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(54) **CIRCUIT ARRANGEMENT FOR AN OPTICAL MONITORING SYSTEM AND METHOD FOR OPTICAL MONITORING**

SCHALTUNGSANORDNUNG FÜR EIN OPTISCHES ÜBERWACHUNGSSYSTEM UND VERFAHREN ZUR OPTISCHEN ÜBERWACHUNG

AGENCEMENT DE CIRCUIT POUR UN SYSTÈME DE SURVEILLANCE OPTIQUE ET PROCÉDÉ DE SURVEILLANCE OPTIQUE

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Description

[0001] The invention relates to a circuit arrangement for an optical monitoring system, in particular for an optical monitoring system for monitoring or measuring a biological parameter, and to a method for optical monitoring, in particular for monitoring or measuring a biological parameter.

[0002] Photoplethysmography, PPG, may be used for example for monitoring or measuring a biological parameter, for example of a person, such as heart rate, pulse rate variability or oxygen saturation in the blood. PPG signals are for example obtained by injecting a light signal by shining light onto a target region of the person's skin, for example by means of a light emitting diode, LED, and measuring a reflected and/or transmitted signal in close proximity, for example about 2.5 mm using for example green light, of the position of the light signal injection.

[0003] PPG techniques may rely on very small physical changes in the thickness and/or volume of blood vessels. Consequently, the obtained PPG signal may have a very high DC or average component but a low AC or fluctuating component. A typical PPG signal obtained for example from light injection at the wrist of a person and corresponding measurement may have a modulation index in the order of a fraction of 1%, for example in the order of 0.05% - 0.3%. Therefore, a signal quality of the PPG signal may be of particular importance for monitoring or measuring the biological parameter by means of PPG.

[0004] Document US 2012/0188292 discloses a sensor device for proximity detection. The sensor device comprises a photodiode and an LED driven by a control circuit and a variable current source connected to a cathode of the photodiode via a switch. An input of an analog-to-digital converter, is connected between the cathode of the photodiode and the switch. The switch is opened during a period of not driving the LED and closed during a period of driving the LED.

[0005] Document US 8,848,202 B2 shows an optical proximity sensor with a driver driving a light source and a light detector. The sensor also includes a current source to selectively provide an offset current, which is combined with a detection signal of the light detector. A resulting compensated current is supplied to an ADC for further processing. In an implementation, the generation of the offset current is synchronized with a transmit signal causing the light source to emit light.

[0006] Document US 4,453,218 discloses a signal filter apparatus for an oximeter device. The device comprises three LEDs configured to emit light with different wavelengths and a detector. Signal portions that are indicative of erroneous or unsuitable radiation readings may be removed by means of the filter apparatus.

[0007] Document US 2003/0069486 A1 relates to a low power pulse oximeter comprising a sensor with a light detector and a light source. The oximeter further comprises an input stage with a dark level removal circuit. When the light source is turned off, a capacitor of the dark level removal circuit is charged to a dark level. When the light source is turned on, the dark level is removed from a measured and amplified signal.

[0008] It is therefore an object to provide an improved concept for optical monitoring of a biological parameter, in particular by means of PPG, that leads to an improved signal quality, in particular PPG signal quality.

[0009] This object is achieved by the subject matter of the independent claims. Further implementations and embodiments are the subject matter of the dependent claims.

[0010] Since the fluctuating component of the PPG signal may be of particular relevance for the monitoring or measurement, low noise and/or high amplification may be required. Such high amplification, however, may bear the risk of running into saturation of the internal signal processing. In addition, ambient light may impair the measurement, for example due to saturation of internal signal processing.

[0011] According to the improved concept, signal noise may be reduced and higher signal amplification may be used, resulting in an improved signal quality.

[0012] According to the improved concept, a current source, in particular a low current and low noise current source, is connected to the input side of a PPG system. The current source generates a reduction current that reduces a detector current obtained from an optical detector. Therein, the reduction current is modulated according to a driving signal for driving a light source, such that the reduction of the detector current is stronger whenever the light source is activated compared to the opposite case. Consequently, a lower average component of signals is achieved allowing for higher amplification and leading to less noise of the system.

[0013] According to the improved concept, a circuit arrangement for an optical monitoring system is provided. The circuit arrangement comprises a driver circuit configured to generate at least one driving signal for driving a light source and a detector terminal for receiving a detector current, in particular from an optical detector. The circuit arrangement further comprises a current source configured and arranged to generate at the detector terminal a reduction current.

[0014] The reduction current has an amplitude which is given by a base value whenever none of the least one driving signal assumes a value suitable for activating the light source. On the other hand, the amplitude of the reduction current is given by a sum of the base value and a reduction value otherwise, that is whenever the at least one driving signal, in particular any of the at least one driving signal, assumes a value suitable for activating the light source. The circuit arrangement also comprises a processing unit configured to generate an output signal depending on a combination of the detector current and the reduction current.

[0015] In this way, the detector current is effectively reduced by the sum of the base value and the reduction value when the at least one driving signal assumes a value suitable for activating the light source and by the base value otherwise. In particular, reduction by the base value may account for ambient light reaching the optical detector, while reduction by the reduction value may account for additional light, for example excess light, from the light source reaching the optical detector.

[0016] This may result in a reduction of an average component of signals, for example the output signal or a signal depending on the detector current and the reduction current. Thus signal quality may be improved due to lower noise and/or higher possible signal amplification.

[0017] The optical monitoring system may for example be a photoplethysmography, PPG, system for example for monitoring and/or measuring a biological parameter, for example of a person. In particular, the optical monitoring system may be a heart rate monitoring, HRM, system, for measuring and/or monitoring a heart rate, a pulse or heart rate variability, PRV, system for measuring and/or monitoring a pulse or heart rate variability and/or a pulse oximetry system for measuring and/or monitoring oxygen saturation, SpO2, in the blood.

[0018] Above and in the following, "light" refers to electromagnetic radiation in general and to visible light, ultraviolet radiation and/or infrared radiation in particular. In particular, the light source is configured to emit light with at least one specified wavelength spectrum, for example in the visible, ultraviolet and/or infrared spectrum. The specified wavelength spectrum may for example correspond to green light of for example 525nm, which may result in a particularly good output signal.

Above and in the following, "optical" is related to electromagnetic radiation in general and to visible light, ultraviolet radiation and/or infrared radiation in particular. In particular, the optical monitoring system may operate based on generation, detection and/or processing of such electromagnetic radiation.

[0019] According to some implementations of the circuit arrangement, the optical detector is configured to detect electromagnetic radiation, for example visible light, ultraviolet radiation and/or infrared radiation and to generate the detector current based on the detected electromagnetic radiation. In particular, the optical detector may be sensitive to such type of electromagnetic radiation that may be emitted by the light source.

[0020] According to some implementations of the circuit arrangement, an output of the current source is connected to the detector terminal for generating the reduction current.

[0021] According to some implementations of the circuit arrangement, a current direction, in particular with respect to the detector terminal, of the reduction current is opposed to a current direction, in particular with respect to the detector terminal, of the detector current. That is, the combination of the detector current and the reduction current, which may constitute an input current of the circuit arrangement, has an absolute value that is smaller than an absolute value of the detector current if an absolute value of the reduction current is non-zero.

[0022] The at least one driving signal assuming a value suitable for activating the light source means that the least one driving signal assumes value that may cause, in particular causes, the light source to emit light.

[0023] According to some implementations of the circuit arrangement, an input current of the circuit arrangement is constituted by the combination of the detector current and the reduction current, in particular by a sum of the detector current and the reduction current.

[0024] According to some implementations of the circuit arrangement, the at least one driving signal corresponds to at least one driving current or controls the at least one driving current for driving the light source. In such implementations, the at least one driving signal assumes a value suitable for activating the light source if the driving current is sufficiently high such that the light source may emit light.

[0025] According to some implementations of the circuit arrangement, the base value is equal to zero. According to some implementations of the circuit arrangement, the base value is non-zero.

[0026] According to some implementations of the circuit arrangement, the reduction value is equal to zero or may be regulated to zero. According to some implementations of the circuit arrangement, the reduction value is non-zero.

[0027] According to some implementations of the circuit arrangement, the base value and the reduction value are both positive.

[0028] According to some implementations of the circuit arrangement, the light source is not comprised by the circuit arrangement.

[0029] According to some implementations of the circuit arrangement, the optical detector is not comprised by the circuit arrangement.

[0030] In particular, the circuit arrangement and in particular the driver circuit may be adapted to operate in combination with different types of light sources and/or optical detectors

[0031] According to some implementations of the circuit arrangement, the optical detector comprises at least one photodetector, for example a photodiode.

[0032] According to some implementations of the circuit arrangement, the circuit arrangement comprises the light source and the light source comprises at least one optical emitter configured and arranged to be driven by at least one driving signal.

[0033] According to some implementations of the circuit arrangement, the at least one optical emitter comprises at least one LED.

