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(54) Title: SPO2 TONE MODULATION WITH AUDIBLE LOWER CLAMP VALUE

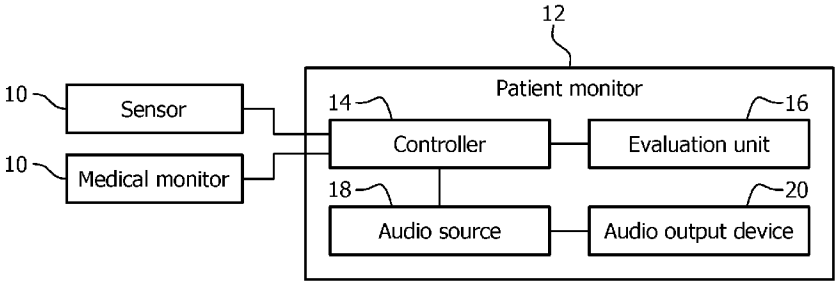

FIG. 1

(57) Abstract: A patient monitor device includes one or more sensors which measure physiological parameters of a patient, a controller which controls an audio source to generate an audible tone and adjust the pitch of the audible tone to indicate the measured physiological parameter according to a mapping scheme, the audio source which generates the audio tone, and an audio output device which outputs the audible tone. The mapping scheme clamping a frequency of the audible tone after reaching a predetermined threshold.

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SPO2 TONE MODULATION WITH AUDIBLE LOWER CLAMP VALUE

The present application relates generally to patient monitoring. It finds particular application in conjunction with SpO2 tone modulation with an audible lower clamp value and will be described with particular reference thereto. However, it is to be understood that it also finds application in other usage scenarios and is not necessarily limited to the aforementioned application.

Pulse oximetry typically involves measurement of the saturated percentage of oxygen in the blood as well as the rate of blood pulsations corresponding to each heartbeat of a patient. Traditionally, pulse oximeter monitors produce tonal signals which have a pitch proportional to the ratio of oxygen saturation and a sequential repetition proportional to the pulse. For example, typical pulse oximeters generate a quick response tone with a fixed frequency for every heartbeat of a patient. Further, these pulse oximeters modulate this tone by mapping the full range of SpO2 values (100% to 0%) to a specific range of different audible frequencies for that tone. This mapping is usually done utilizing a linear relation between the SpO2 values and the frequency of that tone. For example, linear relation mapping produces a tone at a frequency of 662 Hz for a 100% SpO2 value and a tone at a frequency of 163 Hz for a 0% SpO2 value. Another version of this mapping utilizes a logarithmic relationship which matches much better with the human perception of a sequence of tone pitches. A logarithmic relation mapping also produces a tone at a frequency of 662 Hz for a 100% SpO2 value, however, for each 24% drop in SpO2, the frequency of the tone is cut in half. For example, a tone at a frequency of 331 Hz will be produced for a 76% SpO2 value, a tone at a frequency of 165.5 Hz will be produced for a 52% SpO2 value, a tone at a frequency of 82.75 Hz will be produced for a 28% SpO2 value, and a tone at a frequency of 41.37 Hz will be produced for a 4% SpO2 value.

However, in humans, the audible range of frequencies usually ranges from 20 to 20,000 Hz. For both linear and logarithmic relation mapping, the frequency for low Sp02 values are quite low thus making it difficult if not impossible to hear. Typically, the upper frequency for a 100% SpO2 value is chosen to be well supported by the audio system. Providing a mapping such that the frequency of a low SpO2 value is supported by the audio system and can be heard and discerned by the user is very difficult. Further, with a family of monitors with different audio outputs and different limitations of their frequency bands, the produced tones are very ambiguous and inconsistent thus making it difficult to recognize a particular monitor producing a certain tone.

The present application provides new and improved methods and system which overcome the above-referenced problems and others.

In accordance with one aspect, a patient monitoring device is provided. The device includes one or more sensors which measure physiological parameters of a patient, a controller which controls an audio source to generate an audible tone and adjust the pitch of the audible tone to indicate the measured physiological parameter according to a mapping scheme, the audio source which generates the audio tone, and an audio output device which outputs the audible tone. The mapping scheme clamping a frequency of the audible tone after reaching a predetermined threshold.

