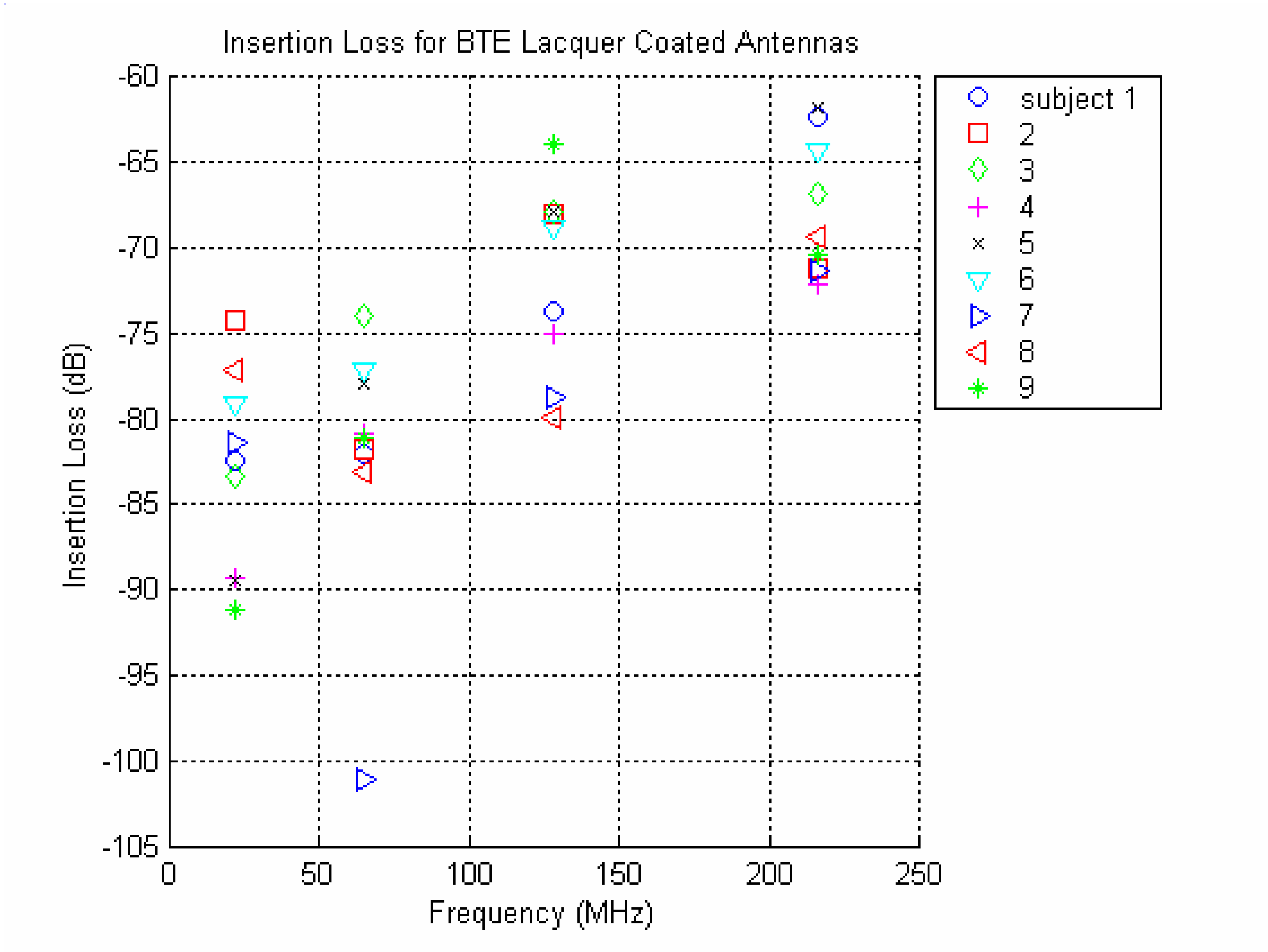
(Using a fixed matching network loses only up to 2 dB.)

