Consideration of Noise Canceling Using Electromagnetic Bone Conduction Device

2026/5/14

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Contents

- Overview of Research
- Measurement
  - Inverting amplifier circuit
  - Reduction requirements
- Conclusion

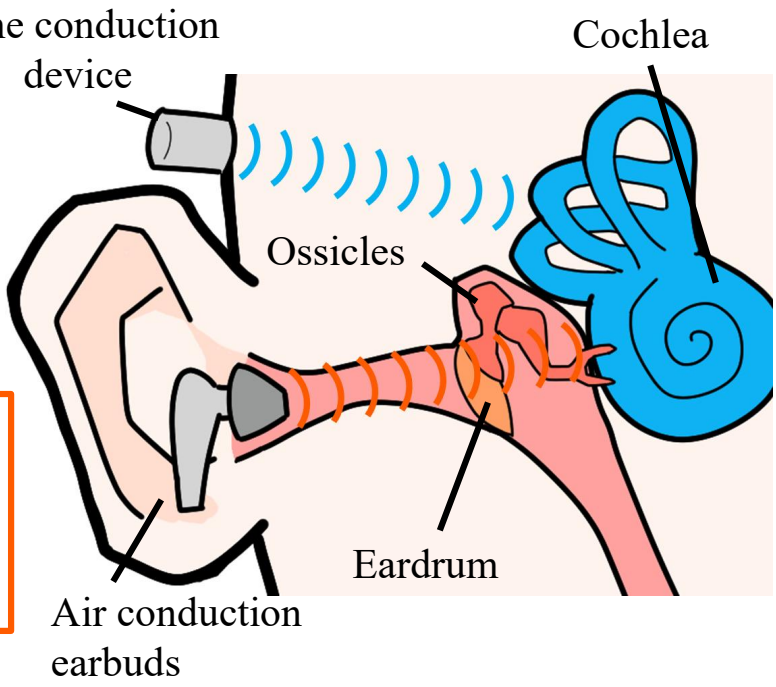
Research Background

Bone conduction

Skull vibrations
→Cochlea

Air conduction

Air vibration
→Ear canal →Ear drum
→Ossicles →Cochlea



- Works even with ear damage
- Hear sounds without blocking your ears

Research Subject and Object

Subject

- Can't block out noise
- Standard control methods do not work

⇩

Object

- Check the noise canceling effect and requirements
- Implementation of noise cancellation

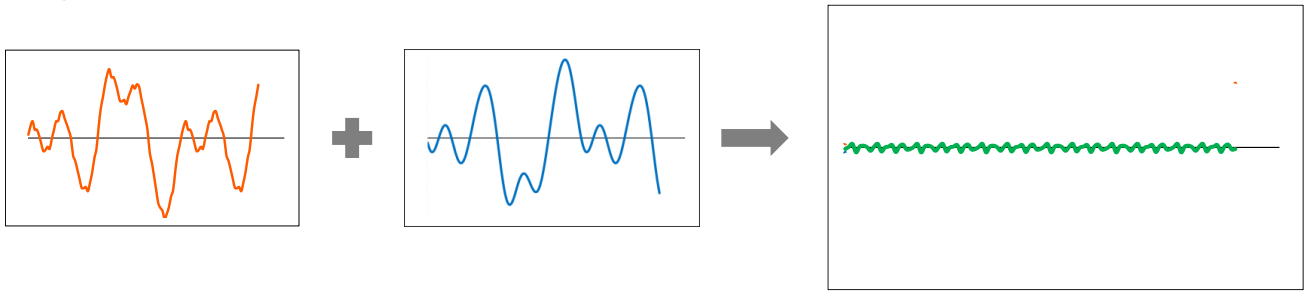
Noise Canceling Method

PNC:Passive noise cancellation

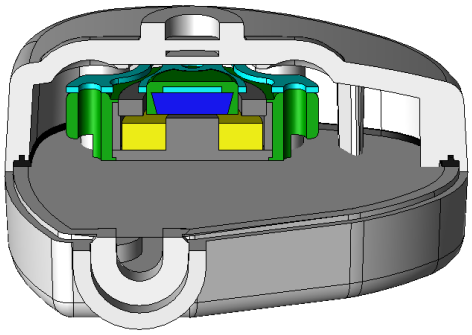
Directly reduce incoming noise using earplugs or earpads.

ANC:Active noise cancellation

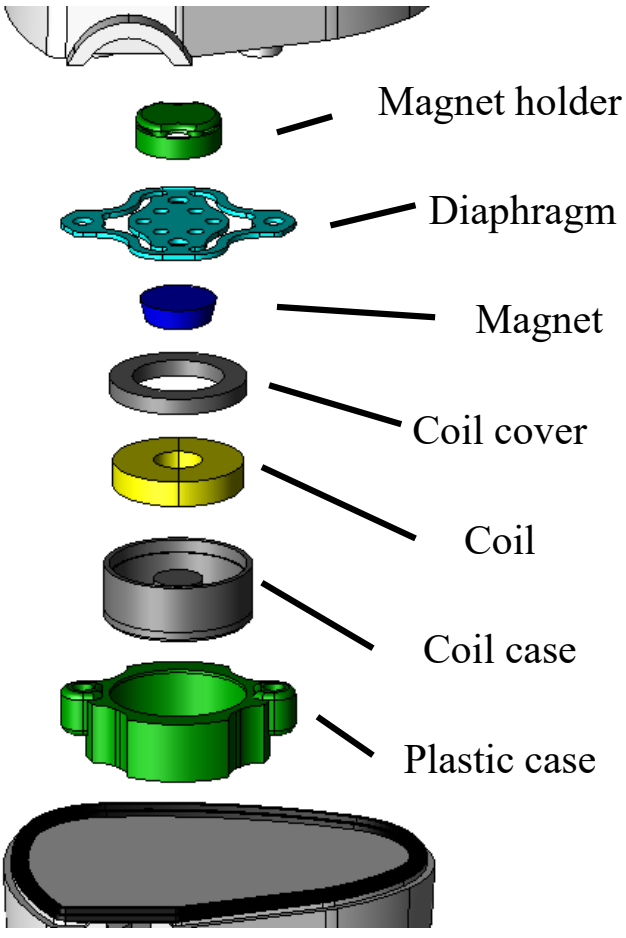
Reduce noise by generating a phase-inverted signal to cancel it out.