In accordance with another aspect, a method for tone modulation with an audible lower clamp value is provided. The method including measuring physiological parameters of a patient with one or more sensors and generating an audible tone and adjusting the pitch of the audible tone to indicate the measured physiological parameter according to a mapping scheme. The mapping scheme clamping a frequency of the audible tone after reaching a predetermined threshold.

In accordance with another aspect, a method is provided. The method including outputting a first audible tone from a first patient monitor with a first audio output device, outputting a second audible tone from a second patient monitor with a second audio output device, the second audio output device having a different audio characteristics than the first audio output device, and transposing the first and second audible tones such that the audible tone being produced matches the audio characteristics of the audio output device.

One advantage resides in providing a mapping scheme which enables low SpO2 values to be heard and easily discerned by a user.

Another advantage resides in defining a lower range limit for SpO2 tone modulation.

Another advantage resides in transposing tones to address different frequency characteristics of various audio output devices.

Another advantage resides in improved patient care.

Still further advantages of the present invention will be appreciated to those of ordinary skill in the art upon reading and understanding the following detailed description.

The invention may take form in various components and arrangements of components, and in various steps and arrangement of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 illustrates a block diagram of a patient monitoring device according to aspects of the present application.

FIGURE 2 illustrates a block diagram of multiple patient monitoring devices according to aspects of the present application.

FIGURE 3 illustrates a flowchart diagram of a method tone modulation with an audible lower clamp value to aspects of the present application.

The present application is directed to Sp02 tone modulation with an audible lower clamp value. One aspect of the present application is directed to limiting the value for the audible frequency to a reasonable clinical value (e.g. 52% = 165.5 Hz for a logarithmic relationship). The user is aware of this audible clamp by modifying other aspects of the tone being output. For example, a double pulse can be provided with a two times 30 milliseconds duration with a space of 20 milliseconds instead of a tone with a 80 milliseconds duration. Another method may use a specific audio tone signal or combine two different audio tone signals such as combining the usual tone for Sp02 clamp with a specific "clamp" tone. Such a scheme avoid tones with lower frequencies representing very low values which may not be heard as the volume of the audible output device may decline in those low ranges. Clamping at a reasonable low frequency and changing the pattern to indicate dangerous SpO2 values is much more clinically appropriate. Further, if sounds are used in a family of devices with different audio output device which have different limitations in their frequency band, those sounds are still almost immediately recognizable by the user. Another aspect of the present application is directed to transposing known sounds that were design for classic output devices, such as speakers to, be used for other smaller audio output device, such as piezo audio elements. For example, transposing an audio tone up three octaves for a piezo audio element may provide an audio signal which can easily be heard or discerned by the user.

With reference to FIGURE 1, a patient (not shown) is monitored by various medical monitoring devices or sensors **10** that measure physiological parameters of the patient and generate physiological data indicative thereof. These medical monitoring devices **10** may include a blood oxygenation (SpO_2), an electrocardiographic (ECG) instrument with ECG electrodes, a medical monitor, which may for example be configured to blood

oxygenation (SpO_2), pulse, or one or more other physiological parameters. Other medical monitoring devices **10** can be associated with a patient, and not all of the above-mentioned medical monitoring devices **10** have to be associated with a patient at any given time. It should be appreciated that while only two medical monitoring devices **10** are illustrated, one or more medical monitoring devices are contemplated. As used herein, medical monitoring devices signifies data sources indicating patient health, or the like. Electronics for receiving signals from the medical monitoring device and for optionally performing signal processing on such signals are embodied in the illustrated embodiment as a multi-functional patient monitor device **12**. The patient monitor device **12**, for example, may be a monitor that travels with the patient, such as the transmitter of an ambulatory patient worn monitoring system, or the like.

The medical monitoring devices **10** report the measured or other physiological data to the patient monitor device **12**. The patient monitor device **12** serves as a gathering point for the physiological data measured by the medical monitoring devices, and provides temporary storage for the data. The collected physiological data is concurrently transmitted to a controller **14** in the patient monitor device**12**. A physiological evaluation unit **16** or computer program in the patient monitor device evaluates the physiological data collected from the patient and determines whether the patient's condition warrants notifying an appropriate medical responder by generating an alarm signal. For example, the patient monitor device **12** checks whether each measured parameter is approaching threshold values, whether a trend of any parameter is approaching a threshold, whether any parameter lacks stability or fluxuates too much, combinations of parameters are approaching a threshold, and other indicators that a patient needs more or less medical monitoring or assistance. The thresholds include values exceeding a limit based on time, severity, escalation, or the like.

