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(54) **MULTI-BIT ADC WITH SIGMA-DELTA MODULATION**

MULTI-BIT-ADC MIT SIGMA-DELTA-MODULATION

CAN MULTI-BIT A MODULATION SIGMA-DELTA

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(56) References cited:

EP-A- 0 381 764	**US-A- 5 815 102**
US-A- 5 913 826	**US-A- 5 921 921**
US-B1- 6 229 466	**US-B1- 6 360 113**

- **ANONYMOUS: "PIC16C63A/65B/73B/74B - 8-Bit CMOS Microcontrollers with A/D Converter" [Online] 18 February 2003 (2003-02-18), MICROCHIP TECHNOLOGY INC , XP002329893 Retrieved from the Internet: URL:http: //web.archive.org/web/20030218133 131/http: //www1.jaycar.com.au/images_uploa ded/PIC16C63.PDF> page 1, line 1 - line 2 page 72, paragraph 2 - paragraph 3 page 73; figures 11-6**
- **PATENT ABSTRACTS OF JAPAN vol. 011, no. 396 (E-568), 24 December 1987 (1987-12-24) & JP 62 159518 A (OKI ELECTRIC IND CO LTD; others: 01), 15 July 1987 (1987-07-15)**
- **NORSWORTHY S R ET AL: "A 14-BIT 80-KHZ SIGMA-DELTA A/D CONVERTER: MODELING, DESIGN AND PERFORMANCE EVALUATION" IEEE JOURNAL OF SOLID-STATE CIRCUITS, IEEE INC. NEW YORK, US, vol. 24, no. 2, 1 April 1989 (1989-04-01), pages 256-266, XP000122348 ISSN: 0018-9200**

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Description

[0001] The present invention relates to oximeters, and in particular to sigma-delta modulators used in connection with analog-to-digital conversion 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] Typically, the analog-to-digital conversion in a pulse oximeter is done using a sigma-delta modulator for analog-to-digital conversion after the signal is demodulated into the separate red and IR signals. An example of a pulse oximeter circuit using sigma-delta modulators is set forth in U.S. Patent No. 5,921,921. This patent shows the use of two sigma-delta modulators, one for the red channel and one for the IR (infrared) channel. The sigma-delta modulators provide 1-bit of digital resolution, with the output of the sigma-delta modulator being filtered to produce a higher resolution signal. This is accomplished by using a fast oversampling rate (typically 1200 Hz) and then filtering to produce the slow, high resolution signal. The gain of the sigma-delta modulator in this patent is controlled by varying the width of the feedback pulse.

[0006] Several Sigma-delta modulators are disclosed in S.R. Norsworthy et al., "A 14-bit 80-kHz sigma-delta A/D converter : modeling, design, and performance evaluation", IEE J.Sol. St. Circuits 24 (1989) April, No. 2, and in EP 0 381 764 A1, JP 10-308 671 (1998), and JP 62-159 518 (1987).

[0007] It is an object of the invention to provide for an improved structure for a oximeter. This object can be achieved by an oximeter as defined in the independent claim. Further enhancements are defined in the dependent claims. The present invention moves the demodulator into the software domain, after the Analog-to-digital Converter (ADC). A sigma-delta modulator is used with a simple ADC. This allows the use of a single signal path for the photo current signal, rather than demodulating into red and IR components as in the prior art, which required two ADCs. The red and IR signals are separated later, in the digital domain using a software or firmware program. By using the same hardware for both red and IR, there is no gain error introduced into one signal but not the other. Since the red and IR will have the same frequency response error, the calculation of blood oxygenation will cancel out this error. The demodulation in software also allows a more sophisticated demodulation scheme to be used.

[0008] The present invention is able to produce an accurate multi-bit ADC conversion with the sigma-delta modulator, rather than the single bit conversion of the prior art, by using a multi-bit feedback Digital-to-analog Converter (DAC) to provide a unique Pulse Width Modulated (PWM) feedback. The feedback DAC is clocked by a stable clock to provide a control output which controls a switch between two voltage references, which are added back into the input signal. The amount of time the high voltage reference is added in versus the amount the low voltage reference is added in provides a PWM signal to give an accurate analog feedback. The invention reduces linearity errors since the feedback is a function of a stable clock signal.

[0009] For a further understanding of the nature and advantages of the present invention, reference should be made to the following description taken in conjunction with the accompanying drawings.

Figure 1 is a block diagram of an oximeter incorporating the present invention.

Figure 2 is a circuit diagram of a two-stage sigma-delta modulator according to an embodiment of the invention.

Figure 3 is a diagram of a typical sigma-delta modulator output.

Figure 4 is a circuit diagram of a sigma-delta modulator not according to the present invention using the sigma-delta modulator for a sample and hold circuit with an analog switch to avoid charge injection.

Figure 5 is a timing diagram illustrating various signals of the circuit of Figure 4.

Figure 6 is a circuit diagram of a sigma-delta modulator not according to the present invention utilizing multiple capacitors in the integrator.