Structure

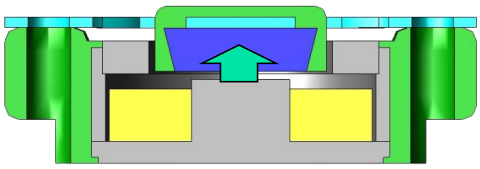


Parts	Material
Diaphragm Coil case Coil cover	SUS430
Magnet	NEOMAX-35AH
Coil	Copper
Magnet holder Plastic case Case	ABS543(Techno)



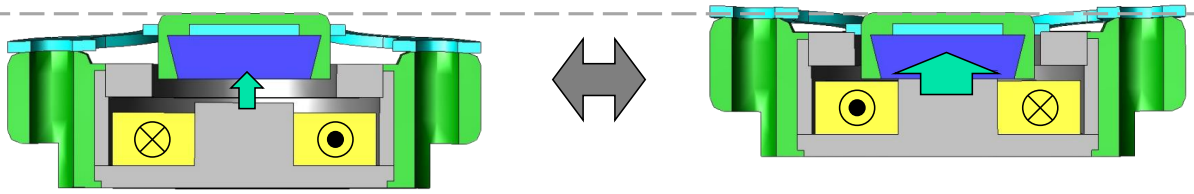
Operational Mechanism

Power off



Constant magnetic force
from magnet flux

Current flow

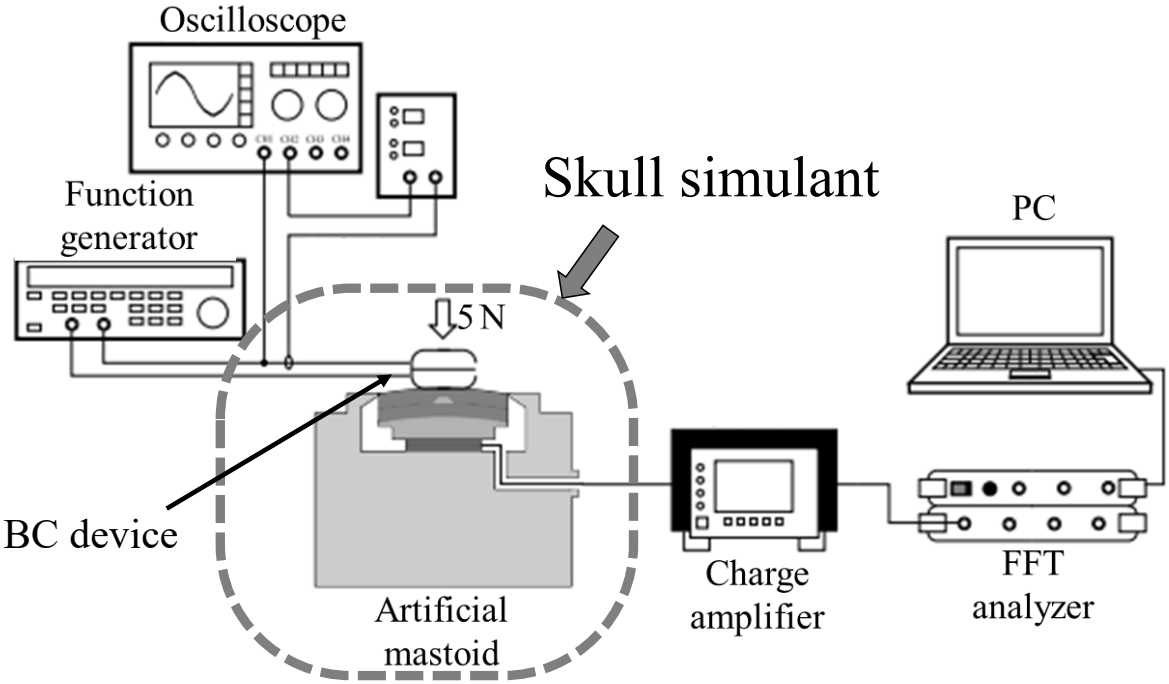


Magnet flux
+
Coil flux