[0034] According to some implementations of the circuit arrangement, the at least one optical emitter and/or the at least one LED is configured to emit visible light, for example red visible light, green visible light, blue visible light, yellow visible light or visible light with another color and/or spectrum, and/or infrared radiation.

[0035] According to some implementations of the circuit arrangement, the light source may comprise a plurality of optical emitters, for example a plurality of LEDs, wherein different optical emitters of the plurality of optical emitters are configured to emit light of the same or of different spectra.

[0036] According to some implementations of the circuit arrangement, each of the optical emitters comprised by the light source is associated to one of the at least one driving signal and is driven by the associated driving signal.

[0037] In implementations, wherein the light source comprises a plurality of optical emitters, each of the optical emitters of the plurality of optical emitters may be utilized for different applications of the circuit arrangement and/or to optical monitoring system. An optical emitter, for example an LED, configured to emit green or yellow visible light may for example be utilized to monitor a heart rate for example at a wrist of a person. An optical emitter, for example an LED, configured to emit red visible or infrared light may for example be used for pulse oximetry. Each of the optical emitters may be associated to an individual current reduction setting, in particular an individual reduction value.

[0038] According to some implementations of the circuit arrangement, the driver circuit is configured to generate the at least one driving signal as a first and at least a second driving signal. The reduction value is given by a first value, that is a first reduction value, whenever the first signal assumes a value suitable for activating the light source. The reduction value is given by a second value, that is a second reduction value, whenever the second driving signal assumes a value suitable for activating the light source. The first and the second reduction value may be equal to or different from each other.

[0039] According to some implementations of the circuit arrangement, a first optical emitter of the light source is driven by the first driving signal and a second optical emitter of the light source is chosen by the second driving signal.

[0040] According to some implementations of the circuit arrangement, the circuit arrangement comprises the light source and the light source comprises a first optical emitter configured and arranged to be driven by the first driving signal and a second optical emitter configured and arranged to be driven by the second driving signal.

[0041] According to some implementations of the circuit arrangement, the driver circuit is configured to generate the first and the second driving signal such that, at a given time, at most one of the at least one driving signal assumes a value suitable for activating the light source.

[0042] According to some implementations of the circuit arrangement, the second reduction value is different from the first reduction value. Consequently, an optimum value for the reduction value may be adjusted for each driving signal and/or optical emitter separately. This may be particularly beneficial for further improvement of signal quality and/or reduction of power consumption.

[0043] According to some implementations of the circuit arrangement, the driver circuit is configured to generate the first and the second driving signal such that, at a given time, at most one of the first and the second driving signal assumes a value suitable for activating the light source.

[0044] According to some implementations of the circuit arrangement, the circuit arrangement comprises the optical detector.

[0045] According to some implementations of the circuit arrangement, the driver circuit comprises at least one driver current source for driving the light source depending on the at least one driving signal.

[0046] According to some implementations of the circuit arrangement, wherein the light source comprises a plurality of optical emitters, the driver circuit comprises a plurality of driver current sources, wherein each of the plurality of driver current sources is associated to one of the plurality of optical emitters and vice versa for driving the associated optical emitter.

[0047] According to some implementations of the circuit arrangement, the current source is configured and arranged to generate at the detector terminal the reduction current, wherein an amplitude of the reduction current is given by the base value whenever the light source does not emit light and by the sum of the base value and the reduction value whenever the light source, in particular an optical emitter comprised by the light source, does emit light.

[0048] In implementations wherein the light source comprises a plurality of optical emitters, the amplitude of the reduction current is given by the base value whenever none of the optical emitters of the plurality of optical emitters does emit light. The amplitude of the reduction current is given by the sum of the base value and the reduction value whenever any of the optical emitters of the plurality of optical images does emit light.

[0049] According to some implementations of the circuit arrangement, the processing unit is configured to generate an intermediate signal by amplifying the combination of the detection current and the reduction current, in particular amplifying the input current. The processing unit is configured to determine a first value of the intermediate signal at a first point in time and a second value of the intermediate signal at a second point in time.

[0050] Therein, the amplitude of the reduction current is given by the sum of the base value and the reduction value at the first point in time and by the base value at the second point in time. That is, at the first point in time, the at least one driving signal, in particular one of the at least one driving signal, assumes a value suitable for activating the light source and at the second point in time, none of the at least one driving signal assumes a value suitable for activating the light source.

[0051] The processing unit is configured to determine a difference between the first and the second value of the intermediate signal and to generate the output signal depending on the determined difference. In this way, the output signal is generated based on a demodulated signal, since otherwise the signal fluctuations due to the pulses driving of the light source may be too high.

[0052] In this way, ambient light rejection may be achieved, making the system more independent with respect to environmental variations or fluctuations.

[0053] According to some implementations of the circuit arrangement, the circuit arrangement, for example the processing unit, further comprises an amplifier circuit configured and arranged to generate the intermediate signal by amplifying the combination of the detection current and the reduction current, for example the input current. The processing unit is configured to generate the output signal based on the intermediate signal.

[0054] According to some implementations of the circuit arrangement, the amplifier circuit comprises a transimpedance amplifier, TIA, with a first input connected to the detector terminal for receiving the combination of the detection current and the reduction current, for example input current.

[0055] According to some implementations of circuit arrangement, the TIA comprises an output connected to the processing unit for supplying the intermediate signal.

[0056] According to some implementations of the circuit arrangement, the TIA comprises a second input connected to a reference terminal.

[0057] According to some implementations of the circuit arrangement, the processing unit is configured to determine a level of signal quality based on the output signal and/or on the intermediate signal and to adapt the reduction value and/or the at least one driving signal, in particular an amplitude, for example a maximum amplitude, of the at least one driving signal, depending on the level of signal quality.

[0058] In such implementations, in particular the reduction value and/or the driving current may be reduced if the level of signal quality is more than sufficiently high for a given application. In this way, a power consumption of the circuit arrangement may be reduced.

[0059] According to some implementations of the circuit arrangement, the processing unit is configured to adapt the reduction value by decreasing an absolute value of the reduction value if the level of signal quality lies above a predefined first quality threshold value.

[0060] According to some implementations of the circuit arrangement, the processing unit is configured to reduce a driving current associated to the at least one driving signal if the level of signal quality lies above a predefined second quality threshold value. The second quality threshold value may be equal to or different from the first quality threshold value.

[0061] According to some implementations of the circuit arrangement, the level of signal quality is given by a signal-to-noise ratio of the intermediate signal and/or the output signal and/or a signal depending on the output signal.

[0062] According to some implementations of the circuit arrangement, the circuit arrangement, for example the processing unit, is configured to generate a motion compensated signal based on the output signal by accounting for effects on the detector current and/or the output signal caused by a motion of the person and/or the circuit arrangement.

[0063] According to some implementations of the circuit arrangement, the level of signal quality is given by a signal amplitude of the motion compensated signal and/or by a signal-to-noise ratio of the motion compensated signal.

[0064] According to some implementations of the circuit arrangement, the level of signal quality is given by a signal quality indicator, SQI, derived from the output signal.

[0065] According to some implementations of the circuit arrangement, the level of signal quality and/or the SQI is derived from the output signal. The level of signal quality and/or the SQI may for example be derived from a heart signal, a frequency variation, a heart frequency variation, an amplitude variation, a heart amplitude variation and/or another quantity and/or signal derived from the output signal.

[0066] According to some implementations of the circuit arrangement, the circuit arrangement, for example the processing unit, further comprises a control unit configured and arranged to determine, at a time when the amplitude of the reduction current is given by the sum of the base value and the reduction value, whether a value of a signal depending on the input current lies within a predefined first range.

[0067] According to some implementations of the circuit arrangement, the control unit is configured and arranged to determine, at a time when the light source does emit light, whether the value of the signal depending on the input current lies within the predefined first range.

[0068] According to some implementations of the circuit arrangement, the control unit is configured and arranged to determine, at a time when the amplitude of the reduction current is given by the base value, whether the value of the signal depending on the input current lies within a predefined second range.

[0069] According to some implementations of the circuit arrangement, the control unit is configured and arranged to determine, at a time when the light source does not emit light, whether the value of the signal depending on the input current lies within the predefined second range.

[0070] According to some implementations of the circuit arrangement, the signal depending on the input current is the intermediate signal.

[0071] According to some implementations of the circuit arrangement, the control unit is configured to adapt the reduction value if it is determined that the value of the signal depending on the input current does not lie within the first range.

[0072] In such implementations, the reduction value may be dynamically adapted to environmental conditions. For example the reduction value may be reduced when signal quality of the output signal is reduced due to a too little or a too large amount of light reaching the optical detector. In turn, signal quality may be further improved in such implementations.

[0073] According to some implementations of the circuit arrangement, the control unit is configured to increase the absolute value of the reduction value if the value of the signal depending on the input current lies above the first range and/or to decrease the absolute value of the reduction value if the value of the signal depending on the input current lies below the first range or vice versa.

