Marketing a Bone Conductive Receiver/Microphone

FUJITA Masahiko, KAWAHARA Takeshi, MORIMOTO Masayuki, KAWASE Hideyuki, YOSHINO Kazumi, HASHIMOTO Youichi

Abstract

NEC TOKIN Corporation has marketed a bone conductive receiver/microphone as a mobile phone accessory that can convey sound to the auditory organs though vibration using a piezoelectric bone conductive speaker. This device has received a favorable evaluation in a field test that was provided to those who have difficulty in hearing, and also with individuals who have normal hearing but are located in a noisy place. The device is suitable not only for people who have difficulty in hearing a conversation with a mobile phone but also for normal hearers who are trying to have a conversation in noisy situation, for example in a running train or at noisy factory site such as in a press shop or near an assembly line. This paper outlines the bone conductive speaker and the standard specifications for a bone conductive receiver/microphone by focusing on the practical use of the bone conductive receiver microphone as well as discussing aspects and design points of the configuration and function of each element part.

Keywords

bone conduction, mobile phone, accessory, multi-layered piezoelectric element, bone conduction speaker, sound leakage, acoustic coupling, noise resistance, phone call

1. Introduction

The "Year 2007 problem" is a recent topic of conversation. One of its issues is the "year 2007 problem and mobile phone." The issue is that many of the baby boomer generation who habitually use mobile phones will retire in year 2007 and will soon become the elderly generation that may have difficulty in hearing. Finding an effective countermeasure to this problem is one of the issues for mobile phone manufacturers and telecommunications providers. In order to solve this problem, NEC TOKIN has developed a bone conduction receiver/microphone as a mobile phone accessory and has made it suitable for practical use.

This product employs a bone conductive speaker using multilayered piezoelectric elements that enable various advantages for mobile phone accessories: 1) audibility in a noisy environment, 2) clearly audible for those who have difficulty in hearing, 3) low power consumption, etc. It is also useful for those who work in noisy offices, factories or on construction sites, and also even for housewives surrounded by noises such as crying babies and TV sounds, etc.

This paper introduces an outline to bone conduction technology and the practical uses of the bone conductive receiver/microphone.

2. An Outline of the Bone Conductive Speaker

The mechanism of hearing sound by ear is illustrated in **Fig. 1.**

A sound (air vibration) generated at a sonic speaker is conveyed to the eardrum through the external auditory canal to strike the eardrum which converts the air vibration into a physical vibration. This vibration strikes the auditory ossicle and is conveyed to the cochlea to be detected as a sound by the auditory nerves and carried to the brain. The bone conductive speaker converts sound information into physical vibration by using an oscillatory actuator instead of a sonic speaker to

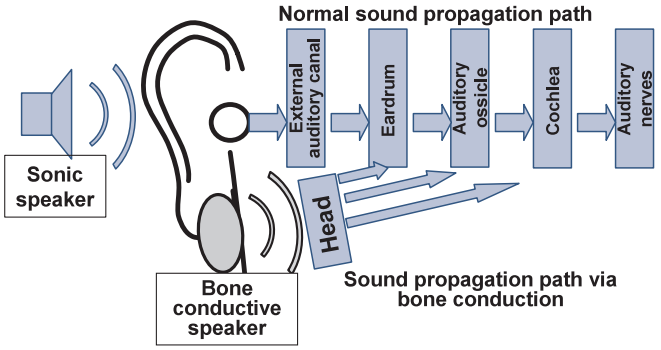

Fig. 1 Sound propagation path of the auditory function.

convey this vibration to the skin around the tragus via the sound path described above. The vibration is conveyed through the head to directly strike the perceptual organs such as the auditory ossicle or cochlea, etc. in order to convey sound information to the brain. This is the fundamental principle of the bone conductive speaker.

3. Outline of the Bone Conductive Receiver/Microphone

3.1 Standard Specifications of the Bone Conductive Receiver/Microphone

In developing the bone conductive receiver/microphone, basic items such as user generation, applicable mobile phones, conversation styles and required functions are examined and the standard specifications have been defined as shown in **Table 1** below.

Details of the standard specifications are described below.

(1) Flip-Type Bone Conductive Receiver/Microphone

Generally speaking, the posture that is the most familiar to users when they make a telephone call, is the conventional telephone receiver style in which the microphone is positioned near to the mouth and the receiver is held to the ear. Current main stream mobile phone design is the flip type, for which users can fold the mobile phone. With this design, users can store and carry it in a compact space while they can use it in almost the same way as with the conventional receiver, which may give a familiar feel to the user. For such reasons, the bone conductive receiver/microphone adopts the familiar structure of the flip type design.