The controller **14** in the patient monitor device **12** also controls an audio source **18** to produce an audible tone which output of an audio output device **20** based on the physiological data. The audio output device includes an electric acoustic transducer, a classic speaker, piezo elements, and the like. For example, the controller **14** controls the audio source **18** to output a short audible tone for each characteristic point in a cardiac cycle. The controller **14** also controls the audio source **18** adjust the pitch of the short audible tone to indicate SpO2 concentration. Specifically, the physiological evaluation unit **16** evaluates the collected physiological data to determine a measurement of the saturation percentage of oxygen in the blood as well as the rate of blood pulsation corresponding to each heartbeat of a patient. The controller **14** then controls the audio source **18** to output an audible tone based

on the oxygen saturation and a sequential repetition proportional to the pulse. As stated above, utilizing typical linear and logarithmic relation mapping schemes to indicate SpO2 concentration and pulse result in numerous problems for the user. The present application addresses these problems by providing an audio mapping scheme which enables low SpO2 values to be heard and easily discerned by a user and defines a lower range limit for SpO2 tone modulation.

Specifically, the controller **14** controls the audio source **18** to output audible tones based on a musical scale, which is non-linear. That is, each octave doubles the frequency. For example, upper C is twice the frequency of middle C. The mapping scheme utilized by the controller **14** step the frequency in the audible tone in full-tone or half-tone increments which are easier for the human ear to distinguish and recognize. For example, the mapping scheme produces a tone at a frequency of 5296 Hz for a 100% SpO2 value, however, for each 24% drop in SpO2, the frequency of the tone is cut in half. In other words, for each 1% change in the blood oxygen concentration the frequency is changed by a half-tone. For example, a tone at a frequency of 2648 Hz will be produced for a 76% SpO2 value, a tone at a frequency of 1324 Hz will be produced for a 52% SpO2 value. The blood oxygen concentrations are also based on a musical scale such that the 100% SpO2 value is upper C and the 52% SpO2 value is lower C. However, due to the challenging hearing or discerning below this frequency range, the frequency of the audible tone is clamped after two octaves or a predetermined threshold. Specifically, after the frequency of the audible tone reaches a predetermined threshold, the frequency would no longer step down and remaining at the predetermined clamp frequency. For example, the frequency of the audible tone is clamped after the 1324 Hz for a 52% SpO2 value, or a quarter of the 5296 Hz for a 100% SpO2 value. Once the lower clamp value is reached, the frequency would no longer step down. Rather, the lowest frequency would merely indicate that the blood oxygen is critically low and needs immediate attention. In another embodiment, once the lower clamp value is reached, other aspects of the audible tone are modified. For example, for saturation values below the lower clamp value, a tone at a frequency of 1324 Hz is produced with a double pulse in order to differentiate it from the 52% SpO2 concentration. In another example, after the lower clamp value, a specific “clamp” tone or a combination of the usual tone and the specific “clamp” tone are produced. It is contemplated that this mapping scheme is utilized to represent physiological parameters other than SpO2 concentration. It is also contemplated that the threshold and clamp value can also be at the upper end of a range. It is further contemplated that the mapping scheme is also used to indicate various behaviors of the physiological

parameters including the physiological parameters approaching threshold values, whether a trend of any parameter is approaching a threshold, whether any parameter lacks stability or fluxuates too much, combinations of parameters are approaching a threshold, and other indicators that a patient needs more or less medical monitoring or assistance.

In another embodiment, the controller **14** transposes the audible tone based on the type of audio output device **20**. For example, various types of audio output devices **20** have different audio characteristics and tonal frequency limitations. For instance, a classic output speaker device such as a speaker (662 Hz) has a much lower optimal frequency range than a smaller audio output device such as a piezo element (5296 Hz). As such, the controller **14** transposes the audible tone being produced to best match the audio characteristics of the audio output device **20** being used. For example, if a classic speaker is being used as the audio output device **20**, the controller **14** will transpose the audible tone to being around the 662 Hz range, whereas if a piezo element is being used as the audio output device **20**, the controller **14** will transpose the audible tone to be around the 5296 Hz range.

