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(71) Applicant (*for all designated States except US*): **NELLCOR PURITAN BENNETT INCORPORATED** [US/US]; 4280 Hacienda Drive, Pleasanton, California 94588 (US).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **PETERSEN, Ethan** [US/US]; 18968 Thornbury Avenue, Castro Valley, California 94546 (US). **CHEW, Bradford, B.** [US/US]; 805 Springbrook Drive, San Ramon, California 94583 (US). **SHEA, William** [US/US]; 4049 Findlay Way, Livermore, California 94550 (US).

(74) Agent: **SLAYDEN, II, Bruce, W.**; Baker Botts L.L.P., 1500 San Jacinto Center, 98 San Jacinto Blvd., Austin, TX 78701-4039 (US).

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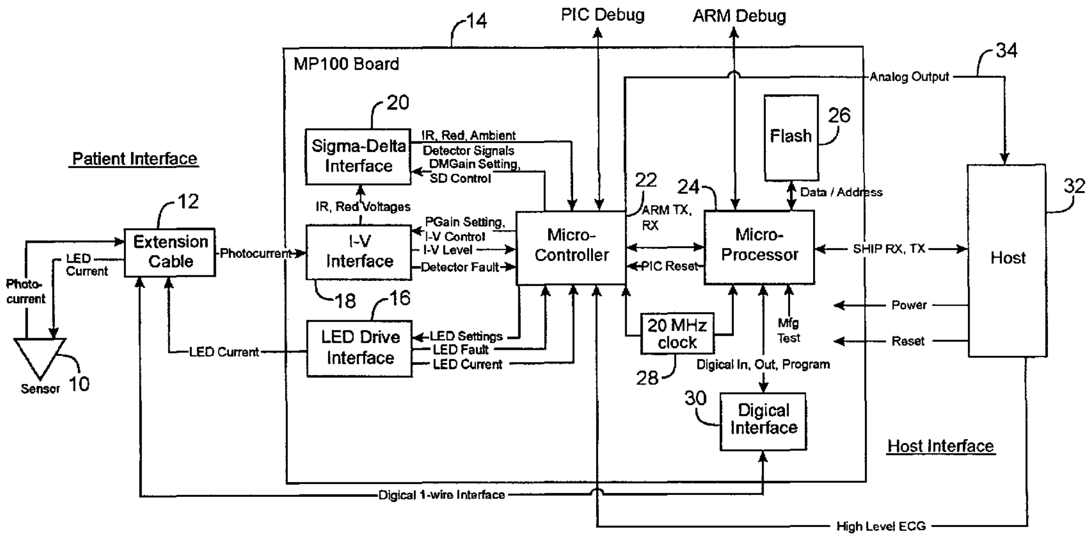
[Continued on next page]

(54) **Title:** OXIMETER CROSS-TALK REDUCTION



(57) **Abstract:** A method and apparatus for reducing cross-talk in an oximeter. The oximeter includes a band pass filter. The amount of cross-talk through the band pass filter is estimated. Based on this estimate, the corner frequencies of the band pass filter are adjusted when it is designed to minimize the cross-talk. In one embodiment, a calibration mode is performed when a sensor is attached to the oximeter. In the calibration mode, the signals are measured with first only the red LED on and then with only the IR LED on. Any signal measured in the off channel is assumed to be a result of cross-talk from the other channel. The magnitude of the cross-talk is determined as a percentage, and subsequently the percentage is multiplied by the actual signal and subtracted from the other LED signal as cross-talk compensation.

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OXIMETER CROSS-TALK REDUCTION

BACKGROUND OF THE INVENTION

[0001] The present invention relates to oximeters, and in particular to methods for reducing cross-talk between red and IR signals in pulse oximeters.

[0002] Pulse oximetry is typically used to measure various blood chemistry characteristics including, but not limited to, the blood-oxygen saturation of hemoglobin in arterial blood, the volume of individual blood pulsations supplying the tissue, and the rate of blood pulsations corresponding to each heartbeat of a patient. Measurement of these characteristics has been accomplished by use of a non-invasive sensor which scatters light through a portion of the patient's tissue where blood perfuses the tissue, and photoelectrically senses the absorption of light at various wavelengths in such tissue. The amount of light absorbed is then used to calculate the amount of blood constituent being measured.

[0003] The light scattered through the tissue is selected to be of one or more wavelengths that are absorbed by the blood in an amount representative of the amount of the blood constituent present in the blood. The amount of transmitted light scattered through the tissue will vary in accordance with the changing amount of blood constituent in the tissue and the related light absorption. For measuring blood oxygen level, such sensors have typically been provided with a light source that is adapted to generate light of at least two different wavelengths, and with photodetectors sensitive to both of those wavelengths, in accordance with known techniques for measuring blood oxygen saturation.

[0004] Known non-invasive sensors include devices that are secured to a portion of the body, such as a finger, an ear or the scalp. In animals and humans, the tissue of these body portions is perfused with blood and the tissue surface is readily accessible to the sensor.

[0005] A typical pulse oximeter will alternately illuminate the patient with red and infrared light to obtain two different detector signals. One of the issues with each signal, for the red and infrared (IR), is cross-talk. For example, the red signal, after filtering, will still be tailing off when the IR LED is turned on, and vice-versa. Typically pulse oximeter circuits include such filters to filter out noise before demodulating, such as the 50 or 60Hz ambient light from fluorescent or other lights, or electrical interference. Such filtering can result in crosstalk when the filtering spreads out the red and IR pulses so they overlap.

