MOBILE ASSISTIVE LISTENING DEVICE

An assistive listening device that comprises a receiver for an FM or digital signal that is tuned to receive a particular FM or digital signal, a signal converter that converts the received signal to a digitized format if needed, and a connector that includes a permanently mounted 3.5mm male 4-conductor headphone audio jack interface and that serves as a conduit for the signal to a recoding or retransmitting device and as a conduit for harvesting power for the mobile assistive listening device.
Declarations under Rule 4.17:

— as to the identity of the inventor (Rule 4.17(i))
— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(H))
— as to the applicant’s entitlement to claim the priority of the earlier application (Rule 4.17(Hi))
— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
Field of Invention

[0001] The present invention is in the field of assistive listening devices for the deaf and hard of hearing or other persons with special needs.

Summary of Invention

[0002] An assistive listening device that comprises a receiver for an FM or digital signal that is tuned to receive a particular FM or digital signal, a signal converter that converts the received signal to a digitized format if needed, and a connector that includes a permanently mounted 3.5mm mate 4-conducfor headphone audio jack interface and that serves as a conduit for the signal to a receding or retransmittal device, preferably a handheld mobile device. The assistive listening device is powered externally through that permanently mounted connective interface and is tuned and controlled externally through the connective interface. Methods employing the assistive listening device to convert human voice audio to text at locations remote from the speaker are also disclosed and claimed.

Details of Invention

[0003] The Invention is a peripheral component device that receives human voice audio transmitted by a personal FM or digital transmitter and transmits that human voice audio to a mobile device, and methods employing the same.
Brief Description of the Drawings

[0004] FIG. 1 is a flow diagram depicting the flow of information or signals through the entire system.

[0005] FIG. 2 is a transverse cross-sectional view of the assistive listening device.

[0006] FIG. 3 is a flowchart depicting the principal actions of the software for the mobile application.

[0007] FIG. 4 is a logic flowchart depicting the communication between the mobile assistive listening device and the secondary receiver.

[0008] FIG. 5 is a diagram of the electronic circuit design of the assistive listening device.

[0009] FIG. 8 is a detailed electronic schematic of the assistive listening device.

[0010] FIG. 7 depicts one embodiment of the assistive listening device.

[0011] FIG. 8 depicts another embodiment of the assistive listening device.
Description of Preferred Embodiments

[0012] Referring initially to the drawings, FIG. 1 is a flow diagram that includes the assistive listening device of the instant invention. The assistive listening device of the instant invention is used normally with spoken voice audio emanating from human 10, which may be live or recorded. Additional sounds may also be included.

[0013] Audio emanating from human 10 is transmitted via initial transmitter with microphone 20 which is then received into the assistive listening device 30 that comprises an FM or digital receiver. The carrier frequencies transmitted by initial transmitter 20 to be received by the FM or digital receiver include, but are not limited to, 72-76 MHz., 216-217 MHz, 900 MHz and 2.4 GHz. The initial transmitter with microphone 20 may be any one of a number of commercially available personal FM or digital transmitters that include a microphone 20, such as are used in the classroom for the deaf and hard of hearing. Commercially available devices include but are not limited to Phonak Inspiro, Phonak Roger, Oticon Amigo family, and others.

[0014] The assistive listening device 30 comprises electronic hardware including an FM or digital receiver, an FM-to-digital converter, and a second transmitter all for the purposes of receiving the FM signal emanating from microphone and transmitter 20, converting that signal into digital format, if necessary, then transmitting the analog or digitized signal to a secondary receiver 40 for further handling or manipulation.