In another embodiment, if multiple patient monitor devices **12** are being used with different audio output devices **20** and those patient monitor devices **12** utilize the same mapping scheme, the controller **14** transposes the audible tone, such that audible tone will operate in different octaves. As shown in FIGURE 2, utilizing the above clamp mapping scheme, a first patient monitor device **40** will operate in upper octave #1 **42** and lower octave #2 **44** and a second patient monitor device **46** will operate in upper octave # **48** and lower octave #4 **50**. It is important to note that each of the octaves is different from one another such that the user can differentiate between patient monitor devices. Thus, for a family of patient monitor devices with different audio output devices all the audible tones are unambiguous but still consistent.

With reference to FIGURE 3, a method for providing tone modulation with an audible lower clamp value is illustrated. In a step **100**, physiological data is received. The frequency for a stepped audible tone is determined based on the physiological data and an audio mapping scheme in a step **102**. In a step **104**, it is checked if the determined frequency of the audible tone would fall predetermined threshold(s). In a step **106**, the audible tone is clamped in response to the audible tone falling outside predetermined threshold(s). In response to being clamped, the audible tone is modified in a step **108**. In step **110** the audible tone is output.

In another embodiment the mapping already includes the clamping in a way that physiological data outside the predetermined threshold(s) is directly mapped to the clamped audible tone.

One having ordinary skill in the art will appreciate in view of the teachings provided herein, features, elements, components, etc. described in the present disclosure/specification and/or depicted in the appended Figures and/or any other Appendixes, may be implemented in various combinations of hardware and software, and provide functions which may be combined in a single element or multiple elements. For example, the functions of the various features, elements, components, etc. shown/illustrated/depicted in the Figures can be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions can be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which can be shared and/or multiplexed. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and can implicitly include, without limitation, digital signal processor ("DSP") hardware, memory (e.g., read-only memory ("ROM") for storing software, random access memory ("RAM"), non-volatile storage, etc.) and virtually any means and/or machine (including hardware, software, firmware, combinations thereof, etc.) which is capable of (and/or configurable) to perform and/or control a process.

Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future (e.g., any elements developed that can perform the same or substantially similar function, regardless of structure). Thus, for example, it will be appreciated by one having ordinary skill in the art in view of the teachings provided herein that any block diagrams presented herein can represent conceptual views of illustrative system components and/or circuitry embodying the principles of the invention. Similarly, one having ordinary skill in the art should appreciate in view of the teachings provided herein that any flow charts, flow diagrams and the like can represent various processes which can be substantially represented in computer readable storage media and so executed by a computer, processor or other device with processing capabilities, whether or not such computer or processor is explicitly shown.

Furthermore, exemplary embodiments of the present invention can take the form of a computer program product accessible from a computer-usable and/or computer-readable storage medium providing program code and/or instructions for use by or in connection with, e.g., a computer or any instruction execution system. In accordance with the present disclosure, a computer-usable or computer readable storage medium can be any apparatus that can, e.g., include, store, communicate, propagate or transport the program for use by or in connection with the instruction execution system, apparatus or device. Such exemplary medium can be, e.g., an electronic, magnetic, optical, electromagnetic, infrared or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include, e.g., a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), flash (drive), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk – read only memory (CD-ROM), compact disk – read/write (CD-R/W) and DVD. Further, it should be understood that any new computer-readable medium which may hereafter be developed should also be considered as computer-readable medium as may be used or referred to in accordance with exemplary embodiments of the present invention and disclosure.

Having described preferred and exemplary embodiments for systems, methods and others, for example (which embodiments are intended to be illustrative and not limiting), it is noted that modifications and variations can be made by persons skilled in the art in light of the teachings provided herein, including the Figures and Appendixes. It is therefore to be understood that changes can be made in/to the preferred and exemplary embodiments of the present application which are within the scope of the embodiments described herein. Modifications and alterations may occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS:

1. A patient monitoring device, the device comprising:

one or more sensors which measure physiological parameters of a patient;

a controller which controls an audio source to generate an audible tone and adjust the pitch of the audible tone to indicate the measured physiological parameter according to a mapping scheme;

the audio source which generates the audio tone;

an audio output device which outputs the audible tone;

wherein the mapping scheme clamps a frequency of the audible tone after reaching a predetermined threshold.