[0006] One approach for dealing with cross-talk in the form of phase distortion, as opposed to the amplitude distortion the present invention addresses, is shown in US Patent No. 5,995,858. This patent shows an approach where the same signal drives the red and IR at opposite phases, giving a phase offset problem. This patent deals with a phase error in the response of the band pass filter of a reference signal causing cross-talk of red into IR and vice versa. In order to minimize or compensate for this phase error, the oximeter is operated with only the IR LED active, and then only with the red LED active. From this, a correction constant is determined that is used in the equation for determining oxygen saturation.

BRIEF SUMMARY OF THE INVENTION

[0007] The present invention provides a method and apparatus for reducing cross-talk in an oximeter. The oximeter includes a band pass filter. The amount of cross-talk through the band pass filter is estimated. Based on this estimate, the corner frequencies of the band pass filter are adjusted to minimize the cross-talk.

[0008] In one embodiment, the band pass filter is a hardware filter, and the corner frequencies are adjusted in the design and selection of the appropriate resistors and capacitors. In another embodiment, the band pass filter is in hardware, and the frequencies can be adjusted during operation or calibration.

[0009] In another embodiment, the present invention also includes a calibration mode which is performed when a sensor is attached to the oximeter. In the calibration mode, the signals are measured with first only the red LED on and then with only the IR LED on. Any signal measured in the off channel is assumed to be a result of cross-talk from the other channel. The effect is linear, enabling it to be compensated for in software. The magnitude of the cross-talk is determined as a percentage, and subsequently the percentage is multiplied by the actual signal and subtracted from the other LED signal as cross-talk compensation.

[0010] For a further understanding of the nature and advantages of the invention, reference should be made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Fig. 1 is a block diagram of an oximeter incorporating the present invention.

[0012] Fig. 2 is a block diagram of a portion of the circuit of Fig. 1 illustrating the placement of a filter according to the present invention.

[0013] Fig. 3 is a circuit diagram of a band pass filter according to an embodiment of the invention.

[0014] Fig. 4 is a timing diagram illustrating the low and high pass filtering effects on the red and IR signals according to an embodiment of the invention.

[0015] Fig. 5 is a circuit diagram illustrating an embodiment of a LED drive circuit including the circuit connections for the calibration mode according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Overall System

[0016] Fig. 1 illustrates an embodiment of an oximetry system incorporating the present invention. A sensor 10 includes red and infrared LEDs and a photodetector. These are connected by a cable 12 to a board 14. LED drive current is provided by an LED drive interface 16. The received photocurrent from the sensor is provided to an I-V interface 18. The IR and red voltages are then provided to a sigma-delta interface 20 incorporating the present invention. The output of sigma-delta interface 20 is provided to a microcontroller 22. Microcontroller 22 includes flash memory for a program, and SRAM memory for data. The processor also includes a microprocessor chip 24 connected to a flash memory 26. Finally, a clock 28 is used and an interface 30 to a digital calibration in the sensor 10 is provided. A separate host 32 receives the processed information, as well as receiving an analog signal on a line 34 for providing an analog display.

Bandpass Filter

[0017] Fig. 2 is a block diagram illustrating the location of the filter according to an embodiment of the invention. Shown is a sensor 10 that is driven by an LED drive circuit 16. The LED drive circuit 16 alternately drives an IR LED 40 and a red LED 42. A photodetector 44 provides a signal to a current-to-voltage (I-V converter 46). The voltage signal is provided to high pass and anti-aliasing filter 48. This block includes the band pass filter according to an embodiment of the invention. The output signal is then provided to a sigma-delta modulator 50. The output of sigma-delta modulator 50 is provided to a demodulator 52, which is then provided to filtering and decimating blocks 54 and 56.

[0018] Fig. 3 illustrates a band pass filter 60 according to an embodiment of the invention. The filter includes an amplifier 62 and a resistor and capacitor circuit comprising capacitors C2, C110, C111, and C40 and resistors R7, R111, R112, R110, and R109. An input to this circuit is provided from I-V converter 46 along a line 64 to a first switch 66 for an offset correction not relevant to the present invention. The signal is then provided to a second switch 68, which is used for a calibration mode according to the present invention. A cross-talk control signal 70 couples the switch to an LED current sense line 72 for calibration mode.

Design of Bandpass Filter

[0019] In the design and manufacture of the band pass filter of Fig. 3, the corner frequencies are adjusted by varying the capacitor and resistor values to offset and minimize the cross-talk effect. The corner frequencies are the high pass and low pass ends of the band pass filter, which is in place to filter out ambient interferences.

[0020] There is a major trade off involved in the design of the band pass filter. It is desirable to have the filter corners as close to the modulation frequency as possible. Raising the frequency of the high pass corner makes the filter better able to reject any AC portion of ambient light. Typically in the US, fluorescent lights have strong AC component at 120Hz and the harmonics of 120Hz. It is desirable to filter this out of the signal. Lowering the cut off frequency of the low pass filter limits the high frequency noise from the I-V converter, and provides some anti-aliasing to keep ambient noise out of the system.

[0021] However, any filtering spreads out the signal in the time domain, for example some of the IR pulse will leak into the dark pulse following it. This has two drawbacks. The first is cross-talk where the IR signal "leaks" into the red signal, and vice versa. The second is an offset resulting from a transient that occurs due to capacitances in the patient cable between the LED wires and the detector wires. When this transient is filtered, part of it leaks into the sampled part of the signal causing an offset. Both of these effects get worse as the corners of the filters are pulled closer to the modulation frequency.

[0022] Tuning the band pass filter to optimize for cross-talk is done when it is designed by adjusting the high pass filter corner and the low pass corner to force the cross-talk to be zero. The size of the Red pulse is measured by comparing the sample P5 (see Fig. 4) to the samples taken in the dark states P4 and P6.

$$\mathrm{Re}d = P5 - \frac{P4 + P6}{2}$$

[0023] Since the signal from the IR pulse is still decaying in the Dark2 time period, the P4 sample will be higher due to the low pass response and the lower due to the high pass response. The effect of the IR pulse on P4 will affect the size of the measured red signal. This is a cause of cross-talk where the IR signal leaks into the Red signal and vice versa.

