(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 298 159 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
21.10.2015 Bulletin 2015/43

(51) Int Cl.:
A61B 5/00 *(2006.01)* ***A61B 5/1455*** *(2006.01)*

(21) Application number: **10181436.6**

(22) Date of filing: **24.03.2000**

(54) **Improved pulse oximeter probe-off detector**

Verbesserter Detektor für Pulsoximetersondenablösung

Modèle amélioré de détecteur de décrochage de la sonde d'un spygmo-oxymètre

(84) Designated Contracting States:
DE FR GB

(30) Priority: **25.03.1999 US 126148 P**

(43) Date of publication of application:
23.03.2011 Bulletin 2011/12

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
06012571.3 / 1 719 449
00916663.8 / 1 171 025

(73) Proprietor: **Masimo Corporation**
Irvine, CA 92618 (US)

(72) Inventors:
- **Diab, Mohamed K.**
  Mission Viejo
  CA 92692 (US)
- **Ali, Ammar Al**
  Trustin
  CA 92782 (US)

(74) Representative: **Vossius & Partner**
Patentanwälte Rechtsanwälte mbB
Siebertstrasse 3
81675 München (DE)

(56) References cited:
US-A- 4 295 475
US-A- 4 399 824
US-A- 4 603 700
US-A- 5 368 041
US-A- 5 846 190

EP 2 298 159 B1

Printed by Jouve, 75001 PARIS (FR)

Description

Background of the Invention

[0001] Oximetry is the measurement of the oxygen status of blood. Early detection of low blood oxygen is critical in the medical field, for example in critical care and surgical applications, because an insufficient supply of oxygen can result in brain damage and death in a matter of minutes. Pulse oximetry is a widely accepted noninvasive procedure for measuring the oxygen saturation level of arterial blood, an indicator of oxygen supply. A pulse oximetry system consists of a sensor attached to a patient, a monitor, and a cable connecting the sensor and monitor. Conventionally, a pulse oximetry sensor has both red and infrared (IR) light-emitting diode (LED) emitters and a photodiode detector. The sensor is typically attached to a patient's finger or toe, or a very young patient's patient's foot. For a finger, the sensor is configured so that the emitters project light through the fingernail and into the blood vessels and capillaries underneath. The photodiode is positioned at the fingertip opposite the fingernail so as to detect the LED transmitted light as it emerges from the finger tissues.

[0002] The pulse oximetry monitor (pulse oximeter) determines oxygen saturation by computing the differential absorption by arterial blood of the two wavelengths emitted by the sensor. The pulse oximeter alternately activates the sensor LED emitters and reads the resulting current generated by the photodiode detector. This current is proportional to the intensity of the detected light. The pulse oximeter calculates a ratio of detected red and infrared intensities, and an arterial oxygen saturation value is empirically determined based on the ratio obtained. The pulse oximeter contains circuitry for controlling the sensor, processing the sensor signals and displaying the patient's oxygen saturation and pulse rate. A pulse oximeter is described in U.S. Patent 5,632,272 assigned to the assignee of the present invention.

[0003] US5846190 refers to a pulse oximeter with several processing channels for measurement signals which are measured during the switched-on phase of transmission diodes and which are used to determine the oxygen saturation (SpO2) of a patient. An additional measurement channel processes an ambient light signal which was measured while the transmission diodes were switched off or their intensity modified, in the same way and thus provides a measure of the spectral composition of the ambient light interference. A noise-signal ratio is derived from the ambient light signal and a measurement signal, which represents a measure of the signal quality and which can be compared with threshold values, where an alarm is triggered if the value falls below the threshold values.

Summary of the Invention

[0004] To compute peripheral arterial oxygen saturation, denoted Sp_aD_2, pulse oximetry relies on the differential light absorption of oxygenated hemoglobin, HbO_2, and deoxygenated hemoglobin, Hb, to compute their respective concentrations in the arterial blood. This differential absorption is measured at the red and infrared wavelengths of the sensor. In addition, pulse oximetry relies on the pulsatile nature of arterial blood to differentiate hemoglobin absorption from absorption of other constituents in the surrounding tissues. Light absorption between systole and diastole varies due to the blood volume change from the inflow and outflow of arterial blood at a peripheral tissue site. This tissue site might also comprise skin, muscle, bone, venous blood, fat, pigment, etc., each of which absorbs light. It is assumed that the background absorption due to these surrounding tissues is invariant and can be ignored. Accordingly, blood oxygen saturation measurements are based upon a ratio of the time-varying or AC portion of the detected red and infrared signals with respect to the time-invariant or DC portion. This AC/DC ratio normalizes the signals and accounts for variations in light pathlengths through the measured tissue.

[0005] FIG. **1** illustrates the typical operating characteristics of a pulse oximeter. During a calibration phase, the pulse oximeter input gain is adjusted higher to accommodate opaque skin and lower to accommodate translucent skin at the sensor site. Variations in blood perfusion at the sensor site result in variations in input signal strength. The graph **100** shows acceptable input sensitivity as a function of gain. The y-axis **110** represents the signal strength (SS), which is the ratio of the peak-to-peak AC signal to the DC signal, expressed as a percentage. The x-axis **120** represents the gain, which is shown with decreasing values along the x-axis. The graph **100** has an unshaded region **130** representing the acceptable operating range of the pulse oximeter and a shaded region **140** representing conditions outside that operating range, which, when detected, will result in a pulse oximeter "probe off" alarm. The operating region **130** has a floor **150** at relatively low gains, representing the highest sensitivity to patients with low perfusion. Because input noise increases with gain, the operating region also has a corner point **160** below which input sensitivity is noise limited and falls off with increasing gain, i.e. increasing opacity.

[0006] A pulse oximeter with the operating characteristics shown in FIG. **1** may fail to detect a probe off condition. This problem occurs when the sensor becomes partially or completely dislodged from the patient, but continues to detect an AC signal within the operating region of the pulse oximeter. Probe off errors are serious because the pulse oximeter may display a normal saturation when, in fact, the probe is not properly attached to the patient, potentially leading to missed desaturation events.

[0007] Failure to detect a probe off condition is the result of the sensor detector receiving light directly from the emitters without transmission through the patient's tissue. The pulse oximeter is particularly vulnerable to probe off errors when operating at its highest sensitivity, where even small induced variations in light directly detected from the emitters have sufficient signal strength to be processed as a physiological signal. In a probe off condition, a detector AC signal can be induced by slight changes in the direct light path between the emitters and detector. For example, small amounts of patient motion, such as chest movement from breathing, can induce a probe off AC signal. As another example, "creep" in the sensor configuration, such as a folded sensor gradually returning to its original unfolded shape after becoming dislodged can also induce a probe off AC signal. Further restricting the operating region **130** shown in FIG. **1** can reduce probe off errors. Such restrictions, however, would also severely limit the ability of the pulse oximeter to make saturation measurements on patients with poor perfusion.

[0008] The present invention is a monitor-based improvement to detecting the probe off condition described above. Of-course, other methods of detecting the probe-off condition could be combined with the present improvement. In particular, an intelligent, rule-based processor uses signal quality measurements to limit the operating region of the pulse oximeter without significant negative impact on low perfusion performance. These signal-quality operating limits are superimposed on those of FIG. **1** to improve probe off detection. In this manner, the pulse oximeter can reject AC signals that have sufficient signal strength to falt within the operating region **130** of FIG. **1,** but that are unlikely to be a plethysmograph signal. One signal quality measurement that is used is pulse rate density, which is the percentage of time detected pulses satisfy a physiologically acceptable model. Another signal quality measurement is energy ratio, which is the percentage of signal energy that occurs at the pulse rate and its harmonics. The operating region of the pulse oximeter is then defined in terms of signal strength versus gain, signal strength versus PR density and energy ratio versus predefined energy ratio limits.

