

System for Detection of Environmental Sound-Based Warning Signals For Personal Mobile Devices

Field of the Invention

5 This invention relates to a personal mobile device that provides audio data to a headphone. More particularly this invention relates to a device connectable between the personal mobile device and headphones that monitors for a warning signal and provides the warning signal to the headphones when a warning signal is detected. Still more particularly, this invention relates to a device connectable between the personal mobile
10 device and the headphones that provides the warning signal to the head phones when a warning signal is detected and headphones are connected; and that charges a power supply using the audio data supplied by the personal mobile device when no headphones are connected.

Summary of the Prior Art

15 The use of earpieces, headphones, or listening devices to listen to audio data from personal mobile devices, such mobile telephone sets, MP3 players, portable video games systems and the like, is quite common. It is well recognized that it is a problem that the use of these listening devices often prevents users from hearing warning signals, such as
20 automobile horns, sirens and other alarms.

One manner for allowing users to hear such warnings is to provide a system inside the personal mobile device that detects the warning signal and provides some type of warning to the user. This type of system is described in US Patent Number 6,014,345,
25 titled "Apparatus And System For Damping External Noises With Means For Producing Sound And Preventing Oversleeping" granted on 11 January 2000 in the name of Schmadeka. The problem with such a system is that the system is integrated into the circuitry of the personal mobile device. Therefore, this type of system is hard to incorporate into existing devices as the system is much easier to incorporate at the time of
30 manufacture of the devices.

A second type of proposed system is a device that is connected between the personal mobile device and the user listening device. Examples of such devices are described in United Kingdom Patent Application Number GB 9724601.1, titled "A Signalling
35 System" published 10 June 1998 in the name of Sennheiser Electronic GmbH & Co KG; US Patent Number 6,782,106 titled "Apparatus and Method for Transmitting Sound"

granted 24 August 2004 in the name of Kong et al.; US Patent Number 5,647,011 titled "Headphone Sound System" issued 8 July 1997 in the name of Garvis; US Patent Publication Number 2004/0179694 titled "Safety Apparatus for Audio Device That Mutes and Controls Audio Output" published 16 September 2004 in the name of Alley. However, the aforementioned systems have a drawback in that the systems determine an emergency or other warning by the level of the sound received. Thus, the audio data from the personal mobile device may be canceled for any loud noises which takes away from the user's enjoyment of the audio data and makes it less likely a user will use the device.

The system described in PCT publication WO 2007/007916 titled "Transmitting Apparatus and Method Capable of Generating a Warning Depending on Sound Types" published 18 January 2007 in the name of Matsushita electric Industrial Co., Ltd. addresses the above problem by providing a system that monitors for specific warning signals by doing feature analysis of external sounds captured by a microphone. However, the described system may only monitor for sounds stored in its memory; and a great amount of processing power and memory are needed to perform monitoring functions. Thus, those skilled in the art are constantly striving to provide a system that accurately identifies warning signals with minimal processing and memory components to reduce manufacturing costs and power consumption.

Summary of the Invention

The above and other problems are solved and an advance in the art is made by a system in accordance with this invention. A first advantage of a system in accordance with this invention is that multiple warning signals may be reliably detected using a digital signal processor. A second advantage of this invention is that the system includes a process to add more warning signals to the warning signals that are detected. A third advantage of this invention is that minimal calculations are used thus a digital signal processor with minimal power and memory requirements may be used. A fourth advantage of a system in accordance with this invention is that the system includes a charging system that uses the audio data received from an audio output device to charge a power supply. A fifth advantage of a system in accordance with this invention is that the system may be easily implemented as the device may be directly connected to the audio output of an audio device.

The above and other advantages are provided by a system in accordance with this invention that is configured in the following manner. The device includes a housing. An

input connector extends through the housing to couple the device to the audio output device to receive audio data from the audio output device. A microphone is also exposed through the housing. The microphone receives external audio signals. An output connector extends through the housing to connect the device to a user listening device and provides audio data to the listening device. The circuitry inside the housing includes a multiplexer and monitoring circuitry. The multiplexer receives audio data from the audio output device through the input connector and external audio data from the microphone; and selectively outputs either the audio data from the audio output device or the external audio data from the microphone to the output connector. The monitoring circuitry receives the external audio data from the microphone, determines whether the external audio data includes a warning signal, and transmits a signal to the multiplexer that causes the multiplexer to provide the external audio data to the output connector in response to a determination that the external data includes a warning signal.

In accordance with some embodiment of this invention, the monitoring circuitry may also transmit a signal to an illumination device in response to a determination that the external audio data includes a warning signal. The illumination device is then illuminated to provide a warning. In accordance with other embodiments, the device includes a vibration module and the monitoring circuitry may also transmit a signal to the vibration module to activate the vibration module in response to a determination that the external audio data includes a warning signal. The vibration module provides a tactile warning that a warning signal was detected. In accordance with some of these embodiments, the device may operate in a stand-alone mode.