[0024] This effect is minimized if the filter is a band pass, with both high pass and low pass effects. The effect of the high pass filtering compensates for the effect of the low pass filtering.

[0025] Thus, the corners are adjusted so that the high pass and low pass signals shown in Fig. 5 are adjusted so that the effect of the high pass filtering compensates for the effect of the low pass filtering to minimize cross-talk. The low pass filter causes a positive cross-talk, and the high pass filter causes an offsetting negative cross-talk.

[0026] In one embodiment, the band pass filter consists of an RC high pass followed by a Salen-Key low pass configured as a second order Butterworth filter. The impedance of the RC high pass section will have an effect on the transfer function of the Salen-Key circuit, however this effect is negligible if capacitance C2 is much larger than C110 and C111. The high pass filter cut off frequency is 32 Hz., and the low pass filter cut off frequency is 12.7 kHz.

Calibration

[0027] In addition to designing the hardware of the band pass filter to reduce cross-talk, a calibration mode allows a further correction for cross-talk using a cross-talk calibration test. A subtle cross-talk effect arises from the filtering in the circuit causing light and dark pulses to spread out into each other in the time domain. Fortunately the effects from the band pass filter are linear and measurable, and so can be compensated for in software. Since this is the result of the filtering, the magnitude of the effect is known ahead of time. A constant is used to subtract the effects of the IR signal from the Red signal and vice versa:

Red' - Red - IR * Kcross

IR' = IR - Red * Kcross

[0028] Fig. 5 is a circuit diagram of an embodiment of LED drive circuit 16 of Fig. 2. Included in the circuit are a connection to the red LED on a line 80, and a connection to the IR LED on a line 82. These are provided through MOSFET transistors 84 and 86 to a 1 ohm resistor 88. In the calibration mode, the LED current sense signal on line 72 is taken from the current through this 1 ohm resistor with line 72 of Fig. 5 connected to line 72 of Fig. 3 as an input through switch 68 to the band pass filter.

[0029] In addition to designing the hardware of the band pass filter to reduce cross-talk, the connection of line 72 in Fig. 5 during a calibration mode allows a further correction for cross-talk using a cross-talk calibration test.

[0030] While doing the cross-talk test, most of the analog circuits on the board are used and so this is a good test to check the integrity of the analog hardware. This test connects the 1Ω current sense resistor 88 to the input to the band pass filter. This way a fixed LED current can inject a signal into the signal acquisition circuits. This allows the operation of the LED drive 16, the band pass filter 60 and the sigma-delta modulator 50 to be verified. In addition, measuring the LED current using the 1Ω resistor allows the LED's current sense circuit to be calibrated more accurately than the 10% tolerance capacitors in the circuit would ordinarily allow.

[0031] Thus, during the calibration mode, current is shunted into the current sense input from the LED drive current. The only analog circuitry not being used is the photodetector and the I-V converter. In a preferred embodiment, whenever a sensor is connected, this is detected and the software automatically does the cross-talk calibration test.

[0032] A 50% drive signal is applied to the LEDs during the calibration circuit to give a sufficiently large signal without going to full range and risking too high of a signal being provided. Alternately, other percentages of the drive current could be used.

[0033] The following steps are performed:

1) Set IR LED to 50%, Red LED to 0; then measure the 0 red signal;

2) Set Red LED to 50%, IR LED to 0; then measure the) IR signal.

[0034] Subsequently, during actual operation, the red cross-talk effect is determined by multiplying the percentage cross-talk times the red signal, and then it is subtracted from the IR signal. The corresponding action is done for the red signal.

[0035] As will be understood by those of skill in the art, the present invention could be embodied in other specific forms without departing from the essential characteristic thereof. For example, the drive current could be obtained in a different manner and a different design could be used for the band pass filter. Alternately, the band pass filter could be used alone, without the software calibration added. Accordingly, the foregoing description is intended to be illustrative, but not limiting, on the scope of the invention which is set forth in the following claims.

WHAT IS CLAIMED IS:

1. A method for reducing cross-talk in an oximeter, comprising:

providing a signal corresponding to an oximeter sensor signal;

applying said signal to a band pass filter;

estimating an amount of cross-talk of a signal through said band pass filter; and

adjusting the corner frequencies of said band pass filter to minimize said cross-talk.

2. The method of claim 1 wherein said band pass filter is a hardware filter.

3. The method of claim 2 wherein said hardware band pass filter is coupled to the output of a current to voltage converter in said oximeter.

4. The method of claim 2 further comprising:

measuring an amount of remaining cross-talk through said hardware band pass filter after said adjusting; and

minimizing said remaining cross-talk by compensation in software of a digitized signal from said hardware band pass filter.

5. The method of claim 2 wherein said measuring comprises:

measuring a current from a red LED with no current provided to an IR LED; and

measuring a current from said IR LED with no current provided to said red LED.

6. The method of claim 5 further comprising:

in a calibration mode, measuring an IR cross-talk signal obtained during an IR LED period, said signal corresponding to cross-talk from a signal from said red LED;

comparing said IR cross-talk signal to said current from said IR LED to determine an IR cross-talk percentage;

measuring a red cross-talk signal obtained during an red LED period, said signal corresponding to cross-talk from a signal from said IR LED;

comparing said red cross-talk signal to said current from said red LED to determine a red cross-talk percentage;

during normal operation of said oximeter, multiplying said IR cross-talk percentage in software by a detected IR signal to give an IR cross-talk signal, and subtracting said IR cross-talk signal from a detected red signal; and

during normal operation of said oximeter, multiplying said red cross-talk percentage in software by a detected red signal to give a red cross-talk signal, and subtracting said red cross-talk signal from said detected IR signal.