Figure 7 is a timing diagram illustrating different signals of the circuit of Figure 6.

Overall System

[0010] 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 which includes a 10 bit A/D converter. Microcontroller 22 includes flash memory for a program, and RAM memory for data. The oximeter 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.

[0011] By using a sigma-delta modulator with the unique PWM feedback of the present invention, the simple, internal ADC of microcontroller 22 can be used and still provide the desired multi-bit precision. The ADC in this embodiment is a 10 bit successive approximation ADC. The precisely controlled PWM feedback connects in a voltage reference through switches 58 and 60, which are then summed in summing nodes with the input signal at the inputs of the integrators. The averaged summed value, between the positive and negative reference voltages, provide the desired feedback. Any error is fed back in the following pulse period.

Sigma-delta Modulator

[0012] Fig. 2 is a circuit diagram of a sigma-delta modulator according to an embodiment of the present invention, including portions of sigma-delta interface 20 and microcontroller 22 of Fig. 1. In particular, an analog input on a line 40 is provided through a resistor 42 to an inverting input of an operational amplifier 44 configured as an integrator 51 with a feedback capacitor 46. The non-inverting input is connected to a reference voltage (Ref). This is followed, through a connecting resistor 48, by a second operational amplifier 50, connected as an integrator 53 with a feedback capacitor 52. The output of operational amplifier 50 is connected to an analog-to-digital converter 54, which is the 10-bit A/D converter in microcontroller 22 of Fig. 1.

[0013] The digital output is fed back through a "digital-to-analog converter" 56 as a feedback circuit through a first switching circuit 58 and a second switching circuit 60. DAC 56 is internal to microcontroller 22, and produces the PWM output signal shown in Fig. 5. In response to the PWM control signal, switching circuit 58 alternately connects a positive or negative reference on lines 62 and 64 through a resistor 66 to connect with the input signal to the inverting input of operational amplifier 44. Similarly, second switching circuit 60 connects a negative and positive reference, inverted from the connections shown for switching circuit 58. These are reference voltages 68 and 70, which are connected through a resistor 72 to the inverting input of operational amplifier 50.

[0014] The feedback signal from digital-to-analog converter 56 is a pulse width modulated (PWM) signal, such as the typical signal shown in Fig. 3 for a sigma-delta modulator illustrating a sine waveform. By using a PWM signal and switching between only two voltages, the linearity of the feedback is a function of the clock signal. Since the clock signal is stable, and can be divided more accurately than the analog voltage, linearity errors are minimized. The multi-bit analog-to-digital converter, rather than the single bit converter of prior art devices, allows a more accurate result with a lower sample rate. This eases the requirements for decimation filtering in software.

Sample and Hold (not part of the invention)

[0015] Fig. 4 is a circuit diagram illustrating the switch controlling the input to the integrator in the sigma-delta modulator, with the switch being used for a sample and hold circuit. Fig. 4 shows many of the same circuit blocks as Fig. 2, such as analog-to-digital converter 54, feedback digital-to-analog converter 56, switching circuit 58, input resistors 42 and 66, and operational amplifier 44 configured as an integrator with capacitor 46. Only a single stage is shown for simplicity, and it is understood that an additional integrator 53 as in Fig. 2 could be added as well, with a similar switch for a sample and hold for the second integrator.

[0016] Fig. 4 adds a D flip-flop 74 and switching circuit 76. Switch 76 disconnects the input 40 from the input of operational amplifier 44 for a hold operation. When the input is reconnected after the sample has been held, a problem can arise since the voltage at the input can vary dramatically due to the feedback circuit through switch 58 and resistor 66. Since this feedback switches between a positive and negative voltage, a significant variation in the input voltage could occur. For example, the feedback might vary between approximately 0-3 volts, with the input being around 1 volt. This would result in a 1.5 volt swing. Such a swing would cause, upon reconnection to the inverting input of operational amplifier 44, a charge injection into capacitor 46, which is undesirable.

[0017] Such a charge injection is avoided by connecting the node 73 to the non-inverting input of operational amplifier 44. This non-inverting input further is connected to a reference voltage. This gives the current which would build up a place to go. The difference in voltage will result in current flow either toward or away from the reference voltage 75. Thus, upon reconnection, there will be minimal charge injection. The result of this structure is that the charge injection from the switch will be essentially constant, to the extent there is any, and it can be canceled out later by processing in a digital domain using a software or firmware program.

[0018] Fig. 5 illustrates certain of the waveforms of the circuit of Fig. 4. The pulse width modified (PWM) signal on line 76 at the output of digital-to-analog converter 56 is shown first. The arrows signify that the width of the pulse will vary depending upon the signal. Next, the sample/hold signal on line 78 is shown, the non-inverting output of D flip-flop 74. Finally, the voltage out (Vo) signal on line 80 at the output of the integrator of operational amplifier 44 and capacitor 46 is shown. As can be seen, the Vo signal decays while the PWM signal is high, and increases or integrates while the PWM signal is low as long as the sample/hold signal is high. While the sample/hold signal is low, the Vo signal is held constant so that it can be sampled. Although illustrated at the same level each time in Fig. 5, the levels would vary with the amount of integration and the width of the pulse from the PWM feedback signal.

