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International Journal on Advanced Electrical and Computer Engineering

ISSN: 2349-9338

Volume 15 Issue 01s, 2026

NeuroVibe – Neural Vibration Pathway for Deaf Users

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Peer Review Information

Submission: 05 Dec 2025

Revision: 25 Dec 2025

Acceptance: 10 Jan 2026

Keywords

NeuroVibe, bone conduction, vibrotactile feedback, hearing impairment, sound-to-vibration conversion, cochlear stimulation, wearable device, frequency response, haptic perception, jawbone conduction, audio-to-vibration system, sensory substitution.

Abstract

People with hearing impairments often feel like they cannot sense the sound from their surroundings. NeuroVibe is an innovative wearable device that provides an alternative way of perceiving sound through bone conduction-based vibrotactile feedback; it transforms the sound frequencies into gentle mechanical vibrations that can easily be perceived via teeth. The device consists of a Bluetooth audio module (Cosmic 104), a mini audio amplifier (PAM8403), a cylindrical vibration motor, a 3.7 V/1800 mAh rechargeable lithium battery, connecting wires, and a protective enclosure. When connected with an audio source, NeuroVibe converts sound frequencies into proportional intensities of vibration that reach the cochlea through the jawbone, enabling the user to feel rather than hear the sound sensation.

This work presents the design of the device, its working mechanism, and its vibration response for alphabetic sound patterns in the 3–7 kHz, frequency range. The results clearly indicate a relationship between frequency and vibration strength, thus pointing out NeuroVibe's potential for being an affordable and effective assistive technology in people with partial or profound hearing loss.

Introduction

Worldwide, deafness has an impact on millions of people; more than 430 million individuals with disabling hearing loss were projected to be affected as per The World Health Organization. Hearing aids have traditionally been used to increase the amount of sound that deaf persons can hear; however, they do not always work for those with profound deafness. New technology has developed rapidly within the haptic and bone conduction interface fields, giving deaf persons the ability to interact with their environment through their sense of touch and the bones in their head, rather than through the ear canal.

NeuroVibe is a completely new type of assistive device that allows users to experience sounds in a way that does not rely on hearing aids, but instead uses the teeth and the jawbone as a natural medium for transmitting sound vibrations. NeuroVibe allows users to feel sound through the mechanical vibration of their teeth and jaw, allowing users to experience and understand sound similarly to how someone without hearing impairment experiences sound.

Literature Review

Many researchers have investigated vibrotactile and bone-conduction aids as auditory substitution devices because promising approaches to help people with hearing impairments. Vibrotactile aids convert acoustic speech signals into vibrotactile signals that convey fundamental voice information via skin. This Method seems particularly promising for time-related auditory cues important in speech recognition, although spectral cues may require more complex signal processing. Few wearable devices, such as multichannel Several studies have developed and tested vibrotactile gloves that produce increased discrimination of speech features through touch. Vibrotactile input added to auditory cues has been shown to enhance perceptual thresholds for certain acoustic features, thus aiding speech comprehension especially in noisy environments. Bone conduction aids bypass the middle ear by transmitting sound vibrations directly through the skull to the cochlea. Extensive study of these devices has reported significant. It improves hearing thresholds, speech perception, and the quality of life for users with either conductive or mixed hearing loss. Bone-anchored hearing aids are surgically implanted and provide stimulation directly. Improving auditory results versus traditional air conduction hearing aids. Bilateral bone conduction whereas aids may further enhance hearing benefits, though outcomes can be variable. The literature highlights consistent While current evidence has shown functional gain and subjective satisfaction, implant loss and adverse events remain considerations.

Recent studies also reveal that combining vibrotactile stimulation with bone conduction results in the improvement of aspects self-voice perception and auditory self-identification, indicating advantages of multisensory integration.in auditory substitution. In summary, vibrotactile and bone-conduction aids represent complementary sensory substitution strategies, utilizing respectively the tactile and bone vibration pathways to enhance or replace Auditory input improves speech perception and enhances quality of life in hearing-impaired populations.