7. A method for compensating for cross-talk in an oximeter, comprising:

providing a signal corresponding to an oximeter sensor signal;

applying said signal to a hardware band pass filter, wherein said hardware band pass filter is coupled to the output of a current to voltage converter in said oximeter;

estimating an amount of cross-talk of a signal through said band pass filter;

adjusting the corner frequencies of said band pass filter to minimize said cross-talk;

in a calibration mode, measuring an IR cross-talk signal obtained during an IR LED period, said signal corresponding to cross-talk from a signal from said red LED;

comparing said IR cross-talk signal to said current from said IR LED to determine an IR cross-talk percentage;

measuring a red cross-talk signal obtained during an red LED period, said signal corresponding to cross-talk from a signal from said IR LED;

comparing said red cross-talk signal to said current from said red LED to determine a red cross-talk percentage;

during normal operation of said oximeter, multiplying said IR cross-talk percentage in software by a detected IR signal to give an IR cross-talk signal, and subtracting said IR cross-talk signal from a detected red signal; and

during normal operation of said oximeter, multiplying said red cross-talk percentage in software by a detected red signal to give a red cross-talk signal, and subtracting said red cross-talk signal from said detected IR signal.

8. An oximeter with reduced cross-talk comprising:

an oximeter sensor input;

a current to voltage converted coupled to said oximeter sensor input;

a band pass filter coupled to said current to voltage converter, said band pass filter having corner frequencies adjusted to minimize cross-talk;

an analog-to-digital converter coupled to said band pass filter for converting a detected signal into a digitized detector signal; and

a processor coupled to said analog-to-digital converter for manipulating a said digitized detector signal and calculating oxygen saturation.

9. The oximeter of claim 8 further comprising:

a test circuit for providing a test signal to said band pass filter;

a memory storing a program for operating said test circuit to estimate an amount of remaining cross-talk and determining red and IR cross-talk compensation factors to be used in software during normal operation of said oximeter.

10. The oximeter of claim 9 wherein said test circuit comprises:

a resistor;

a switching circuit for alternately coupling said resistor to red and IR LEDs; and

a switch for coupling said resistor to said band pass filter.

11. The oximeter of claim 9 wherein said program includes computer readable code for:

in a calibration mode, measuring an IR cross-talk signal obtained during an IR LED period, said signal corresponding to cross-talk from a signal from said red LED;

comparing said IR cross-talk signal to said current from said IR LED to determine an IR cross-talk percentage;

measuring a red cross-talk signal obtained during an red LED period, said signal corresponding to cross-talk from a signal from said IR LED;

comparing said red cross-talk signal to said current from said red LED to determine a red cross-talk percentage;

during normal operation of said oximeter, multiplying said IR cross-talk percentage in software by a detected IR signal to give an IR cross-talk signal, and subtracting said IR cross-talk signal from a detected red signal; and

during normal operation of said oximeter, multiplying said red cross-talk percentage in software by a detected red signal to give a red cross-talk signal, and subtracting said red cross-talk signal from said detected IR signal.

12. An oximeter with reduced cross-talk comprising:

an oximeter sensor input;

a current to voltage converted coupled to said oximeter sensor input;

a band pass filter coupled to said current to voltage converter, said band pass filter having corner frequencies adjusted to minimize cross-talk;

an analog-to-digital converter coupled to said band pass filter for converting a detected signal into a digitized detector signal;

a processor coupled to said analog-to-digital converter for manipulating a said digitized detector signal and calculating oxygen saturation.

a test circuit for providing a test signal to said band pass filter;

a memory storing a program for operating said test circuit to estimate an amount of remaining cross-talk and determining red and IR cross-talk compensation factors to be used in software during normal operation of said oximeter;

wherein said program includes computer readable code for:

in a calibration mode, measuring an IR cross-talk signal obtained during an IR LED period, said signal corresponding to cross-talk from a red LED signal;

comparing said IR cross-talk signal to said current from an IR LED to determine an IR cross-talk percentage;

measuring a red cross-talk signal obtained during an red LED period, said signal corresponding to cross-talk from an IR LED signal;

comparing said red cross-talk signal to said current from a red LED to determine a red cross-talk percentage;

during normal operation of said oximeter, multiplying said IR cross-talk percentage in software by a detected IR signal to give an IR cross-talk signal, and subtracting said IR cross-talk signal from a detected red signal; and

during normal operation of said oximeter, multiplying said red cross-talk percentage in software by a detected red signal to give a red cross-talk signal, and subtracting said red cross-talk signal from said detected IR signal.

13. A method for compensating for cross-talk in an oximeter using a calibration mode, comprising:

providing detector signals corresponding to first and second light emitter wavelengths;

measuring a first cross-talk signal obtained during an first period corresponding to said first light emitter wavelength, said first cross-talk signal corresponding to cross-talk from a signal from said second light emitter wavelength;

comparing said first cross-talk signal to a current from said detector corresponding to a signal of said first wavelength to determine a first cross-talk percentage;

measuring a second cross-talk signal obtained during a second period corresponding to said second light emitter wavelength, said second cross-talk signal corresponding to cross-talk from a signal from said first light emitter wavelength;

comparing said second cross-talk signal to said current from said detector corresponding to a signal of said first wavelength to determine a second cross-talk percentage;

during normal operation of said oximeter, multiplying said first cross-talk percentage in software by a detected first wavelength signal to give a first cross-talk signal, and subtracting said first cross-talk signal from a detected second wavelength signal; and

during normal operation of said oximeter, multiplying said second cross-talk percentage in software by a detected second wavelength signal to give a second cross-talk signal, and subtracting said second cross-talk signal from a detected first wavelength signal.