[0009] The invention is set out in claims 1 and 5.

[0010] In one aspect of the present invention, a probe-off detector has a signal input, a signal quality input and a probe off output. The signal quality input is dependent on a comparison between a sensor output and a physiological signal model. The probe off output provides an indication that the sensor may not be properly attached to a tissue site. The detector comprises a signal strength calculator, a stored relationship between signal strength and signal quality and a comparator. The signal strength calculator has an input in communications with the sensor signal and provides a signal strength output that is dependent on the time-varying component of the sensor signal. The stored relationship defines an acceptable operating region for the sensor. The comparator has signal strength and signal quality as inputs and provides the probe off output based on a comparison of the signal strength and the signal quality with the stored relationship.

[0011] In another aspect of the present invention, a pulse oximetry sensor signal is processed to determine if it is properly attached to a tissue site. The process steps involve setting a signal strength limit that is dependent on signal quality, calculating a signal strength value from the sensor signal, calculating a signal quality value from the sensor signal and indicating a probe off condition if the signal strength is below the limit for the signal quality value previously determined.

Brief Description of the Drawings

[0012]

FIG. **1** is a graph illustrating minimum signal strength operating limits for a pulse oximeter
: FIGS. **2A** and **2B** are graphs illustrating additional minimum signal strength operating limits for a pulse oximeter, based on signal quality according to the present invention;
FIG. 2A is a graph of signal quality operating limits for a pulse oximeter in normal input sensitivity mode;
FIG. **2B** is a graph of signal quality operating limits for a pulse oximeter in high input sensitivity mode;
FIG. **3** is a top-level block diagram of a rule-based intelligent processor that provides the signal quality operating limits illustrated in FIGS. **2A-2B;**
FIG. **4** is a detailed block diagram of the signal strength calculator portion of FIG. **3;**
FIG. **5** is a detailed block diagram of the probe off logic portion of FIG. **3;** and
FIG. **6** is a detailed block diagram of the signal strength dependent checks portion of FIG. **5.**

Detailed Description of the Preferred Embodiments

[0013] FIGS. **2A** and **2B** illustrate how the operating range of a pulse oximeter is modified based on pulse rate density according to one embodiment of the present invention. Calculation of PR density is disclosed in U.S. Provisional Patent Application No. 60/114,127 filed December 30, 1998, and in U.S. Patent Application No. 09/471,510, filed December 23, 1999, entitled "Plethysmograph Pulse Recognition Processor," which is assigned to the assignee of the current

application. The processor described therein has a candidate pulse portion that determines a plurality of potential pulses within the input IR waveform. A physiological model portion of the processor then determines the physiologically acceptable ones of these potential pulses. The processor provides statistics regarding the acceptable pulses. One statistic is pulse density, which is the ratio of the period of acceptable pulses to the duration of a block or "snapshot" of the IR input waveform.

[0014] FIG. **2A** shows a graph **200** of signal strength on the y-axis **210** versus PR density on the x-axis **220** for normal sensitivity. The operating region **260** is shown unshaded, and the probe off region **270** is shown shaded. A signal strength floor **230** of .02, below which a probe off condition exists for all values of PR density, determines one portion of the operating region **260.** That is, no matter how many of the detected plethysmograph pulses are deemed physiologically acceptable, if the signal strength is less than .02, then the pulse oximeter indicates a probe off condition. A signal strength ceiling **250** of .25, above which the pulse oximeter is in a valid operating region for all values of PR density, determines another portion of the operating region **260.** That is, signal quality is ignored if signal strength is above .25. Between the signal strength ceiling **250** and floor **230,** acceptable signal strength is dependent on PR density. The slope of the boundary **240** defining this relationship is:

$$\text{slope} = -(.25-.02)/(.5-.2) = -.23/.3 = -.7667 \quad (1)$$

Thus, this boundary can be defined by the following equivalent equations:

$$SS = -.7667 * PR\ density + .4033 \quad (2)$$

$$PR\ density = -1.3043 * SS + 0.5261 \quad (3)$$

[0015] FIG. **2B** shows a graph **200** of signal strength on the y-axis **210** versus PR density on the x-axis **220** for high sensitivity. This graph is equivalent to that of FIG. **2A** except that the signal strength ceiling **250** is set at .05. Thus, signal quality indicated by PR density is ignored as long as the signal strength is above .05.

[0016] Another signal quality measure, energy ratio, is also imposed on the operating region as an absolute limit. Energy ratio is the percentage of IR signal energy occurring at the pulse rate and associated harmonics compared to total IR energy. The energy ratio is computed by transforming each block of the IR signal into the frequency domain as is well known in the art. The energy ratio is computed by identifying each peak in the resulting spectrum. In one embodiment, the peaks occurring at the pulse rate and its harmonics are identified and summed. This value is divided by the sum of the magnitudes of all peaks and output as the energy ratio. Note that energy ratio computed in this manner is not a true energy calculation because the calculations are based on the peak magnitudes and not the squared magnitudes of the IR signal. In this embodiment, the minimum energy ratio must be .6 if the pulse rate is greater than or equal to 30 and .5 otherwise. That is, 60% (or 50% for low pulse rates) of the signal must be at the pulse rate frequency or its harmonics or the pulse oximeter will indicate a probe off condition. A method for calculating the pulse rate used in this calculation is disclosed in U.S. Patent No. 6,002,952, filed April 14, 1997, entitled "Improved Signal Processing Apparatus and Method," which is assigned to the assignee of the current application.

[0017] FIG. **3** is a block diagram illustrating one embodiment of the improved probe-off detector **300** according to the present invention. The detector has a signal strength calculator **310,** a limit selector **330** and probe-off logic **350.** The signal strength calculator **310** has an IR signal **312** input. This signal is the detected sensor signal after demultiplexing, amplification, filtering and digitization. In a particular embodiment, the IR signal is input to the signal strength calculator **310** at a 62.5 Hz sample rate and in overlapping "snapshots" or blocks of 390 samples, each offset from the previous block by 25 samples. The signal strength calculator **310** creates a signal strength vector output **314** consisting of a set of signal strength scalars for each of these input blocks, as described with respect to FIG. **4** below.

[0018] The limit selector **330** has pulse rate **332** and sensitivity mode **334** inputs. When the sensitivity mode input **334** has a value of **1.** it indicates that the pulse oximeter is in a normal sensitivity mode, corresponding to FIG. **2A.** A value of 0 indicates the pulse oximeter is in a high sensitivity mode, corresponding to FIG. **2B.** The pulse oximeter operator selects the sensitivity mode. The limit selector **330** also has energy ratio limit **336** and signal strength limit **338** outputs, which are input to the probe off logic **350** as absolute minimums of energy ratio and signal strength below which a probe off condition may be indicated **350.** The relationship between the pulse rate **332** and sensitivity mode **334** inputs and the energy ratio **336** and signal strength **338** outputs is specified below:

INPUT STATE	SELECTED LIMIT
pulse rate ≥ 30	minimum energy ratio - 0.6
pulse rate < 30	minimum energy ratio - 0.5
sensitivity mode - 0	minimum signal strength - 0.05
sensitivity mode - 1	minimum signal strength - 0.25

[0019] The probe off logic **350** has as inputs energy ratio **332,** PR density **334** and signal strength vector **314.** These inputs are compared to the energy ratio limit **336** and signal strength limit **338** outputs from the limit selector **330** to determine the operating region of the pulse oximeter. The probe off logic **350** also has a time fuse input **356.** The time fuse **356** is a counter that indicates the number of IR waveform blocks containing no acceptable pulses. Acceptable pulses are determined as described for the calculation of PR density **354,** above. The time fuse **356** input is 1 if there have been no acceptable pulses in a block since startup. The time fuse **356** is reset to 0 each time no acceptable pulses are detected for an input block. For each block where there are no acceptable pulses, the time fuse **356** is incremented by one. The time fuse enables the energy ratio limit and that portion of the signal strength limits above the floor **230** (FIGS. **2A-2B).** This reduces the probability of probe off alarms for transient events. In a particular embodiment, the time fuse **356** is compared to the constants -1 and 5. That is, the energy ratio and signal strength limits are enabled if there have been no acceptable pulses since startup or for more than the previous **5** IR signal blocks.