[0074] According to some implementations of the circuit arrangement, the control unit is configured to adapt the base value if it is determined that the value of the signal depending on the input current does not lie within the second range.

[0075] In such implementations, the base value may be dynamically adapted to environmental conditions, in particular to changing ambient light conditions. For example the base value may be reduced the when ambient light becomes less and/or increased when the ambient light becomes more. In turn, signal quality may be further improved in such implementations.

[0076] According to some implementations of the circuit arrangement, the control unit is configured to increase the absolute value of the base value if the value of the signal depending on the input current lies above the second range and/or to decrease the absolute value of the base value if the value of the signal depending on the input current lies below the second range or vice versa.

[0077] According to some implementations of the circuit arrangement, the control unit is configured to adapt an amplification factor of the amplifier circuit if it is determined that the value of the signal depending on the input current does not lie within the first range and/or does not lie within the second range.

[0078] In such implementations, the base value may be dynamically adapted to environmental conditions, for example to changing ambient light conditions. For example, since the effective reduction of the detector current by the base value reduces an influence of ambient light, the amplification factor may be increased. This may result in a reduced signal-to-noise ratio and increased fluctuating component for example of the intermediate and/or the output signal and consequently in a further improved signal quality.

[0079] According to some implementations of the circuit arrangement, the control unit is configured to increase the amplification factor if the value of the signal depending on the input current lies below the first range and/or to decrease the amplification factor if the value of the signal depending on the input current lies above the first range or vice versa.

[0080] According to some implementations of the circuit arrangement, the control unit is configured to increase the amplification factor if the value of the signal depending on the input current lies below the second range and/or to decrease the amplification factor if the value of the signal depending on the input current lies above the second range or vice versa.

[0081] According to some implementations of the circuit arrangement, the control unit is configured to adapt at least one driving signal, in particular a maximum amplitude of the at least one driving signal, if the value of the signal depending on the input current does not lie within the first range and/or does not lie within the second range.

[0082] In such implementations, the at least one driving signal and/or driving current may be dynamically adapted, for example when signal quality of the output signal is reduced due to a too little or a too large amount of light reaching the optical detector and/or when the ambient light conditions change. In turn, signal quality may be further improved in such implementations.

[0083] According to some implementations of the circuit arrangement, the control unit is configured to increase a driving current for the light source if the value of the signal depending on the input current lies below the first and/or the second range and to decrease the driving current for the light source if the value of signal depending on the input current lies above the first and/or the second range or vice versa.

According to some implementations of the circuit arrangement, the combination of the detector current and the reduction current, for example the input current, is a sum of the detector current and the reduction current. An absolute value of the sum is smaller than an absolute value of the detector current.

According to some implementations of the circuit arrangement, the output signal is a PPG signal or a signal suitable for generating a PPG signal.

According to the improved concept, also a method for optical monitoring according to independent claim 13 is provided.

[0084] The optical monitoring may comprise heart rate monitoring, HRM, pulse or heart rate variability, PRV, monitoring, and/or pulse oximetry.

[0085] According to some implementations of the method, the method further comprises illuminating a target region of an object by means of light emitted by the light source and detecting a fraction of the light being reflected and/or transmitted by the target region and/or a region of the object being adjacent to the target region. The method comprises generating the detector current based on the detected fraction of the light.

[0086] According to some implementations of the method, the reduction current is generated with the amplitude of the reduction current being given by the base value whenever the light source does not emit light and by the sum of the base value and the reduction value whenever the light source, in particular an optical emitter comprised by the light source, does emit light.

[0087] Further implementations of the method are readily derived from the various implementations and embodiments of the circuit arrangement and vice versa.

[0088] In the following, the invention is explained in detail with the aid of exemplary implementations by reference to the drawings. Components that are functionally identical or have an identical effect may be denoted by identical references. Identical components and/or components with identical effects may be described only with respect to the figure where they occur first and their description is not necessarily repeated in subsequent figures.

[0089] In the drawings,

Figure 1 shows an exemplary implementation of a circuit arrangement according to the improved concept;

Figure 2 shows a further exemplary implementation of a circuit arrangement according to the improved concept;

Figure 3 shows a further exemplary implementation of a circuit arrangement according to the improved concept;

Figure 4 shows a demodulated signal occurring in a circuit arrangement for an optical monitoring system; and

Figure 5 shows a demodulated signal occurring in a circuit arrangement according to the improved concept.

[0090] Figure 1 shows an exemplary implementation of a circuit arrangement according to the improved concept. The circuit arrangement comprises a driver circuit DRV, a processing unit PU connected to the driver circuit DRV and to a detector terminal DT, and a current source CS connected to the detector terminal DT. Furthermore, an optical detector OD connected to the detector terminal DT as well as a light source LS connected to the driver circuit DRV are shown. The optical detector OD and the light source LS may be comprised by the circuit arrangement. In alternative implementations the optical detector OD and/or the light source LS are not comprised by circuit arrangement.

[0091] Moreover, an object O, which is not comprised by the circuit arrangement, as well as an emitted light signal LE, a response light signal LR and an ambient light signal LA are shown. The object O may for example be a body part or a part of a body part of a person or animal. The object O may for example be a wrist of a person. For operation, the circuit arrangement and/or the light source LS and the optical detector OD may for example be arranged in close proximity or in contact to the object O.

[0092] The driver circuit DRV may for example generate a driving signal or a plurality of driving signals for driving the light source LS. The driving signal or the plurality of driving signals may for example correspond to a driving current or a plurality of driving currents, respectively, for the light source LS. Based on the driving signal, the light source LS may generate the emitted light signal LE which may illuminate a target region of the object O. In particular, the driving signal may be a pulsed signal that may for example change back and forth between an off-level and an on-level, in this way generating the emitted light signal LE in a pulsed manner. In particular when the driving signal assumes the on-level, the light source LS may be activated, that is may emit light. When the driving signal assumes the off-level, for example is equal to zero, the light source LS may not be activated, that is may not emit light.

[0093] In this way, the emitted light signal LE features on-phases when the driving signal assumes the on-level and the light source LS emits light and off-phases when the driving signal assumes the off-level and the light source LS does not emit light.

[0094] A pulse frequency of the driving signal may for example lie between several Hz and several kHz, for example between 20Hz and 1kHz. In some implementations, the pulse frequency may be adjustable. Consequently, a switching frequency of the light source LS, in particular frequency of switching between the off-phase and the on-phase, may be given by or approximately given by the pulse frequency of the driving signal.

[0095] The light signal may hit the target region of the object O and may be reflected and/or transmitted, in particular partially reflected and/or transmitted, by the object O, for example by the target region and/or a region adjacent to the target region resulting in a response light signal LR. The response light signal LR may for example be detected by the optical detector OD.

[0096] Furthermore, the optical detector OD may also detect an ambient light signal LA. The ambient light signal LA may for example originate from ambient light that may or may not be present in an environment of the circuit arrangement and/or the object O.

[0097] The optical detector OD may for example be implemented as a photodetector, for example a photodiode. In particular, the optical detector OD may be implemented as a photodetector sensitive to light being emitted by the light source, in particular sensitive to the emitted light signal LE.

[0098] Based on the detected response light signal LR and/or the detected ambient light signal LA, the optical detector OD may generate a detector current Id at the detector terminal DT. The current source CS may generate a reduction current Ir at the detector terminal DT, wherein an amplitude of the reduction current Ir depends on the driving signal and/or on the emitted light signal LE. Depending on the optical detector OD, the amplitude of the reduction current Ir may for example lie in the order of tens or hundreds of nA, for example in the order of 50nA or 100nA.

[0099] In particular, during periods when the light source LS emits light, the amplitude of the reduction current Ir is different than during periods when the light source LS does not emit light. That is, amplitude of the reduction current Ir may be modulated according to the driving signal, in particular synchronously with the driving signal switching between the on-level and the off-level. In other words, the reduction current Ir may be modulated according to and/or synchronous to the switching of the light source LS.

[0100] In particular, the amplitude of the reduction current Ir is different during off-phases of the emitted light signal LE than during on-phases of the emitted light signal LE. That is, the amplitude of the reduction current Ir is different during periods when the driving signal assumes the on-level than during periods when the driving signal assumes the off-level. In particular, an absolute value of the reduction current Ir may be smaller during the off-phases of the emitted light signal LE, that is when the driving signal assumes the off-level, than during the on-phases of the emitted light signal LE, that is when driving signal assumes the on-level.

[0101] At the detector terminal DT, the detector current Id and the reduction current Ir are combined resulting in an input current Ii being supplied to the processing unit PU. The processing unit PU then generates an output signal SO based on the input current Ii. The output signal SO is for example a photoplethysmogram, PPG, signal or a signal suitable for generating a PPG signal.