Problem Statement

People with hearing impairments, particularly those who are profoundly deaf, have a difficult time using traditional hearing aids to perceive auditory information. Current assistive technologies that use vibrotactile and bone-conduction interfaces are often complicated, expensive, or uncomfortable to use on a daily basis. There are especially few low-cost, straightforward solutions that use dental bone conduction to increase vibration sensitivity. Additionally, little quantitative research has been done to map sound frequency to vibration amplitude in a way that the teeth and jawbone can reliably perceive. By creating NeuroVibe, an inexpensive, small bone-conduction device that transforms sound frequencies into mechanical vibrations that are transmitted through the teeth to help deaf people perceive sound, this research fills in these gaps.

In order to provide a useful and affordable solution for users who are partially or profoundly deaf, the study intends to design the device, correlate sound frequency with vibration intensity, and assess its accuracy and usability.

The goals of the project are:

1. To create a small, inexpensive vibrotactile bone-conduction apparatus.
2. To find distinct, observable patterns by correlating vibration amplitude with sound frequency.
3. To assess the accuracy of frequency response for various audio inputs.

Methodology

Table 1: Components Used

Sr. No	Component	Specification / Function
1	Bluetooth Audio Module	Cosmic 104 – Wireless audio signal receiver
2	Audio Amplifier Circuit	PAM8403 mini amplifier Boosts Bluetooth output
3	Cylindrical Vibration Motor	Converts electrical signal to mechanical vibration
4	Rechargeable Lithium Battery	3.7 V / 1800 mAh – portable power supply
5	Connecting Wires and Enclosure	Provides electrical connectivity and safety housing

1. Circuit Layout:

A 3.7 V/1800 mAh lithium-ion battery powers a cylindrical vibration motor that is driven by a PAM8403 mini amplifier module and a Bluetooth audio module (Cosmic 104). The module's VIN is fed by the battery's positive terminal, and all components are connected by the common GND. The driver amplifies the Bluetooth board's audio output and transforms electrical audio signals into mechanical vibration.

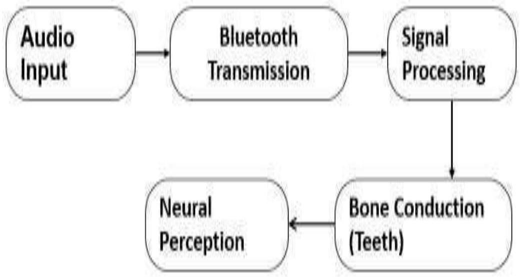

Figure 1. Block diagram of the NeuroVibe system.

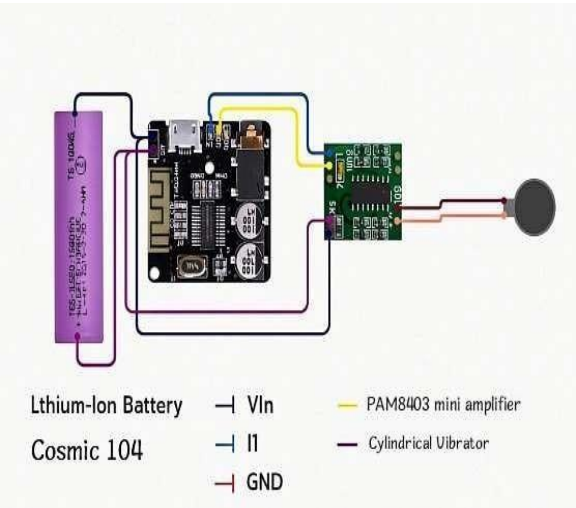

Figure 2. Circuit diagram of NeuroVibe.

2. Assembly Steps:

- Attach the battery + to the Bluetooth module's VIN and the motor-driver's Vcc; connect all grounds.
- Connect the Bluetooth audio output to the input of the mini amplifier.
- Connect the vibration motor terminals to the mini amplifier outputs (OUT1 & OUT2).
- Install the motor in a soft dental pad for bone contact and mount all components inside a tiny enclosure.
- Check the device's vibration response to test tones after pairing it via Bluetooth.