Insertion Loss, ITEs

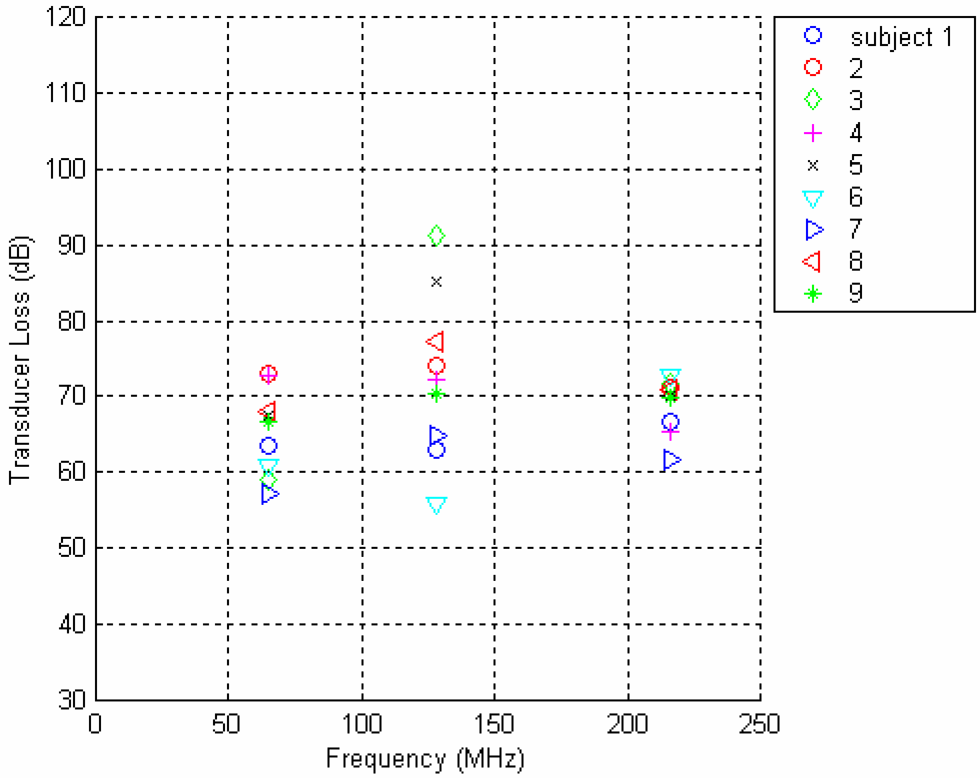


Note: the outlier came from a subject with ill-fitting shells; fit is important

Insertion Loss, BTEs

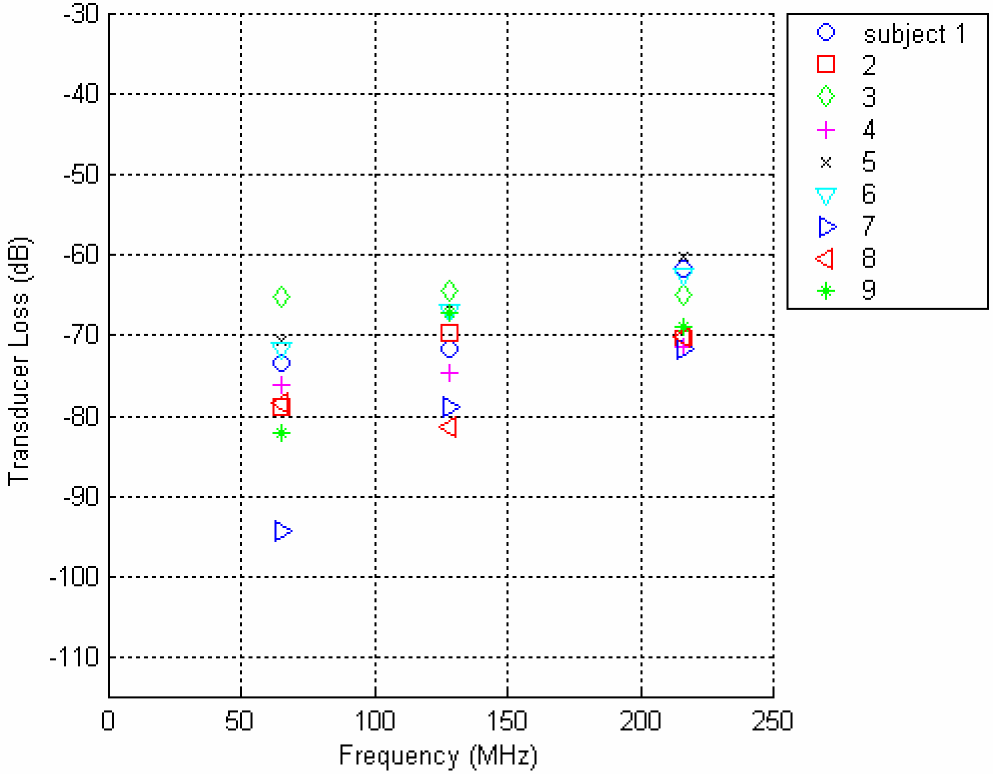


Transducer Loss, ITEs



Note: the resonance between the electrodes and the chokes obscured data at the lowest frequency

Transducer Loss, BTEs



Results

- Frequency choice is less important than hearing aid fit.
  - Ill-fitting ITEs had high losses.
  - Mismatch factors were less accurate for BTEs because of placement uncertainties.
- Signal processors can assume 80 dB loss in the worst case.

Wireless hearing aid communication is possible.

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