In accordance with some embodiments of the invention, the monitoring circuitry includes an analog to digital converter connected to the microphone for converting a sample of the external audio data received by the microphone from analog audio data to digital audio data. The circuitry also includes a digital signal processor that receives the digitized external audio data and performs a detecting process.

In accordance with some embodiments, the detecting process is performed in the following manner. The process begins by receiving digital samples of the external audio data from an analog to digital converter. The process performs a Fourier transform on the digital samples. The transform is used to generate an amplitude versus frequency vector over time of the samples. A peak is then selected from the vector. A frequency of the peak is then compared to the frequency of the reference signal. If the frequency of the

peak is substantially equivalent to the frequency of the reference signal, an amplitude of the peak is compared to the amplitude of the reference signal. If the amplitude of the peak is substantially equivalent to the amplitude of the reference signal, the detection process determines a duration of the digital samples. The duration of the digital sample is then compared to a duration of the reference signal. If the durations are substantially equal, a selection signal is sent to the multiplexer to switch from providing the audio data received from the audio output device to providing external audio data from the microphone. In accordance with some embodiments, each of a group of reference warning signals is compared to the sample by the detection process.

In accordance with some embodiments of this invention, the detection process determines the duration of the peak signals matching the reference signal in the following manner. A subsequent peak is selected from the vector generated for the samples. A frequency of the subsequent peak is then compared to the frequency of the reference signal. If the frequency of the subsequent peak is substantially equivalent to the frequency of the reference signal, an amplitude of the subsequent peak is compared to the amplitude of the reference signal. If the amplitude of the subsequent peak is substantially equivalent to the amplitude of the reference signal, the duration the peaks match the reference signal is determined. This process is repeated until the process has been applied to the last peak in the vector.

In accordance with some embodiments, the device may receive new reference warning signals in the following manner. The device includes an actuator that is exposed through the housing that a user depresses to change the device to a learning mode. In the learning mode, the digital signal processor performs a learning process.

In accordance with some embodiments, the learning process is performed in the following manner. The process begins by receiving digital samples of the warning signal captured by the microphone from an analog to digital converter. The process then performs a Fourier transform on the digital samples. The transform is used to generate an amplitude versus frequency vector over time of the digital samples. The peaks of the sample are then determined from the vector. A first and a second peak are then compared. First, an amplitude difference between the two peaks is calculated. The absolute amplitude difference is compared to a predefined amplitude threshold value. A frequency difference between the first and second peaks is then calculated and the absolute frequency difference is then compared to a predefined frequency threshold value. If the

absolute amplitude difference is less than the predefined amplitude threshold value and the absolute frequency difference is greater than the predefined frequency threshold value, data regarding the sample is stored. Preferably, the data includes the amplitude versus frequency vector over time generated for the samples and a duration of the digital samples.

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In accordance with some embodiments, the device also includes an amplifier element that receives the analog external audio signals and amplifies the signals. In accordance with some embodiments, the device may also include an array of LEDs that are connected to the Digital signal processor and indicate a status of the device.

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In accordance with some embodiments of this invention, the device further includes a battery charging system that is connectable between the audio-in connector and a battery to charge the battery using signals received from the audio-in connector. In some of these embodiments, a switch toggles between a first position that connects the battery charging system to the battery and a second position that connects a power management system for the device to the battery. In accordance with particular one of these embodiments, the switch may be a mechanical switch that is toggled by the insertion and removal of a connector into the audio-out connector of the device.

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In accordance with one of these embodiments, the battery charging system is configured in the following manner. A first resistor is connected between a first audio-in path and the battery. A second resistor is connected between the second audio-in path and the battery. Automatic battery charging circuitry is connected between the first and second audio-in paths and the battery. A capacitor is connected between the first and second audio-in paths and the automatic battery charging circuitry. A first diode is connected between the capacitor and the first audio-in path and a second diode is connected between the capacitor and the second audio-in path. A third diode is then connected between the capacitor and the automatic battery charging circuitry.

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Brief Description of the Drawings

The above and other features and advantage of this invention are described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating a perspective view of a personal mobile device and a warning system device in accordance with an embodiment of this invention;

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Figure 2 illustrating a diagram of the components of the warning system device in accordance with the shown embodiment of this invention;

Figure 3 illustrating an audio-out connector and switch in a first position in accordance with the shown embodiment of this invention;

Figure 4 illustrating an audio-out connector and switch in a second position in accordance with the shown embodiment of this invention;

5 Figure 5 illustrating a power charging system in accordance with the shown embodiment of this invention;

Figure 6 illustrating a flow diagram of a process for detecting a warning signal and providing external audio data to a user in accordance with an embodiment of this invention; and

10 Figure 7 illustrating a flow diagram of a process for providing a new warning signal to detect in accordance with an embodiment of this invention.