[8815] There is software resident in the secondary receiver component 40 that controls
the recordation of the audio received therein and that stores such audio (as an analog or digital signal) on either a focal storage device 60 of the secondary receiver component 40 or at an online cloud service 50 for later playback and perhaps further manipulation. The software in the secondary receiver component 40 also has the ability to send the recorded audio to an offsite location via the Internet to be transcribed using any one of a number of commercially available machine or human generated transcription services. Optionally, the software in the secondary receiver component 40 also has the ability to create, control and receive transcriptions from any one of a number of commercially available machine or human generated transcription services. Commercially available machine or human generated transcription services includes but are not limited to Nuance, VoiceBase, Apple Suh, Google Voice Recognition and others.

[§016] FIG. 2 is a transverse cross-sectional view of the assistive listening device 30. The assistive listening device 30 includes an internal antenna 31 that receives a signal on the carrier frequencies. The printed circuit board assembly (PCBA) 32 of the assistive listening device 30 converts the received signal to a digitized format, if necessary, and retransmits the new digital signal. The new digital signal which is transmitted from the assistive listening device 30 is thereafter received by a secondary receiver component 40.

[0017] The interface between the assistive listening device 30 of the instant invention and the secondary receiver component 40 is accomplished mechanically through a permanently mounted 3.5mm male 4-conductor headphone audio jack 33. The
secondary receiver component 40 is any one of a number of well-known devices that may be used to accept a 3.5mm headphone audio jack 33 and to receive a signal broadcast from the assistive listening device 30. The secondary receiver component 40 devices include, but are not limited to, iaplot computers, mobile smartphones and tablet computers of any screen size. The secondary receiver component 40 may employ an application or software that enables power and frequency tuning or channel selection that is communicated via the 3.5mm male 4-conductor headphone audio jack 33 interface to the assistive listening device 30. Such may be accomplished using frequency-shift keying. Frequency-shift keying (FSK) is a technology in which digital information is transmitted through frequency changes of a carrier wave creating audio tones.

[0018] The assistive listening device 30 is composed of a printed circuit board assembly (PCBA) 32 that itself is comprised of well-known electronic components. Power is provided to the components externally through the permanently mounted 3.5mm male 4-conductor headphone audio jack 33 interface using FSK. PCBA 32 includes circuitry for harvesting power from a signal transmitted from secondary receiver 40 to assistive listening device 30 via the permanently mounted 3.5 mm male 4-conductor headphone audio jack 33 interface. As indicated above, the assistive listening device 30 also controls frequency tuning and/or channel selection through a permanently mounted 3.5mm male 4-conductor headphone audio jack 33 interface using FSK. The assistive listening device 30 may also include automatic channel tuning or manual searching within the carrier frequency range or may include frequency hopping technology.
Alternately, the assistive listening device 30 may have power provided to the components through one or more disposable or rechargeable batteries.

[0019] The software in the secondary receiver component 40 may be a mobile application also referred to as an app, in which the graphics/ user Interface would include but not he limited to "soft" buttons for powering and to provide frequency tuning or channel selection of the assistive listening device 30. Features of the software portion of the invention are not limited to those mentioned above.

[0020] The mobile operating systems for the mobile application can include but are not limited to Apple sOS, Apple OS X, Google Android, Google Chrome and Microsoft Windows.

[0021] FIG. 3 is a flowchart depicting the actions of the software for the mobile application. The software code is programmed to harvest power from hardware received in audio tones to power the assistive listening device 30. The frequency setter software module 38 sends a command to the hardware 30 identifying the desired frequency. The tone generator software module 37 then converts the frequency into binary code. The tone player software module 38 converts the binary code into single frame of audio which are then rendered by the audio renderer software module 39 and sent via the 3.5mm male 4-conductor headphone audio jack to the assistive listening device 30.
[0022] All communication with the assistive listening device is done by sending high and low audio tones in sequence, including commands and powering the assistive listening device 30. The low tone typically is a square wave with a 50% duty cycle with a cycle length of 20 (period length of 40) and the audio on the left and right channels are sent out-of-phase. The high tone typically is a square wave with a 50% duty cycle with a cycle length of 10 (period length of 20) and the audio on the left and right channels are sent out-of-phase.