[0102] The current source CS may for example be implemented as a programmable current source and may for example be controlled by the processing unit PU and/or the driver circuit DRV to generate the reduction current Id as described above. The driver circuit DRV may in particular control a timing of the current source CS. That is, the control driver circuit DRV may control the current source CS to generate the reduction current Ir having an amplitude given by a base value whenever the driving signal assumes the off-level, that is during off-phases of the emitted light signal LE. Furthermore, the driver circuit DRV may control the current source CS to generate the reduction current Ir having an amplitude given by a sum of the base value and a reduction value whenever the driving signal assumes the on-level, that is during on-phases of the emitted light signal LE. An absolute value of the reduction current Ir may for example always be smaller than an absolute value of the detector current Id.

[0103] Alternatively or in addition, the current source LS may comprise a first and a second current source CS1, CS2 (not shown in Figure 1, see Figures 2 and 3), wherein the first current source CS1 is configured to generate a current having an amplitude given by the sum of the base value and the reduction value and the second current source CS2 is configured to generate a current having an amplitude given by the base value. In such implementations, the processing unit PU and/or the driver circuit DRV may be configured to control the current source CS such that it generates the reduction current Id by means of the first current source CS1 during the on-phases of the emitted light signal LE and by means of the second current source CS2 during the off-phases of the emitted light signal LE.

[0104] The current direction of the reduction current Ir is such that the reduction current Ir is effectively subtracting from the detector current Id detector terminal DT. That is, the current direction of the reduction current Ir is such that an absolute value of the input current Ii is always equal to or smaller than an absolute value of the detector current Id. In particular, with | | denoting the absolute value, the following relations hold: $|Ii| = |Id| - |Ir|$ and $|Ir| < |Id|$.

[0105] The reduction of the detector current Id by the reduction current Ir may be less during the off-phases than during the on-phases of the emitted light signal LE. This is for example due to the fact that the response light signal LR and consequently the detector current Id may be significantly larger during the on-phases than during the off-phases, since during the on-phases more light reaches the optical detector OD. The reduction of the detector current Id by the reduction current Ir may also be zero during the off-phases of the emitted light signal LE.

[0106] The output signal SO may then be used to determine, measure and/or monitor a biological parameter of the person or animal, such as heart rate, pulse rate variability and/or oxygen saturation, SpO2. In case of monitoring or measuring SpO2, a value corresponding to the reduction value and/or the reduction current Ir may have to be added mathematically to the output signal SO or to a signal depending on the output signal, since SpO2 measurements may rely on the average as well as on the fluctuating signal components.

[0107] Figure 2 shows a further exemplary implementation of a circuit arrangement according to the improved concept. The implementation of Figure 2 is based on the implementation of Figure 1.

[0108] The processing unit PU comprises an amplifier circuit AC with an input side connected to the detector terminal DT, and a demodulation and signal processing unit DPU connected to an output side of the amplifier circuit AC. The processing unit PU also comprises an analog-to-digital converter ADC connected through the stimulation and signal processing unit DPU.

[0109] The amplifier circuit AC is for example implemented and connected as a transimpedance amplifier, TIA, and comprises an operational amplifier OA with a first input, for example an inverting input, connected to the detector terminal DT and with a second input, for example a non-inverting input, connected to a reference terminal. The amplifier circuit AC comprises a capacitor C, for example a tunable capacitor, connected between the first input of the operational amplifier OA and an output of the operational amplifier OA. The amplifier circuit AC further comprises a resistor R, for example a tunable resistor, connected between the first input and the output of the operational amplifier OA. In alternative implementations of the circuit arrangement, the amplifier circuit AC comprises only one of the resistor R and the capacitor C. By tuning a resistance of the resistor R and/or a capacitance of the capacitor C, an amplification factor of the amplifier circuit AC may be tuned.

[0110] The current source CS may be optimized with respect to noise. In particular a corresponding signal-to-noise ratio of the circuit arrangement may be significantly smaller than a modulation index of the PPG signal, for example smaller by a factor 2 or 5 than a modulation index in the order of 0.05% - 0.3%.

[0111] In the example of Figure 2, the driver circuit DRV comprises a sequencer S and four driver current sources FCS. For the sake of clarity, only one of the driver current sources FCS is shown. The light source LS comprises a first, a second, a third and a fourth optical emitter L1, L2, L3, L4. The optical emitters L1, L2, L3, L4 are for example implemented as LEDs. Each of the optical emitters L1, L2, L3, L4 is connected to an associated one of the driver current sources FCS. In particular, the first optical emitter L1 is connected to a first driver current source, the second optical emitter L2 is connected to a second driver current source, the third optical emitter L3 is connected to a third driver current source and the fourth optical emitter L4 is connected to a fourth driver current source.

[0112] The sequencer S is connected to each of the driver current sources FCS. The sequencer S is also connected to the demodulation and signal processing unit DPU and to the analog-to-digital converter ADC.

[0113] The example of Figure 2, the current source CS comprises a first current source CS1, a second current source CS2 and a switch SW. The first current source CS1 may be configured to generate a current with an amplitude given by the sum of the base value and the reduction value and the second current source CS2 is configured to generate a current with an amplitude given by the base value. The switch SW may for example be controlled by the sequencer S to connect the detector terminal DT to the first current source CS1 during on-phases of the emitted light signal LE and to the second current source CS2 during off-phases of the emitted light signal LE. The first and/or the second current source may be tunable or programmable for adjusting the base and/or the reduction value.

[0114] In alternative implementations, the current source CS may be implemented as a programmable current source as described with respect to Figure 1.

[0115] The sequencer S may control the first driver current source such that it generates a first driving signal, in particular a first driving current, for driving the first optical emitter L1. Analogously, the sequencer S may control the second, third and fourth driver current sources such that they generate a second, a third and a fourth driving signal or driving current for driving the second, the third and fourth optical emitter L2, L3, L4, respectively.

[0116] In particular the sequencer S may control the driver current sources FCS such that only one of the optical emitters L1, L2, L3, L4 may emit light at a given time. Consequently, the operation of the circuit arrangement shown in Figure 2 is analog to the operation of the circuit arrangement shown in Figure 1 as explained above. In particular, on-phases of the emitted light signal LE correspond to periods when any of the driving signals assumes a respective on-level suitable for activating the associated optical emitter. Analogously, off-phases of the emitted light signal LE correspond to periods when none of the driving signals assumes a respective on-level, that is when each of the driving signal assumes a respective off-level not suitable for activating the associated optical emitter.

[0117] The sequencer S may control the current source CS such that it generates the reduction current Ir having an amplitude given by the sum of the base value and the reduction value whenever any of the driving signals assumes a respective on-level and by the base value otherwise.

[0118] The optical emitters L1, L2, L3, L4 may be configured to emit different types of radiation, in particular different colors of light. For example at least one of the optical emitters L1, L2, L3, L4 may be configured to emit green light, at least one of the optical emitters L1, L2, L3, L4 may be configured to emit red light and at least one of the optical emitters L1, L2, L3, L4 may be configured to emit infrared radiation.

[0119] In this way, different optical emitters L1, L2, L3, L4 may be used for different applications of the circuit arrangement and to monitoring system, respectively. For example, an optical emitter configured to emit green light may be used for monitoring a heart rate, while an optical emitter configured to emit red light or infrared radiation, may be used for monitoring an oxygen saturation in the blood.

[0120] In some implementations, the reduction value may be different, depending on which of the driving signal assumes the respective on-level. That is, in case the first optical emitter L1 emits light, the reduction value may be given by a first reduction value, in case the second optical emitter emits light, the reduction value may be given by a second reduction value and so forth. The first, the second, the third and the fourth reduction value may be equal to or different or partially different from each other.

[0121] The amplifier circuit AC amplifies the input current Ii, in this way generating an intermediate signal being supplied to the demodulation and signal processing unit DPU. The demodulation and signal processing unit DPU may generate a demodulated signal SD based on the intermediate signal. To this end, the demodulation and signal processing unit may for example subtract a value of the intermediate signal during an on-phase of the emitted light signal LE and a value of the intermediate signal during an off-phase of the emitted light signal LE from each other. A corresponding timing or clock of the demodulation and signal processing unit DPU may be controlled or provided by the sequencer S.

[0122] Furthermore, the demodulation and signal processing unit DPU may comprise one or more filters for generating the demodulated signal SD by filtering the intermediate signal or a signal depending on the intermediate signal.

[0123] The demodulated signal is supplied to the analog-to-digital converter ADC. The analog-to-digital converter ADC converts for example the analog the modulated signal SD into the digital output signal SO. A corresponding timing or clock of the analog-to-digital converter ADC of the may be controlled or provided by the sequencer S.

[0124] Figure 3 shows a further exemplary implementation of a circuit arrangement according to the improved concept. The implementation of Figure 3 is based on the implementation of Figure 2.