Detailed Description

This invention relates to a personal mobile device that provides audio data to a
15 headphone. More particularly this invention relates to a device connectable between the personal mobile device and headphones that monitors for a warning signal and provides the warning signal to the headphones when a warning signal is detected. Still more particularly, this invention relates to a device connectable between the personal mobile device and the headphones that provides the warning signal to the headphones when a
20 warning signal is detected and headphones are connected; and that charges a power supply using the audio data supplied by the personal mobile device when no headphones are connected.

Figure 1 illustrates an embodiment of device in accordance with this invention and
25 an associated audio output device. Audio output device 100 is a mobile telephone, Personal Digital Assistant (PDA), MP3 player, or other electronic device that provides audio output to audio-out connector 105. Audio output connector 105 is a common connector that couples to a connector of a headphone or other audio playing device. Typically, other types of audio outputs such as output speakers in audio output device are
30 disabled when a connector is inserted into audio output connector 105. One skilled in the art will note that the exact configuration of systems and circuitry in audio output device are not important to understanding this invention and are omitted for brevity.

Device 150 includes housing 152. Audio input connector 155 extends out of one
35 side of housing 152. Audio input connector 155 is a typical prior connector for coupling to an audio output connector of an audio output device, such as audio output connector 105.

As shown, audio input connector 155 is a “male” connector that inserts into a “female” output connector 105. As audio input connector 155 is common in the art, a description of the exact configuration of audio input connector is omitted for brevity. One skilled in the art will recognize that other types of connectors may be used without departing from this invention.

Audio output connector 160 is a connector defined in a side of the housing. Audio output connector 160 is a common connector that couples to a connector of a headphone or other audio playing device. However, one skilled in the art will recognize that other types of output connectors may be used without departing from this invention. In the shown embodiment, audio output connector 160 is on a side opposite of audio input connector 155. However, audio output connector 160 may extend through any of the sides of housing 152 without departing from this invention but preferably output connector 160 does not extend through the same side as input connector 155 to allow user access and to prevent the connection of an output device from interfering with the coupling of audio input device 155 with an audio output connector of audio input device 100.

Housing 152 also has microphone 165 that is accessible through a top surface of housing 152. Microphone 165 receives external audio data that may include warning signals. Preferably, microphone 165 is an Omni-directional microphone capable of receiving sounds from all directions. Array of Light Emitting Diodes (LED) 180 is also shown extending through openings in the top surface of housing 152. Array of LEDs 180 are controlled by circuitry inside the housing and show the status of various systems inside device 150 including, but not limited to, the power supply detection circuitry and audio input connections. Actuator 170 may also protrude through an opening in housing 152. Actuator 170 is a button or other component that may be used to switch from a detection mode to a learning mode as described below. Although microphone 165, actuator 170, and array of LEDs 180 are shown as being accessible through the top surface of housing 152, these components may be accessible through any side or surface of housing 152 without departing from this invention.

Figure 2 illustrates a diagram of the circuitry of device 150 inside housing 152 in accordance with the shown embodiment of this invention. Multiplexer 215 is a standard multiplexer that receives data from a first and second input and selectively outputs one of the two inputs to an output. Audio input connector 155 is connected to a first input of multiplexer 215 and microphone 165 is connected to the second input of multiplexer 215.

The output of multiplexer 215 is then connected to audio output connector 160 to provide the outputted data to a connected listening device.

Microphone 165 is also connected to analog to digital (A/D) converter 205. A/D converter 205 converts the analog external data (sounds) captured by the microphone into digital data for use in the detection and learning processes. The A/D converter 205 is connected to Digital Signal Processor (DSP) 200. To improve the quality of the external audio data, amplifier element 210 may be connected between microphone 165 and other components of device 150.

DSP 200 is connected to memory 290, array of LEDs 180, actuator 170, vibration module 295, and multiplexer 215. DSP 200 is a conventional digital signal processor such as DSPIC30F6014A that can perform a limited set of instructions stored in memory. Memory 290 is a conventional memory that may include ROM, RAM, EEPROM, DRAM, SRAM, any combination of the aforementioned memories and that stores the instructions and data for processes performed by DSP 200 in accordance with this invention. Preferably, memory 290 includes at least 8KB of RAM to support detection of at least five different types of warning signals. However the exact type of DSP used and memory requirements are based on the requirements of the system and are left as a design choice to a designer of the system. DSP 200 receives signals from actuator 170 that cause DSP 200 to select between performing a learning process and a detection process as described below. DSP 200 also transmits signals to array of LEDs 180 to indicate the status of various components of device 150 as described above or to indicate a warning alert. DSP 200 may also transmit signals to vibration module 295 to indicate a warning alert. Furthermore, DSP 200 can transmit signals to multiplexer 215 to select signal from either audio input connector 155 or microphone 165 to output to audio output connector 160. Vibration module 295 and array of LEDs can provide warning alerts in stand alone mode to users that may have difficulties hearing the audio warning signal. DSP 200 may also include buttons 175 to receive command from user such as switching on device 150.