Multiple Capacitor Sigma-delta Modulator (not part of the invention)

[0019] Fig. 6 illustrates a modification of the circuit of Fig. 4 in which capacitor 46 of Fig. 4 is replaced by one of four capacitors, C1, C2, C3, and C4, which are selected by a switching circuit 82.

[0020] In a typical prior pulse oximeter, two separate integrators would need to be used with two separate signal paths and demodulation in the analog domain, so that the two different integrators could use two different capacitors for the red and IR signals. By instead switching in and out capacitors, a single integrator can be used, and the analog domain demodulation circuitry can be eliminated. Instead, the red and IR signals are time-multiplexed through the same integrator, with different capacitors being switched in for the red and IR signals. In addition, two additional capacitors can be added for the dark period in between the red and IR signals. Since the dark signal can vary depending upon whether it follows the IR signal, or follows the red signal, two different capacitors can be provided to correspond to dark 1 and dark 2 signals. Thus, the demodulation of the signal may be moved into the digital domain and be done by a program software or firmware, rather than plan moved into the digital domain and be done by a program in software or firmware, rather than having it done with hardware. This allows the hardware circuitry to be reduced in size by using only a single signal path, saving not only space and cost but also power.

[0021] Fig. 7 illustrates the different signals of Fig. 6, with the PWM, sample/hold, and Vo signals as in Fig. 5, plus showing the voltage input (Vi) signal on input line 40.

[0022] As the input line varies from IR to dark 1 to red to dark 2, switching circuit 82 switches between the different capacitors C1-C4. The switching is controlled by a signal from the controller, since the controller knows when it switches on and off the red and IR LEDs, and thus can switch the capacitors at the same times.

[0023] In one example, the features of Figs. 2, 4, and 6 are combined, providing a two-stage integrator with PWM feedback, a switching circuit for each integrator to function as a sample and hold for the integrators, and multiple capacitors being switched in for each of the integrators. Thus, a single path may be used through the analog hardware circuitry for both red and the IR signals, saving components, cost, circuit size, and power consumption. By moving the demodulation from hardware into the digital domain to be done in software/firmware, there is no need to be concerned about mismatching of the filters for the red and IR signals, since the same filters are used. Since the accuracy of filtering in hardware is dependent upon component tolerance, using the same signal path allows the use of the same hardware, thus eliminating gain error introduced into one signal but not the other. If the red and IR signals have the same frequency response, the ratio-of-ratios (rat-rat) equation used by the software to calculate oxygen saturation will cancel out that error. Also, doing the demodulation in software allows a more sophisticated demodulation scheme to be used than what could be done easily in hardware.

[0024] As will be understood by those with skill in the art, the present invention may be embodied in other specific forms without departing from the essential characteristics thereof as defined in claim 1. For example, a third order modulator could be used, or a higher or lower resolution multi-bit analog-to-digital converter. Innumerable other variations could be made in the circuitry without departing from the essential characteristics of the invention as defined in claim 1. Accordingly, the foregoing description is intended to be illustrative of, but not limiting of, the scope of the invention which is set forth in the following claims.

Claims

1. An oximeter apparatus comprising:

   a sigma-delta modulator having an input coupled to receive an analog sensor (10) signal and further comprising first and second integrators (51, 53);
   a first switching circuit (58), coupled to said input, for switching between connecting first and second reference voltages (Ref-, Ref+) to said input;

   characterized in that the oximeter apparatus further comprises:

a multiple bit analog-to-digital converter (54) coupled to an output of said sigma-delta modulator to provide a digital output; and
a feedback circuit (56) coupled to said output of said sigma-delta modulator, said feedback circuit including a digital-to-analog converter having an input coupled to said digital output of said multiple bit analog-to-digital converter, and an output coupled to said first switching circuit (58) for producing a pulse width modulated output signal controlling the switching between said first and second reference voltages by said first switching circuit; and
a second switching circuit (60), coupled to an input of said second integrator (53) and controlled by said feedback circuit (56), for switching to said second voltage reference (Ref+) when said first switching circuit (58) connects to said first voltage reference (Ref-), and switching to said first voltage reference (Ref-) when said first switching circuit (58) switches to said second voltage reference (Ref+).

2. The oximeter apparatus of claim 1, wherein said first reference voltage is a negative reference voltage (Ref-) and said second reference voltage is a positive reference voltage (Ref+),

3. The oximeter apparatus of claim 1 or 2, wherein said the digital-to-analog converter is formed by a pulse width modulator (56) having an input coupled to said digital output, and an output coupled to said first and second switching circuits (58, 60).

4. The oximeter apparatus of one of the preceding claims, further comprising:

a resistor (66) coupled between said first switching circuit (58) and said input of said sigma-delta modulator.