Change magnetic force
between the magnet and coil
case

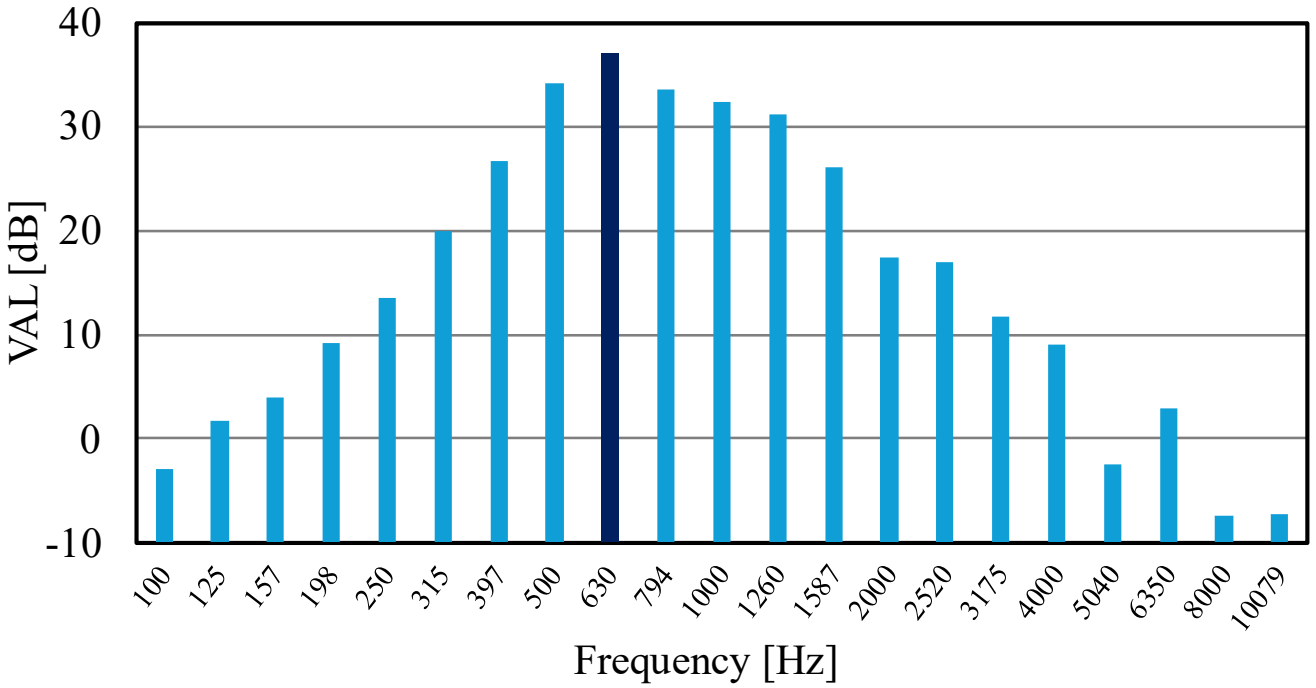
Vibration

Measurement of actual device output



- Apply sine wave voltage
- Measure frequency response using FFT analyzer

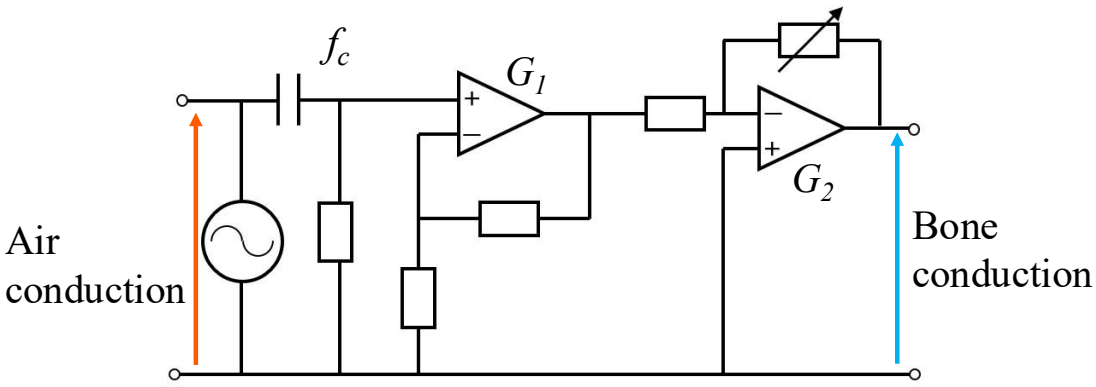
Actual device output



- Output characteristics with a peak at 630 Hz
- Resonance point identified at 630 Hz via structural analysis