In the implementation of Figure 3, the processing unit PU further comprises a control unit CU connected between the amplifier circuit AC and the demodulation and signal processing unit DPU for receiving the intermediate signal.

[0125] The control unit CU determines during an on-phase whether the intermediate signal lies within a predefined first range and/or during an off-phase whether the intermediate signal lies within a predefined second range.

The control unit CU may be connected to the amplifier circuit AC and may be configured to tune the amplification factor of the amplifier circuit AC, for example by tuning the capacitance of the capacitor C and/or the resistance of the resistor R, depending on the intermediate signal. If the intermediate signal lies outside the first range during an on-phase and/or outside the second range during an off-phase, the control unit CU may adjust the amplification factor of the amplifier circuit AC accordingly to drive the intermediate signal back into the first and/or the second range.

Alternatively or in addition, the control unit CU may be connected to the current source CS and may be configured to adapt the base value and/or the reduction value. In particular, if the intermediate signal lies outside the first range during an on-phase, the control unit CU may adapt the reduction value and/or the LED current accordingly to drive the intermediate signal back into the first range. This may for example be particularly advantageous in case only a little amount of light is reaching the optical detector OD, for example for very dark skin tone of the person, due to limited coupling efficiency of light into the object O and/or due to limited efficiency of the light source LS.

If the intermediate signal lies outside the second range during an off-phase, the control unit may adapt the base value accordingly to drive the intermediate signal back into the second range. This may for example be particularly advantageous for compensating a changing ambient light condition.

[0126] Alternatively or in addition, the control unit is connected to the driver current sources DCS. This connection is not shown in Figure 3 the sake of clarity. If the intermediate signal lies outside the first range during an on-phase and/or outside the second range during an off-phase, the control unit CU adjusts the driving signals or driving currents accordingly to drive the intermediate signal back into the first and/or the second range.

Figure 4 shows a demodulated signal SD occurring in a circuit arrangement for an optical monitoring system, in particular in a conventional circuit arrangement for an optical monitoring system. The demodulated signal SD shown in Figure 4 may be understood as demodulated signal SD as occurring in an implementation of one of Figures 2 and 3, wherein the current source CS is not present or the reduction current Ir is zero, respectively.

[0127] On the horizontal axis, time T is shown in arbitrary units and on the vertical axis the demodulated signal SD is shown in arbitrary units. It can be seen that the fluctuating component of the demodulated signal SD is very small compared to the average component of the demodulated signal SD.

[0128] Figure 5 shows a demodulated signal occurring in a circuit arrangement according to the improved concept, for example in the circuit arrangement as described with respect to one of Figures 2 and 3.

[0129] On the horizontal axis, time T is shown in the same arbitrary units as in Figure 4 and on the vertical axis the demodulated signal SD is shown in the same arbitrary units as an Figure 4. It can be seen that the average component of the demodulated signal SD is significantly decreased with respect to the example shown in Figure 4. This is due to the reduction of the detector current Id by the reduction current Ir as described with respect to Figures 1 to 3. Consequently, the amplification factor of the amplifier arrangement AC could be increased without the risk of saturation. Therefore, the fluctuating component of the demodulated signal SD is significantly increased with respect to the example shown in Figure 4.

[0130] The curves of the demodulated signal SD shown in Figure 4 and 5 are based on actually measured signals.

[0131] By means of a circuit arrangement according to the improved concept, an average component of the input current Ii, the output signal SO, the intermediate signal and/or the demodulated signal SD may be reduced due to the reduction of the detector current Id by the reduction current Ir. In particular, the average component may be reduced more during the on-phases than during the off-phases of the emitted light signal LE.

[0132] In implementations wherein the base value is non-zero, the average component is reduced during the off-phases of the emitted light signal LE. However, the reduction is less than during the on-phases, that is when any of the at least one driving signal assumes a value suitable for activating the light source. In this way, also impairing influence of ambient light may be reduced.

[0133] Furthermore, due to the reduction of the input current Ii, for example during the off-phases, the amplification factor of the amplifier circuit AC may be increased without the risk of saturation. The current consumption and/or the size of the amplifier circuit AC may for example be reduced while obtaining similar or better signal-to-noise ratio.

[0134] Also a driving current of the light source LS may be reduced by means of the improved concept since the signal-to-noise ratio, in particular of the whole optical chain of the monitoring system, is improved. This may lead to reduction of power consumption.

[0135] Moreover, compared to the average component of the demodulated signal SD, the fluctuating component of the demodulated signal SD is increased in this way, which may relax requirements on the accuracy of the analog-to-digital converter ADC and/or noise requirements for the amplifier circuit AC, in particular the TIA.

[0136] Consequently, an improved signal quality, in particular an improved PPG signal quality, may be achieved according to the improved concept.

Reference numerals

[0137]

DT	detector terminal
CS, CS1, CS2	current sources
DCS	driver current sources
PU	processing unit
DRV	driver circuit
LS	light source
L1, L2, L3, L4	optical emitters
OD	optical detector
O	object
AC	amplifier circuit
OA	operational amplifier
C	capacitor
R	resistor
DPU	demodulation and signal processing unit
ADC	analog-to-digital converter
S	sequencer
CU	control unit
Ir	reduction current
Id	detector current
Ii	input current
LE	emitted light signal
LR	response light signal
LA	ambient light signal
SO	output signal
SD	demodulated signal

Claims

1. Circuit arrangement for an optical monitoring system, the circuit arrangement comprising

   - a driver circuit (DRV) configured to generate at least one driving signal for driving a light source (LS);
   - a detector terminal (DT) for receiving a detector current (Id), in particular from an optical detector (OD);
   - a current source (CS) configured and arranged to generate at the detector terminal (DT) a reduction current (Ir), wherein an amplitude of the reduction current (Ir)

     - is given by a base value whenever none of the at least one driving signal assumes a value suitable for activating the light source (LS); and
     - is given by a sum of the base value and a reduction value otherwise;

   - a processing unit (PU) configured to generate an output signal (SO) depending on a combination of the detector current (Id) and the reduction current (Ir); **characterized in that** it further comprises
   - a control unit (CU) configured and arranged to

     - determine whether a value of a signal depending on the combination of the detector current (Id) and the reduction current (Ir) lies within a predefined first range at a time when the amplitude of the reduction current (Ir) is given by the sum of the base value and the reduction value and/or lies within a predefined second range at a time when the amplitude of the reduction current (Ir) is given by the base value; and
     - adapt the at least one driving signal if the value of the signal depending on the combination of the detector current (Id) and the reduction current (Ir) does not lie within the first range and/or does not lie within the second range.

2. Circuit arrangement according to claim 1, wherein the processing unit (PU) is configured to

   - generate an intermediate signal by amplifying the combination of the detector current (Id) and the reduction current (Ir);
   - determine a first value of the intermediate signal at a first point in time and a second value of the intermediate signal at a second point in time, wherein amplitude of the reduction current (Ir) is given by the sum of the base value and the reduction value at the first point in time and by the base value at the second point in time;
   - determine a difference between the first and the second value of the intermediate signal; and
   - generate the output signal (SO) depending on the determined difference.

3. Circuit arrangement according to one of claims 1 or 2, wherein the processing unit (PU) is configured to determine a level of signal quality based on the out-

put signal (SO) and to adapt the reduction value and/or the at least one driving signal depending on the level of signal quality.

4. Circuit arrangement according to one of claims 1 to 3, wherein the control unit (CU) is configured to

- adapt the reduction value if the value of the signal depending on the combination of the detector current (Id) and the reduction current (Ir) does not lie within the first range; and/or
- adapt the base value if the value of the signal depending on the combination of the detector current (Id) and the reduction current (Ir) does not lie within the second range.

5. Circuit arrangement according to one of claims 1 to 4, wherein the control unit (CU) is configured to adapt a maximum amplitude of the at least one driving signal if the value of the signal depending on the combination of the detector current (Id) and the reduction current (Ir) does not lie within the first range and/or does not lie within the second range.

6. Circuit arrangement according to one of claims 1 to 5, wherein

- the combination of the detector current (Id) and the reduction current (Ir) is a sum of the detector current (Id) and the reduction current (Ir); and
- an absolute value of the sum is smaller than an absolute value of the detector current (Id).

7. Circuit arrangement according to one of claims 1 to 6, wherein

- the driver circuit (DRV) is configured to generate the at least one driving signal as a first and at least a second driving signal;
- the reduction value is given by a first reduction value whenever the first driving signal assumes a value suitable for activating the light source (LS); and
- the reduction value is given by a second reduction value whenever the second driving signal assumes a value suitable for activating the light source (LS).

8. Circuit arrangement according to claim 7, wherein the second reduction value is different from the first reduction value.

9. Circuit arrangement according to one of claims 7 or 8, further comprising the light source (LS), wherein the light source (LS) comprises a first optical emitter (L1) configured and arranged to be driven by the first driving signal and a second optical emitter (L2) configured and arranged to be driven by the second driving signal.