[0020] The probe off logic **350** has a Boolean probe off output **358** that is set to 1 when the probe off logic **350** detects the pulse oximeter is operating outside permissible limits. Otherwise, the probe off output **358** is 0. The probe off output can be used by the pulse oximeter to trigger a probe off alarm and error message to alert medical personnel to inspect and reattach the sensor or take other appropriate action. The probe off logic **350** is described in more detail below with respect to FIG. **5.**

[0021] FIG. **4** shows further details of the signal strength calculator **310** (FIG. **3).** Each **390** sample block of the IR signal **312** is initially filtered **410** remove any trends in the IR signal **312** that could cause an error in the signal strength calculations. In a particular embodiment, the filter **410** is a bandpass FIR filter with cutoff frequencies of 50 Hz and 550 Hz and a 151 tap Kaiser window having a shape parameter of 3.906. As a result, 150 samples are lost from each 390 sample input block. Thus, the filtered IR output **412** consists of **240** sample blocks.

[0022] Each 240 sample block of the filtered IR output **412** is converted **430** into multiple overlapping sub-blocks. In a particular embodiment, the sub-blocks each consist of 100 samples, and each sub-block is offset by 10 samples from the previous sub-block. Thus, the sub-block converter **430** creates 15 sub-block outputs **432** for each **240** sample filtered IR block **412.** For each sub-block, a max-min calculation **460** is performed. That is, the minimum sample magnitude in a particular sub-block is subtracted from the maximum sample magnitude in that sub-block. Each max-min output **462** is a single scalar representing the signal strength of a particular sub-block. A scalar-to-vector conversion **490** combines the max-min outputs **462** into a vector output **314** containing multiple signal strength values representing the signal strength of a particular block of the IR signal **312.**

[0023] FIG. **5** provides further detail of the probe off logic **350** (FIG. **3).** The probe off logic **350** has three functional checks that each provide a Boolean output. An energy ratio check **510** compares the energy ratio **352** against the energy ratio limit **336** provided by the limit selector **330** (FIG. **3),** specified in the table above. The energy ratio check **510** sets the "poor energy ratio" output **512** if the energy ratio **352** is below the energy ratio limit **336.**

[0024] A time fuse check **520** determines if the time fuse **356** indicates no acceptable pulses have occurred in the IR signal **312** (FIG. **3)** for a sufficiently long time period. If so, a timeout output **522** is set. In a particular embodiment, the time fuse check **520** consists of comparators that determine if the time fuse **356** is -1 or greater than 5, indicating no acceptable pulses since startup or for a longer period than the past 5 blocks of IR signal **312.**

[0025] The signal strength dependent checks **530** determine if the pulse oximeter is within the operating limits described above with respect to FIGS. **2A** and **2B.** If the signal strength, as determined by the signal strength vector **314,** is below the floor **230** (FIGS. **2A-B**), then the signal strength failure output **534** is set. If the signal strength is above the floor **230** (FIGS. **2A-B**) but otherwise outside the operating region, i.e. within the shaded region **270** (FIGS. **2A-B**) above the floor **230** (FIGS. **2A-2B),** then the "poor signal strength" output **532** is set.

[0026] A logical AND function **540** sets a "poor signal quality" output **542** if the poor energy ratio **512,** poor signal strength **532** and timeout **522** outputs are set. A logical OR function **550** sets the probe off output **358** if the poor signal quality **542** or the signal strength failure **534** outputs are set.

[0027] FIG. **6** shows a particular embodiment of the signal strength dependent checks **530** (FIG. **5).** The signal strength vector **314** is converted **610** into the 15 individual signal strength scalars **612.** Relative checks **620** and absolute checks **630** are performed on each of the 15 scalars **612.** Each relative check 620 determines if signal strength is within the signal strength limit **338** relative to PR density **354.** That is, each relative check output **622** is set according to the

following, see Eq. 3 above:

INPUT STATE	RESULT
SS ≥ SS limit	output = 0
PR density> -1.3043●SS+0.5261	output = 0
(SS< SS limit) AND PR density< -1.3043●SS+0.5261	output = 1

[0028] Each absolute check **630** determines if the signal strength is above the absolute minimum floor 230 (FIGS. **2A-2B).** That is, each absolute check output **632** is set according to the following:

INPUT STATE	RESULT
SS ≥ 0.02	output = 0
SS < 0.02	output = 1

[0029] The 15 relative check outputs **622** are processed by a sum and compare **660,** which performs an arithmetic sum of these outputs **622.** If the sum is equal or greater than 5, the poor signal strength output **532** is set. That is, poor signal strength is indicated if at least 1/3 of the scalars in the signal strength vector **314** fail their relative checks **620.** Likewise, the 15 absolute check outputs **632** are processed by a sum and compare **670,** which performs an arithmetic sum of these outputs **632.** If the sum is equal or greater than 5, the signal strength failure output **534** is set. That is, a signal strength failure is indicated if at least 1/3 of the scalars in the signal strength vector **314** fail the absolute checks **630.**

[0030] This improvement to detecting pulse oximetry probe off conditions has been disclosed in detail in connection with various embodiments of the present invention. These embodiments are disclosed by way of examples only and are not to limit the scope of the present invention, which is defined by the claims that follow. One of ordinary skill in the art wiU appreciate many variations and modifications within the scope of this invention.

Claims

1. A probe-off detector (300) providing an indication that an optical pulse oximetry sensor may not be properly positioned proximate a tissue site, said probe-off detector (300) comprising:

probe-off logic (350) configured to receive a signal quality input of a sensor signal from said sensor indicative of an operating region of the sensor; and
a signal strength calculator (310) configured to receive the sensor signal from the sensor and configured to generate a signal strength output dependent on a time-varying component of the sensor signal, wherein the probe-off logic (350) is further configured to indicate a probe-off condition based on a comparison determining that the signal strength output is below an acceptable signal strength value, and wherein the probe-off logic (350) is further configured to determine the acceptable signal strength value based on the signal quality input and a stored relationship between signal strength and signal quality that defines a portion of an acceptable operating region of the sensor.

2. The probe-off detector of claim 1, wherein the probe-off logic (350) comprises a comparator.

3. The probe-off detector of claim 1, wherein the probe-off logic (350) comprises an energy ratio check.

4. The probe-off detector of claim 1, wherein the probe-off logic (350) comprises a time check indicating that no acceptable pulses have occurred for a sufficient time period.

5. A method of detecting that an optical pulse oximetry sensor may not be properly attached to a tissue site by processing a signal of said sensor, the method comprising:

calculating a signal strength value from the time-varying component of the sensor signal of the optical pulse oximetry sensor;
calculating a signal quality value of the sensor signal;

determining, based on a stored relationship between signal strength and signal quality that defines a portion of an acceptable operating region of the sensor, an acceptable signal strength corresponding to the signal quality value; and
indicating a probe-off condition when the signal strength value is below the acceptable signal strength.

6. The method of claim 5, further comprising:

determining a signal strength floor (230), and
indicating a probe-off condition when the signal strength value is below the signal strength floor (230).