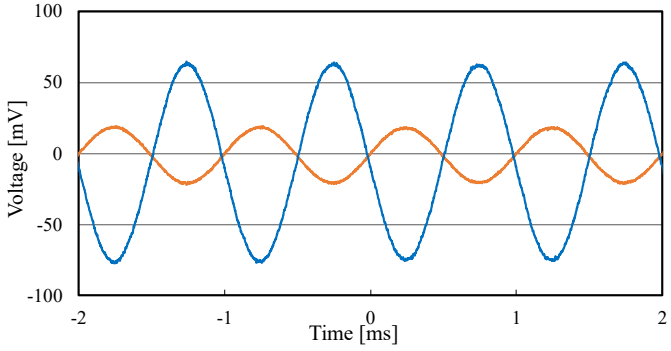
Contents

Inverting Amplifier Circuit Configuration

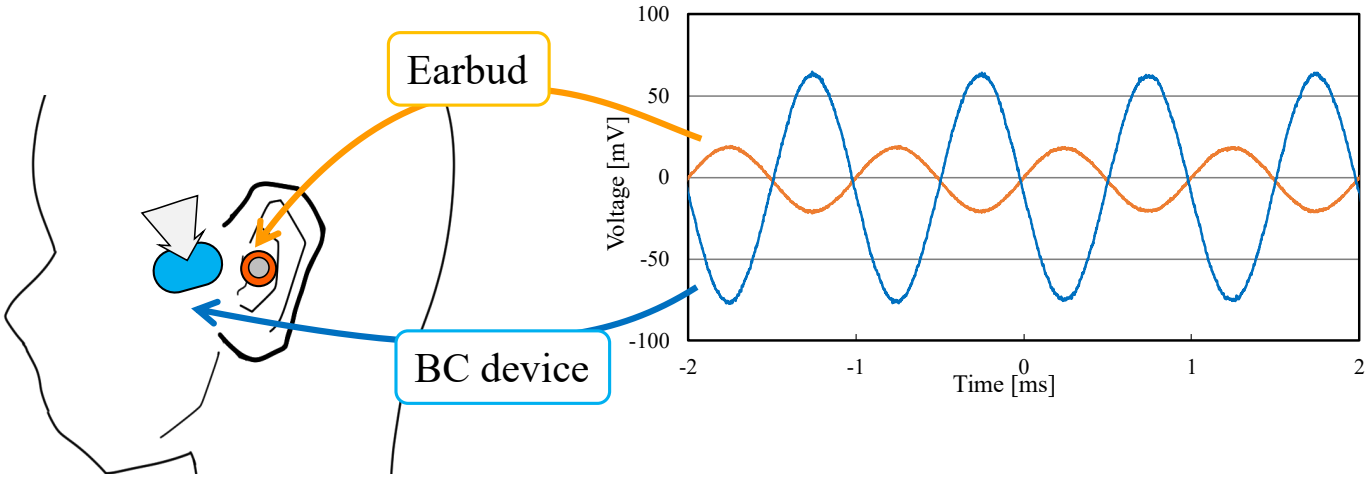


Cut-off frequency	f_c	16.9 Hz
Gain	G_1	23
	G_2	0 ~ 2.5

Adjust using variable resistor



Reduction via Inverted Signal



	500 Hz	1000 Hz	2000 Hz
A	△	○	×
B	×	△	—
C	△	×	—

○ : Effective reduction
△ : Slight change
× : No noticeable change

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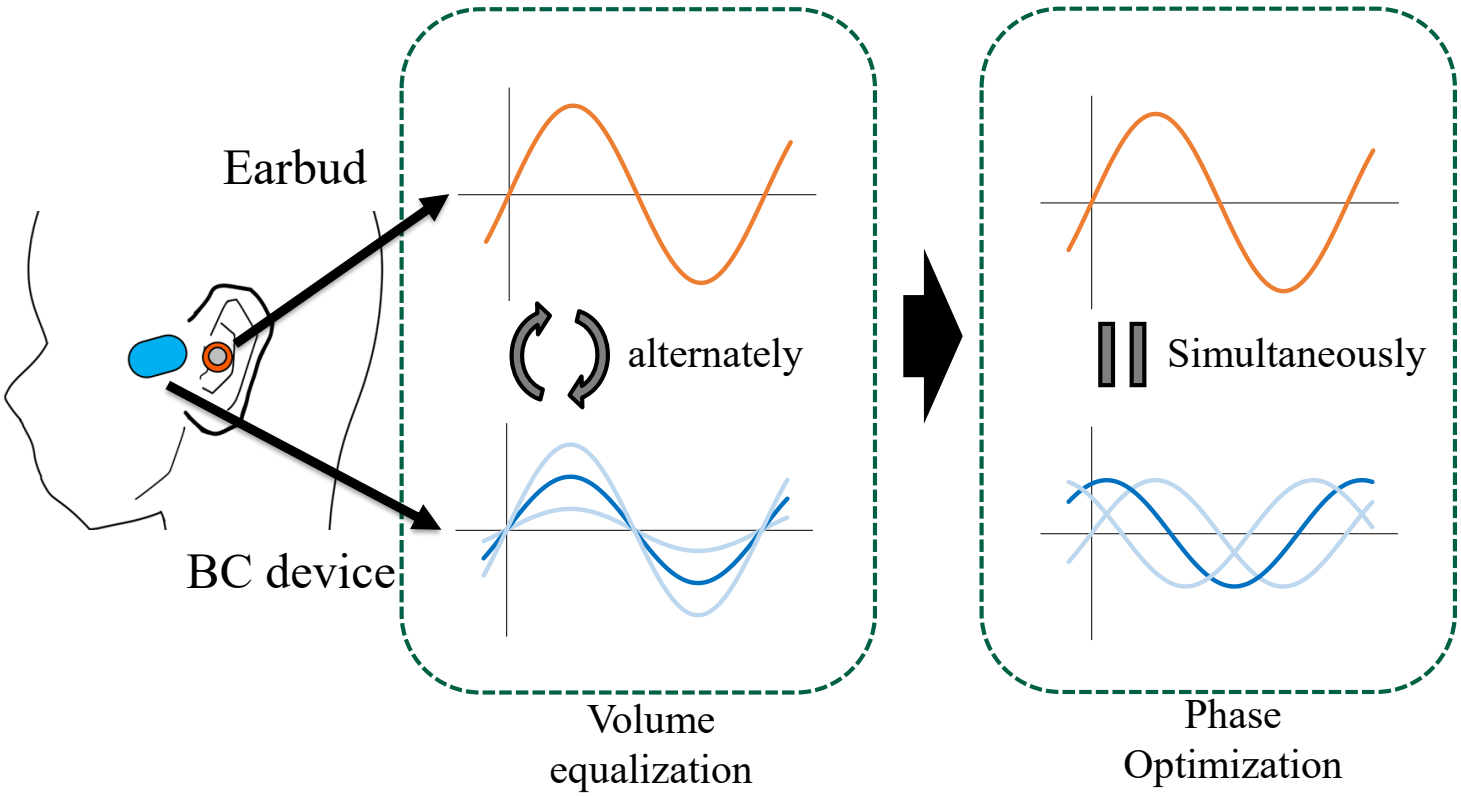
Measurement Procedure