Device 150 also includes a power supply, such as batteries 250, power management system 220, and charging system 230. Preferably, batteries 250 include lithium or other type of battery that may be re-charged by charging system 230. Charging system 230 is connectable between audio input connector 155 and batteries 250; and receives audio data from input audio connector 155 and generates current that can be applied to batteries 250 to re-charge the batteries 250. Power management system 220 is

a conventional system that provides power to various components of device 150 to provide the processes in accordance with this invention. Switch 240 is a switch that selectively connects either power management system 220 or charging system 230 to batteries 250 based upon the connection of a device to audio output 160.

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Figures 3 and 4 illustrate one embodiment of switch 240 in accordance with this invention. In the shown embodiment, switch 240 includes a mechanical switch 330 that is proximate an end of audio output connector 160. Mechanical switch 330 is connected to conductor 360 that, in turn, is connected to batteries 250. Coupling 370 is connected to the
10 end of conductor 360 and is movable by mechanical switch 330 between a first position in which coupling 370 contacts conductor 380 connected to charging system 230 and a second position in which coupling 370 contacts conductor 390 connected to power management system 220. In Figure 3, the input connector 310 of a listening device is not connected to device 150 through audio output connector 160 and coupling 370 is in the
15 first position. Thus, batteries 250 may be recharged by charging system 230 receiving audio data from input audio connector 155 while there is no user listening device connected to audio output connector 160. Furthermore, the other circuitry of device 150 is not connected to batteries 150 and the resources of the batteries are saved.

20 In Figure 4, connector 310 of the listening device is fully inserted into audio output connector 160 such that conductors 320 of connector 310 are in contact with conductors 350 of audio output connector 160. In this position, the end of connector 310 extends through a bottom of audio output connector 160 and forces switch 330 downward. The forcing of switch 330 downward by the end of the connector 310 causes coupling 370 to
25 move to a second position to connect power management system to batteries 250. Thus, DSP 200 and the other components for providing warning signal detection are operational while a user listening device is connected and audio is being received via audio input connector 155.

30 Figure 5 illustrates an embodiment of charging circuitry 230 in accordance with an embodiment of this invention. First audio-in path 401 and second audio-in path 402 receive separate audio signals from input audio connector 155 such as the left audio channel and the right audio channel respectively. First resistor 410 is connected between first audio-in path 401 and batteries 250 and second resistor 411 is connected between
35 second audio in path 402 and batteries 250. First and second resistors 410 and 411 induce a Direct Current (DC) voltage level from the batteries to ensure the DC voltage

generated by the audio signals is above the voltage level of batteries 250 to ensure the current is charging the batteries.

First audio-in path 401 and second audio-in path 402 are connected to diodes 415 and 416 respectively. Diodes 415 and 416 are connected between the audio-in paths and charge pump capacitor 420 to rectify the Alternating Current (AC) of input audio signals into DC signals. Charge pump capacitor 420 is connected between first and second diodes 415 and 416; and third diode 425 which is, in turn connected to automatic charging circuitry 430. Charge pump capacitor 420 stores energy to build up a sufficient amount of instantaneous energy. When the electrical potential across capacitor 420 reaches a sufficient level, current is applied to third diode 425 to bias third diode 425 to apply the current to automatic charging circuitry 430. Automatic charging circuit 430 is a conventional charging circuitry and a detailed description is omitted for brevity. Automatic charging circuit then connects to batteries 250 through switch 240 to charge batteries 250.

In one of the embodiments, device 150 may receive audio data from an audio wave file specifically composed in an arrangement to initiate slow-charging. In particular, the audio wave file comprises a sinusoidal wave to be played from first audio-in path 401, and concurrently a 180 degrees phase shifted sinusoidal wave to be played from second audio-in path 402. This allows continuous charging of capacitor 420 and thus improves re-charging of batteries 250. The audio wave file may be played by the audio output device and received by device 150 via audio input connector 155.