14. The method of claim 13 wherein said first wavelength is red and said second wavelength is IR.

15. An oximeter with reduced cross-talk comprising:

an oximeter sensor input for providing a detected signal;

an analog-to-digital converter for converting said detected signal into a digitized detector signal;

a processor coupled to said analog-to-digital converter for manipulating a said digitized detector signal and calculating oxygen saturation.

a test circuit for providing a test signal;

a memory storing a program for operating said test circuit to estimate an amount of remaining cross-talk and determining first and second cross-talk compensation factors to be used in software during normal operation of said oximeter;

wherein said program includes computer readable code for:

providing detector signals corresponding to first and second light emitter wavelengths;

measuring a first cross-talk signal obtained during an first period corresponding to said first light emitter wavelength, said first cross-talk signal corresponding to cross-talk from a signal from said second light emitter wavelength;

comparing said first cross-talk signal to a current from said sensor corresponding to a signal of said first wavelength to determine a first cross-talk percentage;

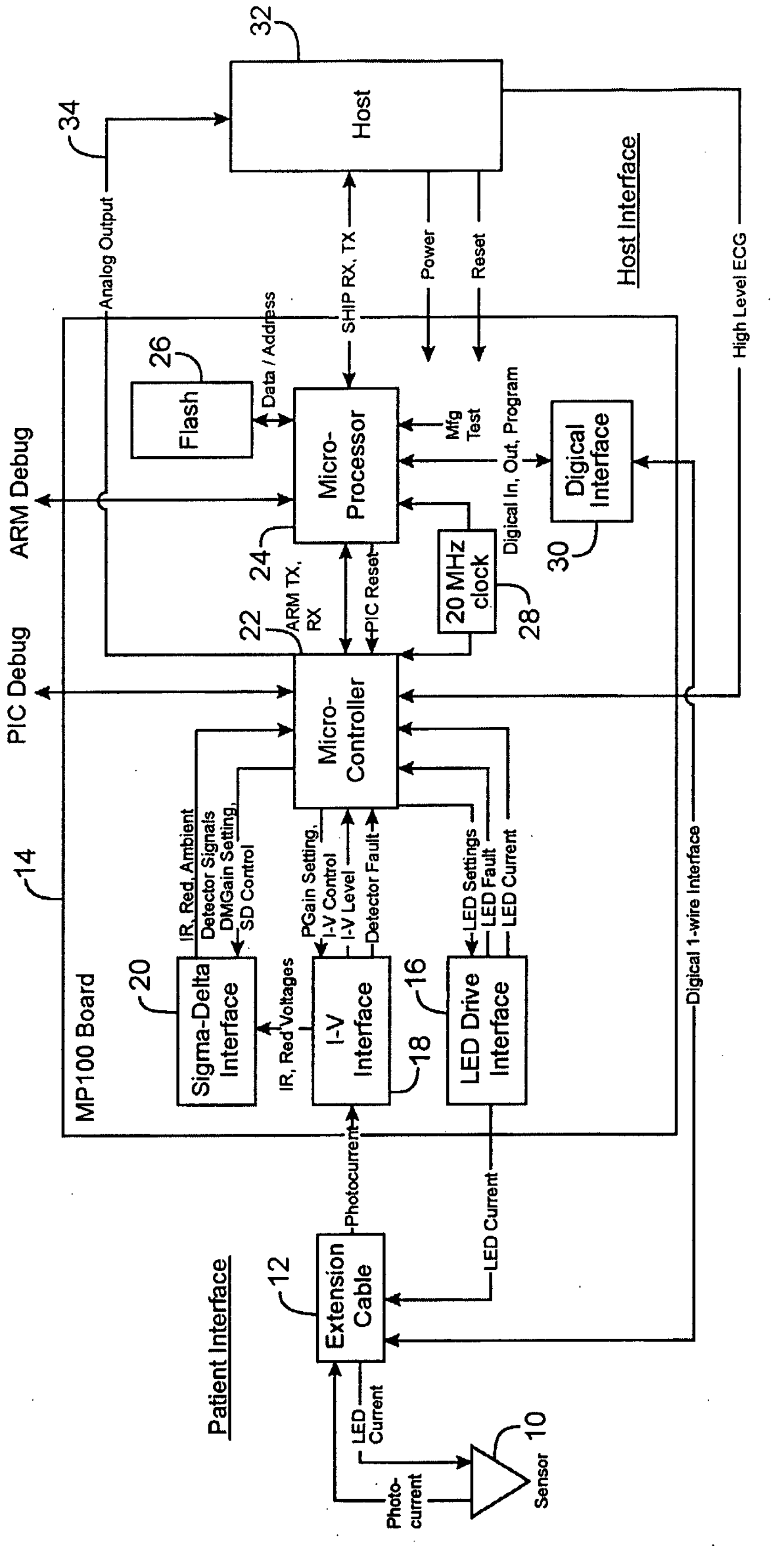
measuring a second cross-talk signal obtained during a second period corresponding to said second light emitter wavelength, said second cross-talk signal corresponding to cross-talk from a signal from said first light emitter wavelength;

comparing said second cross-talk signal to said current from said sensor corresponding to a signal of said first wavelength to determine a second cross-talk percentage;

during normal operation of said oximeter, multiplying said first cross-talk percentage in software by a detected first wavelength signal to give a first cross-talk signal, and subtracting said first cross-talk signal from a detected second wavelength signal; and