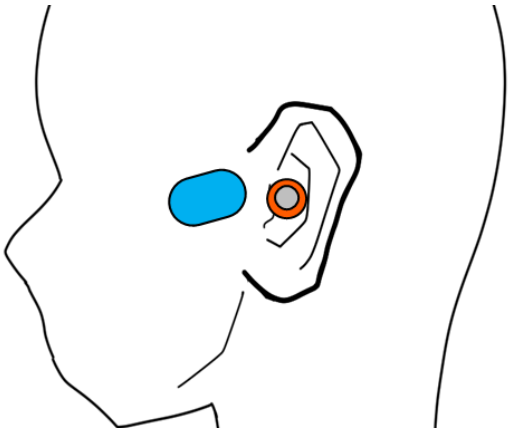


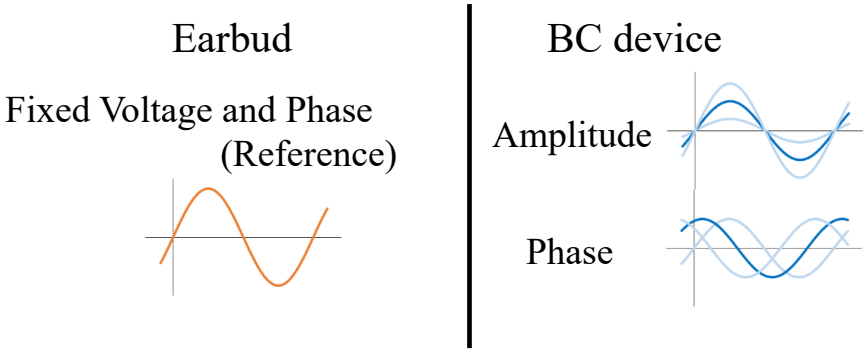
Measurement Procedure

1. Wearing both earbud and BC device on the left ear.

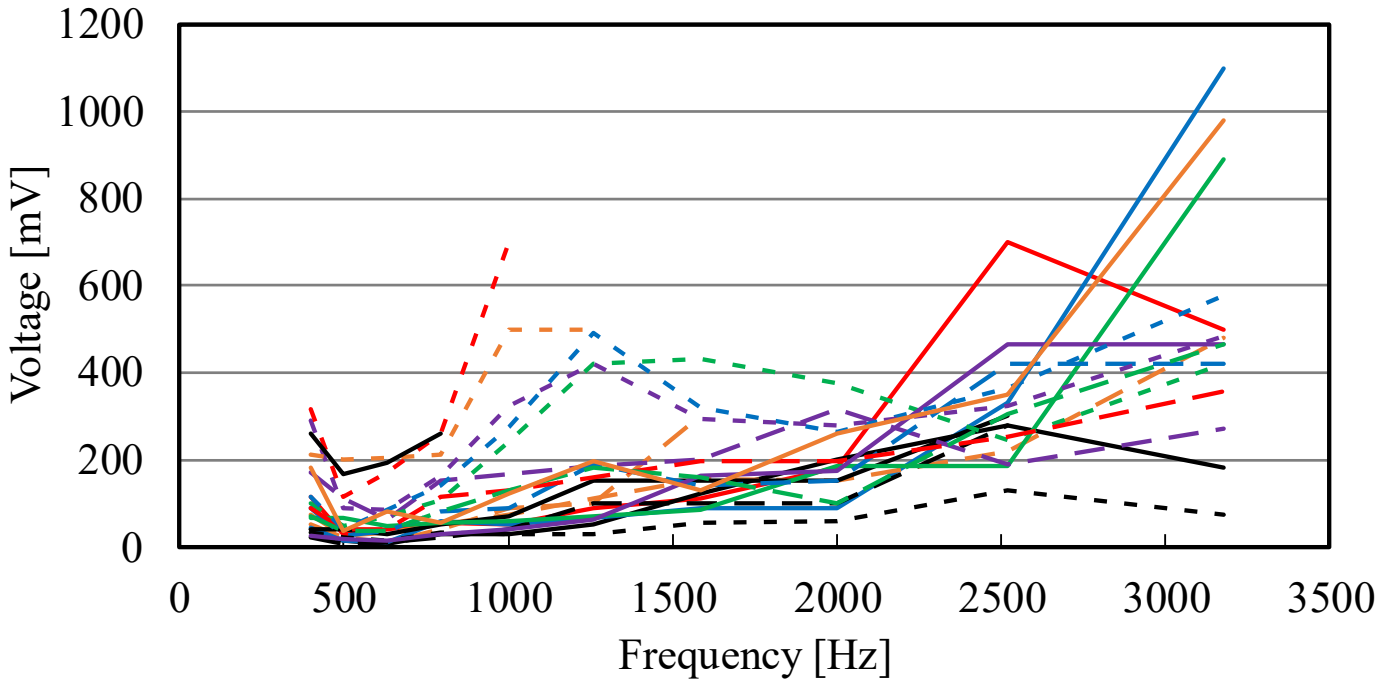
2. Play sound alternately and adjust the BC voltage to match the volume.