3. Data Collection Methods

- To capture voltage amplitude and frequency readings, the NeuroVibe device output was linked to a Digital Storage Oscilloscope(DSO).
- The formula $dB=20\log10(V/V_{ref})$ was used to convert the measured amplitude values into decibels (dB).
- To guarantee accuracy and dependability, several readings were obtained under the same circumstances, and the average values were computed.

4. Assumptions and Limitations

Assumptions –

- The vibration motor output is linearly proportional to input frequency and amplitude.
- Tooth contact provides consistent bone-conduction coupling across tests.
- Battery voltage remains stable during operation.
- External vibrations and electrical noise are negligible.

Limitations –

- Sensation accuracy is impacted by individual variations in dental structure.
- Long-term use is limited by motor heating and comfort.
- Small timing fluctuations could result from Bluetooth latency.
- The prototype is not certified for medical-grade hygiene.

Results

The table represents the observed amplitude, frequency, and corresponding sound intensity levels in decibels(dB) obtained using a NeuroVibe device and a Digital Storage Oscilloscope - DSO. The readings were taken for five different sound signals labelled A to E. Each signal was measured under controlled vibration conditions, in which amplitude and frequency variations were recorded for performance analysis and that sensitivity to the NeuroVibe system.

Table 2. Measured Amplitude, Frequency, And Corresponding dB Levels

Signal	Amplitude (mV)	Frequency (kHz)	dB Level
A	51.20	4.87	34.19
B	40.18	4.19	32.08
C	68.60	5.54	36.73
D	90.40	5.33	39.12
E	15.20	3.18	23.64
F	49.50	5.85	33.89
G	11.20	2.92	20.98
H	185.00	5.98	45.34
I	78.40	3.65	37.89
J	54.40	5.91	34.71
K	71.20	3.45	37.05
L	41.00	6.11	32.26
M	69.60	6.44	36.85
N	68.00	3.35	36.65
O	85.00	5.22	38.59

P	50.80	4.59	34.12
Q	44.00	5.62	32.87
R	65.60	5.90	36.34
S	62.40	6.74	35.90
T	83.20	5.84	38.40
U	48.00	2.98	33.62
V	64.80	6.63	36.23
W	118.40	6.97	41.47
X	58.32	6.85	35.32
Y	76.40	5.30	37.66
Z	71.25	7.52	37.06

These results strongly indicate that the NeuroVibe device accurately reproduces sound intensities using vibrational feedback. The linear drop in dB values with Decreasing amplitude confirms that the system is precisely calibrated and sensitive. Such performance proves that the device can reliably translate auditory signals into tangible vibrations, making it a promising assistive technology for the deaf and hard-of hearing community.

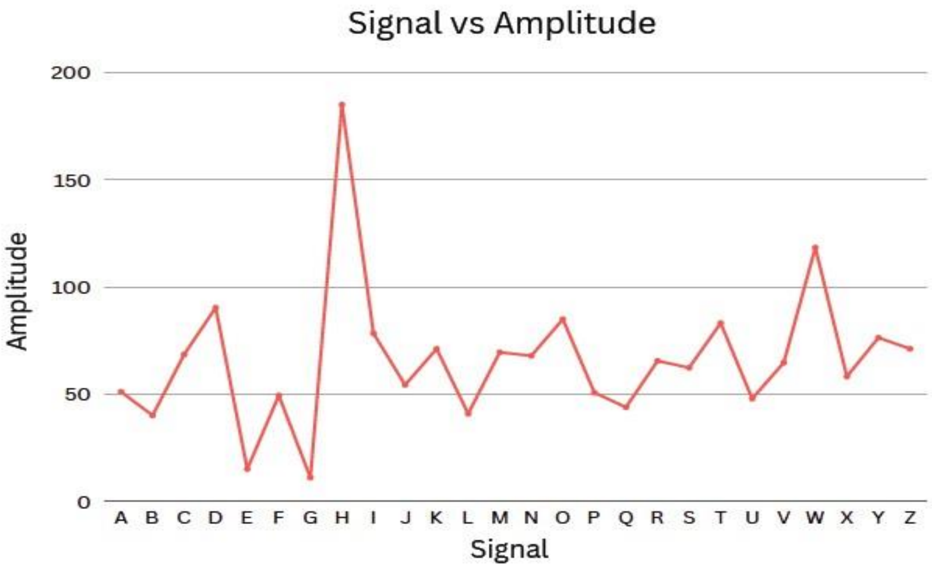

Figure 3. Signal vs amplitude graph.