5. The oximeter apparatus according to one of the preceding claims, further comprising:

wherein said first and/or second integrator (51; 53) is formed by an operational amplifier (44; 50) and a feedback capacitor (46; 52).

6. The oximeter apparatus of claim 5, wherein said multiple bit analog-to-digital converter (54) is implemented in a microcontroller (22).

7. The oximeter apparatus according to one of the preceding claims, wherein a single signal path through said sigma delta modulator is used for both a red and an infrared signal.

8. The oximeter apparatus of claim 7, further comprising:

a memory containing a program for demodulating said digital output into red and infrared digital signals.

Patentansprüche

1. Oximeter-Vorrichtung aufweisend:

einen Sigma-Delta-Modulator mit einem Eingang, der so verbunden ist, dass er ein analoges Sensor (10) Signal empfängt und weiterhin aufweisend einen ersten und einen zweiten Integrierer (51, 53);
einen ersten Schaltkreis (58), der mit dem Eingang gekoppelt ist, um zwischen der Verbindung einer ersten und einer zweiten Bezugsspannung (Ref-, Ref+) mit dem Eingang hin und her zu schalten;

dadurch gekennzeichnet, dass die Oximeter-Vorrichtung weiterhin aufweist:

einen Multi-Bit Analog-Digital-Wandler (54), der mit einem Ausgang des Sigma-Delta-Modulators verbunden ist, um einen Digitalausgang bereitzustellen; und
einen Rückkopplungsschaltkreis (56), der mit dem Ausgang des Sigma-Delta-Modulators verbunden ist, der Rückkopplungsschaltkreis weist einen Digital-AnalogWandler mit einem Eingang, der mit dem Digitalausgang des Multi-Bit Analog-Digital-Wandlers verbunden ist, und einen Ausgang auf, der mit dem ersten Schaltkreis (58) verbunden ist, um ein pulsweitenmoduliertes Ausgangssignal zu erzeugen, welches das Schalten zwischen der ersten und der zweiten Bezugsspannung durch den ersten Schaltkreis steuert; und
einen zweiten Schaltkreis (60), der mit einem Eingang des zweiten Integrierers (53) verbunden ist und der durch den Rückkopplungsschaltkreis (56) gesteuert wird, zum Schalten zu der zweiten Bezugsspannung (Ref+), wenn der erste Schaltkreis (58) zu der ersten Bezugsspannung (Ref-) schaltet, und zum Schalten zu der ersten Bezugsspannung (Ref-), wenn der erste Schaltkreis (58) zu der zweiten Bezugsspannung (Ref+) schaltet.

2. Oximeter-Vorrichtung nach Anspruch 1, wobei die erste Bezugsspannung eine negative Bezugsspannung (Ref-) und die zweite Bezugsspannung eine positive Bezugsspannung (Ref+) ist.

3. Oximeter-Vorrichtung nach Anspruch 1 oder 2, wobei der Digital-AnalogWandler durch einen Pulsweitenmodulator (56) gebildet wird, mit einem Eingang, der mit dem Digitalausgang verbunden ist, und einem Ausgang, der mit dem ersten und dem zweiten Schaltkreis (58, 60) verbunden ist.

4. Oximeter-Vorrichtung nach einem der vorhergehenden Ansprüche, weiterhin aufweisend:

einen Widerstand (66), der zwischen den ersten Schaltkreis (58) und den Eingang des Sigma-Delta-Modulators geschaltet ist.

5. Oximeter-Vorrichtung nach einem der vorhergehenden Ansprüche, weiterhin aufweisend:

wobei der erste und/oder der zweite Integrierer (51; 53) durch einen Operationsverstärker (44; 50) und einen Rückkopplungskondensator (46; 52) gebildet werden.

6. Oximeter-Vorrichtung nach Anspruch 5, wobei der Multi-Bit Analog-Digital-Wandler (54) in einem Mikrocontroller (22) realisiert ist.

7. Oximeter-Vorrichtung nach einem der vorhergehenden Ansprüche, wobei ein einziger Signalpfad durch den Sigma-Delta-Modulator sowohl für ein rotes als auch für ein infrarotes Signal benutzt wird.

8. Oximeter-Vorrichtung nach Anspruch 7, weiterhin aufweisend:

einen Datenspeicher, der ein Programm zur Demodulierung des Digitalausgangs in rote und infrarote digitale Signale aufweist.