3. Play sound simultaneously and adjust the BC phase to minimize the volume.



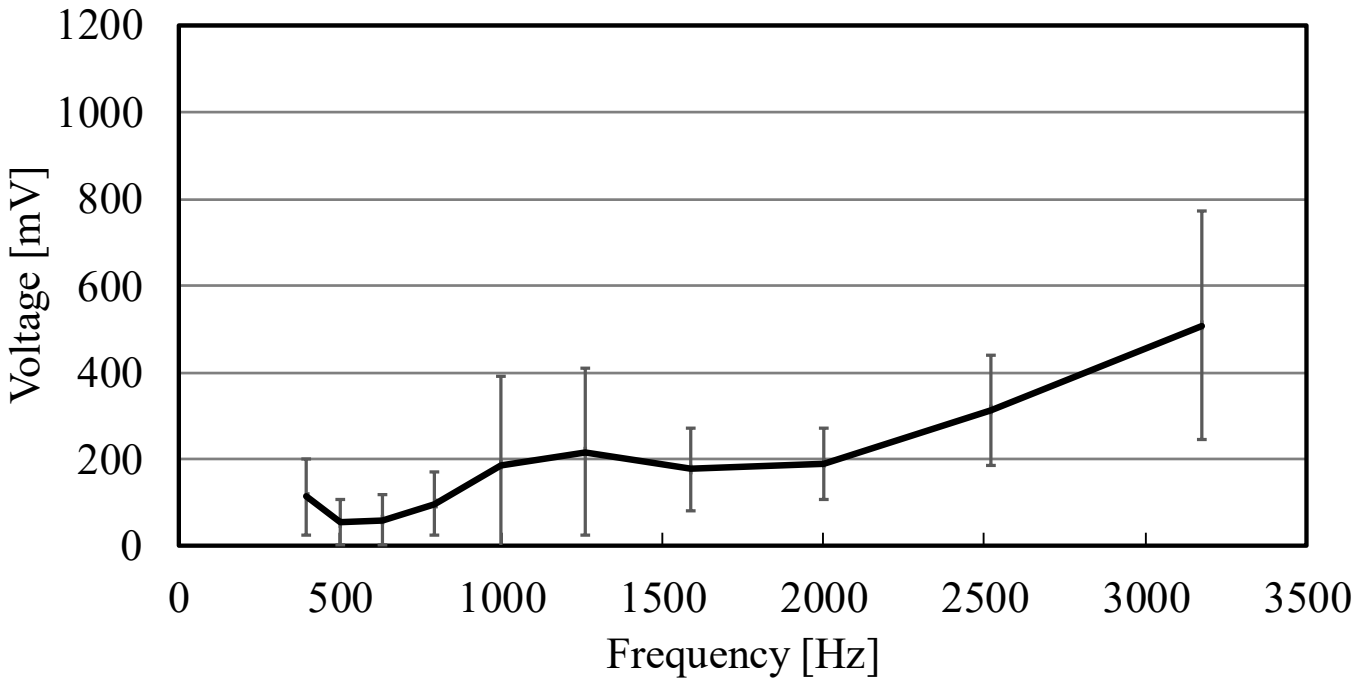


Equally Perceived Voltage



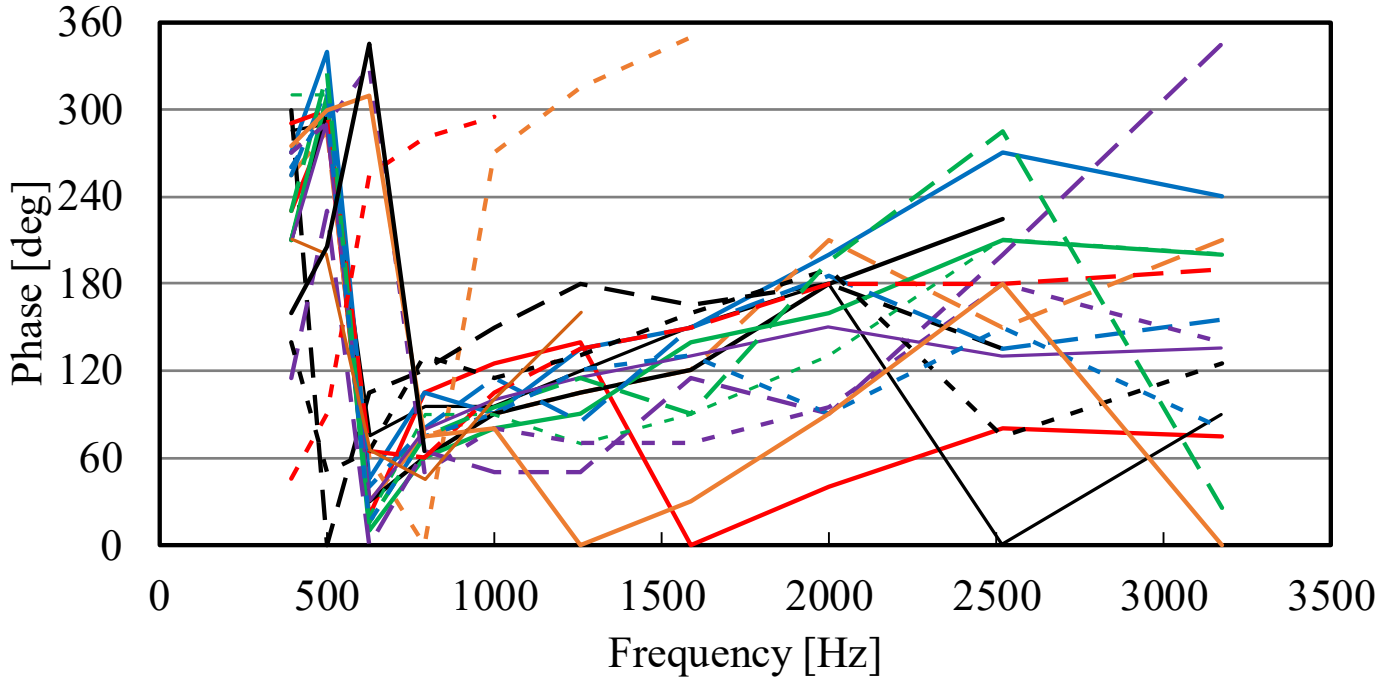
■ Significant voltage increase around 1000 Hz and 3000 Hz
→Higher variability