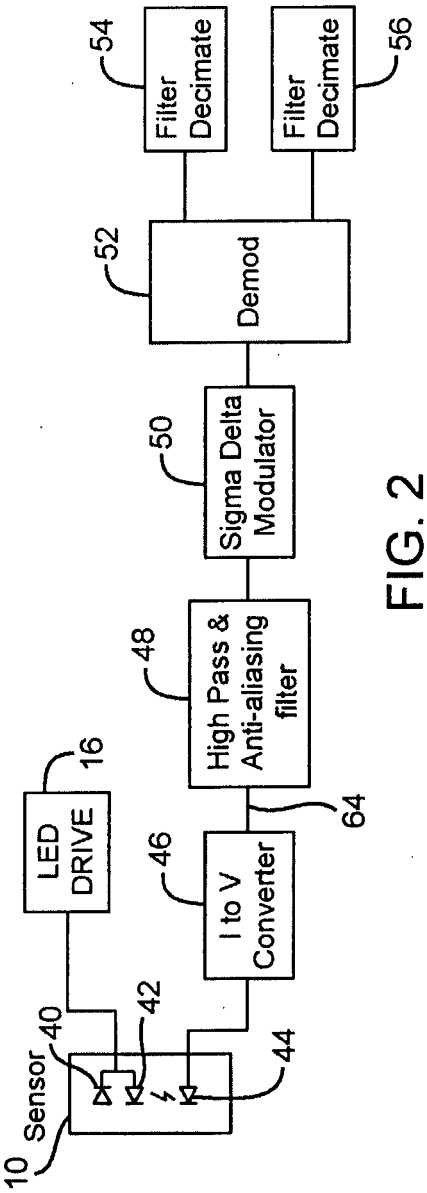
during normal operation of said oximeter, multiplying said second cross-talk percentage in software by a detected second wavelength signal to give a second cross-talk signal, and subtracting said second cross-talk signal from a detected first wavelength signal.

16. The oximeter of claim 15 wherein said first wavelength is red and said second wavelength is IR.



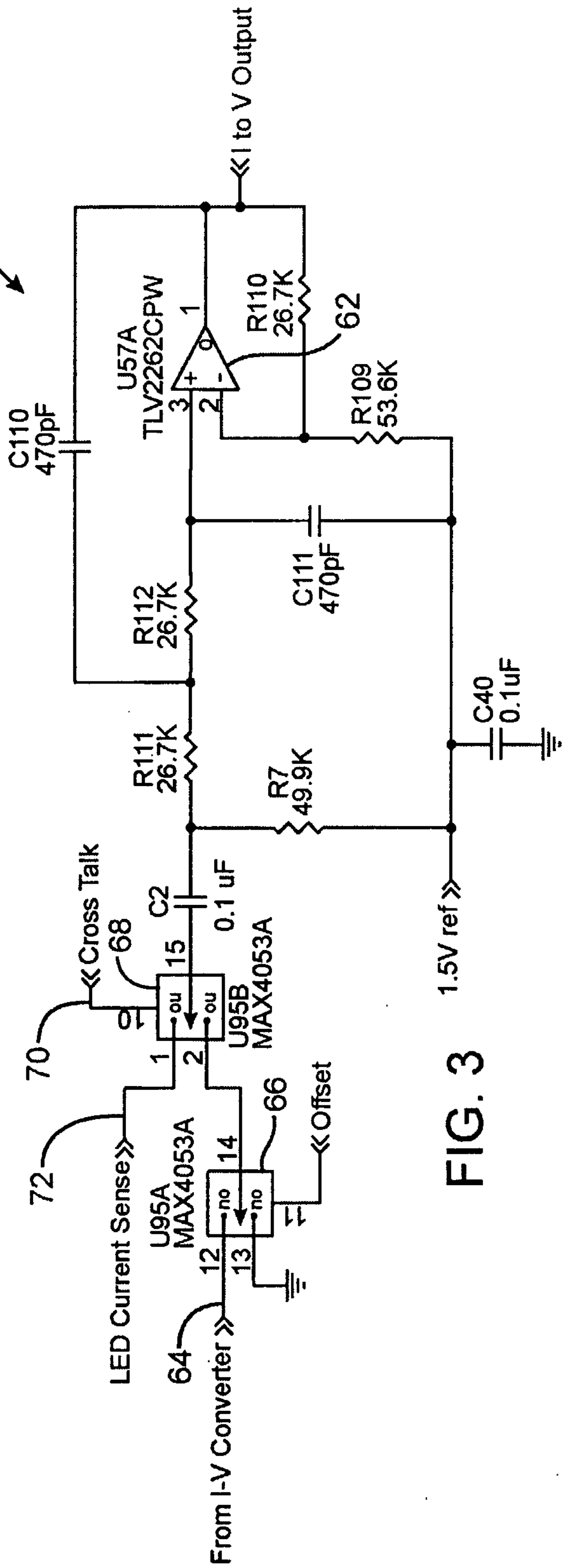
32
Host
34
Analog Output
SHIP RX, TX
Power
Reset
Host Interface
High Level ECG
ARM Debug
PIC Debug
26
Flash
Data / Address
Micro-Processor
Mfg Test
Digical In, Out, Program
Digical Interface
30
24
ARM TX, RX
PIC Reset
20 MHz clock
28
22
Micro-Controller
14
IR, Red, Ambient Detector Signals
DMGain Setting, SD Control
PGain Setting, I-V Control
I-V Level
Detector Fault
LED Settings
LED Fault
LED Current
20
Sigma-Delta Interface
IR, Red Voltages
I-V Interface
18
16
LED Drive Interface
MP100 Board
Digical 1-wire Interface
Photocurrent
LED Current
12
Extension Cable
Patient Interface
LED Current
Photo-current
Sensor
10