7. The method of claim 5, wherein the signal quality value comprises a pulse rate (PR) density of the sensor signal.

8. The method of claim 7, wherein said stored relationship is a function of said pulse rate (PR) density.

9. The method of claim 8, wherein said function is y=mx+b, where y is said acceptable signal strength and x is said pulse rate (PR) density.

10. The method of claim 9, wherein m is approximately -0.8.

11. The method of claim 10, wherein b is approximately 0.4.

12. The method of claim 6, wherein the signal strength floor (230) is approximately 0.02.

13. The method of claim 6, wherein the signal strength floor (230) is responsive to a sensitivity mode.

14. The method of claim 13, wherein said sensitivity mode is responsive to an operator input.

Patentansprüche

1. Sondenablösungsdetektor (300), der eine Anzeige bereitstellt, dass ein optischer Pulsoximetriesensor nicht richtig benachbart zu einer Gewebestelle angeordnet sein kann, wobei der Sondenablösungsdetektor (300) aufweist:

eine Sondenablösungslogik (350), die konfiguriert ist, eine Signalqualitätseingabe eines Sensorsignals von dem Sensor zu empfangen, das einen Betriebsbereich des Sensors anzeigt; und
einen Signalstärkerechner (310) der konfiguriert ist, das Sensorsignal von dem Sensor zu empfangen, und der konfiguriert ist, eine von einer zeitveränderlichen Komponente des Sensorssignals abhängige Signalstärkeausgabe zu erzeugen, wobei die Sondenablösungslogik (350) ferner konfiguriert ist, einen Sondenablösungszustand beruhend auf einem Vergleich anzuzeigen, der feststellt, dass die Signalstärkeausgabe unter einem annehmbaren Signalstärkenwert liegt, und wobei die Sondenablösungslogik (350) ferner konfiguriert ist, den annehmbaren Signalstärkenwert beruhend auf der Signalqualitätseingabe und einer gespeicherten Beziehung zwischen Signalstärke und Signalqualität festzustellen, die einen Abschnitt eines annehmbaren Betriebsbereichs des Sensors definiert.

2. Sondenablösungsdetektor nach Anspruch 1, wobei die Sondenablösungslogik (350) einen Komparator aufweist.

3. Sondenablösungsdetektor nach Anspruch 1, wobei die Sondenablösungslogik (350) eine Energieverhältnisprüfung aufweist.

4. Sondenablösungsdetektor nach Anspruch 1, wobei die Sondenablösungslogik (350) eine Zeitprüfung aufweist, die anzeigt, dass während einer ausreichenden Zeitspanne keine annehmbaren Pulse aufgetreten sind.

5. Verfahren zum Ermitteln, dass ein optischer Pulsoximetriesensor nicht richtig an einer Gewebestelle angebracht sein kann, durch Verarbeiten eines Signals des Sensors, wobei das Verfahren aufweist:

Berechnen eines Signalstärkenwerts aus einer zeitveränderlichen Komponente des Sensorssignals des optischen Pulsoximetriesensors;
Berechnen eines Signalqualitätswerts des Sensorssignals;

Feststellen einer annehmbaren Signalstärke, die dem Signalqualitätswert entspricht, beruhend auf einer gespeicherten Beziehung zwischen der Signalstärke und der Signalqualität, die einen Abschnitt eines annehmbaren Betriebsbereichs des Sensors definiert; und Anzeigen eines Sondenablösungszustands, wenn der Signalstärkenwert unter der annehmbaren Signalstärke liegt.

6. Verfahren nach Anspruch 5, das ferner aufweist:

Bestimmen eines Signalstärkebodens (230), und
Anzeigen eines Sondenablösungszustands, wenn der Signalstärkenwert unter dem Signalstärkeboden (230) liegt.

7. Verfahren nach Anspruch 5, wobei der Signalqualitätswert eine Pulsfrequenz- (PR) Dichte des Sensorssignals aufweist.

8. Verfahren nach Anspruch 7, wobei die gespeicherte Beziehung eine Funktion der Pulsfrequenz- (PR) Dichte ist.

9. Verfahren nach Anspruch 8, wobei die Funktion y=mx+b ist, wobei y die annehmbare Signalstärke ist und x die Pulsfrequenz- (PR) Dichte ist.

10. Verfahren nach Anspruch 9, wobei m annähernd -0,8 beträgt.

11. Verfahren nach Anspruch 10, wobei b annähernd 0,4 beträgt.

12. Verfahren nach Anspruch 6, wobei der Signalstärkeboden (230) annähernd 0,02 beträgt.

13. Verfahren nach Anspruch 6, wobei der Signalstärkeboden (230) auf einen Empfindlichkeitsmodus reagiert.

14. Verfahren nach Anspruch 13, wobei der Empfindlichkeitsmodus auf eine Bedienereingabe reagiert.

Revendications

1. Détecteur à décrochage de sonde (300) fournissant une indication qu'un capteur d'oxymétrie à impulsion optique peut ne pas être correctement positionné à proximité d'un site de tissu, ledit détecteur à décrochage de sonde (300) comprenant :

un module logique de décrochage de sonde (350) configuré pour recevoir une entrée de qualité d'un signal de capteur depuis ledit capteur indicative d'une zone opérationnelle du capteur ; et
un calculateur de résistance de signal (310) configuré pour recevoir le signal de capteur depuis le capteur et configuré pour générer une sortie de résistance de signal dépendante d'un composant variable dans le temps du signal de capteur, dans lequel le module logique de décrochage de sonde (350) est en outre configuré pour indiquer une condition de décrochage de sonde sur la base d'une comparaison déterminant que la sortie de résistance de signal est inférieure à une valeur de résistance de signal acceptable, et dans lequel le module logique de décrochage de sonde (350) est en outre configuré pour déterminer la valeur de résistance de signal acceptable sur la base de l'entrée de qualité de signal et une relation mémorisée entre la résistance de signal et la qualité de signal qui définit une partie d'une zone opérationnelle acceptable du capteur.

2. Détecteur à décrochage de sonde selon la revendication 1, dans lequel le module logique de décrochage de sonde (350) comprend un comparateur.

3. Détecteur à décrochage de sonde selon la revendication 1, dans lequel le module logique de décrochage de sonde (350) comprend un contrôle de rapport énergétique.

4. Détecteur à décrochage de sonde selon la revendication 1, dans lequel le module logique de décrochage de sonde (350) comprend un contrôle de temps indiquant qu'aucune impulsion acceptable ne s'est produite pendant un laps de temps suffisant.

5. Procédé pour détecter qu'un capteur d'oxymétrie à impulsion optique peut ne pas être correctement fixé à un site

de tissu en traitant un signal dudit capteur, le procédé comprenant :

le calcul d'une valeur de résistance de signal à partir d'un composant variable dans le temps du signal de capteur du capteur d'oxymétrie par impulsion optique ;
le calcul d'une valeur de qualité de signal de signal de capteur ;
la détermination, sur la base d'une relation mémorisée entre la résistance de signal et la qualité de signal qui définit une partie d'une zone opérationnelle acceptable du capteur, d'une résistance de signal acceptable correspondant à la valeur de qualité de signal ; et
l'indication d'une condition de décrochage de sonde quand la valeur de résistance de signal est inférieure à la résistance de signal acceptable.

6. Procédé selon la revendication 5, comprenant en outre :

la détermination d'une limite inférieure de résistance de signal (230) et
l'indication d'une condition de décrochage de sonde quand la valeur de résistance de signal est inférieure à la limite inférieure de résistance de signal (230).

7. Procédé selon la revendication 5, dans lequel la valeur de qualité de signal comprend une densité de taux de pulsation (PR) du signal de capteur.

8. Procédé selon la revendication 7, dans lequel ladite relation mémorisée est une fonction de ladite densité de taux de pulsation (PR).