10. Circuit arrangement according to one of claims 1 to 8, further comprising the light source (LS), wherein the light source (LS) comprises at least one optical emitter (L1, L2, L3, L4) configured and arranged to be driven by the at least one driving signal.

11. Circuit arrangement according to one of claims 1 to 10, further comprising the optical detector (OD).

12. Circuit arrangement according to one of claims 1 to 11, wherein the output signal (SO) is a photoplethysmogram, PPG, signal or a signal suitable for generating a PPG signal.

13. Method for optical monitoring, the method comprising

- generating by means of a driver circuit (DRV) at least one driving signal for driving a light source (LS);
- receiving by means of a detector terminal (DT) a detector current (Id) from an optical detector (OD) ;
- generating by means of a current source (CS) a reduction current (Ir), wherein an amplitude of the reduction current (Ir)

  - is given by a base value whenever none of the at least one driving signal assumes a value suitable for activating the light source (LS); and
  - is given by a sum of the base value and a reduction value otherwise;

- generating by means of a processing unit (PU) an output signal (SO) depending on a combination of the detector current (Id) and the reduction current (Ir); and performing by means of a control unit (CU) the following steps:

  - determining whether a value of a signal depending on the combination of the detector current (Id) and the reduction current (Ir) lies within a predefined first range at a time when the amplitude of the reduction current (Ir) is given by the sum of the base value and the reduction value and/or lies within a predefined second range at a time when the amplitude of the reduction current (Ir) is given by the base value; and
  - adapting the at least one driving signal if the value of the signal depending on the combination of the detector current (Id) and the reduction current (Ir) does not lie within the first range and/or does not lie within the second range.

14. Method according to claim 13, further comprising

- illuminating a target region of an object (O) by means of light emitted by the light source;
- detecting a fraction of the light being reflected from and/or transmitted by the target region and/or a region of the object (O) being adjacent to the target region; and
- generating the detector current (Id) based on the detected fraction of the light.

Patentansprüche

1. Schaltungsanordnung für ein optisches Überwachungssystem, wobei die Schaltungsanordnung umfasst:

- eine Ansteuerschaltung (DRV), die dazu ausgelegt ist, mindestens ein Ansteuerungssignal zum Ansteuern einer Lichtquelle (LS) zu generieren;
- einen Detektoranschluss (DT), um einen Detektorstrom (Id) insbesondere aus einem optischen Detektor (OD) zu empfangen;
- eine Stromquelle (CS), die dazu ausgelegt und eingerichtet ist, am Detektoranschluss (DT) einen Reduktionsstrom (Ir) zu erzeugen, wobei eine Amplitude des Reduktionsstroms (Ir)
- immmer dann durch einen Grundwert gegeben ist, wenn das mindestens eine Ansteuerungssignal nicht einen Wert annimmt, der sich zum Aktivieren der Lichtquelle (LS) eignet; und
- andernfalls durch eine Summe des Grundwerts und eines Reduktionswerts gegeben ist;
- eine Verarbeitungseinheit (PU), die dazu ausgelegt ist, ein Ausgangssignal (SO) zu generieren, das von einer Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt;

dadurch gekennzeichnet, dass sie darüber hinaus umfasst:

- eine Steuereinheit (CU), die dazu ausgelegt und eingerichtet ist,
- zu bestimmen, ob ein Wert eines Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, zu einem Zeitpunkt innerhalb eines vordefinierten ersten Bereichs liegt, zu dem die Amplitude des Reduktionsstroms (Ir) durch die Summe des Grundwerts und des Reduktionswerts gegeben ist, und/oder zu einem Zeitpunkt innerhalb eines vordefinierten zweiten Bereichs liegt, zu dem die Amplitude des Reduktionsstroms (Ir) durch den Grundwert gegeben ist; und
- das mindestens eine Ansteuerungssignal anzupassen, falls der Wert des Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, nicht innerhalb des ersten Bereichs liegt und/oder nicht innerhalb des zweiten Bereichs liegt.

2. Schaltungsanordnung nach Anspruch 1, wobei die Verarbeitungseinheit (PU) dazu ausgelegt ist,

- ein Zwischensignal zu generieren, indem die Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) verstärkt wird;
- einen ersten Wert des Zwischensignals zu einem ersten Zeitpunkt und einen zweiten Wert des Zwischensignals zu einem zweiten Zeitpunkt zu bestimmen, wobei die Amplitude des Reduktionsstroms (Ir) durch die Summe des Grundwerts und des Reduktionswerts zum ersten Zeitpunkt und durch den Grundwert zum zweiten Zeitpunkt gegeben ist;
- eine Differenz zwischen dem ersten und dem zweiten Wert des Zwischensignals zu bestimmen; und
- das Ausgangssignal (SO) in Abhängigkeit von der bestimmten Differenz zu generieren.

3. Schaltungsanordnung nach einem der Ansprüche 1 oder 2, wobei die Verarbeitungseinheit (PU) dazu ausgelegt ist, einen Signalqualitätsgrad auf Grundlage des Ausgangssignals (SO) zu bestimmen und den Reduktionswert und/oder das mindestens eine Ansteuerungssignal in Abhängigkeit vom Signalqualitätsgrad anzupassen.

4. Schaltungsanordnung nach einem der Ansprüche 1 bis 3, wobei die Steuereinheit (CU) dazu ausgelegt ist,

- den Reduktionswert anzupassen, falls der Wert des Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, nicht innerhalb des ersten Bereichs liegt; und/oder
- den Grundwert anzupassen, falls der Wert des Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, nicht innerhalb des zweiten Bereichs liegt.

5. Schaltungsanordnung nach einem der Ansprüche 1 bis 4, wobei die Steuereinheit (CU) dazu ausgelegt ist, eine maximale Amplitude des mindestens einen Ansteuerungssignals anzupassen, falls der Wert des Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, nicht innerhalb des ersten Bereichs liegt und/oder nicht innerhalb des zweiten Bereichs liegt.

6. Schaltungsanordnung nach einem der Ansprüche 1 bis 5, wobei

- es sich bei der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) um eine Summe des Detektorstroms (Id) und des Reduktionsstroms (Ir) handelt; und
- ein Absolutwert der Summe kleiner ist als ein Absolutwert des Detektorstroms (Id).

7. Schaltungsanordnung nach einem der Ansprüche 1 bis 6, wobei

- die Ansteuerungsschaltung (DRV) dazu ausgelegt ist, das mindestens eine Ansteuerungssignal als ein erstes und zumindest ein zweites Ansteuerungssignal zu generieren;
- der Reduktionswert immer dann durch einen ersten Reduktionswert gegeben ist, wenn das erste Ansteuerungssignal einen zum Aktivieren der Lichtquelle (LS) geeigneten Wert annimmt; und
- der Reduktionswert immer dann durch einen zweiten Reduktionswert gegeben ist, wenn das zweite Ansteuerungssignal einen zum Aktivieren der Lichtquelle (LS) geeigneten Wert annimmt.

8. Schaltungsanordnung nach Anspruch 7, wobei sich der zweite Reduktionswert vom ersten Reduktionswert unterscheidet.

9. Schaltungsanordnung nach einem der Ansprüche 7 oder 8, darüber hinaus die Lichtquelle (LS) umfassend, wobei die Lichtquelle (LS) einen ersten optischen Emitter (L1), der dazu ausgelegt und eingerichtet ist, durch das erste Ansteuerungssignal angesteuert zu werden, und einen zweiten optischen Emitter (L2) umfasst, der dazu ausgelegt und eingerichtet ist, durch das zweite Ansteuerungssignal angesteuert zu werden.

10. Schaltungsanordnung nach einem der Ansprüche 1 bis 8, darüber hinaus die Lichtquelle (LS) umfassend, wobei die Lichtquelle (LS) mindestens einen optischen Emitter (L1, L2, L3, L4) umfasst, der dazu ausgelegt und eingerichtet ist, durch das mindestens eine Ansteuerungssignal angesteuert zu werden.

11. Schaltungsanordnung nach einem der Ansprüche 1 bis 10, darüber hinaus den optischen Detektor (OD) umfassend.

12. Schaltungsanordnung nach einem der Ansprüche 1 bis 11, wobei es sich bei dem Ausgangssignal (SO) um ein Photoplethysmogramm-PPG-Signal oder ein zum Generieren eines PPG-Signals geeignetes Signal handelt.