FIG. 1



LED DRIVE
16
Sensor
10
40
42
44
I to V Converter
46
64
High Pass & Anti-aliasing filter
48
Sigma Delta Modulator
50
Demod
52
Filter Decimate
54
Filter Decimate
56

FIG. 2



60
I to V Output
C110
470pF
U57A
TLV2262CPW
R110
26.7K
62
R109
53.6K
C111
470pF
R112
26.7K
R111
26.7K
R7
49.9K
C40
0.1uF
C2
0.1 uF
Cross Talk
68
70
U95B
MAX4053A
1.5V ref
LED Current Sense
72
U95A
MAX4053A
66
Offset
From I-V Converter
64

FIG. 3

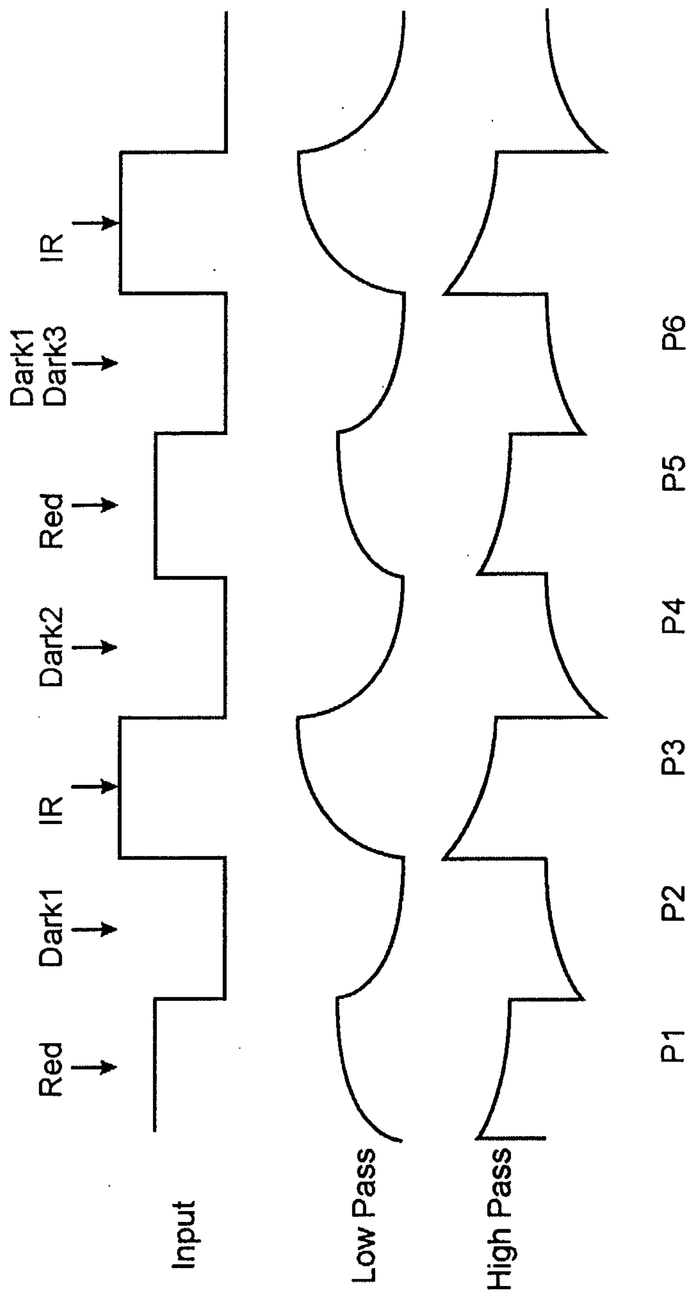

Red
Dark1
IR
Dark2
Red
Dark1
Dark3
IR
Input
Low Pass
High Pass
P1
P2
P3
P4
P5
P6

FIG. 4

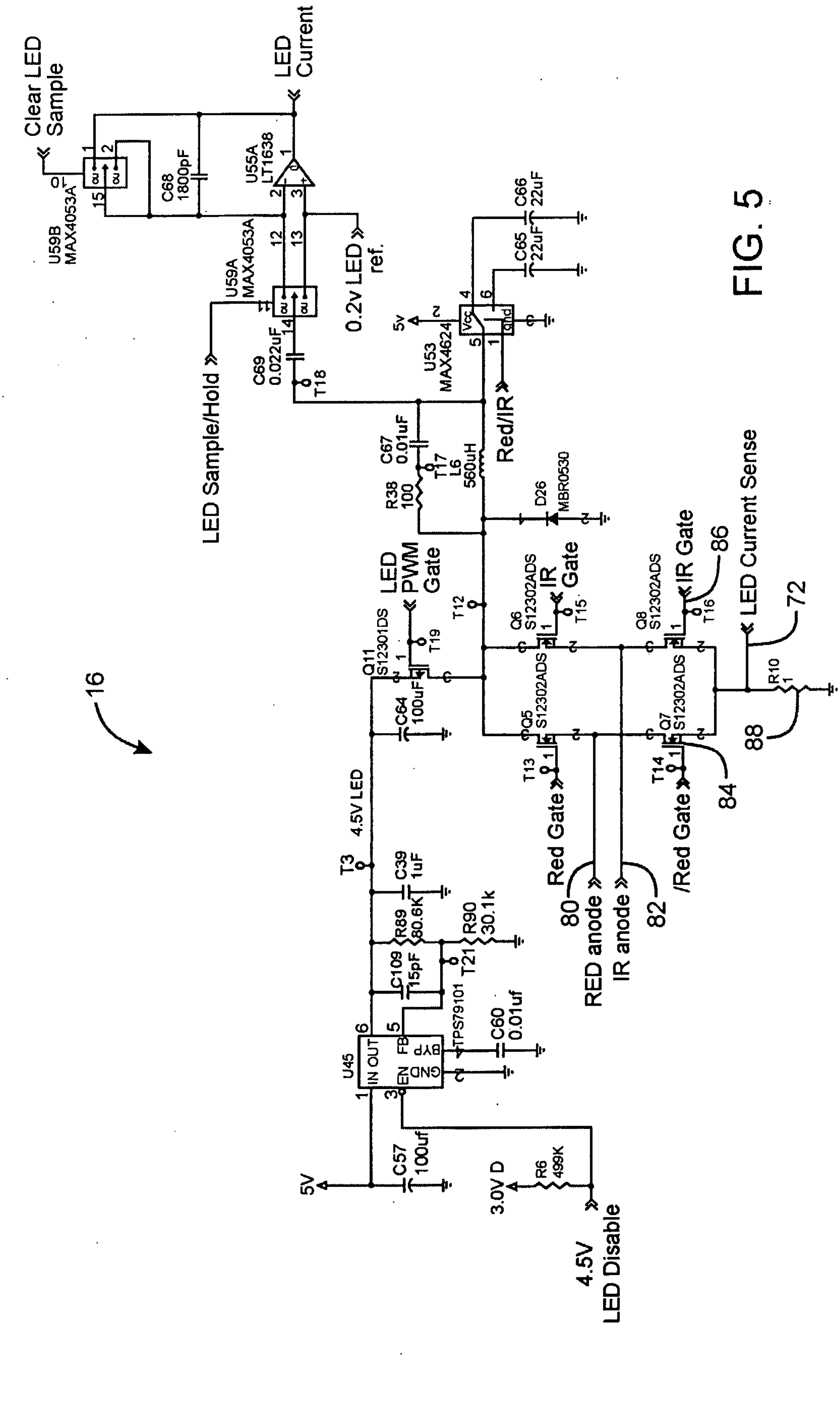

Clear LED Sample
LED Current
U59B MAX4053A
C68 1800pF
U55A LT1638
0.2v LED ref.
U59A MAX4053A
C69 0.022uF
T18
LED Sample/Hold
C66 22uF
C65 22uF
5v
U53 MAX4624
Vcc
gnd
Red/IR
C67 0.01uF
T17
L6 560uH
R38 100
D26 MBR0530
LED PWM Gate
T12
Q6 S12302ADS
IR Gate
T15
Q8 S12302ADS
IR Gate
86
T16
LED Current Sense
72
16
Q11 S12301DS
T19
C64 100uF
Q5 S12302ADS
Q7 S12302ADS
R10
88
T13
T14
84
4.5V LED
T3
C39 1uF
R89 80.6K
R90 30.1k
C109 15pF
T21
Red Gate
80
RED anode
IR anode
82
/Red Gate
U45
IN OUT
EN FB
GND BYP
TPS79101
C60 0.01uf
C57 100uf
5V
3.0V D
R6 499K
4.5V LED Disable

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/006316

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B5/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

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 practical, search terms used)

EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 995 858 A (KINAST ET AL) 30 November 1999 (1999-11-30) column 8, line 65 - column 9, line 1 column 12, line 2 - line 63 -----	1-16