Table 1 Standard specifications of the bone conductive receiver/microphone.

	Item	Specification
1	Type	Flip-type bone conductive receiver/microphone
2	Connection	Flat 10-pin connector
3	Power supply	AAA alkaline battery × 2
4	Standard functions	Phone call/call end, volume switch, sound quality switch, T-coil mode switch
5	Maximum equivalent sound pressure	80dBA or more
6	Sound coupling	Inside the level suitable for practical use
7	Sound leakage	45bBA or less (50cm, 1kHz)
8	Continuous calling hours	Standard: 25 hours
9	Dimension	115(L) × 30(B) × 26.5(H) mm
10	Weight	Approx. 52 g

(2) Cable Connection

The Bluetooth wireless system is expected to be employed in the near future. However, Bluetooth incorporated mobile phones are not yet widely spread in the market and also the Bluetooth system is not yet familiar enough among the target generation. Moreover, in consideration of the practical implications of the already marketed mobile phones, a flat 10-pin connector is employed, so that it can be used as an accessory to the conventional mobile phones.

(3) Batteries

This product, the bone conductive receiver/microphone, is expected to be carried with a mobile phone so that compactness and light weight are essential features of the design. Moreover, the capability of long hours of use and low cost are also demanded. To satisfy these conflicting demands, the AAA alkaline battery is employed for the standard specification in order to meet approximately 25 hours of continuous talk time. Manganese and AAA nickel hydride batteries are also available. Alkaline batteries are available at most convenience stores in Japan, so that this type of battery is more suitable for those who are concerned about the product running cost.

(4) Functions

Based on the principles of ease of use and safety, four standard functions are incorporated with individual switches; phone call/call end, volume switch, sound quality switch and T-Coil mode (Telephone Coil Mode) switch. The power ON/OFF of the product is interlocked with the flip motion of the mobile phone. This feature has also resulted in a smart external design.

(5) Maximum Equivalent Sound Pressure

At present there is no measurement equipment available on the market to measure bone conductive sound pressure. Therefore, the sound volume is measured by the equivalent evaluation method of weighting sound levels between normal sound and bone conduction sound. The bone conductive receiver is produced by considering the “Year 2007 problem and the mobile phone”. Many target users may have difficulty in hearing so that the maximum equivalent sound pressure is set at 80dBA or more.

3.2 Configuration of the Bone Conductive Receiver/Microphone

Details of the bone conductive speaker, the outer case and the drive circuit which are the main configuration issues for the bone conductive receiver/microphone are described below.

(1) The Bone Conductive Speaker

The bone conductive speaker is the most essential part of a bone conductive receiver/microphone. The bone conductive speaker of NEC TOKIN's bone conductive receiver/microphone is composed of our original multi-layered piezoelectric element[1)], which has been employed in many of our products and a displacement magnification mechanism to achieve maximum equivalent sound level of 80dBA or more which is an essential function of the bone conductive receiver/microphone. Moreover, a bone conductive speaker maximally reduces the weight and projected area of the non-drive section in order to decrease the sound leakage. Generally speaking, the weight ratio between the drive section and the fixed section in a vibrating body is 1:N. The greater the value of N, the better the sound leakage performance is. However, with this product's configuration N=7 is employed. The characteristics of the bone conductive speaker and the sonic speaker are shown in **Table 2**. The developed bone conductive speaker has superiority in surrounding noise resistance (talking in a noisy place), sound leakage prevention (confidential communication function), power consumption (portability), however it does have disadvantages such as larger dimension and heavy weight.

Table 2 Comparison of the conventional speaker and the bone conductive speaker.

	Normal sound	Bone conduction: Piezoelectric type
Object	Vibrating air	Bone vibration
Transmission	Non-contact use	Contact use
Volume	Good	Good
Voice quality	Good	Good
Surrounding noise resistance	Poor	Good
Sound leakage	Poor	Good
Power consumption	Poor	Good
Design	Good	Poor
Weight	Good	Poor
Use in a noisy environment	Poor	Good

(2) Outer Case

As shown in **Fig. 2**, a bone conductive speaker is supported by the outer case via the attenuation material while the flip is attached to the outer case and can be rotated due to the hinge.