2. The device according to claim 1, wherein the audio tone includes a short audible tone for each characteristic point in a cardiac cycle and the pitch indicates blood oxygen concentration

3. The device according to either one of claims 1 and 2, wherein the controller steps the frequency of the audible tone in full-tone or half-tone increments based on the blood oxygen concentration.

4. The device according to claim 4, wherein for each on percent change in the blood oxygen concentration the frequency is changed by a half-tone or a full-tone.

5. The device according to any one of claims 1-4 wherein the predetermined threshold is two octaves below the peak frequency.

6. The device according to any one of claims 1-5, wherein the controller modifies the audible tone after reaching the predetermined threshold.

5

7. The device according to any one of claims 1-6, wherein the controller transposes the audible frequency based on a type of audio output device.

8. A method for tone modulation with an audible lower clamp value, the method comprising:

measuring physiological parameters of a patient with one or more sensors;

generating an audible tone and adjusting the pitch of the audible tone to indicate the measured physiological parameter according to a mapping scheme;

wherein the mapping scheme clamps a frequency of the audible tone after reaching a predetermined threshold.

9. The method according to claim 8, wherein the audio tone includes a short audible tone for each characteristic point in a cardiac cycle and the pitch indicates blood oxygen concentration

10. The method according to either one of claims 8 and 9, further including:

stepping the frequency of the audible tone in full-tone or half-tone increments based on the blood oxygen concentration.

11. The method according to claim10, wherein for each on percent change in the blood oxygen concentration the frequency is changed by a half-tone or a full-tone.

12. The method according to any one of claims 8-11, wherein the predetermined threshold is two octaves below the peak frequency.

13. The method according to any one of claims 8-12, further including:

modifying the audible tone after reaching the predetermined threshold.

14. The method according to any one of claims 8-13, further including:

transposing the audible frequency based on a type of audio output device.

15. A method for monitoring patients, the method comprising:

outputting a first audible tone from a first patient monitor with a first audio output device;

outputting a second audible tone from a second patient monitor with a second audio output device, the second audio output device having a different audio characteristics than the first audio output device; and

transposing the first and second audible tones such that the audible tone being produced matches the audio characteristics of the audio output device.

16. The method according to claim 15, wherein the audio characteristics include a frequency limitation.

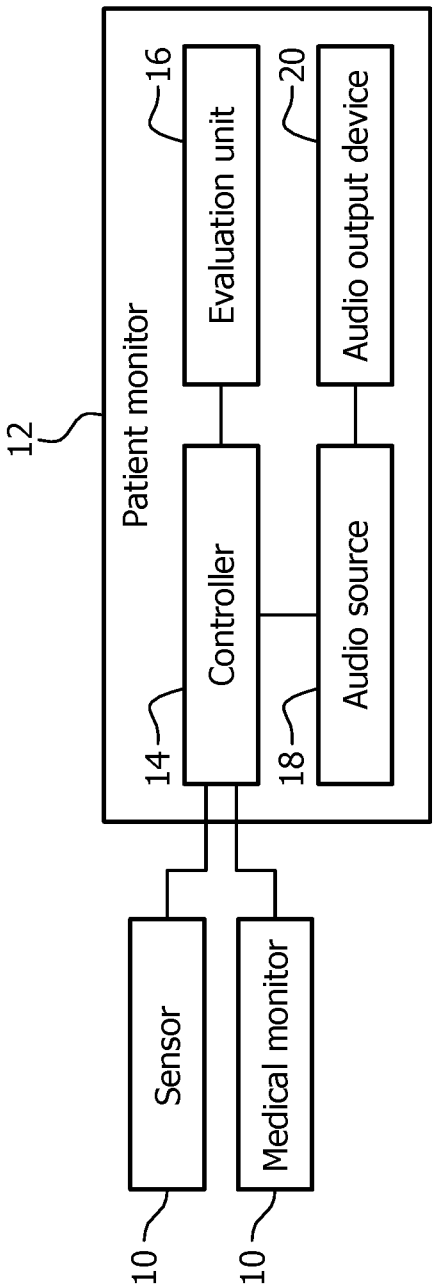
12
Patient monitor
16
Evaluation unit
20
Audio output device
14
Controller
18
Audio source
Sensor
Medical monitor
10
10