13. Verfahren zur optischen Überwachung, wobei das Verfahren umfasst:

- Generieren, und zwar mittels einer Ansteuerungsschaltung (DRV), mindestens eines Ansteuerungssignals zum Ansteuern einer Lichtquelle (LS);
- Empfangen, und zwar mittels eines Detektoranschlusses (DT), eines Detektorstroms (Id) aus einem optischen Detektor (OD);
- Erzeugen, und zwar mittels einer Stromquelle (CS), eines Reduktionsstroms (Ir), wobei eine Amplitude des Reduktionsstroms (Ir)
- immmer dann durch einen Grundwert gegeben ist, wenn das mindestens eine Ansteuerungssignal nicht einen Wert annimmt, der sich zum Aktivieren der Lichtquelle (LS) eignet; und
- andernfalls durch eine Summe des Grundwerts und eines Reduktionswerts gegeben ist;
- Generieren, und zwar mittels einer Verarbeitungseinheit (PU), eines Ausgangssignals (SO), das von einer Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt; und Durchführen, und zwar mittels einer Steuereinheit (CU), der folgenden Schritte:

  - Bestimmen, ob ein Wert eines Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, zu einem Zeitpunkt innerhalb eines vordefinierten ersten Bereichs liegt, zu dem die Amplitude des Reduktionsstroms (Ir) durch die Summe des Grundwerts und des Reduktionswerts gegeben ist, und/oder zu einem Zeitpunkt innerhalb eines vordefinierten zweiten Bereichs liegt, zu dem die Amplitude des Reduktionsstroms (Ir) durch den Grundwert gegeben ist; und
  - Anpassen des mindestens einen Ansteuerungssignals, falls der Wert des Signals, das von der Kombination des Detektorstroms (Id) und des Reduktionsstroms (Ir) abhängt, nicht innerhalb des ersten Bereichs liegt und/oder nicht innerhalb des zweiten Bereichs liegt.

14. Verfahren nach Anspruch 13, darüber hinaus umfassend:

- Beleuchten eines Zielbereichs eines Objekts (O) mittels durch die Lichtquelle emittierten Lichts;
- Erfassen eines Bruchteils des Lichts, das vom Zielbereich und/oder einem Bereich des Objekts (O), der sich angrenzend an den Zielbereich befindet, reflektiert und/oder übertragen wird; und
- Erzeugen des Detektorstroms (Id) auf Grundlage des erfassten Bruchteils des Lichts.

Revendications

1. Agencement de circuit pour un système de surveillance optique, l'agencement de circuit comprenant

- un circuit pilote (DRV) configuré pour générer au moins un signal pilote destiné à piloter une source de lumière (LS) ;
- une borne de détecteur (DT) destinée à recevoir un courant de détecteur (Id), en particulier depuis un détecteur optique (OD);
- une source de courant (CS) configurée et agencée pour générer au niveau de la borne de détecteur (DT) un courant de réduction (Ir), sachant qu'une amplitude du courant de réduction (Ir)
- est donnée par une valeur de base chaque fois qu'aucun de l'au moins un signal pilote n'adopte une valeur apte à activer la source de lumière (LS); et
- est donnée par une somme de la valeur de base et d'une valeur de réduction dans les autres cas;
- une unité de traitement (PU) configurée pour générer un signal de sortie (SO) dépendant d'une combinaison du courant de détecteur (Id) et du courant de réduction (Ir); **caractérisé en ce qu'**il comprend en outre
- une unité de commande (CU) configurée et agencée pour
- déterminer si une valeur d'un signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) est comprise dans une première plage prédéfinie à un moment où l'amplitude du courant de réduction (Ir) est donnée par la somme de la valeur de base et de la valeur de réduction et/ou est comprise dans une deuxième plage prédéfinie à un moment où l'amplitude du courant de réduction (Ir) est donnée par la valeur de base; et
- adapter l'au moins un signal pilote si la valeur du signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) n'est pas comprise dans la première plage et/ou n'est pas comprise dans la deuxième plage.

2. Agencement de circuit selon la revendication 1, sachant que l'unité de traitement (PU) est configurée pour

- générer un signal intermédiaire en amplifiant la combinaison du courant de détecteur (Id) et du courant de réduction (Ir);
- déterminer une première valeur du signal intermédiaire à un premier point dans le temps et une deuxième valeur du signal intermédiaire à un deuxième point dans le temps, sachant que l'amplitude du courant de réduction (Ir) est donnée par la somme de la valeur de base et de la valeur de réduction au premier point dans le temps et par la valeur de base au deuxième point dans le temps;
- déterminer une différence entre la première et la deuxième valeur du signal intermédiaire; et
- générer le signal de sortie (SO) en fonction de la différence déterminée.

3. Agencement de circuit selon l'une des revendications 1 ou 2, sachant que l'unité de traitement (PU) est configurée pour déterminer un niveau de qualité de signal sur la base du signal de sortie (SO) et pour adapter la valeur de réduction et/ou l'au moins un signal pilote en fonction du niveau de qualité de signal.

4. Agencement de circuit selon l'une des revendications 1 à 3, sachant que l'unité de commande (CU) est configurée pour

- adapter la valeur de réduction si la valeur du signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) n'est pas comprise dans la première plage; et/ou
- adapter la valeur de base si la valeur du signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) n'est pas comprise dans la deuxième plage.

5. Agencement de circuit selon l'une des revendications 1 à 3, sachant que l'unité de commande (CU) est configurée pour adapter une amplitude maximale de l'au moins un signal pilote si la valeur du signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) n'est pas comprise dans la première plage et/ou n'est pas comprise dans la deuxième plage.

6. Agencement de circuit selon l'une des revendications 1 à 5, sachant que

- la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) est une somme du courant de détecteur (Id) et du courant de réduction (Ir); et
- une valeur absolue de la somme est inférieure à une valeur absolue du courant de détecteur (Id).

7. Agencement de circuit selon l'une des revendications 1 à 6, sachant que

- le circuit pilote (DRV) est configuré pour générer l'au moins un signal pilote en tant que premier et au moins deuxième signal pilote;

- la valeur de réduction est donnée par une première valeur de réduction chaque fois que le premier signal pilote adopte une valeur apte à activer la source de lumière (LS); et
- la valeur de réduction est donnée par une deuxième valeur de réduction chaque fois que le deuxième signal pilote adopte une valeur apte à activer la source de lumière (LS) .

8. Agencement de circuit selon la revendication 7, sachant que la deuxième valeur de réduction est différente de la première valeur de réduction.

9. Agencement de circuit selon l'une des revendications 7 ou 8, comprenant en outre la source de lumière (LS), sachant que la source de lumière (LS) comprend un premier émetteur optique (L1) configuré et agencé pour être piloté par le premier signal pilote et un deuxième émetteur optique (L2) configuré et agencé pour être piloté par le deuxième signal pilote.

10. Agencement de circuit selon l'une des revendications 1 à 8, comprenant en outre la source de lumière (LS), sachant que la source de lumière (LS) comprend au moins un émetteur optique (L1, L2, L3, L4) configuré et agencé pour être piloté par l'au moins un signal pilote.

11. Agencement de circuit selon l'une des revendications 1 à 10, comprenant en outre le détecteur optique (OD).

12. Agencement de circuit selon l'une des revendications 1 à 11, sachant que le signal de sortie (SO) est un signal de photopléthysmogramme, PPG, ou un signal apte à générer un signal de PPG.

13. Procédé de surveillance optique, le procédé comprenant

- la génération, moyennant un circuit pilote (DRV), d'au moins un signal pilote destiné à piloter une source de lumière (LS);
- la réception, moyennant une borne de détecteur (DT), d'un courant de détecteur (Id) depuis un détecteur optique (OD) ;
- la génération, moyennant une source de courant (CS), d'un courant de réduction (Ir), sachant qu'une amplitude du courant de réduction (Ir)
- est donnée par une valeur de base chaque fois qu'aucun de l'au moins un signal pilote n'adopte une valeur apte à activer la source de lumière (LS); et
- est donnée par une somme de la valeur de base et d'une valeur de réduction dans les autres cas;
- la génération, moyennant une unité de traitement (PU), d'un signal de sortie (SO) dépendant d'une combinaison du courant de détecteur (Id) et du courant de réduction (Ir); et l'exécution, moyennant une unité de commande (CU), des étapes suivantes:

- le fait de déterminer si une valeur d'un signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) est comprise dans une première plage prédéfinie à un moment où l'amplitude du courant de réduction (Ir) est donnée par la somme de la valeur de base et de la valeur de réduction et/ou est comprise dans une deuxième plage prédéfinie à un moment où l'amplitude du courant de réduction (Ir) est donnée par la valeur de base; et
- l'adaptation de l'au moins un signal pilote si la valeur du signal dépendant de la combinaison du courant de détecteur (Id) et du courant de réduction (Ir) n'est pas comprise dans la première plage et/ou n'est pas comprise dans la deuxième plage.

14. Procédé selon la revendication 13, comprenant en outre

- l'éclairage d'une région cible d'un objet (O) moyennant de la lumière émise par la source de lumière;
- la détection d'une fraction de la lumière qui est réfléchie depuis et/ou transmise par la région cible et/ou une région de l'objet (O) qui est adjacente à la région cible; et
- la génération du courant de détecteur (Id) sur la base de la fraction détectée de la lumière.