Figure 6 illustrates a flow diagram of detection process 600 which is a process for detecting warning signals in external audio data captured by microphone 165 in accordance with one embodiment of this invention. Process 600 begins in step 605 by receiving N digital samples of the external audio data captured by microphone 165 from A/D converter 205. Preferably, 256 digital samples of the external audio data are received from microphone 165 that are converted by A/D converter 205. However, one skilled in the art will recognize that N, the number of digital samples, may be any power of 2 and the exact number will depend on sampling frequency of A/D converter 205, the processing rate of DSP 200, the amount of memory 290 available and is left as a design choice to those skilled in the art designing the system. In step 610, a Fourier transform is performed on the data to convert the N samples to the spectrum domain. An amplitude versus frequency vector over time of the sample is then generated from the Fourier transform of the sample in step 615. The amplitude versus frequency vector is a two dimensional vector of the

frequency and amplitude of the samples taken from the Fourier transform of the samples. The vector is generated by extracting the peaks from the transform as determined by amplitude in the frequency domain. A reference signal is then selected in step 617 and the data for the reference signal is read from memory 290. The data includes an amplitude,
5 frequency, and duration of the reference signal. In step 620, a peak is selected from the vector. The frequency of the selected peak is then compared to the frequency of the reference signal in step 630.

If the frequencies of the selected peak and reference are substantially equivalent,
10 the process proceeds to step 635. One skilled in the art will recognize that some tolerance may be included such that frequencies need not be exactly the same without departing from this invention. This tolerance is a design choice that is left to those skilled in the art. Otherwise, the process determines whether there is another reference signal to check in step 640. If there is another reference signal to check, process 600 is repeated from step
15 617. Otherwise, process 600 is repeated from step 605 when a subsequent sample is received.

In step 635, an amplitude of the selected peak is compared to an amplitude of the reference signal. If the amplitude of the selected peak is substantially equivalent to the
20 amplitude of the reference signal, the process proceeds to step 650 to determine a duration that digital sample matches the reference signal. Otherwise, process 600 proceeds to step 640 as described above.

In step 650, the process first determines whether there are subsequent peaks in the
25 vector. If vector includes subsequent peaks, process 600 proceeds to step 655. Otherwise, process 600 proceeds to step 640 as described above. In step 655, a subsequent peak is selected from the vector. The frequency of the subsequent peak is then compared to the frequency of the reference signal in step 660.

If the frequencies of the peak and reference are substantially equivalent, the
30 process proceeds to step 665. One skilled in the art will recognize that some tolerance may be included such that frequencies need not be exactly the same without departing from this invention. This tolerance is a design choice that is left to those skilled in the art. Otherwise, the process determines whether there is another reference signal to check in
35 step 640 as described above.

In step 665, an amplitude of the subsequent peak is compared to an amplitude of the reference signal. If the amplitude of the subsequent peak is substantially equivalent to the amplitude of the reference signal, the process proceeds to step 670 to determine a duration that digital sample matches the reference signal. Otherwise, process 600
5 proceeds to step 640 as described above.

In step 670, the duration that the peaks of the samples match reference signal is determined. In some embodiments, this may be computed from the number of samples and the sampling period. In other embodiments, timers or other timing algorithms in DSP
10 200 may be used to determine the duration without departing from this invention. In step 675, the duration that peaks of the samples match the reference signal is compared to the duration of the reference signal.

If the durations are substantially equivalent, a warning signal is detected and
15 process 600 transmits a selection signal to multiplexer 215 that causes multiplexer to switch from providing the input from audio input connector 155 to providing the external audio data capture by microphone 165 to audio output connector 160 in step 680. The amount of tolerance acceptable between durations is a design choice left to those skilled in the art. In some embodiments, DSP 200 may also transmit a signal to an illumination
20 device, such as array of LEDs 180; and/or vibration module 295 in step 680. Illumination device and/or vibration module then generate a visual and/or tactile warning indicator. The process may then apply a subsequent select signal to revert to the audio from connector 155 being provided by multiplexer 215 either after a set amount of time, such as three seconds or after the warning signal is no longer detected in received samples. After
25 step 680, process 600 repeats from step 605 when more samples are received by DSP 200.

If the durations are not substantially equivalent in step 675, process 600 is repeated from step 650 until the durations are substantially equivalent or the last peak is compared
30 to the reference signal.

In some embodiments, connections of audio input connector 155 and audio output connector 160 are not necessary for the operation of device 150. In these embodiments, device 150 may start process 600 by a push of button 175 or simply inserting audio output
35 connector 160 to operate in a stand alone mode. Upon detecting the warning signal in step 650, DSP 200 will transmit a signal to an illumination device, such as array of LED 180;

and/or vibration module 295 as a warning indicator in step 680 to device 150. Thus, device 150 may be used to provide a warning indicator to people that may have difficulty hearing the warning signal.

