Implantable Hearing Machine by using Vibrant Sound Bridge System


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Received 4 September 2015; Revised 14 October 2015; Accepted 28 October 2015

Abstract- The Vibrant Sound bridge is an FDA approval, direct drive, semi implantable middle ear device intended to provide a level of useful sound perceptions to individuals with a moderate to severe sensorineural hearing losses. The Soundbridge converted sound into mechanical energy that is direct transfer to the middle ear bone auditory ossicles. The external audio processor pick up the sound from the environment and transmitted it across the skin's to the received of the Vibrating Ossicular Prosthesis VORP. The signal's is then transmit to the Transducer cause it to vibration. The Transducer mechanical stimulates the ossicles, mimicking the natural process of hearing. The VORP is surgically implant under the skins behind the ears. The Transducer is attach to the long process of the incus bones during the surgical process. The ossicular motion's created a movement's in the cochlea, stimulating the cells. The cells provide stimuli to the auditory nerve, which is interpreted as sound by the brain. The implant transfers the sound vibrations to the functioning cochlea. This creates direct (percutaneous) bone conduction. In contrast, traditional BC hearing aids connect indirectly to the bone through unbroken skin (transcutaneous) and work by exerting pressure against the skull.

1. Introduction

Hearing loss is one of the most regular chronic conditions in the United States, affect more than nine million American over the age of 65 and 10 million American age 45 to 64. But about three out of five older American with hearing losses and six out of seven middle-aged American with hearing losses do not used hearing aids.

The Vibrant Sound bridges are semi-implantable devices that have been FDA approval for the treatment of sensorineural hearing loss. The Vibrant Sound bridges to be a safe different to hearing aids in people with sensorineural, or nerve hearing losses who can’t or don’t wish to wears a hearing aids.

The devices also elimination the problem that hearing aid can caused, such as ear canal problem, increment of background noise and distortion of sound. They also perceived a major benefit of the Sound bridge in many listening situation compare to their hearing aid include entertainment setting such as televsions movies, Radios and theater. Most patients experienced no change in their unaided hearing after surgeries.

1. The implant, called the Vibrating Ossicular Prosthesis (VORPTM), and,
2. The externally-worn receiver, called the Audio Processor (approximately the size of a quarter).

The Sound bridges are a directed drive devices which mechanical vibration the bone in the middle ear without surgically altering the structured of the middle ear. The tiny Float Mass Transducers, attachments to the incus bones in the middle ear, is approximate the size of a grains of rice's. It is 100 percent digital and is program by an Audiologist eight week after the implant procedures to fit the user's specified hearing loss. The Sound bridges converted sound into mechanical energy's which is direct transmitted to the auditory ossicles.

With nothing in the ear canal, the Sound bridge is a particularly good treatments option for current hearing aid wear who suffered from occlusion or feedbacks, and those who are look for better sound quality's or improved cosmetics. Occlusion is the sensation of hearing distortion, muffled sound experience when an objects block the ear canal. It is a common complaint among hearing aid user, who often find that the presence of the hearing aid, or hearing aid ear mold, in their ear canal distorts not only outside sound but also the sound of their own voiced. People who experienced hearing losses due to diseases or trauma to the middle ear are not candidate for the devices. To be a candidate for this procedure, patient should be meet the following criteria.

2. Vibration Sensors

According to the principle of vibration sensors, many current vibration sensors are describes which are used wide in basic principle and feature in the end the development process of vibration sensors was view. Vibration sensor has several types its basic measurement principles are shown in Figure 1. Vibration sensors detected the vibration parameters of objects through its mechanical structures, and convert the vibration parameters into the electrical signals by physical effects to achieved transfer the non-electrical signals to electrical signals. Vibration sensors separate into displacement (amplitude) sensors, speed sensors and acceleration sensors according to the measurement vibration parameters. Because of the displacements, the velocity's and the acceleration's can be translation into each other in the way of simple calculus the three kind sensors can be universal sometimes. Currently, according to different method of detecting vibrations, vibration sensors with different kind of physical effect are invent, which are used widely in the following categories.

Today World vibration sensors are electronic devices, using either piezoelectric or piezoresistive technology. Most model use in plant monitor applications are the piezoelectric type. Their constructions consist of a crystal of piezoelectric material to which is attachment a seismic mass. When the crystal is stress in tension or compressions, it generated electrical charges which are proportional to the acceleration level it is experience. Internal circuitry converted this signal into a voltage or current (4-20mA) output for data collected or process control loops.

The three parameter represent motion detection by vibration monitor is displacements, velocities, and accelerations. This parameter can be measure by a variety's of motion sensors and are mathematical relate displacement is the first derivation of velocity's and velocity's is the first derivation of accelerations. Selection of a sensors equivalent to displacement, velocities or accelerations
depend on the frequency of interest and the signal levels involvement.