FIG. 1

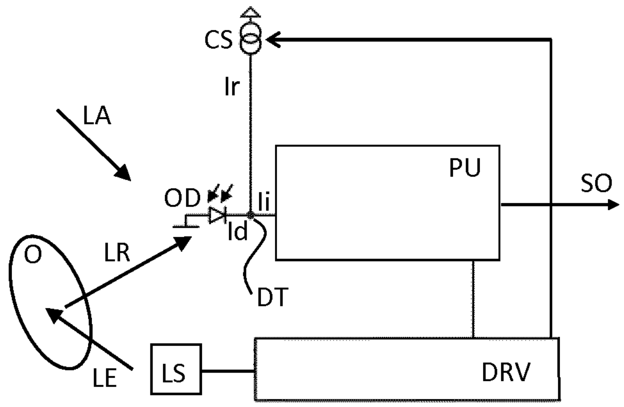
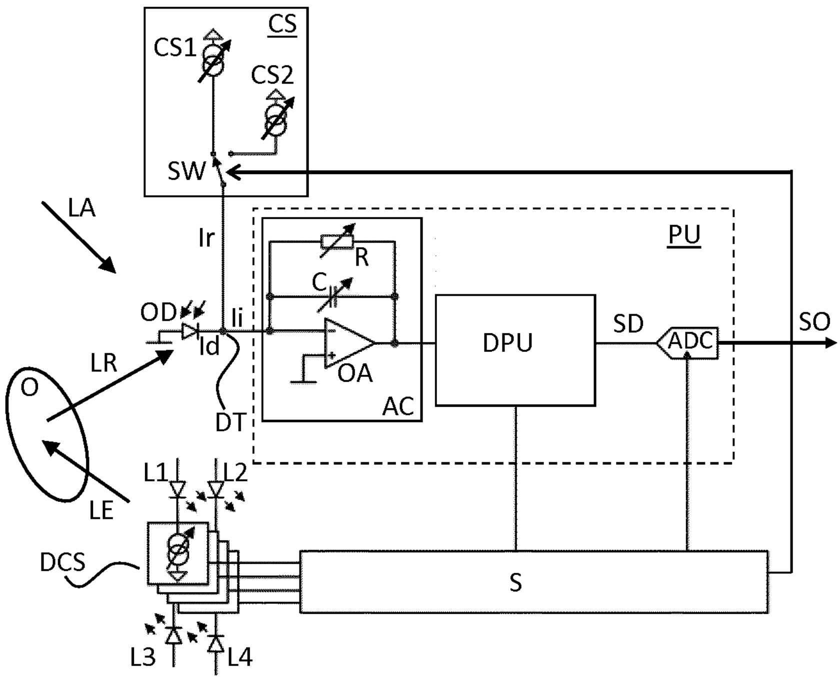

CS
Ir
LA
PU
SO
OD
Ii
Id
O
LR
DT
LS
DRV
LE

FIG. 2


CS
CS1
CS2
SW
LA
Ir
PU
R
C
OD
Ii
Id
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SD
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O
OA
AC
DT
L1
L2
LE
DCS
S
L3
L4

FIG. 3

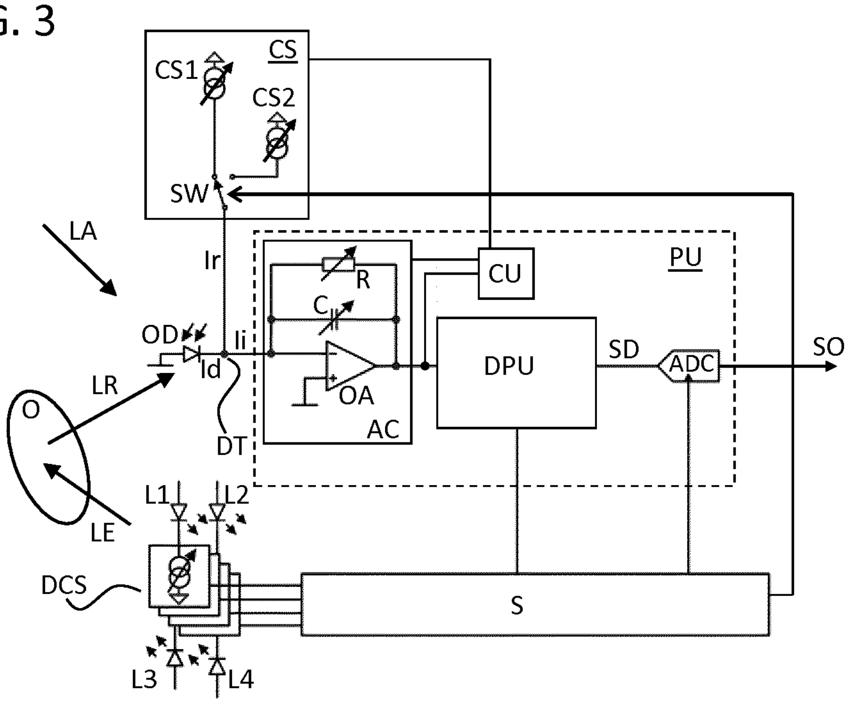


FIG. 4

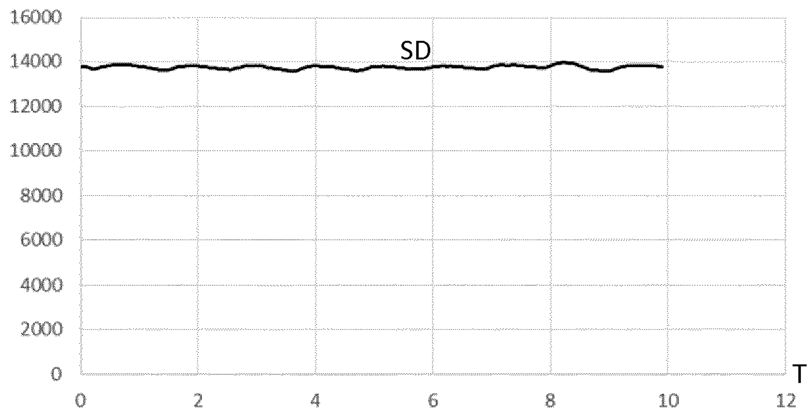
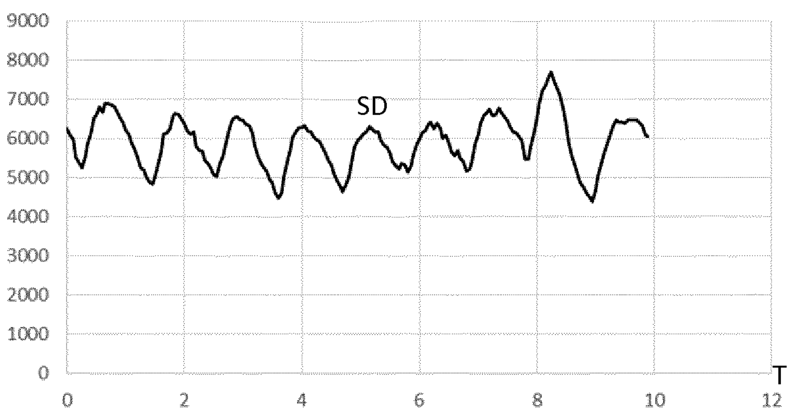


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20120188292 A **[0004]**
- US 8848202 B2 **[0005]**
- US 4453218 A **[0006]**
- US 20030069486 A1 **[0007]**

专利名称(译)	用于光学监测系统的光学装置和用于光学监测的方法		
公开(公告)号	EP3135196B1	公开(公告)日	2019-02-27
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[标]申请(专利权)人(译)	奥地利微系统股份有限公司		
申请(专利权)人(译)	AMS AG		
当前申请(专利权)人(译)	AMS AG		
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IPC分类号	A61B5/1455 A61B5/00		
CPC分类号	A61B5/14552 A61B5/7221 A61B2560/0209 A61B5/02416 H04B10/07		
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外部链接	Espacenet		

摘要(译)

用于光学监视系统的电路装置包括：驱动器电路（DRV），被配置为产生至少一个用于驱动光源（LS）的驱动信号;以及检测器端子（DT），用于接收检测器电流（Ir）。该电路装置还包括电流源（LS），其被配置和布置成在检测器端子（DT）处产生还原电流（Ir）。每当至少一个驱动信号中没有一个呈现适合于激活光源（LS）的值时，减小电流（Ir）具有由基值给出的幅度，否则具有基值和减小值之和。该电路装置还包括处理单元（PU），其被配置为根据检测器电流（Id）和还原电流（Ir）的组合产生输出信号（SO）。

FIG. 1

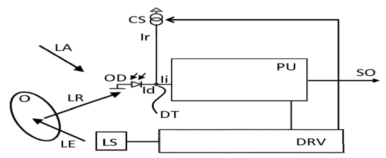

FIG. 2