9. Procédé selon la revendication 8, dans lequel ladite fonction est $y = mx + b$, où y est ladite résistance de signal acceptable et x est ladite densité de taux de pulsation (PR).

10. Procédé selon la revendication 9, dans lequel m est approximativement -0,8.

11. Procédé selon la revendication 10, dans lequel b est approximativement 0,4.

12. Procédé selon la revendication 6, dans lequel la limite inférieure de résistance de signal (230) est d'approximativement 0,02.

13. Procédé selon la revendication 6, dans lequel la limite inférieure de résistance de signal (230) répond à un mode de sensibilité.

14. Procédé selon la revendication 13, dans lequel ledit mode de sensibilité dépend d'une entrée d'opérateur.

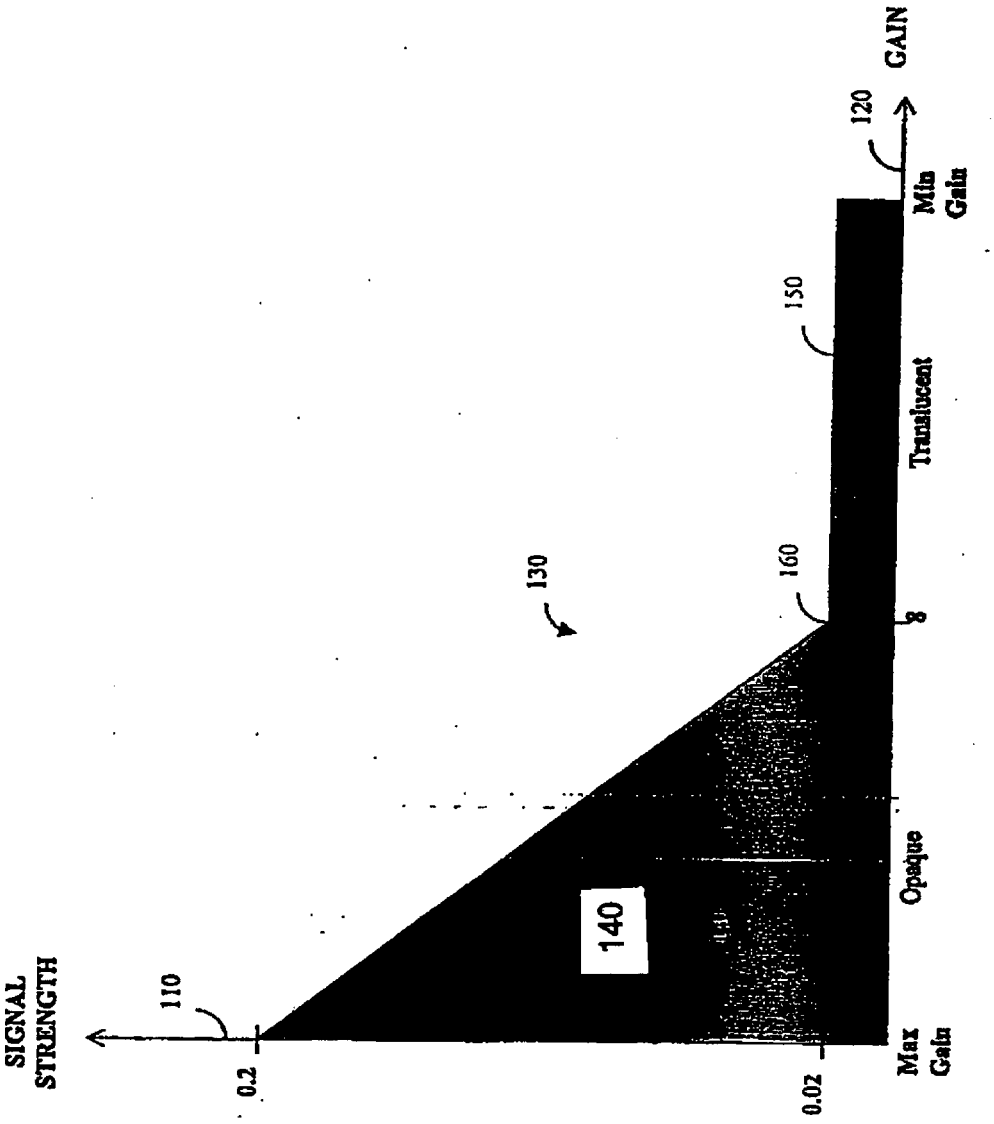
100
130
SIGNAL STRENGTH
110
0.2
0.02
140
160
150
120
GAIN
Max Gain
Opaque
Translucent
Min Gain

FIG. 1

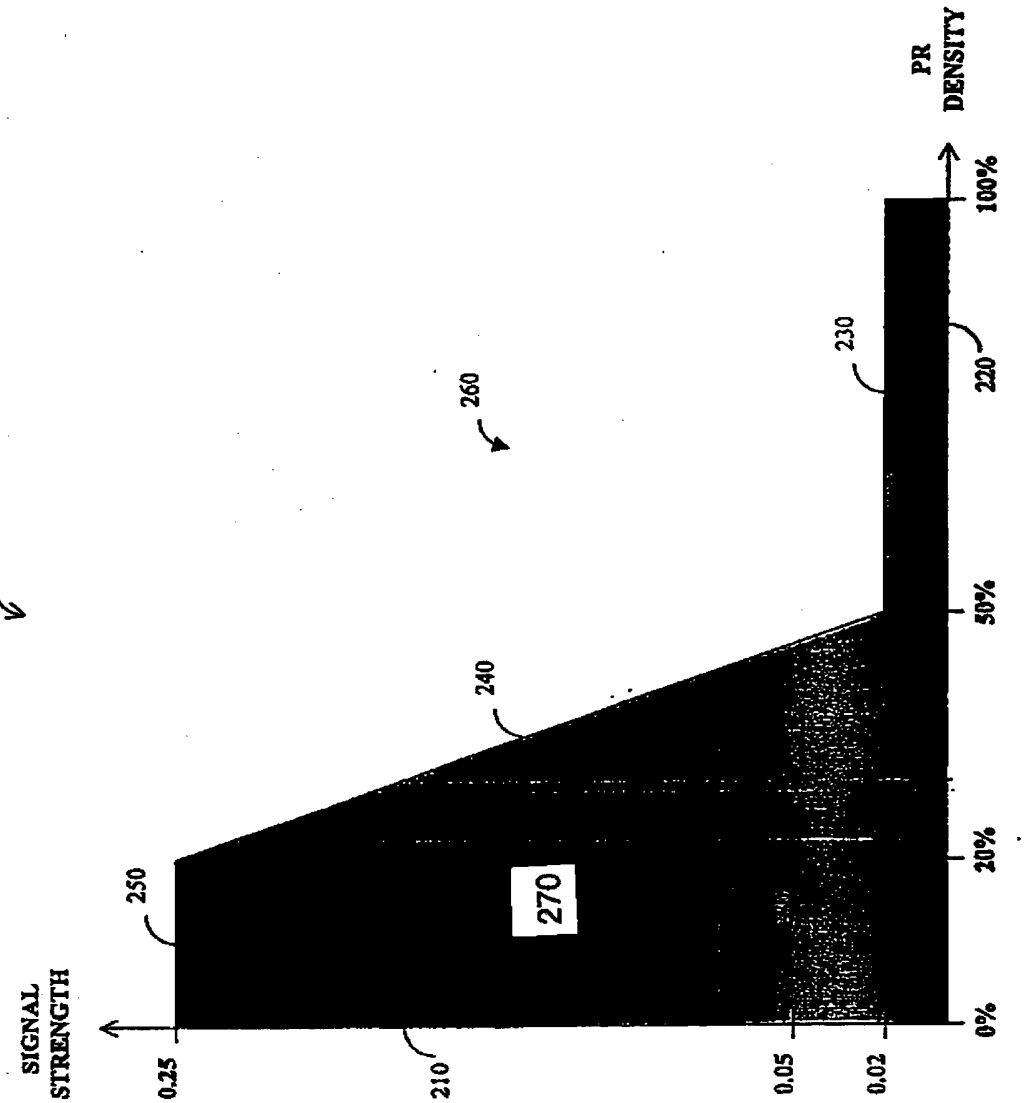
200
260
230
220
240
250
270
SIGNAL STRENGTH
PR DENSITY
0.25
210
0.05
0.02
0%
20%
50%
100%