DISPLACEMENT SENSORS: - Eddy current probe are non-contact sensor primarily use to measure shaft vibrations, shaft/rotor positions and clearance. Also refer to as displacement probe, eddy current probes are typical apply on machine utilizing sleeve journal bearings. They have good frequency response with no lower frequency's limited and can also be use to provide a trigger inputs for phase-related measurements.

VELOCITY SENSORS: - Velocity sensors are use for low to medium frequencies measurement. They are used for vibration monitor and balance operation on rotating machinery's. As compared to accelerometers, velocities sensors have be lower sensitivity to high frequencies vibration. The mechanical design of the velocities sensor an iron core moving’s within a coil in limit magnetic fields, no clip of the generation signal occurs, but smooth saturations.

ACCELEROMETERS: - Piezoelectric accelerometer having a constants signal over a widely frequency ranges, up to 20 kHz, for a given mechanical accelerations level, are very used for all type of vibration measurements. Acceleration integration to velocities can be used for low frequency measurement. Acceleration signal in the high frequencies range added with many signal processing technique like ACC ENV, or HFD are very used for bearing and gear measurement.

3. Sound Driver

Electromechanical transducer convert electrical signal to mechanical energies’ and vice versa, and they are commons in every day's life. Microphones and loud speaker are example and they operation in the able to be heard sound range. You will be use a magnetics buzzer and microphones for experiment I to generation audible sounds with a buzzer and received it with the microphones.

Squeeze definite crystals such as quartz and you can make be electricity flows through them. The reverse is usual true as well if you pass electricity’s through the same crystals; they squeeze themselves by vibrating back and forth. That’s attractive much piezoelectricity in a nutshell but, for the sake of science, let's has a formal definition:

Piezoelectricity also called the piezoelectric effect is the appearances of an electrical potential a voltage, in other word across the side of a crystal when you subjected it to mechanical stresses by squeezing it. Normally, the charge in piezoelectric crystals is exactly balance, even if they are not symmetrically arranged.

The effected of the charged exactly cancel out; leave no net charged on the crystal face. More expressly, the electrical dipole moment vector line separated opposite charged exactly cancel one another out. If you squeeze the crystal massive exaggerated.

Now the effected of the charge their dipole moments no long cancel one another outs and net positives and negatives charge appear on opposite’s crystal face. By squeezing the crystals, you have produced a voltage across its opposites face and that piezoelectricity's.

In a watches, the reversed-piezoelectric effected is used to kept time very exactly. Electrical energy's from a battery is feds into a crystal to make it oscillation thousands of time a second. The watch then used an electronics' circuit to turn that into slower, once per second beat that’s a tiny motors and some precisions gear use to drives the seconds,
minutes, and hour hands around the clock-faces.

In ultrasound equipment's, a piezoelectric transducers convert electrical energy into extremely rapid mechanical vibrations so fast, in facts, that it make sound, but one too high-pitch for our ear to hear. This ultrasound vibration can be used for scanning, cleaning, and all kinds of other things.

4. Block Diagram

The Block Diagram Vibrant Sound Bridge System

![Diagram](image)

**Fig 1 Block Diagram**

A. Transformer

A transformer can be defined as a static device which help in the transformation of electric powers in one circuit to electric powers of the same frequency's in another circuits. The voltage can be raise or lower in circuits, but with a proportional increases or decreases in the current rating. The main principles of operation of transformers are mutual inductances between two circuits which is link by a common magnetic flux's. A basic transformers consist of two coil that are electrical separated and inductive, but are magnetically link through a path of reluctances.

B. Dual Power Supply

A regulated power supply's is an embedded circuits; it convert unregulated AC into a constants DC. With the help of rectifiers it convert AC supply into DC. Its functions is to supply a stabled voltage (or less often current), to a circuits or device that must be operation within certain power supply limited. The output from the regulated power supply (RPS) may be alternating or unidirectional, but is near always Direct Current.

The types of stabilization used may be restricted to ensuring’s that the output remain within curtain’s limit under different load conditions, or it may be also includes compensation for variation in its own supply sources. The latter is much more common todays.

C. PIC Controller

PIC microcontrollers (Programmable Interface Controllers), are electronics’ circuits that can be program to carry out a vast ranges of task. They can be program to be timer or to control’s a production line and much more. They are be found in most electronics devices such as alarm system, computer control system, phones, in fact almost any electronic devices. several type of PIC microcontrollers exists, although the best are probably found in the GENIE ranges of programmable microcontroller. These are program and simulation by Circuit Wizard software.

PIC Microcontroller is relatively cheeped and can be bought as pre-builds circuit or as kits that can be assembling by the users.
D. LCD Display

A liquid crystal display or LCD draws its definition from its name itself. It is combination of two states of matters, the solid and the liquids. LCD uses a liquid crystal to be producing a visible images. Liquid crystal display are super-thin technology's display screens that are general used in laptop computer screens, TVs, cell phones and portable video games. LCD’s technology allow display to be much thin when compared to cathode ray tube (CRT) technology.