Equally Perceived Voltage



- Higher variance around 1000 Hz and 3000 Hz
- Lowest voltage at 630 Hz

Optimal Phase for Reduction



- Shape decrease in 500 ~ 700 Hz
- Full range phase variation around 3000 Hz

Measurement Result

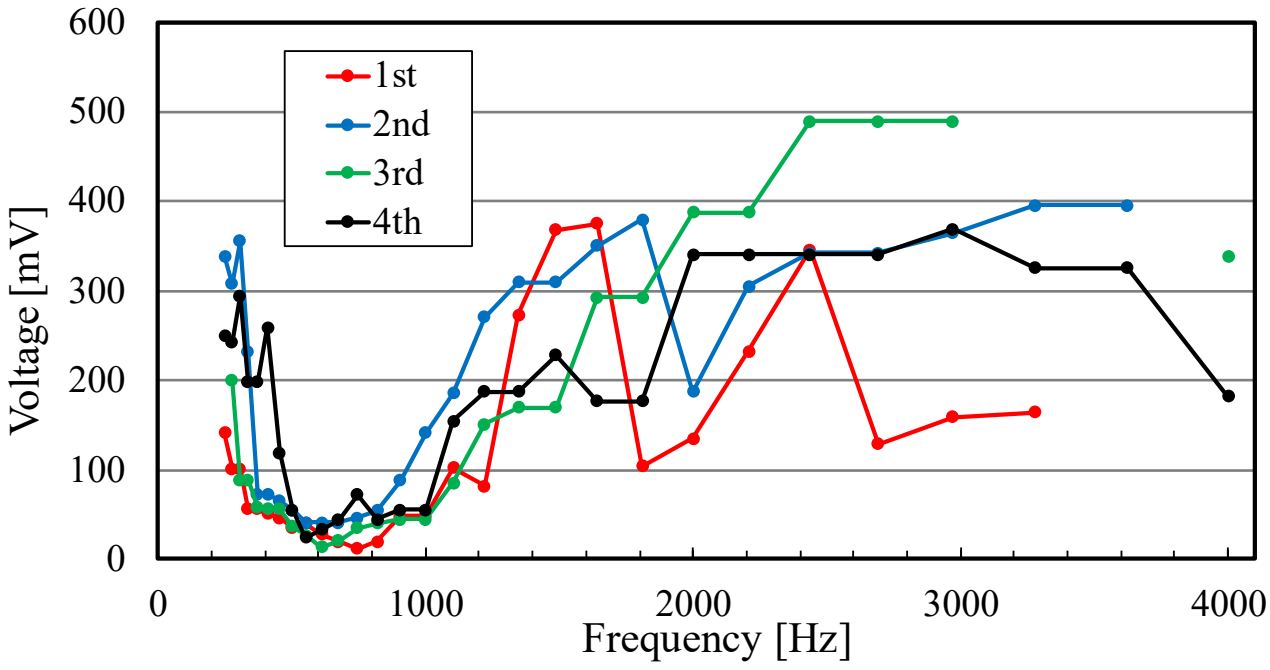
- High voltage and phase variability around 1000 and 3000 Hz

- Fit of the earpiece affects bone conduction volume
- Degradation of BC sound quality above 2000 Hz