FIG. 2A

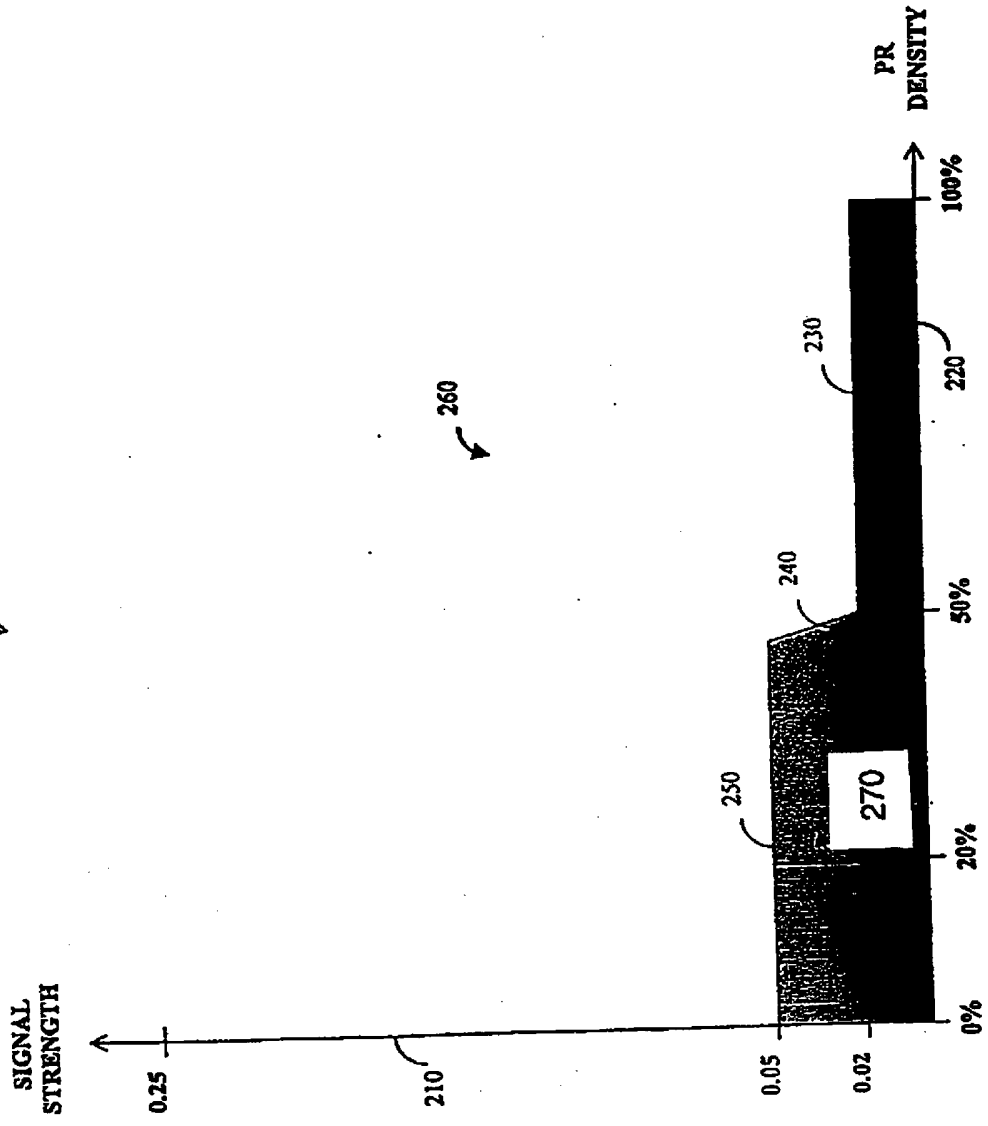
200
260
SIGNAL STRENGTH
0.25
210
0.05
0.02
250
270
240
230
220
PR DENSITY
0%
20%
50%
100%

FIG. 2B

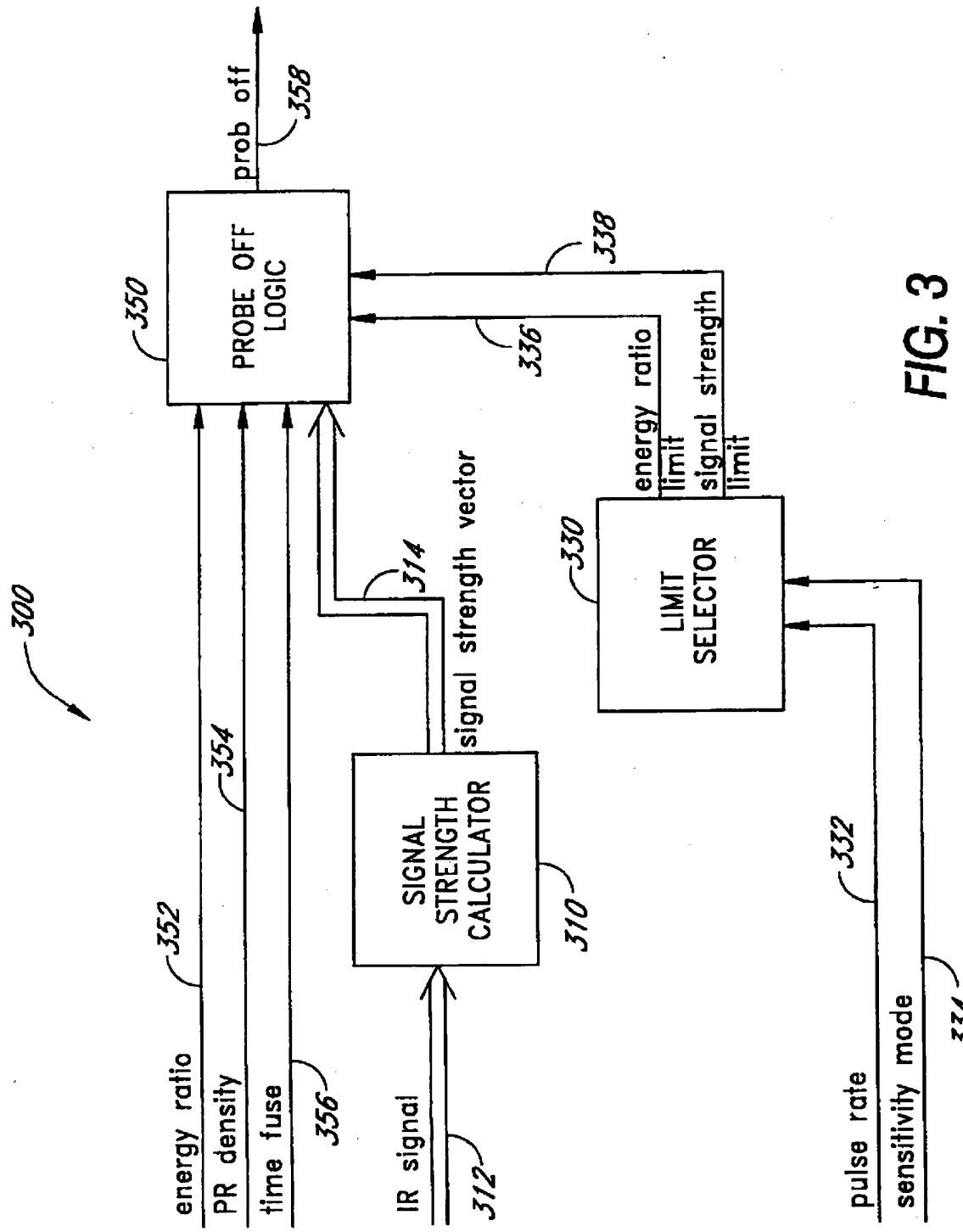
300
PROBE OFF LOGIC
350
prob off
358
338
336
energy ratio limit
signal strength limit
LIMIT SELECTOR
330
signal strength vector
314
SIGNAL STRENGTH CALCULATOR
310
energy ratio
PR density
time fuse
IR signal
352
354
356
312
pulse rate
sensitivity mode
332
334