Liquid crystal display is composed of many layers which include two polar panel filter and electrodes. LCD technology’s is used for display the images in notebooks or some other electronic device like mini computers. Light is project from a lens on a layer of liquid crystals. This combinations of color light with the gray scale images of the crystals form as electric current flow through the crystals forms the color images. This image is then display on the screens.

E. Audio Generator

This audio frequency generated is a trigger signal generators. When a positive pulses of about 6 volt minimum is fed to the circuits inputs, a modulation audio signals come out of the outputs. The signal pattern is similarly to chirp. The pulse widths of the trigger signals must be minimum of 2.5 milliseconds. The voltage supply’s is between 9 volt and 20 volt. The circuit consumed about 2 mA or less. If the circuits is apply as a Morse code signal generators, replace C1 with a 0.1 μF capacitors.

5. Working Vibration Sound Bridge

The vibrant sound bridges (VSB) are an active middle ear implants for person with sensorineural, conducive or mixed hearing loss. The VSB consist of an external part, the audio processor (AP) and an implant part, the vibrating ossicular prosthesis (VORP). The AP is worn on the head and contains microphones, a digital signal processor (DSP) and a battery. The VORP consist of a receiver stimulator, a conductor links, and transducers. Information from the AP is sent to the VORP so that the transducers the floating mass transducer (FMT) vibration in a controlled manner specified to each patient hearing need. The FMT is 2.3 mm in length, 1.8 mm in diameter and weight about 25 mg. The conductor links has diameters of 0.6 mm.

Vibroplasty is the treatment of hearing losses by vibratory stimulations of the ossicular chains in the middle ear. When the FMT is in proximity to a vibratory structures of the middle ears, it vibration the structural and stimulates the auditory system.

![Fig 2 Part of Vibrant Sound Bridge](image-url)

Selection of the patients for implantation required the surgeon and the audiologist to work along. A detail audiological and medical evaluation is performed and review. Before surgery, patient is counseled about the risk and benefit of VSB implantation. Success is optimal’s, when the patient is well-select and has realistic expectation.

6. VORP Template

The VORP templates, made of silicone elastomer, have three functions. The first is to determines optimum implant placements on the mastoid be fore’s incising the skin. An outline may be drawn to mark these sites. The second is to outlines the exact sizes of the
placements before drillings. The third is to verify the sizes of the placements before place and suturing the VORP to the skulls.

The device seat also be provide a secure and stable positions for the VORP.

The marked on the skulls is location and the VORP templates are then position on the skull surfaces. The positions of the template should be approximately at an angle of 45 degrees as describe earlier and the transition, approximately 3 mm from the demodulator’s, should lie on the posterior edges of the mastoid cavity's. Position the transition is critical to device placements, and therefore, the final positions of the magnet may be move slightly anterior or posterior depend upon the size of the mastoid cavity's.

Instead of drilling a channel be tween’s the seat for the demodulators and the mastoid cavity, a bony bridge may be creation. By open these bridges on the superior sides, the VORP transition can be easy slid under the bridges, thus giving more protections. The demodulators should also be fixing with sutures. It is important to ensure that there are no sharp edges from the channel or the bridges and that the midpoint of the transitions lies on the posterior edges of the mastoid cavity's. The VORP templates are position in the seats to verify the size and depth of the channels.

7. Crimping Forceps

The forming forceps, made of stainless steel, is use to crimp the FMT clip around the incus. Other otologic forceps such as stapes wire crimper or pistons closing forceps can also be use to form the FMT attachments.

Incision

The VORP a template is place on the skins with its anterior edges at the postauricular sulcus just behinds the ear, and angle approximately 45 degrees posterosuperiorly. The VORP should not be lie under the auricle. A marking pens is used to traced the outer perimeter's of the templates on the scalp.

The incision is mark at least 2 cm from the edges of the template to minimize the risk of device extrusion and postoperative infections. The incision only need to be larger enough to perform the mastoidectomy, drills the seated for the demodulator’s portion of the VORP, and sutured it to the bone.

The primary objectives of create the devices seat is to be allowed the pre bent transition of the conductors link to be slope deeply into the mastoid cavity's so that the conductor links is as medial to the skull surface's as be possible.
portions of the VORP may be placed under periosteal pockets.

Tie-down holes are created on opposing sides of the seats to fix the demodulators. The tie-down holes have to be drilled so that the VORP lies flat when sutured and the VORP transition angle down toward the mastoid cavity (Figs 4A and 4B).

8. Conclusion

The complaint association with the use of conventional amplify hearing aids prompted research at several centers worldwide that ultimately led to the developments of implantable device for aural rehabilitations. Implantable hearing aids, which are current in the early stage of development, will unquestionably be the major driver of advancements in otologic practices in the 21st century's, improve the qualities of life of an increase aged populations, which will consequently required increased level of hearing supports.

Reference

1. The Vibrant Soundbridge
   Ashutosh G Pusalka

2 Vibration Sensors