The vibration from the bone conductive speaker is conveyed to the head of the user at the same time as it is conveyed to the microphone located on the flip cover through the attenuation and composition materials including the outer case. The vibration conveyed from the bone conductive speaker to the microphone is defined as the level of the acoustic coupling system, which generates the sound echo during telephone talking and the voice quality will be degraded. To avoid this, the level of the acoustic coupling has to be decreased to a level that does not influence talking on a mobile phone. The level of acoustic coupling is very much influenced by the mass of the bone conductive speaker, attenuation material characteristics, bone conductive speaker support architecture and attenuation material operation point setting. It is therefore necessary to understand the characteristics of each of these elements and to optimize their characteristics in order to decrease the level of acoustic coupling. Moreover, the bone conductive receiver/microphone incorporates the bone conductive speaker in a compact outer case. A bone conductive speaker generates rather significant vibration so that the acoustic coupling level and the sound leakage characteristics can be degraded by resonating the vibration with the outer case if the outer case is not sufficiently robust.

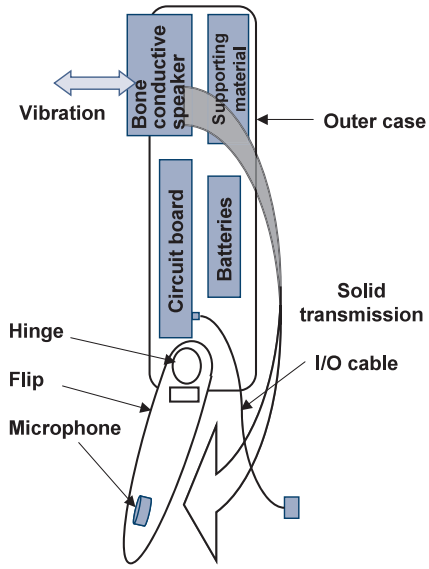

Fig. 2 Conceptual diagram of bone conductive receiver/microphone.

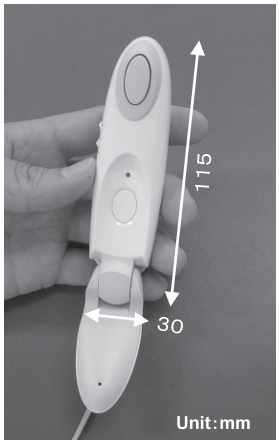

Photo 1 Appearance.

An appearance of the bone conductive receiver/microphone is shown in **Photo 1**. The bone conductive receiver/microphone has been developed in order to fulfill practical purposes by considering the above explained conditions.

(3) Drive Circuit

To meet the need for ease of use and hearing, the drive circuit was designed considering the following points: mechanism to make it more compact and light, decreasing the number of parts, saving space and saving electric power. Details of the design are described below.

1) Bone Conductive Speaker Drive Circuit

To optimize the drive of the multi-layered piezoelectric element, a D-class amplifier is employed for the basic mechanism. At the input signal side, an ALC circuit is installed to reduce the difference (non-uniformity) of the output levels of the earphone terminals among different models of mobile phones, and a pre-amplifier incorporating a switch to adjust the volume and voice quality is installed as a control for the volume and voice quality to a user favorable level. Such a user oriented design is employed and the block diagram is shown in **Fig. 3.**

2) Saving Electric Power

By employing a single chip microcomputer (manufactured by NEC Electronics) to control the power supply for each of the function blocks, a power saving for the entire system can be achieved and a continuous talking time of over 25 hours is enabled from the power obtained from two AAA batteries.

3) Frequency Characteristics

To achieve the easy to hear function, various field tests have been carried out in cooperation with persons of different generations who have normal audibility and those who have difficulty in hearing. Various sound sources including calling voice, music, etc. are used for the field tests. The results with a mobile phone are; a) those that have normal audibility prefer sound characteristics that decrease the high frequency sound, and b) those that have difficulty in hearing due to age prefer those that increase the high frequency sound. The frequency characteristics shown in **Fig. 4** are gained by the drive circuit incorporated in the bone conductive receiver/microphone.