FIG. 3

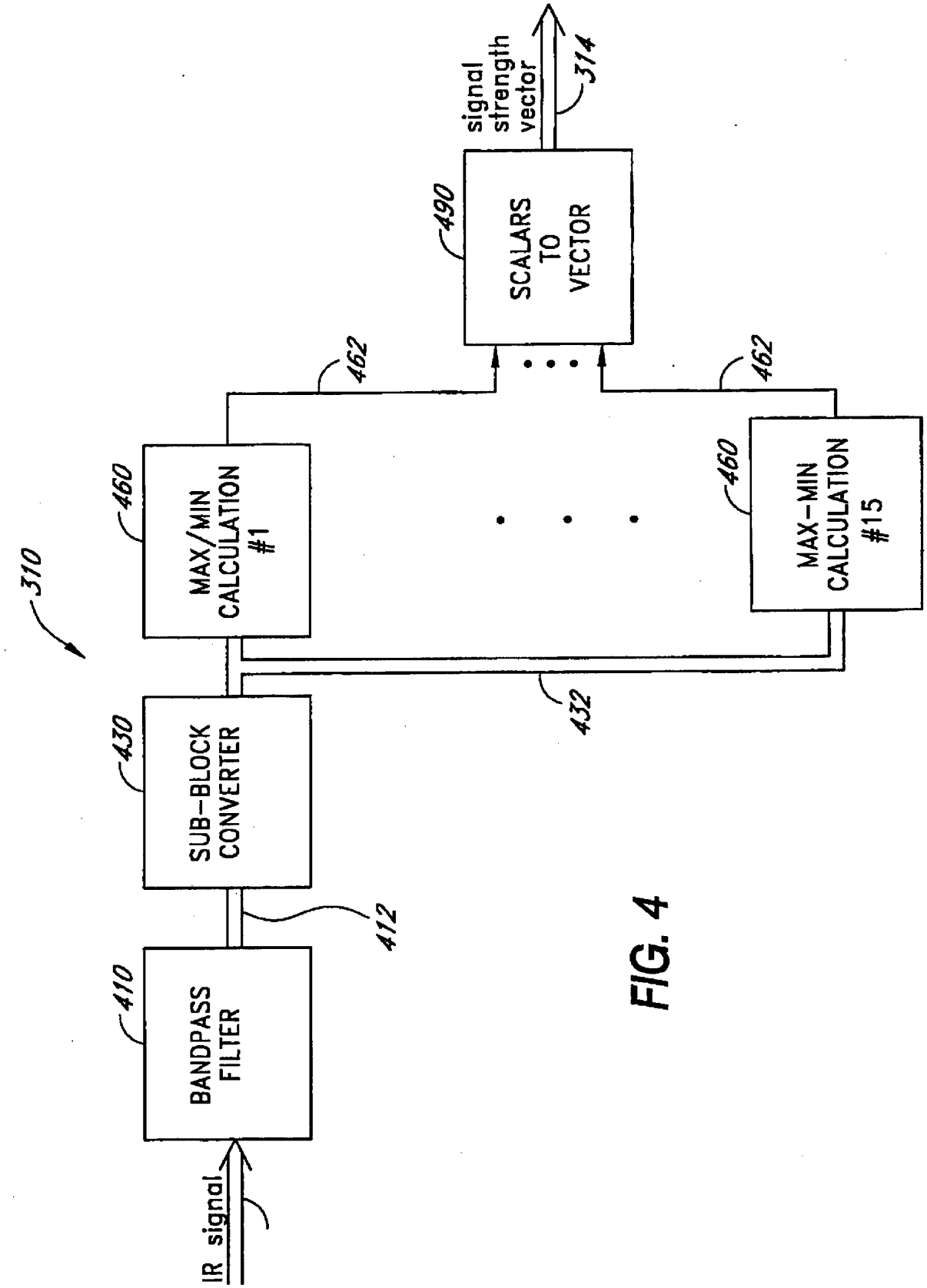
IR signal
BANDPASS FILTER
410
412
SUB-BLOCK CONVERTER
430
MAX/MIN CALCULATION #1
460
MAX-MIN CALCULATION #15
460
462
462
SCALARS TO VECTOR
490
signal strength vector
314
310
432

FIG. 4

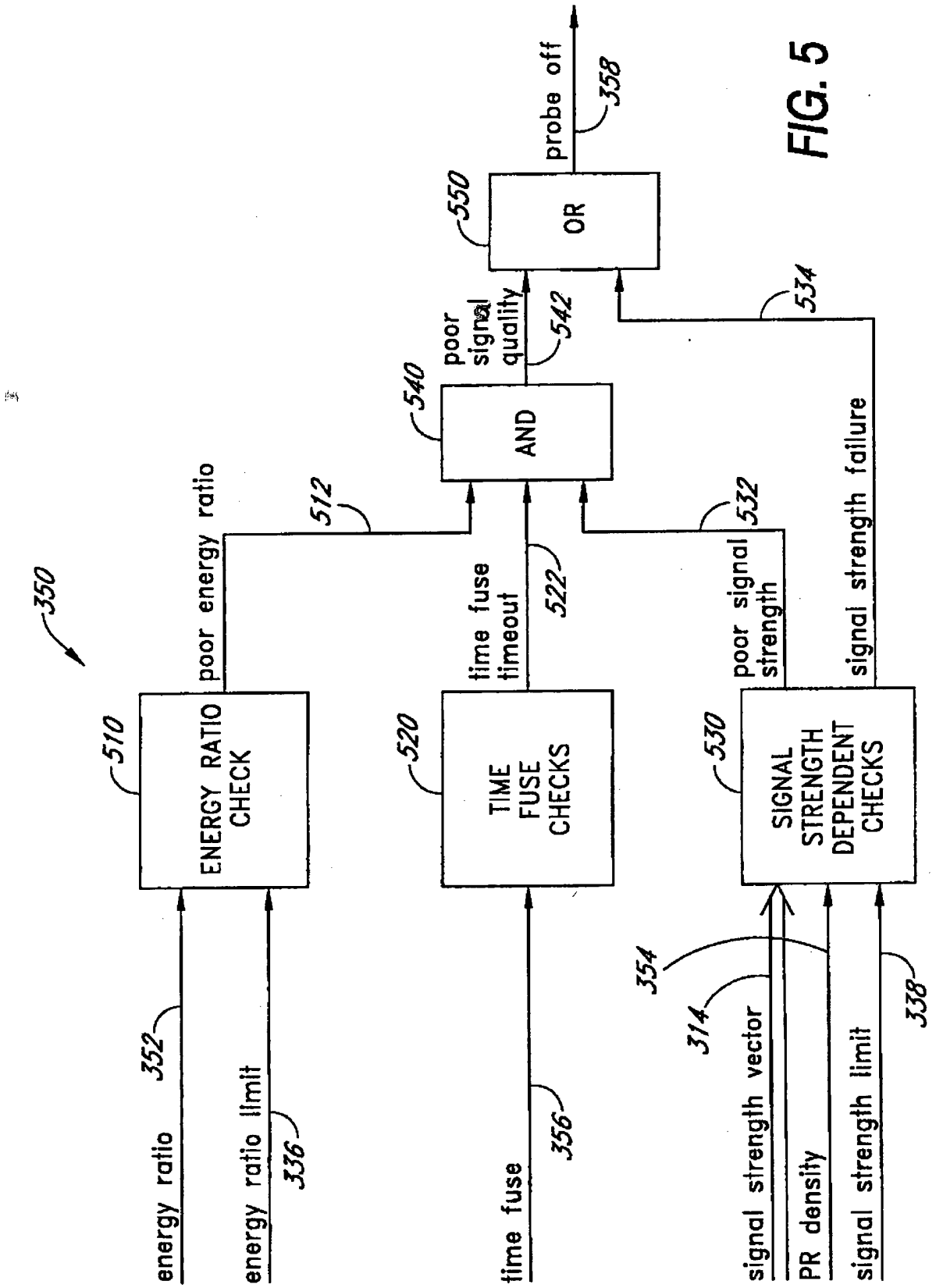
350
510
ENERGY RATIO CHECK
520
TIME FUSE CHECKS
530
SIGNAL STRENGTH DEPENDENT CHECKS
540
AND
550
OR
352
energy ratio
336
energy ratio limit
356
time fuse
354
314
signal strength vector
PR density
338
signal strength limit
512
poor energy ratio
522
time fuse timeout
532
poor signal strength
542
poor signal quality
534
signal strength failure
358
probe off