Revendications

1. Oxymètre comprenant :

un modulateur sigma-delta comportant une entrée couplée pour recevoir un signal d'un capteur analogique (10) et comprenant, en outre, des premier et second intégrateurs (51, 53) ;
un premier circuit de commutation (58) couplé à ladite entrée, pour connecter alternativement des première et seconde tensions de référence (Ref-, Ref+) à ladite entrée ;

caractérisé en ce que l'oxymètre comprend, en outre :

un convertisseur analogique-numérique multibit (54) couplé à une sortie dudit modulateur sigma-delta pour fournir une sortie numérique ; et
un circuit à rétroaction (56) couplé à ladite sortie dudit modulateur sigma-delta, ledit circuit à rétroaction comprenant un convertisseur numérique-analogique comportant une entrée couplée à ladite sortie numérique dudit convertisseur analogique-numérique multi-bit, et une sortie couplée audit premier circuit de commutation (58) pour générer un signal de sortie modulé en largeur d'impulsion qui commande la commutation entre lesdites première et seconde tensions de référence par ledit premier circuit de commutation ; et
un second circuit de commutation (60), couplé à une entrée dudit second intégrateur (53) et commandé par ledit circuit à rétroaction (56), pour commuter sur ladite seconde référence de tension (Ref+) lorsque ledit premier circuit de commutation (58) se connecte à ladite première référence de tension (Ref-), et pour commuter sur ladite première référence de tension (Ref-) lorsque ledit premier circuit de commutation (58) commute sur ladite seconde référence de tension (Ref+).

2. Oxymètre selon la revendication 1, dans lequel ladite première tension de référence est une tension de référence négative (Ref-) et ladite seconde tension de référence est une tension de référence positive (Ref+).

3. Oxymètre selon la revendication 1 ou 2, dans lequel ledit convertisseur numérique-analogique est formé par un modulateur en largeur d'impulsion (56) comportant une entrée couplée à ladite sortie numérique, et une sortie couplée auxdits premier et second circuits de commutation (58, 60).

4. Oxymètre selon l'une des revendications précédentes, comprenant, en outré :

une résistance (66) couplée entre ledit premier circuit de commutation (58) et ladite entrée dudit modulateur sigma-delta.

5. Oxymètre selon l'une des revendications précédentes, dans lequel, en outré :

ledit premier et/ou second intégrateur (51 ; 53) est formé par un amplificateur opérationnel (44 ; 50) et un condensateur de réaction (46 ; 52).

6. Oxymètre selon la revendication 5, dans lequel ledit convertisseur analogique-numérique multibit (54) est mis en oeuvre dans un microcontrôleur (22).

7. Oxymètre selon l'une des revendications précédentes, dans lequel une trajectoire de signal unique à travers ledit modulateur sigma-delta est utilisée à la fois pour un signal rouge et pour un signal infrarouge.

8. Oxymètre selon la revendication 7, comprenant, en outré :

une mémoire contenant un programme de démodulation de ladite sortie numérique en signaux numériques rouges et infrarouges.

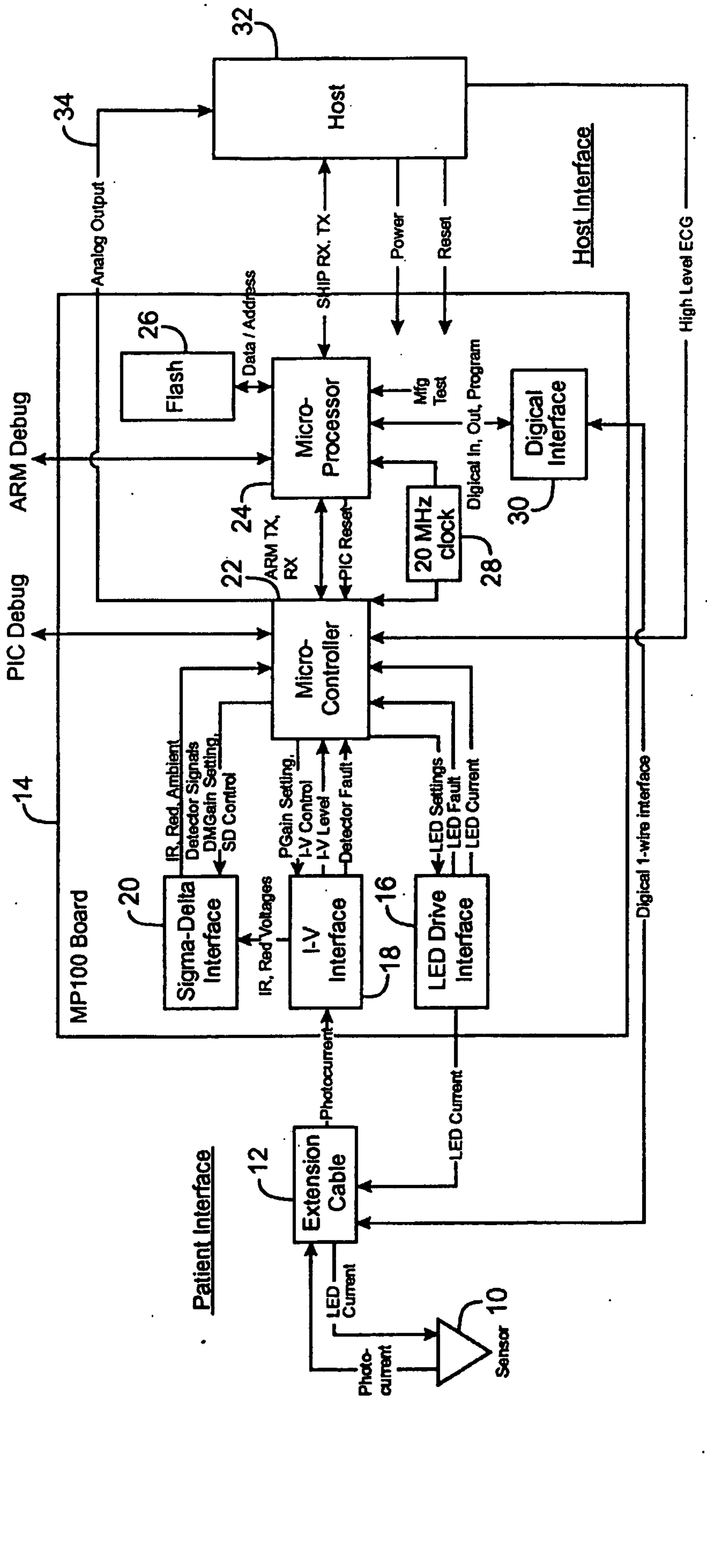
Host Interface
Host
32
34
Analog Output
SHIP RX, TX
Power
Reset
High Level ECG
ARM Debug
PIC Debug
14
MP100 Board
Flash
26
Data / Address
Micro-Processor
24
Mfg Test
Digical In, Out, Program
Digical Interface
30
20 MHz clock
28
ARM TX, RX
22
PIC Reset
Micro-Controller
IR, Red, Ambient Detector Signals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