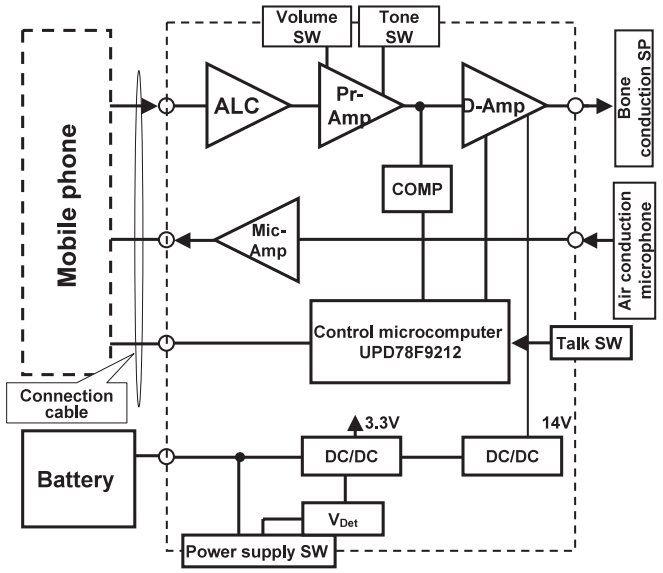

Fig. 3 Drive circuit mechanism.

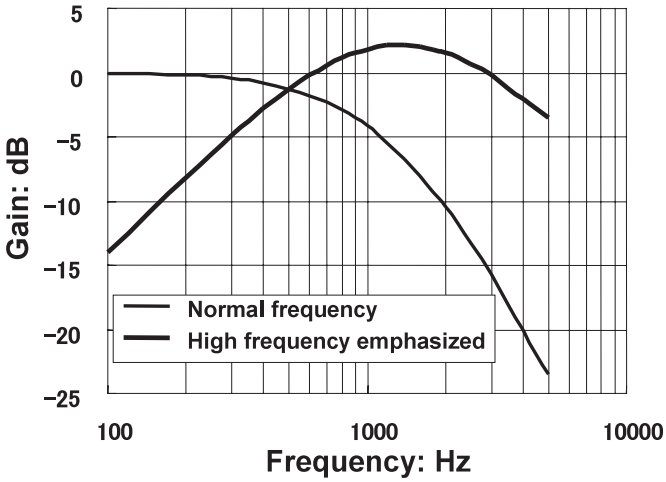

Fig. 4 Circuit frequency characteristics.

(4) Software

The bone conductive receiver/microphone is expected to be used by users of various generations so that a variety of functions is assumed to be mounted.

To meet such a trend, the following are considered in the design of the software.

1) System Design

Power supply ON/OFF interlocked with the flip motion, controlling system such as call/call end function button by software, flexible system control.

2) Saving Power

The consumption power is saved during the no speaking signal so that a continuous talk time of 25 hours is achieved with two AAA alkaline batteries.

3.3 Applications of Bone Conductive Speakers

NEC TOKIN has focused on people's concerns in using a mobile phone, such as "hard to hear" or "cannot hear" and to prepare for the "Year 2007 problem and the mobile phone," we have marketed products using bone conductive speakers. Our bone conductive receiver/microphone conveys sound to perceiving organs as vibration so that it is suitable not only for people who have difficulty in hearing due to their age but also normal hearers who are trying to have conversation with a mobile phone in a running train or in a noisy environment. The device is thus expected to be used by various users.

4. Conclusion

The practical use of the bone conductive receiver is explained so far.

This product is expected to contribute to solving various problems in using a mobile phone, such as "hard to hear" or conducting a conversation in a noisy environment and it is anticipated that the convenience of the mobile phone will thus be increased.

The future developments of the product are;

1) Practical Use of a Wireless Type Product

In parallel with the market spread of Bluetooth mounted mobile phones, wireless type products will be marketed so that users will be free from troublesome cable connections.

2) Transforming Technology into a Module

More convenience will be accelerated by making piezoelectric elements and their peripheral mechanisms and technologies into a module and incorporating the result into mobile phones.

Reference

1) NEC TOKIN Catalog: SEKISOU ATSUDEN AKUCHUEETA (Multi-layer Piezoelectric Actuator), Vol. 02, pp14-17.

Authors' Profiles

FUJITA Masahiko
Department Manager,
REBONE Promotion Department,
Mechatronic Devices Division,
NEC TOKIN Corporation

KAWAHARA Takeshi
Senior Expert,
REBONE Promotion Department,
Mechatronic Devices Division,
NEC TOKIN Corporation

MORIMOTO Masayuki
Group Manager,
REBONE Promotion Department,
Mechatronic Devices Division,
NEC TOKIN Corporation

KAWASE Hideyuki
Manager,
REBONE Promotion Department,
Mechatronic Devices Division,
NEC TOKIN Corporation

YOSHINO Kazumi
Assistant Manager,
REBONE Promotion Department,
Mechatronic Devices Division,
NEC TOKIN Corporation

HASHIMOTO Youichi
Assistant Manager,
REBONE Promotion Department,
Mechatronic Devices Division,
NEC TOKIN Corporation