[0023] Commands are created using a combination of low and high tones. The assistive listening device is powered by sending a continuous low tone, while the assistive listening device 30 is not sending any other commands. Energy is harvested from that low tone utilizing the power-harvesting hardware on PCBA 32. The assistive listening device 30 changes frequencies when given a command to do so. For example, a change frequency command has the following structure, which is repeated five times: (1) a single high tone, (2) a single frequency selection code, (3) a single odd parity bit, and (4) 100 low tones.

[0024] FIG. 4 is logic flow diagram depicting the communication between the mobile assistive listening device 30 and the final receiver 40 via the software. Once the app on the mobile device is started 41 the software identifies if the assistive listening device 30 is plugged in. If the assistive listening device is not in plugged in, normal audio output continues on the mobile device.
[0025] If the assistive listening device 30 is identified as being plugged in, a change frequency command 43 is sent to the assistive listening device. The last recorded frequency is used for this command if no other change has been made in the interim to frequency selection. Once the frequency command is sent, the continuous low power torse 44 is sent until the app is closed or the assistive listening device is unplugged from the mobile device.

[0026] If the assistive listening device is unplugged, normal audio output 42 continues on the mobile device.

[0027] FIG. 5 is a logic flow chart outlining the process of the electronic circuit of the assistive listening device 30. A signal is received by the antenna 31 and sent through the RF Band Filter 130. The RF Band Filter 130 is normally a multipole bandpass filter, tuned to pass the 216-218MHz assistive listening device band while blocking all other frequencies that may interfere (for example broadcast FM, at 87-108MHz). The RF Amp 131 amplifies the filtered signal. Without any amplification, the range is limited to only a few feet. Amplification greatly increases the range.

[0028] The FSK signal conditioning takes the low-level FSK signal from the mobile device jack, filters interference, and boosts it to a level compatible with the microcontroller. The microcontroller decodes the FSK signal from the mobile device, checks for errors, and writes valid frequency change instructions to the Fractional-N PLL. A local oscillator (LO) frequency is generated by the Fractional-N PLL 137, voltage-controlled oscillator (VCO) 138, and LO Amp 135. The Fractional-N PLL 137
divides a 2GMHz reference frequency to create 12.5kHz tuning steps. This base step
frequency is then compared with a divided down version of the LO frequency, and the
difference between the two is used to generate a voltage level for the VCO 136. The
VCO 138 generates a frequency in the 20G-22GMHz range based on this command
voltage. The LO Amp 135 follows the VCO 138 to boost the signal level.

[0028] The RF Mixer 132 operates in the frequency domain, mixing the amplified signal
from the RF Amp 131 with the LO frequency sent from the LO Amp 135. The purpose
is to shift the frequency band from about 216MHz to about 10.7MHz, and additionally to
position the specific frequency of interest exactly at 10.7MHz. The mixer operates on
two frequencies to produce the sum and difference frequencies. For example, 216MHz
Input mixed with 205.3MHz LO produces a 10.7MHz "intermediate frequency" (IF). it
also produces 421,3MHz, which is filtered out.

[0030] The low-level 10.7MHz IF frequency generated by the RF Mixer 132 is passed
through a series of narrow bandpass filters and high-gain amplifiers. Finally, a
quadrature FM detector demodulates the audio signal. The IF Amp 133 and FM
demodulator 134 are single integrated circuit functions. The resulting signal is then sent
to the secondary receiver 40 via the 3.5mm male 4-conductor headphone audio Jack 33.

[0031] The energy-harvesting power supply 140 recovers power from an audio
waveform provided by the secondary receiver 40 via 3.5mm male 4-conductor
headphone audio jack 33. The secondary receiver 40 must drive a stereo audio signal
at maximum output power, consisting of a square wave or around 5-10 kHz. The energy harvesting power supply 140 uses a low-loss diode bridge to turn this AC waveform into a DC voltage, which is then boosted to the system power supply voltage by a high-efficiency DC-DC converter.