17/21 subjects perceived sufficient reduction
with the 397 ~ 2520 Hz range

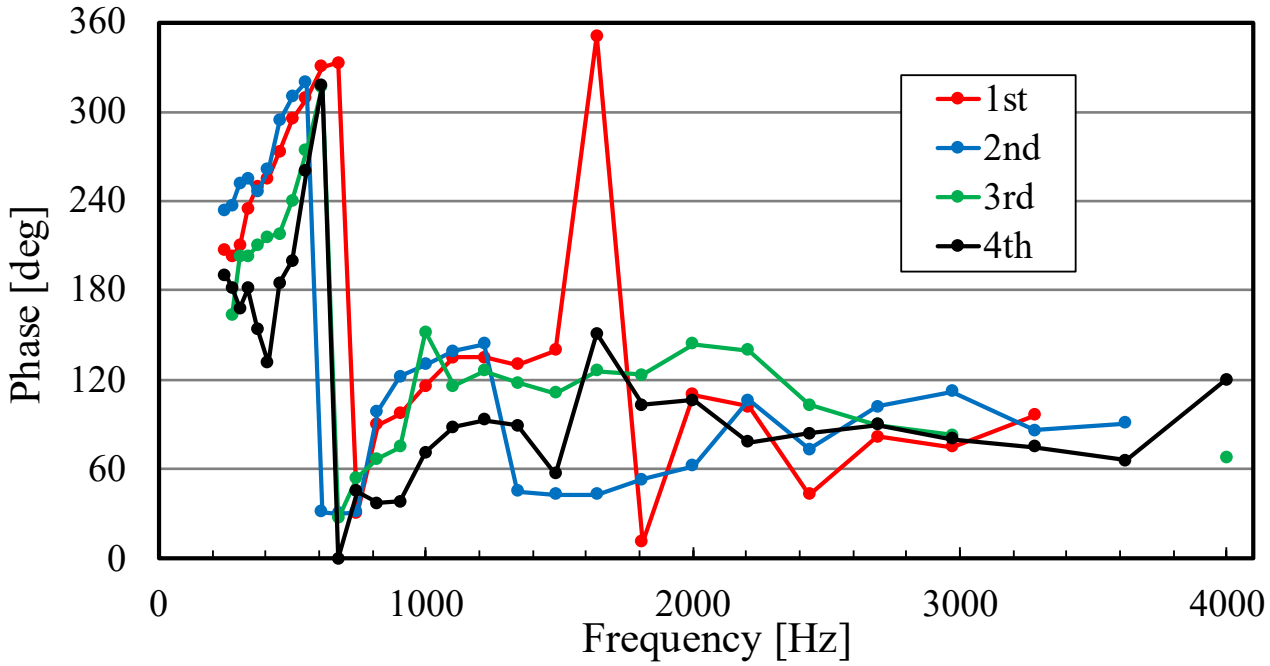
⇨ Variability due to fitting

Equally Perceived Voltage



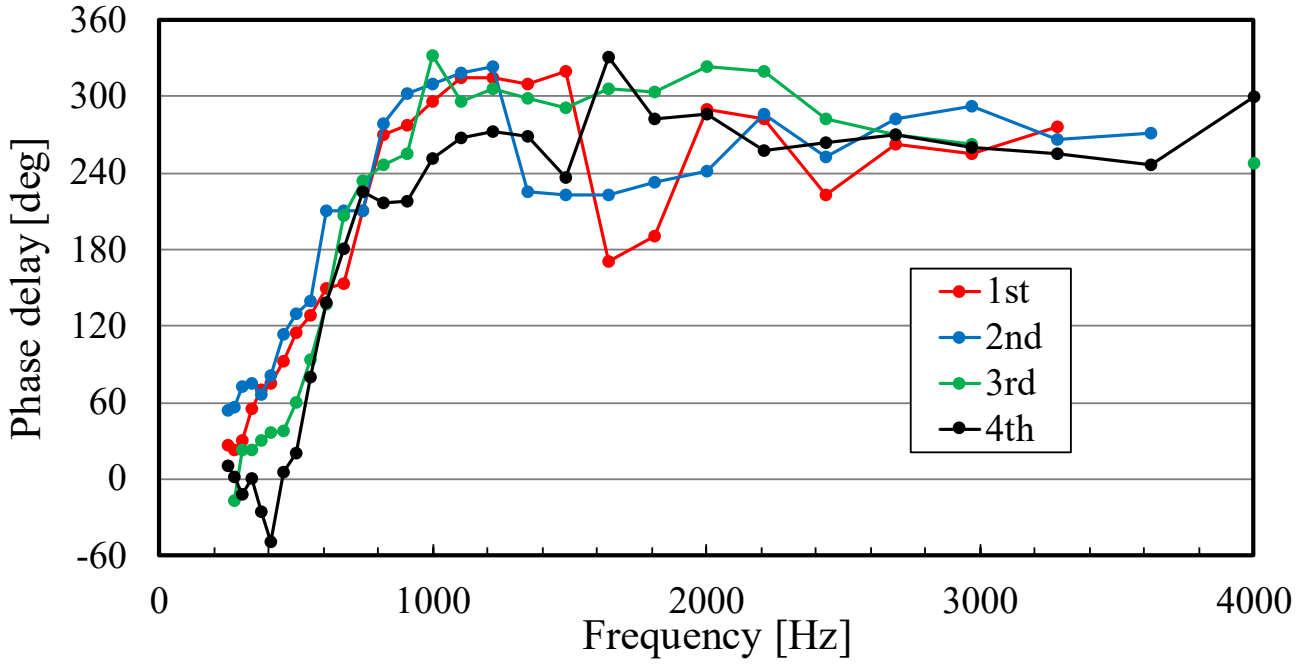
- Lowest voltage at 630 Hz
- Highly variation above 2000 Hz

Optimal Phase for Reduction



- Shape decrease in 500 ~ 700 Hz
- Low variability except around 1600 Hz

Estimated BC Device Delay



- Shape decrease in 500 ~ 700 Hz
- Full range phase variation around 3000 Hz

BC Device Delay

BC sounds perception delay

Possible factor

- High inductive reactance component
- Slow vibration propagation in the skin
- Heavier transducer compared to earbuds
  →High mechanical impedance

Demerit

- Inability to handle
  high-frequency, non-periodic, impulsive noise

Conclusion

Object

- Implementation of noise cancellation

Result

- Effective for periodic noise
  - sufficient reduction with the 397～2520 Hz range
- BC sounds perception delay

Forward

- Check and reduce delay
- Improving output in the high-frequency range