FIG. 5

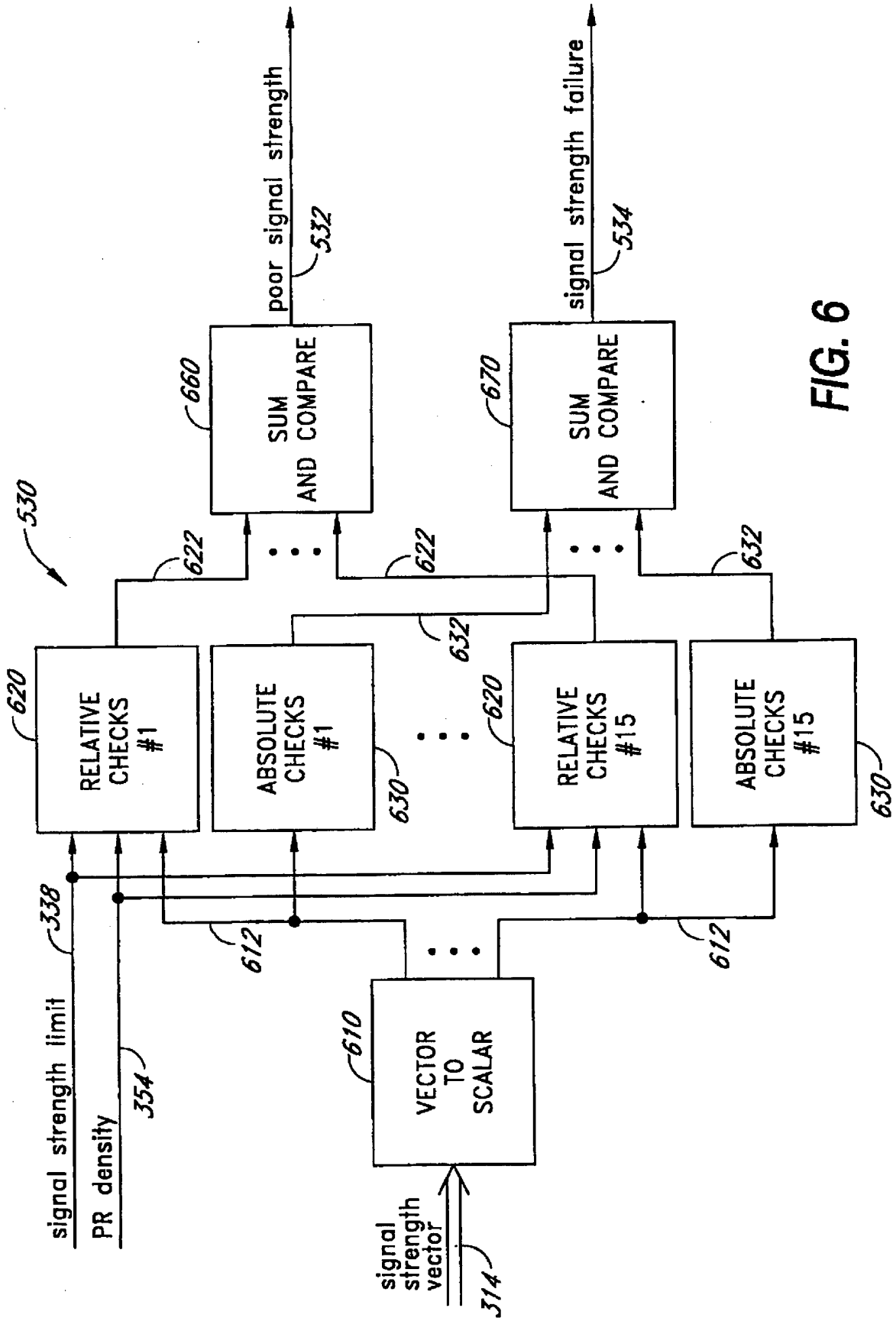
poor signal strength
532
signal strength failure
534
660
SUM AND COMPARE
670
SUM AND COMPARE
530
622
622
632
632
620
RELATIVE CHECKS #1
ABSOLUTE CHECKS #1
630
620
RELATIVE CHECKS #15
ABSOLUTE CHECKS #15
630
338
612
612
signal strength limit
PR density
354
610
VECTOR TO SCALAR
signal strength vector
314

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5632272 A **[0002]**
- US 5846190 A **[0003]**
- US 11412798 P **[0013]**
- US 47151099 A **[0013]**
- US 6002952 A **[0016]**

专利名称(译)	改进的脉搏血氧仪探测器		
公开(公告)号	EP2298159B1	公开(公告)日	2015-10-21
申请号	EP2010181436	申请日	2000-03-24
[标]申请(专利权)人(译)	梅西莫股份有限公司		
申请(专利权)人(译)	Masimo公司		
当前申请(专利权)人(译)	Masimo公司		
[标]发明人	DIAB MOHAMED K ALI AMMAR AL		
发明人	DIAB, MOHAMED K. ALI, AMMAR AL		
IPC分类号	A61B5/00 A61B5/1455 G01N21/35 A61B5/145		
CPC分类号	A61B5/7221 A61B5/14551 A61B5/6843 A61B2560/0276		
优先权	60/126148 1999-03-25 US		
其他公开文献	EP2298159A1		
外部链接	Espacenet		

摘要(译)

基于规则的智能处理器（300）为脉冲血氧计的信号强度操作区域提供基于信号质量的限制。这些限制叠加在典型的增益相关信号强度限制上（314）。如果生理学上产生传感器信号，则允许脉搏血氧仪以最小信号强度操作，从而最大化低灌注性能。如果传感器信号可能是由移位的传感器引起的信号引起的，则会提高信号强度要求。因此，信号质量限制增强了探针关闭检测，而不会显着影响低灌注性能。使用的一种信号质量测量是脉冲速率密度（354），其定义了生理学上可接受的脉冲发生的时间百分比。如果检测到的信号包含很大一部分不可接受的脉冲，则所需的最小信号强度成比例地增加。与脉率密度结合使用的另一种信号质量测量是能量比（352），计算为脉冲率基波和相关谐波中包含的总能量的百分比。