Figure 7 illustrates a flow diagram of learning process 700 which is a process for adding reference warning signals from external audio data captured by microphone 165 in response to receiving a signal from actuator 170 in accordance with one embodiment of this invention. Process 700 begins in step 705 by receiving N digital samples of the external audio data capture by microphone 165 from A/D converter 165. Preferably, 256 digital samples of the external audio data are received from microphone 165 that are converted by A/D converter 165. However, one skilled in the art will recognize that N, the number of digital samples, may be any power of 2 and the exact number will depend on sampling frequency of A/D converter 165, the processing rate of DSP 200 and the amount of memory 290 available and is left as a design choice to those skilled in the art designing the system. In step 710, a Fourier transform is performed on the samples to convert the samples to the spectrum domain. In step 715, an amplitude versus frequency vector over time of the digital samples is generated from the Fourier transform. The peaks of the transform are then determined in step 717. The peaks may then be sorted in a descending order with regards to amplitude in the frequency domain. One skilled in the art will recognize that the sorting of the peaks is to aid the selection of peaks and could also be in an ascending order. Therefore, the exact method of sorting is left to those skilled in the art designing the system. In step 718, a peak and a subsequent peak are selected from sorted transform. The amplitude difference between the first peak and the subsequent peak selected from the vector is calculated in step 720. In step 725, the absolute amplitude difference is compared to a predefined amplitude threshold value. In the described embodiment, the predefined amplitude threshold value is 3dB. However, any value may be used depending on the accuracy required and the exact threshold value used is left as a design choice of those skilled in the art.

If the absolute amplitude difference is less then the predefined amplitude threshold value, the process proceeds to step 730. Otherwise, the process determines whether the selected peaks are the last two peaks in the sample in step 745. If the selected peaks are not the last two peaks, process 700 repeats from step 718. Otherwise, process 700 ends.

In step 730, a frequency difference between the first and subsequent peaks selected from the transform is determined. The absolute frequency difference is then

compared to a predefined frequency threshold value in step 735. In the described embodiment, the frequency threshold value is 100 Hz. However, other values may be used depending on the signals being detected and/or the desired accuracy of the system. Thus, the frequency threshold value is a design choice left to those skilled in the art. If the
5 absolute frequency difference is not greater than the frequency threshold value, process 700 proceeds to step 745 described above. If the absolute frequency difference is greater than the frequency threshold value, process 700 determines the amplitude, frequency, and duration of the qualified peaks in step 740. The data for the reference signal including the determined amplitude, frequency, and duration for a reference warning signal are then
10 stored in memory 290 in step 750. Process 700 then ends.

The above is descriptions of embodiments in accordance with this invention. It is believed that others can and will design alternative systems that infringe this invention as set forth in the following claims.

CLAIMS

1. A device (150) for providing a warning signal to a user receiving audio data from an audio output device (100) using a connected listening device comprising:

- 5 a housing (152);
- an input connector (155) that extends through said housing (152) to couple said device (150) to said audio output device (100) to receive audio data from said audio output device (100);
- a microphone (165) that is exposed through said housing (152) to receive
- 10 external audio signals;
- an output connector (160) that extends through said housing (152) to connect said device (150) to said listening device to provide audio data to said listening device;
- a multiplexer (215) in said housing (152) that receives said audio data from
- 15 said audio output device (100) from said input connector (155) and said external audio data from said microphone (165) and selectively outputs one of said audio data from said audio output device and said external audio data from said microphone to said output connector (160); and
- circuitry (200) in said housing configured to receive said external audio data
- 20 from said microphone, determine whether said external audio data includes a warning signal, and transmits a selection signal to said multiplexer that causes said multiplexer to provide said external audio data to said output connector in response to a determination that said external data includes said warning signal, wherein said circuitry in said housing comprises:
- 25 an analog to digital converter (205) connected to said microphone (165) for converting a sample of audio data received by said microphone from analog audio data to digital audio data; and
- a digital signal processor (200);
- instructions (600) for directing said digital signal processor (200) to:
- 30 receive a plurality of digital samples of an external audio signal (605),
- perform a Fourier transform on said plurality of digital samples (610),
- generate an amplitude versus frequency vector over time of
- 35 peaks extracted from said Fourier transformation of said plurality of samples (615),

select a reference signal (617),
select a peak from said vector (620),
compare a frequency of said peak to a frequency of said
reference signal (630),

5 compare an amplitude of said peak to an amplitude of a
reference signal (635) responsive to a determination that said
frequency of said peak is substantially equivalent to said frequency
of said reference signal,

10 determine a duration that said plurality of digital samples
match said reference signal (670) responsive to a determination that
said amplitude of said peak is substantially equivalent to said
amplitude of said reference signal,

 compare said duration that said plurality of digital samples
match said duration of said reference signal (675), and

15 transmit said selection signal to said multiplexer responsive
to a determination that said duration of said plurality of digital sample
is substantially equivalent to said duration of said reference signal
(680).