FIG. 1

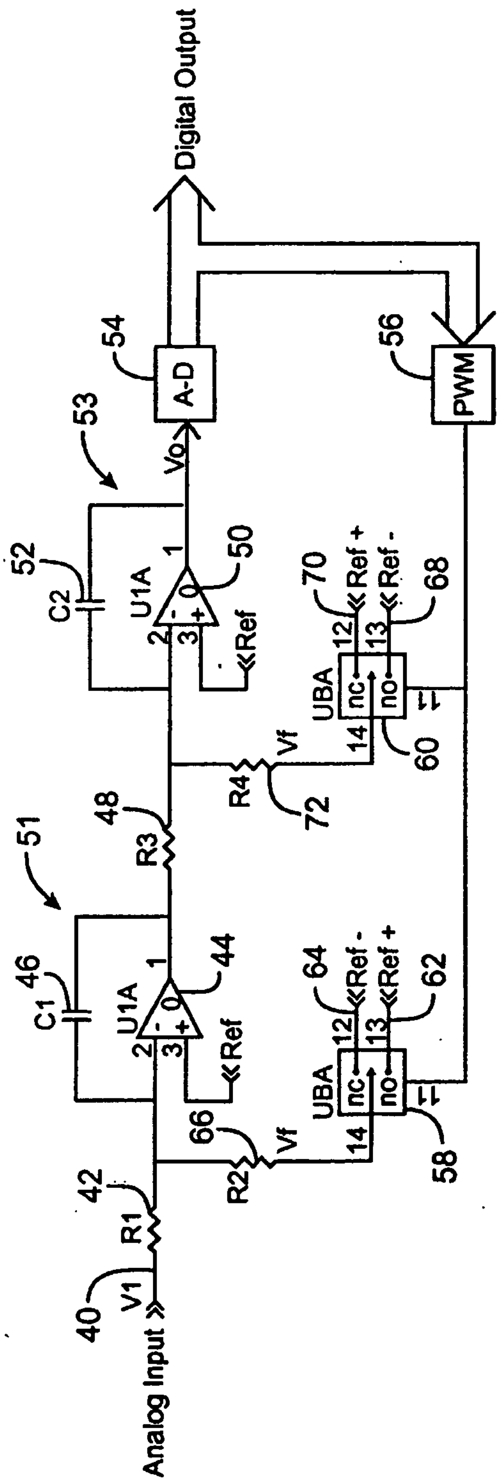
Digital Output
A-D
PWM
Vo
U1A
C2
C1
R1
R2
R3
R4
V1
Vf
Ref
Ref +
Ref -
UBA
nc
no
Analog Input
40
42
44
46
48
50
51
52
53
54
56
58
60
62
64
66
68
70
72