FIG. 1

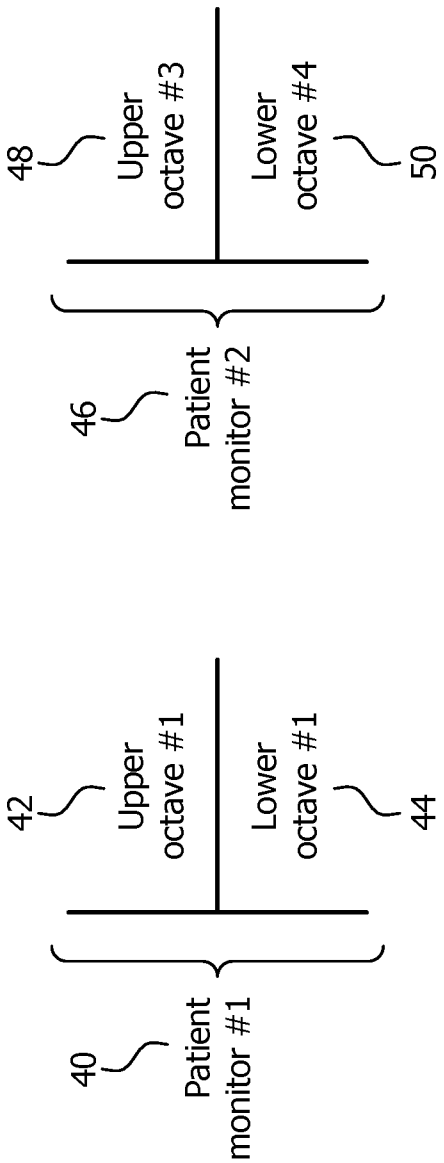
48
Upper octave #3
Lower octave #4
50
46
Patient monitor #2
42
Upper octave #1
Lower octave #1
44
40
Patient monitor #1