[0032] FIG. 8 is a detailed electronic schematic of a possible design layout for the assistive listening device.

[0033] FIGs. 7 and 8 depict two possible designs of the assistive listening device 30. Showing the external case 34 along with the 3.5mm headphone audio jack 33. FIG. 8 further depicts a possible design including an indicator 35, such as a light emitting diode (LED).

[0034] A first use case is a student of any age that may be deaf or hard of hearing using the invention in a classroom setting. The teacher or classroom lecturer would wear a personal FM or digital transmitter with or without a boom microphone and the student would use the invention to transmit audio directly to a mobile device.

[0035] A second use case is an individual of any age that may be deaf or hard of hearing or having some other special need using the invention in settings such as theaters, places of worship, museums, public meeting places, corporate conference rooms, convention centers, and other large areas for gathering to transmit audio directly to a mobile device.
The foregoing descriptions of specific embodiments or the present invention have been presented for the purposes of illustration and description. They are neither intended to be exhaustive nor to limit the invention to the precise forms disclosed, and obviously, many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the Invention and its various embodiments with various modifications as are suited to the particular use contemplated. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the claimed subject matter; but one of ordinary skill in the art may recognize that many further combinations and permutations of the claimed subject matter are possible. It is intended that the scope of the invention be defined most broadly by the specifications and the figures appended hereto and their equivalents. Accordingly, the claimed subject matter is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Therefore, the scope of the invention is not to be limited by the following claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.
CLAIMS

What is claimed is:

1. An assistive listening device system comprising, in combination,
   an assistive listening device;
   a storage means for storing a signal, remote from said assistive listening device;
   and
   a connector means for connecting the transmitter means of said assistive listening device and the storage means.

2. The assistive listening device system of claim 1 wherein the assistive listening device comprises
   a signal receiving means;
   a power means for powering said assistive listening device; and
   a transmitter means.

3. The assistive listening device of claim 2 wherein the signal receiving means includes means for receiving a broadcast FM signal.

4. The assistive listening device of claim 2 wherein the signal receiving means includes means for receiving a digital signal.

5. The assistive listening device of claim 2 wherein the signal receiving means
includes an analog to digital conversion means to convert an analog signal to a digital signal.

8. The assistive listening device of claim 2 wherein the power means is an internal battery.

7. The assistive listening device of claim 2 wherein the power means comprises a circuit internal to the assistive listening device that converts a signal form from a device remote from said assistive listening device to direct current voltage.

8. An assistive listening device system comprising, in combination, an assistive listening device;
a storage means for storing a signal, remote from said assistive listening device;
a connector means for connecting the transmitter means of said assistive listening device and the storage means
wherein the assistive listening device comprises
   a signal receiving means;
a power means for powering said assistive listening device;
a transmitter means;
wherein the power means further comprises a circuit internal to the assistive listening device that converts a signal form from a device remote from said assistive listening device to direct current voltage.
FIG. 1

10 Human

20 Transmitter with Microphone

30 Assistive Listening Device

40 Secondary Receiver

50 Online Cloud Service

60 Local Device Storage
FIG. 3

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36 Frequency Setter
37 Tone Generator
38 Tone Player
39 Audio Renderer
30 Hardware

FIG. 4

41 App Started

43 Device Plugged in
42 Normal Audio Output

44 Frequency Changed

Output Power tone Continuously

Device not Plugged in

Device Unplugged
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04R 25/00 (2014.01)
USPC - 381/312

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - G09B 21/00; H04R 1/10, 25/00, 27/02 (2014.01)
USPC - 381/312, 381/323; 704/201, 704/203

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CPC - G09B 21/00; H04R 1/10, 25/00 (2014.02)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, ProQuest

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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</table>

Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search
04 August 2014

Date of mailing of the international search report
2 AUG 2014

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA-US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer: Blaine R. Copenheaver
PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)