FIG. 2

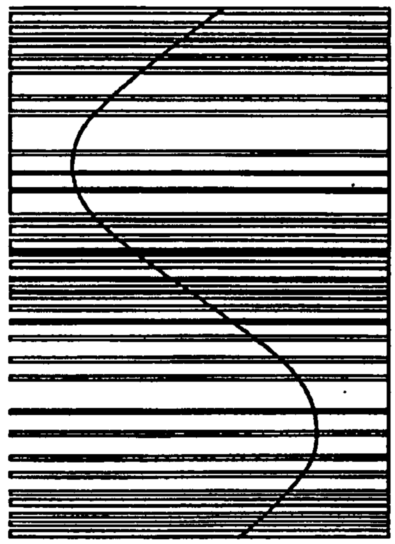

FIG. 3

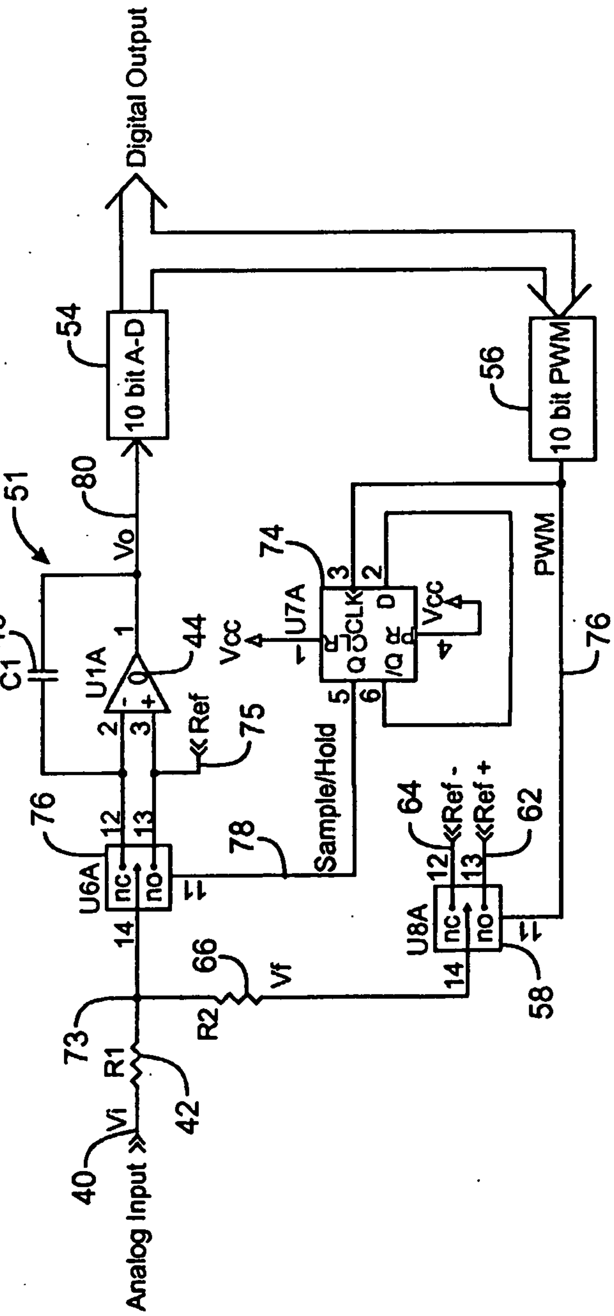
Analog Input
Vi
40
42
R1
73
R2
66
Vf
14
U6A
nc
no
12
13
76
78
Sample/Hold
C1
46
U1A
2
3
1
44
Ref
75
51
Vo
80
10 bit A-D
54
Digital Output
74
U7A
Vcc
CLK
D
5
6
3
2
PWM
76
10 bit PWM
56
U8A
58
64
Ref -
Ref +
62