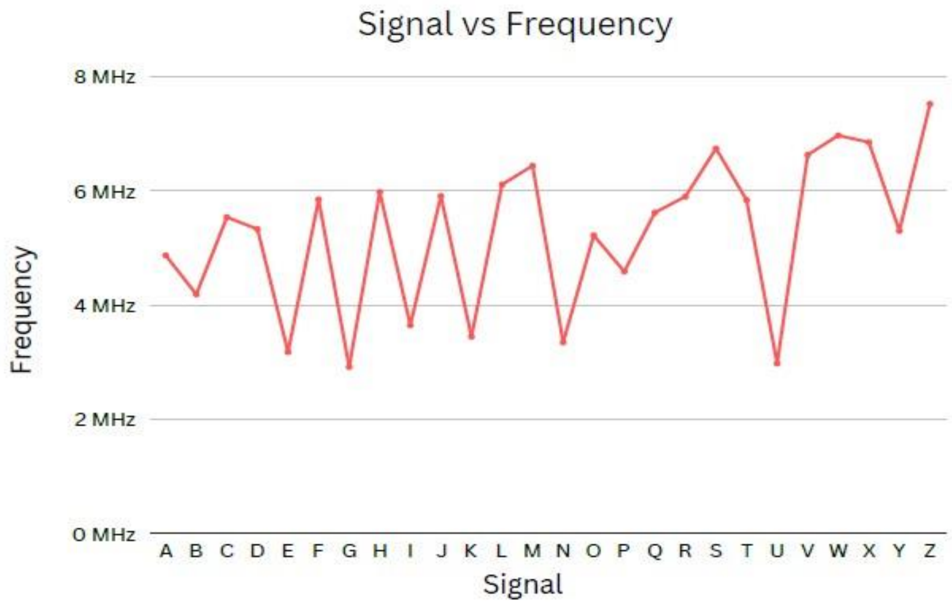

Figure 4. Signal vs frequency graph.

Figure 5. Signal vs dB graph.

The measurement results of the NeuroVibe device show distinct differences in amplitude, frequency, and dB level across the alphabetically labeled signal samples. The Signal vs Amplitude plot displays fluctuating vibration strengths, which imply that the device responses dynamically depending on different input signals. The Signal vs Frequency Graph displays how each test point corresponds to a unique vibration frequency that confirms proper conversion of sound input into distinctive tactile patterns. Finally, the Signal vs dB Values graph depicts the relative intensity of each signal, with higher dB levels representing stronger and more perceivable vibrations. Taken together, these three graphs confirm that the NeuroVibe system translates sound characteristics effectively into measurable vibration patterns suitable for tactile perception.

Conclusion

The experimental results confirm that the NeuroVibe device effectively converts auditory frequencies into Correspondingly, there is vibration during bone transmission. The results obtained show a clear proportional relationship between amplitude and sound intensity in decibels, confirming the precision of the device's signal conversion mechanism. This frequency range of 3–7 kHz that was recorded shows stable system Performance with a minimum amount of distortion will maintain accurate output vibration for variable sound input. This consistent performance verifies the sensitivity and calibration accuracy of the vibration motor and supporting circuitry.

This will involve the incorporation of the Cosmic 104 Bluetooth module, PAM8403 mini amplifier circuit, and the cylindrical vibration motor demonstrated reliable wireless operation with low power consumption and negligible latency. The overall analysis concludes that NeuroVibe is a technically sound, compact, and cost-there are effective assistive devices that can translate sound signals into perceivable vibrations. With its stable frequency response and effective dB mapping further strengthen the possibility of practical implementation in technologies for deaf assistance and tactile sound perception.

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