X	US 2001/002206 A1 (DIAB MOHAMED K ET AL) 31 May 2001 (2001-05-31) paragraphs ‘0050!, ‘0094!, ‘0101!, ‘0102!, ‘0177!, ‘0197! -----	1-16
X	US 6 505 133 B1 (HANNA D. ALAN ET AL) 7 January 2003 (2003-01-07) column 10, line 5 - line 23 -----	1
A	US 4 942 877 A (SAKAI ET AL) 24 July 1990 (1990-07-24) column 11, line 23 - line 50 -----	1,7,8, 12,13,15

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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

"E" earlier document but published on or after the international filing date

"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
22 June 2005	05/07/2005

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Knüpling, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2005/006316

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5995858 A	30-11-1999	NONE	
US 2001002206 A1	31-05-2001	US 6229856 B1	08-05-2001
		US 2004152965 A1	05-08-2004
		EP 1067861 A1	17-01-2001
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		US 2003028357 A1	06-02-2003
US 4942877 A	24-07-1990	JP 63065845 A	24-03-1988

patsnap

专利名称(译)	血氧仪减少串扰
公开(公告)号	EP1722677A1	公开(公告)日	2006-11-22
申请号	EP2005731575	申请日	2005-02-24
[标]申请(专利权)人(译)	内尔科尔普里坦贝内特公司
申请(专利权)人(译)	NELLCOR PURITAN BENNETT INCORPORATED
当前申请(专利权)人(译)	NELLCOR PURITAN BENNETT INCORPORATED
[标]发明人	PETERSEN ETHAN CHEW BRADFORD B SHEA WILLIAM
发明人	PETERSEN, ETHAN CHEW, BRADFORD, B. SHEA, WILLIAM
IPC分类号	A61B5/00
CPC分类号	A61B5/14551 A61B5/7203 A61B5/725
代理机构(译)	GRUBERT，ANDREAS
优先权	10/787541 2004-02-25 US
外部链接	Espacenet

摘要(译)

一种用于减少血氧计中的串扰的方法和设备。血氧计包括带通滤波器。估计通过带通滤波器的串扰量。基于该估计，当设计用于最小化串扰时，调整带通滤波器的转角频率。在一个实施例中，当传感器附接到血氧计时执行校准模式。在校准模式下，首先仅测量红色LED，然后仅打开IR LED，测量信号。假设在关闭信道中测量的任何信号是来自另一信道的串扰的结果。串扰的大小被确定为百分比，并且随后百分比乘以实际信号并且从另一LED信号中减去作为串扰补偿。