FIG. 2

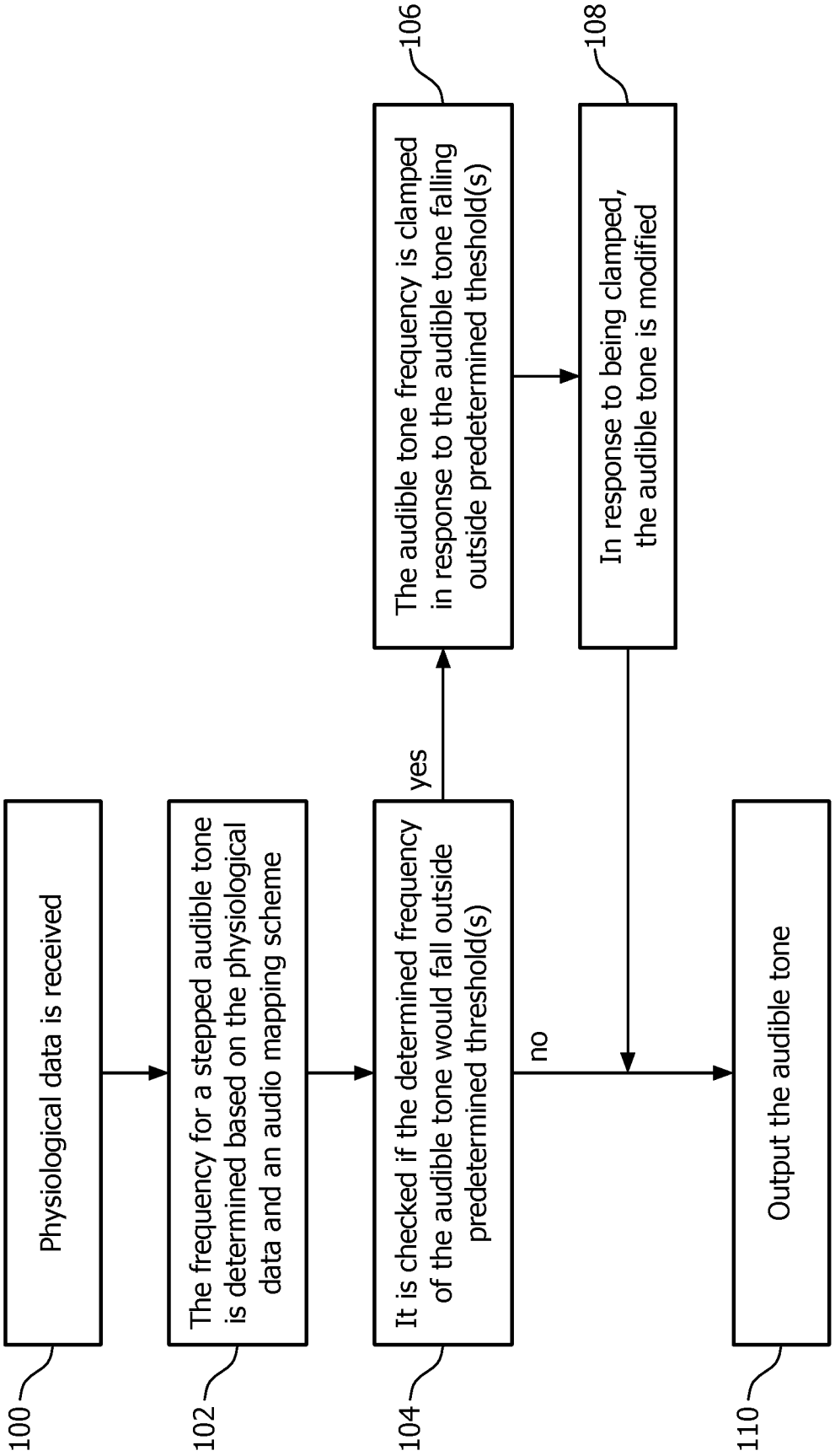
Physiological data is received
100
The frequency for a stepped audible tone is determined based on the physiological data and an audio mapping scheme
102
It is checked if the determined frequency of the audible tone would fall outside predetermined threshold(s)
104
yes
no
The audible tone frequency is clamped in response to the audible tone falling outside predetermined theshold(s)
106
In response to being clamped, the audible tone is modified
108
Output the audible tone
110

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/062200

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/145
ADD.

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)
A61B A63B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/193026 A1 (SCHARF TOM D [US]) 30 September 2004 (2004-09-30) paragraphs [0015] - [0018], [0029] - [0031], [0036] - [0041], [0044] - [0046] figures 1-4	1-16

X	US 2004/243016 A1 (SANDERSON PENELOPE MARGARET [AU] ET AL) 2 December 2004 (2004-12-02)	1,8
A	paragraphs [0003], [0015] - [0021], [0025] - [0028], [0034] - [0040], [0043], [0057], [0062] - [0063], [0068] figure 3	2-7,9-16

A	WO 2012/130274 A1 (THELL RAINER [AT]) 4 October 2012 (2012-10-04) the whole document	1-16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 September 2014	15/09/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Faymann, Juan

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/062200

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/293745 A1 (MCCUTCHEON IAN [US] ET AL) 20 December 2007 (2007-12-20) the whole document	1-16

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/062200

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		NZ 531497 A	24-09-2004
		US 2004243016 A1	02-12-2004
		WO 03017838 A1	06-03-2003
WO 2012130274 A1	04-10-2012	NONE	
US 2007293745 A1	20-12-2007	US 2007293745 A1	20-12-2007
		WO 2007145870 A2	21-12-2007

专利名称(译)	Spo2音调调制，具有可听见的低钳位值		
公开(公告)号	EP3013216A1	公开(公告)日	2016-05-04
申请号	EP2014739552	申请日	2014-06-13
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V. PHILIPS GMBH		
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摘要(译)

患者监测设备包括测量患者生理参数的一个或多个传感器，控制音频源以产生可听音调的控制器，并根据映射方案调节可听音调的音调以指示测量的生理参数，产生音频音调的音频源和输出可听音调的音频输出设备。映射方案在达到预定阈值之后钳制可听音调的频率。