FIG. 4

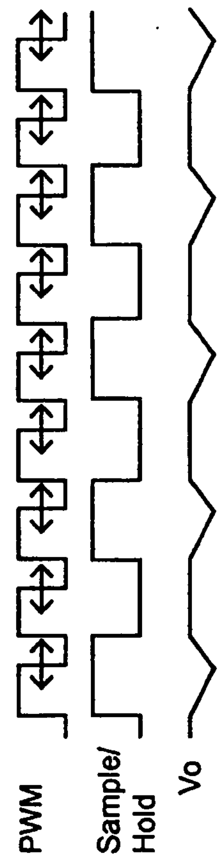
PWM
Sample/
Hold
Vo

FIG. 5

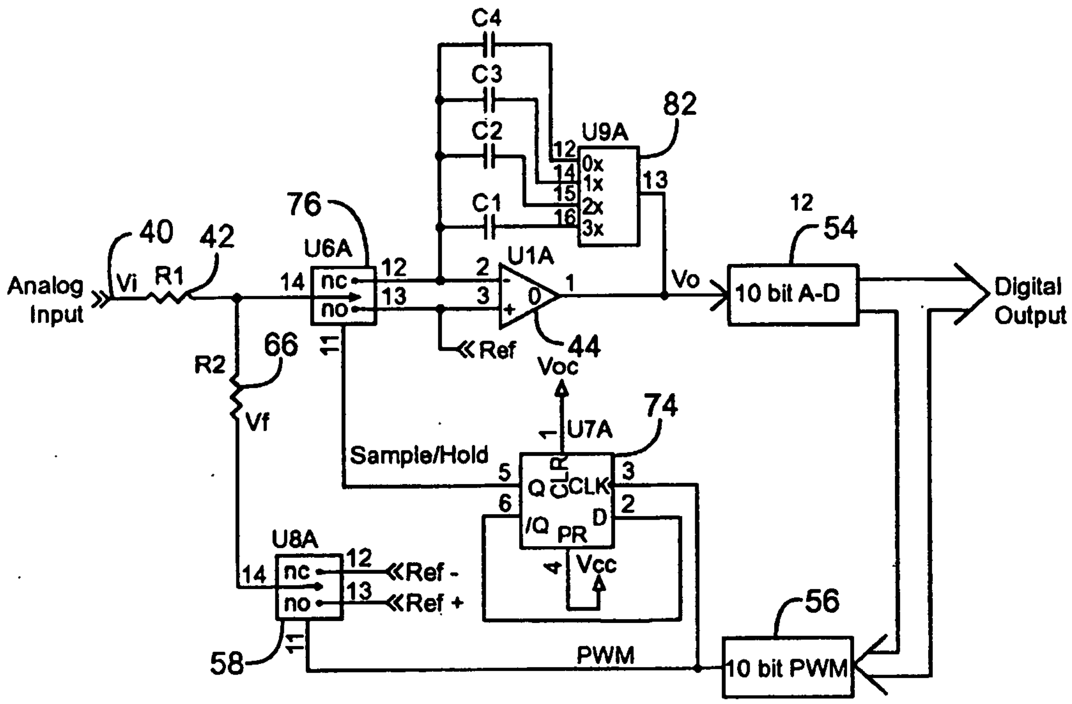
C4
C3
C2
C1
82
U9A
12
14
15
16
0x
1x
2x
3x
13
76
U6A
40
42
Analog Input
Vi
R1
14
nc
no
12
13
11
U1A
2
3
1
0
Vo
12
54
10 bit A-D
Digital Output
Ref
44
Voc
R2
66
Vf
74
U7A
Sample/Hold
5
Q
CLR
CLK
3
6
/Q
PR
D
2
4
Vcc
U8A
14
nc
no
12
13
Ref -
Ref +
58
11
PWM
56
10 bit PWM

FIG. 6

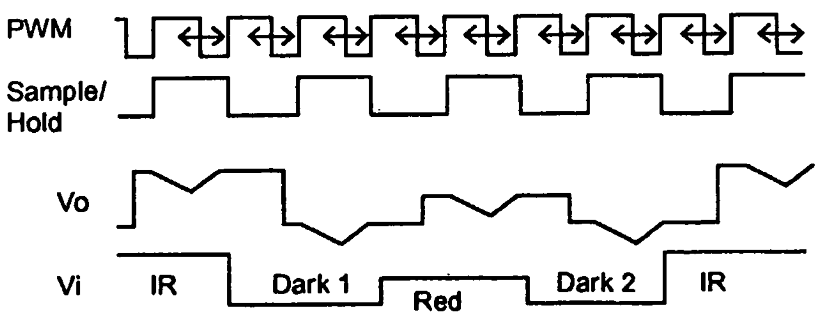
PWM
Sample/ Hold
Vo
Vi
IR
Dark 1
Red
Dark 2
IR

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5921921 A **[0005]**
- EP 0381764 A1 **[0006]**
- JP 10308671 A **[0006]**
- JP 62159518 A **[0006]**

Non-patent literature cited in the description

- **S.R. Norsworthy et al.** A 14-bit 80-kHz sigma-delta A/D converter : modeling, design, and performance evaluation. *IEE J.Sol. St. Circuits,* April 1989, vol. 24 (2 **[0006]**

专利名称(译)	具有sigma-delta调制的多位ADC		
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代理机构(译)	GRUBERT , ANDREAS		
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其他公开文献	EP1722671A2		
外部链接	Espacenet		

摘要(译)

血氧计使用sigma-delta调制器和带有PWM反馈的多位ADC，可实现高精度多位转换。解调是在软件中完成的，因此红色和红外只需要一个硬件路径。多个电容器切换到sigma-delta调制器中的积分器，具有用于红色，IR和暗信号的不同电容器，从而能够使用单个硬件路径。在Σ-Δ调制器的输入端的开关电路用作采样和保持，由PWM反馈控制。

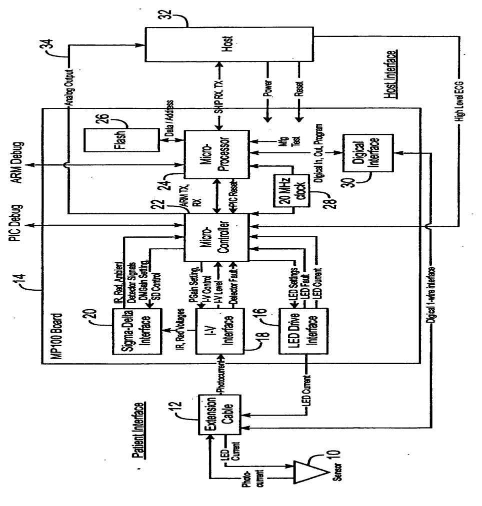

FIG. 1