20 2. The device (150) of claim 1 wherein said circuitry in said housing further
comprises:

 an illumination device (280) exposed through an opening in said housing;

 and

 circuitry (200) in said housing configured to transmit a signal to enable said
25 illumination device in response to said determination that said data includes said
warning signal.

 3. The device (150) of claim 1 wherein said circuitry in said housing further
comprises:

30 a vibration module (295); and

 circuitry (200) in said housing configured to transmit a signal to enable said
vibration module in response to said determination that said data includes said
warning signal.

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4. The device of claim 1 wherein said device operates in a stand-alone mode.

5. The method of claim 1 wherein said instructions for determining said duration comprise:

- 5 1) selecting a subsequent peak from said vector (655),
- 2) compare a frequency of said subsequent peak to a frequency of said reference signal (660),
- 3) compare an amplitude of said subsequent peak to an amplitude of a reference signal (625) responsive to a determination that said frequency of said
- 10 subsequent peak is substantially equivalent to said frequency of said reference signal (665),
- 4) determine a duration of the matching of peaks selected from said vector and said reference signal (670) responsive to a determination that said amplitude of said subsequent peak is substantially equivalent to said amplitude of said reference
- 15 signal,
- 5) repeat instructions 1-4 for each subsequent peak until said duration of said matching is substantially equivalent to said duration of said reference signal or steps 1-4 have been applied to a last peak in said vector (650).

- 20 6. The device (150) of claim 1 further comprising:
 an actuator (170) through said housing (152) that a user depresses to said device to a learning mode; and
 said instructions (600) for directing said digital signal processor further comprise instructions (700) for directing said digital signal processor to:
25 receive a signal from said actuator,
 change to said learning mode in response to said signal from said actuator;
 receive a plurality of digital samples of a warning signal captured by said microphone (705) from said analog to digital converter,
30 perform a Fourier transform on said plurality of digital samples (710),
 generate an amplitude versus frequency vector over time of said transform of said plurality of digital sample,
 determine a plurality of peaks from said amplitude versus frequency vector over time of said plurality of samples (715),
35 determine an amplitude difference between a first of said plurality of peaks and a second of said plurality of peaks (720),

compare an absolute value of said amplitude difference to a predefined amplitude threshold value (725),

determine a frequency difference between said first of said plurality of peaks and said second of said plurality of peaks (730),

5 compare an absolute value of said frequency difference to a predefined frequency threshold value (735),

 determine (740) and store data for said warning signal including an amplitude, a frequency, and a duration for a reference signal in response to determinations that said absolute value of said amplitude difference is less
10 than said predefined amplitude threshold value and said absolute value of said frequency difference is greater than said predefined frequency threshold value (750).

7. The device of claim 6 wherein said instructions (700) further comprise:
15 instructions (600) for directing said digital signal processor (200) to:
 determine a duration of said samples include a qualifying amplitude and a qualifying frequency.

8. The device (150) of claim 1 wherein said instructions further comprise:
20 instructions for directing said digital signal processor to apply said instructions to each of a plurality of reference signals including said reference warning signal (645).

9. The device (150) of claim 1 wherein said circuitry (200) in said housing (152)
25 further comprises:
 an amplifier element (210) that receives said analog external audio signals and amplifies said signals.

10. The device (150) of claim 1 wherein said circuitry (200) further comprises:
30 a plurality of illumination devices (180) exposed through said housing connected to said digital signal processor to provide status indicators for said device.

11. The device (150) of claim 1 further comprising:
35 a battery (250) for providing power to said circuitry (200); and

a battery charging system (230) that is connectable between said input connector (155) and said battery to charge said battery using signals received from said input connector (155).

5 12. The device (150) of claim 11 further comprising:

 a power management system (220) that is connectable to said battery (250) to supply power to said circuitry (200) of said device; and

 a switch (240) movable between a first position to connect said battery charging system (230) to said battery and a second position to connect said power management system (220) to said battery.

10 13. The device (150) of claim 12 wherein said switch (240) comprises:

 a mechanical switch (330) proximate said output connector (160) that is movable between said first and second positions responsive to an insertion or removal of a connector (310) into said output connector.

15 14. The device of claim 13 wherein said battery charging system (230) comprises:

 a first audio-in path and a second audio-in path;

20 a first resistor (410) connected between said first audio-in path and said battery (250);

 a second resistor (411) connected between said second audio-in path and said battery (250);

25 automatic battery charging circuitry (430) connected between said first and second audio-in paths and said battery (250);

 a capacitor (420) connected between said first and second audio-in paths and said automatic battery charging circuitry (430);

 a first diode (415) connected between said capacitor (420) and said first audio-in path;

30 a second diode (416) connected between said capacitor (420) and said second audio-in path; and

 a third diode (425) connected between said capacitor (420) and said automatic battery charging circuitry (430).

35 15. A method (600) for providing an external warning to a user receiving audio data from an audio output device using an external device comprising:

receiving audio data from a connected audio output device (100) in said external device;

receiving external audio data from a microphone (165);

providing said audio data from said connected audio output device (100) to a user listening device;

determining (625,635) said external audio data includes a warning signal, wherein said step of determining comprises:

receiving a plurality of digital samples of an external audio signal (605),

performing a Fourier transform on said plurality of digital samples (610),

generating an amplitude versus frequency vector over time of peaks extracted from said Fourier transformation of said plurality of digital samples (615),

selecting a reference signal (620),

selecting a peak from said from said vector (620),

comparing a frequency of said peak to a frequency of said reference signal (630),

comparing an amplitude of said peak to an amplitude of said reference signal (635) responsive to a determination that said frequency of said peak is substantially equivalent to said frequency of said reference signal,

determining a duration that said plurality of digital samples match said reference signal (670) responsive to a determination that said amplitude of said peak is substantially equivalent to said amplitude of said reference signal,

comparing said duration of said plurality of digital samples and said duration of said reference signal (675),

transmitting said selection signal to said multiplexer responsive to a determination that said duration of said plurality of digital sample signals is substantially equivalent to said duration of said reference signal (680); and

switching (640) from providing said audio data from said audio output device to providing said external audio data from said microphone to said user listening device in response to a determination said external audio data includes said warning signal.

16. The method of claim 15 further comprising:
enabling (640) an illumination device (280) in response to said determination that said external audio data includes said warning signal.

5 17. The method of claim 15 further comprising:
enabling (640) a vibration module (295) in response to said determination that said external audio data includes said warning signal.

18. The method of claim 15 wherein said method is operating in a stand-alone
10 mode in the absence of audio input of said audio output device.

19. The method of claim 15 further comprising:
amplifying said external audio data in response to receiving said external audio data.

15 20. The method of claim 19 wherein said step of determining comprises:
converting said external audio data from analog external audio data to digital external audio data.

20 21. The method of claim 15 wherein said step of determining said duration comprises:

1) selecting a subsequent peak from said vector (655),
2) compare a frequency of said subsequent peak to a frequency of said reference signal (660),

25 3) compare an amplitude of said subsequent peak to an amplitude of said reference signal (625) responsive to a determination that said frequency of said peak is substantially equivalent to said frequency of said reference signal (665),

4) determine a duration of the matching of peaks selected from said vector and said reference signal (670) responsive to a determination that said amplitude of
30 said subsequent peak is substantially equivalent to said amplitude of said reference signal,

5) repeating steps 1-4 for each subsequent peak until said duration of said matching is substantially equivalent to said duration of said reference signal or steps 1-4 have been applied to a last peak in said vector (650).

35

22. The method of claim 15 wherein said step of determining is performed for each of a plurality of reference warning signals.

23. The method of claim 15 further comprising:
receiving a signal from an actuator(170); and
acquiring a new reference warning signal in response to receiving said signal.

24. The method of claim 23 wherein said step of acquiring comprises the steps of:

receiving a sample warning signal from said microphone (705);
performing a Fourier transform on said sample (710);
determining a plurality of peaks from said sample (715);
calculating an amplitude difference between a first of said plurality of peaks and a second of said plurality of peaks (720);
comparing an absolute value of said amplitude difference to a predefined amplitude threshold value (725),
calculating a frequency difference between said first of said plurality of peaks and said second of said plurality of peaks (730);
comparing an absolute value of said frequency difference to a predefined frequency difference value (735); and
storing data regarding said sample in response to determinations that said absolute value of said amplitude difference is less than said predefined amplitude threshold value and said absolute value of said frequency difference is greater that said predefined frequency threshold value (740).

25. The method of claim 15 further comprising:
charging a power supply from said audio data received from said audio output device.

26. The method of claim 25 further comprising:
providing said audio data from an audio wave file played by said audio output device wherein said audio wave file is specifically composed in an arrangement to initiate slow-charging.

27. The method of claim 26 wherein said audio wave file is a sinusoidal wave to be played from a first audio-in path, and a 180 degrees phase shifted sinusoidal wave to be played from a second audio-in path.

5 28. The method of claim 25 further comprising:
 switching between monitoring said external audio data for said warning and
 said charging of said power supply.

10 29. The method of claim 28 further comprising:
 inserting and removing a connector of said user listening device into a
 connector of said external device to cause said switching.